OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE UNIT **2529**

ELECTRONICS

Communication Circuits

TUESDAY 12 JUNE 2007 Afternoon

Time: 1 hour 30 minutes

Additional materials:
Electronic calculator.

Candidate Name

Centre Number | | | | | |

Candidate Number | | | | |

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **120.**
- 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.
- The quality of written communication will be assessed in your answers to all questions.

For Examiner's Use	
1	
2	
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8	
QoWC	
Total	

This document consists of **16** printed pages.

1 The circuit of Fig. 1.1 uses a MOSFET to amplify audio frequency signals.

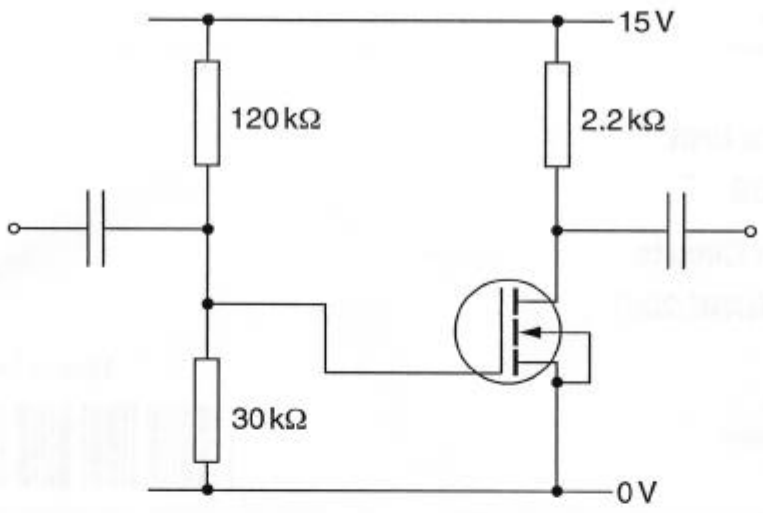

Fig. 1.1

(a) On Fig.1.1, label the input and output terminals of the amplifier. [2]

(b) **(i)** Show that the gate of the MOSFET is held at 3V by the voltage divider when there is no signal at the input.

[3]

(ii) Suggest an ideal value for the voltage at the drain. Justify your answer.

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.....[2]

(c) The graph of Fig. 1.2 shows how the drain-source current of the MOSFET depends on its gate-source voltage.

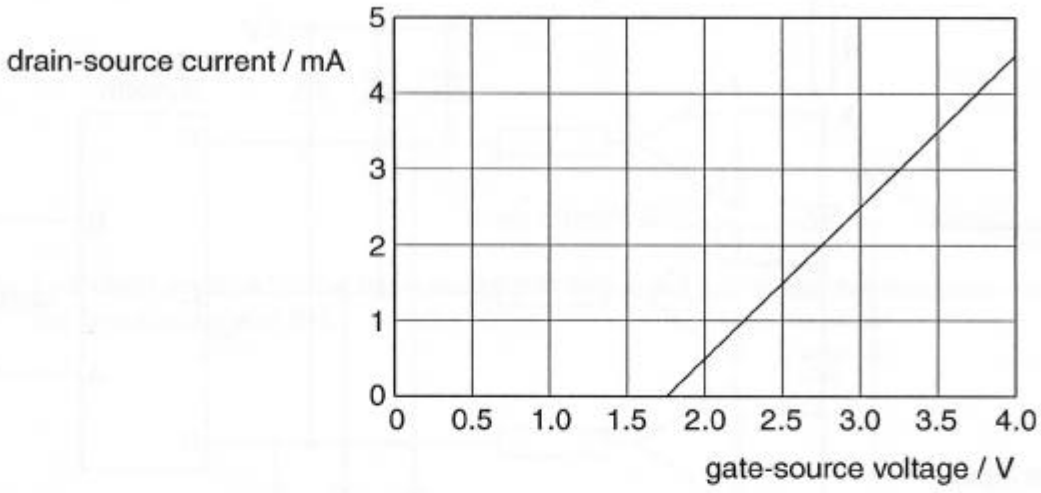

Fig. 1.2

(i) Use the graph to calculate the voltage at the drain when there is no signal at the input of the amplifier.

drain voltage = ... V [4]

(ii) Explain why the amplifier has a negative gain.

