



Wednesday 21 May 2014 – Morning

AS GCE ELECTRONICS

F612/01 Signal Processors

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:
• Scientific calculator

Duration: 1 hour 30 minutes



Candidate forename		Candidate surname	
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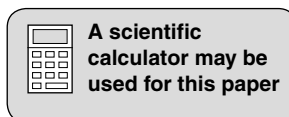
Centre number						Candidate number				
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INSTRUCTIONS TO CANDIDATES


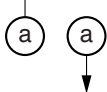

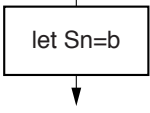
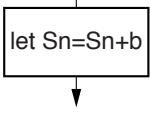
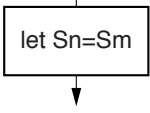
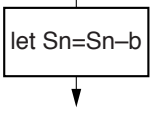
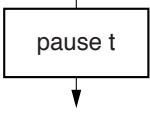
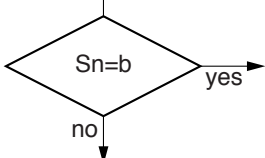
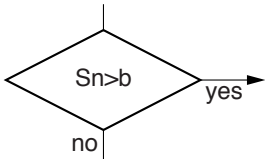
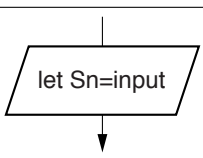
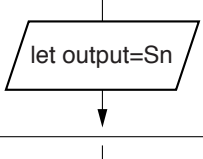
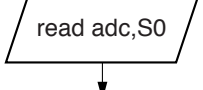
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for your Quality of Written Communication.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.



Data Sheet

symbol	meaning
	start the program
	link to part of the program with the same label a
	stop the program
	place the byte b in register Sn
	add the byte b to the byte in register Sn
	copy the byte in register Sm into register Sn
	subtract the byte b from the byte in register Sn
	introduce a time delay of t milliseconds
	branch if the byte in register Sn is equal to the byte b
	branch if the byte in register Sn is greater than the byte b
	copy the byte at the input port to register Sn
	copy the byte in register Sn to the output port
	activate the analogue-to-digital converter and store the result in register S0

Data Sheet

Unless otherwise indicated, you can assume that:

- op-amps are run off supply rails at +15V and –15V
- logic circuits are run off supply rails at +5V and 0V.

resistance	$R = \frac{V}{I}$
power	$P = VI$
series resistors	$R = R_1 + R_2$
time constant	$\tau = RC$
monostable pulse time	$T = 0.7 RC$
relaxation oscillator period	$T = 0.5 RC$
frequency	$f = \frac{1}{T}$
voltage gain	$G = \frac{V_{\text{out}}}{V_{\text{in}}}$
open-loop op-amp	$V_{\text{out}} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \frac{R_f}{R_d}$
inverting amplifier gain	$G = -\frac{R_f}{R_{\text{in}}}$
summing amplifier	$-\frac{V_{\text{out}}}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} \dots$
break frequency	$f_0 = \frac{1}{2\pi RC}$
Boolean Algebra	$A.\bar{A} = 0$ $A + \bar{A} = 1$ $A.(B + C) = A.B + A.C$ $\overline{A.B} = \bar{A} + \bar{B}$ $\overline{A + B} = \bar{A}.\bar{B}$ $A + A.B = A$ $A.B + \bar{A}.C = A.B + \bar{A}.C + B.C$

Answer **all** the questions.

1 The circuit of Fig. 1.1 contains a bistable made from NOR gates.

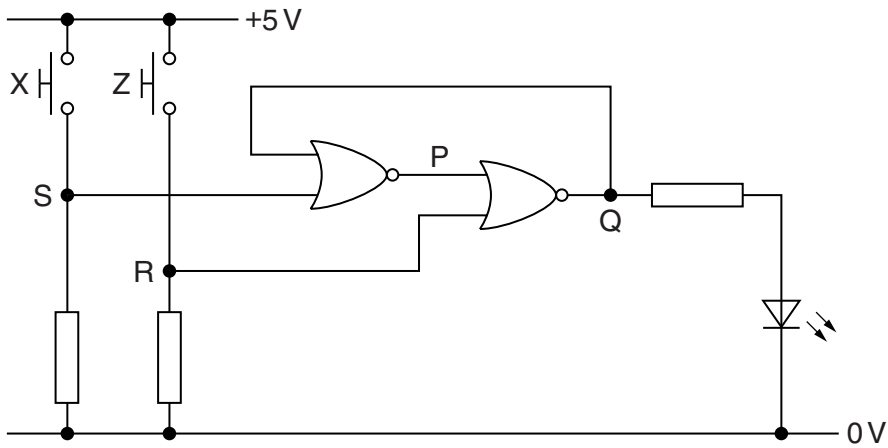


Fig. 1.1

(a) Complete this truth table for a NOR gate.

