

# ELECTRONICS

## advanced circuits



## Safety Notes for Parents and Children

- >>> **NOTE!** Not suitable for children under 3 years of age. There is a risk of choking if small parts are swallowed or inhaled. Store the experiment material and assembled models out of the reach of small children.
- >>> **NOTE!** Only for use by children 8 years and older. Instructions are included for parents or other supervising adults. Please follow them!
- >>> Save the packaging and instructions. They contain important information.
- >>> Never experiment with wall outlets or the household power supply. Never insert wires or other parts into wall outlets! Household voltage can be deadly.
- >>> The experiments will require one 9-volt square battery, which is not included in the kit due to its limited shelf life.
- >>> The supply terminals are not to be short-circuited. A short-circuit could lead to overheating of circuits and battery explosions.
- >>> Batteries are to be inserted with the correct polarity. Press them gently into the battery compartment.
- >>> Always close battery compartments with the lid.
- >>> Non-rechargeable batteries are not to be recharged. They could explode!
- >>> Rechargeable batteries are only to be charged under adult supervision.
- >>> Rechargeable batteries are to be removed from the toy before being charged.
- >>> Different types of batteries or new and used batteries are not to be mixed.
- >>> Exhausted batteries are to be removed from the toy.
- >>> Dispose of used batteries in accordance with environmental provisions.
- >>> Make absolutely sure that metallic objects such as coins or key chains are not left in contact with battery terminals.
- >>> Do not bend, warp, or otherwise deform batteries.
- >>> An adult should check each assembly before use to make sure it is assembled properly.
- >>> After you are done experimenting, remove the batteries from the battery compartments.



## Dear Parents!

Our lives today are surrounded by electronics, and every day we use dozens of electronic devices. So it's all the more important to know how they work.

This experiment kit will provide your children with a safe and simple introduction to electronics. It explains about electronic components such as transistors, LEDs, resistors, and capacitors, and how simple electronic circuits work.

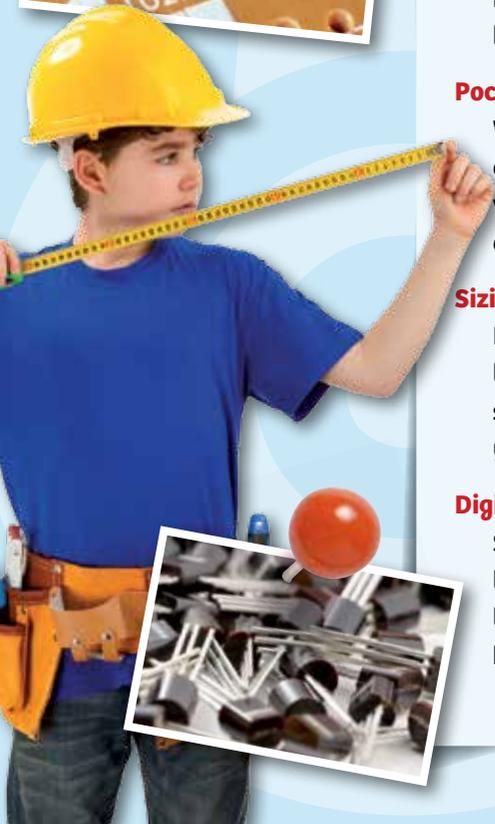
Of course, you may have questions about safety. All of the experiments are powered by the battery compartment included here, which holds an ordinary 9-volt square battery. So the experiments are carried out with the very low and safe electrical current of just nine volts.

In addition, this kit meets U.S. and European safety standards. These standards impose obligations on the manufacturer, but also stipulate that adults should assist their children with advice and assistance with the experiments.

Tell your child to read all the relevant instructions and safety information, and to keep these materials on hand for reference. Be sure to stress the importance of following all the rules and information while performing the experiments.

We wish you and your young electrician a lot of fun with the experiments!





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Your capacitors will have an important role to play in this chapter too. You can use them to construct an adjustable time switch, a red-green flasher, and other useful circuits.

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Your electronics kit has another component in store for you. The 555 timer will help you assemble complex circuits with the use of very few components. Try it!

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In this chapter, you will learn what you can do with your operational amplifier — “op-amp” for short. It can be used for all sorts of devices ranging from a tool for comparing voltages to a “random generator.” And if you combine it with the FM module, you can have a home-made radio alarm right next to your bed.

