THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

ELECTRONICS

Communication Circuits

2529

CUP/T58089

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Calculator

Tuesday 9 June 2009
Afternoon

Duration: 1 hour 30 minutes

2529

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.

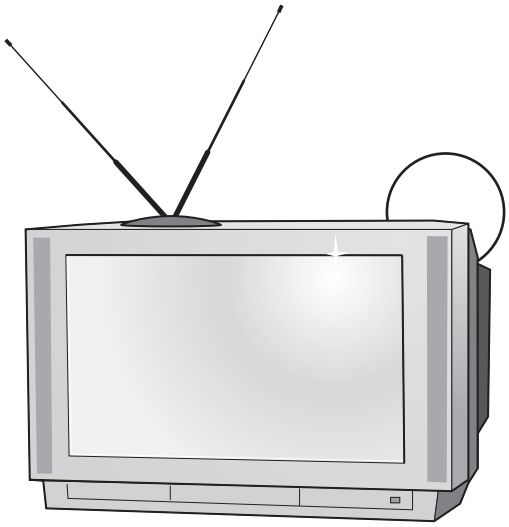
INFORMATION FOR CANDIDATES

- 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**.
- 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 **16** pages. Any blank pages are indicated.

A calculator may be used for this paper

Examiner's Use Only:			
1			
2			
3			
4			
5			
6			
7			
QWC			
Total			

1 A television receiver uses signals from an aerial to display a picture on a screen.



(a) Radio broadcasts use amplitude modulation or frequency modulation.

(i) Describe the difference between amplitude and frequency modulation.

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

(ii) Explain **one** advantage of broadcasting with frequency modulation.

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

(iii) Suggest why the video signal for television is broadcast using amplitude modulation.

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

(b) Use the terms below to explain how the video signal is used to display moving pictures on a television screen.

field **line** **pixel** **raster scan** **synchronisation signals**

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..... **[6]**

(c) Television receivers employ superhet systems to improve their selectivity.
Fig. 1.1 is the incomplete block diagram of a superhet receiver for the video signal.

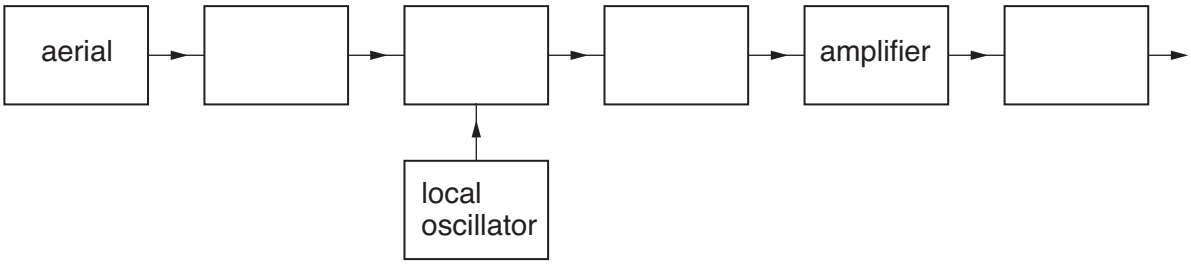

Fig. 1.1

Complete the block diagram by choosing words from this list to put in the boxes.

DAC **detector** **filter** **mixer** **register** **Schmitt trigger** **tuner**

[4]

2 Fig. 2.1 shows a complementary emitter-follower capable of driving ac signals into an 8Ω loudspeaker.

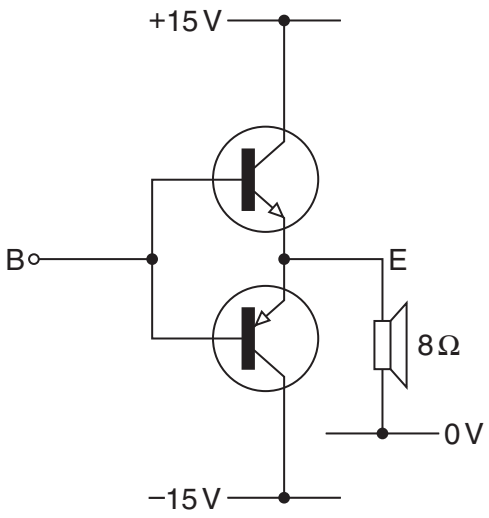

Fig. 2.1

(a) Explain how the circuit of Fig. 2.1 provides power gain for an ac signal.

