

Accessories Selection Guide For Impedance Measurements

April 2001

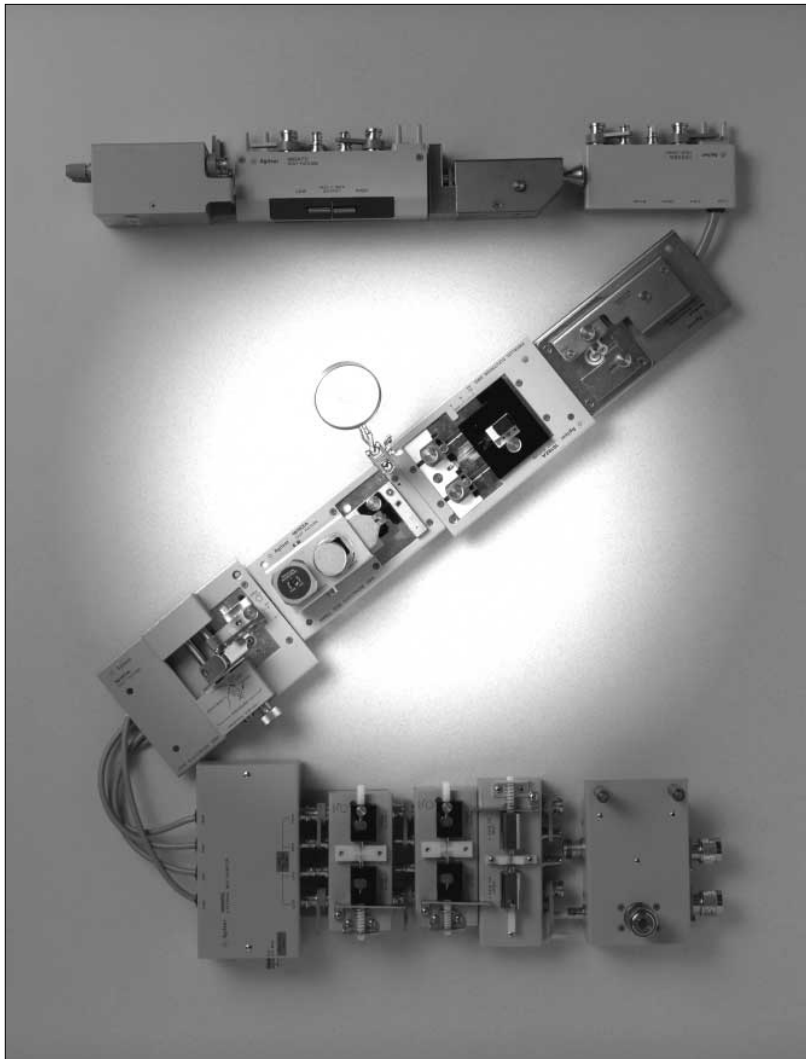


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Introduction

When a device under test (DUT) is measured, a test fixture must be used to connect the instrument to the DUT. A test fixture is an interface specifically designed to connect the instrument and the contact tips of the DUT.

1. What are Agilent Accessories?

Agilent offers a variety of accessories suitable for many applications. They are designed to make measurements simple and reliable. For example, a mechanically and electrically precise test fixture is required to measure the impedance of SMD components. For this measurement, Agilent offers dedicated SMD fixtures for impedance measurement instruments that minimize the measurement errors. Also, specially designed fixtures for other specific applications (such as DC bias test, dielectric material test, and others.) are available. Agilent accessories facilitate a shorter time-to-market with increased confidence by providing accurate and repeatable measurements.

2. Types of Accessories

Agilent accessories can be divided into the following five categories:

Test Fixtures

A test fixture is used to hold the electronic components or materials (physically and electrically) for the measurements. Agilent offers various kinds of 4-Terminal Pair test fixtures and 7 mm test fixtures. Some of them connect directly to the measurement instrument, while others require adapters.

Test Leads

Test leads are used to extend the measurement ports from the UNKNOWN terminals of the instrument to the DUT. Using a flexible test lead, a DUT that cannot be held with test fixtures can be measured regardless of its size or shape. The test leads can also be used as cable extensions when the test sample is located away from the measurement instrument.

Probes

Probes are helpful in measuring components which are already connected to PC boards or have one terminal grounded. The probes shown in this selection guide have a wide frequency range and are simple to use.

Adapters

Adapters are used to adapt the dedicated circuits between the instrument and the test fixtures. The 16085B is a terminal conversion adapter that can convert a 4-Terminal Pair configuration to a 7 mm configuration. The 16065C is an external DC bias adapter that can apply DC bias to the DUT from an external DC bias source.

Others

Also available are DC bias accessories and performance test equipment.

Introduction

3. The Benefits of Agilent Accessories

Each accessory is designed to ensure highly accurate measurements without degrading the performance of the measurement instrument.

- Minimum residual error preserves the accuracy of the measurement instruments.
- Clearly defined error compensation allows easy calculation of error corrections.
- Strict measurement specifications, such as test frequencies and signal levels provide safe and accurate measurements.

This document introduces a group of Agilent accessories that are well suited for the following measurement instruments:

LCR Meters:

- 4263A*/4263B 100 Hz/120 Hz/1 kHz/10 kHz/100 kHz LCR Meter
- 4284A 20 Hz - 1 MHz Precision LCR Meter
- 4285A 75 kHz - 30 MHz Precision LCR Meter
- 4286A* 1 MHz - 1 GHz RF LCR Meter
- 4287A 1 MHz - 3 GHz RF LCR Meter

Capacitance Meters

- 4268A 120 Hz/1 kHz Capacitance Meter
- 4278A 1 kHz/1 MHz Capacitance Meter
- 4279A 1 MHz C-V Meter
- 4288A 1 kHz/1 MHz Capacitance Meter

Resistance Meters

- 4338A*/4338B 1 kHz Milliohm Meter
- 4339A*/4339B DC High Resistance Meter
- 4349A*/4349B DC 4-ch High Resistance Meter

Impedance Analyzers

- 4192A 5 Hz - 13 MHz LF Impedance Analyzer
- 4194A* 100 Hz - 40 MHz Impedance/Gain-Phase Analyzer
- 4291A*/4291B 1 MHz - 1.8 GHz RF Impedance/Material Analyzer
- 4294A 40 Hz - 110 MHz Precision Impedance Analyzer
- E4991A 1 MHz - 3 GHz RF Impedance/Material Analyzer

Combination Analyzers

- 4195A* 100 kHz - 500 MHz Network/Spectrum Analyzer
- 4395A 10 Hz - 500 MHz Network/Spectrum/Impedance Analyzer
- 4396A*/4396B 100 kHz - 1.8 GHz RF Network/Spectrum/Impedance Analyzer

* denotes the instrument is obsolete

4. ISO 9000 Quality Management

ISO 9000 is a set of international standards for quality management and quality assurance. These standards were developed with the goal of documenting and implementing effective quality systems within companies. ISO standards are consistent with Agilent's quality system; in fact, the standards within Agilent Technologies' Quality Maturity System (QMS) exceed the intent of ISO 9000.

Tips for Selecting Appropriate Accessories

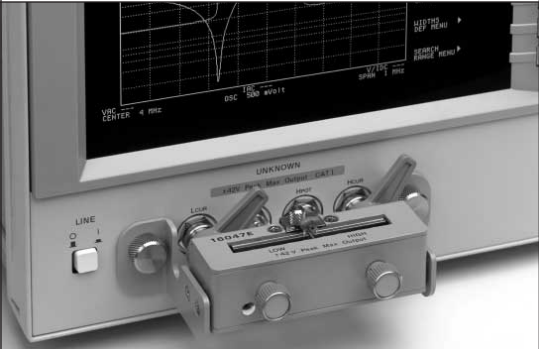



The following topics comprise a helpful guideline for selecting an appropriate accessory for the measurement instrument to be used.

1. Selection By Measurement Application

Agilent accessories can be used in a wide variety of measurement applications. These applications range from basic measurements (such as impedance measurements for discrete devices) to advanced measurements (such as measurement of resistivities or dielectric constants.)

2. Compatibility with Measurement Instruments

Test fixtures/leads are compatible with the measurement instruments when they have the same type of terminal configuration and useable measurement frequency range. The measurement instruments described in this guide are divided into the following four categories based on frequency.

Frequency Range	Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)	Up to 3 GHz (Terminal Configuration: 7 mm)
		
Measurement Instruments	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	4291A/B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, 4286A, 4287A, E4991A Any 4TP instruments (excluding 4294A) + 16085B
Frequency	DC (High Resistance Measurement)	1 kHz (Milliohm Measurement)
		
Measurement Instruments	4339A/B, 4349A/B	4338A/B

Tips for Selecting Appropriate Accessories

3. Frequency, DC bias, and operating temperature/humidity

Each of the Agilent accessories has its own specific operating range. Any measurement performed outside this range can increase residual errors and can cause problems. Be sure that your measurement environment fits the accessory's specific operating range. In the case of humidity, Agilent's accessories can operate at a relative humidity of 95% or less at 40°C. (These same requirements apply to most LCR Meters and Impedance Analyzers.) When the ambient temperature is not approximately 40°C, use an accessory that has no condensation on its surface.

4. DUT (Device Under Test) dimensions

The DUT can vary from chip components, axial/radial leads, or ICs to general electrical devices. Select a test fixture/lead that is suitable for the shape and size of your components or materials.

5. Open & short repeatability and proportional error

Since a test fixture induces an additional error when measuring, the total measurement error is the sum of the measurement instrument's measurement accuracy and the fixture's additional error. Generally, a test fixture's additional error consists of three terms: open repeatability, short repeatability and proportional error. Open and short repeatability exhibit the error factors of the open and short residual impedances which affect the measurements of extremely high and low impedances respectively. Proportional error exhibits the error factor, which is proportional to the size of the impedance being measured. For more details on this subject, please see the Appendix.

6. Furnished accessories

Each test fixture is shipped with a manual and various other accessories needed for measuring. For example, the 42941A impedance probe kit is furnished with a pin probe, 4 adapters (BNC-SMB), 3 spare pins, a carrying case and an operation and service manual.

Tips for Selecting Appropriate Accessories

7. Terminal Adapters

Terminal Adapters convert the instruments terminal configuration into a 7 mm terminal configuration. This means that instruments that do not have a 7 mm terminal connector can use test fixtures with a 7 mm terminal connector. The 16085B converts a 4-Terminal Pair configuration into a 7 mm terminal connector. The 42942A does the same as 16085B, but can only be used with the 4294A.

16085B Terminal Adapter



Dimensions (approx.): 178(W)x90(H)x114(D) [mm]

Weight (approx.): 550 g

Applicable Instruments:

4263B, 4278A, 4279A, 4284A, 4285A, 4194A, 4268A

Frequency: DC to 40 MHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Operating Note	16085-90001	1

42942A Terminal Adapter



Dimensions (approx.): 190(W) x 55(H) x 140 (D) [mm]

Weight (approx.): 800 g

Applicable Instrument:

4294A only

Frequency: 40 Hz to 110 MHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

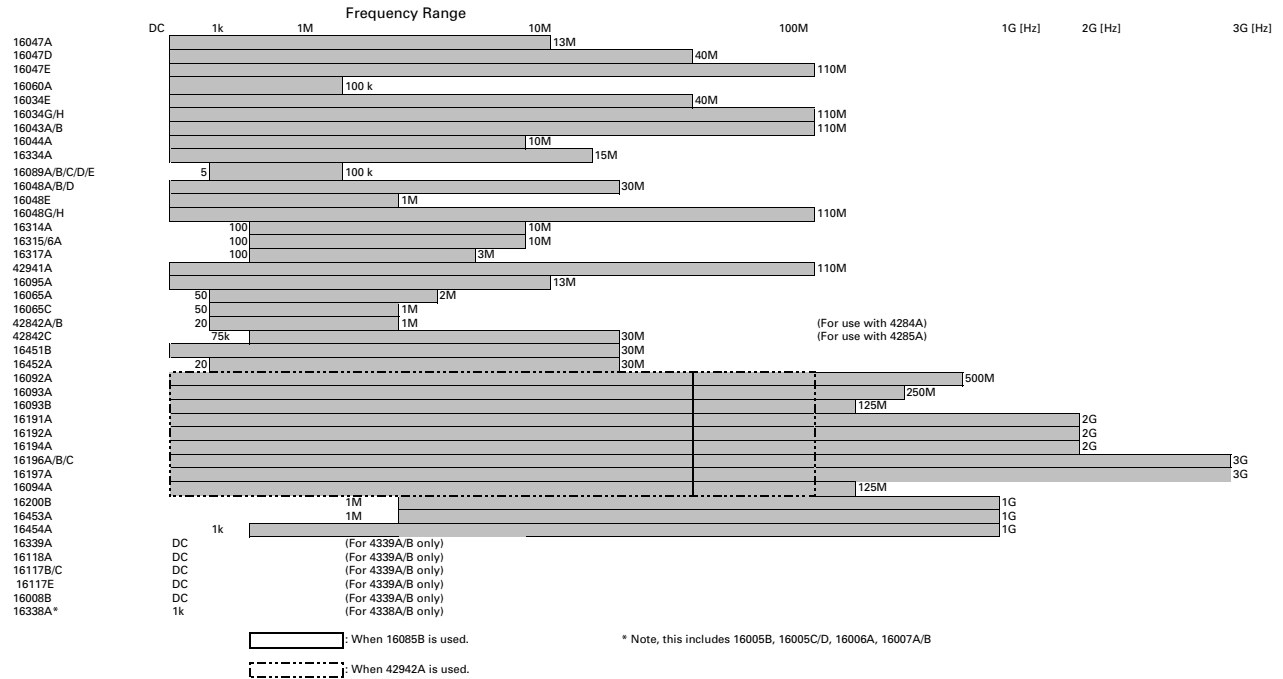
Description	P/N	Qty.
Open Termination	04191-85302	1
Short Termination	04191-85300	1
Load Termination	04191-60043	1
Carrying Case	42942-60011	1
Operation and Service Manual	42942-90010	1

Options:

001: Delete 7 mm open/short/load set

Accessories Catalogue

Applicable Frequency Ranges



Accessories Catalogue

Accessories Organization

This document is organized by measurement frequency and DUT to enable quick selection of an appropriate test fixture for a particular measurement application. The following tables show the various categories in each primary group:

- Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)

Lead Components	16047A/D/E, 16060A
SMD Components	16034E/G/H, 16044A, 16334A, 16043A/B
Other Components	16089A/B/C/D/E
Port/Cable Extension	16048A/B/D/E/G/H
Balanced/Unbalanced Converters	16314A, 16315/6/7A
DC Bias Accessories	42841A, 42842A/B/C, 42843A
Material	16451B, 16452A

- Up to 3 GHz (Terminal Configuration: 7 mm Connector)

Lead Components	16092A, 16093A/B, 16194A
SMD Components	16092A, 16191/2/4A, 16196A/B/C, 16197A
Probes	16094A
DC Bias Accessories	16200B
Material	16453A, 16454A

- DC (High Resistance Measurement)

Lead Components	16339A
SMD Components	16118A, 16339A
Other Components	16117B/C/E
Material	16008B

- 1 kHz (Milliohm Measurement)

Various Components	16338A (With 16143B, 16005B/C/D, 16006A, 16007A/B)
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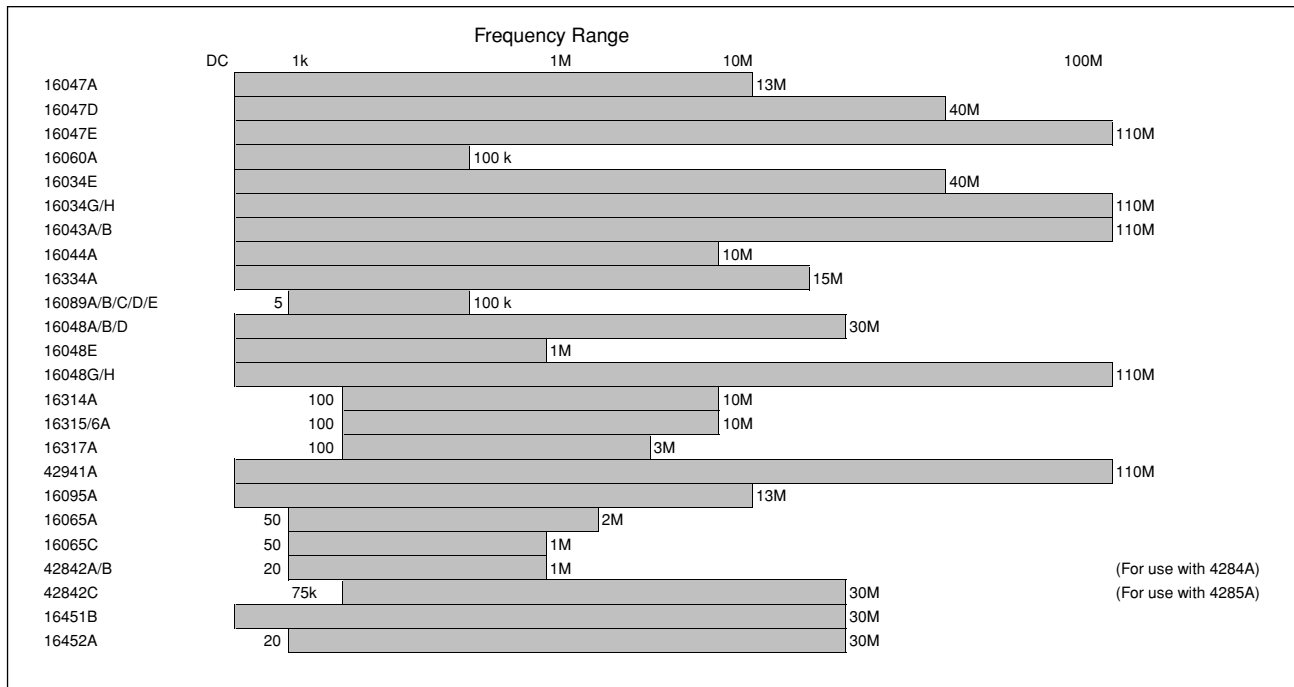
- Other Accessories

Miscellaneous	16064B, 16190B, 16380A/C, 42030A, 42090/1A
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Up to 110 MHz (4-Terminal Pair)

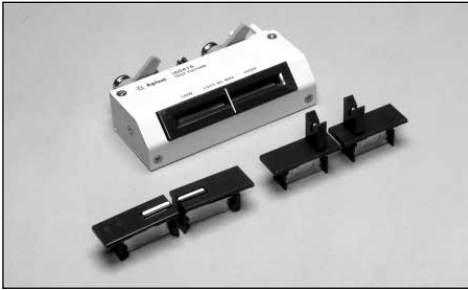
Test Fixtures (4-Terminal Pair) for Impedance Measurements up to 110 MHz



Applicable Instrument

Frequency Range	Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)	Up to 3 GHz (Terminal Configuration: 7 mm)
Measurement Instruments	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	4291A/B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, 4286A, 4287A, E4991A Any 4TP instruments (excluding 4294A) + 16085B
Frequency	DC (High Resistance Measurement)	1 kHz (Milliohm Measurement)
Measurement Instruments	4339A/B, 4349A/B	4338A/B

16047A Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 4-Terminal

Dimensions (approx.):

124 (W) x 31 (H) x 62 (D) mm

Weight (approx.): 205 g

Additional Error:

Type of Error	Impedance
Proportional Error	$\pm 5 \times (f/10)^2$

f: [MHz]

Description: This test fixture is designed for impedance evaluation of axial/radial lead type devices.

The 16047A employs Kelvin contacts which realize a wide impedance measurement range. The contact tip can be changed according to the device shape.

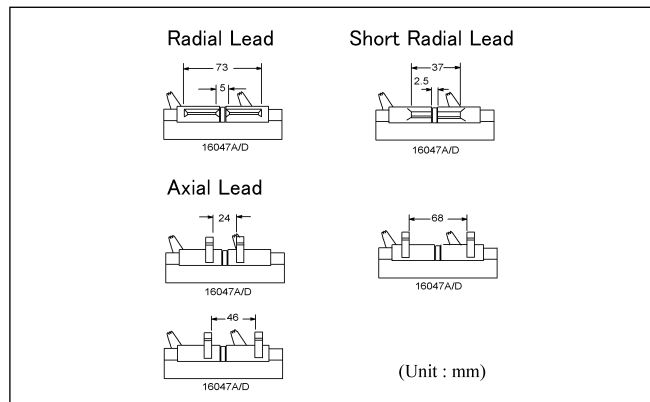
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 13 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See figure with module sizes.



16047A, 16047D module sizes

Furnished Accessories:

Description	P/N	Qty.
Module For Axial Lead	16061-70022	1
Module For Radial Lead mounting on fixture	16061-70021	1
Module For Short Radial Lead	16047-65001	1
Shorting Plate	5000-4226	1
Operating Note	16047-90011	1

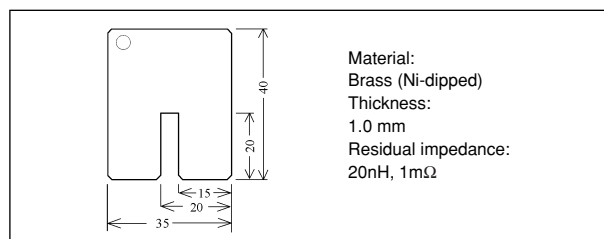
Each module size for the 16047A/D is shown above.

Option:

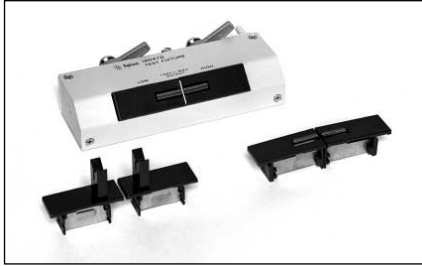
001: Delete Shorting Plate

Compensation and Measurement: Select one of these modules suitable for the DUT's shape. Open and short compensations are recommended before measurement. Short compensation is performed by shorting the contacts of the test fixture with a shorting plate. After performing open and short compensations, the DUT is connected to the test fixture.

P/N 5000-4226



Shorting plate

16047D Test Fixture

Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Dimensions (approx.):

149 (W) x 40 (H) x 72 (D) [mm]

Weight (approx.): 230 g

Additional Error:

Type of Error	Impedance
Proportional Error	$\pm 1.25 \times (f/10)^2$

f: [MHz]

Description: This test fixture is designed for impedance evaluation of axial/radial lead type devices. The 16047D can be used up to a higher frequency, 40 MHz.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 40 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See the 16047A figure with module sizes.

Furnished Accessories:

Description	P/N	Qty.
Shorting Plate	5000-4226	1
Module For Axial Lead	16061-70022	1
Module For Radial Lead mounting on fixture	16061-70021	1
Module For Short Radial Lead	16047-65001	1
Operating Note	16047-90300	1

Option:

001: Delete Shorting Plate

Compensation and Measurement: Open and short compensations are recommended before measurement. Short compensation is performed by shorting the contacts of the test fixture with a shorting plate. After performing open and short compensations, the DUT is connected to the test fixture.

16047E Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Dimensions (approx.):

135 (W) x 40 (H) x 65 (D) [mm]

Weight (approx.): 200 g

Additional Error:

Type of Error	Impedance
Proportional Error $f \leq 15$ MHz	$0.2 \times (f/10)^2$ [%]
Proportional Error $f > 15$ MHz	$4 \times (f/100)$ [%]
Open Repeatability	$2 n+10 \mu \times (f/100)$ [S]
Short Repeatability	$2 m+600 m \times (f/100)$ [Ω]

f: [MHz]

Description: This test fixture is designed for impedance evaluation of lead type devices up to 110 MHz. A guard terminal is available for three terminal devices and a shorting plate comes secured on this fixture.

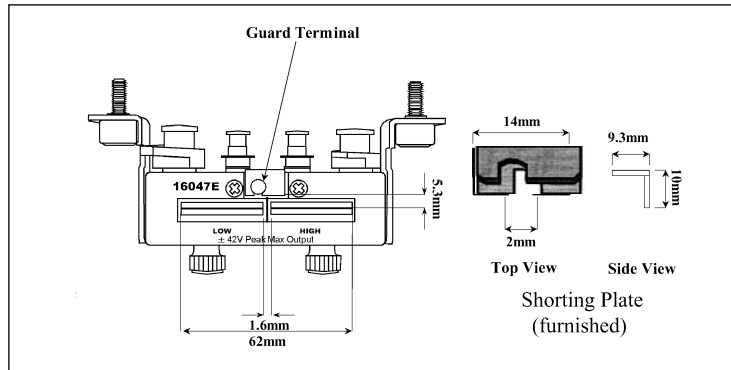
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 110 MHz

Maximum Voltage: ± 42 V peak max.(AC+DC)

Operating Temperature: 0°C to 55°C

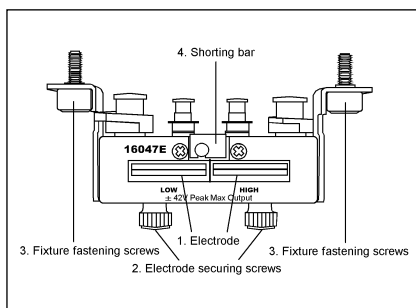
DUT Size: See figure below with 16047E's electrode size.



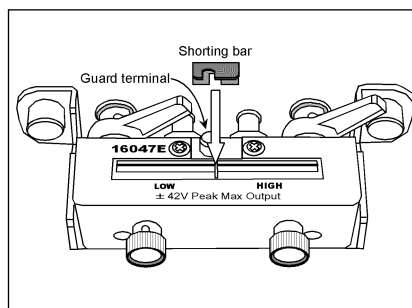
Furnished Accessories:

Description	P/N	Qty.
Angle(right-side)	NA	1
Angle(left-side)	NA	1
Screws	0515-0914	4
Shorting Plate	16047-00621	1
Operation and Service Manual	16047-90040	1

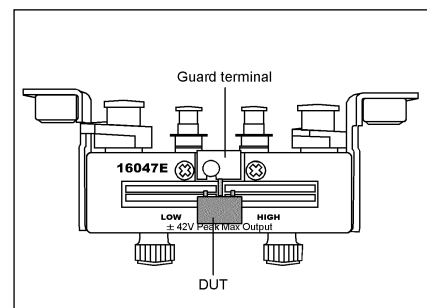
Compensation and Measurement: Open and short compensations are recommended before measurement. Short compensation is performed by shorting the contacts of the test fixture with a shorting plate. After performing open and short compensations, the DUT is connected to the test fixture. The following figures show how compensation and measurement are performed.



Test fixture overview

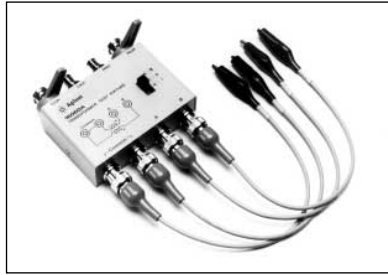


Connecting a shorting plate



Measuring 3-Terminal device

16060A Transformer Test Fixture



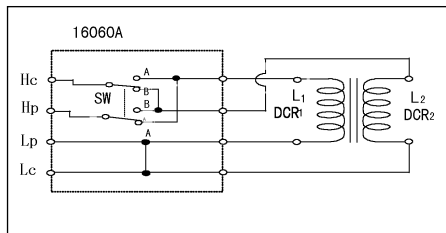
Terminal Connector: 4-Terminal Pair, BNC

DUT Connection:

2-Terminal for L measurement

3-Terminal for N, M measurement

See figure below for more information.



Dimensions (approx.):

90 (W) x 35 (H) x 90 (D) [mm]

Cable Length (approx.): 25cm

Weight (approx.): 300 g

Additional Error: The additional error is negligible when compared to the instrument's accuracy.



4263B with 16060A

Description: This test fixture provides a convenient means of measuring a transformer's self-inductance, mutual inductance, turns-ratio, and dc resistance in the frequency range of dc to 100 kHz, as appropriate for each measurement.

Applicable Instruments: 4263A/B (with Option 001) Only

Frequency: DC to 100 kHz

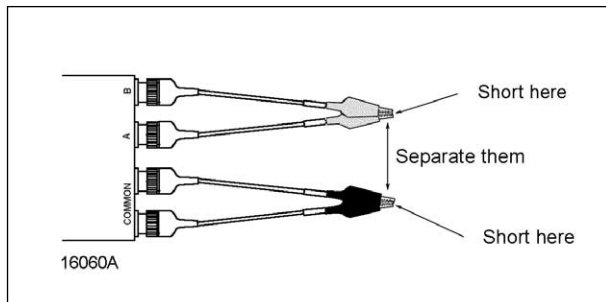
Operating Temperature: 0°C to 55°C

DUT Size: The lead wire of the transformer should not have a diameter greater than 4 mm, otherwise the alligator clip will not be able to clamp onto it properly.

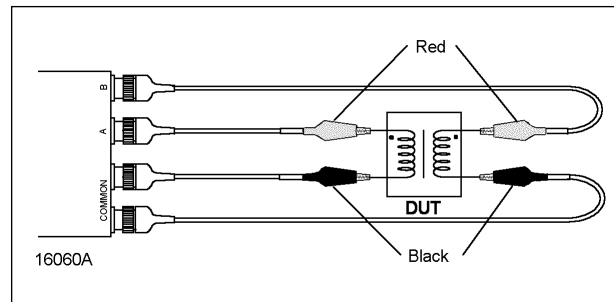
Furnished Accessories:

Description	P/N	Qty.
Test Leads (black), Alligator clip to BNC(m)	16060-61601	2
Test Leads (red), Alligator clip to BNC(m)	16060-61602	2
Operation and Service Manual	16060-90000	1

Compensation and Measurement: Open compensation is recommended before measurement. Open compensation is performed by connecting the alligator clips of "A" and "B" terminals together and separating them from the likewise connected alligator clips of the COMMON terminals. After performing open compensation, the transformer is connected to the test fixture. The "A" and "B" terminals are connected to the high terminals of the transformer. The COMMON terminals are connected to the low terminals of the transformer. The following figures show how compensation and measurement are performed.

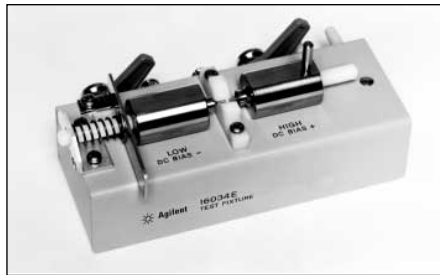


Open compensation



Connecting a transformer

16034E Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Dimensions (approx.):

128 (W) x 60 (H) x 71 (D) [mm]

Weight (approx.): 270 g

Additional Error:

Type of Error	Impedance
Proportional Error	$\pm 1.5 \times (f/10)^2$

f: [MHz]

Description: This test fixture is designed for impedance evaluations of SMD. The minimum SMD size that this fixture is adapted to evaluate is 1.6(L) x 0.8(W) [mm].

