Metrics ICS Driver Manual

Agilent B2900 Series

Metrics ICS

Version 4.5

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The B2900A Instrument Driver

Getting Started: Creating and Executing a Test Setup

The Agilent Technologies B2900A Source Monitor Unit is a high-performance DC parametric measurement instrument. The B2900A series is composed of four different models each with different measurement resolution and power output capabilities. The following B2900A models are supported by Interactive Characterization Software (ICS):

B2900A Models

1. B2901A 100 fA Single Channel Precision Source/Measure Unit
2. B2902A 100 fA Dual Channel Precision Source/Measure Unit
3. B2911A 10 fA Single Channel Precision Source/Measure Unit
4. B2912A 10 fA Dual Channel Precision Source/Measure Unit

B2900A Accessories

N1295A Device/component Test Fixture

This section will walk you through the steps required to create and execute a test setup that measures diode turn-on voltage using the B2900A and the ICS Driver. This is simple measurement, but it will provide you with a general understanding of how ICS and the B2900A are used to measure device characteristics.

Step 1: Cable the Hardware Connections

Cable all the necessary connections between the instrument source units and the test fixture. Connect the required jumpers between the test fixture sockets and personality board. The hardware connections configured in this step will be designated later in ICS' graphic workspace.

The test setup example presented in this section was executed using the B2900A along with the HP16088 Test Fixture and the HP16088-60002 Socket Board. A schematic of the hardware arrangement is shown below.

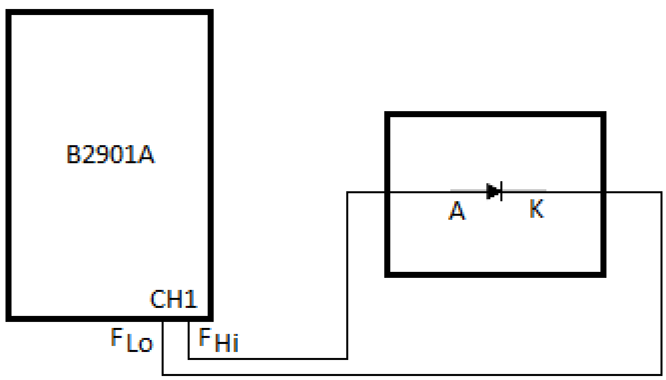


Figure 1.1: A Schematic of the Hardware Arrangement Used to Measure V_{ON} for an NP Diode.

Step 2: Connect the B2900A Instrument Driver

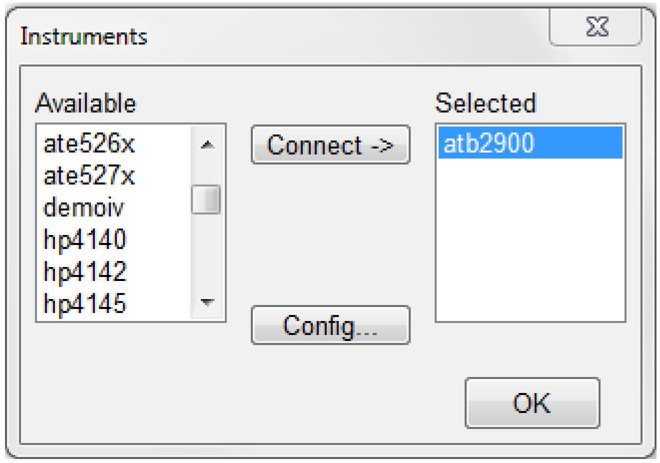


Figure 1.2: Select Instrument dialog used for connecting the instrument

The B2900A Driver is named B2900 and is connected using the Connect Instruments Dialog box accessed from the measurement mode menu bar.

How to Connect the B2900 Driver:

1. Click the CONNECT INSTRUMENTS toolbar button or select INSTRUMENTS/SELECT INSTRUMENT from the ICS measurement mode menu bar. This will open the Connect Instruments Dialog box.
2. Highlight the B2900 driver in the AVAILABLE field.
3. Click the CONNECT button.
4. Your choice will be displayed in the SELECTED field.
5. Clicking the OK button would close the Connect Instruments Dialog box and restore control to the ICS desktop. Keep the Connect Instruments Dialog box displayed for now, because the next step requires you to click the Connect Instruments CONFIG button.

Step 3: Configure the Virtual Device Driver

1. Click the Connect Instruments CONFIG button.
2. Click the "Device Configuration..." button.

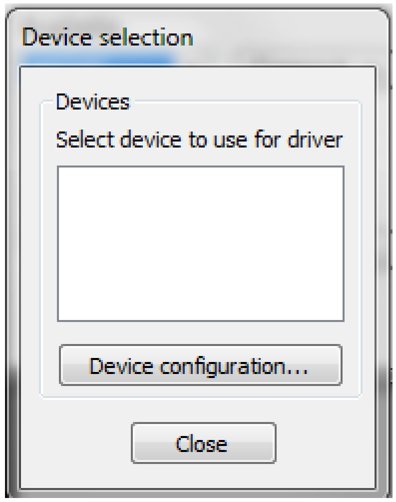


Figure 1.3 - Device Selection dialog used to select the virtual device.

Step 4: Configure the Virtual Device Driver

1. Click the "Agilent" for Manufacturer and "B2900" for the model.
2. Enter a name for the virtual device (i.e. SPA2). This is the common name that this virtual instrument will be known as throughout the system.
3. Specify the number of instances. This is the number of physical B2900 instruments you will be using for the virtual device. If you only have a single instrument this will default to 1.

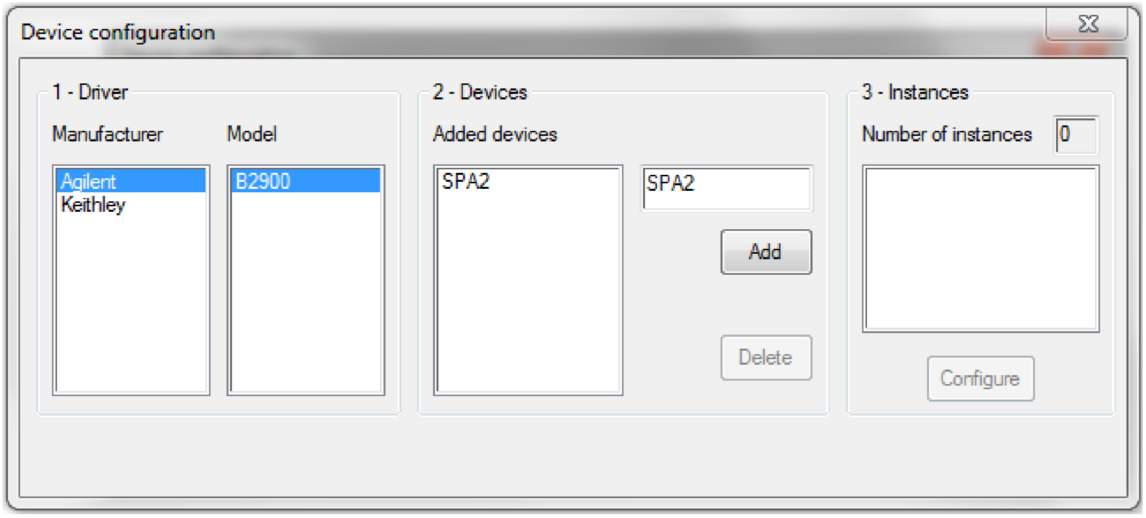


Figure 1.4 - Device Selection dialog used to select the virtual device.

Step 5: Specify the GPIB Address and Model Identities

The B2900A instrument must be connected to your computer with the use of a supported IEEE-488 GPIB card. The GPIB address and the plug-in module identities are specified in the B2900 Configuration Dialog box.

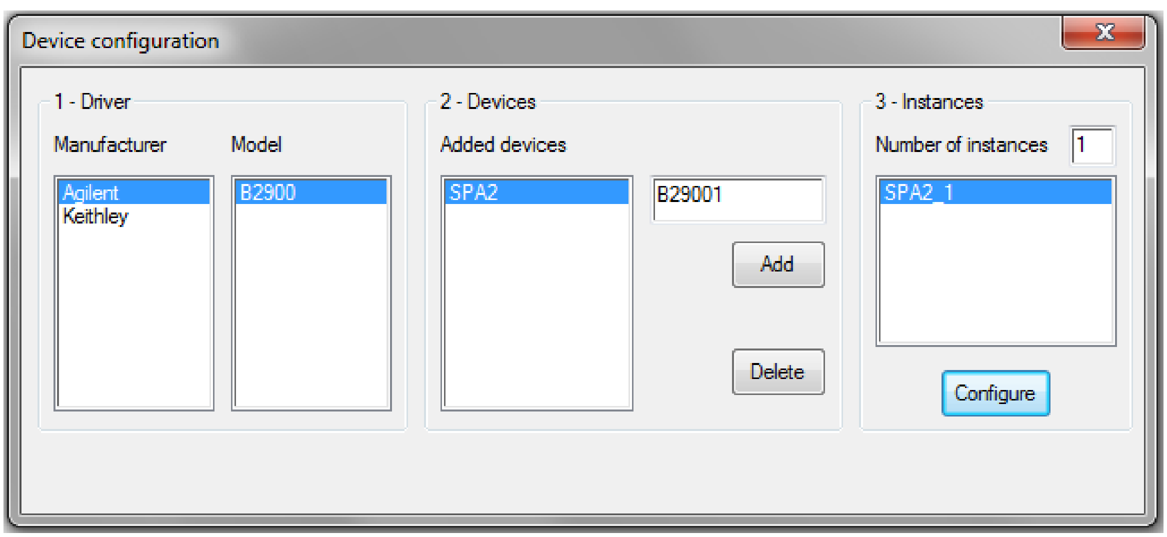


Figure 1.5 - B2900 Configuration Dialog Box

How to Automatically Configure the B2900:

1. Open the B2900 Configuration Dialog box by clicking the "Configure" button at the bottom of the Device Configuration Dialog box.
2. Select GPIB for the "Active interface" and then enter the instrument GPIB address in the GPIB address field. Determine the GPIB address of the instrument by viewing the GPIB Address on the instrument's front panel I/O menu. If you wish to change the GPIB setting, please refer to the B2900 User Manual from Agilent Technologies.
3. Tabbing out of the GPIB address field should automatically connect the device and return its Information. If there is no information displayed then the instrument is not communicating properly at the address specified. You should check the connections and the GPIB address of the instrument if this occurs.

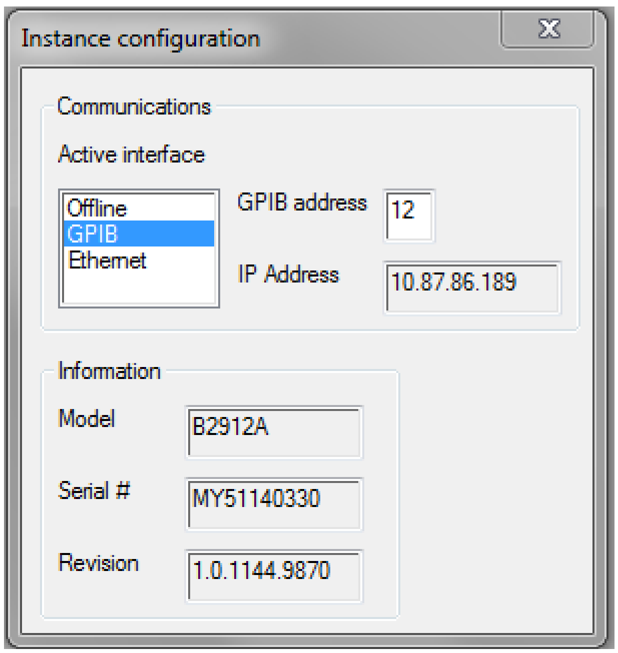


Figure 1.6 - Device Instance Configuration

4. The three unit fields displayed in the Configuration Dialog box correspond to the B2900 mainframe. The Model field label identifies the model of the corresponding instrument; The model number will automatically enumerate the appropriate number of channels for the instrument for example, the B2912A is a dual channel model so "SMU1", "SMU2", will be added to the system. If you were to add another instance of the B2912A then those channels would be added as "SMU3", "SMU4" and so on.

5. Close the Configuration dialog box by clicking the "X" in the window title bar. Click the "X" button located at the top of the Dialog box. This will close the Configuration Dialog box.

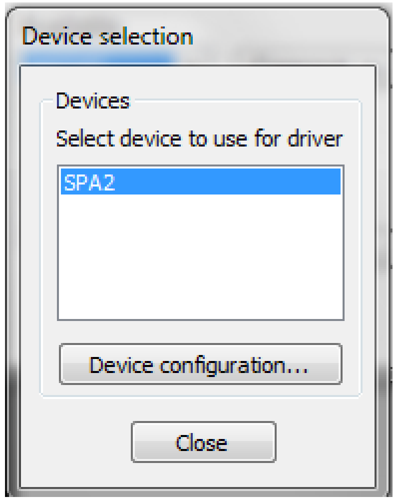


Figure 1.7 - The B2900 Device Selection configured.

