THIS IS A NEW SPECIFICATION

RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

ELECTRONICS

F612

Unit F612: Signal Processors

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Scientific calculator

Monday 18 May 2009
Morning

Duration: 1 hour 30 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

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 the quality of written communication where this is indicated in the question.
- 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
- You are advised to show all the steps in any calculations.
- This document consists of **24** pages. Any blank pages are indicated.

A calculator may be used for this paper

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	$T = 0.7\,RC$
relaxation oscillator period	$T = RC$
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	$A.\overline{A} = 0$
	$A + \overline{A} = 1$ $A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$
	$\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$
	$A.B = \overline{A}.C = A.B + \overline{A}.C + B.C$

symbol	meaning
start	start the program
a a	link to part of the program with the same label a
stop	stop the program
let An=b	place the byte b in register An
let An=An+b	add the byte b to the byte in register An
let An=Am	copy the byte in register Am into register An
let An=An–b	subtract the byte b from the byte in register An
pause t	introduce a time delay of t milliseconds
An=b (yes / no)	branch if the byte in register An is equal to the byte b
An>b (yes / no)	branch if the byte in register An is greater than the byte b
let An=input	copy the byte at the input port to register An
let output=An	copy the byte in register An to the output port
read adc,A0	activate the analogue-to-digital converter and store the result in register A0

Answer **all** the questions.

1 The circuit of Fig. 1.1 operates a car alarm. The movement sensor produces a logic 0 when the car moves and produces a logic 1 when the car is still.

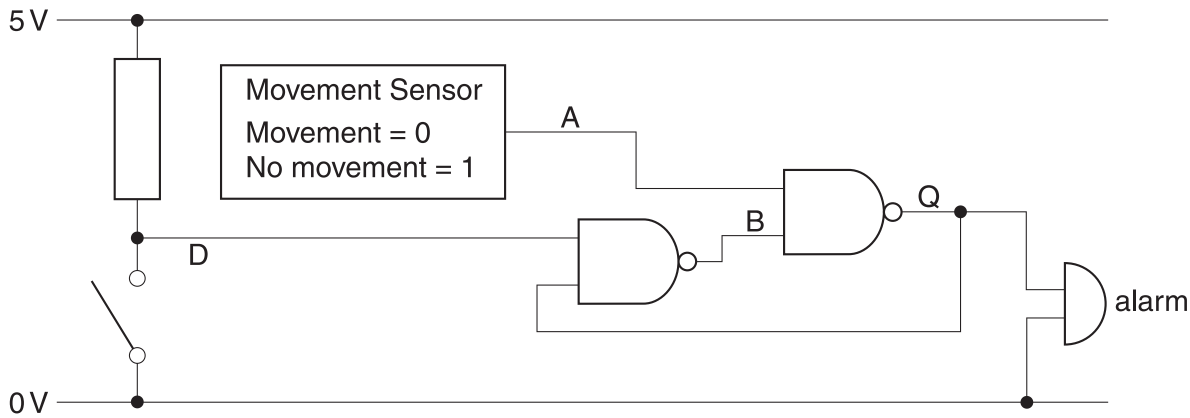


Fig. 1.1

(a) The circuit in Fig. 1.1 contains NAND gates. Complete the truth table for a NAND gate.

A	**B**	**Q**
0	0	
0	1	
1	0	
1	1	

[2]

(b) Initially the alarm is off. Explain what happens to the alarm when the car is moved. Refer to the truth table and Fig. 1.1 in your answer.

....

....

....

.... **[3]**

(c) Explain what happens to the alarm when the car now stops moving.

....

....

....

.... **[4]**

[Total: 9]

2 An amplifier is tested using a sine wave input. The graphs of the input signal (V_{in}) and the output signal (V_{out}) for the amplifier are shown in Fig. 2.1.

