

# **User's Guide**

**Agilent 16441A R-Box**



**Agilent Technologies**

**Agilent Part No. 16441-90000**

**Printed in Japan January 2000**

**Edition 4**

---

## Legal Notice

The information contained in this document is subject to change without notice.

Copyright © 1994 - 2000 Agilent Technologies

This document contains information which is protected by copyright. All rights are reserved. Reproduction, adaptation, or translation without prior written permission is prohibited, except as allowed under the copyright laws.

- **Product Warranty**

Agilent Technologies warrant Agilent Technologies hardware, accessories and supplies against defects in materials and workmanship for the period of one year from the warranty start date specified below. If Agilent Technologies receive notice of such defects during the warranty period, Agilent Technologies will, at its option, either repair or replace products which prove to be defective. Replacement products may be either new or like-new.

Warranty service of this product will be performed at 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 do not warrant that the operation of Agilent Technologies products will be uninterrupted or error free. If Agilent is unable, within a reasonable time, to repair or replace any product to a condition as warranted, customer will be entitled to a refund of the purchase price upon prompt return of the product.

The Agilent Technologies products may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use.

The warranty period begins on the date of delivery or on the date of installation if installed by Agilent Technologies. If customer schedules or delays Agilent Technologies installation more than 30 days after delivery, warranty begins on the 31st day from delivery.

Warranty does not apply to defects resulting from (a) improper or inadequate maintenance or calibration, (b) software, interfacing, parts or supplies not supplied by Agilent Technologies, (c) unauthorized modification or misuse, (d) operation outside of the published environmental specifications for the product, or (e) improper site preparation or maintenance.

To the extent allowed by local law, the above warranties are exclusive and no other warranty or condition, whether written or oral, is expressed or implied and Agilent Technologies specifically disclaim any implied warranties or conditions of merchantability, satisfactory quality, and fitness for a particular purpose.

Agilent Technologies will be liable for damage to tangible property per incident up to the greater of \$300,000 or the actual amount paid for the product that is the subject of the claim, and for damages for bodily injury or death, to the extent that all such damages are determined by a court of competent jurisdiction to have been directly caused by a defective Agilent Technologies product.

To the extent allowed by local law, the remedies in this warranty statement are customer's sole and exclusive remedies. Except as indicated above, in no event will Agilent Technologies or its suppliers be liable for loss of date or for direct, special, incidental, consequential (including lost profit or date), or other damage, whether based in contract, tort, or otherwise.

For consumer transactions in Australia and New Zealand: the warranty terms contained in this statement, except to the extent lawfully permitted, do not exclude, restrict or modify and are in addition to the mandatory statutory rights applicable to the sale of this product to you.

- **Assistance**

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

For any assistance, contact your nearest Agilent Technologies Sales Office.

- **Certification**

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

- **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 elsewhere in this manual may impair the protections provided by the equipment. In addition, it violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies Inc. assumes no liability for customer's failure to comply with these requirements.

- *GROUND THE INSTRUMENT*

This is Safety Class I instrument. To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The power terminal and the power cable must meet International Electrotechnical Commission (IEC) safety standards.

- *DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE*

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

- *KEEP AWAY FROM LIVE CIRCUITS*

Operation personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with 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 install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Agilent Technologies Sales and Service Office for services and repair to ensure that safety features are maintained.

- *DANGEROUS PROCEDURE WARNINGS*

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

---

**WARNING**

---

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

- **Safety Symbols**

The general definitions of safety symbols used on equipment or in manuals are listed below.



Instruction manual symbol: the product will be 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 and potential for electrical shock. Do not touch terminals that have this symbol when instrument is on.



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



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



Indicates earth (ground) terminal.



Alternating current.



Direct current.



ON (Supply).



OFF (Supply).



STANDBY (Supply).

CAT 1

Means INSTALLATION CATEGORY I. Measurement terminals on the rear panel comply with INSTALLATION CATEGORY I.

---

## **WARNING**

---

The warning 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 in injury or death to personal.

---

## **CAUTION**

---

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

- **Herstellerbescheinigung**  
GEÄUSCHEMISSION  
Lpa < 70 dB  
am Arbeitsplatz  
normaler Betrieb  
nach DIN 45635 T. 19
- **Manufacturer's Declaration**  
ACOUSTIC NOISE EMISSION  
Lpa < 70dB  
operator position  
normal operation  
per ISO 7779

---

## Printing History

|            |               |
|------------|---------------|
| Edition 1: | February 1994 |
| Edition 2: | April 1995    |
| Edition 3: | August 1997   |
| Edition 4: | January 2000  |

---



# **User's Guide**

Agilent 16441A R-Box is one of the accessories available for Agilent 4155/4156 Semiconductor Parameter Analyzers. The R-Box is used to add a series resistance (0  $\Omega$ , 10 k $\Omega$ , 100 k $\Omega$ , or 1 M $\Omega$ ) between the 4155/4156's SMU output and your test device (DUT), and is useful for the following measurements:

- negative resistance measurement

R-Box is effective for the negative resistance measurement, because SMUs *cannot* measure negative resistance.

- breakdown measurement

R-Box is effective for preventing excessive current, thus preventing damage to DUT when sudden voltage change occurs.

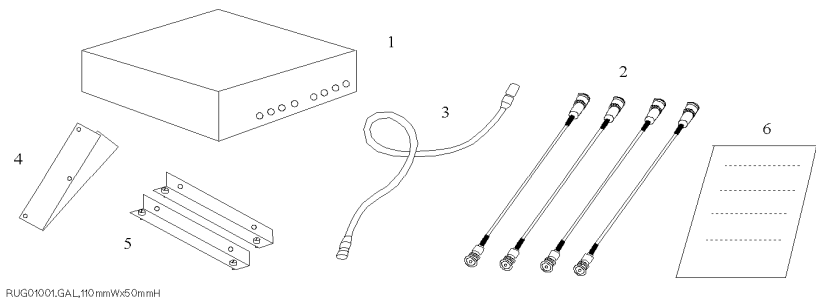
This manual consists of the following sections:

- Introduction
- Operation
- Installation
- Maintenance
- Specifications



# Introduction

The 16441A R-Box contains the following accessories:



|   | Description                         | Agilent<br>Part Number | Quantity |
|---|-------------------------------------|------------------------|----------|
| 1 | R-Box                               | 16441A                 | 1        |
| 2 | 40 cm triaxial cable                | 04155-61605            | 4        |
| 3 | (option 001) 1.5 m control cable    | 04155-61610            | 1        |
|   | (option 002) 3 m control cable      | 04155-61609            | 1        |
| 4 | plate <sup>a</sup>                  | 16440-60001            | 2        |
| 5 | angle <sup>b</sup>                  | 16440-60002            | 2        |
| 6 | <i>User's Guide</i> (this document) | 16441-90000            | 1        |

- a. Three screws are furnished for each plate.
- b. Two screws are furnished for each angle.

