

Surname	Centre Number	Candidate Number
First name(s)		0



GCSE

C490U20-1



WEDNESDAY, 24 MAY 2023 – AFTERNOON

ELECTRONICS – Component 2
Application of Electronics

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	6	
2.	9	
3.	11	
4.	6	
5.	16	
6.	14	
7.	7	
8.	5	
9.	6	
Total	80	

C490U201
01

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 **9**.



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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. Many offices now have drinks machines for employees to buy hot drinks.

A flowchart program is used to control the machine. Part of this flowchart which allows users to select coffee is shown on the page opposite.



- (a) Write these instructions into the correct boxes in the flowchart. [4]

Is milk selected?

Add water

Is sugar selected?

Add coffee

Is coffee selected?

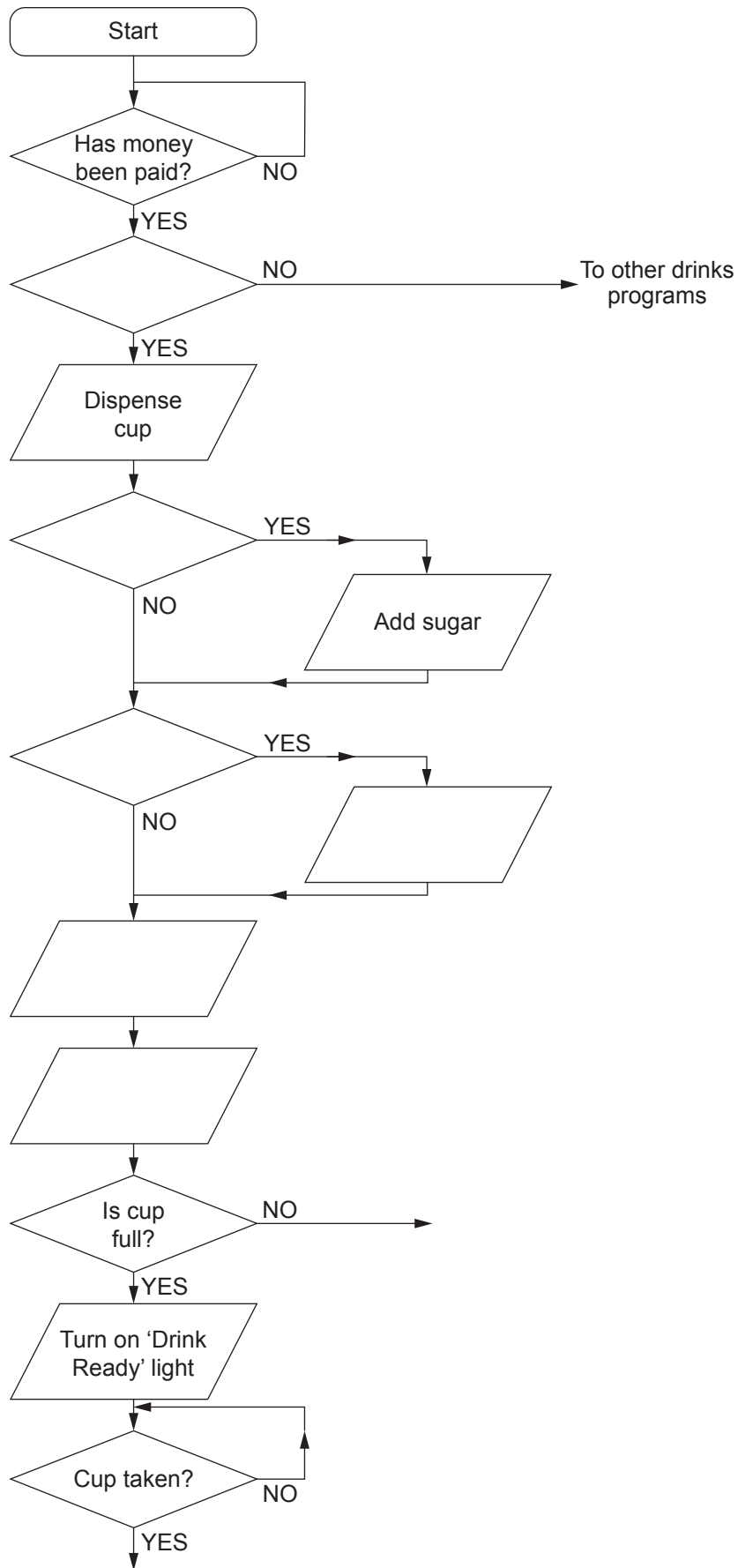
Add milk

- (b) **Add links:**

- to complete the 'NO' path from 'Is cup full?' decision box;
- to complete the 'YES' path from the 'Cup taken' decision box.

[2]





C490U201
05

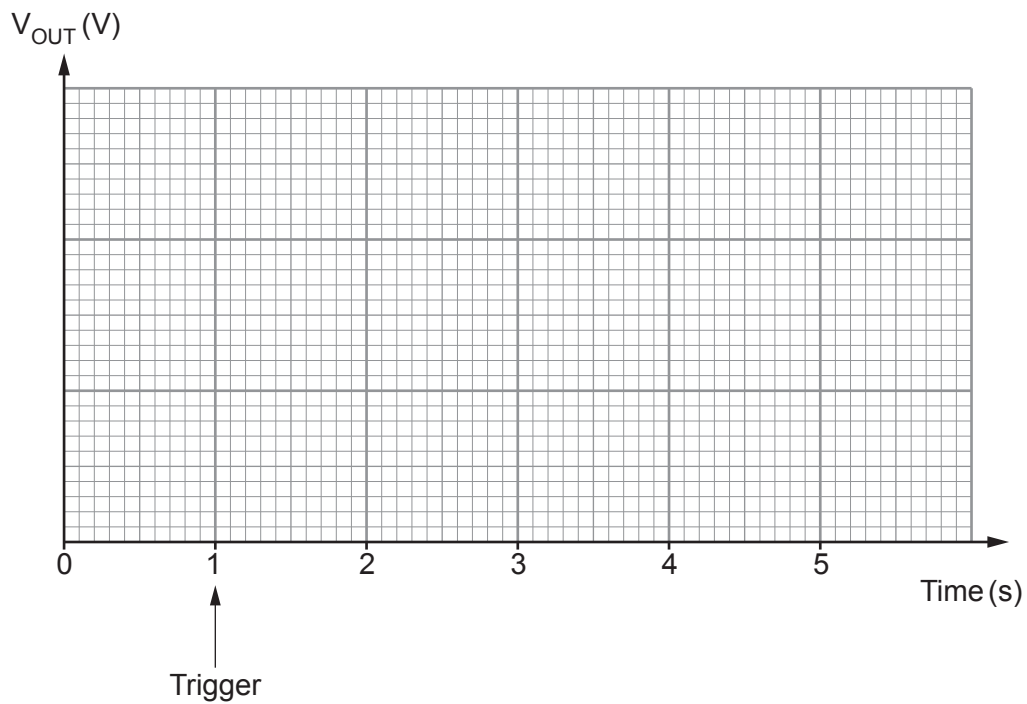


2. (a) During a workshop test, a monostable timer produced a time delay of 3.6 s with an output voltage of 4.5 V when triggered.