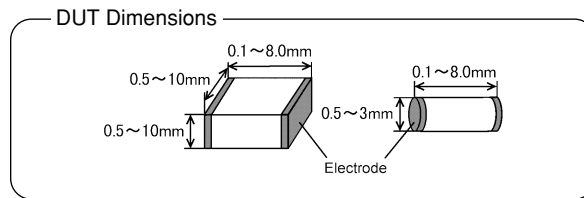
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 40 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

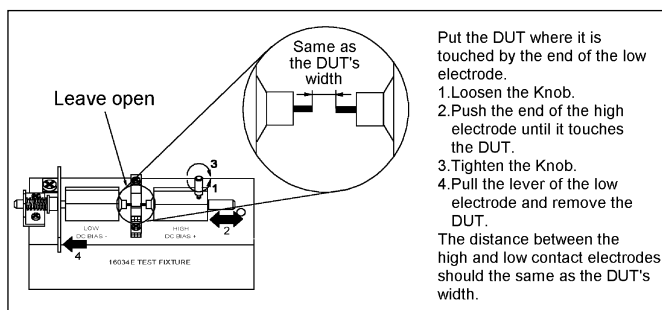
DUT Size: See figure below



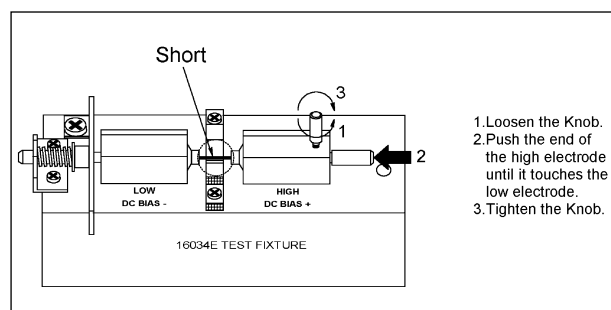
Furnished Accessories:

Description	P/N	Qty.
Operating Manual	16034-90041	1

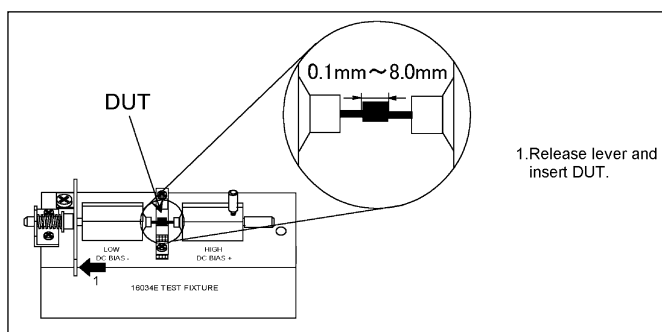
Compensation and Measurement: Open and short compensations are recommended before measurement. Open compensation is performed by separating the high and low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by contacting the high and low electrodes together. After performing open and short compensations, the DUT is inserted into the test fixture. The following figures show how compensation and measurement are performed.



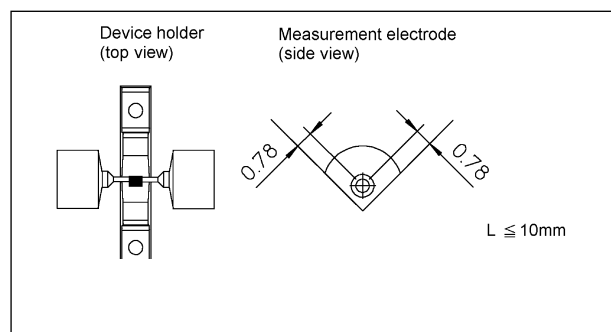
Open compensation



Short compensation

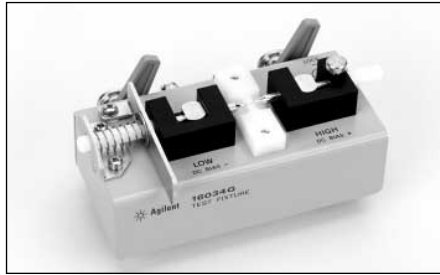


Inserting a DUT



Electrode dimensions

16034G Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Dimensions (approx.):

120(W) x 50(H) x 70(D) [mm]

Weight (approx.): 200 g

Additional Error:

Type of Error	Impedance
Proportional Error	$0.5 \times (f/10)^2$ [%]
Open Repeatability	$5 + 500 \times (f/10)$ [nS]
Short Repeatability	$10 + 13 \times (f/10)$ [mΩ]

f: [MHz]



4284A with 16034G

Description: This test fixture is designed for impedance evaluations of SMD. The minimum SMD size that this fixture is adapted to evaluate is 0.6(L) x 0.3(W) [mm].

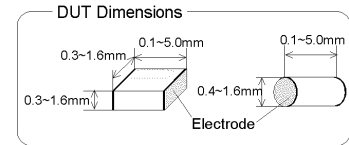
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 110 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

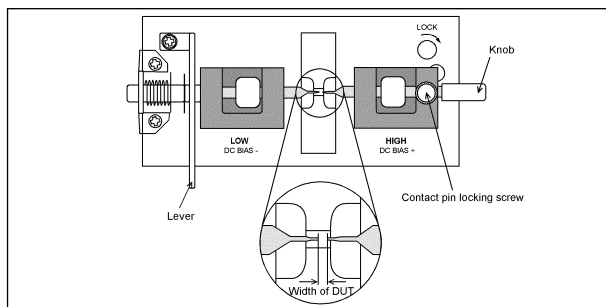
DUT Size: See figure below



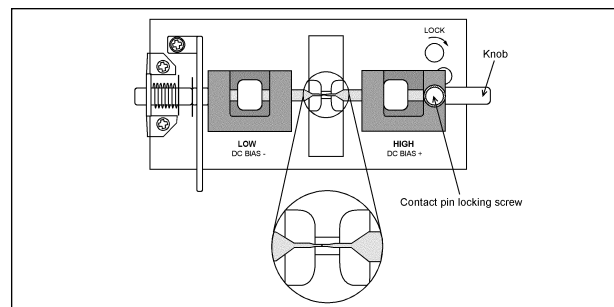
Furnished Accessories:

Description	P/N	Qty.
Case for 100 Ω SMD Resistance	1540-0692	1
100Ω Chip Resistor	0699-2488	10
Operation Manual	16034-90011	1

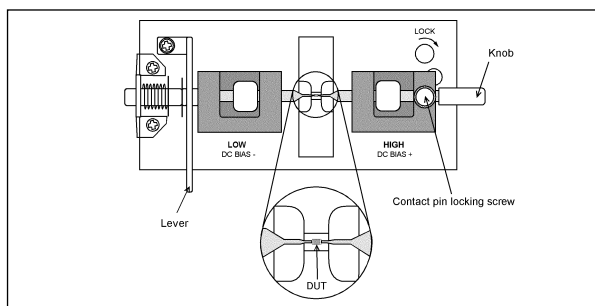
Compensation and Measurement: Open and short compensations are recommended before measurement. When measuring above 3 MHz, load compensation is also recommended. Open compensation is performed by separating the high and the low electrodes from each other. The separation size should be equivalent to the DUT's width. Short compensation is performed placing the high and low electrodes in contact together. Load compensation is performed by using the furnished 100 Ω SMD chip resistor. After performing open, short and load compensations, the DUT is inserted into the test fixture. The following figures show how compensation and measurement are performed.



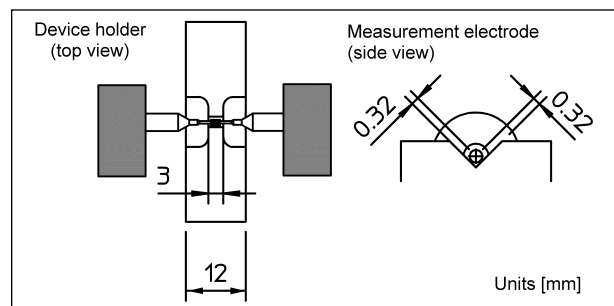
Open compensation



Short compensation

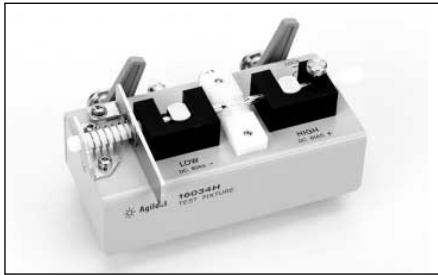


DUT measurement



Dimensions

16034H Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Dimensions (approx.):

120(W) x 50(H) x 70(D) [mm]

Weight (approx.): 200 g

Additional Error:

Type of Error	Impedance
Proportional Error	$0.5 \times (f/10)^2[\%]$
Open Repeatability	$5 + 500 \times (f/10)$ [nS]
Short Repeatability	$10 + 13 \times (f/10)$ [mΩ]

f: [MHz]



4284A with 16034H

Description: This test fixture is designed for impedance evaluations of array-type SMD. The minimum SMD size that this fixture is adapted to evaluate is 1.6(L) x 0.8(W) [mm]. Since the tip of the measurement electrodes are very thin and the device holder is extremely flat, the device can be shifted and the measurement electrodes can contact the each elements of the array-type component.

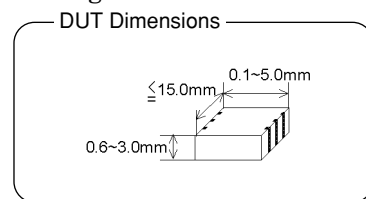
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 110 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

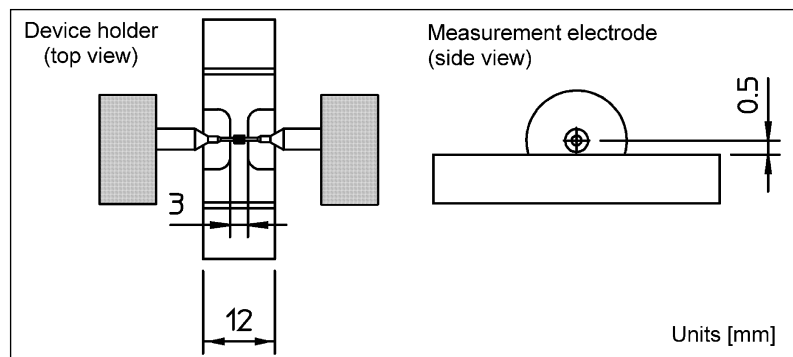
DUT Size: See figure below



Furnished Accessories:

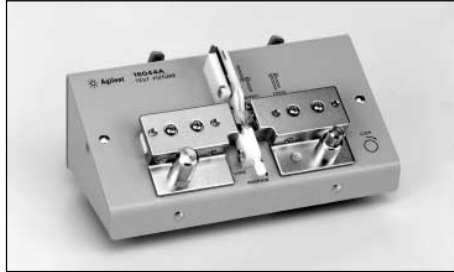
Description	P/N	Qty.
Case for 100 Ω SMD Resistance	1540-0692	1
100Ω Chip Resistor	0699-2488	10
Operation Manual	16034-90012	1

Compensation and Measurement: Open and short compensations are recommended before measurement. When measuring above 3 MHz, load compensation is also recommended. Open compensation is performed by separating the high and the low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by placing the high and low electrodes in contact together. Load compensation is performed by using the furnished 100 Ω SMD chip resistor. After performing open, short and load compensations, the DUT is inserted into the test fixture. Refer to the 16034G figures to see how compensation and measurement are performed.



Electrode dimensions

16044A Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 4-Terminal

Dimensions (approx.):
160(W) x 70(H) x 98(D) [mm]

Weight (approx.): 550 g

Additional Error:

Type of Error	Impedance
Proportional Error	$2 \times (f/10)^2[\%]$
Open Repeatability	$1.5 + 200 \times (f/10)$ [nS]
Short Repeatability	$1.5 + 40 \times (f/10)$ [mΩ]

f: [MHz]

Description: This test fixture is designed for impedance evaluations of low impedance SMD. The minimum SMD size that this fixture is adapted to evaluate is 1.6(L) x 0.8(W) [mm]. The 16044A has a Kelvin (4-Terminal) contact, which ensures repeatable measurements. It is also equipped with a mechanism for easily performing open and short compensation.

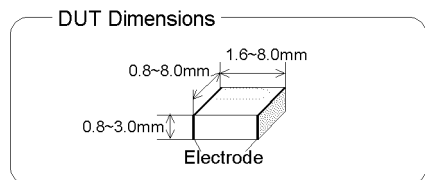
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: DC to 10 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See figure below

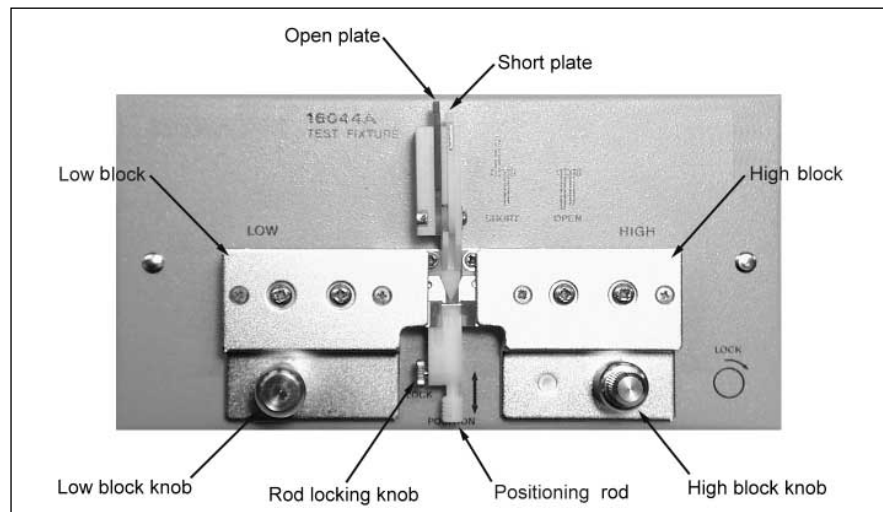


Furnished Accessories:

Description	P/N	Qty.
Cleaning Rod	5182-7586	1
Operation and Service Manual	16044-90020	1

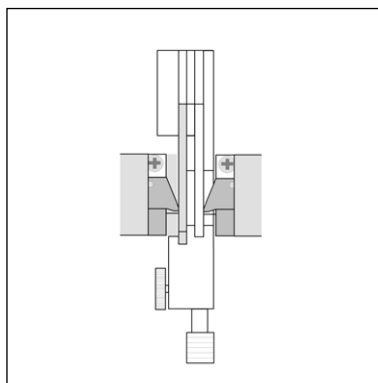
To maintain the measurement precision, it is recommended that contact pins be replaced approximately every 50,000 times (supplementary value).

Order 42110A (spare contact pins 4ea.).

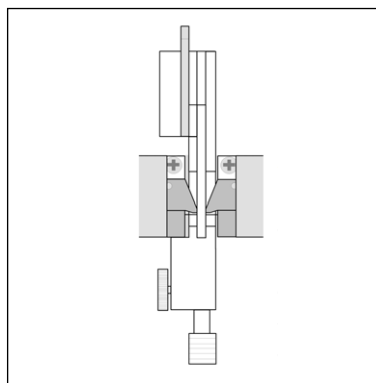


Test fixture overview

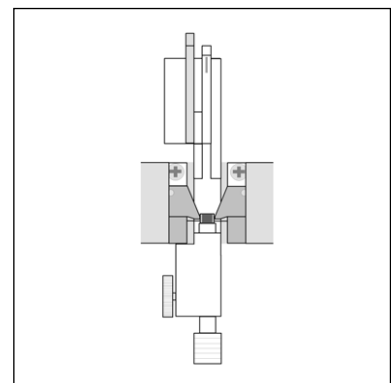
Compensation and Measurement: Open and short compensations are recommended before measurement. Short compensation is performed by bringing down the shorting plate (which is already on the fixture) to short all 4 terminals. Open compensation is performed by bringing down both the open plate and the shorting plate to separate the high terminals from the low terminals. After performing open and short compensations, the DUT is inserted into the test fixture. The figures below show how compensation and measurement are performed.



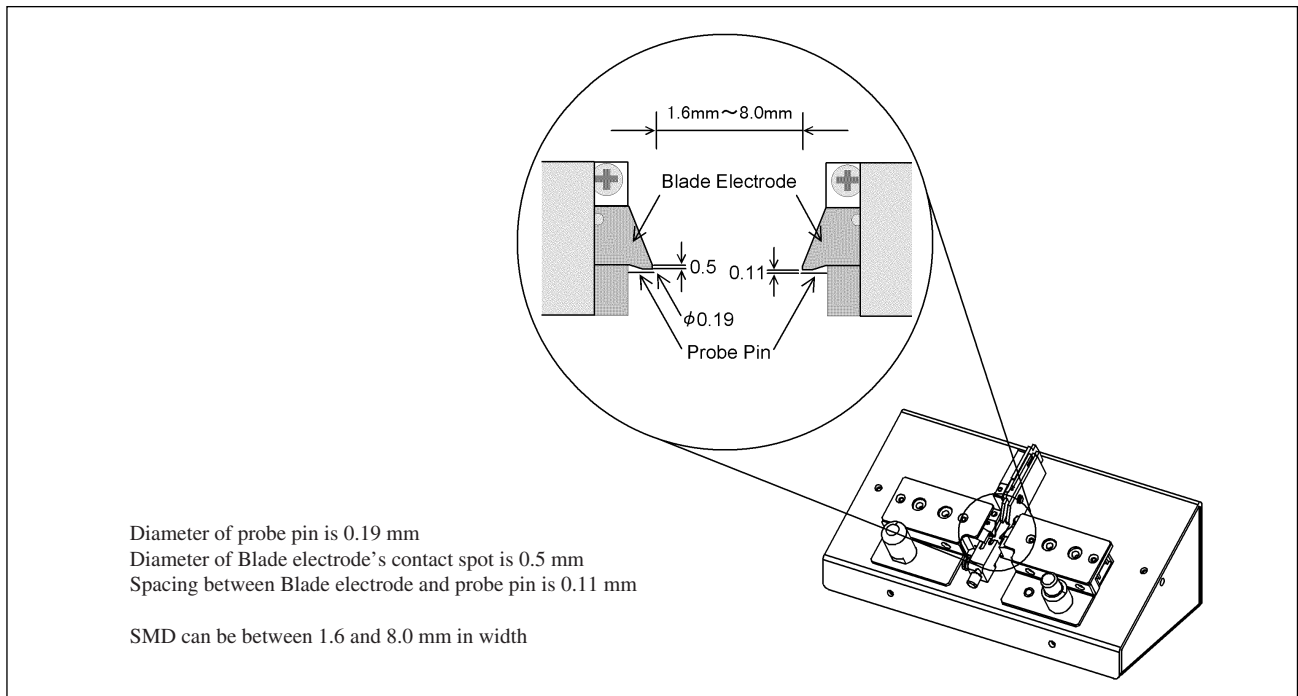
Open compensation



Short compensation



Inserting a DUT



Electrode dimensions

16334A Tweezers Contact Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 2-Terminal

Cable Length (approx.): 1m (from BNC connectors to the top of tweezers)

Weight (approx.): 290 g

Additional Error:

Type of Error	Impedance
Proportional Error	$\pm 2 \times (f/10)^2$

f: [MHz]

Description: This test fixture is designed for impedance evaluations of SMD. The minimum SMD size that this fixture is adapted to evaluate is 1.6(L) x 0.8(W) [mm]. The tweezers' contacts on this fixture makes it easy to hold the DUT.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

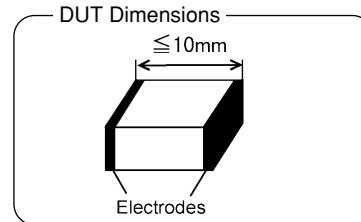
Frequency: DC to 15 MHz

Maximum Voltage: ± 42 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: ≤ 10 mm (width)

See figure below



Furnished Accessories:

Description	P/N	Qty.
Compensation Block	16334-60001	1
Operation Note	16334-90000	1

Compensation and Measurement: Open and short compensations are recommended before measurement. Open and short compensations are performed by using the furnished compensation block. After performing open and short compensations, the DUT is sandwiched by the tweezers' contacts and is measured.

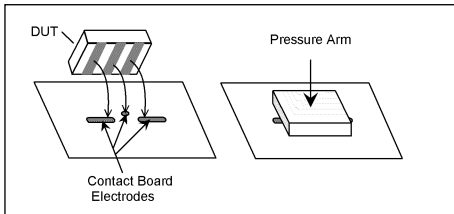
16043A/B 3-Terminal SMD Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

DUT Connection:

3-Terminal (including the guard terminal)



Dimensions (approx.):

75 (W) x 105 (H) x 95 (D) [mm]

Weight (approx.): 500 g (16043A)

330 g (16043B)

Additional Error:

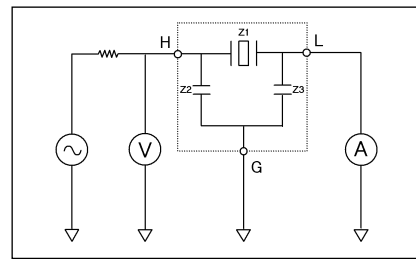
Type of Error	Impedance
Proportional Error	$0.4 + 7.2 \times (f/100)^2$ [%]
Open Repeatability	$10 + 600 \times (f/10)$ [nS]
Short Repeatability	$30 + 6 \times (f/10)$ [mΩ]

Guard Terminal Residual L: ≤ 6 nH

Guard Terminal Residual R: ≤ 20 mΩ

The additional error shown above is the characteristics of when the DUT connection is 2-Terminal. Ideally, in a 3-Terminal DUT connection, the guard effect should be taken into account in the measurement accuracy. To acknowledge the guard terminal's effect, a characteristics equation is provided in the operation manual.

Description: The 16043A/B enable 3-Terminal resonator SMD to be measured by using the guarding technique. Having a 4-Terminal Pair configuration it ensures high precision and repeatability. The 16043A/B accommodates a wide range of SMD sizes by providing 3 different contact boards. The 16043A is equipped with a sliding mechanism to enable the measurement of load capacitors in the 3-Terminal resonator. The 16043B is not equipped with the sliding mechanism. 2-Terminal SMD with bottom electrodes can be measured as well. As shown in the figure below, by connecting the device's G-terminal to instrument's guard terminal, only Z1 or the resonator will be measured.



Guarding technique of an impedance measurement instrument

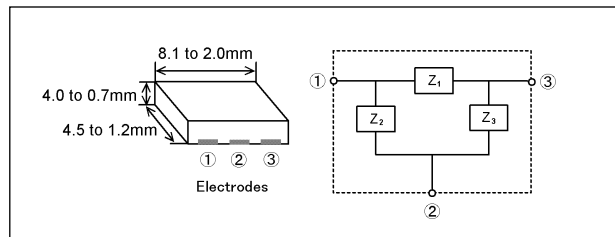
In order to measure Z2 and Z3, the sliding function of 16043A can be utilized.

Applicable Instruments: 4192A, 4194A, 4263A/B, 4268A, 4278A, 4284A, 4285A, 4288A, 4294A

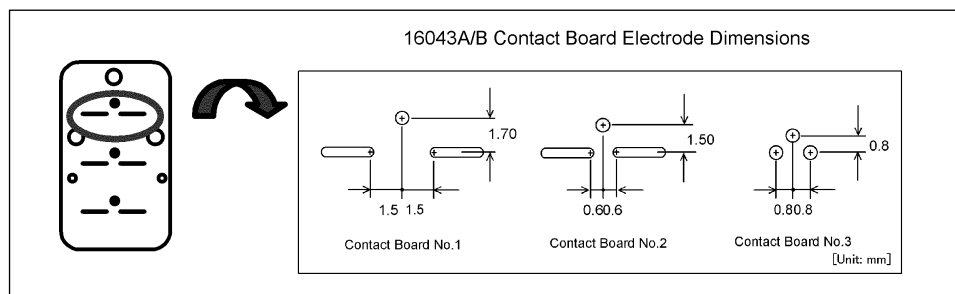
Frequency: DC to 110 MHz

Operating Temperature: 0°C to 70°C

DUT Size: The applicable DUT dimensions are shown below. A contact board is required for measurement and its dimensions and ordering info are shown on the next page.



Electrode configuration of DUT and applicable DUT dimensions

DUT Size:

Electrode configuration for 16043A/B contact board

Three types of contact boards are provided for the 16043A/B and the contact boards are selected accordingly to the DUT size and electrodes' separation. The electrode spacings on the contact boards are shown in the figure above. The 16043A's contact boards are provided with three groups of electrodes (as shown in the figure above) and the sliding mechanism allows the DUT to slide down to the next group of electrode. In order to lay the DUT at an appropriate position on the contact board, a device guide fabricated to fit the size of the DUT is required.

Contact Board	Applicable DUT Size
No.1	8.1 mm × 4.5 mm to 3.7 mm × 3.1 mm
No.2	3.7 mm × 3.1 mm to 2.5 mm × 2.0 mm
No.3	2.5 mm × 2.0 mm to 2.0 mm × 1.2 mm

Select the contact boards, that accommodates the DUT size best. The table to the left shows the applicable DUT sizes for each contact board.

Furnished Accessories:

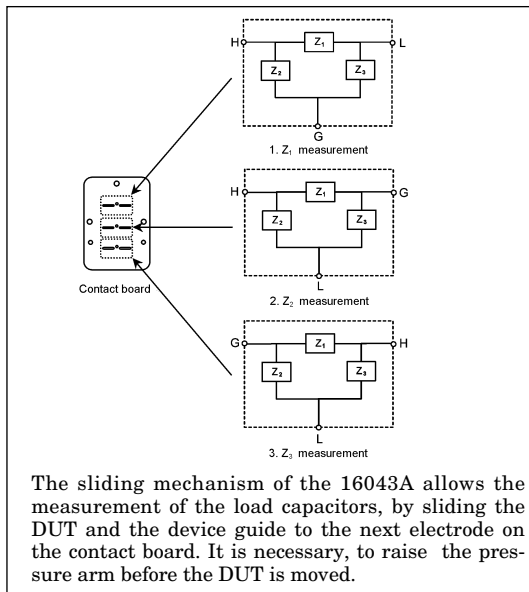
Description	P/N	Qty.
Support Angle for the 4294A	16043-01203	1
Device Guide	16043-00601	3
Screws for the Device Guide	0515-2791	2
Guide Pin	16043-24004	2
Support Angle	16043-01212	1
Tweezer	8710-2081	1
Positioning Tool (16043B only)	16043-00607	1
Carrying Case	16043-60150/60250	1
Operation and Service Manual	16043-90000	1

Options*:

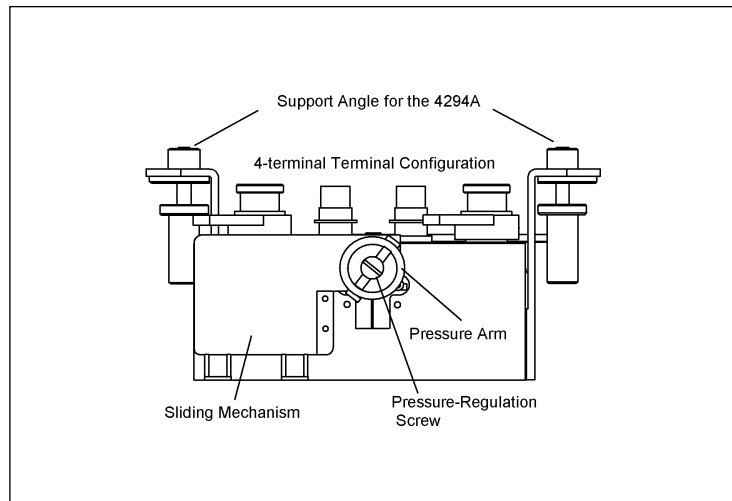
001: Add Contact Board No.1	P/N 16043-66501 (16043A)/16043-66511 (16043B)
002: Add Contact Board No.2	P/N 16043-66502 (16043A)/16043-66512 (16043B)
003: Add Contact Board No.3	P/N 16043-66503 (16043A)/16043-66513 (16043B)
004: Add Additional Device Guide	P/N 16043-00601

*At least one option (001, 002 or 003) must be ordered for 16043A or 16043B.

To maintain the measurement precision, it is recommended to clean the contact boards approximately every 1,000 times. It is recommended to replace the contact boards approximately every 10,000 times. Order 16043U for 16043A and 16043V for 16043B. 16043U/V contain the same options described above. Choose from those options when ordering.



Sliding mechanism for 16043A

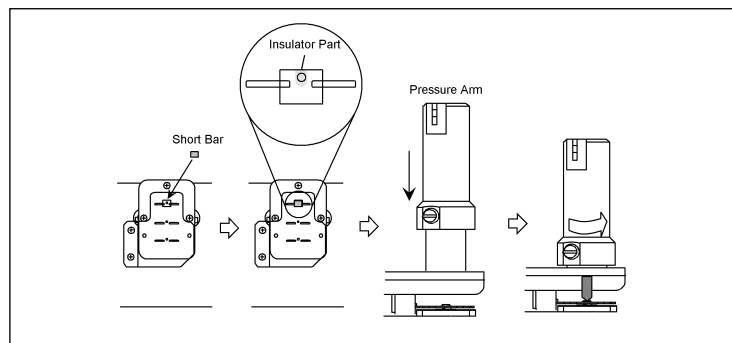


Test fixture overview

Compensation and Measurement:

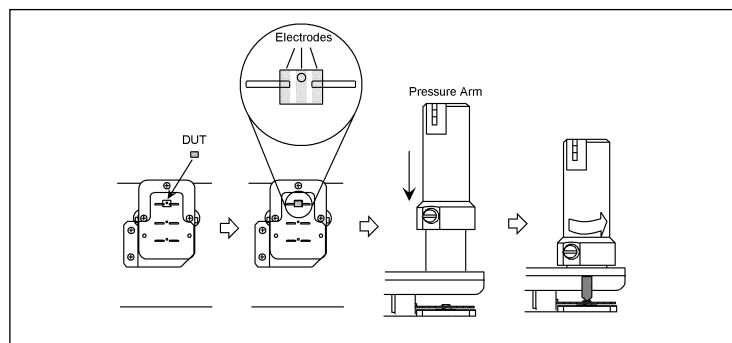
Before measurement, a device guide, which is fabricated to fit the DUT's size must be prepared. A pre-fabricated device guide is furnished and the method of preparation is described in the operation manual. The contact board and the device guide must be connected to the 16043A/B. This is easily accomplished by using the furnished guide pin and screws. For highly precise measurements, it is recommended to perform open and short compensation. Open compensation is performed, by placing nothing between the high and low terminals of the contact board. For short compensation, short the high and low terminals and do not contact the G terminal with the short bar. It is necessary to construct a short bar, which matches the DUT's size. The following figures show how compensation and measurement are performed.

Performing short compensation



1. Place the short bar on the electrodes.
Make sure that the short bar does not connect the G terminal.
2. Lower the pressure arm to hold the short bar in place.
3. Perform short compensation data measurement.

Inserting a DUT



1. Align the DUT with the device guide and place it on the contact board.
2. Lower the pressure arm to hold the DUT in place.
3. Adjust the contact pressure using the pressure regulating screw.
4. Measure.

16089A Large Kelvin Clip Leads**Terminal Connector:**

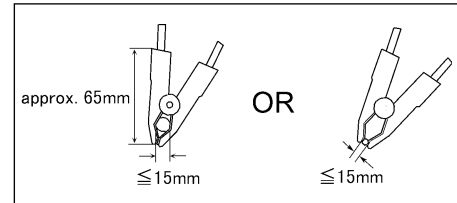
4-Terminal Pair, BNC

DUT Connection: 4-Terminal**Cable Length (approx.):**

0.94m (from connector to clip's tip)

Weight (approx.): 300 g**Additional Error:** The additional error is negligible when compared to the instrument's accuracy.**Description:** This test fixture makes it possible to measure odd-shaped components that cannot be measured with conventional fixtures. It is equipped with two insulated Kelvin clips.**Applicable Instruments:** 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A**Frequency:** 5 Hz to 100 kHz**Maximum Voltage:** ±42 V peak max (AC+DC)**Operating Temperature:** 0°C to 55°C**DUT Size:**

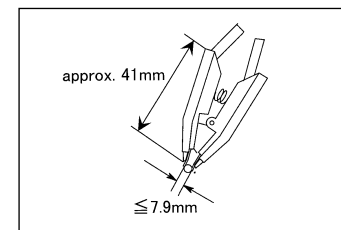
See figure below

**Furnished Accessories:**

Description	P/N	Qty.
Operation and Service Manual	16089-90000	1

Compensation and Measurement: Open and short compensations are recommended before measurement. For open compensation, do not connect the Kelvin clips to anything. Short compensation is performed by holding a shorting plate with the Kelvin clips. After performing open and short compensations, the DUT is held with the Kelvin clips.**16089B Medium Kelvin Clip Leads****Terminal Connector:** 4-Terminal Pair, BNC**DUT Connection:** 4-Terminal**Cable Length (approx.):**

0.94m (from connector to clip's tip)

Weight (approx.): 300 g**Additional Error:** The additional error is negligible when compared to the instrument's accuracy.**Description:** This test fixture makes it possible to measure odd-shaped components that cannot be measured with conventional fixtures. It is equipped with two insulated Kelvin clips.**Applicable Instruments:** 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A**Frequency:** 5 Hz to 100 kHz**Maximum Voltage:** ±42 V peak max (AC+DC)**Operating Temperature:** 0°C to 55°C**DUT Size:** See figure below**Furnished Accessories:**

Description	P/N	Qty.
Operation and Service Manual	16089-90000	1

Compensation and Measurement: Open and short compensations are recommended before measurement. For open compensation, do not connect the Kelvin clips to anything. Short compensation is performed by connecting the Kelvin clips together. After performing open and short compensations, the DUT is held with the Kelvin clips.

