OCR
RECOGNISING ACHIEVEMENT

Thursday 31 May 2012 – Afternoon

A2 GCE ELECTRONICS

F615 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

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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	$f_0 = \dfrac{1}{2\pi RC}$

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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	$\Delta V_{\mathrm{out}} = -V_{in}\dfrac{\Delta t}{RC}$
inductor reactance	$X_L = 2\pi fL$
capacitor reactance	$X_C = \dfrac{1}{2\pi fC}$
resonant frequency	$f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

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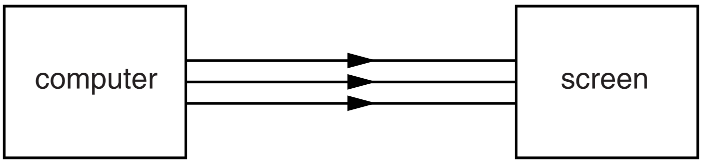
Answer **all** questions.

1 A shop screen uses an array of green LEDs to display information.

A computer transfers information to the screen along three different cables, allowing moving pictures to be displayed.



(a) One of the cables carries a digital video signal. This is a series of binary words, each of which controls the intensity of a different LED in the screen.

(i) Each LED can have 42 different levels of intensity.

Show that this requires a word length of six bits.

....

.... **[1]**

(ii) Each word is sent down the cable as a packet.

Explain why each packet is made up of the six bit word and two extra bits.

....

....

....

....

.... **[3]**

(iii) The screen has 1024 rows of LEDs.

Each row contains 1280 LEDs.

The screen is refreshed at a rate of 40 Hz.

Calculate the minimum bandwidth required for the cable.

bandwidth = ... MHz **[3]**

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(b) The other two cables carry the line and frame synchronisation signals.

Explain how these signals control the raster scan of the LEDs.

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....

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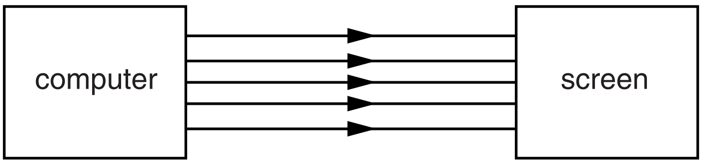
.... **[3]**

(c) The shop decides to update the screen to display moving pictures in full colour.



Explain why the new system will need two more cables to connect the computer to the screen.

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....

....

.... **[3]**

[Total: 13]

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2 Fig. 2.1 is an oscilloscope trace of an amplitude modulated carrier.

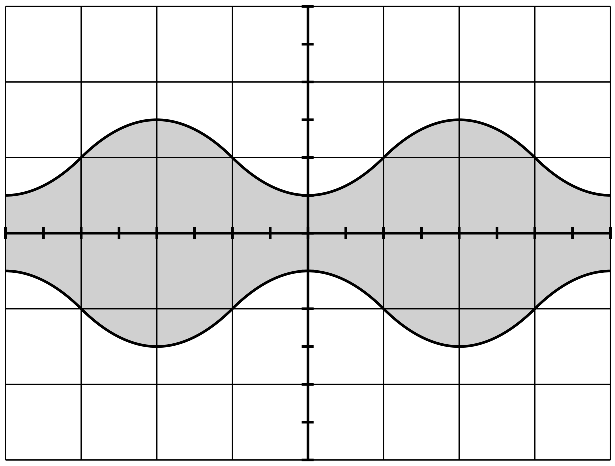

Fig. 2.1

(a) The oscilloscope settings are as follows:

- Y sensitivity 20 mV / div
- timebase 50 μs / div

(i) Use Fig. 2.1 to calculate the amplitude and frequency of the audio frequency signal which is modulating the carrier.

amplitude = ... mV

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

(ii) Calculate the bandwidth required to transmit the modulated carrier.

bandwidth = ... kHz **[1]**

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(b) The frequency of the audio frequency signal is changed to 7 kHz.

The carrier frequency is 400 kHz.

