Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS **ELE2**
Unit 2 Further Electronics

Tuesday 23 May 2006 1.30 pm to 3.00 pm

For this paper you must have:
- a calculator
- a pencil and ruler

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- 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.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Any correct electronics solution will gain credit.
- You are reminded of the need for good English and clear presentation in your answers.

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

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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 perforated sheet at the start of the examination.

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Resistors

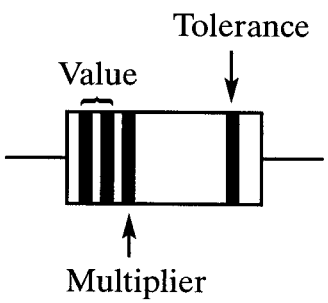
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

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 = ± 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

$R_T = R_1 + R_2 + R_3$ 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

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

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

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

$X_L = 2\pi fL$ reactance

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

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

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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

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

$f = \frac{1.44}{(R_A + 2R_B)C}$ 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

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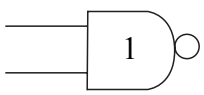
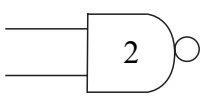
Answer **all** questions in the spaces provided.

1 Latches are used in a system that determines which contestant in a quiz responds first. Each latch is constructed from two NAND gates.

(a) (i) Complete the circuit diagram below for the latch and add pull up resistors onto the two inputs.





(ii) Label the outputs **Q** and $\overline{\mathbf{Q}}$ and the corresponding inputs $\overline{\mathbf{SET}}$ and $\overline{\mathbf{RESET}}$.

(6 marks)

(b) Explain how the latch circuit functions. Assume that **Q** is initially at logic 0.

.....

.....

.....

.....

.....

(3 marks)

9

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2 A student was asked by his father to help him transfer his music collection from cassette tape onto CD. The student measured the output signal from the cassette player and found it to have a typical value of 0.2 V. The sound card in the student's computer required a typical input signal of 1.0 V. The student decided that an amplifier was needed to match the two signal levels.

(a) Calculate the required voltage gain of the amplifier.

.....

(1 mark)

(b) Draw the circuit diagram of a non-inverting amplifier which uses an op-amp.

(2 marks)

(c) If the feedback resistor has a value of 240 kΩ, calculate the value of the other resistor needed to give the required voltage gain.

.....

.....

(2 marks)

(d) Recordings made in this way contained too much high frequency noise (hiss).
To reduce this effect, the amplifier circuit was modified to form a low pass filter with a break point frequency of approximately 8 kHz, by connecting an 82 pF capacitor in parallel with the feedback resistor.

(i) What is meant by the term *low pass filter*?

.....

(ii) What is meant by the term *break point frequency*?

.....

(iii) Show, by calculation, that using an 82 pF capacitor will give a break point frequency of approximately 8 kHz in this amplifier circuit.

.....

.....

(4 marks)

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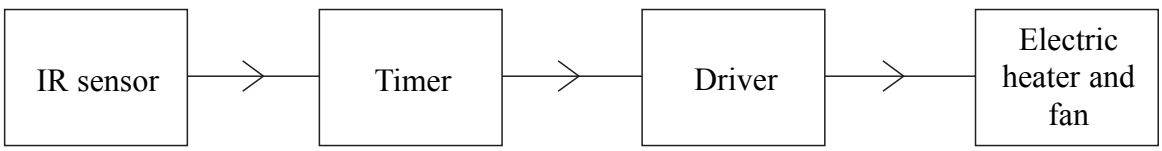
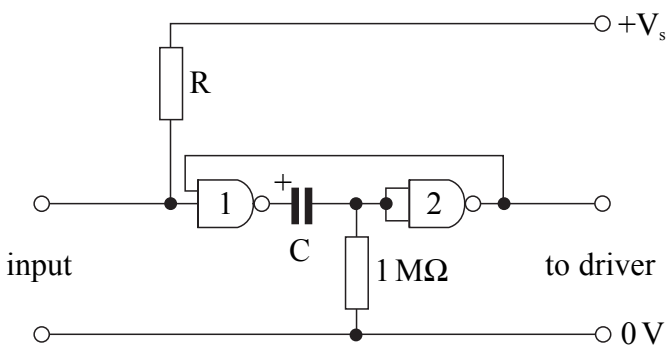
3 An electric hand dryer is activated by an infrared (IR) sensor when a person's hands are put underneath the hot air vent. The system block diagram is shown below.



