Agilent B1500A
Semiconductor Device Analyzer

User's Guide

Agilent Technologies

Notices

Manual Part Number

B1500-90000

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Warranty

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Agilent Technologies	**DECLARATION OF CONFORMITY** According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014	C E

Manufacturer's Name: Agilent Technologies International sarl
Manufacturer's Address: Rue de la Gare 29
Supplier's Address: CH - 1110 Morges
    Switzerland

Declares under sole responsibility that the product as originally delivered

Product Name:	Semiconductor Device Analyzer
	High Power Source/Monitor Unit Module,
	Medium Power Source/Monitor Unit Module,
	High Resolution Source/Monitor Unit Module,
	Multi Frequency Capacitance Measurement Unit Module,
	High Voltage Semiconductor Pulse Generator Unit Module,
	Waveform Generator/Fast Measurement Unit Module
Model Number:	Agilent B1500A
	Agilent B1510A, Agilent B1511A, Agilent B1517A,
	Agilent B1520A, Agilent B1525A, Agilent B1530A
Product Options:	This declaration covers all options of the above product(s)

complies with the essential requirements of the following applicable European Directives, and carries the CE marking accordingly:
    Low Voltage Directive (2006/95/EC)
    EMC Directive (2004/108/EC)
and conforms with the following product standards

EMC	**Standard**	**Limit**
	IEC 61326-1:2005 / EN 61326-1:2006	
	CISPR 11:2003 / EN55011:1998+A1:1999+A2 :2002	Group 1 Class A
	IEC 61000-4-2:2001 /EN 61000-4-2:1995+A1:1998+A2:2001	4 kV CD, 8 kV AD
	IEC 61000-4-3:2002+A1:2002/EN 61000-4-3:2002+A1:2002	3 V/m / 80 MHz-1 GHz / 1.4-2 GHz, 1 V/m / 2-2.7 GHz
	IEC 61000-4-4:2004 / EN 61000-4-4:2004	0.5 kV signal lines, 1 kV power lines
	IEC 61000-4-5:2001/EN 61000-4-5:1995+A1:2001	0.5 kV line-line, 1 kV line-ground
	IEC 61000-4-6:2003 / EN 61000-4-6:1996+A1:2001	3 V, 0.15-80 MHz
	IEC 61000-4-11:2004 / EN 61000-4-11:2004	0 % for 1/0.5 cycle, 0 % for 250/300 cycles, 70 % for 25/30 cycles
	Canada: ICES-001:2004	
	Australia/New Zealand: AS/NZS CISPR 11:2004	
	The product was tested in a typical configuration with Agilent Technologies test systems.	

Safety	IEC 61010-1:2001 / EN 61010-1:2001
	Canada: CAN/CSA-C22.2 No. 1010.1-92, NRTL/C

Supplementary Information:
This DoC applies to above-listed products placed on the EU market after:

July 15, 2009
Date

Toshiyuki Kawaji

QA Manager
Agilent Technologies

- **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

NOTE   This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme à la norme NMB-001 du Canada.

This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/ electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as a "Monitoring and Control instrumentation" product.

Do not dispose in domestic household waste.

To return unwanted products, contact your local Agilent office, or see www.agilent.com/environment/product/ for more information.

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.

NOTE

Agilent B1500A complies with INSTALLATION CATEGORY II for mains input and INSTALLATION CATEGORY I for measurement input terminals, and POLLUTION DEGREE 2 defined in IEC 61010-1.

Agilent B1500A is an INDOOR USE product.

- *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.

⚡ 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.

⏻ STANDBY (Supply).

CAT I 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.

HIGH VOLTAGE SHOCK HAZARD

Agilent B1500A can force dangerous voltages (±200 V for HPSMU, and ±100 V for MPSMU/HRSMU) at the force, guard, and sense terminals. To prevent electric shock hazard, the following safety precautions must be observed during the use of Agilent B1500A.

- Use a three-conductor AC power cable to connect cabinet (if used) and Agilent B1500A to an electric ground (safety ground).

- If you do not use Agilent 16442 Test Fixture, make sure to connect the Interlock terminal to a switch that turns off when the shielding box access door is opened.

- Confirm periodically that interlock function works normally.

- Before touching the connections of the force, guard, and sense terminals, turn Agilent B1500A off and discharge any capacitors whenever possible. If you do not turn Agilent B1500A off, complete "all" of the following items, regardless of any Agilent B1500A settings.

  - Terminate measurement by pressing Stop key, confirm that the Measurement status indicator is not lit.

  - Confirm that the High Voltage indicator is not lit.

  - Open the shielding box access door (open the Interlock terminal).

  - Discharge any capacitors if the capacitance is connected to an SMU.

- Warn workers in the vicinity of Agilent B1500A about dangerous conditions.

高電圧感電注意

Agilent B1500A のフォース、ガード、センス端子には、危険電圧が出力されること
があります（HPSMU の場合は最大 ±200 Vdc、MPSMU/HRSMU の場合は最大 ±100
Vdc）。感電事故防止のため、必ず以下の事柄を守ってください。

• 3 極電源ケーブルを使用して Agilent B1500A を接地すること。

• Agilent 16442 テスト・フィクスチャ以外のフィクスチャ、あるいはプローバを
  使用する場合には、シールド・ボックスにインターロック回路を接続すること。
  インターロック回路とは、シールド・ボックスの蓋を開けた時に Agilent
  B1500A の Interlock 端子を開放にすることができる回路のことをいいます。

• インターロック機能が正常であることを定期的に確認すること。

• フォース、ガード、センス端子に繋がる接続部に触れる前には、測定器の電源
  を切ること。また、測定系にキャパシタが接続されている場合は、キャパシタ
  を放電すること。電源を切らない場合は、以下の事項を全て実施すること。

  • Stopキーを押してMeasurementインジケータが消灯したことを確認すること。

  • 高電圧警告（High Voltage）インジケータが消灯していることを確認するこ
    と。

  • シールド・ボックスの蓋を開ける（Interlock 端子を開放する）こと。

  • キャパシタが SMU に接続されているならば、キャパシタを放電すること。

• 周囲のほかの作業者に対しても、高電圧危険に対する注意を徹底すること。

PRECAUTIONS POUR COMMOTION A HAUTE TENSION

Une tension dangereuse (max. ± pour HPSMU; 200 Vdc, max. ± pour MPSMU/ HRSMU; 100 Vdc) émanant du dispositif Agilent B1500A peut être sortie aux bornes de force, d'appareil de protection ou de détection. Les précautions suivantes doivent être obserées contre commotion électrique accidentelle:

- Mettre à la terre le dispositif Agilent B1500A au moyen du câble d'alimentation tripolair.

- En cas de hors service du dispositif d'essai, FIXTURE Agilent 16442, connecter les bornes de verrouillage (Interlock) de façon à ce que soit ouverte lorsque le couvercle de la boîte de blindage est ouvert.

- Essayer périodiquement le fonctionnement normal de verrouillage.

- Avant de toucher la partie connexion à partir des bornes de force, d'appareil de protection et de détection, mettre hors tension le dispositif Agilent B1500A. Et, en cas de condensateurs connectés au circuit de mesure, décharger ces condensateurs. Lorsque l'alimentation n'est pas mise hors tension, les 4 instructions suivantes doivent être exécutées:

    - Finir la mésure en appuyant sur la touche "Stop"; verifier que l'indicateur "Measurement" n'est pas allumé.

    - S'assurer que soit allumé l'indicateur d'alarme de la haute tension.

    - Ouvrir le convercle de la boîte de blindage (Ouvrir les bornes de verrouillage).

    - En cas de condensateurs connectés à SMU, décharger les condensateurs.

- Alerter d'autres personnes autour de vous contre le danger de haute tension.

Achtung! Gefährliche Spannung

Von den Geräten Agilent B1500A können Spannungen an den Anschlüssen "Force, Guard und Sense" von bis zu 200 V ausgehen. Um elektrischem Schlag vorzubeugen, ist bei der Benützung der Geräte Agilent B1500A folgendes zu beachten:

• Erden Sie das Kabinett (falls verwendet) sowie die Geräte Agilent B1500A mittels dreiadriger Netzleitungen.

• Wenn die Meßfassung, Agilent 16442, zwar angeschlossen, jedoch nicht verwendet wird, schließen Sie die Verriegelungsklemme (Interlock) so an, daß bei geöffnetem Deckel die Stromzuführung zu Agilent 16442 auf jeden Fall unterbrochen wird.

• Vergewissern Sie sich regelmäßig daß die Verriegelungsfunktion korrekt arbeitet.

• Schalten Sie die Geräte Agilent B1500A aus, und entladen Sie alle Kapazitäten bevor Sie die Anschlüsse "Force, Guard und Sense" berühren. Falls Sie die Geräte Agilent B1500A nicht ausschalten, führen Sie unabhängig von den Geräteeinstellungen folgende Schritt durch:

  • Beenden Sie die gegenwärtige Messung durch Drücken der Stop Taste (die Measurement Leuchtdiode erlischt).

  • Vergewissern Sie sich daß die Hochspannungswarnlampe erloschen ist.

  • Öffnen Sie den Deckel der Meßfassung Agilent 16442 (die Verriegelungsklemme (Interlock) öffnen).

  • Entladen Sie alle an SMUs angeschlossenen Kondensatoren (falls vorhanden).

• Informieren Sie Personen in unmittelbarer Nähe der Geräte Agilent B1500A über die Gefährlichkeit der bestehenden Hochspannung, und sichern Sie den Zugang zum Prüfplatz zum Schutz Dritter.

Precautionary Statement

Agilent B1500A Semiconductor Device Analyzer operates in the Microsoft Windows XP Professional environment. Agilent B1500A requires Agilent EasyEXPERT software, a specially-designed Windows XP application program.

- About guarantee and support for Agilent B1500A

  Agilent Technologies guarantees and supports the performance of Agilent B1500A for the same condition as the preload condition when shipped from the factory.

- About updating Agilent EasyEXPERT and the Windows Update

  Agilent Technologies confirms the operation of Agilent EasyEXPERT patch programs and important Windows security patches, and provides recommended update information. Visit Agilent B1500A support site, download the patches, and perform the software update.

- About Windows XP application programs and peripherals (including driver)

  Using commercial products on Agilent B1500A is your responsibility. Agilent Technologies cannot provide compatibility information for commercial products. If problems arise, perform Agilent B1500A system recovery.

- About servicing

  Bench repair service is available at your nearest Agilent Technologies service center. Be aware that the B1500A configuration might be updated to the latest one without notice because of support issues.

  The internal hard disk drive (HDD) might be initialized during servicing. If peripherals are connected, they will be removed.

  When Agilent B1500A is returned, the internal HDD might be initialized. Peripherals will be returned separately.

- Other notes

  - Back up the internal HDD to prevent loss of data by accident or failure.

  - Protect Agilent B1500A from computer viruses.

  - If you connect Agilent B1500A to the network, take care to protect it from computer virus.

Working in Comfort

To optimize your comfort and productivity, it is important that you set up your work area correctly and use your instrument properly. With that in mind, we have developed some set-up and use recommendations for you to follow based on established ergonomic principles. Improper and prolonged use of keyboards and input devices are among those tasks that have been associated with repetitive strain injury (RSI) to soft tissues in the hands and arms. If you experience discomfort or pain while using the instrument, discontinue use immediately and consult your physician as soon as possible. For more information on RSI you may wish to consult the *About Repetitive Strain* Injury section. Please study the recommendations described below. Included there are references to relevant parts of international standards, regulations and guidelines, such as ISO 9241 and the European Community Display Screen Equipment directive. You may also wish to consult your employer's human resources department or other relevant departments for guidance specific to your company.

About Repetitive Strain Injury

Because your comfort and safety are our primary concern, we strongly recommend that you use the instrument in accordance with established ergonomic principles and recommendations. Scientific literature suggests that there may be a relationship between injury to soft tissues -especially in the hands and arms- and prolonged improper use of keyboards or other equipment requiring repeated motions of the hands and forearms. This literature also suggests that there are many other risk factors that may increase the chance of such injury, commonly called Repetitive Strain Injury.

What is RSI?

Repetitive Strain Injury (RSI -also known as cumulative trauma disorder or repetitive motion injury) is a type of injury where soft tissues in the body, such as muscles, nerves, or tendons, become irritated or inflamed. RSI has been a reported problem for those who perform repetitive tasks such as assembly line work, meatpacking, sewing, playing musical instruments, and computer work. RSI also has been observed in those who frequently engage in activities such as carpentry, knitting, housework, gardening, tennis, windsurfing and lifting children.

What causes RSI?

The specific causes of RSI have not been established. Nevertheless, the incidence of RSI has been associated with a variety of risk factors, including:

- Too many uninterrupted repetitions of an activity or motion.

- Performing an activity in an awkward or unnatural posture.

- Maintaining static posture for prolonged periods.

- Failing to take frequent short breaks.

- Other environmental and psychosocial factors.

In addition, there have been reports associating the occurrence of RSI with the use of keyboards, mice, and other input devices. Also, certain medical conditions, such as rheumatoid arthritis, obesity and diabetes, may predispose some people to this type of injury.

What if I experience discomfort?

If you are experiencing any discomfort, seek professional medical advice immediately. Typically, the earlier a problem is diagnosed and treated, the easier it is to resolve.

Mice and Other Input Devices

Various aspects of using mice and other input devices may increase your risk of discomfort or injury. Observing the following recommendations may reduce that risk.

- Try to keep your hand, wrist, and forearm in a neutral position while using your mouse or other input device.

- If you use your thumb to rotate the ball on a trackball or spaceball, keep it in a relaxed, natural shape, and maintain a neutral posture in your hand, wrist, and forearm.

- Hold the mouse gently by draping your fingers over it. Keep your hand relaxed and fingers loose. Do not grip the mouse tightly.

- It takes very little pressure or force from your fingers to activate the buttons or scroll wheel on your mouse, scrolling mouse, trackball, or other input device. Using too much force can place unnecessary stress on the tendons and muscles in your hands, wrists, and forearms.

- If you are using a scrolling mouse, be sure to keep your fingers and hand in a relaxed, neutral position when activating the scroll wheel. Also, this type of mouse features software that can minimize the number of mouse movements or button clicks.

- When using a mouse, trackball, or other input device, position it as close to the keyboard as possible, and keep it at the same level as you do not have to stretch while using it.

- Be sure to keep your mouse and trackball clean. Regular removal of accumulated dust and dirt helps ensure proper tracking and reduces unnecessary hand and wrist motions.

In This Manual

This manual describes the product overview and installation information of Agilent Technologies B1500A. This manual consists of the following chapters:

- Chapter 1, "Getting Started"

  This chapter describes basic operations of Agilent B1500A.

- Chapter 2, "Introduction"

  This chapter describes basic features of Agilent B1500A.

- Chapter 3, "Installation"

  This chapter describes installation, device connection, and maintenance.

- Chapter 4, "Specifications and Options"

  This chapter describes specifications and options of Agilent B1500A.

NOTE   To get the latest firmware/software/electronic manuals/support information, visit Agilent Technologies support site (http://www.home.agilent.com), and click Oscilloscopes, Analyzers, Meters > Parametric & Device Analyzers, Curve Tracers. You can reach the support site for the Agilent B1500A, B1505A, and EasyEXPERT.

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1   Getting Started

This chapter describes the basic operations of Agilent B1500A. Before learning the product details, let's try to use the B1500A briefly. The operations need the B1500A, power cable, and USB keyboard only (USB mouse and stylus pen are optional). Agilent B1500A also requires Agilent EasyEXPERT software as its graphical user interface.

During the operations, you will not connect device under test. Open all measurement terminal.

This chapter consists of the following sections.

- "To Turn On/Off B1500A"

- "To Launch EasyEXPERT"

- "To Use Tracer Test Mode"

- "To Use Application Test Mode"

- "To Use Classic Test Mode"

- "To Perform Measurement"

- "To Use Analysis Tools"

To Turn On/Off B1500A

NOTE   When turning the B1500A on

Open the measurement terminals at the device side when turning the B1500A on. Also disconnect the device from the measurement terminals and open the measurement terminals after the test. If you leave the connection with the device, the device may be damaged by unexpected operations or charge-up of measurement cables.

NOTE   If you use the B1500A at the first time

If this is the first time to turn Agilent B1500 on after the delivery, you need to perform the initial setup of the B1500. See "Inspection and Installation" on page 3-6. After the initial setup and if no users are added, you can automatically logon as "Agilent B1500 User" account without password.

NOTE   If Start EasyEXPERT button is not displayed

Select All Programs > Start EasyEXPERT from the Start menu. The Start EasyEXPERT button will be displayed.

NOTE   Automatic start function

If the automatic start function is on, Agilent EasyEXPERT is launched within the B1500A boot up process. If the function is off, EasyEXPERT is not launched and the Start EasyEXPERT button is displayed.

To turn the automatic start function off, use the Start EasyEXPERT window displayed by the File > Exit menu on the EasyEXPERT main screen. And remove the check from the Option > Auto Start of EasyEXPERT menu.

To Turn B1500A On

1. Connect the power cable from Agilent B1500A to an AC power outlet.

2. Connect the USB keyboard to the B1500A. Optionally, connect the USB mouse to the B1500A.

3. Press the Standby switch (lower right corner of the front panel). Windows, measurement module initialization, and self-calibration will start. For the Windows logon screen, log on Windows.

   After logging on, the Start EasyEXPERT button will be displayed on the screen, or EasyEXPERT will be launched if the automatic start function is on.
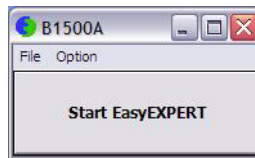
To Turn B1500A Off

Press the Standby switch (lower right corner of the front panel). Windows will be shutdown and the B1500A will become the standby state.
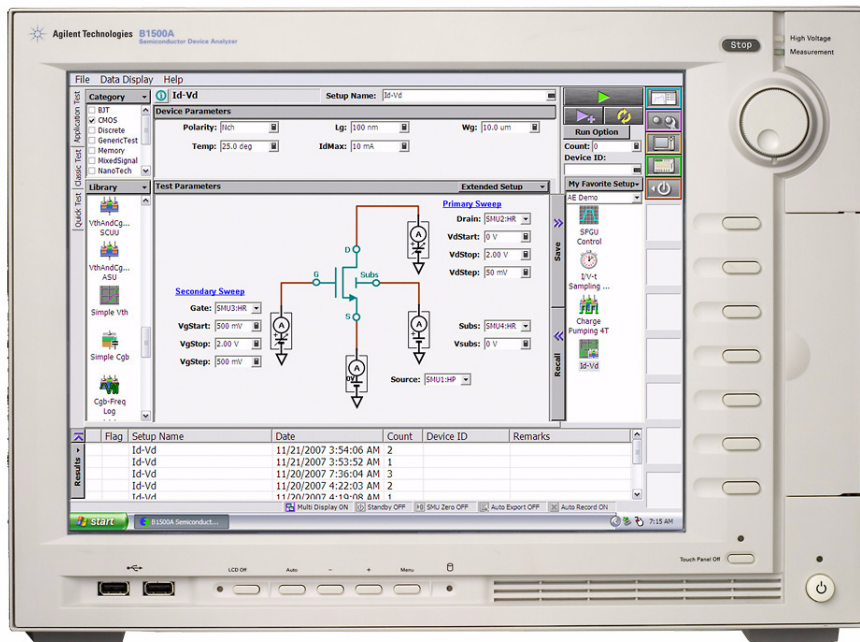
NOTE

Agilent B1500A has the following front panel user interface.

- Stop

  Stops the present measurement or source output immediately.

- Rotary knob

  Rotating the knob moves the marker on the graph window, or increases/decreases/changes the value in the active entry field.

  Pressing the knob sets or enters the value.

- Softkeys

  Seven softkeys are available. Used to select one for the entry field specified or the dialog box. They are also used to recall the test definitions (pre-defined test setups).

- Touch Panel Off

  Enables or disables the touch screen operation.

- Standby switch

  Turns the B1500A on. Pressing the button in the ON state makes the B1500A in the standby state.

- LCD Off

  Enables or disables the LCD panel. LED lights when the LCD is disabled.

- Auto, −, +, Menu

  Four keys are available for the display adjustment. Press Auto to perform adjustment automatically. Use −, +, and Menu to adjust manually.

Agilent B1500A also requires Agilent EasyEXPERT software as its graphical user interface. You can operate Agilent EasyEXPERT by using the touch panel. Use your fingers, stylus pen, and so on for the touch panel operation. The USB keyboard and the USB mouse are also available for operating the EasyEXPERT.

To Launch EasyEXPERT

1. If the automatic start function is off, the Start EasyEXPERT button is displayed. Click the button and wait until the EasyEXPERT main screen or workspace selection screen is displayed.
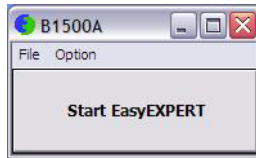
NOTE Workspace is the space created in Agilent B1500A's internal hard disk drive, and is used to store the test setup, test result data, and so on. The workspace can be created and allocated for each user.

2. If this is the first time to start the EasyEXPERT, or if no workspace exists, a workspace will be created automatically.

   Skip to "To Use Tracer Test Mode" on page 1-10, "To Use Application Test Mode" on page 1-12, or "To Use Classic Test Mode" on page 1-14.

3. If only one workspace exists, the B1500A displays the screen as shown in Figure 1-1.

   Skip to "If Only One Workspace Exists" on page 1-7.

4. If two or more workspaces exist, the B1500A displays the screen as shown in Figure 1-3.

   Skip to "To Select Workspace" on page 1-9.

If Only One Workspace Exists

For the screen as shown in Figure 1-1, perform the following steps.

1. If you do not want to create a workspace, select the Yes radio button and click OK.

   Skip to "To Use Tracer Test Mode" on page 1-10, "To Use Application Test Mode" on page 1-12, or "To Use Classic Test Mode" on page 1-14.

2. If you want to create a workspace, select the No radio button and click Next. The B1500A displays the screen as shown in Figure 1-2.

   Skip to "To Create Workspace" on page 1-8.

Figure 1-1   **If Only One Workspace Exists**
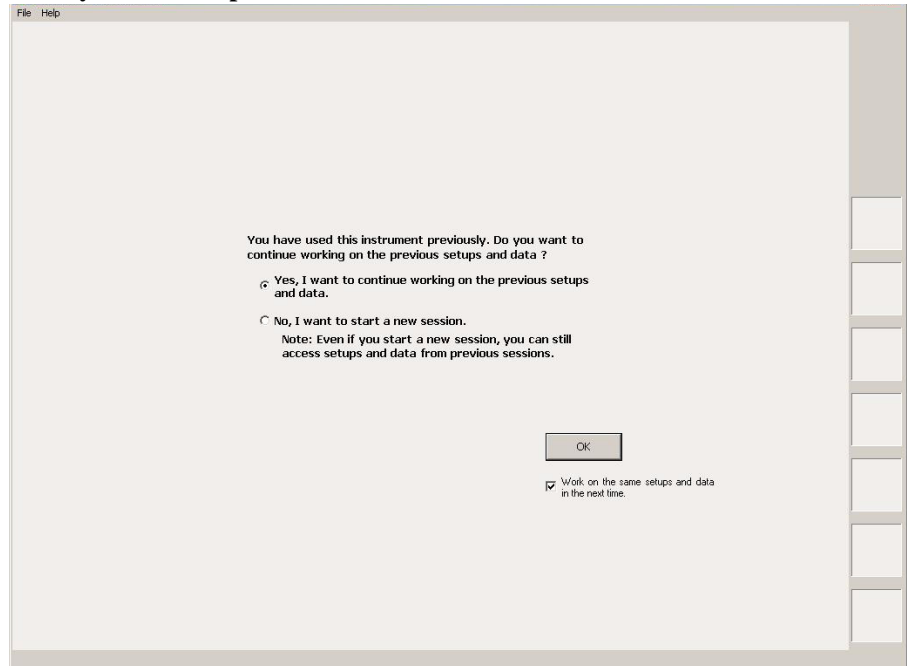
NOTE   Work on the same setups and data in the next time

If this check box is checked, the workspace selection screen will be skipped at the next startup and EasyEXPERT will be launched with the workspace used at the last operation. To perform this setup again, click the File > Close Workspace menu on the EasyEXPERT main screen.

To Create Workspace

For the screen as shown in Figure 1-2, perform the following steps. To cancel creating workspace, click Prev.

1. Enter the name of the new workspace into the above-entry field.

   Check *Allow other users to access this workspace* box if you want to create a public workspace that is opened for all users.

2. If you are the owner of the existing workspace, you can change the name of the existing workspace.

   If you want to rename the existing workspace, enter the name into the below-entry field.

   Check *Allow other users to access this workspace* box if you want to set it to a public workspace that is opened for all users.

3. Click OK.

Skip to "To Use Tracer Test Mode" on page 1-10, "To Use Application Test Mode" on page 1-12, or "To Use Classic Test Mode" on page 1-14.

Figure 1-2   **To Create Workspace**
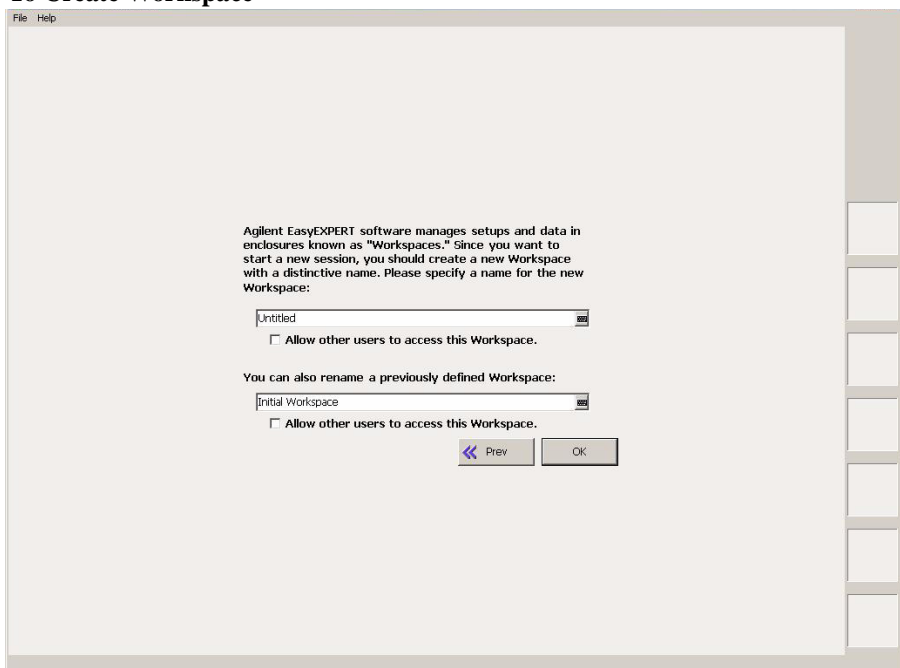
To Select Workspace

For the screen as shown in Figure 1-3, perform the following steps. This example selects the workspace named as *Demo Workspace* that is a public workspace that is opened for all users.

1. Select *Public Workspaces owned by other users* radio button.

2. Click *Demo Workspace* to select it.

3. Click Continue.

Skip to "To Use Tracer Test Mode" on page 1-10, "To Use Application Test Mode" on page 1-12, or "To Use Classic Test Mode" on page 1-14.

Figure 1-3   **To Select Workspace**
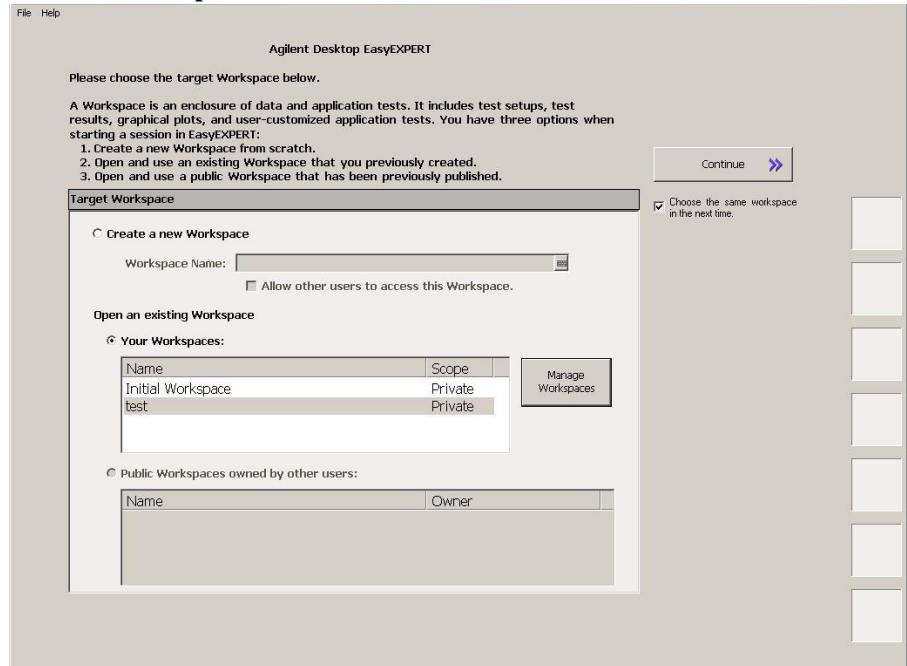
NOTE   Choose the same Workspace in the next time

If this check box is checked, the workspace selection screen will be skipped at the next startup and EasyEXPERT will be launched with the workspace used at the last operation. To perform this setup again, click the File > Close Workspace menu on the EasyEXPERT main screen.

To Use Tracer Test Mode

The following procedure performs the tracer test setup.

1. Click the Tracer Test tab on the main screen. The tab is in the leftmost column on the screen. The I/V Trace screen is displayed. See Figure 1-4.

2. Set the channels at the field below the graph as shown in Table 1-1.

3. Set the measurement condition at the right field of the graph as shown in Table 1-3.

4. Set the graph display condition at the field below the graph as shown in Table 1-2.

To enter the value, use the USB keyboard or the screen/numeric keyboard opened by clicking the right button of the entry field.

To start measurement, click [▶] for the single measurement or [↻] for the repeat measurement.

If the Stop field is highlighted, the range of measurement and graph display can be changed by using the rotary knob during the repeat measurement.

Table 1-1   **I/V Trace Channel Setup**

Unit	V Name	I Name	Mode [a]	Function
SMU1	V1	I1	V	VAR1
SMU2	V2	I2	V	CONST

a. Channel output mode. Set I or IPULSE for the current output and voltage measurement. Set V or VPULSE for the voltage output and current measurement.

Table 1-2   **I/V Trace Graph Setup**

	Name	Scale			Name	Scale	
Y ↑	I1	LIN	±	**→ X**	V1	LIN	+

Table 1-3   **I/V Trace Measurement Setup**

VAR1		CONST	
Mode	LIN-SGL	**Unit**	SMU2
Start	0 V	**Source**	0 V
Stop	1 V	**Compliance**	5 mA
Step	10 mV		
NOS	101		
Interlacing	1		
Compliance	5 mA	**Meas. Time**	2 us
Pwr Comp	OFF	**Step Time**	500 us

Figure 1-4   **Display Example of I/V Trace Screen**
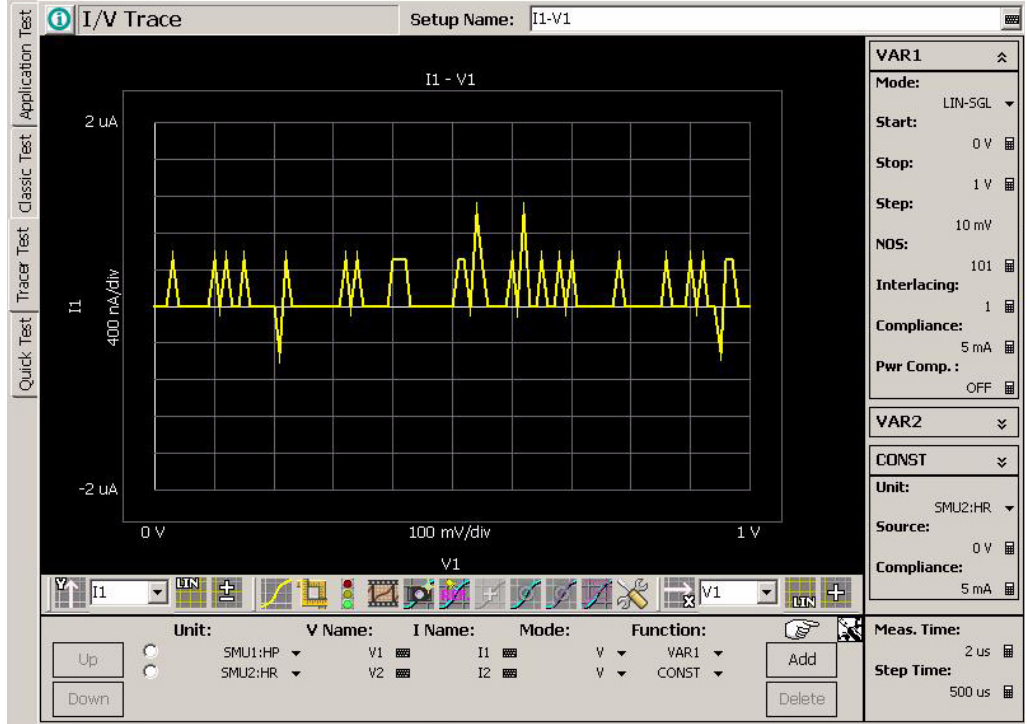
To Use Application Test Mode

For the screen as shown in Figure 1-5, perform the following procedure.

Figure 1-5   **Display Example of EasyEXPERT Main Screen**
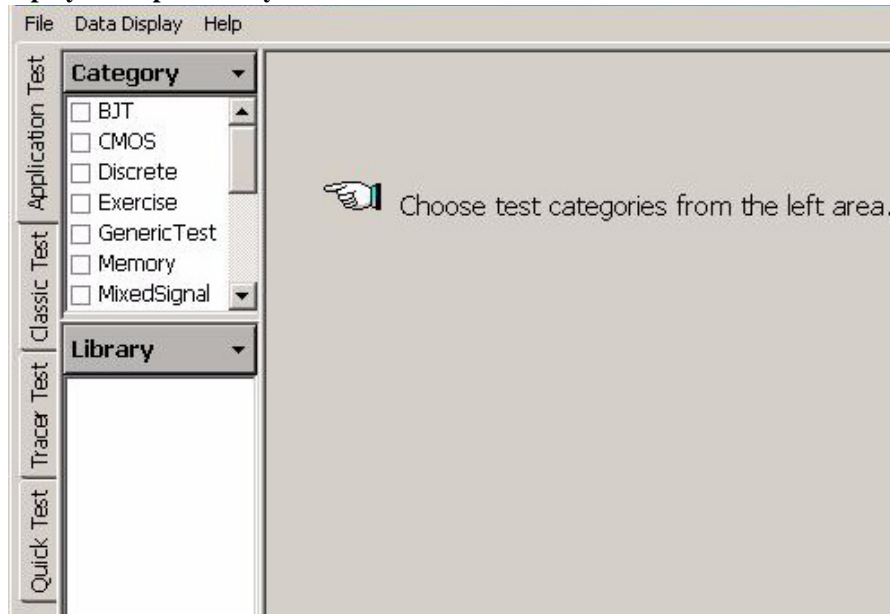
1. Click the Application Test tab on the main screen. The tab is in the leftmost column on the screen.

