

Agilent 16452A Liquid Test Fixture  
**Operation and Service Manual**



**Agilent Technologies**

**Agilent Part No. 16452-90000  
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**Third Edition**

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## Manual Printing History

The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates that are incorporated at reprint do not cause the date to change.) The manual part number changes when extensive technical changes are incorporated.

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## Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific **WARNINGS** given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.

*The Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.*

### **DO NOT Operate In An Explosive Atmosphere**

Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a safety hazard.

### **Keep Away From Live Circuits**

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

### **DO NOT Service Or Adjust Alone**

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

### **DO NOT Substitute Parts Or Modify Instrument**

Because of the danger of introducing additional hazards, do not substitute parts or perform unauthorized modifications to the instrument. Return the instrument to a Agilent Technologies Sales and Service Office for service and repair to ensure the safety features are maintained.

### **Dangerous Procedure Warnings**

**Warnings**, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

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#### **Warning**



**Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting this instrument.**

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The voltage levels found in this test fixture when used with the intended instruments do not warrant more than normal safety precautions for operator safety.

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## Operating Precaution

Do not exceed the operating input power, voltage, and current level and signal type appropriate for the instrument being used, refer to your instrument's operation manual.

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### Caution



Electrostatic discharge (ESD) can damage the highly sensitive microcircuits in your instrument. ESD damage is most likely to occur as the test fixtures are being connected or disconnected. Protect them from ESD damage by wearing a grounding strap that provides a high resistance path to ground. Alternatively, ground yourself to discharge any static charge built-up by touching the outer shell of any grounded instrument chassis before touching the test port connectors.

Never touch the test fixture contacts.

Use a work station equipped with an anti-static work surface.

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## Certification

Agilent Technologies certifies that this product met its published specifications at the time of shipment from the factory. Agilent Technologies further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institution's calibration facility, or to the calibration facilities of other International Standards Organization members.

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## Warranty

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For warranty service or repair, this product must be returned to a service facility designated by Agilent Technologies. Buyer shall prepay shipping charges to Agilent Technologies and Agilent Technologies shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Agilent Technologies from another country.

Agilent Technologies warrants that its software and firmware designated by Agilent Technologies for use with an instrument will execute its programming instruction when properly installed on that instrument. Agilent Technologies does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

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## **Limitation Of Warranty**

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

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*The remedies provided herein are buyer's sole and exclusive remedies. Agilent Technologies shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.*

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## **Assistance**

Product maintenance agreements and other customer assistance agreements are available for Agilent Technologies products.

For any assistance, contact your nearest Agilent Technologies Sales and Service Office. Addresses are provided at the back of this manual.

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## Safety Symbols

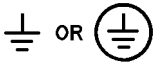
General definitions of safety symbols used on equipment or in manuals.



Instruction manual symbol: the product is marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.



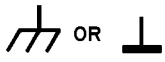
Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with wiring terminals to indicate the terminal which must be connected to ground before operating equipment.



Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (Operation) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.



Alternating current (power line).



Direct current (power line).



Alternating or direct current (power line).

### Warning



**Warning** denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

### Caution



**Caution** sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result damage to or destruction of part or all of the product.

### Note



**Note** denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

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## Typeface Conventions

### *Italics*

Italic type is used for emphasis and for titles of manuals and other publications.

Italic type is also used for keyboard entries when a name or a variable must be typed in place of the words in italics. For example: copy *filename* means to type the word *copy*, to type a space, and then to type the name of a file such as *file1*.

### Computer

Computer font is used for on-screen prompts and messages.

### **HARDKEYS**

Labeled keys on the instrument front panel are enclosed in **□**.

### **SOFTKEYS**

Softkeys located to the right of the CRT are enclosed in **▣**.



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# General Information

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## Introduction

The purpose of this manual is to enable you to use your 16452A Liquid Test Fixture efficiently and confidently.

## Manual Summary

This manual contains the following:

- The specifications of the 16452A (see this chapter).
- Inspecting the 16452A (see Chapter 2).
- Operating the 16452A (see Chapter 3).
- Ordering replaceable parts for the 16452A (see Chapter 4).

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## Product Description

The 16452A Liquid Test Fixture provides accurate dielectric constant and impedance measurements of liquid materials. This fixture allows you to make frequency swept measurements or temperature coefficient measurements that precisely characterize liquid materials.

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## Applicable Instrument

The 16452A has been designed to operate specifically with the following LCR meters and impedance analyzers:

- 4194A Impedance/Gain-Phase Analyzer
- 4284A Precision LCR Meter
- 4285A Precision LCR Meter

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## Accessories

### Furnished Accessories

See Table 2-1 for the accessories supplied with the 16452A.

### Recommended Measurement Cables\*

You need a 4-terminal BNC cable to connect the 16452A and your measurement instrument. For this purpose, Agilent Technologies recommends using the following cables.

For the temperature range of 0 to +55°C	16048A Test leads
For the temperature range of -20 to +125°C	16452-61601 Test leads

\* These cables are not furnished with the 16452A. Order according to your measurement requirements.

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## Specifications

This section lists the complete 16452A specifications. These specifications are the performance standards and limits against which the 16452A is tested. When shipped from the factory, the 16452A meets the following specifications:

<b>Electrode Size (S)</b> .....	$\phi 38 \pm 0.5$ (mm)
<b>Dimension</b> .....	85 (H) $\times$ 85 (W) $\times$ 37 (D) (mm)

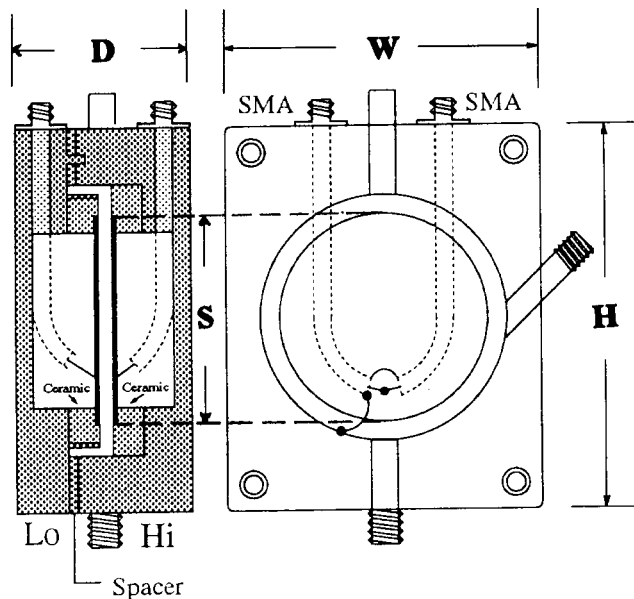


Figure 1-1. Electrode Size of the 16452A (section view)

<b>Weight</b> .....	1.4 kg
<b>Maximum Operating Voltage</b> .....	30 Vrms

**Operating Frequency** ..... 20 Hz to 30 MHz

The operating frequency differs according to the instrument that the 16452A is used with.

With the 4194A ..... 100 Hz to 15 MHz

With the 4284A ..... 20 Hz to 1 MHz

With the 4285A ..... 75 kHz to 30 MHz

**Materials**

Test fixture body (electrodes, spacers, liquid inlet and outlet)

Nickel-plated cobal (Fe 54%, Co 17%, Ni 29%)

Insulator ..... Ceramic (alumina  $Al_2O_3$ )

O-ring ..... Viton (Fluoro rubber)

Insulator soldering ..... Silver-copper and gold-copper

The typical corrosive characteristics of these materials are shown in Appendix A.

**Operating Temperature** ..... -20 to +125°C

The measurement cable's operating temperature is:

16048A ..... 0 to +55°C

16452-61601 ..... -20 to +125°C

**Non-Operating Temperature** ..... -40 to 70°C

## Supplemental Performance Characteristics

This section lists supplemental performance characteristics. Supplemental performance characteristics are not specifications, but are typical characteristics included as additional information for the operator. Supplemental performance characteristics are not guaranteed.

### Electrode gap repeatability (Screw torque: 15 kgf·cm)

Assembly repeatability ..... See Table 1-1.  
 Temperature repeatability (@ 23°C to 125°C) ..... See Table 1-1.

**Necessary liquid volume** ..... See Table 1-1.

**Air Capacitance Value (@ 23 °C ± 5 °C, 1 MHz)** ..... See Table 1-1.

**Table 1-1. Typical Data**

Spacer thickness	1.3 mm	1.5 mm	2.0 mm	3.0 mm
<b>Electrode gap assembly repeatability</b>	0.3 mm±12 μm	0.5 mm±12 μm	1.0 mm±12 μm	2.0 mm±12 μm
<b>Electrode gap temperature repeatability</b>	0.3 mm±2 μm	0.5 mm±2 μm	1.0 mm±2 μm	2.0 mm±2 μm
<b>Necessary liquid volume</b>	3.4 cc	3.8 cc	4.8 cc	6.8 cc
<b>Air capacitance value</b>	34.9 pF ±25%	21.2 pF ±15%	10.9 pF ±10%	5.5 pF ±10%

### Short residual (when using the furnished shorting plate with a 1.3 mm spacer)

Ls (equivalent series inductance) ..... 20 nH  
 Rs (equivalent series resistance) ..... 0.5 Ω

**Temperature expansion coefficient** ..... ≤ ±300ppm/°C

### Additional impedance measurement error

In the following measurement,

- The SHORT compensation is done.
- The calculation is done using the capacitive measurement method (see “Capacitive Measurement Method” in Chapter 3).
- The measurement instrument is an 4194A, 4284A, or 4285A
- The relative dielectric constant is  $1 < |\epsilon_r| < 500$

The fixture error\* is defined by:

$$\text{Error} = A + B [\%] \text{ (See Figure 1-4)}$$

Where,

- A : Obtained from Figure 1-2.
- B : Obtained from Figure 1-3.