The monostable circuit shown below is used for the timer sub-system.



(a) (i) State the function of the resistor R.

.....

(ii) To trigger the monostable, how must its input signal change?

.....

(3 marks)

(b) Explain how the monostable circuit functions once it has been triggered.

.....

.....

.....

.....

(4 marks)

(c) Calculate the value of the capacitor C required to give a time period of 30 s.

.....

.....

(2 marks)

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4 A power amplifier consists of an op-amp driving an n-channel and a p-channel MOSFET arranged as a push-pull circuit.

(a) Explain what is meant by the term *push-pull*.

.....

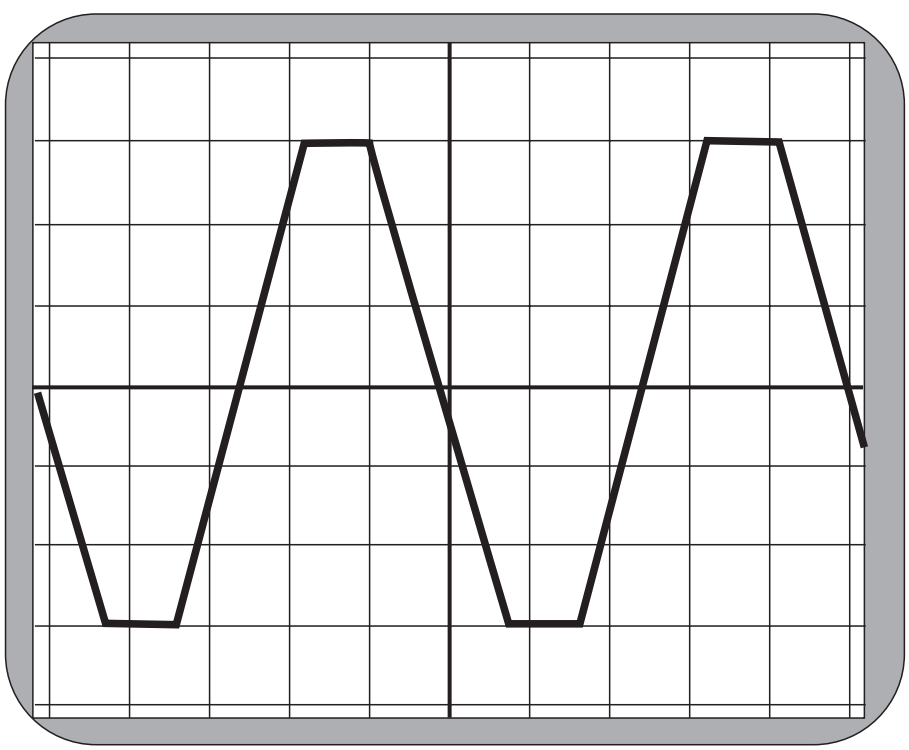
.....

.....

.....

(2 marks)

(b) The amplifier is driven by a sine wave test signal. When operating at full volume into a 4 Ω loudspeaker, an oscilloscope trace of the output shows some distortion as shown below.



(i) State **one** electrical property of the amplifier system that causes this distortion.

.....

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(ii) If the y-scale of the oscilloscope trace is 5 V per division, show that the maximum undistorted rms power output of the amplifier into a 4 Ω loudspeaker would be approximately 28 watts.

.....

.....

.....

(iii) Calculate the rms current through the loudspeaker at this power.

.....

.....

(4 marks)

(c) The push-pull amplifier circuit operates from a ±18 V power supply. When the amplifier is delivering 28 W to the loudspeaker, show that the power supplied to the amplifier is approximately 34 W.

.....

.....

(2 marks)

(d) Explain what happens to the energy that is supplied to the amplifier but not dissipated in the loudspeaker.

.....

.....

