Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

ELECTRONICS — ELE2
Unit 2 Further Electronics

Friday 16 May 2008 9.00 am to 10.30 am

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.
- You may wish to detach this sheet before you begin work.

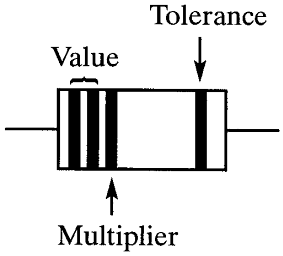
Data Sheet

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 × 1
K means × 1000 (i.e. 10^3)
M means × 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

$G_V = \dfrac{V_{out}}{V_{in}}$ voltage gain

$G_V = -\dfrac{R_f}{R_1}$ inverting

$G_V = 1 + \dfrac{R_f}{R_1}$ non-inverting

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

Astable and Monostable using NAND Gates

$f \approx \dfrac{1}{2RC}$ astable

$T \approx RC$ monostable

555 Astable and Monostable

$T = 1.1RC$ monostable

$\left.\begin{array}{l} t_H = 0.7(R_A + R_B)C \\ t_L = 0.7R_BC \end{array}\right]$ astable

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

Areas outside the box will not be scanned for marking

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

1 Temporary traffic lights are used to control the traffic at roadworks. The traffic lights have a 16-step binary sequence as shown in the table below where R = red, Y = amber, G = green.

D	C	B	A	traffic lights 1	traffic lights 2
0	0	0	0	R	G
0	0	0	1	R	G
0	0	1	0	R	G
0	0	1	1	R	G
0	1	0	0	R	G
0	1	0	1	R	G
0	1	1	0	R	Y
0	1	1	1	R, Y	R
1	0	0	0	G	R
1	0	0	1	G	R
1	0	1	0	G	R
1	0	1	1	G	R
1	1	0	0	G	R
1	1	0	1	G	R
1	1	1	0	Y	R
1	1	1	1	R	R, Y

1 (a) State the value of the step, in hexadecimal, when only the amber lamp is illuminated in **traffic lights 1**.

....

(1 mark)

Question 1 continues on the next page

Areas outside the box will not be scanned for marking

1 (b) Explain why the Boolean expression when the green lamp of **traffic lights 1** is illuminated is given by

$$\mathbf{G = D \cdot \overline{C} \cdot \overline{B} \cdot \overline{A} + D \cdot \overline{C} \cdot \overline{B} \cdot A + D \cdot \overline{C} \cdot B \cdot \overline{A} + D \cdot \overline{C} \cdot B \cdot A + D \cdot C \cdot \overline{B} \cdot \overline{A} + D \cdot C \cdot \overline{B} \cdot A}$$

(2 marks)

1 (c) Show that the expression in part (b) simplifies to:

$$\mathbf{G = D \cdot \overline{B \cdot C}}$$

(3 marks)

Areas outside the box will not be scanned for marking

1 (d) Draw a circuit diagram to show how you would implement the simplified logic expression using several 2-input NAND gates.

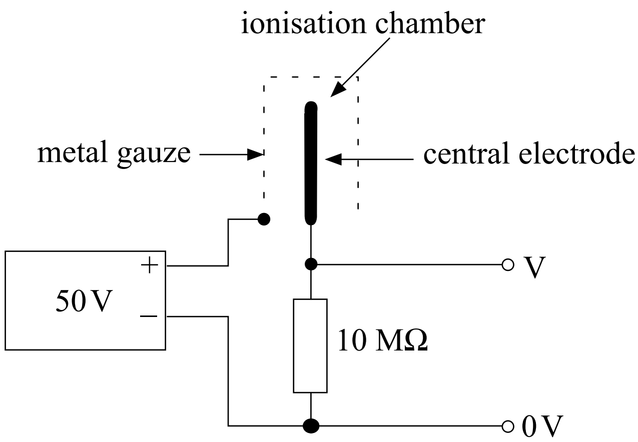
(3 marks)

9

Turn over for the next question

Areas outside the box will not be scanned for marking

2 An ionisation chamber for detecting radioactivity consists of a metal gauze cylinder surrounding a central electrode. The metal gauze is held at a voltage of +50 V with respect to the central electrode. When radiation enters the chamber the gas is ionised and a very small current flows which is directly related to the strength of the radiation. This small current passes through a 10 MΩ resistor.



