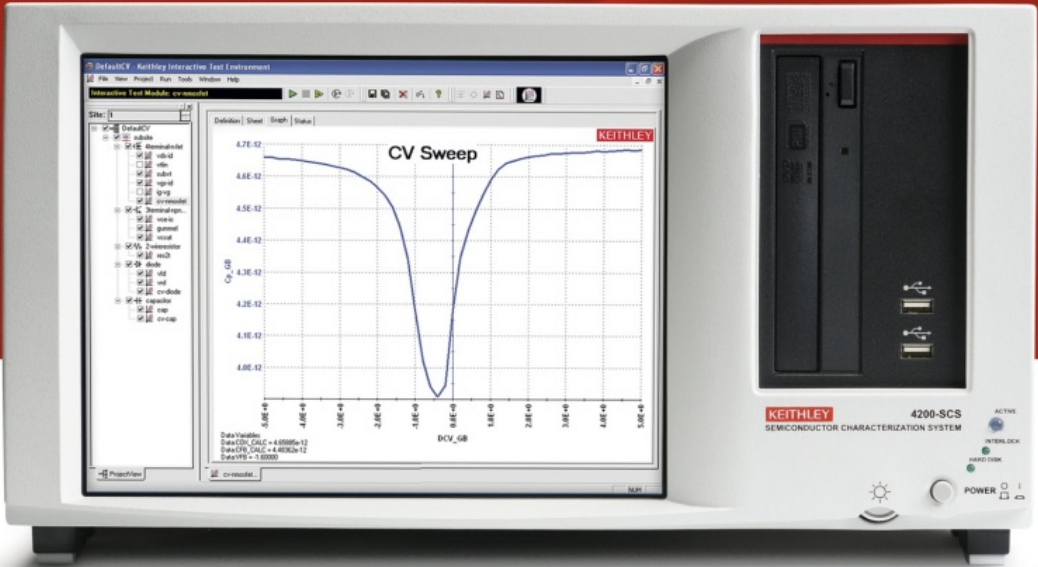


RE-INVENTING TEST & MEASUREMENT THROUGH *SPEED* AND SIMPLICITY

# Model 4200-SCS-PK3 Quick Start Guide



A GREATER MEASURE OF CONFIDENCE



## Safety precautions

Observe the following safety precautions 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 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 rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II connections require protection for high transient overvoltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation. Main supply voltage fluctuations not to exceed  $\pm 10\%$  of the nominal voltage.

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 V DC 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.

The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.

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

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 safety earth 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 safety earth ground using the wire recommended in the user documentation.



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



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



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



This symbol indicates a connection terminal to the equipment frame.



If the mercury 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.

**WARNING** This 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.

**CAUTION** This 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. 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.

To clean an instrument, remove power from the 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 and servicing.

## Power and environmental specifications

For indoor use only.

|                              |  |
|------------------------------|--|
| <b>Power supply</b>          | 100 V to 240 V AC, 50 Hz to 60 Hz                            |
| <b>Maximum VA</b>            | 1000 VA  |
| <b>Operating altitude</b>    | Maximum 2000 m above sea level                               |
| <b>Operating temperature</b> | 10 °C to 40 °C, 5% to 80% relative humidity non-condensing   |
| <b>Storage temperature</b>   | –15 °C to +60 °C, 5% to 90% relative humidity non-condensing |



### CAUTION

Carefully consider and configure the appropriate output-off state, and source and compliance levels before connecting the instrument to a device that can deliver energy. Failure to consider the output-off state, and source and compliance levels may result in damage to the instrument or to the device under test.

# Introduction

The easy-to-use Model 4200-SCS Semiconductor Characterization System performs lab grade DC and pulse device characterization, real-time plotting, and analysis with high precision and sub-femtoamp resolution. The 4200-SCS offers the most advanced capabilities available in a fully integrated characterization system, including a complete, embedded computer with a Microsoft Windows operating system and mass storage. Its self-documenting point-and-click interface speeds and simplifies the process of taking data, so users can begin analyzing their results sooner.

## CD-ROM contents

The CD-ROM that is included with your instrument contains:

- **Installation files for KITE.** These can only be installed on the Model 4200-SCS.

- **Manuals & Specs.** PDFs of the User Manual, Reference Manual, Technical Data, and Quick Start Guide documents.
- **Release Notes.** The latest software release notes and license agreement.
- **Application Notes.** Application notes that demonstrate specific applications.
- **Technical Notes.** Specific technical information.
- **White Papers.** General discussions of testing.
- **Data Sheets.** Data sheets for the 4200-SCS and related equipment. This also includes brochures and other information.

For additional support information, see

<http://www.keithley.com/support>.

Safety

Introduction

Connect

I-V test

C-V test

FAQs  
Next steps

## Unpack and inspect the instrument

### *To unpack and inspect the instrument:*

1. Inspect the box for damage.
2. Open the top of the box.
3. Remove the bag that contains the documentation, standard accessories, CD-ROMs, and optional accessories (such as rack-mount hardware).
4. Remove the packaging insert.
5. Remove the 4200-SCS from the bottom.
6. Inspect the instrument for any obvious signs of physical damage. Report any damage to the shipping agent immediately.



### CAUTION

**Do not lift the 4200-SCS from the front bezel. Lifting the instrument by the front bezel can cause instrument damage.**



In the 4200-SCS-PK3 bundle, you should have received the Model 4200-SCS Semiconductor Characterization System, with:

- Model 4200-SMU medium power SMUs (two)
- Model 4210-SMU high power SMUs (two)
- Model 4210-CVU CVU module
- Keyboard with integrated mouse
- Model 4200-SCS KTE Interactive CD
- Power line cord

Also included should have been the accessories in the photograph:

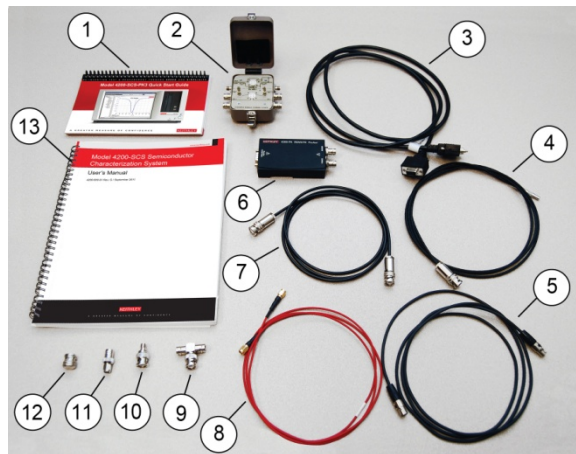
- 1 Model 4200-SCS-PK3 Quick Start Guide (this document)
- 2 Model 8101-PIV component test fixture with sample devices
- 3 Model 4200-RPC-2 remote PreAmp cables (two)
- 4 Model 4200-MTRX ultra low noise SMU triaxial cables (four)
- 5 Model 236-ILC-3 safety interlock cable
- 6 Model 4200-PA remote PreAmps (two)
- 7 Model 4200-TRX-2 ultra low noise triaxial cables (four)
- 8 CA-447A SMA cables, male to male (four)
- 9 CS-701 BNC tee adapters (two)
- 10 CS-1247 SMA female to BNC male adapters (four)

11 CS-1252 SMA male to BNC female adapters (two)

12 CAP-31 protective caps with triaxial connectors (four)

13 Model 4200-SCS User's Manual

Refer to the packing list for additional items that might have shipped with your instrument.



