OCR
RECOGNISING ACHIEVEMENT

Tuesday 21 May 2013 – Afternoon

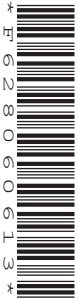## AS GCE ELECTRONICS

F612/01 Signal Processors

Candidates answer on the Question Paper.	**Duration:** 1 hour 30 minutes
OCR supplied materials: None	
Other materials required: • Scientific calculator	

Candidate forename		Candidate surname	

Centre number					Candidate number				

INSTRUCTIONS TO CANDIDATES
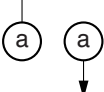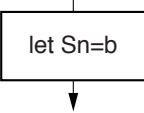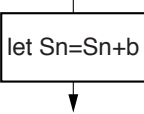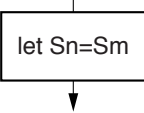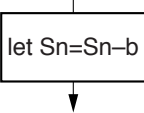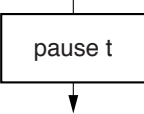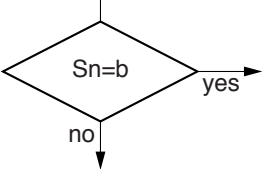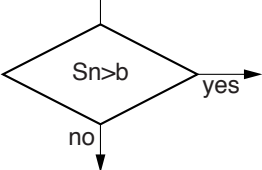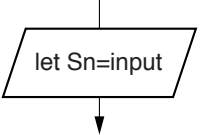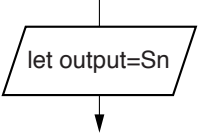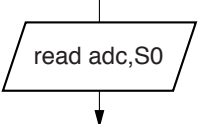
* Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
* Use black ink. HB pencil may be used for graphs and diagrams only.
* Answer **all** the questions.
* Read each question carefully. Make sure you know what you have to do before starting your answer.
* Write your answer to each question in the space provided. 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.

A scientific calculator may be used for this paper

OCR is an exempt Charity

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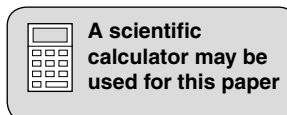
Data Sheet

symbol	meaning
start	start the program
a a	link to part of the program with the same label a
stop	stop the program
let Sn=b	place the byte b in register Sn
let Sn=Sn+b	add the byte b to the byte in register Sn
let Sn=Sm	copy the byte in register Sm into register Sn
let Sn=Sn–b	subtract the byte b from the byte in register Sn
pause t	introduce a time delay of t milliseconds
Sn=b yes / no	branch if the byte in register Sn is equal to the byte b
Sn>b yes / no	branch if the byte in register Sn is greater than the byte b
let Sn=input	copy the byte at the input port to register Sn
let output=Sn	copy the byte in register Sn to the output port
read adc,S0	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	$R = \dfrac{V}{I}$
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	$f = \dfrac{1}{T}$
voltage gain	$G = \dfrac{V_{out}}{V_{in}}$
open-loop op-amp	$V_{out} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \dfrac{R_f}{R_d}$
inverting amplifier gain	$G = -\dfrac{R_f}{R_{in}}$
summing amplifier	$-\dfrac{V_{out}}{R_f} = \dfrac{V_1}{R_1} + \dfrac{V_2}{R_2}\ \dots$
break frequency	$f_0 = \dfrac{1}{2\pi RC}$
Boolean Algebra	$A.\overline{A} = 0$
	$A + \overline{A} = 1$
	$A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$
	$\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$
	$A.B + \overline{A}.C = A.B + \overline{A}.C + B.C$

Turn over

Answer **all** the questions.

1 Fig. 1.1 shows an amplifier based on an op-amp.
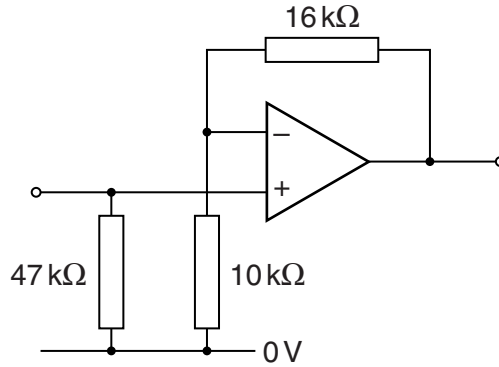
Fig. 1.1

(a) (i) Label the input terminal of the amplifier as **INPUT**. **[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 +0.60 V is applied to the amplifier input.
Complete the table for the three terminals of the op-amp.