P	R	Q

[2]

(b) Explain why the LED glows when only the switch X is pressed.

.....

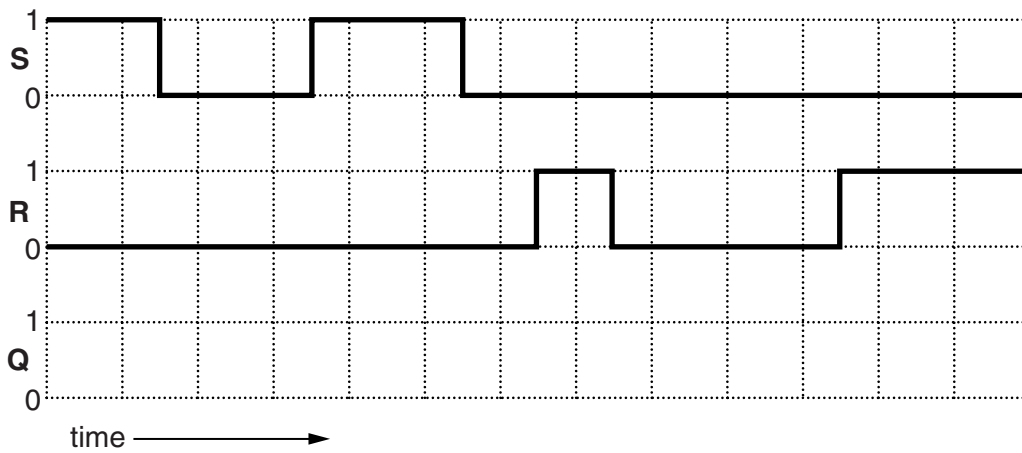
 [3]

(c) Explain what happens to the LED when the switch X is released.

.....

 [3]

(d) Complete the timing diagram below for the bistable of Fig. 1.1.



[1]

[Total: 9]

2 Fig. 2.1 is the circuit symbol for a single D flip-flop.

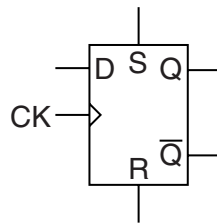


Fig. 2.1

(a) Describe the effect of the input S on Q and \bar{Q} .

.....

.....

.....

..... [2]

(b) Describe how to use the D and CK terminals to store a bit at Q.

.....

.....

.....

..... [2]

[Total: 4]

3 Fig. 3.1 shows a test circuit for an amplifier.

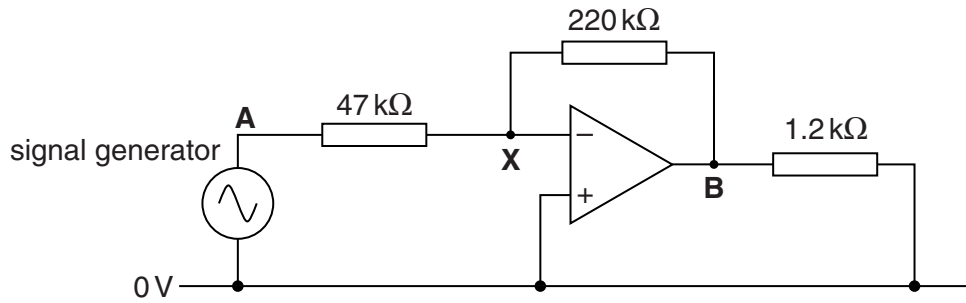


Fig. 3.1

(a) Calculate the voltage gain of the amplifier.

voltage gain = [2]

Fig. 3.2 is an oscilloscope trace of the signal at A.