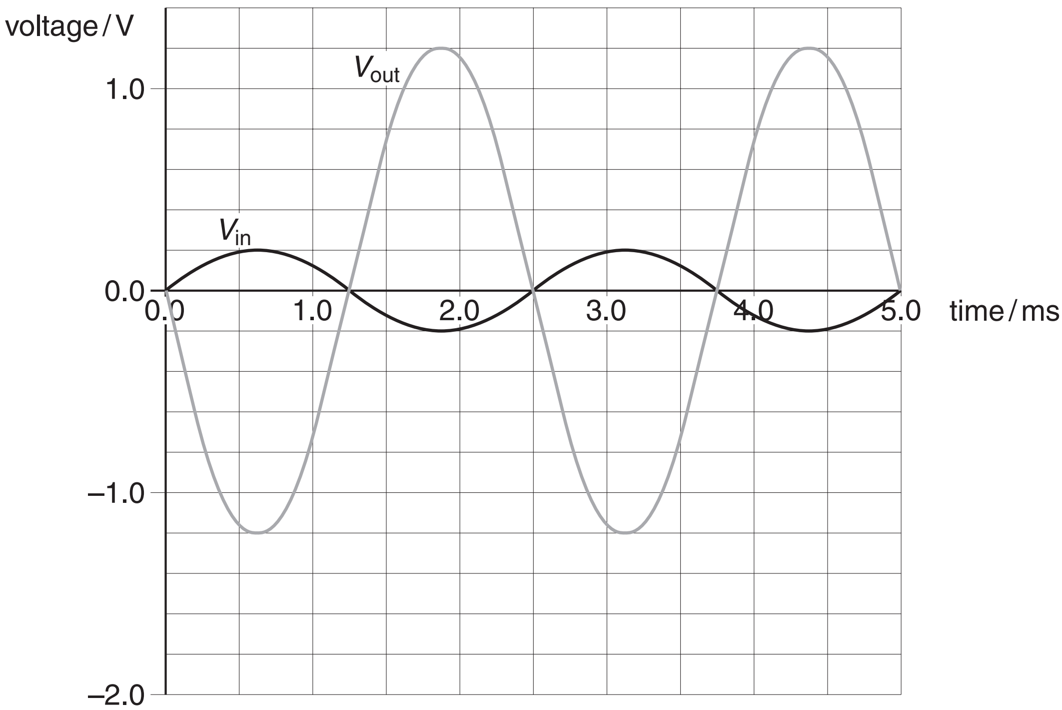


Fig. 2.1

(a) Calculate the gain of the amplifier using information from the graphs of V_{in} and V_{out} in Fig. 2.1.

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

(b) Draw on Fig. 2.2 a circuit for an amplifier with the gain calculated in **(a)**.

Label the input and output terminals.

Give values for all your components.

Justify the values with calculations.

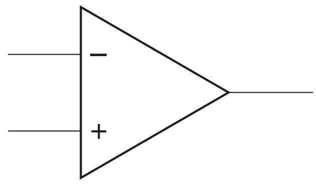


Fig. 2.2 **[5]**

(c) Draw on Fig. 2.2 to show how an electret microphone, pull-up resistor and capacitor can be connected to provide a microphone input to the circuit. You do not have to give component values. **[3]**

[Total: 10]

3 A student builds a circuit to flash some LEDs in a sequence as an electronics project. The student's circuit uses a 3-bit binary counter.

(a) **(i)** Draw a NOT gate and the relevant connections on Fig. 3.1 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.

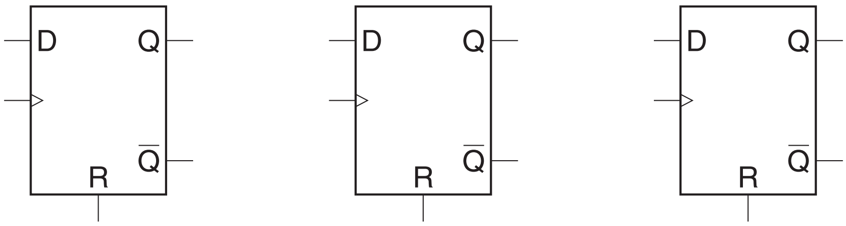


Fig. 3.1

[5]

(ii) Add a logic gate to Fig. 3.1 to make the circuit count from 0 to 5 and reset to 0 on the 6th pulse. **[2]**

(b) Fig. 3.2 shows some components connected to the counter of Fig. 3.1.

