OCR
Oxford Cambridge and RSA

Wednesday 13 June 2018 – Afternoon

A2 GCE ELECTRONICS

F615/01 Communication Systems

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Duration: 1 hour 40 minutes

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

DC (NH/CT) 156533/4

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 computer transfers signals along a cable to a video screen.

(a) The cable carries five different signals along wires.

(i) State the names of the five signals.

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

(ii) Some of the wires carry information as analogue signals.

They could carry digital signals instead.

Explain the advantages of sending information as digital signals.

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

(b) A single wire can carry the information from the computer to the screen using digital signals. One method transmits pictures using seven-bit words to determine the brightness of the pixels on the screen.

(i) How many different brightness levels can each pixel have?

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

(ii) The video screen contains 720 lines of pixels, with 1280 pixels in each line.

Calculate the number of bits of information required for a single picture.

information = ...bits **[2]**

(iii) The frame refresh rate is 60 Hz. This is above the minimum value for video systems.

State **and** explain a value for the **minimum** frame refresh rate for video systems.

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

(iv) As stated, the frame refresh rate is 60 Hz. Do a calculation to estimate the minimum bandwidth required for the cable connecting the computer to the screen.

bandwidth = ... MHz **[2]**

(c) Another method of carrying information from the computer to the screen requires the computer to compress the information before transmitting it to the screen.

(i) Explain an advantage of compressing the information.

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

(ii) Suggest a disadvantage of using compression.

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

2 Fig. 2.1 shows an amplitude modulation circuit.

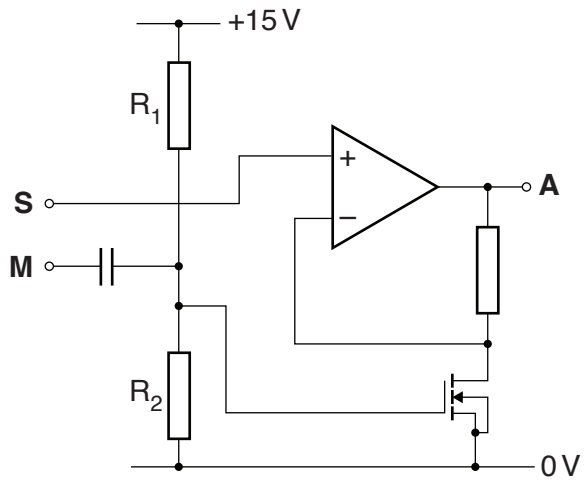

Fig. 2.1

(a) The 5 kHz sine wave signal at **M** modulates the 425 kHz sine wave carrier at **S**.

The resulting amplitude modulated 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**.

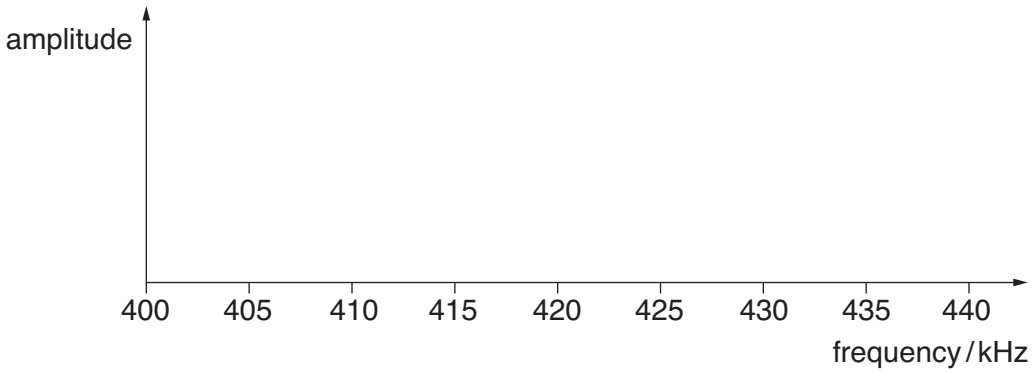

Fig. 2.2

[2]

(b) For the circuit to function correctly, the resistors R_1 and R_2 must hold the gate of the MOSFET at +1.8 V.

If R_1 is 68 kΩ, 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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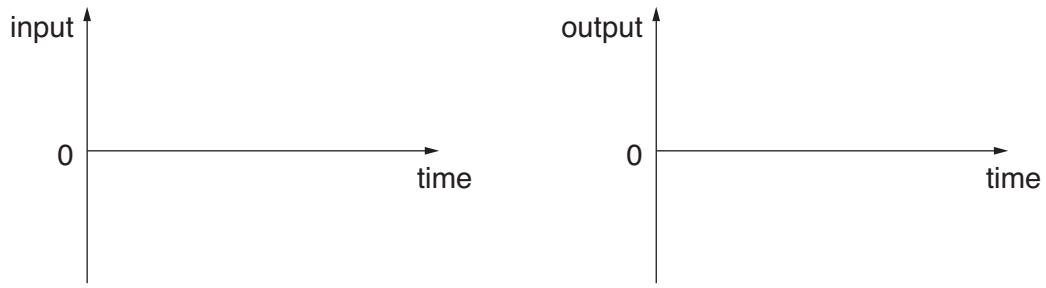
..... **[4]**

