Unit 9 Electrical systems and control

In this unit you will:
- revise component symbols that you learned in Grades 7 and 8
- learn about other components that are found in electrical and electronic circuits
- experiment with simple circuits to see the relationship between current, voltage and resistance to give you a better understanding of Ohm's Law.

In Grades 7 and 8 you learned about various components in electric circuits such as cells and batteries, bulbs, switches, buzzers and motors. Before you continue with this unit, it is important to revise these components.

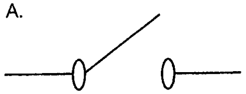
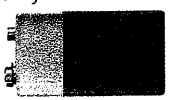
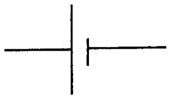
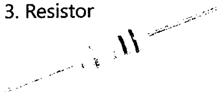
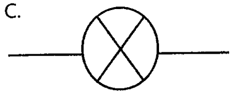
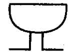
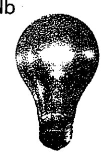
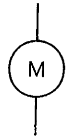
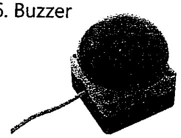
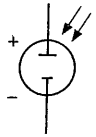
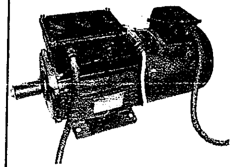
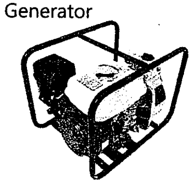
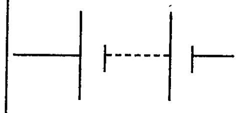
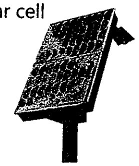
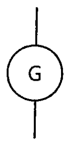
This unit will introduce you to other components that are found in electrical and electronic circuits.

Let us see if you can recall and remember some of the components.

Revise 1 – component symbols

ACTIVITY 1 ELECTRICAL COMPONENTS AND SYMBOLS

1. Match Column A (actual components) with Column B (component symbols). Write down numbers 1 to 9 in your book. Next to each number write the letter of the correct symbol of the component from Column B.

Column A Actual component	Column B Component symbol
1. Cell  © thinkstock.com	A. 
2. Battery  www.conrad.de/medias	B. 
3. Resistor  © wikimedia.org	C. 
4. Switch  © thinkstock.com	D. 
5. Bulb  © thinkstock.com	E. 
6. Buzzer  © wikimedia.org	F. 
7. Motor  © wikimedia.org	G. 
8. Generator  © thinkstock.com	H. 
9. Solar cell  © thinkstock.com	I. 

Now let us revise series and parallel circuits.

Cells in series

Cells are connected in series when the positive terminal of one cell is connected to the negative terminal of another cell. When two or more cells are connected as in the picture in Figure 9.1 on page 92 we call it a battery.

Figure 9.1 Cells connected in series

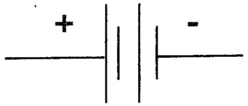


Figure 9.2 Electrical symbol of series connection of cells

Cells in parallel

Cells are connected in parallel when the positive terminal of one cell is connected to the positive terminal of another cell and the negative terminals of the cells are also connected together. See the picture below.

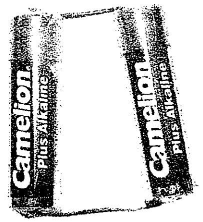


Figure 9.3 Cells connected in parallel

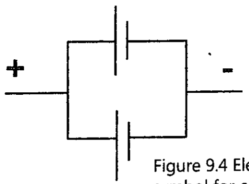


Figure 9.4 Electrical symbol for cells connected in parallel

Bulbs in series

Bulbs are connected in series when one terminal of a bulb holder is connected to the terminal of another bulb holder in a straight line. This can be seen in the picture below.

Figure 9.5 Bulbs connected in series

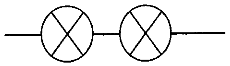


Figure 9.6 Electrical symbol for bulbs connected in series

Bulbs in parallel

Bulbs are connected in parallel when they are placed across one another and their terminals are connected together as seen in the picture. In parallel circuits the current has more than one path to follow.

