Keysight M9601A PXIe Precision Source/Measure Unit

Startup Guide
**Notices**

**Copyright Notice**
© Keysight Technologies 2019, 2020

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies as governed by United States and international copyright laws.

**Manual Part Number**
M9601-90000

**Edition**
Edition 1, October 2019
Edition 2, December 2019
Edition 3, April 2020

**Published by:**
Keysight Technologies Japan K.K.
9-1, Takakura-cho, Hachioji-shi, Tokyo 192-0035 Japan

**Regulatory Compliance**
This product has been designed and tested in accordance with accepted industry standards, and has been supplied in a safe condition. To review the Declaration of Conformity, go to www.keysight.com/go/conformity.

**Warranty**
THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR OF ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT SHALL CONTROL.

KEYSIGHT TECHNOLOGIES DOES NOT WARRANT THIRD-PARTY SYSTEM LEVEL (COMBINATION OF CHASSIS, CONTROLLERS, MODULES, ETC.) PERFORMANCE, SAFETY, OR REGULATORY COMPLIANCE, UNLESS SPECIFICALLY STATED.

**Technology Licenses**
The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

**U.S. Government Rights**
The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101, pursuant to FAR 12.211 and 27.405-3 and Department of Defense FAR Supplement ("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

**Safety Summary**
The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual may impair the protections provided by the product. In addition, it violates safety standards of design, manufacture, and intended use of the product. Keysight Technologies assumes no liability for customer’s failure to comply with these requirements.

- Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.
- This product is INDOOR USE product.
- This product complies with POLLUTION DEGREE 2 defined in IEC 61010-1.
- If an instrument is marked CAT I (IEC Measurement Category I), or it is not marked with a measurement category, its measurement terminals must not be connected to line-voltage mains.

- System installation, safety and performance are the responsibility of the assembler of the system.

**WARNING**
The persons who plan, supervise, consign, and implement the installation, start-up, maintenance, and delivery of this product are required to carefully read documents related to the equipment and take and implement safety measures to prevent accidents. Also, safety and performance of the system in which the equipment is installed are the responsibility of the assembler responsible for the system construction.

**WARNING**
Equipment built in the system may be heavy. So there is the possibility of physical disability in the person by moving the equipment to a high place or moving it from a high place. To prevent accidents, take appropriate safety work means.

**DANGEROUS PROCEDURE WARNINGS**
Warnings, such as above WARNING, shall be complied. Procedures throughout in this manual prevent you from potentially hazard. Their instructions contained in the warnings must be followed.

**BEFORE APPLYING POWER**
Verify that all safety precautions are taken. Make all connections to the instrument before applying power. Note the instrument’s external markings described under "Safety Symbols".

**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.

**DO NOT REMOVE COVERS**
No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock do not remove covers.

**IN CASE OF DAMAGE**
Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel. Return the instrument to a Keysight Technologies sales or service office for services and repair to ensure that safety features are maintained.

**USE ONLY THE SPECIFIC ACCESSORIES**
Specific accessories satisfy the requirements for specific characteristics for using the instrument. Use the specific accessories, cables, adapters, and so on for safety reasons.

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

- Direct current.
- Alternating current.
- Earth ground terminal.
- 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.
- Grounded terminal which indicates the earth potential.
- On supply.
- Off supply.
- Standby supply. The equipment will be marked with this symbol is not completely disconnected from AC mains when power switch is in the standby position.
- In position of a bi-stable push switch.
- Out position of a bi-stable push switch.
- Hazardous voltage and potential for electrical shock. Do not touch terminals that have this symbol when the equipment is on.
- Hot surface. Avoid contact. Surfaces are hot and may cause personal injury if touched.
- Low temperature or freezing conditions. Avoid contact. Surfaces are cold and may cause personal injury if touched.
- Heavy object. Lifting can cause back injury. Use mechanical lifting device to move.
Caution, refer to accompanying documentation. The equipment will be marked with this symbol when it is necessary for the user to refer to the instruction manual.

Read operator’s manual. To indicate that the operator’s manual or card should be read before continuing the operation.

Affixed to product containing static sensitive devices—use anti-static handling procedures to prevent electrostatic discharge damage to component.

IEC Measurement Category I

The CE mark shows that the product complies with all applicable European Directives.

The CSA mark is a registered trademark of the Canadian Standards Association.

