# Potential dividers

Potential division

If a signal in a sensing or control system is too big, it can be reduced by 'tapping off' a fraction of the signal using a potential divider. If a sensor does not itself give a signal but instead changes its resistance in response to the environment, an electrical signal can be obtained from it by making it part of a potential divider. These activities introduce a number of such ways of using a potential divider.

Experiment 1:
Potential divider with fixed resistors

Confirm how the pd splits up across a potential divider.

Experiment 2:
Potential divider with a variable resistor

Make a more versatile potential divider.

Experiment 3:
Rotary potentiometer used as a potential divider

Control an output potential difference or measure an angular displacement.

Experiment 4:
Sensors used in potential dividers

Use a sensor in a potential divider circuit.

Requirements

* resistors (suggested values 300 k, 100 k, 75 k, 150 k)
* 100 k rotary potentiometer (or similar value to range of fixed resistors used).
* power supply, 5 V dc
* clip component holders
* digital multimeters
* 4 mm leads
* LDR (e.g. NORPIZ)
* thermistor (47 k)
* hairdryer
* filament lamp 12 V, 48 W in a suitable holder

# Experiment 1: Potential divider with fixed resistors

Please turn off the power supply or disconnect the battery when you are not taking measurements.

You need two resistors. Measure their resistance using the multimeter. Remember to use the highest resistance range first. Record the values.

Place each resistor in a component holder and connect them in series with the power supply. Switch the multimeter to the volts setting and select the 0–20 V range or other suitable range depending on the multimeter you are using. Measure the potential difference across the power supply. If you have been given a variable supply, you will need to select 5 V and use the voltmeter to check the output voltage. Then measure the potential difference across each of the resistors in turn. Record these measurements in the table. Repeat these measurements for another pair of resistors.

**VS**

**V1**

**V2**

**R2**

**R1**

| resistance / k | R1 = | R2 = | R1 + R2 = |
| --- | --- | --- | --- |
| potential difference / V  | V1 = | V2 = | VS = |

Predict and test

The same current goes through each resistor in series, so the potential difference across each will be in proportion to its resistance. Take another pair of resistors, measure their resistances, and work out the potential difference you should get across each, this time before you try it out.

V1 = R1 / (R1+R2) × VS

# Experiment 2: Potential divider with a variable resistor

Replace one of the two resistors with the potentiometer used as a variable resistor.

Connect the multimeter (in the voltmeter mode) across the potentiometer.

Make sure your power supply is switched on. Watch what happens to the reading as you turn the spindle of the potentiometer.

A varying resistance was made to produce a varying potential difference.

The potential difference across the potentiometer can be made to vary anywhere between 0V and some fraction of the supply voltage. By changing the fixed resistor, see what effect its resistance has on the largest potential difference you can get across the variable resistance. If possible place another voltmeter across the fixed resistor and confirm that the potential difference across that resistor also changes. The two readings should add up to the supply voltage.

Many sensors – strain gauges, thermistors, gas sensors – change resistance in response to a change in whatever they are built to sense. If such a sensor replaces the varying resistance in this circuit, there will be a change in the potential difference across the sensor whenever its resistance changes. The changing potential difference can then be used as an output signal.

# Experiment 3: Rotary potentiometer used as a potential divider

To use the potentiometer itself as the potential divider, connect its ends across the power supply and measure the potential difference between one end and the terminal connected to the sliding contact. Turn the spindle and watch the potential difference change.

Uses of this potential divider

This type of potential divider is used in brightness and volume controls.

Think of some other similar uses in control circuits.

The potentiometer will also be used for measuring displacement.

# Experiment 4: Sensors used in potential dividers

Using a thermistor

1. You need a thermistor and 150 k resistor in series as a potential divider across the power supply. Connect the multimeter across the thermistor. Note the voltmeter reading. Use the hairdryer to warm up the thermistor gently. Note the new voltmeter reading and the warming time used.

2. Change the resistor to 100 k. Allow the thermistor time to cool down. Repeat step 1.

Warm the thermistor with the hairdryer for the same time.

Explain why changing the resistor alters the result.

What must happen to the pd across the resistor as the thermistor warms up?

Using a light dependent resistor (LDR)

1. You need a LDR and 100 k resistor as a potential divider across the power supply. Connect the multimeter across the resistor. Note the voltmeter readings when (i) the lamp is placed close to the LDR, (ii) the lamp is off and (iii) the LDR is covered up.

2. Change the resistor for one of lower value and repeat. What is the effect of changing the resistor value?

Try controlling logic devices

Electronic switches such as the transistor and logic gates are digital devices. They are 'off' below a threshold voltage (often 0.6 V) and 'on' above that voltage. Changing the resistor value in the potential divider allows you to set the conditions that 'turn on' the device.

External references

This activity is adapted from Advancing Physics Chapter 2, 200E

# Tapping off a potential difference



A series circuit is connected as shown in the diagram.

1. What is the potential difference between A and B?
2. An additional resistor of 100  is connected between the 50 resistor and the cells. What is the potential difference between A and B now?
3. The additional 100  resistor is now connected in parallel with the first 100  resistor. What is the potential difference between A and B now?
4. A potential divider is made from a 4 k and a 6 k resistor connected in series with

a 20 V supply. Draw a diagram of the arrangement. What four values of potential difference can be tapped off?

5. A student puts a 12  variable resistor in series with a 6 V battery, expecting to get

a variable potential difference.



The voltmeter is a high resistance digital multimeter. Explain why the circuit won't work. Draw a circuit which would work.

6. B is the wiper of a 100  rotary potentiometer.

What is the full range of the potential difference that

can be tapped off between A and B?

Hints

1. Resistors are in the ratio 50 :100 so the potential difference splits up 1 : 2.

3. Work out the equivalent resistance of the two 100  resistors in parallel first.

6. Find the pd set up across the potentiometer first by looking at the ratio of the resistors

Loading the potential divider





The sliders are at the mid-point of the potential dividers.

1. Find the potential difference recorded by a digital voltmeter of infinite resistance connected as the voltmeter V in each circuit. (The resistance presented by a digital voltmeter is not infinite but it is very much larger than then resistances used in the circuit. If a high resistance voltmeter is not available, connect a 500 Ω resister in parallel with a low resistance one.

2. The digital voltmeter is replaced by a moving coil voltmeter of resistance 500 . Calculate the new readings when using this meter.

3. A 100  rotary potentiometer is connected to a 6 V dc source with negligible internal resistance. The output required is 3 V. The potentiometer is set using a high impedance digital voltmeter connected across the output terminals. A few minutes later someone else checks the output reading using a moving coil voltmeter which has a resistance of 100 . What is the reading now?

Hints

1. Treat the voltmeter and half the resistance of the potentiometer as a parallel resistor combination.

3. The wiper will have been set midway, i.e. dividing the potentiometer into two 50  sections. Treat the voltmeter and half the resistance of the potentiometer as a parallel resistor combination.

 Brightness of bulbs



When two identical lamps are connected in series to a battery of negligible resistance they light normally.

A variable resistor R is now connected across lamp L2. Explain what happens to the brightness of each bulb as the resistance of the variable resistor is:

1. Made low compared to the resistances of the lamps

2. Made high compared to the resistances of the lamps