



Agilent B1500A Semiconductor Device Analyzer

Self-paced Training Manual, 5



Agilent Technologies

Notices

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In This Manual

This document is the self-paced training manual to help you to understand what is Agilent B1500A, what functions the B1500A has, how to use the B1500A, and what applications the B1500A contributes to.

CAUTION

The test setup data described in this manual are only examples. If these example data damage your devices, Agilent is *NOT LIABLE* for the damage.

- Module 1. Introduction

This module explains the product concept and the key features of the B1500A/EasyEXPERT. You will learn about what is the B1500A.

- Module 2. Getting Started

This module explains the basic operations of the B1500A. You will learn about how to launch B1500A/EasyEXPERT and how to perform application test and quick test.

- Module 3. Data Display and Management

This module explains the data display and analysis capabilities of the EasyEXPERT software. You will learn how to use analysis tools, how to change display setup, and how to print/export test result data.

- Module 4. Classic Test Environment

This module explains the classic test mode of the EasyEXPERT. You will learn how to create the classic test setup in the course exercises.

- Module 5. Basic Measurement

This module explains the basic I-V sweep measurement function and the cabling and fixturing issues. You will learn how to measure I-V curves in the course exercises.

- Module 6. Low Current Measurement

This module explains the low current measurement technique. You will learn how to measure the low current in the course exercises.

- Module 7. Measurement Functions

This module explains the measurement functions available with the B1500A. You will learn how to use various measurement functions in the course exercises.

- Module 8. Capacitance Measurement

This module explains the capacitance measurement function. You will learn how to measure the capacitance in a course exercise.

- Module 9. Modifying Application Test Definitions

This module explains a modification example of an application test definition. You will learn how to modify the definition in a course exercise.

- Module 10. Creating Your Test Definitions

This module explains about the application test definition. You will learn how to create your application test definition in a course exercise.

- Module 11. Advanced Definitions and Operations

This module explains how to control external GPIB devices, how to call an execution file, how to perform a repeat measurement, and how to use the prober control script.

- Module 12. Miscellaneous Operations

This module explains what is the status indicator, what is the automatic data export function and the automatic data record function, how to perform selftest and calibration, how to perform SMU zero offset cancel, and such.

- Module 13. SPGU Control and Applications

This module explains the SPGU Control classic test. You will learn how to create the classic test setup and the applications using SPGU in the course exercises.

Class Exercises

Class exercises use the test setup listed below. The test setup data are only examples and included in the Demo.xpg file stored in the Manual CD-ROM.

Module	Exercise	Device	Test setup/definition/data	Page
Module 1	no exercise			
Module 2	Id-Vd measurement	MOSFET	CMOS: Id-Vd	2-19, 27
	Id-Vg, gm-Vg measurement	MOSFET	CMOS: Vth gmMax	2-19, 27
	B2200/E5250 switch control	-	-	2-32
Module 3	Id-Vg, gm-Vg measurement	MOSFET	GMMAX.xtr	3-28
	Using Preview window	-	-	3-31
Module 4	Id-Vd measurement	MOSFET	Trng Id-Vd	4-25
	Multi Channel I/V Sweep Measurement	Bipolar Tr LED	Trng Multi	4-37
	I/V List Sweep Measurement	MOSFET	Trng List	4-51
	I/V-t sampling measurement	0.1 μ F	Trng Sampling	4-64
	C-V sweep measurement	MOSFET	Trng CV	4-76
	B2200/E5250 switch control	-	Trng Switch	4-81
	Direct Control (C-f measurement)	0.1 μ F	Trng C-f	4-88
Module 5	Id-Vd measurement	MOSFET	IDVD, Id-Vd	5-7
	SMU series connection	511 kohm	IRVR	5-24
	SMU parallel connection	1 ohm	Parallel	5-28
	Re measurement, kelvin connection	Bipolar Tr	REKELV	5-38
Module 6	Leak current measurement	-	Zero-check	6-9
	Ultra low current measurement	-	Zero-check-ASU	6-19
	Id-Vg measurement	MOSFET	IDVG	6-20
	Gummel plot	Bipolar Tr	GUMMEL	6-25
Module 7	SMU pulse mode	MOSFET	IDVD-Pulse	7-8
	RC measurement	0.1 μ F and 511 kohm	RC-sampling-log	7-16
	Negative hold time	511 kohm	R-sampl-neg-hold	7-22
	Auto analysis	MOSFET	GMMAX	7-28
	Bias hold function	LED	LED	7-35
	SMU series resistor	511 kohm	IV-res	7-43

Module	Exercise	Device	Test setup/definition/data	Page
Module 8	C-V sweep measurement	MOSFET	CV-1MHz	8-6
Module 9	Modifying application test definition	MOSFET	Trng IdVd Vth.xtd	9-14
			Trng idvd idvg2.xtd	9-32
			Trng idvd idvg3.xtd	9-35
	Using vector data	MOSFET	Trng Cgg-Vg	9-41
Module 10	Creating application test definition	MOSFET	Trng idvd idvg.xtd	10-17
Module 11	no exercise			
Module 12	no exercise			
Module 13	Charge pumping	MOSFET	Charge Pumping 4T 0.1V step	13-20
	Flash memory	MOSFET	Demo-S-NorFlash Endurance	13-29
	ALWG output	511 kohm	ALWG monitor	13-36

NOTE
Demo.xpg file

Demo.xpg file is required to create the Demo preset group which contains the test setup data used by the class exercises. And it is stored in the \data folder on the Agilent B1500A Manual CD-ROM, Edition 4 or later.

The Demo preset group should be created before starting the class exercise. To create the preset group, launch EasyEXPERT and import the file by using the Preset Group Import dialog box opened by clicking My Favorite Setup > Preset Group > Import Preset Group. The test setup data are only examples for the class exercises.

NOTE
.xtd files

The \data folder on the Manual CD-ROM stores some .xtd files. They are the application test definitions used by some class exercises. To use the definition file, import the file by using the Test Definition Import dialog box opened by clicking Library > Import Test Definition. The test definition data are only examples for the class exercises.

NOTE
.xtr files

The \data folder on the Manual CD-ROM stores some .xtr files. They are the sample test results created by executing the test setup which has the same name as the result data. To display these sample test results, import the files by using the Test Result Import dialog box opened by clicking Results > Transport Data > Import.

Test Setup for Class Exercises

The Demo preset group contains the following test setup. The setup data are only examples for the class exercises. The following table lists the test setup name in alphabetical order.

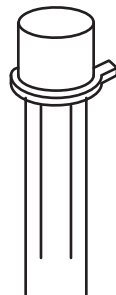
Test Setup Name	Description
ALWG monitor	511 kohm sampling measurement with SPGU ALWG output
Charge Pumping 4T 0.1V step	MOSFET Icp-Vbase measurement
CV-1MHz	MOSFET Cgs-Vg measurement
Demo-S-NorFlash Endurance	MOSFET Endurance test
Fowler-Nordheim	Fowler-Nordheim (FN) plot
GMMAX	MOSFET sqrt_Id-Vg, PEAK-Vg measurement
GUMMEL	Bipolar transistor gummel plot
IDVD	MOSFET Id-Vd measurement
IDVD-Pulse	MOSFET pulsed Id-Vd measurement
Id-Vd	MOSFET Id-Vd measurement, Application Test
IDVG	MOSFET Id-Vg measurement
IRVR	511 kohm I-V measurement
IV-res	511 kohm I-V measurement with SMU series resistor
LED	LED I-V measurement
Parallel	1 ohm I-V measurement, voltage force and current measurement
PG monitor	511 kohm sampling measurement with SPGU VPULSE output
RC-sampling-log	RC sampling measurement, log sampling
REKELV	Bipolar transistor Re measurement
R-sampl-neg-hold	511 kohm sampling measurement with negative hold time
Subthreshold	MOSFET subthreshold measurement
Trng C-f	Direct Control (C-f measurement)
Trng Cgg-Vg	Modifying application test definition using vector data
Trng CV	MOSFET C-V measurement
Trng Id-Vd	MOSFET Id-Vd measurement

Test Setup Name	Description
Trng List	MOSFET Vth-gmmax measurement using I/V List Sweep
Trng Multi	Multi Channel I/V Sweep (Bipolar transistor and LED)
Trng Sampling	0.1 μ F sampling measurement
Trng Switch	B2200/E5250 switch setup, Input 1-3-5-7 to Output 1-3-5-7
Zero-check	SMU open measurement
Zero-check-ASU	SMU open measurement with ASU

Required Devices for Class Exercises

To perform the class exercises, you need the device set (Agilent part number 04156-87001) which contains the following devices.

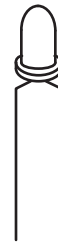
Description	Quantity
N-channel MOSFET	2 ea.
NPN Bipolar Transistor	1 ea.
Red Miniature LED	1 ea.
0.1 μ F Capacitor 50 V	1 ea.
1.0 Ω Resistor 1/8 W	1 ea.
1.1 k Ω Resistor 1/8 W	1 ea.
511 k Ω Resistor 1/8 W	1 ea.



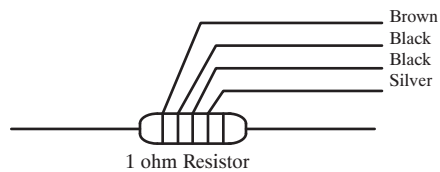
N-ch MOSFET



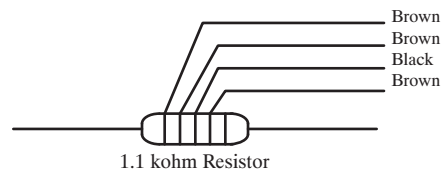
NPN bipolar Transistor



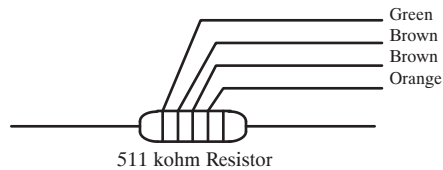
LED



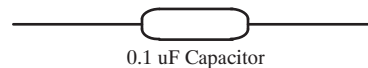
1 ohm Resistor



1.1 kohm Resistor



511 kohm Resistor



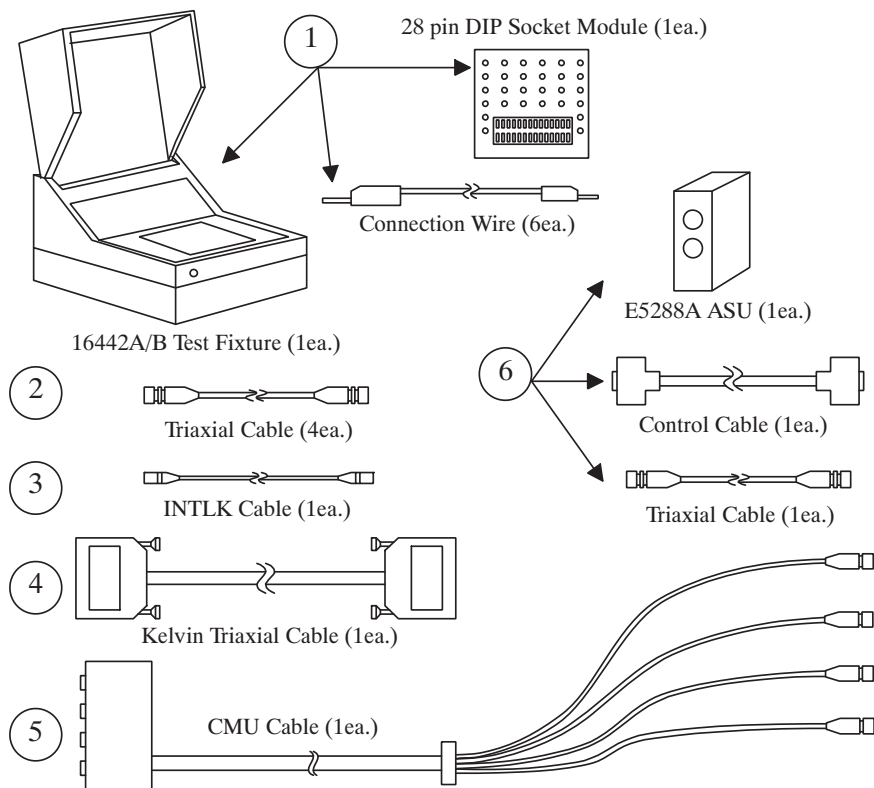
0.1 uF Capacitor

Required Accessories for Class Exercises

To perform the class exercises, you need the following accessories. Prepare the accessories shown below.

Designation	Description	Model No.	Qty.
1	Test Fixture	16442A/B ^a	1 ea.
	28 pin socket module		1 ea.
	Connection wire		6 ea.
2	Triaxial Cable	16494A	4 ea.
3	Interlock Cable	16493J	1 ea.
4	Kelvin Triaxial Cable, for Module 5	16493K	1 ea.
5	CMU Cable, for Module 8	N1300A	1 ea.
6	Atto Sense/Switch Unit, for Module 6	E5288A	1 ea.
	ASU control cable, triax cable, for Module 6	16493M	1 ea.

- a. The 16058A Test Fixture for the 4145A/B may be substituted for the 16442A/B Test Fixture. If you use the 16058A, you also need the 16435A Interlock Adapter.



To perform the flash memory class exercise in Module 13 and if you use the ASU, you need the following accessories.

Description	Model No.	Qty.
ASU (Atto Sense/Switch Unit) with control cable	E5288A	Total 3sets
Triaxial Cable	16494A or equivalent	Total 7ea.
BNC-SMA Cable	16493P	3 ea.
SMA-SMA Cable, for synchronization of SPGU	16493Q	2 ea.

To perform the flash memory class exercise in Module 13 and if you use the selector, you need the following accessories.

Description	Model No.	Qty.
SMU/PG selector with control cable ^a	16440A	2 sets
Selector adapter with control cable	16445A	1 set
Triaxial Cable	16494A or equivalent	Total 7ea.
BNC-SMA Cable	16493P	3 ea.
SMA-SMA Cable, for synchronization of SPGU	16493Q	2 ea.

- a. One selector can be replaced with one ASU.

Module 1. Introduction

- **New Features**
- **EasyEXPERT**
- **To Perform Easy Application Test**
- **User Interface**
- **Modular Mainframe**
- **SCUU/GSWU**
- **ASU**
- **SMU/Pulse Generator Selector**
- **B2200/E5250 Switch Control**
- **Desktop EasyEXPERT**

Module 2. Getting Started

- **To Turn on/off B1500A**
- **To Launch EasyEXPERT**
- **To Specify/Create Workspace**
- **To Perform Application Test**
- **To Save/Recall Your Test Setup**
- **To Export/Import Your Preset Group**
- **To Export/Import Test Record**
- **To Perform Quick Test**
- **To Control Switching Matrix**
- **To Manage Data Display Window**

Module 3. Data Display and Management

- **Data Display window**
- **Graph Analysis Tools**
- **Data Status**
- **To Change Graph/List/Display Setup**
- **To See Print Preview**
- **To Print Display Data**
- **To Copy Graph Plot/List Data**
- **To Save Analysis Result**
- **To Use Preview Window**

Module 4. Classic Test Environment

- **Classic Test Execution Mode**
- **I/V Sweep Measurement**
- **Multi Channel I/V Sweep Measurement**
- **I/V List Sweep Measurement**
- **I/V-t Sampling Measurement**
- **C-V Sweep Measurement**
- **Switching Matrix Control**
- **Direct Control**

Module 5. Basic Measurement

- **SMU Fundamentals**
- **Classic Test Environment**
- **SMUs Connected in Series or Parallel**
- **Cabling and Fixture Issues**
- **Kelvin and Driven Guard**
- **Probes and Prober Connections**
- **Triax and Coax Adapters**
- **Safety Interlock Issues**

Module 6. Low Current Measurement

- **Low-Current Measurement Challenges**
- **Calibration and Zero Cancel**
- **Effect of Cable Movement**
- **ASU for Ultra Low-Current Measurement**
- **Low-Current Subthreshold**
- **Trade-Off Speed Vs Accuracy**
- **Low-Current Gummel Plot**
- **Low-Current Gate Oxide Leakage**

Module 7. Measurement Functions

- **SMU Pulsed Sweep Measurement**
- **I/V-t Sampling Measurement**
- **Negative Hold Time for High Speed Sampling**
- **Auto Analysis**
- **SMU Filter**
- **SMU Series Resistor**
- **Standby Function**
- **Bias Hold Function**

