RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2527**

ELECTRONICS

Signal Processing Circuits

TUESDAY 22 MAY 2007 Morning

Time: 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator.

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **90**.
  You may assume, unless otherwise stated, that:
  (i) the p.d. across a forward-biased silicon diode is 0.70V,
  (ii) the base-emitter p.d. for a conducting silicon transistor is 0.70V,
  (iii) the power supplies for operational amplifiers are +15V and –15V,
  (iv) the saturation levels for operational amplifiers are +13V and –13V,
  (v) logic 1 = 5V and logic 0 = 0V.
- The quality of written communication will be assessed in your answers to all questions.

For Examiner's Use	
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2	
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QoWC	
Total	

This document consists of **15** printed pages and **1** blank page.

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1 Fig. 1.1 shows a circuit with three push switches as inputs and an LED as the output.

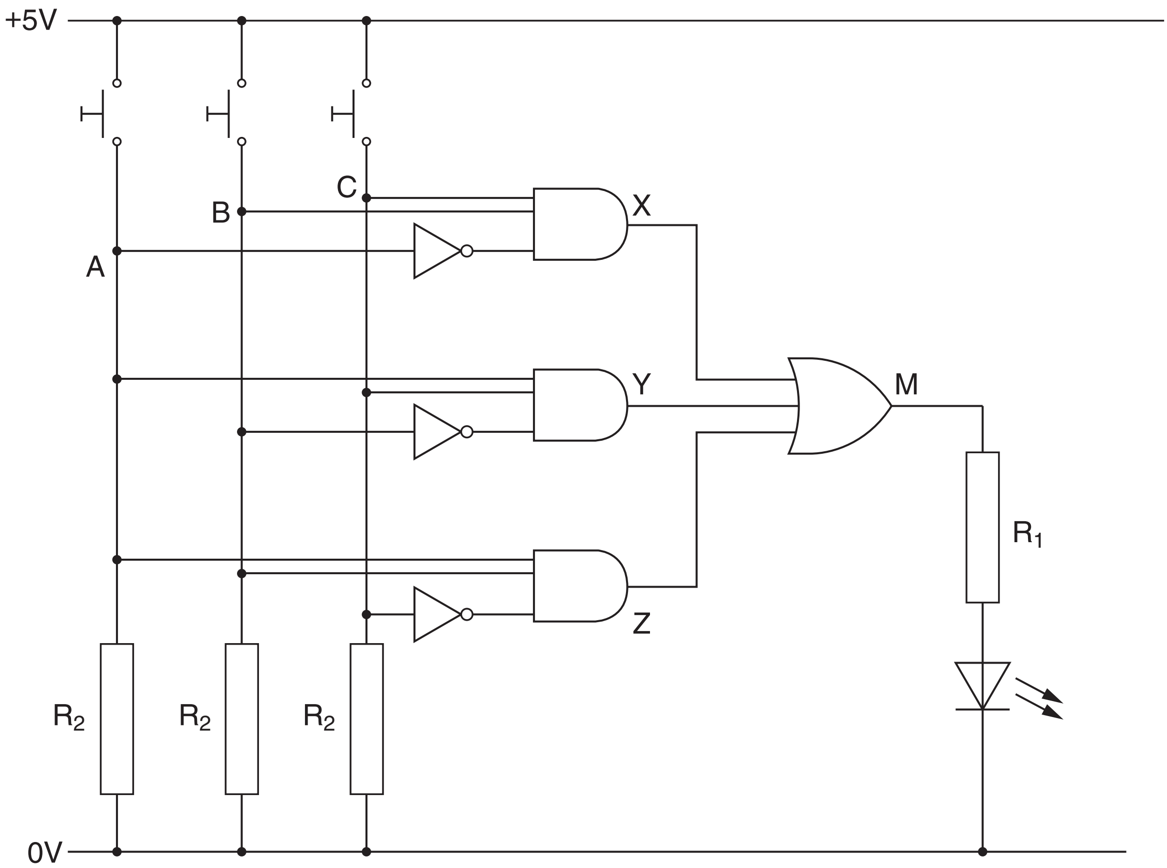

Fig. 1.1

(a) Explain the purpose of the resistors labelled R_2.

....

....

....[2]

(b) State the purpose of the resistor R_1.

....

....[1]

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(c) Write down Boolean expressions for the signals at X, Y and Z in terms of the inputs A, B and C.

