

# Series 2600-PCT-xB Parametric Curve Tracer

## User's Manual

PCT-900-01 Rev. A / January 2015



PCT-900-01A

A Greater Measure of Confidence

**KEITHLEY**  
A Tektronix Company

**Series 2600-PCT-xB**  
**Parametric Curve Tracer**  
**User's Manual**

© 2015, 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.

Document number: PCT-900-01 Rev. A / January 2015



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, 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 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. 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, 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 January 2013.

# Table of Contents

---

<b>Introduction.....</b>	<b>1-1</b>
Welcome .....	1-1
Introduction to this manual .....	1-1
Available configurations .....	1-2
Extended warranty .....	1-2
Contact information .....	1-2
<b>Instruments and connections .....</b>	<b>2-1</b>
Introduction .....	2-1
Unpacking the PCT .....	2-1
About the Model 8010 High Power Device Test Fixture .....	2-2
About the Model 8020 High Power Interface Panel.....	2-3
Safety connections.....	2-3
Connections to protective earth (safety ground).....	2-3
Interlock connections .....	2-4
Connect instruments to the Model 8010 .....	2-5
Connect instruments to the Model 8020 .....	2-6
<b>Getting started with ACS Basic .....</b>	<b>3-1</b>
Introduction .....	3-1
Installing and configuring the GPIB interface.....	3-1
TSP-Link system setup .....	3-2
Assign TSP-Link node numbers.....	3-2
Connect the instrument for communications .....	3-3
ACS Basic software .....	3-4
Software installation .....	3-4
Start ACS Basic .....	3-6
ACS basic test modes.....	3-10
Configure ACS Basic to use the correct device interface.....	3-10
<b>I-V applications for power MOSFETs.....</b>	<b>4-1</b>
Section overview and equipment requirements .....	4-1
On-state characteristics .....	4-2
Configure the test fixture .....	4-2
Collecting I-V curves in trace mode.....	4-4
Configure a fixed plot .....	4-11
Collecting I-V curves in multi-test mode .....	4-13
Digitizing pulses and improving timing .....	4-26
Off-state characteristics .....	4-36
Configure the test fixture .....	4-36
Measuring leakage current in multi-test mode.....	4-38

<b>C-V applications on power MOSFETs .....</b>	<b>5-1</b>
Overview and requirements .....	5-1
Background of MOSFET capacitance measurements.....	5-1
Safety precautions and discharge procedures .....	5-3
Discharging bias tee capacitance within the Model 8010.....	5-3
Discharging bias tee capacitance within the Model 8020.....	5-7
Discharge system capacitance from SMU front panel interface .....	5-8
Model 8010 connections .....	5-9
Connecting instruments to the Model 8010 for power MOSFET capacitance measurements ..	5-9
Connecting the Model 8010 to the device for power MOSFET capacitance measurements...	5-13
Model 8020 connections .....	5-14
Connecting instruments to the Model 8020 for power MOSFET capacitance measurements	5-14
Connecting the Model 8020 to the device for power MOSFET capacitance measurements...	5-17
Perform connection compensations on C-V measurements .....	5-18
Ciss compensation.....	5-19
Coss compensation.....	5-27
Crss compensation .....	5-33
Make a Ciss measurement .....	5-40
Make a Coss measurement .....	5-47
Make a Crss measurement.....	5-59
Optimizing Ciss measurement connections for difficult measurements .....	5-66
<b>Troubleshooting FAQs .....</b>	<b>6-1</b>
Missing cables.....	6-1
2600-PCT-1B and C-V measurements .....	6-1
2600-PCT-2B and C-V measurements .....	6-1
Custom tests in ACS Basic .....	6-2
<b>Index .....</b>	<b>1</b>

## Introduction

### In this section:

---

Welcome .....	1-1
Introduction to this manual .....	1-1
Available configurations .....	1-2
Extended warranty .....	1-2
Contact information .....	1-2

## Welcome

Keithley's Parametric Curve Tracer configurations are complete solutions configured with a variety of high quality instruments, cables, test fixtures, and software. This building block approach offers the advantages of easy upgrade or modifications to meet changing test needs. For example, a low cost 200 V at 10 A system can be purchased initially, and 50 A or 100 A capability can be added later. Additionally, you can use these instruments and accessories with different test system platforms, such as for reliability or device qualification testing.

Keithley's Parametric Curve Trace configurations include everything you need to quickly develop a complete test system.

ACS Basic Edition software provides complete device characterization, including both real-time trace mode for quickly checking fundamental device parameters like breakdown voltage and full parametric mode for extracting precise device parameters. ACS Basic Edition goes beyond traditional curve tracer interfaces by offering a broad array of sample device libraries. More important, you have complete control of all test resources, allowing you to create more advanced tests than previously possible on a curve tracer.

## Introduction to this manual

This manual describes how to set up and use the Parametric Curve Tracer, including:

- Assembling the PCT
- Getting the software running
- Performing tests with the software, using both Trace mode and Parametric Test mode

This manual provides detailed applications to help you achieve success with your Keithley Instruments PCT.

Each application is presented with an overview of the application, followed by instructions to complete the application.

## Available configurations

	Model	Collector / Drain Supply		Step Generator	Auxiliary Supply
		High Voltage Mode	High Current Mode	Base / Gate Supply	
<b>Low Power</b>	2600-PCT-1B	200 V / 10 A	200 V / 10 A	200 V / 10 A	N/A
<b>High Current</b>	2600-PCT-2B	200 V / 10 A	40 V / 50 A	200 V / 10 A	200 V / 10 A
<b>High Voltage</b>	2600-PCT-3B	3 kV / 120 mA	200 V / 10 A	200 V / 10 A	200 V / 10 A
<b>High Current and High Voltage</b>	2600-PCT-4B	3 kV / 120 mA	40 V / 50 A	200 V / 10 A	200 V / 10 A

The Keithley Instruments Model 2651A may be added to increase High Current Mode to either 50 A or 100 A. Other available accessories include the PCT-CVU Multi-frequency Capacitance-Voltage (C-V) Meter, the Model 8010 High Power Device Test Fixture, the Model 8020 High Power Interface Panel, and the CVU-200-KIT and CVU-3k-KIT bias tee kits.

## 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, or call Keithley Instruments corporate headquarters (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 \(http://www.keithley.com\)](http://www.keithley.com).

---

# Instruments and connections

### In this section:

---

Introduction .....	2-1
Unpacking the PCT .....	2-1
About the Model 8010 High Power Device Test Fixture .....	2-2
About the Model 8020 High Power Interface Panel .....	2-3
Safety connections .....	2-3
Connect instruments to the Model 8010 .....	2-5
Connect instruments to the Model 8020 .....	2-6

## Introduction

You must connect the instruments to either the Model 8010 High Power Device Test Fixture or the Model 8020 High Power Interface Panel and then set up the TSP-Link network. The cables supplied with your PCT can be used with either fixture. This section will show you how to make these connections.

If you choose to install the instruments in a rack, rack-mount the units first before connecting the instruments to the test fixture or interface panel. Please refer to the instructions in the rack mount kits for more information.

## Unpacking the PCT

Each PCT configuration is shipped with the latest version of the ACS Basic Software CD-ROM (Keithley Instruments part number ACS-950-01). For the latest drivers and additional support information, see the [Keithley Instruments website](http://www.keithley.com) (<http://www.keithley.com>).

Within the PCT shipping container is a single box labeled "Open Me First" that contains all the instrument accessories, user documentation, and ACS Basic Edition software. Within this box, the accessories for each instrument in your configuration are enclosed in individual boxes and bags. Each box also includes a Product Announcement document describing the contents of each box.

On the same shipping pallet are each SMU of your PCT configuration, as well as any other PCT accessories, such as a Model 8010 High Power Device Test Fixture, a Model 8020 High Power Interface Panel, the PCT-CVU instrument option, or the optional 200 V or 3 KV bias tee kits.

The PCT is generally connected to either a Model 8010 or a Model 8020. The following section provides overview for these devices.

## About the Model 8010 High Power Device Test Fixture

The Model 8010 High-Power Device Test Fixture provides a safe, low noise, complete environment for testing a variety of packaged device types. The replaceable socket module test boards allow for a variety of package types, including the user-supplied socket types.

The Model 8010 allows you to connect one Model 2657A High Power SourceMeter for up to 3 KV testing. You can connect up to two Model 2651A High Power SourceMeters for 15 A DC testing or 50 A or 100 A pulse testing. For lower power terminals, you can connect up to two other SourceMeters, such as Models 2611A, 2612A, 2635A, 2636A, 4200-SMU or 4210-SMU.

The Model 8010 includes:

- Kelvin (remote sense) connections for five instruments
- Guarded pathways for picoampere level measurements even at 3 KV
- An access port for a variety of probes, such as scope or temperature
- Integrated protection circuits to protect Models 2611A, 2612A, 2635A, 2636A, 4200-SMU, and 4210-SMU from high voltage instruments
- Two independent test sockets, one for high current and one for high voltage

The test fixture is fully interlocked, providing safe operation for up to six different instruments. It is declared safe through CE marking and certified through nationally recognized testing laboratories.

The Model 8010 is shipped with two 8010-DTB high power socket module test boards installed. The boards include sockets for TO-247 and axial lead devices.

Additional socket module test boards are available. The 8010-CTB Customizable Test Board allows you to add your own socket. The 8010-DTB-220 Test Board is for use with three-terminal TO-220 or TO-247 devices and is limited to 1000 V and the maximum rated current of the test fixture.

Additionally, the 8010-DTB-CT Curve Tracer Adapter Test Board allows you to use the same socket style installed in Tektronix Series Curve Tracers.

For information on the Model 8010, including fixture setup within a test system, see the Model 8010 High Power Device Test Fixture User's Manual, available at the [Keithley Instruments website \(http://www.keithley.com\)](http://www.keithley.com).

## About the Model 8020 High Power Interface Panel

The Model 8020 has six measurement pathways accommodating 3 kV, 200 V, and 100 A measurements. You can configure five of the pathways with a variety of output connector types to match your probe station. You can configure four pathways with the optional bias tees. This provides high voltage C-V measurements on up to 4 pins of the device under test.

The Model 8020 comes with a selection of resistors that you can install to provide stability and extra protection to the device.

Additionally, the Model 8020 offers the following:

- A common LO reference
- Overvoltage protection for all 200 V channels, ideal for device testing configurations using 200 V SMUs and higher voltage SMUs
- A variety of connector types
- A single interlock interface for multiple instruments
- An interface for adding series resistor elements for measurement stability and absolute current limit
- Optional transient overcurrent protection on the 200 V channels
- Expansion ports to easily link multiple 8020 interface panels

The Model 8020 can be configured to suit your particular probe station and test system. Contact your Keithley Instruments applications engineer or see the Model 8020 High Power Interface Panel User's Manual, available at the [Keithley Instruments website](http://www.keithley.com) (<http://www.keithley.com>)

## Safety connections

### Connections to protective earth (safety ground)

#### WARNING

*The ground wires must be attached to a known protective earth (safety ground) before powering on instruments. Failure to attach the ground wires to a known protective earth may result in electric shock.*

Connections to protective earth (safety ground) are made at terminals labeled with the following symbol.

Figure 1: Protective earth (safety ground) symbol



For detailed Model 8010 and Model 8020 instrument connections diagrams, including safety ground details, see [Connect instruments to the Model 8010](#) (on page 2-5) or [Connect instruments to the Model 8020](#) (on page 2-6).

## Interlock connections

### NOTE

For proper interlock functionality, any instruments connected to the interlock must be powered on or else disconnected from the interlock.

Each Parametric Curve Tracer configuration contains instruments that can output hazardous live voltages. To ensure operator safety, it is important to use the instrument interlock properly with the Model 8010 and Model 8020 test fixtures. Both the Model 8010 and Model 8020 include interlock connectors to interface with Series 26xx and 4200 instruments. Refer to the instrument connection diagrams later in this section for illustrations on how to connect to the individual SMU instruments.

With the Model 8010, the interlock switch is engaged when the lid is closed and latched. When the interlock switch is engaged, a light on the enclosure is illuminated. You can turn on a SMU output only when the interlock switch is engaged. If the lid is open, the interlock switch will not engage and any SMUs with outputs that are configured for high voltage will not turn on.

For the Model 8020, the Interlock OUT connector on its device connections panel side of the unit is designed for use with the supplied 8020-ILC-UNT interlock to unterminated cable. The interlock enables the high voltage outputs of the connected instruments when the normally-open switch at the DUT access point is closed.

The Model 8020 interlock is satisfied only when:

- The top cover to the 8020 is correctly installed and any top covers to other Model 8020s in the test configuration are also correctly installed
- The system interlock is engaged (all normally-open switches are closed at DUT access points of the test configuration)

When the 8020 interlock is satisfied, LEDs on the instrument connections and device connections panels of the 8020 are illuminated.

For detailed information on the interlock requirements for the Model 8010 or Model 8020, see the reference manual for that test fixture. For detailed information on the interlock requirements for a specific SMU, see the reference manual for that SMU.

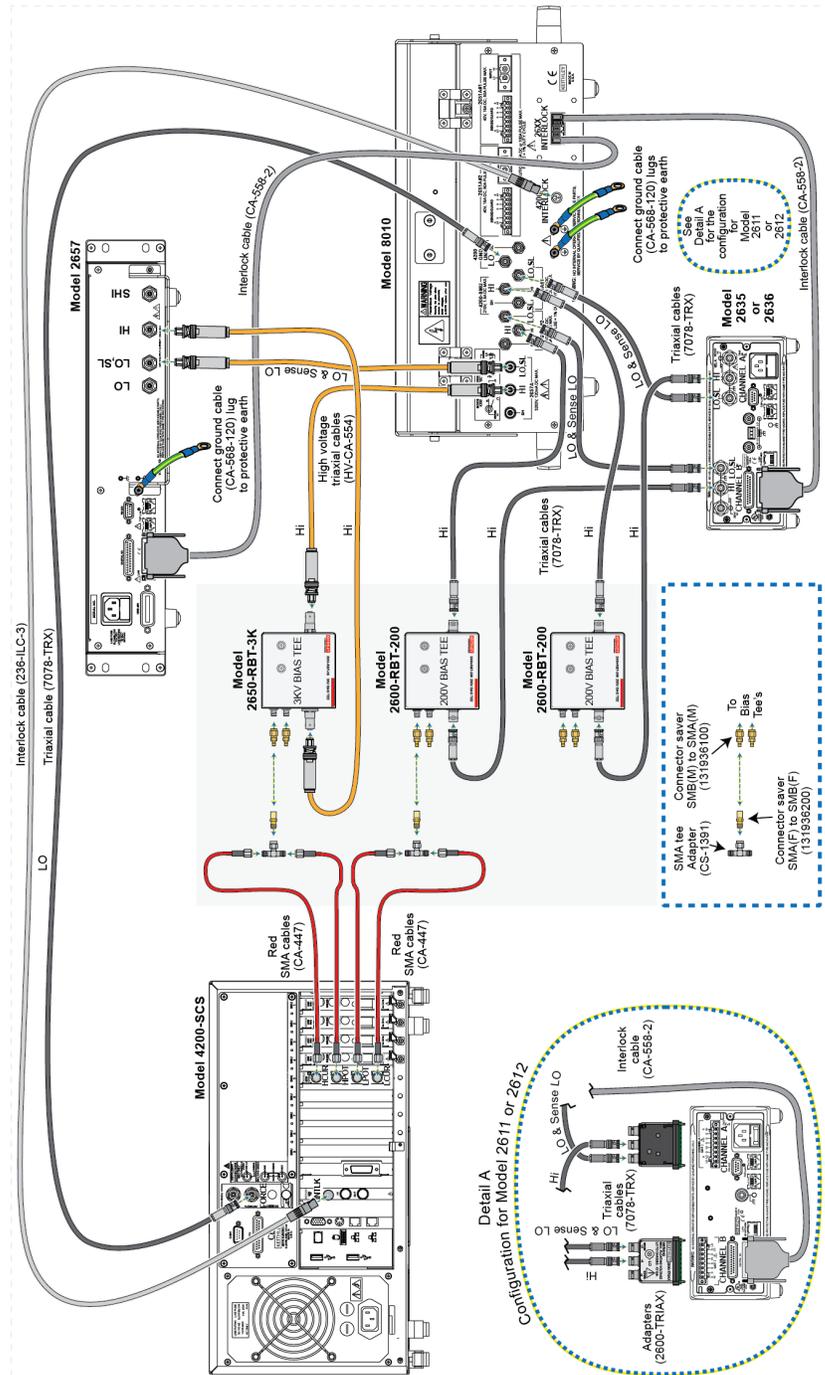
### NOTE

There is no safety interlock on the Model 2651A. The safety interlock is not necessary for this SMU because its output voltage is below hazardous levels. To activate Output Enable, refer to the Model 2651A Reference Manual. Output Enable can be activated using the front panel or by remote control.

# Connect instruments to the Model 8010

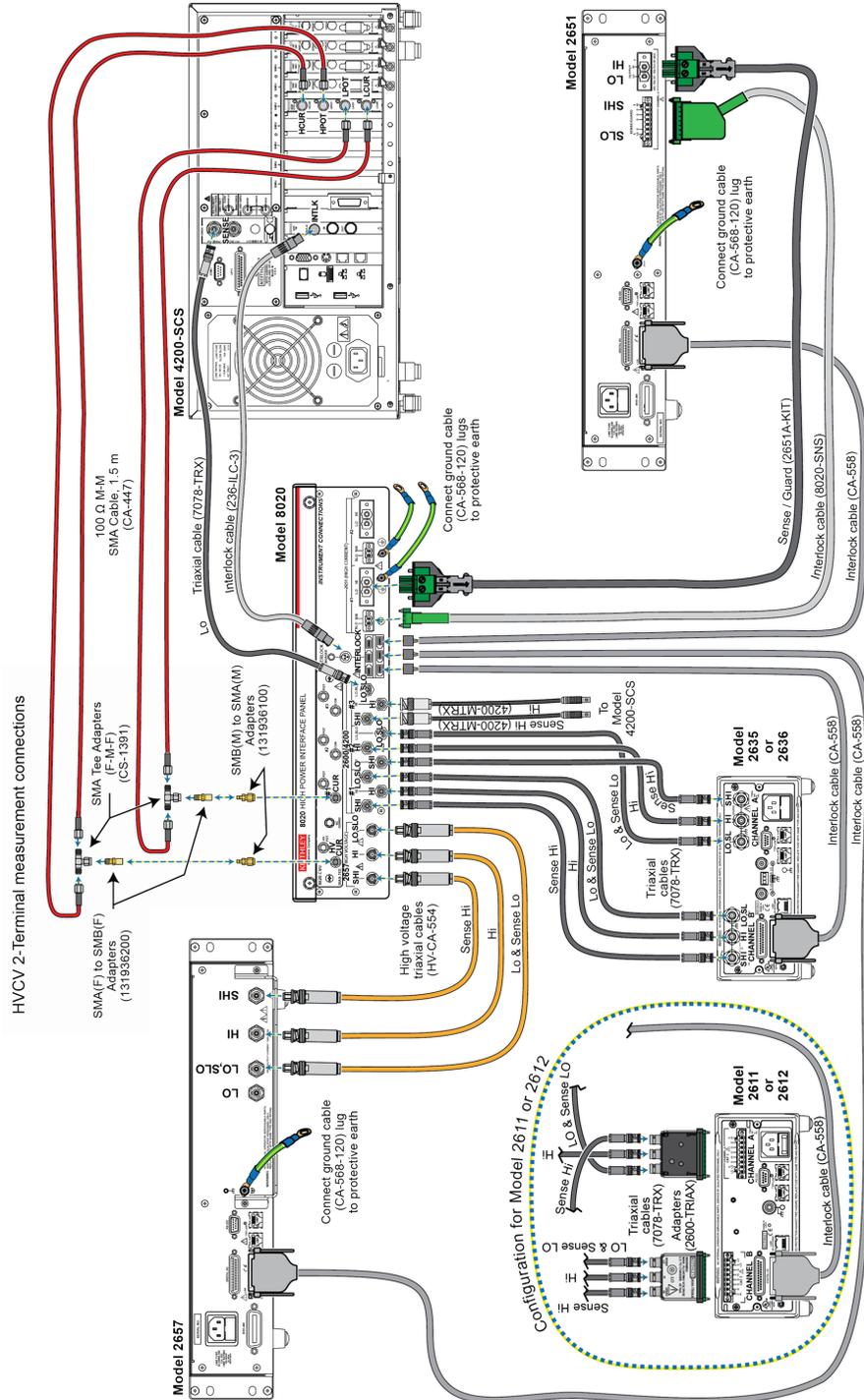
The following diagram depicts connections for I-V and C-V measurements. If you need to make only connections for I-V measurements, refer to the Model 8010 User's Manual.

**Figure 2: Instrument connections to the Model 8010**



# Connect instruments to the Model 8020

Figure 3: Connecting instruments to the Model 8020



---

## Getting started with ACS Basic

### In this section:

---

Introduction .....	3-1
Installing and configuring the GPIB interface .....	3-1
TSP-Link system setup .....	3-2
ACS Basic software .....	3-4

## Introduction

ACS Basic Edition software is optimized for parametric testing of component and discrete (packaged) semiconductor devices. ACS Basic supports all of Keithley's source and measure instrument products, including Series 2600B, Series 2400, and Models 2651A and 2657A SourceMeter Instruments, Model 237 SMU, and Model 4200-SCS SMUs.

ACS Basic has a large device test library to allow you to get a test up and running quickly.

This section will outline how to configure the instruments in the PCT to prepare for connection to ACS Basic, how to install the software, and how to get started using the software.

## Installing and configuring the GPIB interface

### NOTE

If you have ordered the PCT-CVU for high voltage capacitance measurements, a GPIB interface comes installed on the Model 4200-SCS that is included with the PCT-CVU. There is no need to use a separate computer or install the KUSB-488B. Move ahead to TSP-Link system setup, where you will [Assign TSP-Link node numbers](#) (on page 3-2).

ACS Basic software will work with the following GPIB interfaces:

- KUSB-488
- KUSB-488A
- KUSB-488B
- KPCI-488
- KPCI-488A
- KPCI-488LP
- KPCI-488LPA
- NI USB-488
- NI PCI-488

If one of the above interfaces is already installed on your computer, please continue to TSP-Link system setup.

The PCT is supplied with Keithley's Model KUSB-488B GPIB interface. When you are using a separate PC for software control, first install the GPIB interface if there is not one already installed on the PC. The GPIB driver CD and the GPIB interface are located in the "Open Me First" box shipped with the PCT. Insert the CD and follow the on-screen instructions to install the driver and the GPIB interface.

## TSP-Link system setup

ACS Basic automatically assigns the SMU identification numbers based on the TSP-Link setup. The numbers will differ based on your PCT configuration.

### Assign TSP-Link node numbers

Each instrument in the TSP-Link network must have a unique TSP-Link node number. In addition, ACS Basic requires that you set the master node to TSP-Link node number 1 and that each node that is connected to the master has an incremental node number. For example, if you have a TSP-Link network with three nodes, you must assign the instruments to the node numbers 1, 2 and 3. Do not skip numbers.

In PCT configurations, use the Model 2636B as the master node, assigned to node number 1. When present in the PCT, the Model 2657A should be assigned Node Number 2. The Model 2651A should be assigned to 3 only in with the PCT-3B and -4B configurations; with a PCT-2B configuration, the Model 2651A should be assigned to Node 2. If you have a second Model 2651A, assign it to the subsequent node number.

While other node configurations are possible, these assignments allow for simpler use of the default ACS Basic tests.

1. To assign a node number from the front panel of the instrument:
2. Press the MENU key, then select TSPLINK > NODE.
3. Press the navigation wheel  and select the desired number.
4. Press the ENTER key to save the node number.
5. Press the **EXIT** key as needed to return to the main display.

## Connect the instrument for communications

All configurations require a KUSB-488B or similar GPIB adapter cable Model 2636B connecting the instrument and your computer. For additional connections, see the below details for your PCT configuration.

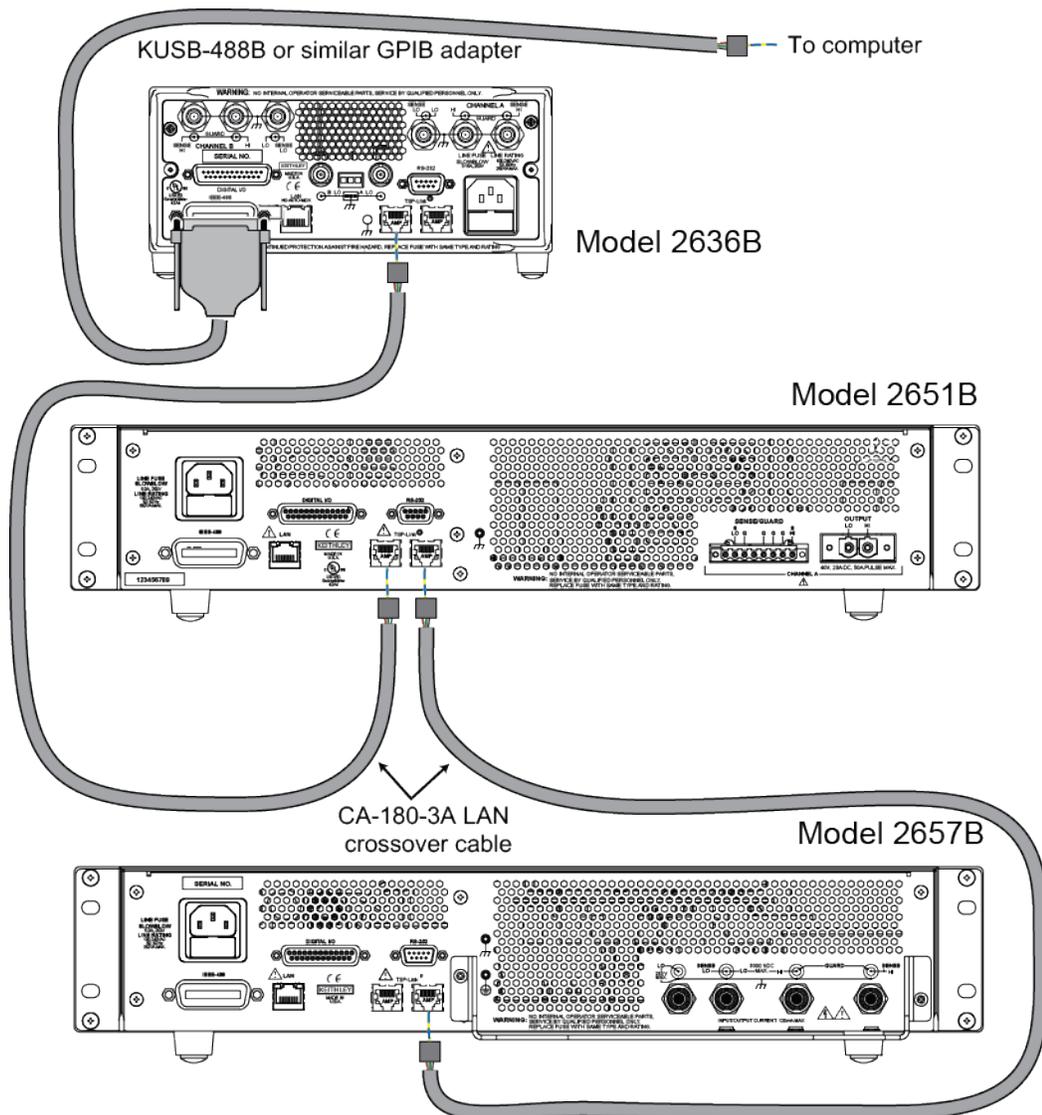
The **2600-PCT-1B** configuration is shipped with the Model 2636B. The KUSB-488B or similar GPIB adapter cable linking the Model 2636B and your computer is the only connection.

The **2600-PCT-2B** configuration is shipped with the Models 2636B and 2651A. For this configuration, connect the TSP-Link port of the Model 2636B to the TSP-Link port of the Model 2651A.

The **2600-PCT-3B** configuration is shipped with the Models 2636B and 2657B. For this configuration, connect the TSP-Link port of the Model 2636B to the TSP-Link port of the Model 2657A.

The below graphic shows a **2600-PCT-4B** configuration. The -4B configuration is shipped with the Models 2636B, 2651A, and 2657B.

**Figure 4: Communications connections**



## ACS Basic software

ACS Basic software can be installed on any computer that meets the minimum configurations as described below. Additionally, ACS Basic software is supported on a computer/laptop for the Series 2600B System SourceMeter<sup>®</sup> units, the Model 4200-SCS, and other external GPIB instruments.

### NOTE

It is recommended that you back up your previous version of ACS or ACS Basic before installing a new version of the software.

#### Minimum configuration for a computer:

Operating System: Microsoft<sup>®</sup> Windows<sup>®</sup> XP Professional Service Pack 3 (SP3), Windows 7 x 86 (32-bit), or Windows 7 x 64 (64-bit).

- CPU: Pentium 4, 2.4 GHz+ or equivalent
- System Memory (RAM): 1 GB
- Hard Disk: 600 MB free space
- Graphics Card: 16 MB of VRAM
- Screen: 1024 x 768, 32-bit True Color

#### Recommended configuration for a computer:

Operating System: Microsoft Windows XP Professional Service Pack 3 (SP3), Windows 7 x 86 (32-bit), or Windows 7 x 64 (64-bit).

CPU: Intel<sup>®</sup> dual core class, AMD Athlon<sup>®</sup> class or higher

- System Memory (RAM): 2 GB
- Hard Disk: 1 GB free space
- Graphics Card: 64 MB of VRAM
- Screen: 1280 x 1024, 32-bit True Color

### NOTE

ACS Basic software can use GPIB cables to communicate with instruments. Before using ACS Basic, you need to make sure that the GPIB driver is functioning properly in your operating system (Windows XP Professional Service Pack 3 or Windows 7).

## Software installation

### NOTE

If you have a PCT-CVU, then the ACS Basic software is already installed on its computer. You can skip ahead to the Start ACS Basic section of this manual.

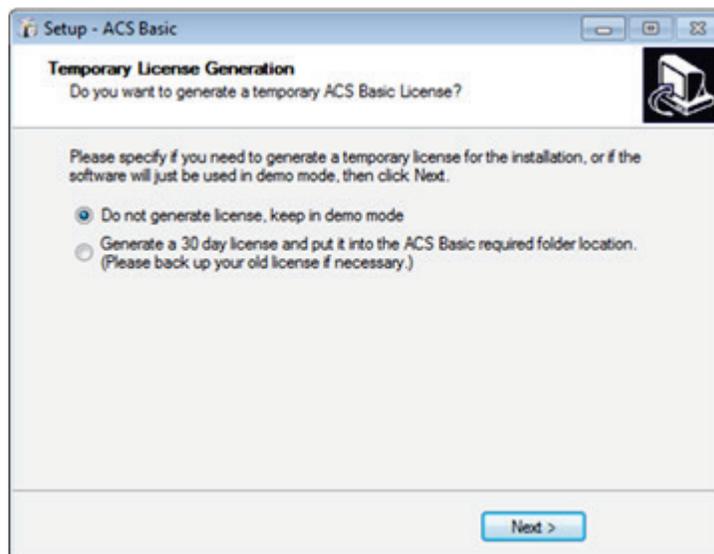
## NOTE

Before installing ACS Basic, make sure you have read and have completed all of the pre-installation requirements (see the previous topic).

### **ACS Basic installation instructions:**

1. Log into Windows as an administrator.
2. Insert the ACS Basic setup disk into the CD-ROM.
3. The CD should open automatically. If it does not open, click **My Computer**, and open the CD.
4. Find the file named **launch.exe** and double-click.
5. When the CD opens you can click on the software to start the installation.
6. Once the ACS Basic Setup Wizard dialog box opens, follow the instructions to install the software on your system.
7. When the installation process is complete, the Temporary License Generation dialog box opens (see next figure).

**Figure 5: Temporary license generation dialog box**



8. If you already have a USB license key, select "Do not generate license, keep in demo mode" in order to continue installation. The USB key for ACS Basic is inside the box labeled "Open Me First" within your shipping carton.

## NOTE

After you have installed ACS Basic software, and before you begin to set up any projects or run any tests, it is recommended that you review the Release Notes. The Release Notes contain valuable information about known issues and provide guidance on how to handle issues that you may encounter. To find the Release Notes, click the **Windows Start icon > All Programs > ACS Basic > Reference > Release Notes** or from the Help menu in the ACS Basic menu toolbar.

## Start ACS Basic

### CAUTION

**FATAL ERROR POSSIBLE.** To avoid fatal errors to instruments, never start the ACS Basic software until all the instruments have completed self-testing. If you are using Series 2600 and 2600B instruments with TSP-Link, always power-on the subordinate instruments first, and then the master. Since the master scans through all the linked subordinate instruments, it must be powered-on after all the subordinate machines are turned on, or errors may occur when you start ACS Basic.

Before you open the ACS software, make sure that all instruments are turned on and all self-tests have completed.

You must also locate the license key, which is included with PCT and located in the "Open First" shipping box. The ACS Basic SafeNet Sentinel USB license key is similar to a standard USB flash drive (see next figure). The USB license key allows you to operate ACS Basic in the professional mode and can be moved from one computer to another (multiple installations) without buying additional licenses.

**Figure 6: USB SafeNet Sentinel license key**



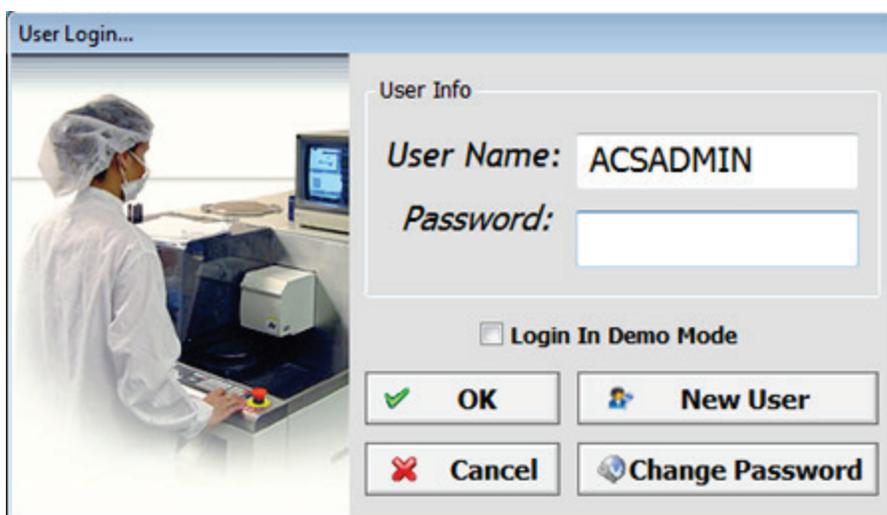
**To start the ACS software:**

1. Insert the USB license key into the USB port of the computer. The computer and ACS Basic software will automatically detect the USB key.

**⚠ CAUTION**

Do not remove the USB key from the computer while you are using the ACS Basic software. If the key is removed, you will receive a warning message that indicates you have 30 seconds to reinsert the USB key in the computer. After the key is reinserted, you must click Continue to keep ACS Basic functioning. If the key is not reinserted before the time has elapsed, the ACS Basic software closes and you will lose all data from your session.

2. Select the ACS software icon on your computer's desktop. The User Login dialog box opens (see next Figure).

**Figure 7: User login**

User Login...

User Info

User Name: ACSADMIN

Password:

Login In Demo Mode

OK New User

Cancel Change Password

3. Type a user name and password in the User Name and Password fields. The default user name is ACSADMIN; however, there is no default password.

## NOTE

More than one new user account can be established at this time. You can establish new accounts by clicking the New User button. To change the password, click the Change Password button.

4. Click **OK**. The ACS software start window opens (see next figure).

**Figure 8: ACS software start window**



## NOTE

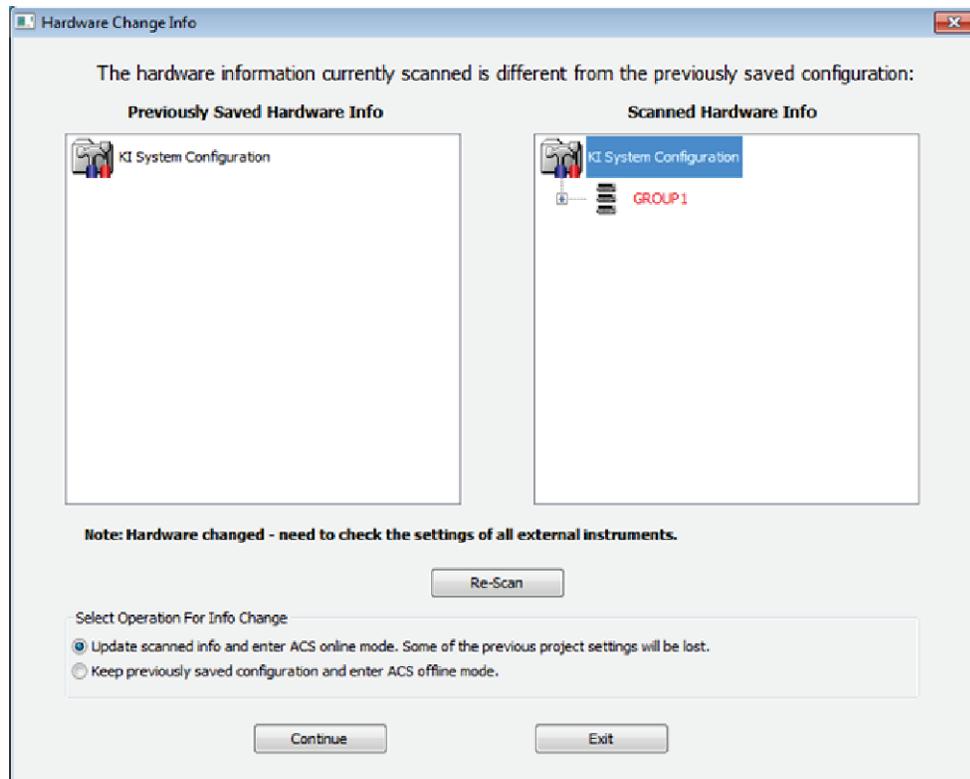
When you start the ACS Basic software, the startup time will depend on how many instruments are in the hardware configuration group. For example, if there are several instruments, the startup time will be longer.

## Verify hardware configuration

When you first start up ACS Basic, the Hardware Change Info dialog box is displayed, as shown below. This dialog box is displayed whenever ACS Basic detects a change in hardware.

ACS Basic automatically assigns the SMU numbers. The numbers will differ based on your PCT configuration and TSP-Link node numbers. See [Assign TSP-Link node numbers](#) (on page 3-2) for the recommended TSP-Link configuration.

**Figure 9: Hardware change info**



### **To verify the hardware configuration:**

1. In the Scanned Hardware Info list, click + display the list of hardware.
2. Verify that all the SMUs in your system were detected.
3. Use the mouse to hover over the each SMU in the tree to display information about the SMU.
4. If the information is correct, select the option "Update scanned info and enter ACS online mode."
5. Click **Continue**.

### **If one or more SMUs are missing:**

- Ensure that the GPIB adapter is securely attached to instrument and is working.
- Ensure that all instruments are powered on.
- Ensure that all TSP-Link cables are secure.

After checking the instruments, click **Re-Scan** to scan the hardware configuration again.

## ACS basic test modes

ACS Basic has three test modes. The following table lists each mode and its usage.

Mode	Usage
Single-test	Open and run a single test on a single device at a time
Multi-test	Create multiple test modules on one or more devices and organize them into a single project. For example, Multi-test mode can perform multiple tests on a single device (target application) or multiple tests on multiple devices (secondary use case). You can work with external instruments (DMMs, switches, and so on) in Multi-test mode much easier than in any other mode.
Trace	Trace mode is for interactive operation with a source meter unit. Trace mode is useful for quickly checking the operating boundaries of a device and for verifying its basic functionality.

In the following sections of this manual, you will learn how to perform common power semiconductor tests in Multi-test mode and in Trace Mode.

