OCR
Oxford Cambridge and RSA

Thursday 26 May 2016 – Afternoon

AS GCE ELECTRONICS

F612/01 Signal Processors

2710431106

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Duration: 1 hour 30 minutes

F612/01

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

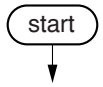
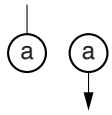
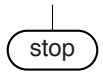
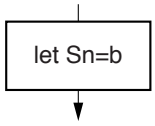
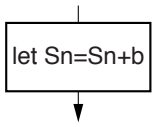
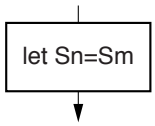
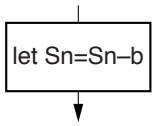
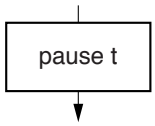
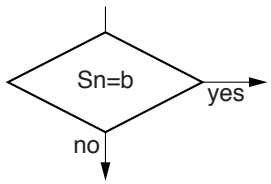
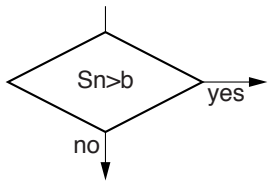
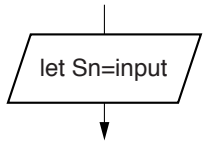
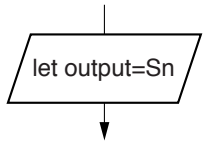
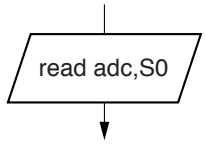
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- 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 **24** pages. Any blank pages are indicated.

A scientific calculator may be used for this paper

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	$T = 0.7RC$
relaxation oscillator period	$T = 0.5RC$
frequency	$f = \frac{1}{T}$
voltage gain	$G = \frac{V_{out}}{V_{in}}$
open-loop op-amp	$V_{out} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \frac{R_f}{R_d}$
inverting amplifier gain	$G = -\frac{R_f}{R_{in}}$
summing amplifier	$-\frac{V_{out}}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} \ldots$
break frequency	$f_0 = \frac{1}{2\pi RC}$
Boolean Algebra	$A.\overline{A} = 0$
	$A + \overline{A} = 1$
	$A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$
	$\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$
	$A.B + \overline{A}.C = A.B + \overline{A}.C + B.C$

Answer **all** the questions.

1 The circuit of Fig. 1.1 contains a bistable made from NAND gates.

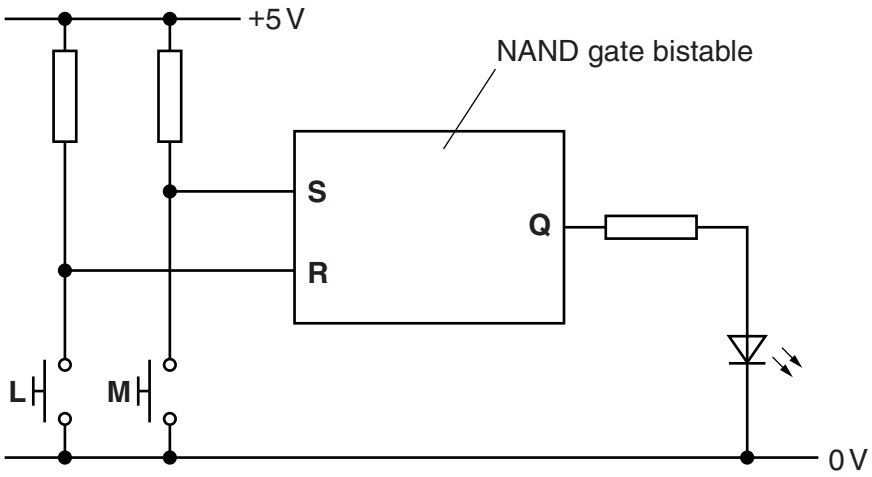


Fig. 1.1

(a) The LED glows when switch **M** is pressed and switch **L** is released.

(i) State what happens to the LED if switch **M** is now released.

..... **[1]**

(ii) Switch **M** is released. Describe the sequence of switch operations required for the bistable to now store a 0.