(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]**

3 Fig. 3.1 shows the block diagram of a demodulator of frequency modulated signals.

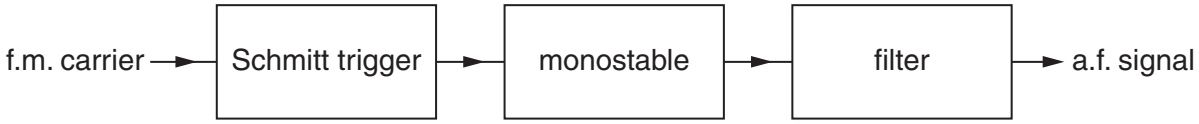

Fig. 3.1

(a) Explain the function of the filter.

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

(b) The monostable produces a pulse of duration 3 µs each time a falling edge arrives from the Schmitt trigger. The pulse goes from 0 V to 5 V and back.

In the space below, draw a circuit diagram for the monostable.

Include all component values and justify them.

[4]

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

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

[1]

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

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]

(iii) 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]**

4 Fig. 4.1 is a circuit diagram for a triangle wave generator.

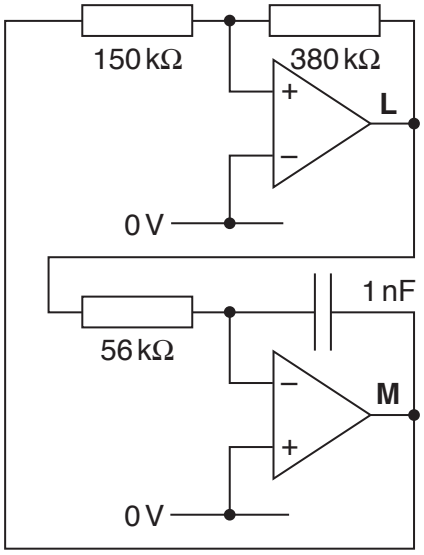

Fig. 4.1

(a) Show that the output of the generator has the following properties:

- amplitude of about 5 V
- frequency of about 11 kHz.

[4]

(b) **(i)** Draw on Fig. 4.1 to show how a comparator should be connected to make the circuit into a pulse-width modulator. Label the input and output of the modulator. **[2]**

(ii) Describe how the signal at the output of the pulse-width modulator is related to the signal at its input.

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

(c) Fig. 4.2 is a demodulator for the modulator you have drawn in Fig. 4.1.

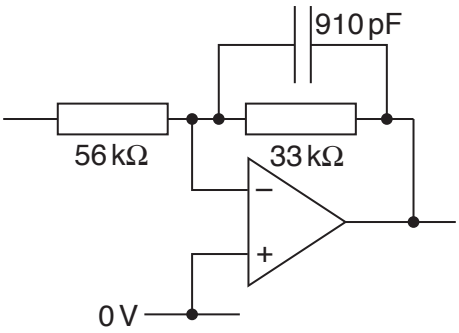

Fig. 4.2

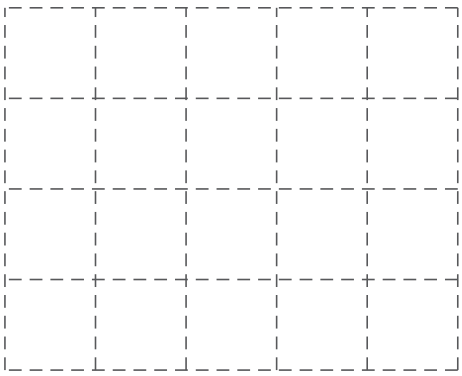

Fig. 4.3

(i) Draw a log-log graph for the transfer characteristic of the demodulator on the axes of Fig. 4.3. Show any calculations you have to do.

[5]

(ii) Explain how the circuit of Fig. 4.2 is an appropriate match to the pulse-width modulator you have drawn in Fig. 4.1.

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

5 **(a)** Explain the meaning of the terms **noise** and **interference** in communication systems.

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

(b) Explain why the use of twisted-pair instead of single cable reduces the amount of interference in transmission, but makes no difference to the noise.

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

(c) The sentences below are about the use of wire cable and optical fibre as the link in a transmission system.

Draw lines to link the **start** of each sentence to its correct **end**.

start	end
Optical fibre …	… is the most affected by noise.
	… is the least affected by interference.
	… carries information as electrical current.
	… can only carry amplitude modulated carriers.
Wire cable …	… always has to use frequency division multiplexing.

[2]

6 Fig. 6.1 is a circuit diagram for a stacked filter in a superhet AM radio receiver.

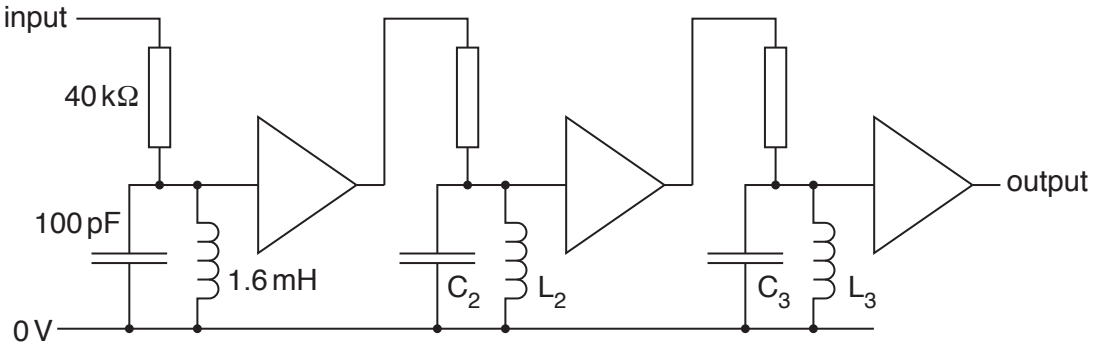

Fig. 6.1

(a) The first parallel LC circuit contains a 1.6 mH inductor.

(i) Show that the reactance of this inductor is about 400 Ω at a frequency of 40 kHz.

[2]

(ii) The graph of Fig. 6.2 shows how the reactance of the 100 pF capacitor depends on frequency. Sketch on the graph to show how the reactance of the 1.6 mH inductor depends on frequency. Label the graph **L**.

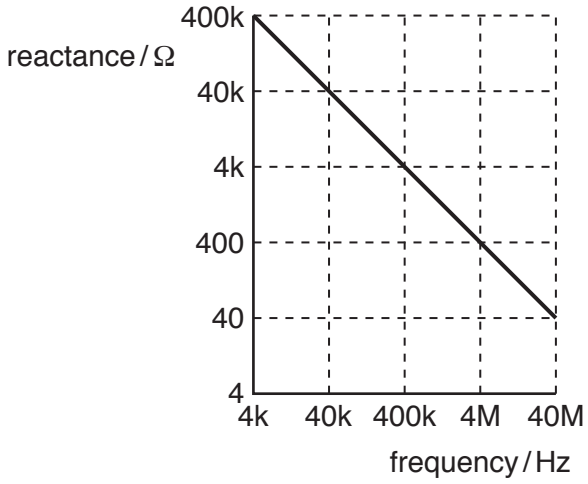

Fig. 6.2

[2]

(iii) Draw on Fig. 6.2 to show how the reactance of the 40 kΩ resistor depends on frequency. Label the graph **R**. **[1]**

(b) The resonant frequency of the second filter is 390 kHz.

The resonant frequency of the third filter is 410 kHz.

(i) Calculate L_2 and C_2 to give the resonant frequency of 390 kHz.

[4]

(ii) Explain why these resonant frequencies have been chosen for the superhet receiver.

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

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

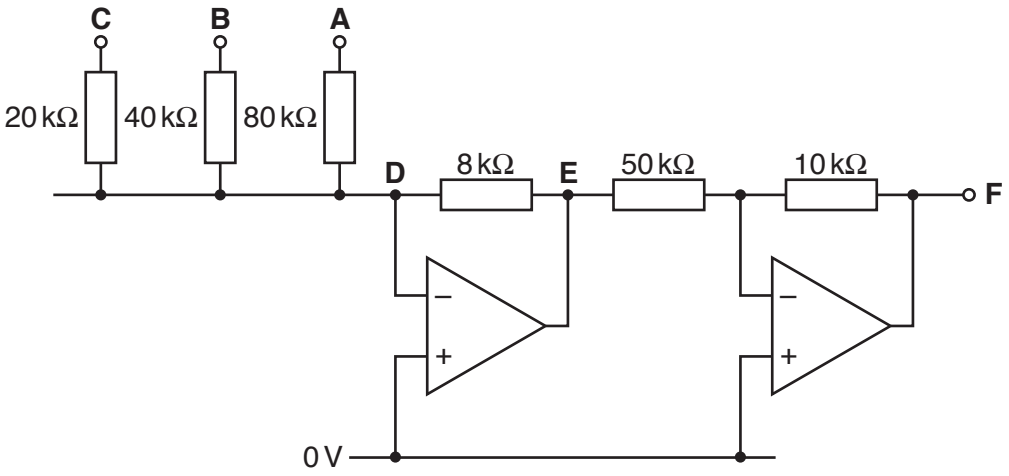

Fig. 7.1

(a) Calculate the gain of the amplifier between **E** and **F**.

gain = ... **[1]**

(b) By considering the word CBA = 001, calculate the resolution of the converter.

resolution = ... V **[3]**

(c) Calculate the range of the converter.

range = ... V to .....V **[3]**

8 **(a)** Computers exchange data with each other using serial digital signals.