## Configure ACS Basic to use the correct device interface

ACS Basic uses the Device Interface Setting to manage the hardware configuration for optimizing the default instrument settings. For correct optimization, open the Hardware Configurator by selecting the Configure Hardware icon on the toolbar. Next, select "Device Interface Setting" in the left navigation pane. See the following two graphics for details.

Figure 10: Hardware Configurator icon



Figure 11: Hardware configurator

The screenshot shows the 'Device Interface Setting' window for a 'Model 8010 High Power Device Test Fixture (Rear View)'. The window includes a 'Device Interface Setting' section with radio buttons for '8010', '8020', and 'Other', and a 'Bas Tee' checkbox. Below this is a 'Note' section with two instructions. The 'SPECIFICATIONS' section lists rear panel connectors and supplemental characteristics such as offset/leakage current, path isolation, and path resistance.

**Device Interface Setting**

Model:  8010  8020  Other

Bas Tee:

Apply

Note:

1. If neither Model 8010 or Model 8020 is used, select "Other".
2. Check "Bas Tee" box if any of the following (bas tee is used):  
 Model 4201-485T (4201-CPU+Prb. C+Power Package)  
 Model CVU-3K42T (8010 Bas Tee option)  
 Model 8020-CUJ (8020 Bas Tee option)

**SPECIFICATIONS**

<b>Rear panel connectors</b>	Three 3-lug high voltage triaxial connectors Eight 3-lug standard triaxial connectors Two 8-pin screw terminal blocks Two 2-pin high current screw terminal blocks One 3-pin circular DIN interlock connector Five 3-pin 26XXX interlock sockets
<b>Offset/leakage current</b>	Less than 10 pA at 1500 V and 20 pA at 3000 V (through the 2657A path) Less than 10 pA at 200 V typical (through the 2600A and 4200 paths) For the 8010-DTB, 8010-DTB-220, or 8010-CTB, add 15 pA at 1500 V (typical, with clean module) to the above leakage characteristic
<b>Path isolation</b>	Resistance: More than 100 GΩ typical from Force HI to Force HI of any two source-measure units (SMUs) Capacitance: Less than 1 pF typical (test frequency = 10 kHz, guarded)
<b>Path resistance</b>	Less than 10 mΩ typical from 2-pin high-current screw terminal block to end of the cable that is connected to the 8 mm banana jack

**Configure the device interface setting in ACS Basic:**

1. Select the radio button of the model of your test fixture or device interface.
2. Select Bias Tee checkbox option if you are using any of the following bias tees: Model CVU-3K-Kit, Model CVU-200-KIT, Model 8020-CVU, or Model 4205-RBT.
3. Select the Apply button.
4. Return to the test setup area of ACS Basic by clicking the test setup icon in the Toolbar (see below graphic).

**Figure 12: Test setup icon**



---

## I-V applications for power MOSFETs

### In this section:

---

Section overview and equipment requirements.....	4-1
On-state characteristics .....	4-2
Off-state characteristics .....	4-36

### Section overview and equipment requirements

This section provides step-by-step instructions to the user on how to use the Parametric Curve Tracer (PCT) to perform common tests on a sample power MOSFET device. These tests include collecting family of curves ( $V_{ds}$ - $I_d$ ) on a power MOSFET and measuring leakage current ( $I_{dss}$ ) using the various modes and features of the ACS Basic software.

The following instructions are tailored to the 2600-PCT-4B that has both high voltage and high current capability. However, the test parameters can be adjusted to suit the PCT configuration and instrumentation that you have.

The PCT is provided with a sample test device, located in the PCT-DOC-KIT box of the "Open Me First" box. The sample device is a 1000 V MOSFET and is available from Fairchild Semiconductor as part number FQH8N100C. You can download a datasheet for this part from the manufacturer's website: <http://www.fairchildsemi.com> (<http://www.fairchildsemi.com>).

#### NOTE

This section refers to SMUs that are numbered as suggested in [Assign TSP-Link node numbers](#) (on page 3-2). Individual configurations can vary.

## On-state characteristics

### Configure the test fixture

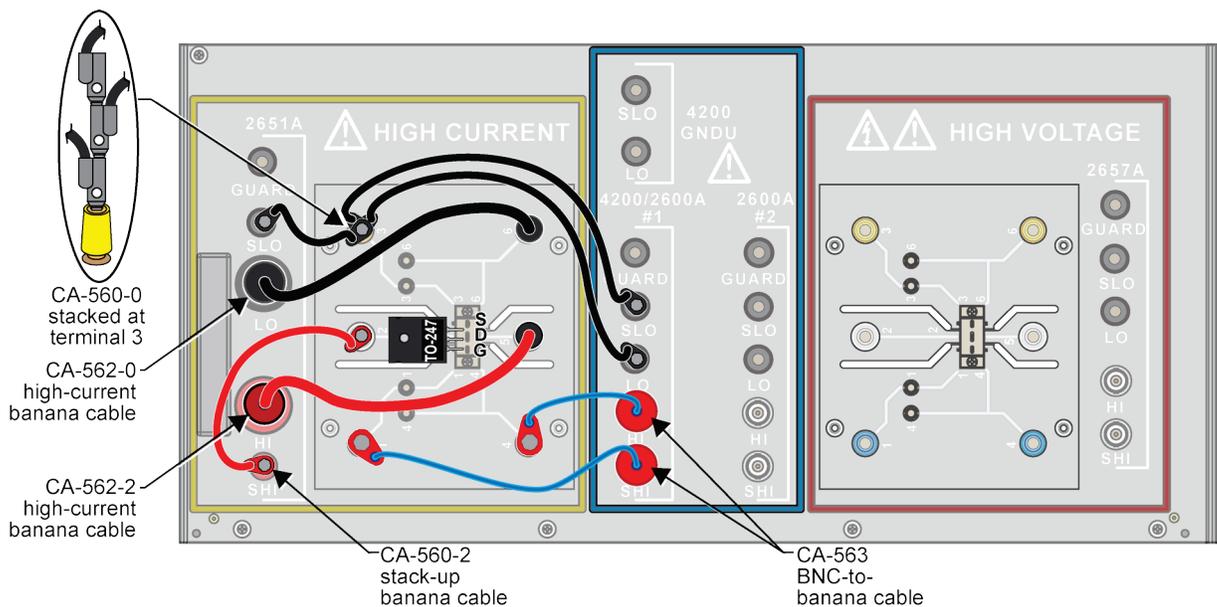
#### NOTE

The PCT supports either the Keithley Instruments Model 8010 or Model 8020 test fixtures. For instructions on how to connect instruments to the 8010 or 8020, refer to Section 2, [Instruments and connections](#) (on page 2-1). To make connections to the device, follow one of the below procedures depending on your test fixture.

#### To configure the Model 8010 test fixture:

1. On the High Current side of the fixture, insert the test device into the test socket. Place the device with the Gate pin closest to the front of the test fixture.
2. Wire the test fixture as shown in the diagram below:
  - Connect the 2651A HI and SHI signals to the Drain terminal.
  - Connect the 2600A #1 HI and SHI signals to the Gate terminal.
  - Connect the LO and SLO signals from both SMUs to the Source terminal.

**Figure 13: Three-terminal DUT with one or two 2651A instruments and Series 2600A instrument connected**





## Collecting I-V curves in trace mode

Trace mode allows you to generate rapid visual results of device characteristics as well as providing real-time control of one of the test parameters. This example application will instruct you on how to collect a family of curves on a MOSFET device.

The PCT is provided with a sample device, located in the PCT-DOC-KIT box of the "Open Me First" box shipped with your PCT configuration. The sample device is a 1000 V MOSFET and is available from Fairchild Semiconductor as part number FQH8N100C. You can download a datasheet for this part from the manufacturer's website at <http://www.fairchildsemi.com> <http://www.fairchildsemi.com>.

These instructions demonstrate how to do the following tasks:

- Configure Trace mode
- Gather a family of curves on a MOSFET using Trace mode
- View and save data in Trace mode

To do the test, you will do the following steps:

1. Enter Trace mode of ACS-Basic
2. Load the IdVd\_StepVg test for the nPowerMOSFET device into the project
3. Configure the settings to match the DUT
4. Run the test
5. View and save the data

### NOTE

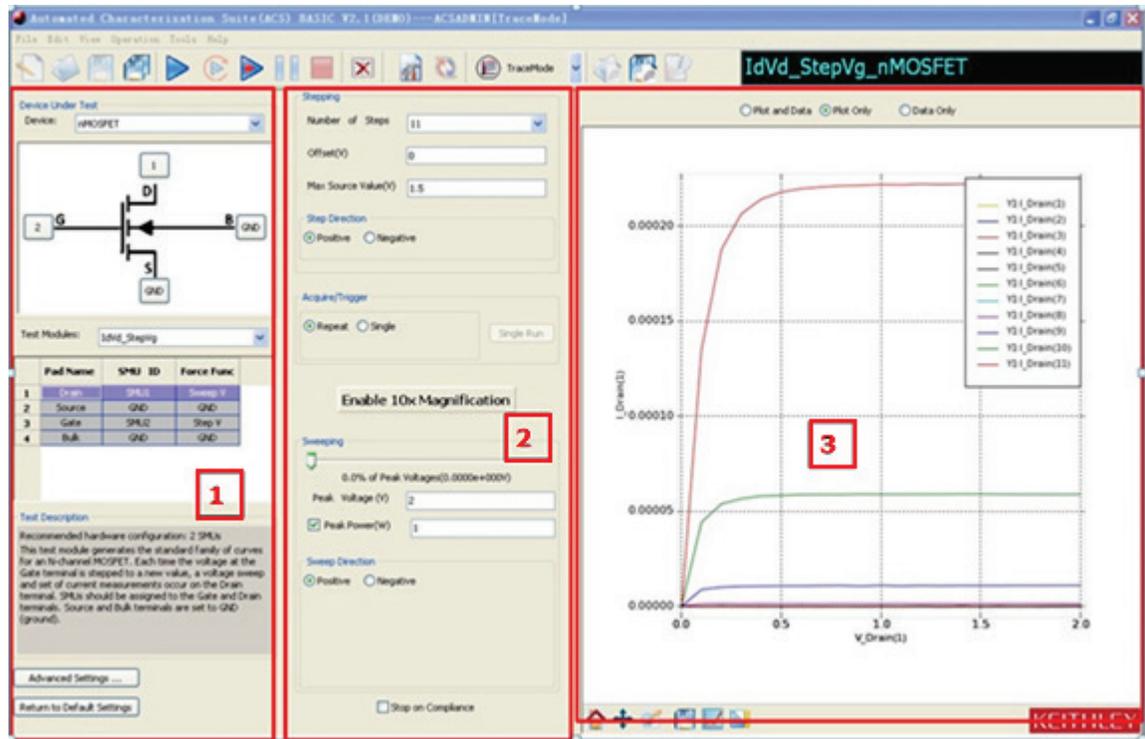
Trace mode only supports the Series 2400, Series 2600B, and the Models 2651A/2657A. However, you cannot connect a Series 2400 and a Series 2600B instrument to the same device. If you are using a Series 2400 on one device terminal, you must use a Series 2400 instrument on the other device terminal(s). However, you can use a Series 2600B and a Model 2650A instrument in any combination. Also, Trace-mode only supports the SCPI protocol for Series 2400 SMUs.

Trace mode provides interactive control of SMU instruments to achieve real-time performance. Only Series 2600B instruments (Models 2601B/2602B, 2611B/2612B, 2635B/2636B), Series 2650A (Models 2651A, 2657A) and Series 2400 instruments (Models 2400, 2401, 2410, 2420, 2425, 2440) are supported. ACS Basic can perform DC and pulse tests on Series 2600B, and 2650A instruments in Trace-mode, but it can only perform DC measurements on Series 2400 instruments.

See the following graphic. The GUI includes:

1. Device setting: used to map the SMU, select the test module, and set the advanced settings.
2. Test setting: used to set the test information when the test module is enabled.
3. Trace Test Data: used to show the test result.

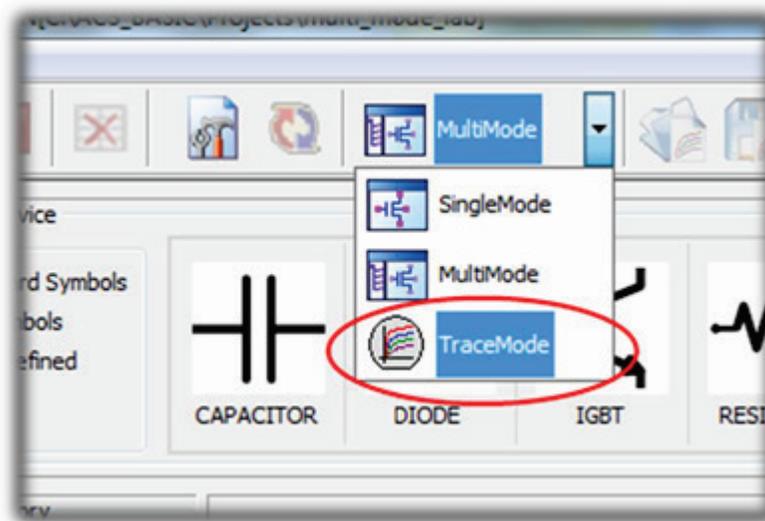
**Figure 15: Trace-mode test GUI**



To collect curves in Trace mode:

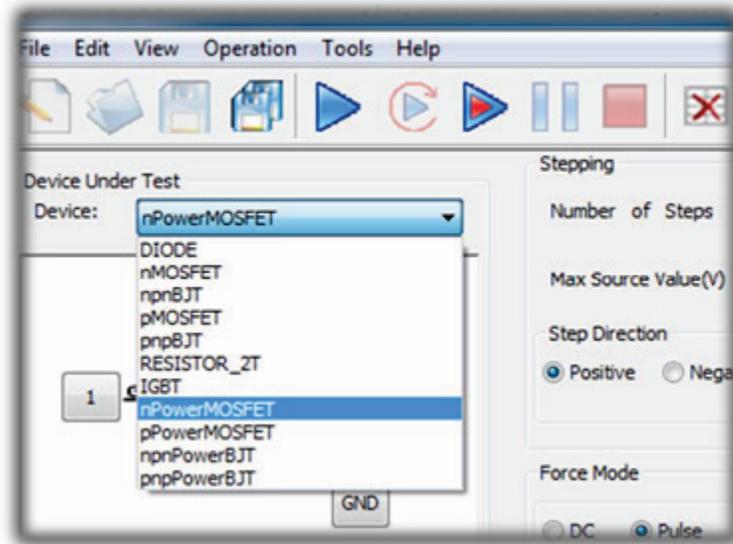
1. Launch ACS Basic.
2. Switch to trace mode by selecting TraceMode from the mode selection drop-down.

Figure 16: Selecting TraceMode option



3. Select nPowerMOSFET from the Device drop-down.

**Figure 17: Selecting nPowerMOSFET**



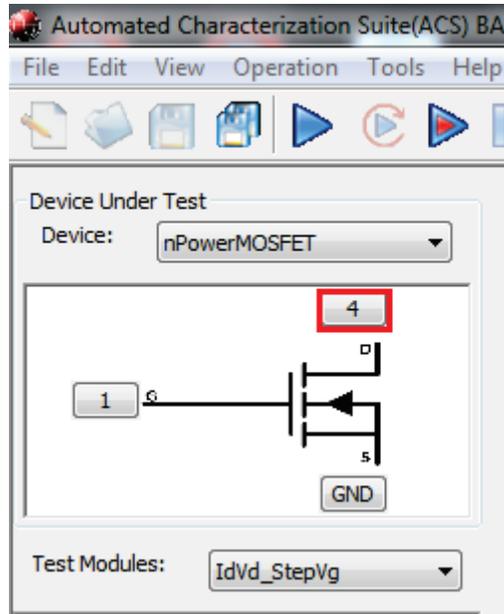
4. Select IdVd\_StepVg from the Test Modules drop-down. The test loads with default settings and sample data.

**Figure 18: Selecting IdVd\_StepVg**



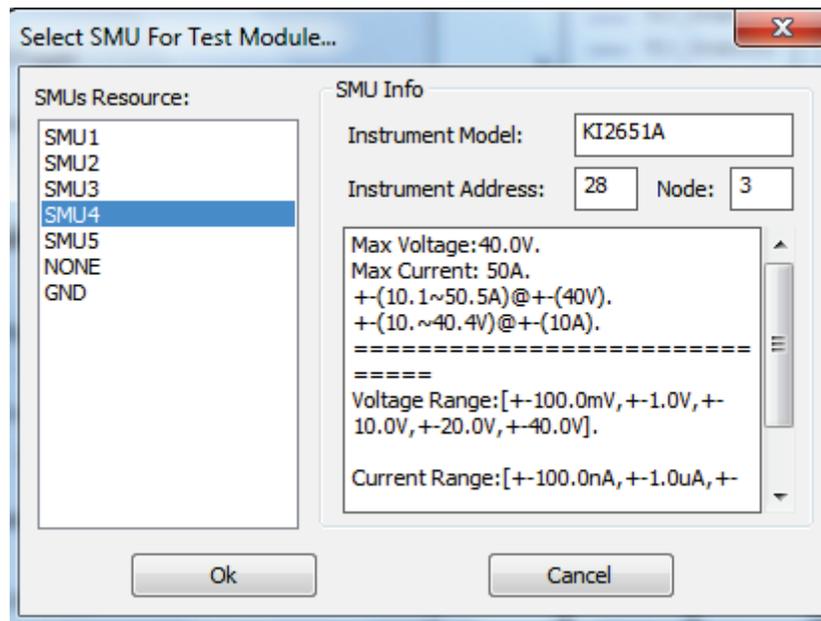
5. Connect a SMU to the desired device terminal by clicking the button next to the device terminal and selecting the appropriate SMU. In the below example, SMU 4 is connected to the Drain terminal.

**Figure 19: Selecting a device terminal for SMU assignment**



6. Select the SMU resource to connect to this device terminal. For this example, we want to connect the high current SMU (2651A, SMU 4) to the Drain.

**Figure 20: SMU 4 settings**



7. Click the OK button to complete the SMU settings.
8. Repeat for the remaining device terminals. For this example, we want to connect 2636A Channel A (SMU1) to the gate and connect the Source to the GND terminal, which represents the Common LO terminal.
9. You can now change the Stepping values. In this instance the gate SMU will step from 5 - 7 V in 0.5 V increments. Therefore, the Number of Steps is 5, the Offset Value is 5 V, the Max Source Value (V) is 7, and the Step Direction is set to Positive. See the below figure.

**Figure 21: Stepping settings**

Stepping

Number of Steps: 5

Offset(V): 5

Max Source Value(V): 7

Step Direction:

Positive  Negative

10. Select your Acquire/Trigger option in Force Mode. The Acquire/Trigger option selects whether the sweep runs once or repeatedly. For this example, select the "repeat" option. See the below figure.

**Figure 22: Force Mode options**

Acquire/Trigger

Repeat  Single

Single Run

11. To adjust the sweeping characteristics, move the Sweeping slider to 0% so that no voltage is applied to the DUT when you start the test. See the below figure.
  - a. For this example, change the Peak Voltage to 10 and make sure that the Sweep Direction is Positive.

**Figure 23: Sweeping slider at 0 percent of peak voltage**

Sweeping

0.0% of Peak Voltages(0.0000e+000V)

Peak Voltage (V): 10

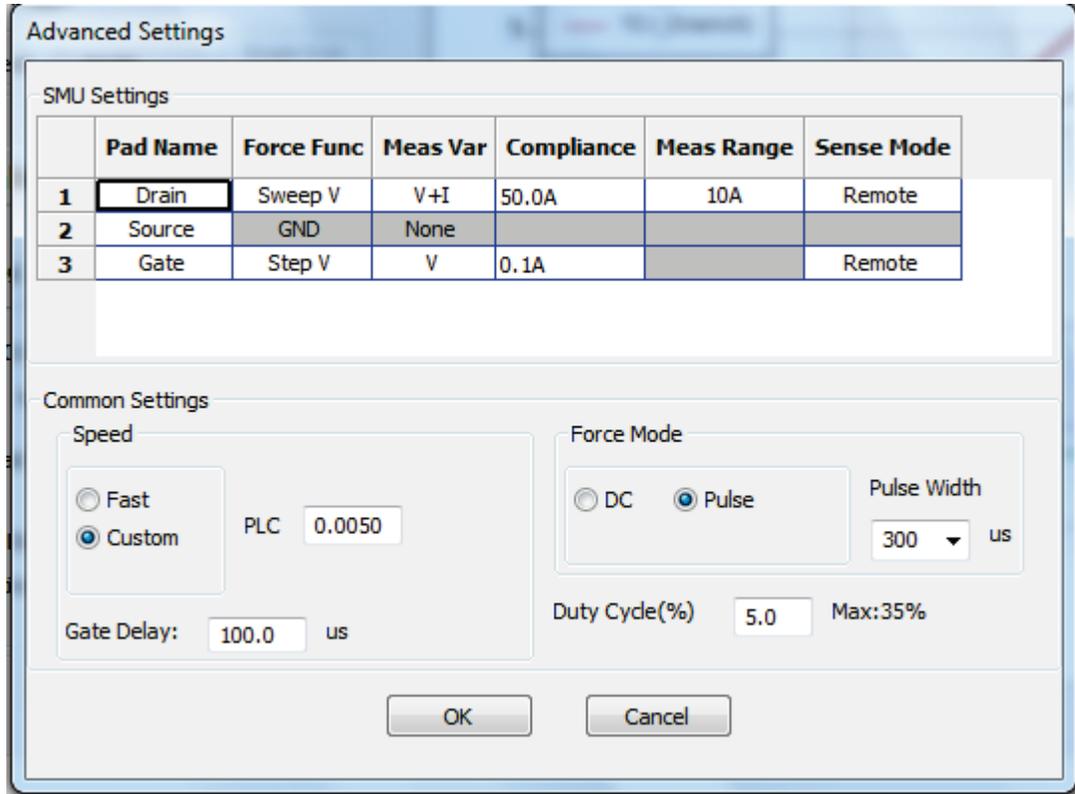
Peak Power (W): 150

Sweep Direction:

Positive  Negative

- To complete the Sweeping and Stepping SMUs configuration, click the Advanced Settings button near the lower-left part of the application window to display the Advanced Settings dialog window (see the below graphic).

**Figure 24: Advanced Settings dialog window**



## NOTE

The Advanced Settings are automatically configured based upon the type of test being run. However, values can be changed to suit the DUT.

13. Adjust the primary Advanced Settings:

- Ensure that the Sense mode is "remote" for both Gate and Drain SMU
- On the drain, change Compliance to 10 A and Meas Range to 10 A
- On the gate, change the Compliance to 100 mA
- Change the Duty Cycle to 5 %

## NOTE

The pulse duty cycle of the pulses impacts the update rate of the display. Using a lower duty cycle will allow higher current without thermal stress to the device. However, a lower duty cycle means that the display will not update as quickly as in this example.

14. Click the OK button to accept the changes.

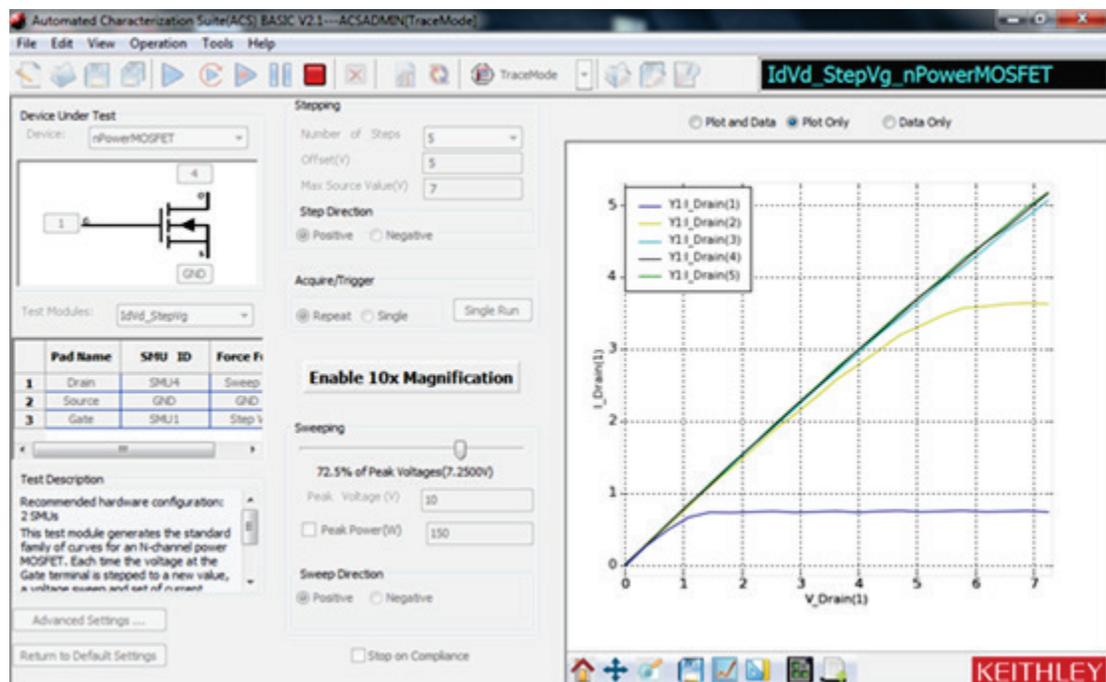
15. Click the Run icon at the top of the application to begin the test. If you configured the Acquire/Trigger mode to "Single", you will need to select the "Single Run" button to start collecting data. With the "Repeat" option, data collection begins when the "run" icon is selected.

**Figure 25: Run icon**



16. Move the Sweeping slider as desired to adjust the peak voltage. Notice that the I-V curves sweep out further as you move the slider right.

**Figure 26: Test results**





## Quick Tip

You can also use the arrows keys on the keyboard to adjust the slider. The up and down arrow keys result in coarse changes in the sweeping voltage of 10 % of peak voltage. The left and right arrow keys result in fine changes in the sweeping voltage of 1 % of peak voltage.

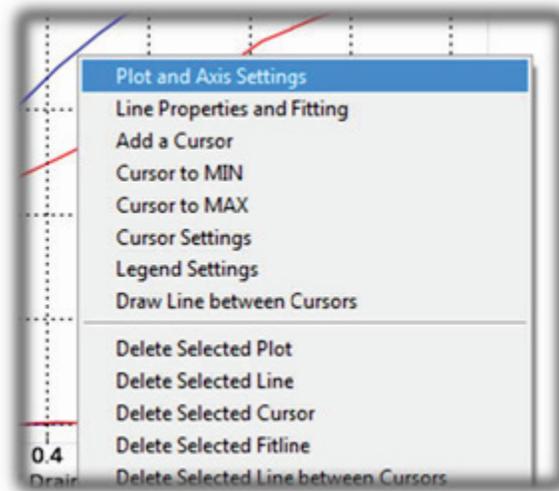
17. Stop the test by clicking the Stop icon at the top of the application window.

## Configure a fixed plot

As you increase the sweep voltage, the graph automatically scales to fit the collected data into the plot. If you prefer a fixed-graph window, follow these steps:

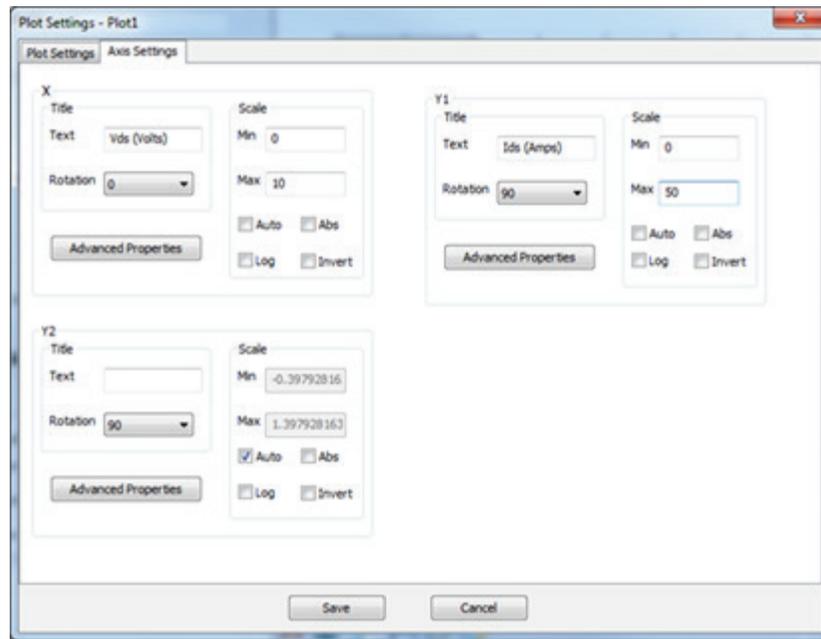
1. Right-click within the plot, then select Plot and Axis Settings from the pop-up menu to display the Plot Settings dialog window.

**Figure 27: Selecting the plot and axis settings window**



2. Select the Axis Settings tab from the Plot Settings window.

**Figure 28: Plot settings dialog window**



3. Make the following modifications to the X-Axis Scale:
  - a. Uncheck Auto
  - b. Change the X-Axis Scale Min to 0
  - c. Change the X-Axis Scale Max to 10
4. Make the following modifications to the Y-Axis Scale:
  - a. Uncheck Auto
  - b. Change the Y-Axis Scale Min to 0
  - c. Change the Y-Axis Scale Max to 10
5. Change the X and Y Axis Title Text:
  - a. Re-name the X-Axis title to "Vds (Volts)"
  - b. Re-name the Y-Axis title to "Ids (Amps)"
6. Click the Save button.

## Collecting I-V curves in multi-test mode

### Introduction

---

In Single-Test and Multi-Test modes, you program all test parameters prior to test operation. Tests run without operator intervention or interaction. These modes are useful for generating precise data on the DUT and for extracting device parameters from the data set.

In this example application, you will collect a family of curves on the sample MOSFET (Fairchild part # FQH8N100C) in Multi-Test Mode. Download a datasheet for this part from [www.fairchildsemi.com](http://www.fairchildsemi.com) <http://www.fairchildsemi.com>.

This example application demonstrates how to do the following tasks:

- Create a MultiMode project in ACS Basic
- Add tests to the project using the built-in test libraries
- Configure a test in Multi-test mode
- View, append, and save data in Multi-test mode

To do the test, you will do the following steps:

1. Place the DUT into the Model 8010 test fixture and configure the connections
2. Enter Multi-Mode of ACS-Basic
3. Create a new Multi-Mode project
4. Load the IdVd\_StepVg test for the nPowerMOSFET device into the project
5. Configure the settings to match the device under test
6. Run the test
7. Save the data

First, let's review the multi-test mode Graphical User Interface.

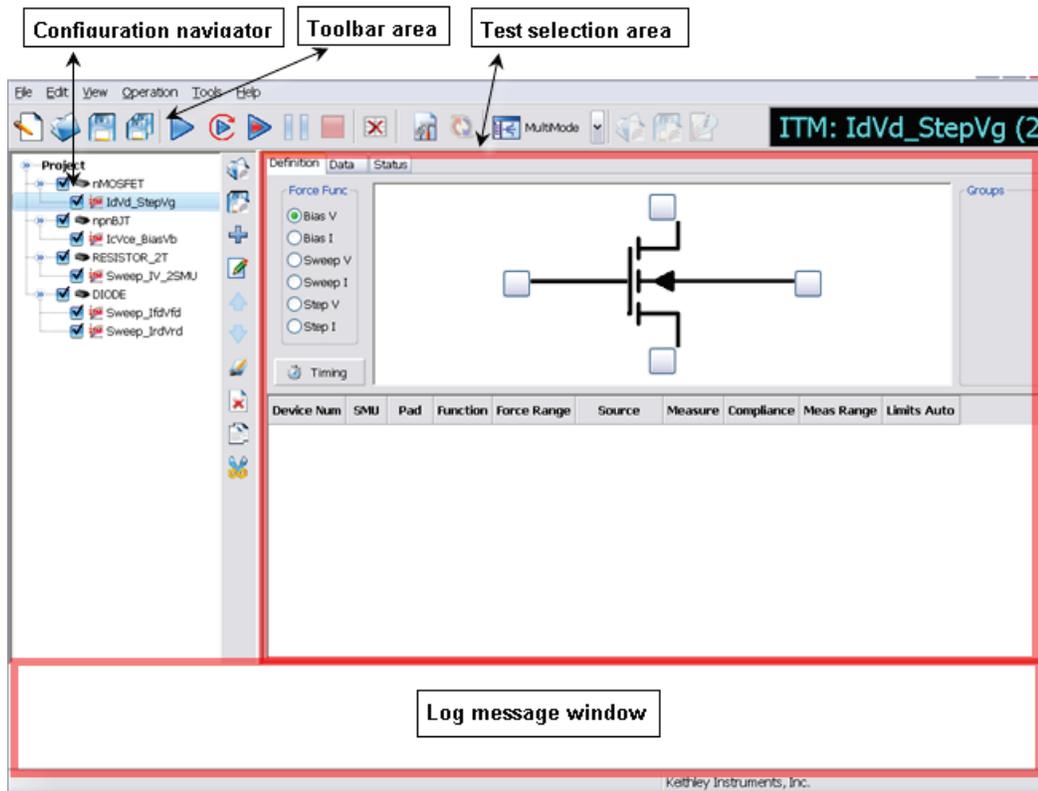
### Multi-test mode GUI overview

---

The configuration navigator (see next figure) has the following logical hierarchy:

- Project
  - Device 1
    - Test module 1 (ITM, STM, or PTM)
    - Test module 2 (ITM, STM, or PTM)
  - Device 2
    - Test module 1 (ITM, STM, or PTM)
    - Test module 2 (ITM, STM, or PTM)

Figure 29: Multi-test mode GUI



The configuration navigator is the primary interface for building, editing, and viewing a project plan, and for specifying and accessing each project plan component.

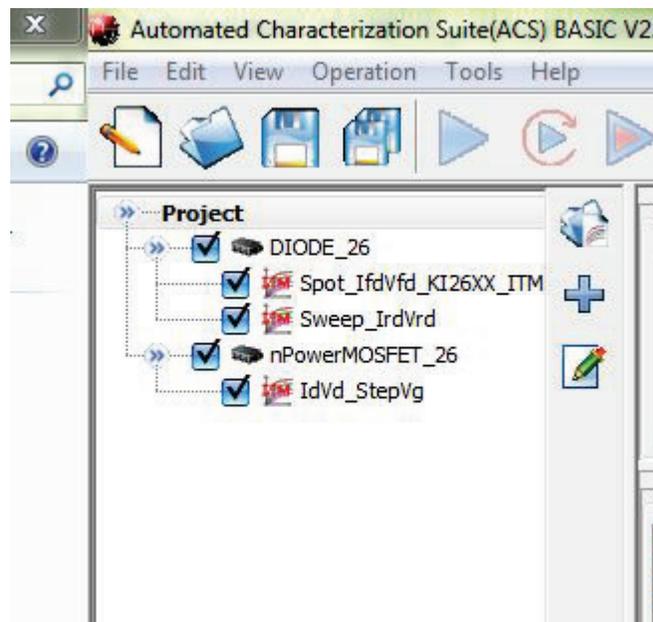
When you select a navigator component (test or device) you can do the following:

- Add a new component
- Delete an existing component
- Run the tests associated with this component

Clicking on a navigator component opens the configuration interface on the right panel that includes settings, test results, and status information.

The next figure displays the typical project plan components that are displayed in the configuration navigator.

**Figure 30: Configuration navigator view, project plan components displayed**



1. **Project** Plan: Defines and sequences all devices tested, and all tests/operations to be performed at each. It typically corresponds to one die on a wafer.
2. **Device** Plan: Defines and sequences all tests for a specific device, including transistors, diodes, and resistors.
3. **ITM**: Completely defines a parametric test without programming, using a series of easily configured graphical user interfaces which show data numerically and graphically in real time. Provides for the display of both raw data and analyzed data.

### Configure the test fixture

The connections to the test fixture for this test using the Model 8010 and Model 8020 test fixtures are the same as for the Collecting IV Curves in Trace Mode and Digitizing Pulses and Improving Timing. Please see the [Configure the test fixture](#) (on page 4-2) topic in either section for details.

## Set up a new MultiMode project

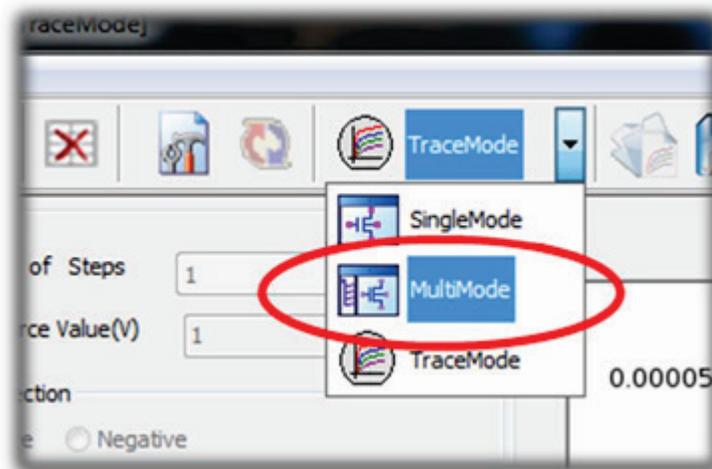
You can use the ACS Basic Multi-test mode to create multiple test modules on one or more devices and organize them into a single project. You can work with external instruments, such as DMMs and switches, in Multi-test mode more easily than in any other mode.

MultiMode starts with the most recently used MultiMode project. In this application, you replace it with a new project.

**To set up a new MultiMode project:**

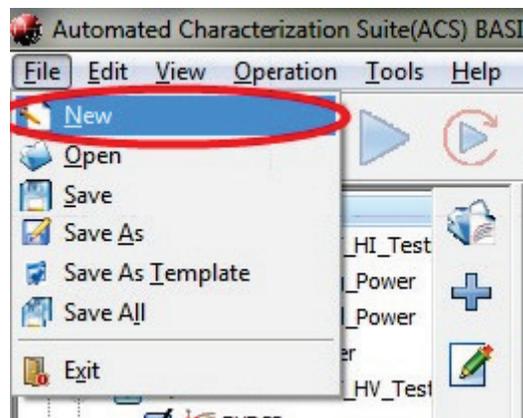
1. Start ACS Basic, if it is not already open.
2. From the Mode Selection list on the operation toolbar, select **MultiMode**.

**Figure 31: Selecting MultiMode**



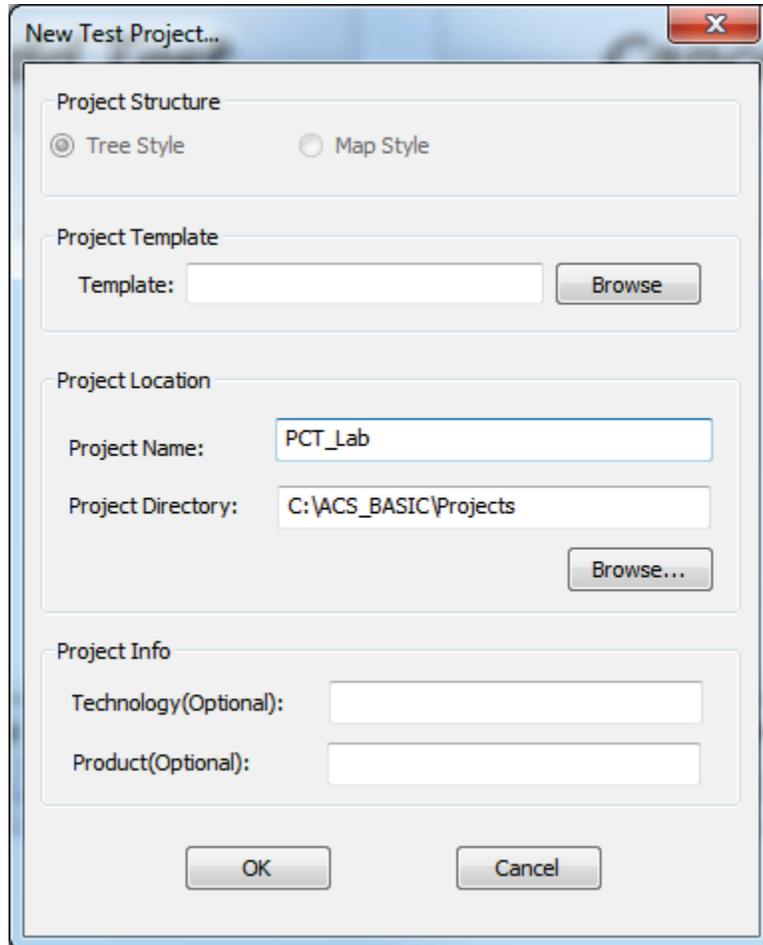
3. From the File menu, select **New**.

