OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

Advanced GCE

Electronics

F614 QP

Unit F614: Electronic Control Systems

Specimen Paper

Candidates answer on the question paper.

Time: 1 hour 40 mins

Additional Materials:
Scientific calculator

Candidate Name	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- 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
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **110**.

FOR EXAMINERS' USE		
Qu.	**Max.**	**Mark**
1	**10**	
2	**19**	
3	**14**	
4	**22**	
5	**21**	
6	**10**	
7	**14**	
TOTAL	**110**	

This document consists of **16** printed pages.

  [QAN 500/2583/1]

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

Microcontroller instructions

The microcontroller contains eight general purpose registers Sn, where to 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 A7 into A0. The lookup table is labelled table: When A7=0 the first byte from the table is returned in A0
- wait1ms - waits 1ms before returning
- readadc - returns a byte in A0 proportional to the voltage at ADC

1 Explain the following as they apply to microcontroller systems.

(a) Look-up table

.....

.....

.....

.....

..... **[2]**

(b) Stack pointer

.....

.....

..... **[2]**

(c) Program counter

.....

.....

.....

..... **[3]**

(d) Subroutine

.....

.....

.....

.....

..... **[3]**

2 A student performs an experiment to measures the transfer characteristics of an n-channel MOSFET.

(a) Draw on the diagram opposite in Fig. 2.1 to show how the circuit should be connected. Include in the diagram a voltmeter to measure the gate-source voltage and an ammeter to measure the drain current.

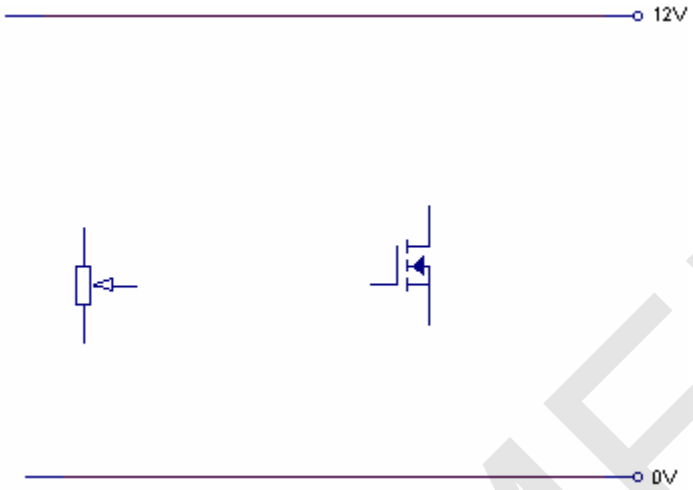

Fig 2.1

[4]

The student draws the graph in Fig. 2.2 from the results of the experiment.

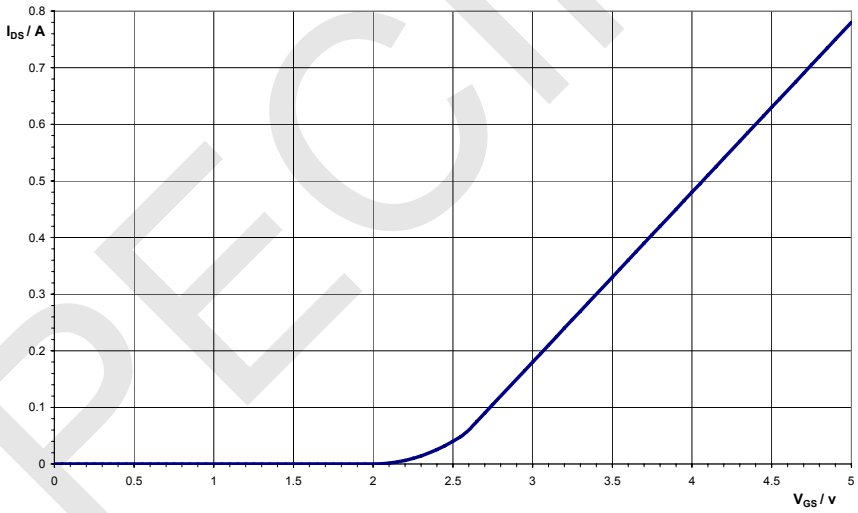

Fig. 2.2

(b) Use the graph to find the threshold voltage of the MOSFET.