2 (a) (i) The maximum current that the detector can produce is 2×10^{-10} A. Calculate the corresponding voltage across the 10 MΩ resistor.

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....

2 (a) (ii) The voltage is to be displayed on a digital meter which has a maximum sensitivity of 200 mV. Calculate the voltage gain required for an amplifier to interface the digital meter to the ionisation chamber.

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(4 marks)

2 (b) It is decided to use a non-inverting op-amp amplifier to provide this gain. State and explain what important property makes a non-inverting amplifier a suitable choice.

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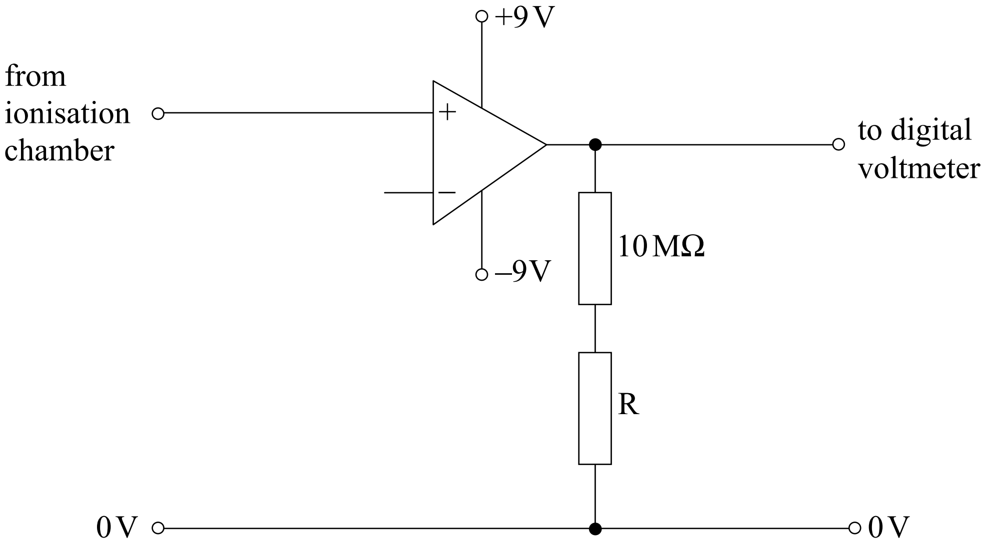
(2 marks)

Areas outside the box will not be scanned for marking

The partly drawn circuit diagram for a non-inverting amplifier is shown below.



2 (c) (i) Complete the circuit diagram by adding the missing connection.

2 (c) (ii) Calculate the value of R needed to produce the voltage gain you have calculated in part (a)(ii).

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....

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....

(3 marks)