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..... **[2]**

(b) Complete the circuit diagram of Fig. 1.2 to show the construction of the NAND gate bistable of **Fig. 1.1**.

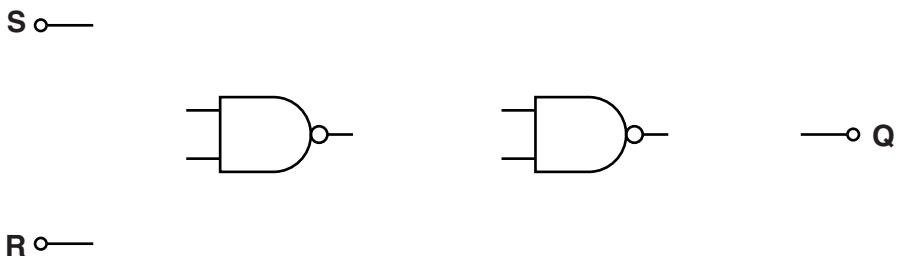

Fig. 1.2

[2]

2 Fig. 2.1 shows how a rising-edge triggered D flip-flop can be made from a master-slave pair of latches.

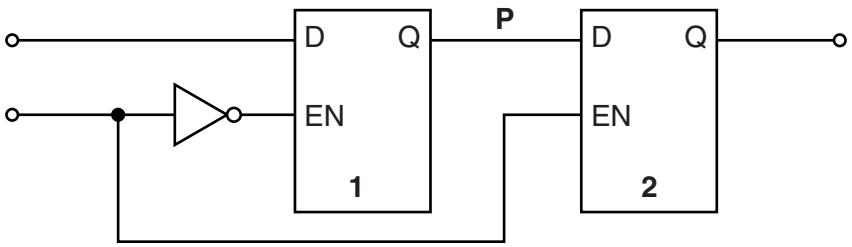

Fig. 2.1

(a) On Fig. 2.1, label the **input**, **output** and **clock** terminals. **[1]**

(b) Explain why a bit placed at the input is **only** copied to the output when the clock goes from low to high.

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..... **[4]**

3 Fig. 3.1 is a circuit diagram for a voltage amplifier constructed by a student.

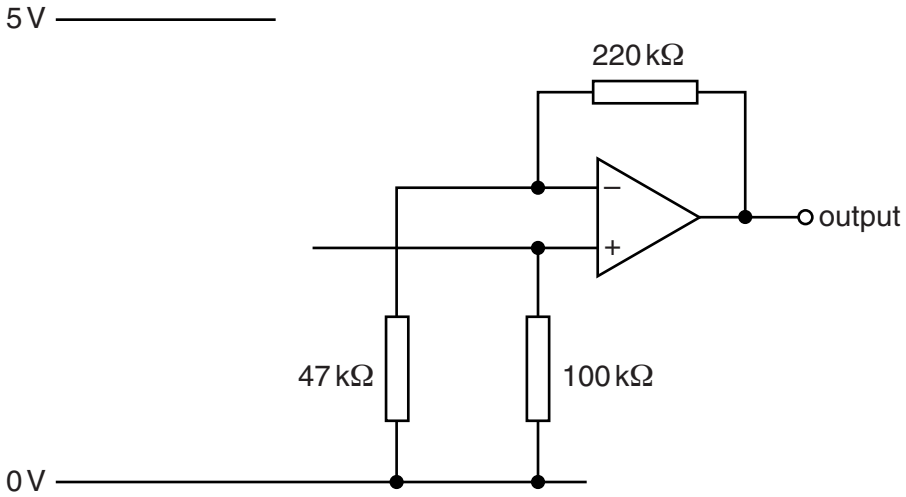

Fig. 3.1

(a) Draw on Fig. 3.1 to show how an electret microphone should be connected to the amplifier input with a resistor and a capacitor. **[2]**

(b) When the student whistles into the microphone, a signal of amplitude 50 mV and frequency 450 Hz appears at the input of the amplifier.
Calculate the amplitude and frequency of the signal at the output.

amplitude = ... mV

frequency = ... Hz
[3]

(c) Explain why the maximum amplitude signal from the microphone which can be amplified without distortion is about 2.3 V.

