OCR
Oxford Cambridge and RSA

Thursday 24 May 2018 – Afternoon

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	

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 barcodes.

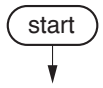
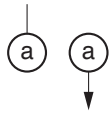
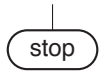
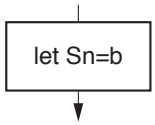
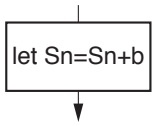
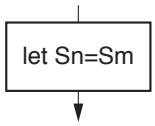
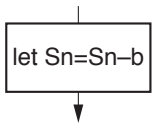
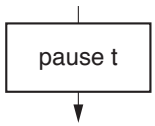
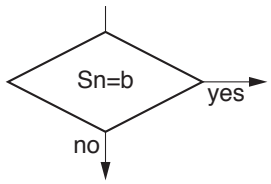
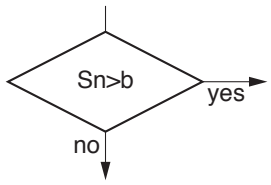
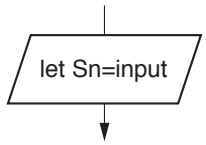
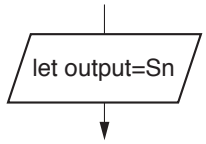
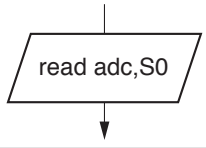
INFORMATION FOR CANDIDATES

- 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.

A scientific calculator may be used for this paper

DC (LK/CT) 156530/4

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

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 NOR gates.

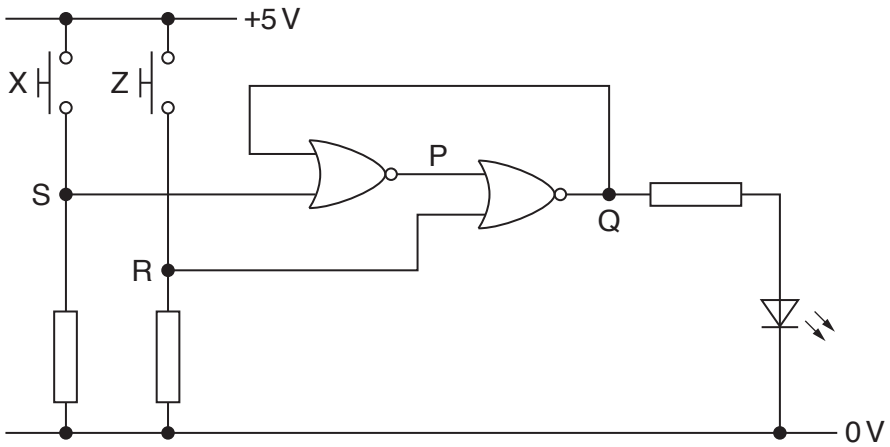


Fig. 1.1

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

S	Q	P

[2]

(b) Explain why the LED does not glow when only the switch **Z** is pressed.

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

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

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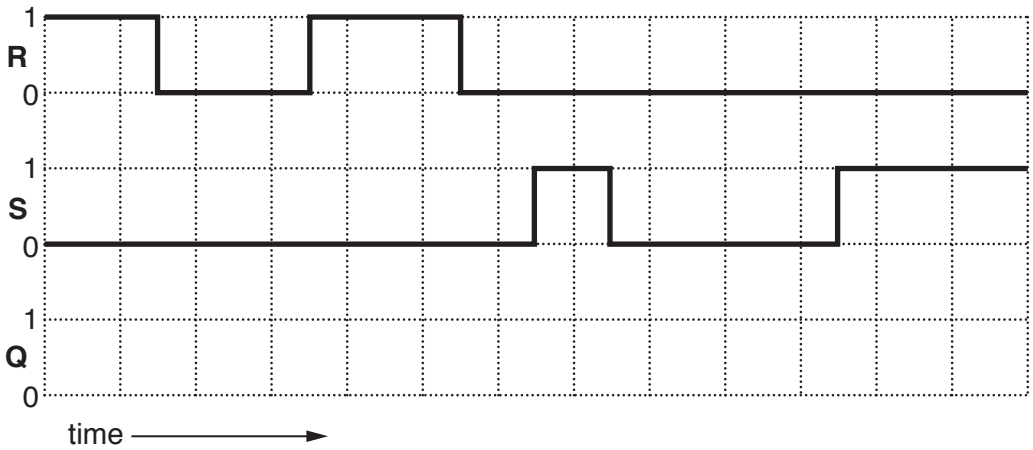
..... **[3]**

