Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2012

Electronics ELEC5

Unit 5 Communications Systems

Thursday 31 May 2012 1.30 pm to 3.00 pm

For this paper you must have:
- a pencil and ruler
- a calculator
- a Data sheet (enclosed).

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

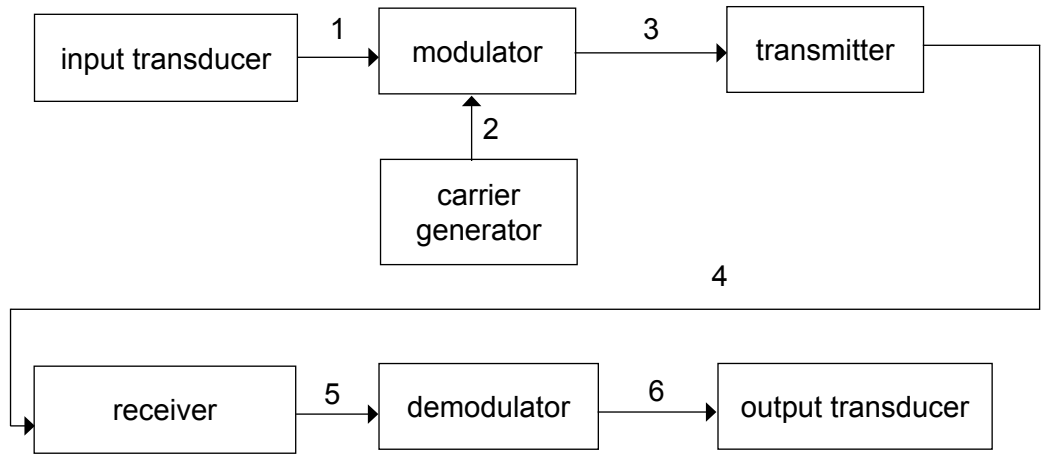
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Answer **all** questions in the spaces provided.

1 A block diagram of a generalised communication system is shown below. The signals between subsystems have been numbered.



1 (a) The type of signal at number 1 is an information signal and at number 3 it is a modulated carrier wave.
State the type of signal that could be at

1 (a) (i) 2 .....
(1 mark)

1 (a) (ii) 4 .....
(1 mark)

1 (a) (iii) 5 .....
(1 mark)

1 (a) (iv) 6 .....
(1 mark)

1 (b) Name a subsystem in the diagram above which could contain

1 (b) (i) a diode .....
(1 mark)

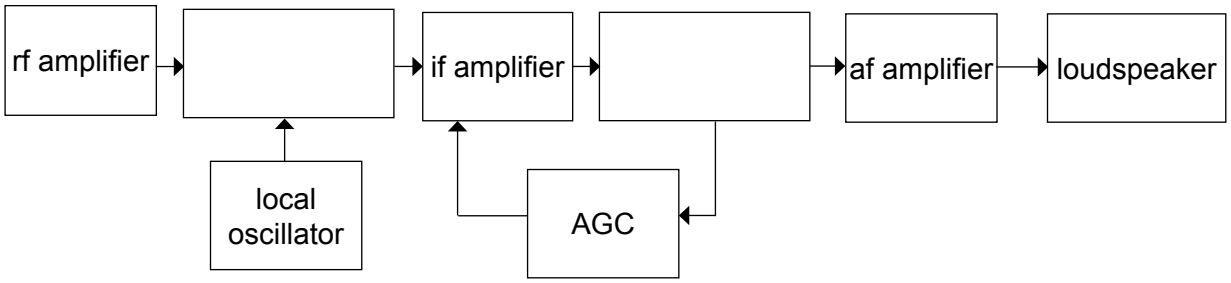
1 (b) (ii) an oscillator.....
(1 mark)

1 (b) (iii) a loudspeaker .....
(1 mark)

1 (b) (iv) a tuned circuit .....
(1 mark)

8

2 A system diagram of a superheterodyne radio receiver is shown below.



2 (a) Complete the diagram by adding the names of the unlabelled blocks. *(2 marks)*

2 (b) (i) What does AGC stand for?

