

*Get in Touch with the Changing User  
Interface of Today's Test Instruments*

Jonathan Tucker  
Keithley Instruments, Inc.

Have you noticed the significant changes within the electrical test and measurement industry – not just to the instruments, but among the user community? Perhaps you're among the one in five electrical engineers who entered the profession within the last decade. Or, maybe you're not an EE but rather in materials engineering, electrochemistry, biotechnology, physics, etc., but you're still expected to configure electrical measurements from time to time. Perhaps you have experienced budget or staffing cuts and are under pressure to do more with fewer resources than in the past. These dynamics are further compounded by growing time-to-market pressures as design cycles continue to shrink. With all of these changes, wouldn't it be great if the test instruments themselves could empower users to learn fast, work smarter, and invent easier?



*Figure 1. The typical electrical test and measurements user profile has changed significantly over the last decade.*

The last half-century has seen continuous improvements to the user interfaces that instruments provide, as well as the emergence of new features and capabilities. But, until relatively recently, interacting with instruments was typically anything but a seamless process. “Taking data” often required manually transcribing readings from an analog dial or using a ruler to measure traces from a strip chart recorder printout.



*Figure 2. Instruments with early analog interfaces often required taking data manually.*

Light-emitting diode (LED) and liquid crystal display (LCD) digital readout displays and push-button control interfaces represented the first substantial interface innovations for on-instrument measurement configuration. This interface and display approach helped to simplify the control menu structure and bring more of the menu structure to the top level of the display. The first communications interfaces, including RS-232, GPIB, etc., were soon added to instruments to support system integration and triggering, remote programming and control, as well as transfer of data to external controllers for analysis and display.



*Figure 3. Digital multimeters with LED and LCD digital displays and pushbutton controls.*

In the 1990s, users began to demand further detail on their measurements, such as the level of current being sourced to the device under test, voltage limits, error messages, etc. This demand eventually led vendors to begin developing brighter, easier-to-read, multi-line vacuum fluorescent displays that could display multiple measurements simultaneously from a single measurement connection. This new display capability also made it possible to present measurements results in more intuitive ways, such as presenting measurement data in a bar graph. To allow users to configure the display settings and performance options, vendors often assigned multiple functions and performance options to the same front panel button.



*Figure 4. Instruments with multi-line display and user-configurable functions offer more information with measurement results.*

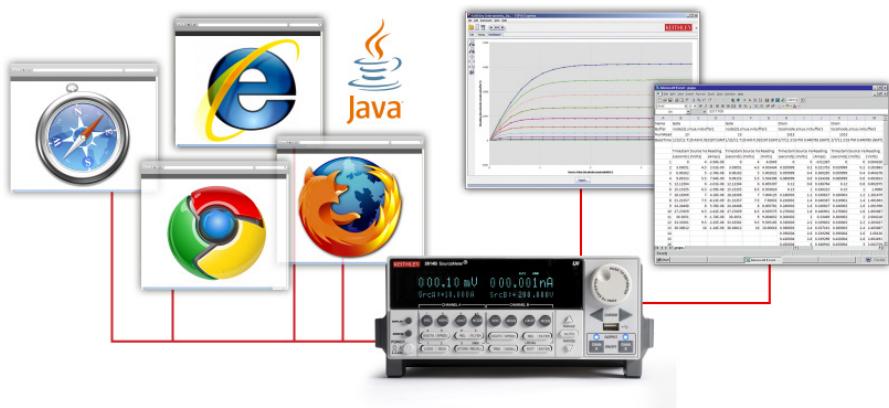
**Table 1** offers an overview of some of the most commonly employed instrument interface types and how well they meet various usability requirements.

