Tuesday 29 May 2012 – Afternoon

A2 GCE ELECTRONICS

F614 Electronics Control Systems

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Duration: 1 hour 40 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 **110**.
- 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

Microcontroller instructions

The microcontroller contains eight general purpose registers Sn, where n = 0, 1, 2 ... 7.
The microcontroller has an eight bit input port, I, an eight bit output port, Q, and an analogue input, ADC.

In the table of assembler instructions given below, Sd is the destination register and Ss the source register.

assembler	**function**
MOVI Sd,n	Copy the byte n into register Sd
MOV Sd,Ss	Copy the byte from Ss to Sd
ADD Sd,Ss	Add the byte in Ss to the byte in Sd and store the result in Sd
SUB Sd,Ss	Subtract the byte in Ss from the byte in Sd and store the result in Sd
AND Sd,Ss	Logical AND the byte in Ss with the byte in Sd and store the result in Sd
EOR Sd,Ss	Logical EOR the byte in Ss with the byte in Sd and store the result in Sd
INC Sd	Add 1 to Sd
DEC Sd	Subtract 1 from Sd
IN Sd,I	Copy the byte at the input port into Sd
OUT Q,Ss	Copy the byte in Ss to the output port
JP e	Jump to label e
JZ e	Jump to label e if the result of the last ADD, SUB, AND, EOR, INC, DEC, SHL or SHR was zero
JNZ e	Jump to label e if the result of the last ADD, SUB, AND, EOR, INC, DEC SHL or SHR was not zero
RCALL s	Push the program counter onto the stack to store the return address and then jump to label s
RET	Pop the program counter from the stack to return to the place the subroutine was called from
SHL Sd	Shift the byte in Sd one bit left putting a 0 into the lsb
SHR Sd	Shift the byte in Sd one bit right putting a 0 into the msb

There are three subroutines provided:

- readtable – copies the byte in the lookup table pointed at by S7 into S0. The lookup table is labelled table: When S7=0 the first byte from the table is returned in S0
- wait1ms – waits 1ms before returning
- readadc – returns a byte in S0 proportional to the voltage at ADC

Datasheet

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	$V_{\text{out}} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \frac{R_f}{R_{\text{d}}}$
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	$\text{A}.\overline{\text{A}} = 0$ $\text{A} + \overline{\text{A}} = 1$
	$\text{A}.(\text{B} + \text{C}) = \text{A}.\text{B} + \text{A}.\text{C}$
	$\overline{\text{A}.\text{B}} = \overline{\text{A}} + \overline{\text{B}}$ $\overline{\text{A} + \text{B}} = \overline{\text{A}}.\overline{\text{B}}$
	$\text{A} + \text{A}.\text{B} = \text{A}$ $\text{A}.\text{B}. + \overline{\text{A}}.\text{C} = \text{A}.\text{B} + \overline{\text{A}}.\text{C} + \text{B}.\text{C}$
amplifier gain	$G = -g_{\text{m}}R_{\text{d}}$
ramp generator	$\Delta V_{out} = -V_{in}\frac{\Delta t}{RC}$

Answer **all** questions.

1 Fig. 1.1 shows an incomplete MOSFET voltage follower circuit.

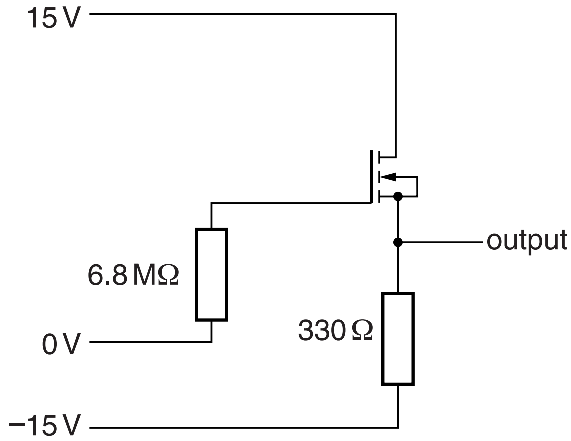


Fig. 1.1

(a) The voltage at the output is –2 V. Calculate the drain-source current through the MOSFET.

drain-source current = ... mA **[4]**

(b) Draw a capacitor on Fig. 1.1 to show how an ac signal can be input to the voltage follower. Write 'input' at the input connection. **[2]**

