

The Ins and Outs of Surface-Mount

Everything you need to know to get started — or get better.

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Today surface-mounted devices (SMD) are found in many consumer electronics products such as TVs, VCRs, camcorders, and compact disc and cassette players. The surface-mounted part has opened up a whole new area of electronic construction. These tiny components are now available to the electronics hobbyist to miniaturize his or her favorite project (**Photo A**).

Now you can build SMD electronic circuits and projects like the big boys. In fact, they are a lot of fun to build. Of course, you must have a steady hand and a great deal of patience.

Because many surface-mounted devices have similar shapes and sizes, sometimes it is difficult to identify them on the chassis. The commercial resistors might appear as round, flat, leadless devices. The ceramic capacitor is a flat solid part with the terminal connections at the outside, tinned ends. The resistor might have several numbers for identification with lines at the ends, while the ceramic capacitor has a line at the top with a letter of the alphabet and numbers. Transistors and diodes are often identified with two

letters. The SMD component terminals are found at each end, except on transistors and IC chips.

The commercial surface-mounted transistor might appear in a chip form with flat contacts at one side, top and bottom, or on both sides. You might find more than one transistor inside one chip. The same applies to fixed diodes and LED SMD parts. Two or more diodes might be found in one component. Remember, you can test these transistors and diodes like the big brother, or standard, components. The SMD part is mounted directly on the PC wiring.

Those tiny components

The SMD part available for electronic construction is marked and mounted somewhat like the commercial SMD component. These SMD components are miniature in size and must be handled with care. Since these parts are so tiny, they can easily be lost or flipped out of sight. For surface-mounted resistors and capacitors, select the physically largest, with the highest wattage and highest working voltage. Choose SMD electrolytic capacitors

with at least a 16-volt rating for small nine-volt electronic projects. Select thick film chip resistors with a 1/8th watt size. Most ceramic chip SMD capacitors have a 50-volt working voltage. These surface-mounted parts are ideal for building the small electronic project (**Photo B**).

Identifying SMD parts

Within the latest TV chassis, surface-mounted parts are soldered directly to the board wiring, while standard components are mounted on top of the PC chassis. The electronics project PC board can be etched so that the SMD parts are mounted on top of the wiring. The most common SMD components available for electronic projects are capacitors, resistors, transistors, ICs, LEDs, diodes, and inductors.

The SMD parts found on the electronics chassis might look like tiny brown, black and gray specks. The fixed resistor might be marked with white numbers upon a black chip. A ceramic capacitor chip might have a letter with a number alongside to identify the value. Some bypass and coupling SMD chip capacitors are not marked at all. The

