

Tektronix

4200A-SCS Parameter Analyzer Introduction

LUNA KIM

KEITHLEY
A Tektronix Company



Agenda

- System overview
 - SMU
 - CVU
 - PMU
 - Clarius Program with Demo
- KCon / KULT / KXCI
- New products

4200A-SCS Parameter Analyzer

ACCELERATING INSIGHT

- Integrated parameter analyzer that reduces characterization complexity, troubleshooting and test set up time.
- Fully characterize a device, material or process
 - DC I-V Source Measure Units (SMU)
 - AC Impedance Capacitance-Voltage Unit (CVU)
 - Pulsed I-V Pulse Measure Unit (PMU)
- Industry's easiest methods to switch between I-V, C-V and Pulsed I-V measurements
- Jumpstart testing with over 250 user-modifiable, searchable application tests
 - No complex programming required
- Industry's first instrument with built-in measurement videos
 - "YouTube-like" experience
 - Get answers faster and investigate unexpected results more quickly



4200A-SCS
Parameter Analyzer

4200A-CVIV
Multi-Switch

A Complete Solution from DC to Pulse

4200A-SCS Parameter Analyzer			
System Software	Clarius™ with >450 application tests/projects/devices		
I-V Measurements	Medium Power SMU 210V, 100mA	High Power SMU 210V, 1A	Remote Pre-amplifier 0.1 fA resolution
Pulse I-V/Transient	Pulse Measure Unit	Pulse Generator Unit	
C-V Measurements	Capacitance-Voltage Unit 1kHz to 10MHz	Ramp-Rate (Quasi Static) C-V	Very Low Frequency VLF C-V
Switching	IV/CV Multi-Switch Module	Remote Preamplifier/Switch Module	Ultra Low Current Switch Matrices
Drivers for Probe stations, temp. controllers, external equipment			

DC I-V Source Measure Units (SMU)

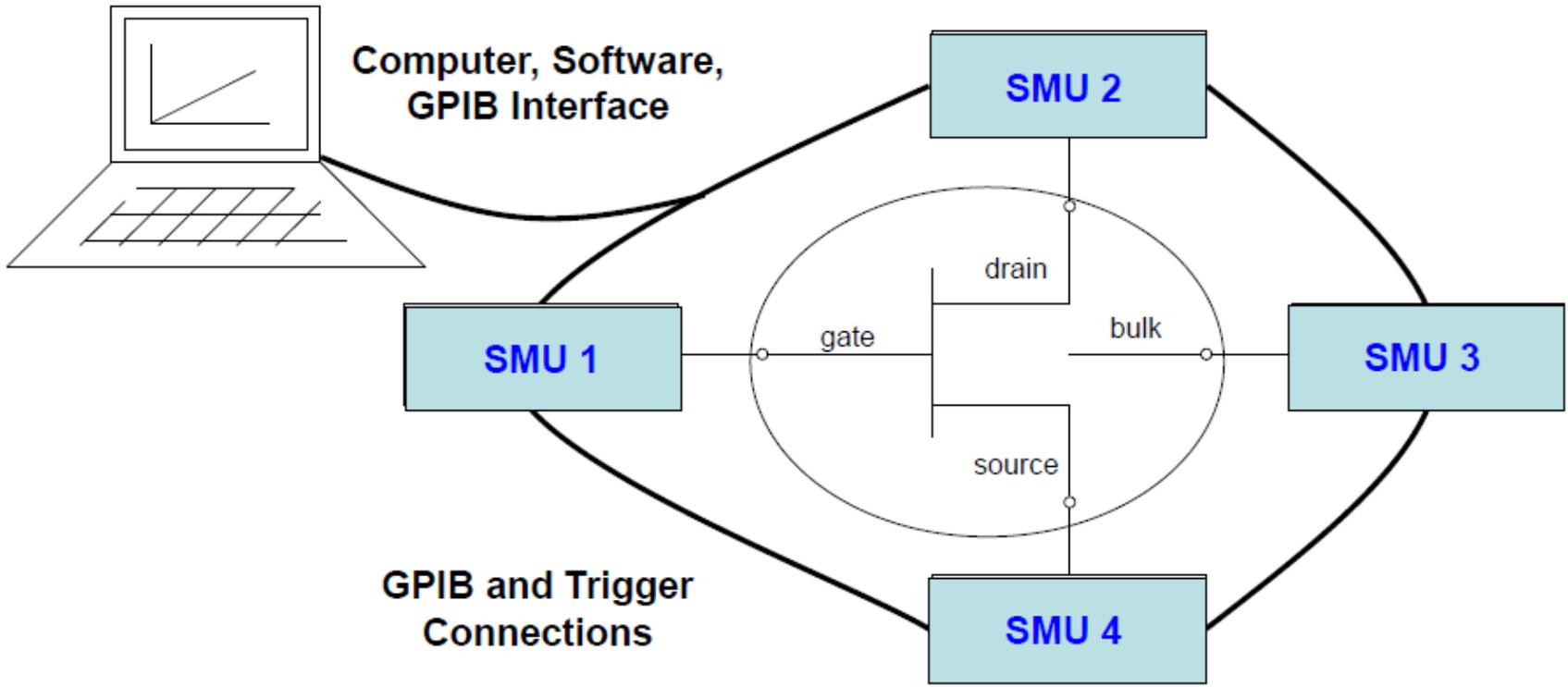
4200-SMU and 4210-SMU

4201-SMU and 4211-SMU

A Parameter Analyzer can have multiples SMUs

Multiple SMUs are required when performing I-V characterization on devices that have more than two terminals like MOSFETs.

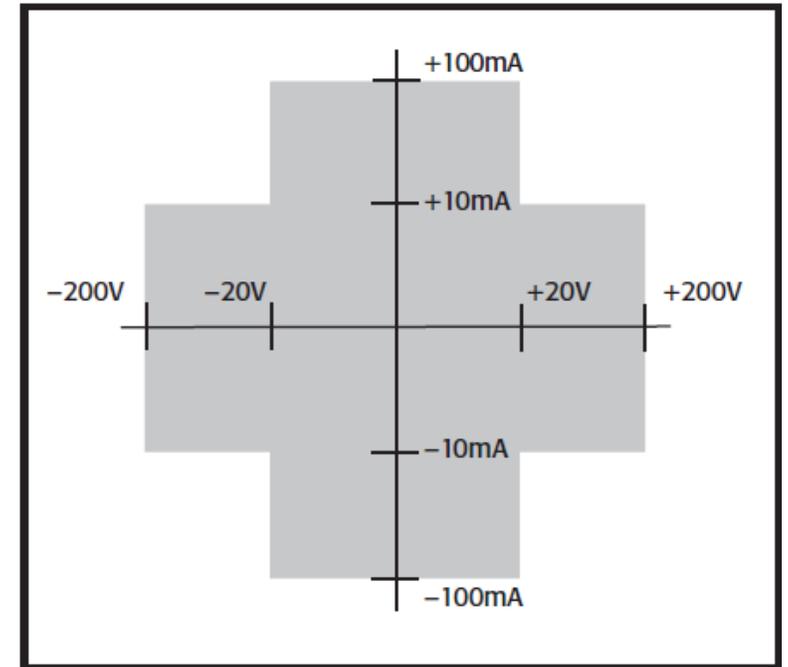
The source and measure timing of all the SMUs in the parameter analyzer are synchronized.



What is a SMU?

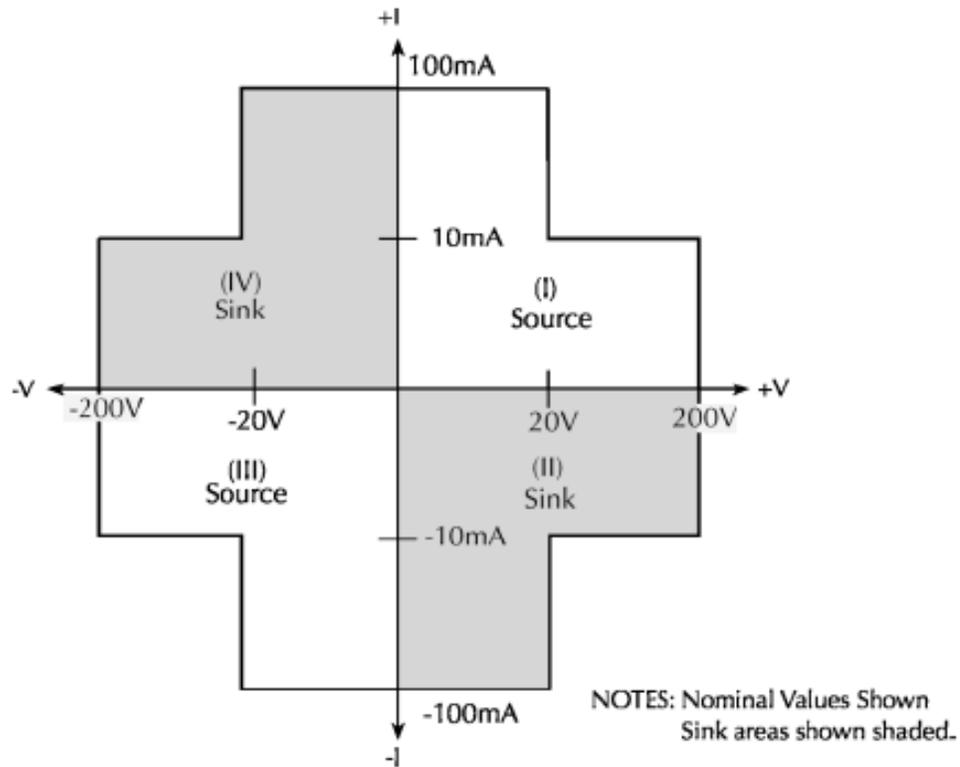
SOURCE MEASURE UNIT (SMU)

- **4200-SMU Medium Power SMU**
 - +/- 210 V, +/- 100 mA, 100 fA resolution
- **4210-SMU High Power SMU**
 - +/- 210 V, +/- 1 A, 100 fA resolution
- **4200-PA optional pre-amplifier**
 - Extends SMU current range and supports 0.1 fA resolution
- 6 ½ digit A/D per SMU for parallel, simultaneous, high-precision measurements
- *All slots in the 4200-SCS can be configured with any SMU*

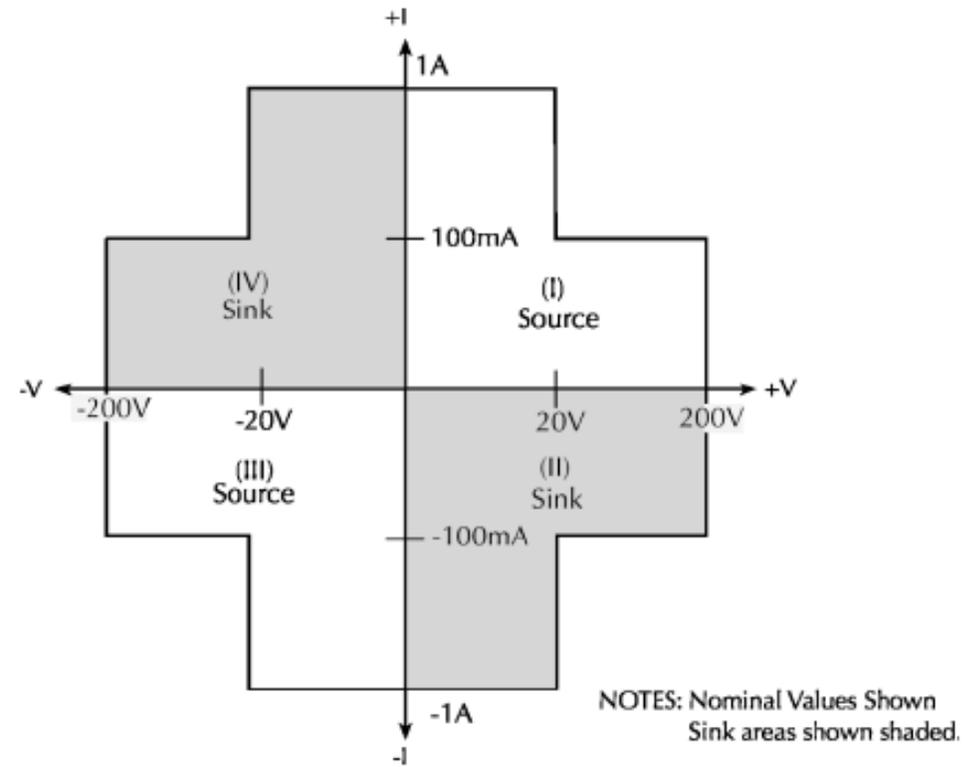


Operating Boundaries

4200-SMU: 105mA, 21V
10.5mA, 210V



4210-SMU: 1.05A, 21V
105mA, 210V

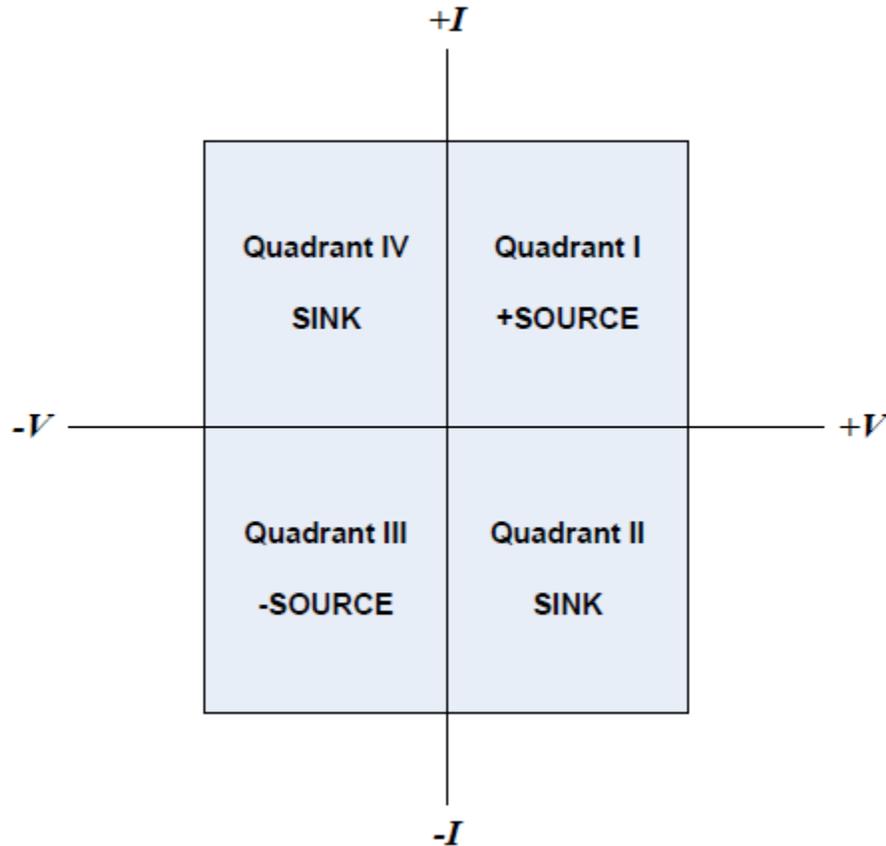


SMU Measurement Characteristics

CURRENT SPECIFICATIONS										
	CURRENT RANGE ¹		MAX. VOLTAGE		MEASURE		SOURCE			
					RESOLUTION ³	ACCURACY ±(% rdg + amps)	RESOLUTION ³	ACCURACY ±(% rdg + amps)		
4210-SMU ² High Power SMU	1	A	21	V	1	μA	0.100% + 200 μA	50	μA	0.100% + 350 μA
	100	mA	210	V	100	nA	0.045% + 3 μA	5	μA	0.050% + 15 μA
	100	mA	21	V	100	nA	0.045% + 3 μA	5	μA	0.050% + 15 μA
	10	mA	210	V	10	nA	0.037% + 300 nA	500	nA	0.042% + 1.5 μA
	1	mA	210	V	1	nA	0.035% + 30 nA	50	nA	0.040% + 150 nA
	100	μA	210	V	100	pA	0.033% + 3 nA	5	nA	0.038% + 15 nA
	10	μA	210	V	10	pA	0.050% + 600 pA	500	pA	0.060% + 1.5 nA
	1	μA	210	V	1	pA	0.050% + 100 pA	50	pA	0.060% + 200 pA
4200-SMU and 4210-SMU with optional 4200-PA PreAmp	100	nA	210	V	100	fA	0.050% + 30 pA	5	pA	0.060% + 30 pA
	10	nA	210	V	10	fA	0.050% + 1 pA	500	fA	0.060% + 3 pA
	1	nA	210	V	3	fA	0.050% + 100 fA	50	fA	0.060% + 300 fA
	100	pA	210	V	1	fA	0.100% + 30 fA	15	fA	0.100% + 80 fA
	10	pA	210	V	0.3	fA	0.500% + 15 fA	5	fA	0.500% + 50 fA
	1	pA	210	V	100	aA	1.000% + 10 fA	1.5	fA	1.000% + 40 fA

VOLTAGE SPECIFICATIONS														
	VOLTAGE RANGE ¹		MAX. CURRENT		MEASURE		SOURCE							
					Resolution ³	Accuracy ±(% rdg + volts)	Resolution ³	Accuracy ±(% rdg + volts)						
200	V ⁴	10.5	mA	105	mA	200	μV	0.015% + 3	mV	5	mV	0.02% + 15	mV	
20	V	105	mA	1.05	A	20	μV	0.01	% + 1	mV	500	μV	0.02% + 1.5	mV
2	V	105	mA	1.05	A	2	μV	0.012% + 150	μV	50	μV	0.02% + 300	μV	
200	mV	105	mA	1.05	A	1	μV	0.012% + 100	μV	5	μV	0.02% + 150	μV	

Four Quadrant Operation



- SMUs can operate in one of four quadrants.
- Quadrants I and III are sourcing (I and V have same polarity):
 - Sourcing SMUs deliver power to load.
- Quadrants II and IV are sinking (I and V have different polarity):
 - Sinking SMUs dissipate power.

