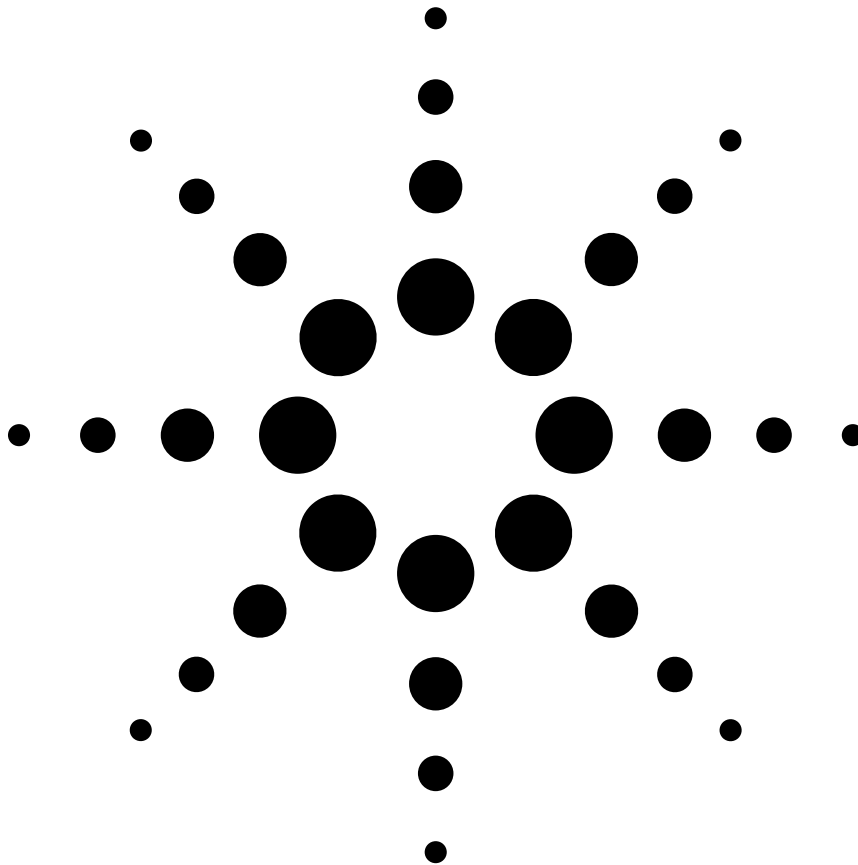


Agilent E4991A RF Impedance/ Material Analyzer

Technical Overview



The new standard in RF impedance
and material measurements.



Agilent Technologies

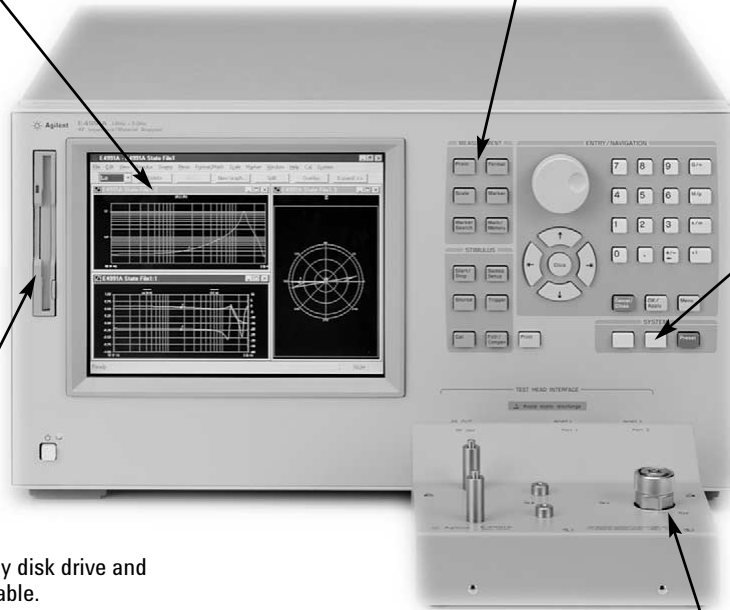
E4991A RF Impedance/ Material Analyzer

Windows®-based user interface

- Windows®-based graphical user interface (GUI) brings an intuitive view of measurement settings and results.
- 8.4-inch TFT color LCD can display up to 5 traces (3 scalar and 2 complex parameters), 9 markers (1 reference marker and 8 markers), and 801 sweep points.

Versatile analysis functions

- Marker analysis and marker limit functions reduce test time.
- Various test signals such as frequency, DC bias and AC signal level are available.
- Equivalent circuit analysis function enables easy modeling of components with 5 different multi-parameter models.



Built-in Visual Basic® for Applications (VBA) programming function

- VBA offers easy programming for automation and further detailed analysis.

Data storage function

- Internal 3 1/2 - inch floppy disk drive and hard disk drive are available.
- Store VBA program, calibration data, and measurement data.
- CITIFILE format is supported for automation tool users.

High accuracy and adaptability

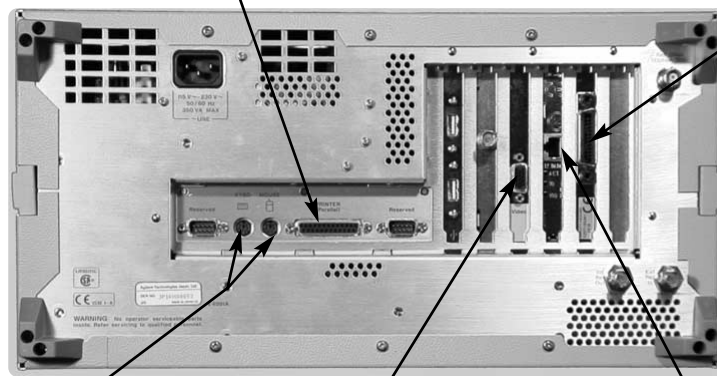
- Test head with 7 mm connector adapts easily to various test fixtures.
- RF I-V technique enables highly accurate measurements up to 3 GHz.

