# PACE Electrical Engineering

Circuit Components

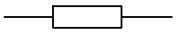
## Introduction

This lesson describes common circuit components and ones that we will be using during the year. The material in this lesson is very important in understanding electronics. Keep it handy and use as a reference while you build electronic circuits.

## Resistors

A resistor is a two-terminal element that resists the flow of electric current. Resistors have a property called resistance which quantifies the extent to which they inhibit current flow. Resistance is measured in ohms. The symbol for ohms is Ω (the Greek letter omega). Resistors have color bands that indicate the value of their resistance. See the resistor color code reference chart to learn how to read the code. The picture to the right shows a 1 kΩ resistor.

resistor (standard)

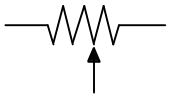


resistor (alternate)

Resistors are used to control how much current flows through another circuit element. In some cases this controls how that element operates. In other cases, it just protects the element from possibly burning out from excessive current.

The figure below the picture shows the circuit symbols for a resistor. In a circuit diagram the resistor may be labeled with its resistance value or it may be labeled with a variable, like $R_1$, with the corresponding resistance value shown in a table next to the diagram.

## Potentiometers



potentiometer

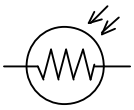
A potentiometer is a variable resistor. It has three terminals and a knob used to control its resistance. Stamped on the bottom of the potentiometer is a resistance value. There are no color bands. This value is its maximum resistance and is the resistance between the two outside terminals. The knob controls the resistance between the middle terminal and each outside terminal.

Typically, a potentiometer is connected into a circuit with the middle terminal and one of the outside terminals. It doesn't matter which one. The resistance between those two terminals varies between 0Ω and the potentiometer's resistance value when the knob is turned.

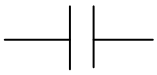
A potentiometer is used to fine tune the operation of a circuit as you'll see when you build the automatic night light circuit. It can also be used, for example, to control the volume of a speaker or buzzer or the brightness of a light.

## Light Dependent Resistors (LDRs)

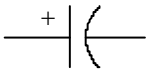
A light dependent resistor is a two-terminal device whose resistance decreases when it is illuminated by increasing light intensity. Without light shining on it, an LDR has an extremely high resistance and conducts little current. When it's illuminated, its resistance drops and more current can flow through it.



## Capacitors



capacitor



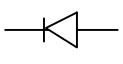

capacitor (polarized)

A capacitor is a two-terminal element that stores charge. Capacitors have a property called capacitance which quantifies their capacity for storing charge. It is measured in farads (symbol: F). Capacitors come in various shapes and sizes, some of which are shown in the figures below. One type requires special attention. Electrolytic capacitors are polarized. This means that it has a positive and negative terminal. Consequently, it matters which way it's wired into a circuit. Other types of capacitors are not polarized and can be inserted either way. The symbol for polarized capacitors has a plus sign to indicate the polarity. On actual electrolytic capacitors the negative terminal is shorter than the positive one and has minus signs on the body next to it.

Some capacitors have a code, such as 103 or 223 that's stamped on them that indicates their capacitance value. The first two digits are the first two significant digits of the capacitance. The third number is the multiplier, the number of zeros to tack on at the end. This gives the capacitance in picofarads (pF). So 103 is 10,000 pF or 10 nF. 223 is 22,000 pF or 22 nF. The electrolytic capacitors typically have their capacitance value written directly on them. The one on the right below is 10 µF.

Capacitors have on other important property. They block the flow of direct current.


## Diodes



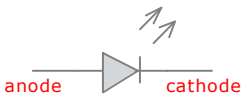
diode

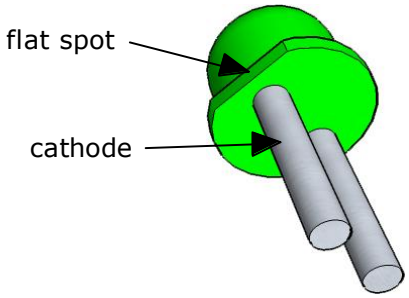
A diode is a two terminal element that conducts a current in only one direction. Consequently, when a diode is wired into a circuit, it must be wired in the correct direction. There is a bar on one side of the diode which corresponds to the line in the diode symbol, which allows one to correctly orient the diode.

Diodes do not have a measurable property, analogous to resistance or capacitance. There are different models and their model number is stamped on them.

## Light Emitting Diodes (LEDs)

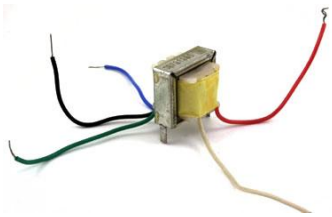
LEDs are diodes that emit light. Because they are diodes, they conduct electricity (and light up) only if wired into a circuit in the correct direction. LEDs come in different sizes and colors. The two terminals of a LED are called the anode and cathode. The shorter terminal is the cathode. The cathode can also be identified by finding a flat spot on the round ridge at the base of the head of the LED. The cathode is the terminal closest to that spot. See the figure below.

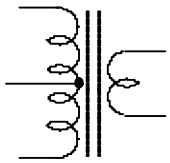


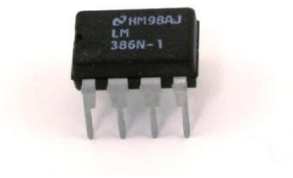

## Transformers

A transformer is a device that converts one voltage to another. Some transformers have four leads with the voltage applied between one pair being *stepped up* or *stepped down* to a different voltage across the other pair. The transformer that you will use in your first circuit project has five leads. It is called a center tapped transformer because the fifth lead taps a point between the leads on one side. The circuit symbol for and a picture of a center tapped audio transformer is below. The packaging for the transformer has a diagram that allows you to match up the wires in the transformer with the leads in its circuit symbol.