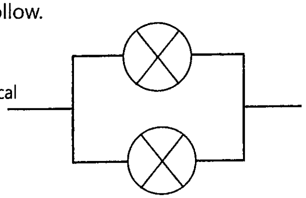


Figure 9.7 Electrical symbol for bulbs connected in parallel

Figure 9.8 Bulbs connected in parallel

Logic gates

A logic gate is an electronic switch that is an assembly of switches connected in a specific way or arrangement. These gates or electronic switches are found in many electronic appliances that we use in our everyday life, for example cellular phones, computers and laptops. There are many types of logic gates. We are going to learn about two of these logic gates, called the AND and the OR logic gates.

Switches in series (AND logic gate)

The AND logic gate consists of two electronic switches connected in series. The way in which this gate functions is that both switches have to be closed for the bulb to light up. If either switch A or B is open the bulb will not light up.

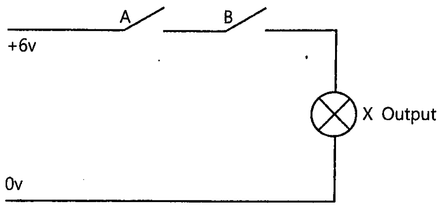


Figure 9.9 Equivalent circuit for an AND gate

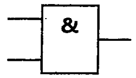


Figure 9.10 Symbol for AND gate

Switches in parallel (OR logic gate)

The OR logic gate consists of two electronic switches connected in parallel. The way in which this gate functions is that either switch A or B have to be closed for the bulb to light up.

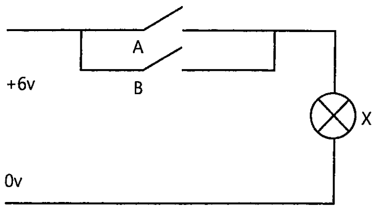


Figure 9.11 Equivalent circuit for an OR gate

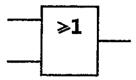


Figure 9.12 Symbol for OR gate

Current flow

In all circuits that you learned about the current flows from positive to negative. This is called conventional current flow.

Revise 2 – simple circuits

Series circuit

A series circuit is when components are connected one after the other in a closed loop. A closed loop means that there must be no break in the circuit. For a circuit to operate normally there must also be no short circuits.

To find out if a circuit is closed or continuous, place your finger on one side of the cell on the circuit diagrams below and follow the wires back to the other side of the cell. Did you see any break in the circuit? There is a continuous path that your finger follows from one end of the cell to the other. The circuit is closed or continuous. Current can only flow in closed circuits.

ACTIVITY 2 CIRCUIT AND COMPONENT IDENTIFICATION

Answer the following questions in your book:

1. Describe how the components are connected in Circuit 1.
2. Name the components in Circuit 2.
3. What is the difference between Circuit 1 and Circuit 2?

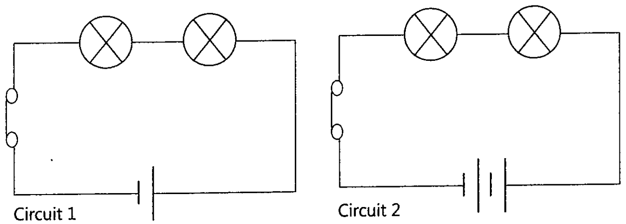


Figure 9.13

Ohm's Law quantitatively

Ohm's Law states that as voltage increases, current increases if resistance is constant.

Action research

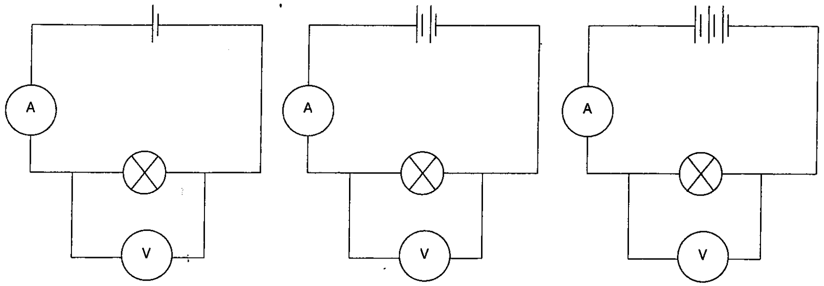
In Grade 8 you learned about Ohm's Law and the relationship between current and voltage and how one quantity affects or influences the other. In Activity 3, you will build three simple circuits to investigate the relationship between current and voltage.