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



[2]

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

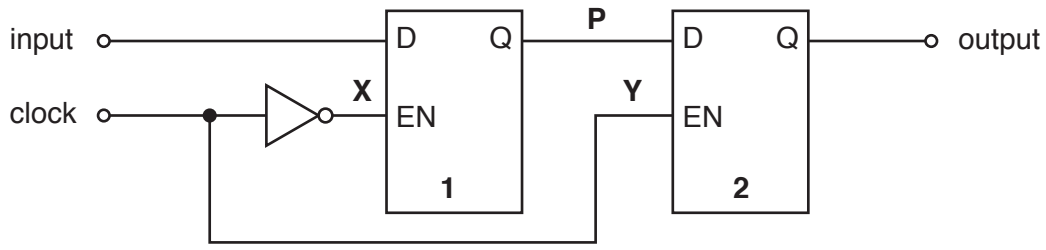


Fig. 2.1

(a) Explain what is meant by a *rising-edge triggered*.

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

(b) The input and the clock are initially held high. **P** and the output are low.

(i) Explain what happens to the signals at **P** and the output when the clock goes low.

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

(ii) Explain what happens to the signals at **P** and the output when clock now goes high.

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

3 Fig. 3.1 shows an amplifier based on an op-amp.

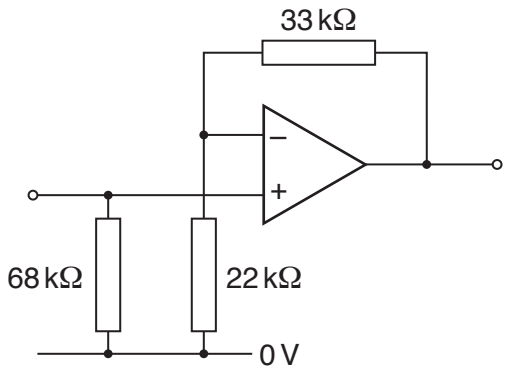

Fig. 3.1

(a) (i) Label the input terminal of the amplifier as **INPUT**, and the output terminal as **OUTPUT**. **[1]**

(ii) State a value for the input impedance of the amplifier.

input impedance = ... kΩ **[1]**

(b) (i) Calculate the voltage gain of the amplifier.

voltage gain = ... **[2]**

(ii) A steady signal of voltage +2.0 V is applied to the amplifier input.

Complete the table for the three terminals of the op-amp.

Non-inverting Input	Inverting Input	Output
+2.0 V		

[2]

(iii) On the axes of Fig. 3.2, draw a transfer characteristic for the circuit of Fig 3.1.

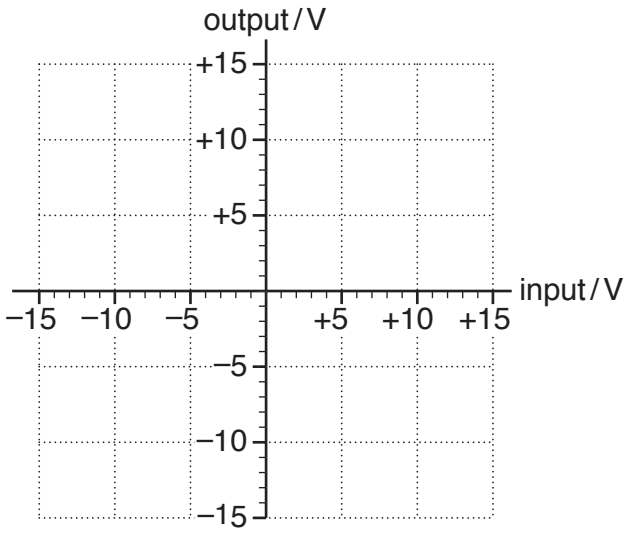

Fig. 3.2

[3]

(c) The amplifier circuit of Fig. 3.1 contains an op-amp with feedback.

Describe the transfer characteristics of an op-amp **without** any feedback.

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

4 A bicycle lamp requires two LEDs to flash on and off. The system uses a 3-bit binary counter.

(a) (i) Draw a NOT gate and the relevant connections on Fig. 4.1 to show how to make a 3-bit counter from the D-type flip-flops.

Label the counter input **ck** and the outputs **C**, **B** and **A** where **C** is the most significant bit.

You do not need to connect **R** at this stage.