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

(b) Fig. 2.2 is a voltage-time graph of a test signal applied at B.

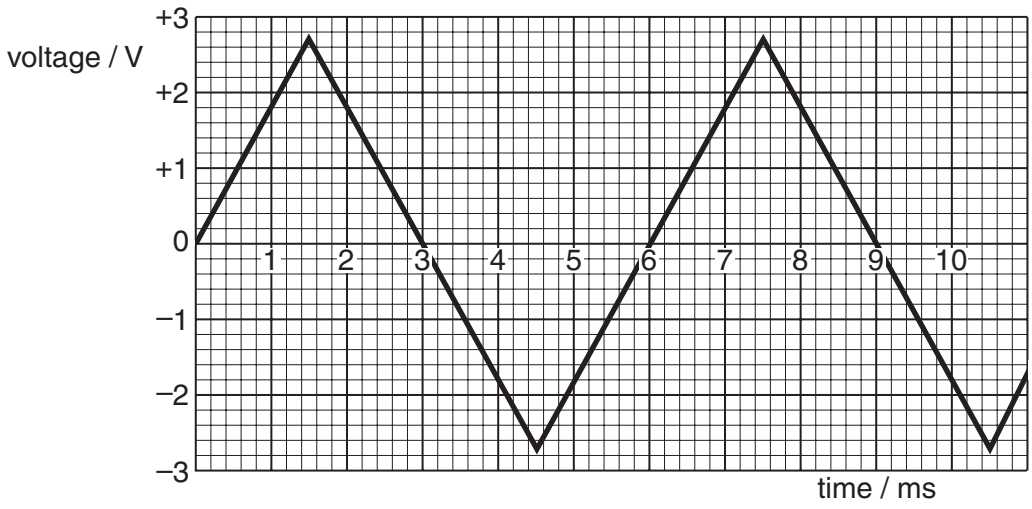

Fig. 2.2

Draw on Fig. 2.2 to show the corresponding signal at E. **[3]**

(c) Signals which pass through the complementary follower of Fig. 2.1 show crossover distortion.

(i) Explain the cause of crossover distortion.

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

(ii) Draw on Fig. 2.1 to show how an op-amp can be used to eliminate crossover distortion, to make a voltage follower. Include a resistor to give the circuit an input impedance of 47 kΩ.

[3]

(iii) Show that the peak power drawn from the source of the test signal by this voltage follower is about 150 μW.

[2]

(iv) Calculate the power gain of the voltage follower.

power gain = ... **[3]**

3 Fig. 3.1 is an incomplete circuit diagram for a three-bit digital-to-analogue converter made from op-amps and resistors.

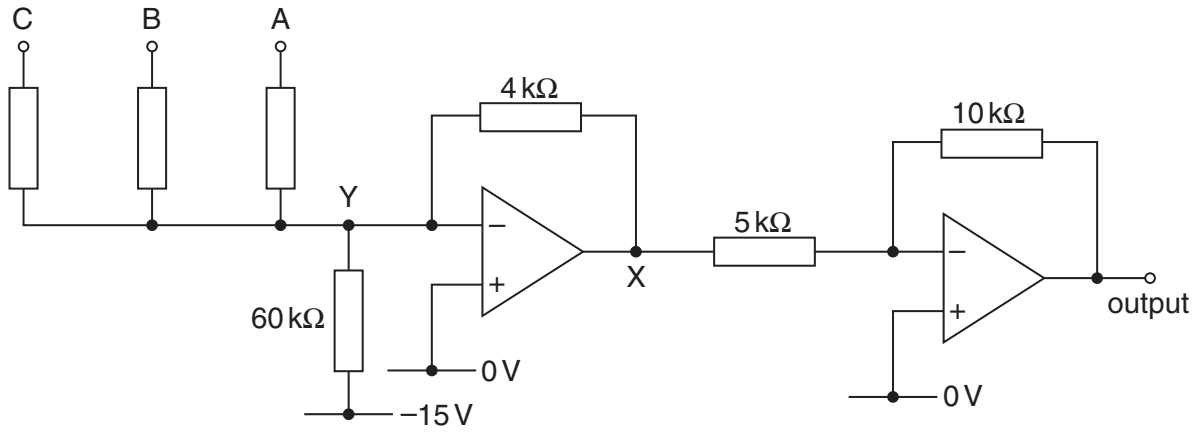

Fig. 3.1

(a) Draw on the axes of Fig. 3.2 to show how the voltage at the output of the circuit depends on the voltage at X.

