Version 1.1

Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2003
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE1
Unit 1 Foundation Electronics

Wednesday 21 May 2003 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 a ball-point pen. Use a 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 30% of the total marks for Electronics Advanced Subsidiary and 15% of the total marks for Electronics Advanced level awards.
- 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			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

Resistors

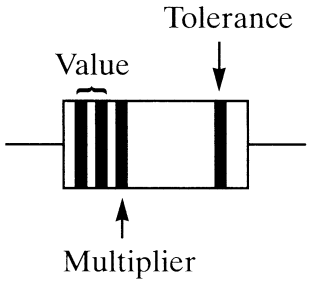
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

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 = ± 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

$T = CR$

ac 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

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

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

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

Electromagnetic Waves

$c = 3 \times 10^8\ m\,s^{-1}$ 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 The Boolean expression for a logic circuit with inputs A and B and output Q is

$$\mathbf{Q = A.B + \overline{A + B}}$$

(a) Complete the diagram below to show how this logic circuit can be constructed from one 2-input AND gate, one 2-input OR gate and one 2-input NOR gate.

A ————

———— Q

B ————

(5 marks)

(b) Label the **two** intermediate points in your diagram in part (a) as C and D.
Complete the truth table to show the logic states of C, D and Q.

A	B	C	D	Q
0	0			
0	1			
1	0			
1	1			

(4 marks)

(c) State what logic function the complete circuit provides.

.....

(1 mark)

10

2 An output indicator in a system is a 6 V 0.06 A filament lamp.
The output of the system is actually 9 V which is too high for the lamp.

(a) (i) Complete the diagram to show how a resistor can be used to reduce the voltage across the lamp.

(ii) Calculate the voltage across the resistor.

.....

(iii) State the value of current through the resistor.

.....

(iv) Calculate the required value of the resistor.

.....

(v) Calculate the power dissipated by this resistor.

.....

(6 marks)

(b) In practice the resistor above is **not** a preferred value.

(i) Which **two** resistor values could be combined to obtain the value in part (a)(iv)?

..... and .....

(ii) In what circuit configuration should these resistors be placed?

.....

(iii) Another approach to solving the problem of choosing an appropriate resistor would be to select a single resistor from the list of preferred values.
What value would you choose if the lamp ratings were **not** to be exceeded?

.....

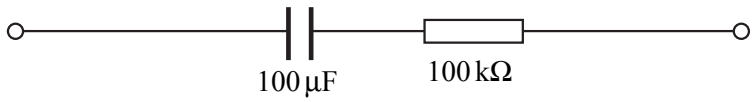
(iv) Give the colour code for this resistor if it has a 5% tolerance.

.....

(8 marks)

14

3 The RC circuit shown below is used in a simple timer.



(a) Calculate the time constant of the circuit.

.....

.....

(2 marks)

(b) With the capacitor initially uncharged, the circuit is connected across a 10 V power supply.

(i) Calculate the time for the capacitor to charge up to half the power supply voltage.

.....

.....

(ii) Calculate the approximate time for the capacitor to charge up to the full power supply voltage.

.....

.....

(iii) The capacitor voltage is connected to a comparator circuit which has a reference voltage of 6.3 V. How long will it take before the comparator switches?

.....

(5 marks)

7

TURN OVER FOR THE NEXT QUESTION

4 A temperature detector is designed for a system that provides ventilation by turning on an electric fan when the temperature rises.

The circuit diagram of the input sub-system is shown in **Figure 1.**

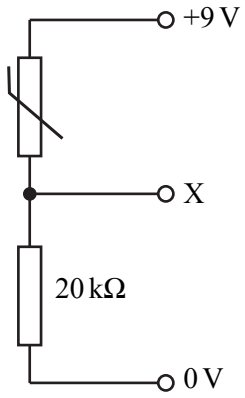


Figure 1

(a) The output of the sub-system at X is required to be half the supply voltage at the minimum operating temperature for the fan.

(i) Calculate the output voltage at X at the minimum operating temperature.

.....

(ii) Calculate the resistance of the thermistor at this temperature.

.....

.....

(iii) Using the extract from the thermistor data sheet in **Figure 2**, determine the actual minimum operating temperature of the system.