**NOTE**

**Inspecting the 16441A upon Receiving**

When the 16441A arrives at your site, make sure that nothing is missing or damaged. Unpack the carton, then check the contents. See figure and table shown above.

If anything is missing or damaged, contact your nearest Agilent Technologies sales office.

## Operation

The R-Box adds a series resistance between the 4155/4156 Semiconductor Parameter Analyzer and DUT. Available resistance values are 0  $\Omega$ , 10 k $\Omega$ , 100 k $\Omega$ , and 1 M $\Omega$ . There are two channels (CH1 and CH2) to connect SMUs.

Switching of resistance is controlled by the 4155/4156. After you set a resistance value on the 4155/4156 setup screen, the R-Box sets the selected resistance value when the 4155/4156 is in the measurement state.

## Available Measurement Units

The R-box is effective for the following SMUs:

- SMU1
- SMU2 or SMU5

If the 4155/4156 is installed with the 41501 PGU/PG Expander which has an HPSMU (High Power SMU), SMU5 is available instead of SMU2.

## Measurement Data Compensation

The resistance value is automatically compensated for by the 4155/4156. So, the data displayed on the GRAPH/LIST screen of the 4155/4156 or data used for user function is the compensated data.

If you connect the R-Box to SMUs other than described above, resistance values are not compensated for automatically. You need to compensate for the resistance values manually, such as by using a user function or calculation in IBASIC program.

---

### NOTE

#### Additional Measurement Channel for Compensation

Be aware that an additional measurement channel is automatically used if *both* the following are true:

- You *force voltage* from channel that is connected to R-Box, and
- You display this voltage variable on the GRAPH/LIST screen, or use voltage variable in user function.

So if both above are true for a channel, and you set another one measurement channel, the 4155/4156 uses two measurement channels automatically.

---

Additional measurement channel is used for the automatic measurement of the current through R-Box. This is necessary to perform compensation calculation.

## Selecting Resistance Value

Install the R-Box as shown in “Installation”, and turn on the 4155/4156. Then do following:

1. Display the CHANNELS: CHANNEL DEFINITION screen of the 4155/4156.
2. Move the field pointer to the SERIES RESISTANCE field. In this field, select:
  - 0 ohm softkey to set 0  $\Omega$  resistance
  - 10k ohm softkey to set 10 k $\Omega$  resistance
  - 100k ohm softkey to set 100 k $\Omega$  resistance
  - 1M ohm softkey to set 1 M $\Omega$  resistance

where, for the following SMUs, select the 0 ohm softkey. Else error occurs.

- SMU defined as the standby channel:

If STBY field is ON, the SMU is defined as the standby channel.

- SMU set to the common mode:

If MODE field is COMMON, the SMU is set to the common mode.

When the 4155/4156 is in the measurement state, the R-Box sets the selected resistance value. In the other operation state (idle state, standby state, or stress force state), the R-Box sets 0  $\Omega$ .

Present resistance setting is also indicated by LEDs on the R-Box front panel.

---

### NOTE

#### If an emergency occurs

If an emergency occurs, resistance value is automatically set to 1 M $\Omega$ .

---

### NOTE

#### Making Kelvin Connection

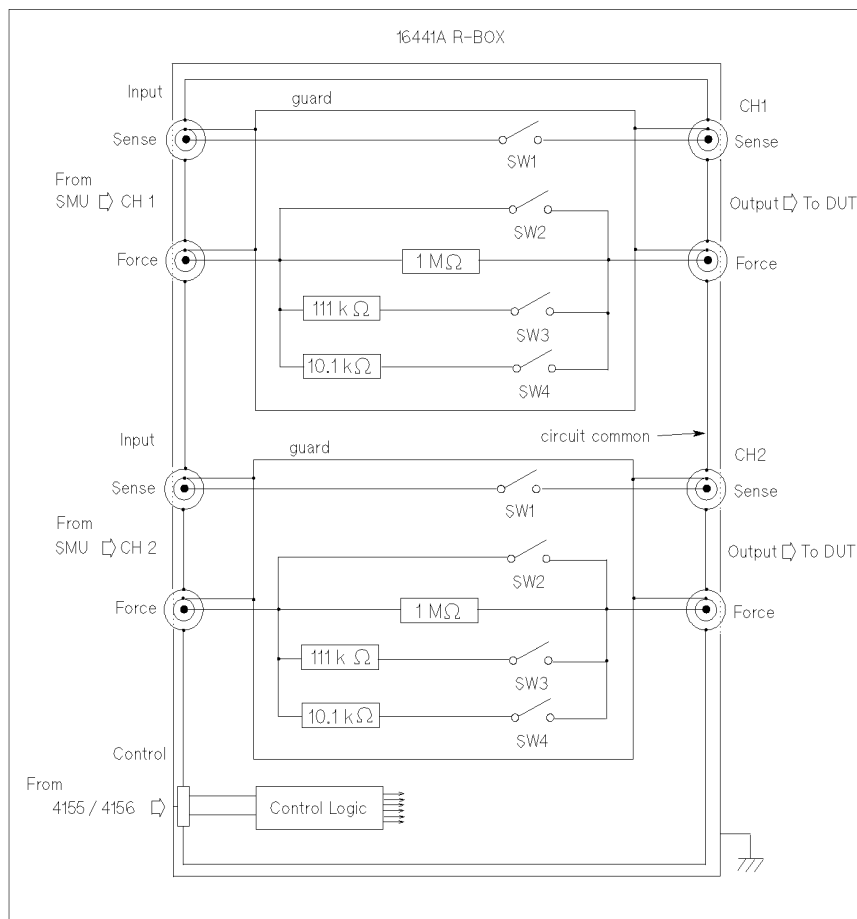
The R-Box makes Kelvin connection only when 0  $\Omega$  is selected.

