Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2002
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE5
Unit 5 Communications Systems

Friday 28 June 2002 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 a blue or black ball-point pen.
- 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 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

- 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.
- Detach this sheet before you begin work.

Data Sheet

Resistors

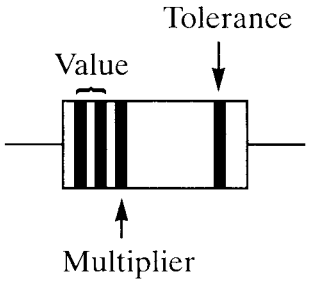
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

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

$T = CR$

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

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

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

1 (a) Draw a labelled block diagram of a simple radio receiver which consists of the following sub-systems:

antenna, **audio amplifier**, **detector/demodulator**, **loudspeaker**, **tuned circuit**.

(5 marks)

(b) The receiver in part (a) is tuned to a carrier frequency of 1.5 MHz.

Calculate

(i) the wavelength of the carrier waves, (c, speed of electromagnetic waves in vacuo = 3×10^8 m s^{-1})

.....

.....

(ii) the length of a halfwave dipole for this frequency.

.....

.....

(3 marks)

(c) The impedance of the antenna is 50 Ω and feeds a coaxial cable.

What must be the impedance of the coaxial cable?

.....

(1 mark)

9

2 (a) Draw a labelled block diagram of a radio transmitter which consists of the following sub-systems:

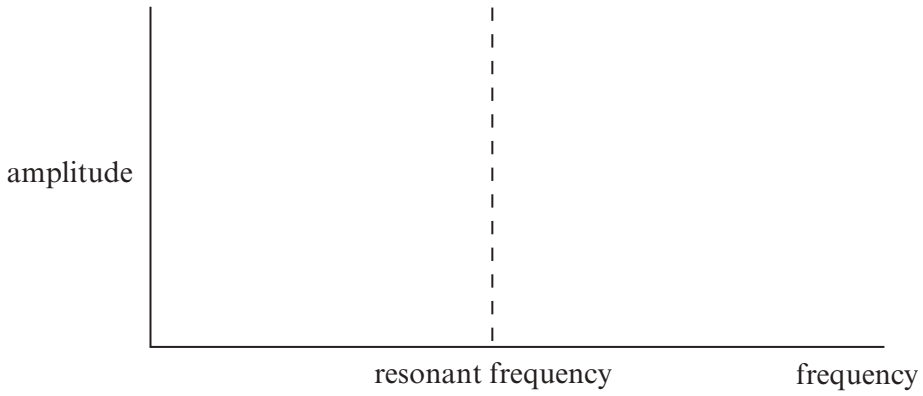
antenna, **carrier generator**, **input transducer**, **modulator**.

(4 marks)

(b) The carrier generator contains a tuned circuit.

(i) Draw **two** curves on the axes below to show the response of high quality factor and low quality factor tuned circuits.

Label the high Q curve "H" and the low Q curve "L".



(ii) A tuned circuit contains a 5 μH coil and a 20 pF capacitor.

Calculate the resonant frequency of this circuit.

.....

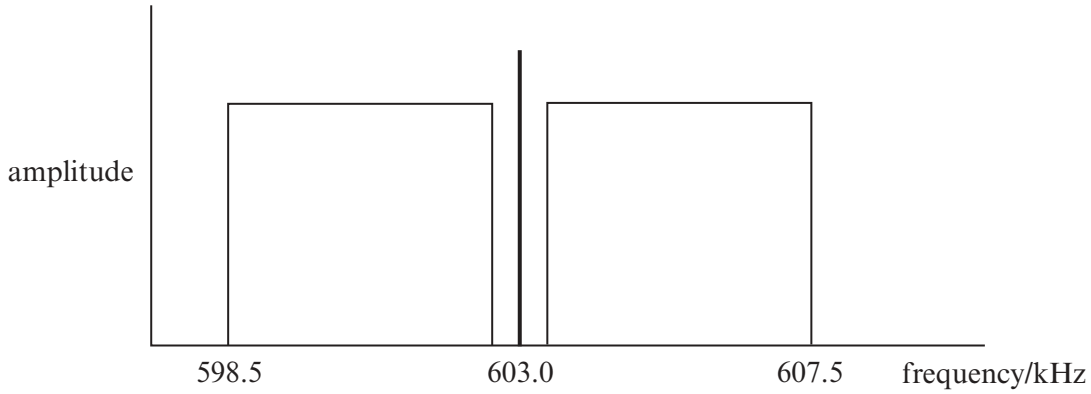
.....

.....

(5 marks)

9

3 A frequency spectrum diagram for an amplitude modulated carrier wave is shown below.



(a) Label the carrier, the lower sideband and the upper sideband. *(3 marks)*

(b) Calculate the value of the highest audio frequency that is modulated on to the carrier wave.

.....

(2 marks)

(c) Which broadcasting band contains this signal?

.....

(1 mark)

(d) Name **one** broadcasting band other than the band you have named in part (c) that would contain

(i) AM signals,

.....

(ii) FM signals.

.....

(2 marks)

8

LEAVE MARGIN BLANK

4 The audio frequency output from the demodulator stage of a radio receiver is 20 mV when fed to a high resistance load.

(a) Name a type of op-amp circuit with a high input resistance which could be used to increase the amplitude of the signal.

.....

(1 mark)

(b) Draw the op-amp circuit described in (a) in the space below.