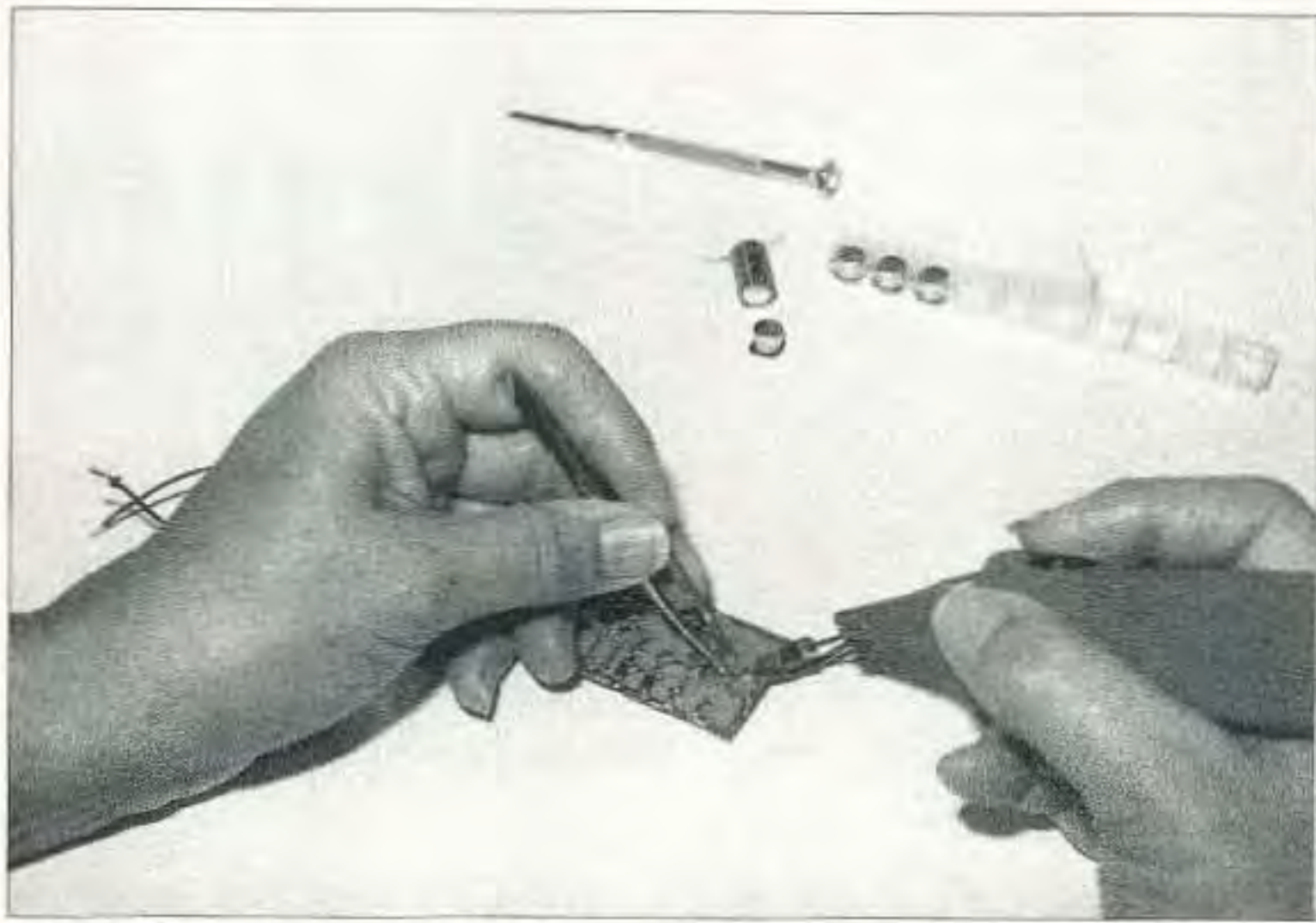


Photo A. Soldering the SMD component into the PC wiring with a battery iron.



Photo C. Four tiny SMD chips are dwarfed by their common equivalents. From left: resistor, transistor, fixed cap, electrolytic.

electrolytic capacitor chip can be identified with a white line at one end, indicating the positive terminal, while the aluminum electrolytic has a black line or area, which is the negative or ground terminal. Besides the polarity marking, the SMD chip electrolytic capacitor might have the capacity value and working voltage stamped on the top side.

The SMD transistor has three terminals, with two on one side and one on the other side. The terminals might be marked 1, 2, and 3. The ceramic IC chip has many terminals on each side, while some microprocessors have gullwing-type terminals. The SMD transistor or IC might have the part marked on top or no markings at all. Some transistors are marked with a number and letter on the top side. Of course, you must have a magnifying glass under a strong light to identify the small numbers and letters on the tiny SMD component.



Photo B. A small AM radio made up of SMD components.

SMD capacitor chips

The SMD ceramic capacitor chip might be available in three or four different case sizes: 1210, 1206, 0805, and 0603. I prefer working with the 1210 and 1206 case sizes, since they are physically the largest chips to work with. For instance, the SMD 1210 case is 3.05 mm in length, 2.54 mm in width, and 1.27 mm thick, while the 1206 is the same length (3.05 mm), 1.52 mm wide, and 1.27 mm thick. Naturally, the smaller the capacity in picofarads (pF), the smaller the case size of the capacitor (**Photo C**).

Most ceramic chip capacitors are available with a 50 volt working voltage. The capacity can range from 0.5 pF to 0.068 μ F. These ceramic chip capacitors are available from some mail order firms in a single (1), 10, 100, 500, or 1000 lot price. It's best to purchase parts at a 10-lot price. The ceramic chip capacitor is used in bypass and coupling electronic circuits.

The surface-mounted chip and dipped mica capacitors are selected for RF, radio, microwave, and resonator circuits. The working voltage might be 100 and 500 volts from 1 to 1000 pF capacitance. These SMD mica capacitors are quite expensive compared to other SMD capacitors.

Remember, the ceramic chip capacitor is a nonpolarized capacitor. You can solder any end into the PC wiring circuit without any problems. The ceramic chip capacitor might have a letter and

number stamped on the top indicating the actual capacitor value, while in other chips there are no markings and only end connections. Always keep those SMD parts inside marked plastic envelopes so they will not get lost or mixed up.

The SMD aluminum electrolytic capacitors are polarized and should have a 16, 25, 35, or 50 V working voltage. Do not use a 10 volt or less working voltage SMD electrolytic in a nine-volt battery circuit, as they have a tendency to break down.

Often the voltage and capacity are stamped on top of the electrolytic capacitor (**Fig. 1**).