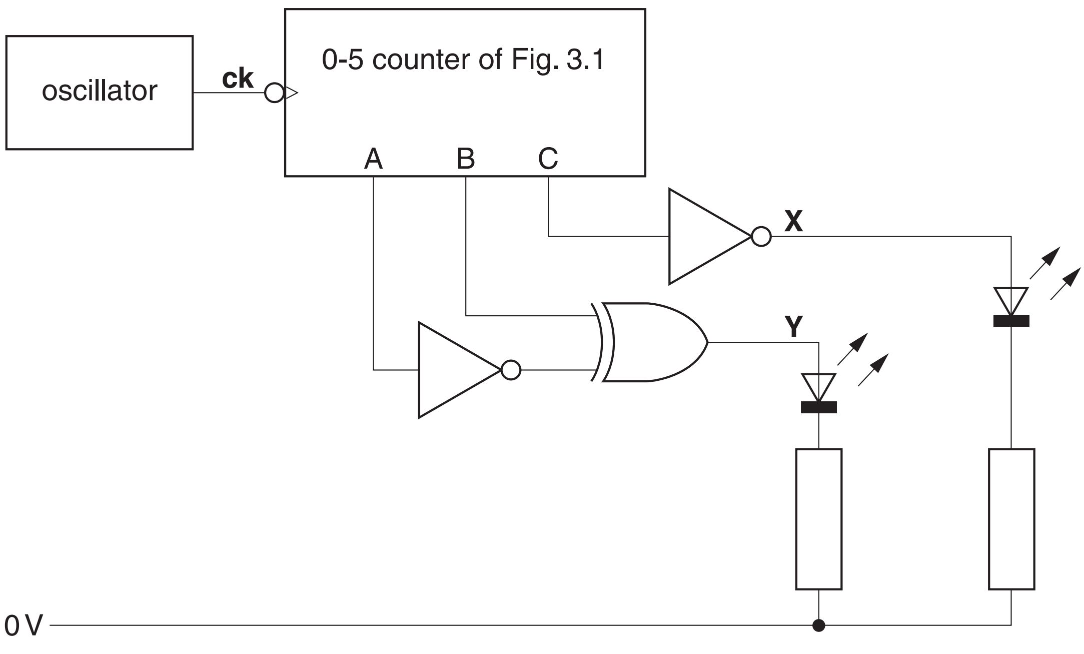


Fig. 3.2

(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		
1	0	1		

[2]

(ii) Use the results from the truth table to complete the timing diagram in Fig. 3.3 for the signals from the circuit in Fig. 3.2.

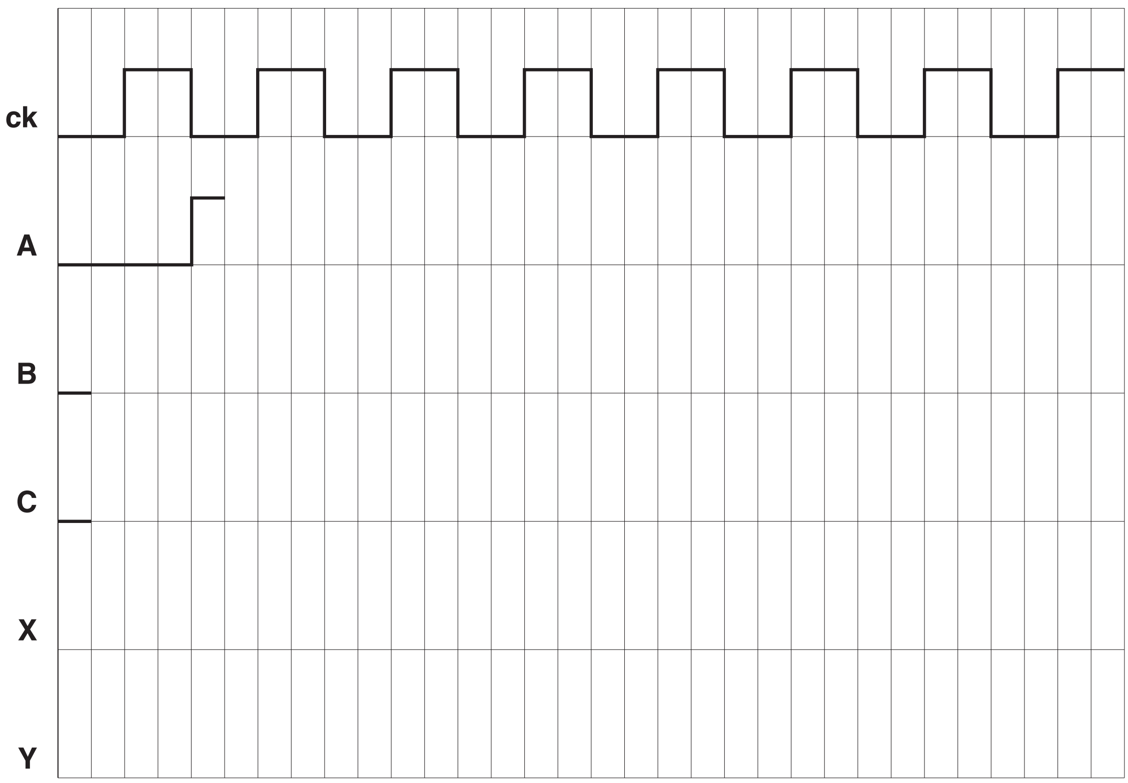


Fig. 3.3

[6]

[Total: 15]