6. Click the "Close" button at the bottom of the Device Selection Dialog box to return to the Select Instruments dialog.

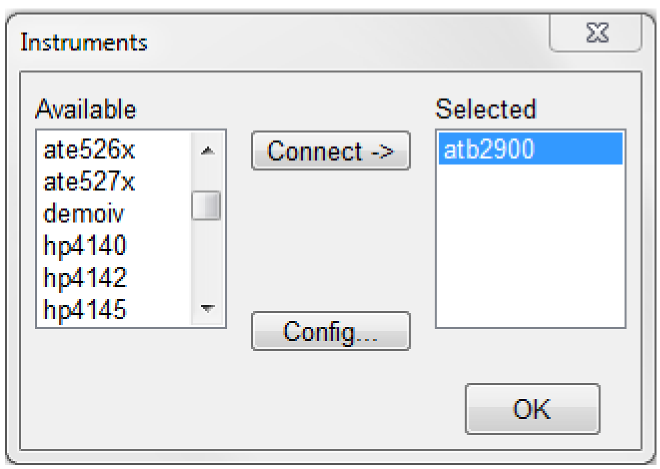
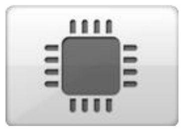


Figure 1.8 - The B2900 Device Selection

7. Click OK to restore control to the ICS desktop.

Step 4: Create the Test Setup

Test setups are created in the Setup Editor. Open the Setup Editor by selecting the SETUP EDITOR toolbar button. In this example, we will create a test setup that measures the forward current of an NP diode with respect to a forward voltage sweep.



Click the corresponding toolbar button to display the Setup Editor.Step 4A: Specify the Test Setup Name

When creating a new test setup, a test setup name must be specified before any other selections or conditions are designated.

How to Specify the Test Setup Name

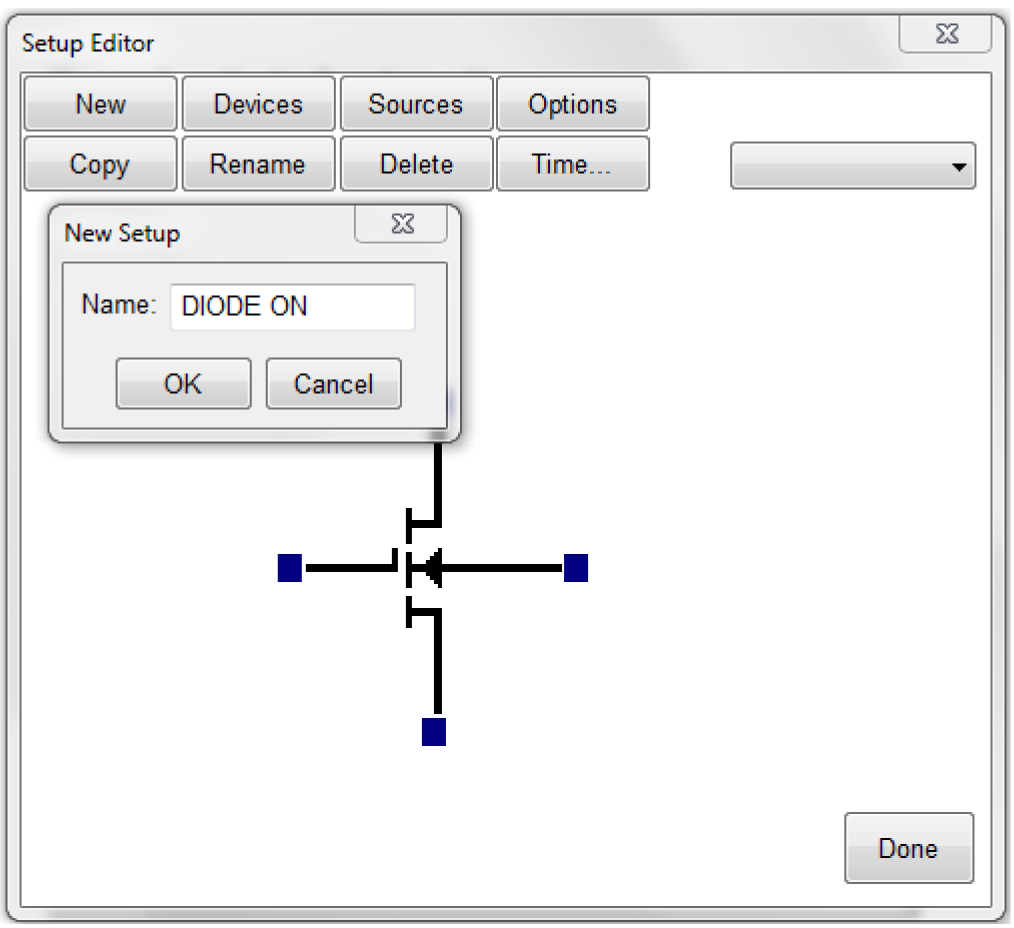


Figure 2.0 - Create New Setup

1. Click the Setup Editor NEW button. This will open the New Setup Dialog box.
2. At the prompt, specify a test setup name. For this example, type "DiodeOn".
3. Click OK. This will close the New Setup Dialog box.
4. The test setup name will appear in the Setup Editor SETUP window.

Step 4B: Select a Device Schematic Corresponding to the DUT

A device schematic is located at the center of the Setup Editor. The device schematic is designed to provide a graphic image of the test fixture socket.

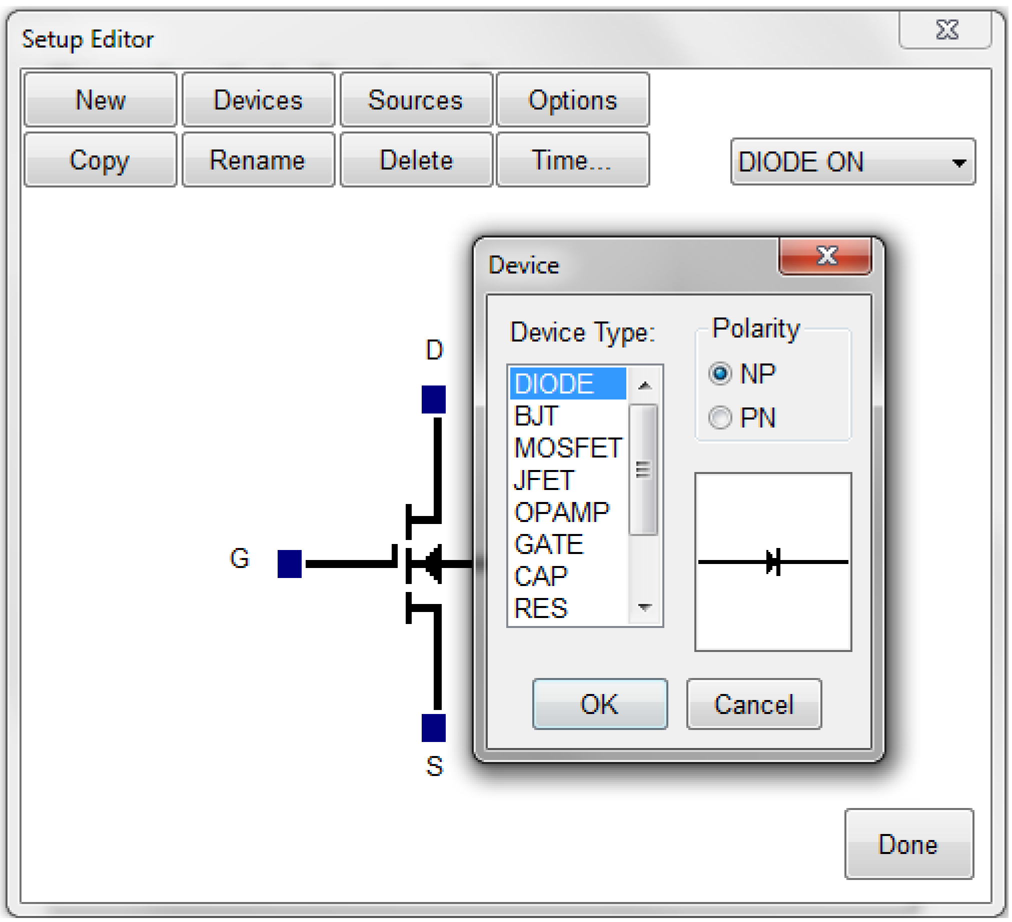


Figure 2.1 - Select Device Type

How to Select a Device Schematic:

1. Click the Setup Editor DEVICES button. This will open the Device Dialog box.

2. The Device Type window will display a list of available device schematics. Select DIODE. Notice the selected schematic is previewed in the small window to the right of the Device Type window.
3. Some device schematics will display a set of polarity switches when selected. Select the "NP" designation for this example.
4. Click OK. This will close the Device Dialog box and display the diode schematic at the center of the Setup Editor.

Step 4C: Designate the Source Unit/DUT Connections

The Source Unit/DUT connections are designated in the Setup Editor. The Setup Editor display is provided as a tool to document the hardware connections required for the corresponding device measurement. The Source Unit/DUT connections designated in the Setup Editor are a graphic representation of the physical connections between the instrument and the test fixture personality board. The connections designated in the Setup Editor must correspond to the reality of your hardware arrangement.

How to Designate the Source Unit/DUT Connections:

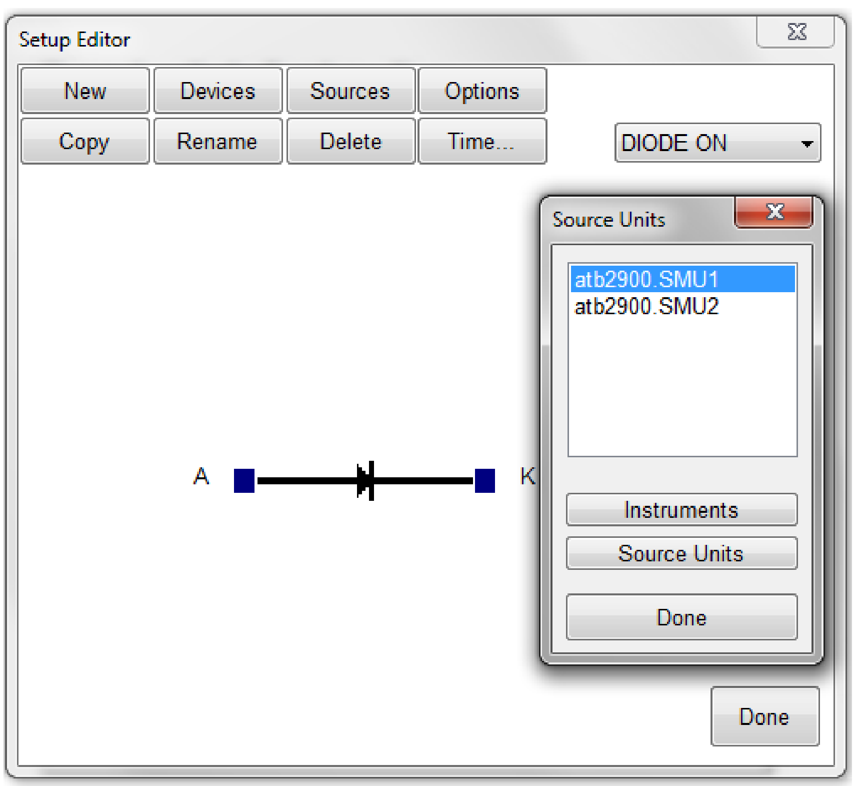


Figure 2.2 - Connect Source Units

1. Select the Setup Editor SOURCES button. This will open the Source Units Dialog box.
2. The Source Units Dialog box will display a list of instrument modules installed in the B2900 and designated in *Step 5: Specify the GPIB Address and Model Identities*.
3. Click on B2912A Dual Channel SMU. This test setup example was created with a B2912A that was designated "SMU1".
4. Designate the Source Unit/DUT connection by clicking on the blue pad corresponding to the appropriate device schematic location. For this example, connect the B2912A to the diode anode by clicking on the corresponding blue pad.
5. Repeat this process for each source connected to the DUT. For this example, no other connections are selected. Note that the GND does not need to be selected.
6. After all of the Source Unit/DUT connections are designated, close the Source Units Dialog box by clicking the Done button in the bottom of the Dialog box.
7. If an incorrect Source Unit/DUT connection is mistakenly designated, then with the Source Unit selected click on the blue pad again to remove the connection. A dialog box will ask if you are sure you want to remove the SMU. Click "Yes" to remove the connection.

The Setup Editor displays a device schematic representing the DUT. Connections are designated by first clicking the "Sources" button and then one of the available source units listed in the Source Units Dialog box.