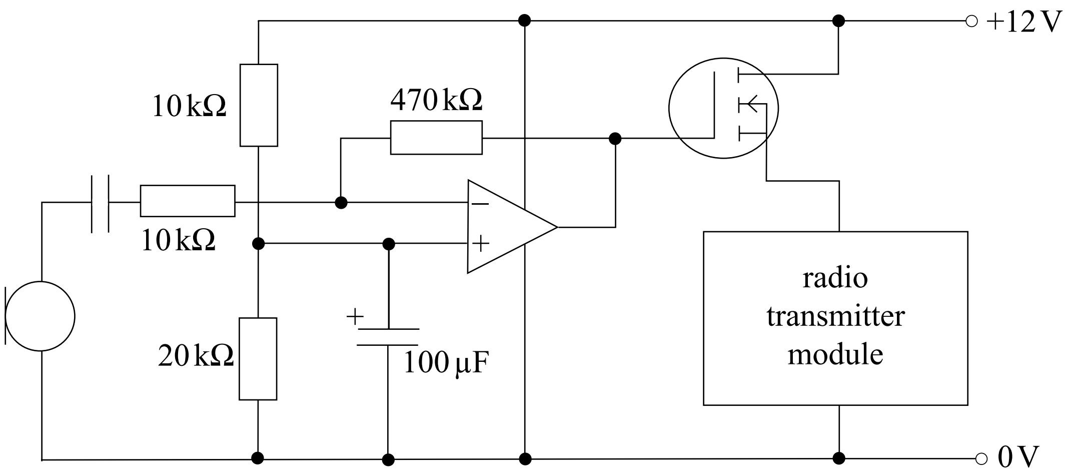
9

Turn over for the next question

Areas outside the box will not be scanned for marking

3 Part of the circuit diagram for a low power radio transmitter is shown below.

The audio amplifier controls the current through the radio transmitter module.



3 (a) (i) Label the source connection of the MOSFET with an S.

3 (a) (ii) What is the name for the circuit arrangement in which the MOSFET is being used?

....

(2 marks)

3 (b) (i) Show that the voltage at the non-inverting input of the op-amp is 8 V.

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3 (b) (ii) With no input signal from the microphone, explain why the voltage on the gate of the MOSFET is also 8 V.

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3 (b) (iii) If the turn on value of V_{gs} for the MOSFET is 2 V, what is the voltage across the radio transmitter module, when there is no signal from the microphone?

....

(4 marks)

Areas outside the box will not be scanned for marking

3 (c) (i) Calculate the voltage gain of the op-amp amplifier.

....

....

3 (c) (ii) If the microphone gives an output of 40 mV, estimate the voltage change that occurs across the radio transmitter module, showing your working.

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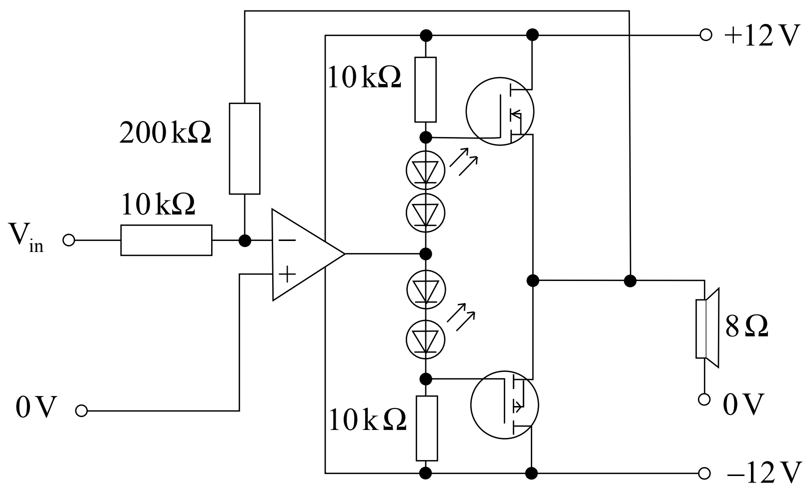
(3 marks)

9

Turn over for the next question

Areas outside the box will not be scanned for marking

4 A student wants to amplify the output from the sound card on his computer so that he can use loudspeakers instead of headphones. His sound card gives a maximum peak output voltage of 500 mV. He wants to use an amplifier circuit that he has found on a website, but needs to decide if it will be suitable.
The circuit diagram is shown below.



4 (a) Show that the peak voltage developed across the loudspeaker will be approximately 10 V when there is an input of 500 mV.

....

....
(2 marks)

4 (b) Calculate the rms output power into the loudspeaker under these conditions.

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(2 marks)

The student is concerned that the amplifier will suffer from *cross-over distortion*.

4 (c) (i) Explain what is meant by cross-over distortion.

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Areas outside the box will not be scanned for marking

4 (c) (ii) State what measures have been taken to reduce cross-over distortion in the circuit.

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(3 marks)

4 (d) With the circuit constructed and working, the student finds that the MOSFETs become very hot. His teacher recommends that he should bolt each MOSFET to a heatsink.

State **two** important features of an efficient heatsink.

....

....

