OCR
Oxford Cambridge and RSA

Tuesday 9 June 2015 – Afternoon

A2 GCE ELECTRONICS

F614/01 Electronic 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

DC (RW/SW) 106798/2

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

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	$T = 0.7RC$
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	$A.\overline{A} = 0$ $A + \overline{A} = 1$
	$A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$ $\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$ $A.B. + \overline{A}.C = A.B + \overline{A}.C + B.C$
amplifier gain	$G = -g_m R_d$
ramp generator	$\Delta V_{out} = -V_{in}\frac{\Delta t}{RC}$

Answer **all** questions.

1 Fig. 1.1 shows an incomplete MOSFET amplifier circuit.

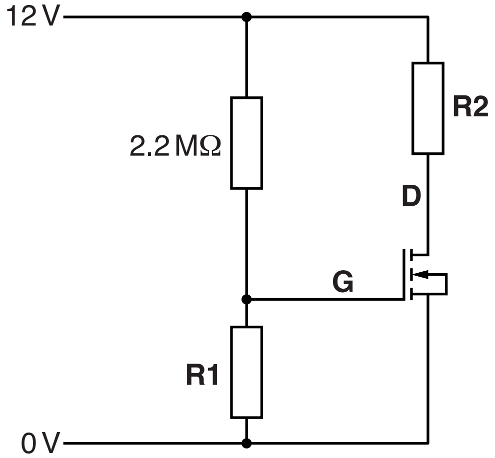

Fig. 1.1

(a) Add components and connections to Fig. 1.1 to show how an a.c. signal can be input and output from the amplifier.
Label the input and the output of the amplifier. **[3]**

(b) Calculate the value of **R1** required to make the voltage at **G** equal to 2.7 V.

value of **R1** = ... Ω **[3]**

(c) The graph in Fig. 1.2 shows some of the MOSFET characteristics.

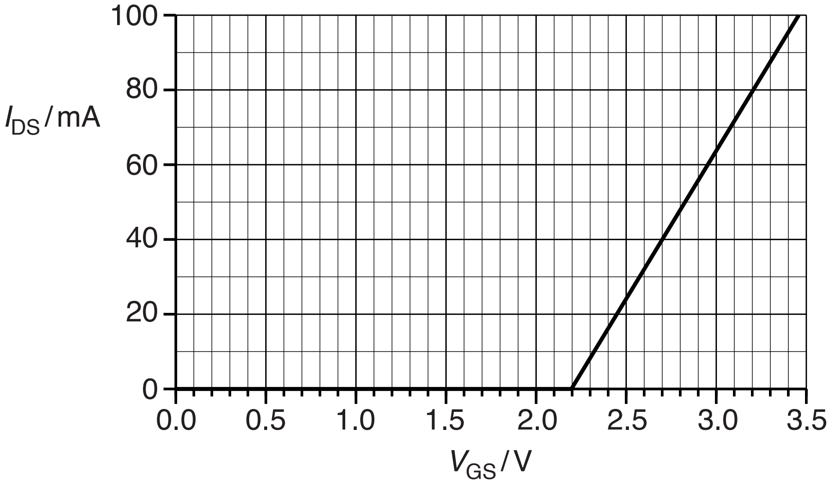

Fig. 1.2

Use the graph in Fig. 1.2 to find the transconductance of the MOSFET.

transconductance = ... S **[1]**

(d) The circuit has been designed to have a voltage of 7 V at **D** when there is no ac signal at the input.

(i) Explain why the circuit has been designed with the voltage at **D** to be about half of the supply voltage.

....

....

.... **[2]**

(ii) Use information from **(b)** and Fig. 1.2 to help calculate the value of **R2**.

value of **R2** = ... Ω **[2]**

(e) Use information from **(c)** and **(d)** to calculate the ac gain of the amplifier.