(1 mark)

9

Turn over for the next question

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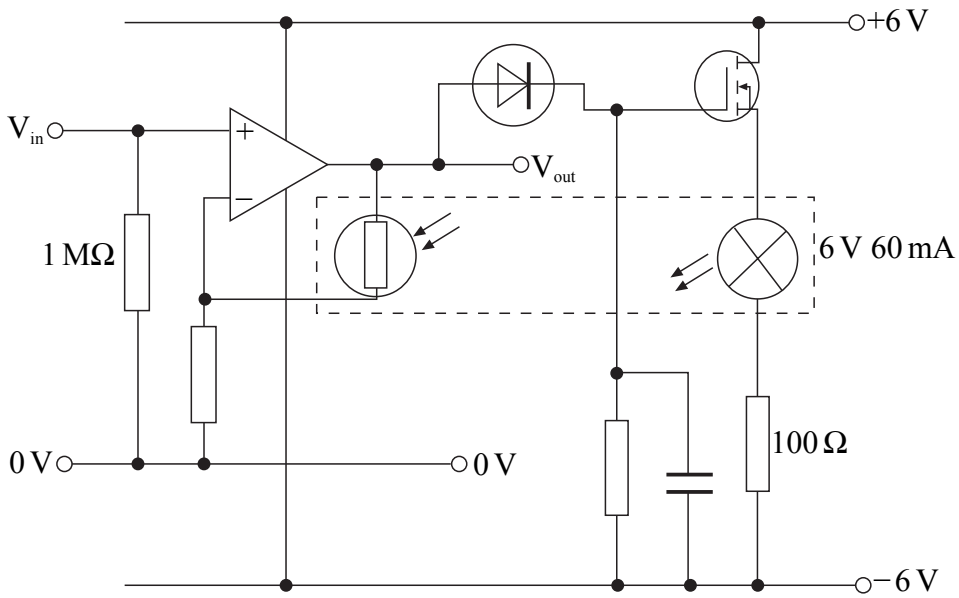
5 The circuit diagram below was found in an analogue sound recording studio.



The lamp and LDR are in a sealed container so that only light from the lamp illuminates the LDR.
The output from the op-amp goes to a MOSFET circuit via a diode.

(a) Name the circuit arrangement for this MOSFET.

.....

(1 mark)

(b) With no input signal to the op-amp, explain why the MOSFET gate voltage is – 0.7 V.

.....

.....

.....

(1 mark)

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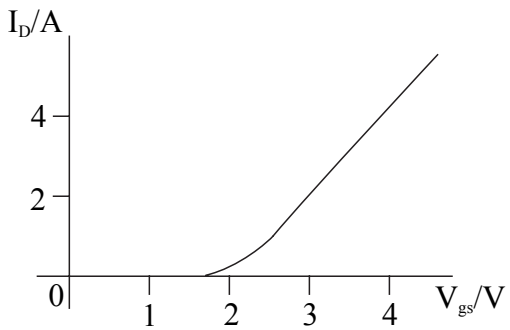
(c) The characteristic for the MOSFET is shown below.



When the lamp is just lit, estimate, giving a reason for your answer, the voltage difference between the gate and the source of the MOSFET in the circuit diagram on **page 10**.

.....

.....

(2 marks)

(d) (i) Explain why the voltage on the gate of the MOSFET will increase when there is an input signal to the amplifier.

.....

.....

(ii) What effect will this increase in voltage have on the brightness of the lamp?

.....

(iii) What effect will this increase in voltage have on the resistance of the LDR?

.....

(iv) What effect will this increase in voltage have on the voltage gain of the amplifier?

.....

(4 marks)

(e) Suggest a use for this complete circuit.

.....

(1 mark)