(2 marks)

9

Turn over for the next question

Areas outside the box will not be scanned for marking

5 All of the electrical activity of the brain occurs at low frequencies, the alpha rhythm having the highest frequency of 8 – 13 Hz. In order to isolate this electrical activity from that of the muscles, which occurs at a higher frequency, the electrical signals are passed through a *low pass filter* with a *break point frequency* of 20 Hz.

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

....

....

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

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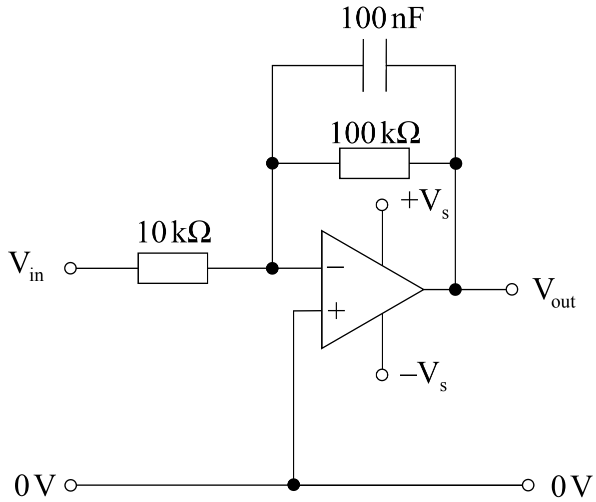
....

(3 marks)

5 (b) The circuit diagram of the low pass filter is shown below.



Calculate the reactance of the 100 nF capacitor at a frequency of 20 Hz.

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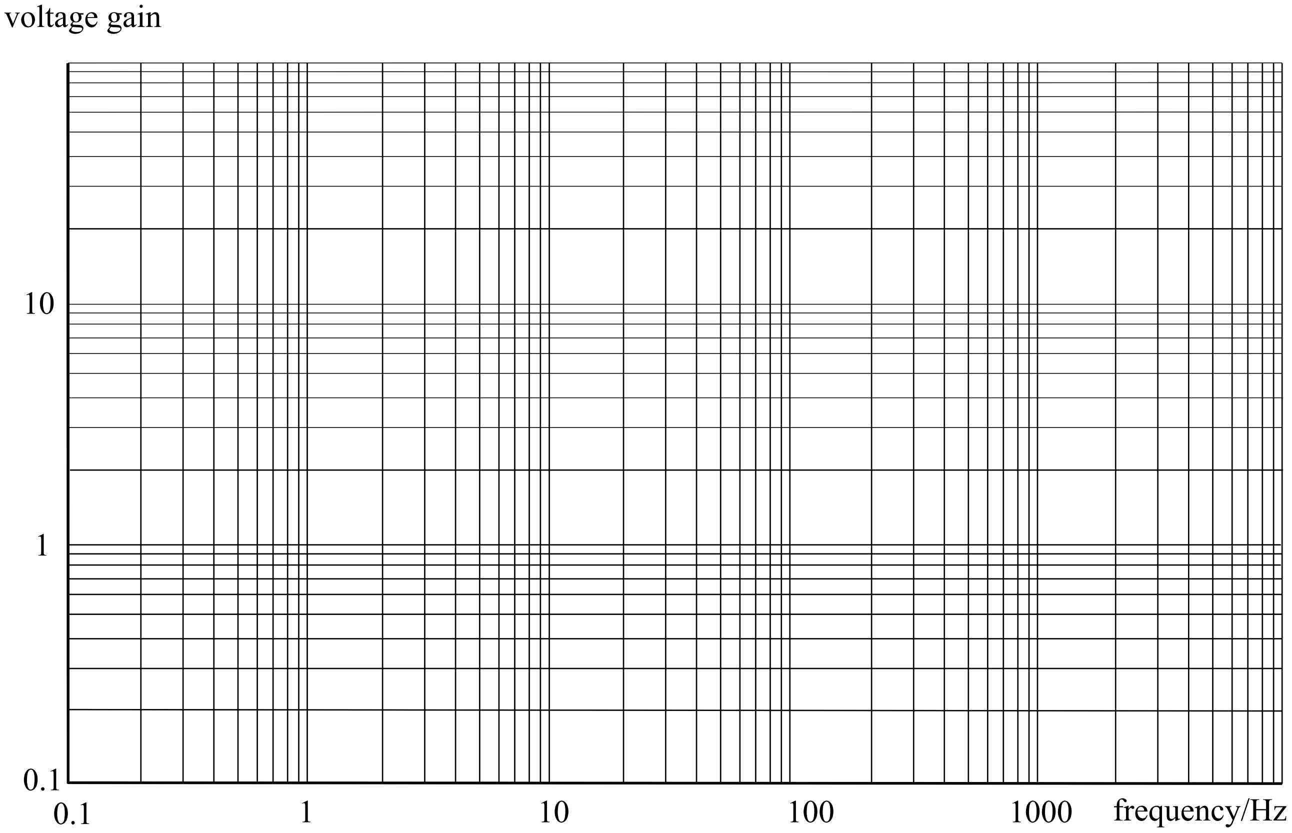
(3 marks)