The top black marked area indicates the ground terminal. Observe the correct polarity of electrolytic capacitors; if installed backwards, they can run warm, overheat, and blow up in your face. They are available from 0.15 to 1000 microfarads (μ F). The SMD aluminum

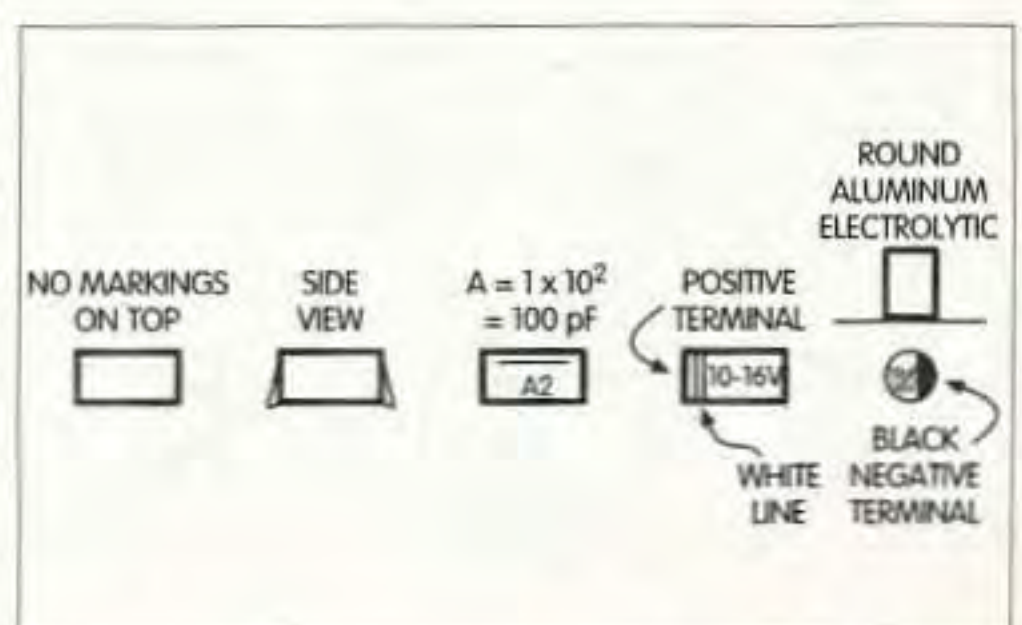


Fig. 1. The ceramic capacitor might have a letter and number on the top side to identify the chip and value.

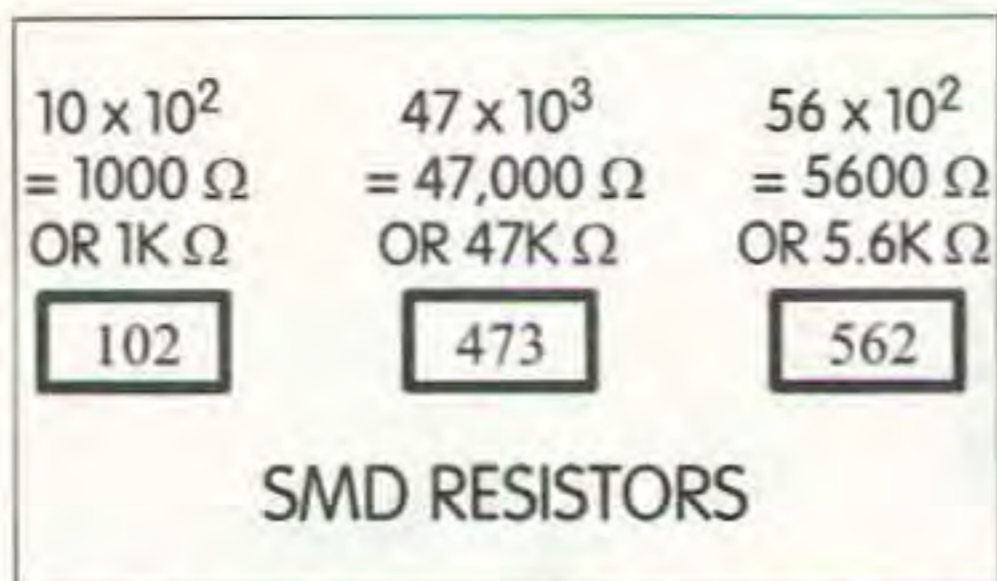


Fig. 2. The SMD chip resistor has several numbers on top to identify the value of resistance.

electrolytic stands up while the solid chip lies down on the PC wiring.

The tantalum electrolytic chip capacitors are found in a smaller capacity and can be purchased in 16, 20, 25, and 35 working voltages. The black polarity bar on the top side is the positive terminal. Most standard electrolytic capacitors have a black line that indicates a negative or ground terminal. These SMD electrolytic capacitors have the reverse, a positive (+) polarity with a black bar at one end. Place the SMD black line at the positive voltage connection.

The tantalum electrolytic are available from 0.47 to 47 microfarads (μF). The SMD aluminum electrolytic capacitor is used in B+, decoupling, and power supply circuits, while the lower-capacity tantalum capacitors might be found in coupling and bypass circuits.