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..... **[2]**

(d) The student adds a tone control with the transfer characteristic shown in Fig. 3.2.

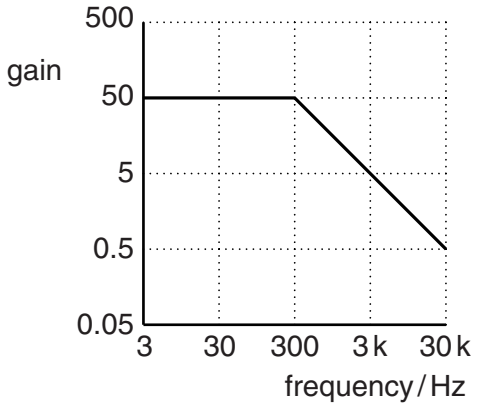

Fig. 3.2

Complete the circuit of Fig. 3.3 to show how the tone control can be assembled. Show all component values and justify them with calculations.

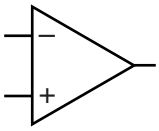

Fig. 3.3

[6]

4 The circuit of Fig. 4.1 makes the LEDs glow in a sequence.

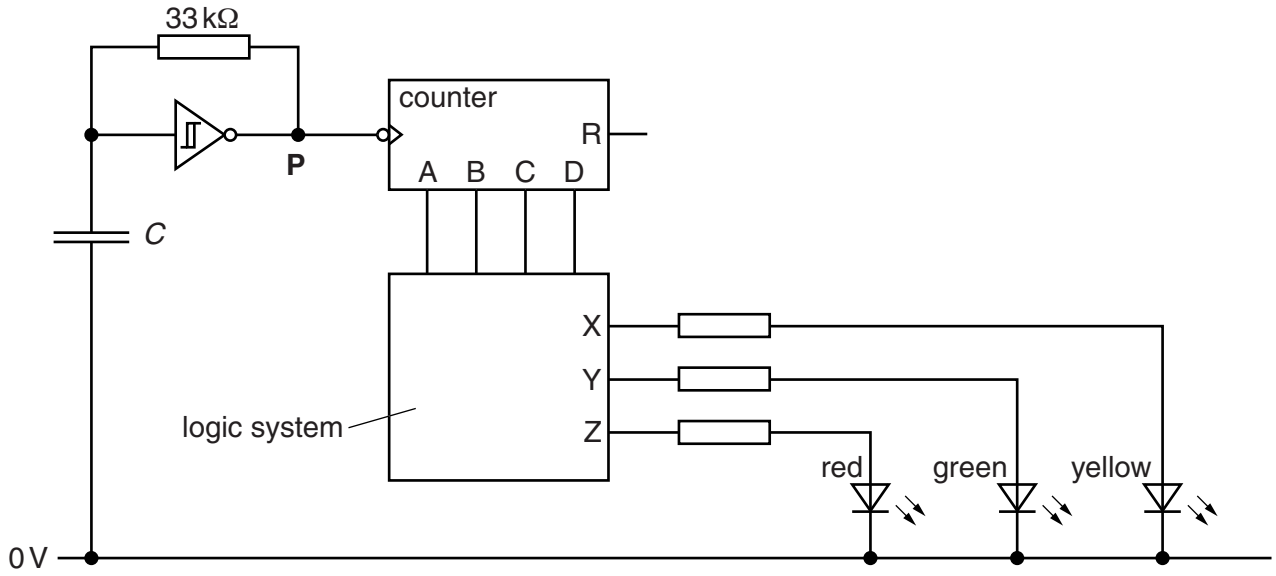

Fig. 4.1

The circuit follows this sequence:

- all three LEDs glow
- only the red and green LEDs glow
- only the red LED glows.

The sequence repeats continuously, with each step lasting for 500 ms.

(a) Calculate a suitable value for the capacitor in the relaxation oscillator.

