Soldering Guidelines

Solder0 R0.1

EE400/1 Design

Revision History

Rev.	Date	Contributor	
0.1	September 2005	L. Wyard-Scott	Updates to reflect changed
			Capstone Design Course for-
			mat and new de/soldering
			equipment.
0.0	January 2004	V.J. Sieben, L. Wyard- Scott, E. Tiong	Creation.

Contents

1	Solo	dering Technique	1	
	1.1	Required Tools	1	
	1.2	Important Soldering Tips	2	
	1.3	Precautions	3	
	1.4	How to Solder Through-Hole Components	4	
	1.5	How to Solder Surface-Mount Components	8	
	1.6	Wire Connectors and Headers	9	
		1.6.1 Crimp Connectors and Pins	9	
		1.6.2 DB Connectors (Solder Cup Type)	10	
		1.6.3 Joining Two Wires	10	
	1.7	Testing Connections	11	
	1.8	Milled Board Soldering	12	
	1.9	Post-Soldering Cleanup	12	
		1.9.1 PCB Cleanup	12	
		1.9.2 Work Area Cleanup	12	
2 Desolder		oldering Technique	13	
	2.1	Solder Pump/Sucker	13	
	2.2	Desoldering Braid/Wick	14	
	2.3	Desoldering Iron	15	
	2.4	Removing Components Effectively	16	
3	3 Glossary			
Bi	bliog	graphy	18	
A Pictures of Tools				

Chapter 1

Soldering Technique

This guide is intended to give an introduction to basic soldering technique. If the reader desires to pursue advanced soldering techniques, there are several books as well as technical institutions that offer detailed courses in the area of soldering.

1.1 Required Tools

Before discussing soldering techniques, one should must set up a "soldering work station". The following is a list of tools for a typical soldering station. See Appendix A for pictures of the various parts listed below.

- 1. Variable temperature soldering iron: used for applying heat to joints during the soldering process.
- 2. Damp sponge: for cleaning soldering iron tip.
- 3. **Rosin-core solder:** to electrically and mechanically bond a component to the PCB.
- 4. Wire cutters or side cutter: for trimming component leads and stripping insulation from wires.
- 5. Needle nose pliers: for holding, placing and shaping components.
- Desoldering pump and/or desoldering braid: for removing solder.
- 7. Scotch tape and/or a "Third Hand": for securing components.

- 8. Safety glasses: for eye protection. These are mandatory in the lab.
- 9. **Magnifier:** to provide more detail during intricate work. A magnifying glass is convenient, but an illuminated magnifier is better.
- 10. Light source: to prevent eye-strain.
- 11. Ventilation: to extract and dispel fumes generated during the soldering process.
- 12. Flux: to clean components and PCB pads.
- 13. Acid brush: to assist in the removal of flux residue.

Prior to soldering it is a good idea to have all components organized as it will make populating the PCB more efficient. Make a BOM (bill of materials) for the PCB, and ensure before soldering that the components have been collected. The schematic and PCB layout will also be referred to when populating the board.

1.2 Important Soldering Tips

The following tips provide a quick guideline on how to make proper joints.

- **Cleanliness:** All parts, including the soldering iron tip, must be clean and free from grease, oxidation and contamination. Solder does not flow over contaminated areas; moreover, solder is repelled by dirt. Severe contamination is evident when solder begins to "bead". A common source of contamination is oxidation. Old components and copper boards will often have an oxide layer that prevents a good solder joint. Ensure all components have shiny leads and the PCB has clean traces. An abrasive such as a blue or pink eraser, emery paper, or stell wool can be used to remove the oxidized layer from the PCB board and components.
- **Tinning:** In addition to being clean, the soldering iron tip must also be tinned (coated with solder). Tinning the tip allows solder to flow on the components more quickly rather than the soldering iron tip itself. Tinning involves adding a few millimetres of solder to the tip and then wiping and rotating the tip on the damp sponge to reveal a shiny surface on the tip of the soldering iron: a thin layer of solder will coat or "tin" the tip of the soldering iron. When done soldering,

tinning the iron is required to protect the tip from oxidation thereby dramatically increasing its life.