\* The measurement accuracy is a complex function of the measurement instrument accuracy and the fixture error.



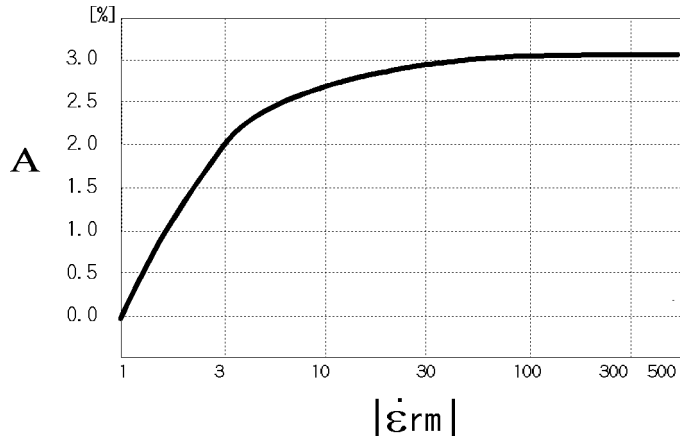


Figure 1-2. Fixture Error (A)

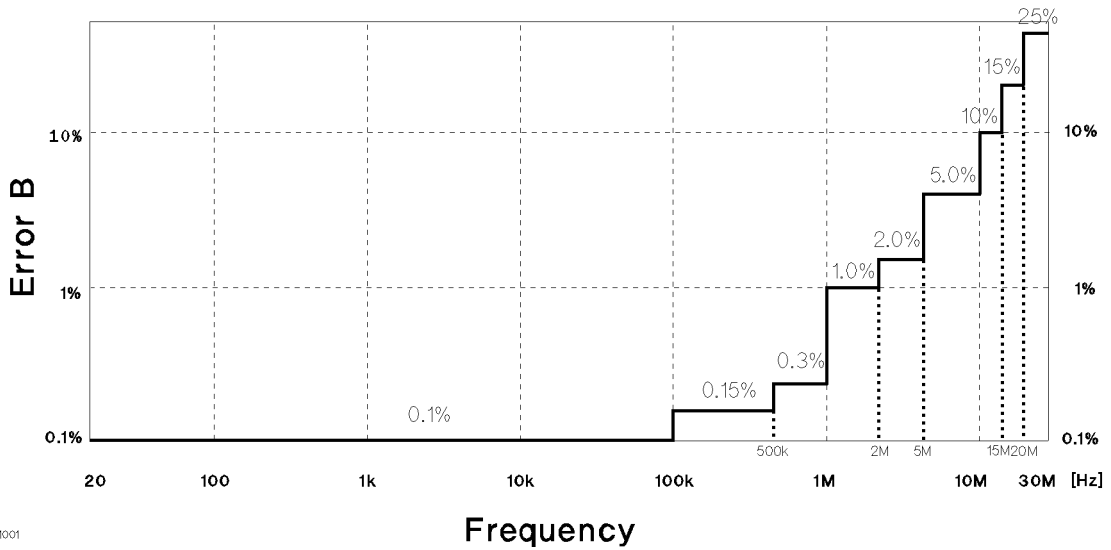
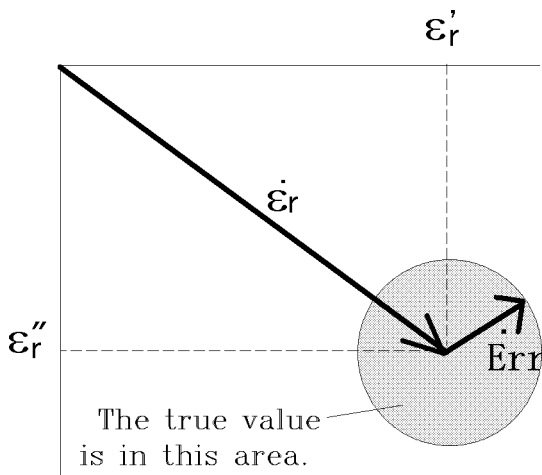


Figure 1-3. Fixture Error (B)



The true value is a vector sum of  $\dot{\epsilon}_r$  and  $\dot{\epsilon}_{err}$ .

Where,

$\dot{\epsilon}_r$  : Measurement result

$\dot{\epsilon}_{err}$  : Fixture Error

$$\frac{|\dot{\epsilon}_{err}|}{|\dot{\epsilon}_r|} \leq A+B[\%]$$

Figure 1-4. Fixture Error (A + B)



## Initial Inspection

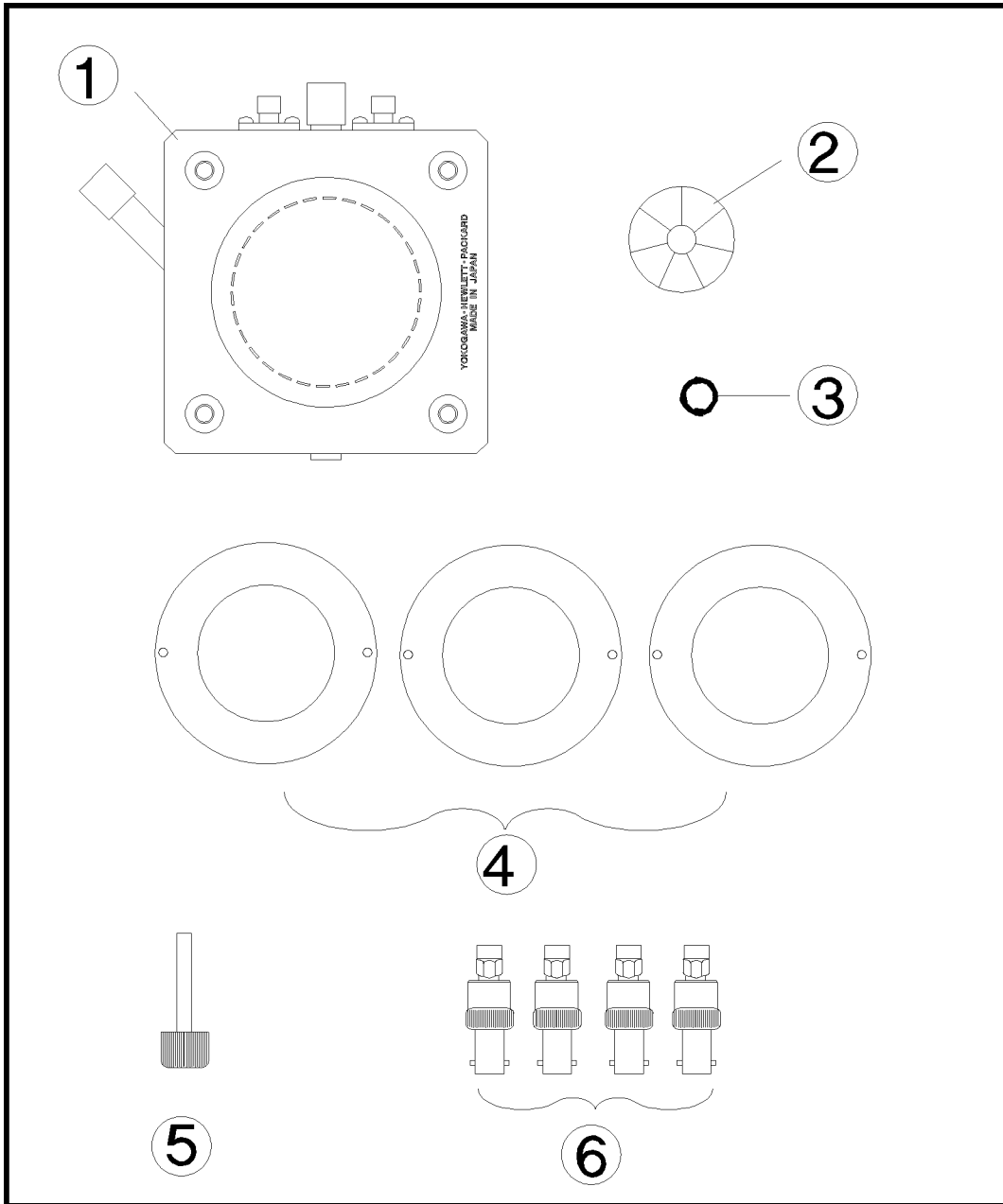
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### Introduction

The liquid test fixture has been carefully inspected before being shipped from the factory. It should be in perfect physical condition, no scratches, dents or the like. It should also be in perfect electrical condition. Verify this by carefully performing an initial inspection to check the liquid test fixture set for signs of physical damage and missing contents. If any discrepancy is found, notify the carrier and Agilent Technologies. Your Agilent Technologies sales office will arrange for repair or replacement without waiting for the claim to be settled.

- Inspect the shipping container for damage. Keep the shipping materials until the inspection is completed.
- Verify that the shipping container contains everything shown in Figure 2-1 and listed in Table 2-1.
- Inspect the exterior of the 16452A for any signs of damage.