ACTIVITY 3 RELATIONSHIP BETWEEN CURRENT AND VOLTAGE

You will need:
- three cells
- 20W resistor or one bulb and bulb holder
- a voltmeter
- an ammeter
- three drawing pins
- sticky tape
- about eight pieces of wire

1. Connect the circuits as shown in the diagrams below. In the circuit diagrams, you will see two new symbols A and V. A is the symbol for an ammeter. We use an ammeter to measure the current in amperes. V is the symbol for a voltmeter. We use a voltmeter to measure voltage in volts. Voltage is the potential difference of a supply of electricity.
2. Copy this table into your book and record the readings you observe on the ammeter and voltmeter in the table.

	Current	Voltage
Circuit 1		
Circuit 2		
Circuit 3		



Circuit 1 (One cell) Circuit 2 (Two cells in series) Circuit 3 (Three cells in series)

Figure 9.14

3. Use your readings to plot a graph showing the relationship between current strength and voltage (potential difference). Notice that resistance (bulb) remained constant.
4. Analyse the graph. What conclusion can you reach about the relationship between current and voltage?
5. Does your conclusion support Ohm's Law?

Summary

- Electrical components have electrical symbols. The symbols make it easy to draw electric circuits.
- Cells are connected in series when the positive terminal of one cell is connected to the negative terminal of another cell.
- Cells are connected in parallel when the positive terminal of one cell is connected to the positive terminal of another cell and the negative terminals are also connected together.

- Bulbs are connected in series when one terminal of a bulb holder is connected to the terminal of another bulb holder in a straight line.
- Bulbs are connected in parallel when they are placed across one another and their terminals are connected together.
- The AND logic gate is made up of two electronic switches connected in series.
- The OR logic is made up of two electronic switches connected in parallel.
- There is a relationship between current, voltage and resistance as expressed by Ohm's Law.

Questions

1. Copy this sentence and fill in the blanks.
   Cells are said to be connected in series when the ____________ terminal of one cell is connected to the ____________ terminal of another cell.
2. Draw the electrical symbols for the following components:
   a) Battery
   b) Resistor
   c) Motor
   d) Solar cell
   e) AND gate
3. Draw an electrical circuit to show an OR gate.

Unit 10 Resistor colour codes

In this unit you will:
- learn how to read the value of resistors
- calculate resistance, current and voltage using Ohm's Law

Resistor

A resistor is a component that limits or controls the flow of current in an electronic circuit. When a resistor is put into a circuit the flow of current is reduced. Resistors are available in various values and can allow different amounts of current to flow. The higher the value of the resistor, the lower the flow of current in the circuit. A resistor is a process device.

Resistor colour codes

Resistors are coded in two ways. Low values are printed on the resistor using numbers and high values are coded using bands of different colours around the resistor. Each colour has a different value and is used to work out the resistance of the resistor. This can be seen in the photo on the right.

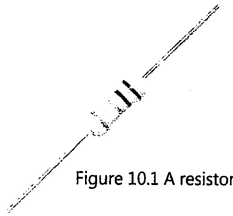
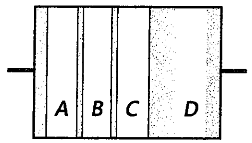


Figure 10.1 A resistor

Resistance is measured in a unit called ohms and represented by a Greek symbol Ω.

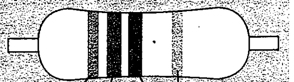
Resistor colour code table

Colour	First Band A	Second Band B	Third Band C	Fourth Band D
Black	0	0	1	± 1%
Brown	1	1	10	± 2%
Red	2	2	100	
Orange	3	3	1000	
Yellow	4	4	10 000	
Green	5	5	100 000	± 0,5%
Blue	6	6	1000 000	± 0,25%
Violet	7	7	10 000 000	± 0,1%
[illegible]	8	8	100 000 000	± 0.05%
White	9	9		
Gold				± 5%
Silver				± 10%



- The first band A is the first colour that indicates the first digit of the resistor value.
- The second band B is the second colour that indicates the second digit of the resistor value.
- The third band C is the third colour that indicates the value that the first and second digits must be multiplied by.
- The fourth band D is the fourth colour that indicates the tolerance* of the resistor. It is an accuracy rating as a percentage.

Let us work out the value of the following resistor.
Refer to the resistor colour code table to help you work out the values of the different colours.



- The first band A is **red** so we write the first digit of the resistor value, that is 2
- The second band B is **violet** so we write the second digit of the resistor value, that is 7
- The third band C is **green** so we multiply the first two digits by 100 000
- The fourth band D is **brown** so tolerance of the resistor is 2%.