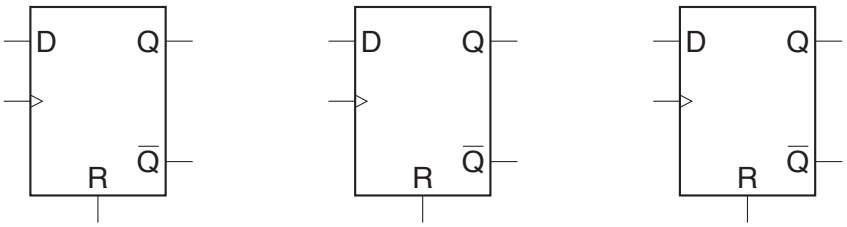


Fig. 4.1

[5]

(ii) Add a logic gate to Fig. 4.1 to make the circuit count from 0 to 4 and reset to 0 on the 5th pulse. **[2]**

(b) Fig. 4.2 shows some components connected to the counter of Fig. 4.1.

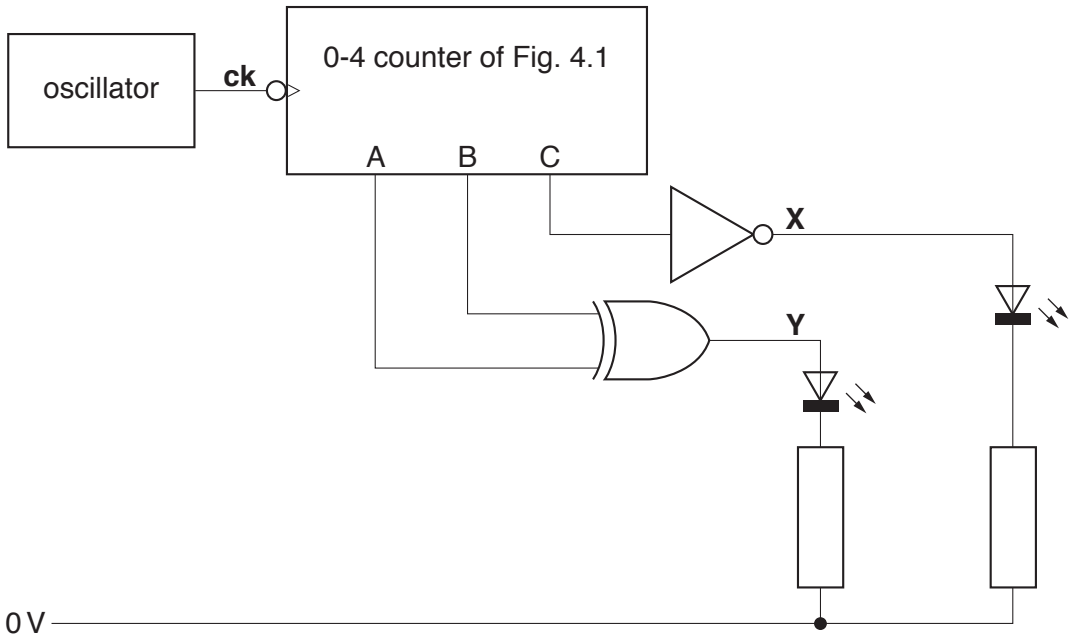


Fig. 4.2

(i) Complete the truth table shown below.

C	B	A	X	Y
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		

[2]

(ii) Use the results from the truth table to complete the timing diagram in Fig. 4.3 for the signals from the circuit in Fig. 4.2.

