

OCR

Oxford Cambridge and RSA

Thursday 21 May 2015 – 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	
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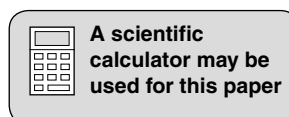
Centre number						Candidate number				
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INSTRUCTIONS TO CANDIDATES


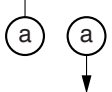

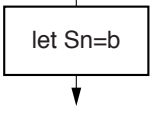
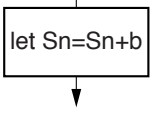
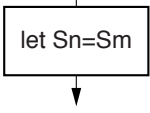
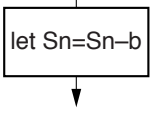
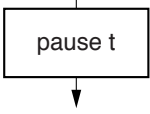
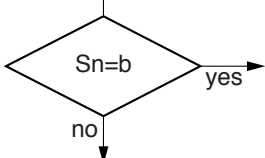
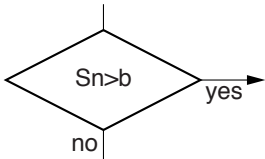
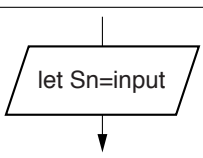
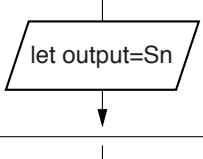
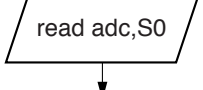
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting 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 is a NOR-gate bistable.

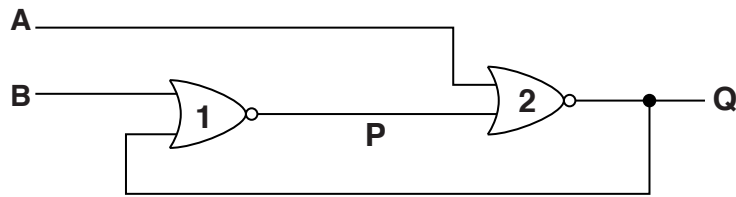


Fig. 1.1

(a) The output of a NOR-gate bistable can be **set** and **reset** with appropriate signals at the **active high inputs**.

(i) Explain the meaning of the terms **set**, **reset** and **active high input**.

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..... [3]

(ii) State what happens to the output **Q** when both inputs go low.

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..... [1]

(b) (i) Complete the truth table below for gate 2 of Fig. 1.1.

A	P	Q
1	1	
1	0	
0	1	
0	0	

[1]

5

(ii) Explain the sequence of signals required to make the bistable store a 1.

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..... [3]

2 The circuit of Fig. 2.1 is a latch made from NAND gates.

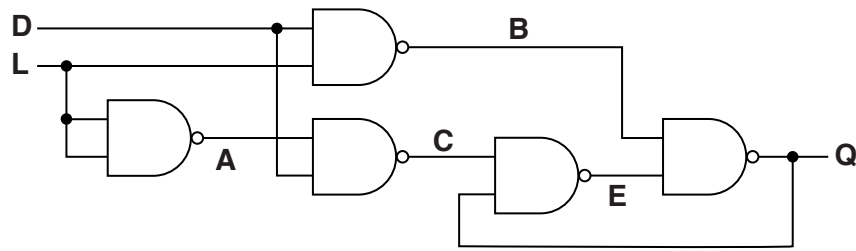


Fig. 2.1

The state of **D** is copied to **Q** whenever the enable input **L** goes high.

Complete the timing diagram of Fig. 2.2.