9

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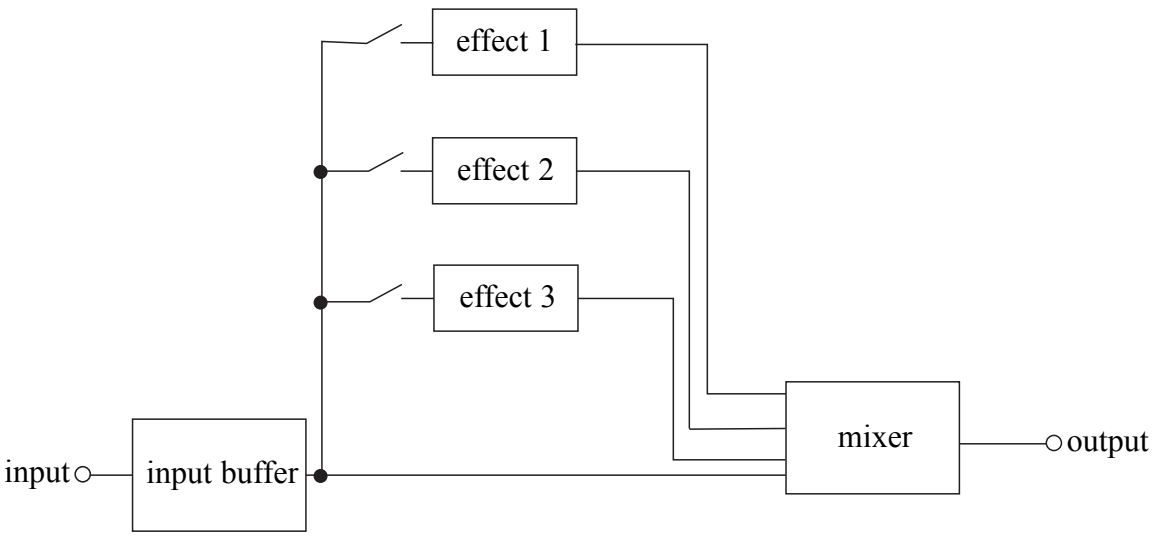
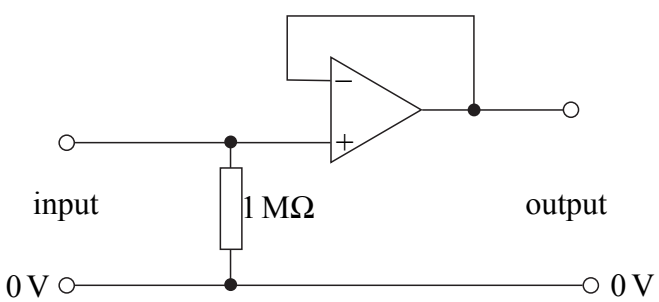
6 A system diagram for a guitar effects unit is shown below. The whole system operates from a ±12 V supply.



(a) The circuit diagram for the input buffer is shown below.



(i) State the voltage gain of this circuit.

.....

(ii) State the input resistance of this circuit.

.....

(2 marks)

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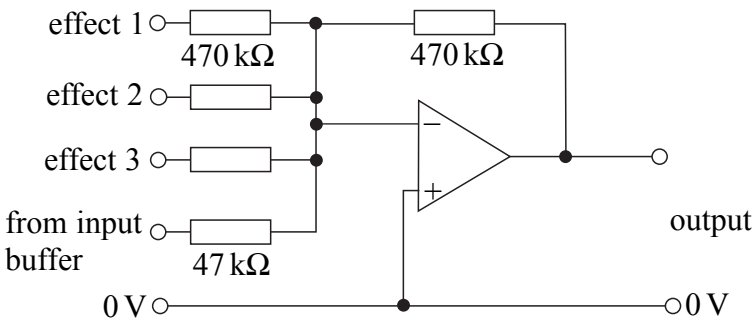
(b) The circuit diagram for the mixer is shown below.



(i) What voltage gain does the mixer circuit give to effect 1?

.....

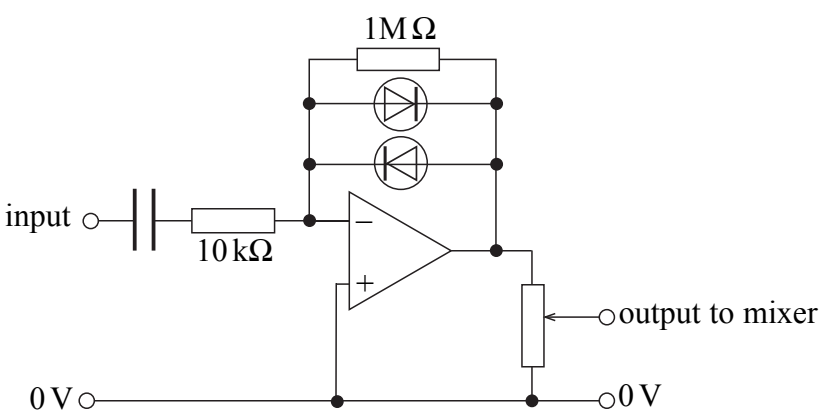
(ii) With the three effects switched off, state **two** differences between the signal at the input and the output of the whole system.

.....

.....

(3 marks)

(c) The circuit diagram for effect 1 is shown below.



(i) Clearly label a virtual earth point on this circuit with the letter **P**.

(ii) Estimate the maximum and minimum signal output voltage from this circuit.

.....

.....

(iii) What is the function of the potentiometer?

.....