Fig. 8.1 is a timing diagram for a typical serial digital signal.

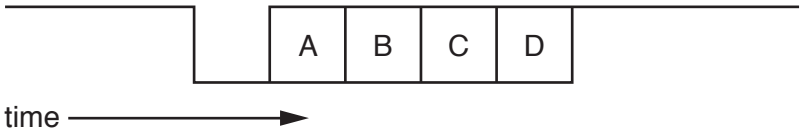

Fig. 8.1

(i) On Fig. 8.1, label the **start** bit and the **stop** bit. **[2]**

(ii) Explain the function of the start and stop bits.

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

(b) The system of Fig. 8.1 has the following properties:

- each packet of data contains 1024 bits
- the cable bandwidth is 12 MHz

(i) Show that each bit of a packet must be on the cable for about 40 ns.

[2]

(ii) Estimate the maximum number of packets passing through the cable in one second.

packets per second = ... **[2]**

9 Fig. 9.1 is the circuit diagram of a simple analogue-to-digital converter.

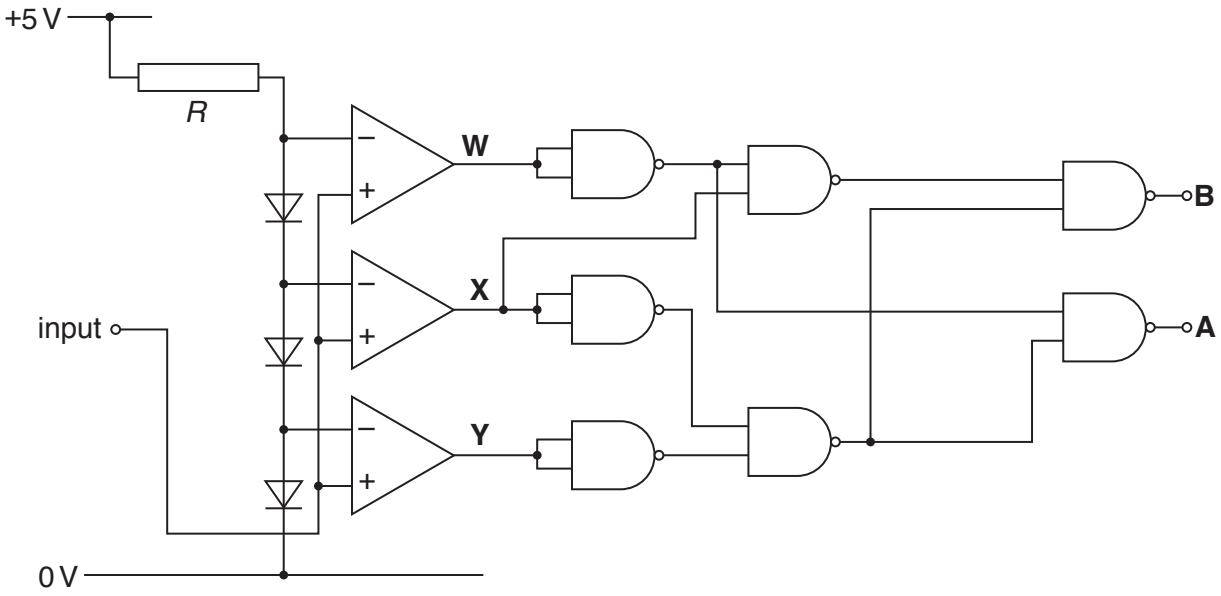

Fig. 9.1

(a) Each of the diodes is rated at 0.7 V, 5 mA.

Calculate a suitable value for the resistor *R* which limits the current in the diodes.

R = ... Ω **[2]**

(b) Each of the op-amps has outputs which saturate at +5 V or 0 V.

(i) Write down a Boolean expression for the output **B** in terms of the signals **W**, **X** and **Y**.

Use the rules of Boolean algebra to simplify your answer.

[2]

(ii) Complete the table with **1** or **0**.

Input Signal	W	X	Y	B	A
0.25 V					1
0.75 V					0
1.55 V					0
2.65 V					1

[4]

(c) The converter has the following specification:

- resolution of 0.7 V
- range of 2.8 V
- word length of 2 bits

Show how these three quantities are related to each other.

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.....

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

(d) The converter has a response time of 12 µs.

Calculate the maximum input frequency that the converter can safely encode.

maximum input frequency = ... Hz **[2]**

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).