THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE
ELECTRONICS
Communication Circuits

2529

Candidates answer on the Question Paper

OCR Supplied Materials:
None

Other Materials Required:
- Calculator

Tuesday 8 June 2010
Morning

Duration: 1 hour 30 minutes

OCE/13821

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- 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).

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 **120**.
- The quality of written communication will be assessed in your answers to all questions.
- You may assume, unless otherwise stated, that:
  (i) the p.d. across a forward-biased silicon diode is 0.70V,
  (ii) the power supplies for operational amplifiers are +15V and –15V,
  (iii) the saturation levels for operational amplifiers are +13V and –13V,
  (iv) logic 1 = 5V and logic 0 = 0V.
- This document consists of **20** pages. Any blank pages are indicated.

A calculator may be used for this paper

OCR is an exempt Charity

1 Fig. 1.1 shows an NPN transistor being used to drive an infra-red LED.

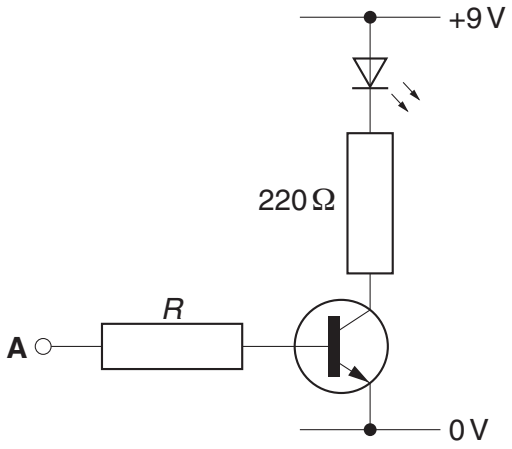

Fig. 1.1

(a) The infra-red LED is rated at 0.9 V, 50 mW.

When the transistor is saturated,

(i) show that the current in the LED is about 40 mA

[3]

(ii) calculate the power of the LED and comment on its value.

power = ... mW **[3]**

(b) The current gain of the transistor is between 75 and 150.

The transistor must saturate when **A** is above +2.5 V.

Calculate a suitable value for the base resistor *R*.

R = ... kΩ **[5]**

2 A computer monitor has the following characteristics:

- 8 levels of grey for each pixel
- 640 pixels in each line
- 350 lines in each field
- 42 fields per second

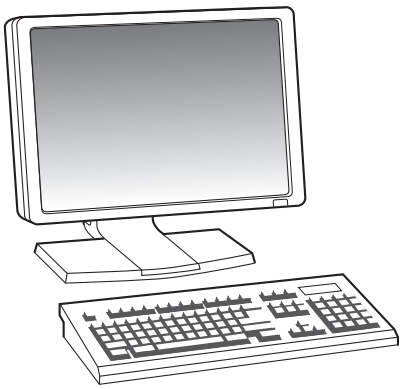

Fig. 2.1

(a) Show that the information for each pixel can be represented by a 3-bit word.

.....

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

(b) The word for each pixel is transmitted from the computer to the monitor in serial form. Five bits are required to transmit each word.

Explain the function of the extra bits.

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.....

.....

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

(c) **(i)** Calculate the bits required for the computer to produce one field.

bits per field = ... **[1]**

(ii) Show that the computer has to feed bits to the monitor at a rate of about 50 Mbits per second.

[1]

(d) By considering the sequence of bits 1010101010…, explain why a cable with a bandwidth of only 25 MHz can be used to connect the computer to the monitor.

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

3 Fig. 3.1 shows a frequency modulator for digital signals.

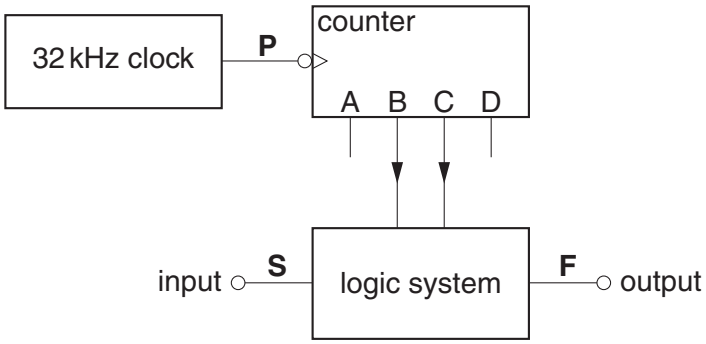

Fig. 3.1

(a) By completing the timing diagram of Fig. 3.2 below, explain why the signal at C has a frequency of 4 kHz.