The RCM mark is a registered trademark of the Australian Communications Authority. This signifies compliance with the Australian EMC Framework Regulations under the terms of the Radio communications Act.

This ISM device complies with Canadian ICES-001.
Cet appareil ISM est conforme à la norme NMB-001 du Canada.

This symbol for an Industrial, Scientific and Medical, Group 1 Class A product. (CISPR 11)

Korea’s safety and EMC mark
China RoHS - Environmentally Green Product Label
China RoHS - Product with Toxic Substance 40 yr EPUP


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 1, this product is classified as a "Monitoring and Control instrumentation" product. Do not dispose in domestic household waste.

To return unwanted products, contact your local Keysight office or visit the following website for more information.

South Korean EMC Declaration

Information to the user:

This equipment has been conformity assessed for use in business environments. In a residential environment this equipment may cause radio interference.

(*) This EMC statement applies to the equipment only for use in business environment.

Cleaning Precautions

To prevent electrical shock, disconnect the Keysight Technologies instrument from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

To clean the connectors, use alcohol in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to energizing the instrument.
Contents

Introduction 7
Related Documentation 7
Step 1: Unpack and Inspect the Module 8
Electrostatic Discharge (ESD) Precautions 8
Before Unpacking 9
Inspect for Damage 9
Return the Module for Service 10
Step 2: Verify Shipment Contents 11
Step 3: Install the Software 12
Requirements 12
Installation Process 12
Step 4: Install the Module 13
Step 5: Verify Operation of the Module 15
To Check Communication 15
To Update the Firmware 16
To Perform Self Test 17
Front Panel Features 18
LED Indicators 19
⚠ Measurement Terminals 19
⚠ Trigger and Interlock Terminals 23
⚠ Connecting a DUT 24
2-Wire Connection or 4-Wire Connection 25
⚠ Floating 27
Guarding  27
Installing Interlock Circuit  29
Maintenance  32
Cleaning  32
Self Test  33
Self Calibration  33
Calibration  34
Introduction

The Keysight M9601A Precision Source/Measure Unit (SMU) delivers fast transient voltage output, high resolution current measurement, easy installation and configuration via the Keysight Connection Expert and a soft front panel (SFP).

- M9601A PXIe Precision SMU, 1.25 MSa/s, 10 fA, 210 V, 315 mA

Keysight also supplies software drivers that allow you to support the modules in many popular PXI chassis and programming environments. You can control the M9601A using IVI drivers. LabVIEW driver is also available.

Related Documentation

This Startup Guide, and the documentation listed below, can be found on the Keysight web site. Visit www.keysight.com/find/m9601a to get the latest documents, specifications, and software.

- Soft Front Panel User’s Guide
- IVI.NET Driver Reference
- IVI-C Driver Reference
- LabVIEW Driver Help
- Data sheet
- Configuration Guide
Step 1: Unpack and Inspect the Module

Keysight’s PXIe chassis and instrument modules are shipped in materials which prevent static electricity damage. The modules should only be removed from the packaging in an anti-static area ensuring that correct anti-static precautions are taken. Store all modules in anti-static envelopes when not in use.

Electrostatic Discharge (ESD) Precautions

Electrostatic discharge (ESD) can damage or destroy electronic components. Use a static-safe work station to perform all work on electronic assemblies. This figure shows a static-safe work station using two types of ESD protection.

- Conductive table mat and wrist strap combination
- Conductive floor mat and heel strap combination

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table mat and wrist strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground.

DO NOT use these techniques for a static-safe work station when working on circuitry with a voltage potential greater than 500 V.
Step 1: Unpack and Inspect the Module

Before Unpacking

Keysight M9601A module is designed to meet IEC/EN61010-1 and must only be installed in the PXIe chassis which is certified by a Nationally Recognized Testing Laboratory. The PXIe chassis must already be installed on a static-safe workbench so that you can install the module soon after unpacking.

Refer to the PXIe chassis manual for chassis installation and details.

Inspect for Damage

After unpacking a module, carefully inspect it for any shipping damage. Report any damage to the shipping agent immediately, as such damage is not covered by the warranty (see warranty information at the beginning of this document).

**CAUTION**
To avoid damage when handling a module, do not touch any exposed components or connector pins.

**NOTE**
Visit www.keysight.com/find/tips for information on preventing damage to your Keysight equipment.
Step 1: Unpack and Inspect the Module

Return the Module for Service

Should it become necessary to return a module for repair or service, follow the steps below.

