Yes, you CAN work with surface-mount devices, or SMDs. All it takes are patience, practice and the right tools—including one which K8TM shows you how to build yourself! Once you've learned a few tricks, working with SMDs can even be FUN!

An Introduction to Surface-Mount Devices

BY DEAN F. POETH II,* K8TM

Surface-mount devices (SMDs) are small! However, they are used in a growing number of amateur radio products. Fortunately, there are several tricks you can learn that will help you succeed when working with these components.

Why SMDs?

SMDs have improved performance over through-hole components due to their smaller size, shorter internal leads, and smaller board layouts. These factors reduce the circuit's parasitic inductance and capacitance. SMDs can also be more cost effective than traditional through-hole components due to the smaller board size, fewer board layers, and fewer holes.

SMDs can be easier to replace than through-hole components on multilayer boards. This is because it is very difficult to heat the long hole on a multilayer board, but much easier to heat just the pad and component terminal of an SMD on the surface of a board.

**218 Gower Rd., Glenville, NY 12302*
e-mail: <dpoeth@worldnet.att.net>

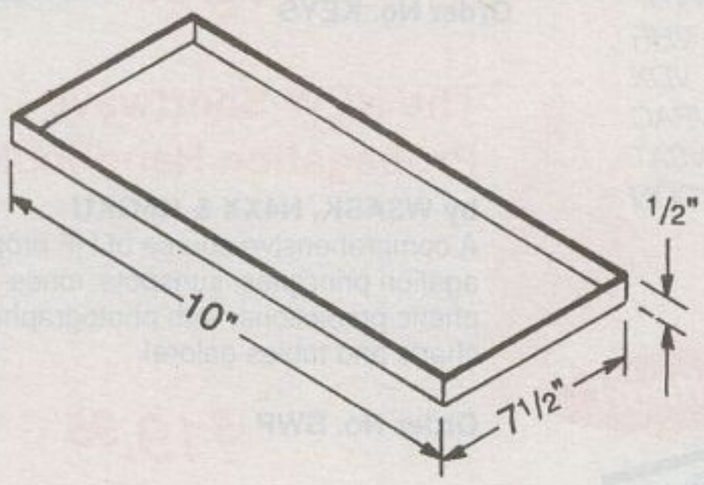


Fig. 1– SMD work tray. Line the inside with several layers of bright-white copy paper. Glue all edges and corners so components cannot slip underneath. Base material is the back of a 8 1/2" × 11" writing tablet.

This article is for those amateurs who would like to experiment with SMDs, yet do not have access to professional SMD rework stations, solder pastes, hot air jets, and illuminated magnifiers. SMDs can be challenging to solder, so it is best to learn general soldering skills on larger components before attempting to work with SMDs.

The methods presented here are not the only ones available. SMD components can be worked with in many different ways (just like through-hole components). The goal of this article is just to give a quick introduction to several methods that the amateur and professional can use to successfully work with this technology.

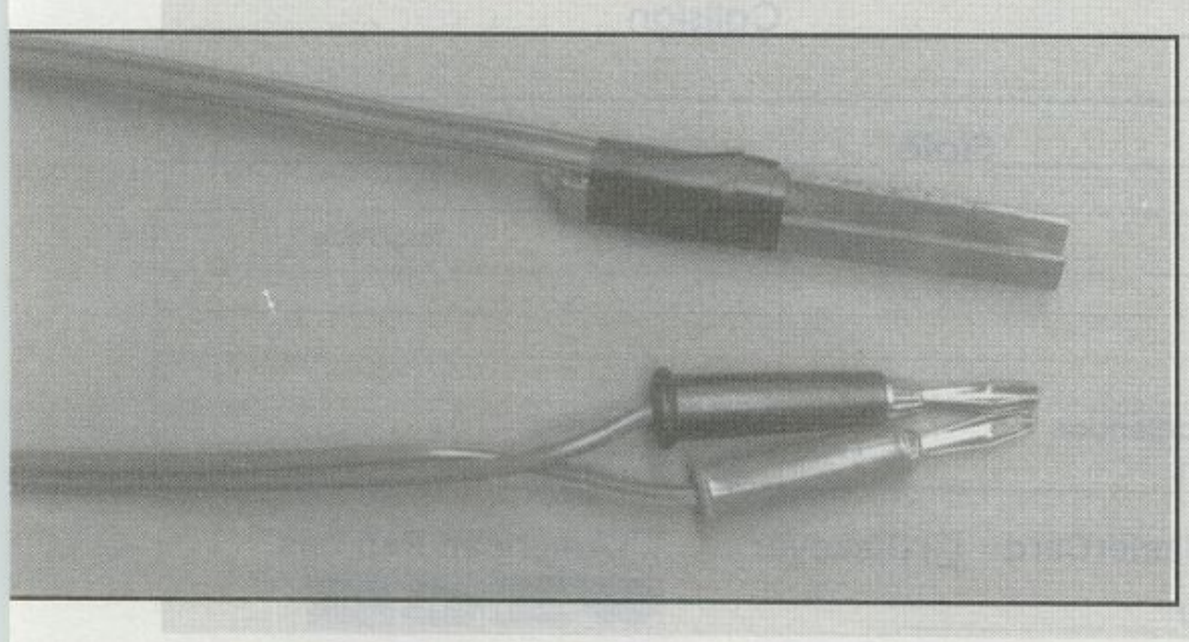
If you know a few tricks, working with SMDs can be fun!

