GCSE

C490U20-1

MONDAY, 20 MAY 2024 – AFTERNOON

ELECTRONICS – Component 2

Application of Electronics

1 hour 30 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

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, black ball-point pen or your usual method.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces provided on the front cover.

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.

USEFUL EQUATIONS

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

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

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

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

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

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

$$I_C = h_{FE} I_B$$

$$T = 1.1RC$$

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

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

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

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

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

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

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 ± 5%

SILVER ± 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

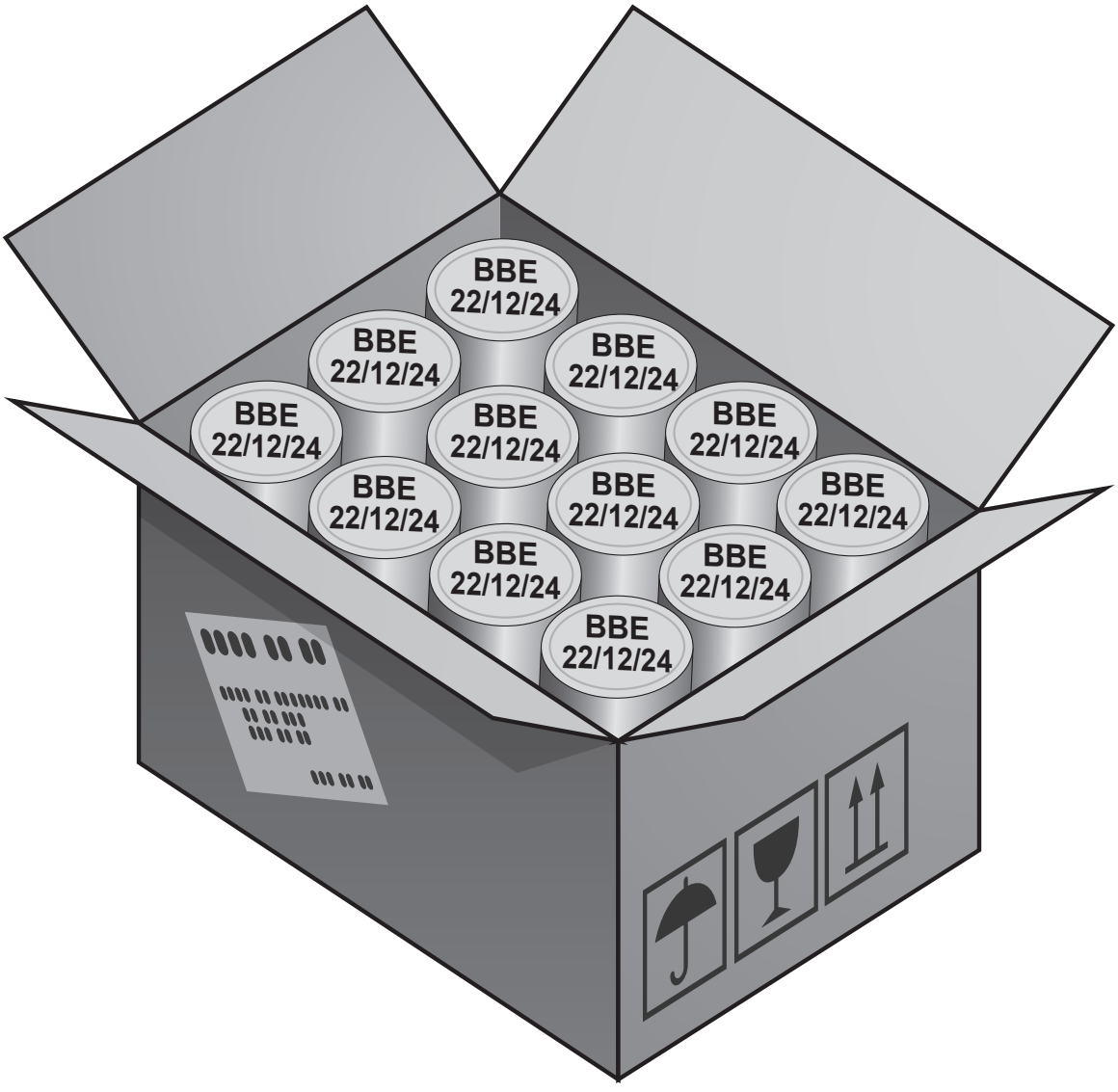
USEFUL EQUATIONS (shown opposite)

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 page 5.



1 (a) INSERT THE COMMANDS BELOW into the appropriate locations in the flowchart opposite 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 marks]

Is Count = 12?

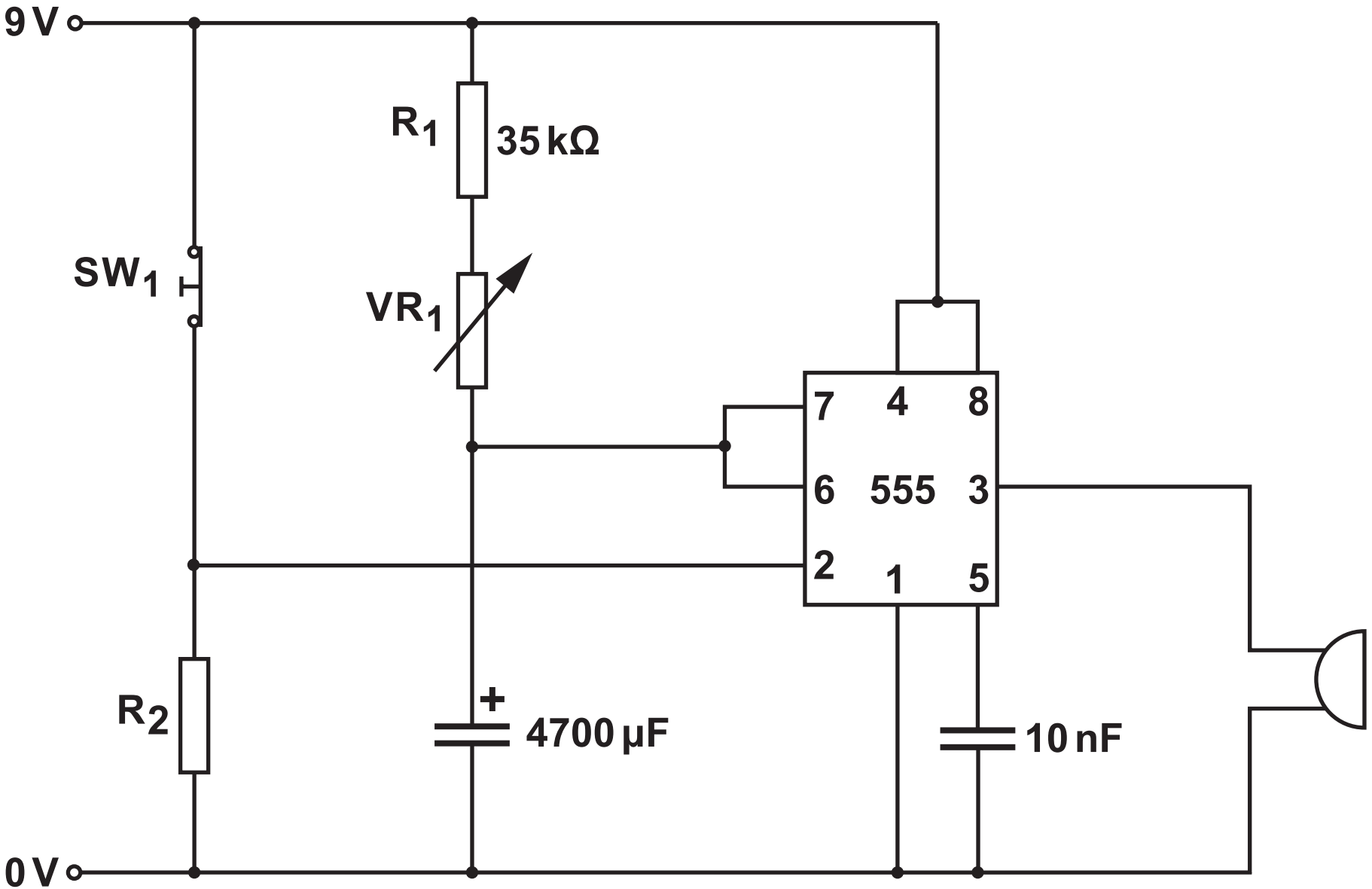
Is jar present?