Non-inverting Input	Inverting Input	Output
+0.60 V		

[2]

(iii) On the axes of Fig. 1.2, draw a transfer characteristic for the circuit of Fig 1.1.

output/V

+15

+10

+5

−15 −10 −5   +5 +10 +15   input/V

−5

−10

−15
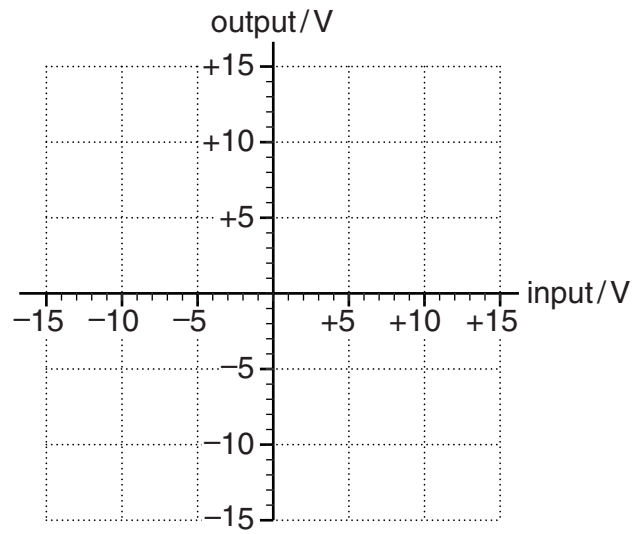
Fig. 1.2

[3]

(c) The amplifier circuit of Fig. 1.1 contains an op-amp with feedback.
Describe the transfer characteristics of an op-amp **without** any feedback.

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....

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.... [3]

[Total: 12]

           Turn over

2 The circuit of Fig. 2.1 produces two pulses at its output when the switch is pressed.
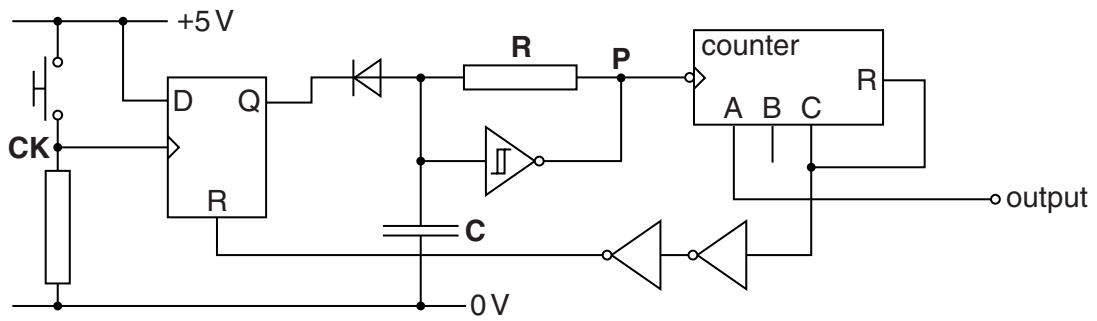
Fig. 2.1

(a) Explain why **Q** goes high each time the switch is pressed.

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....

....

.... **[3]**

(b) The flip-flop controls an oscillator which has a period of 4.0 s.
Calculate suitable values for **R** and **C**.

R = ... kΩ

C = ... µF

[2]

(c) Complete Fig. 2.2 to show how the counter of Fig. 2.1 can be made from flip-flops.
Label the input **P**, the reset **R** and the outputs **A**, **B**, and **C**.
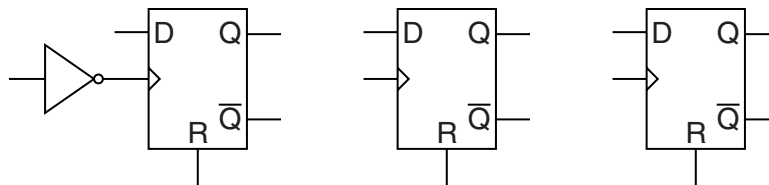
Fig. 2.2

[4]