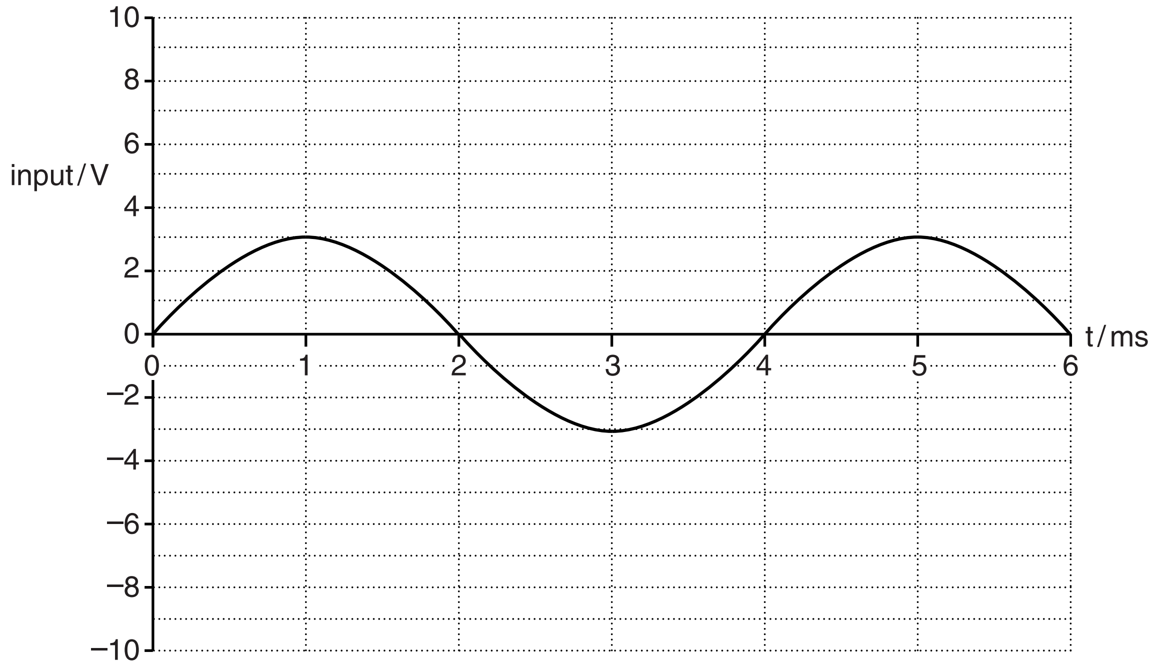
(c) Explain why voltage follower circuits are used.

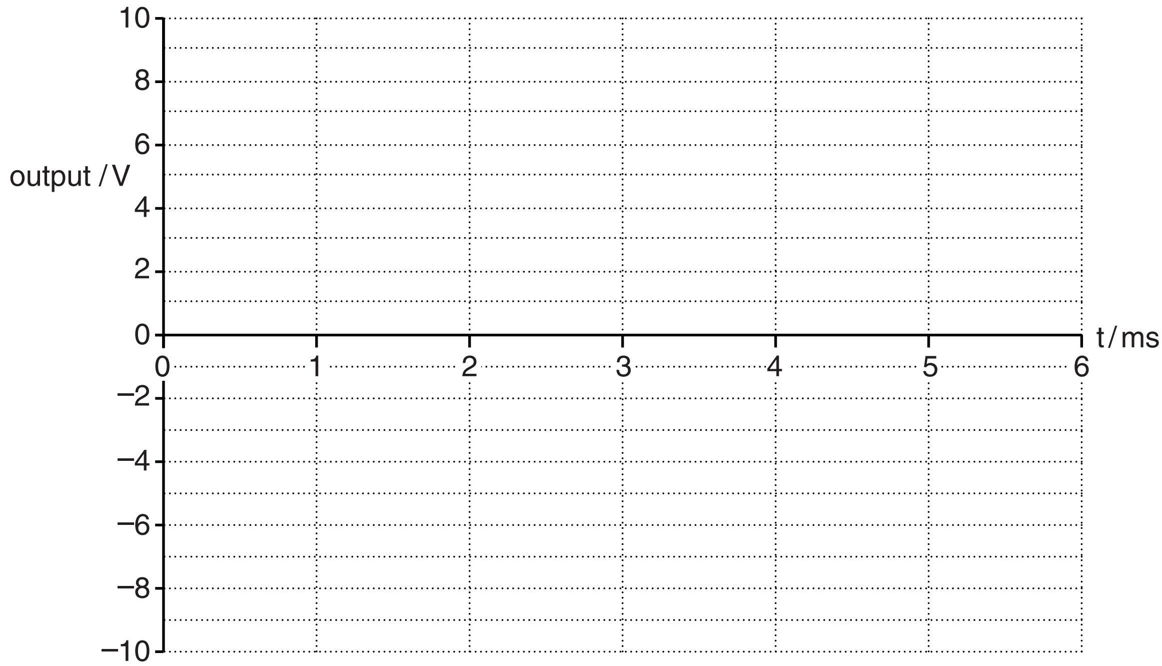
....

