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Centre Number											Candidate Number										
Candidate Signature																					

For Examiner's Use

General Certificate of Education
June 2008
Advanced Level Examination



ELECTRONICS
Unit 4 Electronic Control Systems

ELE4

Tuesday 10 June 2008 1.30 pm to 3.00 pm

For this paper you must have:

- a pencil and a ruler
- a calculator.

Time allowed: 1 hour 30 minutes

Instructions

- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be 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.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Any correct electronic solution will gain credit.
- You are reminded of the need for good English and clear presentation in your answers.

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



Data Sheet

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this perforated sheet at the start of the examination.

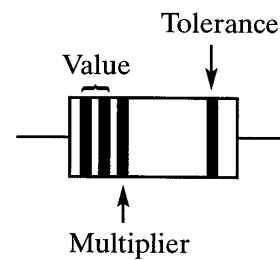


Data Sheet

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 $\times 1$
K means $\times 1000$ (i.e. 10^3)
M means $\times 1\,000\,000$ (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 = $\pm 1\%$,
G = $\pm 2\%$, J = $\pm 5\%$, K = $\pm 10\%$, M = $\pm 20\%$.

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 = $\pm 5\%$, silver = $\pm 10\%$, no band $\pm 20\%$.

Silicon diode $V_F = 0.7\text{ V}$

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

Resistance $R_T = R_1 + R_2 + R_3$ series
 $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ parallel

Capacitance $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ series
 $C_T = C_1 + C_2 + C_3$ parallel

Time constant $T = CR$

A.C. theory $I_{\text{rms}} = \frac{I_o}{\sqrt{2}}$

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

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

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

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

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

Turn over ►



Operational amplifier	$G_V = \frac{V_{out}}{V_{in}}$	voltage gain
	$G_V = -\frac{R_f}{R_1}$	inverting
	$G_V = 1 + \frac{R_f}{R_1}$	non-inverting
	$V_{out} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$	summing
Astable and Monostable using NAND Gates	$f \approx \frac{1}{2RC}$	astable
	$T \approx RC$	monostable
555 Astable and Monostable	$T = 1.1RC$	monostable
	$t_H = 0.7(R_A + R_B)C$	astable
	$t_L = 0.7R_B C$	
	$f = \frac{1.44}{(R_A + 2R_B)C}$	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	



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

- 1 A supplier of leather hides for a furniture manufacturer wants to increase production efficiency by improving the colour matching process. A piece of equipment is to be developed in which light from a white LED is focussed onto the leather sample to be matched and the reflected light is analysed. Different samples from new hides are then placed into the equipment until a good colour match is obtained.

- 1 (a) The white LED has a forward voltage of 4.2 V and a maximum current of 45 mA. The LED circuit is to be operated from 12 V. Calculate a value for the current limiting resistor and select the most suitable value from the E24 series to use in the circuit.

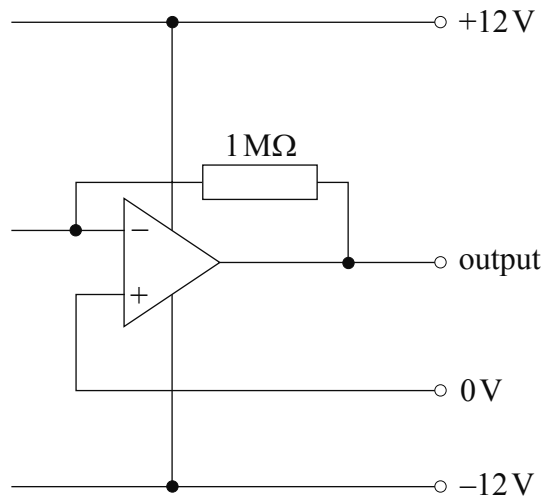
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(3 marks)

- 1 (b) The reflected light is passed through a device which separates out light of different colours and this light falls onto a row of photodiodes. Each photodiode is operated in reverse bias and the output is amplified by the circuit shown below.