# Product Overview



AD002002

Figure 2-1. 16452A Product Overview

**Table 2-1. Contents**

Reference Designator	Description	Part Number	Quantity
①	Liquid test fixture	16452A	1
—	O-ring for electrodes <sup>1</sup>	0905-1275	2
②	Shorting plate	16092-08010	1
③	O-ring for liquid outlet	0905-1277	1
④	Spacer		
	1.3 mm (thickness) /0.3 mm (gap) <sup>2</sup>	16452-00601	1
	1.5 mm (thickness) /0.5 mm (gap)	16452-00602	1
	2.0 mm (thickness) / 1.0 mm (gap)	16452-00603	1
	3.0 mm (thickness) / 2.0 mm (gap)	16452-00604	1
⑤	Lid of liquid outlet	16452-24002	1
⑥	SMA-BNC adapter	1250-1200	4
—	Waterproof cap for BNC connector <sup>3</sup>	1252-5831	4
—	Carrying Case	16452-60101 <sup>4</sup>	1
—	Operation and Service Manual <sup>4</sup>	16452-90000	1
—	Fixture stand <sup>5</sup>		
	Stand body	— <sup>6</sup>	1
	Screw for stand	0515-0914	4
	Stand foot	16452-00611	1

1 The O-rings are assembled in the 16452A.

2 The 1.3 mm spacer is assembled in the 16452A.

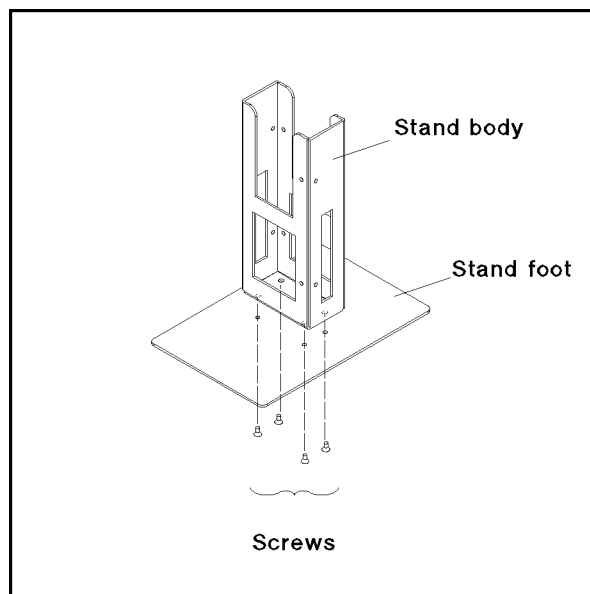
3 The cap is on the SMA-BNC adapter.

4 The carrying case and the *Operation and Service Manual* are not shown in the Figure 2-1.

5 The fixture stand is shown in Figure 2-2. Assemble it as shown in the figure.

6 The stand body is assembled using the two angle irons (16452-01201), and the four screws (0515-0914).

If you ordered a measurement cable (16048A, or 16452-61601), check that the cable is included.



AD002001

**Figure 2-2. Assembling the Fixture Stand**

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## Repackaging the Test Fixture For Shipment

If shipment to a Agilent Technologies service center is required, each test fixture should be repackaged using the original factory packaging materials.

If this material is not available, comparable packaging materials may be used. Wrap the liquid test fixture in heavy paper and pack in anti-static plastic packing material. Use sufficient shock absorbing material on all sides of the 16452A to provide a thick, firm cushion and to prevent movement. Seal the shipping container securely and mark it *FRAGILE*.

## Operation

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### Introduction

This chapter describes how to measure the dielectric constant ( $\epsilon$ ) of the liquid using the 16452A.

- The standard measurement sequence is shown in this chapter.
- Some instructions for the temperature measurement are provided at the back of the chapter.

### Measurement Sequence

Relative permittivity ( $\epsilon_r$ ) can be calculated from the ratio of the capacitance of a material to that of air (nearly equal to that of a vacuum). The standard measurement sequence is as follows:

1. Prepare the test fixture for use.
2. Connect the test fixture.
3. Check the SHORT residual.
4. Set the instrument for capacitance measurement.
5. Do a SHORT compensation.
6. Do the air capacitance ( $C_0$ ) measurement.
7. Do the liquid capacitance and resistance ( $C_p$ ,  $R_p$ ) measurement.
8. Drain the liquid (after measurement).
9. Do the data processing—Calculate dielectric parameter from measurement data.

### Measurement Requirements

- To do the measurement, the following items are required:
  - 16452A liquid test fixture
  - Fixture stand (furnished with the 16452A)
  - SMA-BNC adapter (furnished with the 16452A)
  - Measurement cable (16048A or 16452-61601)
  - 1.3 mm spacer for the SHORT compensation (furnished with the 16452A)
  - Shorting plate for the SHORT compensation (furnished with the 16452A)
  - A spacer (choose one of the furnished four spacers)
  - Measurement instrument ( 4194A, 4284A, or 4285A)
  - Liquid under test (enough for the spacer you are using)
- In addition, the following items are useful:
  - For washing the 16452A, a brush, detergent, cloth, etc.
  - For high temperature measurements, gloves to prevent scalding.

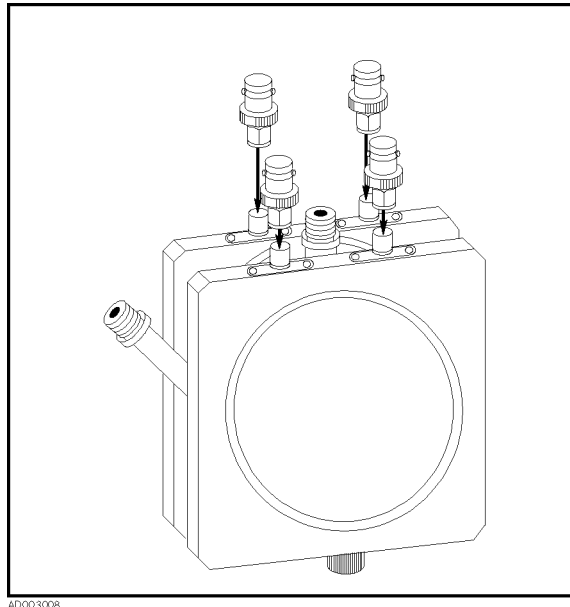
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## Preparation of Test Fixture for Use

Before connecting the test fixture, you must connect the SMA-BNC adapters to the 16452A terminals. Also, the spacer and shorting plate must be set between the electrodes for the SHORT compensation. The 16452A can be separated into High and Low electrodes to make it possible to set the spacer and the shorting plate. The test fixture's electrodes are easier to clean if you separate the electrodes.

### Connecting the SMA-BNC Adapters to the 16452A

Connect the SMA-BNC Adapters to the 16452A SMA-terminals as shown in Figure 3-1. The waterproof caps for the BNC connector should be on when washing the electrodes.

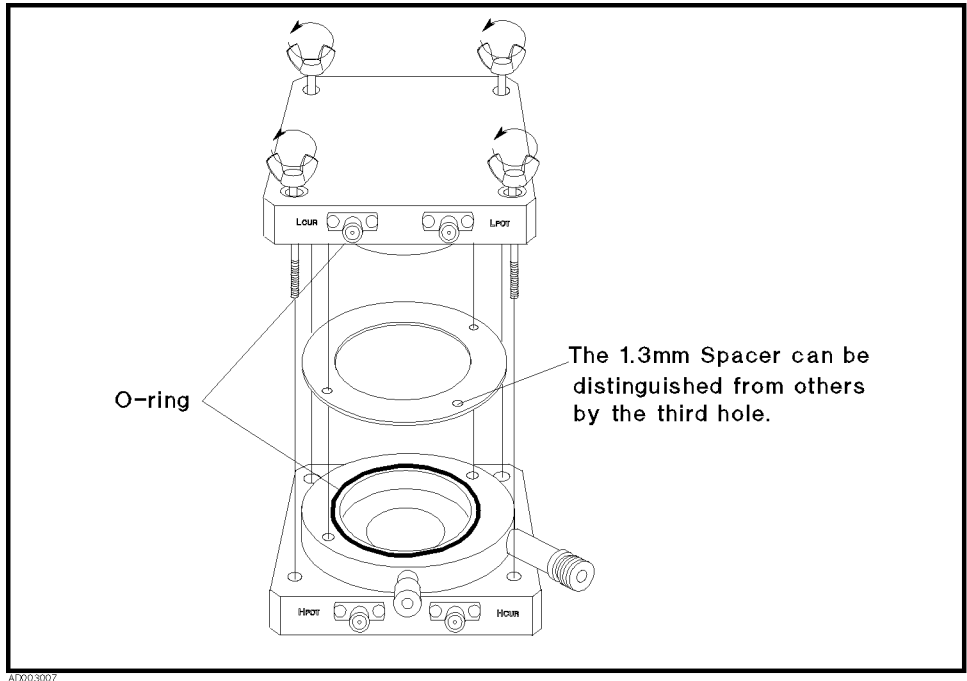


AD003008  
**Figure 3-1. Connecting the SMA-BNC Adapter**



## Separating the Test Fixture into High and Low Electrodes

Separate the test fixture as shown in Figure 3-2.



**Figure 3-2. Separating the Test Fixture into High and Low Electrodes**

## Cleaning and Drying the Electrodes

For the measurement, the 16452A electrodes must be clean. If the 16452A's electrodes are smeared, wash and dry them thoroughly before assembling.

### Caution



Do not use a detergent that corrodes the test fixture. For a list of the materials that are corrosive to the test fixtures, see Appendix A.

### Assembling the Test Fixture

Set the 1.3 mm spacer (electrode distance is 0.3mm) and the shorting plate as required. Then assemble the 16452A as shown in Figure 3-3.

