OCR RECOGNISING ACHIEVEMENT

ADVANCED GCE

ELECTRONICS

F615

Communication Systems

Candidates answer on the question paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Friday 10 June 2011
Afternoon

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. Pencil may be used for graphs and diagrams only.
- 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).
- Answer **all** the questions.
- 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 where this is indicated in the question.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

A scientific calculator may be used for this paper

Data Sheet

Unless otherwise indicated, you can assume that:

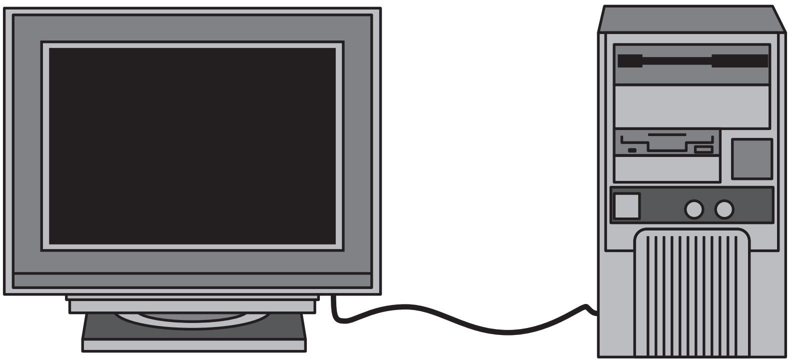
- op-amps are run off supply rails at +15V and –15V
- logic circuits are run off supply rails at +5V and 0V.

resistance	$R = \frac{V}{I}$
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	$G = \frac{V_{out}}{V_{in}}$
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** questions.

1 A computer transfers signals along a cable to a video screen.



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

(i) State the names of the five signals.

....

....

.... **[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 same information from the computer to the screen using digital signals. One method transmits pictures with a grey scale using five-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 600 lines of pixels, with 850 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 40 Hz. This is above the minimum value for video systems.

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

....

....

.... **[2]**

(c) For the method described in **(b)**, do a calculation to estimate the minimum bandwidth required for the cable connecting the computer to the screen.

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

(d) 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]**

[Total: 17]

2 Fig. 2.1 is an incomplete block diagram for a simple AM radio receiver.

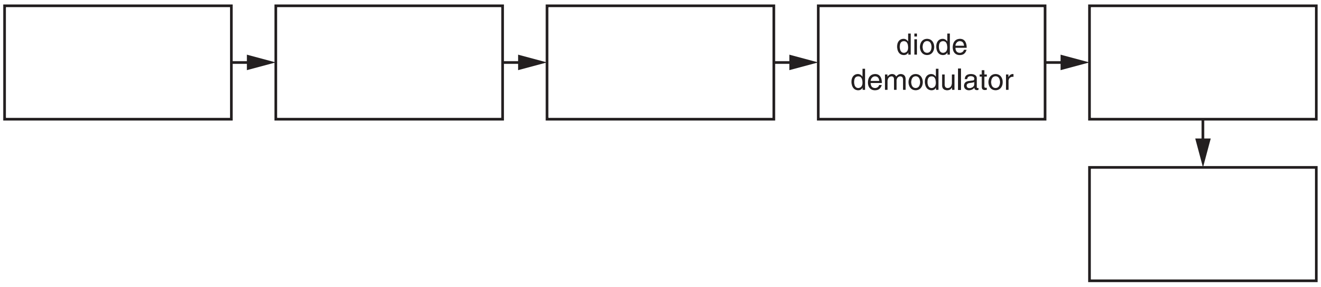

Fig. 2.1

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

aerial **af amplifier** **loudspeaker** **rf amplifier** **tuned circuit**

[4]

(b) The af amplifier is required to have a gain of –50.

Draw on Fig. 2.2 below to show how the amplifier can be made from an op-amp.

State component values and justify them.

