Metrics ICS Driver Manual

ATB1500A/ATB1505A

Metrics ICS

Version 4.5

Table of Contents

The B1500A/B1505A Instrument Driver

Getting Started: Creating and Executing a Test Setup

The Agilent Technologies B1500A/B1505A Semiconductor Device Analyzer/Power Curve Tracer is a high-performance DC and CV parametric measurement instrument. The B1500A is composed of up to ten user-selected plug-in modules. The following B1500A modules are supported by Interactive Characterization Software (ICS):

B1500A DC Modules

1. B1510A High-Power SMU
2. B1511A Medium-Power SMU
3. B1517A Ultra-High Resolution SMU

The B1505A is composed of up to ten user-selected plug-in modules. The following B1505A modules are supported by Interactive Characterization Software (ICS):

B1505A DC Modules

1. B1512A High-Current SMU
2. B1513A High-Voltage SMU
3. N1258A - Module Selector

B1500A CV Modules**

1. B1520 Multi-Freq CMU
2. N1301A Opt 100 SMU CMU Unify Unit
3. N1301A Opt 200 Guard Switch Unit

****Please Note** that the CV modules are fully supported by the VBScript Test Algorithms provided with the IDE (Integrated Developer Environment) option to the ICV software.

This section will walk you through the steps required to create and execute a test setup that measures diode turn-on voltage using the B1500A and the ICS Driver. This is simple measurement, but it will provide you with a general understanding of how ICS and the B1500A 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 B1500A along with the HP16088 Test Fixture and the HP16088-60002 Socket Board. A schematic of the hardware arrangement is shown below.

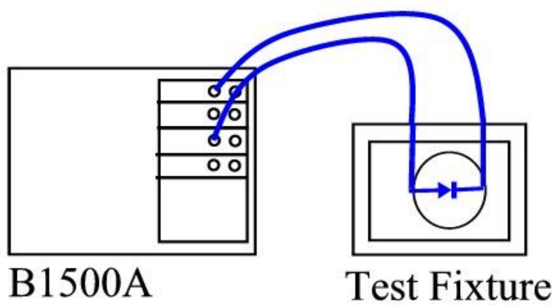
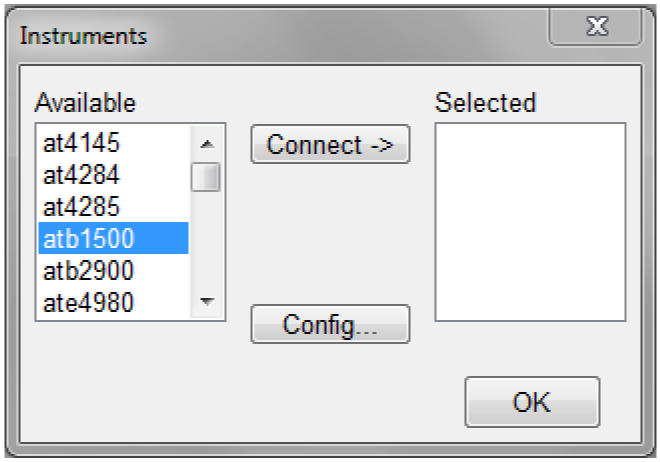


Figure 1: A Schematic of the Hardware Arrangement Used to Measure V_{ON} for an NP Diode.

Step 2: Connect the B1500A Instrument Driver



The B1500A Driver is named ATB1500 and is connected using the Connect Instruments dialogue box accessed from the measurement mode menu bar.

How to Connect the ATB1500 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 dialogue box.
2. Highlight the ATB1500 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 dialogue box and restore control to the ICS desktop. Keep the Connect Instruments dialogue box displayed for now, because the next step requires you to click the Connect Instruments CONFIG button.

Step 3: Specify the GPIB Address and the Plug-In Module Identities

The B1500A 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 ATB1500 Configuration dialogue box.

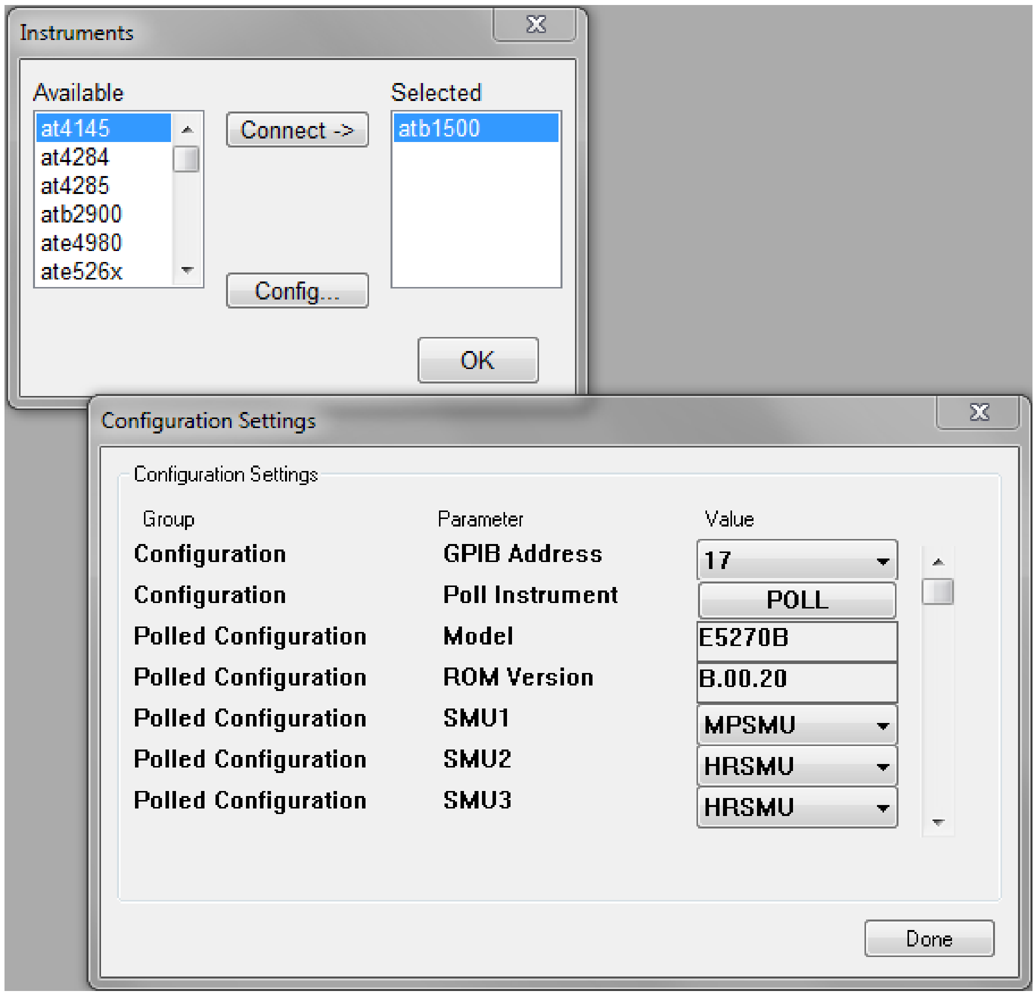


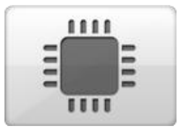
Figure 2: The ATB1500 Configuration Dialogue Box

How to Automatically Configure the ATB1500 Module Identities:

1. If the Connect Instruments dialogue box is no longer displayed from Step 2, click the toolbar CONNECT INSTRUMENTS button or select INSTRUMENT/SELECT INSTRUMENTS from the measurement mode menu bar.
2. Open the ATB1500 Configuration dialogue box by clicking the CONFIG button at the bottom of the Connect Instruments dialogue box.
3. Designate the instrument GPIB address in the GPIB field. Determine the GPIB address of the instrument by viewing the HP-IB Address on the instrument's front panel. If you wish to change the GPIB setting, please refer to the ATB1500 Operation Manual from Agilent Technologies.
4. The ten source unit fields displayed in the Configuration dialogue box correspond to the ten module slots in the ATB1500 mainframe. Each source unit field is referenced by a label displayed in the "Name" column. Each field label identifies the function and slot position of the corresponding module; for example, "SMU1", "SMU2", etc.
5. Each source unit field identifies the type of the instrument module installed at the corresponding mainframe slot. Designate the module identities of all eight source unit fields by clicking the POLL button located in the left-hand corner of the dialogue box. Clicking the POLL button interrogates the instrument and automatically identifies the modules installed at each slot position (for example, "MPSMU") and designates each field label according to the function and slot position of the installed hardware (for example, "SMU1").
6. Any source unit field corresponding to an unoccupied ATB1500 slot will be designated with an "NA". "NA" stands for "Not Applicable". Please note that modules requiring two slots are controlled through the lowest numbered slot. For example, if a B1510A High-Power SMU is installed into Slots #2 and #3, Slot #2 will be designated with the module identity, and Slot #3 will be designated as “NA”.
7. Click the Done button located at the bottom of the dialogue box. This will close the Configuration dialogue box. Click the OK button in the lower right-hand corner of the Connect Instrument dialogue box 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.

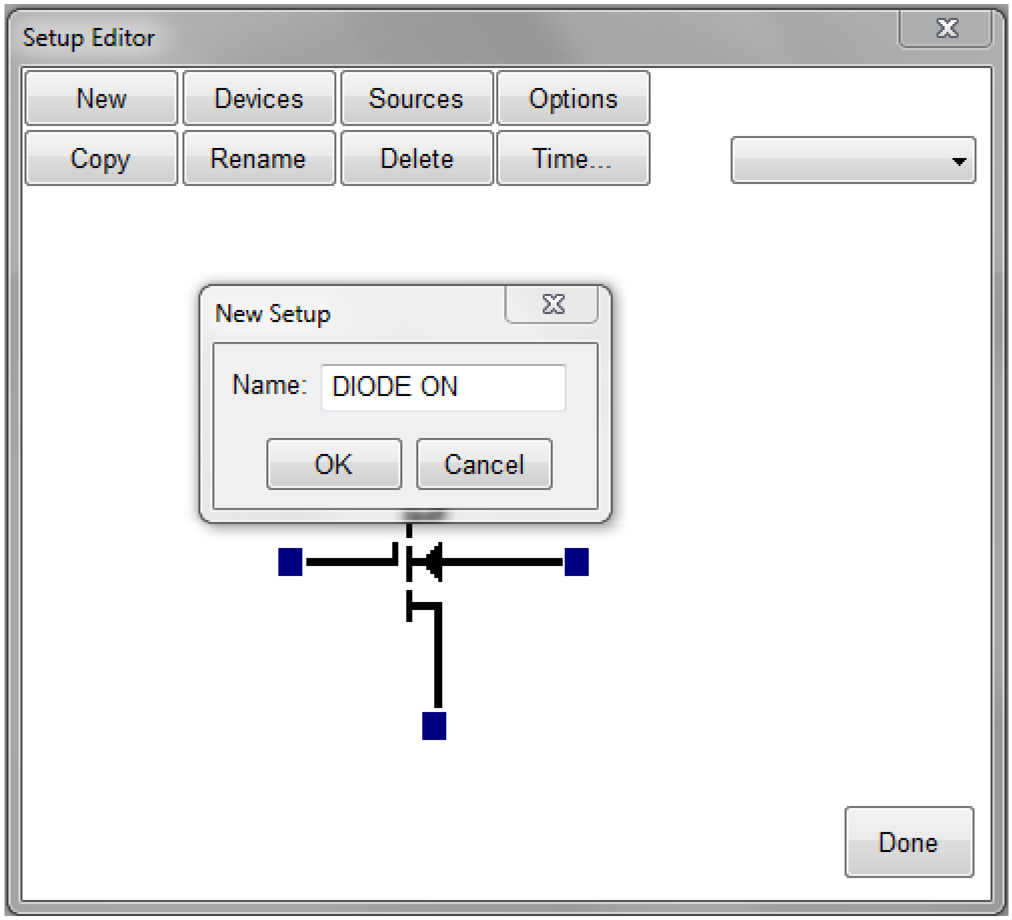


Click the corresponding toolbar button to display the Setup Editor.

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



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

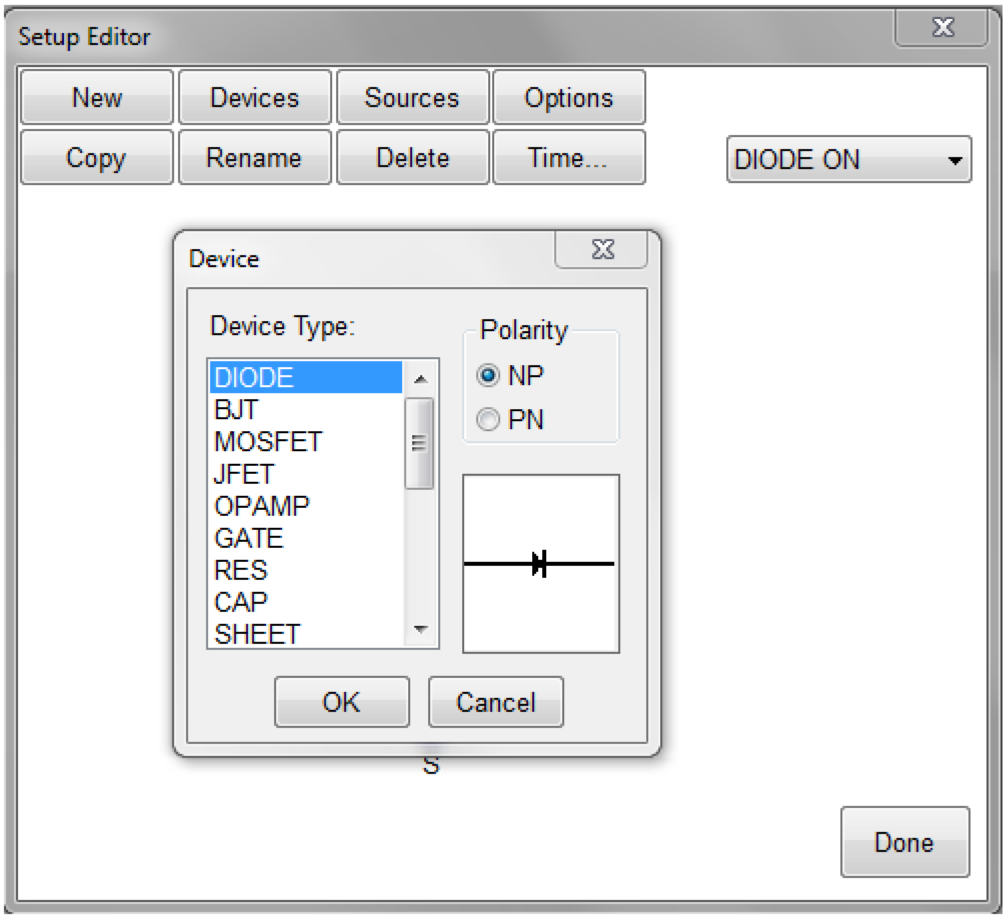
Step 4B: Select a Device Schematic Corresponding to the DUT

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.

How to Select a Device Schematic:

1. Click the Setup Editor DEVICE button. This will open the Device dialogue 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 dialogue box and display the diode schematic at the center of the Setup Editor.

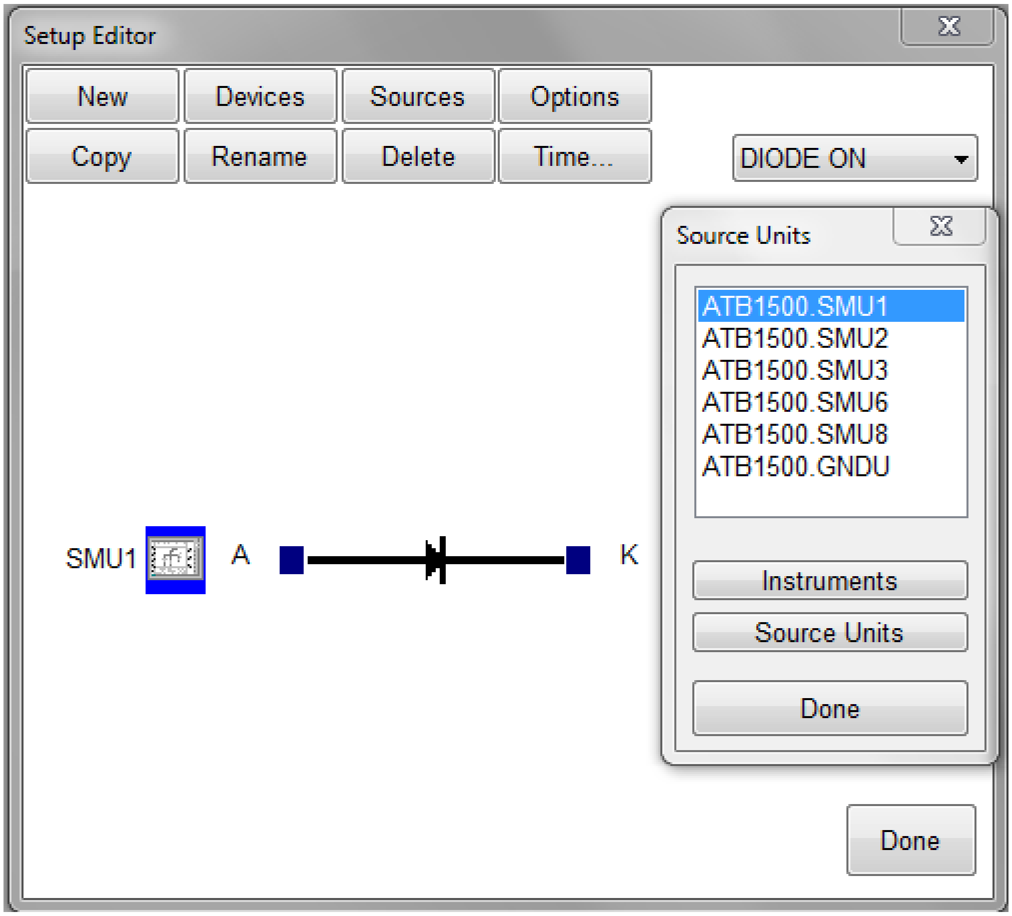


Step 4C: Designate the Source Unit/DUT Connections

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.

The Setup Editor displays a device schematic representing the DUT. Connections are designated by first clicking one of the available source units listed in the Source Units dialogue box. 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.

How to Designate the Source Unit/DUT Connections:



1. Select the Setup Editor SOURCES button. This will open the Source Units dialogue box.
2. The Source Units dialogue box will display a list of instrument modules installed in the ATB1500 and designated in *Step 3: Specify the GPIB Address and Plug-In Module Identities*.
3. Click on a module designation corresponding to a B1510A High Power SMU. This test setup example was created with a B1510A 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 B1510A 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 GNDU does not need to be selected.

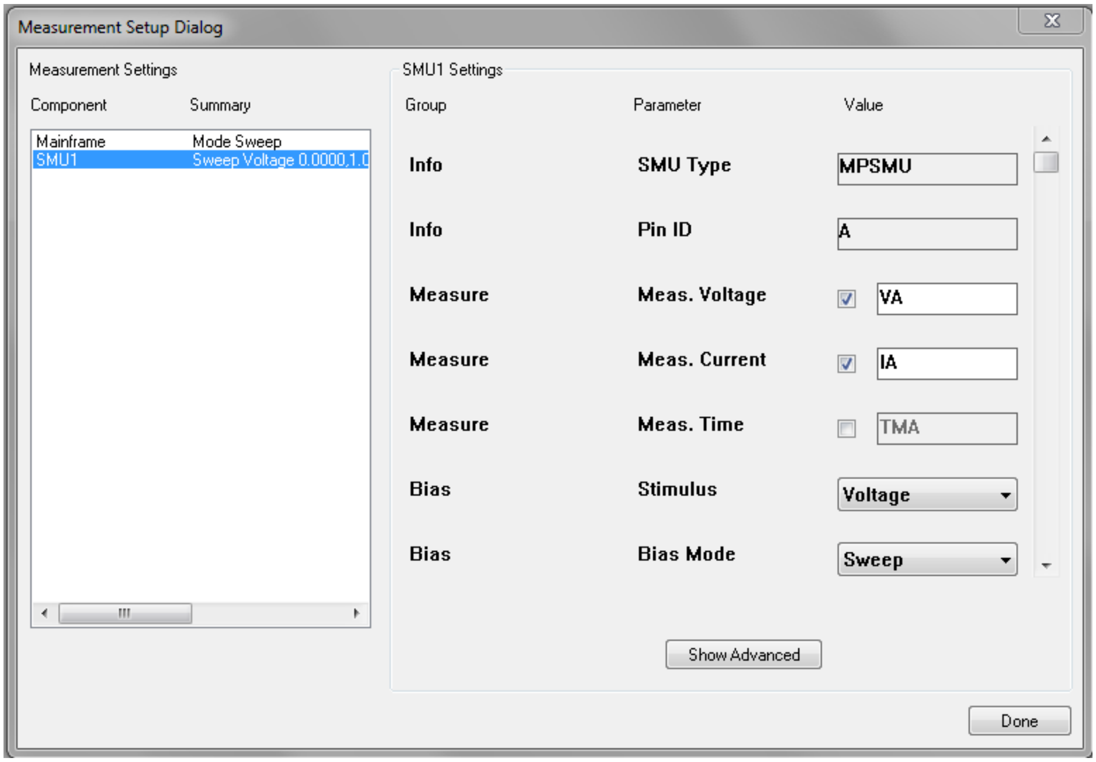
6. After all of the Source Unit/DUT connections are designated, close the Source Units dialogue box by clicking the Done button in the bottom of the dialogue box.
7. If an incorrect Source Unit/DUT connection is mistakenly designated, undesignate the connection as described in *Chapter 2 of the ICS Technical Reference Manual; Removing Instrument/DUT Connections*.