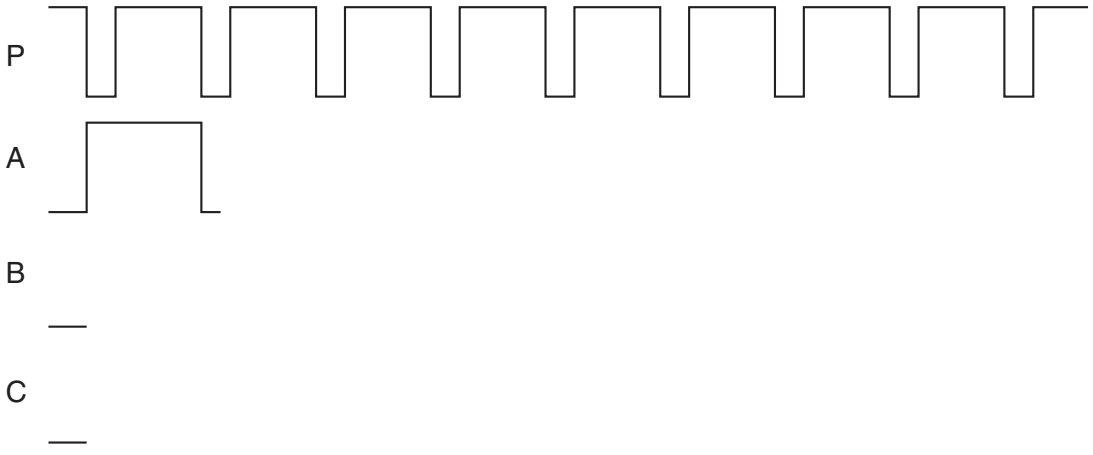

Fig. 3.2

Explanation .....

.....

..... **[5]**

(b) The logic system of Fig. 3.1 is to behave as shown in the table.

state of input S	frequency of output F
0	8 kHz
1	4 kHz

(i) Use 1 and 0 to complete the truth table for the logic system.

S	B	C	F
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

[2]

(ii) Design a circuit for the logic system using NOT, AND and OR gates.

Use Boolean algebra to justify your design.

[5]

4 Fig. 4.1 shows the block diagram of a demodulator of FM signals.

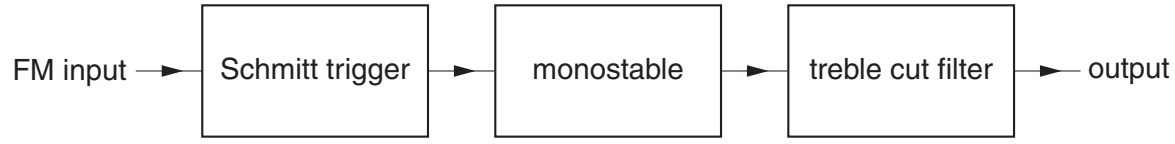

Fig. 4.1

(a) The FM signal is a sine wave at either 4 kHz or 8 kHz received from a distant transmitter. It is processed by a Schmitt trigger before being passed to the monostable.

By describing the transfer characteristics of a Schmitt trigger, explain its function in the system.

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

(b) The monostable is required to produce a pulse at its output every time a falling edge arrives at its input. The pulse is high for 100 μs before returning low.

Show how such a monostable can be assembled from resistors, capacitors and NAND gates. Give all component values and justify them.

[7]

(c) The treble cut filter has the following characteristics:

- a break frequency of 100 Hz
- a low frequency gain of 2.5

(i) Draw on the graph of Fig. 4.2 to show how the gain of the filter varies with frequency.