**Figure 32: Creating a new project**



4. Select **No** to the prompt to save the current project. The New Test Project dialog box opens (see the next figure).

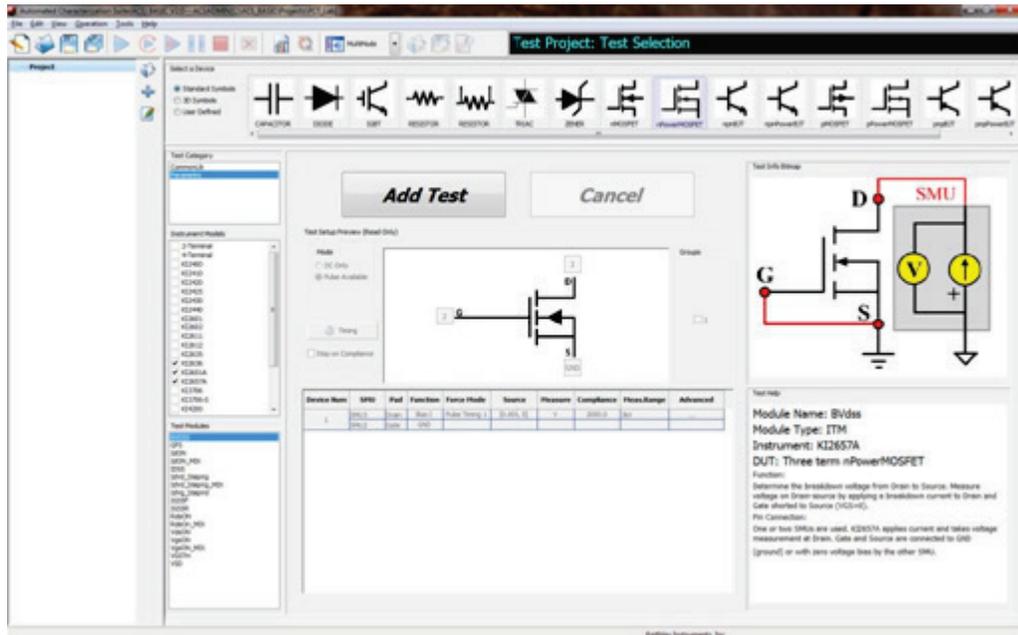
**Figure 33: New test project window**



5. In the Project Name field, enter a project name.
6. Click **OK**.

When the new project opens, the project navigation pane on the left is empty and the test libraries area fills the remainder of the window. The test libraries area is the easiest way to add devices and tests to your project.

**Figure 34: Project navigation and test libraries**

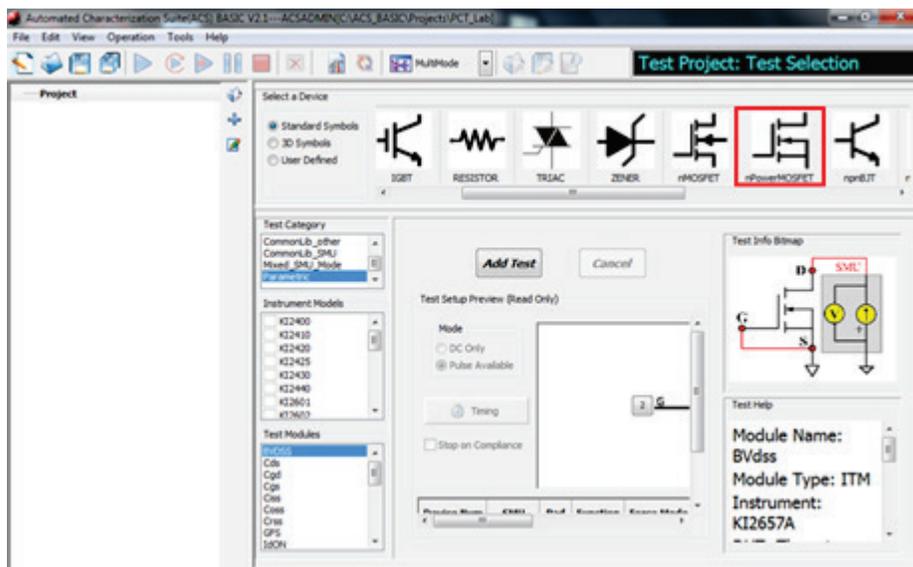


**Add the IdVd\_StepVg test to the project**

*To add the IdVd\_StepVg test to the project:*

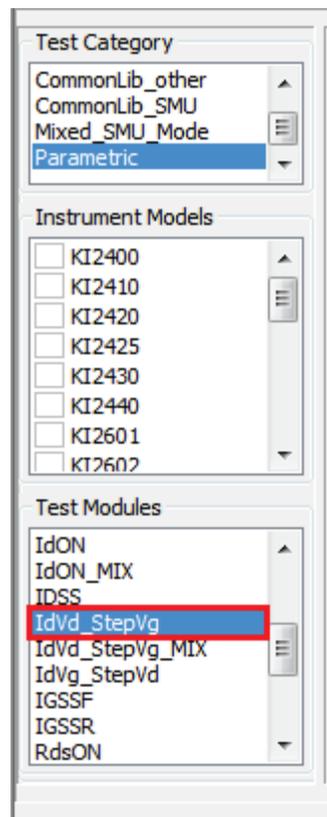
1. From the Select a Device pane, select nPowerMOSFET.

**Figure 35: nPowerMOSFET selected on the Select a Device pane**



2. Select the IdVd\_StepVg test from the Test Modules pane at the bottom left of the window.

**Figure 36: D**



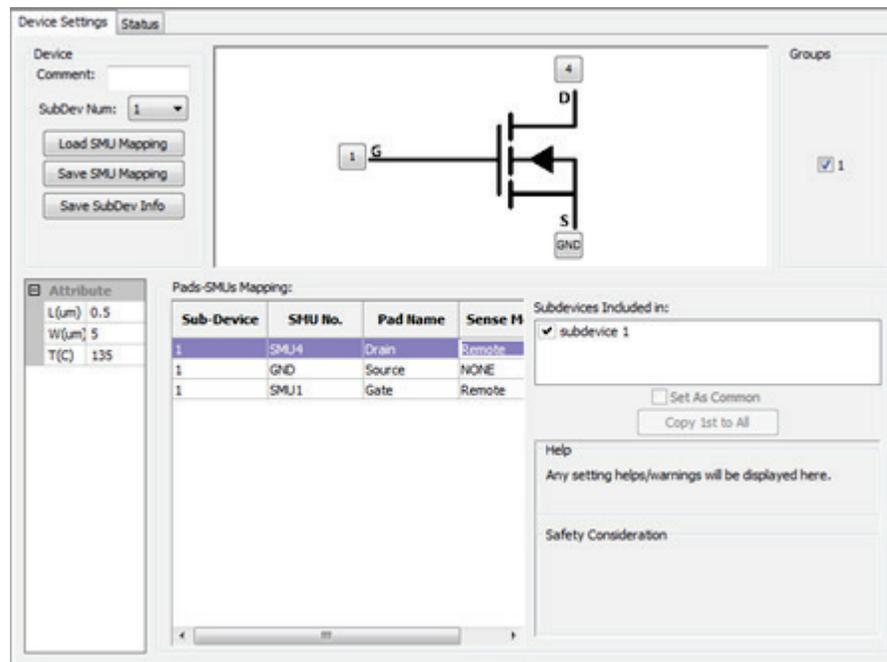
3. Click **Add Test**. The device and test is added to your project tree.

**Figure 37: Device and test added to project tree**



4. In the Project Tree, click the device **nPowerMOSFET\_26**. The Device Settings dialog box opens.

**Figure 38: Device Settings dialog box**



In the Device Settings dialog box, you can configure which SMU is connected to which pin of the device, set the SMU sense mode, and assign a name to the pad. This SMU mapping applies to all tests in the project tree located under the device.

When you added the test to the project, ACS BASIC automatically assigned SMUs to the pins. You should verify that the pin assignments are correct:

- Make sure that the high current SMU (for this example, model 2651A, SMU 4) is connected to the drain
- Make sure that the 2636A Channel A (SMU 1) is connected to the gate
- Make sure that both the gate and drain are configured for remote sense
- Make sure that the source terminal is connected to GND

### Configure the test

You configure the settings each test in the Test Definition dialog box. From this dialog box, you can set every aspect of how your test runs. Many of the settings are pre-configured, but you need to make some changes for this application.

#### Quick Tip

You can check your SMU assignments by hovering the mouse cursor over the pad numbers in the device diagram.

## NOTE

This section refers to SMUs that are numbered as suggested in [Assign TSP-Link node numbers](#) (on page 3-2). Individual configurations can vary.

**To set up the IV curve test:**

1. In the project navigator, click the test named IdVd\_StepVg.
2. For SMU4 (drain), confirm that Compliance is set to **10 A**.
3. For SMU4 (drain), set the Meas. Range to **10A**.
4. For SMU1 (gate), confirm that Compliance is set to **0.1 A**.
5. For SMU4 (drain), double-click the **Source Settings** cell to open the Sweep V Settings dialog box.

**Figure 39: Changing Source settings**

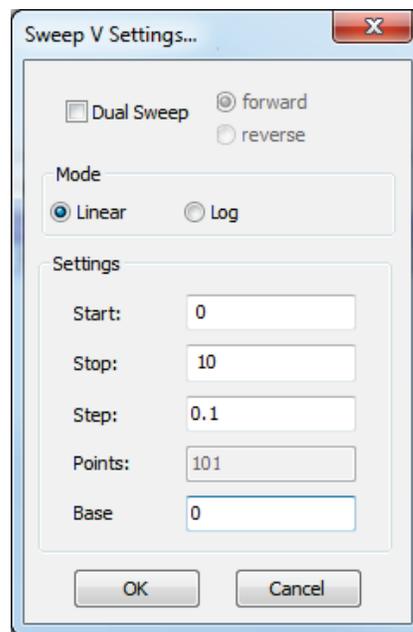
Device Num	SMU	Pad	Function	Force Mode	Source
1	SMU4	Drain	Sweep V	Pulse Timing 1	Linear: [0, 30, 151, 0, 0.2, 0]
	SMU1	Gate	Step V	Pulse Timing 2	[5, 10, 5, 0]

Double-Click  
to change settings



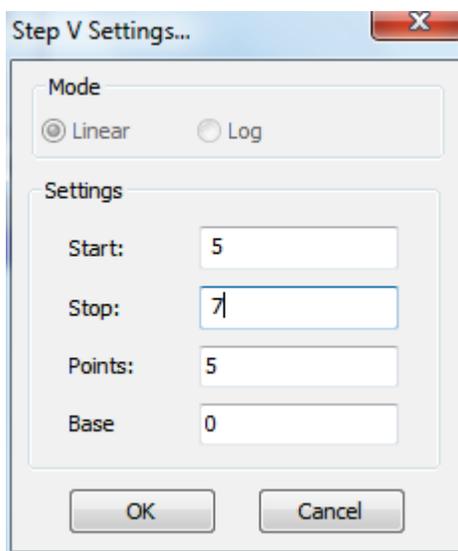
6. Set the Mode to **Linear**.
7. Set the Start value to **0**.
8. Set the Stop value to **10**.
9. Set the Step value to **0.1**.
10. Set the Base value to **0**.
11. Click **OK**.

**Figure 40: Modified Sweep V Settings**



12. For SMU1 (gate), double-click the **Source Settings** cell to open the Step V Settings dialog box.
13. Set the Start value to **5**.
14. Set the Stop value to **7**.
15. Set the Points value to **5**.
16. Set the Base value to **0**.
17. Click **OK**.

**Figure 41: Modified Step V Settings**



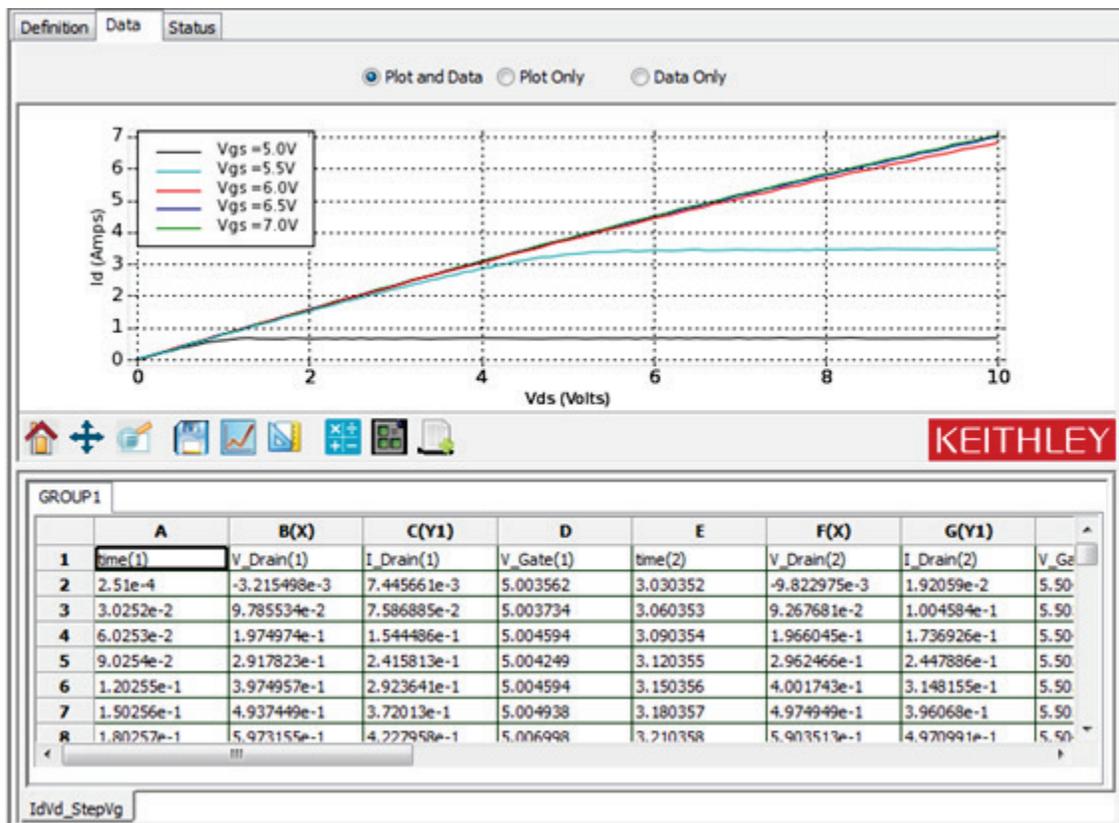
## Run the test

The Data tab contains the data from the last time the test was run. Because this test is new, it contains sample data. When the test is run, the new data overwrites the sample data.

### To run the test:

1. Select the Data tab of the Test dialog box.
2. Click **Run** (▶) to start the test. Once data collection is complete, the test will stop.
3. At the top of the Data tab, select **Plot Only** to get a better view of the plot.
4. Select **Data Only** to get a better view of the data in the spreadsheet.
5. Select **Plot and Data** to return to the dual view.
6. As the test runs and ACS Basic collects data, the curves are displayed on the graph.

Figure 42: Test result curves and data



You can also run the test without overwriting the existing data. This is useful for comparing data between two devices or doing a before and after comparison after making some changes to the test settings or device connections.

**To run the test and append data:**

1. Click **Append Run** to start the test.

**Figure 43: Append Run icon**



After the test runs, you should see the appended data graphed on the plot next to the original data and an additional tab on the datasheet that holds the new data. Because we have not made any changes, the curves of the appended data should align with the original curves. If the curves align, this is a good indicator that you are making settled measurements. If they do not align, there could be a problem with your test configuration.

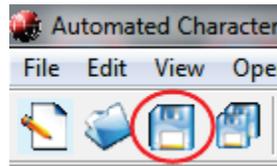
## Save project and data

When you save the project with the Save All icon, all your test settings and collected data are saved with it so the next time you load ACS-Basic and open the test your settings and data will still be there. You can also save the data to a Microsoft Excel spreadsheet or to a .csv file for analysis in another application.

**To save a project:**

1. Click the Save icon in the top toolbar.

**Figure 44: Saving project**



**To save test data:**

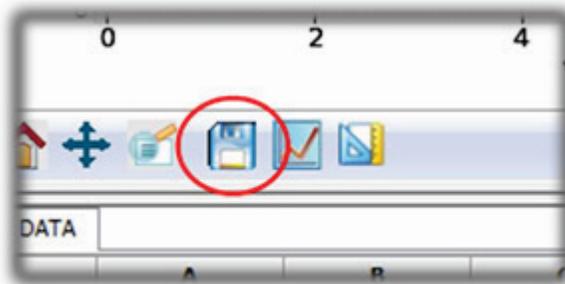
1. Above the plot window in the test results window are radio buttons to change the data view. For this example, select Plot and Data.

**Figure 45: Data view options in test results window**



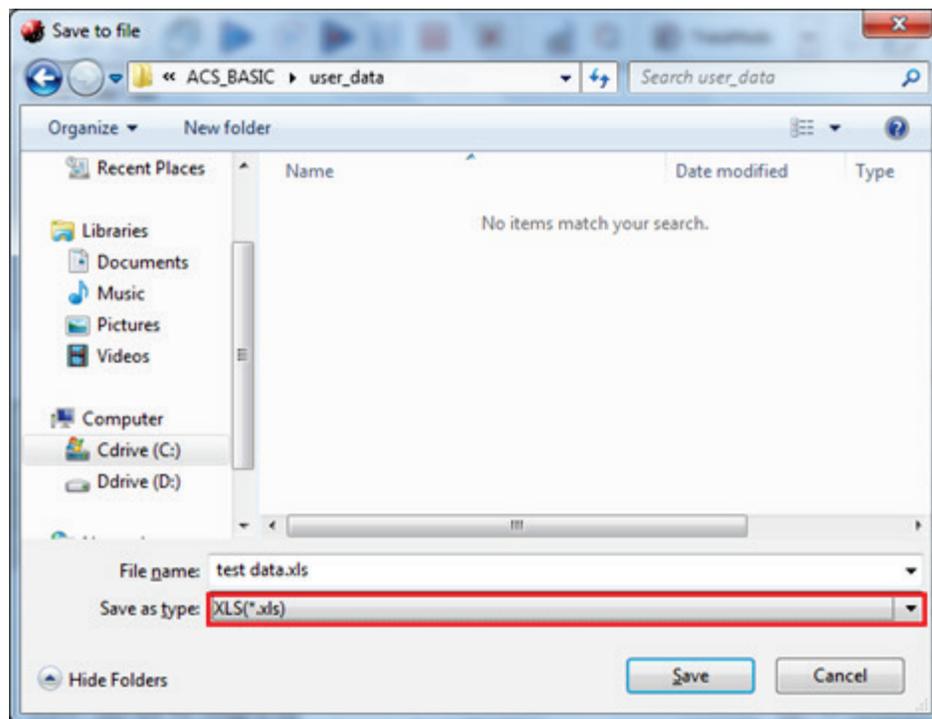
2. Click the Save icon at the bottom of the plot.

**Figure 46: Saving test data**



3. The Save to File dialog window gives you many file format options for saving the test data. The default is .xls.

**Figure 47: Save to File dialog window**



## NOTE

In addition to .xls, you can also save in .csv, .png, .ps, .eps., and .svg formats. Select the "Save as type" drop-down above before you click the Save button to change file formats.

## Digitizing pulses and improving timing

### Introduction

---

For many devices, you must adjust the measurement timing to produce good test results.

In particular, you may need to increase the pulse width to give the test signal more time to settle before making the measurement. Often test engineers will use an oscilloscope to see what the pulse looks like and determine the proper pulse width and measurement time from this information. The Series 2650A SMUs feature a built-in 18-bit fast analog-to-digital (ADC) converter that can digitize the pulse without the need of the scope. This application demonstrates how to use the fast ADC to digitize the output of the SMU to examine the shape of the pulse.

To introduce you to digitizing pulses, this application shows you how to do the following tasks:

- Adjust timing settings
- Digitize the pulse from a data point in the test
- Plot digitized data
- Read the digitized pulse to configure the correct timing settings

To do the test, you will do the following steps:

1. Load the IdVdStepVg test that was created in [Multi-test mode](#) (see "[Collecting I-V curves in trace mode](#)" on page 4-4).
2. Configure the test to digitize a pulse.
3. Configure the plot to display the digitized data.
4. Adjust the timing settings and then use the digitizer to review the changes.

### Configure the test fixture

---

The connections to the test fixture for this test using the Model 8010 and Model 8020 test fixtures are the same as for the Collecting IV Curves in Trace Mode and IV Curves in Multi-test mode. Parametric Mode. Please see the [Configure the test fixture](#) (on page 4-2) topic.



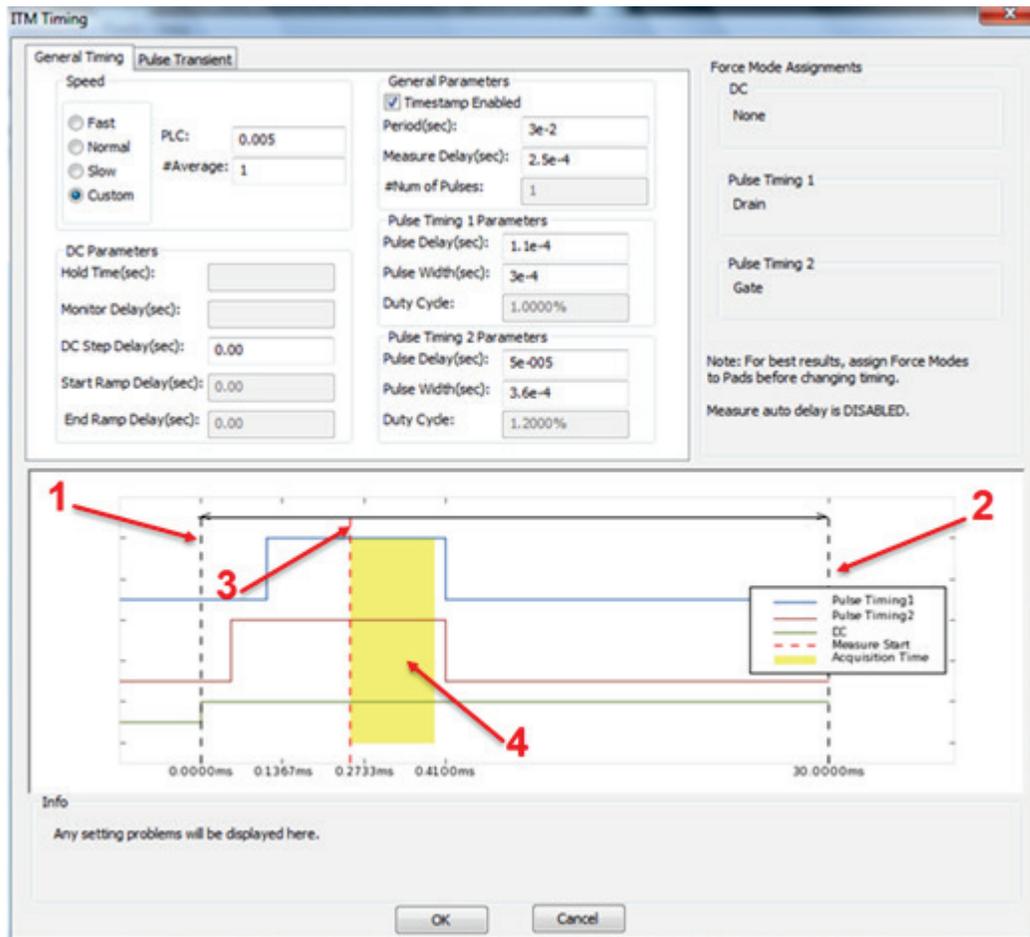
**Configure the General Timing tab settings**

The ITM Timing window (General Timing tab) is where you configure SMU output timing and measurements. The following table describes each of the setting categories.

**ITM Timing window, General Timing tab setting categories**

Category	Function
Speed	Settings for adjusting the measurement aperture of the integrating ADC and configuring any averaging
DC Parameters	Timing settings for outputting DC signals. Most of these settings can only be changed if the test is running under DC Only Mode, which is set in the Test Definition window
General Parameters	Settings for the period between data points and for when the measurement will be taken relative to the start of the period.
Pulse Timing 1 / 2 Parameters	For configuring the Pulse Width of any pulse signals as well as specifying when the pulse will be output relative to the start of the period
Force Mode Assignments	Displays which SMUs have been assigned to each of the three timing configurations

**Figure 49: ITM Timing window**



In the above graphic, the output preview at the bottom of the application window is based upon the settings for the DC, Pulse Timing 1, and Pulse Timing 2 categories.

**Preview output definitions**

- 1 Start of a period
- 2 End of a period
- 3 Measurement trigger time
- 4 Measurement aperture (area)

To ensure good pulsed measurements, this aperture must be contained entirely within the width of the pulse. It should also be placed far enough from the leading edge of the pulse to ensure that the signal has settled before the measurement is started.

To capture digitized pulse waveforms, make sure to capture the timing data by selecting the Timestamp Enabled checkbox in the ITM Timing window.

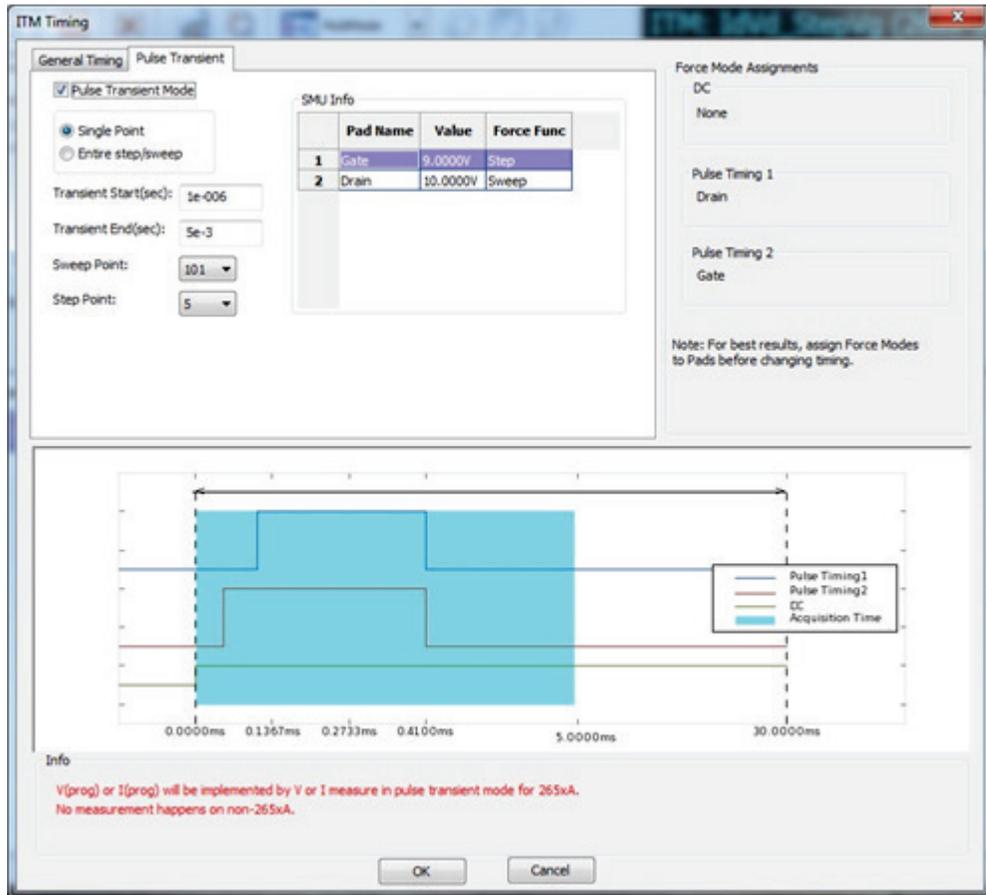
You will also enable and configure Pulse Transient Mode. See the next topic in this section for details.

### Configure the Pulse Transient tab settings

NOTE

The Pulse Transient tab of the ITM Timing window is where you enable and configure the digitizer of the 2650A Series SMUs. The following table describes each of the settings.

**Figure 50: ITM Timing window, Pulse Transient tab**



**ITM Timing window, Pulse Transient tab setting categories**

Setting	tion
Pulse Transient Mode	Used to digitize a single point of the step/sweep sequence. Checking the Pulse Transient Mode box enables the mode and the controls to configure the mode
Single point / Entire step/sweep	Controls whether ACS Basic will go directly to the selected step/sweep point and digitize it or if it will run through the entire step/sweep sequence to digitize the selected point. To get to results quickly, use the Single Point option. However, you might find that the data you get when going directly to the point differs from the data you get when you run the entire sweep. This is most commonly due to device self-heating. To see results that most closely match the output when the full test is ran, select Entire step/sweep
Transient Start / Transient End	Sets the start and end times of the digitizing window and are relative to the start of the period. This window is represented in the above graphic by the blue shaded area.
Sweep Point / Step Point	Selects which points in the step/sweep sequence you want to digitize
SMU Info	Displays the programed levels for the SMUs at that step and sweep point. By default, the last point of the step/sweep sequence is selected, which corresponds to the point where there is 7 V on the Gate and 10 V on the Drain.
Force Mode Assignments	Displays which SMUs have been assigned to each of the three timing configurations

1. Select Step and Sweep points that correspond to a Gate voltage of 6.5 V and a Drain voltage of 5 V.
2. Select the "Pulse Transient Mode" checkbox to enable pulse transient mode.
3. Set Transient Start to 0.
4. Set Transient End to 1e-3.
5. Set the Sweep Point to 51.
6. Set the Step Point to 4.
7. Click the OK button to accept your changes.
8. Switch to the Data tab.
9. Click the run icon to start the test.
10. Your results (shown on the Data tab) will resemble the following graphic.

**Figure 51: ITM Timing test results**



By default, the graph for the IdVd\_StepVg test is configured to show current versus voltage. To get a scope-like view we need to plot the signals versus time. Since the default plot is already setup for displaying the IV curves of the device, it is preferable to not make any changes to its settings when trying to view the digitized data. Instead, create a new plot to graph the data.

**Create a new plot**

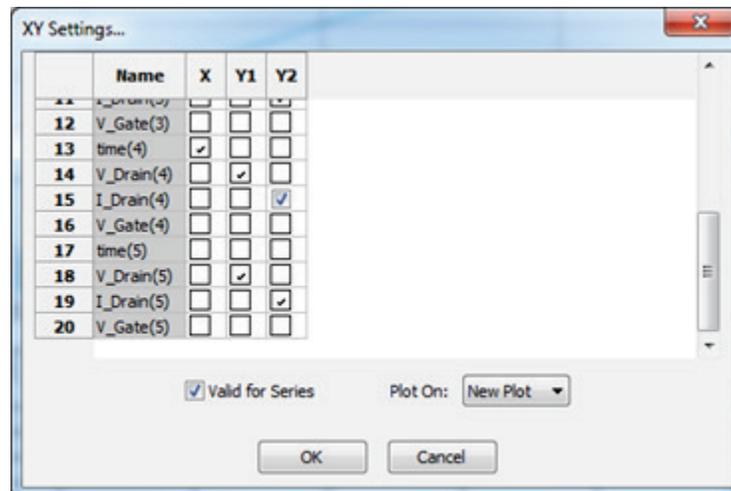
1. Click the plot icon, then select New Plot.

**Figure 52: New Plot**



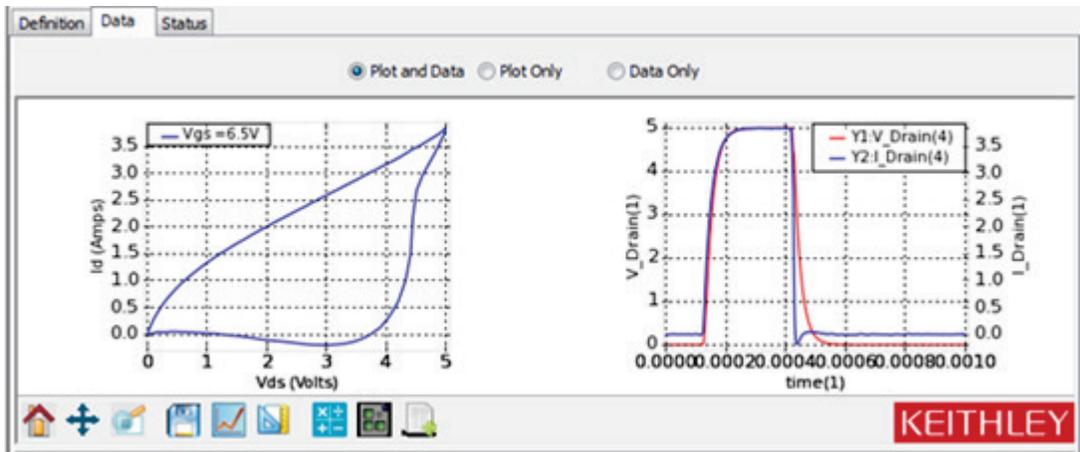
2. In the XY Settings window, scroll down to time(4)
3. Select time(4) under X
4. Select V\_Drain(4) for Y1
5. Select I\_Drain(4) for Y2

**Figure 53: XY Settings window**



The digitized data now appears on a second plot to the right of the original. The voltage waveform is shown on the plot in red while the current waveform is shown on the plot in blue.

**Figure 54: New digitized data**

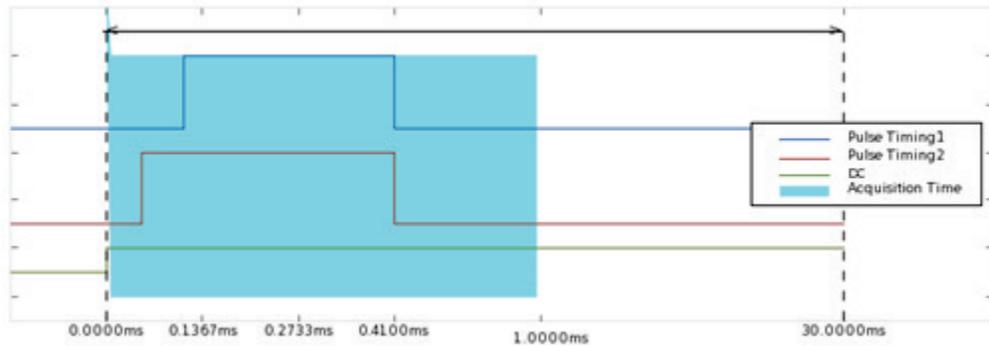


**Adjust the pulse timing settings**

Now that we are able to see the waveform in the plot, we will observe what happens when we change some of the timing settings.

1. Click the Definition tab.
2. Click the Timing button.

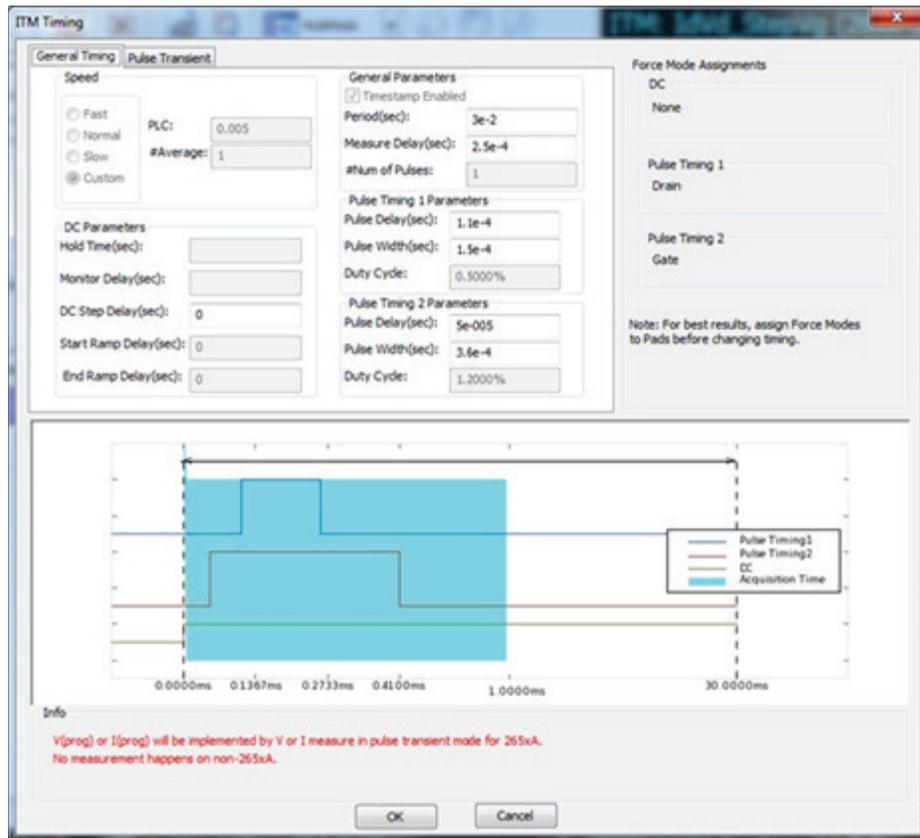
**Figure 55: Timing example waveform**



In this test, the Drain is configured to use Pulse Timing 1 while the Gate is configured to use Pulse Timing 2. The default settings have the rising edge of the Gate signal (Pulse Timing 2) 60  $\mu$ s before the rising edge of the Drain signal and the falling edge of both signals occurring at the same time.

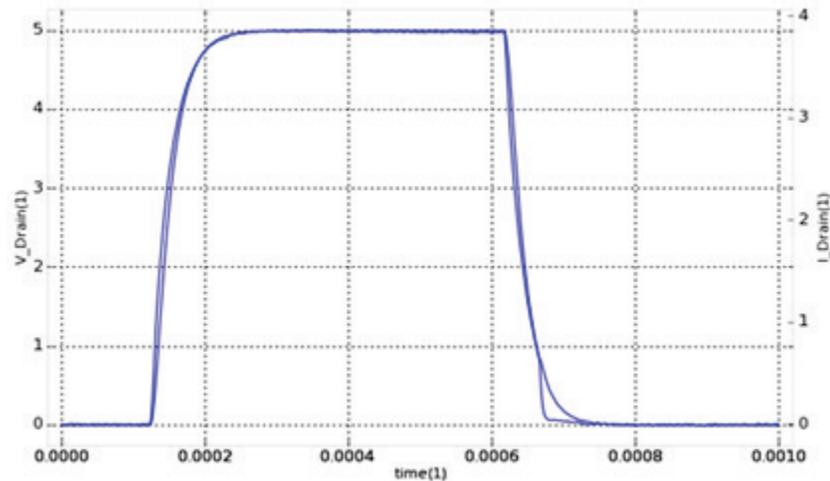
3. Change the Pulse Width of Pulse Timing 1 to 5e-4 (500  $\mu$ s).

**Figure 56: Pulse Width of Pulse timing changed**



4. Change the Pulse Width of Pulse Timing 2 to  $6e-4$  (600 us).
5. Set the measure delay to  $4e-4$  (400 us).
6. Set the period to  $5e-3$  (50 ms).
7. Click the OK button to accept your changes.
8. Select the Data tab of the Test dialog box.
9. Click **Run** (▶) to start the test.

**Figure 57: Graphed results**



After you run the test, you should see a graph similar the one above. These results show that the signal settles quickly, so DC measurements with these timing parameters should produce repeatable measurements.