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

2 Fig. 2.1 shows a diagram of a microcontroller with some of the labels missing.

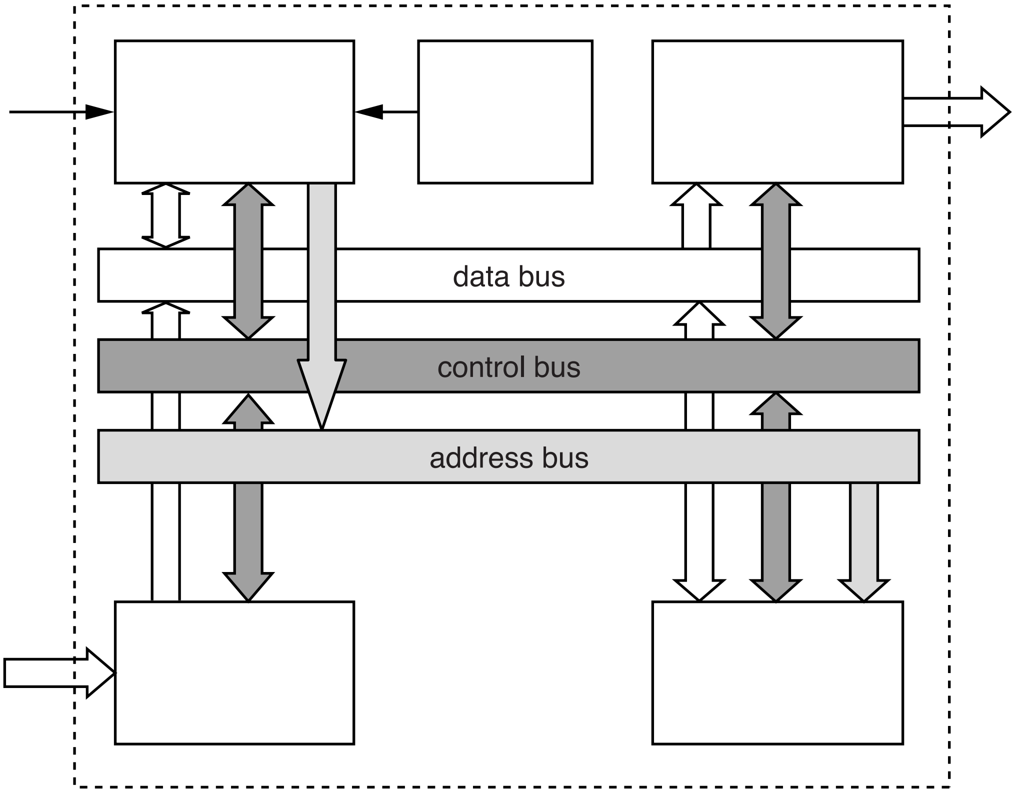

Fig. 2.1

(a) Complete the diagram in Fig. 2.1 by labelling the blocks.
Choose labels from the list below.

clock **CPU** **input port** **mask** **memory** **output port** **stack pointer**

[5]

(b) Describe the data bus and its function in a microcontroller.

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.... **[4]**

(c) Show how a 4-bit input port can be constructed from tristates.
Label the input pins $I_0 – I_3$, the data lines $D_0 – D_3$ and the read signal.

[4]

(d) State **two** uses of the memory in a microcontroller.

....

....

....

.... **[2]**

(e) The program counter is part of a microcontroller.

(i) State the location of the program counter in the microcontroller.

.... **[1]**

(ii) Explain what the program counter is and describe its function.

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.... **[3]**

3 Fig. 3.1 is the block diagram for a memory module.

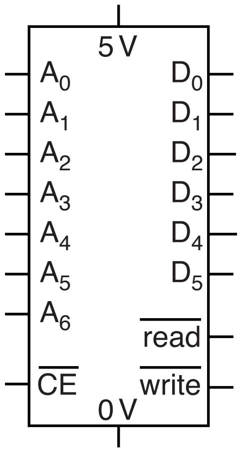


Fig. 3.1

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

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

(b) Calculate the number bits of information the memory module can hold.

number of bits = ... **[1]**

(c) The memory is used to store decimal numbers using two's complement.

Calculate the highest number that the memory can hold.

highest number = ... **[1]**

(d) State and explain the effect of holding $\overline{CE}$ high.

....

....

.... **[2]**

(e) A word is read from the memory location 3A.

State the **voltages** on each address line and control line.