**TIP!**  
 You will find additional information here: “Check It Out”  
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**GOOD TO KNOW!** If you are missing any parts, please contact Thames & Kosmos customer service.

## The components in your kit

This list provides brief descriptions and illustrations of all the components in the experiment kit.



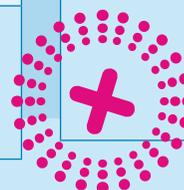
Component Name	Qty.	Component Description	Component Illustration
<b>Battery compartment</b> Item No. 712961 <i>Never connect the two battery terminals directly together! The battery and cables could get hot and cause a fire. Also, the battery would drain very quickly.</i>	1	This is the power pack that supplies the current you need for the electrical experiments. Before starting the experiments, attach a 9-volt square battery to the battery clip. Then, you will be able to draw electrical current from the two terminals (+ and -).	
<b>Selector switch</b> Item No. 705055	1	This electrically connects two of the three contact plugs, depending on the position of the switch knob.	
<b>Push button</b> Item No. 705054	2	This electrically connects the two terminals when you press the button.	
<b>Connector with 4 terminals (X-shaped)</b> Item No. 705050	45	For connecting components. The metal plugs of other components are inserted into the side slits so that they are electrically connected to each other as indicated by the white lines. In the instructions, they are called "X-connectors."	
<b>Straight connector with 2 prongs (I-shaped)</b> Item No. 705051	15	For the electrical connection of components. The two plugs are electrically connected to each other. In the instructions, they are referred to as "I-connectors."	
<b>Angled connector with 2 prongs (L-shaped)</b> Item No. 705052	8	For the electrical connection of components, but in a way that guides the current at a right angle. Looks like an "L," hence referred to as an "L-connector" in the instructions.	





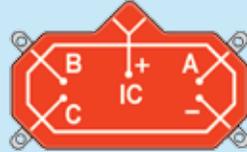
Component Name	Qty.	Component Description	Component Illustration
<b>Connector with 3 prongs (T-shaped)</b> Item No. 705053	6	For electrical connections. The three prongs are electrically connected to each other as indicated by the white lines. Referred to as <b>"T-connectors"</b> in the instructions because their shape is similar to that of a "T."	
<b>Connector with 4 prongs</b> Item No. 712958	3	For the electrical connection of components. Only the two opposite prongs are electrically connected, not all four of them. They are used for creating crossover junctions in the circuit. They are therefore called <b>"bridge connectors"</b> in the instructions.	
<b>Red Light-emitting diode</b> Item No. 712930	1	This emits a red light when current flows through it. Abbreviated as "LED"	
<b>Green light-emitting diode</b> Item No. 712929	1	This lights up in green when current flows through it. Abbreviated as "LED"	
<b>Yellow light-emitting diode</b> Item No. 712931	1	This lights up in yellow when current flows through it. Abbreviated as "LED"	

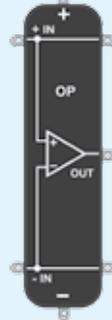
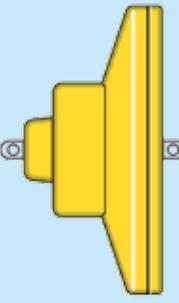
Component Name	Qty.	Component Description	Component Illustration
<b>Infrared Light-emitting diode</b> Item No. 712932	1	The IR diode emits invisible infrared light when current flows through it.	
<b>Transistor (NPN)</b> Item No. 708800	2	The transistor is a fundamental electronic building block. It is hidden inside electronic devices and computer chips, sometimes by the thousands. It serves as an amplifier or electric switch, and will have an important role to play in your experiments. It has three terminals, which it is important not to mix up!	
<b>Transistor (PNP)</b> Item No. 712925	1	This transistor is similar to the NPN type, but it has different properties. The PNP transistor also has three terminal prongs, which you must not mix up! You always have to be careful to use the right transistor. Usually, it will be the NPN type.	



>>> KIT CONTENTS



Component Name	Qty.	Component Description	Component Illustration
<b>Phototransistor</b> Item No. 708803	1	This component reacts to light: It lets electric current pass through more or less easily, depending on illumination.	
<b>Diode</b> Item No. 712926	2	An electrical valve that only allows current to flow in one direction, and blocks it in the other.	
<b>Sound generator (IC)</b> Item No. 708804	1	This orange-colored component produces all kinds of noises created by dozens of transistors inside its housing working together in a complex.  <b>Note! Do not forget to install the 22-Ω resistor when you use the sound generator!</b>	
<b>FM module</b> Item No. 712939	1	This is a miniature VHF radio receiver that you can use to build a radio.	

