

Model 4200A-SCS Parameter Analyzer

User's Manual

4200A-900-01 Rev. A / September 2016



S J ELECTRONICS
POWER • TEST & MEASUREMENT

☎ 0800 583 4455
✉ sales@sjelectronics.co.uk

VISIT ➡
WEBSITE



4200A-900-01A

A Greater Measure of Confidence

KEITHLEY
A Tektronix Company

Model 4200A-SCS

Parameter Analyzer

User's Manual

© 2016, Keithley Instruments

Cleveland, Ohio, U.S.A.

All rights reserved.

Any unauthorized reproduction, photocopy, or use of the information herein, in whole or in part, without the prior written approval of Keithley Instruments is strictly prohibited.

All Keithley Instruments product names are trademarks or registered trademarks of Keithley Instruments. Other brand names are trademarks or registered trademarks of their respective holders.

Actuate®

Copyright © 1993-2003 Actuate Corporation.

All Rights Reserved

Document number: 4200A-SCS-900-01 Rev. A / September 2016

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.


For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.


When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.


If a  screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of danger. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means caution, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F) ; and pollution degree 1 or 2.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of March 2016.

Table of contents

- Introduction..... 1-1**
 - Welcome 1-1
 - Introduction to this manual 1-1
 - Extended warranty 1-1
 - Contact information 1-2
 - USB flash drive contents 1-2
 - Organization of manual sections 1-2
 - Application examples 1-3
 - General ratings 1-3

- Getting started 2-1**
 - Front panel overview 2-1
 - Touch screen basics 2-3
 - Connect a keyboard and mouse 2-3
 - Rear panel overview 2-5
 - Connect an external monitor 2-6
 - Installation 2-6
 - Locating the system 2-7
 - Basic system connections 2-8
 - SMU connections 2-11
 - Powering the 4200A-SCS 2-16

- Create a new project and test 3-1**
 - Introduction 3-1
 - Equipment required 3-1
 - Device connections 3-2
 - Connection schematic 3-2
 - Connect the 4200A-SCS to the DUT 3-3
 - Set up the measurements in Clarius 3-3
 - Select and rename a new project 3-3
 - Add a device 3-5
 - Select a custom test 3-6
 - Configure the test 3-6
 - Execute the test 3-8
 - View and analyze the test results 3-8

- Use the RPM to switch the SMU, CVU, and PMU 4-1**
 - Introduction 4-1
 - Update the RPM configuration in KCon 4-1
 - Equipment required 4-2
 - Device connections 4-2

Connection schematic.....	4-3
Connect the 4200A-SCS to the DUT.....	4-4
Set up the measurements in Clarius.....	4-4
Create a new project.....	4-5
Add a device.....	4-6
Search for and select existing tests in the Test Library.....	4-7
Configure the test.....	4-8
Run the test.....	4-16
Analyze the results.....	4-17
Configure and use a Series 700 Switching System.....	5-1
Introduction.....	5-1
Equipment required.....	5-2
Device connections.....	5-2
Connect the 7072 to the DUT.....	5-3
Connect the 4200A-SCS to the 7072.....	5-4
Update the switch configuration in KCon.....	5-6
Set up the measurements in Clarius.....	5-10
Make I-V measurements on a solar cell.....	6-1
Introduction.....	6-1
Equipment required.....	6-1
Device connections.....	6-2
Device connection schematic.....	6-2
Connect the 4200A-SCS to the DUT.....	6-3
Setting up measurements in the Clarius software.....	6-4
Create a new project.....	6-4
Search for and select a test.....	6-5
Configure the test.....	6-5
Execute the test.....	6-7
Analyze the test results.....	6-8
Additional tests.....	6-9
Make C-V measurements on a MOSCAP.....	7-1
Introduction.....	7-1
Equipment required.....	7-1
Device connections.....	7-1
Connect the 4200A-SCS to the DUT.....	7-2
Set up the measurements in Clarius.....	7-3
Search for and select a project.....	7-3
Configure the test.....	7-4
Perform offset compensation.....	7-8
Run the test.....	7-11
View and analyze the test results.....	7-12
Use the 4200A-CVIV Multi-Switch.....	8-1
Introduction.....	8-1

Equipment required	8-1
Device connections	8-2
Connection schematic	8-3
Set up the measurements in Clarius	8-4
Create and rename a project for I-V and C-V measurements with compensation.....	8-4
Add an action to perform CVU compensation	8-5
Configure the action	8-5
Add a device	8-7
Add an action for switching the SMUs to the device	8-8
Configure the action	8-8
Add a test for making I-V measurements	8-9
Add an action for switching the CVU to the output terminals of the 4200A-CVIV	8-10
Configure the action	8-11
Add a test for making C-V measurements	8-12
Run the project and review the results	8-15
PMU for pulsed I-V measurements on a MOSFET	9-1
Introduction	9-1
Equipment required	9-1
Device connections	9-2
Connection schematic	9-3
Set up the measurements in Clarius	9-4
Create a new project	9-4
Search for and select an existing test	9-5
Configure the test	9-6
Run the test and analyze the results	9-8
Next steps	10-1
Additional information	10-1
Index	1

Introduction

In this section:

Welcome	1-1
Introduction to this manual	1-1
Extended warranty	1-1
Contact information	1-2
USB flash drive contents	1-2
Organization of manual sections	1-2
Application examples	1-3
General ratings.....	1-3

Welcome

Thank you for choosing a Keithley Instruments product. The Model 4200A-SCS Parameter Analyzer performs laboratory-grade DC, I-V, C-V, and pulse device characterization, real-time plotting, and analysis with high precision and subfemtoamp resolution. The 4200A-SCS offers the most advanced capabilities available in a fully-integrated characterization system, including a complete, embedded computer with Microsoft Windows® operating system and mass storage. Its touchscreen interface accelerates and simplifies the process of taking data, so users can begin analyzing their results sooner. Additional features enable stress-measure capabilities suitable for a variety of reliability tests.

Introduction to this manual

This manual provides detailed applications to help you achieve success with your Keithley Instruments 4200A-SCS. In addition, information is provided about the basics of the front panel to familiarize you with the instrument. Finally, included is an overview of each application, followed by instructions to complete the application.

More information about the commands that are used in these applications is available. Refer to the *Model 4200A-SCS Reference Manual*, available from the Learning Center on your 4200A-SCS desktop.

Extended warranty

Additional years of warranty coverage are available on many products. These valuable contracts protect you from unbudgeted service expenses and provide additional years of protection at a fraction of the price of a repair. Extended warranties are available on new and existing products. Contact your local Keithley Instruments office, sales partner, or distributor for details.

Contact information

If you have any questions after you review the information in this documentation, please contact your local Keithley Instruments office, sales partner, or distributor. You can also call the corporate headquarters of Keithley Instruments (toll-free inside the U.S. and Canada only) at 1-800-935-5595, or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the [Keithley Instruments website](http://www.tek.com/keithley) (<http://www.tek.com/keithley>).

USB flash drive contents

Each 4200A-SCS instrument is shipped with a USB flash drive that includes the software and the product information documents.

The 4200A-SCS Product Information USB drive contains:

- **Quick Start Guide:** Provides unpacking instructions, describes basic connections, reviews basic operation information, and provides a quick test procedure to ensure the instrument is operational.
- **User's Manual:** Provides application examples that you can use as a starting point to create your own applications.
- **Reference Manual:** Includes advanced operation topics, maintenance information, troubleshooting procedures, and in-depth descriptions of programming commands.
- **Accessories information:** Documentation for accessories that are available for the 4200A-SCS.

For the latest drivers and additional support information, see the [Keithley Instruments website](http://www.tek.com/keithley) (<http://www.tek.com/keithley>).

Organization of manual sections

This manual is organized into the following sections:

- [Introduction](#) (on page 1-1): Provides an overview of the 4200A-SCS and this manual.
- [Getting started](#) (on page 2-3): Provides high-level guidance on how to install, connect, and power up the 4200A-SCS.
- [Application examples](#) (on page 3-1): Provides detailed examples of how to use the 4200A-SCS in some typical situations.
- [Next steps](#) (on page 10-1): Provides information about additional resources that can help you use the 4200A-SCS.

This manual is also available from the Learning Center, which you can access from your 4200A-SCS desktop.

The PDF version of this manual contains bookmarks for each section. The manual sections are also listed in the Table of Contents at the beginning of this manual.

For more information about bookmarks, see Adobe® Acrobat® or Reader® help.

Application examples

This manual provides application examples that show you how to perform tests from the front panel and over a remote interface. The applications include:

- [Create a new project and test](#) (on page 3-1)
- [Use the RPM to switch the SMU, CVU, and PMU](#) (on page 4-1)
- [Configure and use a Series 700 Switching System](#) (on page 5-1)
- [Make I-V measurements on a solar cell](#) (on page 6-1)
- [Make C-V measurements on a MOSCAP](#) (on page 7-1)
- [Use the 4200A-CVIV Multi-Switch](#) (on page 8-1)
- [PMU for pulsed I-V measurements on a MOSFET](#) (on page 9-1)

NOTE

The default settings used for the devices, tests, and projects in Clarius are generally sufficient to produce usable data when executing a test. However, you may have additional settings you want to apply when you configure your measurements.

General ratings

The 4200A-SCS instrument's general ratings and connections are listed in the following table.

Category	Specification
Supply voltage range	100 V _{RMS} to 240 V _{RMS} , 50 Hz or 60 Hz
Current rating	1000 VA
Input and output connections	See Front panel overview (on page 2-1) and Rear panel overview (on page 2-4).
Environmental conditions	<p>For indoor use only</p> <p>Temperature range: Operating: 10 °C to 40 °C (50 °F to 104 °F) Storage: -15 °C to 60 °C (5 °F to 140 °F)</p> <p>Humidity range: Operating: 5 % to 80 % RH, non-condensing Storage: 5 % to 90 % RH, non-condensing</p> <p>Altitude Operating: 0 to 2000 m (0 to 6252 ft) Storage: 0 to 4600 m (0 to 150925 ft)</p> <p>Pollution degree: 1 or 2</p>

Getting started

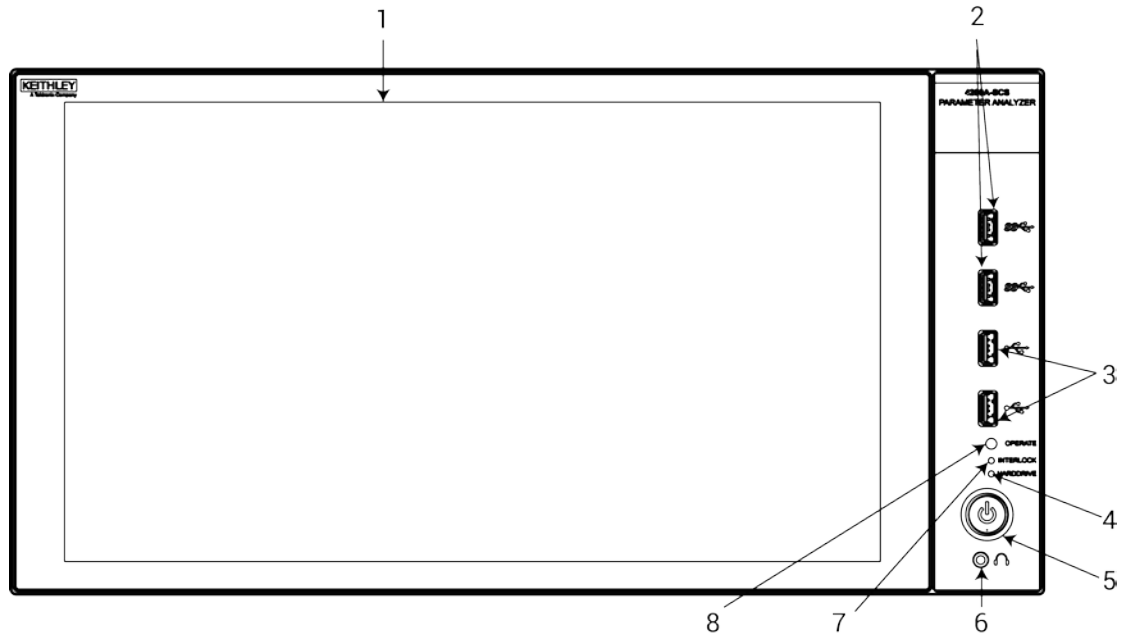
In this section:

Front panel overview	2-1
Rear panel overview	2-4
Installation.....	2-6

Front panel overview

Most of your controls and interfaces are on the front panel of the 4200A-SCS Parameter Analyzer. The next figure shows the front panel of the 4200A-SCS. The components are summarized following the figure.

Figure 1: 4200A-SCS front panel



1	Display	A 1920 p x 1080 p resolution, touch-screen display.
2	Two v3.0 USB ports	Allows you to connect to peripherals such as flash drives, pointing devices, scanners, and external hard drives that are compatible with the USB v3.0 standard.
3	Two v2.0 USB ports	Allows you to connect to peripherals such as flash drives, pointing devices, scanners, and external hard drives that are compatible with the USB v2.0 standard.
4	Hard drive indicator	Illuminates when the hard drive is being accessed.
5	Power switch	Turns the main system power on or off.
6	Headphone connector	Provides a 1/8" stereo output connection.
7	Interlock indicator	Illuminates when the 12 VDC interlock circuit is closed.
8	Operate indicator	Illuminates when any internal cards are energized.

NOTE

4200A-SCS-ND has no display and requires an external monitor.

Touch screen basics

You can operate the 4200A-SCS using the touch screen. You can use your fingers, clean room gloves, or a stylus.

To select and move on the screen:

- To scroll, swipe up or down on the screen.
- To select an item, touch it on the screen.
- To double-click an item, touch it twice.
- To right-click an item, touch and hold, then release to see the options.

To enter information, you can use the on-screen keyboard. Swipe from the left side of the display to open the keyboard.

The touch screen uses standard Microsoft® Windows® touch actions. For additional information on the actions, refer to the Microsoft help information, available from the on-screen keyboard window menu option **Tool > Help Topics**.

You can also adjust the touch settings using the Pen and Touch options in the Windows Control Panel.

Connect a keyboard and mouse

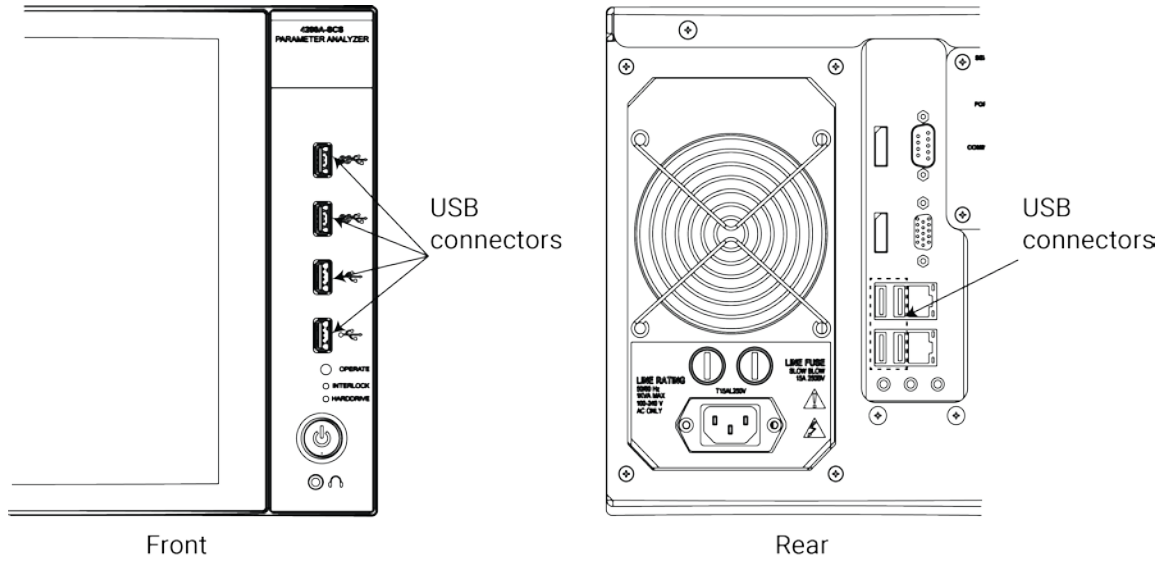
Connect the keyboard to the 4200A-SCS with a USB cable. You can plug it into any of the eight USB ports. The keyboard is shown in the next figure. To ensure proper operation, be sure that the keyboard is connected before power-up.

Figure 2: 4200A-SCS keyboard



If you want to use an optional mouse, connect a USB mouse to any of the 4200A-SCS USB ports.

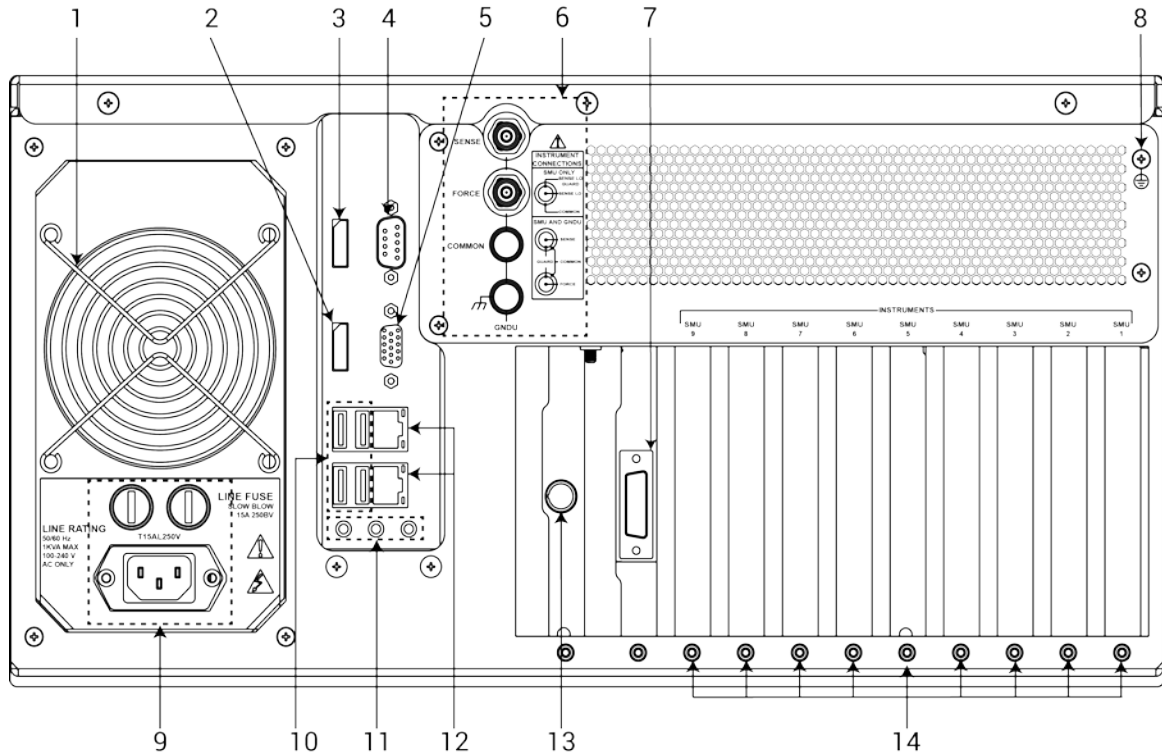
Figure 3: Keyboard connections



Rear panel overview

The following figure shows the rear panel of the 4200A-SCS. The connectors and components are summarized following the figure.

Figure 4: 4200A-SCS rear panel



1	Fan	Provides system cooling.
2	DP port	Provides a standard DisplayPort connection.
3	HDMI port	Provides a standard High Definition Multimedia Interface (HDMI®) connection.
4	Serial port	Connects to an RS-232 peripheral.
5	External monitor port	15-pin video connector.
6	Ground unit	Provides system-level SENSE, FORCE, and COMMON connections.
7	IEEE-488 connector	Connects to peripherals with a GPIB interface.
8	Grounding screw	Connects to protective earth (safety ground)
9	Power receptacle and line fuses	Connects to line power through supplied line cord. Two line fuses protect the instrument.
10	Four v3.0 USB connectors	Allows you to connect to peripherals such as keyboards, pointing devices, printers, flash drives, external hard drives, and printers that are compatible with the USB v3.0 standard.
11	Microphone and speaker connectors	Provides microphone, left speaker, and right speaker connections.
12	Two LAN connectors	Two gigabit LAN connectors interface the unit to ethernet local networks.

13	12 VDC interlock connector	Connects the instrument to a test fixture or prober interlock circuit.
14	Nine instrument slots	Support the factory-installed SMU, CVU, and PMU/PGU cards.

Connect an external monitor

You can connect an external monitor to the 4200A-SCS. For best results, use a 1920x1080p HD monitor to maintain the correct resolution when using the Clarius application.

Installation

This section contains information about handling and installing the 4200A-SCS:

- **Locating the system:** Describes how to select the best operating environment location for your 4200A-SCS.
- **Basic system connections:** Explains how to connect the grounding cable, LAN cable, GPIB-compatible instruments, and the safety interlock to the 4200A-SCS.
- **SMU connections:** Describes the easiest method to make SMU connections to the device under test (DUT).
- **Powering the 4200A-SCS:** Describes line power requirements for the 4200A-SCS, and shows how to connect the power line cord.

CAUTION

When you start one of the Clarius+ software tools for the first time, you are required to respond affirmatively to an on-screen license agreement before proceeding further. If you do not respond, your system will not function until you reinstall the software.

NOTE

The condensed installation information in this section is intended to get your 4200A-SCS set up and ready to turn on as quickly as possible. Detailed information on connections is provided in the *Model 4200A-SCS Reference Manual*.

Locating the system

Locate the 4200A-SCS so that it will operate within the following ambient temperature and humidity limits:

- Temperature: +10 °C to +40 °C
- Relative humidity: 5 % to 80 %, non-condensing

NOTE

SMU and preamplifier accuracy specifications are based on operation at 23 °C \pm 5 °C and between 5 % and 60 % relative humidity. See the 4200A-SCS datasheet at the [Keithley Instruments website \(http://www.tek.com/keithley\)](http://www.tek.com/keithley) for derating factors outside these ranges.

CAUTION

To avoid overheating, operate the instrument only in an area with proper ventilation. Allow at least eight inches of clearance at the back of the mainframe to assure sufficient airflow and comply with the following guidelines:

Operate the instrument in a clean, dust-free environment.

Keep the fan vents and cooling vents from becoming blocked (sides and rear of the instrument).

Do not position any devices adjacent to the instrument that force air (heated or unheated) into cooling vents. This additional airflow could compromise accuracy performance.

When rack-mounting the instrument, ensure adequate airflow around the sides, bottom, and back.

Do not rack-mount high power dissipation equipment adjacent to the 4200A-SCS.

To ensure proper cooling in rack environments with only convection cooling, place the hottest equipment (for example, power supply) at the top of the rack. Place precision equipment, such as the 4200A-SCS, as low as possible in the rack, where temperatures are the coolest. Adding spacer panels below the instrument helps to ensure adequate airflow.

Basic system connections

This section provides basic system connections to get your 4200A-SCS set up and running. More detailed connection information is in the "Connections and configuration" section of the *Model 4200A-SCS Reference Manual*.

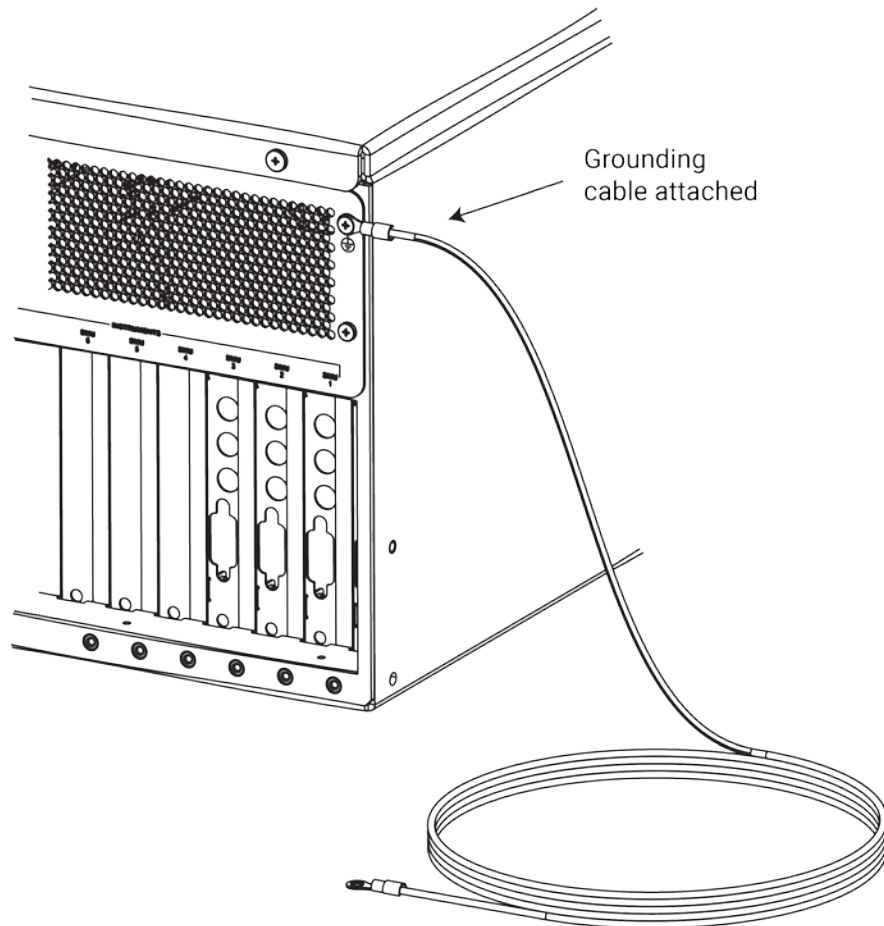
Connecting to protective earth

⚠ WARNING

The 4200A-SCS must be connected to protective earth (safety ground) using the supplied green-yellow ground cable.

Connect one lugged end of the supplied grounding cable to the protective earth (safety ground) screw on the rear of your 4200A-SCS. See the next figure.

Figure 5: Grounding cable connected to the rear of the 4200A-SCS

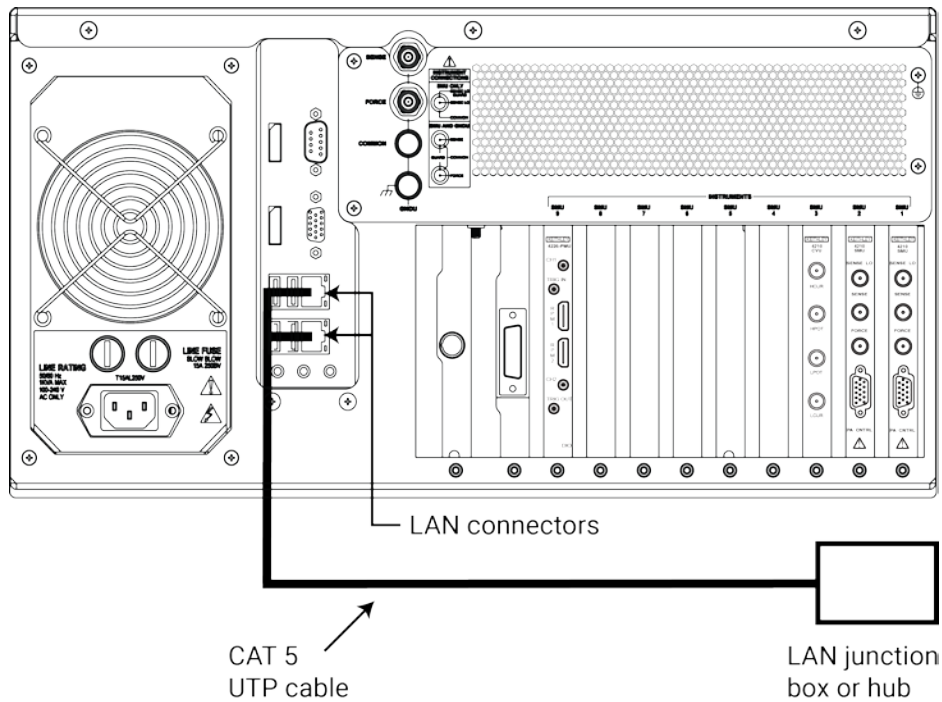


Connecting a LAN cable

The two LAN connectors on the 4200A-SCS are standard RJ-45 connectors intended for use with unshielded twisted pair (UTP) cable. For best results, use only CAT 5 UTP cables equipped with RJ-45 connectors to connect your LANs, as shown in the following figure.

If IP addresses are statically assigned, you need to assign a different IP address to each LAN port.

Figure 6: LAN connections

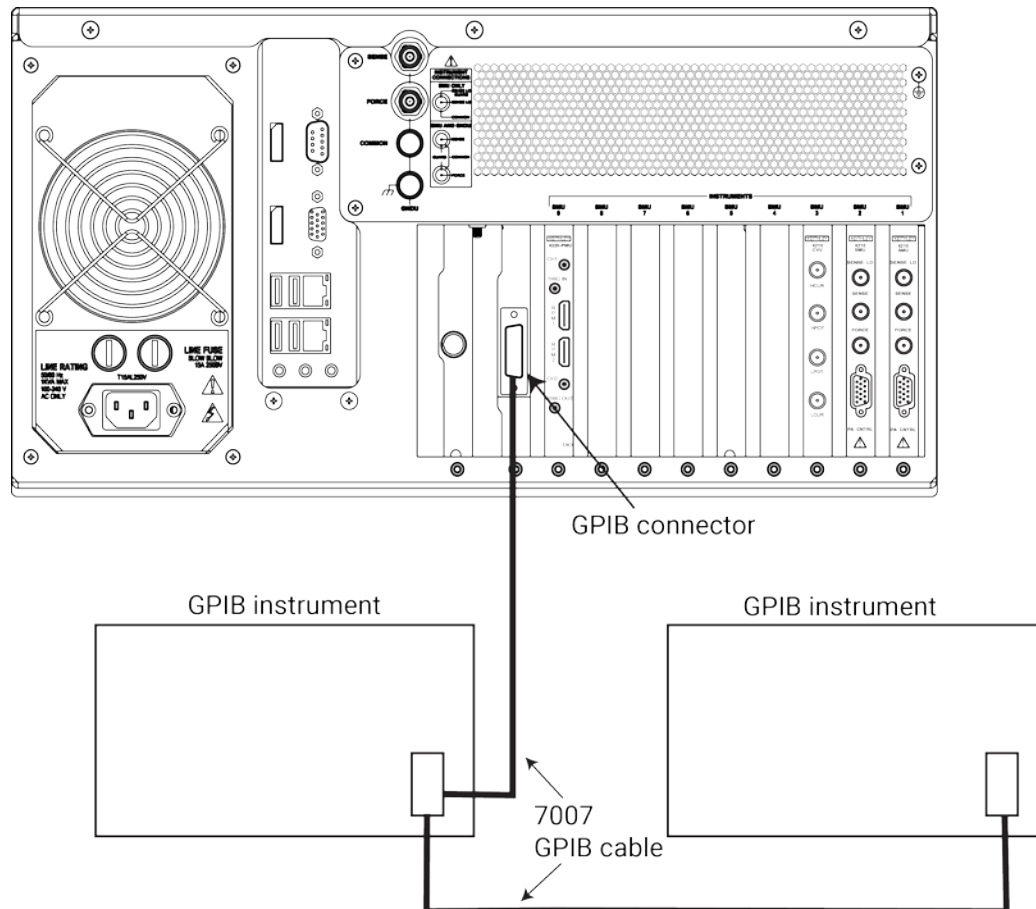


Connecting GPIB instruments

You can use the 4200A-SCS to control one or more external instruments using the IEEE-488 general purpose instrument bus (GPIB). An example of typical instruments used in a test system with the 4200A-SCS are a switching system and an external C-V meter.