(d) Complete the timing diagram of Fig. 2.3 to show what happens after the switch is pressed.
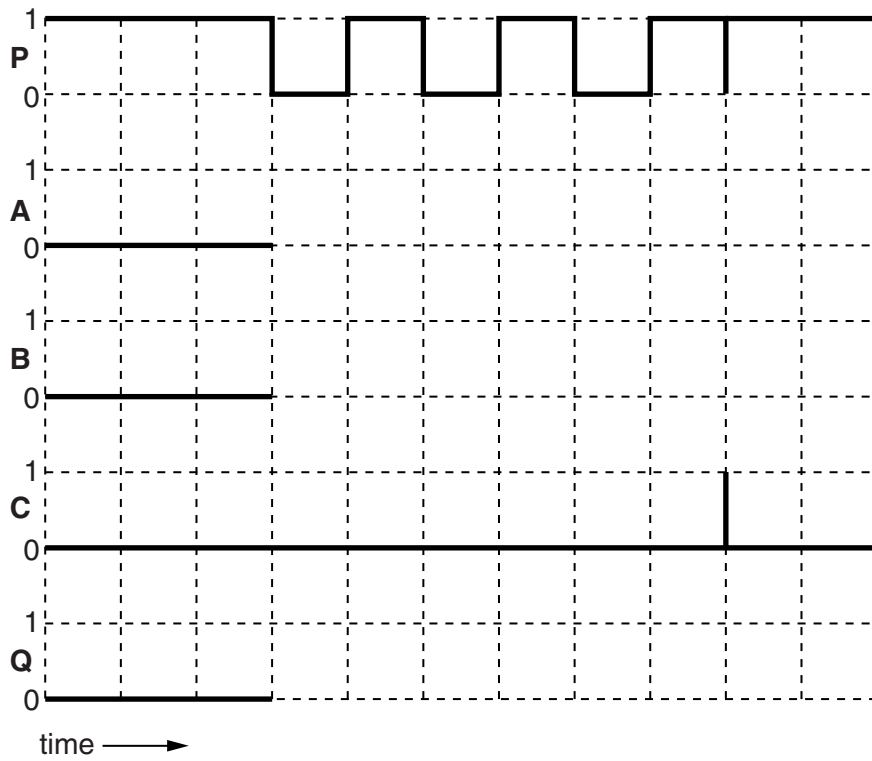
Fig. 2.3

[4]

[Total: 13]

3 A microcontroller has the following specification.
- three 8-bit ports
- six general purpose registers
- one analogue-to-digital converter
- 256 byte program memory space
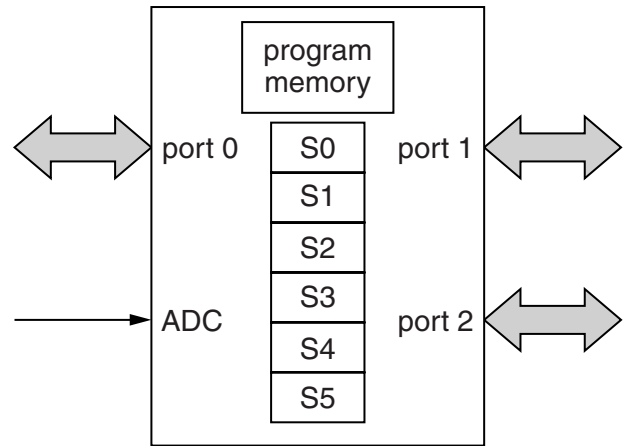
(a) Explain the purpose of the microcontroller ports.

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.... **[2]**

(b) Describe how a register can be used while the microcontroller runs a program.

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.... **[3]**

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

....

....

.... **[2]**

(d) A particular program has the byte 0110 0111 at memory address D2.
Complete the table.

Word in Binary	Word in Hexadecimal
0110 0111	
	D2

[2]

(e) A microcontroller circuit can always be replaced with another circuit made from logic gates, flip-flops and op-amps.
Explain, in detail, the advantages of using the microcontroller circuit.