Parallel interface

- Support parallel interface printers.

GPIB interface

- Automatic measurement system is easily configured with external PC.
- Control external instruments.



External keyboard and mouse interface

- VBA programming made easy.
- Users can perform operations with a mouse for more comfortable operation.

External VGA output

- Display measurement results on a larger VGA monitor.

LAN interface (10 Base T/100 Base TX)

- Control other instruments or simplify test-data sharing.
- Connect to a PC through remote user interface software.

Powerful Analysis Functions to Meet Your Needs

The Agilent E4991A RF impedance/material analyzer provides a total solution for making highly accurate, repeatable and stable measurements of surface mount devices (SMD) and dielectric/magnetic materials.

Recent trends indicate that wireless communications and digital equipment operating frequencies are getting higher, while component sizes are getting smaller. Component and equipment manufacturing engineers need to evaluate components they will be using in their products under their projected operating conditions. The E4991A can evaluate passive component's characteristics up to 3 GHz. Additionally, engineers must measure SMDs as small as 0201(inch)/0603(mm).

Agilent provides various test fixtures for SMDs, designed to help you obtain the impedance parameters with high repeatability. The E4991A offers impedance measurement capabilities for your needs today and into the future.

- Accurate and versatile 3 GHz impedance measurement solution
- Analyze passive component behavior
- Wide range of test fixtures available
- PC connectivity features with Windows®-based technology

Key Specifications

Table 1. E4991A key specifications

| E4991A RF Impedance/Material Analyzer | |
|--|---|
| Operating frequency | 1 MHz to 3 GHz (1 mHz resolution) |
| Impedance parameters | $ Z , \theta_Z, Y , \theta_Y, R, X, G, B, C_S, C_P, L_S, L_P, R_P, R_S, D, Q, \Gamma , \theta_\Gamma, \Gamma_X, \Gamma_Y$ |
| Material parameters ¹ | $ \epsilon_r , \epsilon_r', \epsilon_r'', \mu_r , \mu_r', \mu_r'', \theta, \tan\delta$ |
| Basic impedance accuracy | $\pm 0.8\%$ |
| Test port | 7-mm connector |
| Sweep parameters | Frequency, AC signal level, DC bias level |
| Calibration | Open/short/50 Ω /low-loss capacitor |
| Fixture compensation | Open/short, fixture electrical length |
| Mass storage | 3 1/2 -inch floppy disk drive (MS-DOS® format), hard disk drive |
| Other features | <ul style="list-style-type: none"> •Equivalent circuit analysis function •Built-in VBA for internal programming •Segment sweep |
| DC bias (Option E4991A-001) | |
| DC level | 0 V ~ ± 40 V (1 mV resolution) 100 μ A ~ 50 mA, -100 μ A ~ -50 mA (10 μ A resolution) |

1. Option E4991A-002 is required

Advanced Solution for RF Impedance and Material Measurement

The E4991A provides a powerful tool for component manufacturing R&D engineers and circuit designers of wireless and digital equipment who want to evaluate components from various perspectives. The following are application examples:

Passive components

- RF impedance measurement of chip components such as ceramic capacitors, RF inductors, ferrite beads, and resistors

Semiconductors

- Capacitance-Voltage (C-V) characteristics and Equivalent Series Resistance (ESR) measurements of varactor diodes

Materials

- Permittivity and loss tangent evaluation of plastics, ceramics, printed circuit boards and other dielectric material
- Permeability and loss tangent evaluation of ferrite, amorphous and other magnetic materials

E4991A Provides New Insights into RF Passive Component Behavior

The Agilent E4991A's enhanced frequency coverage up to 3 GHz is compatible with wireless communication applications such as W-CDMA, Bluetooth™, and Wireless LAN. The E4991A's wide impedance coverage and versatile measurement functions allow analysis of RF chip inductors and capacitors under actual operating conditions. A wide range of test fixturing solutions makes tiny chip device measurements even easier.

Quality Factor (Q) and Equivalent Series Resistance (ESR) are critical parameters for the components used in mobile communication equipment. Q and ESR measurements require high accuracy. Prior to the E4991A, there was not a good solution available over 2 GHz. The E4991A offers much improved Q and ESR accuracy over traditional network analyzers; due to the enhanced RF I-V technique that measures voltage and current at the device under test (DUT), along with the innovative low-loss capacitor calibration.

Table 3 provides a brief summary of the key differences between Agilent E4991A and network analyzers.

Low-loss capacitor calibration

The low-loss capacitor calibration of the E4991A improves phase measurement accuracy, which establishes a reference to the reactance axis (-90 degrees) in the impedance plane with its near-zero resistance. Capacitors and inductors are measured close to the reactance axis in the impedance plane, making low-loss capacitance calibration very effective for ESR and Q measurements. (See Figure 1)

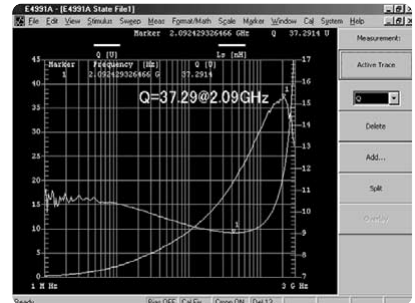


Figure 1. Ls-Q characteristics of a chip inductor

Table 2. Q measurement accuracy (Typical)