A_5 = ... V 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]**

4 Fig. 4.1 shows the circuit diagram of a power supply assembled by a student.

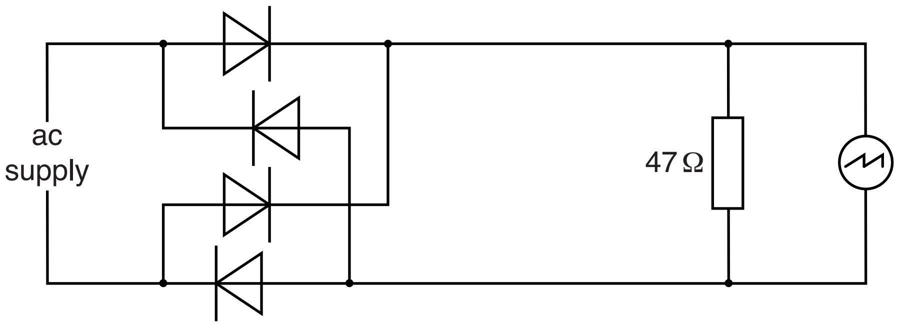


Fig. 4.1

(a) Fig. 4.2 shows how the voltage of the ac supply changes with time.
Draw on Fig. 4.2 to show how the voltage across the oscilloscope in Fig. 4.1 varies with time.

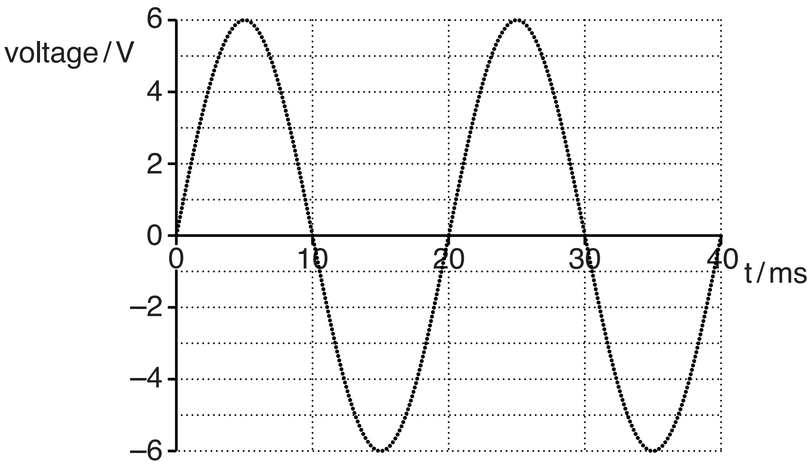
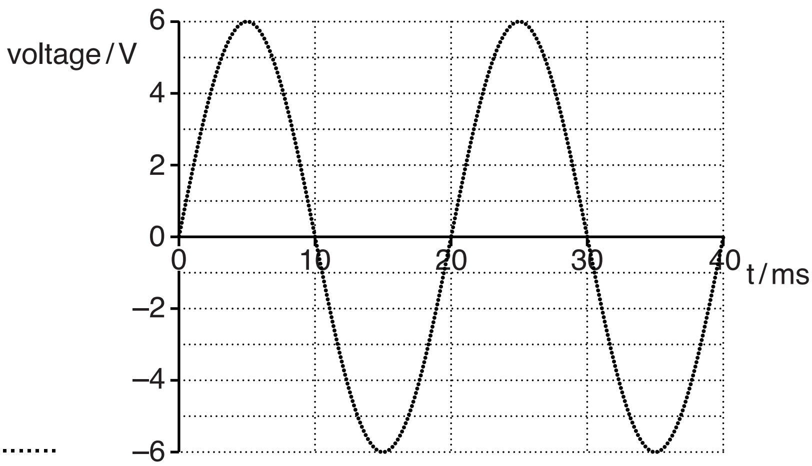


Fig. 4.2 **[4]**

(b) Draw a capacitor on Fig. 4.1 to make a smoothed unstabilised supply across the oscilloscope. **[1]**

(c) Calculate the time constant with a 300 μF capacitor and hence draw on Fig. 4.3 to show the voltage across the oscilloscope.



time constant = ...

Fig. 4.3 **[6]**

(d) An alternative to the power supply in Fig. 4.1 is the switch mode power supply shown in Fig. 4.4.