[4]

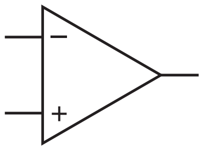

Fig. 2.2

(c) The radio system contains a tuned circuit.

(i) Describe the function of the tuned circuit.

....

.... **[1]**

(ii) The tuned circuit determines the selectivity of the system.

Explain what is meant by selectivity.

....

....

.... **[2]**

(iii) Another important property of a radio receiver is its sensitivity.

Explain **one** change to the system of Fig. 2.1 which would improve its sensitivity.

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....

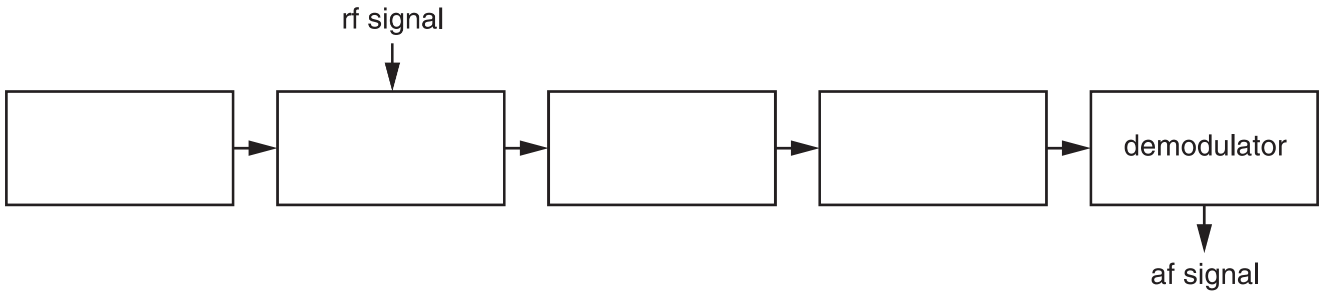
.... **[3]**

(d) A superhet radio receiver performs better than a simple AM receiver.

(i) Complete the block diagram below for a superhet receiver below.

Choose words from this list.

if amplifier **if filter** **local oscillator** **mixer**



[3]

(ii) The bandpass filter in the superhet receiver is centred on 350 kHz.

By describing the flow of signals through the receiver, explain how it can be tuned to receive a channel at 870 kHz.

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.... **[4]**

[Total: 21]

3 Fig. 3.1 is the block diagram of a pulse-width modulator.

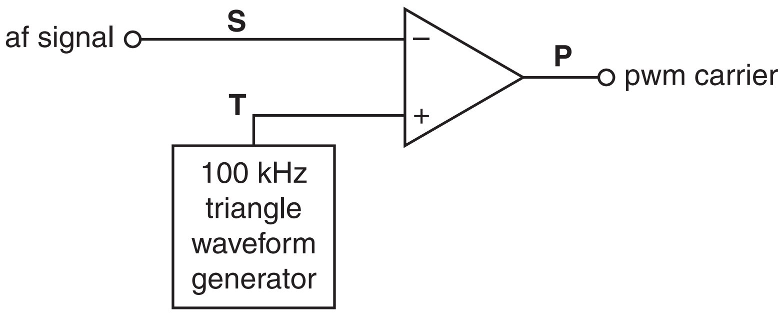

Fig. 3.1

(a) The signal at **T** is a triangle waveform with an amplitude of 7.5 V and a frequency of 100 kHz.

(i) Calculate the period of the waveform.

period = ... μs **[1]**

Fig. 3.2 shows a steady signal of +2.5 V at S.