SMD resistors

The SMD resistor can be identified by numbers stamped on the top side of the chip. These SMD resistors appear in thick film chips of 0805, 1206, 1210, and 2512 case styles. Choose the

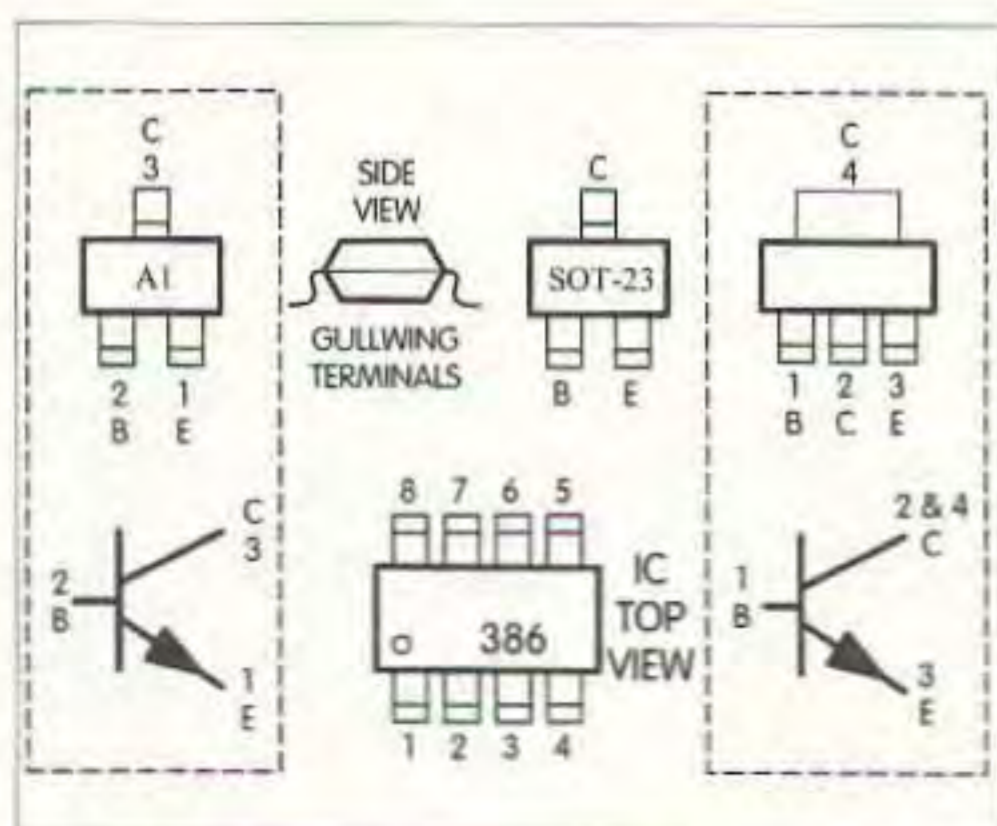


Fig. 3. The SOT-23 general purpose transistor might have a number and letter on the top side.

0805, 1206, and 1210 case styles for electronic construction. The 0805 resistor is 1/10 watt; 1206 style is 1/8 watt; and 1210 is 1/4 watt. The 2512 case is a 1 watt SMD resistor. These SMD fixed resistors appear in 0 Ω , 10 Ω , and 1.0 megohms. The 0 Ω resistor might be used as a feedthrough or to tie two circuits together.

These SMD resistors can be purchased in 1, 10, or 100 lot prices. It's best to choose SMD resistors in a 10-lot pricing of each value. Remember, either end of a resistor can be soldered into the circuit with the resistance value at the top. For instance, the SMD resistor might have 102 stamped on top, where the first two numbers equal the amount and the last number indicates zeros to add. The numbers 1 and 0 thus would equal 10, and two zeros at the end would then mean a 1000 ohm or 1 k resistor or (Fig. 2).

SMD transistors (SMT)

The surface-mounted transistor might appear as a chip with flat contacts at one side, top and bottom, or both sides. You might find more than one transistor inside one chip. The standard or conventional SMD transistor has an SOT-23 package outline, while the one watt power transistor has an SOT-89 outline with a heat sink. The SOT-89 and SOT-223 might consist of two transistors in one chip or in a Darlington arrangement.

The conventional transistor (SOT-23) is a general purpose transistor that you would find in electronic projects. Digi-Key uses part numbers such as FMMT3904CT-ND for the 2N3904 NPN transistor and FMMT3906CT-ND for the 2N3906 PNP type. The Mouser Electronics listings for the same type of transistors have part numbers of MMBT3904 and MMBT3906. The conventional 2N2222 general switching transistor in the SMT types is listed as MMST2222 at Mouser and FMMT2222ACT-ND (NPN) at Digi-Key Corporation.

The SOT-23 general purpose transistor has the collector terminal on one side (at the top), with the base to the left and emitter terminal to the right at the bottom side of package outline. Some have flat or gullwing-type terminals.