Module 8. Capacitance Measurement

- **CMU Fundamentals**
- **Classic Test Environment**
- **CMU Calibration**
- **SCUU for IV/CV Switching**
- **GSWU for Accurate Capacitance Measurement**
- **ASU for IV/CV Switching**

Module 9. Modifying Application Test Definitions

- **To Open Application Test Definition**
- **To Modify Test Definition**
- **To Use Debug Tools**
- **To Use Built-in Functions**
- **To Add Data Display**
- **To Use Auto Analysis**
- **To Use Test Setup Internal Variables**

Module 10. Creating Your Test Definitions

- **What is Test Definition**
- **What is Test Contents**
- **To Open Test Definition Editor**
- **To Define Test Specification**
- **To Define Test Contents**
- **Available Elements**
- **Available Variables**
- **To Define Test Output**

Module 11. Advanced Definitions and Operations

- **To Control External GPIB Devices**
- **To Call Execution Files**
- **To Perform Repeat Measurements**
- **Prober Control Script**

Module 12. Miscellaneous Operations

- **Function Status Indicator**
- **Run Option**
- **Automatic Data Export and Data Record**
- **Calibration**
- **Configuration**
- **XSLT Samples**
- **To Enable System Controller**
- **To Start Desktop EasyEXPERT**
- **To Use 415x Setup File Converter**

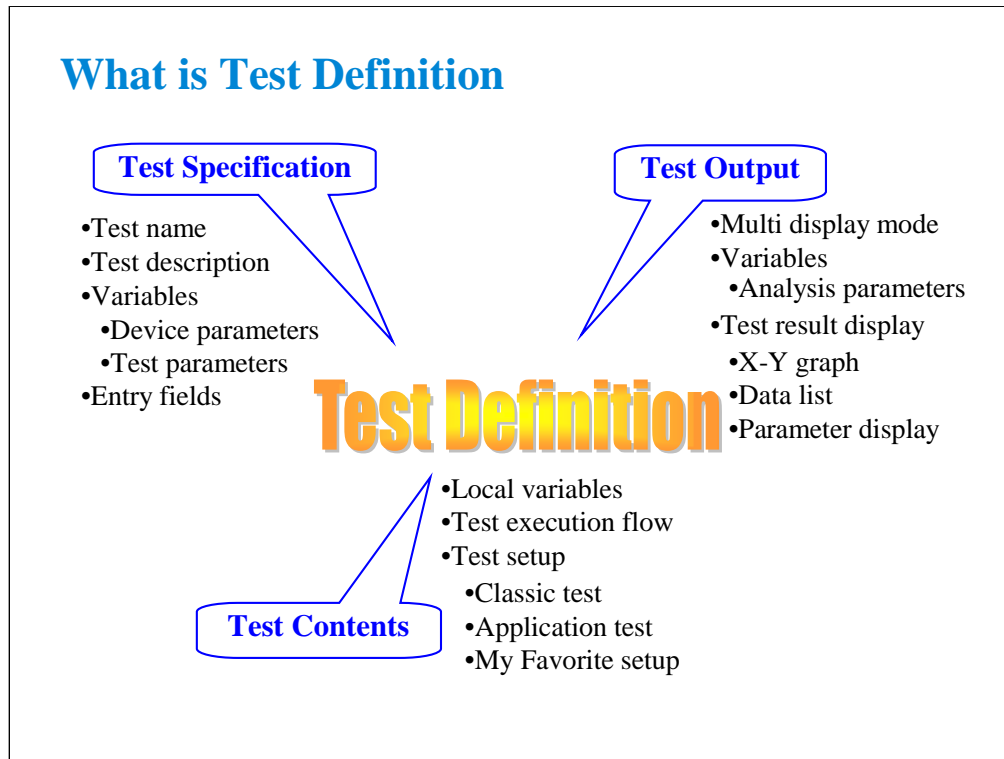
Module 13. SPGU Control and Applications

- **High Voltage SPGU**
- **SPGU Control**
- **Pulse Generator Mode**
- **Charge Pumping**
- **Flash Memory Test**
- **ALWG Mode**

In This Module

- **What is Test Definition**
- **What is Test Contents**
- **To Open Test Definition Editor**
- **To Define Test Specification**
- **To Define Test Contents**
- **Available Elements**
- **Available Variables**
- **To Define Test Output**

This section explains how to create your test definition. You will perform the above tasks to create the definition.



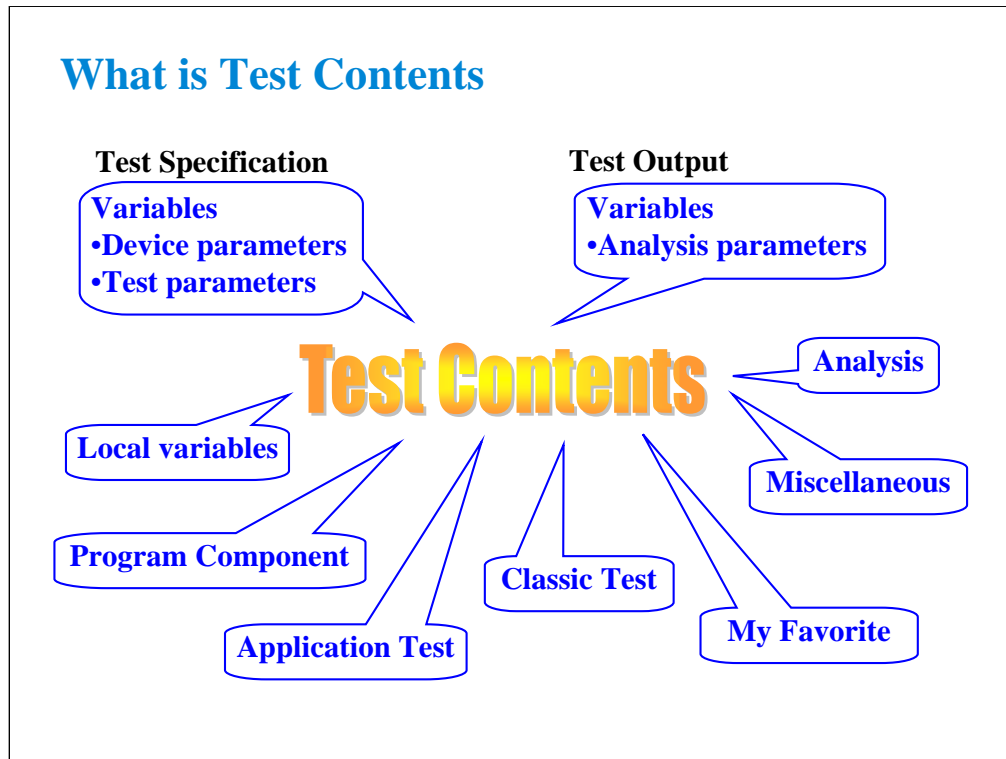
Test definition consists of test specification, test contents, and test output setup. The test specification contains test name, description, device parameters, and test parameters. The parameters will be the variables used to pass the test conditions to the test execution flow or test setup defined in the test contents. Especially for the test parameters, you can specify the position of entry field for each parameter. You can see the entry fields when the main screen displays this application test setup. The test contents are the core of the test definition. You will define the local variables, test execution flow, and test setup. You can define the test setup by selecting application tests, classic tests, or my favorite setup, and entering the test conditions.

The test output setup is optional. If you have the following requirements, declare the analysis parameters and define the display parameters on the Test Output tab screen.

- To send the test data to the subsequent tests
- To make the program branching depends on the test data
- To display/record the calculation result using the test data
- To display/record the test data of this application test
- To change the multi display mode of this application test

Note: You can use the device parameters, test parameters, and analysis parameters in the test execution flow (program flow) of the test contents without declaration of local variables.

Note: If the multi display mode is Disabled, the all test result data will be displayed on the singular Data Display window. If the multi display mode is Enabled, the test result data of the same test setup name will be displayed on the exclusive Data Display window and the test result data of the different test setup name will be displayed on the new Data Display window.

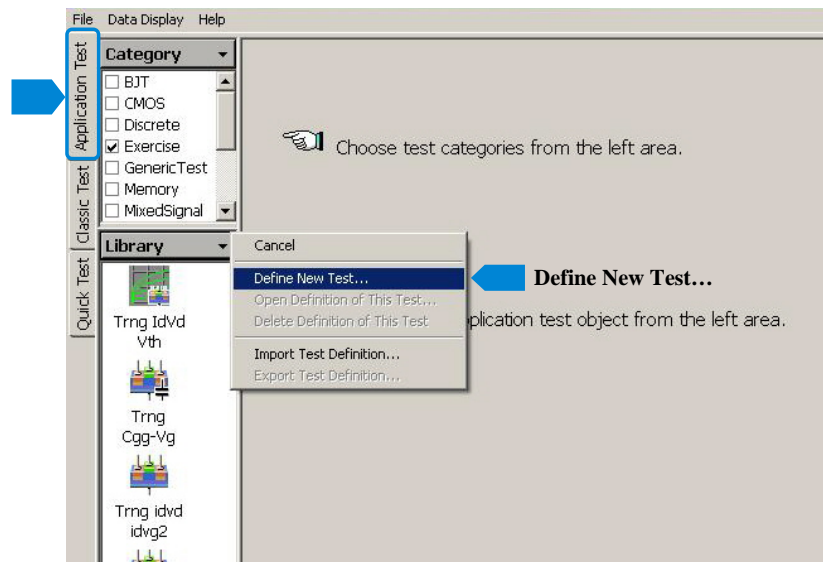


Test contents are the test execution flow (program flow), and is the core of the test definition. In the test contents, the following elements can be defined.

- Local variables
- Program components
- Application tests
- Classic tests
- My Favorite setup
- Analysis components
- Miscellaneous components
- Device parameters defined in the test specification
- Test parameters defined in the test specification
- Analysis parameters defined in the test output

The program is executed from top to bottom in the test execution program list.

To Open Test Definition Editor



To start test definition, open the test definition editor.

Select the Application Test tab, click the Library button, and select the Define New Test... function.
The test definition editor will be opened. See next slide.

To Define Test Specification

Test Information

Category: [] Description: Description of this test.

Test Name: [Untitled]

Icon: [] Browse... Clear

Set test information

Device Parameters Definition

Name	Default	Description
To add a device parameter, press the [Add] button in this area.		

Define device parameters

Properties

Set properties of parameter

Test Parameters Definition

Background: [] Browse... Clear Layout... Add Delete Up Down

Name	Type	Default	Description	Align	X	Y	Width	Ext
To add a test parameter, press the [Add] button in this area.								

The test definition editor provides three tabs, Test Specification, Test Contents, and Test Output. At first define the test specification. Click the Test Specification tab.

In the Test Information area:

- Click the right button in the Category field to specify the category the new test definition belongs.
- Enter the Test Name.
- Select the Icon that will be displayed on the list area below the Library button of the main screen. It is the image file used to select the test definition. See previous slide.
- Enter the Description of the test.

In the Device Parameters Definition area:

- Click Add button to display the entry fields for the parameter.
- Set the Name, Default value, and Description for the parameter. When you add a parameter, you will see the entry fields at the Properties area. The area shows you the properties (minimum value, maximum value, number of effective digits, resolution, and unit) for the device parameter or the test parameter specified by the radio button put on the left of the parameter name.

For the Typical Values... button and the Symbols... button, see online help or User's Guide.

To Define Test Specification

The screenshot shows a software interface for defining test specifications. It includes a menu bar (File, Help), tabs (Test Specification, Test Contents, Test Output), and several functional areas. The 'Test Information' section at the top allows for setting the category, name, and icon of the test. The 'Device Parameters Definition' section features a table with columns for Name, Default, and Description, and buttons for adding, deleting, and ordering parameters. The 'Test Parameters Definition' section at the bottom has a table with columns for Name, Type, Default, Description, Align, X, Y, Width, and Ext, with buttons for browsing, clearing, layout, and adding parameters. A 'Properties' panel on the right is used for setting specific properties for a selected parameter. Two blue boxes with text labels highlight the 'Test Parameters Definition' table and the 'Properties' panel.

In the Test Parameters Definition area:

- Select the Background that will be displayed on the application test setup area of the main screen. Usually it is the image that shows the device connections.
- Set the Name, data type, Default value, and Description for the parameter. When you add a parameter, you will see the entry fields at the Properties area. The area shows you the properties (minimum value, maximum value, number of effective digits, resolution, and unit) for the device parameter or the test parameter specified by the radio button put on the left of the parameter name.
- Set the X, Y, and Width values to specify the position of entry field displayed on the application test setup area.
- Check the Align box to set the X origin of entry field to the left edge of the entry field. Uncheck this box to set it to the left edge of the parameter name placed left next to the entry field.
- Check the Ext box. The entry field will be put on the Extended Test Parameters dialog box that is displayed by clicking the Extended Setup button on the application test setup area of the main screen.

Setup example

Test Information

Category: Exercise
Test Name: Trng idvd idvg
Icon: C:\Program Files\Agilent\B1500\EasyExpert\Gr...
Description: This algorithm performs Id-Vd measurement and Id-Vg measurement, and then returns Vth value.

Device Parameters Definition

Name	Default	Description
Hold	0 s	hold time
Delay	0 s	Delay time

Test Parameters Definition

Background: C:\Program Files\Agilent\B1500\EasyExpert\Gr...
Layout... Add Delete Up Down

Name	Type	Default	Description	Align	X	Y	Width	Ext
Drain	Module	SMU43-R	SMU for drain		570	120	80	
Gate	Module	SMU33-R	SMU for gate		110	120	80	
Source	Module	SMU23-R	SMU for source		200	310	80	
Subs	Module	SMU13-P	SMU for subs		500	310	80	
IdVd_V2start	Numeric	1.000 V	IdVd gate start voltage		110	10	80	
IdVd_V2step	Numeric	500 mV	IdVd gate step voltage		110	40	80	
IdVg_V2start	Numeric	1A	IdVg drain start voltage		110	170	80	

This example sets:

Category: Exercise (This category may be created by the class exercise in Module 9)

Test Name: Trng idvd idvg

Icon: MOSFET.bmp

Device parameters:

Hold and Delay

Background: Vth_Const_Id.PNG

Test parameters:

Drain, Gate, Source, Subs, Idcomp, Igcomp

IdVd_V1start, IdVd_V1step, IdVd_V1stop, IdVd_V2start, IdVd_V2step, IdVd_V2nop

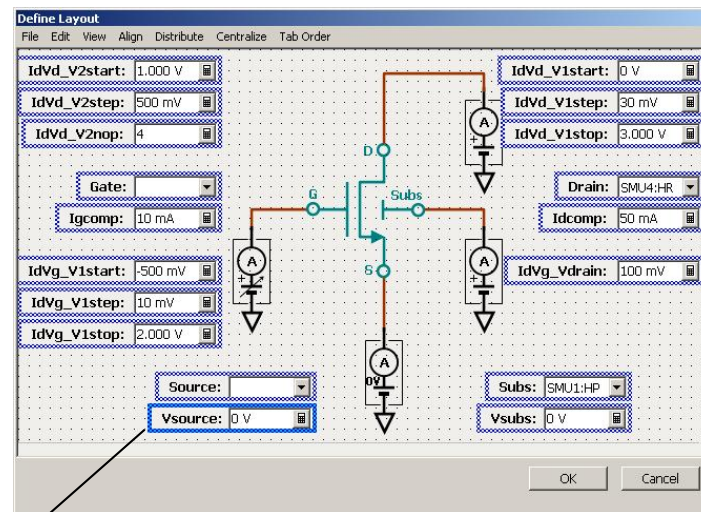
IdVg_V1start, IdVg_V1stop, IdVg_V1step, IdVg_Vdrain

Vsource, Vsubs

Entry field properties: 80 (width) x 30 (distance in vertical direction)

Press the Layout... button to open the Define Layout dialog box.

Setup example - Layout



Primary Entry Field

The Define Layout dialog box is used to define the layout of the test parameter entry fields displayed on the application test setup screen.

The following methods are available for selecting the entry fields.

- Click on the entry field. Multiple entry fields can be selected by clicking on the entry field while holding down the Ctrl key on the keyboard.
- Drag the mouse to draw a rectangle around multiple entry fields.
- Select Select All from the EDIT menu to select all entry fields.

The selected entry fields are outlined by the blue rectangles. The primary entry field, which is the base for layout operations, is surrounded by a highlighted blue rectangle. Only one primary entry field can be selected. To change the primary entry field, click on a selected entry field. The entry field is always that was most recently clicked will be the primary entry field.

The following methods are available for releasing (unselecting) the selected entry fields.