- **Temperature:** Ensure that both the component leads and the PCB's copper layer are heated at the same time. The soldering iron tip should contact both the component and the PCB pad. This will ensure that each surface is relatively close in temperature resulting in a good joint. If there is a temperature difference between the two surfaces, the solder will form a "dry" joint. Soldering irons are typically set around 650 Fahrenheit, depending on the lead-tin ratio of the solder being used. Too much heat causes excessive "sputtering" of flux, and too little doesn't melt the solder in a timely manner.
- **Duration:** The duration that the iron is in contact with the component and PCB is dependent on the size of the joint and your soldering iron temperature. For the typical PCB through-hole joint, it should take a few seconds to heat the joint and apply the solder. This will require practice, so don't expect to be fast if you are a beginner. Excessive heat (several seconds in duration) will damage sensitive semiconductors. If this is a concern, use a heat sink attached to the component leads: sometimes as simple as an alligator clip. These concerns can sometimes be avoided by soldering sockets instead of the semiconductor itself.
- Adequate solder coverage: If too little solder is applied, the joint will not make a secure connection and will cause erratic behaviour. However, if too much solder is applied, the joint may bridge with adjacent joints resulting in electrical shorts. How much solder to apply comes with experience. Figs. 1.4 through 1.7 show good and bad solder joints.
- **Handling:** Most modern electronics systems contain static-sensitive devices. Use proper handling procedures to minimize the likelihood of damage: grounding wrist-straps, grounded soldering irons, grounding mats, etc.

1.3 Precautions

Soldering Irons get very hot (600- 800^{0} F, 315- 425^{0} C), please ensure you follow precautions during use. Basic safety precautions are listed below.

• Never leave your iron turned on while unattended.

- Turn the soldering iron off when it is not being used. If the iron is left on for long periods of idle time, the soldering iron tip will be destroyed through oxidation.
- Eye protection must always be worn when soldering. Hot flux can spit up and into an unprotected eye. In the Capstone Design Lab, use of eye protection is mandatory.
- If the cord of the soldering iron is damaged, inform the lab staff who will ensure it is replaced.
- Never set the soldering iron down on anything other than an iron stand.
- To prevent burning your fingers, use needle nose pliers, heat resistant gloves, or a third hand tool to hold small pieces.
- Familiarize yourself with the safe handling of all materials used during the soldering process. This includes solder, flux, alcohol, and desoldering braid. Each has a Material Safety Data Sheet (MSDS) and can be found in the lab or online. "Safe Operating Procedures" are found posted on the wall close to the soldering facilities.

1.4 How to Solder Through-Hole Components

Most of the soldering done in the Capstone Design Lab is through-hole. A through-hole joint is a type of soldering joint in which the component joins with the PCB pad through a physical hole in the board. The following steps will illustrate how to make a proper through hole solder joint on a PCB.

- 1. Ensure that the printed circuit board and all components are clean. Cleaning can be achieved with a mild abrasive and/or the application of flux.
- 2. Plug in the soldering iron, turn it on, and let it warm up for 2-3 minutes.
- 3. Wet the soldering station sponge with the water provided in the lab. Do not wet the sponge in the bathroom or the water fountain.
- 4. Clean the tip of the soldering iron and tin it with solder.

5. Insert the component into the holes. Ensure that the component is secure by taping the component or by using a third hand. Optionally, the component leads can be clinched as shown in Fig. 1.1. This technique, however, is not recommended for two-sided boards as the flow of solder to the component side is restricted.

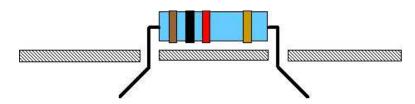


Figure 1.1: Clinched Component Leads

- 6. Apply the soldering iron tip to one side of joint making contact with the component lead and the board copper foil, ensuring that both are heated up to the same temperature as shown in Fig. 1.2 and Fig 1.3. Notice the tinned tip in Fig. 1.3.
- 7. Slowly add a few millimetres of solder to the other side of the joint. DO NOT apply solder to the soldering iron tip. If enough heat was applied to the PCB pad and component wire, the solder will flow freely onto the joint.

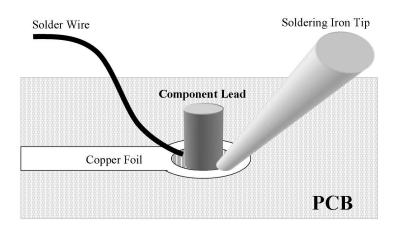


Figure 1.2: Method of Soldering Through Hole Joints

8. Remove the solder when the joint is suitably covered as shown in

6

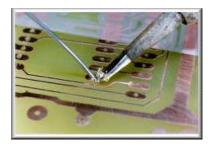


Figure 1.3: Method of Soldering Through Hole Joints, [8]

Fig. 1.4. The goal is to get the joint to be a "fillet": a curve as shown in Fig. 1.4.

