CG1112 Engineering Principles and Practices II

Week 3 Studio 1 – Soldering & Wire-Wrapping
(Preparatory Material)

1. Introduction

In CG1111 you put together circuits on breadboards by plugging in the component legs into the breadboard holes, and connected the components again by plugging the wires into the appropriate holes, like shown in Figure 1.

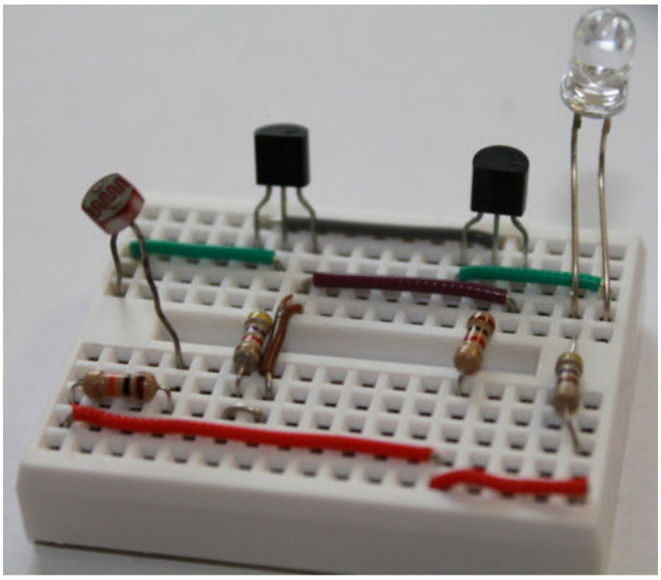

Figure 1: Circuit Prototyping using Breadboard

Unfortunately, as you have undoubtedly found out, circuits built on breadboards aren't very reliable. Wires and components can come loose, causing your circuit to fail. In addition, many of your breadboards don't look as nice as the picture above, and once the circuit gets pretty complicated, such prototyping techniques can be a nightmare, as shown in Figure 2.

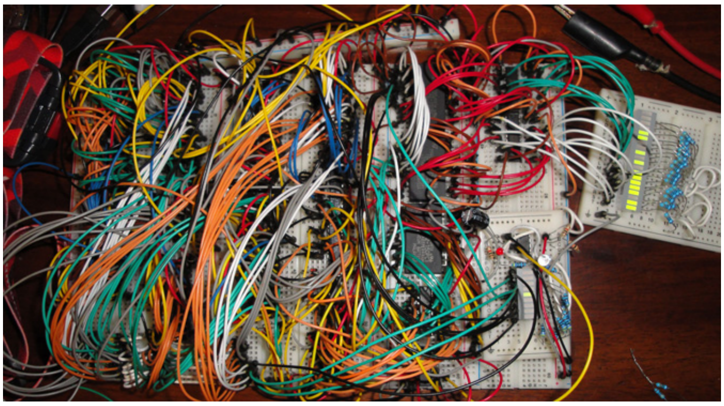

Figure 2: Messy Prototyping

In this studio we will be learning how to solder and wire-wrap. These techniques allow us to permanently connect components and wires together using a metal that melts at a low temperature, to permanently bond the joints.

2. <u>Soldering Equipment</u>

There are several important pieces of soldering equipment that you should be familiar with:

a. <u>Soldering Iron</u>

The soldering iron, together with the solder, are the two most important tools in soldering. The soldering iron consists of a long heating element, and a metal tip that is used for melting the solder:

Figure 3: Low-Cost Soldering Iron (Left), Soldering Iron with Temperature Control (Right)

The cheapest soldering irons just come with the heating element and a fixed tip, and a plug for power. More expensive soldering irons (like the ones you see in our lab) come with a temperature control and changeable tips. Figure 3 shows both these types.

If your soldering iron has a temperature control, for leaded solder you would typically set the temperature to around 300 degrees celsius (300C), and for unleaded solder, you would typically set the temperature to around 350C.

