GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
ELECTRONICS – COMPONENT 1
A490U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2020 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 2020 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.

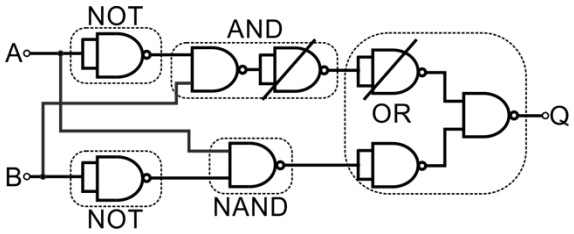
Extended response question

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

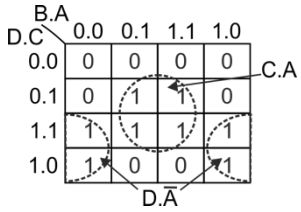
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

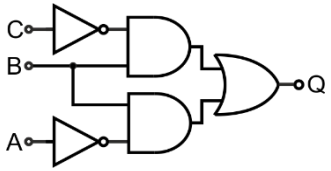
cao = correct answer only
ecf = error carried forward

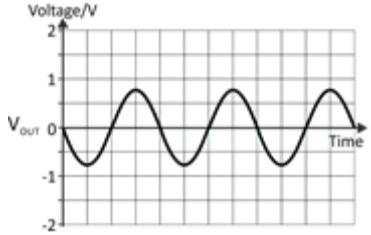
<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="5">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th></tr>
<tr><td>1.</td><td>(a)</td><td>(i)</td><td> 

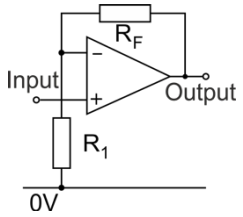
Correct NOT conversion [1]
Correct AND conversion [1]
Correct OR conversion [1]
Correct cancellation - 1 pair only [1]</td><td>1</td><td>1</td><td>2</td><td>4</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Marking:
<table><tr><th>B</th><th>A</th><th>J</th><th>K</th><th>L</th><th>M</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr></table>J = $\overline{A}$ AND K = $\overline{B}$ [1]
L = J AND B AND M = K NAND A [1]
Q = L OR M [1]</td><td>1</td><td>2</td><td></td><td>3</td><td>2</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>L = B . $\overline{A}$
M = ($\overline{\overline{B} . A}$) or ($\overline{B} . \overline{A}$ + B . $\overline{A}$ + B . A)
Q = ($\overline{\overline{B} . A}$ + B . $\overline{A}$) or ($\overline{A} . \overline{B}$ + $\overline{A}$. B + A . B)
One mark per term [3]</td><td>1</td><td>2</td><td></td><td>3</td><td>2</td></tr>
</table>

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(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> Rows 0 to 3 correct [1] Rows 4 to 7 correct [1]	1	1		2	
			Question 1 total	**4**	**6**	**2**	**12**	**4**

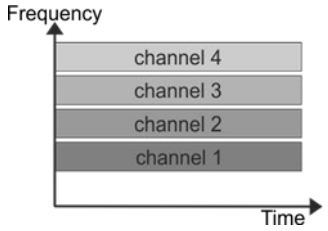
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
2.	*(a)*		 Correct map [1] Groups identified [1] Biggest groups chosen [1] Answer: Q = C.A + D.$\bar{A}$ [1]	2	2		4	2
	(b)		A.B + A + A . $\bar{B}$ = A (1+B+$\bar{B}$) – factorisation (or equivalent) [1] Answer = A [1]	1	1		2	2
	(c)		Q = $\overline{\overline{(A + \bar{B})} + \bar{B}}$ = (A + $\bar{B}$) . B = A . B Use of DMT [1] Answer = A. B [1]	1	1		2	2
	(d)	(i)	<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>0</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>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</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>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td></tr></table> All correct [2] One error - subtract 1 mark	1	1		2	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(ii)	Q = $\overline{C}$.B.$\overline{A}$+$\overline{C}$.B.A+C.B.$\overline{A}$ (or simplified version) [1] Any valid simplification [1] Answer: Q = $\overline{C}$.B+B.$\overline{A}$ [1]	1	2		3	2
		(iii)	 $\overline{C}$.B term [1] B.$\overline{A}$ term [1] Correct use of OR gate [1]			3	3	
			Question 2 total	**6**	**7**	**3**	**16**	**8**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
3.	*(a)*		<table><tr><td>Property</td><td>Ideal value</td></tr><tr><td>Input impedance</td><td>**Infinite**</td></tr><tr><td>Output impedance</td><td>**Zero**</td></tr><tr><td>Slew-rate</td><td>**Infinite**</td></tr><tr><td>CMRR</td><td>**Infinite**</td></tr></table> All four properties correct [1]	1			1	
	(b)		Voltage at non-inverting input = 5V (or equivalent) [1] Voltage at inverting input = 4V (or equivalent) [1] Use of voltage divider formula [1] Output in positive saturation, so red LED lit. [1]	2	2		4	3
	(c)	(i)	Voltage gain = [-]15 - ignore sign [1]	1			1	
		(ii)	 Correct amplitude = 0.75V [1] (or 50mV x (i)) Inverted [1]	1	1		2	1
		(iii)	Currents are equal [1] Use of virtual earth OR infinite input impedance [1]	1	1		2	1
			Question 3 total	**6**	**4**	**0**	**10**	**5**

