Hints and Tips for using Surface Mount Technology (SMT)

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Introduction -

A lot of people avoid dealing with surface mount technology (SMT) because of a lack of good information about it. Whilst there are several good references for commercial assembly, very little is written about hand soldering and prototyping with SMT. This article has been written to introduce the amateur radio operator and experimenter to this interesting technology.

What is Surface Mount Technology? Put Simply - It is a type of electronic component package. Most electronic components can be divided into two categories - through hole (TH) and surface mount (SM). Through-hole components have been used for many years and are designed to be loaded on one side of a printed circuit board (PCB) and soldered on the other. SM components are designed to be loaded and soldered on the same side of the PCB.

Why is SMT used in industry? SMT has several important benefits over though hole technology. They are :

- Faster for automatic machines to place
- Have a smaller physical size for the same electrical function
- Less parasitic (unwanted) effects
- Cheaper in terms of raw material cost

Why should you care about Surface Mount Technology?

"Black Box Operators" aside, SMT is increasingly effecting people involved in the repair, modification or development of electronics. Through hole components are being replaced by their SMT equivalents at a rapid rate as manufacturers increase their investment in SMT production equipment to cash in on the benefits .

Whilst there are exceptions, it is rare to see the use of leaded resistors, capacitors, transistors or integrated circuits in modern consumer electronics. Since the demand for these types of leaded parts is low and decreasing, their cost will rise over the next few years and sourcing them will become difficult. Eventually, supplies will dry up and leaded components will join the domain of valves.

Those of you who doubt these warnings should spend some time and have a look at a modern mobile phone, computer motherboard or amateur radio. An alert observer will note that connectors and electrolytic capacitors are usually among the only leaded parts used. This is mainly because connectors often rely on their leads for mechanical strength and electrolytic capacitors have a shape that does not lend itself towards easy implementation as a surface mount device (SMD). Eventually the solutions to these problems will become cheaper and they too will disappear from electronic equipment in their leaded form.

SMT Myths

Many new facets of amateur radio and experimentation with electronics in general are hampered by the myths that surround them. Some of these myths are :

- SMT needs special and expensive equipment
- SMT components are hard to find
- SMT requires professional PCBs
- SMT requires special training and skills

To use SMT and not get too stressed about it does require the following :

- To have a steady hand
- To practice your technique
- To be invest in a good pair of tweezers
- To have reasonable eyesight or use magnification

Unfortunately, there is not much you can do about the steadiness of your hand, but all the other obstacles can be easily overcome. The main emphasis of this article, is to explain how you can work with SMT with the smallest possible investment of special equipment.

Common SMT Packages

There are three popular package styles used for most passive components. Their names refer to their size (in thousands of an inch or just thou). They are :

- 0603 (60 thou long, 30 thou wide)
- 0805 (80 thou long, 50 thou wide)
- 1206 (120 thou long, 60 thou wide)

Fig 1 - Common discrete SMT components

Fig 1 details the common discrete SMT packages. Diodes, Transistors and IC's all use the SOT package and often measurement with a multi-meter and the two or three character marking on the top of the package is the only way to guess what the component is. Some IC's use larger packages as shown in Fig 2. Several good web sites exist for determining SMT parts from their markings and these are detailed on the VK3EM website.

Fig 2 - Common SOIC package

For the purposes of illustration, only a very small selection of SMT packages have been shown in this article. A more detailed listing including colour pictures can be found on the VK3EM website (See end of article). This may be useful for those who you who recycle parts from junk equipment that uses SMT.

How can SMT help you?

SMT has many benefits over leaded components. These are :

• Where component value tweaking (i.e. : small changes) are needed. SMT capacitors and resistors are easy to parallel together, and quick to solder and de-solder. The chances of "lifting" circuit board tracks are reduced and so is the frustration of trying to work on both sides of a PCB at the same time.

• Where RF signals are being used. Unwanted (ie:parasitic) effects in SMT parts are smaller when compared to leaded parts, which results in better predictability of component characteristics. Leaded packages do no lend themselves to microwave use. However, there are exceptions.

