

Surname	Centre Number	Candidate Number
First name(s)		0



GCSE

C490U20-1



MONDAY, 20 MAY 2024 – AFTERNOON

ELECTRONICS – Component 2

Application of Electronics

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	7	
2.	13	
3.	8	
4.	6	
5.	5	
6.	8	
7.	14	
8.	8	
9.	6	
10.	5	
Total	80	

ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 4.



JUN24C490U20101

INFORMATION SHEET

This information may be of use in answering the questions.

Resistor Colour Codes

Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

The fourth band colour gives the tolerance as follows:

GOLD \pm 5%

SILVER \pm 10%

Resistors E24 series values

10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

Useful equations

$$P = \frac{V^2}{R}$$

$$G = 1 + \frac{R_F}{R_1}$$

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$$

$$G = -\frac{R_F}{R_{IN}}$$

$$I_D = g_M(V_{GS} - 3)$$

$$V_{OUT} = -R_F \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \dots \right)$$

$$I_C = h_{FE} I_B$$

$$T = 1.1RC$$

$$\overline{A+B} = \overline{A} \cdot \overline{B}$$

$$f = \frac{1}{T}$$

$$\overline{A \cdot B} = \overline{A} + \overline{B}$$

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

$$G = \frac{V_{OUT}}{V_{IN}}$$

$$\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$$



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Answer **all** questions.

1. A food processing factory packs jars of produce into boxes after printing a Best Before End (BBE) date on the lids.

This process is controlled by a microcontroller.

An incomplete flowchart for this control program is shown opposite.



- (a) **Insert the commands below** into the appropriate locations in the flowchart to complete the packaging of 12 jars so that the process repeats. Any jars that do not have a readable Best Before End (BBE) date are rejected. [5]

Is Count = 12?

Is jar present?