(i) Draw on the axes of Fig. 2.2 to show the amplitude-frequency graph of the amplitude modulated carrier. **[3]**

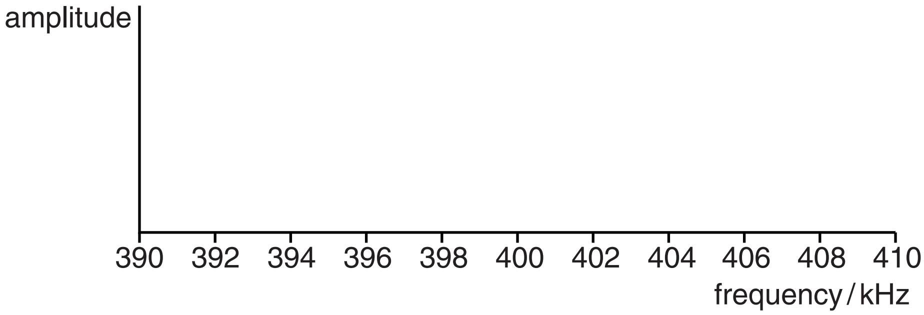

Fig. 2.2

(ii) The amplitude modulated carrier can be demodulated with a diode, a resistor and a capacitor.

Draw a circuit for a demodulator which will recover audio frequency signals in the range 100 Hz to 10 kHz. Label the input and output.

Show all component values. Justify them with calculations.

[4]

[Total: 11]

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3 This question is about the process of frequency modulation.

(a) Explain how the information in an audio frequency (AF) signal is encoded in a frequency modulated (FM) carrier.

....

....

....

.... **[2]**

(b) Here are some statements about frequency modulation.

Put a tick (✓) in the boxes next to the **two** correct statements.

It cannot be used to carry DC signals.	☐
It doesn't pick up any noise in transmission.	☐
The bandwidth is twice the frequency of the AF signal.	☐
The bandwidth is five times that of amplitude modulation.	☐
The signal-to-noise ratio is better than with amplitude modulation.	☐

[2]

(c) Fig. 3.1 is an incomplete block diagram for the demodulator of an FM carrier.

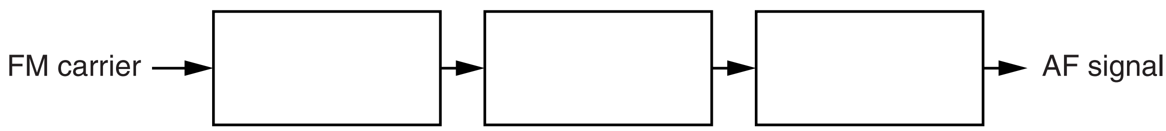

Fig. 3.1

(i) Complete the diagram. **[3]**

(ii) Explain the operation of the demodulator.

....

....

....

....

....

....

.... **[3]**

[Total: 10]

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4 Fig. 4.1 is an incomplete block diagram of a pulse-width modulation (PWM) transmission system which transfers an audio frequency (AF) signal from one place to another.