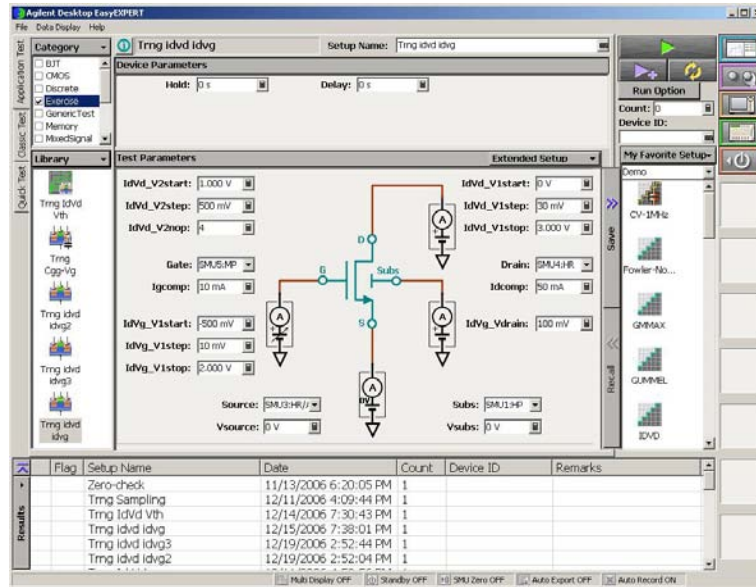
- Click the selected entry field while holding down the Shift key on the keyboard.
- Click outside of the selected entry fields to release all selected entry fields.

The following methods are available for defining the layout of the selected entry fields.

- Drag & drop with the mouse to move the selected entry field(s).
- Change the X/Y values in the property window to move the selected entry field(s).
- Press the arrow keys on the keyboard to move the selected entry field(s).
- Use the functions in the Align menu to align the selected entry field(s) to the primary entry field.
- Use the functions in the Distribute menu to evenly distribute the selected entry fields horizontally or vertically.
- Use the functions in the Centralize menu to move the horizontal or vertical center of all selected entry fields to the horizontal or vertical center of the entry field area.

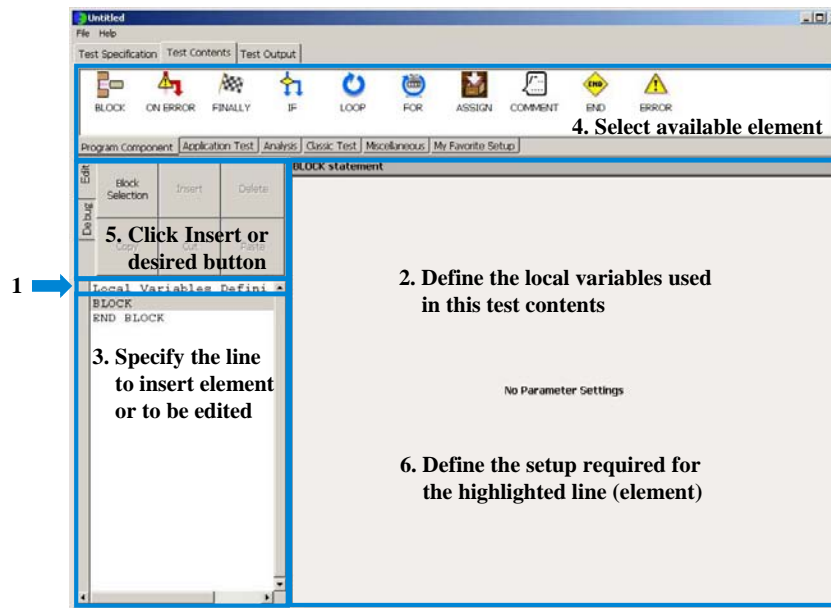
For more information, see online help or User's Guide.

Result example



This is a result example of the test specification setup shown in the previous pages.

To Define Test Contents



Starting to define the test contents:

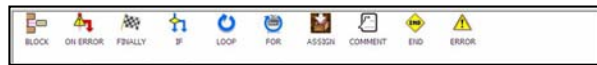
1. Highlight the Local Variables Definition line.
2. Define the local variables used in this test contents (test execution flow).
3. Highlight the line that an element has to be inserted.
4. Highlight an element of Program Component, Application Test, Analysis, Classic Test, Miscellaneous, or My Favorite Setup tab menu.
5. Click the Insert button of the Edit tab menu. The element will be inserted between the highlighted line and the next line.
6. Define the required setup.

To edit the test contents:

1. Optional. Highlight the Local Variables Definition line.
2. Optional. Define the local variables used in this test contents (test execution flow).
3. Highlight the line to be edited.
4. Highlight an additional element if you need.
5. Click the desired button if you need.
6. Define the required setup if you need.

Repeat this to create the test contents (test execution flow).

Available elements



Program Component



Application Test



Analysis



Classic Test



Miscellaneous



My Favorite

Available elements are shown above. The Program Component provides the typical program statements such as IF, LOOP, FOR, and so on. They are used to control the test execution flow. The Application Test, Classic Test, and My Favorite are used to define the test setup/test condition. The Analysis provides the elements used to control auto analysis function and data display. And the Miscellaneous provides other useful elements. For details of elements, see online help or user's guide.

Available variables

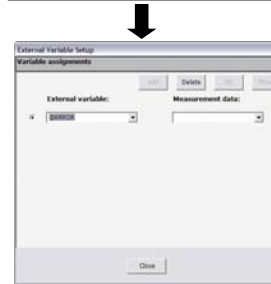
Test Contents
•Local variables

Test Specification
•Device parameters
•Test parameters

Test Output
•Analysis parameters

Do not set the same name for variables and parameters. The name must be unique.

Assign to external variables...



You can connect the variables in test setup with

- Local variables
- Device parameters
- Test parameters
- Analysis parameters

In the test execution flow (program flow), you can use the following variables.

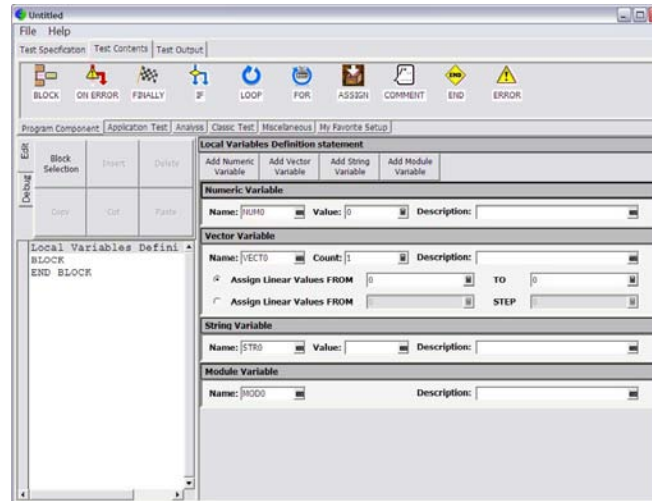
- Variables defined by the Local Variables Definition component
- Device parameters defined in the Test Specification
- Test parameters defined in the Test Specification
- Analysis parameters defined in the Test Output

You may want to read the parameters/variables used in Classic Test setup or Application Test setup defined in the Test Contents. Then use the External Variables Setup dialog box or built-in functions. They can connect the test setup internal variables/parameters to the external variables listed above. For the example variable connections, see “To Use Test Setup Internal Variables” in Module 9.

Note: Application test internal parameter/variable to be connected to an external variable must be the analysis parameter in its test definition.

Defining local variables

Local Variables Definition



Add Numeric Variable button displays the Numeric Variable area that provides the following fields.

- Name: Numeric variable name
- Value: Initial value of the variable
- Description: Additional information for the variable

Add Vector Variable button displays the Vector Variable area that provides the following fields.

- Name: Vector variable name. Two dimensional array.
- Count: Number of elements, or array size
- Description: Additional information for the variable

This area also provides the following radio button used to specify how to set the initial value of the array data automatically.

- Assign Linear Values FROM [value of first element] TO [value of last element]

If $Count > 1$, this sets $first\ value + (N-1) \times (last\ value - first\ value) / (Count - 1)$ to the N -th element. If $Count = 1$, this sets $first\ value (= last\ value)$ to the element.

- Assign Linear Values FROM [value of first element] STEP [step value]

This sets $first\ value + (N-1) \times step$ to the N -th element.

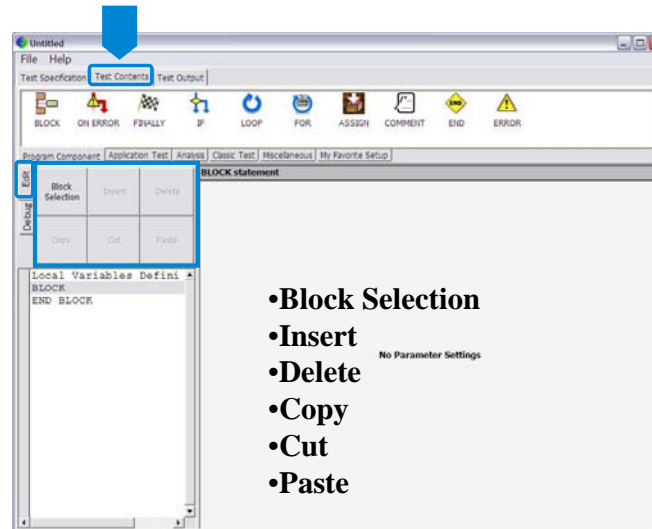
Add String Variable button displays the String Variable area that provides the following fields.

- Name: String variable name
- Value: Initial value of the variable
- Description: Additional information for the variable

Add Module Variable button displays the Module Variable area that provides the following fields.

- Name: Module variable name
- Description: Additional information for the variable

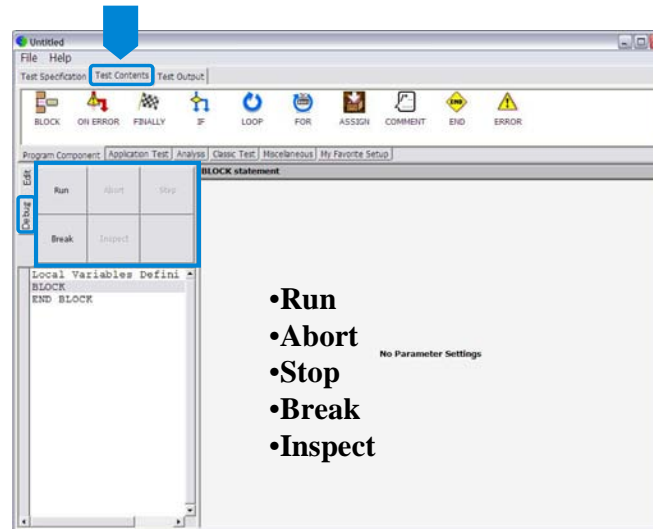
Editing test contents



The Edit tab provides the following buttons:

- Block Selection/Line Selection toggle button selects the edit target selection mode. In the line selection mode, clicking line just selects the line. In the block selection mode, clicking line selects the block the line belongs to.
- Insert button inserts the specified element between the highlighted line and the next line.
- Delete button deletes the highlighted line.
- Copy button copies the highlighted line to the clipboard.
- Cut button moves the highlighted line to the clipboard.
- Paste button inserts the line in the clipboard between the highlighted line and the next line.

Debug menu



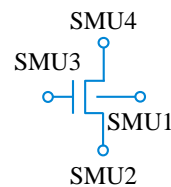
The Debug tab menu provides the following buttons:

- Run button starts the debug (executes the test flow). During execution, the label changes to Pause. Clicking Pause button pauses the execution, and changes the label to Run that is used to continue the debug (execution).
- Abort button aborts the debug (execution).
- Step button executes the highlighted line of the test flow. Clicking the button repeatedly continues the execution by a line.
- Break button sets/releases the break point. For the break point, this button releases the break point from the highlighted line. Program execution will break at the break point automatically.
- Inspect button is available when the debug (execution) is paused or broken. This button opens the Variable Inspector used to monitor value of device parameters, test parameters, analysis parameters, local variables, or system variables.

Class Exercise

Create test definition and perform test.

1. Open test definition editor.
2. Define Test Specification (see previous page)
3. Define Test Contents shown below.
4. Save the definition as Trng idvd idvg.
5. Use debug tools to check the definition.
6. Connect device, and perform test.

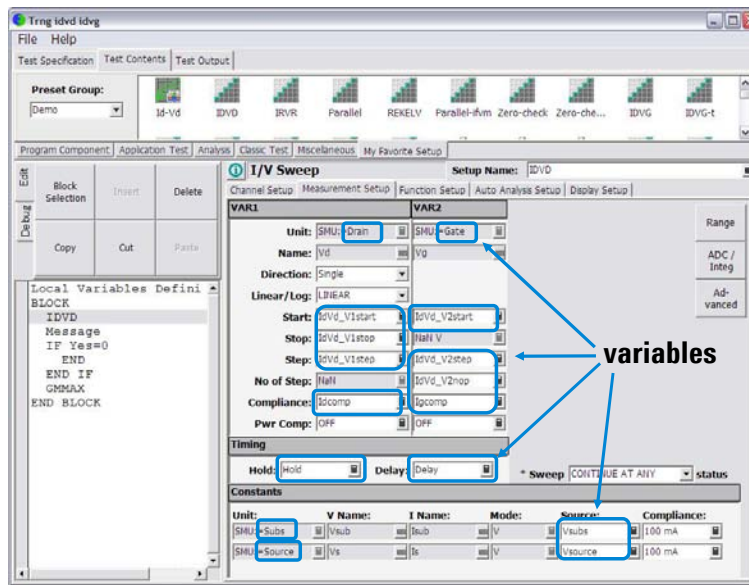


Test Contents:

Local Variables Definition

```
BLOCK
  IDVD
  Message
  IF Yes=0
    END
  END IF
  GMMAX
END BLOCK
```

Test Definition Example

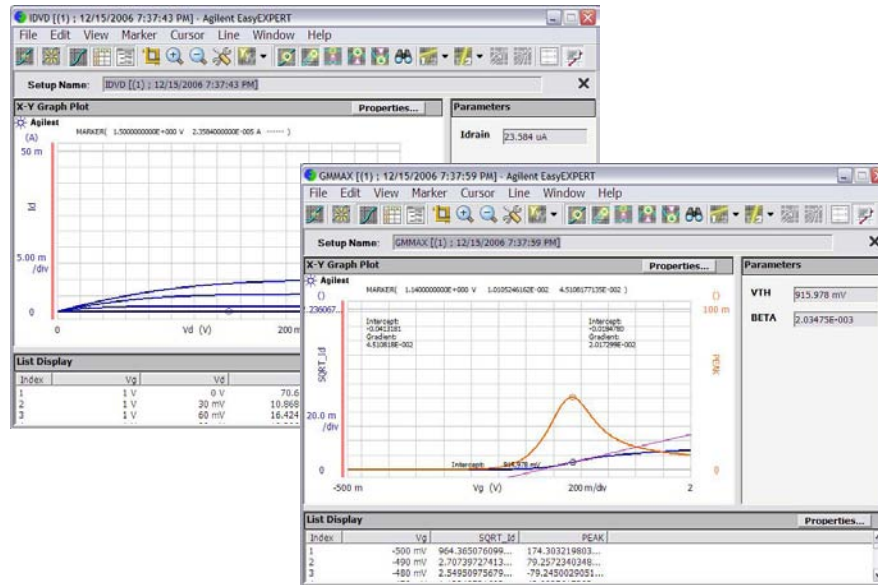


Use IDVD and GMMAX in the Demo preset group (My Favorite Setup) for the test setup.

Use the variables defined in the Test Specification to set the Unit on the Channel Setup, the source values on the Measurement Setup, the Min and Max values on the Display Setup, and so on.