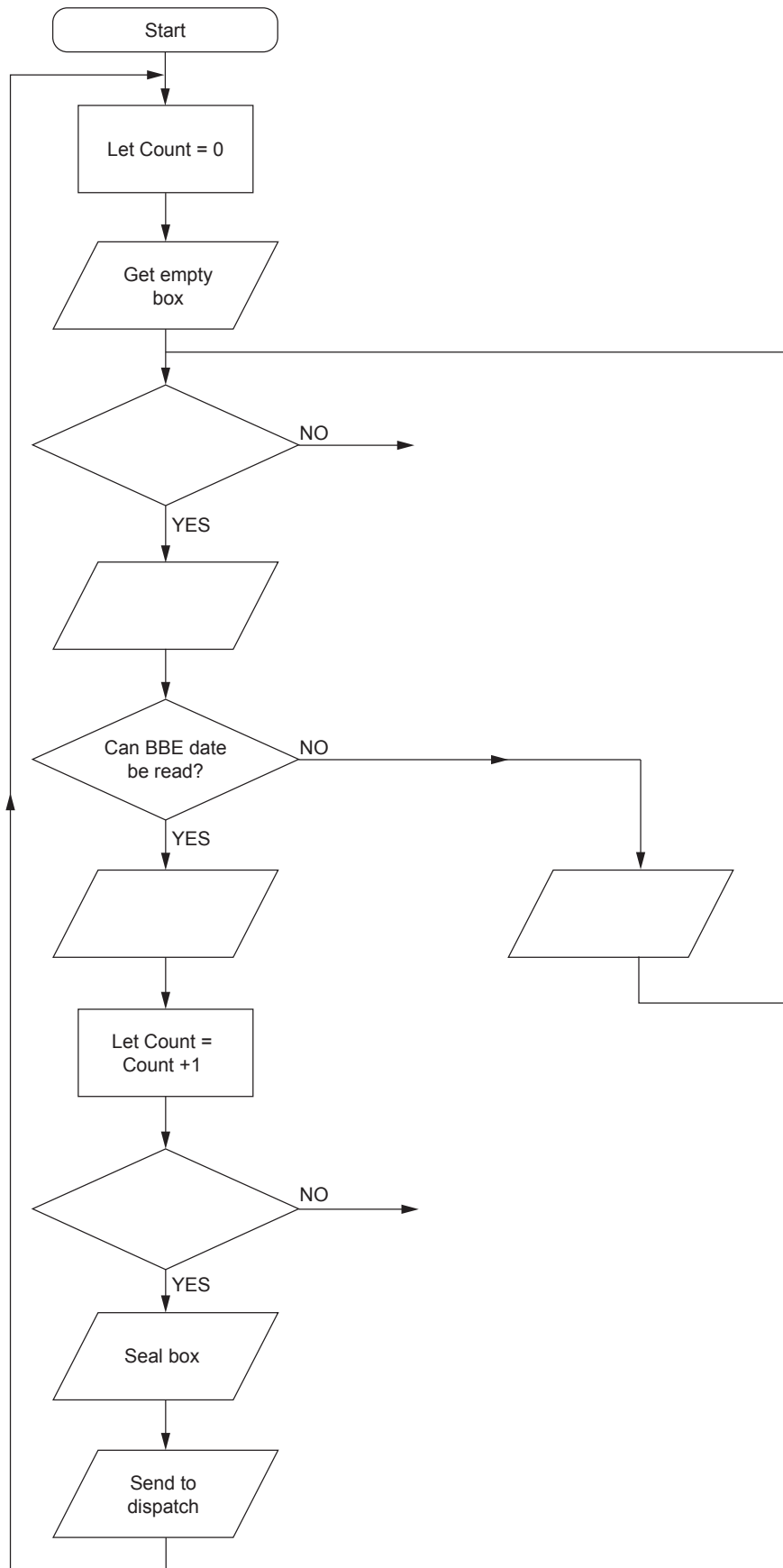
Load jar into box

Print BBE date

Reject jar

- (b) **Add the missing links** from the decision boxes to complete the flowchart. [2]



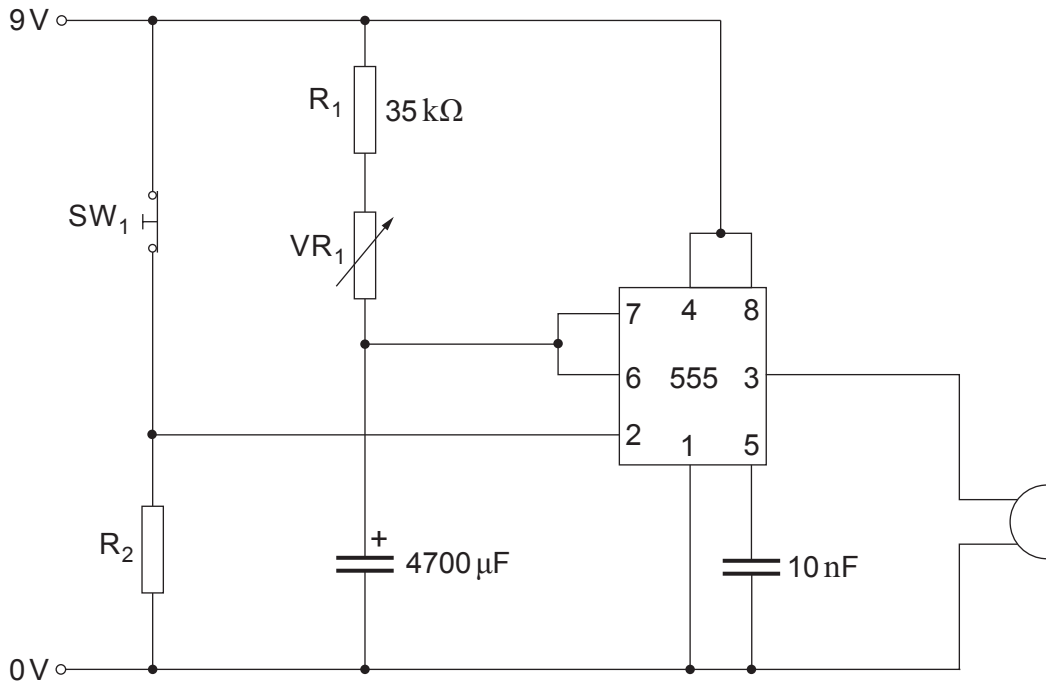


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2. The circuit diagram below shows an egg timer.



(a) The colour code on resistor R_2 is Brown, Black, Orange, Gold. What is the value of R_2 ? [3]

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(b) (i) What is the minimum time delay setting for the egg timer? [3]

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(ii) The maximum time delay required is 8 minutes. Calculate the resistance of VR_1 to provide this delay. [5]

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(c) Describe what happens to the output when the switch SW_1 is pressed and then released. [2]

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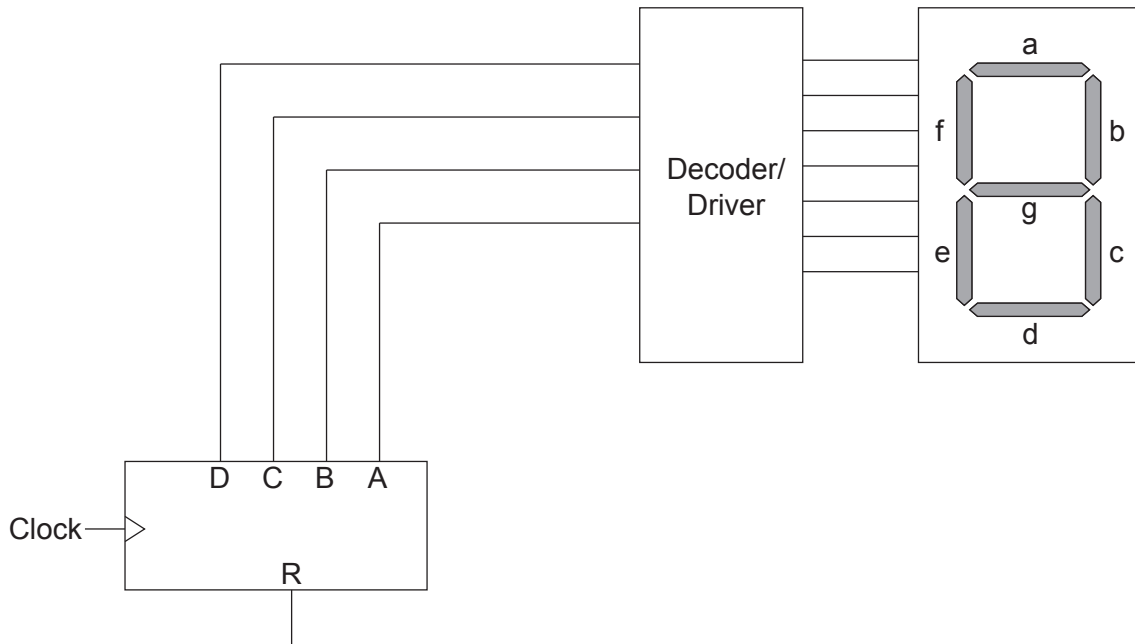
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3. The following circuit contains a binary counter, connected to a 7-segment display decoder/driver and display.