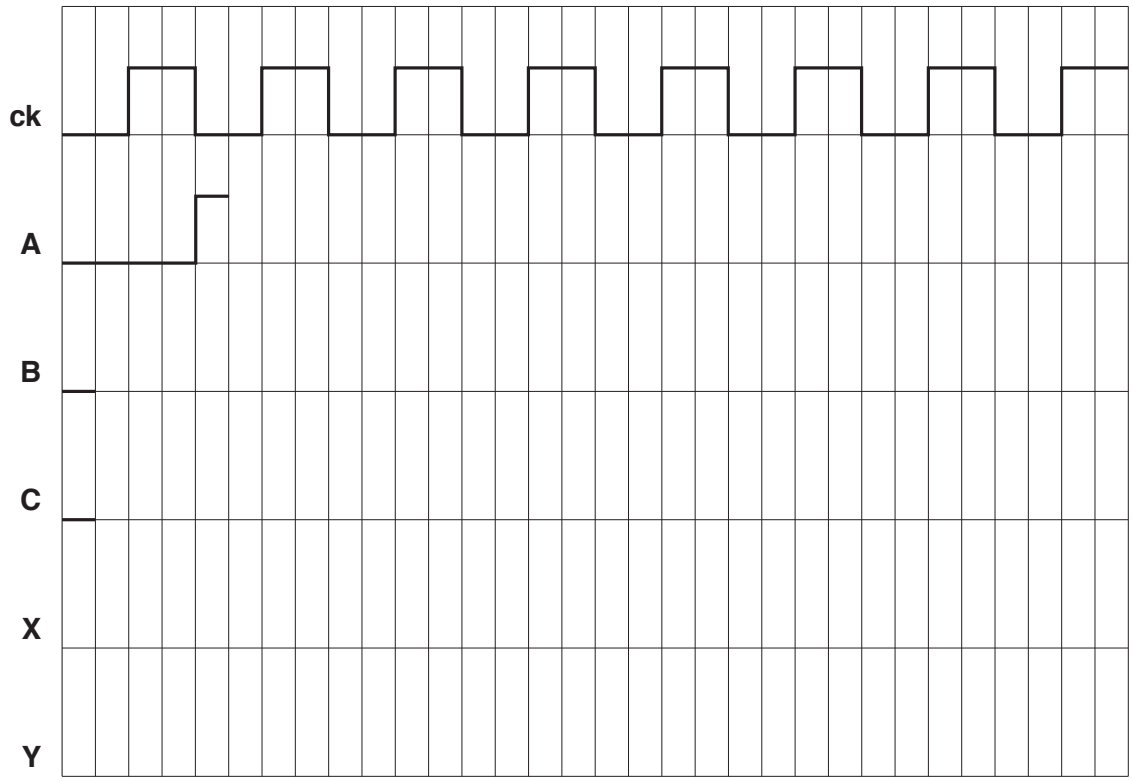


Fig. 4.3

[6]

5 Fig. 5.1 is an incomplete block diagram for an audio amplifier.

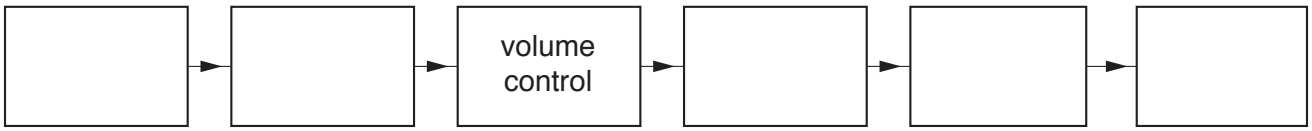


Fig. 5.1

(a) Complete the diagram. Choose from these blocks.

loudspeaker **microphone** **power amplifier** **voltage amplifier** **tone control**

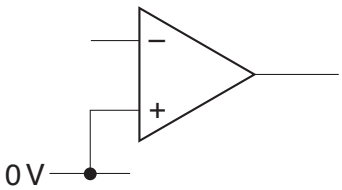
[3]

(b) The tone control is a bass cut filter with the following properties:

- input impedance of 22 kΩ
- high frequency gain of –15
- break frequency of 200 Hz

In the space below, draw a circuit diagram for the filter.

Show all component values and justify them.



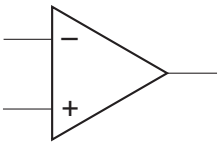
[6]

(c) The voltage amplifier has the following properties.

- voltage gain of –20
- input impedance of 18 kΩ

In the space below, draw a circuit diagram for the voltage amplifier.

Show all component values and justify them.



[3]

(d) The volume control can be made from a potentiometer.

Show below how this can be done. Label the input and output.

[3]

6 Fig. 6.1 shows a microcontroller connected to five different sub-systems.

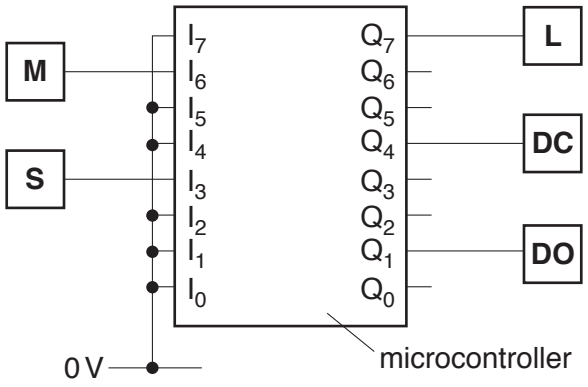


Fig. 6.1

The system controls the doors on a train. The table below summarises the behaviour of the sub-systems.

