Automated Switching and Integrated Semiconductor Testing

Keithley’s semiconductor device characterization experts understand the complexities of combining C-V and I-V instruments to create accurate, efficient measurement systems. Keithley has been helping fabs create integrated semiconductor characterization systems for more than a quarter-century. That includes not only merging diverse measurement instruments into complete systems, but also integrating these systems into a fab’s overall R&D or production environment.

Keithley supplies fully integrated turnkey semiconductor characterization systems customized to user specifications. For example, the System 86 is a factory-integrated, rack-mounted solution that combines the I-V measurement capabilities of the System 90 with the C-V capabilities of the System 82-WIN, then adds a Model 707A Switch Mainframe with appropriate cards and cables. Optional probers and thermal chucks specified by the user can also be incorporated into the system. When operated with the Metrics-ICS software package, this solution can address most device or material characterization applications. C-V measurement capabilities open the door to new system applications, including:

- Developing and integrating new processes
- Research and development on new materials and device structures
- Post-metalization process characterization
- Device reliability testing
- Analyzing failure mechanisms

Device designers and engineers around the world have discovered how Keithley switch hardware simplifies integrating C-V and I-V instruments into high-accuracy systems for semiconductor characterization.
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Widest range of C-V and I-V solutions available
Keithley's total system solutions are much more than simply a collection of instruments and cables. Each System 86 is a complete, economical package of hardware, software, and services. It provides:

- Keithley's unique Simultaneous C-V System.
- Fully guarded I-V and 4-terminal remote sense (Kelvin) measurements on each SMU.
- High voltage and current measurements, up to 1100V or 3A.
- Up to six integrated SMUs from a choice of six I-V instruments.
- Switching matrix mainframes for automatic switching between C-V and I-V measurements on the same DUT.
- Switching cards with up to 8 rows × 72 pins, with the industry's lowest offset current (10fA typical, 100fA max.).

In addition to the measurement hardware, a current Windows-based computer and Metrics-ICS software are typically included for system control.

Matrix switching systems are key elements of Keithley's semiconductor device characterization solutions because they connect the Source-Measure Units (SMUs) and other instruments through the prober to the device under test (DUT). As a result, Keithley systems provide the optimum combination of speed and accuracy for fully-integrated systems.

Precision all along the signal path
C-V and I-V testing require precise measurements, often involving currents of less than 1pA, capacitances less than 1fF, and voltages of just a few microvolts. The switching matrix may also have to switch AC signals at frequencies in the MHz range. The switching matrix design must minimize parasitic capacitances and leakage currents to prevent these artifacts from obscuring low level signals.
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Keithley’s matrix switch mainframes and switch cards have been engineered to control these problems. For example, the Keithley Model 707A Switch Mainframe has three separate analog backplanes, each optimized for a different type of switch card. This allows the use of different card combinations for specific types of tests and eliminates the need for complex harnesses and external wiring. Consequently, stray capacitance and leakage currents are minimized.

The innovative switch and insulation designs used in Keithley cards help reduce signal artifacts. The Model 7174A Low Current Matrix Card is one case in point. This card is designed specifically for high-performance semiconductor characterization applications that use System 93 I-V and System 82-WIN Simultaneous C-V Characterization Systems. These system often include HP 4155 and 4156 parametric analyzers. In the Model 7174A card’s 8 row × 12 column configuration, both the signal and guard connections are switched at each crosspoint. This allows making remote sense (Kelvin) measurements with up to four SMUs, while enabling a high pin count. Also, offset current is reduced dramatically on all pathways to 100fA (10fA typical). By using guarded triaxial connections and a patented air dielectric design, parasitic capacitance, dielectric absorption, and leakage current have been minimized. In addition to the higher accuracy this card allows, settling times are significantly shorter, allowing measurements to be performed many times faster than with other switching technologies.

Keithley’s broad range of switching solutions enhances system integration flexibility:

- A choice of four switch mainframes.
- More than 60 switch cards to fit virtually any C-V or I-V test application.
- High capacity — The Model 707A can link up to six cards via its backplane, providing pin configurations of up to 8 rows × 72 columns.
- Up to five Model 707A mainframes can be cascaded for expansion to a 360-column configuration.
- Most cards can be modified to provide additional instrument connections (for example, six Model 7174A cards can be configured as an 18×60 matrix).

Thirteen different cards are designed specifically for semiconductor characterization applications. Like the 7174A, the Model 7072A card also provides a unique solution for C-V/I-V testing, offering two low leakage (100fA typical) paths, four high isolation general-purpose paths, and two C-V paths. Unlike other cards based on 6×12 matrices that employ multiplexing techniques to provide additional instrument connections, these Keithley semiconductor switching cards offer true 8×12 matrix configurations, allowing up to eight instrument connections at once.
Matrix Switches and Fully Integrated Systems

The Model 707A Switch Mainframe is the basis for many of Keithley’s semiconductor switching solutions. It offers:

- Compatibility with a wide range of matrix and multiplexer cards
- The ability to expand in groups of 12 to 360 columns (2880 matrix crosspoints)
- Fast system integration and test program development time
- Analog backplane for automatic switching card interconnect
- 100 setup non-volatile matrix memory

In-Depth C-V/I-V Applications Expertise

Keithley has been a leader in C-V and I-V test technologies for decades. Today, we continue that tradition by providing industry-leading applications support for our instruments and systems. Our Applications staff will work with you every step of the way to select the most appropriate hardware and software configuration for a particular application. Whether the application calls for a single instrument, a variety of instruments to complement an existing equipment configuration, or a comprehensive system solution, a Keithley C-V/I-V specialist can help you choose the equipment and software that provide the optimum combination of speed and accuracy for your application. We can also work with you to optimize the performance of your facility’s existing I-V and C-V test solutions, such as instruments supplied by H-P. Our Applications Engineer-

Matrix Switch Card Selection Guide

<table>
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<tr>
<th>Card Family</th>
<th>Card Model</th>
<th>Offset Current</th>
<th>Contact Potential</th>
<th>Max. Volts</th>
<th>Max. Current</th>
<th>Channel Configuration</th>
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<tr>
<td>Semiconductor</td>
<td>7174A</td>
<td>&lt;100fA (100A typical)</td>
<td>—</td>
<td>200V</td>
<td>2A</td>
<td>8x12 Matrix</td>
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<td>Triax</td>
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<tr>
<td></td>
<td>7072</td>
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<td>&lt;20µV</td>
<td>200V</td>
<td>1A</td>
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The Model 707A Switching Mainframe

ing department is also available weekdays from 8:00 A.M. to 6:00 P.M. to answer applications questions at our toll-free hotline number: 1-800-348-3735 (USA only).

Most systems are delivered factory-integrated, rack-mounted, and pre-assembled. Our experienced applications engineers are available to help you begin working with systems accurately and efficiently within hours of delivery.