



FROM THE BENCH

by Jeff Bachiochi

Component Control

A Tool for Finding and Handling Small Parts

It's time to take control of your components. You can identify tiny surface-mount parts with a handheld LCR meter. The lightweight tool automatically determines the type of component, inductor, capacitor, or resistor (LCR), and selects the proper range and signal frequency for the most accurate measurement. The component type, measurement results, and test conditions used to determine the results are displayed on a dot-matrix display.

If your work area is like mine, you probably have a small box that collects all the odd components that end up on your bench after a project (see Photo 1a). I am a little more careful when it comes to surface-mount parts. They are usually purchased as taped strips (reels) of parts and are better protected from getting jumbled together with other parts (if left taped). However, one of the big problems with SMT stuff is that it is usually too small to be labeled. Thus, you can easily lose track of parts and their values. I can't tell you how many times I've picked up an SMT part only to have it shoot out from the tweezers never to

be seen again!

Frankly, I'm surprised I haven't seen a good tool like the Advance Devices Smart Tweezers handheld LCR meter sooner (see Photo 1b). The small, lightweight format fits comfortably, enabling operation with just one hand. Although it is designed to easily grab SMT devices with its tweezer-type probes, it can perform its magic on through-hole parts as well.

You can use the Smart Tweezers (ST) to identify and evaluate loose components and those already soldered on a PCB (unpowered). Of course, you may need to have some knowledge of the circuitry to deter-

mine what other devices might be in parallel with and affecting the device under test (DUT).

WHAT DOES IT DO?

The Smart Tweezers meter automatically determines the type of component, resistor, capacitor, or inductor (RCL), and selects the proper range and signal frequency for the highest accuracy measurement. Using a small 32 × 96 dot graphics display, the Smart Tweezers meter clearly displays the component type, measurement results, and test conditions used to determine the results. The display is divided into three areas. The central

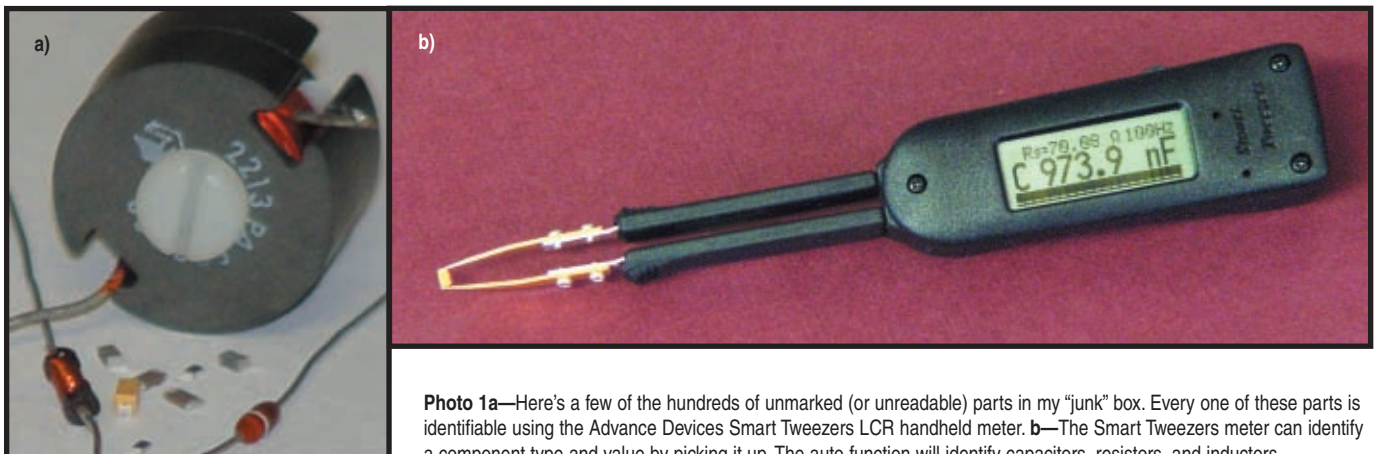


Photo 1a—Here's a few of the hundreds of unmarked (or unreadable) parts in my "junk" box. Every one of these parts is identifiable using the Advance Devices Smart Tweezers LCR handheld meter. **b**—The Smart Tweezers meter can identify a component type and value by picking it up. The auto function will identify capacitors, resistors, and inductors.

