Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2005
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE4
Unit 4 Electronic Control Systems

Thursday 30 June 2005 Morning Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen. Use pencil for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 72.
- Mark allocations are shown in brackets.
- Any correct electronics solution will gain credit.
- The paper carries 15% of the total marks for Electronics Advanced Level award.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

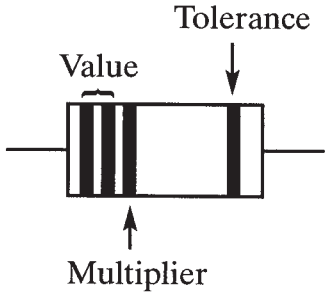
- A perforated *Data Sheet* is provided on pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this sheet before you begin work.

Resistors Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

Resistor Printed Code (BS 1852) This code consists of letters and numbers:
R means × 1
K means × 1000 (i.e. 10^3)
M means × 1 000 000 (i.e. 10^6)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code, F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

Resistor Colour Code

Number	Colour
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Grey
9	White



Tolerance, gold = ± 5%, silver = ± 10%, no band ± 20%.

Silicon diode $V_F = 0.7\,V$

Silicon transistor $V_{be} \approx 0.7\,V$ in the on state
$V_{ce} \approx 0.2\,V$ when saturated

Resistance

$$R_T = R_1 + R_2 + R_3 \quad \text{series}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{parallel}$$

Capacitance

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{series}$$

$$C_T = C_1 + C_2 + C_3 \quad \text{parallel}$$

Time constant $T = CR$

A.C. theory

$$I_{rms} = \frac{I_o}{\sqrt{2}}$$

$$V_{rms} = \frac{V_o}{\sqrt{2}}$$

$$X_C = \frac{1}{2\pi fC} \quad \text{reactance}$$

$$X_L = 2\pi fL \quad \text{reactance}$$

$$f = \frac{1}{T} \quad \text{frequency, period}$$

$$f_o = \frac{1}{2\pi\sqrt{LC}} \quad \text{resonant frequency}$$

Turn over ▶

Operational amplifier

$G_V = \dfrac{V_{out}}{V_{in}}$ voltage gain

$G_V = -\dfrac{R_f}{R_1}$ inverting

$G_V = 1 + \dfrac{R_f}{R_1}$ non-inverting

$V_{out} = -R_f\left(\dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + \dfrac{V_3}{R_3}\right)$ summing

Astable and Monostable using NAND Gates

$f \approx \dfrac{1}{2RC}$ astable

$T \approx RC$ monostable

555 Astable and Monostable

$T = 1.1RC$ monostable

$t_H = 0.7(R_A + R_B)C$
$t_L = 0.7R_BC$] astable

$f = \dfrac{1.44}{(R_A + 2R_B)C}$ two resistor circuit

Electromagnetic Waves

$c = 3 \times 10^8\ \text{m s}^{-1}$ speed in vacuo

List of BASIC Commands

DIM variable [(subscripts)]

DO [{**WHILE** | **UNTIL**} condition]
    [statement block]
LOOP

DO
    [statement block]
LOOP [{**WHILE** | **UNTIL**} condition]

FOR counter = start **TO** end [**STEP** increment]
    [statement block]
NEXT counter

GOSUB [label | line number]
    [statement block]
RETURN

IF condition **THEN**
    [statement block 1]
ELSE
    [statement block 2]

INKEY$

INP (port %)

INPUT [;] ["prompt" {;1, }] variable list (comma separated)

LPRINT [expression list] [{ ;1, }]

OUT port%, data%

PRINT [expression list] [{;1,}]

REM remark

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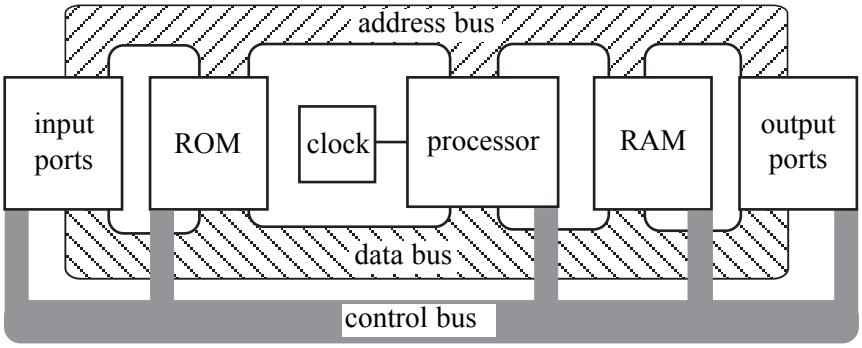
Answer **all** questions in the spaces provided.