.....

.....

.....[2]

(iii) By considering an input signal with an amplitude of 1 V, show that the amplifier has a voltage gain of about –4.

[3]

2 The circuit of Fig. 2.1 converts an analogue signal into an equivalent digital signal.

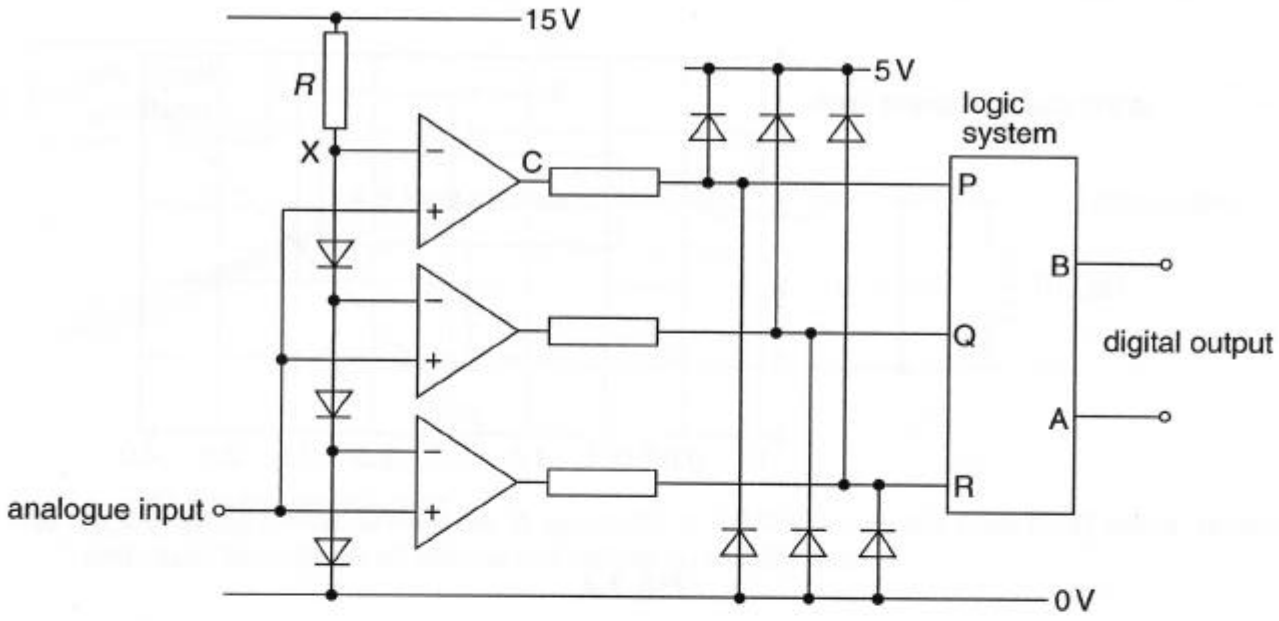

Fig. 2.1

(a) (i) Use the electrical properties of silicon diodes to explain why point X in the circuit is at 2.1 V.

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.....

.....[2]

(ii) Each diode to the left of the op-amps dissipates heat at a rate of 15 mW.
Show that the current in each diode is about 20 mA.

[3]

(iii) Calculate a suitable value for the resistor *R*.

resistance = ... Ω [4]

(b) Complete the sentences. Choose from

5.7V **5V** **4.3V** **0.7V** **0V** **–0.7V**

Each time the op-amp output C saturates positively, the input P of the logic system is clamped to ..... by the diode connected to the ..... supply.

When C saturates negatively, P is clamped to ..... by the diode connected to the ..... supply rail. [4]

(c) **(i)** Complete the table for the circuit of Fig. 2.1. Use only 0 and 1.

analogue input signal/V	P	Q	R	B	A
below 0.7				1	1
between 0.7 and 1.4				0	1
between 1.4 and 2.1				0	0
above 2.1				1	0

[4]

(ii) Write down Boolean expressions for B and A in terms of P, Q and R.

