OCR
RECOGNISING ACHIEVEMENT

Friday 18 May 2012 – Afternoon

AS GCE ELECTRONICS

F612 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. 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

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

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 an op-amp connected as a voltage follower.

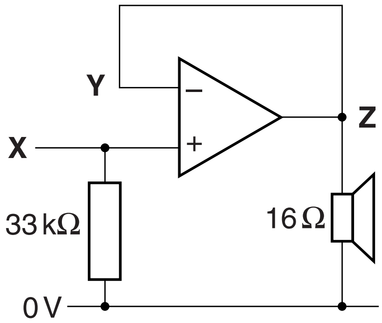
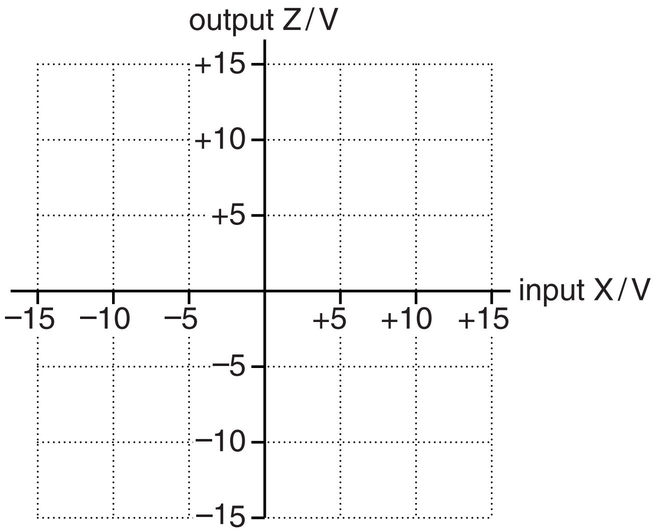


Fig. 1.1

(a) Draw the transfer characteristic of the voltage follower on the axes below.



[3]

(b) Here are some subsystems of an audio amplifier system.

tone control **power amplifier** **voltage amplifier** **volume control**

Which subsystem could be made from the voltage follower of Fig. 1.1?
Put a (ring) around the correct answer. **[1]**

(c) The open-loop gain of the op-amp in Fig. 1.1 is only 120.

(i) Use the equation $V_{out} = A(V_+ - V_-)$ to explain what is meant by the term open-loop gain.

....

....

....

.... **[2]**

(ii) The input of the voltage follower is held at +6 V.
State the voltage at its output.

output voltage = ... V **[1]**

(iii) Show that the current in the loudspeaker is about 400 mA when the input is held at +6 V.

[2]

(iv) Calculate the power delivered to the loudspeaker when the input of the voltage follower is held at +6 V.

power = ... W **[1]**

[Total: 10]

2 The microcontroller of Fig. 2.1 outputs numbers on a seven segment LED display.

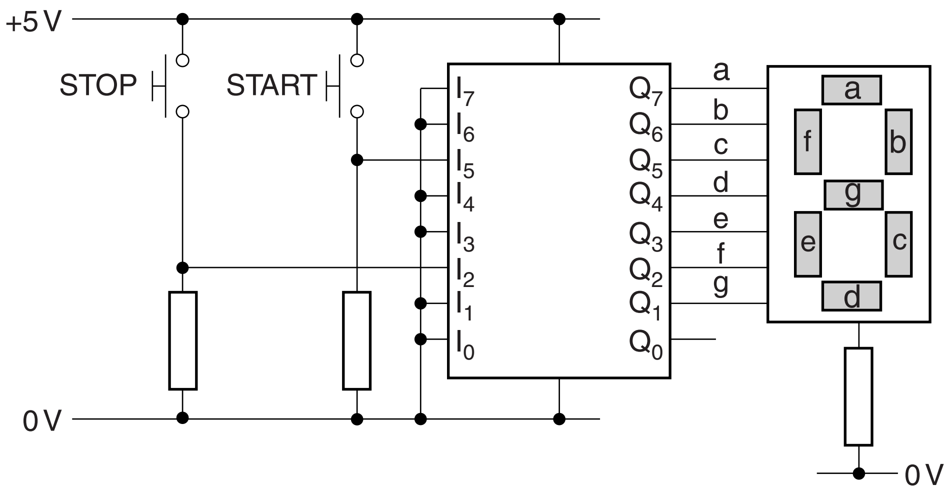
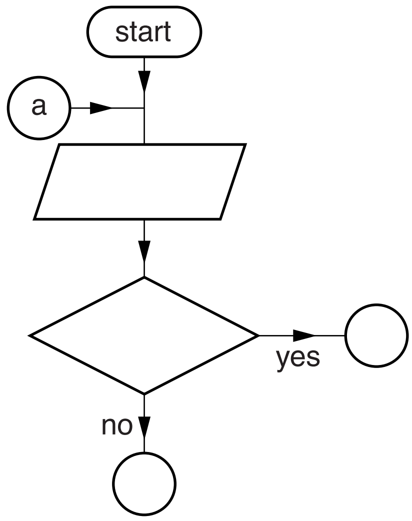


