THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

ELECTRONICS

Communication Systems

F615

OCE/12916

Candidates answer on the Question Paper

OCR Supplied Materials:
None

Other Materials Required:
- Scientific calculator

Tuesday 15 June 2010
Afternoon

Duration: 1 hour 40 minutes

F615

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

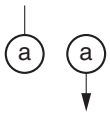
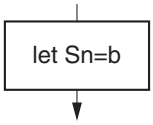
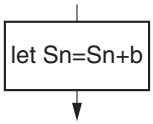
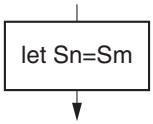
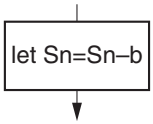
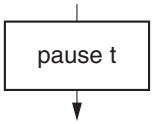
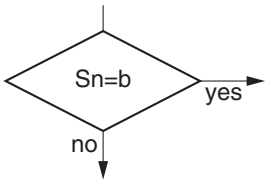
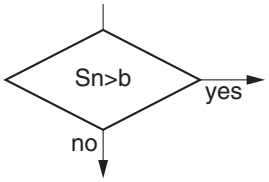
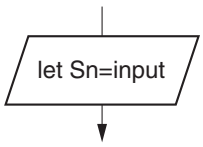
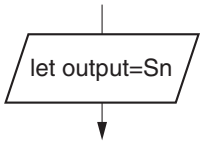
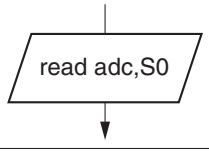
INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **110**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You are advised to show all the steps in any calculations.
- This document consists of **16** pages. Any blank pages are indicated.

A calculator may be used for this paper

symbol	meaning
	start the program
	link to part of the program with the same label a
	stop the program
	place the byte b in register Sn
	add the byte b to the byte in register Sn
	copy the byte in register Sm into register Sn
	subtract the byte b from the byte in register Sn
	introduce a time delay of t milliseconds
	branch if the byte in register Sn is equal to the byte b
	branch if the byte in register Sn is greater than the byte b
	copy the byte at the input port to register Sn
	copy the byte in register Sn to the output port
	activate the analogue-to-digital converter and store the result in register S0

Data Sheet

Unless otherwise indicated, you can assume that:

- op-amps are run off supply rails at +15V and –15V
- logic circuits are run off supply rails at +5V and 0V.

resistance	$R = \frac{V}{I}$
power	$P = VI$
series resistors	$R = R_1 + R_2$
time constant	$\tau = RC$
monostable pulse time	$T = 0.7RC$
relaxation oscillator period	$T = 0.5RC$
frequency	$f = \frac{1}{T}$
voltage gain	$G = \frac{V_{out}}{V_{in}}$
open-loop op-amp	$V_{out} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \frac{R_f}{R_d}$
inverting amplifier gain	$G = -\frac{R_f}{R_{in}}$
summing amplifier	$-\frac{V_{out}}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} \ldots$
break frequency	$f_0 = \frac{1}{2\pi RC}$
Boolean Algebra	$A.\overline{A} = 0$
	$A + \overline{A} = 1$
	$A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$
	$\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$
	$A.B + \overline{A}.C = A.B + \overline{A}.C + B.C$

Answer **all** the questions.

1 The incomplete circuit of Fig. 1.1 is a simple analogue-to-digital converter.

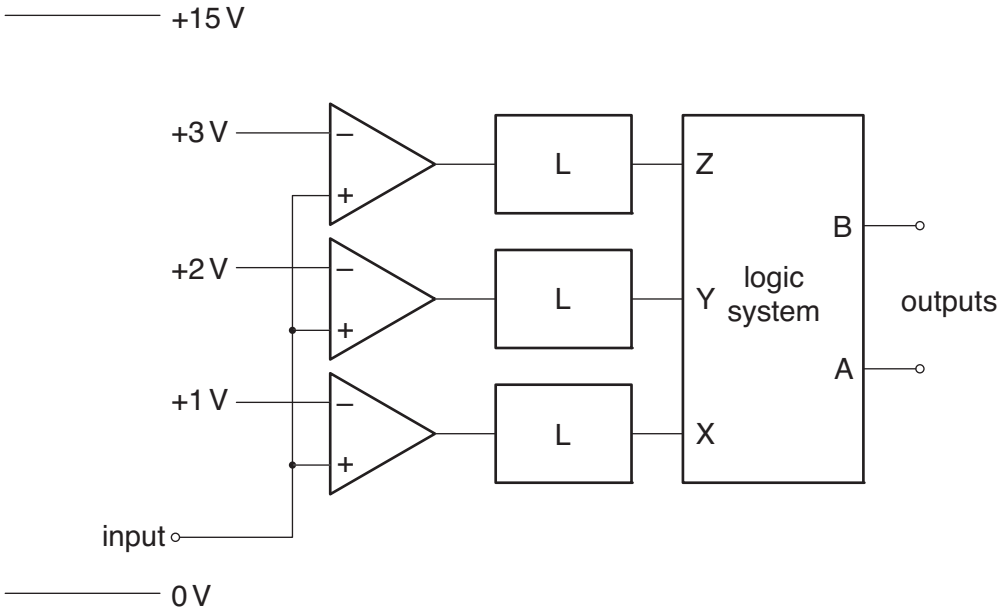


Fig. 1.1

(a) The inverting input of each op-amp has to be held at a different voltage.