*Table 1. Overview of instrument interfaces types.*

| Requirement                   | Single-Line LED Display/ Pushbutton | Single-Line LCD Display/ Pushbutton | Multi-Line VFD/ Pushbutton | Color VGA Display/Soft-key/ Pushbutton |
|-------------------------------|-------------------------------------|-------------------------------------|----------------------------|--|
| High Contrast & Readability   |                                     |                                     | ✓                          | ✓                                      |
| Customizable Display Elements |                                     |                                     | ✓                          | ✓                                      |
| Graphic Modes                 |                                     |                                     |                            | ✓                                      |
| Color                         | Red, Green                          |                                     | ✓                          | ✓                                      |
| Viewing Angle                 |                                     |                                     | ✓                          | ✓                                      |
| Character Size                |                                     | ✓                                   | ✓                          | ✓                                      |
| Multiple Functions            | ✓                                   | ✓                                   | ✓                          | ✓                                      |
| Tree Menu Structure           |                                     |                                     | ✓                          | ✓                                      |
| Long Life                     | ✓                                   | ✓                                   | ✓                          | ✓                                      |
| Low Cost                      | ✓                                   | ✓                                   |                            | ✓                                      |

The good news is that, within the last few years, a growing number of vendors have begun getting serious about taking evolving user characteristics and expectations into account in their interface designs. Some of the more modern electrical test instrument interfaces are beginning to incorporate the concept of “faster time to answer,” such as by offering instruments with web-based interfaces. In fact, some of Keithley’s instruments already feature

easy-to-use, powerful, web-based plug & play test software that make it possible to perform tests through any browser, on any PC, from anywhere in the world. These unique, browser-based user interfaces provide a significant boost in productivity. All that's necessary is to connect the instrument to the Internet via the supplied LAN cable, open any browser and type in the instrument I.P. address, and begin testing.



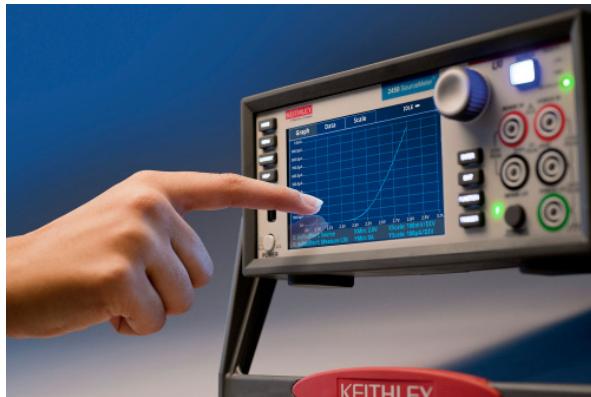
*Figure 5. Innovative instruments with web-based user interfaces support substantial improvements in test productivity.*

Touchscreens represent the next step in the “faster time to answer” progression. Consumer electronics like tablets, smartphones, and cameras already exploit the usability advantages inherent in touchscreen technology. The “see it, touch it, do it” quality of touchscreens not only makes these products fun to use but has made them more accessible to those who might otherwise be hesitant to try them. Touchscreens support faster, more intuitive learning than other control and display approaches. And, because their operation is so intuitive, touchscreens can also give users more confidence in what they’re doing, drastically reducing user learning curves and training requirements while improving accuracy and efficiency. It’s hard to argue with the evidence that touchscreens have made consumer products easier to explore and operate. Fortunately, they are equally applicable to test instrumentation.



*Figure 6. Consumer products like tablets, smartphones, and cameras with gestural multi-touch interfaces are playing a role in the evolution of test instrument interfaces.*

