LCR Meters, Impedance Analyzers and Test Fixtures
Material, Semiconductor, Component and In-Circuit Measurement Solutions
Achieve Success with The Industry Standard for Impedance Measurements

Hewlett Packard, Agilent Technologies, and Keysight Technologies, Inc. have contributed innovations and product excellence in impedance analysis for over half a century. Whether your application is in R&D, production, quality assurance, or incoming inspection, we take pride in contributing to your success. We strive to deliver complete solutions to meet your needs, from impedance analyzers to a wide variety of test accessories. Achieve success with Keysight’s impedance measurement solutions. Keysight offers:

Superior product performance: Keysight products provide the best in class accuracy and the repeatability with the fast measurement speed. Three types of impedance measurement solutions as shown in Table 1 are available meeting the various measurement needs.

Complete solution: Covering frequencies from 5 Hz to 3 GHz along with the wide variety of test accessories, Keysight’s impedance product line offers you the widest selection of equipment for your application. This selection guide gives an overview of all the products and accessories you can choose from.

Appropriate frequency range for your application: Keysight products provide the best performance in the industry with frequency options to meet your needs at an affordable price. You can select the most appropriate frequency range for your application. Flexible frequency upgrade options are also available. You can choose just what you require today with the least amount of investment and upgrade later as needs arise.

Technical expertise: Keysight has decades of experience providing impedance measurement solutions. Years of experience and continuing technical innovations go into the design and manufacturing of each Keysight LCR meter and impedance analyzer. Keysight also has a list of technical publication to assist you in many different applications (see page 15 for full listing.)

Advanced measurement techniques for a wide range of applications

Figure 1 is a comparison of different measurement techniques used in Keysight’s LCR meters and impedance analyzers. As you can see, each technique has special measurement advantages:

- Auto-balancing bridge offers widest impedance measurement range with typical frequency range of 20 Hz to 120 MHz. This technique is best for low-frequency, general-purpose testing.

Table 1. Impedance measurement product type

<table>
<thead>
<tr>
<th>Product Highlights</th>
<th>LCR Meter</th>
<th>Impedance Analyzer</th>
<th>Network Analyzer</th>
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<td>Frequency Sweep Capability</td>
<td>Spot/List</td>
<td>Continuous (Start/Stop, Center/Span)</td>
<td>Continuous (Start/Stop, Center/Span)</td>
</tr>
<tr>
<td>Display</td>
<td>Numeric Only</td>
<td>Graphics</td>
<td>Graphics</td>
</tr>
<tr>
<td>Others</td>
<td>Handler interface, comparator</td>
<td>Equivalent circuit analysis built in, material measurements, in-circuit measurements</td>
<td>Equivalent circuit analysis built in, multiple function in one instrument</td>
</tr>
<tr>
<td>Advantages</td>
<td>Low-cost solution, ease of use, high speed</td>
<td>Widest measurement range, resonant analysis, circuit modeling</td>
<td>Cost-effective, versatile</td>
</tr>
</tbody>
</table>

Figure 1. Impedance measurement techniques of impedance analyzers/LCR meters
– I-V technique covers from 20 Hz to 120 MHz with a more focused impedance measurement range. I-V technique also allows probing for in-circuit testing.

– RF I-V, an enhancement of the I-V technique, offers some of the high-frequency benefit of network analysis while retaining some of the impedance measurement range of the I-V technique. Designed for accuracy and high-frequency performance, the RF I-V technique is excellent for RF component analysis, especially for small inductance and capacitance values.

– In addition, Keysight’s network analyzer offers an impedance measurement solution using the combination of three measurement techniques (reflection, series-thru, and shunt-thru) based on the S-parameter and gain-phase measurements.

How to use this selection guide

Table 2 is a summary of all of Keysight’s impedance products. It is designed to assist you in better comparing Keysight’s wide range of instrumentation and in choosing possible solutions for your applications, depending on your requirements in the following areas:

– Test frequency range
– Device type or application type
– Accuracy requirement (measurement technique)
– Any other special needs

If you find several possible solutions for your application, go to the corresponding pages to find more details about each product.