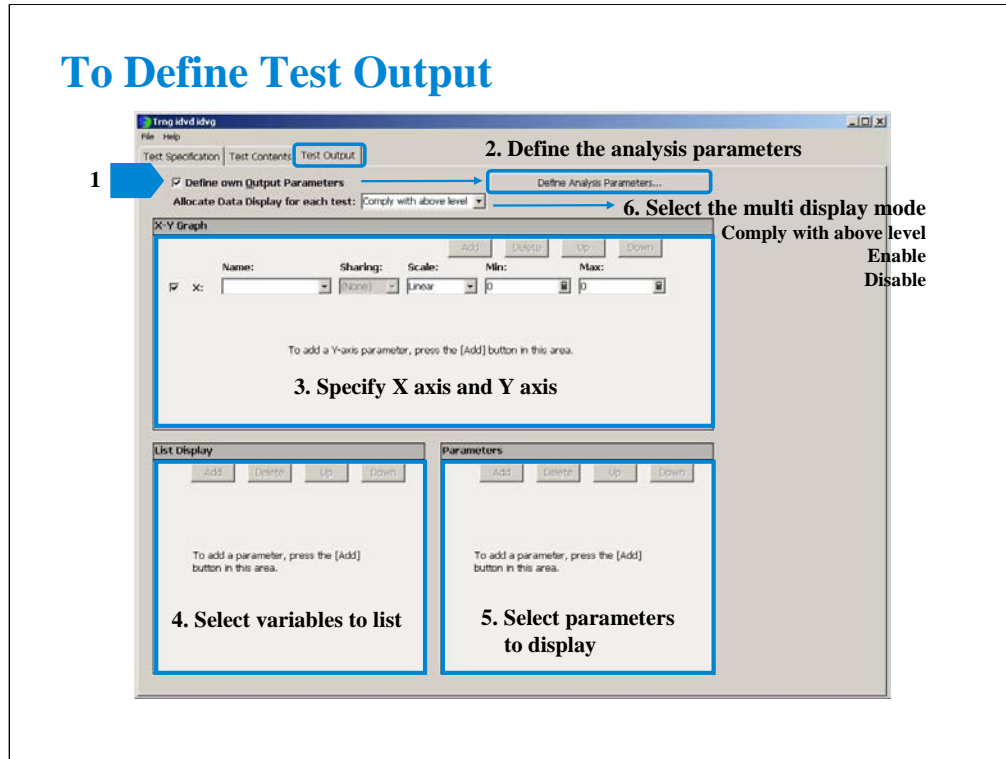
For the example definition, open the Trng idvd idvg definition stored in the \data folder on the Manual CD-ROM. The Manual CD-ROM stores the example test setup and definition data used in this manual.

Measurement Result Example



This is a test result example displayed on the Data Display window.

To Define Test Output



The test output setup is optional. If you have the following requirements, define the analysis parameters and set the display parameters.

- To send the test result data to the subsequent tests in an application test
- To make the program branching depends on the test result
- To make the calculation using the test data in the Test Contents
- To display/record the test result of this application test
- To change the multi display mode of this application test

To define the test output:

1. Check the Define own Output Parameters box.
2. Click the Define Analysis Parameters... button. And define the analysis parameters on the Analysis Parameter Definition window.
3. Specify X axis and Y axis of the X-Y Graph of the Data Display window.
4. Select variables to list in the List Display area of the Data Display window.
5. Select variables to display in the Parameters area of the Data Display window.
6. Select the multi display mode using the Allocate Data Display for each test pull-down menu.

Note: If the multi display mode is Disabled, the all test result data will be displayed on the singular Data Display window. If the multi display mode is Enabled, the test result data of the same test setup name will be displayed on the exclusive Data Display window and the test result data of the different test setup name will be displayed on the new Data Display window.

To Define Test Output Analysis Parameters

Define Analysis Parameters...

Analysis Parameter Definition

Vector Parameters

Name	Unit	Description
VG	V	Gate Voltage
ID	A	Drain Current
GM	S	Transconductance
GM_MAX	S	Maximum Transconductance

Scalar Parameters

Name	Unit	Description
VTH	V	Threshold Voltage

Close

Define the analysis parameters as shown below:

At the Vector Parameters area or the Scalar Parameters area:

1. Click the Add button.
2. Enter the Name, Unit, and Description of the parameter.

For the sweep output/measurement data, use the vector parameter.

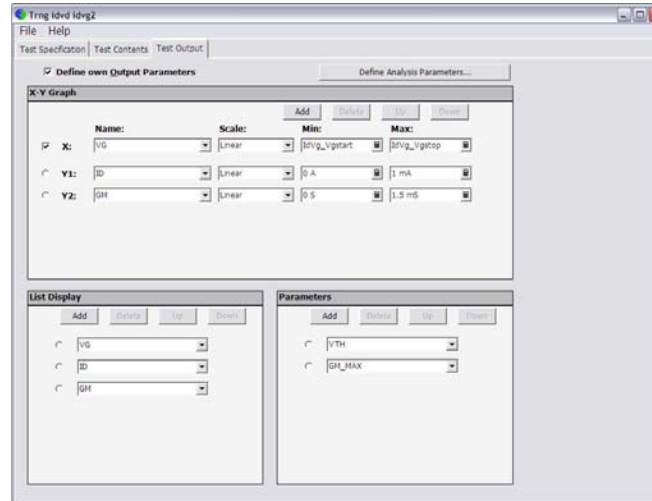
For the spot output/measurement data, use the scalar parameter.

For the data given by the max() and min() built-in function, use the vector parameter.

In this example, VG, ID, and GM are the vector parameter and VTH is the scalar parameter.

GM_MAX is the vector parameter because the max() built-in function is used to calculate this value.

To Define Test Output Display Parameters



This example sets:

X-Y Graph: ID-VG plot for Y1-X graph and GM-VG plot for Y2-X graph

List Display: VG, ID, and GM

Parameters: GM_MAX and VTH

All parameters must be defined in the Analysis Parameter Definition window shown in the previous slide.

The X-Y Graph area is used to set the X axis and Y axis of the X-Y Graph Plot area on the Data Display window.

- Name: Name of variable to plot on the X axis
- Scale: Linear or Log
- Min: Minimum value of the specified axis
- Max: Maximum value of the specified axis

The List Display area selects the variables to be listed on the List Display area of the Data Display window. Up to 20 variables can be set.

The Parameters area selects the variables to be listed on the Parameters area of the Data Display window. Up to 20 parameters can be set.

11 Advanced Definitions and Operations

In This Module

- **To Control External GPIB Devices**
- **To Call Execution Files**
- **To Perform Repeat Measurements**
- **Prober Control Script**

Note:

To Control External GPIB Devices

Miscellaneous: GPIB I/O

Write String	to send a string command to GPIB device
Write Value	to send a command to GPIB device
Read String	to read a string value from GPIB device
Read Value	to read a numeric value data from GPIB device
Read List	to read a vector data from GPIB device
Read STB	to read status byte of GPIB device

GP-IB Control Group Execution Trigger

Device Clear

Go To Local

Local LockOut

You can control external GPIB devices from the EasyEXPERT by using the GPIB I/O statement. The GPIB I/O statement provides the write/read functions shown above. Select a write function and enter the necessary parameters to send a command to the GPIB device. Select a read function and enter the necessary parameters to read response from the GPIB device. For details, see online help or User's Guide.

The followings are the GPIB Control functions.

- Group Execution Trigger: Sends a trigger to the specified GPIB device.
- Device Clear: Sends a device clear to the specified GPIB device.
- Go To Local: Returns the specified GPIB device to the local state.
- Local LockOut: Locks the specified GPIB device.

Note: Before starting, enable System Controller. See Module 12. Also establish the GPIB connection with the external GPIB devices.

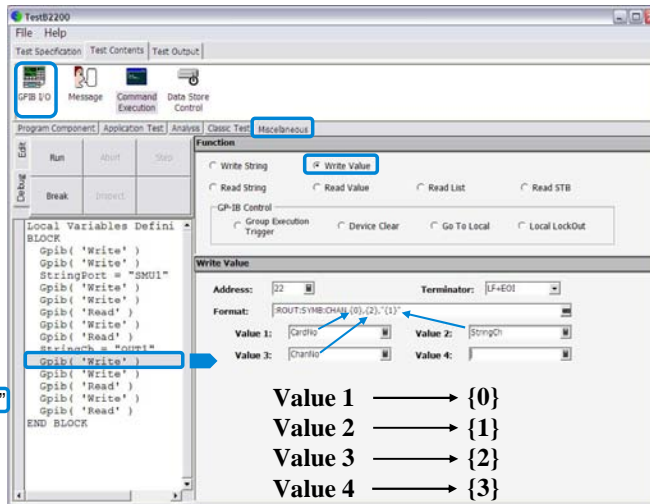
To Control External GPIB Devices

Agilent B2200 control example

To send command

Programming image:

```
*RST
:ROUT:FUNC ACON
(enter "SMU1" to StringPort)
:ROUT:SYMB:PORT {0},{1}"
:ROUT:SYMB:PORT? {0}
(reads string data)
*OPC?
(reads operation complete flag)
(enter "OUT1" to StringCh)
:ROUT:SYMB:CHAN {0},{2},"{1}"
:ROUT:SYMB:CHAN? {0},{2}
(reads string data)
*OPC?
(reads operation complete flag)
```



This slide shows an example setup of the GPIB I/O statement. This is a component of the test contents used to control the Agilent B2200 switching matrix.

This example uses the Write Value function to send the following command to the B2200.

```
:ROUT:SYMB:CHAN {0},{2},"{1}"
```

where, {0} is CardNo, {1} is StringCh, and {2} is ChanNo.

The followings are the reference of the setup editor.

- Address: GPIB address of the device
- Terminator: EOI, LF, CR/LF, LF+EOI, CR/LF+EOI, or NONE (no terminator)
- Format: Command (header and parameters) sent to the device
- Value 1: Value for {0}
- Value 2: Value for {1}
- Value 3: Value for {2}
- Value 4: Value for {3}

{0}, {1}, {2}, and {3} are variable available in the Format field only.

Note: Use double quotes to enter a string to a local variable by using the Assign statement.

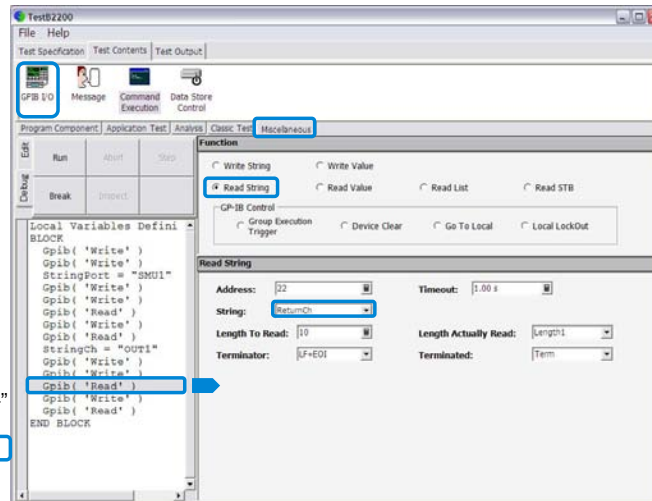
To Control External GPIB Devices

Agilent B2200 control example

To read data

Programming image:

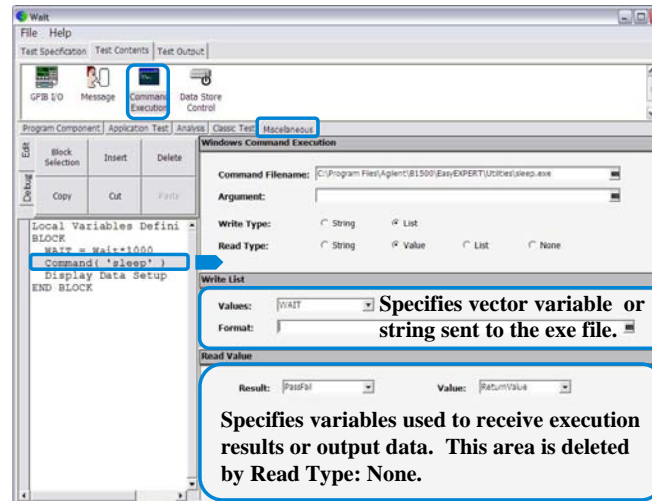
```
*RST
:ROUT:FUNC ACON
(enter "SMU1" to StringPort)
:ROUT:SYMB:PORT {0},{1}
:ROUT:SYMB:PORT? {0}
(reads string data)
*OPC?
(reads operation complete flag)
(enter "OUT1" to StringCh)
:ROUT:SYMB:CHAN {0},{2},{1}
:ROUT:SYMB:CHAN? {0},{2}
(reads string data)
*OPC?
(reads operation complete flag)
```



This example uses the Read String function to read the response from the B2200. This example reads the :ROUT:SYMB:CHAN? query command response. The result (ReturnCh value) must be OUT1.

To Call Execution Files

Miscellaneous: Command Execution



You can call the execution file (EXE file) from the EasyEXPERT. Use the Command Execution statement and define the setup editor as shown in this example.

- Command Filename: Execution file name (command name)
- Argument: Command parameter or argument
- Write Type: String or List (vector data)
- Read Type: String, Value (numeric data), List (vector data), or None (no read data)

If you specify Write String, enter the string sent to the command.

If you specify Write List, enter the name of vector variable sent to the command, and specify the format of data element sent to the command. See next slide.

In the Read String/Value/List area, specify the variables used to receive execution result and output data. There is no entry field for Read Type: None.

- Result: Numeric variable name. Used to store the execution result.
- Value: Numeric variable name for Read Value, or vector variable name for Read List. Used to store the returned data.
- String: String variable name. Used to store the returned data.
- Length Actually Read: Numeric variable name. Used to store the byte length of the returned data.

The above example calls the sleep.exe file used to insert the wait time for program execution. The WAIT value must be defined in msec. After the normal command execution, the sleep.exe returns 1 for Value and 0 for Result. The sleep.exe file is stored in the following folder.

C:\Program Files\Agilent\B1500A\EasyEXPERT\Utilities

To set Format field

{I[,A][:F]}

- **I** **List data index. Or index of element. Integer.**
- **[,A]** **Character length of the specified data element. Positive integer for right-aligned, or negative integer for left-aligned. Optional.**
- **[:F]** **Format identifier. C, D, E, F, G, N, P, R, or X. Lower case is available. Optional.**

Example:

{0,5:E} First element, 5 characters, exponential notation.

{1:G} Second element, general.

{2,10} Third element, 10 characters, general.

The Format field is used to specify the data format of List (vector variable). The strings shown in the above example can be defined in the Format field.

In the strings, the list data index is mandatory. The character length and format identifier are omissible. Then the length is not limited, and the format G is set.

C or c: Circulation

D or d: Decimal numeral

E or e: Exponential notation

F or f: Fixed point

G or g: General

N or n: Numeric

P or p: Percent

R or r: Round trip

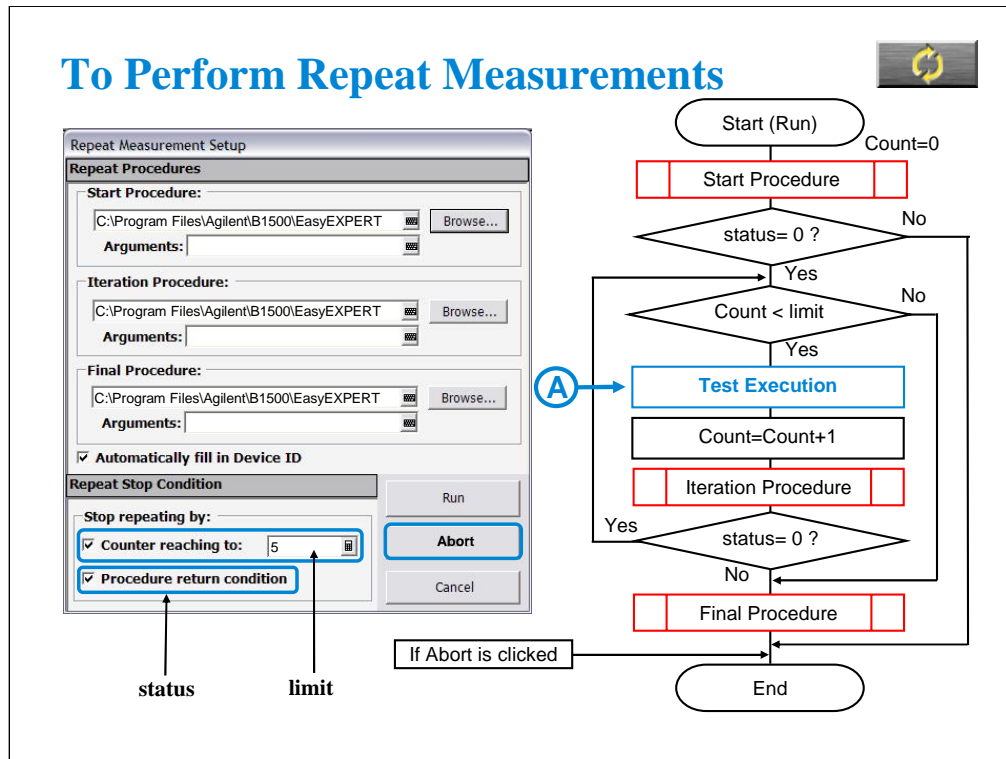
X or x: Hexadecimal numeral

For the format, see online help or manual of the Agilent T&M Programmers Toolkit.