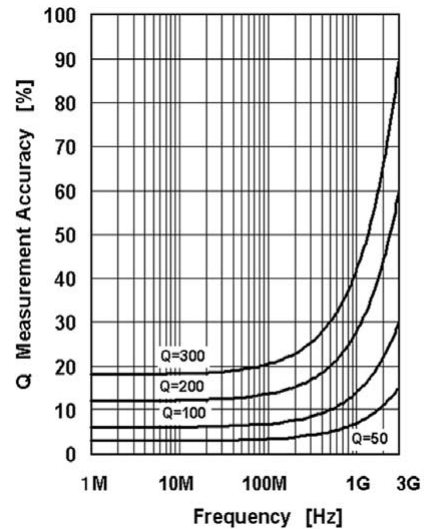


Table 3. Comparison of key characteristics of E4991A and network analyzers

| | E4991A | Network analyzers |
|--------------------------------|--|--|
| Device type | 1 port devices such as inductors, capacitors, and others. | 2 port devices such as filters, amplifiers, and others. |
| Measurement parameters | $ Z $, $ Y $, θ , R, X, G, B, C, L, R, D, Q, Γ | S-parameters, Γ , θ |
| Sweep parameter setting | <ul style="list-style-type: none"> Frequency Test signal level DC bias voltage DC bias current | <ul style="list-style-type: none"> Frequency Test signal level |
| Fixturing | <ul style="list-style-type: none"> Selection from various Agilent test fixtures Built-in fixture compensation function (Accuracy enhancement at DUT connection) | * Prepare custom test fixture or use Agilent channel partner solution |
| Impedance measurement accuracy | <ul style="list-style-type: none"> Accurate high Q device measurement due to low loss capacitor calibration Accurate measurement over non-50 Ω impedance | • Accurate impedance measurement around 50 Ω |
| Other | Equivalent circuit analysis function | |

In-depth Device Characterization

Intuitive graphical user interface

The 8.4-inch color LCD with Windows-based GUI brings an intuitive view of measurement settings and results. The E4991A can display up to 3 scalar and 2 complex parameters simultaneously.

Figure 2 shows a measurement result of a chip bead. You can observe the $|Z|$, R and X parameters on the display at same time. You can also assign each measurement trace in a separate window.

Windows-styled GUI brings the added benefits of mouse operation to the E4991A. Simply drag the mouse over the area you are interested in and you can zoom in quickly and easily. (See Figure 3)

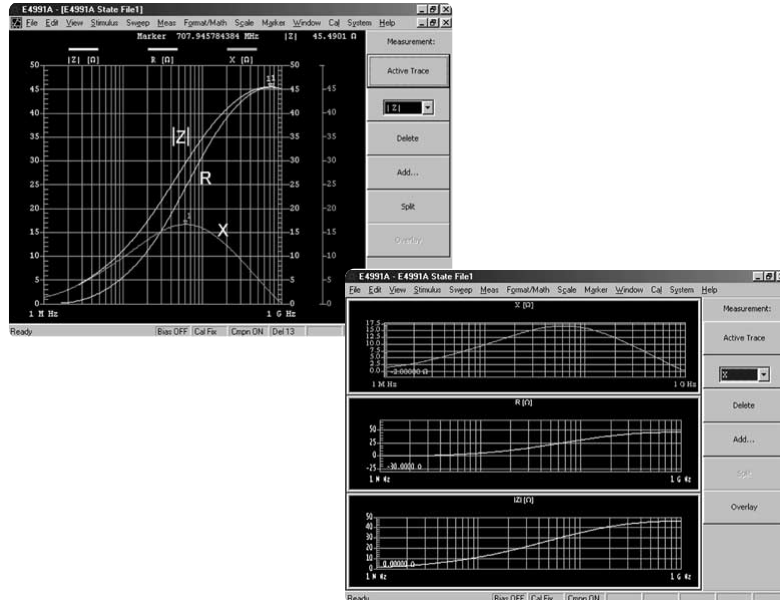


Figure 2. Flexible measurement trace assignment

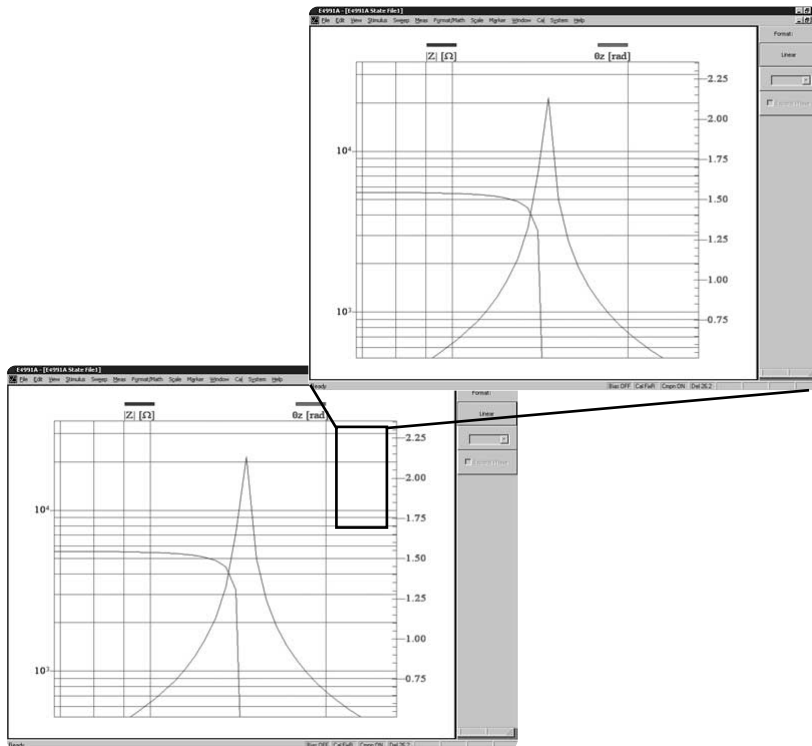


Figure 3. Mouse operation example

DC bias function— Option E4991A-001

For components with voltage and current dependency, such as RF inductors or ceramic capacitors, the DC bias function (Option E4991A-001) supplies DC voltage (± 40 V) and current bias (± 50 mA) across the device. You can easily observe your device behavior under various DC bias conditions without using an external DC bias source.