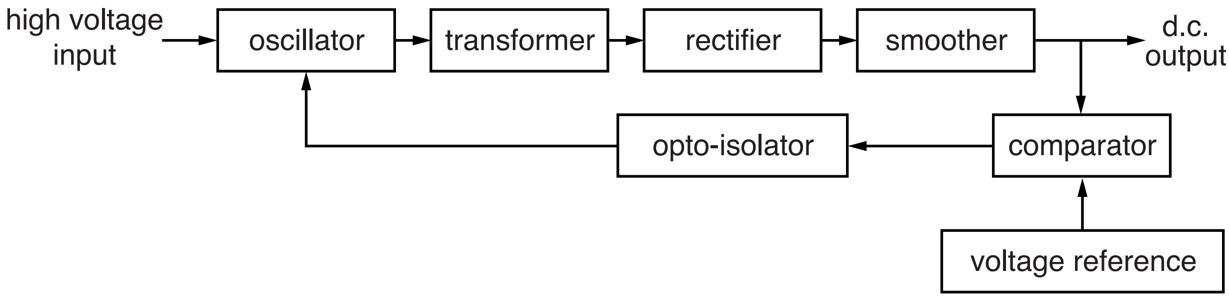


Fig. 4.4

State **two** advantages of the switch mode power supply in Fig. 4.4 compared with the power supply in Fig. 4.1.

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.... **[2]**

(e) Explain how the switch mode power supply works by describing the function of each block in Fig. 4.4.

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.... **[7]**

5 The person in charge of security in a large shop wishes to control the direction the security camera is pointing using a suitable electronic circuit. Fig. 5.1 shows a possible system.

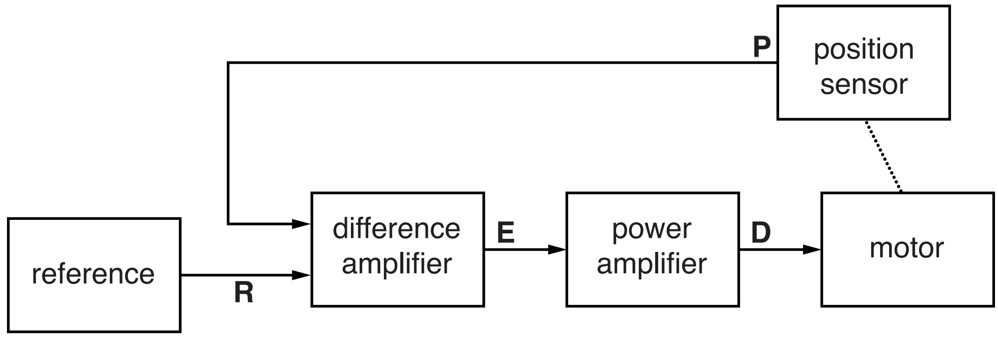


Fig. 5.1

(a) The system uses proportional feedback. Explain why on-off feedback is not suitable for this application.

....

....

.... **[2]**

(b) Add components and connections to Fig. 5.2 to complete the circuit of the difference amplifier in Fig. 5.1. Mark all components with suitable values.