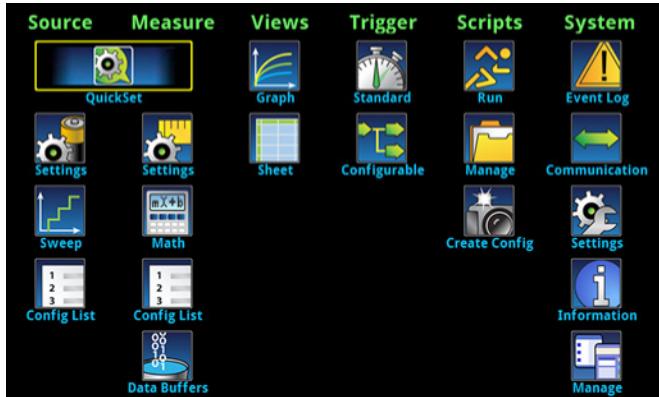
The proliferation of easy-to-use, gestural multi-touch interfaces is driving test instrument manufacturers to develop products that incorporate this same intuitive operation and instant access to information. Keithley has developed a next-generation test instrument that uses an advanced capacitive touchscreen with multi-point, pan-pinch-zoom-swipe operation to bring testing right to the user's fingertips. This Touch, Test, Invent™ design, now available in Keithley's Model 2450 SourceMeter® Source Measure Unit (SMU) Instrument (*Figure 7*), offers a simplified user interface that speeds up the measurement process by helping users test accurately and get results quickly, and allows them to focus on their next breakthrough rather than on learning how to configure the instrument.



*Figure 7. Keithley's Model 2450 is the world's first touchscreen SMU Instrument with capacitive touchscreen with multi-point, pan-pinch-zoom-swipe operation.*

With the Model 2450, operators at all levels of testing sophistication can become expert users practically from the first touch because its intuitive design is highly "learnable." On-board, context-sensitive help eliminates the need to consult a user manual to get the instrument up and running and minimizes the need to consult a manual during use. With

simplified setups configured from the front panel, the Model 2450 supports faster time to measurement and drastic improvements in test productivity.



*Figure 8. The icon-based, flat menu structure that Keithley’s Model 2450 SourceMeter® SMU Instrument offers can reduce the number of configuration steps to half the number typically required by eliminating cumbersome, multi-level menu trees.*

### *Simplifying the user experience*

Some may question whether this new instrument interface approach is for everyone or only for novice or infrequent users. After all, they might reason, some experienced instrument users might be hesitant to adopt touchscreen technology because they’re accustomed to working with front panels with buttons, keys, and knobs and need the tactile feedback that pressing a button or turning a knob provides. However, what’s important to remember is that the addition of a touchscreen to the interface doesn’t rule out incorporating buttons and knobs as needed. The touchscreen can display results using larger, more legible numerals, provide more details about the measurement, or offer graphing capabilities, which earlier single- or dual-line VFD displays couldn’t provide. Also, because touchscreen displays are software defined, they are easily changed to reflect the different controls and indicators required for different applications, freeing up valuable “real estate” on the instrument’s front panel. The intuitive, highly learnable nature of touchscreen-based interfaces can also drastically reduce training time, increase operator accuracy, and improve overall operational efficiencies, which helps drive down the cost to own.

### *Changing the way we interact with instruments*

Keithley’s approach to usability involves minimizing the number of front panel buttons and knobs while transferring many functional controls to the reconfigurable capacitive touchscreen display. The design team placed high emphasis on the level of information provided through the touchscreen, including allowing the user to confirm easily how the

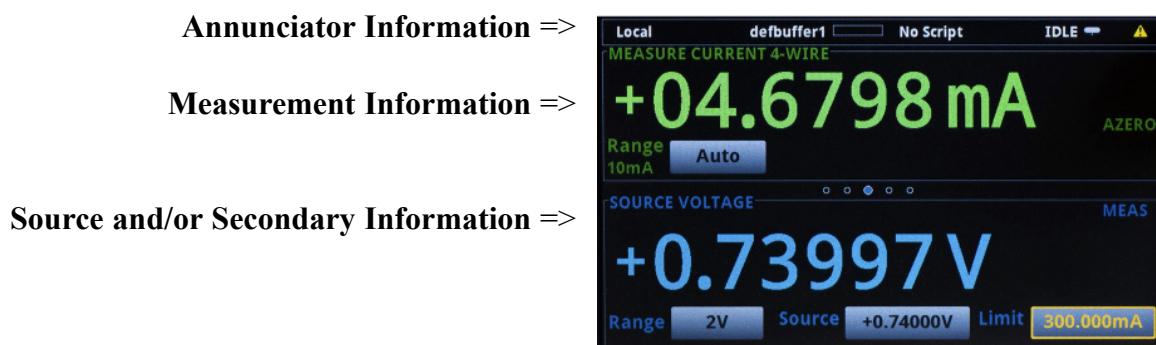
instrument is configured. As *Figure 9* shows, the user can tell at a glance the instrument's measurement range, the source value, and the pre-set current limit.