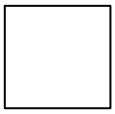


## Integrated Circuits

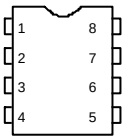



An integrated circuit is complete circuit manufactured in a small package. The package has input and output contact points called pins that allows access to the circuit, but also provides a convenient way to include it in a circuit. For example, the pins fit easily into a breadboard.

There are many different ICs that do different things. Each is labeled by its model number. The IC pictured here is an LM386, which happens to be a power



IC



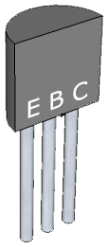

IC (shows physical pin layout)

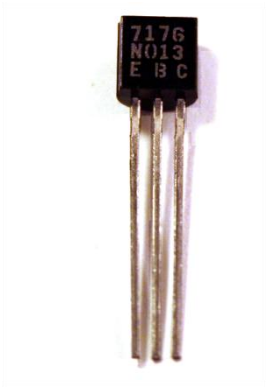
amplifier. ICs may have different numbers of pins. The LM386 has eight pins. Others have 14, 16 or some other number of pins. The ICs always have an even number of pins, although for some, not all the pins are used. Half the pins are attached to the left side of the packaging and half to the right. The top of the IC can be distinguished from the bottom by the notch at the top. The notch also provides a reference point for identifying the pins. They are numbered, starting at 1 from the top left and increasing as one goes down the left side and then up the right side.

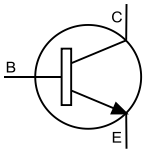
Available with each IC is a specification (also called datasheet) that explains what the IC does; provides, among other things, a diagram of the inside of the IC; and explains what each pin is used for.

## Transistors

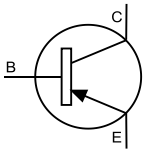
Transistors are three terminal devices that function as electronically controlled switches. There are various types of transistors. The ones we'll be using this year are called *bipolar junction transistors* (BJTs). BJTs are current-controlled switches. Their three terminals are called the base, emitter, and collector. The current into the base controls the current between the emitter and collector. There are two types of BJTs. The NPN type turns on when there is a current into the base and turns off when there isn't. The PNP type turns on when there is no current into the base. Among the NPN and PNP transistors, there are different models. The model numbers are printed on the transistor. In most cases the terminals are marked with E, B, and C for emitter, base, and collect. If they are not marked, the terminals can be determined by looking at the flat side. The emitter is on the left, the base in the middle, and the collector on the right.



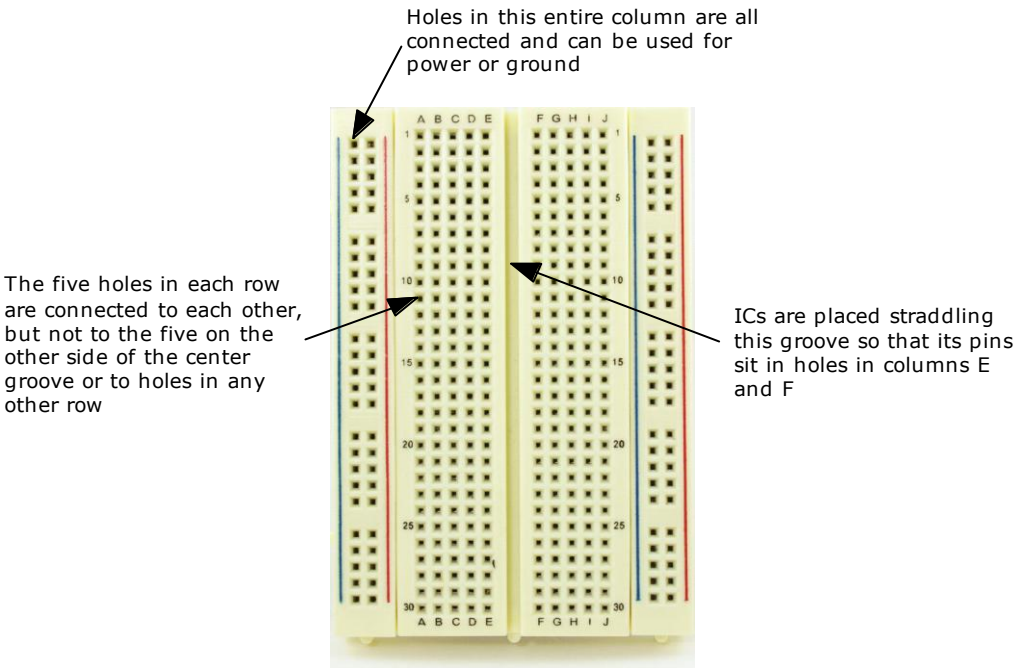

NPN transistor




PNP transistor

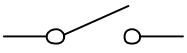
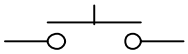
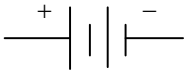
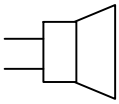
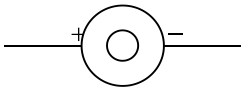
## Breadboards

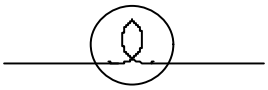
A breadboard is a device used to build, usually temporary, circuits.




## Other Circuit Symbols

Below are additional circuit symbols that you need to know.

| Circuit Element | Circuit Symbol | Circuit Element | Circuit Symbol |
|---|---|---|---|
| Switch |  | Push button switch |  |
| Battery |  | Voltage source |  |
| Speaker |  | Buzzer |  |
| Power |  | Ground |  |

| Circuit Element | Circuit Symbol | Circuit Element | Circuit Symbol |
|---|---|---|---|
| Light Bulb |  | | |