Surname	
Other Names	
Candidate Signature	

AQA

General Certificate of Education
Advanced Level Examination
June 2015

Electronics   ELEC5

Unit 5   Communications Systems

Tuesday 16 June 2015   9.00 am to 10.30 am

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

Time allowed
* 1 hour 30 minutes

A

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.

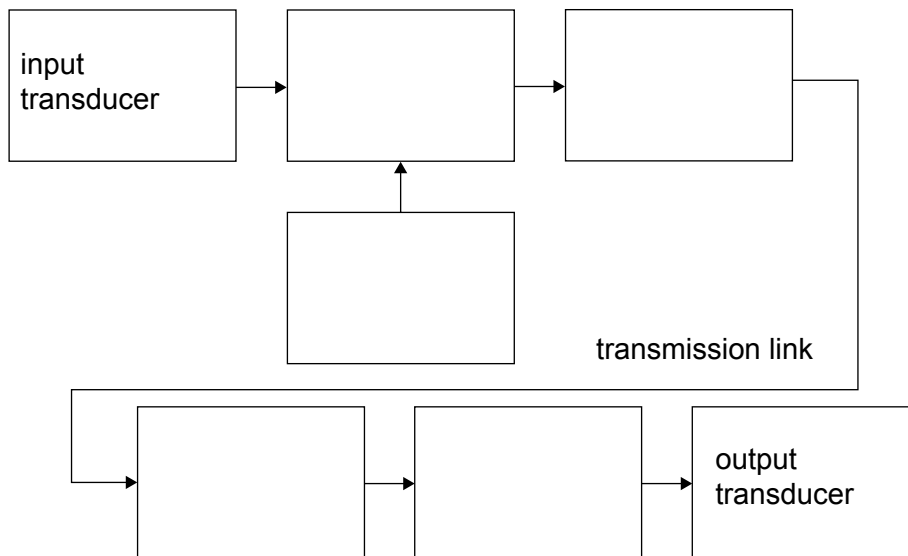Answer **all** questions in the spaces provided.

1 **Figure 1** shows a block diagram of a generalised communications system.

1 (a) Complete the labelling of the block diagram, using the following terms:

carrier wave generator   demodulator   modulator   receiver   transmitter
[2 marks]