X = ...

Y = ...

Z = ...

[3]

(d) Write down a Boolean expression for the output M of the circuit shown in Fig. 1.1.

M = ...

[1]

(e) Complete the truth table below for the output M of the circuit shown in Fig. 1.1.

A	B	C	M
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

[3]

(f) Explain how the LED responds to pressing the switches in Fig. 1.1.

....

....[2]

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2 Fig. 2.1 shows a circuit built around an op-amp.

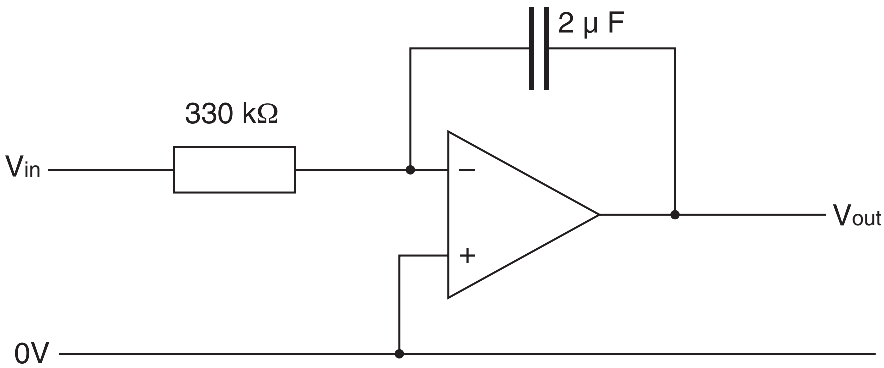

Fig. 2.1

(a) State the name of the circuit in Fig. 2.1.

....[1]

(b) The output voltage V_{out} is initially 0V.

Calculate how V_{out} changes with time when the input voltage V_{in}

(i) is a steady voltage of +5V.

$\frac{V_{out}}{time}$ = ... $V s^{-1}$ [3]

(ii) is a steady voltage of –5V.

$\frac{V_{out}}{time}$ = ... $V s^{-1}$ [1]

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(c) The signal shown in Fig. 2.2 is now applied to the input of the circuit of Fig. 2.1.