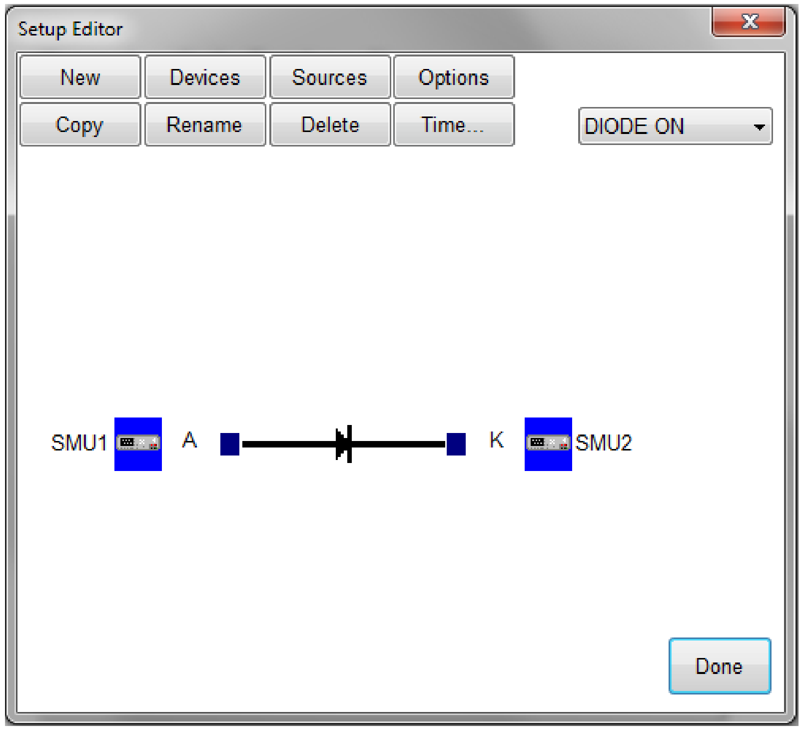
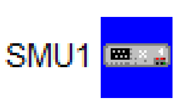


Figure 2.3 - Source Unit Connections

After the source unit is selected, click the blue pad next to one of the device schematic pins. Select the blue pad corresponding to the DUT pin that the source unit will be physically connected to. An instrument icon, along with the name of the connected source unit, will appear next to the device schematic pin as a means of indicating the connection. This example will show how to connect a high power SMU to one end of an NP diode.

Step 4D: Specify the Source/Measure Configuration of Each Source

Every available source has its own Source Unit Setup Dialog box. This Source Unit Setup Dialog box is used to specify the source/measure configuration of the respective module. Once a Source Unit/DUT connection is designated, the corresponding Source Unit Setup Dialog box is opened by clicking on the instrument icon displayed beside the respective device schematic location.



In this example, SMU1 (connected to the anode) will source a linear voltage sweep. The sweep will start at 0.0V and stop at 1.0V and consist of 41 data points. SMU1 will measure voltage (V) and current (I). The SMU2 will be the ground source for the device.

How to Specify the Source/Measure Configuration of Each Source:

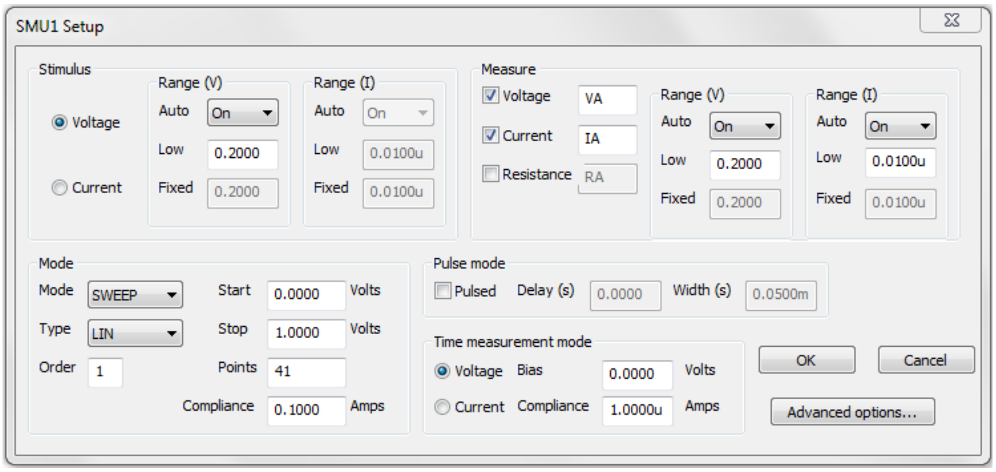


Figure 2.4 - SMU1 Settings

1. Click once on one of the displayed instrument icons to open the Measurement Setup Dialog box corresponding to the connected SMU.
2. Configure the SMU1 controls as shown. Use the mouse or TAB key to move between the different switches and fields in each Source Unit Setup Dialog box.
3. Click the Mode button and select Sweep to open the SMU1 Sweep Settings Dialog box. Configure the sweep controls as shown and click the Done button to exit the SMU1 Sweep Settings Dialog box.
4. Click OK to close a Source Unit Setup Dialog box. If more than one source unit is added, it is possible to move from the edit fields of each by clicking the correct component from the list on the left-hand side of the Measurement Setup Dialog box.
5. Click the SMU2 component to open the SMU2 Settings Dialog box. Configure the SMU2 controls as shown and click the OK button to exit the Measurement Setup Dialog box.

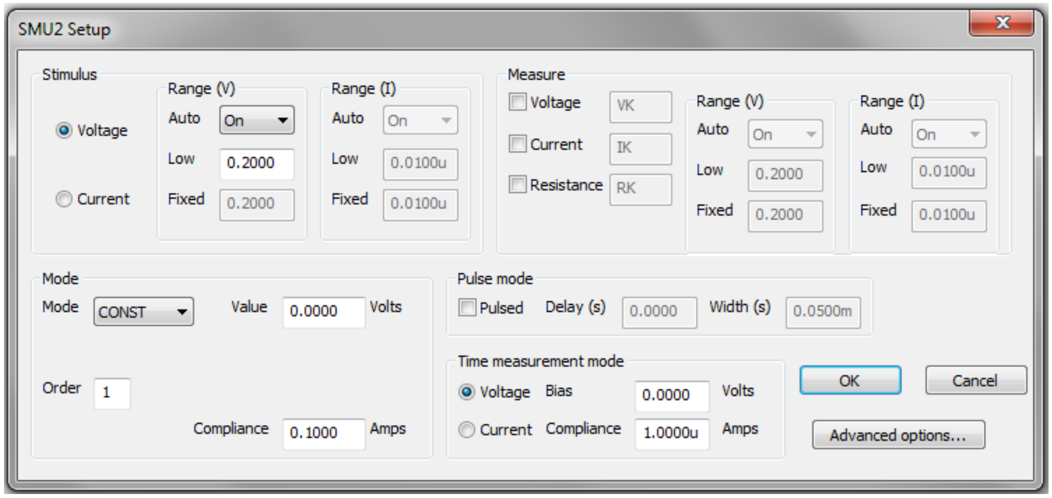


Figure 2.5 - SMU2 Settings

Step 5: Insert the DUT Into the Test Fixture

Insert the DUT into the test fixture personality board according to the Source Unit/DUT connections designated in the Setup Editor.

Step 6: Execute the Measurement

Open the Measurement remote control by clicking the toolbar MEASURE button. Run the DIODE ON test by clicking the Single button on the Measurement remote control.

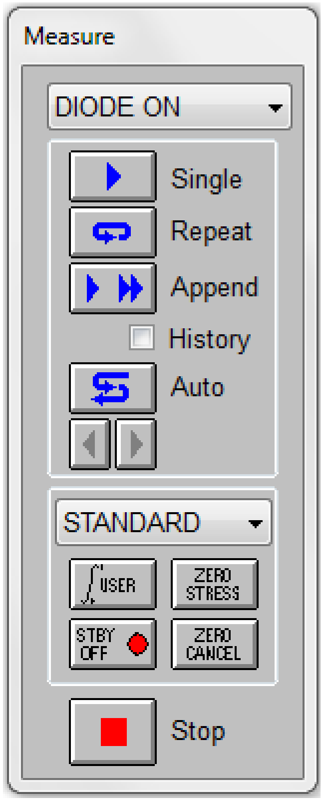
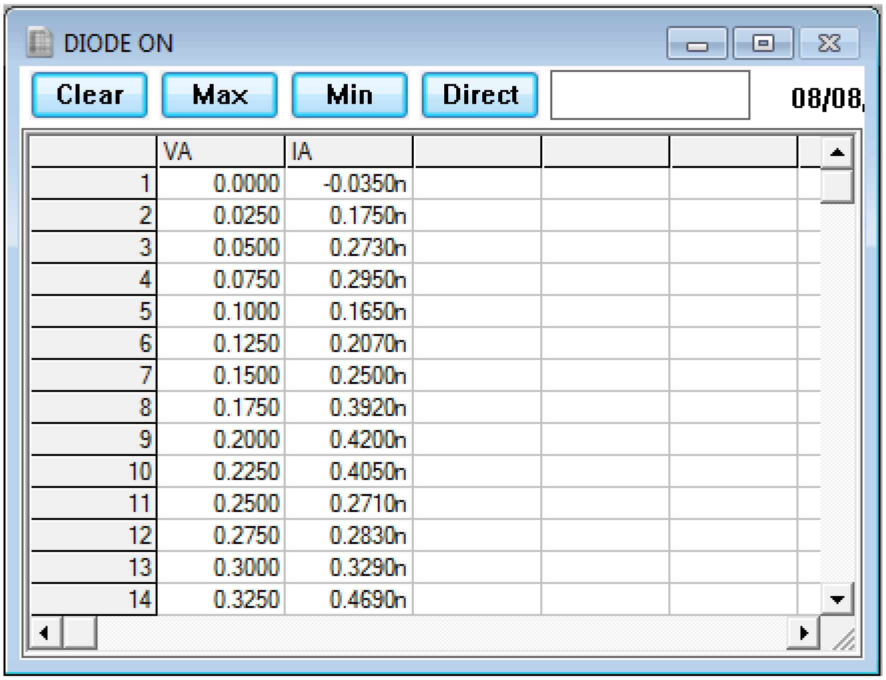


Figure 2.6 - Measure Remote

After a few seconds the measurement will complete.

Step 7: View the Results

Data is automatically generated in the corresponding data window spreadsheet each time the measurement is executed. To display the numerical data, double-click on the minimized blue window labeled "Diode On" at the bottom of the ICS desktop. The spreadsheet existed before you executed the measurement, but it contained no data.



DIODE ON

Clear | Max | Min | Direct | 08/08,

	VA	IA			
1	0.0000	-0.0350n			
2	0.0250	0.1750n			
3	0.0500	0.2730n			
4	0.0750	0.2950n			
5	0.1000	0.1650n			
6	0.1250	0.2070n			
7	0.1500	0.2500n			
8	0.1750	0.3920n			
9	0.2000	0.4200n			
10	0.2250	0.4050n			
11	0.2500	0.2710n			
12	0.2750	0.2830n			
13	0.3000	0.3290n			
14	0.3250	0.4690n			

Figure 2.7 - Select Device Type

Data window spreadsheets are dynamically linked to the test setup. Each time the corresponding test setup is executed, the spreadsheet data is replaced with the most recently measured data. For this reason, the data window spreadsheet is automatically named the same as the test setup.

Step 8: Create a Plot of the Results

A plot window is dynamically linked to a corresponding data window spreadsheet. This means that the plot is regenerated any time there is a change to the corresponding spreadsheet data. If the test setup is executed more than once, the plot window is regenerated after each measurement. Up to ten plots can be created from a single data window spreadsheet, and each plot can be independently formatted.

The steps below will show you how to create a plot of diode current with respect to the forward voltage sweep. This plot will correspond to the DiodeOn data.

How to Create a Plot

1. If there is more than one defined test setup, designate the active test setup in one of two ways:
2. Click once on the appropriate data window spreadsheet icon (the data window can be either displayed or minimized).
3. Click the toolbar setup window arrow and select the desired setup from the displayed drop-down list.
4. Click the CREATE PLOT toolbar button. This will open an empty plot window and the Plot Data Dialog box.
5. Designate the x-axis of the plot by selecting the appropriate data vector listed in the Data Group pull-down box. Only two quantities were measured in the DiodeOn test setup, voltage and current. This example will create a plot of current with respect to voltage. Since voltage will be the x-axis, select "V".
6. Designate the first y-axis of the plot (in our case the only y-axis) by selecting the appropriate data vector in the Data Group. For this example, select "I".

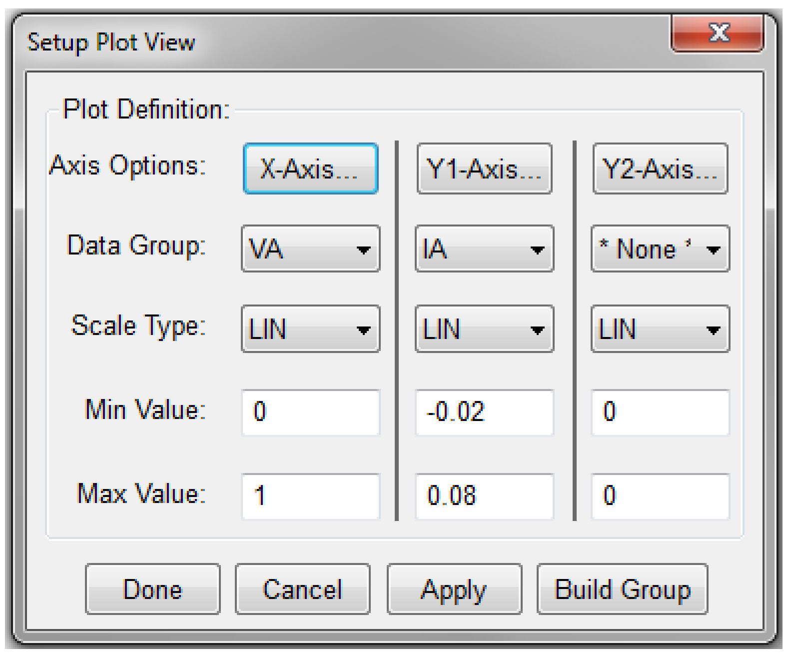


Figure 2.8 - Plot Setup

7. Click the Dialog box APPLY button. This will create the plot but will not close the Plot Data Dialog box. You should notice that at about 0.6V the diode turned on.