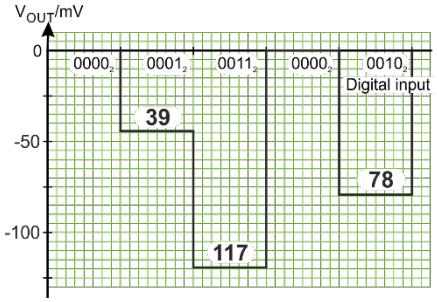
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
4.	*(a)*		Overall gain = 100 x 100 = 10 000 [1] Gain-bandwidth product is fixed for the op-amp used. Where the gain is large, the bandwidth is small. Cascading two amplifiers gives an overall gain equal to the product of their gains but a bandwidth equal to the smaller, (or equivalent answer.) [1]	1	1		2	1
	(b)		 Feedback resistor to inv. input [1] R_1 from inv. input to 0V [1] Input to non-inv. input [1]	3			3	
	(c)		$R_F = 99 \times R_1$ [1] All resistors > 1kΩ [1] Diagram labelled with resistor values [1]	1	1	1	3	1
	(d)	(i)	Bandwidth of B equals that of the preamplifier (=15kHz) as both A and B have the same voltage gain, (=100). [1] Gain-bandwidth product = 100 x 15000 = 1.5MHz [1]	1	1		2	1
		(ii)	At bandwidth limit, voltage gain = 0.7 x max. voltage gain [1] = 70 [1]	1	1		2	1
	(e)		Voltage gain at 1kHz = 100 x 100 = 10000. [1] Input amplitude must be less than, or equal to 12/10000 (= 1.2mV) to avoid saturation. [1]		2		2	1

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(f)		Input to amp **A** = 1mV, so input to amp **B** = 100x1mV= 100mV [1] Output of B = 10V [1] Using slew-rate = $2\ \pi\ f\ V_P$ minimum slew-rate = $2.\pi.(10 \times 10^3).(10) = 630$kV/s [1] (Accept 628.3kV/s)	1	2		3	2
			Question 4 total	**8**	**8**	**1**	**17**	**7**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
5.	*(a)*		Using P = E / t, power = 54 / 3 [1] = 18W [1]	1	1		2	1
	(b)	(i)	Advantage such as: • can be regenerated; [1]	1			1	
		(ii)	Advantage such as: • lack of quantisation noise; [1]	1			1	
	(c)		Advantage such as several signals share the communication medium, increasing data throughput. [1]	1			1	
	(d)	(i)	 Channels occupy separate frequency bands [1] Channels continuous wrt time [1]	2			2	
		(ii)	Using N_{CH} = available bandwidth / channel bandwidth, required bandwidth = N_{CH} x channel bandwidth [1] = 4 x 5 GHz = 20GHz [1]	1	1		2	1
	(e)	(i)	Overall power gain = 36 + (50 x -1.2) + 36 = +12dB [1] Power at **B** = $P_{OUT} = P_{IN} \times 10^{Gaiin/10}$ [1] = $0.1 \times 10^{1.2}$ = 1.6mW [1]	1	2		3	2