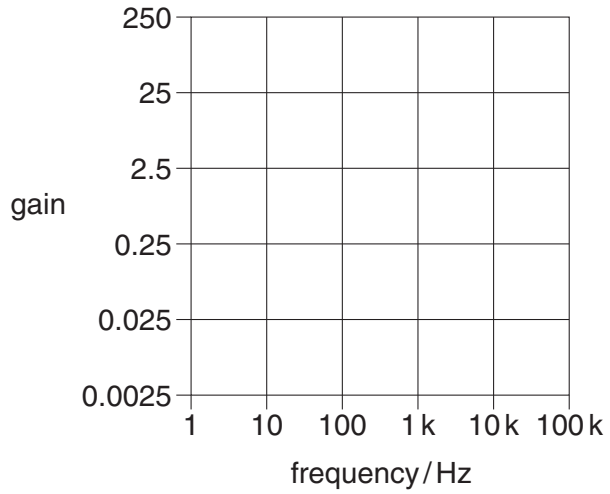

Fig. 4.2

[3]

(ii) Show how the filter can be constructed from resistors, capacitors and op-amps. Give all component values and justify them.

[6]

5 A student has designed the AM radio receiver circuit shown in Fig. 5.1.

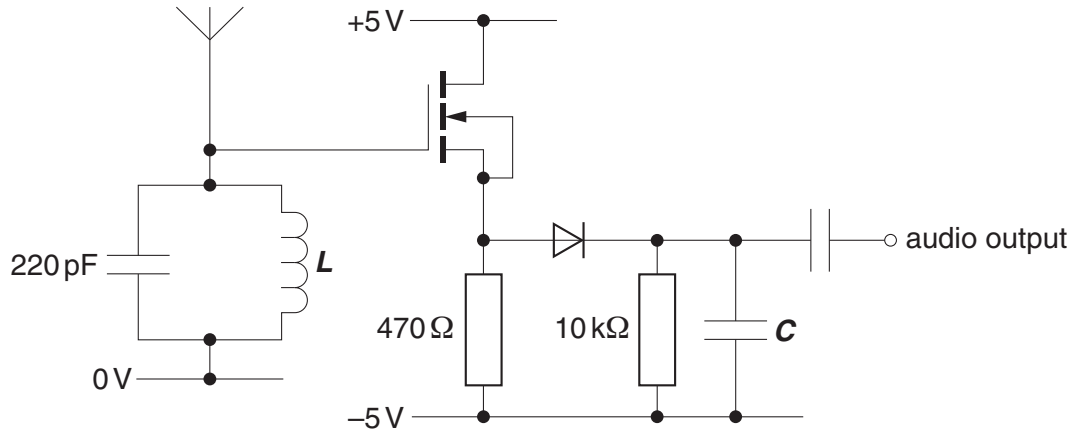

Fig. 5.1

(a) The circuit is required to receive Radio CA which broadcasts at 920 kHz.

Calculate a suitable value for the inductor ***L***.

L = ... H **[3]**

(b) The MOSFET follower improves the performance of the system.

(i) Label the gate, drain and source of the MOSFET on Fig. 5.1. **[1]**

(ii) Describe how the gate and source voltages are related in the MOSFET follower.

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

(iii) Explain how the MOSFET follower improves the performance of the system.

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

(c) Radio CA occasionally broadcasts a test signal.

The student connects an oscilloscope to the **tuned circuit** when this signal is being broadcast.

The test signal is a 5 kHz sine wave which modulates the 920 kHz carrier wave.

(i) Show that the period of the 5 kHz sine wave is 200 μs.

[2]

(ii) The oscilloscope timebase is set to 100 μs/div.

On Fig. 5.2, sketch what the student sees on the screen.

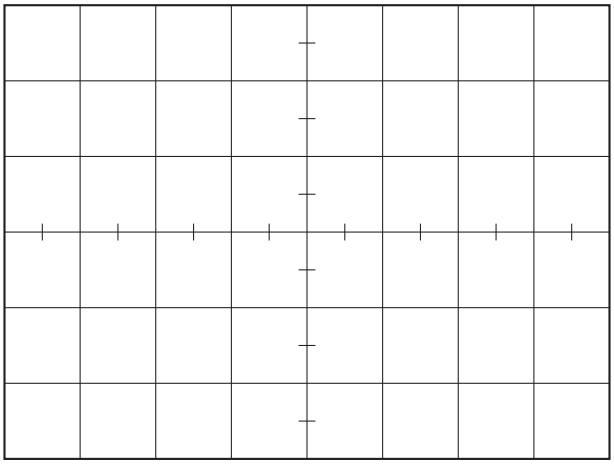

Fig. 5.2

[4]

(d) The right-hand part of the circuit demodulates the amplitude modulated signal.