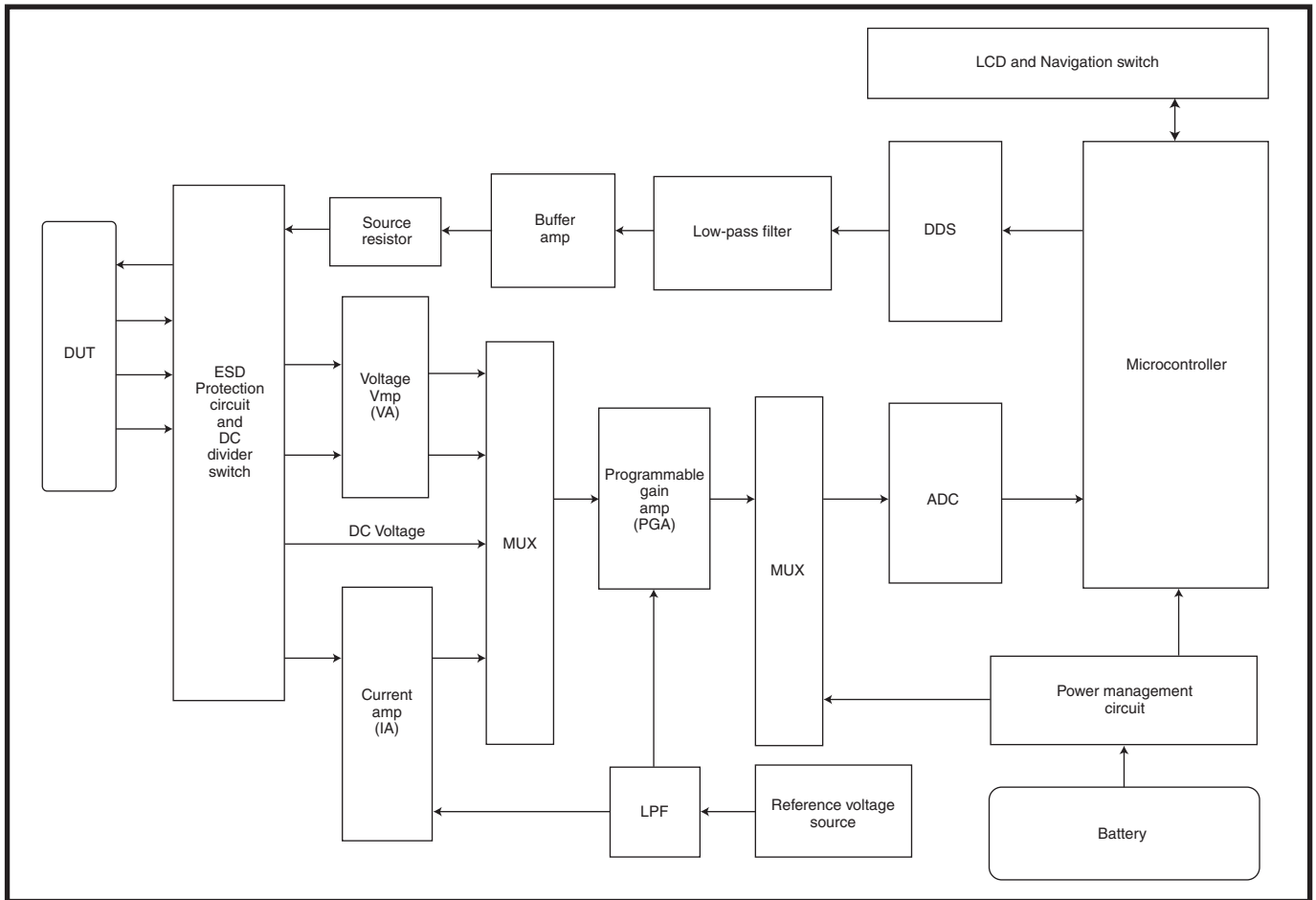


Figure 1—A Texas Instruments MSP430F135 microcontroller orchestrates the user I/O, D/A, A/D, and power management circuitry to identify common devices, including resistors, capacitors, inductors, and diodes.