1. Review the warranty information shipped with your product.

2. Contact Keysight to obtain a Return Material Authorization (RMA) and return address. For assistance in finding Keysight contact information, visit www.keysight.com/find/assist.

3. Write the following information on a tag and attach it to the malfunctioning equipment.
   - Name and address of owner. A Post Office box is not acceptable as a return address.
   - Product model number (for example, M9601A)
   - Product serial number (for example, MYXXXXXXXX). The serial number label is located on the side of the module.
   - Description of failure or service required

4. Carefully pack the module in its original ESD bag and packing carton. If the original carton is not available, use bubble wrap or packing peanuts and place the instrument in a sealed container and mark the container “FRAGILE.”

5. On the shipping label, write ATTENTION REPAIR DEPARTMENT and the RMA number.

NOTE

If any correspondence is required, refer to the product by serial number and model number.
Step 2: Verify Shipment Contents

The following items are included in this shipment.

<table>
<thead>
<tr>
<th>Model number</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M9601A</td>
<td>PXIe Precision Source/Measure Unit, 1.25 MSa/s, 10 fA, 210 V, 315 mA</td>
<td>1</td>
</tr>
<tr>
<td>NA</td>
<td>Quick Startup Poster</td>
<td>1</td>
</tr>
<tr>
<td>NA</td>
<td>Certification of calibration (without test data)</td>
<td>1</td>
</tr>
<tr>
<td>NA</td>
<td>Short bar</td>
<td>1</td>
</tr>
<tr>
<td>NA</td>
<td>Connector-terminal block 2.5 mm 6-terminal</td>
<td>1</td>
</tr>
</tbody>
</table>

Consumable supplies of the M9601A are shown in below.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M9601-87001</td>
<td>Short bar</td>
<td>5</td>
</tr>
<tr>
<td>M9601-87002</td>
<td>Connector-terminal block 2.5 mm 6-terminal</td>
<td>5</td>
</tr>
</tbody>
</table>
Step 3: Install the Software

Requirements

The followings are required for installing the M9601A software.

- Controller (desktop PC, laptop PC, rackmount PC, or PXIe embedded computer) installed with Keysight IO Libraries Suite
- Keysight PXIe chassis which has already been set up

For setting up the controller and the PXIe chassis, refer to the PXIe chassis documentation.

NOTE Minimum 1.5 GB free space is required on the controller for installing the M9601A software.

Installation Process

Visit www.keysight.com/find/m9601a to get the latest version of the M9601A software.

1. Copy the M9601A software installer into the controller.
2. Launch the M9601A software installer.
3. Follow the installer prompts to install the M9601A software.
4. Reboot the controller when prompted by the M9601A software installer.

If a firmware update is available, you can perform the firmware update by using the M960x PXIe Source Measure Unit Soft Front Panel (the M960x SFP) after the module installation. See “To Update the Firmware” on page 16.
Step 4: Install the Module

**CAUTION**
PXIe hardware does not support “hot-swap” (changing modules while power is applied to the chassis) capabilities. Before installing or removing a module to/from the chassis, power down the chassis to prevent damage to the module.

Place the chassis on a static-safe work station (see “Electrostatic Discharge (ESD) Precautions” on page 8). And position it so that there is ample space between the chassis fan intake and exhaust vents. Blockage by walls or obstructions affects the air flow needed for cooling.

For more information about precautions and cooling, refer to the PXIe chassis documentation.

Generic module installation is shown below. It may not reflect your module’s actual size and chassis placement. Install the leftmost module first and continue installing modules from left to right according to the image below.
Step 4: Install the Module

**NOTE**
Before the module installation, make sure that the controller is turned off.

**Procedure**

1. Make sure that the power cord is plugged into a grounded outlet to establish earth ground and to prevent ESD.
2. Make sure that the chassis power switch is off.
3. If the chassis has multiple fan speed settings, ensure that the fans are set to automatic. Do not set the fan speed to low or turn them off.
4. Remove the filler panel that covers the slot in which you want to install the module.
5. Remove thread protectors from the top and bottom mounting screws of the module.
6. Hold the module by the injector/ejector handle, and slide it into the slot.
   - Install the module into the slot of the chassis by placing the module card edges into the front module guides (top and bottom).
   - Slide the module to the rear of the chassis and assure that the injector/ejector handle is pushed down in the unlatched (downward) position.
   - Slide the module completely into the chassis. When you begin to feel resistance, push up on the injector/ejector handle to fully seat the module into the chassis.
7. Latch the module by pulling up on the injector/ejector handle and secure the front panel to the chassis using the module front-panel mounting screws.
8. Tighten the screws on the module front panel. Performance may suffer if the screws are not securely tightened.
9. Install all chassis covers, filler panels, and air scoops after installing the module. Also see CAUTION below.