2. Set the Category field. For example, check the CMOS only. The Library field lists the test definitions.

3. Select a test definition at the Library field. For example, click the *Id-Vg* and *Select* button sequentially. The screen changes the display as shown in Figure 1-6.

4. Change the measurement conditions at the Test Parameters field.

   The following example changes the voltage sweep output.

   a. Set VgStart to `0 V` and VgStep to `0.2 V`.

   b. Set VsubsStep to `-1.0 V`.

To enter the value, use the USB keyboard or the screen/numeric keyboard opened by clicking the right button of the entry field.

See "To Perform Measurement" on page 1-16 to start measurement.

NOTE   Test Definitions

Test definitions are the built-in test setups that have been defined and stored in the EasyEXPERT as the application library. The EasyEXPERT contains more than two hundred test definitions. You can execute the test without modifications. Also you can create your own test setup/definition by making any changes. All furnished test definitions are just sample. Agilent Technologies is NOT LIABLE for any damages caused by the samples.

Figure 1-6   Display Example of Application Test Setup Screen
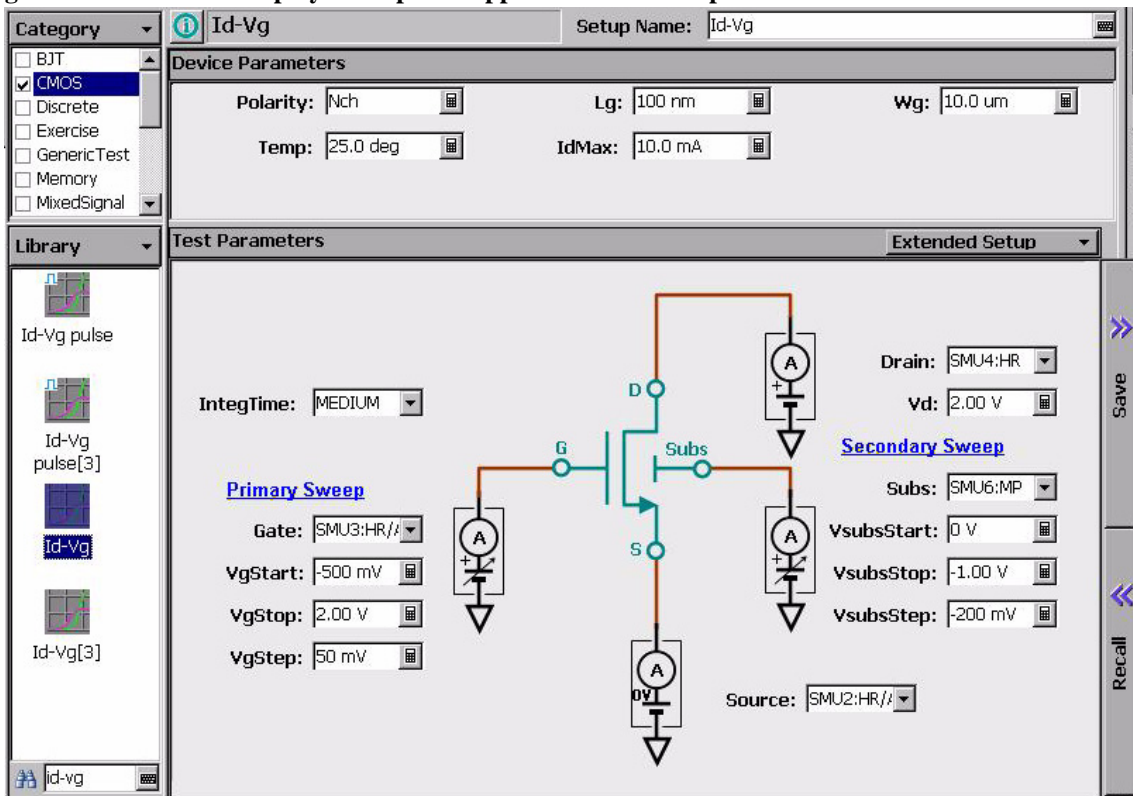
To Use Classic Test Mode

The following procedure performs the I/V Sweep classic test setup.

1. Click the Classic Test tab on the main screen. The tab is in the leftmost column on the screen.

2. Click I/V Sweep and Select button sequentially. The I/V Sweep Channel Setup screen is displayed. See Figure 1-7.

3. Set the Channel Setup parameters as shown in Table 1-4.

4. Click the Measurement Setup tab and set the parameters as shown in Table 1-5.

5. Click the Display Setup tab and set the parameters as shown in Table 1-6.

To enter the value, use the USB keyboard or the screen/numeric keyboard opened by clicking the right button of the entry field.

Figure 1-7   **Display Example of I/V Sweep Channel Setup Screen**
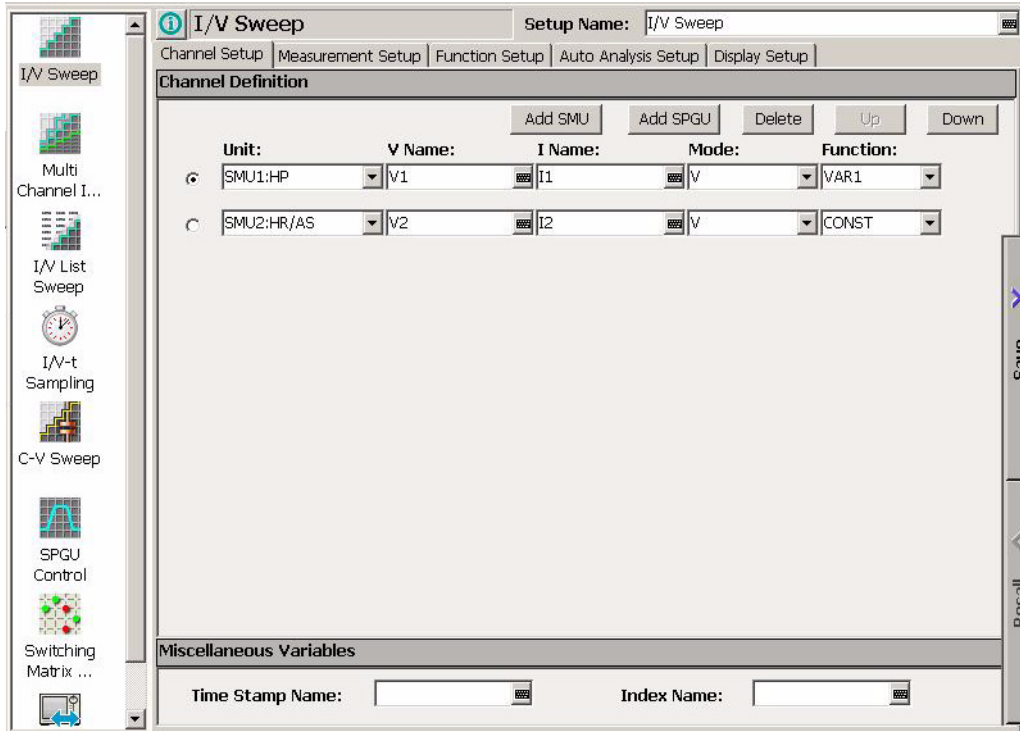
See "To Perform Measurement" on page 1-16 to start measurement.

Table 1-4   **I/V Sweep Channel Setup**

Unit	V Name	I Name	Mode [a]	Function
SMU1	V1	I1	V	VAR1
SMU2	V2	I2	V	CONST

a. Channel output mode. Set I or IPULSE for the current output and voltage measurement. Set V, VPULSE, or COMMON for the voltage output and current measurement.

Table 1-5   **I/V Sweep Measurement Setup**

VAR1		Timing		Constants	
Unit	SMU1	**Hold**	0 s	**Unit**	SMU2
Name	V1	**Delay**	0 s	**V Name**	V2
Direction	Single			**I Name**	I2
Linear/Log	LINEAR			**Mode**	V
Start	0 V			**Source**	0 V
Stop	1 V			**Compliance**	100 mA
Step	10 mV				
No of Step	101				
Compliance	100 mA				
Pwr Comp	OFF	**Sweep**	CONTINUE AT ANY	**status**	

Table 1-6   **I/V Sweep Display Setup**

	Name	Sharing	Scale	Min	Max
X	V1	(None)	Linear	0 V	1 V
Y1	I1	(None)	Linear	-1 pA	1 pA

To Perform Measurement

1. Click the Single button (upper right on the main screen) to start measurement. This opens the Data Display window and starts a single sweep measurement.

   After the measurement, the measurement data is displayed on the Data Display window. For the measurement after performing "To Use Classic Test Mode" on page 1-14, you will have the test result as shown in Figure 1-8. This is the leakage current measurement result because all measurement terminal is opened for performing the procedures described in this chapter.

2. If the automatic data record function has been set to ON (Auto Record ON), Test Result Editor appears on the lower area of the screen when the measurement is completed. See "To Use Test Result Editor" on page 1-17.

Figure 1-8   Display Example of Data Display Window
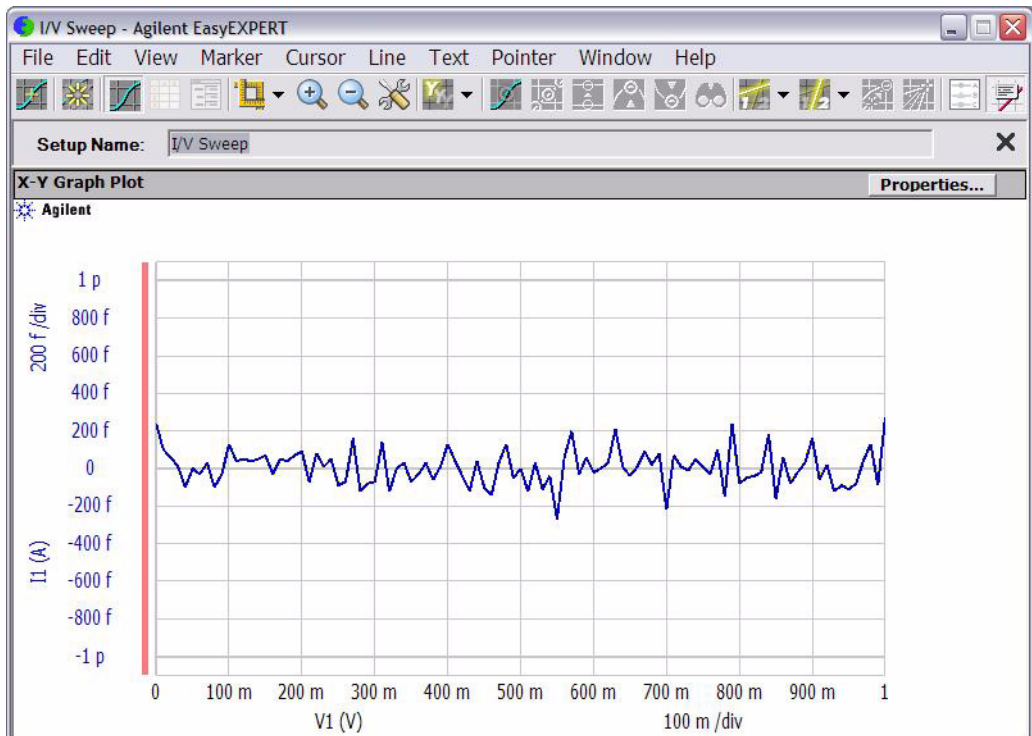
To Use Test Result Editor

The Test Result Editor provides the following GUI to set a flag and remarks to the test result record.
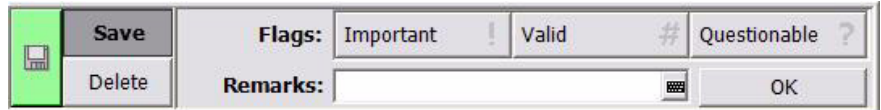
- Save button and Delete button

  Divides test records into groups, Save and Delete.

  Test records in Save-group are always listed in the lower area of the EasyEXPERT main screen.

  Test records in Delete-group can be listed when Results > Filter > Show Deleted Data is checked.

- Flags buttons

  The following buttons are available. You can set one of the following flags.

  - Important ! button

    Sets the important flag (!) to the test result record.

  - Valid # button

    Sets the valid flag (#) to the test result record.

  - Questionable ? button

    Sets the questionable flag (?) to the test result record.

- Remarks field

  You can enter characters into this field. The characters will be recorded as the Remarks value of the test result record.

- OK button

  Applies the setup on the Test Result Editor, and closes this dialog box.

To Use Analysis Tools

The Data Display window provides several analysis functions.

- View menu: used to adjust the graph scale.

- Marker menu: used to display and control the marker.

- Cursor menu: used to display and control the cursor.

- Line menu: used to display and control the lines.

When the marker, cursor, and lines are effective, their parameters are also displayed on the X-Y Graph Plot area.

Figure 1-9 is an example displaying marker, tangent line, and regression line on the test result graph shown in Figure 1-8. You can read position of the marker and the active cursor, and interrupt and gradient of the active line.

Figure 1-9   **Display Example of Analysis Tools**
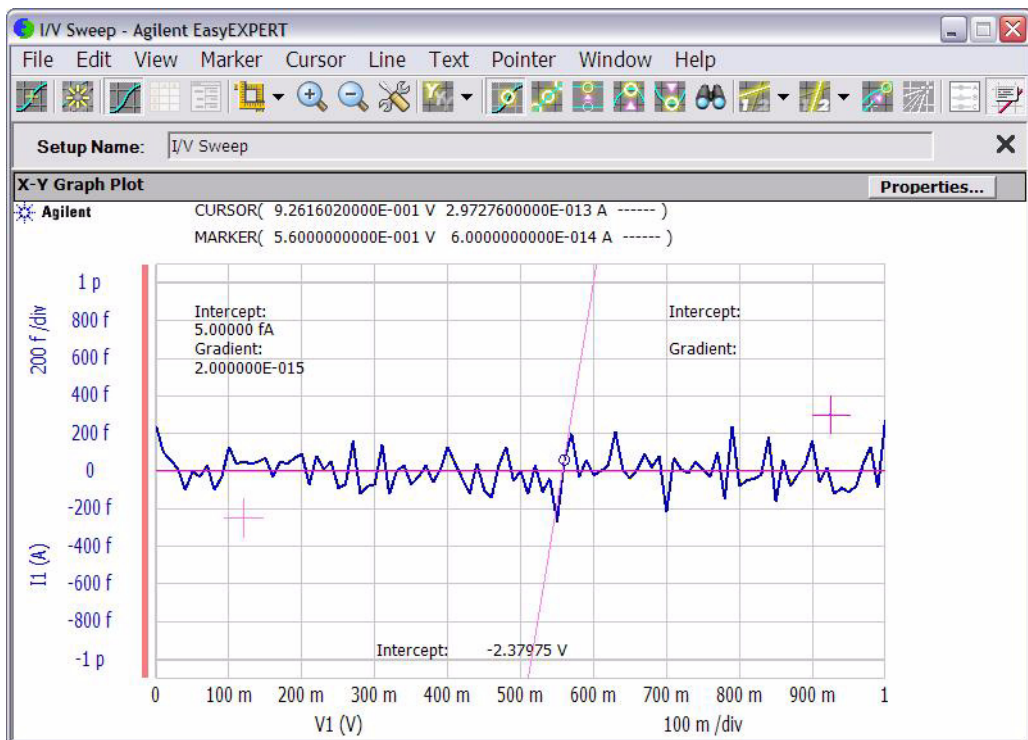
2 Introduction

This chapter describes the basic functions and features of Agilent B1500A Semiconductor Device Analyzer, and consists of the following sections:

- "Overview"

- "Front View"

- "Rear View"

- "Measurement Units"

NOTE   Application Library

Agilent B1500A has installed Agilent EasyEXPERT software as the user interface. The EasyEXPERT contains an application library that is a set of test definitions. The application test can be performed by selecting a test definition and setting the test condition for the actual DUT (device under test).

All test definitions are just sample. If the samples damage your devices, Agilent Technologies is NOT LIABLE for the damage.

NOTE   Utility

The following utility programs (sample) are stored in the folder C:\Program Files\Agilent\B1500\EasyEXPERT\Utilities.

- Prober control programs

- 4155/4156 setup file converter

- sleep.exe program

For more details, see Agilent EasyEXPERT User's Guide.

Overview

Agilent B1500A Semiconductor Device Analyzer is the new generation one box solution for the semiconductor device DC/AC parametric measurement and analysis application. Agilent B1500A provides the DC voltage/current output capability, DC voltage/current measurement capability, and AC signal output and impedance measurement capability. So you can perform a current-voltage sweep measurement and a capacitance-voltage sweep measurement for example by one instrument.

Agilent B1500A also provides an intuitive graphical user interface, touch screen LCD panel, keyboard, and mouse for easy and effective measurement and analysis on the Microsoft Windows environment. You can analyze a measurement result characteristics graph for example by using several tools such as markers, cursors, and lines.

Also, in the GPIB remote control mode, you can control the B1500A from an external computer by using Agilent FLEX command set that is the common language for Agilent semiconductor DC measurement instruments. So you can reuse the measurement program created for Agilent 4155/4156/E5260/E5270.

- Agilent B1500A Semiconductor Device Analyzer

  Mainframe that provides the ground unit (GNDU) and ten empty slots for the measurement facilities, and Agilent EasyEXPERT software for the operating environment. The EasyEXPERT is the GUI based measurement control and analysis software runs on the Microsoft Windows XP Professional.

  The B1500A is equipped with the 15 inch LCD with touch panel, hard disk drive, DVD-ROM/CD-ROM/CD-RW drive, and USB/LAN/GP-IB interfaces. The USB keyboard, the USB mouse, and the stylus pen are available as option.

- HPSMU module

  High power source/monitor unit module. Occupies two slots.

- MPSMU module

  Medium power source/monitor unit module. Occupies one slot.

- HRSMU module

  High resolution source/monitor unit module. Occupies one slot. Needs Agilent E5288A ASU to perform atto level current measurement or automatic switching of the measurement resource connection.

- MFCMU module

  Multi frequency capacitance measurement unit module. Occupies one slot. Needs Agilent N1301A-100 SCUU to perform automatic switching of the measurement resource connection.

- SPGU module

  High voltage semiconductor pulse generator unit module. Occupies one slot. Up to five modules can be installed in one B1500A mainframe. One module provides two output channels. Needs Agilent 16440A and 16445A to perform automatic switching of the measurement resource connection.

- WGFMU module and RSU

  Waveform generator/fast measurement unit module and the remote-sense and switch unit. Occupies one slot. Up to five modules can be installed in one B1500A mainframe. One module provides two channels. See Agilent B1530A *User's Guide* for using the WGFMU.

- Agilent 16440A SMU/Pulse Generator Selector

  Used to switch the measurement resource connected to the DUT. The measurement resource can be SPGU or SMU. Needs the 16445A adapter to use the selector. One selector provides two switching channels.

- Agilent 16445A Selector Adapter

  Used to connect the 16440A selector to the B1500A. Two selectors can be connected.

- Agilent E5288A ASU

  Atto sense and switch unit (ASU). Used to enable the 1 pA range for the atto level current measurement, also switch the measurement resource connected to the DUT. The measurement resource can be HRSMU or the instrument connected to the AUX terminal.

- Agilent N1301A-100 SCUU

  SMU CMU unify unit (SCUU). Used to switch the measurement resource connected to the DUT. The measurement resource can be CMU or one of two SMUs connected to the SCUU.

- Agilent N1301A-200 GSWU

  Guard switch unit (GSWU). Needs the SCUU to use the GSWU. Effective for the accurate impedance measurements by connecting the guard lines between CMU high and low near the DUT.

Agilent EasyEXPERT Software

Agilent EasyEXPERT software is a specially-designed Windows XP application program for controlling Agilent B1500A. The EasyEXPERT provides the easy and effective measurement and analysis environment with intuitive graphical user interface (GUI), touch screen LCD panel, keyboard, and mouse. Some of the functions are listed below.

- Single measurement, repeat measurement, and append measurement
- Switching matrix control

  Supported models:

  - Agilent B2200A/B2201A switching matrix
  - Agilent E5250A switching matrix with E5252A (EasyEXPERT Plus edition)

- Measurement/setup data management by workspace
- Graph display and analysis with markers, cursors, and lines; and auto analysis
- Data import/export capability, data output by CSV/XML format, and graph output by EMF/BMP/GIF/PNG format
- Maintenance; self-test and self-calibration

The EasyEXPERT has the following measurement execution environments.

- Application test
- Classic test
- Tracer test
- Quick test

Application Test   The EasyEXPERT contains an application library that supports typical measurements for CMOS devices, TFT, BJT, memory, nanotechnology devices such as CNT FET, and so on. The application library includes more than two hundred test definitions.

You can perform measurements by choosing the best one for your device under test (DUT) from the application libraries, and modifying and executing it. Modification is really simple. For example, it will be completed by changing the output voltage only to DUT terminals. And the setup with your modifications can be saved and recalled as your setup (*My Favorite Setup*).

Classic Test   You can perform measurements by using the user interface similar to the semiconductor parameter analyzers such as Agilent 4156C. The setup can be made by entering values into the setup tables used for the measurement module control. And it can be saved and recalled as your setup (*My Favorite Setup*). This measurement environment provides the following functions.

- • I/V Sweep

- • Multi Channel I/V Sweep

- • I/V List Sweep

- • I/V-t Sampling

- • C-V Sweep

- • SPGU Control

- • Switching Matrix Control

- • Direct Control

The Direct Control test mode is used to control the measurement modules directly by using the B1500A GPIB control commands and perform measurement. For the control commands, see "Programming Guide".

Tracer Test   Curve tracer test mode. This test allows you to perform the high speed I-V measurement on one screen. The Tracer Test screen provides GUI for selecting the used channels, setting the sweep output, and displaying the measurement result (tracing the I-V curve). Range of the sweep output and measurement can be changed by the rotary knob on the front panel.

Quick Test   You can execute the test setups saved in a preset group (*My Favorite Setup*) sequentially.

Front View

This section describes the front view of Agilent B1500A.
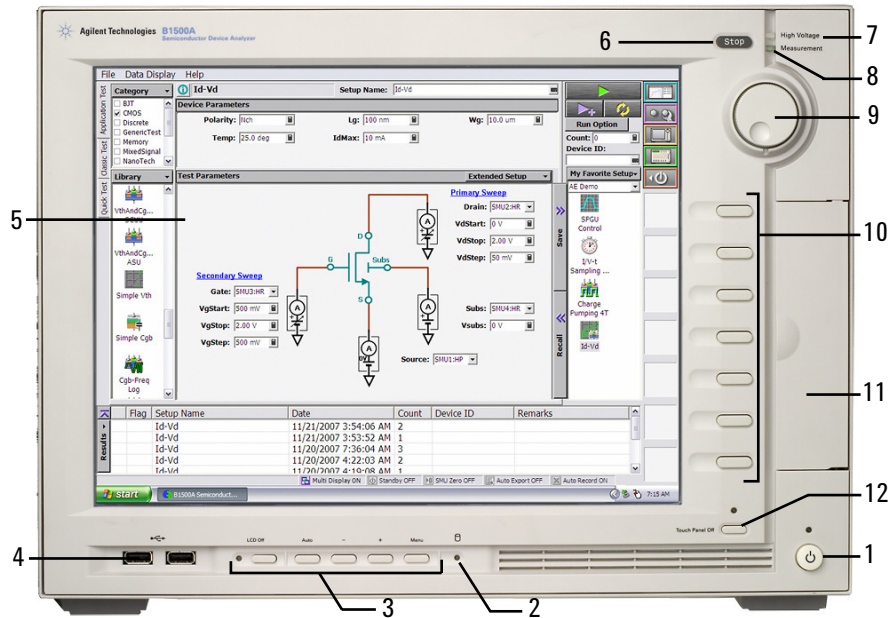
1. Standby switch

   Turns the B1500A on. Pressing the button in the ON state makes the B1500A in the standby state. The green LED lights when the B1500A is in the ON state.

NOTE   When turning the B1500A on

Open the measurement terminals at the device side when turning the B1500A on. Also disconnect the device from the measurement terminals and open the measurement terminals after the measurement. If you leave the connection with the device, the device may be damaged by unexpected operations or charge-up of measurement cables.

2. HDD access indicator

   This green LED lights in the access status of HDD or DVD-ROM/CD-ROM/ CD-RW drive. Do not turn the B1500A off during this LED lights.

3. OSD buttons

   LCD Off enables or disables the LCD panel. The green LED lights when the LCD is disabled.

   Four keys are available for the display adjustment. Press Auto to perform adjustment automatically. Use −, +, and Menu to adjust manually.

4. USB interfaces

   USB, 2 ports. For keyboard, mouse, and so on. USB keyboard and USB mouse are available as option.

5. LCD panel

   15 inch TFT XGA display, 1024 × 768 resolution. Displays the Windows screen, Agilent EasyEXPERT software window, and so on. Touch screen operation is available when the Touch Panel Off indicator does not light.

NOTE   About screen adjustment

If you find swinging or flickering in screen while you use this instrument, perform the screen adjustment. In most cases, the symptoms can be resolved by pressing the Auto button below the LCD panel. The Auto button is used to start the automatic screen adjustment. Also the manual screen adjustment is available by using the adjustment menu displayed by pressing the Menu button.

6. Stop key

   Stops the present measurement or source output immediately.

7. High voltage status indicator

   This red LED lights when a source channel applies more than ± 42 V.

8. Measurement status indicator

   This green LED lights when a measurement channel performs measurement.

9. Rotary knob

   Works on Agilent EasyEXPERT environment. Rotating the knob moves the marker on the graph window, or increases/decreases/changes the value in the active entry field. Pressing the knob sets or enters the value.

10. Softkeys

    Seven softkeys are available for Agilent EasyEXPERT environment. Used to select an alternative for the entry field specified or the dialog box.

11. DVD-ROM/CD-ROM/CD-RW drive

    For data backup, B1500A update, or data transfer.

12. Touch Panel Off key

    Works on Agilent EasyEXPERT environment. Enables or disables the touch
    screen operation. The green LED lights when the touch screen is disabled.

NOTE   To disable the touch panel

Use Touch Panel Device Properties, and remove the check from the Enabled box on
the Advanced tab screen. The Touch Panel Device Properties dialog box can be
opened by selecting Gunze TPDD > Adjust Settings from Windows program menu.
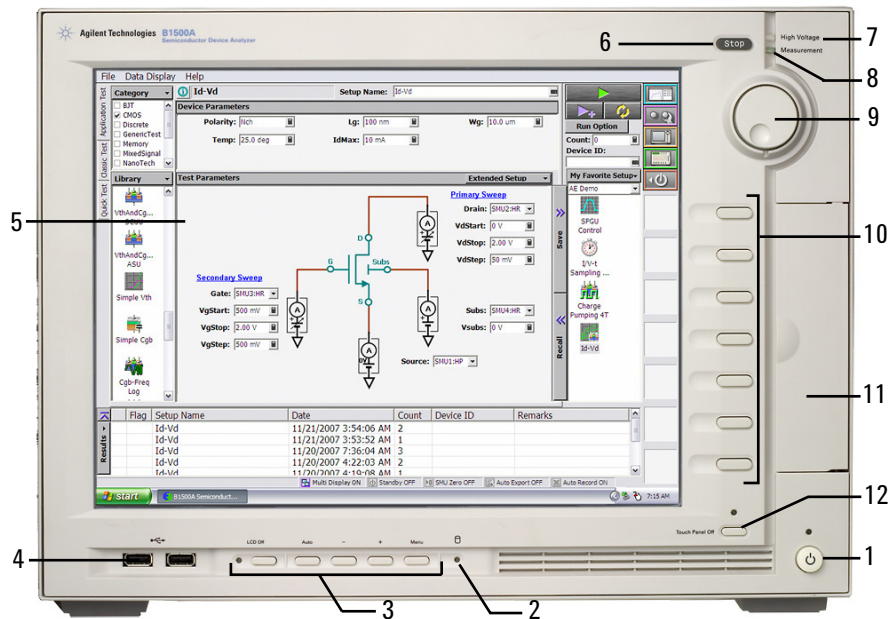
Rear View

This section describes the rear view of Agilent B1500A.
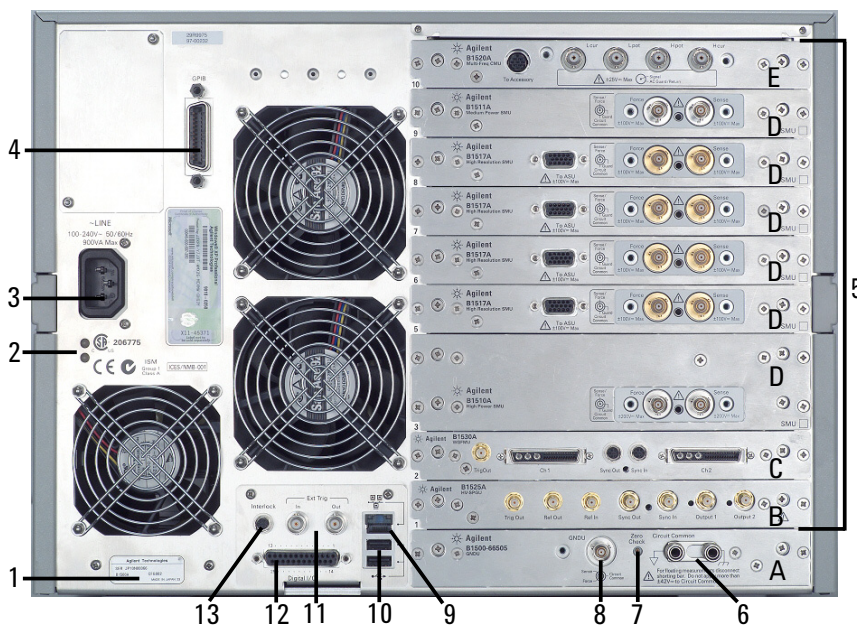
1. Serial number

   You need this *serial number* when using Agilent Technologies telephone assistance program.

2. LED status indicator

   For troubleshooting. Followings are some examples.

   • Both LEDs turn off:

     B1500A is in the standby state and Standby switch is OFF position.

   • One LED turns green:

     Power supply works normally.

   • Both LEDs turn orange:

     B1500A is in the standby state and Standby switch is ON position.

3. LINE input receptacle

   AC power cable is connected to this receptacle.

4. GPIB interface

   Use an Agilent 82357A USB/GPIB interface or Agilent 10833A/B/C/D GPIB cable to connect to an external computer or equipment.

5. Module slot

   Ten slots are available for installing the modules. The B1500A can contain any combination of modules.

   Allowable number of modules installed in one mainframe (each/mainframe): HPSMU 4, MPSMU 10, HRSMU 10, CMU 1, SPGU 5, WGFMU 5

   If the B1500A contains the WGFMU, sum of *Rating* for all module types in the mainframe must be < 60.

   where *Rating = Number of modules × Rating for each module type*

   Rating for each module type: HPSMU 14, MPSMU 2, HRSMU 2, CMU 7, SPGU 12, WGFMU 10

   For example, if the B1500A installs two HPSMU, one CMU, and two WGFMU, the total rating is 2×14+7+2×10=55.

   For each module, see "Measurement Units" on page 2-17. Also, there is a rule for the installation order by the module type. See Chapter 3, "Installation."

6. Circuit Common ( ) and Frame ground ( ) terminals

   Normally, connect the terminals together by using the shorting bar (Agilent part number 5000-4206). For floating measurement, remove the shorting bar.

CAUTION For floating measurement, do not apply voltage more than ±42 V to the Circuit Common terminal. Failure to heed this caution may result in damage to the B1500A.

WARNING **If the Circuit Common terminal is *not* connected to the frame ground terminal (for floating measurement), a potential shock hazard may present. Do not touch any of measurement circuit at any time while a floating measurement is in progress.**

7. Zero Check terminal

Ground reference point of the B1500A.

CAUTION   The Zero Check terminal can be used for the service purpose only. For the B1500A normal operation, leave this terminal open and do not connect anything to this terminal. Connecting anything can damage the B1500A.

8. GNDU terminal

0 V constant voltage source. Used for the reference of measurement ground. Triaxial connector.

9. LAN interface

RJ45 connector.

10. USB interfaces

USB, 2 ports. For keyboard, mouse, or peripherals. USB keyboard and USB mouse are available as option.

11. Ext Trig terminals

Two BNC connectors, one for trigger input, and one for trigger output. For details about the trigger function, see *Programming Guide*.

12. Digital I/O terminal

DSUB 25 pin connector. Can be used for the trigger input/output terminals or an interface to control an external relay circuit and so on. For details, see *Programming Guide*. This connector is also used to connect Agilent 16445A selector adapter.

13. Interlock terminal

Used in conjunction with the interlock function of the B1500A. If the Interlock terminal is open, maximum SMU output is limited to ±42 V. Be sure to connect this terminal to the interlock circuit of the 16442B test fixture or the prober station before performing measurement. For the interlock circuit, see "To Make an Interlock Circuit" on page 3-29.

To verify the interlock function, perform the interlock open/close test on the Main Frame tab screen of the EasyEXPERT Configuration window.

WARNING   **Dangerous voltage of up to the maximum voltage of SMUs may be present at force, guard, and sense terminals if the Interlock terminal is closed.**
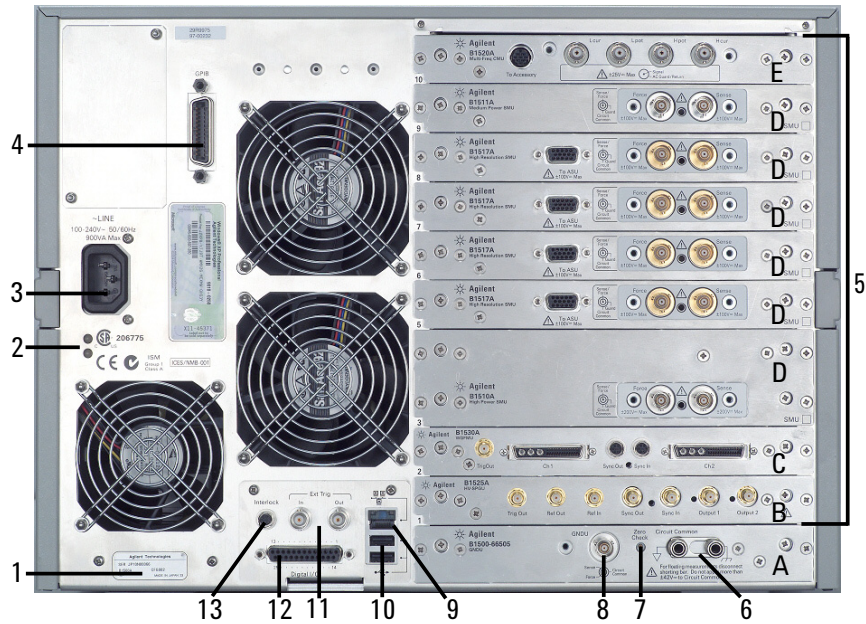
A. GNDU/ADC

Ground unit and A/D converter module. Always installed in the B1500A.