- 9. If the PCB is double-sided, the solder should flow through the hole around the component lead and make a bond on the component side of the board (opposite to the side that the solder was applied). If this "wicking" does not occur, the hole may be undersized, clinching could be blocking the solder's path, or the component lead is not clean.
- 10. Remove the soldering iron and allow the joint to cool naturally.

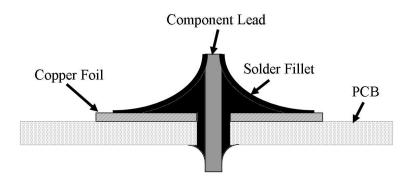


Figure 1.4: Good Solder Joint - Solder Fillet

11. Cut the lead of the component, if necessary.

Fig. 1.6 and Fig. 1.7 below are pictures showing good and bad solder joints.



Figure 1.5: Good Solder Joint, [8]

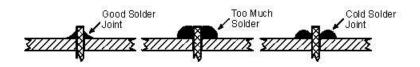


Figure 1.6: Joint Examples, [3]



Figure 1.7: Joint Examples, [2]

8

1.5How to Solder Surface-Mount Components

Surface mount soldering requires more experience and skill than through hole. It is recommended that one practices with through-hole prior to attempting any surface mount soldering. As the name suggests, surface mount involves soldering a component to either the top or bottom surface of a PCB. Depending on the footprint, the pads are usually a spaced closer together (finer pitch), making the soldering more susceptible to solder bridges, etc.

Figs. 1.8 and 1.9 show examples of good surface-mount solder joints.



Figure 1.8: Surface Mount Good Solder Joint, [6]

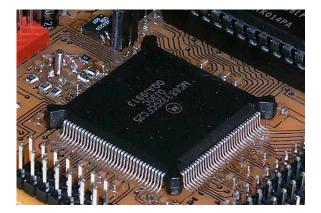


Figure 1.9: Surface Mount IC with Good Solder Joints, [5]

The actual soldering of the joints is similiar to the through-hole method. One difficulty, however, is maintaining the part's alignment on the PCB pads. A good technique is outlined here:

- 1. Align the component on the PCB pads. This can be aided with the use of tweezers and dental picks.
- 2. Secure the component to the PCB by applying a small amount of pressure onto the top of the component using a small slot screwdriver.

An index finger resting on the end of the screwdriver provides enough force to secure the device.

- 3. Solder one of the corner component leads to the PCB pad.
- 4. Align the remaining pads and solder the opposite corner PCB pad.
- 5. Solder the remaining pads in a pattern that does not build-up too much heat in the device.

1.6 Wire Connectors and Headers

When PCBs are manufactured they often have connectors to peripheral devices. These connectors are like other components in how they are soldered onto the PCB. However, the plug that matches the connector usually also requires some soldering. Please note that with very few exceptions, the wire used for cabling is stranded (rather than solid-core) due to its higher strength and flexibility. Below are procedures for a few of the more common plug types.

1.6.1 Crimp Connectors and Pins

- 1. Strip off about 1cm of the wire insulation.
- 2. Place the exposed wire into the crimp-style connector or pin. The wire should just barely show coming out the other side. Some crimp pins have two crimping areas one for the stripped wire, and the other for the wire *with* the insulation.
- 3. Crimp the connector with the appropriate crimping tool. Note that the connectors are colour coded to settings on the crimping tool, try and match the correct colour.
- 4. As added insurance, apply solder to the joint to solidify the connection.

Before crimping all pins destined for a connector housing, start with one and ensure that it fits successfully into the housing. If the crimp is made too tightly, or otherwise mis-shaped, the pin may no longer fit.



Figure 1.10: Colour Coded Crimp Connectors



Figure 1.11: Crimp connector without shrink wrap, [1]

1.6.2 DB Connectors (Solder Cup Type)

- 1. Strip off about 5mm of the wire insulation.
- 2. Tin the wire.
- 3. Slide shrink wrap on the wire.
- 4. Place the wire into the DB connector solder end.
- 5. Apply the soldering iron tip to the connector and wire.
- 6. Apply a few millimetres of solder until the joint is adequately covered.
- 7. Let the joint cool.
- 8. Slide the shrink wrap over the joint and heat the shrink wrap with a heat gun (or other heat source) until the wrap shrinks around the joint.