(and largest) area contains the component type and determined value. The top area shows additional parameters and testing conditions. The bottom area displays a horizontal bar graph indicating the value's percentage of the test range.

If you've had the pleasure of assembling any circuit using surface mount technology (SMT) components, you probably have at least one pair of tweezers for picking up and placing surface-mount devices (SMDs). The Smart Tweezers meter has conductive pincer-like contacts that can measure and identify an SMD if picked up the correct way (see Photo 1b). The small and lightweight enclosure fits well in your hand, kind of like writing with a pen or pencil. At first, I thought the small LCD might be custom glass with specific glyphs. But after playing with it a while, I realized it was a simple dot-matrix display. The design can be used with either of your hands. When configured for lefties, all of the

LCD text and graphics are rotated 180°. I'm guessing this is done rather simply by manipulating the LCD data and where the data is stored (mirroring each most significant for least significant bit/register).

Automatic mode determines the device type (LCR) and measures, calculates, and displays the appropriate value. Manual modes are available to

force the tests to use particular parameters. All modes are accessed via a jog dial—actually three switches (push left, push right, and push down).

WHAT IS GOING ON?

Figure 1 shows the system's major building blocks. The microcontroller of choice is a 16-bit Texas Instruments

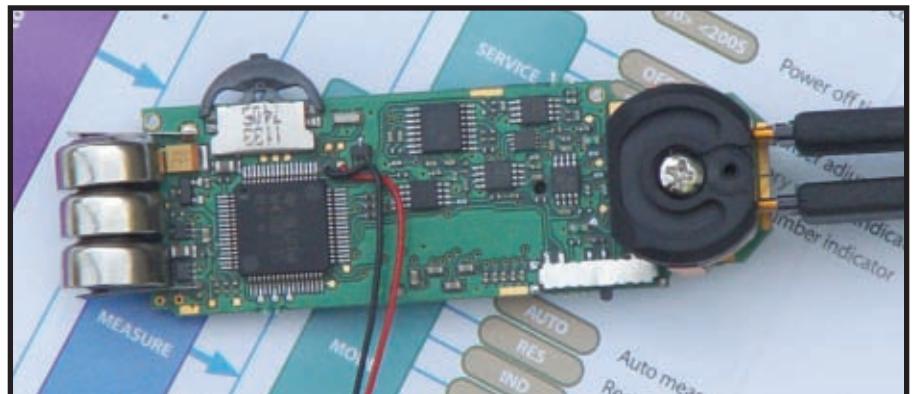


Photo 2—The internal PCB has the MSP430F135 microcontroller and all the other SMT parts (except the LCD) mounted on one side. The three button cell batteries can provide over 80 h of use.

MSP430F135 (see Photo 2). Besides handling the user input/output through a jog-dial/LCD, the microcontroller calculates the impedance of a DUT by measuring the voltage across it and the current through it, as shown in the front-end circuitry (see Figure 2). The MSP430F135 controls both the amplitude and frequency of the voltage source (V_s) and is typically approximately 1 V (sine wave). V_s is applied to the DUT through the source resistance R_s . DUT_V is the voltage measured by the first amplifier (AU) directly across the DUT and is measured by one A/D channel. Current through the DUT (DUT_I) is converted to a proportional voltage by a second amplifier (AI) and the feedback resistor R_I ($V = DUT_I \times R_I$) so it can be read by a second A/D channel.