Compliance

Built-in mechanism that limits current or voltage depending on whether the SMU is configured as a V-Source or I-Source.

SMU as V-Source

- Compliance limits the maximum current that may be output to the device.
- When compliance is reached, the SMU effectively becomes a constant current source

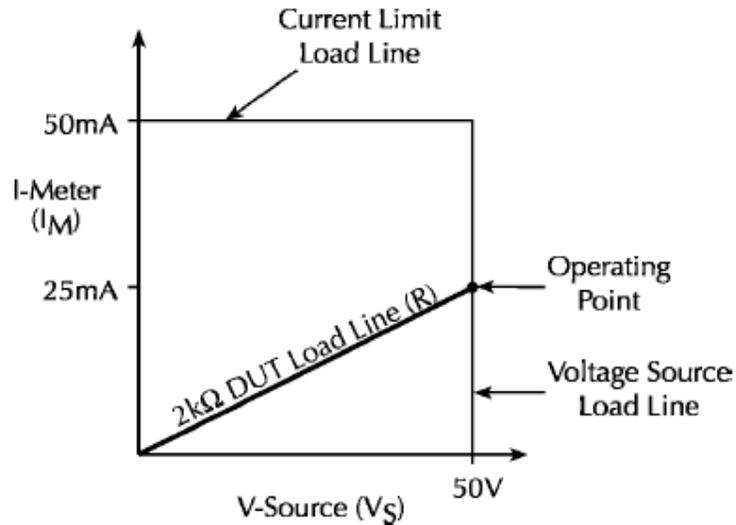
SMU as I-Source

- Compliance limits the maximum voltage that appears across the output terminals (Local sense) or across the device (Remote sense).
- When compliance is reached, the SMU effectively becomes a constant voltage source.

Understanding Compliance

Set Voltage to 50V and Compliance to 50mA

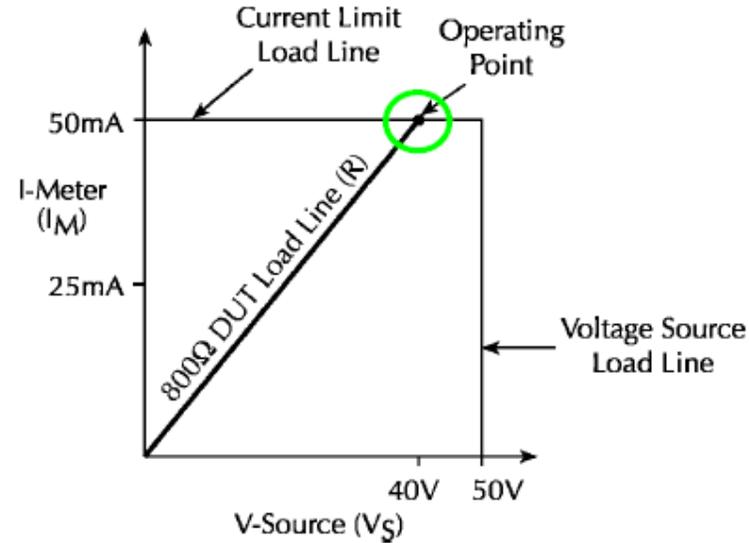
Normal V-Source Operation



$$R = 2k\Omega$$

$$\begin{aligned} I_M &= V_S / R \\ &= (50V) / (2000\Omega) \\ &= 25mA \end{aligned}$$

V-Source in compliance



$$R = 800\Omega$$

$$\begin{aligned} I_M &= V_S / R \\ &= (50V) / (800\Omega) \\ &= 62.5mA \end{aligned}$$

No !
I-Limit is 50mA !!

$$R = 800\Omega$$

$$\begin{aligned} V_S &= I_M \cdot R \\ &= (50mA) \cdot (800\Omega) \\ &= 40V \end{aligned}$$

SMU has become
a current source!

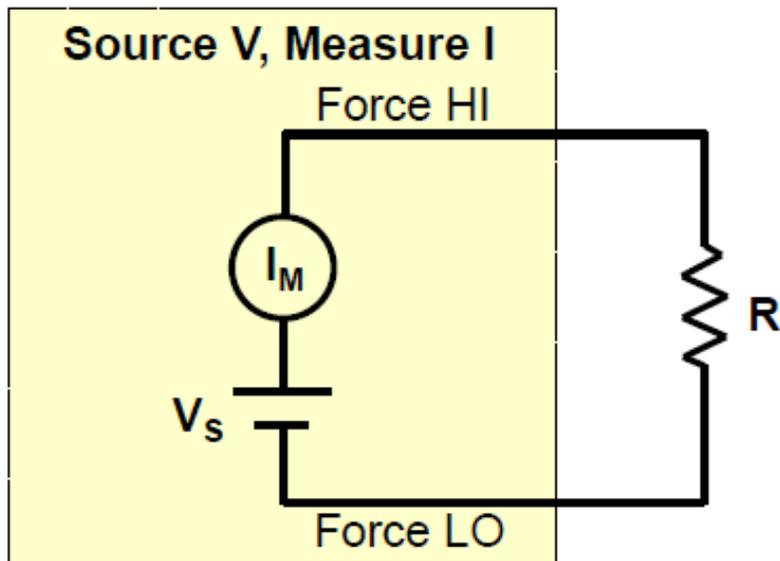
Local vs Remote Sensing

Local Sense

(2-wire measure)

Use when lead resistance is negligible compared to DUT resistance. Examples:

- Measuring resistance of insulators
- Measuring low current

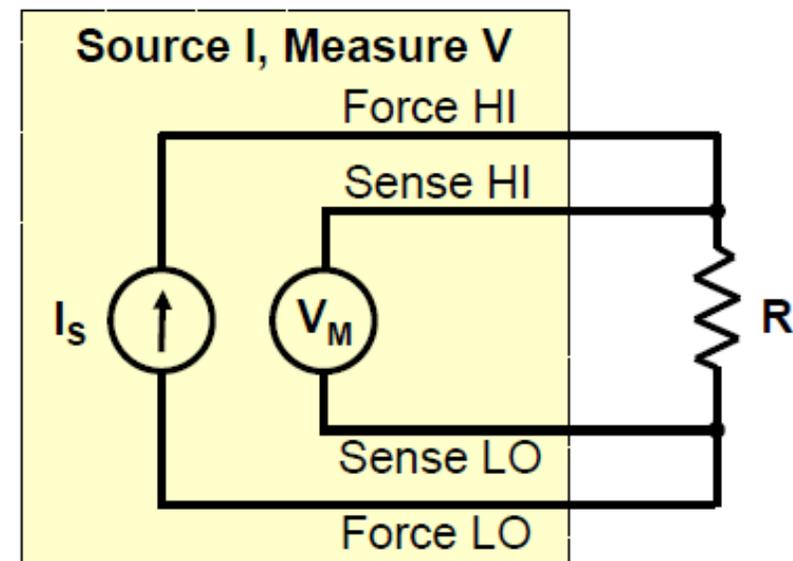


Remote Sense

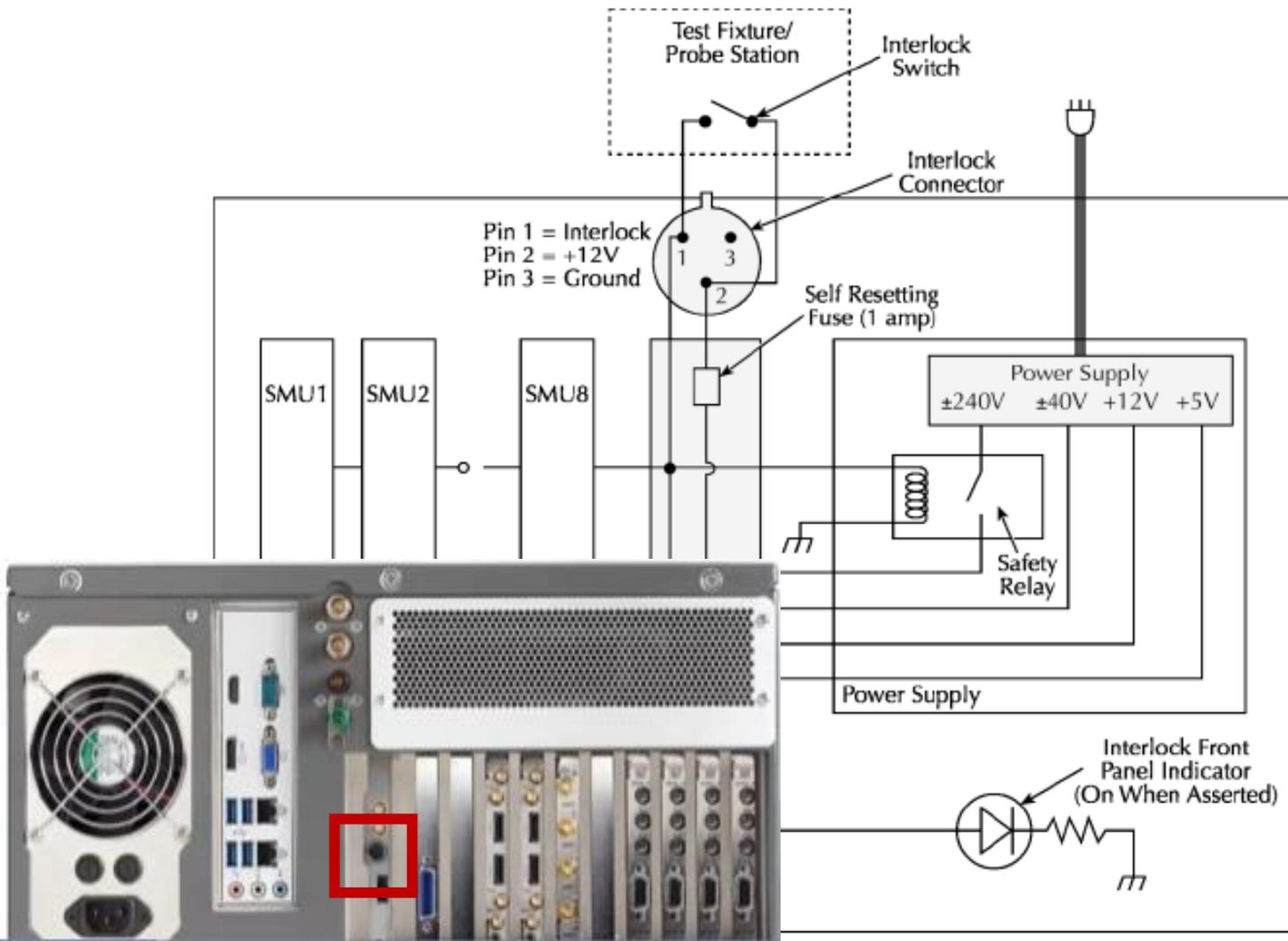
(4-wire measure)

Use to eliminate lead and contact resistance from affecting measure accuracy. Examples:

- Measuring low resistance ($<10\Omega$)
- Sourcing voltage at a high current



Interlock connections



- Without interlock, SMU output is limited to about 42V
- Interlock will engage the 200V range
- Use supplied interlock cable to connect to safety switch on test fixture or probe station dark box
- Safety switch closes circuit between pins 1 and 2 of the interlock cable
- Green Interlock LED on 4200-SCS front panel will be lit when interlock is engaged
- **DO NOT SHORT PIN 3 TO OTHER PINS!**

Capacitance-Voltage Unit (CVU)

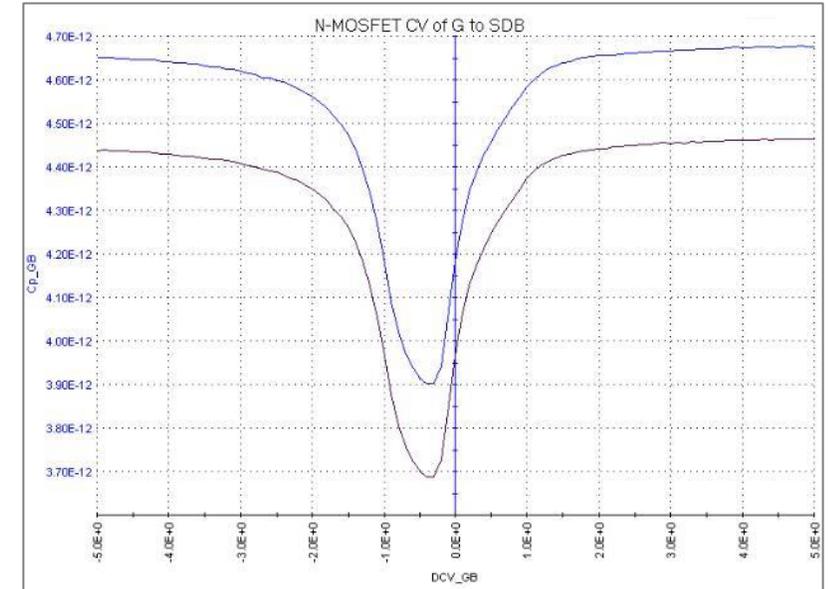
4210-CVU

4215-CVU

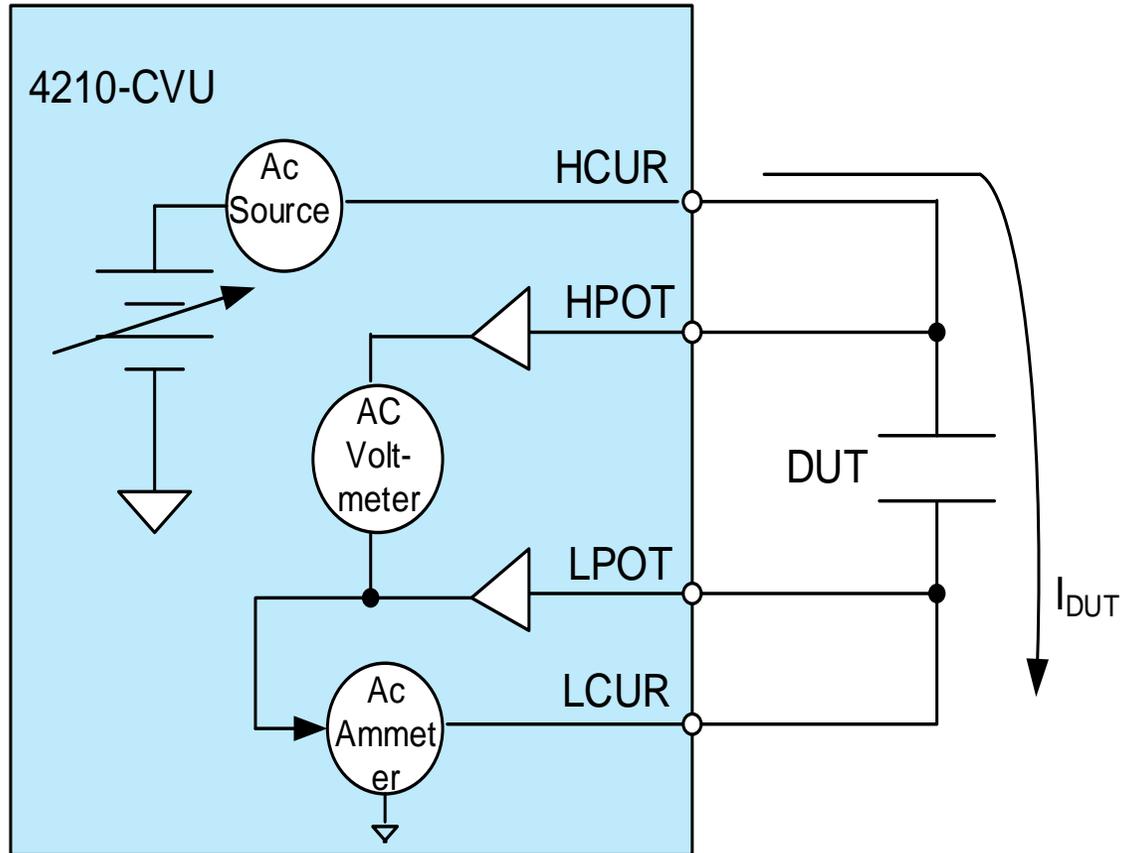
Multi-frequency AC Impedance

4210-CVU CAPACITANCE-VOLTAGE

- Test frequencies from 1KHz to 10MHz
- DC source (sweep) +/-30 V (60 V differential) internal
- External DC bias up to +/- 200V (400V differential) using SMUs
- Extensive sample programs in Clarius library
- Parameter extraction examples



CVU Measurement Overview



Measures AC impedance (Z_{DUT}) of the DUT by sourcing an AC voltage across the device and measuring the resulting AC current and phase.

The time-domain AC values are processed into the frequency-domain to produce the phasor form of the impedance.

The capacitive impedance (and conductance) are calculated based on the measured AC impedance and the phase.

The capacitance is calculated from the impedance and the test frequency:

$$C_{DUT} = \frac{I_{DUT}}{2\pi f V_{ac}}$$

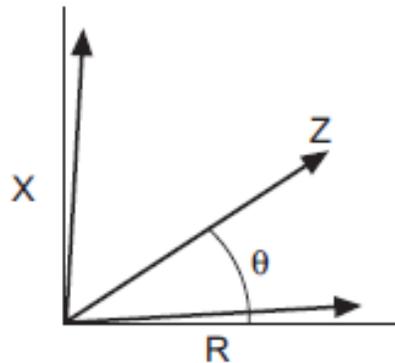
Measured Parameters

The Model 4200-CVU can measure the following parameters:

- Z, Theta Impedance and Phase Angle
- R + jX Resistance and Reactance
- Cp-Gp Parallel Capacitance and Conductance
- Cs-Rs Series Capacitance and Conductance
- Cp-D Parallel Capacitance and Dissipation Factor
- Cs-D Series Capacitance and Dissipation Factor

Figure 15-2 shows the vector diagram and fundamental equations for impedance.