The following figure shows how to connect GPIB instruments to the 4200A-SCS.

Figure 7: 4200A-SCS GPIB instrument connections



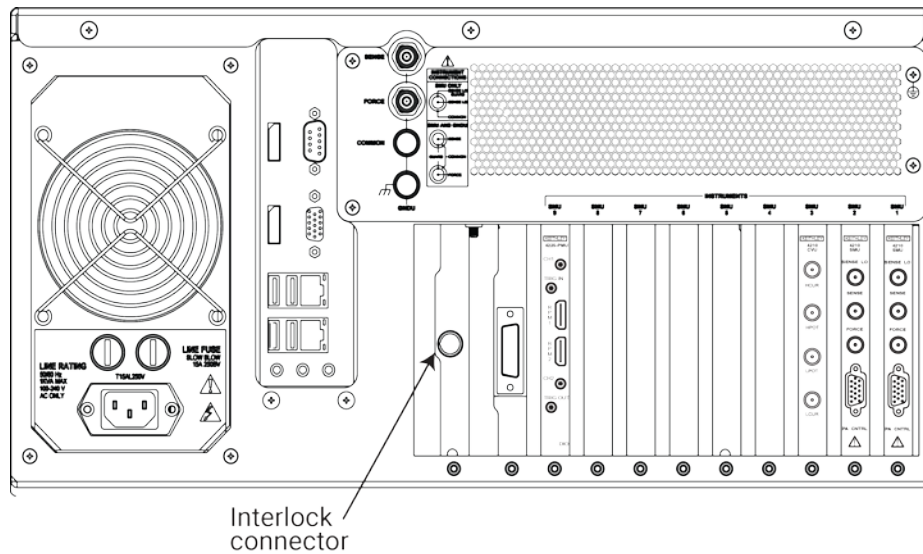
Connecting the interlock

The next graphic shows the location of the interlock connector on the rear panel of the 4200A-SCS.

To connect the interlock:

1. Connect one end of the supplied 236-ILC-3 interlock cable to the interlock connector on the rear panel of the 4200A-SCS rear panel (see the next figure).

Figure 8: Interlock connector on the rear panel of the 4200A-SCS



2. Connect the other end of the interlock cable to a compatible test fixture, such as the Keithley Instruments LR:8028.

For more information, see the "Configuring the safety interlock" topic in the *4200A-SCS Reference Manual*.

SMU connections

The following topics explain how to connect the source-measure units (SMUs) to the device under test (DUT).

⚠ WARNING

Do not touch test cables or connectors when powering up the 4200A-SCS. Hazardous voltage may be output momentarily, posing a safety hazard that could result in personal injury or death.

Do not turn on the 4200A-SCS until you have reviewed the safe power-up procedure in [Powering the 4200A-SCS](#) (on page 2-16).

⚠ CAUTION

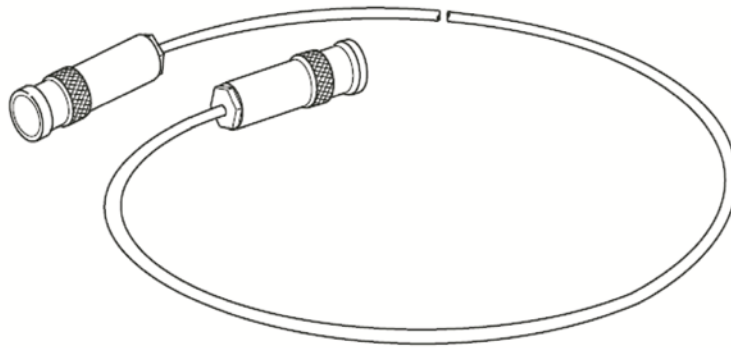
Do not connect the DUT to the 4200A-SCS before powering it up, because the hazardous voltage that may be output momentarily at power-up could damage the DUT.

If your 4200A-SCS includes preamplifiers, all tests should be performed using the preamplifiers, as the installed SMUs were optimized at the factory to use them.

Triaxial cables

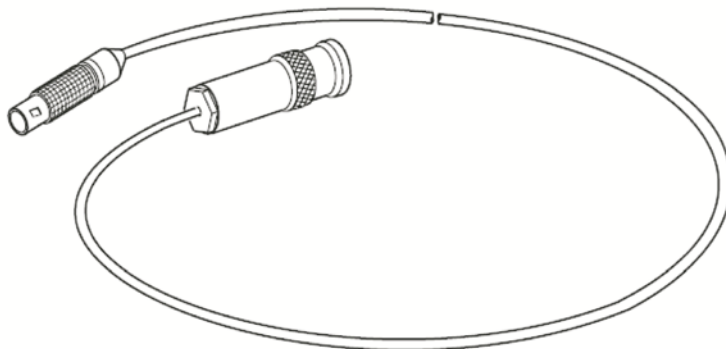
Triaxial cables are supplied to make connections to the DUT (device under test). With preamplifiers installed, use the low-noise triaxial cables, which are terminated with 3-slot triaxial connectors on both ends. One end of the cable connects to the preamplifier and the other end connects to the DUT test fixture or probe station.

Figure 9: Triaxial cable 4200-TRX-X



If your system does not have preamplifiers installed, use the cables that have a miniature triaxial connector on one end and a standard 3-slot triaxial connector on the other end. The cable end that is terminated with the miniature connector connects directly to the SMU, and the other end connects to the test fixture or probe station.

Figure 10: Triaxial cable 4200-MTRX-X



CAUTION

With preamplifiers installed, NEVER make connections directly to any of the miniature triaxial connectors on the SMU modules. This may result in damage to the SMU or DUT or may produce corrupt data.

Basic connections

The simplest method to connect SMUs to the device under test (DUT) is to use one SMU for each terminal of the device. When setting up a test, the FORCE terminal (center conductor) of the SMU is used to apply voltage or current to the device. The FORCE terminal or ground unit can also be used to connect the device terminal to the COMMON circuit.

NOTE

Complete details on connections (including SENSE terminal connections) are provided in the "Connections and configuration" section of the *Model 4200A-SCS Reference Manual*.

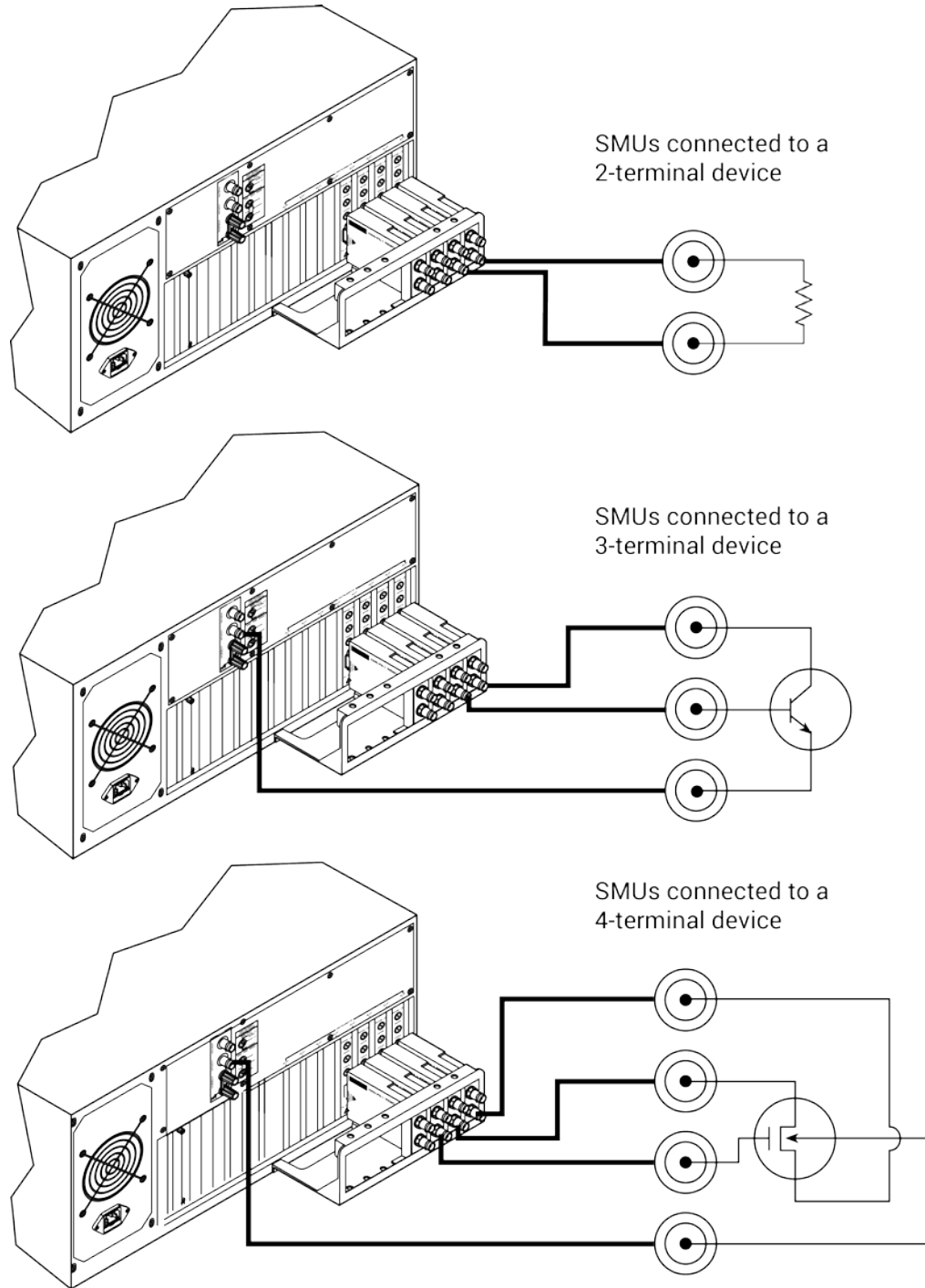
The next figure shows SMU connections to 2-terminal, 3-terminal, and 4-terminal devices. Notice that only the FORCE HI terminal of the SMUs is connected to the device terminals. FORCE HI is the center conductor of the triaxial cable.



CAUTION

Connecting the SMU or ground unit SENSE terminal without the FORCE terminal may damage the instrument and give erroneous results.

Figure 11: SMU (with preamplifiers) connections to DUT



Mounting preamplifiers in a probe station

You can mount the preamplifiers remotely on a probe station using an optional mounting kit. Follow the steps below to mount and connect a remote preamplifier on a probe station. Details are provided in the documentation provided with the mounting kit.

Three remote preamplifier mounting options are available:

- **4200-MAG-BASE:** A magnetic base for mounting a preamplifier onto a probe station platen.
- **4200-VAC-BASE:** A vacuum base for mounting a preamplifier onto a probe station platen.
- **4200-TMB:** A triaxial mounting bracket option for mounting a preamplifier onto a probe station or onto the triaxial mounting panel of a test fixture.

NOTE

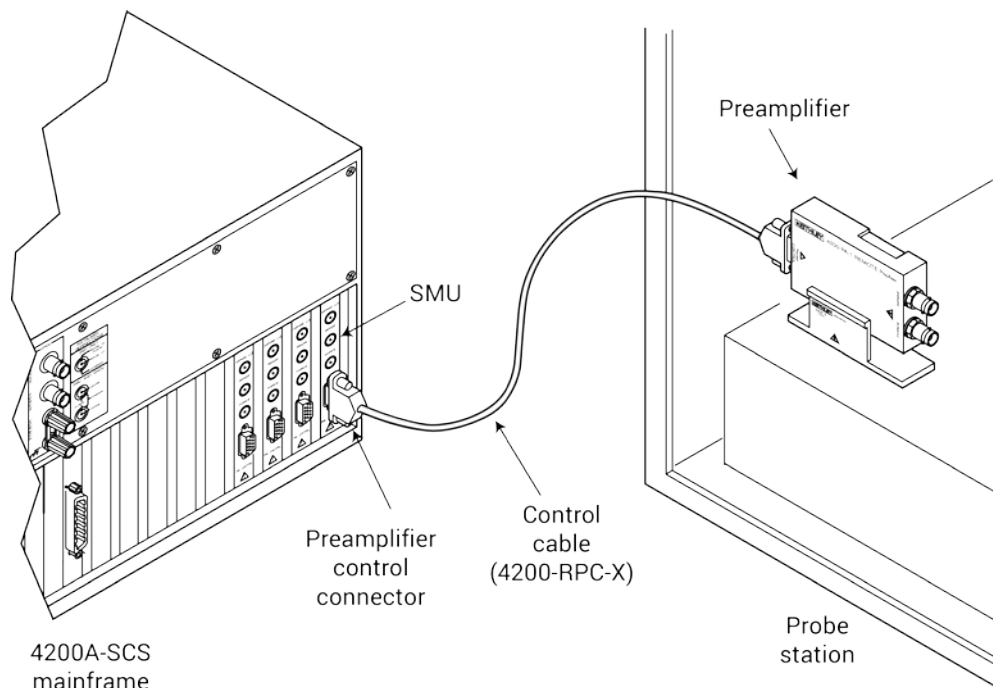
Each preamplifier is matched to the SMU it is connected to. When you disconnect the preamplifiers to mount them to a probe station, make sure to reconnect each one to its matching SMU.

To mount a preamplifier onto a probe station:

1. Turn off the system power for the 4200A-SCS from the front panel.
2. Disconnect the preamplifiers from the rear panel of the 4200A-SCS. They are secured to the rear panel by a mounting bracket.
3. Mount the preamplifier at the remote location using the appropriate mounting kit.
4. Connect the control cable between the preamplifier control connector on the preamplifier and the PA CNTRL connector on the SMU.
5. Make sure that the connecting cable is secure at both ends.

For additional preamplifier details, see the *Model 4200A-SCS Reference Manual*.

Figure 12: Installing a preamplifier on the probe station



Powering the 4200A-SCS

⚠ CAUTION

Operating the instrument on an incorrect line voltage may cause damage, possibly voiding the warranty.

⚠ WARNING

The power cord supplied with the 4200A-SCS contains a separate protective earth (safety ground) wire for use with grounded outlets. When proper connections are made, the instrument chassis is connected to power-line ground through the ground wire in the power cord. In the event of a failure, not using a properly grounded protective earth and grounded outlet may result in personal injury or death due to electric shock.

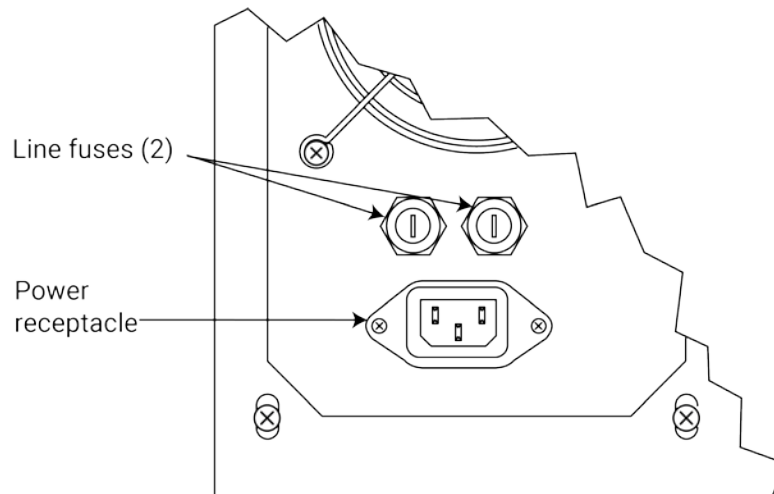
Do not replace detachable mains supply cords with inadequately rated cords. Failure to use properly rated cords may result in personal injury or death due to electric shock.

The 4200A-SCS operates from a line voltage in the range of 100 VAC to 240 VAC, at a frequency of 50 Hz or 60 Hz. Line voltage is automatically sensed, but line frequency is not.

To connect and power the unit:

1. Check to be sure that the operating voltage in your area is compatible.
2. Connect the female end of the supplied power cord to the AC receptacle on the rear panel. See the [Rear panel overview](#) (on page 2-4) for details.

Figure 13: Line power receptacle



3. Connect the other end of the supplied line cord to a grounded AC line power receptacle.
4. Turn the power ON using the front-panel power switch.

NOTE

Although the instrument does not sense power line frequency at power-up, Keithley ships your 4200A-SCS with line frequency settings that match the line frequency that was specified on the order — either for 50 Hz or 60 Hz. However, if necessary, you can change the line frequency setting using the KCon utility. Refer to the Keithley Configuration Utility (KCon) section in the *Model 4200A-SCS Reference Manual*.

NOTE

Operating the 4200A-SCS with the wrong line frequency setting may result in noisy readings because the line frequency setting affects SMU line frequency noise rejection.

5. Allow the instrument to warm up for at least 30 minutes to achieve rated measurement accuracy.

Create a new project and test

In this section:

Introduction	3-1
Equipment required.....	3-1
Device connections	3-2
Set up the measurements in Clarius	3-3

Introduction

This section provides an example of how to create a new blank project and configure a new blank test. You will create a test to be performed on a MOSFET, but the procedure is general and can be applied to different devices and applications.

NOTE

The default settings used for the devices, tests, and projects in Clarius are generally sufficient to produce usable data when executing a test. However, you may have additional settings you want to apply when you configure your measurements.

Equipment required

- One 4200A-SCS, with the following instruments:
 - Two 4200-SMUs or 4210-SMUs
 - Two 4200-PAs
- Three 4200-TRX-2 or 4200-MTRX-2 triaxial cables (supplied with SMU)
- One shielded, three-terminal test fixture with triaxial inputs (such as the 8101-PIV)

Device connections

Using the supplied cables, connect the output terminals of the instruments directly to the MOSFET terminals in the shielded test fixture. The triaxial terminals on the shielded test fixture allow you to connect to the device and maintain a completely shielded and guarded test setup.

⚠ WARNING

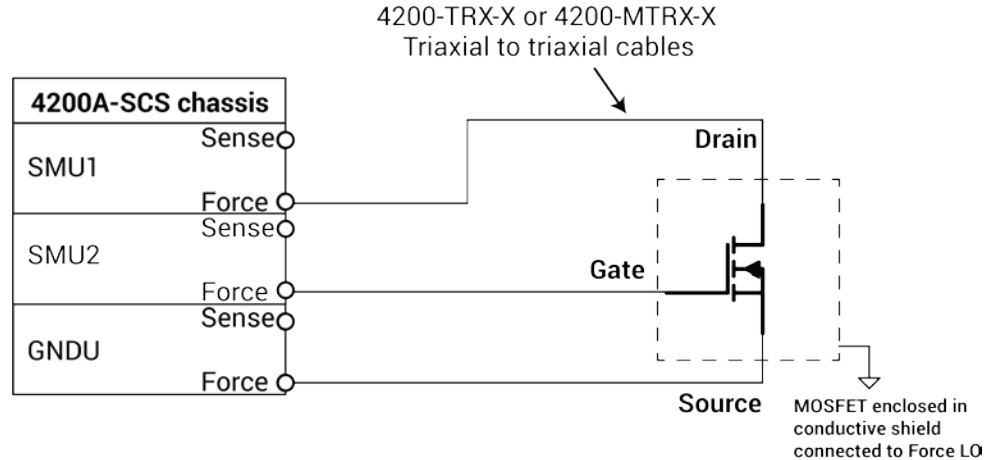
Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Connection schematic

The hardware connections from the output of the instruments in the 4200A-SCS chassis to the test fixture that contains the MOSFET are shown in the following figure. All of the connections are 2-wire, and only the Force terminal of each SMU is used. The SMUs and GNDU are each connected to a different terminal of the 3-terminal MOSFET.

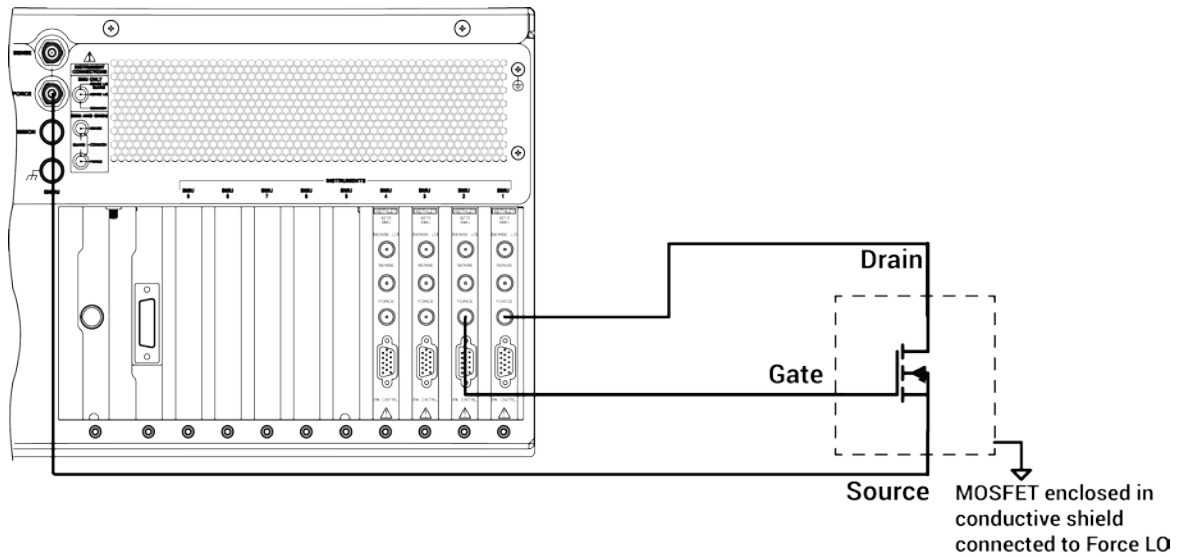
Figure 14: Connections from the 4200A-SCS to a MOSFET



Connect the 4200A-SCS to the DUT

The hardware connections from the output of the instruments in the 4200A-SCS chassis to the test fixture that contains the MOSFET are shown in the next figure.

Figure 15: Rear panel connections from the 4200A-SCS to a MOSFET



Set up the measurements in Clarius

This section describes how to set up the 4200A-SCS to generate a $V_{ds}-I_d$ family of curves for a 3-terminal n-type MOSFET. This general procedure can also be used to create tests for other devices and other applications.

For this example, you will use the Clarius application to:

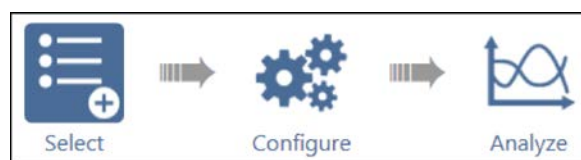
- Select and rename new project
- Add a device
- Select a custom test
- Configure the test
- Execute the test
- View and analyze the test results

Select and rename a new project

To select and rename a new project:

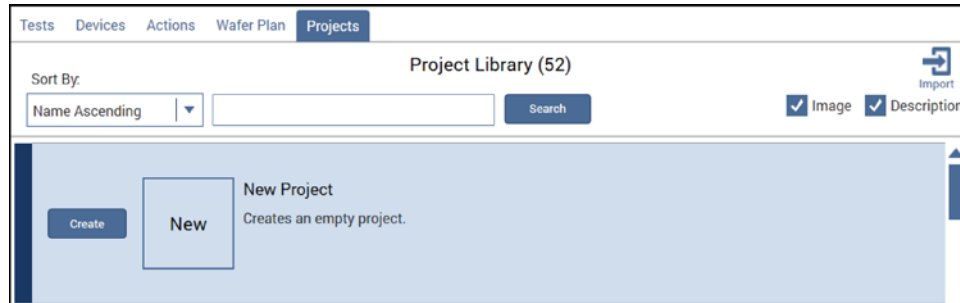
1. Choose **Select**.

Figure 16: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 17: Select a New Project from the Project Library



4. Select **Yes** when prompted to replace the existing project.
5. Assign a title to the project by selecting **Rename** above the project tree.
6. Enter a project name into the text box, then select **Enter**. MOSFET_TEST has been chosen for this example.

Figure 18: Toolbar with Rename function

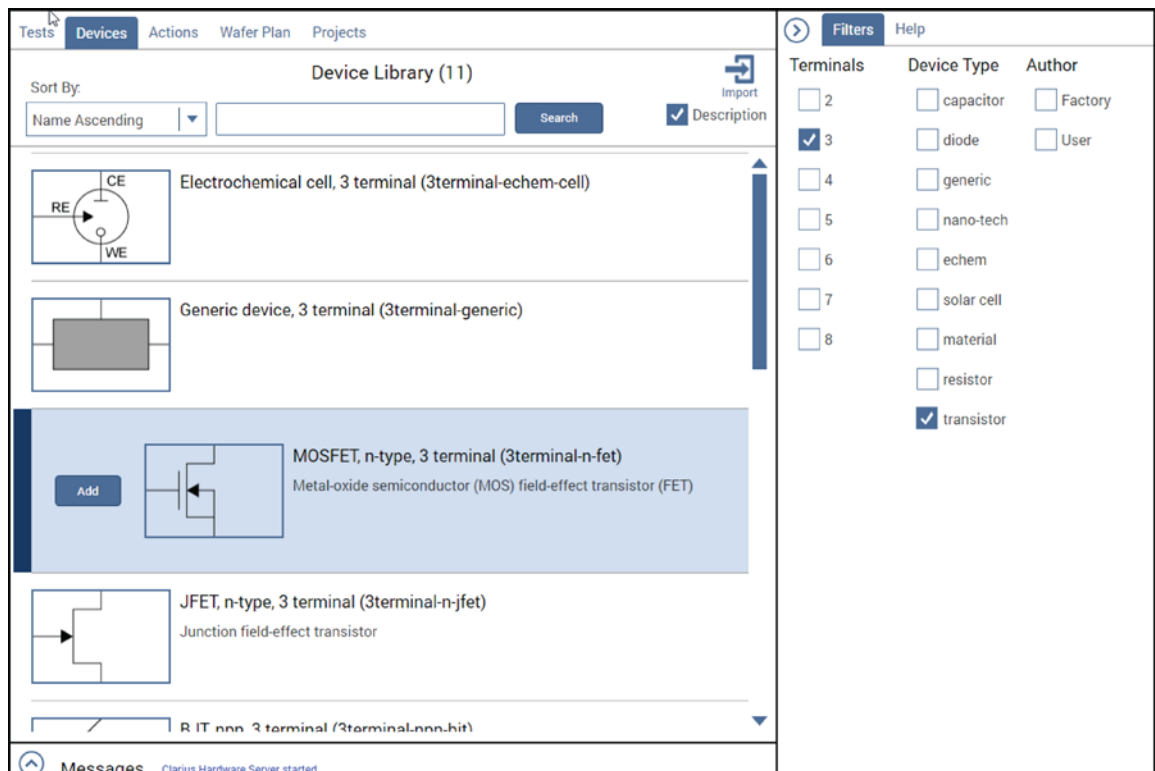


Add a device

To add a device:

1. Select **Devices**.
2. From the Filters pane, select the **3** checkbox under the Terminals heading and **transistor** under the Device Type option from the Filters pane.

Figure 19: Searching for a device using Filters



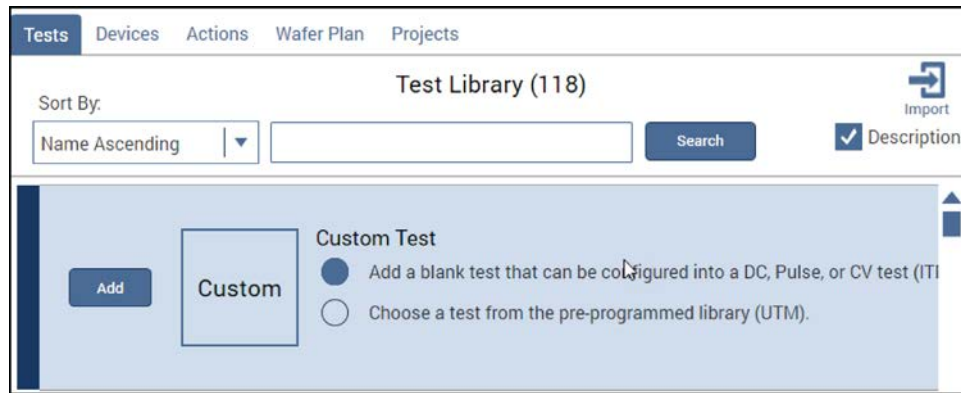
3. Select the **MOSFET, n-type, 3 terminal (3terminal-n-fet)** device, then select **Add** to copy it to the project tree.

Select a custom test

To select a custom test:

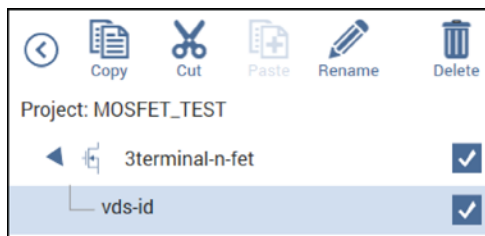
1. Select **Tests**.
2. Select **Custom Test**, then select **Add** to create a new 3-terminal, n-type MOSFET test in the project tree.

Figure 20: Custom Test option



3. Select **Rename** from the toolbar. Enter a test name in the text box, then select **Enter**. `vds-id` was chosen for this example.

Figure 21: MOSFET_TEST project tree with one device and one test

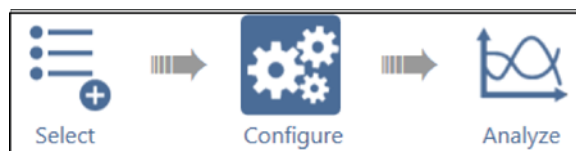


Configure the test

To configure the test:

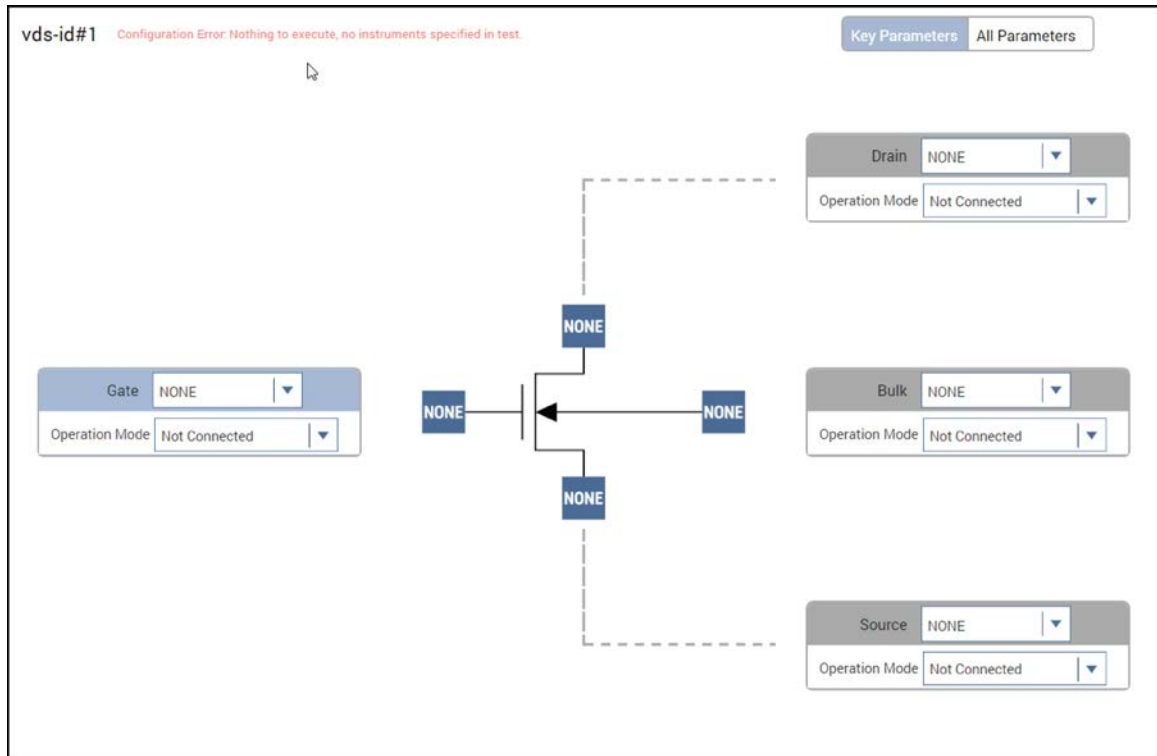
1. Select **Configure**.