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

(c) Use the graph to explain why the transconductance of the MOSFET is about 0.3 S

[2]

[Turn over

(d) The MOSFET is now used to build the amplifier in Fig. 1.3. Draw two capacitors and connections for the input and output for a.c. signals on Fig. 1.3. Label the input and output. **[3]**

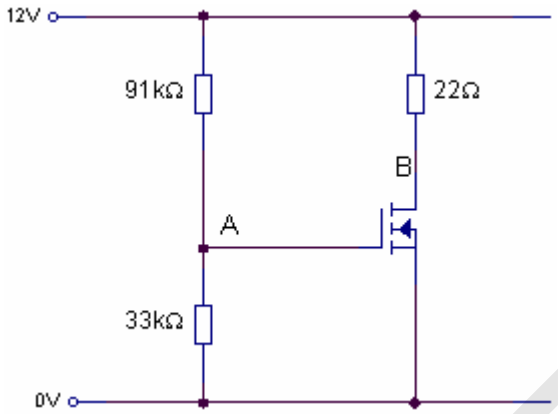

Fig. 1.3

(e) Calculate the gain of the amplifier.

Gain = ... **[2]**

(f) By calculating the voltage at B when there is no a.c. input to the amplifier, comment on the suitability of the circuit as an amplifier of large amplitude signals.

.....

.....

.....

.....

[7]

3 Fig. 3.1 shows a memory chip

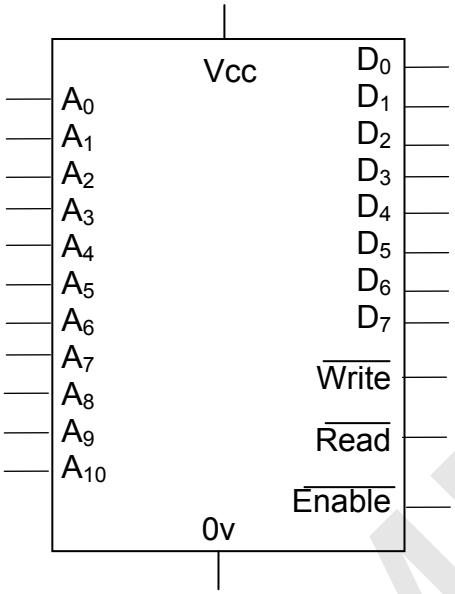

Fig. 3.1

(a) This is a volatile memory chip. Explain what is meant by **volatile**.

.....

.....

..... **[2]**

(b) Calculate how many different addresses the memory chip in Fig. 3.1 contains

Number of addresses = ... **[2]**

(c) The hexadecimal number A3 is put on the data inputs. Write down the binary code for A3 in the table below.

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0

[2]

(d) Describe the sequence of signals required to write the hexadecimal number A3 to address 00110000100 and then read the contents of address 1001001110.

.....

.....

.....

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.....

.....

..... **[5]**

4 Fig. 4.1 shows a mains operated power supply circuit.

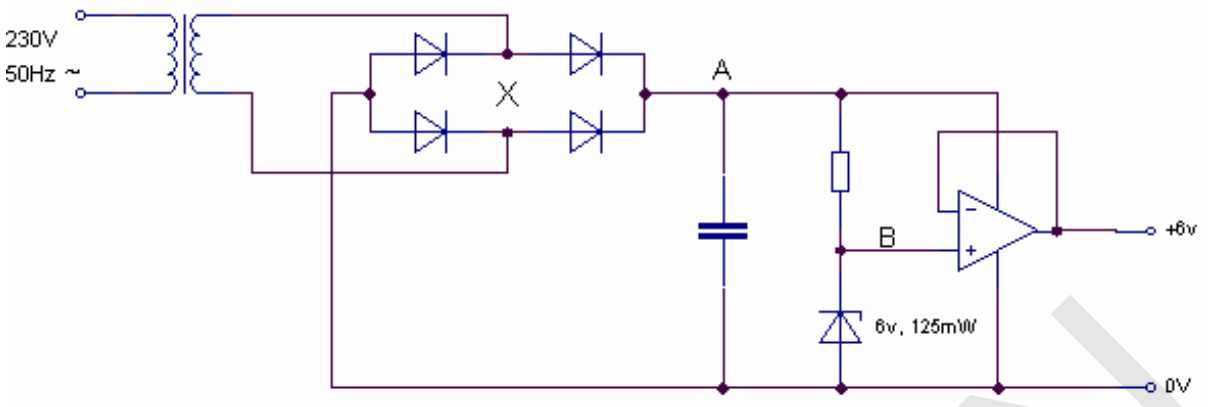


Fig. 4.1

(a) **(i)** Give the full name of the arrangement of components labelled X in Fig. 4.1.