....

.... **[2]**

(d) The graph below shows how the voltage at the input varies with time. Draw on the axes to show how the output voltage varies with time.





[3]

[Total 11]

2 Part of a circuit for controlling the temperature of a soldering iron is shown in Fig. 2.1.

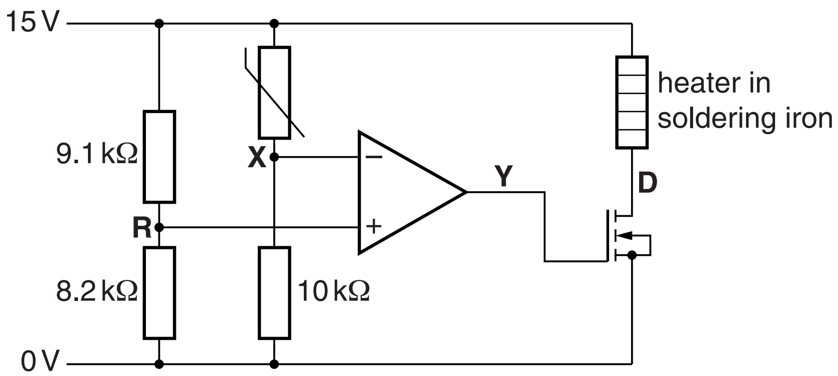


Fig. 2.1

(a) The circuit uses a thermistor to sense the temperature of the soldering iron. Draw a ring around the thermistor on Fig. 2.1. **[1]**

(b) Show that the voltage at **R** is about 7V.

[3]

(c) When the soldering iron is cold the voltage at **X** is 3V. Explain why the heater is on. Refer to the voltages in the circuit in your answer.

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.... **[4]**

(d) **(i)** Explain why the temperature of the soldering iron reaches a constant average value but never stops changing.

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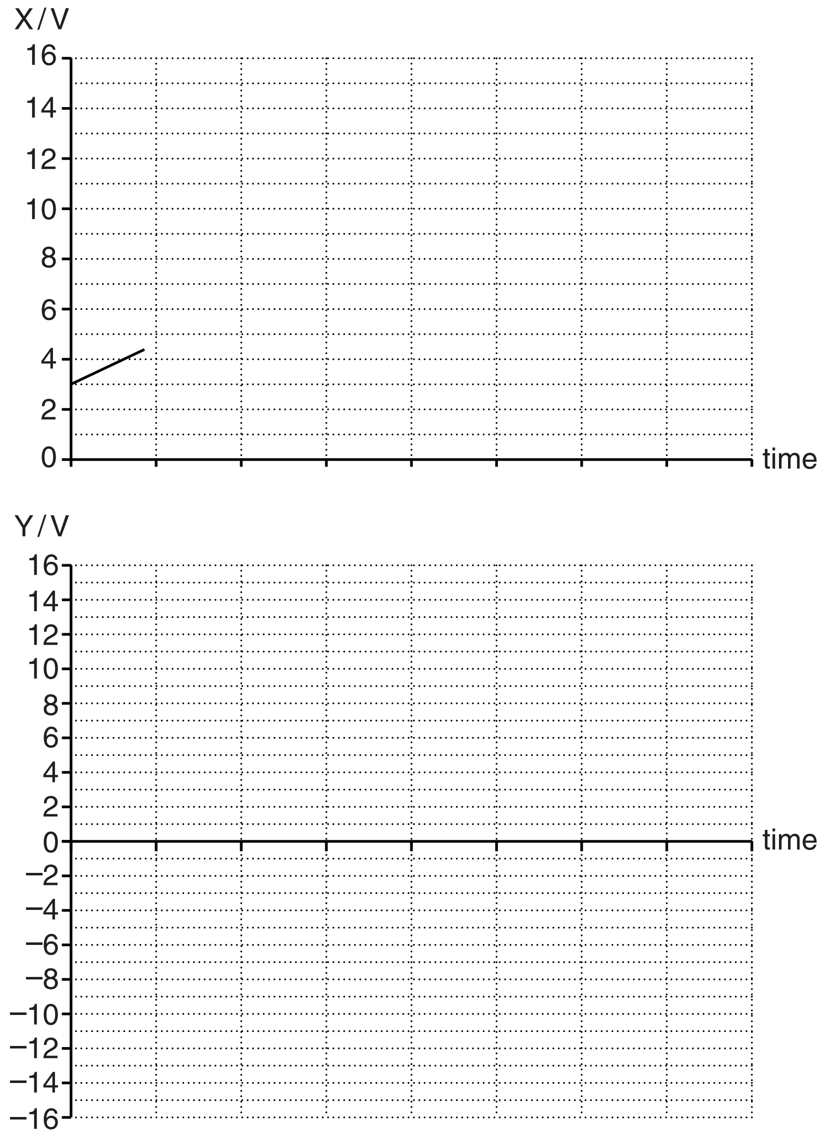
.... **[4]**