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

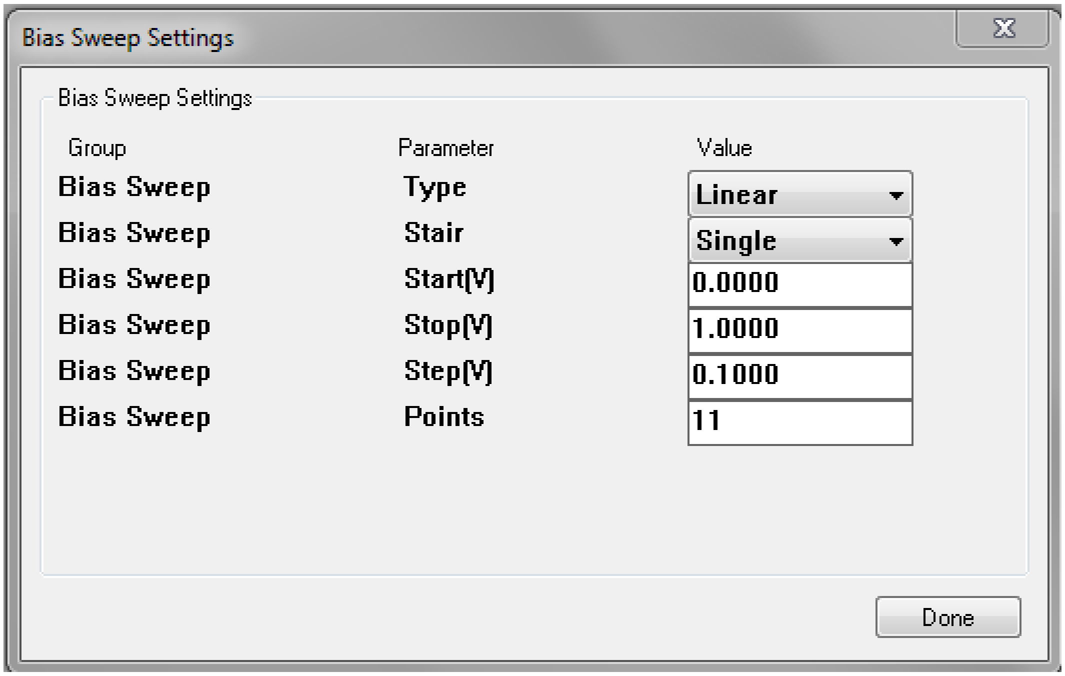
Every available source has its own Source Unit Setup dialogue box. This Source Unit Setup dialogue box is used to specify the source/measure configuration of the respective module. Once a Source Unit/DUT connection is designated, the corresponding Source Unit Setup dialogue box is opened by clicking 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 3.0V and consist of 31 data points. SMU1 will measure voltage (V) and current (I). The SMU3 will be the ground source for the device.

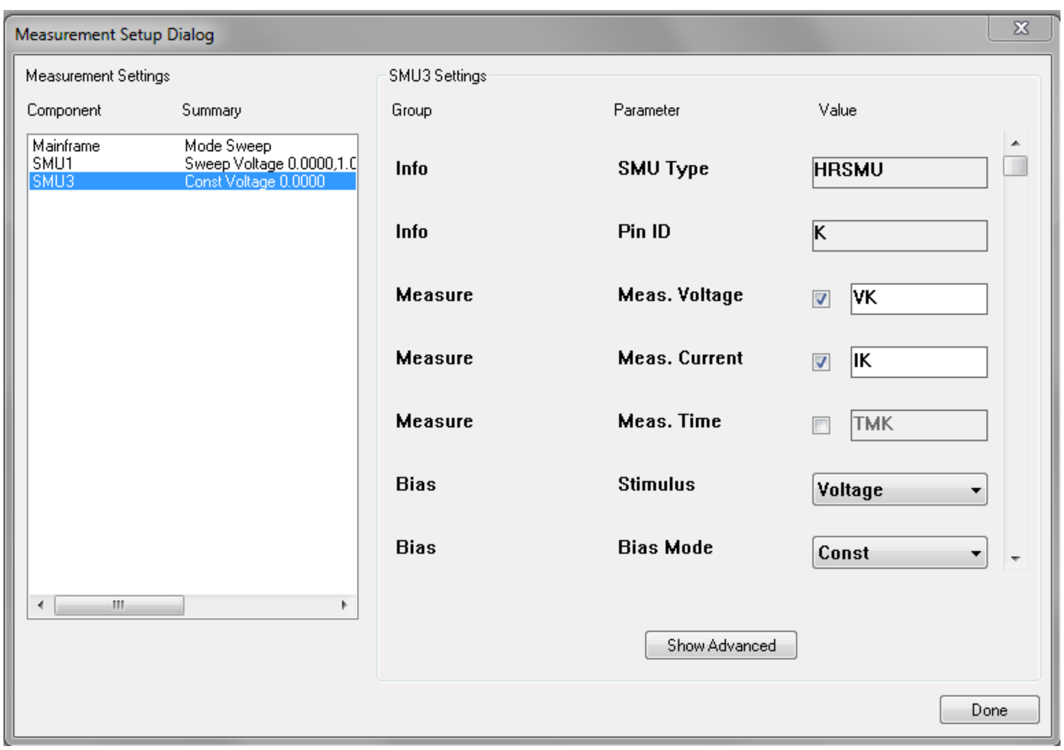
How to Specify the Source/Measure Configuration of Each Source:



1. Click once on one of the displayed instrument icons to open the Measurement Setup dialogue 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 dialogue box.
3. Click the Sweep button to open the SMU1 Sweep Settings dialogue box. Configure the sweep controls as shown and click the Done button to exit the SMU1 Sweep Settings dialogue box.
4. Click Done to close a Source Unit Setup dialogue 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 dialogue box.



5. Click the SMU3 component to open the SMU3 Settings dialogue box. Configure the SMU3 controls as shown and click the Done button to exit the Measurement Setup dialogue box.



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.

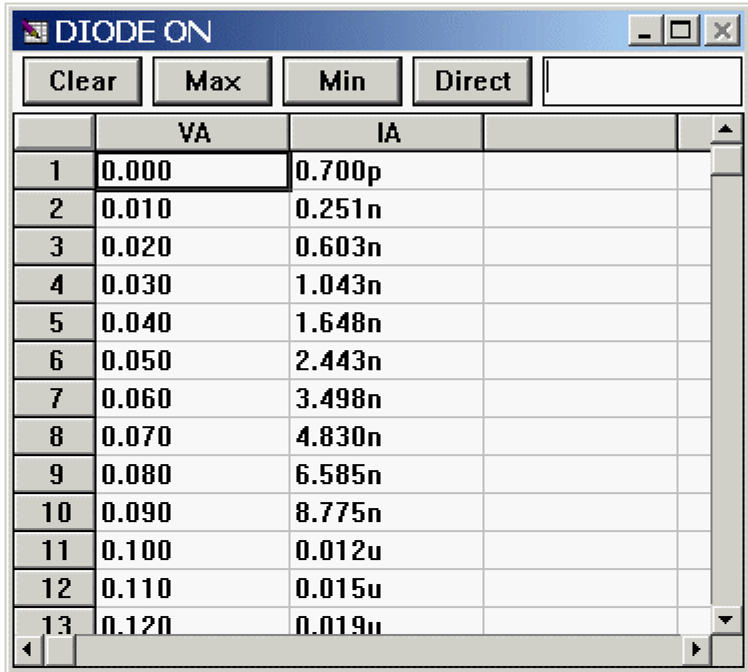
Step 6: Execute the Measurement

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.

After a few moments 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.



	VA	IA	
1	0.000	0.700p	
2	0.010	0.251n	
3	0.020	0.603n	
4	0.030	1.043n	
5	0.040	1.648n	
6	0.050	2.443n	
7	0.060	3.498n	
8	0.070	4.830n	
9	0.080	6.585n	
10	0.090	8.775n	
11	0.100	0.012u	
12	0.110	0.015u	
13	0.120	0.019u	

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

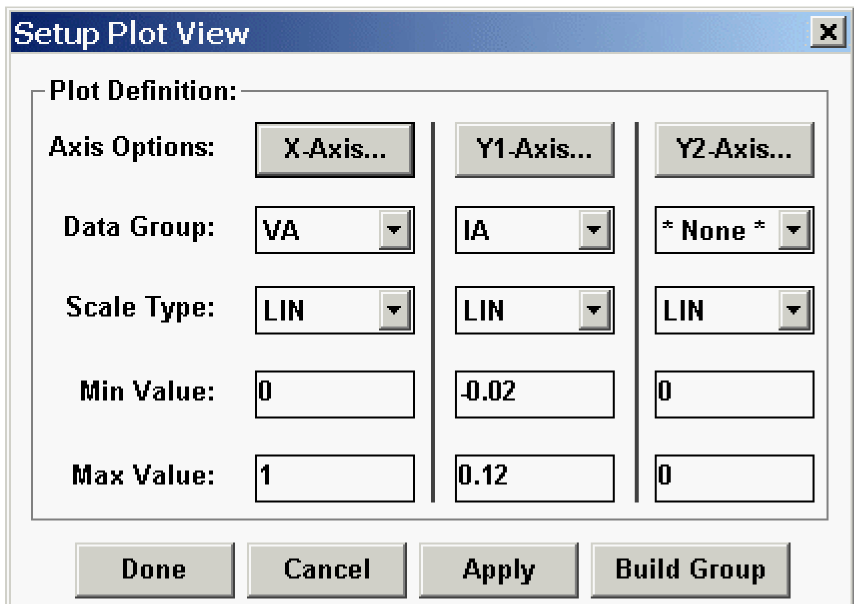
A plot window is dynamically linked to a corresponding data window spreadsheet. This means that the plot is regenerated any time there is a change to the corresponding spreadsheet data. If the test setup is executed more than once, the plot window is regenerated after each measurement. Up to ten plots 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 Diode On data.

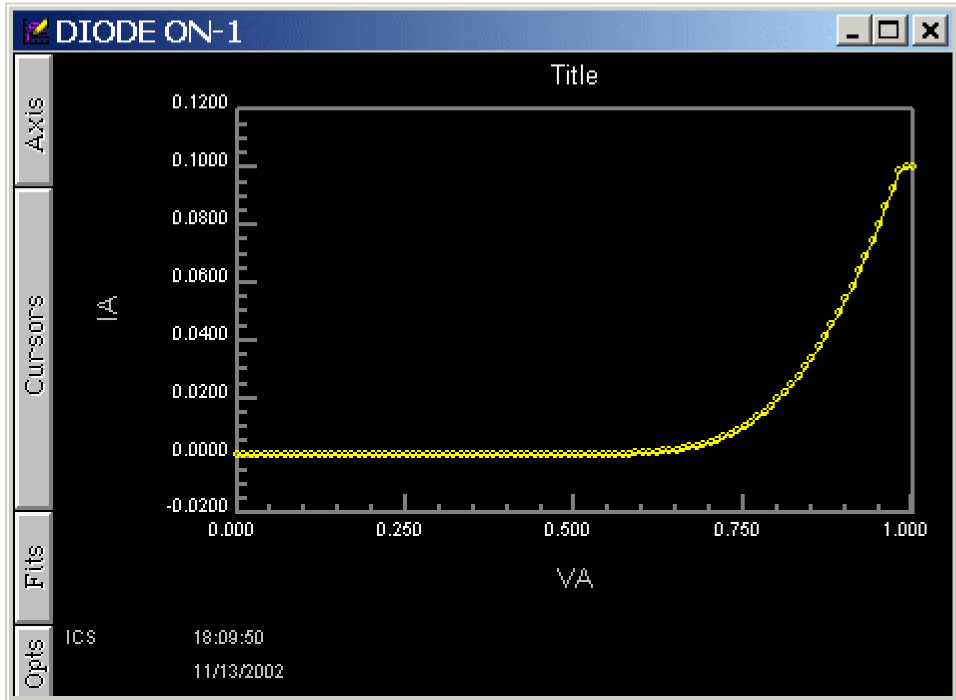
How to Create a Plot

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 dialogue 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".



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



8. Click the DONE button to close the Plot Data dialogue 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 of the ICS Technical Reference Manual; How ICS Stores Information.*

The ATB1500 Configuration Dialogue Box

The ATB1500 Configuration dialogue box identifies the instrument GPIB address and the model number and position of each plug-in module installed in the ATB1500 mainframe.

The ATB1500 Driver must be connected to ICS before the Configuration dialogue box can be opened. If necessary, refer to *Step #2, Connecting the ATB1500 Instrument Driver*. After connecting the ATB1500 Driver, the ATB1500 Configuration dialogue box can be opened from the Connect Instruments dialogue box.

Open the Connect Instruments dialogue box by clicking the corresponding toolbar button. Open the ATB1500 Configuration dialogue box from the Connect Instruments dialogue box by clicking the Connect Instruments CONFIG button.

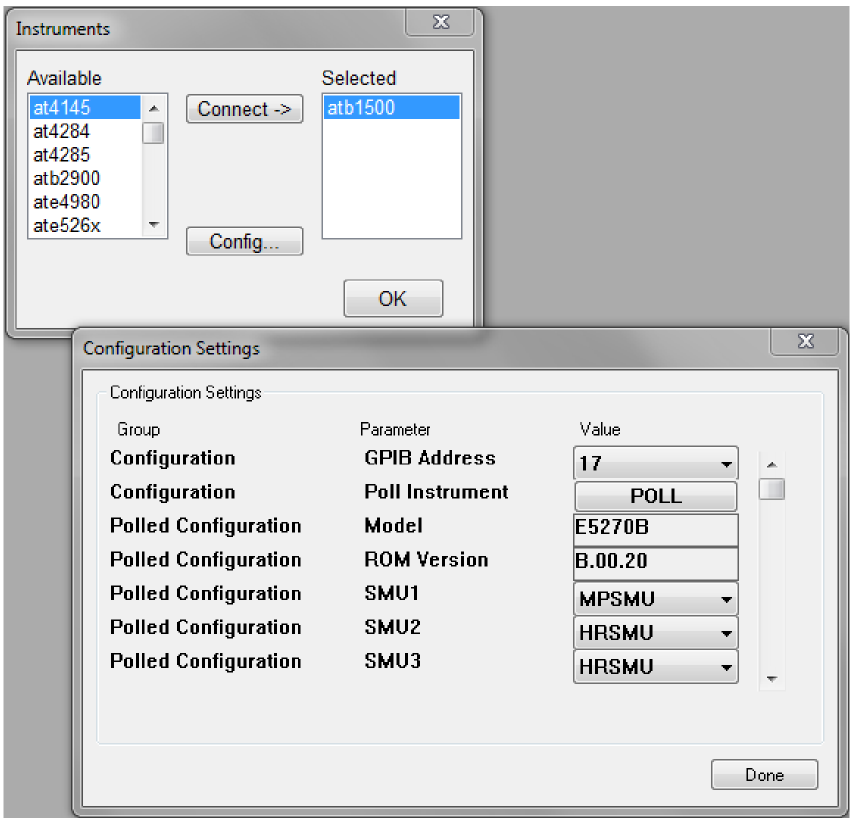


Figure 3: Open the ATB1500 Configuration Dialogue Box from the Connect Instruments Dialogue Box.

Source Unit Fields and Labels

The ATB1500 Configuration dialogue box includes ten source unit fields corresponding to the ten slots available in the ATB1500 mainframe. Each source unit field is used to identify the hardware installed at the corresponding mainframe slot. When a user designates source units later in the application, each instrument module will be identified by the corresponding "SMU" label designated in the "Parameter" column of the ATB1500 Configuration dialogue box. Instrument modules are identified by "SMU" labels instead of the model numbers configured in the source unit fields. This eliminates confusion when two or more identical modules are installed in the ATB1500.

Configuring the Instrument GPIB Address and Module Identities

When reviewing the ATB1500 Configuration dialogue box, the user must be certain that the specified configuration agrees with the physical installation of the hardware modules. For example, if an B1510A High Power SMU is installed in the first mainframe slot, then the "HPSMU" designation must be configured in the first source unit field. The mainframe slot position corresponding to each source unit field is identified in the dialogue box "Parameter" column. Since this slot holds an SMU, the value will not be labeled "NA".

The ATB1500 Configuration dialogue box is configured by first designating the instrument GPIB address and then clicking the POLL button at the top of the dialogue box. The POLL function interrogates the instrument and automatically identifies the modules installed at each slot position (for example, "HPSMU") and designates the name of each field according to the installed hardware (for example, "SMU1").

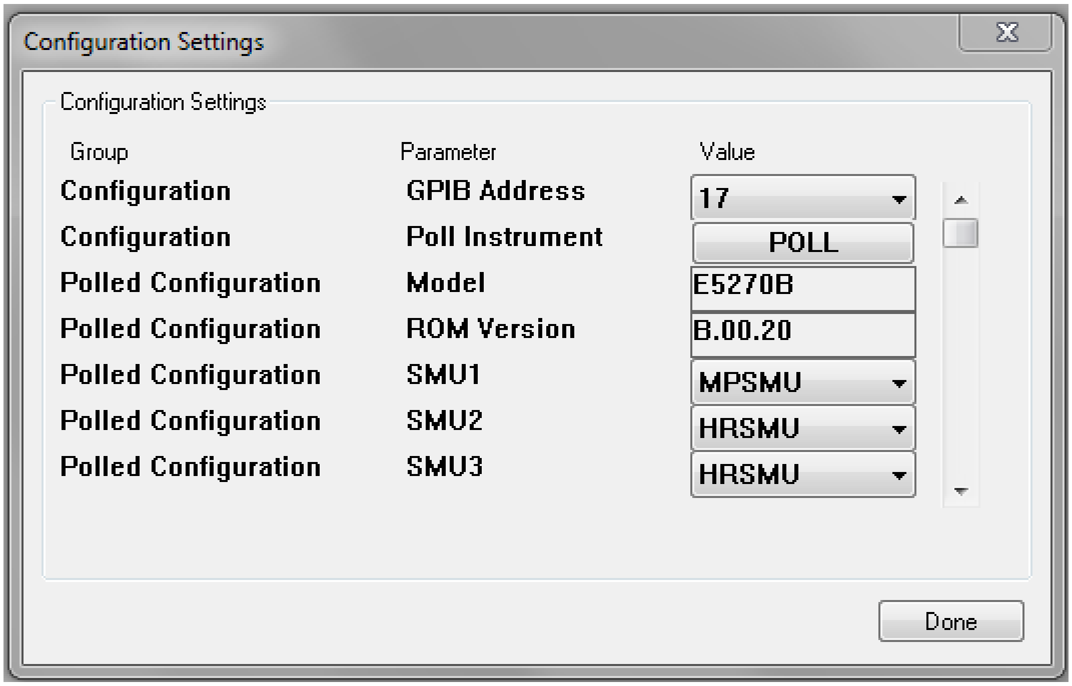


Figure 4: The ATB1500 Configuration Dialogue Box.