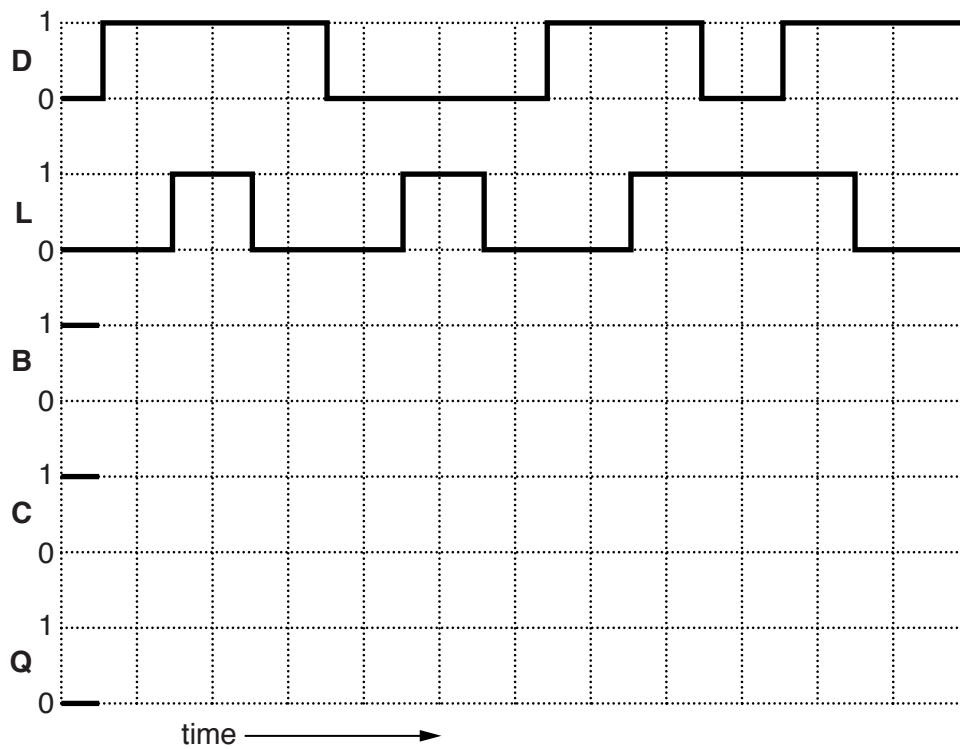


Fig. 2.2

[5]

7

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Question 3 begins on page 8

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8

- 3 A student uses the test arrangement of Fig. 3.1 to verify the transfer characteristic of an inverting amplifier.

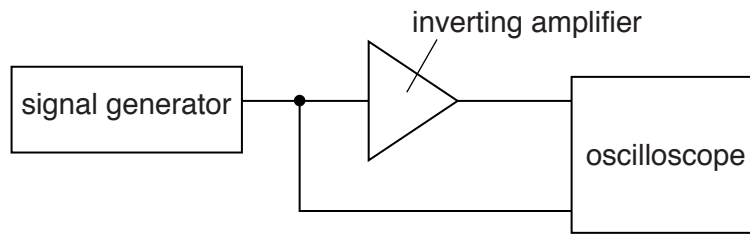


Fig. 3.1

- (a) The inverting amplifier has the following properties.

- voltage gain of -2.5
- input impedance of $30\text{ k}\Omega$

- (i) Fig. 3.2 shows an oscilloscope trace of the signal at the **output** of the amplifier.

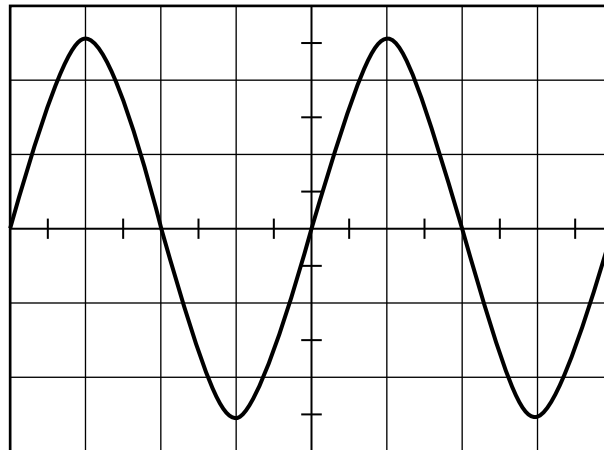


Fig. 3.2

On Fig. 3.2, sketch the trace of the signal at the **input** of the amplifier.