Figure 22: Configure highlighted



- In the project tree, select `vds-id`. Because this test is custom, you must assign functions to all terminals connected to the MOSFET before you can run the test.

Figure 23: All MOSFET terminals unassigned in a blank test

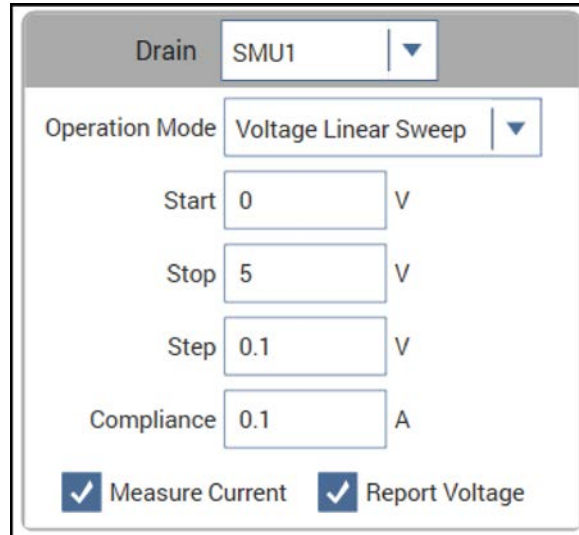


- Set the Gate terminal connection to **SMU2** and set the Operation Mode to **Voltage Step**.
- Change gate the Start, Stop, Step, and Compliance settings to match the next figure or to the gate settings appropriate for your device.

Figure 24: SMU2 steps from 2 to 5 volts, connected to MOSFET Gate terminal

5. Set the Drain terminal connection to **SMU1** and set the Operation Mode to **Voltage Linear Sweep**.
6. Change the Start, Stop, Step, and Compliance settings to match the next figure.

Figure 25: SMU1 sweeps from 0 to 5 volts, connected to MOSFET Drain terminal



7. Set the Operation Mode of the Source terminal to **GNDU**.

Execute the test

Select **Run** to execute the test.

Figure 26: Run



View and analyze the test results

While the test is running, you can view the data in the Analyze pane. Because you created a new test, the axes of the results graph are not assigned. You must assign axes to the graph to view graphical results.

To view and analyze the test results:

1. Select **Analyze**. The Analyze screen appears as a blank spreadsheet and a blank graph with unassigned axes.

Figure 27: Analyze highlighted



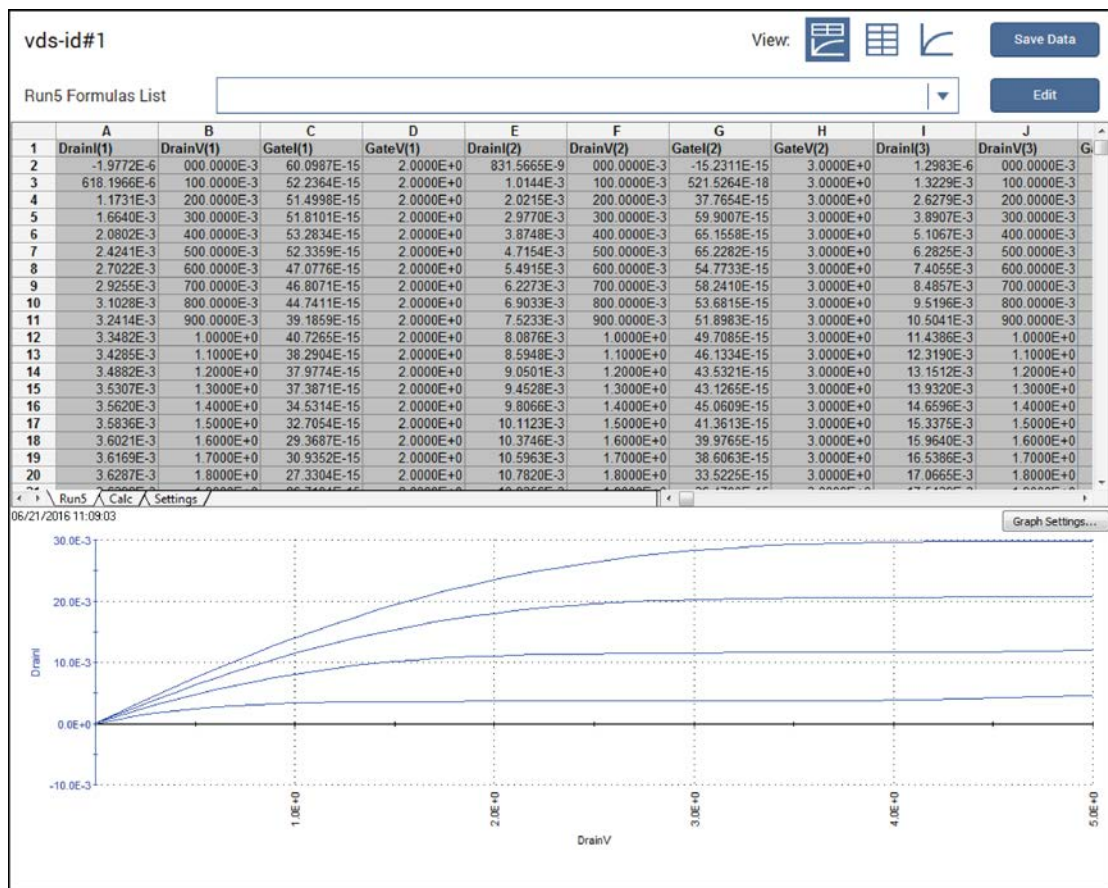
2. Select **Graph Settings...**, then **Define Graph**.
3. Select **Define Graph**.
4. In the Graph Definition screen, assign X to **DrainV** and Y1 to **DrainI**.

Figure 28: Define the graph

Data Series	Sheet	Column	X	Y1	Y2
DrainI*	Data	A...		*	
DrainV*	Data	B...	*		
GateI*	Data	C...			
GateV*	Data	D...			

5. Select **OK** to apply the settings.
6. When you run the test, the sheet populates with the measured data and the graph displays the $v_{ds}-I_d$ family of curves.

Figure 29: Analyze Pane showing test results



Use the RPM to switch the SMU, CVU, and PMU

In this section:

Introduction	4-1
Update the RPM configuration in KCon	4-1
Equipment required.....	4-2
Device connections	4-2
Set up the measurements in Clarius	4-4

Introduction

The 4225-RPM Remote Amplifier/Switch Module is an accessory for the 4225-PMU 2-Channel UltraFast I-V Module. The 4225-RPM has two purposes:

- To extend the current measurement ranges of the PMU to the 100 nA range
- To enable the user to switch between the instruments without changing cables

This section provides an example of how to use the 4225-RPM to switch the 4200-SMU or 4210-SMU, 4210-CVU, and 4225-PMU and make DC I-V, C-V, and pulsed I-V measurements to a single device without having to reconnect the device between measurements.

For this example, make connections from two SMUs, one CVU, and the two-channel PMU to the inputs of two 4225-RPMs. Then make connections from the outputs of the two 4225-RPMs to a diode. Finally, generate DC I-V, C-V, and pulsed I-V measurements.

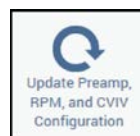
Update the RPM configuration in KCon

The KCon application is used to manage the configuration of the 4200A-SCS, including the 4225-RPM. Before using an RPM for automatic switching, you must update the RPM configuration in KCon. This associates the instruments connected to each RPM and also enables automatic switching between tests.

To update the RPM configuration in KCon:

1. Make sure your device is disconnected from the RPM output terminals.
2. Close the Clarius application.
3. Open the KCon application.
4. Select **Update Preamp, RPM, and CVIV Configuration**.

Figure 30: Update the RPM configuration in KCon



5. Select **Save**.
6. Close KCon.
7. Open the Clarius application.

Equipment required

- One 4200A-SCS with the following instruments:
 - Two 4200-SMUs or 4210-SMUs
 - Two 4200-PAs
 - One 4210-CVU
 - One 4225-PMU
 - Two 4225-RPM
- Four 4200-TRX-2 or 4200-MTRX-2 triaxial cables (supplied with SMU)
- Four CA-447A SMA cables (supplied with CVU)
- Two CA-547-2A RPM interconnect cables (supplied with RPM)
- Four CA-534-24A triaxial cables
- Two 237-TRX-T triaxial tees
- One shielded test fixture with connection to GNDU (Force LO)

Device connections

Using the supplied cables, make connections from the output terminals of the instruments to the input terminals of the two RPMs. Connect the output terminals of the RPMs to the diode in a 4-wire configuration to provide the best measurement accuracy and eliminate the lead resistance effects on I-V and C-V measurements.

WARNING

Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Connection schematic

The hardware connections from the output terminals of the instruments in the 4200A-SCS are connected to the input terminals of the two 4225-RPMs and then from the output terminals of the two RPMs to the diode under test, as shown in the next figure.

The Sense and Force output terminals of 4200-SMU Channel 1 are connected to the SMU Sense and SMU Force connections of 4225-RPM Channel 1 using 4200-TRX-2 or 4200-MTRX-2 triaxial to triaxial cables. The same connection is made between 4200-SMU Channel 2 and 4225-RPM Channel 2, using the same cable model.

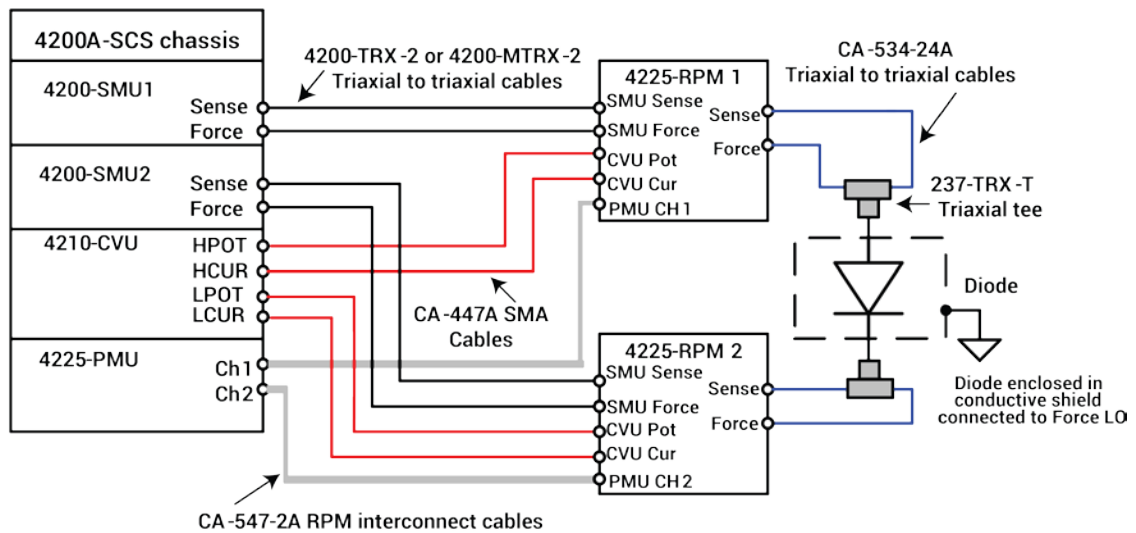
The HPOT and HCUR output terminals of the 4210-CVU are connected to the CVU Pot and CVU Cur inputs of 4225-RPM Channel 1 using CA-447A SMA cables. The LPOT and LCUR output terminals of the 4210-CVU are connected to the CVU Pot and CVU Cur inputs of 4225-RPM Channel 2 using CA-447A SMA cables.

The output terminals of the 4225-PMUs are connected to their respective channels' RPM Control inputs on the 4225-RPMs.

The Force and Sense output terminals from 4225-RPM Channel 1 are connected to the anode of the diode using two triaxial cables (part number CA-534-24A) and a triaxial tee (Model 237-TRX-T). These triaxial cables are rated for accurate low current (I-V) and high frequency (C-V and pulsed I-V) measurements.

The output terminals of 4225-RPM Channel 2 are connected to the cathode of the diode using the same cables and triaxial tee as those for Channel 1. To prevent noisy measurements, enclose the diode in a conductive shield connected to the Force LO terminal of the 4200A-SCS.

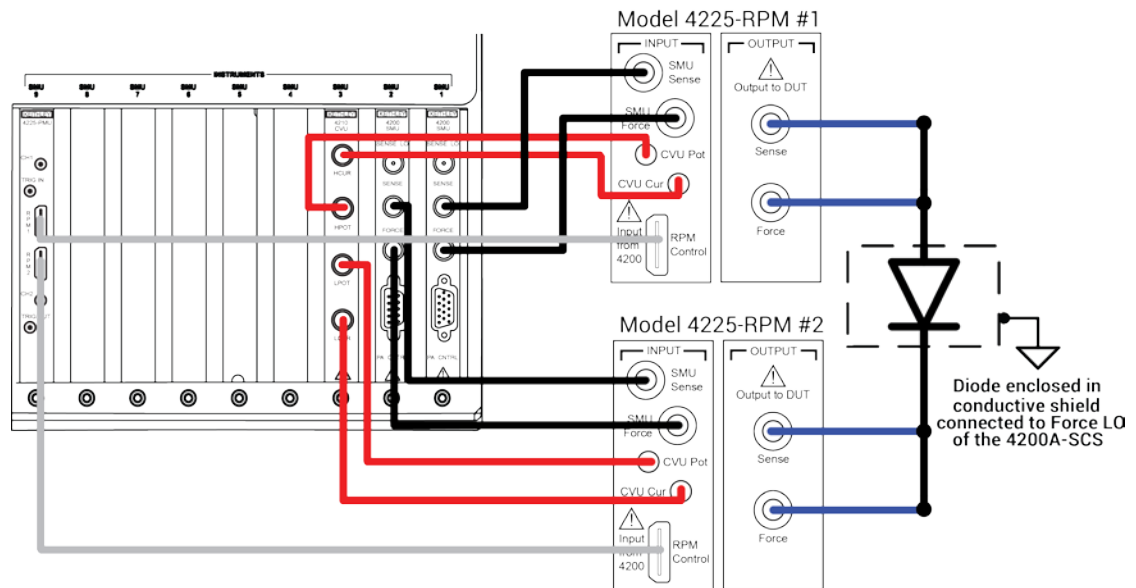
Figure 31: Connections from the 4200A-SCS and 4225-RPMs to the diode



Connect the 4200A-SCS to the DUT

The next figure shows the 4200A-SCS rear-panel connections to the input terminals of two 4225-RPMs and from the outputs of the 4225-RPMs to the diode.

Figure 32: Rear panel connections to the inputs of the 4225-RPM units and from the units to the device



Set up the measurements in Clarius

This section describes how to set up the 4200A-SCS to perform I-V, C-V, and pulsed I-V measurements on a diode. You will create a new project and add a test to the project tree for each measurement type.

For this example, you will use the Clarius application to:

- Create a new project
- Add a device
- Search for and select existing tests in the Test Library
- Configure the tests
- Run the tests
- View and analyze the test results

Create a new project

To create a new project:

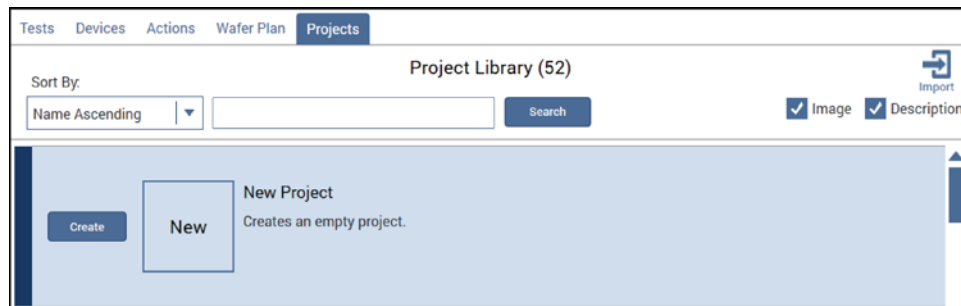
1. Choose **Select**.

Figure 33: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 34: Select a New Project from the Project Library



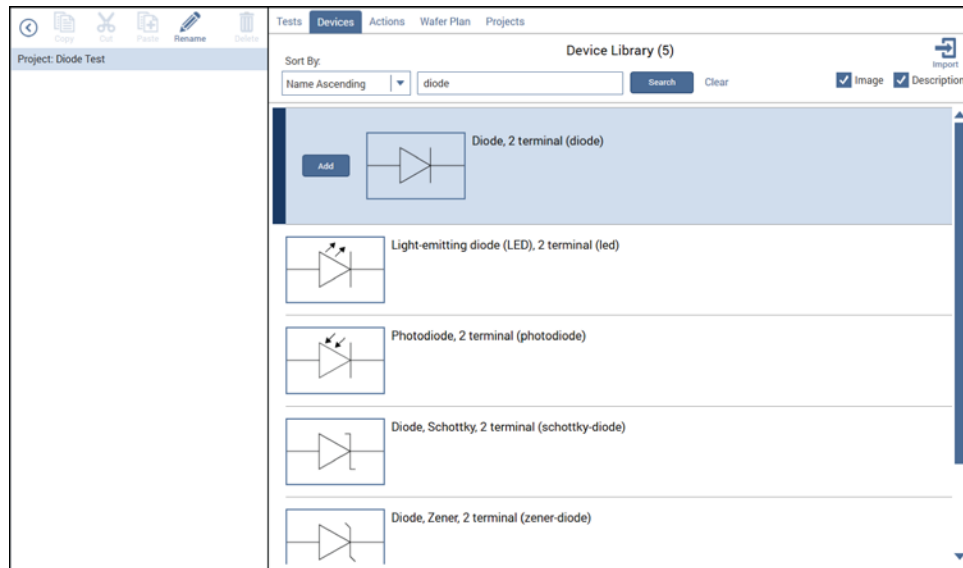
4. Select **Yes** when prompted to replace the existing project.
5. Assign a new title to the project by selecting **Rename**, then enter *Diode Test*.
6. Select **Enter**.

Add a device

To add a device:

1. Select **Devices**.
2. To find a diode device in the Device Library, type `diode` into the search box, then select **Search**.
3. Select the **Diode, 2 terminal** device and **Add** it to the project tree.

Figure 35: Select and add a diode device to the project tree

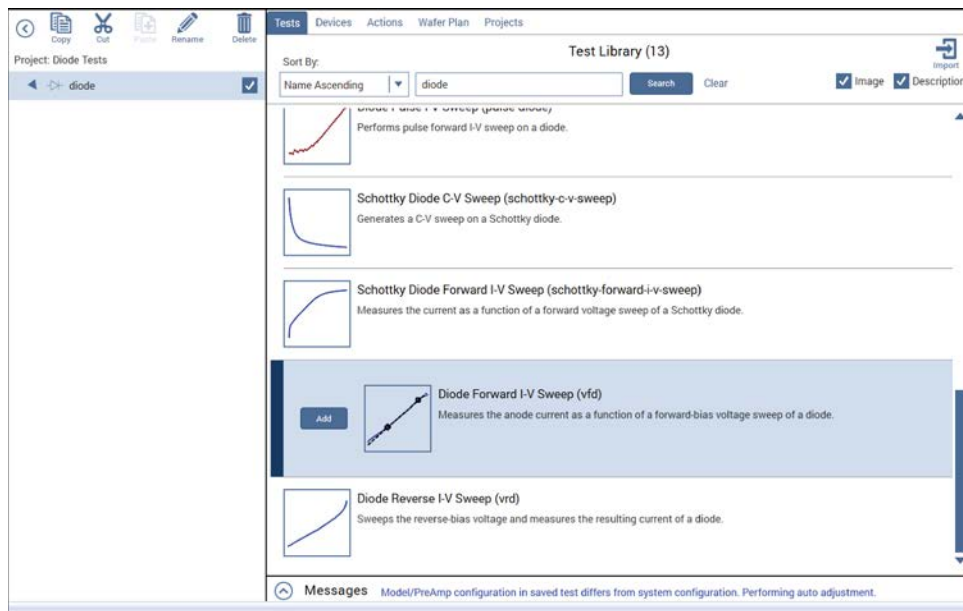


Search for and select existing tests in the Test Library

To search for and select an existing test:

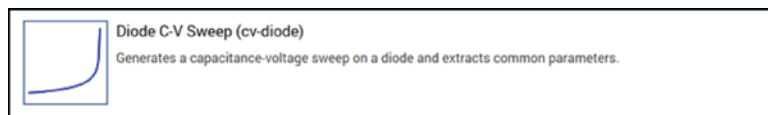
1. Select **Tests**.
2. To find a diode test in the Test Library, type the word `diode` in the search box, then select **Search**.
3. Scroll to find the `Diode Forward I-V Sweep (vfd)` test, then **Add** the test to the project tree.

Figure 36: Adding the Diode Forward I-V Sweep (vfd) test to the project tree



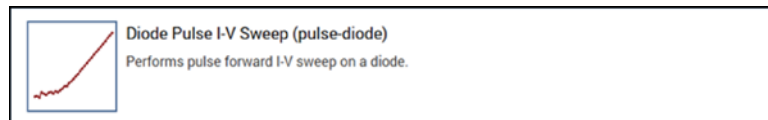
4. Scroll to find the `Diode C-V Sweep (cv-diode)` test, then **Add** this test to the project tree.

Figure 37: Diode C-V Sweep (cv-diode) test



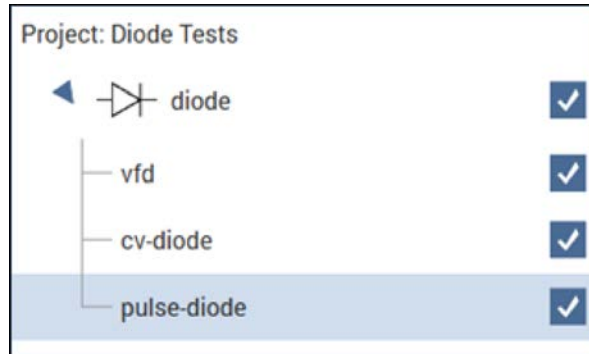
5. Scroll to find the `Diode Pulse I-V Sweep (pulse-diode)` test, then **Add** this test to the project tree.

Figure 38: Diode Pulse I-V Sweep (pulse-diode) test



Your project tree now has three tests.

Figure 39: Three tests added to project tree



Configure the test

To configure the tests:

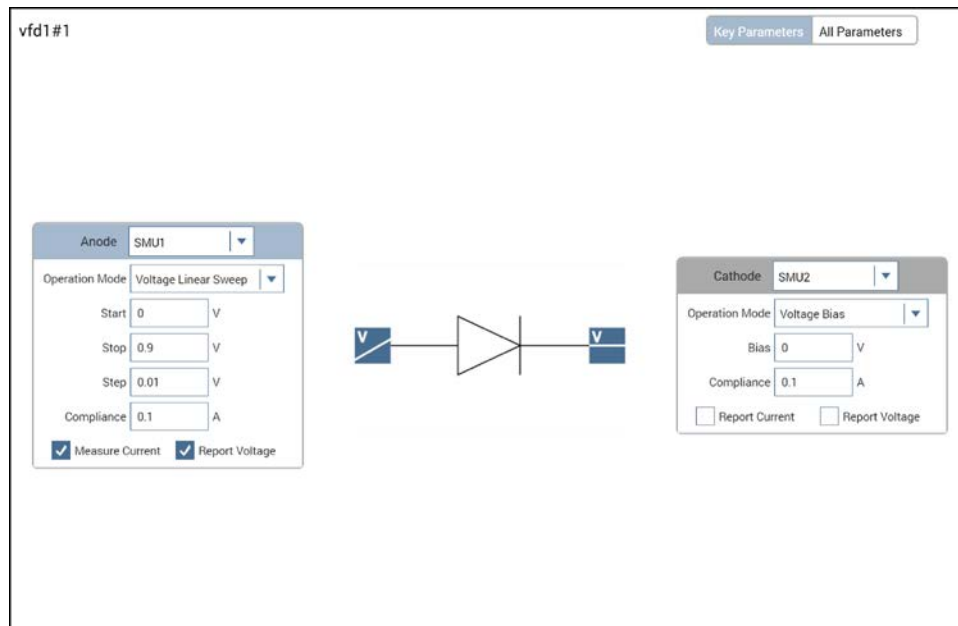
1. Choose **Configure**.

Figure 40: Configure highlighted



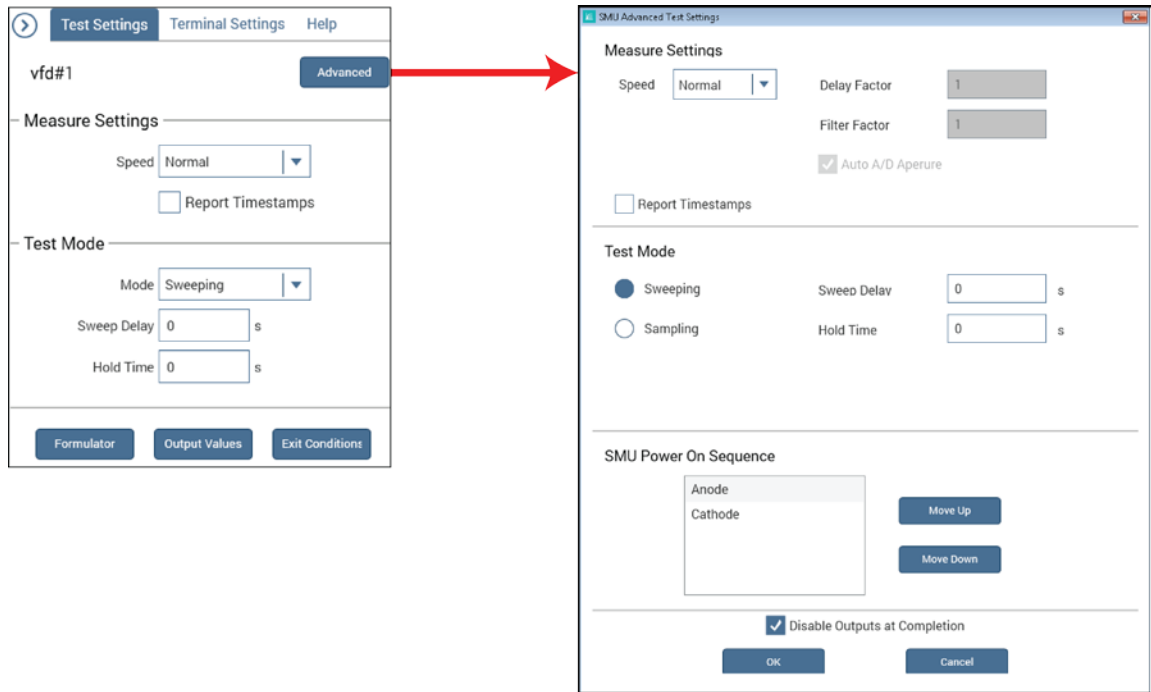
2. In the project tree, select the `vfd` test. Adjust the Anode settings in the Key Parameters pane as needed.

Figure 41: Forward I-V sweep, vfd terminal settings



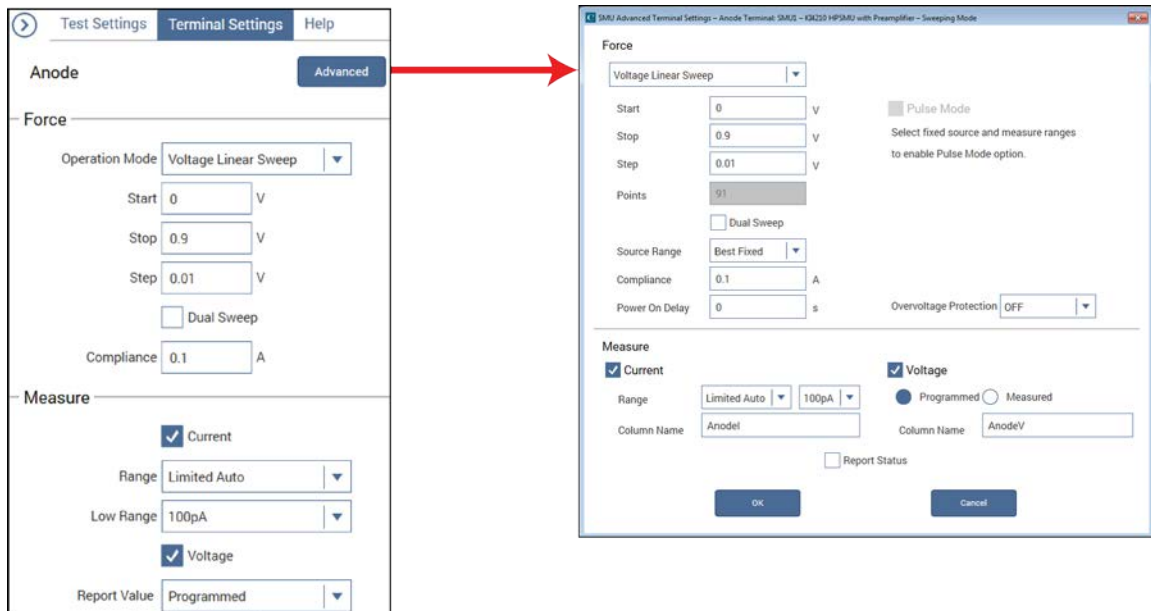
3. In the Test Settings pane, select **Advanced**. Adjust the parameters as needed. Be sure to include the delay between sweep steps.

Figure 42: Test Settings pane and Test Settings Advanced dialog box



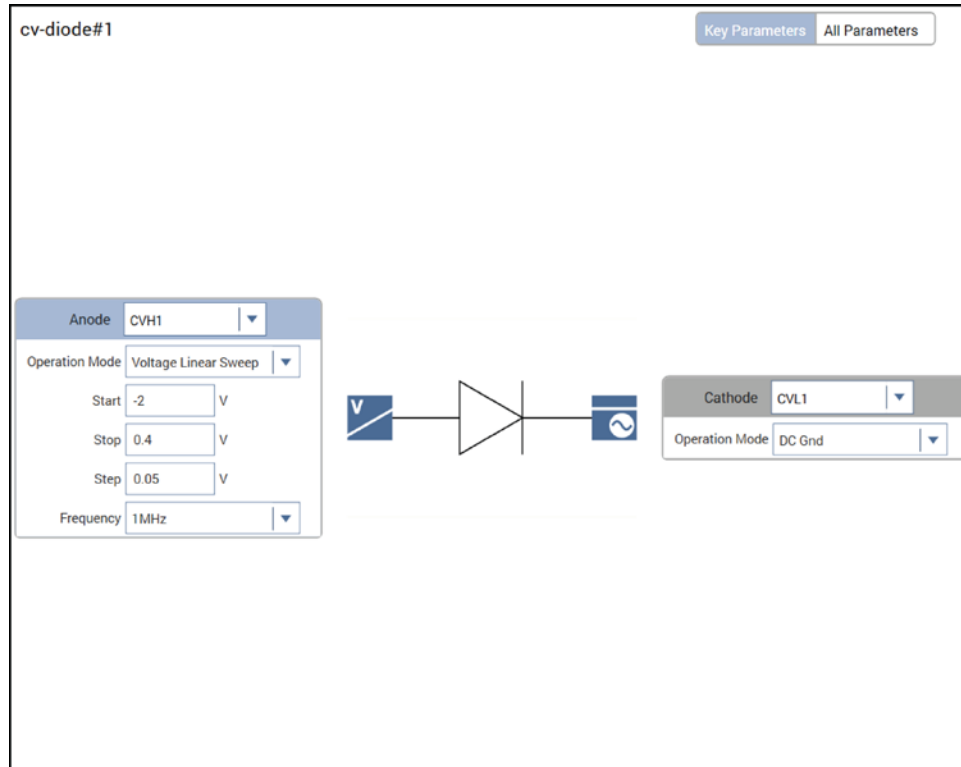
4. Select **OK** to accept the settings.
5. Select **Terminal Settings**.
6. Select **Advanced**.
7. Adjust the voltage source and current measurement parameters as needed.