Component Name	Qty.	Component Description	Component Illustration
<b>555 timer</b> Item No. 712927	1	A special component that you can use to perform all sorts of interesting experiments.	
<b>Op-amp</b> Item No. 712928	1	Operational amplifier: An amplifier component with special, very useful qualities.	
<b>Speaker</b> Item No. 708805	1	It turns noises from the sound generator into something you can hear.	

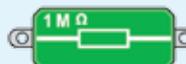


Component Name	Qty.	Component Description	Component Illustration	Component Name	Qty.	Component Description	Component Illustration
<b>Resistor, 22 ohms (22 Ω)</b> Item No. 712951	1	Resistors allow you to regulate the flow of current. They come in various electrical magnitudes, indicated in “ohms” (Ω), “kilohms” (kΩ), or “megohms” (MΩ). Resistors with large values let less current through than ones with smaller values printed on them.  <b>CAUTION! Always use the resistor with the correct specified value!</b>		<b>Resistor, 2.7 kilohms (2.7 kΩ)</b> Item No. 712943	1	Resistors allow you to regulate the flow of current. They come in various electrical magnitudes, indicated in “ohms” (Ω), “kilohms” (kΩ), or “megohms” (MΩ). Resistors with large values let less current through than ones with smaller values printed on them.  <b>CAUTION! Always use the resistor with the correct specified value!</b>	
<b>Resistor, 150 ohms (150 Ω)</b> Item No. 712940	1			<b>Resistor, 3.3 Kilohm (3.3 kΩ)</b> Item No. 712944	1		
<b>Resistor, 470 ohms (470 Ω)</b> Item No. 712941	2			<b>Resistor, 5.6 Kilohm (5.6 kΩ)</b> Item No. 712945	1		
<b>Resistor, 1.5 kilohms (1.5 kΩ)</b> Item No. 712942	1			<b>Resistor, 10 Kilohm (10 kΩ)</b> Item No. 712946	2		



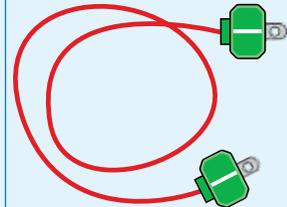
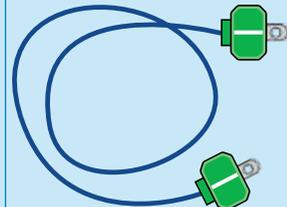
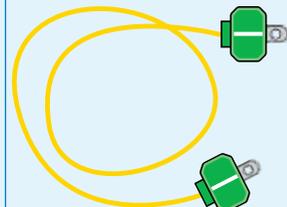
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Component Name	Qty.	Component Description	Component Illustration	Component Name	Qty.	Component Description	Component Illustration	
<b>Resistor, 22 kilohms (22 kΩ)</b> Item No. 708808	2			<b>Resistor, 680 kilohms (680 kΩ)</b> Item No. 712952	1	Resistors allow you to regulate the flow of current. They come in various electrical magnitudes, indicated in “ohms” (Ω), “kilohms” (kΩ), or “megohms” (MΩ). Resistors with large values let less current through than ones with smaller values printed on them.  <b>CAUTION! Always use the resistor with the correct specified value!</b>		
<b>Resistor, 39 kilohms (39 kΩ)</b> Item No. 712947	1			<b>Resistor, 1 megohm (1 MΩ)</b> Item No. 712950	1			
<b>Resistor, 68 kilohms (68 kΩ)</b> Item No. 712948	1			<b>Thermistor (NTC)</b> Item No. 712938	1		A resistor that changes its resistance depending on the temperature — with the resistance dropping as the temperature rises. At room temperature, it’s about 10 kilohms.	
<b>Resistor, 100 kilohms (100 kΩ)</b> Item No. 712949	1			<b>Potentiometer, 100 kΩ</b> Item No. 712934	1		A continuously adjustable resistor with a maximum resistance of about 100 kilohms. Informally known as a “pot.”	
<b>Resistor, 220 kilohms (220 kΩ)</b> Item No. 712953	1			<b>Potentiometer, 10 kΩ</b> Item No. 712933	1		A continuously adjustable resistor with a maximum resistance of about 10 kilohms.	