Table 2. Keysight impedance measurement products

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Freq. range</th>
<th>Positioning</th>
<th>Model</th>
<th>Frequency range (Hz)</th>
<th>Basic Z accuracy1 (%)</th>
<th>Measurement display range (Ω)</th>
<th>Feature4</th>
<th>Measurement technique5</th>
<th>Main application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance analyzer</td>
<td>RF</td>
<td>High performance/ material/high temperature</td>
<td>E4991B</td>
<td>1 M to 3 G</td>
<td>0.65 (0.45 typical)</td>
<td>120 m to 52 k</td>
<td>A,B</td>
<td>RF-I-V</td>
<td>LCR component, material, semiconductor</td>
</tr>
<tr>
<td>Multi function</td>
<td>Option 3L3/3L4/3L5 w/005</td>
<td>5 to 3 G</td>
<td>2 (typical)</td>
<td>1 to 2 k/5 to 20 k/1 m to 5 k (typical)</td>
<td>A,B</td>
<td>Ref/Series/Shunt</td>
<td>LCR component, PDN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LF/HF</td>
<td>High performance/ material/C-V</td>
<td>E4990A</td>
<td>20 to 120 M</td>
<td>0.08 (0.045 typical)</td>
<td>25 m to 40 M</td>
<td>A,B</td>
<td>ABB</td>
<td>LCR component, material, semiconductor</td>
<td></td>
</tr>
<tr>
<td>In-circuit (grounded), C-V</td>
<td>E4990A with 42941A</td>
<td>20 to 120 M</td>
<td>1</td>
<td>50 m to 4 M</td>
<td>A,B</td>
<td>IV</td>
<td>LCR component, semiconductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCR meter</td>
<td>RF</td>
<td>High performance/ high speed measurement</td>
<td>E4982A</td>
<td>1M to 3G</td>
<td>0.8 (0.45 typical)</td>
<td>140 m to 4.8 k</td>
<td>C</td>
<td>RF I-V</td>
<td>LCR component</td>
</tr>
<tr>
<td>LF</td>
<td>High performance/ material/C-V</td>
<td>E4980A/AL</td>
<td>20 to 2 M</td>
<td>0.05</td>
<td>4 m to 100 M</td>
<td>D</td>
<td>ABB</td>
<td>LCR component, material, semiconductor</td>
<td></td>
</tr>
<tr>
<td>Application specific</td>
<td>LF</td>
<td>For capacitor/ high speed measurement</td>
<td>E4981A2</td>
<td>120, 1 k and 1M only</td>
<td>0.07 (0.042 typical)</td>
<td>10 fF to 2 mF</td>
<td>D</td>
<td>ABB</td>
<td>MLCC</td>
</tr>
</tbody>
</table>

1. Basic Z accuracies are best-case values and vary depending on measurement conditions. See product data sheet for detail.
2. Capacitance measurement only.
3. Z range shows the 10% accuracy range.
4. Feature code:
   A: Built-in equivalent circuit analysis
   B: Frequency sweep with color LCD display
   C: Spot frequency with color LCD display
   D: Spot frequency with LCD display
5. Measurement technique code:
   ABB: Auto-balancing bridge
   I-V: I-V method
   RF I-V: RF I-V method
   Ref: Reflection method
   Series: Series-thru method
   Shunt: Shunt-thru method
Impedance Analyzers

Only Keysight impedance analyzers provide unparalleled accuracy from mOhm to Mohm, from 5 Hz to 3 GHz. You can select the appropriate frequency range for your application.

- Frequency, DC bias, and AC voltage/current sweep capability lets you customize where and how test data will be taken.
- Built-in equivalent-circuit analysis computes a multi-element circuit model of the device under test.
- Advanced calibration and compensation methods reduce measurement errors.
- Accessories for permittivity & permeability of materials, high-temperature characterization, various passive components, and impedance probe for grounded measurements available.

E4990A impedance analyzer

- Five frequency options; 20 Hz to 10/20/30/50/120 MHz, upgradable
- ±0.08% (typical ±0.045%) basic impedance measurement accuracy
- 25 mΩ to 40 MΩ wide impedance measurement range (10% measurement accuracy range)
- Measurement speed: 3 ms~ / point (Option 120, and 010/020/030/050 with option 001)