Figure 1

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│ input        │ ───▶ │              │ ───▶ │              │──┐
│ transducer   │      │              │      │              │  │
└──────────────┘      └──────────────┘      └──────────────┘  │
                             ▲                                 │
                      ┌──────────────┐                         │
                      │              │       transmission link │
                      │              │                         │
                      └──────────────┘                         │
      ┌──────────────────────────────────────────────────────┘
      │  ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
      └─▶│              │ ───▶ │              │ ───▶ │ output       │
         │              │      │              │      │ transducer   │
         └──────────────┘      └──────────────┘      └──────────────┘
```

1 (b) Name **three** different media suitable for the transmission link.
[3 marks]

1 ....

2 ....

3 ....

1 (c) (i) State the function of the modulator.
[1 mark]

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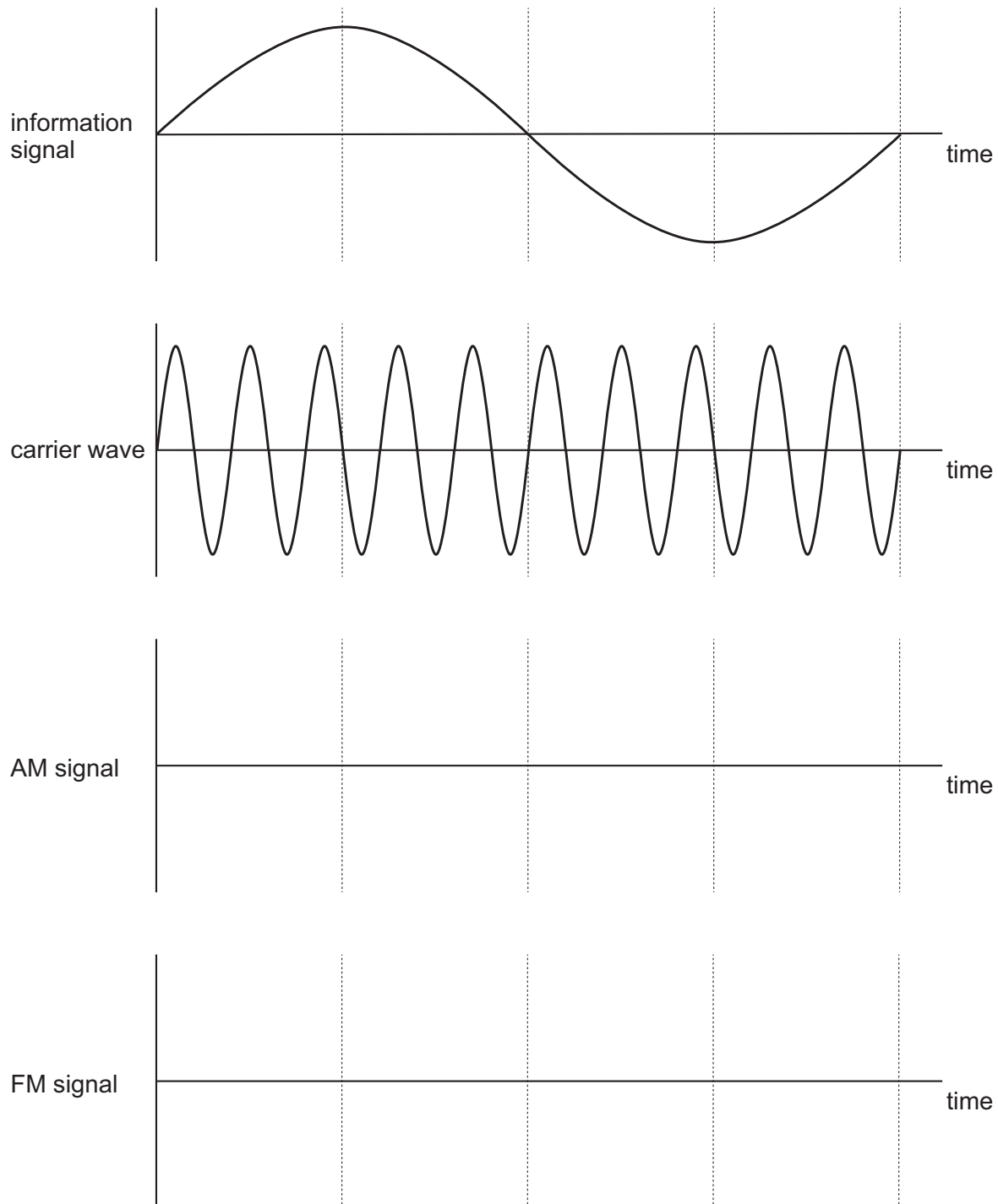
1 (c) (ii) AM and FM are two types of modulation.
An information signal and a carrier wave are shown on the upper axes of **Figure 2**.

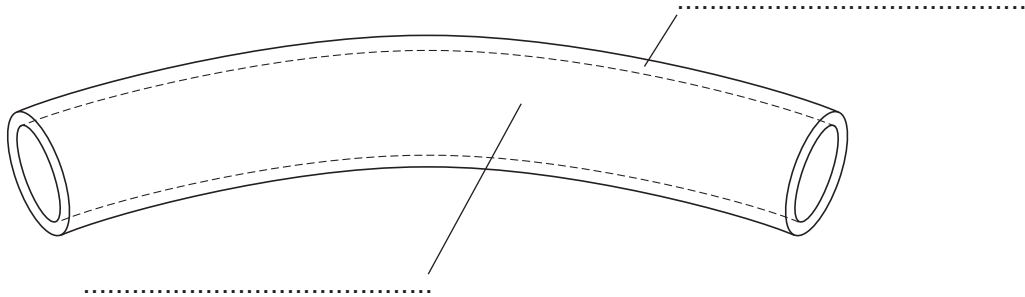Draw on the lower axes the AM signal and the FM signal that these would produce.

[4 marks]

Figure 2

information
signal ——— time

carrier wave ——— time

AM signal ——— time

FM signal ——— time

Turn over ▶

10

2 **Figure 3** shows the basic structure of an optical fibre with an external diameter of approximately 0.25 mm.

Figure 3

....

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2 (a) (i) Label the two parts of the optical fibre on **Figure 3**.

[2 marks]

2 (a) (ii) State the important difference in the properties of the materials used for the two parts of the optical fibre.

Explain why this difference is important.

[3 marks]

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2 (b) Multi-path dispersion is an effect which limits the rate that data can be transmitted through a long optical fibre.

2 (b) (i) Explain what is meant by **multi-path dispersion** and how it limits the rate of data transfer.