For 1 M $\Omega$ , 100 k $\Omega$ , and 10 k $\Omega$  settings, the R-Box always opens the sense line of HRSMU and HPSMU. See “Circuit Diagram” on page 6.

---

## Circuit Diagram

The simplified circuit diagram of the R-Box is shown below.



RUG02001 130h,118w

The table below shows the internal relay positions for each resistance setting.

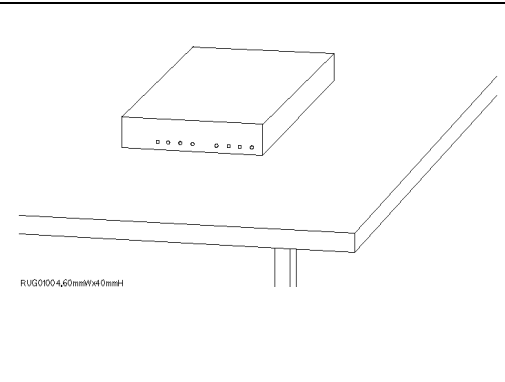
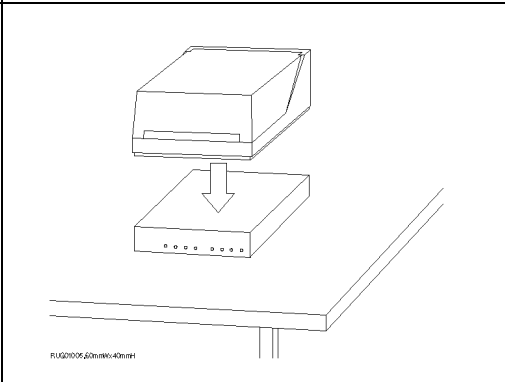
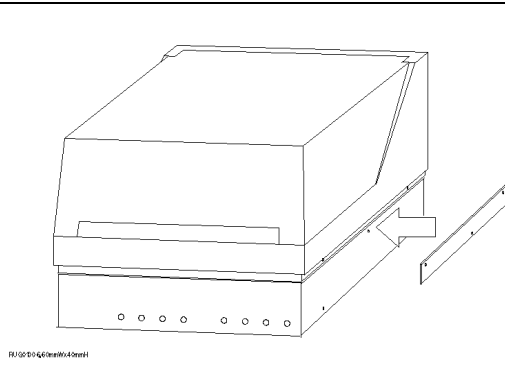
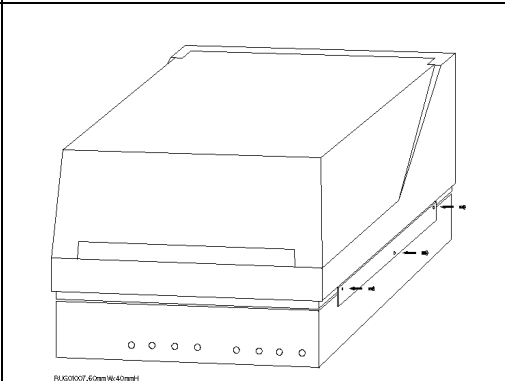
| Settings | Relay Switches |     |     |     |
|----------|----------------|-----|-----|-----|
|          | SW1            | SW2 | SW3 | SW4 |
| 0 Ω      | ON             | ON  | OFF | OFF |
| 10 kΩ    | OFF            | OFF | OFF | ON  |
| 100 kΩ   | OFF            | OFF | ON  | OFF |
| 1 MΩ     | OFF            | OFF | OFF | OFF |

# Installation

This section describes how to attach the R-Box to Agilent 16442A test fixture or to a shielding box, and how to connect it to the 4155/4156.

## To Attach the R-Box to Test Fixture

You can attach your R-Box to Agilent 16442A test fixture as shown below. You need a standard screwdriver.

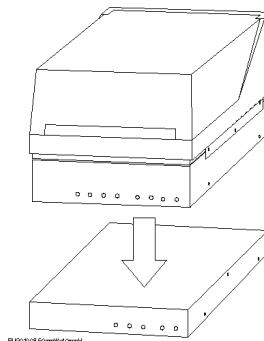
|                                                                                                                                                              |                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Place the R-Box on your workbench.</p>  <p>RUG01D0 4,60mmWx40mmH</p> | <p>2. Place the test fixture on top of the R-Box.</p>  <p>RUG01005 60mmWx40mmH</p>                                      |
| <p>3. Position a plate on both sides.</p>  <p>RUG01014 60mmWx40mmH</p>    | <p>4. Attach each plate using the three flathead screws supplied with the instrument.</p>  <p>RUG01007 60mmWx40mmH</p> |

## User's Guide

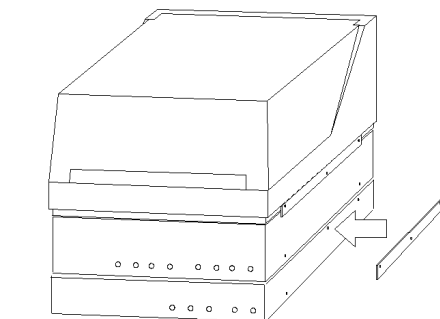
### Installation

The following steps apply when using the 16440A selector:

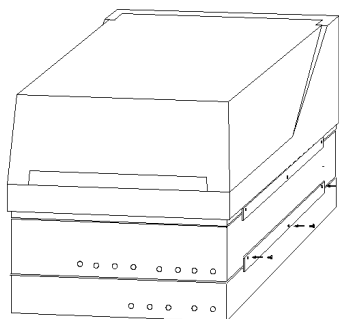
5. Place the selector on your workbench.  
Place the R-Box and the test fixture on top of the selector.