Figure 43: Terminal Settings pane and Terminal Settings Advanced dialog box



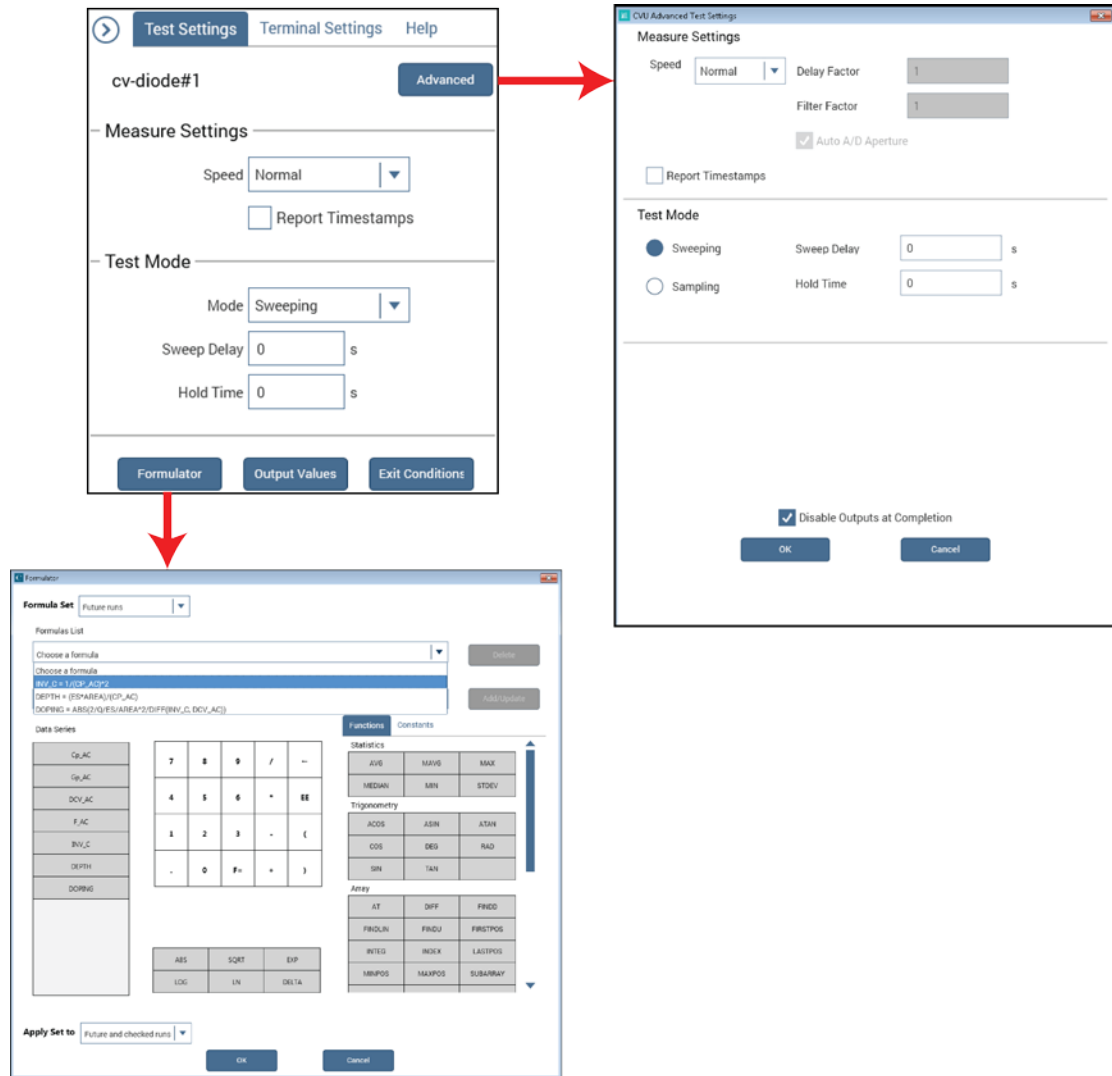
8. Select **OK** to accept the changes.
9. Select the `cv-diode` test from the project tree.
10. Highlight the **Anode** terminal of the diode in the Key Parameters pane
11. Adjust the voltage source and test frequency settings as needed.

Figure 44: Key Parameters pane for the cv-diode sweep test



12. From the Test Settings pane's Advanced dialog box, adjust the timing parameters as needed. Be sure to include the sweep delay time in your adjustments.

Figure 45: Test Settings pane and the Test Settings Advanced and Formulator dialog boxes for the cv-diode sweep test

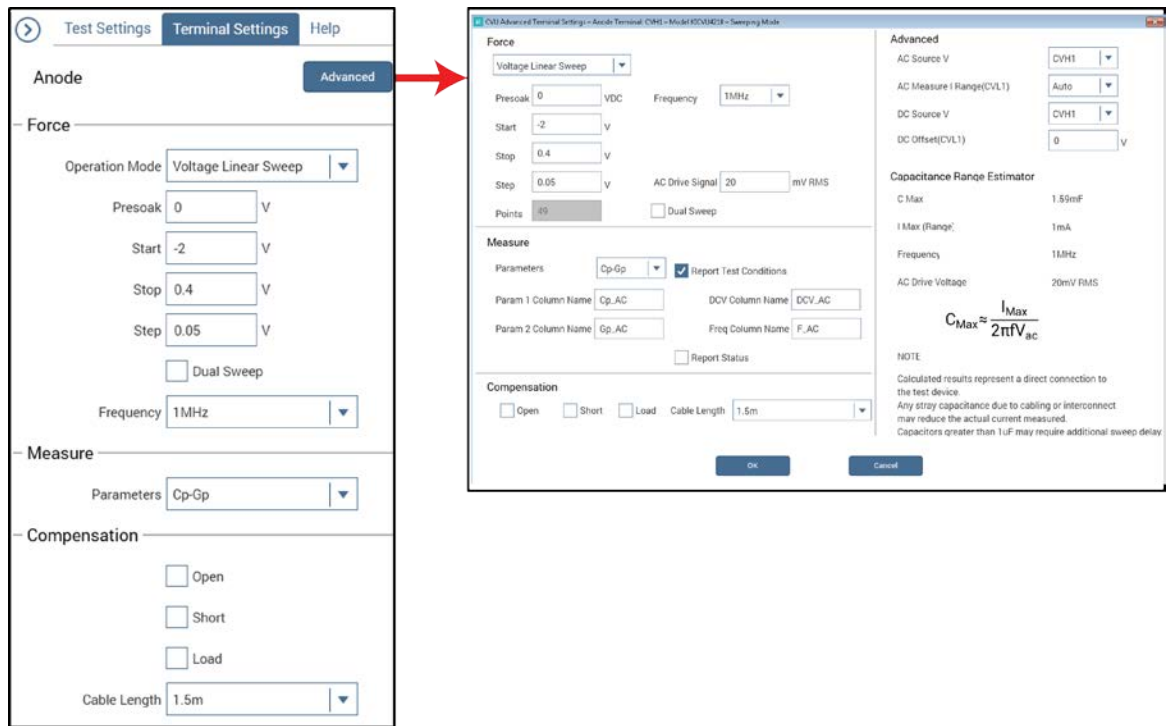


- From the Terminal Settings pane and the Terminal Settings Advanced dialog box of the Anode terminal, adjust the DC voltage source, AC voltage source, and measurement parameters.

NOTE

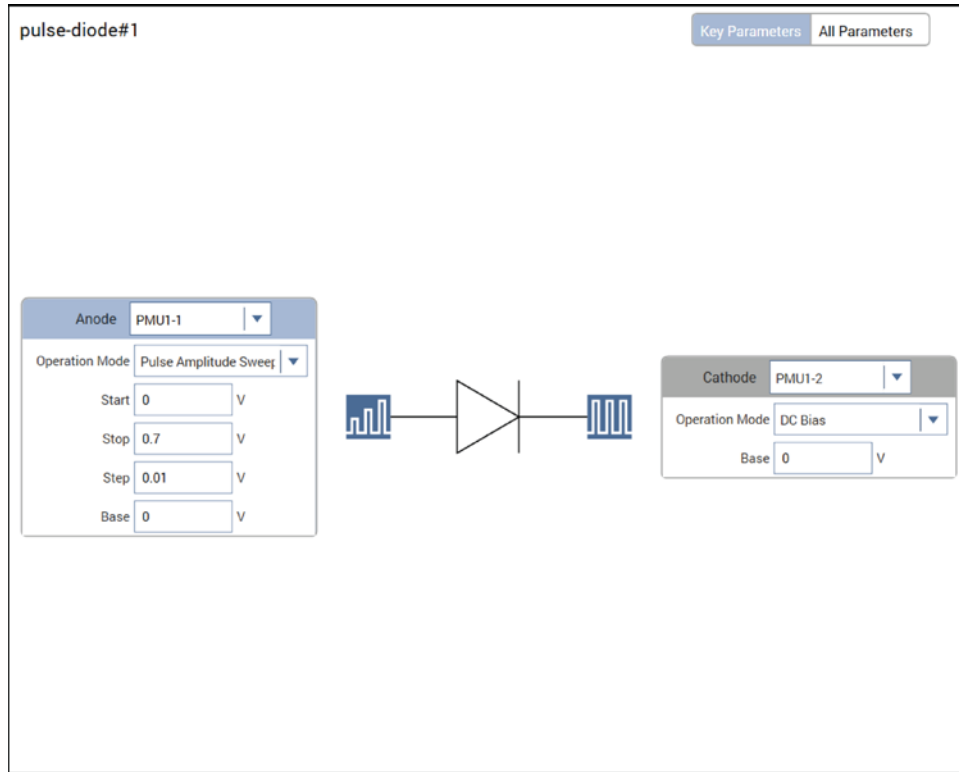
Before the corrections can be applied in the test, you can choose to run the **CVU Connection Compensation** action from the toolbar.

Figure 46: Terminal Settings pane and the Terminal Settings Advanced dialog box for the cv-diode sweep test



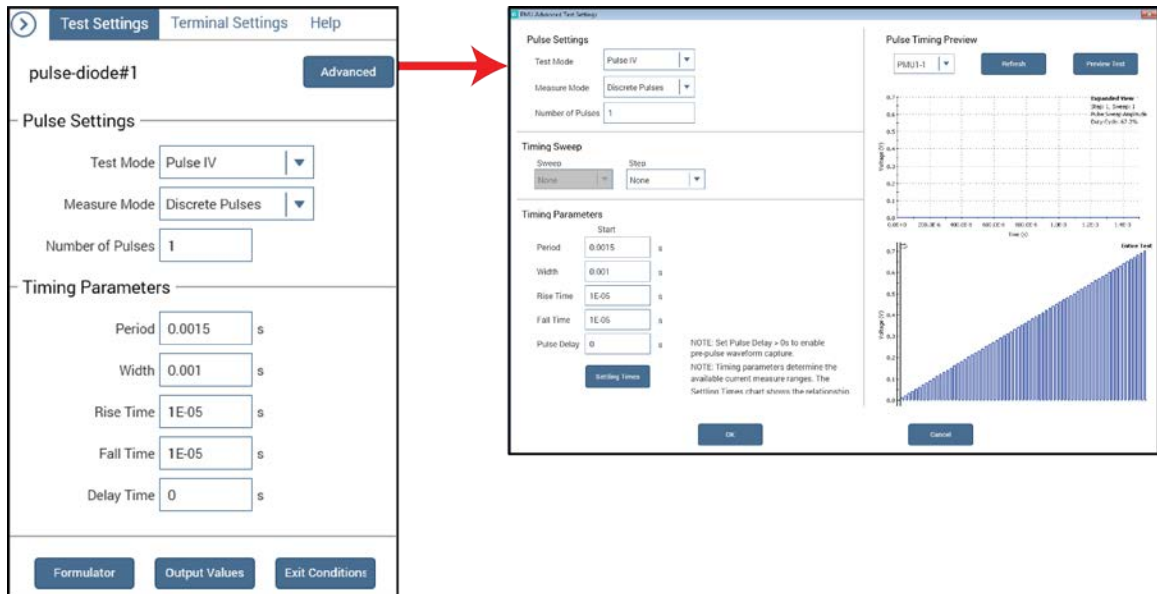
- 14. In the project tree, select the pulse-diode test.
- 15. From the Key Parameters pane, adjust the pulse operation as needed.

Figure 47: Key Parameters pane for the pulse-diode test



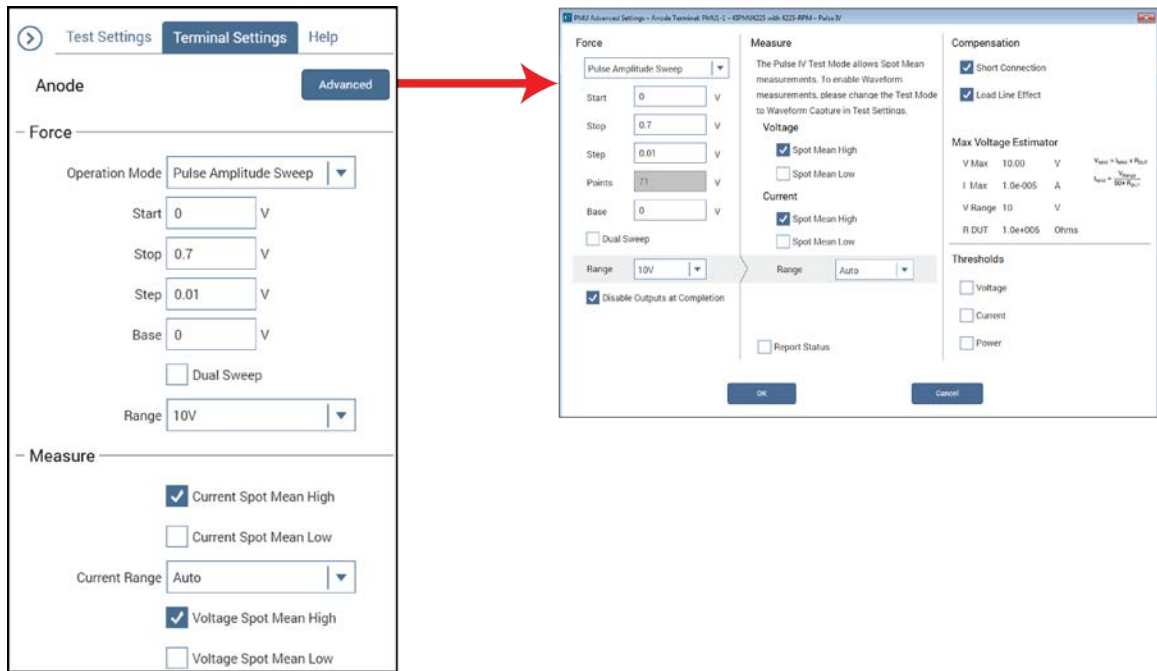
16. Change the Cathode terminal setting to PMU1-2.
17. Select **Test Settings**.
18. Select **Advanced** to adjust the test mode or pulse timing settings, as needed.

Figure 48: Test Settings pane and the Test Settings Advanced dialog box for the Pulse-Diode test



19. Select **OK** to accept the changes.
20. Select the **Anode** terminal.
21. Select **Terminal Settings**.
22. Select **Advanced** to configure the measurements as needed, including spot mean, PMU compensation, and PMU threshold levels.

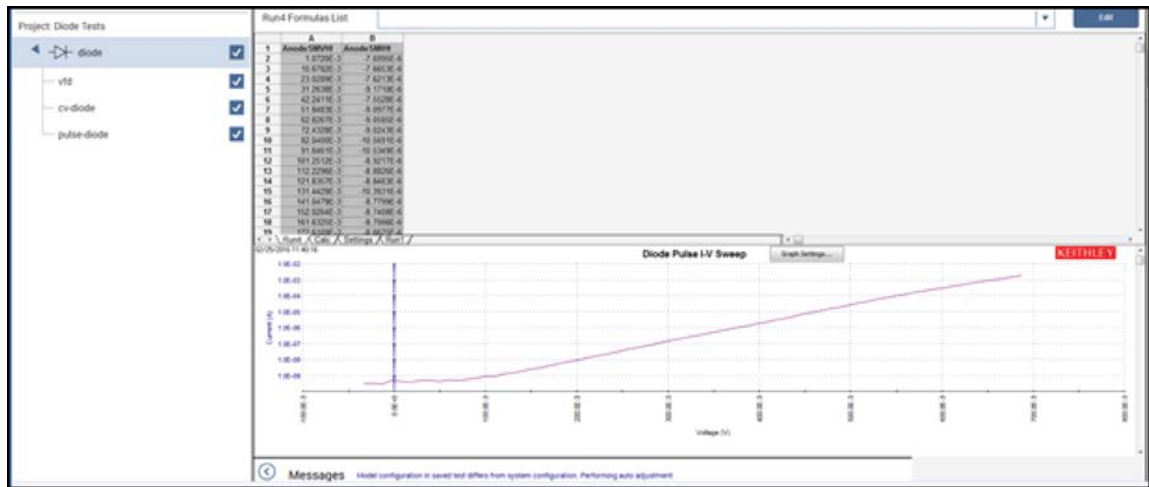
Figure 49: Terminal Settings pane and the Terminal Settings Advanced dialog box for Pulse-Diode test



Run the test

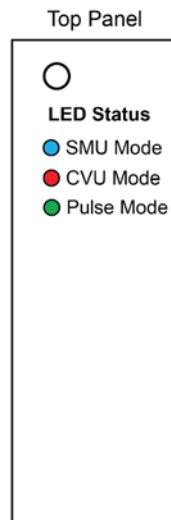
Once the three tests have been configured, you can execute every test under the device by selecting the diode device in the project tree and then **Run**. Select the check boxes for the three tests and the device. The three tests run sequentially and the RPM automatically switches the outputs between the SMU, CVU, and PMU.

Figure 50: Executing the test from the device level



As the instruments switch between tests, the LEDs at the top of the RPMs change color. When the output is connected to the SMU, the LED is blue. When the output is connected to the CVU, the LED is red. When the output is connected to the PMU, the LED is green, which is also the default state.

Figure 51: Top of the 4225-RPM indicating the LED status



Analyze the results

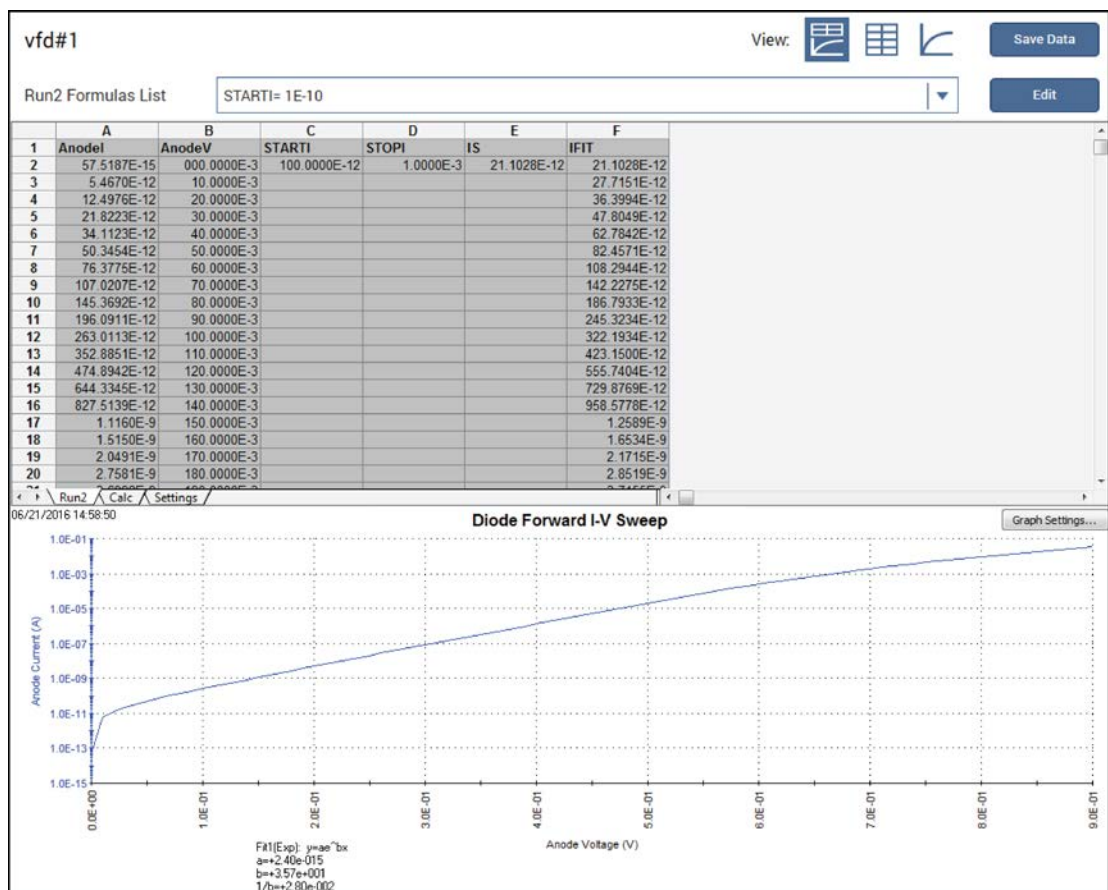
You can select **Analyze** when you run the project to view test results in real-time.

Figure 52: Analyze highlighted



Select a test from the project tree to display its results. The data for the `vfd` test is displayed in the next graphic. Both the data and the graph are displayed in this view.

Figure 53: Analyze pane



Configure and use a Series 700 Switching System

In this section:

Introduction	5-1
Equipment required.....	5-2
Device connections	5-2
Update the switch configuration in KCon	5-6
Set up the measurements in Clarius	5-10

Introduction

This tutorial demonstrates how to configure a Keithley Instruments Series 700 Switching System (707/A/B or 708/A/B) in KCon and then how to use the system to connect any instrument terminal to any test system pin without changing connections. You will also create a new project for an n-channel MOSFET transistor and use the project to make both I-V and C-V measurements using the switching system.

Switching systems are controlled by the 4200A-SCS using the GPIB bus. Use a 7007-1 or 7007-2 GPIB cable to connect your switching system to the 4200A-SCS. Once the switching system and test fixture have been defined in KCon, you use Clarius to set up the connections and automatically connect the instruments to the test system pins using the switching system.

The `connectpins` action from the Action Library is used in Clarius to control switching systems. This action controls the opening and closing of crosspoints in a switching system so that you can connect any row of the matrix card to any (or multiple) columns of the matrix card.

The `connectpins` action is added to the project and runs twice in this example. Each run establishes new connection settings.

For more details about switching system connections and the Action Library, refer to the *Model 4200A-SCS Reference Manual*.

Equipment required

- One 4200A-SCS with the following instruments:
 - Three 4200-SMUs or 4210-SMUs
 - One 4210-CVU
- Eight 4200-MTRX-X cables or 4200-TRX-X cables if using preamplifiers
- Four CA-447A SMA cables (supplied with the CVU)
- Four CS-1247 SMA female to BNC male adapters (supplied with the CVU)
- Two CS-701A BNC Tee adapters (female, male, female)
- Two 7078-TRX-BNC BNC female to triaxial male adapters
- One Series 700 Switching System with 7072 Matrix Card
- One shielded four-terminal test fixture with triaxial inputs
- One n-channel MOSFET transistor

Device connections

The next topics detail the connections from the 7072 to the n-channel MOSFET and the connections from the 4200-SMU or 4210-SMUs, 4210-CVU, and GNDU to the 7072 Matrix Card in the Series 700 Switching System.

WARNING

Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

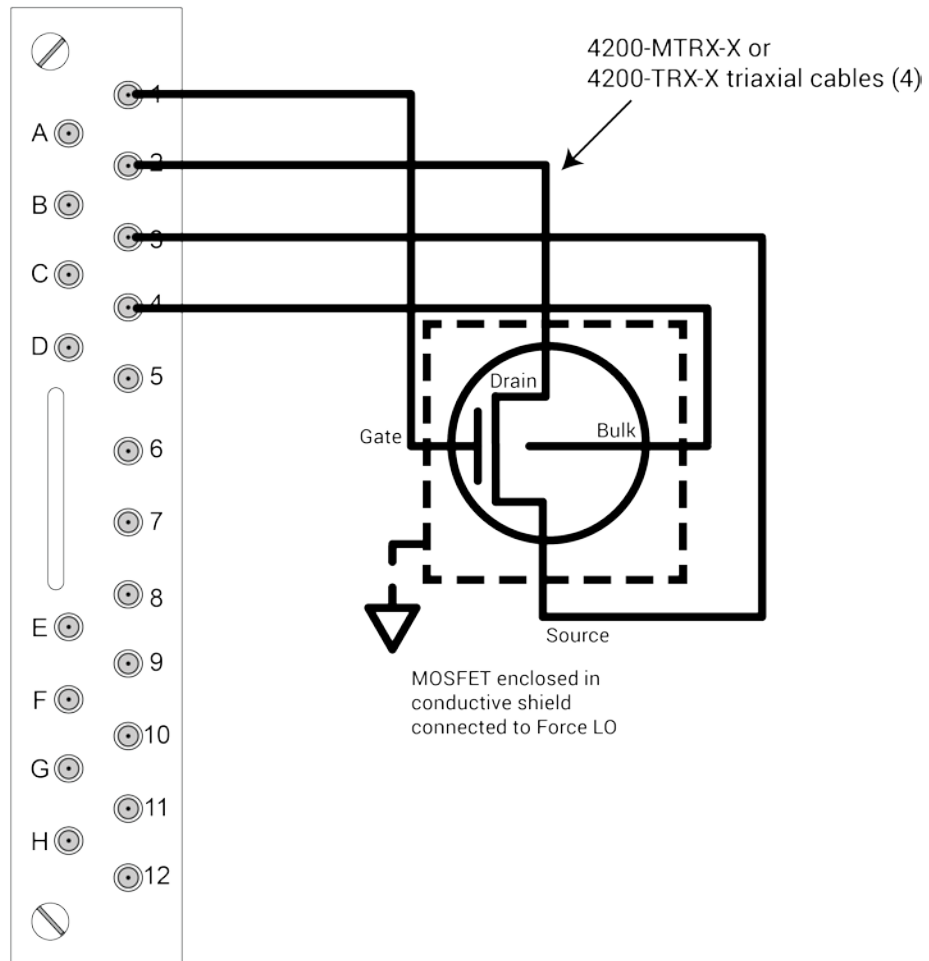
To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Connect the 7072 to the DUT

The hardware connections from the 7072 Matrix Card to the 4-terminal MOSFET DUT are shown in the following figure. Use four 4200-MTRX-X or 4200-TRX-X triaxial cables (if using a preamplifier) to the input terminals of your test fixture.

Figure 54: Connections from the 7072 Matrix Card to the MOSFET DUT

Model 7072 Matrix Card



Connect the 4200A-SCS to the 7072

The hardware connections from the output of the instruments in the 4200A-SCS to the 7072 are shown in the following figure.

To connect the 4200A-SCS and SMUs to the 7072:

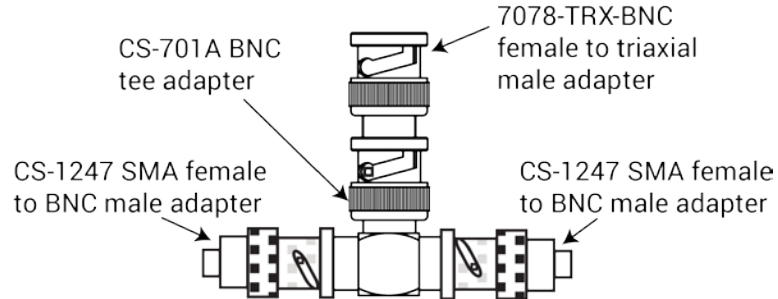
Using four 4200-MTRX-X or 4200-TRX-X triaxial cables, make the following connections:

- 4200A-SCS GNDU to 7072 input terminal E
- 42x0 SMU channel 1 Force to 7072 input terminal A
- 42x0 SMU channel 2 Force to 7072 input terminal B
- 42x0 SMU channel 3 Force to 7072 input terminal C

To connect the 4210-CVU to the 7072:

1. Using the labeled parts in the following figure, assemble a tee adapter to connect the 4210-CVU to the 7072

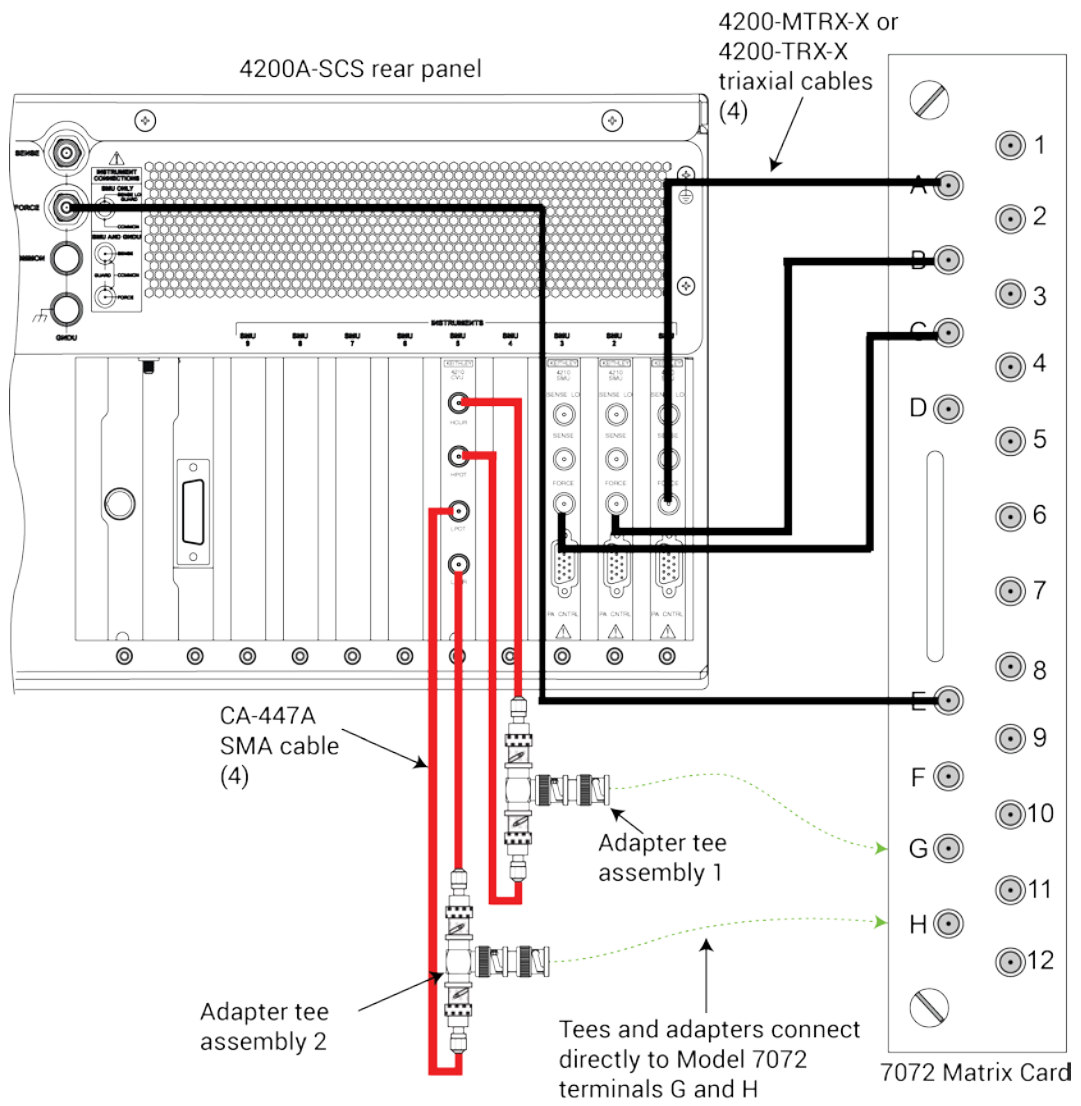
Figure 55: 4210-CVU to 7072 adapter tee assembly



2. Using four CA-447A SMA cables, make the following connections:
 - 4210-CVU HCUR to adapter tee assembly 1
 - 4210-CVU HPOT to adapter tee assembly 1
 - 4210-CVU LPOT to adapter tee assembly 2
 - 4210-CVU LCUR to adapter tee assembly 2
3. Connect adapter tee assembly 1 to input terminal G of the 7072.
4. Connect adapter tee assembly 2 to input terminal H of the 7072.