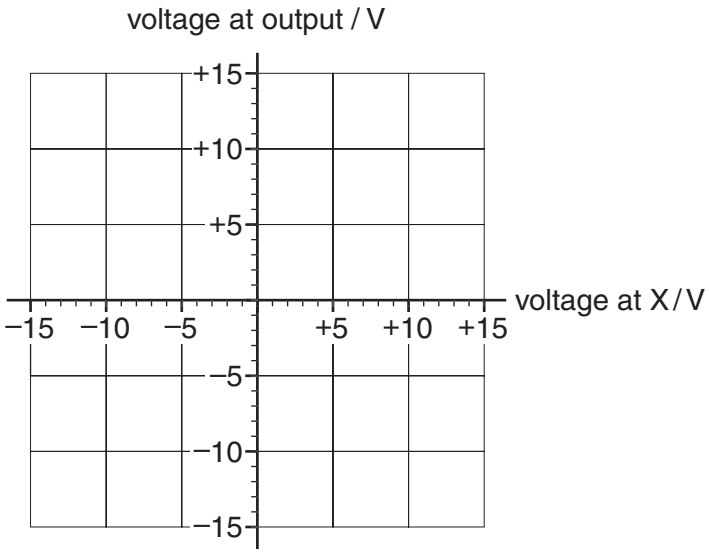

Fig. 3.2

[3]

(b) The input word CBA is set to 000.

(i) Draw an arrow on Fig. 3.1 to show the direction of the current in the 4 kΩ resistor. **[1]**

(ii) Show that the voltage at the output is −2 V.

[3]

(c) The DAC of Fig. 3.1 is used to recreate analogue signals from sequences of three-bit words stored in a memory. The DAC obeys the table below.

input word CBA	output voltage / V
111	+1.5
110	+1.0
101	+0.5
100	0.0
011	–0.5
010	–1.0
001	–1.5
000	–2.0

(i) What are the maximum and minimum amplitudes of non-zero symmetrical analogue signals which can be recreated by the DAC?

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

(ii) It takes 50 µs for the output voltage to settle to its new value after any change of the word CBA. Calculate the maximum frequency of analogue signal which can be recreated by the DAC.

frequency = ... kHz **[4]**

(iii) Using op-amps with faster response times raises the maximum frequency of analogue signal which the DAC can recreate. Explain **another** modification to the circuit which will improve its performance.