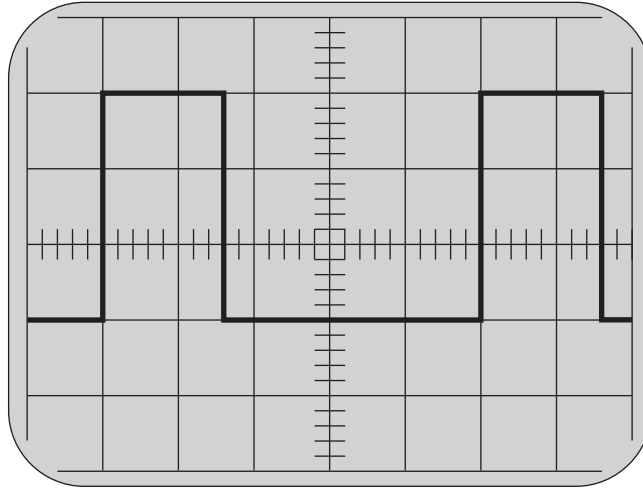
Complete the graph below to show what happens before and after the trigger occurs. Initially V_{OUT} is at 0 V.

Label the voltage axis with suitable values.

[3]



- (b) The following signal from an astable timer is displayed on an oscilloscope screen. The time base is set to 2 ms/cm and the voltage gain is set at 5 V/cm.



- (i) What is the amplitude of this signal? [1]

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.....

- (ii) I. What is the **space** time for this signal? [1]

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- II. What is the **mark** time for this signal? [1]

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- III. Calculate the frequency of this signal. [3]

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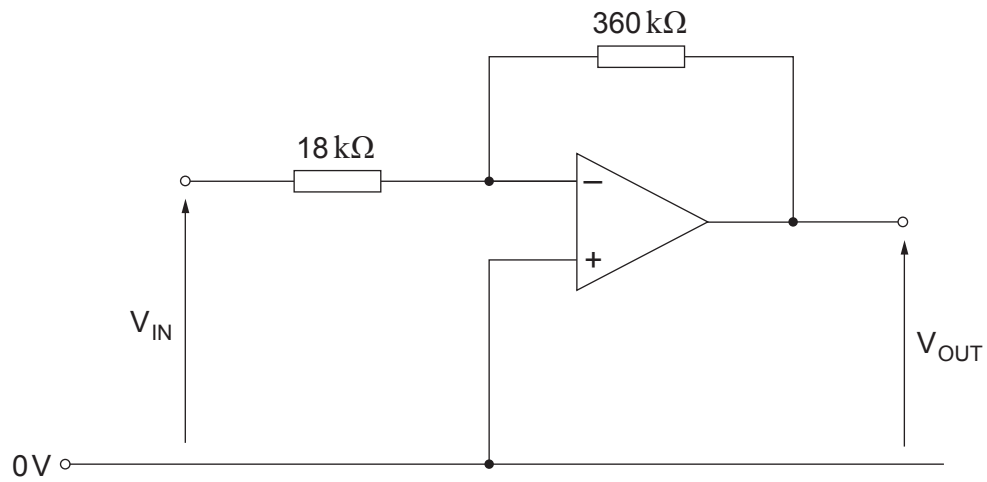
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3. A project uses the following voltage amplifier circuit.



(a) Calculate the voltage gain of this amplifier.

[3]

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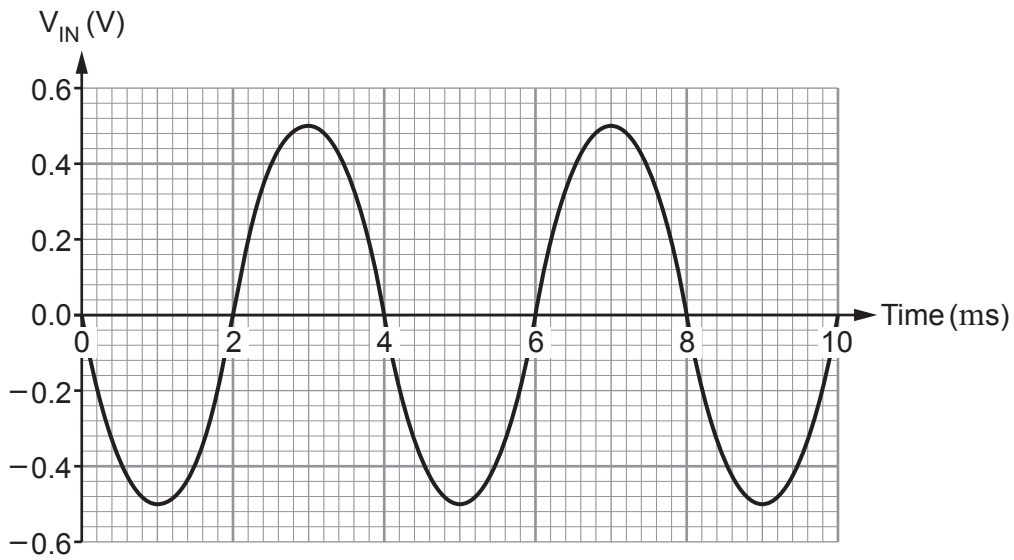
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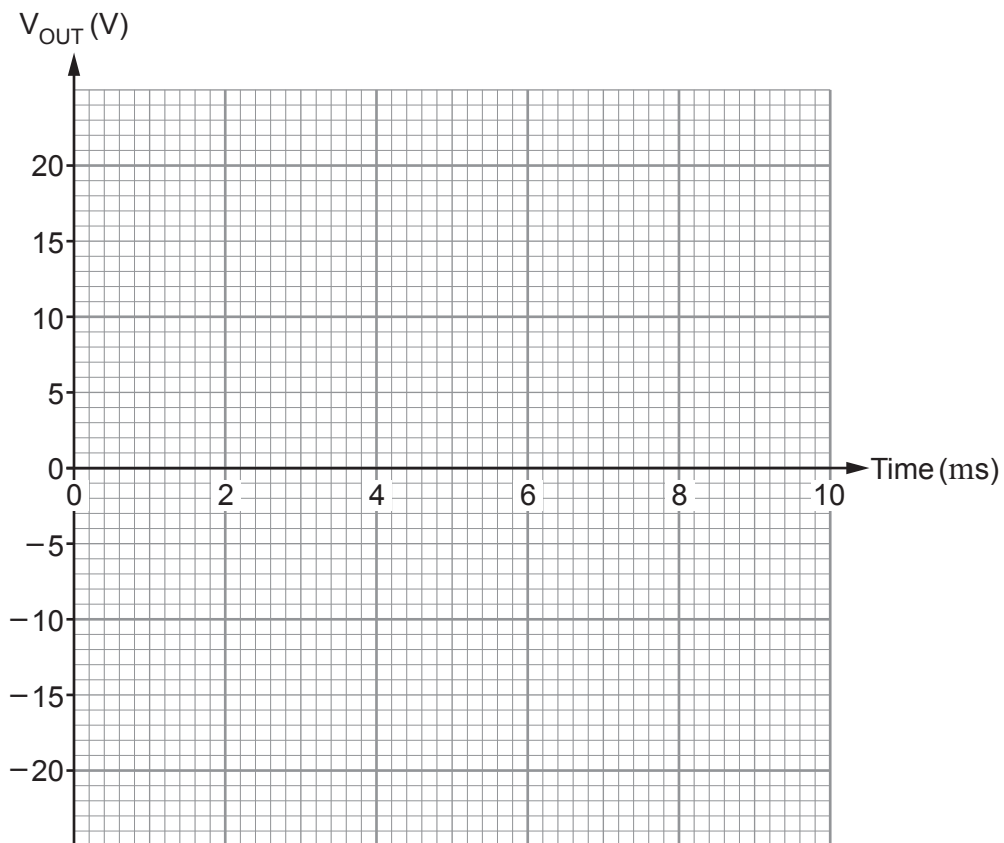
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- (b) The power supply is $\pm 15\text{V}$ and the op-amp saturates at $\pm 13\text{V}$. The following input signal is applied to the op-amp.