E4991B impedance analyzer

- Three frequency options: 1 MHz to 500 M/1 G/3 GHz, upgradable
- ±0.65% (typical ±0.45%) basic accuracy and 120 mΩ to 52 kΩ impedance range (10% measurement accuracy range)
- Measurement parameters: |Z|, |Y|, θ, R, X, G, B, L, C, D, Q, |Γ|, Γx, Γy, 0Γ, Vac, lac, Vdc
- Built-in DC bias (Option 001): 0 V to ±40 V, 0 A to ±100 mA
- 4-channel & 4-trace on 10.4 inch color LCD with touch screen
- Data analysis function: Equivalent circuit analysis, limit line test
- In-circuit or grounded measurement with the 42941A impedance probe (Option 120 only)
- 7-mm test fixtures combined with 42942A Terminal Adapter (Option 120 only)
- Measurement speed: 3 ms~ / point (Option 120, and 010/020/030/050 with option 001)

Dielectric/magnetic material measurement (Option 002): |εr|, εr', εr'', tanδ(ε), |μr|, μr', μr'', tanδ(μ)
- Temperature characteristics measurement (Option 007) and reliable on -wafer measurement (Option 010) capabilities

1. Option 001 is required.
Network Analyzer

E5061B-3L3/3L4/3L5 LF-RF network analyzer

The E5061B-3L3/3L4/3L5 LF-RF network analyzer with the option 005 impedance analysis function offers the network and impedance analysis capabilities in a single instrument. The E5061B-3L3/3L4/3L5 with option 005 is a versatile and cost-effective solution suitable for general R&D use where various kinds of electronic components and circuits need to be evaluated:

- Three frequency options; 5 Hz to 500 M/1.5 G/3 GHz, upgradable
- S-parameter test port (5 Hz to 3 GHz) and gain-phase test port (5 Hz to 30 MHz, 1 M Ω/50 Ω inputs)
- The E5061B-005 supports reflection, series-thru, and shunt-thru methods using the S-parameter test port or gain-phase test port. These methods are suitable for low-to-middle, middle-to-high, and very low milliohm impedance ranges, respectively.¹
- Keysight’s 7 mm type and 4-terminal pair type component test fixtures can be used in the reflection method (at the S-parameter test port) and the series-thru method (at the gain-phase test port).
- Impedance measurement parameters: |Z|, |Y|, θ, R, X, G, B, C, L, D, Q
- Built-in DC voltage bias source (0 to ±40 V, max ±100 mA)

¹ For details about each method’s impedance measurement range, refer to “E5061B-3L3/3L4/3L5 LF-RF Network Analyzer with Option 005 Impedance Analysis Function, Data Sheet” (5990-7033EN).
The Keysight LCR meters provide the best combination of accuracy, speed, and versatility at an affordable price for both R&D and production applications.

- Wide frequency range from 20 Hz to 3 GHz
- Frequency list sweep for continuous testing at multiple frequency points
- Unparalleled measurement accuracy at both high and low impedance range
- With the widest variety of accessories, great for testing of leaded components, surface-mount components, semiconductors, and materials
- Fast measurement speed with superior measurement repeatability
- Handler interface with BIN sorting function for easy test automation in production environment

**E4982A LCR meter**

- 1 MHz to 300 M/500 M/1 G/3 GHz with 100 kHz resolution
- High speed measurement: selectable from 0.9 ms (Mode 1), 2.1 ms (Mode 2), and 3.7 ms (Mode 3)
- 0.8% (typical ±0.45%) basic accuracy
- RF I-V technique provides a wide impedance range (0.14 Ω to 4.8 kΩ, 10% measurement accuracy)
- Highly stable measurement of low-inductance and excellent Q accuracy for meeting chip inductor test requirements
- Handler interface suitable for production testing
- Measurement parameter |Z|, |Y|, θ, R, X, G, B, L, C, D, Q, Rdc, Idc, Vdc, in user-definable combinations of parameters (up to 4 parameters)
- Versatile PC connectivity – GPIB, LAN, USB

**E4980A precision LCR meter**

- 20 Hz to 2 MHz with 4-digit resolution
- 0.05% basic accuracy with superior measurement repeatability at low and high impedance
- Measurement time (at 1MHz): 5.6 ms (SHORT), 88 ms (MED), 220 ms (LONG)
- Option E4980A-001 adds ±20 Vrms/±100 mArms test signal, ±40 V/±100 mA internal dc bias, 2nd DC source, and Vdc/Idc measurement
- Option 201 and 301 add handler interface and scanner interface respectively
- Versatile PC connectivity, LAN, USB (memory/USBTMC), GPIB