16089C Kelvin IC Clip Leads

Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 4-Terminal

Cable Length (approx.):

0.94m (from connector to clip's tip)

Weight (approx.): 300 g

Additional Error: The additional error is negligible when compared to the instrument's accuracy.

Description: This test fixture makes it possible to measure odd-shaped components that cannot be measured with conventional fixtures. It is equipped with two insulated Kelvin clips.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

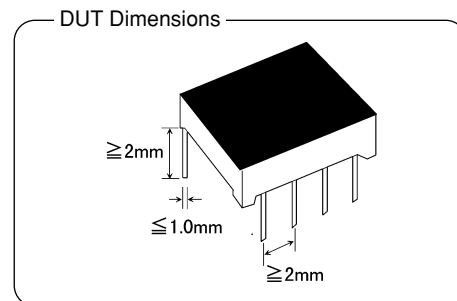
Frequency: 5 Hz to 100 kHz

Maximum Voltage: ± 42 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size:

See figure below

**Furnished Accessories:**

Description	P/N	Qty.
Operation and Service Manual	16089-90000	1

Compensation and Measurement: Open and short compensations are recommended before measurement. For open compensation, do not connect the Kelvin clips to anything. Short compensation is performed by connecting the Kelvin clips together. After performing open and short compensations, the DUT is held with the Kelvin clips.

16089D Kelvin Alligator Clip Leads

Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 4-Terminal

Cable Length (approx.):

0.94m (from connector to clip's tip)

Weight (approx.): 460 g

Additional Error: The additional error is negligible when compared to the instrument's accuracy.

Description: This test fixture makes it possible to measure odd-shaped components that cannot be measured with conventional fixtures. It is equipped with four alligator clips.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: 5 Hz to 100 kHz

Maximum Voltage: ± 42 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: diameter of DUT's leads ≤ 5 mm

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16089-90000	1

Compensation and Measurement: Open and short compensations are recommended before measurement. For open compensation, do not connect the alligator clips to anything. Short compensation is performed by holding a shorting plate with the alligator clips. Make sure that the alligator clips with the "V" markers are next to each other. After performing open and short compensations, the DUT is held with the alligator clips. Connect the same color test clips to the same terminal of the DUT and have the clips with "V" markers be closer to the DUT.

16089E Kelvin Clip Leads

Terminal Connector: 4-Terminal Pair, BNC

DUT Connection: 4-Terminal

Cable Length (approx.):

1.3m (from connector to clip's tip)

Weight (approx.): 260 g

Additional Error: The additional error is negligible when compared to the instrument's accuracy.

Description: This test fixture can measure lead components with low impedance. It has excellent repeatability and low contact resistance. It is equipped with two insulated Kelvin clips.

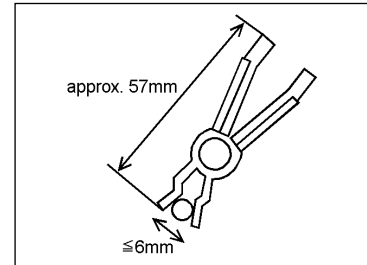
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: 5 Hz to 100 kHz

Maximum Voltage: ± 42 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See figure below

**Furnished Accessories:**

Description	P/N	Qty.
Operation Note	16089-90001	1

Compensation and Measurement: Open and short compensations are recommended before measurement. For open compensation, do not connect the Kelvin clips to anything. Short compensation is performed by holding a shorting plate with the Kelvin clips. After performing open and short compensations, the DUT is held with the Kelvin clips.

16048A Test Leads



Terminal Connector: 4-Terminal Pair, BNC

Cable Length (approx.):

0.94m (from connector to cable tip)

Cable Tip: BNC (male)

Weight (approx.): 315 g

Additional Error: For detailed information, refer to the measurement instrument's specifications.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a BNC female connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A

Frequency: DC to 30 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Terminal Board with BNC(f)x4	16032-60001	1
Operation Manual	16048-90001	1

Compensation and Measurement: Cable length compensation is recommended before measurement. Set the instrument's cable length compensation function to 1 m.

16048B Test Leads



Terminal Connector: 4-Terminal Pair, BNC

Cable Length (approx.):

1m (from connector to cable tip)

Cable Tip: SMC (female)

Weight (approx.): 250 g

Additional Error: For detailed information, refer to the measurement instrument's specifications.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a SMC male connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4288A

Frequency: DC to 30 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Terminal Board with SMC(f)x4	16033-60001	1
Operation Manual	16048-90012	1

Compensation and Measurement: Cable length compensation is recommended before measurement. Set the instrument's cable length compensation function to 1 m.

16048D Test Leads



Terminal Connector: 4-Terminal Pair, BNC
Cable Length (approx.): 1.89 m (from connector to cable tip)
Cable Tip: BNC (male)
Weight (approx.): 460 g
Additional Error: For detailed information, refer to the measurement instrument's specifications.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a BNC female connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instruments: 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A

Frequency: DC to 30 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Terminal Board with BNC(f)x4	16032-60001	1
Operation Manual	16048-90031	1

Compensation and Measurement: Cable length compensation is recommended before measurement. Set the instrument's cable length compensation function to 2 m.

16048E Test Leads



Terminal Connector: 4-Terminal Pair, BNC
Cable Length (approx.): 3.8 m (from connector to cable tip)
Cable Tip: BNC (male)
Weight (approx.): 690 g
Additional Error: For detailed information, refer to the measurement instrument's specifications.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a BNC female connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instruments: 4263A/B, 4284A

Frequency: DC to 1 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

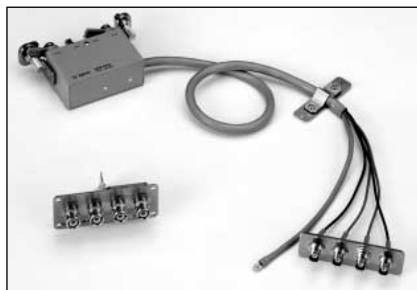
Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Terminal Board with BNC(f)x4	16032-60001	1
Operation Manual	16048-90041	1

Compensation and Measurement: Cable length compensation is recommended before measurement. Set the instrument's cable length compensation function to 4 m.

16048G Test Leads



Terminal Connector: 4-Terminal Pair, BNC

Cable Length (approx.): 1 m

Cable Tip: BNC (female)

Weight (approx.): 460 g

Additional Error: For detailed information, refer to the operation manual or the specifications of 4294A.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a BNC male connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instrument: 4294A

Frequency: DC to 110 MHz

Maximum Voltage: ±42 V peak max (AC+DC)

Operating Temperature: -20°C to 150°C

Furnished Accessories:

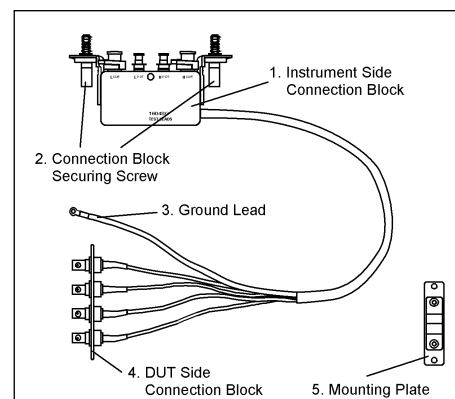
Description	P/N	Qty.
Mounting Plate	NA	1
Operation and Service Manual	16048-90050	1

Options:

001: Add BNC Bracket* (P/N 16048-60003)

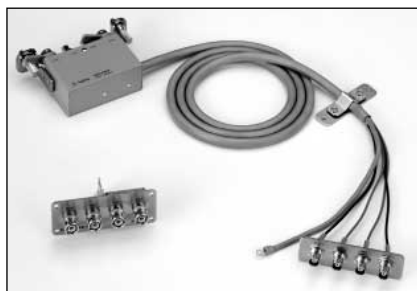
* Here the BNC Bracket refers to the terminal board with four BNC (m) connectors.

Compensation and Measurement: Adapter setup is recommended before measurement. In the adapter setup menu, select 4TP 1M. Then use the 100 Ω resistor furnished with the 4294A to perform phase compensation and load data measurement.



Test fixture overview

16048H Test Leads



Terminal Connector: 4-Terminal Pair, BNC

Cable Length (approx.): 2 m

Cable Tip: BNC (female)

Weight (approx.): 690 g

Additional Error: For detailed information, refer to the operation manual or the specifications of 4294A.

Description: The test leads extend the measurement port with a 4-Terminal Pair configuration. It is provided with a BNC male connector board to allow the attachment of user-fabricated test fixtures.

Applicable Instrument: 4294A

Frequency: DC to 110 MHz

Maximum Voltage: ±42 V peak max (AC+DC)

Operating Temperature: -20°C to 150°C

Furnished Accessories:

Description	P/N	Qty.
Mounting Plate	NA	1
Operation and Service Manual	16048-90050	1

Options:

001: Add BNC Bracket* (P/N 16048-60003)

* Here the BNC Bracket refers to the terminal board with four BNC (m) connectors.

Compensation and Measurement: Adapter setup is recommended before measurement. In the adapter setup menu, select 4TP 2M. Then use the 100 Ω resistor furnished with the 4294A to perform phase compensation and load data measurement.

16314A Balanced/Unbalanced 4-Terminal Converter



Terminal Connector: 4-Terminal Pair, BNC (unbalanced)

DUT Connection: 3 binding posts (balanced)

Dimensions (approx.):

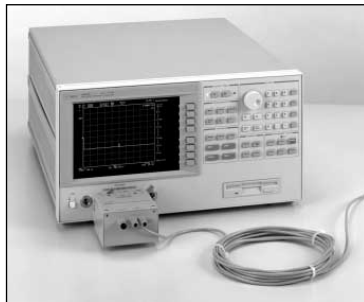
89 (W) x 56 (H) x 133 (D) [mm]

Weight (approx.): 400 g

Additional Error:

Frequency Range	Error
$100 \text{ Hz} \leq f < 1 \text{ MHz}$	$\pm 0.2\%$
$1 \text{ MHz} \leq f < 3 \text{ MHz}$	$\pm 0.5\%$
$f \geq 3 \text{ MHz}$	$\pm 2\%$

(Typical Data)



4294A with 16314A

Description: This balun converts the (unbalanced) 4-Terminal pair configuration to a (balanced) binding posts configuration. It is used to measure a balanced device using an unbalanced measurement instrument.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: 100 Hz to 10 MHz

Nominal Characteristic Impedance:

Unbalanced Side: 50 Ω

Balanced Side: 50 Ω

Insertion Loss: $\leq 1.0 \text{ dB}$ (@ $23^\circ\text{C} \pm 5^\circ\text{C}$, 100 kHz)

Frequency Response: $\leq \pm 1.0 \text{ dB}$ (@ $23^\circ\text{C} \pm 5^\circ\text{C}$, 100 kHz)

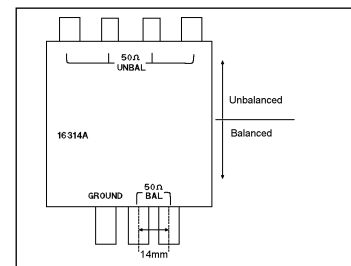
Frequency	Return Loss
$100 \text{ Hz} \leq f < 300 \text{ Hz}$	$\geq 10 \text{ dB}$
$300 \text{ Hz} \leq f \leq 7 \text{ MHz}$	$\geq 20 \text{ dB}$
$7 \text{ MHz} < f \leq 10 \text{ MHz}$	$\geq 17 \text{ dB}$

Frequency	Common Mode Loss
$100 \text{ Hz} \leq f < 3 \text{ MHz}$	$\geq 50 \text{ dB}$
$3 \text{ MHz} \leq f \leq 5 \text{ MHz}$	$\geq 45 \text{ dB}$
$5 \text{ MHz} < f \leq 10 \text{ MHz}$	$\geq 40 \text{ dB}$

specified @ $23^\circ\text{C} \pm 5^\circ\text{C}$

Operating Temperature: 0°C to 55°C

DUT Size: Terminal spacing of balanced side: 14 mm



Furnished Accessories:

Description	P/N	Qty.
50 Ω load resistor	16315-60002	1
Shorting Plate	16315-60003	1
Operation and Service Manual	16315-90001	1

Compensation and Measurement: Open, short and load compensations are recommended before measurement. Short compensation is performed by shorting the binding posts together with the furnished shorting plate. Load compensation is performed by using the furnished 50 Ω load resistor. After performing open, short and load compensations, the DUT is connected to the binding posts of the balun. If the DUT has a characteristic impedance other than 50 Ω , 16316A 100 Ω Balanced/50 Ω Unbalanced Converter or 16317A 600 Ω Balanced/50 Ω Unbalanced Converter can be used instead. To obtain more details about these products, refer to their product overview 5091-6748E.

16095A Probe Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

Cable Length (approx.): 1 m

Weight (approx.): 480 g

Additional Error:

Stay Capacitance	≤ 15 pF
Residual Inductance	≤ 40 nH
Residual Resistance	≤ 100 mΩ

Description: This impedance probe kit is designed for use with the 4192A, but can be used with other 4-Terminal Pair LCR meters and Impedance analyzers as long as the ground lead of the probe is not connected to the instrument's ground terminal. DUTs can be connected by either using the standard probe, the alligator clip adapter or the BNC adapter. The standard probe is best for in-circuit, board-mounted components. The alligator clip is for components too large for the standard probe tip. The BNC adapter is used to connect circuits or networks equipped with BNC connectors.

Applicable Instruments: 4192A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A

Frequency: DC to 13 MHz

Maximum Voltage: ±35 V peak max (AC+DC)

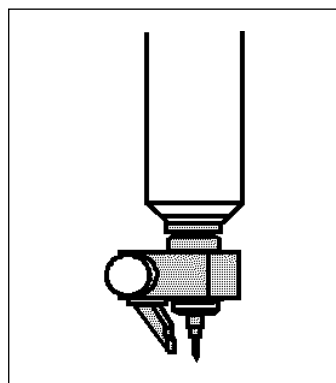
Operating Temperature: 0°C to 55°C

Furnished Accessories:

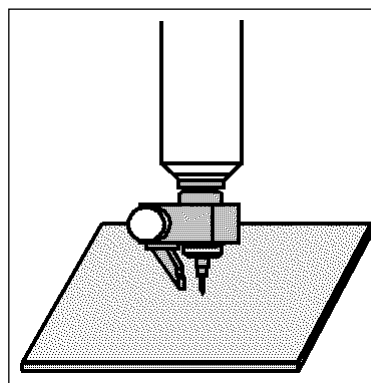
Description	P/N	Qty.
Center Pins for Probe	16095-60012	10
Alligator Clip for Ground (1 ea.)	16095-61611	1
BNC (m) Adapter (1 ea.)	16095-60011	1
Alligator Clip Adapter (1 ea.)	16095-61612	1
Operating Note	16095-90001	1

P/N 16095-65001 ground pins (5ea.) are also available (not furnished).

Compensation and Measurement: Cable length and open and short compensations are recommended before measurement. First, set the instrument's cable length compensation function to 1 m. Short compensation is performed by shorting the probe. To short the probe it is recommended to use a shorting device with gold-plated surfacing (which provides stable contact resistance). The following figures show how compensation is performed.



Open compensation

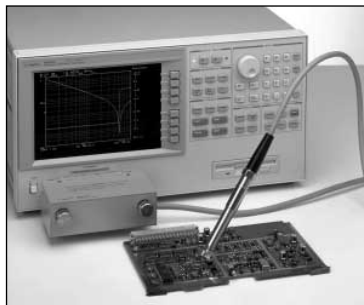


Short compensation

42941A Impedance Probe/Kit



Terminal Connector: 4-Terminal Pair, BNC
Cable Length (approx.): 1.5 m
Weight (approx.): 2400 g
Basic Measurement Accuracy: $\pm 1\%$
 For detailed information, refer to the operation manual or the specifications of 4294A.



4294A with 42941A

Description: This impedance probe kit is designed for use with the 4294A. It provides the capability to perform in-circuit measurements (printed circuit patterns, the input/output impedance of circuits, etc.) with better accuracy and wider impedance coverage from 40 Hz to 110 MHz. DUTs can be connected by either using the standard probe, the alligator clip adapter or the BNC adapter. The standard probe is best for in-circuit, board-mounted components. The alligator clip is for components too large for the standard probe tip. The BNC adapter is used to connect circuits or networks equipped with BNC connectors.

Applicable Instrument: 4294A only

Frequency: 40 Hz to 110 MHz

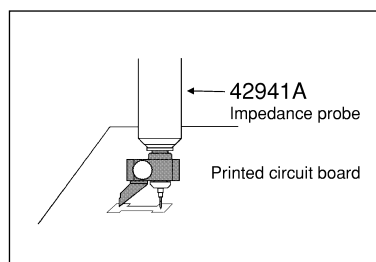
Maximum Voltage: ± 42 V peak max (AC+DC)

Operating Temperature: -20°C to $+75^{\circ}\text{C}$ (probe only)

Furnished Accessories:

Description	P/N	Qty.
Pin Probe	42941-60002	1
Adapter BNC-SMB	1253-0476	1
Spare Pin Set (3 ea.)	42941-60002	1
3.5 mm SHORT	NA	1
3.5 mm LOAD	NA	1
Clip lead	NA	1
Ground lead	04193-61629	1
CARRYING CASE	42941-60011	1
Operation and Service Manual	42941-90010	1

Compensation and Measurement: Adapter setup and compensation is required before measurement. In the Adapter setup menu, select PROBE 42941A. Use the furnished 3.5 mm short and load standards. The open condition can be created by not connecting the probe to anything. Perform phase compensation, short and load data measurements. For compensation, open and short compensation is recommended. Short compensation is performed by shorting the probe. To short the probe it is recommended to use a shorting device with gold-plated surfacing (which provides stable contact resistance) as described for 16095A.



In-circuit measurement

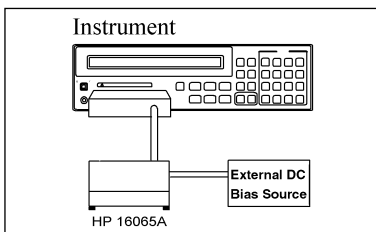
16065A 200Vdc External Voltage Bias Fixture



Terminal Connector: 4-Terminal Pair, BNC
DUT Connection: 4-Terminal
External Bias Input connector: High Voltage BNC(f)
Dimensions (approx.): 180(W) x 120(H) x 200(D) [mm]
Cable Length (approx.): 40 cm
Weight (approx.): 1500 g

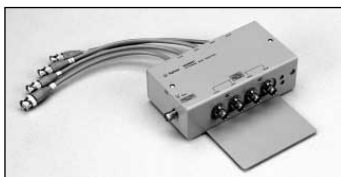


High Voltage BNC(f) connector for external bias input
 BNC(f) connector for voltage monitor output

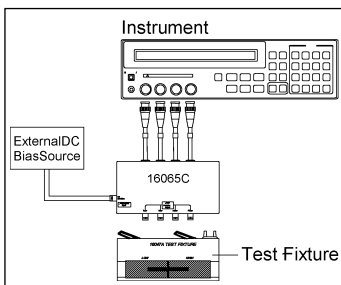


LCR meter with 16065A

16065C 40Vdc External Voltage Bias Adapter



Terminal Connector: 4-Terminal Pair, BNC
External Bias Input connector: BNC(f)
Dimensions (approx.): 160(W) x 50(H) x 150(D) [mm]
Cable Length (approx.): 210 mm
Weight (approx.): 450 g



LCR meter with 16065C

Description: This test fixture makes it possible to measure a DUT with up to ± 200 V DC bias. The same modules of 16047A/D can be used to allow measurements of axial/radial lead components.

Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: 50 Hz to 2 MHz

Maximum Voltage: ± 200 V peak max (AC+DC)

Blocking Capacitor of 5.6 μ F is connected in series with the Hc terminal.

Operating Temperature: 0°C to 55°C

DUT Size: See the 16047A figure with module sizes.

Furnished Accessories:

Description	P/N	Qty.
Module For Axial Lead	16061-70022	1
Module For Radial Lead mounting on fixture	16061-70021	1
Module For Short Radial Lead	16047-65001	1
Operating Note	16065-90010	1

Compensation and Measurement: Open, short and load compensations are recommended before measurement. Short compensation is performed by shorting the contacts of the test fixture with a shorting plate as described for 16047A. Load compensation is performed by inserting a known standard device. After performing open, short and load compensations, the DUT is connected to the test fixture.

Description: This adapter is designed to operate specifically with the 4263A/B, 4268A and the 4278A. By connecting an external DC voltage source to this adapter, a bias voltage of up to ± 40 V can be supplied to a DUT. The DUT can be inserted by connecting any direct attachment 4-Terminal Pair test fixture to the adapter.

Applicable Instruments: 4263A/B, 4268A, 4278A, 4288A

Frequency: 50 Hz to 1 MHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Blocking Capacitor of 50 μ F is connected in series with the Hc terminal.

Operating Temperature: 0°C to 55°C

Applicable Fixtures: 16034E/G/H, 16044A, 16047A/D/E, 16048A/B/D/E, 16089A/B/C/D/E

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16065-90020	1

Compensation and Measurement: Open and short compensations are recommended before measurement. Short compensation is performed by shorting the contacts of the test fixture that is in use. After performing open and short compensations, the DUT is connected to the test fixture.

42841A Bias Current Source



Dimensions (approx.): 426 (W) x 177 (H) x 498 (D) [mm]

Weight (approx.): 18 kg

DC bias Current Accuracy:

Range	Resolution	Accuracy (±)
0.00 A to 1.00 A	0.01 A	1% + 5 mA
1.1 A to 5.0 A	0.1 A	2%
5.1 A to 20.0 A	0.1 A	3%

Description: The 42841A is a bias current source for use with the 4284A or 4285A. The configured measurement system has the capability to perform DC bias current measurements of up to 40 A in the 20 Hz to 1 MHz frequency range and up to 10 A in the 75 kHz to 30 MHz frequency range.

Applicable Instruments: 4284A (Option 002)/4285A (Option002) only

Maximum DC Bias Current: 20 A

Furnished Accessories:

Description	P/N	Qty.
Bias Current Interface Cable	42841-61640	1
Power Cable	depends on country	1
Operation Manual	42841-90010	1

Options:

907: Front handle Kit

908: Rack Mount Kit

909: Rack Flange and Handle Kit

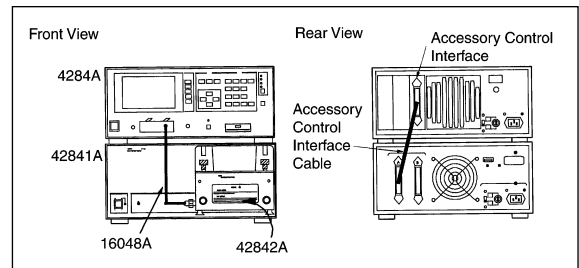
Measurement Configurations:

0-20Adc Bias Configuration (4284A)

4284A with Opt. 002	1 ea.
42841A Bias Current Source	1 ea.
42842A or 42842B Bias Test Fixture	1 ea.
16048A Test Leads	1 ea.

Basic Measurement Accuracy: 2% (< 1 kHz), 1% (≥ 1 kHz)

For detailed information, refer to the operation manual of 42841A



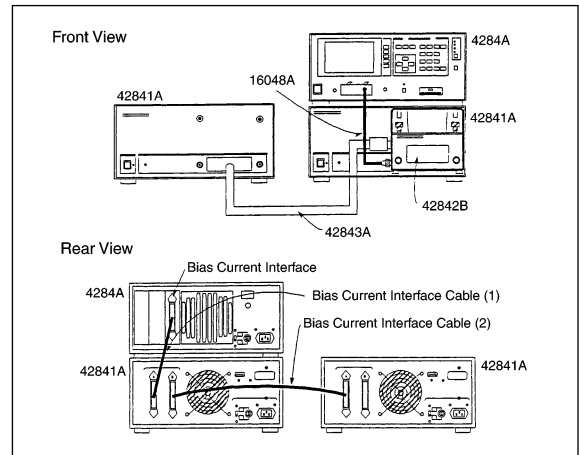
20 A measurement system

0-40Adc Bias Configuration (4284A)

4284A with Opt. 002	1 ea.
42841A Bias Current Source	2 ea.
42842B Bias Test Fixture	1 ea.
42843A Bias Current Cable	1 ea.
16048A Test Lead	1 ea.

Basic Measurement Accuracy: 2% (< 1 kHz), 1% (≥ 1 kHz)

For detailed information, refer to the operation manual of 42841A



40 A measurement system

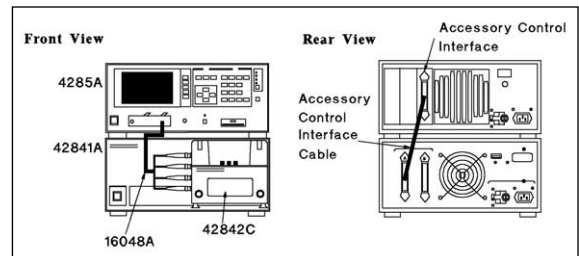
0-10Adc Bias High Frequency Configuration (4285A)

4285A with Opt. 002	1 ea.
42841A Bias Current Source	1 ea.
42842C Bias Test Fixture*	1 ea.
16048A Test Leads	1 ea.

Basic Measurement Accuracy: \sqrt{f} [%] + 4285A's accuracy [%]
f: [MHz]

For detailed information, refer to the operation manual of 42841A

*Opt.001 adds SMD test fixture which is available for 42842C.



Bias current system configuration for 42842C

42842A Bias Current Test Fixture

DUT Connection: 2-Terminal

Bias Voltage Output connector: BNC(f)

Dimensions (approx.):

216(W) x 173(H) x 235(D) [mm]

Weight (approx.): 2500 g

Basic Measurement Accuracy:

2%(< 1 kHz), 1% (≥ 1 kHz)

For detailed information, refer to the operation manual of 42841A.

Description: This test fixture is designed for use with the 42841A. It is connected directly to the bias current output terminals of the 42841A. The following features ensure accurate and safe DC bias measurements:

- Clear plastic cover is provided for safe measurements.
- Opening the cover decreases the voltage generated by back-e.m.f. (electromotive force) to a level below 40 V within 0.1 second.
- Heat-sensitive switch prevents DUT from overheating.
- Also equipped with DC bias voltage monitoring.

Applicable Instrument: 4284A (Option 002)

Frequency: 20 Hz to 1 MHz

Maximum DC Bias Current: 20 A

Operating Temperature: 5°C to 45°C

DUT Size: Smaller than 80(W) x 80(H) x 80(D) [mm]

Furnished Accessories:

Description	P/N	Qty.
Shorting Plate	42842-00607	1
Operation and Service Manual	42842-90001	1

Compensation and Measurement: Short compensation is recommended before measurement. Short compensation is performed by shorting the measurement terminals together with the furnished shorting plate. After compensation, connect the DUT to the measurement terminals and close the test fixture cover.

42842B Bias Current Test Fixture

DUT Connection: 2-Terminal

Bias Voltage Output connector: BNC(f)

Dimensions (approx.):

237(W) x 173(H) x 235(D) [mm]

Weight (approx.): 3000 g

Basic Measurement Accuracy:

2% (< 1 kHz), 1% (≥ 1 kHz)

For detailed information, refer to the operation manual of 42841A.

Description: This test fixture is designed for use with the 42841A. It is connected directly to the bias current output terminals of the 42841A. The following features ensure accurate and safe DC bias measurements:

- Clear plastic cover is provided for safe measurements.
- Opening the cover decreases the voltage generated by back-e.m.f. (electromotive force) to a level below 40 V within 0.1 second.
- Heat-sensitive switch prevents DUT from overheating.
- Also equipped with DC bias voltage monitoring.

Applicable Instrument: 4284A (Option 002)

Frequency: 20 Hz to 1 MHz

Maximum DC Bias Current: 40 A

Operating Temperature: 5°C to 45°C

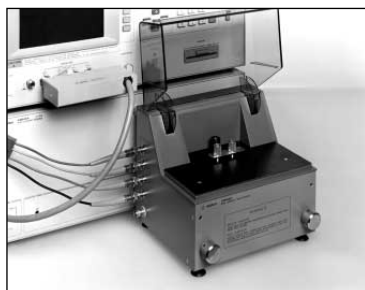
DUT Size: Smaller than 80(W) x 80(H) x 80(D) [mm]

Furnished Accessories:

Description	P/N	Qty.
Protection Caps	1401-0240	2
Shorting Plate	42842-00607	1
Operation and Service Manual	42842-90001	1

Compensation and Measurement: Short compensations is recommended before measurement. Short compensation is performed by shorting the measurement terminals together with the furnished shorting plate. After compensation, connect the DUT to the measurement terminals and close the test fixture cover.

42842C Bias Current Test Fixture



DUT Connection: 2-Terminal
Bias Voltage Output connector: BNC(f)
Dimensions (approx.):
 213(W) x 173(H) x 235(D) [mm]
Weight (approx.): 3100 g
Basic Measurement Accuracy:
 \sqrt{f} [%] + 4285A's accuracy [%]
 f: [MHz]

For detailed information, refer to the operation manual of 42841A.

Description: This test fixture is designed for use with the 42841A. It is connected directly to the bias current output terminals of the 42841A. The following features ensure accurate and safe DC bias measurements:

- Clear plastic cover is provided for safe measurements.
- Opening the cover decreases the voltage generated by back-e.m.f. (electromotive force) to a level below 40 V within 0.1 second.
- Heat-sensitive switch prevents DUT from overheating.
- Also equipped with DC bias voltage monitoring

Applicable Instrument: 4285A (Option 002) only

Frequency: 75 kHz to 30 MHz

Maximum DC Bias Current: 10 A (2 A max for Option 001 SMD Test Fixture)

Operating Temperature: 0°C to 45°C

DUT Size: Smaller than 60(W) x 50(H) x 60(D) [mm]

Furnished Accessories:

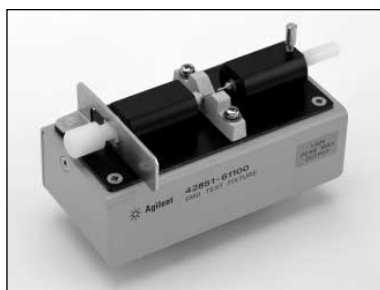
Description	P/N	Qty.
Shorting Plate	42842-00607	1
Operation and Service Manual	42842-90001	1

Options:

001: SMD Test Fixture P/N 42851-61100

Compensation and Measurement: Short compensation is recommended before measurement. Short compensation is performed by shorting the measurement terminals together with the furnished shorting plate. After compensation, connect the DUT to the measurement terminals and close the test fixture cover.

P/N 42851-61100



DUT Connection: 2-Terminal
Dimensions (approx.): 122(W) x 60(H) x 58(D)[mm]
Weight (approx.): 145 g



4285A with 42842C and P/N 42851-61100

Description: This test fixture is supplied with Option 001 for 42851A and Option 001 for 42842C. It is designed for the impedance evaluations of SMD. The minimum SMD size that this fixture is adapted to evaluate is 1.6(L) x 0.8(W) [mm].