• A significant number of modern components are only available in SMT form. If you want to play with them, then you have no choice but to use SMT!

• Where space is limited. This is dependent on the circuit type and layout, but SMT parts like decoupling capacitors and pull up resistors can be used to reduce the space required on the PCB. SMT parts fit neatly across the gaps on VERO board and can be mixed with designs using leaded parts.

•Where drilling holes is a problem. Anyone who has made a PCB understands the frustration of trying to work on two sides at once. SMT simplifies this because you load and solder all on the same side. Components can be used on both sides of the PCB without interference, or a solid ground plane can be used on one side with holes drilled only for ground connections.

•Where a pre existing circuit needs modification. Forgot to add that series capacitor, diode or resistor. Cut the track and insert a SMT. The solution is simple, small and tidy (no holes)!

Tips for soldering SMT Parts

Good soldering technique will come with practice, but these tips will guide you in the right direction. If you need to practice use SMT resistors as they are not damaged easily.

- Keep the circuit board clean. Isopropanol or wood alcohol is suitable for removing light oils and grease. PCB's should always be washed under warm water, then oven dried at 60 degrees Celsius for 10 to 15 minutes. Handle the PCB by the edge only and avoid touching copper with your bare hands.

- Use the right soldering iron for the job. You don't need to purchase a temperature controlled iron, special SMT tip or SMT hot gas reflow station. These tools might be used in industry, but only to save time and increase reliability.
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  All sorts of SMT soldering jobs can be done with the common Weller workstation. The important point is select the right tip (i.e.: have several tips on hand). As with any soldering job, the general idea is to have the joint up to temperature and soldered in a few seconds. Think about how much of a "heat sink" the joint will be and choose the tip based on that. Use of larger tips should be limited to areas of large solid copper plane (i.e.: ground plane). For all jobs except very very small parts, I use a the common Weller PT-8 7 tip as shown in Fig 3. With practice, you will learn what tip suits you best.

Fig 3 - Soldering Iron and Tip suitable for SMT

• Use L.M.P (Low Melting Point Solder) if you are experimenting. LMP solder is very similar to 60/40 solder, except that it contains 2% Silver. This Silver "loading" has two effects. It lowers the melting point (a few degrees) and it reduces the rate at which component metalisation leeches into the solder itself.

SMT resistors, capacitors, ferrite beads, etc. all make there electrical connections via metalised pads deposited on a substrate (Alumina, ceramic, ferrite, etc). The metal used is often Nickel or a related alloy. One problem with soldering the same joint several times, is that each time the joint is heated, some of the Nickel leaves the component and joins the solder. The is called "leeching". Leeching is only a problem when the solder joint of a metalised component is heated several times. Leeching occurs at a faster rate with standard 60/40 solder than what it does with LMP solder.

The downside of LMP solder is that it is about 3 times the price of 60/40 solder and harder to obtain, although sources of supply have been quoted at the back of this article.

If a kit was being built, where the component values are known, then 60/40 solder will be fine. If component changes are often and likely, then LMP would be more advantages for a long term reliable solder connection.

•Some people use "solder cream" sold by various shops. The advantage of solder cream, is that it has more flux than regular solder. The solder cream is made up of very fine balls of solder mixed with a water based flux.

Unfortunately, solder cream was never intended to be used with a soldering iron. In fact, because the solder sits in a water based flux solution, the cream needs to be "dried" out (i.e. : the water has been driven off) before the solder can be melted. This can be done by moving the iron tip close to the joint for a few seconds prior to moving onto the joint.

In experimentation quantities, solder cream is only available as 60/40 mix. In my opinion, the SMT experimenter would be better off to use LMP solder and extra flux (from a tube or a pen) rather than solder paste. It is a matter of personal preference. If you like using the paste, then go for it!

•Use solder flux where possible. One of the biggest problems with soldering SMT parts is that the amount of flux within the solder core is not sufficient for the joint. Professional SMT manufacturers use "solder cream" and controlled temperature ovens. However, soldering iron temperatures are far less controlled and often the flux has evaporated before the joint has solidified, leading to dry joint which is often dull in complexion.