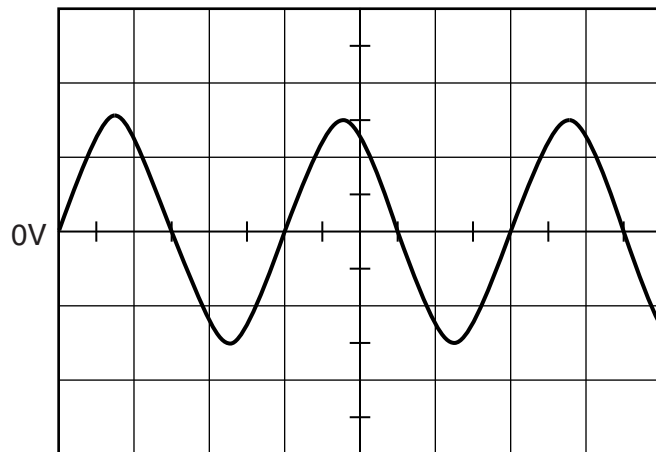


Fig. 3.2

(b) The oscilloscope settings are as follows:

- vertical scale 500 mV/div
- timebase setting 200 μs/div

Calculate the amplitude and frequency of the signal at B.

amplitude = V

frequency = kHz [4]

(c) Describe and explain the distortion of the signal at **B** when the amplitude of the test signal at **A** is raised to 3.0V.

.....

.....

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.....

.....

..... [3]

(d) In a test of the amplifier's power gain, a fixed voltage of 1.2V is applied to **A**, as shown in Fig. 3.3.

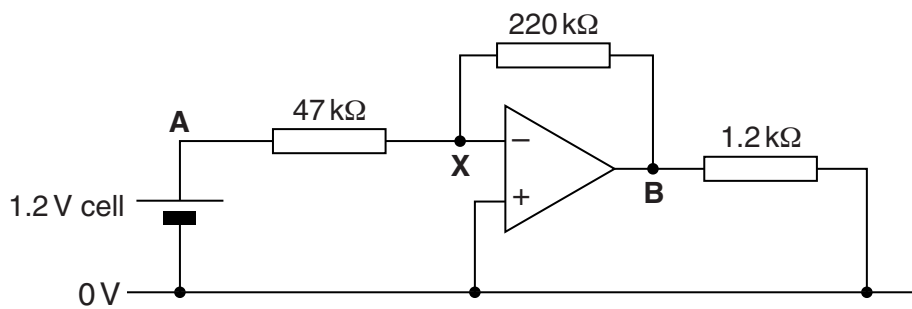


Fig. 3.3

(i) State the voltage at **X**.

voltage = V [1]

(ii) Calculate the current in the cell.

current = μA [2]

(iii) Calculate the power of the cell.

power = μW [2]

(iv) Calculate the power output of the amplifier.

power output = mW [2]

[Total: 16]