Do not make your iron too hot. Doing so can damage sensitive components (relatively easy, but possibly expensive to fix), and worse, remove copper pads from the board (absolute devil to fix).

Yes, the soldering iron is HOT, so be careful not to touch the metal parts. Figure 4 shows how NOT to hold a soldering iron (unless you like third degree burns on your hand)

Figure 4: How NOT to hold a soldering iron

You should always hold the rubber or plastic grip of the soldering iron. Not the metal part.

There are several different types of tips as shown in Figure 5:

Figure 5: Different Types of Soldering Tips

Typically you would choose a tip that suits the job you are doing. If you are soldering very tiny components (e.g. surface mount components), you would use a small tip. If you had to apply a large amount of solder, e.g. to tin a thick piece of wire (see "tinning" below), you would use a broad wedge-shaped tip like the leftmost and rightmost tips in the picture above.

There is even a scoop soldering tip like this that is good for soldering many legs of a surface mount device at the same time. Note that this only works for boards that have been properly coated to prevent solder from sticking BETWEEN legs (google "solder mask" to find out more)

Figure 6: Scoop Soldering Tip

b. Solder

The word “solder” is both a noun and a verb. It is a verb when you are assembling your circuit - “please solder that component on”. It is a noun when referring to the metal that is melted to bond your components and wires together.

Electronics solder comes in a roll, like what is shown in Figure 7. It can be leaded or lead-free. Leaded solder melts at a lower temperature, flows better and smells better. Lead-free solder melts at a higher temperature, flows as quickly as a pregnant and drunk lemur, and smells like one too, but with severe diarrhoea. Despite these undesirable qualities, as **responsible, MORAL citizens of the world who care about SUSTAINABILITY** WE MUST USE LEAD-FREE SOLDER. You also need to use lead-free solder in order for your products to get RoHS (Reduction of Hazardous Substances) certification.

Figure 7: Solder Roll

For our work we will use “multicore solder” or “rosin core solder”. Both types of solder are hollow, and the hollow space is filled with a chemical called “flux”, which cleans the joint to allow the solder to bond the components better. There is also solid-core solder which does not have flux. You should avoid these.

Solder comes in several different thicknesses. For our purposes a thickness of about 0.8 mm is ideal. If you had to solder very large joints (rare), you may want to consider solder that is 1.0 mm or more thick. If you are soldering very fine components, you will want to use solder that’s about 0.4 to 0.6 mm, together with a fine-tip soldering iron.

When buying your own solder, please check that it is for electronics. Some multicore solder meant for other applications comes with flux that can corrode and destroy electronic components.

Solder can also come in bars like what is shown in Figure 8:

Figure 8: Solder Bars

Unless you happen to own a wave soldering machine (in which case I really want to be your best friend), do not buy these.

c. Soldering Stand

The soldering iron gets really hot: Not just the tips, but any metal part. Placing your soldering iron on something flammable like paper will result in you burning down the lab.

Do not do this. Other people need to use the lab.

Instead you should use a soldering iron stand (Figure 9):

Figure 9: Soldering Iron Stand

The stand comes with a spring to hold the iron, and a piece of sponge or steel gauze to clean the tip. When you need to put the iron down, slide it into the spring.

Do not place the iron on the sponge for extended periods. You will get a lot of steam, and eventually smoke and fire. And burn down the lab.

d. Soldering Fan

In the days of yore when the Marlboro Man reigned supreme, nobody really bothered about the effects of solder smoke, particularly smoke from the flux.

Today we are slightly fussier, and there is less appreciation for accumulating years of oily flux smoke in one's lungs, so the use of soldering fans (Figure 10) has become mandatory.

Figure 10: Soldering Fan

When soldering, place the wider side in front of you, and switch it on (after plugging it into the wall and turning on the mains). The fan has a carbon fibre filter that will absorb almost all the smoke, keeping you from breathing them in.