(ii) Complete the voltage-time graphs for **X** and **Y** to illustrate your answer to **(d)**. Assume the graph starts when the soldering iron is switched on from cold.



[4]

[Total 16]

3 Fig. 3.1 shows a memory module.

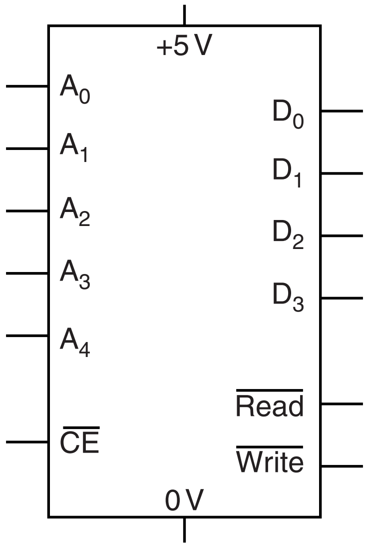


Fig. 3.1

(a) Calculate the number of memory locations in the memory module.

number of memory locations = ... **[2]**

(b) State the largest decimal number that each memory location can hold.

largest decimal number = ... **[1]**

(c) State the voltages on each address line and control line when memory address 03 is being read.

A_4 = ……V A_3 = ……V A_2 = ……V A_1 = ……V A_0 = ……V

$\overline{CE}$ = ……V $\overline{Read}$ = ……V $\overline{Write}$ = ……V **[5]**

(d) Describe the sequence of signals required to store the decimal number 2 at memory location 04.

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....

.... **[5]**

(e) Fig. 3.2 shows a larger memory module.