.....

(1 mark)

2 (b) (ii) Explain the purpose and action of the AGC subsystem.

purpose .....

.....

action .....

.....

.....

(3 marks)

2 (c) The radio receiver receives a signal on a frequency of 1215 kHz.
The if amplifier is tuned to 455 kHz and the local oscillator frequency is higher than the signal frequency.
Calculate the local oscillator frequency.

.....

(1 mark)

2 (d) (i) A second station on a different frequency is heard at the same time as the wanted station. Explain why this is so.

.....

.....

.....

.....

(2 marks)

2 (d) (ii) Calculate the image, or second channel frequency.

.....

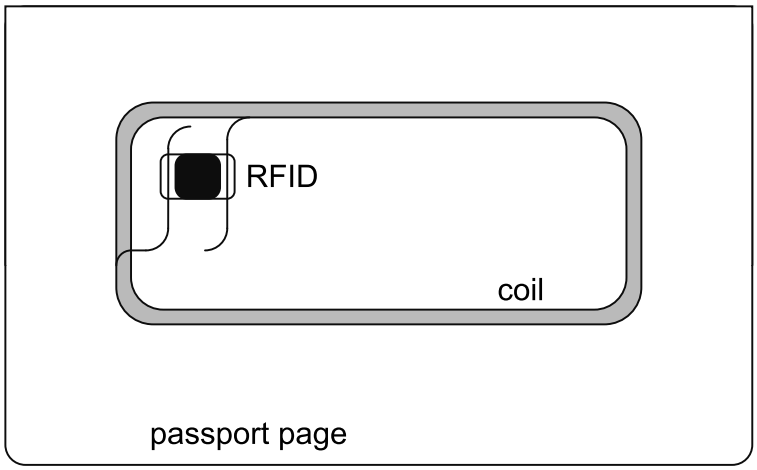
.....

(2 marks)

11

Turn over for the next question

3 Modern UK passports contain a Radio Frequency Identification Device (RFID) chip connected to a coil of wire.



3 (a) The RFID chip operates at a frequency of 13.56 MHz. The RFID chip has an effective capacitance of 20 pF in parallel with the coil.
Calculate the required inductance of the coil.

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(4 marks)

3 (b) Calculate the length of a half wave dipole aerial for this frequency. Explain why a coil of wire is used at the immigration control desk for reading the data on the RFID instead.

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.....

(3 marks)

3 (c) The quality factor, Q, of a tuned circuit is $\frac{f}{\Delta f}$

If the bandwidth, Δf, of the tuned circuit in a passport is 100 kHz, calculate the quality factor of the tuned circuit.

.....

(1 mark)

3 (d) Assume the bandwidth given in part (c) represents the highest bit rate that can be used to transfer data from the RFID. Estimate, using a calculation, the length of time it would take to read 1 KB of data.

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(2 marks)

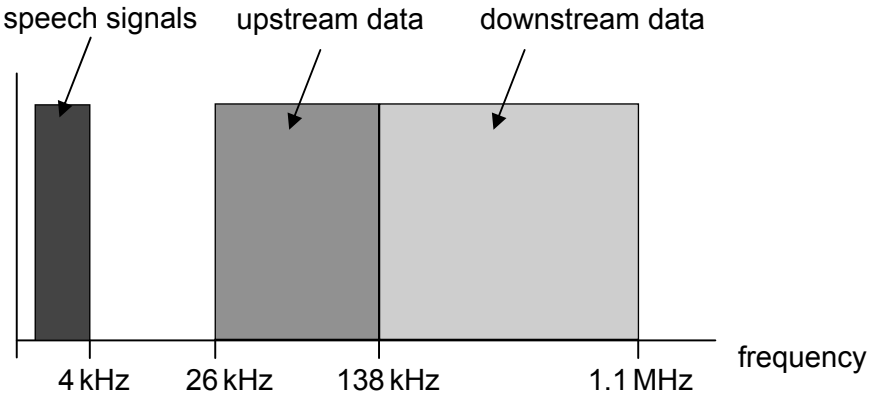
10

Turn over for the next question

4 Broadband Internet services can make use of the wired telephone network to transmit digital computer data. The system uses a technique called ADSL, where the frequencies used for the data are above the normal range for speech, which is about 300 Hz – 4 kHz.