B =

A =

[4]

(iii) In the space below, draw a circuit diagram for the logic system, using only NOT, AND and OR gates.

[5]

3 A two-way radio contains a camera which can take pictures and transmit them to another two-way radio.

(a) The analogue data from each pixel of the camera is converted into a digital format before transmission.

(i) Explain **two** advantages of sending the information as a digital signal.

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.....[4]

(ii) Explain **two** advantages of sending the information in its original analogue format.

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.....[4]

(b) The screen of the two-way radio has 160 rows of pixels, with 240 pixels in each row. Each pixel requires three bytes to establish its colour and intensity.

(i) Explain why a single picture requires about 1 million bits of information.

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.....[3]

(ii) The bandwidth available for transmitting this information to another two-way radio is 64 kHz.
Show that it takes about 10 seconds to transmit 1 million bits of information from one radio to the other.

[3]

(iii) Suggest **three** ways of reducing the time needed to send a picture from one two-way radio to another.

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.....[3]

4 **(a)** Describe the difference between amplitude modulation and frequency modulation of a carrier.

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.....[3]

The circuit of Fig. 4.1 is a demodulator of f.m. signals.

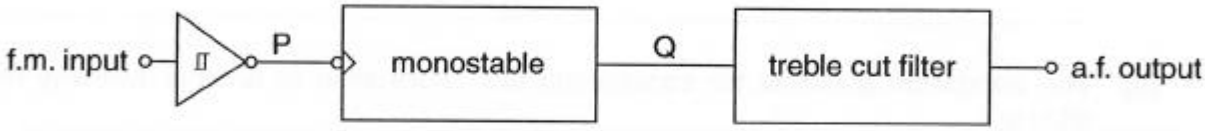

Fig. 4.1

(b) The Schmitt trigger NOT gate processes the f.m. input before it reaches the monostable. State how this processing changes the f.m. input.

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.....

.....[1]

(c) The monostable produces a 5V pulse of duration 2μs at Q each time a falling edge arrives at P. Draw in the space below to show how the monostable can be made from NAND gates, resistors and capacitors. Show all component values and justify them.

[6]

(d) Fig. 4.2 shows the gain-frequency graph for the treble cut filter.

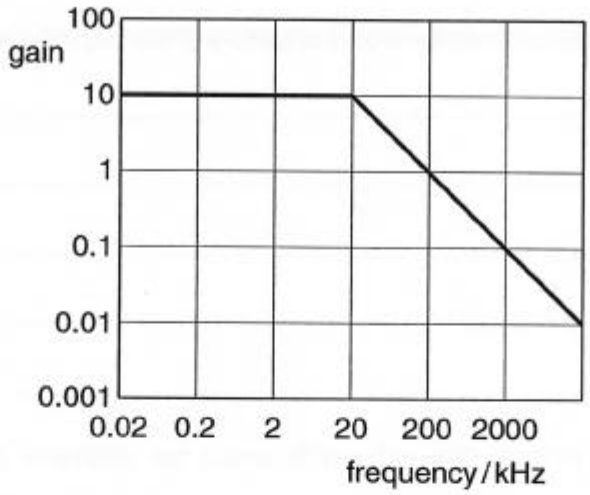


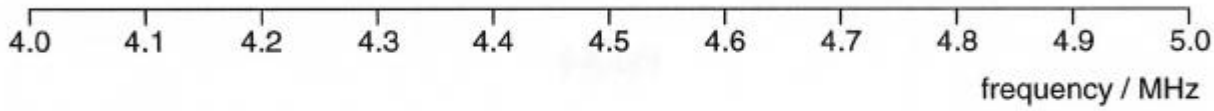
Fig. 4.2

In the space below, show how the treble cut filter can be constructed from an op-amp, resistors and capacitors. Show all component values and justify them.

[6]

5 A sine wave test signal with a frequency of 150 kHz is amplitude modulated onto a carrier of frequency 4.5 MHz.

(a) (i) On Fig. 5.1, sketch the amplitude-frequency graph of the modulated carrier.