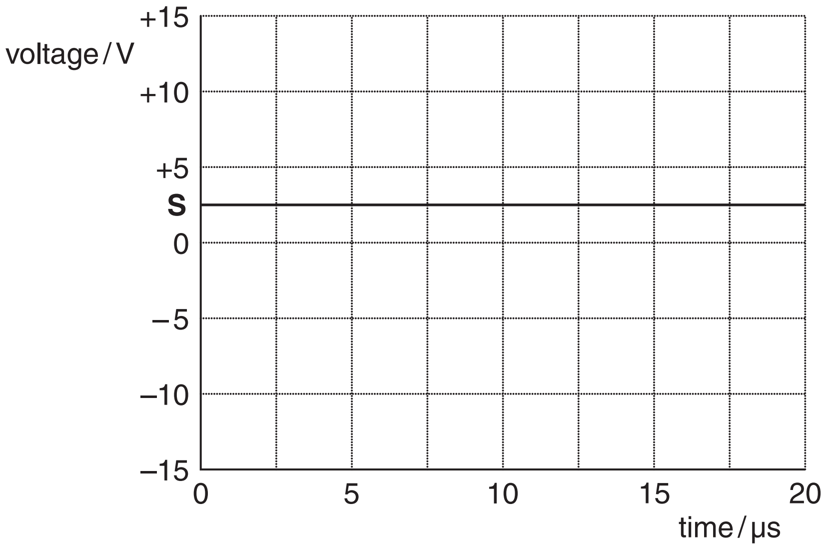

Fig. 3.2

(ii) On the axes of Fig. 3.2, sketch the waveform of the signal at **T**. **[3]**

(iii) On the axes of Fig. 3.2, sketch the waveform of the signal at **P**. **[3]**

(b) The pwm carrier at **P** in Fig. 3.1 can be demodulated by a filter with the transfer characteristic of Fig. 3.3.

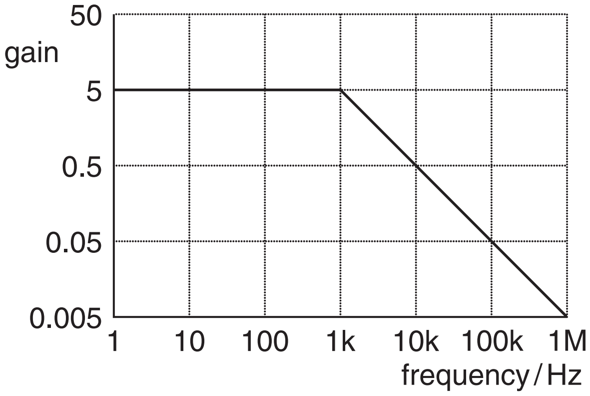

Fig. 3.3

(i) Draw on Fig. 3.4 below to show how the filter can be made with an op-amp.

Show all component values and justify them.

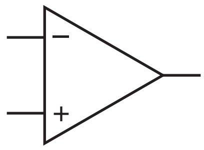

Fig. 3.4

[5]

(ii) Explain the factors that limit the range of af signals at **S** in Fig. 3.1 which can be transmitted by this pulse-width modulation system.

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.... **[3]**

[Total: 15]