Draw on Fig. 1.1 to show how this can be accomplished with four resistors.

No component values are required. **[2]**

(b) At the output of each op-amp there is a sub-system labelled **L**.

Its transfer characteristic is given in the table.

input	**output**
+13V	+5V
–13V	0V

Draw in the space below to show how **L** can be constructed from diodes and resistors. Show all component values and justify them.

[3]

(c) The logic system in Fig. 1.1 is required to obey this truth table.

Z	Y	X	B	A
1	1	1	1	0
0	1	1	1	1
0	0	1	0	1
0	0	0	0	0

(i) Explain why a possible expression for output A is $A = Y.\overline{Z} + X.\overline{Y}$.

[2]

(ii) Draw a circuit to generate $A = Y.\overline{Z} + X.\overline{Y}$ using only NAND gates.

Use Boolean algebra to justify your circuit.

[4]

(iii) Write down a simplified expression for B.

B = ... **[1]**

(d) All analogue-to-digital converters have a **range** and a **resolution**.

Explain the meaning of these terms and state their values for the circuit of Fig. 1.1.

Range .....

.....

Resolution.....

..... **[4]**

[Total: 16]

2 Fig. 2.1 shows an amplitude modulator circuit.

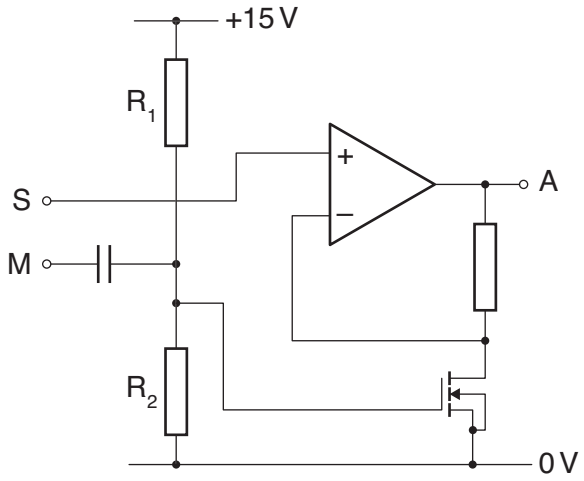


Fig. 2.1

(a) The 10 kHz sine wave signal at M modulates the 415 kHz sine wave carrier at S.

The resulting AM signal appears at A.

(i) Describe the process of amplitude modulation.

You do not have to explain how this is done by the circuit.

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..... **[2]**

(ii) On the axes of Fig. 2.2, sketch an amplitude-frequency graph for the amplitude modulated signal at A.

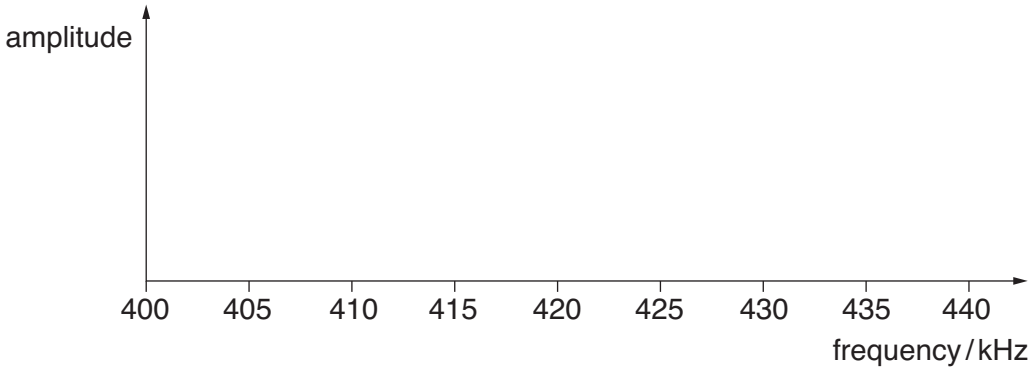

Fig. 2.2

[2]

(b) For the circuit to function correctly, the resistors R_1 and R_2 must hold the gate of the MOSFET at +2.2V.