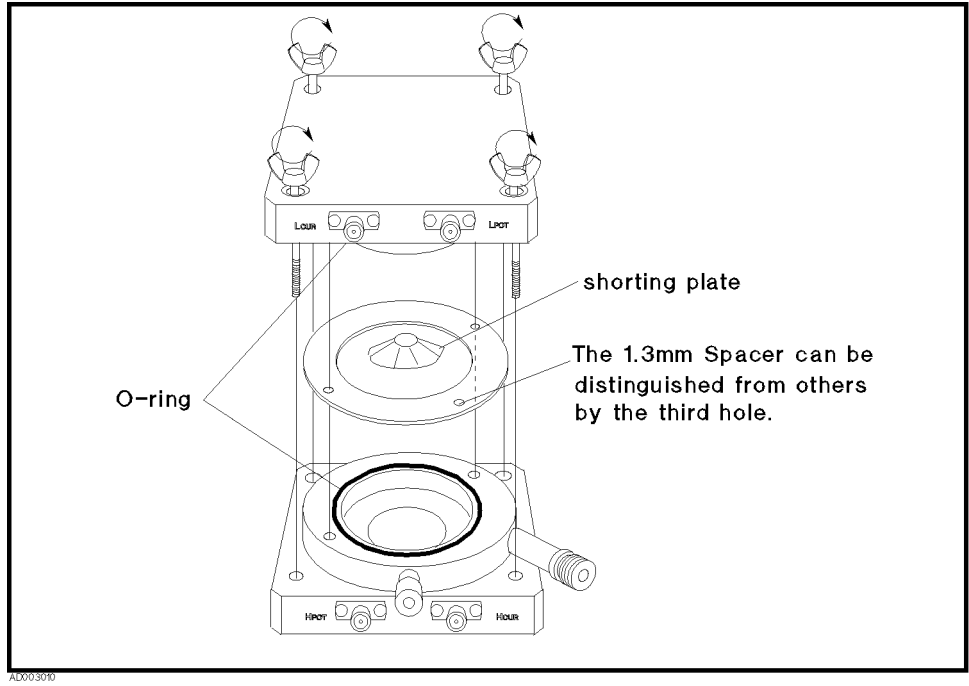


Figure 3-3. Assembling the Test Fixture for a SHORT Compensation

### Putting the Lid On the Liquid Outlet

Put the lid on the liquid outlet as shown in Figure 3-4.

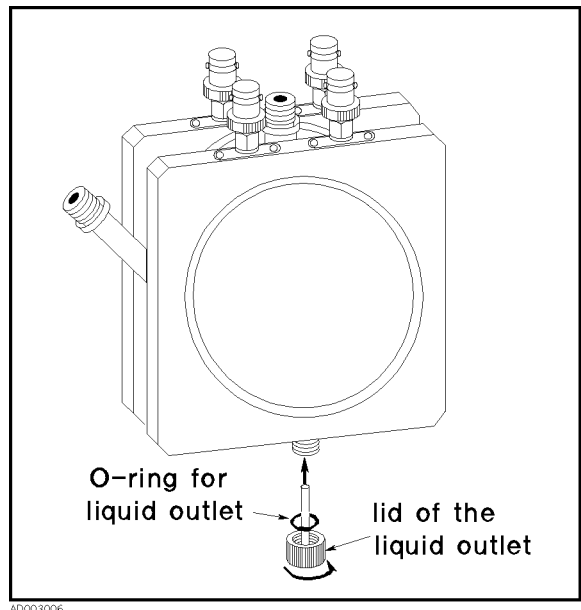


Figure 3-4. Putting the Lid On

## Connecting the Test Fixture

Use a 4-terminal-pair BNC cable to connect the 16452A and your measurement instrument. Agilent Technologies recommends using the following cables:

For the temperature range of 0 to +55°C                      16048A Test leads  
For the temperature range of -20 to +125°C                    16452-61601 Test leads

Select the cable that matches your measurement.

## Using the 4194A

1. Set the cable length.

When using the 16048A or 16452-61601 cable, set the cable length to 1 m, as follows:

Turn the 4194A OFF. Then set the Cable Length switch to 1 m (Figure 3-5). After setting the switch, turn the 4194A ON.

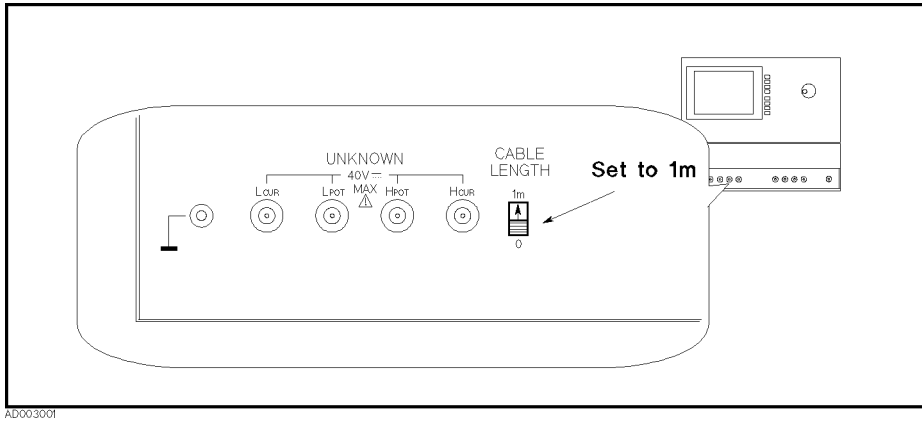


Figure 3-5. Cable length switch (4194A)

2. Take the BNC adapter caps off and connect the test fixture to the unknown terminal using the cables (L<sub>p</sub>: L<sub>POT</sub>, L<sub>c</sub>: C<sub>CUR</sub>, H<sub>p</sub>: H<sub>POT</sub>, H<sub>c</sub>: H<sub>CUR</sub>).

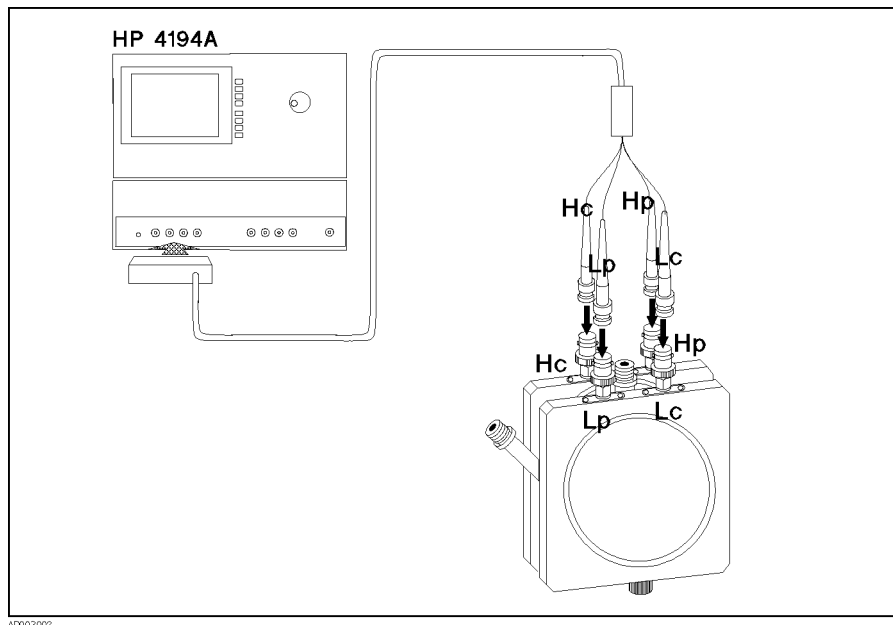


Figure 3-6. Connecting the Test Fixture (4194A)

## Using the 4284A/4285A

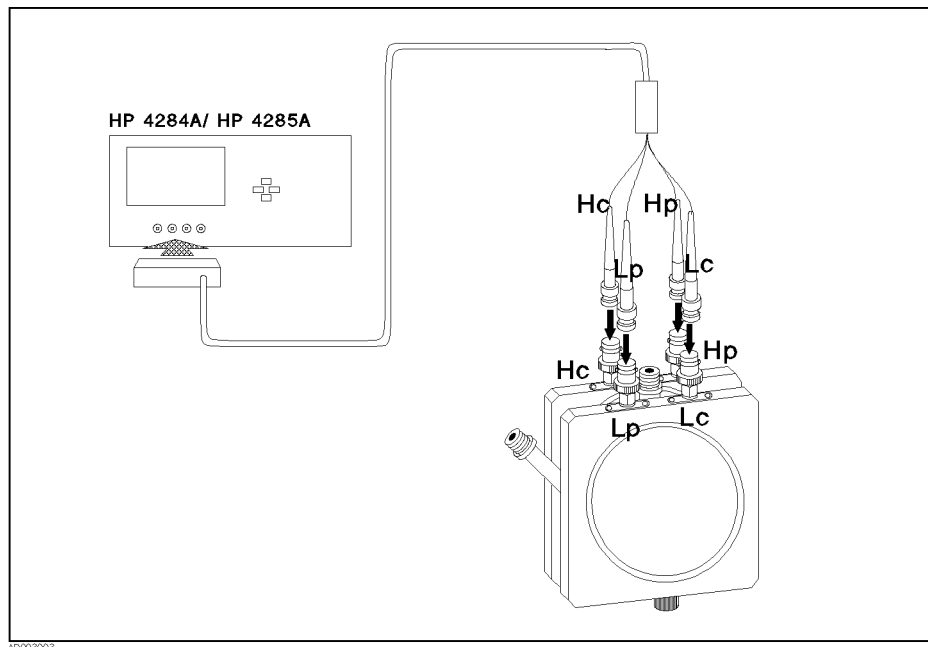
1. Set the cable length.

When using the 16048A or 16452-61601\* cable, set the cable length to 1 m, as follows:

- a. Press **MEAS SETUP** **CORRECTION**.
- b. Place the cursor on **CABLE** : using **←** **⇒** **↑** **↓**.
- c. Press **1m**.

When you use the test leads for the first time, you must perform the cable correction. For information on how to perform the correction, see the *4284A/4285A Operation Manual*.

2. Take the BNC adapter caps off and connect the test fixture to the unknown terminal using the cables (Lp: L<sub>POT</sub>, Lc: C<sub>CUR</sub>, Hp: H<sub>POT</sub>, Hc: H<sub>CUR</sub>).