1.6.3 Joining Two Wires

- 1. Slide shrink wrap on one of the wires.
- 2. Tin or coat each wire with some solder.
- 3. Join the wires in a way that provides a good mechanical connection (such as twisting together) and apply the soldering iron tip and some solder.



Figure 1.12: DB Connector with shrink wrap, [7]

- 4. Let the joint cool.
- 5. Slide shrink wrap over the joint and heat the shrink wrap with a heating gun or a heat source until it the the wrap shrinks around the joint.



Figure 1.13: Two wire joint insulated by shrink wrap, [4]

1.7 Testing Connections

After completely soldering a component to a PCB, it is good practice to ensure connectivity between the component wire leads and the PCB pads they are soldered to. A DMM (Digital Multi-Meter) is sufficient to determine connectivity; many DMMs include an audible connectivity setting, but failing this, measure the joint resistance.

1.8 Milled Board Soldering

In-lab manufacture of PCBs uses a technique known as "milling". The milling technique involves cutting out the PCB tracks and pads from the copper-clad board.

Due to its construction, a milled PCB is susceptible to solder-bridging across the milled grooves, particularly when an excess of solder is used. Finding a short caused by a bridge is a difficult task, particularly when many solder joints exist. To this end, make a limited number of solder connections and then test for bridges using a multimeter.

1.9 Post-Soldering Cleanup

1.9.1 PCB Cleanup

The flux left behind by rosin-core solders, or perhaps as part of the cleaning process, needs to be removed from the PCB. Due to the flux's sticky nature, dirt gathers and contributes to short-circuiting problems. The most frustrating part of this situation is that a short does not necessarily occur immediately. Weeks, or even years later, a short can develop.

To remove flux, alcohol is used. Apply the alcohol liberally and then brush away with an acid brush, starting at the center of the PCB and working out toward the edges. This is a time-consuming task, but a clean board is well-worth the effort.

1.9.2 Work Area Cleanup

The importance of keeping your work area clean cannot be emphasized enough. When clear of obstructions and garbage, handling a hot soldering iron is safer. The soldering process itself involves chemicals and substances which are known to have ill-effects in humans. Wiping-down the work-area surfaces with a moist paper towel will help reduce some contamination. When you are done soldering, **wash your hands with soap and water** to get rid of contamination. The primary concern here is accidental ingestion of the chemicals. For more information, please refer to the Safe Operating Procedures, posted in the lab's soldering area.

Chapter 2

Desoldering Technique

Desoldering may be required for several reasons:

- a component may have failed
- a wrong part was installed;
- a design modification necessitates a change; or
- if a board contains expensive components that can be salvaged.

Whatever the reason, there are three common techniques to remove solder from a joint: using a desoldering pump, a desoldering wick, or desoldering iron.

Regardless of the method used, if it is permissible to destroy the part during removal, then a lot of time and effort can be saved. For instance, using wire cutters to trim off all the pins of a through-hole IC so they can be removed individually makes the removal process much easier. In most cases, avoiding damage to the PCB is of paramount importance.

2.1 Solder Pump/Sucker

A desoldering pump is exactly what it sounds like: a pump that sucks up solder. Usually the pump is spring-loaded and provides a recoil when released. The four steps below outline how to desolder a joint using a desoldering pump.

1. Prime the desoldering pump. This involves depressing the desoldering pump spring. The pump will click when correctly depressed.

2. Heat the joint from one side with the soldering iron tip. Wait 1-2 seconds until the solder begins to melt from the soldering iron heat.

 $\mathbf{14}$

3. Put the pump tip on the other side of the joint. Don't be afraid to actually touch the joint.



Figure 2.1: Desoldering with a Solder Pump, [8]

4. Press the desoldering pump spring-release button to suck up the solder.

This procedure should be repeated if the joint has a significant amount of solder. If done correctly the joint should eventually look as shown in Fig. 2.2 shown below.

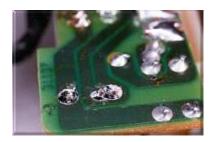


Figure 2.2: Clean Joint from Desoldering with a Solder Pump, [8]

2.2**Desoldering Braid/Wick**

A desoldering braid removes solder from a joint using a technique known as "wicking". Desolder braid is a piece of material that sponges up molten solder by capillary action that draws solder away from the joint the braid. The following procedure outlines the basic steps involved in desoldering a joint using desoldering braid.