Exercise

Try to improve your test definition as you want.

- **To Use Built-in Functions**
- **To Use Read Out Functions**
- **To Control External GPIB Devices**
- **To Call Execution Files**



Repeat measurement is performed as shown in this flowchart. The status is a response returned by the start/iteration procedure. The Count is the accumulated number of test executions. They are the stop condition of the repeat measurement.

The repeat measurement stop function is enabled by the following check boxes.

- Counter reaching to
- Procedure return condition

If the first box is checked and the limit value is specified, the repeat measurement will be stopped if $\text{Count} \geq \text{limit}$. To perform the repeat measurement, set the limit value more than the number of devices under test or remove check from this box.

If the second box is checked, the repeat measurement will be stopped if status is not 0.

When the second box is checked, the device ID automatic setup function is available and is enabled/disabled by using the following check box. The function enters the device_id value to the Device ID of the test result record. The device_id is a response returned by the start/iteration/subsite procedure.

- Automatically fill in Device ID

The Repeat Measurement Setup dialog box provides the following action buttons.

- Run: Starts repeat measurement.
- Abort: Stops repeat measurement immediately.
- Cancel: Closes the Repeat Measurement Setup dialog box.

Start/Iteration/Final Procedure:

Enter the full path name of the procedure. For example, enter as follows.

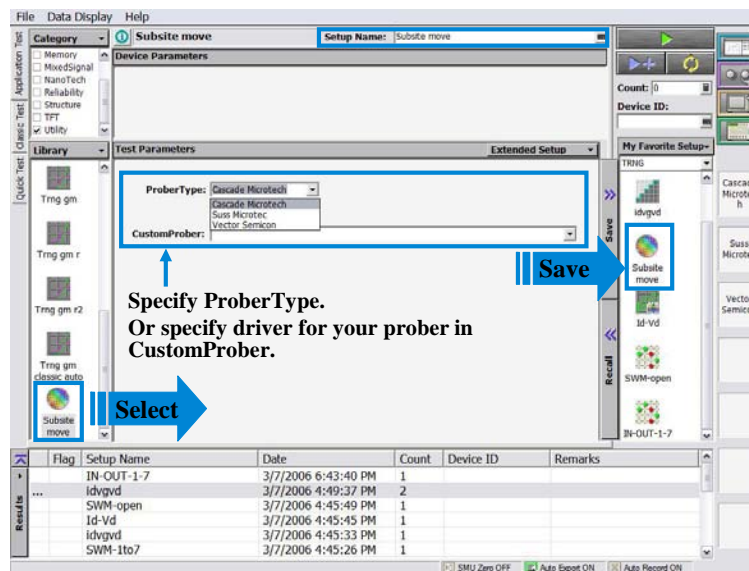
C:\Program Files\Agilent\B1500\EasyEXPERT\Utilities\ProberControl\suss\Start_suss.exe

Arguments:

Enter the options of the procedure. See the following pages describing about procedures. For example, enter -a GPIB0::5::INSTR -I C:\temp\prb.log.

If you use the sub die move operation (subsite procedure), the flowchart must be changed. See page 11-18.

Subsite move Test Setup



If you do not use the sub die (subsite) move operation, skip this page.

Click Application Test tab and open the Subsite move test setup in the Utility category. On the Subsite move setup screen, specify ProberType (Cascade, Suss, or Vector) or driver for your prober in CustomerProber, and save it as a setup in your preset group (My Favorite Setup). Then you can use the setup for your quick test. See next page.

The Subsite move setup moves wafer chuck to the next subsite, reads device ID from the prober, and sets it to the Device ID of the test result record.

For more details of the test setup, open the Test Definition window.

In the Subsite move test definition, an execution file callProbeDvr.exe is used. This file is used to send Subsite_xxxx.exe to the prober specified by the prober_info.ini file and receive the response; status and device_id. The callProberDvr.exe has the following input/output parameters.

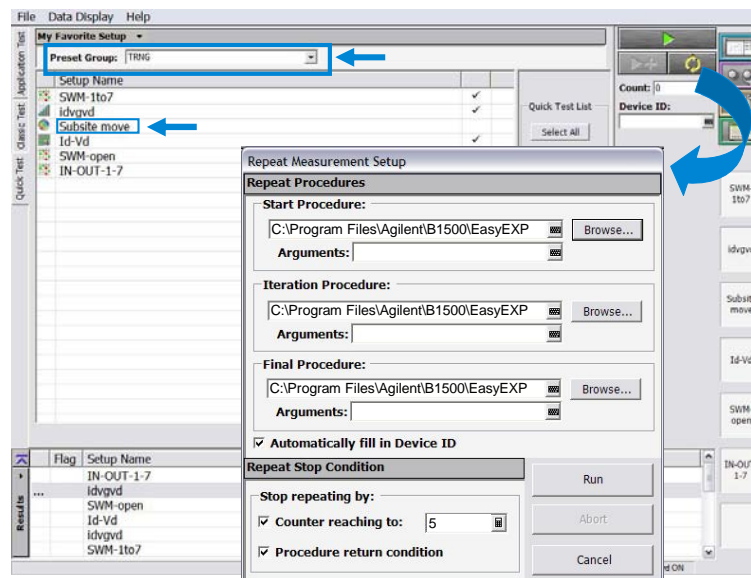
Input: Full path of Subsite_xxxx.exe

Output: status; 0 (no error) or 1 (error)

Output: device_id

Note: The callProberDvr.exe refers to the prober_info.ini file for the GPIB address and log file name. Do not set the Arguments of Subsite_xxxx.exe.

To Use Subsite move



If you do not use the sub die (subsite) move operation, skip this page.

To perform the test with the sub die move operation, do as follows.

1. Add the Subsite move test setup to your preset group (My Favorite setup).
2. Set your preset group and test setups in the Quick Test tab screen.
3. Open the Repeat Measurement Setup dialog box.
4. Specify the procedures and the repeat measurement condition.
5. Start repeat measurement.

The Subsite move setup must be entered after measurements for a sub die.

Prober Control Script

- **Prober information file** **Use prober control script in EasyEXPERT**
 prober_info.ini **Repeat Measurement Setup window**
 - **Start Procedure**
 Start_xxxx.exe
 - **Iteration Procedure**
 Iterator_xxxx.exe
 - **Final Procedure**
 Final_xxxx.exe
 - **Subsite Procedure**
 Subsite_xxxx.exe
- xxxx:**
- **cascade**
 - **suss**
 - **vector**



Prober control script is sample program used for semi-automatic prober control. The Agilent EasyEXPERT can call the script by using the Repeat Measurement Setup window.

See page 11-9 to call the script and perform repeat measurement.

See page 11-14 for the prober information file.

See page 11-13 for the start procedure.

See page 11-15 for the iteration procedure.

See page 11-16 for the final procedure.

See page 11-17 for the subsite procedure.

To use the prober control script, specify the start/iteration/final procedure in the Repeat Measurement Setup dialog box (see page 11-9). And use the Subsite move test setup in your quick test to control sub die move. The Subsite move setup uses the subsite procedure for moving wafer chuck to the next subsite. See page 11-10 and 11-11.

Start_xxxx.exe

- **Arguments:** -a GPIB_address
-l log_file_name

Example:
-a GPIB0::5::INSTR -l C:\temp\prb.log

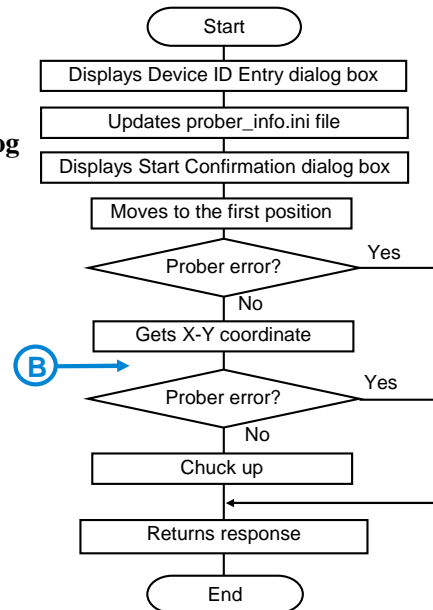
- **Response:** XML format data

```
<Response>
  <Break>status</Break>
  <Target>device_id</Target>
</Response>
```

status: 0 (no error) or 1
device_id: prefix:coordinate

Example:

```
<Response>
  <Break>0</Break>
  <Target>waf1a:3 1</Target>
</Response>
```



To specify the start procedure in the Repeat Measurement Setup dialog box, enter the full path name of Start_xxxx.exe into the Start Procedure field.

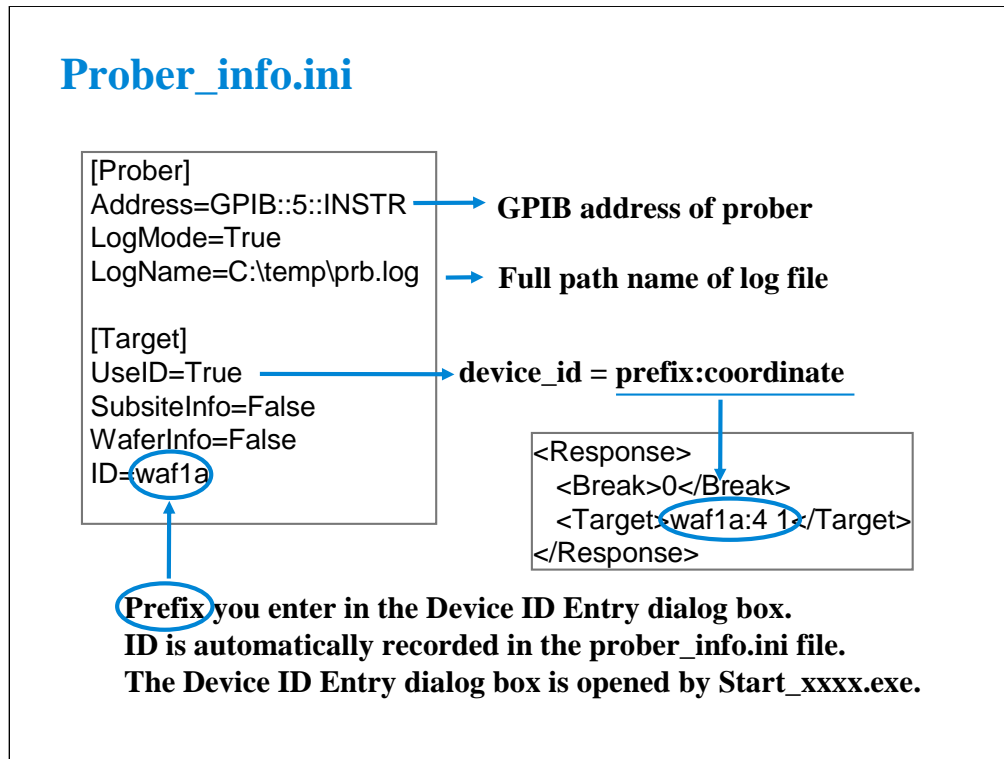
After the repeat measurement is started, this procedure displays the Device ID Entry dialog box and waits for your input. On the dialog box, enter a string used for the prefix of device_id. After that, you will see the Start Confirmation dialog box that is used to confirm your wafer setup status. Load wafer and perform wafer alignment, then click OK on the dialog box. The procedure moves wafer chuck to the first probing position, checks the prober status, gets the X-Y coordinate of the probing position, and sets the wafer chuck to the UP position. At last, the procedure returns the response.

The status is 0 or 1. It is used for the EasyEXPERT repeat measurement stop function. When the Procedure return condition box is checked in the Repeat Measurement Setup dialog box, the repeat measurement will be stopped if status is not 0.

The device_id is a string for the Device ID of the test result record. When the Automatically fill in Device ID box is checked in the Repeat Measurement Setup dialog box, the device_id will be entered to the Device ID of the test result record.

If you use the subsite procedure, the flowchart must be changed. See page 11-18.

Note: To ignore the Arguments, set the GPIB address and log file name in the prober_info.ini.



The prober information file is necessary to execute the prober control script. Before starting tests, open this file, edit it as you want, and overwrite it. The name must be prober_info.ini.

The prober_info.ini file stores the information shown below.

- Address: GPIB address of prober
- LogMode: Log file creation mode; True or False
- LogName: Log file name (full path)
- UseID: Device ID creation mode; True or False
- SubsiteInfo: Set always False. This is just a place holder.
- WaferInfo: Set always False. This is just a place holder.
- ID: Ignore this variable. This is just a pass parameter.

If the procedures specify the -a option, the Address value is not used.

If the procedures specify the -l option, the LogName value is not used.

To create a log file, set LogMode=True.

To use the prefix:coordinate format for the device_id value, set UseID=True. If UseID=False, the device_id value will be coordinate, not prefix:coordinate. The prefix will be the value entered in the Device ID Entry dialog box that is opened by Start_xxxx.exe. This function is available when the Automatically fill in Device ID check box is checked.

Iterator_xxxx.exe

- **Arguments:** -a GPIB_address
-l log_file_name

Example:
-a GPIB0::5::INSTR -l C:\temp\prb.log

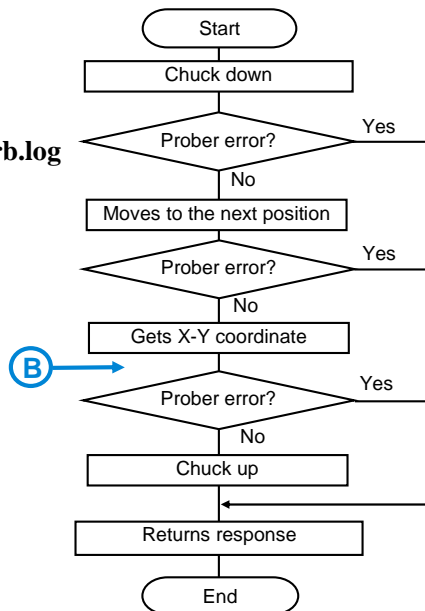
- **Response:** XML format data

```
<Response>
  <Break>status</Break>
  <Target>device_id</Target>
</Response>
```

status: 0 (no error) or 1
device_id: prefix:coordinate

Example:

```
<Response>
  <Break>0</Break>
  <Target>waf1a:4 1</Target>
</Response>
```



To specify the iteration procedure in the Repeat Measurement Setup dialog box, enter the full path name of Iterator_xxxx.exe into the Iteration Procedure field.

The procedure is called after the measurement is completed for a die. This procedure sets wafer chuck to the DOWN position, moves it to the next probing position, checks the prober status, gets the X-Y coordinate of the probing position, and sets the wafer chuck to the UP position. At last, the procedure returns the response.

The status is 0 or 1. It is used for the EasyEXPERT repeat measurement stop function. When the Procedure return condition box is checked in the Repeat Measurement Setup dialog box, the repeat measurement will be stopped if status is not 0.

The device_id is a string for the Device ID of the test result record. When the Automatically fill in Device ID box is checked in the Repeat Measurement Setup dialog box, the device_id will be entered to the Device ID of the test result record.

If you use the subsite procedure, the flowchart must be changed. See page 11-18.

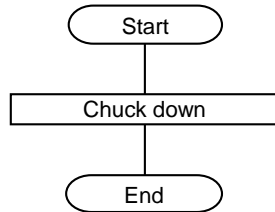
Note: To ignore the Arguments, set the GPIB address and log file name in the prober_info.ini.

Final_xxxx.exe

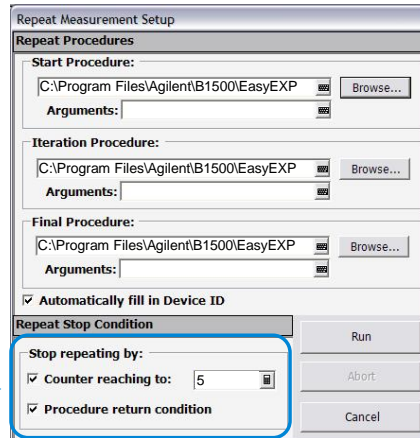
- Arguments: -a GPIB_address
-l log_file_name

Example:
-a GPIB0::5::INSTR -l C:\temp\prb.log

- Response: none



Stop condition



To specify the final procedure on the Repeat Measurement Setup dialog box, enter the full path name of Final_xxxx.exe into the Final Procedure field.

The procedure is called after one of the stop condition is detected. This procedure sets wafer chuck to the DOWN position.

Note: To ignore the Arguments, set the GPIB address and log file name in the prober_info.ini.