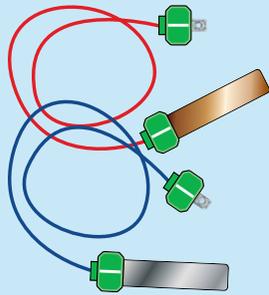
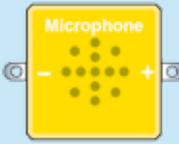
Component Name	Qty.	Component Description	Component Illustration
<b>Electrolytic capacitor, 470 microfarads (470 <math>\mu</math>F)</b> Item No. 712954	1	Capacitors have important tasks to perform in circuits. They come in a variety of electrical magnitudes, indicated in "microfarads" ( $\mu$ F). Only install the 470- $\mu$ F capacitor as shown in the circuit diagrams. <b>CAUTION! Always pay attention to the correct value and the polarity (the direction of the + sign), or they might get damaged.</b>	
<b>Electrolytic capacitor, 100 microfarads (100 <math>\mu</math>F)</b> Item No. 708810	2	Only install the 100- $\mu$ F capacitor as shown in the circuit diagrams. <b>CAUTION! Always pay attention to the correct value and the + sign, or they might get damaged.</b>	
<b>Electrolytic capacitor, 10 microfarads (10 <math>\mu</math>F)</b> Item No. 712955	2	Again, only install the 10- $\mu$ F capacitor as shown in the circuit diagrams. <b>CAUTION! Always pay attention to the correct value and the + sign, or they might get damaged.</b>	
<b>Capacitor, 0.1 microfarad (0.1 <math>\mu</math>F)</b> Item No. 708812	2	With this capacitor, it makes no difference which way around you install it.	

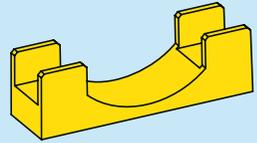
Component Name	Qty.	Component Description	Component Illustration
<b>Capacitor, 0.01 microfarad (0.01 <math>\mu</math>F)</b> Item No. 712956	2	With this capacitor as well, it makes no difference which way around you install it.	
<b>Red connecting wire with plugs</b> Item No. 712959	3	For connecting electronic components. At the ends, there are contacts that fit into the green X-connectors. Referred to as "red wire" for short, and primarily used to make a connection to a positive terminal.	
<b>Blue connecting wire with plugs</b> Item No. 713310	3	Like the red connecting wire with plugs, but in a different color. In the instructions, it is referred to as "blue wire" for short. Primarily used to make a connection to a negative terminal.	
<b>Yellow connecting wire with plugs</b> Item No. 713311	3	Like the red and blue connecting wire with plugs, but yellow. In the instructions, it is referred to as "yellow wire" for short. Use it for connections inside the circuit that don't specifically have anything to do with a positive or negative terminal.	



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Component Name	Qty.	Component Description	Component Illustration
<b>Electrode set</b> Item No. 712957	1	The electrode set consists of two wires. The red wire has a piece of copper sheeting at one end, and the blue wire has a piece of zinc sheeting.	
<b>Voltage and Current Meter</b> Item No. 712937	1	You can use this multipurpose meter to measure voltage and current strength. It has three measurement switch settings: 10 volts (10 V) for voltage measurements, 100 milliamperes (100 mA) for current strength measurements, and 500 microamperes (500 $\mu$ A) for particularly strong currents <b>CAUTION! Be very careful with this instrument, and always be sure to follow the instructions in the manual. Otherwise it could get damaged.</b>	
<b>Microphone</b> Item No. 712936	1	The microphone converts speech or noises into current oscillations. <b>CAUTION! Always note the plus and minus signs when inserting it.</b>	

Component Name	Qty.	Component Description	Component Illustration
<b>Holder</b> Item No. 712960	2	These are for holding the narrow side of the IR diode and phototransistor, so that they are positioned across from each other.	
<b>Divider Tool</b> Item No. 706078	1	You can use this to separate the inserted components or connectors apart without bending the plugs. Slide it between the components and push the components apart.	