Figure 15-2
Vector diagram for impedance (**Z**)



$$|Z| = \sqrt{R^2 + X^2}$$

$$Z = R + jX$$

$$\theta = \arctan\left(\frac{X}{R}\right)$$

$$R = Z \cos \theta$$

$$X = Z \sin \theta$$

$$Y = \frac{1}{Z} = (G + jB)$$

Z = Impedance

theta = Phase Angle

R = Resistance

X = Reactance

Y = Admittance

G = Conductance

Unique Tools to Simplify C-V Measurements

EXCLUSIVE FEATURES FOUND ONLY IN 4200A-SCS

- Move the AC measurement and DC Bias to least noisy terminal with just a mouse click
 - No re-cabling or changing the test setup
 - Faster research and time to answer
- Real time capacitance measurements
 - Check your switch matrix, prober connections before beginning a test
- Confidence Check
 - Reveals problems before you begin C-V test
 - Provides troubleshooting tips

The screenshot displays the software interface for the 4200A-SCS. On the right, the 'Advanced' settings panel includes:

- AC Source V: CVH1
- AC Measure I Range(CVL1): Auto
- DC Source V: CVH1
- DC Offset(CVL1): 0 V

Below this is the 'Capacitance Range Estimator' section:

- C Max: 1.59mF
- I Max (Range): 1mA
- Frequency: 1MHz
- AC Drive Voltage: 30mV RMS

On the left, a 'CVU1 Confidence Check' window is open, showing a 'Status' section with the following text:

Performing Open Check
Sourcing HI side
The open circuit Offset Impedance with Noise on HI Side Source and Sense Cables appear to be Open!
Anything smaller than 150K Ohms

Sourcing LO side
The open circuit Offset Impedance with Noise on LO Side Source and Sense Cables appear to be Open!

Open Check FAILED!

Troubleshooting:

- Are you using the Red Keithley Cables?
- Check your cables for proper connection/ proper torque.
- Check for shorted or open cables.
- Is the chuck connected? What is the chuck isolation from ground? Is the chuck generating noise?
- Is there a high energy noise source near the prober, such as a power panel or large motor or RF source?

At the bottom of the confidence check window are three buttons: 'Check Open', 'Check Short', and 'Exit'.

Overlaid on the bottom right of the confidence check window is the following equation:

$$C_{Max} \approx \frac{I_{Max}}{2\pi f V_{ac}}$$

Calculating Inductance

Even though the 4210-CVU does not measure inductance directly, the inductance can be extracted in the Formulator from the Impedance (Z), Phase Angle (theta, θ), and the Test Frequency (f).

$$X = Z \sin \theta$$

$$L = X / 2\pi f$$

The Measured Options Parameters must be set to “Z, theta”.

NOTE: The units for “theta” are in degrees. To use the trig functions in the Formulator, you must convert to rads using the “rad” function as shown below.

Formulator

Formula:

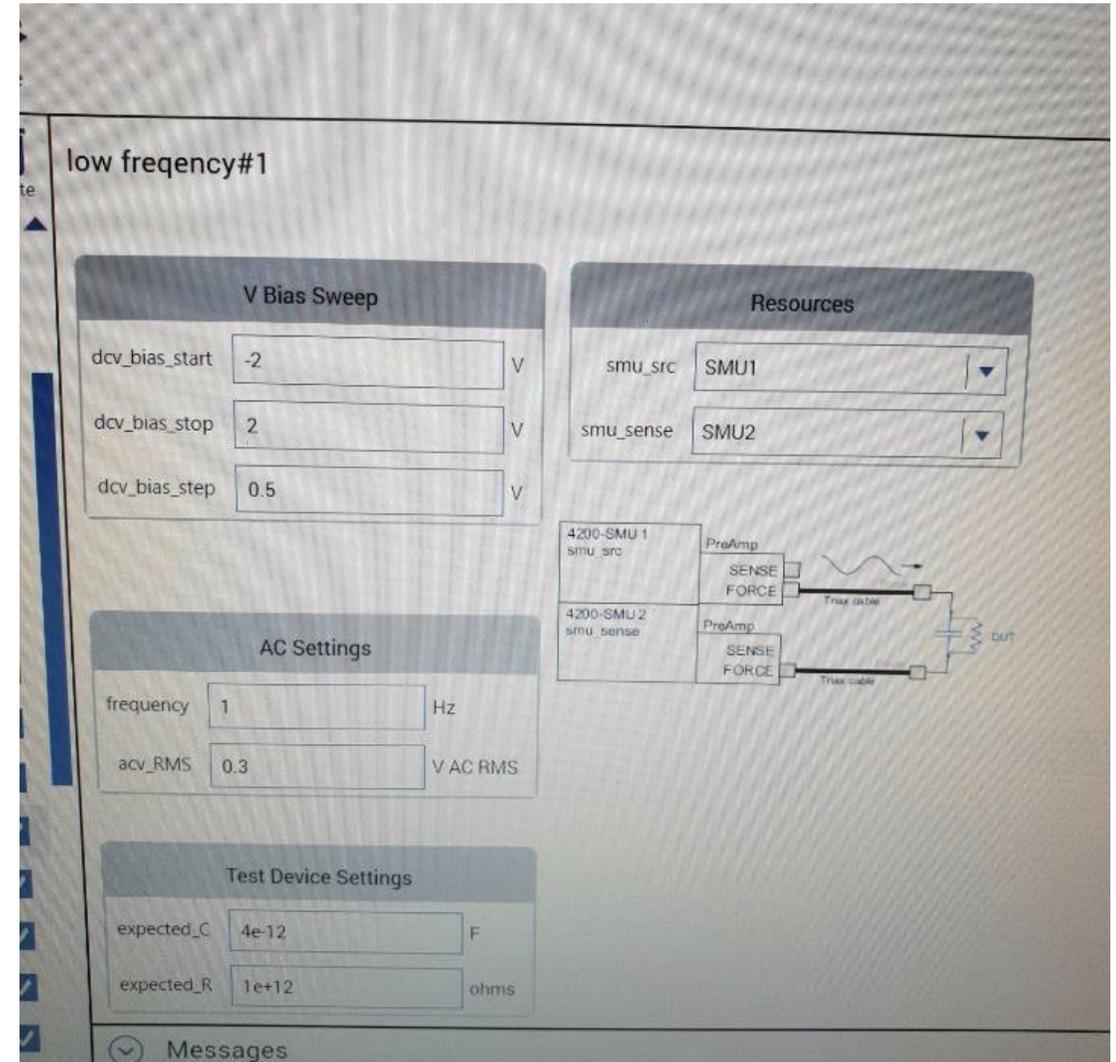
$L = JX / (2 * \text{PI} * F_AB)$
 $JX = Z_AB * \text{SIN}(\text{RAD}(\text{THETA_AB}))$

	A	B	C	D
1	Z_AB	Theta_AB	F_AB	L
2	201.2324E+0	89.6566E+0	10.0000E+3	3.1791E-3
3	201.2161E+0	89.6538E+0	10.0000E+3	3.1800E-3
4	201.2274E+0	89.6600E+0	10.0000E+3	3.1778E-3
5	201.2336E+0	89.6614E+0	10.0000E+3	3.1773E-3
6	201.2417E+0	89.6572E+0	10.0000E+3	3.1791E-3
7	201.2281E+0	89.6566E+0	10.0000E+3	3.1791E-3
8	201.2226E+0	89.6583E+0	10.0000E+3	3.1783E-3
9	201.2371E+0	89.6578E+0	10.0000E+3	3.1787E-3

Very Low Frequency

KEITHLEY ONLY

- UTM
- SMU-based
- Test frequencies from 0.1Hz to 10Hz
- Measures from 1pF ~ 10nF



Ultra-fast Pulse Measure Unit

4225-PMU and 4225-RPM

4225-PMU Basic Capabilities

- Voltage Source
 - 1 slot, 2 channels
 - 2 source ranges (10V, 40V: both into 50Ω)
- Current measure range
 - 10V : 10mA, 200mA
 - 40V : 100uA, 10mA, 800mA
 - With 4225-RPM : extends to 100nA
- Up to 6 cards per chassis
 - 12 channels per chassis, all synchronized

Remote Preamplifier/Switch Module

4225-RPM

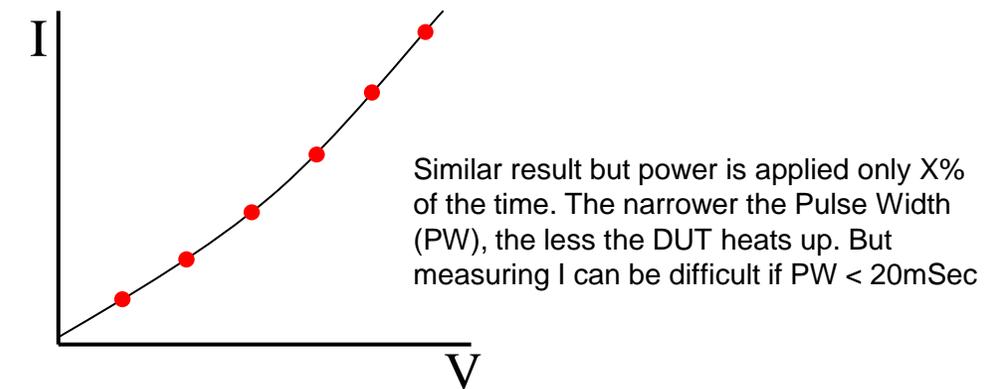
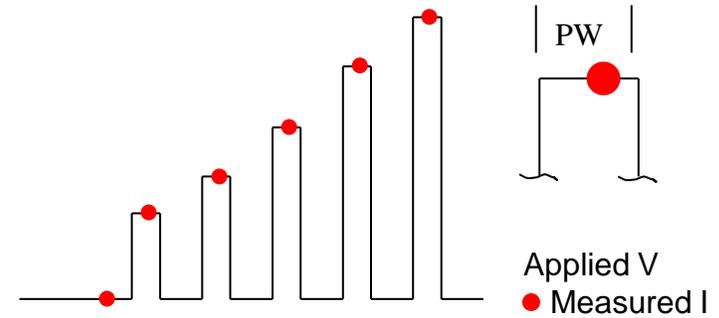
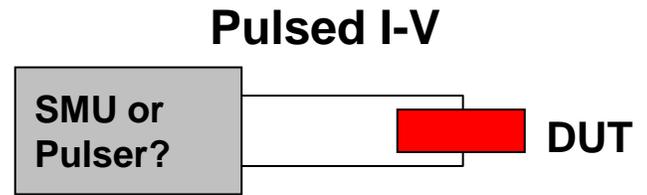
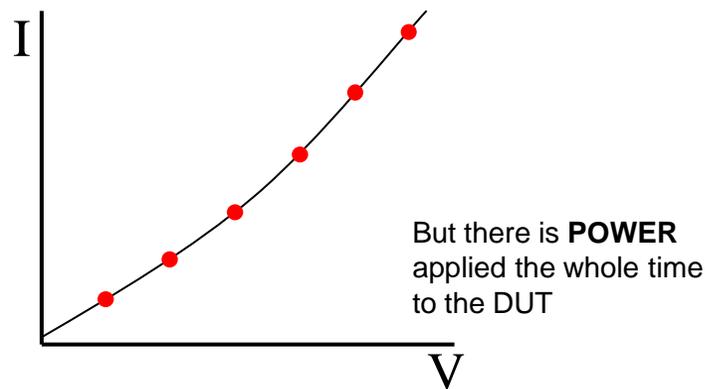
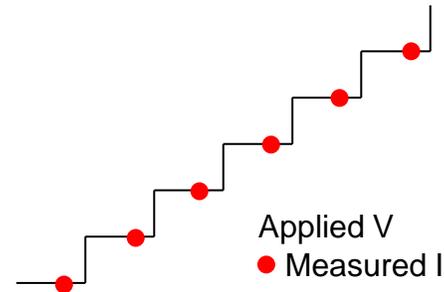
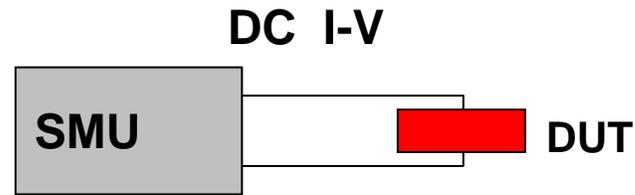
- Single channel module simplifies connections to DUT and extends current range of PMU
- Automatic switching between I-V, C-V and Ultra-fast Pulsed I-V measurements
 - No changing test setup or cables
- Extends the current range of the 4225-PMU
 - Provides current sensitivity down to tens of pico-amps
 - Reduces cable capacitance effects
- Magnetic and vacuum base available for easy installation on prober platen



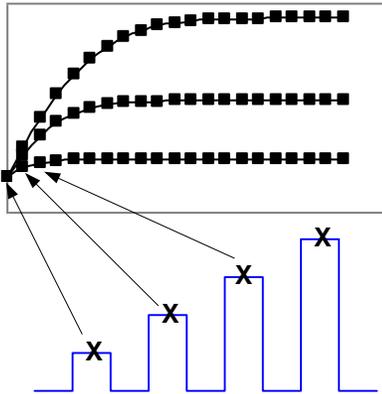
Why is Pulsed I-V needed?

DC-LIKE RESULTS

- Minimizes self-heating effects (Joule heating)
- Certain tests require pulsing, for example, non-volatile memory devices



Operating Modes of 4225-PMU

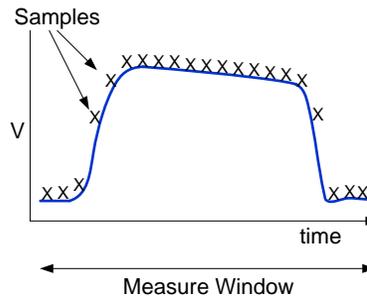


Pulsed I-V

- Pulse and measure with DC-like results
- Step, sweep, pulse train and DC outputs

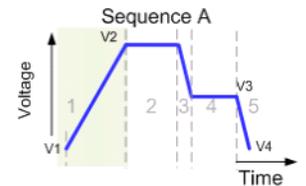
Transient I-V

- waveform capture
- time-based current and voltage measurements



Pulsed Sourcing

- Two-level or multi-level pulsing
- Arbitrary Waveform Generator
- Segment ARB

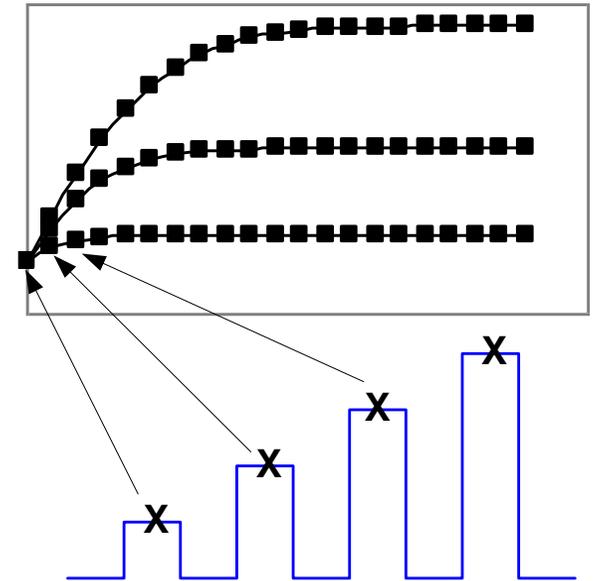


Sequence A Definition			
Segment	Start V	Stop V	Duration
1	V1	V2	T1
2	V2	V2	T2
3	V2	V3	T3
4	V3	V3	T4
5	V3	V4	T5

Pulsed I-V Mode

425-PMU PULSED I-V

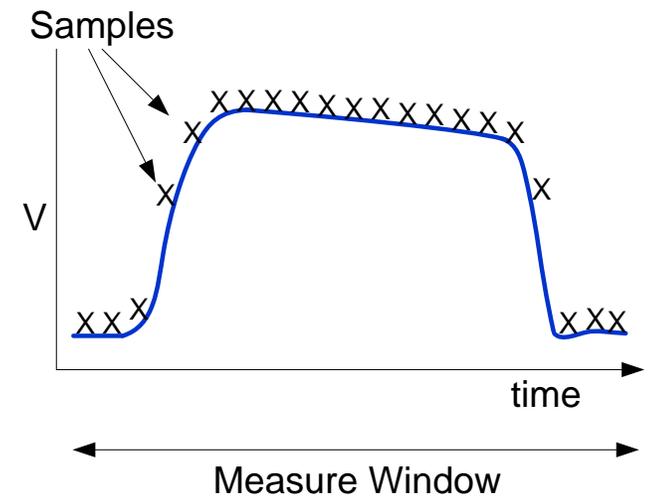
- Pulsed source and a corresponding high speed, time-based measurement that provides DC like results.
- For each pulse an average of readings are taken in a predefined window – called “spot mean”.
- User defines the parameters include:
 - Pulse width
 - Duty cycle
 - Rise/fall times
 - Amplitude



Transient I-V Mode

4225-PMU WAVEFORM CAPTURE MODE

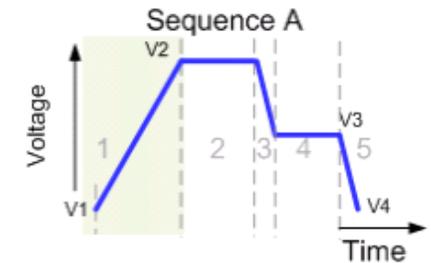
- Transient I-V is also known as Waveform Capture similar to an oscilloscope
- Time-based current and/or voltage measurement that captures the pulsed waveform.
- Used to evaluate a dynamic test circuit
- Used as a diagnostic tool for choosing the appropriate pulse settings in the pulse I-V mode.