4 The circuit of Fig. 4.1 contains an incomplete three-bit counter.

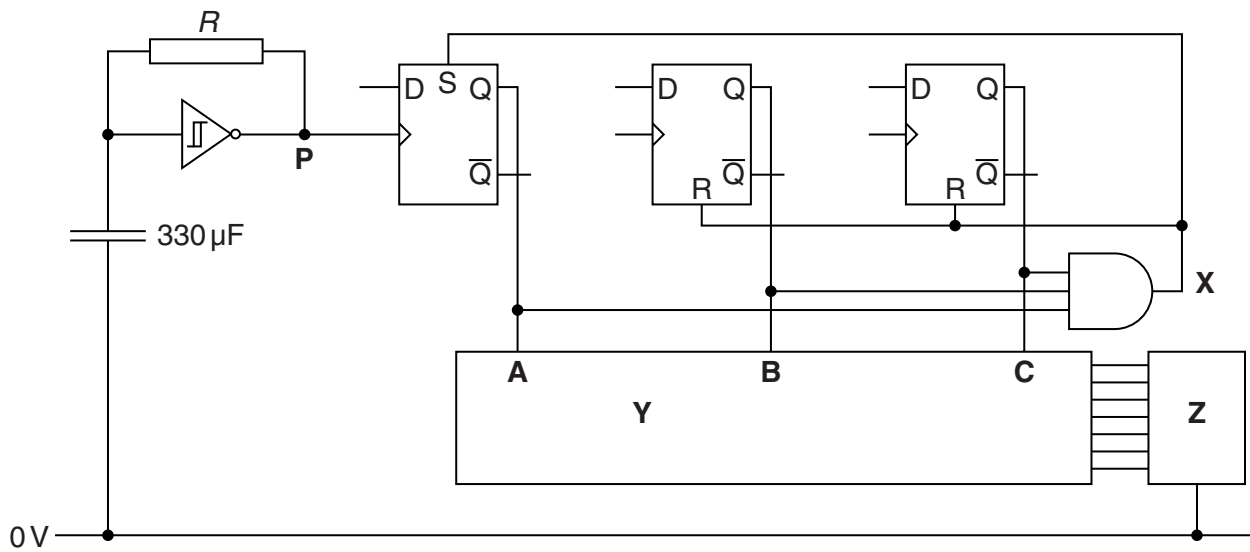


Fig. 4.1

(a) Draw on Fig. 4.1. to complete the circuit for the three-bit counter. [2]

(b) Name the blocks marked Y and Z in Fig. 4.1. State their function in the system.

Y

.....

.....

.....

Z

.....

.....

[4]

(c) The whole system displays the following sequence of numbers continuously:

123456123456123456....

(i) Complete this table.

C	B	A	display
0	1	0	2
0	1	1	
			4

[2]

(ii) Explain why the system displays the number 1 immediately after the number 6.

.....

.....

.....

..... [3]

(iii) Each number in the sequence is displayed for 10s.
Calculate a suitable value for the resistor *R*.

R = kΩ [2]

[Total: 13]

5 The circuit of Fig. 5.1 produces the same pattern of pulses each time it is triggered.

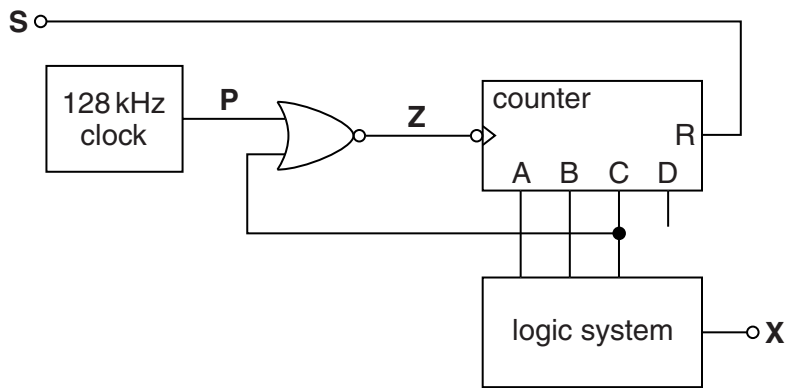


Fig. 5.1

(a) (i) Complete this table for the system.

pulses at Z	C	B	A	X
none	0	0	0	1
one				0
two	0	1	0	1
three	0	1	1	1
four				0

[1]

(ii) Use the rules of Boolean algebra to show that $X = \bar{C}.B + \bar{C}.\bar{A}$.

[2]

(iii) In the space below, draw a circuit diagram for the logic system, using NOT, AND and OR gates.

[3]

(b) At the end of the sequence, **X** remains low.
Explain why **X** remains low until **S** is pulsed high.

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.....

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..... [3]

[Total: 9]

6 Fig. 6.1 is an incomplete block diagram for a public address system.

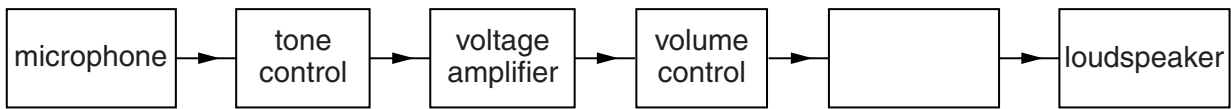


Fig 6.1

(a) (i) Write on Fig. 6.1 to complete the block diagram. [1]

(ii) Explain why this block is necessary for the system.

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.....

.....

..... [2]

(b) The voltage amplifier has a gain of +50 and an input impedance of 47 kΩ. Complete Fig. 6.2 to show the circuit diagram of the voltage amplifier. Show all component values and justify them with calculations.

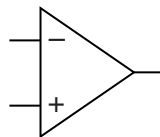


Fig. 6.2

[5]

(c) Fig. 6.2 is the circuit diagram of the tone control.