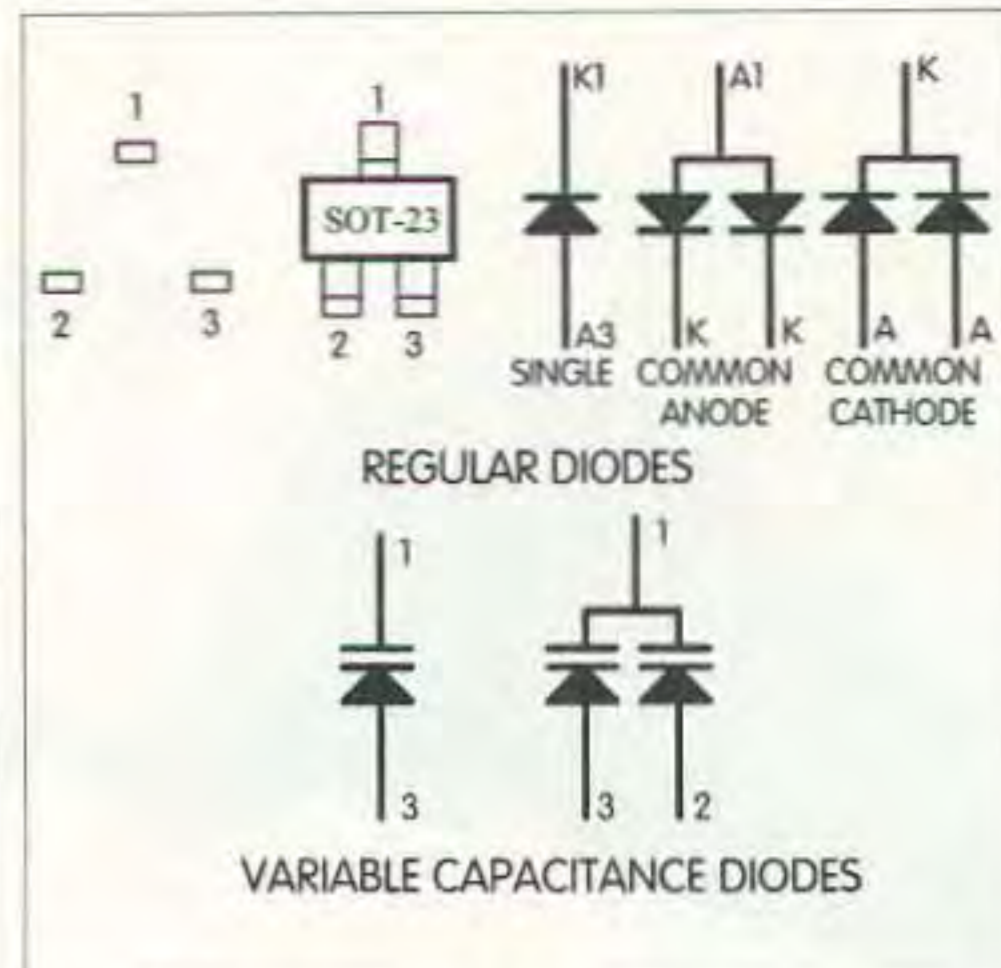


Fig. 4. The fixed diode terminals are listed as numbers and more than one diode may be found in one chip.

These transistors can be tested with the transistor tester or with the diode test of the digital-multimeter (DMM).

You can identify the SOT-23 general purpose FM3906CT by a 2A stamped on top, and the FM3904CT by a 1A. The CMPT2222A switching transistor has a C1P on its top (body) (Fig. 3).

IC chips

The SMD IC chip is constructed somewhat like the standard IC with gullwing terminals. Usually these static-sensitive devices arrive in dark static-sensitive bags. Terminal 1 is identified by a U or indentation circle on top and is found at the bottom left hand corner, looking down upon the chip. For instance, the linear LM386 low power amp IC is an SMT p/n LM386-1-ND at Digi-Key and has an SO-8 outline. The 386 numbers are stamped on top with an indented circle at terminal 1.

IC chip devices are neither heatproof nor shockproof. They are made of ceramic or plastic molding, and they should not be subject to direct shock. Do not apply unnecessary stress to the chip. Handle SMD semiconductors with extreme care. Install the chip flat upon the printed circuit board.

SMD diodes

The leadless, fixed, Schottky barrier, zener, and variable capacitance diodes appear in SOT-23 packages. These diodes might look like three-legged

transistors. The SMD diode can be identified by two alphabet letters or numbers. You might find one or two fixed diodes in one chip (**Fig. 4**). Only two terminals are used with one fixed diode, while all three terminals are used with two diodes in one SOT-23 chip. These diodes can be purchased in one (1), 10, and 100 lot pricing.