Load jar into box

Print BBE date

Reject jar

(b) ADD THE MISSING LINKS from the decision boxes to complete the flowchart. [2 marks]


9 V
R1
35 kΩ
SW1
VR1
7
4
8
6
555
3
2
1
5
R2
+
4700 µF
10 nF
0 V

2. The circuit diagram opposite 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 marks]

_____

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

_____

_____

_____

_____

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

_____

_____

_____

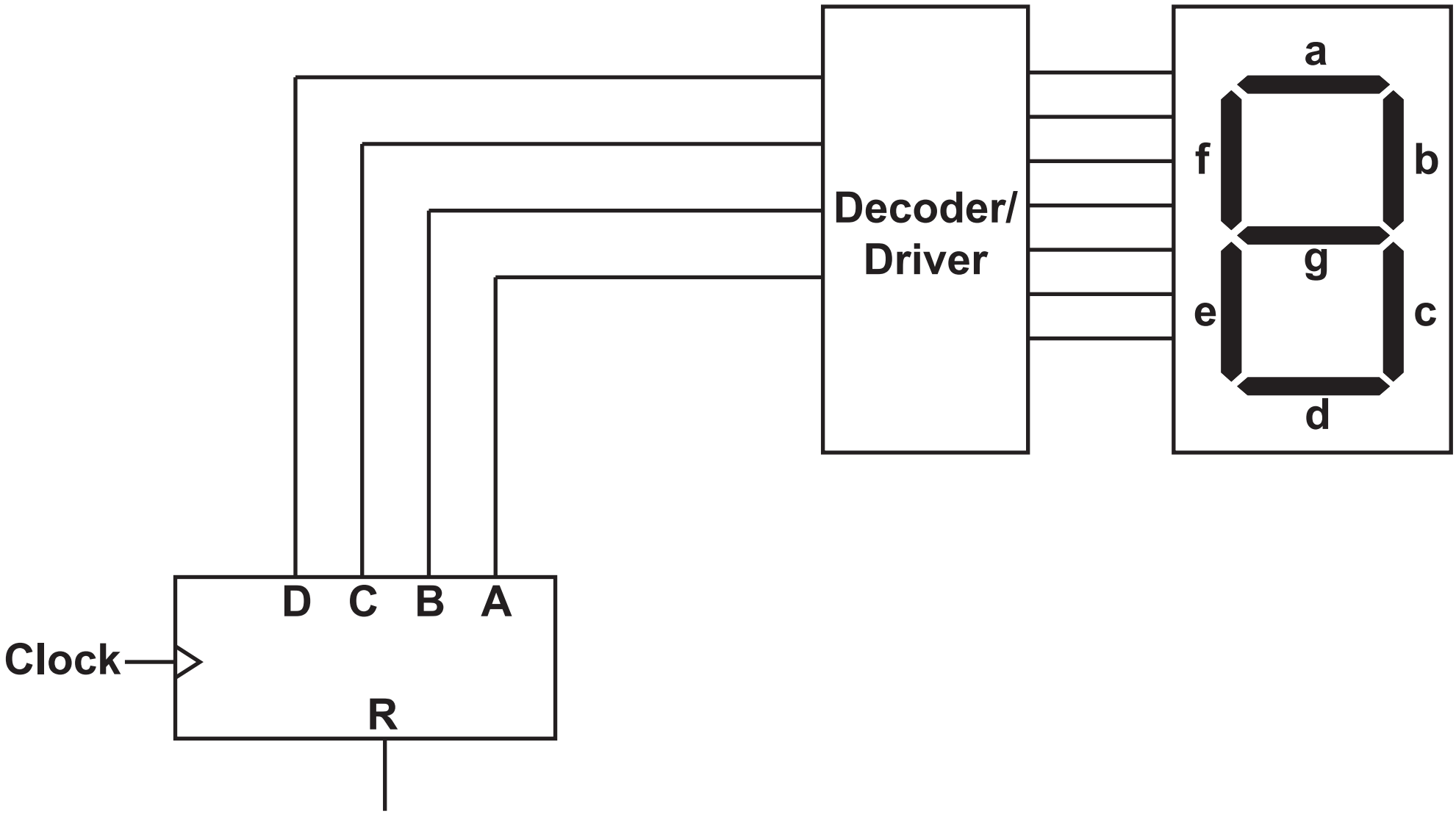
_____

_____

_____

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

[2 marks]


Decoder/
Driver
a
b
c
d
e
f
g
D
C
B
A
Clock
R

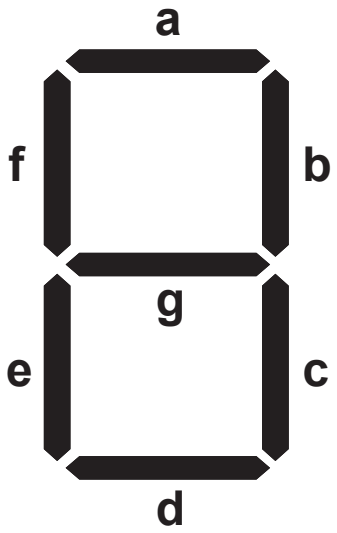
3. The circuit opposite contains a binary counter, connected to a 7-segment display decoder/driver and display.

(a) (i) Complete the following table for the counter. [1 mark]

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 marks]

3 (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.