# Connect the instrument

## Important test system safety information

This system contains instruments that can produce hazardous voltages. It is the responsibility of the test system installer, maintenance personnel, and service personnel to make sure the system is safe during use and is operating properly. You must also realize that in many test systems a single fault, such as a software error, may output hazardous signal levels even when the system indicates that there is no hazard present. It is important that you consider the following factors in your system design and use:

- The international safety standard IEC 61010-1 defines voltages as hazardous if they exceed 30 V RMS and 42.4 V peak, or 60 V DC for equipment rated for dry locations. Keithley Instruments, Inc. products are only rated for dry locations.
- Read and comply with the specifications of all instruments in the system. The overall allowed signal levels may be constrained by the lowest rated instrument in the system. For example, if you are using a 500 V power supply with a 300 V DC rated switch, the maximum allowed voltage in the system is 300 V DC.
- Make sure any test fixture connected to the system protects the operator from contact with hazardous voltages, hot surfaces, and sharp objects. Use shields, barriers, insulation, and safety interlocks to accomplish this.
- Cover the device under test (DUT) to protect the operator from flying debris in the event of a system or DUT failure.
- Double-insulate all electrical connections that an operator can touch. Double insulation ensures the operator is still protected even if one insulation layer fails. Refer to IEC 61010-1 for specific requirements.



- Make sure all connections are behind a locked cabinet door or other barrier. This protects the system operator from accidentally removing a connection by hand and exposing hazardous voltages. Use high-reliability fail-safe interlock switches to disconnect power sources when a test fixture cover is opened.
- Where possible, use automatic handlers so operators are not required to access the DUT or other potentially hazardous areas.
- Provide training to all users of the system so they understand all potential hazards and know how to protect themselves from injury.
- In many systems, during power up, the outputs may be in an unknown state until they are properly initialized. Make sure the design can tolerate this situation without causing operator injury or hardware damage.

## NOTE

To keep users safe, always read and follow all safety warnings provided with each of the instruments in your system.

## Install the instrument

The Model 4200-SCS can be used on a bench or in a rack. Please see the instructions that came with your rack-mount kit if you are installing the Model 4200-SCS in a rack.

## Wiring the interlock

### WARNING

**The Model 4200-SCS is provided with an interlock circuit that must be positively activated for the high voltage output to be enabled. The interlock facilitates safe operation of the equipment in a test system. Bypassing the interlock could expose the operator to hazardous voltages that could result in personal injury or death.**

**Asserting the interlock allows the SMU and preamp terminals to become hazardous. SMU and preamp terminals should be considered hazardous even if the outputs are programmed to be low voltage. Precautions must be taken to prevent a shock hazard by surrounding the test device and any unprotected leads (wiring) with double insulation for 250 volts, Category I. See EN61010-1 safety standards for details.**

If you need voltages greater than  $\pm 40$  volts for testing, you must add an interlock switch to the fixture. This ensures that hazardous voltages are not present when the exterior enclosure of the fixture is open. It also enables the Model 4200-SCS to output higher voltages when the exterior enclosure of the fixture is closed.

When the safety interlock signal is asserted (the switch is closed and the signal is connected to +12 V), all the voltage ranges of the SMUs are functional. When the safety interlock signal is not asserted (the switch is open), the 200 V range on the SMUs is disabled, limiting the nominal output to  $\pm 40$  V.

If you need voltages greater than  $\pm 40$  volts, you must also connect the exterior of the test fixture enclosure to protective earth (safety ground). Take care to ensure that the wiring (FORCE, GUARD, and SENSE) in the fixture does not electrically contact the exterior enclosure.

There are low voltage and high voltage test fixtures for the Model 4200-SCS. Low voltage fixtures, such as the Model 8101-PIV that is included with this bundle, are intended for applications that are less than  $\pm 40$  volts. For these applications, an interlock is not needed.

High-voltage test fixtures, such as the Keithley Instruments LR8028, can be used with applications that are greater than  $\pm 40$  volts. The test fixture has a safety interlock switch connected to its lid. When the lid is closed, the interlock circuit is closed (asserted), and SMU  $\pm 200$  V ranges are enabled. Conversely, the interlock circuit is open (de-asserted) when the lid is open, and the SMU  $\pm 200$  V ranges are disabled. High-voltage test fixtures require extra precaution to ensure there are no shock hazards.

For correct operation with the Model 4200-SCS, the test fixture should have a normally open switch that is used for the interlock. An open interlock condition occurs when the switch is open.

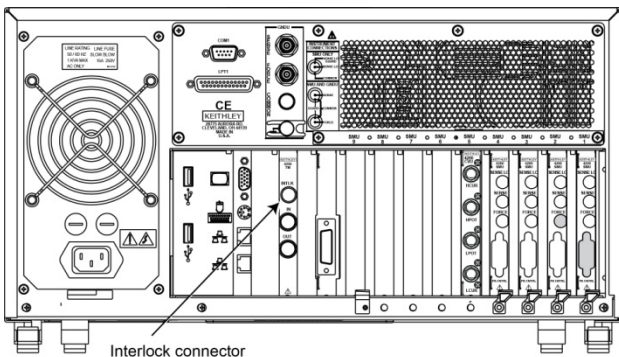
## NOTE

For the examples shown in this quick start guide, you do not need to use an interlock.

The Model 4200-SCS functions on all current ranges and up to  $\pm 40$  volts without asserting the interlock. When the interlock is not asserted, the maximum voltage on the SMU and preamp terminals is not hazardous.

### *To connect the interlock cable:*

1. Connect one end of the supplied interlock cable (part number 236-ILC-3) to the rear panel of the Model 4200-SCS. The location of the rear panel connector is shown in the following graphic.



2. Connect the other end of the connector to the test fixture.

## Connections for testing

If you are testing discrete devices, you need a test fixture that is equipped with 3-lug triaxial connectors. The Model 8101-PIV test fixture that is included with the Model 4200-SCS-PK3 allows the Model 4200-SCS to be connected to a discrete device.

For connections to a probe station for on-wafer testing, see the Model 4200-SCS Reference Manual.

### NOTE

The outer shield of the triaxial cables connects the Model 8101-PIV to the Model 4200 chassis, which connects to common.

