OCR
Oxford Cambridge and RSA

Wednesday 14 June 2017 – Afternoon

A2 GCE ELECTRONICS

F615/01 Communication Systems

5 8 1 9 1 9 0 3 6

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Duration: 1 hour 40 minutes

F 6 1 5 0 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

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**.
- Quality of written communication will be assessed in this paper.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

A calculator may be used for this paper

OCR is an exempt Charity

Turn over

Data Sheet

Unless otherwise indicated, you can assume that:

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

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	$A.\overline{A} = 0$
	$A + \overline{A} = 1$
	$A.(B + C) = A.B + A.C$
	$\overline{A.B} = \overline{A} + \overline{B}$
	$\overline{A + B} = \overline{A}.\overline{B}$
	$A + A.B = A$
	$A.B + \overline{A}.C = A.B + \overline{A}.C + B.C$
amplifier gain	$G = -g_m R_d$
ramp generator	$\Delta V_{out} = -V_{in}\frac{\Delta t}{RC}$
inductor reactance	$X_L = 2\pi fL$
capacitor reactance	$X_C = \frac{1}{2\pi fC}$
resonant frequency	$f_0 = \frac{1}{2\pi\sqrt{LC}}$

Answer **all** the questions.

1 A small advertising display in a supermarket has the following specification:

- 768 rows of pixels
- 1380 pixels in each row
- full colour
- refresh rate of 35 Hz

(a) (i) Each row contains three different types of pixel.

Explain why this is necessary.

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

(ii) The intensity of each pixel is controlled by a 4-bit word.

Calculate the maximum number of different intensity levels for each pixel.

number of levels = ... **[1]**

(b) A distant computer sends the words for the pixels in serial form down a cable.

(i) Explain why the computer has to send a 6-bit word to control the intensity of each pixel.

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

(ii) The cable contains three separate wires.

One carries the video signal which controls the intensity of the pixels.

State the names of the signals carried by the other two wires and explain why the two wires are required.

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(iii) Explain why the rate at which the computer has to place bits on the video wire is about 200 Mbits s^{-1}.

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(iv) Calculate the minimum bandwidth needed for the video wire.

bandwidth = ... MHz **[1]**

(c) The supermarket decides to upgrade its advertising displays. A single distant computer can control 24 different displays connected to the cable, instead of just one, with a different full colour video showing on each display.

Explain why the computer will need to place 11-bit words on the video wire in the upgraded system.

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

2 Fig. 2.1 is a circuit diagram for an amplitude modulator and an amplitude-frequency graph of the signal at **C**.

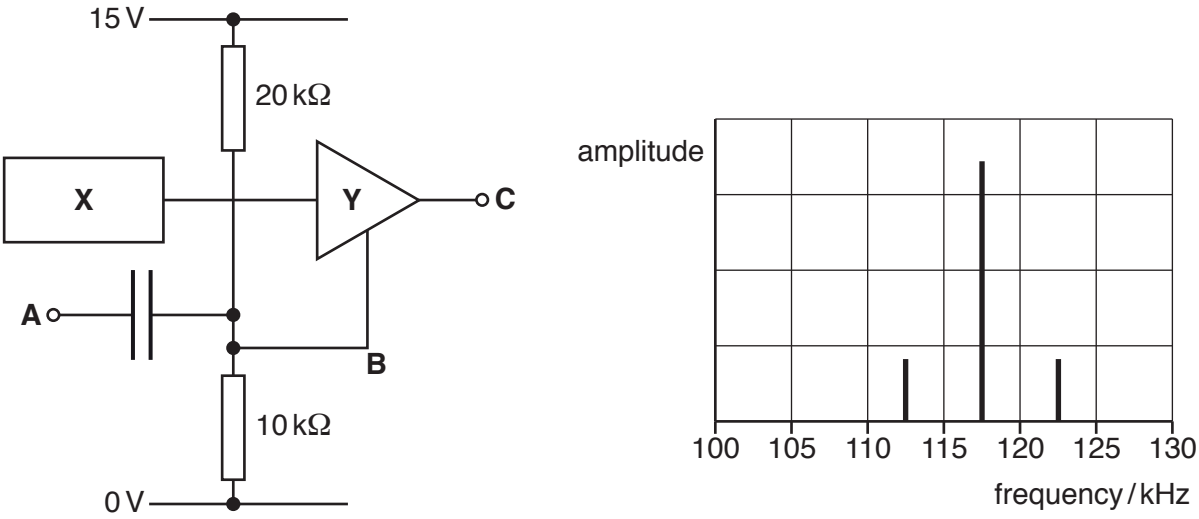

Fig. 2.1

(a) Use quantitative information in Fig. 2.1 to describe

(i) the output signal of the block labelled **X**

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

(ii) the signal presented at **A**

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

(iii) the signal at **B**.