Fig. 2.1

The microcontroller is programmed to display the sequence 321321321 ..., when the switch labelled START is pressed briefly. Each number appears on the display for only 0.5 s.
The display goes blank when the switch labelled STOP is pressed briefly.

(a) Complete this flowchart for the first part of the program in the microcontroller. It has to do the following:
- copy the input port to register S7
- pass control to **b** if only the switch labelled START has been pressed
- pass control to **a** if START has not been pressed

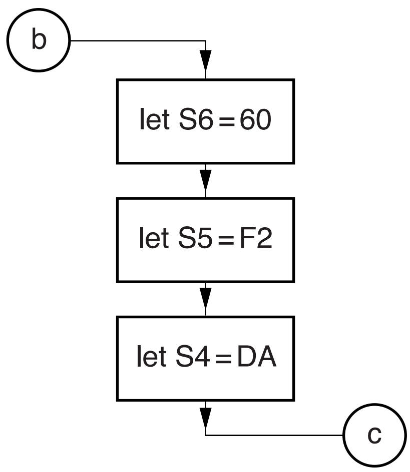
Use **only** the symbols from the Data Sheet.



[4]

(b) The next part of the program loads up registers with the words which display 3, 2 and 1 on the LED display. Complete the table below.

register	binary word	display
S6	0110 0000	
S5		
S4		

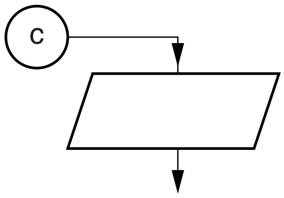


[3]

(c) The final part of the program makes the microcontroller behave as follows:

- blank the display if STOP is pressed and START is not pressed, and return to the start of the whole program
- otherwise display 3 then 2 then 1 for 0.5 s each before checking the state of the STOP switch again

Complete the flowchart for the final part of the program in the space below. **[6]**



[Total: 13]

3 Fig. 3.1 is an incomplete block diagram for an audio amplifier system.

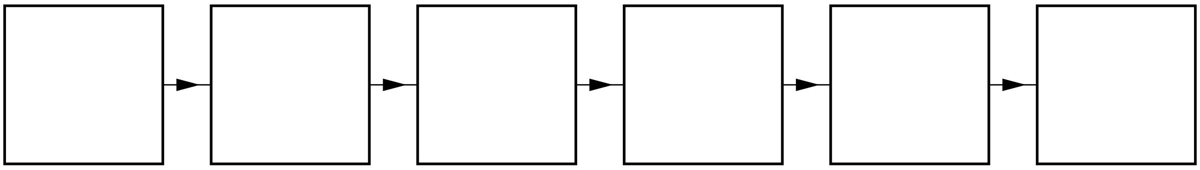


Fig. 3.1

(a) Complete the block diagram of Fig. 3.1. Choose words from the list below.

loudspeaker   microphone   power amplifier   tone control   voltage amplifier   volume control

[4]

(b) The audio amplifier system uses an electret microphone.

(i) Draw on Fig. 3.2 to show how an electret microphone should be connected to an amplifier with a resistor and a capacitor. **[3]**

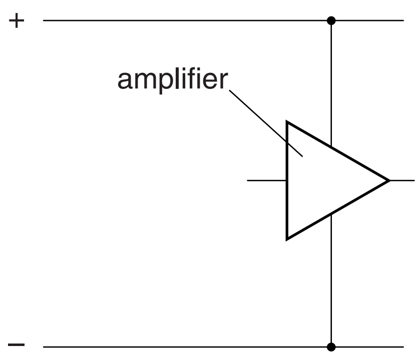


Fig. 3.2

(ii) The **output** impedance of the microphone is 10 kΩ.
Suggest a suitable value for the **input** impedance of the amplifier.
Justify your choice.