Label the input and output connections of the circuit.

(4 marks)

(c) Choose and calculate suitable values for the components in your circuit so that the output voltage will be 800 mV.

.....

.....

(3 marks)

(d) This circuit is then examined for its suitability as a rf amplifier.

(i) What property of the op-amp is relevant in the design of a rf amplifier?

.....

(ii) Give a suitable value for this property if the circuit is to amplify a 1 MHz signal by a factor of 25.

.....

(2 marks)

10

5 (a) Draw a diagram of a cross-section of an optical fibre. Label on your diagram regions of low and high refractive index.

(2 marks)

(b) An optical fibre laid on a curve will still allow transmission of an optical signal. Explain what property of the system allows this and how the light travels along a curved fibre.

.....

.....

.....

.....

.....

(3 marks)

(c) State what solid state devices are used for

(i) the generation of an optical signal,

.....

(ii) the reception of an optical signal.

.....

(2 marks)

(d) State **two** advantages of the use of optical fibres in a telephone system.

1. .....

.....

2. .....

.....

(2 marks)

Turn over ►

LEAVE MARGIN BLANK

6 A mobile telephone system has a total bandwidth available of 16 MHz at the base station. Each mobile telephone requires an operating bandwidth of 8 kHz for reception and a further 8 kHz for transmission during a call.

(a) What type of signal links the handset to the base station?

.....

(1 mark)

(b) Calculate the maximum number of telephone calls that can be supported by the base station at one time.

.....

.....

(2 marks)

(c) Calculate the highest modulating frequency that can be encoded using the information given above.

.....

.....

(2 marks)

(d) Modern mobile telephones use digital communications systems.

(i) How are digital signals communicated?

.....

.....

(ii) Name **three** techniques that can be used to modulate a carrier with a digital signal.

1. .....

2. .....

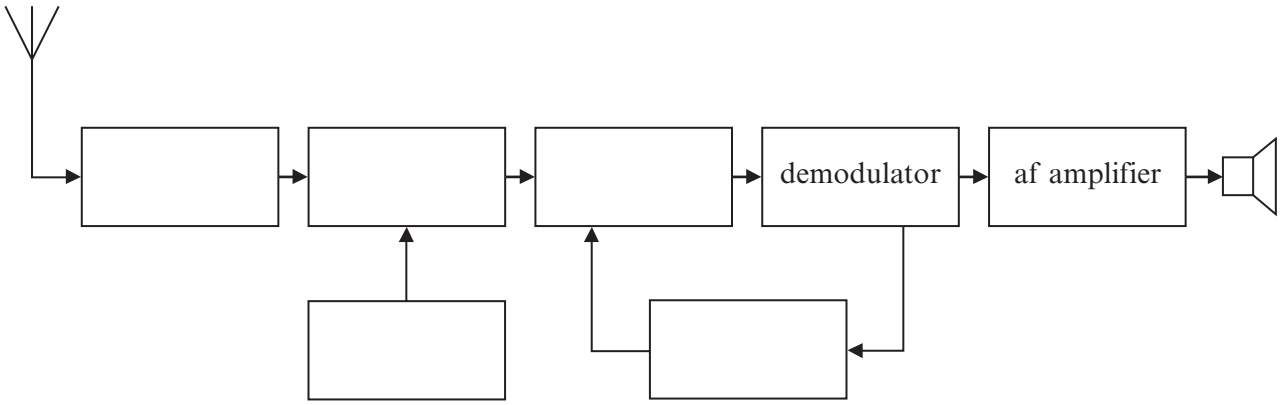
3. .....

(4 marks)

9

TURN OVER FOR THE NEXT QUESTION

7 (a) Complete the block diagram of a superheterodyne radio receiver.



(5 marks)

(b) The output circuit of the af amplifier in part (a) above is a push-pull circuit.

(i) Explain what a push-pull circuit is.

.....

.....

(ii) The push-pull circuit can create a form of distortion which is more obvious at a low volume level. State what type of distortion this is and explain how it can be reduced.

.....

.....

.....

.....

.....

(iii) The push-pull amplifier has a ± 12 V supply and is connected to a 4 Ω loudspeaker. Estimate, by calculation, the maximum output power of the amplifier.

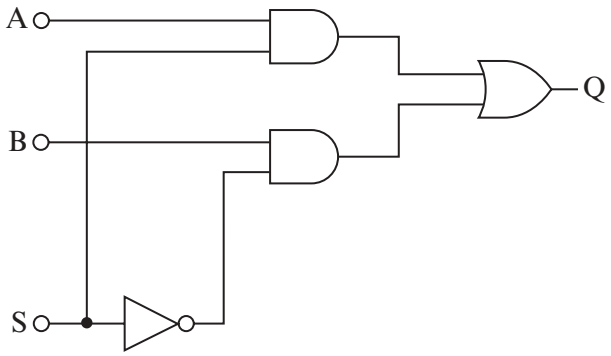
.....

.....

.....

(5 marks)

(c) Part of a logic system for a data multiplexer system is shown below.



(i) Complete the truth table for this logic system.

A	B	S	Q
0	0	0	
1	0	0	
0	1	0	
1	1	0	
0	0	1	
1	0	1	
0	1	1	
1	1	1	

(4 marks)

(ii) Convert this logic system into one using **four** NAND gates only. Draw the converted system below.

(4 marks)

END OF QUESTIONS

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