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(b) Describe the transfer characteristics of the block labelled **Y** in Fig. 2.1.

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

(c) **(i)** In the space below, draw a circuit diagram of a suitable demodulator for the circuit of Fig. 2.1.

Show component values and justify them with calculations.

[5]

(ii) Explain the operation of the demodulator circuit which you have drawn.

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3 This question is about the incomplete analogue-to-digital converter (ADC) circuit shown in Fig. 3.1.

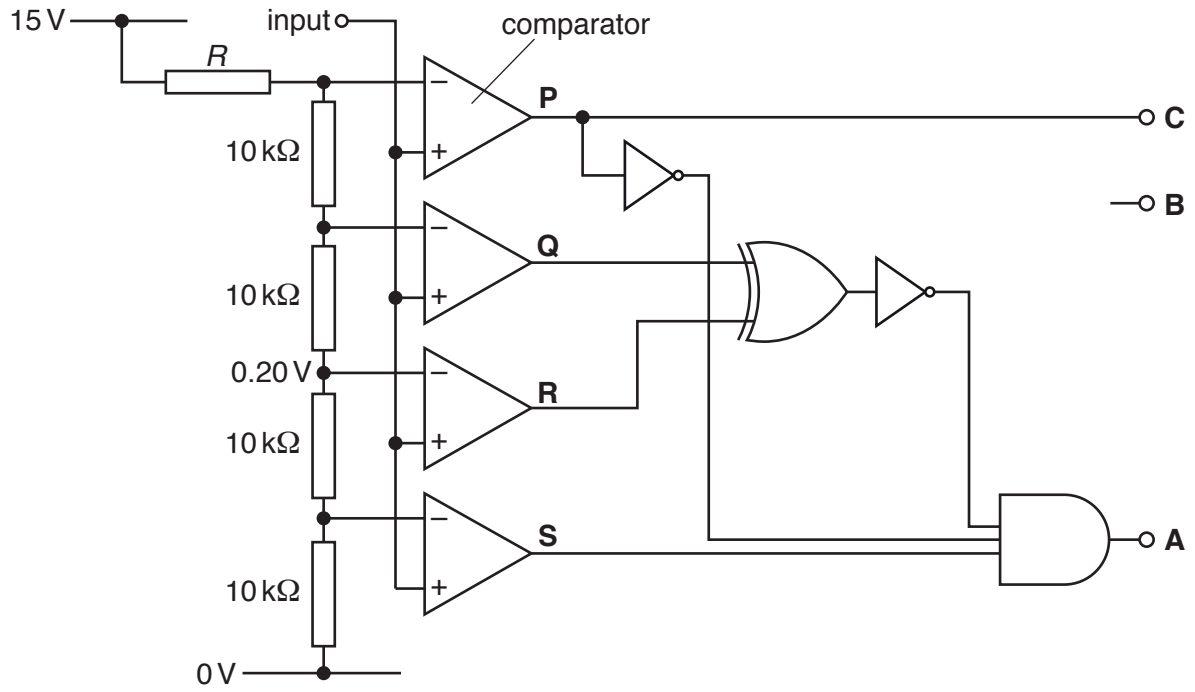

Fig. 3.1

(a) Describe the function of an ADC.

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(b) **(i)** Explain why the ADC of Fig. 3.1 has a resolution of 0.1 V.

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(ii) Calculate a value for the resistor *R*. Show all the steps in your working.