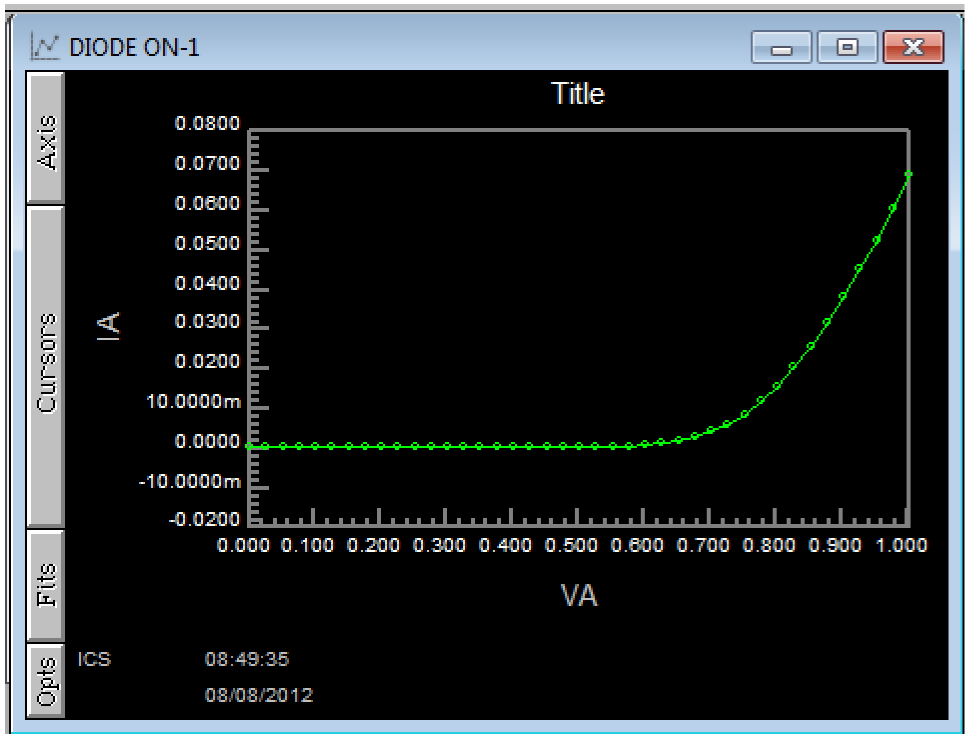


Figure 2.9 - Plot Window

8. Click the DONE button to close the Plot Data Dialog box.

Step 9: Save the Results into a Project File

A project file includes all of the information necessary to execute a test setup or group of test setups. A single project file includes: 1) the instrument driver selection, 2) any defined test setup(s), and 3) all of the data and plot windows associated with the test setup(s). For more information about project files, refer to *Chapter 1: How ICS Stores Information* in the ICS reference materials.

The B2900 Configuration Dialog Box

The B2900 Configuration dialog box identifies the instrument GPIB address and the model number and enumeration of the available source units based on the model of the installed B2900 mainframe.

The B2900 Driver must be connected to ICS before the Configuration Dialog box can be opened. If necessary, refer to *Step #2, Connecting the B2900 Instrument Driver*. After connecting the B2900 Driver, the B2900 Configuration Dialog box can be opened from the Connect Instruments Dialog box.

Open the Connect Instruments Dialog box by clicking the corresponding toolbar button.

Open the B2900 Configuration Dialog box from the Connect Instruments Dialog box by clicking the Connect Instruments CONFIG button.

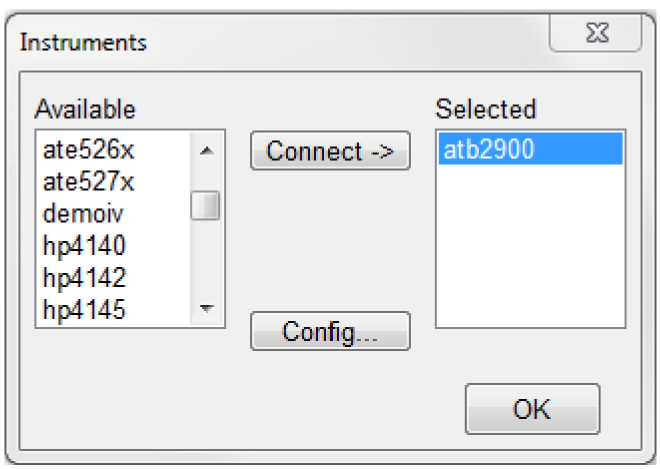


Figure 3.0 - Connect Instruments Dialog Box.

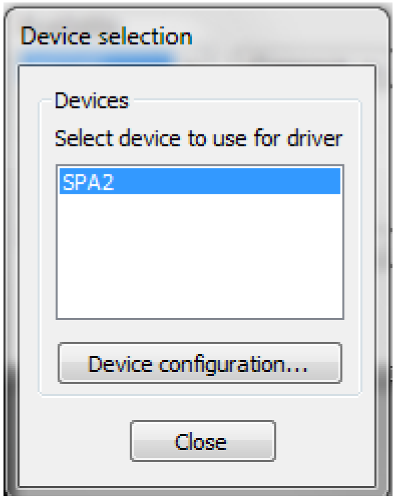


Figure 3.1 - Virtual Device Selection

Virtual Device Configuration and Labels

The B2900 Configuration Dialog box includes three fields corresponding to the available drivers. The driver list displays the Manufacture and base Models available. The "Added Devices" field is used to identify the hardware installed and configured. The "Number of Instances" specifies the number of mainframes that are to be added to the virtual device. When a user designates an instance the driver automatically enumerates the source units to be available later in the application. Each instance will be identified by the corresponding index label designated in the "Devices" column of the B2900 Configuration Dialog box. Instances are identified by "Device" label (i.e. SPA1_1, SPA1_2, SPA_3, etc.) instead of the model numbers configured in the source unit fields. This eliminates confusion when two or more identical modules are installed in the B2900.

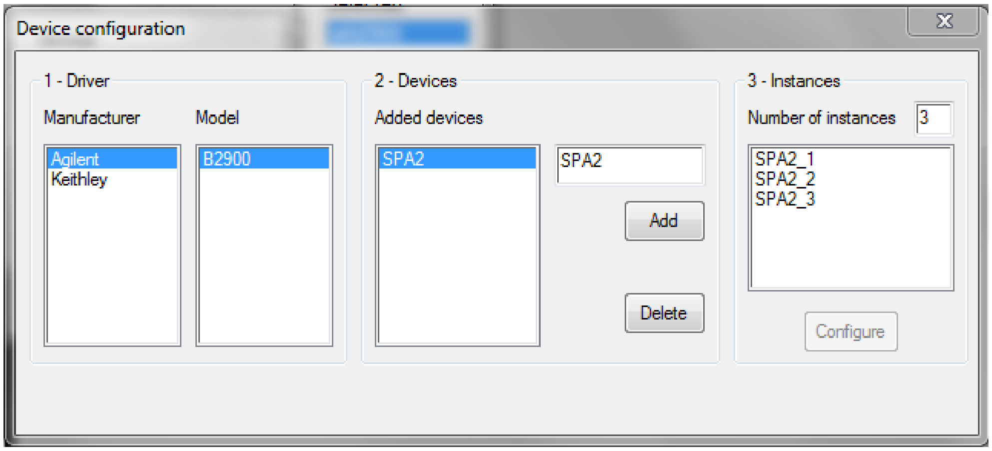


Figure 3.2 - Virtual Device Configuration

Configuring the Instrument GPIB Address

When reviewing the B2900 Device Configuration Dialog box, the user must be certain that the specified configuration agrees with the physical installation of the hardware. For example, if an B2912A Dual Channel SMU is installed in the first mainframe instance, then the "SPA1_1" designation must be configured as the first instance list selection. The mainframe in each position corresponding to each of the devices to be identified in the "Instances" column.

The B2900 Device Configuration Dialog box is configured by first selecting the instance and then entering the instrument GPIB address and then tabbing out of the address field. A *IDN? function interrogates the instrument and automatically identifies the model installed. The name of each field according to the installed hardware (for example, "B2912A").

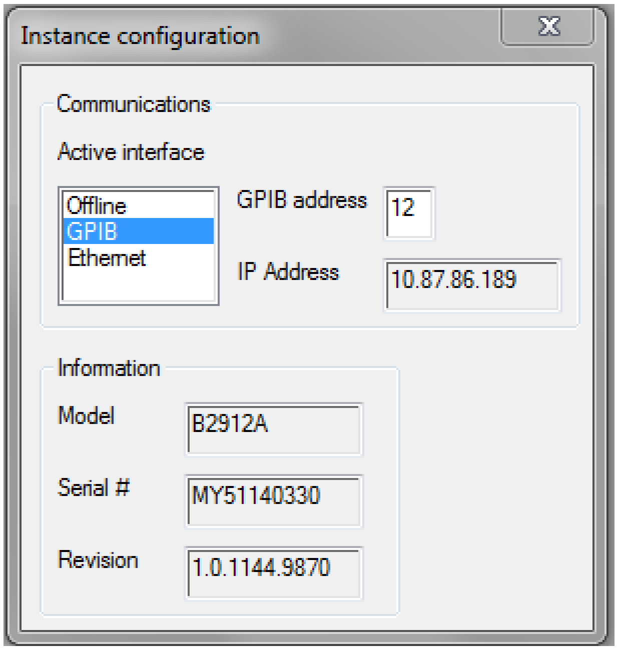


Figure 4: SPA1_1 Instance Configuration

Any Information field corresponding to <Unknown> means that mainframe is off-line and not communicating properly at the specified address.

Polling Errors and Warnings

ICS will display a short sequence of error messages if the GPIB card is not installed but will fail silently if the instrument experiences a timeout after attempting to locate the instrument on the GPIB bus. The "Information" fields will display <Unknown> if the instrument is Off-line, if the instrument is not connected to the GPIB cable, or if the GPIB address is wrong. If the instrument is connected to your computer through a daisy-chain of GPIB cable connections, each instrument in the cable path must be turned ON.

When to Update the B2900 Configuration Dialog Box

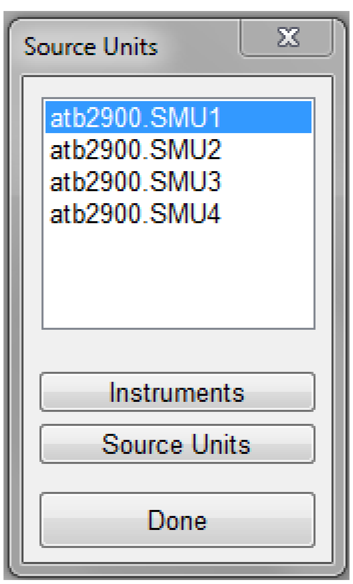
It is only necessary to configure or update the B2900 Configuration Dialog box when either of two situations occur:

1. The B2900 Driver is connected to ICS for the first time.
2. The B2900 instance configuration is altered or the instrument GPIB address is changed.

The information displayed in the B2900 Configuration Dialog box is stored in memory when the user manually specifies the box contents or after the user selects the instrument. The B2900 configuration is written to the ICS40.INI file as soon as the "Close" button is selected in the Configuration Dialog box. The B2900 Driver connection is documented in the corresponding project file when FILE/SAVE or FILE/SAVE AS is selected. When the project file is opened, ICS will automatically connect the B2900 Driver and arrange the B2900 Configuration Dialog box according to the designations recorded in the ICS40.INI file. This eliminates the need to repeatedly connect the B2900 Driver or arrange the Configuration Dialog box each time an B2900 project file is opened. After initially arranging the B2900 Configuration Dialog box, there is no need for the user to review the Dialog box unless the module configuration is altered or the instrument GPIB address is changed.

Source Unit Availability

The SOURCE UNITS Dialog box contains a list of available instrument modules that can be used to build a test setup. The contents of this Dialog box represent the instrument modules installed in and enumerated in the B2900 virtual device driver as designated in the B2900 Configuration Dialog box under the Instances column.



The SOURCE UNITS Dialog box does not include a source unit representing the GND. The Ground can be a physical connection the force low output or may be specified as an SMU with a 0.0V constant supply that provides a measurement ground reference for the Device Under Test (DUT) but does not have to be configured.

It is possible to open a project file that was created with a mainframe configuration that does not match the configuration of the instrument presently available. This is called a hardware mismatch. A hardware mismatch is more precisely defined in the paragraphs that follow.

When a test setup is created, the association between the mainframe (for example, "B2911A") and the source unit field label (for example, "SMU1") is stored as part of the test setup. This association is obtained from the B2900 configuration defined in memory when the test setup is created. Test setups are stored in project files, thus the B2900 configuration associated with each test setup is recorded in the corresponding project file. After the project file is created, the user may alter the B2900 configuration. The user may change the GPIB address, or the user may add new instances or move existing instances to new index positions. Any one or more of these situations will alter the B2900 configuration. If the B2900 configuration changes, the user must update the B2900 Configuration Dialog box. Failing to do so will generate a hardware mismatch error when the user attempts to execute a test setup. The user can update the B2900 Configuration Dialog box by using the Device Configuration dialog. As soon as the B2900 Configuration Dialog box is updated, the new B2900 configuration is stored in memory. The new B2900 configuration is written to the ICS40.INI file as soon as the "OK" button is selected in the Configuration Dialog box.