1 The sub-system diagram of a general purpose microcontroller system for controlling industrial processes is shown below.



(a) What is the function of the clock?

.....

(1 mark)

(b) Explain why the data bus has to be bidirectional.

.....

.....

(1 mark)

(c) Which sub-system:

(i) contains the Arithmetic Logic Unit; .....

(ii) is most likely to contain the control program code; .....

(iii) is used for the temporary storage of information; .....

(iv) writes information onto the address bus? .....

(4 marks)

(d) The address bus is 12-bit and the data bus is 8-bit. What is the maximum amount of memory that can be addressed directly by the system?

.....

(1 mark)

(e) Explain why memory mapping the input and output ports would reduce the maximum amount of memory that could be addressed.

.....

.....

.....

(2 marks)

2 (a) Briefly describe **two** major hardware differences between a personal computer (PC) and a neural network.

.....

.....

.....

.....

(2 marks)

(b) State with a reason in each case, **one** application which is better performed by a PC and **one** application which is better performed by a neural network.

.....

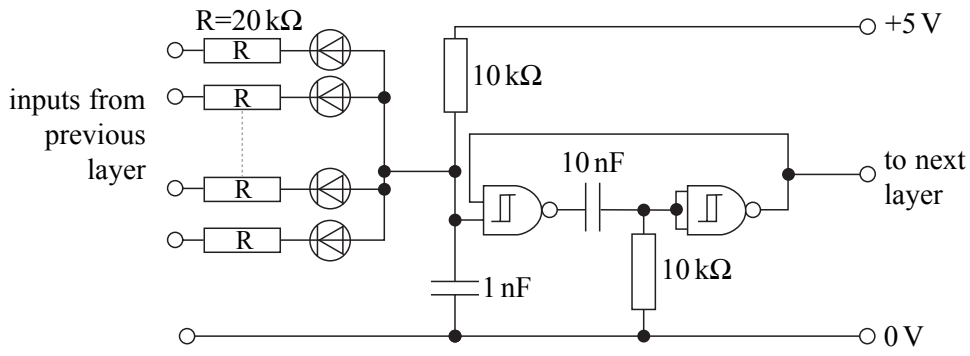
.....

.....

.....

(2 marks)

In an attempt to produce a neural network, a student decides to model each processing element on the monostable circuit below.



(c) Estimate the time period of the monostable using the formula on the data sheet and showing your calculation.

.....

.....

(2 marks)

(d) State the effect on the monostable of the following inputs:

(i) one input is taken to logic 0 and held there, all the others being at logic 1;

.....

(ii) two inputs are taken to logic 0 and held there, all the others being at logic 1;

.....

(iii) three inputs are taken to logic 0 and held there, all the others being at logic 1.

.....