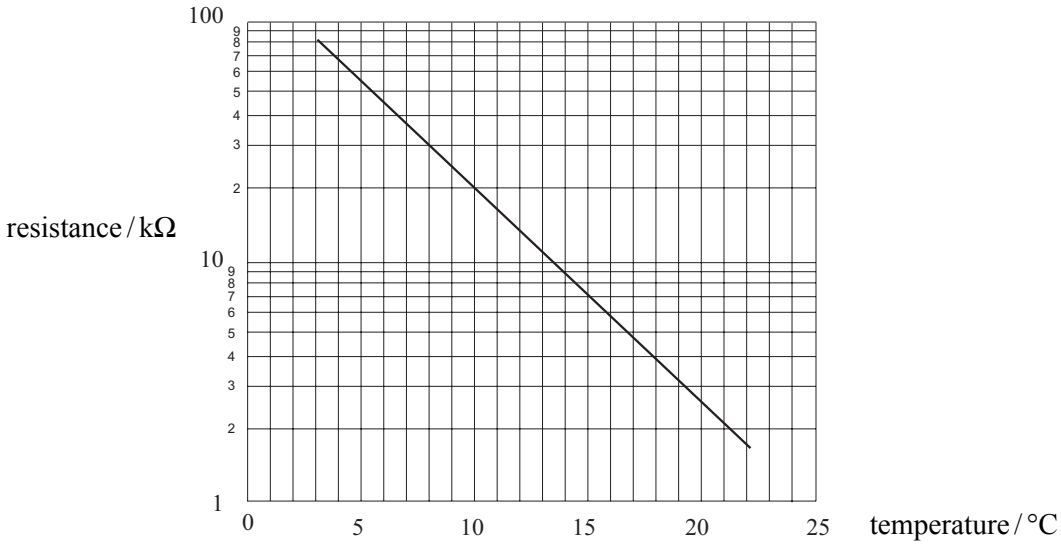


Figure 2

minimum operating temperature .....

(5 marks)

(b) The input sub-system in **Figure 1** opposite is connected to a MOSFET which is used to drive the fan motor.

(i) Draw a circuit diagram of the whole system which includes the input sub-system, MOSFET and fan motor.
Include in your diagram a protection diode for the MOSFET.

(ii) Explain why the protection diode is necessary.

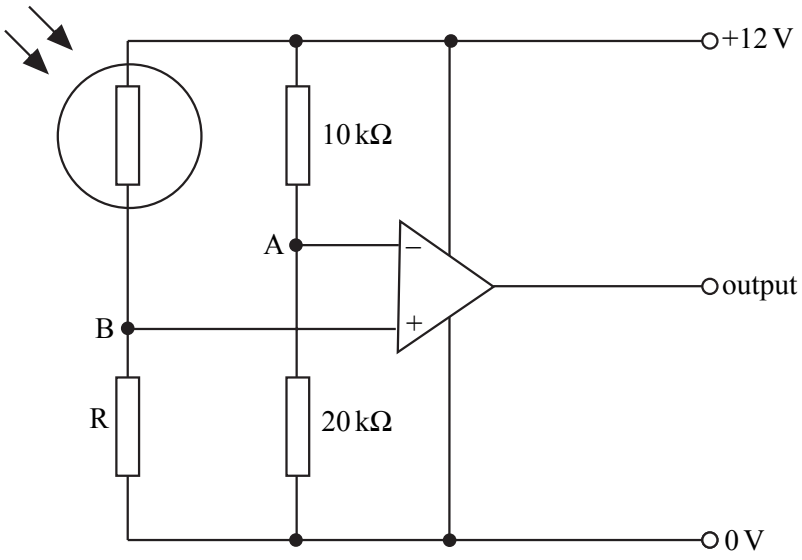
.....

.....

(5 marks)

10

5 In an industrial process the light level is monitored because the light level should be within a certain range.
The circuit diagram below shows the input stage and process stage of the system.



(a) Name the function of the process stage.

.....

(1 mark)

(b) Calculate the voltage at point A in the circuit.

.....

.....

(2 marks)

(c) Calculate a suitable value for R that would protect the LDR by ensuring that no more than 10 mA can flow through it.

.....

.....

(2 marks)

(d) Describe the operation of the circuit by comparing the voltages at A and B as the light level increases from darkness to very bright light.
State whether the output is high or low in each case.

.....

.....

.....

.....

(4 marks)

(e) An ideal op-amp would give output voltages of 0 V and 12 V in this circuit. The saturated output voltages of a typical op-amp in this circuit are +3 V and +9 V. The forward voltage drop of a single red LED is 1.8 V and if it was used as an output indicator on its own it would light up on both output voltages.

Draw on the circuit diagram opposite a suitable output circuit that would emit light only when the higher output voltage is present.
Explain how your circuit functions.

.....

.....

.....

(4 marks)

13

TURN OVER FOR THE NEXT QUESTION

6 (a) A 555 timer is used as an astable.