Solder flux has other advantages. Because of its liquid nature, it increases the conduction of heat from the iron tip to the joint. It also increases the surface tension of the molten solder which helps to achieve a reliable joint and minimises the chance of bridging finely spaced pins.

Flux has the disadvantage that it is generally sticky, and can require special flux removers to remove. Soapy water and ultrasonic baths are one solution, but this requires a second wash in fresh water and a bake in the oven. Flux can also carry contaminants which may effect circuits operating in the microwave region or circuits with very high impedance's, especially in VCOs. Some fluxes contain lead based chemicals, and it is wise to use gloves to avoid direct skin contact.

Flux is available from several hobby shops and other outlets in syringe (see Fig 4) and pen application form. In general, the use of extra flux makes SMT soldering much easier and increases solder joint reliability. However, you may not need it at all.

Fig 4 - Solder Flux is sold in syrynges for easy application.

•Use a good magnifying lamp or other magnification source. SMT parts are very small. SMT solder joints are at least four times smaller again. Since its the solder joint that should concern you most (especially if you want to build something reliable) it is useful to have a source of magnification. Some examples are shown in Fig 5.

Fig 5 - Cheap and useful magnification sources

•Most people with reasonable eyesight should be able to solder without magnification and check the joint under magnification later. For those who have relatively poor eyesight (like myself) , special "jeweller's eyes" that sit on the head can help. Good lighting is essential.

• Dont work in a cluttered space. Give yourself room to move around, and orientate the PCB so its easy to reach the joint your trying to solder.

•Buy a good pair of tweezers. You will be amazed how much easier SMT soldering becomes. In fact, out of all the equipment I have suggested, I feel this is the most important. Both soldering and de soldering will involve your tweezers, so they are a worthwhile investment. If possible, get a quality set where the two ends meet together accurately.

Fig 6 - Tweezers come in various shapes and sizes.

Soldering small SMT Parts

The following technique should be used for soldering small SMT parts such as resistors, capacitors, inductors, transistors, etc, with a soldering iron.

1.) Add a small amount of flux to the area (if required) and add a small amount of solder to one pad.
2.) Pick up component in tweezers making sure component is horizontal. Alternatively, just move the component until it is close to the final position.
3.) Whilst holding the component with your tweezers, melt the solder on the pad and move the component into position.
4.) Remove your iron but continue holding the component until the solder has solidified. Check to see that the component is sitting flat on the PCB. If not, re-melt solder whilst pushing gently on top of the component with tweezers.
5.) Solder the other side of the component.
6.) Re-melt the first solder joint and let solidify. This ensures both joint are stable during solidification.
7.) Check your work under magnification.
8.) The joint should be shiny and concave. If you added too much solder, wick up with small solder wick and try again. See Fig 7 for joint quality.

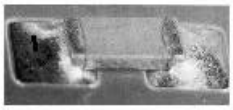
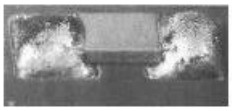
1206 - Insufficient Solder	***1206 - Adequate Solder***	***1206 - Excessive Solder***
		
SOT - Insufficient Solder	**SOT - Adequate Solder**	**SOT - Excessive Solder**
		

Fig 7 - 1206 and SOT Solder Joints. Insufficient, Adequate and Excessive Joints.

Soldering Integrated Circuits

IC's require a similar but slightly different technique.

1.) Add flux to the pads where the IC is to be soldered.
2.) Add a small amount of solder to one of the corner pin pads.
3.) Line up the IC with the pads on the PCB. Double check the IC orientation.
4.) Melt the solder with your iron and move the IC into position with your tweezers. Let the solder solidify.
5.) Solder the diagonally opposite pin. Check under magnification that all pins line up with there respective pads.
6.) Solder the rest of the pins and check work under magnification.
7.) Special techniques may be needed for some packages (see below).

De-soldering Small SMT Components

1. Add excess solder to one side of the component.
2. Whilst the side with excess solder remains molten, move your iron to the other joint and gently push the component off the pads.
3. Clean up pads with solder wick.

