Electronics

A Level Physics 9702

J. Rowing • Vijay International School Praslin

By the end of this topic I can...

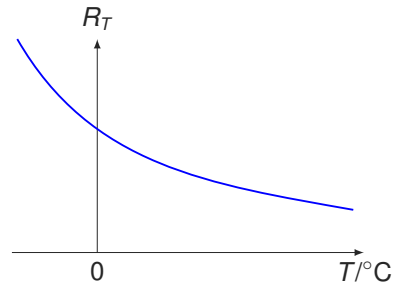
- describe the thermistor, LDR and strain gauge
- use $\Delta R/R = 2\Delta l/l$ for a strain gauge
- describe the piezo-electric transducer
- analyse a potential divider and a sensing circuit

Electronic systems

- **sensor**: picks up a change in a physical property
- **processing unit**: produces an output voltage
- **output device**: indicates the change

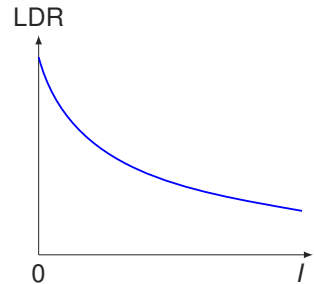
Thermistor

- resistance varies with **temperature**
- **NTC**: resistance **decreases** as temperature rises
- non-linear: exponential decay shape
- higher temperature: more **free electrons**



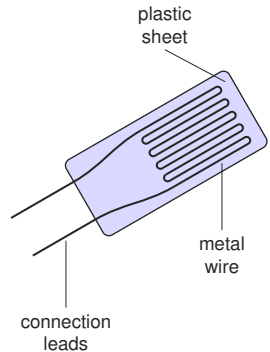
Light-dependent resistor

- resistance **decreases** as light intensity increases
- non-linear
- light frees bound electrons: more **free electrons**
- dark: 10^5 to 10^7 Ω; bright: 10^2 to 10^3 Ω



Strain gauge

- folded metal wire sealed on a plastic sheet
- stretched: length **increases**, resistance changes
- used to measure the width of a crack



Strain gauge equations

Volume of wire constant: longer **and** thinner, so a factor of two:

$$\frac{\Delta R}{R} = \frac{2\Delta l}{l}$$

- length only: $\Delta R/R = \Delta l/l$
- both effects add: factor 2

Example: strain gauge

Example: strain gauge

$$\frac{\Delta R}{R} = \frac{2\Delta l}{l} = 2 \times 0.0010 = 0.0020$$

$\Delta R = 0.0020 \times 120 = 0.24\ \Omega$, so $R = 120.24\ \Omega$ ($\approx 120.2\ \Omega$)

Piezo-electric transducer

- mechanical energy $\leftrightarrow$ electrical energy
- **compressed**: p.d. across it
- a.c. voltage: vibrates, makes sound (**loudspeaker**, buzzer)
- sound: a.c. voltage (**microphone**)



microphone



loudspeaker

Potential divider

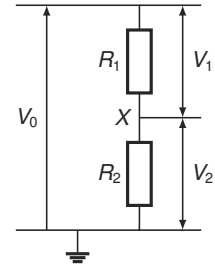
Potential divider

Two **resistors in series** across a fixed voltage supply.

- same current: $V_1/V_2 = R_1/R_2$
- R_1 up: V_1 up, V_2 down

$$V_1 = \frac{R_1}{R_1 + R_2} V_0$$

$$V_2 = \frac{R_2}{R_1 + R_2} V_0$$



Example: potential divider

Example: potential divider

$$V_1 = \frac{2.0}{2.0 + 6.0} \times 12 = 3.0 \text{ V} \qquad V_2 = \frac{6.0}{2.0 + 6.0} \times 12 = 9.0 \text{ V}$$

(check: $3.0 + 9.0 = 12$ V)

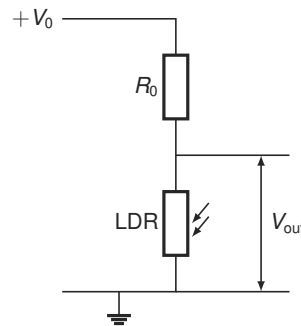
Example: light sensor

For the sensing circuit shown, suggest how the output voltage changes as the light level increases.

Example: light sensor

For the sensing circuit shown, suggest how the output voltage changes as the light level increases.

Light intensity increases, so the resistance of the LDR decreases.
The current in the circuit increases, so the p.d. across R_0 increases.
So the p.d. across the LDR becomes smaller: V_{out} **decreases**.
(Check with $V_{out} = \dfrac{R_{LDR}}{R_{LDR} + R_0} V_0$: lower R_{LDR} gives lower V_{out}.)



Example: LDR output

Example: LDR output

$$V_{\text{out}} = \frac{12}{12 + 8.0} \times 15 = 9.0 \text{ V}$$

Example: design a sensor

Example: design a sensor

Connect an NTC thermistor in series with a fixed resistor R across the supply, and take V_{out} across the **fixed resistor**.

As temperature rises the thermistor's resistance falls, so the current increases and the p.d. across R increases. (Equivalently the thermistor takes a smaller share of V_0.) So V_{out} rises.

Key equations

resistance $R = \dfrac{\rho l}{A}$

strain (area const) $\dfrac{\Delta R}{R} = \dfrac{\Delta l}{l}$

strain gauge $\dfrac{\Delta R}{R} = \dfrac{2\Delta l}{l}$

divider $V_1 = \dfrac{R_1}{R_1 + R_2} V_0$

ratio $\dfrac{V_1}{V_2} = \dfrac{R_1}{R_2}$