For more information on the module installation, refer to the PXIe chassis documentation.

**CAUTION**
Ensure that filler panels are installed in all empty slots. Missing filler panels will impact cooling of the chassis and may cause RFI (radio frequency interference) with other devices.
Step 5: Verify Operation of the Module

To Check Communication

Perform the following procedure to check the communication between the module and the controller.

1. Make sure that the chassis and the controller are turned off.
2. If you are using a remote controller, connect a PXIe cable between the chassis and the controller.
3. Power up the chassis. Verify that the chassis fans are operating and free of obstructions that may restrict airflow.
4. Power up the controller.
5. Check that the controller automatically recognizes the module in the device manager; e.g. via Start menu > Windows System Tools > Control Panel > Device Manager. The module should be visible in the device tree.
   The controller might request a reboot. Reboot the controller, if requested.
6. Check if the module is also visible in the Keysight Connection Expert; e.g. via Start menu > Keysight Connection Expert.
   If something went wrong and the module is not shown in the PXIe section, it may be necessary to reboot the controller once more.
Step 5: Verify Operation of the Module

To Update the Firmware

If a firmware update is available, perform the following procedure to update the firmware of the M9601A modules.

1. Click **Start menu > Keysight M960x Source Measure Unit > M960x SFP**. The Connect to Instrument dialog box will open.

2. In the list on the window, highlight the M9601A modules to connect, and click **Connect** to launch the Keysight M960x PXIe Source Measure Unit Soft Front Panel (the M960x SFP).

3. Confirm that the Access indicator on the M9601A front panel turns green. Refer to Figure 1-1 and Table 1-3 for LED status.

4. Select **Firmware Update...** from the Utilities menu. The Firmware Update dialog box will open.

5. Select the latest version of the firmware, if it is available.
   
   If the select menu displays “No change”, there are no firmware updates.

6. Click **Update** at the bottom of the Firmware Update dialog box to start the firmware update.

   When the firmware is updated successfully, the message appears in the Firmware Update dialog box.

7. Close the M960x SFP.

8. Restart your system; Power down the controller, then the chassis, and power up the chassis, then the controller.
Step 5: Verify Operation of the Module

To Perform Self Test

You can perform the self test by using the M960x PXiE Source Measure Unit Soft Front Panel (the M960x SFP).

NOTE
Before performing the self test, turn the instrument output off and disconnect cables from the measurement terminals.

1. Click Start menu > Keysight M960x Source Measure Unit > M960x SFP. The Connect to Instrument dialog box will open.
2. In the list on the window, highlight the M9601A modules to connect, and click Connect to launch the M960x SFP.
3. Confirm that the Access indicator on the M9601A front panel turns green. Refer to Figure 1-1 and Table 1-3 for LED status.
4. Select Self Test... from the Utilities menu. The Self Test dialog box will open.
5. Click Run Self Test at the bottom of the Self Test dialog box to start the self test. When the self test is completed, the results will be displayed in the Self Test dialog box.

NOTE
If the module fails the self test, it will be defective. See “Return the Module for Service” on page 10 to return the modules to Keysight.

CAUTION
Use the module within the rating. If you input a signal above the rating, the module will be damaged.
Front Panel Features

This section describes the connectors and the indicators on the M9601A front panel.

- “LED Indicators”
- “Measurement Terminals”
- “Trigger and Interlock Terminals”

Figure 1-1 M9601A Front Panel
LED Indicators

The M9601A module has two LED indicators, Access and Status. These indicators show the status of the M9601A. See Table 1-3 for the meanings. If the emergency shutdown occurs, both indicators turn red.