Pulsed Sourcing

4225-PMU SEGMENT ARBITRARY WAVEFORM

- **Two-level pulsing:** user inputs a high and low value of the pulse. Can choose to measure the “spot mean” at both the high and low values.
- **Multi-level pulsing with Segment Arb:** user inputs individual segments of the desired pulse. This mode allows measuring.
- **Arbitrary Waveform Generator (KPULSE):** user creates the arbitrary waveform in KPULSE and then implements the waveform in a UTM. This mode does not allow measuring.



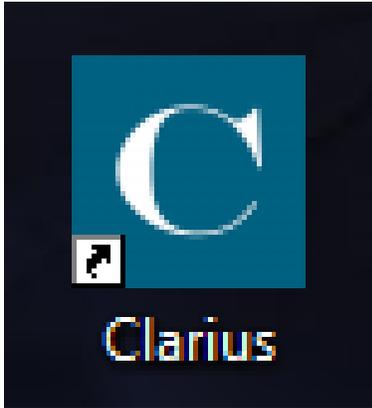
Sequence A Definition			
Segment	Start V	Stop V	Duration
1	V1	V2	T1
2	V2	V2	T2
3	V2	V3	T3
4	V3	V3	T4
5	V3	V4	T5

Segment Arb

New Clarius™ User Interface

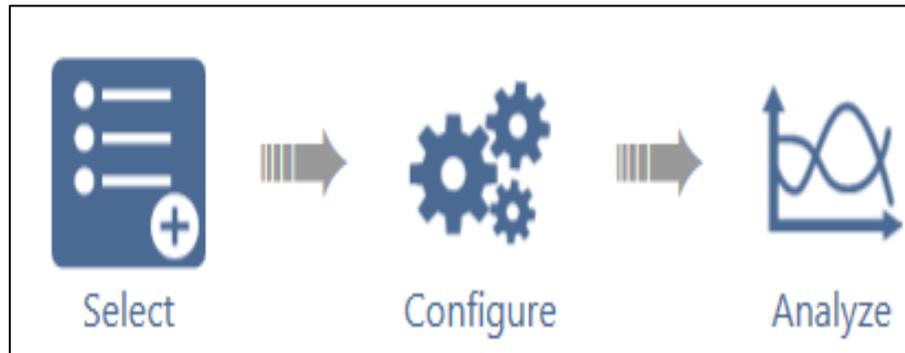
Clear, Uncomplicated Analysis

Clarius Software

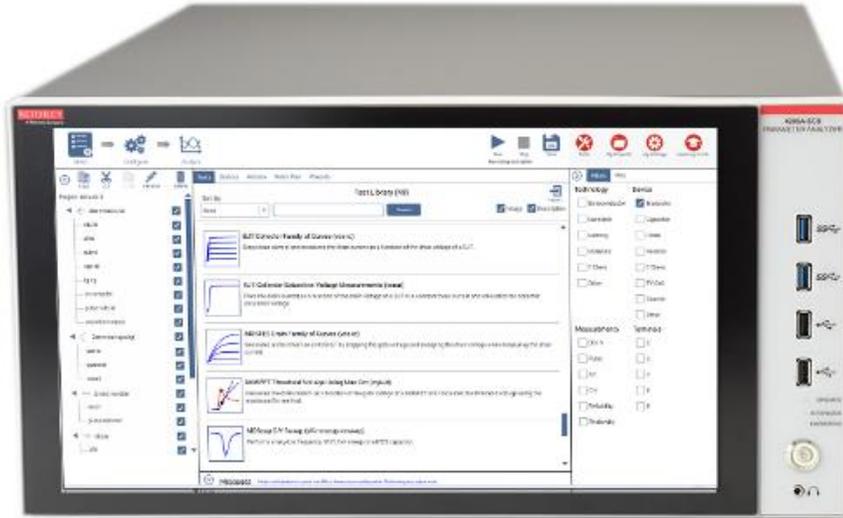


- Primary user interface for the 4200A.
 - Replaces the KITE software.
 - Includes built-in Help and Learning Center
 - Embedded Videos
-
- Finding, setting up, and viewing the results is broken down in 3 easy steps:

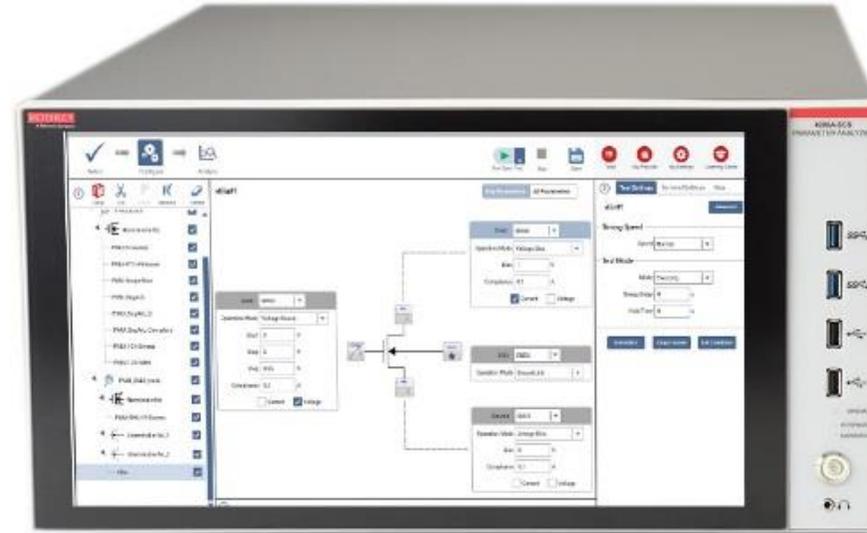
- ✓ Select
- ✓ Configure
- ✓ Analyze



Select – Configure – Analyze Views



Select



Configure



Analyze

Select View



Clarius Select Screen

The screenshot displays the Clarius Select software interface. At the top, a toolbar contains icons for 'Select' (highlighted with a red box), 'Configure', and 'Analyze'. A red line labeled 'Library' spans the top of the main content area. On the left, a 'Project Tree' (labeled 'Project Tree') shows a hierarchy of test configurations under 'Project: default_1', including '4terminal-n-fet', '3terminal-npn-bjt', '2-wire-resistor', and 'diode'. The main area is titled 'Test Library (119)' and features a 'Search Bar' (labeled 'Search Bar') with a 'Sort By' dropdown set to 'Name Descending' and a 'Search' button. Below the search bar, a list of test items is shown, each with a thumbnail and a description: 'Custom Test', 'MOSFET Waveform Capture (waveform-meas)', 'MOSFET Threshold Voltage Using Linear Line Fit (vtlin)', 'Diode Reverse I-V Sweep (vrd)', and 'Molecular Wire I-V Sweep (voltage-sweep)'. On the right, a 'Filters' panel (labeled 'Filters') allows filtering by 'Technology' (Semiconductor, Nanotech, Memory, Materials, E Chem, Other), 'Device' (Transistor, Capacitor, Diode, Resistor, E Chem, PV Cell, Generic, Other), 'Measurements' (DC I-V, Pulse, AC, C-V, Reliability, Resistivity), and 'Author' (Factory, User). The bottom of the screen shows the Windows taskbar with the system clock at 9:09 AM on 6/28/2016.

Projects Library

Contains predefined projects and also can create own project.

The screenshot displays the 'Projects Library' interface. At the top, navigation tabs include 'Tests', 'Devices', 'Actions', 'Wafer Pla', and 'Projects', with 'Projects' highlighted and circled in red. Below the tabs, the title 'Project Library (53)' is shown. A 'Sort By' dropdown is set to 'Name Ascending', and a search bar is present. Checkmarks for 'Image' and 'Description' are visible. An 'Import' icon is also present.

The main content area lists several projects:

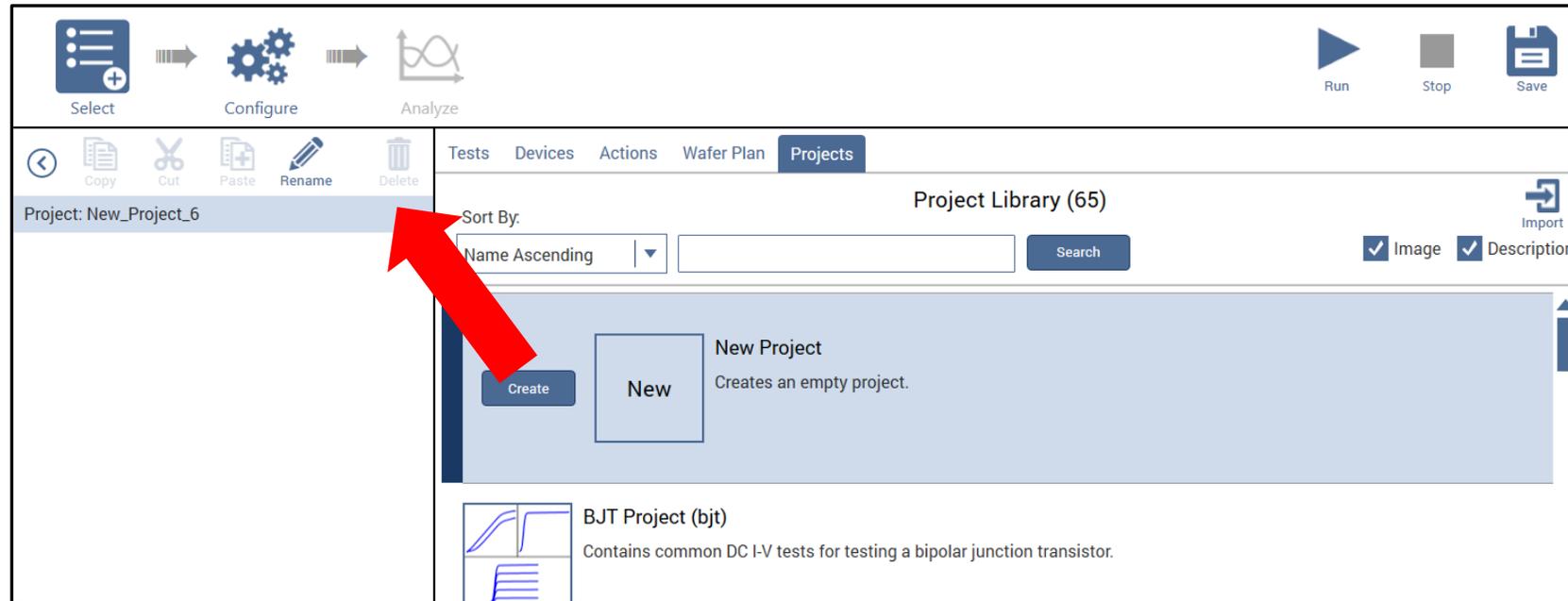
- High Voltage C-V Tests (cvu-highv)**: Contains high voltage C-V measurement examples for a zener diode, MOS Cap, capacitance, and Schottky diode.
- MOS Capacitor C-V Project (cvu-moscap)**: Makes C-V measurements on a MOS capacitor and extracts common measurement parameters.
- Demo Project (default)**: Includes common DC I-V, C-V, and pulse I-V tests for MOSFETs, BJTs, resistors, diodes, and capacitors.
- Diode Project (diode-project)**: Contains DC I-V, C-V, and pulse I-V tests for a PN junction.
- Electromigration Project (em-const-i)**: Does an electromigration test using current stressing on a metal line structure.

The right sidebar contains filter options:

- Technology**: Semiconductor, Nanotech, Memory, Materials, E Chem, Other.
- Device**: Transistor, Capacitor, Diode, Resistor, E Chem, PV Cell, Generic, Other.
- Measurements**: DC I-V, Pulse, AC, C-V, Reliability, Resistivity.
- Terminals**: 2, 3, 4, 6, 8.
- Author**: Factory, User.

Select and Open a New Project

Instead of using one of the preconfigured projects from the Library, you can choose to create a New Project.



Open a Project from the Library

To open a project or test, select (or highlight) it and then press Create.
The project will open up into the Project Tree.

The screenshot displays a software interface for managing projects. At the top, there are three main workflow buttons: 'Select' (with a plus icon), 'Configure' (with a gear icon), and 'Analyze' (with a graph icon). To the right of these are 'Run' (play button), 'Stop' (square button), and 'Save' (floppy disk icon).

Below the workflow buttons is a toolbar with icons for 'Copy', 'Cut', 'Paste', 'Rename', and 'Delete'. The main area is titled 'Project Library (3)' and includes a 'Sort By' dropdown set to 'Name Ascending', a search box containing 'demo', and a 'Search' button. There are also checkboxes for 'Image' and 'Description', and an 'Import' icon.

The library contains three project entries:

- Demo Project (default)**: Includes common DC I-V, C-V, and pulse I-V tests for MOSFETs, BJTs, resistors, diodes, and capacitors. A red arrow points from the '4terminal-n-fet' item in the left tree to the 'Create' button for this project.
- Probing Wafer Sites Project (probesites)**: Demonstrate automated device testing using the 4200A-SCS, a Series 700 Switch System, and a probe station.
- Probing Wafer Subsites Project (probesubsites)**: Demonstrate automated device testing using the 4200A-SCS, a Series 700 Switch System, and a probe station.

The left sidebar shows a tree structure under 'Project: default':

- 4terminal-n-fet (selected)
- vds-id
- vtlin
- subvt
- vgs-id
- ig-vg
- cv-nmosfet
- pulse-vds-id
- waveform-meas
- 3terminal-npn-bjt
- vce-ic
- gummel
- vcsat
- 2-wire-resistor
- res2t

Wafer Plan

Contains sites and subsites.
A site is used for

The screenshot displays the 'Wafer Plan Library (2)' interface. At the top, there are navigation tabs: 'Tests', 'Devices', 'Actions', 'Wafer Plan' (circled in red), and 'Projects'. Below the tabs, the title 'Wafer Plan Library (2)' is centered. On the left, there is a 'Sort By:' dropdown menu set to 'Name Ascending'. To the right of the dropdown is a search input field and a 'Search' button. Further right, there are two checked checkboxes: 'Image' and 'Description', and an 'Import' button with a right-pointing arrow icon. The main content area lists two items:

- Site**: Accompanied by a circular grid icon with a small square in the center. Description: 'Adds a site to the test plan.'
- Subsite**: Accompanied by a circular grid icon with a magnifying glass over it. Description: 'Adds a subsite to the test plan.'

Devices

Contains sites and subsites.
A site is used for

The screenshot shows the 'Device Library (46)' interface. The 'Devices' tab is highlighted with a red circle. The interface includes a search bar, a sort dropdown set to 'Name Ascending', and an 'Import' button. The device list includes:

- Comb capacitor structure, 2 terminal (2terminal-combcap)
- Electrochemical cell, 2 terminal (2terminal-echem-cell)
- Generic device, 2 terminal (2terminal-generic)
- MIS capacitor, 2 terminal (2terminal-miscap)
Metal-insulator semiconductor (MIS) capacitor
- MISFET, n-type, 2 terminal (2terminal-misfet-n)
Metal-insulator semiconductor (MIS) field-effect transistor (FET), with the source, drain, and bulk terminals tied together

The right-hand filter panel includes:

- Terminals: 2, 3, 4, 5, 6, 7, 8
- Device Type: capacitor, diode, generic, nano-tech, echem, solar cell, material, resistor, transistor
- Author: Factory, User

Tests

Contains sites and subsites.
A site is used for

The screenshot displays a web interface for a Test Library. At the top, there are navigation tabs: Tests, Devices, Actions, Wafer Plan, and Projects. The 'Tests' tab is selected and circled in red. Below the navigation is the title 'Test Library (119)' and an 'Import' button. A search bar is present with a dropdown menu set to 'Name Ascending' and a 'Search' button. There are also checkboxes for 'Image' and 'Description'. The main content area lists five test entries, each with a small graph icon and a description:

- CNTFET Capacitance vs Voltage Sweep (cntfet-cvsweep)**: Measures the capacitance as a function of a voltage bias sweep of a carbon nanotube FET.
- CNTFET Drain Family of Curves (cntfet-vds-id)**: Generates a V_{ds} - I_d test on a carbon nanotube FET by stepping the gate voltage and sweeping the drain voltage while measuring the drain current.
- CNTFET Drain Current vs Gate Voltage (cntfet-vgs-id)**: Sweeps the gate voltage (V_g) and measures the drain current (I_d) at a constant drain voltage (V_d) on a carbon nanotube FET.
- CNTFET Single Pulse I-V (cnt-pulse)**: Outputs a single voltage pulse to characterize the transient response of the carbon nanotube FET and graphs the current and voltage as a function of time.
- Custom Segment Arb Waveform (customwaveform)**: Defines a single Segment ARB sequence for each PMU channel.

On the right side, there are filter sections:

- Technology**: Semiconductor, Nanotech, Memory, Materials, E Chem, Other.
- Device**: Transistor, Capacitor, Diode, Resistor, E Chem, PV Cell, Generic, Other.
- Measurements**: DC I-V, Pulse, AC, C-V, Reliability, Resistivity.
- Author**: Factory, User.
- Terminals**: 2, 3, 4, 6, 8.