[3]

Fig. 5.1

(ii) State the bandwidth of this modulated carrier.

bandwidth = ... kHz [1]

(b) In the space below, show how a resistor, capacitor and diode can be used to demodulate the modulated carrier. Show all component values and justify them.

[5]

6 The shift register of Fig. 6.1 converts pulses in serial form into a four-bit binary word.

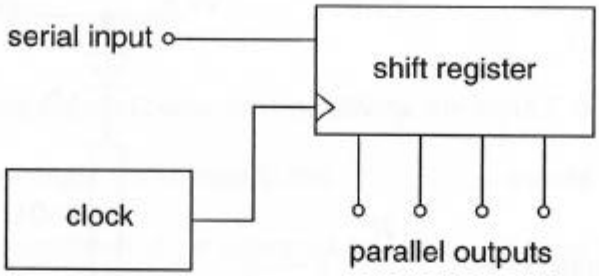
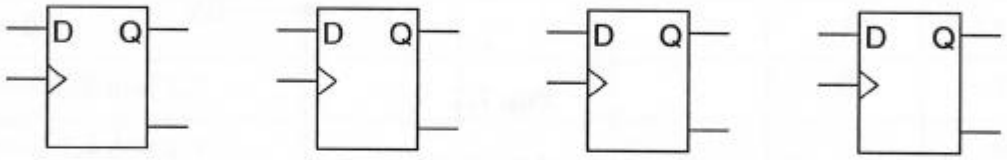


Fig. 6.1

(a) On Fig. 6.2, show how the shift register can be made from D-type flip-flops. Label the inputs and outputs.



[4]

Fig. 6.2

(b) Explain why the first and last bits of a word sent in serial form have to be different.

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.....

.....[2]

7 The circuit of Fig. 7.1 shows an NPN transistor used to switch an infrared LED on and off.

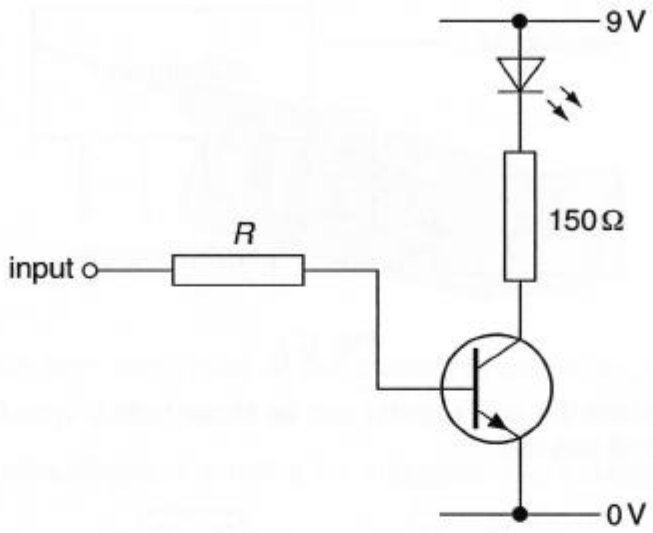


Fig. 7.1

(a) Label the base, emitter and collector of the transistor. [1]

(b) The voltage across the LED is 1.2 V when it is switched on.
Show that the current in the LED is about 50 mA when the transistor is saturated.

[3]

(c) The current gain of the transistor is 180.

(i) Calculate the minimum base current required to saturate the transistor.

base current = ... mA [2]

(ii) Calculate a value for the base resistor *R* which will just make the transistor saturate when the input voltage is 5V.

R= ..... kΩ [3]

8 The circuit of Fig. 8.1 allows an audio frequency (a.f.) test signal to be amplitude modulated onto a carrier frequency of 4.3 MHz. The signal at Y oscillates between 0 V and the voltage at X.