Subsite_xxxx.exe

- **Arguments:** **-a GPIB_address**
 -l log_file_name

Example:
-a GPIB0::5::INSTR -l C:\temp\prb.log

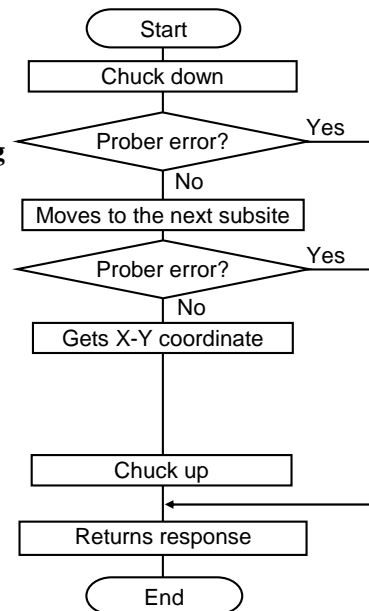
- **Response:** **XML format data**

```
<Response>
  <Break>status</Break>
  <Target>device_id</Target>
</Response>
```

status: **0 (no error) or 1**
device_id: **prefix:coordinate**

Example:

```
<Response>
  <Break>0</Break>
  <Target>waf1a:3 1</Target>
</Response>
```



To realize sub die move operation, you need to define Subsite_xxxx.exe in your test definition and create your application test setup. However, you do not need to take care of this procedure by using the Subsite move test setup included in the application library. The Subsite move setup moves wafer chuck to the next subsite, reads device ID from the prober, and sets it to the Device ID of the test result record.

Open the Subsite move test setup and save it as a setup in your preset group (My Favorite Setup). Then you can use the setup for your quick test.

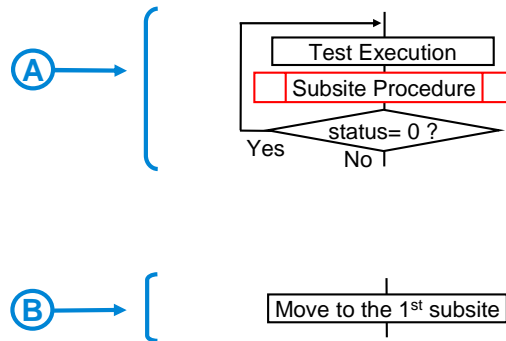
Note: To use the Subsite move setup, set the GPIB address and log file name in the prober_info.ini. And ignore the Arguments for Subsite_xxxx.exe.

Note: If you use a Suss prober, the number of Subsite move setups used in your quick test (die test) is important. It must be N-1; N is the number of subsites defined in the prober.

The status is 0 or 1. It is used for the EasyEXPERT repeat measurement stop function. When the Procedure return condition box is checked in the Repeat Measurement Setup dialog box, the repeat measurement will be stopped if status is not 0.

The device_id is a string for the Device ID of the test result record.

To Change Execution Flow



If you use the subsite procedure, change the flowchart as follows.
On the page 11-9, replace the box A with the block A shown above.
On the page 11-13 and 11-15, insert the box B shown above to the position B of the flowchart.

In This Module

- **Function Status Indicators**
- **Run Option**
- **Automatic Data Export and Data Record**
- **Calibration**
- **Configuration**
- **XSLT Filters**
- **To Enable System Controller**
- **To Start Desktop EasyEXPERT**
- **To Use 415x Setup File Converter**

This module describes the above topics. You will understand what is the function status indicator, how to change the function status, how to perform selftest and calibration, how to perform SMU zero offset cancel, and so on.

Function Status Indicators

The screenshot shows a software interface with a table of data and five function status indicators at the bottom. Blue arrows point from each indicator to its corresponding ON or OFF state.

Date	Count	Device ID	Remarks
5/10/2007 6:42:51 PM	1		
4/23/2007 5:09:36 PM	8		
4/23/2007 9:12:45 AM	1		
12/19/2006 2:52:44 PM	1		
12/19/2006 2:52:04 PM	1		
12/15/2006 7:38:01 PM	1		

Indicators and their status changes:

- Multi Display OFF** → **Multi Display ON** (Multiple data display OFF ➡ ON)
- Standby OFF** → **Standby ON** (Standby function OFF ➡ ON)
- SMU Zero OFF** → **SMU Zero ON** (SMU zero offset cancel OFF ➡ ON)
- Auto Export OFF** → **Auto Export ON** (Automatic data export OFF ➡ ON)
- Auto Record ON** → **Auto Record OFF** (Automatic data record ON ➡ OFF)

Function status indicators let you know the status OFF or ON of the following functions. The indicators are placed at the bottom of the main screen.

Multi Display OFF/ON: Shows the multiple data display function OFF or ON status.

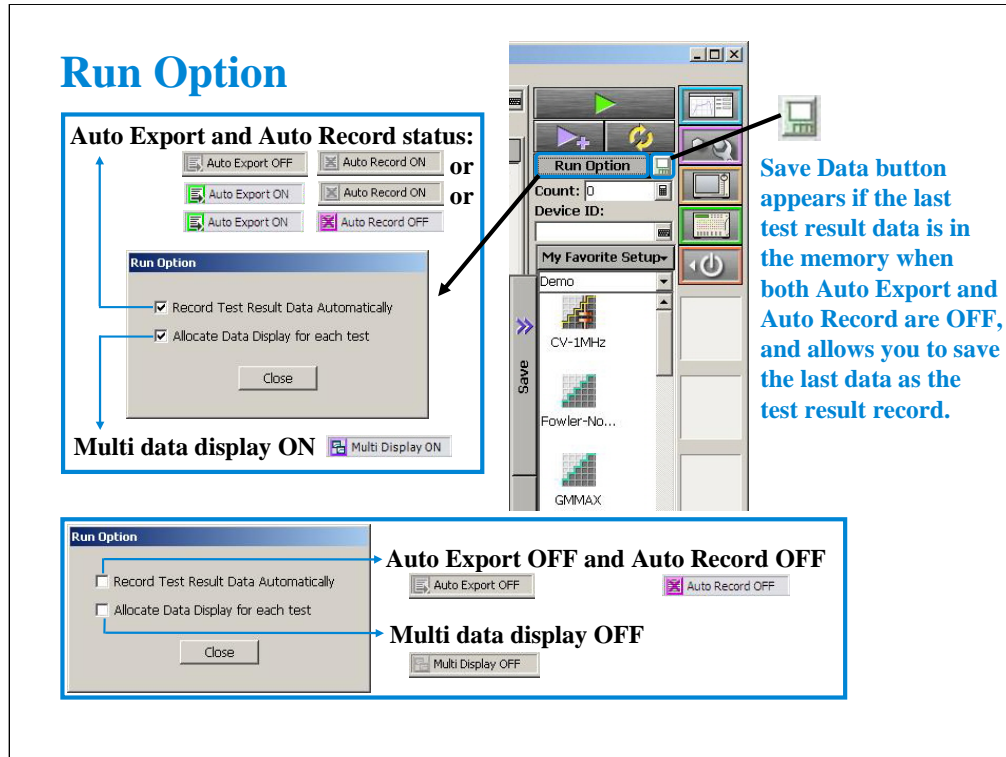
Standby OFF/ON: Shows the standby function OFF or ON status.

SMU Zero OFF/ON: Shows the SMU zero offset cancel function OFF or ON status.

Auto Export OFF/ON: Shows the automatic data export function OFF or ON status.

Auto Record ON/OFF: Shows the automatic data record function ON or OFF status.

Clicking indicator controls the function ON/OFF directly or opens the dialog box or window which controls the function status.



Run Option button opens the Run Option dialog box used to change the status of the automatic data record function, the automatic data export function, and the multiple data display function.

If the Record Test Result Data Automatically check box is checked, both or one of the automatic data record function and the automatic data export function will be set to ON. To specify the function status, see the next page.

If the Record Test Result Data Automatically check box is not checked, both functions are set to OFF. In this status, both data record and data export are not performed. So the test execution time will be reduced. Also, EasyEXPERT memorizes the last test result data. And it can be saved as a test result record by clicking the Save Data button right next to the Run Option button. This status will be useful for probe contact check, defect analysis, and so on.

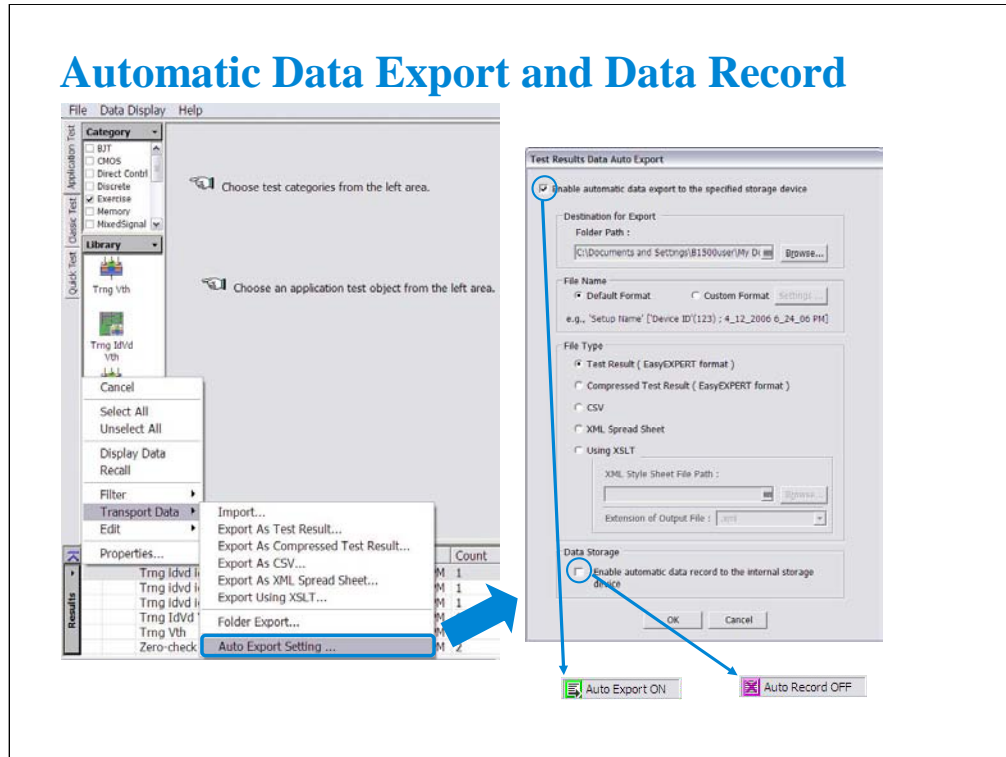
The multiple data display function ON or OFF can be controlled by clicking the Multi Display indicator or by using the Allocate Data Display for each test check box on the Run Option dialog box.

About the multiple data display function:

If this function is OFF, the all test result data will be displayed on the singular Data Display window.

If this function is ON, the test result data of the same test setup name will be displayed on the exclusive Data Display window and the test result data of the different test setup name will be displayed on the new Data Display window.

Automatic Data Export and Data Record

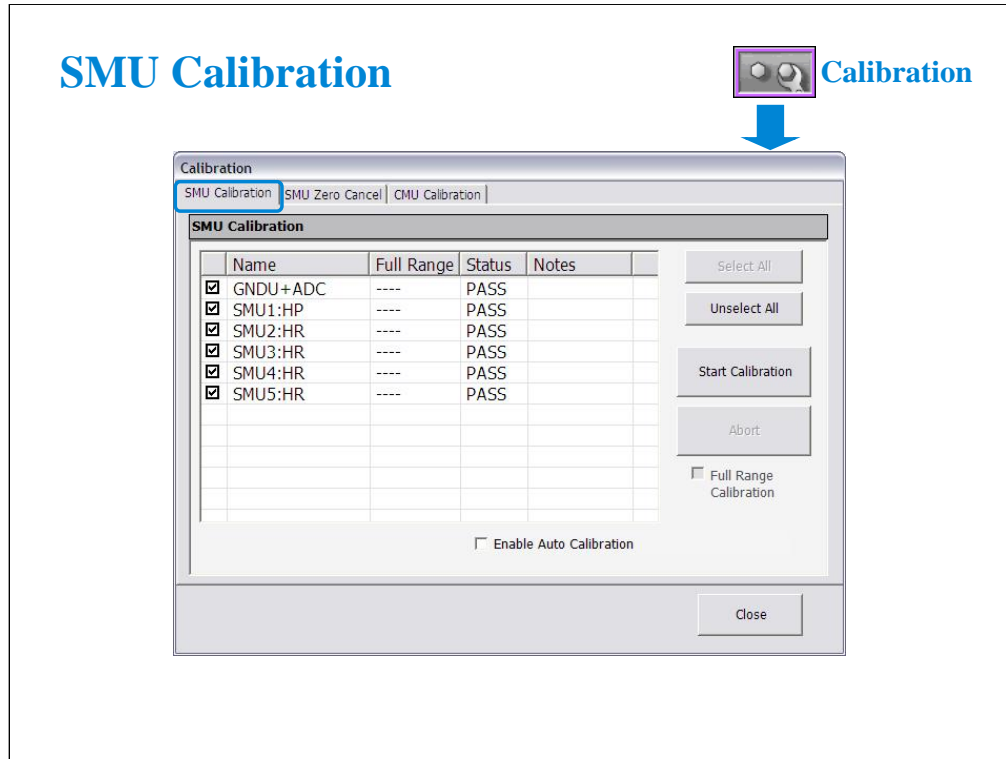


The automatic data export function and the automatic data record function can be enabled or disabled by using the Test Results Data Auto Export dialog box. This dialog box is displayed by clicking these indicators or selecting the Results > Transport Data > Auto Export Setting... menu.

The automatic data export function is used to export the test result data automatically to the storage device you specify. You can specify the destination (storage device), exported file name, and file type. To set the automatic data export function to enable (set to ON), check the Enable automatic data export to the specified storage device check box.

The automatic data record function is used to save the test result data to the internal HDD automatically. This function can be disabled if the automatic data export function is enabled. To disable the automatic data record function, remove the check from the Enable automatic data record to the internal storage device check box.

Even if both data export and data record functions are enabled, the functions can be set to OFF by removing the check from the Record Test Result Data Automatically check box on the Run Option dialog box.



The Calibration window is opened by clicking the Calibration button. The SMU calibration screen of this window is used to perform the calibration of SMUs. The list area of this screen lists Name, Full Range, and Status.

Name: Name of module. To select, check the left check box.

Full Range: For the high resolution SMU (HRSMU) connected to the atto sense/switch unit (ASU). Full range calibration on or off.

Status: Calibration status. Pass or fail.

Notes: Error information when calibration failed.

To perform the self-calibration, specify the modules, open the measurement terminals of the corresponding modules, and click the Start Calibration button.

Full Range Calibration:

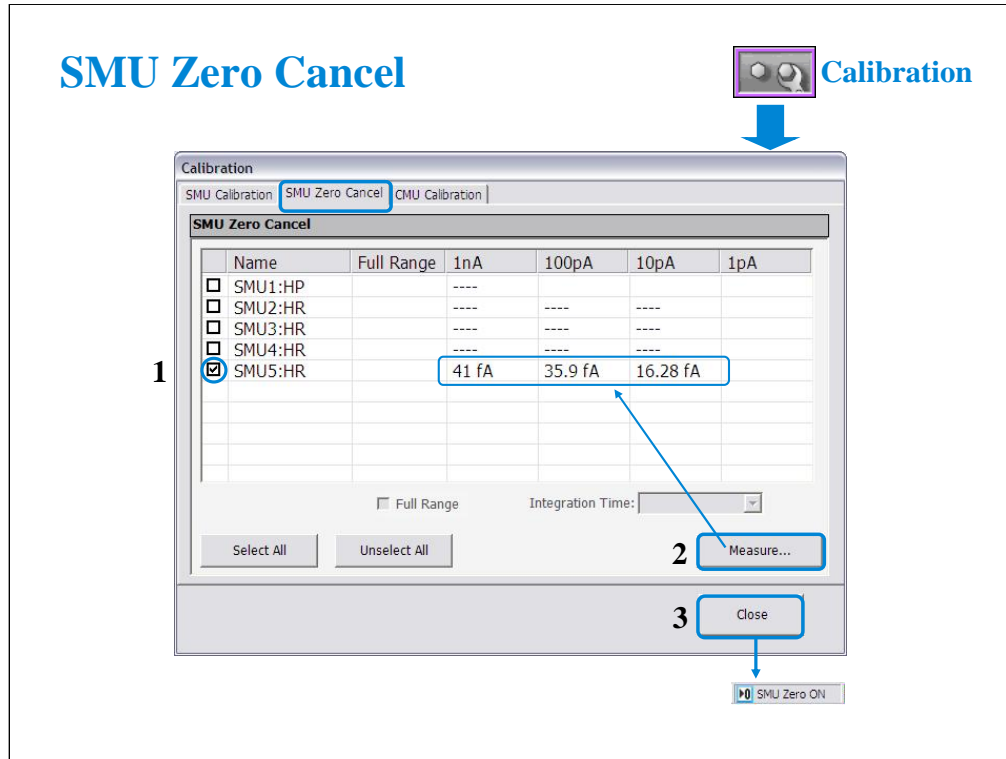
For the HRSMU connected to the ASU. Enables or disables the full range calibration. If this box has been unchecked, the B1500 does not use the 1 pA range.