## Off-state characteristics

### Configure the test fixture

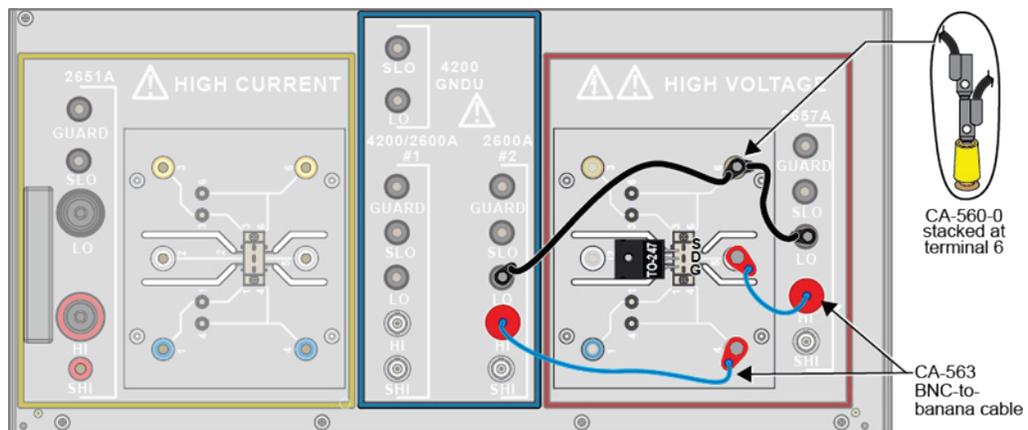
#### NOTE

The PCT supports either the Keithley Instruments Model 8010 or Model 8010 test fixtures. Follow one of the below procedures depending on your test fixture.

#### To configure the Model 8010 test fixture:

1. On the High Voltage side of the Model 8010 test fixture, insert the test sample device into the test socket. Place the device with the Gate pin closest to the front of the test fixture.
2. Wire the test fixture as shown in the diagram below:
  - Connect the 2657A HI signal to the Drain terminal.
  - Connect the 4200/2600 #2 signal to the Gate terminal.
  - Connect the LO terminals of the 2657A and the 4200/2600 #2 signal to the Source terminal.

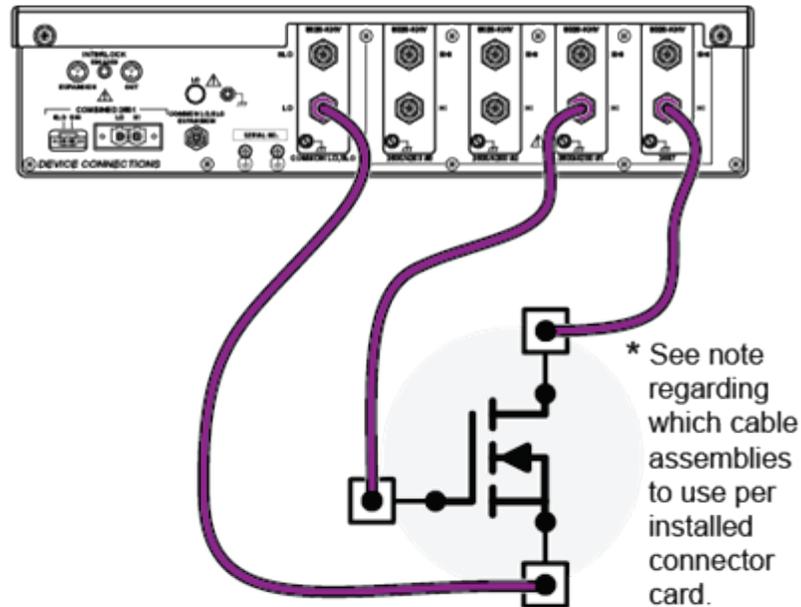
**Figure 58: Leakage current measurement test fixture configuration**



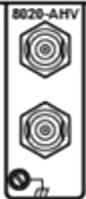
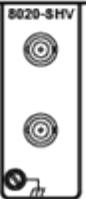
**To configure the Model 8020 interface panel:**

1. Wire the test fixture as shown in the diagram below:
  - Connect the LO signal to the Source terminal of the device.
  - Connect the 2657 HI signal to the Drain terminal of the device.
  - Connect the 2600/4200 #1 HI signal to the Gate terminal of the device.

**Figure 59: Configuring the 8020 interface panel for leakage current measurement**



\* Cable assemblies will depend upon the connector card the user installs

			
<p><u>Connector Card:</u> 8020-AHV</p> <p><u>Cable Assembly:</u> User supplied</p>	<p><u>Connector Card:</u> 8020-KHV</p> <p><u>Cable Assembly:</u> Model HV-CA-554</p>	<p><u>Connector Card:</u> 8020-SHV</p> <p><u>Cable Assembly:</u> User supplied</p>	<p><u>Connector Card:</u> 8020-STC</p> <p><u>Cable Assembly:</u> Model 7078-TRX or Model 4200-TRX</p>

## Measuring leakage current in multi-test mode

### Introduction

Characterizing a semiconductor device in its off-state includes leakage current measurements and requires sourcing a voltage and measuring a small current. This measurement requires very sensitive equipment with proper guarding and shielding to make an accurate measurement. The Parametric Curve Tracer handles each of these requirements so that the user can get results quickly and easily.

To introduce you to measuring leakage current, this application shows you how to use Multi-test mode to perform an  $I_{dss}$  test on a high voltage MOSFET using the sample part provided in the PCT-DOC-KIT (Fairchild part # FQH8N1100C). Download a datasheet for this part from [www.fairchildsemi.com](http://www.fairchildsemi.com) (<http://www.fairchildsemi.com>) to compare data taken with the device specs.

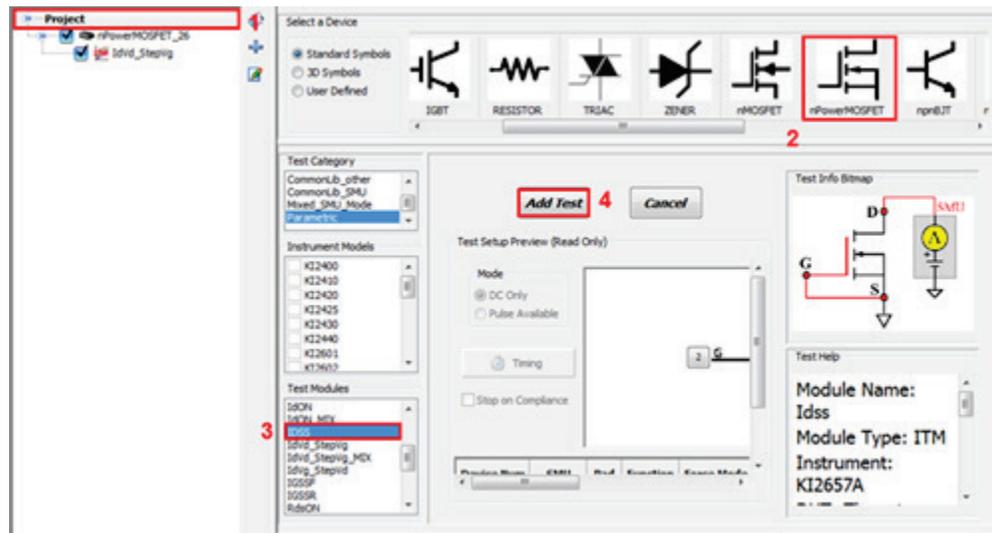
To do the test, you will do the following steps:

1. Configure the connections to the device
2. Add the  $I_{dss}$  test to the project
3. Configure the test settings to suit the DUT
4. Run the test and obtain the leakage current from the device

### Add and configure the $I_{dss}$ test

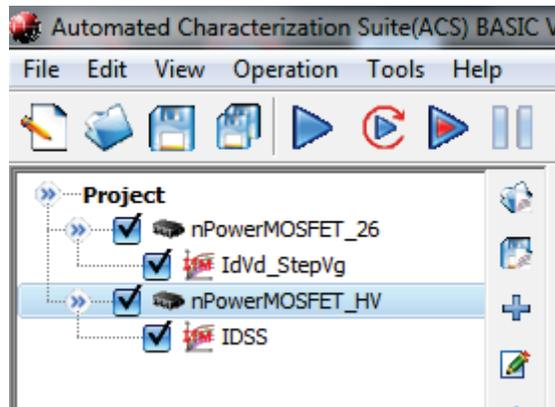
1. Click on Project in the Project Navigation Tree to display the Test Libraries window.

Figure 60: Test Libraries window



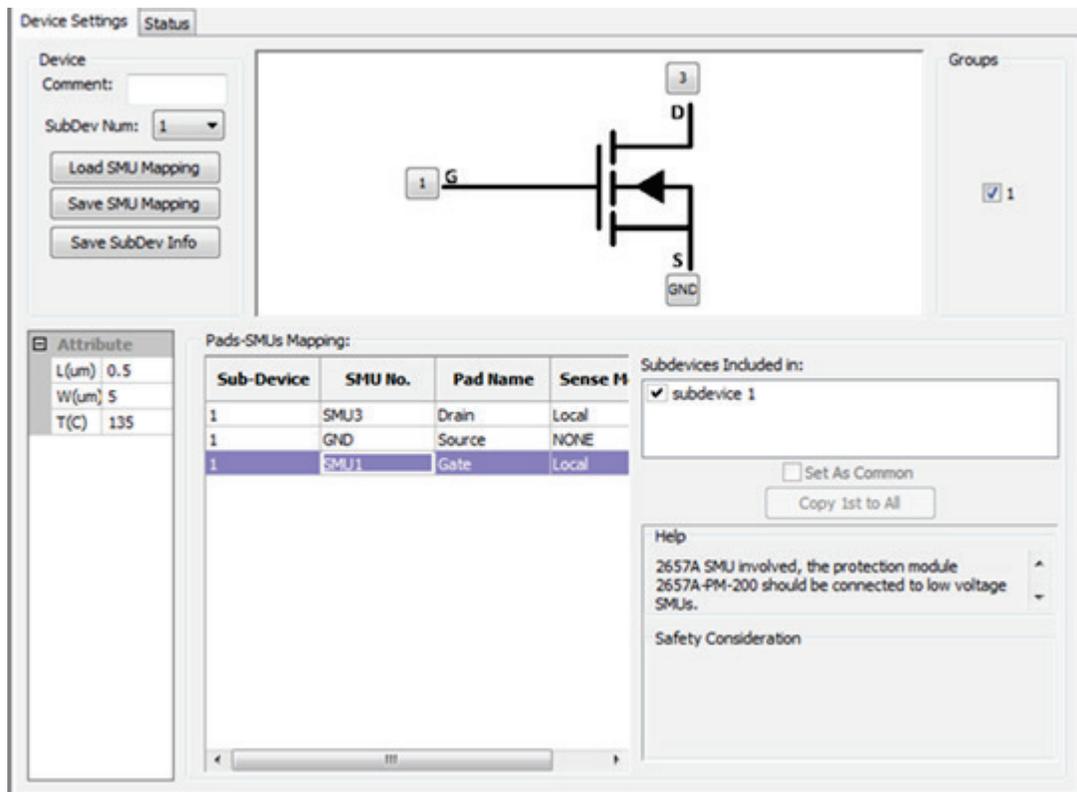
2. Select the nPowerMOSFET device from the Select a Device pane at the top of the window.
3. Select the IDSS test from the Test Modules pane at the bottom left of the window.
4. Click the Add Test button to add the test to your project.
5. Select New device, then click the OK button.
6. You will now see a device nPowerMOSFET\_26\_1 in your project tree. Right-click on the device and select Rename.
7. Change the name to nPowerMOSFET\_HV.
8. Press <Enter> to save the change.

**Figure 61: New device in project navigation tree**



9. Select the nPowerMOSFET\_HV device.
10. Use Pads-SMUs mapping, then follow one of the next steps, depending on your test fixture.
  - For the Model 8010, attach SMU 3 (2657A) to the Drain and the SMU2 (2636B SMU B) to the Gate
  - For the Model 8020, configure the SMU3 (2657A) to the Drain and SMU1 (2636B SMU A) to the Gate
11. Set the Sense Mode for both SMUs to Local.
12. Configure the Source terminal to GND.

**Figure 62: Device Settings window (Model 8020 connections)**



13. Select the Idss test under the IGBT\_26 device in the Project Navigation Tree.
14. Click the Definition tab.
15. Set the Source value to 1000 V.

**Figure 63: Setting Source value to 1000 V**

Device Num	SMU	Pad	Function	Force Mode	Source	Measure	Compliance	Meas.Range	Advanced
1	SMU3	Drain	Bias V	DC	1000.0	I+V	0.001	auto	...
	SMU1	Gate	GND						

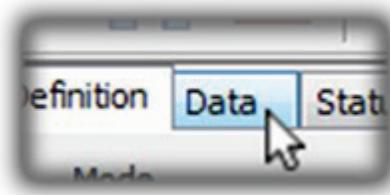
16. For the gate SMU (SMU 1 or SMU 2), set the source function to GND.
17. Set the compliance (current limit) of both SMUs to 1 mA.
18. Select measurement of current and voltage for SMU 3 (2657).

 **Quick Tip**

If you want to profile the leakage current of the device as a function of voltage, set the source function to sweep V. Configure the sweep settings in the Source field.

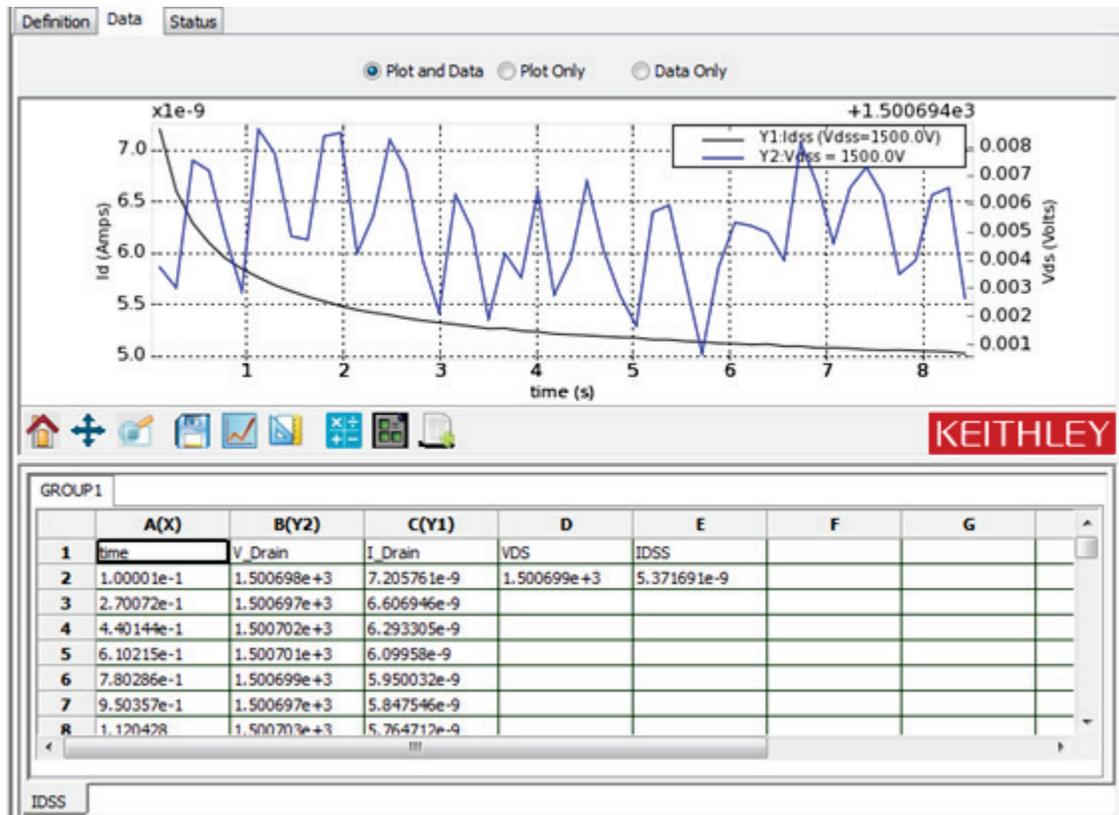
19. Select the Data tab.

**Figure 64: Data tab**



20. Sample data for the DSS test is displayed.

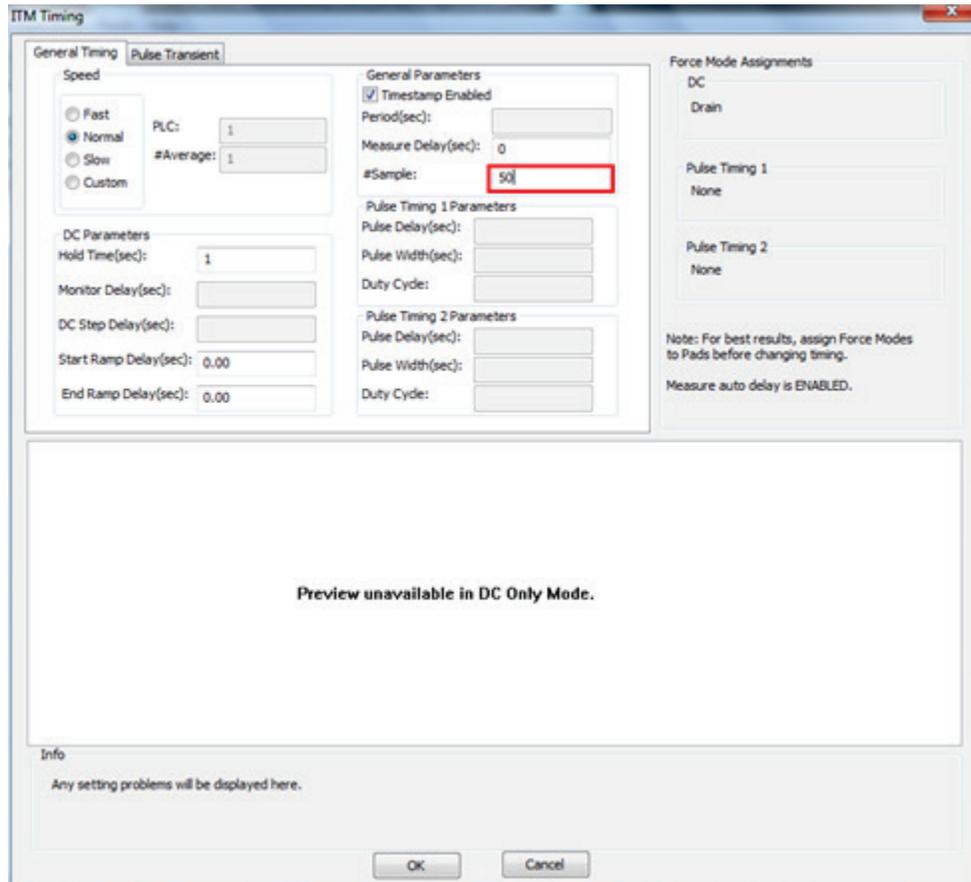
**Figure 65: Data tab with sample DSS test data**



The current through the device and the voltage across the device are plotted versus time on the graph. This test works by sourcing the test voltage and taking many readings. The readings are then averaged to give you a final value.

You can adjust the number of samples taken and averaged in the Timing window of the test. Under General Parameters, enter the desired number of readings for "# Sample." See the below graphic.

**Figure 66: Sample quantity adjustment**

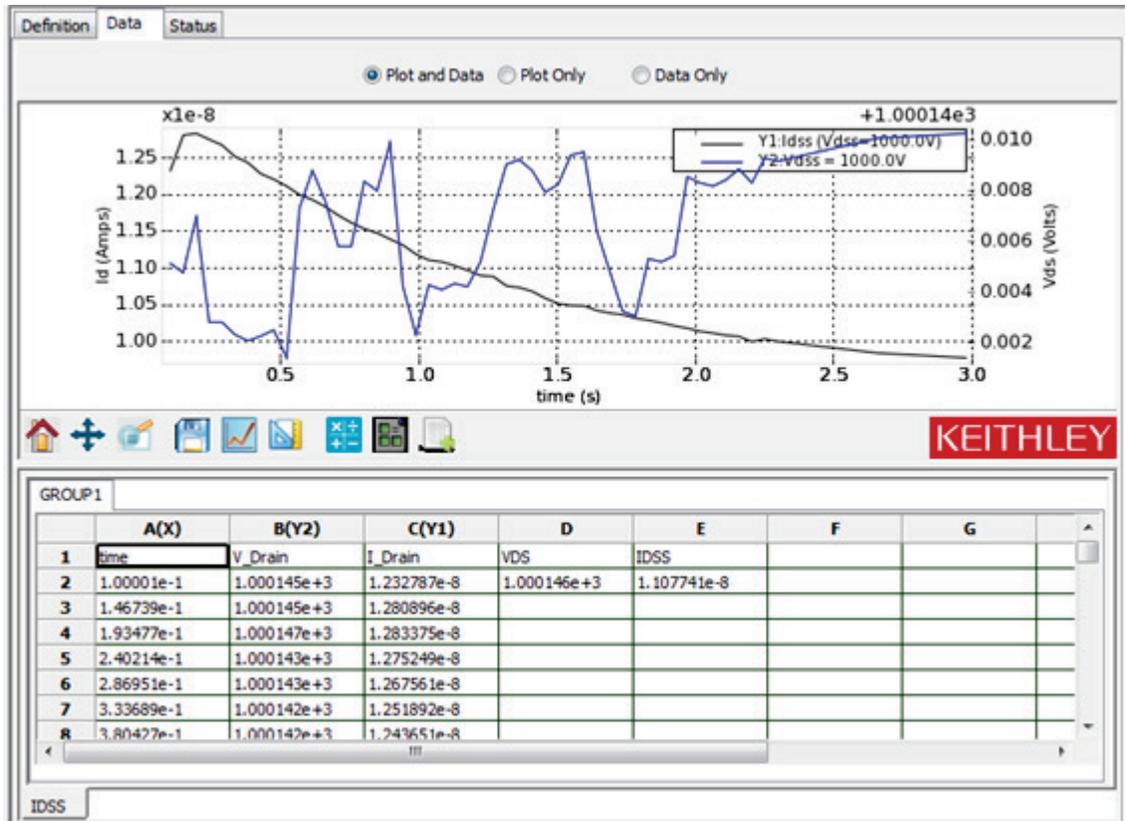


You can also configure the test to stop if the compliance (current limit) is reached. Check the "stop on compliance" checkbox to have the test automatically stop if any SMU reaches current limit.

### Run the test

1. Click the Run icon to start the test.

Figure 67: Data and results of IDSS test

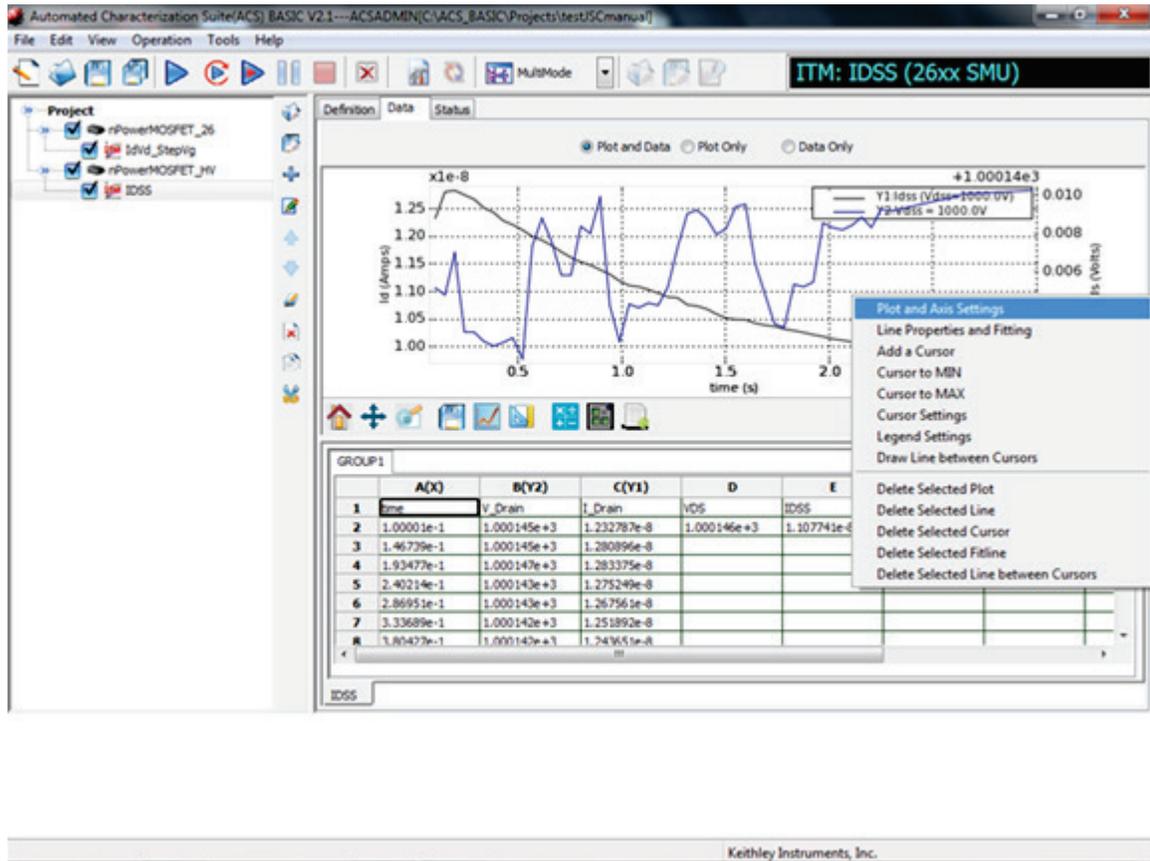


The data you collect should look similar to the data seen here. While the voltage data may appear noisy at first, take note of the scale of the plot. You can simplify the plot by adjusting the scale for the voltage readings in the Data tab.

**To simplify the plot:**

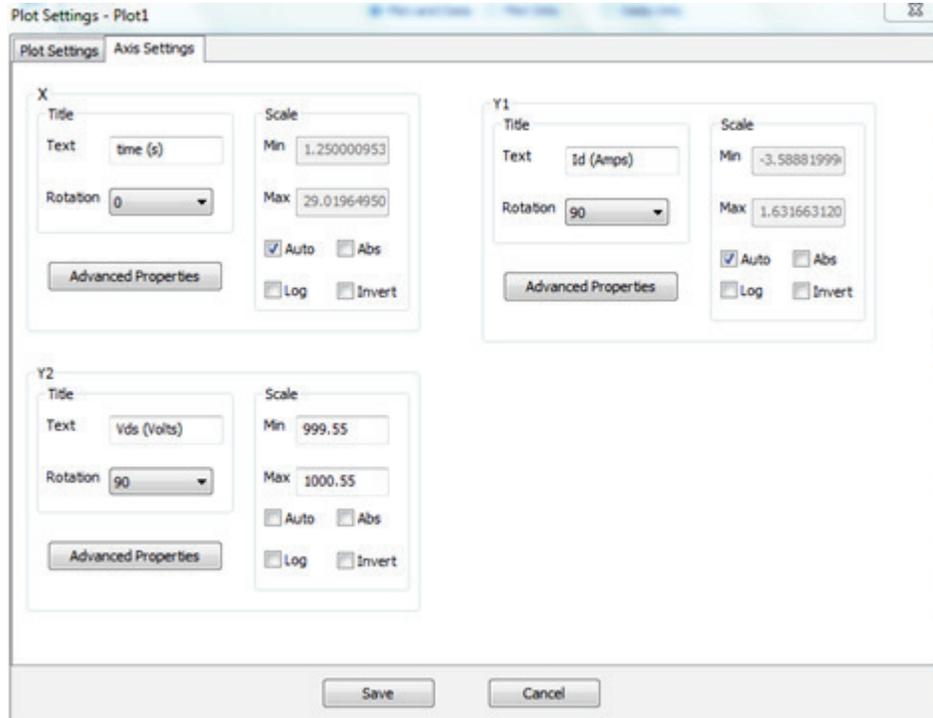
1. Right-click the graph and select Plot and Axis settings.

**Figure 68: Plot and Axis settings**



2. Select the Axis Settings tab.
3. For Y2, un-select the "auto" checkbox and set the min and max values to 999.55 and 1000.55 respectively.

**Figure 69: Plot and Axis settings window**

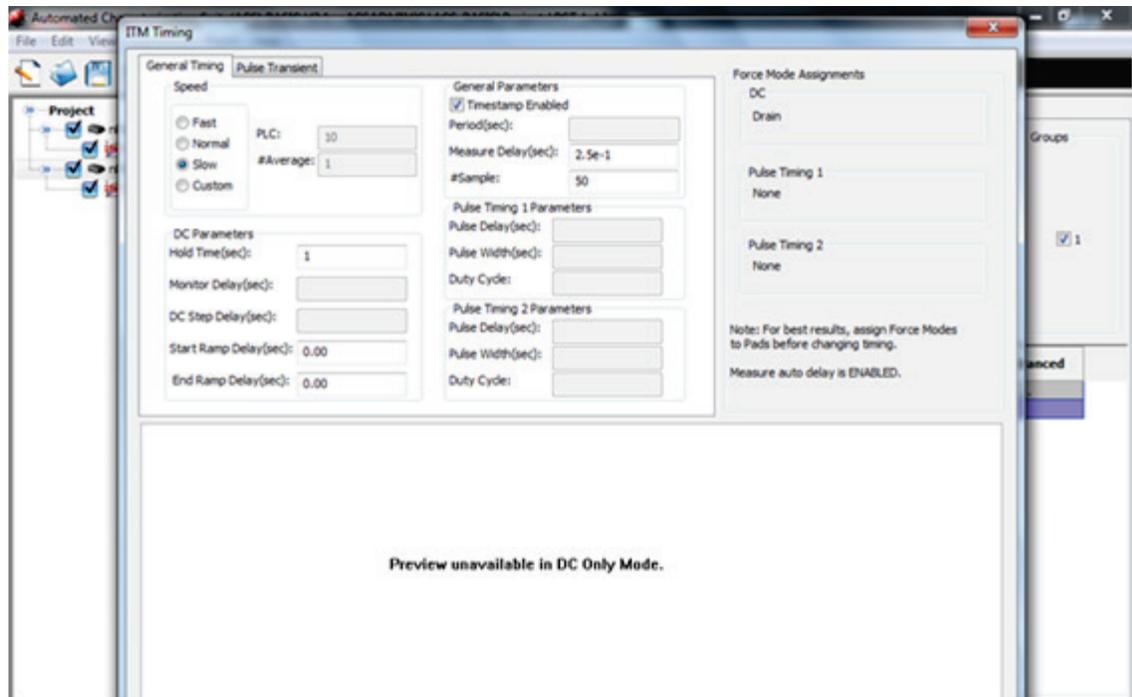


4. Click the Save button.

You can improve the stability of the current measurements by adjusting the timing. Accurate low current measurements typically involve significant settling time and longer integration times.

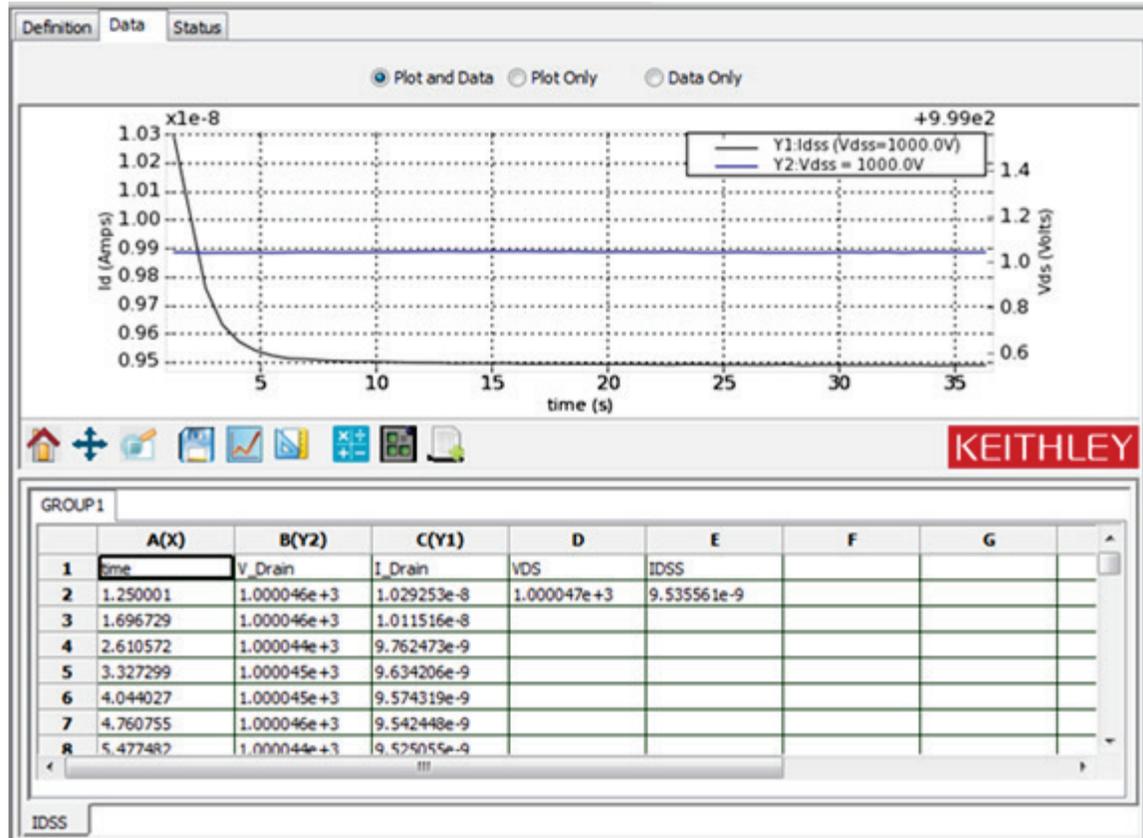
**To refine the  $I_{dss}$  results:**

1. Open the ITM Timing window by selecting the "Timing" button.
2. Set the Hold Time to 1 s.
3. Set the speed to Slow.
4. By default, auto delay is enabled, but you can add delay time. Set the Measure Delay to 0.25 s, which will set the SMU to delay 250 ms beyond the auto delay time for increased settling. See the below graphic for an example.

**Figure 70: ITM Timing window with settings**

5. Click OK to apply the settings.
6. Click the Run button
7. Note the improved Idss results. Your refined results should be similar to those in the below graphic.

**Figure 71: Refined Idss results**



The datasheet for the sample device specifies a 10  $\mu$ A maximum value for Idss. The measured leakage current should be much smaller than the specification. Such specifications are typically created using traditional curve tracers, which have limited current measurement resolution and are generally unable to measure currents less than 10  $\mu$ A. If the measured value exceeds the specification, then the device is likely damaged. Verify connections and then re-test.



## C-V applications on power MOSFETs

### In this section:

Overview and requirements .....	5-1
Background of MOSFET capacitance measurements .....	5-1
Safety precautions and discharge procedures .....	5-3
Model 8010 connections .....	5-9
Model 8020 connections .....	5-14
Perform connection compensations on C-V measurements ..	5-18
Make a Ciss measurement.....	5-40
Make a Coss measurement .....	5-47
Make a Crss measurement.....	5-59

### Overview and requirements

This section will cover circuit-level power MOSFET capacitance measurements on a device up to 3 kV using a Keithley Instruments Model 8020 with the optional 8020-CVU installed or the Model 8010 with the CVU-3K-KIT option and a 2600-PCT-3B with the PCT-CVU accessory unit.

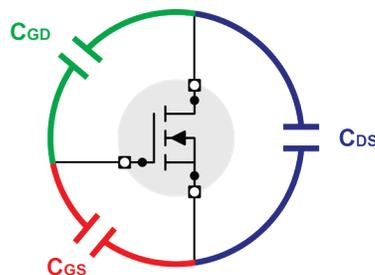
See the Model 8010 and Model 8020 User Guides, available on the Keithley Instruments website ([www.keithley.com](http://www.keithley.com) (<http://www.keithley.com>)) for connection information on 2 terminal devices and for component-level capacitance measurements of power MOSFETs.

### Background of MOSFET capacitance measurements

There are two different ways to look at the capacitance of three-terminal power semiconductor devices such as MOSFETs, BJTs, and IGBTs: at the component level and at the circuit level. Looking at the capacitances at the component level involves a characterization of capacitance between every device terminal. Looking at the capacitance at the circuit-level involves a characterization of the combination of component level capacitances.

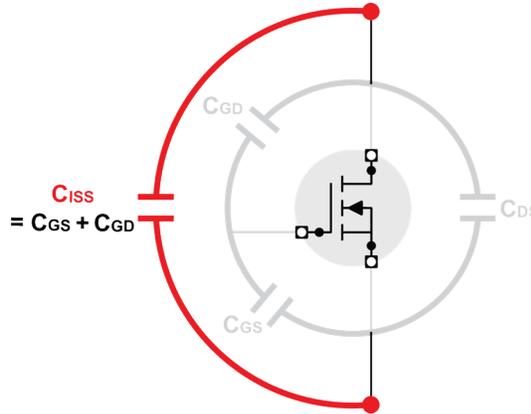
As an example, the below figure illustrates the component level capacitances of a power MOSFET.

**Figure 72: Component level capacitances for power MOSFET**

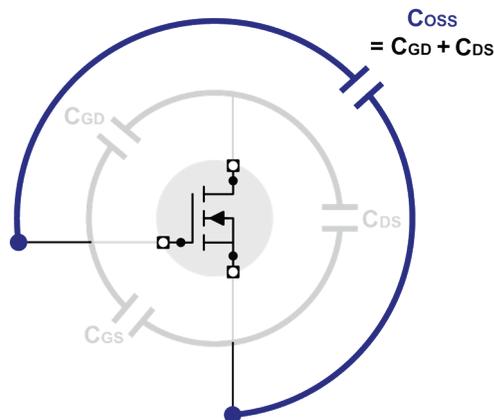


The next 3 figures illustrate the relationship between the component level and circuit-level capacitances for a power MOSFET. Similar capacitance measurements can also be made for BJT and IGBT devices.

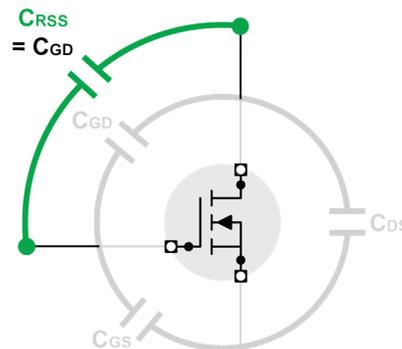
**Figure 73: Diagram of input capacitance for a power MOSFET**



**Figure 74: Diagram of output capacitance for a power MOSFET**



**Figure 75: Diagram of reverse transfer capacitance for a power MOSFET**



Device capacitance typically varies with applied voltage. Complete characterization of the DUT requires knowledge of the capacitance at the maximum rated voltage. The remainder of this section will review the safety precautions, connection diagrams between the instrumentation, the Model 8020, and the DUT for high voltage capacitance measurements.

## Safety precautions and discharge procedures

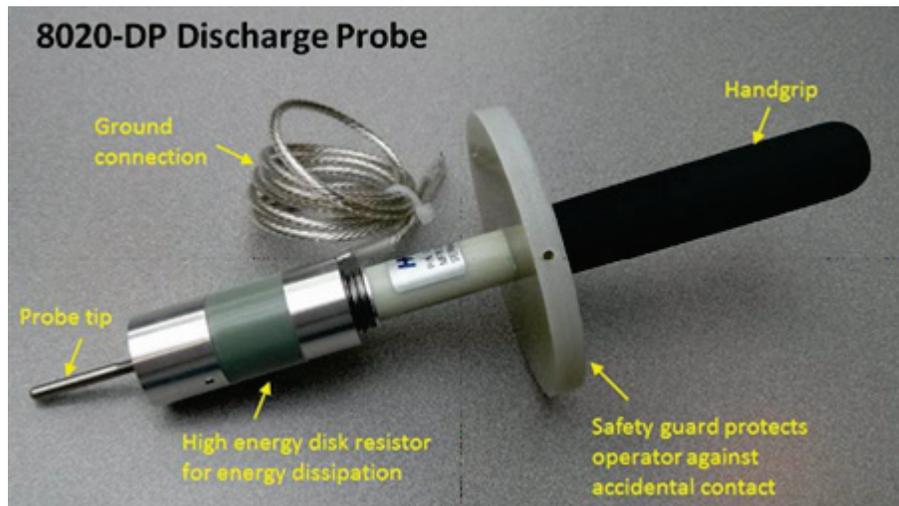
### Discharging bias tee capacitance within the Model 8010

The capacitance of the bias tees in the Model CVU-200-KIT and CVU-3K-KIT can hold charge. Devices with sufficient capacitance can also hold charge. A shock hazard exists if a proper discharge is not performed and you open the Model 8010 cover and touch one of the instrument or device terminals within the fixture. Never assume that the safety interlock discharges the system.