B. SPGU module

The semiconductor pulse generator unit (SPGU) has the Output 1 and Output 2 terminals and the following terminals to synchronize the operation between SPGUs or with an external equipment.

Ref Out/Sync Out: Connect to the Ref In/Sync In of the slave SPGU.

Ref In/Sync In: Connect to the Ref Out/Sync Out of the master SPGU.

Trig Out: Connect to the trigger input terminal of the equipment synchronized with the SPGU output.

CAUTION Connect the Ref Out/In, Sync Out/In, and Trig Out terminals to the specified terminal properly. Connecting to the other terminal may result in damage to the SPGU.

In the EasyEXPERT operation mode, the SPGU outputs can be specified by the PG number. PG1 and PG2 are assigned to the Output 1 and Output 2 terminals of the SPGU at the lowest position. And the following PG numbers are assigned to the outputs of the upper SPGUs in sequence. Use the PG number label furnished with the B1500A or equivalent to identify the SPGU channel number.

⚠ C. WGFMU module

The waveform generator/fast measurement unit (WGFMU) has the Ch 1 and Ch 2 terminals and the following terminals to synchronize the operation between WGFMUs or with an external equipment.

Sync Out: Connect to the Sync In of the slave WGFMU.

Sync In: Connect to the Sync Out of the master WGFMU.

Trig Out: Connect to the trigger input terminal of the equipment synchronized with the WGFMU output.

CAUTION Connect the Sync Out/In, and Trig Out terminals to the specified terminal properly. Connecting to the other terminal may result in damage to the WGFMU.

Connect the connection cable between the WGFMU and the RSU (remote-sense and switch unit) before turning the B1500A on. Changing the cable connection in the power on state may damage the WGFMU and RSU. See Agilent B1530A *User's Guide* for cable connection and usage.

⚠ D. SMU module

The source/monitor unit (SMU) has two triaxial connectors, force and sense, for the Kelvin connections. The HRSMU (high resolution SMU) also provides a D-sub connector (To ASU terminal) which is used to connect the dedicated ASU (atto sense and switch unit). The HPSMU (high power SMU) occupies two slots.

In the EasyEXPERT operation mode, the SMUs can be specified by the SMU number. SMU1 is assigned to the SMU at the lowest position. And the following SMU numbers are assigned to the upper SMUs in sequence. Use the SMU number label furnished with the B1500A or equivalent to identify the SMU number.

NOTE To use the ASU, connect the connection cables between the HRSMU and the dedicated ASU before turning the B1500A on.

WARNING
There are potentially hazardous voltages (200 V for HPSMU, and 100 V for MPSMU/HRSMU/ASU) present at the Force, Sense, and Guard terminals of Agilent B1500A. To prevent electrical shock, the following safety precautions must be observed during the use of the B1500A.

    a.   Use a three-conductor AC power cable to connect the cabinet (if used) and the B1500A to an electrical ground (safety ground).

    b.   If you do *not* use the 16442B test fixture, you must install and connect an interlock circuit that opens the Interlock terminal when the shielding box access door is opened.

    c.   Confirm periodically that the interlock function works normally.

    d.   Before touching the connections on the Force, Guard, and Sense terminals, turn the B1500A off and discharge any capacitors. If you do *not* turn the B1500A off, complete *all* of the following items, regardless of the B1500A settings.

       •   Press the **Stop** key to set the module output off.

       •   Confirm that the High Voltage indicator is not lit.

       •   Open the shielding box access door (open the Interlock terminal).

       •   Discharge any capacitors connected to an SMU.

    e.   Warn persons working around the B1500A about dangerous conditions.

E. CMU module

The multi frequency capacitance measurement unit (MFCMU) has four coaxial connectors, Lcur, Lpot, Hpot, and Hcur, for the four-terminal pair connection. The Hcur and Hpot have to be connected together at a terminal of the device under test (DUT). Also the Lcur and Lpot have to be connected together at the other terminal of the DUT. Then, the guard lines of four-terminal pair must be connected together.

CAUTION
Do not apply voltage more than ±25 V to the MFCMU input terminals. Failure to heed this caution may result in damage to the module.

Measurement Units

Agilent B1500A can be equipped with the following measurement modules.

- "GNDU - Ground Unit"

- "HPSMU - High Power SMU"

- "MPSMU - Medium Power SMU"

- "HRSMU - High Resolution SMU"

- "MFCMU - Multi Frequency CMU"

- "HVSPGU - High Voltage SPGU"

- "WGFMU - Waveform Generator/Fast Measurement Unit"

See Agilent EasyEXPERT *User's Guide* for the functions available for Agilent EasyEXPERT software. See *Programming Guide* for the functions available for the GPIB remote mode. See Agilent B1530A *User's Guide* for using the WGFMU.

GNDU - Ground Unit

Agilent B1500A is equipped with the ground unit (GNDU). The GNDU is a 0 V constant voltage source, and used for the reference of measurement ground. Also the GNDU can sink up to ± 4.2 A, so it is effective for using the HPSMU (high power SMU). Figure 2-1 is a simplified circuit diagram of GNDU.

Figure 2-1   **Simplified GNDU Circuit Diagram**
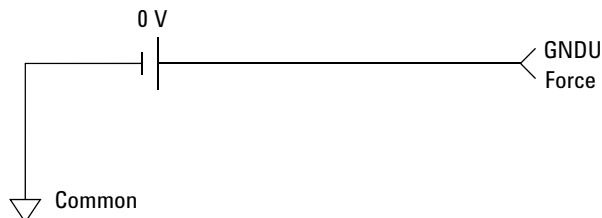
About SMU

Source/monitor unit (SMU) can apply DC voltage or current, and can measure DC current or voltage. Figure 2-2 is a simplified SMU circuit diagram. The SMU can perform the following operations:

- Apply voltage and measures current

- Apply current and measures voltage

- Apply voltage and measures voltage

- Apply current and measures current

NOTE   To select the SMU operation mode in the GPIB remote condition, enter the CMM command.

Figure 2-2   **Simplified SMU Circuit Diagram**
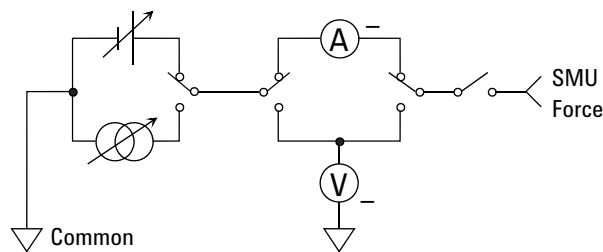
Compliance

The SMU has a compliance feature that limits output voltage or current to prevent damage to the device under test. When the SMU applies voltage, you can specify current compliance. When the SMU applies current, you can specify voltage compliance. For details about the compliance, see Agilent EasyEXPERT *User's Guide*.

HPSMU - High Power SMU

This section describes typical specification of the high power source/monitor unit (HPSMU) for Agilent B1500A. Maximum four modules can be installed in one mainframe.

•   Maximum voltage, current, output power: ± 200 V, ± 1 A, 20 W

•   Minimum range: 2 V, 1 nA

•   Output/measurement value and resolution: see Table 2-1 to Table 2-4.

Figure 2-3   HPSMU Output and Measurement Ranges
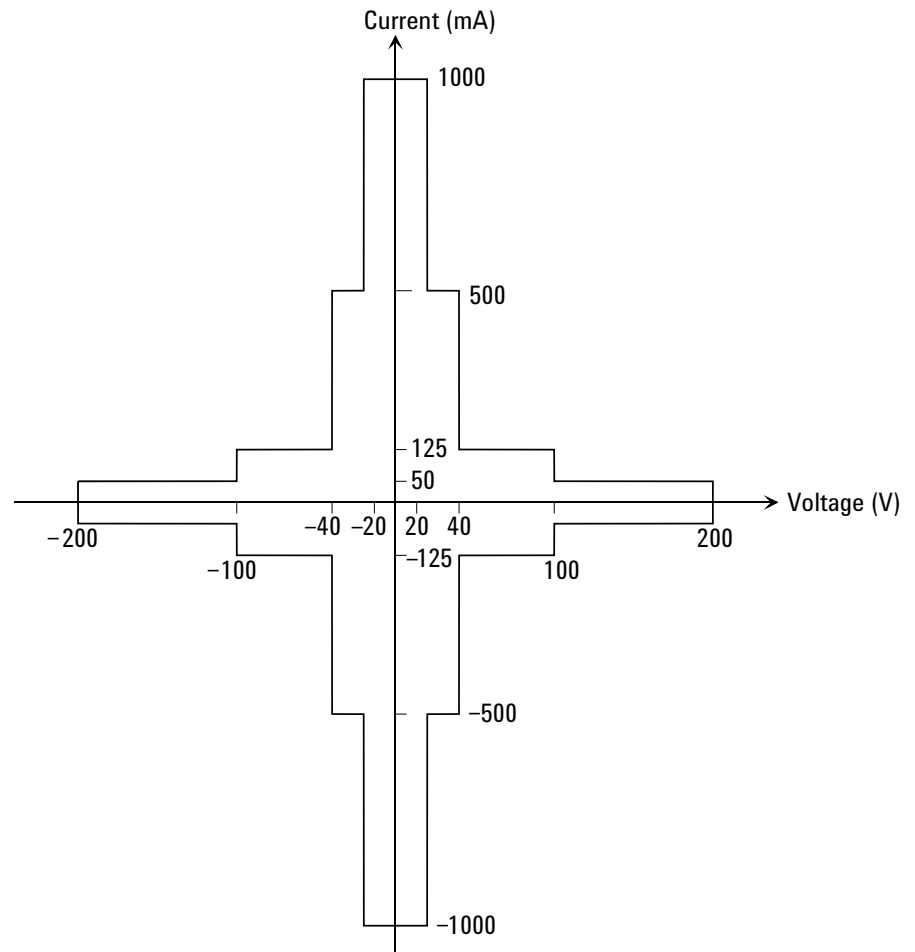
Table 2-1   **HPSMU Output Voltage Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Current
2 V	$0 \leq |V| \leq 2$ V	100 μV	± 1000 mA
20 V	$0 \leq |V| \leq 20$ V	1 mV	± 1000 mA
40 V	$0 \leq |V| \leq 40$ V	2 mV	± 500 mA
100 V	$0 \leq |V| \leq 100$ V	5 mV	± 125 mA
200 V	$0 \leq |V| \leq 200$ V	10 mV	± 50 mA

Table 2-2   **HPSMU Output Current Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Voltage
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	± 200 V
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	± 200 V
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	± 200 V
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	± 200 V
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	± 200 V
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	± 200 V
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	± 200 V
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	± 200 V
100 mA	$0 \leq |I| \leq 50$ mA	5 μA	± 200 V
	50 mA $< |I| \leq 115$ mA	5 μA	± 100 V
1 A	$0 \leq |I| \leq 50$ mA	50 μA	± 200 V
	50 mA $< |I| \leq 125$ mA	50 μA	± 100 V
	125 mA $< |I| \leq 500$ mA	50 μA	± 40 V
	500 mA $< |I| \leq 1$ A	50 μA	± 20 V

Table 2-3   **HPSMU Measurement Voltage Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
2 V	$0 \leq |V| \leq 2.2$ V	100 μV	2 μV
20 V	$0 \leq |V| \leq 22$ V	1 mV	20 μV
40 V	$0 \leq |V| \leq 44$ V	2 mV	40 μV
100 V	$0 \leq |V| \leq 110$ V	5 mV	100 μV
200 V	$0 \leq |V| \leq 200$ V	10 mV	200 μV

Table 2-4   **HPSMU Measurement Current Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	10 fA
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	10 fA
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	100 fA
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	1 pA
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	10 pA
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	100 pA
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	1 nA
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	10 nA
100 mA	$0 \leq |I| \leq 115$ mA	5 μA	100 nA
1 A	$0 \leq |I| \leq 1$ A	50 μA	1 μA

a. This column is applied to the auto ranging or the limited auto ranging. For fixed ranging, maximum measurement value is **Range** column value.

MPSMU - Medium Power SMU

This section describes typical specification of the medium power source/monitor unit (MPSMU) for Agilent B1500A.

- Maximum voltage, current, output power: $\pm$ 100 V, $\pm$ 100 mA, 2 W

- Minimum range: 0.5 V, 1 nA

- Output/measurement value and resolution: see Table 2-5 to Table 2-8.

Figure 2-4   **MPSMU Output and Measurement Ranges**
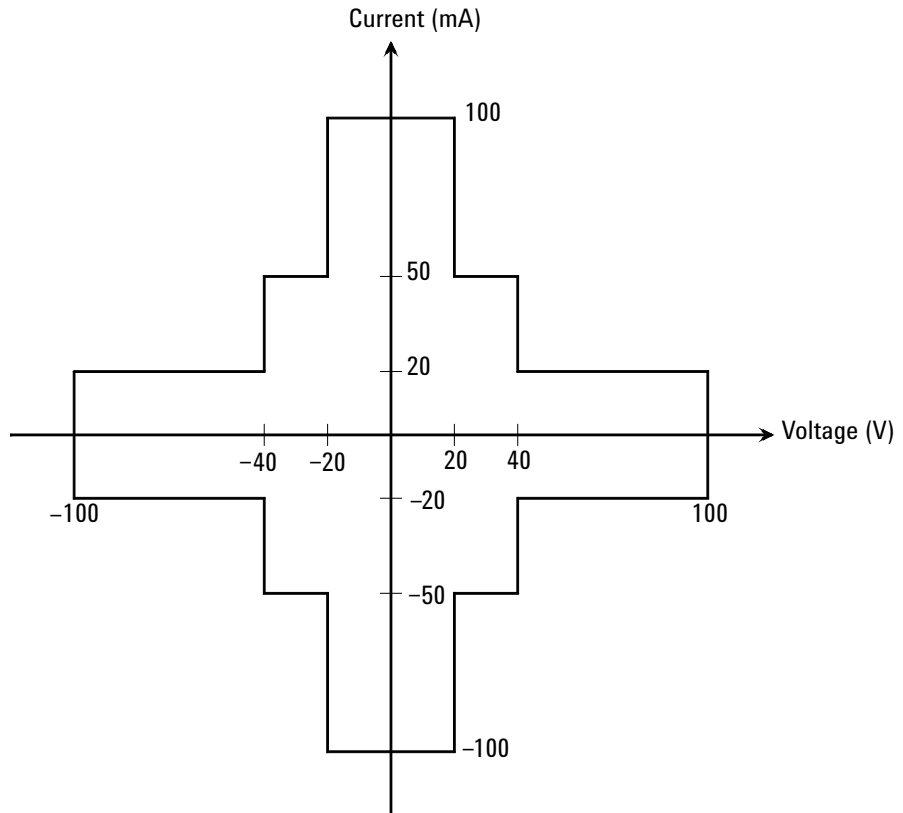
Table 2-5   **MPSMU Output Voltage Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Current
0.5 V	$0 \leq |V| \leq 0.5$ V	25 μV	± 100 mA
2 V	$0 \leq |V| \leq 2$ V	100 μV	± 100 mA
5 V	$0 \leq |V| \leq 5$ V	250 μV	± 100 mA
20 V	$0 \leq |V| \leq 20$ V	1 mV	± 100 mA
40 V	$0 \leq |V| \leq 20$ V	2 mV	± 100 mA
	20 V $< |V| \leq 40$ V	2 mV	± 50 mA
100 V	$0 \leq |V| \leq 20$ V	5 mV	± 100 mA
	20 V $< |V| \leq 40$ V	5 mV	± 50 mA
	40 V $< |V| \leq 100$ V	5 mV	± 20 mA

Table 2-6   **MPSMU Output Current Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Voltage
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	± 100 V
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	± 100 V
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	± 100 V
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	± 100 V
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	± 100 V
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	± 100 V
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	± 100 V
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	± 100 V
100 mA	$0 \leq |I| \leq 20$ mA	5 μA	± 100 V
	20 mA $< |I| \leq 50$ mA	5 μA	± 40 V
	50 mA $< |I| \leq 100$ mA	5 μA	± 20 V

Table 2-7   **MPSMU Measurement Voltage Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
0.5 V	$0 \leq |V| \leq 0.55$ V	25 μV	0.5 μV
2 V	$0 \leq |V| \leq 2.2$ V	100 μV	2 μV
5 V	$0 \leq |V| \leq 5.5$ V	250 μV	5 μV
20 V	$0 \leq |V| \leq 22$ V	1 mV	20 μV
40 V	$0 \leq |V| \leq 44$ V	2 mV	40 μV
100 V	$0 \leq |V| \leq 100$ V	5 mV	100 μV

Table 2-8   **MPSMU Measurement Current Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	10 fA
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	10 fA
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	100 fA
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	1 pA
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	10 pA
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	100 pA
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	1 nA
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	10 nA
100 mA	$0 \leq |I| \leq 100$ mA	5 μA	100 nA

a. This column is applied to the auto ranging or the limited auto ranging.
For fixed ranging, maximum measurement value is **Range** column value.

HRSMU - High Resolution SMU

This section describes typical specification of the high resolution source/monitor unit (HRSMU) for Agilent B1500A.

• Maximum voltage, current, output power: ± 100 V, ± 100 mA, 2 W

• Minimum range: 0.5 V, 10 pA (1 pA when the E5288A ASU is used)

• Output/measurement value and resolution: see Table 2-9 to Table 2-12.

Figure 2-5   HRSMU Output and Measurement Ranges
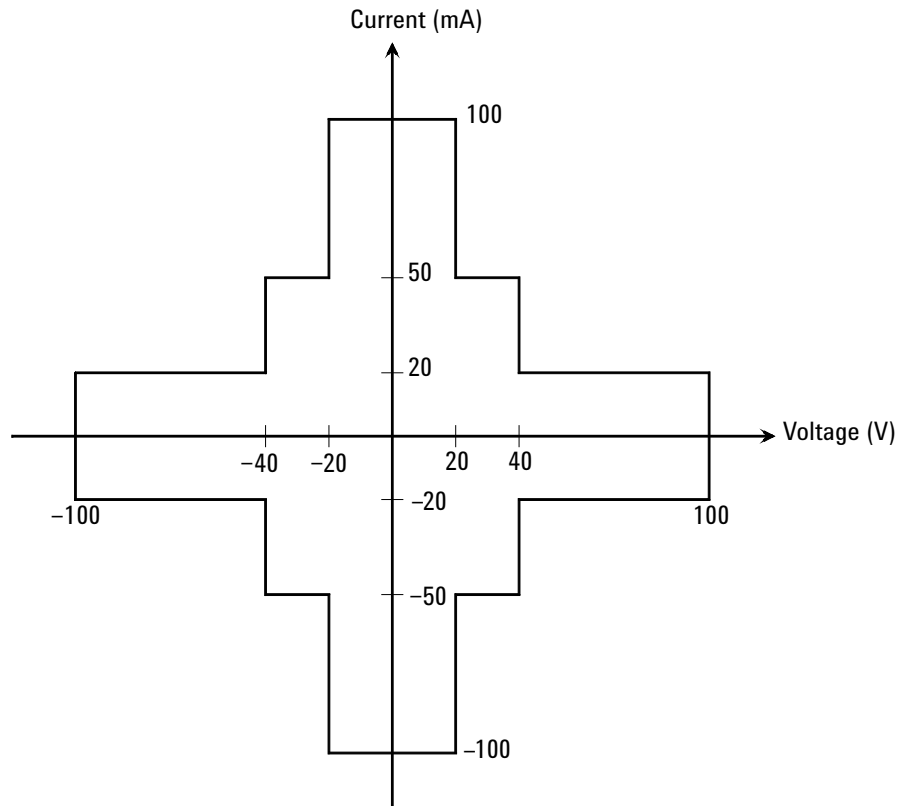
Table 2-9   **HRSMU Output Voltage Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Current
0.5 V	$0 \leq |V| \leq 0.5$ V	25 μV	± 100 mA
2 V	$0 \leq |V| \leq 2$ V	100 μV	± 100 mA
5 V	$0 \leq |V| \leq 5$ V	250 μV	± 100 mA
20 V	$0 \leq |V| \leq 20$ V	1 mV	± 100 mA
40 V	$0 \leq |V| \leq 20$ V	2 mV	± 100 mA
	20 V $< |V| \leq 40$ V	2 mV	± 50 mA
100 V	$0 \leq |V| \leq 20$ V	5 mV	± 100 mA
	20 V $< |V| \leq 40$ V	5 mV	± 50 mA
	40 V $< |V| \leq 100$ V	5 mV	± 20 mA

Table 2-10   **HRSMU Output Current Ranges and Resolutions**

Range	Output Value	Setting Resolution	Maximum Voltage
1 pA [a]	$0 \leq |I| \leq 1.15$ pA	1 fA	± 100 V
10 pA	$0 \leq |I| \leq 11.5$ pA	5 fA	± 100 V
100 pA	$0 \leq |I| \leq 115$ pA	5 fA	± 100 V
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	± 100 V
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	± 100 V
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	± 100 V
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	± 100 V
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	± 100 V
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	± 100 V
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	± 100 V
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	± 100 V
100 mA	$0 \leq |I| \leq 20$ mA	5 μA	± 100 V
	20 mA $< |I| \leq 50$ mA	5 μA	± 40 V
	50 mA $< |I| \leq 100$ mA	5 μA	± 20 V

a. Available when the E5288A Atto Sense and Switch Unit (ASU) is used.

Table 2-11   **HRSMU Measurement Voltage Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
0.5 V	$0 \leq |V| \leq 0.55$ V	25 μV	0.5 μV
2 V	$0 \leq |V| \leq 2.2$ V	100 μV	2 μV
5 V	$0 \leq |V| \leq 5.5$ V	250 μV	5 μV
20 V	$0 \leq |V| \leq 22$ V	1 mV	20 μV
40 V	$0 \leq |V| \leq 44$ V	2 mV	40 μV
100 V	$0 \leq |V| \leq 100$ V	5 mV	100 μV

Table 2-12   **HRSMU Measurement Current Values and Resolutions**

Range	Measurement Value [a]	Measurement Resolutions	
		High Speed ADC	High Resolution ADC
1 pA [b]	$0 \leq |I| \leq 1.15$ pA	100 aA	100 aA
10 pA	$0 \leq |I| \leq 11.5$ pA	1 fA	1 fA / 400 aA [b]
100 pA	$0 \leq |I| \leq 115$ pA	5 fA	2 fA / 500 aA [b]
1 nA	$0 \leq |I| \leq 1.15$ nA	50 fA	10 fA
10 nA	$0 \leq |I| \leq 11.5$ nA	500 fA	10 fA
100 nA	$0 \leq |I| \leq 115$ nA	5 pA	100 fA
1 μA	$0 \leq |I| \leq 1.15$ μA	50 pA	1 pA
10 μA	$0 \leq |I| \leq 11.5$ μA	500 pA	10 pA
100 μA	$0 \leq |I| \leq 115$ μA	5 nA	100 pA
1 mA	$0 \leq |I| \leq 1.15$ mA	50 nA	1 nA
10 mA	$0 \leq |I| \leq 11.5$ mA	500 nA	10 nA
100 mA	$0 \leq |I| \leq 100$ mA	5 μA	100 nA

a. This column is applied to the auto ranging or the limited auto ranging.
   For fixed ranging, maximum measurement value is **Range** column value.
b. Available when the E5288A Atto Sense and Switch Unit (ASU) is used.

NOTE   To connect ASU

The specifications are satisfied and guaranteed for the exclusive combination of the ASU and the HRSMU. So confirm the serial number of the ASU and connect it to the dedicated HRSMU properly.

To connect the ASU, see "To Connect ASU" on page 3-17.

To confirm the serial number, see Agilent EasyEXPERT *User's Guide*.

NOTE   Before using 1 pA range

The measurement channel connected to the ASU supports the 1 pA range. To use the 1 pA range, set the 1 pA fixed range or the 1 pA limited auto ranging.

The B1500A automatically performs the compensation of the data measured by the 1 pA range and returns the compensated data. You can use either the pre-stored offset data or the pre-measured offset data.

To measure the offset data, perform the self-calibration before starting the measurement for a DUT. This offset data is temporarily memorized until the B1500A is turned off.

MFCMU - Multi Frequency CMU

This section describes typical specification of the multi frequency capacitance measurement unit (CMU) for Agilent B1500A. The CMU performs the impedance measurement and returns the specified measurement data such as Cp-G. Only one module can be installed in one mainframe.

• Measurement parameters: See Table 2-13.

  All measurement parameters are supported by Agilent B1500A in the GPIB remote mode. However, Agilent EasyEXPERT software supports the Cp-G, Cp-D, Cs-Rs, and Z-θ measurements only.

• AC signal, output frequency:

  1 kHz to 5 MHz

  Setting resolution: 1 mHz (1 kHz to), 10 mHz (10 kHz to), 0.1 Hz (100 kHz to), or 1 Hz (1 MHz to 5 MHz)

• AC signal, output level:

  10 mVrms to 250 mVrms, 1 mV resolution

• DC bias:

  0 to ± 100 V

  Setting resolution: 1 mV (0 to ± 25 V) or 5 mV (to ± 100 V)

  DC bias > ± 25 V is available when using the SMU CMU unify unit (SCUU).

• Measurement range:

  For the fixed ranging mode, measurement range (impedance range) must be specified to perform measurement. Table 2-14 shows the available measurement ranges and the corresponding impedance value. And Figure 2-6 shows the calculation example of the impedance vs frequency characteristics of a capacitive load. Use these information to decide the measurement range.

  Impedance Z is calculated by the following formula.

  $Z = 1 / (2\pi f C)$

  where f is frequency (Hz) and C is capacitance (F).

Table 2-13   **Measurement Parameters**

Primary Parameter	Secondary Parameter
R (resistance, Ω)	X (reactance, Ω)
G (conductance, S)	B (susceptance, S)
Z (impedance, Ω)	θ (phase, radian)
Z (impedance, Ω)	θ (phase, degree)
Y (admittance, S)	θ (phase, radian)
Y (admittance, S)	θ (phase, degree)
Cp (parallel capacitance, F)	G (conductance, S)
Cp (parallel capacitance, F)	D (dissipation factor)
Cp (parallel capacitance, F)	Q (quality factor)
Cp (parallel capacitance, F)	Rp (parallel resistance, Ω)
Cs (series capacitance, F)	Rs (series resistance, Ω)
Cs (series capacitance, F)	D (dissipation factor)
Cs (series capacitance, F)	Q (quality factor)
Lp (parallel inductance, H)	G (conductance, S)
Lp (parallel inductance, H)	D (dissipation factor)
Lp (parallel inductance, H)	Q (quality factor)
Lp (parallel inductance, H)	Rp (parallel resistance, Ω)
Ls (series inductance, H)	Rs (series resistance, Ω)
Ls (series inductance, H)	D (dissipation factor)
Ls (series inductance, H)	Q (quality factor)

Table 2-14   Measurement Range for Fixed Ranging Mode

Impedance Z	Measurement range (impedance range)		
	$1\text{ kHz} \leq \text{ f} \leq 200\text{ kHz}$	$200\text{ kHz} < \text{f} \leq 2\text{ MHz}$	$2\text{ MHz} < \text{f} \leq 5\text{ MHz}$
$0 \leq \text{ Z} < 100\ \Omega$	$50\ \Omega$	$50\ \Omega$	$50\ \Omega$
$100\ \Omega \leq \text{ Z} < 300\ \Omega$	$100\ \Omega$	$100\ \Omega$	$100\ \Omega$
$300\ \Omega \leq \text{ Z} < 1\text{ k}\Omega$	$300\ \Omega$	$300\ \Omega$	$300\ \Omega$
$1\text{ k}\Omega \leq \text{ Z} < 3\text{ k}\Omega$	$1\text{ k}\Omega$	$1\text{ k}\Omega$	$1\text{ k}\Omega$
$3\text{ k}\Omega \leq \text{ Z} < 10\text{ k}\Omega$	$3\text{ k}\Omega$	$3\text{ k}\Omega$	$3\text{ k}\Omega$
$10\text{ k}\Omega \leq \text{ Z} < 30\text{ k}\Omega$	$10\text{ k}\Omega$	$10\text{ k}\Omega$	
$30\text{ k}\Omega \leq \text{ Z} < 100\text{ k}\Omega$	$30\text{ k}\Omega$	$30\text{ k}\Omega$	
$100\text{ k}\Omega \leq \text{ Z} < 300\text{ k}\Omega$	$100\text{ k}\Omega$		
$300\text{ k}\Omega \leq \text{ Z}$	$300\text{ k}\Omega$		

Figure 2-6   Impedance vs Frequency Characteristics of Capacitive Load, Calculation Example
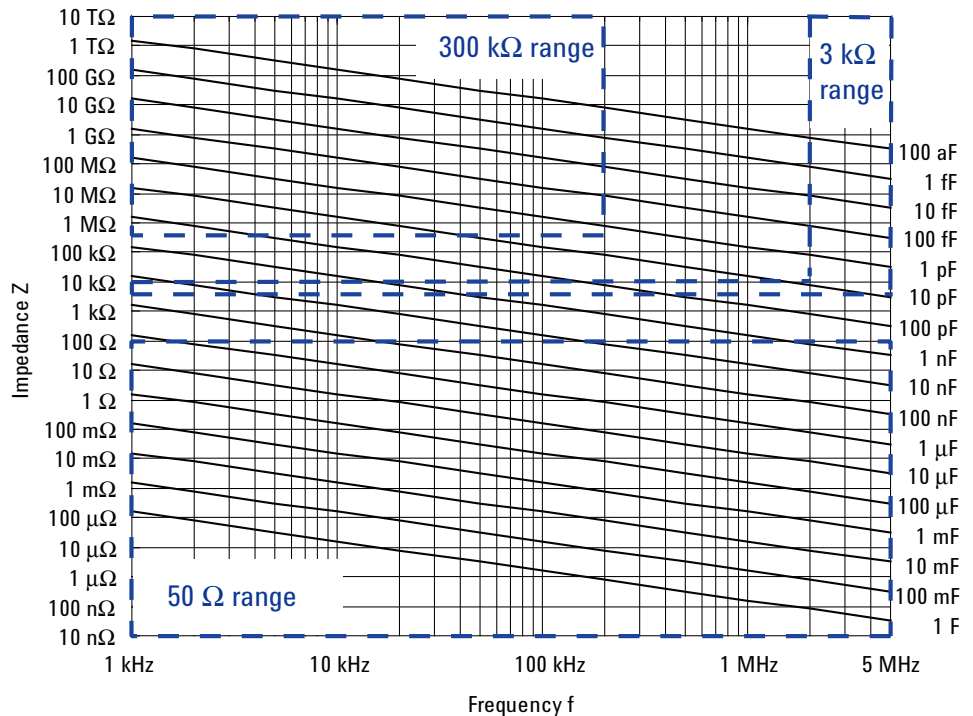
HVSPGU - High Voltage SPGU

This section describes key specification of the high voltage semiconductor pulse generator unit (SPGU) for Agilent B1500A. Maximum five modules can be installed in one mainframe.

- Number of output channels: 2 channels per module

- Output impedance: 50 Ω

- Output level: 0 to $\pm$ 40 V (open load), $\pm$ 20 V (50 Ω load), 1 mV resolution

- SPGU operation mode:

  PG (pulse generator) or ALWG (arbitrary linear waveform generator)

- Channel output operation mode:

  Free run, duration, or pulse count (PG mode)/sequence count (ALWG mode)

- PG output mode:

  2-level pulse or 3-level pulse, for each channel

- Pulse timing parameters:

  Period: 20 ns to 10 s, 10 ns resolution

  Width: 10 ns to period−10 ns, resolution 2.5 ns or 10 ns (transition time > 8 μs)

  Delay: 0 to period−20 ns, resolution 2.5 ns or 10 ns (transition time > 8 μs)

  Transition time (leading time or trailing time): 8 ns to 400 ms, resolution 2 ns or 8 ns (transition time > 8 μs)

- Pulse switch, which is more durable than mechanical relays, and better suited for frequent switching applications.

- Automatic voltage level adjustment by specifying load impedance of DUT

Figure 2-7   **SPGU Simplified Circuit Diagram**
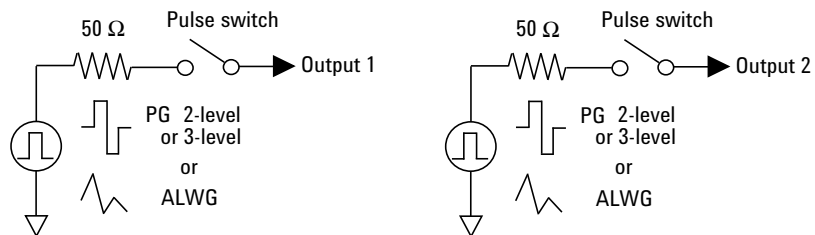
WGFMU - Waveform Generator/Fast Measurement Unit

This section describes typical specification of the waveform generator/fast measurement unit (WGFMU) for Agilent B1500A. Maximum five modules can be installed in one mainframe.

- Number of channels: 2 channels per module

- Function:

  Voltage output and current or voltage sampling measurement with minimum sampling interval of 5 ns

- Current measurement range: 1 μA, 10 μA, 100 μA, 1 mA, or 10 mA

- Operation mode: PG mode, Fast IV mode, or DC mode

- PG mode:

  ALWG (arbitrary linear waveform generator) voltage output and voltage measurement (VFVM).

  Output level: −5 V to 5 V for open load or −2.5 V to 2.5 V for 50 Ω load

  Minimum pulse width: 100 ns

- Fast IV mode:

  ALWG voltage output and current or voltage measurement (VFIM or VFVM).

  Output level: 0 to −10 V, 0 to 10 V, or −5 V to 5 V

  Minimum pulse width: 300 ns

- DC mode:

  DC voltage output and current or voltage measurement (VFIM or VFVM).