(i) Explain how the diode, 10 kΩ resistor and capacitor ***C*** act as a demodulator.

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

(ii) Show that 2 nF is a suitable value for the capacitor ***C***.

[2]

6 Fig. 6.1 shows an a.c. amplifier circuit designed by a student.

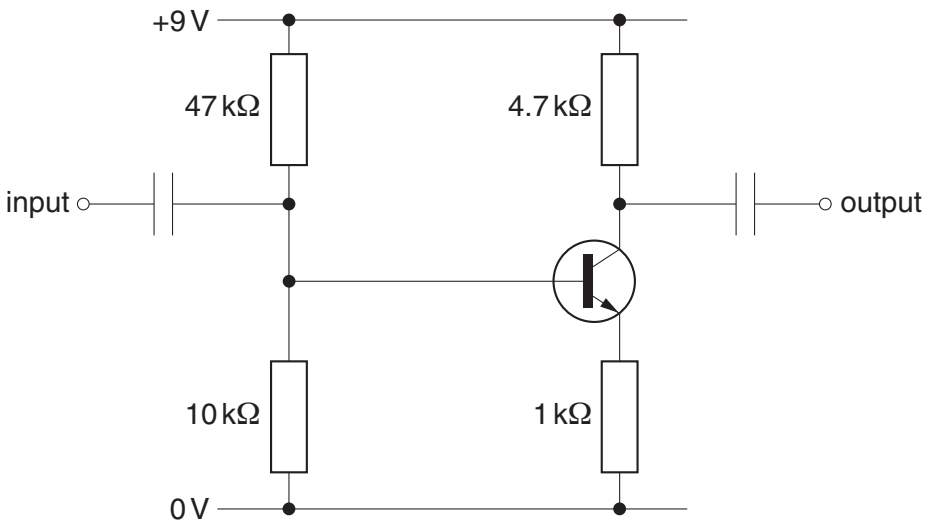

Fig. 6.1

(a) The emitter of the transistor is at 0.8 V when there is no signal at the input.

(i) Show that the emitter current is about 1 mA.

[2]

(ii) State the value of the collector current.

collector current = ... mA **[1]**

(iii) Calculate the voltage at the collector.

collector voltage = ... V **[3]**

(b) The student uses two resistors to hold the base of the transistor at a steady voltage when no signal is present at the input.

(i) Do a calculation to show that the junction of the 47 kΩ and 10 kΩ resistors should be at +1.6 V if the base current of the transistor is zero.

[3]

(ii) Draw on Fig. 6.1 to show how the student should connect a voltmeter to measure the voltage at the base. **[2]**

(iii) The student inserts the voltmeter correctly **without** the transistor in the circuit. The voltmeter reads 1.6 V, as expected.

The student then inserts the transistor correctly and notices that the voltmeter reading drops to 1.5 V. Explain why the reading drops.

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

(c) The student expects the gain of the circuit to be about –5.

(i) Do a calculation to show that the gain is about –5.

[2]

(ii) By considering the effect of a small rise in the voltage of the base, explain why the gain of the circuit is negative.

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

7 A communication system uses time division multiplexing to send two separate audio frequency signals (**A** and **B**) down a single optical fibre. The optical fibre carries digital signals. Fig. 7.1 is an incomplete block diagram for the system.

