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Technical Process

Introductory Guide to Soldering Electronic Circuit Boards

For many new electronics hobbyists and technicians, soldering electronic circuit boards can be a daunting task. I know that's how it was for me when I began soldering 5 years ago at my first technical internship. But it doesn't have to be difficult. Thanks to valuable instruction from my mentor, the proper tools, and a good bit of practice, I was able to become proficient in soldering within a few weeks. Now I've soldered hundreds of boards and I feel confident in my skills enough to tackle just about any soldering task. It just takes practice. With proper safety, knowledge, and practice, skill in soldering opens the door to more professional and complete electronics projects as well as potential employment as an electronics technician.

First, we'll talk about the equipment that is necessary to begin soldering. Then, safety precautions must be addressed in order to ensure the wellbeing of all persons involved in the process of soldering, including yourself. After setting up our soldering station properly, we'll start with the basics of soldering and take the process step-by-step. To finish up, we'll look at some tips and tricks to practice as you apply your newly-learned skills to your own projects.

Gathering the Tools

Let's begin by gathering our materials. Look at Figure 1, at right, for a list of all the essential tools of the trade and some of my preferred options. This list is not comprehensive, but will be a good starting point for the essential items.

The soldering iron is made up of few different pieces including the station, the iron, and the tip. The station contains the electronics and controls that deliver the power to the iron.

Figure 1

Essential Soldering Tools:

- Soldering iron, which comes with the following:
  - Station
  - Iron
  - Tip
- Solder
- Safety glasses
- Vice or handless tool
- Metal clippers
- Tweezers
- Sponge or steel wool
- Your project components
- Access to a standard electrical outlet

The pencil-like device that connects to the station is the iron. Additionally, the soldering iron's tip is attached to the end of the iron. All soldering iron packages contain the necessary parts and have instructions for setting the system up correctly. There are many soldering irons on the market, ranging from $7 to $500 and up. Decent beginner's soldering stations range from $60-$120, such as the Hakko FX-888D. My favorite higher end soldering iron is the Pace ST-50 for about $350.

Maybe the most obvious piece of equipment is the solder itself. Any standard solder will be acceptable for the vast majority of soldering stations. Most solders have a rosin core that makes the solder flow onto the metal easier and are made of a tin-lead alloy (Sn60Pb40); thus, many solders are called 60-40 solder. For home use, I recommend lead-free solder for easy disposal and safety. This typically has a higher melting point, but removes or reduces the lead contained in the solder. For

beginners, whatever type of solder you choose, I recommend using a solder with a rosin core to make the solder flow onto the circuit easily.

The other essential tools are less complicated. Safety glasses are necessary to prevent solder from entering the eyes. Any standard safety glasses will work and if you already wear eyeglasses, additional safety glasses may not be needed. A small vice or handless tool helps to hold the circuit board or component in place when soldering. Just be sure the vice is large enough for your circuit board. The metal clippers will allow you to clip the legs off your components. Tweezers allow you handle the electronic components more easily and safely. Additionally, a sponge or steel wool will allow you to clean off your tip.

Finally, electronic components come in many forms. Most of the components used in hobbyist electronics and prototypes use through-hole components. These through-hole components are designed such that the ends of the component fit into designated holes in a printed circuit board (PCB). In this guide, I'll assume that you're working with components like this. See Figure 2, below, to see an example of a few through-hole components. The components shown include a resistor, two capacitors and an integrated circuit (IC). Notice that each component has two or more legs.

Figure 2

Each through-hole component has at least two legs that fit through holes in the PCB.

Safety First

Soldering requires the appropriate tools, but even more importantly, it requires precaution. After gathering the tools, you'll want to set up your soldering station safely.

For a list of the basic safety precautions, see Figure 3, below. The list should be used as a basic reminder and you can follow the tips described above in order to make your experience safe for you and those around you.

