Introduction to Soldering

Ammar Alsibai, events@cse-club.com Fall 2014

Introduction

This workshop focuses on soldering for the beginner and explains how you can solder a variety of components using a few different techniques - from the classy to the downright caveman. Although soldering can seem daunting at first, once you give it a try you will see that in most applications it’s quite simple to do.

Goal

Your goal today is to be able to solder a small circuit onto a proto board, and be able to get the circuit working. You will be required to get your hands dirty and map out your design on the proto board, place components and make permanent connections using solder. A battery has been provided to you so that you may test your circuit.

What is Soldering

Soldering is the process of using a filler material (solder) to join pieces of metal together. Soldering occurs at relatively low temperatures (around 400 degrees Fahrenheit) as compared to brazing and welding, which actually melt and fuse the materials themselves at higher temperatures. In soldering the filler material becomes liquid, coats the pieces it is brought into contact with, and is then allowed to cool. As the solder cools it hardens, and the two materials are joined. Soldering is a quick way to join many types of materials, from copper pipe to stained glass. It creates an electrically conductive strong bond between components that can be re-heated (desoldered) if you should ever want to disconnect two items joined together. It’s great for joining electrical components and wires and is used in just about everything electronic. *Caution! : Solder contains lead which is known to cause birth defects and lots of other nasty things! So please take care not to inhale the fumes (THEY ARE TOXIC) coming off your solder and soldering iron tip while soldering.

Materials

Today you will be given:

- Proto Board
- Led’s (light emitting diodes)
- Resistors (470ohm)
- 2032 button cell lithium battery
- Wire
- Soldering Iron
- Solder

- Sponge

Your Soldering Iron

Using a soldering iron to solder, it’s a great heat source that heats up and cools down quickly and can maintain a pretty constant temperature. Soldering irons can be purchased from a variety of places. I have picked up some at RadioShack - evil yes, but convenient, some from the hardware store, some from garage sales and a bunch more from retailers online. Low wattage (15-40 watt) soldering irons work best for soldering components on circuit boards while more powerful (60-140 watt) soldering irons work well joining thicker materials like braided speaker wire. If you use too powerful of a soldering iron on a circuit board you might damage the components you are trying to join. I like to keep a low-wattage iron around for detail work, and a high-wattage iron that I can use when I am not too concerned about exposing the material I am working with to high temperatures. It’s a real pain to solder thick wires without a powerful soldering iron.

Your Solder

There are lots of kinds of solder available. They come in different thicknesses from around .02” to some really thick stuff you would only use on copper pipe with a butane torch. You use thin solder for detailed work like putting resistors onto circuit boards and thicker solder for joining larger materials like speaker wire. I use solder around .025” for most jobs. Most solder is made from a combination of tin and lead - it’s about a 60% tin, 40% lead mix depending on what solder your using. Some solder will contain a small amount of silver. This pushes the melting temperature up a bit, but the silver helps the solder to flow and makes a stronger joint. If you are worried about burning whatever you’re working with, try to stay away from solder with silver in it, but it works very well if Your just joining wires or something that won’t be easily damaged. The last thing to know about solder is that you want to use a solder that has a rosin core. The rosin acts as a flux when soldering and helps the connection - it’s also the kind that’s most readily available at the hardware store and from electronics suppliers. The solder we are working with today is a rosin core solder.

Setting up your iron

Plug it in!

First things first, the tip of the soldering gets hot - up to 800 degrees Fahrenheit, so don’t touch it. I know this seems obvious, but many people seem to burn themselves at some point while soldering.

If Your using a new soldering iron you will want to put a small amount of solder on the tip of the hot iron before you start working. This is called tinning the iron and you only have to do it with a new iron. Once you start using it will usually have some solder on it already and be ready to go.

Once the iron reaches temperature (some irons take minutes to do this and some irons take seconds), I like to clean the tip of my iron on a wet sponge. You can wet the sponge on your soldering base if you have one, or you can just use a damp sponge or steel wool. Gently touch the tip of the soldering iron to the sponge and clean off any old bits of solder that might be stuck to it. It will sizzle a bit; this is normal. Next it’s time to pay some attention to the material Your soldering. If Your soldering wire, you’ll need to strip back about 1/2” of insulation to expose the bare wire. If your joints are going to be wire-to-wire or wire-to-lead, you can twist them together tightly before soldering. Electrical components placed on a circuit board don’t need much prep work; just seat them where you want them and find a way to hold them in place with clips or by bending the leads outward slightly so they stay put when you turn the circuit board over.