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

4 The circuit of Fig. 4.1 uses a MOSFET to allow amplitude modulation of the signal from a 70 kHz oscillator.

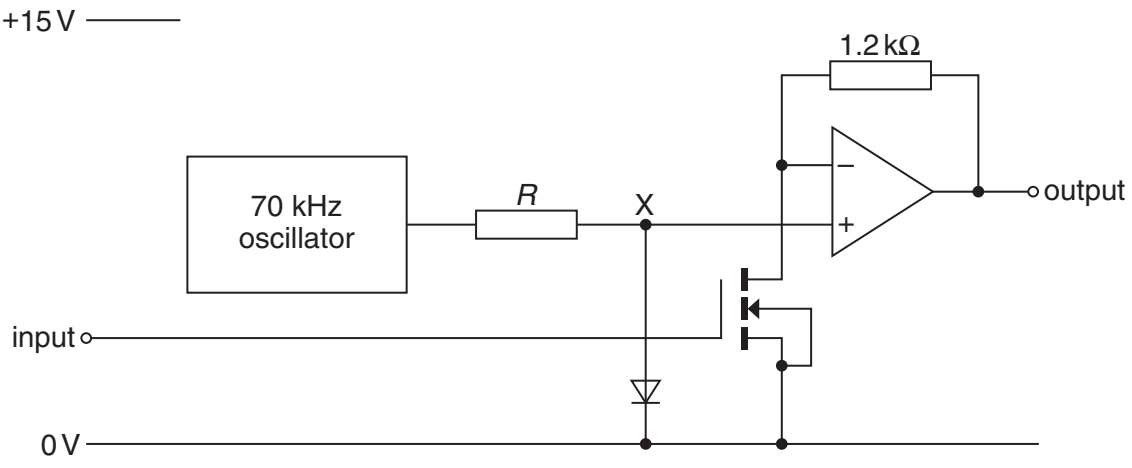

Fig. 4.1

(a) Show in the space below how a 70 kHz oscillator can be assembled from NOR gates, resistors and capacitors. Give all component values and justify them.

[5]

(b) The signal at the output of the oscillator in Fig. 4.1 passes through a resistor-diode network before entering the non-inverting input of the op-amp.
Describe and explain the signal at X.

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

(c) The signal at X is amplified by the non-inverting amplifier formed by the op-amp, 1.2 kΩ resistor and the MOSFET. The gate-source resistance of the MOSFET can be varied from infinity to 100 Ω by altering the voltage at the gate.

(i) Describe how the drain-source resistance depends on the gate-source voltage.

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

(ii) Calculate the maximum and minimum values for the gain of the amplifier.

maximum gain = ...

minimum gain = ...

[3]

(d) The modulating signal is a sine wave alternating between +250 mV and –250 mV with a frequency of 2 kHz. This has to be biased at +3 V with a capacitor and a pair of resistors before it enters the gate of the MOSFET.

(i) Draw on Fig. 4.1 to show the bias network of two resistors and a capacitor.

[3]

(ii) Calculate suitable values for the resistors in the bias network.

[3]

5 The circuit of Fig. 5.1 converts the analogue signal at its input into a four-bit binary word at its outputs.

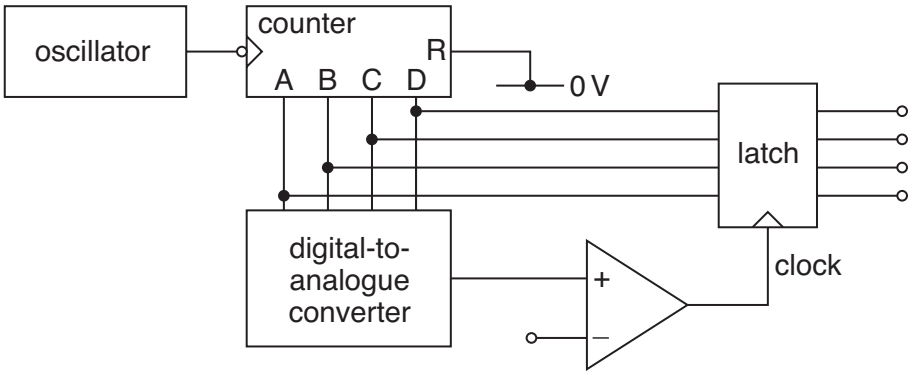

Fig. 5.1

(a) Label the **input** terminal on Fig. 5.1. **[1]**

(b) The circuit contains a four-bit latch. On Fig. 5.2, show how the latch can be constructed from four D-type flip-flops. Label the inputs, outputs and clock terminals.

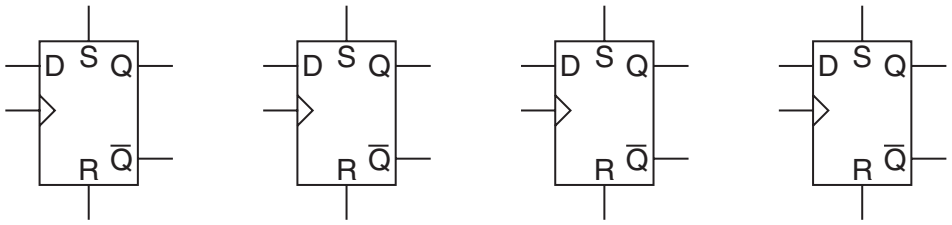

Fig. 5.2

[5]

(c) The circuit of Fig. 5.1 is required to clock the latch 20 000 times per second.

Suggest a suitable value for the frequency of the oscillator. Justify your choice.