There are several different packages the SMD diode may appear in. The SMD signal diode SD914 or MMBD914 might appear in an SOT-23 package, while an SMD S1 signal diode appears in a round LL-34 chip. The SMD zener diode might be found in a flat round chip, or in an SOT-23 package. The case and power rating of a 3.6 V zener diode rated at 200 mW, 300 mW, and 400 mW are found in an SOT-23 package. The LL-34 case zener diode is rated at 500 mW in a round package. The SMD one-watt zener diode appears in a round (SM-1) or PSM flat chip. All SMD diodes can be tested with the diode test of the DMM.

Which side is up?

Mount the SMD resistor with the numbers on top and black side upward. The bypass or coupling chip capacitor, which might not have any markings on the body, should be mounted with the contact points downward on the end pads. Mount the small chip electrolytic capacitors with the capacity and voltage listed on top with contacts at the bottom. Make sure the white line on the top side of SMD capacitor connects to the positive voltage. The top black edge of the aluminum electrolytic capacitor is connected to ground.

The transistor is mounted with the number and letter (example: 1A) upward with the terminals over the three PC pads. Place the indented dot of the SMD IC at terminal one on the PC wiring. Make sure all terminals line up with the PC pads and connections.

Mounting SMD components

Fixed SMD capacitors and resistors are constructed so that solder is applied to each end, which then lies upon a solder pad of the PC wiring. If the resistor or capacitor lies over a piece of PC wiring, I like to place a thin piece

of cellophane tape over the wiring before the part is mounted. This method prevents any part from shorting between wiring and component.

First, I prefer to mount all fixed capacitors, then resistors, and then semiconductors last. Take one part out of the package at a time. Remove the part from the strip by sliding a razor or knife blade under the piece of cellophane, and then place the SMD part on a sheet of white paper. Seal the remaining parts on the cut tape strip with a piece of tape. Return all parts back to the original package or bag. Seal up with tape or staple the plastic packet so parts will not spill out.

Before installation, test each resistor for correct resistance and fixed capacitors for possible leakage. Measure for correct resistance and capacity leakage with the 2 k Ω range of your ohmmeter. Carefully place the meter test probes at each end of the component for a correct test. Likewise, check each SMD transistor or diode on the diode test of a digital multimeter (DMM), if one is available. Double check the polarity of diodes and electrolytic capacitors before and after installation.

Grasp the tiny component with a pair of small tweezers and hold the ends to be soldered over the correct set of pads. Make sure the wiring pads are tinned with solder. Choose the smallest diameter of rosin solder for those tiny connections. Tack one end in with the soldering iron. A dab of solder will

do. Then go to the opposite end and apply enough solder to make a clean soldered joint. You are soldering the ends of the SMD part to the PC wiring pads. Go back and resolder the tacked-in side. A good soldered bond on the end of the SMD component will have a bright, clean connection.

Choose a 30-watt (or less) soldering iron with a fine point. A battery soldering iron is ideal and makes tiny bright connections. Do not leave the iron on the joint too long; it will damage the SMD part or lift the PC pad and wiring. Double-check the soldered connection with the magnifying glass. After installation, check for correct resistance across the fixed resistor and leakage across the capacitor.

The semiconductors are the most difficult SMD components to solder into the circuits. They have such tiny connections. Try to center the three transistor terminals over the right soldered pads or tabs with the small tweezers. Tack in one terminal to hold it into position. Then carefully solder up all three terminals with the fine point of the soldering iron. Be very careful not to apply too much heat from the iron and destroy the transistor.

Check for the indentation or dot on top of IC that indicates terminal 1. Make sure terminal 1 is at the right pad. Double-check to see if all IC terminals are over each PC wiring pad. Tack in one terminal on each side of the IC so it will stay in position. Now solder up

all IC terminal connections to the PC wiring. Inspect each connection with the magnifying glass.

Test between each IC element or terminal with the 200- Ω range of the DMM for leakage. Sometimes too much solder will lap over and cause leakage between the two terminals. Make an in-circuit diode-transistor test of each diode and transistor. You want to make sure the transistor or IC is not damaged and has good clean soldered connections.

The resistance and diode tests of resistors, capacitors, transistors, and ICs ensure that no parts are damaged, the correct part is in the right position, and good soldered connections are made. This increases the likelihood that the electronics project will perform after all parts are mounted. When it's fired up for the first time, and it works, there are no greater rewards.

Testing components

Test each SMD component after it's mounted and soldered. Inspect each soldered connection with a magnifying glass. Check the resistance of each SMD resistor. Check each capacitor for leakage. Take a low-ohm continuity measurement across coils and inductors.

You will note that when a resistance measurement is made across the electrolytic capacitors, the meter hand will charge up or the DMM numbers will rise and fall as the capacitor discharges. Reverse the test probes and the capacitor will charge up again according to the amount of capacity of the electrolytic. The charge is very small on a 10 μF electrolytic capacitor when compared to a 100 μF one. The charge and discharge of the electrolytic indicates a good connection, normal capacitor, and no shorts or leakage.