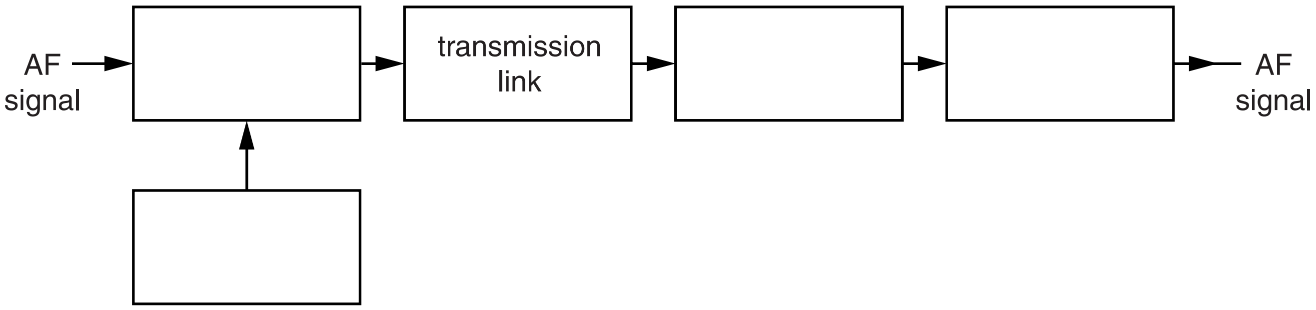


Fig. 4.1

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

bass cut filter **inverting amplifier** **op-amp comparator**

Schmitt trigger **treble cut filter** **triangle waveform generator**

[4]

(b) Fig. 4.2 is a voltage-time graph for a PWM carrier.

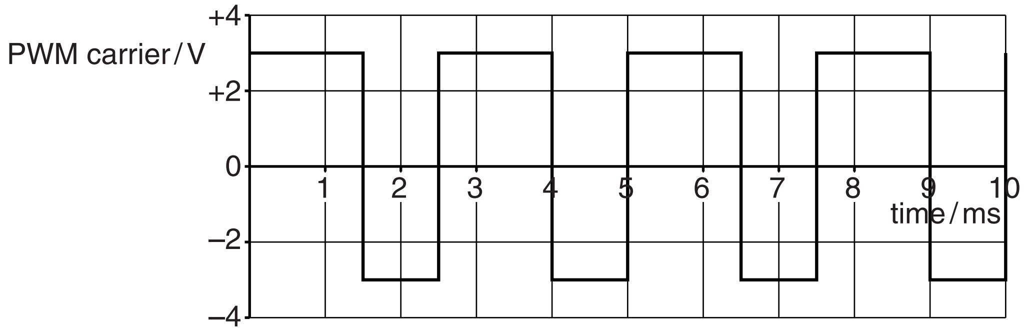


Fig. 4.2

(i) Do a calculation to show that the average voltage of one cycle of the PWM carrier is about +0.5 V.

[1]

(ii) Explain why the maximum AF signal frequency which can be encoded by the PWM carrier is 200 Hz.

....

....

....

.... **[2]**

[Total: 7]

5 Fig. 5.1 is the block diagram for a transmission system which uses twisted-pair cable as a transmission link.

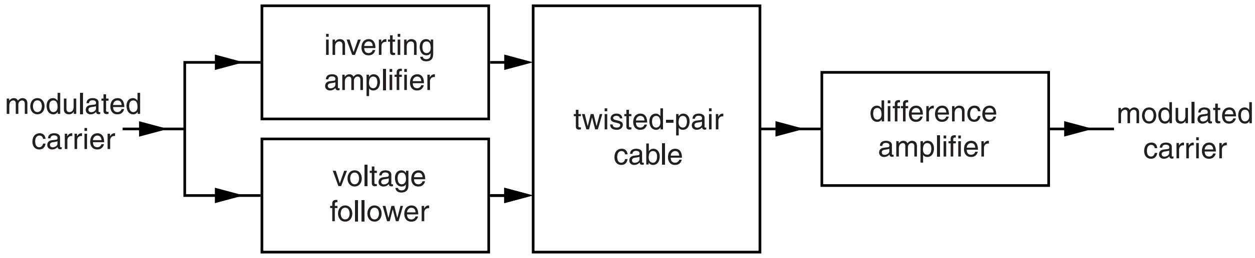
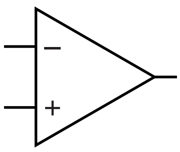
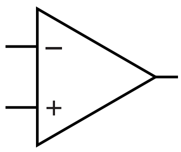
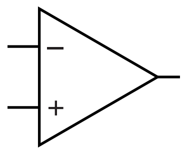


Fig. 5.1

(a) Complete the table below with circuit diagrams of an inverting amplifier, a voltage follower and a difference amplifier. No component values are required.

inverting amplifier	voltage follower	difference amplifier
		

[3]

(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.

....

....

....

....

....