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.... **[4]**

[Total: 13]

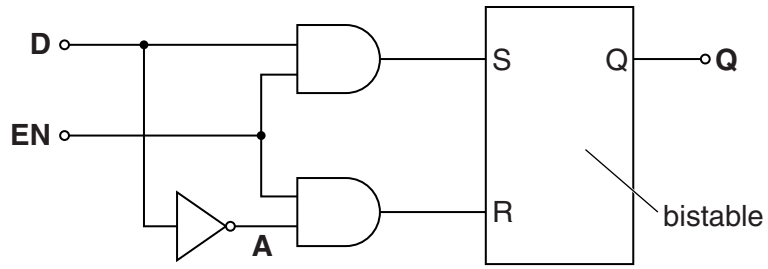**4** The incomplete circuit of Fig. 4.1 is a latch.

Fig. 4.1

(a) Complete the timing diagram of Fig. 4.2 to show the behaviour of the latch.
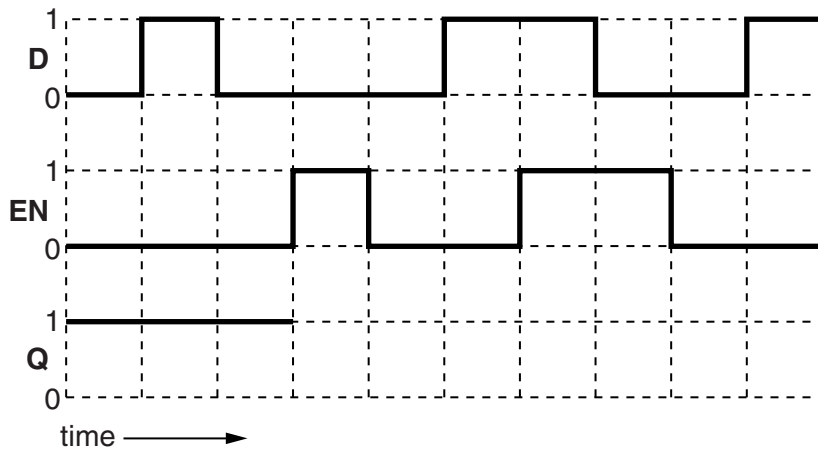
Fig. 4.2

[3]

(b) Complete the truth table for the logic circuit of Fig. 4.1.

D	EN	A	S	R
0	0			
0	1			
1	0			
1	1			

[3]

(c) Complete Fig. 4.3 to show how the bistable of Fig. 4.1 can be made from a pair of NOR gates.

S o———

R o———
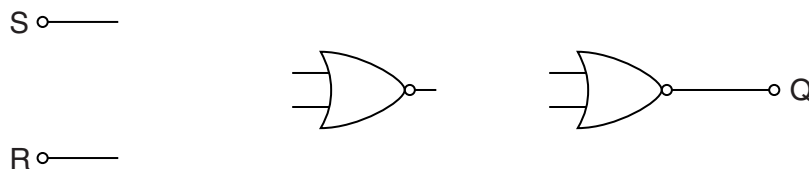
Fig. 4.3

[2]

[Total: 8]

5 Fig. 5.1 is the transfer characteristic of a bandpass filter.
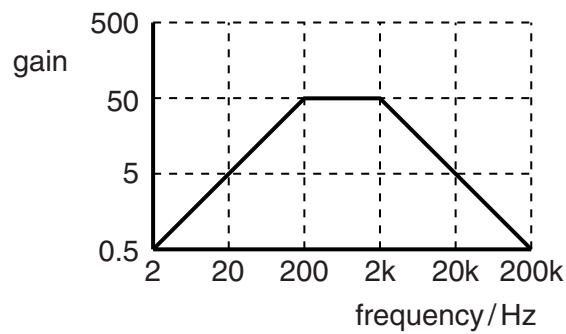
Fig. 5.1

Draw on Fig. 5.2 to show how the filter can be assembled.
Include all component values and justify them with calculations.