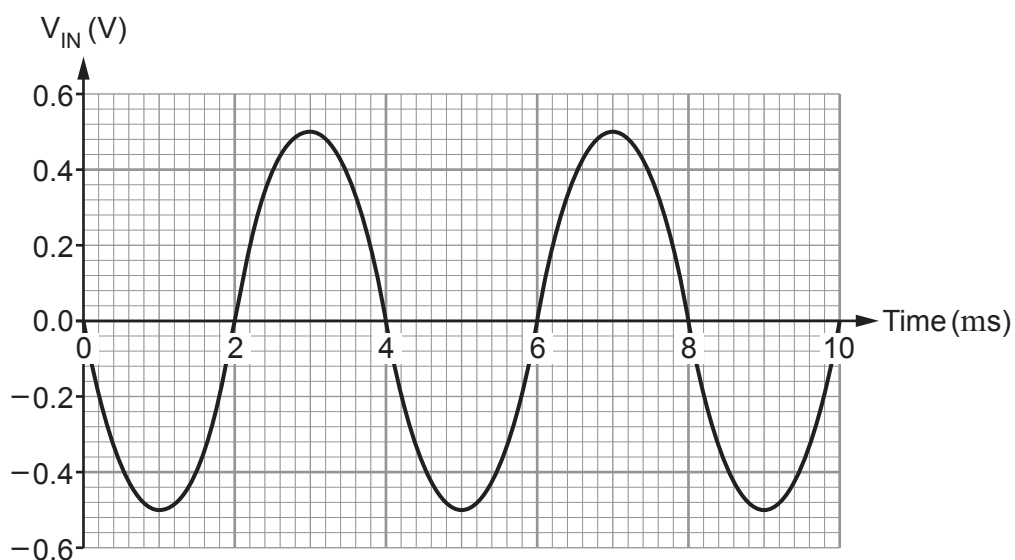
- (i) Determine the amplitude of the input signal. [1]
- (ii) Calculate the amplitude of the output signal. [1]
-
- (iii) Complete the graph below to show the expected output signal. [3]



C490U201
09

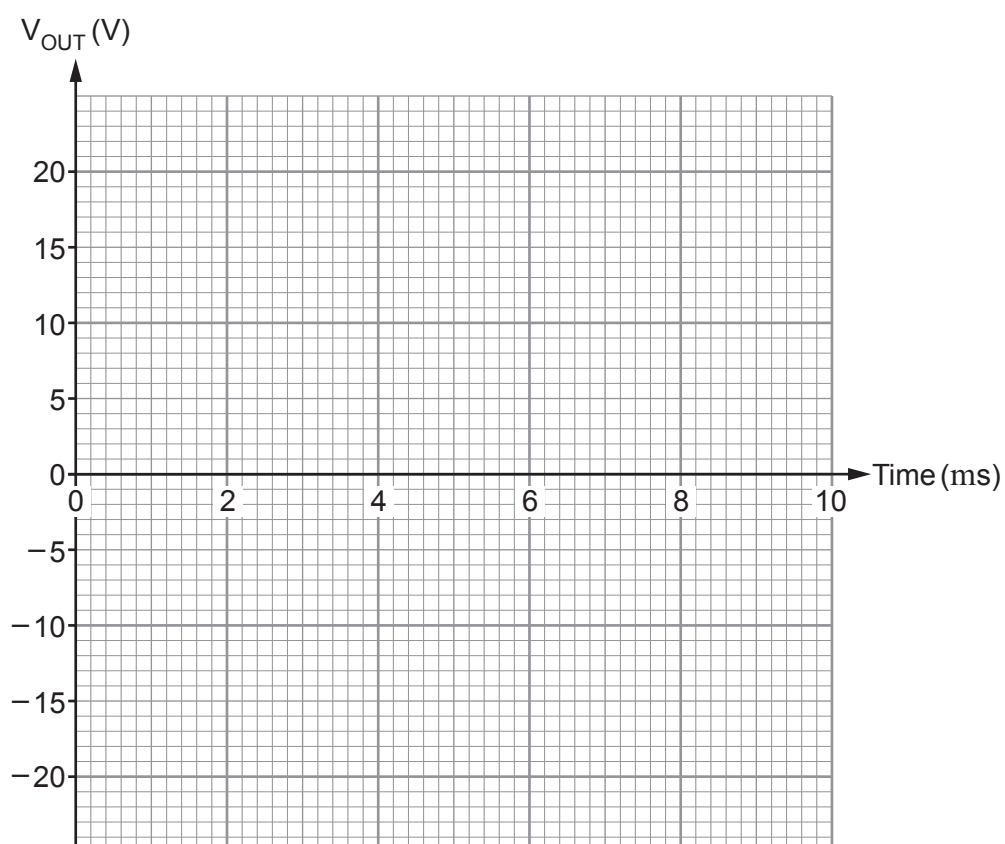


- (c) The same input signal is now applied to a **non-inverting** amplifier with a gain of 40. The same $\pm 15\text{V}$ power supply is used and the amplifier also saturates at $\pm 13\text{V}$.