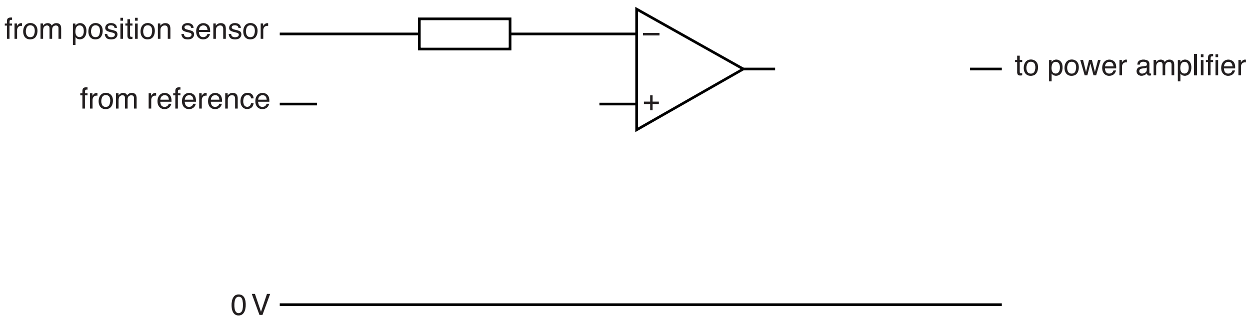
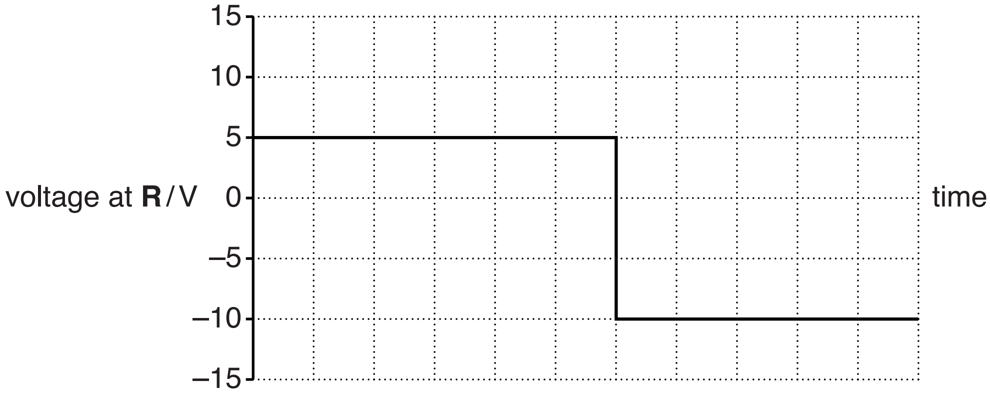


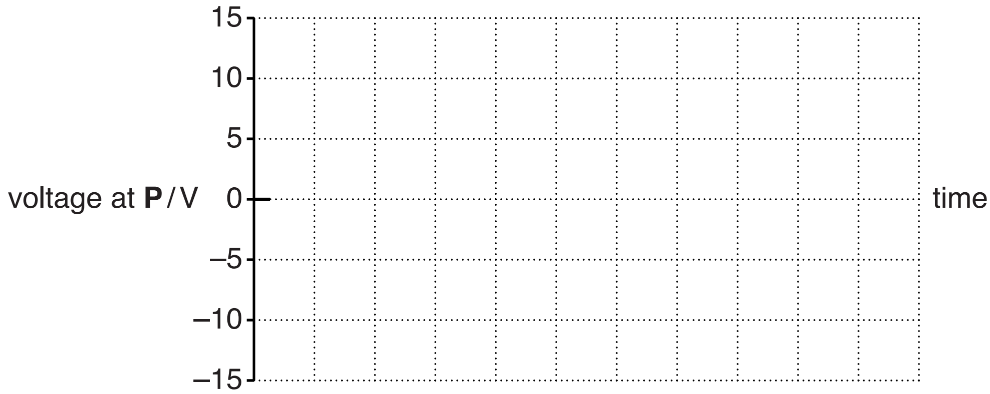
Fig. 5.2 **[5]**

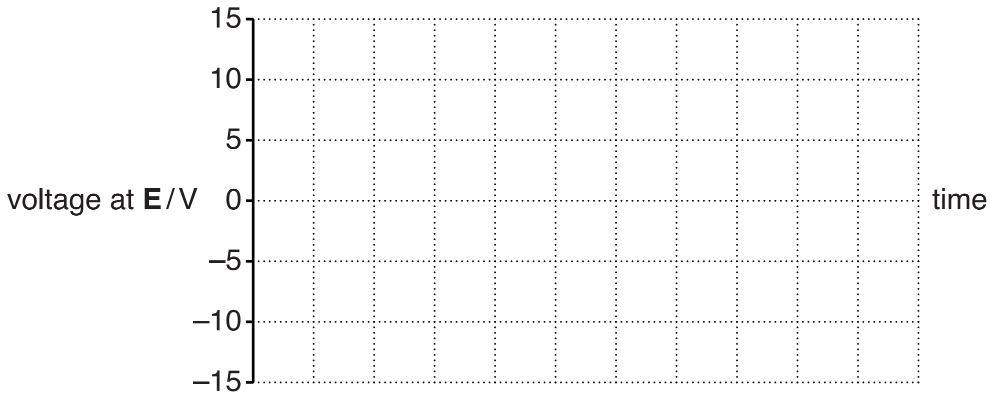
(c) The power amplifier has a gain of 2. Draw a circuit diagram for the power amplifier based on a high power op-amp and any other components you require. Label the input and output and give component values.