Draw a diagram to illustrate your answer.

[4 marks]

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2 (b) (ii) One way of eliminating multi-path dispersion is to use a mono-mode fibre, which typically has a core diameter of $5 \ \mu m$.

Suggest how this could eliminate this type of dispersion.

[1 mark]

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Turn over ▶

3 The audio signals on an audio CD are digitally encoded. Part of the audio CD specification describes the encoding as:

'PCM with 16-bit values sampled at 44.1 kHz'.

3 (a) Explain why 44.1 kHz is a suitable sampling frequency for high quality audio recording.

[3 marks]

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....

3 (b) Calculate the number of different voltage levels which can be detected in each sample.

[1 mark]

....

3 (c) The **quantisation error** is the voltage step difference between each level.
The peak-to-peak signal voltage is 5 V.

Calculate the quantisation error for an audio CD.

[2 marks]

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....

3 (d) A call centre uses an audio CD to play music to callers while they are waiting for their calls to be answered. The telephone system operates in the frequency range 300 Hz to 3 kHz.

Describe **two** different effects this will have on the quality of the music the callers hear.

[2 marks]

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8

Turn over for the next question

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Turn over ▶

4 A house has an outside rainwater storage tank. The tank is fitted with a 4-bit digital level sensor so that the water level can be monitored from inside the house.

4 (a) Calculate the number of different water levels that can be detected.

[1 mark]

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4 (b) The water level information could be transmitted to a display inside the house using either a serial or a parallel communication link.

Describe what is meant by:

[2 marks]

serial transmission ....

....

parallel transmission. ....

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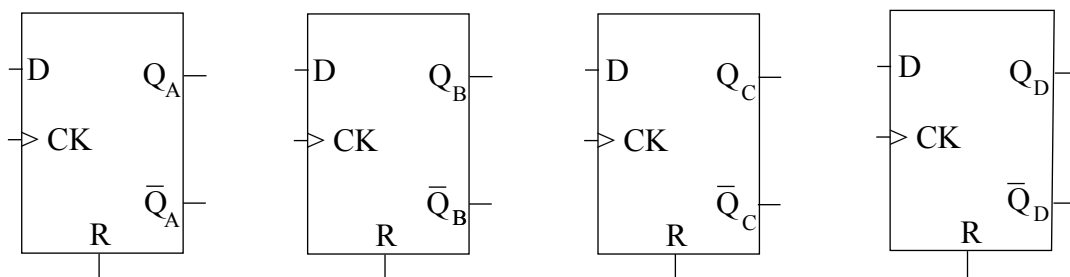
4 (c) (i) A serial-to-parallel converter can be made using D-type flip-flops.

