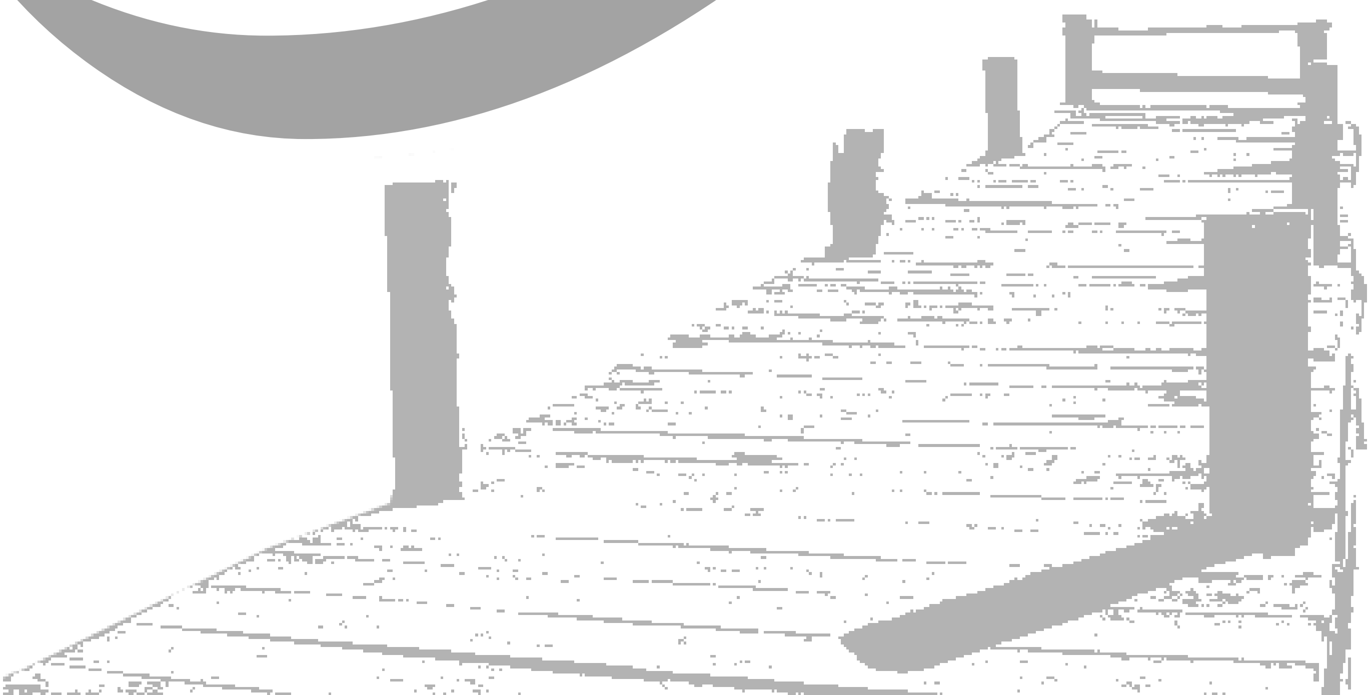
GCE
AS and A Level

Electronics

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 5: ELEC5
Communication Systems

Version 1.1



Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
Advanced Level Examination
version 0.2

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS **ELEC5**
Unit 5 Communication Systems

SPECIMEN PAPER

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.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the space provided.
- Show the working of your calculations.
- 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 80.
- The marks for the 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			
Number	Mark	Number	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.