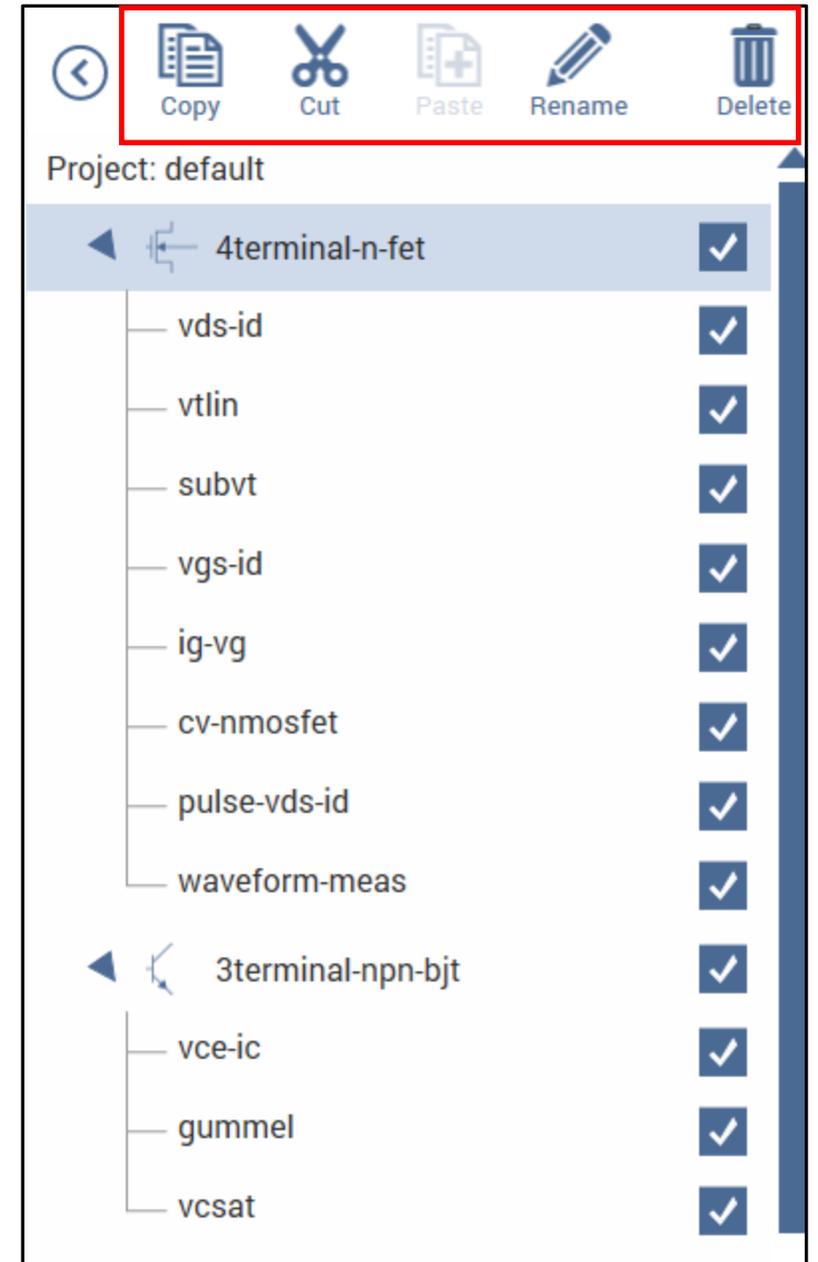
Project Tree

Project Trees no longer require Sites and Subsites.

Across the top of the Project Tree are new functions:

- **Copy, Cut, and Paste:** Used to move and add tests.
- **Rename:** All names in the project tree can be renamed.
- **Delete:** removes tests from Project Tree

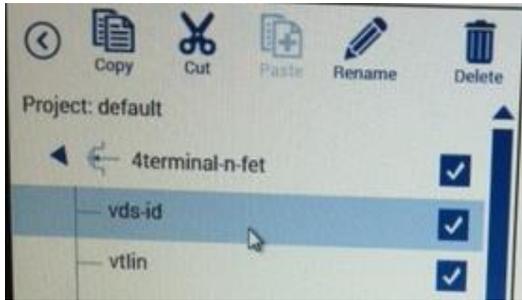
The new functions are also available by right clicking on test.



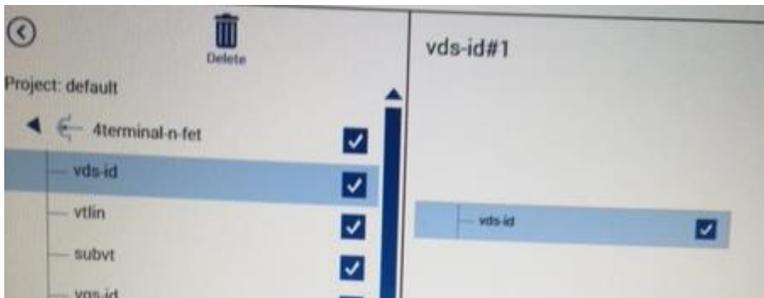
Relocate objects in the Project Tree

The location of an object within a project can also be changed by dragging it to a new spot in the project tree. Here is example of moving vds-id test:

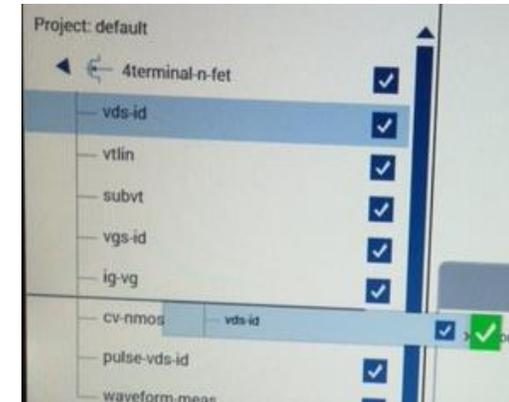
1. Highlight the test (vds-id) you want to move.



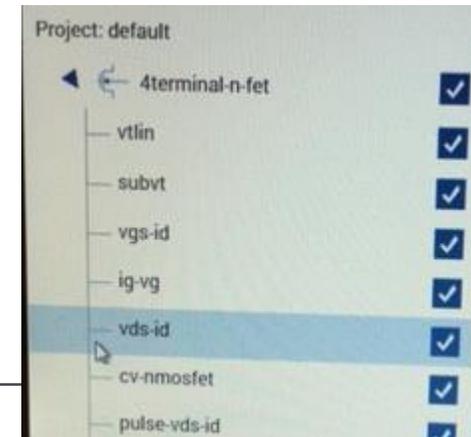
2. Drag the highlighted test to the right.



3. Move the test back towards project tree until line will be above where you want to place the test.

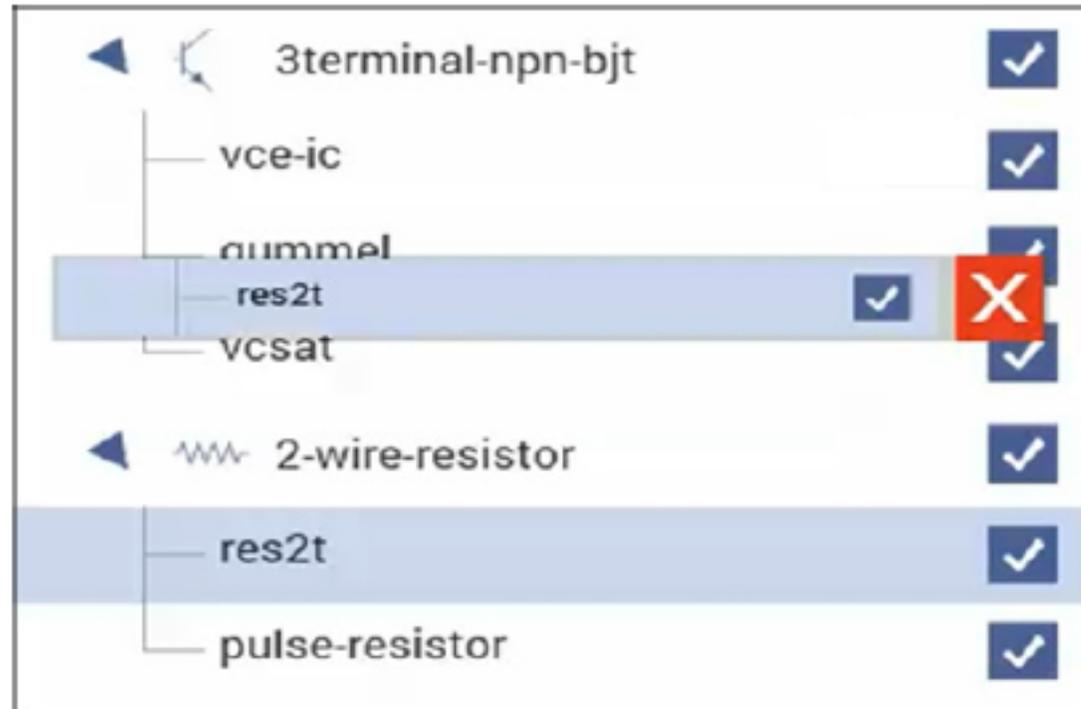


4. vds-id test in new location in project tree.



Relocate objects in the Project Tree

If the object cannot be located in the selected location, a red X is displayed. In the example below, a resistor test cannot be placed under a BJT device.



Configure View



Configure View

The screenshot displays the 'Configure View' of a software interface. The main window is titled 'default - Clarius - [vds-id#1]'. The top toolbar includes icons for 'Select', 'Configure' (highlighted with a red box), 'Analyze', 'Run', 'Stop', 'Save', 'Tools', 'My Projects', 'My Settings', and 'Learning Center'. The 'Configure' button is also labeled 'Set Parameters' in red text.

On the left side, there is a 'Project Tree' (labeled in red) showing a hierarchy of components: '4terminal-n-fet', 'vds-id', 'vtlin', 'subvt', 'vgs-id', 'ig-vg', 'cv-nmosfet', 'pulse-vds-id', 'waveform-meas', '3terminal-npn-bjt', 'vce-ic', 'gummel', 'vcsat', '2-wire-resistor', 'res2t', 'pulse-resistor', 'diode', and 'vfd'. The 'vds-id' component is selected.

The central area shows a circuit diagram for 'vds-id#1'. It features a MOSFET model with three voltage sources: 'Gate' (SMU3), 'Drain' (SMU2), and 'Source' (SMU1). Each source has its own configuration panel. The 'Gate' panel is set to 'Voltage Step' with Start: 2V, Stop: 5V, Step: 1V, and Compliance: 0.1A. The 'Drain' panel is set to 'Voltage Linear Sweep' with Start: 0V, Stop: 5V, Step: 0.1V, and Compliance: 0.1A. The 'Source' panel is set to 'Voltage Bias' with Bias: 0V and Compliance: 0.1A. Checkboxes for 'Measure Current' and 'Report Voltage' are visible for the Drain and Gate sources.

On the right side, there are 'Test Settings' and 'Terminal Settings' panels (labeled in red as 'Test Settings and Terminal Settings'). The 'Test Settings' panel includes 'Measure Settings' (Speed: Normal, Report Timestamps: unchecked) and 'Test Mode' (Mode: Sweeping, Sweep Delay: 0s, Hold Time: 0s). Buttons for 'Formulator', 'Output Values', and 'Exit Conditions' are located below these settings.

At the bottom, a 'Messages' pane displays the text: 'Model/PreAmp configuration in saved test differs from system configuration. Performing auto adjustment.'

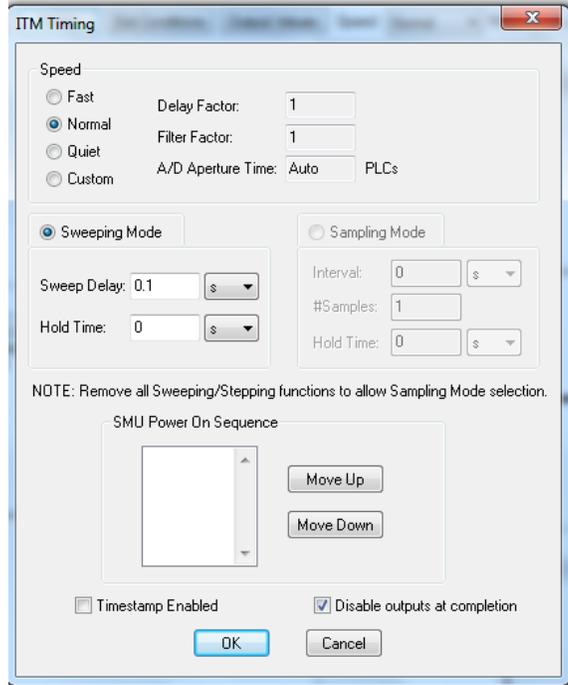
Project Tree

Set Parameters

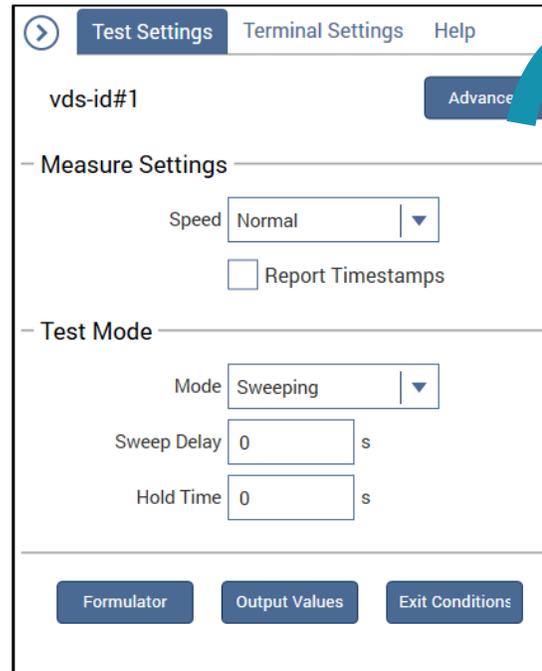
Test Settings and Terminal Settings

Test Settings (timing) -SMU (CVU)

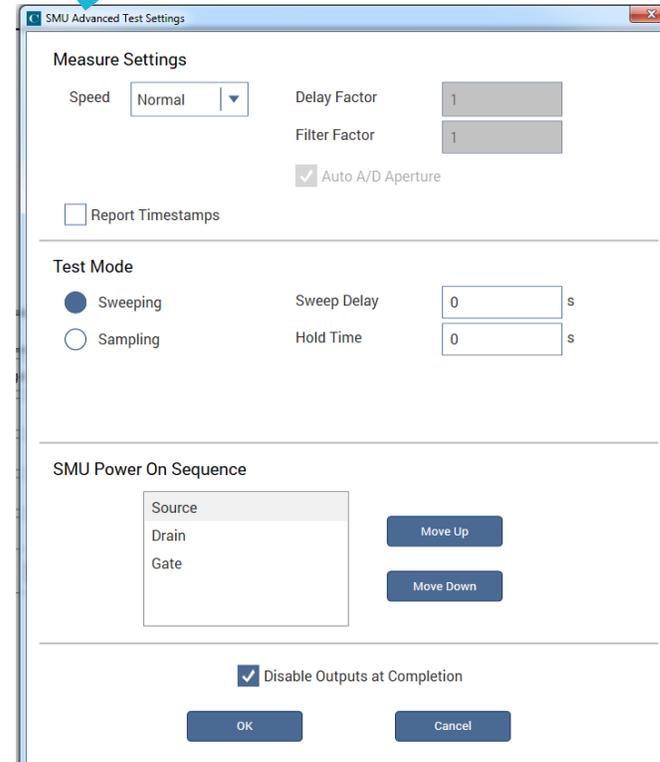
4200 Timing Window



4200A Test Settings Pane



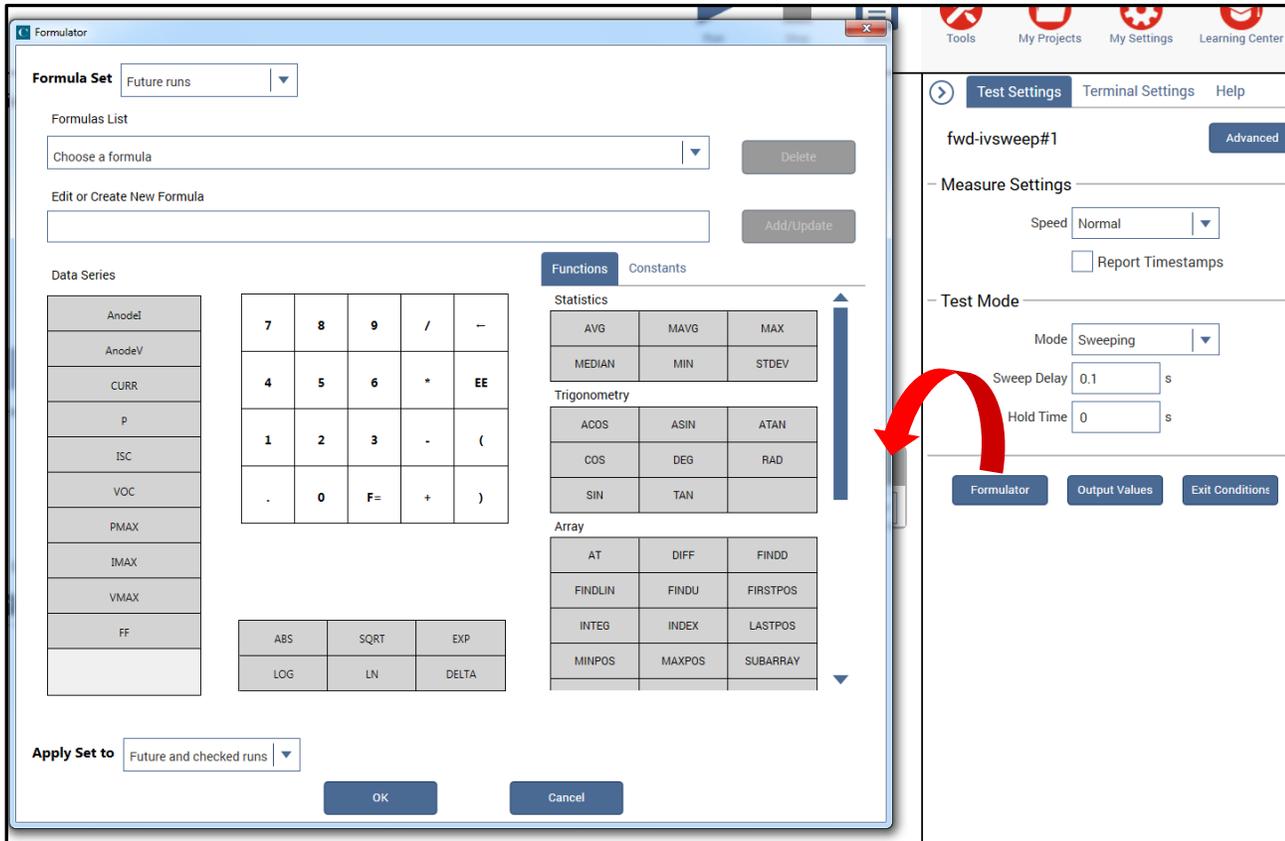
4200A Advanced Test Settings Window



On right hand side of screen is Test Settings pane. The Test Settings pane is where timing parameters are set for the SMU, CVU, and PMU.