## Make keyboard and printer connections

1. Connect the printer connection to the USB port or the parallel port, as needed for your printer.
2. Connect the keyboard to the USB port or mouse and keyboard connector on the rear panel.

You can also connect an external monitor (user-supplied) to the Model 4200-SCS.

## Connect the test fixture and DUT to the 4200-SCS

To connect the test fixture and DUTs for the:

- I-V test, see the I-V Test section graphic “Make connections for the I-V test.”
- C-V test, see the C-V Test section graphic “Make connections for the C-V test.”

## Power up the instrument

The 4200-SCS operates from a line voltage of 100 V to 240 V at a frequency of 50 Hz or 60 Hz. Make sure the operating voltage in your area is compatible.



### WARNING

**The power cord supplied with the Model 4200-SCS contains a separate 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. Failure to use a grounded outlet may result in personal injury or death due to electric shock.**

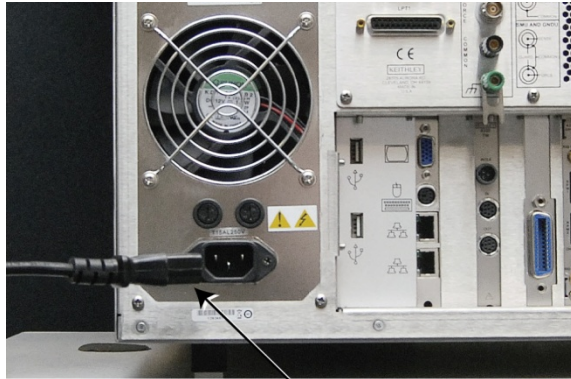


### CAUTION

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

### *To connect line power:*

1. Make sure the front panel power switch is in the off (0) position.
2. Connect the socket of the supplied power cord to the power module on the rear panel.



Power line cord

3. Connect the plug of the power cord to a grounded AC outlet.
4. Turn on the instrument by pressing the front panel **POWER** switch to the ON (I) position. The instrument starts up and loads the Microsoft Windows operating system and the Keithley Interactive Test Environment (KITE) software.



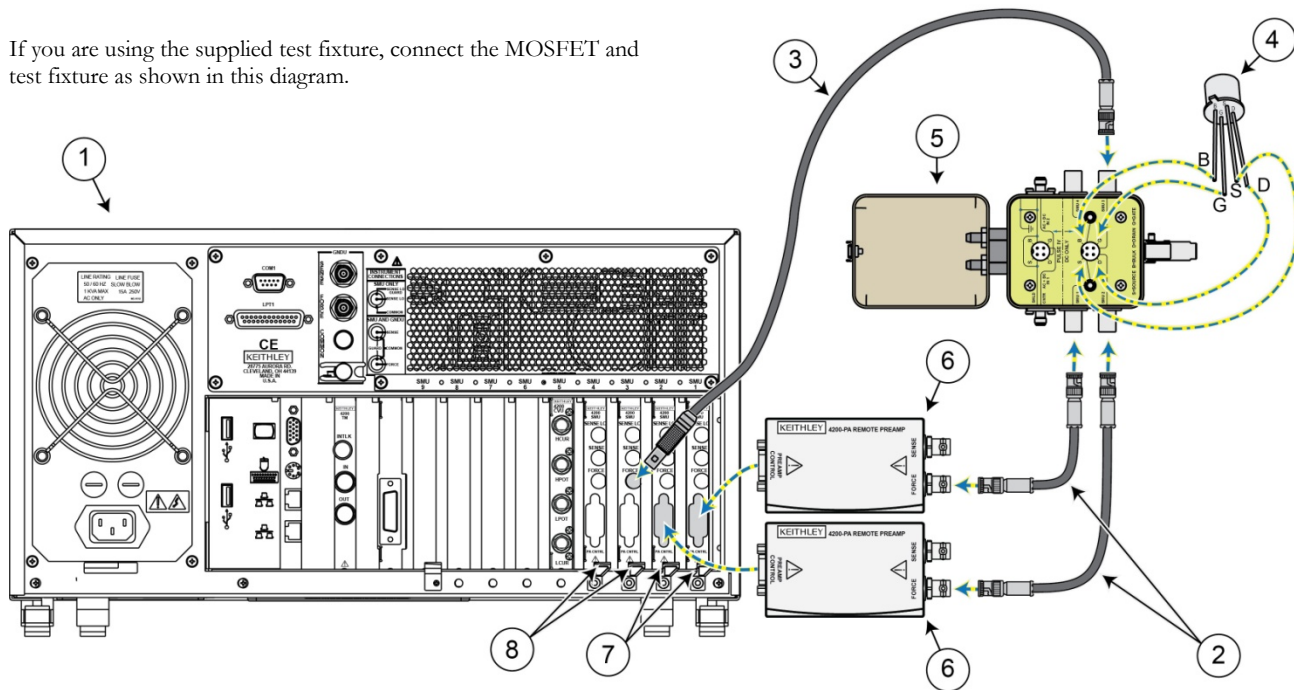
Power switch

## NOTE

The first time you start the KTE-Interactive software tool, the license agreement is displayed. You must answer Yes to use the tool.

## Make connections for the I-V test

If you are using the supplied test fixture, connect the MOSFET and test fixture as shown in this diagram.



| Item | Description  | Qty | Notes  |
|------|--|-----|--|
| 1    | Model 4200-SCS system                                | 1   |  |
| 2    | Model 4200-TRX Ultra Low Noise PreAmp Triaxial Cable | 2   | Triaxial to triaxial cable that connects 4200-PA to a test fixture                       |
| 3    | Model 4200-MTRX                                      | 1   | Ultra low noise SMU triaxial cable (mini triaxial, connects 4200 SMUs to a test fixture) |
| 4    | TG-439 nMOSFET (DUT)                                 | 1   | Plug into the test socket that is labeled DC ONLY  |
| 5    | Model 8101-PIV Component Test Fixture                | 1   |  |
| 6    | Model 4200-PA Remote PreAmp                          | 2   |  |
| 7    | Model 4200-SMU module                                | 2   |  |
| 8    | Model 4210-SMU module                                | 2   |  |

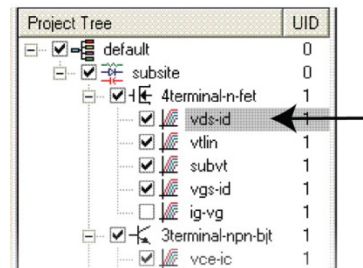
## Perform an I-V test on a MOSFET

### *To start a test:*

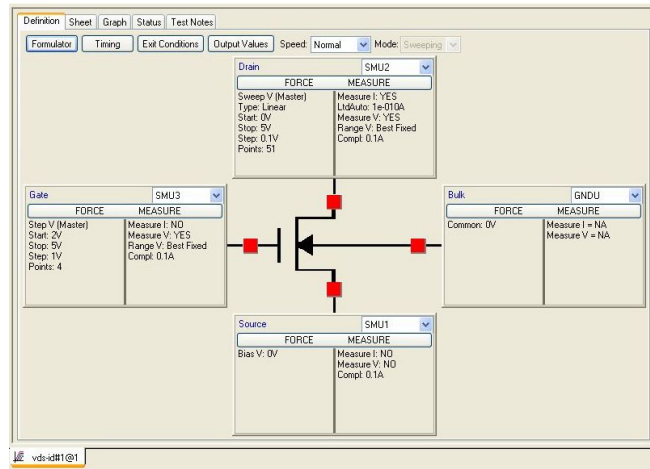
1. The Project Navigator should be displayed when KITE starts.

