GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
ELECTRONICS – COMPONENT 1
A490U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2023 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

PRINCIPLES OF ELECTRONICS

SUMMER 2023 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.

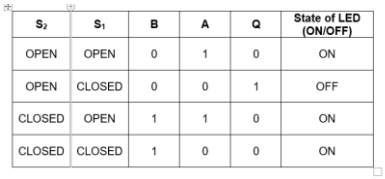
Extended response question

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.

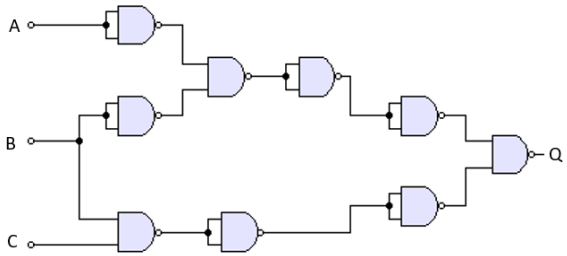
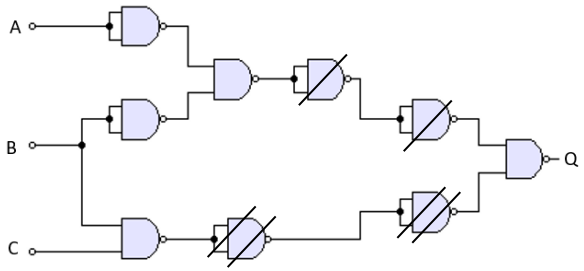
Marking abbreviations

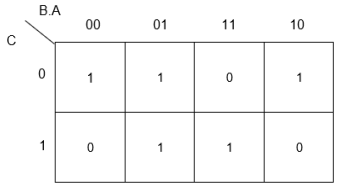
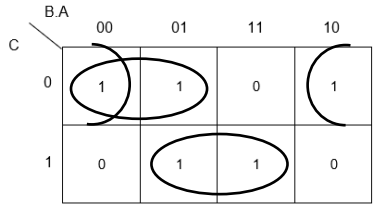
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
1	(a)	(i)	NOR gate	1			1	
		(ii)	 One mark for each column (4) (ecf for Q and LED)	3	1		4	
	(b)		R=V/I = 5-2/14 x 10^{-3} = 214 Ω Correct voltage used (1) Equation rearranged and correct substitution (1) Answer (1) 220Ω selected (1)	2	2		4	3
			Question 1 total	**6**	**3**	**0**	**9**	**3**

S_2	S_1	B	A	Q	State of LED (ON/OFF)
OPEN	OPEN	0	1	0	ON
OPEN	CLOSED	0	0	1	OFF
CLOSED	OPEN	1	1	0	ON
CLOSED	CLOSED	1	0	0	ON

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
2	(a)	(i)	J = $\overline{A + B}$ (1) K = B.C (1) Q = $\overline{A + B}$ + B.C (1)	2	1		3	3
		(ii)	 NOR (1) AND (1) OR (1)			3	3	
		(iii)	 Both pairs correct (1)	1			1	