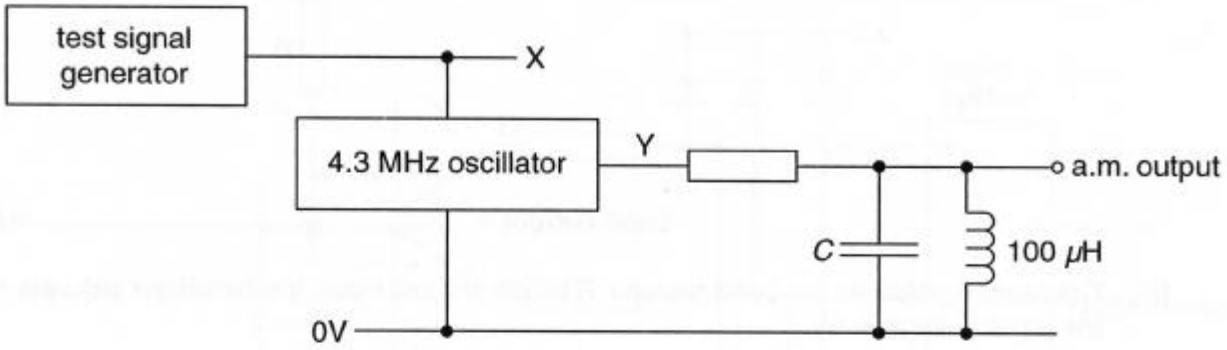


Fig.8.1

(a) In the space below, show how to assemble a 4.3 MHz oscillator from NOR gates, resistors and capacitors. Show all component values and justify them.

[5]

(b) The *LC* network acts as a bandpass filter for the 4.3 MHz signal from the oscillator. Calculate a suitable value for the capacitor *C*.

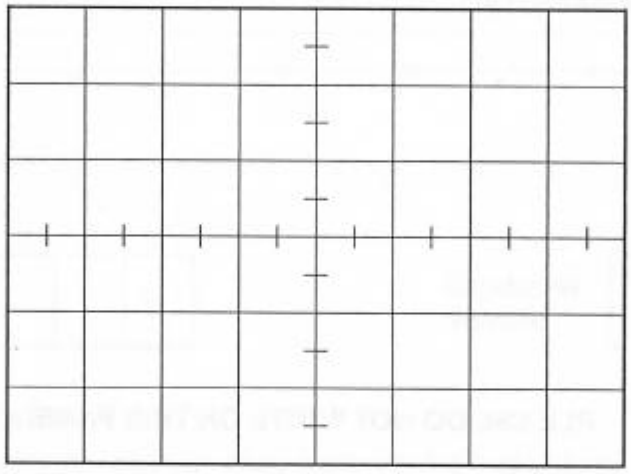
C= ..... F [3]

(c) The a.f. test signal is a sine wave of amplitude 1 V added to a constant 4 V d.c. bias, so that it goes between 3 V and 5 V with a frequency of 3.2 kHz.

(i) Show that the period of the a.f. test signal is about 300 μs.

[3]

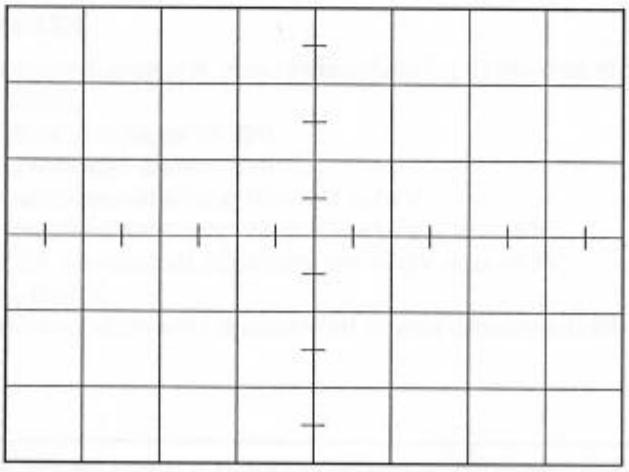
(ii) An oscilloscope is used to measure the voltage at X.
The timebase is set at 50 μs/division and the vertical amplifier at 2 V/division, with 0 V at the centre of the screen.
On Fig. 8.2, sketch the trace seen on the screen.



[4]

Fig. 8.2

(iii) The oscilloscope is now used to measure the voltage at the a.m. output, without any change to its settings or the a.f. test signal. On Fig. 8.3, sketch the trace seen on the screen.



[3]

Fig. 8.3

Quality of Written Communication [3]