Electrical Switches

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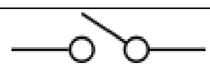
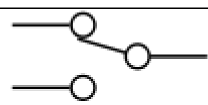
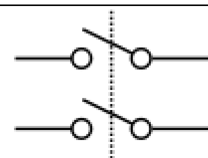
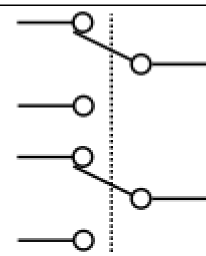
Think for a moment about all the devices in your house that are powered by electricity. Are they always on? Nearly all electrical devices have some type of **switch** that is used to turn the device on and off. If a light fixture is permanently attached to a ceiling or wall, then most likely there is a wall switch that turns the light on and off. How do you turn on your TV? Maybe there are two ways: 1) by using a remote 2) by pressing a button on the TV. Both methods use a switch. In the first method the remote control causes an internal switch in the TV to turn the power on and off (this may be a type of switch called a relay). It is likely that pressing the power button on the TV itself also controls the same internal switch of the TV. What about the electric stove in your kitchen (I am assuming you have an electric stove, not a gas one)? If you want to make one of the stove elements hot, then you may need to turn a knob on the stove for that element. The knob is connected to a special kind of switch that turns the element on and also controls how hot the element becomes by controlling the amount of electrical current flowing through the element. Do you use a hair dryer? When you plug the hair dryer into a wall receptacle does it power on? Most likely there is a power switch on the hair dryer. Now here is a trick question. Is there a switch on the refrigerator in your kitchen? Well, you may not be able to find one, but there is one inside. The refrigerator is equipped with a thermostat to control the temperature. When the temperature inside is not cold enough, the thermostat turns on an electric motor that is connected to a compressor. The action of the compressor causes the refrigerator to cool down. When it is cold enough again, the thermostat turns off the electric motor. You have probably noticed that your refrigerator makes a soft running noise (on) sometimes and sometimes it does not make any noise (off). The thermostat includes a switch that turns the refrigerator motor on and off. These are just some examples of switches on electrical devices in your house.

Electrical engineers use various terms to describe different types of electrical switches. A **single throw** switch is a simple type. In one position the switch is open (off) and in a second position it is closed (on). A **double throw** switch is more complex. It may have two or three positions. If it has two positions, then both positions are on. However, each on position controls a separate circuit. Suppose you had two light bulbs, each on a separate circuit. And let us say you wanted to turn either one or the other light bulb on. Then you could use a double throw switch for this job. If the double throw switch has three positions, then one position is open (off) and two positions are closed (on).

Switches can also be described by the number of poles. A one pole switch has only one arm for making and breaking electrical contacts. A double pole switch has two arms that are not connected electrically to each other. We can combine the terms throw and pole together to describe a switch. For example, a single pole single throw switch (SPST) has one on and one off position and is used to control one circuit. Although you may not realize it, you probably use single pole double throw switches (SPDT) every day. In your house do you have a light in the ceiling that can be turned on and off by two different switches? Those switches are the SPDT type (also called “3-way”). A double pole double throw switch is even more complex. It can be used for tasks like reversing the direction of rotation of a DC electric motor, which you will discover in this lesson.

You can find diagrams (schematics) of switches on page 63 of your robotics notebook and in the table below. There is a DPDT switch mounted on your circuit board just like the one in Figure 1. There are two arms of metal connected to an insulating black handle. Each of the arms is part of one pole. When the switch is positioned down on the right side, the center terminal of each pole is connected to its respective right terminal. When the switch is positioned down on the left side, the center terminal of each pole is connected to its respective left terminal. There are six terminals on this switch where wires can be connected. I have selected this DPDT switch for you to use because it can also be wired for the other types as well (SPST, SPDT, DPST).

Figure 1 a knife type DPDT switch

 SPST	 SPDT	 DPST	 DPDT

The terminals of a switch are represented by circles in the diagrams above. These are the symbols engineers use for switches when drawing schematics of circuits. The angled lines represent the arms of the switches and the horizontal lines represent the wires connecting to the terminals. For the double pole switches notice that there is a dotted vertical line, which indicates that the two poles are connected mechanically but not electrically. In other words, if the switch handle is down, both arms must be down and if up, both arms must be up. However, there is no electrical connection between the two poles.

