| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | | Candidate Number | | | | | | | | | |
| Candidate Signature | | | | | | | | | | | | |

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

# ELECTRONICS ELE1
# Unit 1 Foundation Electronics

Thursday 26 May 2005 Afternoon 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 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 | | | |
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| Total (Column 1) → | | | |
| Total (Column 2) → | | | |
| TOTAL | | | |
| Examiner's Initials | | | |

**Data Sheet**

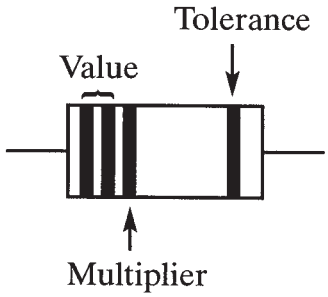
- A perforated *Data Sheet* is provided on pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this perforated sheet at the start of the examination.

**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**

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

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

**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**

$G_V = \frac{V_{out}}{V_{in}}$ 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, }]

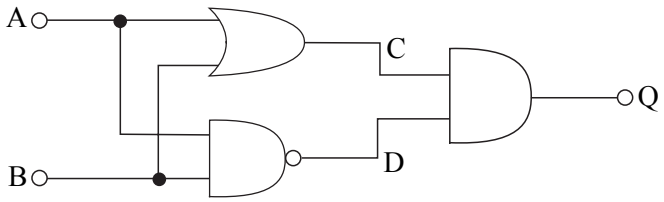
**OUT** port%, data%

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

**REM** remark

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

**1** A logic circuit is shown below.




(a) Complete the truth table below to show the operation of this logic circuit.

| A | B | C | D | Q |
|---|---|---|---|---|
| 0 | 0 | | | |
| 0 | 1 | | | |
| 1 | 0 | | | |
| 1 | 1 | | | |

*(4 marks)*

(b) Write the Boolean expressions for the signals at points C and D in terms of the inputs A and B.

C = .....

D = .....

*(2 marks)*

(c) Write a Boolean expression for Q

(i) in terms of C and D, Q = .....

(ii) in terms of A and B. Q = .....

*(2 marks)*

(d) A single gate can replace the combination of gates above.

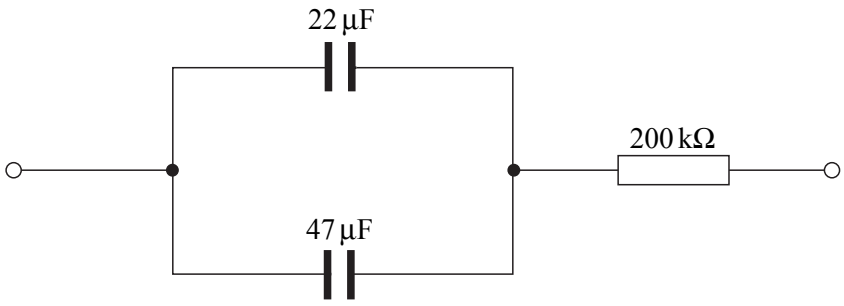
(i) Name the gate. .....

(ii) Draw the logic circuit symbol for this gate.

*(2 marks)*

10

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




(a) (i) Calculate the combined capacitance of the two capacitors in the circuit.

.....

(ii) Calculate the time constant of the circuit.

.....

*(3 marks)*

(b) Both capacitors are initially uncharged. When connected to a power supply, calculate:

(i) the time for the capacitors to charge to half the power supply voltage;

.....

(ii) the time for the capacitors to become fully charged.

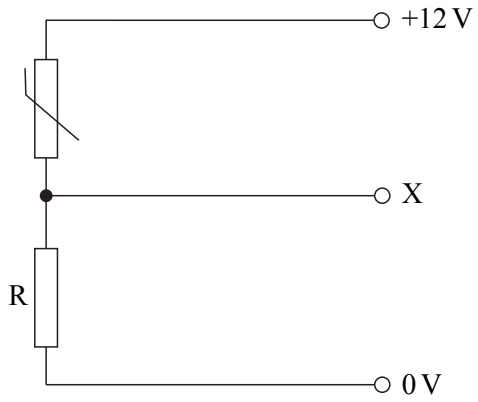
.....