Table 1-3 LED Status

<table>
<thead>
<tr>
<th>LED</th>
<th>LED state</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>Solid Green</td>
<td>The module is turned on, the initialization is completed, and the operation is ready.</td>
</tr>
<tr>
<td></td>
<td>Flashing Green</td>
<td>The &quot;Identify PXIe module&quot; feature is on.</td>
</tr>
<tr>
<td></td>
<td>Solid Red</td>
<td>Emergency shutdown occurs.</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>The module is turned off.</td>
</tr>
<tr>
<td>Status</td>
<td>Solid Green</td>
<td>Output is enabled and the output voltage is within ±42 V.</td>
</tr>
<tr>
<td></td>
<td>Solid Yellow</td>
<td>Output is enabled and the output voltage is over ±42 V.</td>
</tr>
<tr>
<td></td>
<td>Solid Red</td>
<td>Emergency shutdown occurs.</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>Output is disabled.</td>
</tr>
</tbody>
</table>

Measurement Terminals

The M9601A has the following measurement terminals. You can make 2-wire connection using the High force and Low force terminals or 4-wire connection (Kelvin connection) using the High force, High sense, Low force and Low sense terminals. The Kelvin connection is effective for high current measurement.

**WARNING**

There are potentially hazardous voltages (±210 V) present at the High force, High sense, and Guard terminals of this instrument. To prevent electrical shock, the following safety precautions must be observed during the use of the instrument.

- Use a three-conductor AC power cord to connect the cabinet (if used) and the instrument to an electrical ground (safety ground).
Front Panel Features

- If an interlock circuit is not installed in your test fixture or connection interface, you must install and connect the interlock circuit that opens the interlock terminal when the shielding box access door is opened.
- If you change the connection interface, test fixture, prober, and such, connect an interlock cable to the one actually used.
- Confirm periodically that the interlock function works normally.
- Before touching the connections on the High force, High sense, and Guard terminals, turn the instrument off and discharge any capacitors. If you do not turn the instrument off, complete all of the following items, regardless of the instrument settings.
  - Disable the output, and confirm that the Status indicator turns off.
  - Confirm that the Status indicator does not turn yellow.
  - Open the fixture cover or the shielding box access door (open interlock).
  - Discharge any capacitors connected to a channel.
- Warn persons working around the instrument about dangerous conditions.

---

**WARNING**

Une tension dangereuse (max. ± pour; 210 Vdc) émanant du dispositif l'instrument peut être sortie aux bornes High force, High sense et Guard. Les précautions suivantes doivent être obserées contre commotion électrique accidentelle.

- Utilisez un cordon d'alimentation CA à trois connecteurs pour connecter la cabine (si utilisée) et l'instrument à la mise électrique à la terre (sol de sécurité).
- Si un circuit de sécurité n'est pas installé dans votre test d'installation ou dans votre interface de connexion, vous devez installer et connecter le circuit de sécurité qui ouvre la borne d'enclenchement lorsque la porte d'accès à la protection de la boîte est ouverte.
- Si vous changez l'interface de connexion, un test d'installation, la sonde, ou toute autre élément, connectez un cordon d'enclenchement à celui utilisé actuellement.
- Vérifiez régulièrement que la fonction de verrouillage fonctionne normalement.
Front Panel Features

- Avant de toucher les connexions des bornes High force, High sense et Guard, éteignez l'instrument et déchargez tous les condensateurs. Si vous n'éteignez pas l'appareil, complétez tous les éléments suivants, indépendamment des réglages de l'appareil.
  - Désactiver la sortie, et confirmez que la LED Status est éteint.
  - Vérifiez que la LED Status ne devienne pas jaune.
  - Ouvrez le couvercle d'appareil ou la protection du boîtier de la porte d'accès (verrouillage ouvert).
  - Déchargez tous les condensateurs connectés au réseau.
  - Déchargez tous les condensateurs connectés au réseau.

⚠️ HF and HS

High force, Low force, and High sense terminals (Triaxial connector)

These connectors are used to connect a device under test (DUT). If you make the 2-wire connection, use the HF connector only, and open the HS connector. The HS connector is used to make the 4-wire connection (Kelvin connection).

Each connector has three conductors: core, inner shield, and outer shield. These conductors are the measurement terminals as shown in the following figure.

CAUTION

Never connect the Guard terminal to any output, including the frame/chassis ground or any other guard terminal. Doing so will damage the M9601A.
Front Panel Features

**LS**  
Low sense terminal (SMB connector)

This connector is used for the 4-wire connection (Kelvin connection). If you make the 2-wire connection, open this connector.

