Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2006
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS **ELE5**
Unit 5 Communications Systems

Tuesday 13 June 2006 1.30 pm to 3.00 pm

For this paper you must have:
- a calculator
- a pencil and ruler

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- 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.
- The marks for 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

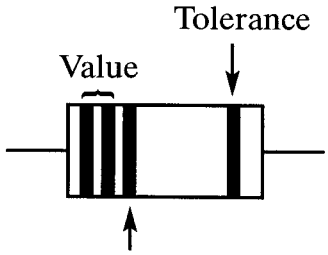
- A perforated *Data Sheet* is provided on pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this perforated sheet at the start of the examination.

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 $T = CR$

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

$$G_V = \frac{V_{out}}{V_{in}} \quad \text{voltage gain}$$

$$G_V = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G_V = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

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

Astable and Monostable using NAND Gates

$$f \approx \frac{1}{2RC} \quad \text{astable}$$

$$T \approx RC \quad \text{monostable}$$

555 Astable and Monostable

$$T = 1.1RC \quad \text{monostable}$$

$$\left.\begin{aligned} t_H &= 0.7(R_A + R_B)C \\ t_L &= 0.7R_BC \end{aligned}\right] \quad \text{astable}$$

$$f = \frac{1.44}{(R_A + 2R_B)C} \quad \text{two resistor circuit}$$

Electromagnetic Waves

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

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) A radio transmitter uses the following sub-systems:

carrier generator **input transducer** **modulator** **transmitter**

Draw a labelled block diagram to show how these sub-systems are connected.

(4 marks)

(b) Electromagnetic signals can be transmitted using a variety of media.

State, with a reason in each case, which medium is best

(i) if a large bandwidth is required,

medium .....

reason .....

(ii) if one end of the communications link is mobile,

medium .....

reason .....

(iii) if a high level of security is required.

medium .....

reason .....

(6 marks)

10

2 (a) Describe how the information signal amplitude and frequency are encoded on to a carrier using amplitude modulation (AM).

amplitude .....

.....

frequency .....

.....

(2 marks)

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

amplitude .....

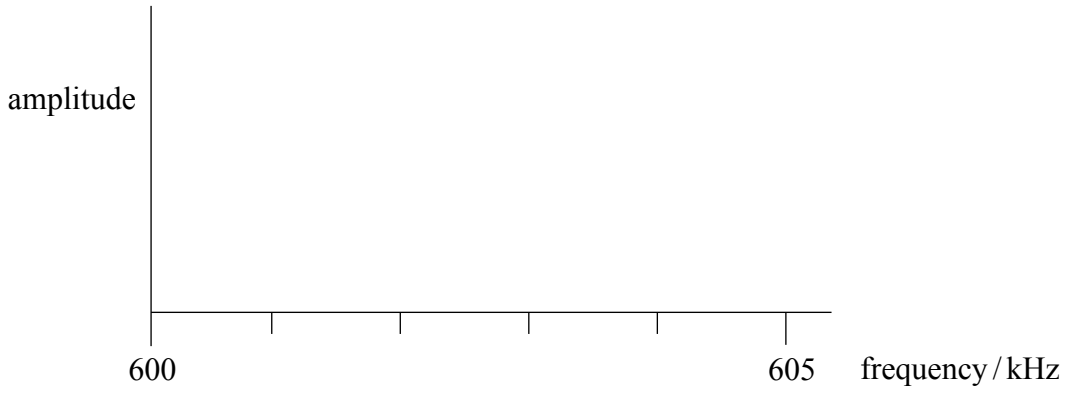
.....

frequency .....

.....

(2 marks)

(c) An AM transmitter uses a carrier frequency of 603 kHz which is modulated with an information signal of a single frequency of 440 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)

10

3 The demodulator stage in a radio receiver has an output voltage of 25 mV but only when connected to a very high resistance load. This stage is connected to the af amplifier.

(a) What type of op-amp circuit could best be used for the af amplifier?

.....

(1 mark)

(b) Draw this type of circuit in the space below.
R_1 has a value of 15 kΩ, and R_f has a value of 300 kΩ.
Label these components with their correct values on your diagram and label the input and output connections to the circuit.