The Model 2657A SMU is programmed in ACS Basic to safely discharge the bias tee and device capacitance after completing a high voltage C-V test. However, an operator error, a power outage, or an unforeseen event can leave a dangerous charge in the system. Therefore, the Model CVU-3K-KIT includes the 8020-DP High Voltage Discharge Probe. Use this discharge probe to manually discharge the bias tee capacitance and system capacitance within the Model 8010 by touching the banana jacks and BNC connectors inside of the fixture.

See the below graphic for an overview of the Model 8020-DP High Voltage Discharge Probe.

**Figure 76: Model 8020-DP High Voltage Discharge Probe**



**Perform system capacitance discharge with the Model 8020-DP High Voltage Discharge Probe:**

1. Connect the Model 8020-DP High Voltage Discharge Probe ground connection cable to an unused protective earth screw on one of the bias tees.

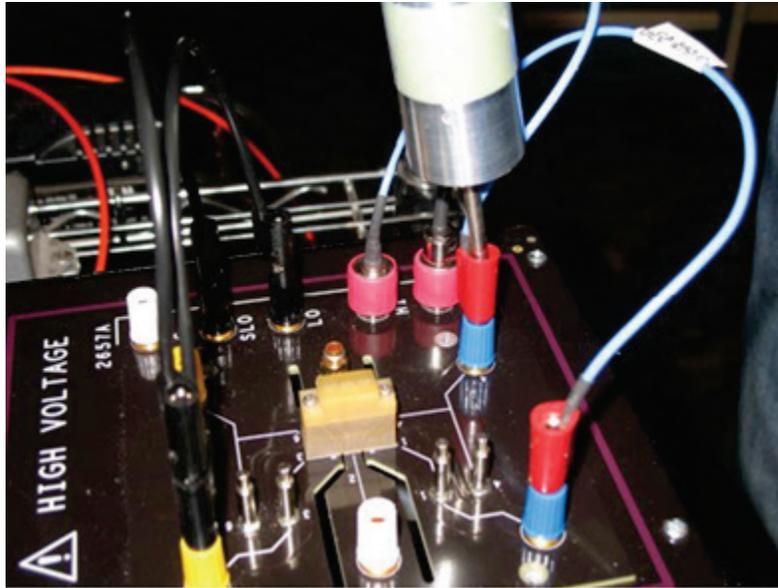
**Figure 77: 8020-DP connected to bias tee protective earth screw**

**⚠ CAUTION**

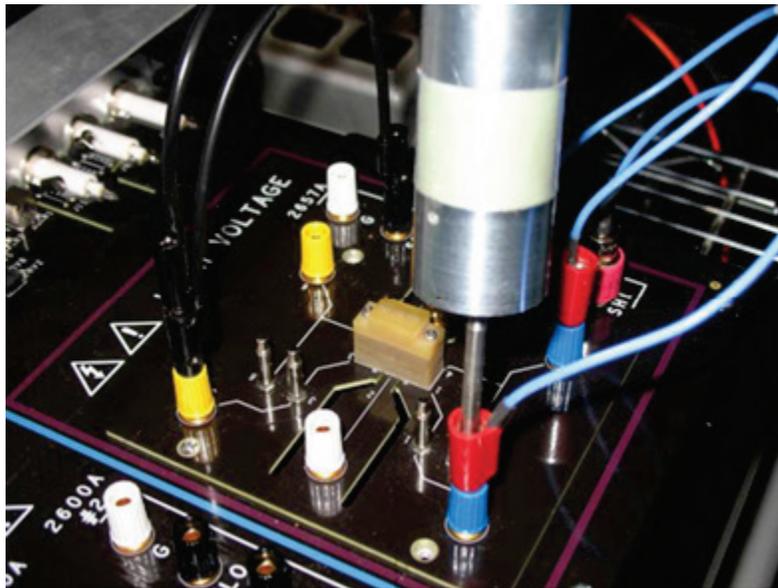
Do not stack cable connectors on the protective ground screw. Connect only to an unused screw.

2. Open the lid of the Model 8010 test fixture.
3. While holding the 8020-DP by the handgrip only, use the probe tip to contact the terminals on the device test board that connect the HI and SHI terminals of the 2657A (see the following 2 graphics).

**Figure 78: Contacting the HI terminal of the Model 8010 test board**

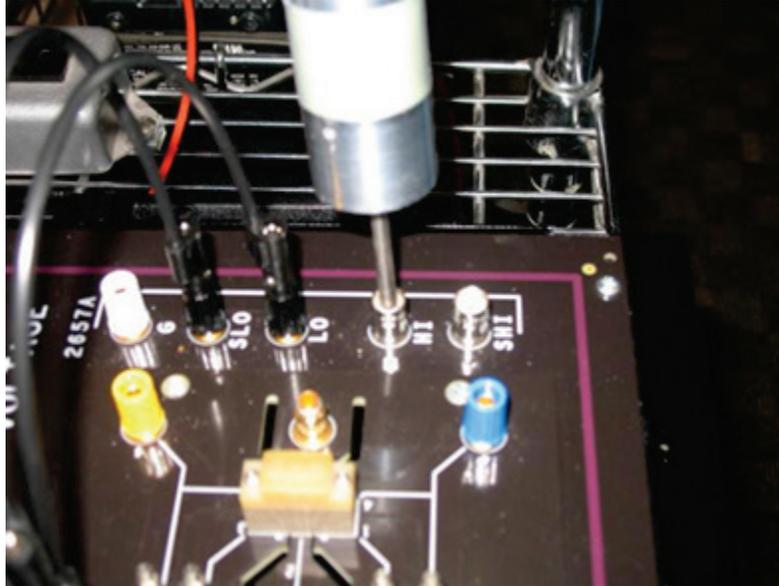


**Figure 79: Contacting the SHI terminal of the Model 8010 test board**



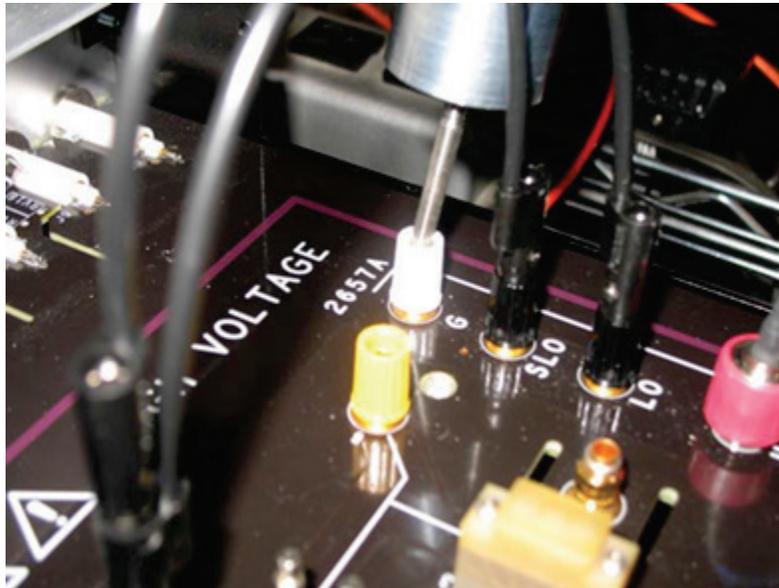
4. If there is no cable connected to the HI and SHI connections of the 2657A, use the discharge probe to contact the center conductors of the HI and SHI BNC connectors.

**Figure 80: Contacting the HI BNC connector of the Model 8010 test fixture**



5. Maintain contact for at least 1 second to safely discharge system capacitance.
6. Contact the GUARD banana jack of the Model 2657A.

**Figure 81: Contacting the GUARD banana connector of the Model 8010 test board**



7. Maintain contact for at least 1 second.
8. Repeat discharge procedure on the HI and SHI terminals of the Model 2600/4200 within the Model 8010 fixture.

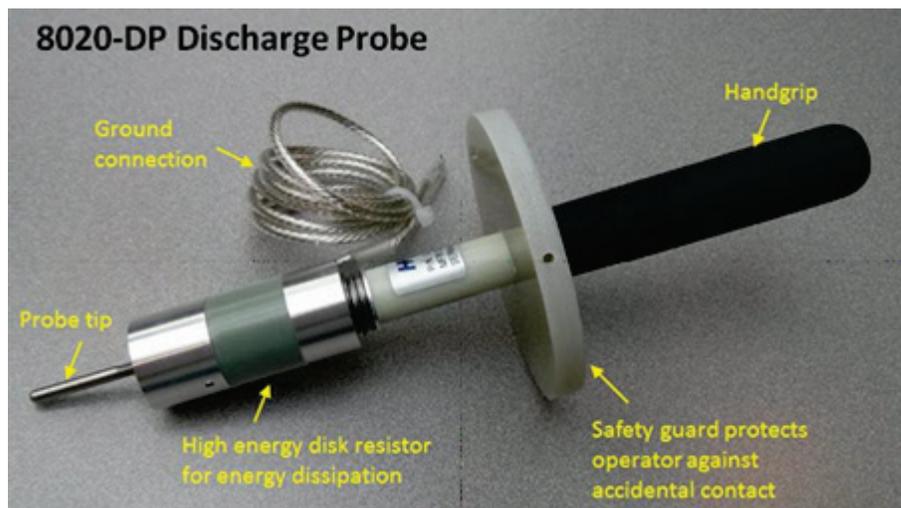
## Discharging bias tee capacitance within the Model 8020

The 8020-CVU option for the Model 8020 has internal capacitance that can hold charge. A shock hazard exists if a proper discharge is not performed and the user removes the 8020 top cover or in other ways accesses a live terminal in the system. Never assume the safety interlock discharges the system.

Be sure to use the SMU to discharge the capacitance properly after each test and before removing the top cover of the 8020 or accessing live terminals in the system. The Model 2657A SMU is programmed in ACS Basic to safely discharge the bias tee and device capacitance after completing a High Voltage CV test. A user error or another unforeseen event, such as a power outage, can leave a dangerous charge in the system, the Model 8020 with the 8020-CVU option includes a high voltage discharge probe, Model 8020-DP. Use this discharge probe to manually discharge the bias tee capacitance and system capacitance prior to making adjustments on the 8020 main board or at the device interface.

See the below graphic for an overview of the Model 8020-DP High Voltage Discharge Probe.

**Figure 82: Model 8020-DP High Voltage Discharge Probe**



**Perform system capacitance discharge with the Model 8020-DP High Voltage Discharge Probe:**

1. Connect the Model 8020-DP High Voltage Discharge Probe ground connection cable to an unused protective earth screw on the Model 8020 (see the below graphic).

**Figure 83: Protective earth (safety ground) screw locations on the Model 8020**

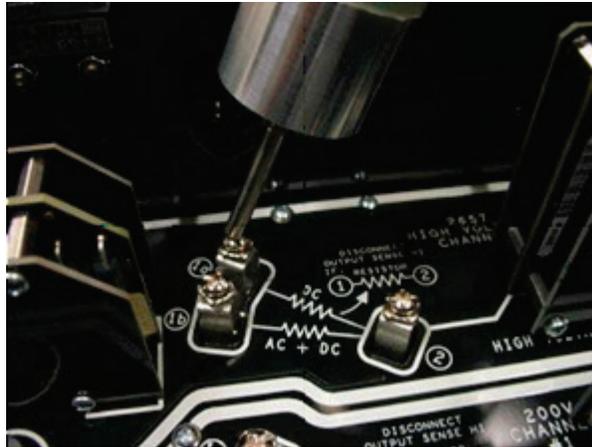


## ⚠ CAUTION

Do not stack cable connectors on the protective ground screw. Connect only to an unused screw.

2. Remove the top cover of the Model 8020 High Power Interface Panel.
3. While holding the 8020-DP by the handgrip only, use the probe tip to contact each of the posts at notes 1a, 1b, and 2 on the Model 8020 main board for the high voltage channel and each of the 200 V channels (see the following graphic).

**Figure 84: Contacting nodes on the Model 8020 main board**



4. Maintain contact for at least 1 second to safely discharge system capacitance.

## Discharge system capacitance from SMU front panel interface

If you are controlling the SMUs from the front panel interface, a best practice is to discharge system capacitance with the SMU output on. Configure the SMU to force 0 V and measure current with a current limit of at least 1 mA. A current measurement of approximately 0 mA indicates a proper discharge. The Keithley Instruments ACS Basic software executes this discharge procedure after completing a High Voltage CV test. ACS Basic will set the Model 2657A output to 0 V with a current limit of 1 mA and hold for 1 second prior to turning off the output. See the below graphic for an illustration.

**Figure 85: Model 2657A executing discharge**



## Model 8010 connections

Use the following graphics to connect your SMUs, PCT-CVU, and CVU-3K-KIT to the Model 8010. You will need to reference these drawings for both the connection compensation and capacitance measurement procedures.

### WARNING

*The ground wires must be attached to a known protective earth (safety ground) before turning on the instruments. Failure to attach the ground wires to a known protective earth (safety ground) may result in electric shock.*

### NOTE

The following graphics rely upon a SMU per bias tee. With the Model 2600-PCT-1B and 2600-PCT-2B, there are not enough appropriate SMUs to connect to bias tees. For these configurations, connect the force terminal of the GNDU of the PCT-CVU to the bias tee that connects to the Source terminal of the FET or the Emitter terminal of the BJT or IGBT.

## Connecting instruments to the Model 8010 for power MOSFET capacitance measurements

### Model 8010 Crss test connections

---

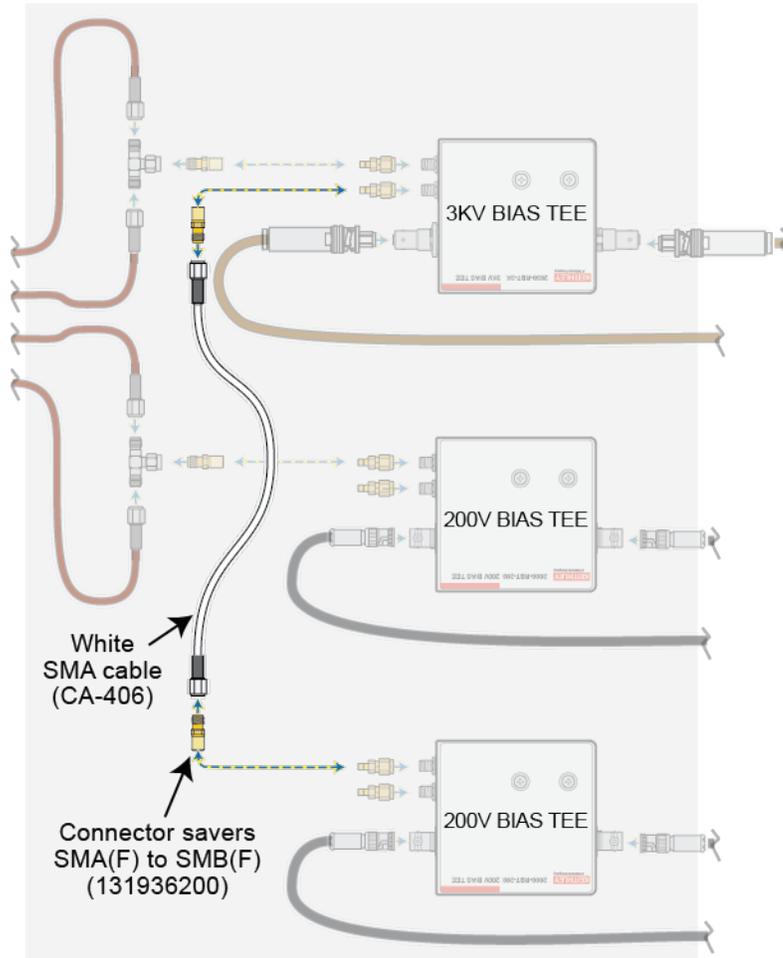
The next graphic shows the Model 8010 SMU, PCT-CVU, and CVU-3K-KIT connections for the Crss test.



### Model 8010 Ciss test connections

The next graphic shows the Model 8010 SMU, PCT-CVU, and CVU-3K-KIT connections for the Ciss test.

**Figure 87: Instrument connections to the Model 8010 for Ciss test**  
 CVU-3k-KIT 3-Terminal CISS measurement connections

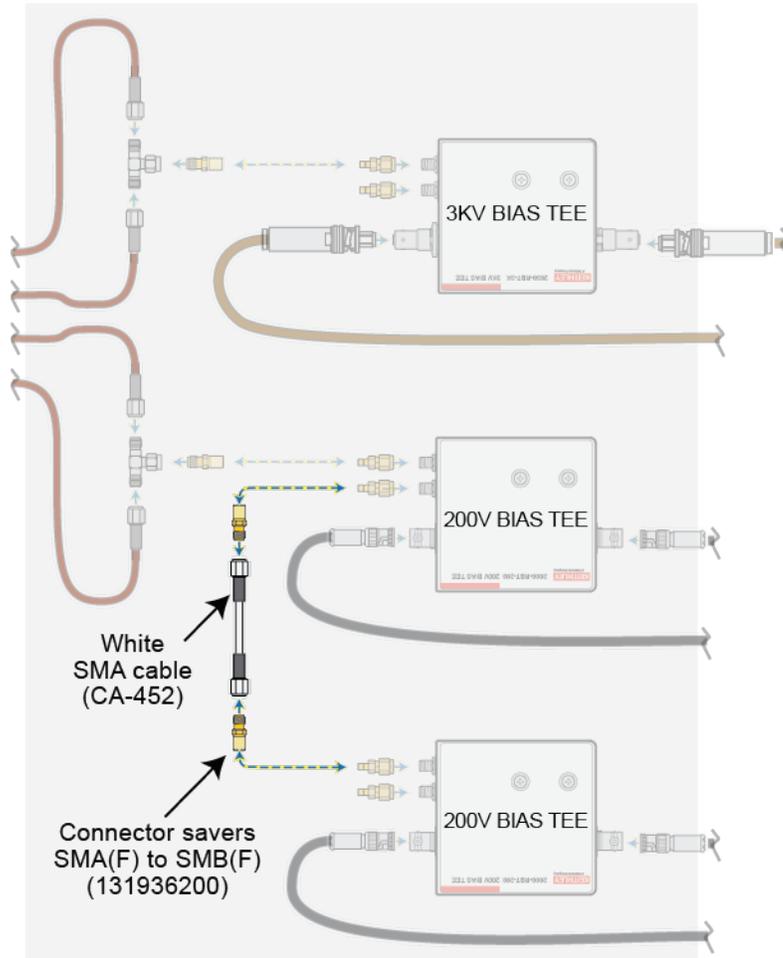


### Model 8010 Coss test connections

The next graphic shows the Model 8010 SMU, PCT-CVU, and CVU-3K-KIT connections for the Coss test.

**Figure 88: Instrument connections to the Model 8010 for the Coss test**

CVU-3k-KIT 3-Terminal COSS measurement connections

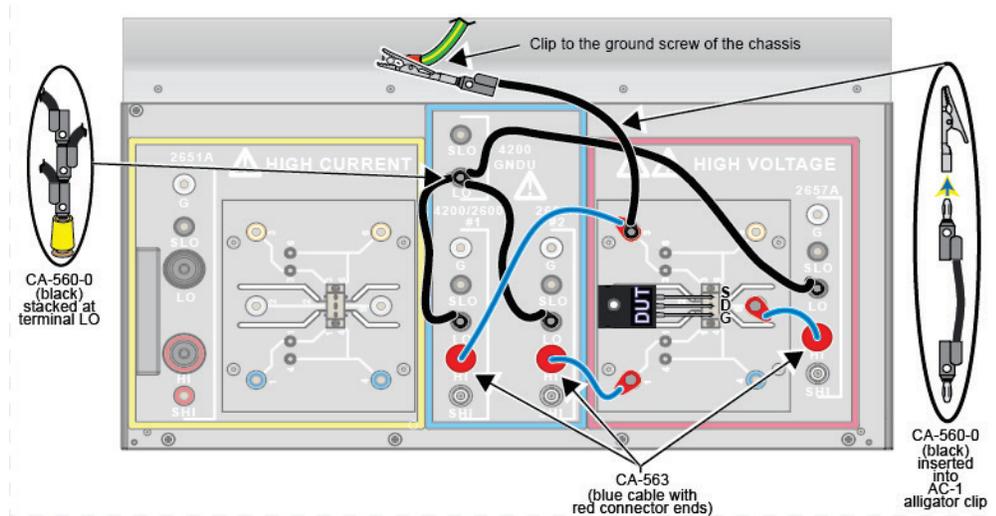


## Connecting the Model 8010 to the device for power MOSFET capacitance measurements

### Model 8010 connections to the device for Crss

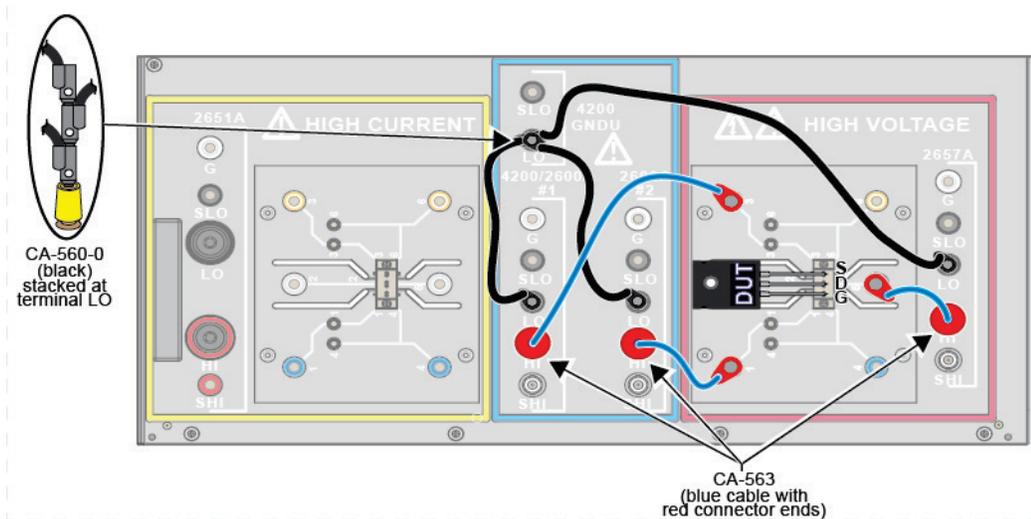
The next graphic shows the Model 8010 connections to a power MOSFET for the Crss test.

**Figure 89: Model 8010 Device connections for Crss test**



### Model 8010 connections to the device for Ciss and Coss

**Figure 90: Model 8010 device connections for Ciss and Coss tests**



## Model 8020 connections

### Connecting instruments to the Model 8020 for power MOSFET capacitance measurements

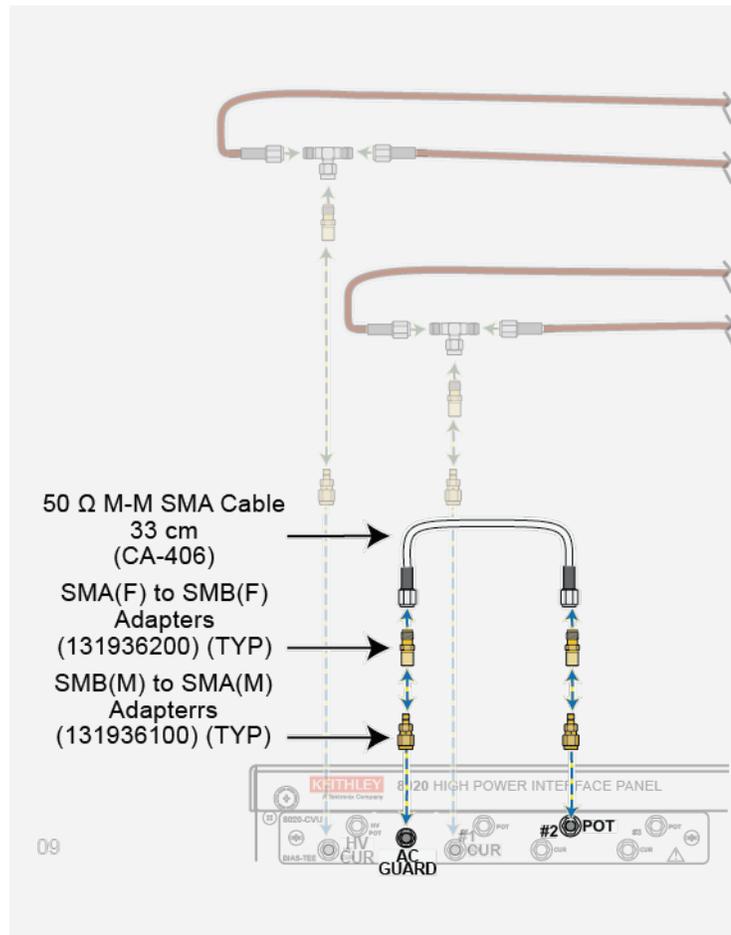
#### NOTE

The following graphics rely upon a SMU per bias tee. With the Model 2600-PCT-1B and 2600-PCT-2B, there are not enough appropriate SMUs to connect to bias tees. For these configurations, connect the force terminal of the GNDU of the PCT-CVU to the bias tee that connects to the Source terminal of the FET or the Emitter terminal of the BJT or IGBT.

### Model 8020 Crss test connections

The following graphic shows the Model 8020 connections for the Crss test.

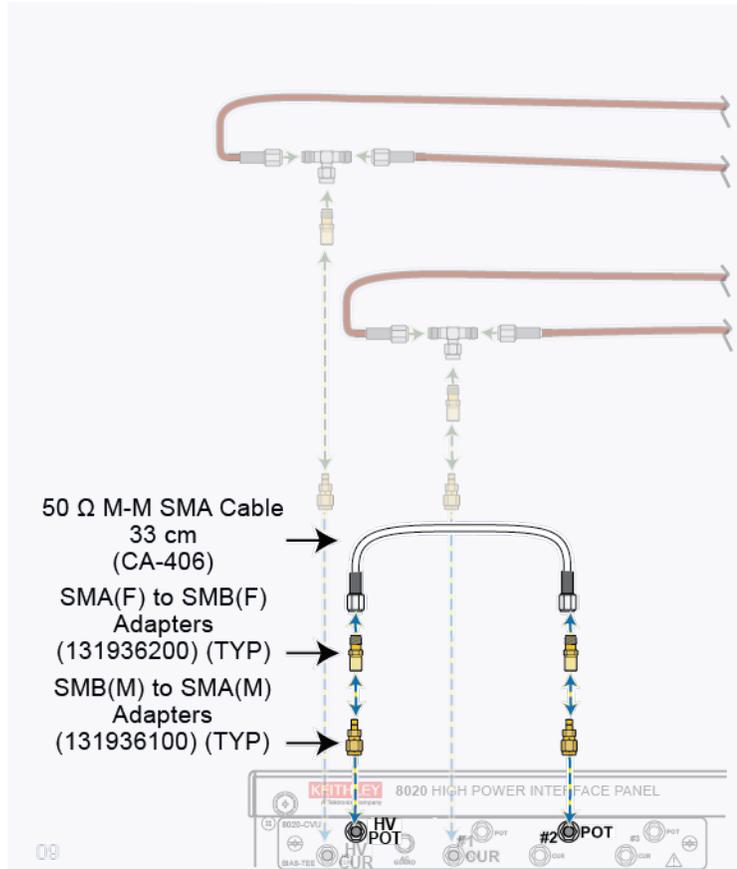
Figure 91: Instrument Connections to the Model 8020 for the Crss test



### Model 8020 Ciss test connections

The next graphic shows the Model 8020 connections for the Ciss test.

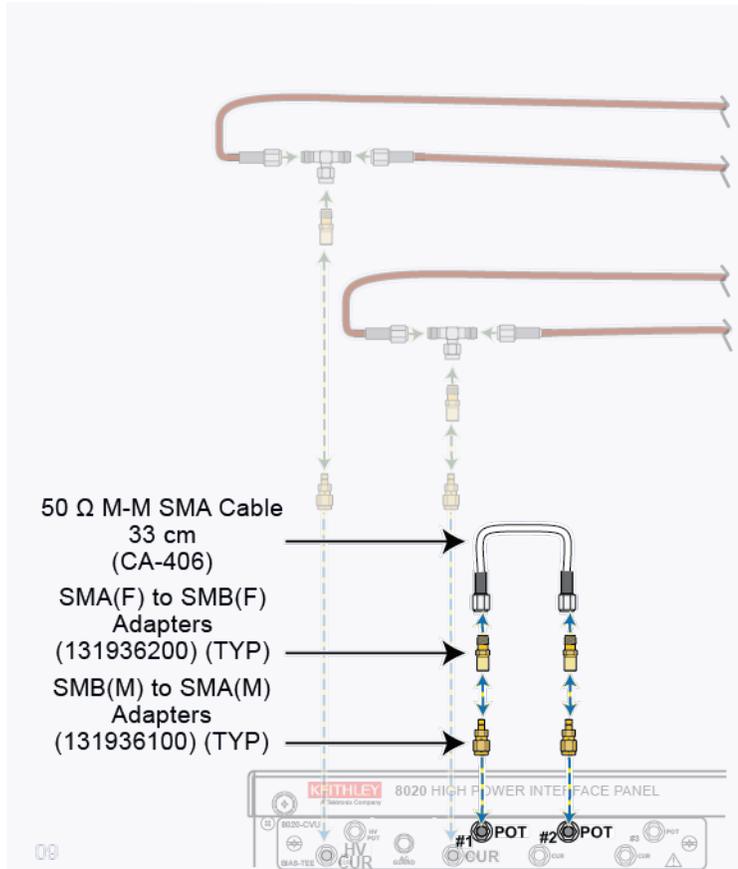
**Figure 92: Instrument Connections to the Model 8020 for the Ciss test**



### Model 8020 Coss connections

The next graphic shows the Model 8020 connections for the Coss test.

**Figure 93: Instrument Connections to the Model 8020 for the Coss test**

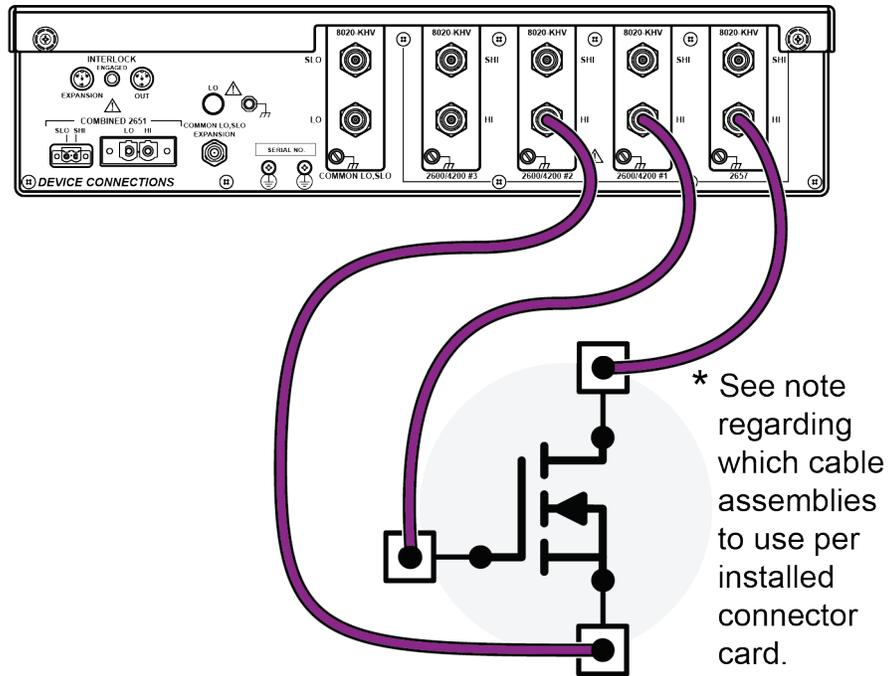


## Connecting the Model 8020 to the device for power MOSFET capacitance measurements

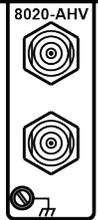
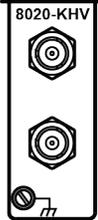
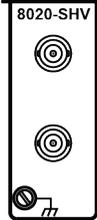
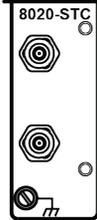
### Model 8020 test connections to the device

The next graphic shows the Model 8020 connections to the device under test for Ciss, Coss, and Crss measurements.

Figure 94: Model 8020 connections to the device



\* Cable assemblies will depend upon the connector card the user installs

			
<u>Connector Card:</u> 8020-AHV	<u>Connector Card:</u> 8020-KHV	<u>Connector Card:</u> 8020-SHV	<u>Connector Card:</u> 8020-STC
<u>Cable Assembly:</u> User supplied	<u>Cable Assembly:</u> Model HV-CA-554	<u>Cable Assembly:</u> User supplied	<u>Cable Assembly:</u> Model 7078-TRX or Model 4200-TRX

## Perform connection compensations on C-V measurements

Stray capacitance, resistance, and inductance in the test setup cause measurement errors. These errors will vary with setup and their impact varies with frequency. To remove these errors from the measurement, perform connection compensation. Because there are connection changes between capacitance measurements of a power MOSFET, each capacitance measurement requires a separate open and short compensation. ACS Basic stores correction data for each capacitance measurement. This section will detail how to perform the compensations for the three circuit-level capacitance measurements:  $C_{iss}$ ,  $C_{oss}$ , and  $C_{rss}$ .

Perform open and short compensation whenever the test configuration changes. This includes cabling and adapter changes, as well as changes to the bias tee configurations.

Though compensations can be performed individually for each capacitance measurement, this section steps you through the open and short compensations for all of the circuit level capacitance parameters ( $C_{iss}$ ,  $C_{oss}$ , and  $C_{rss}$ ).

## Ciss compensation

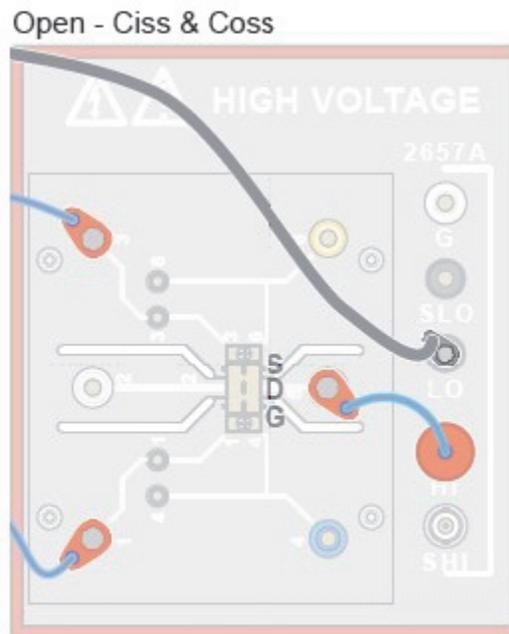
### NOTE

Before you begin connection compensations, make sure that you have connected your instruments correctly. See the [Model 8010 Ciss test connections](#) (on page 5-11) or [Model 8020 Ciss test connections](#) (on page 5-15) topics of this manual.

**Perform open compensation for the Ciss measurement using the Model 8010:**

1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture (see the below graphic), then close the lid of the test fixture.

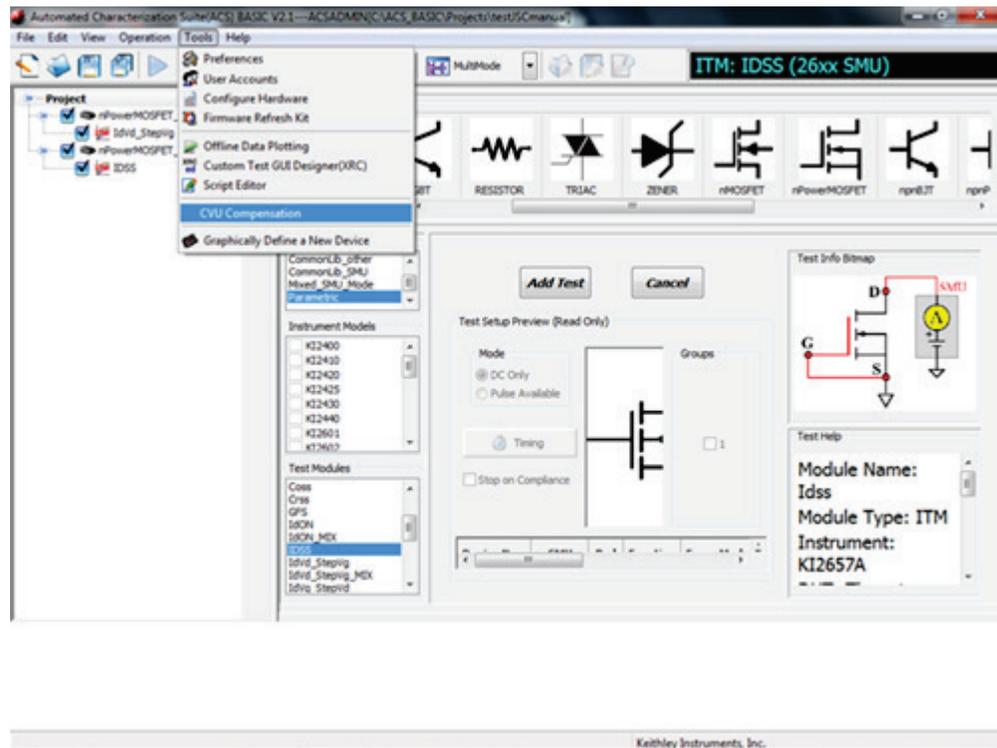
**Figure 95: Internal 8010 connections for Ciss open compensation**



Perform open connection with no device inserted.

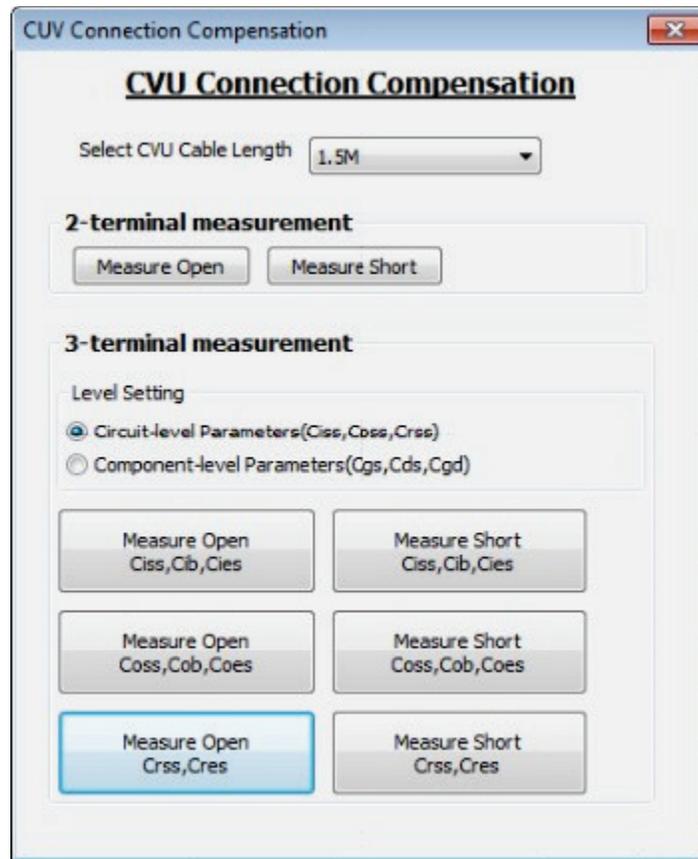
2. If using the Model 8020, remove the DUT or lift the probes on a probe station to disconnect from the device.
3. In ACS Basic, open Multi-Mode test if it is not already open. Refer to section 4 for information on setting up a Multi-mode project.
4. Click on the Tools menu and Select CVU Compensation (see below graphic).