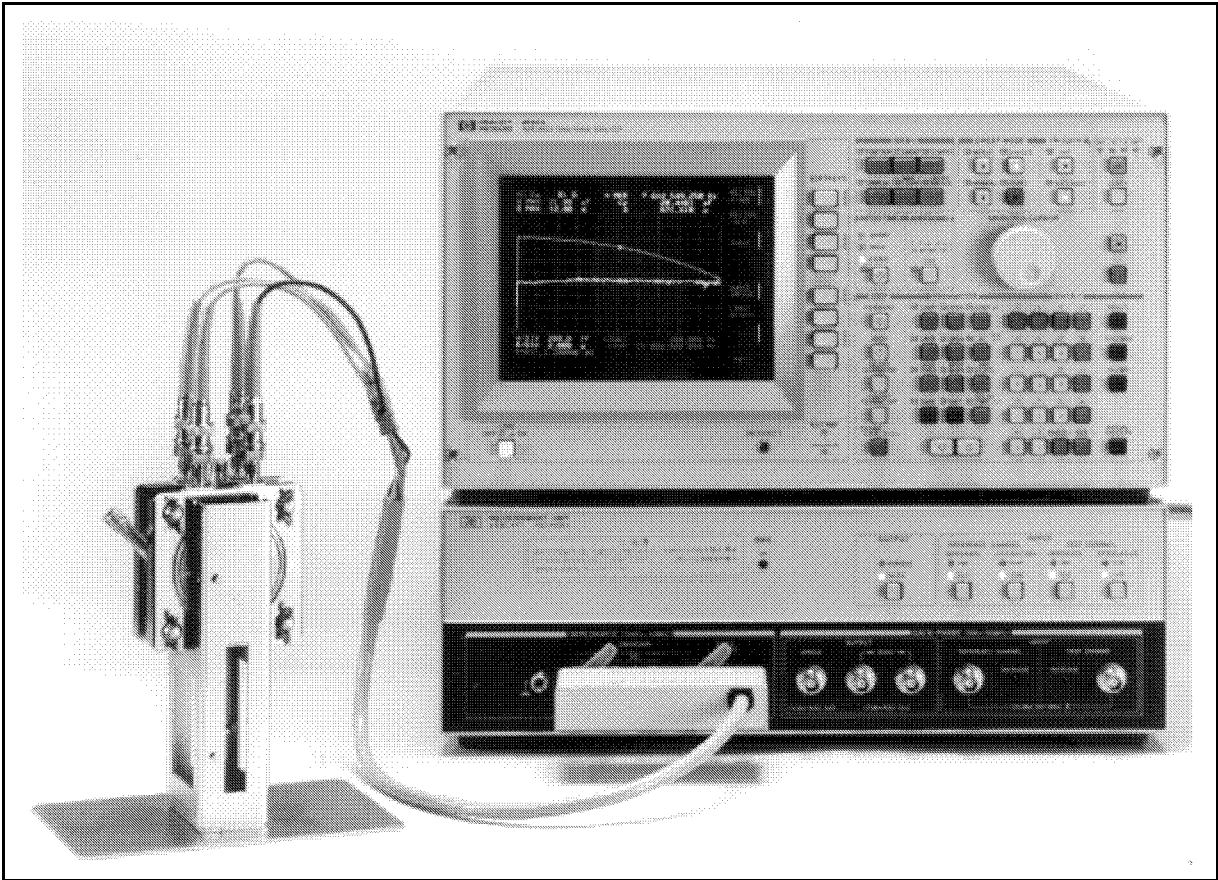


**Figure 3-7. Connecting the Test Fixture (4284A/4285A)**

\* The 16452-61601 cable can be used in the same manner as the 16048A cable with 4284A/4285A.

**Fixture Stand Usage**

The fixture stand sets the test fixture stable and upright as required during the measurement.



**Figure 3-8. Fixture Stand Usage**

---

## Checking the SHORT Residual

Before using the test fixture, you should check its electrical performance. You can confirm its performance by checking the SHORT residual. The SHORT residual must be measured with the compensation function OFF because the compensation cancels the SHORT residual.

### Using the 4194A

1. Set the compensation function OFF:
  - a. Press **COMPEN** **OPEN OFS on/off**. (When the softkey is dark, the compensation is OFF.)
  - b. Press **COMPEN** **SHRT OFS on/off**. (When the softkey is dark, the compensation is OFF.)
2. Select the measurement parameter “Ls-Rs”:
  - a. Press **FUNCTION** **IMPEDANCE Ls-Rs**.
3. Check the SHORT residual is the required value:
  - a. Press **DISPLAY** menu **AUTO SCALE A**.
  - b. Press **more 1/3** **AUTO SCALE B**.
  - c. Press **REPEAT** until the light is ON.
  - d. Check that the Ls and Rs value at 1 MHz is in the following range:

Ls < 20 nH Rs < 0.5 Ω
--------------------------

### Using the 4284A/4285A

1. Set the compensation function OFF:
  - a. Press **MEAS SETUP** **CORRECTION**.
  - b. Move the cursor to **OPEN :** and press **OFF**.
  - c. Move the cursor to **SHORT:** and press **OFF**.
  - d. Move the cursor to **LOAD :** and press **OFF**.
2. Select the measurement parameter “Ls-Rs”:
  - a. Press **DISPLAY FORMAT**.
  - b. Move the cursor to **FUNC :** and press **more 1/6 more 2/6 more 3/6 Ls-Rs**.
3. Check the SHORT residual value at 1 MHz is in the following range:

Ls < 20 nH Rs < 0.5 Ω
--------------------------

## If the SHORT Residual is Out of Range

1. Check the connection of the test fixture and the measurement cable. Also, check the shorting plate connection.
  - Is the spacer width in the 16452A 1.3 mm?
  - Does the shorting plate contact to both high and low electrodes?
  - Are the electrodes clean and free from rust?
2. If the problem cannot be corrected, please contact the nearest Agilent Technologies sales office.

---

## Setting the Instrument for Capacitance Measurement

To measure the dielectric constant ( $\epsilon$ ), the test fixture uses a capacitance-measurement method. This is done by measuring Cp (parallel equivalent capacitance) and Rp (parallel equivalent resistance) and then calculating the dielectric constant ( $\epsilon$ ) and the dielectric loss ( $\tan \delta$ ).

### Using the 4194A

1. Select the measurement parameter “Cp-Rp”:
  - a. Press **(FUNCTION)** **IMPEDANCE** **more 1/3** **more 2/3** **Cp-Rp**.
2. Select the other settings depending on each application.

### Using the 4284A/4285A

1. Select the measurement parameter “Cp-Rp”:
  - a. Place the cursor on FUNC using **(←)** **(→)** **(↑)** **(↓)**.
  - b. Press **Cp-Rp**.
2. Select the other settings depending on each application.

---

## Performing a SHORT Compensation

Confirm that the 1.3 mm spacer and the shorting plate are set as specified in the “Preparation of Test Fixture for Use”.

---

**Note** The OPEN and LOAD compensations are not required for the 16452A.



---

### Using the 4194A

1. Press **COMPEN** **ZERO SHORT** **(ENTER/EXECUTE)**.
2. Press **SHRT OFS ON**.

---

**Note** After the ZERO SHORT measurement, the 4194A goes to SINGLE SWEEP mode. To select the REPEAT SWEEP mode, press **(REPEAT)** until the light turns on.



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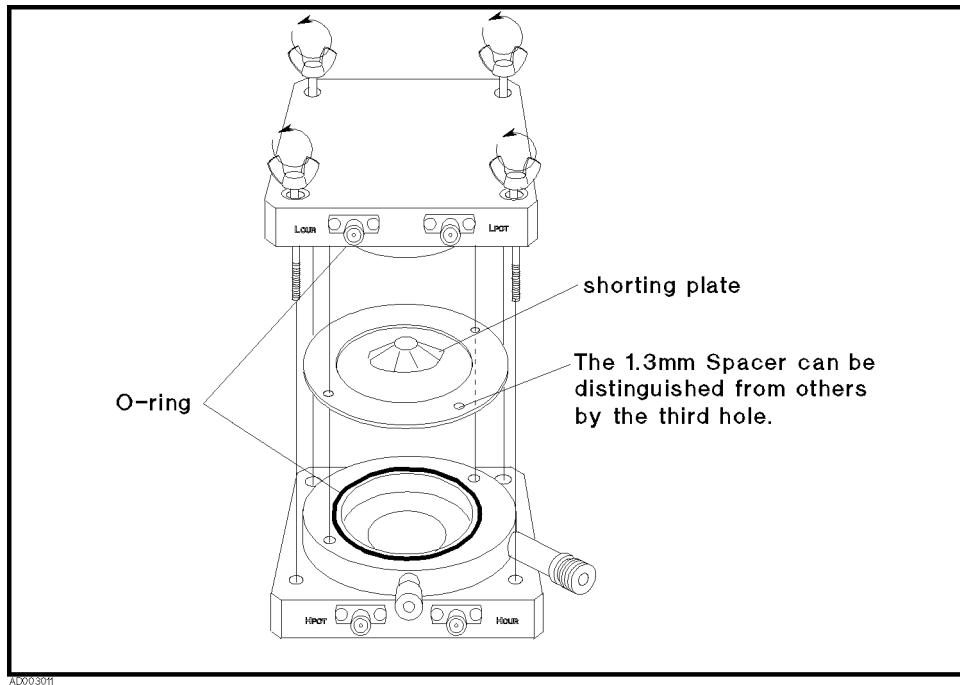
### Using the 4284A/4285A

1. Press **MEAS SETUP** **CORRECTION**.
2. Place the cursor on SHORT using **(←)** **(→)** **(↑)** **(↓)**.
3. Press **MEAS SHORT**.
4. After the SHORT measurement is completed, press **ON**.