..... **[2]**

(ii) Describe the function of X.

.....

.....

.....

..... **[3]**

(b) Sketch the transfer characteristics for X on the axes below

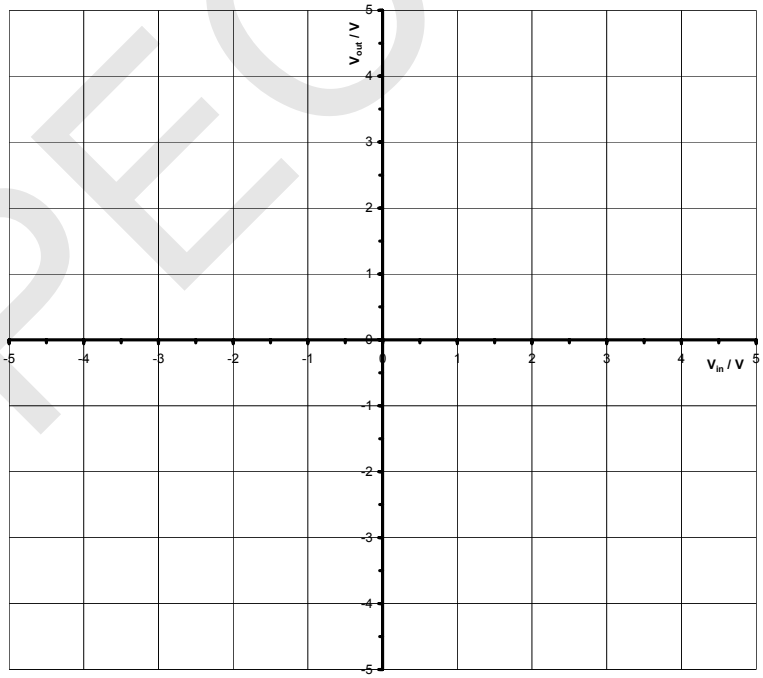


Fig 3.2

[3]

[Turn over

(c) Explain how the capacitor smoothes the voltage at point A.

.....

.....

.....

..... **[3]**

(d) The zener diode and resistor hold point B at a steady +6 V.

The zener diode has a power rating of 125mW.

(i) Show that the maximum safe current for the zener diode is about 20 mA.

[3]

(ii) Select a suitable value for the resistor. Justify your choice with a calculation.

Resistor value ..... Ω **[3]**

(e) Complete these sentences for the op-amp.

The op-amp has ..... feedback.

This makes the ..... at the output and non-inverting terminal the same.

The op-amp allows the ..... at its output to be much larger than at its input. **[3]**

(f) State two advantages of replacing the power supply in Fig. 4.1 with a switch mode power supply.

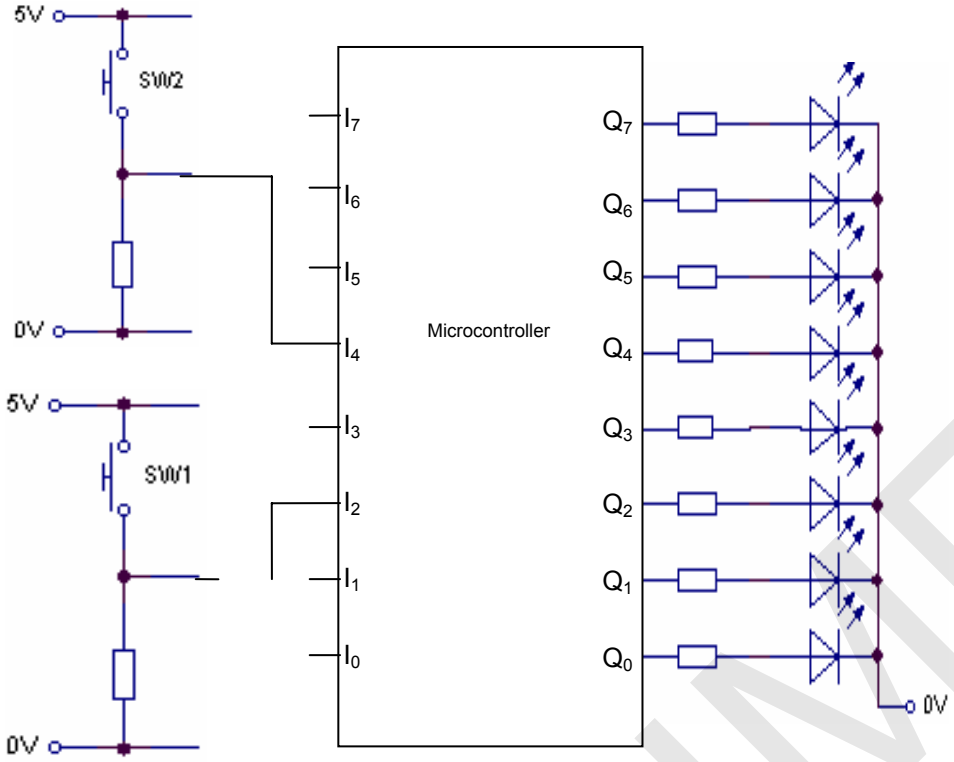
.....