- (a) (i) Complete the following table for the counter.

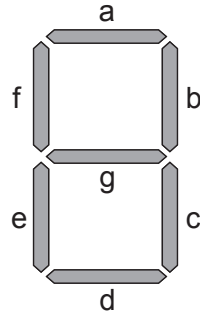
[1]

Clock pulse	D	C	B	A
0	0	0	0	0
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				



(ii) Add a logic gate and connections **to the circuit diagram** to ensure that the largest number displayed is '5'. [4]

(b) The arrangement of the seven LED segments that make up the display is shown on the following diagram. A segment lights when a logic 1 signal is applied.



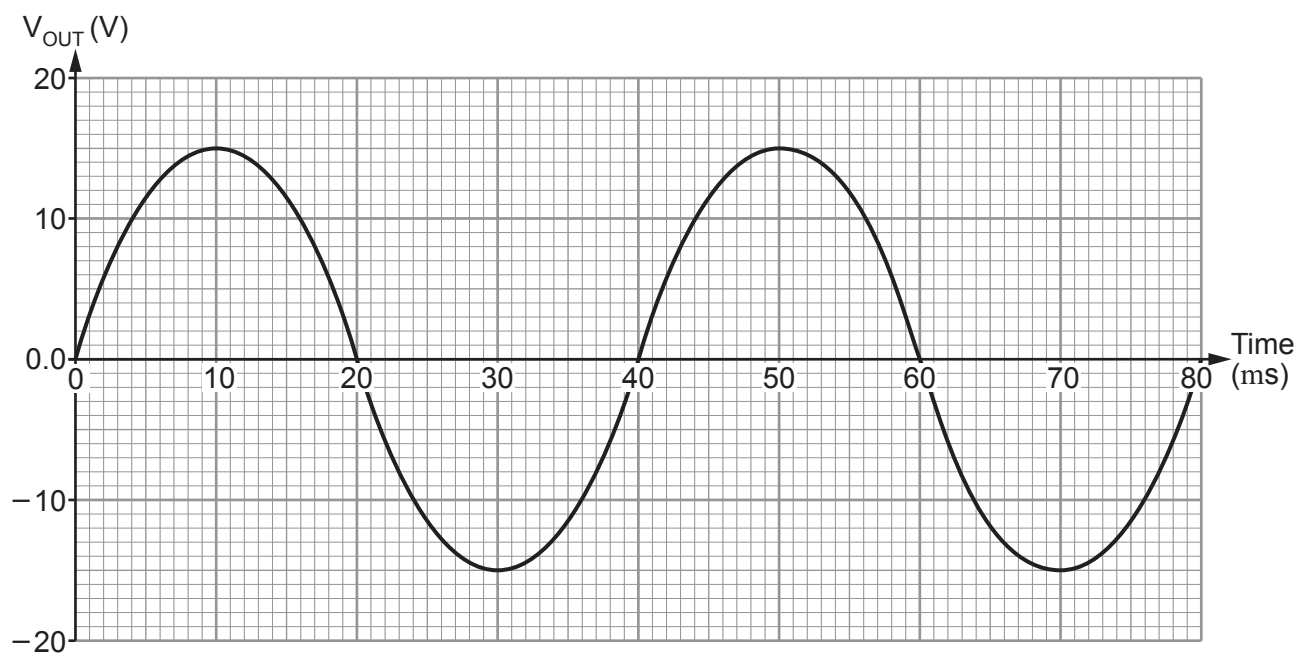
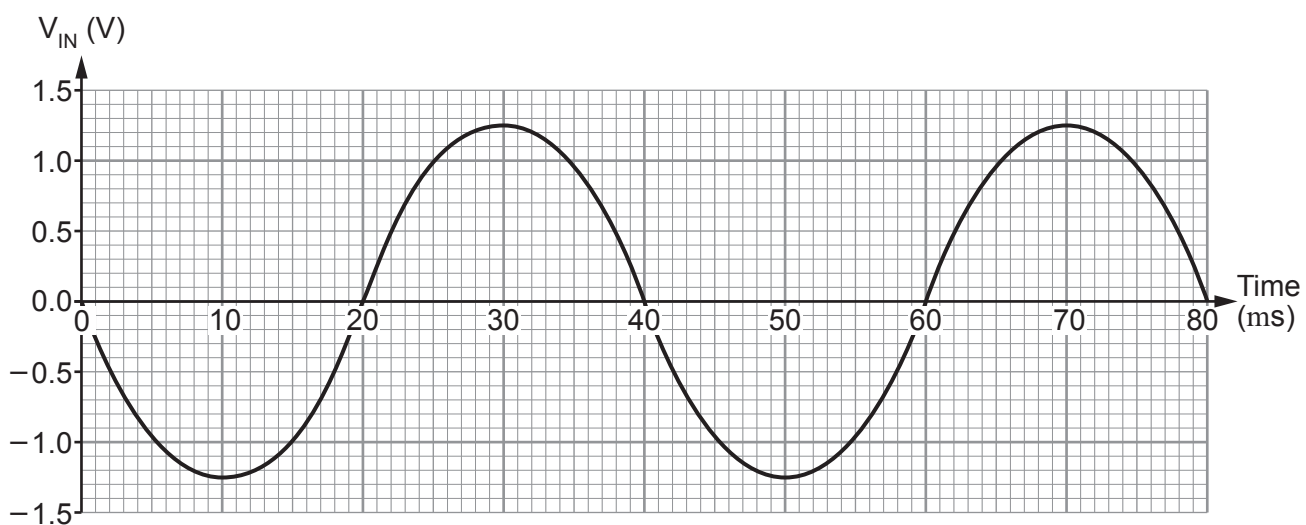
A **different** circuit uses a decoder to display letters on the 7-segment display. Complete the following table. [3]