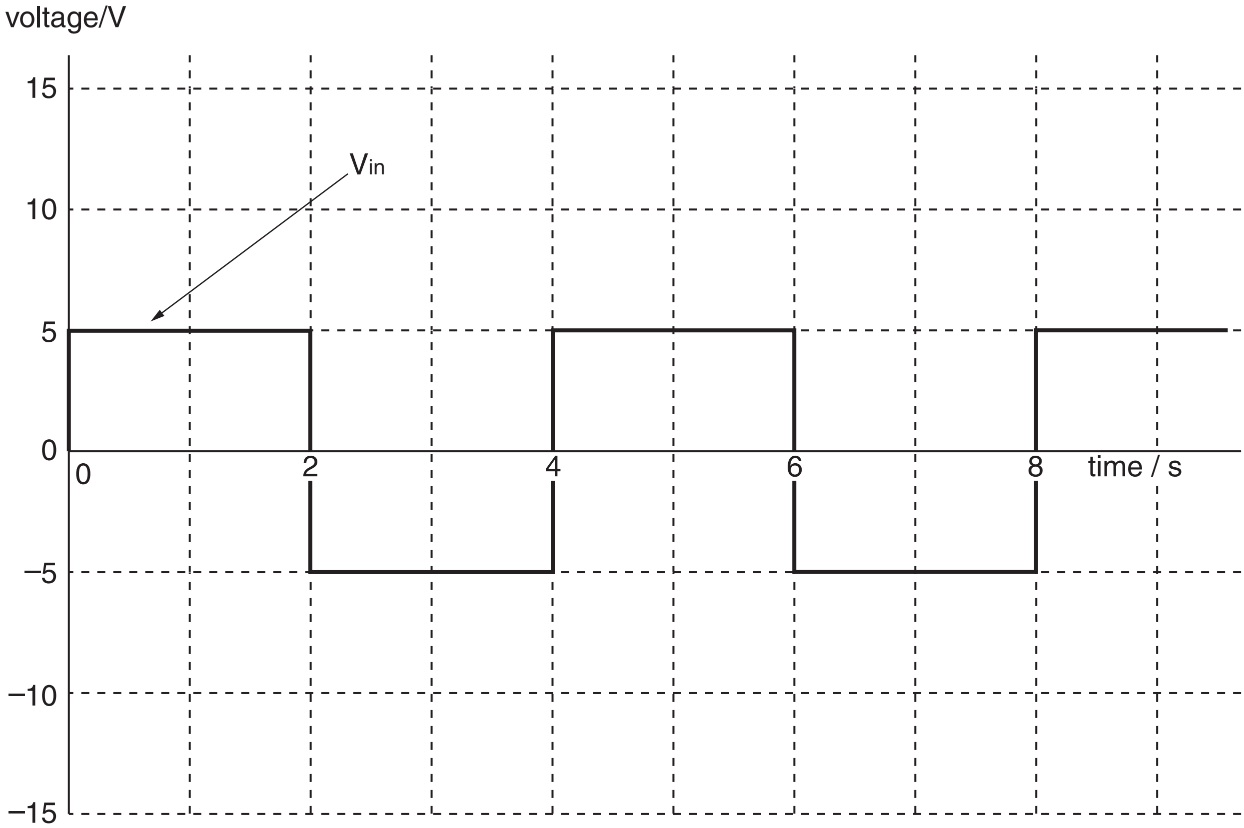

Fig. 2.2

On the same axes of Fig. 2.2, draw the output voltage V_{out} as a function of time.
You should assume that, at the start, V_{out} is zero.

[4]

(d) Explain how the output of the circuit of Fig. 2.1 would change if the input voltage became a +5V/0V clock pulse of the same frequency instead of the ±5V symmetrical square wave signal shown in Fig. 2.2.

....

....

....[2]

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3 Fig. 3.1 shows the frequency response of a filter circuit.

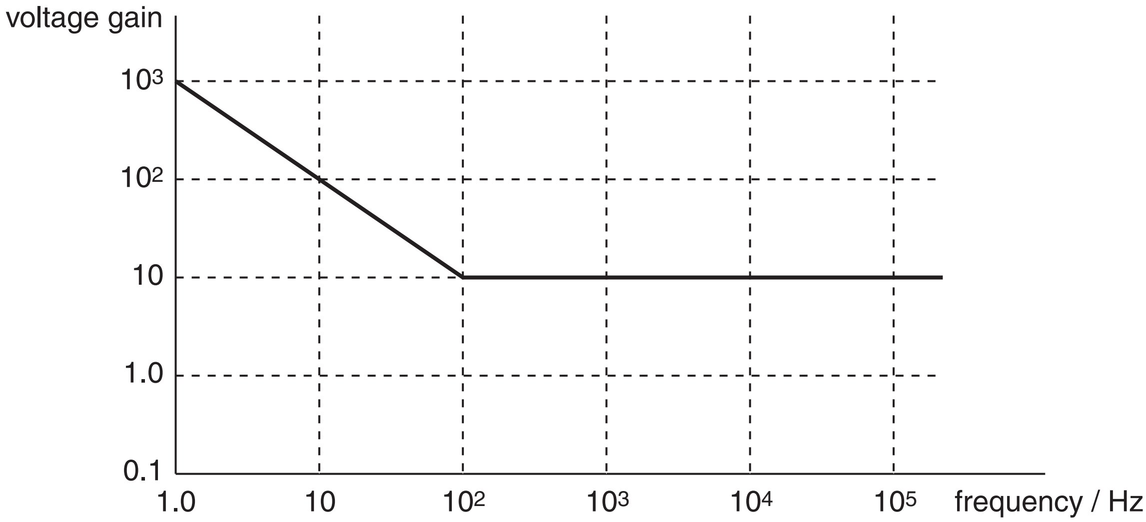
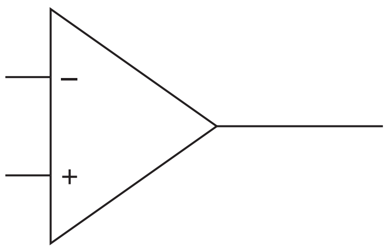


Fig. 3.1

(a) Draw a ring around the type of filter circuit which will generate the frequency response shown in Fig. 3.1.

Bass cut **Band pass** **Treble boost** **Bass boost** **Treble cut** [1]

(b) Draw a labelled circuit diagram for the filter with the frequency response shown in Fig. 3.1. Your filter should have an input impedance of 39 kΩ and use the op-amp shown in Fig. 3.2. Show all component values and explain how you calculated them.