Any source unit field corresponding to an unoccupied mainframe slot must be designated with the "NA" selection. "NA" stands for "Not Applicable". Modules requiring two slots are controlled through the lower-most numbered slot. For example, if a B1510A High-Resolution SMU is installed in Slots #3 and #4, Slot #3 will be designated as "HRSMU", and Slot #4 will be designated as "NA".

Configuring Module Identities Automatically

The ATB1500 Driver includes a Poll function that will automatically arrange the ATB1500 Configuration dialogue box. The Poll function is activated by first designating the instrument GPIB address and then clicking the POLL button at the top of the dialogue box. The POLL function interrogates the instrument and automatically identifies the modules installed at each slot position and designates the name of each field according to the installed hardware. Empty mainframe slots will be designated as "NA" (Not Applicable).

Detailed instructions outlining how to automatically configure the ATB1500 Configuration dialogue box are presented in *Step 3: Specify the GPIB Address and the Plug-In Module Identities* earlier in this section.

Polling Errors and Warnings

ICS will display a short sequence of error messages if the GPIB card times-out after attempting to locate the instrument on the GPIB bus. (The time-out limit is designated in the GPIB Setup dialogue box. The GPIB Setup dialogue box is opened by selecting INSTRUMENTS/GPIB SETUP from the measurement mode menu bar.) The GPIB card will time-out if the instrument is OFF, if the instrument is not connected to the GPIB cable, or if the EasyExpert Software is running. 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.

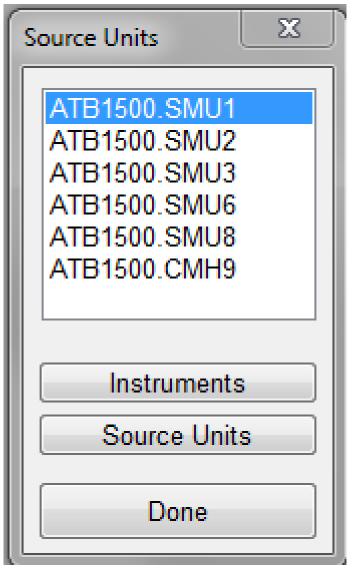
When to Update the ATB1500 Configuration Dialogue Box

It is only necessary to configure or update the ATB1500 Configuration dialogue box when either of two situations occur:

1. The ATB1500 Driver is connected to ICS for the first time.
2. The ATB1500 module configuration is altered or the instrument GPIB address is changed.

The information displayed in the ATB1500 Configuration dialogue box is stored in memory when the user manually specifies the box contents or after the user polls the instrument. The ATB1500 configuration is written to the ICS40.INI file as soon as the OK button is selected in the Configuration dialogue box. The ATB1500 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 ATB1500 Driver and arrange the ATB1500 Configuration dialogue box according to the designations recorded in the ICS.INI file. This eliminates the need to repeatedly connect the ATB1500 Driver or arrange the Configuration dialogue box each time an ATB1500 project file is opened. After initially arranging the ATB1500 Configuration dialogue box, there is no need for the user to review the dialogue box unless the module configuration is altered or the instrument GPIB address is changed.

Source Unit Availability



The SOURCE UNITS dialogue box contains a list of available instrument modules that can be used to build a test setup. The contents of this dialogue box represent the instrument modules installed in the ATB1500 and designated in the ATB1500 Configuration dialogue box.

The SOURCE UNITS dialogue box does not include a source unit representing the GNDU. The Ground Unit is 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 module identity (for example, "B1511A") and the source unit field label (for example, "SMU5") is stored as part of the test setup. This association is obtained from the ATB1500 configuration defined in memory when the test setup is created. Test setups are stored in project files, thus the ATB1500 configuration associated with each test setup is recorded in the corresponding project file. After the project file is created, the user may alter the ATB1500 configuration. The user may change the GPIB address, or the user may add new modules or move existing modules to new slot positions. Any one or more of these situations will alter the ATB1500 configuration. If the ATB1500 configuration changes, the user must update the ATB1500 Configuration dialogue 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 ATB1500 Configuration dialogue box by using the Poll function. As soon as the ATB1500 Configuration dialogue box is updated, the new ATB1500 configuration is stored in memory. The new ATB1500 configuration is written to the ICS40.INI file as soon as the OK button is selected in the Configuration dialogue 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 ATB1500 configuration stored in memory. (For example, does the first slot position identified as "SMU5" really correspond to an "B1511A"?) 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 ATB1500 configuration stored in memory. This verification detects inconsistencies that result when the user changes the ATB1500 configuration but fails to update the ATB1500 Configuration dialogue 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 slot position) 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 ATB1500 configuration.
2. Restore the mainframe configuration to the original configuration reported by the error message(s).

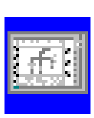
The Measurement Setup Dialogue Box

The setup conditions of each source unit are independently controlled with the Measurement Setup dialogue box. There is a Settings dialogue box that corresponds to each ATB1500 module. The ATB1500's Measurement Setup dialogue box is accessed from the Setup Editor.

Once the Measurement Setup Dialogue box is opened, all features of the instrument

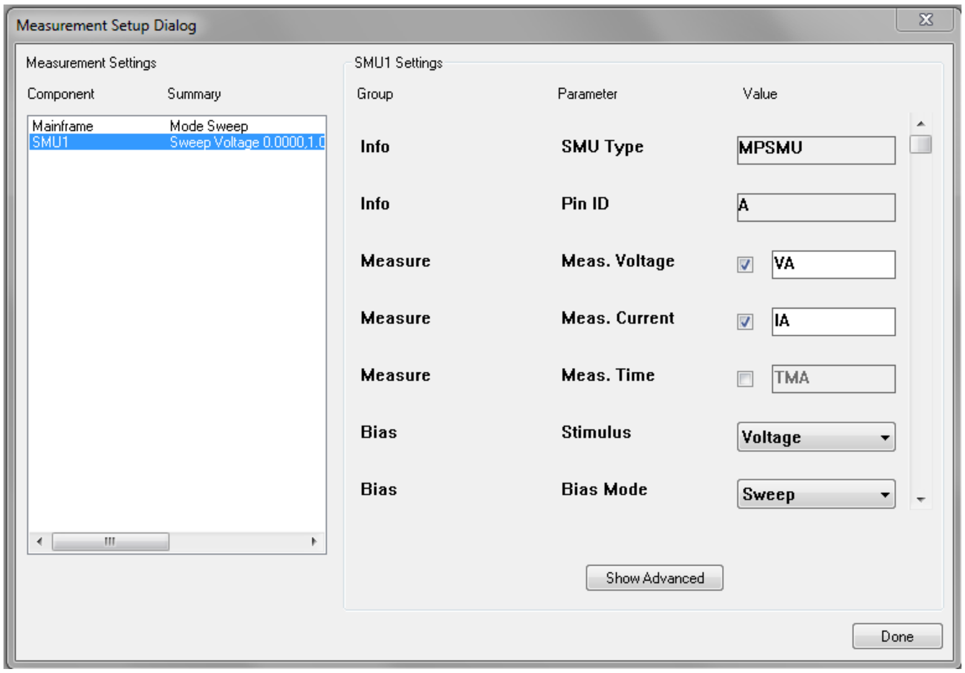
(including Mainframe Setup options) can be accessed. This is different from other ICS drivers which require the opening of several dialogue boxes to perform these functions.

How to Display the Measurement Setup Dialogue Box:



In order to display the Measurement Setup dialogue 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 dialogue box.
2. Click once on the desired source unit listed in the Measurement Settings area of the Measurement Setup Dialogue box.
3. The settings for the selected SMU will appear in the right side of the Measurement Setup Dialogue box.



The Measurement Setup dialogue box is used to specify the source/measure configuration of each ATB1500 module. The contents of Measurement Setup dialogue box are outlined below:

1. **Measurement Settings:** This field displays the selected SMUs as well as the Mainframe mode.
2. **SMU Settings Field:** This field contains the setup for the corresponding SMU.
3. **SMU Type Field:** This field displays the smu designation for the corresponding ATB1500 module.
4. **Pin ID Field:** This field contains the name of the device pin it is attached to in the Setup Editor.
5. **Meas. Voltage Field:** This field allows the selection of the Voltage values to be returned to the Data Spreadsheet.
6. **Meas. Current Field:** This field allows the selection of the Current values to be returned to the Data Spreadsheet.
7. **Meas. Time Field:** This field allows the selection of the Time values to be returned to the Data Spreadsheet.

8. **Stimulus Field:** This field consists a pull-down menu used to identify whether the sourcing signal is a voltage or a current.
9. **Bias Mode Field:** This field consists of a pull-down menu that allows the selection of the sourced signal type (Const, Sweep, Step, etc.).
10. **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.
11. **Compliance Field:** This field allows the setting of the Source compliance level.
12. **Meas. Range Type Field:** This field allows the selection of the type of measurement ranging control via a pull-down menu.
13. **Meas. Range Limit Field:** This field allows the setting of the measurement range value.

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

1. **Power Comp. Field:** This field allows the activation of the Power Compliance option of the ATB1500.
2. **Power Comp. (W) Field:** This field sets the power compliance value.
3. **ADC Type Field:** This field allows the selection of either High Speed (HS) or High Resolution (HR) ADC unit of the ATB1500.
4. **Output Range Type Field:** This field allows the selection of the type of Output ranging control via a pull-down menu.
5. **Output Range Limit Field:** This field allows the setting of the Output range value.
6. **Pulse Configuration Controls:** This group consists of the switch and fields necessary to configure the sourcing signal in a pulse mode.
7. **Seq. Number Field:** This field sets the output's turn-on order.
8. **Output Filter Field:** This switch turns on and off the source unit's output filter mode.
9. **Series Res. Field:** This field allows the activation of the ATB1500's internal series resistor for this output.
10. **Range Manage Field:** This field allows the activation of the ATB1500's internal Enhanced Auto Ranging for Current Measurement for this output.

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 ATB1500 Mainframe Setup dialogue box.

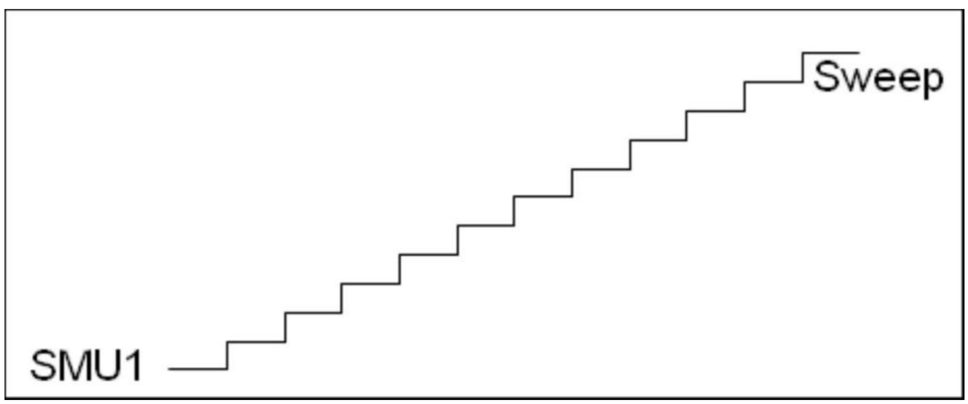
The type of Sweep Controls available for selection is dependent upon the Mainframe Mode that is selected. More information about the Mainframe Mode is presented later in the *Mainframe Options* section of this manual.

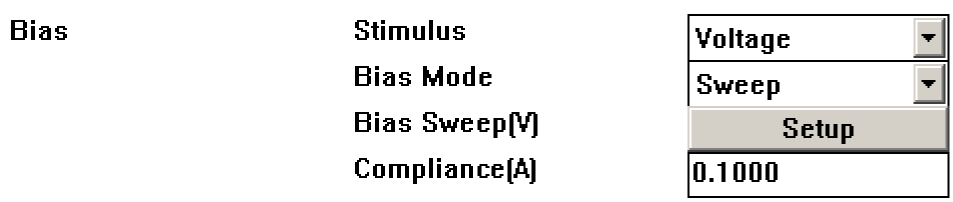
Bias Mode

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, synchronized sweep, step, constant supply, custom step, custom sweep, custom sync, or multi-sweep. To select the desired bias mode, use the pull-down menu in the BIAS MODE field. Click on the desired mode.

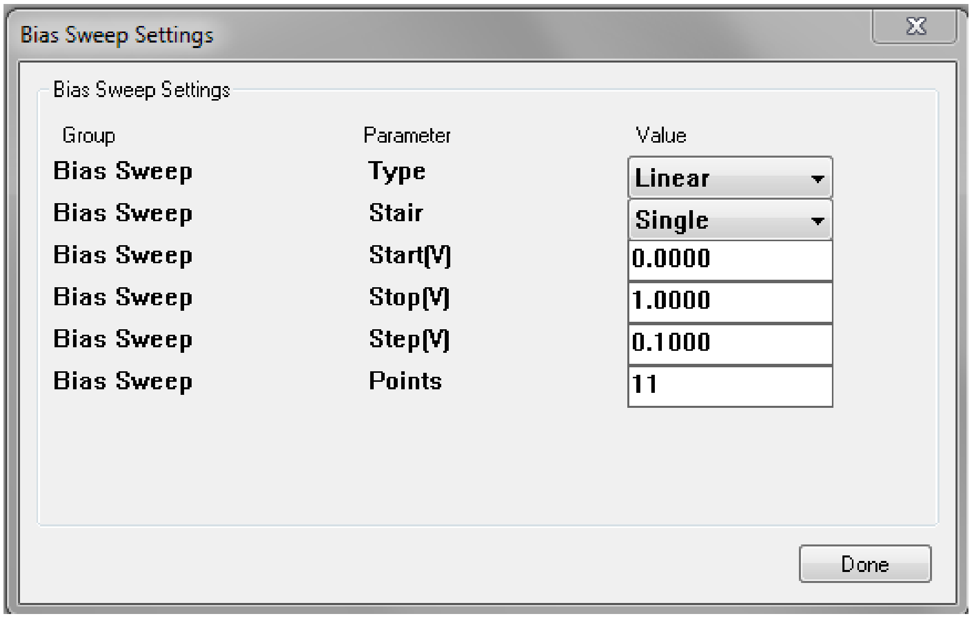
For an explanation of the bias modes used in conjunction with the pulse option, please refer to the *Pulse Configuration* section.

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 **Setup** button.

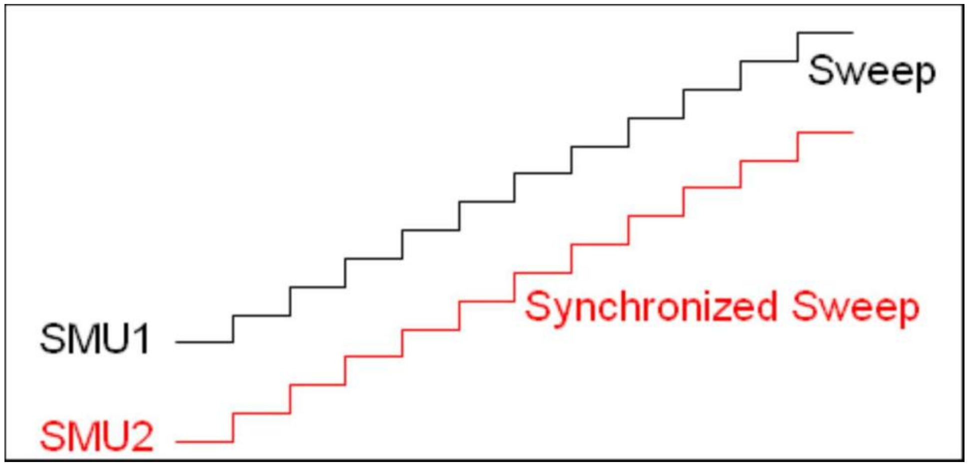


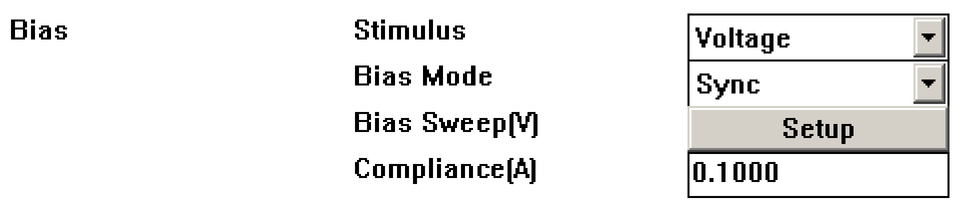
When creating a test setup that includes a second, synchronized sweep signal, the sweep application described in this section is the primary sweep signal. Double sweeps consisting of ascending and descending sweep directions are supported by this driver.

How to Source a Sweep Signal:

1. Select the Mainframe Settings and verify that the Mode is set to SWEEP.
2. Select the SMU component that is to be the sweep source.
3. Select the "SWEEP" designation from the available options listed in the BIAS MODE field.
4. Click the **Setup** button to open the Sweep Settings dialogue box.
5. 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.
6. Specify if the sweep will be a Single or Double (consisting of ascending and descending sweep directions) type.
7. Specify the sweep signal boundary values in the START and STOP fields.
8. Enter the number of data points that will comprise the sweep signal in the POINTS field.
9. If a linear sweep type is selected, the Sweep controls will include a STEP field. The STEP field will be calculated automatically after a value is entered in the POINTS field and the cursor is moved to another location (or OK is selected). If desired, the calculated STEP can be updated by the user. If a new value is entered in the STEP field, the POINTS field will be updated to accommodate the new STEP value. If any of the other fields are edited, the STEP field will be automatically updated to accommodate the change.

Synchronized Sweep Mode

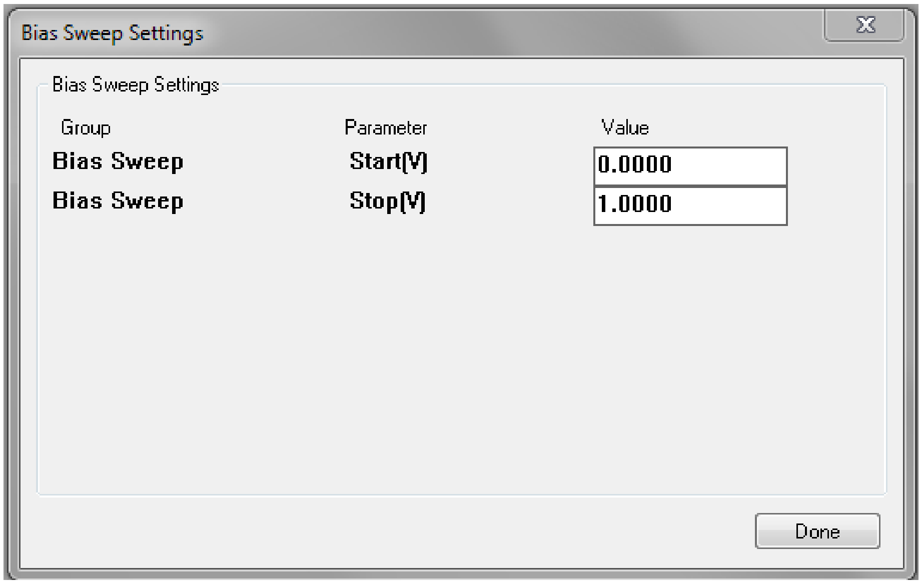




A synchronized sweep is a linear sweep signal that is synchronized in time with a primary sweep signal applied by another source unit.

A source unit can force a synchronized output only when the output of another source unit in the test setup is configured in a sweep mode. If a synchronized sweep mode is designated in a test setup that does not include a primary linear sweep signal, ICS will display an error message when the user attempts to exit the Measurement Setup.

The stimulus of the synchronized 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.