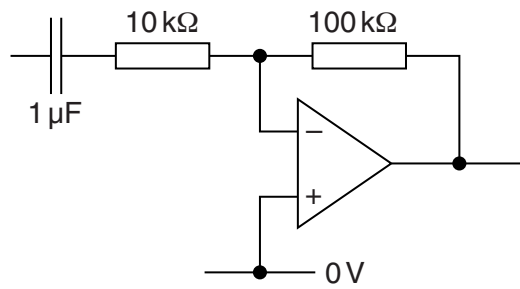


Fig. 6.2

(i) Calculate the break frequency of the tone control.

break frequency = Hz [2]

(ii) Draw on Fig. 6.3 to show the transfer characteristic of the tone control.

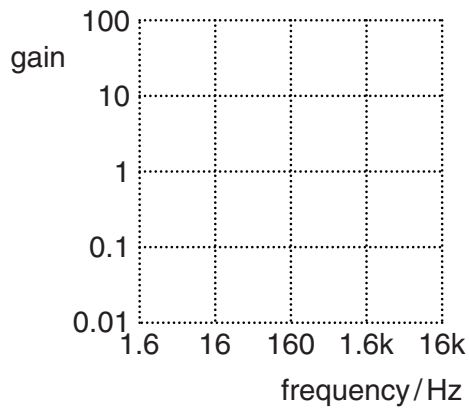


Fig. 6.3

[3]

[Total: 13]

7 The microprocessor system of Fig. 7.1 is a security system for a door.

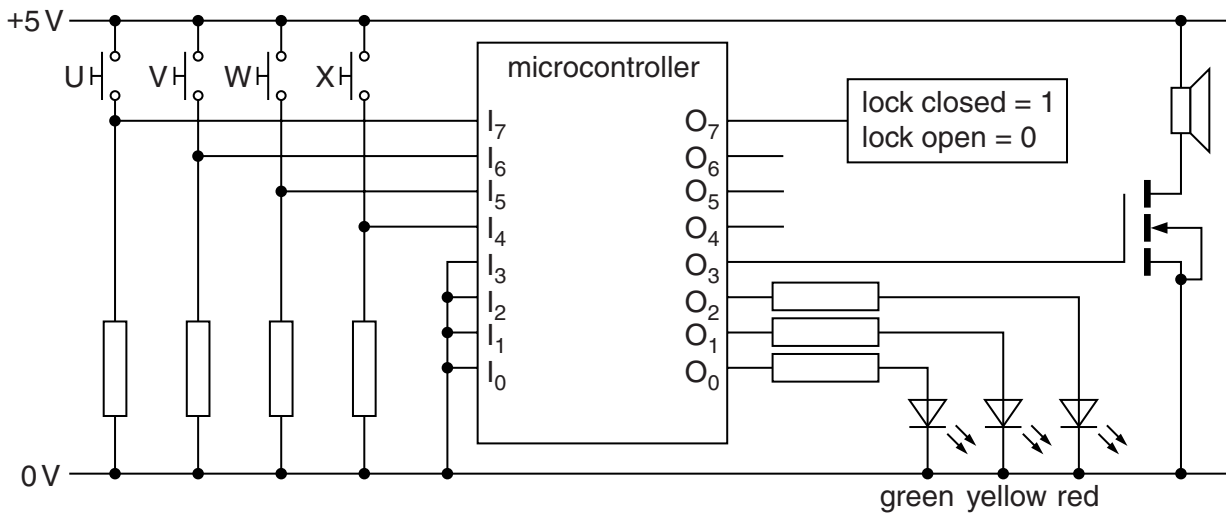
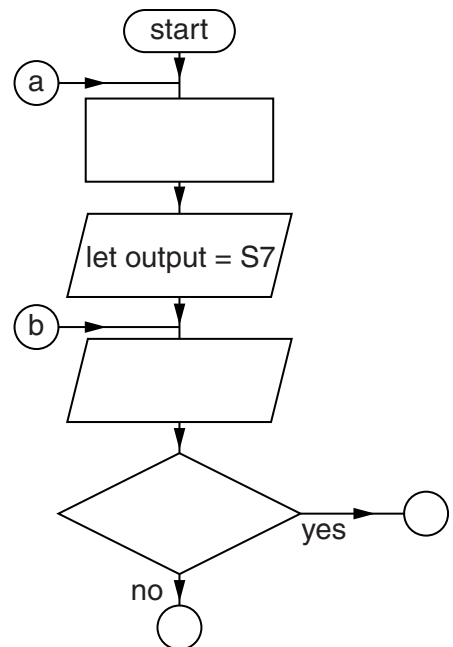


Fig. 7.1

(a) An incomplete flowchart for the first part of the program is shown opposite. It is required to make the microcontroller behave as follows:

- close the lock
- make the red LED glow
- wait until any key is pressed
- pass control to c when any key has been pressed

Complete the flowchart. Use only symbols from the data sheet.