If the Project Navigator is not displayed, open the **View** menu and select **Project Navigator**.

2. Double-click **vds-id** (located under 4terminal-n-fet) to display the Definition tab in the KITE Workspace.



The Definition tab, shown here, is where you define the test.





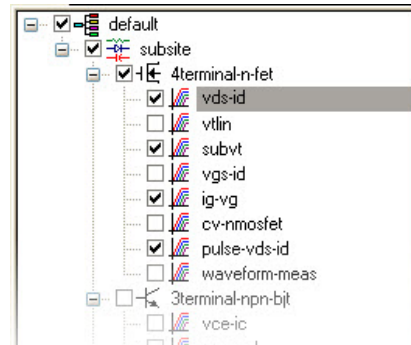
## NOTE

Because the vds-id project is already defined for the sample MOSFET that is included with the Model 4200-SCS-PK3, you do not need to change these parameters.

## Run the vds-id test


KITE can run a single test or a sequence of tests.

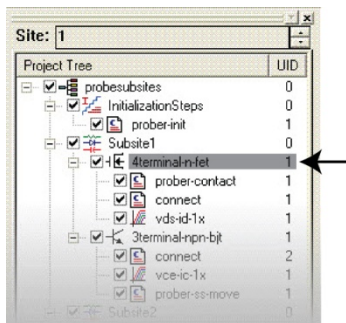
To run a single test, check the test and click it. The test should be highlighted. When you click , only that test will run. For example, in the following graphic, when you click , only the vds-id test will run.






To run a sequence of tests, check the tests you want to run, then check and click the device, subsite, or project item that contains the tests.

For example, in the following graphic, when you click , all the checked tests under 4terminal-n-fet will run:



In the following example, only one test is run.

### ***To run the vds-id test:***

1. In the navigator, double-click the vds-id test to highlight it and display the data sheets for the test.
2. On the toolbar, click .

While the test is running, the Run Test button turns gray and the Abort Test button turns red. In addition, the Measuring indicator (on the lower right corner of the front panel) is on.

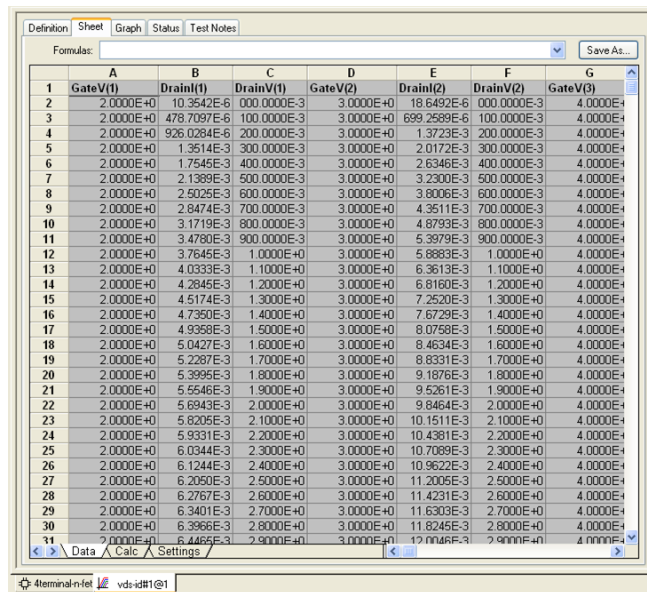
3. When the test is complete, the Run Test button turns green.

## View results of the vds-id test

To view data from the vds-id test, you can use the data sheets, which are similar to Microsoft Excel spreadsheets.

### *To view the results of the vds-id test:*

1. Click the **Sheet** tab for the test.
2. Select the tab below the data for the type of information you would like to view:
  - **Data:** Displays the data.
  - **Calc:** Provides data manipulation and graphing tools similar to Microsoft Excel.
  - **Settings:** Information about the last test that was executed.



The screenshot shows a spreadsheet application with tabs for Definition, Sheet, Graph, Status, and Test Notes. The 'Sheet' tab is active, displaying a table with 30 rows of data. The columns are labeled A through G, representing different test parameters. The data is presented in scientific notation, with values ranging from 0.0000E+0 to 18.6432E-6. The bottom of the window shows a terminal window with the command 'vds-id#1@1'.