  Output level: 0 to −10 V, 0 to 10 V, or −5 V to 5 V

Figure 2-8　　　　　**WGFMU Simplified Circuit Diagram**
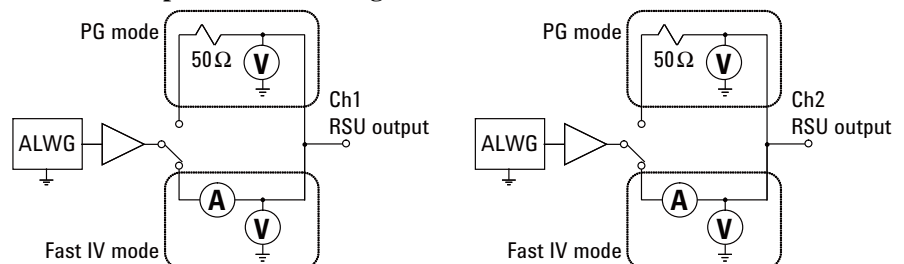
Introduction
Measurement Units

3 Installation

This chapter describes how to install Agilent B1500A and accessories.

- "Requirements"

- "Inspection and Installation"

- "Installing Accessories"

- "Mounting Connectors"

- "Connecting Measurement Devices"

- "Capacitance Compensation When Using Switching Matrix"

- "Maintenance"

- "About Plug-in Modules"

To change the GPIB address of the B1500A, see "To Change GPIB Address" on page 3-9. To control external GPIB devices from the B1500A/EasyEXPERT, see "To Enable System Controller" on page 3-10.

WARNING ⚠ **There are potentially hazardous voltages (200 V for HPSMU, and 100 V for MPSMU/HRSMU/ASU) present at the Force, Sense, and Guard terminals of Agilent B1500A. To prevent electrical shock, the following safety precautions must be observed during the use of the B1500A.**

- **Use a three-conductor AC power cable to connect the cabinet (if used) and the B1500A to an electrical ground (safety ground).**

- **If you do *not* use the 16442B test fixture, you must install and connect an interlock circuit that opens the Interlock terminal when the shielding box access door is opened.**

- **Confirm periodically that the interlock function works normally.**

- **Before touching the connections on the Force, Guard, and Sense terminals, turn the B1500A off and discharge any capacitors. If you do *not* turn the B1500A off, complete *all* of the following items, regardless of the B1500A settings.**

    - **Press the Stop key to set the module output off.**

    - **Confirm that the High Voltage indicator is not lit.**

    - **Open the shielding box access door (open the Interlock terminal).**

    - **Discharge any capacitors connected to an SMU.**

- **Warn persons working around the B1500A about dangerous conditions.**

Requirements

This section contains information on:

- "Power Requirements"
- "Operating Environment"
- "Storaging/Shipping Environment"
- "Installation Requirements"
- "Power Cable"

Power Requirements

The B1500A can operate from any single-phase AC power source supplying 90 to 264 V at 47 to 63 Hz. The maximum power consumption is 900 VA.

Operating Environment

The B1500A is specified to operate within the following environmental conditions:

Temperature: 5 °C to 40 °C

Humidity: 20 % to 70 % RH, non-condensing

Altitude: 0 to 2,000 m (6,561 ft.)

Storaging/Shipping Environment

The B1500A is specified to store/ship within the following environmental conditions:

Temperature: -20 °C to 60 °C

Humidity: 10 % to 90 % RH, non-condensing

Altitude: 0 to 4,600 m (15,092 ft.)

Installation Requirements

The B1500A has cooling fans. To ensure adequate airflow, make sure that there is sufficient clearance around the cooling fans: 6 inches (150 mm) behind, 3 inches (70 mm) on the sides, and 0.5 inch (12 mm) above and below.

If the airflow is restricted, the internal operating temperature will be higher. This may reduce the instrument's reliability, or cause the thermal-protection circuits to turn the instrument off.

Also make sure that there is enough space for connecting/disconnecting the power cable easily.

Power Cable

CAUTION   Before applying AC line power to the B1500A, ensure that the correct power cable is used.

In accordance with international safety standards, this instrument is equipped with a three-prong power cable. When connected to an appropriate AC power outlet, this cable grounds the instrument frame. The type of power cable shipped with each instrument depends on the country of destination. Refer to PN in the following table for Agilent part numbers of the power cables available.

If the plug on the cable does not fit the power outlet, or the cable is to be attached to a terminal block, cut the cable at the plug end and re-wire it. This work should be performed by a qualified electrician, observing all local electrical codes.

The color coding used in the cable will depend on the cable supplied. If a new plug is to be connected, it must meet local safety requirements and include the following features:
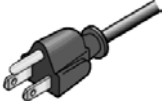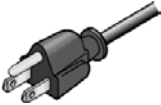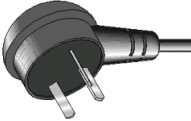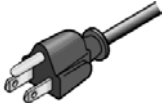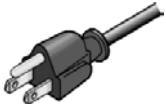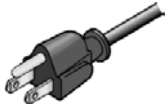
- adequate load-carrying capacity (see "Specifications" on page 4-3.)
- ground connection
- cable clamp

WARNING   **For protection from electrical shock, do *not* interrupt the power cable ground.**

• Plug: BS 1363/A, 250 V, 10 A • PN: 8120-4420	• Plug: AS 3112, 250 V, 10 A • PN: 8120-4419	• Plug: CEE 7 sheet VII, 250 V, 10 A • PN: 8120-4519	• Plug: NEMA 5-15P, 125 V, 10 A • PN: 8120-6825
• Plug: NEMA 6-15P, 250 V, 10 A • PN: 8120-3996, 8120-0698	• Plug: SEV 1011, 250 V, 10 A • PN: 8120-2104	• Plug: SR 107-2-D1, 250 V, 10 A • PN: 8120-2956	• Plug: IS 1293 and IS 6538, 250 V, 10 A • PN: 8120-4211
• Plug: JIS C 8303, 125 V, 12 A • PN: 8121-0743	• Plug: Israel SI 32, 250 V, 10 A • PN: 8120-5182	• Plug: IRAM 2073-10A, 250 V, 10 A • PN: 8120-6870	• Plug: CEI 23-16, 250 V, 10 A • PN: 8120-6978
• Plug: GB 1002 figure 3, 250 V, 10 A • PN: 8120-8376	• Plug: SANS 164-1, 250 V, 10 A • PN: 8120-4211, 8121-0564	• Plug: TISI 166, 250 V, 10 A • PN: 8121-1866	• Plug: NBR 14136, 250 V, 10 A • PN: 8121-1809
• Plug: CNS 10917-2, 125 V, 10 A • PN: 8120-6825, 8121-1635	• Plug: CS 0017:2003, 250 V, 10 A • PN: 8120-8871, 8121-1638		

Inspection and Installation

This section describes what to do when you receive the B1500A and accessories.

1. Inspect the shipment. See "To Inspect B1500 and Accessories".

2. Verify the B1500A operation and perform initial setup. See "To Perform Initial Setup".

3. Install the B1500A in the appropriate place. See "Requirements" on page 3-3.

To use the B1500A briefly, see "Getting Started" on page 1-1.

To change the Windows logon setting, see "To Change Windows Logon Setting" on page 3-9.

To change the GPIB address of the B1500A, see "To Change GPIB Address" on page 3-9.

To allow the B1500A/EasyEXPERT to control external GPIB devices, see "To Enable System Controller" on page 3-10.

To Inspect B1500 and Accessories

Perform the following inspections when the B1500A and accessories arrive at your site.

1. Before unpacking any components, inspect all boxes for any signs of damage that might have occurred during shipment, such as:

   • dents

   • scratches

   • cuts

   • water marks

   If you suspect any damage, notify your local Agilent Technologies sales or service office.

2. When you open the boxes that contain the B1500A and accessories, check the components against the contents lists attached to the boxes.

   If anything is missing, notify your local Agilent Technologies sales or service office.

To Perform Initial Setup

After you receive the B1500A, perform the following setup.

1. Make sure that the Standby switch is set to off.

2. On the B1500A rear panel, connect the Circuit Common terminal to the frame ground terminal by using a shorting-bar.

3. If you use Agilent 16444A-001 USB keyboard and/or the 16444A-002 USB mouse, connect it to an USB port of the B1500A.

4. Connect the power cable from the B1500A to an AC power outlet.

5. Open the measurement terminals and press the Standby switch to turn on the B1500A.

   If the B1500A is operating correctly, the power-on self-test is automatically performed. If problems arise, see Agilent EasyEXPERT *User's Guide*.

6. Wait for the *Welcome to Microsoft Windows* screen. On the screen, select the Next button.

7. For the message *How should dates and currency appear?*, set as follows:

   • I live closest to this region: (for example, United States)

   • I type mostly in this language: (for example, English)

   • I use this type of keyboard: (for example, US)

     If you use the 16444A-001 USB keyboard, select US.

8. Select the Next button.

9. For the message *What time zone are you in?*, select your present location (for example, Pacific Time (US & Canada); Tijuana). Then select the Next button.

10. For *The End User License Agreement*, select *Yes, I accept*. Then select the Next button.

11. For the message *Help protect your PC*, select *Not right now*. Then select the Next button.

12. For the message *What's your computer's name?*, do not anything. Just select the Next button.

13. For the message *What's your Administrator password?*, do not anything. Just select the Next button.

14. For the message *Checking your internet connectivity*, select the Skip button.

15. For the message *Thank you!*, select the Finish button.

     The initial setup is completed by restarting Windows.

     To use the B1500A briefly, see "Getting Started" on page 1-1.

After the initial setup, the B1500A internal Windows has the following setup:

- Location: United States

- Language: English

- Keyboard: English (US)

- Time Zone: Pacific Time (US & Canada); Tijuana

- Network connection: none

- Computer name: Unique name set by factory

     You can change the computer name after the initial setup. It must be unique.

- Password of Administrator: not defined

     You can set the password after the initial setup. If you set it, do not forget it.

- Pre-defined users: Administrator, Agilent B1500 User, and AgilentOnly

     You can add users after the initial setup. Add users as you need.

     Agilent B1500 User is the account for automatic logon. Password is not set to this account.

     AgilentOnly is the account for Agilent service personnel. Do not delete this account. This account is password protected.

NOTE   Other Windows setup

You can set other setup of Windows after the initial setup. It is your responsibility.

If you connect Agilent B1500 to the network, take care to protect it from computer virus.

NOTE   Agilent Technologies cannot guarantee the performance and provide compatibility information for all B1500s under several conditions. If problems arise, perform Agilent B1500 system recovery. To perform recovery, see Agilent EasyEXPERT *User's Guide*.

To Change Windows Logon Setting

Agilent B1500A initially enables Windows automatic logon. If you want to change this setting, select *All Programs > Control Auto Logon* from the Start menu. Control Auto Logon is displayed on the browser. Then click one of the following buttons on the browser and follow the setup script.

• Enable Auto Logon

• Disable Auto Logon

NOTE   If you set a password for the user account *Agilent B1500 User*, disable the automatic logon.

To Change GPIB Address

When Agilent B1500A is shipped from the factory, the GPIB address is set to 17. To change the GPIB address, perform the following procedure.

1. If the EasyEXPERT software is running, terminate it as shown below:

   a. Select the menu function *File > Exit* on the EasyEXPERT main screen.

   b. Click [x] at the upper right corner of the Start EasyEXPERT button.

2. Select *All Programs > Agilent IO Libraries Suite > Agilent Connection Expert* from the Start menu. Agilent Connection Expert window appears.

3. At the *Instrument I/O on this PC* area, select GPIB0, and click the Change Properties... button. Agilent 82350 PCI GPIB Interface - GPIB0 window appears.

4. Change the GPIB Address value.

5. Remove the check from the *Auto-discover instruments connected to this interface* box.

6. Click the OK button on Agilent 82350 PCI GPIB Interface - GPIB0 window.

7. On the Reboot Required dialog box, click the Reboot Now button, and reboot the B1500A.

To Enable System Controller

To allow Agilent B1500A/EasyEXPERT to control external GPIB devices, perform the following procedure.

1. If the EasyEXPERT software is running, terminate it as shown below:

    a. Select the menu function *File > Exit* on the EasyEXPERT main screen.

    b. Click [x] at the upper right corner of the Start EasyEXPERT button.

2. Select *All Programs > Agilent IO Libraries Suite > Agilent Connection Expert* from the Start menu. Agilent Connection Expert window appears.

3. At the *Instrument I/O on this PC* area, select GPIB0, and click the Change Properties... button. Agilent 82350 PCI GPIB Interface - GPIB0 window appears.

4. Set the GPIB Address value to 21 that is the typical address number for the system controller.

5. Check the *System Controller* box.

6. Remove the check from the *Auto-discover instruments connected to this interface* box.

    This disables the automatic device detection. So the Connection Expert cannot detect the instruments connected to the GPIB interface by itself.

7. Click the OK button on Agilent 82350 PCI GPIB Interface - GPIB0 window.

8. On the Reboot Required dialog box, click the Reboot Now button, and reboot the B1500A.

NOTE   To Disable System Controller

If the B1500A is the system controller, you cannot control the B1500A by using an external computer. To disable the system controller, change the steps 4 and 5 for setting the GPIB Address value to *not* 21 and removing the check from the *System Controller* box, and perform the procedure to the step 8.

Installing Accessories

This section describes how to install the B1500A and accessories. Additional information regarding airflow can be found in the "Installation Requirements" on page 3-4.

This section describes how to:

- "To Connect 16442B Test Fixture"

- "To Connect Connector Plate"

- "To Connect ASU"

- "To Connect SCUU/GSWU"

- "To Connect GNDU Adapter"

- "To Interconnect SPGUs"

NOTE   Before connecting accessory to MFCMU

Turn the B1500A off before connecting the SCUU, the SCUU cable, or the CMU cable to the MFCMU.

WARNING   **There are potentially hazardous voltages of up to ± 100 V (MPSMU/HRSMU) or ± 200 V (HPSMU) at the Force, Sense, and Guard terminals. To prevent electrical shock, do *not* expose these lines.**

WARNING   **To prevent electrical shock during use, install an interlock circuit (see page 3-29) and connect the Interlock cable (see page 3-16).**

CAUTION   The GNDU can sink current of up to 4.2 A. Use Agilent 16493L GNDU cable to connect the GNDU to a test fixture or a connector plate.

Do *not* use normal triaxial cable (Agilent 16494A) because the maximum current rating of the cable is 1 A.

CAUTION   Never connect the Guard terminal to any output, including circuit common, chassis ground, or any other guard terminal. Doing so will damage the SMU.

To Connect 16442B Test Fixture

See this section if you use Agilent 16442B Test Fixture. This section describes how to set up the 16442B and how to connect the B1500A to the 16442B.

To Set up 16442B

You can stabilize the 16442B as shown in the figure below.
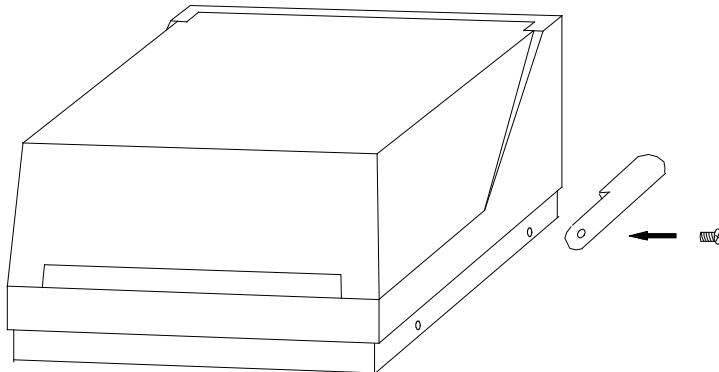
1. Put a stabilizer on both sides of the test fixture.

2. Attach each stabilizer to the unit with a flathead screw.

To Connect 16442B

Use the cables shown in Table 3-1 to connect from the B1500A connectors to the 16442B's relative connectors.

NOTE Making non-Kelvin connection

The Force terminals can be used to force and measure DC voltage or current. If you want to simplify the cable connections, open the Sense terminals and connect the Force terminals only to the test fixture by using the triaxial cables.

If you make the Kelvin connection, use both Force and Sense terminals. Connecting the Force and Sense lines together at the terminal of the device under test minimizes the measurement error caused by the residual resistance of the connection cables. The Kelvin connection is effective for the low resistance measurement and the high current measurement.

Table 3-1   **To Connect 16442B**

Cables	16442B Terminals	B1500A Terminals	
Agilent 16493J Interlock Cable, 3 m or 1.5 m	Intlk	Interlock	
Agilent 16493L GNDU Cable, 3 m or 1.5 m	GNDU	GNDU	
Agilent 16493K Kelvin Triaxial Cable, 3 m or 1.5 m, for the Kelvin connection. Up to 3 SMUs can be connected to the 16442B by the Kelvin connection.	SMU1	SMU	Force
	SMU2		Sense
	SMU3	SMU	Force
	SMU4		Sense
	SMU5	SMU	Force
	SMU6		Sense
Agilent 16494A Triaxial Cable, 3 m or 1.5 m, for the non-Kelvin connection	SMU1	SMU	Force
	SMU2	SMU	Force
	SMU3	SMU	Force
	SMU4	SMU	Force
	SMU5	SMU	Force
	SMU6	SMU	Force
Agilent 16493P SPGU Cable, 3 m or 1.5 m	PGU1	SPGU	Output 1
	PGU2		Output 2
Agilent N1300A CMU Cable[a], 3 m or 1.5 m	PGU1	CMU	Hcur/Hpot
	PGU2		Lcur/Lpot

a. To extend the four-terminal pair (4TP) connection to the 16442B inputs, connect the Hcur and Hpot cables together and the Lcur and Lpot cables together by using the BNC T-type adapter (female-female-male, Agilent part number 1250-2405), then connect them to the 16442B inputs.
To extend the 4TP connection to the socket module inputs, connect the cables to the PGU1, PGU2, VSU1, VSU2, VMU1, or VMU2 connector individually, and connect the Hcur and Hpot terminals together and the Lcur and Lpot terminals together at the socket module inputs.
It is ok to leave open the ground wire extended from the CMU cable.

To Connect Connector Plate

The available connector plates are listed in Table 3-2. Option 001 provides the through connectors except for the Interlock connector that provides the soldering patterns at the back side. For the option 002, the back of each connector is designed for soldering. For connector plate installation information, refer to *Agilent 16495 Installation Guide*.

For the 16495H/J, the insulator is inserted between the panel and the outer conductor of Triax connectors/BNC connectors.

Use the cables shown in Table 3-3 to connect from the B1500A connectors to the connector plate's relative connectors. For the cable connections from the connector plate to the DUT interface such as manipulator and probe card, see "Mounting Connectors" on page 3-27 as reference.

NOTE   Making non-Kelvin connection

The Force terminals can be used to force and measure DC voltage or current. If you want to simplify the cable connections, open the Sense terminals and connect the Force terminals only to the connector plate by using the triaxial cables.

If you make the Kelvin connection, use both Force and Sense terminals. Connecting the Force and Sense lines together at the terminal of the device under test minimizes the measurement error caused by the residual resistance of the connection cables. The Kelvin connection is effective for the low resistance measurement and the high current measurement.

Table 3-2   **Connector Plates**

Model	Option Item	Connectors
16495F	16495F-001	Triax. (f-f) ×12, GNDU (f-f) ×1, Interlock (f) ×1
	16495F-002	Triax. (f) ×12, GNDU (f) ×1, Interlock (f) ×1
16495G	16495G-001	Triax. (f-f) ×24, GNDU (f-f) ×1, Interlock (f) ×1
	16495G-002	Triax. (f) ×24, GNDU (f) ×1, Interlock (f) ×1
16495H	16495H-001	Triax. (f-f) ×6, Coax. (f-f) ×6, GNDU (f-f) ×1, Interlock (f) ×1
	16495H-002	Triax. (f) ×6, Coax. (f) ×6, GNDU (f) ×1, Interlock (f) ×1
16495J	16495J-001	Triax. (f-f) ×8, Coax. (f-f) ×4, GNDU (f-f) ×1, Interlock (f) ×1
	16495J-002	Triax. (f) ×8, Coax. (f) ×4, GNDU (f) ×1, Interlock (f) ×1
16495K	16495K-001	Connector plate, rubber holder

Table 3-3   **To Connect Connector Plate**

Cables	Connector Plate	B1500A Terminals	
Agilent 16493J Interlock Cable, 3 m or 1.5 m	Intlk	Interlock	
Agilent 16493L GNDU Cable, 3 m or 1.5 m	GNDU	GNDU	
Agilent 16493K[a] Kelvin Triaxial Cable, 3 m or 1.5 m, for the Kelvin connection 16495F provides the inputs 1 to 12 (6 Kelvin). 16495H provides the inputs 1 to 6 (3 Kelvin). 16495J provides the inputs 1 to 8 (4 Kelvin).	odd number	SMU	Force
	even number		Sense
Agilent 16494A Triaxial Cable, 3 m or 1.5 m, for non-Kelvin connection 16495H provides the inputs 1 to 6. 16495J provides the inputs 1 to 8.	odd number or even number	SMU	Force
Agilent 16493P SPGU Cable, 3 m or 1.5 m 16495H provides the inputs 7 to 12. 16495J provides the inputs 9 to 12.	odd number or even number	SPGU	Output 1
			Output 2
Agilent N1300A CMU Cable[b], 3 m or 1.5 m 16495H provides the inputs 7 to 12. 16495J provides the inputs 9 to 12.	odd number or even number	CMU	Hcur/Hpot
			Lcur/Lpot

a. Use Agilent 16494B Kelvin Triaxial Cable to connect to Agilent E5250A Low Leakage Switch Mainframe or the connector plate for Agilent 4142B Modular DC Source/Monitor by the Kelvin connection.

b. To extend the four-terminal pair (4TP) connection to the connector plate inputs, connect the Hcur and Hpot cables together and the Lcur and Lpot cables together by using the BNC T-type adapter (female-female-male, Agilent part number 1250-2405), then connect them to the connector plate inputs. To extend the 4TP connection to the DUT interface, connect the cables to the connector plates input connectors individually, and connect the Hcur and Hpot terminals together and the Lcur and Lpot terminals together on the DUT interface. See Figure 3-17.

It is ok to leave open the ground wire extended from the CMU cable.

⚠ **Connecting the interlock terminal**

The B1500A provides the Interlock connector to prevent you from receiving an electrical shock from high voltage (more than ± 42 V). If the Interlock connector is open, the B1500A *cannot* force high voltage more than ± 42 V.

When using the 16442B test fixture, connect the Interlock connectors together using the 16493J interlock cable.

If you use the 16495F/G/H/J connector plate, your own connector plate, or your own test fixture, make an interlock circuit as shown in "To Make an Interlock Circuit" on page 3-29. Then connect the B1500A Interlock connector to the external interlock connector by using the 16493J interlock cable.

To Connect ASU

Agilent E5288A Atto Sense and Switch Unit (ASU) will add the 1 pA range to the high resolution SMU (HRSMU) when it is connected between the HRSMU and the device under test (DUT). The ASU also provides the input selection function when instruments are connected to the SMU input and the AUX input.

NOTE   For the installation of the ASU and the connection to the DUT interface (probe card, manipulators, and so on), contact your favorite prober vender. The prober vender will have the solutions. Dimensions of the ASU are 132 mm (W) × 88.5 mm (H) × 50 mm (D) excluding the connectors.

Figure 3-1   **Image of ASU Installation**
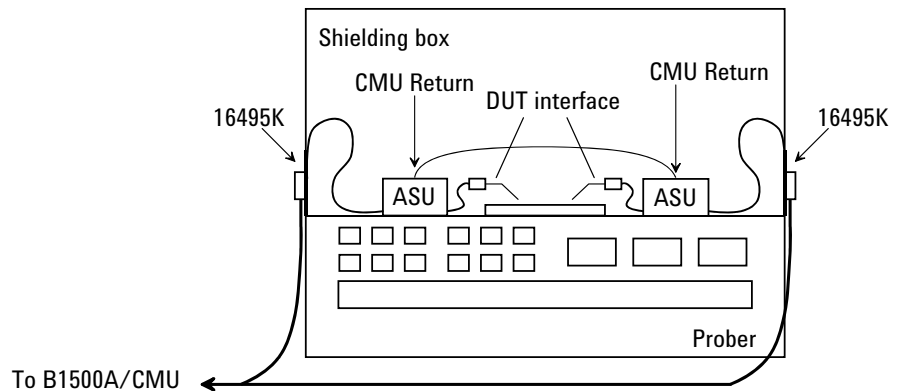
Required parts
- Agilent 16495K Connector plate
- Agilent 16493M ASU cable
- Agilent N1300A CMU cable or Agilent 16048D/E test leads
- Agilent N1254A-108 Magnet stand
- BNC cable, coaxial cable, manipulator, wire, and so on

To install 16495K   Fix the 16495K plate to the shielding box or something that will cover the DUT interface. See *Agilent 16495 Installation Guide*. The 16495K is the plate that has the mechanism to block the light from the cable hole used to pass the cables in the shielding box.

To install ASU

1. Fix the ASU in the shielding box. The ASU must be fixed to the best position for accessing its connectors. Agilent N1254A-108 Magnetic Stand will be useful for fixing the ASU.

2. Pass the 16493M (D-sub cable, triaxial cable), N1300A CMU cable, 16048D/E test leads, BNC cable and so on through the cable hole of the 16495K. They will be connected between the ASU and the instruments

3. Connect the D-sub cable to the ASU D-sub connector.

   Connect the triaxial cable to the ASU Force terminal.

   Connect the cable to the ASU CMU-cur/AUX In terminal. See Figure 3-2.

   • For the MFCMU, connect the N1300A CMU cable.

   • For Agilent 4284A LCR meter, connect Agilent 16048D/E test leads.

   • For the instrument other than the MFCMU or the 4284A, connect the BNC cable to the CMU-cur/AUX In terminal. And open the CMU-pot terminal or cover it by using the BNC open cap.

4. Adjust the cable length in the shielding box, and catch in the cables by using the cover of the 16495K.

5. Connect the cable extended from the DUT interface to the ASU output terminal.

   For the non Kelvin connection, open the Sense terminal or cover it by using the triaxial open cap.

To connect B1500A

1. Turn the B1500A off.

2. Connect the D-sub cable from the ASU to the HRSMU D-sub connector.

3. Connect the triaxial cable from the ASU to the HRSMU Force terminal.

NOTE   The specifications of the ASU are guaranteed while it is connected to the exclusive HRSMU. Confirm the serial number of the ASU, and connect it properly. See Agilent EasyEXPERT *User's Guide*.

To connect other instrument to AUX

To connect the instrument other than the MFCMU or the 4284A:

1. Turn the instrument off.

2. Connect the BNC cable from the ASU CMU-cur/AUX In terminal to the instrument. Prepare an adapter if the instrument's input/output connector is not BNC.

Figure 3-2   To Connect ASU
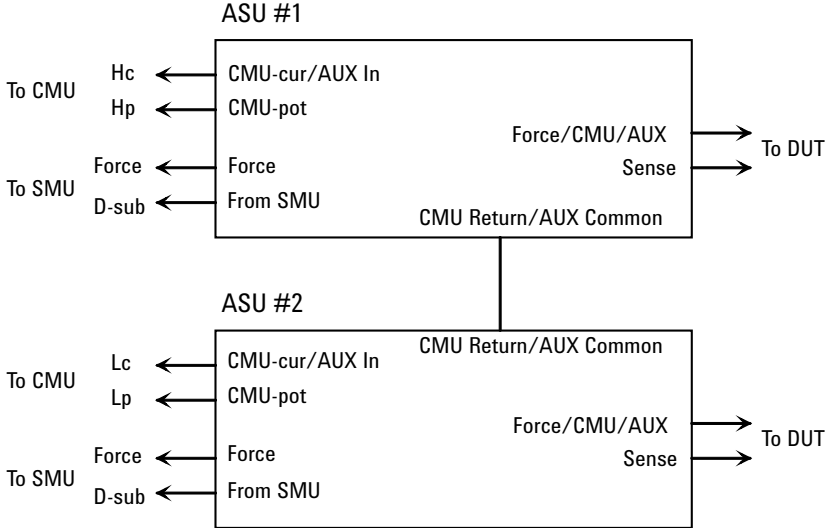
Figure 3-3   To Set Shorting Bar
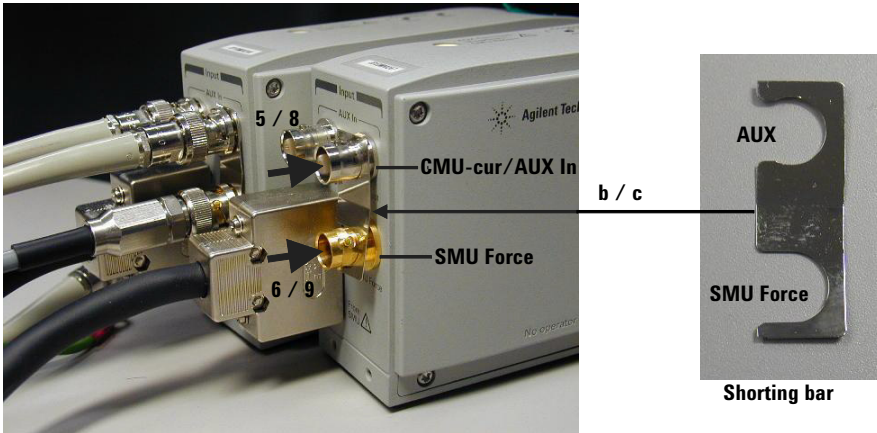
**To connect
MFCMU/4284A to
AUX**

Perform the following procedure to connect the MFCMU or the 4284A. See Figure 3-2 and Figure 3-3.

Prepare a shorting bar furnished with the ASU. The shorting bar is effective for reducing the offset capacitance caused by connecting a measurement terminal to the chuck of a wafer prober.

1. Turn the instrument off.

2. Prepare two ASUs (#1 and #2) and two shorting bar. And perform the following procedure for each ASU.

   a. Disconnect the triaxial cable from the ASU if it is connected to the ASU Force terminal.

   b. Face the concave side of the shorting bar to front.

   c. Slide the shorting bar from the right side of the connectors.

3. Connect the cable to the instrument. For the MFCMU, use the N1300A CMU cable. For the 4284A, use the 16048D/E test leads. It is ok to leave open the ground wire extended from the cable.

4. Connect the high potential (Hp) cable of the test leads to the ASU #1 CMU-pot terminal.

5. Connect the high current (Hc) cable to the ASU #1 CMU-cur/AUX In terminal. The shorting bar is fixed to the ASU #1 by the step 5 and 6.

6. Connect the triaxial cable from the HRSMU #1 Force terminal to the ASU #1 Force terminal.

7. Connect the low potential (Lp) cable to the ASU #2 CMU-pot terminal.

8. Connect the low current (Lc) cable to the ASU #2 CMU-cur/AUX In terminal. The shorting bar is fixed to the ASU #2 by the step 8 and 9.

9. Connect the triaxial cable from the HRSMU #2 Force terminal to the ASU #2 Force terminal.

10. Prepare the connection wire (both pin terminals) furnished with the ASU and connect it between the CMU Return terminals of the ASU #1 and ASU #2 together.

NOTE   About ASU output cables

To perform capacitance measurements accurately, the cable length between DUT and the ASU output must be as short as possible.

To Connect SCUU/GSWU

Agilent N1301A-100 SMU CMU Unify Unit (SCUU) is used to switch the module (CMU or SMU) to be connected to the DUT. The SCUU is available for the MPSMU and HRSMU.

Agilent N1301A-200 Guard Switch Unit (GSWU) is used to connect the CMU high and low guard lines together near the DUT. The connection is broken when the SCUU is in the SMU connection state. The GSWU is effective for the accurate impedance measurement.

NOTE   For the installation of the SCUU/GSWU and the connection to the DUT interface (probe card, manipulators, and so on), contact your favorite prober vender. The prober vender will have the solutions. Dimensions of the SCUU are 148 mm (W) × 75 mm (H) × 70 mm (D). Dimensions of the GSWU are 33.2 mm (W) × 41.5 mm (H) × 32.8 mm (D).

Figure 3-4   **Image of GSWU Installation**
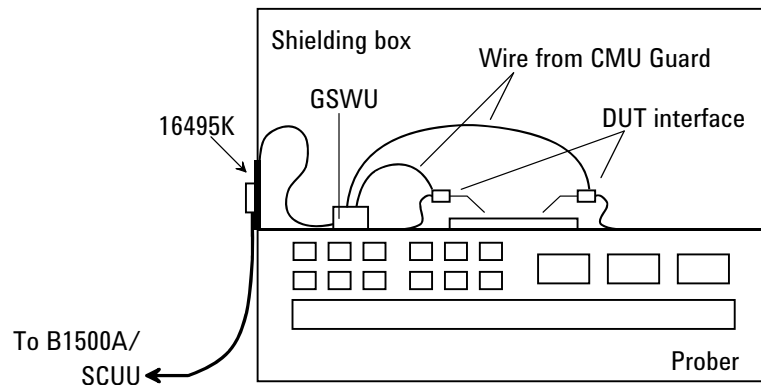
Required parts
- Agilent 16495K Connector plate
- Agilent N1301A-201/202 GSWU cable (if GSWU is used)
- Agilent N1301A-102 SCUU cable (if SCUU is not attached to the MFCMU)
- Agilent N1301A-110 Magnet stand (if GSWU is used)
- BNC cable, coaxial cable, manipulator, wire, and so on

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To install 16495K　　Fix your necessary 16495 connector plates to the shielding box or something that will cover the DUT interface. See *Agilent 16495 Installation Guide*. For the GSWU installation, the 16495K is required. It is the plate that has the mechanism to block the light from the cable hole used to pass the cables in the shielding box.

Before starting　　1. GSWU is furnished with wires (2 ea.) for the connection between the GSWU and the DUT interface Guard terminal. If it is too short to connect them, prepare additional wire.

　　2. Turn the B1500A off.

Figure 3-5　　　　**To Connect SCUU/GSWU**
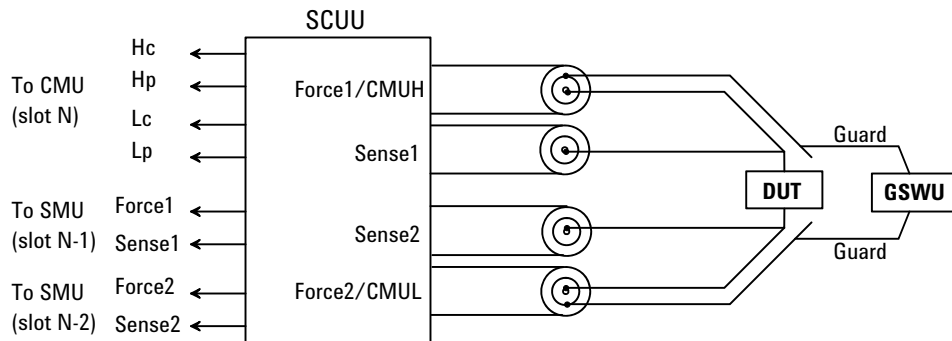
**To connect
SCUU/GSWU 1**

To attach the SCUU to the B1500A:

1. Attach the SCUU to the B1500A rear panel connectors for the MFCMU in the slot N and two SMUs in the slots N-1 and N-2 (N: integer, 3 to 10).