Fig. 5.2

[8]

[Total: 8]

12
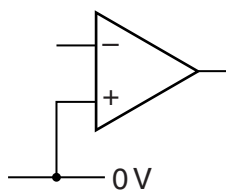
6 Fig. 6.1 shows a microcontroller circuit which monitors the temperature of a freezer.
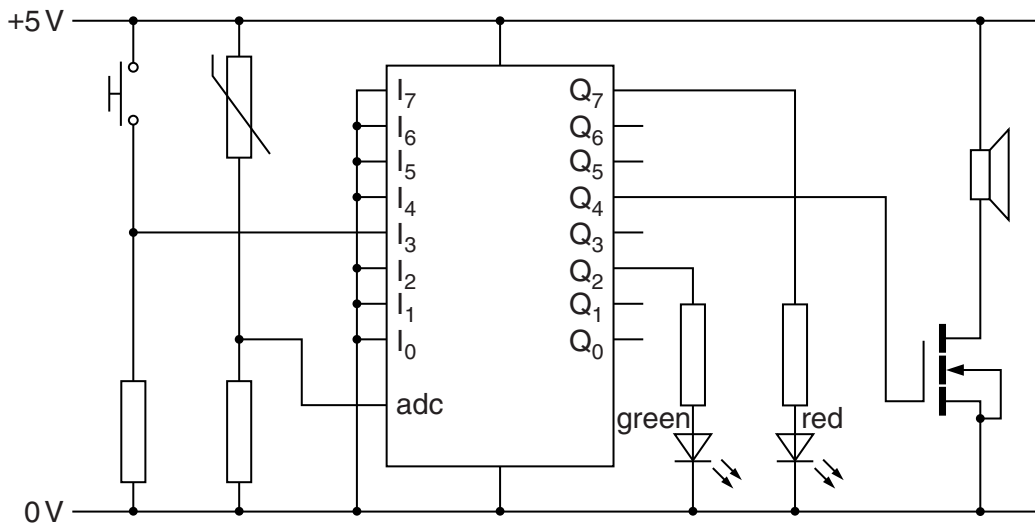
Fig. 6.1

(a) The first part of the microcontroller program switches on the green LED when the temperature of the thermistor is below −20 °C, making the output of the adc less than 8B. Otherwise program flow passes to **b**.
Complete the flowchart of Fig. 6.2 for this part of the program. Use only symbols from the Data Sheet.

Fig. 6.2

[3]

(b) The program checks the temperature of the freezer once every second.
Complete the flowchart of Fig. 6.3 for this part of the program.

Fig. 6.3

[1]

(c) The final part of the program flowchart is shown in Fig. 6.4.
Explain the effect of this part of the program on the output devices, and how the program flow is affected by the input devices.

Fig. 6.4

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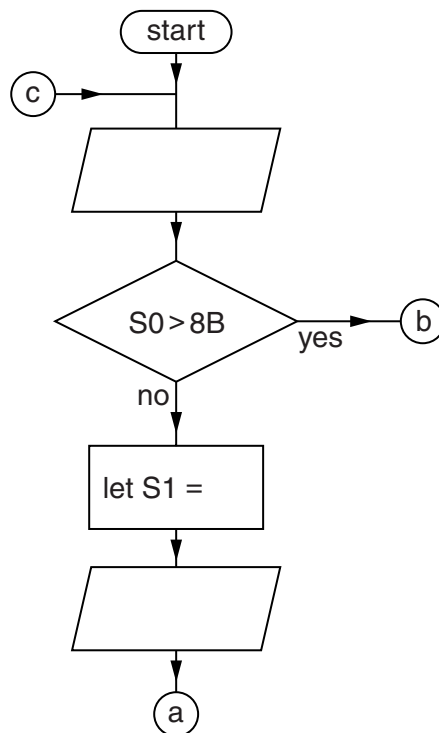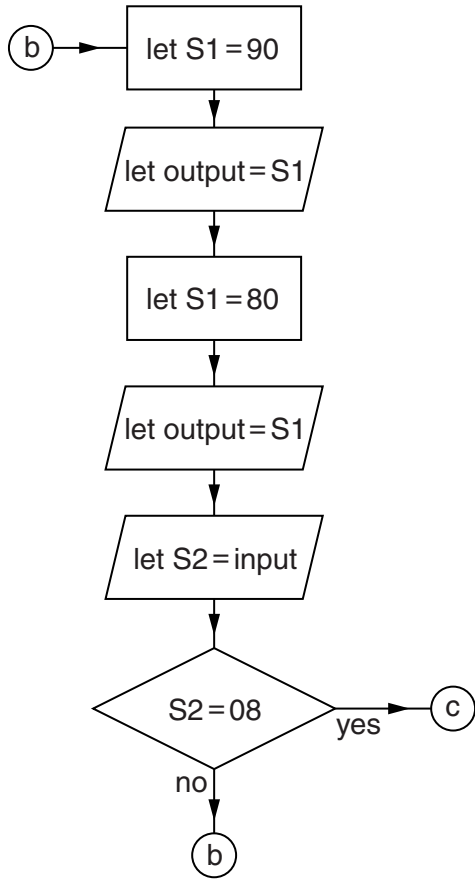...