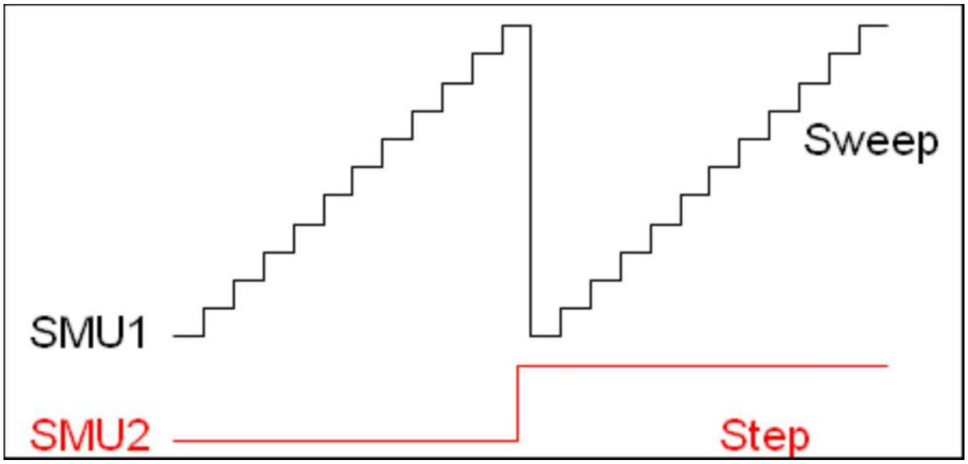
While the *timing* of the primary and secondary sweep signals is synchronized, the magnitudes can differ. The magnitude of the synchronized sweep signal is specified by designating a start and stop value. The sync source will automatically have the same number of POINTS.

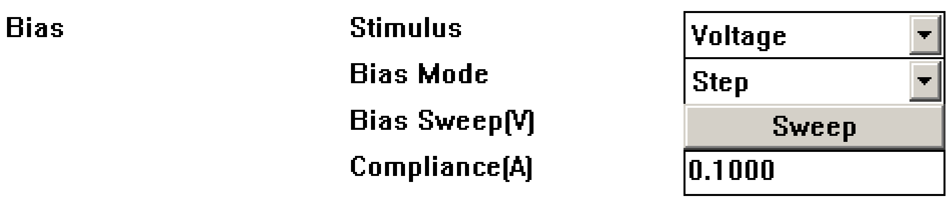
How to Source a Synchronized Sweep Signal:

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

1. Select the "SYNC" 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.
5. Click the Done button.

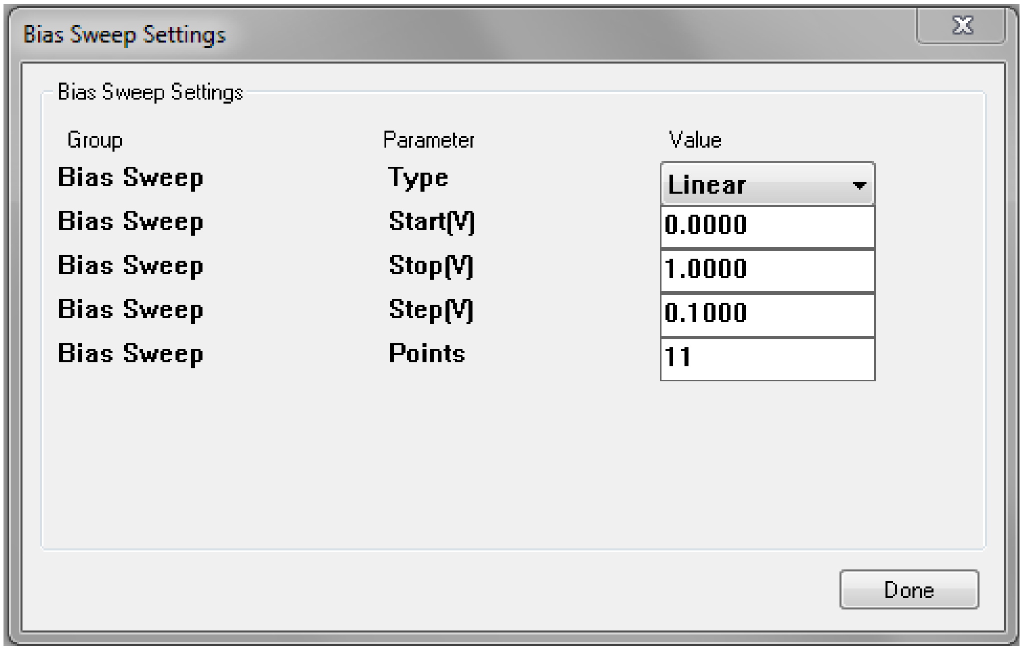
Step Mode





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.

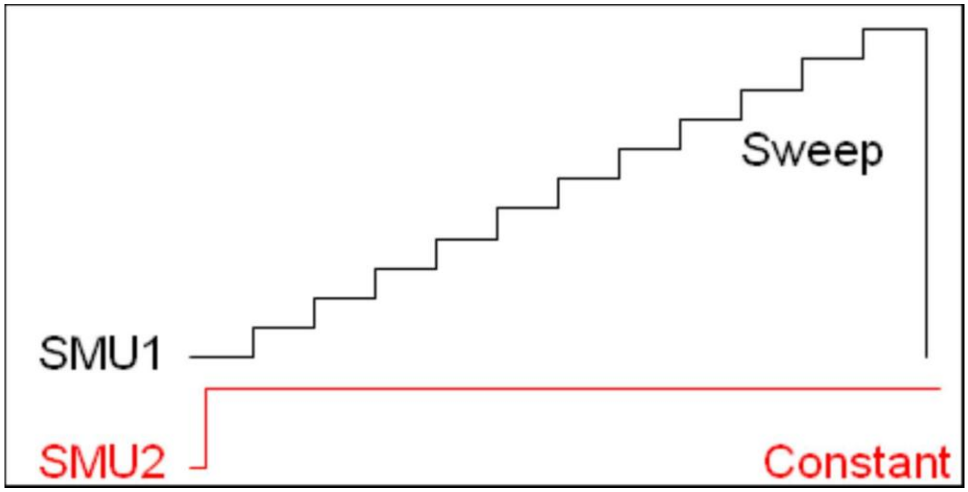
The step mode generates a constant output signal while a second source unit generates a staircase sweep signal. After the staircase sweep signal reaches the specified STOP value, the magnitude of the step output is incremented by the STEP value and the staircase sweep signal is triggered again. This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

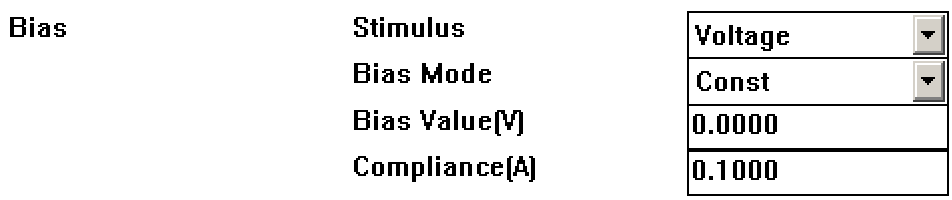


How to Source a Step Signal:

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



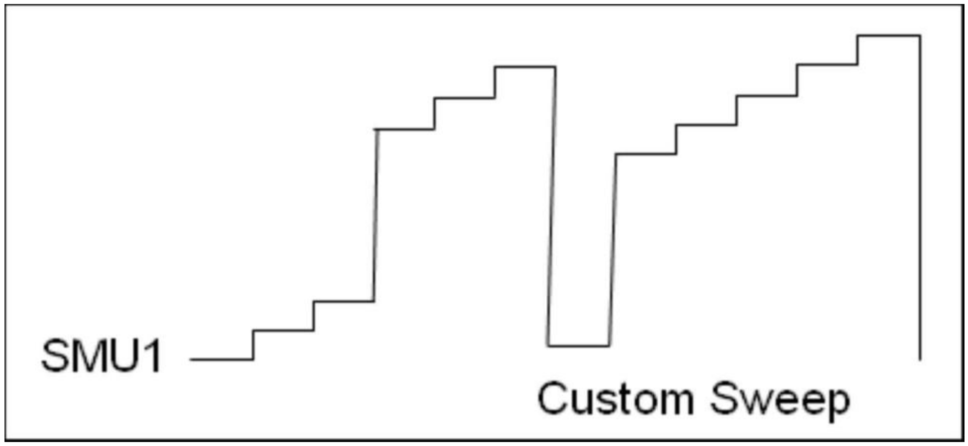


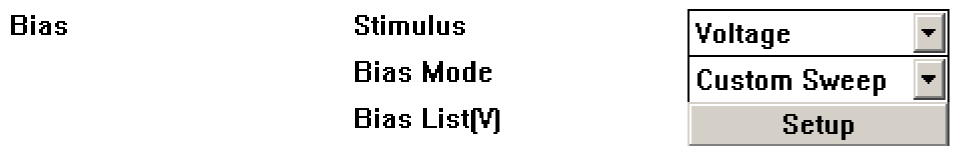
The constant mode generates a signal that remains at a constant magnitude throughout the duration of the test setup. Constant is typically kept on an SMU in conjunction with a second SMU performing a Sweep of some type.

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.

Custom Sweep Mode





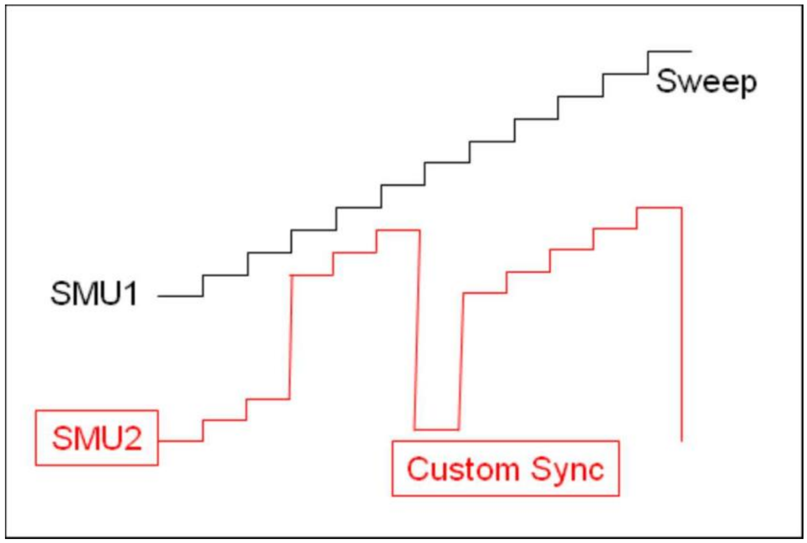
The custom sweep mode generates user-defined sweep signal between two specified boundary values. The settings are configured by clicking the **Setup** button.

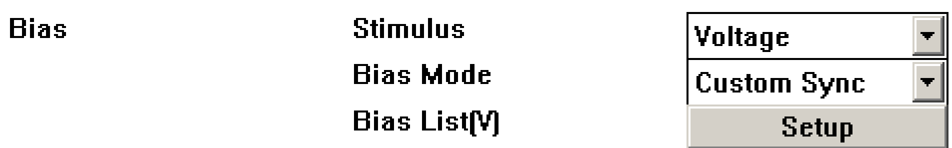
When creating a Custom Sweep, the Mainframe Mode must be selected as CUSTOM SWEEP.

How to Source a Custom Sweep Signal:

1. Select the Mainframe Settings and verify that the Mode is set to CUSTOM SWEEP.
2. Select the SMU component that is to be the custom sweep source.
3. Select the "CUSTOM SWEEP" designation from the available options listed in the BIAS MODE field.
4. Click the **Setup** button to open the Sweep Settings dialogue box.
5. Each sweep point is added to a list. The list is created by clicking ADD and specifying the sweep point.
6. After creating the list of points, click the DONE button.

Custom Sync Mode





The custom sync mode generates user-defined sweep signal. The settings are configured by clicking the **Setup** button.

The Custom Sync mode is only available when the Mainframe Mode is CUSTOM SWEEP.

A source unit can force a custom synchronized output only when the output of another source unit in the test setup is configured in a custom sweep mode. If a custom sync mode is designated in a test setup that does not include a primary custom sweep signal, ICS will display an error message when the user attempts to exit the Measurement Setup.

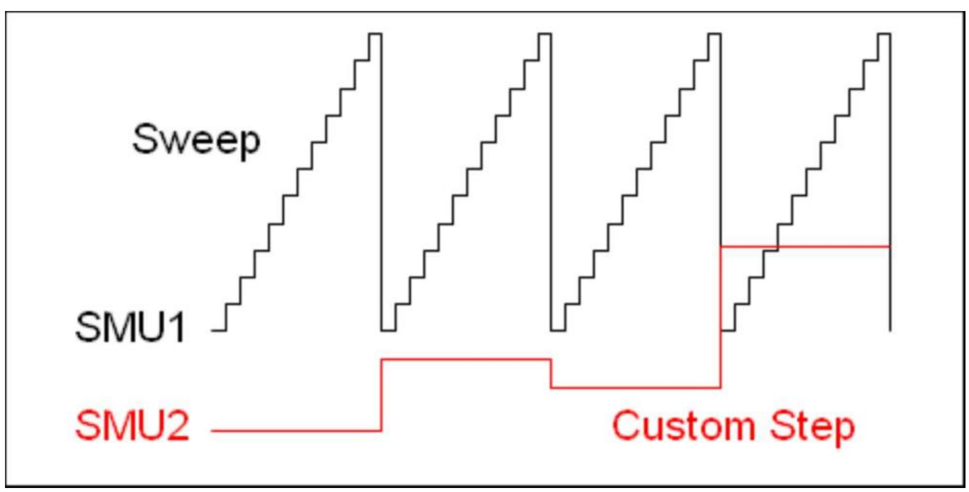
The stimulus of the custom sync sweep signal must match the stimulus of the primary sweep. In other words, if the primary sweep is a voltage output, the synchronized sweep must be a voltage output also. If the stimulus modes of the primary and synchronous outputs disagree, ICS will generate an error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

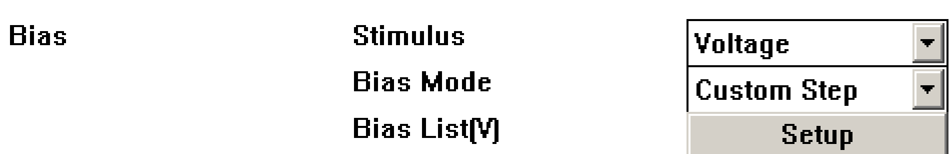
While the *timing* of the primary and secondary sweep signals are synchronized, the magnitudes can differ. The magnitude of the synchronized sweep signal is specified at each individual sweep value. The custom sync source MUST have the same number of POINTS.

How to Source a Custom Sync Sweep Signal:

1. A custom sync sweep signal is functional only when a custom sweep signal is forced by another source unit.
2. Select the "CUSTOM SYNC" designation from the available options listed in the BIAS MODE field.
3. Make certain that the selected Stimulus switch (VOLTAGE or CURRENT) agrees with the output stimulus of the primary sweep signal. If the stimulus mode of the output signals disagree, ICS will generate an error message when the user attempts to exit the Measurement setup.
4. Click the Setup button.
5. Each sweep point is added to a list. The list is created by clicking ADD and specifying the sweep point.
6. After creating the list of points, click the DONE button.

Custom Step Mode





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

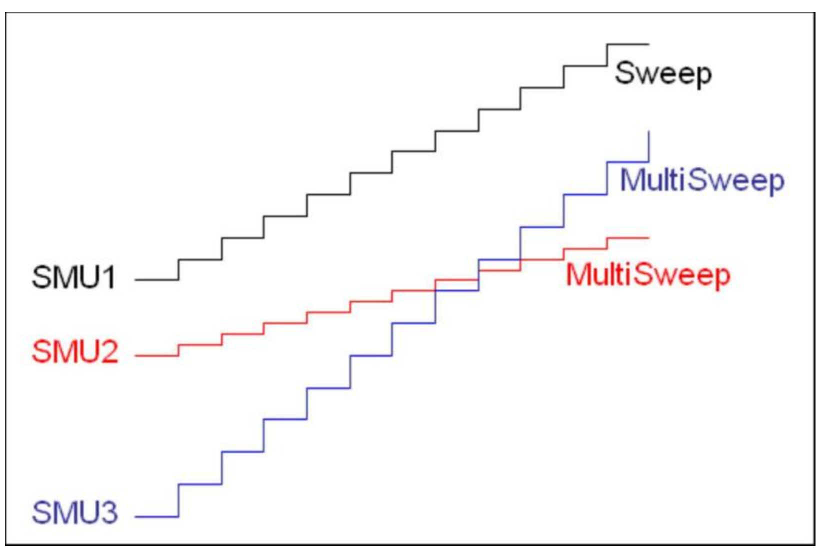
The Custom Step mode is only available when the Mainframe Mode is SWEEP, CUSTOM SWEEP, or MULTISWEEP.

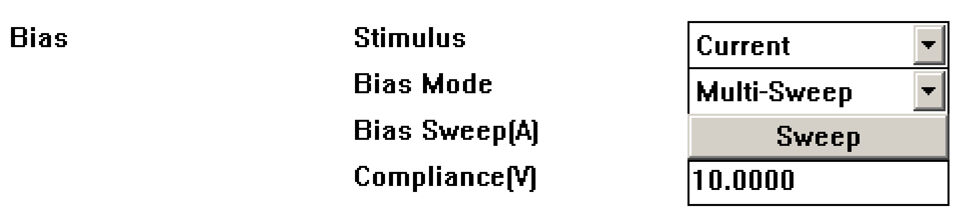
The custom step mode generates a constant output signal while a second source unit generates a staircase sweep signal. After the staircase sweep signal reaches the specified STOP value, the magnitude of the step output is incremented to the next value and the staircase sweep signal is triggered again.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

How to Source a Custom Step Signal:

1. Select the "CUSTOM STEP" designation from the available options listed in the BIAS MODE field.
2. Click the Setup button.
3. Each sweep point is added to a list. The list is created by clicking ADD and specifying the sweep point.
4. After creating the list of points, click the DONE button.

Multi-Sweep Mode



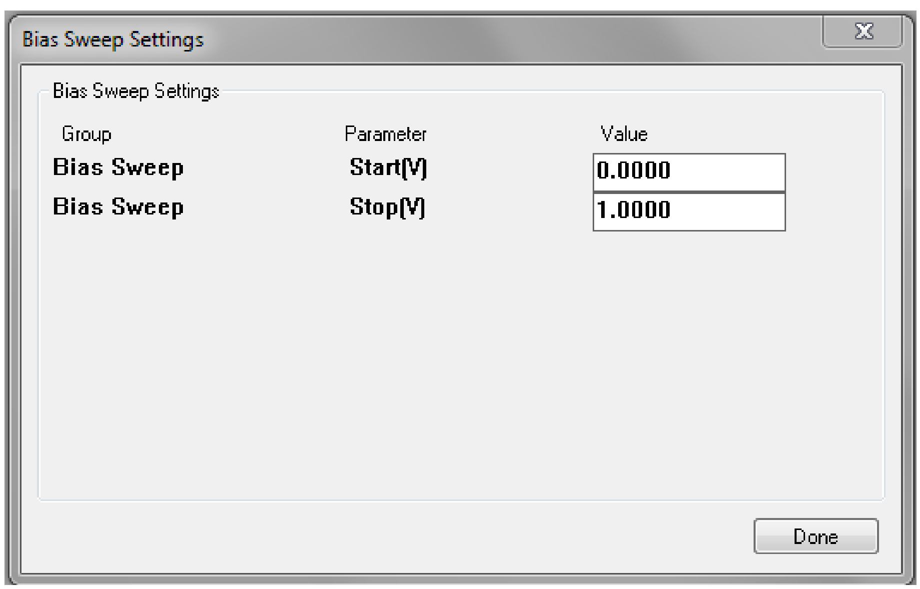


The Multi-sweep mode allows more than one and up to ten SMU's to sweep at the same time. The Multi-sweep works by defining one SMU as the primary (SWEEP) source. This source has all of the normal sweep setup inputs available including START, STOP, POINTS, and STEP. All other SMU's that will perform a sweep are configured as MULTI-SWEEP in the BIAS MODE. The settings for each multi-sweep source are only the START and STOP and are configured by clicking the **Setup** button.

The Multi-sweep mode is only available when the Mainframe Mode is MULTI-SWEEP.

A source unit can force a multi-sweep output only when the output of another source unit in the test setup is configured in a sweep mode. If a multi-sweep mode is designated in a test setup that does not include a primary sweep signal, ICS will display an error message when the user attempts to exit the Measurement Setup.

The stimulus of the multi-sweep signal *is not required* to match the stimulus of the primary sweep. In other words, if the primary sweep is a voltage output, the synchronized sweep can be either a voltage or current output.



While the *timing* of the sweep and multi-sweep signals are synchronized, the magnitudes can differ. The START and STOP values of the multi-sweep signal is specified for each individual multi-sweep source.

How to Source a Multi-Sweep Signal:

A multi-sweep signal is functional only when a sweep signal is forced by another source unit.