The final value of the resistor = 27 × 100 000 Ω
= 2 700 000Ω ± 2 % or 2,7MΩ ± 2%

Word Box

tolerance: a certain specification that a component is manufactured to
inversely: something that is opposite

ACTIVITY 1 WORK OUT RESISTOR VALUES

Refer to the resistor colour code table and work out the values of the following resistors. Write your answers in your book.

1. Red, green, brown
2. Brown, black, yellow
3. Blue, white, orange
4. Red, green, black
5. Orange, red, green

Ohm's Law

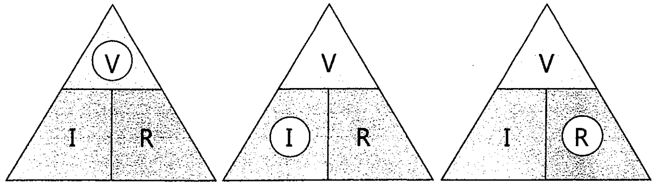
Ohm's Law states that the current in a circuit is directly proportional to the voltage and inversely* proportional to the resistance provided the temperature is kept constant.

It is important for you to know the units of measurement.

Quantity	Unit	Symbol
Current	Ampere	A
Voltage	Volt	V
Resistance	Ohm	Ω

In Unit 9 you learned about Ohm's Law and how voltage, current and resistance affect each other. In this unit we are going to perform calculations on these quantities and learn how each quantity affects each of the others.

Ohm's Law triangle



$V = I \times R$
Use to calculate V if I and R are known.

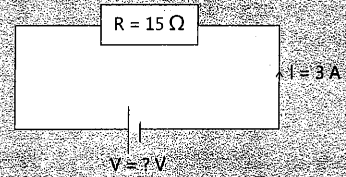
$I = \frac{V}{R}$
Use to calculate I if V and R are known.

$R = \frac{V}{I}$
Use to calculate R if V and I are known.

Note: **R** represents the resistance of a resistor in ohms (Ω).
V represents the potential difference in volts (V).
I represents the current strength in amperes (A).

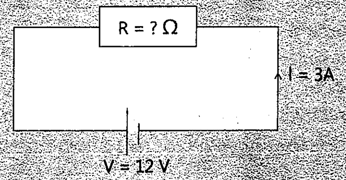
Examples of how to calculate voltage, resistance and current

1.



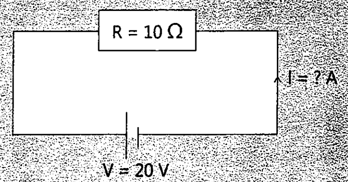
$V = I \times R$ V
$= 3 \times 15$V
$= \underline{45\ V}$

2.



$R = \frac{V}{I}$ Ω
$= \frac{12}{3}$ Ω
$= \underline{4\ Ω}$

3.



$I = \frac{V}{R}$ A
$= \frac{20}{10}$ A
$= \underline{2\ A}$

ACTIVITY 2 CALCULATE RESISTANCE, CURRENT AND VOLTAGE

Draw circuit diagrams and calculate the unknown values for the following questions in your book.

1. A bulb draws a current of three amperes from a 30 volt battery. Calculate the resistance that the bulb offers to the flow of current.
2. A motor has a resistance of 15 ohms and it is connected to a battery that supplies 25 volts. Calculate the current that the motor uses so that it turns at the correct speed.
3. A generator has a resistance of 12 ohms. It generates a current of three amperes. Calculate the voltage that it will be supplying.

Summary

- A resistor is a component that limits or controls the flow of current in an electronic circuit.
- A resistor is a process device.
- Low value resistors often have their resistance value printed on them in numbers.
- Higher value resistors are coded using colour bands. The first three bands give the value of the resistor in ohms. The fourth band is an accuracy rating as a percentage.
- Resistance is measured in a unit called ohms and represented by a Greek symbol Ω.
- Ohm's law states that the current in a circuit is directly proportional to the voltage and inversely proportional to the resistance, provided the temperature is kept constant.