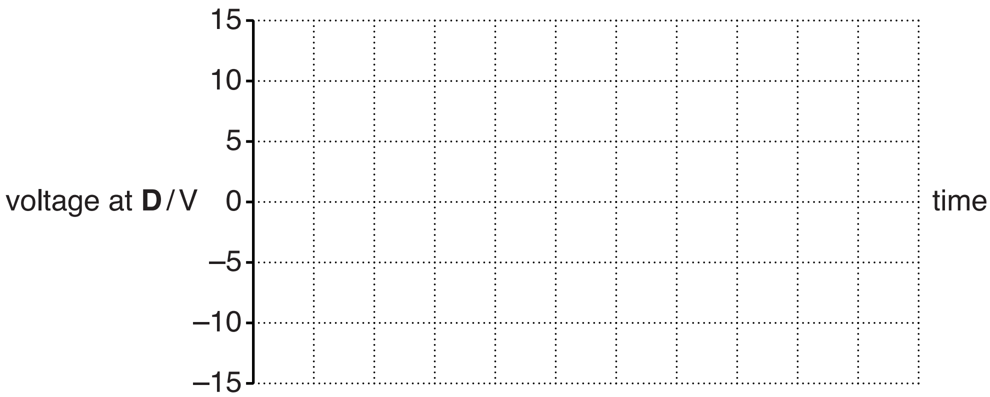
[4]

(d) Complete the graphs of voltage against time for the system in Fig. 5.1 when it is first switched on.
The voltage at **P** is initially 0 V.



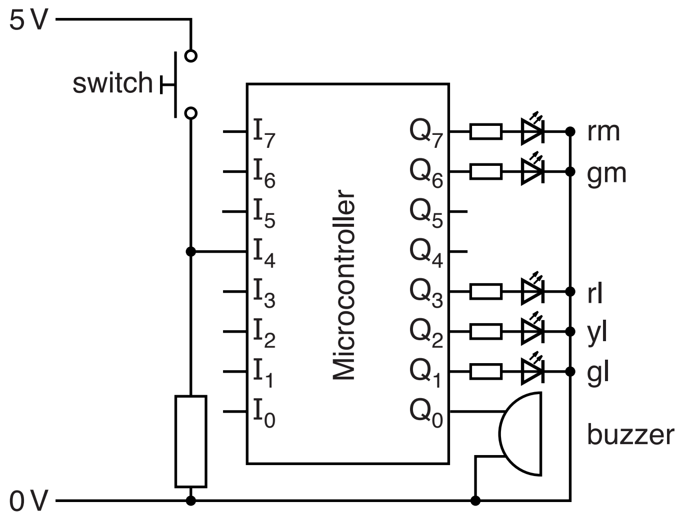






[6]

6 Fig. 6.1 shows the circuit and main program for a student project which controls a model set of traffic lights at a pedestrian crossing.




```
loop: RCALL glrm
      RCALL chkbutton
      RCALL ylrm
      RCALL rlgm
      RCALL ylgm
      JP    loop
```

Fig. 6.1

(a) Complete the subroutine `ylrm` to turn on the LEDs yl and rm and leave everything else off.

```
ylrm:      RCALL wait20s
```

....

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.... **[4]**

(b) Complete the subroutine `chkbutton` which waits for the signal from the switch to go high before returning to the main program.

`chkbutton:` ....

....

....

....

.... **[5]**

(c) Describe in detail the effect of the subroutine `ylgm` on the circuit in Fig. 6.1.
The subroutine wait20s waits for 20 seconds.
The subroutine wait250ms waits for 250 milliseconds.

```
ylgm:       RCALL wait20s
            MOVI  S2, 09
            MOVI  s3, 10
            MOVI  S4, 49
nxt:        OUT   Q, s2
            EOR   S2, S4
            RCALL wait250ms
            DEC   s3
            JNZ   nxt
            RET
```

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.... **[6]**

(d) Write the subroutine `wait20s` to wait for 20s before returning.
You should use the subroutine `wait1ms` which waits for 1 millisecond in your subroutine.