**Figure 96: Tools > CVU Compensation**



5. The CVU Connection Compensation window is displayed (see below graphic).

**Figure 97: CVU connection compensation dialog window options**



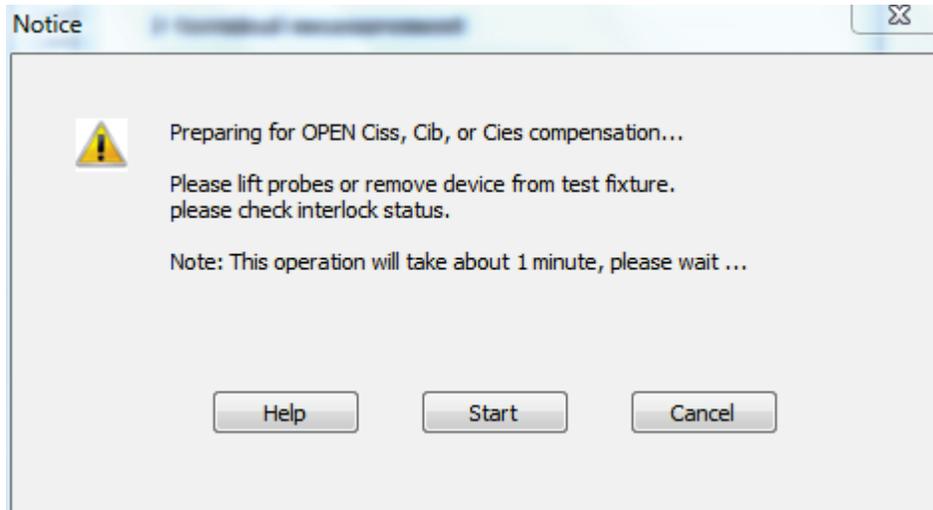
## NOTE

If this CV connection compensation window does not appear, make sure that you device interface settings are correct in the hardware configurator. The bias tee checkbox must be selected. Refer to [Getting started with ACS Basic](#) (on page 3-1) for more details.

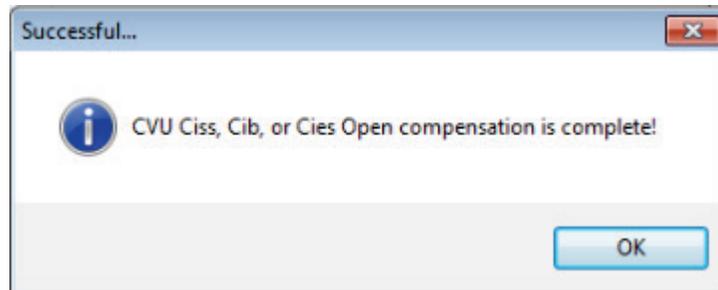
6. Select the appropriate CVU Cable Length according to the cables that you have. 1.5m cables are supplied with the PCT-CVU.
7. Under 3-terminal measurement, select the Circuit-level Parameters radio button in the Level Setting.

8. Select the Measure Open Ciss, Cib, Cies button.
9. The Measure Open for Ciss, Cib, Cies window is displayed (see the below graphic). Clicking the Help button displays the detailed information for compensation connections and provides the translation for device terminal terminology.

**Figure 98: Measure Open dialog window**



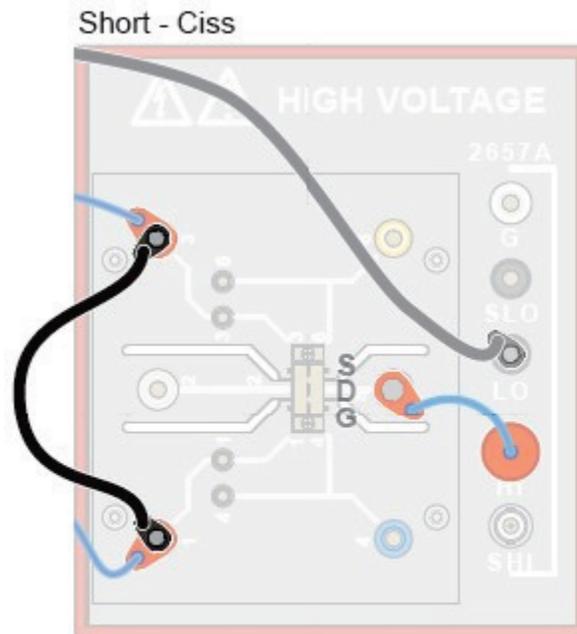
10. Click the Start button to begin the open compensation measurement.
11. A progress window will appear. Open compensation may take up to 90 seconds to complete.
12. When the measurement is complete, click OK to confirm (see the below graphic).



13. Leave the CVU Connection window open for the rest of the compensations.

**Perform short compensation for Ciss measurement**

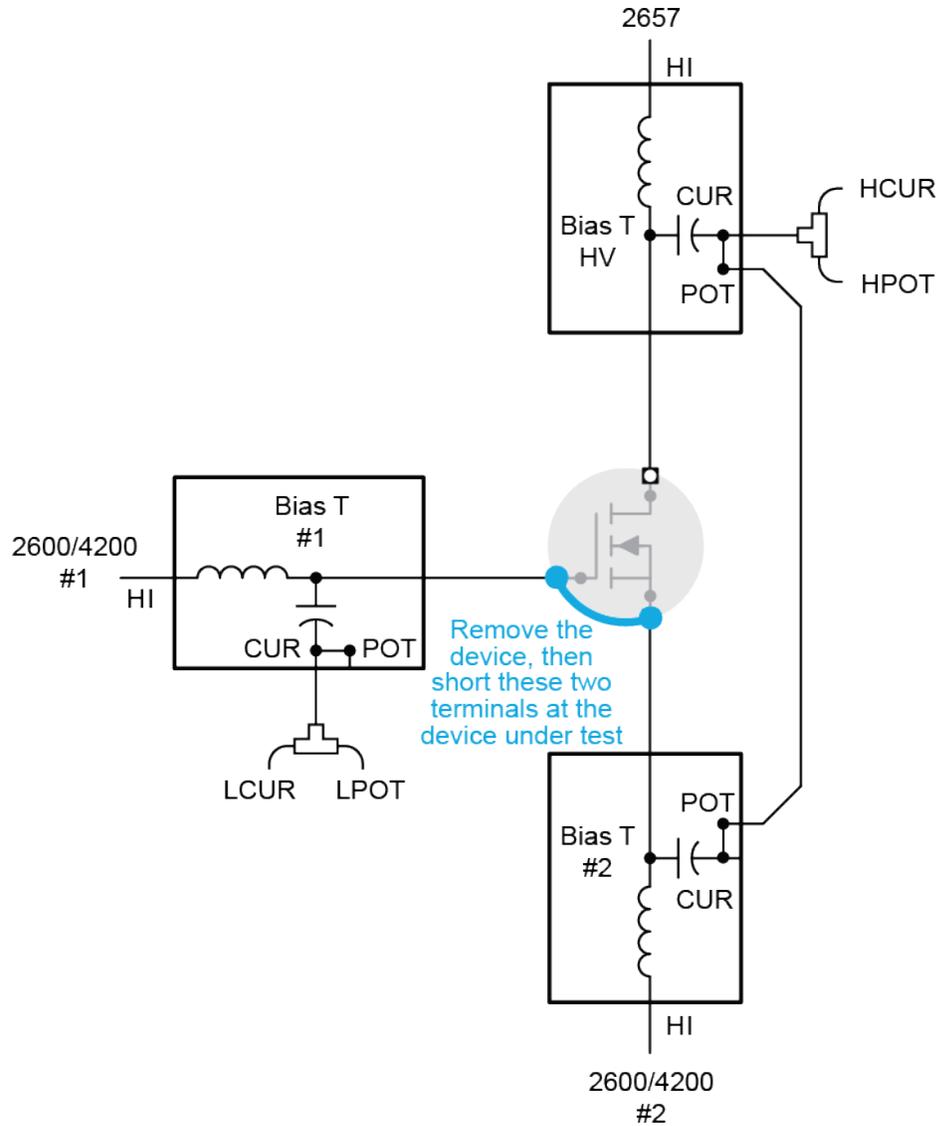
1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture.
2. Use a banana jumper to short the gate and source terminals (see the next graphic), then close the lid of the test fixture.

**Figure 99: Internal 8010 connections for Ciss short compensation**

Perform Ciss short connection with no device inserted and install a short between probes or fixture terminals that would connect to the Source and Gate of the FET.

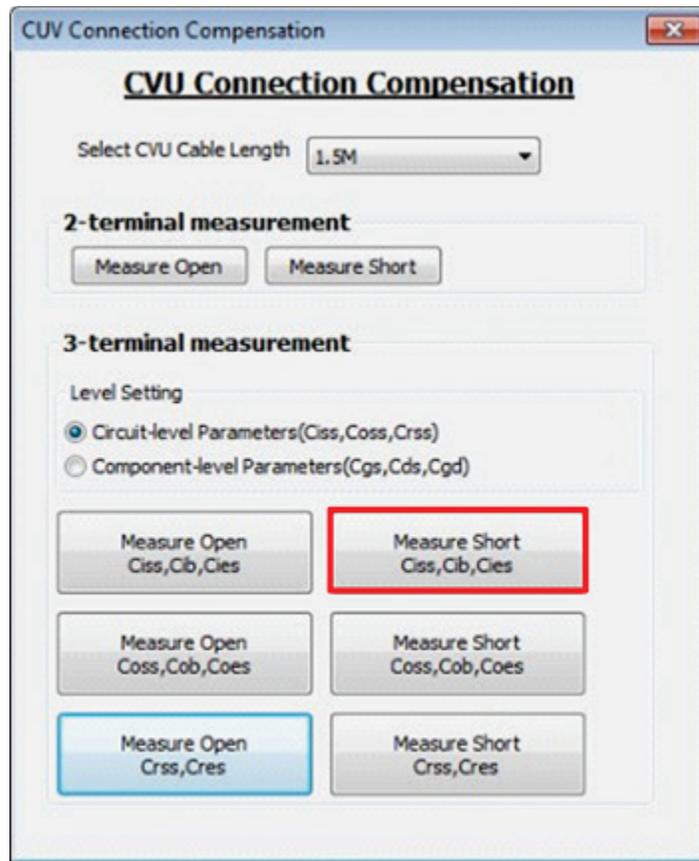
3. If using the Model 8020, remove or disconnect from the device and place a short between the connections to the gate and source terminals. Note the location of the short in the following figure.

**Figure 100: Ciss measurement, short compensation**

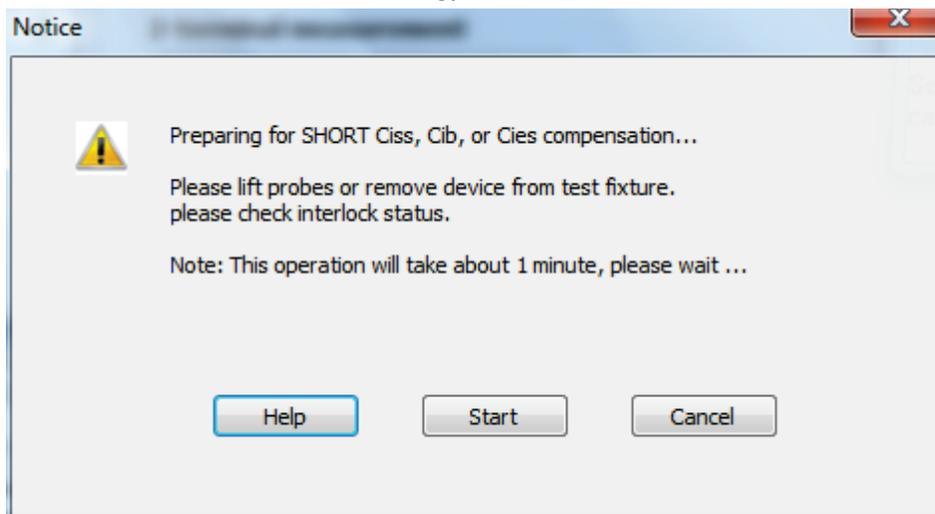


- 4. Select the Measure Short Ciss, Cib, Cies button.

Figure 101: CVU connection compensation settings

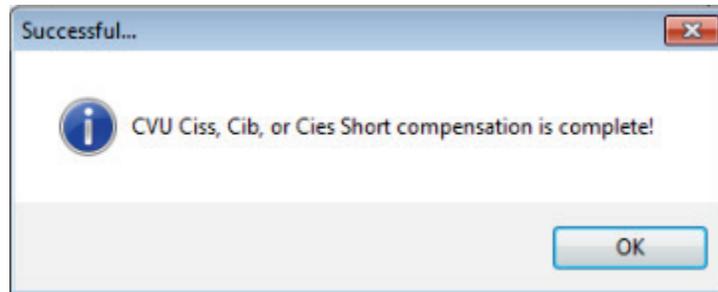


- 5. The Measure Short for Ciss, Cib, Cies window is displayed (see the below graphic). Clicking the Help button displays the detailed information for short compensation connections. It also provides the translation for device terminal terminology.



6. Click the Start button to begin the short compensation measurement.
7. A progress window will appear. Short compensation may take up to 90 seconds to complete.
8. When the measurement is complete, Click OK to confirm (see the below graphic).

**Figure 102: Compensation complete dialog window**



9. Leave the CVU Connection window open for the rest of the compensations.
10. Remove the shorting wire to proceed to the next connection compensation measurement.

## Coss compensation

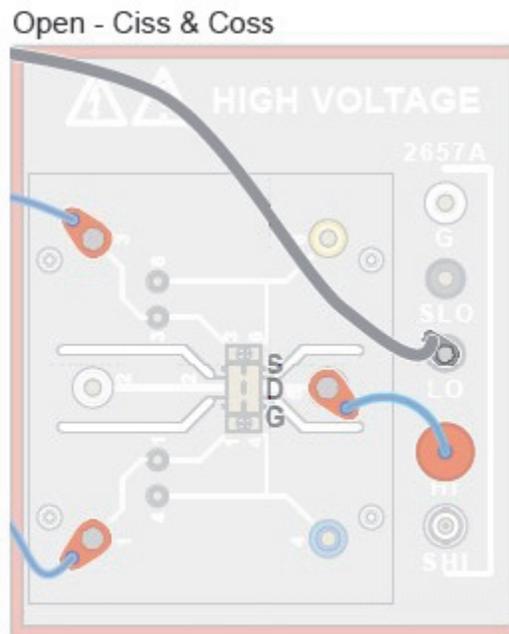
### NOTE

Before you begin connection compensations, make sure that you have connected your instruments correctly. See the [Model 8010 Coss test connections](#) (on page 5-12) and [Model 8020 Coss test connections](#) (on page 5-16) sections of this manual.

#### **Perform open compensation for Coss measurement**

1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture (see the below graphic), then close the lid of the test fixture.

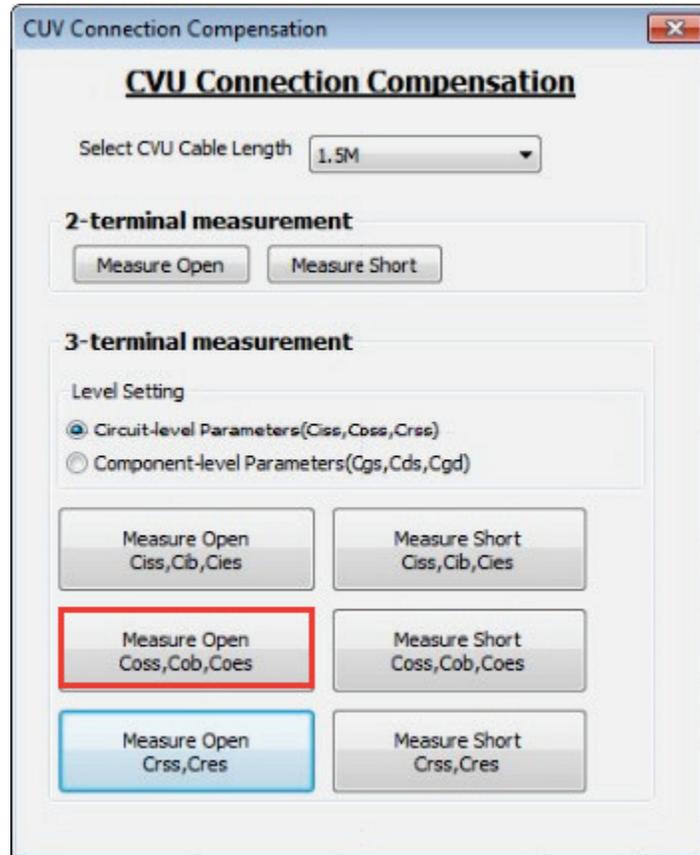
**Figure 103: Internal 8010 connections for Coss open compensation**



Perform open connection with no device inserted.

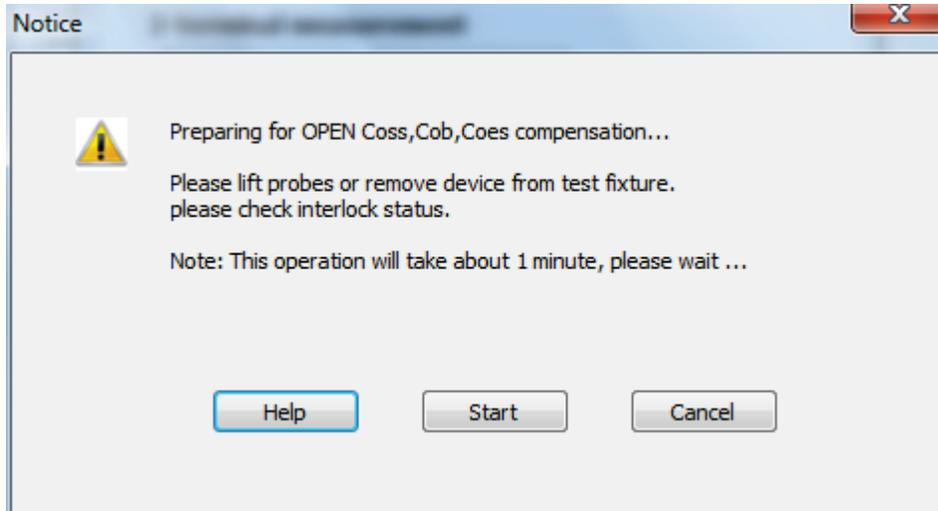
2. If using the Model 8020, remove the DUT or lift the probes on a probe station to disconnect from the device.
3. In the CVU Connection Compensation dialog window of the ACS Basic software, select the Measure Open Coss, Cob, Coes button (see the below graphic).

**Figure 104: CVU connection compensation dialog window options**



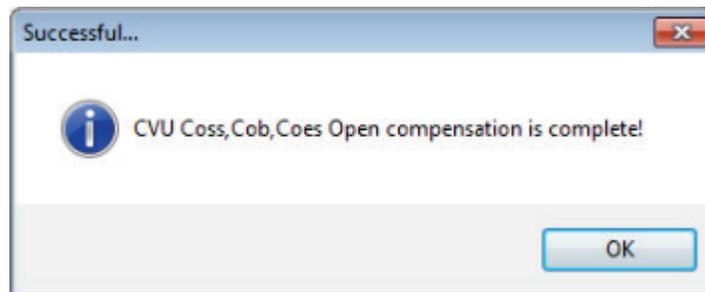
4. The Measure Open for Coss, Cob, Coes window is displayed. Clicking the Help button displays the detailed information for compensation connections and provides the translation for device terminal terminology.

**Figure 105: Measure Open dialog window**



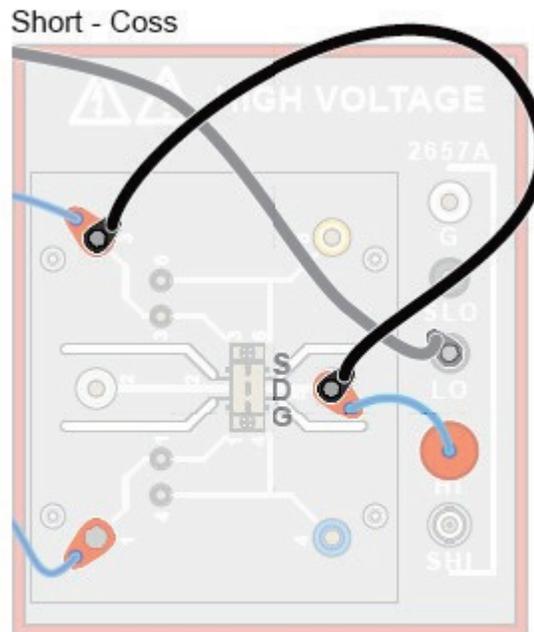
5. Click the Start button to begin the open compensation measurement.
6. A progress window will appear. Open compensation may take up to 90 seconds to complete
7. When the measurement is complete, click OK to confirm (see the below graphic). Leave the CVU Connections Compensation dialog window open for the remaining compensations.

**Figure 106: Compensation complete dialog window**



**Perform short compensation for  $C_{oss}$  measurement**

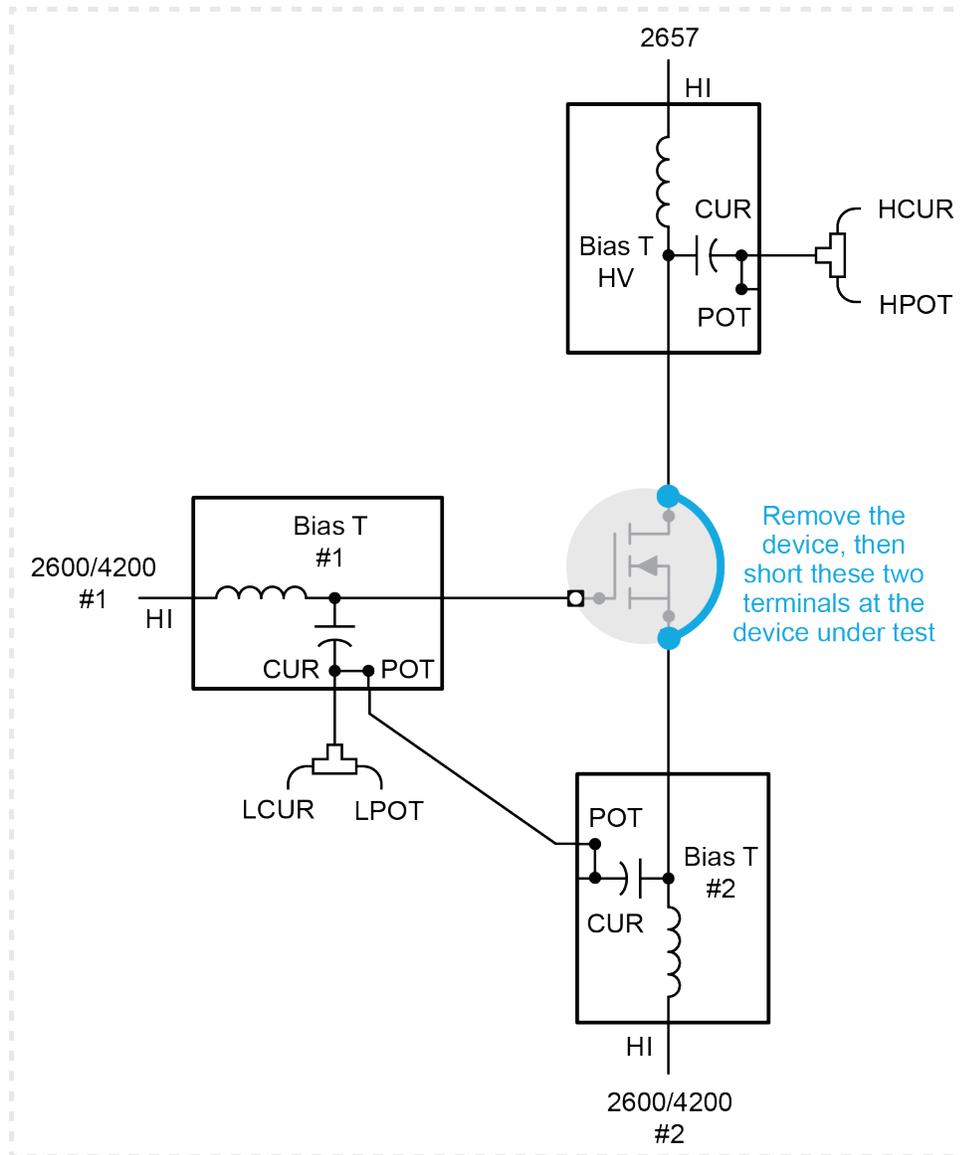
1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture (see the below graphic).
2. Short the Source and Drain terminals using a banana jumper, then close the lid of the Model 8010.

**Figure 107: Internal Model 8010 connections for  $C_{oss}$  short compensation**

Perform  $C_{oss}$  short connection with no device inserted and install a short between probes or fixture terminals that would connect to the Source and Drain of the FET.

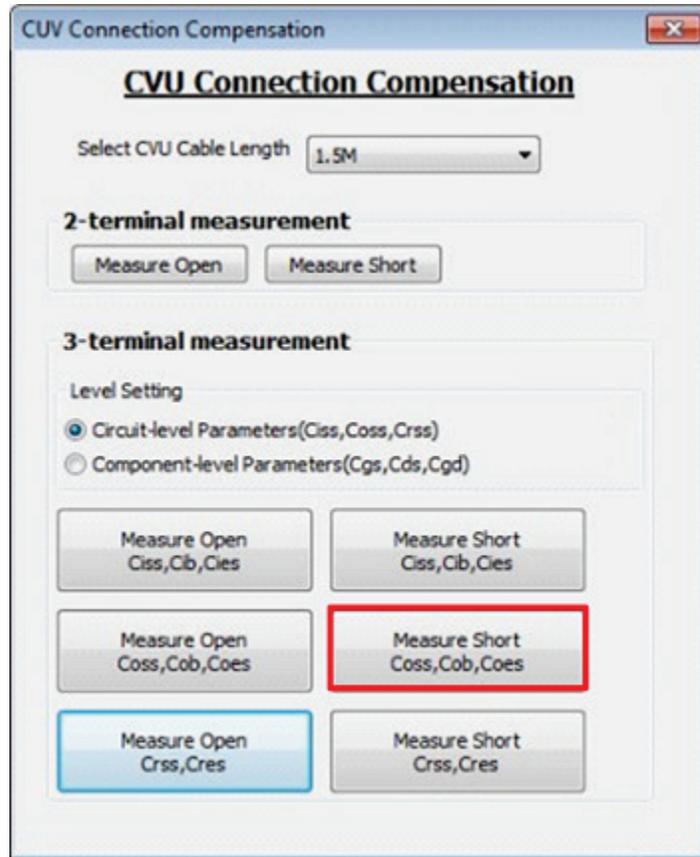
3. If using the Model 8020, remove or disconnect from the device and place a short between the connections to the drain and source terminals. In this compensation, we are only compensating for the larger of  $C_{gd}$  and  $C_{ds}$  (typically  $C_{ds}$ ). Note the location of the short in the following graphic.

**Figure 108: Coss measurement, short compensation**



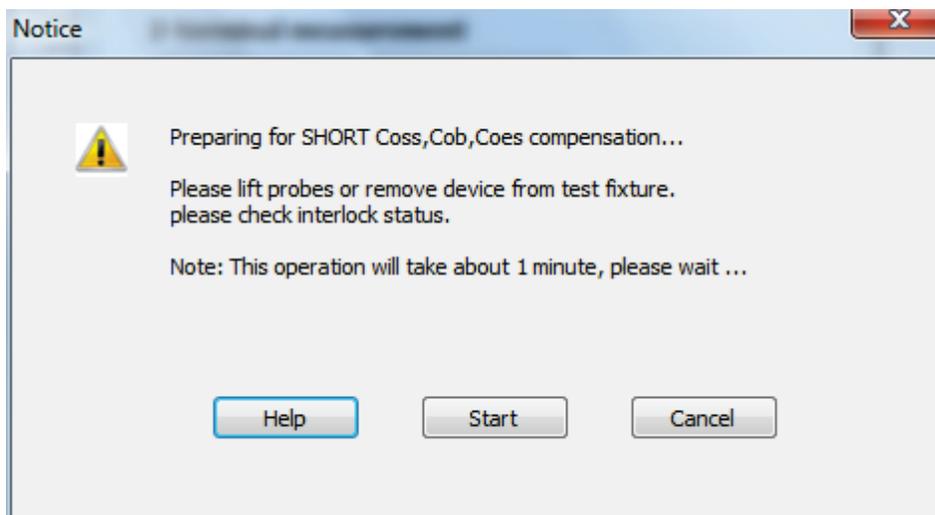
- In the CVU Connections Compensation window, click the Measure Short Coss, Cob, Coes button.

**Figure 109: CVU connection compensation dialog window options**



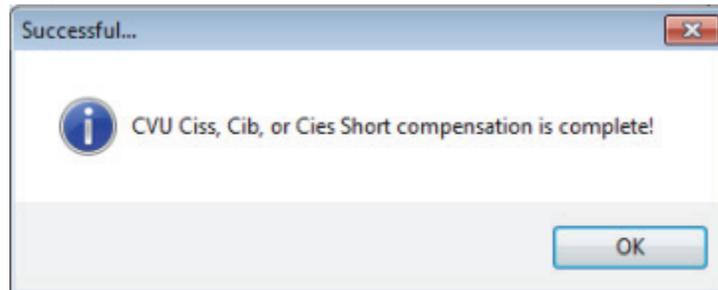
- The Measure Short for Coss, Cob, Coes window is displayed (see the below graphic). Clicking the Help button displays the detailed information for short compensation connections. It also provides the translation for device terminal terminology.

**Figure 110: Measure short for Coss, Cob, Coes dialog**



6. Click Start in the Measure Short for Coss, Cob, Coes window to start the short compensation measurement.
7. While running the short compensation measurement, a progress window will appear. The short compensation will take less than 90 seconds to complete.
8. When the measurement is complete, Click OK to confirm (see the below graphic).

**Figure 111: Compensation complete dialog window**



9. Remove the shorting wire to proceed to the next connection compensation measurement. Leave the CVU connection compensation dialog window open to complete the remaining compensations.

## Crss compensation

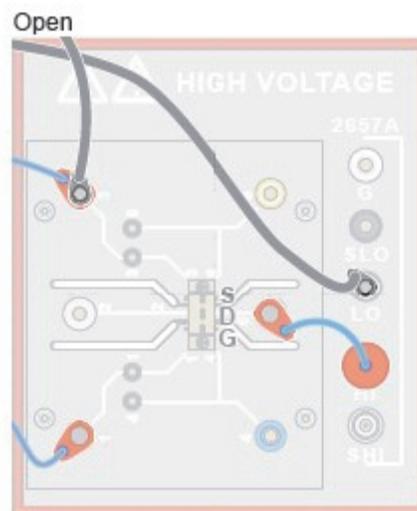
### NOTE

Before you begin connection compensations, make sure that you have connected your instruments correctly. See the [Model 8010 Crss test connections](#) (on page 5-10) and [Model 8020 Crss test connections](#) (on page 5-14) sections of this manual.

#### **Perform an open compensation for Crss measurement**

1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture (see the below graphic), then close the lid of the test fixture.

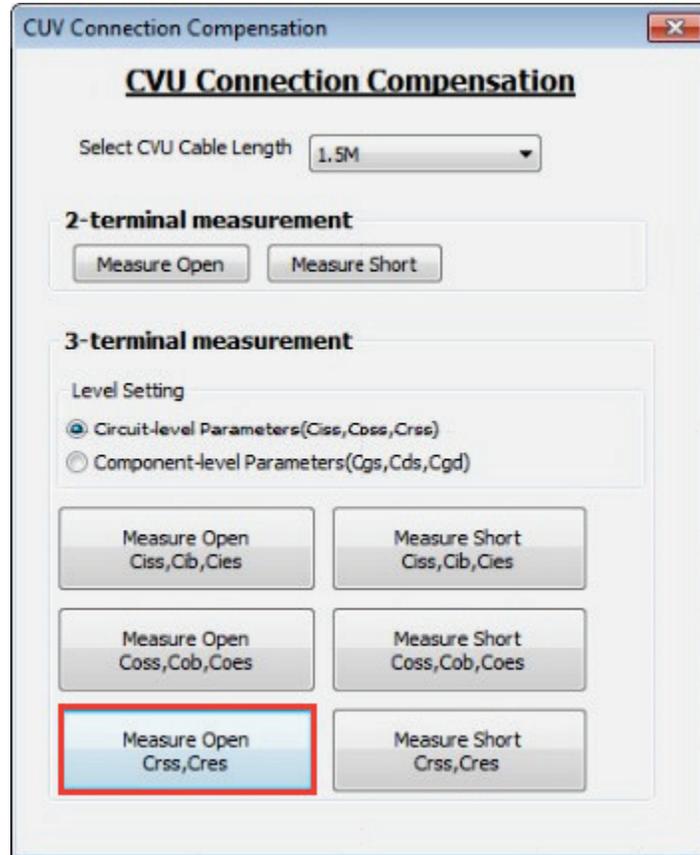
**Figure 112: Internal 8010 connections for Crss short compensation**



Perform open connection with no device inserted.

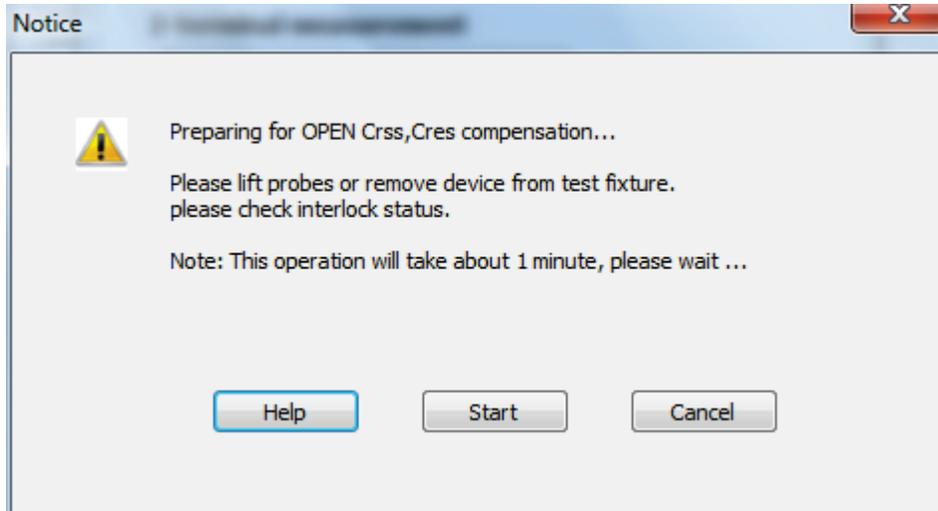
2. If using the Model 8020, remove the DUT or lift the probes on the probe station to disconnect from the device.
3. In the CVU Connection Compensation window, select the Measure Open Crss, Cres button.

**Figure 113: CVU connection compensation dialog window options**



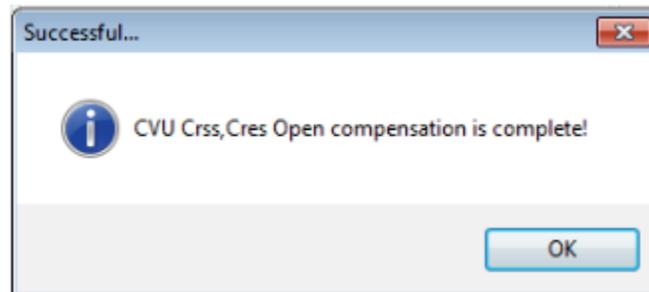
4. The Measure Open for Crss, Cres window is displayed (see the below graphic). Clicking the Help button displays the detailed information for compensation connections and provides the translation for device terminal terminology.

**Figure 114: Measure Open dialog window**



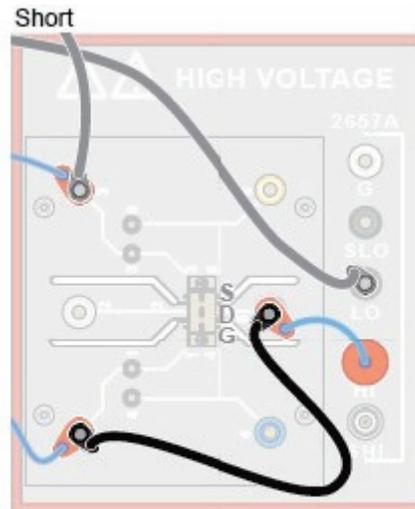
5. Click the Start button to begin the open compensation measurement.
6. A progress window will appear. The open compensation will take up to 90 seconds to complete.
7. When the measurement is complete, select the OK button to confirm (see the below graphic). Leave the CVU Connection Compensations dialog window open for the remaining compensations.

**Figure 115: Compensation complete dialog window**



**Perform short compensation for  $C_{rss}$  measurement**

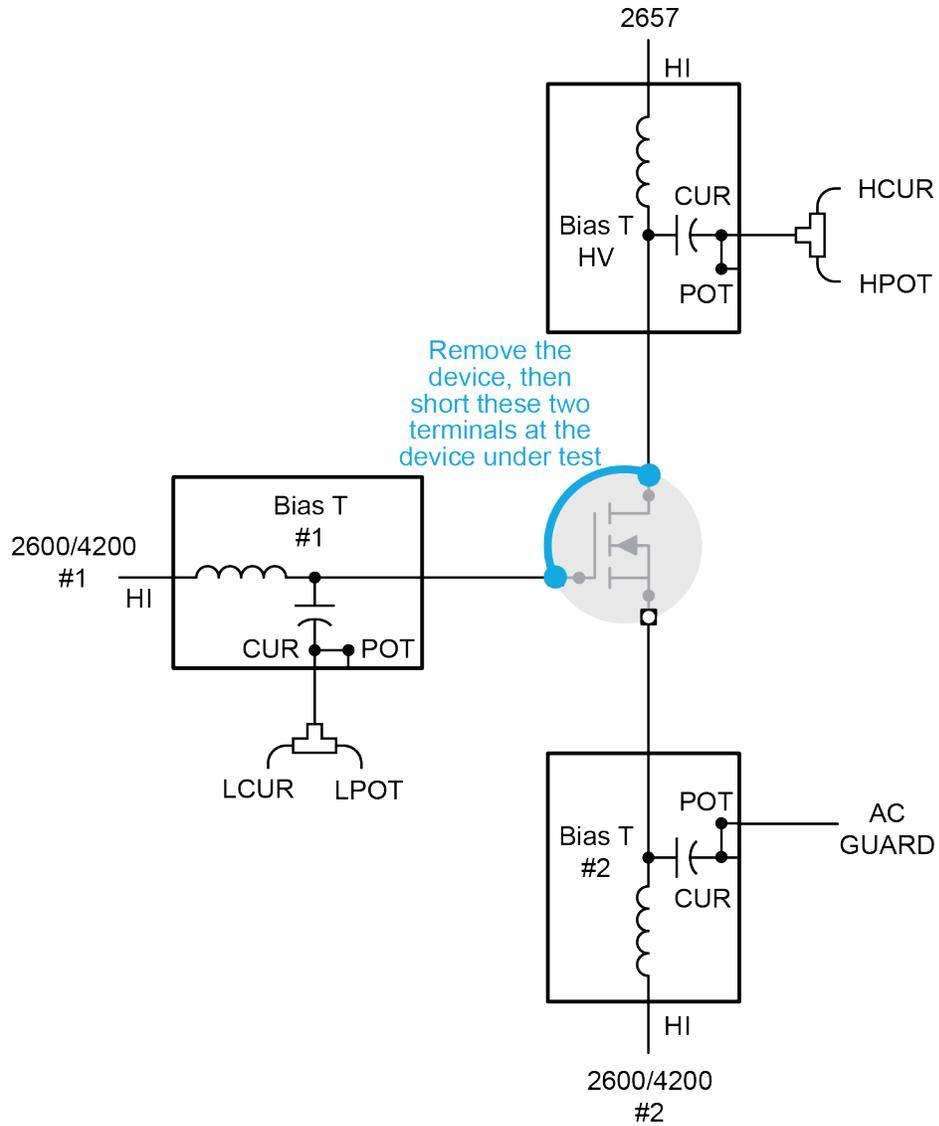
1. If using the Model 8010, make sure that no device is inserted in the device socket in the test fixture, then install a shorting wire between the drain and gate using a banana jumper (see the below graphic). Close the lid of the test fixture.

