Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2003
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE5
Unit 5 Communications Systems

Thursday 26 June 2003 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 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 20% of the total marks for Electronics Advanced level award.
- 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			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

Resistors

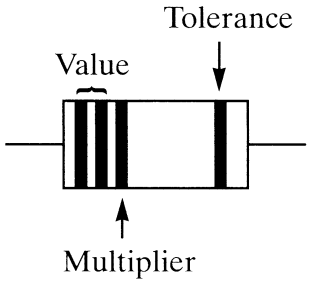
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

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, }]

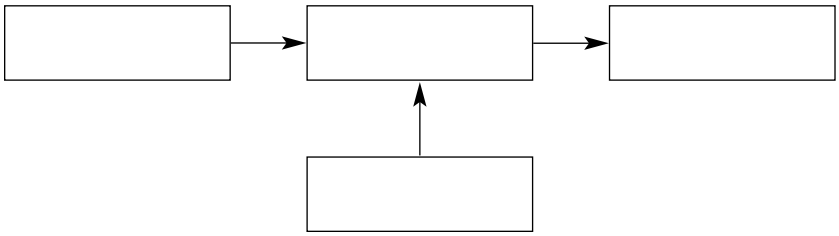
OUT port%, data%

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

REM remark

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

1 (a) Label the block diagram of a radio transmitter shown below.



(4 marks)

(b) The transmitter is connected to a half-wave dipole of 50 Ω impedance, with coaxial cable.

State the required impedance of the cable.

.....

(1 mark)

(c) The length of the half-wave dipole is 2 m from end to end.

Calculate:

(i) the wavelength the antenna is designed for,

.....

(ii) the frequency of the transmitter that would be suitable for this antenna.
(the speed of electromagnetic waves in vacuo, $c = 3 \times 10^8 \, m \, s^{-1}$)

.....

.....

(3 marks)

8

2 An amplitude modulated transmitter operates on a frequency of 540 kHz.
This transmitter is modulated by a single audio frequency of 440 Hz.

(a) Draw a frequency spectrum diagram of the signal to show the carrier and side frequencies. Label **all** the features of your diagram and state the frequencies of **all** the components of the spectrum.

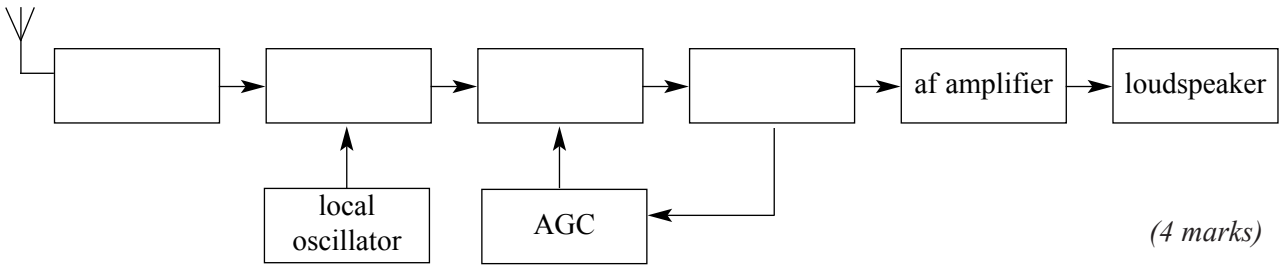
(6 marks)

(b) Draw a time waveform of this signal if the depth of modulation is 100%.
Mark and label on your diagram the period of the carrier wave and the period of the modulation.

(3 marks)

9

3 (a) Complete the labelling of this block diagram of a superhet receiver by naming appropriate sub-systems for the **four** blank boxes.



(4 marks)

(b) Part of the af amplifier is an op-amp inverting amplifier with a voltage gain of –20 and an input impedance of 10 kΩ.

(i) Draw a circuit for this amplifier in the space below.
Choose and calculate suitable values for the resistors and label them.

(ii) Calculate the output voltage of the amplifier circuit when its input voltage is +50 mV.

.....

.....

(6 marks)

10

4 The output sub-system of an audio amplifier in a radio receiver is a push-pull output stage using a p- channel and an n- channel MOSFET.

(a) Draw the circuit of this output stage in the space below.
Label the p- channel and the n- channel MOSFETs with p and n respectively.

(3 marks)

(b) Explain the operation of this circuit as the input signal changes from a positive to a negative value.

.....

.....

.....

(2 marks)

(c) Name **two** types of distortion this amplifier could produce.

1 .....

2 .....

(2 marks)

(d) (i) Name the piece of hardware on which MOSFETs are normally mounted when used in a push-pull amplifier.