The connector has two conductors: core and shield. These conductors are the measurement terminals as shown in the following figure.

---

**LF and frame/chassis**

Low force terminal and frame/chassis terminal

These terminals are connected together by using the short bar when the M9601A is shipped from the factory. The short bar must be connected to perform the grounded measurement.

If you want to perform the floating measurement, or if you want to connect another instrument’s ground to the Low force, remove the short bar, and leave the terminals open. Then use the Low force terminal on the HF or HS connector to connect the other instrument.

---

**CAUTION**

For the floating measurement, do not apply voltage over ±40 V to the Low force terminal. Failure to heed this caution may result in damage to the M9601A.

---

**CAUTION**

Do not apply current or voltage to the frame/chassis terminal. Doing so will damage the M9601A.
Trigger and Interlock Terminals

The M9601A has the following terminals for the trigger signal input/output and the interlock circuit status detection.

The M9601A has a 6-pin terminal block on the front panel. The pin assignment of the terminal block is shown in Figure 1-1. You can connect these terminals by using a connector-terminal block furnished with the M9601A and ferrule terminal cables such as Keysight PX0101A-001/002 BNC to ferrule terminal cable.

Trig 1 and Trig 2

External trigger 1 and 2 terminals

These terminals are used to make synchronization with other modules or instruments. You can specify the direction (input/output), the polarity (positive/negative), and the pulse width of the trigger signal. The output trigger is push-pull, and the trigger level is 0 V to 3.3 V at high impedance. The input trigger must be the TTL level.

Intlk

Interlock terminals

These terminals are used to connect an interlock circuit which is installed in your test fixture or shielding box. The interlock circuit can be created by using two mechanical switches and wire as shown in Figure 1-5. If the interlock terminals are opened or the interlock circuit is opened, the M9601A output voltage is limited to ±42 V or less as you specified. If you set 0, the interlock function will be same as inhibit control.

For more details, see “Installing Interlock Circuit” on page 29.

CAUTION

Do not connect the interlock terminals to anything other than the interlock circuit. Applying current or voltage to the terminals may damage the M9601A.

WARNING

Dangerous voltage, instrument maximum output voltage may appear at the High force, High sense, and Guard terminals if the interlock terminals are closed or the interlock circuit is closed.

Une tension dangereuse, une tension de sortie maximale de l'appareil peut apparaître aux bornes High force, High sense et Guard si la borne Interlock est fermée.
Connecting a DUT

This section describes how to connect a device under test (DUT) to the M9601A, and includes the following descriptions.

- “2-Wire Connection or 4-Wire Connection”
- “Floating”
- “Guarding”

**WARNING**

To avoid touching the end of the extension cable or the terminal area with the DUT, cover over the conductors with insulator. Also it is important to protect the terminal area by using the grounded shield cover and such.

To prevent electrical shock and DUT damage, do not connect or disconnect the DUT while the instrument is applying voltage or current.

When you touch the DUT after the measurement, devise a countermeasure of residual charge and heat to prevent electrical shock and burn. Use gloves and any tool. Also have enough time for discharge and radiation.

Afin d’éviter de toucher l’extrémité du câble d’allongement ou l’aire de la borne avec l’appareil mis sous tension (MST), couvrez les conducteurs avec l’isolant. En outre, il est important de protéger la zone de la borne en utilisant le couvercle d’écran à la mise à terre, ou tout autre élément.

Afin d’éviter toute décharge électrique et dommage MST, ne branchez ou déconnectez pas la sortie MST alors que la source de sortie est appliquée.

Lorsque vous touchez le MST après la mesure, élaborez une contre-mesure de la charge résiduelle et du chauffage afin d’éviter tout choc électrique et toute brûlure. Utilisez des gants et des outils. Prévoyez également du temps pour la décharge et la radiation.

**NOTE**

Set the instrument output off when changing the connections. If not, the DUT may be damaged.
Connecting a DUT

Connecting the interlock circuit
The M9601A provides an interlock function to prevent the user from receiving an electrical shock from high voltages over the limit which is programmable, within ±42 V. If the interlock terminals are open, the M9601A cannot apply a high voltage.

For high voltage measurement, connect the interlock terminals to the interlock circuit as described in “Installing Interlock Circuit” on page 29.

NOTE
Generally, environmental conditions, such as electromagnetic environment, have a negative impact on the performance of the instrument. Use coaxial cables and shielding technique to minimize the impact.