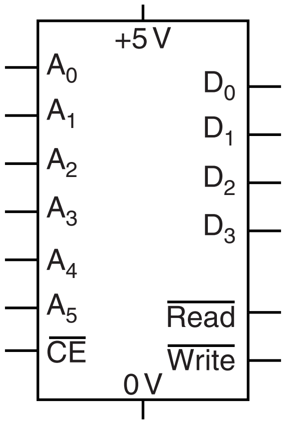
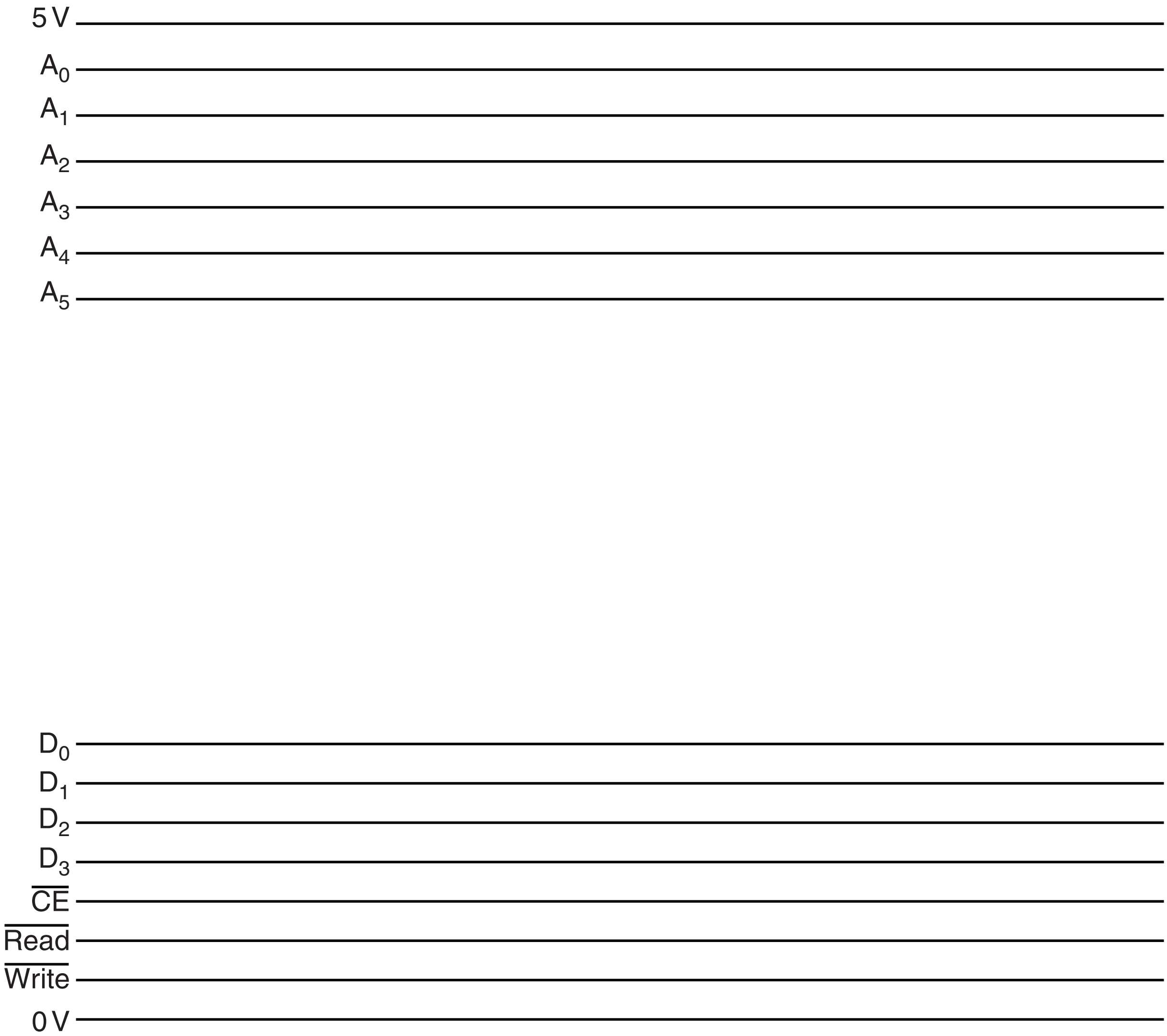


Fig. 3.2

Complete the diagram below to show how the larger memory module can be made from memory modules which are the same as Fig. 3.1 and logic gates.



[6]

[Total 19]

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4 This question is about microcontrollers.

(a) Describe what the **address bus** is in a microcontroller and what it is used for.

....

....

....

.... **[3]**

(b) State the location and describe the function of the **program counter** in a microcontroller.

....

....

....

....

.... **[4]**

(c) Show how a 4-bit output port of a microcontroller can be made from D flip-flops. Label the inputs from the data bus and the outputs.

[4]

(d) State the function of the **reset** pin on a microcontroller.

....

....