**E4980AL precision LCR meter**

- 20 Hz to 300 kHz/500 kHz/1 MHz with 4-digit resolution
- 0.05% basic accuracy with superior measurement repeatability at low and high impedance
- Measurement time (at 1MHz): 12 ms (SHORT), 118 ms (MED), 343 ms (LONG)
- Option 201 and 301 add handler interface and scanner interface respectively
- Versatile PC connectivity, LAN, USB (memory/USBTMC), GPIB

**E4981A 120 Hz/1 kHz/1 MHz capacitance meter**

- 120 Hz, 1 kHz and 1 MHz test frequencies
- High speed measurement: 2.3 ms (1 MHz), 3.0 ms (1 kHz), 11.0 ms (120 Hz)
- Basic accuracy C: 0.07%, (typical ±0.042%) D: 0.0005 (typical ±0.0003)
- Handler and scanner interfaces suitable for production testing
- Measurement parameters: C, D, Q, ESR, G
- SLC feature provides constant test voltage for high-value capacitor measurements
Test Fixtures and Accessories (Four-Terminal-Pair)

Basic test fixtures

16034G small SMD/chip test fixture
Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16034H SMD/chip test fixture
Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Suitable for array-type devices

16034E SMD/chip test fixture
Frequency: ≤ 40 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16047E test fixture
Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16334A SMD/chip tweezers test fixture
Frequency: ≤ 15 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16047A axial & radial test fixture
Frequency: ≤ 13 MHz (Kelvin contact)
Maximum Voltage: ±42 V peak max. (AC+DC)

16047E test fixture
Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16089A/B/C clip leads
Clip type: A/B/C: Kelvin
Frequency: 5 Hz to 100 kHz
Cable length: A/B/C: 0.94 m
Maximum Voltage: ±42 V peak max. (AC+DC)
Test Fixtures and Accessories (Four-Terminal-Pair)

External DC bias fixtures

16065A axial and radial test fixture with safety cover

Frequency: 50 Hz to 2 MHz
Maximum external dc bias: ±200 V
Blocking capacitor of 5.6 μF is connected in series with the Hc terminal

16065C external bias adapter

Frequency: 100 Hz to 1 MHz
Maximum external dc bias: ±40 V
Blocking capacitor of 100 μF is connected in series with the Hc terminal

Terminal adapters

42942A four-terminal-pair to 7 mm terminal adapter

Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Use with only E4990A-120

Test leads

16048A/D/E BNC test leads

Frequency: A: ≤ 30 MHz, D: ≤ 30 MHz, E: ≤ 2 MHz
Cable length: A: 0.94 m, D: 1.89 m, E: 3.8 m
Maximum Voltage: ±42 V peak max. (AC+DC)

16048G/H BNC test leads

Frequency: ≤ 120 MHz
Cable length: G: 1 m, H: 2 m
Maximum Voltage: ±42 V peak max. (AC+DC)
Use with only E4990A
Test Fixtures and Accessories (Four-Terminal-Pair)

Material measurements

16451B dielectric test fixture
Measurement parameters: capacitance (C), dissipation factor (D), and dielectric constant ($\varepsilon'_r$, $\varepsilon''_r$)
Material-under-test size:
 thickness: ≤ 10 mm
diameter: 10 to 56 mm
Frequency: ≤ 30 MHz

16452A liquid test fixture
Measurement parameter: capacitance (C), dielectric constant ($\varepsilon'_r$, $\varepsilon''_r$)
Liquid sample
Quantity: ≤ 6.8 ml
Frequency: 20 Hz to 30 MHz

Others

42941A impedance probe kit
Frequency: ≤ 120 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Probe cable length: 1.5 m
Use with only E4990A-120

Test Fixtures and Accessories (7-mm Terminal)

RF SMD/chip components

16196A/B/C/D SMD test fixture
Coaxial fixture for parallel electrode SMDs.
Frequency: dc to 3 GHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Applicable SMD size:
16196A: 1.6 mm x 0.8 mm
16196B: 1.0 mm x 0.5 mm
16196C: 0.6 mm x 0.3 mm
16196D: 0.4 mm x 0.2 mm

16197A bottom-electrode SMD test fixture
Frequency: dc to 3 GHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Applicable SMD size: from 1005 (mm)/0402 (inch) to 3225 (mm)/1210 (inch).
Accommodation of the 0603 (mm)/0201 (inch) size is available with Option 001.