Note : The trick here is make one side of the component a larger thermal mass and heat that side first. This may not work for all parts, especially those sitting on large ground planes.

De-Soldering Small Outline Integrated Circuits

This technique only works for SO-IC (50 thou spaced devices). Smaller devices may require hot air for removal.

1.) Apply flux to the IC pins.
2.) Use solder wick to remove as much solder as possible from each pin.
3.) Thread fine enamelled wire under one row of pins.
4.) Secure one end of the wire on a nearby component (i.e. : Large Electrolytic).
5.) Starting at the loose end, heat each pin and pull wire simultaneously. Pull the wire as close to the PCB as practical. As the solder between the pin and pad melts, the wire will pop out and leave the pin standing free of the pad (and bent up slightly).
6.) Repeat steps 3 to 5 for the other side.

What parts can you recycle?

Some SMT parts can be quite expensive when purchased in small quantities. All sorts of SMT parts can be recovered from surplus and junk equipment (providing it uses SMT parts of course!). It will not only save you money, but give you good practice at de-soldering. The VK3EM web site contains colour pictures of many SMT components so you can identify them.

If you use recycled components, perform an electrical check on them. Ceramic capacitors cause the most problems (they crack easily). Inductors, transistors and resistors can all be verified for correct operation. However, excessive heat may damage but not destroy the device.

Special Techniques

Whilst the purpose of this article is to detail the use of SMT with equipment most amateurs already have, there are a few exceptions. One of these is the use of hot air instead of a soldering iron. Hot air SMD rework stations are very expensive, but a much cheaper source of hot air is a Weller Pyropen with a hot air tip (Fig 8). Usually used for heat shrink, the hot air tip makes removing SMT parts a breeze (albeit a very hot one!). Use of flux around the component to be removed will help the heat conduction into the part and the PCB.

One of the draw backs with this technique is that surrounding components may also become molten and may possibly be blown off their pads. This is more of a problem in high density PCB's with very small components when your trying to remove a large component, such as an IC. This can be overcome by folding up a small piece of brass sheet to fit over the component in question. The brass provides a heat shield, and ensures surrounding components remain on their pads.

Fig 8 - Hot air tip on a Pyropen

Surface Tension - Your best friend?

SMT is shrinking the size of component packaging at an alarming rate. How does one possibly avoid shorting pins with spacings like 0.3mm or even less. The answer is simple. You don't! What do I mean by this! With such small pin spacings, you would go crazy trying to solder each pin individually. With the aid of flux, you can increase the surface tension of solder to such a point that it difficult to bridge the gap between pins and cause a short.

Several techniques exist, but an easy one is apply flux and make sure each pin is soldered without caring about shorts. Then, return to the pins with solder wick and soak up the excess solder. This will leave solder between the pin and the pad, but not between the pins.

Alternatively, you can simulate a wave soldering action by starting with a ball of molten solder and massaging it down a row of pins. This is the method I use to solder 100 pin TQFP packages onto prototype boards. It helps to have the PCB a slight angle so that the molten solder ball does not need to work against gravity. You must use lots of flux to keep that surface tension up.

The ball of solder quite literally rolls along the fine pins, leaving a nicely formed joint between the PCB pad and the pin, but without shorts between pins. No air or special solder paste needed. I did tell you surface tension was your best friend!

Some soldering iron manufacturers now make special soldering iron tips that are hollow, spefically designed for use with this process. They are called wave tips. As always, a bit of practice helps. Find a dead mobile phone (full of very finely pitched SMT), and practice yourself.

Conclusion

This article has described some methods which may simplify the use of SMT for the amateur experimenter. It is by no means complete and further information can be obtained from the VK3EM web site http://www.geocities.com/vk3em.

Sources of Parts :

Quality Tweezers, Low Melting Point Solder and Flux can be purchased (small quantities) from :

Mextronics Co Pty Ltd
Factory B, 84 Industrial Drive
Braeside Vic 3195
Telephone: 03 9587 3888
Facsimile: 03 9587 3836

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