When a user opens a project file, ICS will verify that the correspondence between the test setup source unit labels and the module identities agree with the B2900 configuration stored in memory. (For example, does the first instance identified as "SMU1" really correspond to an "B2911A"?) If there is a disagreement, ICS will identify the inconsistency but will not display a hardware mismatch error until the respective test setup is executed.

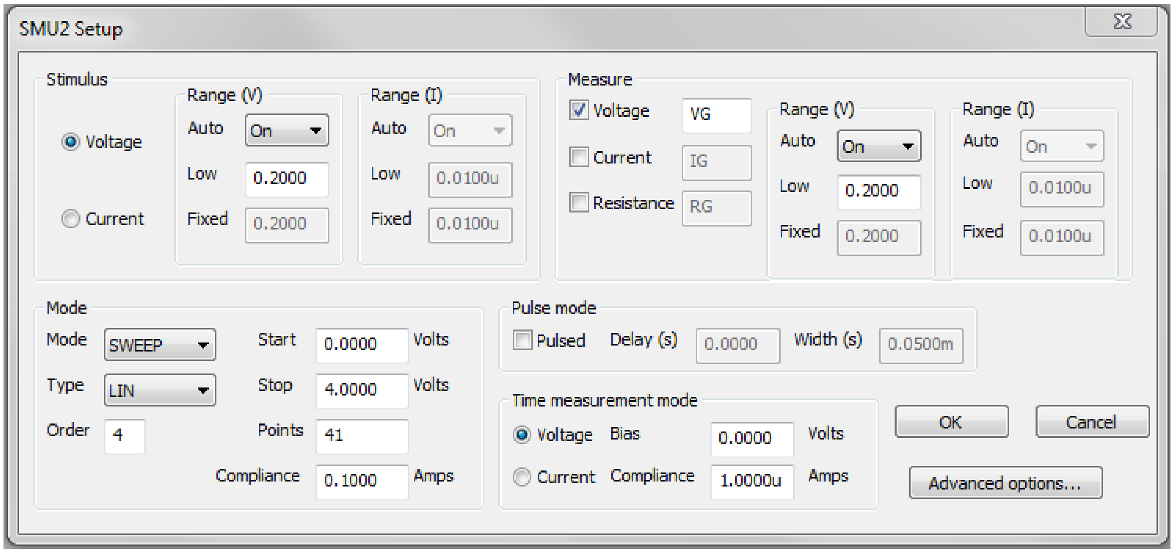
When the user selects a test setup and clicks the toolbar MEASURE button, ICS will do two things. First, ICS will display an error message reporting any hardware inconsistencies that were detected when the project file was opened. If there were none, ICS will then interrogate the instrument and ensure that the correspondence between the module identities and slot positions reported by the instrument agrees with the B2900 configuration stored in memory. This verification detects inconsistencies that result when the user changes the B2900 configuration but fails to update the B2900 Configuration Dialog box. If this comparison agrees, ICS will execute the test setup. If it does not, ICS will display a hardware mismatch error.

When the user attempts to execute a test setup that includes a hardware mismatch, ICS will display a message box informing the user of the problem. The message box will identify the source unit label (which also identifies the instance) corresponding to the error. The message box will also list the module identity stored in memory followed by the module identity returned from the corresponding mainframe position.

The user has two options when a hardware mismatch is encountered:

1. Delete the test setup and create a new test setup using the active B2900 configuration.
2. Restore the mainframe configuration to the original configuration reported by the error message(s).

The Measurement Setup Dialog Box



The setup conditions of each source unit are independently controlled with the Measurement Setup Dialog box. There is a Settings Dialog box that corresponds to each B2900 channel. The B2900's Measurement Setup Dialog box is accessed from the Setup Editor.

Once the Measurement Setup Dialog box is opened, all features of the instrument (including Mainframe Setup options) can be accessed. This is different from other ICS drivers which require the opening of several Dialog boxes to perform these functions.

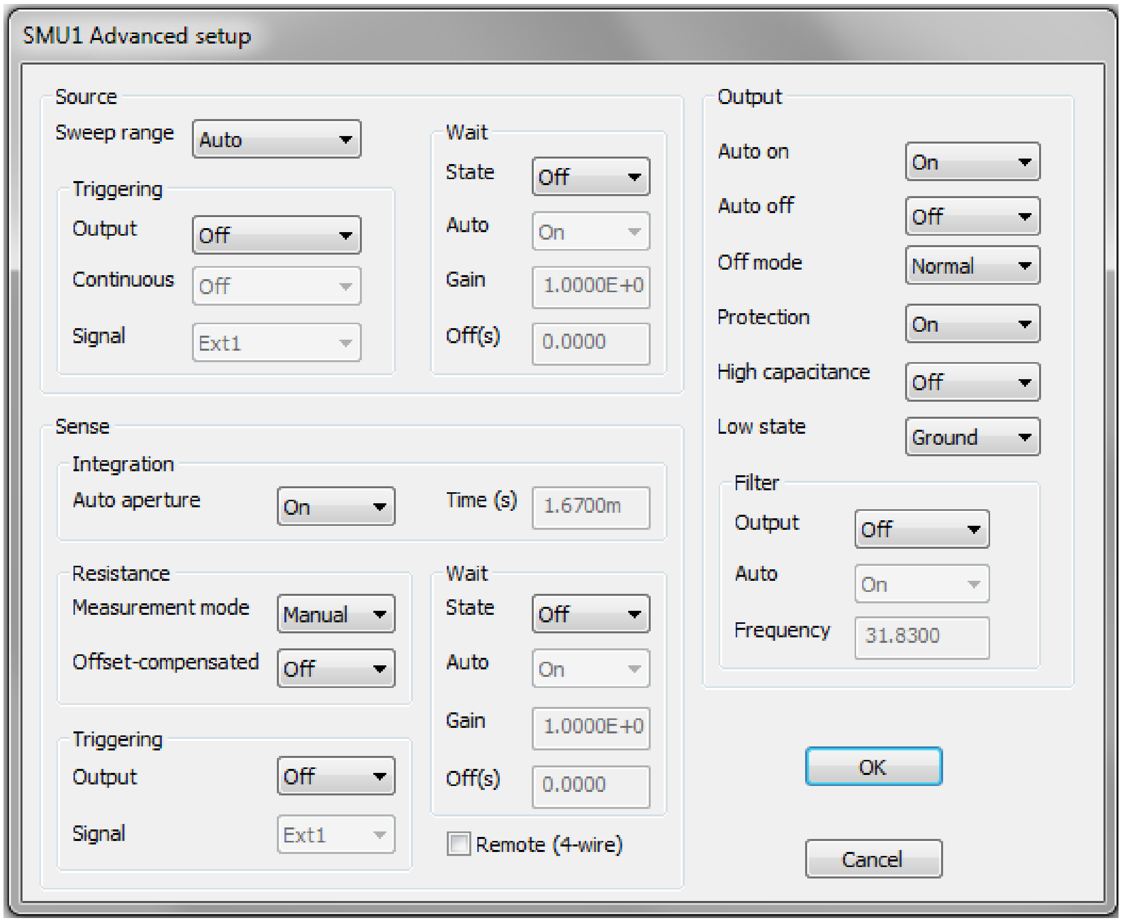
How to Display the Measurement Setup Dialog Box:

In order to display the Measurement Setup Dialog box, the corresponding source must be assigned to a DUT pin represented by the device schematic.

1. Click once on the instrument icon to open the Measurement Setup Dialog box.
2. Click once on the desired source unit listed in the Measurement Settings area of the Measurement Setup Dialog box.
3. The settings for the selected SMU will appear in the Measurement Setup Dialog box.

Measurement Setup Dialog box is used to specify the source/measure configuration of each B2900 channel. The contents of Measurement Setup Dialog box are outlined below:

1. **Stimulus Group:** This group consists a radio button used to identify whether the sourcing signal is a voltage or a current. User selectable Source Range values can also be specified.
2. **Measure Group:** This group allows the selection of the Voltage, Current, Resistance values to be returned to the Data Spreadsheet. User selected Measure Range values can also be specified.
3. **Bias Mode Group:** This field consists of a pull-down menu that allows the selection of the sourced signal type (Const, Sweep, Step) and LIN or LOG type.
4. **Seq. Order Field:** This field sets the output's turn-on order.
5. **Bias Field:** This field allows the setup of the bias value. In the case of a sweep source the field will contain a button to open the source configuration.
6. **Compliance Field:** This field allows the setting of the Source compliance level.
7. **Pulse Group:** This field allows the setup of the pulse mode. In the case of a pulsed source the available fields provide for specifying delay time and pulse width.
8. **Time Bias Group:** This field allows the setup of the time bias value. In the case of a time bias mode measurement these values will override the settings for bias and compliance specified in the Bias Mode Group.



At the bottom of the setup box is a button labeled **Advanced options**. This button allows additional settings to be displayed. The additional settings are listed below.

1. **Source Group:** This field allows the selecting Auto, Best Fixed or Fixed for the Source Range mode of the B2900.
2. **Source Triggering:** This group sets the source trigger output mode and signal source.
3. **Source Wait:** This field allows the selection Source Wait state, gain and offset of the B2900.
4. **Sense Group:** This field allows the selection of the type of integration control via a pull-down menu and Time field.
5. **Sense Resistance Measurement:** This field allows the setting of the Resistance measure mode and off-set compensation.
6. **Sense Triggering:** This group consists of the switch and fields necessary to configure the sense triggering and trigger signal.
7. **Remote Sense Field:** This field allows the activation of the B2900's internal 4-Wire remote sensing for this output.
8. **Ouput Group:** This group allows the activation of the B2900's output management including Auto On/Off protection, output capacitance and ground state.

9. **Output Filter Group:** This switch turns on and off the source unit's output filter mode.

Sweep Controls

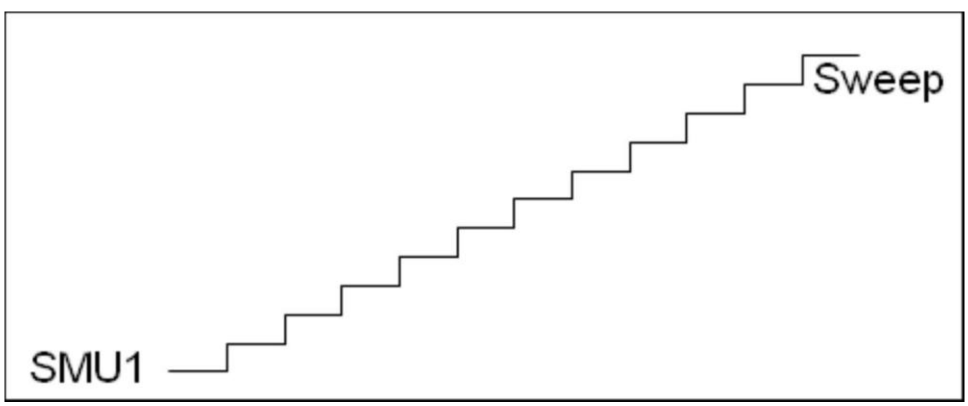
Sweep controls are used to specify the shape and boundaries of the sourcing signal, as well as the sourcing signal's compliance limit. Timing and averaging configurations are defined in the B2900 Mainframe Setup Dialog box.

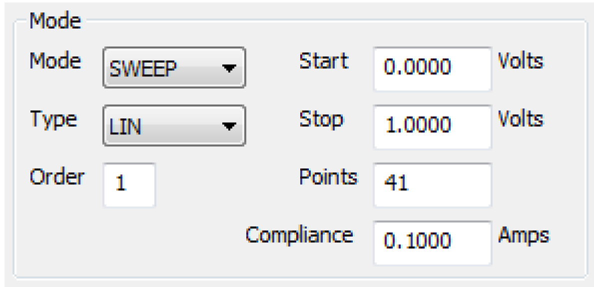
Bias Mode

The sourcing signal shape is selected from a list of signal shapes available in the BIAS MODE field. The sourcing signal may be characterized as a sweep, step, or constant supply. To select the desired bias mode, use the pull-down menu in the BIAS MODE field. Click on the desired mode.

For an explanation of the bias modes used in conjunction with the pulse option, please refer to the *Pulse Sweep Mode* section below.

Sweep Mode





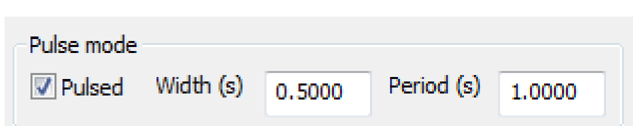
The sweep mode generates either a linear or logarithmic staircase sweep signal between two specified boundary values. The settings are configured by clicking the **Mode** button.

When creating a test setup that includes a second, synchronized sweep signal, the sweep application described in this section is the primary sweep signal. Double sweeps consisting of ascending and descending sweep directions are supported by this driver.

How to Source a Sweep Signal:

1. Select the "SWEEP" designation from the available options listed in the BIAS MODE field.
2. Click the **Mode** button to open the Sweep Settings Dialog box.
3. The data point distribution of the sweep signal can be either linearly or logarithmically distributed between the START and STOP values specified. Select between a linear or logarithmic distribution by selecting the appropriate designation in the TYPE field.
4. Specify the sweep signal boundary values in the START and STOP fields.
5. Enter the number of data points that will comprise the sweep signal in the POINTS field.
6. Enter the Compliance limit value for the sweep signal in the COMPLIANCE field.