Applicable Instrument: 4285A (Option 002) only

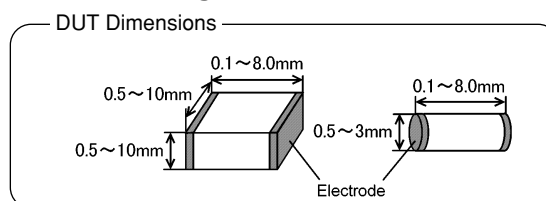
Frequency: 75 kHz to 30 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

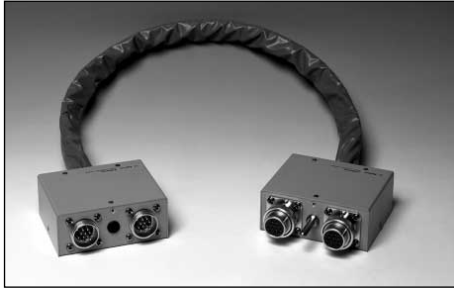
Maximum DC Bias Current: 2 A

Operating Temperature: 0°C to 55°C

DUT Size: See figure below



Compensation and Measurement: Refer to the procedure for 16034E.

42843A Bias Current Cable

Cable Length (approx.): 960 mm

Weight (approx.): 1200 g

Description: The 42843A is designed for use with 42841A and 42842B, 40 A DC bias measurement configuration. It provides a shielded connection between 42841A and 42842B.

Applicable Instrument: 4284A (Option 002)

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	42842-90001	1

16451B Dielectric Test Fixture



Terminal Connector: 4-Terminal Pair, BNC

Dimension (approx.): See page 40

Cable Length (approx.):

0.8 m (from connector to electrodes)

Weight (approx.): 3700 g

Measurement Accuracy

(supplemental performance characteristics):

$$\epsilon'_r \text{ accuracy } \left(\frac{\Delta \epsilon'_{rm}}{\epsilon'_{rm}} \right)$$

$$\tan \delta < 0.1 :$$

$$Az + 0.04 f^2 \epsilon'_{rm} \epsilon_0 \left(\frac{\pi \left(\frac{d}{2} \right)^2}{t} \right) + \frac{100 (\epsilon'_{rm} - 1)}{(\epsilon'_{rm} - \frac{t}{0.01})} [\%]$$

ϵ * Loss Tangent Accuracy ($\Delta \tan \delta$)

$$\tan \delta < 0.1 : Ad + Ea + Eb$$

$$Ea = 0.005 + 0.0004 f^2 \epsilon'_{rm} \epsilon_0 \left(\frac{\pi \left(\frac{d}{2} \right)^2}{t} \right)$$

$$Eb = \frac{\tan \delta}{100} \frac{\Delta \epsilon'_{rm}}{\epsilon'_{rm}}$$

f: measured frequency [Hz] $f \leq 30\text{MHz}$

ϵ'_{rm} : measured permittivity

$\tan \delta$: measured dissipation factor

ϵ_0 : permittivity of air $8.854 \times 10^{-12} [\text{F/m}]$

d: diameter of electrode {A,B}

t: thickness of material [mm]

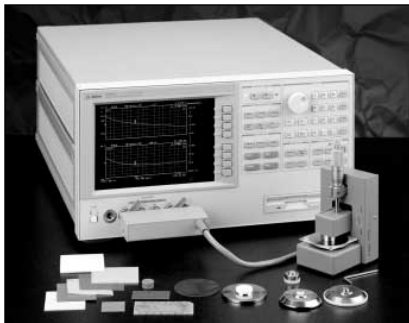
Az: Impedance measurement error of instrument

Ad: D measurement error of instrument

The material is assumed to be ideally flat.

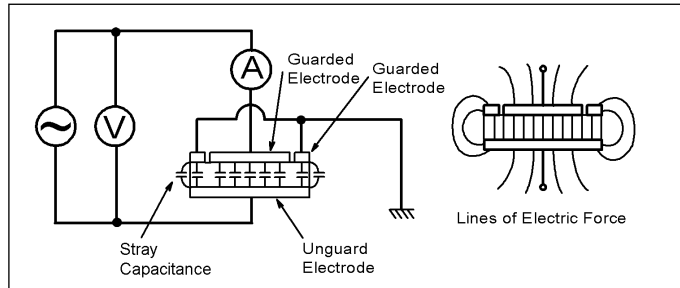
The above equation is applicable for electrodes A and

B when using the contacting electrode method.



4294A with 16451B

Description: The 16451B is used to evaluate the dielectric constant of solid dielectric materials accurately, and complies with ASTM D150. The 16451B employs the parallel plate method, which sandwiches the material between two electrodes to form a capacitor. LCR meter or an Impedance Analyzer is then used to measure the capacitance created from the fixture. A measurement block diagram of the parallel plate method is shown below:

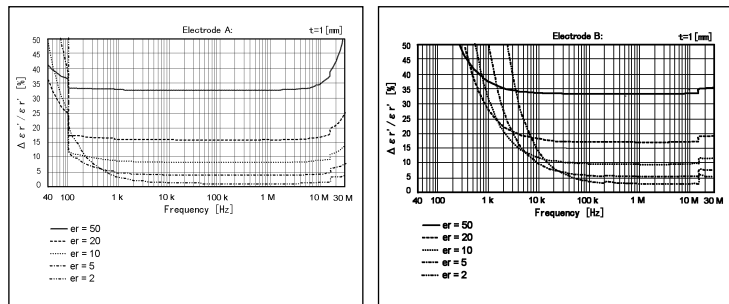


Parallel plate method

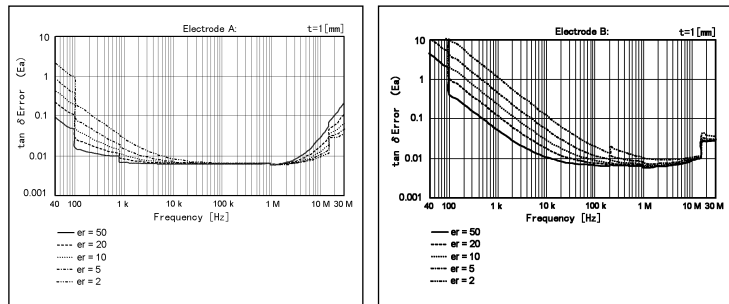
Notice the stray capacitance, which is formed on the test material as shown in the figure above. The guard electrode helps to eliminate the stray capacitance at the edge of the electrode.

Basic Measurement Accuracy (including the 4294A):

Typical Permittivity (ϵ') Measurement Accuracy:



Typical Loss Tangent ($\tan \delta$) Measurement Accuracy:



4294A Measurement Settings;

1. Osc level : 500 mV
2. BW: 5
3. Adapter setup : 1 m
4. Compensation : Open, short and load

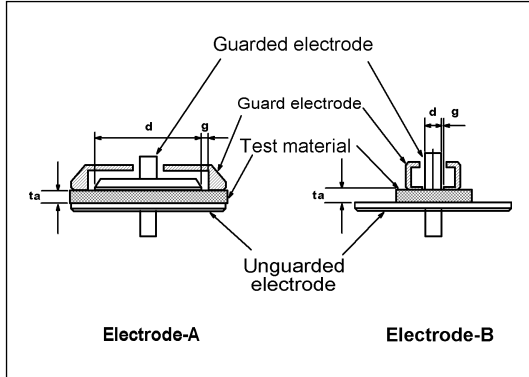
Applicable Instruments: 4192A, 4194A (Impedance Mode), 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A

Frequency: ≤ 30 MHz

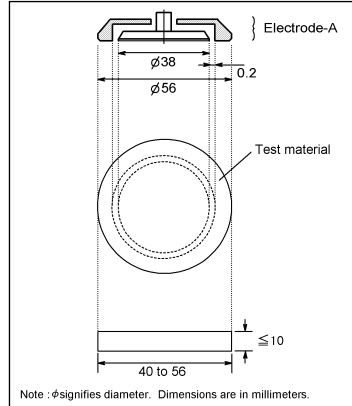
Maximum Voltage: ±42 V peak max. (AC+DC)

Operating Temperature: 0°C to 55°C

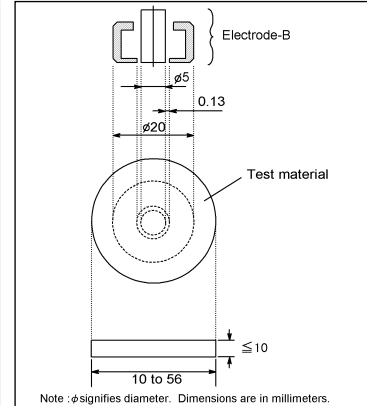
Material Size:



Electrodes for contacting electrode method
(Rigid Metal Electrode)



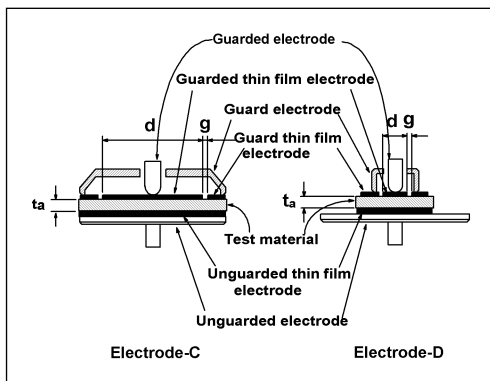
Material size for electrode-A



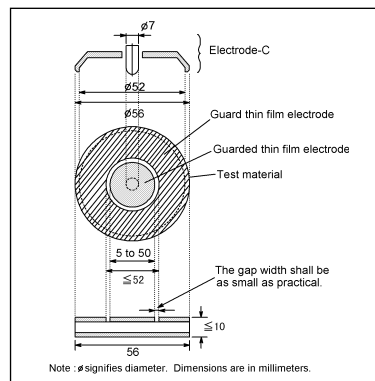
Material size for electrode-B

Equipped with Electrodes A and B for flat and smooth materials.

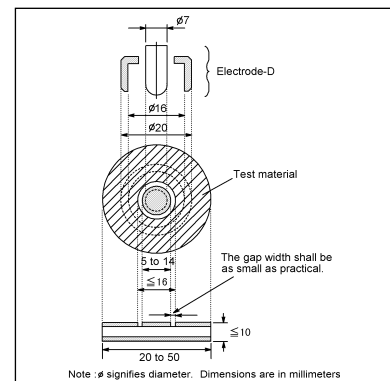
Electrode Type	Diameter of MUT	Thickness of MUT	Diameter of Electrode	Max. Frequency
A	40 mm ~ 56 mm	$t \le 10$ mm	38 mm	30 MHz
B	10 mm ~ 56 mm	$t \le 10$ mm	5 mm	30 MHz



Electrodes for contacting electrode method
(Thin Film Electrode)



Material size for electrode-C



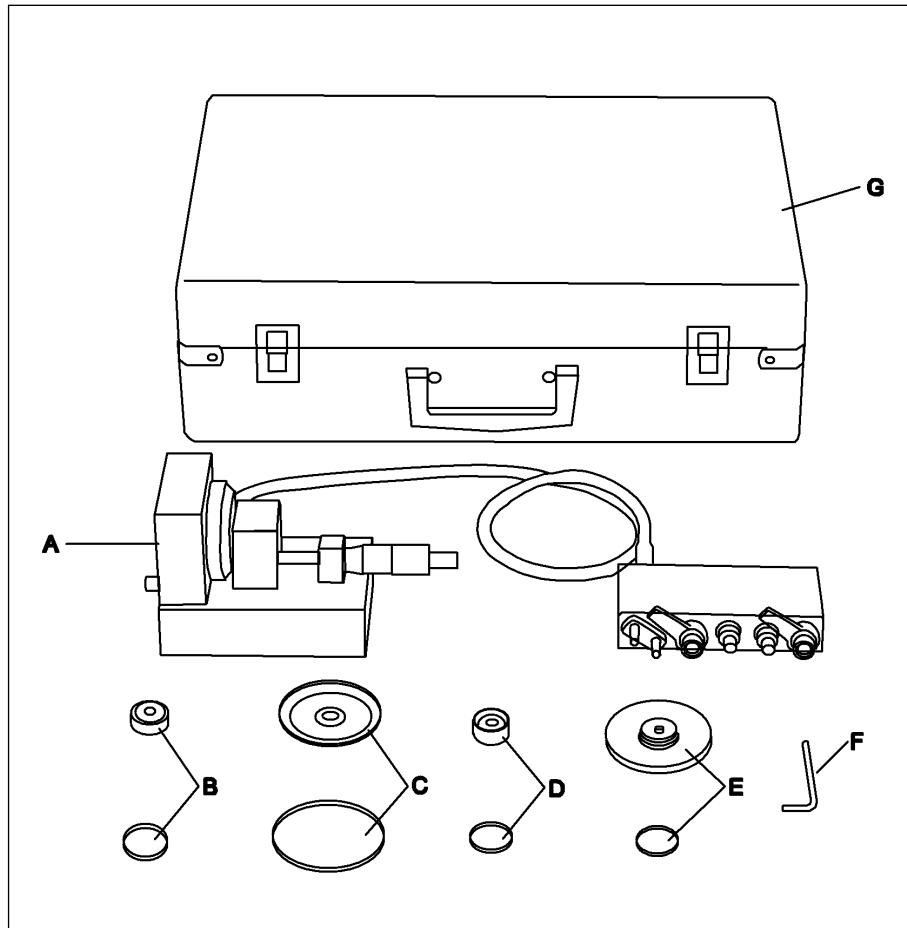
Material size for electrode-D

Equipped with Electrodes C and D for rough or extremely thin materials.

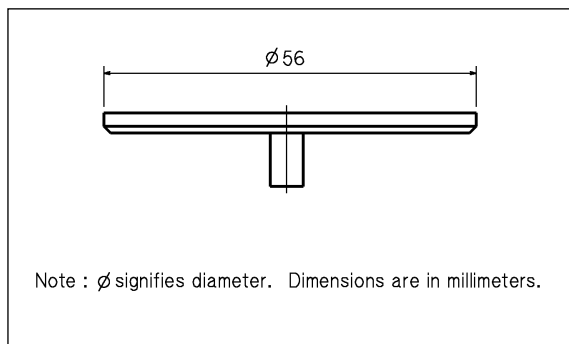
Electrode Type	Diameter of MUT	Thickness of MUT	Diameter of Electrode*	Max. Frequency
C	56 mm	$t \le 10$ mm	5 ~ 50 mm	30 MHz
D	20 mm ~ 56 mm	$t \le 10$ mm	5 ~ 14 mm	30 MHz

* diameter of applied thin film electrode

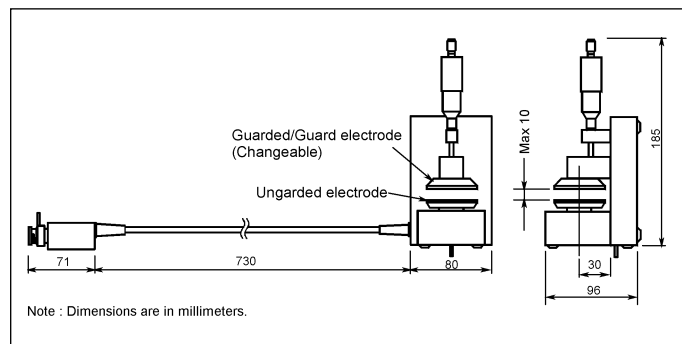
Furnished Accessories:



Description	P/N	Qty.	
Test Fixture including Electrode-A, unguarded electrode and cover	16451-61001	1	A
Electrode-B and cover	16451-60013	1	B
Electrode-C and cover	16451-60012	1	C
Electrode-D and cover	16451-60014	1	D
Attachment for error compensation and cover	16451-60021	1	E
Hex key (for replacing electrodes)	8710-1181	1	F
Carrying Case	16451-60001	1	G



Dimensions of unguarded electrode



Dimensions of fixture assembly

Compensation and Measurement: There are three measurement methods for the 16451B. They are the Contacting Electrode Method (used with 16451B's rigid metal electrode, without any electrodes on the material under test), the Contacting Electrode Method (used with thin film electrodes made on the material under test), and the Non-Contacting Electrode (Air Gap method). Select the suitable measurement method and the suitable electrode for the material under test according to the following table.

Summary of Measurement Method

Measurement Method	Contacting Electrode Method (used with Rigid metal electrode)	Contacting Electrode Method (used with thin film electrode)	Non-contacting Electrode Method
Accuracy	Low→ High		
Operation	Simple→ Complex		
Applicable Materials	Thick, solid and smooth materials	Materials on which thin film can be applied without changing its characteristics	Thick, and soft materials. Rough materials also.

Open and short compensations are recommended in combination with the cable length compensation before measurement. When measuring above 5 MHz with the 4285A or the 4294A*, load compensation is also recommended. First, set the instrument's cable length compensation function to 1 m. Then, open and short compensation is performed by using the furnished electrode attachment. Load compensation is performed, by preparing a working standard. After performing open, short and load compensations, the MUT is sandwiched by the parallel electrodes and the capacitance is measured. Relative permittivity is calculated from the measured capacitance in the following manner:

$$\epsilon_r' = \frac{t_a \times C_p}{\pi \times \left(\frac{d}{2}\right)^2 \times \epsilon_o}$$

- ϵ_r' : Relative permittivity
- C_p : Capacitance (measurement data)
- ϵ_o : 8.854×10^{-12} [F/m]
- t_a : Average thickness of test material
- d : Diameter of guarded electrode

*For more information on load compensation with the 4294A, see section 13 of the 4294A programming manual.

16452A Liquid Dielectric Test Fixture

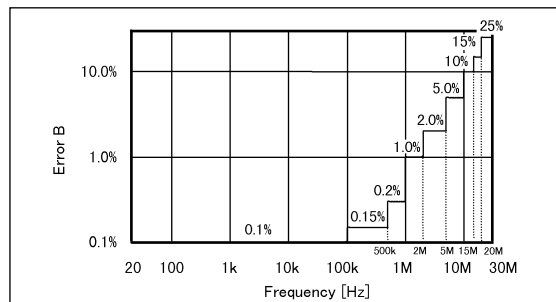


Terminal Connector: 4-Terminal Pair, SMA
Dimensions (approx.): 85(H) x 85(W) x 37(D) [mm]
Weight (approx.): 1400 g
Measurement Accuracy: A + B + C [%]

Electrode gap (mm)	A (%)
0.3	0.005 × M.R.P
0.5	0.006 × M.R.P
1.0	0.008 × M.R.P
2.0	0.020 × M.R.P

M.R.P is Measurement Relative Permittivity

Error B [%]



Error C [%] = Measurement Error of Instrument



4284A with 16452A

Description: This test fixture provides accurate dielectric constant and impedance measurements of liquid materials. The 16452A employs the parallel plate method, which sandwiches the liquid material between two electrodes to form a capacitor. A LCR meter or an impedance analyzer is then used to measure the capacitance created from the fixture.

Applicable Instruments: 4194A, 4284A, 4285A, 4294A

Frequency: 20 Hz to 30 MHz

Operating Temperature: -20°C to 125°C

Maximum Voltage: ±42 V peak max. (AC+DC)

Material Capacity: Required sample liquid capacity depends on the gap of the electrodes.

Gap of electrodes	0.3 mm	0.5 mm	1 mm	2 mm
Air Capacitance	34.9 pF ±25%	21.2 pF ±15%	10.9 pF ±10%	5.5 pF ±10%
Sample liquid capacity	3.4 ml	3.8 ml	4.8 ml	6.8 ml
Applicable Frequency	20 Hz – 30 MHz			

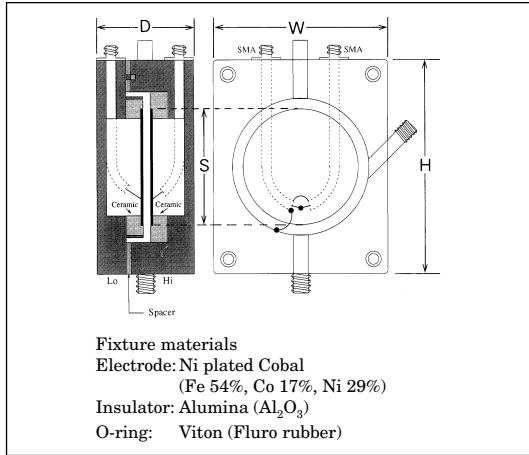
Furnished Accessories:



Description	P/N	Qty.	
Shorting Plate	16092-08010	1	E
O-ring for Liquid Outlet	0905-1277	1	D
Spacer (1.3 mm thickness)	16452-00601	1	F
Spacer (1.5 mm thickness)	16452-00602	1	F
Spacer (2.0 mm thickness)	16452-00603	1	F
Spacer (3.0 mm thickness)	16452-00604	1	F
Lid of Liquid Outlet	16452-24002	1	G
SMA-BNC Adapter	1250-1200	4	H
Waterproof Cap for BNC Connector	1252-5831	4	I
Carrying Case	16452-60101	1	-
Operation and Service Manual	16452-90000	1	-
Angle Iron of Stand Body for Fixture Stand	16452-01201	2	-
Screw of Stand Body for Fixture Stand	0515-0914	4	C
Screw for Fixture Stand	0515-0914	4	-
Electrode (High and Low)	NA	2	A,B

Requires the following interface cables to connect to a measurement instrument. Select accordingly to the required temperature conditions.

Temperature	Model# or P/N	Cable Length (approx.)
0°C to 55°C	16048A	0.94 m
-20°C to 125°C	16452-61601	1 m
-20°C to 150°C	16048G for 4294A only	1 m



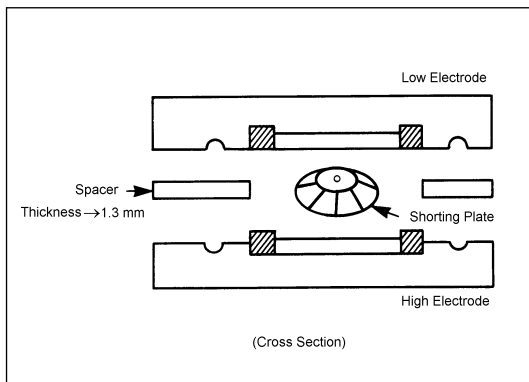
Test fixture overview

Compensation and Measurement: Open (Air-Capacitance) and short compensations are recommended in combination with the cable length compensation before measurement. First, set the instrument's cable length compensation function to 1 m. Then, short compensation is performed by using the furnished shorting plate. Open compensation is not performed, but its values are used in the dielectric constant equation as shown below:

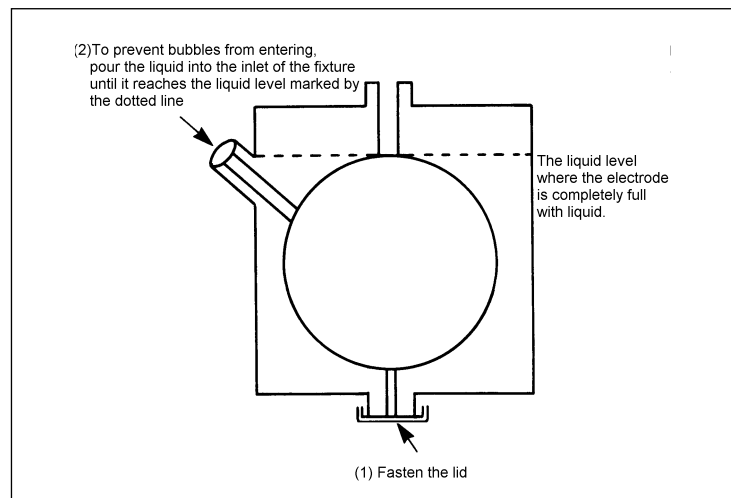
$$\epsilon_r = \alpha \left(\frac{C_p}{C_o} - j \frac{1}{\omega C_o R_p} \right)$$

- α : Correction coefficient
- ϵ_r : Relative dielectric constant
- C_p : Liquid capacitance (measurement data)
- C_o : Air capacitance (measurement data) or open compensation data
- R_p : Equivalent parallel resistance (measurement data)
- ω : Angular frequency ($\omega=2\pi f$)

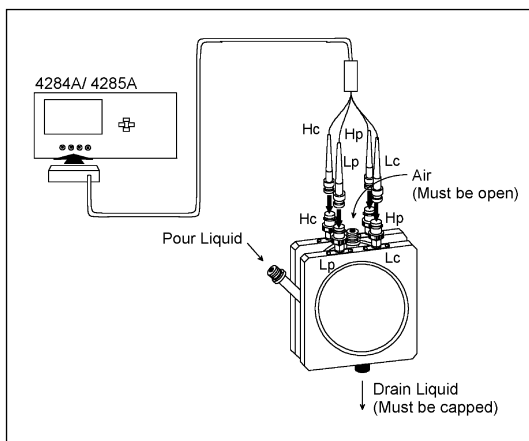
The following figures below show how compensation and measurement is performed.



Short compensation



Pouring the liquid into the fixture



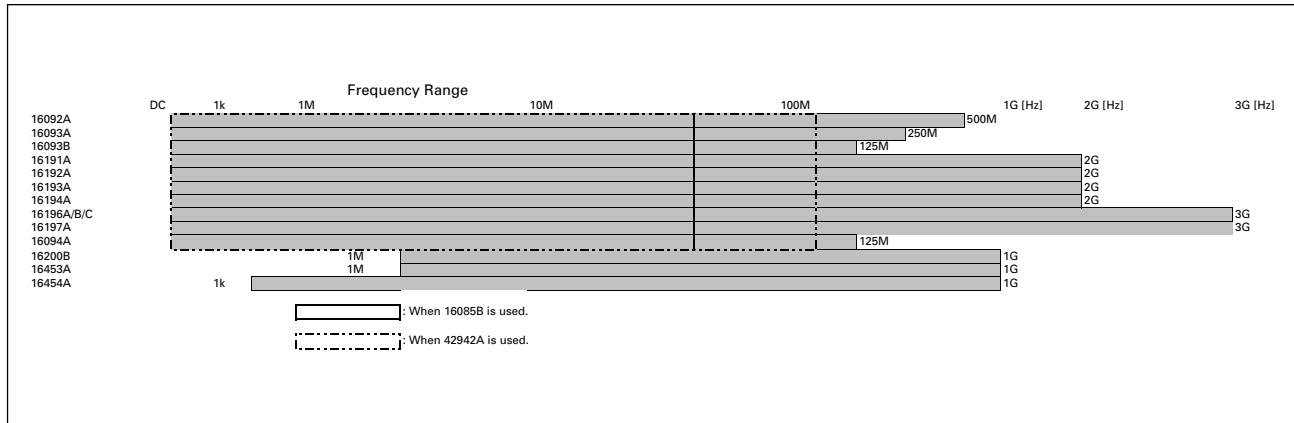
Method of connection

Note: the 16452A is not capable of measuring salt or ionic solutions or other liquids with bulk conductivity due to the electrode polarization phenomenon.

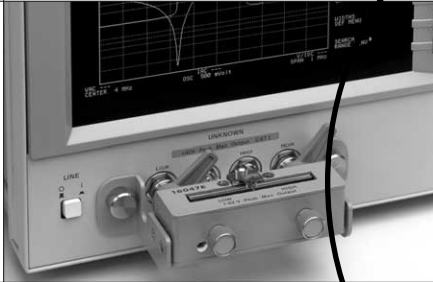


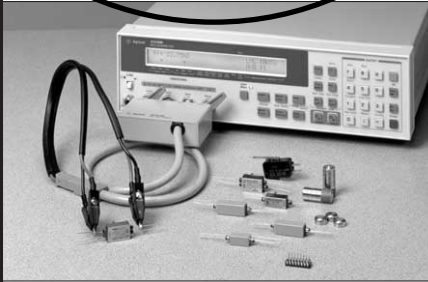
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Up to 3 GHz (7 mm)

Test Fixtures (7 mm connector) for Impedance Measurements up to 3 GHz



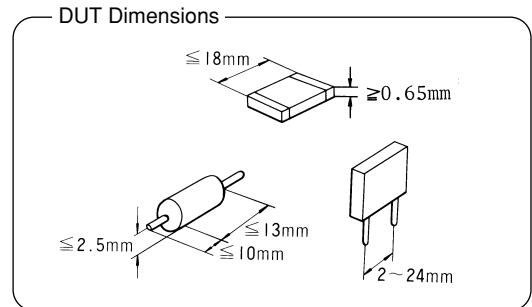
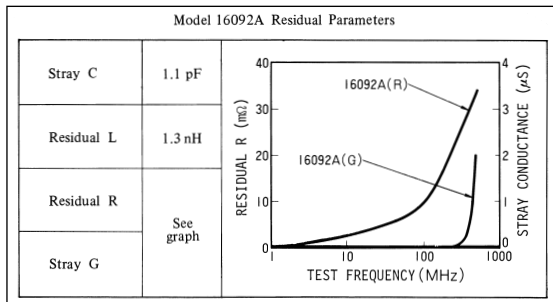
Applicable Instrument

Frequency Range	Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)	Up to 3 GHz (Terminal Configuration: 7 mm)
		
Measurement Instruments	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	4291A/B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, 4286A, 4287A, E4991A Any 4TP instruments (excluding 4294A) + 16085B
Frequency	DC (High Resistance Measurement)	1 kHz (Milliohm Measurement)
		
Measurement Instruments	4339A/B, 4349A/B	4338A/B

16092A Spring Clip Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 3.4 mm
Dimensions (approx.): 150(W) x 70(H) x 80(D) [mm]
Weight (approx.): 180 g
Additional Error: See figure below



Description: This test fixture is designed for impedance evaluation of both lead and SMD. It is furnished with two modules that can be readily screwed onto the plate to measure either lead or SMD.

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 500 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

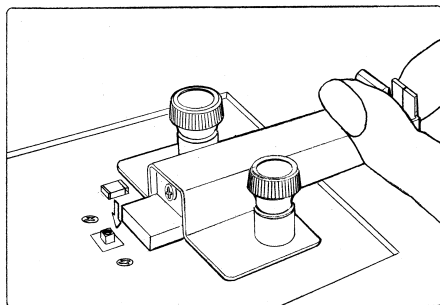
Operating Temperature: 0°C to 55°C

DUT Size: See figure below

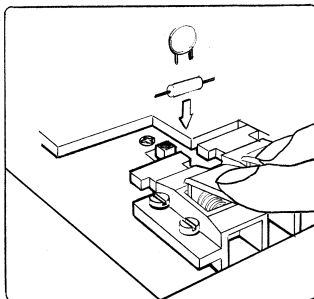
Furnished Accessories:

Description	P/N	Qty.
Shorting Plate	16092-08010	1
Operating Note	16092-90010	1

Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. When using the SMD module, open compensation is performed by separating the high and the low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by contacting the high and low electrodes together. When using the lead component module, open compensation is performed by not having the module-electrodes be connected to anything. Short compensation is performed by using the furnished shorting plate. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture.



Inserting the SMD



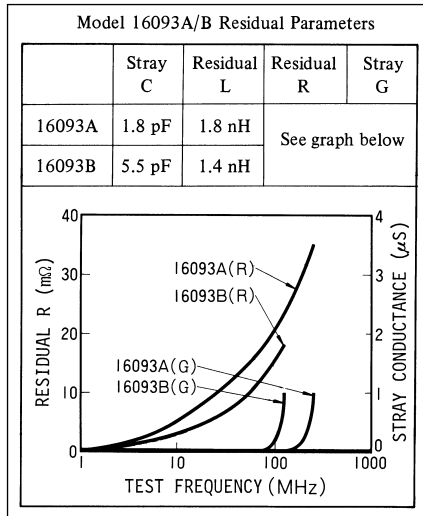
Inserting the leaded component

* Obsolete measurement configuration

16093A Binding Post Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 3.4 mm
Dimensions (approx.): 150(W) x 70(H) x 80(D) [mm]
Weight (approx.): 135 g
Additional Error: See figure below



Description: This test fixture is designed for impedance evaluation of axial/radial lead type devices. Two binding posts separated by an interval of 7 mm ensure optimum contact of lead components.