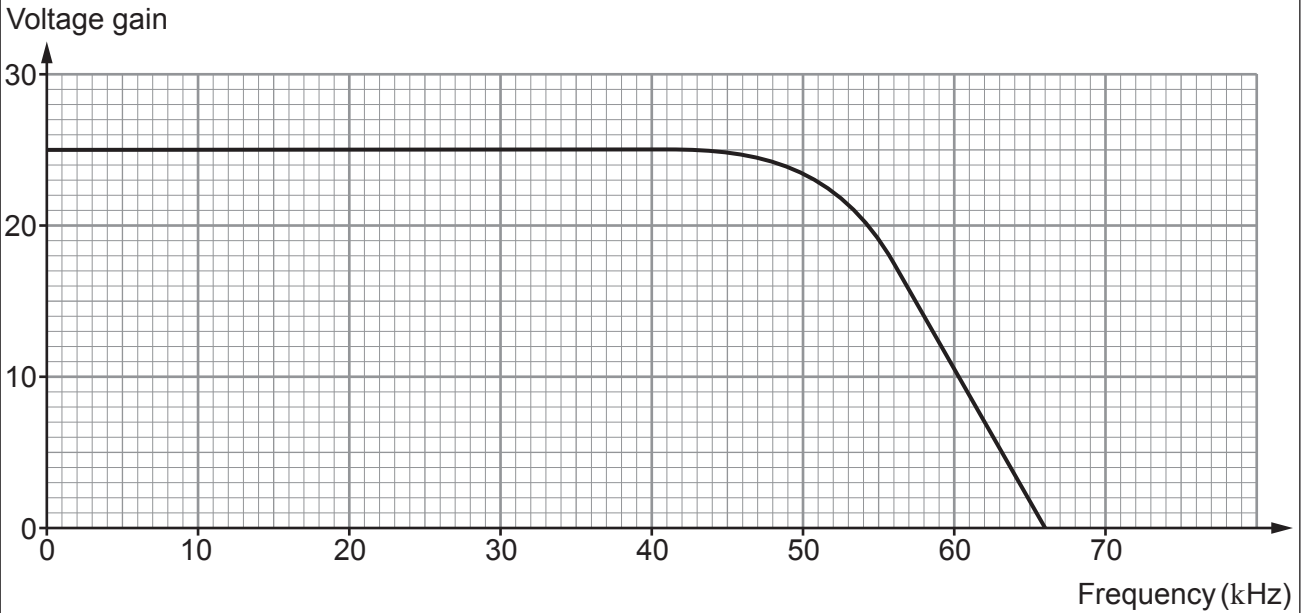


Complete the graph below to show the expected output voltage.

[3]



4. The following shows the voltage gain-frequency graph for an amplifier circuit based on an op-amp.



(a) What is the gain of the amplifier at 33 kHz? [1]

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(b) Determine the bandwidth of this amplifier. **Show clearly on the graph** how you obtained your answer. [3]

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(c) What is the effect on the bandwidth when the voltage gain is halved? [2]

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C490U201
11

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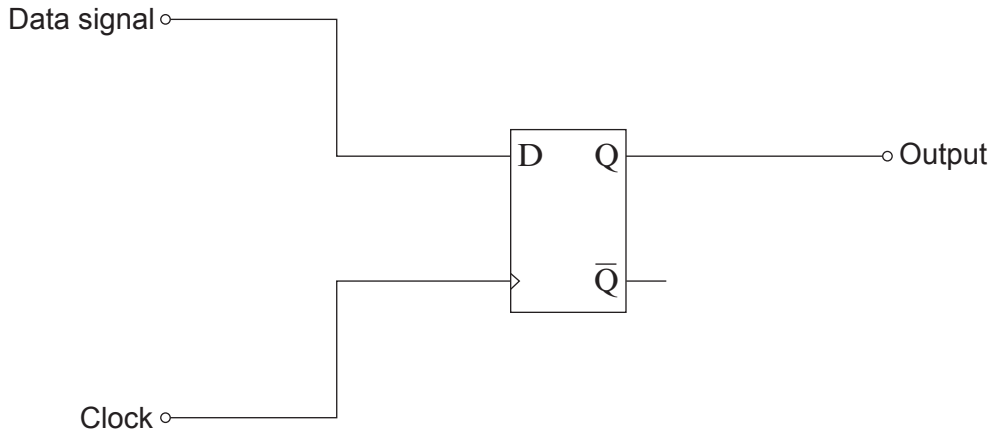
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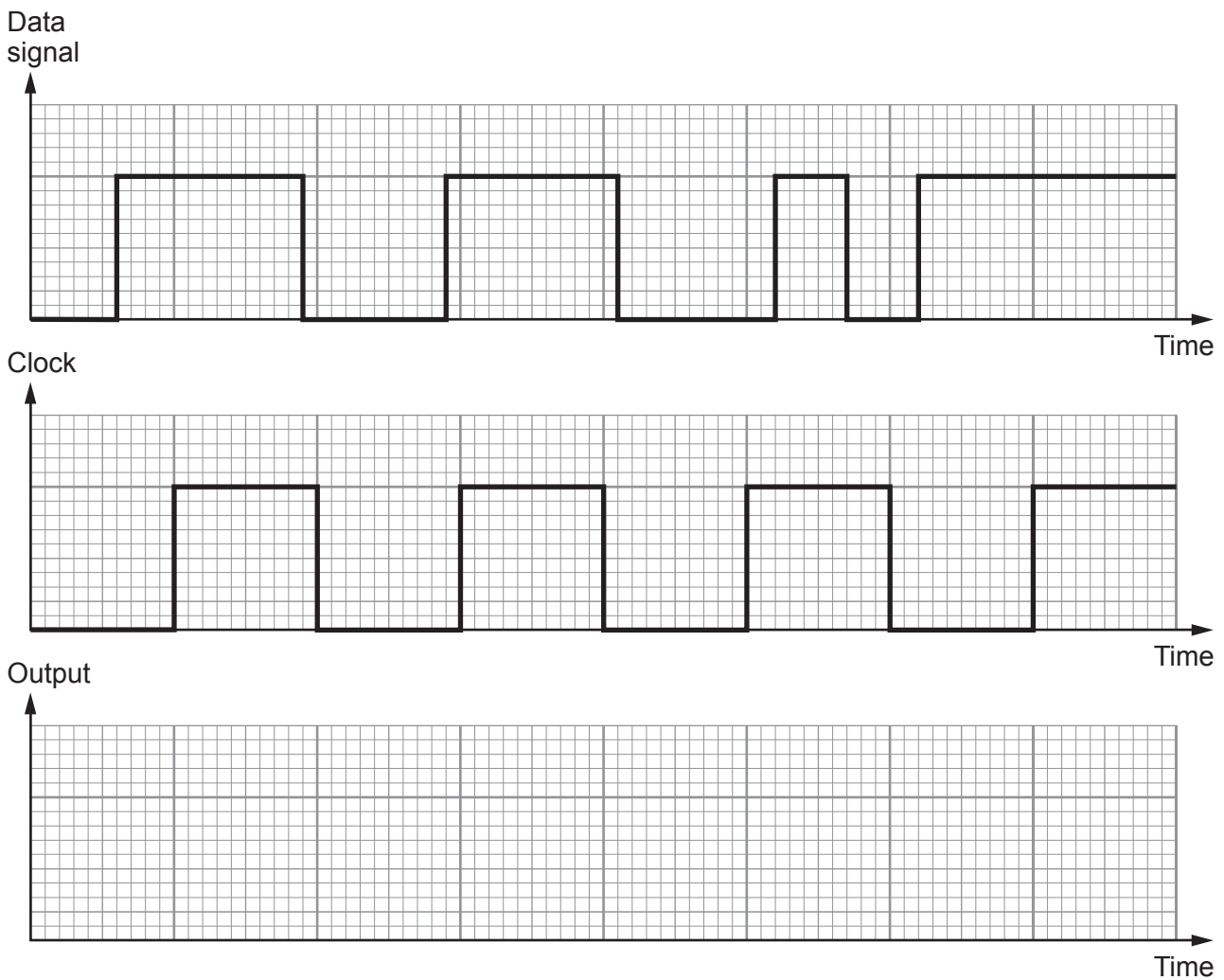