.... **[1]**

[Total 12]

5 The circuit in Fig. 5.1 is used as part of an in-car phone charger.

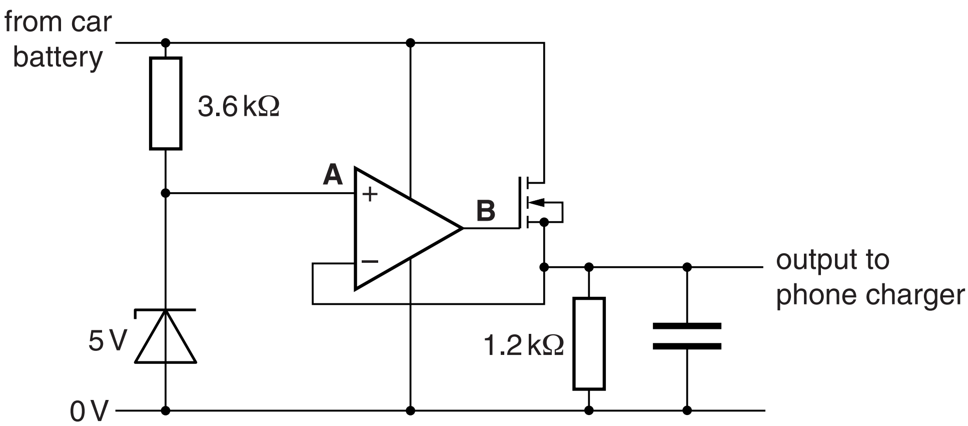

Fig. 5.1

(a) Explain why the output voltage of the circuit is 5V when the voltage from the car battery is 14V. Refer to the voltages at **A** and **B** in your answer. The threshold voltage of the MOSFET is 3V.

....

....

....

.... **[5]**

(b) Show that the current through the MOSFET is about 4 mA when there is nothing connected to the output of the circuit and the voltage from the car battery is 14V.

[2]

(c) Calculate the power dissipated in the MOSFET when the voltage from the car battery is 14 V and there is nothing connected to the output.

power in MOSFET = ... W **[3]**

(d) Explain why the MOSFET is needed in the circuit.

....

....

.... **[2]**

(e) Suggest why the circuit only works well when the voltage from the car battery is at least 10 V.

....

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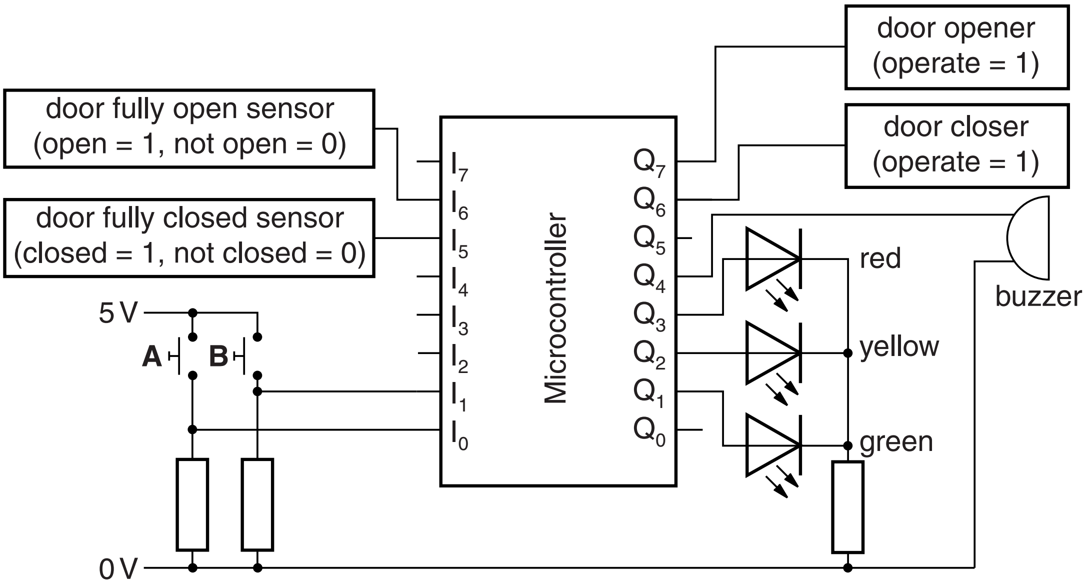
.... **[2]**

[Total 14]

6 The microcontroller circuit and program in Fig. 6.1 operate the sliding doors on a train. The main program calls a number of subroutines to operate the train doors, LEDs and buzzer.




```
main: RCALL   opendoor
      RCALL   switcha
      RCALL   warn
      RCALL   closedoor
      RCALL   switchb
      JP      main
```

Fig. 6.1

(a) The subroutine `opendoor` opens the train doors. Explain what each part of the subroutine does by filling in the explanation on each line. Look at Fig. 6.1 and refer to the electronic devices connected to the inputs and outputs in your explanations. The first one has been done for you.