Tools and Equipment

The tools and equipment you will need are shown in the sidebar. Self-locking tweezers cost only a few dollars (available from S. LaRose Inc., 1-888-752-7673, <www.slarose.com>) and work much better than regular tweezers. Select a low-wattage (15 or 25 watt) or temperature-controlled (600° F) pencil soldering iron with a pointed tip.

Tools and Equipment

- Safety goggles
- Self-locking tweezers
- 600° F or low-wattage soldering pencil with a sharply pointed tip
- Small-diameter solder 63/37 (eutectic)
- RMA solder paste
- Desoldering braid
- Plastic scouring pads
- Duco™ cement
- Toothpicks
- Small fan (to gently blow fumes away from face)
- Heat gun
- Magnet
- Flexible-neck lamp with 100 watt frosted bulb
- 4X watchmaker's loupe or magnifying glass



The test tweezers are made from two pieces of printed-circuit-board material separated by a small hardwood block.

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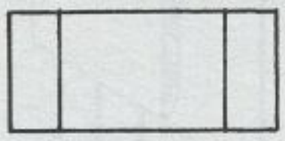
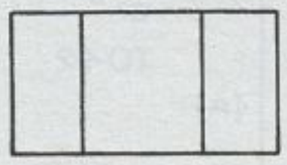
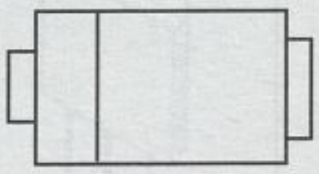
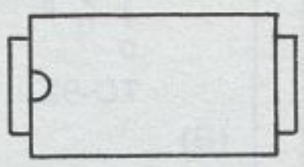
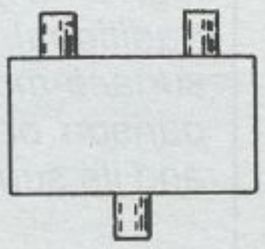
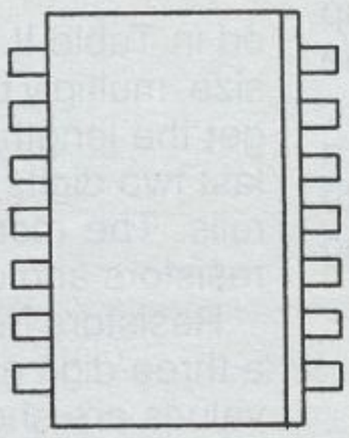
COMPONENT	SHAPE	MARKINGS
Chip resistor		Labeled with value (see Table 3)
Chip capacitor		Not marked
Polarized capacitor		Plus end marked with band, value marked
Diode		Cathode end marked with notch or band
SOT (Small Outline Transistor)		May be unmarked or marked with house numbers
SOIC (Small Outline Integrated Circuit)		May be marked, unmarked, or house numbered. Pin one marked with beveled side, dot, band, or notch.

Table I– Shape and markings of some common SMDs.