5. This question involves different applications of a D-type flip-flop.

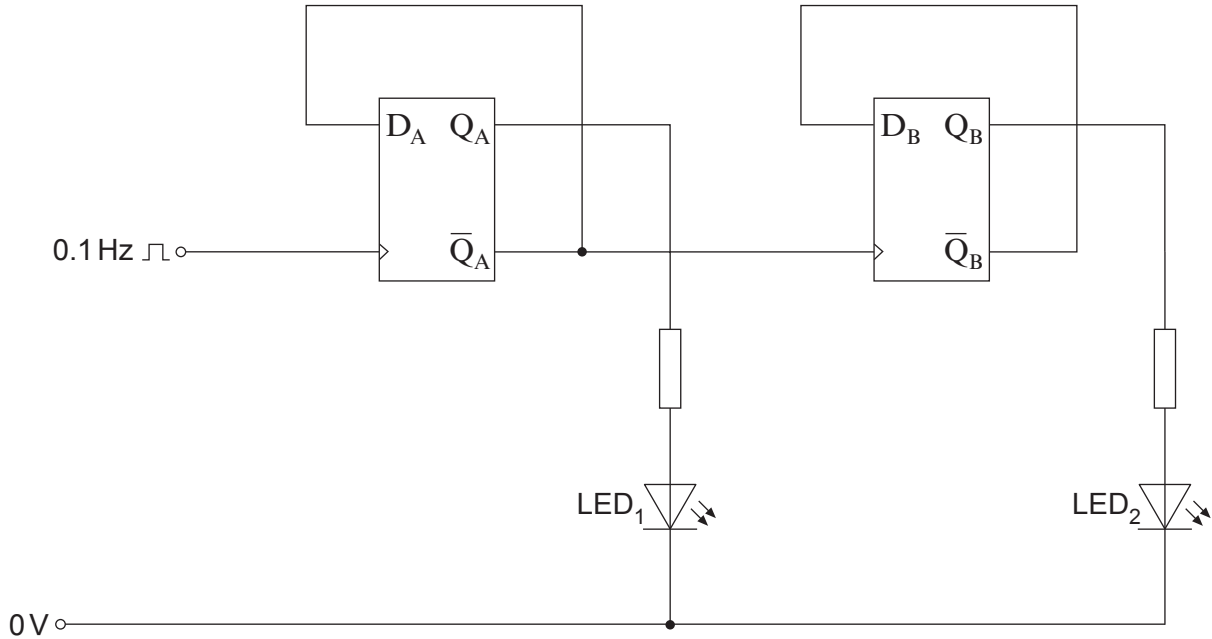
- (a) The following diagram shows a rising-edge-triggered D-type flip-flop connected to a digital data signal and a clock.



Complete the output graph below for the digital data signal and clock signal. The output is initially low. [4]



(b) The diagram shows a pulse generator connected to a 2-bit counter.



(i) The two LEDs are initially off. Complete the table below with 'On' or 'Off' to show the state of each LED. [2]

Clock pulse	LED ₁	LED ₂
Start	Off	Off
1
2
3
4
5

(ii) The frequency of the pulse generator is 0.1 Hz. [2]

I. What is the frequency of the \bar{Q}_A output?

II. What is the frequency of the Q_B output?



(iii) Calculate the time that LED₂ is on during the first five clock pulses. [3]

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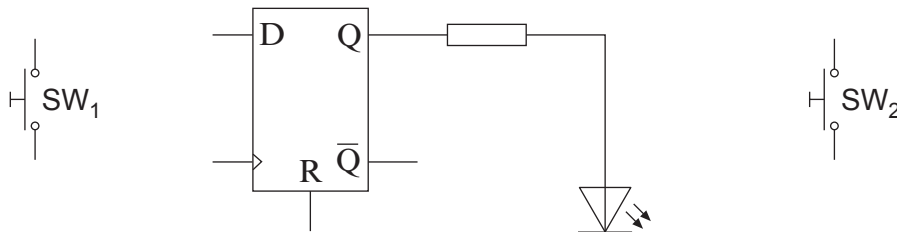
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(c) A D-type flip-flop can be used as a latch. Complete the circuit design of the latch below so that pressing:

- switch SW₁ makes the LED turn on;
- switch SW₂ resets the latch so that the LED turns off.