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

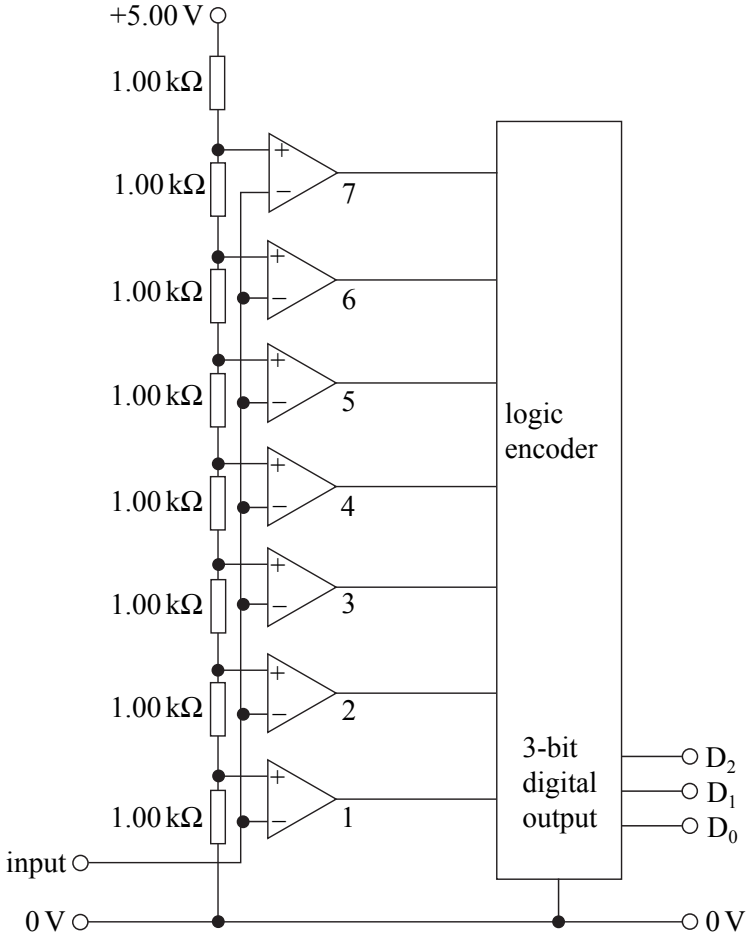
3 (a) State **one** advantage and **one** disadvantage of a flash ADC (Analogue to Digital Converter) compared to a digital ramp ADC.

.....

.....

(2 marks)

(b) The circuit diagram for a 3-bit flash ADC is shown below.



(i) Calculate the resolution of the ADC.

.....

(ii) What is the function of each op-amp?

.....

(iii) Calculate the number of op-amps required for a 12-bit flash ADC?

.....

.....

(3 marks)

(c) Complete the truth table for the logic encoder.

logic encoder output			**output of op-amps**						
D_2	D_1	D_0	1	2	3	4	5	6	7
0	0	0	0						
0	0	1	1						
0	1	0	1						
0	1	1	1						
1	0	0	1						
1	0	1	1						
1	1	0	1						
1	1	1	1						

(2 marks)

(d) Draw a logic circuit to encode the outputs from the op-amps to output D_1.

(2 marks)

9

4 A control system has its software written in QBasic. Two of the subroutines are listed below.

(a) The first subroutine reads information from two 1-bit sensors.

```
routine1:
X = INP(&H379)
X = X AND 192
IF X = 64 OR X = 128 THEN RETURN
GOTO routine1
```

(i) What is the function of the first statement?

.....

(ii) From which port is data being read?

.....

(iii) What is the function of the third line of the subroutine?

.....

.....

(iv) To which of the input lines are the sensors connected?

.....

(4 marks)

(b) The subroutine 'polls' the input port.

(i) What is meant by the term 'polling'?

.....

.....

(ii) Explain how else the control system could be alerted when data needs to be read into the system from the port.

.....

.....

(3 marks)

(c) The second subroutine is shown below.

```
routine2:
FOR N = 1 TO T%
NEXT N
IF INKEY$ = CHR$(27) THEN END
RETURN
```

(i) What information must be supplied to this subroutine?

.....

(ii) Suggest a use for this subroutine.

.....

.....

(2 marks)

9

TURN OVER FOR THE NEXT QUESTION

5 (a) Explain how an open loop control system differs from a closed loop control system.