- 1 (b) (i) Label the virtual earth point with the letter X.
- 1 (b) (ii) Add a photodiode to the circuit diagram above so that it is operating in reverse bias, its output is amplified and the resulting output is a positive voltage.
- (4 marks)
- 1 (c) Calculate the output voltage when the photodiode leakage current is 5 μ A.

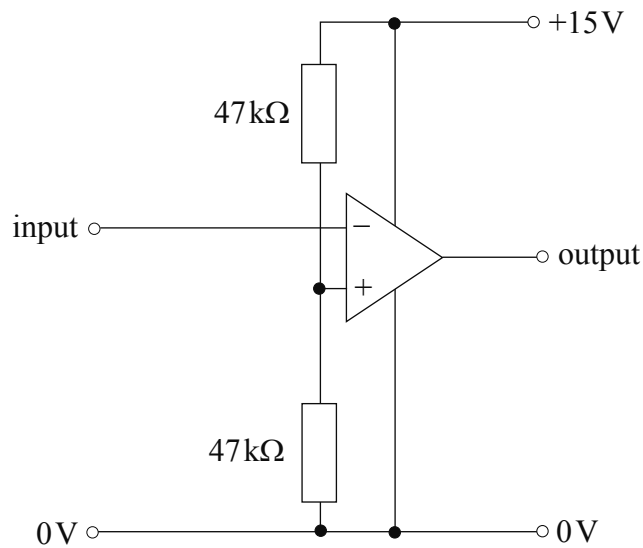
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(2 marks)

Turn over ▶

2 In the circuit diagram below the op-amp is functioning as a comparator.



2 (a) (i) What property of an op-amp makes it suitable for use as a comparator?

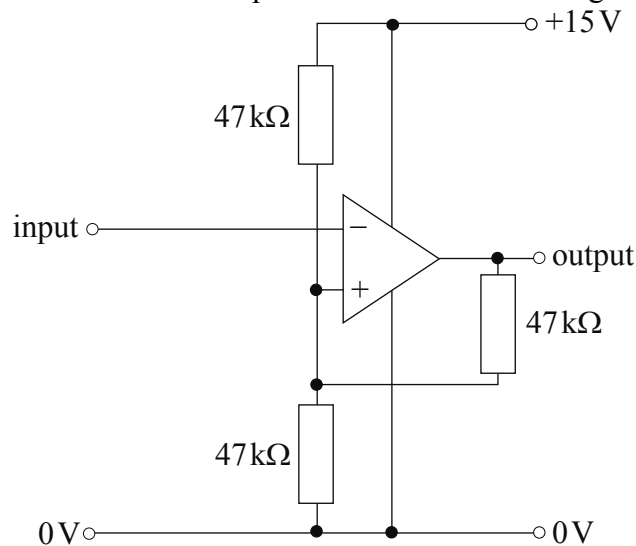
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2 (a) (ii) For an ideal op-amp, what range of input voltages is needed to make the output saturate at +15V?

.....

(2 marks)

2 (b) When a 47kΩ resistor is added to the circuit, as shown below, the range of input voltages needed to make the output saturate at +15V changes.



2 (b) (i) Show, by calculation, that if the output is +15V, the input must be less than +10V.

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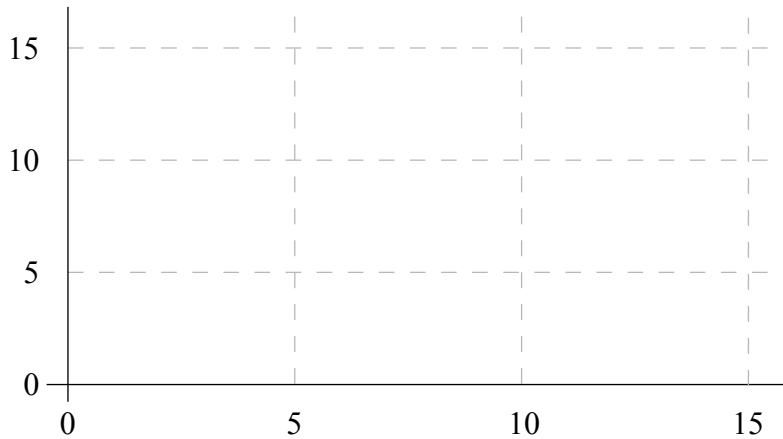
- 2 (b) (ii) Show, by calculation, that the input voltage must be greater than +5 V for the output to be 0 V.