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.... [7]

[Total: 11]

Turn over

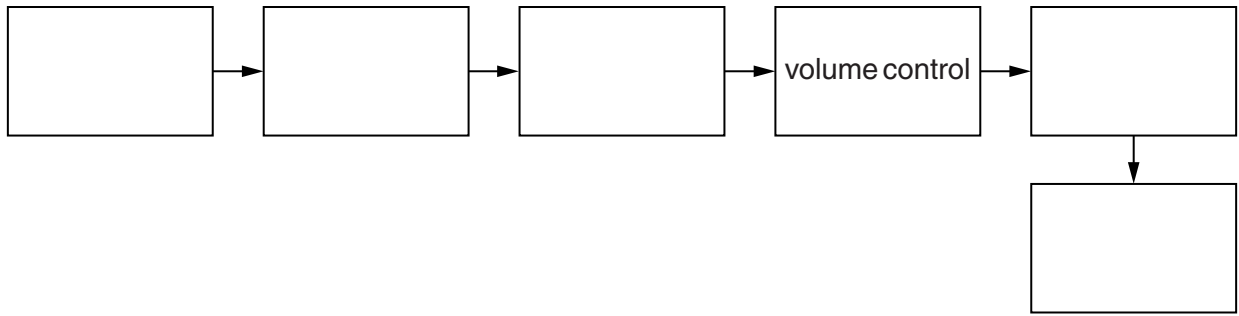**7** Fig. 7.1 is an incomplete block diagram for a simple audio amplifier system.

Fig. 7.1

(a) Complete the diagram of Fig. 7.1 by choosing blocks from this list.

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

[4]

(b) The voltage amplifier in Fig. 7.2 has the following characteristics:
- voltage gain of −20
- input impedance of 30 kΩ

Draw a suitable amplifier based on the op-amp in Fig. 7.2.
Show all component values and justify them with calculations.

Fig. 7.2
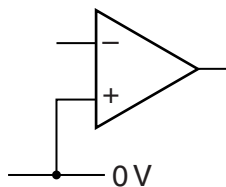
[4]

(c) For each of these blocks from Fig. 7.1:
  • state its effect on the signal at its input
  • explain why it is needed in a real audio system

(i) the volume control

....

....

....

.... **[2]**

(ii) the tone control

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....

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.... **[2]**

(iii) the voltage amplifier

....

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.... **[2]**

[Total: 14]

Turn over

8 Fig. 8.1 is an incomplete block diagram for a system which generates a continuous sequence of output states.
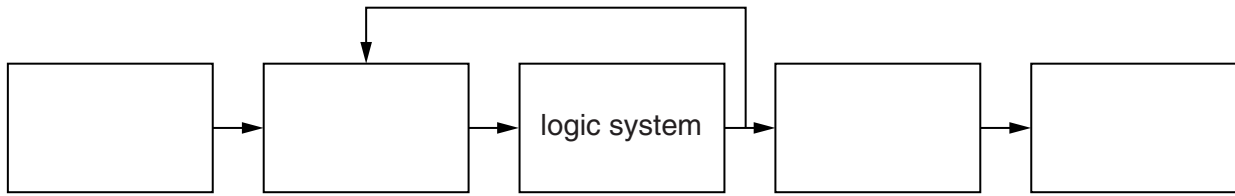
Fig. 8.1

(a) Complete the block diagram of Fig. 8.1 by choosing words from the list.

binary counter **display** **driver** **oscillator**

[3]

(b) Here is a truth table for the logic system.
The inputs are C, B and A.

C	B	A	R	X
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	0
1	0	0	0	1
1	0	1	1	0

(i) Write down Boolean expressions for the outputs **X** and **R** in terms of the inputs **C**, **B** and **A**.

[2]

(ii) Draw a circuit diagram for the logic system, using NOT, AND and OR gates.

[3]

[Total: 8]

Quality of Written Communication [3]

END OF QUESTION PAPER

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