This should be common sense, but nonetheless please DO NOT CLEAN YOUR SOLDERING IRON TIP ON THE CARBON FILTER.

e. Sucker

No, not a dumb person, but a tool to suck up solder if you make a mistake, as can be seen in Figure 11:

Figure 11: Desoldering Pump (Solder Sucker)

To use this, push the piston down, then heat up the solder that you want to remove (on the joint or surface, not on the roll of solder wire), place the nozzle of the sucker on the melted solder then press the button to release the piston and suck up the solder. Repeat until you have removed a sufficient amount of solder to fix the problem.

The sucker is properly called a "desoldering pump", but you're very welcome to shout "PASS ME THAT SUCKER!" to your team mates.

f. Optional Tools

There are some other things that are nice to have (I have them for myself) but not necessary:

Helping Hands

These are great because soldering can involve the use of up to four hands: One hand to hold the iron, one to hold the solder, one to hold the board and one to hold the component being soldered. Helping Hands (Figure 12) really helps a lot, and some come with magnifiers to help you see those really tiny joints.

Figure 12: Helping Hands

For EPP2, use your team mates' hands to help you.

Desoldering Braids

A desoldering braid (Figure 13) is a copper braid that is great for soaking up solder. To use, heat the solder you want to remove, and press the braid on the melted solder to absorb it.

Note that your fingers should not be directly contacting the part of the braid that is on the melted solder. You will get burnt.

Figure 13: Desoldering Braid

Microscope

No, not this:

But a nifty USB microscope with 20-200x zoom that lets you see what you are doing. Particularly useful if you are doing surface mount (SMD) soldering.

Figure 14: USB Microscope

For our labs ask a team mate to hold a magnifier for you.

3. How To Solder

Preparation

1. Turn on the soldering iron and set the temperature. 300 degC for lead solder, 350 degC for non-lead solder.
2. Wait for the temperature to stabilize.
3. Put a small amount of deionized water on the sponge. It should be damp but not flooded.
4. Wipe the tip of the iron on the sponge to remove any dirt.
5. “Tin” the iron. Do this by gently applying solder to the tip to coat it completely. It should be just coated. If you have a ball of solder hanging off the tip, wipe it off and try again.

Tinning (Not Always Needed)

If you are using wires with bare strands like this (Figure 16) and you need to solder it onto a flat copper pad, you need to tin the wire. You also need to tin your wire if you are soldering it onto things like the XT60 connector, used in drones.

YOU DO NOT NEED TO TIN WIRE IF YOU ARE SOLDERING INTO A HOLE IN THE BOARD.

Figure 16: Stranded Wires

To tin your wire:

1. Use your fingers to twist the strands together.
2. Pull out a short section of solder from the reel and leave it hanging out like this (Figure 17):

Figure 17: Solder Lead

3. Use the iron to heat the bare wire strands for a second.
4. Place the heated wire strands against the solder that is hanging out, and use the iron to heat the solder to melt it onto the wire.
5. Turn the wire and repeat until it is completely coated in solder.

You also need to apply a ball of solder to the flat copper pad. You can do this by heating the pad, then applying solder to the pad until it melts and forms a nice ball.

To solder the wire onto the pad, heat the tinned wire till the solder melts, then quickly bring it down onto the ball of solder on the pad to melt it. The solder on the wire and on the pad will melt together to form a strong joint.

Soldering

It's a bit complicated to explain here. Watch this video instead. :)

https://www.youtube.com/watch?v=Qps9woUGkvI

Finishing Up

After soldering, you MUST do the following:

1. Clean the tip of the iron on the sponge pad.
2. Tin the tip.
3. Switch off the soldering iron.
4. Clean up your work area.

3. <u>Wire-Wrapping</u>

Wire-Wrapping is another way of prototyping circuits in the development phase. It is done when you are confident of the circuit connections and wish to have a more reliable circuit board. Wire-Wrapping involves 30AWG wires and a Wire-Wrapping Tool.

The steps involved are as follows:

Step 1: Strip the 30 AWG wire by inserting it between the wire wrap tool's blades. Pull the wire to remove the insulation (Figure 18).