*(4 marks)*

7

**3** An electronic system is designed to turn on an LED when the room temperature rises to a set level.

The circuit diagram of the temperature sensor is shown below.




(a) The thermistor used in the circuit has a resistance of 45 kΩ at 0 °C, 13 kΩ at 25 °C and 1 kΩ at 100 °C.

(i) Calculate the value of the resistor, R, that would give a current of 1 mA through the thermistor when the temperature is 100 °C.

.....

.....

(ii) Using the value of R from part (i), calculate the output voltage at X when the temperature is 25 °C.

.....

.....

*(5 marks)*

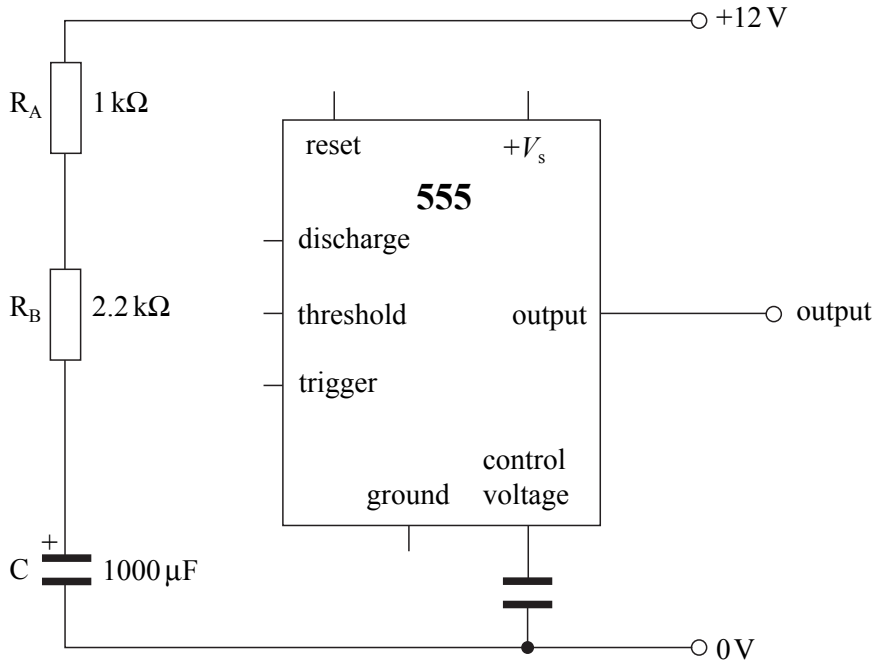
(b) The temperature sensor is connected to an op-amp comparator circuit which gives a positive output to turn on an LED when the temperature rises to 25 °C. Draw a circuit diagram of the whole system. Component values are not required.

*(4 marks)*

9

**4** A 555 timer IC is used in a circuit to generate control pulses for an industrial process.

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




*(6 marks)*

(b) Calculate:

(i) using the equation from the data sheet, the time that the output is low ($t_L$);

.....

.....

(ii) using the equation from the data sheet, the time that the output is high ($t_H$).