External DC bias adapter

If you require even higher DC current bias, the Agilent 16200B external DC bias adapter allows you to apply larger DC bias across the device of up to ± 5 A through a 7-mm test port by using an external DC current source. E4991A operating frequency is limited to 1 GHz with the 16200B.

Extracting the equivalent circuit parameters

The equivalent circuit analysis function offers more detailed circuit models over the standard 2-parameter model. Five different multi-parameter models accommodate different types of devices, such as ceramic capacitors or crystal resonators. You can simulate the impedance trace of your own equivalent parameter values and then compare it with actual measurement traces. The extracted parameters can also be used with electronic design automation (EDA) tools to improve modeling accuracy.

Figure 4 shows the C-V characteristic measurement of a varactor diode. Sweeping DC voltage from 0.5 V to 4.5 V, you can easily read capacitance change (11.27 pF) using the delta marker function. Evaluate DC bias voltage dependency on components easily. DC current bias measurement is also available so that you can evaluate characteristics of inductors, such as, saturation or hysteresis.

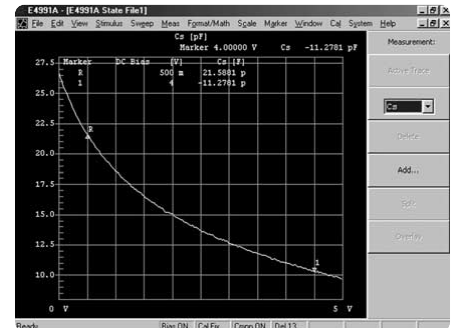


Figure 4. Varactor diode capacitance vs. DC voltage characteristics

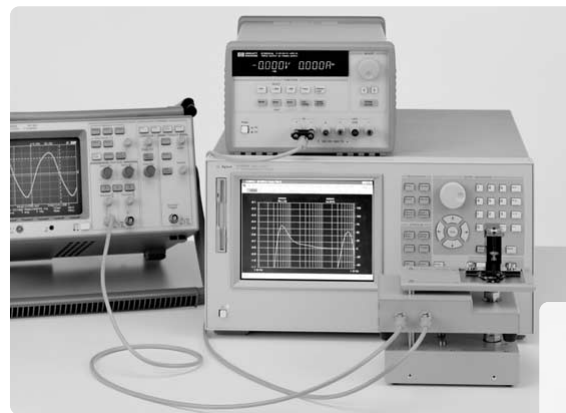


Figure 5. 16200B DC bias adapter connected to the E4991A



Figure 5-1. 16200B

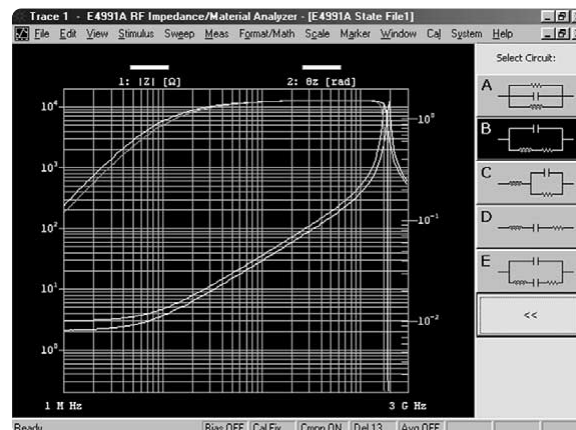


Figure 6. Equivalent circuit analysis models

Increase Productivity with Segment Sweep Function

The segment sweep function enables different measurement setups in a single sweep by dividing the sweep range into segments. Each segment, including the frequency range, number of points, averaging factor, DC bias level (V or I), and test signal level can be set independently. (See Figure 7) Segment sweep function can drastically reduce your test time when you need specific data in a wide frequency range. With segment sweep, you can avoid repeatedly changing instrument setups. (See Figure 7-1)

| Segment No. | Start [Hz] | Stop [Hz] | Hop [Hz] | Avg | Osc [dBm] | Bias Lvl [V] | Bias Lvl [A] |
|-------------|------------|-----------|----------|-----|-----------|--------------|--------------|
| 1 | 1 M | 500 M | 100 | 1 | -10.000 | 0.0000 | 2.0000 m |
| 2 | 1 G | 1.4 G | 40 | 8 | -10.000 | 0.0000 | 2.0000 m |
| 3 | 1.7 G | 1.9 G | 100 | 16 | -5.0000 | 0.0000 | 2.0000 m |
| 4 | 1.93 G | 2 G | 80 | 16 | -5.0000 | 0.0000 | 2.0000 m |

Figure 7. Segment list table

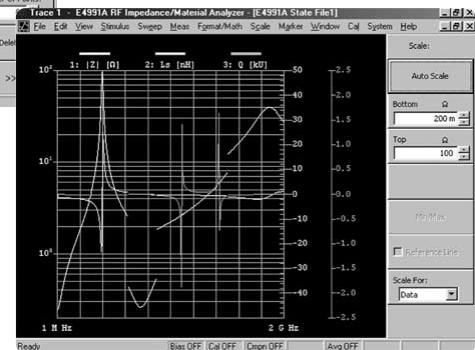


Figure 7-1. Segment sweep measurement example

Various Text Fixtures are Ready to Use

The 16197A and 16196A/B/C are test fixtures that accommodate passive surface mount devices (SMD) and have high repeatability and stable frequency characteristics up to 3 GHz.