C = ... μF **[2]**

(b) Complete the pulse table below for the system of Fig. 4.1.

pulse at P	C	B	A	X	Y	Z	R
0	0	0	0	1	1	1	0
1							0
2							0
3							1

[3]

(c) Draw on Fig. 4.1 to show how a logic gate can be used to generate the signal at R. **[2]**

(d) Draw straight lines to link each **output** of the logic system with its correct **expression** in terms of its inputs.

output
X
Y
Z

expression
$\overline{C}.B.A$
$\overline{C + B}$
$\overline{C.B}$
$\overline{C + B + A}$
$\overline{C}.(\overline{B.A})$

[3]

5 The system shown in Fig. 5.1 allows signals from two separate sources to be combined and played through a loudspeaker.

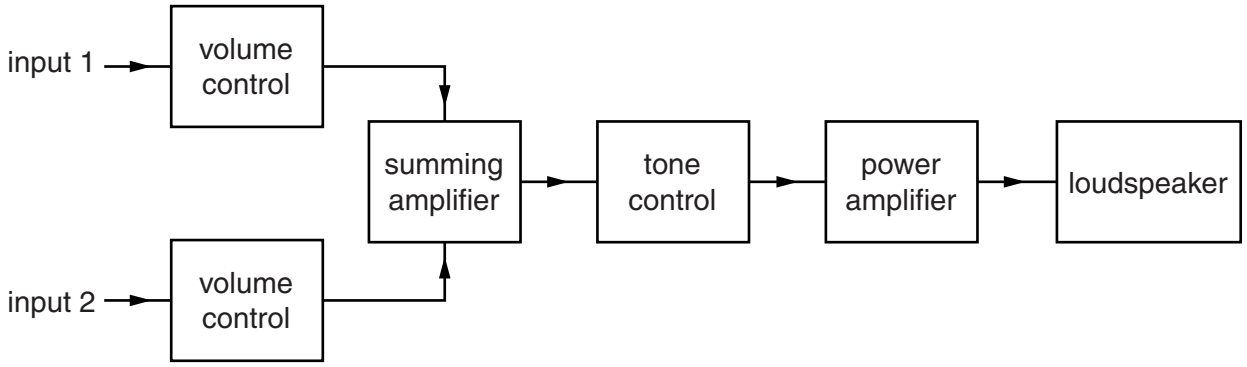

Fig. 5.1

(a) Describe the transfer characteristic of the volume control shown in Fig. 5.2.

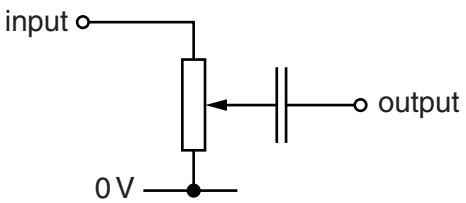

Fig. 5.2

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..... **[3]**

(b) Each input of the summing amplifier has the following characteristics:

- a voltage gain of 20.
- an input impedance of 50 kΩ.

Complete the circuit of Fig. 5.3 to show how the summing amplifier can be assembled. Give all component values and justify them with calculations.

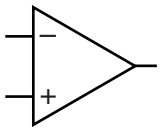

Fig. 5.3

[3]

(c) A circuit for the tone control is shown in Fig. 5.4.

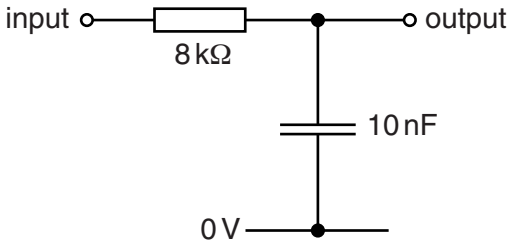

Fig. 5.4

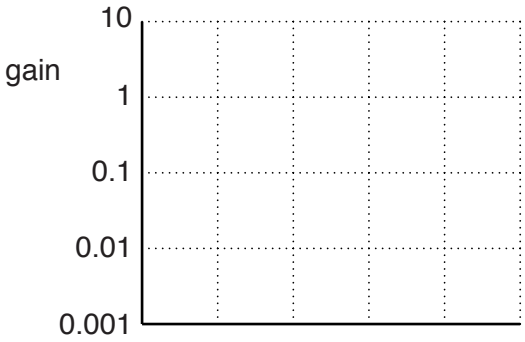

Fig. 5.5

(i) Calculate the break frequency of the tone control. On the axes of Fig. 5.5, draw the transfer characteristic for the tone control.
Label the frequency axis with suitable values. **[4]**

(ii) Suggest why the tone control has been included in the system of Fig. 5.1.

