Colin Lewis
Deep Space Antenna
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Note to students:
If you are placing a device on your PCB that may be easily affected by temperate or voltage, put risers on your board so that the device can be easily changed if it breaks.

Introduction
The goal for this note is to introduce students to soldering and debugging PCBs, as well as to point out a few things that I have learned along the way. This tutorial will cover adding components to a PCB, determining why a section of your soldered PCB may not be working and workarounds for these problems. We will begin with an introduction to the equipment you will be using, then go through how to use the equipment, and finally how to debug all of the mistakes you made while soldering your board.

Soldering Equipment
The number one resource, as UC Davis EEC 134 students, is the Engineering Student Design Center. Within the ESDC is the Engineering Fabrication Laboratory or EFL, where students have access to a wealth of equipment for soldering. To gain access to the EFL, students must take a one-hour class on how to use all of the equipment and proper safety measures while present inside of the EFL. The number one rules is that safety goggles must be worn, and headphones may not. The first machine, and the most important for this class, is the pick and place machine.

Pick and Place Machine

This machine allows users to add solder to their boards in very small quantities and then use a tiny vacuum tube to pick up a device and place it on the board. There is a camera near the vacuum tube to provide users with an up-close view of where the device is being place on the board.

Once all of the components are added to the PCB, the solder needs to be melted to form a connection between the device and the pad on the PCB. The reflow oven can handle three sizes of PCBs: small, medium, and large.

Reflow Oven (Easy Bake Oven)

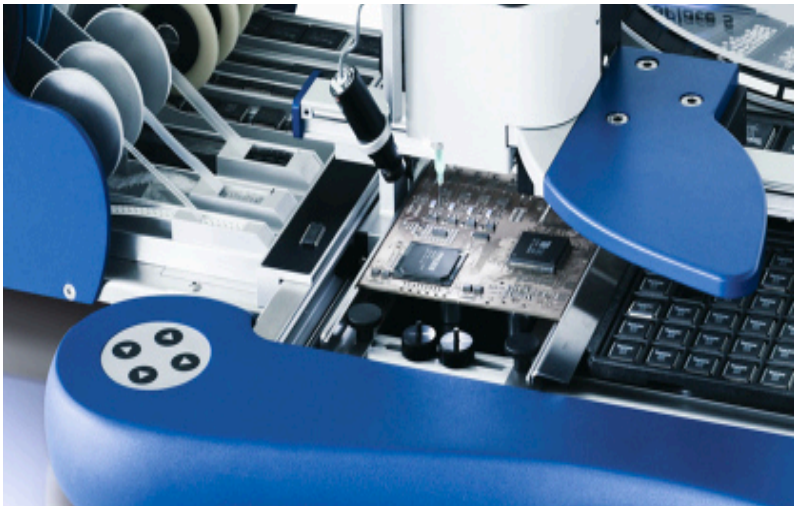
The most often used equipment for our team was the soldering iron and the hot air gun. This combination of equipment is just as capable as the pick and place and reflow oven combination. Although it requires steady hands to place components without a vacuum, it is much quicker to add them to the board.

Soldering Iron, Hot Air Gun, and Heat Vacuum

Instructions for Soldering

Pick and Place and Reflow Oven:

1. To solder your PCB with the pick and place, begin by placing your board on the machine inside of the rails. Then close the rails and tighten the screw so that the PCB does not budge when touched. You can turn the machine on by flipping the switch on left side of rear panel.

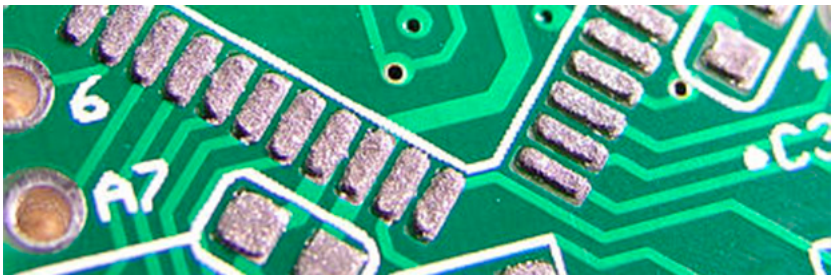


Pick and Place PCB Placement

2. Next, make sure that your solder is placed in the metal ring next to the vacuum tube. The tube is tightened with the Allen wrench sitting on the shelf above the pick and place machine. The placement of your solder tube needle needs to be slightly above the vacuum tube needle so that when you press the vacuum tube needle against the board, the solder will dispense onto the footprint You can also dispense solder by using the foot pedal on the floor.
3. With the direction pad shown in the photo above, choose your operation in the same manner. There will be four options, one for each direction, but we typically only use two.
    a. To use the vacuum to pick up a device:
        - Press the left-direction pad button for vacuum
        - Press the up-direction pad for automatic
    b. To use the solder dispenser:
        - Press the up-direction pad for solder
        - Press the up-direction pad for automatic
4. It is recommended to put the solder down first then to place the component on top of the solder. To do this, choose the solder dispense using the directions above, then, either using the footpad or the vacuum tube dispense method, direct the solder tube