4 The circuit in Fig. 4.1 is a filter based around an op-amp.

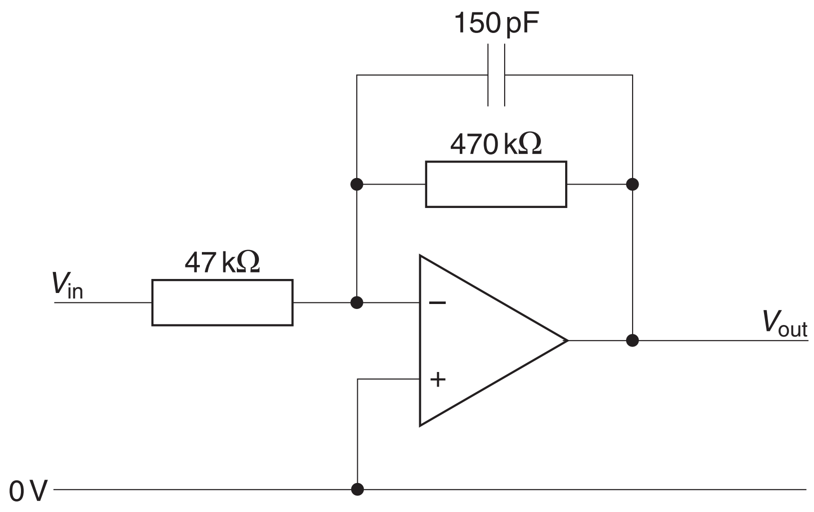


Fig. 4.1

(a) Put a ring around the name of the filter circuit in Fig. 4.1.

bandpass filter **bass cut filter**

passive filter **treble cut filter**

[1]

(b) Calculate the break frequency of the circuit in Fig. 4.1.

break frequency = ... Hz **[3]**

(c) Calculate the gain of the circuit for the frequency range where the capacitor can be ignored.

gain = ... **[1]**

(d) Draw a graph of gain against frequency for the circuit in Fig. 4.1 on the axes in Fig. 4.2.

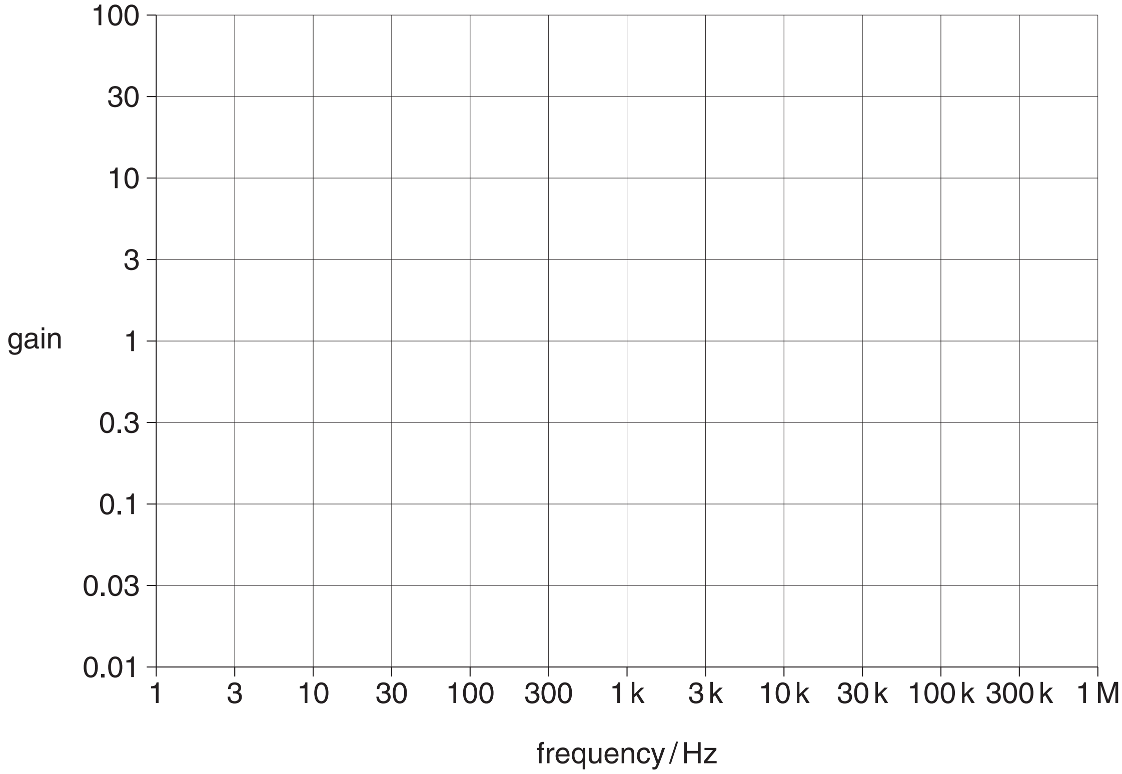


Fig. 4.2

[4]

[Total: 9]

5 A student builds a circuit to tell customers which cash register to go to in a shop. When a switch is pressed:

- the beeper makes a sound for 1 second;
- the LED corresponding to the switch glows;
- the LED continues to glow until another switch is pressed.

