Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

For Examiner's Use

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS **ELE1**
Unit 1 Foundation Electronics

Tuesday 22 May 2007 9.00 am to 10.30 am

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

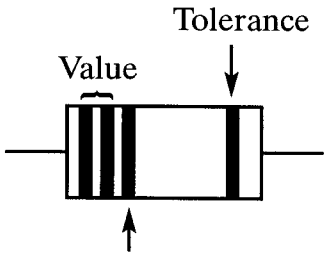
- A perforated *Data Sheet* is provided on pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this perforated sheet at the start of the examination.

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

Turn over ▶

Operational amplifier

$$G_V = \frac{V_{out}}{V_{in}} \quad \text{voltage gain}$$

$$G_V = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G_V = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

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

Astable and Monostable using NAND Gates

$$f \approx \frac{1}{2RC} \quad \text{astable}$$

$$T \approx RC \quad \text{monostable}$$

555 Astable and Monostable

$$T = 1.1RC \quad \text{monostable}$$

$$\left.\begin{aligned} t_H &= 0.7(R_A + R_B)C \\ t_L &= 0.7R_BC \end{aligned}\right] \quad \text{astable}$$

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

Electromagnetic Waves

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

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 equation for a logic circuit with inputs A and B and output Q is

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

(a) Complete the truth table to show the logic values of the terms below for all the combinations of variables A and B.

A	**B**	$\overline{\mathbf{A}}$	$\overline{\mathbf{B}}$	$\overline{\mathbf{A}} + \overline{\mathbf{B}}$	**A + B**	**Q**
0	0					
0	1					
1	0					
1	1					

(*5 marks*)

(b) Complete the diagram below to show how a logic circuit can be constructed from **two** NOT gates, **two** OR gates and **one** AND gate to represent the Boolean equation above.

(*5 marks*)

(c) State which single logic gate has the same function as the complete circuit above.

.....

(*1 mark*)

11

2 A student designs an electronic system to make an audible tone that pulses on and off repeatedly when the temperature exceeds a certain level.

(a) Draw a system diagram to show a possible design using the following subsystems

af astable **AND gate** **comparator**

slow astable **sounder** **temperature sensor**.

(*6 marks*)

(b) In which subsystem could

(i) an op-amp be used, ...

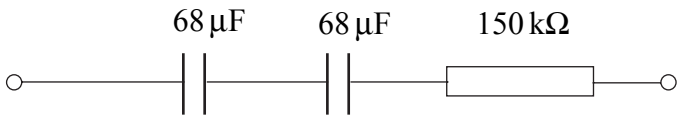
(ii) a thermistor be used, ...

(iii) a logic gate be used? .....

(3 marks)

9

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



(a) Calculate

(i) the combined capacitance of the two capacitors in this circuit,

.....

.....

(ii) the time constant of this circuit.

.....

(*4 marks*)

(b) The timer switches when the capacitors are discharged to half the power supply voltage.
Neglecting any current taken by the timing circuit and assuming the capacitors are initially fully charged. Calculate

(i) how long it will take for the capacitors to discharge to half the power supply voltage,

.....

(ii) approximately how long it will take for the capacitors to totally discharge.

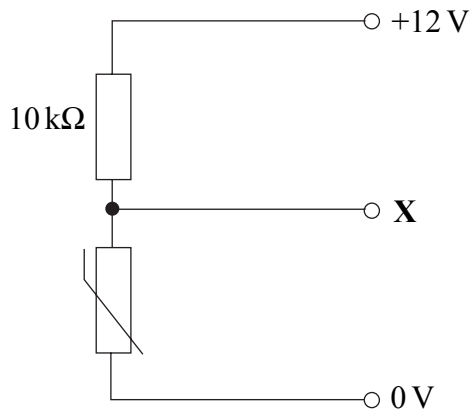
.....

(3 marks)

7

Turn over for the next question

4 A temperature sensor input subsystem is shown below.



(a) The thermistor shown above has a resistance of 30 kΩ at 0 °C, 15 kΩ at 25 °C, and 2 kΩ at 100 °C.

(i) At what temperature given above will the current through the circuit be the largest?

.....

(ii) Explain why the maximum current will flow at this temperature.

.....

(iii) Calculate the value of this current.

.....

.....

(iv) Calculate the output voltage at **X** at this temperature.

.....

.....

(5 marks)

(b) The temperature sensor subsystem is to be connected to a comparator circuit to detect when the water in an electric kettle boils.

(i) What reference voltage must the comparator have to detect boiling water?

.....

(ii) Draw a suitable circuit for the comparator if it is to produce a high output when the water boils.
Choose suitable values for the resistors in the voltage divider, labelling them on your circuit diagram.