   Connection will be easy by bringing the control connectors together before bringing the BNC connectors.

2. Fix the GSWU in the shielding box. The GSWU must be fixed to the best position for accessing its connectors.

3. Pass the GSWU cable (Agilent N1301A-201/202) through the cable hole of the 16495K. And connect it between the SCUU and the GSWU.

4. Adjust the cable length in the shielding box, and catch in the cables by using the cover of the 16495K.

5. Connect the proper cables from Force1/CMUH and Force2/CMUL to the 16495 connector plates or the DUT interface. See Figure 3-5.

   For the Kelvin connections, also connect the proper cables from Sense1 and Sense2 to the 16495 connector plates or the DUT interface.

6. Connect the wires (furnished, 2 ea.) to the GSWU.

7. Connect one of the wires to the Guard terminal extended from CMUH of SCUU. Then the wire should contact the Guard terminal as close to the device as possible.

8. Connect another one to the Guard terminal extended from CMUL of SCUU. Then the wire should contact the Guard terminal as close to the device as possible.

NOTE	About SCUU output cables

To perform capacitance measurements accurately, the cable length between DUT and the SCUU output must be as short as possible.

**To connect
SCUU/GSWU 2**

1. Attach an end of the SCUU cable (Agilent N1301A-102) to the SCUU.

   Connection will be easy by putting the SCUU and the cable connection box on the flat table, and bringing the control connectors together before bringing the BNC connectors.

   If the SCUU is fixed inside the shielding box, pass the SCUU cable through the cable hole of the 16495K.

2. Fix the SCUU inside or outside the shielding box. The SCUU must be fixed to the best position for accessing its connectors. Agilent N1301A-110 Magnetic Stand will be useful for fixing the SCUU.

3. Attach the other end of the SCUU cable to the B1500A rear panel connectors for the MFCMU in the slot N and two SMUs in the slots N-1 and N-2 (N: integer, 3 to 10).

   Connection will be easy by bringing the control connectors together before bringing the BNC connectors.

4. Fix the GSWU in the shielding box. The GSWU must be fixed to the best position for accessing its connectors.

5. Connect the GSWU cable (Agilent N1301A-201/202) between the SCUU and the GSWU.

   If the SCUU is fixed outside the shielding box, pass the GSWU cable through the cable hole of the 16495K.

6. Adjust the cable length in the shielding box, and catch in the cables by using the cover of the 16495K.

7. Connect the proper cables from Force1/CMUH and Force2/CMUL to the 16495 connector plates or the DUT interface. See Figure 3-5.

   For the Kelvin connections, also connect the proper cables from Sense1 and Sense2 to the 16495 connector plates or the DUT interface.

8. Connect the wires (furnished, 2 ea.) to the GSWU.

9. Connect one of the wires to the Guard terminal extended from CMUH of SCUU. Then the wire should contact the Guard terminal as close to the device as possible.

10. Connect another one to the Guard terminal extended from CMUL of SCUU. Then the wire should contact the Guard terminal as close to the device as possible.

NOTE   About SCUU output cables

To perform capacitance measurements accurately, the cable length between DUT and the SCUU output must be as short as possible.

To Connect GNDU Adapter

The ground unit (GNDU) output is the single triaxial connector. Agilent N1254A-100 GNDU to Kelvin Adapter enables to change it to the dual triaxial connector. Connect the adapter to the GNDU connector on the rear panel, then connect a Kelvin triaxial cable to extend the GNDU terminal. Maximum current is restricted when the Kelvin triaxial cable is used. See Table 3-4.

Figure 3-6   **Agilent N1254A-100 GNDU to Kelvin Adapter**

Agilent N1254A-100 GNDU to Kelvin Adapter

Force

Dual Triaxial (female)

Triaxial (male)

Sense

Common

To GNDU connector   To 16493K Kelvin triaxial cable
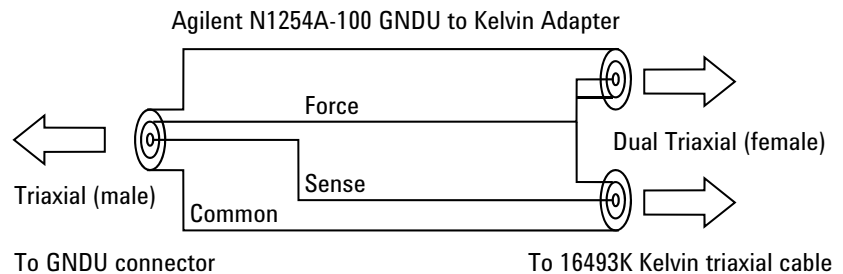
Table 3-4   **Kelvin Triaxial Cable and Maximum Current**

Model No. or Option Item	Description	Maximum Current
16493K-001	1.5 m Kelvin Triaxial Cable	3.0 A
16493K-002	3 m Kelvin Triaxial Cable	2.6 A

To Interconnect SPGUs

If multiple SPGUs have been installed, connect the SPGUs by using the following parts. See Figure 3-7.

- SPGU-SPGU connection cable16493Q, (number of SPGUs−1)×2 ea.

- SMA open cap, 4 ea.

Figure 3-7 **SPGU Module Connection Example, Four Modules**
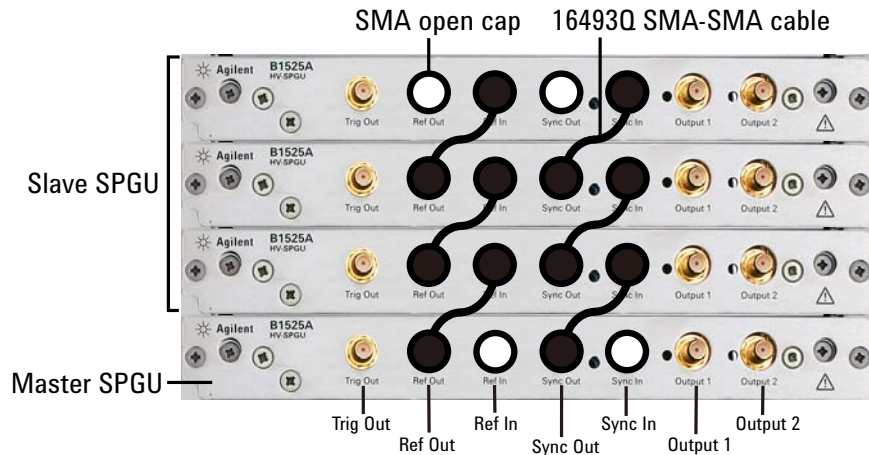
If multiple SPGUs have been installed, connect the SPGUs as shown in Figure 3-7. This connection makes it possible to perform the synchronous output by the multiple SPGU channels. In this figure, the master SPGU is the module which outputs the reference signal and the slave SPGUs are the modules which follow to the reference signal.

The Trig Out terminal must be connected to the trigger input terminal of the external equipment to make the synchronized operation of it.

CAUTION Connect the Ref Out/In, Sync Out/In, and Trig Out terminals to the specified terminal properly. Connecting to the other terminal may result in damage to the SPGU.

Mounting Connectors

Previous sections described how to install the available accessories, and *Agilent 16495 Installation Guide* provides the information on how to install connector plates on the shielding box. However, you may choose to mount connectors directly on your own connector plate or test fixture.

To do this, you will need to make connector holes and mount the connectors yourself. This section contains information on connector hole dimensions.

To mount connectors:

1. Select the appropriate parts for your application. See Table 3-5.

2. Make the holes and mount the connectors. See Table 3-6.

   For Kelvin connections, use Agilent 16493K Kelvin triaxial cable. The Kelvin triaxial cable requires a Kelvin triaxial connector, which has two connector holes and three screw holes.

3. Build the interlock circuit shown in "To Make an Interlock Circuit" on page 3-29.

4. Attach cables from the connectors to the DUT (device under test). See "To Connect GNDU Output" on page 3-32, "To Connect SMU Output" on page 3-33, and "To Connect MFCMU Output" on page 3-39.

Table 3-5   **Recommended Parts**

Usage	Agilent Part No.	Description
Making an interlock circuit	1252-1419C	Interlock Connector (6 pin, female)
	3101-0302 or 3101-3241	Switch
	1450-0641	LED ($V_F \cong 2.1$ V @ $I_F = 10$ mA)
	8150-5680	Wire
Connecting GNDU to DUT	1250-2457	Triaxial Connector (female)
	8121-1189 or 8150-2639	Coaxial Cable or Wire
Connecting SMU to DUT	1250-2457	Triaxial Connector (female)
	8121-1191	Low Noise Coaxial Cable
Connecting MFCMU to DUT	1250-0118	BNC Connector (female)
	8120-0367	Coaxial Cable (50 Ω)
	8150-0447	Wire

Table 3-6   **Dimensions of Connector Holes**

⚠ **To Make an Interlock Circuit**

The interlock circuit is designed to prevent electrical shock when a user touches the measurement terminals.

CAUTION   You must install an interlock circuit on a shielding box to prevent hazardous voltages when the door of the shielding box is open.

Figure 3-8 shows the pin assignments of the interlock connector that should be mounted on a connector plate or test fixture.

Figure 3-8   **Interlock Connector Pin Assignments**

Plug side view   Wiring side view
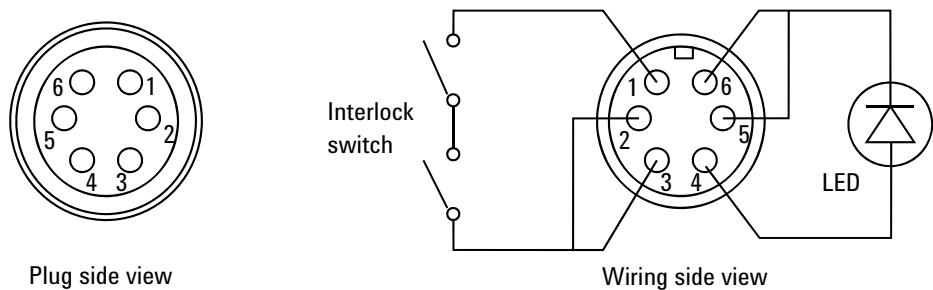
WARNING   **Potentially hazardous voltages may be present at the Force, Guard, and Sense terminals when the interlock terminals are shorted.**

Installing the interlock circuit

Install the interlock circuit as follows:

1. Mount two mechanical switches on your shielding box, so that the switches close when the door of the shielding box is closed, and open when the door is opened. For the dimensions of the switch, see Figure 3-10 and Figure 3-11 below.

2. Mount an LED on your shielding box. For the dimensions of the LED, see Figure 3-9.

3. Use wire to connect the two switches in series between pin number 1 and 2 (or 3) of the interlock connector. See Figure 3-8.

4. Use wire to connect the LED between pin number 4 and 5 (or 6) of the interlock connector. See Figure 3-8.

If Agilent B1500A Interlock connector is connected to the interlock circuit, Agilent B1500A SMU *cannot* force more than ± 42 V when the door is open. When the door is closed, it can force more than ± 42 V.

When more than ± 42 V is forced from an SMU, the LED lights to indicate *high voltage output*.

Figure 3-9   **Dimensions of the LED (Agilent part number 1450-0641)**

Figure 3-10   **Dimensions of the Interlock Switch (Agilent part number 3101-0302)**

Figure 3-11   **Dimensions of the Interlock Switch (Agilent part number 3101-3241)**
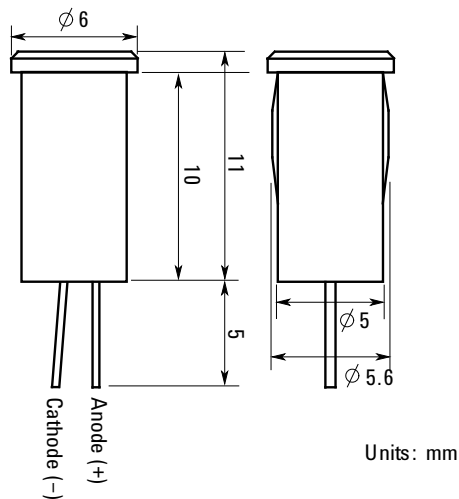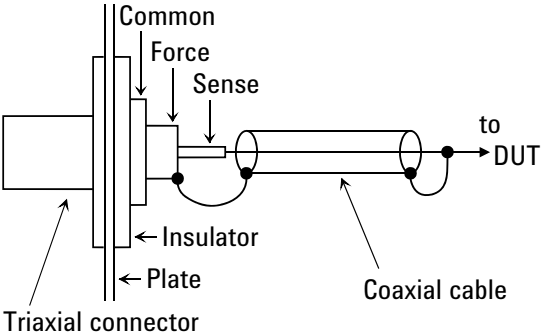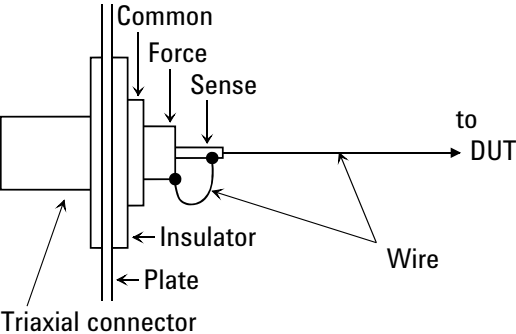
To Connect GNDU Output

The GNDU output connection examples are shown in Table 3-7

Table 3-7   **GNDU Output Connections**

Kelvin connections	non-Kelvin connections
Use a low-noise coaxial cable (Agilent part number 8121-1189) from the connector to the prober, socket, or DUT as shown. To cancel the effects of cable resistance, connect the Sense line and Force line as close as possible to the terminal of the DUT.	Short the Sense and Force on the connector as shown below. Measurement data will include the residual resistance of the connection wire. Use AWG 22 single-strand insulated wire (Agilent part number 8150-2639) from the connector plate to the prober, socket, or DUT. For a quick connection where measurement accuracy is not critical, connect only Force to the DUT, without shorting the Sense and Force. With this connection, the measurement data will include residual resistance from the connection cable between the GNDU and the connector plate.

CAUTION   Use Agilent 16493L GNDU cable to connect the GNDU to your connector plate or test fixture. Do *not* use the triaxial cable. The GNDU is rated for up to 4.2 A, while the maximum current rating of the triaxial cable is 1 A.

To Connect SMU Output

The SMU output connection examples are shown in Table 3-8.

WARNING   **Potentially hazardous voltages, up to ± 100 V (MPSMU/HRSMU) or ± 200 V (HPSMU), are present at the Force, Sense, and Guard terminals.**

To prevent electrical shock, do not expose these lines.

Before turning Agilent B1500A on, connect the Interlock terminal to an interlock circuit.

Before you touch any connections to these terminals, turn Agilent B1500A off, disconnect the power cable, and discharge any capacitors.

CAUTION   Never connect the Guard terminal to any output, including circuit common, chassis ground, or any other guard terminal. Doing so will damage the SMU.

NOTE   Low-Noise Coaxial Cable

For the extended measurement paths over the connector plate, use low-noise coaxial cable (Agilent part number 8121-1191). This cable can maximize the guard effects and minimize the impression of the external noise.

Figure 3-12 shows the cutting example of this cable. Key point is the isolation between the conductive layer and the center conductor. So, cut and trim the end of the cable as shown in this figure by using a cutter and so on.

Figure 3-12   **Coaxial Cable Cutting Example**
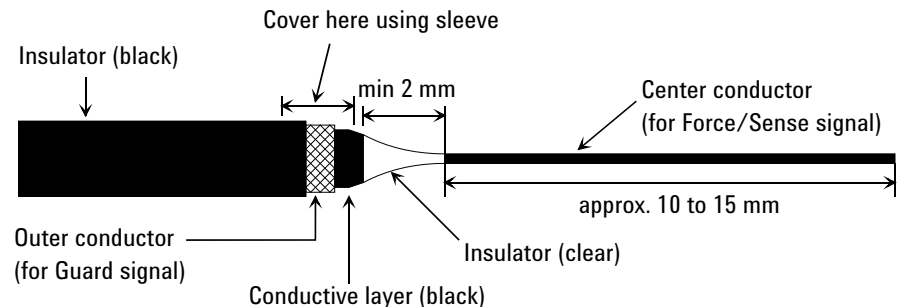
Table 3-8   **SMU Output Connections**

Kelvin connections	non-Kelvin connections
Use low-noise coaxial cable (Agilent part number 8121-1191) from the connector to the prober, socket, or DUT as shown.	Use low-noise coaxial cable (Agilent part number 8121-1191). The following figure is for the connection using Kelvin triaxial cable.
See Figure 3-13 and Figure 3-15 for the ASU and SCUU connections respectively.	For the connection using triaxial cable, connect the cable to the Force terminal only.
To cancel the effects of cable resistance, connect the Sense line and Force line as close as possible to the DUT terminal.	In this connection, measurement data will include residual resistance from the connection cable.
To prevent oscillations, do not use cables longer than 1.5 m.	See Figure 3-14 and Figure 3-16 for the ASU and SCUU connections respectively.

NOTE   To Minimize Leakage Current

For the highly accurate current forcing and measurements, surround all force and sense lines by a guard as far as possible, and physically stable the cables with tape.

Figure 3-13   **ASU Output Kelvin Connection**
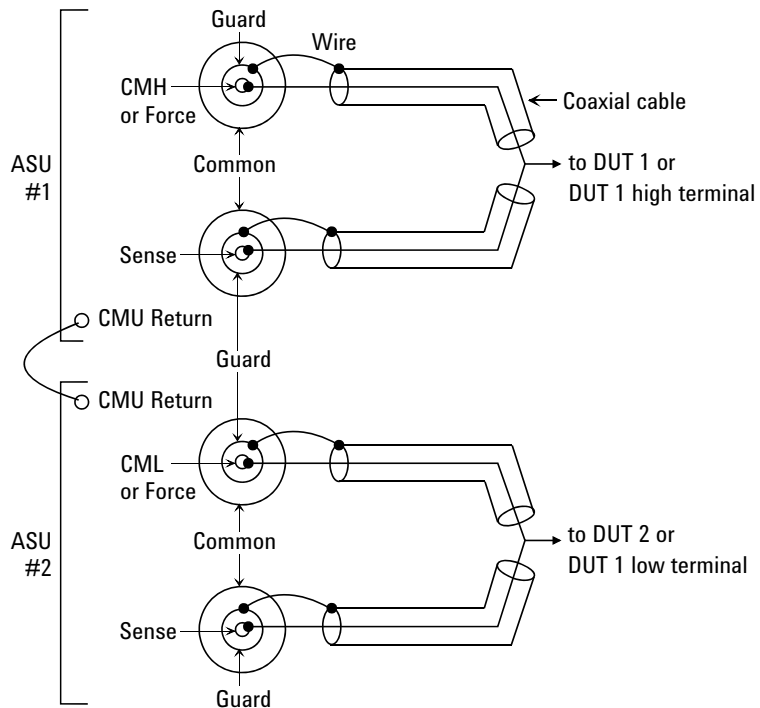
The ASU inputs can be connected to the instruments by using a control cable, a triaxial cable, and two coaxial cables. The cables can be connected to the ASU inside the shielding box through the 16495K plate.

The ASU outputs should be connected to the DUT by using coaxial cables and wires as shown above.

When a SMU is used for the measurements, the Kelvin paths will work as same as Table 3-8.

When a four-terminal pair (4TP) instrument is used, the sense lines can be ignored. And a Kelvin path is used for the high signal, and the other one is used for the low signal. For the accurate impedance measurements, a wire must be connected between the ASU#1 CMU Return and the ASU#2 CMU Return.

If the 4TP instrument is not used, you can ignore the CMH, CML, CMU Return, and the DUT1 high and low terminals.

Figure 3-14   **ASU Output non-Kelvin Connection**
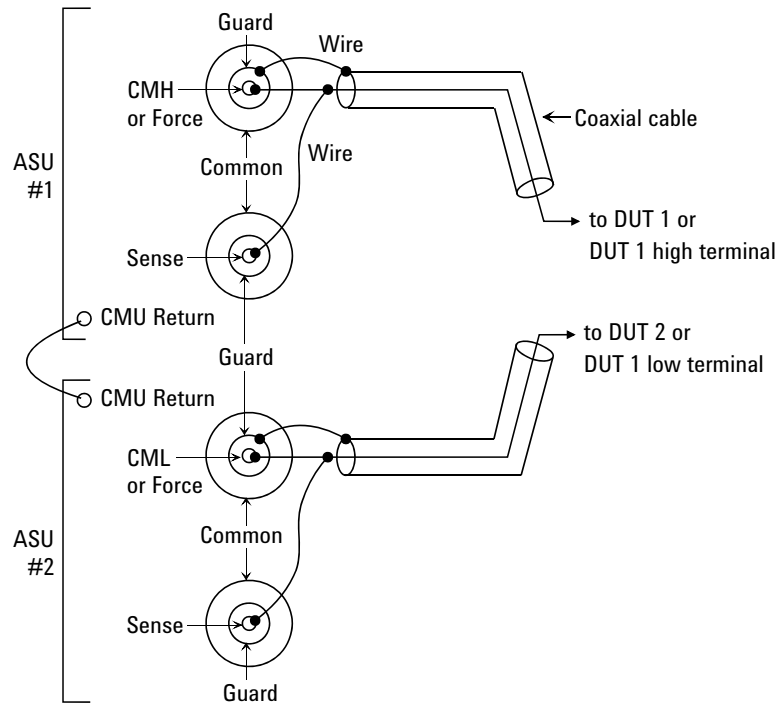
The ASU inputs can be connected to the instruments by using a control cable, a triaxial cable, and two coaxial cables. The cables can be connected to the ASU inside the shielding box through the 16495K plate.

The ASU outputs should be connected to the DUT by using coaxial cables and wires as shown above.

When a SMU is used for the measurements, the Kelvin paths/force lines will work as same as Table 3-8. Then the sense line is not extended to the DUT.

When a four-terminal pair (4TP) instrument is used, the sense lines can be ignored. And a force line is used for the high signal, and the other one is used for the low signal. For the accurate impedance measurements, a wire must be connected between the ASU#1 CMU Return and the ASU#2 CMU Return.

If the 4TP instrument is not used, you can ignore the CMH, CML, CMU Return, and the DUT1 high and low terminals shown above.

Figure 3-15   **SCUU Output Kelvin Connection**
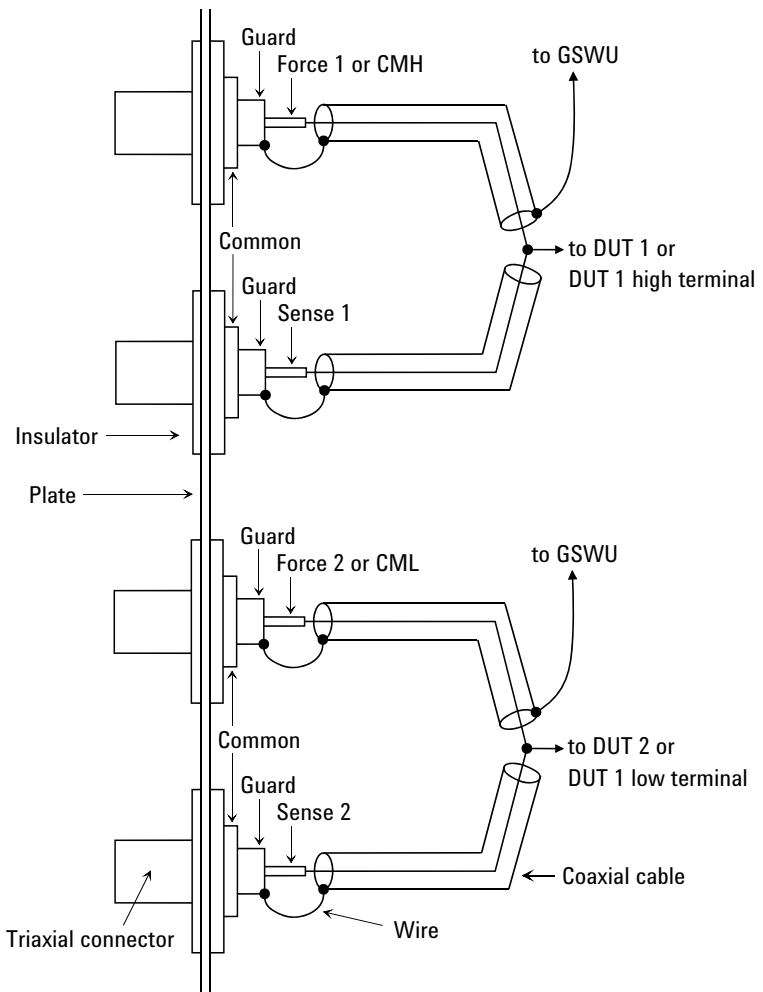
The SCUU should be connected to the DUT by using coaxial cables and wires as shown above. Also the SCUU should be connected to the GSWU inside the shielding box by using a control cable through the 16495K plate.

When a SMU is used for the measurements, the Kelvin paths will work as same as Table 3-8.

When the MFCMU is used, the sense lines can be ignored. And a Kelvin path is used for the CMU high, and the other one is used for the CMU low. For the accurate impedance measurements, wires must be connected to the GSWU from the CMH guard and the CML guard as near as possible to the DUT.

Figure 3-16   **SCUU Output non-Kelvin Connection**
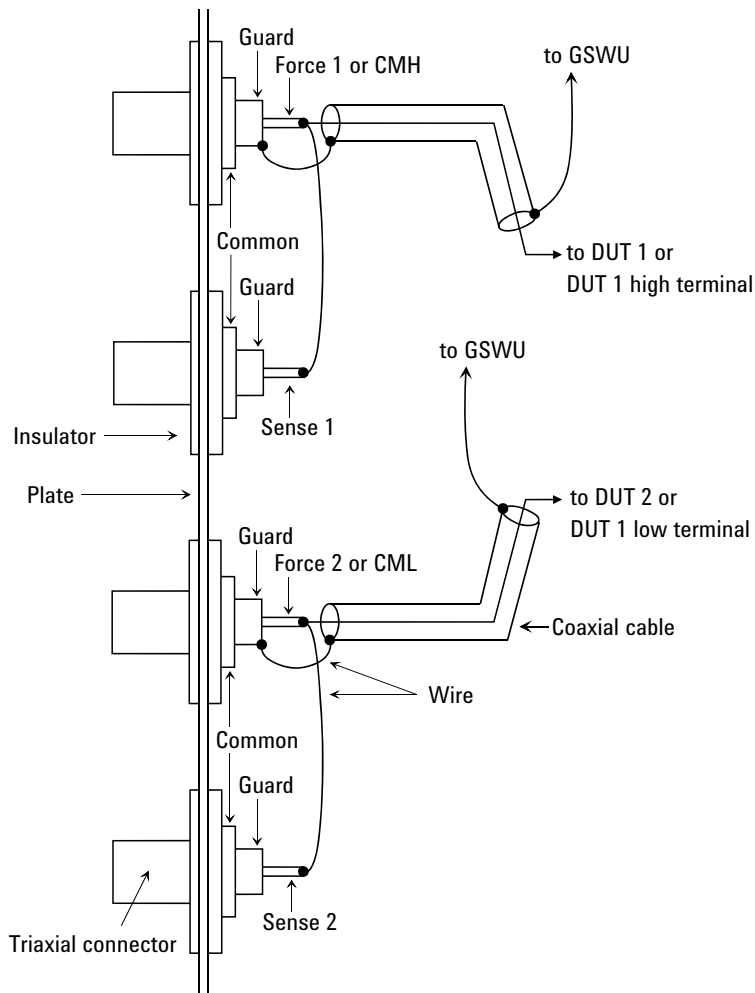
The SCUU should be connected to the DUT by using coaxial cables and wires as shown above. Also the SCUU should be connected to the GSWU inside the shielding box by using a control cable through the 16495K plate.

When a SMU is used for the measurements, the Kelvin paths/force lines will work as same as Table 3-8. Then the sense line is not extended to the DUT.

When the MFCMU is used, the sense lines can be ignored. And a force line is used for the CMU high signal, and the other one is used for the CMU low signal. For the accurate impedance measurements, wires must be connected to the GSWU from the CMH guard and the CML guard as near as possible to the DUT.

To Connect MFCMU Output

The MFCMU output connection example is shown in Figure 3-17. This connection is for the MFCMU without the SCUU. Then Agilent N1300A-001/002 CMU cable should be used for the connection between the MFCMU and the connectors you mount. It is ok to leave open the ground wire extended from the CMU cable.

Figure 3-17   **MFCMU Output Connection**
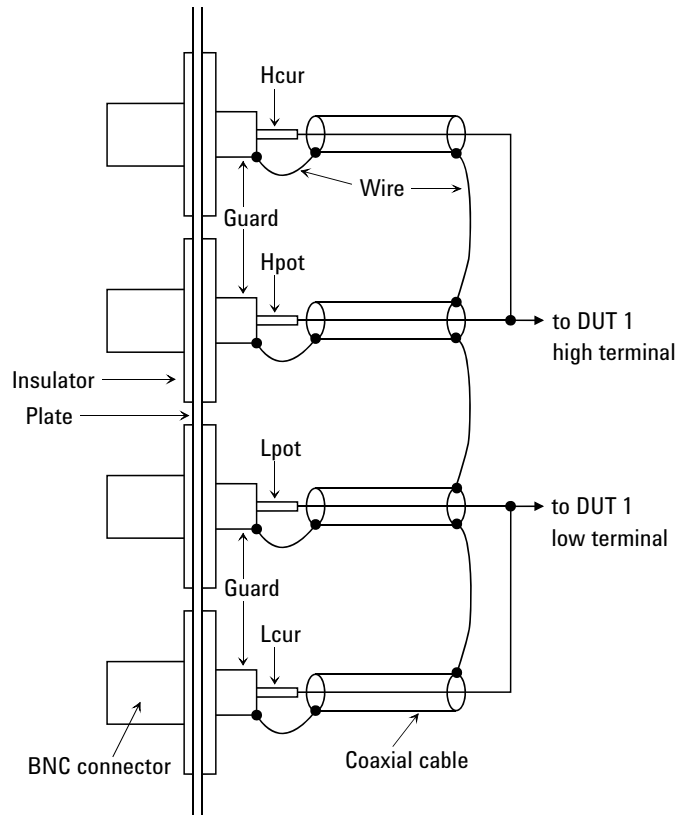
The Hcur/Hpot/Lcur/Lpot lines should be connected to the DUT as shown above.

Use a 50 Ω coaxial cable (Agilent part number: 8120-0367) for the Hcur/Hpot/Lcur/Lpot lines connection. Use a wire for the guard connection.

Connecting Measurement Devices

This section describes how to connect device under test (DUT) to the 16442B test fixture, and how to connect cables to the connector plate.

If you use a wafer prober, see wafer prober manuals.

Note that you must set the module output off when connecting or disconnecting DUTs. If not, the DUTs may be damaged.

To set the module output off, press the **Stop** key.

This section has the following descriptions:

- "Using Test Fixture"

- "Using Connector Plate"

NOTE Kelvin connection and non-Kelvin connection

To make the Kelvin connection, use both Force and Sense terminals. Connecting the Force and Sense lines together at the terminal of the DUT (device under test) minimizes the measurement error caused by the residual resistance of the connection cables. The Kelvin connection is effective for the low resistance measurement and the high current measurement.

If you want to simplify the cable connections, open the Sense terminals and use the Force terminals only. This is the non-Kelvin connection. The Force terminals can be used to force and measure dc voltage or current.

Using Test Fixture

1. Press the **Stop** key to set the module output off.

2. Select a proper socket module for your DUT, then set the socket module on the test fixture.

3. Mount your DUT on the socket module.

4. Connect between the socket module and the test fixture by using the proper test leads.

5. Close the lid of the test fixture.

    To force more than $\pm$ 42 V, close the lid of the test fixture. Otherwise, the interlock function will stop Agilent B1500A output.

To connect between the socket module and the test fixture, you can use test leads that have the following terminals:

*   Miniature banana-to-miniature banana

*   Miniature banana-to-pin plug

*   Miniature banana-to-miniature clip

WARNING	**Make sure that the lid is closed properly before starting measurement. Do not perform the measurement when a test lead is protruding from the test fixture and the lid.**

CAUTION	Do not connect or disconnect your DUT while Agilent B1500A is forcing voltage or current. Otherwise, your DUT may be damaged.

CAUTION	Do not touch the terminals of the test leads. Oil, perspiration, and dirt prevent good electrical contact, deteriorate insulation, and degrade measurement accuracy.

Connections for High Current Measurements

When you force or measure a large current, you may want to use a **Kelvin (4-wire) connection** to eliminate the residual resistance effects of test leads and contacts. For example, you can use the following connections as Kelvin connections on the test fixture.

Examples: Kelvin Connection
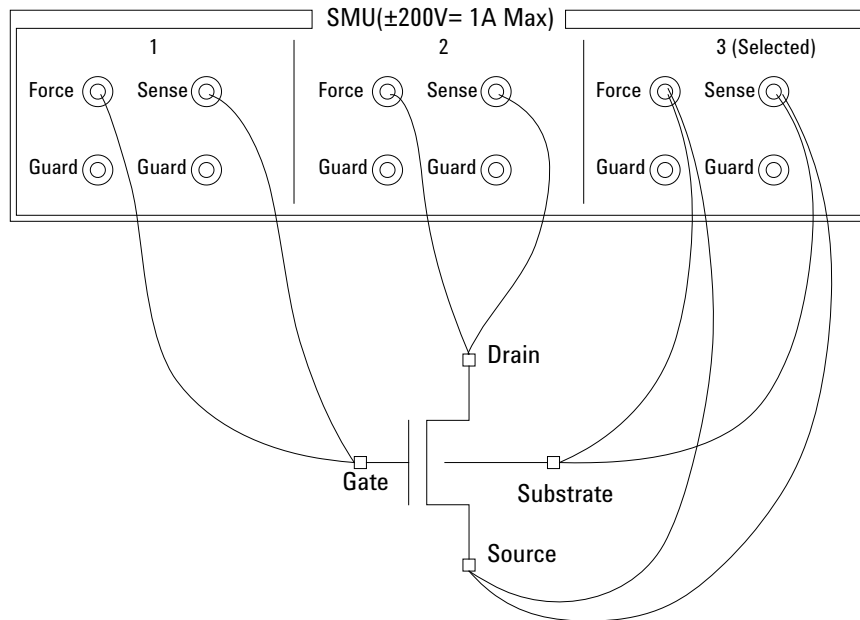
To cancel the effects of the residual resistance, test leads must be connected as close as possible to the DUT.