Additional components can be added to your design as required. [5]

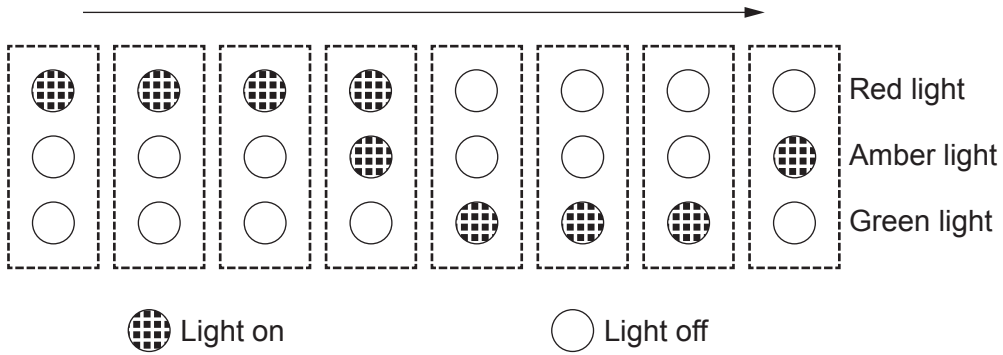
6V ○—————



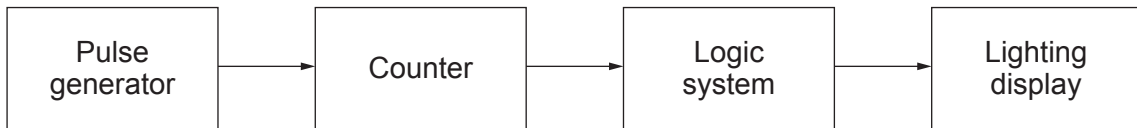
0V ○—————



6. A student wants to make a set of traffic lights to control the traffic on a model roadway. The lighting sequence required is shown below:



Here is the overall block diagram for the traffic light system.



- (a) (i) Complete the following truth table to produce the necessary traffic light sequence. A logic 1 is required to turn on a light in the display. [1]

Counter outputs			Display outputs		
C	B	A	Red light	Amber light	Green light
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

- (ii) The **Red** output can be obtained using a single logic gate. Write down the Boolean equation for this output. [1]

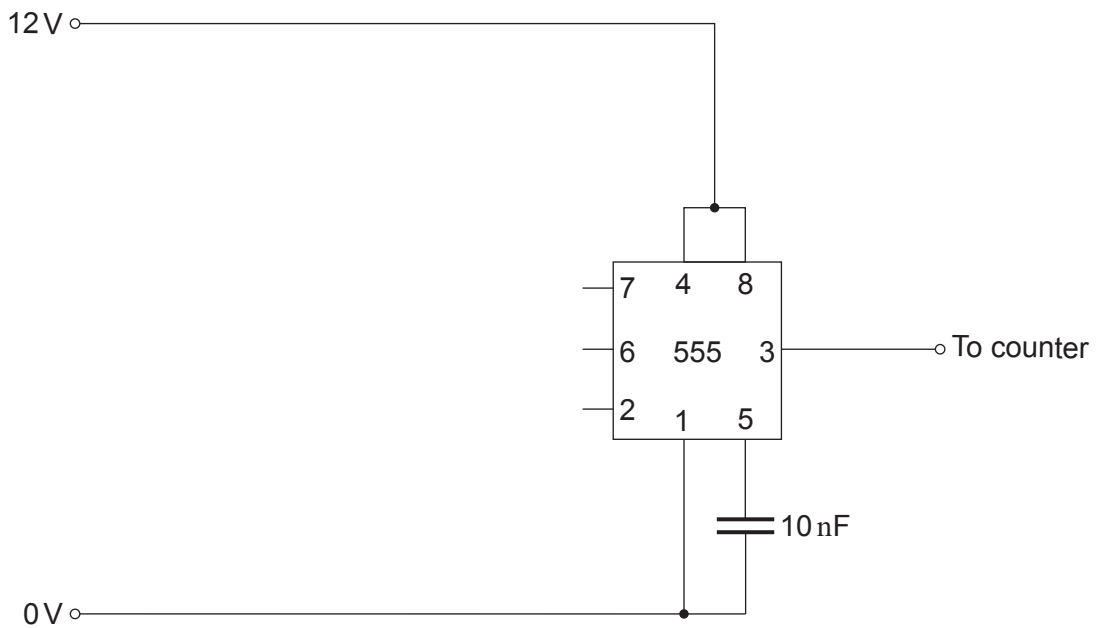
Red output =



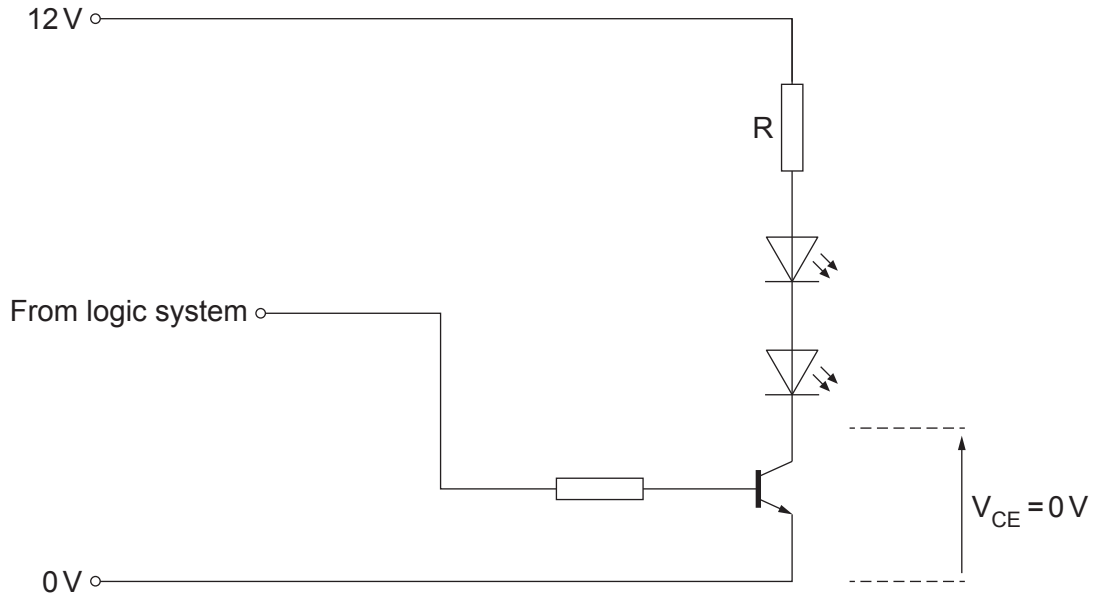
(iii) Write down the Boolean equation for the **Amber** output. [3]

Amber output =

(b) Complete the design of the pulse generator by adding the necessary components and connections. [4]



- (c) The traffic light model contains two LEDs of each colour connected in series. Each pair of coloured LEDs are driven from a transistor switch like the one shown below.