.... **[3]**

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(c) The sentences below describe the benefits and drawbacks of using radio waves, 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.
Radio wave …	… carries information as electrical current.
	… can only carry amplitude modulated carriers.
Wire cable …	… always has to use frequency division multiplexing.

[3]

(d) Explain how the signal-to-noise ratio of information recovered by the receiver depends on the method of modulation (AM, FM or PWM) used by the transmitter.

....

....

....

....

....

.... **[3]**

[Total: 12]

6 Fig. 6.1 is the transfer characteristic (frequency response) of a bandpass filter.

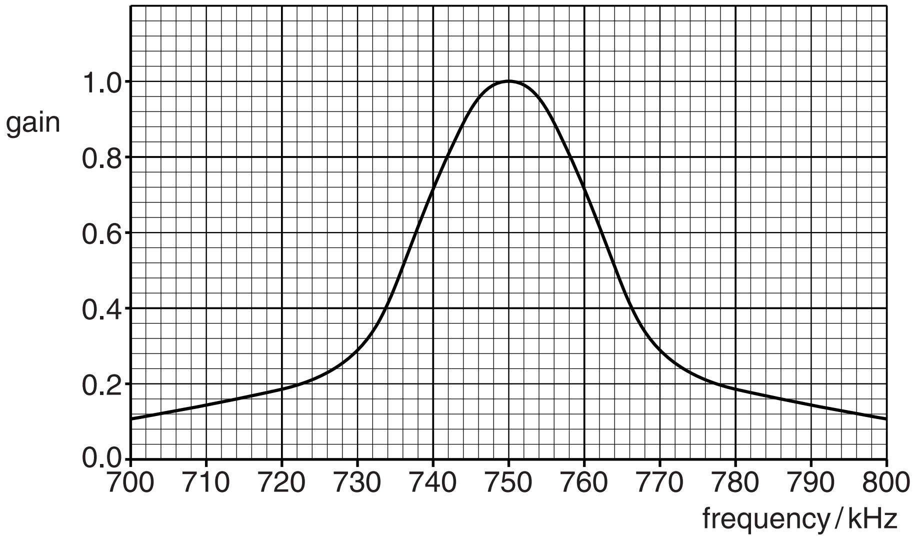

Fig. 6.1

(a) The bandpass filter is assembled from a 22 kΩ resistor, a 47 pF capacitor and an inductor.

(i) Draw a circuit diagram for the bandpass filter in the space below.

Label the input and output.

[2]

(ii) Calculate the inductance L of the inductor.

L = ... μH **[4]**

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(iii) Explain why the filter has the transfer characteristic of Fig. 6.1.

....

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....

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.... **[3]**

(b) Fig. 6.2 is an unlabelled block diagram of a transmission system which allows two separate signals to simultaneously pass along a single cable.

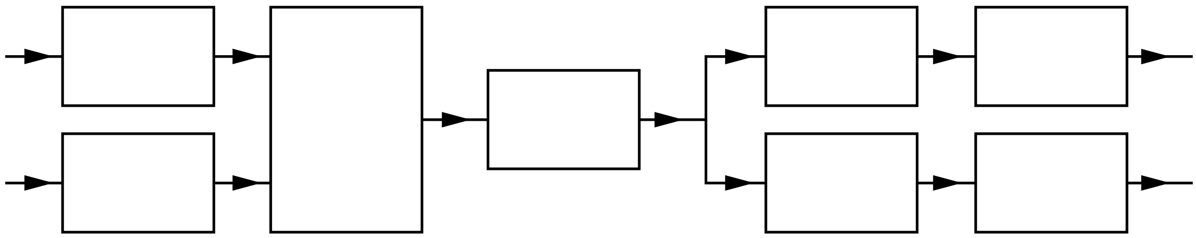

Fig. 6.2

(i) Label the block diagram. Choose from the labels below.

cable **demodulator** **filter** **modulator** **summing amplifier**

[5]

(ii) Each signal contains frequencies between 50 Hz and 5 kHz, and the system employs amplitude modulation. The maximum frequency that can be sent down the cable is 12 MHz.