.....

(ii) Describe the function of this piece of hardware in this application.

.....

.....

.....

(3 marks)

10

5 (a) Draw a labelled diagram of a cross-section of a coaxial cable.

(3 marks)

(b) Name **two** other media for transmitting signals, **one** wired system other than a coaxial cable, and **one** non-wired system.

1 .....

2 .....

(2 marks)

(c) Name **two** different methods of transmitting many signals on a single communications circuit.

1 .....

2 .....

(2 marks)

(d) In a mobile phone system, the sample rate in the ADC is 8 kHz, the ADC generates an 8-bit output.

(i) What is the maximum frequency of the signal that should be fed to the ADC for sampling?

.....

(ii) Calculate the bit rate of the resulting digital signal.

.....

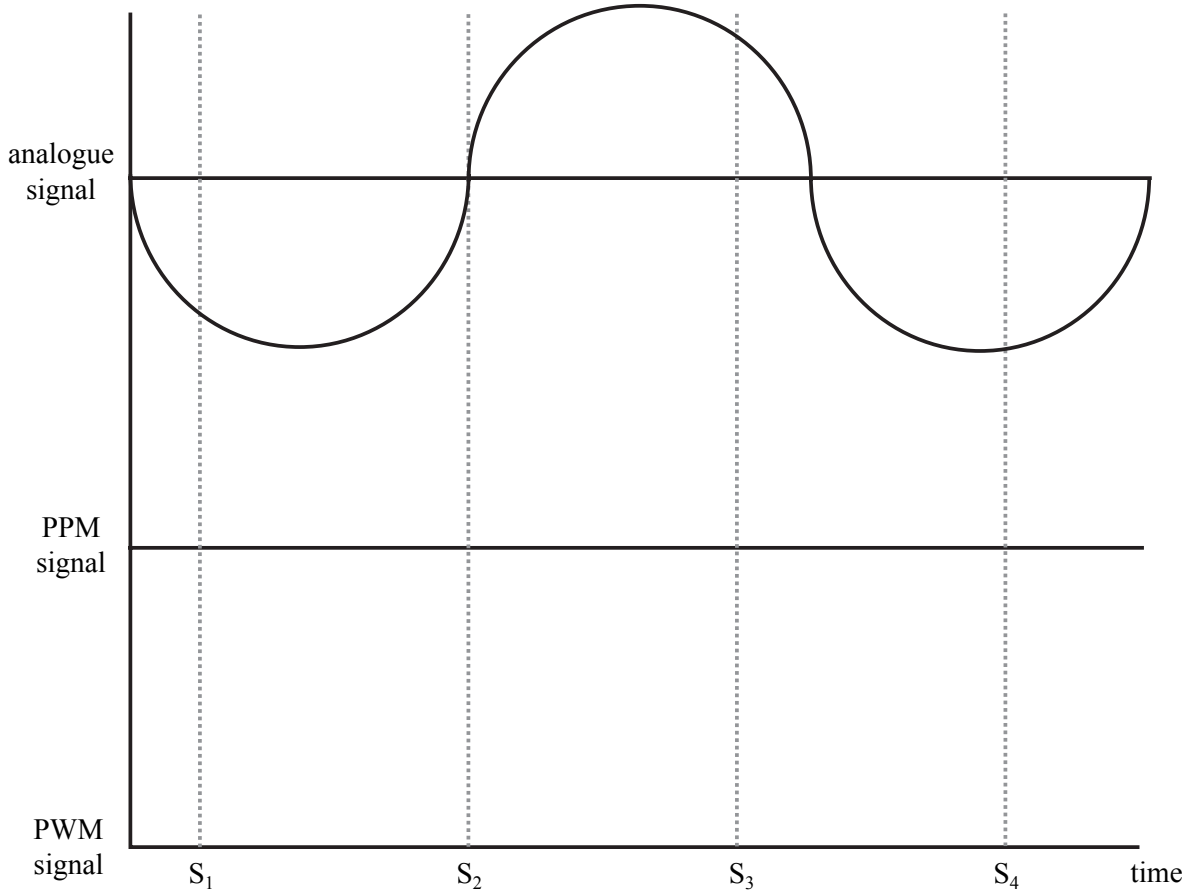
(3 marks)

10

6 (a) An analogue signal is converted into digital form.
Sampling points are marked on the timing diagram below as S_1, S_2, S_3 and S_4.
Draw on this diagram the resulting digital signal when the analogue signal shown is converted into:

(i) a pulse position modulated signal (PPM), and

(ii) a pulse width modulated (PWM) signal.