Using Connector Plate

This section provides the information useful for connecting cables and probing needles to a connector plate.

- "To Reduce Leakage Current"

- "To Measure Low Resistance"

To Reduce Leakage Current

To reduce the leakage current caused by connection cables, the guard technique is effective. Connect the probing needles to the terminals of the connector plate by using coaxial cables as shown below:

1. At end of cable, connect coaxial center conductor to force terminal of connector plate, and connect coaxial outer conductor to guard terminal of connector plate.

2. At another end, connect coaxial center conductor to tail of the probing needle. Never connect the outer conductor at this cable end.

   Extend the outer conductor as close as possible to the probing needle.

Example

The following example connection can be used to reduce the leakage current. Extend the outer conductor as close as possible to the probing needle. This also reduces the induced noise.
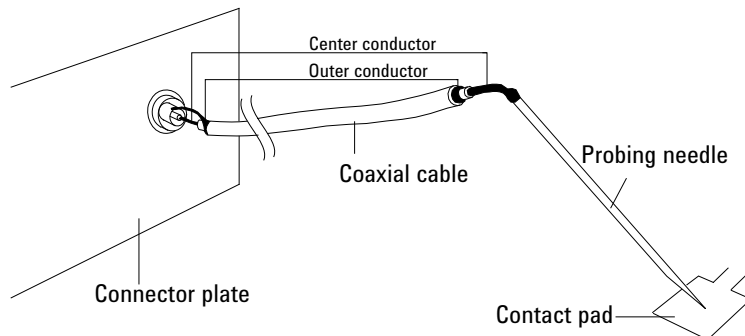
| | WARNING | **Do not touch the guard terminal with bare hands because you may be shocked by high voltage. The potential of the guard terminal is equal to the output voltage.** |

WARNING   **Do not touch the guard terminal with bare hands because you may be shocked by high voltage. The potential of the guard terminal is equal to the output voltage.**

CAUTION   Never connect the guard terminal to any other output, including circuit common, frame ground, or the terminals of any other unit. Doing so may damage the unit.

Guarding

Guarding reduces the leakage current between the measurement points and instrument. This is important when you measure low current.

The following figure shows the theory of guarding. The buffer amplifier (×1) keeps the potential of the guard conductor at the same potential as the force conductor, so current does not flow between the force and guard conductors. Therefore, the current measured by SMU is same as current at measurement point because no current is leaked.
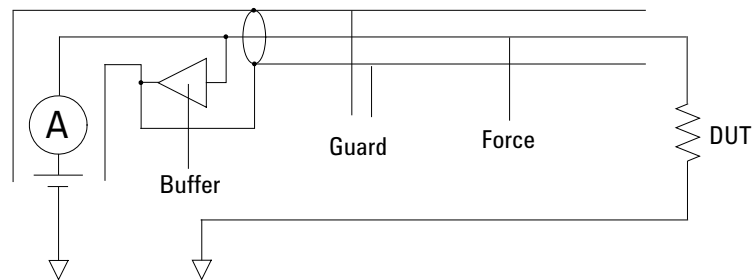
To Measure Low Resistance

When you measure a low resistance, high current flows through the DUT. This high current increases the measurement error caused by the residual resistance of cables. To cancel the effect of this resistance, you can use *Kelvin connections* (4-wire), which means the force and sense lines are extended separately to the DUT.

Connect the probing needles to the terminals of the connector plate by using test leads or coaxial cables. Following instruction uses the coaxial cables:

1. At end of cable, connect coaxial center conductor to force terminal of connector plate, and connect coaxial outer conductor to guard terminal of connector plate.

2. At another end, connect coaxial center conductor to tail of the probing needle. Never connect the outer conductor at this cable end.

   Extend the outer conductor as close as possible to the probing needle.

3. Repeat 1 and 2 for the sense terminal of connector plate.

4. Contact the probing needles from force and sense terminals as close as possible to the DUT.

Example

The following example connection can be used to measure low resistance. The sense line is extended to the probing pad, and contacts the force line through the pad, so the voltage drop due to the residual resistance caused by cables and test leads is canceled.
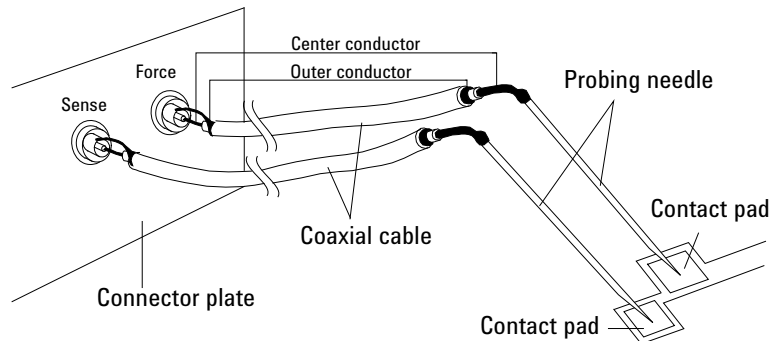
This example uses test leads. To reduce the leakage current, use coaxial cables.

Kelvin Connection

Kelvin connections give good measurement results when you force high-current. The following figure shows the equivalent circuits for Kelvin and non-Kelvin connections.

- For the non-Kelvin connection, the voltmeter measures the voltage drop of resistances r_{F1}, R_{DUT}, and r_{F2}.

- For the Kelvin connection, the voltmeter measures the voltage drop of resistance R_{DUT} only. The impedance of the voltmeter is very high, so the voltage drop of resistances r_{S1} and r_{S2} can be ignored.

(a) non-Kelvin connection   (b) Kelvin connection
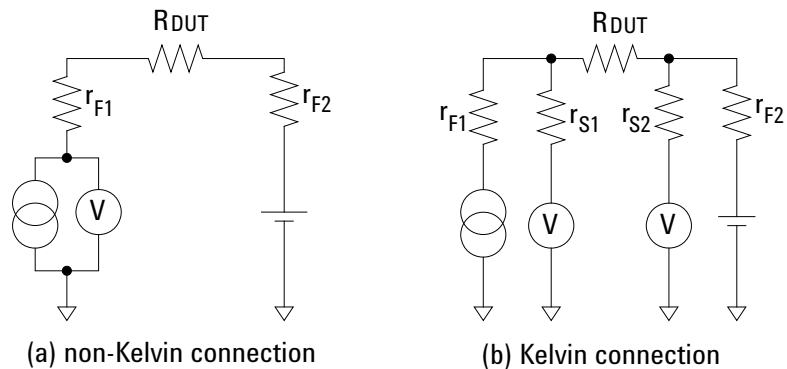
The Kelvin connection is effective even when forcing voltage. The voltage drop due to the residual resistance of the force line wiring is fed back to the voltage source via a comparator in the sense line. The input impedance of comparator is high, and current flow into the sense line is very low. So output error is not significant if the sense line wiring has a residual resistance of 10 Ω or less. Therefore, the specified voltage appears at the sense point (point where sense line contacts force line)

Capacitance Compensation When Using Switching Matrix

When the capacitance/conductance measurement is performed through Agilent B2200A/B2201A/E5250A switching matrix, Agilent B1500A measures the capacitance/ conductance of the path including a DUT (device under test), matrix switches, extension cables and so on. So, the data measured by the B1500A is far from the DUT's capacitance/conductance.

Agilent EasyEXPERT provides the functions used to compensate the data measured in the environments described in "Required Conditions" on page 3-48. This section explains how to perform compensation.

•   "Required Conditions"

•   "To Create Compensation Data File"

NOTE   Corrected data by the function is not guaranteed. But typical data (supplemental data) is as follows.

Capacitance measurement accuracy (typical): ±1 % ±0.5 pF

This typical data is for the following measurement conditions:

Measurement frequency: 1 kHz to 5 MHz

Measurement range: Maximum 1000 pF

Measurement terminal: At the end of Agilent 16494A/B/C cable connected to the switch module output terminals.

The typical data does not apply to anything extended from the 16494A/B/C cable. The conditions described in "Required Conditions" on page 3-48 must be satisfied.

Required Conditions

The following conditions must be satisfied to use the capacitance compensation function. For the instrument connections, see Figure 3-18.

- Setting of the MFCMU

  - Range of the measurement frequency: 1 kHz to 5 MHz

  - Measurement function: Cp-G, Cp-D, Cs-Rs, or Z-Th. There is no limitation.

  - Calibration

    Perform the MFCMU open calibration at the end of the measurement paths in front of the switching matrix inputs. If you also perform the short calibration (optional), prepare the BNC thru adapter (Agilent part number 1250-0080, 1 ea.).

  - Total cable length of both Hc-Hp side and Lc-Lp side must be the same.

- Switching matrix input ports

  Use Agilent N1300A CMU cable to connect the MFCMU. The BNC-T adapters (2 ea., Agilent part number 1250-2405 for each) are required to connect between the Hc and Hp terminals and between the Lc and Lp terminals. Connect the Hc-Hp cable and the Lc-Lp cable as follows. It is ok to leave open the ground wire extended from the CMU cable.

  Hc-Hp: Input 13 (B2200A/B2201A) or AUX INPUT CV1 (E5250A)

  Lc-Lp: Input 14 (B2200A/B2201A) or AUX INPUT CV2 (E5250A)

- Switching matrix output terminals

  Use the Agilent 16494A triaxial cable to extend the outputs to the connector plate or the Agilent B2220A probe card interface (only for B2200A/B2201A). For the Kelvin connection, use the Agilent 16494B/C Kelvin triaxial cable.

- Ahead of the connector plate

  Recommended cable: Agilent part number 8121-1191 Triaxial cable

  You can also use another type of triaxial cable, coaxial cable, or combination of these.

  To approximate the capacitance/conductance of the DUT, you need to obtain the appropriate compensation coefficients for your measurement environment, and create your compensation data file. See Figure 3-18.

In Figure 3-18, C1 (DATA04), C2H (DATA05), C2L (DATA06), C3H (DATA07), C3L (DATA08) are the compensation coefficients defined in the compensation data file. where, CxH is for the path connected to the MFCMU Hc-Hp terminal, and CxL is for the path connected to the MFCMU Lc-Lp terminal.

When Agilent B2220A probe card interface is used, obtain the coefficients for C3x, and create your compensation data file. In this case, probe card will be used for the C3x path.

When the connector plate is used, obtain the coefficients for C2x and C3x, and create your compensation data file. In this case, triaxial cable with connector plate will be used for the C2x path. And coaxial cable with positioner will be used for the C3x path.

For obtaining the compensation coefficients and creating the compensation data file, see "To Create Compensation Data File" on page 3-50.

Figure 3-18   **Extension Cables and Compensation Coefficients**
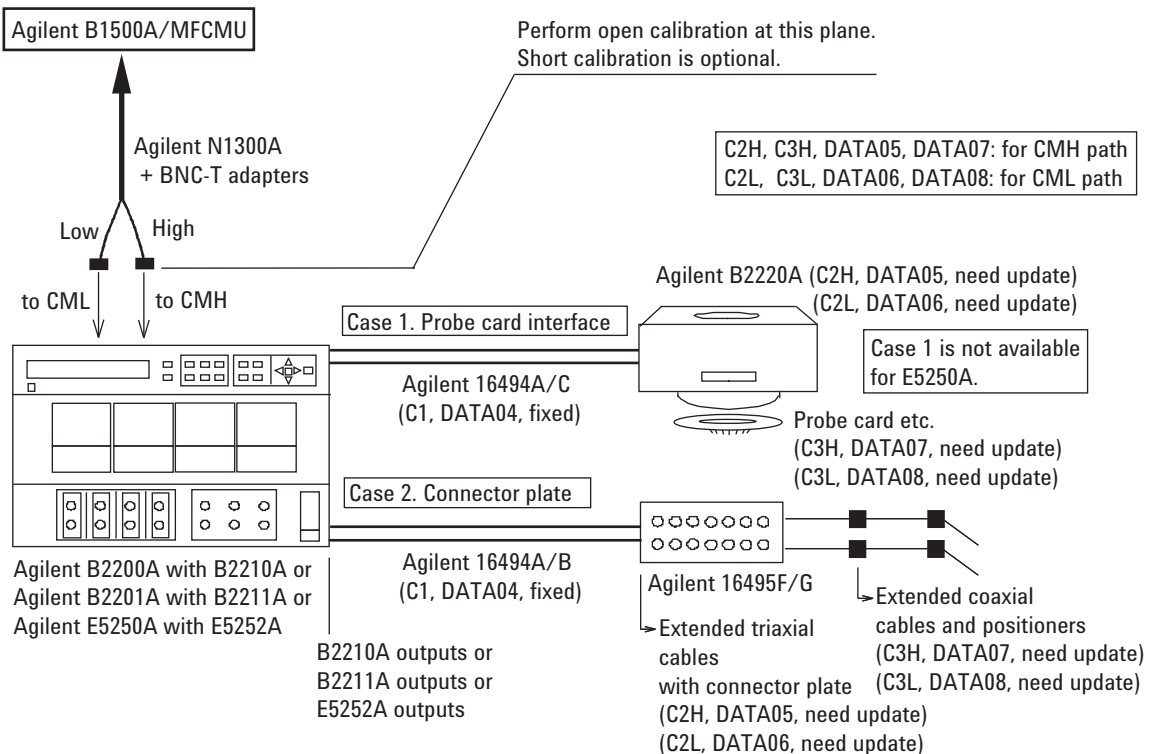
To Create Compensation Data File

This section explains how to create the compensation data file. To perform the capacitance compensation, enter the file name of the compensation data file to the User Compensation Data File field of the Extended Configuration dialog box opened from the Switching Matrix tab screen of the Configuration window.

1. Create a text file (e.g. C:\temp\c_data.txt) that contains the information as shown below.

   • For B2200A/B2201A:

   ```
   #
   # Compensation data file for B2210A/Cable connection/3m triax cable
   #
   #
   # MB          Mother Board
   # MH          Matrix Path High
   # ML          Matrix Path Low
   # C1          Agilent Triax Cable
   # C2H         Probe card I/F or User Triax cable High
   # C2L         Probe card I/F or User Triax cable Low
   # C3H         Probe card or User Coax cable High
   # C3L         Probe card or User Coax cable Low
   #
   format version 1.0
   B2210A
   CABLE
   #
   #     R[Ohm]           L[H]             C[F]
   #-------------------------------------------------
   MB    0.000000e+00     5.250000e-08     2.940000e-11
   MH    2.430000e+00     6.310000e-10     1.930000e-10
   ML    2.490000e+00     5.970000e-07     1.920000e-10
   C1    6.300000e-01     1.250000e-06     1.600000e-10
   C2H   1.007000e-01     4.000000e-07     8.000000e-11
   C2L   1.007000e-01     4.000000e-07     8.000000e-11
   C3H   1.140000e-01     5.440000e-07     1.300000e-10
   C3L   1.140000e-01     5.440000e-07     1.300000e-10
   ```

   The 15th line specifies the used switch module, B2210A or B2211A.

   The 16th line specifies the DUT interface, PCIF or CABLE. PCIF indicates that Agilent B2220A probe card interface is used. CABLE indicates that the connector plate is used.

   The lines C2H to C3L should be modified for each measurement environment. See Table 3-9. Do not modify the other lines.

NOTE   EasyEXPERT provides the template of the compensation data file for the B2200A/B2201A. See Table 3-11. Select and use the template suitable for your measurement environment.

- For E5250A:

```
# E5250A   C Compensation coefficient data table
#
#   CAUTION : Do not add or delete "REVISION" line and "DATAxx" line.
#             Change the value for R,L,C of DATA05,06,07 or 08.
#
REVISION   A.03.00
#          R [ohm]    L [H]      C [F]
DATA00     74.65E-3   140.00E-9  58.44E-12   # Frame Path 1
DATA01     75.41E-3   90.00E-9   67.13E-12   # Frame Path 2
DATA02     231.41E-3  450.00E-9  178.85E-12  # Card Path High
DATA03     177.56E-3  390.00E-9  135.45E-12  # Card Path Low
DATA04     100.70E-3  400.00E-9  80.00E-12   # Triax Cable     [/m]
DATA05     100.70E-3  400.00E-9  80.00E-12   # User Triax Cbl H [/m]
DATA06     100.70E-3  400.00E-9  80.00E-12   # User Triax Cbl L [/m]
DATA07     114.00E-3  544.00E-9  130.00E-12  # User Coax Cbl H  [/m]
DATA08     114.00E-3  544.00E-9  130.00E-12  # User Coax Cbl L  [/m]
DATA09     0.00E-3    0.00E-9    1.20E-12    # Stray Capacitance
# END of Data
```

The lines DATA05 to DATA08 should be modified for each measurement environment. See Table 3-9. Do not modify the other lines.

Table 3-9   **Compensation Coefficients and Modifications**

Compensation coefficients	Modifications of data file
C2H (DATA05) C2L (DATA06)	For the connector plate, change the R, L, C values in the lines. The value must be changed to the R, L, C values of the C2H (DATA05) path and the C2L (DATA06) path (triaxial cable with connector plate) shown in Figure 3-18. For Agilent B2220A probe card interface, do not modify the lines.
C3H (DATA07) C3L (DATA08)	Change the R, L, C values in the lines. The value must be changed to the R, L, C values of the C3H (DATA07) path and the C3L (DATA08) path shown in Figure 3-18. For the connector plate, the coaxial cable with positioner will be the appropriate path. For Agilent B2220A probe card interface, the probe card will be the appropriate path.

2. Measure the R, L, C values of the for C2H (DATA05), C2L (DATA06), C3H (DATA07), and C3L (DATA08) by using the MFCMU. See "To obtain compensation coefficients" on page 3-53.

   After the measurements, calculate the per meter value of the R, L, C, and record them into the following table.

Compensation coefficients	Explanation		
	R (Ω)	**L (H)**	**C (F)**
C2H (DATA05)			
C2L (DATA06)			
C3H (DATA07)			
C3L (DATA08)			

3. Launch a text editor and open the compensation data file created at step 1.

   Change the R, L, C values of the C2H (DATA05), C2L (DATA06), C3H (DATA07), and C3L (DATA08) lines to the values recorded at step 2. Do not change any other lines.

4. Save the file as your compensation data file (e.g. C:\temp\my_env_1.txt).

   To perform the capacitance compensation, enter the file name of the compensation data file to the User Compensation Data File field of the Extended Configuration dialog box, and execute the measurement.

   Before starting measurement, perform the CMU calibration. For details, see Agilent EasyEXPERT *User's Guide*.

To obtain compensation coefficients

Obtain the compensation coefficients as shown below.

1. Select the measurement frequency (Fmeas) used for the capacitance measurement of a device under test (DUT), and set it to the MFCMU. The coefficients must be measured at the same frequency.

2. Perform the MFCMU open calibration at the measurement terminal. Optionally, perform short calibration if you want.

3. See Table 3-10 and Figure 3-19, and set the MFCMU.

4. Connect the path/cable corresponding to C3H (DATA07) shown in Figure 3-18 to the MFCMU. Then measure and record the R, L, and C values.

5. Connect the path/cable corresponding to C3L (DATA08) to the MFCMU. Then measure and record the R, L, and C values.

6. If you use the connector plate, perform the following procedure.

    a. Connect the path/cable corresponding to C2H (DATA05) to the MFCMU. Then measure and record the R, L, and C values.

    b. Connect the path/cable corresponding to C2L (DATA06) to the MFCMU. Then measure and record the R, L, and C values.

Table 3-10   **R, L, C Measurement Conditions**

Parameter	Frequency	Function	Terminals
R	1 kHz to 5 MHz [a]	–	A and B
L		SERIES	see note [b]
C		PARALLEL	A and C

a. R, L, C of all coefficients must be measured with the same frequency setting.
b. For triaxial cable, connect B to F directly, and measure L between A and E.
   For coaxial cable, ignore E and F, and connect B to D directly, and measure
   L between A and C.

Figure 3-19   **Compensation Coefficient Measurement Terminals of Extended Cables**

GUARD (C)   GROUND (E)   GROUND (F)   GUARD (D)

Insulator

FORCE or SENSE (A)   Triaxial Cable   FORCE or SENSE (B)
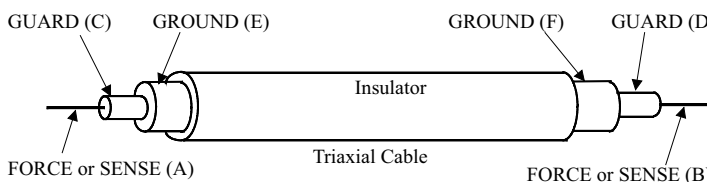
Table 3-11   Template Compensation Data Files for B2200A/B2201A

| File name[a] | Measurement environment that template targets | | | |
	Switch module	Cable[b]	DUT interface[c]	Coefficients to be modified
<path>\b2210a\pcif\triax\3m.data	B2210A	16494A-002	B2220A	C3H and C3L
<path>\b2210a\pcif\triax\4m.data		16494A-005		
<path>\b2210a\pcif\kelvin\3m.data		16494C-002		
<path>\b2210a\pcif\kelvin\4m.data		16494C-005		
<path>\b2210a\cable\triax\1_5m.data		16494A-001	16495F/G	C2H, C2L, C3H, and C3L
<path>\b2210a\cable\triax\3m.data		16494A-002		
<path>\b2210a\cable\triax\4m.data		16494A-005		
<path>\b2210a\cable\kelvin\1_5m.data		16494B-001		
<path>\b2210a\cable\kelvin\3m.data		16494B-002		
<path>\b2210a\cable\kelvin\4m.data		16494C-005		
<path>\b2211a\pcif\triax\3m.data	B2211A	16494A-002	B2220A	C3H and C3L
<path>\b2211a\pcif\triax\4m.data		16494A-005		
<path>\b2211a\pcif\kelvin\3m.data		16494C-002		
<path>\b2211a\pcif\kelvin\4m.data		16494C-005		
<path>\b2211a\cable\triax\1_5m.data		16494A-001	16495F/G	C2H, C2L, C3H, and C3L
<path>\b2211a\cable\triax\3m.data		16494A-002		
<path>\b2211a\cable\triax\4m.data		16494A-005		
<path>\b2211a\cable\kelvin\1_5m.data		16494B-001		
<path>\b2211a\cable\kelvin\3m.data		16494B-002		
<path>\b2211a\cable\kelvin\4m.data		16494C-005		

a. <path>: \Program Files\Agilent\B1500\EasyEXPERT\B220xA\ccdata
b. Model number of the cable connected between the switch module and the DUT interface.
c. Agilent B2220A probe card interface or Agilent 16495F/G connector plate.

Maintenance

Maintenance should be performed periodically to keep Agilent B1500A in good condition.

Cleaning

Before performing cleaning, turn off the instrument, and disconnect power cable from the rear panel. Use a dry cloth to clean the external case parts.

To prevent electrical shock, do not perform cleaning when the instrument is turned on, and do not use a wet cloth.

Self-test and Diagnostics

Agilent B1500A provides the following functions to check the operation. Perform the following functions as necessary. Open the measurement terminals to perform self-test, self-calibration, or diagnostics.

•   Self-test

•   Self-calibration

•   Diagnostics

If problems arise, contact Agilent Technologies. For details, see Agilent EasyEXPERT *User's Guide*.

NOTE   ⚠️   Interlock Open/Close test and High Voltage LED test

Interlock function limits the SMU maximum output voltage to ± 42 V when the measurement terminal is touchable. For safety, this function must be checked before using the B1500A after power on at least once a day by performing the diagnostics.

Calibration

Calibration and adjustments must be performed periodically so that the instruments satisfy the specifications, and keep a good condition. It is recommended to perform the calibration once a year at least. For the calibration and adjustments, contact Agilent Technologies. Trained service personnel will perform the calibration and adjustments. Also see Agilent EasyEXPERT *User's Guide*.

About Plug-in Modules

Agilent Technologies is responsible for the module installation of Agilent B1500A. Contact Agilent Technologies for the module installation. Then send the following equipment and accessories to Agilent Technologies.

- B1500A

- Plug-in modules to be installed

- ASU, for installing the exclusive HRSMU or retrofitting ASU only

- Connection cable between ASU and HRSMU, for installing the exclusive HRSMU or retrofitting ASU only

- RSU, for installing WGFMU

- Connection cable between RSU and WGFMU, for installing WGFMU

For returning ASU or RSU, do not forget to notify the combination of the unit, connection cable, and module channel.

WARNING   **To prevent electrical shock, turn off Agilent B1500A and remove the power cable before removing the connection cables.**

NOTE   About B1500A which supports SPGU and WGFMU

SPGU and WGFMU are supported by the B1500A serial numbered JP40N*xxxxx* and later. The other B1500A needs the mainframe upgrade to support the module. Contact Agilent Technologies to upgrade the B1500A.

NOTE   Module locations after servicing

After the module installation, upgrade, and so on, the B1500A will be returned with the module configuration decided by the rule shown in Table 3-12. If you want to change the module locations, consult the service personnel before servicing.

Module Type and Locations

Module locations when the B1500A is shipped from the factory are shown in Table 3-12. This table shows the relative locations by the module types.

If the SPGUs are installed, the SPGUs must be installed in the slots from the slot number 1. And if the SPGU and the WGFMU are not installed and the HPSMUs are installed, the HPSMUs must be installed in the slots from the slot number 1. Then the same type of modules must be installed in the contiguous slots.

For example, if the module configuration is two HPSMU, two MPSMU, and one CMU, the B1500A will be shipped with the HPSMUs of the slots 1 to 4, the MPSMUs of the slots 5 to 6, the CMU of the slot 7, and the blank panels of the slots 8 to 10.

Table 3-12   **Module Installation Rule**

Slot Number and Location		Module Type
10	top	B1520A Multi Frequency CMU
:	:	B1511A Medium Power SMU
:	:	B1517A High Resolution SMU
:	:	B1510A High Power SMU
:	:	B1530A WGFMU
1	:	B1525A High Voltage SPGU
0	bottom	GNDU/ADC (always installed)

4   **Specifications and Options**

This chapter describes the specifications and the options of of Agilent B1500A Semiconductor Device Analyzer.

- "Specifications"

- "Accessories and Options"

Specifications

This section lists specifications and supplemental information for the B1500A and its associated modules. The specifications are the standards against which the B1500A and its associated modules are tested. When the B1500A and any of its associated modules are shipped from the factory, they meet the 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 instrument.

Hardware

- "Specification Conditions"

- "Mainframe"

- "MPSMU/HRSMU"

- "ASU"

- "HPSMU"

- "SMU Common Specifications"

- "SMU Supplemental Information"

- "MFCMU"

- "SCUU/GSWU"

- "HV-SPGU"

- "Selector"

- "Selector Adapter"

- "WGFMU/RSU"

Specification Conditions

The measurement and output accuracy are specified at the rear panel connector terminals when referenced to the Zero Check terminal. The B1530A WGFMU measurement and output accuracy are specified at the output terminal of the RSU. Accuracy is specified under the following conditions:

1. Temperature: 23 °C ± 5 °C

2. Humidity: 20 % to 60 %

3. After 40 minutes warm-up followed by self-calibration

4. Ambient temperature change less than ± 1 °C after self-calibration execution, not applicable for MFCMU and WGFMU

5. Measurement made within one hour after self-calibration execution, not applicable for MFCMU and WGFMU

6. Calibration period: 1 year

7. SMU integration time setting:

   1 PLC (1 nA to 1 A range, voltage range)

   20 PLC (100 pA range)

   50 PLC (1 pA to 10 pA range)

   Averaging of high speed ADC: 128 samples per 1 PLC

8. SMU filter: ON

9. SMU measurement terminal connection: Kelvin connection

10. WGFMU load capacitance: 25 pF or less

NOTE   Agilent Technologies is responsible for removing, installing, and replacing the B1500A modules. Contact your nearest Agilent Technologies to install and calibrate the B1500A modules.

Mainframe

The B1500A supports ten slots for plug-in modules.

Module	Slots occupied	Range of operation	Measurement resolution
B1510A HPSMU	2	−200 V to 200 V, −1A to 1 A	2 μV, 10 fA
B1511A MPSMU	1	−100 V to 100 V, −100 mA to 100 mA	0.5 μV, 10 fA
B1517A HRSMU	1	−100 V to 100 V, −100 mA to 100 mA	0.5 μV, 1 fA
E5288A ASU [a]	−	−100 V to 100 V, −100 mA to 100 mA	0.5 μV, 0.1 fA
B1520A MFCMU	1	1 kHz to 5 MHz	0.035 fFrms [b]
B1525A HV-SPGU	1	± 40 V (80 Vp-p)	50 μV
B1530A WGFMU	1	−3 V to 3 V, −5 V to 5 V, 0 V to 10 V, −10 V to 0 V [c]	0.014 % of the range [d]

    a. The E5288A Atto Sense and Switch Unit (ASU) is connected with the B1517A High Resolution SMU (HRSMU).

    b. Dispersion of measurement values when connecting a DUT 10 pF to the measurement terminals under the measurement condition of frequency 1 MHz, signal level 250 mVac, and measurement time 1 PLC. The display resolution is 0.000001 fF at 1 fF order by 6 digits display.

    c. Fast IV mode supports 0 to ± 10 V not supported by PG mode.

    d. Display resolution

• Maximum module configuration

    The B1500A can contain any combination of modules.

    Allowable number of modules installed in one mainframe (each/mainframe): HPSMU 4, MPSMU 10, HRSMU 10, MFCMU 1, HV-SPGU 5, WGFMU 5

    If the B1500A contains the WGFMU, sum of *Rating* for all module types in the mainframe must be < 60.

    where *Rating = Number of modules × Rating for each module type*

Rating for each module type: HPSMU 14, MPSMU 2, HRSMU 2, MFCMU 7, HV-SPGU 12, WGFMU 10

- Maximum voltage between common and ground

  $\leq \pm 42$ V

- Ground unit (GNDU)

  The GNDU is furnished standard with the mainframe.

  - Output voltage: 0 V ± 100 μV

  - Maximum sink current: ± 4.2 A

  - Output terminal/connection: Triaxial connector, Kelvin (remote sensing)

  - Load capacitance: 1 μF, supplemental information

  - Cable resistance: supplemental information

Terminal	Cable resistance
Sense	≤ 10 Ω
Force	< 1 Ω (Is ≤ 1.6 A) < 0.7 Ω (1.6 A $<$ Is ≤ 2.0 A) < 0.35 Ω (2.0 A $<$ Is ≤ 4.2 A) where Is is the current being sunk by the GNDU.

MPSMU/HRSMU

MPSMU: Medium Power Source/Monitor Unit

HRSMU: High Resolution Source/Monitor Unit

- Voltage range, resolution, and accuracy

  See Table 4-1 for high resolution ADC and Table 4-3 for high speed ADC.

- Current range, resolution, and accuracy

  See Table 4-2 for high resolution ADC and Table 4-4 for high speed ADC.

  Specified measurement resolution is limited by fundamental noise limits. Minimum displayed resolution is 1 aA at 1 pA range by 6 digits. Measurements made in the lower ranges can be greatly impacted by vibrations and shocks. These specifications assume an environment free of these factors.

- Power consumption

  Voltage source mode:

Voltage range (V)	Power consumption[a] (W)
0.5	$Ic \times 20$
2	$Ic \times 20$
5	$Ic \times 20$
20	$Ic \times 20$
40	$Ic \times 40$
100	$Ic \times 100$

  a. Ic is the current compliance setting.

  Current source mode:

Voltage compliance[a] (V)	Power consumption[b] (W)
$Vc \leq 20$	$Io \times 20$
$20 < Vc \leq 40$	$Io \times 40$
$40 < Vc \leq 100$	$Io \times 100$

  a. Vc is the voltage compliance setting.
  b. Io is the output current.

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Table 4-1   **Voltage range, resolution, and accuracy (high resolution ADC)**

Range	Force resolution	Measurement resolution	Force accuracy ±(%+mV)[a]	Measurement accuracy ±(%+mV)[a]	Maximum current
±0.5 V	25 µV	0.5 µV	±(0.018 + 0.15)	±(0.01 + 0.12)	100 mA
±2 V	100 µV	2 µV	±(0.018 + 0.4)	±(0.01 + 0.14)	100 mA
±5 V	250 µV	5 µV	±(0.018 + 0.75)	±(0.009 + 0.25)	100 mA
±20 V	1 mV	20 µV	±(0.018 + 3)	±(0.009 + 0.9)	100 mA
±40 V	2 mV	40 µV	±(0.018 + 6)	±(0.01 + 1)	b
±100 V	5 mV	100 µV	±(0.018 + 15)	±(0.012 + 2.5)	

a. ±(% of output/measured value + offset value in mV)

b. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo), Vo is the output voltage.

Table 4-2   **Current range, resolution, and accuracy (high resolution ADC)**

Range	Force resolution	Measurement resolution	Force accuracy ±(%+A+A)[a]	Measurement accuracy ±(%+A+A)[a]	Maximum voltage
±1 pA[b]	1 fA	0.1 fA	±(0.9+15E-15)	±(0.9+12E-15)	100 V
±10 pA[c]	5 fA	0.4 fA[b] / 1 fA	±(0.46+3E-14+Vo×1E-17)	±(0.46+15E-15+Vo×1E-17)	100 V
±100 pA[c]	5 fA	0.5 fA[b] / 2 fA	±(0.3+1E-13+Vo×1E-16)	±(0.3+3E-14+Vo×1E-16)	100 V
±1 nA	50 fA	10 fA	±(0.1+3E-13+Vo×1E-15)	±(0.1+2E-13+Vo×1E-15)	100 V
±10 nA	500 fA	10 fA	±(0.1+3E-12+Vo×1E-14)	±(0.1+1E-12+Vo×1E-14)	100 V
±100 nA	5 pA	100 fA	±(0.05+3E-11+Vo×1E-13)	±(0.05+2E-11+Vo×1E-13)	100 V
±1 µA	50 pA	1 pA	±(0.05+3E-10+Vo×1E-12)	±(0.05+1E-10+Vo×1E-12)	100 V
±10 µA	500 pA	10 pA	±(0.05+3E-9+Vo×1E-11)	±(0.04+2E-9+Vo×1E-11)	100 V
±100 µA	5 nA	100 pA	±(0.035+15E-9+Vo×1E-10)	±(0.03+3E-9+Vo×1E-10)	100 V
±1 mA	50 nA	1 nA	±(0.04+15E-8+Vo×1E-9)	±(0.03+6E-8+Vo×1E-9)	100 V
±10 mA	500 nA	10 nA	±(0.04+15E-7+Vo×1E-8)	±(0.03+2E-7+Vo×1E-8)	100 V
±100 mA	5 µA	100 nA	±(0.045+15E-6+Vo×1E-7)	±(0.04+6E-6+Vo×1E-7)	d

a. ±(% of output/measured value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.

b. Available when Agilent E5288A Atto Sense and Switch Unit (ASU) is used.

c. Available for HRSMU.

d. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io), Io is the output current.