Label	Instruction	Explanation
`opendoor:`	`MOVI  S4, 88` `OUT   Q, S4`	turn on door opener and red LED
	`MOVI  S3, 40`	....
`loop:`	`IN    S2, I`	....
	`AND   S2, S3`	....
	`JZ    loop`	....
	`MOVI  S4, 08` `OUT   Q, S4`	....
	`RET`	....

[6]

(b) The subroutine `warn` is shown below.

```
warn: MOVI   S5, 02
loop: MOVI   S6, 10
      OUT    Q, S5
      RCALL  wait10s
      SHL    S5
      SUB    S6, S5
      JNZ    loop
      RET
```

The subroutine `wait10s` produces a delay of 10 seconds.

Explain the effect of the subroutine `warn` on the circuit.

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....

.... **[4]**

(c) The subroutine `switcha` waits until switch **A** has been pressed and then returns to the main program. Write the code for the subroutine `switcha`.

`switcha:` ....

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....

.... **[5]**

(d) Write the subroutine `wait10s` to produce a delay of 10 seconds. You should use the instruction `RCALL wait1ms` which produces a delay of 1 ms in your code.

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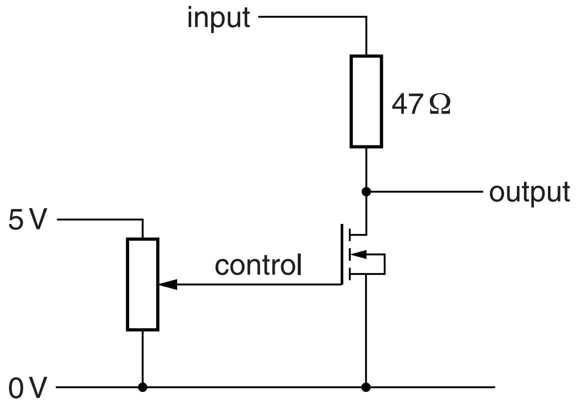
.... **[6]**

[Total 21]

7 An engineer designs an electronic volume control for the music system in a supermarket. The electronic volume control circuit and the graph of the MOSFET characteristics are shown in Fig. 7.1.



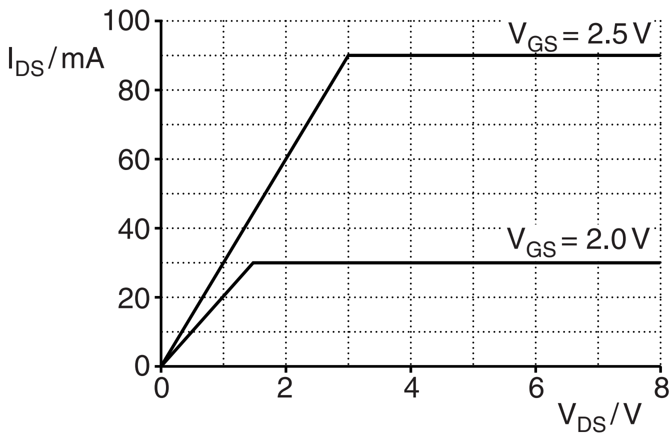


Fig. 7.1

(a) Mark the drain, gate and source on the MOSFET in Fig. 7.1 with the letters **D**, **G** and **S**. **[2]**

(b) Do a calculation to show that the resistance of the MOSFET is about 30 Ω when the voltage at **control** is 2.5 V and **input** is small.

resistance of MOSFET = ... Ω **[2]**

(c) Calculate the amplitude of **output** when voltage at **control** is 2.5 V and the amplitude of **input** is 0.8 V.

amplitude of output signal = ... V **[2]**

(d) Explain what happens to **output** when **control** is reduced to 2 V without changing **input**.

....

....

.... **[2]**

(e) Explain why the electronic volume control will only work well for small input signals. Refer to the graph of characteristics in your answer.

....

....

.... **[2]**

(f) Explain what will happen to **output** when voltage at **control** is 2.5V and the amplitude of **input** is increased slowly from 0.8V to 8V.

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.... **[4]**

[Total 14]

Quality of Written Communication [3]

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