To clean the circuit board before soldering you will need a nonconductive abrasive pad. Don't use steel wool or a steel-wool scouring pad, since they may leave small (almost microscopic) steel wires behind. A strong magnet is useful for finding dropped components. You will also need a 4X watchmakers loupe or magnifying glass. Use this to read the component markings on chip resistors and electrolytic capacitors.

The Work Area

SMDs are very small, so the first thing to do is to make them "look" bigger. The trick is to illuminate the work surface with a *very* bright light. To illustrate this effect, take some difficult-to-read fine print (like on the back of a credit-card application) and try reading it in a dimly lit room, and then try reading it a few inches from a bright desk lamp. The difference is dramatic.

A swing-arm desk lamp with a 100 watt frosted bulb positioned close to the work surface works very well. The lamp should be adjustable from 6 to 24 inches above the desktop. Regular room lighting or shop lights just are not bright enough. It is also helpful to set up the lamp so it can be swung over the edge of the desk and illuminate the floor. This helps with finding dropped components.

The second trick is to work on an absolutely clean, bright-white surface. The SMD work tray shown in fig. 1 works very well. The white paper gives contrast to the components, and the small sides help prevent the SMDs from getting lost.

To build the SMD work tray, start by removing the cardboard back from an $8\frac{1}{2}$" × 11" writing tablet. On one side, glue two sheets of bright-white copy paper using rubber cement. Two sheets are necessary because the paper is not completely opaque. When the glue has

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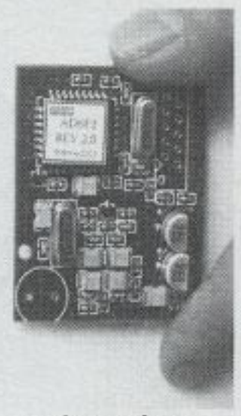

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1206*	0.126	0.063
2010	0.200	0.100
2512	0.250	0.125

** The most common size for SMD resistors and chip capacitors*

Table II– Common SMD case sizes.

Resistor Marking	Resistor Value (ohms)
105	1 meg
820	82
272	2.7K
104	100K

Table III– Typical resistor markings and corresponding values.

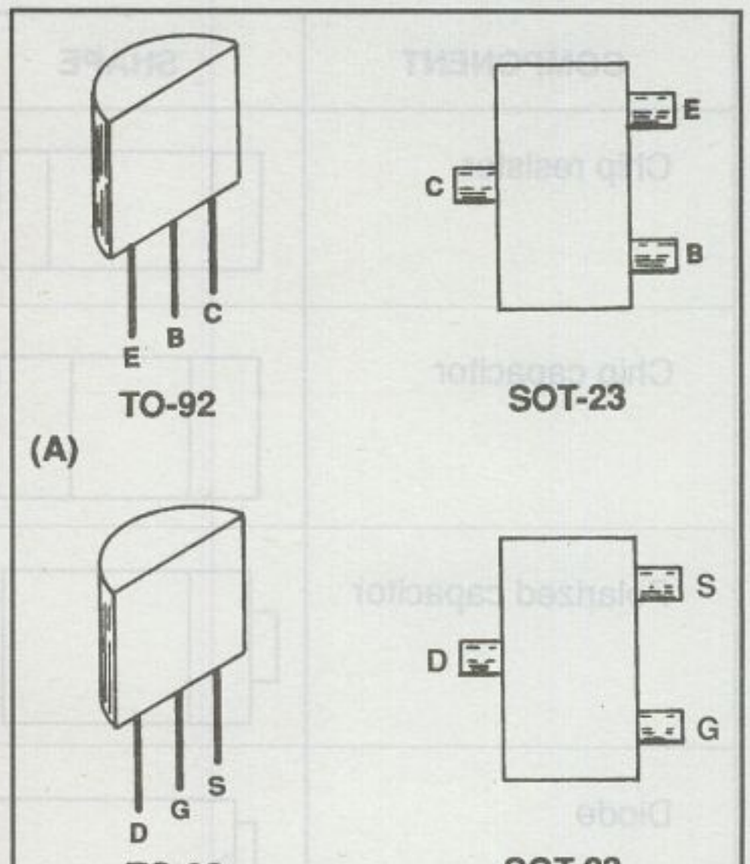


Fig. 2– (A) Comparison between a traditional bipolar transistor and its surface-mount counterpart. (B) Comparison between a traditional FET and its surface-mount counterpart.

dried, flip it over and draw a box 1/2 inch in from all four sides. Bend the cardboard at the lines, forming a 7 1/2" × 10" tray. Fold up each corner. Glue the corners together using white glue. Clamp each corner using a clothespin until the glue dries.