needle to where you want to dispense and press down until there is enough solder to cover the footprint.

a. Note: The soldering paste is very forgiving because it shrinks after being heated. Typically, too much solder can create a short between the two pads of your component, but with the paste, much of the material will dissipate into a wax like substance leaving only the solder between the footprint and the component.



PCB with Soldering Paste

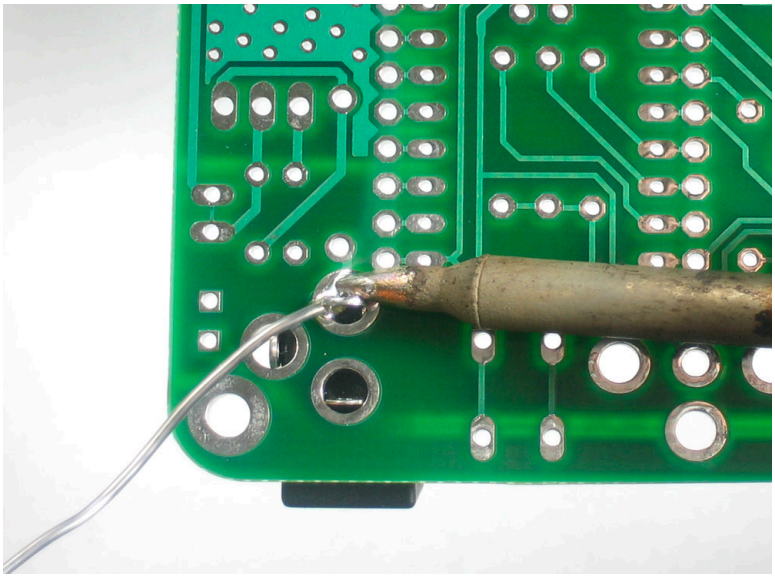
5. Once you dispense the soldering paste on all of the footprints, then place the components onto the solder using the vacuum. Choose the vacuum setting using the directions above and then carefully place your components within reach of the vacuum needle. Gently touch the component with the tip of the vacuum needle to securely pick it up and then move it to the area you want to place it. You can twist the vacuum using the metal handle to place the component in the correct orientation. Once you are ready to place the component, push the metal handle down until you make contact with the board, once you give it a little extra push the vacuum needle will retract inside slightly, and the vacuum will stop, leaving the component in place.

6. After all of your components have been placed on the PCB you can melt the soldering paste using the reflow oven. To use the reflow oven first turn it on with the large power button on the front. The controls are very similar to the pick and place machine. Use the direction pad to choose your settings.
    a. Start by pressing right-direction to choose settings
    b. Choose the direction based on the size of your board
    c. Press the right-direction to enter your settings
    d. The tray will open so you can place your PCB in between the metal slides
    e. Press the right-direction to close the tray and begin the reflow process
    f. Once complete, your PCB will emerge, and your components will be soldered

Soldering Iron and Hot Air Gun:

1. Using the soldering iron can be quite helpful if you need to work faster or make adjustments to a PCB. It is also essential for through-hole components. You can turn on the equipment by pressing the power switch on the front face. Clamp your PCB down with one of the laboratory tools so that it does not move around during soldering.
    a. For through-hole components:

i. Turn on the soldering iron by choosing the appropriate number corresponding with the soldering iron (different for each station). Then press both the up and down arrow simultaneously next to the display and the blue light on the soldering iron will illuminate signaling that it has begun to heat to temperature. The temperature is shown on the display and can be modified by pressing either the up or the down button.
ii. Place your component through the hole you want it to make a connection with.
iii. Use the soldering iron to heat the board and the component evenly for one second before adding the solder. Then lightly touch the tip of the iron and the solder should melt into place. Pull the solder away quickly after a small mountain appears over the connection. Then pull the soldering iron away and your component is in place.



