



### Section B

Answer **all** questions in this section.

0 1 . 1

**MOSFETs are commonly used in circuits where low power consumption is important to extend battery life.**

**State and explain the property of MOSFET devices that makes them useful in these circuits.**

**[2 marks]**

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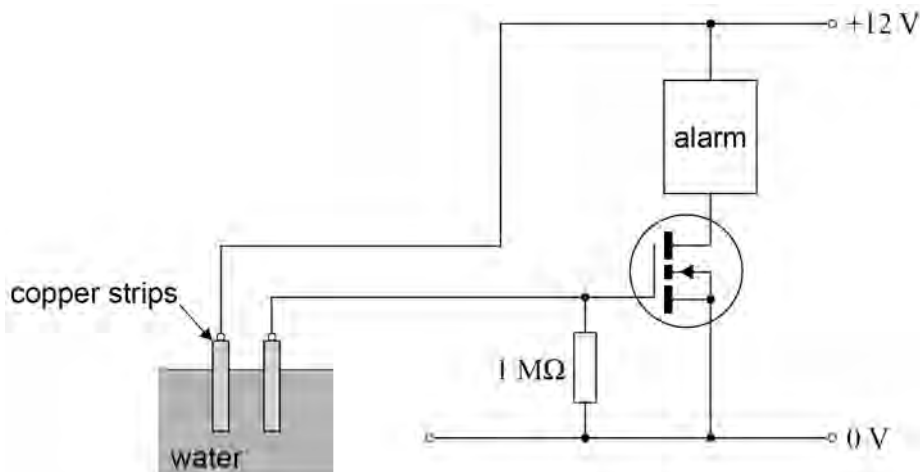
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**Figure 1** shows an N-channel enhancement mode MOSFET, being used as part of a circuit for the water level alarm in a garden pond. When the gap between the copper strips is filled with water the MOSFET turns on and the alarm sounds.

**Figure 1**



0 1 . 2

**Explain the reason for the 1 MΩ resistor in this application.**

**[2 marks]**

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0 1

3

The circuit is tested by immersing the copper strips in the water, and bringing them closer together until the alarm sounds.

$V_{th}$  for the MOSFET in **Figure 1** is 2.4 V.

Determine the resistance of the water between the copper strips when the alarm sounds.

[2 marks]

resistance = \_\_\_\_\_ M $\Omega$

0 2 . 1

Describe what is meant by amplitude modulation (am).

[1 mark]

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0 2 . 2

A radio wave has an unmodulated frequency of 120 kHz. It is amplitude modulated by a signal from an audio transducer of frequency 2.2 kHz.

Calculate the bandwidth of the modulated wave.

[1 mark]

bandwidth = \_\_\_\_\_ kHz

0 2 . 3

Explain why frequency modulation (fm) is not used for commercial radio transmissions in the medium and long wave bands.

[1 mark]

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0 2 . 4

State and explain **one** advantage of transmitting digital signals using frequency modulation (fm) rather than amplitude modulation (am).

[2 marks]

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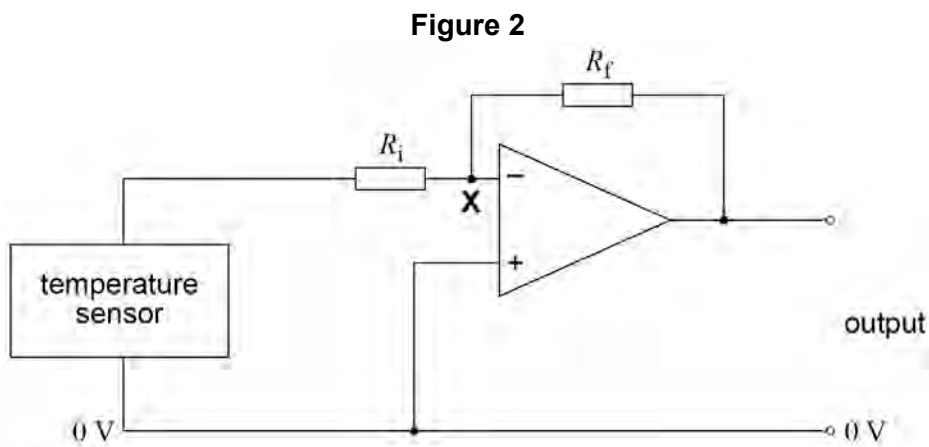
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0 3

**Figure 2** shows a circuit that includes an ideal operational amplifier. A student uses this circuit to amplify the signal from the sensor before further processing by the system.



0 3

. 1

Point X in **Figure 2** is said to be a virtual earth.

Explain the meaning of the term virtual earth in this type of circuit.

[2 marks]

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0 3

. 2

The temperature sensor produces a signal that changes by 10 mV for every degree Celsius change in temperature. The signal is 0 mV when the temperature of the sensor is 0 °C.

The value of  $R_i$  is 22 k $\Omega$  and the value of  $R_f$  is 270 k $\Omega$ .

Calculate the output voltage  $V_{OUT}$  of the circuit in **Figure 2** when the sensor is at a temperature of 50 °C.