Questions

Quantity	Unit	Symbol
	Ampere	A
Voltage		V
Resistance	Ohm	

1. Copy this table and complete it by filling in the missing values.
2. Correct the following statement to make it true:
   Ohm's law states that the resistance in a circuit is directly proportional to the current and directly proportional to the voltage, provided the temperature is kept constant.
3. Work out the value of the following resistors:
   a) Black, brown, black
   b) White, green, orange
   c) Orange, blue, red
4. A solar panel supplies 2A of current to a 20Ω motor.
   a) Draw the electrical circuit.
   b) Calculate the voltage the solar panel supplies to the motor.

Unit 11 Electronic components

In this unit you will:
- learn about more complex switches, how they function and their applications
- find out about diodes, LEDs, transistors, sensors and capacitors
- use some of these components in circuits that you will build and see how they function
- learn about where and how these sensors are used in everyday life

In your study of electrical systems and control you have learned about bulbs, resistors, batteries and simple switches. There are many other different types of components that make up the electronic circuits. They perform different functions in controlling the currents and voltages so that the circuits can do different functions. The photograph on the right shows different electronic components that have been connected together to form one circuit.

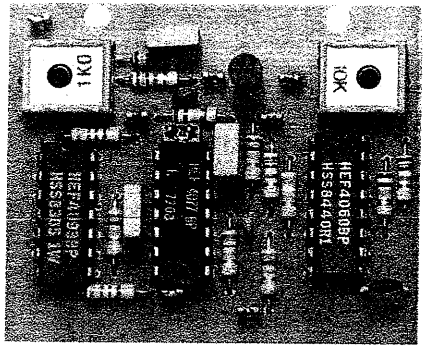


Figure 11.1 Circuit board with various electronic components

Switches

The main function of a switch is to allow or stop the flow of current in a circuit. Switches have become more complex components in that they have been designed in different ways to switch current flow and also the manner in which they can be operated.

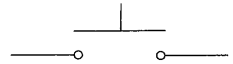
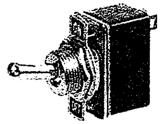
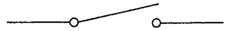
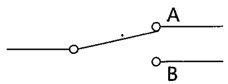
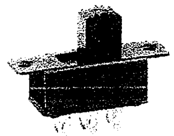
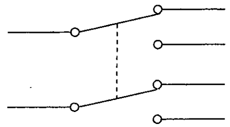
Switches are **control devices**. Manual switches are controlled by the user.

Switches are manufactured with contact points inside them that perform the different tasks they are designed for.

Let us look at the different terms that are associated with switches:

Pole – The pole is the number of switching contact sets. It is the part that moves inside a switch that controls the current flow.
Throw – The throw is the number of paths that the current has to flow inside the switch.

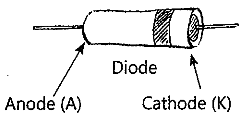
The table on the following page summarises the different types of switches.

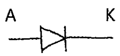
Type of switch	Actual switch	Symbol
Push switch To operate this switch, push once and it switches on, push again and it switches off. A similar switch is found on your television set.		
Single pole single throw (SPST) These are the normal on or off switches.		
Single pole double throw (SPDT) Switching can be in both positions. Here a red bulb can be switched on when the switch is in position A and a blue bulb can be switched on when the switch is in position B.		
Double pole double throw (DPDT) The switch can have two on positions or two off positions. These switches can be connected to change the direction of a motor. The dotted line on the symbol indicates that both contacting poles move together when the switch is operated.		

Diode

A diode allows current to flow in one direction only. Current flows from the positive type material (P type) to the negative type material (N type).

This component is made from a P type and an N type material. The positive side of the diode is called the anode and the negative side is called the cathode. A diode is used in many electronic devices such as televisions, computers, CD players and microwave ovens.





Symbol for diode

Figure 11.2 A diode

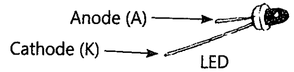
Light emitting diode (LED)

LEDs are similar in operation and construction to a diode in that they also allow current to flow in one direction only. This component is mainly used as an **indicating device**. They emit light when current passes through them therefore this device is classified as an output device.

LEDs are available in various sizes and colours. They are available in red, orange, green, yellow, amber, blue and white.

You will find this device on your television, hi-fi, CD and DVD player. When these appliances are on you will see a small red or maybe green LED indicating that the power is on.

The advantage of using LEDs as indicating devices is that they consume* very little current and give off very little heat.