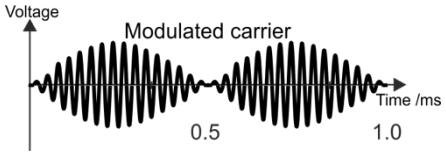
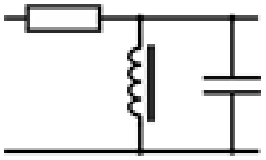
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(ii)	SNR = 10 x $\log_{10}$(signal power / noise power) = 10 x $\log_{10}$(0.1 / .001) [1] = +20dB [1]	1	1		2	1
		(iii)	Attenuation reduces the signal power so SNR decreases [1]	1			1	
			Question 5 total	**10**	**5**	**0**	**15**	**5**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
6.	*(a)*	(i)	Lowest sampling freq. = 2 x highest signal freq. = 30kHz [1]	1			1	1
		(ii)	The higher the sampling frequency, the greater the number of samples that need processing and storing and so the more complex the electronic system, (or equivalent answer). [1]	1			1	
	(b)	(i)	Resolution = 250 / 256 mV [1] = 0.98mV (Accept 1mV) [1]	1	1		2	1
		(ii)	Reduce reference voltage, V_{REF} (or equivalent answer). [1]	1			1	
		(iii)	Using no. of resistors = 2^n, where n = no. of bits in output, [1] $256 = 2^8$, so that each sample contains n = 8 bits. [1]	1	1		2	1
		(iv)	The analogue input voltage exceeds the ADC input voltage range, i.e. 250mV, (or equivalent answer). [1]	1			1	
	(c)		Sampling rate = 35kHz, - 35000 samples per second. In 2 minutes, (120s) 120 x 35000 = 4 200 000 samples [1] Each sample is 8 bits long, so 33.6 Mbits are needed. [1]		2		2	2

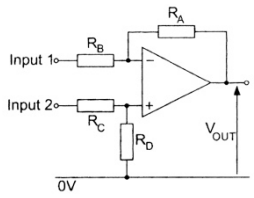
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(d)	(i)	Resistor R_4 = 64kΩ [1]		1		1	1
		(ii)	All inputs are 0V except for **A**, which is 10V. Voltage gain on channel A = -2 / 512 = -3.9 x 10^{-3} [1] Hence output = (-3.9 x 10^{-3}) x 10 = [-]39mV (ignore sign) [1]		2		2	2
		(iii)	 Correct output for '1' (allow ecf from (ii)) [1] Correct outputs for '0', '2' and '3' (allow ecf from (ii)) [1] Negative output voltages [1]	1	2		3	2
			Question 6 total	**7**	**9**	**0**	**16**	**10**

