

SMD Soldering

1 Overview

We want to share with you some soldering techniques that will allow you to solder 0.5mm pitch devices and small 0603 components. This is by no means a certification course! There is a lot of information, training, and practice that goes into proper soldering. We just want to show you the basics.

This packet with associated tutorial videos is available online at:

<http://www.sparkfun.com/commerce/present.php?p=BEE-6-SolderingBasics>

Soldering is the act of heating up a pad on a PCB (printed circuit board) and a pad or wire on a component. Adding solder to these two heated pads causes the solder to melt. The solder will flow towards the heated pad and component. Removing the iron, the solder will quickly solidify creating an electrical contact and a very strong mechanical joint.

Jumpers are bad. A jumper (also known as a 'solder bridge') is an electrical connection that should not be there. As ICs and components get smaller and smaller, their pads are being located closer and closer to one another. This tight packing of pads increases the chance of accidentally soldering two neighboring pads to each other - in other words a 'solder bridge' or 'jumper' is created. We will show you how to minimize and remove bad jumpers.

2 The Rules

- **Rule 1:** Irons get hot. Don't poke your lab partner in the eye with it.
- **Rule 2:** You need to wet your sponge. This may seem counter-intuitive, *just do it*. I hate seeing people ruin irons because they're too lazy to get the sponge wet. This wet sponge is used to clean the corrosion on the tip of the iron. A dry sponge does nothing but damage the tip. Every time you pull the iron from the stand, it's a good idea to swipe the tip on the sponge just to clean it off and get a nice silver tip - it will allow you to solder much quicker and more cleanly.

- **Rule 3:** The point on the iron-tip is NOT the hottest part. This takes some getting used to. Learn to use the side of the tip near the point. It's all about getting the heat to flow from the iron to the joint. If you sit in one spot for a long period of time and nothing is flowing, take a step back, clean your tip, add a bit a solder to the tip, and try soldering the joint again.
- **Rule 4:** The soldering iron is only there for heat, not solder. You use the iron to heat two things - the part and the board, and then you add solder to the two heated parts. You *do not* add a glob of solder to the tip and then rub this mess against the two things you're trying to solder together. Use the side of the iron (remember, not the point) to heat the two parts while adding solder from the opposite side.
- **Rule 5:** Perfectionism kills. If you solder a joint, and it looks alright, let it be. Do not solder, then touch up, and re-solder, and then have to touch up a third time. This heating/reheating stresses the PCB (printed circuit board). You will quickly delaminate the board, lifting traces, pads, and destroying the board. Do this for fun on your own time.
- **Rule 6:** This is really getting ahead of ourselves here, but it's good to hear as many times as possible. When soldering joints that have a lot of thermal weight, heat the joint up for an additional 5-10 seconds. When you solder to a big part or a pad that has a lot of copper attached to it (very common with GND connections), it takes a few extra seconds for the iron to pump enough heat into the part to get it to the correct temperature to form a connection. If you notice your iron tip feels 'sticky', or if you see the solder balling to the pin instead of flowing to the joint, this is because one part of the joint is not hot enough. Hold the iron on the joint for a few extra seconds and allow the solder to flow correctly.

3 Tools and Soldering

You should have a few things in your soldering area:

- **Soldering Iron:** Variable temperature is nice to have. Digital, high-end units *are not* necessary to do SMD soldering. \$10 is far too little, but \$500 is a waste of money. Expect to spend between \$50 and \$100 for an entry level soldering iron.
- **Tweezers:** These are held in your 'bad' hand to hold the component while using the iron in your good

hand.

- **Wire cutters** : These are used to trim off leads from through hole components, cutting part tapes, breaking parts apart, and a range of other uses. Good to have close by.
- **Solder wick**: Sometimes called desoldering braid. This is a flat braided copper wire with added flux. You use this to wick or absorb solder from places it should not be. We use #2 size wick from Techspray. 25' will cost you about \$10.
- **Water**: This is to wet your sponge. A squeeze bottle is nice to have on hand. If you have not already, wet your sponge.
- **Solder**: We use 63/36 Sn/Pb solder. This is a mix of tin and lead with a special additive called flux. Solder comes in various gauges (wire sizes). We prefer to use 0.025" or 0.031" diameter solder. A 1 pound spool will cost ~\$30 and should last you a long time.