The connections are shown in the following figure.

Figure 56: 4200A-SCS to 7072 Matrix Card connections



Update the switch configuration in KCon

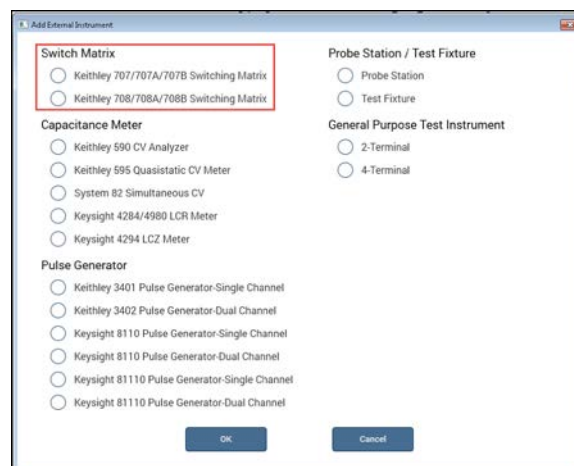
After completing the switch and device connections, use KCon to manage the configuration of all instrumentation controlled by the 4200A-SCS software. You use KCon to:

- Add a switching system to the 4200A-SCS configuration
- Add a test fixture to the system configuration
- Configure the test fixture
- Add a matrix card to the switching system
- Configure the matrix card connections

To add a switching system to the 4200A-SCS configuration:

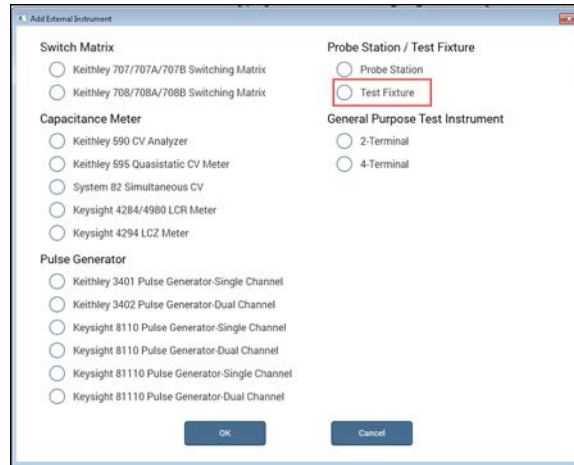
1. From the desktop, open the KCon application.
2. In the bottom left of the KCon application window, select **Add External Instrument**.
3. In the dialog box that appears, select your switching system. The Series 700 Switching Systems are highlighted in the next figure.

Figure 57: Add External Instrument box, Series 700 Switching Systems highlighted



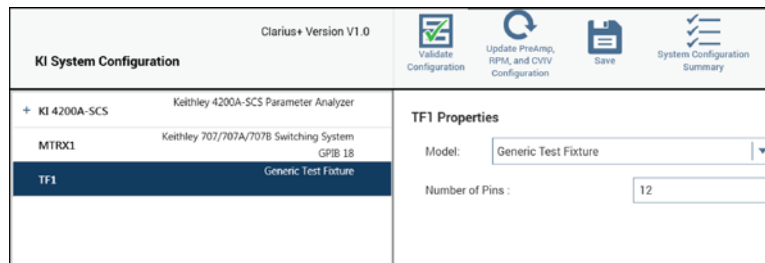
4. Select **OK**.
5. Select **Add External Instrument** again, then select **Test Fixture**.

Figure 58: Add External Instrument dialog box, Test Fixture highlighted



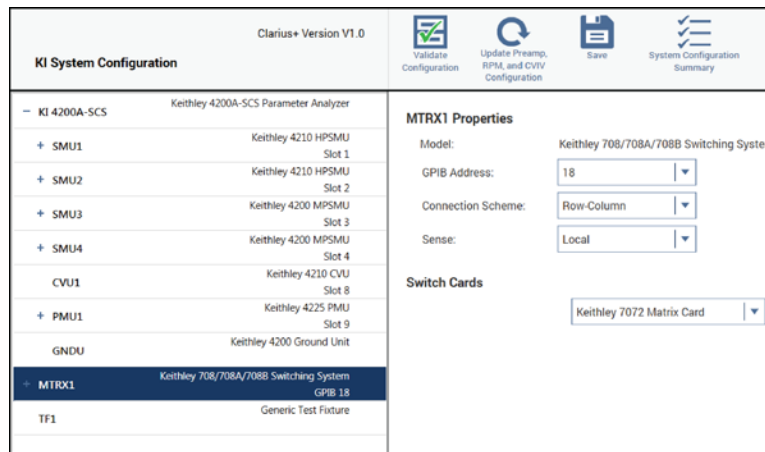
6. Select **OK**.
7. From the configuration navigator, select the test fixture you just added (TF1).
8. Set the number of pins equal to the number of output pins in your switching system (**12** for this example, using one 7072 matrix card).

Figure 59: Properties for a Generic Test Fixture



9. From the configuration navigator, select the switching system you just added (MTRX1).
10. In the Properties pane, add the 7072 Matrix Card to the correct slot of the switching system.
11. Confirm that the GPIB Channel of your device (0 to 30) matches the channel shown in the Properties. The next figure shows a Keithley Instruments 707/707A/707B Switching System with the matrix card installed in slot 1.

Figure 60: Properties pane of Keithley 708/708A/708B Switching System with one 7072 Matrix Card



NOTE

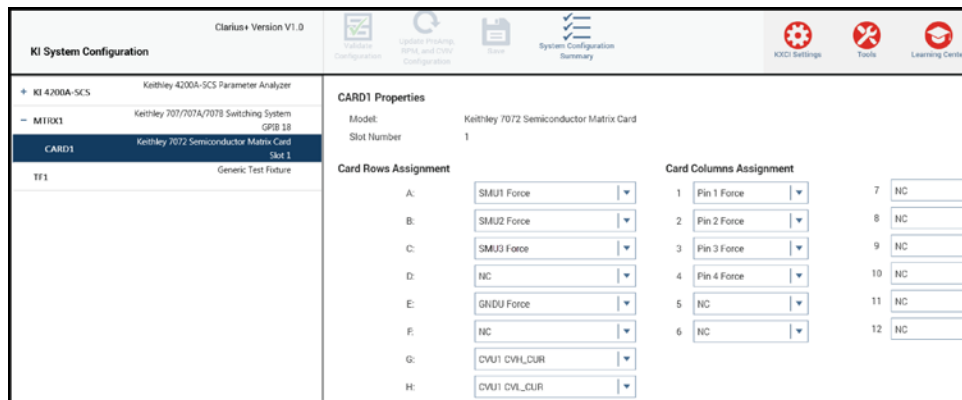
If you are using a 707B or 708B Switching System, you must use the control panel on the front of your switching system to enable DDC and change the command set to 70XA by following these steps:

1. Select **Menu**.
2. Select **DDC**.
3. Select **Enable**.
4. Select **70XA-VERSION**.

This allows the switching system to be controlled by the 4200A-SCS.

12. Select the **+** symbol next to MTRX1 to see the settings for the added 7072 Matrix Card (CARD1).
13. Select the 7072 Matrix Card.
14. Complete the Card Rows Assignments according to how you connected the instruments to the 7072. For this example, the assignments are:
 - **Row A - SMU1 Force**
 - **Row B - SMU2 Force**
 - **Row C - SMU3 Force**
 - **Row E - GNDU Force**
 - **Row G - CVU1 CVH_CUR**
 - **Row H - CVU1 CVL_CUR**
15. Under the Card Columns Assignment heading, designate at least the first four columns with pin assignments that match their column number. For example, Pin 1 Force to column 1.

Figure 61: Completed Properties pane for the 7072 Matrix Card



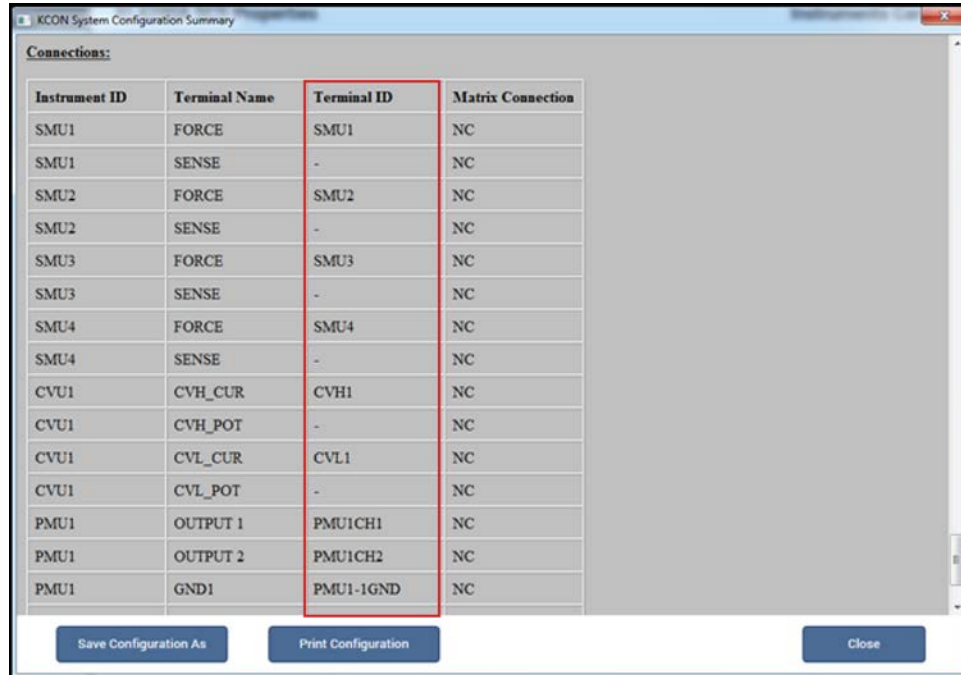
16. From the KCon toolbar, select **Validate Configuration** to ensure that the switching system is connected properly.

Figure 62: Validate Configuration icon



17. Select **Save** to save the system configuration.
18. Select **System Configuration Summary**, then scroll down to the Connections section. You can select **Save Configuration As** or **Print Configuration**, as you will need these names when setting the switching system connections in Clarius. The default values for the most common instruments are shown in the next figure.

Figure 63: System Configuration Summary: Default Terminal ID Connections



Instrument ID	Terminal Name	Terminal ID	Matrix Connection
SMU1	FORCE	SMU1	NC
SMU1	SENSE	-	NC
SMU2	FORCE	SMU2	NC
SMU2	SENSE	-	NC
SMU3	FORCE	SMU3	NC
SMU3	SENSE	-	NC
SMU4	FORCE	SMU4	NC
SMU4	SENSE	-	NC
CVU1	CVH_CUR	CVH1	NC
CVU1	CVH_POT	-	NC
CVU1	CVL_CUR	CVL1	NC
CVU1	CVL_POT	-	NC
PMU1	OUTPUT 1	PMU1CH1	NC
PMU1	OUTPUT 2	PMU1CH2	NC
PMU1	GND1	PMU1-1GND	NC

19. Close the window when you are finished.
20. Close the KCon application.

Set up the measurements in Clarius

After closing KCon, open the Clarius application from the desktop. In this section, you will use the Clarius application to configure and run two tests on an n-channel MOSFET transistor: A plot of drain current versus drain voltage using the SMUs and a C-V sweep. By using the Series 700 Switching System, you do not need to rearrange cables between the tests.

For this example, you use the Clarius application to:

- Create a new project
- Add a device
- Add an action
- Configure the action
- Search for and add two tests
- Run the project and view the tests

To create a new project:

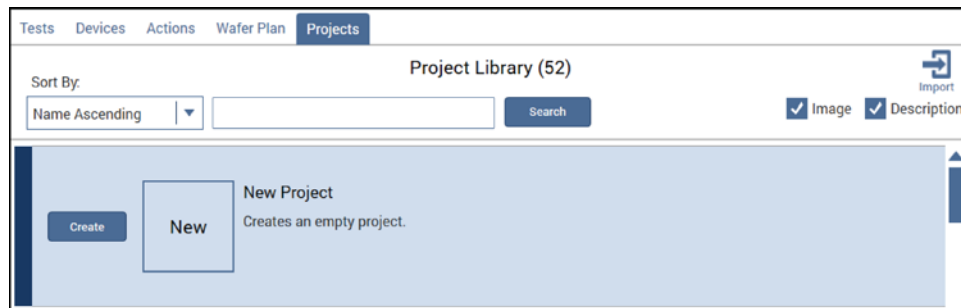
1. Choose **Select**.

Figure 64: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 65: Select a New Project from the Project Library



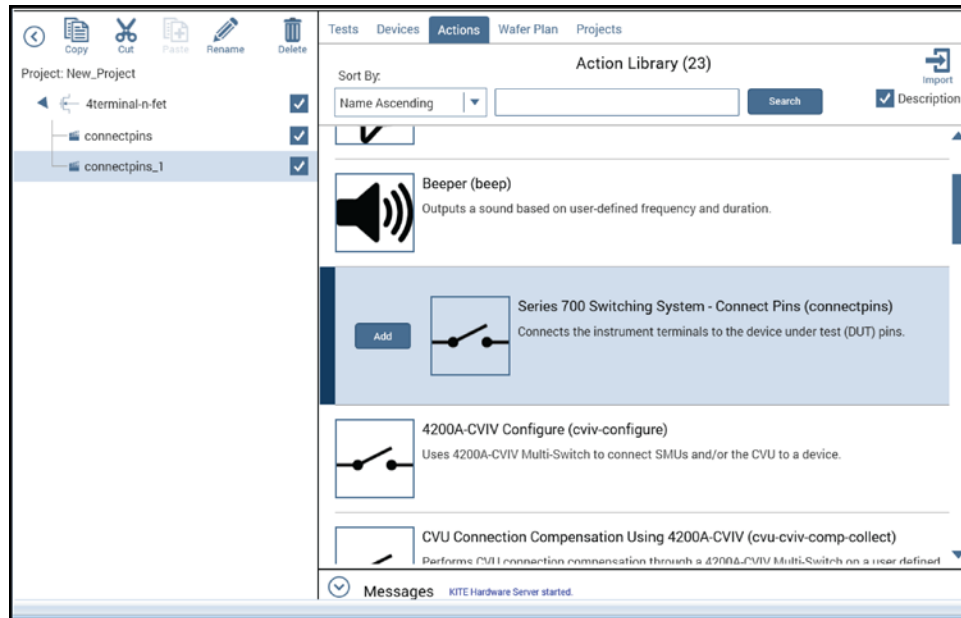
4. Select **Yes** when prompted to replace the existing project.

To add a device:

1. Select **Devices**.
2. Select **Search**.
3. Scroll to the **MOSFET, n-type, 4 terminal** device (4terminal-n-fet), then **Add** it to the project tree.

To add the connectpins action:

1. Select **Actions**.
2. Select **Search**.
3. Scroll to the connectpins action, then **Add** it to the project tree twice.

Figure 66: connectpins added twice**To configure the connectpins action:**

1. Select the first connectpins action you added to the project tree.
2. Select **Configure**.

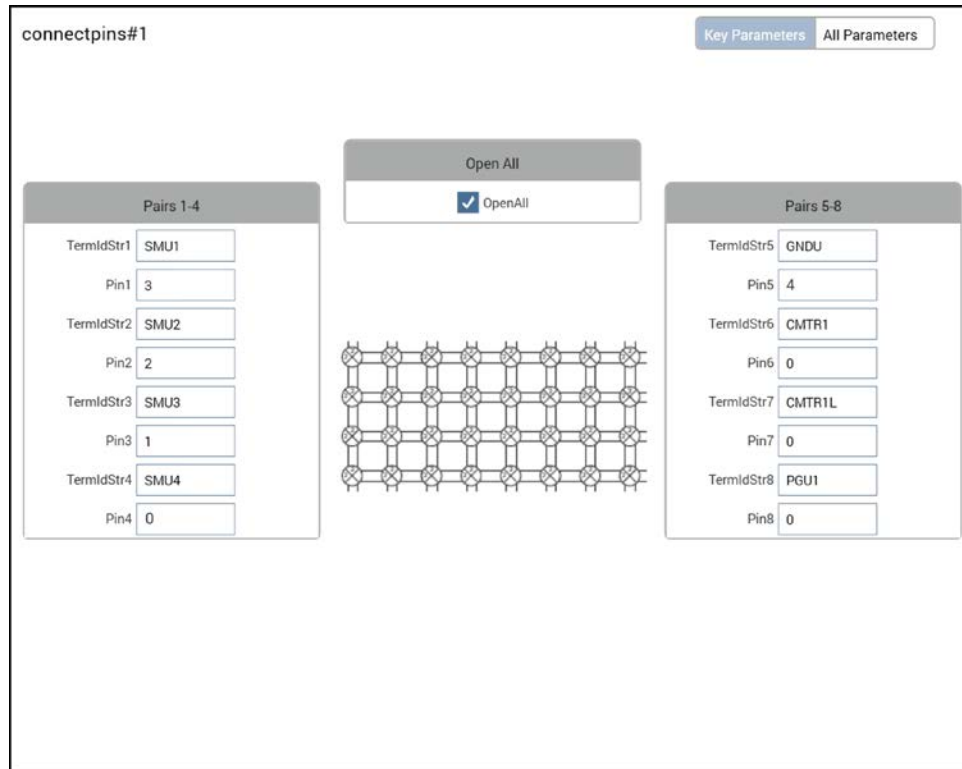
Figure 67: Configure highlighted

3. Make the following connections using the pairs of TermIdStr# and Pin# text fields in the action:
 - **SMU1 – Pin 3**
 - **SMU2 – Pin 2**
 - **SMU3 – Pin 1**
 - **GNDU – Pin 4**

When you are finished, the Key Parameters view of the action should look like the next graphic. The listed order of the instruments does not matter so long as each instrument is paired with the correct pin number.

In this example, assigning TermIdStr1 to **SMU1** and Pin 1 to **3** connects SMU1 to Pin 3 on the matrix.

Figure 68: connectpins device connections



NOTE

If you select the OpenAll check box, the `connectpins` action opens all crosspoints before closing the specified pairs. This is usually the preferred behavior. However, since `connectpins` only has eight field pairs, the action can only close eight crosspoints during each run. To close more crosspoints, use multiple `connectpins` actions.

4. Select **Save**.
5. Select the second `connectpins` action you added to the project tree.
6. Make the following connections using the pairs of TermIdStr# and Pin# text fields in the action:
 - **CVH1 – Pin 1**
 - **CVL1 – Pin 2**
 - **CVL1 – Pin 3**
 - **CVL1 – Pin 4**

When you are finished, the Key Parameters view of the action will look like the next graphic.

Figure 69: Second connectpins connections

connectpins1#1

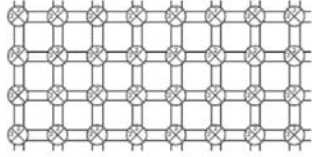
Key Parameters
All Parameters

Pairs 1-4

TermIdStr1	CVH1
Pin1	1
TermIdStr2	CVL1
Pin2	2
TermIdStr3	CVL1
Pin3	3
TermIdStr4	CVL1
Pin4	4

Open All

OpenAll



Pairs 5-8

TermIdStr5	GNDU
Pin5	0
TermIdStr6	CMTR1
Pin6	0
TermIdStr7	CMTR1L
Pin7	0
TermIdStr8	PGU1
Pin8	0

7. Select **Save**.

To search for and add existing tests from the Test Library:

1. Choose **Select**.

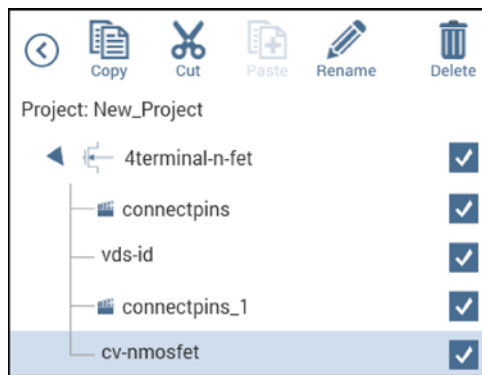
Figure 70: Select highlighted



2. Select **Tests**.
3. Type `vds` into the search box.
4. Scroll to the `vds-id` test and **Add** it to the project tree.
5. Drag the `vds-id` test between the two `connectpins` actions.
6. Clear the search box, then type `cv` into the search box.
7. Scroll to the `cv-nmosfet` test and **Add** it to the project tree.
8. Drag the `cv-nmosfet` test after the second `connectpins` action.

Your project tree will look like the next figure.

Figure 71: Project tree showing tests and actions in the proper order



To run the project and view the tests:

1. In the project tree, select `New_Project`.
2. Select **Run** to start the test. The two actions and tests run sequentially with the `connectpins` actions setting the crosspoints before the tests are executed.

You can select **Analyze** when you run the project to view test results in real-time.

Figure 72: Analyze highlighted



To view the results of a test either as it runs or after it has completed, select the test in the project tree.

Make I-V measurements on a solar cell

In this section:

Introduction	6-1
Equipment required.....	6-1
Device connections	6-2
Setting up measurements in the Clarius software	6-4

Introduction

This example shows how to use a 4200-SMU or 4210-SMU instrument to perform a forward-biased voltage sweep on a solar cell in a 4-wire configuration. Current is measured on each step of the sweep and an I-V graph is generated from the collected data. The Formulator calculates common electrical characteristics of the cell.

These instructions show you how to make connections from the SMU to the solar cell and how to add the forward bias I-V test into a new project and automate the measurements.

From the I-V characteristics measured by the 4200A-SCS, you can determine important parameters about the solar cell, including:

- Maximum current (I_{\max}) and voltage (V_{\max})
- Maximum power (P_{\max})
- Open-circuit voltage (V_{oc})
- Short-circuit current (I_{sc})

Equipment required

- One 4200A-SCS with one 4200-SMU or one 4210-SMU
- Four triaxial cables (4200-TRX-2 or 4200-MTRX-2)
- One solar cell
- One light source

Device connections

Connect your preamplifier or SMU output terminals to the solar cell in a 4-wire configuration. This provides the best measurement accuracy and eliminates the effects of the resistance of the test leads and unwanted voltage drops.

⚠ WARNING

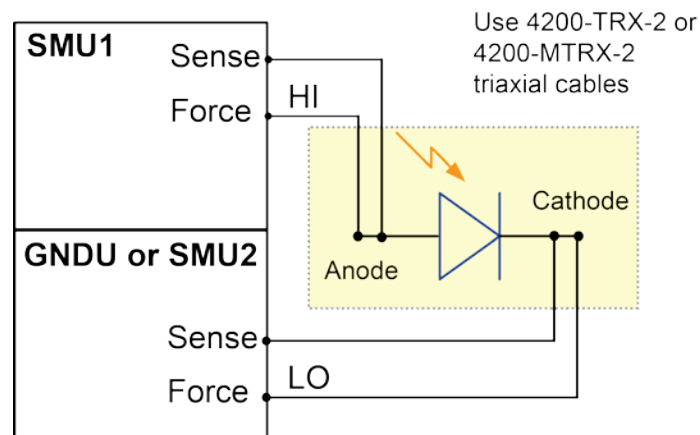
Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Device connection schematic

Connections to the solar cell can be made using two SMUs or one SMU and the Ground Unit (GNDU). The next figure shows the connection schematic for the application.

Figure 73: Solar cell device connection schematic



Connect the 4200A-SCS to the DUT

The following two figures show the 4200A-SCS rear-panel connections for the two methods mentioned in the [Device connection schematic](#) (on page 6-2) topic. You can make the connections shown in the following graphics using four 4200-TRX-2 or 4200-MTRX-2 triaxial cables.

Figure 74: Rear-panel connections using two SMUs

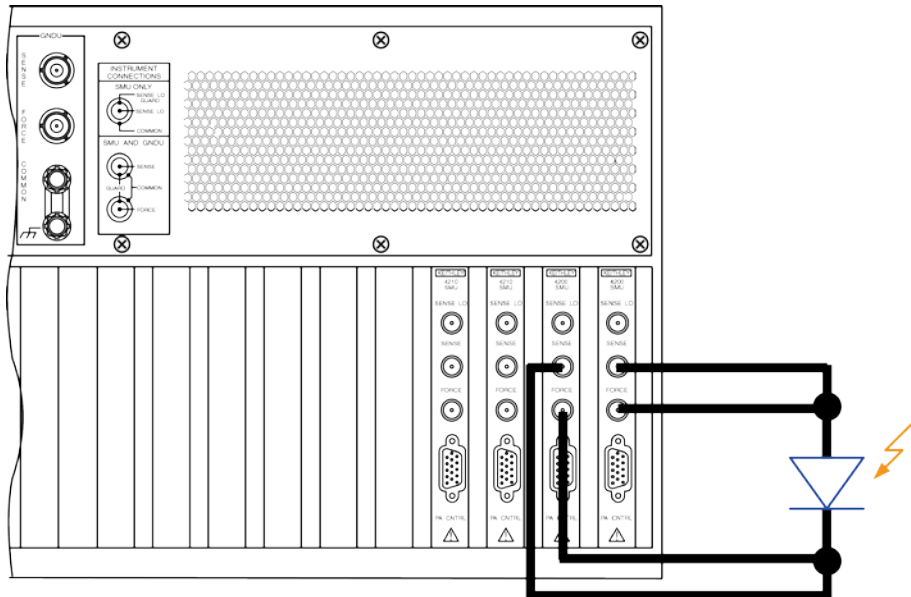
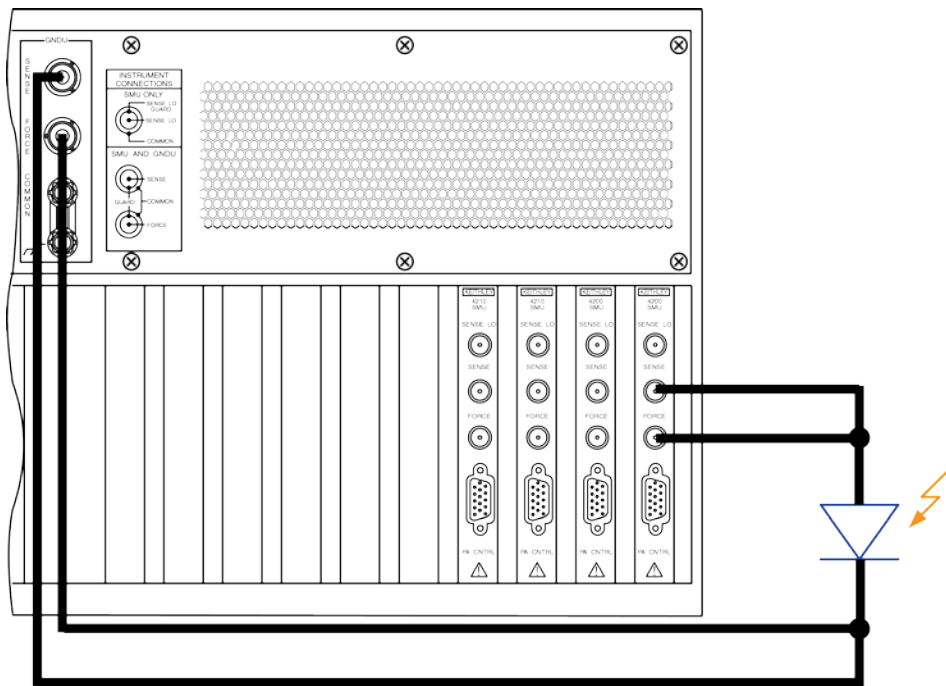


Figure 75: Rear panel connections using one SMU and GNDU



Setting up measurements in the Clarius software

This section demonstrates how to set up the 4200A-SCS to perform an I-V sweep on a solar cell. The `fwd-ivsweep` test measures current at each step of a user-configured voltage sweep. An I-V curve is generated from the acquired data, and device parameters are calculated in the Formulator.

For this example, use the Clarius application to to:

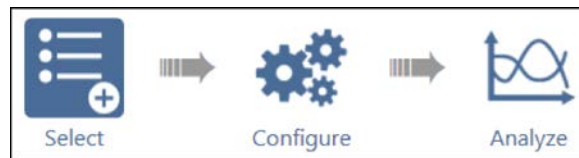
- Create a new project
- Search for and select a test
- Configure the test
- Execute the test
- View and analyze the test results

Create a new project

To create a new project:

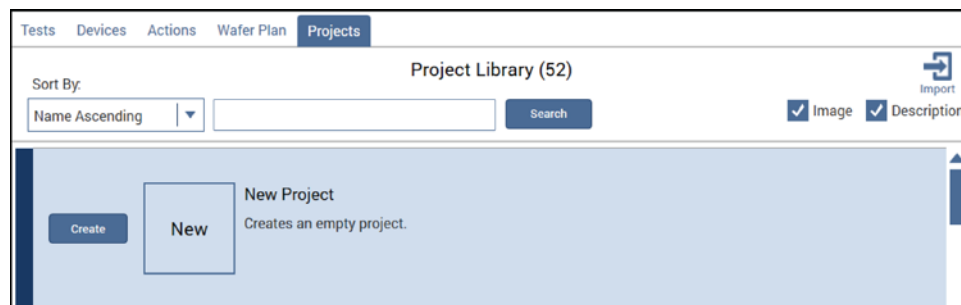
1. Choose **Select**.