6. Position a plate on both sides.



7. Attach each plate using the three flathead screws supplied with the instrument.

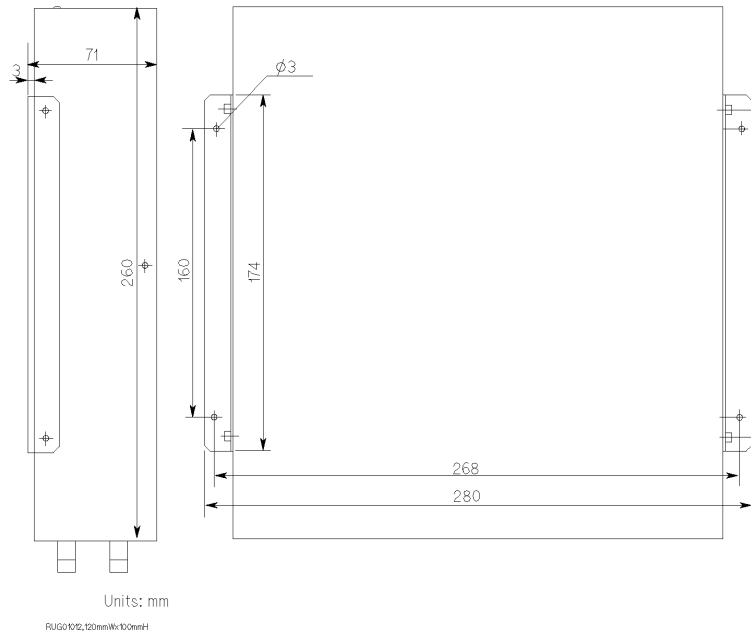


To attach one more selector, repeat steps 5 to 7 again.

## To Attach the R-Box to Shielding Box

You can attach your R-Box to a shielding box. You need a standard screwdriver.

The following figure shows the spacing of the 16441A screw holes. You need to prepare four screws and nuts to match the screw holes.

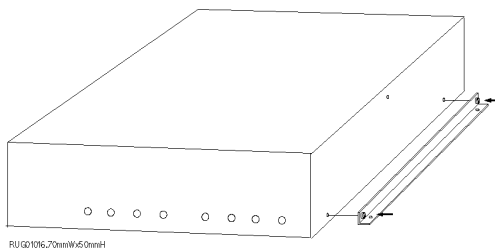


## User's Guide

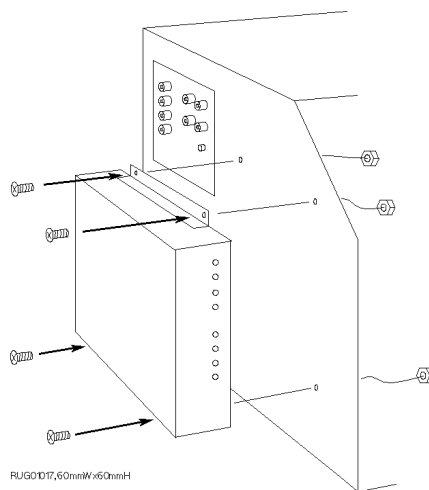
### Installation

Attach the R-Box to the shielding box as shown below:

1. Attach an angle bracket to each side of the R-Box, using the screws supplied.

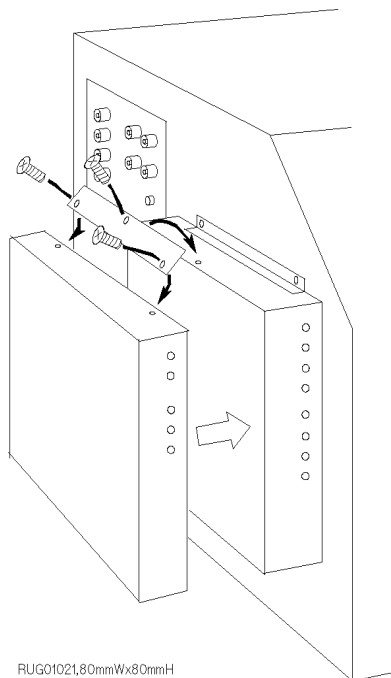


2. Place the R-Box on the side panel of the shielding box.
3. Position four nuts on the inside panel of the shielding box.
4. Attach the angle bracket to the shielding box using four flathead screws.





If you use the 16440A selector, attach the selector to the R-Box as shown below:



## Connecting the R-Box to the 4155/4156

Before connecting the R-box to the 4155/4156 and 41501, turn off the instruments.

1. Connect the To R-Box terminal on the 4155/4156 rear panel to the Control terminal on the R-Box rear panel using a 3.0 m or 1.5 m control cable.
2. Connect the instrument measurement terminals to the R-Box input terminals as shown below:

| Instrument terminals | R-Box Input         | Cable                              |
|----------------------|---------------------|------------------------------------|
| 4155 MPSMU           | Input Force         | 3 m or 1.5 m Triaxial Cable        |
| 4156 HRSMU           | Input (Force/Sense) | 3 m or 1.5 m Kelvin Triaxial Cable |
| 41501 MPSMU          | Input Force         | 3 m or 1.5 m Triaxial Cable        |
| 41501 HPSMU          | Input (Force/Sense) | 3 m or 1.5 m Kelvin Triaxial Cable |