[4]

(b) The next part of the flowchart sets up registers which will eventually be copied to the output port. Explain the effect of copying S6 and S5 to the output port.

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.....

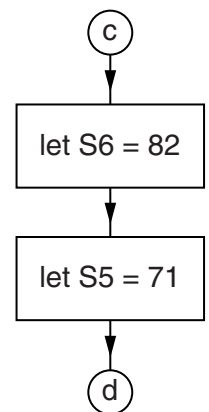
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[4]

(c) The main part of the program is shown in Fig. 7.2.

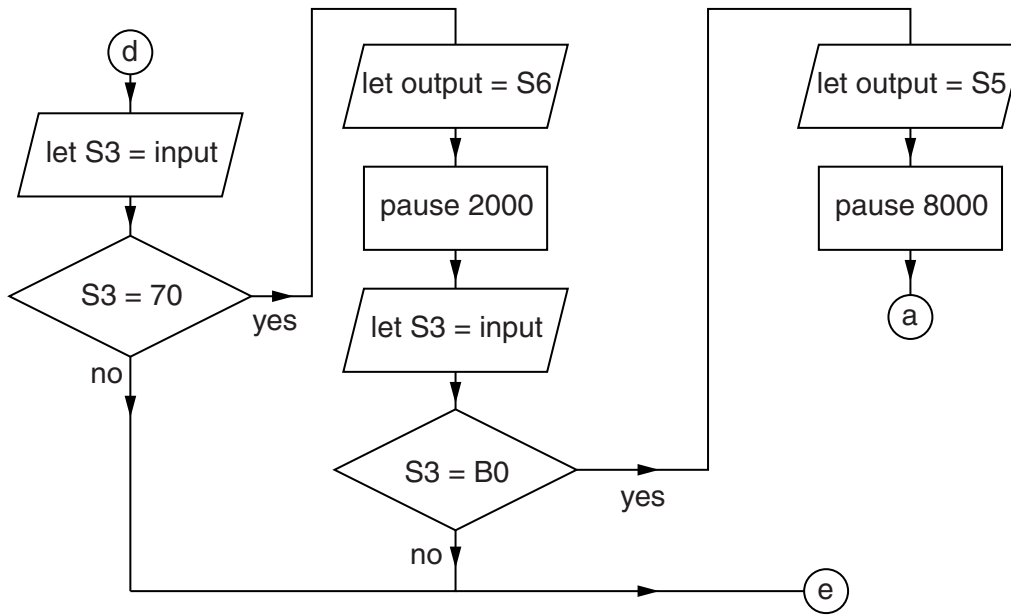


Fig. 7.2

To open the door, the user has to press the keys in response to signals from the LEDs. Use the flowchart above to describe what the user must do to open the door.

.....

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[5]

(d) The last part of the flowchart makes the system behave as follows:

- keep the lock closed
- make all the LEDs glow
- feed a continuous 250Hz square wave into the speaker

Complete the flowchart below from e.