Data Sheet

Resistors

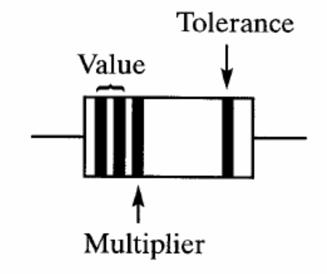
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater

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

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$ parallel

Capacitance

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$ series

$C = C_1 + C_2 + C_3$ parallel

Time constant $T = CR$, $T_{½} = 0.69\ CR$

ac theory

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$X_C = \frac{1}{2\pi fC}$$ reactance

$X_L = 2\pi fL$ reactance

$$f = \frac{1}{T}$$ frequency, period

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$ 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
	$V_{out} = (V_+ - V_-)\frac{R_f}{R_1}$	difference
555 Astable and Monstable	$T = 1.1RC$	monostable
	$\left.\begin{array}{l} t_H = 0.7\,(R_A + R_B)C \\ t_L = 0.7\,R_B C \end{array}\right\}$	astable
	$f = \frac{1.44}{(R_A + 2R_B)C}$	
Electromagnetic waves	$c = 3 \times 10^8\ \text{m s}^{-1}$	speed in vacuo

Assembler language microcontroller instructions

Mnemonic	Operands	Description	Operation	Flags	Clock cycles
NOP	none	No operation	none	none	1
CALL	K	Call subroutine	stack <=PC PC <=K	none	2
RET	none	Return from subroutine	PC <= stack	none	2
INC DEC	R R	Increments the contents of R Decrements the contents of R	(R) <= (R) + 1 (R) <= (R) – 1	Z Z	1 1
ADDW ANDW SUBW ORW XORW	K K K K K	Add K to W AND K with W Subtract K from W OR K and W XOR K and W	W <= W + K W <= W • K W <= W – K W <= W + K W <= W ⊕ K	Z, C Z, C Z, C Z, C Z, C	1 1 1 1 1
JMP	K	Jump to K (GOTO)	PC <= K	none	2
MOVWR MOVW MOVRW	R K, W R	Move W to the contents of R Move K to W Move the contents of R to W	(R) <= W W <= K W <= (R)	Z Z Z	1 1 1

Turn over for the first question

LEAVE MARGIN BLANK

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

1 (a) In the space below draw a block diagram in the space below of a generalised communication system using the following terms

carrier generator	**demodulator**	**input transducer**
modulator	**output transducer**	**receiver**
transmitter		

(*7 marks*)

Explain the meaning of the following terms

1 (b) (i) communication

………………………………………………………………………………………

………………………………………………………………………………………

1 (b) (ii) bandwidth and capacity to carry information.

………………………………………………………………………………………

………………………………………………………………………………………

(*5 marks*)

12

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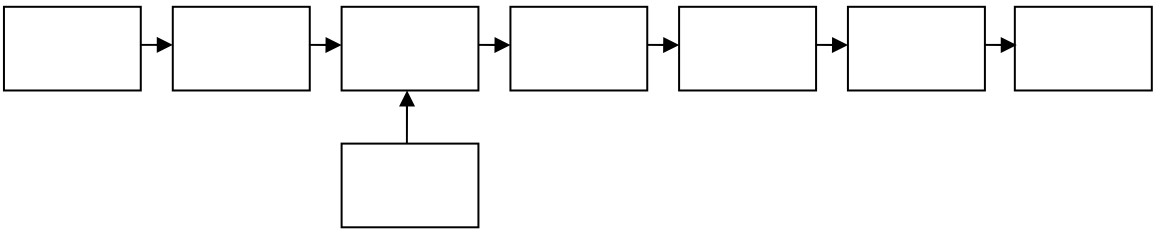
2 (a) A superhet radio receiver uses the following subsystems

aerial	**af amplifier**	**demodulator**	**if amplifier and filter**
mixer	**local oscillator**	**loudspeaker**	**rf amplifier.**

Label the block diagram below to show how these subsystems are connected.



(*4 marks*)

The receiver picks up a signal at 98.1 MHz and the local oscillator produces an output at 87.4 MHz.

2 (b) (i) Calculate which **two** new frequencies will be present at the mixer output.

…………………………………………………………………………………

…………………………………………………………………………………

2 (b) (ii) Which **one** of the frequencies you have calculated in part (b)(i) will pass through the if amplifier and filter?