(4 marks)

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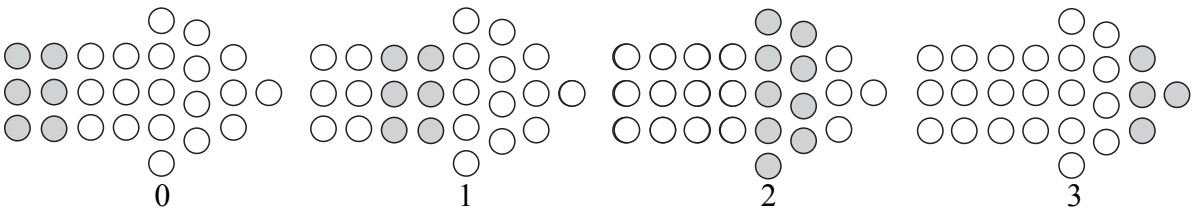
7 In order to show the direction of the nearest exit in the event of a fire, scrolling LED displays are used. The layout of LEDs on such a display is shown below, together with the order in which the scrolling occurs.

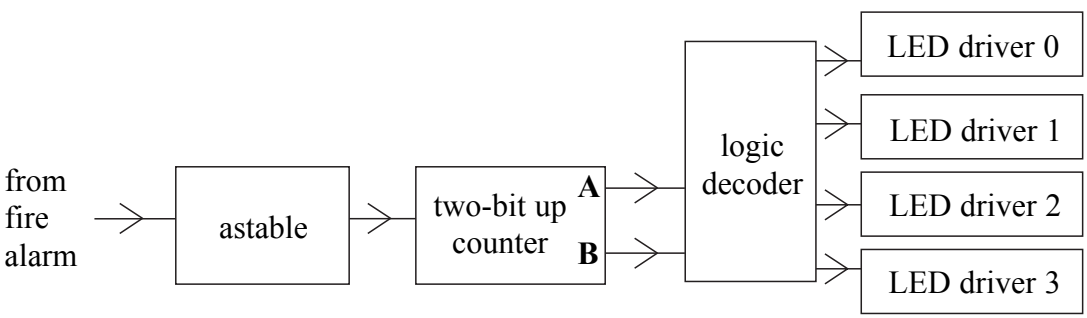


Key

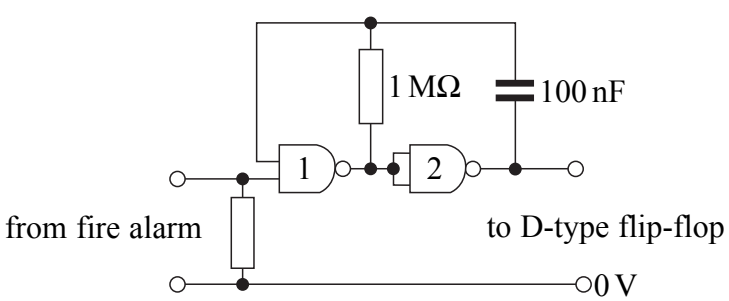
● LED on

○ LED off

A block diagram for the system is shown below.



(a) The circuit diagram for the astable sub-system is shown below.



(i) Explain why a logic 1 input is required from the fire alarm to enable the astable circuit.

.....

.....

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(ii) Once enabled, explain how the astable circuit functions.

.....

.....

.....

.....

.....

.....

.....

(iii) Estimate the frequency of this astable circuit.

.....

.....

(8 marks)

(b) The two-bit up counter is made from two D-type flip-flops.

(i) In the space below draw the circuit diagram of a two-bit up counter.

(ii) Under what input conditions is the logic state of the **D** input transferred to the **Q** output?

.....

(4 marks)

Question 7 continues on the next page

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(c) The outputs of the two-bit up counter are **A** and **B**, as shown in the block diagram on **page 14**. **A** is the least significant bit. Each LED driver sub-system needs a logic 1 input to switch on its LEDs.
Complete the Boolean expression for each output of the logic decoder. The first one is completed for you.

LED driver 0 = $\overline{\mathbf{A}}.\overline{\mathbf{B}}$

(i) LED driver 1 .....

(ii) LED driver 2 .....

(iii) LED driver 3 .....

(3 marks)

(d) Using only NAND gates, and the two-bit up counter outputs **A** and **B**, draw circuit diagrams for each of these logic decoder functions.

(i) LED driver 0

(ii) LED driver 1

(iii) LED driver 2

(3 marks)

END OF QUESTIONS

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