(i) Complete the circuit diagram in **Figure 3** to show how the 555 IC is connected as an astable by adding wire links, two resistors R_A and R_B and a capacitor C.

Label the components you have added.

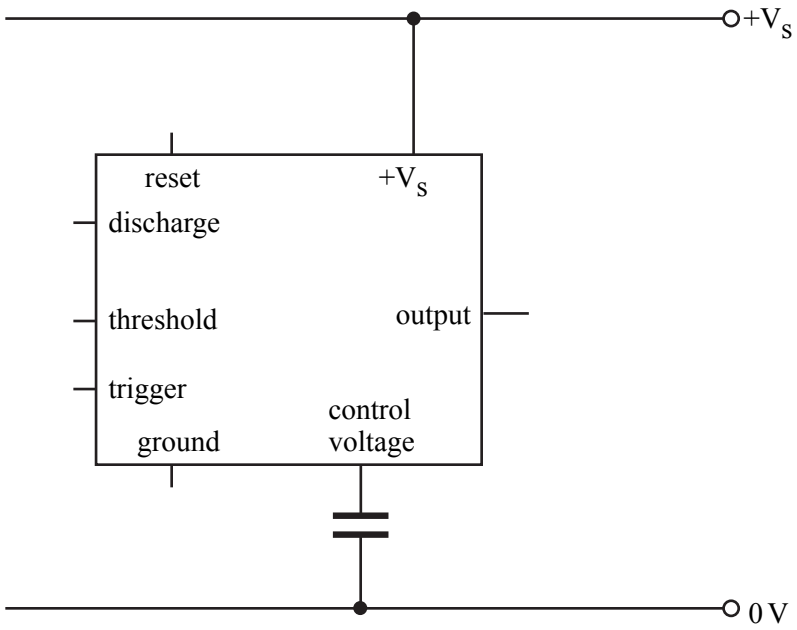


Figure 3

(ii) Calculate the frequency of the output of the astable if R_A is 1 kΩ, R_B is 100 kΩ and C is 0.01 μF.

.....

.....

(8 marks)

(b) The signal from the astable in **Figure 3** is combined with that of another astable which produces a 1 Hz signal to produce a pulsed signal. Draw a system diagram including the two astables and a logic gate to show how this can be achieved.

(3 marks)

(c) The pulsed signal from part (b) is controlled by a further logic gate and a monostable so that an output is only available for a preset time.
Complete the circuit diagram in **Figure 4** to show how a 555 IC is connected as a monostable by adding wire links, resistor R and capacitor C.
Label each component and the input to the sub-system.

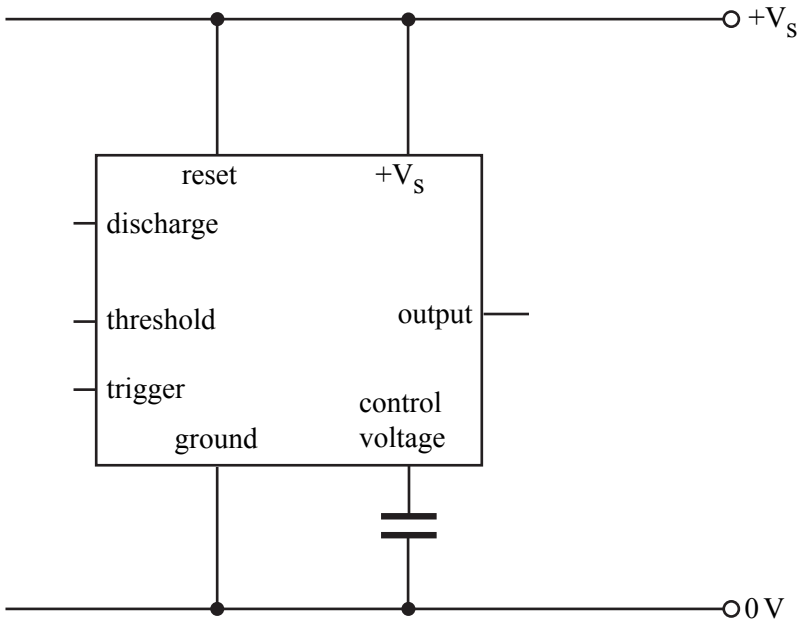


Figure 4

(4 marks)

(d) The whole system is used to provide an output for an alarm driven from three sensors A, B and C. Output Q is a logic 1 when the alarm should sound. The truth table for this is shown below.

A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

Write down a Boolean expression for Q in terms of A, B and C.

.....

(3 marks)

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END OF QUESTIONS