3.1 Iron Tip and Temperature

Soldering irons for electronics will vary in temp range from 200 to 500C (400 to 800F). Do not crank your iron up to 500C and leave it there. This will quickly and efficiently burn out the heater and tip. Normal soldering temperatures are in the 300 to 350C range. If you're wondering what temp to use with your given solder, turn on the iron and test the tip heat by touching solder to it.

Lead Solder Melting Point : ~190C

Lead Free Solder Melting Point : ~220C

The tip of the iron will wear out over time. *Never* abrasively clean the tip of your iron with sand paper or iron wool. Sanding off the residuals from the iron tip will permanently damage it. Always use a wet sponge and solder to clean the tip of an iron.

Before you replace the iron into the holder, it is recommended to add some solder to the end of your tip. This will create a molten layer of solder protecting the tip from corrosion and oxidation. This protective layer will oxidize (turn black) instead of the tip. Swiping the tip across the wet sponge will easily clean this black layer off leaving you with a clean and shiny iron tip.

3.2 Lead vs. Lead-Free

The European Union has passed various directives and legislation to reduce the amount of electrical and haz-

ardous waste. Lead is an element that has been shown to cause lead poisoning and various health problems. Don't let this scare you. Handling lead solder is not a direct health hazard. We recommend you wash your hands after handling solder, soldering irons, and electrical parts and you should be appropriately protected to lead exposure. You should always keep food and drink away from your workstation to avoid accidental spills and to prevent cross contamination.

Lead-free solder is a solder with a metal makeup that does not contain Pb. The most common lead-free solder makeup is SnAgCu where silver has replaced the lead. Lead-free solder allows electronics to be manufactured under RoHS standards, but tends to stress soldering equipment and soldering iron tips. For prototyping, we recommend lead solder since it is easier to use and the tools are generally lower cost.

3.3 Rosin Core Solder and Flux

'Rosin core' Solder has a additive called flux or rosin in the middle of the wire. This flux changes the surface tension of the metals. Basically, flux allows the solder to flow into smaller spaces than pure metal would normally be able to. You really can't solder without flux.

While soldering with rosin core solder, you will notice slight white smoke raising from the soldering iron. This is completely normal. This is just the flux burning off. The white smoke is not hazardous but in rare cases, can be a mild irritant. If you find your eyes are watering or itching, you may want to use a fan or smoke absorber to reduce exposure. Electronics manufacturers will often have a full ventilation system to help minimize extended exposure. Since we won't be soldering for months at a time, this small amount of flux shouldn't be more than a mild hindrance.

Flux is your friend, but it often leaves a sticky residue on your board that is slightly acidic. Electronics manufacturers will remove flux to prevent it from corroding the contacts. Since this can take many years to have an appreciable effect, we don't really care about cleaning prototypes.

As you are soldering, you are burning off flux (hence the smoke). If you heat and re-heat a joint, you run the risk of burning off all the flux and so the solder won't flow correctly. That's why they invented flux pens. These are pens that deliver small amounts of pure flux. These can be very handy for tight pitch soldering jobs.

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They are not generally needed for soldering.

The pitch of a component refers to the distance between pins or pads. The closer the pads are, the higher the risk of a solder jumper. ‘Easy’ to solder pitch distances are ~1mm. ‘Tight pitch’ distances are 0.5mm and smaller. With a little practice, 0.5mm pitch is not a problem.

3.4 Safety Precautions

Irons are a little dangerous just because of the high temperature tips. Experienced solderers (I’m jinxing myself here) rarely or almost never burn themselves. A little practice and proper handling will become second nature.

If you do burn yourself, immediately set the iron back in the iron stand and get the burn area under cool, running water. This will minimize the extent of a burn.

4 Soldering SMD Components

- Always check your polarity before you solder. Many capacitors, LEDs, ICs, and connectors have a certain orientation that *must be* maintained when soldering polarized components to the board or else the board may not function correctly. Check three times, solder once. The silkscreen should indicate which way the device should go. When in doubt, ask the designer of the board. Believe me, it is easier to ask once, then to fix 10 bad boards.
- If you really check your polarity, then don’t worry - if things go completely wrong, we can show you how to fix any problems with green wires and hot-air rework. You *cannot* solder something so incorrectly that you ruin a PCB. You can always fix your mistakes with a little patience.
- Start from the center of the SMD area and work you way out. It can get dense and difficult to get your iron into areas with tall components.
- Do not remove an item from the holding tape until you need the component. Many 0603 components are easily lost once they are removed from their tape. Components come in a white paper ‘tape’ to allow for machine production. This is just a method to hold the component. You will need to peel back the top cover of a cut paper tape to get to the components inside.
- Add solder to one pad. While that pad is molten, slide the component into place. Align the component, then solder the other connections.