**Figure 116: Internal 8010 connections for  $C_{rss}$  short compensations**

Perform  $C_{GD}$  short connection with no device inserted and install a short between probes or fixture terminals that would connect to the Gate and Drain of the FET.

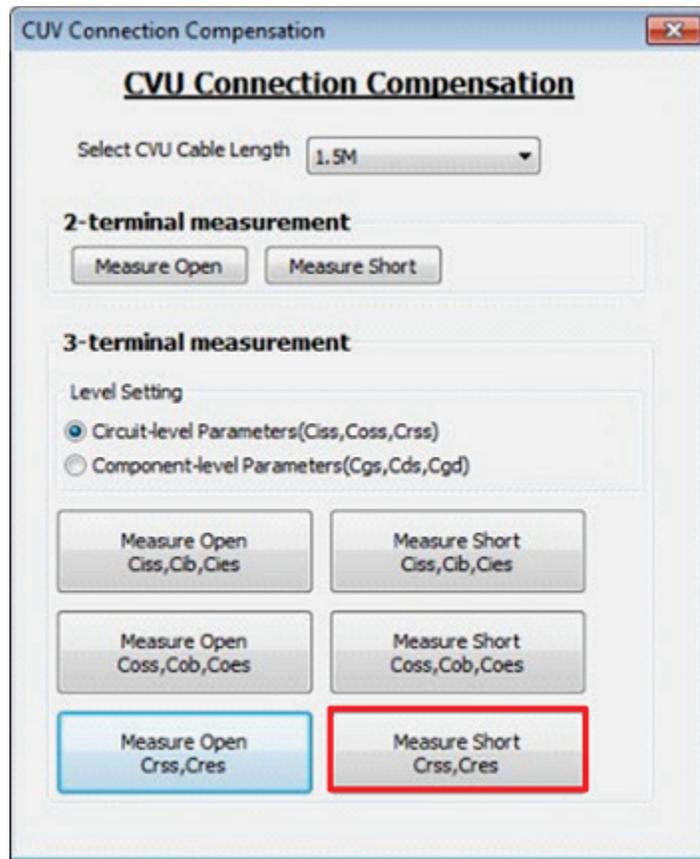
- For the Model 8020 remove or disconnect from the device and place a short between the connections to the gate and drain terminals. Note the location of the short in following figure.

**Figure 117: Cgd / Crss measurement, short compensation**



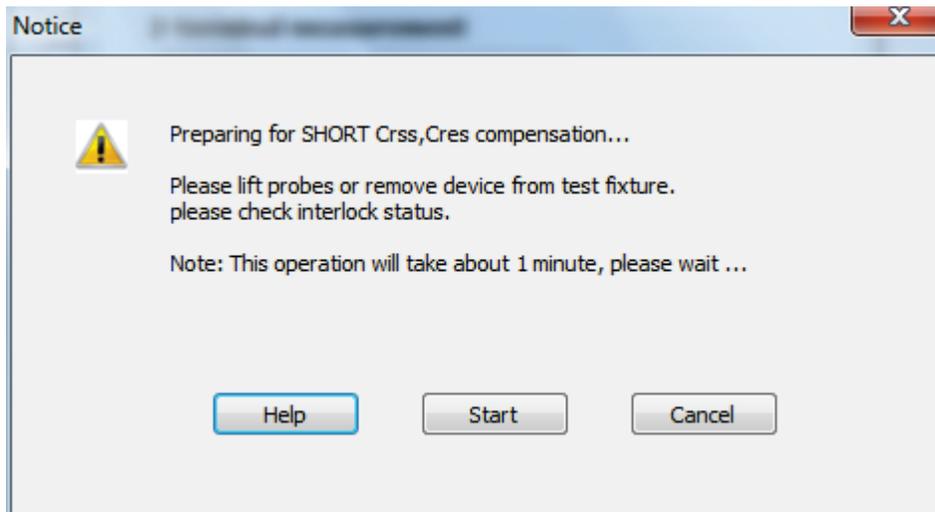
3. Select the Measure Short Crss, Cres button.

**Figure 118: CVU connection compensation dialog window options**



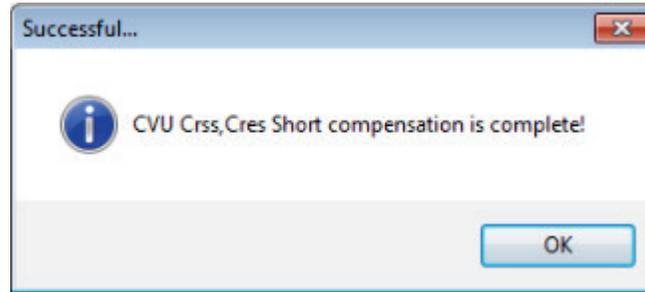
4. The Measure Short for Crss, Cres window is displayed. Clicking the Help button displays the detailed information for compensation connections and also provides the translation for device terminal terminology (see the below graphic).

**Figure 119: Measure Short for Crss, Cres dialog**



5. Click the Start button to begin the open compensation measurement.
6. A progress window will appear. The open compensation will take less than 90 seconds to complete.
7. When the measurement is complete, select the OK button to confirm (see the below graphic).

**Figure 120: Compensation complete dialog window**



8. Remove the shorting wire between the source and drain terminals. For the Model 8010, also remove the connection between the source terminal and the 8010 chassis.

All connection compensations are now complete. Close the CVU Connections Compensations window in ACS Basic by clicking the X in the upper right corner of the window.

## Make a Ciss measurement

### NOTE

Before you make measurements, make sure that you have connected your instruments correctly. See the [Model 8010 Ciss test connections](#) (on page 5-11) or [Model 8020 Ciss test connections](#) (on page 5-15) sections of this manual.

#### **Connect to the device**

If using the Model 8010, insert the device into the 8010 test fixture. If using the Model 8020, make contact with the device at the probe station.

#### **Software procedure**

Ensure that Multi-test mode is open in the ACS Basic software. See [Collecting I-V curves in Multi-test mode](#) (see "[Collecting I-V curves in trace mode](#)" on page 4-4) for detailed software configuration.

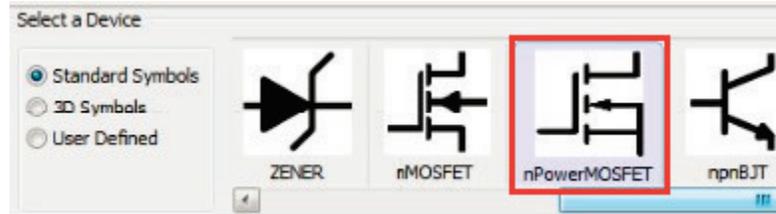
#### **Make a Ciss measurement**

### NOTE

Make sure that you have performed open and short connection compensations prior to making a measurement. See the previous section, [Perform connection compensations on C-V measurements](#) (on page 5-18), for more information and instructions.

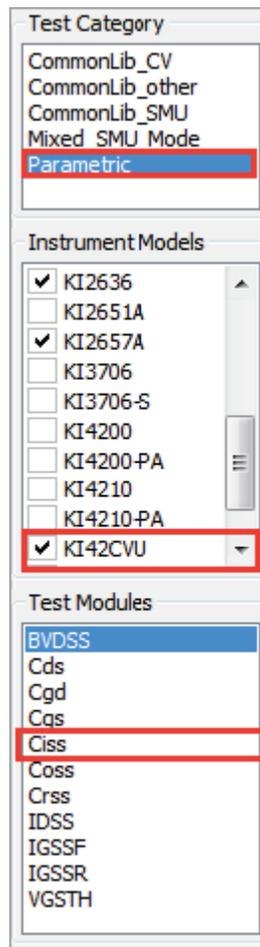
1. Select the nPowerMOSFET from Select a Device panel (see the below figure).

**Figure 121: Selecting the nPowerMOSFET device**



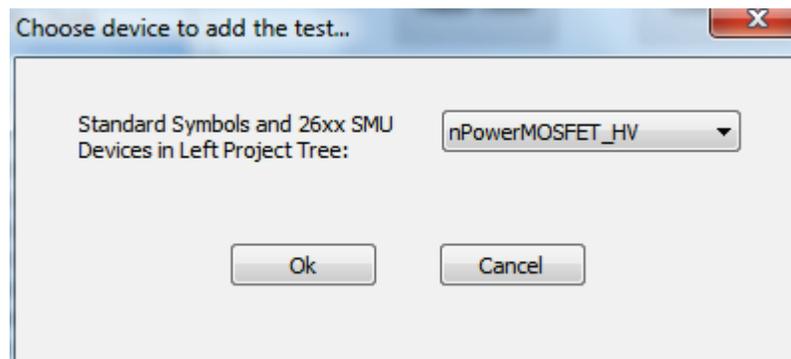
2. Select Parametric from Test Category (see below graphic).

**Figure 122: Test options**



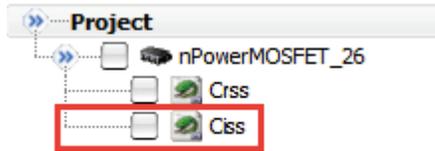
3. Select KI42CVU from Instrument Models.
4. Select Ciss from Test Modules.
5. Click the Add Test button to add the Ciss test to the project tree.
  - If prompted with Choose device to add the test, select the desired device from the drop-down menu and click OK (see below figure).

**Figure 123: Choosing device**



- 6. Double Click on Ciss test (see the below graphic) in the project tree to open the test to display the Ciss test module.

**Figure 124: Ciss test in project tree**

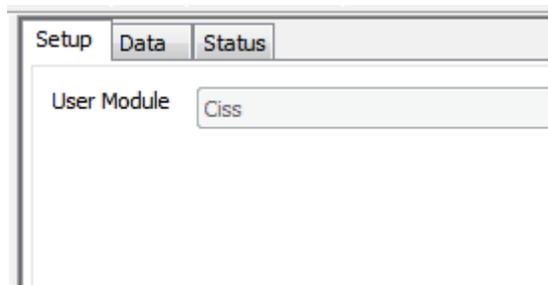


**NOTE**

The Ciss module is a Python Test Module (PTM). As such, it references global SMU numbers. If you are using a Model 4200-SCS and you have SMU cards installed in its chassis, the SMU identification numbers will differ from those previously used for I-V tests. Refer to the Hardware Configuration topic in the ACS Basic User's Manual for details.

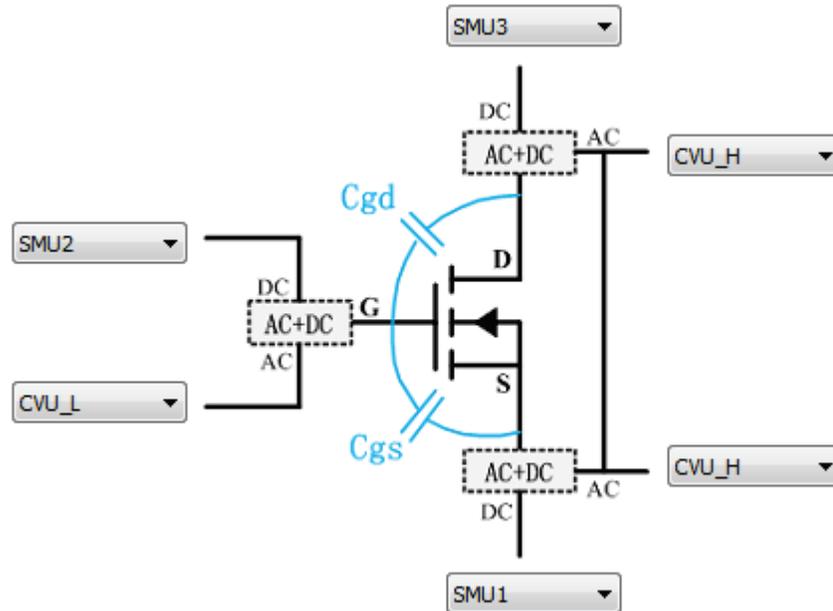
- 7. Click the Setup tab.

**Figure 125: Ciss setup tab**



8. Assign the SMUs as follows. These settings assume the use of a 2600-PCT-3B or 2600-PCT-4B as configured according to the [Getting started with ACS Basic](#) (on page 3-1) section of this manual. Use the actual SMU number for your configuration (see the below graphic).

**Figure 126: Ciss SMU assignments and block diagram (Model 8010 connections)**



***If using the Model 8010, use these configuration settings***

- **Drain DC:** SMU3 (2657), AC: CVU\_H
- **Gate DC:** SMU2 (2600B, ch B), AC: CVU\_L
- **Source DC:** SMU1 (2600B, ch A), AC: CVU\_H

***If using the Model 8020, use these configuration settings***

- **Drain DC:** SMU3 (2657), AC: CVU\_H
- **Gate DC:** SMU1 (2600B, ch A), AC: CVU\_L
- **Source DC:** SMU2 (2600B, ch B), AC: CVU\_H

## NOTE

The Gate AC and Source AC instruments are linked automatically. This represents the hardware connection of the white SMA cable (CA-406A) shorting the two 200 V bias tees.

## 💡 Quick Tip

Hover the mouse pointer over the SMU pad to display the corresponding instrument model number.

9. Enter your desired values in the test settings table.
10. For the included sample device (Fairchild part number FQH8N100C), sweep voltage at the drain from 0 - 1000 V in 10 V steps.
11. Adjust the sweep values by clicking on the "Source" field for the drain SMU.
12. Configure the drain SMU to measure voltage.
13. Configure the gate and source SMUs to have a source function of bias V with a source value of 0V.
14. For the CVU, set the measurement frequency to 1 MHz by selecting the Frequency field and then selecting 1 MHz from the list box.
15. Use the default ACV of 30 mVrms.
16. Use the Cp-Gp-D model.

**Figure 127: Test settings table**

The screenshot displays the software interface for setting up a MOSFET test. At the top, there are tabs for 'Setup', 'Data', and 'Status'. Below these, the 'User Module' is set to 'Ciss'. A 'CVU Connection Compensation' box shows a data file 'Ciss\_Cb\_Oes\_Comp.csv' and options for 'Open', 'Short', and 'Using 8010 factory compensation'. A 'Timing' button is also present.

The central diagram shows a MOSFET with its Drain (D), Gate (G), and Source (S) terminals. SMU3 is connected to the Drain, SMU2 to the Gate, and SMU1 to the Source. Each SMU connection is labeled with 'DC' and 'AC+DC'. The Drain and Source connections are also labeled with 'AC'. Two CVU units, CVU\_L and CVU\_H, are connected to the Drain and Source respectively, with 'AC+DC' and 'AC' labels. Capacitors Cgd and Cgs are indicated between the Gate and Drain, and Gate and Source.

Below the diagram is a table with two sections. The first section lists SMU settings for pads D, G, and S. The second section lists CVU settings for pad D\_G.

Pad	SMU	Pad Name	Function	Source	Measure	Compliance	Meas.Range	Adv
D	SMU3	Drain	Sweep V	[0, 0, 1000, 101]	V	0.001		
G	SMU2	Gate	Bias V	[0, 0]	None	0.001		
S	SMU1	Source	Bias V	[0, 0]	None	0.001		

Pad	CVU	Pad Name	Function	Frequency	ACV	Model	Adva
D_G	CVU_L	Ciss	C vs. V	1M Hz	30mVRms	Cp-Gp-D	..

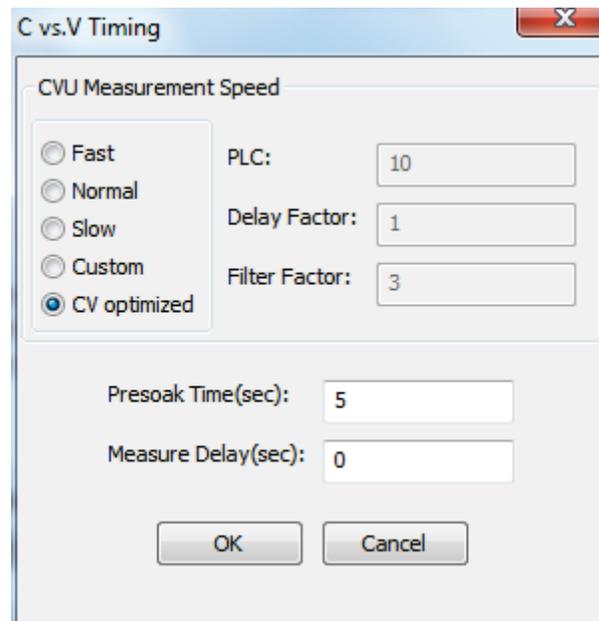
At the bottom of the interface, there are buttons for 'Script', 'GUI', 'Import', and 'Save'.

## Quick Tip

For the Ciss test module, the capacitance measurement function is fixed to capacitance vs. voltage. To view capacitance as a function of frequency, use the Generic HV C-V Test under the CommonLib\_CV test category. Refer to the ACS Basic software user's manual for information on using this test module.

17. Click the Timing button.
18. Ensure that C-V optimized is selected and the presoak time is 5 seconds, then click OK to close the window. See the below graphic.

**Figure 128: C-V timing window**



19. Select the Open and Short boxes in the CVU Connection Compensation area to apply the compensation to the measured data.

The latest compensation will be loaded automatically. If no prior compensation has been performed, you may receive the below error message (see the below graphic). To perform the compensation, see the previous section, [Perform connection compensation on C-V measurements](#) (see "[Perform connection compensations on C-V measurements](#)" on page 5-18).

**Figure 129: Compensation warning**

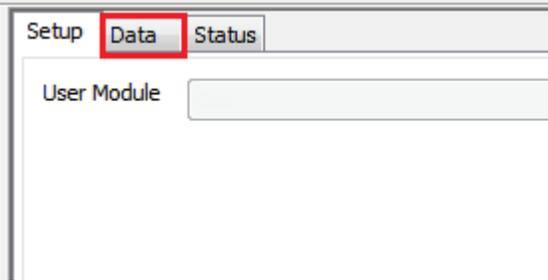


**Quick Tip**

If you have the Model 8010 and are using the CVU-3K-KIT, you can also use built-in compensation data by selecting the "Using 8010 factory compensation" checkbox. This allows you to make quick validation on the device capacitance without performing the complete compensation for your specific environment.

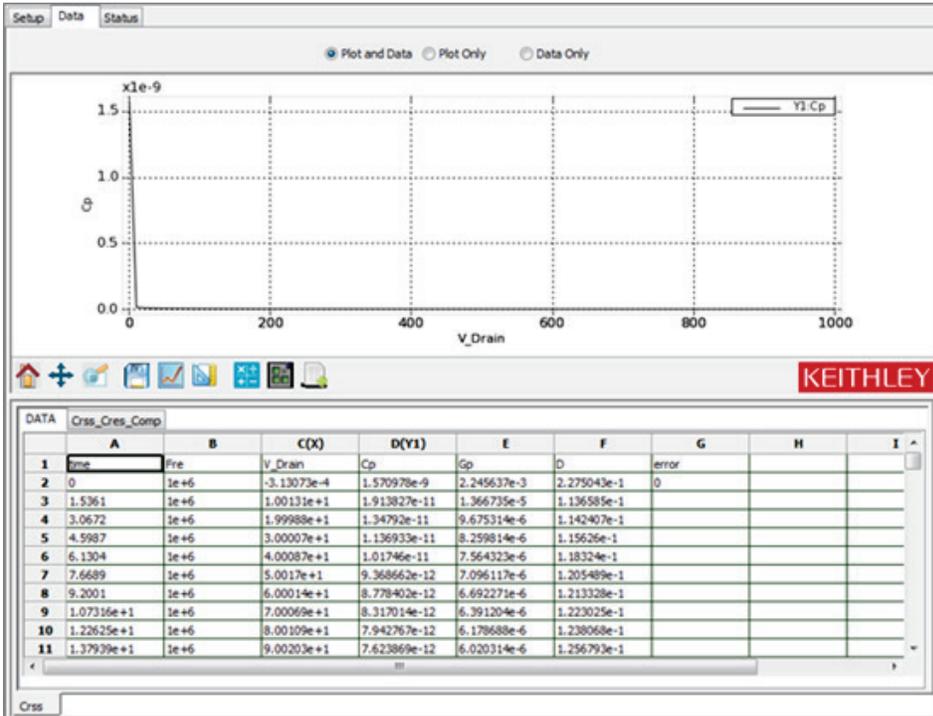
20. Sample data and pilots are included with the test. Switch to the Data tab (see the following graphic).

**Figure 130: Data tab**



21. Click the Run icon to start the test. The results should appear close to those in the below graphic.

**Figure 131: Run icon**



**WARNING**  
 If high voltage is used during the test, make sure a proper discharge procedure is performed before removing the top cover the Model 8020 or making connection changes inside of the Applications Test Fixture.

## Make a Coss measurement

### *Coss measurement connection verification*

#### NOTE

Before you make measurements, make sure that you have connected your instruments correctly. See the [Model 8010 Coss test connections](#) (on page 5-12) or [Model 8020 Coss test connections](#) (on page 5-16) sections of this manual.

Connections to the device within the Model 8010 or at the device connections panel of the Model 8020 are the same as for the Ciss test. Therefore, the connections are not changed.

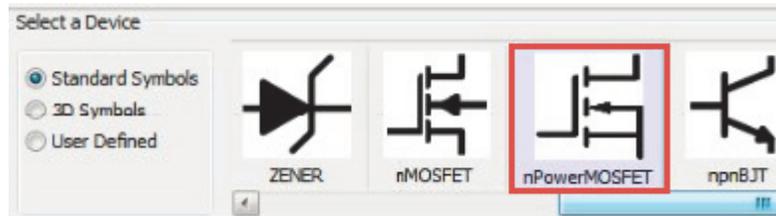
### *Make a Coss measurement*

#### NOTE

Make sure that you have performed open and short connection compensations prior making a measurement. See the previous section, [Perform connection compensations on C-V measurements](#) (on page 5-18), for more information and instructions.

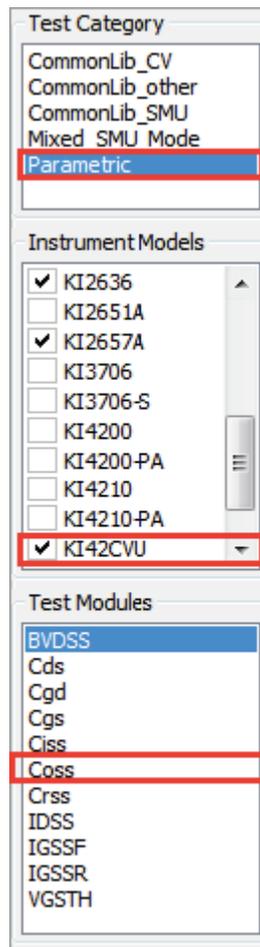
1. Open the test library by clicking on "Project" in the Navigator or by clicking the Library icon in the vertical tool bar.
2. Select the nPowerMOSFET from Select a Device panel (see the below figure).

**Figure 132: PCT\_CossMeas1**



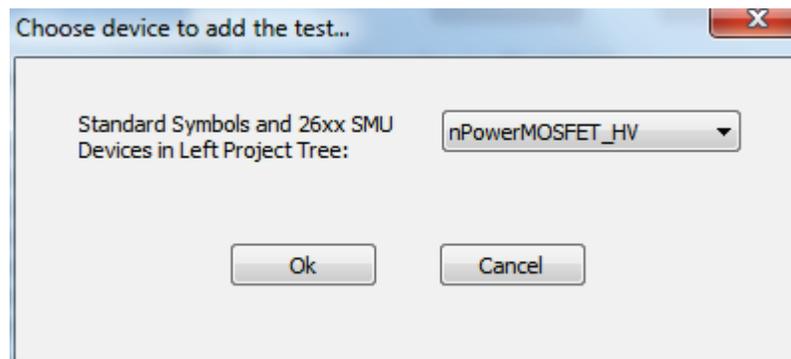
3. Select Parametric from Test Category (see below graphic).

**Figure 133: Test options**



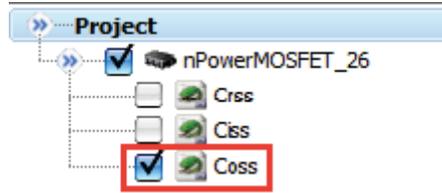
4. Select KI42CVU from Instrument Models.
5. Select Coss from Test Modules.
6. Click the Add Test button to add the Coss test to the project tree.
  - If prompted with Choose device to add the test, select the desired device from the drop-down menu and click OK (see below figure).

**Figure 134: Choosing device**



- 7. Double Click on the Coss test in the project tree to open the test to display the Coss test module (see the below figure).

**Figure 135: Coss test in project tree**

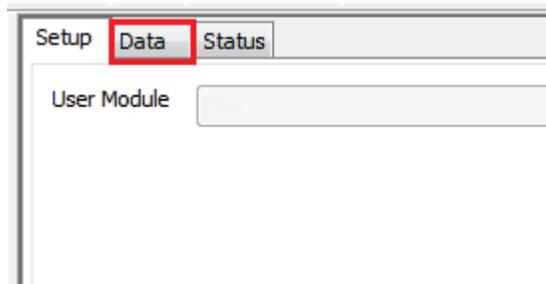


**NOTE**

The Ciss module is a Python Test Module (PTM). As such, it references global SMU numbers. If you are using a Model 4200-SCS and you have SMU cards installed in its chassis, the SMU identification numbers will differ from those previously used for I-V tests. Refer to the Hardware Configuration topic in the ACS Basic User's Manual for details.

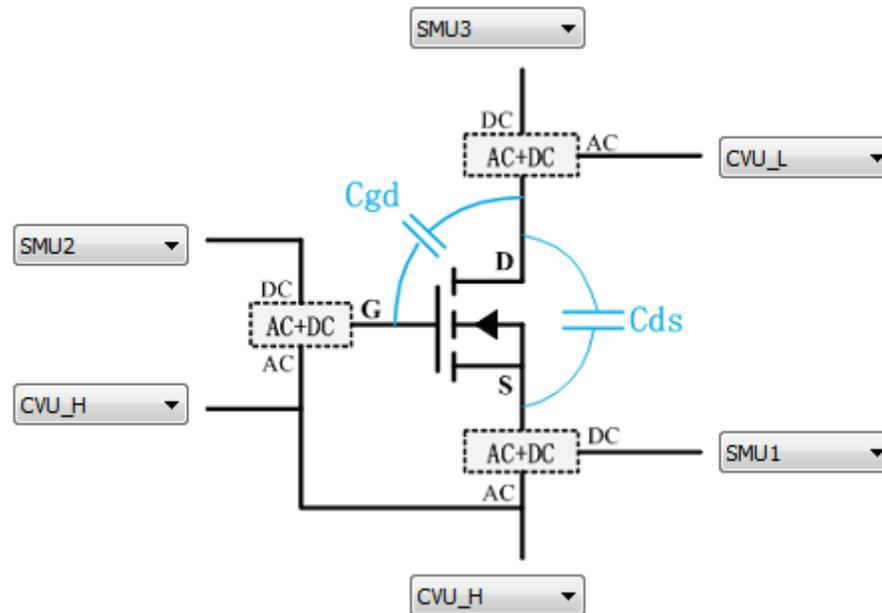
- 8. Click on the setup tab.

**Figure 136: Ciss setup tab**



9. Assign the SMUs as follows. Use the actual SMU number for your configuration (see the below graphic).

**Figure 137: Coss SMU assignments and block diagram (Model 8010 connections)**



**If using the Model 8010, use these configuration settings**

- **Drain DC:** SMU3 (2657A), AC: CVU\_L
- **Gate DC:** SMU2 (2600B, ch B), AC: CVU\_H
- **Source DC:** SMU1 (2600B, ch A), AC: CVU\_H

**If using the Model 8020, use these configuration settings**

- **Drain DC:** SMU3 (2657A), AC: CVU\_L
- **Gate DC:** SMU1 (2600B, ch A), AC: CVU\_H
- **Source DC:** SMU2 (2600B, ch B), AC: CVU\_H

## NOTE

The Gate AC and Source AC instruments are linked automatically in the software. This represents the hardware connection of the white SMA cable (CA-406) shorting the two 200 V bias tees.

**Quick Tip**

Hover the mouse pointer over the SMU pad to display the corresponding instrument model number.

10. For the included sample device (Fairchild part number FQH8N100C) sweep voltage at the drain from 0 - 1000 V in 10 V steps. Adjust the sweep values by clicking on the Source field for the drain SMU.
11. Configure the drain SMU to measure voltage.
12. Configure the gate and source SMUs to have a source function of bias V with a source value of 0 V.
13. For the CVU, set the measurement frequency to 1 MHz by clicking on the Frequency field and selecting 1 MHz from the list box.
14. Use the default ACV of 30 mVrms.
15. Use the CP-G-D model.

**Figure 138: Test settings table**

The screenshot shows a software interface for configuring a test. On the left, there is a 'CVU Connection Compensation' section with a data file path, a 'Last Saved' timestamp, and checkboxes for 'Open', 'Short', and 'Using 8010 factory compensation'. A 'Timing' button is also present. The central part of the interface features a circuit diagram of a MOSFET with terminals D (Drain), G (Gate), and S (Source). The diagram is annotated with capacitors: Cgd between D and G, and Cds between D and S. Various SMU (Source Measurement Unit) and CVU (Current Voltage Unit) components are connected to the terminals, with dropdown menus for selection. Below the diagram are two tables summarizing the test settings.

Pad	SMU	Pad Name	Function	Source	Measure	Compliance	Meas.Range	Adv
D	SMU3	Drain	Sweep V	[0, 0, 1000, 101]	V	0.001		
G	SMU2	Gate	Bias V	[0, 0]	None	0.001		
S	SMU1	Source	Bias V	[0, 0]	None	0.001		

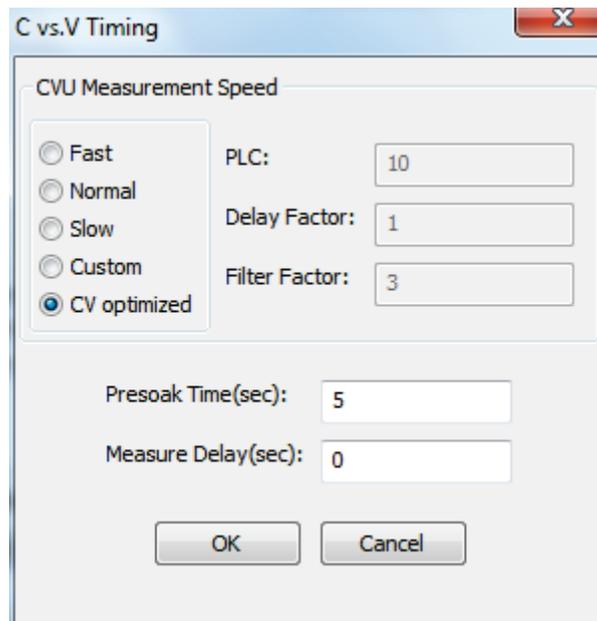
Pad	CVU	Pad Name	Function	Frequency	ACV	Model	Adva
G_D	CVUH_L	Coss	C vs.V	1M Hz	30mVRMs	Cp-Gp-D	..

## Quick Tip

For the Coss test module, the capacitance measurement function is fixed to capacitance vs. voltage. To see capacitance as a function of frequency, use the Generic HV C-V Test under the CommonLib\_CV test category. Refer to the ACS Basic software user's manual for information on using this test module.

16. Click on the Timing button.
17. Ensure that CV optimized is selected and the presoak time is 5 seconds, then click OK to close the window. See the below graphic.

**Figure 139: C-V timing window**



18. Check the Open and Short boxes in the CVU Connection Compensation area to apply the compensation to the measured data.

The latest compensation will be loaded automatically. If no prior compensation has been performed, you may receive the below error message (see below graphic). To perform the compensation, see the previous section, [Perform connection compensation on C-V measurements](#) (see "[Perform connection compensations on C-V measurements](#)" on page 5-18).

**Figure 140: Warning that compensation was not performed**

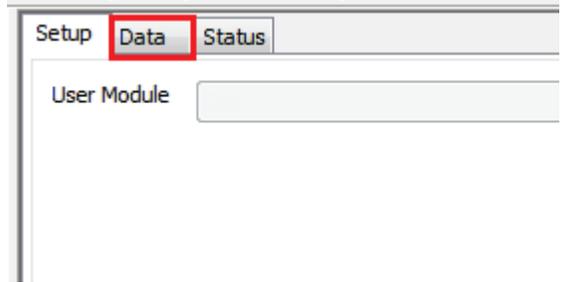


**Quick Tip**

If you have the Model 8010 and are using the CVU-3K-KIT, you can also use built-in compensation data by selecting the "Using 8010 factory compensation" checkbox. This allows you to make quick validation on the device capacitance without performing the complete compensation for your specific environment.

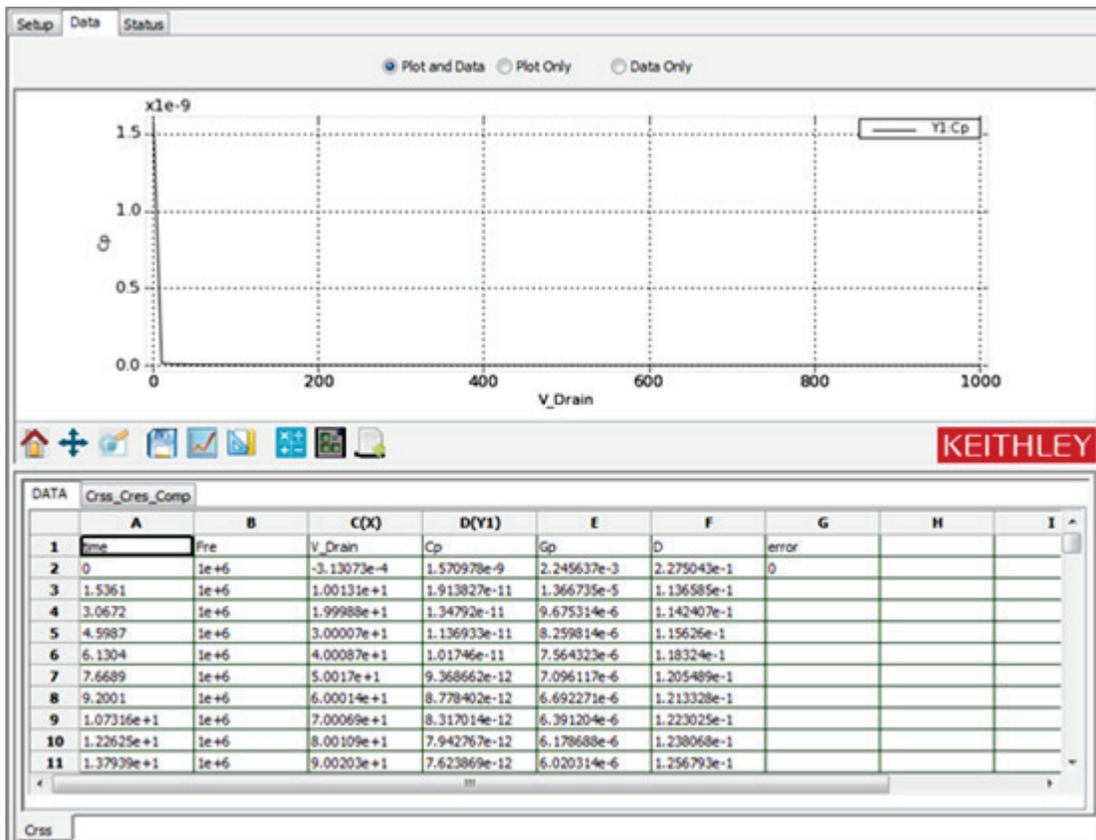
- Sample data and pilots are included with the test. Switch to the Data tab (see the following graphic).

**Figure 141: Data tab**



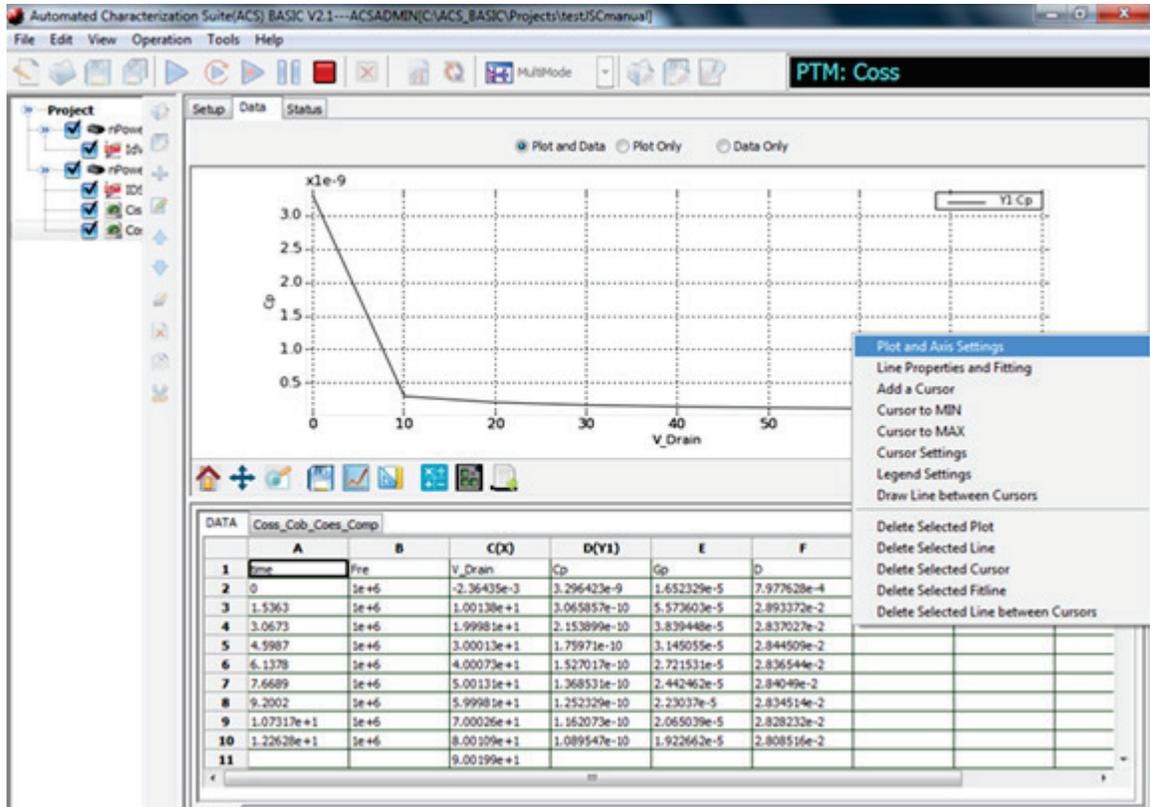
- Click the Run icon to start the test (see below graphic).