.....

..... **[2]**

5 In this question you should use the instructions set in the data sheet.

The circuit and program in Fig. 5.1 operate a red LED bike light.




```
start:  movi   S0,0
        out    Q,S0
        rcall
buttoncheck
first:  movi   S7,0
next:   rcall
tableread
        out    Q,S0
        rcall
wait100ms
        in     S0,I
        movi   S1,10
        and
S0,S1
        jnz    start
        inc    S7
        movi   S3,6
        sub
```

Fig. 5.1

(a) Explain what the first two lines of the program do to the circuit

```
movi    S0,0
out     Q,S0
```

.....

.....

..... **[2]**

(b) The subroutine *buttoncheck* allows the on switch to carry out its function. Explain how the subroutine works referring to the relevant switch.

Labels	Instructions		Explanation
buttoncheck:	in	S0,I	.....
	movi	S1,04	.....
	and	S0,S1	.....
	jz	buttoncheck	.....
	ret		.....

[5]

[Turn over

(c) The subroutine *tableread* gets the data from the table to make the lights come on in the sequence shown below. Complete the table in hexadecimal

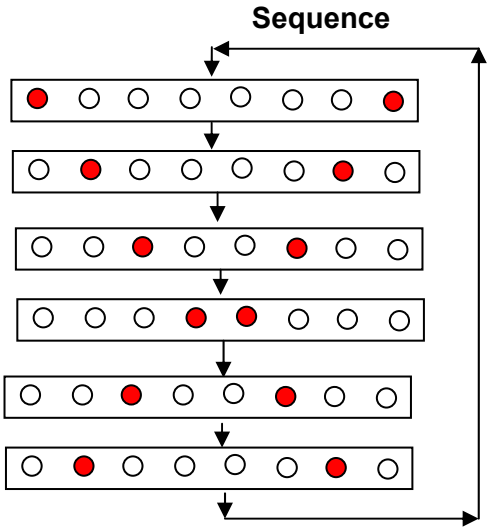


Fig. 5.2

table: .....

.....

.....

.....

.....

.....

[5]

(d) Now write a subroutine to produce a time delay of 100ms called "delay". The subroutine "wait1ms" produces a delay of 1ms. Call the subroutine "wait1ms" from your subroutine.

Labels	Instructions	Explanations
wait100ms:	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

[5]

(e) Explain how the program allows the user to turn off the lights. Copy out the instruction which performs this task.

.....

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.....

.....