The 16197A is a test fixture that can hold chip devices that have electrodes at the bottom. Various sizes and shapes of devices are supported. The 16197A supports the following EIA/EIAJ standard sizes:

- 0201 (inch)/0603 (mm)¹
- 0402 (inch)/1005 (mm)
- 0603 (inch)/1608 (mm)
- 0805 (inch)/2012 (mm)
- 1208 (inch)/3216 (mm)
- 1210 (inch)/3225 (mm)
- Non-standard shape (requires modification of the holder part)

The 16196A/B/C series are coaxial-structured high performance test fixtures, which achieve high repeatability and stability up to 3 GHz. The 16196x series simplifies operation significantly and eliminates operation-related errors. The 16196x series supports chip devices as small as 0201 (inch)/0603 (mm) size. Each test fixture model supports respectively shaped devices as follows:

| Model | Device size supported |
|--------|-----------------------|
| 16196A | 0603 (inch)/1608 (mm) |
| 16196B | 0402 (inch)/1005 (mm) |
| 16196C | 0201 (inch)/0603 (mm) |



Figure 8. Agilent 16197A bottom electrode SMD test fixture



Figure 9. Agilent 16196B parallel electrode SMD test fixture

¹ Option E4991A-001 is required.

Connectivity Advances with PC and Windows-based Technology

Visual Basic for applications (VBA) helps automate tasks

The built-in VBA is available for customization and automation of complex measurement procedures. You can create macro programs in the Integrated Development Environment (IDE) of VBA in a similar manner to Visual Basic® operation.

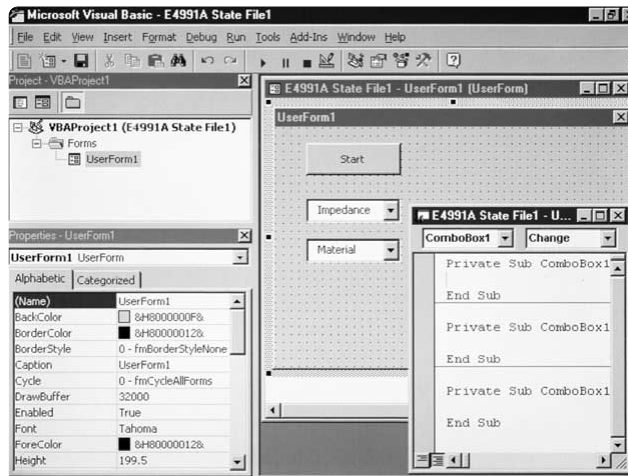


Figure 10. VBA

Link to EDA tools

Using electronic design applications such as Agilent's Advanced Design System (ADS), in conjunction with the E4991A, can help you optimize and verify the performance of your device with simulated circuit modeling. You can easily store measured data in CITIFILE format and import to EDA software tools. (Agilent's ADS software may be purchased separately from the E4991A.)

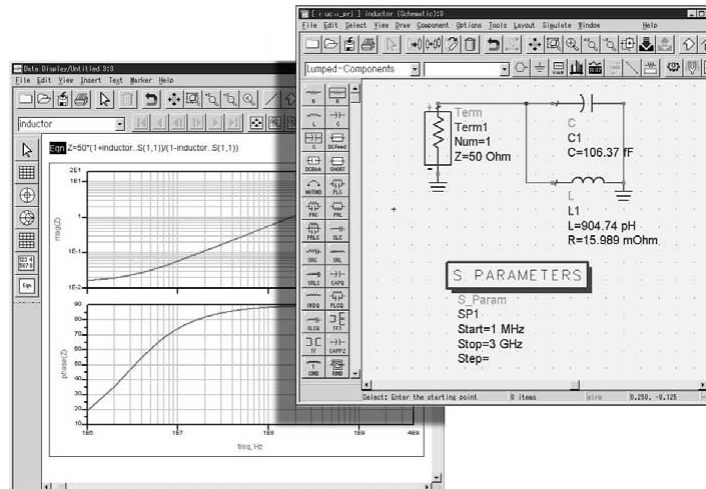


Figure 11. ADS figure

LAN interface enables seamless connectivity with PC environment

Using the remote user interface software provided with the E4991A, you can easily correct data and troubleshoot over the LAN interface. The remote user interface brings the instrument control panel to the PC display via LAN. You can gain control of instruments in physically separate locations. Easily share your measurement data with other applications, such as spreadsheets, through a file or via the clipboard.

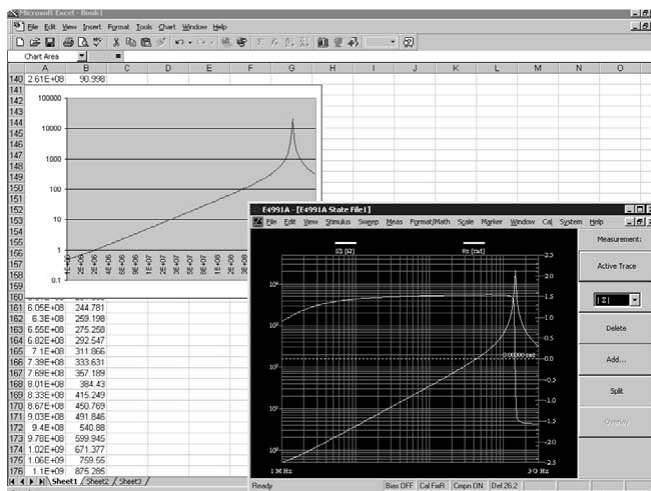


Figure 12. Remote user interface

Material Analysis Made Easy

The dielectric and magnetic measurement software (Option E4991A-002) provides direct readout of material parameters such as permeability and permittivity up to 1 GHz. The dielectric material test fixture, 16453A, and the magnetic material test fixture, 16454A, eliminate designing time-consuming custom test fixtures.