[5]

7 Fig. 7.1 shows a circuit for controlling the brightness of an LED.
The LED conducts when there is 3.4 V across it.

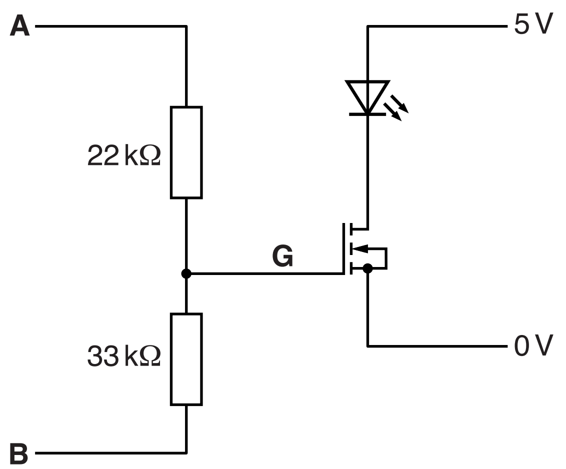

Fig. 7.1

(a) Show that the voltage at **G** is 3 V when the voltage at **A** is 5 V and the voltage at **B** is 0 V.

[1]

(b) Fig. 7.2 shows how I_{DS} depends on V_{DS} when V_{GS} = 3 V.

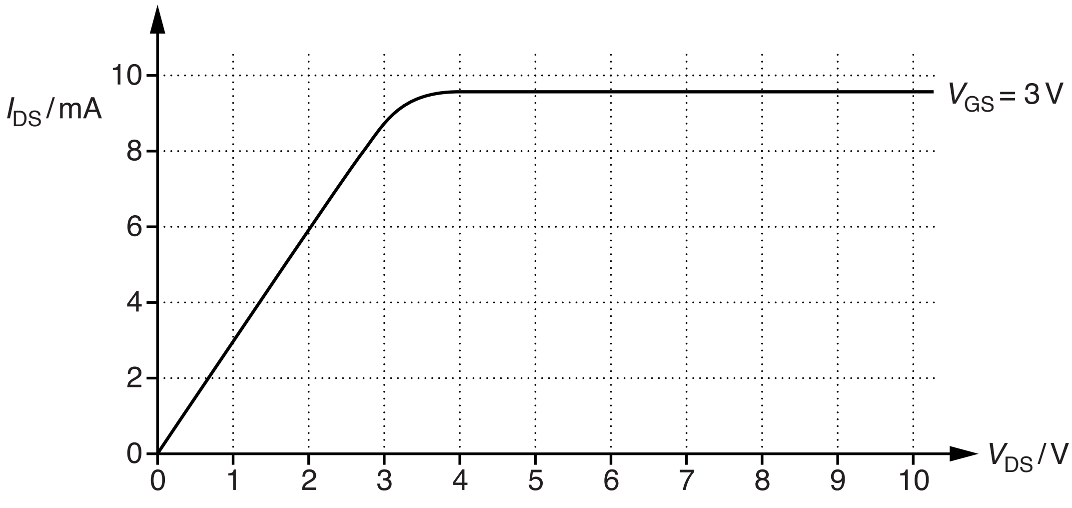

Fig. 7.2

Calculate the resistance of the MOSFET when the voltage at **A** is 5 V and the voltage at **B** is 0 V.

resistance = ... Ω **[1]**

(c) The LED conducts when there is a voltage of 3.4 V across it.
Calculate the current through the LED when the voltage at **A** is 5 V and the voltage at **B** is 0 V.

current through LED = ... mA **[2]**

(d) The voltages are changed so that the voltage at **A** is 0 V and the voltage at **B** is 5 V, reducing the voltage at **G**.

Sketch a curve on Fig. 7.2 for the new voltage at **G** and hence explain the effect this has on the brightness of the LED.

....

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....

....

.... **[3]**

Quality of written communication **[3]**

END OF QUESTION PAPER

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