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

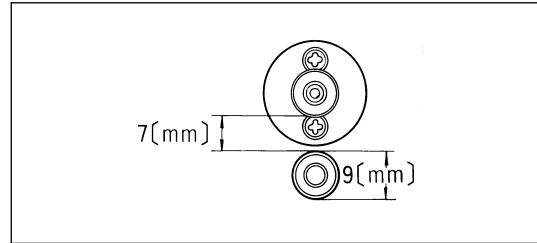
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 250 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See figure below



Post spacing

Furnished Accessories:

Description	P/N	Qty.
Shorting Plate	16092-08010	1
Operating Note	16093-90001	1

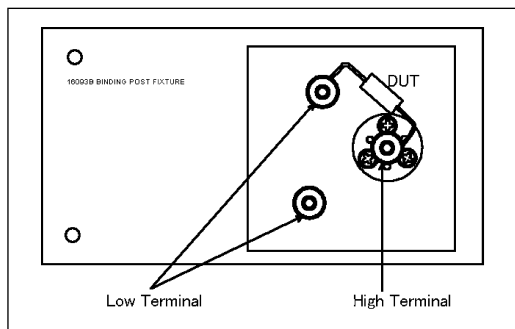
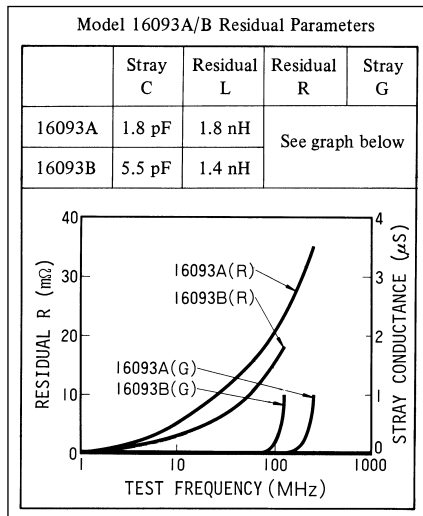
Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Open compensation is performed by not having the binding posts be connected to anything. Short compensation is performed by using the furnished shorting plate. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture.

* Obsolete measurement configuration

16093B Binding Post Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 3.4 mm
Dimensions (approx.): 150(W) x 70(H) x 80(D) [mm]
Weight (approx.): 175 g
Additional Error: See figure below



Inserting the leaded component

Description: This test fixture is designed for impedance evaluation of axial/radial lead type devices. A third binding post is provided as a guard terminal for three terminal devices.

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

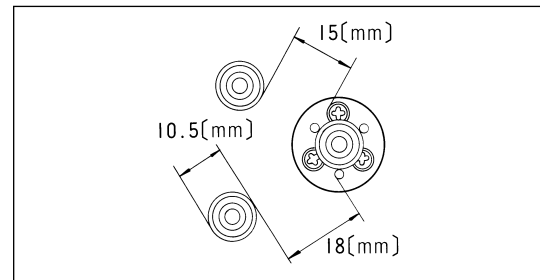
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 125 MHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: 0°C to 55°C

DUT Size: See figure below



Post spacing

Furnished Accessories:

Description	P/N	Qty.
Shorting Plate	16092-08010	1
Operating Note	16093-90011	1

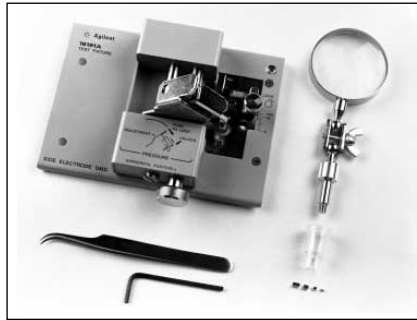
Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Open compensation is performed by not having the binding posts be connected to anything. Short compensation is performed by using the furnished shorting plate. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture.

16194A High Temperature Component Test Fixture

This test fixture is designed for not only lead devices but SMD as well. See the SMD section for a description of 16194A.

* Obsolete measurement configuration

16191A Side Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 14 mm
Dimensions (approx.): 150(W) x 70(H) x 110(D) [mm]
Weight (approx.): 500 g
Additional Error:

Type of Error	Impedance
Proportional Error	$1.5 \times f^2$ [%]
Open Repeatability	$2 + 30 \times f$ [μ S]
Short Repeatability	$30 + 250 \times f$ [m Ω]

f: [GHz]

Description: This test fixture is designed for impedance evaluations of side electrode SMD. The minimum SMD size that this fixture is adapted to evaluate is 2 (L) [mm].

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

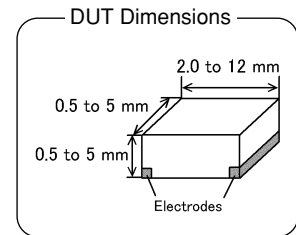
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 2 GHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: -55°C to +85°C

DUT size: 2.0 to 12 mm (length)



Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16191-90010	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-1181	1
Case for Shorting Devices	1540-0692	1
Shorting Devices	See below	See below

Shorting Device Size and Part Number (Furnished)

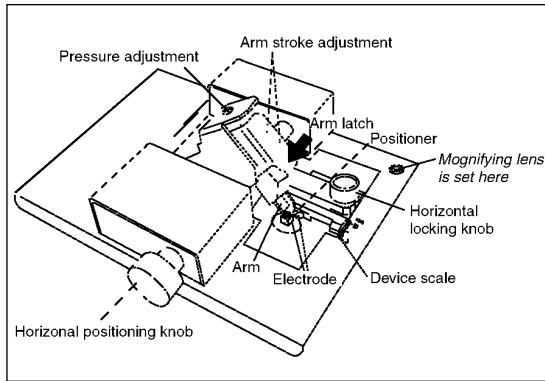
Size	P/N	Qty.
1 x 1 x 2.4 (mm)	16191-29001	1
1.6 x 2.4 x 2 (mm)	16191-29002	1
2.4 x 2.4 x 3.2 (mm)	16191-29003	1
2.4 x 2.4 x 4.5 (mm)	16191-29004	1

EIA/EIAJ Industrial Standard Sized

Shorting Device Size and Part Number (Option 010)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	16191-29005	1
1.6 x 0.8 x 0.8 (mm)	16191-29006	1
2.0 x 1.2 x 0.8 (mm)	16191-29007	1
3.2 x 1.6 x 0.8 (mm)	16191-29008	1

* Obsolete measurement configuration



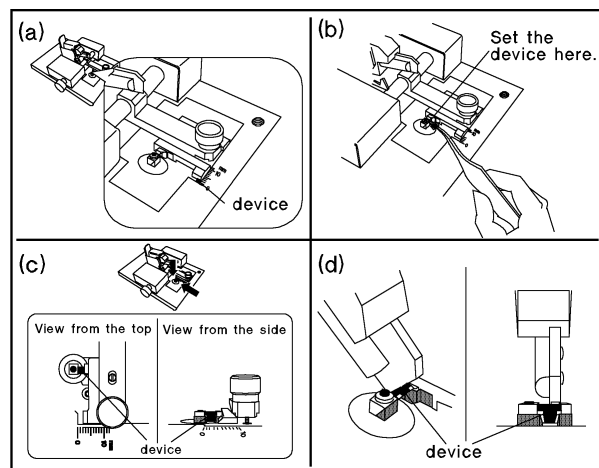
Test fixture overview

Options:

- 001: Delete the magnifying lens and tweezers
- 010: Add the special shorting bar set
- 011: Delete furnished shorting bar set (standard set)

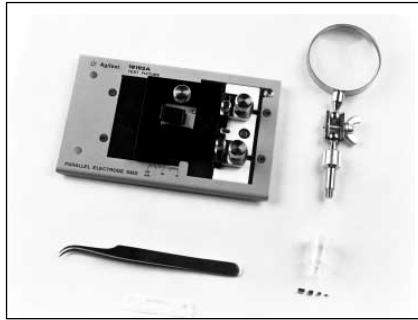
Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Then open compensation is performed by separating the high and the low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by using the furnished or option 010 shorting bar set. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. The following figures show how measurement is performed.

- a) Set the device within the device scale and adjust the positioner.
- b) Place the device on the electrode.
- c) Adjust the horizontal positioning knob and tighten the horizontal locking knob.
- d) Latch off the pressure arm and turn down the arm. Measure the device.



Positioning the device

16192A Parallel Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 11 mm
Dimensions (approx.): 150(W) x 70(H) x 90(D) [mm]
Weight (approx.): 400 g
Additional Error:

Type of Error	Impedance
Proportional Error	$1.5 \times f^2$ [%]
Open Repeatability	$2 + 30 \times f$ [μ S]
Short Repeatability	$30 + 250 \times f$ [m Ω]

f: [GHz]

Description: This test fixture is designed for impedance evaluations of parallel electrode SMD. The minimum SMD size that this fixture is adapted to evaluate is 1 (L) [mm].

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

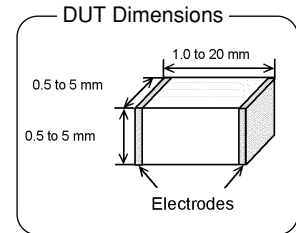
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 2 GHz

Maximum Voltage: ± 40 V peak max (AC+DC)

Operating Temperature: -55°C to +85°C

DUT size: 1 mm to 20 mm (length)



Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16192-90010	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-1181	1
Insulator	16192-09002	1
Case for Shorting Devices	1540-0692	1
Shorting Devices	See below	See below

Shorting Device Size and Part Number (Furnished)

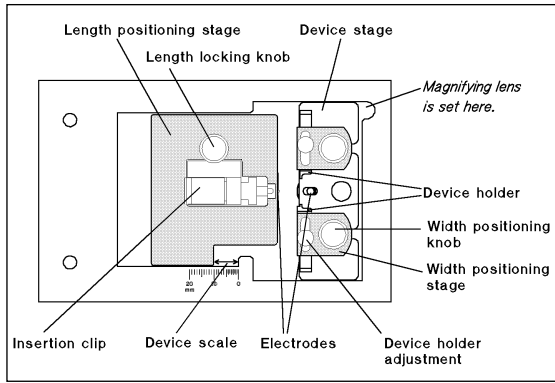
Size	P/N	Qty.
1 x 1 x 2.4 (mm)	16191-29001	1
1.6 x 2.4 x 2 (mm)	16191-29002	1
2.4 x 2.4 x 3.2 (mm)	16191-29003	1
2.4 x 2.4 x 4.5 (mm)	16191-29004	1

EIA/EIAJ Industrial Standard Sized

Shorting Device Size and Part Number (Option 010)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	16191-29005	1
1.6 x 0.8 x 0.8 (mm)	16191-29006	1
2.0 x 1.2 x 0.8 (mm)	16191-29007	1
3.2 x 1.6 x 0.8 (mm)	16191-29008	1

* Obsolete measurement configuration



Test fixture overview

Options:

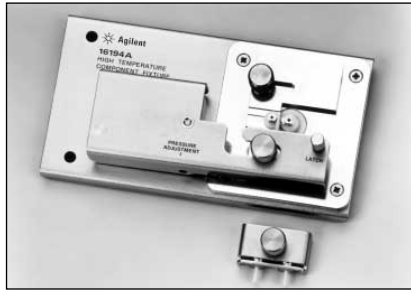
- 001: Delete the magnifying lens and tweezers
- 010: Add the special shorting bar set
- 011: Delete furnished shorting bar set (standard set)

Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Then open compensation is performed by separating the high and the low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by using the furnished or option 010 shorting bar set. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. The following figures show how compensation and measurement is performed.

<p>a. Place the shorting device/DUT so that it contacts the electrode.</p> <p>b. Adjust the two knobs and the two device holders to hold the shorting device/DUT.</p> <p>c. Tighten knob A while pushing the lever.</p> <p>d. Release the lever to hold the shorting device/DUT. Perform short compensation or measure the DUT.</p> <p>e. Set the DUT on the test fixture just as you set the shorting device in the SHORT compensation.</p> <p>f. Push the black lever and remove the DUT. Perform open compensation.</p>	
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Electrodes configuration and SMD size

16194A High Temperature Component Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 50 mm
Dimensions (approx.): 150(W) x 40(H) x 80(D) [mm]
Weight (approx.): 350 g
Additional Error:
SMD:

Type of Error	Impedance
Proportional Error	$20 \times f^2$ [%]
Open Repeatability	$80 + 250 \times f$ [μ S]
Short Repeatability	$0.2 + 2.5 \times f$ [Ω]

Leaded device:

Type of Error	Impedance
Proportional Error	$20 \times f^2$ [%]
Open Repeatability	$80 + 250 \times f$ [μ S]
Short Repeatability	$0.4 + 12.5 \times f$ [Ω]

f: [GHz]

Description: This test fixture is designed for measuring both axial/radial leaded devices and SMD within the temperature range from -55 to $+200^\circ\text{C}$ (recommended to be used with 4291A/B's high temperature test head).

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 500 MHz (with open and short compensation)

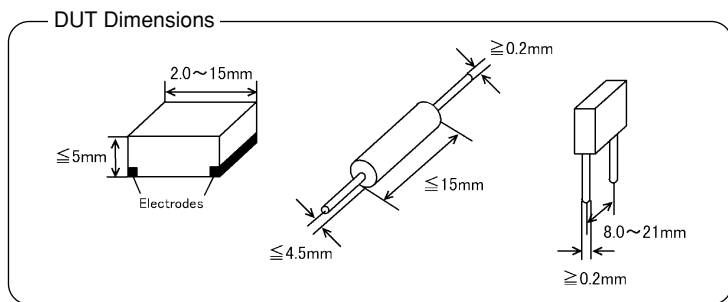
DC to 2 GHz (with open and short and load compensation)

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: -55°C to $+200^\circ\text{C}$

DUT size: See figure below.

Furnished Accessories:



Description	P/N	Qty.
Operation and Service Manual	16194-90010	1
Tweezers	8710-2081	1
50 Ω Chip Resistor	0699-2829	10
Wrench	8710-1181	1
Case for Shorting Devices	1540-0692	1
Shorting Devices	See below	See below

Shorting Device Size and Part Number (Furnished)

Size	P/N	Qty.
1 x 1 x 2.4 (mm)	16191-29001	1
1.6 x 2.4 x 2 (mm)	16191-29002	1
2.4 x 2.4 x 3.2 (mm)	16191-29003	1
2.4 x 2.4 x 4.5 (mm)	16191-29004	1

EIA/EIAJ Industrial Standard Sized

Shorting Device Size and Part Number (Option 010)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	16191-29005	1
1.6 x 0.8 x 0.8 (mm)	16191-29006	1
2.0 x 1.2 x 0.8 (mm)	16191-29007	1
3.2 x 1.6 x 0.8 (mm)	16191-29008	1

* Obsolete measurement configuration

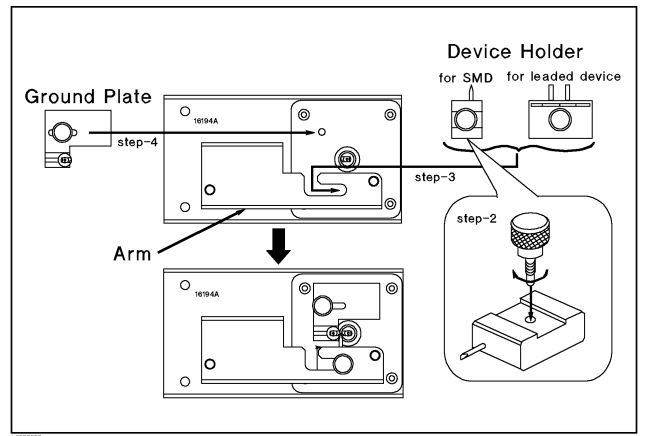
Options:

010: Add the special shorting bar set

011: Delete furnished shorting bar set (standard set)

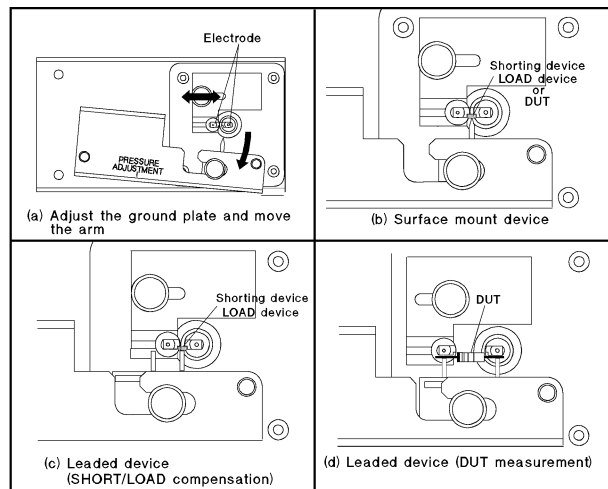
Compensation and Measurement: Before beginning the measurement, the appropriate device holder (for a SMD or lead component) must be prepared with the test fixture. The following figure shows how the device holder is exchanged to match the device type.

1. Remove the ground plate
2. When measuring SMD, attach the knob on the device holder.
3. Select the device holder suitable for the device type. Loosen its knob and insert into the arm.
4. Set the ground plate.



Exchanging the device holder

The next step is to perform open and short compensations in combination with the electrical length compensation. When measuring above 500 MHz, load compensation is also recommended. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Then open compensation is performed by separating the high and the low electrodes from each other. The separation should be equivalent in size to the DUT's width. Short compensation is performed by using the furnished or option 010 shorting bar set. Load compensation is performed by using the furnished 50 Ω SMD chip resistor. After performing open, short, and load compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. The following figures show how measurement is performed.



Placing the device

16196A Parallel Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 26.2 mm
Dimensions (approx.): 140(W) x 48(H) x 78(D) [mm]
Weight (approx.): 250 g
Additional Error:

Type of Error	Impedance
Proportional Error	$1.0 \times f^2$ [%]
Open Repeatability	$5 + 40 \times f$ [μ S]
Short Repeatability	$30 + 125 \times f$ [m Ω]

f: frequency [GHz]



4287A with 16196A

Description: This test fixture is designed for impedance evaluations of parallel electrode SMDs. It achieves stable frequency characteristics up to 3 GHz and provides highly repeatable measurements. The applicable SMD size code is 0603 (inch)/1608 (mm).

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

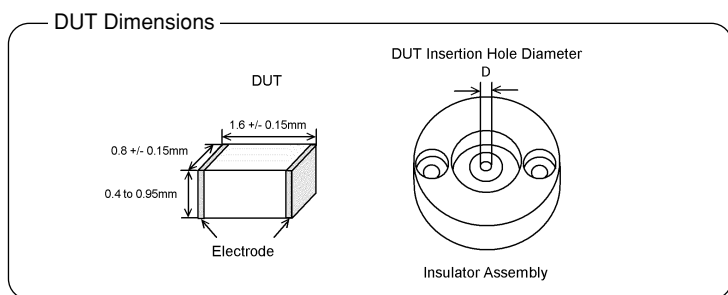
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: dc to 3 GHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: -55°C to $+85^\circ\text{C}$

DUT size: The applicable SMD size is 0603 (inch)/1608 (mm). For details, see the figure below.

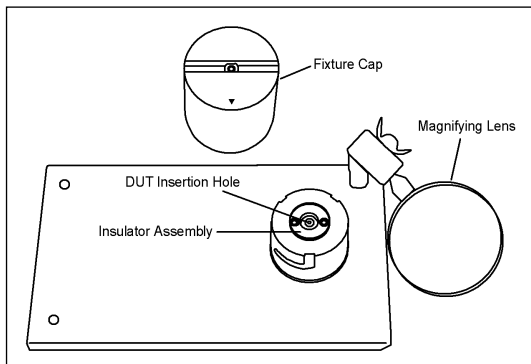


The 16196A is furnished with three different insulator assemblies, since any gaps between the DUT and the cylindrical insulator will result in improper positioning and subsequent measurement errors. Select an insulator assembly that reduces the gap the most. See the table below for dimensions of the insulator assemblies.

	Hole Diameter of Insulator assembly (mm)	SMD case size examples Length,Width, Height (mm)
16196A	ϕ 1.34	1.6 x 0.8 x 0.8
	ϕ 1.14	1.6 x 0.8 x 0.6
	ϕ 1.08	1.6 x 0.8 x 0.5

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16196-90020	1
Insulator Assembly ϕ 1.34 mm	16196-60112	1
Insulator Assembly ϕ 1.14 mm	16196-60113	1
Insulator Assembly ϕ 1.08 mm	16196-60114	1
Open Plate	16196-29002	1
Short Plate	16196-29026	1
Push Ring	16196-24004	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-0909	1
Cleaning Rod	5182-7586	1
Carrying Case	16196-60150	1



Fixture overview

* Obsolete measurement configuration

Options:

001: Delete the magnifying lens and tweezers

To maintain adequate measurement performance, keep the electrodes and the short plate in good condition. Contaminants and abrasion on these parts considerably affect measurement results, especially for low value measurements. Periodic fixture cleaning and part replacement is recommended to avoid deterioration of measurement performance. The 16196x fixtures are designed with simplicity in mind, so that an operator can easily replace parts. Spare parts, which are likely to be abraded, are supplied with the 16196U Maintenance Kit.

16196U Maintenance Kit

Opt. 010 Upper electrode, 5 piece set (common to all 16196x models)

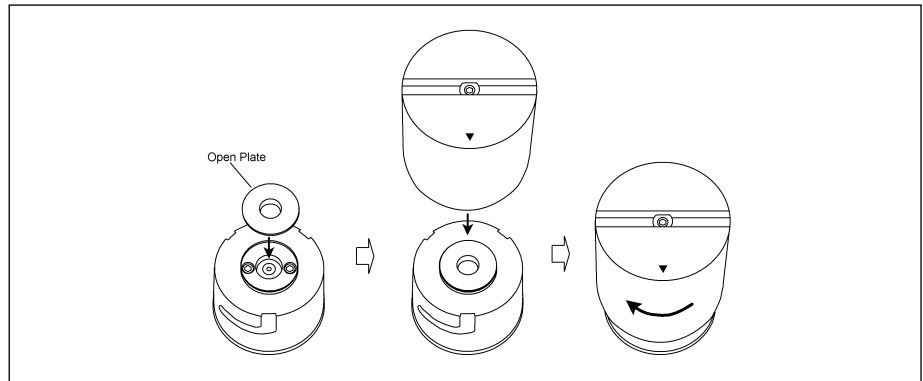
Opt. 100 Short plate for 0603 (inch)/1608 (mm) size, 5 piece set (for 16196A)

Opt. 110 Lower electrode, 5 piece set (for 16196A)

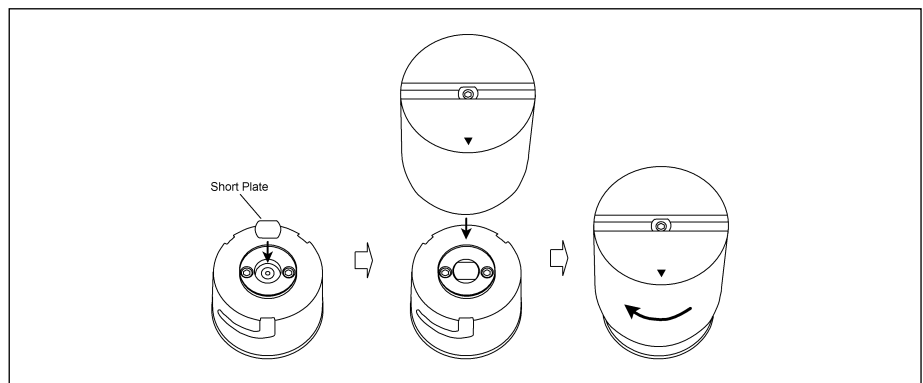
*This measurement configuration is obsolete

Compensation and Measurement: First of all, install the appropriate insulator assembly into the fixture. Then, perform compensation. Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Next, open compensation is performed by placing the furnished open plate on top of the insulator assembly. Short compensation is performed by placing the furnished shorting plate on top of the insulator assembly. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. Once the measurement of the DUT is complete, remove the DUT from the fixture, by using the furnished push ring. The following figures show how compensation and measurement is performed.

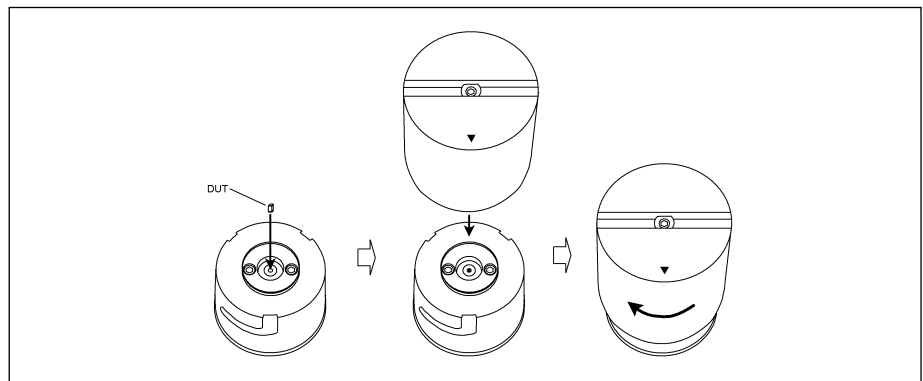
Compensation and Measurement continued



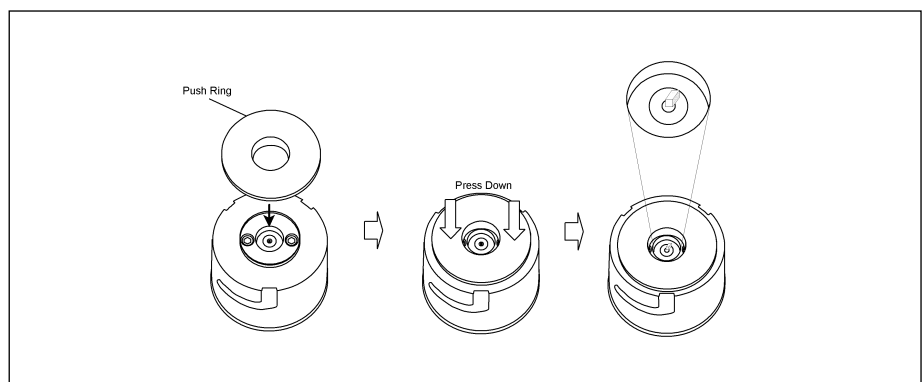
Open Compensation



Short Compensation



DUT Measurement



Removing a DUT

16196B Parallel Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 26.9 mm
Dimensions (approx.): 140(W) x 48(H) x 78(D) [mm]
Weight (approx.): 250 g
Additional Error:

Type of Error	Impedance
Proportional Error	$1.0 \times f^2$ [%]
Open Repeatability	$5 + 40 \times f$ [μ S]
Short Repeatability	$30 + 125 \times f$ [m Ω]

f: frequency [GHz]

Description: This test fixture is designed for impedance evaluations of parallel electrode SMDs. It achieves stable frequency characteristics up to 3 GHz and provides highly repeatable measurements. The applicable SMD size code is 0402 (inch)/1005 (mm).

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

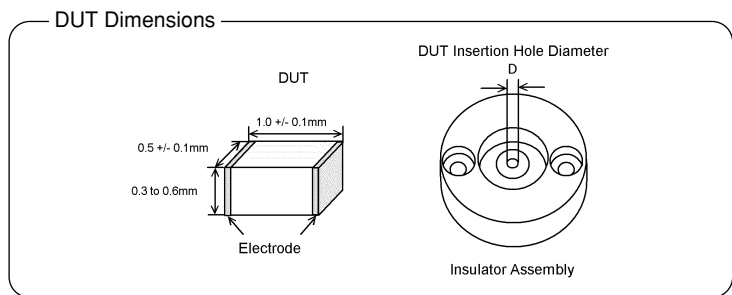
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: dc to 3 GHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: -55°C to +85 °C

DUT size: The applicable SMD size is 0402 (inch) /1005 (mm). For details, see the figure below.



The 16196B is furnished with three different insulator assemblies, since any gaps between the DUT and the cylindrical insulator will result in improper positioning and subsequent measurement errors. Select an insulator assembly that reduces the gap the most. See the table below for dimensions of the insulator assemblies.

	Hole Diameter of Insulator assembly (mm)	SMD case size examples Length,Width, Height (mm)
16196B	ϕ 0.85	1.0 x 0.5 x 0.5
	ϕ 0.75	1.0 x 0.5 x 0.35
	ϕ 0.68	1.0 x 0.5 x 0.35

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16196-90020	1
Insulator Assembly ϕ 0.85 mm	16196-60112	1
Insulator Assembly ϕ 0.75 mm	16196-60113	1
Insulator Assembly ϕ 0.68 mm	16196-60114	1
Open Plate	16196-29002	1
Short Plate	16196-29027	1
Push Ring	16196-24004	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-0909	1
Cleaning Rod	5182-7586	1
Carrying Case	16196-60250	1

* Obsolete measurement configuration

Options:

001: Delete the magnifying lens and tweezers

To maintain adequate measurement performance, keep the electrodes and the short plate in good condition. Contaminants and abrasion on these parts considerably affect measurement results, especially for low value measurements. Periodic fixture cleaning and part replacement is recommended to avoid deterioration of measurement performance. The 16196x fixtures are designed with simplicity in mind, so that an operator can easily replace parts. Spare parts, which are likely to be abraded, are supplied with the 16196U Maintenance Kit.

16196U Maintenance Kit

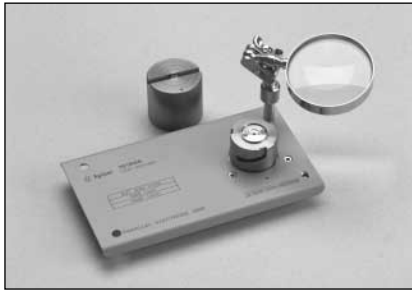
Opt. 010 Upper electrode, 5 piece set (common to all 16196x models)

Opt. 200 Short plate for 0402 (inch)/1005 (mm) size, 5 piece set (for 16196B)

Opt. 210 Lower electrode, 5 piece set (for 16196B)

Compensation and Measurement: First of all, install the appropriate insulator assembly into the fixture. Then, perform compensation. Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Next, open compensation is performed by placing the furnished open plate on top of the insulator assembly. Short compensation is performed by placing the furnished shorting plate on top of the insulator assembly. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. Once the measurement of the DUT is complete, remove the DUT from the fixture, by using the furnished push ring. Refer to the 16196A figures to see how compensation and measurement is performed.

16196C Parallel Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 27.1 mm
Dimensions (approx.): 140(W) x 48(H) x 78(D) [mm]
Weight (approx.): 250 g
Additional Error:

Type of Error	Impedance
Proportional Error	1.0 x f ² [%]
Open Repeatability	5 + 40 x f [μS]
Short Repeatability	30 + 125 x f [mΩ]

f: frequency [GHz]

Description: This test fixture is designed for impedance evaluations of parallel electrode SMDs. It achieves stable frequency characteristics up to 3 GHz and provides highly repeatable measurements. The applicable SMD size code is 0201 (inch)/0603 (mm).

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

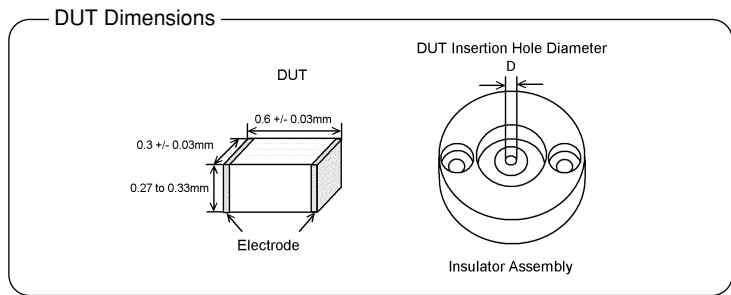
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: dc to 3 GHz

Maximum Voltage: ±40 V peak max (AC +DC)

Operating Temperature: -55°C to +85°C

DUT size: The applicable SMD size is 0201 (inch)/0603 (mm). For details, see the figure below.



The 16196C is furnished with one insulator assembly. See the table below for the dimensions of the insulator assembly.