.....

(3 marks)

- 2 (c) On the axes below, sketch a graph to show how the output voltage varies with the input voltage.

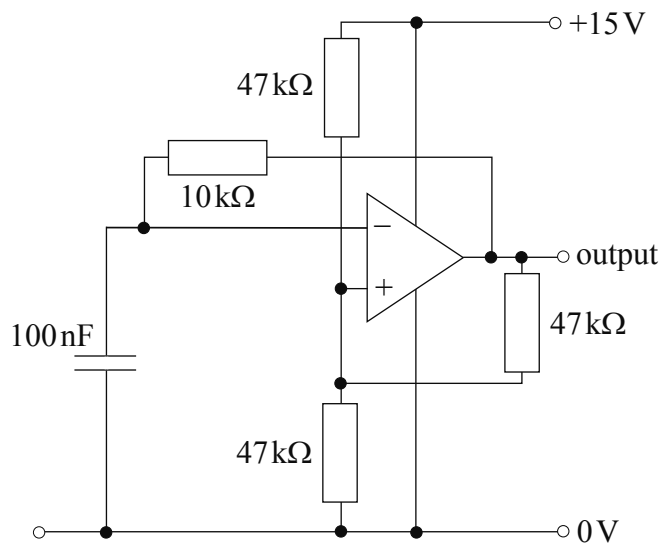
output voltage/V



input voltage/V

(2 marks)

- 2 (d) A capacitor and resistor are added to the circuit as shown in the diagram below.



Hence, by comparison with a 555 timer, or otherwise, calculate the time period of the pulses from the output of the circuit.

.....

(2 marks)

Turn over ►

3 A Network Attached Storage (NAS) system contains four 500 GB hard disk drives, which provide a total storage of 2 TB (2×10^{12} bytes). It is estimated that a human brain contains of the order of 10^{12} neurons. By considering the brain as a Neural Network, compare the brain and the NAS under the following headings

3 (a) (i) how the information is stored,

.....

.....

3 (a) (ii) total storage capacity,

.....

.....

3 (a) (iii) reliability of the stored information.

.....

.....

(3 marks)

3 (b) In order to reduce the effects of global warming local authorities, are increasingly using Artificial Neural Network (ANN) systems to control traffic lights in order to optimise the flow of traffic.

3 (b) (i) Compare the processing of data in an ANN with that of a conventional computer.

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3 (b) (ii) Explain why the control of traffic lights is better suited to an ANN than a conventional computer.

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(4 marks)

3 (c) Suggest, with a reason, an application for which an ANN would be unsuitable.

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(2 marks)



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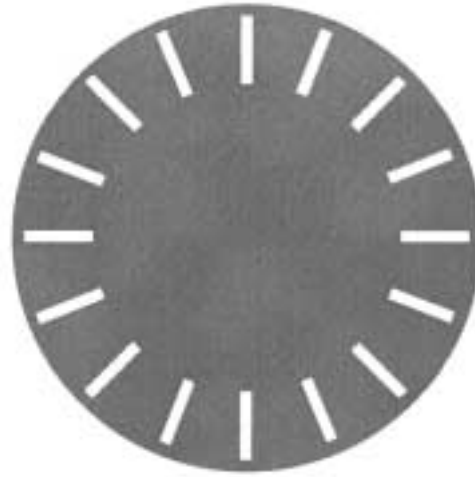


- 4 To sense the angular rotation of a conventional motor, a designer can either use an optical shaft encoder or a slotted disk.

Optical shaft encoder



Slotted disk



- 4 (a) (i) What is the angular resolution of the slotted disk shown in the diagram above?

.....

- 4 (a) (ii) What is the angular resolution of the optical shaft encoder shown in the diagram above?