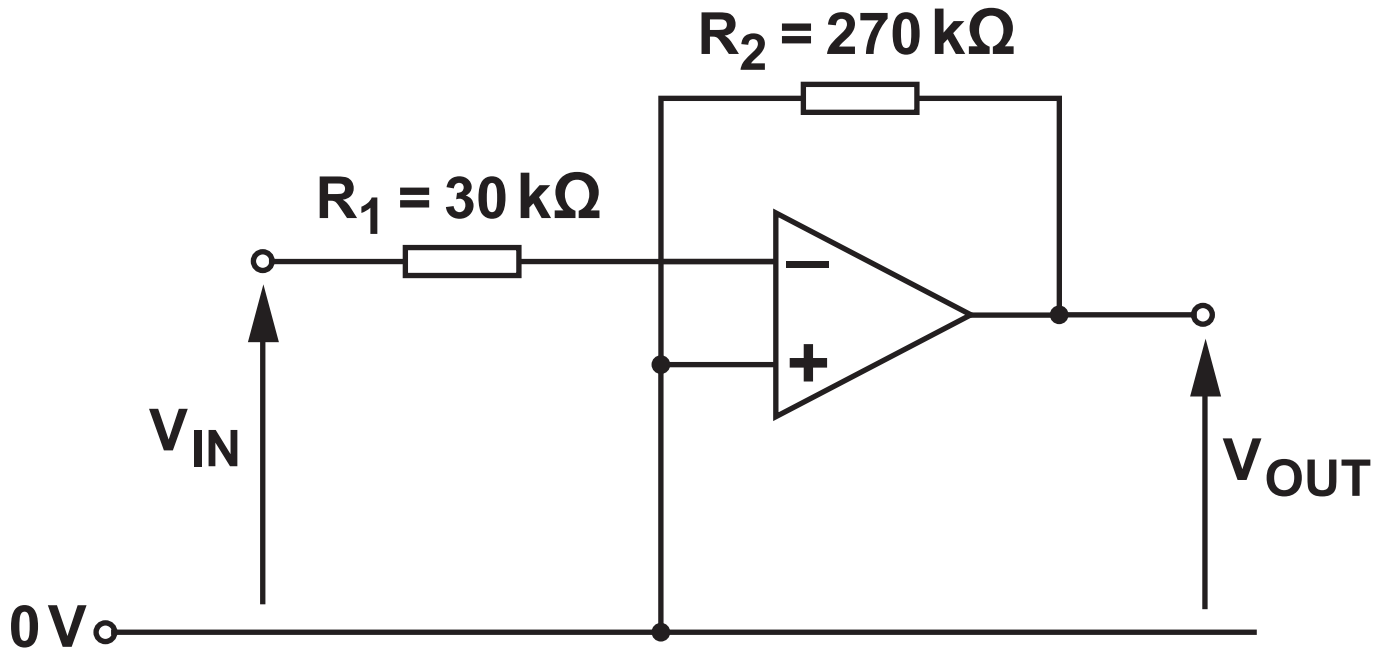


A DIFFERENT circuit uses a decoder to display letters on the 7-segment display. Complete the following table. [3 marks]

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

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

The suggested amplifier design is shown below. It is powered with a ±18 V supply.



Evaluate the design, including appropriate calculations. Suggest any modifications that may need to be made to the design to satisfy the specification. [6 marks QER]

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.

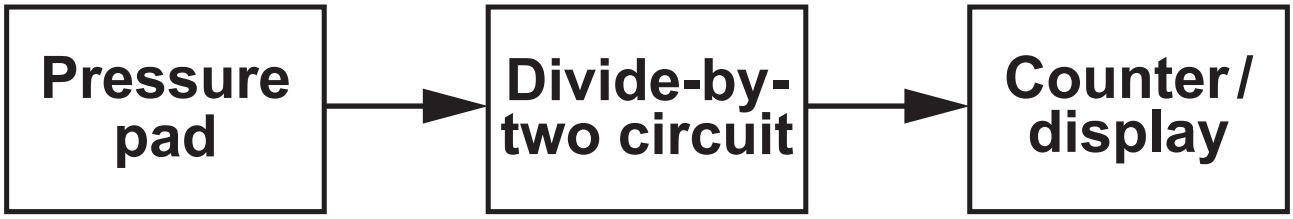
DRAW THE GRAPH of the waveform obtained at the output of the Schmitt inverter for the input waveform shown opposite. [5 marks]

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.

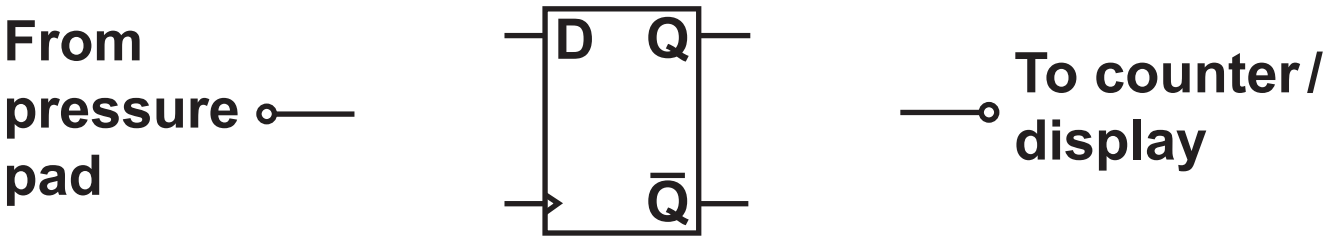


(a) Why is a divide-by-two circuit needed? [1 mark]

_____

_____

6 (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 marks]



6 (c) **The first graph opposite 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 $\overline{Q}$ outputs.
The Q output is initially at logic 0. [4 marks]

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

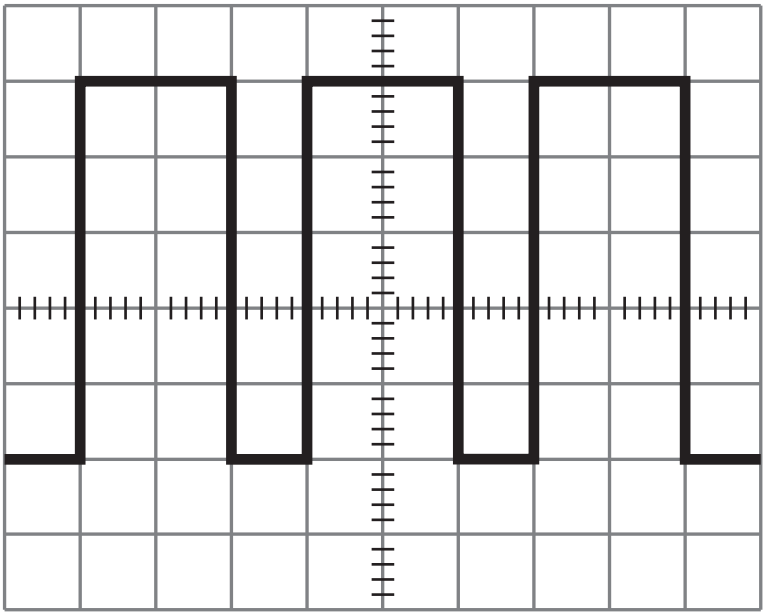
INVERTER

TIME DELAY

PULSE GENERATOR

LATCH

Answer: _____



7 (b) The output of an astable circuit is connected to an oscilloscope.
The trace shown opposite is produced.

The oscilloscope controls are set as follows:

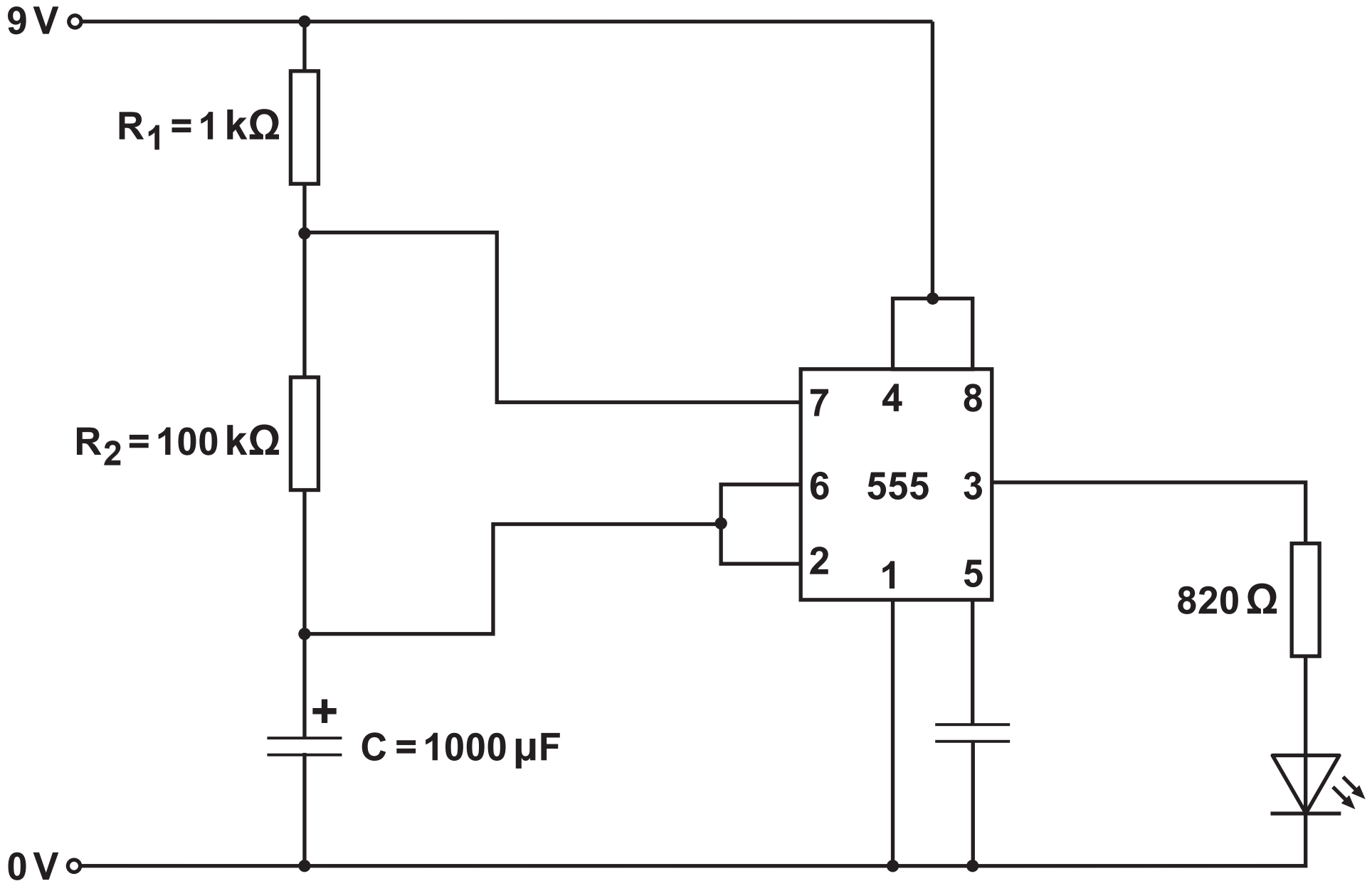
Voltage gain = 250 mV / cm
Time base = 2 ms / cm

Use the trace to find:

(i) the AMPLITUDE of the signal; [1 mark]

(ii) the PERIOD of the output signal. [1 mark]

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


9 V
R1 = 1 kΩ
R2 = 100 kΩ
7
4
8
6
555
3
2
1
5
820 Ω
+
C = 1000 µF
0 V

7 (d) The circuit diagram opposite 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 marks]**

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

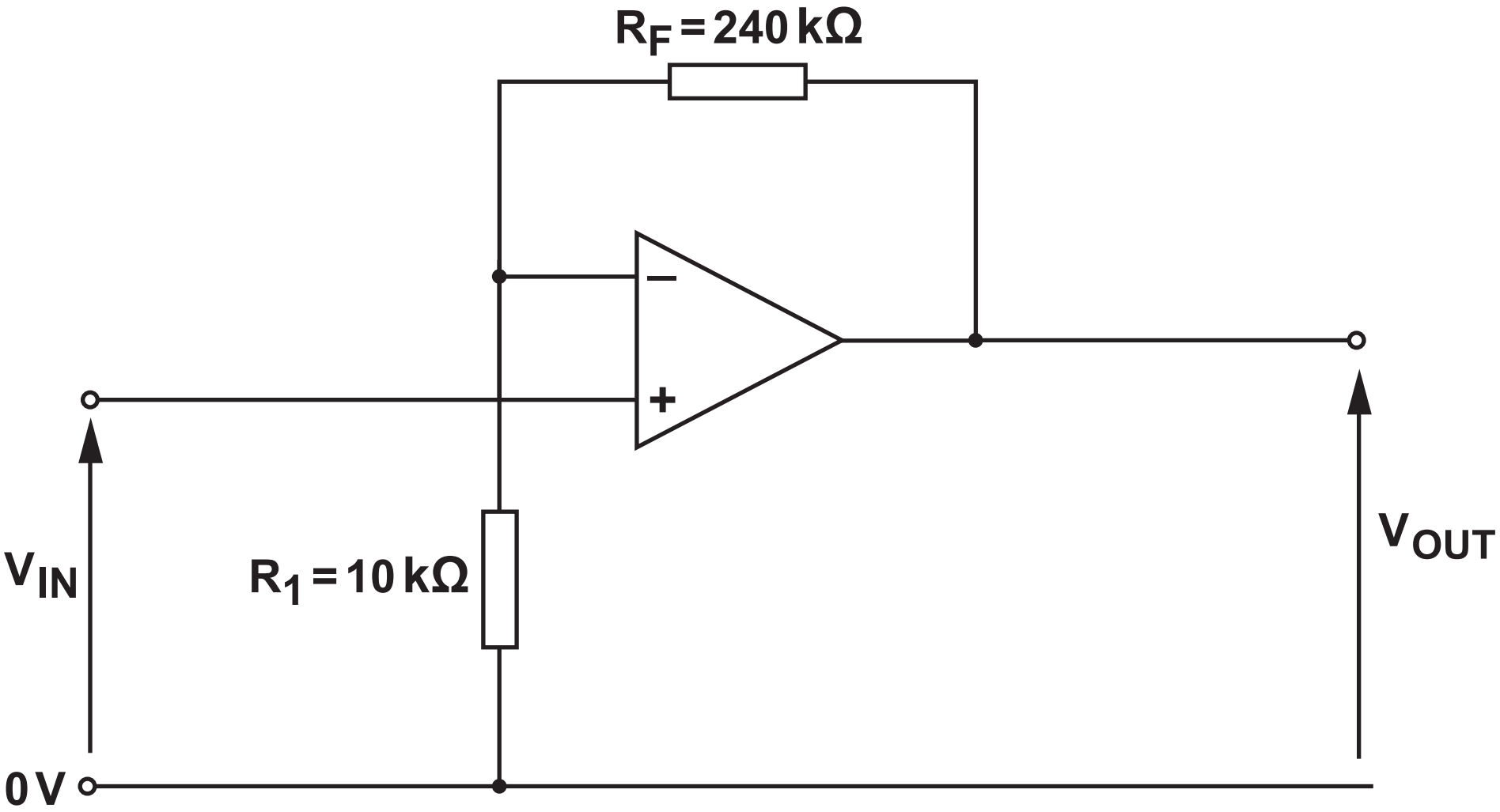
$$T_{OFF} = 0.7 \times R_2 \times C.$$ **[3 marks]**


Voltage
Time

7 (d) (iii)

Sketch the shape of the output signal produced by this astable on the blank graph opposite. Adding a scale to the axes is NOT required. [1 mark]

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


$R_F = 240\,k\Omega$
−
+
V_{IN}
$R_1 = 10\,k\Omega$
V_{OUT}
0 V

8. The circuit opposite shows an op-amp configured as an amplifier. It is connected to a ±15 V power supply. Saturation occurs at ±14 V.

(a) Calculate the voltage gain of this amplifier.