Calculate the maximum number of different signals that can be sent simultaneously down the cable.

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

[Total: 16]

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

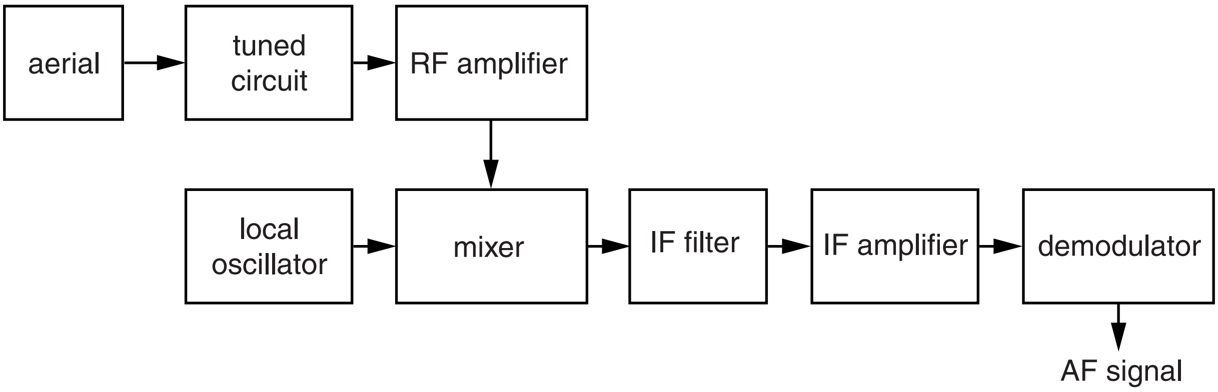

Fig. 7.1

(a) Draw a circuit diagram for the aerial and tuned circuit.

Label the output to the RF amplifier.

[2]

(b) Explain the advantage of including the RF amplifier in the circuit.

....

....

....

.... **[2]**

(c) The IF filter blocks all signals except those between 300 kHz and 400 kHz.

Suggest a suitable frequency for the local oscillator for the system to receive a radio station at 27.62 MHz.

frequency = ... MHz **[2]**

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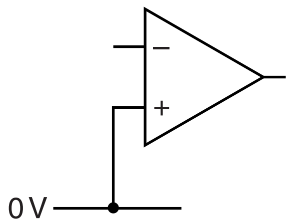
(d) The IF amplifier is a bass cut filter with the following transfer characteristics:

- break frequency 10 kHz
- input impedance 22 kΩ
- high frequency gain 35

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

Show all component values.

Justify them with calculations.



[5]

[Total: 11]

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8 Fig. 8.1 is a circuit diagram for a three-bit digital-to-analogue converter (DAC).

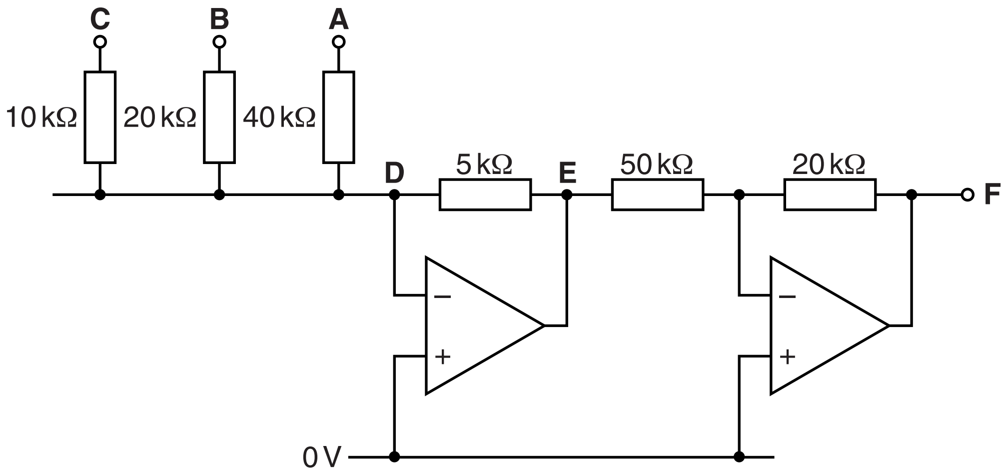

Fig. 8.1

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

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

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

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

(iii) Calculate the range of the converter.