Areas outside the box will not be scanned for marking

5 (c) Sketch onto the grid below how the voltage gain of this filter circuit varies with frequency.



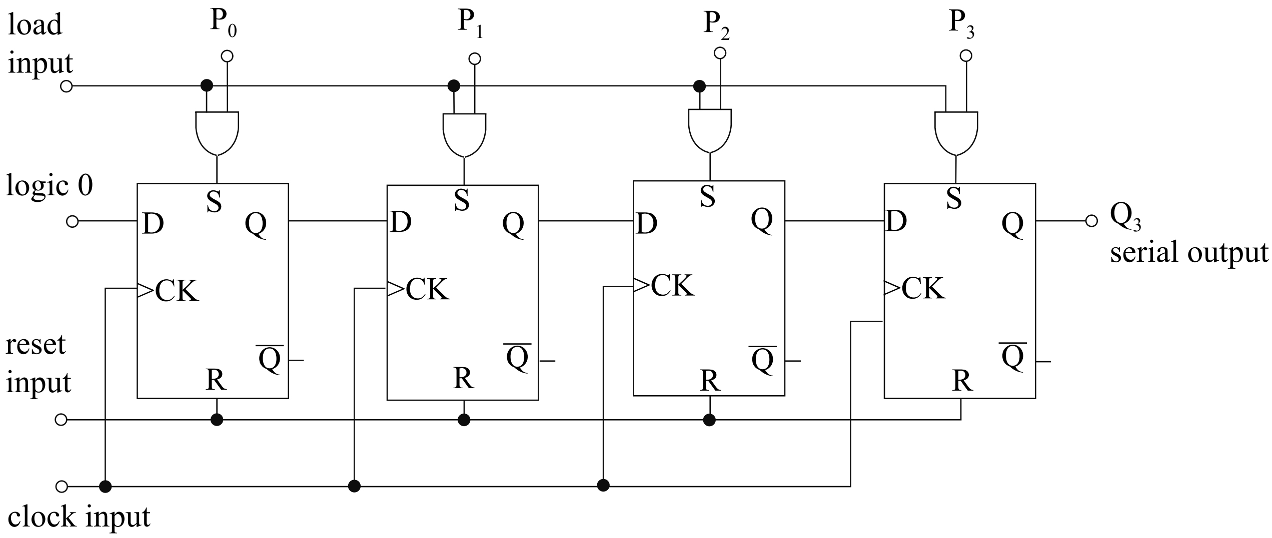
(3 marks)

9

Turn over for the next question

Areas outside the box will not be scanned for marking

6 The shift register circuit below is used by a student to convert parallel data to serial data. The parallel data is sent to P_0, P_1, P_2 and P_3 and the serial output is taken from Q_3.



6 (a) Explain how a shift register works.

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(3 marks)

6 (b) (i) Explain why it is necessary in this circuit to reset the shift register before loading new parallel data.

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....

6 (b) (ii) State the logic level of the load input for parallel data to be loaded into the shift register.