Figure 3

Safety First! Remember to take the following precautions when soldering:

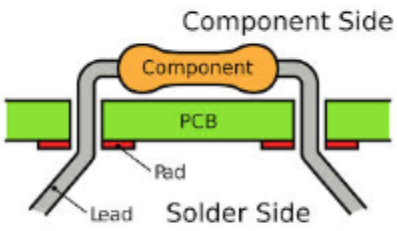
- Set up your workbench in a well-ventilated location
- Keep children away from work location
- Be aware that tip temperatures can reach more than 700°F
- Wear safety glasses
- Wear long sleeves and close-toed shoes
- Remove power sources from electronic components that will be serviced

First, set the soldering station up in a well-ventilated lab or workshop. Gather all tools and electronic components that you will be working on. Keep children away from the workshop if working at a school or at home. Be cautious! The soldering iron tip can reach temperatures over 700°F. Before turning the soldering station on, prepare yourself by wearing your safety glasses. It's also advisable, but not necessary, to wear long-sleeves and close-toed shoes so that any hot solder that comes off your workbench doesn't burn your skin. Also be sure that any electronics components that you plan to work on are not connected to a power source. This will prevent any of the electronics from short-circuiting.

Soldering a Circuit

1. ***Turn the soldering iron on.*** To begin, plug the soldering iron into an outlet. Turn on the soldering iron and, if the soldering iron has a variable temperature setting, set it to 650°F. Give the soldering iron about 1 minute to heat up.
2. ***Set up the circuit board.*** Place the circuit board in the vice or handless tool. Do this in a way that allows you to lay components on it so they lay flat without sliding off.
3. ***Tin the tip.*** Pick up the heated iron with your dominant hand as if it were a pencil. With your other hand, grasp the strand of solder. Hold the end of the strand of solder to the tip of the soldering iron. The solder should melt quickly (within a few seconds) and flow onto the tip. If this doesn't work right away, hold the solder to the tip longer. If this still doesn't work, you may increase the temperature of the soldering iron incrementally. A 5° increase is typical. This process is called"tinning" the iron.
4. ***Place the component.*** Now that the soldering tip is tinned, we may begin soldering a component onto the circuit board. Begin by matching a component with the designated holes in the PCB. For any passive components, like a resistor, capacitor, or inductor, this will be two holes about half a centimeter apart. Bend the legs of the component so that each leg fits through the holes. Insert the components legs all the way into the holes. The component should lie flat on the PCB and the legs of the component should hang below the PCB. Be sure that you have done this so that the component's body is on the opposite side of the PCB as the exposed metal (pads) of the holes, seen in Figure 4, at right. From underneath the PCB, bend the legs outward until they lie flat on the bottom-facing side of the PCB. It helps if you hold the component on the top-side of the PCB still so it doesn't move upward while you bend the legs. Now this component is ready for soldering!

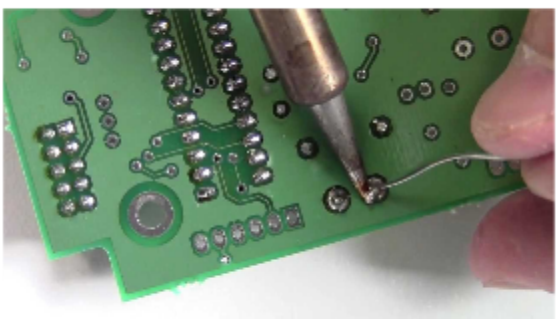
Figure 4



Insert the legs of the component through the holes of the PCB so that the pads are on the opposite side of the PCB as the component.

5. ***Begin to solder.*** Since the soldering iron tip is tinned and the component is in place, we may begin soldering the component to the PCB. We will solder one end of the component and then the other. Be sure that the metal pads of the PCB are facing up. Then, grasp the soldering iron in your dominant hand and the solder in your other hand. Place the soldering iron tip on one of the metal pads on the PCB so that it touches the metal pad and the metal of the component at the same time, as seen in Figure 5, below. The metal of both the component and the hole will heat up. Let the metal heat up for a few seconds and then place the tip of the solder in your left hand on the metal of either the pad or the component. If the metal has heated enough, the solder will melt on contact. If it doesn't, hold it on longer. If this still doesn't work, you may need to increase the temperature of the soldering station in 5° increments.