.....

- 4 (a) (iii) Explain how the angular resolution of the optical shaft encoder could be increased.

.....

.....

(3 marks)

- 4 (b) The slotted disk, when operated with a single LED and light sensor, provides information about how far the disk has rotated. What additional information can be obtained when an optical shaft encoder is used?

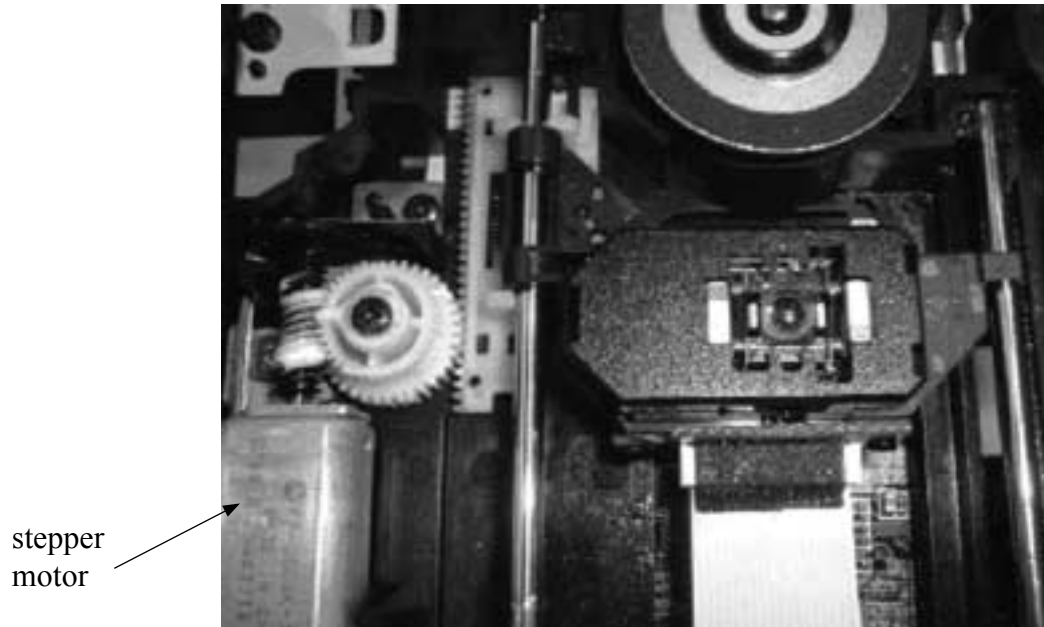
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(2 marks)



- 4 (c) The photograph below shows part of the read head control mechanism for a CD-ROM drive.



The position of the head is controlled by a stepper motor in the bottom left-hand corner of the photograph. Give **two** reasons, with supporting explanations, why a conventional motor would not be suitable for controlling the position of the CD-ROM drive head.