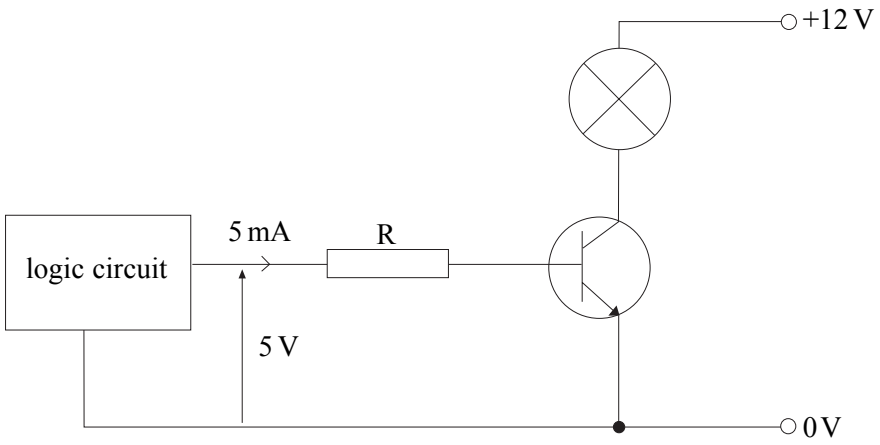
.....

.....

*(4 marks)*

10

**5** An npn junction transistor is used to switch the current through a 12 V 6 W lamp.
The input signal to the transistor is from a logic circuit that gives an output of 5 mA at 5 V.
The circuit is shown below.




(a) The base-emitter voltage of the transistor when switched on is 0.7 V.

(i) Calculate the voltage across the resistor, R, when the transistor is switched on.

.....

(ii) Calculate the resistance of R required to limit the base current to 5 mA.

.....

.....

(iii) Resistors of this value are not available. Which two identical resistors from the E24 series would combine to give the required resistance?

.....

(iv) Write the colour code for **one** of these resistors if it has a 5% tolerance.

..... ..... ..... .....

*(9 marks)*

(b) (i) Calculate the collector current of the transistor when the lamp is fully switched on.

.....

.....

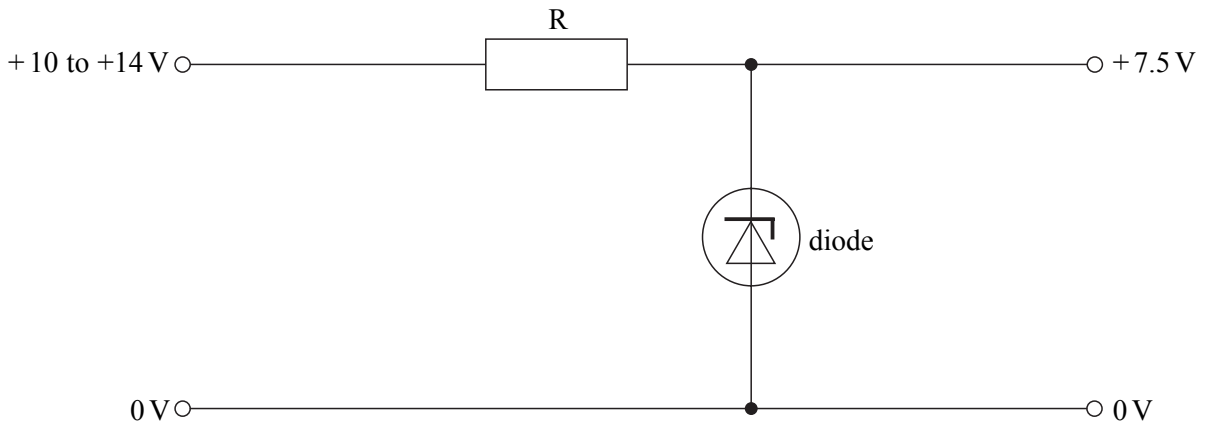
(ii) Calculate the required current gain (ratio of collector current to base current) of the transistor in this circuit.

.....

.....

*(4 marks)*

**6** A regulated voltage supply circuit is shown below. The input voltage varies from 10 V to 14 V. The required output voltage is 7.5 V.




(a) (i) Name the type of diode required in this circuit.

.....

(ii) What voltage rating should be chosen for the diode?

.....

(iii) In which bias direction is the diode connected?

.....