**Figure 142: Run icon**



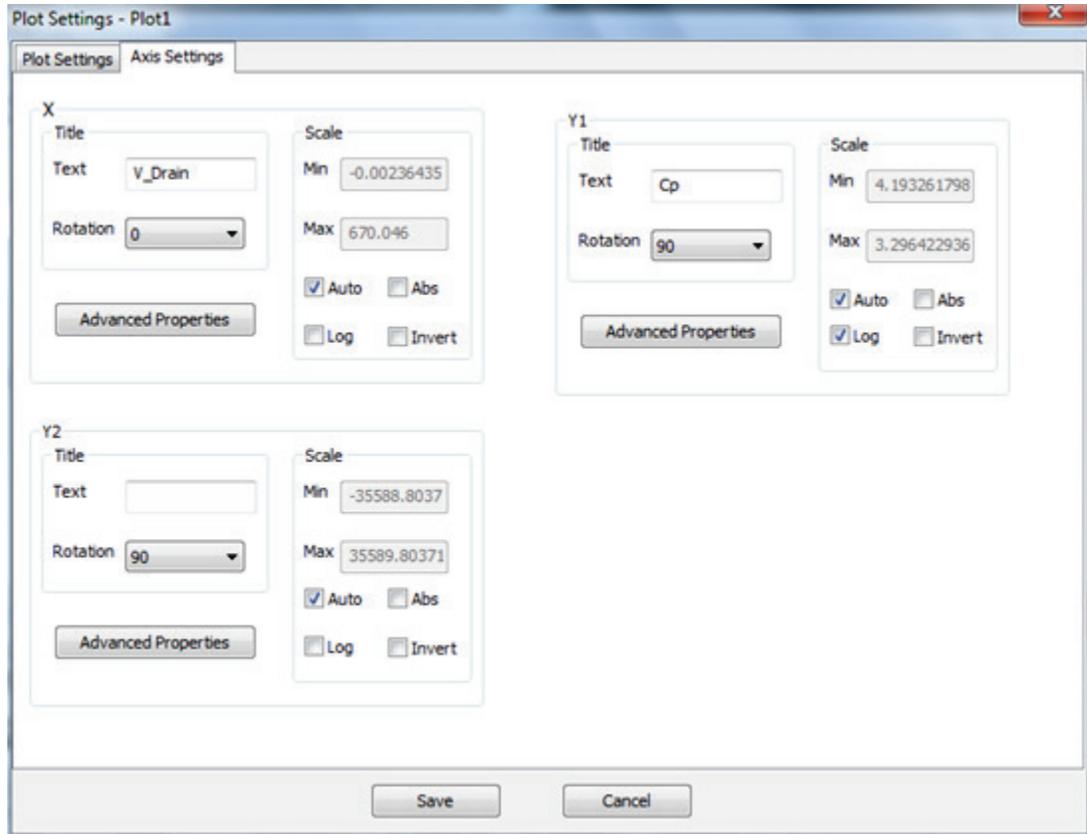
21. When the test runs you will note that this device has a large change in Coss data. Therefore a log scale on the y-axis may be appropriate. You can adjust the Plot and Axis settings by right-clicking the plot area.

Figure 143: C-V Coss test plot axis settings



22. Select the Axis settings tab.
23. Under Y1, select Log, then click the Save button (see the following graphic).

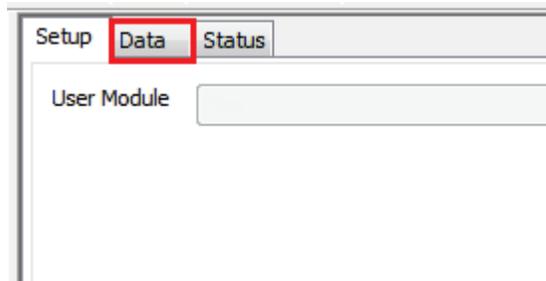
**Figure 144: Coss axis settings window**



You will note that there is a large change in the data between 0.1 and 10 V. You can take a closer look at this change by running a second sweep and appending the data.

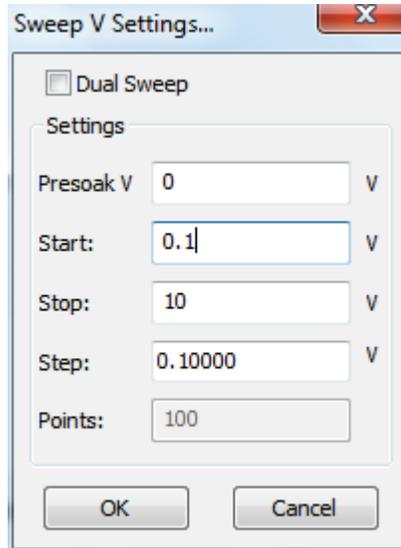
24. Click on the setup tab.

**Figure 145: Ciss setup tab**



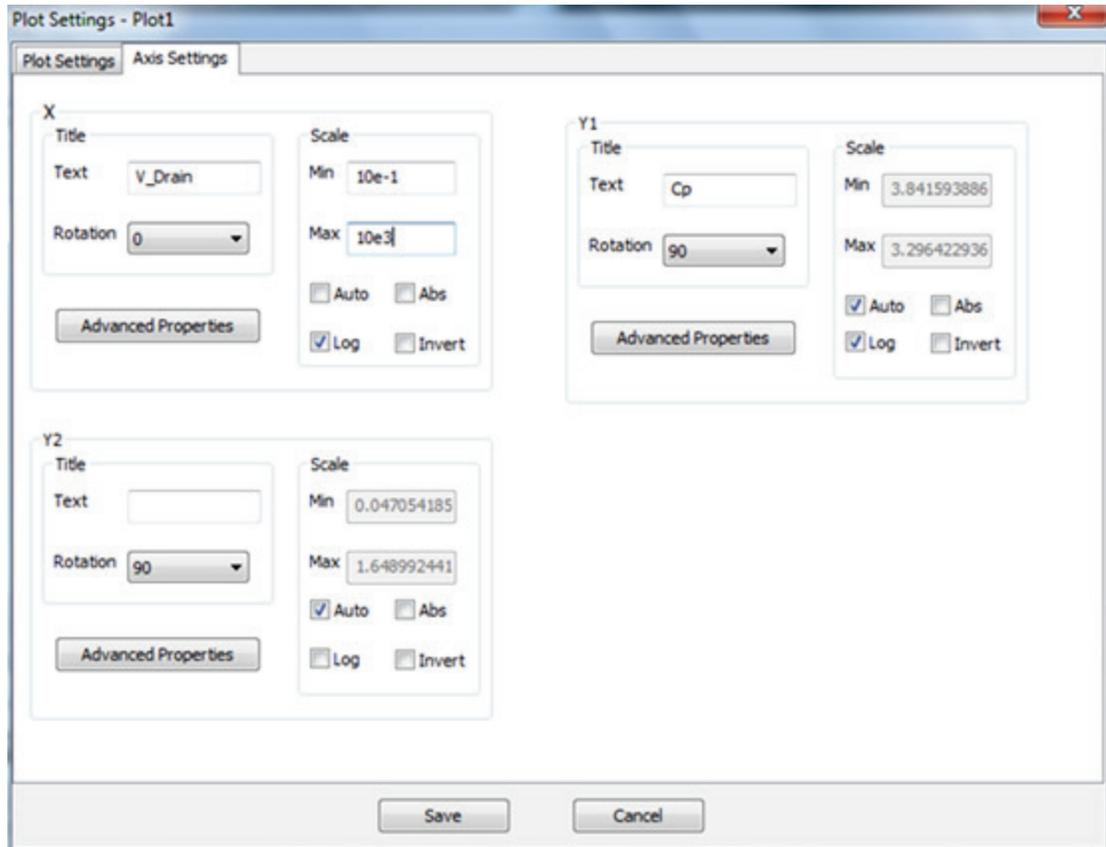
25. Double-click the source field for the Drain SMU to adjust the SweepV settings to sweep from 0.1V - 10 V in 0.1 V steps.

**Figure 146: Coss SweepV settings**



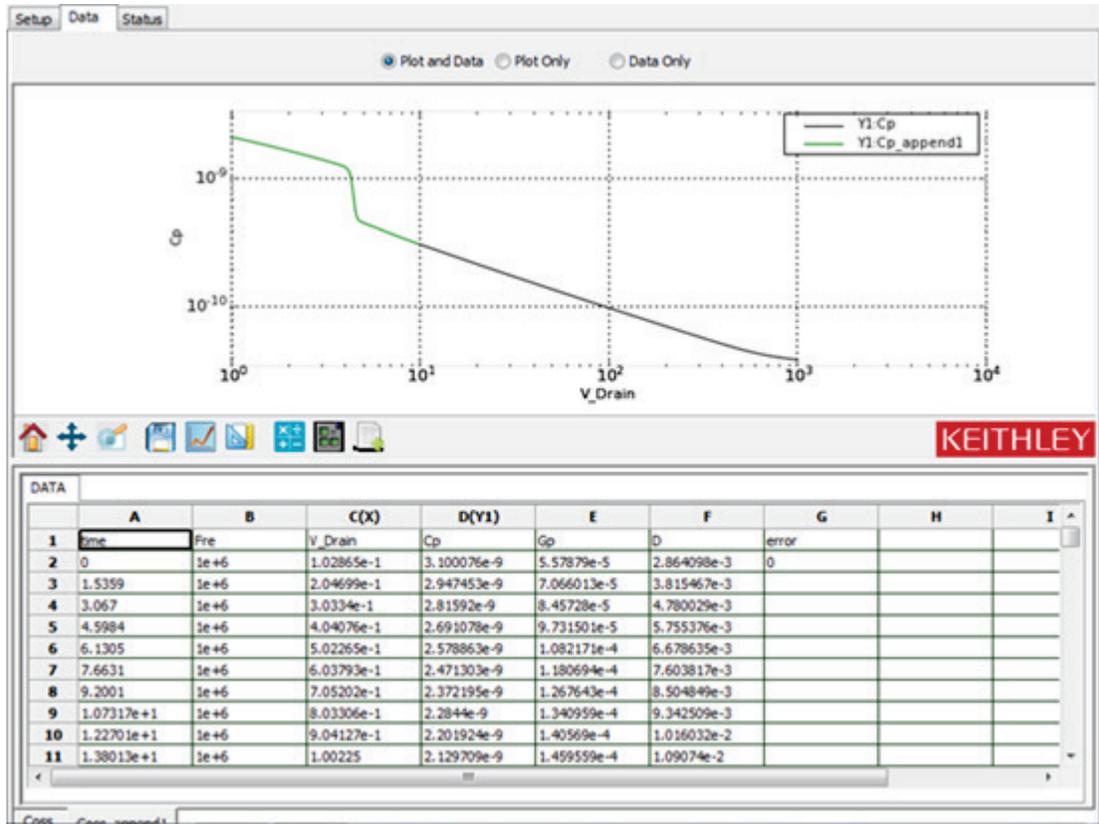
26. Click on the Data tab, then click the "Append Run" icon in the toolbar.
27. You can also adjust the X-axis to a log scale. Right-click on the graph and select "Plot and Axis Settings". Click on the "Axis Settings" tab and then check the "Log" checkbox under X. Uncheck "Auto" and set the minimum to  $10e-1$  and the max to  $10e3$ .

**Figure 147: Coss plot axis settings Log X**



- 28. Click the Save button.
- 29. When the test completes, the data should appear similar to the below graphic.

**Figure 148: Coss results from both sweeps**



**⚠ WARNING**

*If high voltage is used during the test, make sure a proper discharge procedure is performed before removing the top cover the Model 8020 or making connection changes inside of the Applications Test Fixture.*

## Make a Crss measurement

### *Crss measurement connection verification*

#### NOTE

Before you make measurements, make sure that you have connected your instruments correctly. See the [Model 8010 Crss test connections](#) (on page 5-10) or [Model 8020 Crss test connections](#) (on page 5-14) sections of this manual.

There is one change within the Model 8010 test fixture, but no changes at the device connections panel of the Model 8020 for this test.

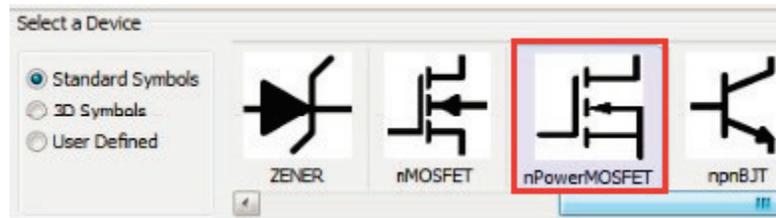
### *Make a Crss measurement*

#### NOTE

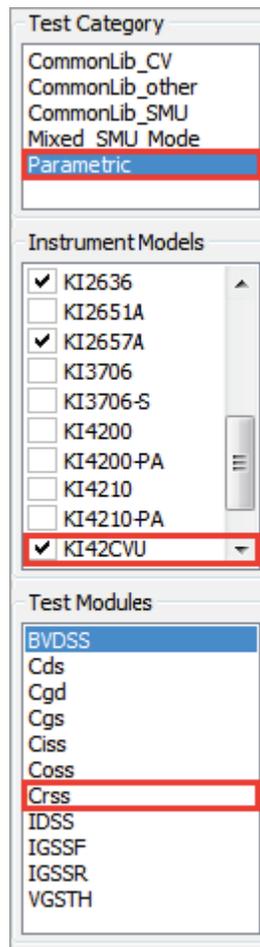
Make sure that you have performed open and short connection compensations prior making a measurement. See the previous section, [Perform connection compensations on C-V measurements](#) (on page 5-18), for more information and instructions.

1. Open the test library in the ACS Basic software by clicking on Project in the navigator or by clicking the library icon in the vertical toolbar.
2. Select the nPowerMOSFET from Select a Device panel (see the below figure).

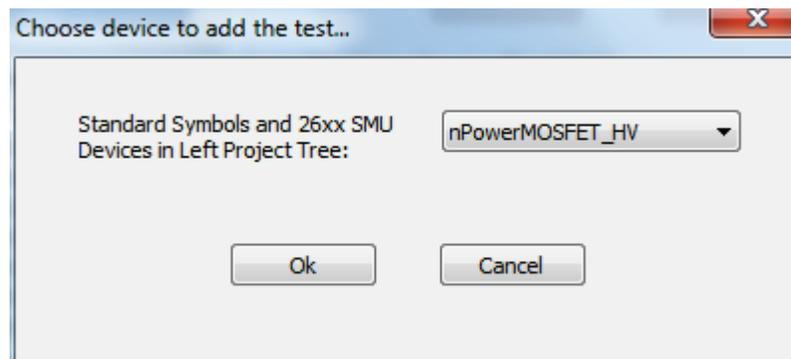
**Figure 149: Selecting the nPowerMOSFET device**



3. Select Parametric from Test Category (see below graphic).

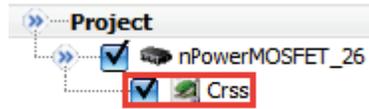
**Figure 150: Test options**

4. Select KI42CVU from Instrument Models.
5. Select Crss from Test Modules.
6. Click the Add Test button to add the Crss test to the project tree.
  - If prompted with Choose device to add the test, select the desired device from the drop-down menu and click OK (see below figure).

**Figure 151: Choosing device**

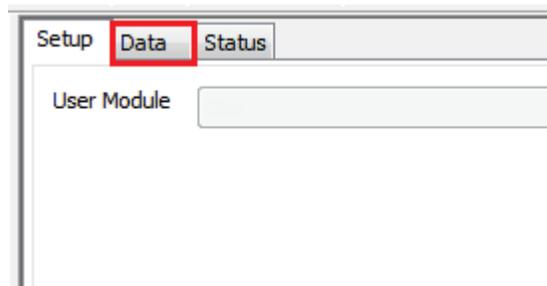
7. Double Click on the Crss test in the project tree to open the test to display the Crss test module (see the below figure).

**Figure 152: Crss test in project tree**



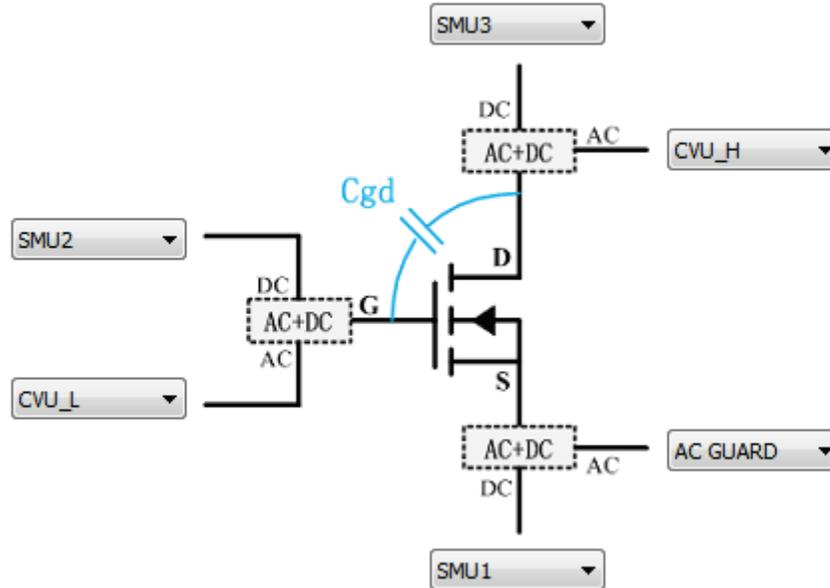
8. Click on the setup tab.

**Figure 153: Ciss setup tab**



9. Assign the SMUs as follows. Use the actual SMU number for your configuration (see the below graphic).

**Figure 154: Crss SMU assignments and block diagram (Model 8010 connections)**



**If using the Model 8010, use these configuration settings**

- **Drain** DC: SMU3 (2657A), AC: CVU\_H
- **Gate** DC: SMU2 (2600A, ch B), AC: CVU\_L
- **Source** DC: SMU1 (2600A, ch A), AC: AC GUARD

**If using the Model 8020, use these configuration settings**

- **Drain** DC: SMU3 (2657A), AC: CVU\_H
- **Gate** DC: SMU1 (2600B, ch A), AC: CVU\_L
- **Source** DC: SMU2 (2600B, ch B), AC: AC GUARD

**Quick Tip**

Hover the mouse pointer over the SMU pad to display the corresponding instrument model number.

- For the included sample device, Fairchild part number FQH8N100C, sweep voltage at the drain from 0 - 1000 V in 10 V steps. Adjust the sweep values by clicking on the Source field for the drain SMU.
- Configure the drain SMU to measure voltage.
- Configure the gate and source SMUs to have a source function of bias V with a source value of 0 V.
- For the CVU, set the measurement frequency to 1MHz by clicking on the Frequency field and selecting 1MHz from the list box.
- Use the default ACV of 30 mVrms
- Use the CP-G-D mode.

**Figure 155: Test settings table**

The screenshot shows the software interface for a Parametric Curve Tracer. At the top, there are tabs for 'Setup', 'Data', and 'Status'. Below that, the 'User Module' is set to 'Crss'. A central diagram shows a MOSFET with its Drain (D), Gate (G), and Source (S) terminals connected to SMU3, SMU2, and SMU1 respectively. Each SMU connection includes an 'AC+DC' block and an 'AC' block. A capacitor labeled 'Cgd' is connected between the Gate and Drain. To the left, a 'CVU Connection Compensation' window is open, showing a data file 'Crss\_Crsc\_Comp.csv' and options for 'Open', 'Short', and 'Using 8010 factory compensation'. Below the diagram is a table with columns: Pad, SMU, Pad Name, Function, Source, Measure, Compliance, Meas.Range, and Adv. The table lists settings for pads D, G, and S. At the bottom, there is another table with columns: Pad, CVU, Pad Name, Function, Frequency, ACV, Model, and Adv. The bottom table shows settings for pad D.G, CVU CVU\_H\_L, Pad Name Crss, Function C vs.V, Frequency 1M Hz, ACV 30mVRMs, and Model Cp-Gp-D. At the very bottom, there are buttons for 'Script', 'GUI', 'Import', and 'Save'.

Pad	SMU	Pad Name	Function	Source	Measure	Compliance	Meas.Range	Adv
D	SMU3	Drain	Sweep V	[0, 0, 1000, 101]	V	0.001		
G	SMU2	Gate	Bias V	[0, 0]	None	0.001		
S	SMU1	Source	Bias V	[0, 0]	None	0.001		

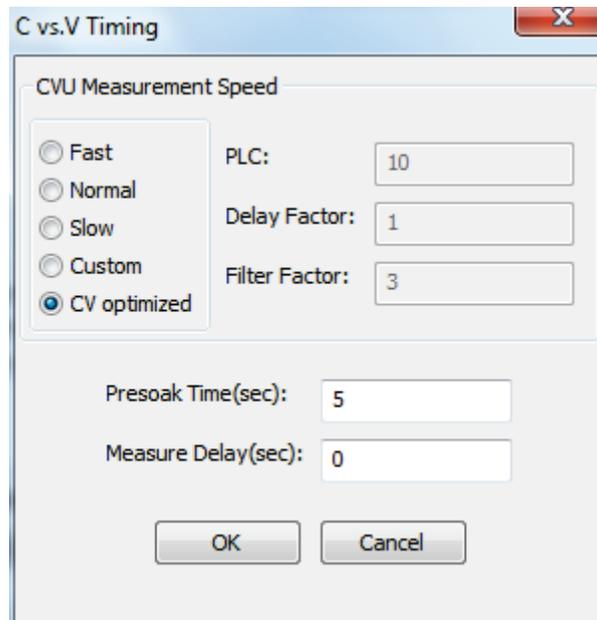
Pad	CVU	Pad Name	Function	Frequency	ACV	Model	Adv
D.G	CVU_H_L	Crss	C vs.V	1M Hz	30mVRMs	Cp-Gp-D	

## Quick Tip

For the Crss test module, the capacitance measurement function is fixed to capacitance vs. voltage. To see capacitance as a function of frequency, use the Generic HV CV Test under the CommonLib\_CV test category. Refer to the ACS BE user's manual for information on using this test module.

16. Click the Timing button.
17. Ensure that CV optimized is selected and the presoak time is 5 seconds.

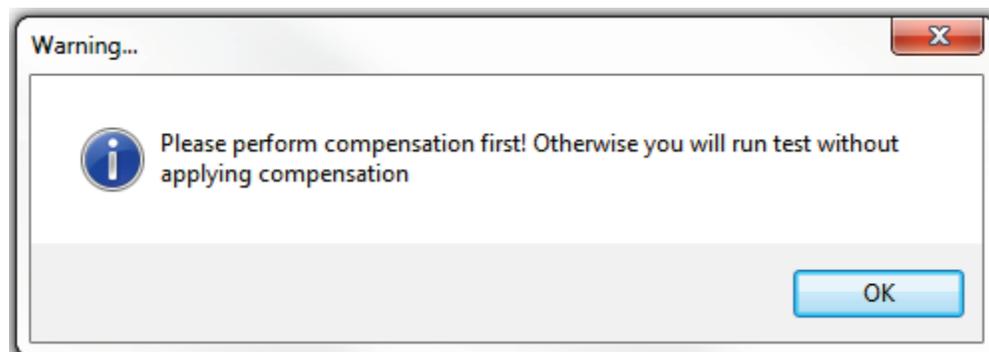
**Figure 156: C-V timing window**



18. Check the Open and Short boxes in the CVU Connection Compensation area enable to apply the compensation to the measured data.

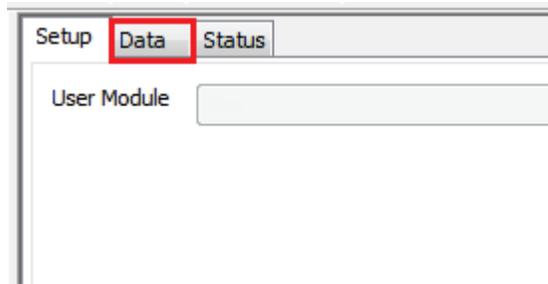
The latest compensation will be loaded automatically. If no prior compensation has been performed, you may receive the below error message (see below graphic). To perform the compensation, see the previous section, [Perform connection compensation on C-V measurements](#) (see "[Perform connection compensations on C-V measurements](#)" on page 5-18).

**Figure 157: Warning that compensation was not performed**



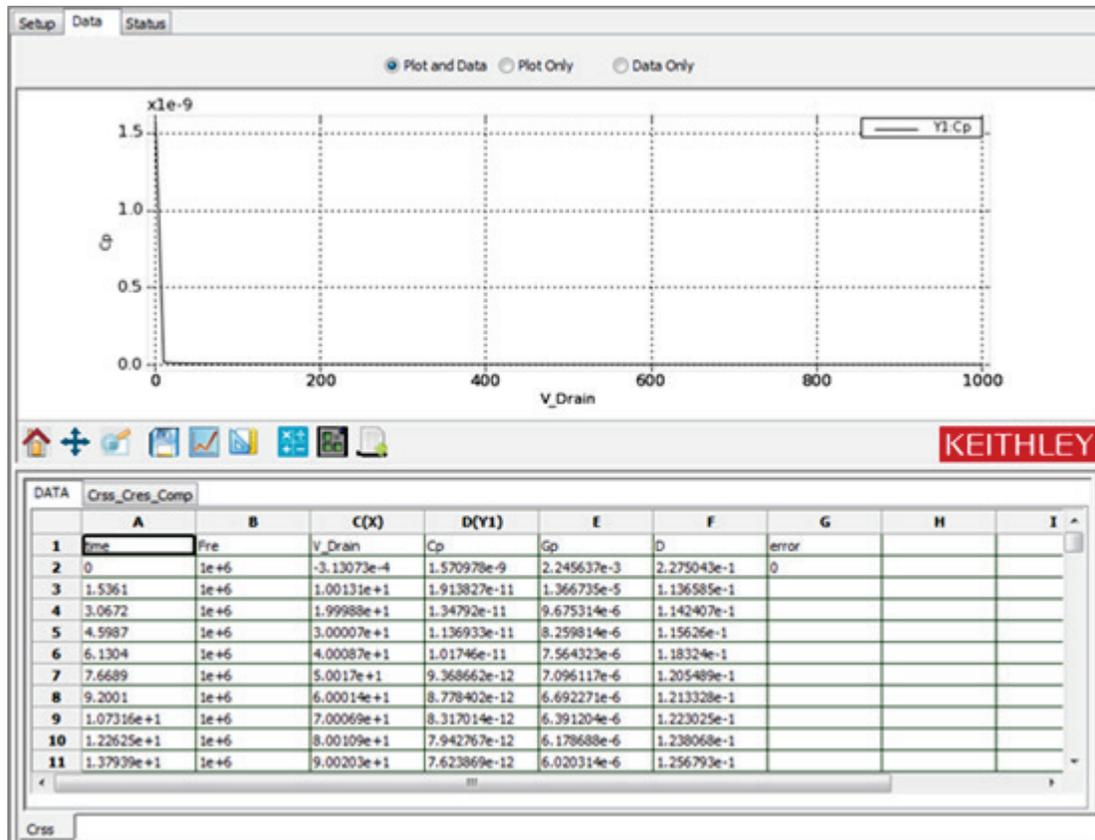
- Sample data and pilots are included with the test. Switch to the Data tab (see the following graphic).

**Figure 158: Data tab**

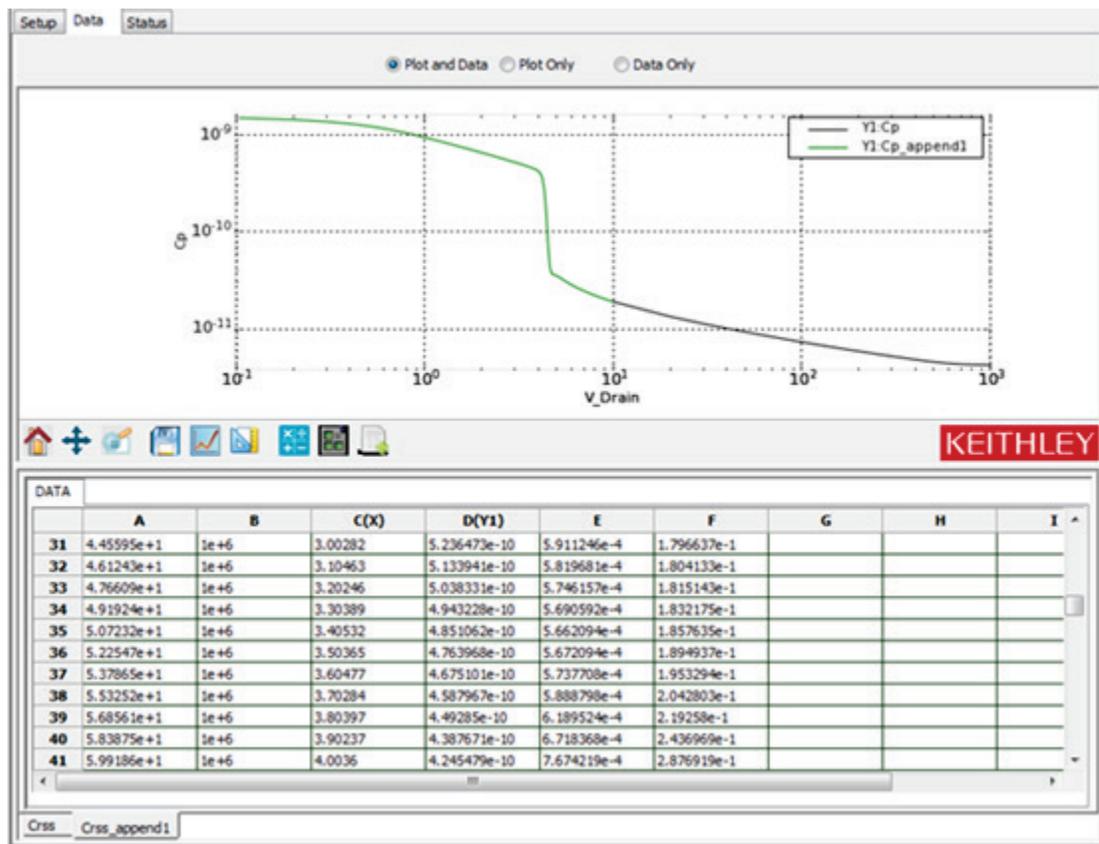


- Click the Run icon to start the test (see below graphic).

**Figure 159: Run icon**



21. As was true for the  $C_{oss}$  data for this device, there is a large change in the measured data for  $C_{rss}$ . You can adjust the Plot and Axis settings to plot on a log scale by right-clicking the plot area and selecting Plot and Axis settings.
22. Check the "Log" checkbox for Y1.
23. Take a closer look at the data between 0.1 and 10 V by running a second sweep and appending the data. Go back to the Setup tab and change the sweep settings by double clicking the Source field for the Drain SMU.
24. Append the data from this second sweep to the original data by clicking the AppendRun button in the tool bar.
25. Set the X-axis to log scale by right-clicking the graph and selecting "Plot and Axis Settings".
26. Select the Axis settings tab, then check the "Log" checkbox for the X axis. Uncheck "Auto" and enter min and max scales of  $10e-1$  and  $10e3$  respectively.
27. Click the Save button to apply the settings. The final results should be similar to the below graphic.

Figure 160:  $C_{rss}$  data run 2

## ⚠ WARNING

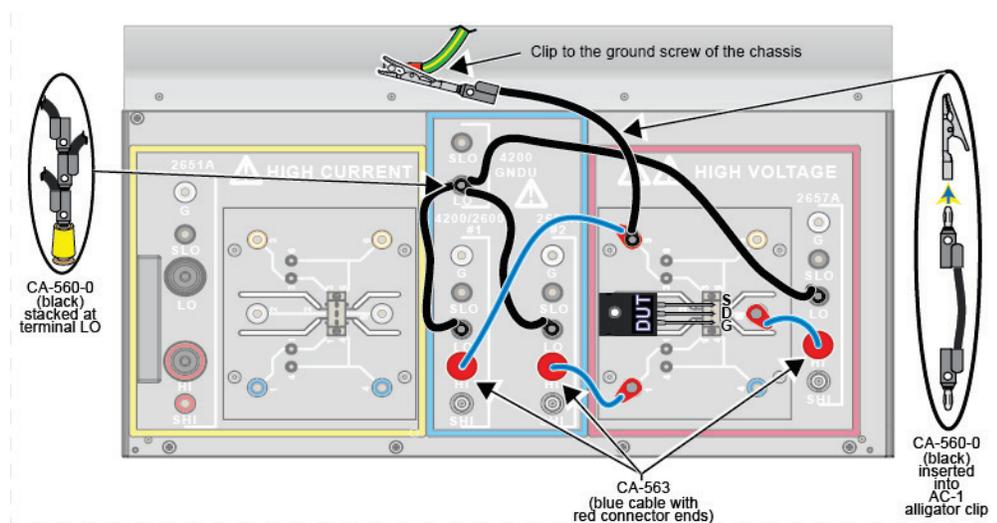
*If high voltage is used during the test, make sure a proper discharge procedure is performed before removing the top cover the Model 8020 or making connection changes inside of the Applications Test Fixture.*

## Optimizing Crss measurement connections for difficult measurements

Crss measurement accuracy is affected by the size of the Cds and Cgs capacitors. The proximity of AC guard to the device under test also impacts Crss accuracy. AC guard should be very near the virtual ground of the C-V meter, which is the return shield for the C-V measurements (the outer shell of the triaxial cable).

If AC guard differs widely from virtual ground, then it is not an effective guard terminal. In some cases, you will need to adjust connections in order to get a better AC guard voltage and thus a better Crss measurement. Evidence of a need to change connections is when Crss differs from the expected value or is very unstable across frequency. To improve measurements, you can also connect the FET Source Terminal to ground close to the device under test. The Model 8010 uses these optimized connections by using a banana jumper and alligator clip to connect the FET source terminal to the chassis of the Model 8010. See the below graphic for details.

**Figure 161: Model 8010 test board improved connection setup**



When using the Model 8020 with a probe station, you may find that connecting to the Common LO terminal or using a shorting plug at the connector nearest the probe accomplishes this. See the following graphics for details.

The first connection diagram (see next graphic) details connections to Common LO. The diagram following this shows how to make a short at the device under test, perhaps at the probe station positioner. It may be possible to do this using an adapter that shorts the center conductor to the outer shell, so long as the outer shell connects to chassis ground.

**Figure 162: Crss measurement optimization, method 1**

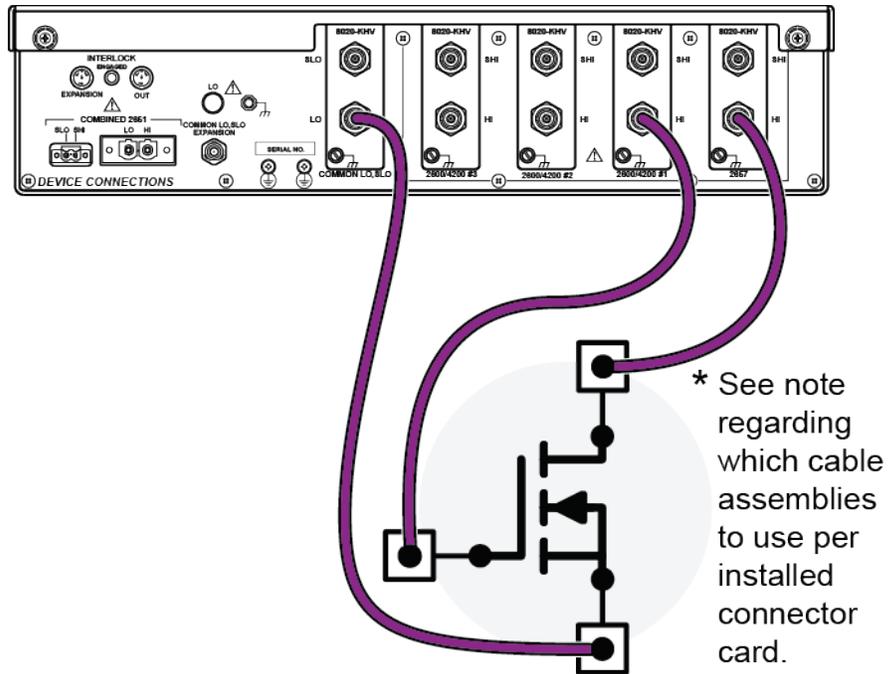
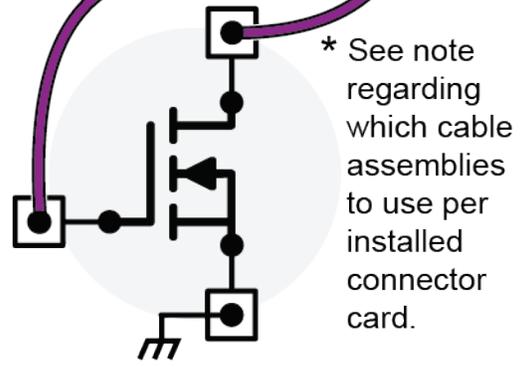
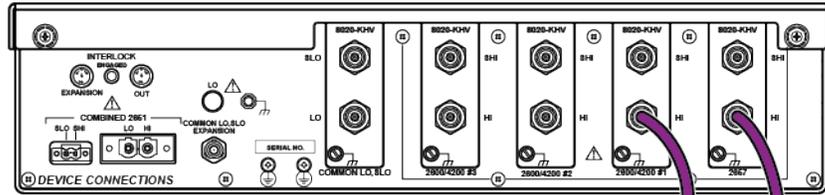
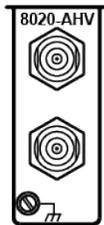


Figure 163: Crss measurement optimization, method 2



\* See note regarding which cable assemblies to use per installed connector card.

\* Cable assemblies will depend upon the connector card the user installs



Connector Card:  
8020-AHV

Cable Assembly:  
User supplied



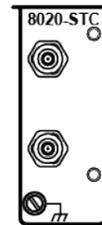
Connector Card:  
8020-KHV

Cable Assembly:  
Model HV-CA-554



Connector Card:  
8020-SHV

Cable Assembly:  
User supplied



Connector Card:  
8020-STC

Cable Assembly:  
Model 7078-TRX  
or  
Model 4200-TRX

---

## Troubleshooting FAQs

### In this section:

---

Missing cables.....	6-1
2600-PCT-1B and C-V measurements.....	6-1
2600-PCT-2B and C-V measurements.....	6-1
Custom tests in ACS Basic.....	6-2

### Missing cables

Q: I opened my instrument box and didn't find any cables to connect to the test fixture or interface panel.

A: All cables required to connect instrument to 8010 or 8020 are individually packaged and are included in the "Open Me First" box.

### 2600-PCT-1B and C-V measurements

Q: I have a 2600-PCT-1B and I want to use C-V. I don't have a third SMU. How do I connect to the DC input of the third bias tee?

A: Connect the force terminal of the GNDU of the PCT-CVU to the third bias tee. In this configuration, there will be no bias possible at the third bias tee. Detailed drawings of this connection this using the 2636B and the CVU-200-KIT Bias Tee Kit are provided in the Model 8010 User's Manual. See the Keithley Instruments website at [www.keithley.com](http://www.keithley.com) <http://www.keithley.com> for more information.

### 2600-PCT-2B and C-V measurements

Q: I have a 2600-PCT-2B and I want to use C-V. Can I connect the Model 2651A to the third bias tee? How can I do this?

A: Do not connect the Model 2651A to a bias tee, because the bias tee cannot support the current capability of the instrument. Connect the force terminal of the GNDU of the PCT-CVU to the third bias tee. In this configuration, there will be no bias possible at the output of the third bias tee.

## Custom tests in ACS Basic

Q: Can I use ACS Basic to create tests not included in the device library?

A: Yes. You can use ITMs to configure specific settings for each SMU connected to the device or you can write custom code using Script Test Modules (STMs) or Python Test Modules (PTMs) to control other instruments. See the ACS Basic manual for more information on creating custom tests.

## A

### ACS Basic

- device interface configuration • 3-10
- hardware configuration, verifying • 3-9
- installation • 3-4
- test modes • 3-10

## C

- configurations, available • 1-2
- connections • 2-3, 2-4, 2-5, 2-6
  - safety • 2-3
  - to the Model 8010 • 2-5
  - to the Model 8020 • 2-6
- contact information • 1-2

## E

- extended warranty • 1-2

## F

- FAQs • 6-1

## G

### GPIB

- interface connection • 3-1
- setup • 3-1

## T

- troubleshooting • 6-1
  - FAQs • 6-1
- TSP-Link
  - nodes • 3-2

## W

- warranty • 1-2

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.keithley.com](http://www.keithley.com)

---



A Greater Measure of Confidence