The circuit is shown in Fig. 5.1.

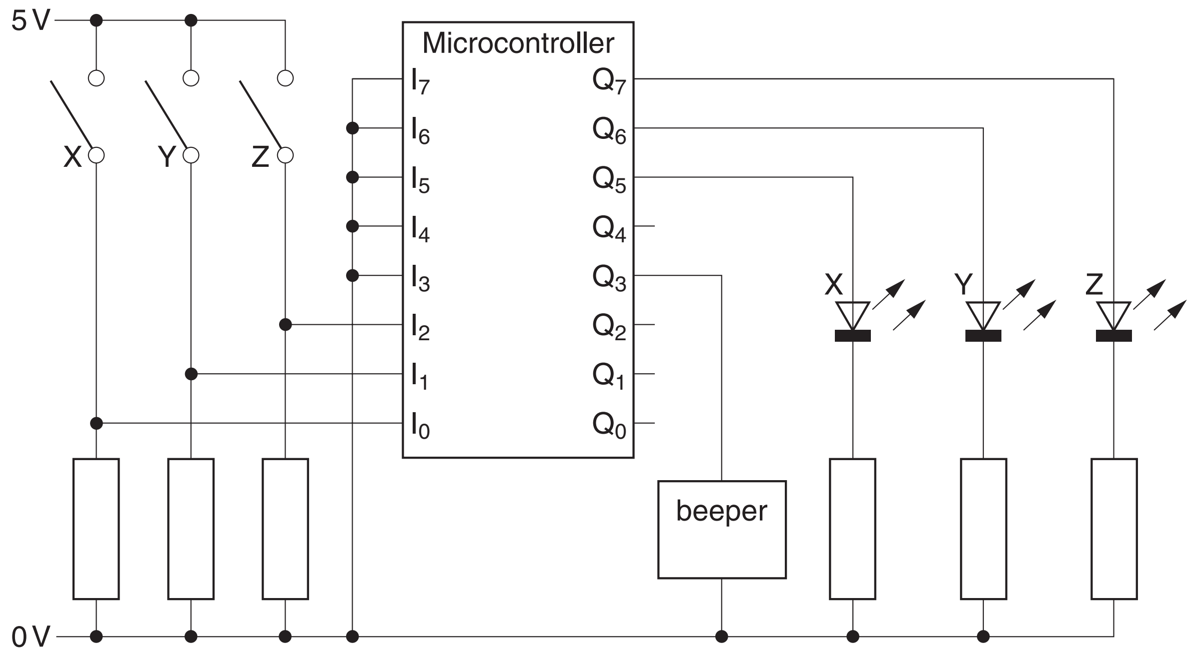


Fig. 5.1

(a) The student could have used logic gates and flip-flops instead of a microcontroller.

State **two** advantages of using a microcontroller instead of logic gates and flip-flops for this circuit.

....

....

.... **[2]**

(b) At some point the microcontroller is required to turn on only the beeper and LED Y.