The DUT's impedance is a combination of resistance and capacitive or inductive reactance. The proportions

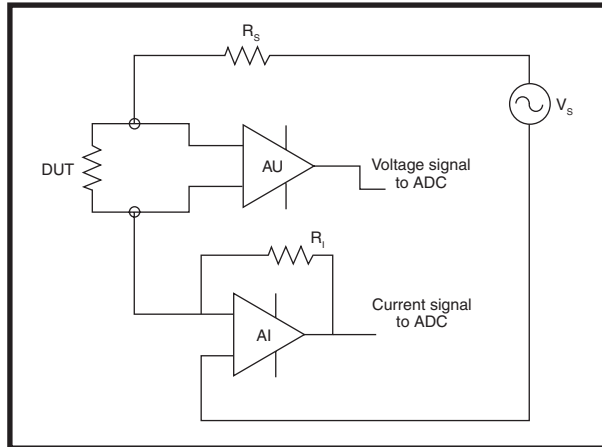


Figure 2—The analog front end uses a DAC to provide AC excitation to the DUT. The resultant voltage across and current through the device is measured by A/D circuitry to provide data back to the microcontroller.

of each of these are based on the relationships between applied voltage and the measured voltage and current. With an ideal resistive DUT, the impedance, and thus resistance, is the same because the DUT_I and DUT_V are in phase. With an ideal capacitor DUT, the impedance is the capacitive reactance because the DUT_I will lead the DUT_V by 90°. The capacitance

must be calculated based on:

$$C = \frac{-1}{2\pi f X_C} \quad [1]$$

With an ideal inductor DUT, the impedance is the inductive reactance because the DUT_I will lag the DUT_V by 90°. The inductance must be calculated based on:

$$L = \frac{-1}{2\pi f X_L} \quad [2]$$

Manufacturing and materials will play a role in a device's quality. Capacitors, inductors, and even resistors may be less than ideal components. We all consider a resistor to be pretty much an ideal device. However, many resistors are made by depositing a material on a form and etching or cutting a spiral pattern in the coating, creating a lengthy strip to achieve the required value, but also looking a bit like an inductor. This is perhaps more clearly seen in wire-wound resistors. While this is usually

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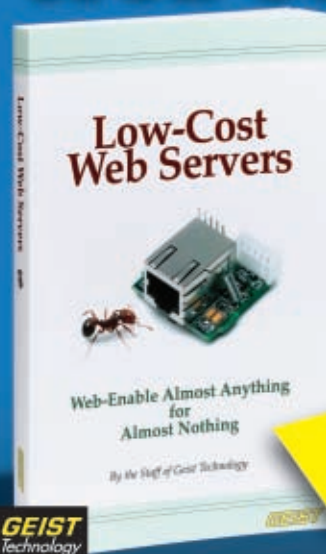
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minimal, it must be considered in circuits where the frequencies used may cause this inductance to affect circuit operation.

All current-carrying conductors are inductors to some extent. That is, the magnetic field created by a change in current in them is not instantaneous and therefore opposes the change. This opposition can be enhanced by providing a medium (core) that collects and hangs onto the magnetic energy, as well as concentrating (wrapping) the conductors around the core. As shown in the previous equations, there is a direct relationship between the inductance (opposition to change) and frequency (rate of change). Therefore, testing a component at a number of frequencies is required to obtain measurement results that are within analytical limits. It's likely an inductor will be somewhat less than ideal. Series resistance will be part of the DUT's impedance. This can be determined by the phase relationship between the DUT_v and the DUT_i . With the ideal

resistor (phase shift = 0°) and the ideal inductor (phase shift = 90°), any inductor that is not ideal will have a resistive/inductive reactance relationship of phase difference equals $\arctan(X_L/R)$. The relationship (X_L/R) is also known as the quality factor (Q). The closer the inductor is to ideal, the higher the Q.