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..... **[2]**

(d) (i) Explain why the system contains a power amplifier.

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..... **[2]**

(ii) A circuit for the power amplifier is shown in Fig. 5.6. State and explain the voltage at **Z**.

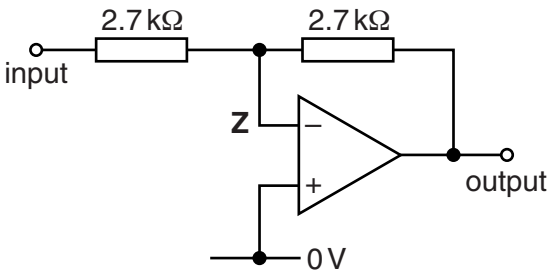

Fig. 5.6

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..... **[4]**

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Question 6 begins on page 14

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6 The circuit of Fig. 6.1 counts up from zero when a pulse is applied to **G**.

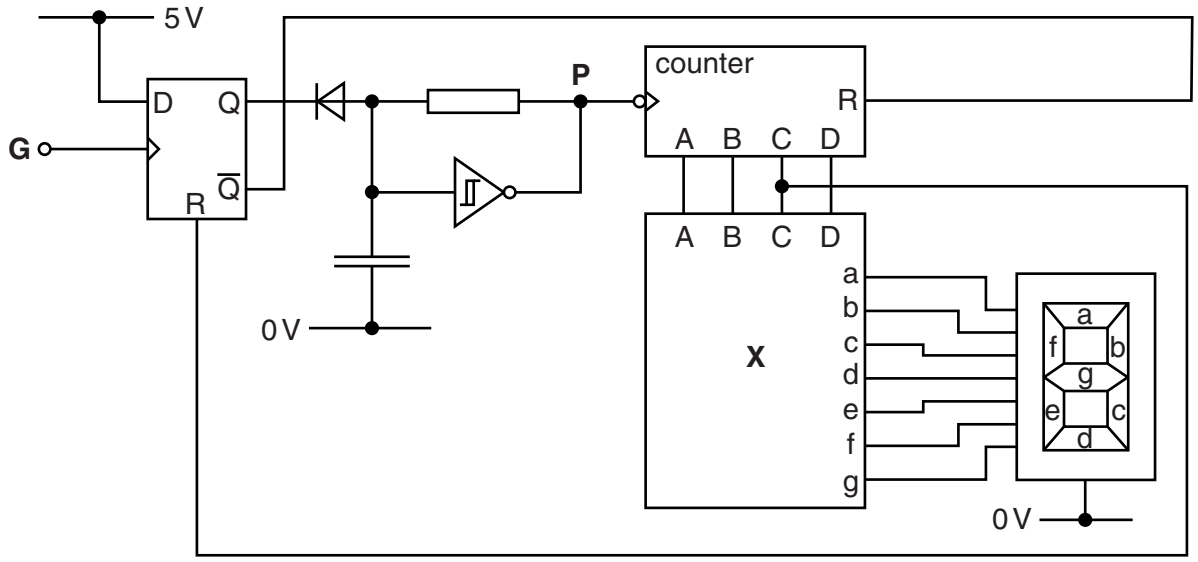

Fig. 6.1

(a) The block marked **X** in Fig. 6.1 is a decoder made from logic gates.
Explain the function of the block marked **X**.

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..... **[3]**

(b) Complete the timing diagram of Fig. 6.2.