Complete **Figure 4** to show how four D-type flip-flops can be connected to form a serial-to-parallel shift register.

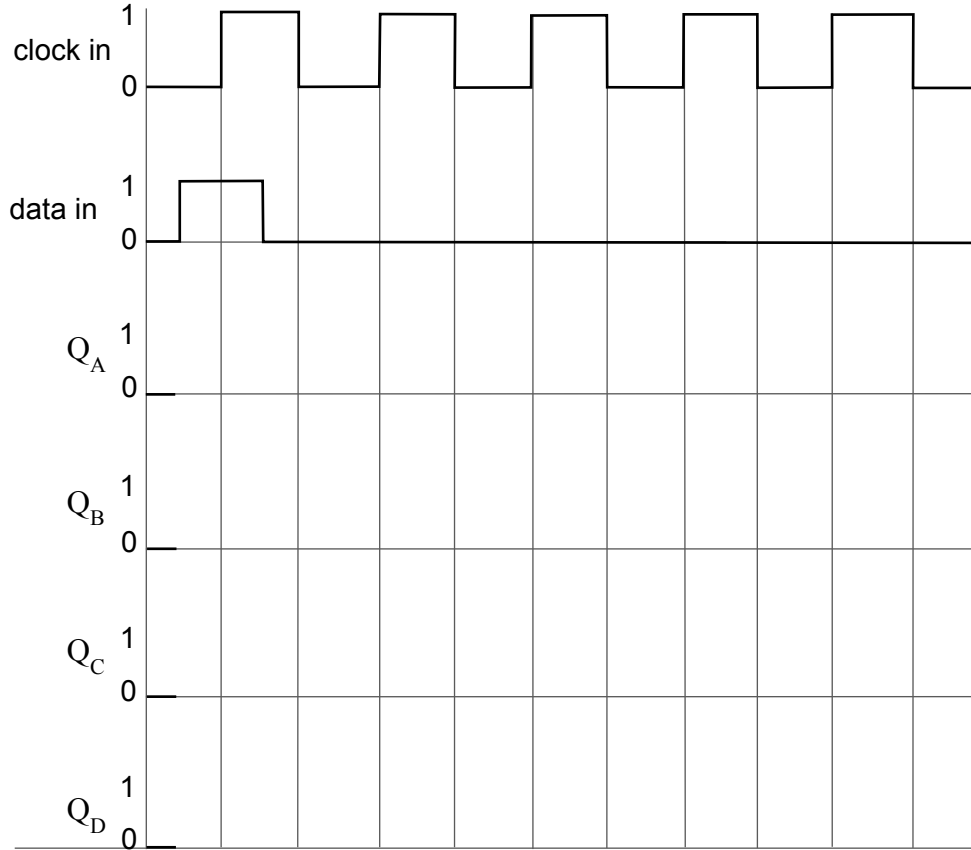Label the serial data input, clock input and parallel outputs.

[6 marks]

Figure 4

4 (c) (ii) Complete the timing diagram in **Figure 5** to show the action of a 4-bit shift register.

[4 marks]

Figure 5

Turn over for the next question

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5   The first mobile phone systems were analogue. Modern mobile phone systems use digital communication.

5 (a)   Explain how an analogue speech signal can be converted to a digital signal using an analogue-to-digital converter.

[3 marks]

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5 (b)   Name **two** different types of digital modulation.

[2 marks]

1 ....

2 ....

5 (c)   Mobile phone networks use packet switching for communication between base stations.

5 (c) (i)   State what is meant by a packet.

[1 mark]

....

5 (c) (ii)   Name **two** items that would be in a packet.

[2 marks]

1 ....

2 ....

5 (c) (iii)   State **two** reasons why **packet switching** is used.

[2 marks]

1..

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2..

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5 (d) A passenger on a train is making a call on a mobile phone.

Explain how the caller is connected to the network, is able to carry on a two-way conversation and remains connected, even though the train travels a considerable distance during the call.

Credit will be given for the correct use of relevant technical terms.

The terms you use in your answer should include:
- control channel
- uplink
- downlink
- base station
- cellular.

[5 marks]

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Turn over ▶

6 In order to reduce the bandwidth needed for transmission of an audio speech signal, the signal is filtered to remove high frequencies.

6 (a) Explain what is meant by the **bandwidth** of a signal.

[2 marks]

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6 (b) Name the type of filter needed to remove high frequencies.

[1 mark]

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6 (c) (i) Draw the circuit diagram of a passive filter to remove high frequencies, using a resistor and a capacitor.