Data received by your computer from the Internet (i.e. downloaded) are called downstream data, and data sent from your computer to the internet (i.e. uploaded) are called upstream data.

This is shown in the diagram below.



4 (a) Calculate the bandwidth allocated to the computer downstream data signals.

.....

(1 mark)

4 (b) The upstream and downstream data bands are each divided into many sections, called sub-channels, each of which is approximately 4.31 kHz wide. Calculate the maximum number of **downstream** sub-channels possible.

.....

(1 mark)

4 (c) Each one of the 4.31 kHz wide sub-channels is used for data and many sub-channels are used simultaneously for this purpose. This is why ADSL can achieve such high speeds.
Because of the complex way in which data is encoded into the sub-channels, each sub-channel can carry data at a maximum rate of about 56 kbps. Show that the maximum downstream data rate for ADSL is about 12 Mbps.

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.....

(2 marks)

4 (d) In practice a maximum rate of 8 Mbps is more commonly achieved. Assume that each byte of data has a stop bit, a start bit and a parity bit added to it before sending. Calculate how long it would take at this rate of 8 Mbps to download a movie, with a size of 3 GBytes.

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(3 marks)

4 (e) Explain why the maximum possible uploading speed is lower than the maximum possible downloading speed.

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(2 marks)

4 (f) State why it is reasonable, given common usage, that the uploading speed is less than the downloading speed.

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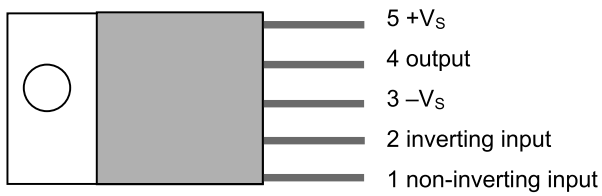
(1 mark)

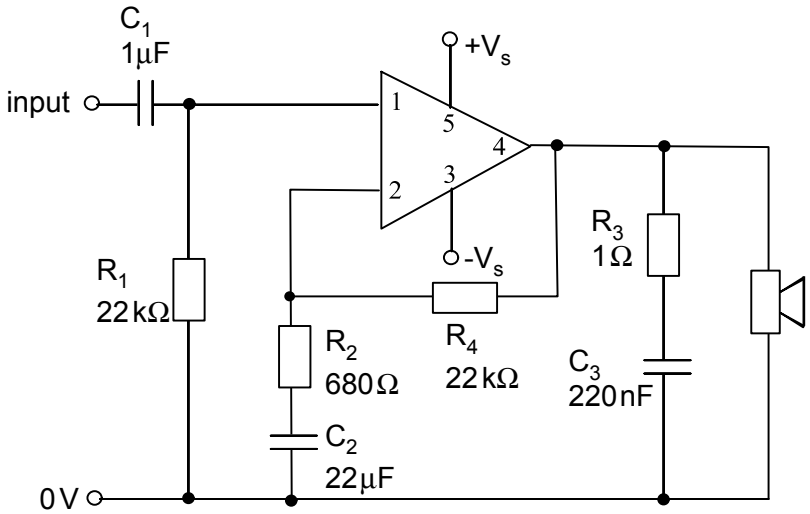
10

Turn over for the next question

5 The TDA2030 is an audio power IC amplifier which operates from a maximum supply voltage of ±18 V. The pin connections and a simplified application circuit have been found in the data sheet shown below.

TDA2030 DATA SHEET





5 (a) State whether the amplifier is connected in inverting or non-inverting configuration. Explain your answer.

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.....

.....

(2 marks)

5 (b) C_1 and R_1 form a filter for the input signal.

5 (b) (i) State the type of filter formed by C_1 and R_1.

.....

(1 mark)

5 (b) (ii) Calculate the breakpoint frequency of this filter.

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.....

.....

(3 marks)

5 (c) What is the effect of the inclusion of R_3 and C_3 in this circuit?