4 The circuit of Fig.4.1 is an analogue-to-digital converter (ADC).

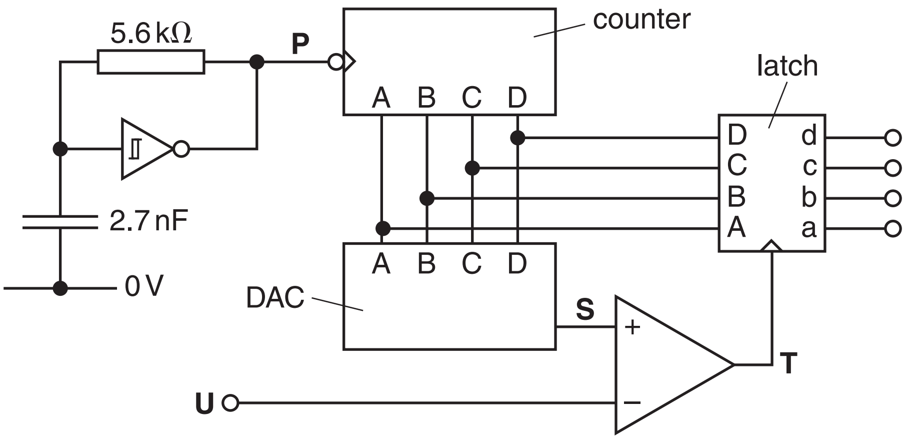
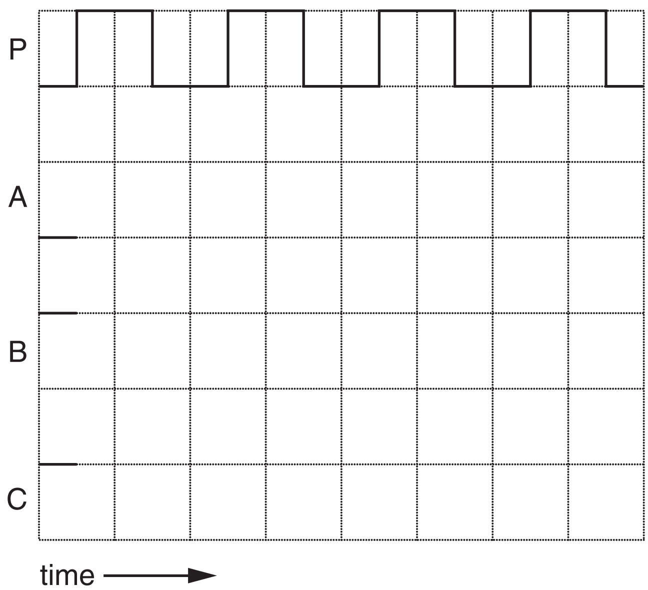


Fig. 4.1

(a) Show that the pulses at **P** have a frequency of about 100 kHz.

[2]

(b) Complete the timing diagram below for the counter. CBA is initially 110.



[3]

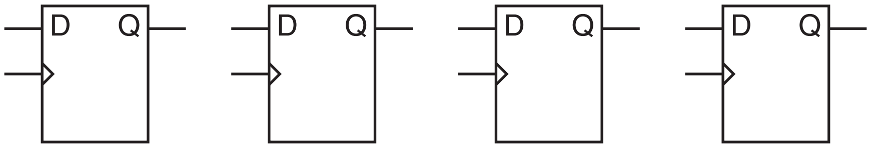
(c) The digital-to-analogue converter (DAC) of Fig. 4.1 has a resolution of 0.1 V.

The lowest voltage at **S** is 0.0 V. Calculate the highest voltage.

highest voltage = ... V **[2]**

(d) Draw on the diagram below to show how the latch of Fig. 4.1 can be made from D flip-flops.

Label all inputs and outputs.



[3]

(e) Explain how the analogue-to-digital converter of Fig. 4.1 operates.

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.... **[4]**

(f) Explain why the signal at **U** should have a frequency of less than 4 kHz.

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.... **[3]**

[Total: 17]