1. Select the "MULTI-SWEEP" designation from the available options listed in the BIAS MODE field.
2. Click the SWEEP button.
3. Enter the START and STOP values.
4. Click the DONE button.
5. Repeat for each multi-sweep source.

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 ATB1500 Operation Manual for an overview of the ATB1500 compliance configurations and power limitations.

Detecting Compliance Events

If the Display Errors switch is selected in the Mainframe Settings dialogue box, ICS will display a message if a compliance limit is detected. (The Mainframe Setup dialogue box is opened by clicking the Setup Editor OPTIONS button or by clicking the MAINFRAME component in the Measurement Setup dialogue 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 dialogue box.

Output Filter Switch

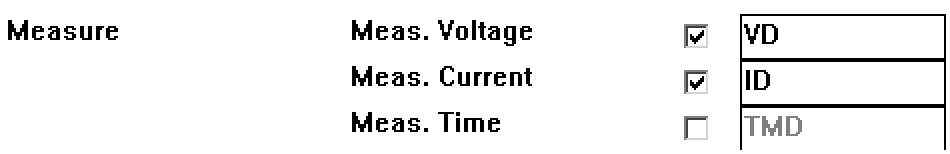
The ATB1500 modules include a low-pass filter at the digital-to-analog converter (DAC) output. The default position of this switch is OFF. For more details concerning the function and applicability of the Output Filter switch, please refer to the ATB1500 Operation Manual.

Stimulus Controls

The stimulus menu consists of two selections: VOLTAGE and CURRENT. This specifies the characteristic of the forcing signal. Timing and averaging configurations are defined in the ATB1500 Mainframe Setup dialogue box.

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. For example, the E5281A MPSMU can be configured to source a voltage and monitor a current, or source a current and monitor a voltage. However, selecting the forcing signal characteristic DOES NOT automatically specify the data that will be written to the corresponding data window. 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 TIME. 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 ATB1500 Mainframe Setup dialogue 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 TIME 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 ATB1500 pulse mode, please refer to the *Pulse Configuration* section.

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 TIME 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.

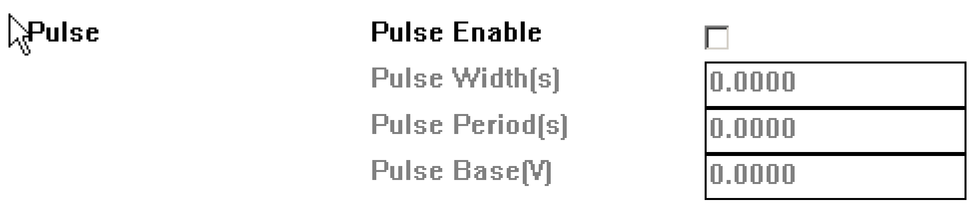
For example, consider the DC collector characteristics of a bipolar transistor. The DC collector characteristics are obtained by generating a family of Ice vs. Vce curves. This setup was created by applying a stepped current supply to the base and a swept voltage supply to the collector. The source unit 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.

Pulse Configuration Controls



The Pulse Configuration Controls are used to apply the selected sourcing mode in a pulse configuration.

The Pulsed mode can only be assigned to a single output.

Pulse Width

The pulse width is the length of time during which the ATB1500 will force the pulse value. The pulse width specification does not include the time during which the ATB1500 forces the base value of the pulse.

Pulse Period

The pulse period is the total cycle time between consecutive pulse triggers. The pulse period is the sum of the pulse width and the base value output duration. Therefore, the base value output duration of each pulse period is equal to the pulse period minus the pulse width.

Pulse Base

The base value is the bias forced during the period of time that the pulse is not applied.

The Mainframe Setup Dialogue Box

Clicking the OPTIONS button in the Setup Editor will open the ATB1500 Mainframe Setup dialogue box. The ATB1500 Mainframe Setup dialogue box includes the controls necessary to specify the mode, timing, integration, options, ADC settings, and triggering.

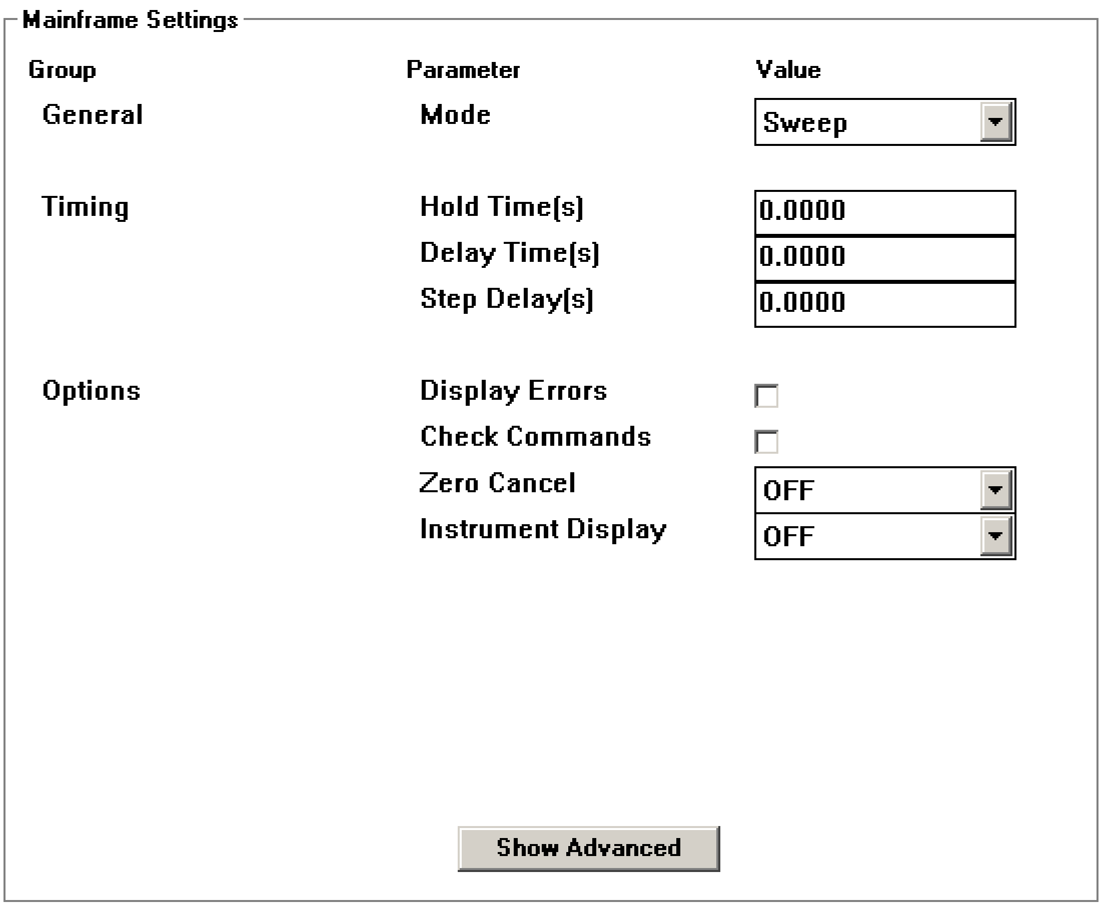


Figure 7: The Mainframe Setup Dialogue Box

The contents of the ATB1500 Mainframe Setup dialogue box are global to every module in the test setup. The ATB1500 mainframe options are only applied to the test setup in which they were specified. Once a new test setup is defined, the mainframe options can be re-specified without changing the configuration of the mainframe options in a previously defined test setup.

The ATB1500 Mainframe Setup dialogue box is displayed by clicking the Setup Editor OPTIONS button after first designating at least one Source Unit/DUT connection.

Mode

Group	Parameter	Value
General	Mode	Sweep

The Mode setting allows the user to select the way that the instrument will be used. Selecting the Mode allows the driver to simplify the SMU configuration windows. Further description of the Mainframe Modes is found in "The B1500A Mainframe Modes".

Sweep Source Timing Controls

Timing	Hold Time(s)	0.0000
	Delay Time(s)	0.0000
	Step Delay(s)	0.0000

The Sweep Source Timing Controls specify the timing configurations of any sweep mode sourcing signal. Values entered in the sweep source timing fields are interpreted in units of seconds.

Hold Time

The hold time is the length of time the ATB1500 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.

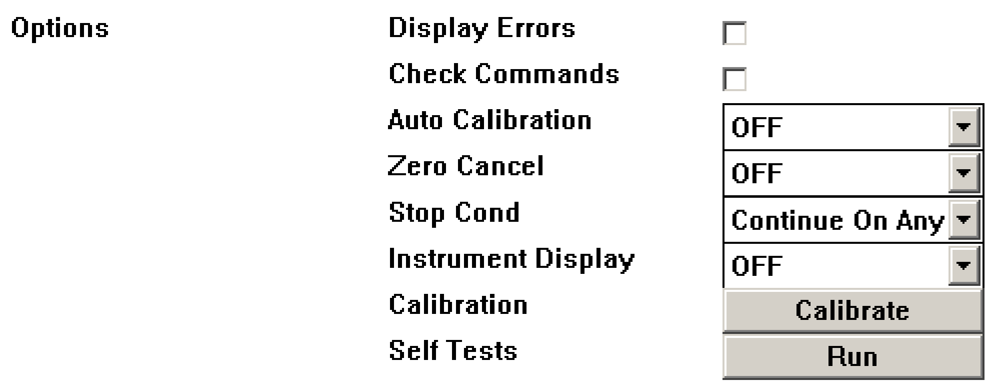
Delay Time

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.

Step Delay Time

The step delay time is the length of time between the measurement and the sweep signal magnitude increment.

Options



The Options Group contains specialized functions for the ATB1500 mainframe. The options are listed below.

Display Errors

This option when selected will force the software to report any error condition reported by the instrument, including Compliance.

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.

Auto Calibration

This function activates the Auto Calibration flag for the instrument. The instrument will then automatically perform calibration functions at regular intervals.

Zero Cancel

This option activates the Zero Cancel feature of the B1500A.

Stop Condition

This sets the Stop Condition flag on the instrument. When measuring the instrument can be set to Stop on Any Abnormal event or to Continue on Any Event. The Continue on Any option will result in the instrument NOT stopping when a channel reaches compliance.

Instrument Display

This option turns off the update of the Instrument display.

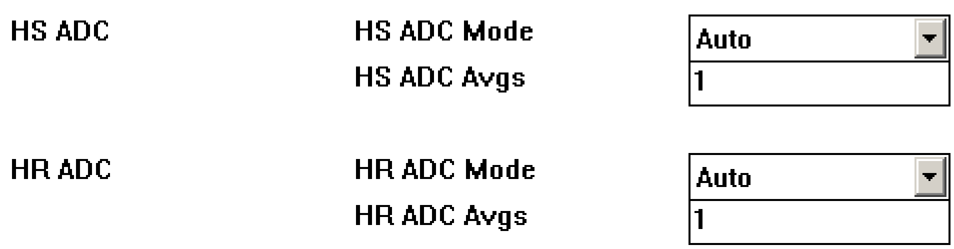
Calibration

The Calibration button causes the instrument to IMMEDIATELY perform its calibration routines.

Self Tests

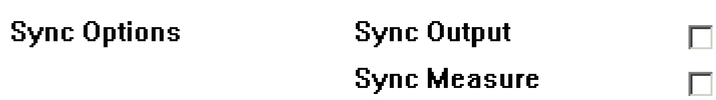
The Self Test button causes the instrument to IMMEDIATELY perform its self test routines.

ADC Setting Controls



The ADC Setting Controls are used to define the Measurement Integration Time. Please refer to the section of this manual titled *Controlling Integration time* for more details.

Sync Options Controls

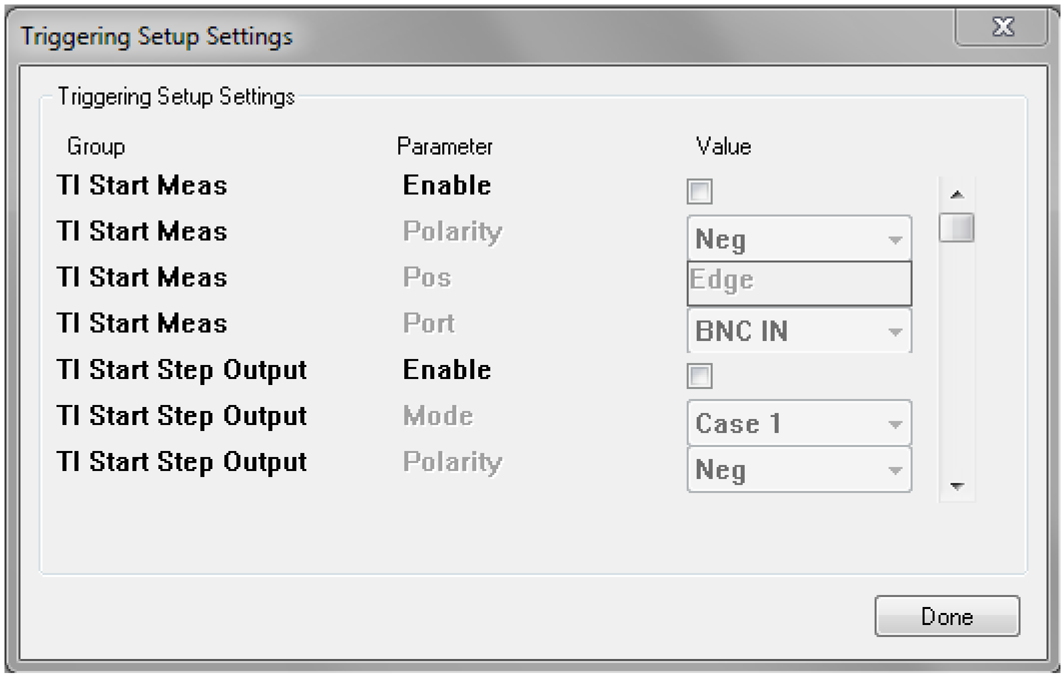


The Sync Options Controls allow the user to select if the instrument synchronizes the output signal or the measurement. This function is only applicable for the Mainframe Mode of MULTI-SWEEP.

Triggering Controls

Triggering **Triggering** **Setup**

The Triggering Controls Group contains setup functions for the triggering functions of the B1500A mainframe. For a detailed explanation of the ATB1500 triggering modes please refer to the Agilent B1500A Reference Manual provided by Agilent.



Triggering Modes

1. *TI Start Meas*- **Start Measurement Trigger.** When a trigger is received, the E5270 starts the measurement.
2. *TI Start Step Output*- **Start Step output setup Trigger.** When a trigger is received, the E5270 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, multi channel sweep, or pulsed spot measurement.
3. *TI Start Step Meas*- **Start step measurement trigger.** When a trigger is received, the E5270 starts the measurement at each sweep step. This function is available for the staircase sweep or multi channel sweep measurement.
4. *TO Comp. Step Output*- **Step output setup completion trigger.** The E5270 sends a trigger when the output setup is completed at each sweep step or the pulsed output setup is completed. This function is available for the staircase sweep, pulsed sweep, staircase sweep with pulsed bias, multi channel sweep, or pulsed spot measurement.

5. *TO Comp. Step Meas*- **Step measurement completion trigger.** The E5270 sends a trigger after measurement at each sweep step. This function is available for the staircase sweep or multi channel sweep measurement.
6. *TO Comp. Meas*- **Measurement completion trigger.** The E5270 sends a trigger after measurement.

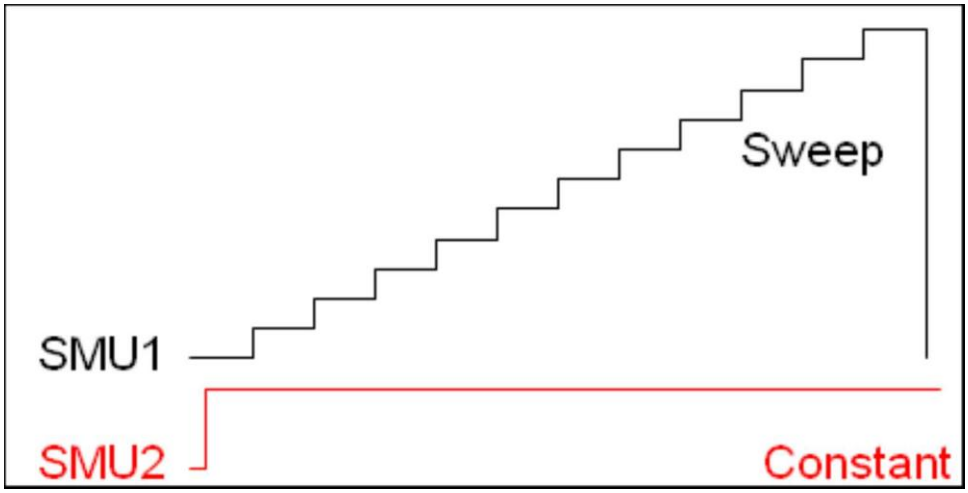
The B1500A Mainframe Modes

The B1500A driver allows the setup of the instrument into specific modes. These modes allow for easier setup of the test by removing options that are not applicable for a specific test method. This section of the manual describes the Mainframe Modes and the SMU setups allowed, respectively.

	SMU Bias Mode								
		Const	**Step**	**Sync**	**Sweep**	**Multi-Sweep**	**Custom Step**	**Custom Sync**	**Custom Sweep**
Mainframe Mode	Sweep Mode	*	*	*	*		*		
	Spot Mode	*							
	Multi-Sweep Mode	*	*		*	*	*		
	Custom Sweep Mode	*	*				*	*	*
	ICS Time Mode	*							
	HS Sampling Mode	*							
	Sampling Mode	*							
	Stress Mode	*							

Sweep Mainframe Mode

The Sweep Mainframe mode is the mode for most measurements that require the sweep of one of the device terminals. One of the SMUs must be set in Sweep Mode and the remaining can be setup in Constant, Step, Sync, or Custom Step Bias Mode.

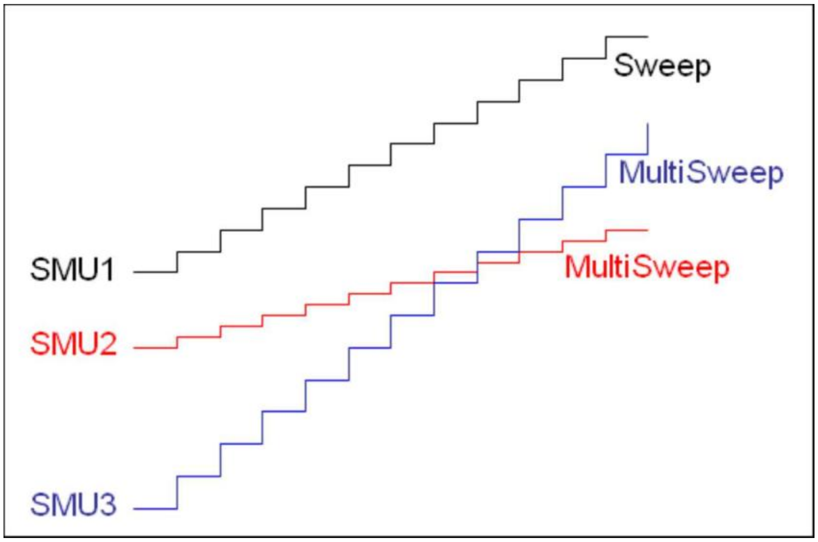


Spot Mainframe Mode

The Spot Mainframe mode is the mode for measurements that test only a single bias point of the device terminals. All of the SMUs must be set in Constant Mode.