Figure 13. E4991A with material test fixtures

Dielectric material testing

The 16453A employs the parallel plate method for dielectric constant and loss tangent measurements up to 1 GHz. It is well-suited for measuring a sheet of solid substrate material, such as PC board, ceramic or polymer. Simple measurements are possible by inserting the material between the electrodes. With E4991A Option E4991A-002, material measurement function, you can display permittivity parameters directly on the analyzer's display.



Figure 14. 16453A Dielectric material fixture

Material size requirements

Diameter ≥ 15 mm
Thickness ≤ 3 mm

Magnetic material testing

The 16454A is used for permeability measurements up to 1 GHz on the E4991A. This single-wound, coil-structured test fixture holds toroidal-shaped magnetic materials such as soft-ferrite and magnetic cores. It is possible to accommodate different sizes of toroidal cores by exchanging small (smaller than 8 mm diameter) and large adapters. To use the 16454A, you need the material measurement function (Option E4991A-002).



Figure 15. 16454A Magnetic material fixture

Material size requirements

Small size:

Outer diameter ≤ 8 mm
Inner diameter ≥ 3.1 mm
Thickness ≤ 3 mm

Large size:

Outer diameter ≤ 20 mm
Inner diameter ≥ 5 mm
Thickness ≤ 8.5 mm

Accurate impedance measurement with probe station



Figure 16. Agilent E4991A with probe station

More ICs or circuit modules are used in electronic circuits to save spaces, more capacitors or inductors, such as thin dielectric layers and pattern inductors, tend to be developed on wafer or substrate. These devices usually have a small capacitance or inductance like pF, nH. The Agilent E4991A RF impedance/material analyzer, with Option E4991A-010 probe station connection kit, offers an accurate on-wafer or micro-component impedance measurement solution up to 3 GHz.

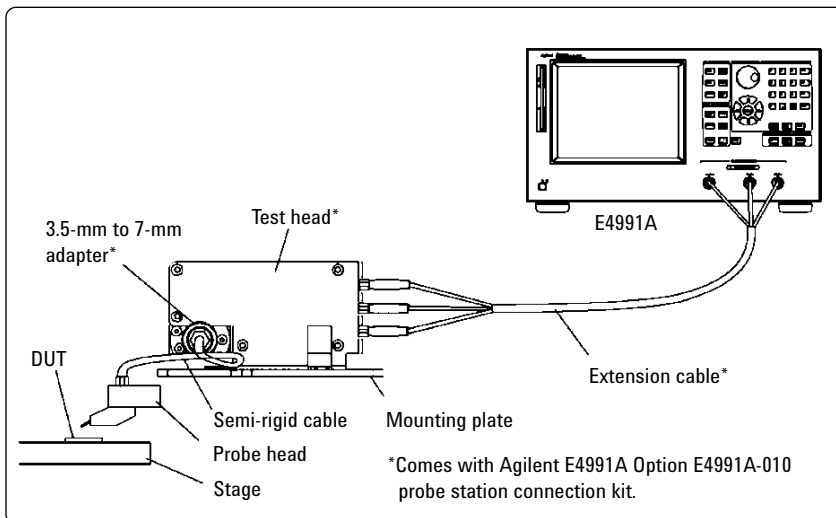


Figure 17. Probe measurement configuration using E4991A Option E4991A-010

Easy installation

When connecting the E4991A to probe stations, the accuracy degradation, caused by port extension and improper calibration, always becomes a big issue. The Option E4991A-010 probe station connection kit, for E4991A provides all necessary parts as one option and solves this problem. This option includes a smaller test head, extension cables, adapters, a connecting plate and detailed installation procedures. Probe stations are provided from Cascade Microtech, Inc. With this kit, you can easily establish a reliable measurement system in the short time.

Impedance measurement specification at the extended test head port

The E4991A's Option E4991A-010 has a guaranteed impedance measurement specification at the end of the extended 7-mm test head port. This is an important element for accurate measurement, because the port extension usually de-grades the measurement accuracy. The situation becomes even worse if the cable used has an improper characteristic. Agilent solved this issue by preparing reliable extension cables and making a special test head. This test head is small enough to be brought closer to probe stations, so that the measurement error caused by this extra length is also minimized.



Figure 18. Agilent E4991A Option E4991A-010 probe station connection kit

Wide and repeatable impedance measurement

Agilent E4991A can cover wider impedance range than network analyzers. In general, network analyzers are good at measuring impedance near 50Ω , but the accuracy gets worse for impedance away from 50Ω . The E4991A is designed to measure non- 50Ω impedance as well, so it can give much better accuracy especially when you measure small capacitance and inductance like 1 pF and 1 nH . The E4991A is repeatable over time and temperature, too. This is another benefit of dedicated impedance analyzers.

What is E4991A Option E4991A-010

The E4991A Option E4991A-010 includes following items:

- Smaller E4991A test head
- Extension cables
- $7\text{mm} - 3.5\text{mm}$ (f) adapter x 1 ea.
- N (m)-SMA(f) adapter x 3 ea.
- Installation manual

What else do you need for a system?