(4 marks)

(b) A 555 monostable circuit can be used as part of a PWM system to produce pulses when triggered by the sampling pulses.
The timing resistor is 10 kΩ and the capacitor is 0.01 μF.

(i) Calculate the duration of the pulses that the 555 timer will produce.

.....

.....

(ii) Which function (pin) of the 555 timer can affect the duration of the pulses?

.....

(3 marks)

7

TURN OVER FOR THE NEXT QUESTION

7 (a) Part of a PCM system requires a shift register.

(i) What does PCM stand for?

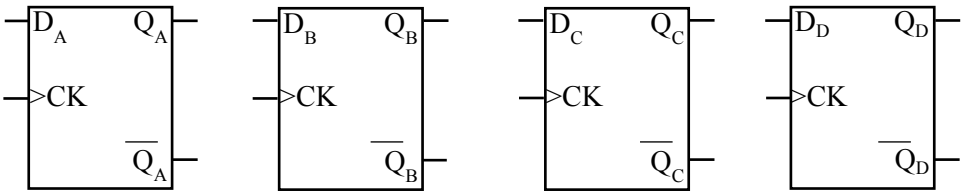
P ..... C..... M.....

(ii) What type of shift register is required to convert data from the output of an 8-bit ADC to a form suitable for communication on a single wire?

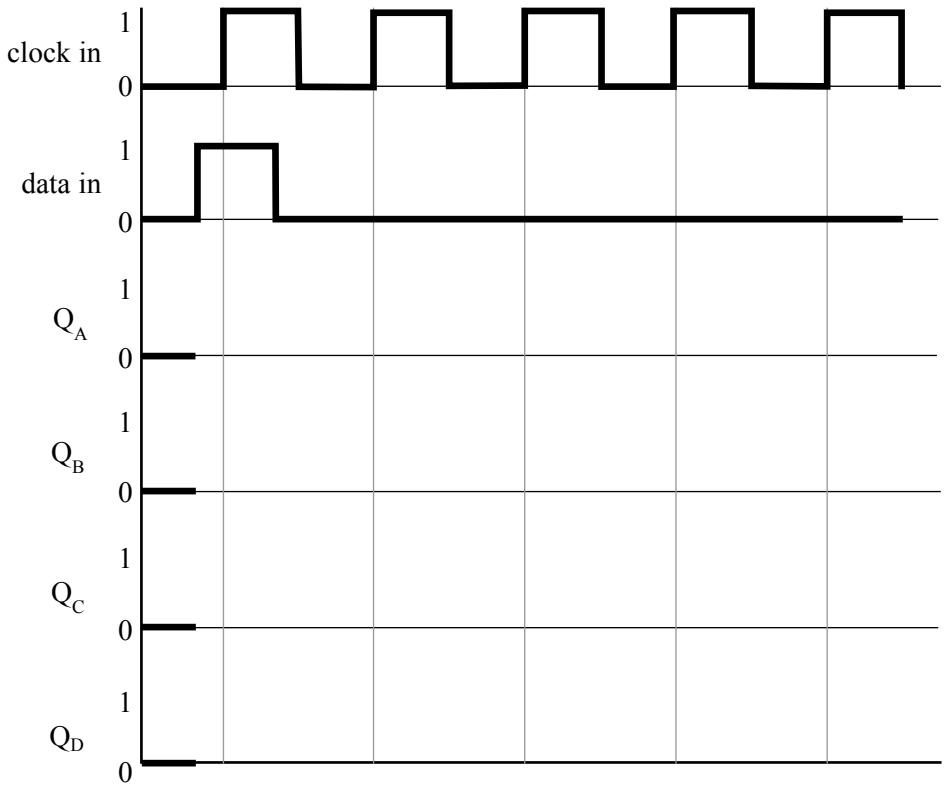
.....

(3 marks)

(b) (i) The diagram below shows four D-type flip-flops. Show how these can be connected as a shift register that can accept a single data line input and convert the signal input to 4 bits available simultaneously at some later time.
Label data in, clock, outputs, and draw the connections required.



(ii) Complete the timing diagram below to show the action of this shift register.



(9 marks)

(c) (i) Name a digital communications system that enables data from several different sources to be transmitted in sequence on a single communication circuit.

.....

(ii) This type of system can be constructed using logic gates.
The Boolean expression for a two input system (where A and B are the signal inputs and S is the input select signal) is:

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

Draw a logic circuit diagram of this system using appropriate gates.
Label the inputs and the output.

(6 marks)

18

END OF QUESTIONS