…………………………………………………………………………………

2 (b) (iii) Which other radio frequency will the receiver respond to?

…………………………………………………………………………………

2 (b) (iv) What is the name of this response in part (b)(iii)?

…………………………………………………………………………………

(*7 marks*)

11

Turn over

3 (a) How is the information signal amplitude and information signal frequency are encoded on to the carrier wave using amplitude modulation (AM)?

Information signal amplitude is encoded as ……………………………………..

…………………………………………………………………………………

Information signal frequency is encoded as ……………………………………..

…………………………………………………………………………………

(*2 marks*)

3 (b) Describe how the information signal amplitude and information signal frequency are encoded on to the carrier wave using frequency modulation (FM).

Information signal amplitude is encoded as ……………………………………..

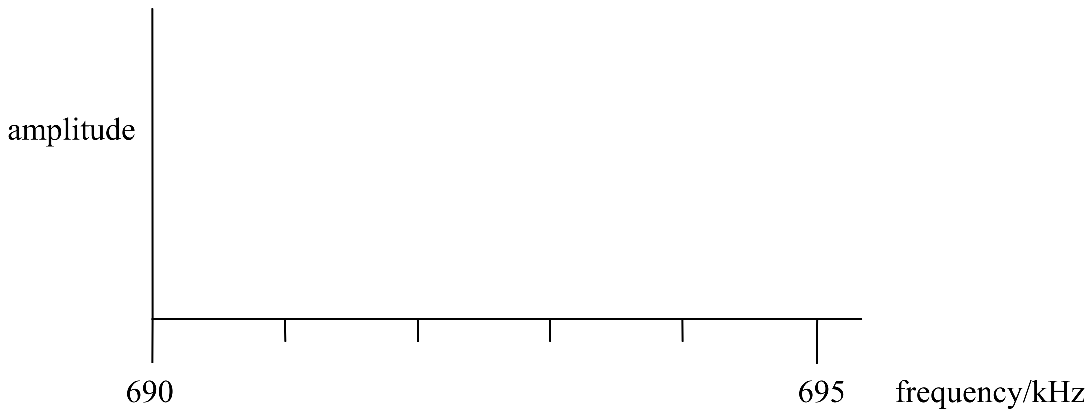
…………………………………………………………………………………

Information signal frequency is encoded as ……………………………………..

…………………………………………………………………………………

(*2 marks*)

3 (c) An AM transmitter uses a carrier frequency of 693 kHz which is modulated with an information signal of a single frequency of 512 Hz.
Draw a complete frequency spectrum diagram of the modulated carrier.
Label all the features of your diagram and state the frequencies of all the components of the modulated signal.



(*6 marks*)

3 (d) Give **one** example of a radio communication system that uses FM. Discuss what advantages using FM brings to the system.

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(*2 marks*)

12

Turn over for the next question

4 PMR446 walkie-talkies are Personal Mobile Radios which operate at frequencies of about 446 MHz. They can be used without a licence in most parts of Europe. Regulations require that the maximum power is 500 mW and equipment must be handheld with a fixed antenna. The range can vary from a few hundred metres (in a city) to a few kilometres (flat countryside).

Eight adjacent FM channels are available, with frequencies as follows:

Channel	**Frequency (MHz)**
1	446.00625
2	446.01875
3	446.03125
4	446.04375
5	446.05625
6	446.06875
7	446.08125
8	446.09375

Two ways of allowing more than eight separate communications are used. In one (CTCSS), one of about 50 low-pitch audio tones, ranging from 67 to 254 Hz, is transmitted with the signal.

4 (a) Calculate the bandwidth allocated to each channel.

…………………………………………………………………………………………

(*1 mark*)

4 (b) The visible aerial on the equipment is 5 cm long. Comment on the likely efficiency of this aerial when compared to its wavelength and explain other factors which limit the range of communication between two walkie-talkies, and why the range may vary with location.