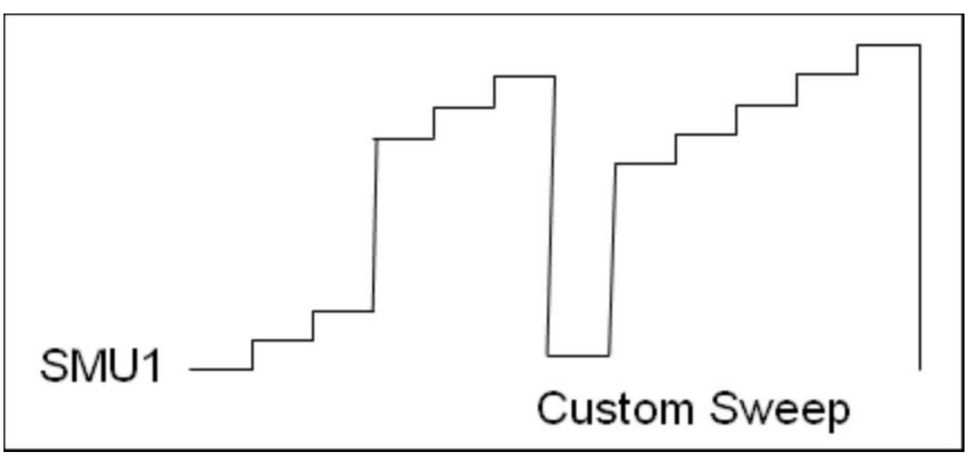
Multi-Sweep Mainframe Mode

The Multi-Sweep Mainframe mode is the mode for parallel measurements of several devices at the same time by sweeping several SMUs simultaneously. One of the SMUs must be set in Sweep Mode and other SMUs to be swept are set to Multi-Sweep mode and the remaining can be setup in Constant, Step, Custom Step Bias Mode.



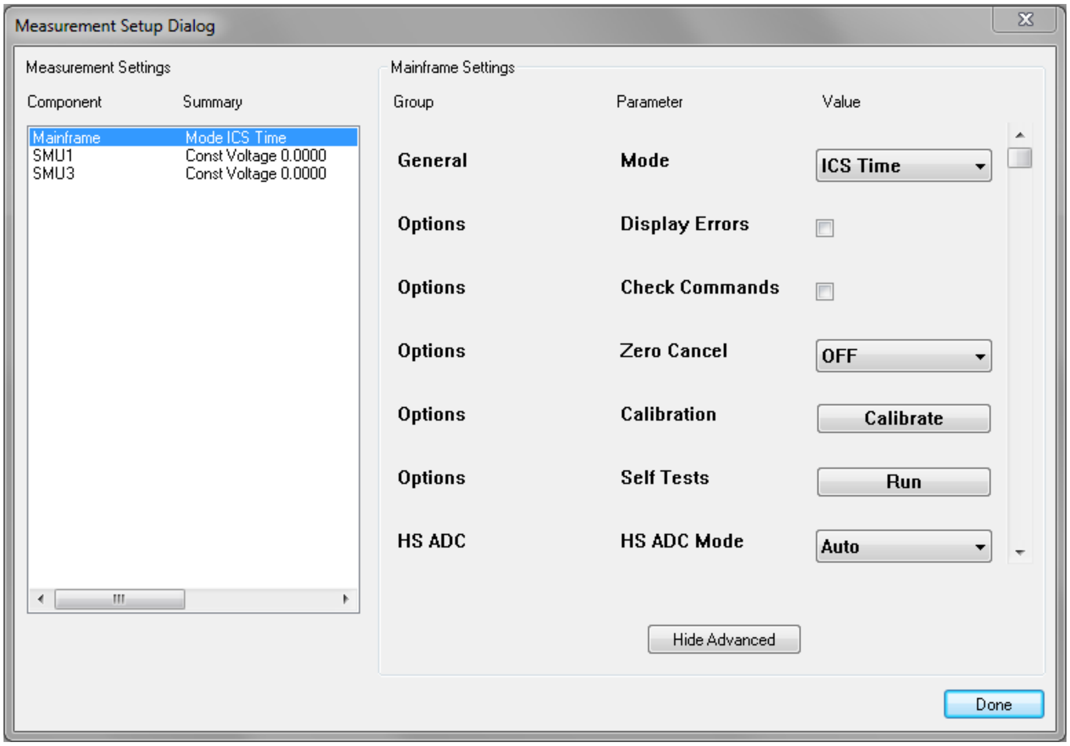
Custom Sweep Mainframe Mode

The Custom Sweep Mainframe mode is the mode for applying a sweep that is a non-standard set of points that cannot be simply defined as Start, Stop, and Number of Steps. One of the SMUs must be set in Custom Sweep Mode and the remaining can be setup in Constant, Step, Custom Step, and Custom Sync Bias Mode.



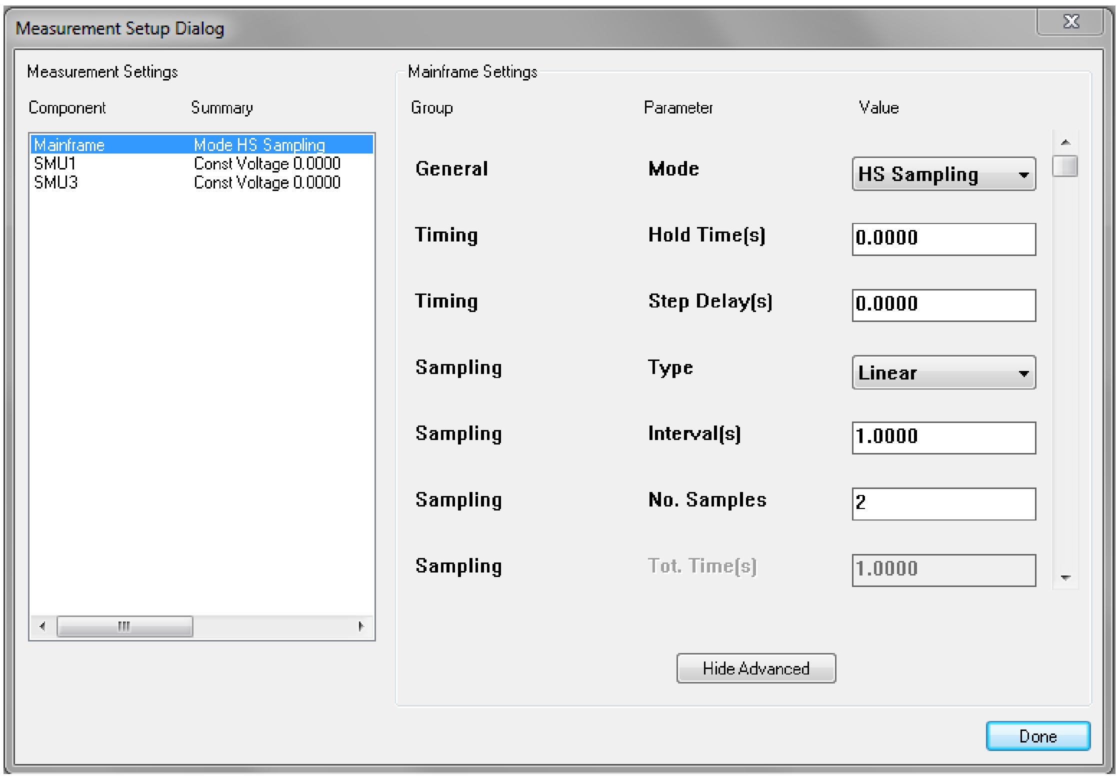
ICS Time Mainframe Mode

The ICS Time Mainframe mode allows the test setup to be created exactly like the older versions of ICS. **If you are not using an old project, use the HS Sampling or Sampling Modes instead**. A constant bias is applied while the DUT is measured at specified time intervals. All of the SMUs must be set in Const Mode.



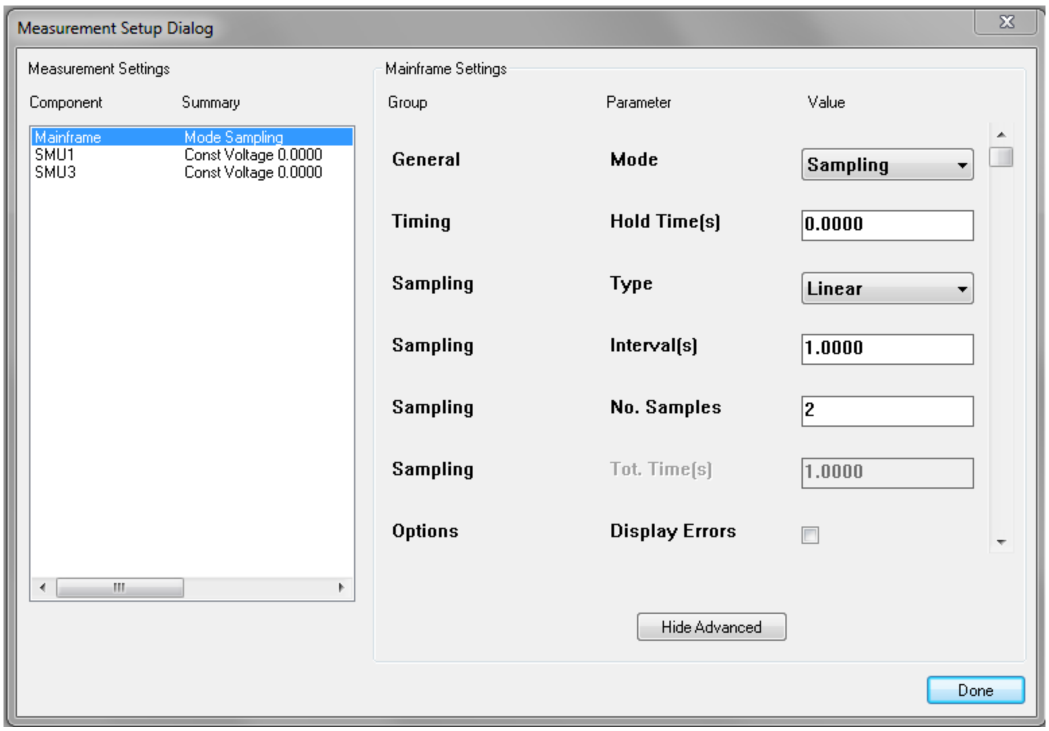
HS Sampling Mainframe Mode

The HS Sampling Mainframe mode allows the test setup to use the internal sampling capability of the instrument. The internal sampling is the fastest possible sampling mode for the instrument. A constant bias is applied while the DUT is measured at specified time intervals that are set in the "Timing" Mainframe Setting. All of the SMUs must be set in Const Mode.



Sampling Mainframe Mode

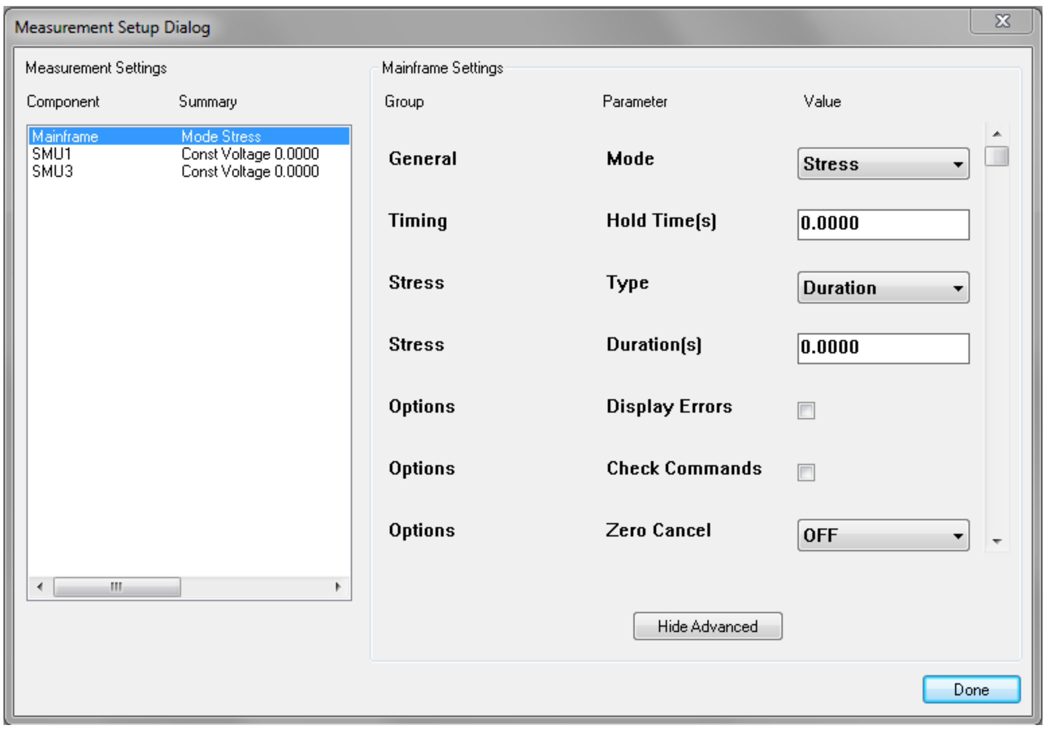
The Sampling Mainframe mode allows the test setup to use the external sampling capability of the instrument. The external sampling is a slower sampling mode for any instrument as the samples are triggered externally. A constant bias is applied while the DUT is measured at specified time intervals that are set in the "Timing" Mainframe Setting. All of the SMUs must be set in Const Mode.



Stress Mainframe Mode

The Stress Mainframe mode allows the test setup to stress a device for a set period of time.

- The selected terminals are measured only at the beginning and end of the stress period.
- All of the SMUs must be set in Const Mode.
- The length of the Stress time is set in the Duration field.



Controlling Integration Time

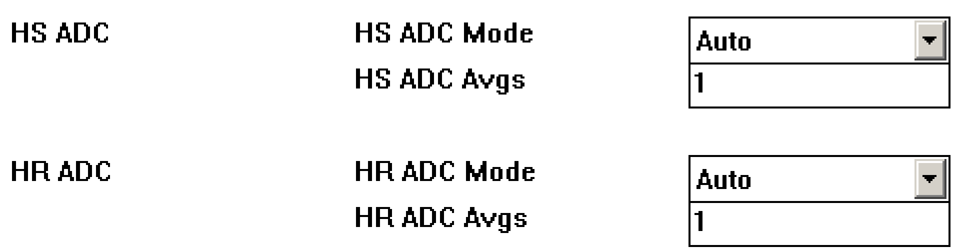
Integration time is the time required to get measurement data. The longer the integration time, the better the data is a generally true statement, however sometimes the trade-off between increasing the integration time and the quality of the data becomes unfavorable. In some cases, the increased measurement time does not yield significantly better data. It is therefore important to properly control the integration Time to achieve the best data in an acceptable test time.

The ATB1500 driver has two sets of controls for setting the Integration Time.

The first is by using the ICS Measurement Remote Control. The Measurement Remote Control has a button that allows the selection of four (4) different Integration Modes. These modes are defined by ICS and are detailed below.

Integration Type	**ADC Selected**	**ADC Mode**	**Averages**
SHORT	HS	AUTO	1
SHORT	HR	AUTO	8
MEDIUM	HS	AUTO	128
MEDIUM	HR	AUTO	32
LONG	HS	AUTO	512
LONG	HR	AUTO	64

By default, ICS will have the Measurement Remote Control Integration Mode set to User. This will allow the Integration Time to be controlled by the settings in the Instrument Mainframe Options.



The Integration Time calculations are listed here.

1. HS ADC, AUTO MODE- Number of averaging samples = N x reference
   where reference is the number of averaging samples automatically set by the Agilent B1500; this cannot be changed. Specify the N value shown above. Available values are 1 to 1023. Initial value is 1.
2. HS ADC, MANUAL MODE- Specify the Number of averaging samples (N). Available values are 1 to 1023. Initial value is 1.
3. HS ADC, PLC MODE- Number of averaging samples = N x 128
   Specify the N value shown above. Available values are 1 to 100. Initial value is 1. The Agilent B1500 gets 128 samples in a power line cycle. Hence, the N value is equal to the number of power line cycles.
4. HR ADC, AUTO MODE- Integration Time = N x reference
   where reference is the integration time automatically set by the Agilent B1500; this cannot be changed. Specify the N value shown above. Available values are 1 to 127. Initial value is 6.
5. HR ADC, MANUAL MODE- Integration Time = N x 80 microseconds
   Specify the N value shown above. Available values are 1 to 127. Initial value is 3.
6. HR ADC, PLC MODE- Integration Time = N / power line frequency
   Specify the N value shown above. Available values are 1 to 100. Initial value is 1. The N value is equal to the number of power line cycles.

Getting Started: Creating and Executing a CV Test Setup using the MFCMU

This section will walk you through the steps required to create and execute a sample test setup. This sample test setup will measure gate capacitance, Cg, of a transistor as a function of voltage. This characteristic was measured with the Agilent B1520A MFCMU and the HP16442A Test Fixture.

Step 1: Connect a Test Fixture or Cable Set to the Instrument

The capacitance example presented in this section was performed with the HP16442A Test Fixture. Connect a compatible four-terminal pair cable set to the instrument UNKNOWN terminals.

Use standard length test cables, "1m", "2m", or "4m" as appropriate. Any other cable length will induce inaccuracies that must be accounted for. Refer to the Agilent B1500A Operation Manual to review the cable compensation selection procedure.

Step 2: Connect the ATB1500's Instrument Driver

The ATB1500 Driver is connected to ICS in the Connect Instruments dialogue box. The Connect Instruments dialogue box is accessed by choosing the CONNECT IN-STRUMENTS toolbar button or by selecting INSTRUMENTS/SELECT INSTRU-MENT from the main menu bar.

How to Connect the ATB1500 Driver:

1. Click the CONNECT INSTRUMENTS toolbar button or select INSTRUMENTS/SELECT INSTRUMENT from the measurement mode menu bar. This will open the Connect Instruments dialogue box.
2. Highlight the ATB1500 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 dialogue box and restore control to the ICS desktop. Keep the Connect Instruments dialogue box displayed for now, because the next step requires you to click the Connect Instruments CONFIG button.

Step 3: Designate the GPIB Address and Options Status

Connect the Agilent B1500A instrument to your computer using a standard IEEE-488 GPIB (General Purpose Interface Bus) as described in the Agilent B1500 Operation Manual. The GPIB hardware discussed in the Operation Manual is Agilent's implementation of the IEEE-488 Standard Digital Interface for programmable instrumentation. Please refer to the Agilent B1500A Operation Manual to review the GPIB cable length limitations and connection restrictions recommended by Agilent Technologies.

The ATB1500 Configuration Settings dialogue box is used to designate the instrument's GPIB address. The Configuration Settings dialogue box also reports the installed Options.

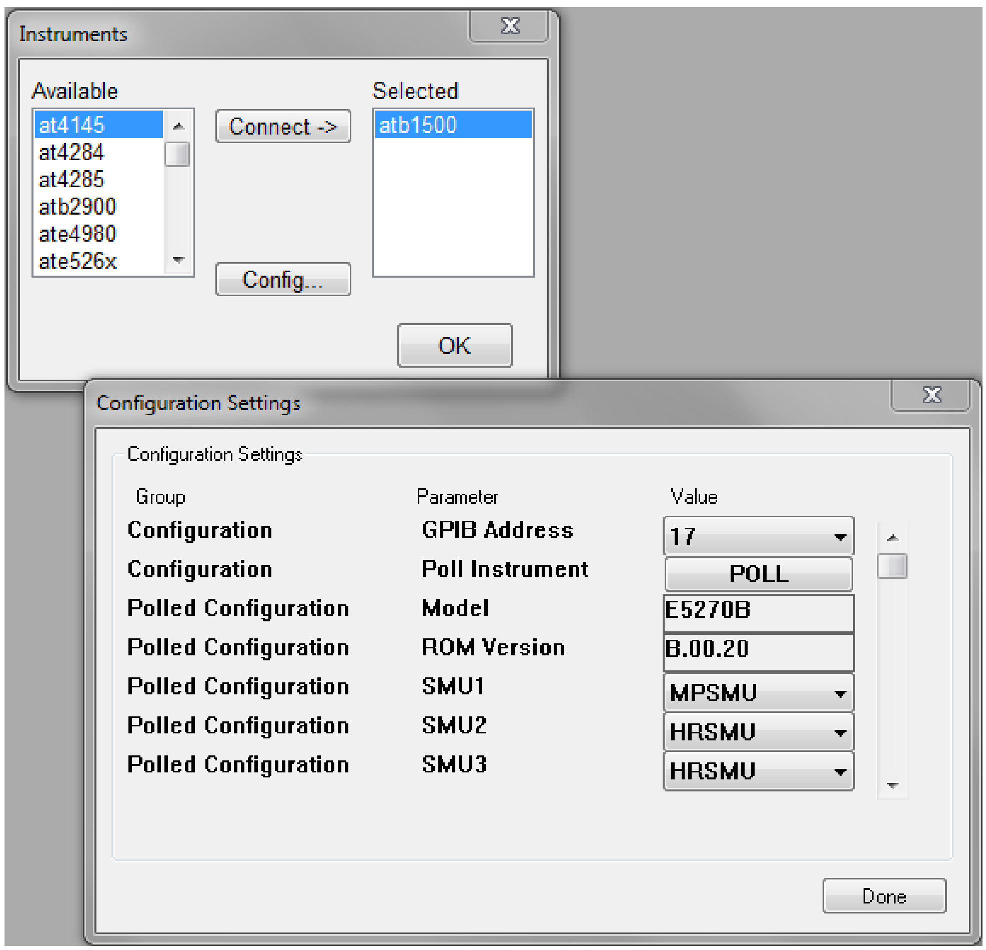


Figure 1: How to Define the B1500A GPIB Address

How to Specify the B1500A GPIB Address:

1. The Connect Instruments dialogue box should still be displayed from the last step. If it isn't, click the toolbar CONNECT INSTRUMENTS button or choose INSTRUMENTS/SELECT INSTRUMENT from the main menu bar. This will re-open the Connect Instruments dialogue box.
2. Open the B1500's Configuration Settings dialogue box by clicking the CONFIG button at the bottom of the Connect Instruments dialogue box.
3. Select the B1500's GPIB address in the GPIB field. The GPIB address is designated in the System Configuration page under the SYSTEM menu. If you wish to change the GPIB address, please refer to procedure outlined in the ATB1500 Operation Manual.