.....

(1 mark)

5 (d) State which of the components you could alter to change the overall gain of the system. Explain your answer.

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.....

.....

.....

(2 marks)

5 (e) State **two** factors which limit the output power that can be obtained from a circuit made using this IC.

.....

.....

(2 marks)

11

Turn over for the next question

6 (a) Describe how a person holding a conversation on a mobile phone is connected to the base station. Include in your answer the terms uplink, downlink, analogue and digital, and explain how the incoming and outgoing signals are separated.

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(5 marks)

6 (b) GSM mobile phones are allocated a frequency channel when in contact with a base station. Each frequency channel has the capacity for eight users.

6 (b) (i) Name the type of system that gives access to eight users on the same channel.

.....

(1 mark)

6 (b) (ii) A base station may use sixteen different frequency channels, one of which is used for administration. How many mobile phone users can be accommodated on this base station?

.....

(2 marks)

6 (b) (iii) Each base station frequency channel has a bandwidth of 200 kHz. Calculate the total bandwidth occupied by the base station in part (ii) above.

.....

(1 mark)

6 (b) (iv) How do adjacent base stations operate without causing interference to each other given that the total bandwidth allocated to all mobile communications on this band is 25 MHz?

.....

(1 mark)

6 (b) (v) Explain how the whole country is provided with mobile phone services with such a limited number of channels available.

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(2 marks)

6 (c) At popular sports, music and social events it is necessary for mobile phone service providers to install temporary base stations.

Explain why this is necessary.

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(2 marks)

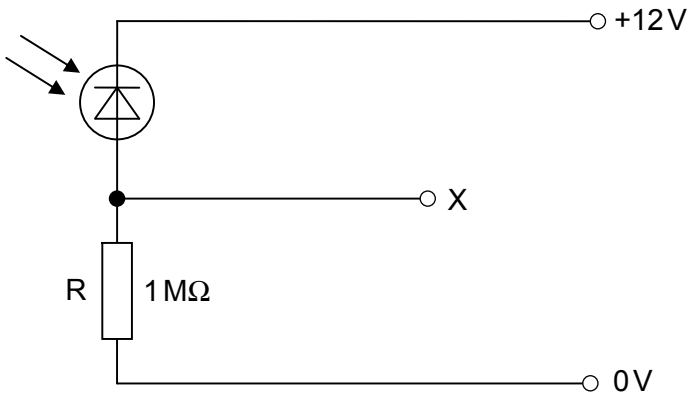
14

Turn over for the next question

7 Part of a data sheet for a PIN photodiode intended for an optical fibre communication system is shown below.

Reverse leakage dark current	max 5 nA
Sensitivity (reverse current caused by light)	0.6 A/W
Capacitance (at zero bias)	10 pF
Response time (to 95% amplitude)	5 ns

7 (a) The PIN photodiode is used in the following circuit which converts an optical signal travelling along a fibre into an electrical signal.



7 (a) (i) In what bias direction is the photodiode connected?

.....

(1 mark)

7 (a) (ii) Calculate the maximum voltage at X that exists when the photodiode is in the dark.

.....

.....

(2 marks)

7 (a) (iii) Sensitivity is the reverse current caused by the light power that hits the active area of the device.

Calculate the current through the photodiode and then the voltage at X when light of power 1μW hits the active area of the photodiode.

Current .....

.....

Voltage at X .....

.....

(3 marks)

7 (a) (iv) Calculate the time constant of the circuit assuming the photodiode acts as a simple capacitor.

.....

.....

(2 marks)

7 (a) (v) Suggest a reason why the response time of the photodiode given in the datasheet is much less than the value you have calculated in part (iv).

.....

.....

(1 mark)

7 (a) (vi) The output voltage at X is low even when an optical signal is present. Suggest **two** ways of increasing the output voltage.

.....

.....

(2 marks)

Question 7 continues on the next page

7 (b) The power of the optical signal received at the photodiode, after passing through the optical fibre, is found to be less than the transmitted power.

Describe and explain **two** possible causes of this.

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(5 marks)

16

END OF QUESTIONS