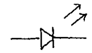

Symbol for LED

Figure 11.3 An LED

When you observe the actual component, the longer terminal is the anode* and the shorter terminal is the cathode*. If you look closely through the casing of the LED, you will notice that the cathode is flat and larger than the anode.

Word Box

consume: use
amplify: to magnify or make large
anode: the terminal of a device where current flows in from outside
cathode: the terminal of a device where current flows out

Transistor

Transistors have two main functions in electronic circuits. They can be used as an electronic switch to allow current to flow in a circuit or stop current from flowing. Transistors also have the ability to amplify* a current. The amount of current amplification is called the **current gain**.

There are two types of transistors, negative-positive-negative (NPN) and the positive-negative-positive (PNP).

In this unit we are going to focus on the NPN type transistor. This transistor is a three layer device with two negative type materials sandwiching a positive type material, hence the name NPN. Each layer has a terminal connected to it making a transistor a three terminal device. The terminals are labelled as **emitter (E), base (B) and collector (C).**

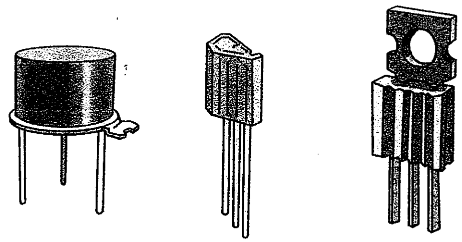
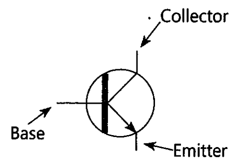


Figure 11.4 Examples of transistors



Symbol for transistor

You will need:
- 10 kΩ and 470 Ω resistor
- two 5mm LEDs
- BC 108 transistor
- switch
- 9 volt battery and battery clip
- breadboard
- one piece of connecting wire

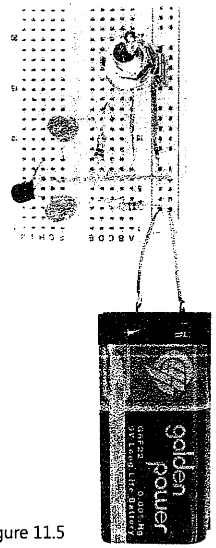


Figure 11.5

ACTIVITY 1 CONNECT A SIMPLE TRANSISTOR CIRCUIT

In this activity we will demonstrate a transistor being used as an amplifier. A small signal will be amplified into a larger signal.

1. Study the circuit diagram below and identify the components from the component list.
2. Insert the components into the breadboard as they are connected in the circuit diagram and as shown in the photograph.
3. Close the switch as shown and observe what happens. Look closely at the brightness of the LEDs.
4. Record your observation in your book.

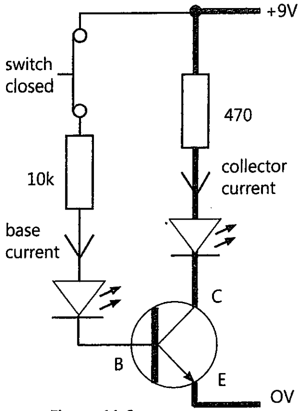


Figure 11.6

Sensors

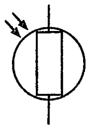
A sensor is a device that responds to a physical quantity which can be in the form of heat, light, sound, pressure, motion, magnetism, moisture, wind and various other quantities. Sensors are important because they help make our lives easier. Sensors are control devices. In this unit we are going to focus on three sensors or control devices.

Light dependent resistor (LDR)

An LDR is dependent on light for it to function. The resistance of the LDR is very high when no light shines on it, preventing current from flowing through it.

The LDR has a window on the top of the device. When light shines on the window, the resistance of the component decreases to a very low value and current can then flow through the component.

This component is used in a day-night sensor which switches lights on in the evening and off at dawn. You may have noticed street lights being switched on and off. This is controlled by a day-night sensor that is controlled by the LDR.



Symbol for LDR

Figure 11.7 LDR

Thermistor

A thermistor is a type of resistor whose resistance changes with temperature. There are two types of thermistors, the positive temperature coefficient* (PTC) and the negative temperature coefficient (NTC).

In a PTC type thermistor (+t) the resistance increases with an increase in temperature.

In a NTC type thermistor (-t) the resistance decreases with an increase in temperature.

Thermistors are used in motor cars to sense the temperature of the coolant or oil in the engine. They can also be used for measuring temperature in various equipment or machinery and this information can be displayed on a screen.

