The Art and Science of Soldering

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At fundamental skill in electrical engineering is that of soldering. It is a skill that is developed over time by doing. The idea is simple: to form an electrical and mechanical connection of parts using a molten alloy of lead and tin with a soldering iron.

Using solder we join two or more metals at a temperature below their melting point. Solder provides a metal solvent action between the solder and metal(s) being joined. This “solution” of metal in the solder results in an intermediate alloy being formed. This provides metal and electrical continuity and results in low resistance connections. A solder joint also allows for torsional stress due to temperature changes without rupture of the joint.

How we do Soldering

Tinning the tip: If you are using your soldering iron for the first time you need to tin the tip. This is also true if you are using a new tip for the first time. Tinning is the process of heating up the iron and applying a thin coat of solder to the tip. This helps to achieve maximum heat transfer to the item you are trying to solder and also protects the tip from oxidation.

Cleaning the tip: Buy a simple soldering stand, with a holder for the iron and a small sponge on the base. The sponge is used to clean the tip. It must be saturated with cold water, just to the point of dripping. It should be oriented so that the tip is drawn through and not across the grooves in the sponge. Cleaning is accomplished by quickly drawing the tip through the groove just before making a joint. This helps to keep the tip working at peak efficiency. When you are finished with a session of soldering, put thin coating of solder onto the tip as it cools. This keeps the tip sealed nicely, preventing oxidation.

Preparing the surfaces: This can be accomplished if necessary, through “tinning”. Tinning is simply coating the surfaces to be soldered with a thin layer of solder. This step can be skipped on circuit boards, as the risk of destroying the land is too great.

Making the Joint: Find some way to secure the work so that it doesn’t move during soldering. Sudden movement while soldering can produce a crystalline joint.

All parts including the iron tip itself must be clean and free from oxide contamination as solder will not flow onto contaminated metal. Oxide layers repel the molten solder. This condition is evident when solder beads up into little balls, and not flowing into the joint. You can use a knife blade to scrape oxidized leads or fine sandpaper to clean printed circuit board traces. A rubber eraser works well on printed circuit boards.

As previously mentioned it is often helpful to “tin” the surfaces to be soldered. A terminal pin or lug on a potentiometer would be an example. You would not try and tin leads to be inserted into a printed circuit board.

To make the joint, position the tip of the soldering iron against the surfaces to be soldered. The principle idea is to thermally connect to all surfaces in the joint. There are two tricks to accomplish this. One is to apply just a tiny amount of solder to the tip. This helps form a solder bridge between the tip and the joint allowing a more efficient transfer of heat to the joint. Secondly, you must push against the joint with some force. Not much, perhaps on the order of one-half a pound of force. Beginners often just very lightly touch the joint with the tip. Applying

appropriate pressure will ensure an efficient and rapid heat transfer to the joint. The longer you are heating the joint, the more likely damage to the parts will result.

Once the thermal bridge is established, lay the end of the solder against the metal you are soldering being careful to keep it from touching the tip of the iron. You want the pieces in the joint to melt the solder, not the iron. If the joint pieces cannot melt the solder, then they are not hot enough.

When the solder begins to melt, feed it into the joint until there is just enough to fill any gaps. When removing the iron, be careful not to shake or bump the joint. This can result in a crystalline or “cold joint” which will crack over time. Also remember that more solder is not better.

The whole process from application of the tip to the joint to the removal of the tip is typically two to 4 seconds. The time it takes to make a joint depends on the temperature and wattage rating of your iron and thermal mass of the joint. Semiconductors, some capacitors and plastic connectors are sensitive to heat and should be soldered with care taken not to “camp out” on the joint for too long.

After making a joint, do not clean the tip on the sponge. Just put the iron back in the holder. This leaves a protective layer of solder on the tip from the last connection made. Therefore if the iron goes unused for a few minutes, the tip will be protected from oxidation which shortens its life.