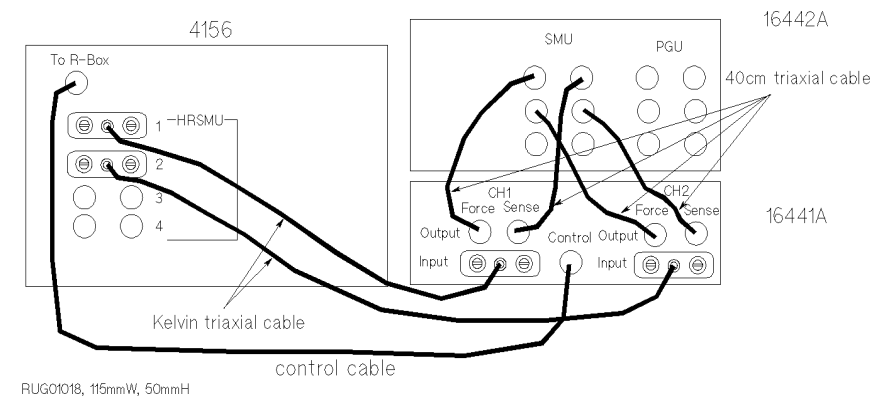
3. Connect the R-Box output terminals to the input terminals of the 16442A test fixture or an connector plate using 40 cm triaxial cables as shown below:

| R-Box Output              | 16442A Input or Connector Plate Input |      |      |
|---------------------------|---------------------------------------|------|------|
| Output Force <sup>a</sup> | SMU1, 2, 3, 4, 5, or 6                |      |      |
| Output Force <sup>b</sup> | SMU1                                  | SMU3 | SMU5 |
| Output Sense <sup>b</sup> | SMU2                                  | SMU4 | SMU6 |

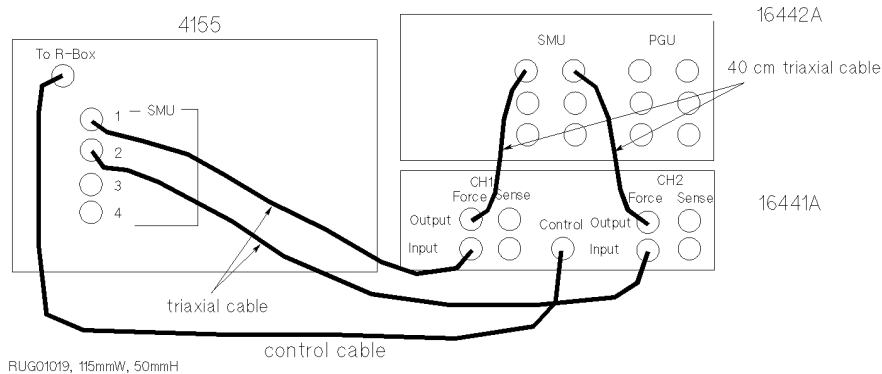
- a. For non-Kelvin connection.
- b. For the Kelvin connection, two triaxial cables must be used to connect the R-Box and the 16442A, instead of a Kelvin triaxial cable.

When you use the connector plate, use a low-noise coaxial cable (Agilent part number: 8120-3674) from the connector plate to DUT. If you use insufficiently insulated cables, leakage current may occur.

The following figure shows example connections with the 4156.



The following figure shows example connections with the 4155.



## Maintenance

This section provides the following maintenance information:

- Cleaning
- Servicing

### Cleaning the R-Box

To maintain high performance, the R-Box must be kept clean. Oil, perspiration, hair, dust, and dirt degrade board insulation, which increases leakage current and decreases measurement accuracy.

Agilent Technologies recommend the following cleaning procedure:

1. Make sure that voltage or current is *not* present at any channel.
2. Disconnect all cables from the R-Box.
3. Using lint-free paper, gently wipe the chassis. For any area that will not come clean, dip the lint-free paper into alcohol and wipe the area gently.

### Servicing the R-Box

This section provides information for trained service personnel to repair the R-Box.

When a replaceable part, which is shown with the Agilent part number in this section, needs to be replaced, order the parts from the nearest Agilent Technologies Sales and Service Office.

---

#### WARNING

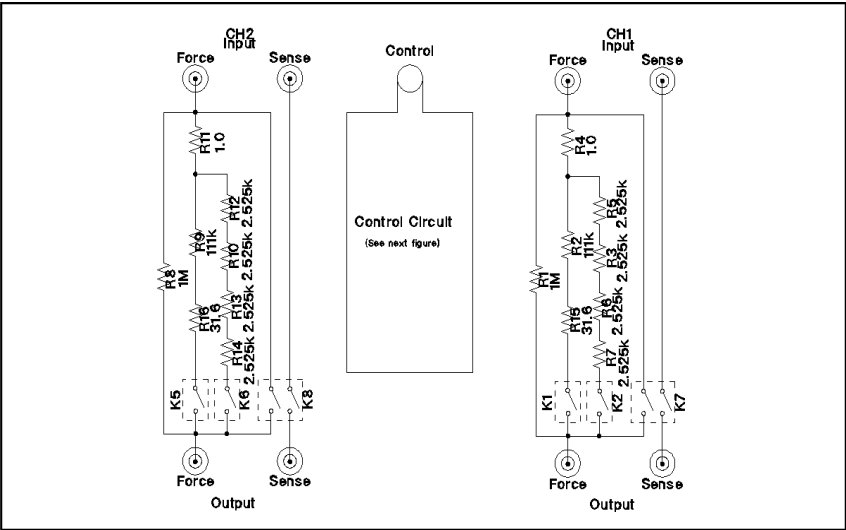
---

**High voltages may be present in the selector when voltage or current is added to the R-Box. Dangerous voltage may be generated on wires or parts and the danger of electric shock exists.**

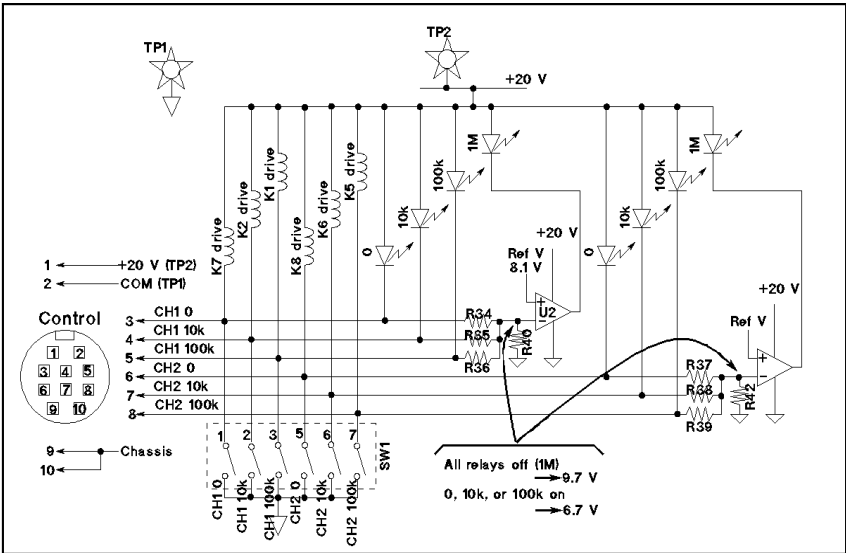
Make sure that terminals are not connected to the instruments before you repair the R-Box.