*Figure 9. New Model 2450 user interface approach.*

The touchscreen's buttons work in conjunction with the physical buttons and the quick-navigation control knob to help users navigate instrument operation with confidence. The push buttons provide quick access to menus, quick configurations and function selection, triggering, and the context-sensitive on-screen help. The control knob allows operating the on-screen controls mechanically without the need to touch the display for situations in which screen contact is impractical. The knob also allows selecting menus, tabbing through editable fields, and increasing or decreasing values.

The Model 2450's five-inch touchscreen has three display regions:



*Figure 10. Breakdown of the Model 2450 touchscreen display.*

The on-screen buttons indicate the configuration settings, including the measurement range and set values. When the instrument is in Auto-Ranging mode, the display will also indicate the range on which the instrument is operating.

The touchscreen's swipe capability simplifies revealing detailed measurement information quickly without the need to navigate a confusing menu structure. *Figure 11* illustrates three typical swipe views.

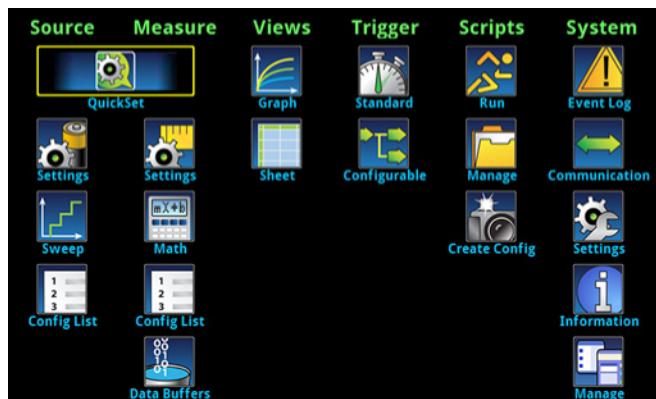


*Figure 11.* Three various swipe screen views on the secondary information line of the Model 2450.

### Flat menu structures

Many test vendors continue to design instruments with multi-level menu structures, which can be confusing to navigate. Instruments that use soft-key architectures sometimes force users to go as much as six layers deep to reach the desired selection. Keithley's touchscreen GUI eliminates this confusion with a flat menu architecture that ensures any configurable parameter is just two on-screen touches or pushbutton presses away.

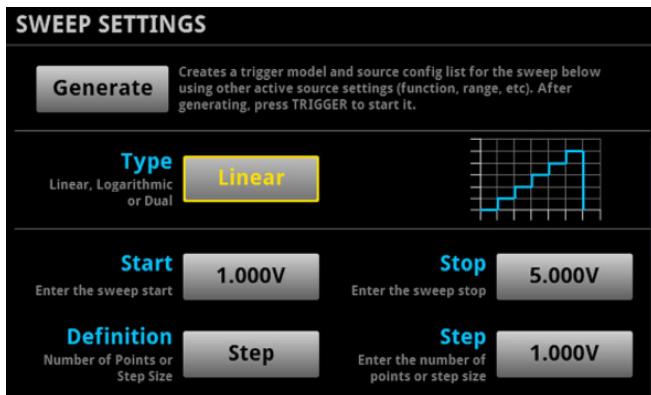
As shown previously, the Model 2450's main menu screen (*Figure 12*) makes instrument navigation an intuitive experience by representing many functions and parameters graphically.