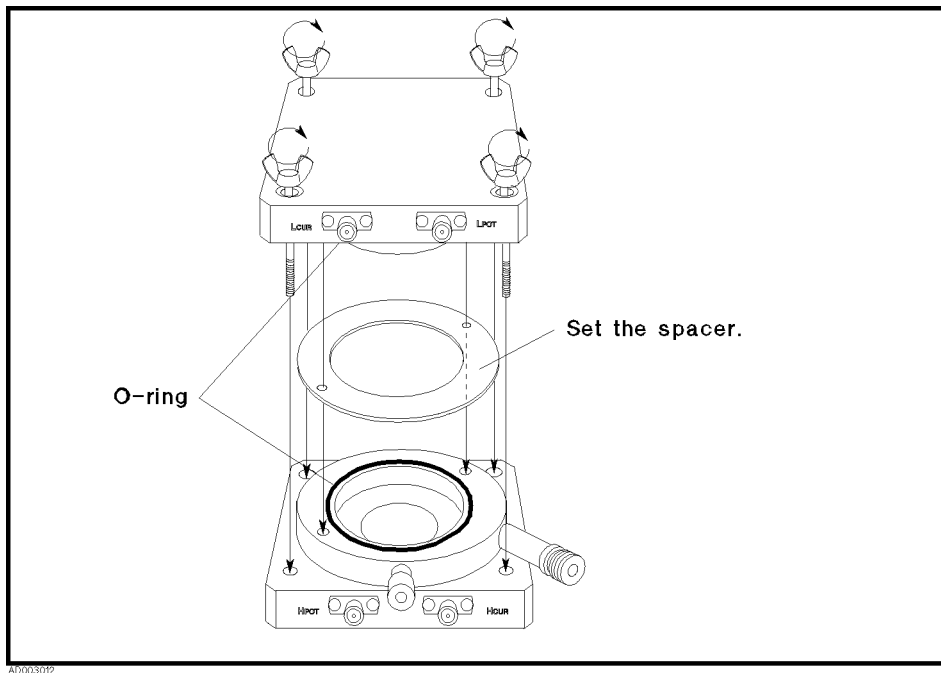
## Air Capacitance ( $C_0$ ) Measurement

1. Separate the test fixture as shown in Figure 3-9.



**Figure 3-9. Separating the Test Fixture into High and Low Electrodes**

2. Remove the shorting plate and select the spacer that is to be used to measure the liquid. Then assemble the test fixture.



**Figure 3-10. Test Fixture Assemble for Measurement**

3. Measure the air capacitance value ( $C_0$ ) and record the measurement data. The data is used to calculate the dielectric parameter.

**Note**



Compare the measured value with the value in the “Supplemental Characteristics” in Chapter 1.

If the value is not correct, check the following:

- Was the spacer correctly chosen and set?
- Are the O-rings set correctly?
- Are the high and low electrodes put tightly together?

Then perform the measurement procedure again

## Liquid Capacitance and Resistance ( $C_p$ , $R_p$ ) Measurement

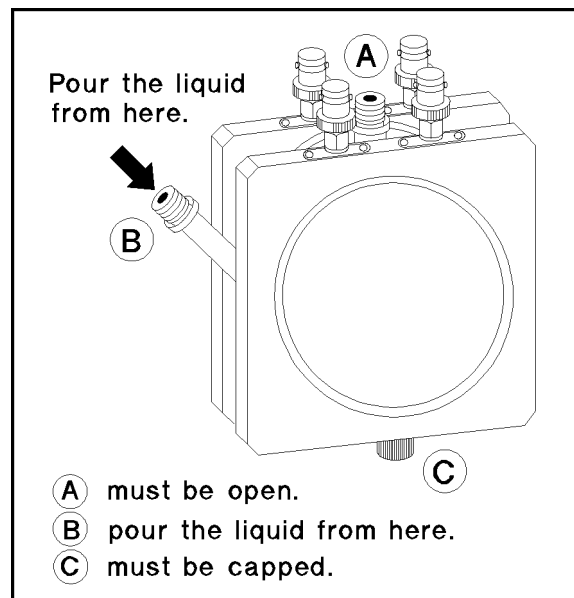
**Warning**



Be careful when dealing with liquids (especially volatile and/or flammable liquid such as oil or organic solvents) that can cause an accident. Accidents such as an explosion, ignition, emission of poison gas, scalding (by heat or chemicals), and so on, are possible

To prevent any accidents, establish a strict process for the measurements. (For example, using appropriate ventilation, a gas mask, and gloves.)

1. Pour the liquid under test into the 16452A until the liquid fills tube (B). Pour the liquid gently so that air does not get mixed in with the liquid.



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Figure 3-11. Pouring the Liquid under Test

---

**Warning**

**When you pour the liquid, be careful that the liquid does not leak from the test fixture.**

- **An 16452A assembled in the wrong manner (for example, lack of the O-rings or the spacer) will cause liquid leakage. Assemble the 16452A again if leakage is found.**

**If the problem cannot be corrected, please contact the nearest Agilent Technologies sales office.**

---

**Warning**

**DO NOT enclose the liquid in the 16452A. Carburetion of the liquid enclosed in the 16452A can cause an explosion of the 16452A.**

---

2. Measure the capacitance and equivalent parallel resistance value ( $C_p$ ,  $R_p$ ) of the liquid under test and record the measurement data. The data is used to calculate the dielectric parameter.
- 

**Warning**

**DO NOT apply a dc test signal to the 16452A. The dc signal can cause electrolysis of the liquid.**

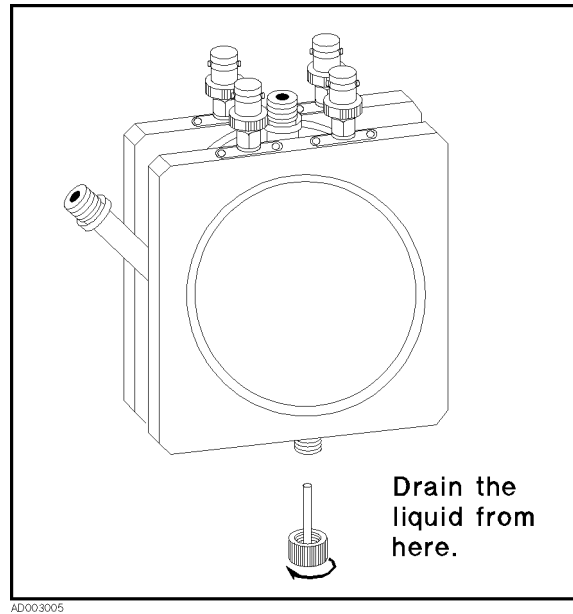
---

When you use the 16452A in a thermostatic chamber or an oil tank, see the “Performing Temperature Measurements” procedure.

---

## Drain the Liquid (After Measurement)

1. Turn the lid of the liquid outlet and take it off. Drain the liquid (Figure 3-12).



**Figure 3-12. Taking the Lid Off**

2. Wash and dry the test fixture.

---

## Data Processing—Calculate Dielectric Parameter from Measurement Data

The dielectric parameter ( $\epsilon$ ) is calculated from the following equation.

$$\dot{\epsilon}_r = \alpha \left( \frac{C_p}{C_0} - j \frac{1}{\omega C_0 R_p} \right) \quad (1)$$

Where,

$\alpha$	Correction coefficient (see next page)
$\dot{\epsilon}_r$	Relative dielectric constant (complex)
$C_p$	Liquid capacitance (measurement data)
$C_0$	Air capacitance (measurement data)
$R_p$	Equivalent parallel resistance (measurement data)
$\omega$	Angular frequency ( $\omega = 2\pi f$ )
$f$	Frequency

### Measurement Theory

The relative dielectric constant indicates the energy value of a material in an electric field. It is represented as a complex quantity. The relative dielectric constant ( $\dot{\epsilon}_r$ ) is defined as the ratio of the material's dielectric constant ( $\dot{\epsilon}$ ) to that of a vacuum ( $\epsilon_0 = 8.854 \times 10^{-12}$ ).

$$\dot{\epsilon}_r = \frac{\dot{\epsilon}}{\epsilon_0}$$

Also,

$$\dot{\epsilon}_r = \epsilon'_r - j\epsilon''_r \quad (2)$$

Loss tangent

$$\tan \delta = \frac{\epsilon''_r}{\epsilon'_r}$$

Where,

$\epsilon'_r$	Relative dielectric constant
$\epsilon''_r$	Dielectric loss

The 16452A and Agilent impedance analyzer/LCR meter use the “Capacitive Method” for obtaining relative permittivity by measuring the capacitance of a material that is sandwiched between parallel electrodes.