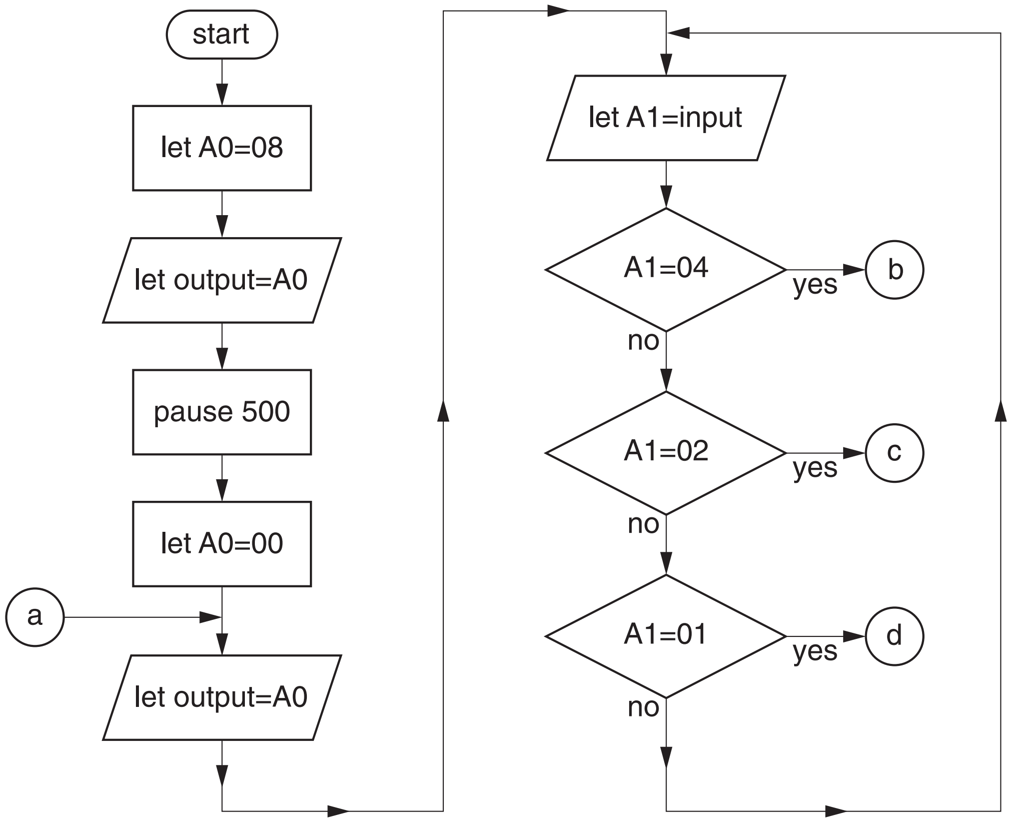
(i) Write down the binary number output by the microcontroller.

.... **[2]**

(ii) Write down the hexadecimal number output by the microcontroller.

.... **[1]**

(c) Here is the program stored in the microcontroller. Use the flowchart symbols on the Data Sheet to explain the function of each step of the program, relating it to the circuit of Fig. 5.1.



....

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....

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....

....

.... **[8]**

(d) The section of flow chart which connects (b) to (a) makes the beeper sound for one second and makes the correct LED glow until another switch is pressed.

Use the flowchart symbols from the datasheet to write the program for the section between (b) and (a).

[5]

[Total: 18]

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6 An amplifier is used to amplify the signal from a temperature sensor.

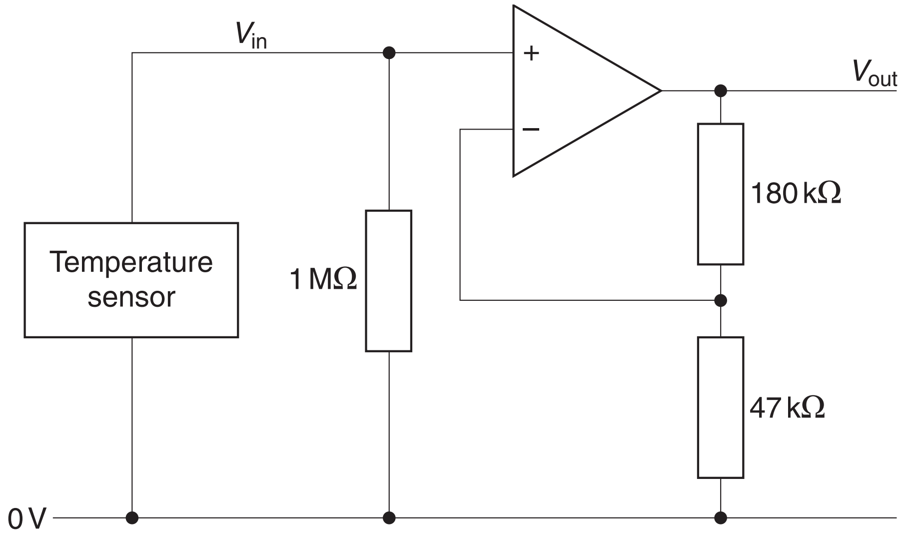


Fig. 6.1

(a) Show that the voltage gain of the amplifier in Fig. 6.1 is about 5.

[2]

(b) Draw on the diagram in Fig. 6.1 to show how you would connect a voltmeter to measure the output voltage. **[2]**

(c) Calculate the output voltage shown on the voltmeter when the temperature sensor produces a voltage of 0.60 V at V_{in}.

output voltage = ... V **[2]**

(d) Draw on the axes of Fig. 6.2 to show how the output voltage of the amplifier depends on the input voltage.