A capacitor, on the other hand, opposes a change in voltage due to its physical makeup. The leads of a capacitor are connected to large plates held just a fraction of an inch apart by thin insulating material. Ideally, there is infinite resistance between the plates. When a voltage is applied across the plates, maximum current flows because the potential difference between the source and the plates is greatest. Electrons are in fact not flowing through the device but being stored on (or released from) the plates. The electrons create an electric charge (voltage) across the plates. As the potential between the source voltage and the plate voltage decreases, so does the current flow. Capacitance

goes up as the plate size increases or the spacing decreases. Although the dielectric insulating material also affects capacitance, it has a greater effect on losses that are affected by things like temperature and frequency. As shown in the previous equations, there is a direct relationship between the capacitance (opposition to change) and frequency (rate of change). Therefore, testing a component at a number of frequencies is required to obtain measurement results that are within analytical limits. It's likely a capacitor will be somewhat less than ideal. There will be some parallel resistance that will be part of the DUT's impedance. This can be determined by the phase relationship between the DUT_v and the DUT_i . With the ideal resistor (phase shift = 0°) and the ideal capacitor (phase shift = 90°), any nonideal capacitor will have a resistive/capacitive reactance relationship of phase difference equals $\arctan(X_C/R)$. The relationship (R/X_C) is also known as the dissipation factor (D). The closer the

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capacitor is to ideal, the lower D will be.

FINGERTIP CONTROL

The jog dial provides up, down, and select functions. An initial press (in any direction) initializes the Smart Tweezers and configures it to the last selected functions before it turns itself off. You can immediately begin taking measurements of components. A second push brings up a menu of functions you may choose from. The menu road map is shown in Figure 3. Choosing AUTOSET resets all parameters to the default setting and returns you to Operational mode. There are two other selections you can choose instead of EXIT, SYSTEM, and MEASURE. If you choose SYSTEM, you can select one of the four system settings: SOUND, DISPLAY, TIMEOUT, and SERVICE. If you choose MEASURE, you can select one of the seven modes of operation: AUTO, RES, IND, CAP, DIODE, VOLTAGE, and TRACE.

The system settings enable you to customize the operation of the Smart Tweezers. The SOUND setting

enables/disables a beep whenever a measurement is taken. The DISPLAY setting lets you set the display's contrast and determine whether the display is formatted for right- or left-hand use. Finally, the TIMEOUT setting lets you set the timeout (the delay after any measurement or selection before shutting off) from 10 to 200 s.

While the Smart Tweezers can measure most devices using the AUTO mode (RES/IND/CAP), you can use the measurement settings to change or force a mode of operation. For instance, if you have a wire-wound resistor, you can select inductor (IND) to determine the resistor's inductive reactance due to its physical makeup. If the DUT is a diode, you must force a switch to DIODE mode. A pictograph of a diode will be displayed with its orientation matching the polarity of the connection. The VOLTAGE selection allows for measurements of up to ± 8 V. A tiny slide switch on the side of the case must be moved to enable this function. (The LCD prompts you when to slide it.) Note that the auto-off function is

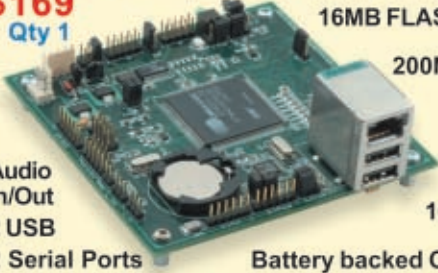
disabled while this switch is used. TRACE mode is similar to VOLTAGE. Instead of a text display of the voltage value, a graphic display over time is used, like an oscilloscope. You can dynamically change the time base using the left/right jog dial switches. Because of the delicate and sensitive front end, you should not measure live circuits with more than 1.6 V without selecting VOLTAGE or TRACE modes and moving the slide switch as prompted.

PRACTICAL LIMITS

There are a few things that might seem obvious but must be taken into consideration for the most accurate measurements. When measuring small resistances, the physical connection resistance between the (gold plated) tips and the DUT is approximately 25 m Ω (this can vary with contact pressure). You must subtract this from the measured value, if appropriate, when it is a large percentage of the DUT. For the most accurate measurements of small capacitors (pF), you should force the test frequency into its highest range (10 kHz).