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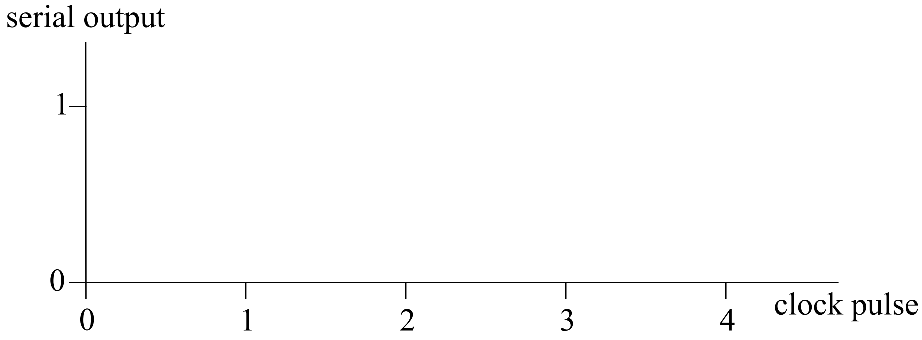
(2 marks)

Areas outside the box will not be scanned for marking

6 (c) The hexadecimal number **B** is loaded into the shift register. Sketch onto the diagram below the serial output.



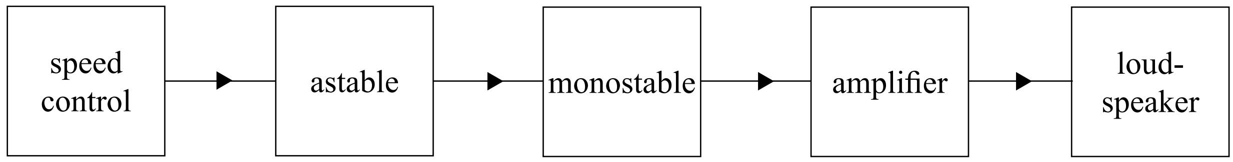
(4 marks)

9

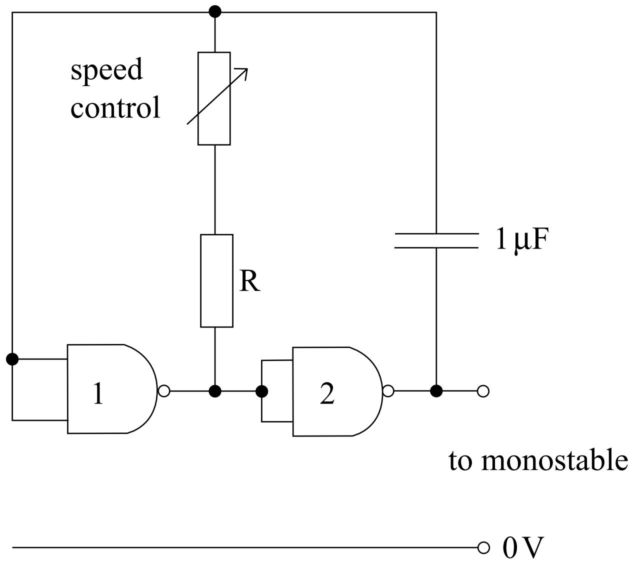
Turn over for the next question

Areas outside the box will not be scanned for marking

7 A metronome is a device used by musicians to help keep in time. It produces a click to time the beat of the music. The system diagram of a simple metronome is shown below.



The circuit diagram for the astable is shown below.



7 (a) (i) The metronome produces a maximum rate of 240 clicks per minute. What is the required frequency of the astable?

....

7 (a) (ii) Calculate a suitable value for R using the formula on the Data Sheet.

....

....

(3 marks)

7 (b) If the minimum number of clicks per minute is 30, calculate a suitable value for the speed control variable resistor.