Finally, place what you want to solder on a surface you don’t mind getting a little burn mark on - scrap wood works well. Basically you just don’t want the components moving around on you when you go to solder them. There are lots of ways to orient the wires/components so you don’t have to hold them in place while you solder them. Find what works best for you. Hopefully your soldering iron has reached temperature by now, because Your ready to solder!

A little circuit design to get the lights on

You were given some Led’s resistors and a battery. You are tasked today to get a single Led turned on and working with a single resistor protecting the Led from the battery. There are a couple different ways to get this done. It will be up to you to create the circuit and make it permanent through soldering.

Ohms Law

`Voltage=Current×Resistance`

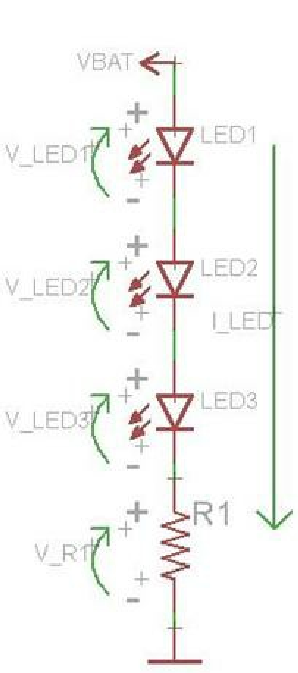
Light Emitting Diodes

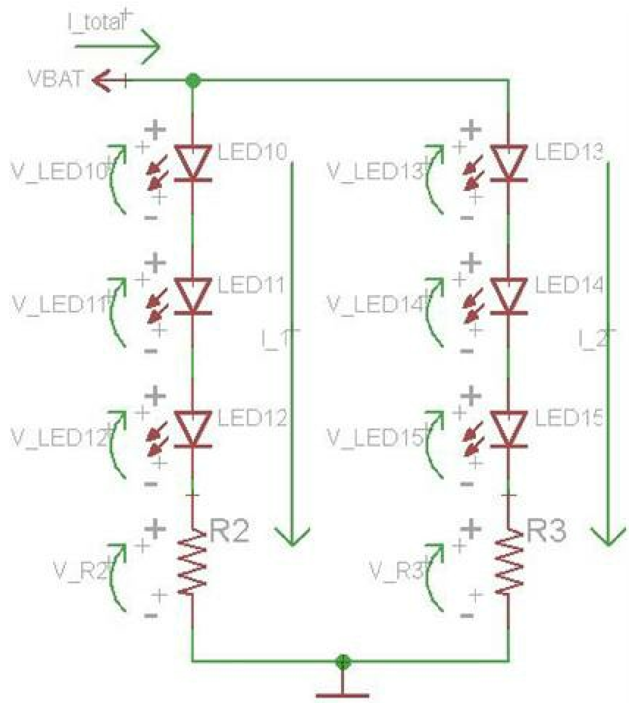
Led’s are a type of diode which light up when a voltage and current are applied to them. Every type of LED is different. White LEDs are typically around 3 V while red LEDs are typically around 2 V. Also, different kinds have vastly different current ratings, from 20 mA to 2 A. Common 3 mm or 5 mm LEDs are more in the 40 mA range. Unless you are just messing around and learning, you should always use a series resistor with an LED to control the current through it. Also, if you burn out an LED, don’t breathe in the fumes from it. LEDs have some pretty nasty chemicals inside of them that aren’t meant for inhalation.

Note: LEDS are polar. Meaning they only work in one direction, the longer lead is your positive end, while the shorter lead is your negative.

In general, the more current through an LED, the higher its voltage drop will be, and the brighter the LED will shine. However, each LED has a maximum voltage and current rating. An LED has almost no internal resistance, so connecting it directly to a battery will put the full battery voltage through the LED. It will shine very brightly for a little while, then overheat from the high current draw and burn out. Had you placed a 470 ohm resistor a 470 ohms in series with the LED it would have been fine

As far as arranging the LEDs, you can do it in many ways. To do it in series:





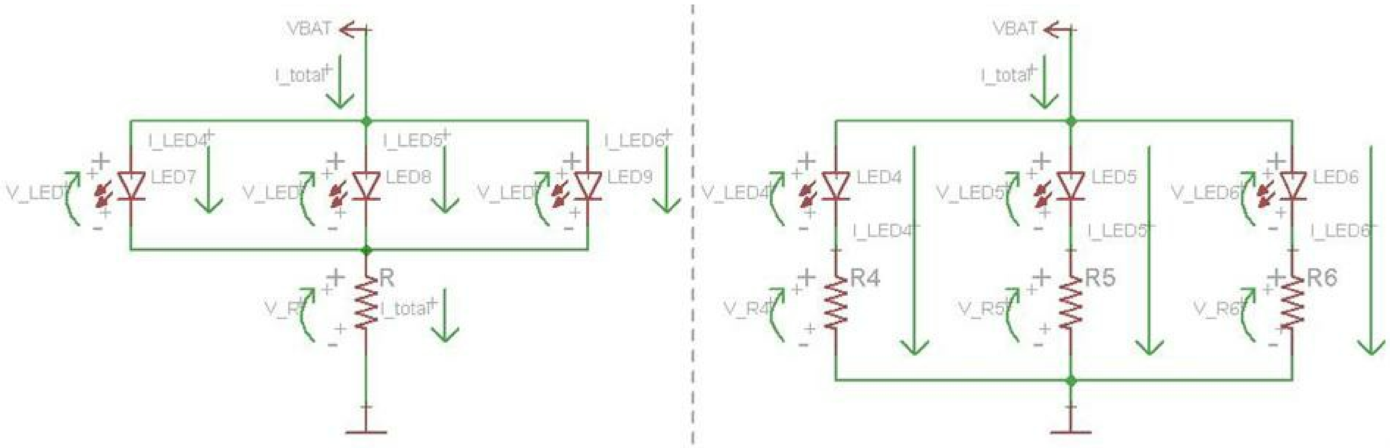
When things are in series, then share a current but have individual voltages. On the left are 3 LEDs in series with a series resistor. Since they are in series, they will “share” a current, meaning the same number of amps will pass through everything. However, each component will have its own voltage drop. Similar rated LEDs will not typically have identical voltages, so while LED1 may drop 3 V, LED2 may drop 3.2 V and LED3 may drop 2.8 V. In this case, the resistor (R1) will “limit” the current through the LEDs by dropping whatever voltage is left over. The battery voltage is given by the following equation:

```
VBAT=VLED1+VLED2+VLED3+VR1
```

If (on average) each LED is dropping 3 V, then there is VBAT−3×3V left over. With a 12 V battery, VR1=3V. The current through everything would be VR1/R1=ILED. If R1=1000Ω, then ILED=3V/1000Ω=3mA. A lower resistance will equal a higher current, but since the LED voltage drop is dependent upon the LED current, it is not always that simple to pick out the proper series resistance.

On the right are 2 parallel banks of 3 series LEDs, each with its own series resistor. All of the calculation are the same in this circuit as they were in the first. The only additional thing to note is that the total voltage across the left string will be equal to the total voltage across the right string because the strings are in parallel. However, the current through each string could be different, depending on the chosen series resistance in each string. The total current flowing from the battery is equal to the two string currents added together.

To do it in parallel



When things are in parallel, they share a voltage but have individual currents. The circuit to the left is common, but not very smart. The 3 LEDs are in parallel and share a single series resistor. In this manner, the LEDs are “forced” to have identical voltage drops. A lower source voltage is necessary here. The total current is still set by the single resistor, similar to the above circuits. This total current is equal to the sum of the three LED currents. For example, with a 6 V battery, 3 V LED (on average), and a 1000 ohm resistor, the LED current would be (6v-3v)/1000 ohms = 1mA the circuit is really only a bad idea if you are operating the LEDs near their max current. Since the LEDs won’t draw identical currents at the same voltage (each one is a little bit different) then one may burn out, causing the current through the other two to immediately go up since they share the current limiting resistor. This will likely cause the other LEDs to burn out as well.

On the right is the best way to do this, with each LED having its own series resistor. In this way, the current through each LED can be controlled, and each LED will continue working if any of the other ones burn out. ILED=VR/R. Each LED and resistor combination will have a total voltage drop equal to each other LED and resistor combination, but each LED can have a different current, depending upon the size of the resistor.

If you have a high voltage source, say 12 V, it is common to use parallel strings of series LEDs, such as the right circuit in the first image. Using a single LED will mean a much higher voltage drop across the resistor. This works, it is just a lot of wasted power. If you have a low voltage source, say 5 V, it is common to use parallel strings of LED and resistor combinations, such as the right circuit in the second image. If the voltage source is nearly identical to the rated LED voltage, say 2 V - 3 V, then you can omit the series resistor and connect the LEDs in parallel directly across the battery.

Soldering to the proto board (through hole)

When soldering LED and resistor leads into proto boards you want to heat the metal contact on the board and the lead itself. Applying too much heat can damage the proto board or even your components.

Touch the tip of the iron to the crack between the lead and the metal pad on the circuit board. After waiting a couple of seconds, dip the tip of the solder into the joint and placed a very small amount of solder at the connection - no more than the head of a pin or so.