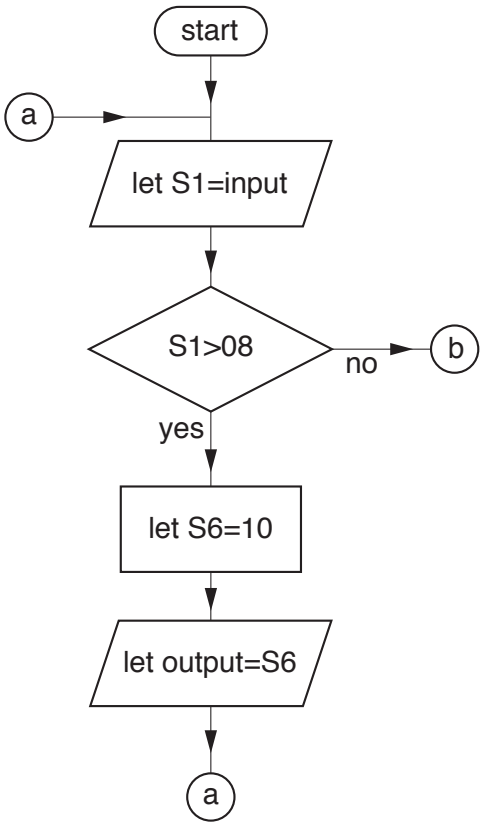
sub-system	device	transfer characteristic
S	push switch	only goes high when pressed
M	sensor	only goes high when the train is moving
L	light	only glows when high
DC	door closer	doors close when high
DO	door opener	doors open when high

(a) Complete the truth table for the word at the input port.

conditions	binary	hexadecimal
train moving switch not pressed	0100 0000	40
train stationary switch pressed		08
train moving switch pressed	0100 1000	
train stationary switch not pressed		

[3]

(b) The flowchart for part of the program in the microcontroller is shown below.



(i) Explain why program control passes to **b** only when the train is stationary.

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

(ii) State and explain the state of the three outputs when the train is moving.

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

(c) The incomplete flowchart for the rest of the program is shown below.

It has to make the system behave as follows:

- when the train is stationary the light comes on
- when the push switch is pressed the doors open
- the doors remain open for 20 s
- the light goes off and the doors close

Complete the flowchart below using only the symbols in the Data Sheet on page 2.

[6]

7 Fig. 7.1 is the circuit diagram for a system which produces a train of pulses at **P** each time there is a short pulse at **S**.

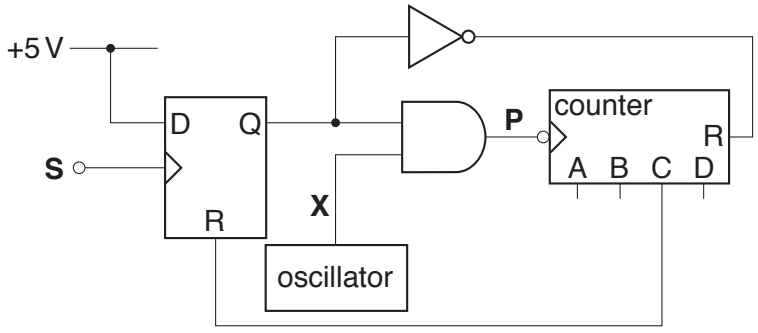

Fig. 7.1

(a) The oscillator produces a continuous train of pulses at **X**.

Those pulses only get through to **P** after there is a pulse at **S**.

Explain why.

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

(b) Explain why only four pulses appear at **P** for each pulse at **S**.

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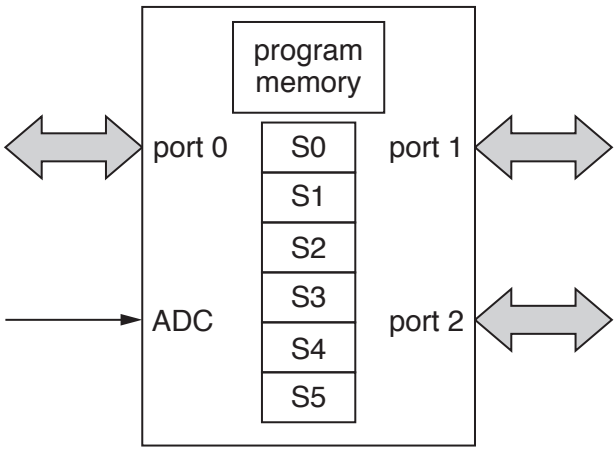
..... **[4]**

8 A microcontroller has the following specification.

- three 8-bit ports
- six general purpose registers
- one analogue-to-digital converter
- 256 byte program memory space



(a) Explain the purpose of the microcontroller ports.

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

(b) What is an analogue-to-digital converter?

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

(c) A microcontroller circuit can always be replaced with another circuit made from logic gates, flip-flops and op-amps.

State and explain the advantages of using a microcontroller circuit instead of these other components.

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..... **[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).