Figure 5



Place the tip and the solder on the metal pad or component to let the solder melt onto the PCB.

6. ***Fill the hole.*** As the solder melts, slowly feed more solder into the hole. Continue to do so until the solder has filled the hole without overflowing. If done correctly, the solder should appear to have fused to both the hole and the metal of the component. The solder should be mostly shiny and look as if there is no noticeable transition between the metal of the hole and the metal of the component. Remove the soldering iron tip as soon as you are satisfied with the amount of solder on the junction between the metal of the hole and the metal of the component (called the joint). Solder will not flow onto the joint if the iron is not in contact with the area. It's okay to add solder, remove the the tip, and then repeat several times.
7. ***Go with the flow.*** Sometimes the solder won't cooperate as you might expect. Feel free to change the angle or placement of the soldering iron or the solder when in contact with the joint. It will take some practice to get used to the amount of time required for your solder to melt or to heat up the metal of the joint.
8. ***Solder the other end.*** Once you are satisfied with one end of the component, let the joint cool; it will remain hot for up to a minute. Then you may tackle the other side of the component. Repeat the process you just completed. Feel free to move the PCB and the vice in any orientation that give you better access to the joint. Just be sure to leave the vice on the workbench and don't put your face too close to the PCB (no closer than about 6 inches). When finished soldering, your component should look like the one in Figure 6, at right.
9. ***Build your PCB.*** This process may be repeated with all of your components until your PCB is complete.
10. ***Clip the legs.*** Once you are satisfied with how your components are soldered to the PCB, you may remove the PCB from the vice and use the metal clippers to clip the excess metal off the legs. Be sure not to clip the legs on the same side as the component or you will have to solder on a new part!
11. ***Clean up.*** Once you've finished your PCB, be sure to allow the board to cool for a minute and turn off the soldering station. You may remove the PCB from the vice and use it as you see fit. If you won't be soldering again soon, be sure to clean your workbench and put away the solder and tools. It is best to wash your hands after handling solder to remove lead or other chemicals from your body.

Figure 6

After soldering a component, it should lay flat on the PCB.

More Techniques

There are many types of solders, soldering iron tips, components, and circuit boards. Here, we've covered the basics, but there are a few techniques that will help with further practice.

1. ***Clean the tip.*** Sometimes excess solder remains on the tip of the soldering iron when you don't really want it there. Most soldering iron kits come with a sponge or some steel-wool that allows you to wipe off the tip. If using a sponge, apply water to it to keep it damp. For either the sponge or steel-wool, make sure it is stationary and you can clean the tip one-handed in the middle of soldering a joint. Don't press to hard or hold the tip on the cleaning medium for too long (a

second or two should be plenty). After cleaning the tip, re-tin the tip of the soldering iron.

2. ***Use tweezers.*** If the soldering task does not use a PCB, there may be many loose components. Here, a vice will not be as helpful and you may have to use a hands-free tool to hold components. If this option is not available to you or you have multiple components that must be soldered together, tweezers may be helpful. These allow you to hold the component as you heat it with the soldering iron without burning yourself. Grab the iron in your dominant hand and apply excess solder to the tip. Using your other hand, grab the tweezers and use them to grasp the component near the soldering site. Apply the excess solder to the desired joint. If you work quickly enough, you can solder the joint with just the excess solder on the tip. Sometimes you will have to re-apply solder to the tip multiple times before the soldering joint is finished. This technique requires practice, but will open new possibilities for soldering jobs.

Keep Practicing

If all of this seems too difficult, just take a deep breath, away from the soldering fumes, of course. The procedure and techniques described above take time and repetition to master. When fatigue sets in or frustration takes the fun out of the project, the best practice is to step away for a few minutes and come back to the project when you've recovered.

Hopefully, you've learned enough about the tools you need, safety precautions you must take, and the basic procedures for soldering that you are confident you can tackle any basic soldering project. Feel free to refer back to this guide any time you need a refresher. There are also many good soldering tutorials online, if you wish to search there. Some of my favorite sites include makezine.com and sparkfun.com. Keep practicing and you'll be a soldering expert in no time!