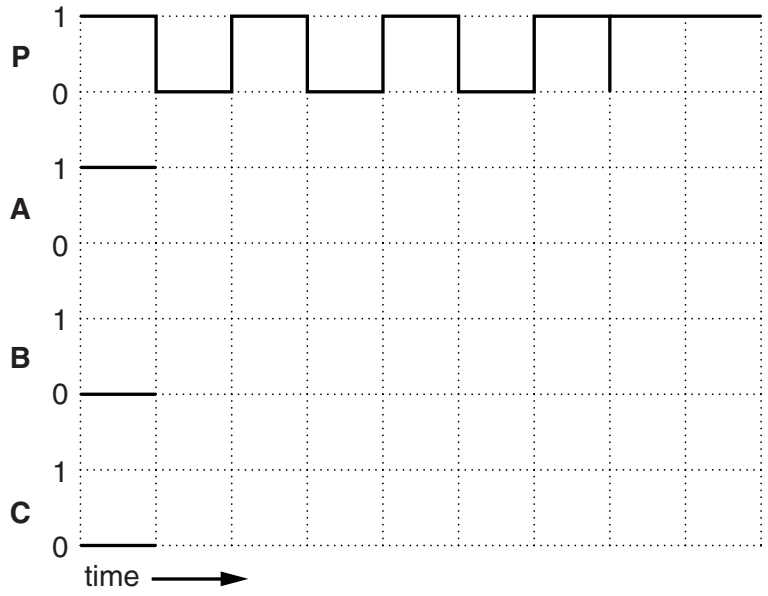

Fig. 6.2.

[4]

(c) Explain in detail how a pulse at the input **G** allows the circuit to display the sequence of numbers.

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..... **[5]**

7 The microcontroller shown in Fig. 7.1 contains five four-bit registers.

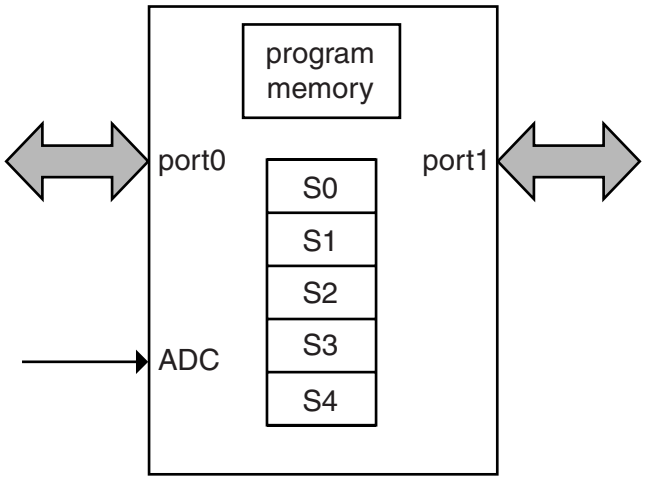

Fig. 7.1

(a) Each register can hold a four-bit word.

(i) Draw on Fig. 7.2 to show how one of the registers can be made from four D flip-flops. Label the **input, output** and **clock** terminals.

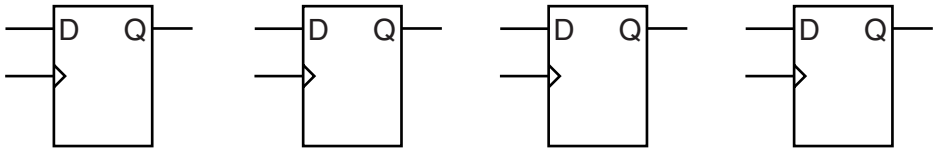

Fig. 7.2

[3]

(ii) Each of these registers can be used to hold a word which will eventually appear at the output port.

Describe **three** other ways in which registers are used during the running of a program.

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..... **[3]**

(b) Explain the difference between the terms **hardware** and **software** as applied to a microcontroller system.