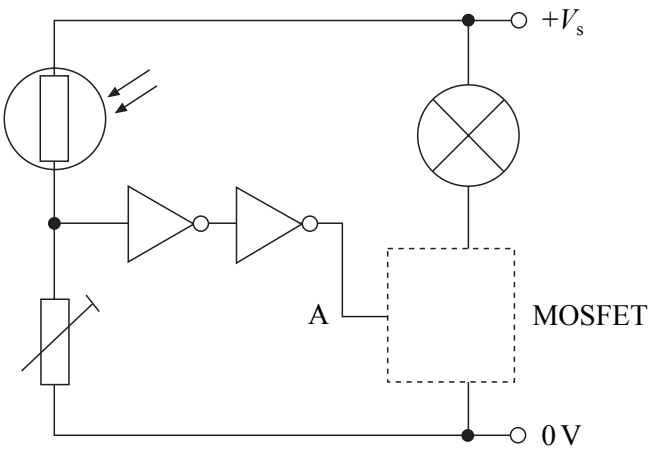
.....

.....

.....

(2 marks)

(b) The circuit diagram for an electronic control system is shown below.



(i) Draw, in the dotted box on the circuit diagram above, the correctly connected symbol for a MOSFET.

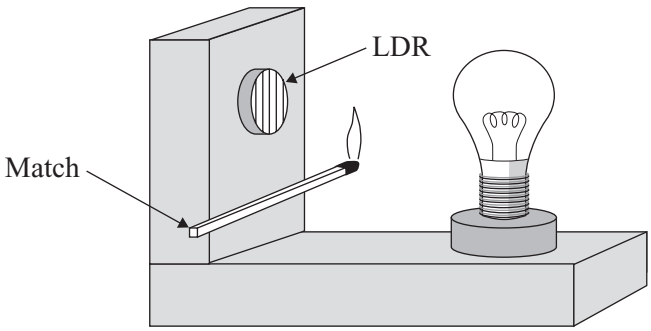
(ii) Explain why point A is at logic 1 when the LDR is strongly illuminated.

.....

.....

(4 marks)

(c) The lamp and LDR are arranged as shown below.



When a lighted match is held near to the LDR, the lamp lights and remains lit even when the match is removed.

(i) State the type of feedback used in the system.

.....

(ii) Explain why the lamp remains lit even when the match is removed.

.....

.....

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

6 An Analogue to Digital Converter (ADC) has three control lines:

EoC End of Conversion

$\overline{\textbf{OE}}$ Output Enable for tristate buffer

$\overline{\textbf{SC}}$ Start Conversion

(a) (i) Explain what is meant by a tristate buffer.

.....

.....

(ii) Explain why a tristate buffer is necessary for interfacing the ADC to the data bus of a microprocessor system.

.....

.....

(iii) Under what conditions will $\overline{\textbf{OE}}$ be logic 0.

.....

(3 marks)

(b) Draw a flow diagram for a program which continuously reads analogue data into a microprocessor system.

(4 marks)

(c) State **two** factors which limit the speed of conversion of a digital ramp ADC.

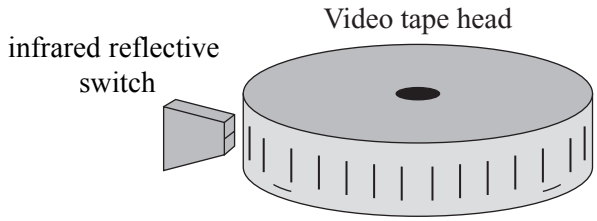
.....

.....

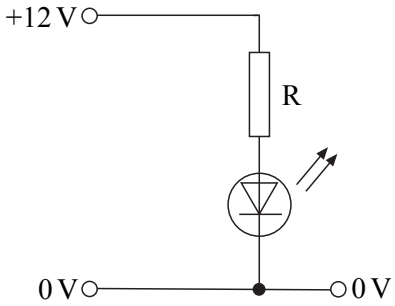
(2 marks)

9

7 An infrared reflective switch is used to maintain constant speed of rotation of the tape head in a video recorder.



(a) The diagram for the infrared LED circuit is shown below. The forward voltage of the LED is 1.5 V and its maximum current is 20 mA. It is operated from a 12 V supply.



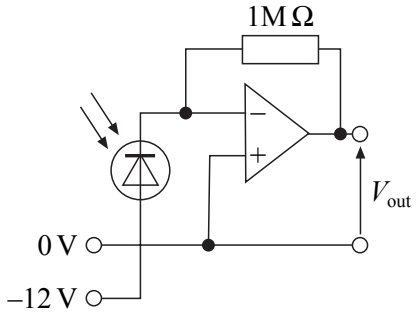
Calculate a suitable preferred value for the resistor, R.