Step 4: Create the Test Setup

Test setups are created in the Setup Editor. Open the Setup Editor by selecting the SETUP EDITOR button. This example will demonstrate how to create a test setup that measures the capacitance, Cg, of a transistor as a function of voltage.

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

1. Click the Setup Editor NEW button. This will open the New Setup dialogue box.
2. At the prompt, specify a test setup name. For this example, type "Cgate".
3. Click OK. This will close the New Setup dialogue 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. ICS provides a library of different device schematics. Select a schematic that is a representation of the DUT.

The device schematic does not have to match the pin layout of the Device Under Test. The device schematic is provided as a convenience for the user so that the user can document the terminal connections required for the corresponding test setup.

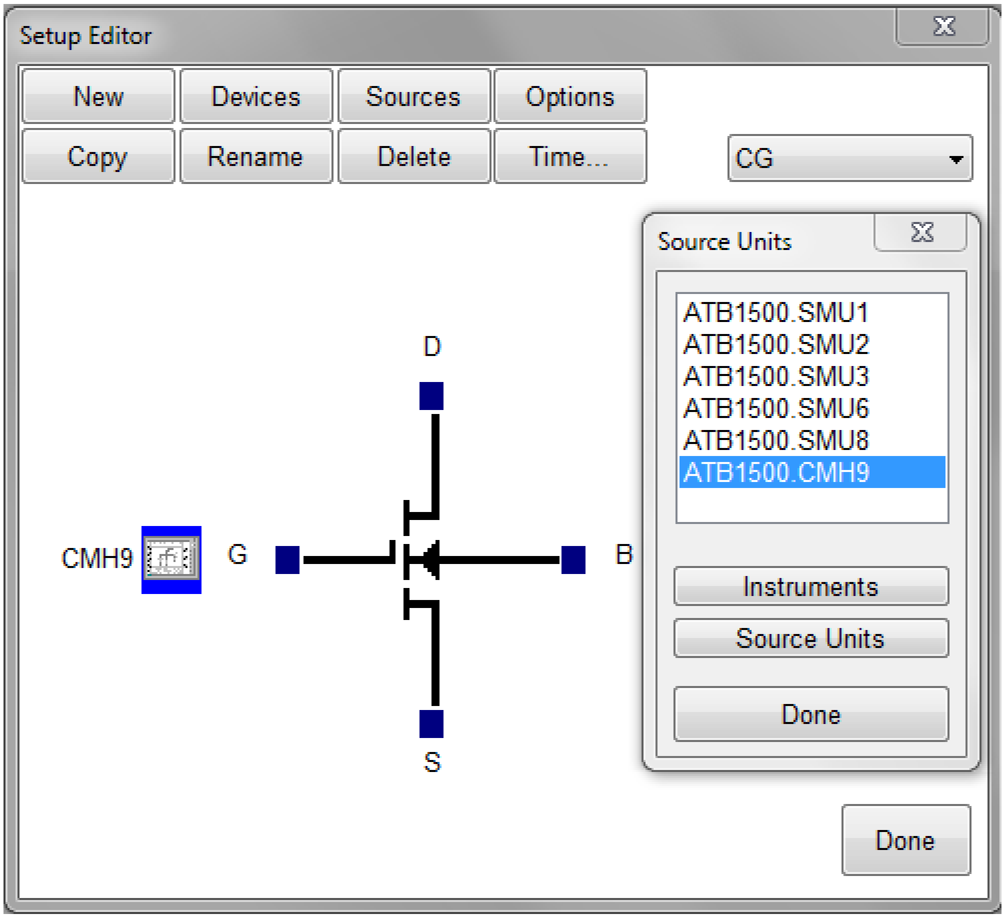
A MOSFET schematic will appear at the center of the Setup Editor when the Setup Editor is first opened. The MOSFET device is the default Setup Editor schematic. To change the default device schematic, refer to *Chapter 2 of the ICS Technical Reference Manual; The Setup Editor*.

How to Select a Device Schematic:

1. Click the Setup Editor DEVICE button. This will open the Device dialogue box.
2. The Device Type window will display a list of available device schematics. Select "MOSFET". Notice the selected schematic is previewed in the small window to the right of the Device Type window.
3. Click OK. This will close the Device dialogue box and display the capacitor schematic at the center of the Setup Editor.

Step 4C: Designate the Instrument/DUT Connections

The connections between the instrument UNKNOWN terminals and the device under test are designated in the Setup Editor. The Setup Editor display is provided as a tool to document the test fixture or test lead connections required for the corresponding device measurement. The connections designated in the Setup Editor must correspond to the orientation of the DUT in the test fixture or the connections between the DUT and the instrument test leads.

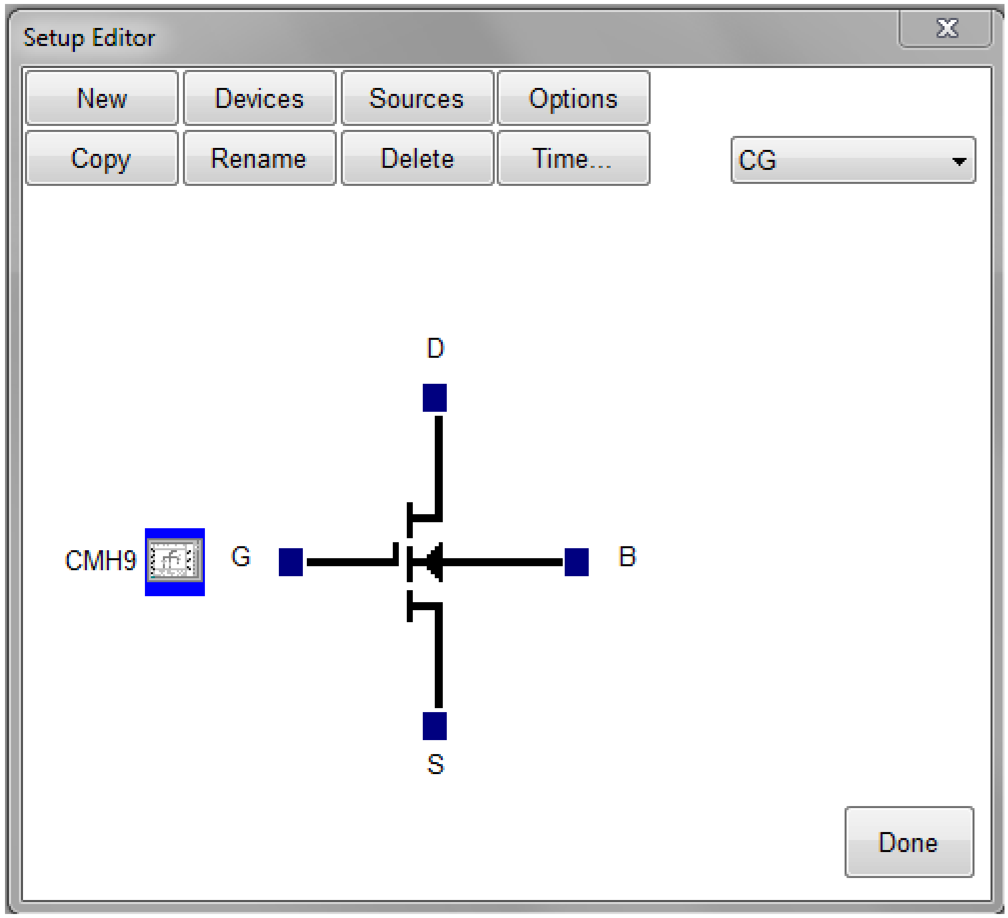


The Setup Editor should display a device schematic that is representative of the DUT (refer to the last step, if necessary). Connections are designated by first clicking the "CMHx" source listed in the Source Units dialogue box (where ‘x’ is the slot number that the MFCMU is inserted in. After the source is selected, click the blue pad next to one of the device schematic pins. An instrument icon, along with the name of the connected source, will appear above the device schematic pin as a means of indicating the connection.

How to Designate the Instrument/DUT Connections:

1. Select the Setup Editor SOURCES button. This will open the Source Units dialogue box.
2. The Source Units dialogue box will display two sources. One of the sources is designated "high" (ATB1500.CMH9).
3. Click on the "ATB1500.CMH9" designation.
4. Designate the intended orientation of the DUT in the HP16442A Test Fixture by clicking the blue pad next to the emitter.
5. The “low” CML is assumed to be connected to the K or Sub so there is no need to assign it to the blue pad. An instrument icon will appear for the CMH connection.

6. Close the Source Units dialogue box by clicking the "DONE" in the upper left-hand corner of the dialogue box.
7. If an incorrect DUT connection is mistakenly designated, un-designate the connection as described in *Chapter 2 of the ICS Reference Manual; Removing Instrument/DUT Connections.*



Step 4D: Specify the Setup Configuration of the Instrument

The measurement configuration of the B1500A is controlled from the ATB1500 Setup dialogue box. The B1500A Setup dialogue box is opened by clicking the instrument icon next to the "CMH" connection.

In this example, the B1500A will source a 0.025V 100kHz signal while applying a voltage sweep across the gate of a MOS transistor. The voltage bias will sweep from -0.0V to 1.0V and consist of 51 data points. Capacitance (Cg) and bias voltage (Vg) will be returned as data.

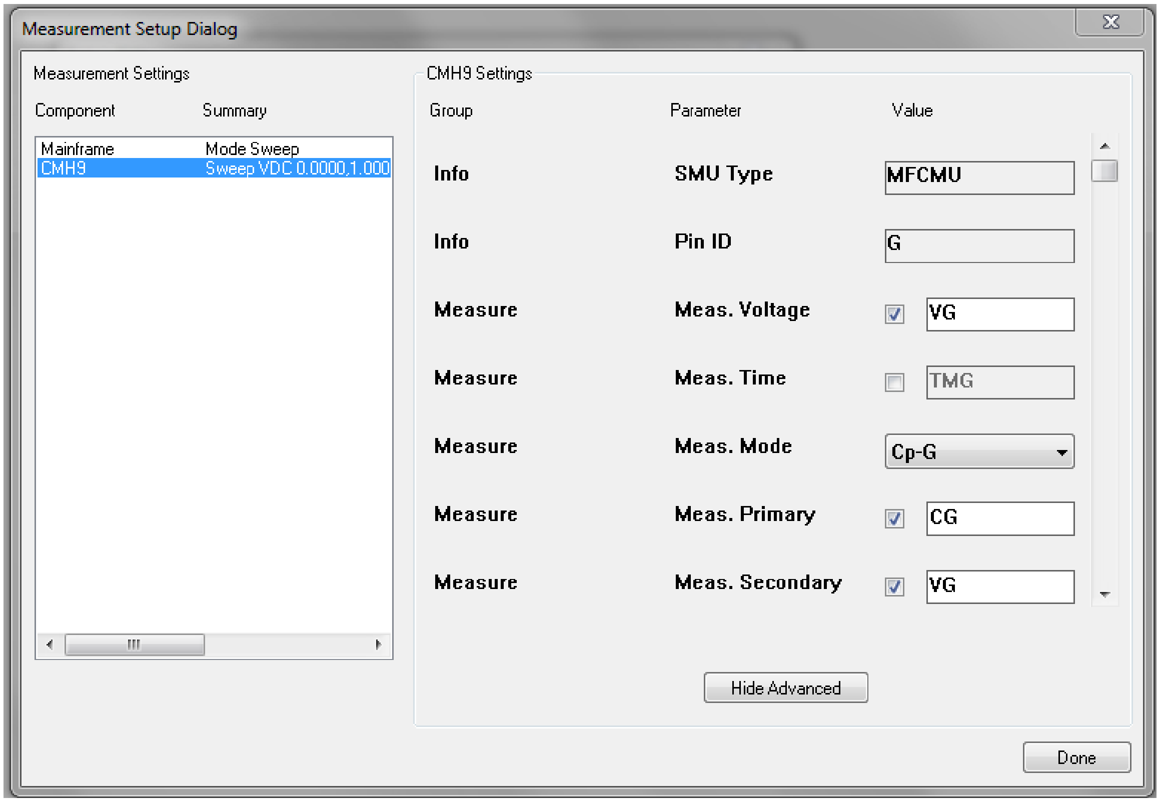


Figure 2: ATB1500 Setup Configuration for the C_g Test Setup

How to Specify the Instrument Setup Configuration:

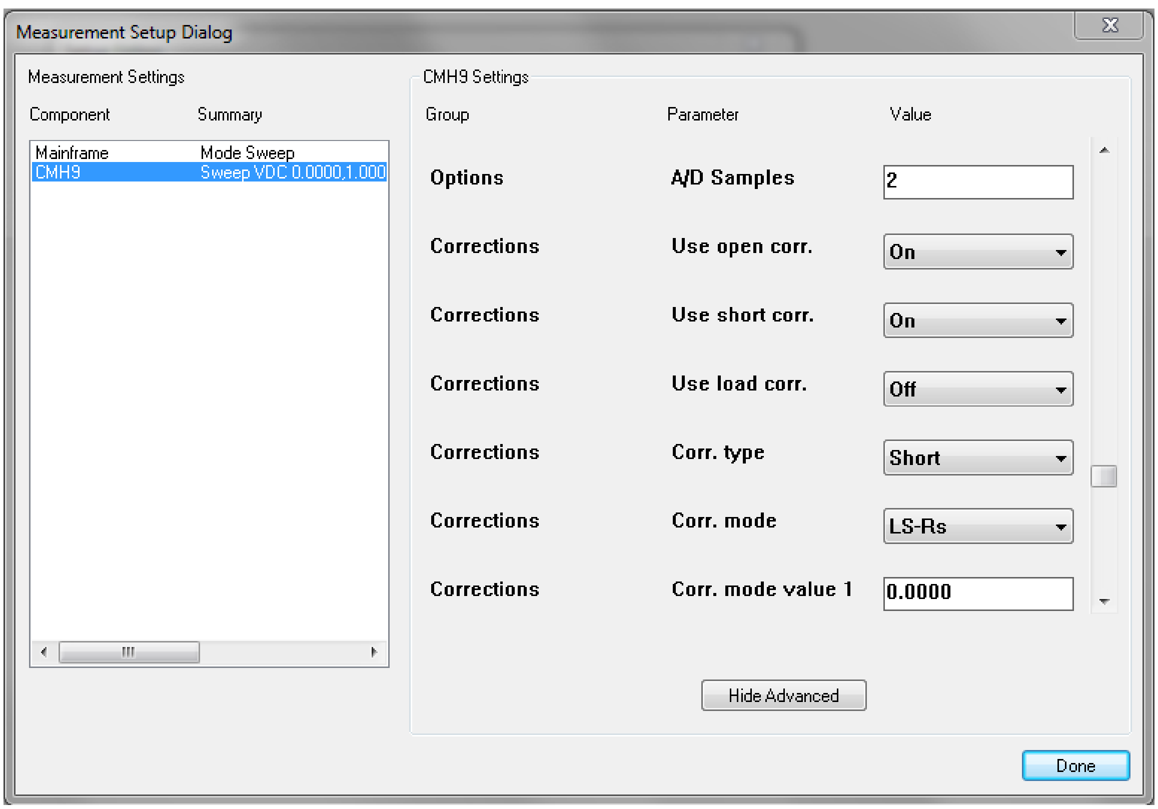
1. Click once on the "CMH" instrument icon to open the ATB1500 CMH Settings dialogue box.
2. Configure the controls as shown in Figure 2. Use the mouse or TAB key to move between the different switches and fields.
3. Click OK to close the ATB1500 Setup dialogue box.

Step 5: Calibrate the Instrument

The parasitic effects of the test fixture introduce device measurement inaccuracies. To eliminate this problem, the B1500 includes an Open and Short Correction function that compensates for the LCR characteristics inherent to the test fixture. The correction functions are controlled from the Calibration dialogue box. Calibrate the instrument as described below.

How to Calibrate the B1520A MFCMU:

1. Open the Setup Editor and create a measurement.
2. Calibrate dialogue box by clicking the Setup Editor CMHx in the Measurement Setup Dialog box. Click the **Show Advanced** button.
3. Make certain that no device is inserted in the test fixture. Click the "Corr. Type" button to set the OPEN Correction state. Click the Perform Correction "RUN" button in the last page for performing an Open measurement. The B1500 will perform the open correction.
4. After completing the Open Correction function, short the test fixture HIGH and LOW terminals. Click the "Corr. type" button to set the SHORT Correction type. Click the Perform Correction "RUN" button in the last page. The B1500 will perform the short correction.
5. Set the "Use open corr." and "Use short corr." to ON
6. The instrument is successfully calibrated. Remove the short between the test fixture HIGH and LOW terminals. Click the DONE button to restore control to the Setup Editor.



The procedure outlined above is a presentation of the minimal calibration requirements necessary for the C measurement specified in the example test setup. For a thorough discussion of the calibration functions, refer to *The B1500 MFCMU Calibration* later in this section.

Step 6: Insert the DUT into the Test Fixture

Insert the DUT into the test fixture sockets according to the DUT connections designated in the Setup Editor. For the C_g measurement described in this section, insert the device so that the Gate is connected to the HIGH terminals of the B1500. Connect the substrate to the LOW terminals.

Step 7: Execute the Measurement

Execute the test setup by clicking the toolbar MEASURE button. This will cause a window to open that contains the “Measurement Remote Control”. Click the single button to start the measurement.

Step 8: View the Results

Data is automatically written to the corresponding data window spreadsheet each time the measurement is executed. To display the numerical data, double-click on the white spreadsheet icon labeled Cgate at the bottom of the ICS desktop. The spreadsheet was created after the Cgate test setup name was specified in the Setup Editor, but it contained no data.

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 9: 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. If the data window spreadsheet is edited, the plot window is updated by clicking the REDRAW button at the top of the spreadsheet. 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 C_{ibo} with respect to the voltage sweep.

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. Clicking once on a data window spreadsheet icon will display a system menu. Ignore this display and proceed with Step 4.
3. Click the toolbar setup window arrow and select the desired setup from the displayed drop-down list.
4. Click the NEW PLOT toolbar button. This will open an empty plot window and the Plot Data dialogue box.
5. Designate the independent variable of the plot by double-clicking on the appropriate data vector listed in the Data window. Two quantities were measured in the C_{ibo} test setup: capacitance and voltage. There should be two data vectors in the dialogue box Data window: "CPA" and "Bias" (according to the data vector labels specified in Figure 2). This example will create a plot of capacitance with respect to the voltage sweep. Since voltage will be the independent variable, select "Bias" for the X-axis.
6. Designate a dependent variable by selecting “CPA” in the dialogue box for the Y1-axis.
7. Click the dialogue box APPLY button. This will create the plot but will not close the Plot Data dialogue box.
8. Click the Done button to close the Plot Data dialogue box.

Step 10: 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 of the ICS Gettting Started Guide; How ICS Stores Information*.

The B1500A Mainframe CV Modes

The ATB1500A driver allows the setup of the instrument into specific modes. These modes allow for easier setup of the test by removing options that are not applicable for a specific test method. This section of the manual describes the Mainframe Modes and the MFCMU setups allowed, respectively.