Figure 18: Wire Stripping

Step 2: Make sure to strip away enough wire to wrap around a terminal for a sufficient connection (Figure 19). About 2cm should be enough.

Figure 19: Stripped Wire

Step 3: Insert the exposed wire into the hole along the side (Figure 20). Make sure to insert the wire on the side with the notch and place the wire in the cut along the side of the cylinder.

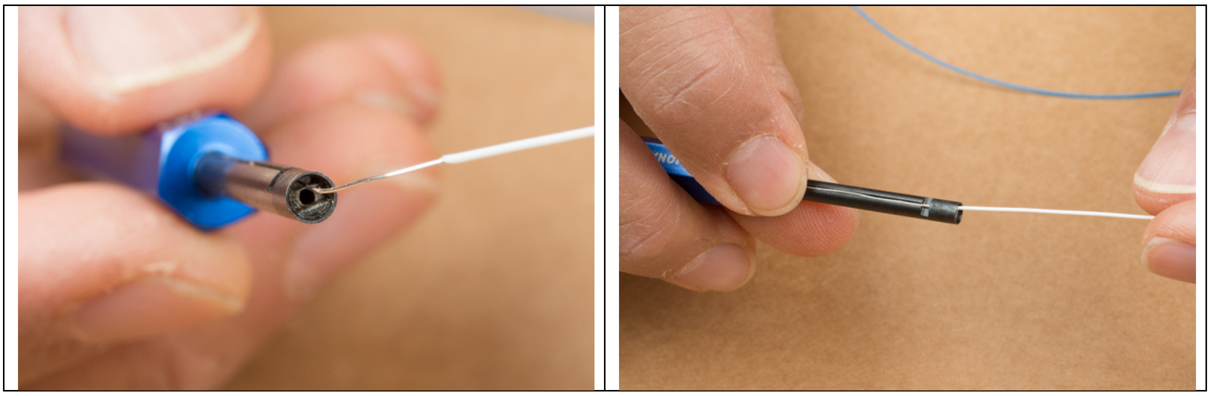
Figure 20: Inserting Wire into Notch

Step 4: Insert the wire into header pin (Figure 21). In this case, male header pins were used on a mini-breadboard. We will use this first to practise and get better at it.

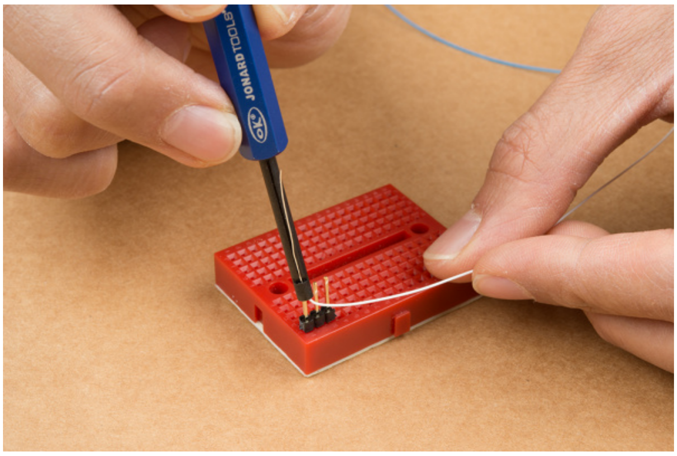

Figure 21: Inserting Wire into Header

Step 5: Rotate the tool clockwise to begin wrapping the wire around the square header pin (Figure 22). Hold the wire and header pins down with your other hand. Continue rotating the tool so that all of the stripped wire wraps around the pin.