Besides the E4991A with Option E4991A-010, a probe station and probe heads need to be purchased separately. This option works with any probe stations, but we recommend Cascade Microtech probe stations, because this combination was carefully checked to work well. The following are product examples:

- Summit 9000, 11000, or 12000 series probe station
- ACP-series or HPC-series probe head
- Impedance Standard Substrate (ISS)
- Adjustable mounting plate for the E4991A test head.
- Semi-rigid cable for the probe head connection

These products are provided by Cascade Microtech, Inc.

Integrated Temperature Characteristic Testing

A temperature characteristic test solution is now available

The temperature characteristic test kit, E4991A Option E4991A-007, is a new solution of temperature characteristic measurement for components and materials. This solution provides highly accurate temperature characteristic analysis capability within the wide temperature range from -55°C to $+150^{\circ}\text{C}$ with a powerful temperature drift compensation function.

Figure 19 shows the typical 10% measurement accuracy range of the E4991A compared to the 4291B. The 4291B requires both low and high impedance test heads for obtaining the wide impedance measurement range. On the other hand, the E4991A covers the wider impedance measurement range with a single test head.

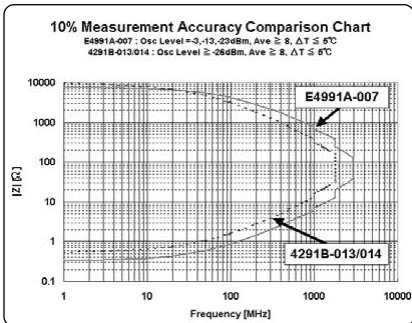


Figure 19. Typical 10% measurement accuracy comparison chart

The temperature drift compensation function is a new technology that is adopted in the E4991A. Unlike the 4291B, open/short compensation can be performed at pre-defined temperature points so that temperature drift errors can be drastically reduced as shown in Figure 20.

Easy integration with the ESPEC¹ temperature chamber

ESPEC supplies a temperature chamber, while Agilent provides all other necessary accessories and a sample program for creating an automated temperature characteristic test system. Figure 21 shows the contents of the E4991A Option E4991A-007.

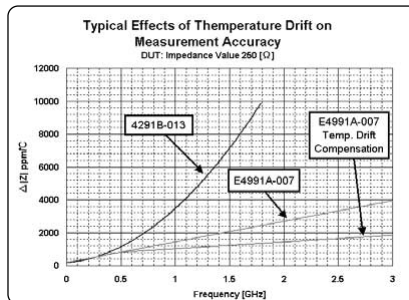


Figure 20. Effect of the temperature drift compensation function

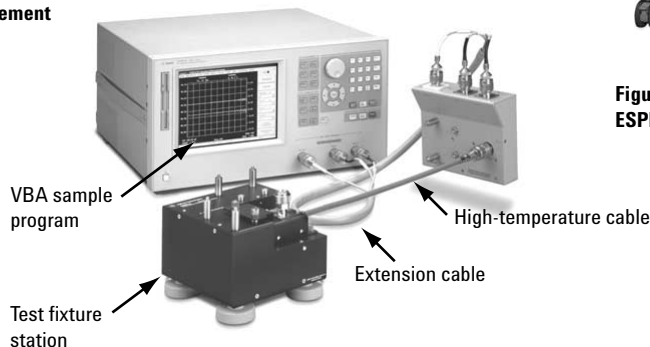


Figure 21. Contents of the E4991A Option E4991A-007

A VBA sample program is compatible with the ESPEC bench-top temperature chamber, SU-261, so that you can easily integrate an automated temperature characteristic test system Figure 22. The SU-261 provides a wide temperature range from -60°C to $+150^{\circ}\text{C}$; which covers the entire temperature range of Option E4991A-007. Also, this sample program can be modified to fit other companies' temperature chambers. In addition, the VBA sample program provides an intuitive GUI interface; which provides the temperature chamber control, measurement parameter setup, and temperature profile setup with easy operation.



Figure 22. The E4991A Option E4991A-007 with the ESPEC bench-top temperature chamber (SU-261)

1. ESPEC is an Agilent channel partner.

Test Fixture Accessories

16197A bottom electrode SMD test fixture

Designed for bottom electrode SMDs up to 3 GHz. Adjustable electrodes accommodate a wide array of sizes. This fixture is designed to evaluate SMDs between 0.6 mm¹ and 3.2 mm in length.

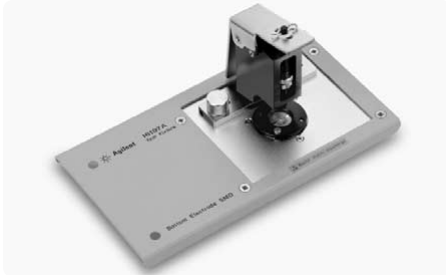


Figure 23. 16197A

16196A/B/C parallel electrode SMD test fixture

Designed for SMDs with electrodes on both sides up to 3 GHz. Dedicated design for specific shape of the devices eliminates repeatability errors and significantly improves usability. 0603 inch/1608 mm (16196A), 0402 inch/1005 mm (16196B) and 0201 inch/0603 mm (16196C) are supported.



Figure 24. 16196A/B/C

16191A bottom electrode SMD test fixture

Designed for bottom electrode SMDs up to 2 GHz. Adjustable electrodes accommodate a wide array of sizes. This fixture is designed to evaluate SMDs between 2.0 mm and 12.0 mm in length.



Figure 25. 16191A

1. Option E4991A-001 is required.
2. Frequency is limited to 2 GHz.
3. Option 16197A-001.

16192A parallel electrode SMD test fixture

Holds chip devices with electrodes on both sides up to 2 GHz. Adjustable electrodes can accommodate a wide array of sizes. This fixture is adapted to evaluate SMDs between 1.0 mm and 20.0 mm in length.