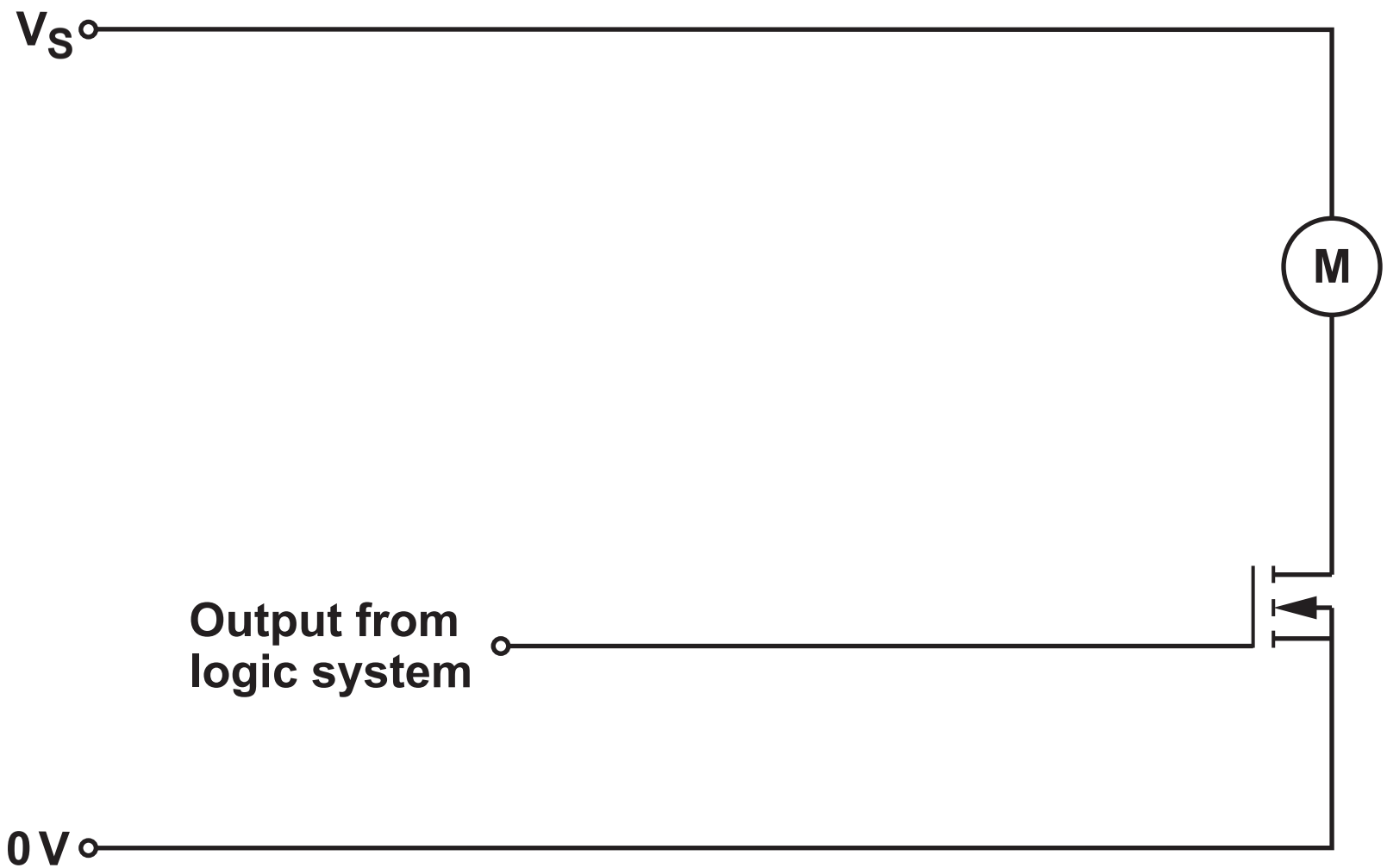
[3 marks]

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

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

[1 mark]

8


V_S
M
Output from
logic system
0 V

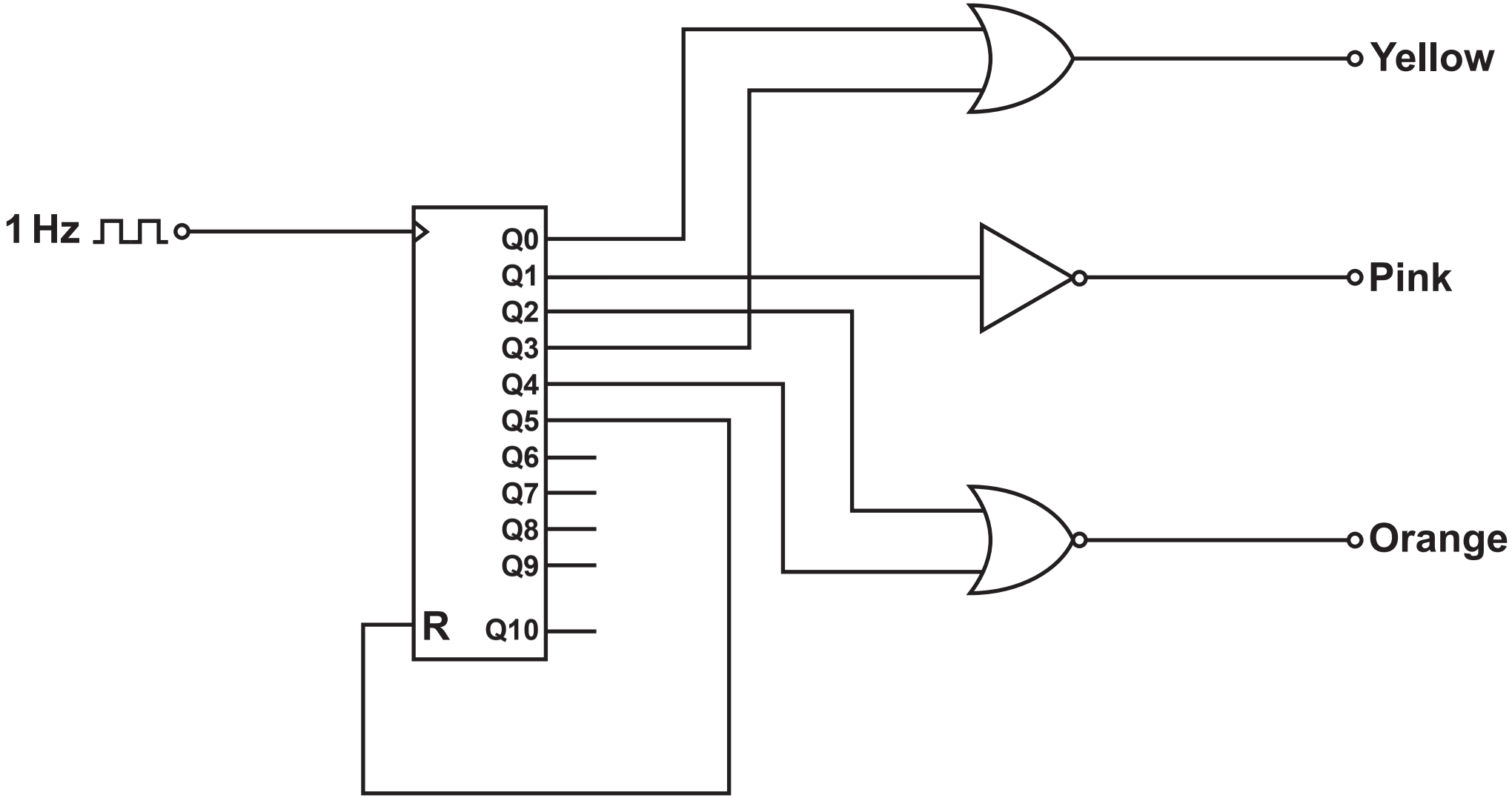
9. **A motor is to be switched on by the output of a logic system. A MOSFET interface is used to provide the power needed for the motor, as shown opposite.**