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

(d) Complete the truth table for the binary counter.

pulse	A	B	C	D
0	0	1	0	1
1	1			
2				
3				
4				

[4]

(e) Explain how the circuit of Fig. 5.1 operates.

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..... **[6]**

6 The incomplete circuit of Fig. 6.1 is a receiver of four-bit serial words.

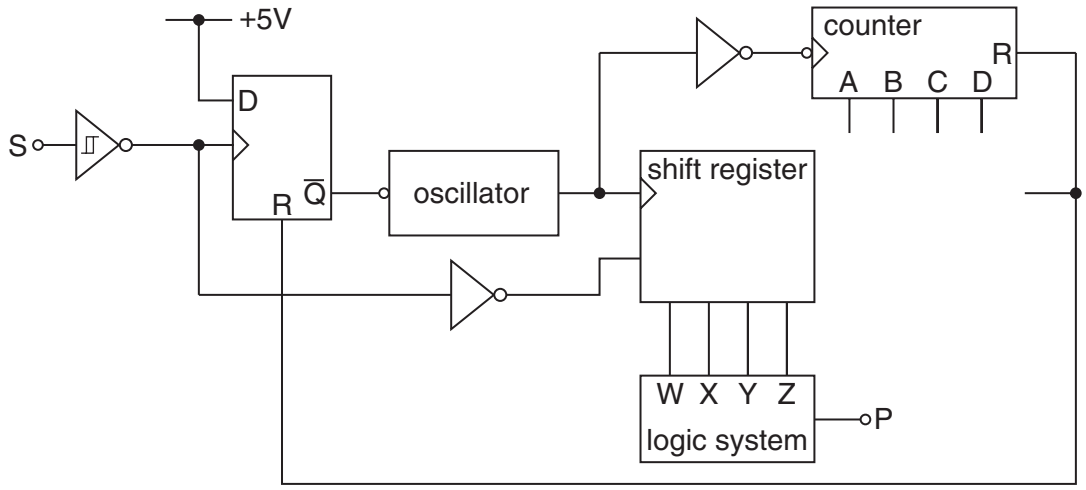

Fig. 6.1

(a) The words arrive at S in serial format, passing through an inverting Schmitt trigger.

(i) Explain the function of the Schmitt trigger.

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

(ii) In the space below, draw the circuit diagram for an inverting Schmitt trigger based on an op-amp and resistors. Select component values for trigger thresholds at +5V and –5V. Justify your choice of values.

[6]

(b) The counter of Fig. 6.1 is required to reset on every fifth pulse that it counts. Draw a logic gate on Fig. 6.1 to do this. The most significant bit of the counter is D.

[3]

(c) The output P of the logic system of Fig. 6.1 is required to only go high for the following three values of the word WXYZ:

0011

1011

0111

(i) Write down a Boolean expression for P in terms of W, X, Y and Z.

[3]

(ii) By applying De Morgans Theorem to $(\overline{X} + \overline{W}).(\overline{\overline{Y} + \overline{Z}})$, show that it is a correct expression for P.

[3]

(iii) In the space below, draw a logic circuit to generate $P = (\overline{X} + \overline{W}).(\overline{\overline{Y} + \overline{Z}})$.

[4]

7 Fig. 7.1 shows an aerial connected to a tuned circuit.

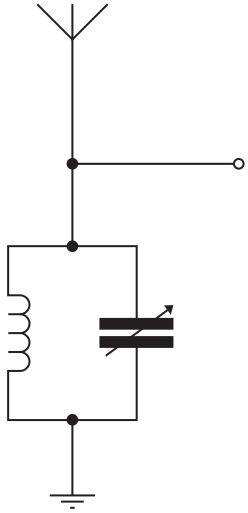

Fig. 7.1

(a) The aerial receives radio waves from many different broadcast channels. Explain how the tuned circuit is able to select a signal from just one of those channels.

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

(b) The inductor has a fixed value of 270 μH. Calculate the setting of the capacitor for the system to select a channel whose carrier frequency is set at 1.2 MHz.

capacitance = ... pF **[3]**

(c) The inductor is replaced with another with the same inductance but a larger resistance. Explain what effect this has on the performance of the tuned circuit.

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

Quality of Written Communication **[3]**

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