Figure 76: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 77: Select a New Project from the Project Library



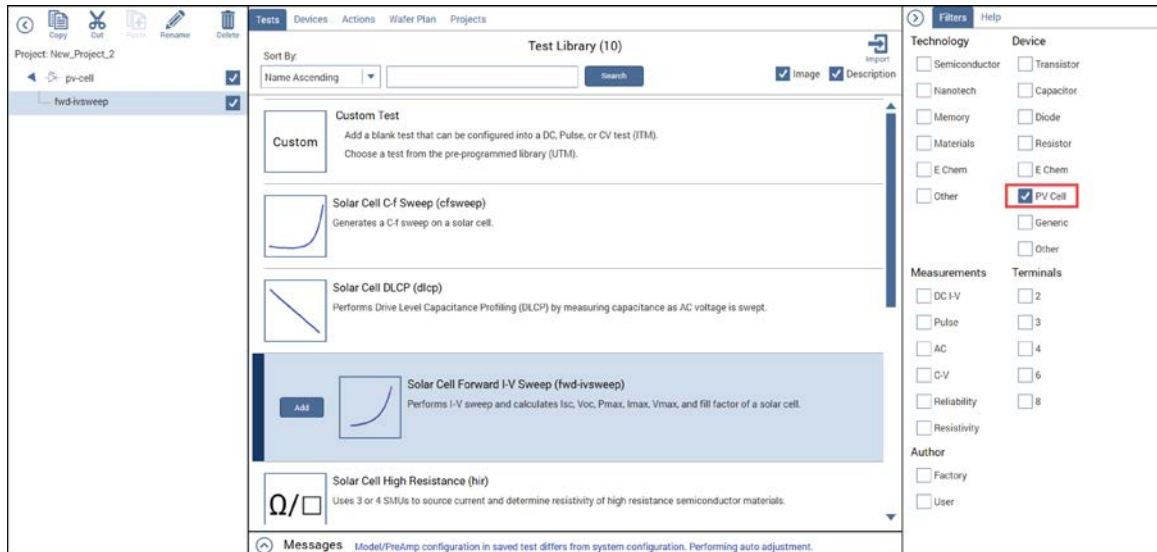
4. Select **Yes** when prompted to replace the existing project.

Search for and select a test

To search for and select the test:

1. Select **Tests**.
2. Select the **PV Cell** check box, then select **Search**.

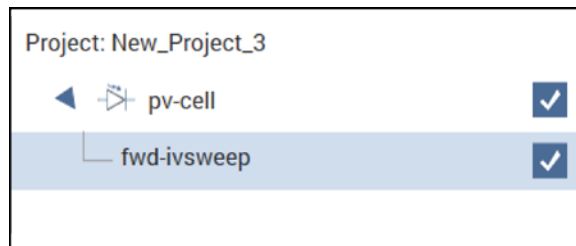
Figure 78: Use filters to select the solar cell I-V voltage sweep test



3. Select the **Solar Cell Forward I-V Sweep (fwd-ivsweep)** test.
4. Select **Add**.

The test is displayed in the project tree.

Figure 79: Test added to the project tree



Configure the test

To configure the test:

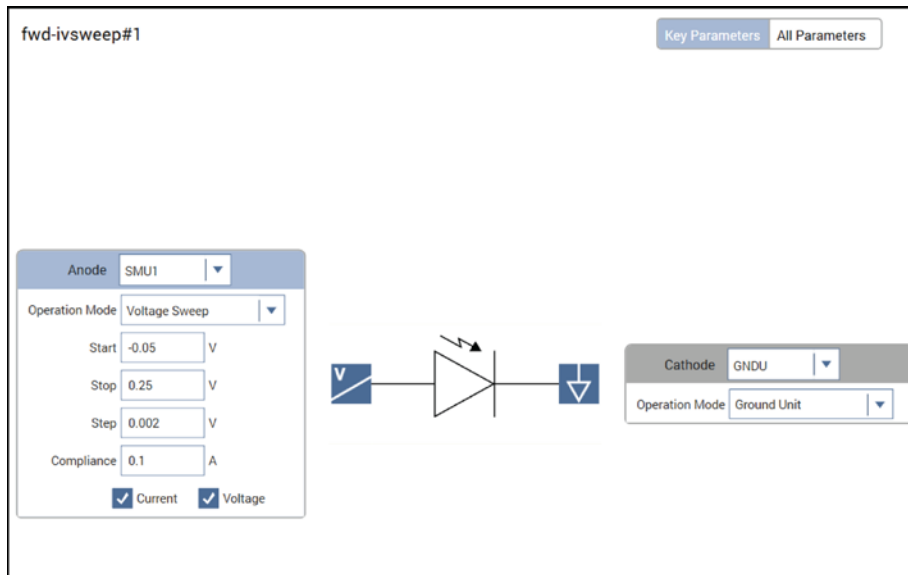
1. Select the `fwd-ivsweep` solar cell I-V test in the project tree.
2. Select **Configure**.

Figure 80: Configure highlighted



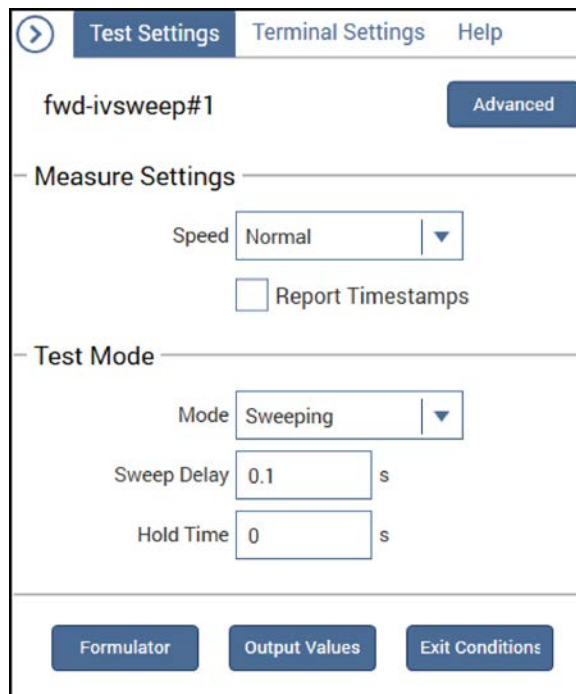
- Adjust the Anode settings as needed.

Figure 81: Key Parameters pane for the I-V sweep of a solar cell



- In the Test Settings pane, adjust the Measure Settings and Test Mode as needed.

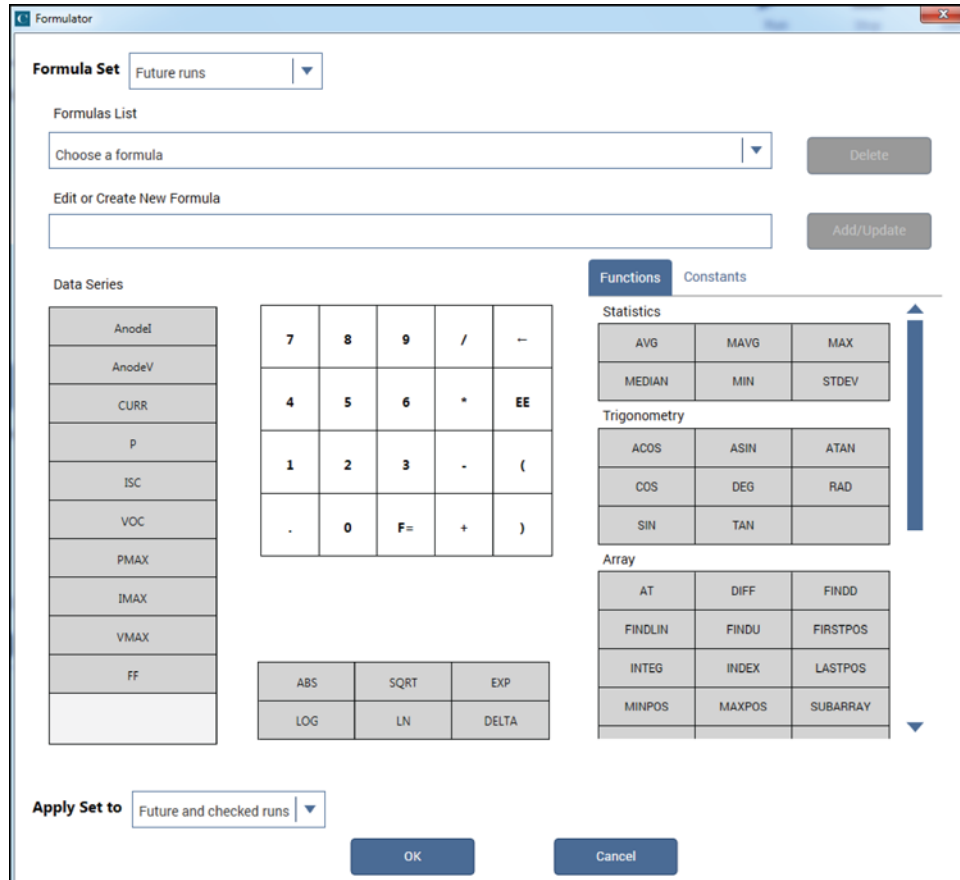
Figure 82: Test Settings pane



NOTE

The Formulator is also located in the Test Settings pane. If you select the Formulator in the Test Settings pane, the Formulator dialog box will appear as shown in the figure below.

Figure 83: Formulator dialog box



This test calculates V_{oc} , I_{sc} , P_{max} , and other device parameters. See the *Electrical Characterization of Photovoltaic Materials and Solar Cells with the 4200A-SCS Parameter Analyzer* application note for details on Formulator calculations. You can also add new formulas or edit existing formulas. See the "Formulator" topic in the *Model 4200A-SCS Reference Manual* for more information.

Execute the test

1. Highlight the `fld-ivsweep` test in the project tree.
2. Select **Run** to execute the test.

Figure 84: Run



Analyze the test results

You can select **Analyze** when you run the project to view test results in real-time.

Figure 85: Analyze highlighted



You can also use the View icons in the upper-right of the center pane to choose between **Sheet only**, **graph only**, or **Sheet + Graph**. The **Sheet only** view is shown in the next figure.

Figure 86: Sheet only view selected, View icons highlighted

fwd-ivsweep#1 View:

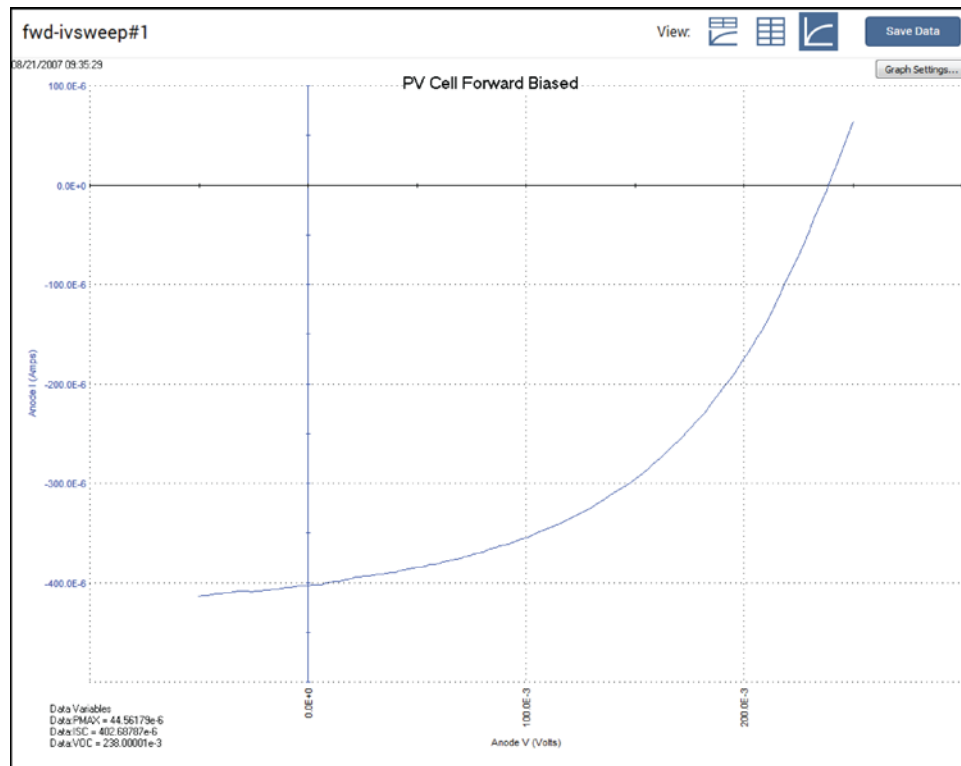
Run1 Formulas List CURR= ABS(ANODEI) Edit

	A	B	C	D	E	F	G	H	I	J
1	AnodeI	AnodeV	CURR	P	ISC	VOC	PMAX	IMAX	VMAX	FF
2	-413.3802E-6	-50.0000E-3	413.3802E-6	-20.6690E-6	402.6879E-6	238.0000E-3	44.5617E-6	289.3623E-6	154.0000E-3	464.9516E-3
3	-412.7658E-6	-48.0000E-3	412.7658E-6	-19.8127E-6						
4	-412.6070E-6	-46.0000E-3	412.6070E-6	-18.9799E-6						
5	-412.0101E-6	-44.0000E-3	412.0101E-6	-18.1284E-6						
6	-411.1007E-6	-42.0000E-3	411.1007E-6	-17.2682E-6						
7	-410.6701E-6	-40.0000E-3	410.6701E-6	-16.4268E-6						
8	-409.9707E-6	-38.0000E-3	409.9707E-6	-15.5788E-6						
9	-409.8355E-6	-36.0000E-3	409.8355E-6	-14.7540E-6						
10	-409.3015E-6	-34.0000E-3	409.3015E-6	-13.9162E-6						
11	-408.8281E-6	-32.0000E-3	408.8281E-6	-13.0625E-6						
12	-408.1941E-6	-30.0000E-3	408.1941E-6	-12.2458E-6						
13	-408.7257E-6	-28.0000E-3	408.7257E-6	-11.4443E-6						
14	-409.3095E-6	-26.0000E-3	409.3095E-6	-10.6420E-6						

The sheet displays the results with the voltage and current data labeled Anode V and Anode I, respectively. The formulas calculated in the Formulator are shown in the right-most columns. They include the maximum power (P_{MAX}), open circuit voltage (VOC), short circuit current (ISC), and fill factor (FF). More information about the Sheet and Formulator function can be found in the *Model 4200A-SCS Reference Manual*.

To see an expanded view of the graphed test results, select the **Graph only** view. The following graph shows the sweep of an illuminated silicon photovoltaic (PV) cell generated by the SMU.

Figure 87: Test results showing I-V graph of an illuminated solar cell



Because the system SMUs can sink current, the curve can pass through the fourth quadrant and allow power to be extracted from the device ($I-$, $V+$). If you want to have the data displayed in the first quadrant, use the Formulator to multiply the current by -1 and plot this calculated result instead.

You can also show previous test runs in the graph window by selecting them under the Run History tab. Select the check box next to the tests you want to display, and the test curves are displayed in the graph window. If you select multiple run histories, the graphs are overlaid.

Additional tests

You can add other solar cell tests to the project. Search for `solar cell` in the Test library to find additional tests.

Make C-V measurements on a MOSCAP

In this section:

Introduction	7-1
Equipment required.....	7-1
Device connections	7-1
Set up the measurements in Clarius	7-3

Introduction

Capacitance-voltage (C-V) measurements are commonly used in studying gate-oxide quality in detail. These measurements are made on two-terminal devices called MOS capacitors, which are MOSFETs without a source and drain. C-V test results offer device and process information, including bulk and interface charges. Many MOS device parameters, such as oxide thickness, flat band voltage, and threshold voltage, can also be extracted from the C-V test data.

This section provides an example of how to use the 4210-CVU CV Analyzer to make a C-V sweep on a MOS capacitor and derive common parameter extractions from the C-V data using the Formulator.

Equipment required

- One 4200A-SCS with the following instruments and accessories:
 - One 4210-CVU
 - Four CA-447A SMA cables
 - Four CS-1247 SMA female to BNC male adapters
 - Two CS-701 BNC tee adapters

Device connections

Using the supplied cables, make connections from the output terminals of the 4210-CVU to the MOS capacitor.

WARNING

Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

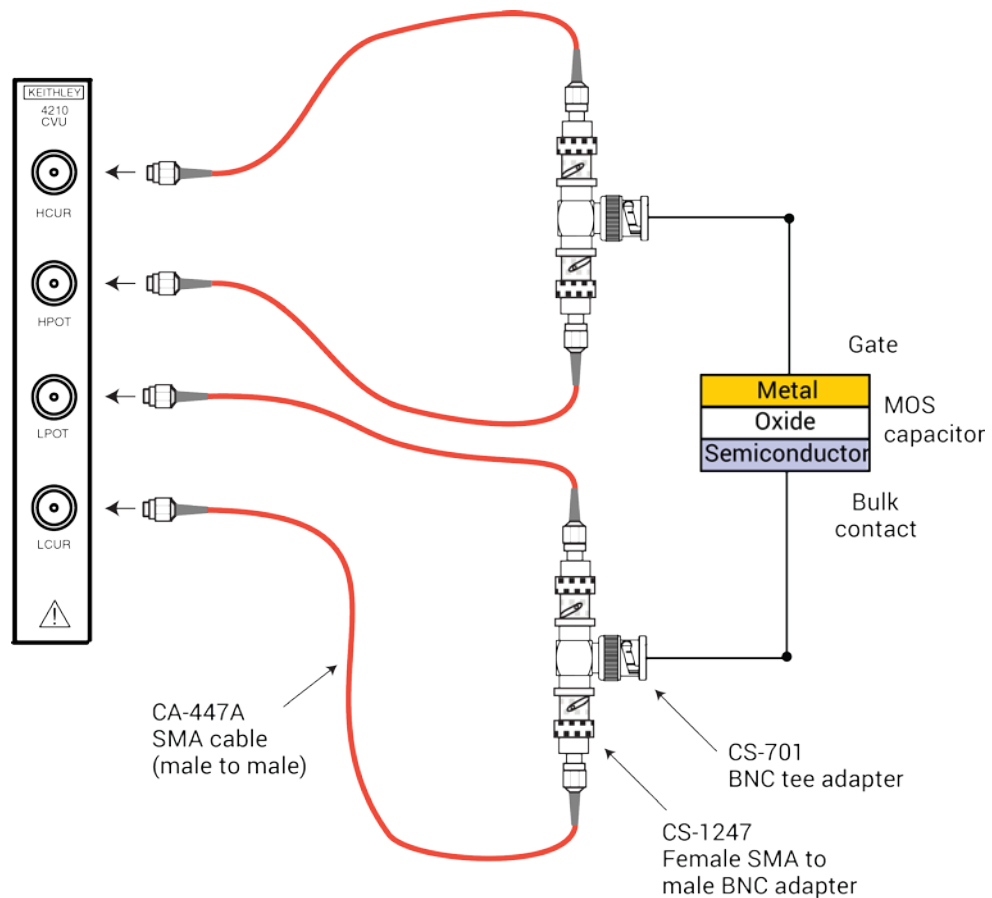
Connect the 4200A-SCS to the DUT

The hardware connections from the output terminals of the CVU to the MOS capacitor are shown in the following figure. Connect one cable to each of the CVU terminals, then connect one SMA female to BNC male adapter to the end of each cable.

The cables from the HCUR and HPOT terminals are coupled with the BNC tee adapter and are then connected to the gate of the MOS capacitor. The cables from the LCUR and LPOT terminals are also connected together with the BNC tee adapter and then are connected to the bulk of the MOS capacitor.

In the Clarius application, you will configure HCUR to be the high terminal of the AC ammeter and HPOT to be the high of the DC voltage source.

Figure 88: Connections from the 4210-CVU to the MOS capacitor



Set up the measurements in Clarius

This section describes how to set up the Clarius application to make a C-V sweep on a MOS capacitor. You select an existing project from the project library and configure a C-V sweep test.

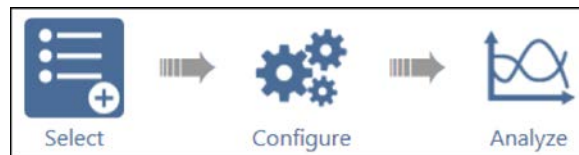
For this example, you will use Clarius to:

- Search for and select a project in the Project Library
- Configure the test
- Perform offset compensation
- Run the test and review the results

Search for and select a project

1. Choose **Select**.

Figure 89: Select highlighted



2. Select **Projects**.
3. Type `MOS cap` into the search bar, then select **Search**.
4. Select **MOS Capacitor C-V** project (`cvu-moscap`).
5. Select **Create**.
6. Select **Yes** when prompted to replace the existing project.

The project is displayed. This project has three C-V tests for a MOS capacitor, as shown in the next figure.

Figure 90: MOS capacitor C-V project tree with three tests



Configure the test

To configure the C-V sweep test, you set the source and measure parameters, define the timing parameters, and adjust the constants and formulas for extracting parameters from the C-V data.

This test makes a capacitance measurement at each step of a user-configured voltage sweep. A C-V graph is generated from the acquired data and several device parameters are calculated in the Formulator.

To configure the test:

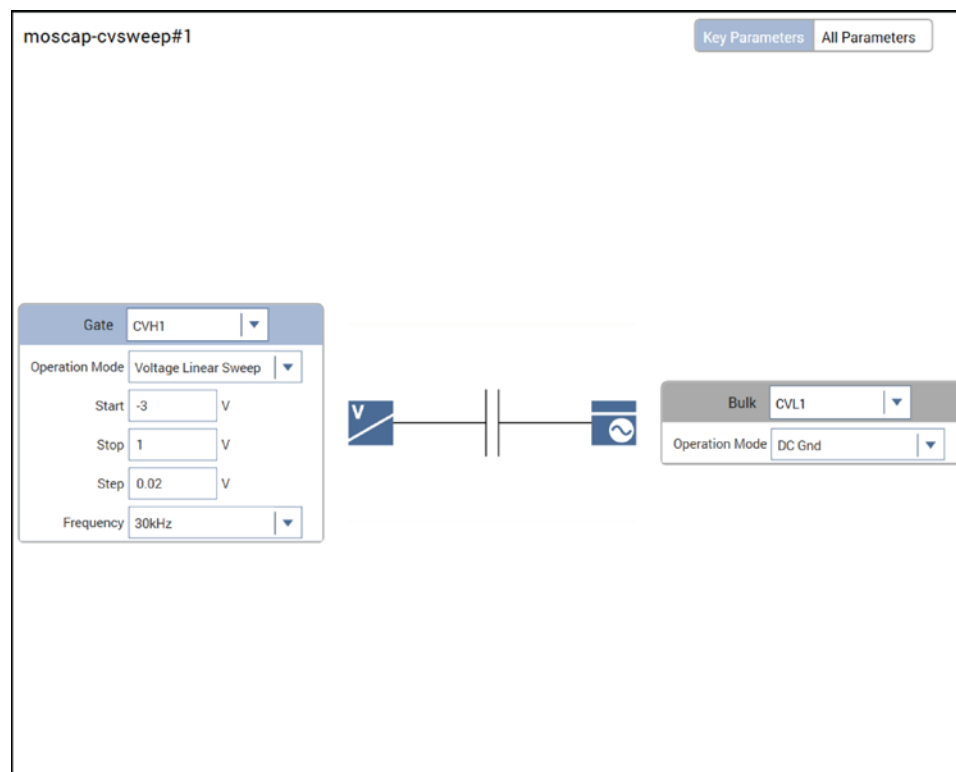
1. Select **Configure**.

Figure 91: Configure highlighted



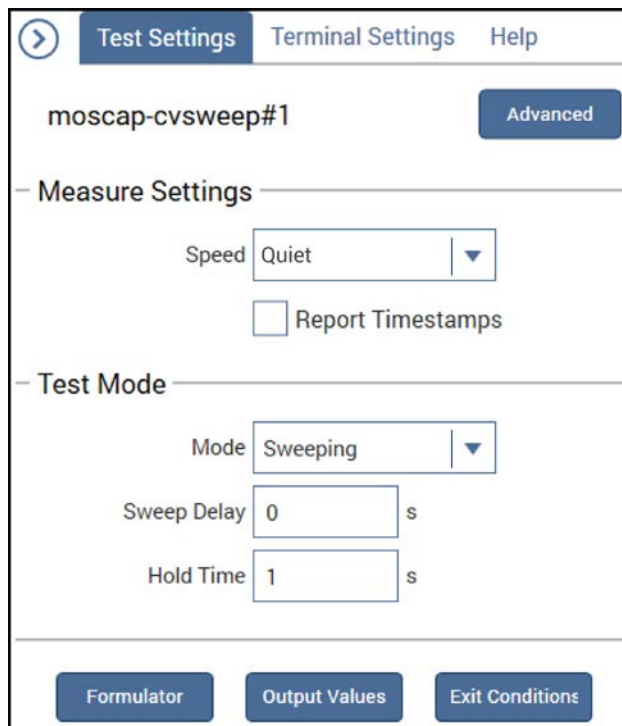
2. In the project tree, highlight the `moscap-cvsweep` test.
3. In the Key Parameters pane, adjust the voltage sweep and test frequency values as needed.

Figure 92: Key parameters for the C-V sweep of a MOS capacitor



4. In the Test Settings pane, set the Speed to **Quiet** for sensitive capacitance measurements.

Figure 93: Test Settings pane



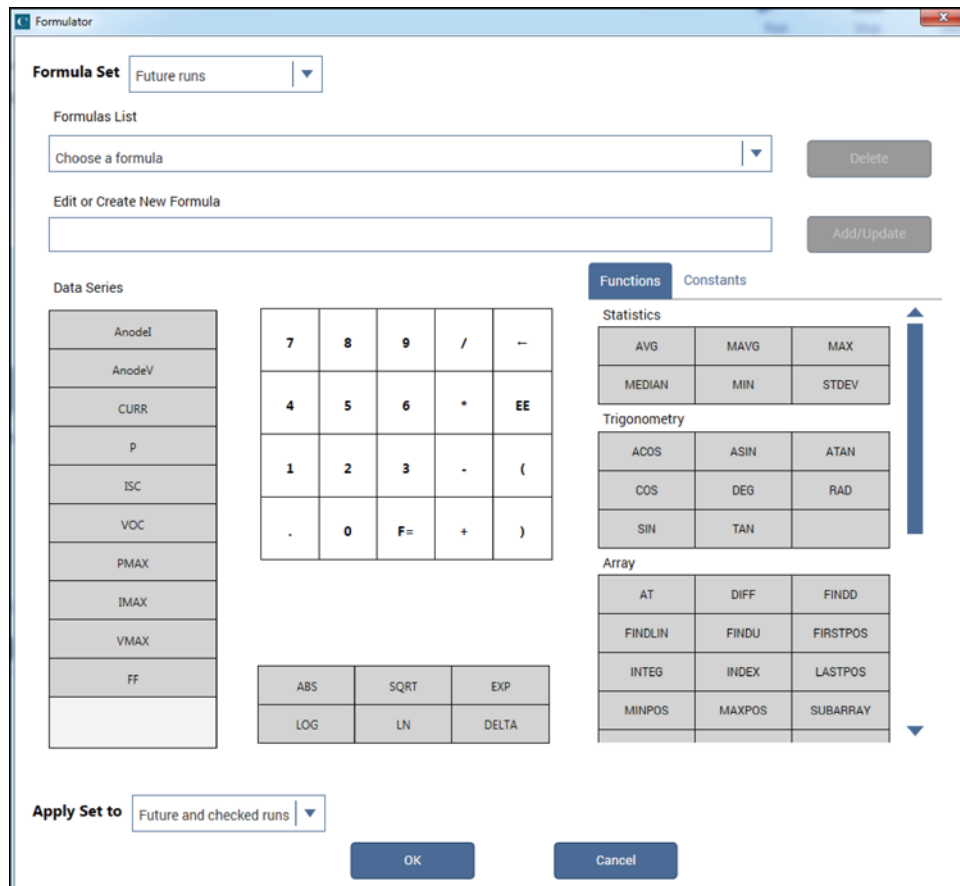
- Adjust the Sweep Delay as needed.

NOTE

The Formulator is located in the Test Settings pane. Select **Formulator** to display a dialog box, shown in the next figure.

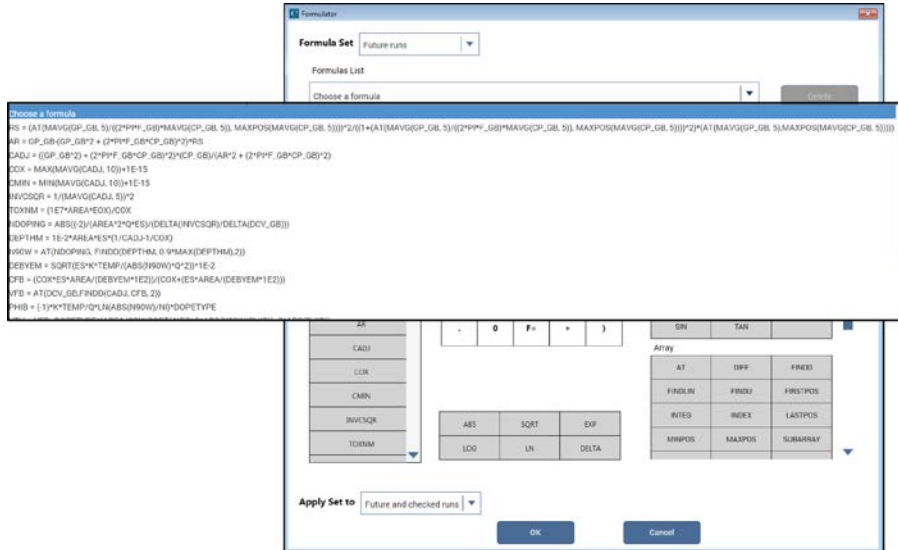
The Formulator in this test contains equations for deriving common MOS capacitor parameters from the C-V data. Examples of these parameters include the oxide capacitance, oxide thickness, flatband voltage, flatband capacitance, threshold voltage, and doping concentration. You can view, edit and add equations in this dialog box.

Figure 94: Formulator dialog box



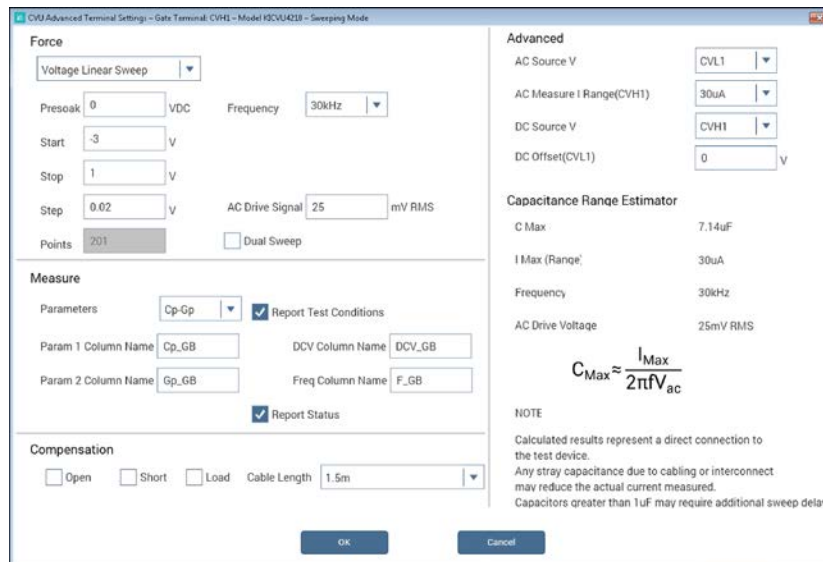
The next figure shows some of the equations that are included with this test. In the Constants area of the Formulator, you can change the parameters that are used in the formulas, such as the gate area and temperature.

Figure 95: Formulas listed in the Formulator



1. Select **OK** to accept changes made in the Formulator.
2. From the Terminal Settings Advanced dialog box, adjust the DC voltage source, measurement parameters, AC drive voltage, and enable compensation as needed.

Figure 96: Terminal Settings pane and Terminal Settings Advanced dialog box



From the Advanced dialog box, adjust the settings for the CVH1 and CVL1 terminals of the CVU as needed.

In this test, the CVH1 terminals are internally connected to the AC ammeter and the HI of the DC voltage source by default. The CVH1 terminals are externally connected to the gate of the MOS capacitor. The CVL1 terminals are internally connected to the AC voltage source and the LO of the DC voltage source and are externally connected to the bulk of the MOS capacitor or to the prober chuck.