Both traces have the same oscilloscope vertical amplifier setting of 2 V/div . [3]

- (ii) Draw in the space below to show how the amplifier can be constructed from an op-amp and resistors. Show all component values.

[4]

9

(b) The amplifier of Fig. 3.1 alters some properties of the input signal but leaves others unaltered.

(i) State **one** property of the input signal which is altered by the amplifier.

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 [1]

(ii) State **two** properties of the input signal which are **not** altered by the amplifier.

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 [2]

(c) Sketch the transfer characteristic of the inverting amplifier of Fig. 3.1 on the axes of Fig. 3.3.

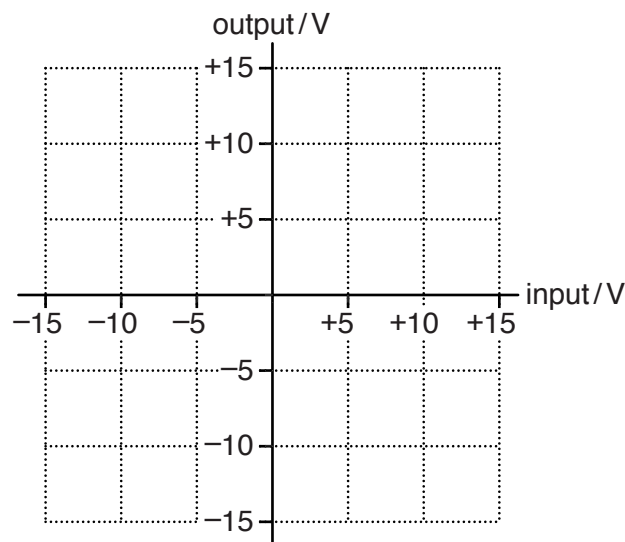


Fig. 3.3

[3]

4 The circuit of Fig. 4.1 shows a microphone connected to an amplifier.

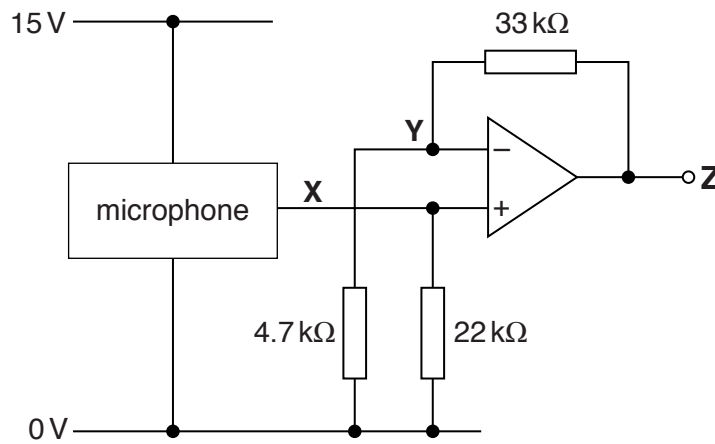


Fig. 4.1

(a) During a test of the system, the microphone produces a signal at X which has an amplitude of 150 mV.

(i) Calculate the amplitude of the signal at Z.

amplitude = V [3]

(ii) Use the transfer characteristics of an op-amp to explain why the signals at X and Y are almost identical.

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..... [4]

(b) The microphone has an output impedance of 12 kΩ.

(i) Explain why replacing the 22 kΩ resistor with a 120 kΩ resistor would improve the performance of the circuit.

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..... [4]

(ii) In another test, the amplitude of the signal at X is 250 mV when the 22 kΩ resistor is in place.

Calculate the amplitude of the signal at X when the 22 kΩ resistor is replaced with a 120 kΩ resistor.

amplitude = mV [4]

12

- 5 Fig. 5.1 contains the circuit symbol for a D flip-flop.