You will be amazed how much of a difference just a bright light and white work surface will make when working with these components.

SMD Safety Precautions

Surface-mount components are very small, and therefore special precautions (in addition to those required when working with through-hole components) must be taken.

- Do not eat or drink when working with surface-mount components.
- Do not use cups, plates, or any food-related items to hold or store surface mount components.
- Keep surface-mount components away from children and pets.
- Wear safety goggles.
- Work away from the edge of a desk or workbench to ensure that components will not fall on the floor.
- Keep a strong light and magnet available to search for components that have dropped on the floor

Identifying SMDs

The general shapes of some common SMDs are shown in Table I. Note that many components (such as chip capacitors) are not routinely labeled. This is why the test tweezers (described below) are so useful. Typical case sizes for chip resistors and capacitors are listed in Table II. To find the approximate size, multiply the first two digits by 10 to get the length in mils, and multiply the last two digits by 10 to get the width in mils. The most common size for chip resistors and chip capacitors is 1206.

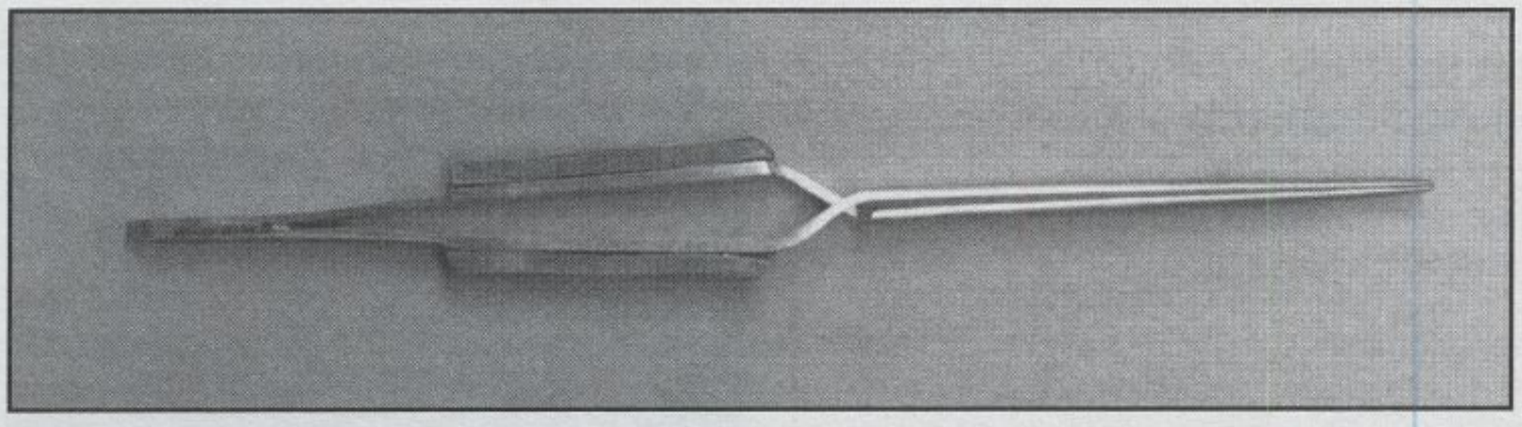
Resistors frequently are marked with a three-digit number, and some typical values are shown in Table III. The first two numbers are the significant digits of the value, and the last digit is the multiplier (the number of zeros to add to the first two digits). For example, a chip resistor labeled 102 has a value of 1000 ohms, or 1K ohms.

SMD transistors are shown in fig. 2(A) and (B) and are compared to the common T0-92 transistor case style. Notice that the leads for the SOT-23 are totally different than for the TO-92.