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(*4 marks*)

4 (c) Explain why the transmission of an extra tone, as in the CTCSS system does **not** interfere with the speech signal.

…………………………………………………………………………………………

…………………………………………………………………………………………

(*1 mark*)

4 (d) Draw a circuit diagram for a circuit which can amplify the tone by a factor of 10 while attenuating the speech signal. Identify the type of circuit you have chosen and state the name and value of the relevant parameter you have chosen so that it might achieve the desired result.
Calculate suitable values of circuit components and mark them on the circuit diagram.

Type of circuit………………………………………………………………

Relevant parameter………………………………value…………………..

(6 marks)

12

5 In a mobile phone system, audio frequencies above 4 kHz must be removed before sampling of the microphone signal can take place.

5 (a) Draw the circuit diagram of an active filter that would achieve this.

(*2 marks*)

5 (b) In the active filter circuit, the input resistor is 10 kΩ and the capacitor is 2.2 nF. Show that the value of the feedback resistor required is approximately 18 kΩ.

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(*2 marks*)

5 (c) Calculate the voltage gain of this circuit at a frequency well below the breakpoint frequency.

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....

(*2 marks*)

5 (d) What minimum sampling rate must be used for the filtered microphone signal? Explain why.

Sampling rate ……………………………………………………………………...

Explanation ……………………………………………………………………..

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(*3 marks*)

5 (e) What factors affect the maximum number of mobile telephones which can be supported in one cell.

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(*3 marks*)

___ 12

Turn over for the next question

Turn over

6 (a) Draw and label a diagram of a cross-section through a step-index optical fibre.

(*1 mark*)

6 (b) (i) By what processes do optical signals travel along curved sections of the optical fibre?

....

6 (b) (ii) What output transducer could be used to launch an optical signal into an optical fibre?

....

6 (b) (iii) What input transducer could convert a high data rate pulsed optical signal into an electrical signal?

....

(*3 marks*)

What is the name given to the effect on an optical signal of

6 (c) (i) the signal losing power as it travels along the optical fibre,

....

6 (c) (ii) the signal pulses becoming spread out in time as they travel along,

....

6 (c) (iii) the signal leaking out of the fibre at tight bends or couplings.

....

(*3 marks*)

6 (d) Discuss the advantages and disadvantages of an optical fibre system, compared with a wired system.

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(*4 marks*)

11

Turn over for the next question

7 The function of a 2 to 1 data multiplexer is described by the following Boolean equation.

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

7 (a) Using the Boolean equation or otherwise, draw a logic diagram using any gates that would give this function.

(*4 marks*)

7 (b) State and explain the practical application of this system, describing the function of the input signal S.

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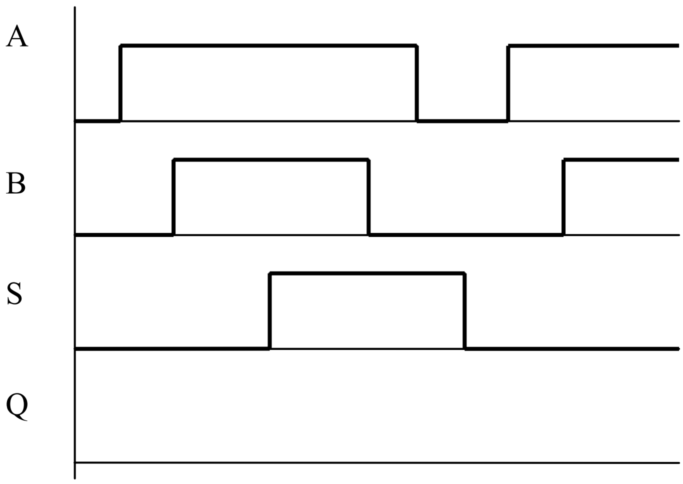
(*3 marks*)

7 (c) The diagram below shows two signals A and B, and signal S. Complete the diagram to show the state of the output Q.



(*3 marks*)

10

END OF QUESTIONS