|    | A         | B           | C            | D         | E           | F            | G         |
|----|-----------|-------------|--------------|-----------|-------------|--------------|-----------|
| 1  | GateV(1)  | DrainI(1)   | DrainV(1)    | GateV(2)  | DrainI(2)   | DrainV(2)    | GateV(3)  |
| 2  | 2.0000E+0 | 10.3542E-6  | 0.00.0000E-3 | 3.0000E+0 | 18.6432E-6  | 0.00.0000E-3 | 4.0000E+0 |
| 3  | 2.0000E+0 | 478.7097E-6 | 100.0000E-3  | 3.0000E+0 | 699.2589E-6 | 100.0000E-3  | 4.0000E+0 |
| 4  | 2.0000E+0 | 926.0284E-6 | 200.0000E-3  | 3.0000E+0 | 1.3723E-3   | 200.0000E-3  | 4.0000E+0 |
| 5  | 2.0000E+0 | 1.3514E-3   | 300.0000E-3  | 3.0000E+0 | 2.0172E-3   | 300.0000E-3  | 4.0000E+0 |
| 6  | 2.0000E+0 | 1.7545E-3   | 400.0000E-3  | 3.0000E+0 | 2.6346E-3   | 400.0000E-3  | 4.0000E+0 |
| 7  | 2.0000E+0 | 2.1389E-3   | 500.0000E-3  | 3.0000E+0 | 3.2300E-3   | 500.0000E-3  | 4.0000E+0 |
| 8  | 2.0000E+0 | 2.5025E-3   | 600.0000E-3  | 3.0000E+0 | 3.8006E-3   | 600.0000E-3  | 4.0000E+0 |
| 9  | 2.0000E+0 | 2.8474E-3   | 700.0000E-3  | 3.0000E+0 | 4.3511E-3   | 700.0000E-3  | 4.0000E+0 |
| 10 | 2.0000E+0 | 3.1719E-3   | 800.0000E-3  | 3.0000E+0 | 4.8793E-3   | 800.0000E-3  | 4.0000E+0 |
| 11 | 2.0000E+0 | 3.4780E-3   | 900.0000E-3  | 3.0000E+0 | 5.3979E-3   | 900.0000E-3  | 4.0000E+0 |
| 12 | 2.0000E+0 | 3.7645E-3   | 1.0000E+0    | 3.0000E+0 | 5.8883E-3   | 1.0000E+0    | 4.0000E+0 |
| 13 | 2.0000E+0 | 4.0333E-3   | 1.1000E+0    | 3.0000E+0 | 6.3613E-3   | 1.1000E+0    | 4.0000E+0 |
| 14 | 2.0000E+0 | 4.2845E-3   | 1.2000E+0    | 3.0000E+0 | 6.8160E-3   | 1.2000E+0    | 4.0000E+0 |
| 15 | 2.0000E+0 | 4.5174E-3   | 1.3000E+0    | 3.0000E+0 | 7.2520E-3   | 1.3000E+0    | 4.0000E+0 |
| 16 | 2.0000E+0 | 4.7350E-3   | 1.4000E+0    | 3.0000E+0 | 7.6729E-3   | 1.4000E+0    | 4.0000E+0 |
| 17 | 2.0000E+0 | 4.9358E-3   | 1.5000E+0    | 3.0000E+0 | 8.0758E-3   | 1.5000E+0    | 4.0000E+0 |
| 18 | 2.0000E+0 | 5.0427E-3   | 1.6000E+0    | 3.0000E+0 | 8.4634E-3   | 1.6000E+0    | 4.0000E+0 |
| 19 | 2.0000E+0 | 5.2287E-3   | 1.7000E+0    | 3.0000E+0 | 8.8331E-3   | 1.7000E+0    | 4.0000E+0 |
| 20 | 2.0000E+0 | 5.3995E-3   | 1.8000E+0    | 3.0000E+0 | 9.1876E-3   | 1.8000E+0    | 4.0000E+0 |
| 21 | 2.0000E+0 | 5.5546E-3   | 1.9000E+0    | 3.0000E+0 | 9.5261E-3   | 1.9000E+0    | 4.0000E+0 |
| 22 | 2.0000E+0 | 5.6943E-3   | 2.0000E+0    | 3.0000E+0 | 9.8464E-3   | 2.0000E+0    | 4.0000E+0 |
| 23 | 2.0000E+0 | 5.8205E-3   | 2.1000E+0    | 3.0000E+0 | 10.1511E-3  | 2.1000E+0    | 4.0000E+0 |
| 24 | 2.0000E+0 | 5.9331E-3   | 2.2000E+0    | 3.0000E+0 | 10.4381E-3  | 2.2000E+0    | 4.0000E+0 |
| 25 | 2.0000E+0 | 6.0344E-3   | 2.3000E+0    | 3.0000E+0 | 10.7089E-3  | 2.3000E+0    | 4.0000E+0 |
| 26 | 2.0000E+0 | 6.1244E-3   | 2.4000E+0    | 3.0000E+0 | 10.9622E-3  | 2.4000E+0    | 4.0000E+0 |
| 27 | 2.0000E+0 | 6.2050E-3   | 2.5000E+0    | 3.0000E+0 | 11.2005E-3  | 2.5000E+0    | 4.0000E+0 |
| 28 | 2.0000E+0 | 6.2767E-3   | 2.6000E+0    | 3.0000E+0 | 11.4231E-3  | 2.6000E+0    | 4.0000E+0 |
| 29 | 2.0000E+0 | 6.3401E-3   | 2.7000E+0    | 3.0000E+0 | 11.6303E-3  | 2.7000E+0    | 4.0000E+0 |
| 30 | 2.0000E+0 | 6.3966E-3   | 2.8000E+0    | 3.0000E+0 | 11.8245E-3  | 2.8000E+0    | 4.0000E+0 |
| 31 | 2.0000E+0 | 6.4455E-3   | 2.9000E+0    | 3.0000E+0 | 12.0045E-3  | 2.9000E+0    | 4.0000E+0 |

## Print the results of the vds-id test

You can print the Data, Calc, or Settings sheet.

### *To print one or a few sheets:*

1. Select the sheet. You can also press Ctrl and select multiple sheets to print.
2. Select **File**, then **Print**.
3. Choose **Selected Sheets**.
4. Click **OK**.

### *To print the all sheets:*

1. Select **File**, then **Print**.
2. Choose **Entire Workbook**.
3. Click **OK**.

### *To export the information:*

1. Open the worksheet that contains the data to be exported.
2. Select **Save As** (in the upper right corner).
3. Choose **Entire Workbook**.
4. Click **OK**.
5. From the Save As dialog box, specify a file name and path. The default directory path for exporting data is C:\S4200\kiuser\export.
6. Click **Save**.

## View the graph for the vds-id test

To display the graph for the vds-id test, click the Graph tab for the test.

A sample graph is shown below. In this example, there are four I-V curves – one for each gate voltage.

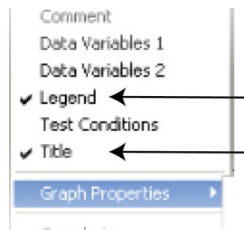
## Customizing the graph

The graph was customized to include the Legend box and use different colors for the graph series. These options are available through the Graph Settings button.

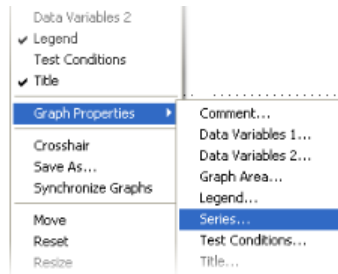
### *To customize a graph:*

1. Right-click the graph. The Graph Settings menu is displayed.  
(You can also select the Tools menu and select Graph Settings.)

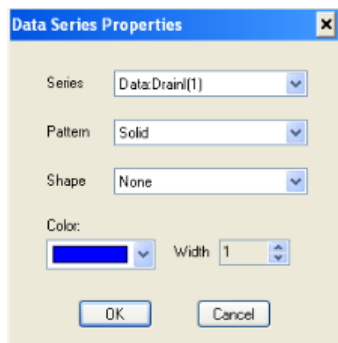
2. To include a Legend and Title, select those options from the Graph Settings menu.