2-Wire Connection or 4-Wire Connection
When connecting a device under test (DUT), you can choose the connection type either 2-wire connection or 4-wire connection.

If you want to simplify the connections, use 2-wire connection by connecting the force terminals only, while the sense terminals will remain open.

To make 4-wire connection, well known as Kelvin connection, use both force and sense terminals. Connecting the force and sense lines together at the terminal of the DUT minimizes the measurement error by the residual resistance of the test leads or cables. This connection is effective for low resistance measurements and high current measurements.
Connecting a DUT

Figure 1-2  Simplified SMU Circuit Diagram

2-wire connection

Frame/chassis

4-wire connection

Frame/chassis

Figure 1-3  2-Wire Connection and 4-Wire Connection
Connecting a DUT

Floating

When the M9601A is shipped from the factory, the Low force terminal is connected to the frame/chassis terminal by using the short bar. The short bar must be connected to perform the grounded measurement.

If you want to perform the floating measurement or if you want to connect another instrument's ground to the Low force, remove the short bar, and leave the terminals open. Then use the Low force terminal on the HF or HS connector to connect the other instrument.

---

**CAUTION**

For the floating measurement, do not apply voltage over \( \pm 40 \) V to the Low force terminal. Doing so will damage the M9601A.

---

**CAUTION**

Do not apply current or voltage to the frame/chassis terminal. Doing so will damage the M9601A.

---

**WARNING**

To prevent electrical shock, do not touch any of measurement circuit at any time while a floating measurement is in progress. Also use accessories that comply with IEC 61010-031. All terminals and the extended conductors must be isolated by using insulation caps, sleeves, etc.

Afin d'éviter toute décharge électrique, ne touchez aucune mesure de circuit à tout moment lorsque la mesure de flotte est en cours. Utiliser également des accessoires qui sont conformes à la norme IEC 61010-031. Toutes les bornes et les conducteurs prolongés doivent être isolés en utilisant des bouchons d'isolation, des manchons, etc.

---

Guarding

Guarding reduces the leakage current between the instrument and a DUT. This is important when you perform low current measurements.

The overview of the guard technique for the grounded measurement is shown in Figure 1-4. The guard shield is necessary to prevent the leakage current in the measurement environment: extension cable, test fixture, shielding box, and so on. So it is important to use a triaxial cable such as Keysight PX0102A-001 Low noise triaxial cable (1.5 m). The buffer amplifier keeps the potential of the Guard (inner
Connecting a DUT

shield of triaxial cable) at the same potential as the High force (core), so that the current does not flow between the core and the inner shield. Therefore ideally, the current measured by the instrument is the same as the current at the DUT terminal because there is no leakage current. For several connection examples such as the floating measurement, refer to the configuration guide (5992-4193EN).

Figure 1-4 Guard Technique for Grounded Measurement

NOTE

Low force signal comes from the outer shield of the HF connector. In the grounded measurement, the outer shield of the triaxial connector must be electrically isolated from the shield of your test fixture or shielding box. Do not connect the outer shield to anything other than the low terminal of DUT.

CAUTION

Never connect the guard shield to any output, including the frame/chassis ground or any other guard terminal. Doing so will damage the M9601A.
Installing Interlock Circuit

The interlock circuit is a simple electric circuit as shown in Figure 1-5. The circuit electrically opens when the access door is opened, and closes when the door is closed.

The M9601A module cannot apply high voltage over the limit when the interlock terminals are open. The limit value is programmable, within ±42 V. To perform high voltage measurements, the M9601A interlock terminals must be connected to the interlock circuit installed in the measurement environment such as the shielding box. The interlock circuit is important and necessary to prevent electrical shock when the user touches the measurement terminals.

Figure 1-5  Interlock Circuit

<table>
<thead>
<tr>
<th>Shielding box</th>
<th>Access door</th>
<th>Mechanical switches</th>
<th>Connector-termination block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BNC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ferrule terminal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interlock high</td>
<td>Keysight PX0101A-001 or equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interlock low</td>
<td>Insulator</td>
</tr>
</tbody>
</table>

**WARNING**

Hazardous voltage, instrument maximum output voltage may appear at the High force, High sense, and Guard terminals if the interlock terminal is closed. To prevent electrical shock, do not expose these lines.