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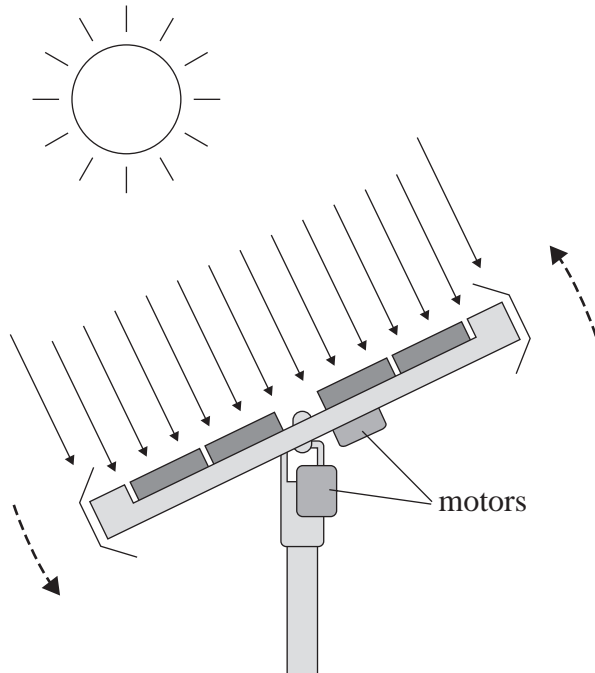
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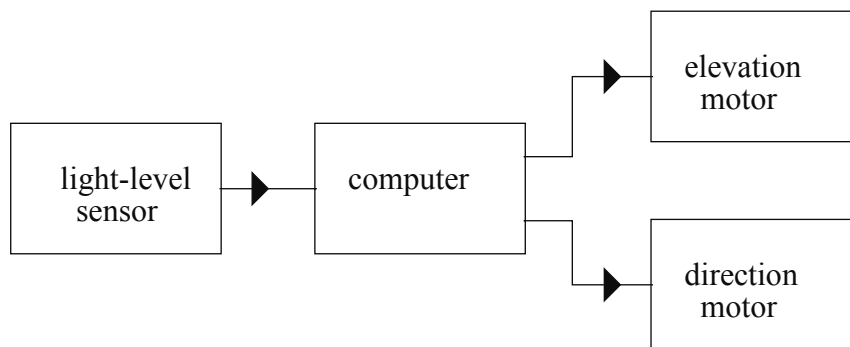
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(4 marks)

- 5 A solar panel system tracks the sun during the day in order to maximise its power output. The system consists of two motors, one to control horizontal direction and one to control elevation. It also has a light-level sensor which moves with the solar panels.



A system diagram is shown below.



- 5 (a) Explain whether this is an open or closed loop system.

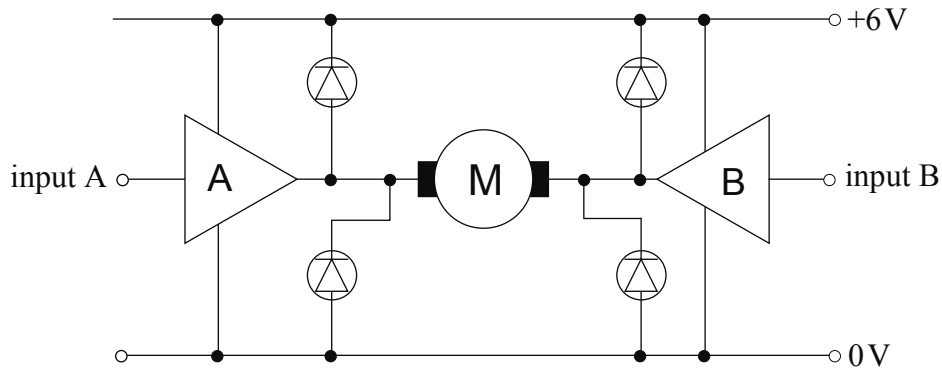
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(1 mark)



- 5 (b) The drive circuit for each of the dc motors is shown below.



A and B are both high current switching circuits. Each has a truth table as shown below.

Input	Output
0	0
1	1

- 5 (b) (i) What is the function of the diodes in the circuit?

.....

.....

- 5 (b) (ii) Complete the truth table below, indicating what the motor will do.

Input A	Input B	Motor
0	0	
0	1	
1	0	
1	1	

(4 marks)