Soldering a through-hole component

b. Surface mount components can be soldered this way, too but it can be very difficult when the iron tip is larger than the component. This method is not recommended and should only be used if absolutely necessary.

2. This method only works for surface mount components and devices, not through-hole. For all through-hole devices, I used the soldering iron. The hot air gun was enormously helpful with soldering on components and taking components off of the PCB. The hot air gun combined with a toothpick were the two items I used to solder almost all of my PCBs.
    a. The idea is that you get some soldering paste and put it on all of the pads you want your components to connect to similar to what was explained with the pick and place. I used the soldering paste because it's forgiving and it's wieldy, so it sticks to the pad and it can be distributed in small quantities, easily. I put the soldering paste on the narrow end of the toothpick and then use it to precisely

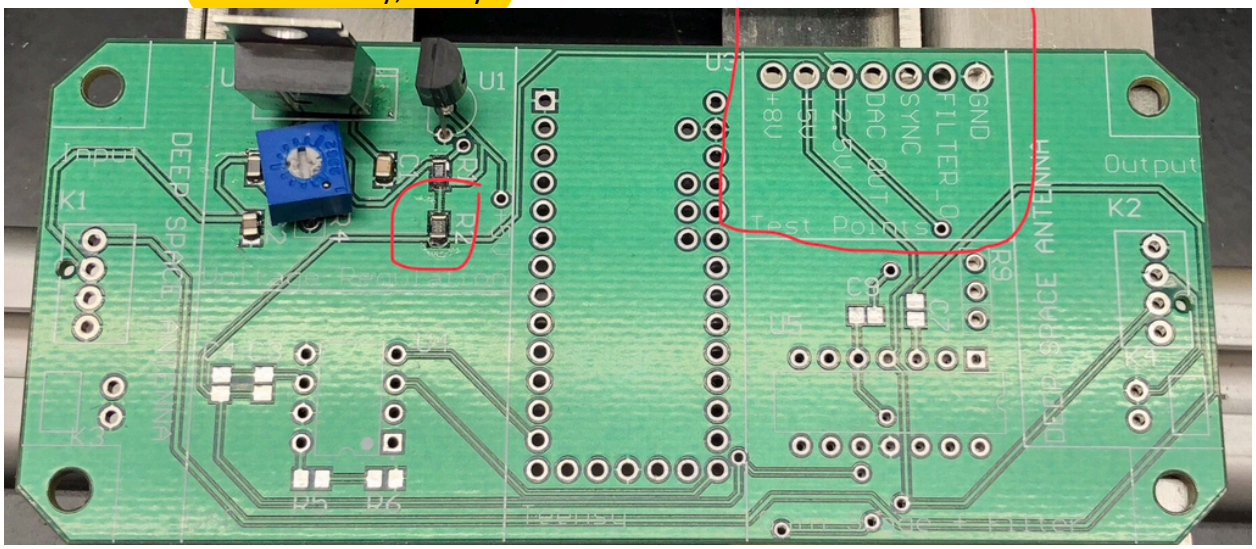
add soldering paste to the PCB pad where I want my component to be. You can add soldering paste straight from the soldering paste tube through the needle but it's often larger than the pad and tends to come out in large clumps.

b. After all of your components are in place, turn on your hot air gun by selecting the corresponding number on the front face, then press both the up and down button simultaneously, similar to turning on the soldering iron. The air needs to be turned down to about 20-25% so the components don't fly away, never to be seen again. Finally, blow the hot air vertically down on each of the components until the solder begins to melt, then make sure to heat up all four sides of the component so that all of the soldering paste has melted.

Debugging

Debugging begins when you design the PCB. Precautions need to be taken to allow for some error in the assembly process.

1. First, make sure that each section of your PCB is segregated through a wire containing a 0Ω resistor so that you can take it off to determine issues.
2. Place test points throughout the board so that you can read your voltages and signals at each point in the section. This takes minimal time during the design process and can help immensely while debugging and testing.
3. Test continuity on all resistors, capacitors, and devices. This setting can be found on most digital multi-meters and looks like an LED.
    a. Turn the DMM on and put the setting to continuity.
    b. Take the two ends (black and red) and place them on either side of your component.
    c. If a sound is emitted from the device, there is continuity. This can be tested by putting the two ends together before testing components. Sometimes the sound may be turned off so make sure to test the two ends before checking your PCB.
    d. Resistors, capacitors, and most devices should not have continuity. Inductors will have continuity, always.



0Ω Resistor and Test Points for Signals and Voltages