Pulse Sweep Mode



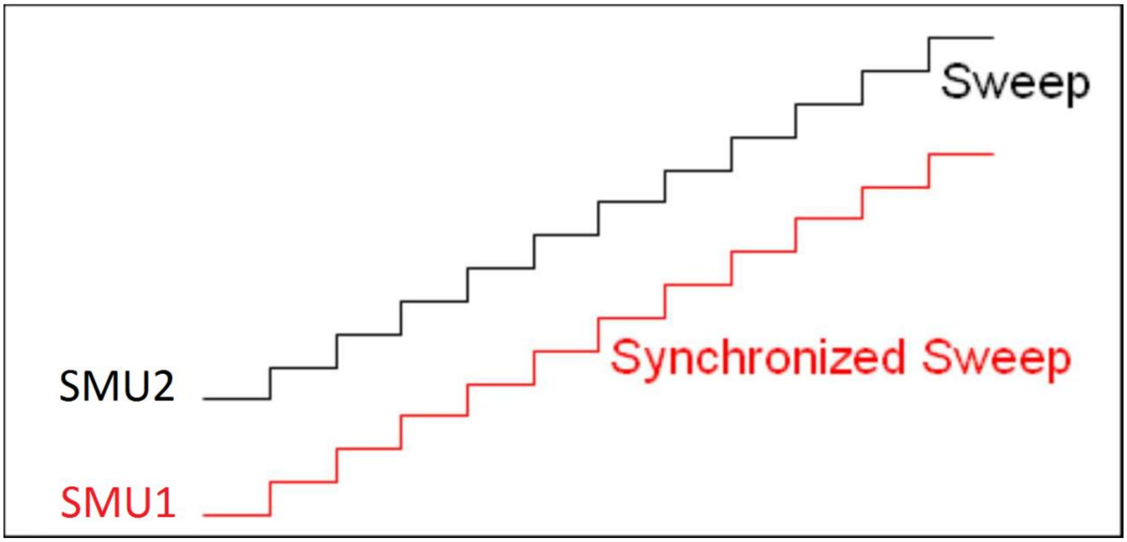
Pulse Width

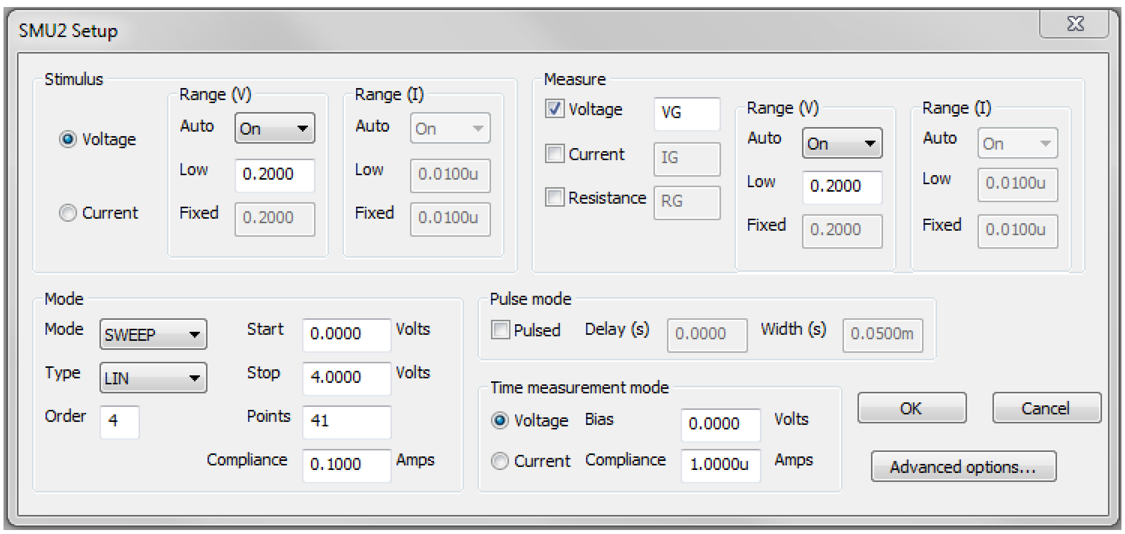
The pulse width is the length of time during which the KI2600 will force the pulse value.

Pulse Period

The pulse period is the total cycle time between consecutive pulse triggers.

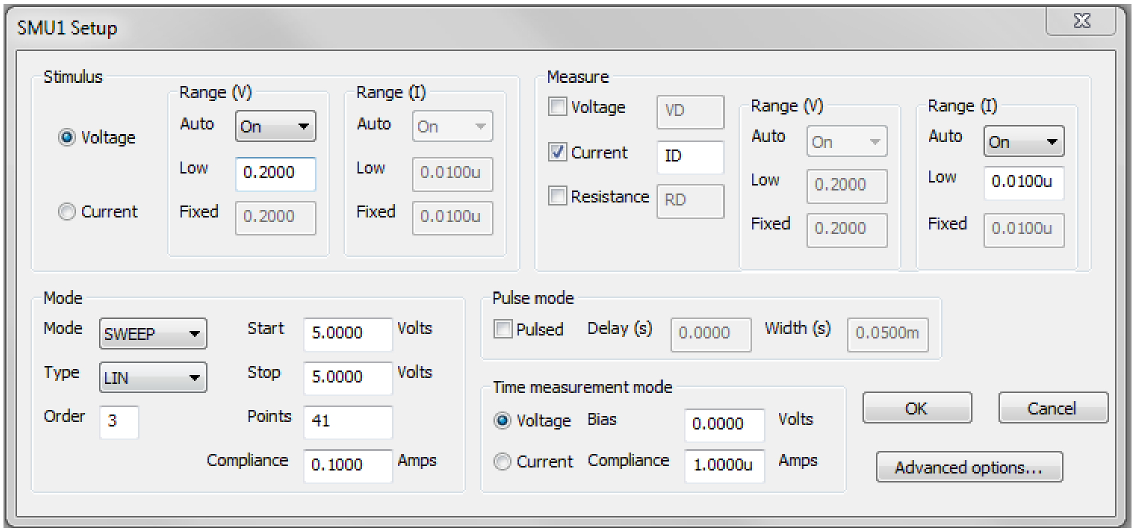
Synchronized Sweep





A synchronized sweep is a second linear sweep signal that is synchronized in time with a primary sweep signal applied by another source unit.

The stimulus of the secondary sweep signal must match the stimulus of the primary sweep. In other words, if the primary sweep is a voltage output, the synchronized sweep must be a voltage output also. If the stimulus modes of the primary and synchronous outputs disagree, ICS will generate an error message when the user attempts to exit the Measurement Setup.



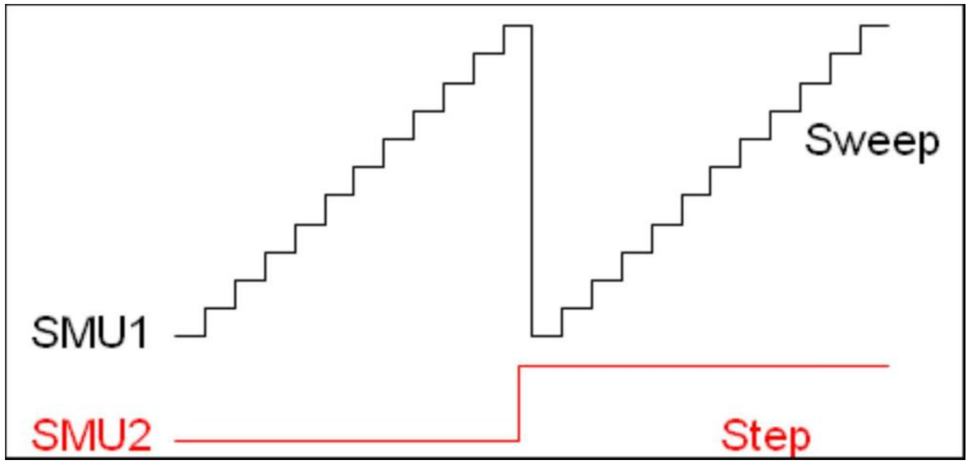
While the *timing* of the primary and secondary sweep signals is synchronized, the magnitudes can differ. The magnitude of the synchronized sweep signal is specified by designating a start and stop value. The secondary sweep source should have the same number of POINTS specified.

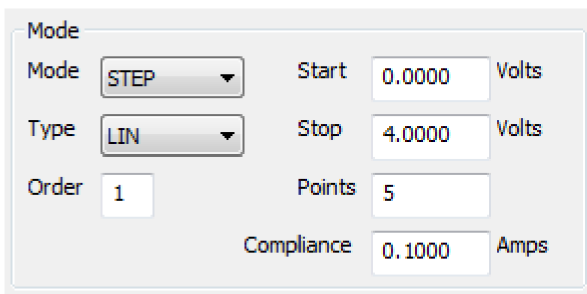
How to Source a Synchronized Secondary Sweep Signal:

A synchronized sweep signal is functional only when a linear sweep signal is forced by another source unit.

1. Select the "SWEEP" designation from the available options listed in the BIAS MODE field.
2. Make certain that the selected Stimulus switch (VOLTAGE or CURRENT) matches the output stimulus type of the primary sweep signal. If the stimulus mode of the output signals do not match, ICS will generate an error message when the user attempts to exit the Measurement setup.
3. Click the Setup button.
4. Specify the START and STOP values. For a const source START and STOP should be the same value.
5. Specify the same number of POINTS as the Primary Sweep.
6. Click the OK button.

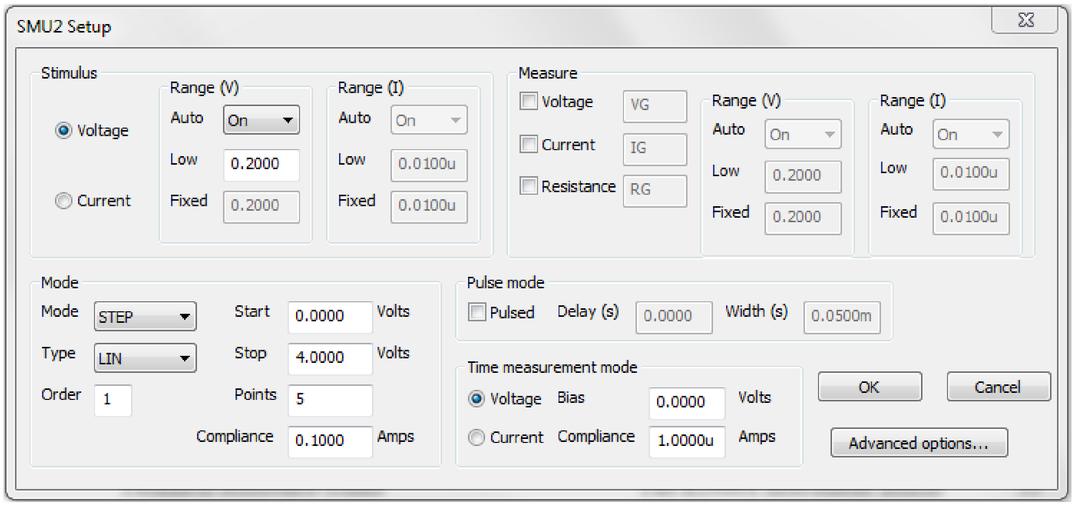
Step Mode





The step mode forces a constant output while another source unit in the test setup forces a sweep signal. The step mode is functional only in test setups that include a second source unit configured in sweep mode.

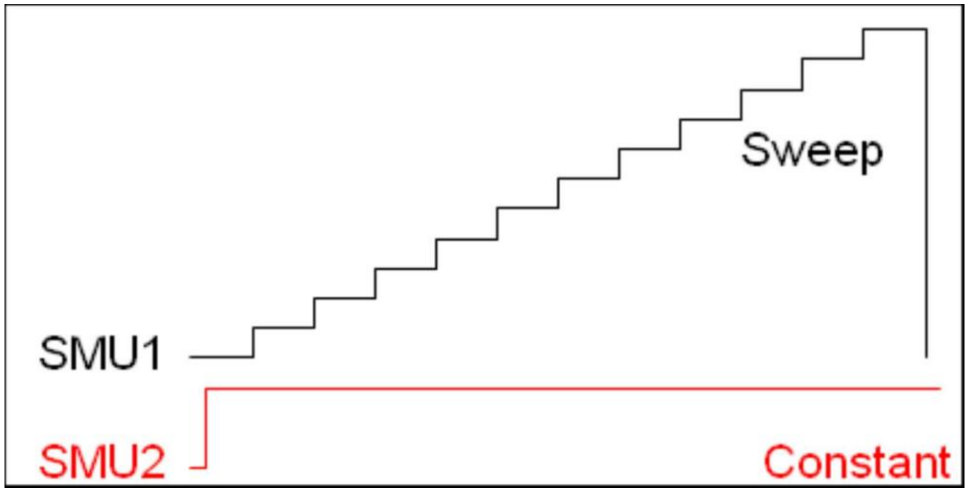
The step mode generates a constant output signal while a second source unit generates a staircase sweep signal. After the staircase sweep signal reaches the specified STOP value, the magnitude of the step output is incremented by the STEP value and the staircase sweep signal is triggered again. This process continues until the STOP value of the step signal is reached.