Question 5 continues on the next page



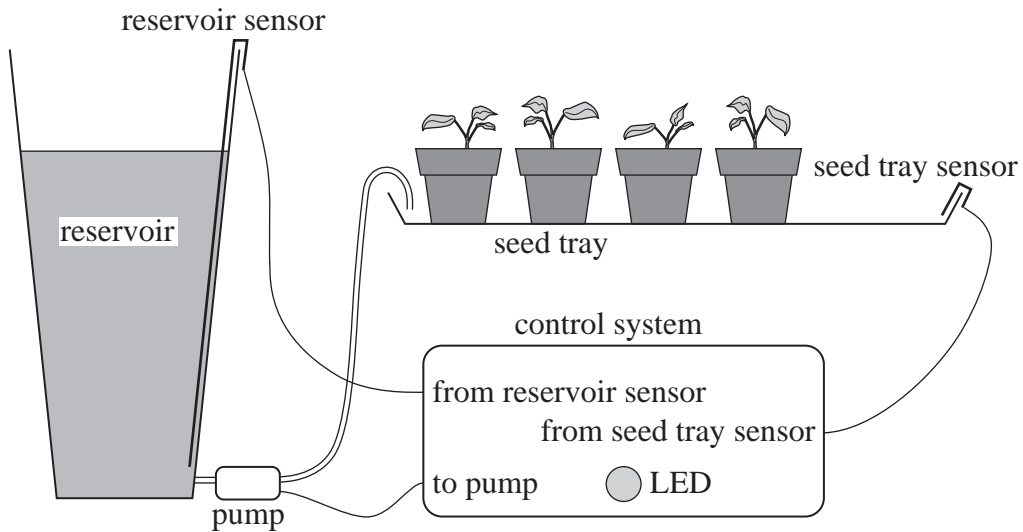
- 5 (c) In operation, the computer will change the horizontal direction of the solar panels slightly and check to see if the output from the light level sensor increases. If it does, it will leave the panels pointing in that direction. If the light level decreases, then it will move the panels in the other horizontal direction. It will then do the same for the elevation of the panels. It repeats this continuously throughout the day until the light level falls too low for electricity to be generated.

Draw a flow chart in the space below to represent the operation of this system.

(4 marks)



6 An automatic watering system for pot plants is shown below.



If the seed tray sensor is dry (logic 1), then the pump must be turned on (logic 1) until the seed tray sensor becomes wet (logic 0). If the reservoir sensor is dry (logic 1), because the reservoir is empty, then the warning LED must be illuminated (logic 1) but the pump must not be turned on even if the seed tray is dry.

6 (a) Summarise the information given above in the truth table below.

tray sensor	reservoir sensor	pump	LED
wet	wet		
wet	dry		
dry	wet		
dry	dry		

(3 marks)

Question 6 continues on the next page



- 6 (b) Using NAND gates only, draw a circuit diagram for this system in the space below.

seed tray
sensor ○ —————

—————○ output to pump

reservoir
sensor ○ —————

—————○ output to LED

(4 marks)

- 6 (c) A MOSFET is to be used to interface the logic circuit to the pump. What characteristics of a MOSFET make it suitable for this application?

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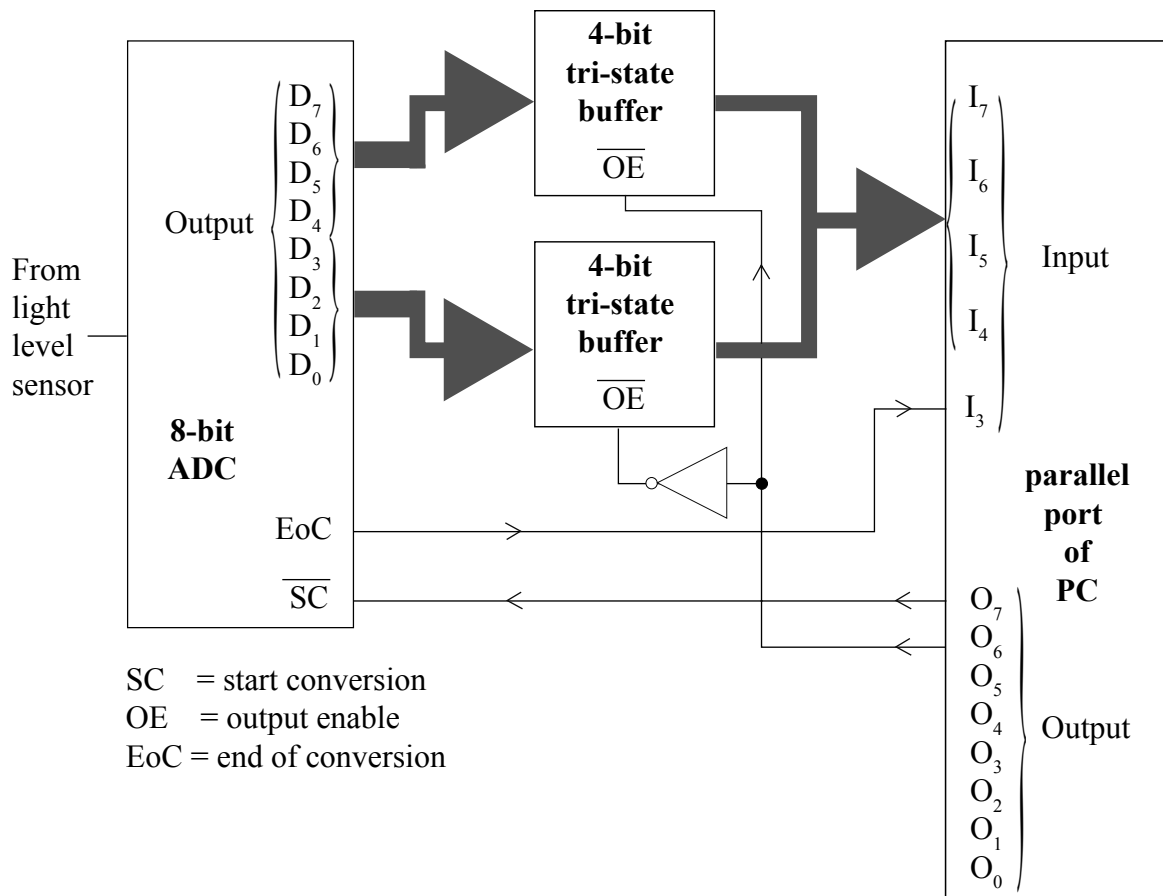
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(2 marks)