[2 marks]

$V_{OUT} =$  \_\_\_\_\_ V

**0 3 . 3** The circuit is powered by a -15 V - 0 - +15 V supply. Explain why this circuit will not detect temperatures above 122 °C. **[2 marks]**

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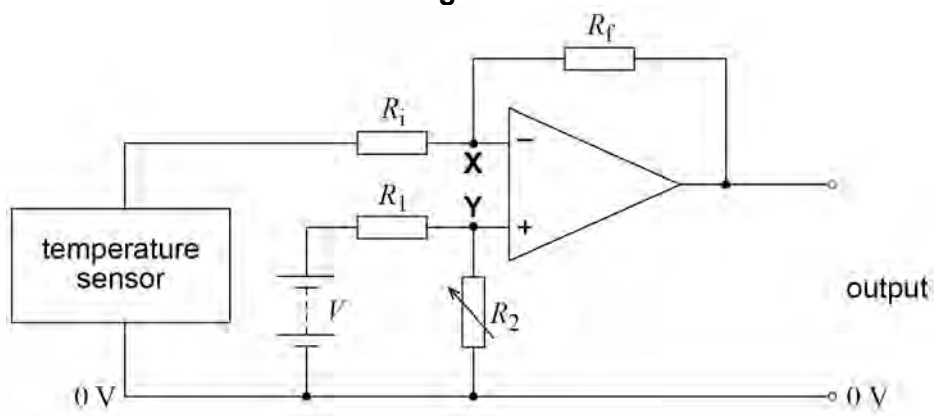
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**0 3 . 4** A student suggests a modification to the circuit in **Figure 2** to form a difference amplifier circuit for a thermostat. The modified circuit is shown in **Figure 3**.

**Figure 3**



The output controls a circuit that switches the heater off when the output is positive.

Explain how this circuit operates so that the heater switches off when the temperature reaches a pre-determined level.

**[3 marks]**

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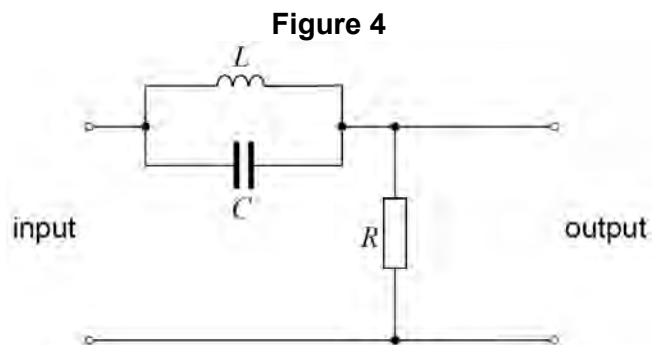


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0 4

An engineer uses copper cable to connect an intercom system between her office and workshop. The signals have to travel a long distance and she finds that interference (hum) from the mains supply is a problem. She reduces the interference using a filter tuned to the frequency of the mains supply. The mains frequency is 50 Hz.

**Figure 4** shows her solution which is based on a parallel  $L$ - $C$  resonant circuit.



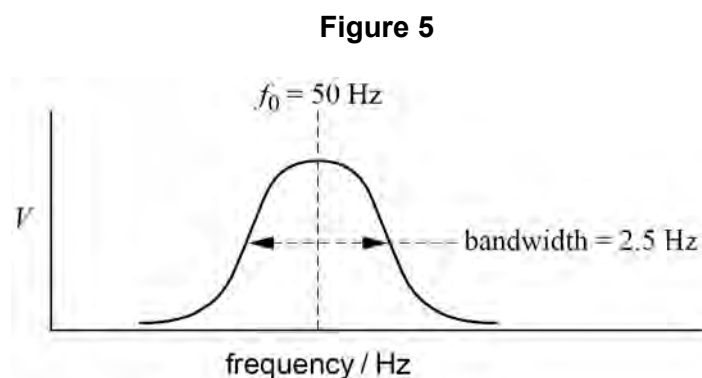
0 4 . 1 The engineer uses a 2.0 H inductor.

Calculate the required value for  $C$  for the filter to operate at 50 Hz.

[2 marks]

capacitance = \_\_\_\_\_ F

**Figure 5** is the response curve for the inductor-capacitor circuit which shows how the pd  $V$  across the inductor-capacitor circuit varies with frequency.



Question 4 continues on the next page

**0 4** . **2** Calculate, from the graph, the Q factor of the inductor-capacitor circuit.

**[1 mark]**

Q factor = \_\_\_\_\_

**0 4** . **3** The inductor is replaced to one that has an inductance of 8.0 H and a lower resistance than that of the original inductor. The capacitor is not changed. Describe how this change affects the response curve of the inductor-capacitor circuit.

**[2 marks]**

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**0 6**

The Boolean equation for a particular logic circuit with inputs A and B and output Q is:

$$Q = (A \cdot B) + (\bar{A} \cdot \bar{B})$$

**0 6****1**

**Table 1** shows intermediate logic signals for the circuit, and the overall output, Q, for all combinations of the inputs A and B.

Complete the missing two entries in the truth table.

**[1 mark]****Table 1**

A	B	$\bar{A}$	$\bar{B}$	A . B	$\bar{A} \cdot \bar{B}$	Q
0	0	1	1	0	1	
0	1	1	0	0	0	0
1	0	0	1	0		0
1	1	0	0	1	0	1

**0 6****2**

Complete the diagram in **Figure 6** to show the logic circuit that has the same function as the Boolean equation given in part 6. Your circuit should contain only **two** AND gates, **two** NOT gates, and **one** OR gate.

**[3 marks]****Figure 6**

A ○ —

B ○ —

— ○ Q

**END OF QUESTIONS****Turn over ▶**

**There are no questions printed on this page.**