..... **[4]**

6 Part of the electronic system to work like two six sided dice is shown in Fig. 6.1 below. .

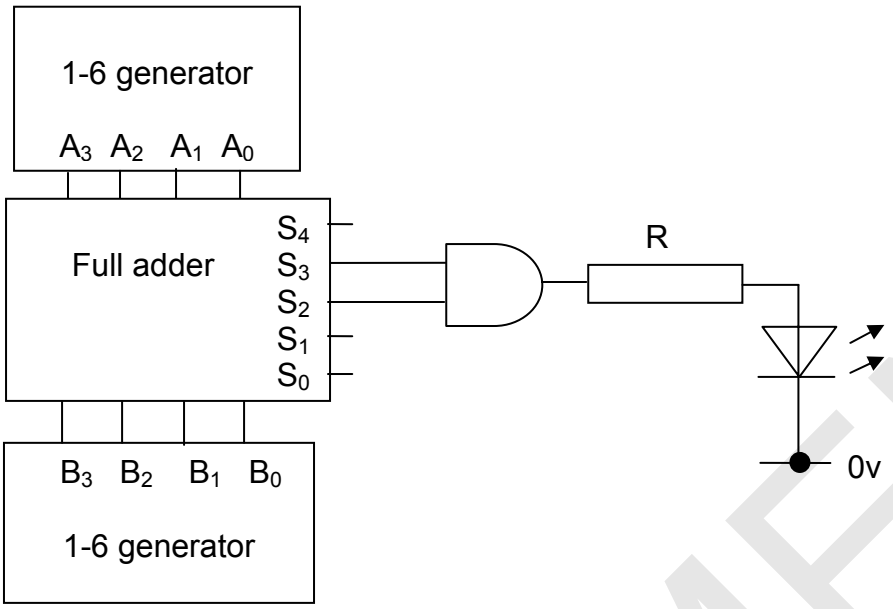

Fig. 6.1

(a) The output of the AND gate is at 5v when it is high. Calculate a suitable value for the resistor R so that the LED glows when Q is high. State your assumptions about the LED.

.....

.....

.....

..... **[4]**

(b) Explain why the LED turns on when A_3 A_2 A_1 A_0 = 0110 and B_3 B_2 B_1 B_0 = 0110.

.....

.....

.....

..... **[3]**

(c) In the space below, draw a circuit whose LED only glows when the output of both generators is not the same ($A_3\ A_2\ A_1\ A_0 \neq B_3\ B_2\ B_1\ B_0$). Explain the operation of your circuit.

[3]

7 Fig. 7.1 shows a circuit designed to control the speed and direction of a small d.c. motor M.

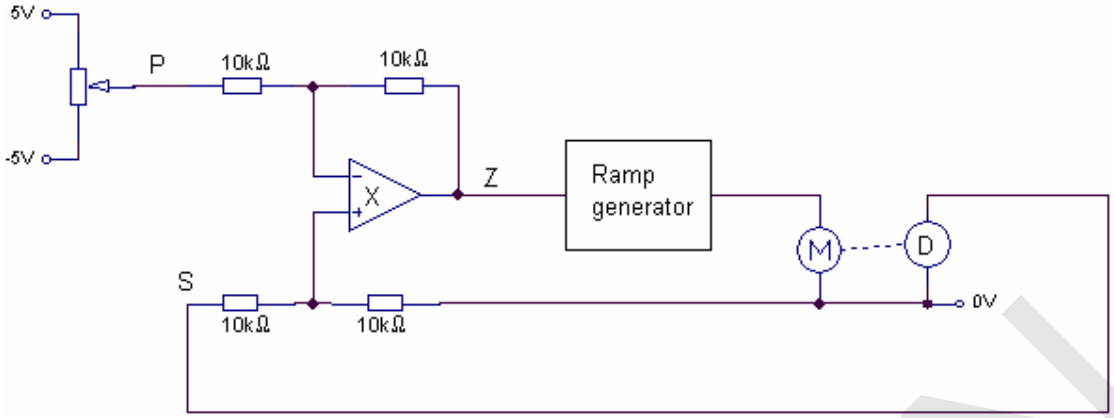

Fig. 7.1

The speed sensor D is turned by the shaft of the motor and produces a d.c. voltage *S*.

(a) State the name of the circuit built around the op-amp X in Fig. 7.1.

..... **[1]**

(b) Give a formula for the voltage *Z* at the output voltage of the op-amp Z in terms of the voltage *P* and the voltage *S*.

Z = ... **[1]**

(c) **(i)** Complete Fig. 7.2 for an ramp generator using the op-lamp. Label the input and the output.

You do not need to give component values.