- 7 The analogue output voltage from a light-level sensor is digitised by an 8-bit ADC (Analogue to Digital Converter) before being read by a computer system. A circuit diagram is shown below.



- 7 (a) Explain why the analogue output voltage from the light level sensor cannot be read directly by the computer.

.....

.....

(2 marks)

- 7 (b) The computer input port is only 5-bit, and the output from the ADC is 8-bit. To interface the ADC to the input port, two *tri-state* buffers are used as shown above.

- 7 (b) (i) Explain the meaning of the term tri-state.

.....

.....

Question 7 continues on the next page



- 7 (b) (ii) Explain why the least significant nibble of data from the ADC is read into the computer when O_6 of the output port is at logic 1.

.....

(4 marks)

- 7 (c) If the ADC gives an output of 255 when there is an incident light level of 15 300 lux, calculate the resolution of the ADC, in lux. (Assume the light sensor has a linear response.)

.....

(2 marks)

- 7 (d) List, in sequence, the outputs and inputs required by the PC in order to read a byte of data from the ADC.

.....

(4 marks)

- 7 (e) The subroutine called by the main program to check the state of the End of Conversion output of the ADC is shown below.

```
eoc:
DO
X% = INP(&H379)
X% = X% AND 8
LOOP UNTIL X% = 8
RETURN
```

- 7 (e) (i) What is the address of the port into which this data is read?

.....



- 7 (e) (ii) Explain purpose of the statement **X% = X% AND 8**.

.....

.....

(3 marks)

The subroutine called by the main program to read the data from the ADC is shown below.

PCOUT% is the variable used to store the byte that has been sent to the output port.

```
nibble:
PCOUT% = PCOUT% OR 64
OUT(&H378), PCOUT%
Y% = INP(&H379) AND 240
Y% = Y%/16
PCOUT% = PCOUT% AND 191
OUT(&H378), PCOUT%
Y% = Y% + (INP(&H379) AND 240)
RETURN
```

- 7 (f) (i) What effect does the statement **PCOUT% = PCOUT% OR 64** have on the value of **PCOUT%**?

.....

- 7 (f) (ii) What is the function of the statement **Y% = Y%/16**?

.....

- 7 (f) (iii) What effect does the statement **PCOUT% = PCOUT% AND 191** have on the value of **PCOUT%**?

.....

(3 marks)

END OF QUESTIONS

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