In this lesson, you will need to use the switch in Figure 1 as a SPST switch and as a SPDT switch (in the next lesson you will use it as a DPDT switch). This can be done by using only some of the terminals for the SPST and SPDT switches. All six terminals must be used to make the switch function as a DPDT.

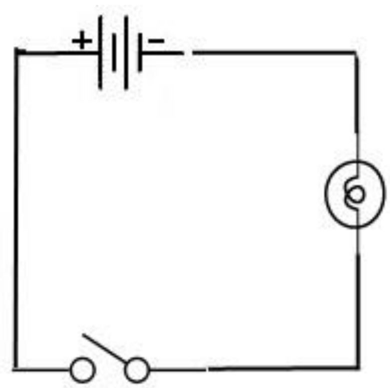


Figure 2 SPST switch with light bulb

Figure 2 is a very simple circuit schematic, containing a battery for power (the battery symbol has plus and minus signs to indicate polarity), one light bulb, and a single pole single throw switch (SPST). As you can see in the figure, the SPST switch has only two terminals (circles). It is a one pole switch because it has one arm. There are only two positions for the switch. If the arm touches both terminals the switch is closed (on). If the arm only touches one terminal, the switch is open (off).

The circuit schematic in Figure 3 is the typical "3-way" switch configuration of house lighting, where two switches are wired to turn a light on or off. The circuit contains two SPDT switches. Each switch has three terminals and two positions. Together, the two switches provide four combinations of switch positions. Each of the combinations is illustrated. Two of the combined switch positions result in a closed circuit and the other two in open circuits. Therefore, either switch can be used to turn the light on and off. Suppose there is a light in the ceiling of a hallway and you would like to place a switch at each end of the hallway. Each switch should be capable of turning the light on or off. The circuit diagramed in Figure 3 is the solution to that problem.

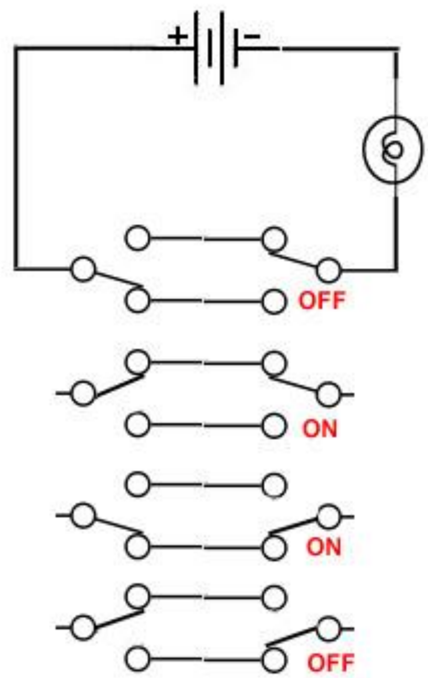


Figure 3 light bulb with two SPDT switches

Figure 4 is a photo of an actual 3-way switch used in house wiring. Notice that it has three terminals. The common terminal is the one that is connected inside to the switch arm. The traveler terminals are the terminals that the arm contacts. When the switch is in the up position, one of the traveler terminals is connected to the common terminal. When the switch is in the down position, the other traveler terminal is connected to the common terminal.

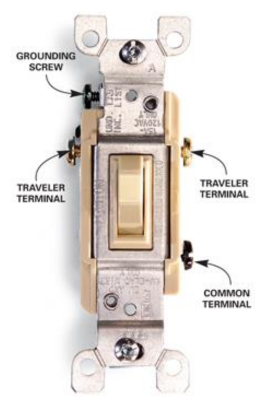


Figure 4 3-way switch (SPDT)

(continued on next page)

Motors that run on direct current (DC) spin clockwise or counterclockwise depending on the polarity of wire connections to the DC power source (battery). A DPDT switch can be wired to make the motor spin in one direction or the other depending on the switch position. Suppose we are designing an electric golf cart that must move forward and backward. We could control the direction of the cart with a DPDT switch as diagramed in Figure 5. Notice that when the switch arms are up, the plus side of the battery is connected to the top terminal of the motor. However, when the switch arms are down, the plus side of the battery is connected to the bottom terminal of the motor. The polarity of the connections to the motor are opposite for up and down positions of the switch (this symbol:  indicates that the crossing wires do not connect to each other).