	Hole Diameter of Insulator assembly (mm)	SMD case size examples Length,Width, Height (mm)
16196C	φ 0.47	0.6 x 0.3 x 0.3

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16196-90020	1
Insulator Assembly φ 0.47 mm	16196-60312	1
Open Plate	16196-29002	1
Short Plate	16196-29028	1
Push Ring	16196-24004	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-0909	1
Cleaning Rod	5182-7586	1

Options:

001: Delete the magnifying lens and tweezers

To maintain adequate measurement performance, keep the electrodes and the short plate in good condition. Contaminants and abrasion on these parts considerably affect measurement results, especially for low value measurements. Periodic fixture cleaning and part replacement is recommended to avoid deterioration of measurement performance. The 16196x fixtures are designed with simplicity in mind, so that an operator can easily replace parts. Spare parts, which are likely to be abraded, are supplied with the 16196U Maintenance Kit.

* Obsolete measurement configuration

16196U Maintenance Kit

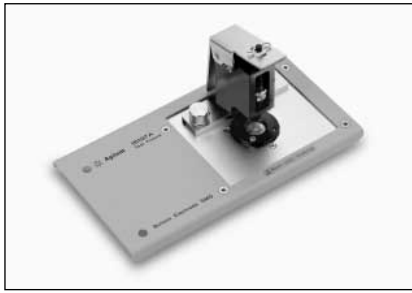
Opt. 010 Upper electrode, 5 piece set (common to all 16196x models)

Opt. 300 Short plate for 0201 (inch)/0603 (mm) size, 5 piece set (for 16196C)

Opt. 310 Lower electrode, 5 piece set (for 16196C)

Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Next, open compensation is performed by placing the furnished open plate on top of the insulator assembly. Short compensation is performed by placing the furnished shorting plate on top of the insulator assembly. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the test fixture. Once the measurement of the DUT is complete, remove the DUT from the fixture, by using the furnished push ring. Refer to the 16196A figures to see how compensation and measurement is performed.

16197A Bottom Electrode SMD Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 14 mm
Dimensions (approx.): 160(W) x 70(H) x 86(D) [mm]
Weight (approx.): 300 g
Additional Error:

Type of Error	Impedance
Proportional Error	$1.2 \times f^2$ [%]
Open Repeatability	$2 + 30 \times f$ [μ S]
Short Repeatability	$30 + 150 \times f$ [m Ω]

f: frequency [GHz]

Description: This test fixture is designed for impedance evaluations of bottom electrode SMDs. It achieves stable frequency characteristics up to 3 GHz and provides highly repeatable measurements. This test fixture supports various SMD sizes, as small as 1005 (mm)/0402 (inch) and as large as 3225 (mm)/1210 (inch). Accommodation of the 0603 (mm)/0201 (inch) size is available with option 001.

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

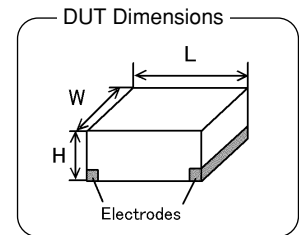
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: dc to 3 GHz

Maximum Voltage: ± 40 V peak max (AC +DC)

Operating Temperature: -55°C to $+85^\circ\text{C}$

DUT size: See figure and table below:



E4991A with 16197A

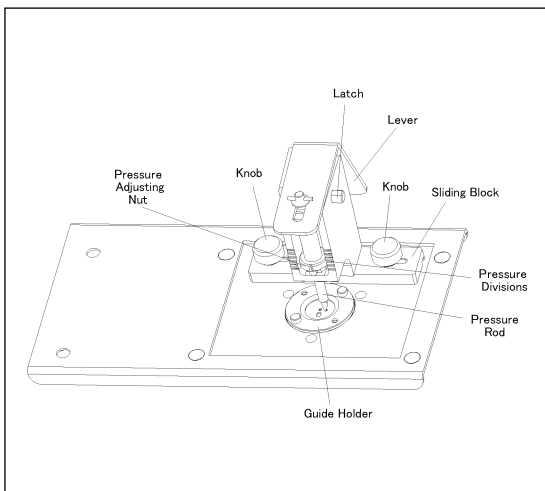
Standard Option	Applicable SMD Size	
SMD Size Code	L x W [mm]	H [mm]
3216 (mm)/1210 (inch)	$(3.2 \pm 0.15) \times (2.5 \pm 0.15)$	$H \geq 0.4$
3216 (mm)/1206 (inch)	$(3.2 \pm 0.15) \times (1.6 \pm 0.15)$	$H \geq 0.4$
2012 (mm)/0805 (inch)	$(2.0 \pm 0.15) \times (1.25 \pm 0.15)$	$H \geq 0.4$
1608 (mm)/0603 (inch)	$(1.6 \pm 0.15) \times (0.8 \pm 0.15)$	$H \geq 0.4$
1005 (mm)/0402 (inch)	$(1.0 \pm 0.1) \times (0.5 \pm 0.1)$	$H \geq 0.4$

Option 001	Applicable SMD Size	
SMD Size Code	L x W [mm]	H [mm]
0603 (mm)/0201 (inch)	$(0.6 \pm 0.03) \times (0.3 \pm 0.03)$	$H \geq 0.25$

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16197-90000	1
Blank Device Guide	16197-25006	1
Magnifying Lens	16193-60002	1
Tweezers	8710-2081	1
Wrench	8710-0909	1
Carrying Case	16197-60050	1
Case for Shorting Devices	1540-0692	1
Short Plate	See below	See below

* Obsolete measurement configuration



Test fixture overview

Shorting Device Size and Part Number (Furnished)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	16191-29005	1
1.6 x 0.8 x 0.8 (mm)	16191-29006	1
2.0 x 1.2 x 0.8 (mm)	16191-29007	1
3.2 x 1.6 x 0.8 (mm)	16191-29008	1

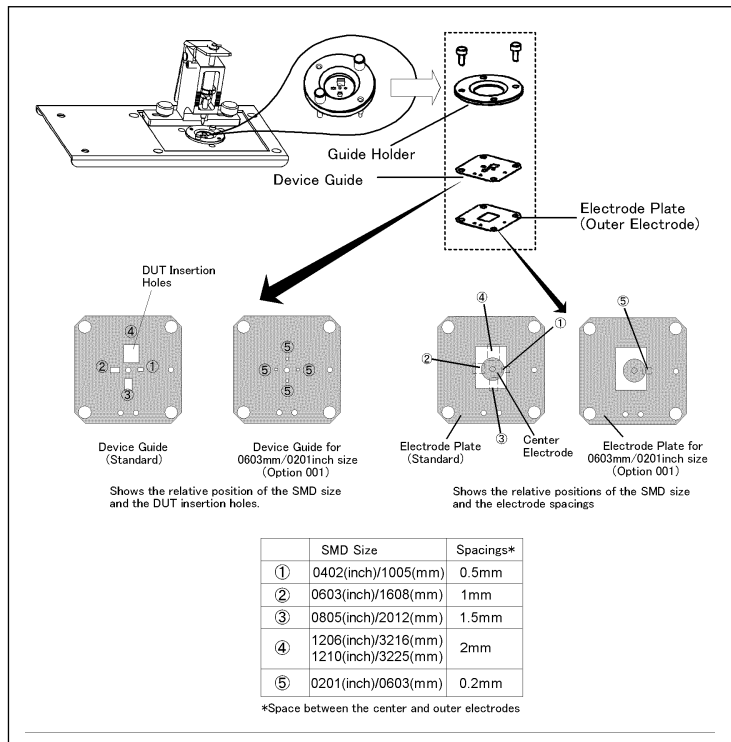
Shorting Device Size and Part Number (Option 001)

Size	P/N	Qty.
0.6 x 0.3 x 0.3 (mm)	16197-29001	4

Options:

001: Add 0603 (mm)/0201 (inch) Device Guide Set

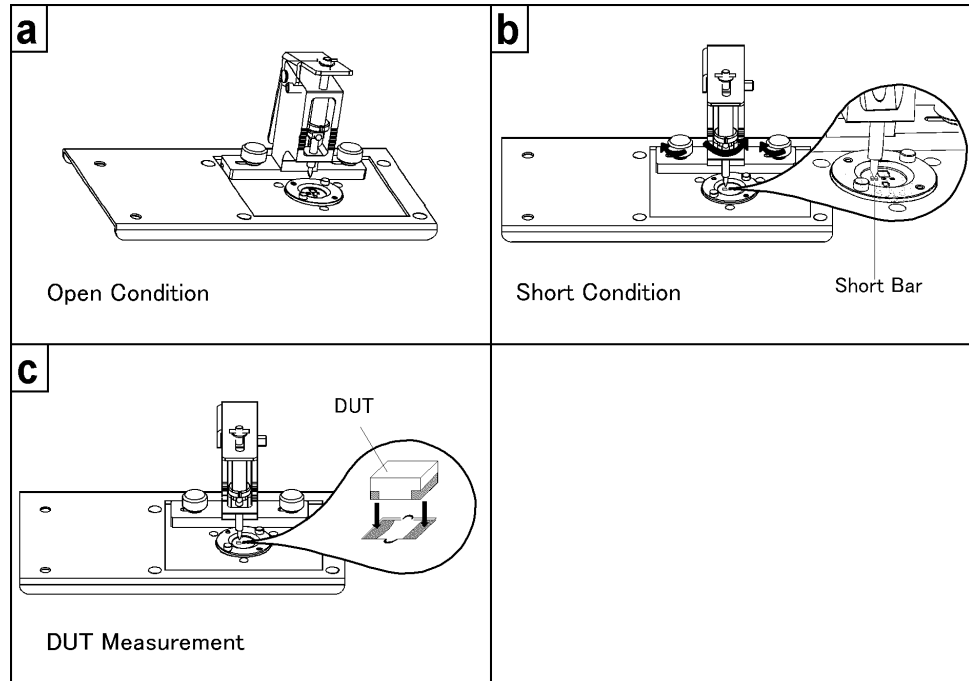
The 16197A's electrode spaces are 0.5 mm, 1 mm, 1.5 mm and 2 mm and the device guide matches these spaces with appropriate insertion holes for the applicable SMD. The 0.2 mm electrode spacing is available with option 001, which includes a device guide with 0603 mm/0201inch insertion holes, an electrode plate and 4 shorting devices.



Electrodes configuration and SMD size

Compensation and Measurement: First of all, select the appropriate device insertion hole. If the device insertion hole is not positioned in the pressure arm's contact range, reposition the device guide and the electrode plate. Once this is prepared, perform compensation. Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the mea-

surement instrument first. Next, open compensation is performed by not placing anything in the device insertion hole. Short compensation is performed by placing the furnished shorting device in the device insertion hole. After performing open and short compensations in combination with the electrical length compensation, the DUT is inserted into the device insertion hole. Once the measurement of the DUT is complete, remove the DUT from the fixture. The following figures show how compensation and measurement is performed.

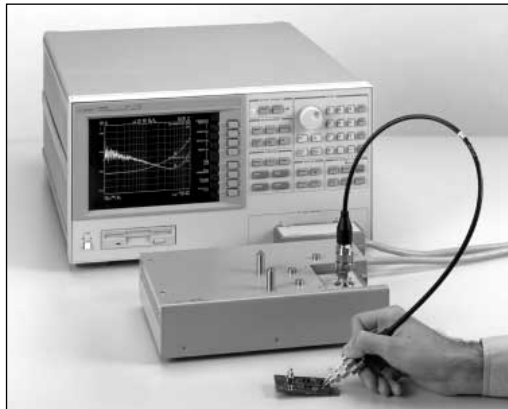
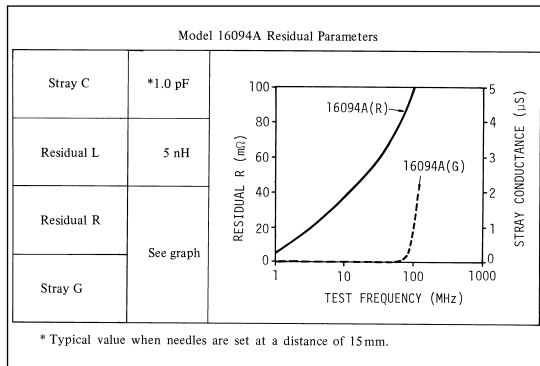


Compensation and measurement

16094A Probe Test Fixture



Terminal Connector: 7 mm
DUT Connection: 2-Terminal
Electrical Length: 23.2 mm
Weight (approx.): 25 g
Additional Error: See figure below



4291B with 16094A

Description: 16094A is used along with the 7 mm cable (P/N 8120-4779). Together they provide the capability to perform in-circuit measurements (printed circuit patterns, the input/output impedance of circuits, etc.).

Applicable Instrument: 4287A, 4291B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396B w/Opt.010 + 43961A, E4991A, (4195A + 41951A, 4286A, 4291A, 4396A)*

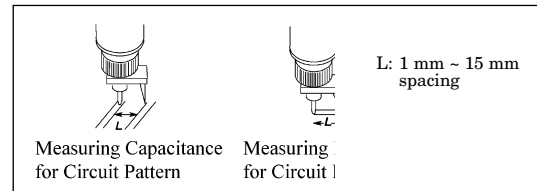
When used with 16085B: 4192A, 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, (4194A, 4263A)*

Frequency: DC to 125 MHz

Maximum Voltage: ±40 V peak max (AC +DC)

Operating Temperature: 0°C to 55°C

DUT size: See figure below.



Furnished Accessories:

Description	P/N	Qty.
Operating Note	16094-90000	1

Compensation and Measurement: Open and short compensations are recommended in combination with the electrical length compensation before measurement. The fixture's electrical length must be entered into the electrical length compensation function of the measurement instrument first. Then open compensation is performed by separating the high and the low electrodes from each other. Short compensation is performed by shorting the probe. To short the probe it is recommended to use a shorting device with gold-plated surfacing (which provides stable contact resistance) as described for 16095A.

* Obsolete measurement configuration

16200B External DC Bias Adapter



Terminal Connector: 7 mm
DC BIAS Input connector: BNC(f)
Voltage Monitor connector: BNC(f)
Dimensions (approx.): 165(W) x 65 (H) x 130(D) [mm]
Weight (approx.): 500 g



Connection example

Description: This test fixture is designed to operate with the 4286A or 4291A/B. It allows you to supply a bias current across the device of up to 5Adc through a 7 mm port by using an external dc current source.

Applicable Instruments: 4286A, 4287A, 4291A/B, 4294A + 42942A, 4395A/B w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, E4991A

Frequency: 1 MHz to 1 GHz

DC Bias: Up to 5A, 40 V

Operating Temperature: 0°C to 55°C

Applicable Fixtures: 16191A, 16192A, 16193A, 16194A, 16196A/B/C, 16197A, 16092A, 16093A/B

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16200-90000	1
Shorting Devices	See Below	See Below
50 Ω Chip Resistor	See Below	See Below

Shorting Devices' Size and Part Number (option 001)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	16191-29005	1
1.6 x 0.8 x 0.8 (mm)	16191-29006	1
2.0 x 1.2 x 0.8 (mm)	16191-29007	1
3.2 x 1.6 x 0.8 (mm)	16191-29008	1

Load Devices' Size and Part Number (option 001)

Size	P/N	Qty.
1 x 0.5 x 0.5 (mm)	5182-0433	1
1.6 x 0.8 x 0.8 (mm)	5182-0434	1
2.0 x 1.2 x 0.8 (mm)	5182-0435	1
3.2 x 1.6 x 0.8 (mm)	5182-0436	1

Options:

001: For 4291B users, Add Working Std Set

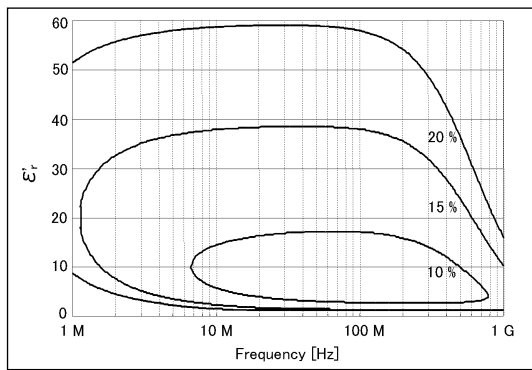
Compensation and Measurement: When using the 4291B, follow these instructions: Perform open, short, load and low-loss calibration at the 7 mm test port of the 4291B. Connect the 16200B to the 7 mm test port, and connect the test fixture onto the 16200B. Open, short, and load compensations are recommended before measurement. Use the short bars and 51 Ω SMD resistors furnished with 16200B's option 001 to perform short and load compensation respectively.

When using other instruments, follow these instructions: Connect the 16200B to the 7 mm test port of the measurement instrument. Perform open, short, load (and low-loss calibration) at the 7 mm test port of the 16200B. Then, connect the test fixture onto the 16200B and perform open, short, and electrical length compensations in the usual manner.

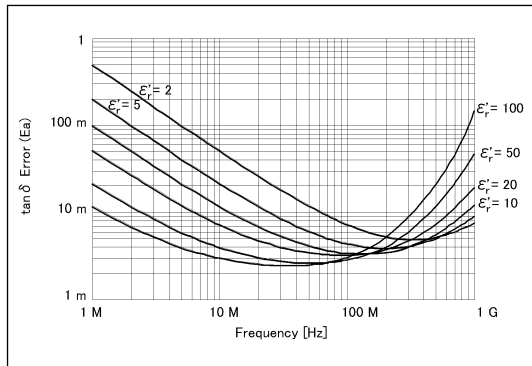
16453A Dielectric Material Test Fixture



Terminal Connector: 7 mm
Dimensions (approx.): 130(H) x 50(W) x 60(D) [mm]
Weight (approx.): 600 g
Measurement Accuracy (including the E4991A):



Typical Permittivity (ϵ_r) Measurement Accuracy (@ thickness = 1 mm)



Typical Loss Tangent ($\tan \delta$) Measurement Accuracy (@ thickness = 1 mm)



E4991A with 16453A

Description: The 16453A is designed for accurate dielectric constant and loss tangent measurements on the E4991A/4291A/B. It employs the parallel plate method, which sandwiches the material between two electrodes to form a capacitor. E4991A/4291A/B measures the capacitance created from the fixture, and option 002 firmware calculates the relative complex permittivity as described in the 16451B. Adjustment to insure parallel electrodes is required when using the 16451B. This adjustment is not required with 16453A because the fixture has a flexible electrode that adjusts automatically to the material surface.

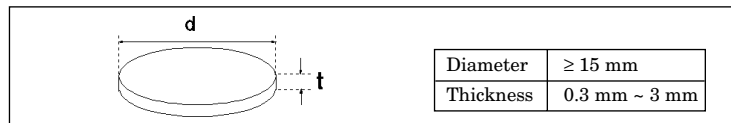
Applicable Instruments: E4991A (with Option 002 Add Material Measurement Firmware), 4291A/B (with Option 002)
Frequency: 1 MHz to 1 GHz

Maximum Voltage: ±40 V peak max (AC+DC)

Operating Temperature: -55°C to 200°C

Requires 4291A/B (Option 013) High Temperature High Impedance Test Head if the operating temperature is less than 0°C, or greater than 55°C. The E4991A does not have a high temperature test head.

Material Size:



Furnished Accessories:

Description	P/N	Qty.
Fixture Holder	16453-01213	1
Load	16453-60021	1
Tweezers	8710-2081	1
Carrying Case	16453-60011	1
Operation and Service Manual	16453-90000	1

Compensation and Measurement: Open, short and load compensations are recommended before measurement. Open compensation is performed by separating the high and the low electrodes from each other. Short compensation is performed by connecting the high and low electrodes together. Load compensation is performed by using the furnished load material. After performing open, short and load compensations, the material under test is inserted into the test fixture.

16454A Magnetic Material Test Fixture



Terminal Connector: 7 mm

Dimensions (approx.):

(Large Test Fixture) 30(D) x 35(H) [mm]

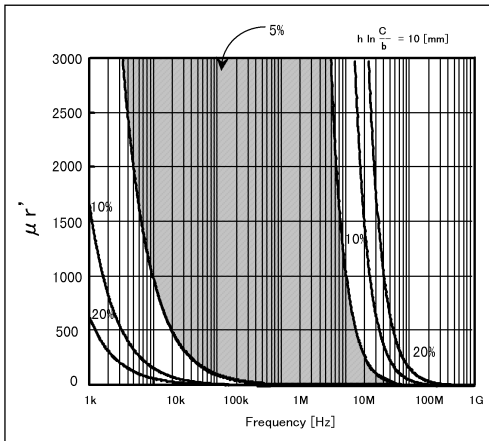
(Small Test Fixture) 24(D) x 30(H) [mm]

Weight (approx.):

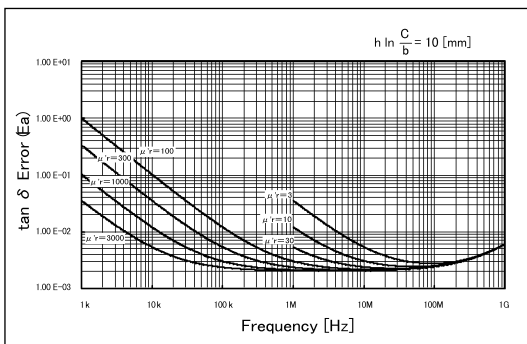
(Large Test Fixture) 140 g

(Small Test Fixture) 120 g

Measurement Accuracy (typical.):

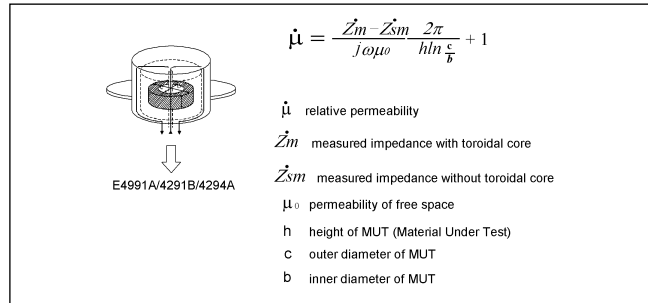


Typical Permeability ($\mu r'$) Measurement Accuracy (@ $h * \ln c/b = 10$)



Typical Loss Tangent ($\tan \delta$) Measurement Accuracy (@ $h * \ln c/b = 10$)

Description: The 16454A is designed for accurate permeability measurements of toroidal-shaped magnetic materials. Since the construction of this fixture creates one turn around the toroid (with no magnetic flux leakage), the need of winding a wire around the toroid is unnecessary. The following figure shows the one-turn mechanism and how complex permeability is calculated from it.



Permeability measurement method of 16454A

Complex permeability is calculated from the inductance with and without the toroid. When E4991A/4291B with option 002 is used as the measurement instrument, direct readouts of complex permeability are possible. In addition, it is furnished with a small and a large fixture to adapt to a wide range of sizes.

Applicable Instruments: E4991A (with option 002), 4291A/B (with option 002 Add Material Measurement Firmware, option 012 or 014 Add Low Z impedance head), 4294A

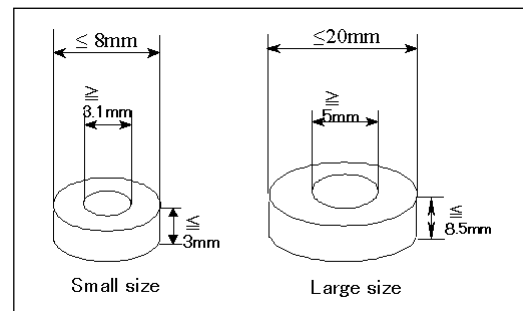
Frequency: 1 kHz to 1 GHz,

DC Bias: -500 mA to +500 mA (max)

Operating Temperature: -55°C to 200°C

(Requires 4291A/B (option 014) High Temperature Low Impedance Test Head, if the 4291A/B is used with this fixture.) The E4991A and 4294A do not have a high temperature test head.

Material Size: See figure below.



Material size



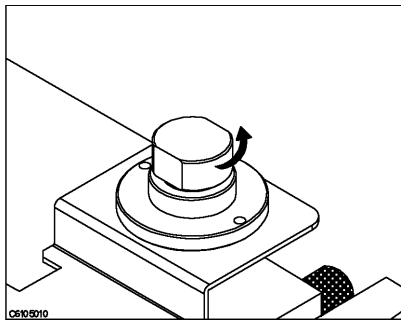
E4991A with 16454A

Furnished Accessories:

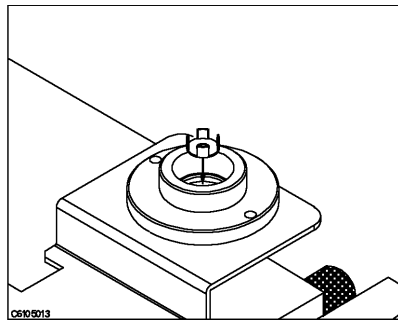
Description	P/N	Qty.
Fixture Holder	16454-00601	1
Tweezers	8710-2081	1
Screw, Hex Recess	0515-1050	1
Holder A	16454-25001	1
Holder B	16454-25002	1
Holder C	16454-25003	1
Holder D	16454-25004	1
Holder Case	1540-0622	1
Hex Key (for replacing fixtures)	8710-1181	1
Carrying Case	16454-60101	1
Specification and Service Manual	16454-90000	1

Compensation and Measurement: Short compensation is required before measurement. Short compensation is performed by only inserting the MUT holder into the test fixture. After performing short compensation, the MUT is inserted into the fixture as shown below.

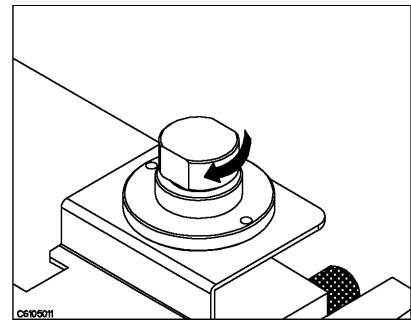
Short Compensation



Remove the cap of the fixture

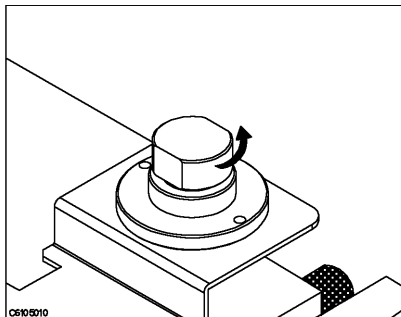


Place a MUT holder only in the fixture

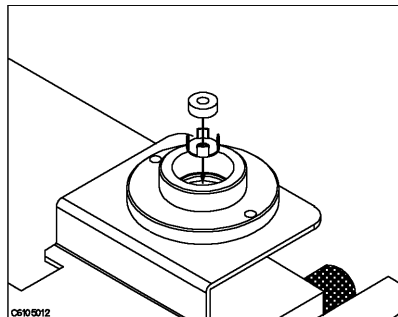


Replace the cap by screwing tightly

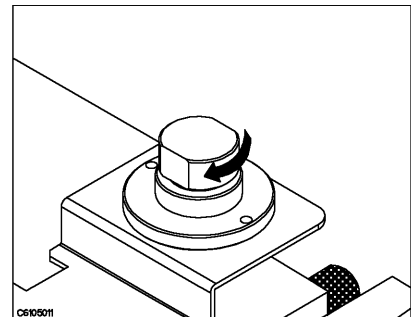
Placing the MUT on the Test Fixture as follows:



Remove the cap of the fixture



Place a MUT onto the MUT holder and insert it into the fixture.



Replace the cap by screwing tightly

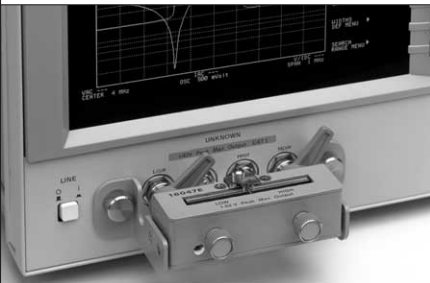



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DC (High resistance)

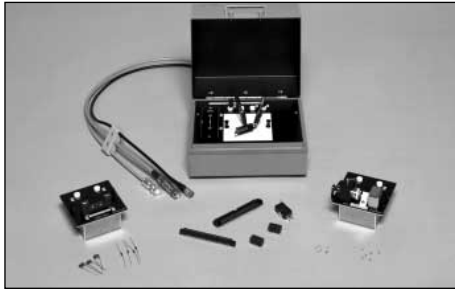
Test Fixtures for DC (High Resistance) Measurements

Test Fixture	Frequency	Applicable Instrument
16339A	DC	4339A/B
16118A	DC	4339A/B
16117B/C	DC	4349A/B
16117E	DC	4349A/B
16008B	DC	4339A/B

Applicable Instrument

Frequency Range	Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)	Up to 3 GHz (Terminal Configuration: 7 mm)
		
Measurement Instruments	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	4291A/B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, 4286A, 4287A, E4991A Any 4TP instruments (excluding 4294A) + 16085B
Frequency	DC (High Resistance Measurement)	1 kHz (Milliohm Measurement)
		
Measurement Instruments	4339A/B, 4349A/B	4338A/B

16339A Component Test Fixture



Terminal Connector:

Type	Connector
Input	Triaxial (special screw-type)
Output	High Voltage BNC (special type)
Control	Interlock connector*

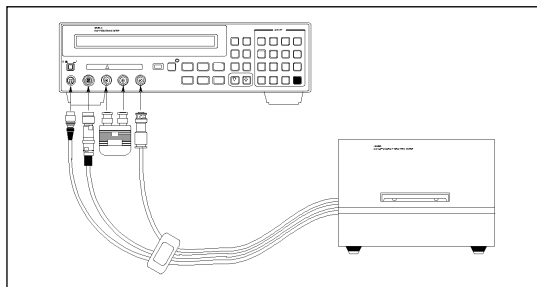
* Interlock Connector enables and disables the application of source voltage from the measurement instrument.

DUT Connection: 2-Terminal (with triaxial cable)

Dimensions (approx.): 200(W) x 140(H) x 230 (D) [mm]

Cable Length (approx.): 0.8 m

Weight (approx.): 2200 g



4339B with 16339A

Description: The 16339A is designed to operate specifically with 4339A/B. It is provided with three component modules, which are used to hold SMD, lead and various type of devices. Electrical noise effects are reduced by the employment of a shielded case. A built-in interlocking circuit enables safe high-voltage measurements.

Applicable Instruments: 4339A/B Only

Frequency: DC

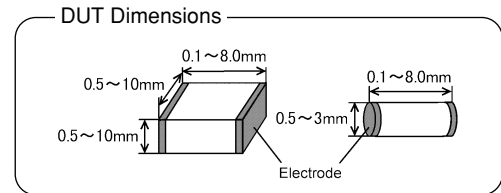
Maximum Voltage: 1000 V

Maximum Current: 10 mA

Resistance Measurement Range: 1×10^3 to $2 \times 10^{16} \Omega$

Operating Temperature: 0°C to 55°C

DUT Size: For Alligator Clip and Flat Table, lead diameter ≤ 5 mm

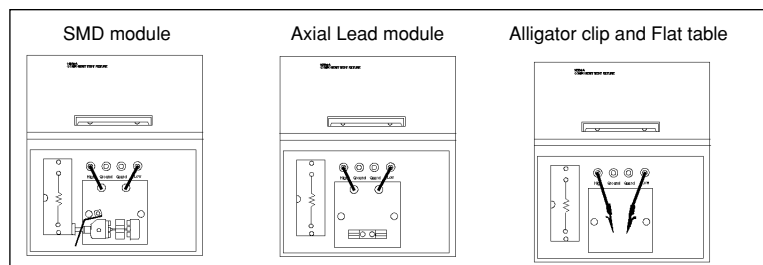


SMD module

Furnished Accessories:

Description	P/N	Qty.
Axial Lead Module	16339-60102	1
SMD Module	16339-60101	1
Flat Table	16339-60004	1
Miniature Banana-Plug cable	16339-61621	2
100 k Ω Output Resistor	16339-61001	1
1 M Ω Output Resistor	16339-61002	1
10 M Ω Output Resistor	16339-61003	1
100 M Ω Output Resistor	16339-61004	1
Alligator Clip	8710-1984	2
Carrying Case	16339-60001	1
Operation and Service Manual	16339-90010	1

Compensation and Measurement: Open compensation is recommended before measurement. When using the axial lead module, have no DUT connected to the electrodes. When using the SMD module, separate the high and low electrodes from each other. The separation should be equivalent in size to the DUT's width. When using the alligator clip and flat table, remove the alligator clips from the input terminals of the test fixture. After preparing the open condition of the respective module, close the top cover and then perform open compensation. Finally, the DUT is inserted into the respective module. The following figure shows the three component modules.