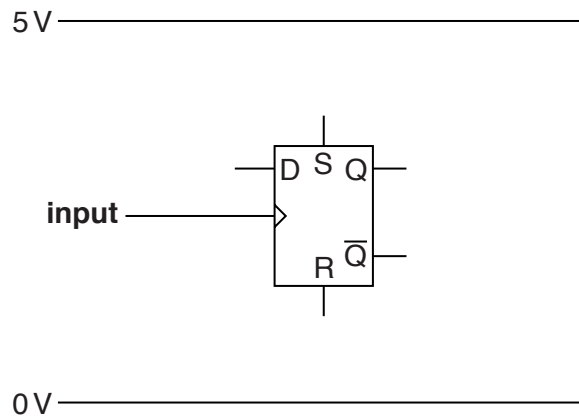


Fig. 5.1

- (a) (i) Draw on Fig. 5.1 to show how the flip-flop should be connected to count pulses at the terminal labelled **input**.
Label the **output** of the counter. [3]
- (ii) Complete the timing diagram of Fig. 5.2 to show the behaviour of the counter of Fig. 5.1.

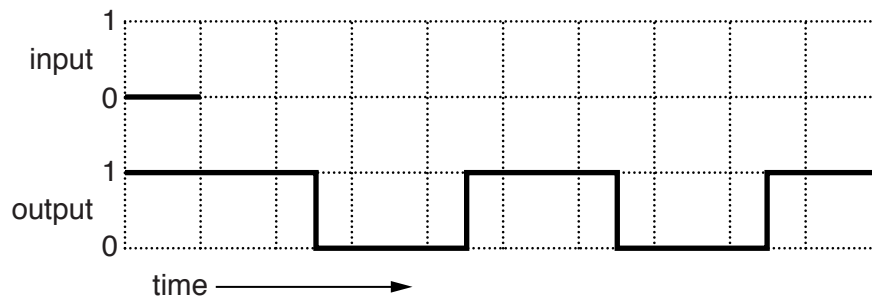


Fig. 5.2

[2]

(b) Fig. 5.3 shows a four-bit counter and a logic gate.

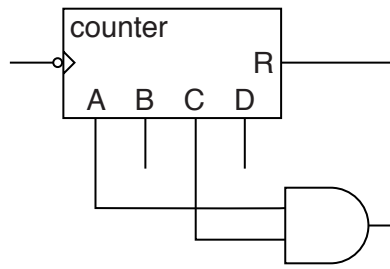


Fig. 5.3

(i) Explain the effect of the logic gate on the behaviour of the circuit of Fig. 5.3.

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..... [2]

(ii) Complete the pulse table for the circuit of Fig. 5.3.

pulse	A	B	C	D
0	1	1	0	0
1				
2				
3				
4				

[3]

(iii) A signal of frequency 15 kHz is applied to the input of the circuit of Fig. 5.3.

Calculate the frequency of the signal at C.

frequency = kHz [1]

6 The circuit of Fig. 6.1 makes a pair of LEDs glow in a continuous sequence.



Fig. 6.1

(a) Show that each cycle of the sequence lasts for about 35 seconds.

[4]

(b) Fig. 6.2 shows part of the logic system of Fig. 6.1.

Complete the timing diagram of Fig. 6.3.