Table 4-3   Voltage range, resolution, and accuracy (high speed ADC)

Range	Force resolution	Measurement resolution	Force accuracy ±(%+mV)[a]	Measurement accuracy ±(%+mV)[a]	Maximum current
±0.5 V	25 μV	25 μV	±(0.018 + 0.15)	±(0.01 + 0.25)	100 mA
±2 V	100 μV	100 μV	±(0.018 + 0.4)	±(0.01 + 0.7)	100 mA
±5 V	250 μV	250 μV	±(0.018 + 0.75)	±(0.01 + 2)	100 mA
±20 V	1 mV	1 mV	±(0.018 + 3)	±(0.01 + 4)	100 mA
±40 V	2 mV	2 mV	±(0.018 + 6)	±(0.015 + 8)	[b]
±100 V	5 mV	5 mV	±(0.018 + 15)	±(0.02 + 20)	

a. ±(% of output/measured value + offset value in mV)

b. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo), Vo is the output voltage.

Table 4-4   Current range, resolution, and accuracy (high speed ADC)

Range	Force resolution	Measurement resolution	Force accuracy ±(%+A+A)[a]	Measurement accuracy ±(%+A+A)[a]	Maximum voltage
±1 pA[b]	1 fA	0.1 fA	±(0.9+15E-15)	±(1.8+12E-15)	100 V
±10 pA[c]	5 fA	1 fA	±(0.46+3E-14+Vo×1E-17)	±(0.5+15E-15+Vo×1E-17)	100 V
±100 pA[c]	5 fA	5 fA	±(0.3+1E-13+Vo×1E-16)	±(0.5+4E-14+Vo×1E-16)	100 V
±1 nA	50 fA	50 fA	±(0.1+3E-13+Vo×1E-15)	±(0.25+3E-13+Vo×1E-15)	100 V
±10 nA	500 fA	500 fA	±(0.1+3E-12+Vo×1E-14)	±(0.25+2E-12+Vo×1E-14)	100 V
±100 nA	5 pA	5 pA	±(0.05+3E-11+Vo×1E-13)	±(0.1+2E-11+Vo×1E-13)	100 V
±1 μA	50 pA	50 pA	±(0.05+3E-10+Vo×1E-12)	±(0.1+2E-10+Vo×1E-12)	100 V
±10 μA	500 pA	500 pA	±(0.05+3E-9+Vo×1E-11)	±(0.05+2E-9+Vo×1E-11)	100 V
±100 μA	5 nA	5 nA	±(0.035+15E-9+Vo×1E-10)	±(0.05+2E-8+Vo×1E-10)	100 V
±1 mA	50 nA	50 nA	±(0.04+15E-8+Vo×1E-9)	±(0.04+2E-7+Vo×1E-9)	100 V
±10 mA	500 nA	500 nA	±(0.04+15E-7+Vo×1E-8)	±(0.04+2E-6+Vo×1E-8)	100 V
±100 mA	5 μA	5 μA	±(0.045+15E-6+Vo×1E-7)	±(0.1+2E-5+Vo×1E-7)	[d]

a. ±(% of output/measured value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.

b. Available when Agilent E5288A Atto Sense and Switch Unit (ASU) is used.

c. Available for HRSMU.

d. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io), Io is the output current.

ASU

ASU: Atto Sense and Switch Unit

- Maximum voltage, AUX path

  100 V (AUX input to AUX common)

  100 V (AUX input to circuit common)

  42 V (AUX common to circuit common)

- Maximum current, AUX path

  0.5 A (AUX input to Force output)

- Band width (at -3 dB), AUX port

  30 MHz, supplemental information

NOTE   Connect ASU to dedicated HRSMU

The specifications are satisfied and guaranteed for the exclusive combination of the ASU and the HRSMU. So confirm the serial number of the ASU and connect it to the dedicated HRSMU properly.

NOTE   Connection path control

Disable source output of the SMU and other instrument connected to the ASU inputs before controlling the ASU connection path.

HPSMU

HPSMU: High Power Source/Monitor Unit

• Voltage range, resolution, and accuracy

    See Table 4-5 for high resolution ADC and Table 4-7 for high speed ADC.

• Current range, resolution, and accuracy

    See Table 4-6 for high resolution ADC and Table 4-8 for high speed ADC.

    Specified measurement resolution is limited by fundamental noise limits.

• Power consumption

    Voltage source mode:

Voltage range (V)	Power consumption[a] (W)
2	$Ic \times 20$
20	$Ic \times 20$
40	$Ic \times 40$
100	$Ic \times 100$
200	$Ic \times 200$

    a. Ic is the current compliance setting.

    Current source mode:

Voltage compliance[a] (V)	Power consumption[b] (W)
$Vc \leq 20$	$Io \times 20$
$20 < Vc \leq 40$	$Io \times 40$
$40 < Vc \leq 100$	$Io \times 100$
$100 < Vc \leq 200$	$Io \times 200$

    a. Vc is the voltage compliance setting.
    b. Io is the output current.

Table 4-5   **Voltage range, resolution, and accuracy (high resolution ADC)**

Range	Force resolution	Measurement resolution	Force accuracy ±(%+mV)[a]	Measurement accuracy ±(%+mV)[a]	Maximum current
±2 V	100 µV	2 µV	±(0.018 + 0.4)	±(0.01 + 0.14)	1 A
±20 V	1 mV	20 µV	±(0.018 + 3)	±(0.01 + 0.14)	1 A
±40 V	2 mV	40 µV	±(0.018 + 6)	±(0.01 + 1)	500 mA
±100 V	5 mV	100 µV	±(0.018 + 15)	±(0.012 + 2.5)	125 mA
±200 V	10 mV	200 µV	±(0.018 + 30)	±(0.014 + 2.8)	50 mA

a. ±(% of output/measured value + offset value in mV)

Table 4-6   **Current range, resolution, and accuracy (high resolution ADC)**

Range	Force resolution	Measurement resolution	Force accuracy ±(%+A+A)[a]	Measurement accuracy ±(%+A+A)[a]	Maximum voltage
±1 nA	50 fA	10 fA	$±(0.1+3E-13+Vo×1E-15)$	$±(0.1+3E-13+Vo×1E-15)$	200 V
±10 nA	500 fA	10 fA	$±(0.1+3E-12+Vo×1E-14)$	$±(0.1+25E-13+Vo×1E-14)$	200 V
±100 nA	5 pA	100 fA	$±(0.05+3E-11+Vo×1E-13)$	$±(0.05+25E-12+Vo×1E-13)$	200 V
±1 µA	50 pA	1 pA	$±(0.05+3E-10+Vo×1E-12)$	$±(0.05+1E-10+Vo×1E-12)$	200 V
±10 µA	500 pA	10 pA	$±(0.05+3E-9+Vo×1E-11)$	$±(0.04+2E-9+Vo×1E-11)$	200 V
±100 µA	5 nA	100 pA	$±(0.035+15E-9+Vo×1E-10)$	$±(0.03+3E-9+Vo×1E-10)$	200 V
±1 mA	50 nA	1 nA	$±(0.04+15E-8+Vo×1E-9)$	$±(0.03+6E-8+Vo×1E-9)$	200 V
±10 mA	500 nA	10 nA	$±(0.04+15E-7+Vo×1E-8)$	$±(0.03+2E-7+Vo×1E-8)$	200 V
±100 mA	5 µA	100 nA	$±(0.045+15E-6+Vo×1E-7)$	$±(0.04+6E-6+Vo×1E-7)$	[b]
±1 A	50 µA	1 µA	$±(0.4+3E-4+Vo×1E-6)$	$±(0.4+15E-5+Vo×1E-6)$	

a. ±(% of output/measured value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.

b. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current.

Table 4-7   **Voltage range, resolution, and accuracy (high speed ADC)**

Range	Force resolution	Measurement resolution	Force accuracy $\pm$(%+mV)[a]	Measurement accuracy $\pm$(%+mV)[a]	Maximum current
$\pm$2 V	100 μV	100 μV	$\pm$(0.018 + 0.4)	$\pm$(0.01 + 0.7)	1 A
$\pm$20 V	1 mV	1 mV	$\pm$(0.018 + 3)	$\pm$(0.01 + 4)	1 A
$\pm$40 V	2 mV	2 mV	$\pm$(0.018 + 6)	$\pm$(0.015 + 8)	500 mA
$\pm$100 V	5 mV	5 mV	$\pm$(0.018 + 15)	$\pm$(0.02 + 20)	125 mA
$\pm$200 V	10 mV	10 mV	$\pm$(0.018 + 30)	$\pm$(0.035 + 40)	50 mA

a. $\pm$(% of output/measured value + offset value in mV)

Table 4-8   **Current range, resolution, and accuracy (high speed ADC)**

Range	Force resolution	Measurement resolution	Force accuracy $\pm$(%+A+A)[a]	Measurement accuracy $\pm$(%+A+A)[a]	Maximum voltage
$\pm$1 nA	50 fA	50 fA	$\pm$(0.1+3E-13+Vo$\times$1E-15)	$\pm$(0.25+3E-13+Vo$\times$1E-15)	200 V
$\pm$10 nA	500 fA	500 fA	$\pm$(0.1+3E-12+Vo$\times$1E-14)	$\pm$(0.25+2E-12+Vo$\times$1E-14)	200 V
$\pm$100 nA	5 pA	5 pA	$\pm$(0.05+3E-11+Vo$\times$1E-13)	$\pm$(0.1+2E-11+Vo$\times$1E-13)	200 V
$\pm$1 μA	50 pA	50 pA	$\pm$(0.05+3E-10+Vo$\times$1E-12)	$\pm$(0.1+2E-10+Vo$\times$1E-12)	200 V
$\pm$10 μA	500 pA	500 pA	$\pm$(0.05+3E-9+Vo$\times$1E-11)	$\pm$(0.05+2E-9+Vo$\times$1E-11)	200 V
$\pm$100 μA	5 nA	5 nA	$\pm$(0.035+15E-9+Vo$\times$1E-10)	$\pm$(0.05+2E-8+Vo$\times$1E-10)	200 V
$\pm$1 mA	50 nA	50 nA	$\pm$(0.04+15E-8+Vo$\times$1E-9)	$\pm$(0.04+2E-7+Vo$\times$1E-9)	200 V
$\pm$10 mA	500 nA	500 nA	$\pm$(0.04+15E-7+Vo$\times$1E-8)	$\pm$(0.04+2E-6+Vo$\times$1E-8)	200 V
$\pm$100 mA	5 μA	5 μA	$\pm$(0.045+15E-6+Vo$\times$1E-7)	$\pm$(0.1+2E-5+Vo$\times$1E-7)	[b]
$\pm$1 A	50 μA	50 μA	$\pm$(0.4+3E-4+Vo$\times$1E-6)	$\pm$(0.5+3E-4+Vo$\times$1E-6)	

a. $\pm$(% of output/measured value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.

b. 200 V (Io $\leq$ 50 mA), 100 V (50 mA < Io $\leq$ 125 mA), 40 V (125 mA < Io $\leq$ 500 mA), 20 V (500 mA < Io $\leq$ 1 A), Io is the output current.

SMU Common Specifications

- Output terminal/connection

  Dual triaxial connector, Kelvin (remote sensing)

- Voltage/current compliance (limiting)

  The SMU can limit output voltage or current to prevent damaging the device under test.

  - Voltage compliance:

    0 V to ± 100 V (MPSMU, HRSMU)

    0 V to ± 200 V (HPSMU)

  - Current compliance:

    ± 10 fA to ± 100 mA (HRSMU with ASU)

    ± 100 fA to ± 100 mA (HRSMU)

    ± 1 pA to ± 100 mA (MPSMU)

    ± 1 pA to ± 1 A (HPSMU)

  - Compliance accuracy:

    Same as the current or voltage set accuracy.

- Pulsed measurement

  - Width: 500 μs to 2 s

  - Period: 5 ms to 5 s

    Period $\geq$ Width+2 ms (when Width $\leq$ 100 ms)

    Period $\geq$ Width+10 ms (when Width > 100 ms)

  - Resolution: 100 μs

- Pulse setting accuracy (fixed measurement range), supplemental information

  - Width: 0.5 % + 50 μs

  - Period: 0.5 % + 100 μs

- About measurement accuracy

  - RF electromagnetic field and SMU measurement accuracy

    Voltage and current measurement accuracy may be affected by RF electromagnetic field of strength over 3 V/m at frequencies 80 MHz to 1 GHz and 1.4 GHz to 2.0 GHz, and 1 V/m at frequencies 2.0 GHz to 2.7 GHz. The extent of this effect depends upon how the instrument is positioned and shielded.

  - Induced RF field noise and SMU measurement accuracy

    Voltage and current measurement accuracy can be affected by induced RF field noise strengths greater than 3Vrms in the frequency range of 150 kHz to 80 MHz. The extent of this effect depends upon how the instrument is positioned and shielded.

SMU Supplemental Information

- Maximum allowable cable resistance (Kelvin connection)

  Sense: 10 Ω

  Force: 10 Ω ($\leq$ 100 mA), 1.5 Ω (> 100 mA)

- Voltage source output resistance (Force line, Non-Kelvin connection)

  0.2 Ω (HPSMU)

  0.3 Ω (MPSMU, HRSMU)

- Voltage measurement input resistance: $\geq 10^{13}$ Ω

- Current source output resistance: $\geq 10^{13}$ Ω (at 1 nA range)

- Current compliance setting accuracy (for opposite polarity)

  For 1 pA to 10 nA ranges: Setting accuracy $\pm$ 12 % of range

  For 100 nA to 1 A ranges: Setting accuracy $\pm$ 2.5 % of range

- Maximum capacitive load

  For 1 pA to 10 nA ranges: 1000 pF

  For 100 nA to 10 mA ranges: 10 nF

  For 100 mA and 1 A ranges: 100 μF

- Maximum guard capacitance

    900 pF (HPSMU, MPSMU, HRSMU)

    660 pF (HRSMU with ASU)

- Maximum shield capacitance

    5000 pF (HPSMU, MPSMU, HRSMU)

    3500 pF (HRSMU with ASU)

- Maximum guard offset voltage

    $\pm$ 1 mV (HPSMU)

    $\pm$ 3 mV (MPSMU, HRSMU)

    $\pm$ 4.2 mV (HRSMU with ASU, Iout $\leq$ 100 μA)

- Noise characteristics (filter ON)

    Voltage source: 0.01 % of V range (rms.)

    Current source: 0.1 % of I range (rms.)

- Overshoot (filter ON), typical

    Voltage source: 0.03 % of V range

    Current source: 1 % of I range

- Range switching transient noise (filter ON)

    Voltage ranging: 250 mV

    Current ranging: 70 mV

- Slew rate: 0.2 V/μs (maximum)

- Voltage range, resolution, and accuracy (high speed ADC)

    See Table 4-9.

- Current range, resolution, and accuracy (high speed ADC)

    See Table 4-10.

    Specified measurement resolution is limited by fundamental noise limits. Minimum displayed resolution is 1 aA at 1 pA range by 6 digits.

    Measurements made in the lower ranges can be greatly impacted by vibrations and shocks. These specifications assume an environment free of these factors.

Table 4-9   **Voltage range, resolution, and accuracy (high speed ADC), supplemental information**

Range	Measurement resolution	Measurement accuracy $\pm(\%+mV)$[a]	Range	Measurement resolution	Measurement accuracy $\pm(\%+mV)$[a]
±0.5 V [b]	25 µV	$\pm(0.01 + 0.25)$	±40 V	2 mV	$\pm(0.015 + 8)$
±2 V	100 µV	$\pm(0.01 + 0.7)$	±100 V	5 mV	$\pm(0.02 + 20)$
±5 V [b]	250 µV	$\pm(0.01 + 2)$	±200 V [c]	10 mV	$\pm(0.035 + 40)$
±20 V	1 mV	$\pm(0.01 + 4)$			

a. $\pm$(% of reading + offset value in mV). Averaging is 128 samples in 1 PLC.
b. Available for MPSMU/HRSMU.
c. Available for HPSMU.

Table 4-10   **Current range, resolution, and accuracy (high speed ADC), supplemental information**

Range	Measurement resolution	Measurement accuracy $\pm(\%+A+A)$[a]	Range	Measurement resolution	Measurement accuracy $\pm(\%+A+A)$[a]
±1 pA [b]	0.1 fA	$\pm(1.8+12E\text{-}15)$	±10 µA	500 pA	$\pm(0.04+2E\text{-}9+Vo\times1E\text{-}11)$
±10 pA [c]	1 fA	$\pm(0.5+15E\text{-}15+Vo\times1E\text{-}17)$	±100 µA	5 nA	$\pm(0.03+2E\text{-}8+Vo\times1E\text{-}10)$
±100 pA[c]	5 fA	$\pm(0.3+3E\text{-}14+Vo\times1E\text{-}16)$	±1 mA	50 nA	$\pm(0.03+2E\text{-}7+Vo\times1E\text{-}9)$
±1 nA	50 fA	$\pm(0.1+3E\text{-}13+Vo\times1E\text{-}15)$	±10 mA	500 nA	$\pm(0.03+2E\text{-}6+Vo\times1E\text{-}8)$
±10 nA	500 fA	$\pm(0.1+2E\text{-}12+Vo\times1E\text{-}14)$	±100 mA	5 µA	$\pm(0.04+2E\text{-}5+Vo\times1E\text{-}7)$
±100 nA	5 pA	$\pm(0.05+2E\text{-}11+Vo\times1E\text{-}13)$	±1 A [d]	50 µA	$\pm(0.4+3E\text{-}4+Vo\times1E\text{-}6)$
±1 µA	50 pA	$\pm(0.05+2E\text{-}10+Vo\times1E\text{-}12)$			

a. $\pm$(% of reading + fixed offset in A + proportional offset in A), Vo is the output voltage in V.
b. Available when Agilent E5288A Atto Sense and Switch Unit (ASU) is used.
c. 10 pA and 100 pA ranges are available for HRSMU with or without ASU.
d. Available for HPSMU.

MFCMU

MFCMU: Multi Frequency Capacitance Measurement Unit

- Measurement functions

  - Measurement parameters: Cp-G, Cp-D, Cp-Q, Cp-Rp, Cs-Rs, Cs-D, Cs-Q, Lp-G, Lp-D, Lp-Q, Lp-Rp, Ls-Rs, Ls-D, Ls-Q, R-X, G-B, Z-θ, Y-θ

  - Ranging: Auto or fixed

  - Measurement terminal: Four-terminal pair configuration, four BNC (female) connectors

  - Cable length: 1.5 m or 3 m, automatic identification of accessories

- Test signal

  - Frequency

    Range: 1 kHz to 5 MHz

    Resolution: 1 mHz (minimum)

    Accuracy: ± 0.008 %

  - Output signal level

    Range: 10 mVrms to 250 mVrms

    Resolution: 1 mVrms

    Accuracy:

    ± (10.0 % + 1 mVrms) at the measurement port of the MFCMU

    ± (15.0 % + 1 mVrms) at the measurement port of the MFCMU cable (1.5 m or 3.0 m)

  - Output impedance: 50 Ω, typical

  - Signal level monitor

    Range: 10 mVrms to 250 mVrms

    Accuracy (open load):

    ± (10.0 % of reading + 1 mVrms) at the measurement port of the MFCMU

    ± (15.0 % of reading + 1 mVrms) at the measurement port of the MFCMU cable (1.5 m or 3.0 m)

- DC bias function

  - DC bias

    Range: 0 to $\pm$ 25 V

    Resolution: 1 mV

    Accuracy: $\pm$ (0.5 % + 5.0 mV) at the measurement port of the MFCMU or the MFCMU cable (1.5 m or 3.0 m)

  - Maximum DC bias current, supplemental information:

Impedance range (Ω)	Maximum DC bias current (A)
50	10×10^{-3}
100	10×10^{-3}
300	10×10^{-3}
1×10^3	1×10^{-3}
3×10^3	1×10^{-3}
10×10^3	100×10^{-6}
30×10^3	100×10^{-6}
100×10^3	10×10^{-6}
300×10^3	10×10^{-6}

  - Output impedance: 50 Ω, typical

  - DC bias monitor

    Range: 0 to $\pm$ 25 V

    Accuracy (open load): $\pm$ (0.2 % of reading + 10 mV) at the measurement port of the MFCMU or the MFCMU cable (1.5 m or 3.0 m)

- Sweep characteristics

  - Available sweep parameters: DC bias voltage, oscillator level, frequency

  - Sweep type: linear, log

  - Sweep mode: single, double

  - Sweep direction: up, down

  - Number of measurement points: maximum 1001

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- Measurement accuracy

  Measurement accuracy at the measurement port of the MFCMU or the MFCMU cable (1.5 m or 3.0 m)

  - $|Z|$ accuracy: $\pm$ E (%)

  - θ accuracy: $\pm$ E/100 (radian)

  - C accuracy:

    $\pm$ E (%) at Dx $\leq$ 0.1

    $\pm$ E$\times$(1+Dx^2)$^{1/2}$ (%) at Dx > 0.1

  - D accuracy:

    $\pm$ E/100 at Dx $\leq$ 0.1

    $\pm$ E$\times$(1+Dx)/100 at Dx > 0.1

  - G accuracy:

    $\pm$ E/Dx (%) at Dx $\leq$ 0.1

    $\pm$ E$\times$(1+Dx^2)$^{1/2}$/Dx (%) at Dx > 0.1

  where,

  Zx: Impedance measurement value (Ω)

  Dx: Measurement value of D

  $E = E_P' + (Z_S' / |Zx| + Y_O' \times |Zx|) \times 100$ (%)

  $E_P' = E_{PL} + E_{POSC} + E_P$ (%)

  $Y_O' = Y_{OL} + Y_{OSC} + Y_O$ (S)

  $Z_S' = Z_{SL} + Z_{OSC} + Z_S$ (Ω)

  For the parameter value, see Table 4-11 to Table 4-13. Calculation example of the measurement accuracy is also shown in Table 4-14.

  Specification conditions:

  - Temperature: 23 °C $\pm$ 5 °C

  - Integration time: 1 PLC or 16 PLC

Table 4-11   **Parameters E_{POSC}, Z_{OSC}**

Oscillator level Vosc mV	E_{POSC} %	Z_{OSC} mΩ
$125 <$ Vosc $\leq$ 250	0.03×(250/Vosc−1)	5×(250/Vosc−1)
$64 <$ Vosc $\leq$ 125	0.03×(125/Vosc−1)	5×(125/Vosc−1)
$32 <$ Vosc $\leq$ 64	0.03×(64/Vosc−1)	5×(64/Vosc−1)
Vosc $\leq$ 32	0.03×(32/Vosc−1)	5×(64/Vosc−1)

Vosc is oscillator level in mV.

Table 4-12   **Parameters E_{PL}, Y_{OL}, Z_{SL}**

Cable length	E_{PL} %	Y_{OL} nS	Z_{SL} mΩ
1.5 m	0.02+3×f/100	750×f/100	5.0
3 m	0.02+5×f/100	1500×f/100	5.0

f is frequency in MHz. If measurement cable is extended, open compensation, short compensation, and load compensation must be performed.

Table 4-13   **Parameters Y_{OSC}, Y_O, E_P, Z_S**

Frequency f Hz	Y_{OSC} nS	Y_O nS	E_P %	Z_S mΩ
$1k \leq$ f $\leq$ 200k	1×(125/Vosc−0.5)	1.5	0.095	5.0
$200k <$ f $\leq$ 1M	2×(125/Vosc−0.5)	3.0	0.095	5.0
$1M <$ f $\leq$ 2M	2×(125/Vosc−0.5)	3.0	0.28	5.0
$2M <$ f	20×(125/Vosc−0.5)	30.0	0.28	5.0

Vosc is oscillator level in mV.

Table 4-14   **Example of calculated C/G measurement accuracy**

Frequency	Measured Capacitance	C Accuracy [a]	Measured Conductance	G Accuracy [a]
5 MHz	1 pF	± 0.61 %	≤ 3 µS	± 192 nS
	10 pF	± 0.32 %	≤ 31 µS	± 990 nS
	100 pF	± 0.29 %	≤ 314 µS	± 9 µS
	1 nF	± 0.32 %	≤ 3 mS	± 99 µS
1 MHz	1 pF	± 0.26 %	≤ 628 nS	± 16 nS
	10 pF	± 0.11 %	≤ 6 µS	± 71 nS
	100 pF	± 0.10 %	≤ 63 µS	± 624 nS
	1 nF	± 0.10 %	≤ 628 µS	± 7 µS
100 kHz	10 pF	± 0.18 %	≤ 628 nS	± 11 nS
	100 pF	± 0.11 %	≤ 6 µS	± 66 nS
	1 nF	± 0.10 %	≤ 63 µS	± 619 nS
	10 nF	± 0.10 %	≤ 628 µS	± 7 µS
10 kHz	100 pF	± 0.18 %	≤ 628 nS	± 11 nS
	1 nF	± 0.11 %	≤ 6 µS	± 66 nS
	10 nF	± 0.10 %	≤ 63 µS	± 619 nS
	100 nF	± 0.10 %	≤ 628 µS	± 7 µS
1 kHz	100 pF	± 0.92 %	≤ 63 nS	± 6 nS
	1 nF	± 0.18 %	≤ 628 nS	± 11 nS
	10 nF	± 0.11 %	≤ 6 µS	± 66 nS
	100 nF	± 0.10 %	≤ 63 µS	± 619 nS

a. The calculation examples are specified under the conditions Dx = 0.1, 1 PLC integration time, 30 mVrms test signal level, and at four-terminal pair port of MFCMU.

SCUU/GSWU

SCUU: SMU CMU Unify Unit

GSWU: Guard Switch Unit

The SCUU multiplexes the outputs from two SMUs (MPSMUs and/or HRSMUs) and the CMU. The SCUU outputs are two sets of Kelvin triaxial ports (Force and Sense). The SCUU also allows the SMUs to act as DC bias sources in conjunction with the CMU. Special cables are available to connect the SMUs and CMU with the SCUU, and an auto-detect feature automatically compensates for the cable length going to the SCUU.

The GSWU contains a relay that automatically opens for IV measurements and closes for CV measurements, forming a guard return path to improve CV measurement accuracy.

- Supported SMU: MPSMU and HRSMU
- SCUU
  - Inputs

    Triaxial port: Force1, Sense1, Force2, and Sense2

    BNC port: for MFCMU

    Control port: for MFCMU
  - Outputs

    Triaxial port: Force1/CMUH, Sense1, Force2/CMUL, and Sense2

    Control port: for GSWU

    LED: SMU/CMU output status indicator
  - Docking mode

    Direct and indirect mode
- GSWU
  - Input

    Control port: for SCUU

    Mini pin plug port: Guard1 and Guard2
  - Output

    LED: Connection status indicator

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- SCUU supplemental information

  - SMU path

    Offset current: < 20 fA

    Offset voltage: < 100 μV at 300 sec

    Closed channel residual resistance: < 200 mΩ

    Channel isolation resistance: > 10^{15} Ω

  - CMU path

    - Test signal

      - Signal output level additional errors (CMU bias, open load):

        $\pm$ 2 % (direct docking)

        $\pm$ 7 % (indirect docking)

      - Signal output level additional errors (SMU bias, open load):

        $\pm$ 5 % (direct docking, $\geq$ 10 kHz)

        $\pm$ 10 % (indirect docking, $\geq$ 10 kHz)

      - Output impedance: 50 Ω, typical

      - Signal level monitor additional errors (open load):

        $\pm$ 2 % (CMU bias), direct docking

        $\pm$ 5 % (SMU bias), direct docking

        $\pm$ 7 % (CMU bias), indirect docking

        $\pm$ 10 % (SMU bias), indirect docking

    - DC bias function

      - DC voltage bias (CMU bias)

        Range: 0 to $\pm$ 25 V

        Resolution: 1 mV

        Additional errors (for CMU bias): $\pm$ 100 μV (open load)

      - DC voltage bias (SMU bias)

        Range: 0 to $\pm$ 100 V

        Resolution: 5 mV

Additional errors (for SMU voltage output accuracy): $\pm$ 100 μV (open load)

- DC bias monitor additional errors (open load):

  $\pm$ 20 mV, direct docking

  $\pm$ 30 mV, indirect docking

- Output impedance: 50 Ω, typical

- DC output resistance: 50 Ω (CMU bias), 130 Ω (SMU bias)

- Measurement accuracy

  Impedance measurement error is given by adding the following additional error Ee to the MFCMU measurement error.

  $Ee = \pm (A + Zs / |Zx| + Yo \times |Zx|) \times 100$ (%)

  Zx: Impedance measurement value (Ω)

  A: 0.05 % (direct docking) or 0.1 % (indirect docking)

  Zs: $500 \times (1 + f)$ mΩ (f: frequency in MHz)

  Yo: $1 + f \times 10$ nS (direct docking, $\times$ 2 for indirect docking)

  When the measurement terminals are extended by using the measurement cable, the measurement accuracy is applied to the data measured after performing the open/short/load correction at the DUT side cable end.

  Specification conditions:

  - Temperature: 23 °C $\pm$ 5 °C

  - Integration time: 1 PLC or 16 PLC

HV-SPGU

HV-SPGU: High Voltage Semiconductor Pulse Generator Unit

- Number of output channels: 2 channels per module

- Modes: pulse, constant, and free run

- Standard pulse mode

  - Two level pulse

  - Three level pulse per one channel

  - Pulse period: 30 ns to 10 s

- Delay range: 0 s to 9.99 s

- Delay resolution: minimum 2.5 ns

- Output count: 1 to 1,000,000

- Voltage monitor minimum sampling period: 5 μs

- Trigger output

  Level: TTL

  Timing: Synchronized with pulse period

  Trigger width: Pulse period $\times$ 1/2 (pulse period $\leq$ 10 μs), maximum 5 μs (pulse period $>$ 10 μs)

- Pulse range and pulse parameter: See Table 4-15.

- Pulse/DC output voltage and accuracy: See Table 4-16.

Figure 4-1   **SPGU pulse setup parameters**
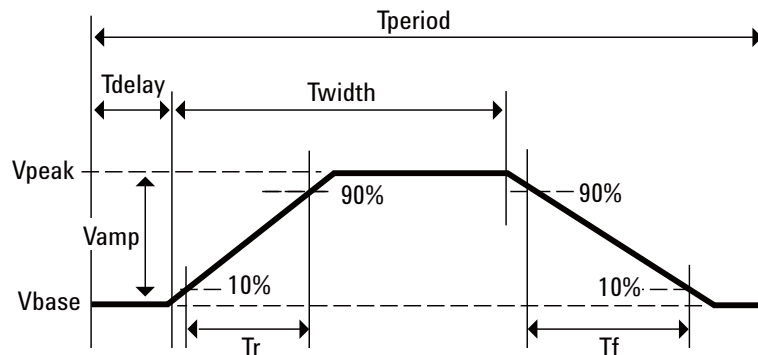
Table 4-15   **Pulse range and pulse parameter**

Item		Value [a]
Frequency range		0.1 Hz to 33 MHz
Pulse period	Programmable range	30 ns to 10 s
	Resolution	10 ns
	Minimum	100 ns (Vamp ≤ 10 V)
	Accuracy	± 1 % (± 0.01 % [b])
Pulse width	Programmable range	10 ns to (period −10 ns)
	Resolution	2.5 ns (Tr and Tf ≤ 8 μs)
		10 ns (Tr or Tf > 8 μs)
	Minimum	50 ns (25 ns, typical) at Vamp ≤ 10 V
	Accuracy	± (3 % + 2 ns)
Transition time (leading time Tr and trailing time Tf) [c]	Programmable range	8 ns to 400 ms
	Resolution	2 ns (Tr and Tf ≤ 8 μs)
		8 ns (Tr or Tf > 8 μs)
	Minimum (typical)	< 15 ns (Vamp ≤ 10 V)
	Minimum	20 ns (Vamp ≤ 10 V)
		30 ns (Vamp ≤ 20 V)
		60 ns (Vamp > 20 V)
	Accuracy	−5 % to 5 % + 10 ns (Vamp ≤ 10 V)
		−5 % to 5 % + 20 ns (Vamp ≤ 20 V)
Output relay switching time [d]	Open/close	< 100 μs

a. Unless otherwise stated, all specifications assume a 50 Ω termination.
b. Typical minimum. This is the supplemental information.
c. The time from 10 % to 90 % of Vamp which is the amplitude of output pulse.
d. The time it takes the open state relay to open or close.

Table 4-16   **Pulse/DC output voltage and accuracy**

Item	Value	Condition
Output voltage (Vout)	−20 V to +20 V	50 Ω load
	−40 V to +40 V	open load
Accuracy [a]	± (0.5 % + 50 mV)	open load
Amplitude resolution	0.2 mV (± 10 V range)	50 Ω load
	0.8 mV (± 40 V range)	
	0.4 mV (± 10 V range)	open load
	1.6 mV (± 40 V range)	
Output connectors	SMA	
Source impedance	50 Ω [b]	
Short circuit current	800 mA peak (400 mA average [c])	
Overshoot/pre-shoot/ringing [d]	± (5 % + 20 mV)	50 Ω load
Output limit	Monitoring over current limit	

    a. At 1 μs after completing transition.

    b. Typical (± 1 %)

    c. Specification condition: $N \times 0.2 + Itotal < 3.0$ A where, N is the number of installed HV-SPGUs, and $Itotal$ is DC current output by all modules (including HV-SPGUs)

    d. Following the specified condition with transition time.

- ALWG (arbitrary linear waveform generator) function

   Arbitrary linear waveform generator (ALWG) mode

   - Output complex waveform per one channel of HV-SPGU

   - Define multi-level pulse and multi-pulse waveform including open state pulse with ALWG GUI editor

   - Sequential pulse waveform from user-defined pulse waveform

   - 1024 points per one channel

- • Programmable timing range: 10 ns to 10 s, 10 ns resolution

- • SPGU supplemental information

  - • Pulse width jitter: 0.001 % + 150 ps

  - • Pulse period jitter: 0.001 % + 150 ps

  - • Maximum slew rate: 1000 V/μs (50 Ω load)

  - • Noise: 10 mVrms (at DC output)

  - • Advanced feature:

    Voltage monitor: The HV-SPGU has a voltage monitor function to measure the voltage at the DUT terminal.

    Measurement accuracy (open load): ± (0.1 % of reading + 25 mV)

    Measurement resolution: 50 μV

    Note: Specified at 1 PLC (20 ms = (5 μs sample + 5 μs interval)× 2000 samples)

    Voltage compensation: The HV-SPGU can measure the impedance of DUT and adjust the output voltage according to the DUT impedance.