Word Box

coefficient: a component whose value changes with temperature

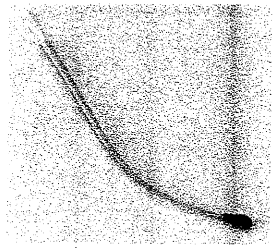
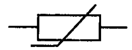


Figure 11.8 Thermistor



Symbol for thermistor

Touch or moisture detector

There are many different types of touch or moisture detectors. These components work when you touch the sensor switch with your finger and the switch electronically closes. This completes the circuit and allows current to flow through.

This sensor uses the moisture that we have in our body. Moisture or water conducts electricity. Some taps have touch or moisture detectors. When you touch the sensor with your finger, it automatically closes the circuit so that a valve opens and lets the water flow through the tap. This circuit also has a timer that keeps the valve open for a few seconds and it then shuts off the water.

You may have come across these sensors in hotels or restaurants where basins have 'automatic' taps that open when you touch them. These taps are fitted with a touch detector.

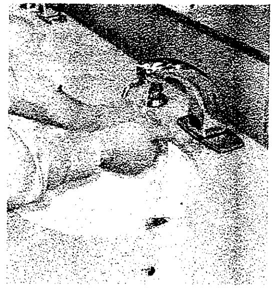


Figure 11.9 Some taps have touch or moisture detectors

Symbol for moisture detector

Capacitor

A capacitor is similar to a cell in that it can store an electric charge. The difference between a capacitor and a cell is that a capacitor stores a charge for a short period of time and then releases the charge.

When a capacitor is connected to a resistor, it functions as a timing circuit in electronic circuitry.
Capacitors are classified in two main groups, **polarised** and **non-polarised** capacitors.

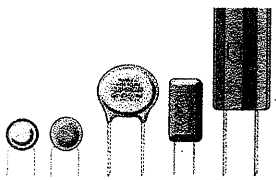
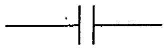


Figure 11.10 Capacitors



Symbol for capacitor

A polarised capacitor has to be connected in a specific way as it has a positive and a negative terminal.

A non-polarised capacitor can be connected in any direction as there is no positive or negative terminal.

Summary

- The main function of a switch is to allow or stop the flow of current in a circuit.
- Switches are control devices.
- A diode allows current to flow in one direction only. Current flows from the positive type material (P type) to the negative type material (N type).
- LEDs are mainly used as indicating devices.
- Transistors allow current to flow in a circuit or stop current from flowing and they can also amplify current.
- A sensor responds to a physical quantity which can be in the form of heat, light, sound, pressure, motion, magnetism, moisture and wind.
- Sensors are control devices.
- A light dependent resistor is dependent on light for it to function.
- A thermistor's resistance changes with temperature.
- A touch or moisture detector closes the circuit when touched by a 'wet' finger.
- A capacitor can store and then release energy.

Questions

1. List one application of the following components:
   a) Push switch
   b) LED
   c) LDR
   d) Moisture sensor
   e) Thermistor
2. What is the advantage of using a LED as an indicating device?
3. Draw electrical symbols for the following components:
   a) Diode
   b) Transistor
   c) Thermistor
   d) Capacitor

Unit 12 Simple electronic circuits

In this unit you will:
- draw and construct different circuits and observe how they function
- focus on an LED, LDR, thermistor and a capacitor when constructing your circuits

You have learned about different electronic components and how they function. You will now combine different components and see how they function in simple electronic circuits. You will also use the correct circuit symbols to draw the different electronic circuits before you make them.

ACTIVITY 1 CONNECTING A LIGHT EMITTING DIODE (LED) WITH A LOAD RESISTOR (RL)

You will need:
- 5mm LED
- 470Ω resistor
- switch
- three 1,5 volt cells connected in series
- battery holder
- breadboard

1. Draw a circuit diagram using the correct circuit symbols. The components must be shown connected in series. Refer to the photo in Figure 12.1 to help you in drawing your circuit diagram.
2. Work in a group. Insert the components into the breadboard as shown in your circuit diagrams and on the photograph on the right.
3. Close the switch and observe what happens. Record your observations in your book. What do you think would happen if the resistor was replaced with a piece of connecting wire? Write down your predictions.