Perform offset compensation

C-V measurements on a MOS capacitor are generally performed on a wafer using a prober. The 4210-CVU is connected to the MOS capacitor through cables, adapters, and a prober. Cabling adds stray capacitance to measurements.

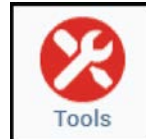
To correct for the stray capacitance, Clarius has tools for offset correction. Correction is a two-part process: You perform the corrections for open, and then you enable the corrections in the Terminal Settings pane.

Open compensation is generally used for high impedance measurements ($< 10 \text{ pF}$ or $> 1 \text{ M}\Omega$), while a short compensation correction is generally performed for low impedance measurements ($> 10 \text{ nF}$ or $< 10 \text{ }\Omega$). For a short compensation, you would select Measure Short, and then short the probe to the chuck.

To perform the corrections:

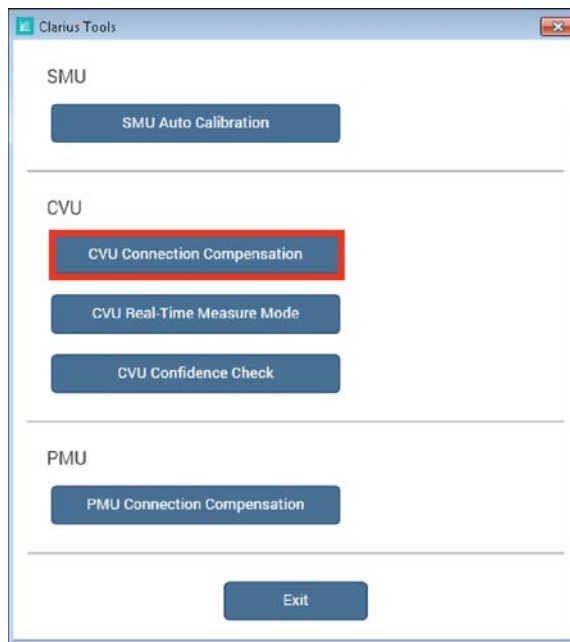
1. Select **Tools**.

Figure 97: Tools icon in Clarius



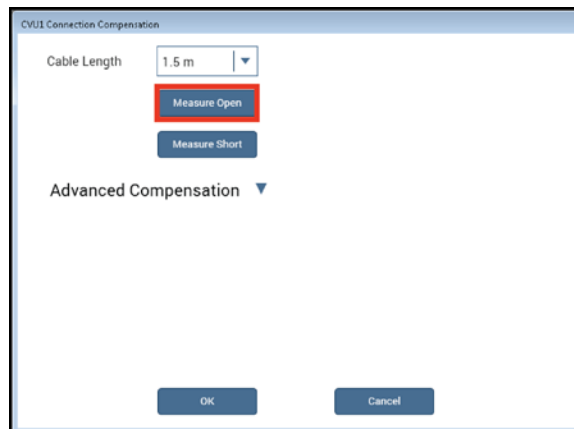
2. Select **CVU Connection Compensation** from the Clarius Tools dialog box.

Figure 98: Clarius Tools dialog box



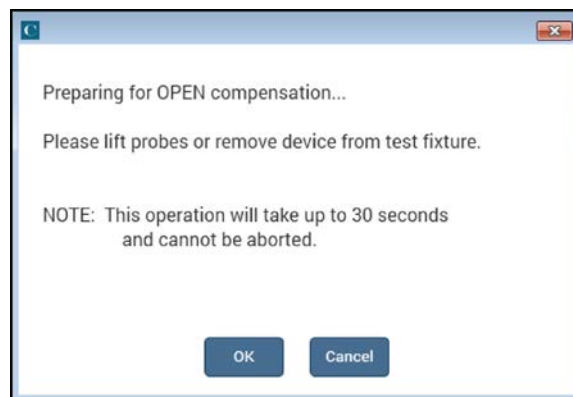
3. Disconnect the probes from the DUT.
4. Select **Measure Open**.

Figure 99: CVU Connection Compensation dialog box



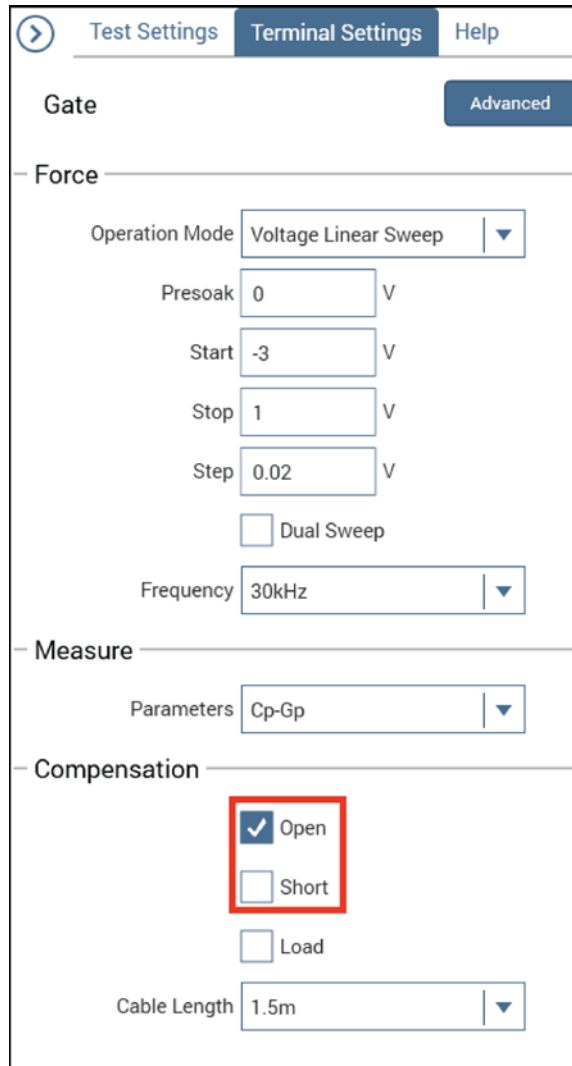
5. Select **OK**. You are prompted to verify that the probes have been disconnected from the DUT.

Figure 100: Prompt to remove probes from DUT



6. Make sure that the probes have been disconnected from the DUT, then select **OK**. The compensation runs, and a dialog box confirms that the compensation has run successfully.
7. From the Terminal Settings pane, enable the corrections by selecting the **Open** or **Short** checkbox, as needed.

Figure 101: Enabling CVU Compensation



Run the test

Select **Run** to execute the test.

Figure 102: Run



View and analyze the test results

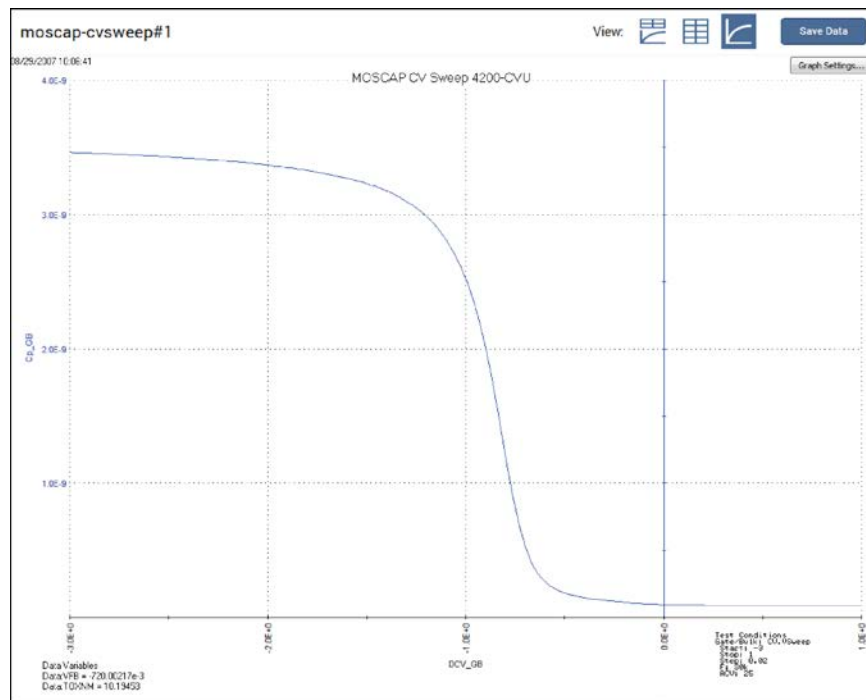
You can select **Analyze** when you run the project to view test results in real-time.

Figure 103: Analyze highlighted



The C-V data is plotted on the graph as the `moscap-cvsweep` test executes.





Figure 104: Graph in the Analyze pane



You can also click the Run sheet of the Analyze pane, as highlighted in the next figure, to display more data. For example, you can display a holistic view of the parameters for a device.

Figure 105: C-V data in the sheet

moscap-cvsweep#1

View:     Save Data Edit

Run1 Formulas List RS= (AT(MAVG(GP_GB, 5))/(2*PI*F_GB)*MAVG(CP_GB, 5)), MAXPOS(MAVG(CP_GB, 5)))^2/(1+(AT(MAVG

	A	B	C	D	E	F	G	H	I	J	K
1	Cp GB	Gp GB	DCV GB	F GB	RS	AR	CADJ	COX	CMIN	INVC	SCQR
2	3.4645E-9	36.4846E-6	3.0000E+0	30.0000E+3	85.3264E+0	19.4742E-9	3.4754E-9	3.4698E-9	90.0692E-12	#REF	#REF
3	3.4633E-9	36.4740E-6	-2.9800E+0	30.0000E+3		4.7268E-9	3.4741E-9				
4	3.4621E-9	36.4524E-6	-2.9600E+0	30.0000E+3		158.2666E-12	3.4729E-9				82.9086E+15
5	3.4609E-9	36.4374E-6	-2.9400E+0	30.0000E+3		10.4458E-9	3.4717E-9				82.9667E+15
6	3.4597E-9	36.4158E-6	-2.9200E+0	30.0000E+3		13.5522E-9	3.4705E-9				83.0257E+15
7	3.4585E-9	36.3938E-6	-2.9000E+0	30.0000E+3		17.2961E-9	3.4693E-9				83.0845E+15
8	3.4572E-9	36.3699E-6	-2.8800E+0	30.0000E+3		19.1980E-9	3.4680E-9				83.1443E+15
9	3.4559E-9	36.3514E-6	-2.8600E+0	30.0000E+3		28.4879E-9	3.4667E-9				83.2056E+15
10	3.4547E-9	36.3206E-6	-2.8400E+0	30.0000E+3		23.3835E-9	3.4655E-9				83.2676E+15
11	3.4534E-9	36.3083E-6	-2.8200E+0	30.0000E+3		39.6584E-9	3.4641E-9				83.3307E+15
12	3.4521E-9	36.2819E-6	-2.8000E+0	30.0000E+3		40.3526E-9	3.4628E-9				83.3955E+15
13	3.4507E-9	36.2581E-6	-2.7800E+0	30.0000E+3		45.5286E-9	3.4614E-9				83.4610E+15
14	3.4493E-9	36.2374E-6	-2.7600E+0	30.0000E+3		55.0267E-9	3.4600E-9				83.5275E+15
15	3.4480E-9	36.2034E-6	-2.7400E+0	30.0000E+3		48.0724E-9	3.4587E-9				83.5952E+15
16	3.4465E-9	36.1833E-6	-2.7200E+0	30.0000E+3		58.5557E-9	3.4572E-9				83.6643E+15
17	3.4451E-9	36.1589E-6	-2.7000E+0	30.0000E+3		63.6099E-9	3.4558E-9				83.7338E+15
18	3.4436E-9	36.1332E-6	-2.6800E+0	30.0000E+3		69.5090E-9	3.4543E-9				83.8057E+15
19	3.4421E-9	36.1037E-6	-2.6600E+0	30.0000E+3		70.9472E-9	3.4528E-9				83.8791E+15
20	3.4406E-9	36.0822E-6	-2.6400E+0	30.0000E+3		81.4972E-9	3.4513E-9				83.9541E+15
21	3.4390E-9	36.0475E-6	-2.6200E+0	30.0000E+3		80.0865E-9	3.4497E-9				84.0308E+15
22	3.4375E-9	36.0144E-6	-2.6000E+0	30.0000E+3		79.8444E-9	3.4481E-9				84.1090E+15
23	3.4358E-9	35.9866E-6	-2.5800E+0	30.0000E+3		86.8085E-9	3.4464E-9				84.1885E+15
24	3.4342E-9	35.9480E-6	-2.5600E+0	30.0000E+3		82.0969E-9	3.4448E-9				84.2691E+15
25	3.4325E-9	35.9198E-6	-2.5400E+0	30.0000E+3		88.1696E-9	3.4431E-9				84.3516E+15
26	3.4309E-9	35.8909E-6	-2.5200E+0	30.0000E+3		94.6727E-9	3.4414E-9				84.4342E+15
27	3.4292E-9	35.8622E-6	-2.5000E+0	30.0000E+3		101.1837E-9	3.4397E-9				84.5191E+15
28	3.4274E-9	35.8265E-6	-2.4800E+0	30.0000E+3		102.8567E-9	3.4379E-9				84.6060E+15
29	3.4256E-9	35.7885E-6	-2.4600E+0	30.0000E+3		101.8689E-9	3.4361E-9				84.6951E+15
30	3.4238E-9	35.7543E-6	-2.4400E+0	30.0000E+3		105.9497E-9	3.4343E-9				84.7873E+15
31	3.4219E-9	35.7237E-6	-2.4200E+0	30.0000E+3		114.7982E-9	3.4324E-9				84.8822E+15
32	3.4199E-9	35.6793E-6	-2.4000E+0	30.0000E+3		111.9690E-9	3.4304E-9				84.9795E+15
33	3.4179E-9	35.6533E-6	-2.3800E+0	30.0000E+3		128.3570E-9	3.4283E-9				85.0793E+15
34	3.4159E-9	35.6002E-6	-2.3600E+0	30.0000E+3		116.8718E-9	3.4263E-9				85.1827E+15
35	3.4138E-9	35.5684E-6	-2.3400E+0	30.0000E+3		128.2407E-9	3.4242E-9				85.2879E+15
36	3.4116E-9	35.5340E-6	-2.3200E+0	30.0000E+3		140.0366E-9	3.4220E-9				85.3942E+15
37	3.4094E-9	35.4767E-6	-2.3000E+0	30.0000E+3		127.7582E-9	3.4198E-9				85.5035E+15
38	3.4073E-9	35.4462E-6	-2.2900E+0	30.0000E+3		141.0168E-9	3.4177E-9				85.6165E+15
39	3.4050E-9	35.3947E-6	-2.2600E+0	30.0000E+3		137.1490E-9	3.4154E-9				85.7313E+15
40	3.4026E-9	35.3588E-6	-2.2400E+0	30.0000E+3		151.2832E-9	3.4129E-9				85.8492E+15
41	3.4002E-9	35.3087E-6	-2.2200E+0	30.0000E+3		150.5264E-9	3.4105E-9				85.9712E+15
42	3.3976E-9	35.2624E-6	-2.2000E+0	30.0000E+3		154.9863E-9	3.4081E-9				86.0970E+15
43	3.3953E-9	35.2176E-6	-2.1800E+0	30.0000E+3		161.6198E-9	3.4058E-9				86.2259E+15

Run1 Calc Settings

Use the 4200A-CVIV Multi-Switch

In this section:

Introduction	8-1
Equipment required.....	8-1
Device connections	8-2
Set up the measurements in Clarius	8-4

Introduction

This section provides an example of how to use the 4200A-SCS and Model 4200A-CVIV Multi-Switch to perform I-V and C-V measurements on the same device without having to manually change connections to the device between tests.

The 4200A-CVIV allows you to switch between I-V and C-V measurements as well as make C-V measurements between output terminals of the 4200A-CVIV.

The 4200A-CVIV can be equipped with up to four 4200-PA Remote Preamplifiers or 4200-CVIV-SPT SMU Pass-Thru modules.

A MOSFET is used as the device in this example, but the same procedure applies for all devices.

For additional information on the 4200A-CVIV, see the *Model 4200A-CVIV Multi-Switch User's Guide*.

Equipment required

- One 4200A-SCS with the following instruments:
 - Four 4200-SMUs or 4210-SMUs
 - Four 4200-PAs or 4200A-CVIV-SPTs (two 4200A-CVIV-SPTs are supplied with the 4200A-CVIV)
 - One 4210-CVU
- One 4200A-CVIV
- Four 4200-TRX-2 or 4200-MTRX-2 triaxial cables (supplied with the SMU)
- Four 4200-TRX-0.75 Cables (triaxial cables, approximately 30 in. each)
- Four CA-447A SMA cables (supplied with the CVU)
- One shielded four-terminal test fixture with triaxial inputs

Device connections

If you will use 4200-PA Remote Preamplifiers with the 4200A-CVIV, the modules are installed directly in the instrument. If you will not be using preamplifiers, the 4200A-CVIV-SPT SMU Pass-Thru modules are installed in the instrument. You can then make connections from the output of the 4200-SMU cards to the triaxial inputs of the 4200A-CVIV-SPT modules. To install preamplifiers or the 4200A-CVIV-SPT modules, see the *Model 4200A-CVIV Multi-Switch User's Guide* for instructions.

You will also make connections from the 4210-CVU to the SMA inputs of the 4200A-CVIV using the CA-447A SMA cables supplied with the CVU. The *Model 4200A-CVIV Multi-Switch User's Guide* contains additional connection information.

From the output of the 4200A-CVIV, use the 4200-TRX-0.75 triaxial cables to connect the CVIV to the shielded test fixture. The triaxial terminals on the shielded test fixture allow you to connect directly to the MOSFET while maintaining a completely shielded and guarded test setup. The triaxial cables can also be connected to a wafer probing station. A triaxial-to-coaxial adapter can be used to connect to test fixtures or probe stations that only have coaxial inputs.

NOTE

The inner shield of the triaxial cable can have voltages up to 200 V present during SMU operation. Any triaxial-to-coaxial adapter used for conversion should connect the inner conductor and the outer shield to the coaxial connector only.

WARNING

Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

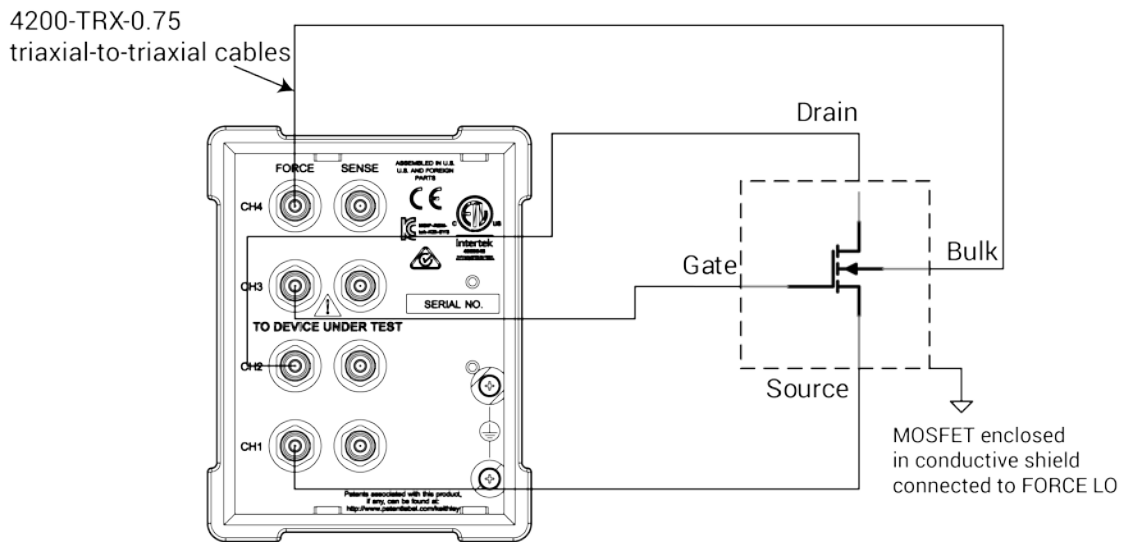
To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Connection schematic

Make the hardware connections from the output terminals of the 4200A-CVIV to the MOSFET, as shown in the following figure. In this example, 2-wire (local sense) measurements are made at the MOSFET, so four triaxial cables are connected from each Force output terminal of the 4200A-CVIV to the device.

Each 4200A-CVIV output is connected to a different terminal of the 4-terminal MOSFET. The 4200-TRX-0.75 triaxial cables are recommended for use on the output of the 4200A-CVIV. These cables are used to ensure that both low current I-V measurements and high frequency C-V measurements can be made with high accuracy.

Figure 106: Connections from the 4200A-CVIV to MOSFET



Set up the measurements in Clarius

This section describes how to set up the 4200A-SCS to control the 4200A-CVIV to automatically switch between I-V and C-V measurements.

For this example, you use the Clarius application to:

- Create a new project
- Add and configure a C-V compensation action
- Add a MOSFET device
- Add an action for switching the SMUs
- Add a test for making I-V measurements
- Add an action for switching the CVU
- Add a test for making C-V measurements
- Run the project
- View and analyze the test results

The project created in this example is used for two different purposes:

1. The project collects C-V connection compensation constants for all of the 4200A-CVIV channel configurations that include C-V measurements. This step only needs to be performed once per configuration.
2. The project runs the tests on the MOSFET. The 4200A-SCS is configured to connect the SMUs to the MOSFET and produce a V_{ds} - I_d family of curves, then the project re-configures the 4200A-SCS to connect the 4210-CVU to the MOSFET and perform a C-V measurement between the gate of the MOSFET (CV HI) and the source, drain, and bulk (CV LO).

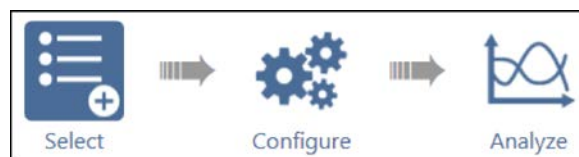
You can use this same general procedure to create tests for other devices and for other applications. You can also configure the project to perform multiple I-V measurements and multiple C-V measurements on the same device with different 4200A-CVIV configurations.

Create and rename a project for I-V and C-V measurements with compensation

To create and rename a project for I-V and C-V measurements with compensation:

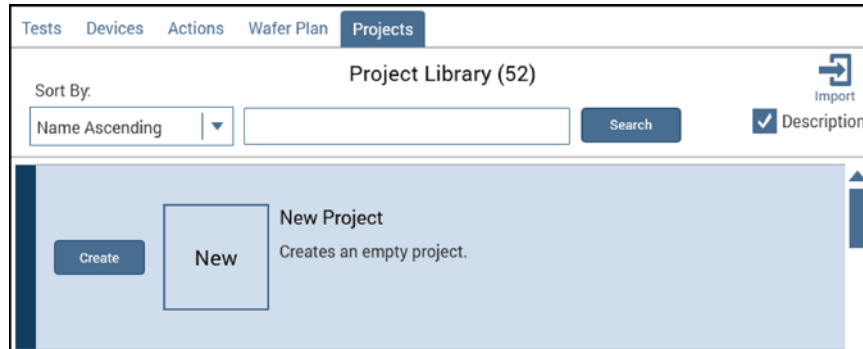
1. To begin a new project, choose **Select**.

Figure 107: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 108: New project option, Projects tab



4. Select **Yes** when prompted to replace the existing project.
5. Give a new title to the project by selecting **Rename** from the toolbar. Enter a project name into the text box, then select **Enter**. CVIV_COMPENSATION is the test name for this example.

Figure 109: Rename function located above the project tree



Add an action to perform CVU compensation

The `cvu-cviv-comp-collect` action configures the 4200A-CVIV to the selected channel configuration and performs compensation.

To add an action:

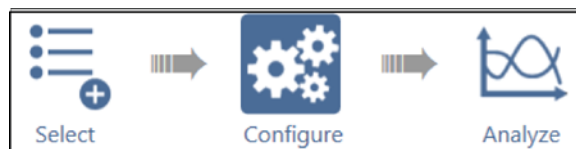
1. Select **Actions**.
2. To find the action, enter `cviv` into the search bar, then select **Search**.
3. Select the `cvu-cviv-comp-collect` action, then select **Add** to copy it to the project tree.

Configure the action

To configure the action:

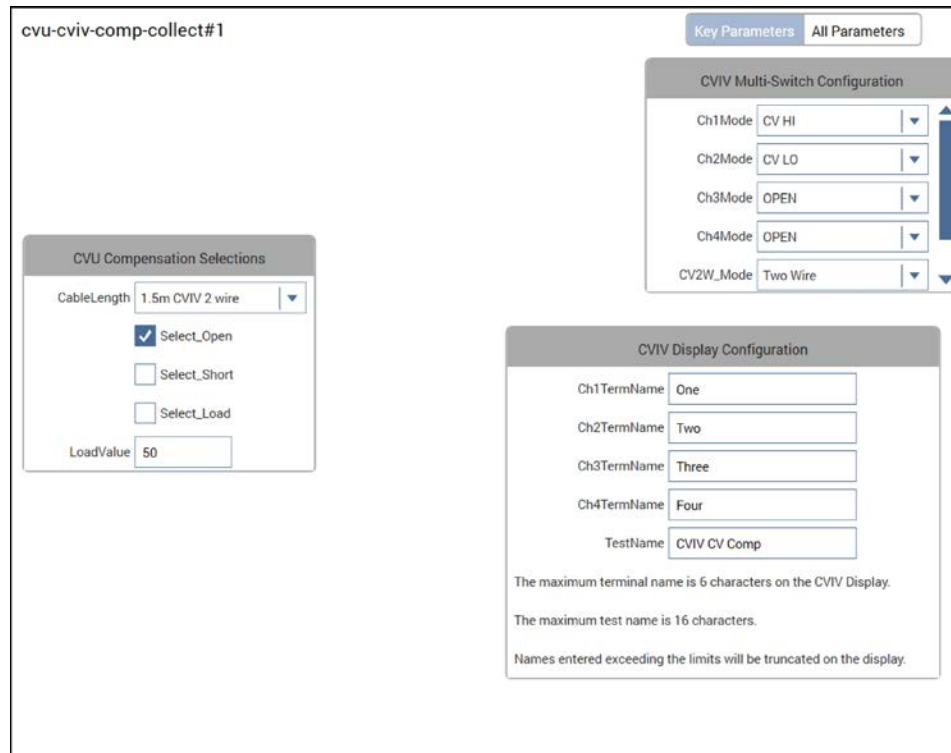
1. Choose **Configure**.

Figure 110: Configure highlighted



- From the project tree, select the `cvu-cviv-comp-collect` action.

Figure 111: cvu-cviv-comp-collect Action



- From the CVIV Multi-Switch Configuration terminal settings box, set the output mode of the 4200A-CVIV to **Two Wire**.

NOTE

The following step changes the name of each channel to match each channel's corresponding MOSFET terminal. This step is not necessary for the action to run, but you can see which terminals correspond to each output terminal by viewing the 4200A-CVIV display.

- In the CVIV Display Config box, change the name of each channel to match the corresponding MOSFET terminal
- In the CVIV Display Configuration box, Set channel 3 (Gate) to **CV HI** and the remaining channels 1, 2, and 3 to **CV LO**.
- From the CVU Compensation Selections, enable open correction by selecting **Select_Open**.
- Make sure that the DUT is disconnected.
- Select **Run** to configure the 4200A-CVIV and collect compensation constants.

Figure 112: Run the action



9. A dialog box is displayed with instructions to remove the device-under-test (DUT) from the test fixture or lift the probes before performing open compensation. Remove the DUT before selecting **OK**.
10. Return the DUT to the test fixture when compensation completes.
11. In the project tree, clear the check box next to the `cvu-cviv-comp-collect` action.

NOTE

Clearing this action alerts the software to not perform the compensation collection if the whole project is executed. It is not necessary to collect compensation constants each time the test is executed. To recollect the compensation constants, select the action and its check box in the project tree, then select **Run**.

The compensation constants are stored in a database that links each 4200A-CVIV configuration to a set of compensation values. These values are recalled if compensation is enabled in a CVU test while using this 4200A-CVIV configuration.

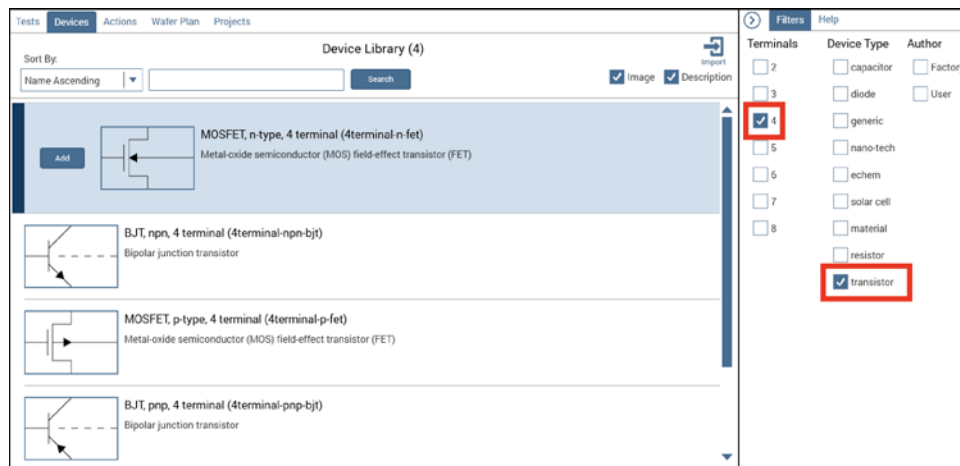
For optimal results, the compensation collection action must be executed for every 4200A-CVIV configuration that is used throughout the test sequence.

Add a device

To add a device:

1. Choose **Select**.
2. Select **Devices**.
3. In the Filters pane, select **4** under the Terminals column and **Transistor** under the Device Type column.

Figure 113: Searching for a device using Filters



4. Select the **MOSFET, n-type, 4 terminal (4terminal-n-fet)** device, then select **Add** to copy it to the project tree.

Add an action for switching the SMUs to the device

To add an action:

1. Select **Actions**.
2. Type `cviv` into the search bar, then select **Search**.
3. Select the `cviv-configure` action, then select **Add** to copy it to the project tree.

Configure the action

To configure the action:

1. Select **Configure**.

Figure 114: Configure highlighted



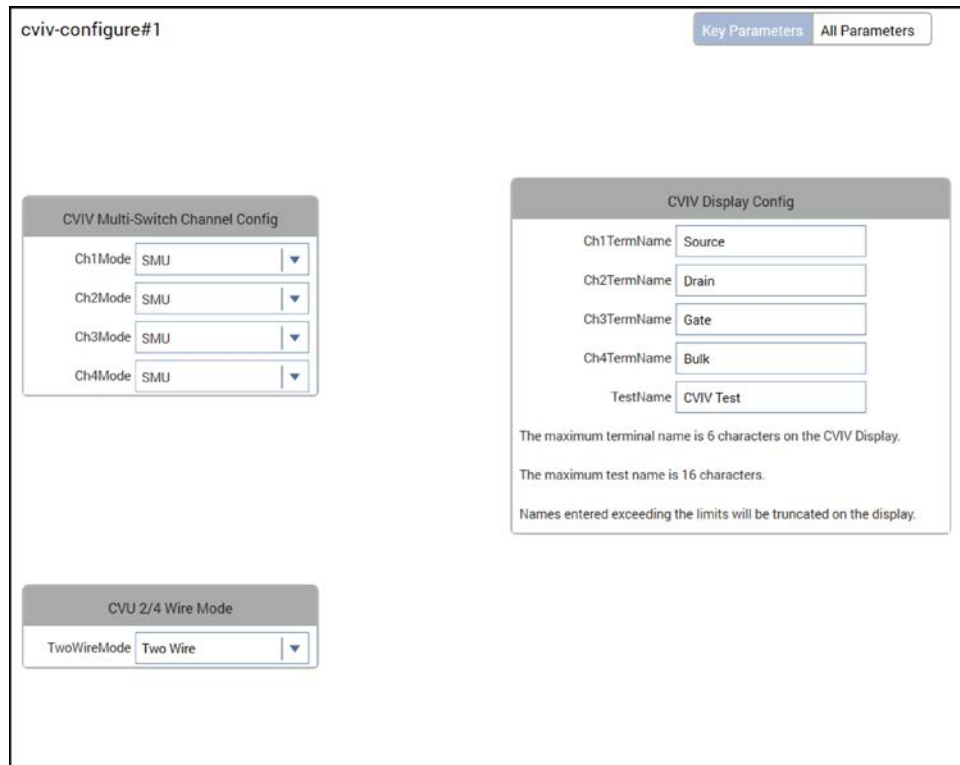
2. In the project tree, highlight the `cviv-configure` action.
3. In the CVU 2/4 Wire Mode settings, set the output mode of the 4200A-CVIV to **Two Wire**.
4. In the CVIV Display Config settings, change the name of each channel to match the corresponding MOSFET terminal. These names appear on the display of the 4200A-CVIV.