Formulator

The Formulator is accessed in the Test Settings pane.



- Updated dialog box.
- You can choose which Runs you want to apply the formulas.

Key Parameters View

Key Parameters of a terminal include the name of the terminal, the device connected to the terminal, the operation mode, and basic settings for that mode.

Notice the operation mode icons next to each terminal.

The screenshot shows the 'Key Parameters' view for a device terminal labeled 'vds-id#1'. A large blue arrow points down to the interface. The interface is divided into three main sections: Gate, Drain, and Source, each with its own configuration panel. In the center, a schematic diagram shows a MOSFET with a gate terminal, a drain terminal, and a source terminal, each connected to a corresponding parameter panel. The Gate panel is set to SMU3, Voltage Step mode, with Start at 2V, Stop at 5V, Step at 1V, and Compliance at 0.1A. The Drain panel is set to SMU2, Voltage Linear Sweep mode, with Start at 0V, Stop at 5V, Step at 0.1V, and Compliance at 0.1A. The Source panel is set to SMU1, Voltage Bias mode, with Bias at 0V and Compliance at 0.1A. Checkmarks indicate that current measurement is enabled for Drain and Gate, and voltage reporting is enabled for all three terminals.

vds-id#1

Key Parameters All Parameters

Drain SMU2

Operation Mode Voltage Linear Sweep

Start 0 V

Stop 5 V

Step 0.1 V

Compliance 0.1 A

Measure Current Report Voltage

Bulk GNDU

Operation Mode Ground Unit

Source SMU1

Operation Mode Voltage Bias

Bias 0 V

Compliance 0.1 A

Measure Current Report Voltage

Gate SMU3

Operation Mode Voltage Step

Start 2 V

Stop 5 V

Step 1 V

Compliance 0.1 A

Measure Current Report Voltage

All Parameters View



Or, if you want to view all the terminal parameters at once, select the All Parameters view.

vds-id#1

Key Parameters All Parameters

Terminal	Gate	Drain	Bulk	Source
Instrument	SMU3	SMU2	GNDU	SMU1
Force				
Operation Mode	Voltage Step	Voltage Linear Sweep	Ground Unit	Voltage Bias
Bias				0 V
Start	2 V	0 V		
Stop	5 V	5 V		
Step	1 V	0.1 V		
Points	4	51		
Dual Sweep		<input type="checkbox"/>		
Range	Best Fixed	Best Fixed		Best Fixed
Compliance	0.1 A	0.1 A		0.1 A
Power On Delay	0 s	0 s		0 s
Over Voltage Protection	OFF	OFF		OFF
Measure				
Current	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>
Column Name		DrainI		
Range		Limited Auto		

Terminal Settings panes

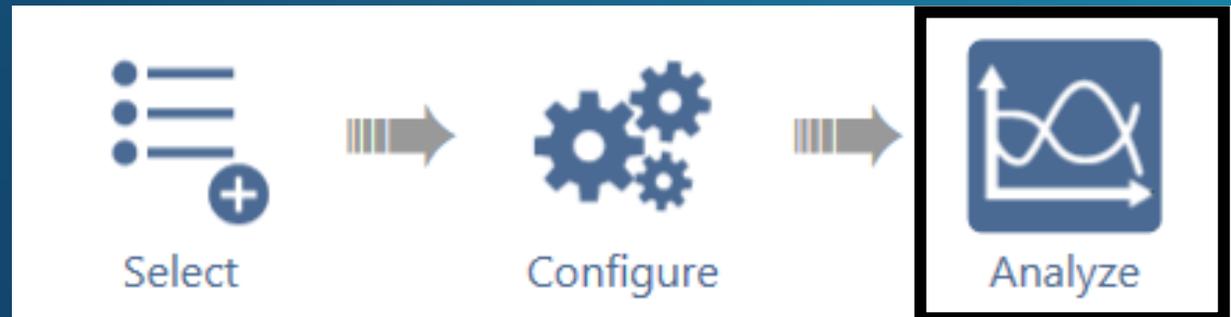
The most common terminal settings are available in the center pane when Key Parameters is selected. Additional common test settings are available in the right Terminal Settings pane. The SMU, CVU, and PMU have different panes.

Most Common Settings in Key Parameters View

Additional settings

Highlight the terminal that you want to show in the right hand pane

Analyze View



Analyze View

Project Tree

Sheet and Graph Views

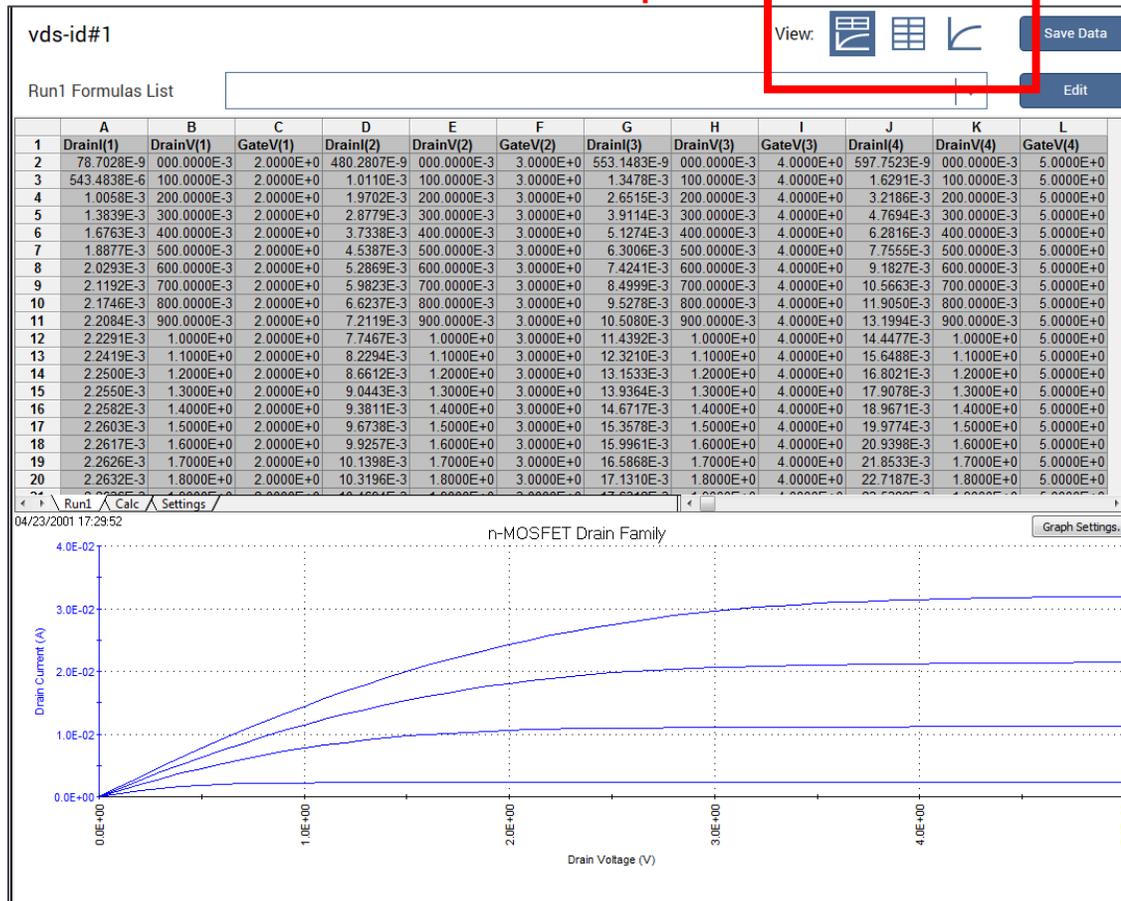
Run History

Run	Date	Time	Exec
Run5	2016-06-21	11:12:23.521	199 s
Run4	2016-06-21	11:04:05.567	202 s
Run3	2016-06-21	10:57:52.516	10 s
Run2	2016-06-21	10:55:03.670	10 s
Run1	2016-06-21	10:53:35.565	19 s

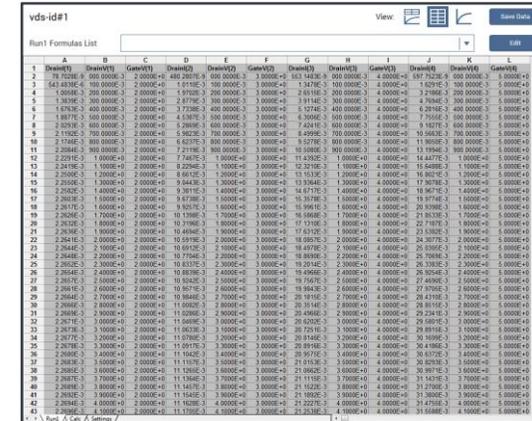
Analyze View

The Analyze View enables the user to simultaneously view both readings logged in the Sheet and graphing in real time.

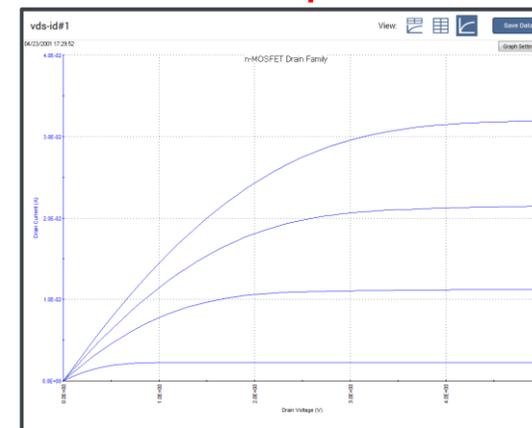
Sheet and Graph



Sheet



Graph



Run History

The 4200A has one Run button for executing all tests and projects.

Run History

Run	Date	Exec	Stars
<input checked="" type="checkbox"/>	Run9 2016-07-05 17:16:42.938	10 s	☆☆☆
<input checked="" type="checkbox"/>	Run8 2016-07-05 17:16:28.350	9 s	☆☆☆
<input type="checkbox"/>	Run7 2016-07-05 17:15:07.171	10 s	☆☆☆
<input type="checkbox"/>	Run6 2016-07-05 17:14:05.482	9 s	☆☆☆
<input checked="" type="checkbox"/>	Run5 2016-07-05 17:13:49.733	10 s	☆☆☆
<input checked="" type="checkbox"/>	Run4 2016-07-05 17:13:35.781	10 s	☆☆☆
<input type="checkbox"/>	Run3 2016-07-05 17:11:46.156	10 s	☆☆☆
<input checked="" type="checkbox"/>	Run2 2016-07-05 17:11:31.326	12 s	☆☆☆
<input type="checkbox"/>	Run1 2016-07-05 12:51:42.017	0 s	☆☆☆

Only the checked boxes appear on the Graph and Sheet.

Analyze View – Terminal Settings

To be able to easily make changes as you are actively testing, there is a Terminal Settings tab to quickly make parameter changes to your test.

The screenshot displays the Analyze View of a test software interface. The main window shows a graph titled "vds-id#1" with the subtitle "n-MOSFET Drain Family". The graph plots Drain Current (A) on the y-axis (ranging from 0.0E+00 to 4.0E-02) against Drain Voltage (V) on the x-axis (ranging from 0.0E+00 to 4.0E+00). Several curves are visible, representing different test conditions. The interface includes a toolbar with "Select", "Configure", and "Analyze" buttons, and a sidebar with a project tree showing various test components like "4terminal-n-fet", "3terminal-npn-bjt", "2-wire-resistor", and "diode". A red box highlights the "Terminal Settings" panel on the right, which is currently active. This panel contains settings for four SMUs: Gate (SMU3), Drain (SMU2), Bulk (GNDU), and Source (SMU1). The Gate (SMU3) section shows "Operation Mode" set to "Voltage Step", "Start" at 2.1 V, "Stop" at 5.1 V, "Step" at 1 V, and "Compliance" at 0.1 A. The Drain (SMU2) section shows "Operation Mode" set to "Voltage Linear Sweep", "Start" at 0 V, "Stop" at 5 V, "Step" at 0.1 V, and "Compliance" at 0.1 A. The Source (SMU1) section shows "Operation Mode" set to "Voltage Bias". The Bulk (GNDU) section shows "Operation Mode" set to "Ground Unit". The interface also includes a "Messages" panel at the bottom showing "Total Execution Time: 00:00:00:09".

Run History

You can have up to **10,000** Runs for each test.

If exceed 10,000 oldest Run will be removed first.

- A timestamp that shows the date and time when the test was run.
- The execution time.
- Rating stars that you can use to flag specific tests.
- Notes. Select the **More** link and select the text box to add notes about the run. Select **Enter** when the notes are complete.

The screenshot displays the 'Run History' interface with the following data:

Run ID	Timestamp	Execution Time	Rating	Checked
Run7	2016-07-09 12:11:41.592	Exec: 10 s	3 stars	<input checked="" type="checkbox"/>
Run6	2016-07-09 12:10:11.380	Exec: 9 s	2 stars	<input type="checkbox"/>
Run5	2016-07-09 12:09:26.084	Exec: 10 s	3 stars	<input type="checkbox"/>
You Can Add Title	2016-07-09 12:09:03.154	Exec: 10 s	3 stars	<input type="checkbox"/>
temperature 300K (Run3)	2016-07-09 12:04:59.151	Exec: 10 s	3 stars	<input type="checkbox"/>
Run2	2016-07-09 12:04:31.640	Exec: 12 s	2 stars	<input checked="" type="checkbox"/>
Run1	2016-07-09 12:03:52.753	Exec: 0 s	3 stars	<input type="checkbox"/>

At the bottom of the interface, there are navigation controls including a date filter set to '7/9/2016', a page indicator '1 of 1', and a 'Date Search' button.

Others

The background is a gradient of blue and teal. It features several diagonal lines and shapes. A prominent feature is a large, light blue parallelogram with a fine halftone dot pattern, positioned in the lower right quadrant. Other elements include solid teal and light blue diagonal bands and shapes that create a sense of depth and movement.

Software Apps – Desktop

4200 Apps - KTEI



Complete Reference

Complete Reference contains manuals, white papers, applications notes, release notes and other related literature



KITE

KITE – Keithley Interactive Test Environment



KULT

KULT – Keithley User Library Tool



KCON

KCON – Keithley Configuration Utility



KXCI

KXCI – Keithley External Control Interface

4200A Apps – Clarius+



Learning Center

Learning Center contains manuals, white papers, applications notes, release notes, videos and other related literature



Clarius

Clarius – Keithley Interactive Test Environment



KULT

KULT – Keithley User Library Tool



KCon

KCon – Keithley Configuration Utility



KXCI

KXCI – Keithley External Control Interface

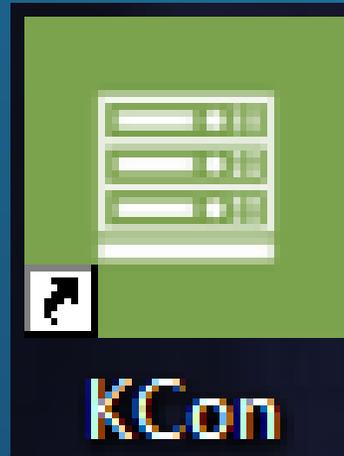


KPulse

KPulse – Keithley Pulse

KCon

Keithley Configuration Utility



KCon

Keithley CONfiguration Utility

Clarius+ Version V1.0

KI System Configuration

Validate Configuration | Update Preamp, RPM, and CVIV Configuration | Save | System Configuration Summary

KXCI Settings | Tools | Learning Center

KI 4200A-SCS Properties

Model: Keithley 4200A-SCS Parameter Analyzer

System Serial Number: 1234567

Platform Version: 4200A-300-1

System Software Version: 4200A-852-1.0

Clarius+ Version: V1.0

Powerline Frequency: 60 Hz

SMU Autorange Method: Normal

SMU Standby Range: 10mA

Instrument Cards

Slot 1:	Keithley 4210 HPSMU
Slot 2:	Keithley 4210 HPSMU
Slot 3:	Keithley 4200 MPSMU
Slot 4:	Keithley 4200 MPSMU
Slot 5:	Empty
Slot 6:	Empty
Slot 7:	Empty
Slot 8:	Keithley 4210 CVU
Slot 9:	Keithley 4225 PMU