## Circuit Block Diagram

Circuit Block Diagram is shown below:



Control Circuit is shown below:



## Performance Verification

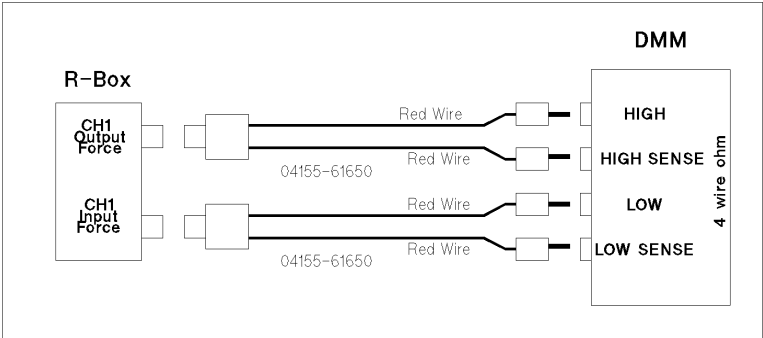
This section provides information to verify the performance of the R-Box without the 4155/4156.

For the procedures to verify the performance of the R-Box by using the 4155/4156, refer to the *4155/4156 Service Manual*.

|                        |                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Test Equipments</b> | <b>Digital Multi Meter</b> | Agilent Technologies 3458A or equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                        | <b>Power Supply</b>        | can force 20 V and 100 mA.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                        | <b>Connection Cables</b>   | 04155-61650, 2ea                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Test Condition</b>  | <b>Temperature</b>         | $23 \pm 3$ °C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                        | <b>DMM Condition</b>       | <ul style="list-style-type: none"><li>• 4 wire ohm measurement</li><li>• AUTO RANGE</li><li>• Within one year from the last calibration</li><li>• Has been warmed up</li><li>• NPLC 100</li><li>• OCOMP ON</li><li>• All other settings are same as PRESET NORM</li><li>• Within 24 hours from the last auto-calibration (ACAL)</li><li>• The ambient temperature changes is less than <math>\pm 1</math> °C from the last ACAL</li><li>• Operating temperature is <math>\pm 5</math> of the temperature of calibration (Tcal)</li></ul> |

Test Procedure

- 1. Apply dc voltage to the control circuit of the R-Box by the power supply as follows:  
**TP1**            0 V  
**TP2**            +20 V
- 2. Connect the R-Box and DMM as follows:

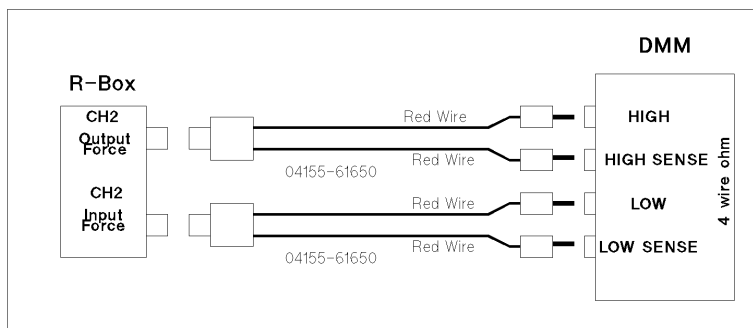


- 3. Change the setting of the SW1 on the circuit board of the R-Box and verify the resistance value measured by the DMM as follows:

CH1 Path Test:

| Test Path | SW1 Setting |     |     |     |     |     | Resistance Value Test Limit (Ω) |
|-----------|-------------|-----|-----|-----|-----|-----|---------------------------------|
|           | 1           | 2   | 3   | 5   | 6   | 7   |                                 |
| 10kΩ      | OFF         | ON  | OFF | OFF | OFF | OFF | 9991.78 to 10008.22             |
| 100kΩ     | OFF         | OFF | ON  | OFF | OFF | OFF | 99962.8 to 100037.2             |
| 1MΩ       | OFF         | OFF | OFF | OFF | OFF | OFF | 998800 to 1001200               |
| 0Ω        | ON          | OFF | OFF | OFF | OFF | OFF | 0 to 0.5                        |

4. Change the connection between the R-Box and DMM as follows:



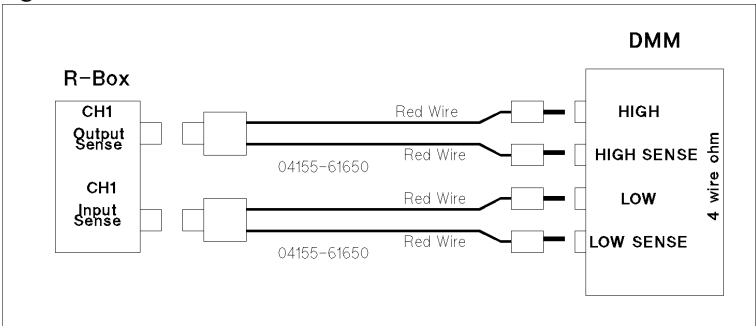
5. Change the setting of the SW1 on the circuit board of the R-Box and measure the resistance value by the DMM to verify the resistor paths as follows:

CH2 Path Test:

| Test Path     | SW1 Setting |     |     |     |     |     | Resistance Value Test Limit ( $\Omega$ ) |
|---------------|-------------|-----|-----|-----|-----|-----|------------------------------------------|
|               | 1           | 2   | 3   | 5   | 6   | 7   |                                          |
| 10k $\Omega$  | OFF         | OFF | OFF | OFF | ON  | OFF | 9991.78 to 10008.22                      |
| 100k $\Omega$ | OFF         | OFF | OFF | OFF | OFF | ON  | 99962.8 to 100037.2                      |
| 1M $\Omega$   | OFF         | OFF | OFF | OFF | OFF | OFF | 998800 to 1001200                        |
| 0 $\Omega$    | OFF         | OFF | OFF | ON  | OFF | OFF | 0 to 0.5                                 |



6. Change the connection between the R-Box and DMM as follows:

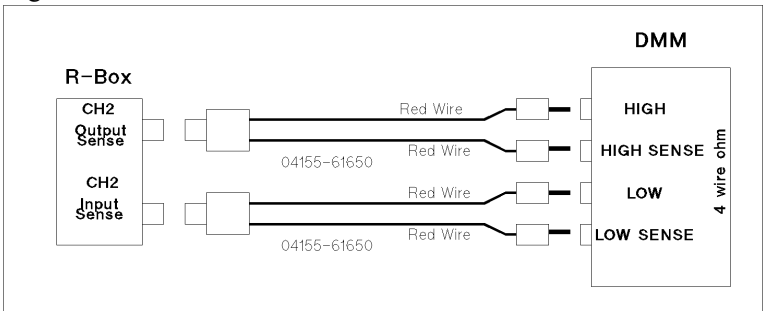


7. Change the setting of the SW1 on the circuit board of the R-Box and measure the resistance value by the DMM to verify the resistor paths as follows:

Sense Path Test:

| Test Path  | SW1 Setting |     |     |     |     |     | Resistance Value Test Limit ( $\Omega$ ) |
|------------|-------------|-----|-----|-----|-----|-----|------------------------------------------|
|            | 1           | 2   | 3   | 5   | 6   | 7   |                                          |
| 0 $\Omega$ | ON          | OFF | OFF | OFF | OFF | OFF | 0 to 0.5                                 |

8. Change the connection between the R-Box and DMM as follows:



9. Change the setting of the SW1 on the circuit board of the R-Box and measure the resistance value by the DMM to verify the resistor paths as follows:

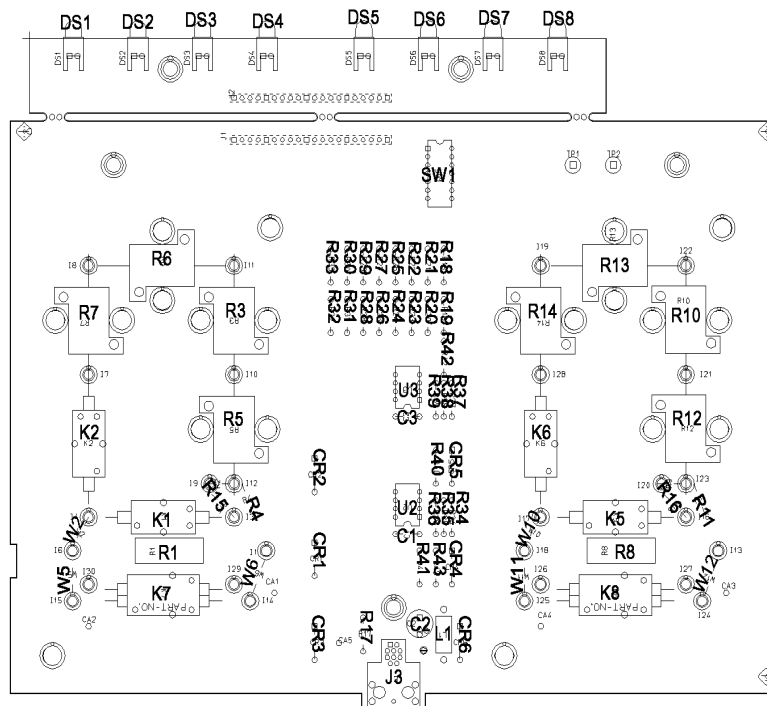
Sense Path Test:

| Test Path  | SW1 Setting |     |     |    |     |     | Resistance Value Test Limit ( $\Omega$ ) |
|------------|-------------|-----|-----|----|-----|-----|------------------------------------------|
|            | 1           | 2   | 3   | 5  | 6   | 7   |                                          |
| 0 $\Omega$ | OFF         | OFF | OFF | ON | OFF | OFF | 0 to 0.5                                 |

## Replaceable Parts

When wiring or soldering, use low hydrochloric acid solder (Agilent part number: 8090-0433) to prevent the flux in the solder from spreading unnecessarily. When soldering, make sure the terminals do not make contact with each other. After soldering, make sure that there are no lint bridges so that leakage current is minimal.

### Parts Location on the Circuit Board Assembly:



| Reference Designation | Agilent Part Number | Description                      |
|-----------------------|---------------------|----------------------------------|
| R1                    | 0698-2036           | Resistor 1M $\Omega$ 0.1 % .25 W |
| R3                    | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R4                    | 0699-0208           | Resistor 1 $\Omega$ 5 % .25 W    |
| R5                    | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R6                    | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R7                    | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R8                    | 0698-2036           | Resistor 1M $\Omega$ 0.1 % .25 W |
| R10                   | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R11                   | 0699-0208           | Resistor 1 $\Omega$ 5 % .25 W    |
| R12                   | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R13                   | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R14                   | 0699-3702           | Resistor 2.525K $\Omega$ 0.02 %  |
| R15                   | 0757-0180           | Resistor 31 $\Omega$ 6 1 %       |
| R16                   | 0757-0180           | Resistor 31 $\Omega$ 6 1 %       |
| R17                   | 0757-0442           | Resistor 10K $\Omega$ 1 % .125 W |
| R18                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R19                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R20                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R21                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R22                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R23                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R24                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R25                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R26                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R27                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R28                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R29                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R30                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R31                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R32                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |

| Reference Designation | Agilent Part Number | Description                      |
|-----------------------|---------------------|----------------------------------|
| R33                   | 0757-0418           | Resistor 619 $\Omega$ 1 % .125 W |
| R34                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R35                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R36                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R37                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R38                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R39                   | 0757-0465           | Resistor 100K $\Omega$ 1 %       |
| R40                   | 0698-3160           | Resistor 31.6K $\Omega$ 1 %      |
| R41                   | 0698-3160           | Resistor 31.6K $\Omega$ 1 %      |
| R42                   | 0698-3160           | Resistor 31.6K $\Omega$ 1 %      |
| R43                   | 0698-3162           | Resistor 46.4K $\Omega$ 1 %      |
| CR1                   | 1901-0050           | Diode                            |
| CR2                   | 1901-0050           | Diode                            |
| CR3                   | 1901-0050           | Diode                            |
| CR4                   | 1901-0050           | Diode                            |
| CR5                   | 1901-0050           | Diode                            |
| CR6                   | 1901-0050           | Diode                            |
| L1                    | 9140-0210           | Inductor 100 $\mu$ H 5 %         |
| C1                    | 0160-4832           | Capacitor 0.01 $\mu$ F 100 V     |
| C2                    | 0180-3468           | Capacitor 47 $\mu$ F 50 V        |
| C3                    | 0160-4832           | Capacitor 0.01 $\mu$ F 100 V     |
| U2                    | 1826-0065           | IC 311                           |
| U3                    | 1826-0065           | IC 311                           |
| K1                    | 0490-1930           | Reed Relay                       |
| K2                    | 0490-1930           | Reed Relay                       |
| K5                    | 0490-1930           | Reed Relay                       |
| K6                    | 0490-1930           | Reed Relay                       |
| K7                    | 0490-1929           | Reed Relay                       |
| K8                    | 0490-1930           | Reed Relay                       |

| Reference Designation | Agilent Part Number | Description             |
|-----------------------|---------------------|-------------------------|
| W2                    | 8159-0005           | Wire (Resistor 0Ω )     |
| W5                    | 8159-0005           | Wire (Resistor 0Ω )     |
| W6                    | 8159-0005           | Wire (Resistor 0Ω )     |
| W10                   | 8159-0005           | Wire (Resistor 0Ω )     |
| W11                   | 8159-0005           | Wire (Resistor 0Ω )     |
| W12                   | 8159-0005           | Wire (Resistor 0Ω )     |
| DS1                   | 1990-0967           | LED Green               |
| DS2                   | 1990-0967           | LED Green               |
| DS3                   | 1990-0967           | LED Green               |
| DS4                   | 1990-0967           | LED Green               |
| DS5                   | 1990-0967           | LED Green               |
| DS6                   | 1990-0967           | LED Green               |
| DS7                   | 1990-0967           | LED Green               |
| DS8                   | 1990-0967           | LED Green               |
| J3                    | 1252-5466           | Connector 10 pin Female |
| SW1                   | 3101-2885           | Switch - DIP            |

## Specifications

The "supplemental information" and "typical" entries, in the following specifications are not warranted, but provide useful information about the functions and performance of the instruments.

The following specifications data is specified at  $23 \pm 5$  °C and 50 % relative humidity.

- Function

Agilent 16441A R-BOX adds a selectable series resistor to the SMU output. You can select the resistor from the setup page, and the voltage drop due to the series resistor is automatically calculated. There are the limitations on measurement with Agilent 4155/4156 Semiconductor Parameter Analyzers and R-Box:

- If you measure device characteristics including negative resistance over 1 M $\Omega$  with the 4155/4156 and R-Box, there is a possibility that they cannot measure it.
- There is a possibility that the 4155/4156 cannot perform measurement circumstances.

- Resistance value and accuracy

Number of SMU channels that can add resistor: 2

Following resistance values are available for each channel (CH1, CH2):

- 1 M $\Omega$
- 100 k $\Omega$
- 10 k $\Omega$
- 0  $\Omega$

**resistance accuracy**      0.3 % between Input and Output terminals  
(at  $23 \pm 5$  °C and 50 % relative humidity)

- Kelvin connection

Kelvin connection is effective only when 0  $\Omega$  is selected.

- Voltage and current range
  - maximum voltage: 200 V
  - maximum current: 1 A (when 0  $\Omega$  is selected)
- Accessories (furnished). See “Introduction” for details.
  - Option 001
    - 1.5 m control cable (Agilent part number 04155-61610)
    - 40 cm triaxial cable (Agilent part number 04155-61605)
  - Option 002
    - 3.0 m control cable (Agilent part number 04155-61609)
    - 40 cm triaxial cable (Agilent part number 04155-61605)
- Accessories (optional)
  - 1.5 m Kelvin triaxial cable (Agilent 16493K option 001)
  - 3.0 m Kelvin triaxial cable (Agilent 16493K option 002)
  - 1.5 m triaxial cable (Agilent 16493C option 001)
  - 3.0 m triaxial cable (Agilent 16493C option 002)
- General specifications
  - Environment

|                       |                                                        |
|-----------------------|--------------------------------------------------------|
| Operating temperature | 5 °C to 40 °C                                          |
| Storage temperature   | –40 °C to 60 °C                                        |
| Operating Humidity    | 15 % to 80 % relative humidity<br>(at no condensation) |
| Storage Humidity      | 5 % to 90 % relative humidity at 60 °C                 |

- Weight  
Approximately 1.6 kg

## Supplemental Information

The following reference data is specified at  $23 \pm 5$  °C and 50% relative humidity.

**Leakage current** less than 100 fA at 100 V

**Residual resistance** 0.3  $\Omega$  typical (when 0  $\Omega$  is selected)

**Output channel stray capacitance**

|                 |                                                                             |
|-----------------|-----------------------------------------------------------------------------|
| force to common | 0.3 pF typical (at DC, without cable)                                       |
| force to guard  | 15 pF typical<br>(when 1 M $\Omega$ or 100 k $\Omega$ is selected at 1 MHz) |
|                 | 40 pF typical (when 10 k $\Omega$ is selected at 1 MHz)                     |
| guard to common | 150 pF typical at 1 MHz                                                     |