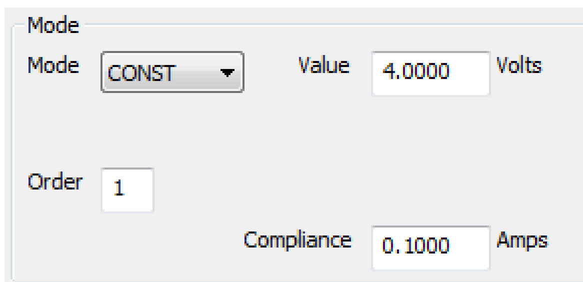


How to Source a Step Signal:

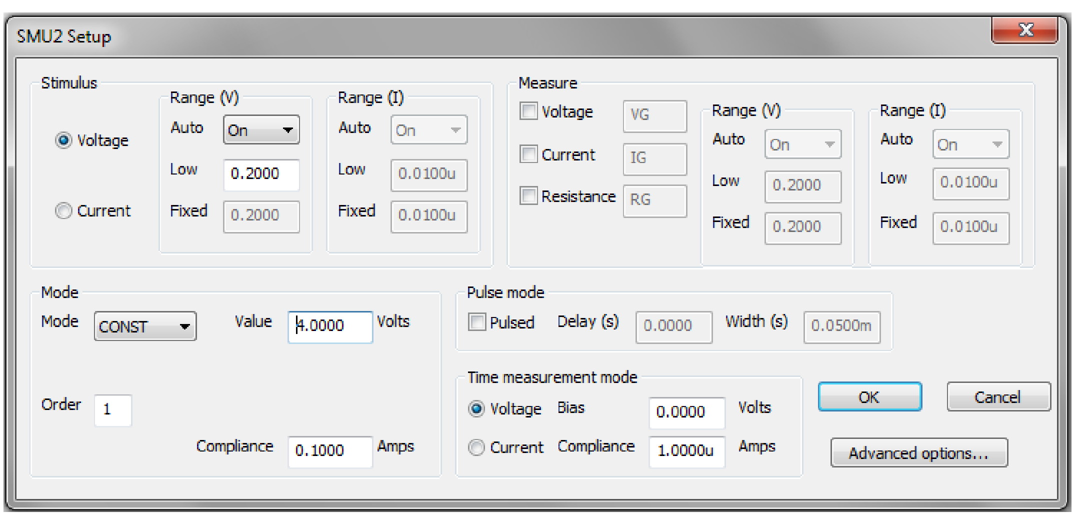
1. Select the "STEP" designation from the available options listed in the BIAS MODE field.
2. The step sequences can be either linearly or logarithmically calculated between the START and STOP values specified in Step #3. Select between either a linear or logarithmic step sequences by specifying the appropriate designation in the TYPE field.
3. Specify the range of the step signal in the START and STOP fields.
4. Specify the increment quantity in the POINTS field.
5. If a linear step sequence is configured in the TYPE field, the increment size will be displayed in the STEP field. After a value is entered in the POINTS field and the cursor is moved to another location (or OK is selected), the STEP field will be calculated automatically. If desired, the calculated STEP can be updated by the user. If a logarithmic step sequence is configured in the TYPE field, the STEP field will not be displayed.

Constant Mode





The constant mode generates a signal that remains at a constant magnitude throughout the duration of the test setup. Constant is typically kept on an SMU in conjunction with a second SMU performing a Sweep of some type.



How to Source a Constant Signal:

1. Select the "CONST" designation from the available options listed in the BIAS MODE field.
2. Specify the signal magnitude in the BIAS VALUE field.

Compliance

The COMPLIANCE field is used to specify the limiting magnitude of a measured signal. When a source unit is sourcing voltage and measuring current, a current compliance must be specified. Similarly, if a source unit is sourcing current and measuring voltage, a voltage compliance must be specified.

The compliance limit allows the user to execute a test setup that is within an acceptable power range of the device by limiting the operating range of the source unit. For example, if a 1mA compliance limit is specified for a source unit that is sourcing a sweep voltage and returning a current, the source unit will supply an increasing voltage signal until a 1mA current is returned.

The maximum compliance limit that ICS will allow is determined by the operating boundaries of the instrument. Please refer to the B2900 Operation Manual for an overview of the B2900 compliance configurations and power limitations.

Detecting Compliance Events

If the Display Errors switch is selected in the Mainframe Settings Dialog box, ICS will display a message if a compliance limit is detected. (The Mainframe Setup Dialog box is opened by clicking the Setup Editor OPTIONS button or by clicking the MAINFRAME component in the Measurement Setup Dialog box). The message box will identify the source unit in compliance. The Continue on Any option will result in the instrument NOT stopping when a channel reaches compliance, otherwise the data for all points after compliance is reached is returned as zero.

As a default, the Display Errors switch is OFF. If you want ICS to identify compliance events, make certain that the Display Errors switch is selected in the Mainframe Setup Dialog box.

Output Filter Switch

The B2900 modules include a low-pass filter at the digital-to-analog converter (DAC) output. The default position of this switch is OFF. For more details concerning the function and applicability of the Output Filter switch, please refer to the B2900 Operation Manual.

When configuring modules that can source and monitor either voltage or current, selecting the characteristic of the forcing signal defines the characteristic of the measured signal. All data doesn't have to be returned, but the data can be the sourcing signal itself (calculated), the complement of the sourcing signal (measured), or both. Data return specifications are defined in the Measure Group menu.

Measure Controls

The Measure Group control box consists of three switches: VOLTAGE, CURRENT, and RESISTANCE. In addition to the three measure switches, a text field is located to the right of each switch.

These switches and text fields are used to specify and label the data that will be returned when the test setup is executed. Timing and averaging configurations are defined in the B2900 Advanced Options Dialog box.

Specifying Returned Data

ICS may be configured to return the sourcing signal, the sourcing signal complement, the measurement time, a combination of these, or none.

A source unit's measurement configuration is specified by turning on or off the VOLTAGE, CURRENT, and RESISTANCE switches located in the Measure Group control box.

Four possible measurement configurations are described below. For an explanation of these configurations used in conjunction with the B2900 pulse mode, please refer to the *Pulse Configuration* section of this chapter.

THE SOURCING SIGNAL IS RETURNED: To specify this configuration, select the switch that matches the characteristic of the sourcing signal.

In this mode of operation, the returned values are not true measurements. The returned values are calculations based upon the source setup.

For example, consider the gate threshold characteristic of a MOSFET. In a gate threshold test setup, a constant voltage is applied to the drain, while a swept voltage is applied to the gate. The gate threshold characteristic is a plot of Ids vs. Vgs. Therefore, Vgs, the voltage sweep applied to the gate, must be returned since Vgs data is required for the plot. The gate current is not important in this test setup. The source unit connected to the gate is configured to apply a voltage sweep and return only the values of the applied sweep.

THE SOURCING SIGNAL COMPLEMENT IS RETURNED: To specify this configuration, select the switch corresponding to the opposite characteristic of the sourcing signal.

For example, consider the gate threshold example described above. The sourcing signal on the drain is a constant voltage supply. However, the same source unit is also measuring Ids, the drain current. Returning Vds would not provide any useful information, because Vds is a constant value throughout the test setup.

BOTH THE SOURCING SIGNAL AND ITS COMPLEMENT ARE RETURNED: To specify this configuration, both switches should be ON.

For example, consider the DC forward current gain of a bipolar transistor in common emitter mode. In this test setup a swept voltage supply is applied to the collector. The plot of the forward current gain is a plot of Ice vs. Vce. Therefore, both Ice and Vce must be returned since Ice and Vce data is required to construct the plot.

NO RETURN MEASUREMENTS ARE RETURNED: To specify this configuration, all switches should be OFF.

For example, consider the forward transfer characteristics of a MOSFET. In this test setup a constant supply of 0.0V is applied to the source in order to establish a grounding condition. The forward transfer characteristic is a plot of Ids vs. Vds. Both of these measurements are obtained from the source unit connected to the drain. Since the gate current present in this mode is very small relative to the drain current, measuring the source current will not provide any useful information. As a result, the source unit connected to the source supplies a constant 0.0V, but returns nothing.

MEASUREMENT TIME: The time at which each value is measured is returned as a data vector.

Labeling Measured Data

All of the data that corresponds to a single curve is collectively referred to as a "data vector". Each data vector is identified by a "data vector label" that must be defined in the text field to the right of the VOLTAGE, CURRENT, or RESISTANCE switch. A data vector label can be any alphanumeric string up to six characters in length.

THE DATA VECTOR LABEL CANNOT END WITH A NUMBER.

The presence of only three data vector fields does not mean that only two data vectors can be specified in a test setup. In fact, by using a combination of step and sweep source units, many data vectors can be defined per test setup.

Test setups that use a combination of stepped sources and swept sources can return both sequential and non-sequential data vectors. Test setups that use a combination of constant sources and swept sources only return non-sequential data vectors.

Sequential Data Vectors

A sequential data vector is a device characteristic that is described by a family of unique curves. Each curve is measured in response to a stepped bias condition. Sequential data vectors are the result of test setups that include stepped sources and repeated sweeps.

For example, consider the DC collector characteristics of a bipolar transistor. The DC collector characteristics are obtained by generating a family of Ice vs. Vce curves. This setup was created by applying a stepped current supply to the base and a swept voltage supply to the collector. The source unit connected to the collector returned both collector voltage (Vce) and collector current (Ice). Each time the base current was stepped to a new value, a unique Ice curve was obtained in response to the collector voltage sweep. The result of this test setup was a family of unique Ice curves. Ice is a sequential data vector because collector current is described by a family of unique curves measured in response to stepped base current.

Non-Sequential Data Vectors

A non-sequential data vector is a device characteristic that is described by a single curve.

For example, consider the example presented in the previous section, *Sequential Data Vectors*. The DC collector characteristics of a bipolar transistor were obtained by generating a family of Ice vs. Vce curves. This test setup was created by applying a stepped current supply to the base and a swept voltage supply to the collector. The source unit connected to the collector returned both collector voltage (Vce) and collector current (Ice). Because the base current was stepped, this test setup returned a family of Ice curves. The voltage sweep applied to the collector during each base current step was the same. Therefore, Vce is a non-sequential data vector, because Vce can be described by a single curve.

Advanced Setup Dialog Box

Clicking the Advanced Options button in the SMU Setup Dialog will open the B2900 Advenced Setup Dialog box. The B2900 Advanced Setup Dialog box includes the controls necessary to specify the source ranging mode, timing, integration, options, and triggering.

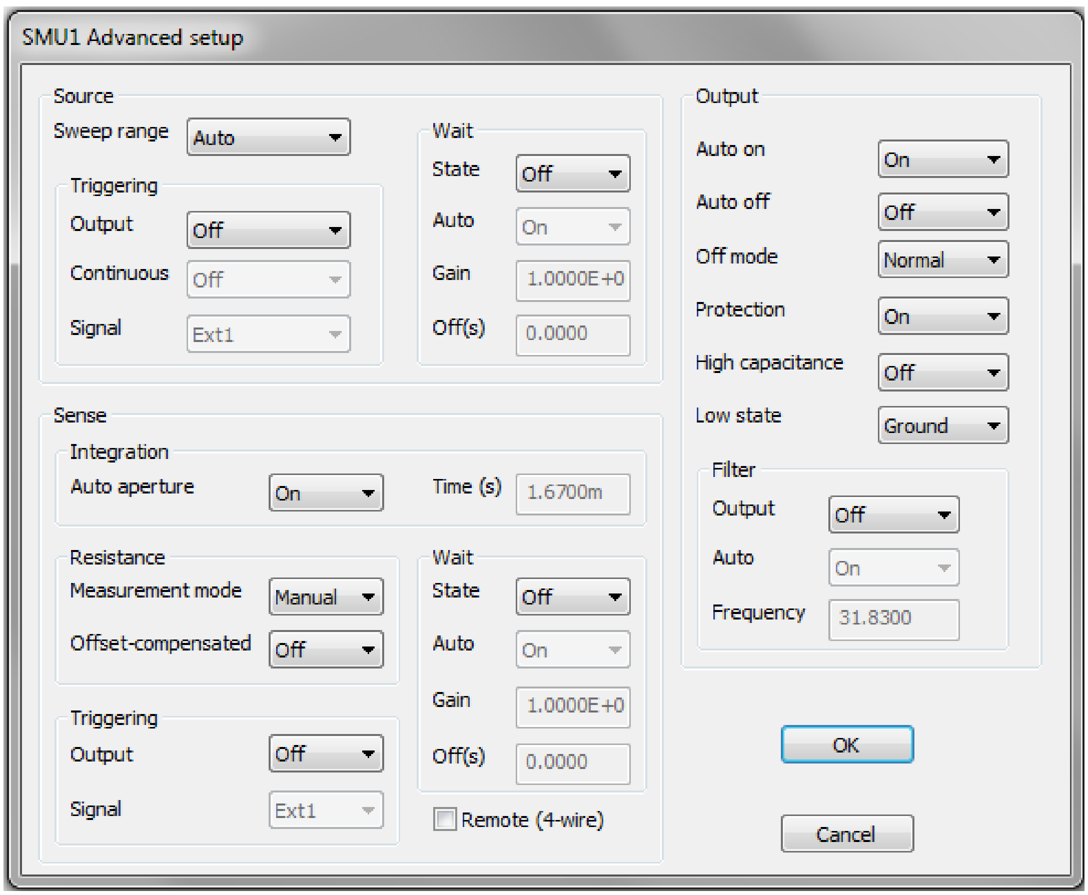
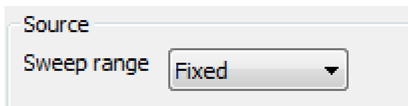


Figure 7: The Advanced Setup Dialog Box

The contents of the B2900 Advanced Setup Dialog box are global to each SMU in the test setup. The B2900 mainframe options are only applied to the test setup in which they were specified. Once a new test setup is defined, the Advanced options can be re-specified without changing the configuration of the Advanced options in a previously defined test setup.