Information about the system is as follows:

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

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

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


1 Hz
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
R
Q10
Yellow
Pink
Orange

10. The circuit diagram opposite 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 marks]

(i) Yellow = _____

(ii) Orange = _____

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

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

5

END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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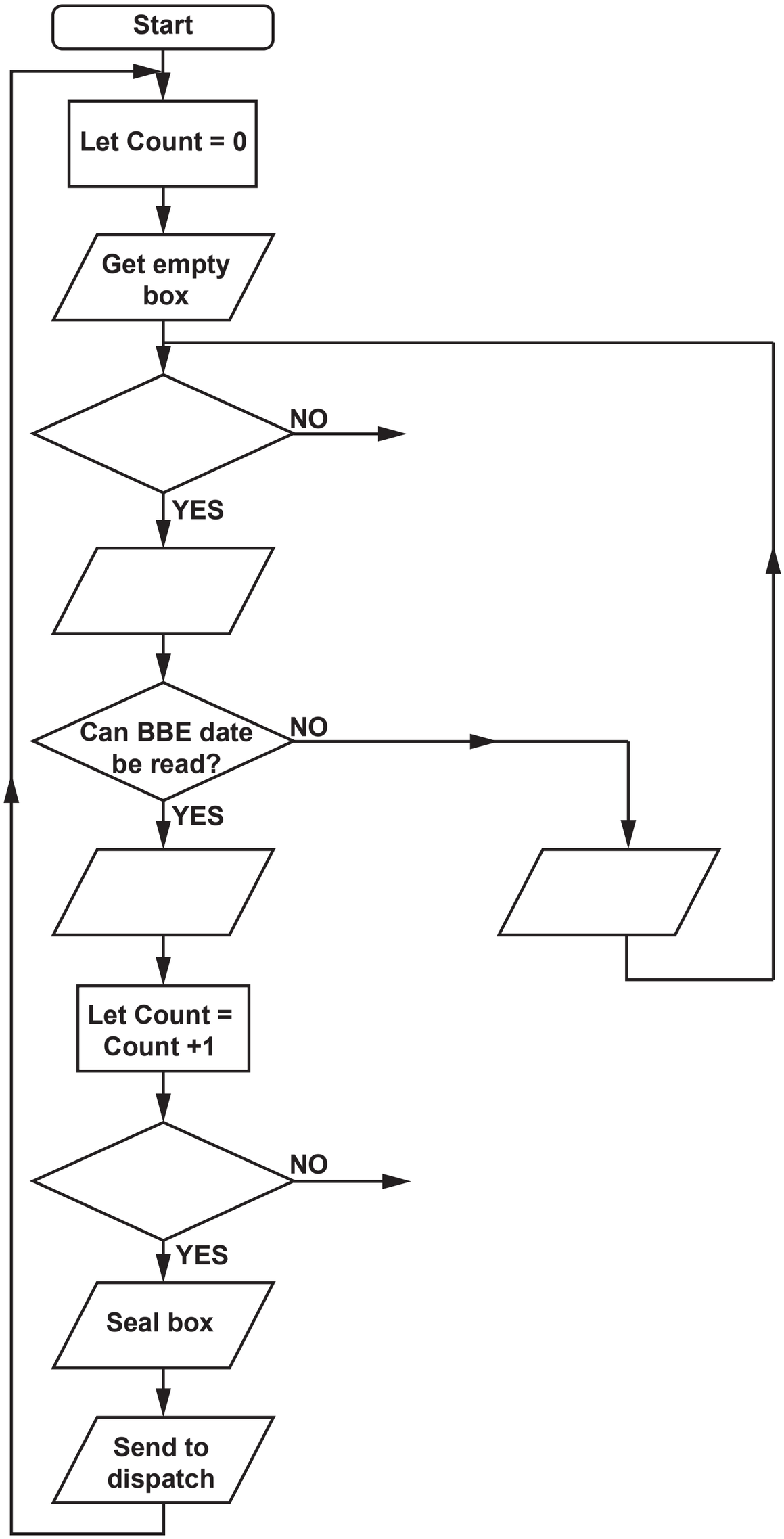
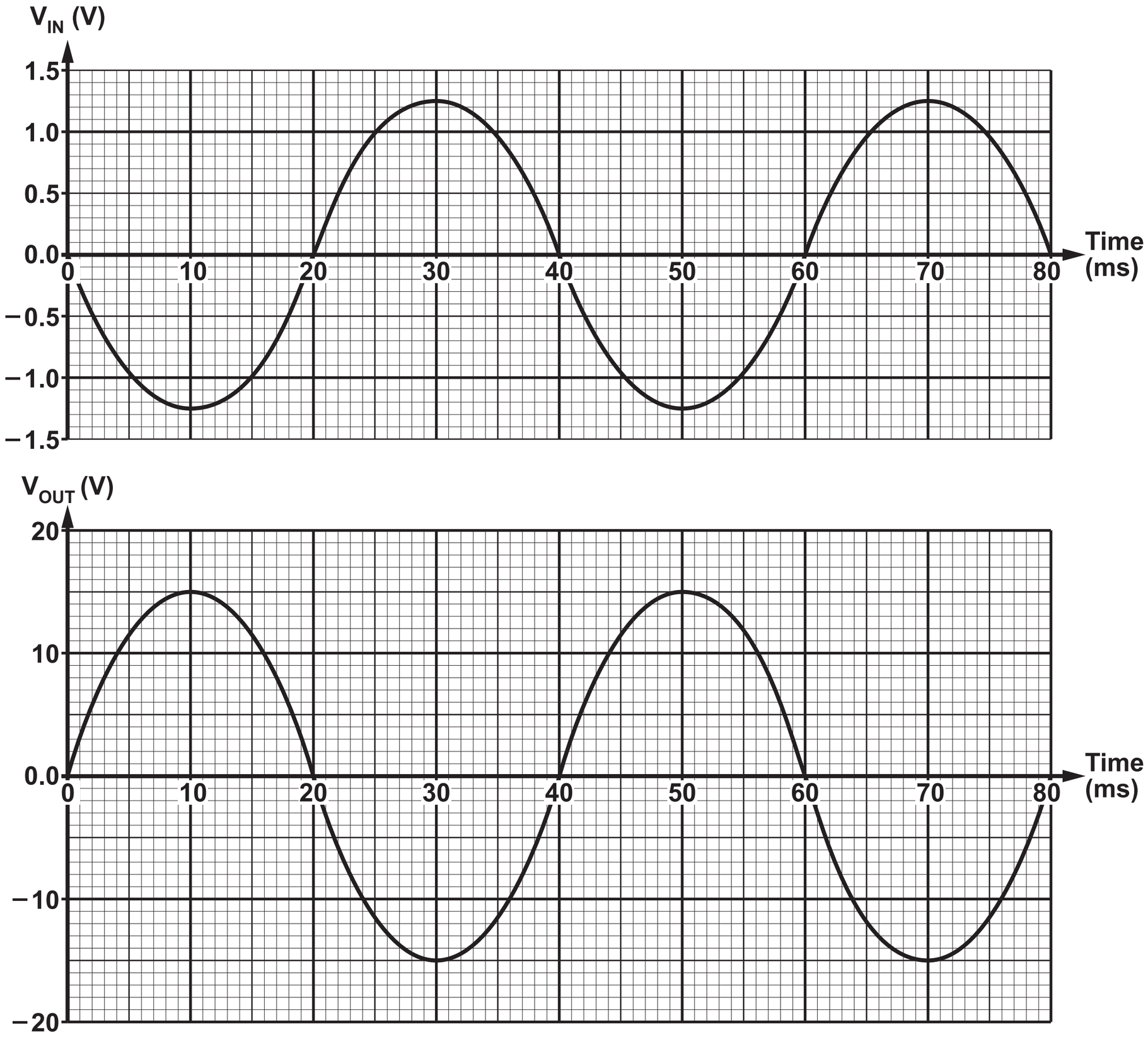
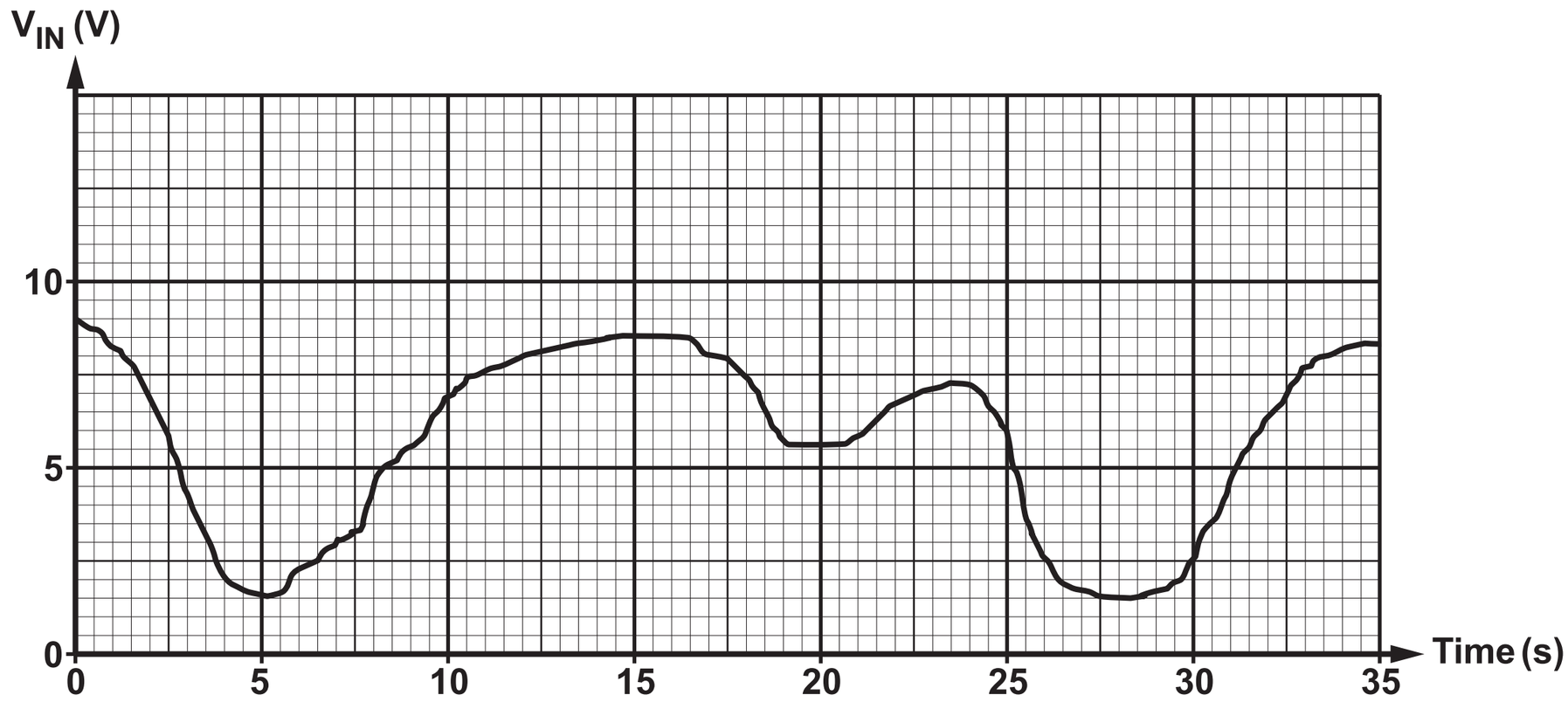
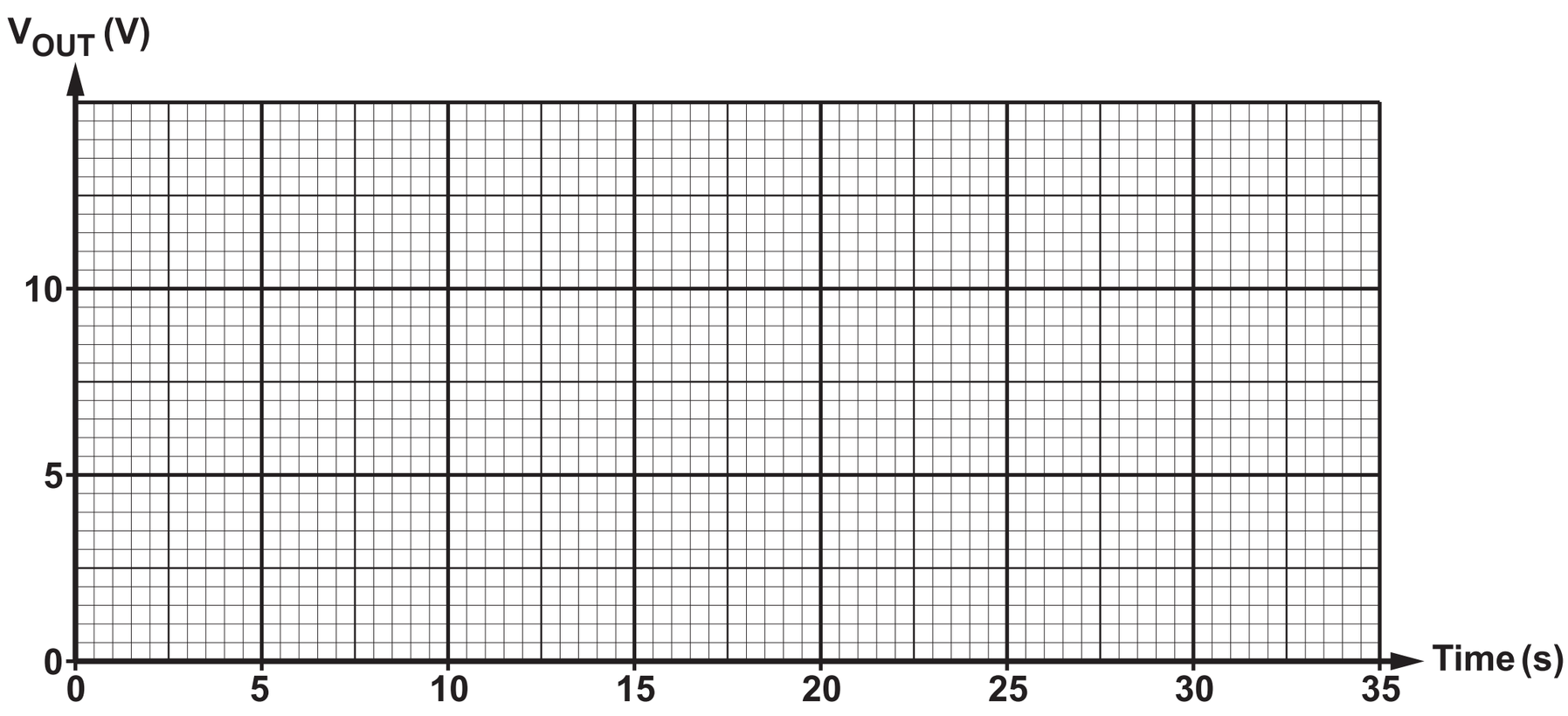
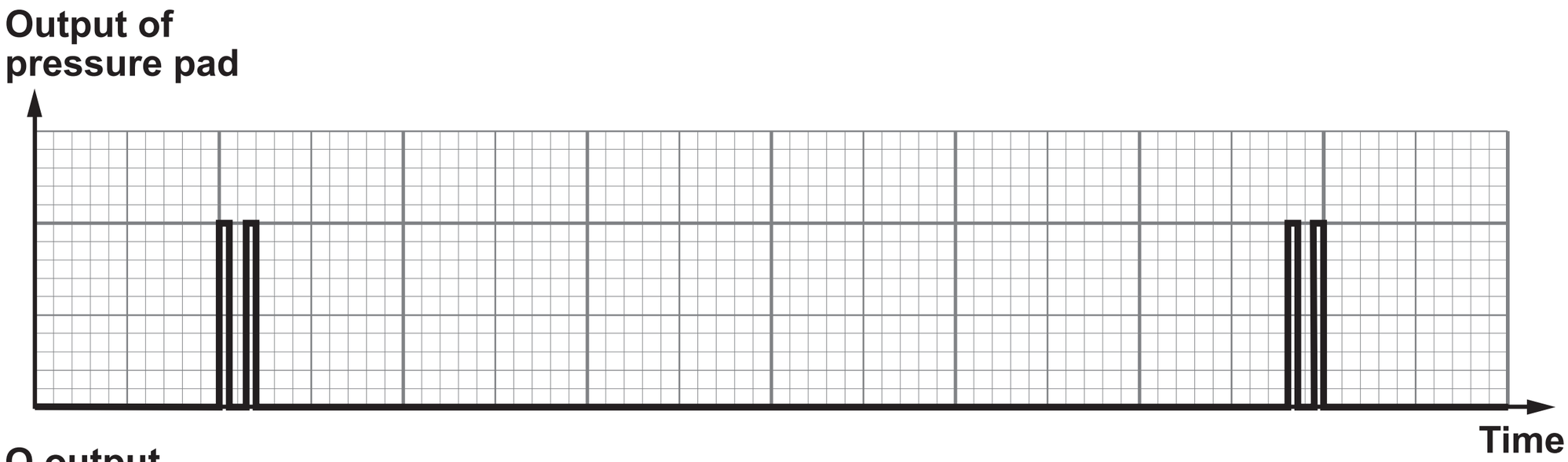
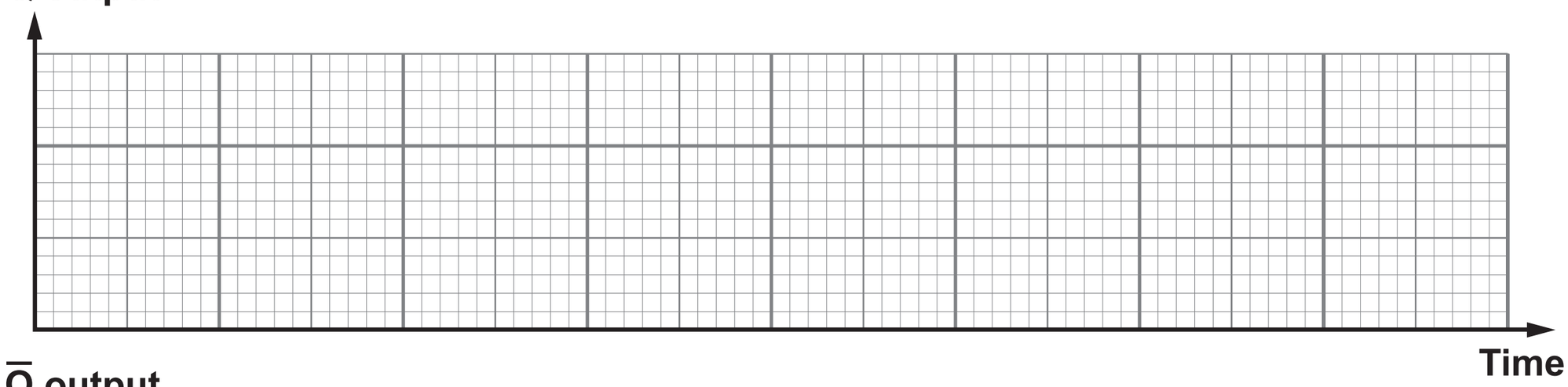