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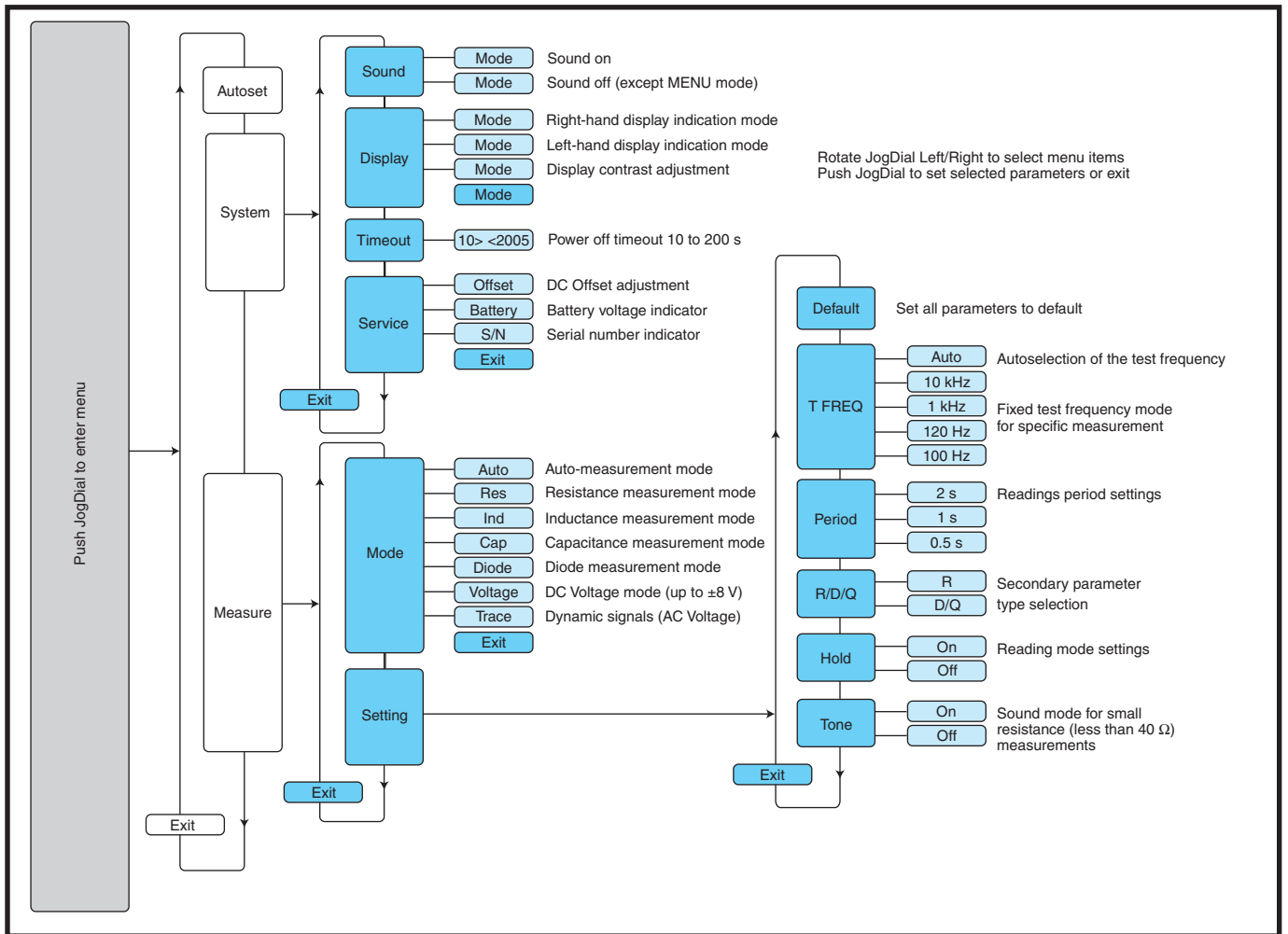


Figure 3—The dot-matrix LCD provides resultant data as well as function menus for changing default parameters. You can scroll through the menu selections using the jog dial's left/right switches. By pressing it, you can choose the highlighted selection. Use this chart to follow the menu hierarchy.

Measuring physically small size capacitors will inherently add a small offset of up to a couple of puffs (picofarads) due to the close proximity of the tips. Measuring inductive extremes is most accurate by forcing the test frequency as well (highest frequency for low values and lowest frequency for high values).