The B2900 Advanced Setup Dialog box is displayed by clicking the SMU Advamced Options button after first designating at least one Source Unit/DUT connection.

Sweep Range Controls



The Sweep Source Ranging Controls specify the ranging configurations of any sweep mode sourcing signal. Values are Best, Fixed and Auto.

Wait State

The hold time is the length of time the B2900 will wait while allowing the starting value of the sweep signal to settle. The hold time is only applicable to the initial application of the sweep signal. After the sweep signal starts to increment, the delay time is the only parameter used to accommodate settling times. When applying a sweep source, the total delay prior to measuring the starting magnitude of the sweep signal is actually the sum of the hold time and delay time. The sweep source hold time specification is independent of the pulsed source hold time.

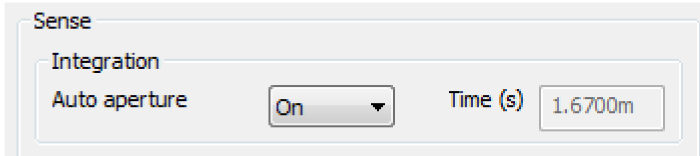
Delay Time

The delay time is the length of time between the sweep signal magnitude increment and the point at which an SMU obtains a measurement. The delay time allows the output at each sweep increment to settle before a measurement is made.

Command Errors

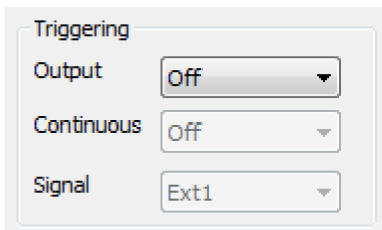
This option forces the software to make a secondary verification of all commands sent. This is accomplished by sending GPIB commands to check for errors after EVERY GPIB command. This will slow the instrument performance down and is recommended only when working with Metrics Technology to resolve an instrument error.

Integration Time Controls



The Integration Controls are used to define the Measurement Integration Time. Please refer to the section of the Agilent B2900 User's Manual for more details.

Triggering Controls



The Source Triggering Controls Group contains setup functions for the triggering functions of the B2900 mainframe. For a detailed explanation of the B2900 triggering modes please refer to the Agilent B2900 Users Manual provided by Agilent.

Source Triggering Settings

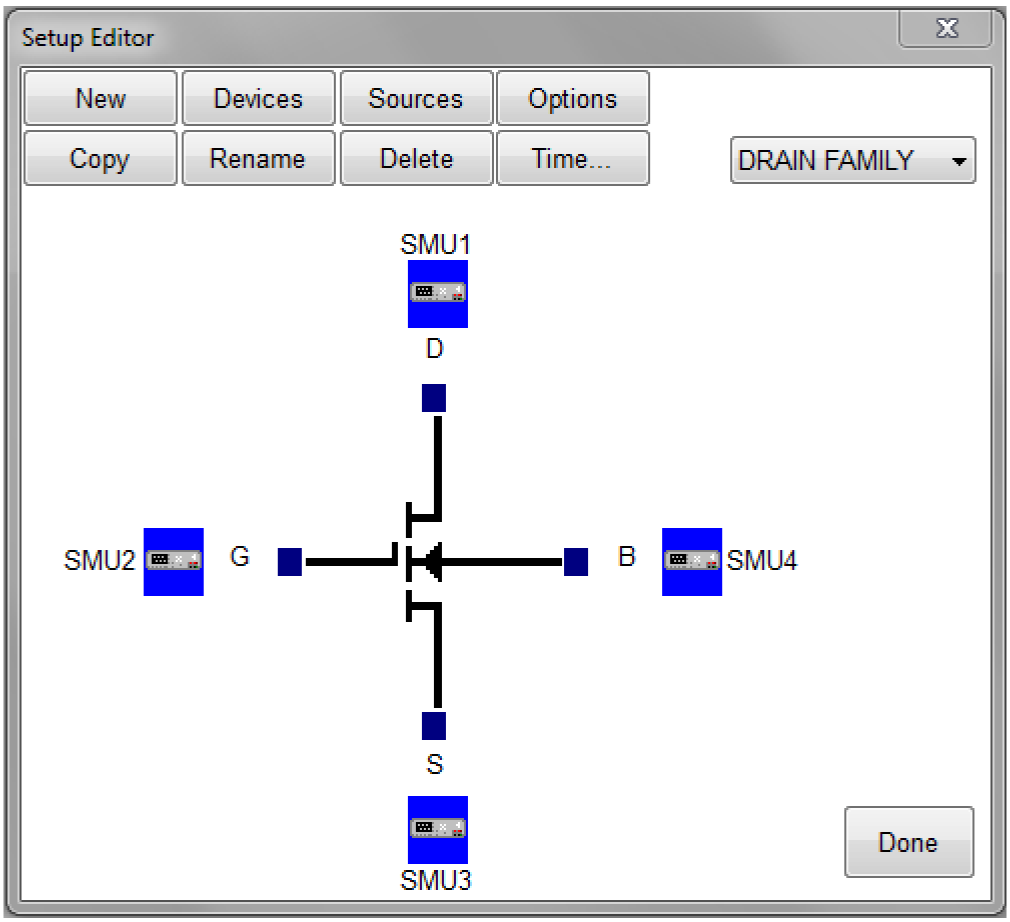
1. *Trigger Output*- **ON/OFF Trigger** is output, the B2900 starts the measurement.
2. *Trigger Continuous*- Trigger is output continuously by the B2900 starts the output setup at each sweep step or the pulsed output setup. This function is available for the staircase sweep, pulsed sweep, staircase sweep with pulsed bias, or pulsed spot measurement.
3. *Trigger Signal*- Specifies the trigger source output for the measurement.

Sense Triggering Settings

1. *Trigger Output*- **ON/OFF** Trigger is output, the B2900 starts the measurement.
2. *Trigger Signal*- Specifies the trigger sense input for the measurement.

Drain Family

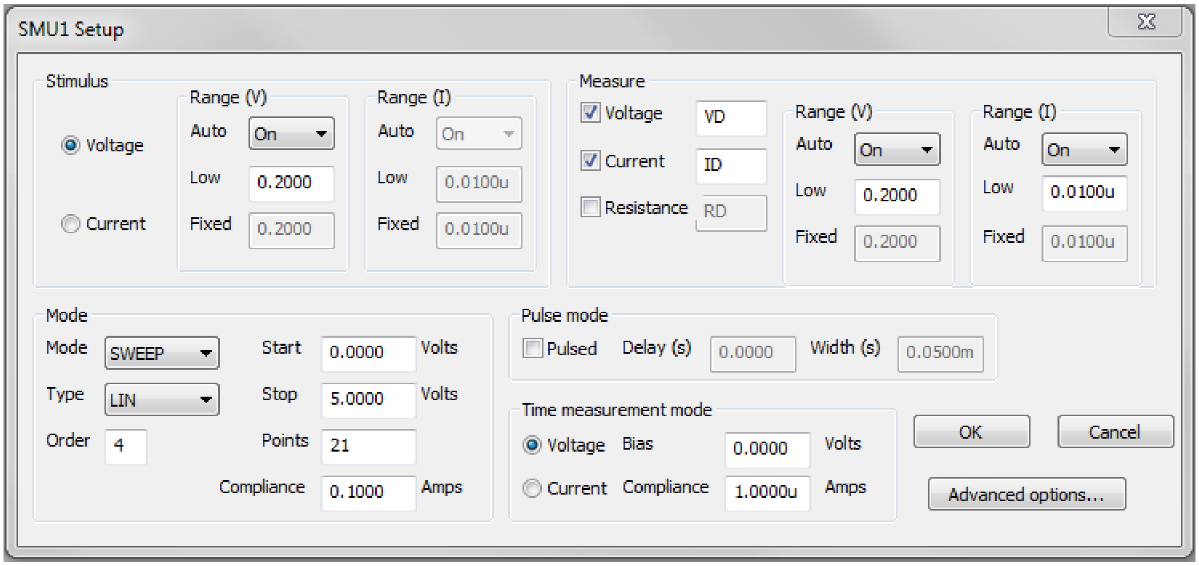
This setup measured the DC collector characteristics of a SD214 N-Channel MOSFET transistor. A voltage sweep was applied to the Drain for a series of stepped Gate currents. A family of curves was generated by measuring and plotting the Drain current with respect to the Drain voltage sweep for each Gate voltage step. The following source units and setup conditions were used:



Drain Family Setup Conditions

SMU Setups

Drain: SMU1



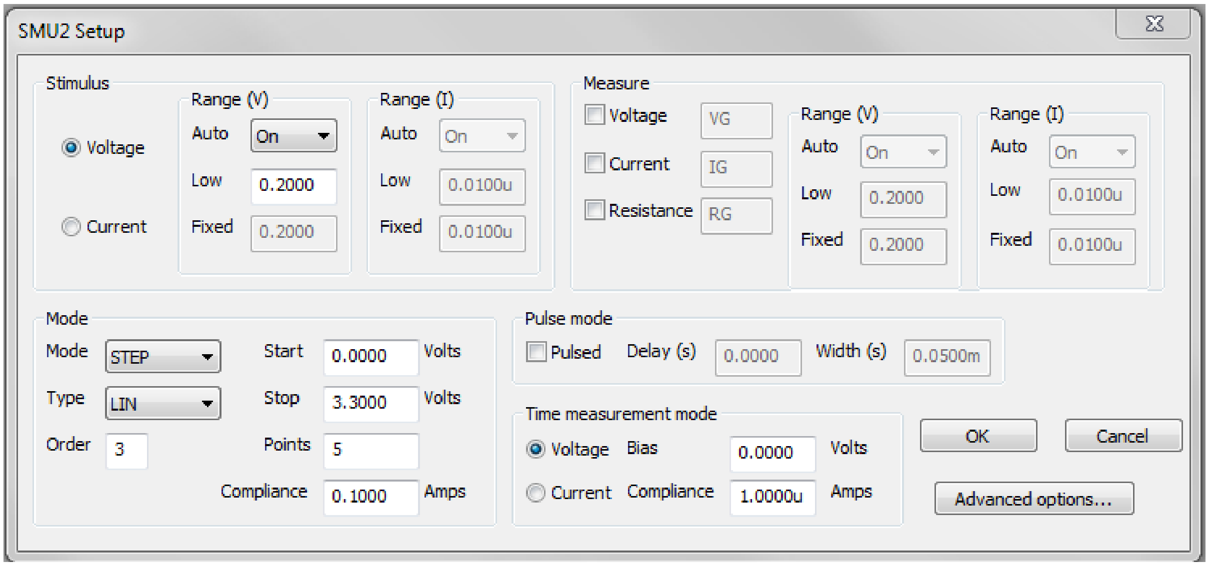
MEASURE: VD, ID

STIMULUS: Voltage

BIAS MODE: Sweep

SWEEP: 0-5V, 21 POINTS

Gate: SMU2



MEASURE: None

STIMULUS: Voltage

BIAS MODE: Step

SWEEP: 0 V to 3.3 V, 5 POINTS

Results

DRAIN FAMILY

Clear | Max | Min | Direct | 08/06/2012 1

	VD	ID	ID2	ID3	ID4	ID5
1	0.0000	-0.0210n	-8.7770n	-2.8388u	-6.2870u	-6.9751u
2	0.2500	0.3170n	0.4439u	1.1138m	2.2504m	3.0886m
3	0.5000	0.3320n	0.4463u	1.7223m	4.1479m	5.8712m
4	0.7500	0.3430n	0.4470u	1.9544m	5.6808m	8.3285m
5	1.0000	0.2650n	0.4475u	2.0239m	6.8599m	0.0105
6	1.2500	0.3100n	0.4490u	2.0451m	7.7087m	0.0122
7	1.5000	0.4170n	0.4471u	2.0508m	8.2699m	0.0137
8	1.7500	0.5060n	0.4464u	2.0522m	8.6088m	0.0148
9	2.0000	0.4400n	0.4457u	2.0533m	8.7970m	0.0157
10	2.2500	0.3650n	0.4476u	2.0554m	8.9034m	0.0163
11	2.5000	0.3710n	0.4483u	2.0572m	8.9737m	0.0167
12	2.7500	0.4890n	0.4490u	2.0581m	9.0266m	0.0170
13	3.0000	0.4560n	0.4470u	2.0582m	9.0703m	0.0172
14	3.2500	0.5370n	0.4461u	2.0583m	9.1100m	0.0173
15	3.5000	0.5020n	0.4473u	2.0608m	9.1446m	0.0174
16	3.7500	0.5590n	0.4480u	2.0619m	9.1727m	0.0175