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

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(b) The digital-to-analogue converter (DAC) is part of the time-division multiplexing transmission system of Fig. 8.2.

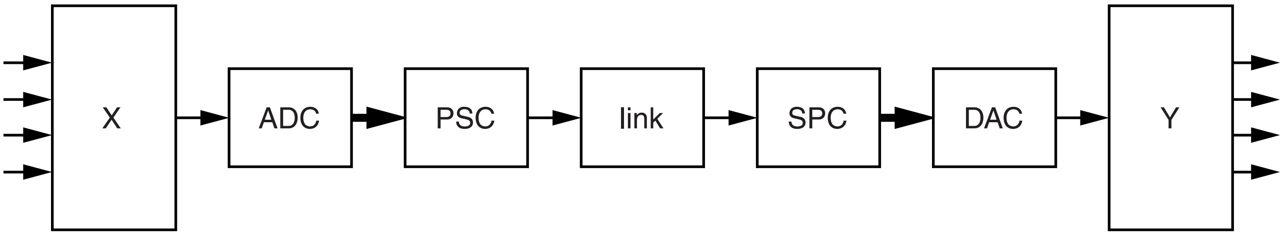

Fig. 8.2

(i) Draw lines to link each **block** to its **function** in the system.

block	**function**
X	transmits a word one bit at a time
ADC	codes the input voltage as a binary word
PSC	directs a signal to one of many destinations
SPC	selects one of many audio frequency signals
Y	creates a word out of bits arriving one after the other

[4]

(ii) The link carries information about the signals present at the four inputs on the left in Fig. 8.2. Explain what else it must carry.

....

....

....

....

.... **[2]**

[Total: 13]

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9 Fig. 9.1 is the circuit diagram of a serial transmitter of three-bit words.

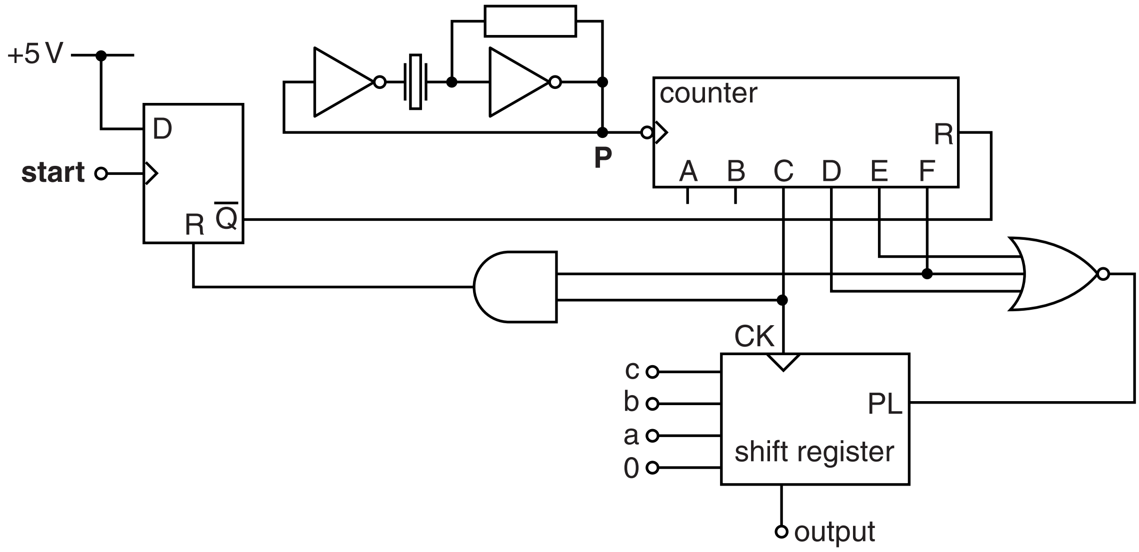

Fig. 9.1

(a) The system uses a crystal oscillator with a frequency of 1024 kHz.