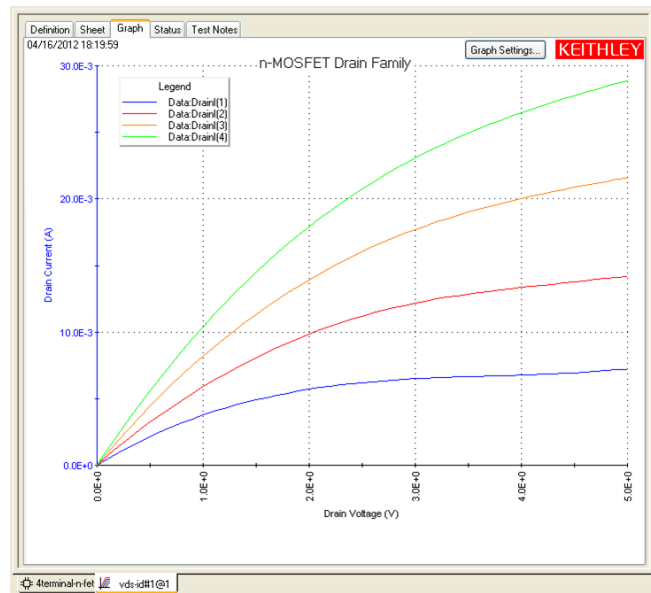
3. To use different colors for the graph series, select **Graph Properties**, then select **Series**. The Data Series Properties dialog box is displayed.



4. Select the colors for each series.

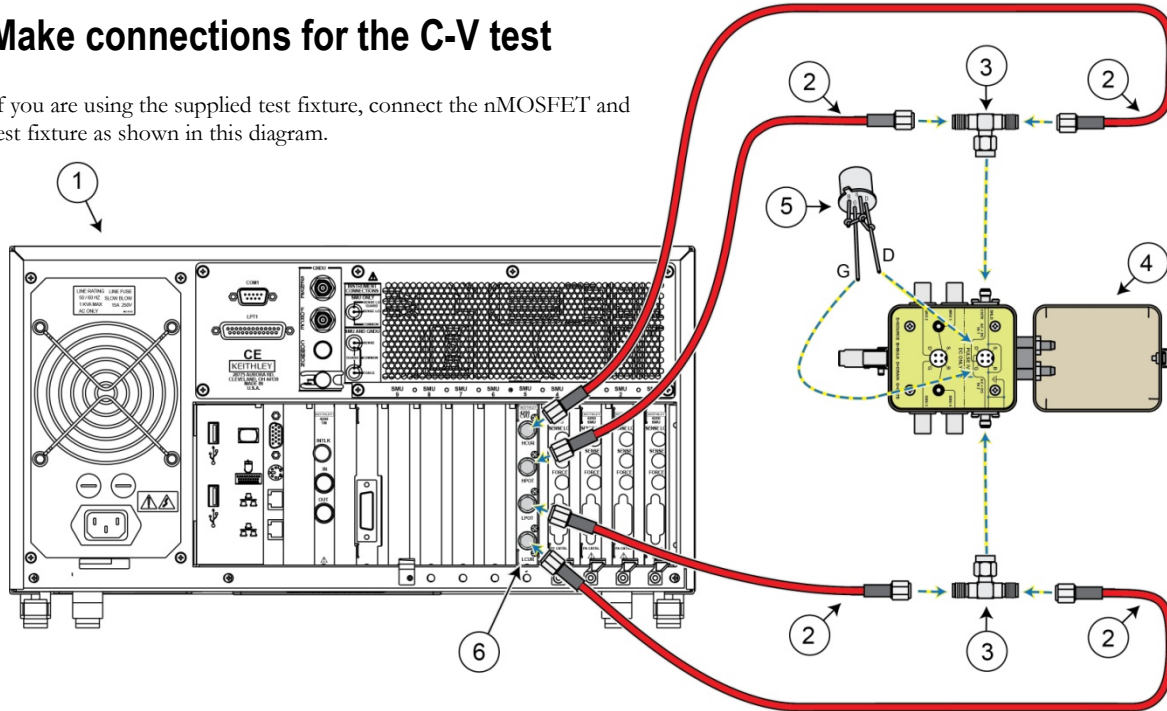


5. Click **OK**. The series and color information is displayed.



## Make connections for the C-V test

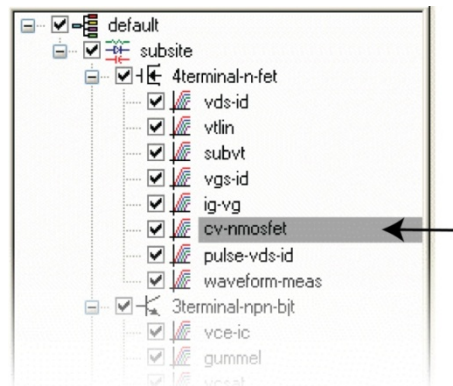
If you are using the supplied test fixture, connect the nMOSFET and test fixture as shown in this diagram.



| Item | Description  | Qty | Notes  |
|------|--|-----|--|
| 1    | Model 4200-SCS system  | 1   |  |
| 2    | Model CA-447A  | 4   | SMA cable, male to male,<br>100 $\Omega$ , 1.5 m |
| 3    | Model CS-1391  | 2   | SMA tee adapter<br>(female-male-female)          |
| 4    | Model 8101-PIV<br>Component Test Fixture                     | 1   |  |
| 5    | 8101-309 (nMOSFET with<br>S-D-B connected together<br>(DUT)) | 1   | Plug into PULSE IV test<br>socket                |
| 6    | Model 4210-CVU Module  | 1   |  |

## Perform a C-V test on an nMOSFET

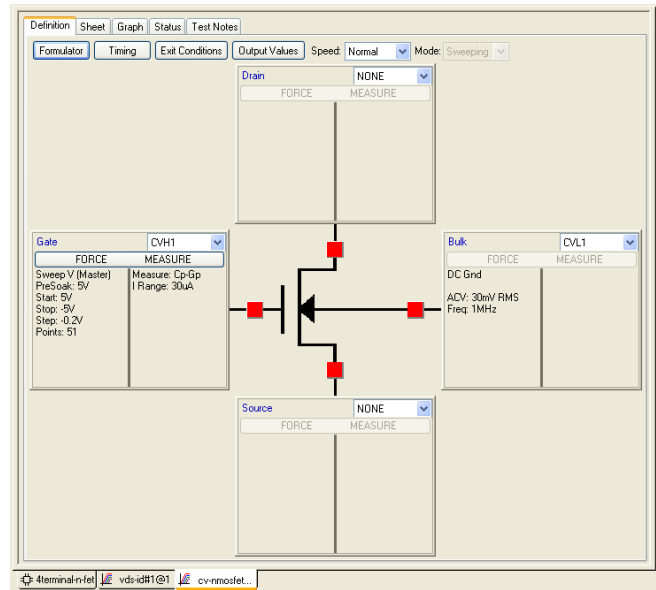
1. In the Project Navigator, select the **cv-nmosfet** test. This test is located under the **4terminal-n-fet** library.