(4 marks)

(c) Calculate, using data given earlier in this question:

(i) the voltage gain of this amplifier circuit,

.....

.....

(ii) the output signal voltage from this circuit.

.....

(4 marks)

(d) The op-amp IC used has a gain-bandwidth product of 1 MHz.
Calculate the bandwidth of this circuit.

.....

(1 mark)

10

4 (a) A radio receiver contains a parallel LC circuit, where L has a value of 50 μH and C has a value of 300 pF.

(i) Suggest a use for this circuit in the receiver.

.....

(ii) This circuit has a high quality factor. Explain the effect this will have on the performance of the receiver.

.....

.....

(iii) Calculate the resonant frequency of this circuit.

.....

.....

(iv) Draw a resonance curve for this circuit. Label your axes.

(6 marks)

(b) The radio receiver is unable to receive weak signals.

(i) What aspect of the receiver's performance requires improvement?

.....

(ii) What circuit should be added to the receiver to improve this?

.....

(2 marks)

8

5 (a) (i) State and describe **three** differences between analogue and digital communication.

1 .....

.....

2 .....

.....

3 .....

.....

(3 marks)

(ii) Explain briefly how these differences might affect the choice of one method over the other.

.....

.....

.....

.....

.....

(3 marks)

(b) Name **two** different techniques for transmitting many signals on one carrier.

1 .....

2 .....

(2 marks)

8

6 (a) (i) State a secure medium through which optical signals can travel.

.....

(ii) State how optical signals can travel along paths that are not straight.

.....

.....

(iii) State **two** factors that limit the range of optical signals.

1 .....

2 .....

(iv) An LED is used as a light source in an optical communications system. The LED has a forward voltage drop of 2 V and operates from a power supply of 12 V. Calculate the value of the series resistor necessary to limit the LED forward current to 10 mA.

.....

.....

.....

(6 marks)

(b) In a mobile phone circuit, audio frequencies above 4 kHz must be removed before sampling takes place.

(i) Draw the circuit diagram of an active treble cut filter.

(ii) In the active filter circuit, the input resistor is 10 kΩ, the feedback resistor is 39 kΩ and the capacitor is 1 nF.
Show that the break point frequency is approximately 4 kHz.

.....

.....

.....

.....

(iii) Calculate the voltage gain of this circuit at a frequency well below the break point frequency.

.....

.....

.....

(iv) What sampling rate must be used for the mobile phone system where frequencies up to 4 kHz are transmitted? Explain why this is.

Sampling rate .....

Explanation .....

.....

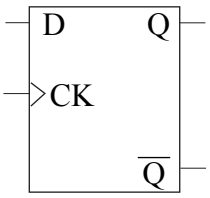
.....

(12 marks)

18

Turn over for the next question

7 The symbol for a D-type flip-flop is shown below.



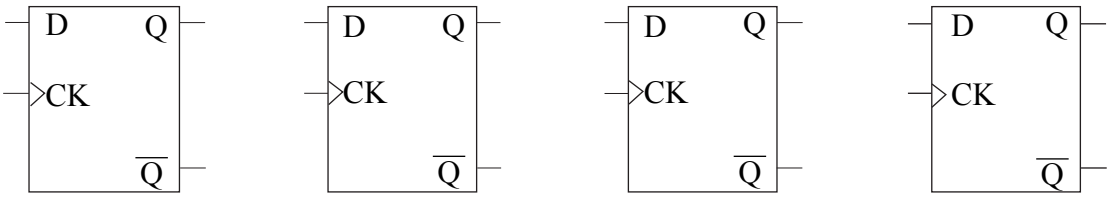
(a) Describe the function of the D-type flip-flop.

.....

.....

(2 marks)

(b) Complete the diagram below to show how a shift register is constructed from D-type flip-flops. Label the data and clock inputs, and the data output for the complete system.



(4 marks)

(c) Data can be communicated in serial or parallel form.

Explain which form is better for long distance communication.

.....

.....

.....

(2 marks)

8

END OF QUESTIONS