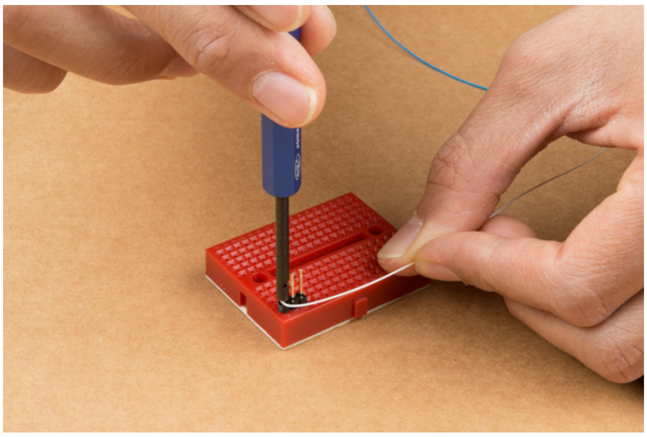
Figure 22: Wrapping wire around header

Step 6: Remove the tool from the pin. When completed, the wire's insulation should start at the bottom of the pin (Figure 23).

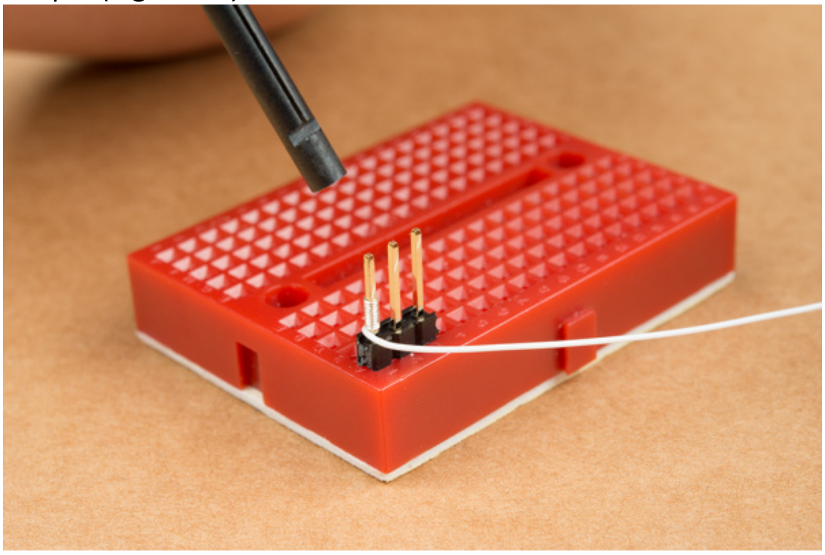

Figure 23: Wire Wrapped Pin

Step 7: If you require more connections on the same pin, wrap more wires around the top of the first connection and repeat the steps outlined above. The amount you can stack depends on the length of the header pin (Figure 24).

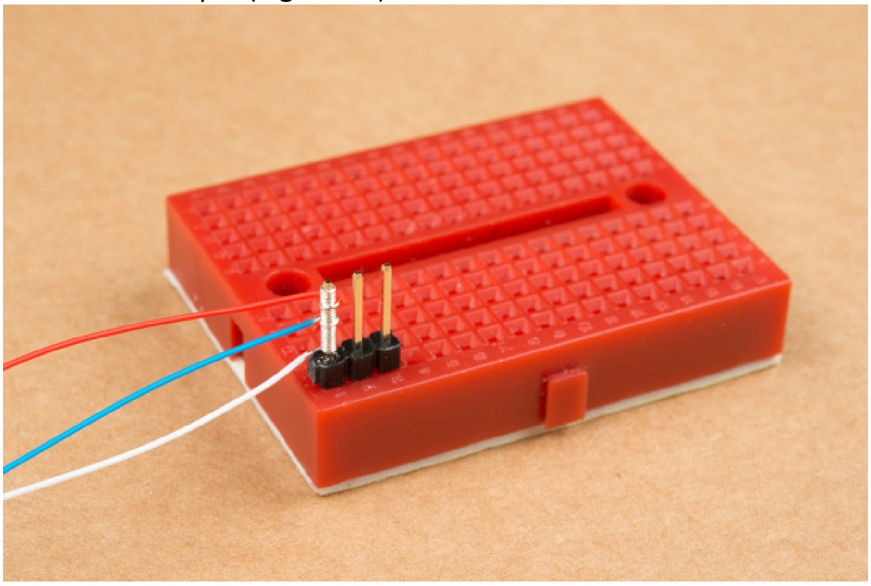

Figure 24: Multiple wire wraps on the same pin

Removing Wrapped Wires

If you need to disconnect the wire from the pin, follow these steps.