Once the solder pools a bit and soaks into the joint remove the solder wire and then the iron. I remove the solder a second or two before I remove the iron so that the tip of the solder doesn’t get stuck to the joint. The solder begins to harden as soon as you remove the iron.

Using the proper amount of solder is more important while soldering small components on a circuit board than when soldering wires. If you apply too much solder and it pools up outside of the metal pad, it can cause a short. Too little solder and your component won’t make a good connection with the circuit board and might not work the way you want it to. When you’ve got the right amount of solder it looks like a small ant hill that forms right at the base of the lead and the circuit board. Once you’ve got your components soldered into the circuit board, you can go back and cut off the excess leads. This is pretty easy to do, and there isn’t much technique here. Just a few quick tips before you snip:

It’s best to use a sharp wire cutter that has just one side of its cutting edge beveled. This way you can get a smooth flat cut when you cut off the lead.

It’s also a good idea to cut the leads pretty close to the circuit board to minimize the risk of creating a short.

Extra Stuff

Surface mounting components onto a circuit board

Soldering components onto a circuit board when the leads can be pushed through holes in the board is the easier of the two methods of soldering small components onto boards. Many circuit components need to be surface mounted on circuit boards, which forces you to be a little more precise then when you can work on the bottom side of the board.

To solder something onto the surface of a circuit requires a process called tinning. Tinning is when you apply a small amount of solder onto the materials you are joining before you connect them. In this case, it involves putting some solder on a contact on the surface of the circuit board then attaching the component to the solder pool.

First touch the tip of the iron onto a small pad on top of the circuit board, introduce a small amount of solder onto the pad and take the iron away.

After a few seconds, pick up the component you want to solder with a set of tweezers, heat up the small glob of solder you just placed down and gently lower the component into the pool of hot solder. Take the iron away, hold the component in place for a few seconds longer and release the component from the tweezers.

Then go to the other side of the component and finish making the connection by soldering the remaining two contacts together.

Surface soldering is done like this because you need to lower the component into place by hand, so it's hard to hold the iron, the tweezer and the solder all at the same time. Additionally, tinning is just a good thing to do while soldering small components. I didn't tin the wires before I soldered them because they were so big I was sure I was going to be apply enough solder to make a good connection. However, when soldering small components or doing surface mount soldering like this, tinning can be really helpful because you basically already have your solder applied to your pieces before you go to connect them. There is no need to glob on more solder and run the risk of getting it in a place where you don't want it to be.

Soldering wire

Start soldering just two pieces of wire together because it's the most forgiving way to learn. You can't really get the wires too hot - the insulation might start to melt a bit, but Your not going to hurt the wire.

With the wires you want to join twisted together and held in place, pick up your soldering iron in one hand and your solder in the other.

Touch the tip of the soldering iron to the wires and keep it there.

The wires will begin to heat up. At some point over the next 2-10 seconds (depending on how hot your iron is) the wires will be hot enough to melt the solder. You can touch the solder to the wires (not to the tip of the iron!) periodically to see if it's hot enough. It's tempting to just touch the solder to the tip of the iron and melt it right away, but don't!

You will end up making what’s called a cold solder joint. This occurs when you melt the solder around the joint, but you aren’t melting the solder into your joint or onto your components to make a good connection. It’s much better to wait the few seconds and melt the solder onto the hot wire itself.

If you touch the solder to the wire and it begins to smoke and melt, the wires are hot enough. Add the tip of your solder to the joint as necessary. You want to introduce enough solder to cover the wires, but not so much that you create a big glob of solder at the bottom of the joint.

Once you’ve got what you think is enough solder on the joint, pull the solder away and then remove the soldering iron.

Fixing Mistakes (Desoldering)

Desoldering is the process of removing solder at a joint to disconnect two components, wires or materials. You might have to do this if you want to replace a component that’s gone bad, or if you want to change something about your design once it’s already soldered into place. To desolder wires you can usually just heat up the connection and wiggle them around until they come free. Better yet, if you have the slack, just cut the wire at the connections, strip, and resolder as necessary.

With leads that are mounted through holes on a circuit board it takes a little more finesse. To desolder something delicate its best to use a desoldering pump, or bulb which will actually suck up the molten solder and remove it from the joint. Soldering wicks or braided copper wire also work well to suck up unwanted solder.

Soldering is pretty forgiving, and its usually pretty easy to fix a mistake. If you put down a little too much solder or position something incorrectly you can usually reheat your joint, melt the solder, and then reposition your component as necessary. Solder can be heated and cooled as many times as you need to get your joint the way you want it. So don’t be discouraged if it takes you a couple of tries to get it down - you will still end up with a good connection if you stick with it.