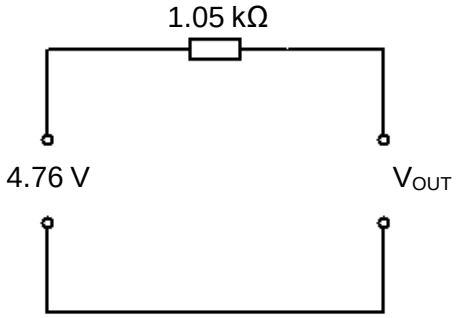
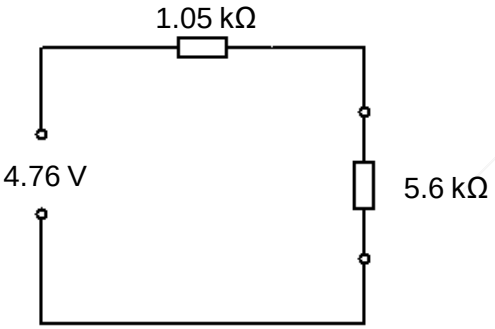
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iv)	Fewer ICs needed (1)	1			1	
	(b)		$\bar{A}+\overline{\overline{B}.\overline{A}}$ (1) $\bar{A}$ + B.A (1) $\bar{A}$ + B (1)	1	2		3	3
	(c)	(i)	 All correct (2) -1 each error		2		2	
		(ii)	 One group correct (1) Minimum number of groups (1) Q = $\bar{C}.\bar{B}$ + $C.A$ + $\bar{C}.\bar{A}$ (1) or/ Q = $\bar{B}.A$ + $C.A$ + $\bar{C}.\bar{A}$ (1)		3		3	
			Question 2 total	**5**	**8**	**3**	**16**	**6**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
3	(a)	(i)	$R_P = R_1 \times R_2 / R_1 + R_2 = 5.6k \times 3.9k / 5.6k + 3.9k$ (1) $= 2.3\ k\Omega$ (1)	1	1		2	2
		(ii)	$V_T = 9 - 0.7 = 8.3$ V (1) $I_1 = V_T / R_T = 8.3 / (2.3k + 2.2k)$ (1) $= 1.84$ mA (1)	1	2		3	3
		(iii)	Voltage across $R_3 = IR_3 = 1.84m \times 2.2k = 4.06$ V (1) $V_{OUT} = 4.05 + 0.7 = 4.75$ V (1)	1	1		2	2
		(iv)	$P = I^2R_3 = (1.84 \times 10^{-3})^2 \times 2.2 \times 10^3 = 7.45$ mW Equation and substitution (1) Answer (1) or alternative method (P=VI) (ecf)		2		2	2
		(v)	$V_{OUT} = 9$ V (1)	1			1	
			Question 3 total	**4**	**6**	**0**	**10**	**9**

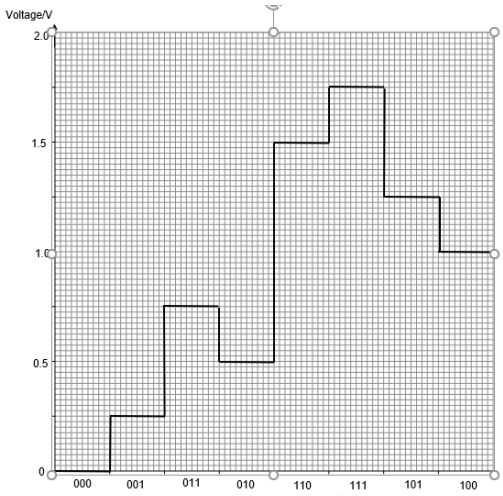
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
4	(a)	(i)	B=0, A=0 LED off (1) B=0, A=1 LED flashing (1) at 4 Hz (1) B=1, A=0 LED on (1) B=1, A=1 LED flashing (1) at 2 Hz (1)	2	4		6	1
		(ii)	Can be reconnected to perform a different function/can be reprogrammed (1) (accept other creditable answers)	1			1	
	(b)	(i)	Time Division Multiplexing (1)	1			1	
		(ii)	Data from each channel transmitted alternately in a fixed time. (1) The channel is allocated by the select inputs. (1) Eg. $S_1 = 0$, $S_0 = 0$ selects channel 0 $S_1 = 0$, $S_0 = 1$ selects channel 1 (1)	3			3	
			Question 4 total	**7**	**4**	**0**	**11**	**1**