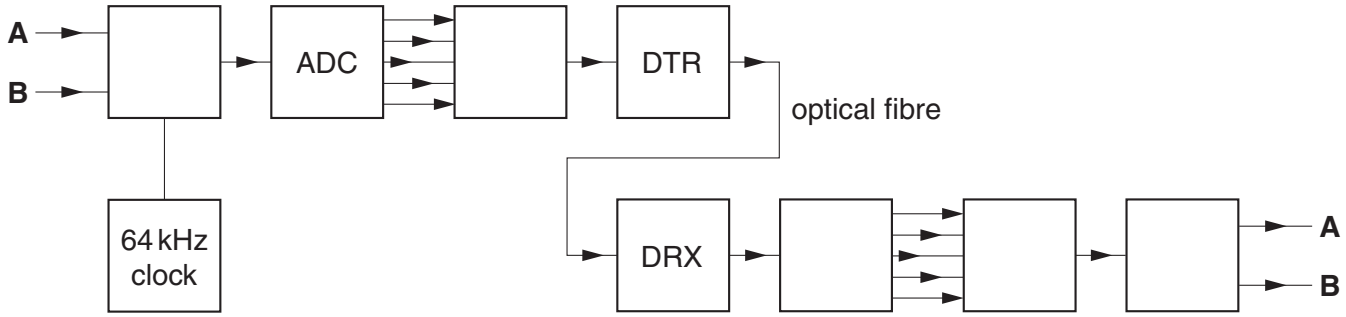

Fig. 7.1

(a) Complete the diagram by naming the empty blocks. Choose from:

name of block	abbreviation
multiplexer	MUX
demultiplexer	DMX
serial-to-parallel converter	SPC
parallel-to-serial converter	PSC
digital-to-analogue converter	DAC
analogue-to-digital converter	ADC

[4]

(b) The information in the analogue signal is transmitted along the optical fibre in digital form.

(i) Describe the difference between an analogue signal and a digital one.

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.....

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

(ii) Explain why information in digital signals is less likely to be lost in transmission than information in analogue signals.

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

(c) The serial-to-parallel converter contains a five-bit shift register.

(i) Complete Fig. 7.2 below to show how the shift register can be assembled from D-type flip-flops.

Label the serial input, parallel outputs and clock terminal.

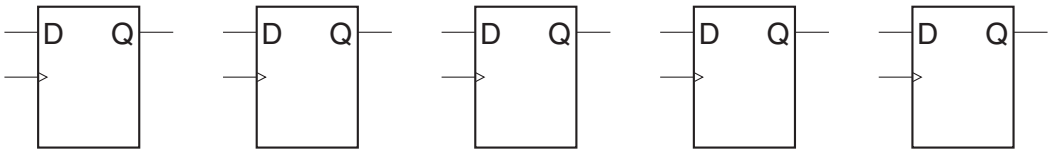

Fig. 7.2

[4]

(ii) Describe the behaviour of a single D-type flip-flop.

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.....

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

(iii) Explain how the shift register performs the operation of serial to parallel conversion.

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

8 The circuit of Fig. 8.1 contains a summing amplifier.

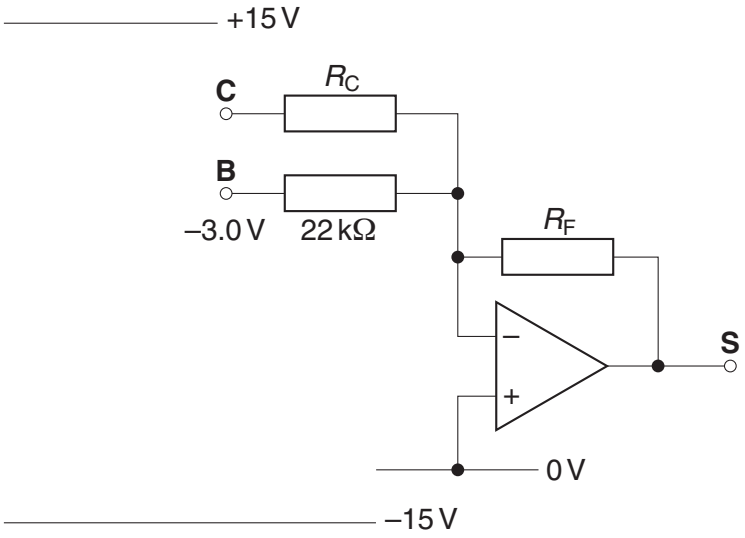

Fig. 8.1

(a) Draw on Fig. 8.1 to show how a potentiometer could be used to set **B** at –3.0 V. **[2]**

(b) The circuit forms part of the serial port of a computer. It converts logic signals at **C** into signals for transmission at **S**. This is shown in the table.

signal at C	signal at S
+5.0 V	–12 V
0.0 V	+12 V

(i) By supposing that **C** is at 0 V, show that R_F must be about 90 kΩ.

[3]

(ii) By supposing that **C** is at +5 V, calculate a suitable value for R_C.

R_C = ... kΩ **[3]**

Quality of Written Communication **[3]**

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