Segment							Letter displayed
a	b	c	d	e	f	g	
1	0	0	0	1	1	1	
1	0	1	1	0	1	1	
							L

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4. The following graphs show the input signal and required output from an amplifier.



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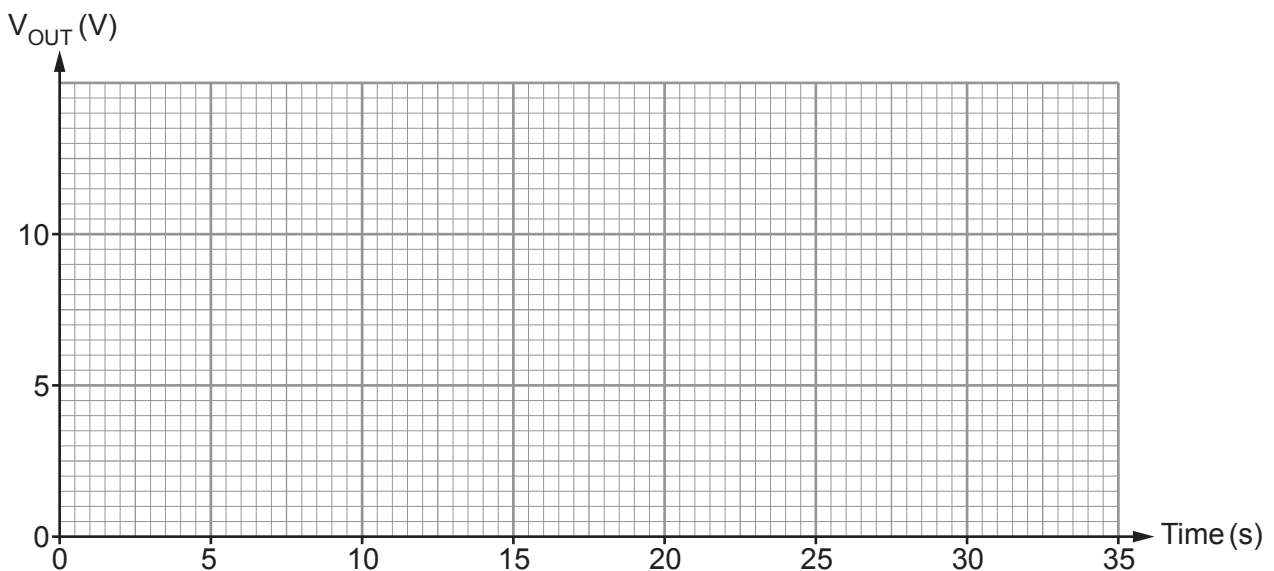
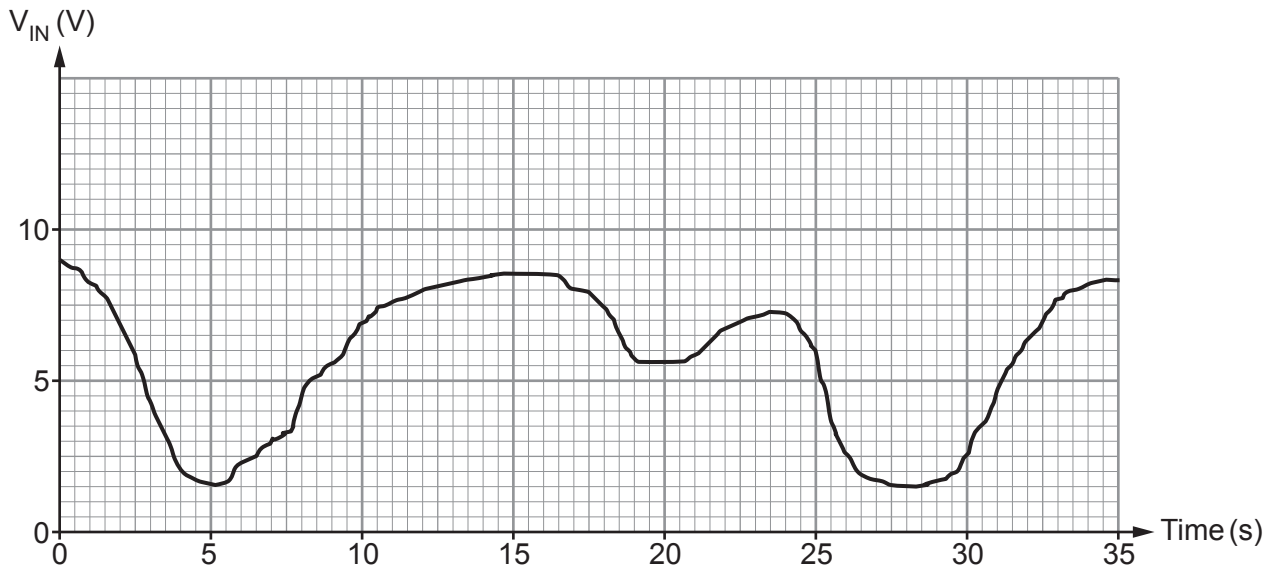
6