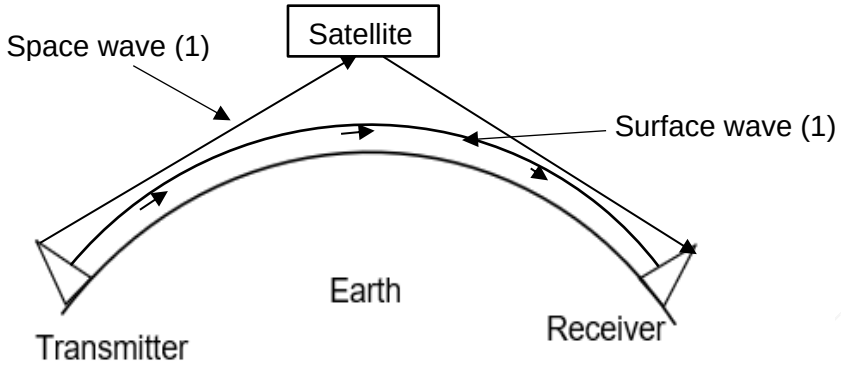
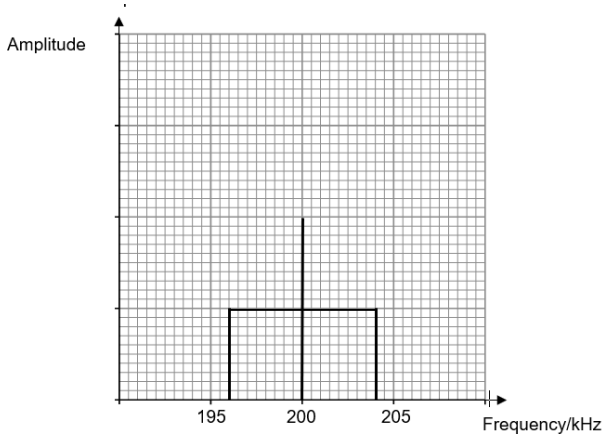
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
5	(a)		$V_1 = V_{IN} \times R_2/R_1 + R_2 = 15 \times 10/15 + 10 = 6$ V Formula and substitution (1) Answer (1)	1	1		2	2
	(b)		$V_X = V_{IN} \times R_2/(R_{LDR} + R_2)$ $6 = 15 \times 2.2/(R_{LDR} + 2.2)$ (1) Rearranging (1) $R_{LDR} = 3.3\ k\Omega$ (1) (ecf from part (a)) Or ratio method	1	2		3	3
	(c)		In the dark the LDR has a higher resistance, V_X will become lower than V_Y (1) so V_z will become negative saturation/0 V and the green LED will come on. (1) In the light the LDR has a lower resistance so V_X will increase and when above $V_Y/6$ V then V_Z will become positive saturation 12 V and the red LED will come on. (1)			3	3	
			Question 5 total	**2**	**3**	**3**	**8**	**5**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
6	(a)		Diode in parallel with motor in reverse bias. (1)	1			1	
	(b)		$P = I_D^2 \times r_{DSon} = 8^2 \times 0.32$ (1) = 20.48 W (1) (accept 20.5 W)	1	1		2	2
	(c)		$I_D = g_M (V_{GS} - 3)$ $8 = 1.4 (V_{GS} - 3)$ (1) Formula and substitution $V_{GS} = 8/1.4 + 3$ (1) Rearrangement = 8.7 V (1) Answer	1	2		3	2
			Question 6 total	**3**	**3**	**0**	**6**	**4**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
7	(a)	(i)	V_{OC} = 10x2.0x10^3/2.2x10^3+2.0x10^3 = 4.76 V (1) I_{SC} = 10/2.2x10^3 = 4.5454 = 4.55 mA (1) (accept 4.5 mA) R_{EQ} = 4.76/4.55x10^{-3} = 1.05 kΩ (ecf from either of above) (1)  Circuit with values (1)	1	3		4	3
		(ii)	 Circuit (1) V_{OUT} = 4.76x5.6x10^3/(1.05x10^3+5.6x10^3) (1) = 4.01 V (1)	1	2		3	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(b)		V_R = 15-10=5 V (1) I_R = 200 + 10 = 210 mA (1) R = V_R/I_R = 5/210mA = 23.8 Ω (1) (Accept 24 Ω)		3		3	3
	(c)		V_X = 1.95 x 10/(2.01 + 1.95) = 4.92 V (1) V_Y = 5 V (1) V_{OUT} = (V_Y – V_X) x (R_F/R_1) = (5 – 4.92) x 100/1 (1) = 7.57 V (1) (Accept 7.6 V) (-1 mark for a sign error in answer)		4		4	4
			Question 7 total	**2**	**12**	**0**	**14**	**12**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
8	(a)	(i)	$V_X = -V_A \times R_F/R_A = -8 \times 10/320$ (1) $= -0.25$ V (1)	1	1		2	2
		(ii)	+ 0.25 V (ecf from (i)) (1)	1			1	
		(iii)	6 x 0.25 = 1.5 V Identification of $110_2 = 6$ (1) Answer (1) or/ use of method in parts (i) and (ii) (2)		2		2	2
	(b)		 All correct (3) One error (2) Two errors (1)		3		3	
			Question 8 total	**2**	**6**	**0**	**8**	**4**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
9	(a)	(i)		2			2	
		(ii)	$\lambda = c/f = 3 \times 10^8 / 400 \times 10^3$ (1) = 750 m (1)	1	1		2	2
	(b)	(i)	 Carrier at 200 kHz (1) Side frequencies at 196 and 204 kHz (1) (Accept sketched graph with values marked on correctly)	2			2	