R = ...kΩ **[3]**

(c) Each comparator in Fig. 3.1 has the following transfer characteristic.

input condition	output
inverting input < non-inverting input	+5 V
inverting input > non-inverting input	0 V

(i) Complete this truth table for the circuit of Fig. 3.1.

input	P	Q	R	S	C	B	A
0.00 V to 0.09 V	0	0	0	0		0	
0.10 V to 0.19 V						0	
0.20 V to 0.29 V						1	
0.30 V to 0.39 V						1	
0.40 V to 0.49 V	1	1	1	1		0	

[3]

(ii) The logic system for generating the output **B** is missing from Fig. 3.1.

In the space below, draw a suitable logic system using **only** NAND gates.

Justify your logic system with Boolean algebra.

[3]

(iii) In the space below, show how a single comparator with these transfer characteristics can be assembled from an op-amp, a diode and resistors. Show component values and justify them.

[4]

4 This question is about commercial FM radio broadcasting in the USA.

(a) Explain what is meant by the term FM.

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

(b) The FM band covers the frequency range 87.9 MHz to 107.9 MHz. Each station in that band can broadcast signals with frequencies between 20 Hz and 20 kHz.

(i) Calculate the maximum number of stations which could broadcast in the same area of the country.

maximum number of stations = ... **[3]**

(ii) In practice, stations in the same area are allocated channels with a bandwidth of 200 kHz.

Explain why this bandwidth is allocated.

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

(c) In principle, these radio broadcasts could use AM instead of FM.

(i) State and explain **one advantage** of using AM instead of FM.

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

(ii) State and explain **one disadvantage** of using AM instead of FM.

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5 Fig. 5.1 shows the input and output connections to a parallel-in serial-out (PISO) shift register.

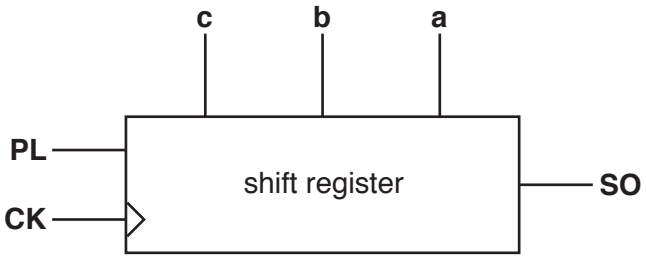

Fig. 5.1

The shift register has the following transfer characteristics.

When **PL** is pulsed high:

- the word **cba** is loaded into the register
- **0** is placed at **SO**.

The next four rising edges at **CK** place **a**, then **b**, then **c** and finally **1** at **SO** in turn.

Complete the circuit diagram of Fig. 5.2 to show how the PISO can be constructed.

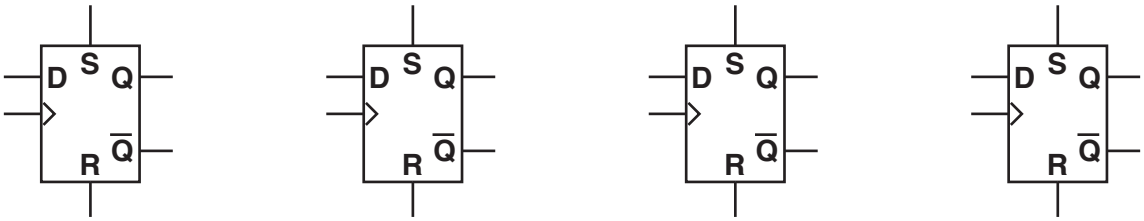

Fig. 5.2

[7]