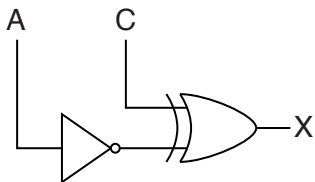


Fig. 6.2

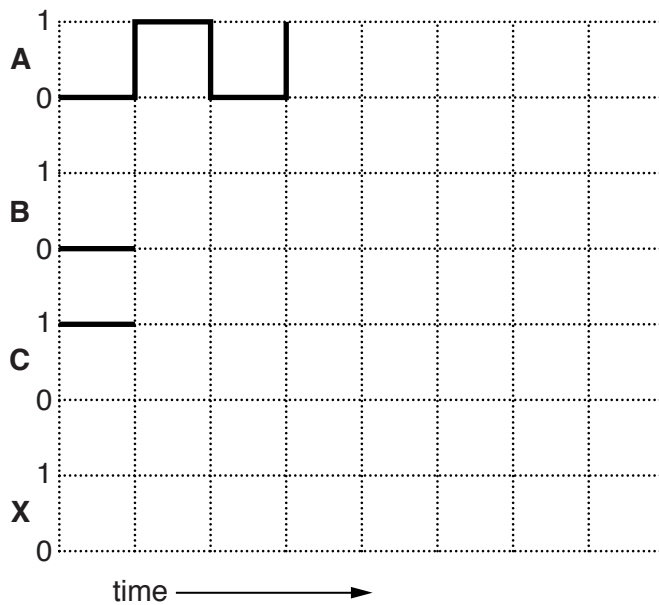


Fig. 6.3

[4]

15

(c) The green LED connected to Y only glows for these three states of the counter:

- CBA = 010
- CBA = 110
- CBA = 011

(i) Write down a Boolean expression for Y in terms of C, B and A.

You do not have to simplify it.

[1]

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

[2]

(iii) Draw a NAND gate circuit in the space below to show how Y can be generated from C, B and A.

[3]

7 The microcontroller system of Fig. 7.1 is programmed to act as a flood alarm.

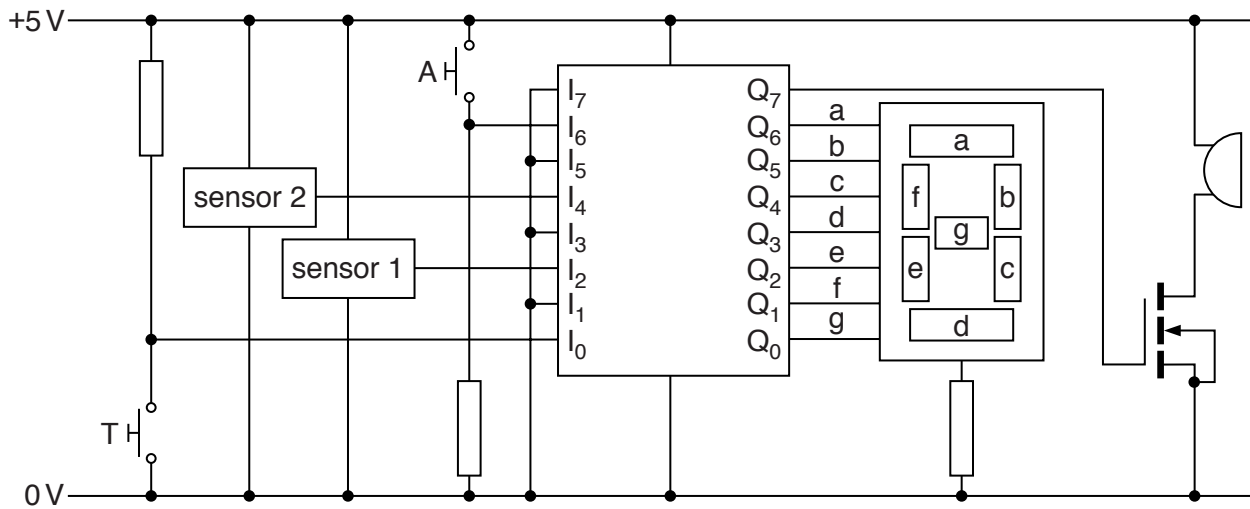


Fig. 7.1

Each sensor is in a different location and only outputs a 1 when it is underwater.

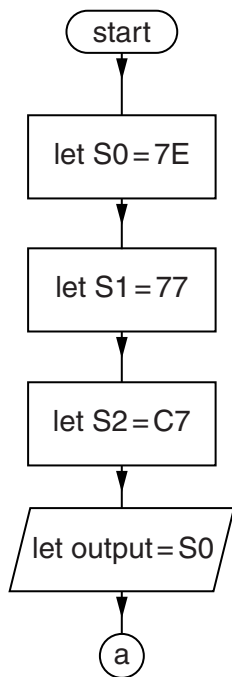


Fig. 7.2

(a) The first part of the program flowchart is shown in Fig. 7.2.