NOTE

This step is not necessary for the test to run, but it allows you to see which terminal each output is connected to by viewing the 4200A-CVIV display.

5. In the CVIV Multi-Switch Channel Config box, set all of the terminals to **SMU**.

Figure 115: cviv-configure action for I-V testing

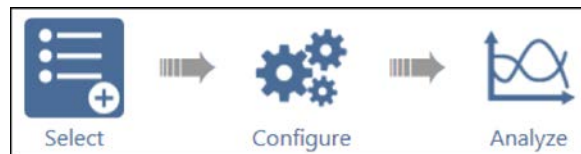


Add a test for making I-V measurements

To add a test:

1. Choose **Select**.

Figure 116: Select highlighted



2. Select **Tests**.
3. To find the test, type `vds-id` into the search bar, then select **Search**.
4. Select the `vds-id` test, then select **Add** to copy it to the project tree.
5. Select **Configure**.

Figure 117: Configure highlighted



6. Configure the source and measure parameters of SMU 1 (Source), SMU 2 (Drain), and SMU 3 (Gate) as needed.
7. Assign the instrument of the Bulk terminal to be **SMU 4** and set its Operation Mode to **Voltage Bias**.

Figure 118: Bulk channel 4 SMU voltage bias configuration

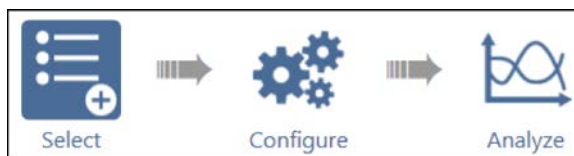
8. Verify that the Bias is set to **0 V** and the Compliance is set to **0.1 A**.

Add an action for switching the CVU to the output terminals of the 4200A-CVIV

To add an action:

1. Choose **Select** to return to the Library.

Figure 119: Select highlighted



2. Select **Actions**.
3. To find the action, type `cviv` into the search bar, then select **Search**.
4. Select the `cviv-configure` action, then select **Add** to copy it to the project tree.

Configure the action

To configure the action:

1. Select **Configure**.

Figure 120: Configure highlighted



2. In the project tree, highlight the `cviv-configure` action.

Figure 121: Populated `cviv-configure` action

cviv-configure#1

Key Parameters
All Parameters

CVIV Multi-Switch Channel Config

Ch1Mode

Ch2Mode

Ch3Mode

Ch4Mode

CVIV Display Config

Ch1TermName

Ch2TermName

Ch3TermName

Ch4TermName

TestName

The maximum terminal name is 6 characters on the CVIV Display.
The maximum test name is 16 characters.
Names entered exceeding the limits will be truncated on the display.

CVU 2/4 Wire Mode

TwoWireMode

3. In the CVU 2/4 Wire Mode box, set the output mode of the 4200A-CVIV to **Two Wire**.
4. In the CVIV Display Config box, change the name of each channel to match the corresponding MOSFET terminal they are connected to.
5. In the CVIV Multi-Switch Channel Config box, set Ch3Mode to **CV HI** and the remaining three terminals to **CV LO**.

Add a test for making C-V measurements

To add a test:

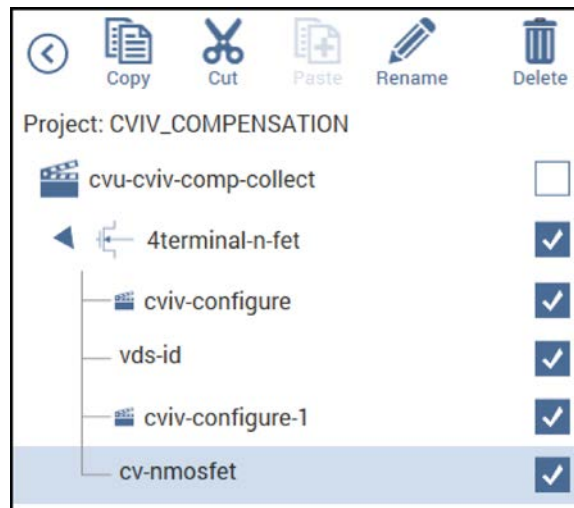
1. Choose **Select**.

Figure 122: Select highlighted



2. Select **Tests**.
3. Type `cv-nmosfet` into the search bar, then select **Search**.
4. Select the `cv-nmosfet` test, then select **Add** to copy it to the project tree.

Figure 123: Project tree before enabling open compensation



5. Select **Configure** to configure the test.

Figure 124: Configure highlighted



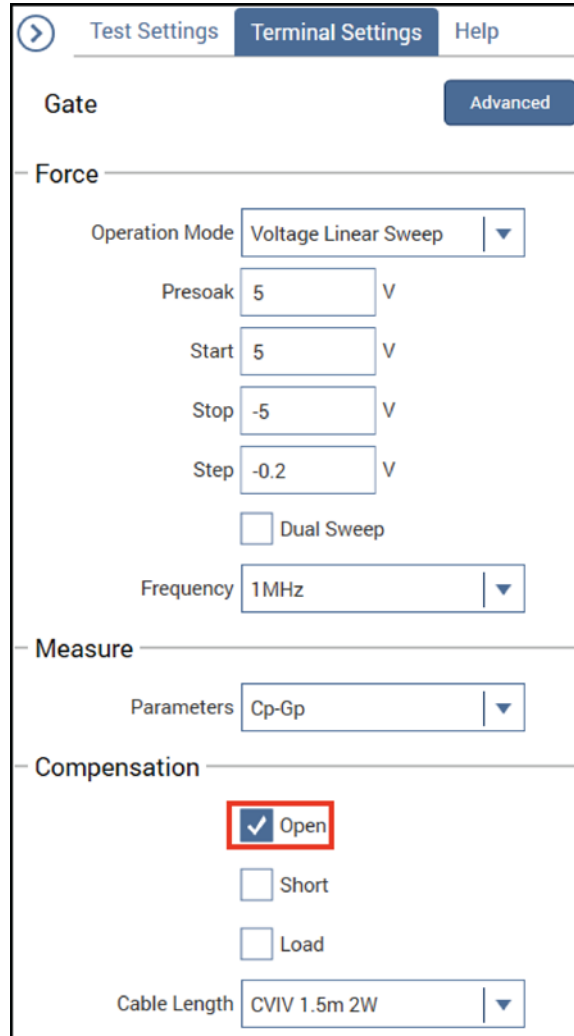
- 6. Select the **Gate** terminal.

Figure 125: Selected Gate terminal

Gate	CVH1	▼
Operation Mode	Voltage Linear Sweep	▼
Start	5	V
Stop	-5	V
Step	-0.2	V
Frequency	1MHz	▼

- 7. Configure the voltage settings and test frequency as needed.
- 8. In the right pane, select **Terminal Settings** and enable **Open** compensation.
- 9.

Figure 126: Terminal Settings panel with Open compensation selected



Run the project and review the results

To run the project and review the results:

1. Select the test name at the top of the project tree. In this example it is called `CVIV_COMPENSATION`.
2. Select **Run** to start the test. The two actions and two tests run sequentially, and the 4200A-CVIV is configured by the `cviv-configure` action.
3. Select **Analyze** to view the results.

Figure 127: Analyze highlighted



4. Select the `cv-nmosfet` test to view the results of only the C-V test.
5. Select the `vds-id` test to view the results of only the I-V test.

PMU for pulsed I-V measurements on a MOSFET

In this section:

Introduction	9-1
Equipment required.....	9-1
Device connections	9-2
Set up the measurements in Clarius	9-4

Introduction

The Model 4225-PMU Ultra-Fast I-V Module can be used to make both pulsed I-V measurements and transient I-V measurements (waveform capture) on a device.

Pulsed I-V refers to a test with a pulsed voltage source and a corresponding high speed, time-based current measurement that provides DC-like results. You can define the parameters of the pulse, including the pulse width, duty cycle, rise/fall times, and amplitude.

Transient I-V, or waveform capture, is a time-based current and/or voltage measurement that is typically the capture of a pulsed waveform. Transient I-V measurements can be used to test a dynamic test circuit or as a diagnostic tool for choosing the appropriate pulse settings in the pulsed I-V mode.

This section provides an example of how to use the 4225-PMU along with the optional Model 4225-RPM Remote Preamplifier/Switch Module to make a pulsed I-V measurement on a MOSFET. The example explains how to set up a pulsed voltage step applied to the gate terminal using PMU1 channel 1 and a pulsed voltage sweep to the drain terminal using PMU1 channel 2. The drain current is measured as a function of the drain voltage and displayed in the graph in the Analyze pane.

Equipment required

- One 4200A-SCS with the following instruments:
 - One 4225-PMU
 - Two 4225-RPMs
- Two CA-547-2A RPM interconnect cables (supplied with the 4225-RPM)
- Two CS-712 male triaxial to female BNC adapters, guard removed (supplied with 4225-RPM)
- Two CS-1247 male BNC to female SMA adapters (supplied with the 4225-RPM)
- Two CA-452A SMA to SMA cables (supplied with the 4225-RPM)
- Two 4200-PRB-C SMA to SSMC Y adapter cables

Device connections

Using the supplied cables, make connections from the output terminals of the two 4225-RPMs to the MOSFET.

WARNING

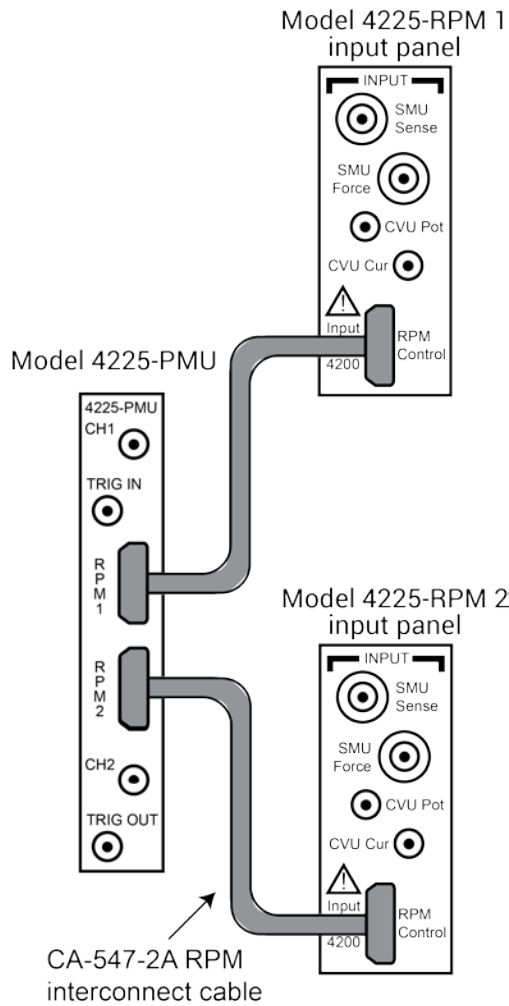
Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never connect or disconnect from the 4200A-SCS while the output is on.

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads, conductors, or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering up the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test lead and conductors.

Connection schematic

The hardware connections from the output terminals of the PMU and the two RPMS to the MOSFET are shown in the following figures. Connect one CA-547-2A RPM interconnect cable from each PMU channel to the appropriate RPM. At the output of each RPM, connect the triax to BNC adapter, BNC to SMA adapter, and finally the SMA to SMA cable.

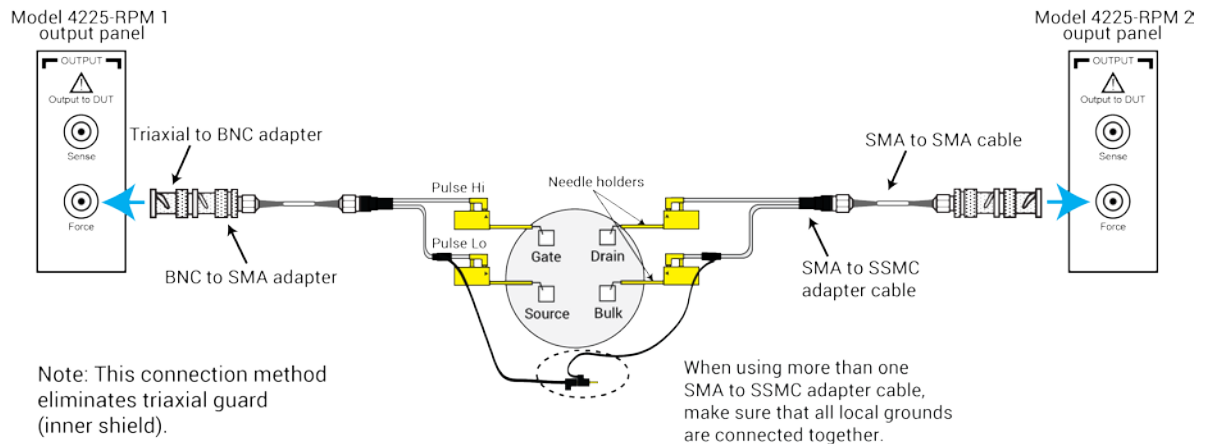
Figure 128: Connections from the PMU to the RPM inputs



Connect the SMA cables to either probes or a test fixture that is connected to the MOSFET. RPM1 is connected to the gate of the MOSFET and RPM2 is connected to the drain of the MOSFET. The shields of the SMA cables are the PMU LO connection and must be connected to the source and bulk terminals of the MOSFET. The shields of the two SMA cables should be connected together as close as possible to the device.

The example below illustrates connections from the RPMs to the SMA to SSMC adapter cables (4200-PRB-C) and then to the probes and device terminals on a wafer. For more information on this cable and similar connections, see the *Model 4200A-SCS Reference Manual*.

Figure 129: Connections from RPM outputs to the MOSFET on a wafer



Set up the measurements in Clarius

This section describes how to set up the Clarius application to make a pulsed I-V sweep on a MOSFET.

For this example, you will use the Clarius application to to:

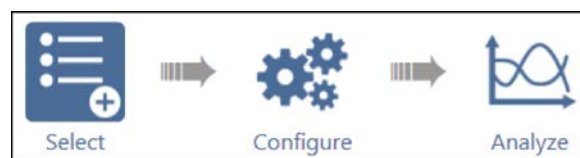
- Create a new project
- Search for and select an existing test
- Configure the test
- Run the test and analyze the results
- View and analyze the test results

Create a new project

To create a new project:

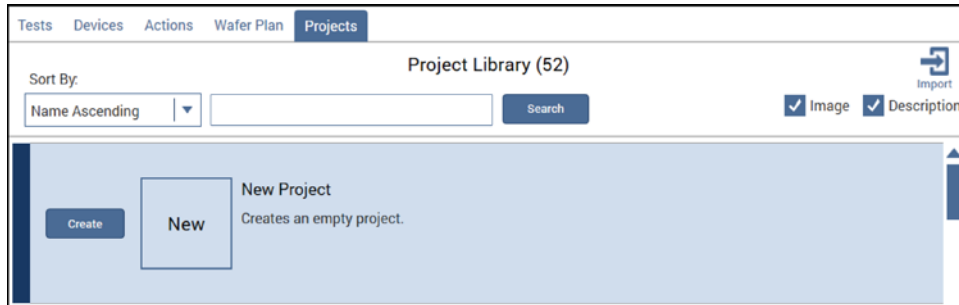
1. Choose **Select**.

Figure 130: Select highlighted



2. In the Library, select **Projects**.
3. Select and then **Create a New Project**.

Figure 131: Select a New Project from the Project Library



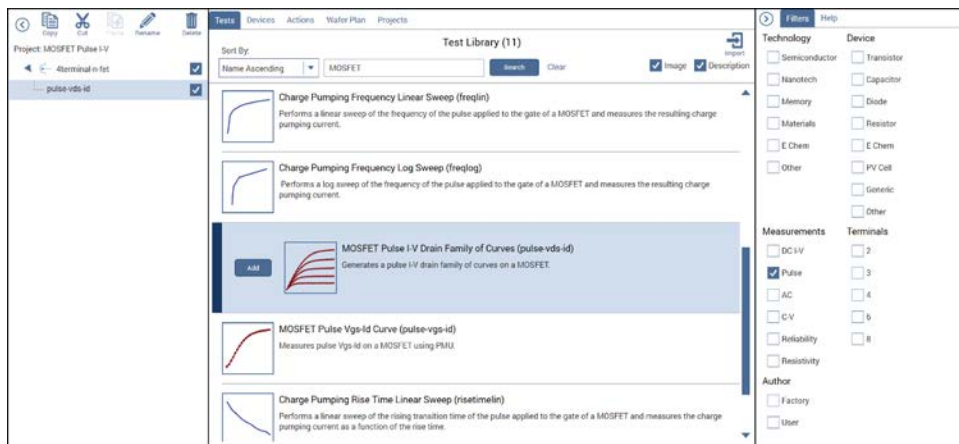
4. Select **Yes** when prompted to replace the existing project.
5. Assign a new title to the project by selecting **Rename** and then entering MOSFET Pulse I-V.
6. Select **Enter**.

Search for and select an existing test

To search for and select an existing test:

1. Select **Tests**.
2. Type MOSFET into the search bar, then select **Pulse** in the Filters pane under Measurements.
3. Select the **MOSFET Pulse I-V Drain Family of Curves (pulse-vds-id)** test, then **Add** it to the project tree.

Figure 132: Selecting the MOSFET Pulse I-V Drain Family of Curves test from the Test library



Configure the test

To configure the test:

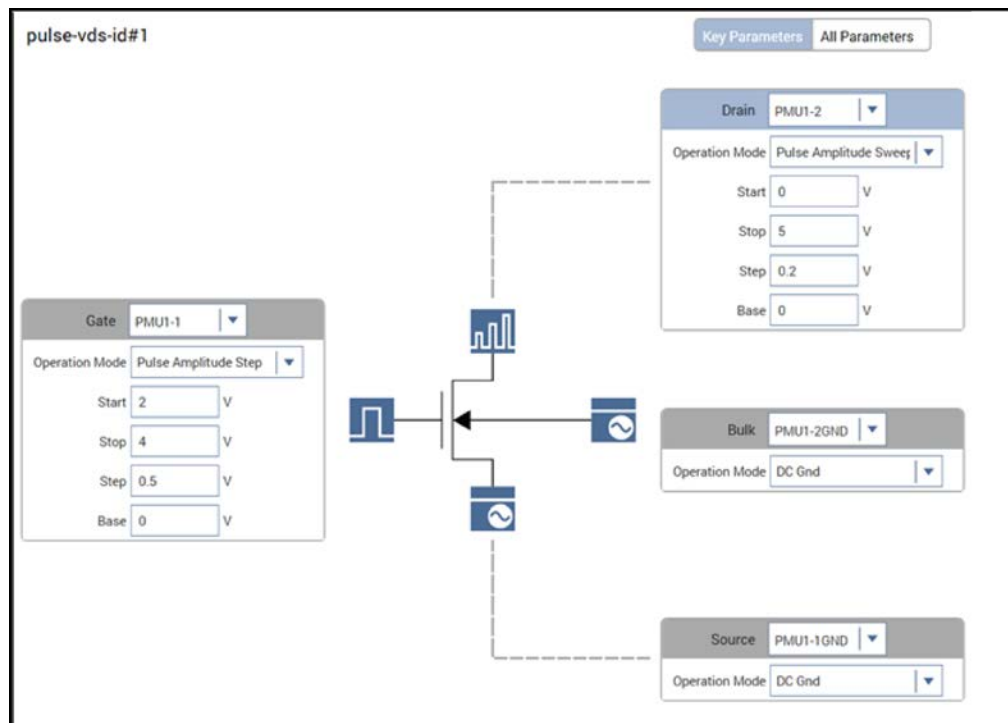
1. Select **Configure**.

Figure 133: Configure button highlighted



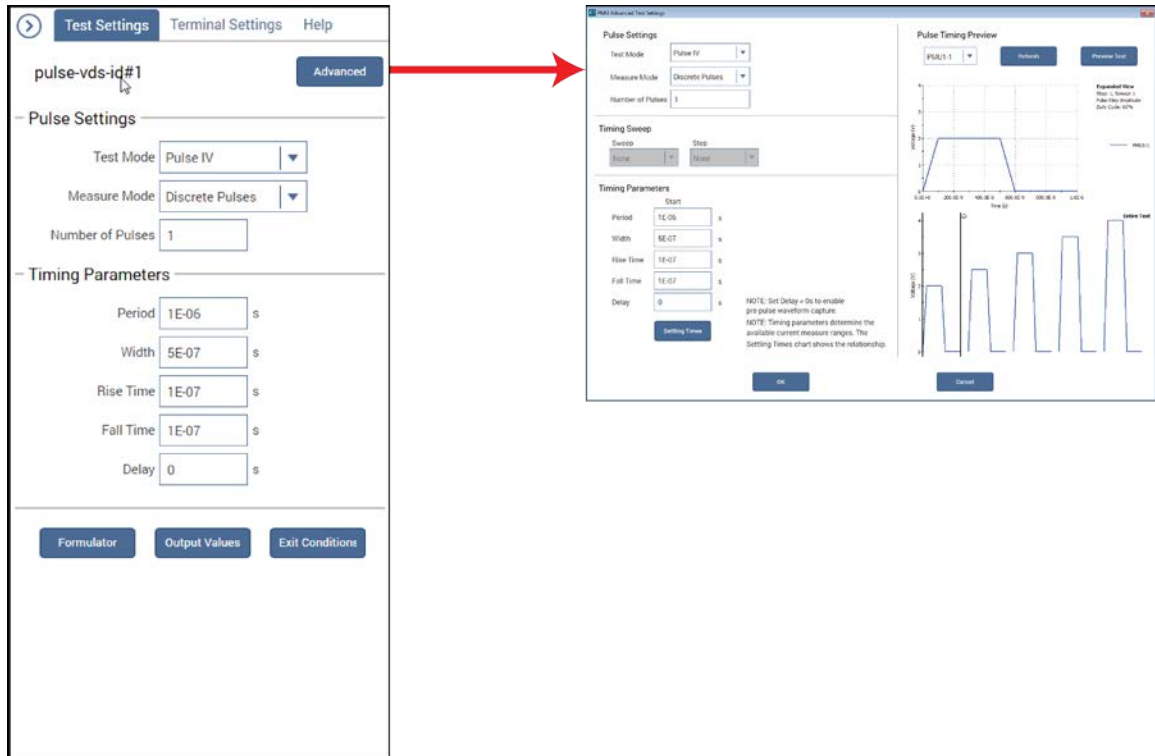
2. From the Key Parameters pane, adjust the pulse voltage sweep levels of PMU1-2 on the Drain terminal and the Pulse Step Voltage of PMU1-1 on the Gate terminal, as needed.

Figure 134: Key Parameters pane for the pulse-vds-id test



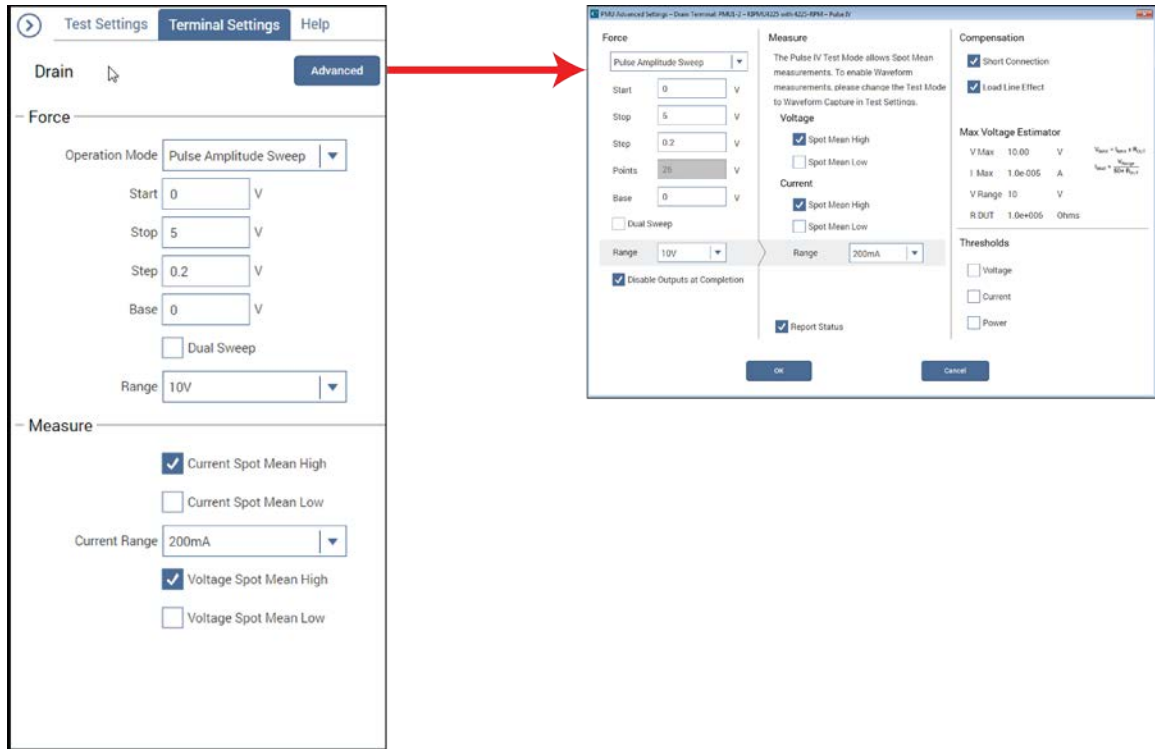
- From the Test Settings pane and Advanced Test Settings dialog box, adjust the Pulse Settings and Timing Parameters, as needed.

Figure 135: Test Settings pane and Test Settings Advanced dialog box



- From the Terminal Settings pane and Advanced Terminal Settings dialog box, you can adjust the voltage source and current measurement parameters, as needed.

Figure 136: Terminal Settings pane and Terminal Settings Advanced dialog box



Run the test and analyze the results

Select **Run** to execute the test.

Figure 137: Run



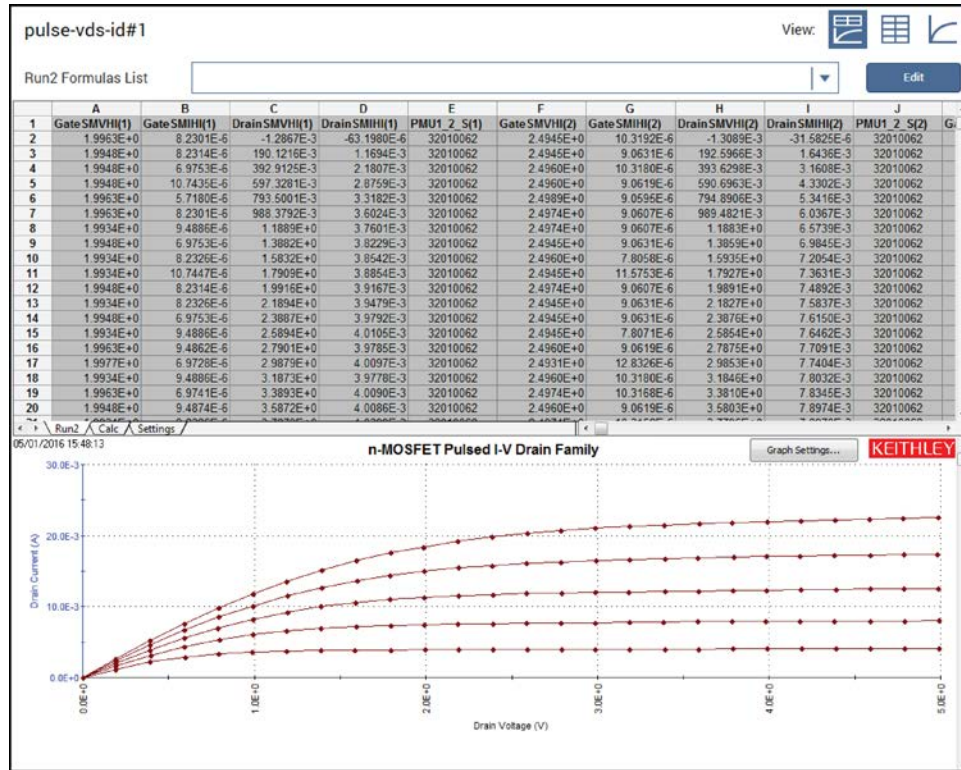
You can select **Analyze** when you run the project to view test results in real-time.

Figure 138: Analyze highlighted



The data and the graph are displayed in the Analyze pane as shown in the next figure.

Figure 139: Analyze results pane with data and graph displayed



In this section:

[Additional information.....](#) 10-1

Additional information

This manual has prepared you to start using your new 4200A-SCS Parameter Analyzer for your applications. For more detailed information, refer to the Learning Center, which you can access by selecting this icon on your desktop:

Figure 140: 4200A-SCS Learning Center icon



The Learning Center contains a variety of content to help you learn how to use your 4200A-SCS, including

- The *Model 4200A-SCS Parameter Analyzer Reference Manual*
- Videos
- Application notes
- Release notes
- Test and device descriptions
- The Keithley Instruments Low-Level Measurements Handbook

Also see the [Keithley Instruments website](http://www.tek.com/keithley) (<http://www.tek.com/keithley>) for support and additional information about the instrument, including:

- Updated drivers
- Keithley forums
- Information about related products

Your local Field Applications Engineer can help you with product selection, configuration, and usage. Check the website for contact information.

Index

C

- Connect Path
 - GPIB instruments • 2-10
 - LAN • 2-9
- connection
 - basic • 2-13
 - LAN • 2-9, 2-12
 - SMU • 2-11, 2-13

F

- front panel • 2-1

G

- GPIB
 - instrument connections • 2-10

I

- install
 - preamp on probe station • 2-15

L

- LAN connections • 2-9, 2-12

M

- Model 4200A-SCS system
 - Hardware features and capabilities
 - Instrument panels
 - Front panel • 2-1
- monitor connections, external • 2-5
- monitor, external • 2-5
- Mounting PreAmps in a probe station • 2-15

R

- Rear panel • 2-4

S

- SMU
 - SMU connections • 2-11, 2-13
 - basic • 2-13
 - Triax cables • 2-12
- System Administration
 - 4200-SCS disk maintenance software
 - video settings

- monitor, external • 2-5

- System Connections
 - GPIB instruments • 2-10
 - LAN • 2-9

T

- Triax cables • 2-12

Specifications are subject to change without notice.
All Keithley trademarks and trade names are the property of Keithley Instruments.
All other trademarks and trade names are the property of their respective companies.

Keithley Instruments
Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168 • 1-800-935-5595 • www.tek.com/keithley



A Greater Measure of Confidence