**You will also need:**

Pencil, felt-tip pen, scissors, cardboard, tape, plastic ruler or set square, metal paper clips, aluminum foil, rag, hair dryer, plastic comb, piece of cloth, piece of plastic wrap, table salt, tap water, deionized (purified) water (drug store or hardware store), fruit juice, cola, ice cubes, cup or drinking glass, flashlight, desk lamp, TV remote, stop watch, magnifying lens, mirror, and various objects made of the following materials: glass, paper, plastic, wood, metal, porcelain.



## EXPERIMENT 15

## More or less resistance

What effect does a resistor have on a circuit? You can easily find out by using the selector switch.

### HERE'S HOW

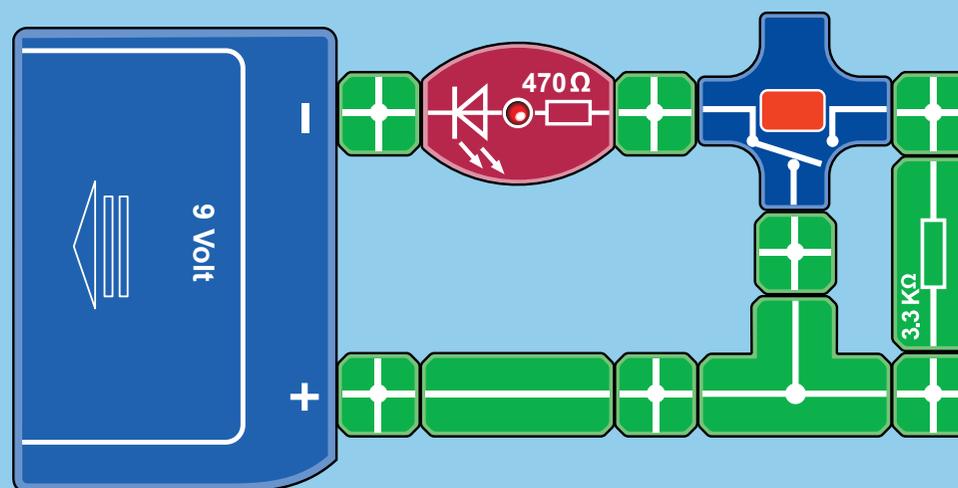
Try both settings of the selector switch.

Watch how the brightness of the LED changes.

In addition to the 3.3-k $\Omega$  resistor, try testing the other resistors in the kit as well.

### WHAT'S HAPPENING?

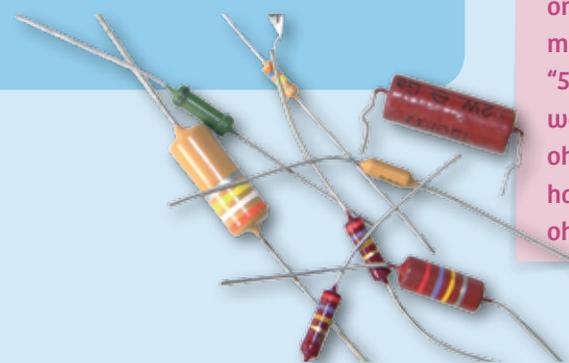
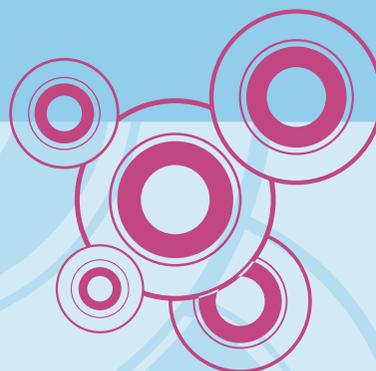
Follow the path of the current: Depending on the setting of the switch, it will flow directly to the LED or will have to pass through the resistor — in which case the LED becomes noticeably darker.



### RESISTORS IN VARIOUS SIZES

Resistors are components that possess a certain electrical resistance value. Usually, they look like little cylinders with two terminal wires. The ones in the kit are integrated into plastic housings.