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..... **[2]**

8 The microcontroller circuit of Fig. 8.1 controls the indicator lights of a car.

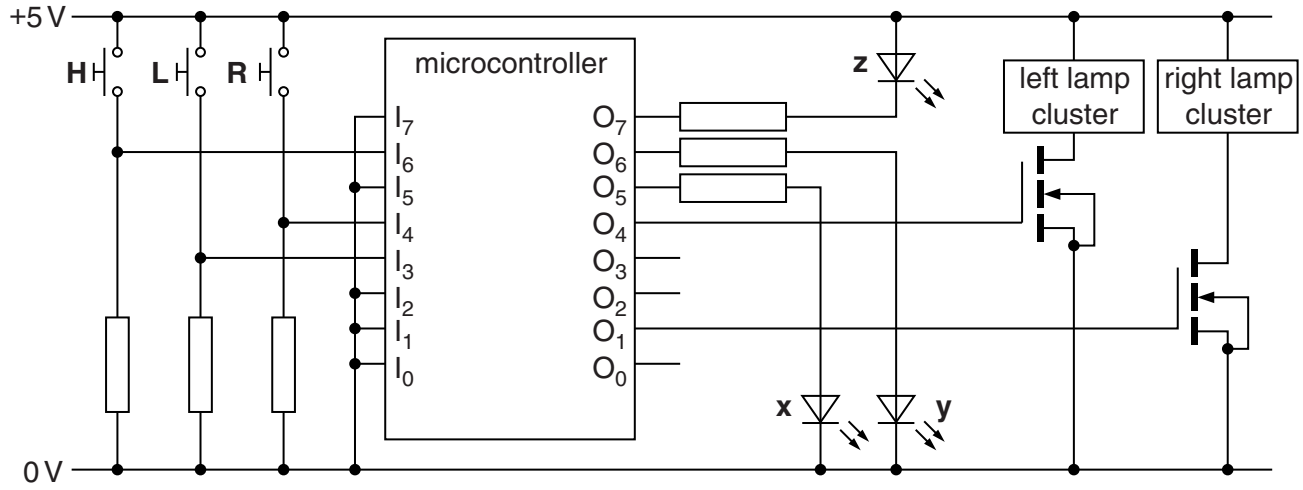

Fig. 8.1

(a) The first part of the microcontroller program has to switch off all the LEDs and lamp clusters. It then loads three registers with bytes for output later in the program.

(i) Complete the flowchart of Fig. 8.2 for this part of the program.
Use only symbols from the data sheet. **[2]**

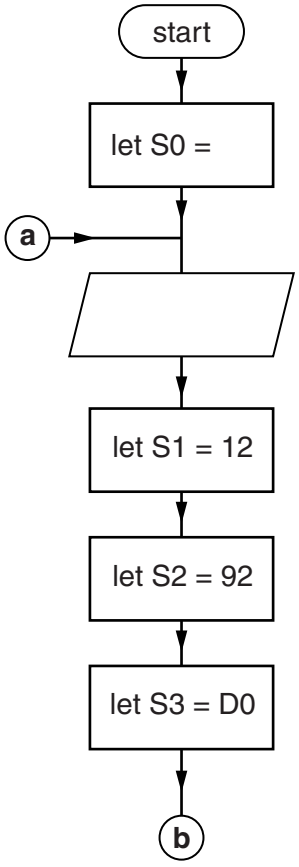

Fig. 8.2

(ii) Explain the effect of copying S3 to the output port.

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..... **[3]**

(b) The incomplete flowchart of Fig. 8.3 shows the next part of the program.