### Capacitive Measurement Method

The dielectric coefficient ( $\epsilon'_r$ ) and loss ( $\epsilon''_r$ ) can be calculated from the capacitance and electrode dimensions.

$$\epsilon'_r = \frac{t \times C_p}{A \times \epsilon_0}$$

$$\epsilon''_r = \frac{\sigma}{\omega \times \epsilon_0} = \frac{t}{\omega \times R_p \times \epsilon_0 \times A}$$

(Where, the conductivity  $\sigma = \frac{t}{A \times R_p}$ , A is area of electrode, t is gap between electrodes. )

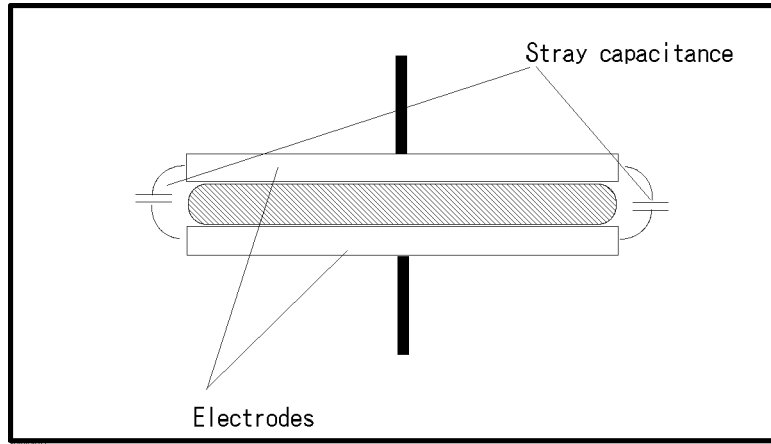
The dielectric constant of a vacuum ( $\epsilon_0$ ) is calculated from the capacitance of the vacuum (Approximately equal to air capacitance  $C_0$ ).

$$\epsilon_0 = \frac{t \times C_0}{A}$$

Therefore, the equation (2) can be rewritten in the same form as equation (1), when  $\alpha = 1$ .

### Correction Coefficient

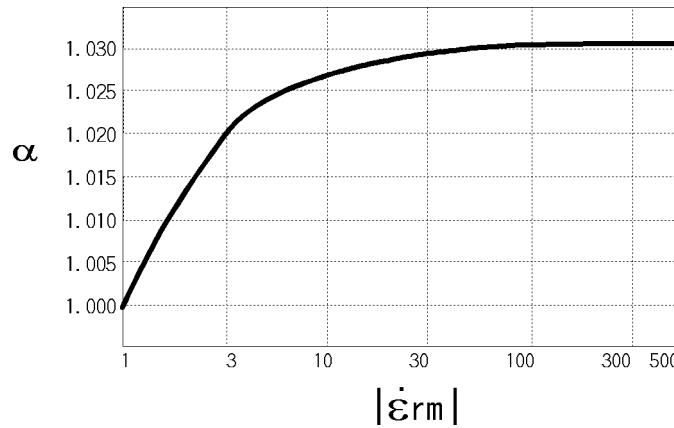
The measured data ( $C_p$ ,  $C_o$ ) contains the stray capacitance, which alters by the dielectric constant.



**Figure 3-13. Stray Capacitance**

The stray capacitance can be cancelled by multiplying the correction coefficient ( $\alpha$ ), as shown in equation (1). The value of  $\alpha$  is calculated by following equation.

$$\alpha = \frac{100|\dot{\epsilon}_{rm}|}{97.0442|\dot{\epsilon}_{rm}| + 2.9558}$$



**Figure 3-14. Correction Coefficient**

Where,  $\dot{\epsilon}_{rm}$  is the right side of equation (1), enclosed by ( ).

$$\dot{\epsilon}_{rm} = \frac{C_p}{C_o} - j \frac{1}{\omega C_o R_p}$$

Therefore,

$$|\dot{\epsilon}_{rm}| = \sqrt{\frac{C_p^2}{C_o^2} + \frac{1}{(\omega C_o R_p)^2}}$$

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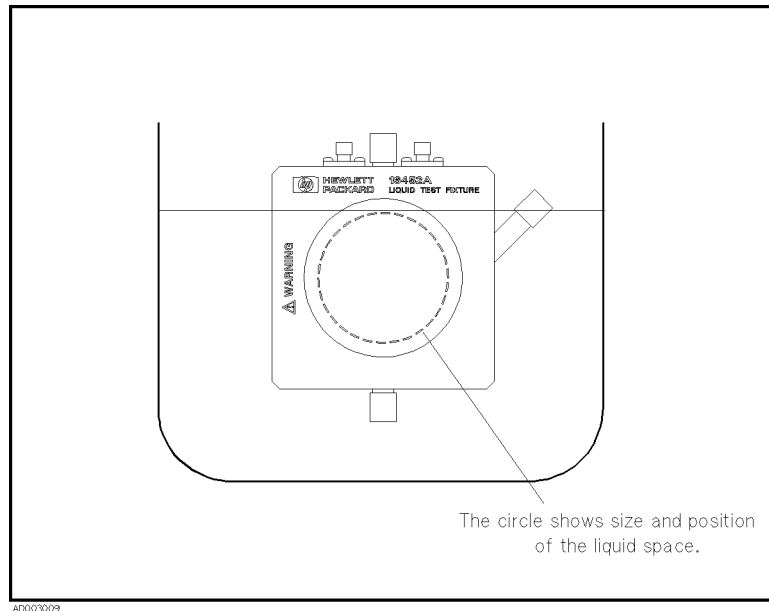
## Performing Temperature Measurements

The following information is provided for users who use the 16452A in a thermostatic chamber or an oil tank.

- The 16452A is specified to operate in the temperature range of  $-20$  to  $125^{\circ}\text{C}$ . You should be aware not only of the heat resisting property of the 16452A, but also that of the measurement cable. The heat resisting properties of the Agilent Technologies-recommended cables are:

0 to $+55^{\circ}\text{C}$	16048A
$-20$ to $+125^{\circ}\text{C}$	16452-61601

- When you use the thermocouple to monitor the inside temperature of the test fixture, be careful not to short the electrodes.
- When you use the 16452A in an oil tank, soak the whole circle shown in Figure 3-15 (the circle shows the size and position of the liquid space of the 16452A).



**Figure 3-15. Soaking the 16452A in the Oil Tank**

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### Warning



**DO NOT touch the heated test fixture, cable, and fixture stand with your naked hand. Use gloves to prevent scalding.**





# Service

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## Introduction

This chapter covers assembly replacement and troubleshooting information.

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**Warning**

**These servicing instructions are for use by qualified personnel only. Do NOT perform any servicing (other than that contained in the operating section) unless you are qualified to do so.**

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## Assembly Replacement

Table 4-1, Table 4-2, and Table 4-3 list the replaceable parts for the 16452A. The parts listed can be ordered from your nearest Agilent Technologies Office. Ordering information must include the Agilent part number and the quantity required.

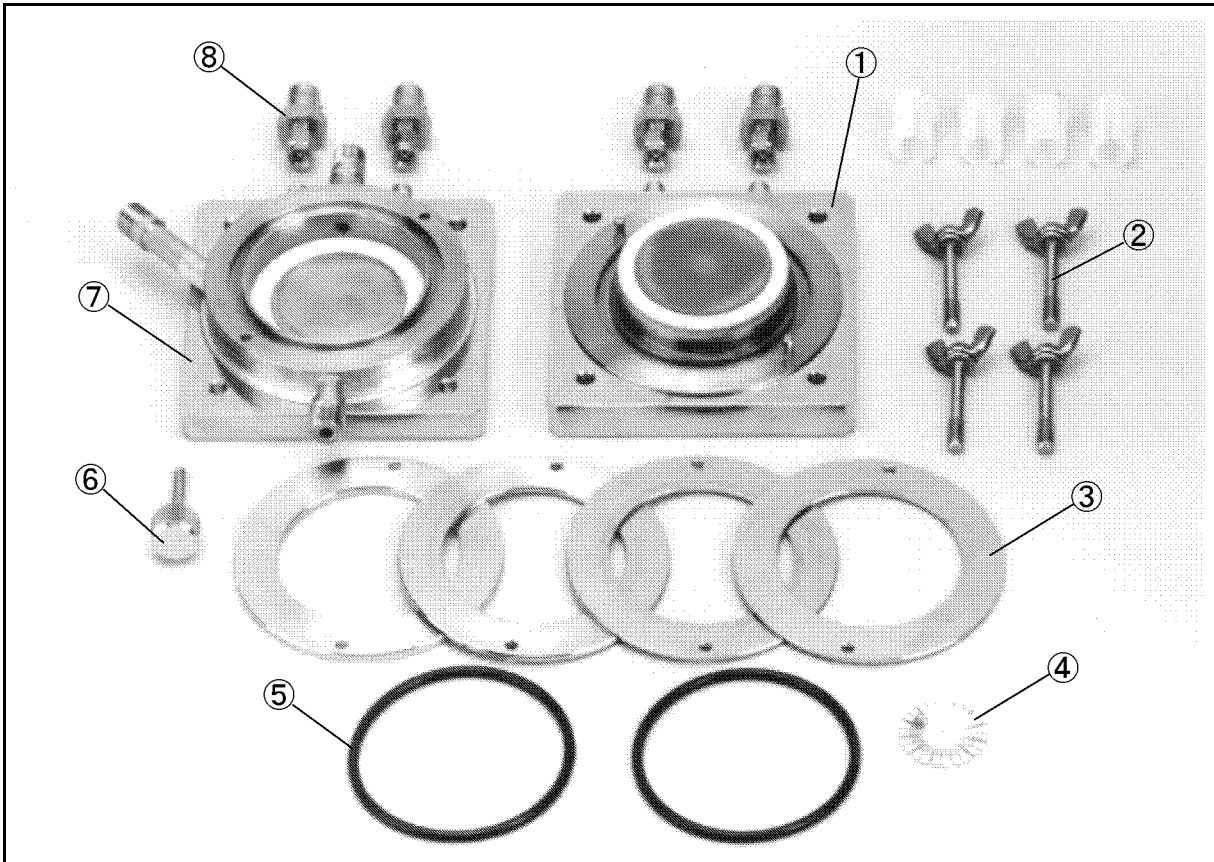


Figure 4-1. 16452A Replaceable Parts (Major Parts)

Table 4-1. Replaceable Parts (Major Parts)