If R_1 is 47kΩ, calculate a suitable value for R_2.

R_2 = ... kΩ **[2]**

(c) Explain how the circuit of Fig. 2.1 performs amplitude modulation.

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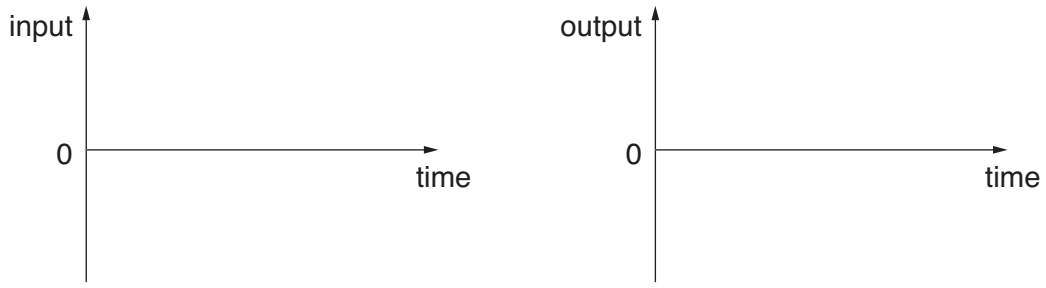
..... **[4]**

(d) **(i)** Draw a circuit which could be used to demodulate the signal at A.
No component values are required.

[2]

(ii) By sketching voltage-time graphs of signals at the input and output of the circuit you have drawn, explain how your circuit operates.



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..... **[4]**

[Total: 16]

3 FM radio broadcasts use carrier frequencies between 87.5 MHz and 108.0 MHz, allocating each channel a bandwidth of only 200 kHz.

(a) Show that about 100 different FM stations can broadcast in any one area.

[1]

(b) The number of different stations can be increased if AM is used instead of FM.

(i) Estimate how many stations could be broadcast between 87.5 MHz and 108.0 MHz if AM is used instead of FM.

Justify your answer.

[2]

(ii) FM is used instead of AM for most broadcast radio because it has a much higher signal-to-noise ratio. Explain how this is possible.

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..... **[4]**

(c) The circuit of Fig. 3.1 uses a resistor and parallel LC circuit to make a simple bandpass filter. The filter is centred on 2.4 MHz.

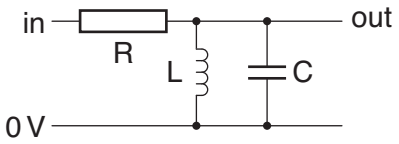

Fig. 3.1

(i) The inductor has a value of 22 μH.

Calculate a suitable value for the capacitor C, in pF.

C = ... pF **[3]**

(ii) By describing how the reactance of each of the components of Fig. 3.1 changes with frequency, explain its filtering action.

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..... **[6]**

(d) The ideal 200 kHz bandpass filter for the FM receiver should have the transfer characteristic of Fig. 3.2.

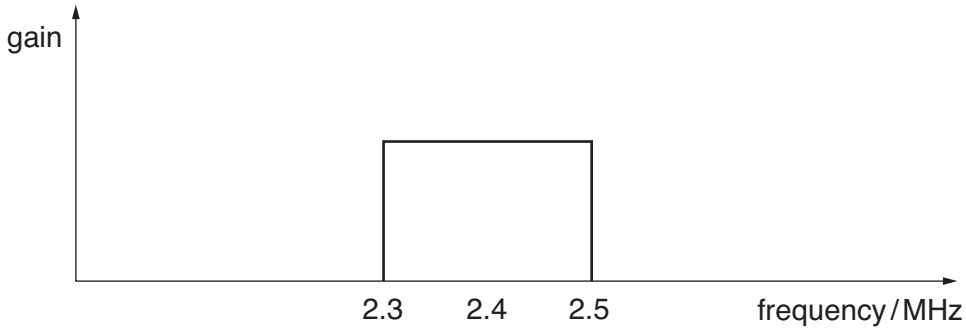

Fig. 3.2

(i) Sketch on Fig. 3.2 the transfer characteristic for the filter of Fig. 3.1 **[1]**

(ii) Draw a circuit diagram below to show how simple filters of the type shown in Fig. 3.1 can be combined to make a single bandpass filter with the characteristic of Fig. 3.2.

[3]

(iii) Explain how your circuit operates.

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..... **[2]**

[Total: 22]

4 Fig. 4.1 shows an incomplete block diagram for a simple telephone system which transfers binary words down a single link.