Testing and Measuring SMDs

Testing SMDs or measuring their values can be a challenge if you use regular test probes. The components will tend to flip or spin out of the probe tips when you apply pressure, which can be very frustrating.

A better way is to make the test tweezers shown in fig. 3(A) and (B). These tweezers grip the component using the copper foil on printed-circuit-board material, which is connected to the input of an autoranging ohmmeter or capacitance meter. The Craftsman autoranging multimeter model 82040 (about $20) works well for this job.



Self-locking tweezers are much easier to use than the non-locking variety when working with surface-mount components.

The tweezers are an easy one-evening project. Start by cutting out two strips of circuit-board material and a small wood spacer. I used oak for the spacer, but any hardwood should work. Polish the PC board's copper foil using a nonconductive abrasive pad until it is shiny. Next, glue the circuit-board pieces to the spacer (foil side in) using five-minute epoxy. When the epoxy has fully cured (about one hour), close the tips together and sand them until they are flush and square. Then solder the test leads to the foil. Use electrical tape or heat-shrink tubing to keep the wires out of the way. Keep the leads to the meter short if you are using a capacitance meter to prevent picking up noise or lead capacitance.

To use the tweezers, simply connect them to an autoranging ohmmeter or capacitance meter and grip the SMD. Very rapid measurements are possible using this simple tool. I frequently use it to sort surplus SMD components and to double-check component values right before mounting them to a circuit board.

Removing SMDs From Surplus PC Boards

Practice components can be removed from surplus boards by using an electric heat gun (available at most hardware stores) to slowly heat a small area of the board. Be sure to wear safety goggles. Once the solder begins to melt, gently tap the edge of the board on the bench to remove the components. With care and practice even semiconductors can be removed without damage. I do this job outside, because heating the board may cause it to smell or smoke a little.

Removing Individual SMDs

SMDs can be removed using special soldering stations employing custom desoldering tips or hot-air jets. If these are not available, you can (with a little practice) remove components using desoldering braid and flux.

To remove an SMD that is already mounted to a circuit board, you will need a roll of fresh desoldering braid and RMA (rosin, mildly activated) flux (liquid or paste). Desoldering braid oxidizes over time, so if it looks dull, replace it.

Infiltrate about one inch of the desoldering braid with flux (if it didn't come that way). Lay the braid over the solder joint and gently press down with the tip of a soldering pencil. The solder will wick into the braid. Each area of braid can only be used once, so trim it after each try. Repeat several times for each solder joint until all solder (except a very thin film) has been removed.

Grip the component with tweezers and gently twist to release the component (don't pull or you may lift the pads). If the component does not release from the pads, go back and try to remove more solder.