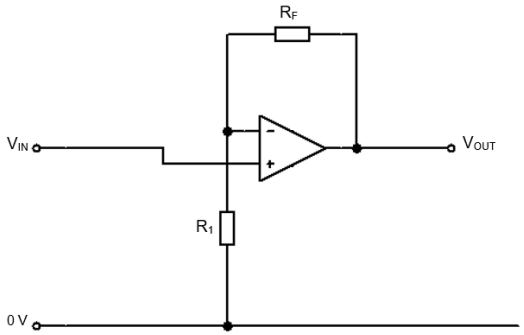
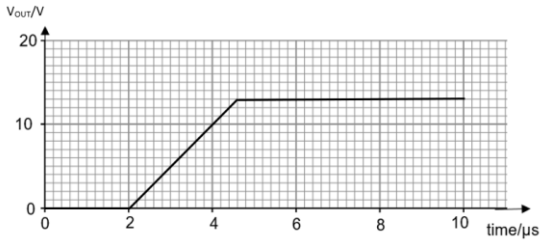
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(ii)	Bandwidth = 204 – 196 = 8 kHz (1) (or/ 2 x 4k = 8 kHz)		1		1	
	(c)	(i)	$\beta = \Delta f_C/f_i = 65 \times 10^3/4 \times 10^3$ (1) = 16.25 (1)	1	1		2	2
		(ii)	Bandwidth = $2(\Delta f_0 + f_i) = 2\ (65x10^3 + 4x10^3)$ (1) = 138 kHz (1) Or use of Bandwidth = $2(1+ \beta)\ f_i = 2\ (1 + 16.25) \times 4x10^3 = 138$ kHz	1	1		2	2
	(d)		AM has lower bandwidth than FM **for the same audio signal** (1) So can have more radio stations in a frequency range (1)	2			2	
			Question 8 total	**9**	**4**	**0**	**13**	**6**

<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>10</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Parameter</th><th>Ideal value</th></tr>
<tr><td>Input impedance</td><td>Infinite</td></tr>
<tr><td>Output impedance</td><td>Zero</td></tr>
<tr><td>Open loop gain</td><td>Infinite</td></tr>
<tr><td>Slew rate</td><td>Infinite</td></tr>
<tr><td>CMRR</td><td>Infinite</td></tr>
<tr><td>Gain-bandwidth product</td><td>Infinite</td></tr>
</table>

Two correct (1)
All correct (2)</td><td>2</td><td></td><td></td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Indicative content:

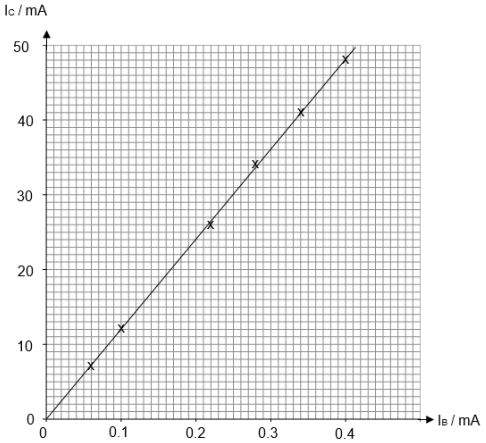
Equipment used – signal generator, op-amp in an inverting or non-inverting amplifier, oscilloscope.
Measurements made – (keeping the gain fixed) measure V_{IN}, V_{OUT} at different frequencies.
How use results – Plot a graph of the gain at different frequencies (or of V_{OUT} vs frequency) or plot a graph of log (gain) vs log (frequency).
Find the bandwidth from the graph by reading off the frequency at which the gain drops to 0.7 x gain or from the “knee” of the two-line approximation if the log-log graph used.
Find the gain-bandwidth product by multiplying the gain by the bandwidth.
Showing how to calculate the gain.</td><td></td><td></td><td>6</td><td>6</td><td></td></tr>
</table>

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
			5-6 marks Most equipment and measurements made. Extensive analysis of how the measurements are used to determine the Gain-bandwidth product. Method may include graph but not necessary. There is a sustained line of reasoning which is coherent, substantiated and logically structured. The information included in the response is relevant to the argument. **3-4 marks** Two pieces of equipment or measurements and good analysis of how the measurements are used to determine the Gain-bandwidth product. 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 not relevant to the argument. **1-2 marks** One piece of equipment or measurement to be made. Some analysis but this may be limited. 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. **0 marks** No attempt made or no response worthy of credit.					