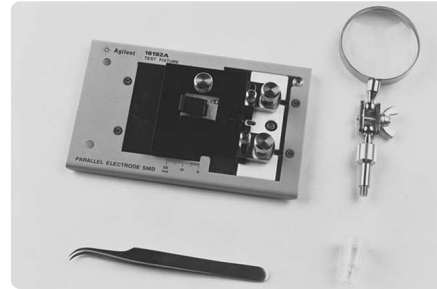


Figure 26. 16192A

16194A parallel electrode SMD test fixture

Holds both lead devices and SMDs up to 2 GHz. It is furnished with two device holders that can be easily attached to measure either type of DUT.



Figure 27. 16194A

SMD test fixture selection guide

| DUT size | Parallel electrodes SMD | Bottom electrode SMD |
|----------------------------|-------------------------|----------------------|
| 0201 (inch)/0603 (mm) | 16196C | 16197A ³ |
| 0402 (inch)/1005 (mm) | 16196B | 16197A |
| 0603 (inch)/1608 (mm) | 16196A | 16197A |
| 0805 (inch)/2012 (mm) | 16192A ² | 16197A |
| 1206 (inch)/3216 (mm) | 16192A ² | 16197A |
| 1210 (inch)/3225 (mm) | 16192A ² | 16197A |
| Over 1210 (inch)/3225 (mm) | 16192A ² | 16191A ² |

E4991A

Configuration and Accessory Guide

Ordering information

Agilent E4991A RF impedance/material analyzer includes: Impedance test head, calibration kit (50 Ω load, open, short, low loss capacitor, torque wrench), power cable, CD-ROM (firmware/VBA software), and CD-ROM (manual).¹

Configuration guide

Choose the option from the group <A> depending on your requirement for frequency reference function. Then, choose the appropriate options from the option group , <C>, <D>, and <E>.

- Choose ONE and ONLY one (Options are mutually exclusive)
- Choose any combination

<A> For frequency reference function

- E4991A-800 standard frequency reference, no DC bias
- E4991A-1D5 high stability frequency reference

 For test function

- E4991A-001 DC bias
- E4991A-002 material measurement firmware
- E4991A-007 temperature characteristic test kit
- E4991A-010 probe station connection kit

<C> For calibration certificate

- E4991A-A6J ANSI Z540 compliant calibration

<D> For accessories

- E4991A-810 keyboard
- E4991A-820 mouse
- E4991A-1CM rackmount kit

- E4991A-1CN front handle kit
- E4991A-1CP handle/rack mount kit

<E> For manual²

- E4991A-ABA U.S. - English localization
- E4991A-ABJ Japan - Japanese localization
- E4991A-0BW service manual

Accessories³

16197A⁴ bottom electrode SMD test fixture (up to 3 GHz)

Options

- 16197A-001 add 0201 (inch)/0603 (mm) device guide set
- 16197A-ABA U.S. - English localization
- 16197A-ABJ Japan - Japanese localization

16196A/B/C⁵ parallel electrode SMD test fixture (up to 3 GHz)

Options

- 16196A/B/C-710 add magnifying lens and tweezers
- 16196A/B/C-ABJ Japan - Japanese localization
- 16196A/B/C-ABA U.S. - English localization

16196U maintenance kits for 16196X

Options

- 16196U-010 upper electrode set (5 ea)
- 16196U-100 1608 (mm) short plate set (5 ea)
- 16196U-110 1608 (mm) lower electrode set (5 ea)
- 16196U-200 1005 (mm) short plate set (5 ea)
- 16196U-210 1005 (mm) lower electrode set (5 ea)

- 16196U-300 0603 (mm) short plate set (5 ea)
- 16196U-310 0603 (mm) lower electrode set (5 ea)

- 16200B external DC bias adapter (up to 1 GHz)

- 16190B performance kit
- 16195B 7-mm coaxial calibration kit
- 16092A SMD test fixture (up to 500 MHz)

16191A⁶ bottom electrode SMD test fixture (DC to 2 GHz)

Options

- 16191A-701 short bars set (1 x 1 x 2.4, 1.6 x 2.4 x 2, 3.2 x 2.4 x 2.4, 4.5 x 2.4 x 2.4) mm
- 16191A-710 add magnifying lens and tweezers
- 16191A-010 EIA/EIAJ industry sized short bar set

16192A⁶ parallel electrode SMD test fixture (DC to 2 GHz)

Options

- 16192A-701 short bars set (1 x 1 x 2.4, 1.6 x 2.4 x 2, 3.2 x 2.4 x 2.4, 4.5 x 2.4 x 2.4) mm
- 16192A-710 add magnifying lens and tweezers
- 16192A-010 EIA/EIAJ industry sized short bar set

- 16094A probe test fixture (up to 125 MHz)
- 16453A dielectric material test fixture (up to 1 GHz)
- 16454A magnetic material test fixture (up to 1 GHz)

1. Test fixtures, a keyboard, a mouse, and a printed manual are not furnished as standard.

2. Printed manual is not furnished as standard.

3. Additional accessory details can be found in the *Accessories Selection Guide for Impedance Measurements*, publication number 5965-4792E.

4. Must specify one of language options (ABA or ABJ) for operation manual for shipment with product.

5. Magnify lens and tweezers are not furnished as standard. Must specify one of language options (ABA or ABJ) for operation manual for shipment with product.

6. Short bar set, magnify lens, and tweezers are not furnished as standard.

Key Web Resources

Please visit our component manufacturer industry area at:
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