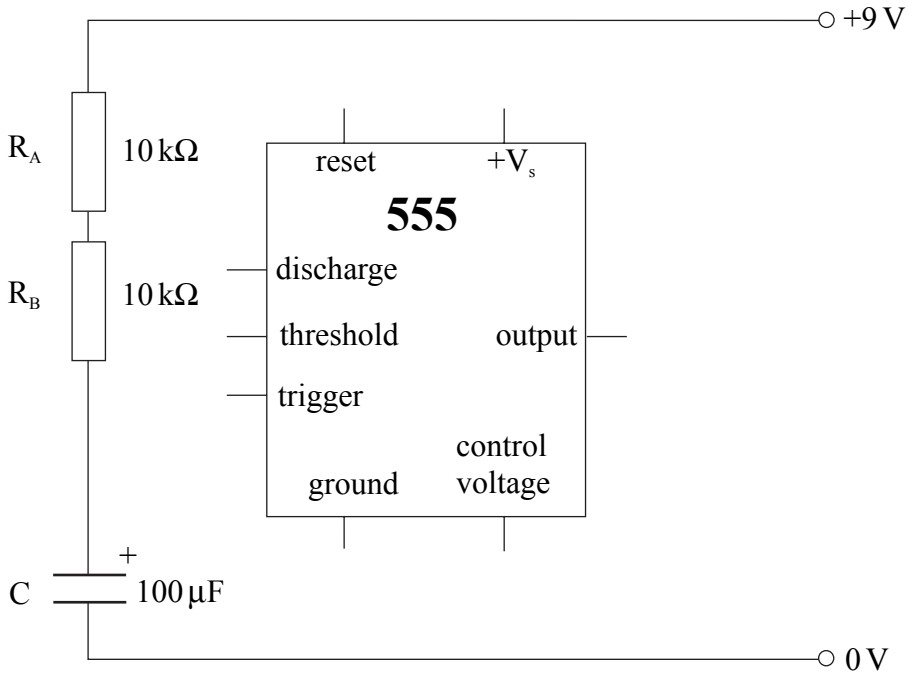
(5 marks)

10

5 A 555 timer IC is connected as an astable.

(a) (i) Complete the circuit diagram below to show how the 555 timer IC is connected as an astable.

(ii) Draw an LED and series resistor connected to the output so that the LED lights when the output is high.



(*6 marks*)

(b) (i) Calculate the time for which the LED will be on.

.....

.....

(ii) Calculate the time for which the LED will be off.

.....

.....

(iii) Calculate the frequency of the output pulses.

.....

.....

(6 marks)

12

6 A student designs an automatic porch light that will switch on when it gets dark. To give enough light a 40 W lamp that operates from 12 V is chosen.

(a) Why can this lamp **not** be controlled directly from a comparator or logic gate?

.....

.....

(1 mark)

(b) The student then considers the choice of lamp drivers available.

(i) Name **two** semiconductor active devices that could be used to control the lamp.

1 .....

2 .....

(ii) Which electromagnetic device could also be used?

.....

(iii) What other component must be used with the electromagnetic device to protect the rest of the circuit?

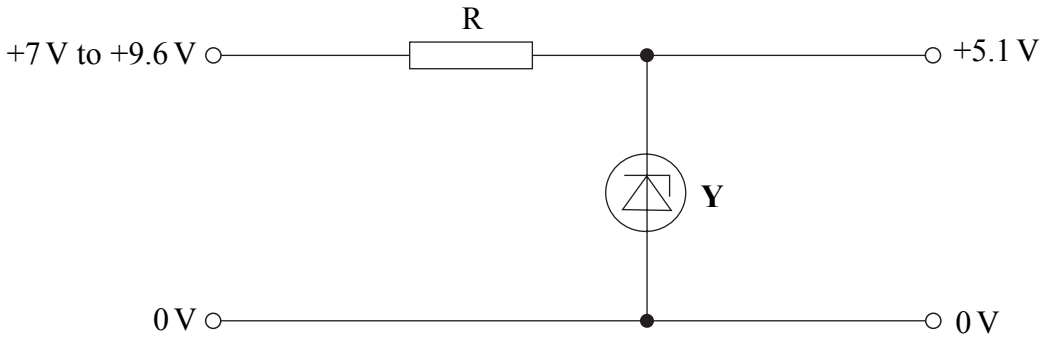
.....

(4 marks)

5

Turn over for the next question

7 The power supply circuit shown below gives an output voltage of 5.1 V when connected to a 9 V battery.
The 9 V battery gives an output of 9.6 V when it is new, falling to 7 V at the end of its useful life.



(a) (i) Name the component **Y** in the circuit.

.....

(ii) What voltage rating should be chosen for **Y**?

.....

(iii) In which bias direction is component **Y** connected?

.....

(4 marks)

(b) The maximum output current from this circuit is 50 mA.
Under this condition the current through **Y** is 5 mA.
Calculate

(i) the current flow through R,

.....

(ii) the voltage across R when the input voltage is 7 V,

.....

(iii) the required value of resistance R,

.....

(iv) which preferred value should be chosen for R if the current through **Y** is not to fall below 5 mA.

.....

(5 marks)

(c) A new battery which has a voltage of 9.6 V is connected to the input of this circuit with the value of R chosen in part (b)(iv).
Calculate

(i) the new voltage across R,

.....

(ii) the new current through R,

.....

(iii) the power now dissipated by R.

.....

(4 marks)

(d) With the new battery and when no current is drawn from the output of the circuit calculate

(i) the current through component **Y**,

.....

(ii) the power dissipated by component **Y**.

.....

(2 marks)

(e) (i) Calculate the maximum useful output power delivered by this circuit.

.....

(ii) Comment on the efficiency of this circuit for providing a stable 5.1 V output voltage from a small 9 V battery.

.....

.....

(3 marks)

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END OF QUESTIONS

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