*Figure 12.* Model 2450 flat approach to menuing.

For example, to create a simple current vs. voltage (I-V) sweep on the Model 2450, the user simply presses the front-panel MENU button, then selects Sweep from the Source column.

It takes only two steps to reach the screen for creating a sweep, with no need to go back and forth between multiple displays and menu levels.



*Figure 13. Model 2450 single menu screen for creating an I-V sweep.*

### *Productivity improvements*

To verify the productivity of this new approach to instrument configuration, we compared the Model 2450's usability with that of another source measure unit (SMU) instrument that uses a soft-key architecture (*Figure 14*). We created four common user scenarios to assess how many steps were required to set up each SMU from the front panel. All tests were performed starting from the instruments' power-up default setting.



*Figure 14. Competitive SMU using soft-key user interface.*

#### Scenarios:

##### 1. Digital Voltmeter Operation

- Set up the instrument to behave just like an autoranging digital voltmeter.

## 2. Ohmmeter Operation

- Set up the instrument to behave just like an autoranging digital ohmmeter to make a 4-wire resistance measurement.

## 3. Source V, Measure I. Then Source I, Measure V

- Set up the instrument to source 10V, set the current limit to 200mA, and then measure the current.
- Set up the instrument to source 10mA, set the voltage limit to 20V, and then measure the voltage.

## 4. I-V Sweep

- Create a linear sweep from -10V to +10V with a step size of 100mV and an I-Limit (compliance) value of 100mA. Set a source delay time of 500ms.

The results of the four tests are outlined in *Table 2*.

*Table 2. Results of four user scenarios.*

| Scenario | Model 2450 Actions/Steps | Competitive SMU Action/Steps | Touchscreen Improvement |
|----------|--------------------------|------------------------------|-------------------------|
| #1       | 3 steps                  | 10 steps                     | 7 steps, 70%            |
| #2       | 3 steps                  | 11 steps                     | 8 steps, 73%            |
| #3       | 17 steps                 | 23 steps                     | 6 steps, 26%            |
| #4       | 24 steps                 | 37 steps                     | 13 steps, 35%           |

Configuring measurements using Keithley's touchscreen SMU takes substantially fewer steps than the competitive SMU that uses a soft-key approach for typical use cases, making it possible to achieve significant productivity gains quickly.

## Conclusion

Bench instruments that employ a software-definable touchscreen system will improve productivity, allow a faster time to measurements, and offer a lower cost of test than traditional hard-key and soft-key front panel interfaces. By using a touchscreen approach and maintaining consistency in the location and functions of pushbuttons and touch buttons, users will be able to move quickly from one instrument type to another with minimal training. Even those who use the instrument infrequently can get back up to speed quickly simply by using the instrument.

With more information about the instrument setup and measurement condition literally at users' fingertips, Keithley's new interactive instrument will enable scientists and engineers to **learn faster, work smarter, invent easier**.

\* \* \*

### ***Biographical Note***

**Jonathan Tucker** is a Senior Marketing and Product Manager for Keithley Instruments, which is part of the Tektronix test and measurement portfolio. He joined Keithley in 1987. During his tenure, he has served in a variety of positions, including manufacturing test engineer, applications engineer, applications manager, product manager, and business development manager. He holds a BSEE from Cleveland State University (Cleveland, Ohio) and an MBA from Kent State University (Kent, Ohio). He was a 2007 recipient of the Nano Science and Technology Institutes (NSTI) Fellow Award for outstanding contributions towards the advancement of the Nanotechnology, Microtechnology, and Biotechnology community. Jonathan is a Senior Member of IEEE and was recently the IEEE Nanotechnology Council Standards Committee Chairman. His technical interests include nanotechnology, amateur radio, software defined radio technology, and JAVA/HTML web programming.

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+31-40-267-5506  
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