Une tension dangereuse, une tension de sortie maximale de l'appareil peut apparaître aux bornes High force, High sense et Guard si le couvercle de l'équipement est fermé. Afin d'éviter toute décharge électrique, n'exposez pas ces lignes.
Installing Interlock Circuit

**CAUTION**

Do not connect the interlock terminals to anything other than the interlock circuit. Applying current or voltage to the terminals may damage the M9601A.

**Requirements**
- Mechanical switch (Keysight N1254A-402 or equivalent), 2 ea.
- Connector-terminal block 2.5 mm 6-terminal, 1 ea.
- BNC to ferrule terminal cable (Keysight PX0101A-001 (1.5 m), PX0101A-002 (3.0 m), or equivalent), 1 ea.
- BNC connector (jack to soldering terminals), 1 ea.
- Connection wires

**Procedure**
1. Mount two mechanical switches onto your shielding box, so that the switches close when the access door is closed, and open when the access door is opened. See Figure 1-6 for the switch dimensions.
2. Mount a BNC connector onto your shielding box. Be sure that the outer shield of the BNC connector is electrically isolated from the shielding box.
3. Use a wire, and connect the two switches in series between the soldering terminals of the BNC connector as shown in Figure 1-5.
4. Connect the connector-terminal block to the M9601A.
5. Connect the BNC to ferrule terminal cable to the interlock terminals of the M9601A.
6. Connect the BNC to ferrule terminal cable to the BNC connector on the shielding box.

You can also connect the mechanical switches directly to the connector-terminal block by using connection wires and ferrule terminals.
Installing Interlock Circuit

Figure 1-6 Dimension of the Interlock Switch (Keysight N1254A-402)

Units: mm
Maintenance

This section describes the maintenance tasks of the M9601A.

• “Cleaning”
• “Self Test”
• “Self Calibration”
• “Calibration”

Cleaning

To prevent electrical shock, disconnect the chassis from the mains before cleaning.

Use a dry soft cloth or a soft cloth slightly dampened with water or a mild soap and water solution to clean the external surfaces of the chassis, modules, and accessories. Do not use detergents or chemical solvents.

Do not attempt to clean internally.

To clean the connectors, use alcohol in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to energizing the instrument.

**WARNING**

**SHOCK HAZARD**

To avoid any risk of electric shock, unplug the PXIe chassis before cleaning.

**RISQUE D’ÉLECTROCUTION**

Pour éviter tout risque de choc électrique, débranchez le châssis PXIe avant le nettoyage.

---

**CAUTION**

Do not use too much liquid in cleaning the PXIe chassis. Water can enter the PXIe chassis panels and damage sensitive electronic components. Make sure that the PXIe chassis is completely dry before reconnecting the power cord.
Self Test

Keysight M9601A provides the self test function to check the operation. It is recommended to perform the self test for the following condition or purpose.

- If emergency shutdown occurs.
  In this condition, both the Access and Status indicators turn red. The shutdown condition will be solved after passing the self test.
- If you feel that the instrument may be defective.
- For preventive maintenance.

**NOTE**
Before performing the self test, turn the instrument output off and disconnect cables from the measurement terminals.

To perform self test
See “To Perform Self Test” on page 17.

Self Calibration

Keysight M9601A provides the self calibration function to maintain the measurement performance. If the environmental temperature changes ±5 °C or more, perform the self calibration. This is effective for the accurate measurements by minimizing the effect of thermal drift. The self calibration must be performed after warming-up of 40 minutes.

**NOTE**
Before performing the self calibration, turn the instrument output off and disconnect cables from the measurement terminals.

To perform self calibration
1. Click Start menu > Keysight M960x Source Measure Unit > M960x SFP. The Connect to Instrument dialog box will open.
2. From the list on the window, highlight the M9601A modules to connect and click Connect to launch the Keysight M960x Source Measure Unit Soft Front Panel.
3. Confirm that the Access indicator on the M9601A front panel turns green. Refer to Figure 1-1 and Table 1-3 for LED status.
Maintenance

4. Select **Self Calibration**... from the Utilities menu on the soft front panel to open the Self calibration dialog box.

5. Click **Run Self Cal.**.

Calibration

Calibration and adjustments must be performed periodically so that the instrument can meet its specifications, and keep good condition. It is recommended to perform the calibration once a year at least. For the calibration and adjustments, contact Keysight Technologies. Trained service personnel will perform the calibration and adjustments.