....

....

....

.... **[2]**

(c) The tone control is an active treble cut filter with the following characteristics.

- a break frequency of 2 kHz
- a low frequency gain of 5
- an input impedance of 30 kΩ

(i) Sketch the transfer characteristics of the tone control on Fig. 3.3. **[3]**

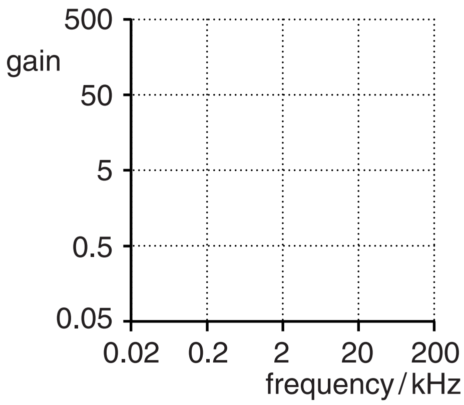


Fig. 3.3

(ii) Draw on Fig. 3.4 to show how the filter can be assembled.
Do calculations to justify your choice of component values. **[5]**

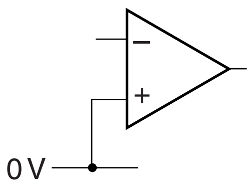


Fig. 3.4

[Total: 17]

4 Fig. 4.1 is an incomplete circuit diagram for a system which generates a continuous sequence of outputs at X, Y and Z.

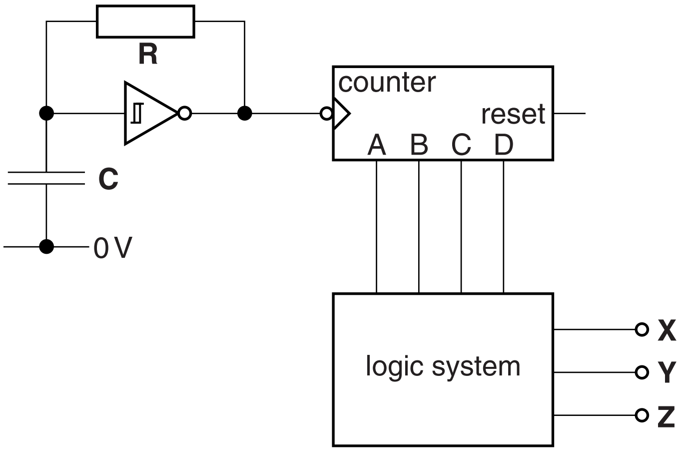


Fig. 4.1

(a) The counter must be reset on every fifth pulse from the oscillator.
Draw on Fig. 4.1 to show how this can be done with a logic gate. **[2]**

(b) The period of the oscillator must be 4.0 s.
Suggest suitable values for **R** and **C**.

R = ... kΩ

C = ... F
[2]

(c) (i) Complete the truth table below for the logic system.

state	**C**	**B**	**A**	**X**	**Y**	**Z**
0	0	0	0	1	0	0
1				1	1	0
2				0	1	0
3				0	1	1
4				0	0	1

[2]

(ii) Write down a Boolean algebra expression for Z in terms of C, B and A.
You do not need to simplify the expression.

[2]

(iii) Draw in the space below a circuit made from NOT, AND and OR gates to generate Z from C, B and A.

[3]

[Total: 11]

5 **(a)** Describe the behaviour of a NAND gate.

....

....

.... **[2]**

(b) The circuit in Fig. 5.1 is a bistable made from NAND gates.

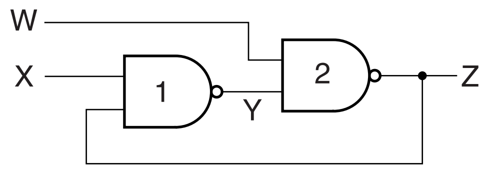


Fig. 5.1

(i) A NAND gate bistable has **active-low inputs** which can be used to **set** and **reset** the bistable. Explain the meaning of the terms in **bold**.

....

....

....

....

.... **[3]**

(ii) Use the behaviour of NAND gates to explain the state of output Z when W is high and X is low.

....

....

....

....

....