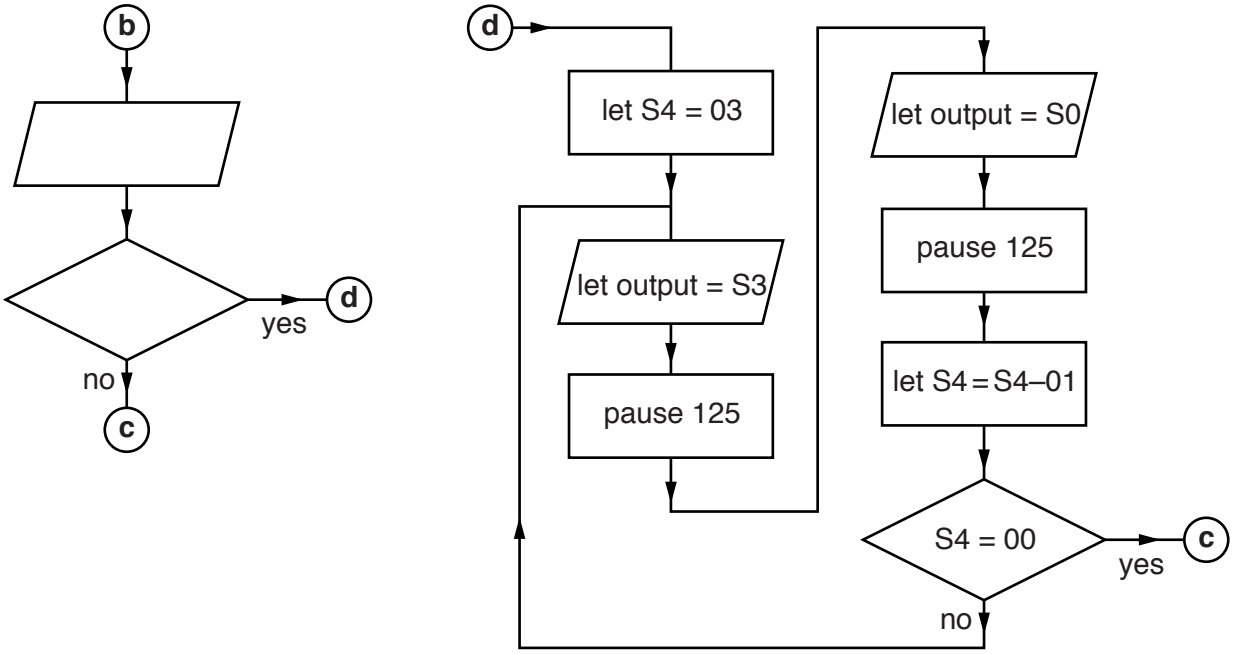

Fig. 8.3

(i) The program passes control to **d** if the switch marked **L** is closed.
Complete the flowchart of Fig. 8.3. **[2]**

(ii) Explain the effect on the system of the program shown between **d** and **c** in the flowchart.

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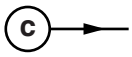
..... **[5]**

(c) The next part of the program makes the system behave as follows:

- when only **H** is closed, turn both lamp clusters and the LED **z** on and off with a frequency of 2 Hz, then pass control to **e** once **H** is open again
- otherwise, pass control directly to **e.**

Complete the flowchart of Fig. 8.4.
The microcontroller circuit from Fig. 8.1 is repeated opposite.



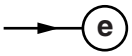
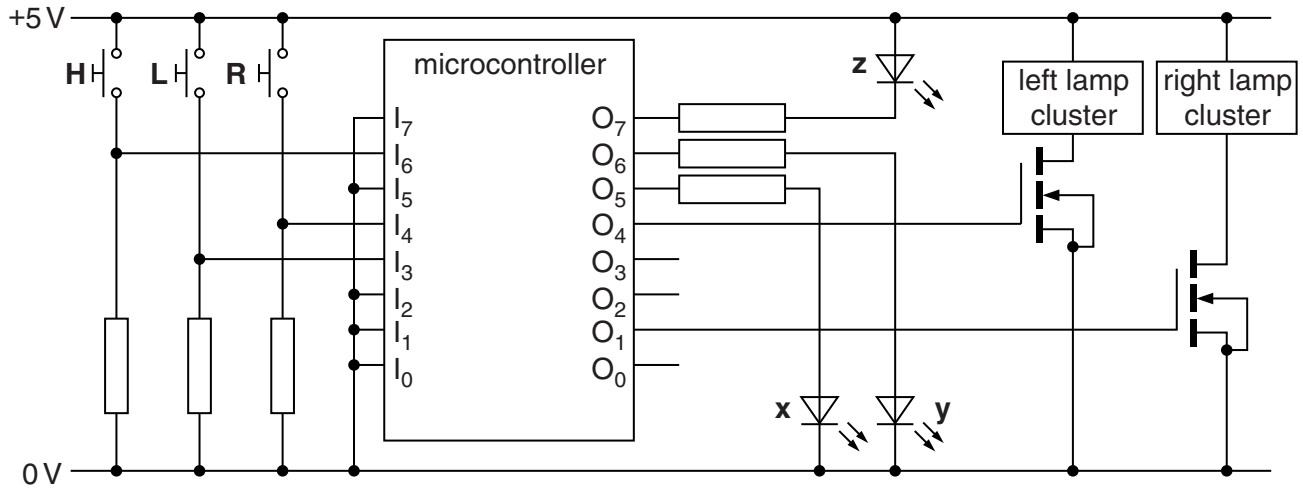


Fig. 8.4



[4]

Quality of Written Communication [3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).