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(b)	(i)	 V_{IN} and V_{OUT} connected correctly (1) R_F correct (1) R_1 correct (1) $G = 1 + R_F/R_1$ so $25 = 1 + R_F/R_1$ $24 = R_F/R_1$ (1) Both resistors > 1 kΩ (1)			5	5	2
		(ii)	Gain = V_{OUT}/V_{IN} $V_{IN} = V_{OUT}$/gain 13/25 (1) =0.52 V or 520 mV (1)	1	1		2	2
		(iii)	 Starting at 2 μs and rises to +13V (1) Correct gradient (1)		2		2	1

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iv)	Slew rate = $2\pi f V_P$ $f = SR/2\pi V_P = 5x10^6/2\pi$ x 12.5 = 63.7 kHz Selection of formula and substitution of values (1) Rearragement (1) Answer (1) (accept 64 kHz)	1	2		3	2
			Question 10 total	**4**	**5**	**11**	**20**	**7**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
11	(a)	(i)	Signal from one wire inducing a signal in adjacent wire (1)	1			1	
		(ii)	Number of signals = 250/3.9 = 64.1 (1) so 64 (1)	1	1		2	1
	(b)		38 = $10 \log_{10} (P_S / 93 \times 10^{-6})$ (1) 3.8 = $\log_{10} (P_S / 93 \times 10^{-6})$ (1) $10^{3.8} = (P_S / 93 \times 10^{-6})$ (1) $P_S = 10^{3.8} \times 93 \times 10^{-6}$ (1) P_S = 0.587W (1) (accept 0.59 W)	1	4		5	4
	(c)	(i)	$f_b = 1/2\pi RC$ $3.4 \times 10^3 = 1/2\ \pi R \times 22 \times 10^{-9}$ Values with correct multipliers in equation (1) Correct rearrangement (1) R = 2128 Ω / 2.13 kΩ (1)	1	2		3	2
		(ii)	$X_C = 1/2\pi fC = 1/2\pi \times 2 \times 10^3 \times 22 \times 10^{-9}$ (1) = 3617 Ω (1) $Z = \sqrt{R^2 + X_C^2} = \sqrt{(2128^2 + 3617^2)}$ = 4197 Ω (1) $V_{OUT} = V_{IN} \times X_C / Z = 9 \times 3617 / 4197$ (1) = 7.76 V (1) ecf from (c) part (i)	2	3		5	4
			Question 11 total	**6**	**10**		**16**	**11**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
12	(a)	(i)	 Points plotted correctly (1) -1 for each error Best fit straight line (1)		2		2	2
		(ii)	Gradient = $\Delta I_C / \Delta I_B$ = 48/0.4 (1) =120 (1) Range 115 – 125.	1	1		2	2
	(b)	(i)	3.4 V read from graph. (1)		1		1	1
		(ii)	I_C = 12/150 = 0.08 A (1) $I_B = I_C/h_{FE}$ = 0.08/70 = 1.14 mA (1) $R_B = V/I_B$ = 3.4 – 0.7/1.14 x 10^{-3} = 2.36 kΩ (1) 2.2 kΩ (preferred value) (1)	1	3		4	3
			Question 12 total	**1**	**7**	**0**	**9**	**8**

COMPONENT 1

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

QUESTION	AO1	AO2	AO3	TOTAL MARK	MATHS
1	6	3	0	**9**	3
2	5	8	3	**16**	6
3	4	6	0	**10**	9
4	7	4	0	**11**	1
5	2	3	3	**8**	5
6	3	3	0	**6**	4
7	2	12	0	**14**	12
8	2	6	0	**8**	4
9	9	4	0	**13**	6
10	4	5	11	**20**	7
11	6	10	0	**16**	11
12	2	7	0	**9**	8
TOTAL	**52**	**71**	**17**	**140**	**76**