Step 1: Use the other end of the tool and rotate it in a counterclockwise direction (Figure 25).

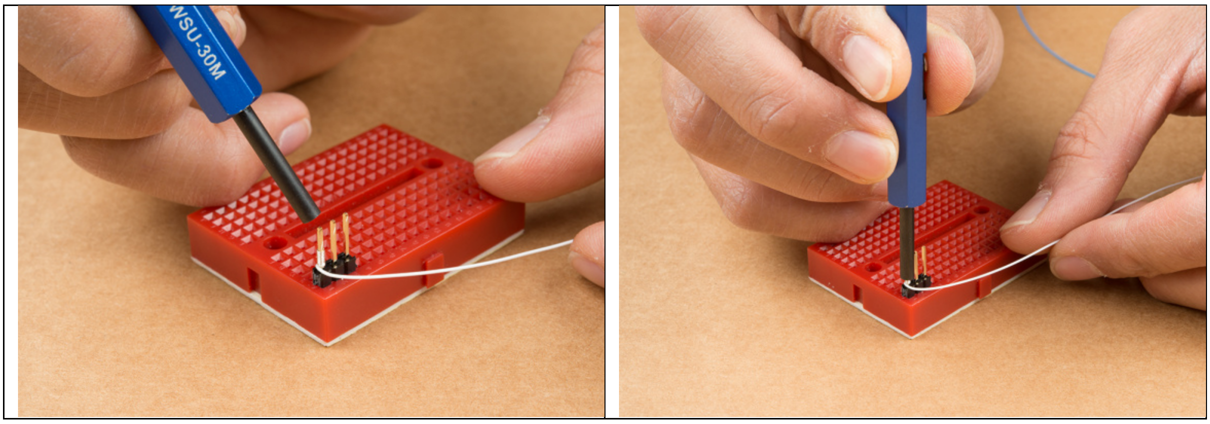

Figure 25: Unwrapping a Wire

Step 2: Once the wire wrap is loosened, pull the wire away from the pin (Figure 26).

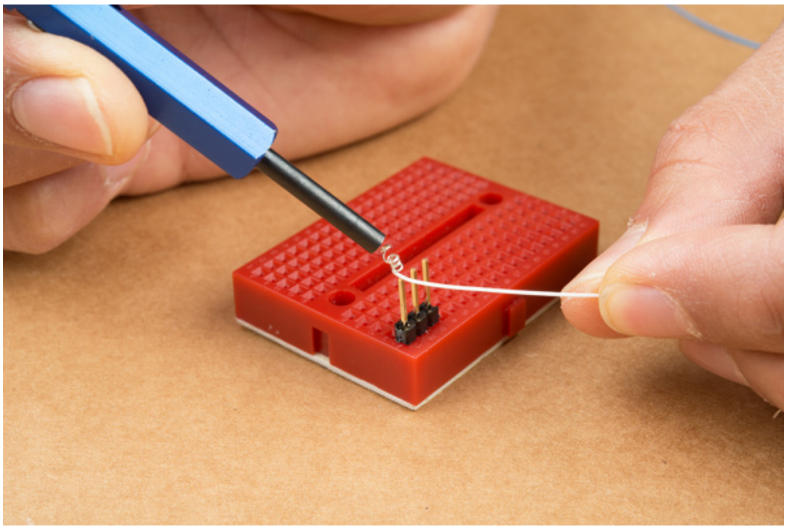

Figure 26: Removing Wire

Once you unwrap a piece of wire, it becomes brittle and can easily break. You should not re-wrap that same exposed wire on another pin. Instead, cut the exposed (stripped) part away and strip a new section of the wire again.

Conclusion

This preparatory material has exposed you to both Soldering and Wire-Wrapping. Have fun in your studio as you try these techniques to prototype your own board.

THE END