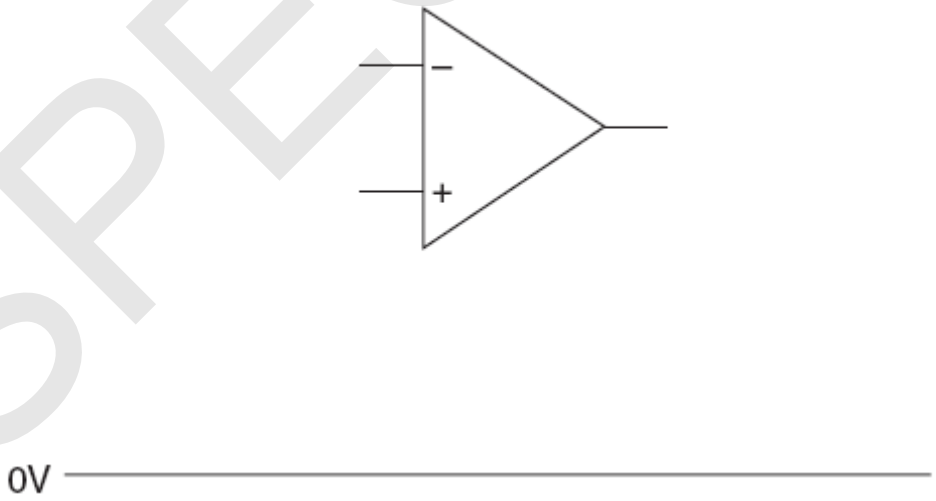

Fig. 7.2

[4]

[Turn over

(ii) Describe how the ramp generator output responds to an input of:

0V .....

.....

+5V .....

..... **[2]**

(d) As the motor speeds up the voltage at S rises.

P is initially set to 0V causing the motor to be stationary and the speed sensor output *S* is 0V. The potentiometer wiper is moved so that P becomes +5 V.

Describe and explain how the system reacts.

The quality of your written communication will be assessed in this question.

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.....

.....

..... **[9]**

Paper Total [110]

OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

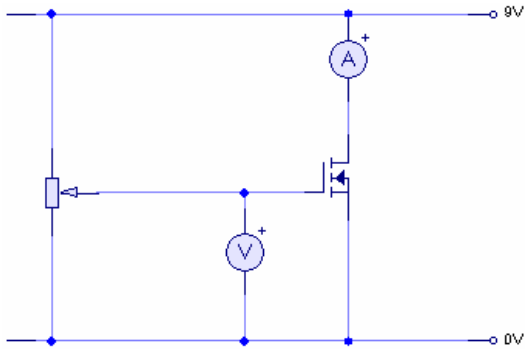
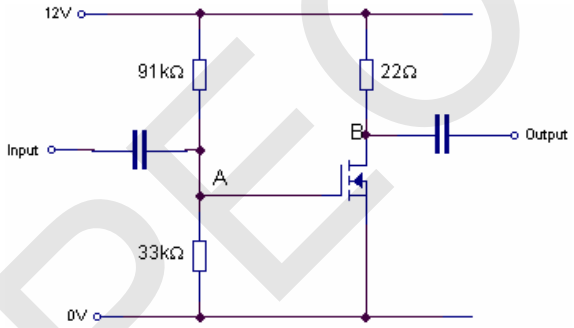
ELECTRONICS F614 MS

Unit F614: Electronic Control Systems

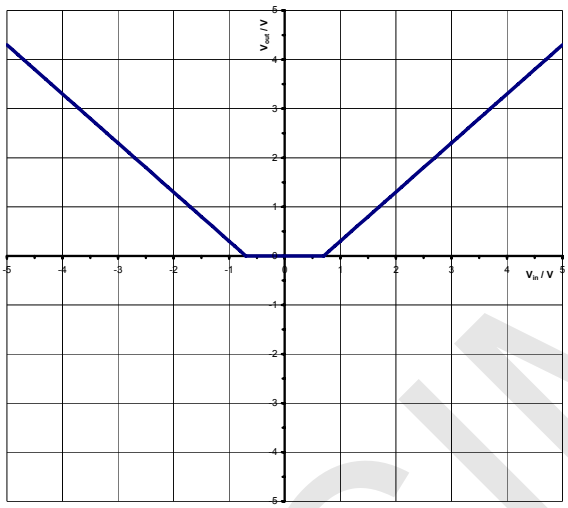
Specimen Mark Scheme

The maximum mark for this paper is **110**.

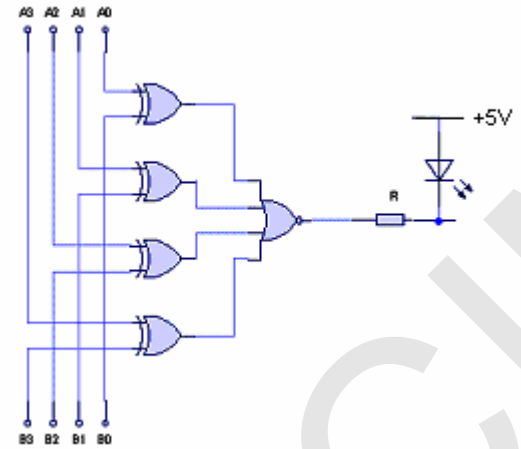
Question Number	Answer	Max Mark
1(a)	area of memory (1) used to store (ordered/indexed) data (1)	[2]
(b)	register in CPU (1) used to store the address of the data at the top of the stack (1)	[2]
(c)	register in CPU (1) used to store the address (1) of the next instruction (1)	[3]
(d)	set of instructions (1) to perform a particular task (1) stored in memory (1) can be called form anywhere in program can be called repeatedly (maximum 3 marks)	[3]