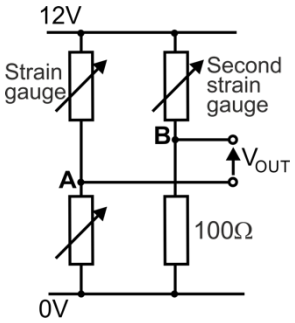
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
7.	*(a)*	(i)	The vehicle should stop at segment **E** [1]	1			1	
		(ii)	 Segment G correct [1] Segment H correct [1]		2		2	2
		(iii)	Pure binary could lead to misleading results at a boundary between segments. There, when more than one bit changes state, spurious, erroneous readings could occur. As a result, the vehicle could determine its position incorrectly. [1]	1			1	
		(iv)	Number of storage locations = 50 Number of locations addressed by 'n' bits (and so 'n' strips) $=2^n$ [1] Hence, 'n' = 6 - there needs to be 6 strips. [1]		2		2	2
	(b)	(i)	Voltage across $R_1 = 5 - 1.8 = 3.2V$ [1] Current through $R_1 = 40mA$ Using Ohm's law, $R_1 = 3.2 / 40 \times 10^{-3} = 80\Omega$ [1]		2		2	2
		(ii)	Voltage drop across $R_2 = 3.7 - 0.7 = 3.0V$ [1] Using Ohm's law, current through $R_1 = 3.0 / 1 \times 10^3 = 3mA$ [1]		2		2	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iii)	Collector current (through R_3) = 60 x 3mA = 180mA [1] Voltage drop across R_3 = 27 x 180 x 10^{-3} = 4.86V [1] Remaining voltage across **T** (i.e. at **B**) = 5 - 4.86 = 0.14V [1] (Allow ecf from (ii)		3		3	3
	(c)	(i)	Input voltage, $V_{GS} = 3 + (I_D / g_m)$ = 3.4V Evidence of drain current e.g.4/5 [1] Use of rearranged formula [1] Correct answer [1]	1	2		3	3
		(ii)	Power dissipated = 0.8^2 x 3.5 x 10^{-3} = 2.2mW Use of formula [1] Correct answer [1]	1	1		2	2
			Question 7 total	**4**	**14**	**0**	**18**	**16**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
8.	*(a)*		Frequency f = c / λ = 10GHz [1] Correct label on spectrum [1]	1	1		2	1
	(b)		 AM waveform [1] Correct signal frequency [1] Correct depth of modulation [1]	1	2		3	2
	(c)	(i)	 L and C in parallel [1] Series resistor [1]	2			2	
		(ii)	C = 1 / (4 π^2 f^2 L) [1] = 50nF [1]	1	1		2	2
		(iii)	R_D = 1 x 10^{-5} / 0.3 x 50x10^{-9} = 667Ω [1] Use of formula [1]		2		2	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iv)	$Q = 2 \times \pi \times f_0 \times L / r_L = 47$ [1] Use of formula [1] Bandwidth = $f_0 / Q = 225 \times 10^3 / 47 = 4.79$kHz [1] Use of formula [1]		4		4	4
			Question 8 total	**5**	**10**	**0**	**15**	**11**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
9.	*(a)*	(i)	When balanced, V_{OUT} = 0V [1] Voltage at A = Voltage at B = 6V [1] Resistance of pot = resistance of strain gauge = 120Ω [1]	1	2		3	3
		(ii)	Voltage at A is 50mV lower then voltage at B = 5.95V [1] Voltage at A = 12 / (120 + S) x 120 [1] S = [(12/5.95)x120]-120 [1] S=122Ω [1]	1	3		4	4
	(b)		Voltage gain = 10 / 0.02 = 500 [1] R_A/R_B = 500 [1] R_A = R_D and R_B = R_C AND all resistors > 1kΩ [1]  Inverting input circuit correct [1] Non-inverting input correct [1]			5	5	3

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(c)		Introduce a second identical strain gauge [1] positioned to experience same temperature changes [1] but no strain [1]  	1	2		3	
			Question 9 total	**3**	**7**	**5**	**15**	**10**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
10.			**Indicative content:** **In darkness**: Thevenin equivalent circuit for light sensing unit gives V_{OC} = 12V and R_{EQ} = 100Ω. Output current of 60mA gives a voltage drop of 6V across R_{EQ} leaving 6V across the output - the lamp lights **In daylight:** Thevenin equivalent circuit now gives V_{OC} = 9.6V and R_{EQ} = 80Ω. A current will flow through the lamp. For example, a current of 50mA would cause a voltage drop of 4V across R_{EQ}, leaving 5.6V across the lamp. The lamp will glow dimly in daylight, wasting energy and reducing the battery life. (Other approaches are possible.) **Improvements -** • Use a transistor switch to operate the lamp, triggered by the light-sensing unit. The transistor boosts the current drawn from the light-sensing unit. • Replace the 100Ω fixed resistor with a variable resistor so that the light level at which the lamp lights can be controlled.			6	6	6

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
			5-6 marks A detailed analysis, including improvements, is given for all factors identified above. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** A general account is given of the situation in daylight and in darkness. There is an attempt to suggest improvements. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** The performance of the system is discussed in qualitative terms only. The candidate recognises the flaw in the design. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** No attempt made or no response worthy of credit.					
			Question 10 total	**0**	**0**	**6**	**6**	**6**

A LEVEL ELECTRONICS - COMPONENT 1

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS
1	4	6	2	12	4
2	6	7	3	16	8
3	6	4	0	10	5
4	8	8	1	17	7
5	10	5	0	15	5
6	7	9	0	16	10
7	4	14	0	18	16
8	5	10	0	15	11
9	3	7	5	15	10
10	0	0	6	6	6
TOTAL	**53**	**70**	**17**	**140**	**82**