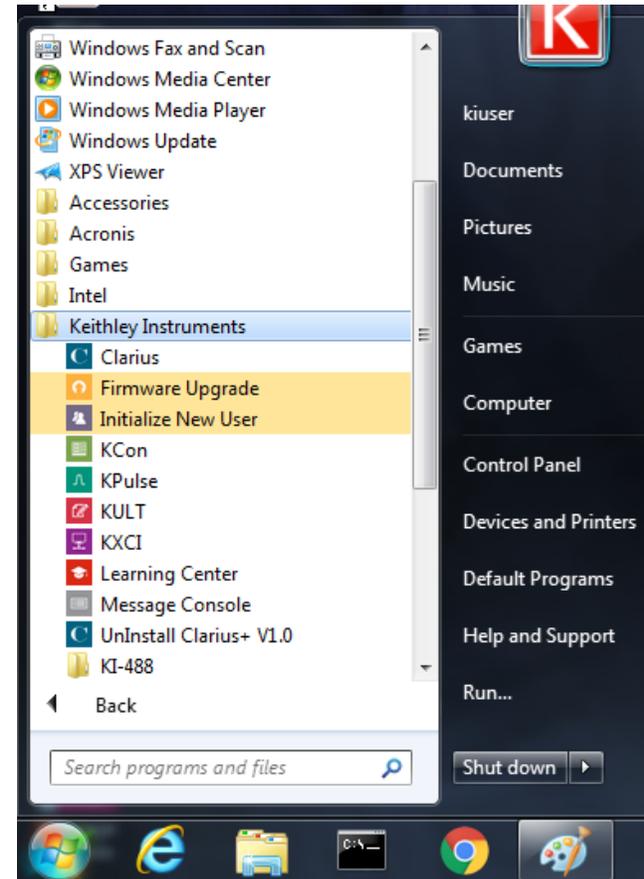
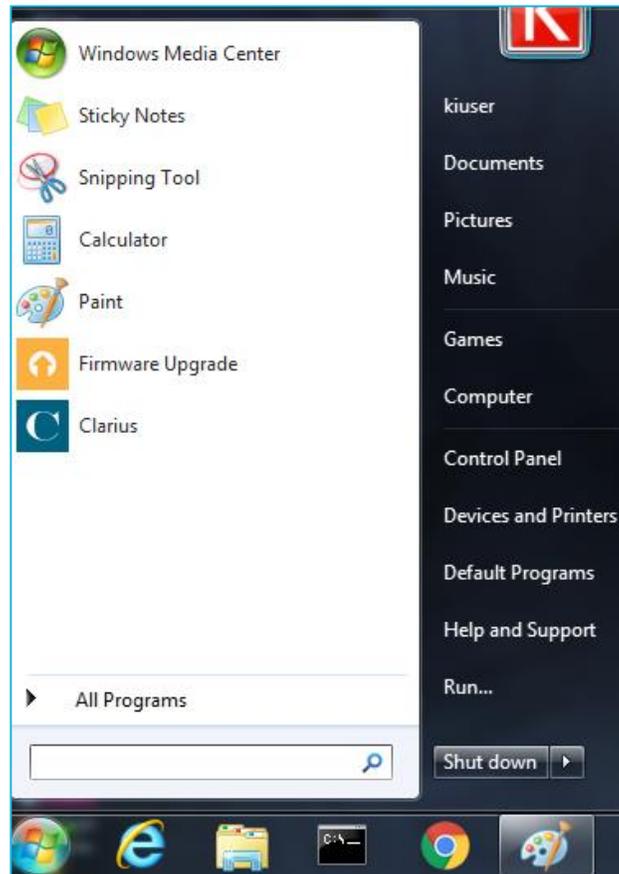
Keithley 4200A-SCS Parameter Analyzer

SMU1	Keithley 4210 HPSMU Slot 1
PA1	Keithley 4200 PreAmp
SMU2	Keithley 4210 HPSMU Slot 2
PA2	Keithley 4200 PreAmp
SMU3	Keithley 4200 MPSMU Slot 3
PA3	Keithley 4200 PreAmp
SMU4	Keithley 4200 MPSMU Slot 4
PA4	Keithley 4200 PreAmp
CVU1	Keithley 4210 CVU Slot 8
PMU1	Keithley 4225 PMU Slot 9
RPM1-1	Keithley 4225 RPM
RPM1-2	Keithley 4225 RPM
GNDU	Keithley 4200 Ground Unit

Add External Instrument | Remove External Instrument

New Firmware Upgrade Utility

To verify or update the firmware revision of the instruments, use the Firmware Upgrade utility. Firmware Upgrade can be found from the Start menu by going to All Programs -> Keithley Instruments -> Firmware Upgrade.



Firmware Upgrade Utility

Instrument	Slot	Installed FW Version	Upgrade FW Version	Status
SMU1	1	M30	<i>Up to date</i>	Up to date
SMU2	2	M30	<i>Up to date</i>	Up to date
SMU3	3	M30	<i>Up to date</i>	Up to date
SMU4	4	M30	<i>Up to date</i>	Up to date
CVU1	8	2.12e04	<i>Up to date</i>	Up to date
PMU1	9	2.02e01	<i>Up to date</i>	Up to date
RPM1-1	9	2.00	<i>Up to date</i>	Up to date
RPM1-2	9	2.00	<i>Up to date</i>	Up to date
TUM1	31	0.41.7	0.41.9	Upgrade Required

Press the Upgrade button to start procedure

Upgrade Close

Instrument	Slot	Installed FW Version	Upgrade FW Version	Status
SMU1	1	M30	<i>Up to date</i>	Up to date
SMU2	2	M30	<i>Up to date</i>	Up to date
SMU3	3	M30	<i>Up to date</i>	Up to date
SMU4	4	M30	<i>Up to date</i>	Up to date
CVU1	8	2.12e04	<i>Up to date</i>	Up to date
PMU1	9	2.02e01	<i>Up to date</i>	Up to date
RPM1-1	9	2.00	<i>Up to date</i>	Up to date
RPM1-2	9	2.00	<i>Up to date</i>	Up to date
TUM1	31	0.41.7	0.41.9	Installing

Upgrading: TUM1

Abort Close

KCon

Keithley Configuration Utility

Clarius+ Version V1.0

Validate Configuration | Update Preamp, RPM, and CVIV Configuration | Save | System Configuration Summary

KXCI Settings | Tools | Learning Center

— KI 4200A-SCS | Keithley 4200A-SCS Parameter Analyzer | KI 4200A-SCS Properties | Instrument Cards

— SMU1 | Keithley 4210 HPSMU | 4210 HPSMU
PA1 | Keithley 4200 PreSMU | 4210 HPSMU
— SMU2 | Keithley 4210 HPSMU | 4200 MPSMU
PA2 | Keithley 4200 PreSMU | 4200 MPSMU
— SMU3 | Keithley 4200 MPSMU | 4200 MPSMU
PA3 | Keithley 4200 PreSMU | 4210 CVU
— SMU4 | Keithley 4200 MPSMU | 4225 PMU
PA4 | Keithley 4200 PreSMU |
CVU1 | Keithley 4210 CVU |
— PMU1 | Keithley 4225 PMU |
RPM1-1 | Keithley 4225 RPM |
RPM1-2 | Keithley 4225 RPM |
GNDU | Keithley 4200 Ground |

KEITHLEY

Keithley Instruments - Model 4200A system configuration information

System Information:

Model: Keithley 4200A-SCS Parameter Analyzer	
Date	07/11/2016
System name	4200A-SCS
System serial number	1234567
SBC serial number	
Platform version	4200A-300-1
Operating system version	4200A-852-1.0
KTE Interactive version	
Powerline frequency	60 HZ
KXCI Settings	SMU1 = SMU1 SMU2 = SMU2 SMU3 = SMU3 SMU4 = SMU4

Save Configuration As | Print Configuration | Close

Add External Instrument | Remove External Instrument

KCon Admin

Clarius* Version: V1.9.1

System Configuration

Scan System Validate Save Summary KXCI Settings Tools Learning Center

4200A-SCS Keithley 4200A-SCS Parameter Analyzer

SMU1	Keithley 4211 HPSMU Slot 1
SMU2	Keithley 4211 HPSMU Slot 2
SMU3	Keithley 4211 HPSMU Slot 3
CVU1	Keithley 4215 CVU Slot 6
PMU1	Keithley 4225 PMU Slot 8
GNDU	Keithley 4200 Ground Unit
PRBR1	Fake Prober

4200A-SCS Properties

Model: Keithley 4200A-SCS Parameter Analyzer

System Serial Number: 1473602

Platform Version: 4200A-300-3

System Software Version: 4200A-852-1.9.1

Clarius* Version: V1.9.1

Powerline Frequency: 60 Hz

SMU Autorange Method: Normal

SMU Standby Range: 10 mA

Instrument Cards

Slot 1:	Keithley 4211 HPSMU
Slot 2:	Keithley 4211 HPSMU
Slot 3:	Keithley 4211 HPSMU
Slot 4:	Empty
Slot 5:	Empty
Slot 6:	Keithley 4215 CVU
Slot 7:	Empty
Slot 8:	Keithley 4225 PMU
Slot 9:	Empty

Properties View Calibration View

Add External Instrument Remove External Instrument

ID : kconclient -systemtest
PW : KIST

KULT

Keithley User Library Tool



KULT

- **KULT** is a tool used to create and manage *user libraries*.
- A user library is a collection of one or more *user modules*.
- User modules are C programming language subroutines.
- User libraries are created to control instrumentation, analyze data, or perform any other system automation task programmatically.
- Once a user library has been successful built using **KULT**, its user modules can be executed using **KITE/Clarius**.
- To execute a **KULT** user module in **KITE/Clarius**, you create a UTM and connect it to the user module.

KULT

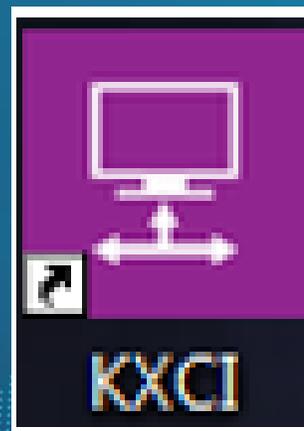
The screenshot displays the KULT software interface for editing a module. The window title is "KULT: Module 'Rdson42XX.c' Library 'KI42xxolib'". The interface is divided into several sections:

- Menu bar:** Located at the top left, containing "File", "Edit", "Options", and "Help".
- Module identification area:** Located below the menu bar, containing fields for "Library: KI42xxolib", "Module: Rdson42XX", and "Return Type: int".
- Library visible or hidden display:** A "Library Visible" checkbox and an "Apply" button.
- Module-parameter display area:** A text area containing the module's parameter list: `#include "ulib_internal.h"` and `int Rdson42XX(double Vg, double Vd1, double Vd2, int GatePin, int`.
- Module code-entry area:** A text area containing the module's code, including parameter verification and connection logic.
- Terminating-brace area:** A text area containing the closing brace and comment: `) /* End Rdson42XX.c */`.
- Tab area:** A tabbed interface with "Parameters", "Includes", "Description", and "Build" tabs. The "Parameters" tab is active, showing a table of parameters.
- Status bar:** Located at the bottom right, displaying the "KEITHLEY" logo.

Parameter Name	Data Type	I/O	Default	Min	Max
Vg	double	Input	2	-10	10
Vd1	double	Input	3	-10	10
Vd2	double	Input	5	-10	10

KXCI

Keithley External Control Interface



KXCI

- KXCI allows you to use an external computer to remotely control.
 - operation by GPIB, Ethernet
- The SMU, CVU, and PMU each have different types of command sets.
- Can call KULT user libraries remotely
- When controlled by an external computer, the Model 4200 functions like any other GPIB instrument.
- The GPIB command set is provided in Section 9 of the Model 4200 Reference Manual.

KXCI

The screenshot shows the KXCI software interface with several annotated components:

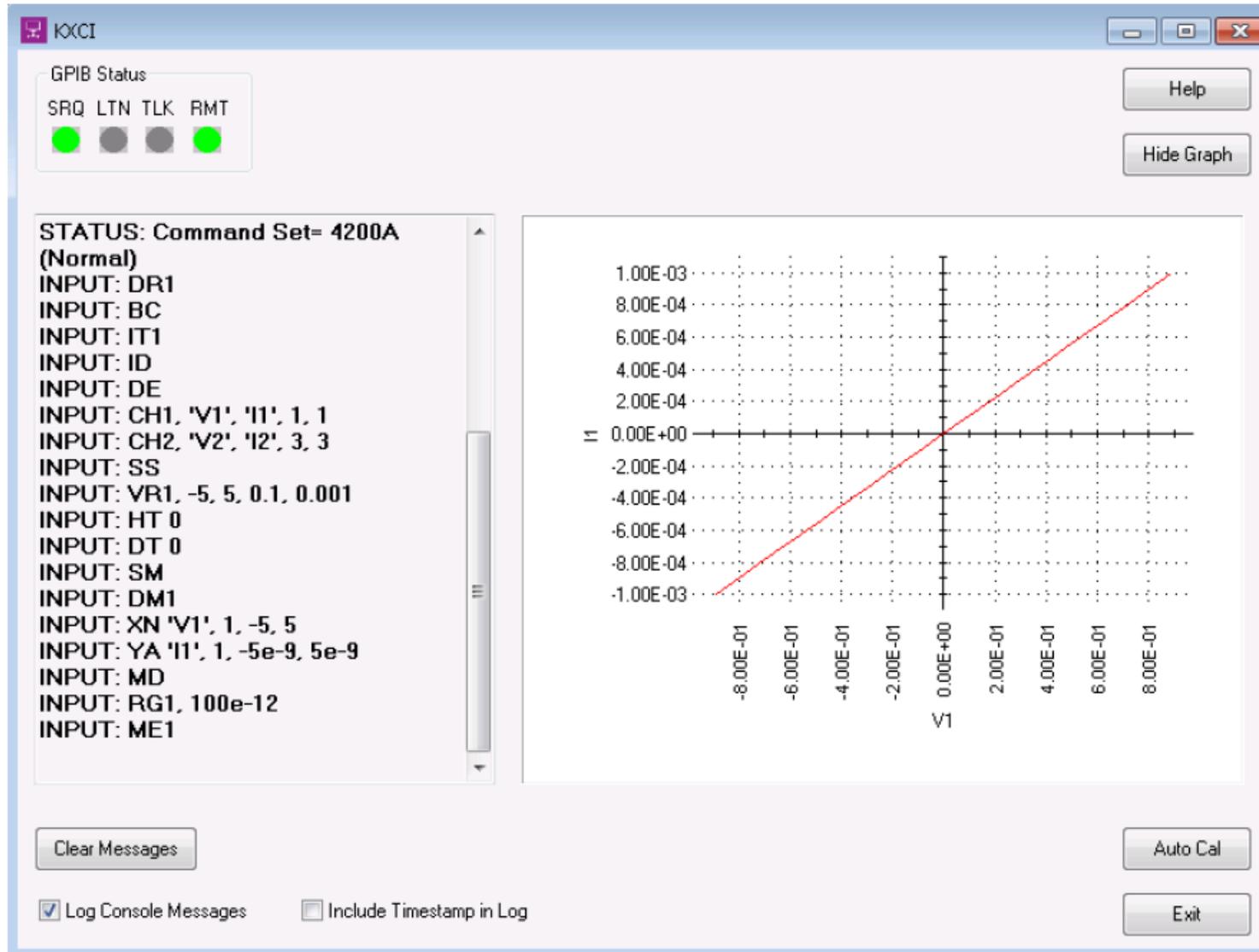
- Graph display area:** A large white rectangular area on the right side of the window, currently displaying the text "No graph information available." An arrow points from the label to this area.
- Hide or Show Graph button:** A button labeled "Hide Graph" located in the top right corner of the window. An arrow points from the label to this button.
- GPIB Status indicators:** A group of four circular indicators labeled "SRQ", "LTN", "TLK", and "RMT" located in the top left corner of the window. An arrow points from the label to this group.
- KXCI settings in this area:** A vertical scrollable list of status messages on the left side of the window. A red rectangular box highlights a specific message: "Running autozero on SMU1". An arrow points from the label to the scrollable area.
- Command, message, and data display area:** The entire scrollable list of messages on the left side of the window. An arrow points from the label to this area.

The scrollable message list contains the following text:

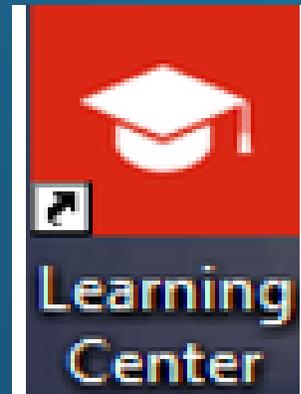
```
2017/02/03 - 07:43:16 STATUS:
KPCI-488LP CARD NOT DETECTED
2017/02/03 - 07:43:18 STATUS:
Running autozero on SMU1
2017/02/03 - 07:43:19 STATUS:
Running autozero on SMU2
2017/02/03 - 07:43:19 STATUS:
GPIB communication started
2017/02/03 - 07:43:19 STATUS:
Address= 17
2017/02/03 - 07:43:19 STATUS:
EOI= On
2017/02/03 - 07:43:19 STATUS:
String Terminator= CR/LF
2017/02/03 - 07:43:19 STATUS:
Reading Delimiter= Comma
2017/02/03 - 07:43:19 STATUS:
Command Set= 4200A (Normal)
```

Other interface elements include a "Clear Messages" button at the bottom left, "Auto Cal" and "Exit" buttons at the bottom right, and "Log Console Messages" and "Include Timestamp in Log" checkboxes at the bottom center.

KXCI Test



Learning Center



Learning Center

The screenshot shows a web browser window with the URL <http://clariusweb/LearningCenter/index.htm>. The page title is "The Learning Center". The navigation menu includes "Contents", "Index", and "Search". The "Contents" menu is expanded, showing a tree structure of topics.

Welcome to the Learning Center

[Next](#)

Welcome to the Learning Center

The Learning Center contains product and application information regarding the Model 4200A-SCS Parameter Analyzer.

The Learning Center contains a variety of content to help you learn how to use your 4200A-SCS. It includes the options shown in the following table.