Enable Auto Calibration:

Enables or disables the auto-calibration capability. If this box has been checked (function ON), and the B1500 automatically starts calibration for all modules every 30 minutes if the output switches of all modules are off for 30 minutes.

NOTE:

To perform calibration correctly, open the measurement terminals. If auto-calibration is enabled, do not forget to open the measurement terminals or disconnect the device under test from the terminals after measurement.



The SMU Zero Cancel screen is used to perform the SMU zero offset current measurement and set the SMU zero offset cancel function.

This function subtracts the offset current from the current measurement raw data, and returns the result as the measurement data. This function is used to compensate the error factor (offset current) caused by the measurement path such as the measurement cables, manipulators, or probe card.

To enable this function, perform the following procedure.

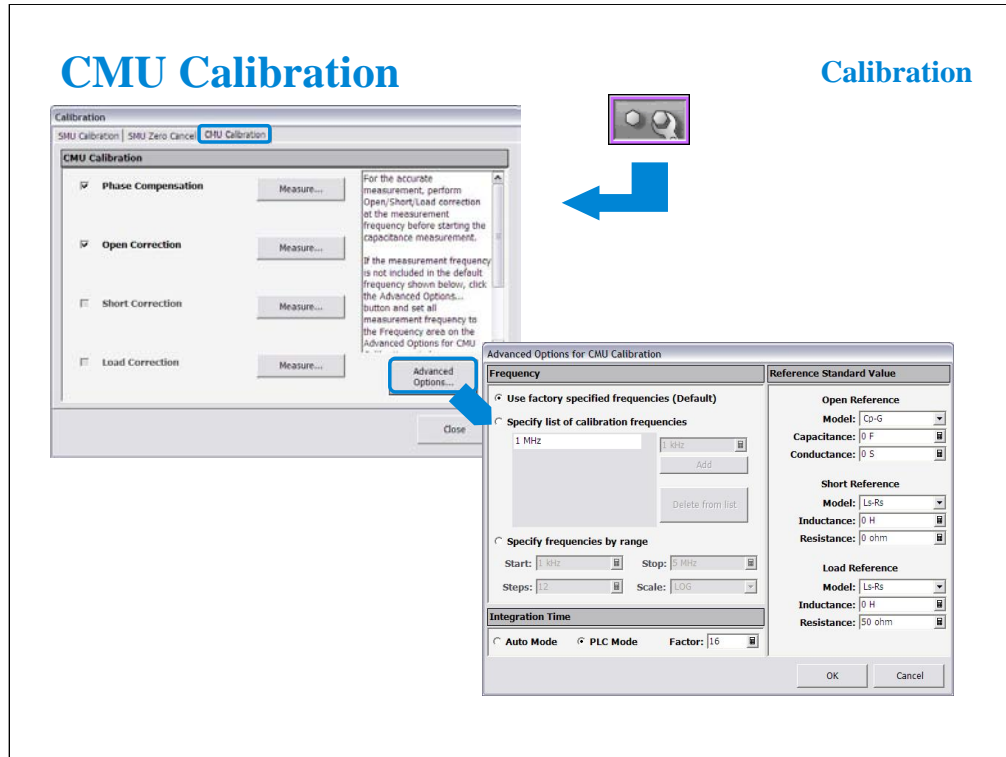
1. Check the left box of the Name column to specify the module to enable this function.
2. Click the Measure... button to perform the zero offset current measurement and wait until the measurement is completed. The measurement data will be displayed in the appropriate cell.
3. Click the Close button to enable the zero offset cancel function.

To disable the function, uncheck the left box of the Name column, and click the Close button.

Note:

The offset cancel is not available for measurement over 100 nA range. For 10 nA range measurement, the offset cancel is performed by using the 1 nA range offset value. For measurement by a range less than 10 nA, the offset value measured by each range is used.

For more information, see online help or User's Guide.



The CMU Calibration screen is used to perform the measurement data correction of the multi frequency capacitance measurement unit (MFCMU). For the easy way, perform the phase compensation and the open correction at least. The check boxes left of the Open/Short/Load Correction and the Phase Compensation are effective after the corresponding measurement is performed.

Measure...: Opens a dialog box used to perform correction/compensation data measurement. To perform the measurement, follow the dialog box.

Advanced Options...: Opens the “Advanced Options for CMU Calibration” dialog box used to set the frequencies for the correction data measurement and the reference values of the working standard. See the next page.

To perform the open correction and the phase compensation, open the measurement terminals.

To perform the short correction, connect the measurement terminals together.

To perform the load correction, connect your load standard between the high terminal and the low terminal.

NOTE:

For a more accurate measurement, perform Open/Short/Load correction at the measurement frequency before starting the capacitance measurement.

If the measurement frequency is not included in the list of default frequencies below, click the Advanced Options... button and set the measurement frequency on the Frequency area of the Advanced Options for CMU Calibration window.

Default frequencies:

1 k, 2 k, 5 k, 10 k, 20 k, 50 k, 100 k, 200 k, 500 k, 1 M, 1.2 M, 1.5 M, 2 M, 2.5 M, 2.7 M, 3 M, 3.2 M, 3.5 M, 3.7 M, 4 M, 4.2 M, 4.5 M, 5 MHz

Advanced Options for CMU Calibration

This dialog box is opened by clicking the Advanced Options... button, and is used to set the information required to measure the open/short/load correction data and the phase compensation data. This dialog box provides the following action button.

OK: Applies the setup changes and closes this dialog box.

Cancel: Cancel the setup changes and closes this dialog box.

Frequency: You can select the measurement frequency setup mode from the following modes.

Measurement frequency setup modes:

Default (Use factory specified frequencies): Usually, select this mode. 23 points are automatically set. They are 1 k, 2 k, 5 k, 10 k, 20 k, 50 k, 100 k, 200 k, 500 k, 1 M, 1.2 M, 1.5 M, 2 M, 2.5 M, 2.7 M, 3 M, 3.2 M, 3.5 M, 3.7 M, 4 M, 4.2 M, 4.5 M, and 5 MHz.

Specifies by list: Select this mode when you want to set the frequencies independently. The frequency must be 1 kHz to 5 MHz. The number of frequencies must be 1 to 101. Click Add to open a dialog box, and enter the value. For the unnecessary value, highlight the value and click Delete.

Specifies by range: Select this mode when you want to set the frequencies sequentially and automatically. Specify the start frequency, the stop frequency, the number of steps, and the scale LINEAR/LOG. The start frequency must be less than the Stop value and at least 1 kHz. The stop frequency must be more than the Start value and no more than 5 MHz. The number of steps must be 2 to 1001.

NOTE:

If the device measurement frequency is not equal to the correction data measurement frequency, calculation will be performed automatically to get the correction data for the device measurement frequency, and the calculated correction data will be used for the data correction of the measurement data.

Advanced Options for CMU Calibration

Advanced Options for CMU Calibration

Frequency

☒ Use factory specified frequencies (Default)

☐ Specify list of calibration frequencies

1 MHz 1 kHz

☐ Specify frequencies by range

Start: 1 kHz Stop: 5 MHz

Steps: 12 Scale: LOG

Reference Standard Value

Open Reference

Model: Cp-G

Capacitance: 0 F

Conductance: 0 S

Short Reference

Model: Ls-Rs

Inductance: 0 H

Resistance: 0 ohm

Load Reference

Model: Ls-Rs

Inductance: 0 H

Resistance: 50 ohm

Integration Time

☐ Auto Mode ☒ PLC Mode Factor: 16

Integration Time area defines the integration time used for measuring phase compensation data or open/short/load correction data. The number of averaging samples (Mode=AUTO) or the averaging time (Mode=PLC) is set.

Mode: A/D converter operation mode, AUTO or PLC.

Factor: Factor for the initial value. For details, see online help or user's guide.

Advanced Options for CMU Calibration

Advanced Options for CMU Calibration

Frequency

☒ Use factory specified frequencies (Default)

☐ Specify list of calibration frequencies

1 MHz 1 kHz Add Delete from list

☐ Specify frequencies by range

Start: 1 kHz Stop: 5 MHz Steps: 12 Scale: LOG

Integration Time

☐ Auto Mode ☒ PLC Mode Factor: 16

Reference Standard Value

Open Reference

Model: Cp-G

Capacitance: 0 F

Conductance: 0 S

Short Reference

Model: Ls-Rs

Inductance: 0 H

Resistance: 0 ohm

Load Reference

Model: Ls-Rs

Inductance: 0 H

Resistance: 50 ohm


OK Cancel

Reference Standard Values area provides the following entry fields used to set the reference values of the open/short/load standard. If you use the standard, enter the reference values to the entry fields.
OPEN Reference: Capacitance and Conductance. If you do not use the reference, enter 0 in the both fields.

SHORT Reference: Inductance and Resistance. If you do not use the reference, enter 0 in the both fields.

LOAD Reference: Inductance and Resistance

Main Frame

 **Configuration**

System Information

Model Identification:

Line Frequency:

EasyEXPERT Rev.:

Firmware Rev.:

Host ID:

Main Frame Diagnosis

	Item	Status	
<input checked="" type="checkbox"/>	Trigger I/O	----	
<input checked="" type="checkbox"/>	Digital I/O	----	
<input checked="" type="checkbox"/>	Touch Panel Switch	----	
<input checked="" type="checkbox"/>	LCD	----	
<input checked="" type="checkbox"/>	High Voltage LED	----	
<input checked="" type="checkbox"/>	Measurement LED	----	
<input checked="" type="checkbox"/>	Front Key	----	

The Configuration window is opened by clicking the Configuration button, and is used to display the system information and event log, as well as to perform diagnostics and self-test.

The Main Frame screen is used to display the system information and perform diagnostics.

Model Identification: Displays the instrument ID. B1500A.

Line Frequency: Sets the power line frequency, 50 Hz or 60 Hz.

EasyEXPERT Rev.: Displays the revision number of the EasyEXPERT.

Firmware Rev.: Displays the revision number of the B1500 firmware.

Host ID: Displays the host id of the B1500A internal computer.

Main Frame Diagnosis: This area lists Item and Status.


Item: Name of diagnostics item. To select, check the left check box.

Status: Diagnostics status. Pass or fail.

To perform diagnostics, specify the items to perform and click the Start Diagnosis button. A dialog box is opened. Follow the dialog box to perform the diagnostics. Some items need your judgement, pass or fail. Also you will need to connect an adapter, press keys, check LEDs, and so on.

The Host ID is important for the B1540A-002 users and the B1541A-002 users. It is necessary to activate the EasyEXPERT or Desktop EasyEXPERT Software Plus features. For details, see the Software Entitlement Certificate.

Modules

 **Configuration**

Slot Configuration

	Slot	Module Type	Name	Status	SCUU	Notes
<input checked="" type="checkbox"/>	11	B1500A	GNDU+ADC	PASS		
<input checked="" type="checkbox"/>	1	B1510A	SMU1:HP	PASS		
<input checked="" type="checkbox"/>	3	B1510A	SMU2:HP	PASS		
<input checked="" type="checkbox"/>	5	B1517A	SMU3:HR	PASS		
<input checked="" type="checkbox"/>	6	B1517A	SMU4:HR	PASS		
<input checked="" type="checkbox"/>	7	B1520A	CMU1:MF	PASS		

Select All

Unselect All

Start Self Test

Recover Module

Abort

Accessory Configuration

Status LED: ON

The Modules screen is used to perform self-test of modules.

Slot: Slot number where the module is installed. To select, check the left check box.

Module Type: Module model number

Name: Module name

Status: Self-test status, Passed, Failed, Recovered, or ---- (self-test has not been performed)

SCUU: Specifies if the module is connected to the SCUU.


Notes: Error information when the module self-test failed.

To perform self-test, specify the modules, open the measurement terminals of the corresponding modules, and click the Start Self Test button.

Recover Module button is for the service use only. This button makes the failed modules respond again. This button does not solve the problem that causes the Failed status.

Status LED: Enables (ON) or disables (OFF) the status indicator (LED) of the ASU (Atto Sense and Switch Unit) and the SCUU (SMU CMU Unify Unit).

ASU


Configuration

ASU List

Slot	Module Type	Name	ASU Serial Number	ASU I/O Path
1	B1510A	SMU1:HP		
3	B1517A	SMU2:HR		
4	B1517A	SMU3:HR		
5	B1517A	SMU4:HR		
6	B1517A/E5288A	SMU5:HR/AS	* s/n mismatch	SMU
7	B1511A	SMU6:MP		
8	B1511A	SMU7:MP		
9	B1511A	SMU8:MP		
10	B1520A	CMU1:MF		

* NOTE: The specifications are satisfied and guaranteed for the exclusive combination of the ASU and the HRSMU. So confirm the serial number of the ASU and connect it to the dedicated HRSMU properly.

ASU I/O Path:

The ASU screen is available if the B1500A installs the HRSMU connected to the ASU (Atto Sense/Switch Unit), and shows the ASU information.

Slot: Slot number

Module Type: Type of module

Name: Module name or SMU name

ASU Serial Number: Serial number of the ASU connected to the HRSMU. This cell does not show the serial number if no ASU is connected or unpaired ASU is connected.

ASU I/O Path: ASU input to output connection, SMU or AUX

If the ASU I/O Path field is set to SMU, the ASU makes the path from the ASU Force input to the ASU output.

If the ASU I/O Path field is set to AUX, the ASU performs automatic switching in every test. The ASU makes the path from the AUX In input to the ASU output for the test without the HRSMU and makes the path from the ASU Force input to the ASU output for the test with the HRSMU.

Switching Matrix Configuration

General Information

Switching Matrix Type: B2200A Femto Leakage Switch MainFrame

GPIB Address: 22 Poll Start Self Test

B2200A/B2201A Input Port Configuration Extended Configuration

SWM IN1: SMU1:HP <input type="checkbox"/> Kelvin	SWM IN9:
SWM IN2:	SWM IN10:
SWM IN3: SMU2:HP <input type="checkbox"/> Kelvin	SWM IN11:
SWM IN4:	SWM IN12:
SWM IN5: SMU3:HR <input type="checkbox"/> Kelvin	SWM IN13: CMU1:MF <input type="checkbox"/> CMU
SWM IN6:	SWM IN14:
SWM IN7: SMU4:HR <input type="checkbox"/> Kelvin	
SWM IN8:	

The Switching Matrix screen is used to establish the GPIB connection with Agilent B2200A/B2201A/E5250A switching matrix and define the B2200A/B2201A/E5250A input port connections.

Switching Matrix Type: Displays the type of the switching matrix or No Switching Matrix.

GPIB Address: Specifies the GPIB address of the switching matrix. 1 to 30.

Poll: Confirms if the switching matrix of the specified GPIB address is connected to the B1500A.

Start Self Test: Starts the selftest of the switching matrix.

SWM IN#: Switching matrix input ports. Enter the label used to specify the input port to the right entry field. The port name and the connected module name can be the label. The character : (colon) cannot be used. Checking the Kelvin check box grays out the coupled even number port. Checking the CMU check box grays out SWM IN10 for the E5250A or SWM IN14 for the B2200A/B2201A. The input ports IN11 to IN14 are not available for the E5250A.