The voltage $V_{CE} = 0V$ and the voltage across a green LED is 2.1V when it is on. Determine the preferred value of R required to limit the current through the green LEDs to no more than 25mA. [5]

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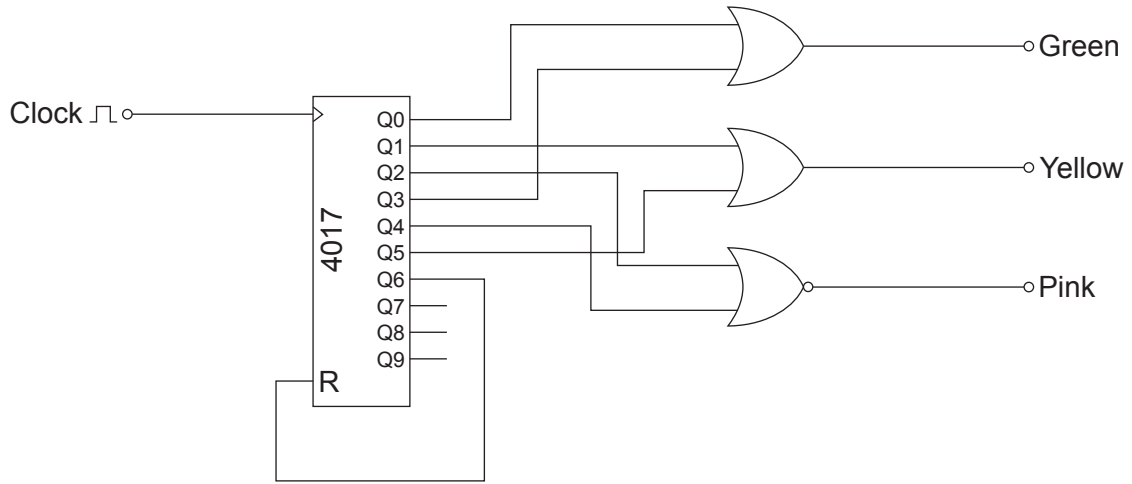


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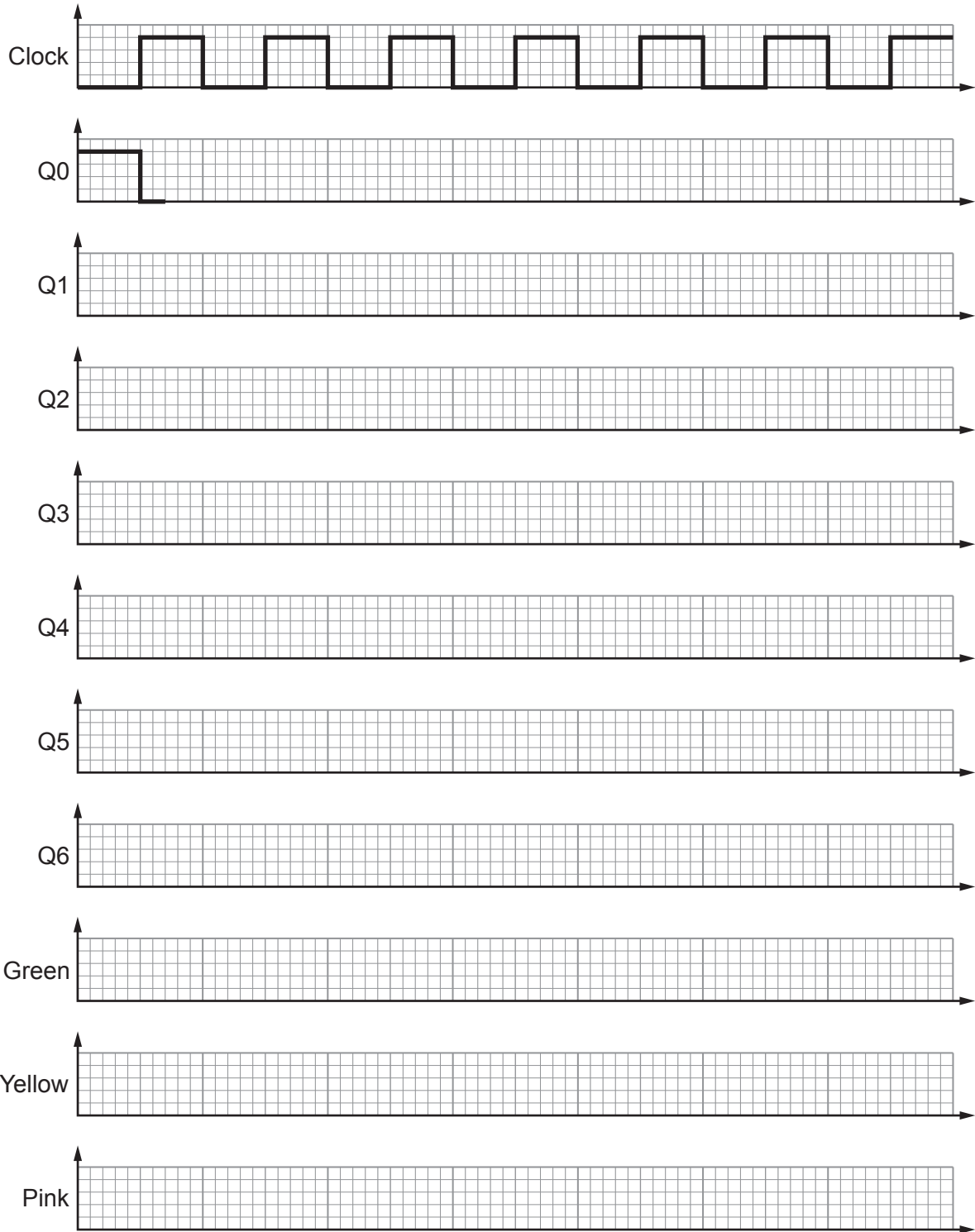
7. The 4017 decade counter can be used to produce a repeating sequence. The circuit below shows the 4017 set up to produce a light sequence.



Complete the timing diagram opposite. Initially Q0 = 1.

