

Overview

In this unit your students should:

- discover the electrical behaviour of potentiometers, thermistors and LDRs
- learn how to calculate the output signal of a voltage divider
- learn how to design voltage dividers

This should not require more than 4 hours of class time.

Hour	Suggested Activity
1	<p>Briefly introduce the idea of a sensor as a useful electronic system which converts an aspect of the environment into a voltage. Then launch them straight into the first three steps of the Environmental Sensors practical. You will need to show them how to use a multimeter to measure resistance.</p> <p>Introduce the voltage divider as a resistance-to-voltage converter. Run over how to calculate the voltage at the output terminal. You may need to show them how to transpose $V = IR$ and deal with prefixes.</p> <p>Set them to do questions 2 and 3 from the Resistive Sensors exercises.</p> <p>Ask them to study 2.1 of the text book and finish the first three questions of the Resistive Sensors exercises before the next session.</p>
2	<p>Launch them straight into last four steps of the Environmental Sensors practical. If they have not yet met logic gates, they will need access to the Integrated Circuits and Discrete Components data sheets. If it is their first session with breadboard, they will need some advice about power supplies and the placing of components, such as LEDs and integrated circuits.</p> <p>For step 4, they should choose a pull-down resistor whose value is the closest match to the thermistor's resistance at 20 °C.</p> <p>As they finish, let them go on to question 4 of the Resistive Sensors exercises.</p> <p>Ask them to answer question 1 on page 33 of the text book before the next session.</p>
3	<p>They should do the Voltage dividers practical in this session. You may need to introduce them to the resistor colour code on the Discrete Components data sheet. Students who get stuck on step 4 should consult page 22 of the text book.</p> <p>As they finish, get them started on question 5 of the Resistive Sensors exercises.</p> <p>Ask them to finish off all of the questions of the Resistive Sensors exercises before the next session.</p>
4	<p>Get them to work through questions 2, 3 and 4 from page 33 of the text book. Keep an eye on their answers as they write them. Insist on all steps being shown for calculations (as in the text book) and on thorough descriptions and explanations for question 3. They may need to look up the circuit symbol of an AND gate in the text book.</p> <p>Briefly introduce the idea of an op-amp as an integrated circuit which converts the analogue (any value) output of a voltage divider sensor into a digital (one of two values) signal.</p> <p>Ask them to study 2.2 of the text book and answer question 1 of the Op-amps and Diodes exercises before the next session.</p>

Model Answers

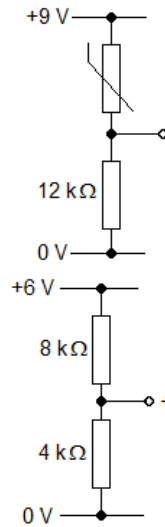
1 (a) A thermistor is a resistor whose resistance decreases with increasing temperature.

(b)

(c) $R_{\text{tot}} = 19.2 \text{ k}\Omega$

$$I = V/R = 9 / 19.2 \times 10^3 = 4.7 \times 10^{-4} \text{ A}$$

$$V = IR = 4.7 \times 10^{-4} \times 12 \times 10^3 = 5.6 \text{ V}$$

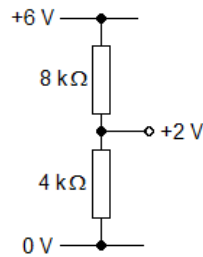


2 $I = 10 \times 50 \mu\text{A} = 5.0 \times 10^{-4} \text{ A}$

$$R_{\text{total}} = V/I = 6 / 5.0 \times 10^{-4} = 1.2 \times 10^4 \Omega \text{ or } 12 \text{ k}\Omega$$

$$R_{\text{bottom}} = V/I = 2 / 5.0 \times 10^{-4} = 4.0 \times 10^3 \text{ or } 4 \text{ k}\Omega$$

$$R_{\text{top}} = 12 - 4 = 8 \text{ k}\Omega$$



3 (a) The top component is a variable resistor. Its value depends on the angle of its shaft. The bottom component is an LDR. Its resistance increases with decreasing light intensity.

(b) The voltage at the output increases as the light intensity falls. This because reducing the light intensity raises the total resistance of the system, decreasing the current, resulting in a smaller voltage across the variable resistor. Reducing the resistance of the variable resistor increases the current, resulting in a larger voltage drop across the LDR.

4 (a)

(b) $I_{\text{pot}} = V/R = 5 / 50 \times 10^3 = 1.0 \times 10^{-4} \text{ A}$

$$I_{\text{res}} = 1.0 \times 10^{-5} \text{ A}$$

$$R_{\text{tot}} = V/I = 5 / 1.0 \times 10^{-5} \text{ A} = 5.0 \times 10^5 \Omega \text{ or } 500 \text{ k}\Omega$$

$$R_{\text{bottom}} = V/I = 2.5 / 1.0 \times 10^{-5} = 2.5 \times 10^5 \Omega \text{ or } 250 \text{ k}\Omega$$

$$R_{\text{top}} = 500 - 250 = 250 \text{ k}\Omega$$