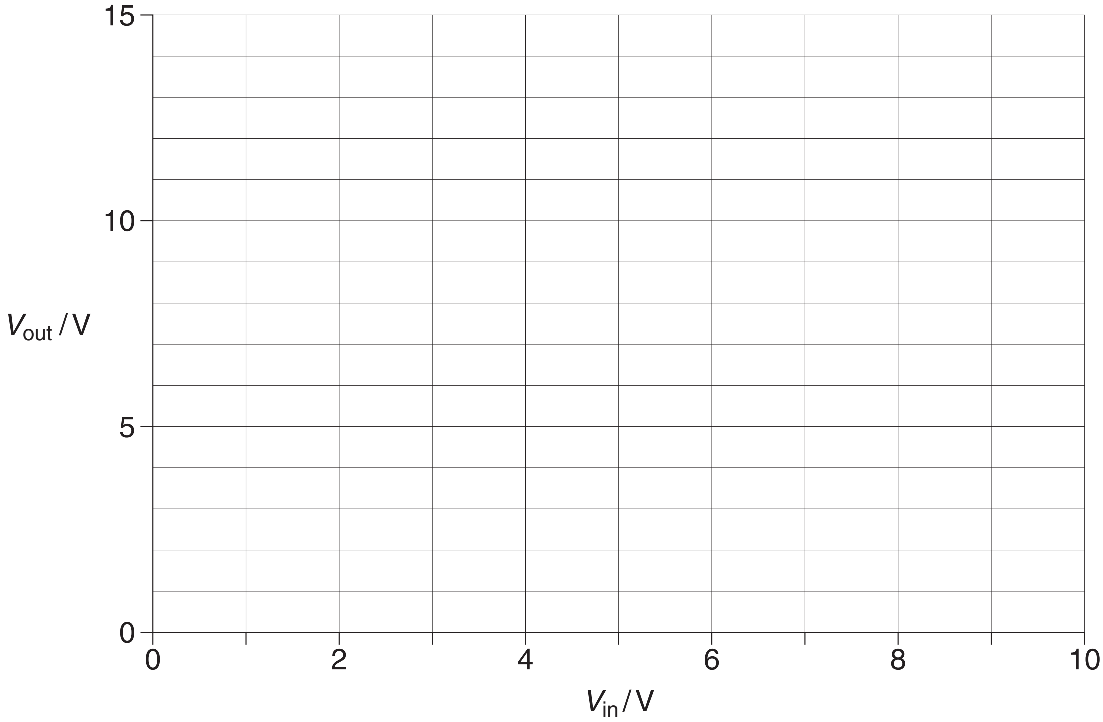


Fig. 6.2

[4]

[Total: 10]