2. Double-click **cv-nmosfet** to display the Definition tab.

The Definition tab, shown in the next graphic, is where you define the test. In the test shown in this Definition tab, the device is connected to the CVH1 and the CVL1 terminals of the Model 4210-CVU. The default setting shows the DC bias is swept from 5 V to  $-5$  V in 0.2 V steps, with a 1 MHz capacitance measurement taken at each step.

Note that the device used for this test has source, drain, and bulk connected through the drain lead of the device.





## Run the cv-nmosfet test

### *To run the cv-nmosfet test:*

1. In the Project Tree, make sure the cv-nmosfet test is checked and highlighted.

2. On the toolbar, click .

While the test is running, the Run Test button turns gray and the Abort Test button turns red. In addition, the Measuring indicator (on the lower right corner of the front panel) is on.

3. When the test is complete, the Run Test button turns green.

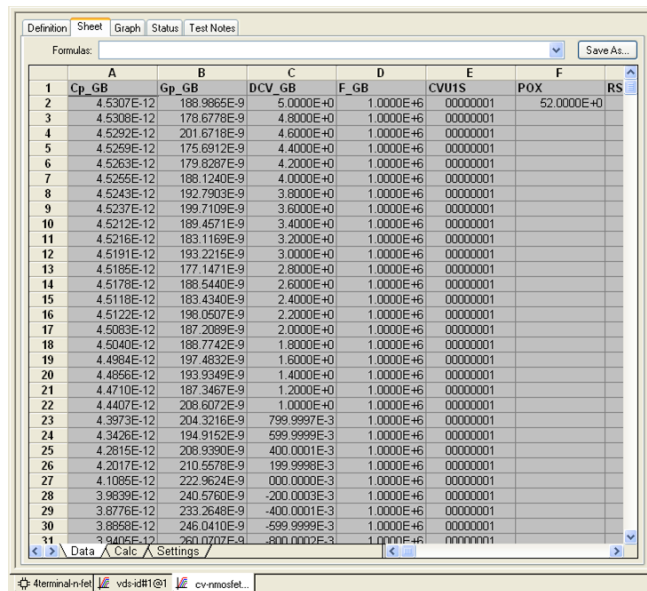
## View results of the cv-nmosfet test

To view data from the cv-nmosfet test, you can use the data sheets, which are similar to Microsoft Excel spreadsheets.

### *To view the results of the cv-nmosfet test:*

1. Click the **Sheet** tab for the test.
2. Select the tab for the type of information you would like to view:
  - **Data:** Displays the data.

- **Calc:** Provides data manipulation and graphing tools similar to Microsoft Excel.
- **Settings:** Information about the last test that was executed.



|    | A          | B           | C            | D         | E         | F          | RS |
|----|------------|-------------|--------------|-----------|-----------|------------|----|
| 1  | Cp_GB      | Gp_GB       | DCV_GB       | F_GB      | CVHS      | POX        |    |
| 2  | 4.5307E-12 | 188.9865E-9 | 5.0000E+0    | 1.0000E+6 | 0.0000001 | 52.0000E+0 |    |
| 3  | 4.5308E-12 | 178.6778E-9 | 4.8000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 4  | 4.5292E-12 | 201.6718E-9 | 4.6000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 5  | 4.5259E-12 | 175.6912E-9 | 4.4000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 6  | 4.5263E-12 | 179.8287E-9 | 4.2000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 7  | 4.5255E-12 | 188.1240E-9 | 4.0000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 8  | 4.5243E-12 | 192.7903E-9 | 3.8000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 9  | 4.5237E-12 | 199.7109E-9 | 3.6000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 10 | 4.5212E-12 | 189.4571E-9 | 3.4000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 11 | 4.5216E-12 | 183.1169E-9 | 3.2000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 12 | 4.5191E-12 | 193.2215E-9 | 3.0000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 13 | 4.5185E-12 | 177.1471E-9 | 2.8000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 14 | 4.5178E-12 | 188.5440E-9 | 2.6000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 15 | 4.5118E-12 | 183.4340E-9 | 2.4000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 16 | 4.5122E-12 | 198.0507E-9 | 2.2000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 17 | 4.5083E-12 | 187.2089E-9 | 2.0000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 18 | 4.5040E-12 | 188.7742E-9 | 1.8000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 19 | 4.4984E-12 | 197.4832E-9 | 1.6000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 20 | 4.4856E-12 | 193.9349E-9 | 1.4000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 21 | 4.4710E-12 | 187.3467E-9 | 1.2000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 22 | 4.4407E-12 | 208.6072E-9 | 1.0000E+0    | 1.0000E+6 | 0.0000001 |            |    |
| 23 | 4.3973E-12 | 204.3216E-9 | 799.9997E-3  | 1.0000E+6 | 0.0000001 |            |    |
| 24 | 4.3426E-12 | 194.9152E-9 | 599.9999E-3  | 1.0000E+6 | 0.0000001 |            |    |
| 25 | 4.2815E-12 | 208.9390E-9 | 400.0001E-3  | 1.0000E+6 | 0.0000001 |            |    |
| 26 | 4.2017E-12 | 210.5578E-9 | 199.9998E-3  | 1.0000E+6 | 0.0000001 |            |    |
| 27 | 4.1085E-12 | 222.9624E-9 | 000.0000E-3  | 1.0000E+6 | 0.0000001 |            |    |
| 28 | 3.9839E-12 | 240.5760E-9 | -200.0003E-3 | 1.0000E+6 | 0.0000001 |            |    |
| 29 | 3.8776E-12 | 233.2648E-9 | -400.0001E-3 | 1.0000E+6 | 0.0000001 |            |    |
| 30 | 3.8858E-12 | 246.0410E-9 | -599.9999E-3 | 1.0000E+6 | 0.0000001 |            |    |
| 31 | 3.9405E-12 | 260.0707E-9 | -800.0002E-3 | 1.0000E+6 | nnnnnnnn  |            |    |

## Print results of the cv-nmosfet test

You can print the Data, Calc, or Settings sheet.

### *To print one or a few sheets:*

1. Select the sheet. You can also press Ctrl and select multiple sheets to print.
2. Select **File**, then **Print**.
3. Choose **Selected Sheets**.
4. Click **OK**.

### *To print the all sheets:*

1. Select **File**, then **Print**.
2. Choose **Entire Workbook**.
3. Click **OK**.

### *To export the information:*

1. Open the worksheet that contains the data to be exported.
2. Select **Save As** ( in the upper right corner).
3. Choose **Entire Workbook**.

