Light Emitting Diodes

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In Lesson 3 we will experiment with direction of current flow. The electricity supplied to your home is alternating current (AC). Recall that AC changes direction of current flow, while direct current (DC) flows only in one direction. In the United States, homes are supplied with 60 cycle AC. That means the direction of current flow changes 120 times each second! Many appliances and electrical devices in your home can operate on alternating current (electric stove, refrigerator, washer, drier, incandescent light bulbs, etc.). However, electronic devices, such as a computer, cell phone or television, require direct current to operate properly. If the device is powered by battery, there is no problem because batteries supply direct current. However, if the electronic device is connected to an electrical receptacle in your home, then the AC must be converted to DC.

Conversion of AC to DC is brought about by using semiconductors called diodes. Diodes have a special property that allows electrical current to flow in one direction, but not in the opposite direction. Figure one is the schematic symbol used for a diode. I have added plus and minus signs to the symbol. Recall that by convention, current flows from positive to negative. The arrow in the symbol indicates the direction of allowed current flow. The heavy vertical line reminds us that current is not allowed to flow in the opposite direction (right to left). When we place a diode in a circuit and apply AC current, the diode permits current flow only in the direction of the arrow.

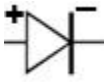

Figure 1 Diode

If we use only one diode in our circuit, then the end result is pulsating DC current. There will be 60 pulses of current each second in the direction of the arrow. During each cycle ($1/60^{th}$ of a second), current flows from left to right for half the cycle and during the other half, no current flows at all (the diode blocks the current).

Pulsating DC is not an acceptable power source for electronic devices because it introduces excessive "noise" into the circuits. In order to produce acceptable DC power, we need to use several diodes and additional components called capacitors. We will learn more about this in a future lesson. For now we will just experiment with one diode in Lesson 3.

The LED (light emitting diode) is a special kind of diode. In addition to allowing current flow only in one direction, it also emits light when current is flowing through the diode. LEDs are commonly used in electronic devices where a light source is required (power indicator, etc.). You will be using several LEDs when you build your line following robot later this year.

In Lesson 3 you will be using an LED that emits red light. I have included technical information about this LED at the end of this paper, which was provided by the supplier. The LED was supplied by LITE-ON ELECTRONICS, INC .

If we apply excessive voltage to an LED, it will be destroyed immediately. The LED is designed to operate within a limited voltage range. In the table on page three of the supplier's data sheet, we see that the typical forward voltage for the LED is 2.0 volts and that the maximum forward voltage should be 2.6

volts. Already we can see there will be a problem in using the LED with our circuit board, which supplies either 1.5 volts or 3.0 volts. One voltage is too low, the other too high. However, we can solve this problem if we add a resistor to our circuit. That is exactly what you will do in Lesson 3. I have supplied for you either a 47 ohm or 56 ohm resistor to be used in series with the LED.

In Lesson 1 you learned about parallel and series circuits. Recall that in series circuits, each load in the circuit drops the voltage a fraction of the supplied voltage. This is exactly what we want to do here. We need to supply 2.0 volts to the LED but must use a 3.0 volt battery supply. That is possible if the resistor in series with the LED drops the voltage by one volt. Now we will go through the calculations an engineer would do in order to select a proper resistor. That is, we need to know how much resistance the resistor should supply.

First we need some additional information from the data sheet. On page 2 of the data sheet, we see that the Peak Forward Current should not be more than 120 milliamps. However, this is only for a LED that is flashing on and off, being on only $1/10^{th}$ of the time. The continuous forward current maximum is 30 milliamps. That is the figure we need because our LED will be on continuously. Now we have the information we need to make our calculations (the LED needs 2.0 volts and no more than 30 milliamps current, and we will be using a 3.0 volt battery). Now we can apply Ohm's Law to find the resistance required for our resistor. Our resistor must drop 1.0 volt with 30 milliamps of current.

Resistance = Voltage/Current

Resistance = 1.0 volt/0.030 amp

Resistance = 33 ohms

If we use a 33 ohm resistor in series with our LED, the voltage supplied to the LED will be about 2.0 volts with a current of 30 milliamps. You will notice that this resistance is less than the resistance I have provided for you. It is usually a good idea to be a little conservative when designing our circuit. Perhaps it is better if we design it to use less current so that the LED will be protected for sure. Of course, the LED will not produce as much light if we reduce the current, so that is the trade-off we need to consider. Suppose we use a 47 or 56 ohm resistor instead? That just happens to be the resistors I have in stock that are a little higher in resistance than 33 ohms.

Current = Volts/Resistance = 1.0 volt/47 ohms = 0.021 amp or 21 milliamps

Current = 1.0 volt/56 ohms = 0.018 amp or 18 milliamps

Therefore, if we use a 47 or 56 ohm resistor in series with the LED, then we will limit the current to about two thirds of the maximum rating. I think that is a good result. Also keep in mind that two fresh batteries in series supply slightly more than 3.0 volts. Therefore, if we used a 33 ohm resistor with fresh batteries, we would exceed the maximum rated current. Also note from the data sheet that the reverse maximum voltage is 5 volts. Diodes can block current in the reverse direction only up to a certain voltage. In this case you would be in trouble if you applied more than 5 volts in the reverse direction.