[7]

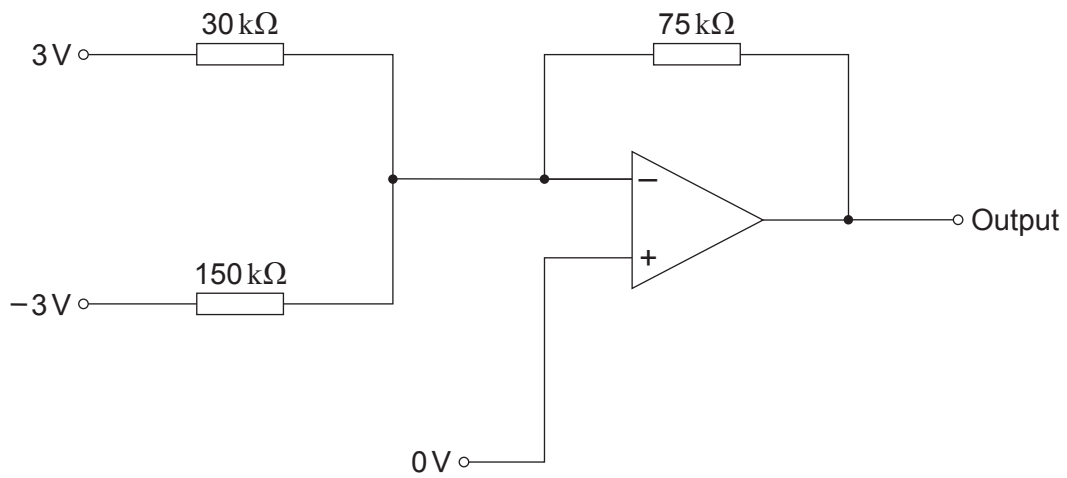




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8. A circuit for a summing amplifier is shown below with two test signals applied to the inputs.



- (a) Calculate the output voltage of the summing amplifier. The power supply is $\pm 9\text{V}$ and the op-amp saturates at $\pm 8\text{V}$. [4]

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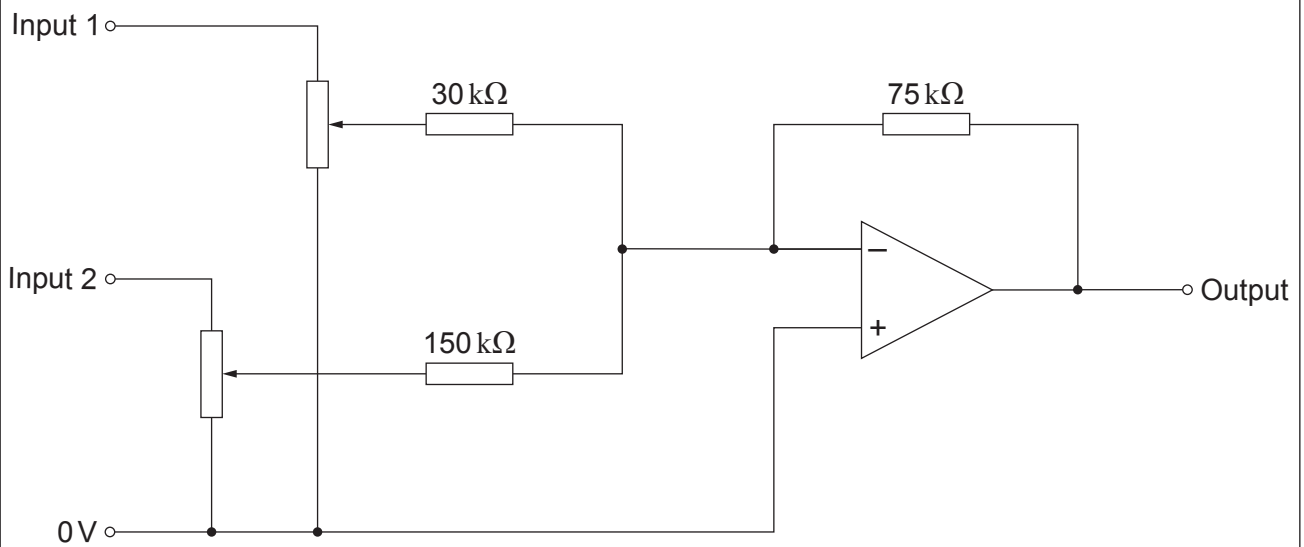
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(b) The summing amplifier is modified to make an audio mixer as shown below.



What is an advantage of this modification?

[1]

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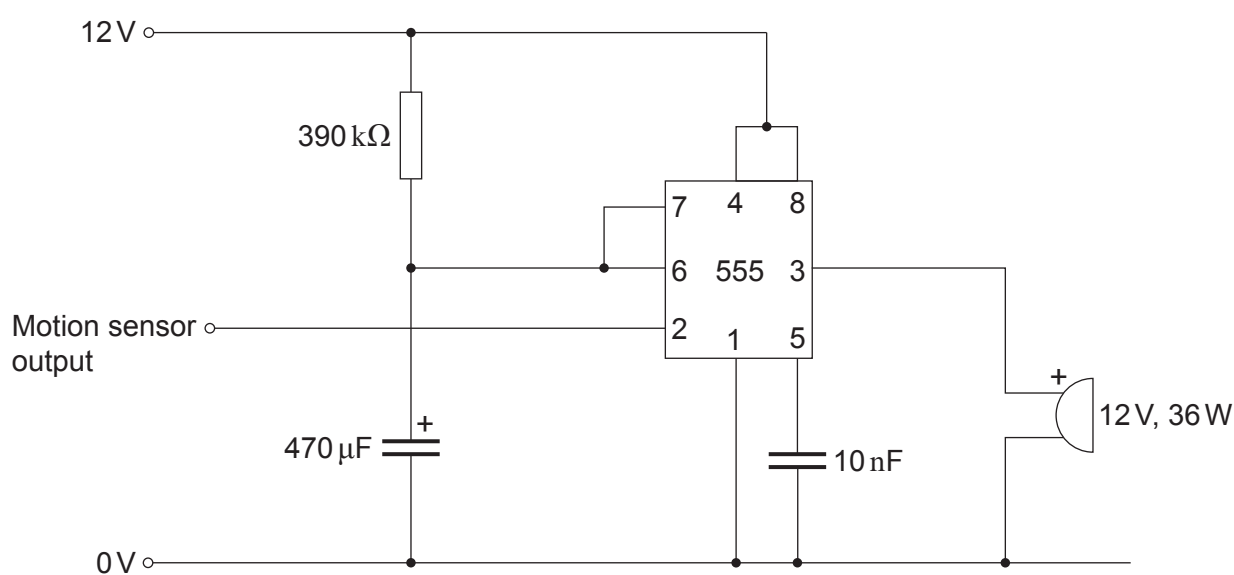
9. A local garage wants to install a warning alarm activated by a motion sensor which turns on a siren for approximately 20s when someone approaches the garage when it is closed.

The specification for the design of the circuit is:

- the siren is activated by a motion sensor;
- the siren should operate for approximately 20s before turning off automatically.

The motion sensor produces a short logic 1 pulse when motion is detected.

A proposed design solution is shown below.



Evaluate the circuit design using relevant calculations to determine whether it is a suitable design. Describe any changes required to meet the specification. [6 QER]

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