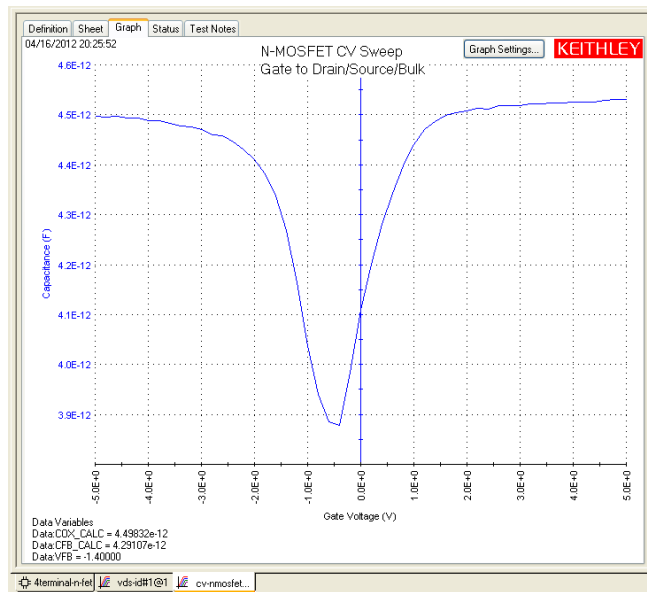
4. Click **OK**.
5. From the Save As dialog box, specify a file name and path. The default directory path for exporting data is C:\S4200\kiuser\export.
6. Click **Save**.

## View the graph for the cv-nmosfet test

To display the graph for the cv-nmosfet test, click the Graph tab for the test.

A sample graph is shown here. In this example, the C-V curve is measured between the gate and the source/drain/bulk. Notice that the COX, CFB, and VFB parameters are extracted and displayed on the screen.

You can customize graphs with options that are available through the Graph Settings menu.




## FAQs

### My data looks odd or is wrong. What should I do?

Verify the connections from the instrument to the test fixture. Also check the connections from the DUT to the test fixture socket.

### The Run Test button is not green

You cannot run the selected test if the Run Test button () is not green. This can occur:

- If a test is still running.
- The check box for the test is cleared.
- Changes to the test setup were made but not saved.

If a selected test will still not run, click the Status tab for the test. The tab provides status information for the test.

### I cannot unplug the mini triaxial cable (Model 4200-MTRX) from the SMU

The mini triaxial connector is a locking connector. To remove it, pull the knurled part of the connector back.

### A configuration error has been detected and I cannot launch KITE

This occurs when the physical configuration does not match the KCON-defined configuration or when there are communication problems between instruments and the Model 4200-SCS. Run KCON; from the **Tools** menu, select **Validate Configuration** to verify the system configuration.

This can also occur if the PreAmp or RPM is removed or reconnected. In this case, you must update the system configuration. Run KCON; from the **Tools** menu, select **Upgrade PreAmp and RPM Configuration**.

Note that PreAmps are SMU-specific. For example, a PreAmp that is configured for SMU1 cannot be connected to SMU2.

## Next steps

See the Model 4200-SCS Complete Reference, which is preinstalled on your system. To access the Complete Reference, click Help in the KITE menu. You can also press F1. The Model 4200-SCS Complete Reference includes the following documents:

- **Model 4200-SCS User Manual:** Contains basic information about using the system, plus application-based examples that will help familiarize you with the instrument.
- **Model 4200-SCS Reference Manual:** Provides detailed information about all features of the instrument.
- **Application notes:** Detailed applications that demonstrate specific applications.
- **Data sheets:** Technical data regarding the 4200-SCS and related accessories.
- **Keithley Instruments website**

See [www.keithley.com](http://www.keithley.com) for support and additional information about the instrument.

Safety

Introduction

Connect

I-V test

C-V test

FAQs  
Next steps

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

---

**KEITHLEY**

A G R E A T E R M E A S U R E O F C O N F I D E N C E

KEITHLEY INSTRUMENTS, INC. • 28775 AURORA RD. • CLEVELAND, OH 44139-1891 • 440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY • [www.keithley.com](http://www.keithley.com)

**BELGIUM**

Sin-Pieters-Leeuw  
Ph: 02-3630040  
Fax: 02-3630064  
[info@keithley.nl](mailto:info@keithley.nl)  
[www.keithley.nl](http://www.keithley.nl)

**CHINA**

Beijing  
Ph: 86-10-8447-5556  
Fax: 86-10-8225-5018  
[China@keithley.com](mailto:China@keithley.com)  
[www.keithley.com.cn](http://www.keithley.com.cn)

**FRANCE**

Saint-Aubin  
Ph: 01-64532020  
Fax: 01-60117726  
[info@keithley.fr](mailto:info@keithley.fr)  
[www.keithley.fr](http://www.keithley.fr)

**GERMANY**

Germering  
Ph: 089-84930740  
Fax: 089-84930734  
[info@keithley.de](mailto:info@keithley.de)  
[www.keithley.de](http://www.keithley.de)

**INDIA**

Bangalore  
Ph: 080-26771071, -72, -73  
Fax: 080-26771076  
[support\\_india@keithley.de](mailto:support_india@keithley.de)  
[www.keithley.com](http://www.keithley.com)

**ITALY**

Peschiera Borromeo (Mi)  
Ph: 02-5538421  
Fax: 02-55384228  
[info@keithley.it](mailto:info@keithley.it)  
[www.keithley.it](http://www.keithley.it)

**JAPAN**

Tokyo  
Ph: 81-3-5733-7555  
Fax: 81-3-5733-7556  
[info.jp@keithley.com](mailto:info.jp@keithley.com)  
[www.keithley.jp](http://www.keithley.jp)

**KOREA**

Seoul  
Ph: 82-2-574-7778  
Fax: 82-2-574-7838  
[keithley@keithley.co.kr](mailto:keithley@keithley.co.kr)  
[www.keithley.co.kr](http://www.keithley.co.kr)

**MALAYSIA**

Penang  
Ph: 60-4-643-9679  
Fax: 60-4-643-3794  
[SEA@keithley.com](mailto:SEA@keithley.com)  
[www.keithley.com](http://www.keithley.com)

**NETHERLANDS**

Gorinchem  
Ph: 0183-635333  
Fax: 0183-630821  
[info@keithley.nl](mailto:info@keithley.nl)  
[www.keithley.nl](http://www.keithley.nl)

**SINGAPORE**

Singapore  
Ph: 65-6747-9077  
Fax: 65-6747-2991  
[SEA@keithley.com](mailto:SEA@keithley.com)  
[www.keithley.com](http://www.keithley.com)

**SWITZERLAND**

Zürich  
Ph: 044-8219444  
Fax: 044-8203081  
[info@keithley.ch](mailto:info@keithley.ch)  
[www.keithley.ch](http://www.keithley.ch)

**TAIWAN**

Hsinchu  
Ph: 886-3-572-9077  
Fax: 886-3-572-9031  
[info\\_tw@keithley.com](mailto:info_tw@keithley.com)  
[www.keithley.com.tw](http://www.keithley.com.tw)

**UNITED KINGDOM**

Theale  
Ph: 0118-9297500  
Fax: 0118-9297519  
[info@keithley.co.uk](mailto:info@keithley.co.uk)  
[www.keithley.co.uk](http://www.keithley.co.uk)