6 Fig. 6.1 is an incomplete block diagram for a simple AM radio receiver for a radio station.

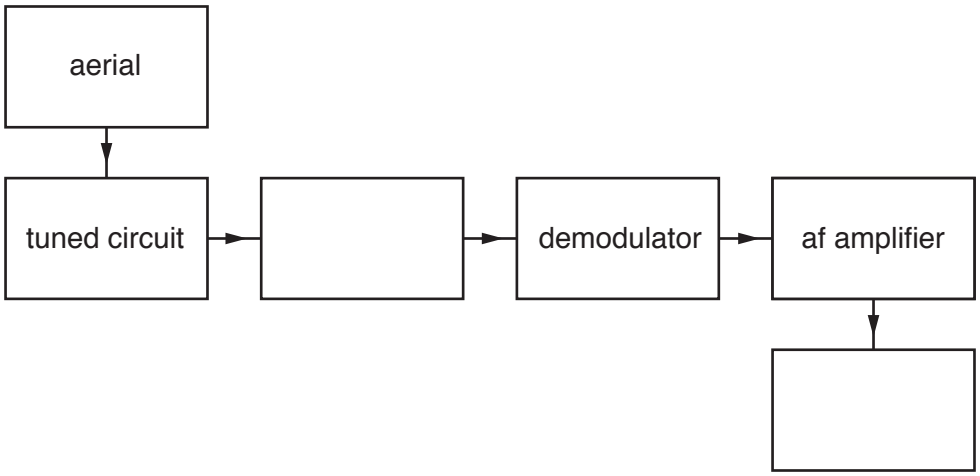

Fig. 6.1

(a) **(i)** Complete the block diagram of Fig. 6.1. **[2]**

(ii) State the function of each of the blocks that you completed.

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

(b) The radio station broadcasts voice and music signals from 50 Hz to 5.0 kHz on a carrier frequency of 1.400 MHz.

(i) In the space below, draw a circuit diagram of the aerial and tuned circuit.

Show all component values and justify them with calculations.

[5]

(ii) Describe the function of the aerial and tuned circuit.

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(c) Fig. 6.2 is a block diagram for the af amplifier.

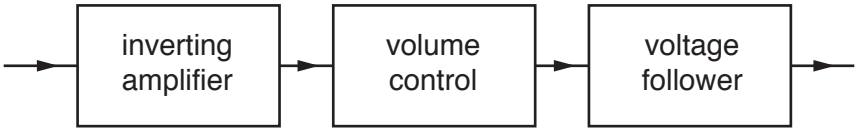

Fig. 6.2

The gain of the af amplifier can be varied between 0 and –200 for audio signals above 50 Hz. Signals below 50 Hz are filtered out by the inverting amplifier.

Draw a circuit diagram for the af amplifier in the space below.

Show all component values and justify them with calculations.

[8]

7 Fig. 7.1 is a circuit diagram for a 4-bit digital-to-analogue converter (DAC).

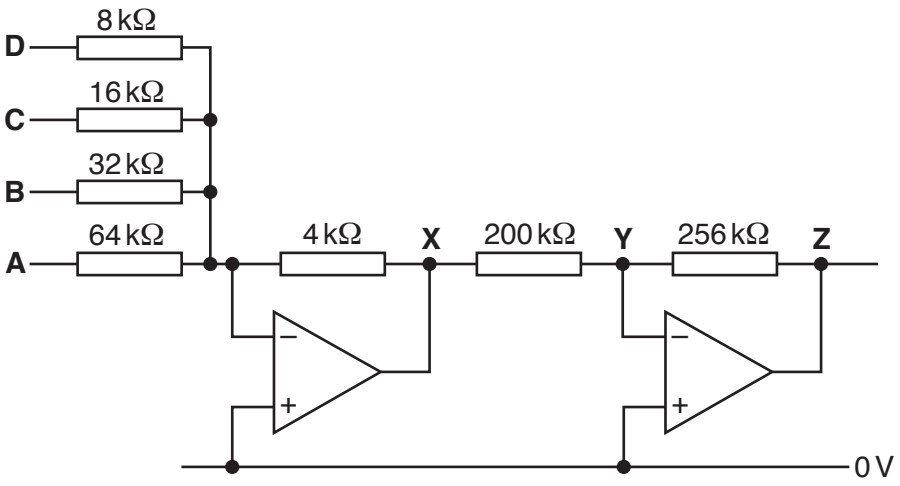

Fig. 7.1

(a) The binary word at the input terminals hold **D**, **C**, **B** and **A** at +5 V or 0 V.

(i) By calculating the voltage at **X**, show that the voltage at **Z** is 1.6 V when **DCBA** = 0100.

[3]

(ii) Calculate a value for the resolution of the DAC.

resolution = ... V **[2]**

(iii) Calculate the range of the DAC.

range = ...V to .....V **[2]**

(b) The DAC of Fig. 7.1 has a response time of 20 μs.

(i) Explain the meaning of the term *response time*.

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(ii) Explain why the DAC only works correctly if the signal being converted has a frequency of less than 25 kHz.

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(c) DACs are widely used in time-division multiplexing systems.

State and explain the purpose of a time-division multiplexing system.

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Quality of written communication [3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).