[10]

Fig. 3.2

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(c) Describe the experiment you would set up and what measurements you would take in order to produce the graphical result shown in Fig. 3.1.

Draw a block diagram of your set up around the filter circuit of Fig. 3.3.

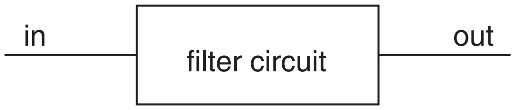

Fig. 3.3

....

....

....

....[6]

4 Fig. 4.1 shows a logic system with three inputs A, C and E and output Q.

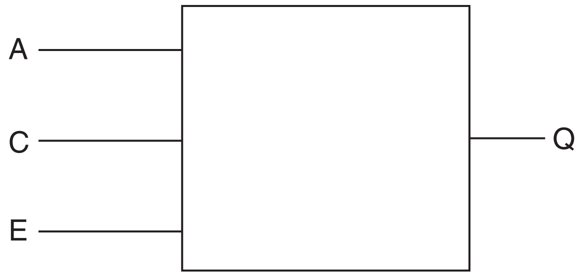

Fig. 4.1

(a) The signals at A, C, E and Q are logic signals. Explain what this means.

....

....[2]

(b) The electronic operation of a logic system is normally written down in one of three ways:
- truth table
- Boolean expression
- circuit diagram

It can also be expressed in words.
The logic system of Fig. 4.1 operates as follows;
The output Q is only logic 1 when A and C are different and E is logic 1.

(i) Complete the truth table for the logic system of Fig. 4.1.

A	C	E	Q
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

[2]

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(ii) Write down a Boolean expression for your truth table.

....[2]

(iii) Using any type of logic gates, draw on Fig. 4.2 a circuit diagram which will operate as required.

[3]

Fig. 4.2

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5 For a project, a student decides to use an LDR in a circuit, to be set up outside, which will count up the number of days in a year. At the end of the year, the circuit is to set off an alarm.
Fig. 5.1 shows how the resistance of the LDR, exposed to the sky, varies with light intensity.

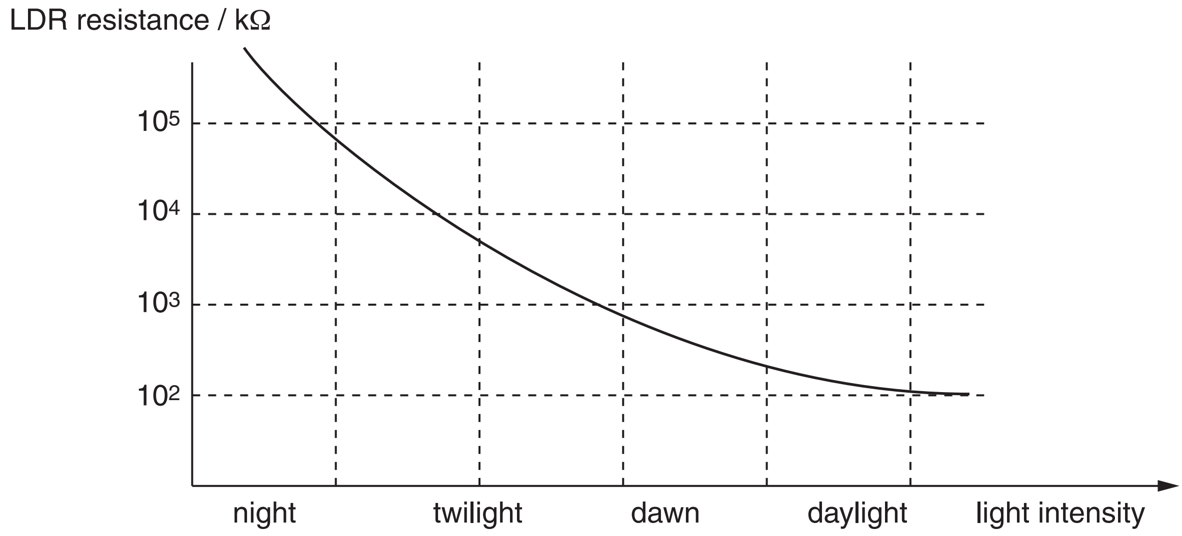

Fig. 5.1

(a) The student begins by using the LDR in the circuit shown in Fig. 5.2.

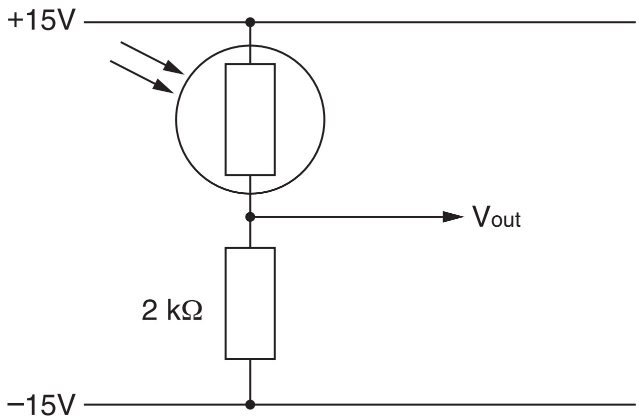

Fig. 5.2

State the name of the arrangement of series resistors in the light sensor circuit shown in Fig. 5.2.

....[1]

(b) The student chooses two values of LDR resistance to define a light point and a dark point during a typical day. At the light point, the LDR has a resistance of 400 Ω.

(i) Show that the current in the series resistors is 12.5 mA.

[2]

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(ii) Show that the voltage across the LDR is 5V.

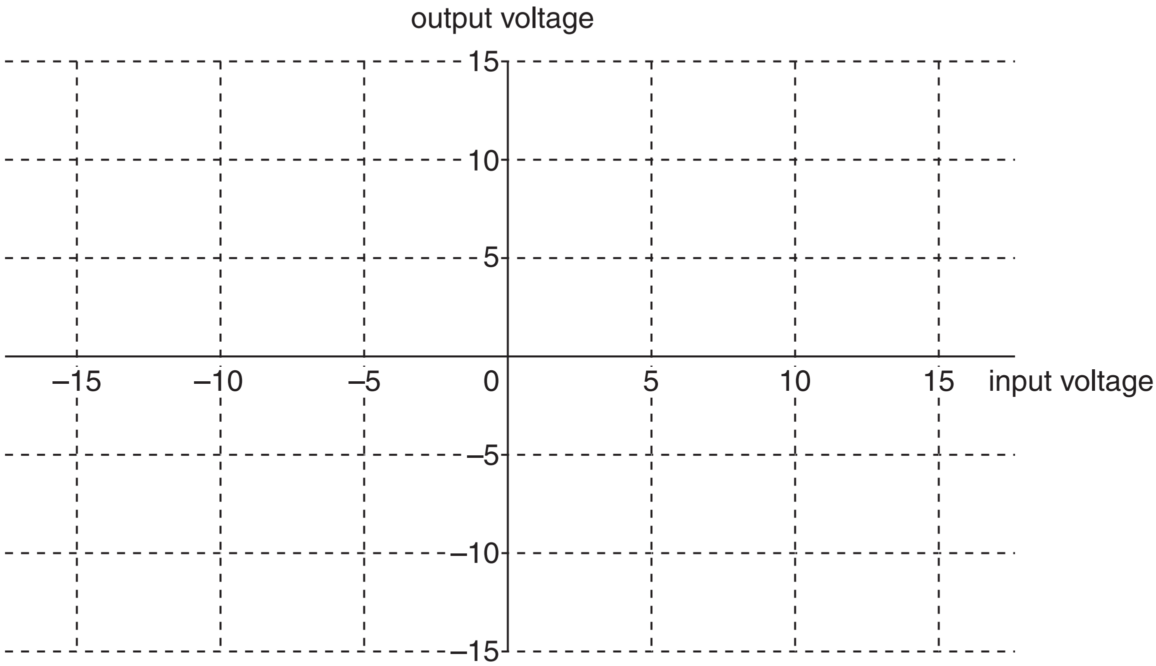
[2]

(iii) Calculate the output voltage V_{out}.

V_{out} = ... V [1]

(c) The student intends to use V_{out} of the circuit of Fig. 5.2 as the input to a non-inverting Schmitt trigger circuit with switching thresholds set to the light point of +10V and the dark point of –10V.

(i) On the axes of Fig. 5.3, draw a graph of the output voltage of the Schmitt trigger circuit as a function of its input voltage.



[4]

Fig. 5.3

(ii) Suggest why it is necessary to use a Schmitt trigger circuit for the daily light switching rather than a simple comparator.

....

....

....[2]

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6 Fig. 6.1 shows a 3-bit binary up-counter circuit containing three D-type flip-flops.

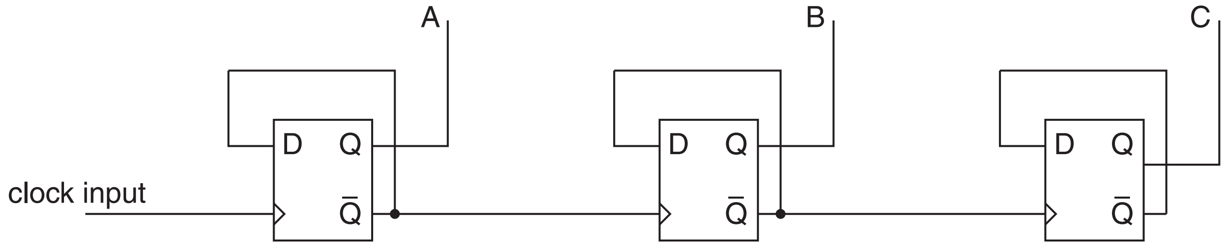


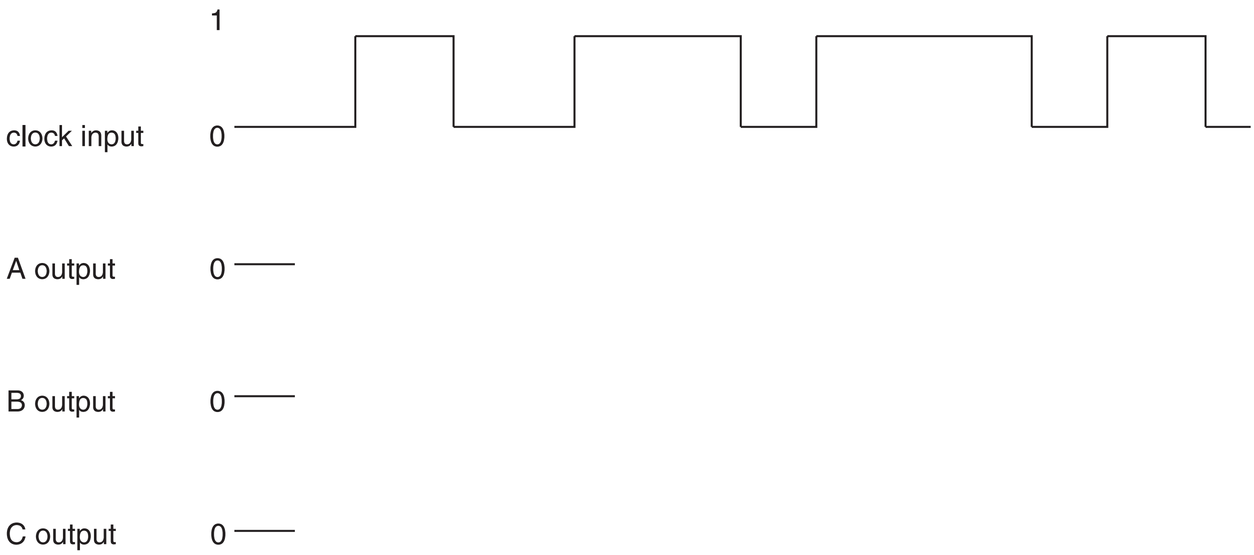
Fig. 6.1

(a) Explain why each D-type flip-flop has the $\overline{Q}$ output connected to its D input.

....

....[2]

(b) Fig. 6.2 shows a series of clock pulses which are applied to the clock input of Fig. 6.1.
Draw on Fig. 6.2 to show how the states A, B and C change in time.
Assume that the output ABC starts from a reset state.



[6]

Fig. 6.2

(c) State and explain the maximum number of different output states of the counter shown in Fig. 6.1.

....

....[2]

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(d) (i) Explain why at least 9 D-types flip-flops would be required to build a counter capable of counting up to 365 (the number of days in a year).