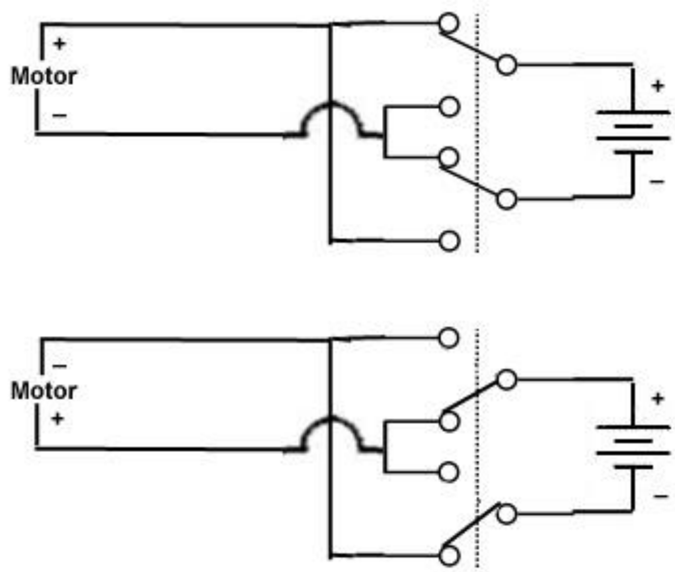


Figure 5 wiring of a DPDT switch to control the direction of spin of a DC motor

Figure 6 is a DPDT toggle switch. Notice that it has 6 terminals for wire connections. You will use a switch like this when you build your line following robot later this year.

(your activities begin on the next page)

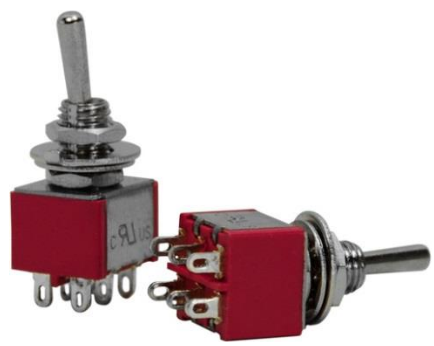


Figure 6 DPDT toggle switch

Module 1, Activity B – Off and On

Turn to page 64 in your Robotics Notebook. In this activity you will complete three challenges. Your work will be slightly different than that described in the Robotics Notebook because you will be using a circuit board equipped with a switch. Therefore, you should follow the directions below rather than the directions in the notebook.

Challenge 1: using your circuit board and wire jumpers, connect the series circuit of light bulbs you wired in a previous activity so that they operate with the switch of the circuit board. Wire the switch so that it operates like a SPST switch. Before you close the switch, have your advisor check your wiring. Remember to avoid a short circuit in your wiring. A short circuit is a path by which electricity can flow from one side of the battery to the other side without flowing through a light bulb. After your advisor checks your circuit, close the switch to confirm that it will turn the lights on. Then make a drawing of your circuit in the space provided in your Robotics Notebook on page 64.

Challenge 2: using your circuit board and wire jumpers, rewire the parallel circuit of light bulbs you wired in a previous activity so that only one light bulb operates with the switch of the circuit board (the other two bulbs should always remain on regardless of the switch position). Wire the switch so that it operates like a SPST switch. Before you close the switch, have your advisor check your wiring. Remember to avoid a short circuit in your wiring. After your advisor checks your circuit, close the switch to confirm that it will turn the one light on. The other two light bulbs should remain on regardless of the switch position. Then make a drawing of your circuit in the space provided in your Robotics Notebook on page 64.

Challenge 3: using your circuit board and wire jumpers, wire your switch to operate like a SPDT switch. The switch should be connected to two light bulbs. In one switch position one light bulb should be on. In the opposite switch position, the other light bulb should be on. Before you close the switch, have your advisor check your wiring. Remember to avoid a short circuit in your wiring. After your advisor checks your circuit, close the switch in both positions to confirm that each position turns on only one light bulb and that the different positions turn on different light bulbs. Then make a drawing of your circuit in the space provided in your Robotics Notebook on page 64.

Once you have finished these activities, you will move on to the next lesson which covers direction of current flow.