.... **[2]**

(iii) Complete the timing diagram of Fig. 5.2 for the bistable of Fig. 5.1. **[3]**

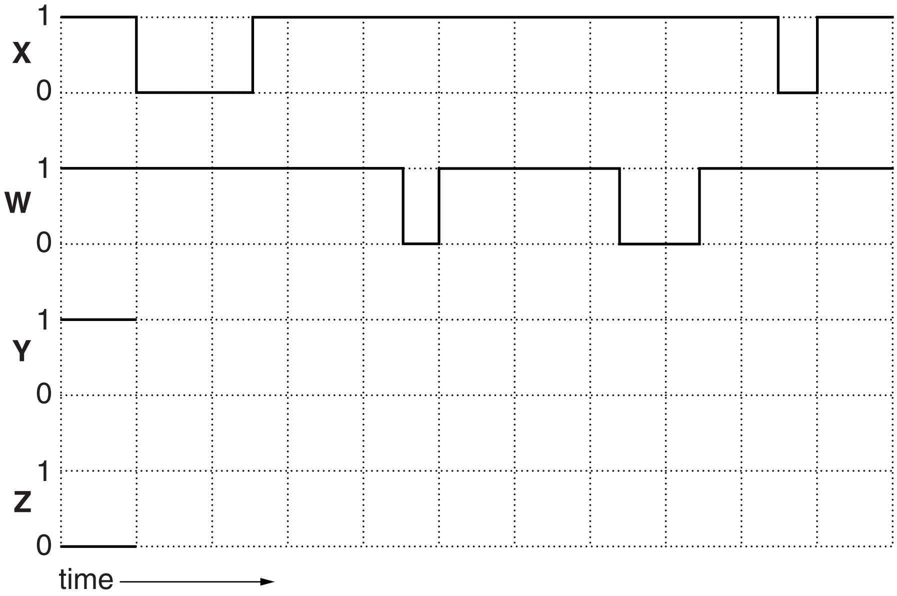


Fig. 5.2

[Total: 10]

6 Fig. 6.1 shows a block diagram for a simple timer which gives the time in seconds.

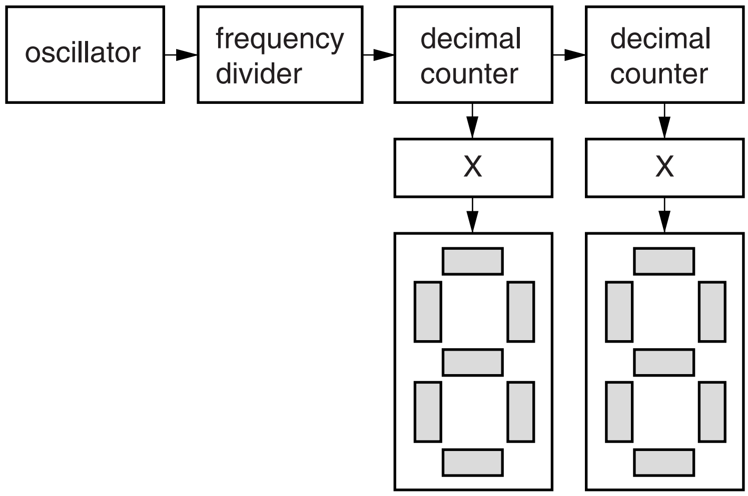


Fig. 6.1

(a) The frequency divider contains a chain of 10 D flip-flops, each arranged as a one-bit counter.

(i) Complete Fig. 6.2 to show how to arrange a D flip-flop and NOT gate as a one-bit counter. Label the input and output.

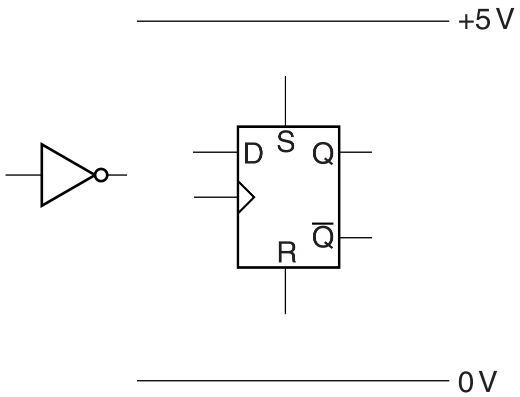


Fig. 6.2

[4]

(ii) The output of the chain of ten D flip-flops is a square wave with a frequency of 1.00 Hz. Calculate the frequency of the oscillator.

frequency = ... Hz **[1]**

(iii) Give a reason why the oscillator should be a crystal oscillator instead of a relaxation oscillator.

....

....