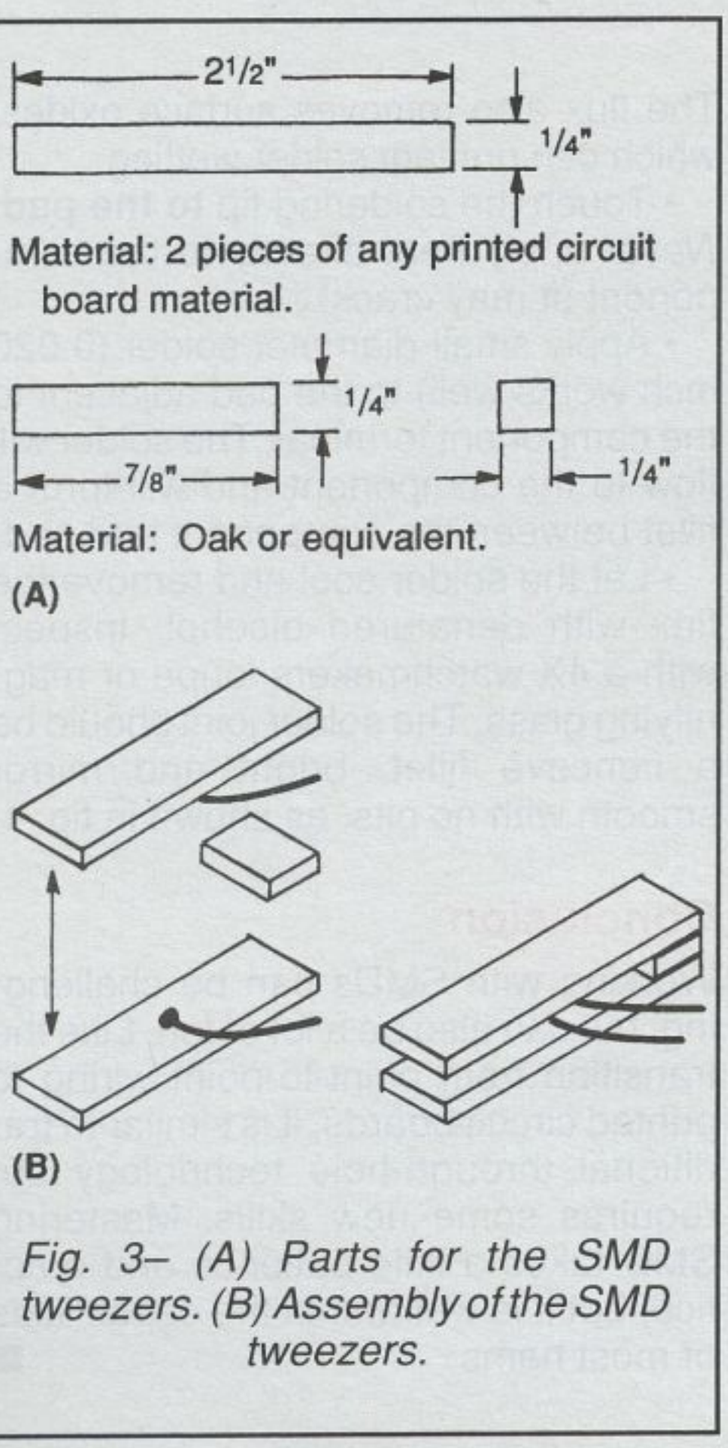


Fig. 3– (A) Parts for the SMD tweezers. (B) Assembly of the SMD tweezers.

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This technique takes practice, so try removing several components from a surplus board before attempting it on an important project.

Soldering SMDs

There are several ways to successfully solder SMD components to a circuit board. Some are easier to learn than others, and some require the use of special materials (such as solder paste, which is a mixture of powdered solder and flux) or special equipment (such as SMD solder stations).

The easiest way I have found to solder SMDs is to first glue the components in position on a PC board, then solder the connections. The procedure is:

• Clean the copper side of the board with a nonconductive abrasive pad until it is shiny. Wipe off any residue with a tissue and denatured alcohol.

• Glue the components into position using Duco cement. Apply the cement to the end of a toothpick, then use the toothpick to apply a drop of cement to the circuit board. Do not get any glue on the pads or any place where you want the solder to flow.