5 Fig. 5.1 shows a variable frequency oscillator (VFO) and its transfer characteristic.

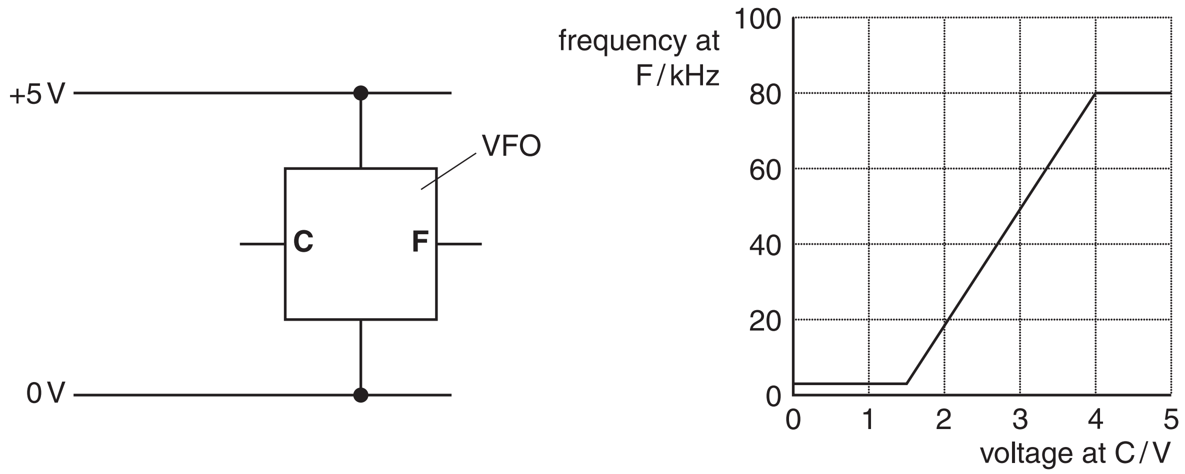

Fig. 5.1

(a) The VFO of Fig. 5.1 is part of a system which performs frequency modulation.

(i) Describe how frequency modulation carries information about an audio frequency signal.

....

....

.... **[2]**

(ii) Draw on Fig. 5.1 to show how a pair of resistors can be used to set the frequency at **F** to 50 kHz. Show component values and justify them.

[3]

(iii) Draw on Fig. 5.1 to show how a capacitor allows the audio frequency signal to modulate the square wave at **F**. **[1]**

(b) The system of Fig. 5.1 is tested with an audio frequency (a.f.) signal whose amplitude is 1 V, as shown in Fig. 5.2 below.

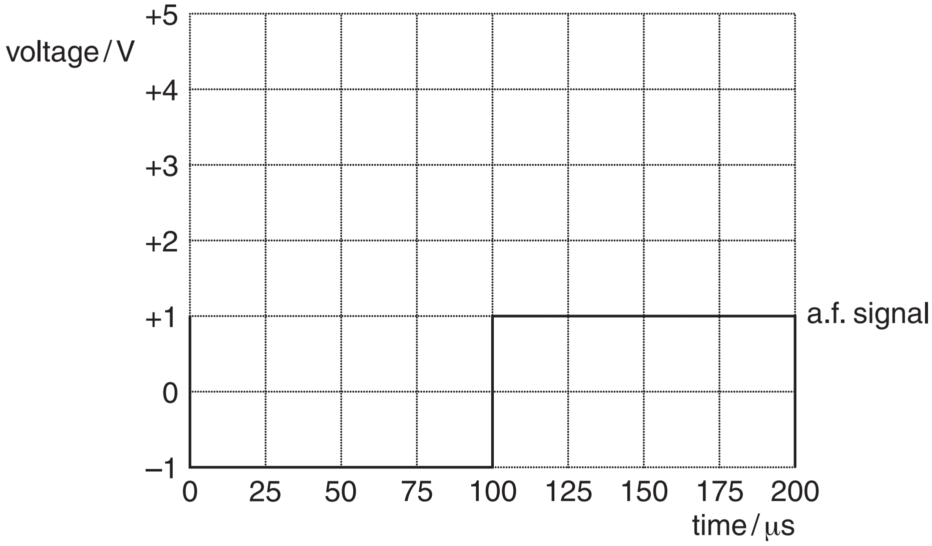

Fig. 5.2

(i) Explain why the period of the square wave at **F** is 50 μs when the voltage of the a.f. signal is –1 V.