Figure 4-2   **ALWG setup table and pattern example**

Point	Time	Voltage
1	0	0.0 V
2	50 ns	0.0 V
3	70 ns	15.0 V
4	100 ns	15.0 V
5	200 ns	0.0 V
6	300 ns	0.0 V
7	320 ns	10.0 V
8	400 ns	10.0 V
9	450 ns	0.0 V
10	500 ns	0.0 V
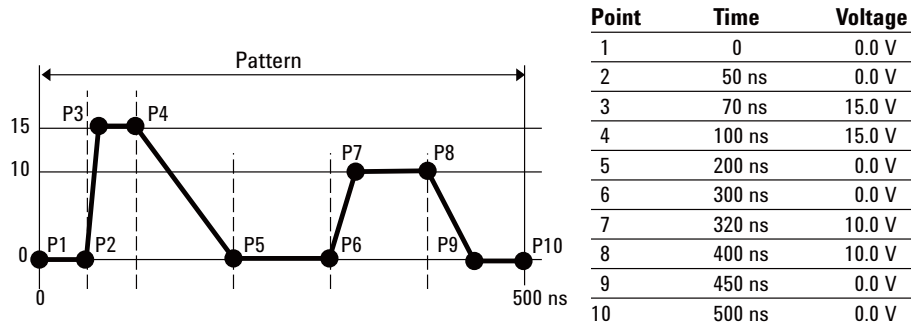
Figure 4-3   **ALWG complex waveform example**
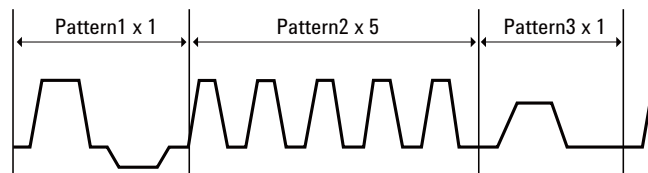
Selector

Agilent 16440A SMU/pulse generator selector switches either a SMU or PGU to the associated output port. You can expand to four channels by adding an additional 16440A. The PGU port on channel 1 provides a "PGU OPEN" function, which can disconnect the PGU by opening a semiconductor relay. Agilent B1500A and 16445A are required to use the 16440A.

The following specifications data is specified at 23 °C ± 5 °C (73 °F ± 9 °F) and 50 % relative humidity.

- Channel configuration: 2 channels (CH 1 and CH 2). Can add the additional 2 channels (CH 3 and CH 4) by adding another 16440A (selector expander).

	Input	Output
Channel 1 (CH 1)	2 (SMU and PGU [a])	1
Channel 2 (CH 2)	2 (SMU and PGU)	1
Channel 3 (CH 3) [b]	2 (SMU and PGU [a])	1
Channel 4 (CH 4) [b]	2 (SMU and PGU)	1

    a. PGU channels 1 and 3 have a built-in series semiconductor relay.
    b. Available when a selector expander is installed.

- Voltage and current range

Input port	Maximum voltage (V)	Maximum current (A)
SMU	200	1.0
PGU	40	0.2 [a]

    a. This is peak-to-peak ac current.

Selector Adapter

Agilent 16445A selector adapter is required to control and to supply DC power to the 16440A selector.

- Power requirement: 100 to 240 V, 50/60 Hz

- Maximum volt-amps (VA): 20 VA

WGFMU/RSU

WGFMU: Waveform Generator/Fast Measurement Unit

RSU: Remote-sense and Switch Unit

The WGFMU is a self-contained module offering the combination of arbitrary linear waveform generation (ALWG) with synchronized fast current or voltage (IV) measurement. The ALWG function allows you to generate not only DC, but also various types of AC waveforms. In addition to this versatile sourcing capability, the WGFMU can also perform measurement in synchronization with the applied waveform, which enables accurate high-speed IV characterization.

- Number of output channels: 2 channels per module

- Modes: Fast IV, PG (pulse generator), DC, and SMU pass-through

- Measurement functions: See Table 4-17.

- Voltage force accuracy, resolution, and timing: See Table 4-18.

- Voltage measurement accuracy, resolution and noise: See Table 4-19.

- Current measurement accuracy and resolution: See Table 4-20.

- RF electromagnetic field and WGFMU measurement accuracy

  The voltage and current measurement accuracy and the timing accuracy between modules may be affected by RF electromagnetic field of strength over 3 V/m at frequencies 80 MHz to 1 GHz and 1.4 GHz to 2.0 GHz, and 1 V/m at frequencies 2.0 GHz to 2.7 GHz. The extent of this effect depends upon how the instrument is positioned and shielded.

- RSU

  - Output terminal

    - Connector: SMA

    - Source impedance: 50 Ω (nominal), at DC output in PG mode

  - SMU path

    - Maximum voltage: ± 25 V

    - Maximum current: ± 100 mA

  - V Monitor terminal

    - Connector: BNC

    - Source impedance: 50 Ω (nominal), at DC output

The V Monitor terminal outputs a buffered signal equal to 1/10 of the Output terminal voltage (into a 50 Ω load).

- WGFMU to RSU cable length

  The WGFMU and RSU are connected by a special composite cable. The following configurations are available.

  - 3 m

  - 5 m

  - 1.5 m

  - 2.4 m + connector adapter + 0.6 m

  - 4.4 m + connector adapter + 0.6 m

  Note: The connector adapter is used when routing the cable through the prober's connector panel.

- ALWG function: See Table 4-21.

- Trigger output

  Level: TTL

  Trigger width: 10 ns

  Generated synchronously with ALWG waveform.

- Software

  - Instrument library for WGFMU control (supported operating systems: Microsoft Windows XP Professional SP2 and Vista Business SP1)

  - NBTI and general-purpose EasyEXPERT Application Tests

  - Sample programs (NBTI and general-purpose measurement using WGFMU and RTS data analysis)

- WGFMU supported prober vendors

  Cascade Microtech

  Suss MicroTec

  Vector Semicon

  Note: The maximum number of installable RSUs for a given prober depends upon the available space. Please contact your local sales representative for details on connecting and mounting the WGFMU and RSU.

- WGFMU supplemental data

    - RSU SMU path

        Leakage current: < 100 pA

        Residual resistance: < 300 mΩ

    - Jitter: < 1 ns

    - Skew between channels: < 3 ns, under no electrostatic discharge condition

    - Trigger output skew: < 3 ns

    - Current range change time: < 150 μs

        This is the time until the measured current settles within ± 0.3 % of the final result value after the range change.

    - Minimum rise/fall time: See Table 4-22. This is the minimum setting value effective for suppressing overshoot and distortion.

    - Settling time: See Table 4-23. This is the time until the measured value settles within ± 0.3 % of the final result value after the output voltage is changed from the initial value (0 V). Applicable condition: Rise time = 10 ns

    - Minimum pulse width: See Table 4-24. This is the time until the pulse peak output value (0 to 5 V) settles within ± 0.3 % of the setup value after the output voltage is changed from the initial value (0 V). Applicable condition: Rise time is set to the minimum rise/fall time shown in Table 4-22.

Table 4-17   **Measurement functions, voltage forcing, voltage measurement, and current measurement**

Mode	Function	V force ranges	V measure ranges	I measure ranges
Fast IV	V force/ I measure, V force/ V measure	−3 V to +3 V, −5 V to +5 V, −10 V to 0 V, 0 V to +10 V	−5 V to +5 V, −10 V to +10 V	1 μA, 10 μA, 100 μA, 1 mA, 10 mA
PG	V force/ V measure	−3 V to +3 V, −5 V to +5 V	−5 V to +5 V	−
DC	V force/ I measure, V force/ V measure	−3 V to +3 V, −5 V to +5 V, −10 V to 0 V, 0 V to +10 V	−5 V to +5 V, −10 V to +10 V	1 μA, 10 μA, 100 μA, 1 mA, 10 mA
SMU pass through	Measurement using SMU	Maximum ± 25 V	−	Maximum ± 100 mA

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Table 4-18   **Voltage force accuracy, resolution, and timing**

V force (Fast IV mode)	−5 V to +5 V, −10 V to 0 V, 0 V to +10 V
V force (PG mode)	−5 V to +5 V, open load −2.5 V to +2.5 V, 50 Ω load
Accuracy	± 0.1 % of setting ± 0.1 % of range [a]
Resolution [b]	96 µV (−3 V to +3 V) 160 µV (all ranges except for −3 V to +3 V)
Overshoot/undershoot	± (5 % + 20 mV) [c]
Noise	Maximum 0.1 mV$_{rms}$ [d]
Rise time T_{rise} (10 to 90 %)/ Fall time T_{fall} (90 to 10 %)	Accuracy: −5 % to +(5 % + 10 ns) of setting [e]
	Minimum: 24 ns, PG mode and 50 Ω load
Pulse period	Timing accuracy: ± 1 % of setting [f]
	Minimum: 100 ns, PG mode and 50 Ω load
Pulse width	Accuracy: ± (3 % + 2 ns) [g]
	Minimum: 50 ns, PG mode and 50 Ω load

a. Independent of the range or the mode. DC constant voltage output. Load
   impedance must be ≥ 1 MΩ (1 µA range) or ≥ 200 kΩ (all other current
   ranges) for Fast IV mode, or ≥ 1 MΩ for PG mode.
b. Can vary at most 5 % based on the result of calibration
c. PG mode, 50 Ω load, T_{rise} and T_{fall} >16 ns with the 1.5 m cable, >32 ns
   with 3 m cable, or >56 ns with 5 m cable
d. Theoretical value for the observed time 100 ns to 1 ms, supplemental
   information
e. PG mode, 50 Ω load, T_{rise} and T_{fall} ≥ 24 ns
f. PG mode, 50 Ω load, pulse period ≥ 100 ns
g. PG mode, 50 Ω load, pulse width ≥ 50 ns

Table 4-19　　　　　**Voltage measurement accuracy, resolution, and noise**

Accuracy	$\pm$ (0.1 % of reading + 0.1 % of range) [a]
Resolution [b]	680 μV, -5 V to $+5$ V range 1.4 mV, -10 V to $+10$ V range
Noise [c]	Maximum 4 mV$_{rms}$ (-5 V to $+5$ V range)

a. Independent of the range or the mode. DC constant voltage output. Applicable condition: 10,000 averaging samples for 10 μA range and above; 100,000 averaging samples for the 1 μA range
b. Display resolution. Can vary at most 5 % based on the result of calibration
c. 0 V output, open load, no averaging. Maximum 1.5 mV$_{rms}$ as supplemental information

Table 4-20　　　　　**Current measurement accuracy, resolution, and noise**

Accuracy	$\pm$ (0.1 % of reading + 0.2 % of range) [a]
Resolution [b]	0.014 % of range
Noise (Effective resolution)	Maximum 0.2 % of range [c]

a. Independent of the range or the mode. DC constant voltage output. Applicable condition: 10,000 averaging samples for 10 μA range and above; 100,000 averaging samples for the 1 μA range
b. Display resolution. Can vary at most 5 % based on the result of calibration
c. Effective value at 0 V output, open load, and no averaging. Supplemental information

Table 4-21　　　　　**ALWG and sampling measurement capability**

Maximum number of vectors	2048
Maximum number of sequences	512
Maximum number of loop counts	1 to 10^{12}
Length of a vector	10 ns to 10,000 s with 10 ns resolution
Sampling rate	5 ns, or 10 ns to 1 s with 10 ns resolution
Averaging time	10 ns to 20 ms with 10 ns resolution
Hardware memory	About 4 M data points/channel (typical)

Table 4-22   **Minimum rise/fall time**

Mode	Current measurement range	Minimum rise/fall time			Load conditions
		0 to 1 V	0 to 5 V	0 to 10 V	
PG mode	NA	30 ns	30 ns	NA	25 pF, open
Fast IV mode	10 mA	80 ns	80 ns	80 ns	25 pF, 1 MΩ
	1 mA	250 ns	250 ns	250 ns	
	100 μA	600 ns	600 ns	1.5 μs	
	10 μA	2 μs	4.5 μs	7 μs	
	1 μA	6 μs	–	–	
	–	–	35 μs	75 μs	25 pF, open

Table 4-23   **Settling time, at Rise time = 10 ns**

Mode	Current measurement range	Settling time		Load conditions
		Voltage measurement	Current measurement	
PG mode	NA	150 ns	NA	25 pF, open
Fast IV mode	10 mA	150 ns	100 ns	25 pF, 1 kΩ
	1 mA	150 ns	250 ns	25 pF, 10 kΩ
	100 μA	400 ns	1 μs	25 pF, 100 kΩ
	10 μA	1.2 μs	10 μs	25 pF, 1 MΩ
	1 μA	6 μs	80 μs	25 pF, 10 MΩ

Table 4-24   **Minimum pulse width, for pulse peak voltage = 0 to 5 V**

Mode	Current measurement range	Minimum pulse width	Load conditions
PG mode	NA	170 ns	25 pF, open
Fast IV mode	10 mA	180 ns	25 pF, 1 kΩ
	1 mA	500 ns	25 pF, 10 kΩ
	100 μA	1.6 μs	25 pF, 100 kΩ
	10 μA	14.5 μs	25 pF, 1 MΩ
	1 μA	115 μs	25 pF, 10 MΩ

Agilent EasyEXPERT Software

Functions

- Operation mode

  - Application test mode

  - Classic test mode

  - Tracer test mode

  - Quick test mode

- Key functions

  - Categorized and predefined application test library

  - GUI-based application test editor

  - Save/recall My Favorite setups

  - Define/customize application library

  - Execute measurement (single/repeat/append)

  - Quick test execution

  - Direct control (GPIB FLEX)

  - Save/recall measurement data and settings

  - Test result data management

  - Import/export device definition, measurement settings, my favorite setup, measurement data, and application library

  - Graph plot display/analysis/printing

  - Switching matrix control

  - Workspace management

  - Self-test, self-calibration, diagnostics

Application library

Sample application tests are supplied for the following categories. They are subject to change without notice.

Structure, CMOS, Bipolar (BJT), Memory, Mixed Signal Device, TFT, Discrete, Reliability, Power Device, Nanotechnology, Utility

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Measurement mode details

Agilent B1500A supports the following measurement modes:

- Staircase sweep

- Multi-channel sweep (EasyEXPERT does not support VAR1')

- Pulsed sweep

- Staircase sweep with pulsed bias

- IV sampling

- High speed IV sampling

- CV sweep

- C-t sampling

- C-f sweep

- List sweep

- Linear search (supported by FLEX command)

- Binary search (supported by FLEX command)

Each SMU can be set to VAR1 (primary sweep), VAR2 (secondary sweep), VAR1' (synchronous sweep), or CONST (constant voltage/current source).

- VAR1

  Primary sweep controls the staircase (DC or pulsed) voltage or current sweep.

  Maximum number of VAR1 steps: $N_1 = 1001$

- VAR2

  Subordinate linear staircase or linear pulsed sweep. After primary sweep is completed, the VAR2 unit output value is changed.

  Maximum number of VAR2 steps: $N_2 = 1001$ (condition: $1 \leq N_1 \times N_2 \leq 128128$)

- VAR1'

  Staircase or pulse sweep synchronized with the VAR1 sweep. Sweep is made with a user specified ratio and offset values.

  VAR1' = a × VAR1 + b

  "a" is the user specified ratio, and "b" is the user specified offset value.

- CONST

  A source unit can be set as a constant voltage or current source depending on the unit.

- Staircase sweep measurement mode

  Forces swept voltage or current, and measures DC voltage or current. One channel can sweep current or voltage while up to ten channels can measure current or voltage. A second channel can be synchronized with the primary sweep channel as an additional voltage or current sweep source.

  Number of steps: 1 to 1001

  Sweep mode: linear or logarithmic (log)

  Sweep direction: single or double sweep

  Hold time: 0 to 655.35 s, 10 ms resolution

  Delay time: 0 to 65.5350 s, 100 μs resolution

- Pulsed sweep measurement mode

  Forces pulsed swept voltage or current, and measures DC voltage or current. A second channel can be programmed to output a staircase sweep voltage or current synchronized with the pulsed sweep output.

- Staircase sweep with pulsed bias measurement mode

  Forces swept voltage or current, and measures DC voltage or current. A second channel can be programmed to output a pulsed bias voltage or current. A third channel can be synchronized with the primary sweep channel as an additional voltage or current sweep source.

- Sampling (time domain) measurement mode

  Displays the time sampled voltage/current data (by SMU) versus time.

  Sampling channels: up to 10

  Sampling mode: linear or logarithmic (log)

  Sampling points: 1 to 100,001/(number of channels) for linear sampling, 1 to 1 + (number of data for 11 decades) for log sampling

  Sampling interval range: 100 μs + 20 μs × (number of channels −1) to 2 ms in 10 μs resolution, or 2 ms to 65.535 s in 1 ms resolution

  Hold time, bias hold time: −90 ms to −100 μs in 100 μs resolution, 0 to 655.35 s in 10 ms resolution

---

Measurement time resolution: 100 μs

- Standby mode

  SMUs in "Standby" remain programmed to their specified output value even as other units are reset for the next measurement.

- Current offset cancel

  This function subtracts the offset current from the current measurement raw data, and returns the result as the measurement data. This function is used to compensate the error factor (offset current) caused by the measurement path such as the measurement cables, manipulators, or probe card.

- Timestamp

  The B1500A supports a time stamp function utilizing an internal quartz clock.

  Resolution: 100 μs

- Other measurement characteristics

  - Measurement control:

    Single, repeat, append, and stop

  - SMU setting capabilities:

    Limited auto ranging, voltage/current compliance, power compliance, automatic sweep abort functions, self-test, and self-calibration

Arithmetic and analysis functions

- User functions

  Up to 20 user-defined functions can be defined using arithmetic expressions.

  Measured data and pre-defined variables can be used in the computation. The results can be displayed on the LCD.

- Arithmetic operators

  +, −, *, /, ^, abs (absolute value), at (arc tangent), avg (averaging), cond (conditional evaluation), delta, diff (differential), exp (exponent), integ (integration), lgt (logarithm, base 10), log (logarithm, base e), mavg (moving average), max, min, sqrt, trigonometric function, inverse trigonometric function, and so on

- Physical constants

  Keyboard constants are stored in memory as follows:

- q: Electron charge, 1.602177E−19 C

- k: Boltzman's constant, 1.380658E−23 J/K

- ε (e): Dielectric constant of vacuum, 8.854188E−12 F/m

- Engineering units

  The following unit symbols are also available on the keyboard.

  a (10^{-18}), f (10^{-15}), p (10^{-12}), n (10^{-9}), u or μ (10^{-6}), m (10^{-3}), k (10^3), M (10^6), G (10^9), T (10^{12}), P (10^{15})

Analysis capabilities

- Overlay graph comparison

  Graphical plots can be stored and overlaid.

- Scale

  Auto scale and zoom

- Marker

  Marker to min/max, interpolation, direct marker, and marker skip

- Cursor

  Direct cursor

- Line

  Two lines, normal mode, grad mode, tangent mode, and regression mode

Auto analysis function

On a graphics plot, the markers and lines can be automatically located using the auto analysis setup. Parameters can be automatically determined using automatic analysis, user function, and read out functions.

- Data variable display

  Up to 20 user-defined parameters can be displayed on the graphics screen.

- Analysis functions

  Up to 20 user-defined analysis functions can be defined using arithmetic expressions.

  Measured data, pre-defined variables, and read out functions can be used in the computation. The results can be displayed on the LCD.

- Read out functions

  The read out functions are built-in functions for reading various values related to the marker, cursor, or line.

Graph plot

- Display mode

  Data display window can be printed. Only X-Y graph can be printed.

- Graph plot file

  Graph plot can be stored as image data to clip board or mass storage device.

  File type: bmp, gif, png, emf

Output

- Display mode

  X-Y graph, list, and parameter

- X-Y graph display

  X-axis and up to eight Y-axis. Linear and log scale. Real time graph plotting.

- List display

  Measurement data and calculated user function data are listed in conjunction with VAR1 step number or time domain sampling step number. Up to 20 data sets can be displayed.

Other functions

- Import/export files

  File type: Agilent EasyEXPERT format, XML-SS format, CSV format

- Data storage

  Hard disk drive, DVD-ROM/CD-R/CD-RW drive

- Interfaces

  GPIB, interlock, USB (USB 2.0, 2 ea. on front, 2 ea. on rear),
  LAN (100BASE-TX/10BASE-T), trigger in/out, digital I/O

- Trigger I/O

  Only available using GPIB FLEX commands.

  Trigger in/out synchronization pulses before and after setting and measuring DC voltage and current. Arbitrary trigger events can be masked or activated independently.

- External instruments supported by EasyEXPERT Standard edition:

  Supported by switching matrix GUI: B2200A, B2201A

  Supported by application tests: E5250A (E5252A cards), 4284A/E4980A, 81110A, 3458A

- External instruments supported by EasyEXPERT Plus edition:

  All external instruments supported by EasyEXPERT Standard edition

  Also supported by switching matrix GUI: E5250A (E5252A cards)

Furnished Software

- Prober control execution files

- Desktop EasyEXPERT software with license-to-use for Standard edition

- 4155/56 setup file converter tool (supported operating systems: Microsoft Windows 2000 Professional, XP Home, XP Professional, and Vista Business)

- VXI*plug&play* driver (supported operating systems: Microsoft Windows 2000 Professional and XP Professional)

Agilent Desktop EasyEXPERT Software

Desktop EasyEXPERT is the same software that is built-in to the Agilent B1505A Semiconductor Device Analyzer, except that it runs on a standalone PC and no support of the tracer test. Just like standard EasyEXPERT, Desktop EasyEXPERT supports all aspects of parametric test, from basic manual measurements to test automation across a wafer in conjunction with a semi-automatic wafer prober.

Features and benefits

- Large application test library

  Desktop EasyEXPERT comes with over 200 application tests conveniently organized by device type, application, and technology. Many of these application tests will run on the 4155/4156 without modification, and you can easily edit and customize the furnished application tests to fit your specific needs.

- Offline capability

  Desktop EasyEXPERT can be run in either online or offline mode. In the offline mode you can perform tasks such as analyzing data and creating new application tests. This frees up your existing analyzer from being needed for development work and enables you to use it for its primary purpose: making measurements.

- GUI-based classic test mode

  Desktop EasyEXPERT offers a classic test mode that maintains the look, feel, and terminology of the 4155/4156 user interface. In addition, it improves the 4155/4156 user interface by taking full advantage of Microsoft Windows GUI features.

- Easy test sequencing

  A GUI-based Quick Test mode enables you to perform test sequencing without programming. You can select, copy, rearrange and cut-and-paste any application tests with a few simple mouse clicks. Once you have selected and arranged your tests, simply click on the measurement button to begin running an automated test sequence.

- Prober control

  All popular semi-automatic wafer probers are supported by Desktop EasyEXPERT. You can define wafer, die, and module information for probing across an entire wafer. You can also combine wafer prober control with either Quick Test mode or an application test based test sequence to perform multiple testing on various devices across the wafer.

- Automatic data export

  Desktop EasyEXPERT has the ability to automatically export measurement data in real time, in a variety of formats. You can save data to any drive connected to the PC. If you wish, you can export data to a network drive and view test results on your desktop PC as your instruments are performing the testing in your lab.

System requirements

The following are the minimum requirement for executing Desktop EasyEXPERT.

Operating system and service pack	Microsoft Windows XP Professional SP2	Microsoft Windows Vista Business SP1
Processor	Intel Celeron 2 GHz	Vista certified PC with 1 GB memory
Memory	512 Megabytes DDR266	
Display	XGA 1024×768 (SXGA 1280×1024 recommended)	
HDD	1 GB free space on the C drive, 10 GB (30 GB recommended) free space on a drive for test setup/result data storage.	
.NET Framework	Microsoft .NET Framework Ver 2.0 Redistributable Package Microsoft .NET Framework 2.0 SP1	Microsoft .NET Framework Ver 3.0
IO libraries	Agilent IO Libraries Suite 15.0 (for online mode)	

- Supported GPIB I/F (for online mode):

	B1500A	4155B/C, 4156B/C
Agilent 82350B	Supported	Supported
Agilent 82357A	Not supported	Supported
Agilent 82357B	Not supported	Supported

- Supported instruments:

  B1500A, 4155B, 4156B, 4155C, and 4156C

  Supported 4155/4156 firmware: HOSTC: 03.08 or later and SMUC: 04.08 or later

- External instruments supported by Desktop EasyEXPERT Standard edition:

  Supported by switching matrix GUI: B2200A, B2201A

  Supported by application tests: E5250A (E5252A cards), 4284A/E4980A, 81110A, 3458A

- External instruments supported by Desktop EasyEXPERT Plus edition:

  All external instruments supported by Desktop EasyEXPERT Standard edition

  Also supported by switching matrix GUI: E5250A (E5252A cards)

Supported 4155/4156 functionality

- Desktop EasyEXPERT Standard edition:

  I/V Sweep, B2200A/B2201A switching matrix GUI control

- Desktop EasyEXPERT Plus edition:

  The following functions are additionally supported.

  I/V-t Sampling except thinned out mode, VSVMU except differential voltage measurement using VMU, PGU (41501B), E5250A/E5252A switching matrix GUI control

- Setup converter tool

  In addition to Desktop EasyEXPERT, Agilent supplies a free setup converter tool that runs on any Windows-based PC. This tool can convert 4155 and 4156 setup files (file extension MES or DAT) into equivalent Desktop EasyEXPERT classic test mode setup files.

General Specifications

- Temperature range

  Operating   +5 °C to +40 °C

  Storage   −20 °C to +60 °C

- Humidity

  Operating   20 % to 70 %RH, non-condensing

  Storage   10 % to 90 %RH, non-condensing

- Altitude

  Operating   0 to 2,000 m (6,561 ft.)

  Storage   0 to 4,600 m (15,092 ft.)

- Power requirement: 90 to 264 V, 47 to 63 Hz

- Maximum volt-amps (VA): 900 VA

- Regulatory compliance

  EMC   IEC61326-1 / EN61326-1
                  AS/NZS CISPR 11

  Safety   CSA C22.2 No.1010.1-1992
                  IEC61010-1 / EN61010-1
                  UL Std No. 61010B-1

- Certification: CE, CSA(c/us), C-Tick

- Dimensions

  B1500A: 420 mm (W) × 330 mm (H) × 575 mm (D)

  N1301A-100 SCUU: 148 mm (W) × 75 mm (H) × 70 mm (D)

  N1301A-200 GSWU: 33.2 mm (W) × 41.5 mm (H) × 32.8 mm (D)

  E5288A ASU: 132 mm (W) × 88.5 mm (H) × 50 mm (D)

  B1531A RSU: 45.2 mm (W) × 70 mm (H) × 82 mm (D)

  16440A Selector: 250 mm (W) × 50 mm (H) × 275 mm (D)

  16445A Selector adapter: 250 mm (W) × 50 mm (H) × 260 mm (D)

- Weight

  B1500A (empty) 20 kg, B1510A 2.0 kg, B1511A 1.0 kg, B1517A 1.2 kg,
  E1520A 1.5 kg, E1525A 1.3 kg, E1530A 1.3 kg, E1531A 0.13 kg, E5288A 0.5
  kg, N1301A-100 0.8 kg, N1301A-200 0.1 kg, 16440A 1.1 kg, 16445A 1.0 kg

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Accessories and Options

Agilent B1500A is furnished with the following accessories.

- Power cable, 1 ea.

- Manual CD, 1 ea.

- Desktop EasyEXPERT CD, 1 ea.

- License-to-use for Desktop EasyEXPERT Standard edition, 1 license

- Software CD (including VXI*plug&play* driver and utility tools), 1 ea.

- WGFMU Instrument Library and Sample Program CD, 1 ea.

- Disk set for Agilent 4155B/4155C/4156B/4156C firmware update, 1 set

- SMU number label for the B1500A installed with SMU, 1 sheet

- PG number label for the B1500A installed with SPGU, 1 sheet

Table 4-25 lists the options and the available accessories for Agilent B1500A.

Table 4-25   Options and Accessories

Model Number	Option Item	Description
B1500A		Semiconductor Device Analyzer
	B1500A-050	50 Hz power line frequency
	B1500A-060	60 Hz power line frequency
	B1500A-A6J	ANSI Z540 compliant calibration
	B1500A-UK6	Commercial cal. certificate w/ test data
	B1500A-ABA	Paper manual set, English
	B1500A-ABJ	Paper manual set, Japanese
B1510A		High Power Source/Monitor Unit module (HPSMU)
B1511A		Medium Power Source/Monitor Unit module (MPSMU)
B1517A		High Resolution Source/Monitor Unit module (HRSMU)
B1520A		Multi Frequency Capacitance Measurement Unit module (MFCMU)
B1525A		Semiconductor Pulse Generator Unit module (SPGU)
B1530A		Waveform Generator/Fast Measurement Unit (WGFMU)
B1531A		Remote-sense and Switch Unit (RSU)
B1540A		Agilent EasyEXPERT software
	B1540A-001	Standard edition
	B1540A-002	Adds support instrument (E5250A/E5252A switching matrix is supported)
B1541A		Agilent Desktop EasyEXPERT software
	B1541A-001	Standard edition
	B1541A-002	Adds support instrument and function (E5250A/E5252A switching matrix is supported, and 4155/4156 support function is expanded)

Model Number	Option Item	Description
E5288A		Atto Sense and Switch Unit (ASU)
	E5288A-001	Add triaxial and D-sub cables, 1.5 m
	E5288A-002	Add triaxial and D-sub cables, 3 m
N1253A		Accessories for Digital I/O
	N1253A-100	Digital I/O T-cable
	N1253A-200	Digital I/O BNC Box
N1254A		Accessories
	N1254A-100	GNDU Kelvin Adapter
	N1254A-108	ASU Magnetic Stand
N1300A		CMU cable
	N1300A-001	1.5 m length
	N1300A-002	3 m length
N1301A		Accessories for CMU
	N1301A-100	SMU CMU Unify Unit (SCUU)
	N1301A-102	SCUU cable, 3 m
	N1301A-110	SCUU magnetic stand
	N1301A-200	Guard Switch Unit (GSWU)
	N1301A-201	GSWU cable, 1.5 m
	N1301A-202	GSWU cable, 3 m
16440A		SMU/Pulse Generator selector
	16440A-001	Control cable, 1.5 m
	16440A-002	Control cable, 3.0 m
	16440A-003	Control cable, 40 cm for second selector

Model Number	Option Item	Description
16442B		Test fixture
	16442B-010	Add triaxial cables, 1.5 m, 4 ea.
	16442B-011	Add triaxial cables, 3 m, 4 ea.
	16442B-800	Extra blank teflon board
	16442B-801	Universal socket module, 0.1 inch pitch, with 10 pins
	16442B-802	Universal socket module, 0.075 inch pitch, with 10 pins
	16442B-803	Universal socket module, 0.05 inch pitch, with 10 pins
	16442B-810	Extra pin set (for universal socket module, 10 pins.)
	16442B-811	Extra wire set (mini banana to pin plug, 6 ea.)
	16442B-812	Extra wire set (pin plug to pin plug, 6 ea.)
	16442B-813	Extra wire set (mini banana to mini clip, 6 ea.)
	16442B-814	Extra wire set (mini banana to mini banana, 6 ea.)
	16442B-821	Socket module, 4-pin TO package
	16442B-822	Socket module, 18-pin DIP package
	16442B-823	Extra socket module, 28-pin DIP package
	16442B-890	Extra accessory case
16444A		Accessories for B1500A
	16444A-001	USB keyboard
	16444A-002	USB mouse
	16444A-003	Stylus pen
16445A		Selector adapter for 16440A
	16445A-001	Control cable (B1500 to 16445A), 1.5 m
	16445A-002	Control cable (B1500 to 16445A), 3.0 m

Model Number	Option Item	Description
16493G		Digital I/O connection cable
	16493G-001	1.5 m length
	16493G-002	3 m length
16493J		Interlock cable
	16493J-001	1.5 m length
	16493J-002	3 m length
	16493J-003	5 m length
16493K		Kelvin triaxial cable (B1500 to B1500)
	16493K-001	1.5 m length
	16493K-002	3 m length
16493L		GNDU cable
	16493L-001	1.5 m length
	16493L-002	3 m length
	16493L-003	5 m length
16493M		Triaxial and D-sub cables for ASU
	16493M-001	1.5 m length
	16493M-002	3 m length
16493N		GNDU cable for B2200 Kelvin input
	16493N-001	2 m length
16493P		SPGU output connection cable (SMA to BNC)
	16493P-001	1.5 m length
	16493P-002	3 m length
16493Q		SPGU–SPGU connection cable (SMA to SMA)
	16493Q-001	8 cm length

Model Number	Option Item	Description
16493R		WGFMU Cables and Accessories
	16493R-001	WGFMU-to-RSU cable, 0.6 m
	16493R-002	WGFMU-to-RSU cable, 2.4 m
	16493R-003	WGFMU-to-RSU cable, 3 m
	16493R-004	WGFMU-to-RSU cable, 5 m
	16493R-005	WGFMU-to-RSU cable, 4.4 m
	16493R-006	WGFMU-to-RSU cable, 1.5 m
	16493R-101	SSMC short-open cable for current return path, 50 mm
	16493R-102	SSMC short-open cable for current return path, 75 mm
	16493R-202	SMA-SSMC cable between RSU and DC probe, 200 mm
	16493R-302	SMA-SMA cable between RSU and RF probe, 200 mm
	16493R-801	WGFMU connector adapter (female-female)
	16493R-802	Magnet stand for RSU
	16493R-803	Sync terminal connection cable
16494A		Triaxial cable
	16494A-001	1.5 m length
	16494A-002	3 m length
	16494A-003	80 cm length
	16494A-004	40 cm length
	16494A-005	4 m length
16494B		Kelvin triaxial cable (B1500 to E5250)
	16494B-001	1.5 m length
	16494B-002	3 m length
	16494B-003	80 cm length

Model Number	Option Item	Description
16495F		Connector plate w/ 12×triax., Interlock, GNDU
	16495F-001	Bulkhead feedthrough connectors (female to female)
	16495F-002	Connectors to contacts for soldering
16495G		Connector plate w/ 24×triax., Interlock, GNDU
	16495G-001	Bulkhead feedthrough connectors (female to female)
	16495G-002	Connectors to contacts for soldering
16495H		Connector plate w/ 6×triax., 6×coax., Interlock, GNDU
	16495H-001	Bulkhead feedthrough connectors (female to female)
	16495H-002	Connectors to contacts for soldering
16495J		Connector plate w/ 8×triax., 4×coax., Interlock, GNDU
	16495J-001	Bulkhead feedthrough connectors (female to female)
	16495J-002	Connectors to contacts for soldering
16495K		Connector plate with universal cable holder
	16495K-001	Connector plate with rubber holder