Label the input and the output.

[2 marks]

6 (c) (ii) The resistor in the filter has a value of $1 \text{ k}\Omega$.

Calculate the capacitor value required to give a breakpoint frequency of 4.0 kHz.

[3 marks]

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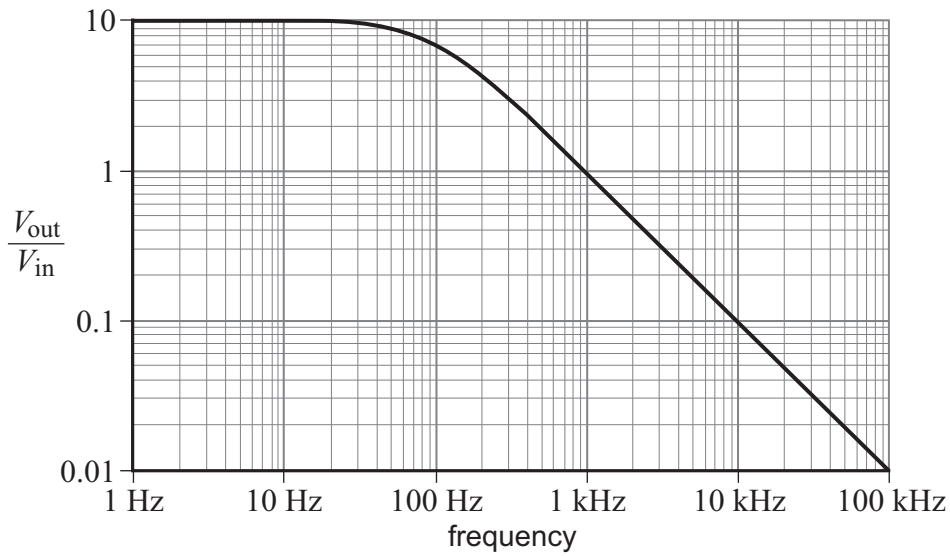
6 (d) **Figure 6** shows the response of a different filter to remove high frequencies.

Figure 6

6 (d) (i) State how the graph shows that this must be an **active** filter.

[1 mark]

....

6 (d) (ii) Circle the value closest to the breakpoint frequency of this filter.

[1 mark]

30 Hz   100 Hz   200 Hz   1 kHz

6 (d) (iii) A 2 V, 5 kHz signal is applied to the input of this filter.

Calculate the output signal voltage.

[2 marks]

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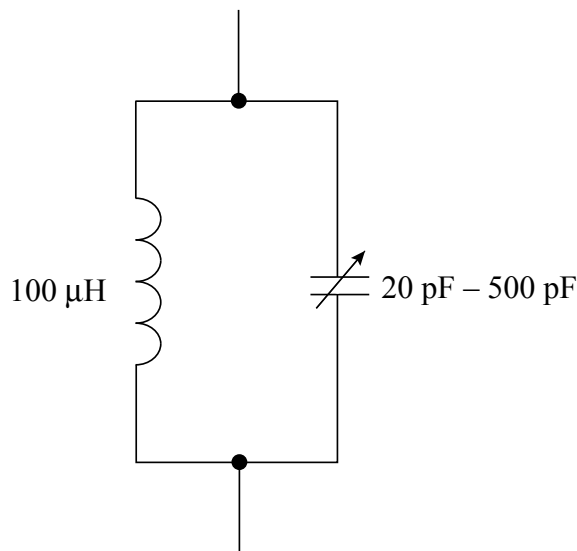
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Turn over ▶

7 (a) Draw a labelled block diagram to show how the subsystems below would be connected to form a simple radio receiver.

aerial   af amplifier   detector   loudspeaker   tuned circuit

[3 marks]

7 (b) **Figure 7** shows the tuned circuit for a simple radio receiver.

Figure 7

$100\ \mu H$ $20\ pF - 500\ pF$

BBC Radio 5 Live is broadcast using a carrier frequency of $909\ kHz$.

Calculate the value of the variable capacitor when the circuit is tuned to receive this radio station.

[3 marks]

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7 (c) The simple radio receiver suffers from poor selectivity.
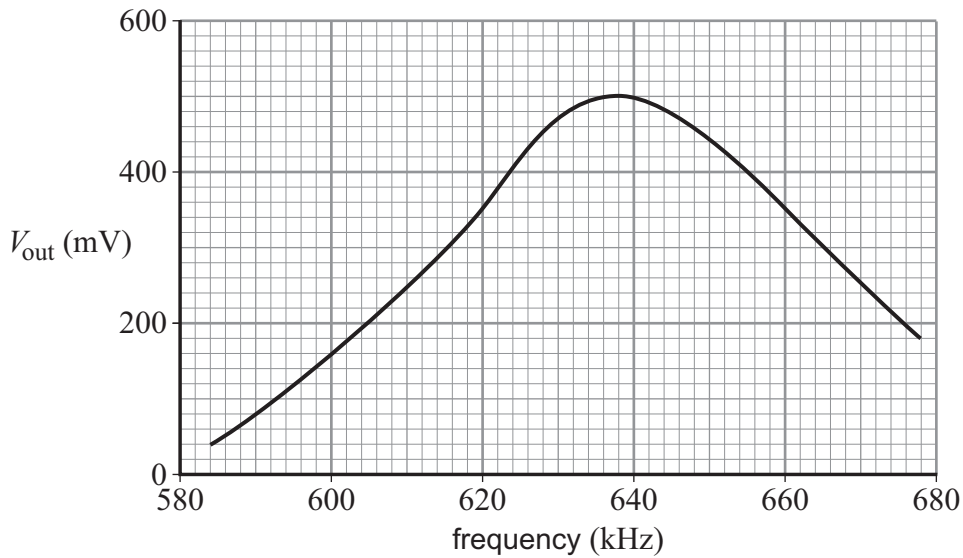State the meaning of the term **poor selectivity**.

[1 mark]

....

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7 (d) The tuned circuit is adjusted to receive a different radio station.
Figure 8 shows the response of the tuned circuit.

Figure 8

7 (d) (i) Determine the resonant frequency of the tuned circuit, using the graph (**Figure 8**).

[1 mark]

....

7 (d) (ii) Calculate the bandwidth of the tuned circuit, using the graph (**Figure 8**).

[2 marks]

....

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7 (d) (iii) Calculate the quality factor of the tuned circuit.

[2 marks]

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END OF QUESTIONS

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