Component module configurations

16118A Tweezers Test Fixture



Terminal Connector:

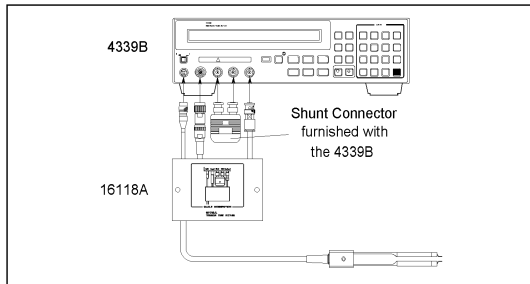
Type	Connector
Input	Triaxial (special screw-type)
Output	High Voltage BNC (special type)
Control	Interlock connector*

* Interlock Connector enables and disables the application of source voltage from the measurement instrument.

DUT Connection: 2-Terminal (with triaxial cable)

Cable Length (approx.): 1 m

Weight (approx.): 410 g



4339B with 16118A

Description: The 16118A is designed to operate specifically with 4339A/B. The tweezer’s contacts, which makes it easy to hold SMD. Electrical noise effects are reduced by the employment of shielded-cables. A built-in interlocking circuit enables safe high-voltage measurements.

Applicable Instruments: 4339A/B Only

Frequency: DC

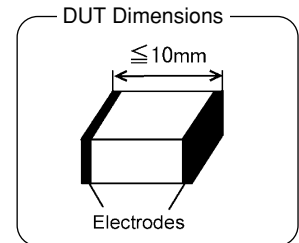
Maximum Voltage: 100 V

Maximum Current: 0.87 mA

Resistance Measurement Range: 1×10^7 to $1 \times 10^{11} \Omega$

Operating Temperature: 0°C to 55°C

DUT Size: See figure below



Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16118-90010	1

Compensation and Measurement: Open compensation is recommended before measurement. Separate the electrodes from each other. The separation should be equivalent in size to the DUT’s width. After performing open compensation, the DUT is sandwiched by the tweezers’ contacts and is measured.

16117B Low Noise Test Leads



Terminal Connector:

Type	Connector
Input	Triaxial (special screw-type)
Output	High Voltage BNC (special type)
Control	Interlock connector*

* Interlock connector enables and disables the application of source voltage from the measurement instrument.

DUT Connection: 2-Terminal (with triaxial cable)

Cable Length (approx.): 1 m (connector to clips)

Weight (approx.): 280 g

Description: The 16117B is designed to operate specifically with 4339A/B. With its wide jaw clips, it is capable of holding DUTs with large terminals. The clips can be replaced with probes (option 001) for measurements of small DUTs such as PC boards or IC sockets. Option 002 enables the construction of simple custom-made test leads. Electrical noise effects are reduced by the employment of shielded-cables. A built-in interlocking circuit enables safe high-voltage measurements.

Applicable Instruments: 4339A/B Only

Frequency: DC

Maximum Voltage: 1000 V

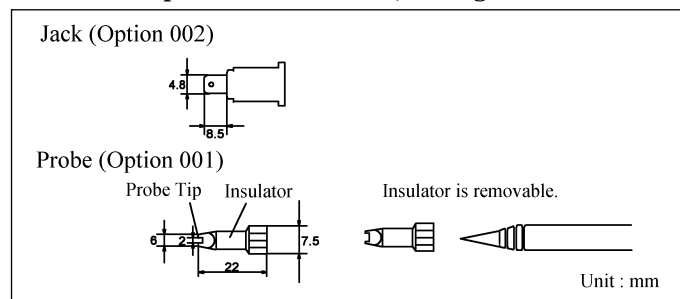
Maximum Current: 0.5 mA

Resistance Measurement Range: 1×10^3 to $1 \times 10^{11} \Omega$

Operating Temperature: 0°C to 55°C

DUT Size: For clips, lead diameter ≤ 30 mm

For probes and sockets, see figure below:



Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16117-90040	1

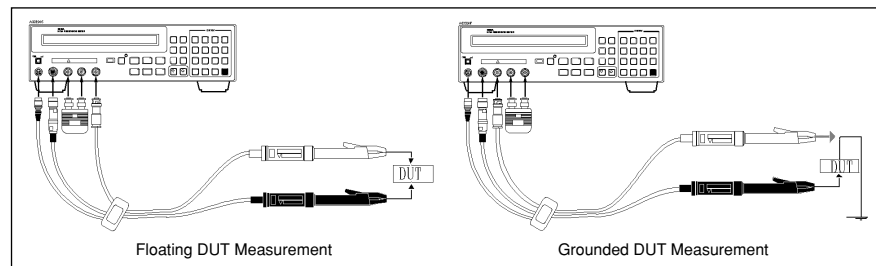
Options:

001: Add Pin Probes (2 ea.)

002: Add Soldering Sockets (2 ea.)

009: Delete Alligator Clips

Compensation and Measurement: Open compensation is recommended before measurement. Separate the test clips (or probes) from each other. After performing open compensation, the DUT is connected to the clips (or probes). The DUT can be measured in two configurations: floating and grounded. The connections are shown in the figure below:



Floating and grounded DUT measurement

16117C Low Noise Test Leads



Terminal Connector:

Type	Connector
Input	Triaxial (special screw-type)
Output	High Voltage BNC (special type)
Control	Interlock connector*

* Interlock connector enables and disables the application of source voltage from the measurement instrument.

DUT Connection: 2-Terminal (with triaxial cable)
Cable Length (approx.): 1 m (connector to connector)
Weight (approx.): 290 g

Description: The 16117C is designed to operate specifically with 4339A/B. It comes with a separate triaxial (special screw-type) female connector and a high-voltage BNC (special type) female connector, so that the terminal configuration of the 4339A/B can be converted to any other configuration. Therefore, custom-made test fixtures can easily be constructed.

Applicable Instruments: 4339A/B Only

Frequency: DC

Maximum Voltage: 1000 V

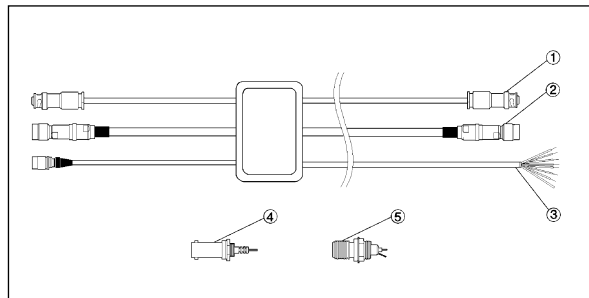
Maximum Current: 10 mA

Resistance Measurement Range: 1×10^3 to $1 \times 10^{16} \Omega$

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Triaxial (special screw-type) female connector	1250-2228	1
High Voltage BNC (special type) female connector	1250-2317	1
Operation and Service Manual	16117-90031	1



Adapter features

1. Triaxial cable. The measured signal is carried on the center conductor of this connector. This is a special screw-type triaxial connector and is not compatible with standard triaxial connectors.
2. High-voltage BNC cable. This connector provides the source voltage to the 16117C. This is a high-voltage BNC connector and is not compatible with standard BNC connectors.
3. Interlock cable. This connector enables the interlock function which enables and disables the application of source voltage from the 4339A/B when the interlock line is connected and disconnected respectively.
4. High-voltage BNC (special type) female connector
5. Triaxial (special screw-type) female connector.

16117E Low Noise Test Leads



Terminal Connector: Triaxial (m)

Cable Length (approx.): 1 m (connector to connector)

Weight (approx.): 130 g

Description: The 16117E is designed to operate specifically with 4349A/B. It is used to connect the 4349A/B and the DUT. Hence, four 16117E test leads are required when using four channels of the 4349A/B. Its cable is equipped with triaxial connectors on both ends. It is also furnished with a triaxial female connector for connection with the DUT and external voltage source.

Applicable Instruments: 4349A/B Only

Frequency: DC

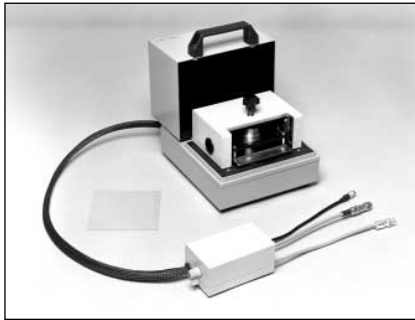
Maximum Voltage: 250 V

Operating Temperature: 0°C to 45°C

Furnished Accessories:

Description	P/N	Qty.
Triaxial female connector	1250-1906	1

16008B Resistivity Cell



Terminal Connector:

Type	Connector
Input	Triaxial (special screw-type)
Output	High Voltage BNC (special type)
Control	Interlock connector*

* Interlock Connector enables and disables the application of source voltage from the measurement instrument.

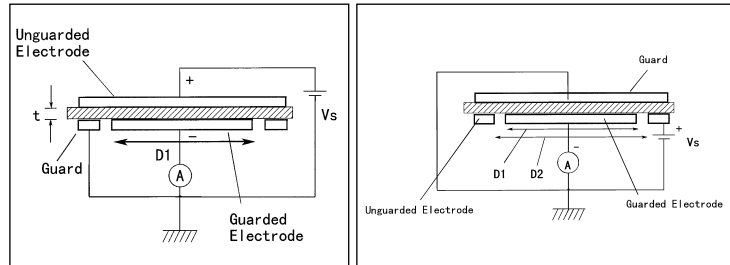
DUT Connection: 2-Terminal (with triaxial cable)

Dimensions (approx.): 240(W) x 180(H) x 240(D) [mm]

Cable Length (approx.): 1.2 m (connector to electrodes)

Weight (approx.): 7000 g

Description: The 16008B is designed to operate specifically with 4339A/B. It is used to measure surface or volume resistance/resistivity of insulation materials. The following figures show the block diagrams of resistivity measurements.



Volume resistivity measurement

Surface resistivity measurement

Volume resistivity is measured across the material (MUT) by the unguarded and guarded electrodes. Surface resistivity, on the other hand, is measured along the surface of the MUT (between the guarded and the unguarded electrodes). Notice that the role of the guard and unguarded electrodes switch, when measuring volume and surface resistivity.

16008B is provided with three different electrode sizes to meet size requirements by different measurement standards. The guarded electrode eliminates measurement errors due to the edge effect and arbitrary contact pressure can be applied to the material under test. It is also equipped with a high-voltage protection cover to shut off power when opened.

Applicable Instruments: 4339A/B Only

Frequency: DC

Maximum Voltage: 1000 V

Maximum Current: 10 mA

Resistance Measurement Range:

Volume Resistivity Measurement Range:

up to $4.0 \times 10^{18} \Omega\text{cm}$

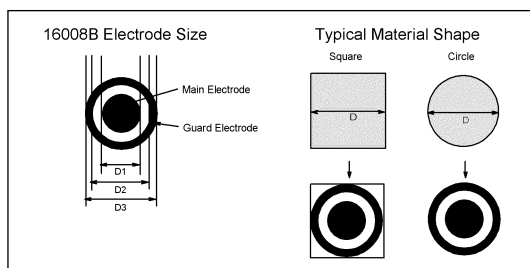
Surface Resistivity Measurement Range:

up to $4.0 \times 10^{17} \Omega$

Operating Temperature: -30°C to +100°C (excluding selector switch)

Material Size: Select an electrode so that outer diameter of guarding electrode is smaller than the DUT's diameter.

See figure and table below for more details:



Electrode sizes and applicable material sizes

D1	D2	D3	Ordering Information	D
Main Electrode	Guard Electrode (Inner Diameter)	Guard Electrode (Outer Diameter)	—	Material Size
26 mm	38 mm	48 mm	Supplied with Opt.001 or 002	50 mm* to 125 mm
50 mm	70 mm	80 mm	Standard - equipped	82 mm* to 125 mm
76 mm	88 mm	98 mm	Supplied with Opt.001	100 mm* to 125 mm

* Outer Diameter of Guard Electrode + 2 mm
Thickness: 10µm to 10 mm

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16008-90011	1

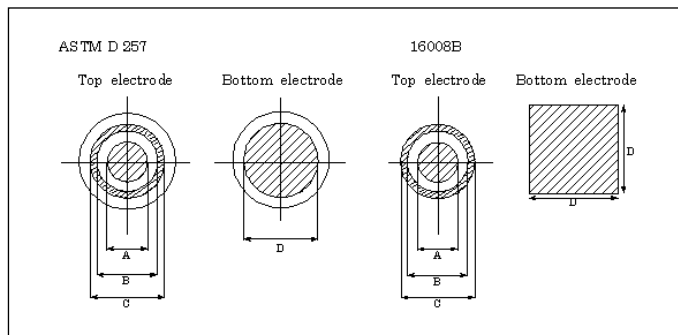
Options:

001: Add 26 & 76 mm diameter electrodes

002: Add 26 mm diameter electrode

Compensation and Measurement: Using the selector switch on the 16008B, select either the volume resistivity or surface resistivity measurement configuration. Open compensation is recommended before measurement and when the measurement configuration is switched. Separate the upper electrode from the main electrode by turning the contact pressure load knob until the upper electrode does not move. Then, close the top cover and perform open compensation. After open compensation, the material under test (MUT) is placed on the main electrode and the upper electrode is placed over it. Next, turn the load knob to adjust the electrode contact pressure on the MUT. Close the top cover and measure the MUT's surface or volume resistivity.

It is vital to make measurements, which are compatible to a certified test method (standard). It is shown below that the 16008B can make resistivity measurements which are compatible with ASTM D257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials. In the figure and tables shown below, the size and shape is compared for two pairs of electrodes: one that is specified in ASTM D257 and the one that is used with the 16008B Resistivity Cell. The similarity implies that the 16008B is compatible with ASTM D257.



Compatibility with ASTM D257

ASTM D257's recommended electrode sizes

	Choice 1	Choice 2
A	76 mm	25 mm
B	88 mm	38 mm
C	100 mm	50 mm
D	100 mm	50 mm

16008B electrode sizes

	Option 001	Option 001 / 002
A	76 mm	26 mm
B	88 mm	38 mm
C	98 mm	48 mm
D	110 mm	110 mm

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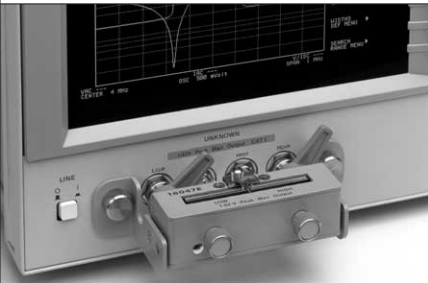

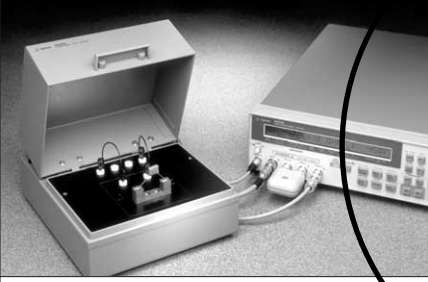

1 kHz (Milliohm)

Test Fixtures for Milliohm Measurements (1 kHz)

Test Fixture	Frequency	Applicable Instrument
16338A*	1 kHz	(For 4338A/B only)

*: Note, this includes 16005B, 16005C/D, 16006A, 16007A/B

Applicable Instrument

Frequency Range	Up to 110 MHz (Terminal Configuration: 4-Terminal Pair)	Up to 3 GHz (Terminal Configuration: 7 mm)
		
Measurement Instruments	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	4291A/B, 4294A + 42942A, 4395A w/Opt.010 + 43961A, 4396A/B w/Opt.010 + 43961A, 4286A, 4287A, E4991A Any 4TP instruments (excluding 4294A) + 16085B
Frequency	DC (High Resistance Measurement)	1 kHz (Milliohm Measurement)
		
Measurement Instruments	4339A/B, 4349A/B	4338A/B

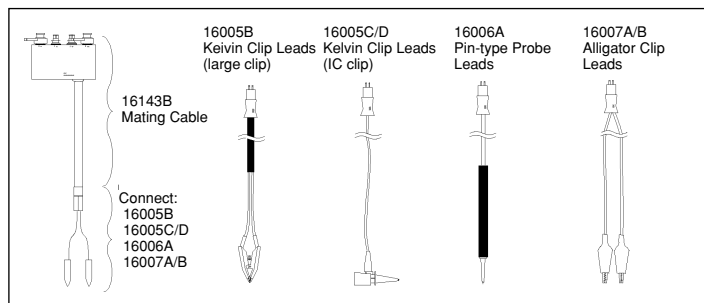
16338A Test Lead Kit



Terminal Connector: 4-Terminal, BNC

DUT Connection: 4-Terminal

Description: The 16338A contains four types of test leads and a mating cable, which are designed to operate with the 4338A/B. These test leads can be mixed or matched depending on the type of sample being measured. The test leads and mating cable are shown in the figure below:



Available test leads

Applicable Instruments: 4338A/B Only

Frequency: 1 kHz

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Kelvin Clip Leads (large)	16005B	2
Kelvin Clip Leads (small, red)	16005C	1
Kelvin Clip Leads (small, black)	16005D	1
Pin-Type Probe Leads	16006A	2
Alligator Clip Lead (red)	16007A	1
Alligator Clip Lead (black)	16007B	1
Mating Cable	16143B	1
Carrying Case	16338-60001	1
Operation and Service Manual	16338-90000	1

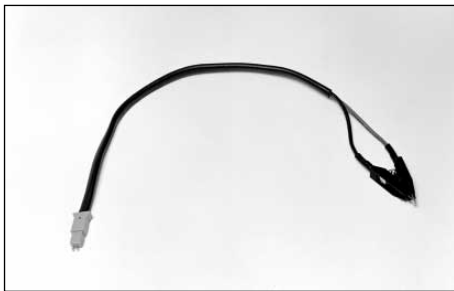
Compensation and Measurement: Short compensation is recommended before measurement. When using the 16005B or the 16005C/D, first connect the voltage terminals together and the current terminals together. Then, connect the two pairs of voltage and current terminals together. When using the 16006A, firmly press the probes against a shorting plate. Make sure that all four electrodes of the probes contact via the shorting plate and are placed closely to each other. The shorting plate should have very low residual impedance, so a high conductive metal plate should be used. When using 16007A/B, hold a shorting plate with the alligator clips. Make sure that the voltage leads (or black leads) are next to each other.

16143B Mating Cable



Terminal Connector: 4-Terminal, BNC
Cable Length (approx.): 60 cm
Weight (approx.): 220 g

16005B Kelvin Clip Leads



DUT Connection: 4-Terminal
Cable Length (approx.): 40 cm
Weight (approx.): 40 g

16005C/D Kelvin IC Clip Leads



16005C (black clip)



16005D (red clip)

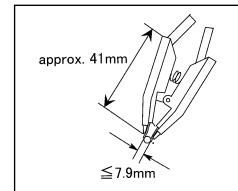
DUT Connection: 4-Terminal
Cable Length (approx.): 40 cm
Weight (approx.): 20 g

Description: The 16143B is designed to operate specifically with the 4338A/B. It is used to connect any combination of two test lead types to the 4338A/B.

Applicable Test Leads: 16005B, 16005C/D, 16006A, 16007A/B

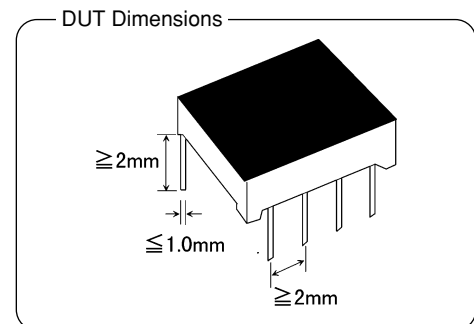
Description: The 16005B is useful when measuring test devices that have large terminals. It incorporates the Four-Terminal (Kelvin) connection method for accurate low resistance measurements. The jaws of the 16005B are a set of electrically independent contacts. The current terminal feeds the test current to the DUT while the voltage terminal detects the voltage across the DUT. Furthermore, the contact design assures accurate measurement down to the lowest resistance range.

DUT Size: See figure below



Description: The 16005C/D is useful when measuring test devices that have thin leads. It incorporates the Four-Terminal (Kelvin) connection method for accurate low resistance measurements. The jaws of the 16005C/D are a set of electrically independent contacts. The current terminal feeds the test current to the DUT while the voltage terminal detects the voltage across the DUT. Furthermore, the contact design assures accurate measurement down to the lowest resistance range.

DUT Size: See figure below



16006A Pin-type Leads



DUT Connection: 4-Terminal
Cable Length (approx.): 40 cm
Weight (approx.): 15 g

Description: The 16006A is designed for press-on contact measurements such as printed board conductivity or through-hole measurements. The probe tip is a voltage terminal and the outer conductor is a current terminal. The probe tip is spring-loaded, so that both terminals firmly contact the DUT.

16007A/B Kelvin Alligator Clip Leads



16007A (red clip)



16007B (black clip)

DUT Connection: 4-Terminal
Cable Length (approx.): 40 cm
Weight (approx.): 20 g

Description: The 16007A/B is designed for standard Four-Terminal measurements. Each pair of test leads has a separate alligator clip for voltage and current terminals. The 16007A is furnished with red covers and the 16007B is furnished with black covers.

DUT Size: lead diameter ≤ 4 mm

Other Accessories

16064B LED Display/Trigger Box



Terminal Connector: Handler Interface Cable

Cable Length (approx.): 1.5 m

Dimensions (approx.): 200(W) x 40(H) x 100(D) [mm]

Weight (approx.): 800 g

Description: The 16064B is designed to operate specifically with 4263A/B, 4338A/B, and 4339A/B. Comparator results which are sent from the measurement instrument, are displayed by LEDs on the 16064B. The parameters that are displayed are shown in the table below:

LED Indicator	4338A/B	4339A/B	4263A/B
Primary LOW	●	●	●
Primary IN	●	●	●
Primary HIGH	●	●	●
Secondary LOW	●	●	●
Secondary IN	●	●	●
Secondary HIGH	●	●	●
Over Current		●	
Over Voltage	●		
No Contact	●	●	●

Furthermore, it can lock the front panel keys of the measurement instrument and trigger a measurement.

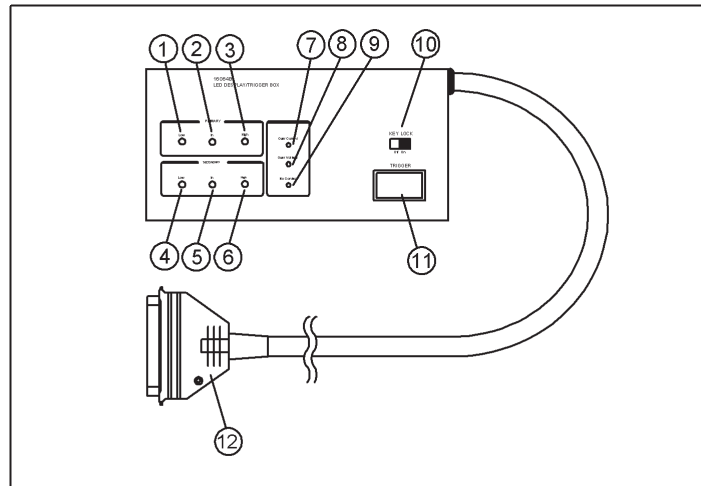
Applicable Instruments: 4263A/B, 4338A/B, 4339A/B

Operating Temperature: 0°C to 55°C

Furnished Accessories:

Description	P/N	Qty.
Operation and Service Manual	16064-90010	1

1. Primary result indicator (LOW)
2. Primary result indicator (IN)
3. Primary result indicator (HIGH)
4. Secondary result indicator (LOW)
5. Secondary result indicator (IN)
6. Secondary result indicator (HIGH)
7. Over current indicator
8. Over voltage indicator
9. No contact indicator
10. Key Lock Switch
11. Trigger Key
12. Handler Interface Connection Cable



Test fixture overview

Other Accessories

16190B Performance Test Kit



Terminal Connector: 7 mm

Dimensions (approx.): 350(W) x 100(H) x 270(D) [mm]

Weight (approx.): 2.0 kg

Description: The 16190B is a performance test kit designed to verify the impedance measurement accuracy of LCR meters or impedance analyzers that have a 7 mm measurement terminal. Refer to the instrument's operation/service manual for the method of using these standards.

Applicable Instrument: E4991A, (4286A, 4291A)*
4287A, 4291B, 4294A + 42942A

Furnished Accessories:

Description	P/N	Qty.
Airline, 50 Ω , 7 mm	N/A	1
Cap, Protection	1401-0123	2
50 Ω Termination	N/A	1
Open Termination	N/A	1
Short Termination	N/A	1
Cap, Termination Protection	16190-25011	3
Wrench, 1/2 and 8/15, Open End	8710-1770	1
Carrying Case	16190-60250	1
Floppy Diskette for Calibration Data	N/A	1
Calibration Report	N/A	1
Operating Note	16190-90010	1

* Obsolete Instrument

Other Accessories

16380A Standard Capacitor Set



Terminal Connector: 4-Terminal Pair, BNC

Dimensions (approx.): 142(W) x 88(H) x 112(D) [mm]
(capacitors)

Weight (approx.): 8.0 kg (including case and 4 capacitors)

Description: The 16380A is a standard capacitor set consisting of four precision capacitors -1 pF (16381A), 10 pF (16382A) 100 pF (16383A), 1000 pF (16384A). These capacitors are primarily used for performance tests of Agilent's 4-Terminal Pair LCR meters and impedance analyzers. Refer to the instrument's operation/service manual for the method of using these standards.

Applicable Instrument: 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A, (4192A, 4194A, 4263A)*

	16381A	16382A	16383A	16384A
Capacitance	1 pF	10 pF	100 pF	1000 pF
Nominal Accuracy	0.10 %			
Calibration Accuracy	0.01 %			
Calibration Stability	≤50 ppm/year			
Dissipation Factor	≤0.0001			

Furnished Accessories:

Description	P/N	Qty.
16381A (1 pF)	N/A	1
16382A (10 pF)	N/A	1
16383A (100 pF)	N/A	1
16384A (1000 pF)	N/A	1
Short Termination	N/A	1
BNC (f) -(f) Adapters	1250-0080	4
Calibration Report	N/A	1
Carrying Case	16380-85101	1
Operating Note	16380-90001	1

* Obsolete Instrument

Other Accessories

16380C Standard Capacitor Set



Terminal Connector: 4-Terminal Pair, BNC

Dimensions (approx.): 142(W) x 88(H) x 112(D) [mm]
(capacitors)

Weight (approx.): 7.0 kg (including case and 3 capacitors)

Description: The 16380C is a standard capacitor set consisting of three precision capacitors -0.01 μF (16385A), 0.1 μF (16386A), and 1 μF (16387A). These capacitors are primarily used for performance tests of Agilent's 4-Terminal Pair LCR meters and impedance analyzers. Refer to the instrument's operation/service manual for the method of using these standards.

Applicable Instrument: 4263B, 4268A, 4278A, 4284A, 4288A, 4294A, (4194A, 4263A)*

	16385A	16386A	16387A
Capacitance	0.01 μF	0.1 μF	1 μF
Nominal Accuracy	0.10 %		
Calibration Accuracy	0.01 %		
Calibration Stability	≤ 50 ppm/year		
Dissipation Factor	≤ 0.004	≤ 0.005	≤ 0.007

Furnished Accessories:

Description	P/N	Qty.
16385A (1 pF)	N/A	1
16386A (10 pF)	N/A	1
16387A (100 pF)	N/A	1
BNC (f) -(f) Adapters	1250-0080	4
Calibration Report	N/A	1
Carrying Case	16380-85102	1
Operating Note	16380-90211	1

* Obsolete Instrument

Other Accessories

42030A Four-Terminal Pair Standard Resistor Set



Terminal Connector: 4-Terminal Pair, BNC

Dimensions (approx.): 94(W) x 31(H) x 67(D) [mm] (resistors)

Weight (approx.): 3.7 kg (including case and 9 resistors)

Description: The 42030A is a standard resistor set consisting of nine precision resistor standards which range from 1 m Ω to 100 k Ω . These resistors are primarily used for performance tests of Agilent's 4-Terminal Pair LCR meters and impedance analyzers. Refer to the instrument's operation/service manual for the method of using these standards.

Applicable Instrument: 4263B, 4268A, 4284A, 4294A, 4338B, (4192A, 4263A, 4338A)*

Model	DC Resistance
42031A	1 m Ω \pm 0.2%
42032A	10 m Ω \pm 0.2%
42033A	100 m Ω \pm 0.2%
42034A	1 Ω \pm 0.2%
42035A	10 Ω \pm 0.1%
42036A	100 Ω \pm 0.1%
42037A	1 k Ω \pm 0.1%
42038A	10 k Ω \pm 0.1%
42039A	100 k Ω \pm 0.1%

Furnished Accessories:

Description	P/N	Qty.
42031A (1 m Ω)	N/A	1
42032A (10 m Ω)	N/A	1
42033A (100 m Ω)	N/A	1
42034A (1 Ω)	N/A	1
42035A (10 Ω)	N/A	1
42036A (100 Ω)	N/A	1
42037A (1 k Ω)	N/A	1
42038A (10 k Ω)	N/A	1
42039A (100 k Ω)	N/A	1
Calibration Report	N/A	1
Carrying Case	42030-60100	1
Operation and Service Manual	42030-90001	1

* Obsolete Instrument

Other Accessories

42090A Open Termination



Terminal Connector: 4-Terminal Pair, BNC

Dimensions (approx.): 94(W) x 31(H) x 67(D) [mm]

Weight (approx.): 120 g

Description: The 42090A is an open termination and is primarily used for performance tests of Agilent's 4-Terminal Pair LCR meters and impedance analyzers. Refer to the instrument's operation/service manual for the method of using this standard.

Applicable Instrument: 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A, (4192A, 4263A)*

42091A Short Termination



Terminal Connector: 4-Terminal Pair, BNC

Dimensions (approx.): 94(W) x 31(H) x 67(D) [mm]

Weight (approx.): 120 g

Description: The 42091A is a short termination and is primarily used for performance tests of Agilent's 4-Terminal Pair LCR meters and impedance analyzers. Refer to the instrument's operation/service manual for the method of using this standard.

Applicable Instrument: 4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4294A, 4338B, (4192A, 4263A, 4338A)*

* Obsolete Instrument

The Concept of a Test Fixture's Additional Error

1. System Configuration for Impedance Measurement

Very often, the system configured for impedance measurements utilizes the following components (See figure below as well).

1. Impedance measurement instrument
2. Cables and adapter interfaces
3. Test Fixture



System configuration for impedance measurement

The Impedance measurement instrument's characteristic measurement accuracy is defined at the measurement port of the instrument. This means that the accuracy at the measurement port has traceability and the measurement values are guaranteed.

In an actual measurement, there can be an extension of the measurement port with a cable or an adapter conversion to match the test fixture's terminal configuration. For this reason, cables and conversion adapters are provided for connectivity with the measurement port. These cables (and adapters) are designed with the intent to maintain high accuracy of the measurement instrument while extending the measurement port. Most of the time, the measurement accuracy of the instrument and the cable (or adapter) are specified together as a whole.

A test fixture is an accessory used to connect the DUT to the measurement instrument. Many test fixtures are provided to adapt to various shapes and sizes. It is either connected directly to the measurement port of the instrument or to the port of the extension cable or conversion adapter as described earlier. Its structure determines the applicable frequency range and signal level. Hence, it is necessary to use the appropriate one for the corresponding measurement conditions. In addition, each test fixture has its own characteristic additional error, which is listed in its operational manual.