Test each transistor with the diode-test of the DMM. Place the red probe (positive) of an NPN transistor at the base (B) terminal and black probe (negative) at the collector (C) terminal (Fig. 5). Note the normal diode-junction test resistance. Leave the red probe (+) at the base (B) terminal and place the black probe (-) at the emitter terminal. Notice that the two different

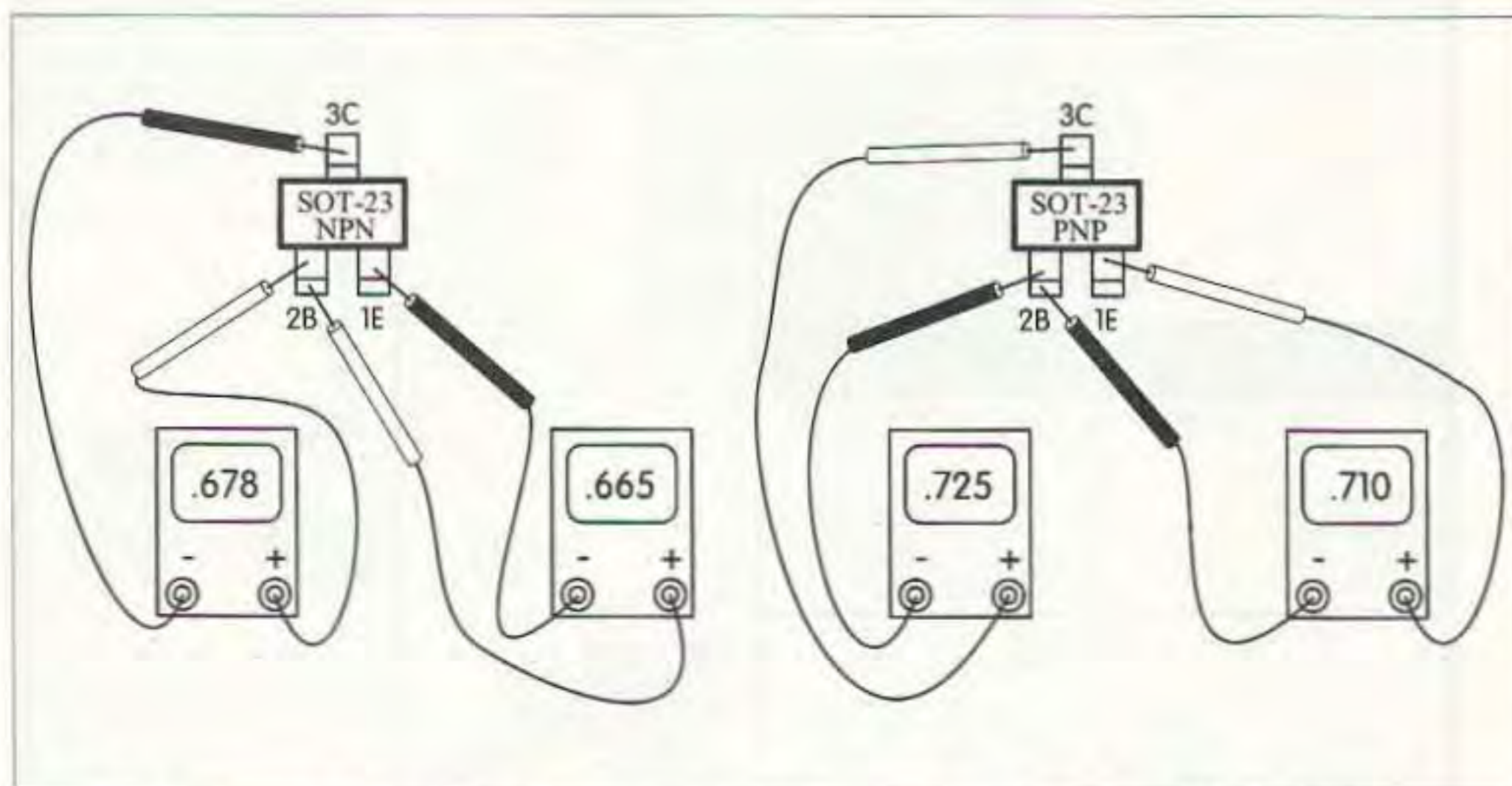


Fig. 5. Checking the normal transistor with a diode-test of the DMM. This diagram shows the forward bias test only. All junctions should show a very high resistance in the reverse bias configuration.