16092A axial, radial, and SMD test fixture
Frequency: ≤ 500 MHz
Maximum Voltage: ±42 V peak max. (AC+DC)

16198A bottom-electrode SMD test fixture
Frequency: dc to 3 GHz
Maximum Voltage: ±42 V peak max. (AC+DC)
Applicable SMD size: 0201 (mm)/008004 (inch) and 0402 (mm)/01005 (inch).
16192A parallel-electrode SMD test fixture

Frequency: dc to 2 GHz
Maximum Voltage: ±42 V peak max (AC+DC)

16194A high temperature component test fixture

Frequency: dc to 2 GHz
Maximum Voltage: ±42 V peak max (AC+DC)
Operating temperature: -55 °C to +200 °C

16200B external DC bias adapter

Frequency: 1 MHz to 1 GHz
Maximum external dc bias: Up to 5 A, ±40 V

Material measurements

16453A dielectric test fixture

Frequency: 1 MHz to 1 GHz
Sample size (smooth sheets only):
  thickness: 0.3 mm to 3 mm
  diameter: ≥ 15 mm

16454A magnetic test fixtures

Frequency: 1 kHz to 1 GHz
Sample size (toroids only):
  height: ≤ 8.5 mm
  inner diameter: ≥ 3.1 mm
  outer diameter: ≤ 20 mm

Test Fixtures and Accessories (E5061B)

16201A N-type to 7 mm terminal adapter

Frequency: ≤ 3 GHz
Maximum Voltage: ±42 V peak max (AC+DC)
Use with only E5061B
Simplify and Improve Your Measurements with Keysight's Test Accessories

Selecting a test fixture is as important as selecting the right instrument. Keysight offers a wide range of accessories for axial, radial, and SMD/Chip devices. In addition, a variety of test leads are available to simplify remote testing and systems applications. External test fixtures with safety covers are also available.

You will improve your measurement results with the proper test fixture.
- more reliable and repeatable measurement
- higher through-put
- fewer handling errors
- tighter test limits
- better measurement accuracy

<table>
<thead>
<tr>
<th>Table 3. Test accessories/fixtures</th>
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<td>16034E</td>
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<tr>
<td>16034G</td>
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<tr>
<td>16034H</td>
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<tr>
<td>16047A</td>
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<tr>
<td>16047E</td>
</tr>
<tr>
<td>16048A</td>
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<td>16048B</td>
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<td>16048E</td>
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<td>16048H</td>
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<td>16065A</td>
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<td>16089A/B/C</td>
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<tr>
<td>16092A</td>
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<tr>
<td>16192A</td>
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<tr>
<td>16194A</td>
</tr>
<tr>
<td>16196A/B/C/D</td>
</tr>
<tr>
<td>16197A</td>
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<tr>
<td>16198A</td>
</tr>
<tr>
<td>16200B</td>
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<tr>
<td>16201A</td>
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<tr>
<td>16334A</td>
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<tr>
<td>16451B</td>
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<td>16452A</td>
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<tr>
<td>16453A</td>
</tr>
<tr>
<td>16454A</td>
</tr>
<tr>
<td>42941A</td>
</tr>
<tr>
<td>42942A</td>
</tr>
</tbody>
</table>

Note: Refer to the accessory descriptions for frequency and operational limits.
1. 3.5-mm (M) to 7-mm adapter is required
2. 42942A is required.
3. Compatible when used in conjunction with 16201A.
4. E4991B-002 is required
5. E4980AL only

For additional product information and literature, visit our Accessories Web site: www.keysight.com/find/impedance-accessory
Helping You Make Better Measurements

Keysight’s application knowledge can help you make better measurements.

Impedance Measurement Handbook (P/N 5950-3000) is a comprehensive guide to impedance measurements. The handbook covers from basics to applications and you can learn valuable measurement techniques to support your test challenges.

1. Impedance Measurement Basics
2. Impedance Measurement Instruments
3. Fixturing and Cabling
4. Measurement Error and Compensation
5. Impedance Measurement Applications and Enhancements

Complementary Products and Accessories

To help you find a complete solution, we have listed the following companies that make complementary products or specialized accessories for Keysight’s impedance measurement products. Please contact each company directly if you are interested in its products. (Keysight does not make any special endorsement of these companies’ products; this list is for reference only.)