Question Number	Answer	Max Mark
2(a)	ends of potentiometer connected to 0V and 12V and wiper of potentiometer connected to gate of MOSFET (1) source connected to 0V and drain connected to 12V (1) correct ammeter connected in series with drain (or source) (1) correct voltmeter connected between gate and 0V (1) 	[4]
(b)	Answers in the range 2.1V – 2.4V (1)	[1]
(c)	current from graph / voltage from graph (eor) (1) $\Delta I_{DS} / \Delta V_{GS} = 0.3S$ (1)	[2]
(d)	labelled input to A (1) and labelled output from B (1) both through capacitors (1) 	[3]
2(e)	-0.3 x 22 (eor) (1) = -6.6 (1)	[2]
2(f)	Stretch & Challenge, only award marks for fully correct answers. calculation: • voltage at A is 3.2 V • giving a drain current of 0.24 A • voltage drop across drain resistor is 5.3 V • so B is at 6.7 V suitability: • B can move up by 5.3 V • but only down by 5.3 - 2.4 = 2.9 V • amplifier doesn't allow maximum possible amplitude output	[4] [3]

<table>
<tr><th>Question Number</th><th>Answer</th><th>Max Mark</th></tr>
<tr><td>3(a)</td><td>Forgets data (1)
when supply removed (1)</td><td>[2]</td></tr>
<tr><td>(b)</td><td>2^{11} (1)
=2048 (2^8=256 gets 1 mark, 2^{10}=1024 gets 1 mark)</td><td>[2]</td></tr>
<tr><td>(c)</td><td><table><tr><td>D_7</td><td>D_6</td><td>D_5</td><td>D_4</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td></tr></table> (1)
<table><tr><td>D_3</td><td>D_2</td><td>D_1</td><td>D_0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td></tr></table> (1)
One mark for each correct nibble</td><td>[2]</td></tr>
<tr><td>(d)</td><td>[Make Read= 1, Make Write=1, Make Enable =1]
Make A_{10}-A_0 = 00110000100, Make D_7-D_0 = A3 (1)
Make Write = 0, Make Enable = 0 (1)
Make Enable = 1 Make Write = 1 (1)
Make A_{10}-A_0 = 1001001110 (1)
Make Read=0, Make Enable =0 (1)
[Read data]
One mark for each point in correct sequence</td><td>[5]</td></tr>
</table>

Question Number	Answer	Max Mark
4(a)(i)	Bridge / Full-wave (1) Rectifier / Diode (1)	[2]
(ii)	converts alternating voltage/current (ACCEPT a.c.) (1) into direct voltage/current (ACCEPT d.c.) (1) (ACCEPT "rectifies" or wtte [1]) converts negative voltage/current into positive (ACCEPT diagrams of full-wave rectification) (1)	[3]
(b)	 45° up from 0.7v in upper right quadrant (1) 0v between -0.7v an +0.7v (1) 45° down to -0.7v in upper left quadrant (1)	[3]
(c)	Stretch & Challenge, only award marks for fully correct answers. • charges up from diode bridge • at peak voltage of mains supply • discharges slowly through rest of circuit between peak voltages	[3]
(d)(i)	$P = VI$ (NOT $P = I^2R$) (1) $I = P/V = 125\times10^{-3}/6 = \underline{2.08}\times10^{-2}$ A or $\underline{2.1}\times10^{-2}$ A (1) units conversion (e.g. 1 mW = 10^{-3} W, 1 mA = 10^{-3} A) (1)	[3]
(ii)	$R = V/I$ (eor) (1) V = 11 - 6 = $\underline{5\text{ V}}$ (1) I between 21 mA and 0.2 mA ecf incorrect V (11 or 6), I: e.g. $R = 5/20\times10^{-3} = 250\ \Omega$ (235 Ω to 25 kΩ) (1)	[3]
(e)	negative (1) voltage (1) current / power (1)	[3]
(f)	Smaller / lighter (1) More efficient (NOT safer, cheaper) (1)	[2]