[2]

(ii) Draw on Fig. 5.2 to show the square wave from **F** as it alternates between 5 V and 0 V during the 200 μs shown. **[3]**

[Total: 11]

6 Fig. 6.1 shows computers able to communicate with each other along a single cable.

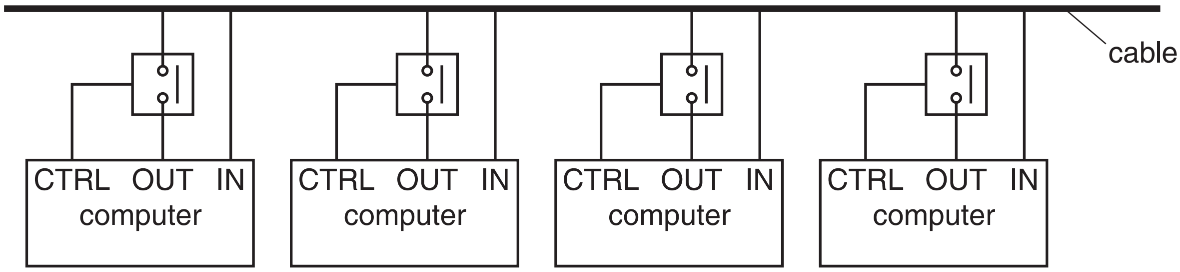

Fig. 6.1

(a) Each computer is connected to the cable by two wires.

The wire OUT carries data to the cable.

The wire IN carries data from the cable.

Only the OUT wire is connected to the cable by an analogue switch.

(i) Complete the truth table for an analogue switch. Choose words from the list.

disconnected **high** **low**

input	**control**	**output**
low	low	
low	high	
high	low	
high	high	

[2]

(ii) Explain why only the OUT wire needs an analogue switch.

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.... **[3]**

(iii) Although many computers can place data on the cable, only one can do so at any one time. Explain how this situation is achieved.

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.... **[3]**

(b) The computers exchange data with each other using serial digital signals.

Fig. 6.2 is a timing diagram for a typical serial digital signal.

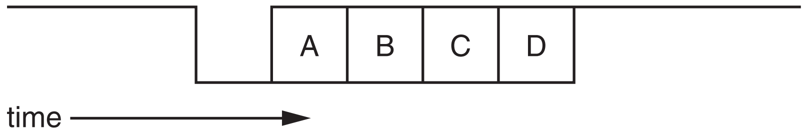

Fig. 6.2

(i) On Fig. 6.2, label the **start** bit and the **stop** bit. **[2]**

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

....

....

.... **[2]**

(c) The system of Fig. 6.1 has the following properties:

- each packet of data contains 512 bits
- the cable bandwidth is 4 MHz

(i) Explain why each bit of a packet must be on the cable for about 130 ns.

[2]

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

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

[Total: 16]

7 Fig. 7.1 is the circuit diagram for a triangle waveform generator.

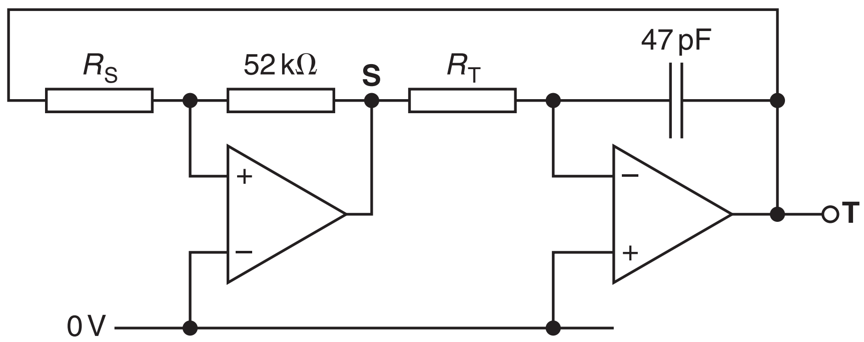

Fig. 7.1

(a) The amplitude of the waveform at **T** is 7.5 V.

Explain why this requires R_S to have a value of 30 kΩ.

[3]

(b) The frequency of the waveform at **T** is 100 kHz.

Explain why this requires R_T to have a value of 92 kΩ.

[3]

(c) Explain how the circuit of Fig. 7.1 produces a triangle waveform.

Start off with **S** at +13V.

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.... **[4]**

[Total: 10]

Quality of Written Communication [3]

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