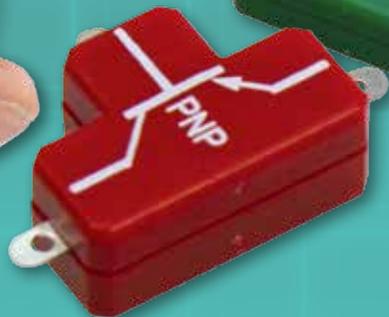
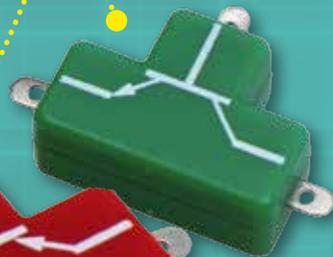
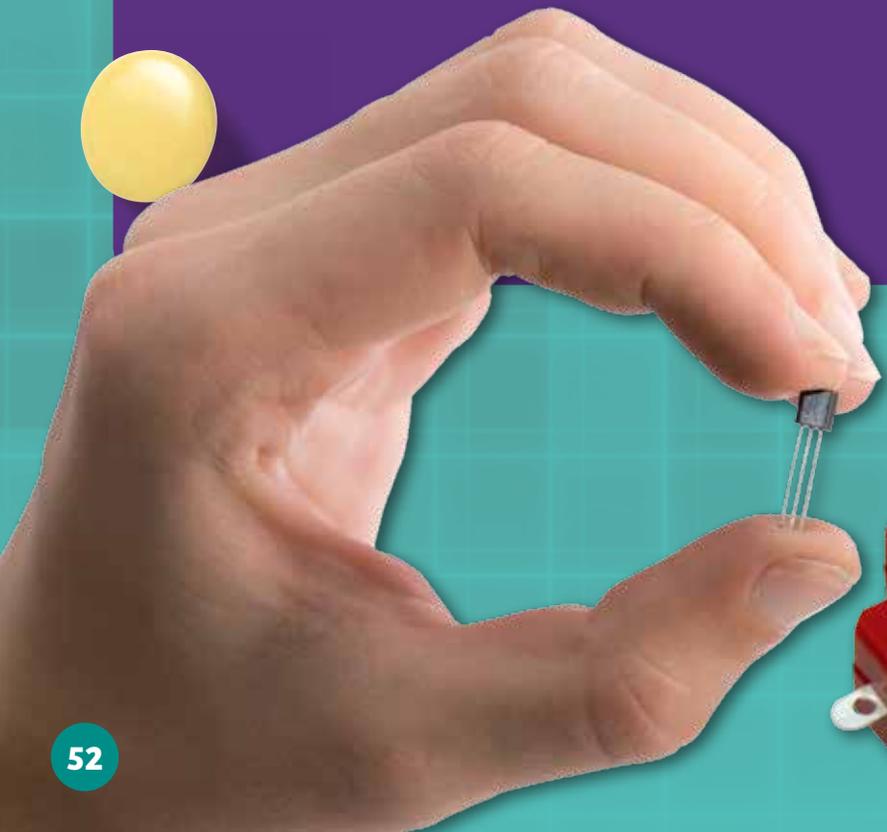
Because resistors play an important role in electronics, they come in lots of different magnitudes. Their magnitude, or value, is indicated in “ohms” (symbolized as “ $\Omega$ ”). The higher the value, the greater the resistance, and the harder it is for current to pass through it. A value of one “kilohm” (k $\Omega$ ) equals 1,000 ohms, while one “megohm” (M $\Omega$ ) equals 1 million ohms. A resistor with “5.6 k $\Omega$ ” written on it, in other words, has a value of 5,600 ohms, while the 1.5-M $\Omega$  one has a value of 1,500,000 ohms.



# Digitally Connected

In this chapter's experiments, you will be learning about what is widely accepted as the most important component in electronics — **the transistor.**

The transistor has many uses. You will start by using it as an electrically activated switch. Switches like this form the basis of all digital technology — in other words, computers. Each computer chip contains billions of transistors.



## TIP!

Remember that the kit contains two different types of transistors: the NPN type and the PNP type. You have to be careful to use the right one each time..

## Radios yesterday and today

It was only about 100 years ago in an experiment carried out at Brant Rock, Massachusetts, that the first radio transmissions were sent wirelessly.

The technical foundations had already been laid about ten years before then by the inventor **Nicola Tesla**, and the Italian **Guglielmo Marconi** subsequently improved the technology for transmission and reception. He was the first person to show that radio waves can cross great distances, even across the Atlantic.

At first, though, radio messages were only sent in the form of Morse signals — in other words, they were telegrams or distress calls. It was not until the 1920s that radio stations started regular operation.

There were not many listeners in the beginning, and the only available reception devices were primitive ones requiring large antennas and headphones. But once **radios were equipped with amplifier tubes ("vacuum tubes")**, reception improved and speakers were added to create something more like the radios we know today.