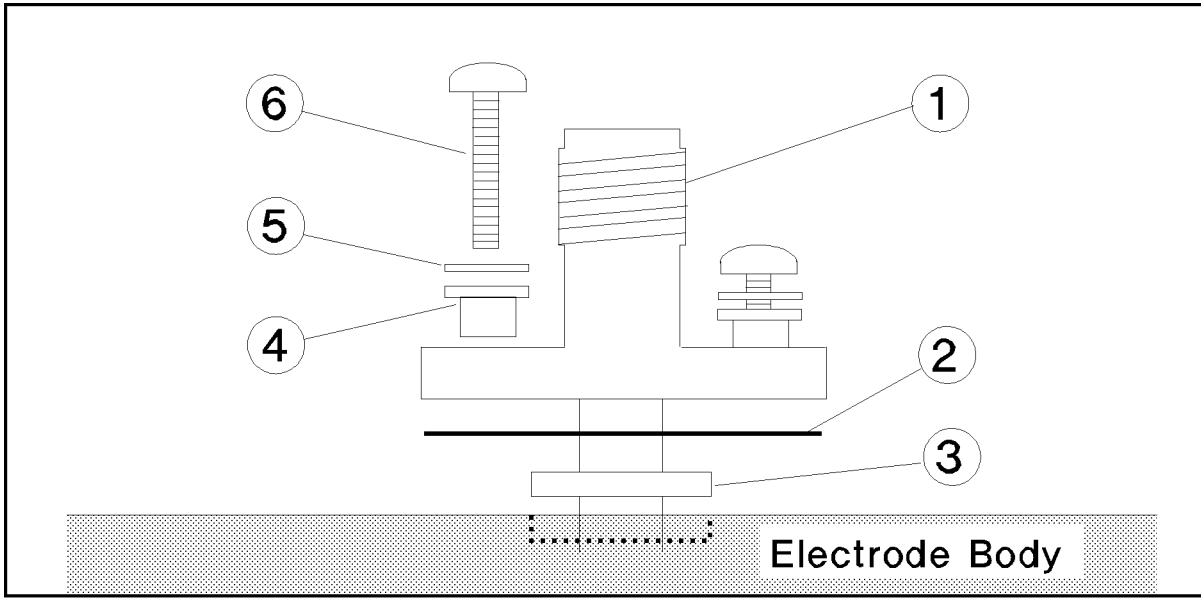
Ref. Desig.	Agilent Part Number	Qty.	Description
1	16452-60002	1	Low Electrode Assembly <sup>1</sup>
2	16452-24001	4	Screw
3	16452-00601	1	Spacer, 1.3 mm (thickness) / 0.3 mm (gap)
	16452-00602	1	Spacer, 1.5 mm (thickness) / 0.5 mm (gap)
	16452-00603	1	Spacer, 2.0 mm (thickness) / 1.0 mm (gap)
	16452-00604	1	Spacer, 3.0 mm (thickness) / 2.0 mm (gap)
4	16092-08010	1	Shorting Plate
5	0905-1275	2	O Ring
6	16452-24002	1	Lid of Liquid Outlet
	0905-1277	1	O Ring for Lid
7	16452-60001	1	High Electrode Assembly <sup>1</sup>
8	1250-1200	4	SMA(m)-BNC(f) Adapter

<sup>1</sup> Assembling procedure of the electrode is described later in this chapter.

**Table 4-2. Replaceable Parts (Other parts)**

<b>Agilent Part Number</b>	<b>Qty.</b>	<b>Description</b>
16452-04001	2	Round Cover for Back of the Electrode
0905-1276	2	O Ring for the Cover
0515-0994	8	Screw for the Cover
1252-5831	4	Waterproof Cap for BNC Connector
16452-01201	2	Angle Iron for the Stand
16452-00611	1	Plate for the Stand Foot
0515-0914	8	M3 Screw for the Stand
16452-60101	1	Carrying Case
16452-90000	1	Operation and Service Manual

## Electrode Assembly

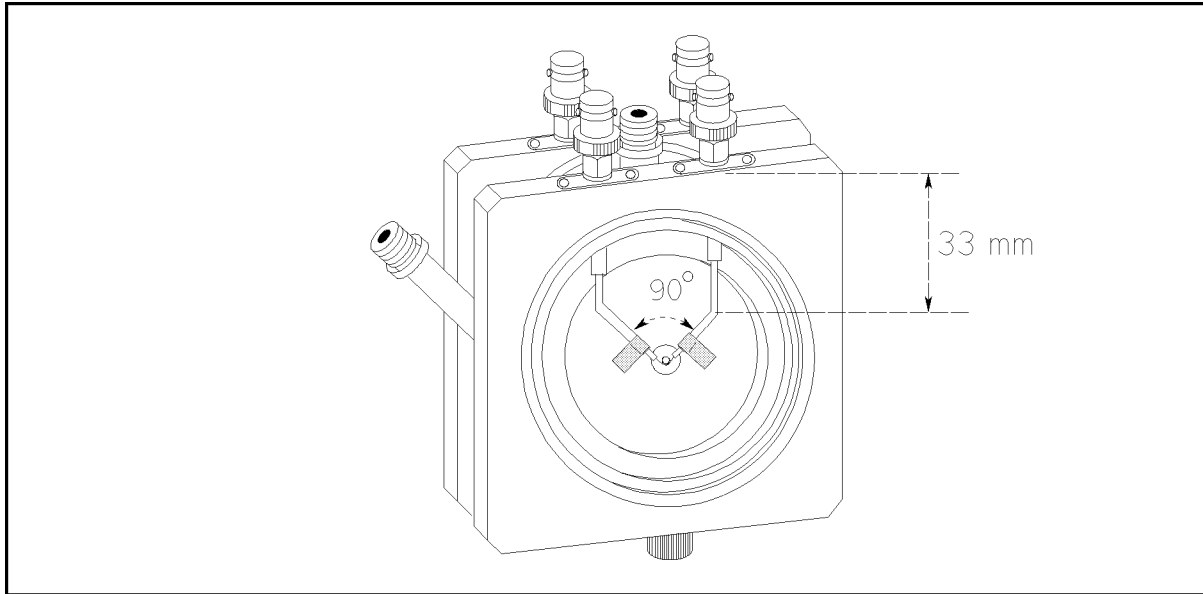


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**Figure 4-2. 16452A Replaceable Parts (Around SMA Connector)**

**Table 4-3. 16452A Replaceable Parts (Around SMA Connector)**

Ref. Desig.	Agilent Part Number	Qty.	Description
1	16452-61603	2	SMA Cable Assembly for High Electrode
	16452-61602	2	SMA Cable Assembly for Low Electrode
2	16452-25001	4	Insulator
3	16452-29001	4	O Ring
4	16452-25002	8	Insulator
5	2190-0654	8	Washer, M2
6	0515-0976	8	Screw, M2



**Figure 4-3. Inside of the Electrode Assembly**

### **Assembling Procedure for Electrode**

See Figure 4-2 and Table 4-3 for the reference designators.

1. Pass the SMA cable assembly ① through the insulator ② and the O ring ③.
2. Insert the cable into the electrode body, and connect it using the insulators ④, the washers ⑤ and the screws ⑥.
3. Bend the semi-rigid cable at 33 mm from the top face of the electrode body as described in Figure 4-3, and set the angle between the semi-rigid cables close to 90 °.
4. Solder the semi-rigid cables to the center pin of the electrode.
5. Solder the shield of the cable to the copper round plate using solder wick.

---

## Troubleshooting

When the short residual resistance is out of the limit, check the fixture connection, the shorting plate, and the surface of the electrodes. If the surface of the electrode is damaged, electrode assembly replacement is required for restoring proper electrical performance.

When the short residual inductance is out of the limit, check the angle of the semi-rigid cables in back of the electrode assemblies. The angle should be close to 90 °. Also check the shield of the semi-rigid cables are connected only at the copper round plate.

---

**Caution** Do not polish the surface with powder to protect the electrode.



## Liquids that Corrode the Test Fixture

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The appendix A provides information about the liquids that corrode the test fixture.

The liquid under test directly contacts the following materials:

- Nickel – the test fixture body (electrodes, spacers, liquid inlet and outlet).
- Ceramic (alumina  $\text{Al}_2\text{O}_3$ ) – the insulator around the electrodes.
- Rubber (Fluoro rubber) – the O-rings.
- Silver-copper and gold-copper – the insulator soldering.

Do not use the test fixture with liquids that corrode these materials. Typical corrosive liquids for each material are listed in the following sections.

---

### Nickel Corrosive Liquid

Corrosive liquid	Little-corrosive liquid	Non-corrosive liquid
acid oxidant and salt oxidant For example, nitric acid ( $\text{HNO}_3$ ) nitrous acid ( $\text{HNO}_2$ ) ferric chloride ( $\text{FeCl}_3$ ) cupric chloride ( $\text{CuCl}_2$ ) mercuric chloride ( $\text{HgCl}_2$ )  acetic acid ( $\text{CH}_3\text{CO}_2\text{H}$ ) <sup>1</sup> formic acid ( $\text{HCO}_2\text{H}$ ) <sup>1</sup> citric acid ( $\text{HO}_2\text{CC}(\text{OH})(\text{CO}_2\text{H})_2 \cdot \text{H}_2\text{O}$ ) <sup>1</sup>	hydrochloric acid ( $\text{HCl}$ ) sulfuric acid ( $\text{H}_2\text{SO}_4$ ) organic acid	alkali salt

<sup>1</sup> In the case of high temperature and air-mixed.

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## **Ceramic (alumina : $\text{Al}_2\text{O}_3$ ) Corrosive Liquid**

Aqueous solution of fluoride corrodes the ceramic.

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## **Viton (Fluoro rubber) Corrosive Liquid**

Ketone and ester corrode the Viton.

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## **Silver-copper and gold-copper**

Strong acid liquid corrodes silver-copper and gold-copper.