5. A data sheet gives the following information about a Schmitt inverter:

- The output changes from logic 1 to logic 0 when a **rising** input voltage reaches 8 V.
- The output changes from logic 0 to logic 1 when a **falling** input voltage reaches 3 V.
- The Schmitt inverter output has logic 0 = 0 V and logic 1 = 9 V.

Draw the **graph** of the waveform obtained at the output of the Schmitt inverter for the input waveform shown below. [5]

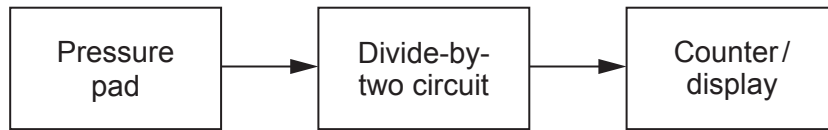


6. The 'Madison' men's event is a cycling race which lasts for 200 laps of a velodrome track.

During training to build endurance, a cyclist practises riding for 200 laps of the track. A lap counter displays how many laps the cyclist has completed. There is a pressure pad on the track. This outputs a pulse when a wheel goes over it.



A block diagram for the lap counter is shown below.

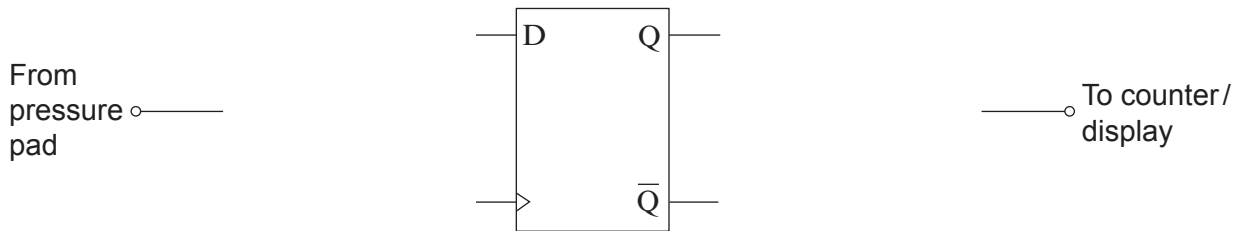


- (a) Why is a divide-by-two circuit needed? [1]

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- (b) A rising edge-triggered D-type flip-flop is used to make the divide-by-two circuit. **Complete the diagram below** so that it provides the divide-by-two function. [3]

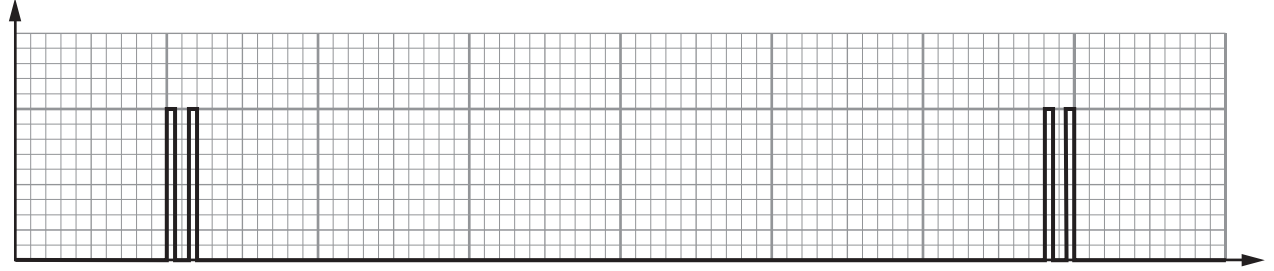


- (c) The first graph shows the output of the pressure pad which is connected to the divide-by-two circuit.