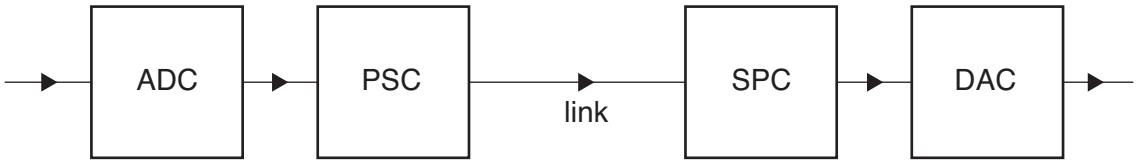

Fig. 4.1

(a) The block marked ADC converts the voltage at its input into a binary word on several parallel lines. Describe the function of the other three blocks.

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..... **[3]**

(b) The ADC generates 8400 six-bit words each second.

(i) State the highest frequency of analogue signal which can be transmitted through the system without distortion. Justify your answer.

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..... **[2]**

(ii) Each word has 0 placed in front of it before sending it down the link.

Explain the function of this bit.

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..... **[2]**

(iii) Show that the bandwidth required to transmit this signal down the link is about 30 kHz.

[3]

(c) The actual bandwidth of the link is 3 MHz. The use of packets of serial digital signals can increase the number of independent analogue signals transmitted down the link.

Describe the contents of a packet to explain how time-division multiplexing allows many analogue signals to be sent across the link.

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..... **[6]**

[Total: 16]

5 Fig. 5.1 shows part of a four-bit digital-to-analogue converter.

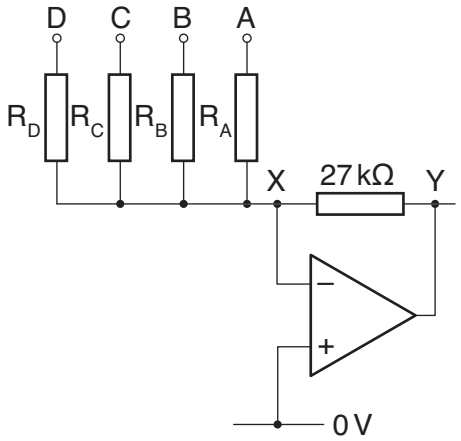

Fig. 5.1

(a) State the voltage at point X. Give a reason for your answer.

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..... **[2]**

(b) The circuit of Fig. 5.1 is required to obey this table.

word at DCBA	voltage at Y
9	–1.80 V
A	–2.00 V
C	–2.40 V

Use the information to calculate values for the four input resistors.

[4]

(c) The signal at Y is processed by a treble cut filter with the following characteristics.

- break frequency of 4.2 kHz
- low frequency gain of – 4.0

Draw a circuit for the filter in the space below.
Show all component values and justify them.

[5]

(d) A serial-in parallel-out shift register provides the signal DCBA for the digital-to-analogue converter.

(i) The shift register has two inputs SI and CK.
Suggest their function for the shift register.

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..... **[2]**

(ii) Complete the circuit of Fig. 5.2 to show how the shift register can be assembled from D flip-flops. Label all inputs and outputs.

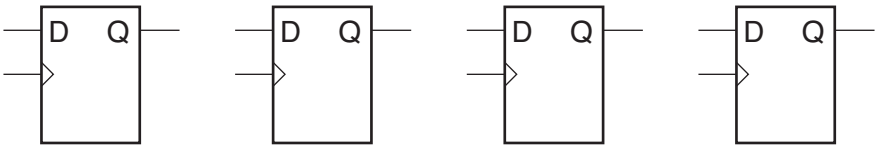

Fig. 5.2

[4]

[Total: 17]

6 A computer sends video information to a monitor screen as the five separate signals listed below.

blue **frame sync** **green** **line sync** **red**

(a) Some of the signals are analogue, others are digital.

Put a ring around the digital signals. **[2]**

(b) Explain how three of the signals control the intensity of a pixel on the screen.

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..... **[2]**

(c) Describe the role of the other two signals for displaying a picture on the screen.

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..... **[3]**

(d) Each frame has 512 lines of red pixels, with 1024 pixels in each line.

The frame refresh rate is 50 Hz.

Calculate the minimum bandwidth required for the cable which carries the red signal.

bandwidth = _____ MHz **[3]**

[Total: 10]

7 A modulated carrier can transfer information using a radio wave.

The radio wave travels through the air.

(a) Describe **two** other ways in which a modulated carrier can transfer information.

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..... **[4]**

(b) As radio waves move away from a transmitter they acquire noise and interference which affect the quality of the information being carried.

(i) Explain the meaning of the terms **noise** and **interference**.

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..... **[2]**

(ii) What else happens to a radio wave to affect the quality of its information?

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..... **[1]**

(c) Which of the methods of transferring a modulated carrier mentioned in **(a)** is least affected by the factors you have listed in **(b)**? Give reasons for your answer.

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..... **[3]**

[Total: 10]

Quality of Written Communication **[3]**

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE