Wednesday 11 June 2014 – 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	

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. 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.

A calculator may be used for this paper

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	$R = \dfrac{V}{I}$
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	$f = \dfrac{1}{T}$
voltage gain	$G = \dfrac{V_{out}}{V_{in}}$
open-loop op-amp	$V_{out} = A(V_+ - V_-)$
non-inverting amplifier gain	$G = 1 + \dfrac{R_f}{R_d}$
inverting amplifier gain	$G = -\dfrac{R_f}{R_{in}}$
summing amplifier	$-\dfrac{V_{out}}{R_f} = \dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} \ldots$
break frequency	$f_0 = \dfrac{1}{2\pi RC}$

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	$G = -g_{\mathrm{m}}R_{\mathrm{d}}$
ramp generator	$\Delta V_{\mathrm{out}} = -V_{in}\frac{\Delta t}{RC}$
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** questions.

1 Fig. 1.1 shows the five connections which carry digital information from a computer to a colour monitor.

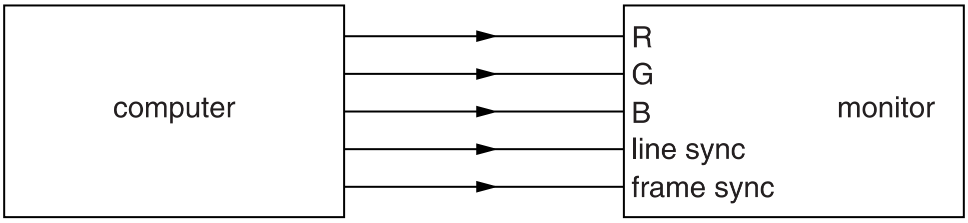

Fig. 1.1

(a) Explain how the **five** signals control the raster scan which displays a colour picture on the monitor screen.

....

....

....

....

....

.... **[5]**

(b) Each of the three video signals are packets of 7-bit words.
Explain why this suggests about 30 different levels of intensity for each pixel.

....

....

....

.... **[3]**

(c) Each video signal has its own cable.
The bandwidth of each video signal is 170 MHz.

Calculate the rate at which each packet passes through each video cable.

packet rate = ... MHz **[2]**

Fig. 1.2 is an oscilloscope trace of the frame sync signal.

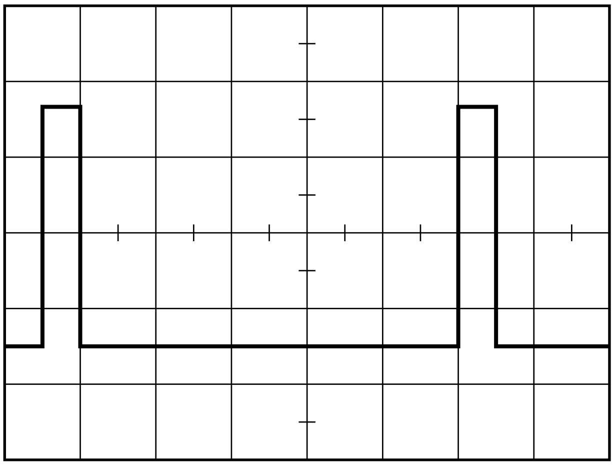

Fig. 1.2

(d) The oscilloscope settings are as follows:

- timebase setting 2 ms/div
- vertical scale 500 mV/div

Show that the refresh rate is about 100 Hz.

[2]

[Total: 12]

2 Fig. 2.1 shows a voltage-controlled amplifier and its transfer characteristic.

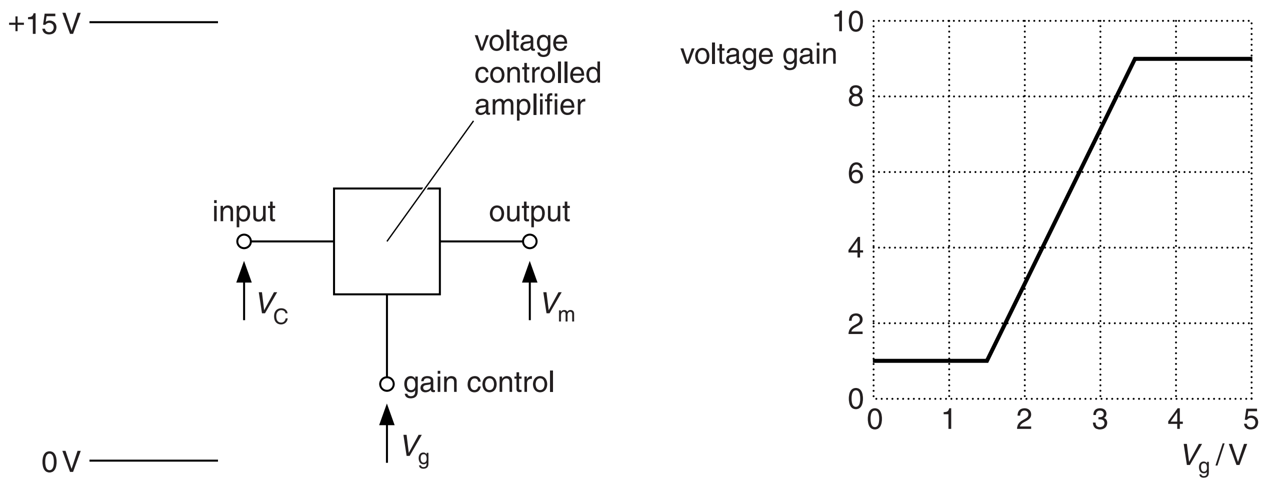

Fig. 2.1

(a) The amplifier is part of an amplitude modulator. The amplifier alters the amplitude of the carrier signal V_C by an amount which depends on the value of the signal V_g.

(i) In the absence of a modulating signal, the amplifier gain needs to be 5.
Draw on Fig. 2.1 to show how a pair of resistors can be used to bias the amplifier. Show component values and justify them with calculations.

[3]

(ii) Draw on Fig. 2.1 to show how a capacitor should be connected to allow an audio frequency signal V_S to amplitude modulate the carrier signal V_C. **[1]**

(iii) Suggest the maximum amplitude of audio frequency signal V_S which should be used. Explain your choice.

....

....

....

....

....

.... **[3]**

(b) Fig. 2.2 shows an amplitude demodulator for use with the modulator of Fig. 2.1.

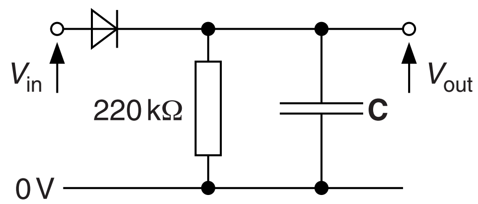

Fig. 2.2

(i) The carrier signal V_C has a frequency of 450 kHz.
Calculate a suitable value for the capacitor **C** if the audio frequency signal ranges from 50 Hz to 5 kHz.

C = ... pF **[2]**

(ii) The diode in Fig. 2.2 has a voltage drop of 100 mV in forward bias.
On Fig. 2.3 draw a voltage-time graph for V_{out} when V_{in} has the following properties.

carrier frequency	450 kHz
signal frequency	5 kHz
maximum carrier amplitude	600 mV
minimum carrier amplitude	200 mV

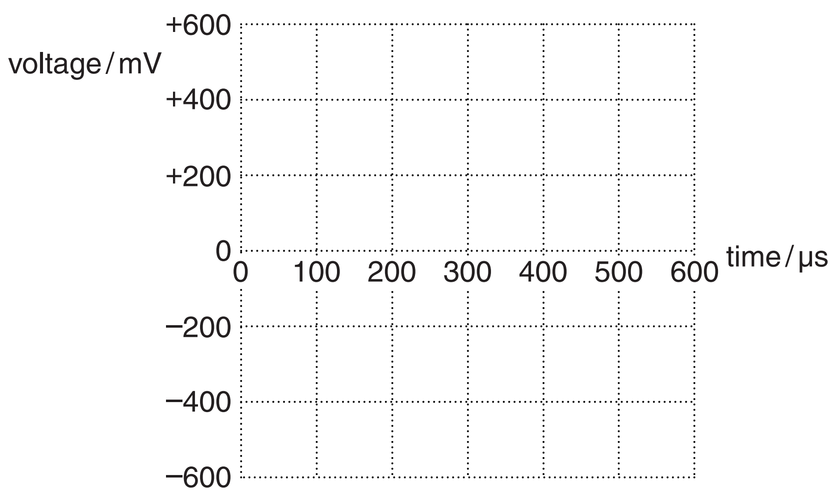

Fig. 2.3

[3]

[Total: 12]

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

Fig. 3.1

(a) Explain the function of the Schmitt trigger.

....

....

....

.... **[2]**

(b) The monostable produces a pulse of duration 2 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) Fig. 3.2 contains the circuit diagram for the filter.

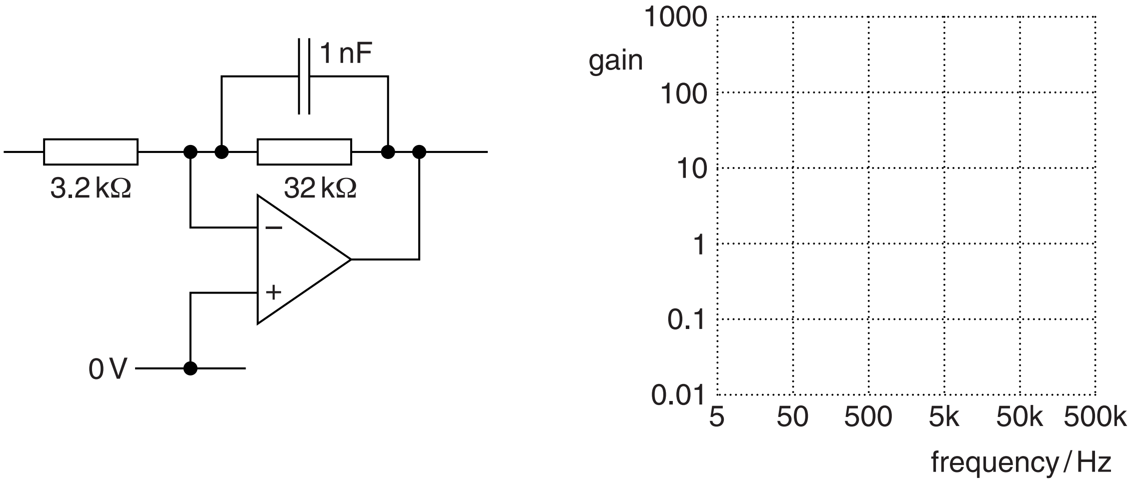

Fig. 3.2

(i) Draw a gain-frequency graph for the filter on the axes of Fig. 3.2.
Show your calculations in the space below.

[4]

(ii) Calculate a value for the bandwidth required by the f.m. carrier.

bandwidth = ... kHz **[2]**

[Total: 12]

4 Fig. 4.1 is the circuit diagram of a pulse-width modulator (PWM).

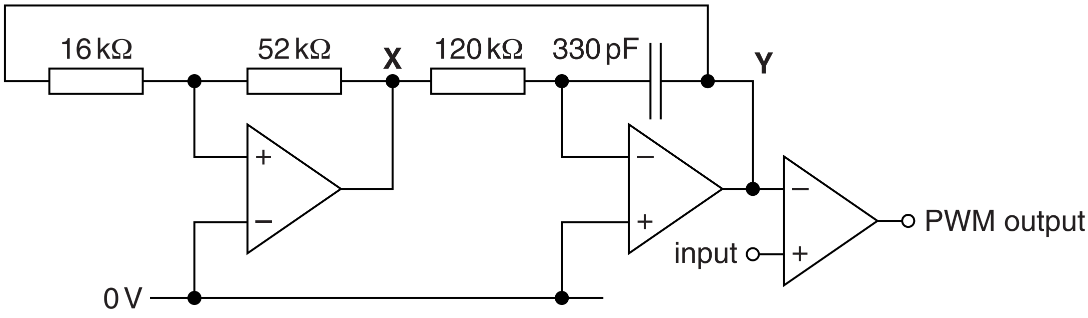

Fig. 4.1

(a) **X** is the output of the Schmitt trigger. It is either positive or negative.
Explain, with calculations, why the signal at **Y** has to be raised above +4.0 V to change **X** from negative to positive.

[3]

(b) Calculate how long it takes for the signal at **Y** to rise from –4.0 V to +4.0 V.

time = ... μs **[2]**

(c) Calculate the highest frequency signal at the modulator input which will be correctly encoded.

frequency = ... kHz **[3]**

(d) Fig. 4.2 is an incomplete block diagram for a demodulator of a PWM signal.

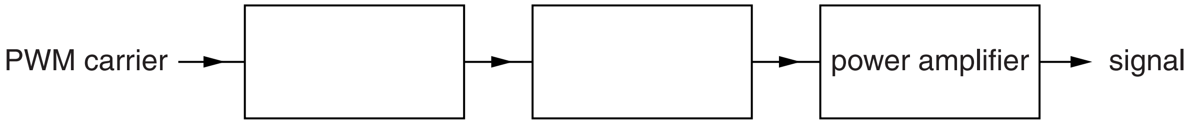

Fig. 4.2

(i) Complete the block diagram. Choose from the list below.

ramp generator **Schmitt trigger** **tone control** **treble cut filter** **voltage amplifier**

[2]

(ii) Suggest a reason why the system contains a power amplifier.

....

....

....

.... **[1]**

[Total: 11]

5 This question is about the transmission of signals as pulses of waves.

(a) Name the type of wave which carries pulses down an optical fibre.

.... **[1]**

(b) State and explain what happens to these pulses as they move along the fibre.

....

....

.... **[2]**

(c) Explain why optical fibre transmission systems usually have large values for their signal-to-noise ratio.

....

....

....

....

.... **[3]**

(d) Optical fibre systems do **not** have problems with interference. This is partly because of the opaque cladding around the fibres.

(i) Explain why interference is a problem for systems which use radio waves.

....

....

....

....

.... **[3]**

(ii) Explain how this can be overcome by systems which use radio waves.

....

....

....

....

.... **[3]**

[Total: 12]

6 This question is about the use of frequency division multiplexing (FDM) for mobile phone systems. A mobile phone uses radio waves for two-way communication with the nearest phone mast.

(a) Suggest why mobile phone systems use FDM.

....

....

....

....

.... **[3]**

(b) A particular mast uses the frequencies between 909.375 MHz and 915.625 MHz.
How many phones can simultaneously communicate with the mast if each phone signal has a bandwidth of 64 kHz?

number of phones = ... **[2]**

(c) The phones communicate by amplitude modulating a digital signal onto a carrier.
Calculate the number of phones which could simultaneously communicate with the mast if frequency modulation was used instead. Explain your answer.

[3]

(d) Show in the space below how a bandpass filter for a phone can be assembled from a resistor, inductor and capacitor. Label the input and output.
No component values are required.

[2]

[Total: 10]

7 Fig. 7.1 is an incomplete block diagram for part of a superhet radio receiver.

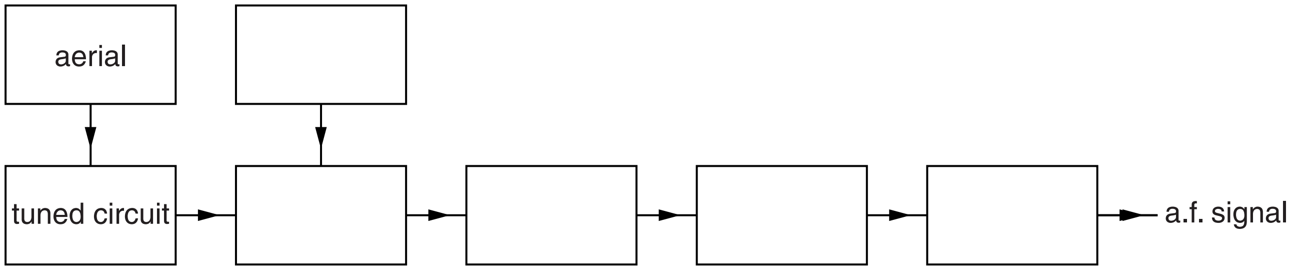

Fig. 7.1

(a) Complete the block diagram. Choose from the list below.

amplifier **demodulator** **filter** **mixer** **oscillator** **ramp generator** **Schmitt trigger**

[5]

(b) The tuned circuit contains a 4.7 nH inductor and a variable capacitor.
The circuit is to select a signal at 902.50 MHz from the aerial.
Calculate the required setting of the variable capacitor.

capacitor = ... pF **[2]**

(c) Explain why a superhet receiver has better selectivity than a simple radio receiver.

....

....

....

....

....

....

....

....

.... **[4]**

(d) Fig. 7.2 shows the rest of the block diagram for the superhet receiver.

Fig. 7.2

The voltage amplifier has these properties:

- input impedance 100 kΩ
- voltage gain +50

Complete Fig. 7.3 to show how the amplifier can be assembled.
Show all component values.

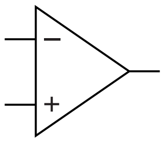

Fig. 7.3

[4]

[Total: 15]

8 Fig. 8.1 shows the circuit diagram of a 6-bit analogue-to-digital converter (ADC).

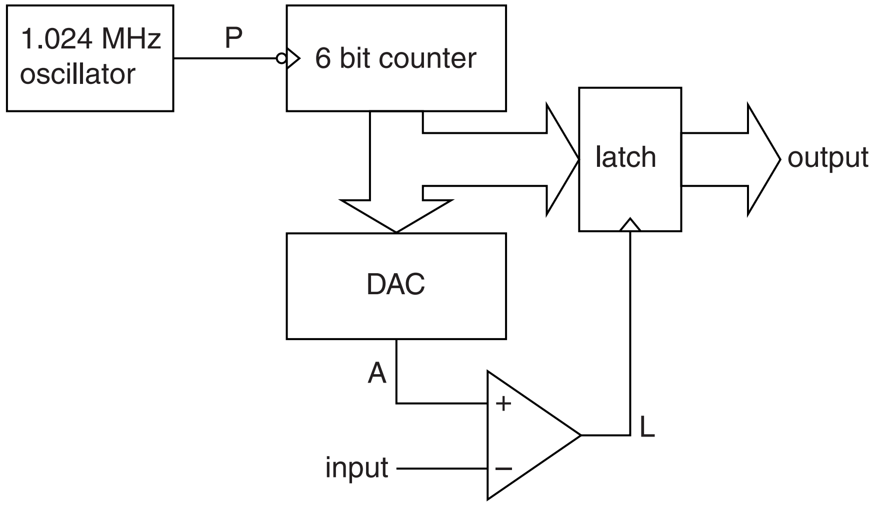

Fig. 8.1

(a) The block labelled DAC is a 6-bit digital-to-analogue converter.

(i) Describe the behaviour of a digital-to-analogue converter.

....

....

.... **[1]**

(ii) The DAC in Fig. 8.1 has a resolution of 100 mV.
Show that the range of the DAC is 6.3 V.

[2]

(b) Describe the behaviour of the block labelled **latch**.

....

....

....

....

.... **[3]**

(c) Explain why the sample rate of the ADC of Fig. 8.1 is 16 kHz.

....

....

....

....

.... **[2]**

(d) Explain how the ADC of Fig. 8.1 converts the voltage at **input** into a 6-bit word at **output**.

....

....

....

....

....

....

....

.... **[5]**

[Total: 13]

9 Fig. 9.1 shows how a number of computers (labelled A to Z) can exchange packets of data along a single cable.

Fig. 9.1

(a) Each packet is a 1024-bit word.
It starts with a 0 (the start bit) and ends with a 1 (the stop bit).
Name the other parts of the packet and explain their function.

....

....

....

....

.... **[4]**

(b) For correct transmission, each packet must be the only one on the line at that instant.

Explain how this is achieved by the computers.

....

....

....

....

.... **[3]**

(c) Each computer has a serial transmitter and serial receiver connected to the cable.
Explain why only one of them is connected to the cable through an analogue switch.

....

....

....

....

.... **[3]**

[Total: 10]

Quality of Written Communication **[3]**

END OF QUESTION PAPER

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

PLEASE DO NOT WRITE ON THIS PAGE