(i) Complete the table below.

hexadecimal	binary
7E	01111110
77	
C7	

[1]

(ii) Explain, in detail, the effect of copying the contents of register S0 to the output port.

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[3]

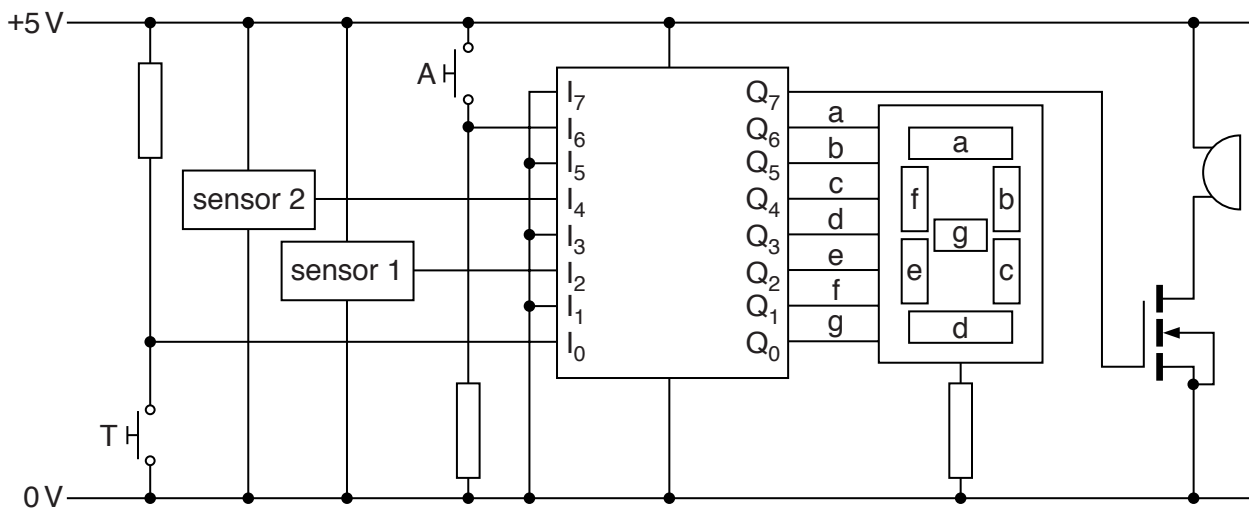
(c) The last part of the flowchart makes the system behave as follows:

- if there is a flood, continually display 'F' and turn on the buzzer
- if switch T is closed, display '8' and turn on the buzzer for 500 ms, then return control to a.

Draw a suitable flowchart in the space below. A copy of Fig. 7.1 is provided at the bottom of the page.

(b)

[4]



Copy of Fig. 7.1

8 Fig. 8.1 is the transfer characteristic of a tone control.

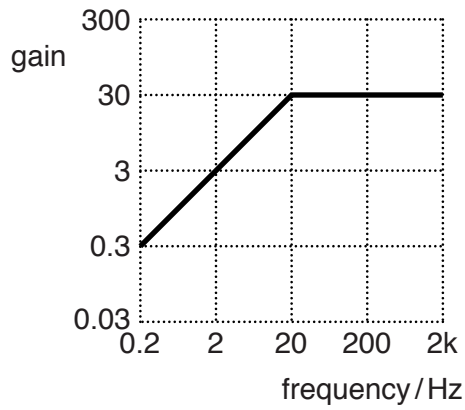


Fig. 8.1

(a) Explain why an audio system might contain this tone control.

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..... [2]

(b) Complete the circuit of Fig. 8.2 to show how the tone control can be assembled.

Show all component values and justify them with calculations.

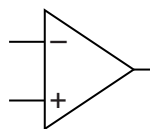


Fig. 8.2

[5]

Quality of Written Communication [3]

END OF QUESTION PAPER

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