Videos provide quick tutorials on a variety of topics	Application notes, white papers, and technical notes describe how to use the 4200A-SCS for specific instruments and devices and how to address specific issues	The Keithley Low Level Measurements Handbook is the industry's premier technical reference for making precision DC current, voltage, and resistance measurements
User Manual content explains how to do initial setup and application examples that help you learn to use your 4200A-SCS	PDF versions of the User Manual, Reference Manual, and Quick Start Guides and other general product information	Release notes contain information about this version of the software release
Reference Manual content provides detailed information on all aspects of 4200A-SCS operation	The Technical Data Sheet provides an overview of the 4200A-SCS and accessories. It also includes specifications	Accessory information provides links to documents regarding cables, rack mount kits, and other 4200A-SCS accessories
Keithley forums (requires internet connection) provides a place where users can share information	4200A-SCS website (requires internet connection)	Keithley and Tektronix website (requires internet connection)

New products

4201-SMU and 4211-SMU

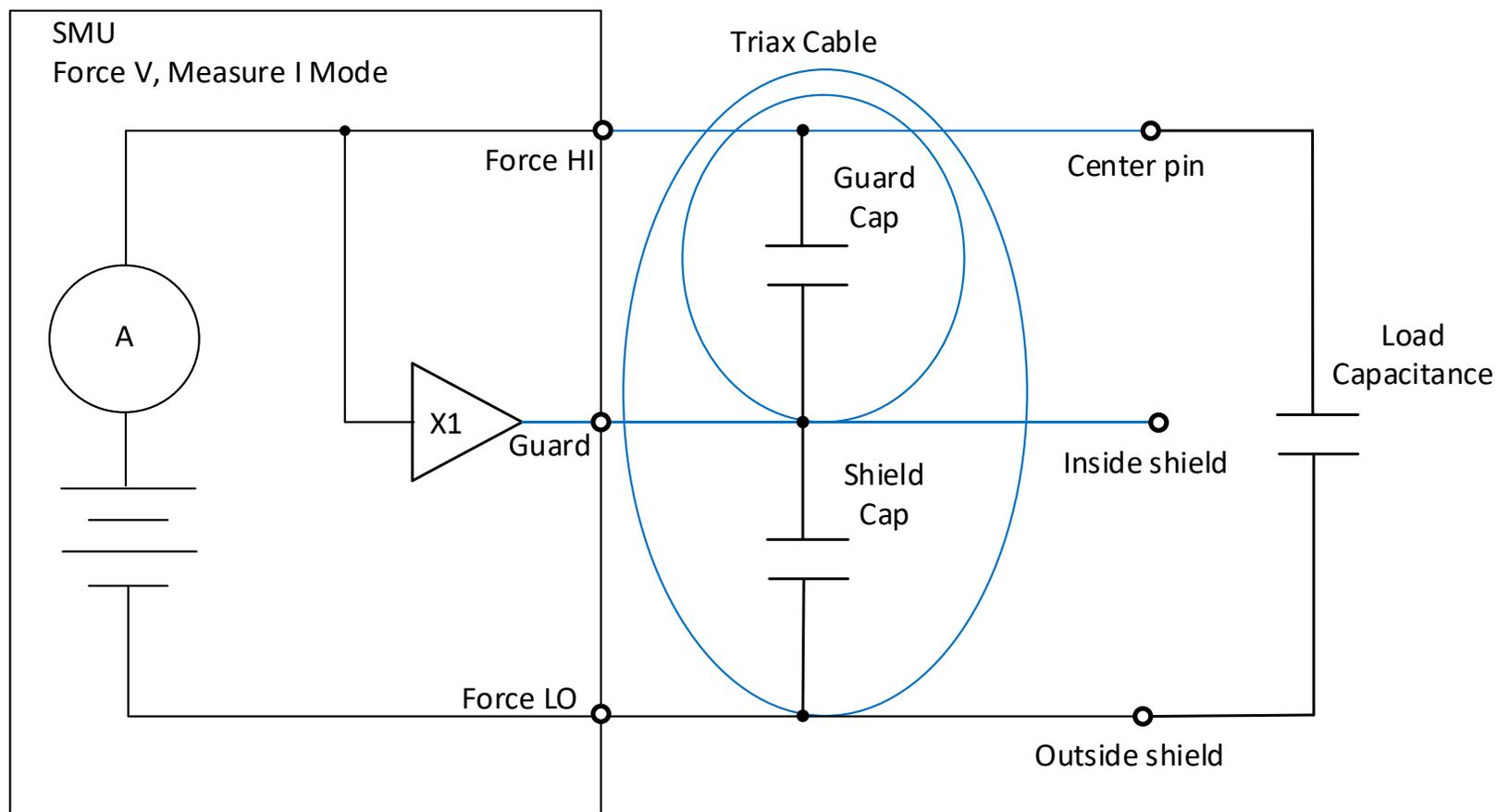
4215-CVU

V1.7 Released – New SMUs

- New features include:
 - Release of two new SMUs:
 - **4201-SMU Medium Power SMU** – same specs as 4200-SMU except **higher cap specs**
 - **4211-SMU High Power SMU** – same specs as 4210-SMU except **higher cap specs**
- This upgrade is no charge to customers with 4200A with Win 10.
- If users do not have Win10 and want to upgrade to V1.6, they can purchase **4200A-WIN10-UP** which includes both Win 10 and V1.5. Then upgrade to V1.6.

New SMUs! Models 4201-SMU, 4211-SMU

INCREASED MAXIMUM CAPACITANCE SPECS FOR IMPROVED STABILITY WHEN MAKING SENSITIVE LOW CURRENT MEASUREMENTS

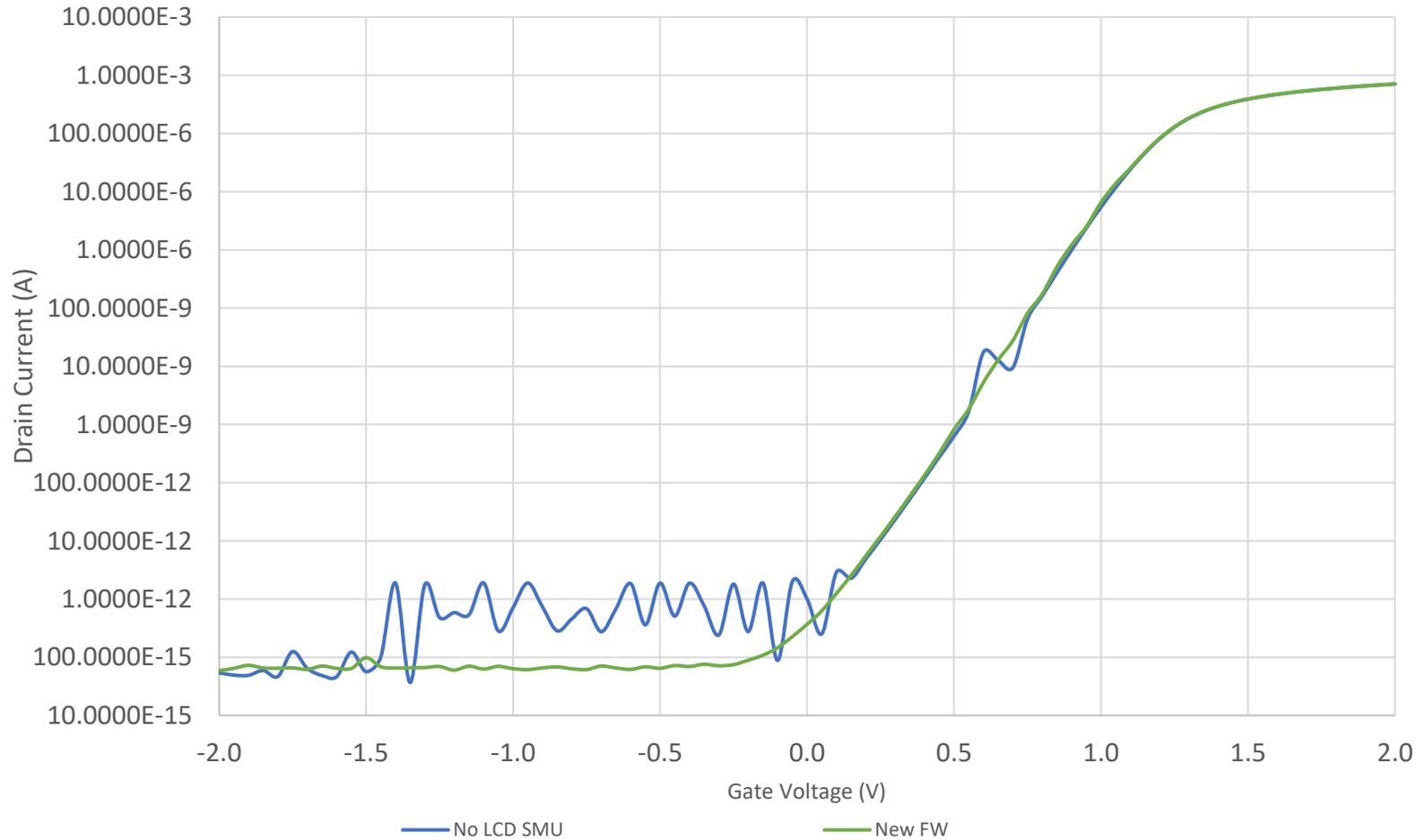


PRELIMINARY SPECS:

- Max Guard Capacitance:
42X0-SMU spec: 100pF
New 42X1-SMU spec: 5nF
- Max Shield Capacitance:
42X0-SMU spec: 330pF
New 42X1-SMU spec: 10nF
- Max Load Capacitance:
42X0-SMU spec: 10nF
New 42X1-SMU spec: 10 μ F

Long Cables: MOSFET Id-Vg (TG-439 Demo DUT)

Run Settings: Sweep 2 to -2 V on Gate, Measure Current on Drain, Limited Auto 1pA, 20m Cable, best fixed source range,

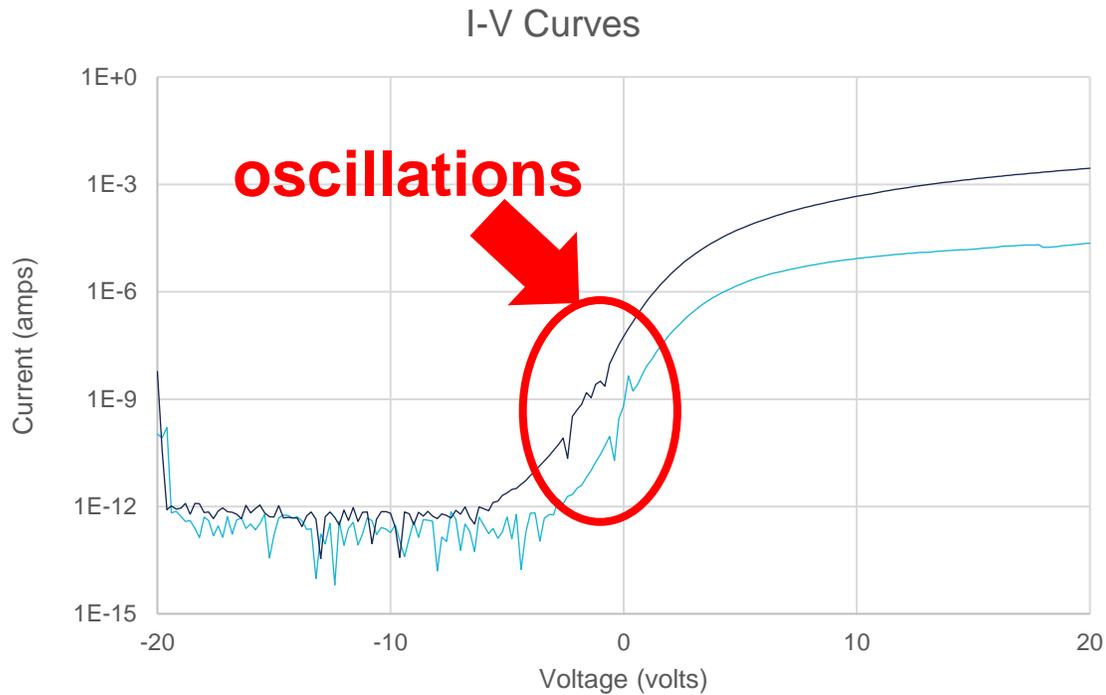


Drain SMU:

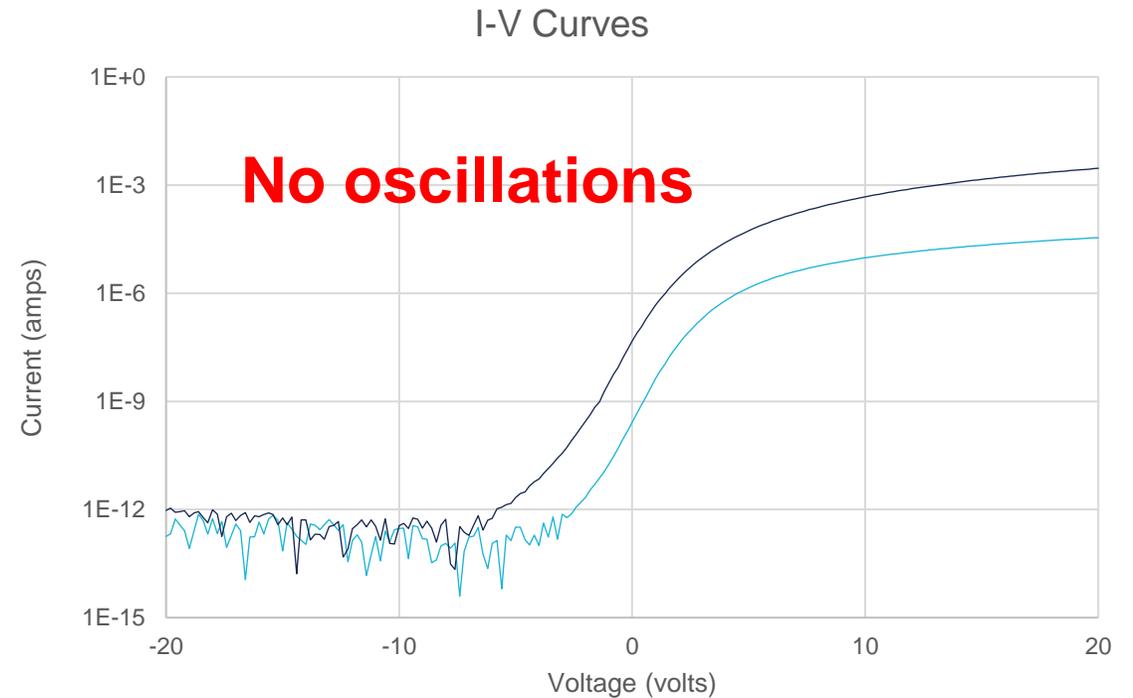
Blue Curve— 4200-SMU
Green Curve - 4201-SMU

OLED Device for Display

SATURATION AND LINEAR TRANSFER CURVES



Measured with 4200-SMU



Measured with 4211-SMU

V1.8 Released – New CVU

Here are some of the proposed list of new features:

- New 4215-CVU
- KULT Editor
- New Graph Tool
- USB controlled external instruments (still being defined)
- New projects and tests

4215-CVU Preliminary Specs

Has all the capabilities of the 4210-CVU and....

- 1V rms ac drive voltage
- 1kHz to 10Mhz, with 1kHz test frequency resolution
 - For example, 8.121 MHz is a test frequency
- Logarithmic frequency sweep capability
- Y-theta measurement function
- Averaging Filter Modes: Noise reduction, point averaging

Why higher AC drive voltage?

- Measuring very small capacitances, <pF
- Making high impedance measurements (or measuring low capacitance at a low test frequency)

Example: 10pF device with 10kHz test frequency and 100mV ac drive voltage:

$$C = \frac{I_{ac}}{(2 * \pi * f * V_{ac})} \text{ or } I_{ac} = C(2 * \pi * f * V_{ac}) = 10pF(2 * \pi * 10kHz * 100mV) = 63nA_{ac}$$

The lowest current range full scale is 1uA. By increasing the voltage to 1Vac the measured current becomes 630nA ac which becomes easier to measure.

- Keysight B1500A MFCMU ac drive voltage: 10mV to 250mV rms

Key Specs



Key Specs

Modules	Description	Key Measurements	Range
4200-SMU 4201-SMU	Medium power Source Measure Unit	<ul style="list-style-type: none"> DC I-V VLF C-V (Very low frequency C-V) QSCV 	± 100 mA, ± 210 V
4210-SMU 4211-SMU	High power Source Measure Unit		± 1 A, ± 210 V
4200-PA	Remote Preamplifier Module		Extends current ranges for all SMU's
4210-CVU 4215-CVU	Capacitance-Voltage Unit	<ul style="list-style-type: none"> AC Impedance C-V, C-f, C-t 	1 kHz – 10 MHz ± 30 V built-in DC bias (60 V differential) ± 210 V DC bias with SMU's
4200A-CVIV	I-V/C-V Multi-Switch Module	DC I-V and C-V with automatic switching	-
4225-PMU	Ultra-Fast Pulse Measure Unit	<ul style="list-style-type: none"> Pulsed I-V SegmentARB® multi-level pulsing Transient Waveform Capture 	± 40 V (80 V p-p), ± 800 mA 200 M Sa/s simultaneous I and V measure 2048 unique segments 20 ns PW source only 60 ns PW source/measure
4225-RPM	Remote Preamplifier/Switch Module	DC I-V, C-V, Pulsed I-V with automatic switching	Extends current range of 4225-PMU unit
4220-PGU	High Voltage Pulse Generator Unit	<ul style="list-style-type: none"> Pulsed voltage source SegmentARB® multi-level pulsing 	± 40 V (80 V p-p) 2048 unique segments
Ground Unit	Low noise, ground unit	-	Triaxial connection: 2.6 A Binding post: 9.5 A

Thank you

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