Question Number	Answer	Max Mark
5(a)	Makes the outputs all zero (1) to make all the LEDs turn off (1)	**[2]**
5 (b)	in A0,I — Copy the input pin values to A0 (1) movi A1,04 — Put the value 00000100 into A1 and A0,A1 — Mask to ignore all but I3 (1) to look at SW1 (1) jz buttoncheck — If SW1 not pressed go back to check input again (1) ret — If SW1 pressed return to main program (1)	**[5]**
5 (c)	81 (1) 42 (1) 24 (1) 18 (1) 24 42 } Both for this mark (ecf from lines 2 and 3) (1)	**[5]**
5(d)	wait100ms: movi A4,64 (1) loop: rcall wait1ms (not including label) (1) dec A4 (1) jnz loop (including label in correct place) (1) ret (1)	**[5]**
5(e)	Identified instructions include "in S0,I" (1) Other instructions identified "moviS1,10 and S0,S1 jnz start" (1) Explanation Get the values from the input pins Mask for SW2 (1) If pressed go to start of program and turn lights off otherwise continue (1)	**[4]**

Question Number	Answer	Max Mark
6(a)	Assumptions: LED forward voltage V_F = 2v (allow 1.7v – 2.3v) (1) AND LED forward current I = 10mA (allow 5mA – 20mA) R = (5 – V_F)/I (only 1 mark if 5/I) (2) = 300Ω (135Ω - 660Ω) (1)	**[4]**
(b)	0110 + 0110 = 01100 (OR convert to decimal and back to binary) (1) therefore S3=1 and S2=1 (1) makes output of AND gate 1 (1)	**[3]**
(c)	Stretch & Challenge, only award marks for fully correct answers. • circuit which works correctly e.g.  • Boolean algebra to explain operation of circuit • why LED only glows when nibbles are different	**[3]**

Question Number	Answer	Max Mark
7(a)	Difference amplifier	[1]
(b)	Z = S - P	[1]
(c)(i)	non-inverting input connected to 0V (1) Resistor to inverting input (1) Capacitor in negative feedback (1) Input and output labelled (1)	[4]
(ii)	0V Output stays frozen (or wtte) (1) +5V Output decreases linearly (1)	[2]
(d)	Any 6 of the following marking points: • When P = +5V and S = 0V then Z = -5V • Ramp generator output voltage starts to rise • Motor starts to turn • Speed sensor output voltage rises • Output of summing amp Z gets less • Output of ramp generator rises more slowly • Motor continues to speed up • When output of speed sensor S = P then Z = 0V • Output of ramp generator stays the same and motor continues to run at constant speed This question will also be assessed on quality of written communication. **3** The candidate expresses complex ideas extremely clearly and fluently. Sentences and paragraphs follow on from one another smoothly and logically. Arguments are consistently relevant and well structured. There will be few, if any, errors of grammar, punctuation and spelling. **2** The candidate expresses straightforward ideas clearly, if not always fluently. Sentences and paragraphs may not always be well connected. Arguments may sometimes stray from the point or be weakly presented. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas. **1** The candidate expresses simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weaknesses in these areas. **0** The language has no rewardable features.	[9]
	Paper Total	[110]

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total	Synoptic
1(a)	2			**2**	
1(b)	2			**2**	
1(c)	3			**3**	
1(d)	3			**3**	
2(a)	2	2		**4**	2
2(b)	1			**1**	
2(c)	2			**2**	
2(d)	2	1		**3**	
2(e)		2		**2**	
2(f)		7		**7**	2
3(a)	2			**2**	
3(b)		2		**2**	
3(c)		2		**2**	2
3(d)	1	4		**5**	
4(a)(i)	2			**2**	
4(a)(ii)	3			**3**	
4(b)		3		**3**	
4(c)	3			**3**	
4(d)(i)		3		**3**	3
4(d)(ii)		3		**3**	3
4(e)		3		**3**	3
4(f)	2			**2**	
5(a)		2		**2**	
5(b)		5		**5**	
5(c)		5		**5**	
5(d)		5		**5**	
5(e)		4		**4**	
6(a)	1	3		**4**	4
6(b)	1	2		**3**	
6(c)	2	1		**3**	3
7(a)	1			**1**	
7(b)	1			**1**	
7(c)(i)	4			**4**	
7(c)(ii)	1	2		**2**	
7(d)	4	5		**9**	
Totals	**45**	**65**	**0**	**110**	**22**