.....

.....

(3 marks)

(b) The photodiode circuit is shown below.



The photodiode current in the dark is 0.1 μA and in the light is 6 μA.

(i) Show that the output voltage when the photodiode is in the light is + 6 V.

.....

.....

(ii) Calculate the output voltage when the photodiode is in the dark.

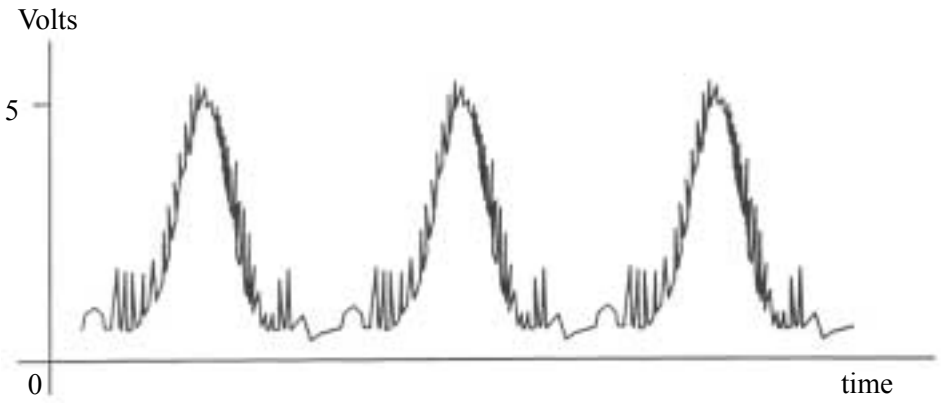
.....

.....

(3 marks)

QUESTION 7 CONTINUES ON THE NEXT PAGE

(c) The resulting signal from the photodiode op-amp is noisy and is shown in the graph below.



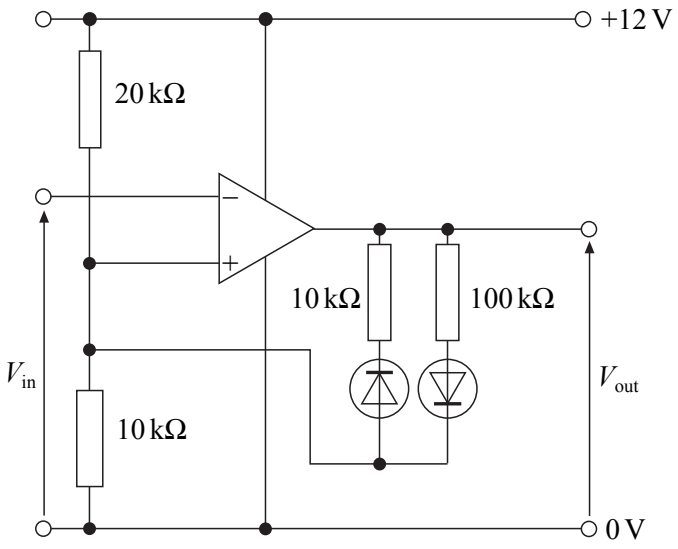
The signal is cleaned using a Schmitt trigger circuit.
Explain why a Schmitt trigger is able to clean the signal.

.....

.....

(2 marks)

(d) The Schmitt trigger circuit is shown below.



Assume that the op-amp is ideal and the diodes have no forward voltage drop and zero reverse leakage current.

Estimate, showing your working:

(i) the lower switching voltage;

.....

.....

(ii) the upper switching voltage.

.....

.....

(4 marks)

(e) It is suggested that if the tape head were driven by a stepper motor then the quantity of electronics would be reduced and the speed of rotation would be more accurate.

(i) What is a stepper motor?

.....

.....

(ii) Would a stepper motor reduce the quantity of electronics needed, and would the speed of rotation be more accurate? Justify your answer.

.....

.....

.....

.....

.....

.....

(6 marks)

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END OF QUESTIONS

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