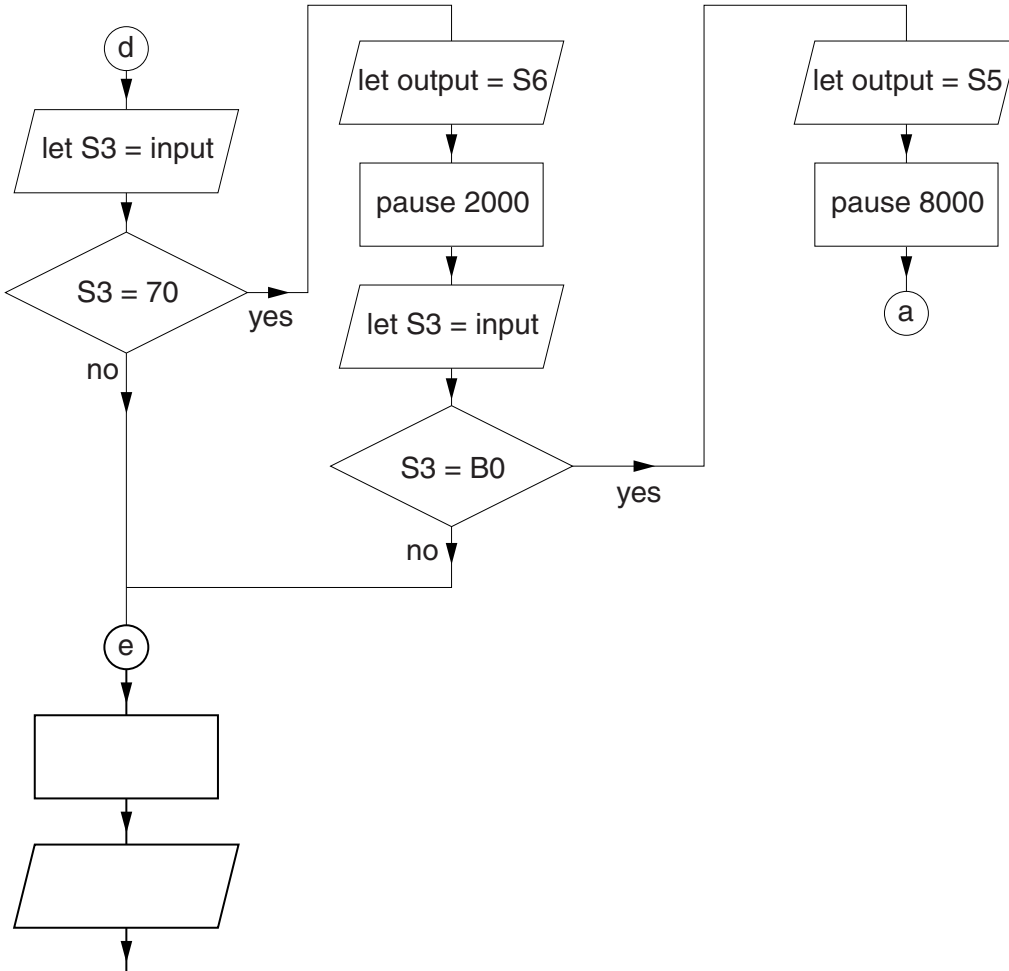


Fig. 7.2

[4]

[Total: 17]

8 Fig. 8.1 shows an op-amp connected to make an amplifier.

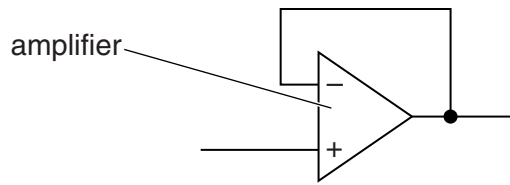


Fig. 8.1

(a) Use the equation $V_{out} = A(V_+ - V_-)$ to show that the voltage gain of the amplifier is given by

$$G = \frac{A}{1 + A}$$

[2]

(b) Calculate the voltage gain when the open-loop gain of the op-amp is 2×10^5 .

$G = \dots\dots\dots$ [1]

(c) Complete the transfer characteristic of Fig. 8.2 for the amplifier.

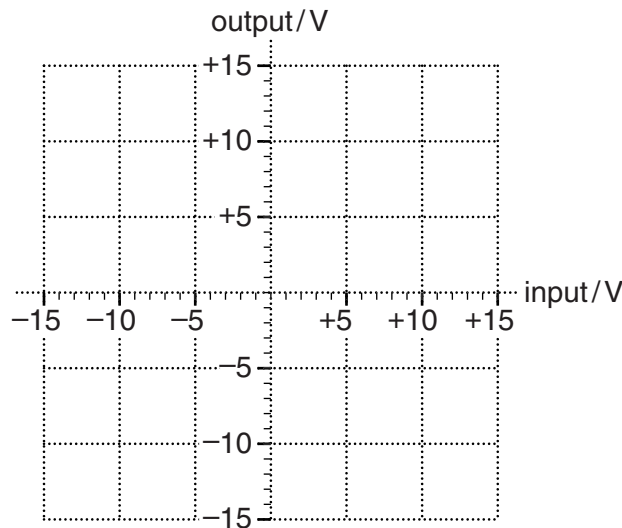


Fig. 8.2

[3]

[Total: 6]

Quality of written communication [3]

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