<table>
<thead>
<tr>
<th>Company name</th>
<th>Product specialty/expertise</th>
<th>Web site address</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-Ring Tech (ART)</td>
<td>Component testing, sorting and taping machine</td>
<td><a href="http://www.allring-tech.com.tw">www.allring-tech.com.tw</a></td>
</tr>
<tr>
<td>ArumoTech</td>
<td>Custom test fixtures</td>
<td><a href="http://www.arumotech.co.jp">www.arumotech.co.jp</a></td>
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<tr>
<td>Axisnet</td>
<td>Impedance measurement system under high power condition</td>
<td><a href="http://www.axisnetinc.com">www.axisnetinc.com</a></td>
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<tr>
<td>Beta LaserMike</td>
<td>Automated LAN cable test system</td>
<td><a href="http://www.betalasermike.com">www.betalasermike.com</a></td>
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<tr>
<td>BH Electronics</td>
<td>Wideband transformers</td>
<td><a href="http://www.bhelectronics.com">www.bhelectronics.com</a></td>
</tr>
<tr>
<td>Cascade Microtech</td>
<td>RF and microwave probes and accessories for semiconductor and IC apps.</td>
<td><a href="http://www.cascademicrotech.com">www.cascademicrotech.com</a></td>
</tr>
<tr>
<td>Electro Scientific Industries (ESI)</td>
<td>Component testing, sorting and taping machine</td>
<td><a href="http://www.esi.com">www.esi.com</a></td>
</tr>
<tr>
<td>ESPEC</td>
<td>Temperature chamber for component and material testing.</td>
<td><a href="http://www.espec.com">www.espec.com</a></td>
</tr>
<tr>
<td>HCUNI</td>
<td>Material measurement solutions</td>
<td><a href="http://www.hcuni.com">www.hcuni.com</a></td>
</tr>
<tr>
<td>Humo Laboratory</td>
<td>Capacitor and crystal device testing and sorting machine</td>
<td><a href="http://www.humo.co.jp">www.humo.co.jp</a></td>
</tr>
<tr>
<td>Inter-Continental Microwave (ICM)</td>
<td>Automated device handling systems, RF and microwave test fixtures</td>
<td><a href="http://www.icmicrowave.com">www.icmicrowave.com</a></td>
</tr>
<tr>
<td></td>
<td>and non-coaxial calibration standards.</td>
<td></td>
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<tr>
<td>Kanto Electronic Application and</td>
<td>Materials measurement solutions</td>
<td><a href="http://www.kead.co.jp">www.kead.co.jp</a></td>
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<td>Development (KEAD)</td>
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<td>KEYCOM</td>
<td>Materials measurement solutions</td>
<td><a href="http://www.keycom.co.jp">www.keycom.co.jp</a></td>
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<tr>
<td>Material-Wave Interactions (MWI)</td>
<td>Materials measurement solutions</td>
<td><a href="http://www.mwilab.com">www.mwilab.com</a></td>
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<tr>
<td>Laboratories</td>
<td></td>
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</tr>
<tr>
<td>North Hills Signal Processing</td>
<td>Wideband transformers (baluns) for balanced measurement.</td>
<td><a href="http://www.northhills-sp.com">www.northhills-sp.com</a></td>
</tr>
<tr>
<td>Seiwa Giken</td>
<td>Energy and battery test solution</td>
<td><a href="http://www.seiwa-giken.co.jp">www.seiwa-giken.co.jp</a></td>
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<tr>
<td>Systemhouse Sunrise</td>
<td>C-V test solution for solar cells</td>
<td><a href="http://www.ssunrise.co.jp">www.ssunrise.co.jp</a></td>
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<tr>
<td>SUMTEC</td>
<td>Materials measurement solutions</td>
<td><a href="http://www.sumtec.biz">www.sumtec.biz</a></td>
</tr>
<tr>
<td>Sine Yo Feng (SYF)</td>
<td>Component testing and taping machine</td>
<td><a href="http://www.syfpt.com.tw">www.syfpt.com.tw</a></td>
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<tr>
<td>TOKYO WELD</td>
<td>Component testing, sorting and taping machine</td>
<td><a href="http://www.tokiyoweld.com">www.tokiyoweld.com</a></td>
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