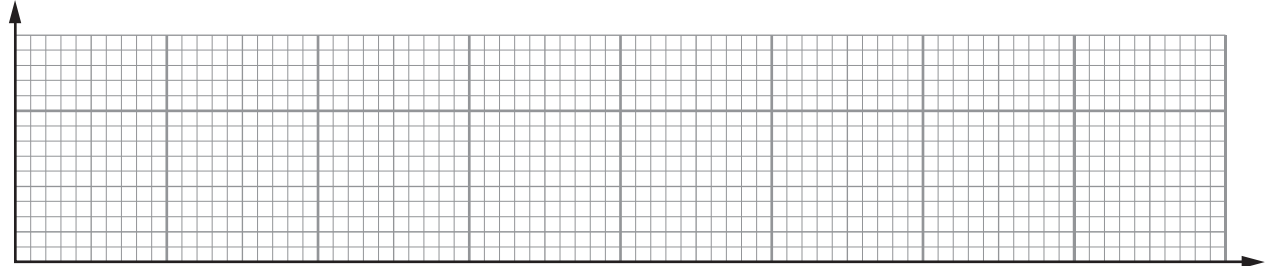
Use the axes provided to draw the signals at the Q and \bar{Q} outputs.
The Q output is initially at logic 0.

[4]

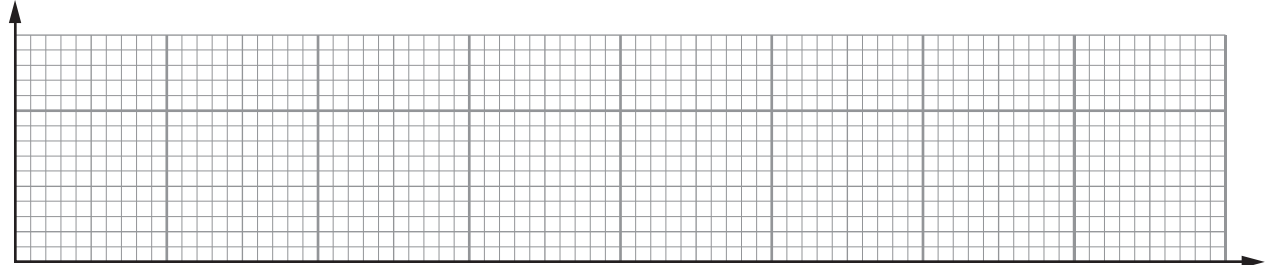
Output of pressure pad



Q output



\bar{Q} output



8



7. (a) Which of the following is another name for an astable circuit? [1]

Inverter

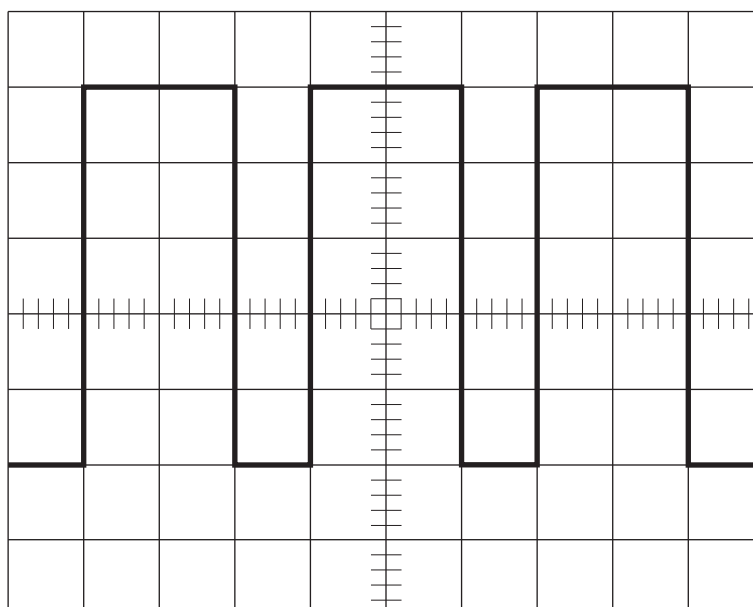
Time Delay

Pulse Generator

Latch

Answer:

- (b) The output of an astable circuit is connected to an oscilloscope. The following trace is produced.