Start
Let Count = 0
Get empty box
NO
YES
Can BBE date be read?
NO
YES
Let Count = Count +1
NO
YES
Seal box
Send to dispatch

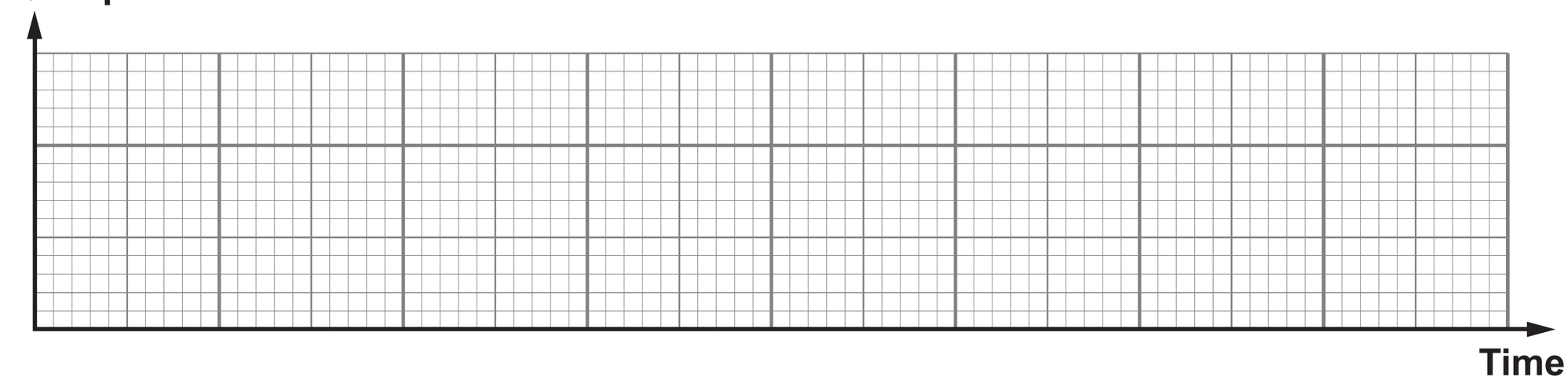

V_{IN} (V)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
10
20
30
40
50
60
70
80
Time (ms)
V_{OUT} (V)
20
10
0.0
−10
−20
0
10
20
30
40
50
60
70
80
Time (ms)


V_{IN} (V)
10
5
0
0
5
10
15
20
25
30
35
Time (s)


V_{OUT} (V)
10
5
0
0
5
10
15
20
25
30
35
Time (s)


Output of
pressure pad
Time


Q output
Time


$\overline{Q}$ output
Time