To recap the steps:

1. Ensure all the parts are clean
2. Secure the work
3. Wipe the tip off on a damp sponge
4. Touch the iron tip with a small amount of solder.
5. Heat all parts of the joint with the iron
6. Continue heating, and apply sufficient solder to make the joint
7. Remove the iron
8. Return the iron to its stand without cleaning it
9. Do not move parts until the solder has cooled

How it should look: A good joint will be shiny and smooth. Solder will not completely cover all the wires, but incase them, leaving concave surfaces between them and the wire tips sticking out. A bad solder joint will look dull, more grey than silver. If you need to redo a joint, start from scratch, removing most of the solder you can.

What is solder made of? What does flux do? Electronics grade solder is composed of approximately 60% lead and 40% tin. This is commonly referred to as “40/60”. (When referring to tin/lead solders, the tin content is usually given first.)

Solder also contains a core of “flux” which helps the molten solder to flow more easily over the joint. Flux removes oxides which arise during heating, and is seen as a brown fluid bubbling away on the joint. If possible, clean the flux from solder joints afterwards with alcohol or flux remover. Then examine the joint so that you can make a decision whether it is a good joint or not. Flux residue can hide a bad solder joint.

Can soldering be harmful? The fumes from soldering are not good for you, so always solder in a well ventilated area. Wearing safety glasses at all times, is a good idea, as you will find yourself leaning over your work, bringing your eye dangerously close to some very hot substances.

What kind of solder should I use?

Common hand soldering: Kester #44 This solder has been the industry standard for many years. You can't go wrong with this one.

Water cleaned circuits or difficult to solder metals: Kester #331 This is a high-activity water-soluble core flux for soldering difficult metals. A simple wash in hot tap water cleans the flux off very well.

If cleaning is not possible: Kester #245 This is an excellent no-clean solder. The little bit of residue left can be removed with alcohol.

Solder is produced in different diameters. A 0.031 in. diameter is fine for most work. For surface mount parts, a smaller 0.025 in. solder is easier to use.

Do solder joints have to be cleaned? For Kester #245 and #44, it is safe to leave the flux residues on the board as they are non-corrosive and non-conducting. Kester #331 residue must be washed off within a few days of soldering or the solder joint can become dull. This residue conducts electricity and will cause high impedance circuits to fail especially in high moisture environments. If left on a joint, Kester #331 flux residue will eventually corrode the joint.

What tip temperature should I use? This depends on the alloy and flux. For rosin flux or water soluble (Kester #44 or #331) a temperature of approximately 700˚ F. For Kester #245 approximately 650˚ F.

Temperature control is a very desirable feature in a soldering iron. Many of the cheapest irons have no form of temperature regulation. A temperature-controlled iron will be much more expensive, sixty to one-hundred sixty dollars. These will have some form of built-in thermostatic control, to ensure that the temperature at the tip is maintained at a fixed temperature.

What wattage iron should I use? Typically, a power rating of between 15-25 watts is fine for most fine electronics work. A higher wattage does not mean the iron is hotter. It simply means that there is more power available to deliver to larger joints.

What about ESD protection? More expensive soldering irons use static-dissipative materials in their construction and have grounded tips to ensure that static can not build up on the iron. These are called ESD (electrostatic discharge) safe irons. If you are serious about your electronic work, get an ESD safe iron.

How do I desolder? Desoldering is most easily done with desoldering braid "solder wick". Use of a desoldering pump is not advised. The pumps sucking action creates a static charge on the joint which may damage sensitive components. Also the jumping action of the pump can completely remove a pad from a printed circuit board. When heated to 500-700 degrees, the adhesive holding the copper to the board looses 80% of its strength.

Solder wick is a fine copper braid soaked with flux. When heated and applied to a joint, the solder is sucked up by capillary action into the wick.

To use the braid, press a short length of braid down onto the joint with the tip of the iron. The iron will heat the braid, which will subsequently melt the solder, which is drawn up into the braid. Be very careful that you do not "scrub" the board with the wick. You will tear the traces off.You need to be careful to heat the braid, not the solder, allowing the heat to transfer from the braid to the solder.