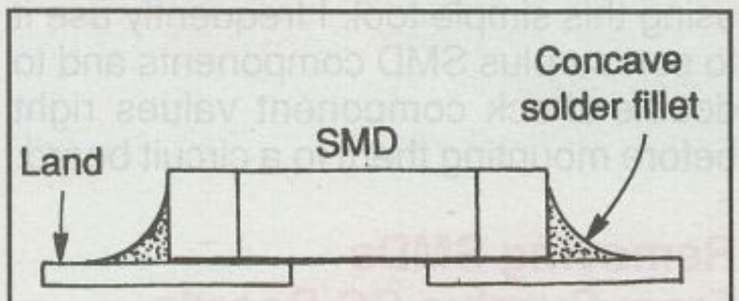
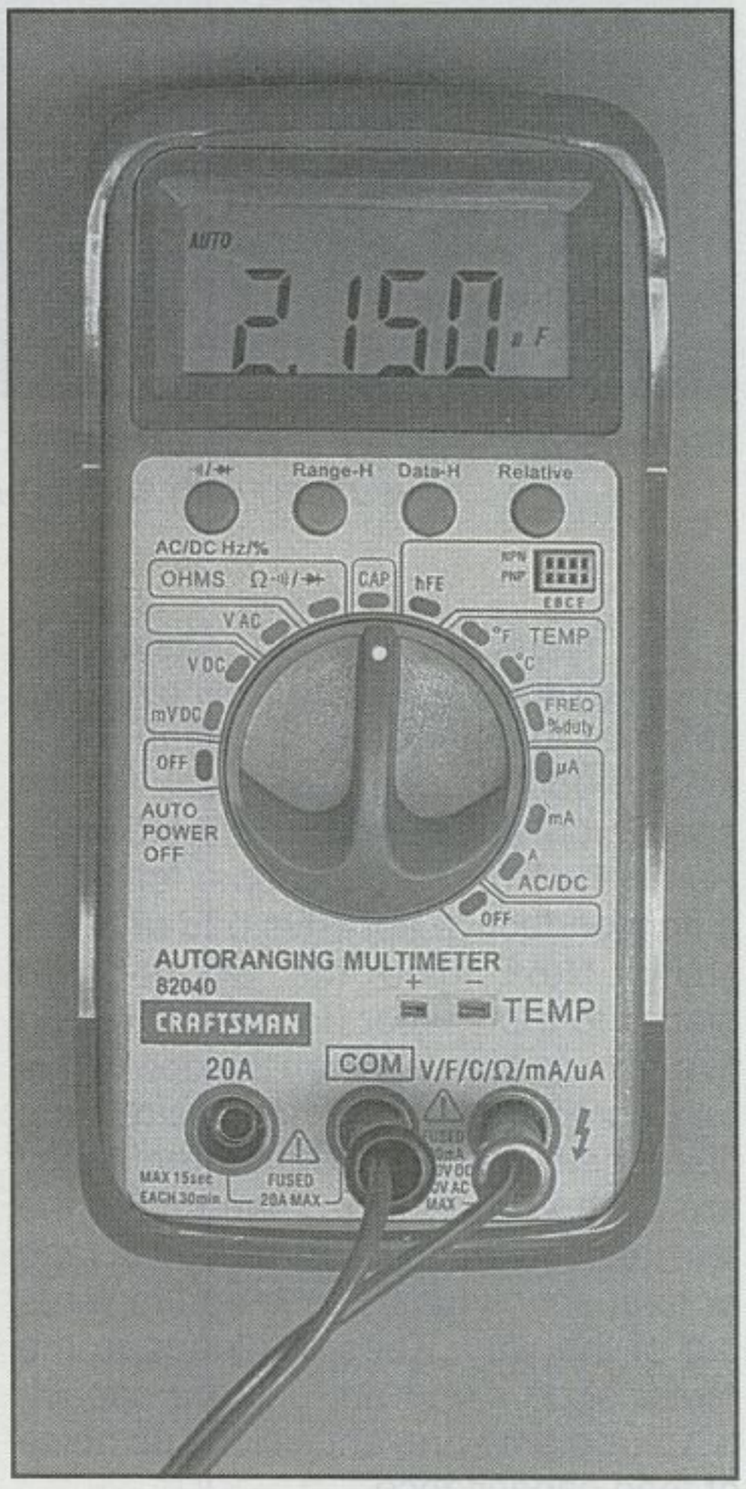


Fig. 4– Side view of an SMD solder joint.

• Using self-locking tweezers, position the components on the board. Let the adhesive dry.

• Gently nudge the components sideways with a toothpick. If a component moves, try gluing it again.

• Apply RMA-type paste flux to the component terminals and pads using a toothpick. Apply the flux where you want solder to flow. The function of the flux is to conduct heat from the soldering tip uniformly to the pad and component. The flux also removes surface oxides, which can prevent solder wetting.



A simple multimeter can be used to measure the capacitance of an SMD component using the test tweezers.

• Touch the soldering tip **to the pad**. *Never* apply heat directly to the component (it may crack).

• Apply small-diameter solder (0.020 inch works well) to the pad adjacent to the component terminal. The solder will flow to the component and will form a fillet between the component and pad.

• Let the solder cool and remove the flux with denatured alcohol. Inspect with a 4X watchmakers loupe or magnifying glass. The solder joint should be a concave fillet, bright and mirror smooth with no pits, as shown in fig. 4.

Conclusion

Working with SMDs can be challenging, but can also be a lot of fun. Like the transition from point-to-point wiring to printed circuit boards, it is similar to traditional through-hole technology but requires some new skills. Mastering SMD takes a little patience and practice, but it is well within the capabilities of most hams. ■

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