The oscilloscope controls are set as follows:

Voltage gain = 250 mV/cm

Time base = 2 ms/cm

Use the trace to find:

- (i) the **amplitude** of the signal; [1]

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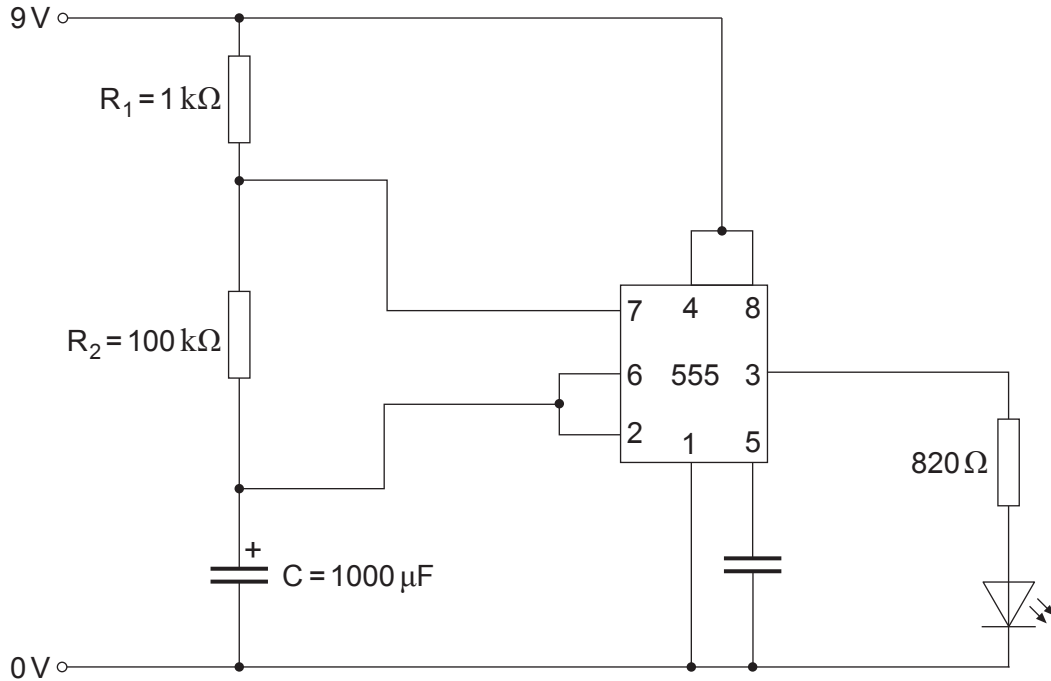
- (ii) the **period** of the output signal. [1]

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(c) Determine the mark-space ratio of the output signal. [1]

(d) The circuit diagram below shows a 555 timer astable circuit.



(i) Calculate the 'mark' (T_{ON}) time for this astable using the formula

$$T_{ON} = 0.7 \times (R_1 + R_2) \times C.$$

[3]

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(ii) Calculate the 'space' (T_{OFF}) time for this astable using the formula

$$T_{OFF} = 0.7 \times R_2 \times C.$$

[3]

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- (iii) Sketch the shape of the output signal produced by this astable. Adding a scale to the axes is **not** required. [1]



- (iv) Calculate the frequency produced by this 555 astable. [3]

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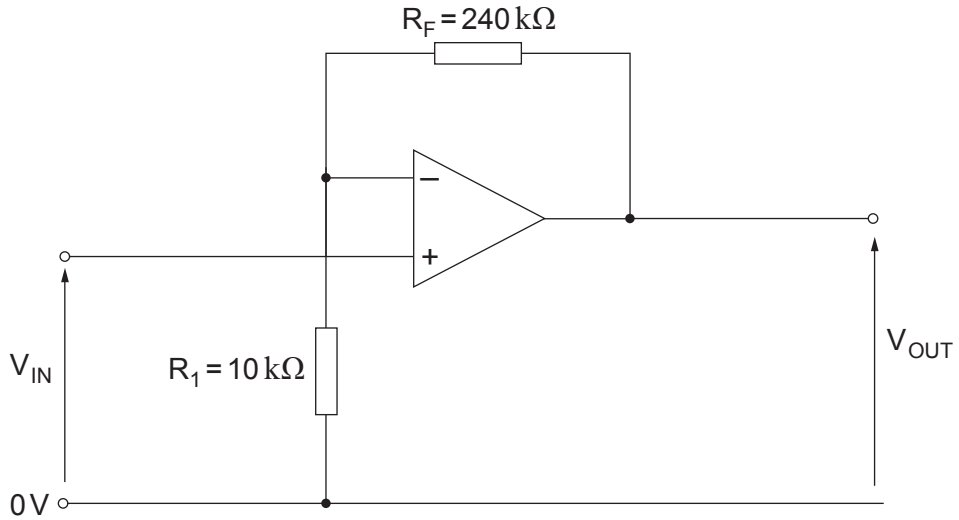
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8. The following circuit shows an op-amp configured as an amplifier. It is connected to a $\pm 15\text{V}$ power supply. Saturation occurs at $\pm 14\text{V}$.