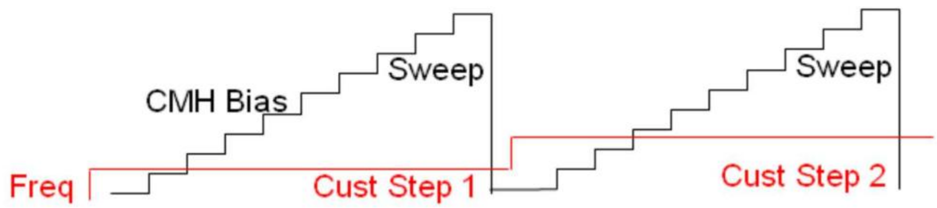
	MFCMH Bias/Freq/or Osc Mode			
		Const	**Sweep**	**Custom Step**
Mainframe Mode	Sweep Mode	*	*	*
	Spot Mode	*	*	*
	Custom Sweep Mode	*	*	*
	ICS Time Mode	*	*	*
	Sampling Mode	*	*	*
	Stress Mode	*	*	*

The B1500A instrument has several different sources that can be varied during a measurement. These sources are the Frequency, Oscillator Amplitude, and Bias.

- One source can be swept during a measurement.
- Other sources must be constant.

To create a "Family of Curves" use the Custom Step to change the values of the sources that are not being swept. A sample would be to perform a Bias sweep (CMH) at several different frequencies. To do this:

1. Set the Mainframe Mode to Sweep.
2. Set the CMH Bias sweep points.
3. Set the Oscillator Bias.
4. Set the Oscillator Frequency to Custom Step and select the series of frequencies.

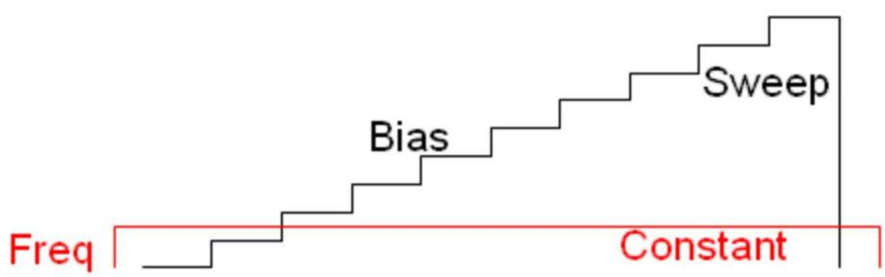


When the test is run, the following process will occur.

1. The first frequency will be programmed to the instrument along with the Oscillator Bias.
2. The CMH will then be swept through the list of biases.
3. The Oscillator will be set to the second frequency in the list.
4. The CMH will be swept through the same list of biases as in step 2.
5. The oscillator will be set to the next frequency and the process repeats.

Sweep Mainframe Mode

The Sweep Mainframe mode is the mode for most measurements that require the sweep of one of the device terminals. One of the CMU's values must be set in Sweep Mode and the remaining can be setup in Constant, or Custom Step Mode.

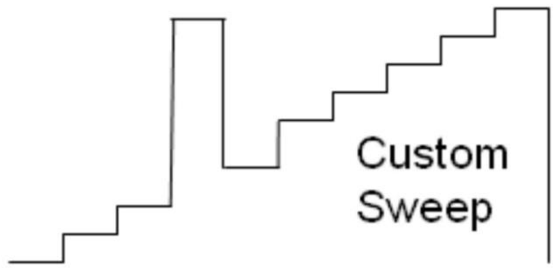


Spot Mainframe Mode

The Spot Mainframe mode is the mode for measurements that test only a single bias point of the device terminals. All of the MFCMU's values must be set in Constant Mode.

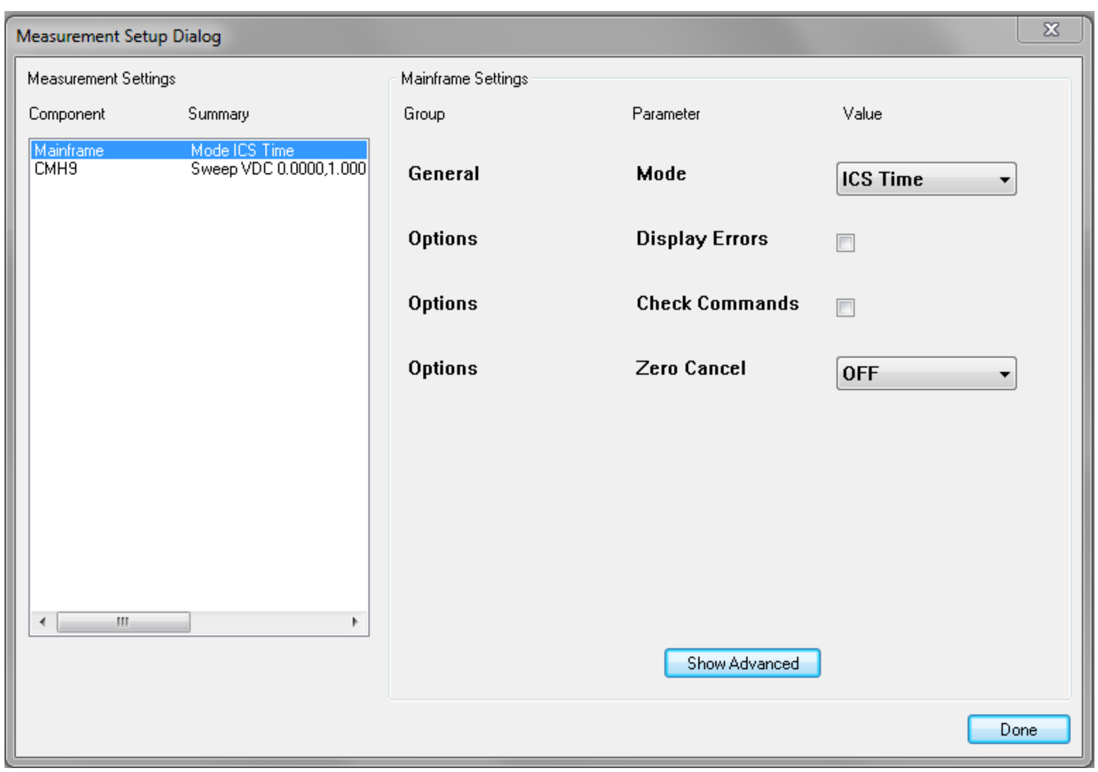
Custom Sweep Mainframe Mode

The Custom Sweep Mainframe mode is the mode for applying a sweep that is a non-standard set of points that cannot be simply defined as Start, Stop, and Number of Steps. One of the MFCMU's inputs must be set in Custom Sweep Mode and the remaining can be setup in Constant or Custom Step Mode.



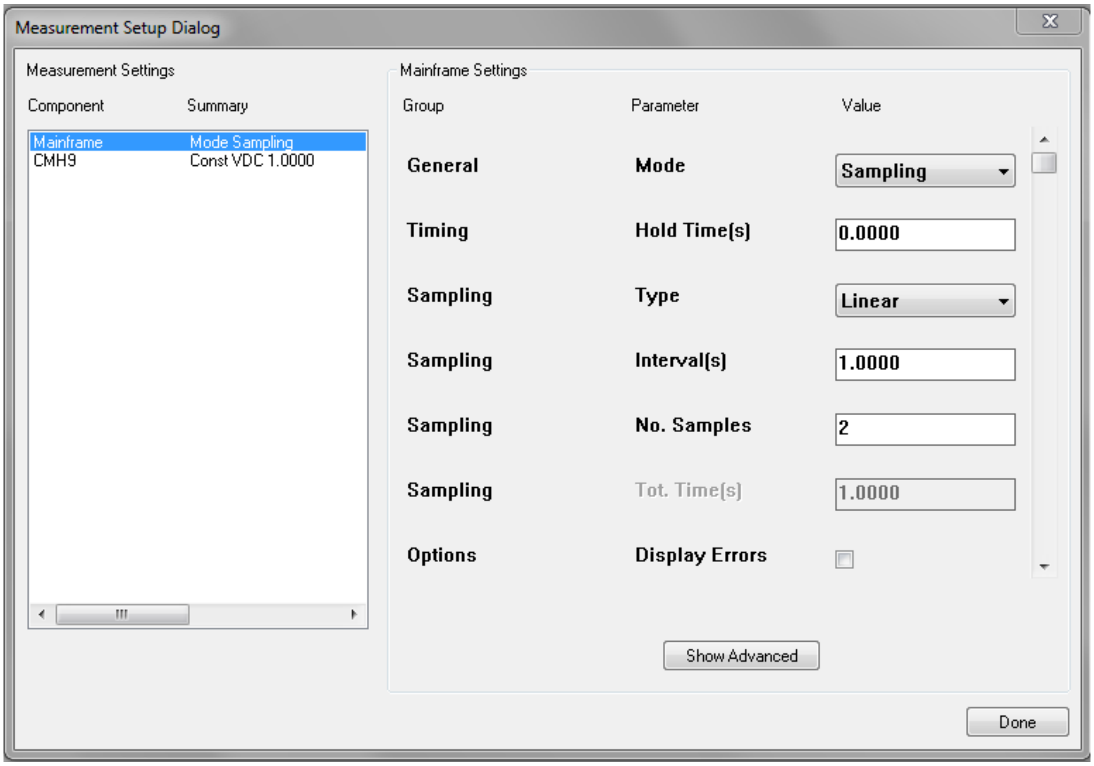
ICS Time Mainframe Mode

The ICS Time Mainframe mode allows the test setup to be created exactly like the older versions of ICS. **If you are not using an old project, use the Sampling Mode instead**. A constant bias is applied while the DUT is measured at specified time intervals. All of the MFCMU's inputs must be set in Const Mode.



Sampling Mainframe Mode

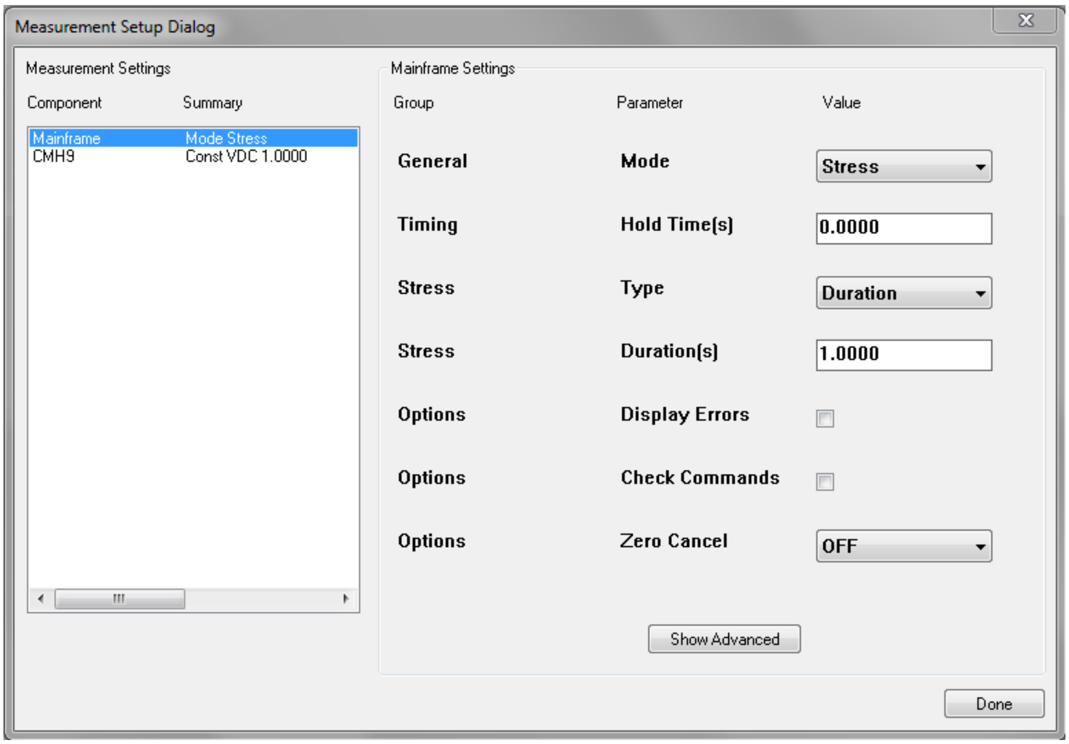
The Sampling Mainframe mode allows the test setup to use the external sampling capability of the instrument. The external sampling is a sampling mode for any instrument that the samples are triggered externally. A constant bias is applied while the DUT is measured at specified time intervals that are set in the "Timing" Mainframe Setting. All of the MFCMU's inputs must be set in Const Mode.



Stress Mainframe Mode

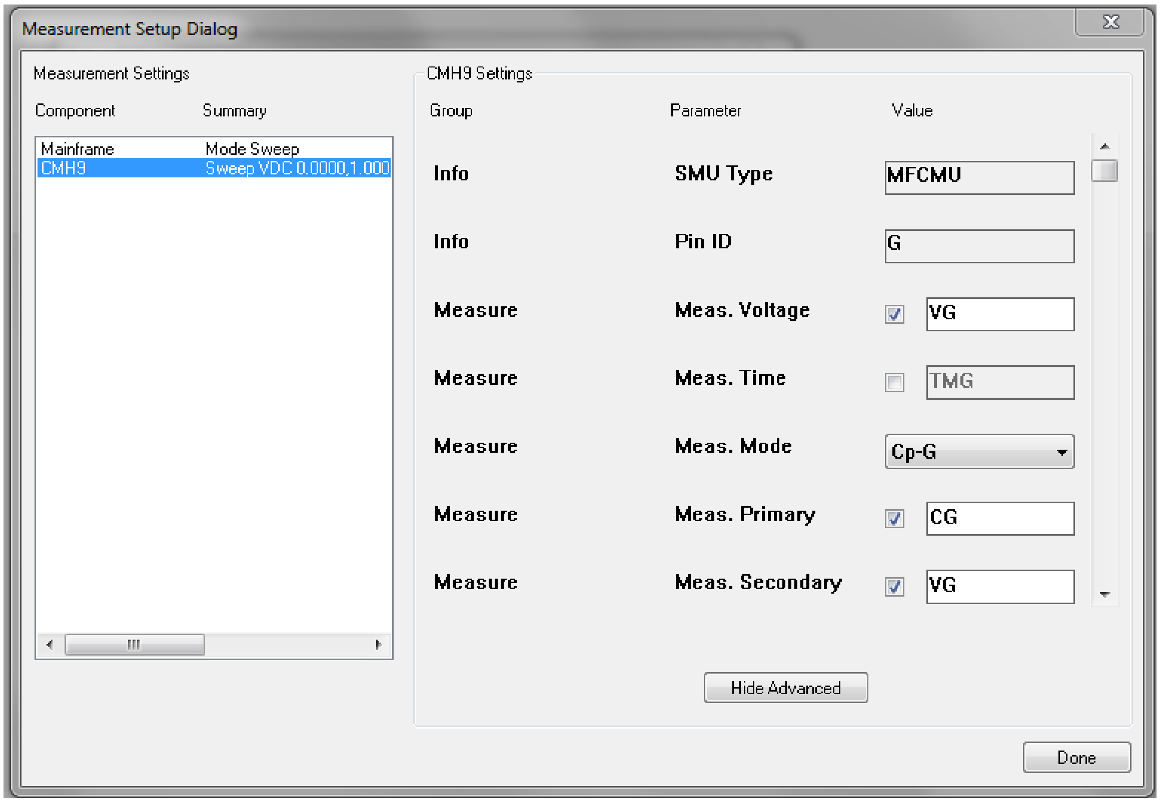
The Stress Mainframe mode allows the test setup to stress a device for a set period of time.

- The selected terminals are measured only at the beginning and end of the stress period.
- All of the CMU's inputs must be set in Const Mode.
- The length of the Stress time is set in the Duration field.



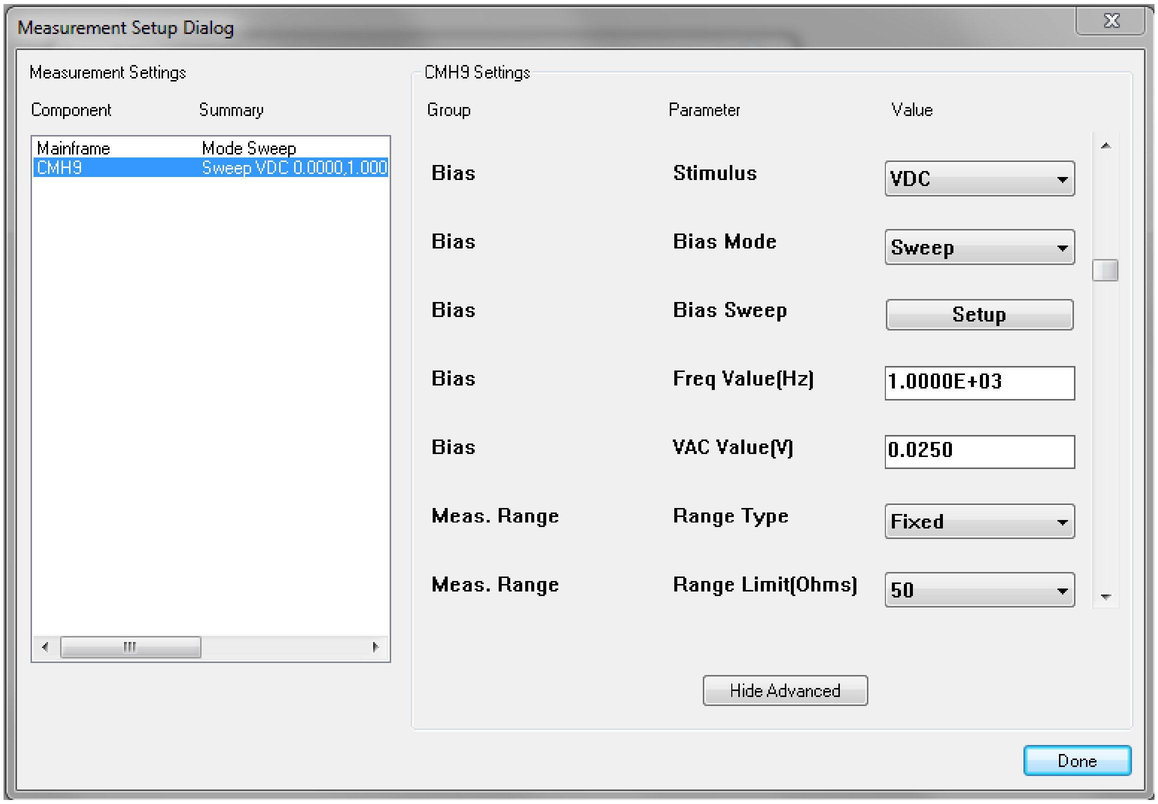
The Source Unit Setup Dialogue Box

The Source Unit Setup dialogue box is used to specify the source/measure configuration of each ATB1500 module.



The contents of CMH Measurement Setup dialogue box are outlined below:

1. **SMU Type Field:** This field displays the MFCMU designation for the corresponding ATB1500 module.
2. **Pin ID Field:** This field contains the name of the device pin it is attached to in the Setup Editor.
3. **Meas. Voltage Field:** This field enables the selection of voltage measurement and the measured data label
4. **Meas. Time Field:** This field enables the selection of time measurement and the measured data label
5. **Meas. Mode Field:** This field displays the selection of measurement LCRZ functions available.
6. **Meas. Primary Field:** This field allows the selection and naming of the first measured value from the instrument.
7. **Meas. Secondary Field:** This field allows the selection and naming of the second measured value from the instrument.



8. **Bias Stimulus Field:** This field allows the selection of the VDC bias, VAC Voltage or Frequency.
9. **Bias Mode Field:** This field allows the selection of the DC bias to be Constant or Swept.
10. **Bias Setup Field:** This field allows the setting a constant Bias value or a sweep setting of the Bias to be forced by the instrument.
11. **Freq Value Field:** This field allows the selection and naming of the frequency measured value from the instrument.
12. **Freq Value Field:** This field allows the selection and naming of the oscillator measured value from the instrument.
13. **Freq Mode Field:** This field allows the selection of the oscillator frequency to be Constant, Stepped, or Swept.
14. **Freq Value Field:** This field allows the setting of the oscillator frequency of the instrument.
15. **Range Type Field:** This field allows the selection of the measure range FIXED or AUTO
16. **Range Limit Field:** This field allows the selection of the impedance for FIXED range only from 50 ohms to 300K ohms.