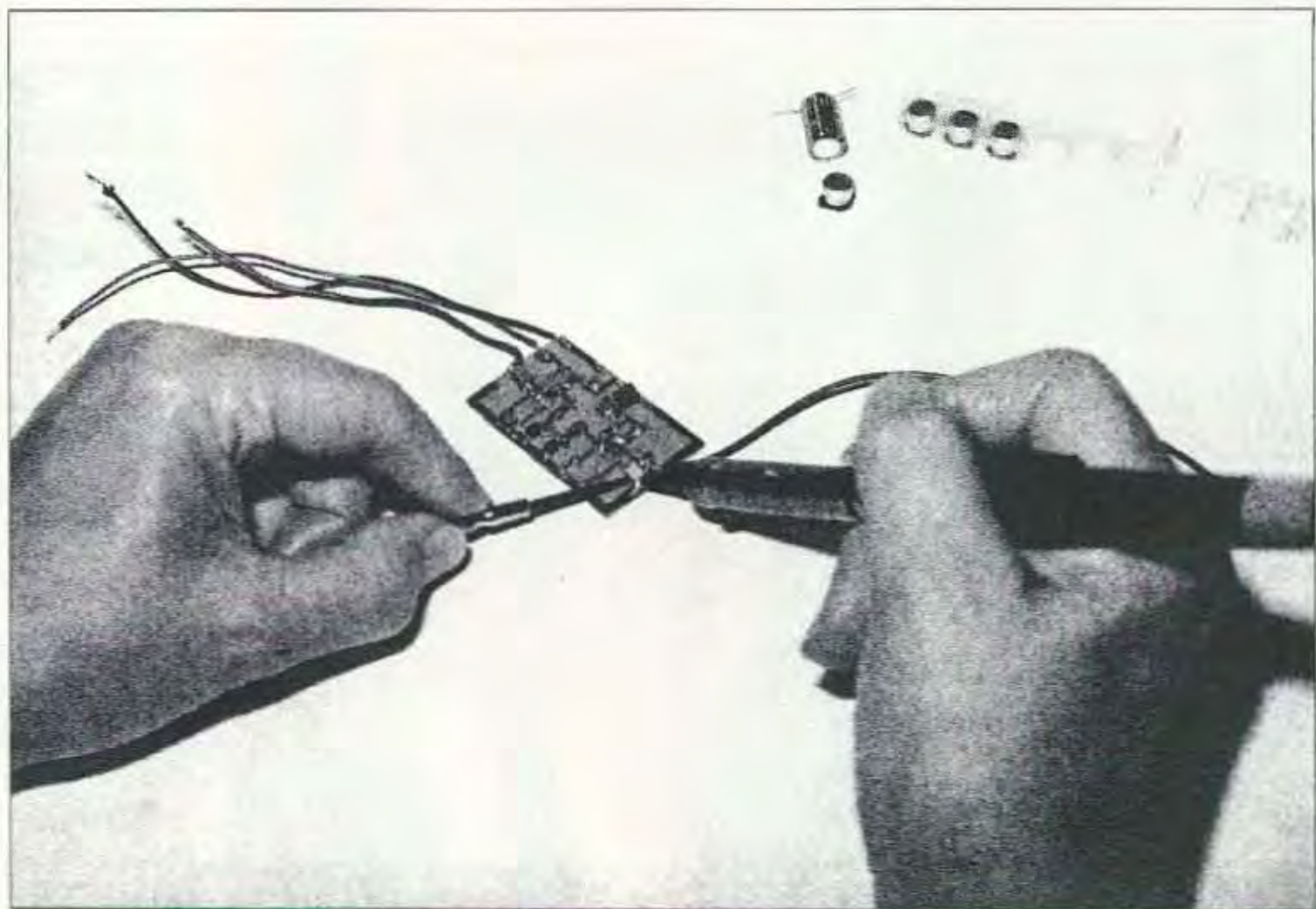


Photo D. Apply heat from the iron and pry up on chip to remove it from soldering pads.

resistance measurements are quite close with a normal transistor.

Now reverse the test leads. An infinite reading indicates a good or normal transistor. If a low resistance measurement is found below 100 Ω , in both directions, the transistor is leaky. The transistor is shorted between two elements if the reading is below 5 Ω . The leaky or shorted transistor will have a low ohm measurement with reverse test leads in both directions. Often, the defective transistor becomes leaky between collector and emitter terminals.

Removing SMD components

If you have placed the SMD part in the wrong spot or have damaged the tiny parts with too much heat, the component must be removed from the PCB. Remove fixed SMD capacitors and resistors by applying the iron first at one end and then quickly to the other. Pry up the SMD part with a small screwdriver. By quickly heating both ends, the small chip can be removed. Throw the removed part away. Do not try to reuse it.

Heat each individual terminal of the transistor and pry up each terminal with a pocket knife or small screwdriver (**Photo D**). Do the same with each gullwing terminal of the damaged IC until all terminals are removed. Touch up the soldering pads with solderwick and soldering iron. Lift the excess solder from the PC pads and wiring.

Where to locate SMD parts

Most SMD components for electronics projects can be ordered through electronics mail-order firms. You may have to shop around to acquire special SMD parts. Digi-Key and Mouser Electronics handle most SMD components, while other mail order firms might handle only capacitors and resistors. You can identify SMD parts with a typical case mounting, diamond markings, or SMD listings in the parts catalog. 73

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