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Oxford Cambridge and RSA

Tuesday 16 June 2015 – Morning**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	
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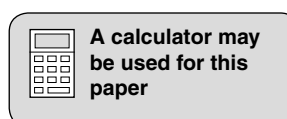
Centre number						Candidate number				
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INSTRUCTIONS TO CANDIDATES

- 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. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

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 your Quality of Written Communication.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.



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	$T = 0.7 RC$
relaxation oscillator period	$T = 0.5 RC$
frequency	$f = \frac{1}{T}$
voltage gain	$G = \frac{V_{\text{out}}}{V_{\text{in}}}$
open-loop op-amp	$V_{\text{out}} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \frac{R_f}{R_d}$
inverting amplifier gain	$G = -\frac{R_f}{R_{\text{in}}}$
summing amplifier	$-\frac{V_{\text{out}}}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} \dots$
break frequency	$f_0 = \frac{1}{2\pi RC}$

3

Boolean Algebra

$$A.\bar{A} = 0$$

$$A + \bar{A} = 1$$

$$A.(B + C) = A.B + A.C$$

$$\overline{A.B} = \bar{A} + \bar{B}$$

$$\overline{A + B} = \bar{A}.\bar{B}$$

$$A + A.B = A$$

$$A.B + \bar{A}.C = A.B + \bar{A}.C + B.C$$

amplifier gain

$$G = -g_m R_d$$

ramp generator

$$\Delta V_{\text{out}} = -V_{\text{in}} \frac{\Delta t}{RC}$$

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** questions.

1 Fig. 1.1 shows the three cables between a video camera and a black-and-white monitor.

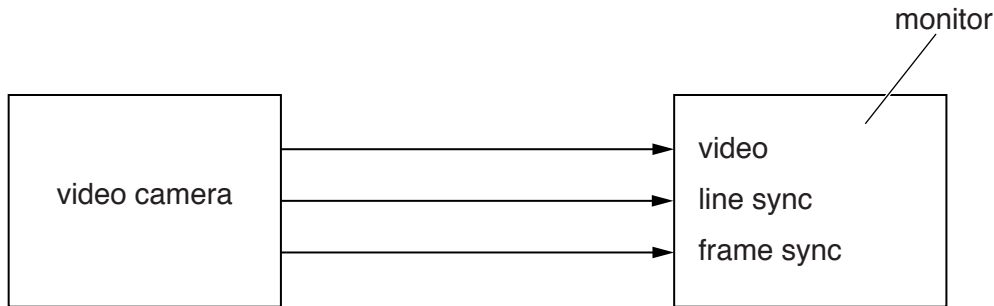


Fig. 1.1

(a) (i) The video cable carries an analogue signal. Explain how the monitor uses this signal in the creation of the image on its screen.

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..... [4]

(ii) The line sync cable carries a digital signal, consisting of short pulses at intervals of $80\mu\text{s}$. Explain how the monitor uses this signal in the creation of the image on its screen.

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..... [2]

(iii) The monitor has 320 pixels in each row of the display. Calculate the bandwidth required for the video signal.

bandwidth = MHz [2]

- (iv) The monitor has 220 rows of pixels in each frame of the display.
Calculate the frame refresh rate and explain its effect on the image.

frame refresh rate = Hz

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..... [4]

- (b) Explain how the cables shown in Fig. 1.1 will need to be modified for the monitor to display an image in colour instead of in black and white.

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..... [3]

6

- 2 The amplitude-frequency graph of Fig. 2.1 is for an amplitude modulated carrier.

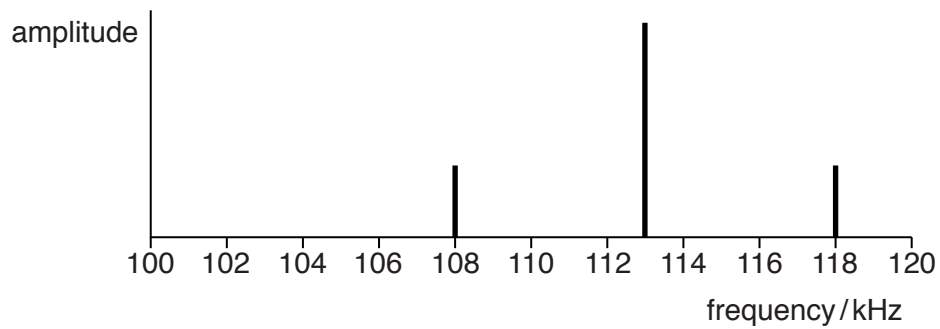


Fig. 2.1

- (a) The signal that modulates the carrier has an amplitude of 30 mV. Use information in Fig. 2.1 to sketch a voltage-time graph on the axes of Fig. 2.2 for the modulating signal.

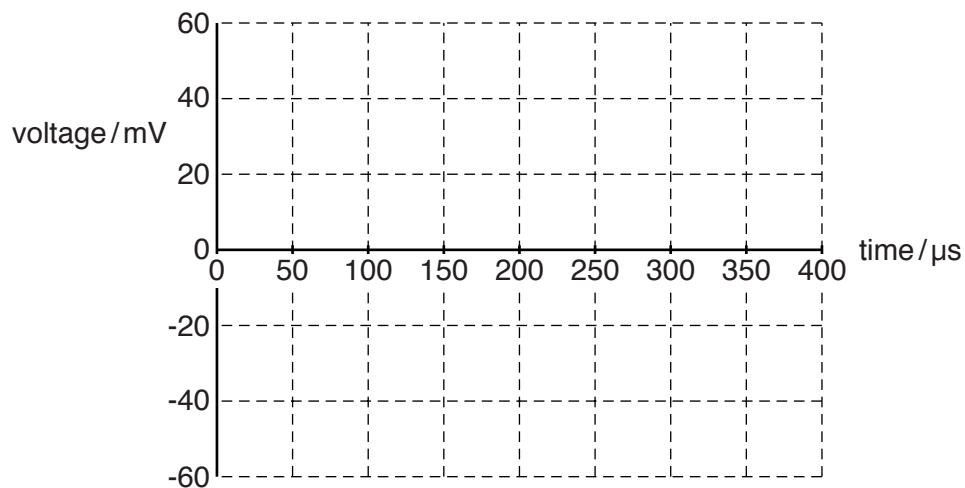


Fig. 2.2

[3]

- (b) The modulator shown in Fig. 2.3 is a voltage-controlled amplifier whose gain is determined by the voltage at **Y**. Complete the sentence below about the action of the modulator.

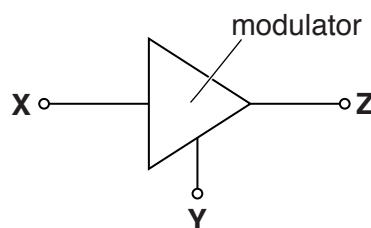


Fig. 2.3

The AM signal of Fig. 2.1 appears at when a signal of frequency 5 kHz is applied to and a frequency of kHz is applied to

[2]

(c) Fig. 2.4 shows a demodulator for the AM signal of Fig. 2.1.

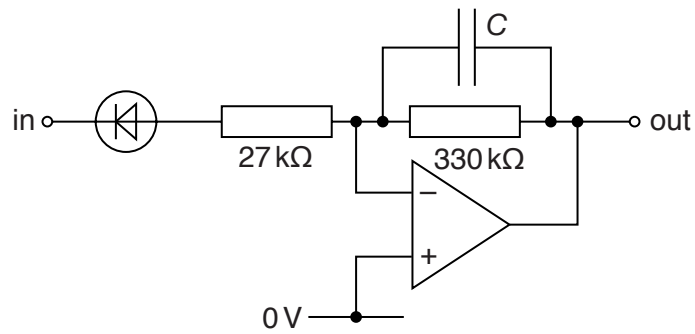


Fig. 2.4

(i) Calculate a suitable value for the capacitor in the circuit.

$C = \dots\dots\dots$ F [3]

(ii) By describing the transfer characteristics of a diode, explain how the circuit of Fig. 2.4 performs the operation of demodulation.

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3 Fig. 3.1 is a block diagram of a frequency modulation transmission system.

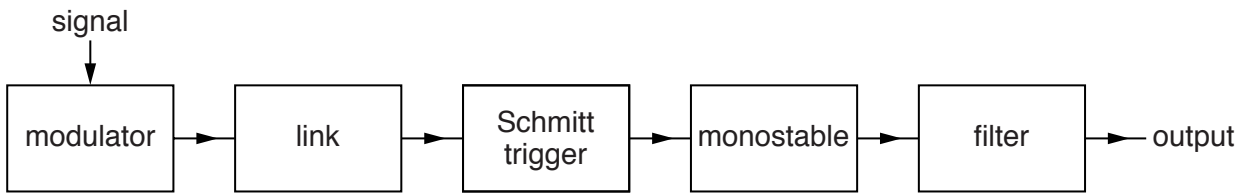


Fig. 3.1

The system transmits in the frequency band between 27.1 MHz and 27.3 MHz.

(a) Describe the transfer characteristic of the modulator.

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..... [3]

(b) Calculate the maximum frequency of signal that the system can transmit successfully.

frequency = kHz [2]

(c) Explain the function of the Schmitt trigger at the end of the link.

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..... [2]

(d) Explain how the monostable and filter perform the operation of frequency demodulation.

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

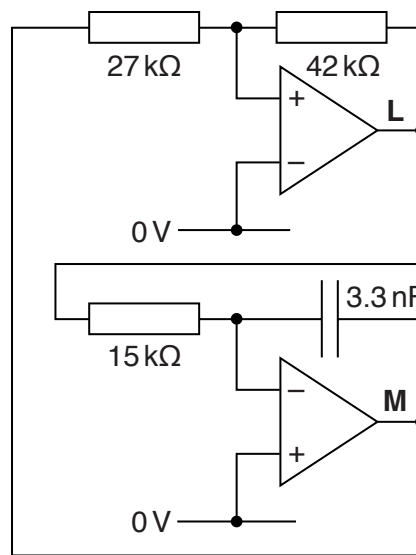


Fig. 4.1

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

- amplitude of about 8V
- frequency of about 10kHz.

[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.

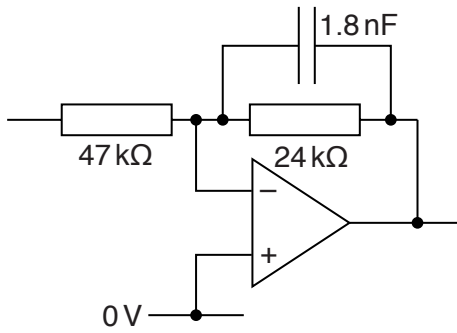


Fig. 4.2

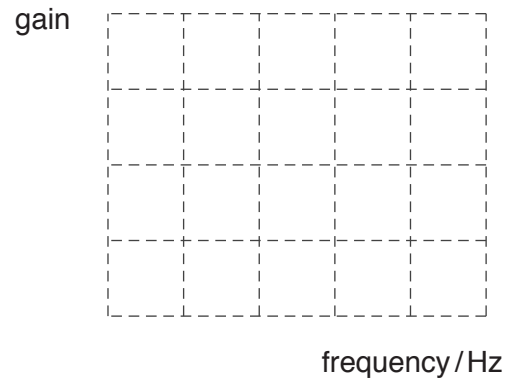


Fig. 4.3

(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 Fig. 5.1 shows a circuit for sending information down a twisted-pair cable.

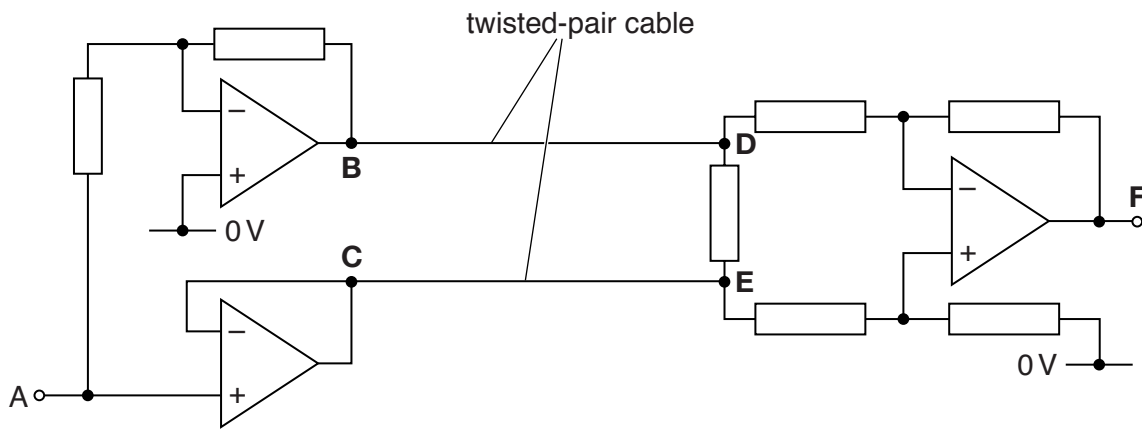


Fig. 5.1

The system of Fig. 5.1 transmits interference-free signals over long distances.

(a) Suggest, with a reason, another way of reducing interference.

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 [2]

(b) Explain why the two wires in the cable are twisted together.

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 [2]

(c) By describing how the op-amps process the signals which pass through them, explain how the system of Fig. 5.1 transmits interference-free signals.

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 [5]

6 Broadcast radio in the medium wave (MW) band uses frequency division multiplexing (FDM).

(a) Explain how FDM allows many different radio stations in the MW band to broadcast music at the same time.

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..... [2]

(b) The MW band in Europe has the following properties:

- stations use amplitude modulation
- each station can transmit signals of frequency up to 4.5 kHz
- the band contains frequencies in the range 527 kHz to 1.607 MHz.

(i) Calculate the maximum number of different stations which can broadcast in the MW band.

number of stations = [2]

(ii) Explain why stations in the MW band are **not** allowed to use frequency modulation.

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..... [2]

(iii) Explain the advantage of broadcasting using FM instead of AM.

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..... [3]

7 Fig. 7.1 is a block diagram for a superhet radio receiver.

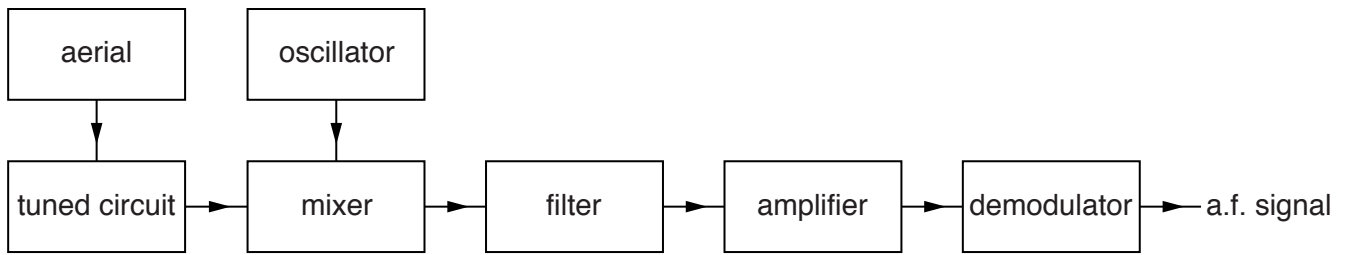


Fig. 7.1

The receiver is tuned to a transmitter which uses amplitude modulation on a carrier frequency of 3650 kHz.

- (a) Draw a circuit diagram for the aerial and tuned circuit in the space below. Show component values and justify these values with a calculation.

[5]

- (b) The filter in Fig. 7.1 only transmits frequencies between 450 kHz and 490 kHz.

- (i) Calculate the frequency of the oscillator when the receiver is tuned to a transmitter at 3650 kHz.

oscillator frequency = kHz [2]

- (ii) Describe the functions of the oscillator, mixer and filter.

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..... [4]

(c) A superhet receiver has excellent sensitivity and selectivity.

(i) Explain which block in Fig. 7.1 determines the **sensitivity** of the receiver.

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..... [2]

(ii) Explain which block in Fig. 7.1 determines the **selectivity** of the receiver.

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..... [2]

8 Fig. 8.1 is a block diagram of a digital transmission system for an analogue signal.



Fig. 8.1

(a) (i) Describe the function of the block labelled X.

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..... [2]

(ii) Describe the function of the block labelled Y.

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..... [2]

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

- a conversion time of $125\ \mu\text{s}$
- a range of -2.0V to $+2.0\text{V}$
- a resolution of 25mV .

(i) Calculate the length of the binary word produced by the ADC.
Explain your working.

word length = [3]

(ii) Calculate the maximum frequency of analogue signal that the system can transmit without distortion.
Explain your working.

maximum frequency = Hz [3]

Question 8 continues on next page

(c) Fig. 8.2 is a block diagram for the PSC of Fig. 8.1.

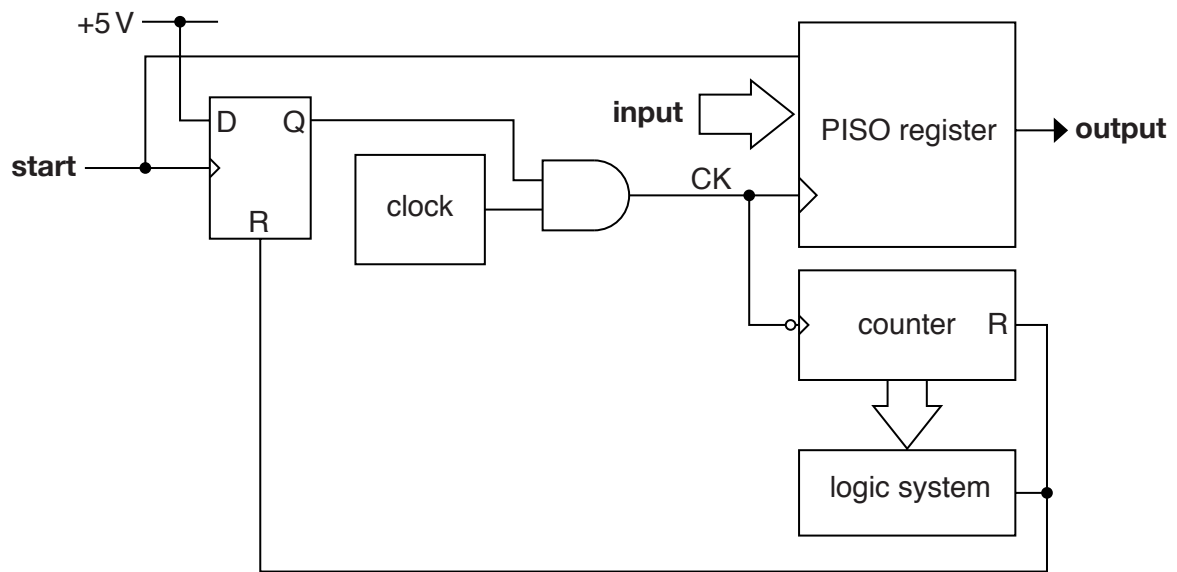


Fig. 8.2

(i) Describe the effect on the system, in Fig. 8.2, of a short pulse at **start**.

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..... [5]

- (ii) Explain how the number of flip-flops required to make the PISO register in Fig. 8.2 is determined by the length of the word at **input**.

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..... [3]

Quality of written communication [3]

END OF QUESTION PAPER

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