.... **[1]**

(b) The circuit of Fig. 6.1 uses a pair of seven segment LED displays to show the time in seconds. Complete these sentences for the function of the two blocks labelled X.
Choose words from this list.

four **nought** **one** **seven** **six** **ten** **two**

Each decimal counter outputs a __________ bit word, where each bit can be __________ or __________ .

Block X converts each of the __________ different words from the counter into the appropriate __________ bit word for the LED display. **[4]**

(c) Fig. 6.3 shows how the D flip-flops in the counters of Fig. 6.2. can be assembled from a pair of latches **L** and **R**.

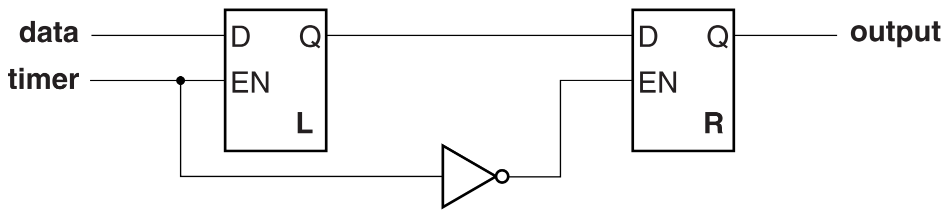


Fig. 6.3

The six statements (A to F) below can be used to explain the operation of the circuit of Fig. 6.3.

A The input **timer** is raised high.

B The input **timer** is returned low.

C Latch **R** allows the bit at D through to **output**.

D The bit at **data** is copied to output Q of latch **L**.

E Latch **L** does not allow the bit at **data** through to Q.

F The bit to be stored is placed at **data** while **timer** is low.

Fill the empty boxes below to show the correct order of statements.

F					

[3]

[Total: 13]

7 The audio amplifier circuit of Fig. 7.1 contains a summing amplifier and a volume control.

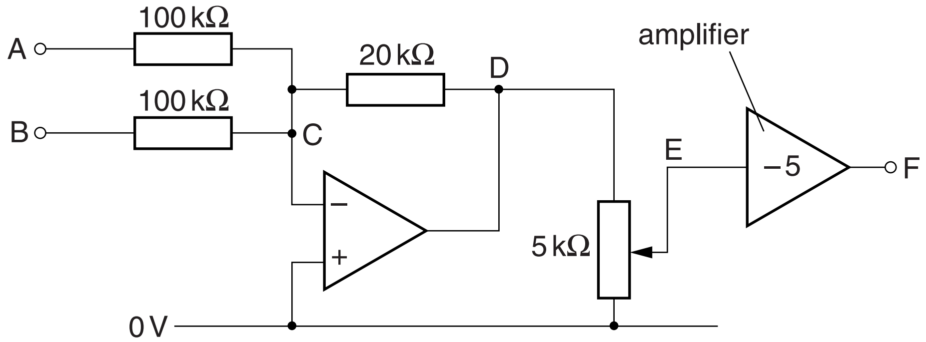


Fig. 7.1

(a) The circuit contains a volume control.
Put a (ring) around the component which provides the volume control. **[1]**

(b) A is held at +5.2 V and B at –1.3 V. Calculate the voltage at D.

voltage = ... V **[3]**

(c) The amplifier between E and F has a gain of –5.
Complete Fig. 7.2 to show how the amplifier can be constructed.
Show all component values.

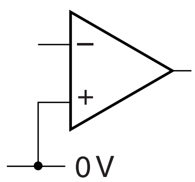


Fig. 7.2

[3]

[Total: 7]

8 This question is about the use of microcontrollers to build electronic systems.

(a) Draw straight lines to link the start of each sentence to its correct end.

start	end
The software is ...	... a digital system.
	... an analogue system.
The hardware is ...	... the memory of the microcontroller.
	... the logic gates in the microcontroller.
The computer is ...	... the machine code stored in the memory.
	... the plastic covering of the microcontroller.
The microcontroller is ...	... needed to convert a flowchart into machine code.

[4]

(b) Electronic systems can either be made from microcontrollers or from flip-flops, logic gates and op-amps.

(i) It is often cheaper to make systems from microcontrollers because they are widely used. Give a reason why microcontrollers are widely used.

....

....

.... **[1]**

(ii) Systems made from flip-flops, logic gates and op-amps do not require the use of an expensive computer. Suggest **another** advantage of building a system with flip-flops, logic gates and op-amps.

....

....

.... **[1]**

[Total: 6]

Quality of Written Communication [3]

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