2. Measurement System Accuracy

The equation for the accuracy of a measurement system is shown below:

$$(\text{Measurement Accuracy}) = (\text{Instrument's Accuracy}) + (\text{Test Fixture's Additional Error})$$

The measurement instrument's accuracy is determined by an equation with terms, which are dependent on frequency, measured impedance and signal level. By substituting the respective measurement conditions into the equation, the measurement accuracy is calculated. If a cable or a conversion adapter is used, then the specified measurement accuracy is the accuracy of the measurement instrument with the cable or adapter. This combined measurement accuracy is shown in the instrument's operational manual.

The equation for the test fixture's additional error is shown below:

$$Z_e = \pm \{ A + (Z_s/Z_x + Y_o \bullet Z_x) \times 100 \} (\%)$$

$$D_e = Z_e/100 (D \leq 0.1)$$

Z_e	: Additional Error for Impedance (%)
D_e	: Additional Error for Dissipation Factor
A	: Test Fixture's Proportional Error (%)
$Z_s/Z_x \times 100$: Short Offset Error (%)
$Y_o \bullet Z_x \times 100$: Open Offset Error (%)
Z_s	: Test Fixture's short Repeatability (Ω)
Y_o	: Test Fixture's open Repeatability (S)
Z_x	: Measured Impedance Value of DUT(Ω)

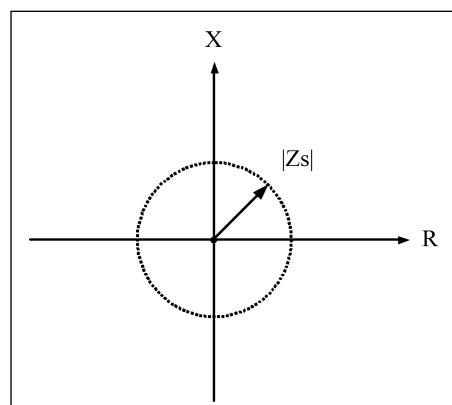
Proportional error, open and short repeatability are mentioned in the test fixture's operational manual and in this accessory guide. By inputting the measurement impedance and frequency (proportional error, open and short repeatability are usually a function of frequency) into the above equation, the fixture's additional error can be calculated.

Proportional Error:

The term, proportional error (A), was derived from the error factor, which causes the absolute impedance error to be proportional to the impedance being measured. If only the first term is taken out of the above equation and multiplied by Z_x , then $\Delta Z = A \bullet Z_x$ (Ω). This means that the absolute value of the impedance error will always be A times the measured impedance. The largeness of proportional error is dependent upon how complicated the test fixture's construction is. Conceptually, it is dependent upon the stability of each element of the fixture's equivalent circuit model. From previous experience, proportional error is proportional to the frequency squared.

Short Offset Error:

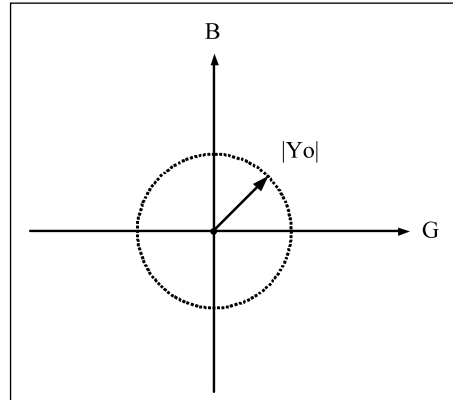
The term, $Z_s/Z_x \times 100$, is called short offset error. If Z_x is multiplied to this term, then $\Delta Z = Z_s$ (Ω). It can be concluded that this term affects the absolute impedance error, by adding an offset. Short repeatability (Z_s) is determined from the variations in multiple measurements of the test fixture in short condition. After performing short compensation, the measured values of the short condition will distribute around 0 in the complex impedance plane. The maximum value of the impedance vector is defined as short repeatability. This is shown in the figure below. The larger short repeatability is the more difficult it is to measure small impedance values. For example, if the test fixture's short repeatability is 100 m Ω , then the additional error of an impedance measurement under 100 m Ω will be more than 100%. In essence, short repeatability is made up of a resistance and an inductance part, which become larger as the frequency becomes higher.



Definition of short repeatability

Open Offset Error:

The term, $Y_o \cdot Z_x \times 100$ is called open offset error. If the same analysis is carried out with admittance, then it can be concluded that this term also affects the absolute admittance error, by adding an offset. Open repeatability (Y_o) is determined from the variations in multiple measurements of the test fixture in open condition. As shown in the figure below, the maximum value of the admittance vector in the complex admittance plane is defined as open repeatability. The larger open repeatability is, the more difficult it is to measure large impedance values. Open repeatability is made up of a resistance and a capacitance part, which become larger as the frequency becomes higher.



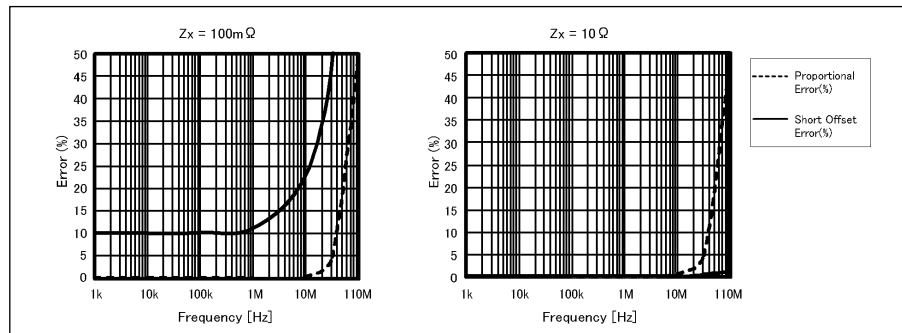
Definition of open repeatability

3. New Market Trends and the Additional Error for Test Fixtures

New Devices:

Recently, the debut of extremely low ESR capacitors and the trend to use capacitors at much higher frequencies, have made low impedance measurements more strongly demanded than in the past. As a result, the test fixture's short repeatability has become increasingly important. In the figure below, the relationship between proportional error, short offset error and frequency are shown when measuring low impedance. Notice that when the measured impedance is less than 100 mΩ, short offset error influences the entirety of the test fixture's additional error. As shown in the figure below, when the DUT's impedance is 100 mΩ and the test fixture's short repeatability is 10 mΩ, the short offset error will be 10%. Since the proportional error is minimal in low frequencies, the additional error will be 10% as well.

For the additional error of test fixtures, up until now, it was common to just specify the proportional error (A). As shown in the 10Ω measurement case (same figure down below), if the measured impedance is large in comparison to the test fixture's short repeatability, then short offset error can be ignored completely. This is the reason why open and short offset error was not specified previously. Test fixtures that are only specified with proportional error in this accessory guide are due to this reason. On the contrary, for measured impedance from 1Ω to 10 kΩ proportional error (A) alone is sufficient to express the test fixture's additional error.

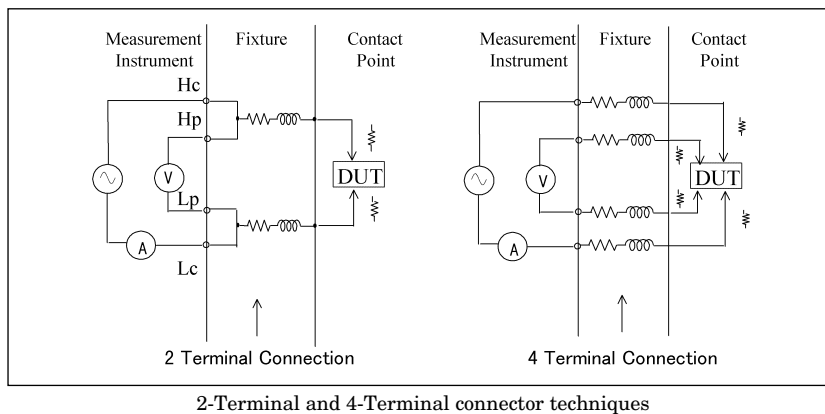


Relationship between proportional error, short offset error and frequency when measuring low impedance

Terminal Connector Method:

In order to make short repeatability small, there are test fixtures which utilize the 4-Terminal connector method (for example 16044A). By employing this technique, the effect of contact resistance is reduced and short repeatability is drastically improved. As a result, the range of accurate low impedance measurements is vastly expanded.

In the figure below, the difference between the 2-Terminal connector and the 4-Terminal connector is shown. In a 2-Terminal connector, the contact resistance, which exists between the fixture's contact and the DUT, is measured together with the DUT's impedance. Contact resistance cannot be eliminated by compensation because the value changes each time the DUT is contacted.



In a 4-Terminal connector, the voltage and current terminals are separate. Since the input impedance of the voltmeter is large, no current flows to the voltage terminals. Hence, the voltage that is applied across the DUT can be accurately detected without being affected by the contact resistance. Also, the current that flows through the DUT flows directly into the current terminal and is accurately detected without being affected by the contact resistance. Due to the reasons stated above, it is possible to eliminate the effect of contact resistance and realize a small short repeatability.

Test Fixture's Adaptability for a Particular Measurement:

In order to make use of what has been discussed previously, the test fixture's adaptability for a particular measurement will be focused upon. To see whether a test fixture is adaptable, it is important to think about the test fixture's additional error (proportional error, short and open repeatability), measurement impedance and the test frequency range.

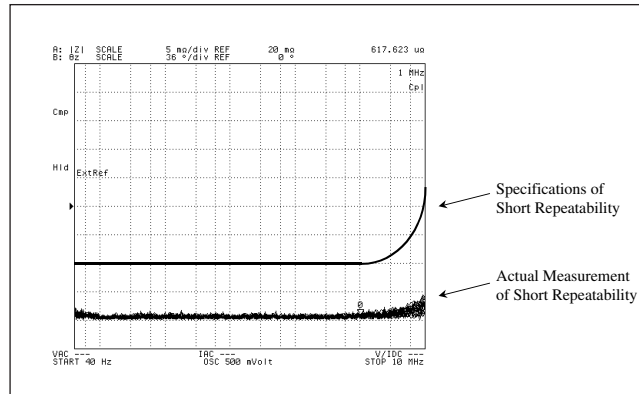
If the measurement impedance is in the 1 to 10 k Ω range, use only proportional error to calculate the additional error of the test fixture. It is fine to assume that this is a close approximation to the fixture's additional error.

If the measurement impedance is not in this range, use proportional error, short and open offset errors to calculate the test fixture's additional error. Recent test fixtures have all three terms specified in their operational manual, so use these values for the calculation.

Some of the recent test fixtures (16044A), due to their structure, have different performance characteristics with different measurement instruments. For these test fixtures refer to their operational manual for more details about the specifications.

So, how are test fixtures, which are not specified with short and open repeatability, assessed whether they are adaptable or not? This assessment is made possible by using the following method to approximate short and open repeatability. To measure a test fixture's short repeatability, measure the impedance of the short condition after performing short compensation. Take the shorting plate out of the fixture and then insert it back in. Measure the short condition again. By repeating this process at least 50 times, it will show the variations in the short condition (See figure below). The final step to determine an approximation of short repeatability is to add a margin to the values

obtained. For open repeatability, measure the admittance of the test fixture’s open condition. In the same way, determine open repeatability by measuring at least 50 times.



Measurement of short repeatability (16034G)

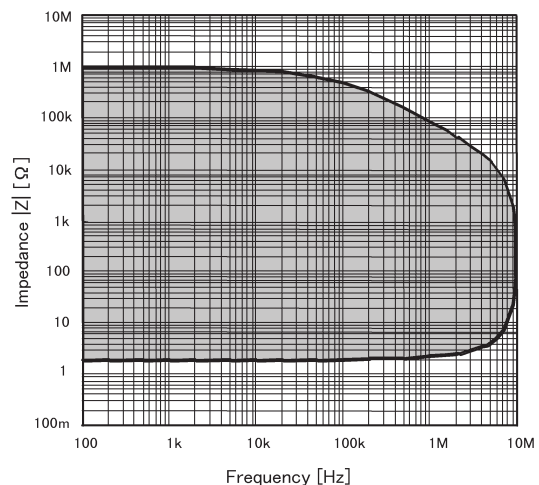
Measurement Settings

- Measurement Instrument : 4294A
- Measurement Frequency : 40 Hz-10 MHz
- Measurement Parameter : Z-θ
- Compensation : Performed short Compensation
- Bandwidth : 3
- Measurement Method : Inserted the shorting plate, measured the short condition, and then removed the shorting plate. Repeated this for 50 times.
- Display Method : Overlaying traces by using the Accumulate Mode

Lastly of all, a method to visually analyze the accurate measurement range of a test fixture is introduced. This method is only appropriate when all three error-terms (proportional error, open and short repeatability) are known. The table below shows the additional error of 16034G. The whole equation, with all three terms can be solved for measurement impedance rather than additional error, for example when additional error is equal to 0.5%. If the obtained impedance values are plotted with measurement impedance (y-axis) against frequency (x-axis), a graph similar to the one shown down below can be obtained. The shaded area shows the range of impedance that can be measured with an additional error better than 0.5%. In the same way, other graphs can be drawn with other additional error values to better visualize the accuracy that can be obtained for a given impedance and frequency range. The operational manuals of recent test fixtures present such graphs.

Additional Error of 16034G

Type of Error	Impedance
Proportional Error	$0.5 \times (f/10)^2$ [%]
Open Repeatability	$5 + 500 \times (f/10)$ [nS]
Short Repeatability	$10 + 13 \times (f/10)$ [mΩ]



Additional error ≤ 0.5%

Error Compensation

Agilent measurement instruments incorporate one of the following four types of error compensation functions to eliminate residual impedance effects in test fixtures:

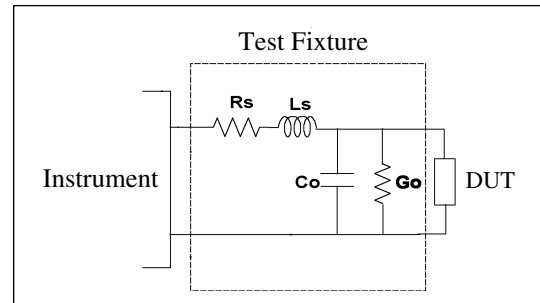
1. Open/short Compensation

For a simple measurement system, represented by the equivalent circuit model shown below, residual impedance values R_s and L_s and admittance values C_o and G_o can be corrected by:

- (i) Measuring open condition for the test fixture’s admittance.
- (ii) Measuring short condition for the test fixture’s impedance
- (iii) Measuring the test sample, then subtracting the admittance and impedance.

The above procedure is performed internally by the open/short compensation.

When the test fixture is directly connected to the measurement instrument, the open/short compensation sufficiently corrects the measurement error.



2. Open/short/load Compensation

When the measurement system is too complicated to be represented as the above equivalent circuit model, the open/short compensation cannot completely compensate for the residual impedance. In this case, the open/short/load compensation is used rather than the open/short compensation.

The open/short/load compensation is particularly effective when, for example, the 16065A is used with the measurement instrument.

The following table lists measurement instruments and available compensation functions.

Model	Open compensation	Short compensation	Load compensation	Load’s input parameters
4192A	●	●	–	–
4194A	●	●	–	–
4263A	●	●	●	R-X (GPIB only)
4263B	●	●	●	Z-Q, R-X, Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, Cs-Rs, Ls-D, Ls-Q, Ls-Rs
4268A	●	●	●	Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, Cs-Rs
4278A	●	●	●	Cp-D, Cp-G
4279A	●	●	●	Cp-D, Cp-G
4284A	●	●	●	same as measurement parameters
4285A	●	●	●	same as measurement parameters
4286A	●	●	●	Rs-Ls
4287A	●	●	–	–
4288A	●	●	●	Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-Q, Cs-Rs
4291A/B	●	●	●	Rs-Ls
4294A	●	●	●	Rs-Ls
4338B	–	●	–	–
4339A/B	●	–	–	–
E4991A	●	●	–	–

–: N/A

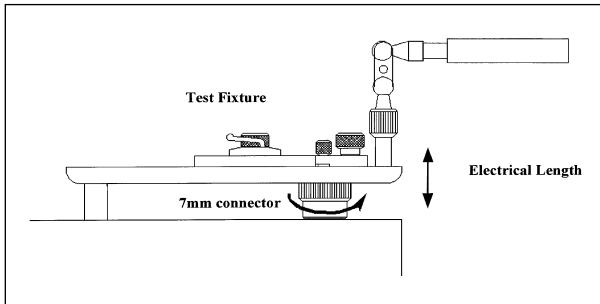
●: Available

* For more details of the compensation functions, refer to the instruction manuals supplied with the measurement instrument or Application Note 346-3 (P/N 5091-6553E)

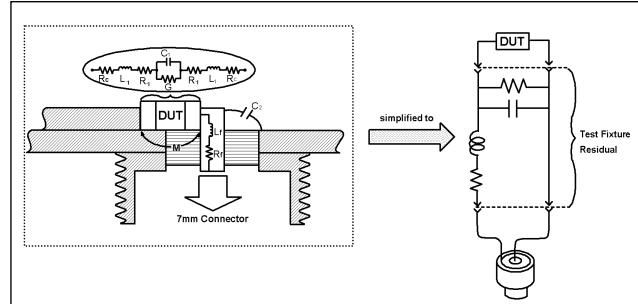
For more details of the compensation functions, please see the instruction manuals supplied with the measurement instruments or Application Note 346-3 (P/N 5091-6553E).

3. Electrical Length Compensation

In a single-port (Two-Terminal) impedance measurement at higher frequencies (RF region or higher), the wavelengths of the electrical signal are so short that the length of the signal transmission line including the test fixture and cables can cause an undesirable phase shift error. The phase shift error is corrected by the electrical length compensation, which should be performed in combination with the open/short compensation.



Electrical length of a test fixture



Residual parameters in the measuring circuit

The following measurement instruments are equipped with electrical length compensation function.

Model	Compensation Function
4195A + 41951A	Test Port Extension
4286A	Electrical Length Compensation/Port Extension
4287A	Electrical Length Compensation/Port Extension
4291A/B	Electrical Length Compensation/Port Extension
4294A + 42942A	Electrical Length Compensation/Port Extension
4395A + Option 010 + 43961A	Electrical Length Compensation/Port Extension
4396A/B + Option 010 + 43961A	Electrical Length Compensation/Port Extension
E4991A	Electrical Length Compensation/Port Extension

The electrical length is specified for the following test fixtures:

Model	Electrical Length
16092A	3.4 mm
16093A	3.4 mm
16093B	3.4 mm
16094A	23.2 mm
16191A	14.0 mm
16192A	11.0 mm
16193A	14.0 mm
16194A	50.0 mm
16196A	26.2 mm
16196B	26.9 mm
16196C	27.1 mm
16197A	14.0 mm

4. Cable Length Compensation

When the test sample is measured with an instrument having a Four-Terminal Pair configuration, the additional length of the test-lead extension between the instrument and the test sample, in conjunction with the measurement frequency, influences the amplitude and phase of the signal being measured. This must be taken into account, particularly for measurements performed at frequencies of 100 kHz or higher, since the modification of the amplitude and phase of the signal can cause the internal measurement circuit to malfunction or create an unexpected measurement error. Such circuit malfunctions and measurement errors can be avoided with cable length compensation. Cable length compensation should therefore be performed prior to the open/short compensation.

When the following measurement instruments and test leads are used in combination, the undesired effects described above can be eliminated by performing the cable length compensation (the values in the table represent cable length settings):

Model	16048A	16048B	16048D	16048E	16048G	16048H
4192A	1 m	1 m	–	–	–	–
4194A	1 m	1 m	–	–	–	–
4263A/B	1 m	1 m	2 m	4m	–	–
4268A	1 m	1 m	2 m	–	–	–
4278A	1 m	1 m	2 m	–	–	–
4279A	1 m	1 m	2 m	–	–	–
4284A	1 m	1 m	2 m ¹	4 m ¹	–	–
4285A	1 m	–	2 m	–	–	–
4288A	1 m	1 m	2 m	–	–	–
4294A	–	–	–	–	1 m	2 m

–: N/A

¹: Available for 4284A with Option 006.

Measurement Repeatability

Dirty electrodes on the test fixture cause an increase in the contact resistance. This increase in resistance can cause poor measurement repeatability. To maintain clean test electrodes on the test fixtures, use the recommended cleaning kit (P/N 8830-0002).

Model Number	Name	Applicable Measurement Instrument (s)	Page (s)
16005B	Kelvin Clip Leads	4338A/B with 16143B	79
16005C/D	Kelvin IC Clip Leads	refer to 16005B	79
16006A	Pin-Type Leads	refer to 16005B	80
16007A/B	Alligator Clip Leads	refer to 16005B	80
16008B	Resistivity Cell	4339A/B	74-75
16034E	SMD/Chip Test Fixture	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	14
16034G	SMD/Chip Test Fixture, Small	refer to 16034E	15
16034H	SMD/Chip Test Fixture, General	refer to 16034E	16
16043A/B	3-Terminal SMD Test Fixture	refer to 16034E	20-22
16044A	SMD/Chip Test Fixture, Four-Terminal, 10 MHz	refer to 16034E	17-18
16047A	Axial and Radial Test Fixture	refer to 16034E	10
16047D	Axial and Radial Test Fixture	refer to 16034E	11
16047E	Axial and Radial Test Fixture, 110 MHz	refer to 16034E	12
16048A	One Meter Test Leads, BNC	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A	26
16048B	One Meter Test Leads, SMC	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4288A	26
16048D	Two Meter Test Leads, BNC	4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A	27
16048E	Four Meter Test Leads, BNC	4263A/B, 4284A	27
16048G	One Meter Test Leads, BNC, 110 MHz	4294A	28
16048H	Two Meter Test Leads, BNC, 110 MHz	4294A	28
16060A	Transformer Test Fixture	4263A/B (w/Option 001)	13
16064B	LED Display/Trigger Box	4263A/B, 4338A/B, 4339A/B, 4349A/B	81
16065A	Ext. Voltage Bias with Safety Cover (≤ 200 vdc)	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	32

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Model Number	Name	Applicable Measurement Instrument (s)	Page (s)
16065C	External Bias Adapter (≤40 vdc)	4263A/B, 4268A, 4278A, 4288A	32
16085B	Four-Terminal Pair to 7 mm Adapter	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A	5
16089A/B /C/D/E	Kelvin Clip Leads	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	23-25
16092A	RF Spring Clip : Axial, Radial and SMD	4192A, 4193A, 4194A, 4194A + 41941A, 4195A 41951A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4286A, 4287A, 4288A, 4291A/B, 4294A + 42942A, 4396A/B (Opt. 010) + 43961A, 4395A (Opt. 010) + 43961A, E4991A	45
16093A	RF Two Terminal Binding Post	refer to 16092A	46
16093B	RF Three Terminal Binding Post	refer to 16092A	47
16094A	RF Probe Tip/Adapter	refer to 16092A	64
16095A	LF Impedance Probe	4192A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A	30
16117B	Low Noise Test Leads	4339A/B	72
16117C	Low Noise Test Leads	4339A/B	73
16117E	Low Noise Test Leads	4349A/B	73
16118A	SMD/Chip Tweezers	4339A/B	71
16143B	Mating Cable	4338A/B	79
16190B	Performance Test Kit	E4991A, 4286A, 4291A, 4287A, 4291B, 4294A+ 42942A	82
16191A	Bottom-Electrode SMD Test Fixture	4192A, 4193A, 4194A, 4194A + 41941A, 4195A + 41951A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4286A, 4287A, 4288A, 4291A/B, 4294A + 42942A, 4396A/B (Opt. 010) + 43961A, 4395A (Opt. 010) + 43961A, E4991A	48-49
16192A	Parallel Electrode SMD Test Fixture	refer to 16191A	50-51
16194A	High Temperature Component Text Fixture	refer to 16191A	52-53
16196A/B/C	Parallel Electrode SMD Test Fixure	refer to 16191A	54-60
16197A	Bottom Electrode SMD Test Fixure	refer to 16191A	61-63

Model Number	Name	Applicable Measurement Instrument (s)	Page (s)
16200B	External DC Bias Adapter	4286A, 4287A, 4291A/B, 4396A/B w/opt.010+43961A 4395A w/opt.010+43961A, E4991A	65
16314A	Four-Terminal Balun	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	29
16334A	SMD/Chip Tweezers	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	19
16338A	Test Lead Kit for 4338A/B	4338A/B	78
16339A	Component Test Fixture for 4339A/B	4339A/B	70
16380A	C Standards Set	4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A, 4192A, 4194A, 4263A	83
16380C	C Standards Set	4263B, 4268A, 4278A, 4284A, 4288A, 4294A, 4194A, 4263A	84
16451B	Dielectric Material Test Fixture	4192A, 4194A, 4263A/B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A	38-41
16452A	Liquid Test Fixture	4194A, 4284A, 4285A ,4294A	42-43
16453A	Dielectric Material Test Fixture	4291A/B	66
16454A	Magnetic Material Test Fixture	4291A/B, 4294A	67-68
42030A	Four-Terminal Pair Standard Resistor Set	4263B, 4268A, 4284A, 4294A, 4338B, 4192A, 4263A, 4338A	85
42090A	Open Termination	4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4288A, 4294A, 4192A, 4263A	86
42091A	Short Termination	4263B, 4268A, 4278A, 4279A, 4284A, 4285A, 4294A, 4338B, 4192A, 4263A, 4338A	86
42841A	Bias Current Source	4284A, 4285A (w/option 002)	33
42842A/B	Bias Current 20A/40A Test Fixture	4284A (w/option 002)	34-35
42842C	Bias Current 10A Test Fixture	4285A (w/option 002)	36
42843A	Bias Current Cable	4284A (w/option 002)	37
P/N 42851-61100	SMD Test Fixture	4285A (w/option 002)	36
42941A	Impedance Probe Kit	4294A	31
42942A	Four-Terminal Pair to 7 mm Adapter	4294A	5

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Test Fixture Selection By SMD Size

Size ¹	Fixture Contacts	4-Terminal Pair (up to 110MHz)	7mm (up to 3GHz)
0201(inch)/0603(mm)	Parallel	16034G	16196C
	Bottom	–	16197A ²
0402(inch)/1005(mm)	Parallel	16034G	16196B, 16192A ³
	Bottom	–	16197A
0603(inch)/1608(mm)	Parallel	16034E ⁴ /G, 16044A ⁵	16196A, 16192A ³
	Bottom	–	16197A
0805(inch)/2012(mm)	Parallel	16034E ⁴ /G, 16044A ⁵	16192A ³
	Bottom	16043A/B	16197A, 16191A ³
1210(inch)/3225(mm)	Parallel	16034E ⁴ /G, 16044A ⁵	16192A ³
	Bottom	16043A/B	16197A, 16191A ³
Larger sizes ⁶	Parallel	16034E ⁴ /G, 16044A ⁵	16192A ³
	Bottom	16043A/B	16191A ³

Notes:

1. Sizes are in EIA/EIAJ SMD size codes.
2. Requires option 001
3. $f \leq 2$ GHz
4. $f \leq 40$ MHz
5. $f \leq 10$ MHz
6. Please see the descriptions of the fixtures to find out the maximum DUT size

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Accessories vs. Instruments Matrix

Test Accessories / Fixtures			4263B	4268A	4279A	4284A	4285A	4287A	4288A	4294A	4294A with 42942A	4395A with opt 010 and 43961A	4396B with opt 010 and 43961A	E4991A
16034E	SMD/Chip Test Fixtures	DC-40MHz	●	●	●	●	●		●	●				
16034G	SMD/Chip Test Fixture, Small	DC-110MHz	●	●	●	●	●		●	●				
16034H	SMD/Chip Test Fixture, Array	DC-110MHz	●	●	●	●	●		●	●				
16043A/B	3-Terminal SMD Test Fixture	DC-110MHz	●	●	●	●	●		●	●				
16044A	SMD/Chip Test Fixture, Kelvin Contacts, 10MHz	DC-10MHz	●	●	●	●	●		●	●				
16047A	Axial and Radial Test Fixture	DC-13MHz	●	●	●	●	●		●	●				
16047D	Axial and Radial Test Fixture	DC-40MHz	●	●	●	●	●		●	●				
16047E	Axial and Radial Test Fixture,110MHz	DC-110MHz	●	●	●	●	●		●	●				
16048A	One Meter Test Leads, BNC	DC-30MHz	●	●	●	●	●		●					
16048B	One Meter Test Leads, SMC	DC-30MHz	●	●	●	●			●					
16048D	Two Meter Test Leads, BNC	DC-30MHz	●	●	●	●	●		●					
16048E	Four Meter Test Leads, BNC	DC-1MHz	●			●								
16048G	One Meter Test Leads, BNC, 110MHz	DC-110MHz								●				
16048H	Two Meter Test Leads, BNC, 110MHz	DC-110MHz								●				
16060A	Transformer Test Fixture	DC-100kHz	●											
16065A	Ext. Voltage Bias with Safety Cover (<=200 vdc)	50Hz-2MHz	●	●	●	●	●		●	●				
16065C	External Bias Adapter (<=40 vdc)	50Hz-1Mz	●	●					●					
16085B	Four-Terminal Pair to 7mm Adapter	DC-40MHz	●	●	●	●	●		●					
16089A/B/C/D/E	Kelvin Clip Leads	5Hz-100kHz	●	●	●	●	●		●	●				
16092A	RF Spring Clip : Axial, Radial and SMD	DC-500MHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16093A	RF Two Terminal Binding Post	DC-250MHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16093B	RF Three Terminal Binding Post	DC-125MHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16094A	RF Probe Tip/Adapter	DC-125MHz	● ^{1,2}	● ^{1,2}	● ^{1,2}	● ^{1,2}	● ^{1,2}	● ^{1,2}	● ^{1,2}		● ²	● ²	● ²	● ²
16095A	LF Impedance Probe	DC-13MHz	● ³	● ³	● ³	● ³	● ³		● ³					
16191A	Side (Bottom) Electrode SMD Test Fixture	DC-2GHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16192A	Parallel Electrode SMD Test Fixture	DC-2GHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16194A	High Temperature Component Text Fixture	DC-2GHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16196A/B/C	Parallel Electrode SMD Test Fixture	DC-3GHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16197A	Bottom Electrode SMD Test Fixture	DC-3GHz	● ¹	● ¹	● ¹	● ¹	● ¹	● ⁴	● ¹		●	●	●	●
16200B	External DC Bias Adapter	1MHz-1GHz						● ⁴			●	●	●	●
16314A	4-Terminal Balun (50 Ohm Bal. to 50 Ohm Unbal.)	100Hz-10MHz	●	●	●	●	●		●	●				
16315A	One Terminal (BNC) Balun (50 Ohm Bal. to 50 Ohm Unbal.)	100Hz-10MHz										●	●	
16316A	One Terminal (BNC) Balun (100 Ohm Bal. to 50 Ohm Unbal.)	100Hz-10MHz										●	●	
16317A	One Terminal (BNC) Balun (600 Ohm Bal. to 50 Ohm Unbal.)	100Hz-3MHz										●	●	
16334A	SMD/Chip Tweezers	DC-15MHz	●	●	●	●	●		●	●				
16451B	Dielectric Material Test Fixture	5Hz-30MHz	●	●	●	●	●		●	●				
16452A	Liquid Test Fixture	20Hz-30MHz				●	●		●					
16453A	Dielectric Material Test Fixture	1MHz-1GHz												●
16454A	Magnetic Material Test Fixture	1kHz-1GHz									●			●
42842A/B	High Bias Current 20A/40Test Fixture	20Hz-1MHz				●								
42842C	High Bias Current 10A Test Fixture	75kHz-30MHz					●							
42941A	Impedance Probe Kit	DC-110MHz								●				
42942A	Four-Terminal Pair to 7mm Adapter	DC-110MHz								●				

Note : Refer to the accessory descriptions for frequency and operational limits. ¹ Compatible when used in conjunction with 16085B.

² 7mm to 7mm cable is required ³ Do not connect the ground lead to the instrument

⁴ 3.5mm to 7mm Adapter is required



**Agilent Technologies’
Test and Measurement Support, Services,
and Assistance**

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent’s overall support policy: “Our Promise” and “Your Advantage.”

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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