USE IT

After each project, I spend a little (sometimes too little) time cleaning up my workspace. It's not unusual for there to be a bunch of leftover components on my bench top. If I'm bad, I sweep them into a box of miscellaneous parts. If I'm worse, I toss them out! Many parts are unique enough to be easily separated and put back into their proper places. Components like connectors and ICs (generally anything that is large enough) can be handled through divide-and-conquer

techniques. When it comes to smaller discrete or SMT parts, I need to get out the hand magnifier to read values. While the colored stripes on 5% resistors are noticeable, I often can't tell which end is which with the resistors that are 5%. Even though I know 0603 SMT resistors have digit values on them, I can't make them out, even with a magnifier. Other small surface-mount capacitors and inductors have room only for a logo. I no longer need to strain my eyes and guess at which parts I'm trying to store away because I can use Smart Tweezers to pick up, identify, and place the part in one easy movement.

I've always used a small pair of tweezers to help position SMT components on PCBs that I hand assemble. I'm pretty good at soldering tiny devices. One of the most frustrating things is to find that I've either used

the wrong part in the right place or the right part in the wrong place. Being able to verify a part's type and value prior to hand soldering is helpful in the long run. Likewise, being able to identify components and values that have been placed and soldered can save time. You don't have to remove and replace a part because you don't know if it's the right part. This goes a long way in reducing stress, especially when a circuit is not working correctly. Of course, you need to know how the component is connected in the circuit to determine if its measured value is being affected by the surrounding components. Note that you should always measure components with the circuit in an unpowered state, unless you are specifically using the Smart Tweezers in the voltage mode.

Have you ever had a circuit you were trying to understand? Maybe you

needed to determine the cut-off frequency of an analog filter? The ST is a great tool to help you identify the components and values used in a circuit so you can make the calculation necessary to determine operating parameters. While the Smart Tweezers is made for measuring those parts that fit between its fingertips, you can put clip leads on its tips and measure physically larger parts as well.

Are you a coil winder? Say you need that power inductor for some switching circuit and want to wrap your own coil. After winding what you've calculated to be the proper turn ratio, you will wonder if it will be close enough to do the job. The Smart Tweezers can give you peace of mind by measuring the inductance (and the ESR as well). You can also experiment with how the inductance is affected by the core material you are using.

PORTABILITY

Thanks to the extremely low power requirements of Texas Instruments' MSP430F135, the Smart Tweezers

device operates for over 80 h on three alkaline (357 A) button cells. For me, shelf life will most likely be the limiting factor on operational life. The auto-off feature will keep your batteries from running down should you forget to turn it off. Even with intermittent use in a production environment, your batteries should last weeks. If you don't want to be bothered with keeping a supply of batteries on hand, there is a rechargeable option.

You can upgrade your standard Smart Tweezers device any time because the inductive charger is field-upgradeable. Simply replace three alkaline cells in the Smart Tweezers with the 3.6-V NiMH battery and solder in the inductive receiver. The inductive transmitter is fully assembled and can run off either an AC wall wart or via USB (power only).

Inductive charging is becoming a hot item for cell phones and other devices. I think inductive charging deserves a column of its own, so let me know if you'd like to see more on that technology, or any other topic for that matter.

The Smart Tweezers device is just the kind of tool I would have liked to design. It combines a good mix of analog and digital circuitry into a compact, easy-to-use unit. The low-power design is kind on current consumption, which helps stretch battery life. You will find this tool invaluable when verifying, analyzing, and identifying components both in and out of circuit. ☐

Jeff Bachiochi (pronounced BAH-key-AH-key) has been writing for Circuit Cellar since 1988. His background includes product design and manufacturing. You can reach him at jeff.bachiochi@imaginethatnow.com or at www.imaginethatnow.com.

SOURCES

Smart Tweezers Handheld LCR meter
Advance Devices Corp.
www.advancedevices.com

MSP430F135 Microcontroller
Texas Instruments, Inc.
www.ti.com

System on Module

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2.6 KERNEL

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