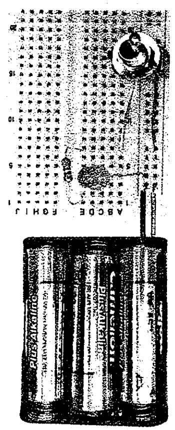


Figure 12.1

ACTIVITY 2 USING A LIGHT DEPENDENT RESISTOR TO SWITCH ON A BUZZER

You will need:
- LDR
- buzzer
- two 1,5 volt cells connected in series
- battery holder
- breadboard

1. Draw a circuit diagram using the correct circuit symbols. The components must be shown connected in series. Refer to the photograph in Figure 12.2 on the next page to help you draw your circuit diagram.

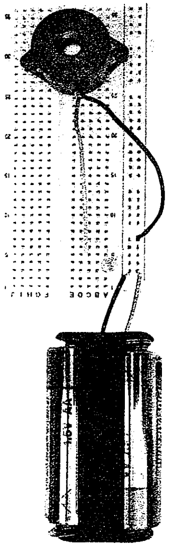


Figure 12.2

2. Work in a group. Refer to your circuit diagrams and this photograph. Insert the components into the breadboard.
3. Observe the loudness of the buzzer. Place your finger over the window on the LDR and observe the sound. Record your observations and explain why this happens.

You will need:
- BC 108 transistor or equivalent NPN transistor
- buzzer
- thermistor
- variable resistor 10 kΩ
- 1 kΩ resistor
- 6 volt battery or equivalent 6 volt DC power supply
- battery holder
- breadboard

ACTIVITY 3 USING A THERMISTOR TO SWITCH ON A BUZZER

1. Refer to the list of components on the left and identify them in the photograph in Figure 12.3. Draw a circuit diagram using the correct symbols. Refer to the photograph to help you draw your circuit diagram.
2. Work in a group. Insert the components into your breadboard as shown on the photograph.
3. Record your observation in your book.
4. Use matches or a lighter to heat the thermistor for about five seconds and observe the difference in the sound of the buzzer.
5. Allow the thermistor to cool down and observe the sound of the buzzer. Write down your observations in your book. Explain why the heat causes such changes in the circuit.

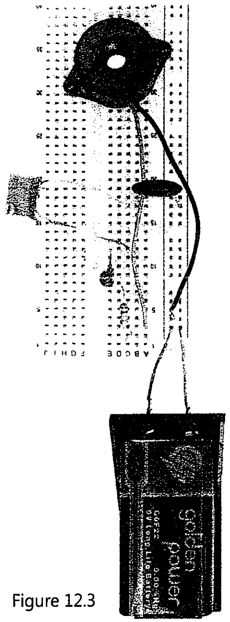


Figure 12.3

You will need:
- LED
- 470 Ω resistor
- 1000 μ farad capacitor
- 6 volt battery (You can use a 9 volt battery if you do not have a 6 volt battery)
- battery holder or clip
- switch
- connecting wire

ACTIVITY 4 CHARGING AND DISCHARGING OF A CAPACITOR

1. Refer to the list of components in the "You will need" box and identify them in the photograph on the next page. Draw a circuit diagram using the correct circuit symbols. The components must be connected in parallel. Refer to the photograph in Figure 12.4 on the next page to help you draw your circuit diagram.

2. Work in a group. Insert the components into your breadboard. Look at your circuit diagrams and the photograph to help you.
3. Put the switch in the on position and record your observation.
4. Now put the switch into the off position and observe what happens. Write your observation in your book. Write an explanation why you think the circuit behaves the way it does when it is switched off.

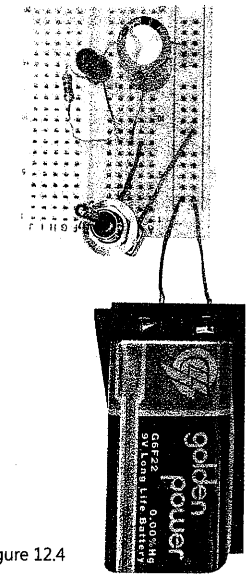


Figure 12.4

Summary

In this unit you have learned:
- how to construct circuits using a breadboard
- how components function when they are put into a circuit
- how to make and write observations when testing circuits

Questions

1. Refer to Activity 1 on page 107. Explain what will happen if you remove the 470 Ω resistor from the circuit and connect the LED directly to the switch.
2. Explain how the following components function:
   a) LDR
   b) Thermistor