*(3 marks)*

(b) The minimum diode current is 10 mA. The required output current from the circuit is 100 mA.

(i) Calculate the current through the resistor, R, when the output current is 100 mA.

.....

(ii) Calculate the voltage across R when the input voltage is at its minimum of 10 V.

.....

(iii) Calculate the required resistance of R.

.....

(iv) Which preferred value of resistance should be chosen in this case?

.....

*(5 marks)*

(c) The input voltage now rises to its maximum of 14 V.

(i) Calculate the voltage across R.

.....

(ii) Calculate the current through R at this voltage using the value of R from part (b) (iv).

.....

(iii) Calculate the power dissipated by R at this voltage.

.....

(iv) Resistors are available in power ratings of 0.25 W, 0.5 W, 1 W, 2 W and 4 W. Which is the lowest acceptable power rating for the resistor?

.....

*(6 marks)*

(d) The power supply input voltage remains at 14 V, but no current is drawn from the output of the regulator circuit.

(i) What is the current through the diode under these conditions?

.....

(ii) Calculate the power dissipated by the diode under these conditions.

.....

(iii) This type of diode is available in 0.4 W, 1.3 W and 5 W ratings. Choose the most suitable rating for this diode.

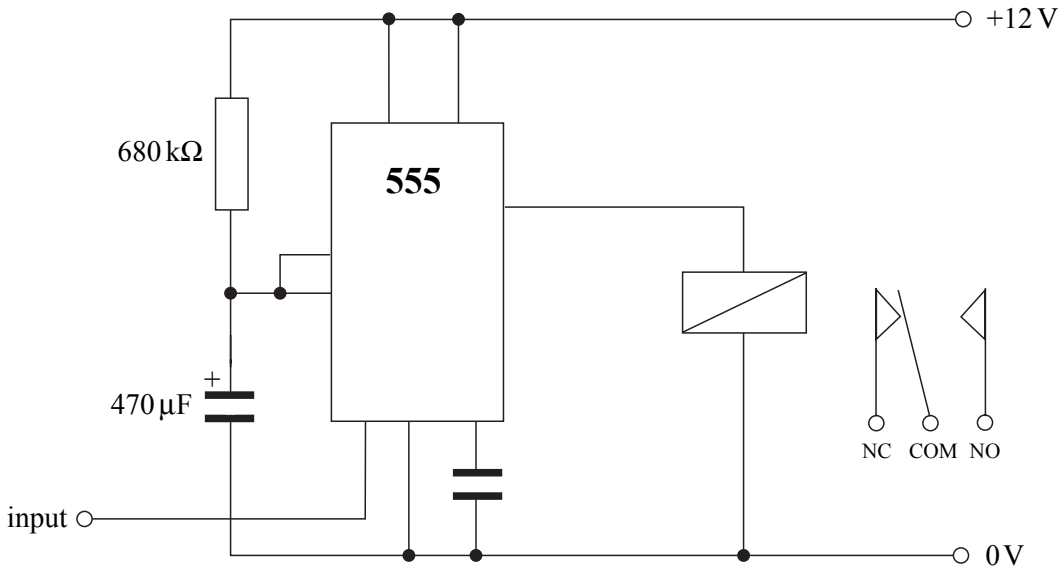
.....

*(4 marks)*

18

**TURN OVER FOR THE NEXT QUESTION**

**7** A 555 monostable circuit is used to control an electromagnetic relay.




(a) Using the equation from the data sheet, calculate the time period of the monostable circuit.

.....

*(2 marks)*

(b) How should the input change to set the monostable into its unstable state?

.....

*(1 mark)*

(c) Which contact on the relay would be connected to the common terminal (COM) when the monostable output is high?

.....

*(1 mark)*

(d) Add to the circuit diagram above the component required to protect the 555 IC from the large induced voltage generated by the relay coil when it switches off.

*(1 mark)*

5

**END OF QUESTIONS**