(i) Calculate the frequency of the signals at CK.

frequency = ... kHz **[1]**

(ii) Explain why the system uses a crystal oscillator instead of a relaxation oscillator.

....

....

....

.... **[2]**

(b) (i) Explain why the counter ignores pulses at P until a pulse arrives at **start**.

....

....

....

....

....

....

.... **[4]**

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(ii) Complete the timing diagram of Fig. 9.2 for the system. **[3]**

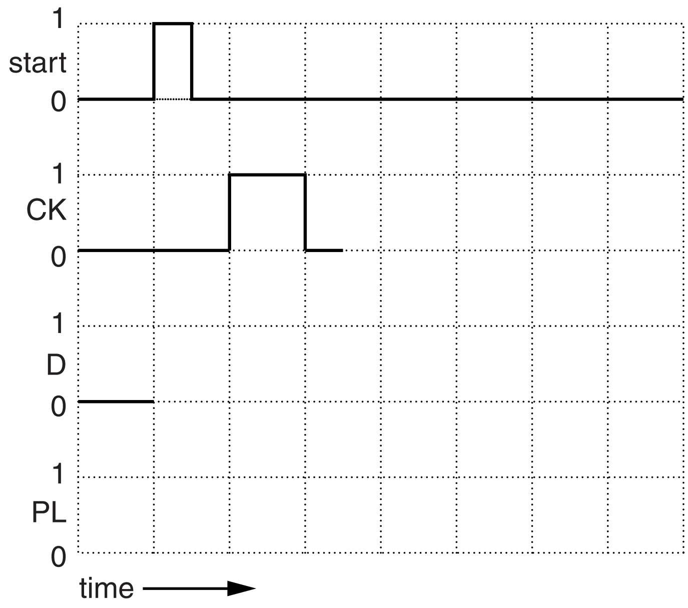

Fig. 9.2

(c) The behaviour of the shift register is summarised in this table.

PL	shift register behaviour
1	rising edge at CK loads register with word **cba0** at the parallel inputs
0	rising edge at CK shifts each bit to the right, making the left-hand bit high

Fig. 9.3 is an incomplete circuit diagram for the shift register.

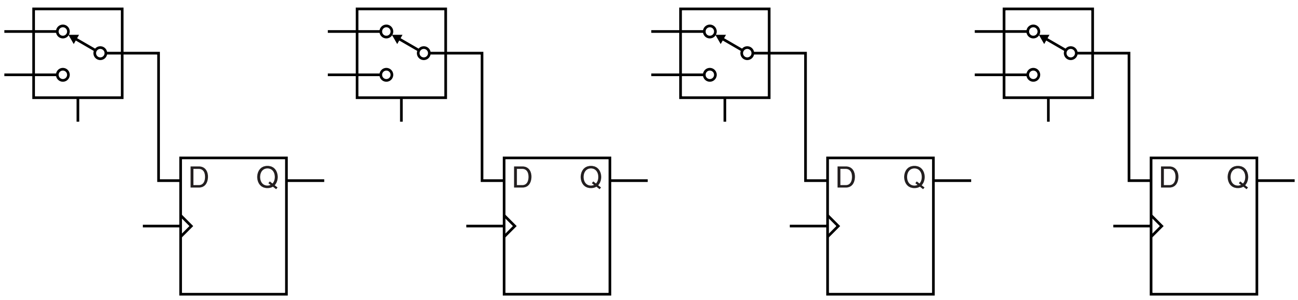

Fig. 9.3

Complete the circuit diagram. Label all inputs and outputs. **[4]**

[Total: 14]

Quality of Written Communication [3]

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