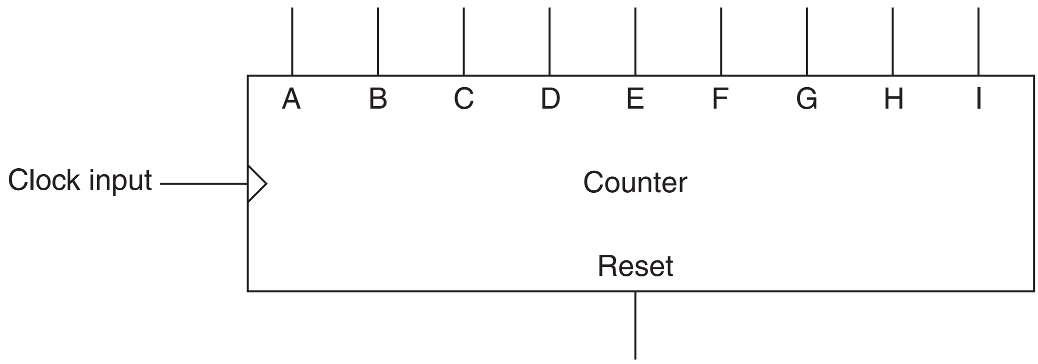
....

....[2]

(ii) Write out the decimal number 365 in binary and indicate the least significant bit.

[2]

(iii) Fig. 6.3 shows a 9-bit counter with A as the least significant bit.
Draw on Fig. 6.3 to show how the counter can be reset once 365 pulses have been received.



[2]

Fig. 6.3

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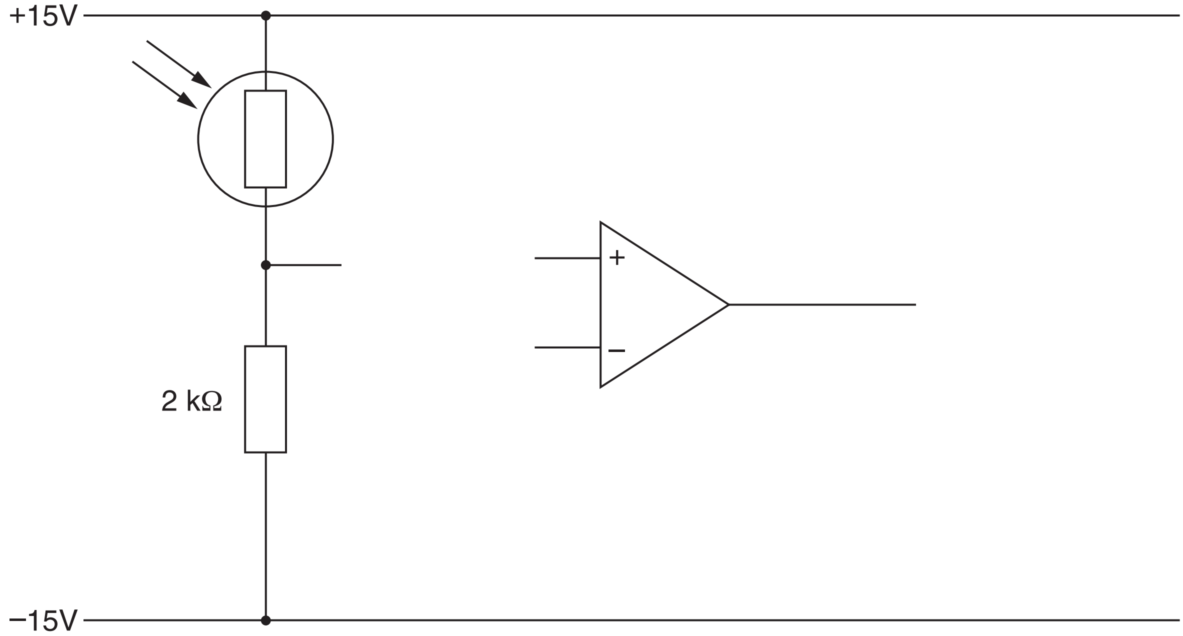
7 The light sensing circuit of Fig. 7.1 is to be used as the input to a non-inverting Schmitt trigger with switching thresholds of ±10V.

(a) On Fig. 7.1 complete the diagram quoting appropriate resistor values.



[7]

Fig. 7.1

(b) In the space below, draw a circuit which will convert the op-amp output of +13V into +5V and the output of –13V into 0V.

[3]

Quality of written communication [3]

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