(a) Calculate the voltage gain of this amplifier. [3]

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(b) Calculate the maximum value of V_{IN} to prevent clipping distortion. [4]

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(c) A different amplifier has a bandwidth of 200kHz when its gain is 30. If the gain is changed to 60, what will be the new value of the bandwidth? [1]

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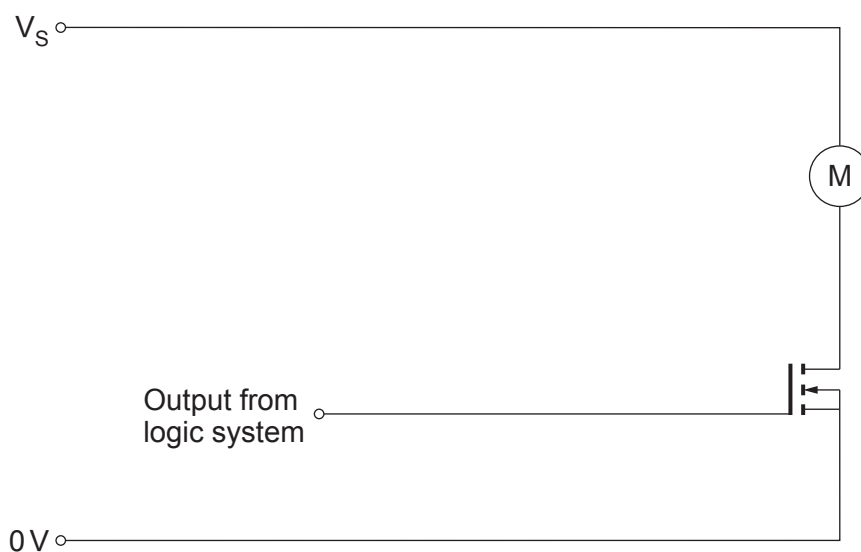
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9. A motor is to be switched on by the output of a logic system. A MOSFET interface is used to provide the power needed for the motor.

Information about the system is as follows:

- The logic system outputs 0V when at logic 0, and 9V when at logic 1.
- The motor has a power rating of 108W.
- The MOSFET has a transconductance of 0.3 S.
- The MOSFET is just saturated when the input voltage is 9V.



- (a) Calculate the current through the motor when the logic system provides a logic 1 output. [3]

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- (b) Calculate the voltage V_S that ensures the motor runs at its full power. [3]

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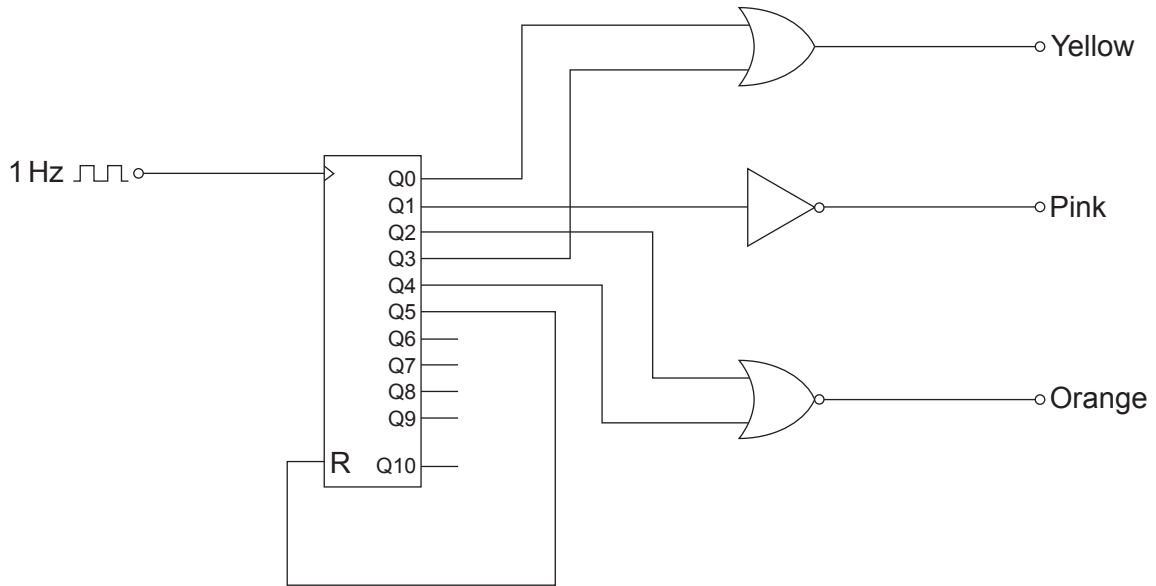
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10. The following circuit diagram shows a sequence generator based on a decade counter. The sequence repeats continuously.



(a) Give the Boolean expressions for the yellow and orange outputs. [2]

(i) Yellow =

(ii) Orange =

(b) Logic 1 turns a light on. Complete the table to show if the lights are on or off. [3]

Pulse	Light outputs		
	Yellow	Pink	Orange
0			
1			
2			
3			
4			
5			

END OF PAPER

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