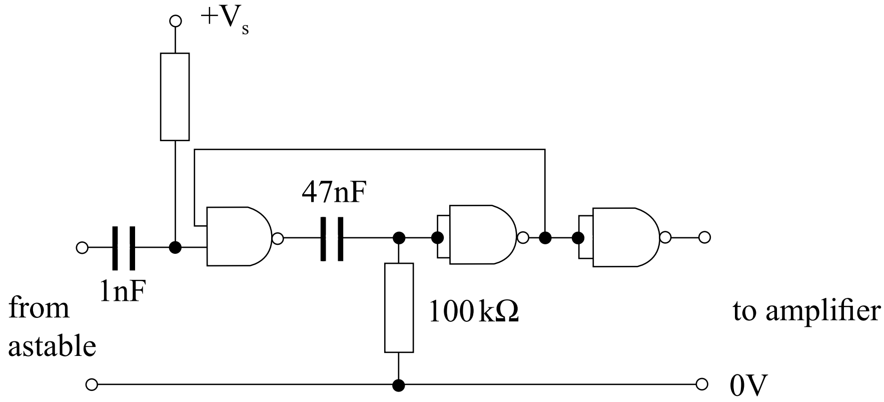
....

....

(2 marks)

Areas outside the box will not be scanned for marking

The circuit diagram for the monostable is shown below.



7 (c) (i) Calculate the time period of the pulse from the monostable using the formula on the Data Sheet.

....

....

7 (c) (ii) Explain how the monostable circuit operates once it has been triggered.

....

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....

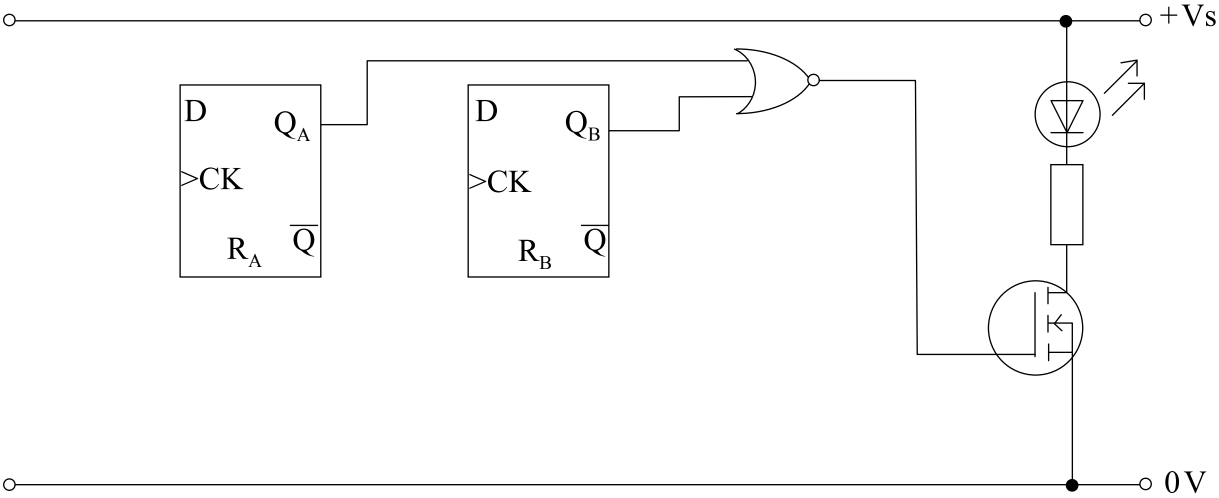
....

(6 marks)

Question 7 continues on the next page

Areas outside the box will not be scanned for marking

Having built the metronome, a student decides to modify it so that it flashes a LED every two, three or four clicks. He decides to build a 2-bit counter using D-type flip-flops. The diagram below shows two D-type flip-flops and the LED flashing circuit.



7 (d) (i) Add the connections necessary to make the two flip-flops into a 2-bit up-counter and show where the output from the monostable would be connected in order to make them count.

7 (d) (ii) Explain under what conditions the LED will light.

....

....

(4 marks)

7 (e) In order to make the LED flash every two, three or four clicks, it is necessary to design a logic circuit to control the reset terminals, R, of the flip-flops. Complete the table below for the logic states that must be applied to each of the reset pins. Choose from **0**, **1** or $\mathbf{Q_A \bullet Q_B}$

No of clicks	$\mathbf{R_A}$	$\mathbf{R_B}$
2	0	1
3		
4		

(3 marks)

18

END OF QUESTIONS

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