- If alignment is not good, do not solder more than pad 1! Heat pad 1, re-adjust component until aligned correctly, then move on to soldering other connections.

5 Soldering Tips and Tricks

1. If you’ve got a jumper that is hard to remove, check the PCB layout and make sure that the jumper is not supposed to be there. There are many occasions in which two neighboring pins are connected together. This connection can cause natural jumpers because of heat transfer. If this is the case, leave the jumpered pins as they are.
2. If you’ve got a jumper that is hard to remove, add solder. And then wick away the jumper. By adding solder, you induce more flux into the jumper allowing the jumper to be more easily removed or ‘gripped’ by the solder wick.
3. Be gentle when removing through-hole components. Sure, you can clip the leads and remove the remaining bits of a leaded resistor; just be careful when removing the leads. Solder blobs have been known to go air-born which can lead to eye injury. Also, stressing the pads by pulling too hard can damage the PCB. Take your time.
4. If a jumper is really persistent, check trick #1 then add a little flux to the jumper and try wicking away the jumper.
5. If things go truly sideways, hot-air is your friend. You can always remove a component, no matter how large, with a hot-air gun.
6. Watch your tip (and hot-air gun) around plastic components. You won’t understand this until you damage a connector or an enclosure. A soldering iron tip is hot and, unless you are careful, it will melt metal, plastic, and sometimes PCBs.
7. If you’ve significantly heated and re-heated an area, you may want to add flux. This is a sign that you are a perfectionist. See Rule 5 on page 1. You should not generally need to add flux to a board.
8. When green-wire fixing a joint, strip only the very end of your 30 gauge wire. The more wire you have exposed the more likely you are to solder or short it to another component.
9. Long sleeves are okay, but may interfere with small SMD devices laying out on the table. We recommend short sleeves, when convenient, to reduce the risk of brushing components off the work area.

6 Prototype Validation

1. When building up an unknown, untested design, it is recommended that you build up the design a block at a time. The odds are against you. More than likely, something is significantly wrong with the prototype PCB, design, ICs, schematic, and/or act of god. Build up the power supply and test it. Then build up the communications block and test it. Then, and only then, build up the core.
2. Test for continuity between VCC and GND before hooking up any prototype.
3. PCBs are not perfect. Often there are designer faults (two traces completely overlap causing short), or there is a manufacturing defect (the ground pour nudges into a VCC rail). Even high quality PCB fab houses produce bad PCBs now and again. When testing a prototype design, assume the worst - a short between VCC and GND.
4. Use a bench power supply if possible to test your prototype. Set your voltage to the needed level and limit your current to a minimum. There is no reason to hook your 5V 100mA design to 9V and 3A. It will smoke!
5. Test every feature and/or function of a design before revision. Do not rush to fix the first problem you find - there are probably many more. There is no sense in revising 1 or 2 problems on a board, paying \$100 for the next revision, only to find out there are 4-5 more problems.

7 Glossary of Terms

0603 : This is a term used to describe the size of a 2-terminal component such as a resistor or capacitor. 0603 = 0.063"x0.031". 0805, 1206, and others are used to describe the physical size of a given component. Wikipedia 'Surface mount technology' for more information.

GND : Ground connection

Jumper : A metal connection, also known as a 'solder bridge', that connects two or more adjacent pins that should not be there. This is normally used as a negative term. There are some jumpers that are ok (example: two GND pins next to each other).

Polarity : Some components (such as ICs, capacitors, LEDs, etc) have some sort of an indicator to indicate

how the component needs to be oriented within the circuit. LEDs have a longer leg for the anode.

RoHS : Restriction of Hazardous Substances. Requires manufactured electronics made for the European Union to be free of various substances including lead. See <http://www.rohs.eu/english/legislation/rohs-legislation.html> for more information.

SMD : Surface Mount Device. SMT is also commonly used as 'Surface Mount Technology'.

VCC : Normally indicates the power pins of the device. Does not indicate what voltage is required. Do not assume VCC is 5V or 3.3V - read the datasheet!