- 1. Place the desoldering braid over the joint.
- 2. Press the desoldering braid onto the joint with the soldering iron tip. This will apply heat to the desoldering braid and the joint allowing the molten solder to flow.
- 3. Wait for the solder to melt. The solder should flow onto the braid and away from the joint.



Figure 2.3: Desoldering with a Solder Wick, [8]

4. Cut off the solder coated portion of the desoldering braid. There should be no copper visible in the portion that is removed: braid is very expensive.

2.3 Desoldering Iron

Using a desoldering iron, available with higher-end soldering stations, is similar to using a solder sucker. The desoldering iron is essentially a soldering iron with a built-in vacuum.

- 1. Make contact between the iron and the joint to be desoldered, ensuring the vacuum opening is not blocked.
- 2. Once the solder on the joint has become molten, depress the button on the iron to activate the vacuum.

It is very important for the life of the desoldering iron that the vacuum assembly be cleaned after every session of use. Please ask the lab personnel for a description of the cleaning procedure.

As with a normal soldering iron, the desoldering iron tip should be tinned before and after every use.

2.4 Removing Components Effectively

To remove a component with little or no damage to the PCB or component takes practice and **patience**. Often when removing a component, PCB pads and tracks may be damaged by "lifting" off the board. Below are some tips that may be useful when removing components from a PCB.

- Desolder all joints pertaining to a component prior to removal. It may be necessary to go over the joints several times before all the solder is removed. Practice patience.
- Use pliers and *gently* pull on components while applying heat to the joints. The assistance of a friend can help with this.
- Do not pull with force, because the PCB pads and tracks will be damaged.
- Do not try and remove components by prying them.
- Do not try to push the component out of the holes with the soldering tip. This will certainly lift the copper pad off of the PCB and ruin the iron tip.
- In order to get better thermal conductivity between the iron and the solder joint, it is sometimes effective to *add* a small amount of solder.

Chapter 3

Glossary

- **BOM:** Bill of Materials, which contains a list of all components and values contained on a particular PCB. Used as a "shopping list".
- **Desoldering Braid:** A material used to remove solder with capillary action.
- **Desoldering Pump:** A device used to remove solder with a swift vacuum action.
- **Flux:** Cleans the surfaces that are being heated by bringing contaminants to the surface. Most solders include flux in their core. For excessive contamination use a flux pen.
- **Footprint:** The spacing pattern or layout of pads for a particular component or integrated chip, as used on a PCB.
- **PCB (Printed Circuit Board):** A fibreglass board upon which copper traces are laminated to make connections between various components. The copper traces serve as flat wires connecting various components.
- **Shrink Wrap:** A tube that fits over a wire, that when heated shrinks to provide insulation and support for the joints.

Bibliography

- [1] R. Glass. Electrical wire soldering for beginners. Technical report. http://www.airheads.org/contrib/solder.html.
- [2] D. Lauder. How to solder. Technical report, Oct 2001. http://dragon.herts.ac.uk/ eleqdml/teaching/general/soldering/.
- [3] W. М. Leach. The leach amp. Technical report, See 2000. section Assembly Circuit on of Boards, http://users.ece.gatech.edu/ mleach/lowtim/part2.html.
- [4] Macroman. Cutting neon string. Technical report. http://www.bit-tech.net/article/59/.
- [5] K. Maxon. Have you seen my new soldering iron? Technical report. http://www.seattlerobotics.org/encoder/200006/oven-art.htm.
- [6] NIST. Archive of surface evolver code. Technical report. http://www.ctcms.nist.gov/solder/archive.html.
- [7] Serial Tester. Serial tester. Technical report. http://army-gps.robins.af.mil/tech/Serial-tester/proc06.jpg.
- [8] A. Winstanley. The basic electronics soldering and desoldering guide. Technical report, Feb 1999. http://www.epemag.wimborne.co.uk/solderfaq.htm.

Appendix A

Pictures of Tools

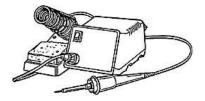


Figure A.1: Soldering Iron



Figure A.2: Solder Wire



Figure A.3: Desolder Pump



Figure A.4: Desolder Braid

Soldering Guidelines (Solder0)	Revision 0.1
	21



Figure A.5: Third Man