7 Fig. 7.1 shows a counter circuit with a seven-segment display at the output.

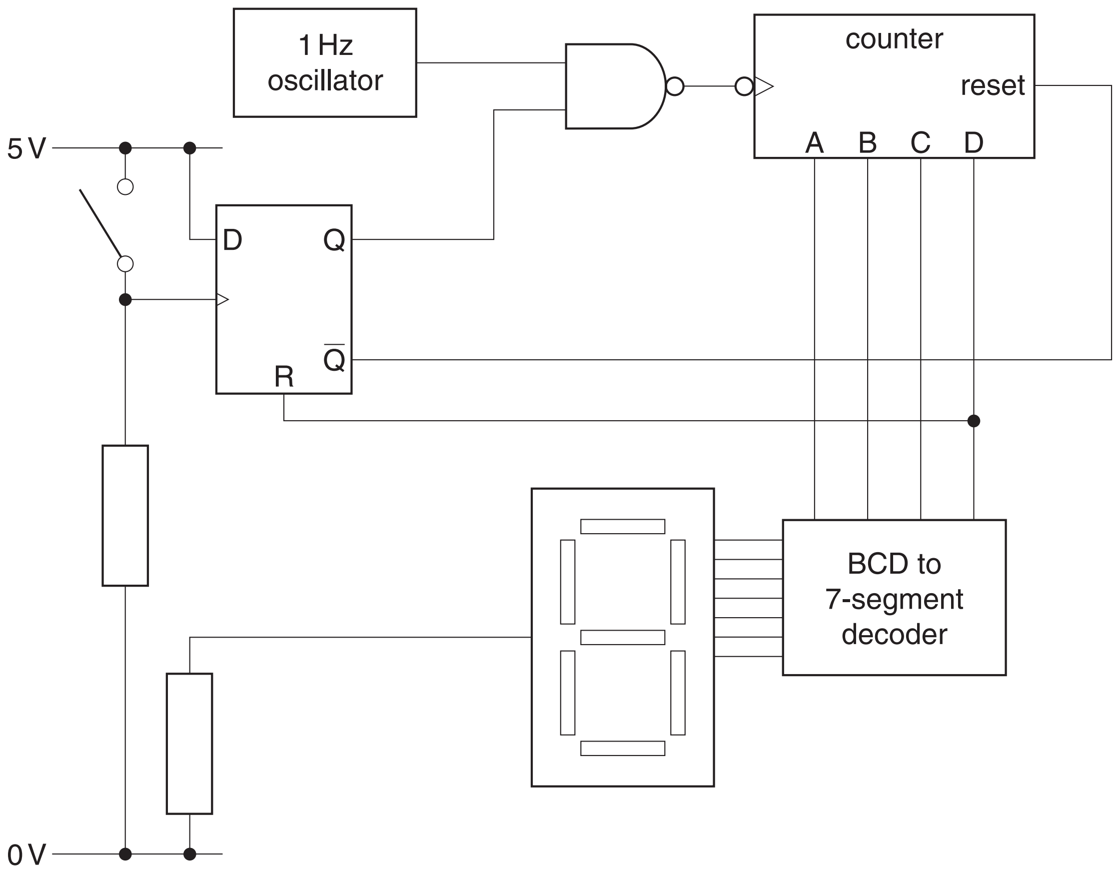
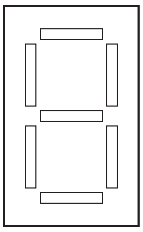
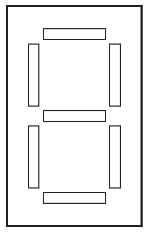
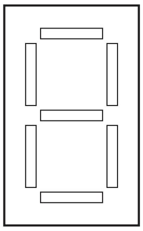
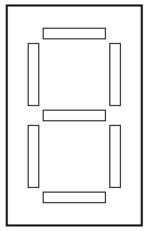
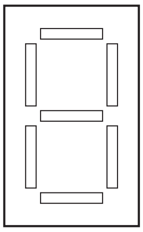
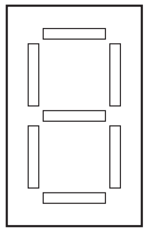
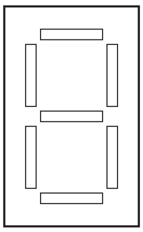
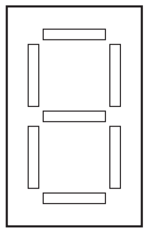
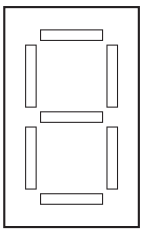
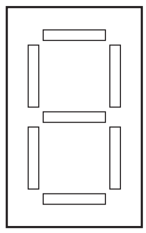


Fig. 7.1

(a) Use the table to show what happens when the switch is briefly pressed and released by shading in the correct segments on the display.

Time	Display	Time	Display
1 second after switch pressed		6 seconds after switch pressed	
2 seconds after switch pressed		7 seconds after switch pressed	
3 seconds after switch pressed		8 seconds after switch pressed	
4 seconds after switch pressed		9 seconds after switch pressed	
5 seconds after switch pressed		10 seconds after switch pressed	

[4]

(b) Explain the sequence of outputs.

....

....

....

....

....

.... **[5]**

[Total: 9]

8 Fig. 8.1 shows a light sensor and amplifier.

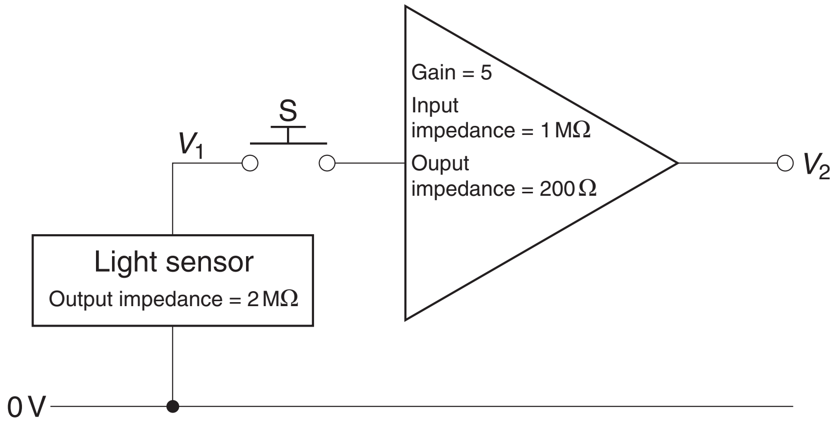


Fig. 8.1

(a) When the switch S is pressed V_2 is 5.6 V. Show that V_1 is about 1 V whilst S is pressed.

[1]

(b) Explain why the voltage at V_1 suddenly increases when S is released.

....

....

....

.... **[3]**

(c) Calculate the voltage at V_1 when S is released.

V_1 = ... V **[3]**

Quality of Written Communication **[3]**

[Total: 10]

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