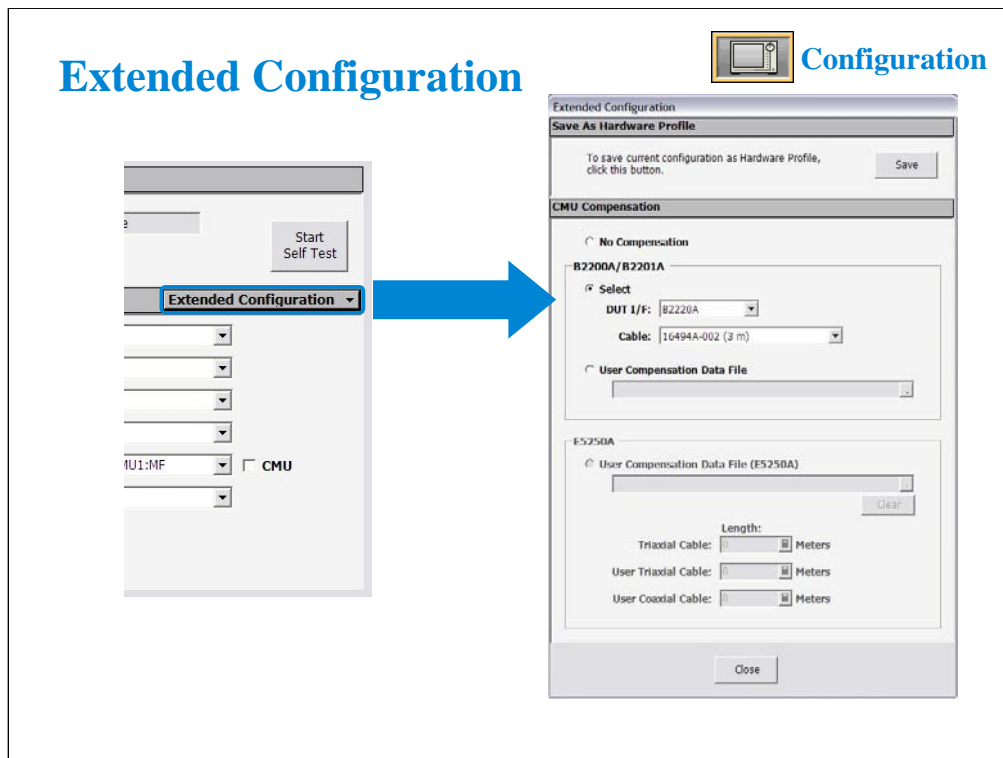
Kelvin: Check this box if this port is used for the Kelvin connection.

CMU: To perform capacitance measurement through the switching matrix, check this check box and set CMU1:MF to the SWM IN9 for the E5250A or the SWM IN13 for the B2200A/B2201A. And connect MFCMU to the Input 9 and 10 of the E5250A or the Input 13 and 14 of the B2200A/B2201A. To perform capacitance compensation, see User's Guide.

Extended Configuration: Opens the Extended Configuration dialog box. See the next page.

Note: Standard revision of EasyEXPERT does not support the E5250. The E5250 control is a feature of the B1540A-002/B1541A-002.

Note: The E5255A installed in the E5250A is not supported.



This dialog box is opened by clicking the Extended Configuration button in the Configuration window Switching Matrix screen.

Save as Hardware Profile is used to save the hardware profile that is the B2200A/B2201A/E5250A hardware configuration and the measurement module connection. Click the Save button to save the present hardware profile. The hardware profile can be made for each workspace individually.

CMU Compensation is used to select the compensation mode of the capacitance measurement using the B2200A/B2201A/E5250A. Click one of the radio buttons, No Compensation, Select, and User Compensation Data File. For the capacitance compensation, see User's Guide.

- No Compensation:

Select this radio button if you do not need the capacitance compensation. The raw data without compensation is displayed and saved.

- Select:

Select this radio button to perform the capacitance compensation for the path from the B2200A/B2201A input ports to Agilent 16495F/G connector plate or Agilent B2220A probe card interface. The data after compensation is displayed and saved.

DUT I/F field is used to specify the model number of the path you use. The selections are the 16495F/G and B2220A.


Cable field is used to specify the model number of the cable from the B2200A/B2201A output to the DUT I/F. The selections are the 16494A/B/C-001/002/005. This mode cannot perform the capacitance compensation for the cables to positioner/manipulator or the probe card.

- User Compensation Data File:

Select this radio button to perform the capacitance compensation for the path from the B2200A/B2201A/E5250A input ports to the end of positioner/manipulator or probe card. See User's Guide. The data after compensation is displayed and saved.

Note: Standard revision of EasyEXPERT does not support the E5250. The E5250 control is a feature of the B1540A-002/B1541A-002.

Note: The E5255A installed in the E5250A is not supported.

 **Configuration**

SMU/PG Selector

16440A SMU/PG Selector

☒ **Enable SMU/PG Selector**

	SMU Assignment:	Input/Output Path:
Selector CH1:	SMU2:HR	Normally PGU (AUX)
Selector CH2:	SMU3:HR	Always SMU
Selector CH3:	SMU4:HR	Normally PGU (AUX)
Selector CH4:	SMU5:HR	Always SMU

The SMU/PG Selector screen is used to specify the input connection and the channel connection status of the Agilent 16440A SMU/PG selector.

Enable SMU/PG Selector: Check this box to use the selector.

Selector CH1/CH2: Indicates the channels 1 and 2 of the first selector respectively.

Selector CH3/CH4: Indicates the channels 1 and 2 of the second selector respectively.

SMU Assignment: Specifies the SMU connected to the SMU input of the selector channel CH1, CH2, CH3, or CH4.

Input/Output Path: Specifies the connection status of the selector channel CH1, CH2, CH3, or CH4.

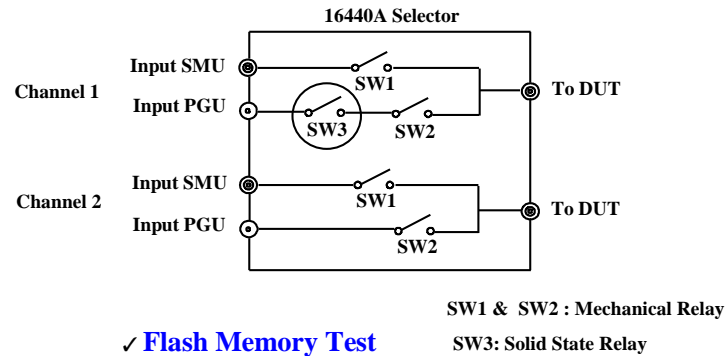
Always SMU: Makes the selector channel “SMU on” state.

Normally PGU (AUX): Performs automatic switching in every test. The selector channel normally makes the “PGU on” state and makes the “SMU on” state only for the test which uses the SMU connected to the Input SMU terminal.

The CH1 and CH3 also provides the “PGU open” state which is set by using the Advanced window of the Measurement Setup.

SMU/PG Selector

- Easy to switch between SMU and PGU
- Solid state relay

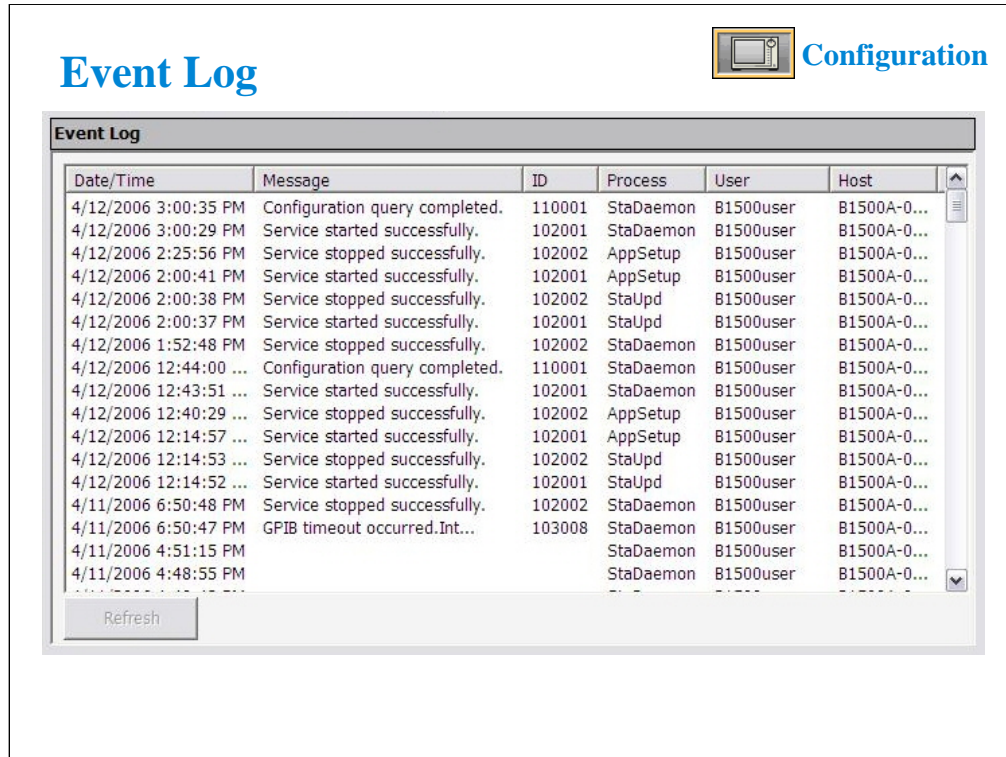


- ✓ Flash Memory Test
- ✓ Transistor photomons

The selector has two channels as shown above. Each channel has two ports (SMU and PGU). External pulse generators can also be connected. The connectors are Triax for SMUs and outputs, and BNC for PGUs.

Up to two selectors (four channels) may be required for some reliability tests such as Flash EEPROM.

As a special design for Flash memory, a solid state relay was added to float the drain. This eliminates wear and tear of millions of closures that would occur with a mechanical relay.



The Event Log screen displays the event log.

Date/Time: Displays date and time of the event.

Message: Event message

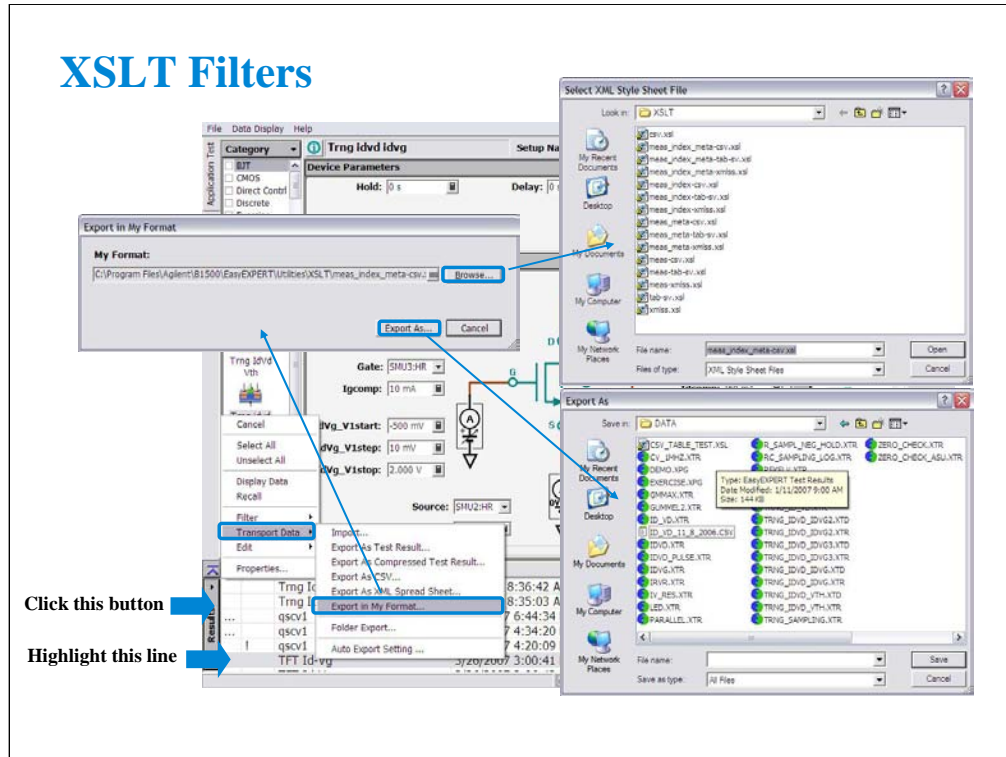
ID: Process ID of the event

Process: Process name

User: User name. Windows login name.

Host: Host name of the B1500

The Refresh button refreshes the event log.



The XSLT (XSL-Transformation, eXtensible Stylesheet Language Transformation) filter files are used to export test records. The fifteen filter files listed below are stored in the C:\Program Files\Agilent\B1500\EasyExpert\Utilities\XSLT folder.

The following filter files are used for exporting the measurement data only.
meas-csv.xml, meas-tab-sv.xml, meas-xmlss.xml

The following filter files are used for exporting the measurement data with the index.
meas-index-csv.xml, meas-index-tab-sv.xml, meas-index-xmlss.xml

The following filter files are used for exporting the measurement data with the meta data.
meas-meta-csv.xml, meas-meta-tab-sv.xml, meas-meta-xmlss.xml

The following filter files are used for exporting the measurement data with the index and the meta data.

meas-index-meta-csv.xml, meas-index-meta-tab-sv.xml, meas-index-meta-xmlss.xml

The following filter files are used for exporting all data including the test setup.
csv.xml, tab-sv.xml, xmlss.xml

Where, the meta data contains the test name, the setup name, the record time of the test results, the device ID, the counter number, the flag of the test results, and the remarks on the test results.

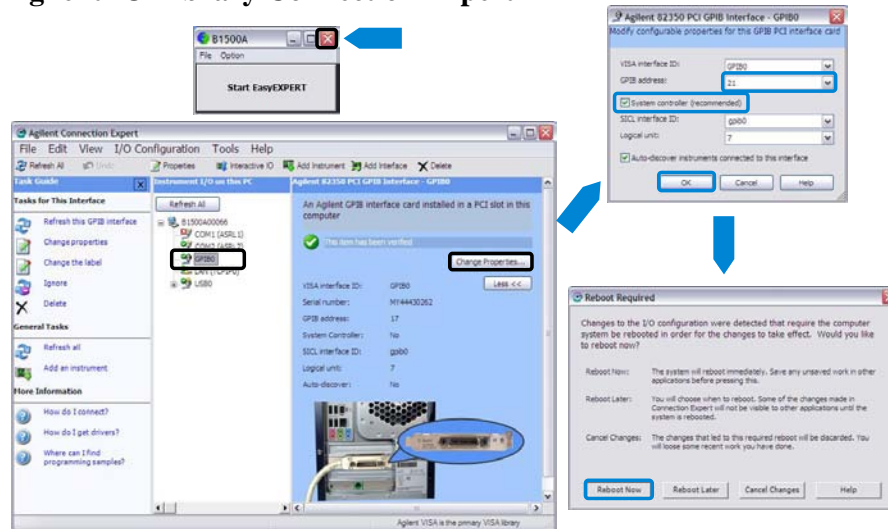
Filter files that contain *xmlss* in the file name export test record in the XML Spread Sheet format.

Filter files that contain *csv* or *tab-sv* in the file name use a comma or a tab for the data separator.

For more information, see online help or User's Guide.

To Enable System Controller

Agilent IO Library Connection Expert



To control external GPIB devices, the B1500A must be set to system controller. Exit the EasyEXPERT, and close the Start EasyEXPERT window. After that, launch the Agilent Connection Expert by clicking Start, All Programs, Agilent IO Library Suite, and Agilent connection Expert.

On the Agilent Connection Expert, change the GPIB configuration of the B1500A.

- Select GPIB0.
- Click Change Properties... button.
- Change GPIB address to 21 that is the typical address number for the system controller.
- Check System controller box.
- Click OK button.
- Reboot the B1500A.

To Start Desktop EasyEXPERT

Execution Mode

GPIB Communication

☐ Online

VISA interface ID: GPIB0

GPIB address: 7

☒ Offline

Model: B1500A

OK Cancel

EasyEXPERT Database

Move To

EasyEXPERT Database Path:

..User#1

Browse...

OK Cancel

Database Backup Creation Wizard

Database Restoration Wizard

Important:
To set the same configuration as the B1500A, copy the following file from B1500A to your PC. The location must be the same.

\\Documents and Settings\\All Users\\Application Data\\Agilent Technologies, Inc\\EasyEXPERT\\UnitConfigB1500A.xml

To open the Start EasyEXPERT window, click Start > Programs > Start EasyEXPERT menu. This window provides the Option menu used to open the following dialog box.

Gpib Communication:

Select Online if the B1500A, 4155B/C, or 4156B/C is connected to your computer and you want to control it via GPIB. Or else select Offline.

Database Backup Creation Wizard:

Use this wizard to create the EasyEXPERT database backup (xdb file).

Database Restoration Wizard:

Use this wizard to restore the EasyEXPERT database backup. The wizard can restore the xdb file or the backup which is a copy of the folder that contains the EasyEXPERT database.

EasyEXPERT Database:

Specify the EasyEXPERT Database path if you want to move the database to the other folder.

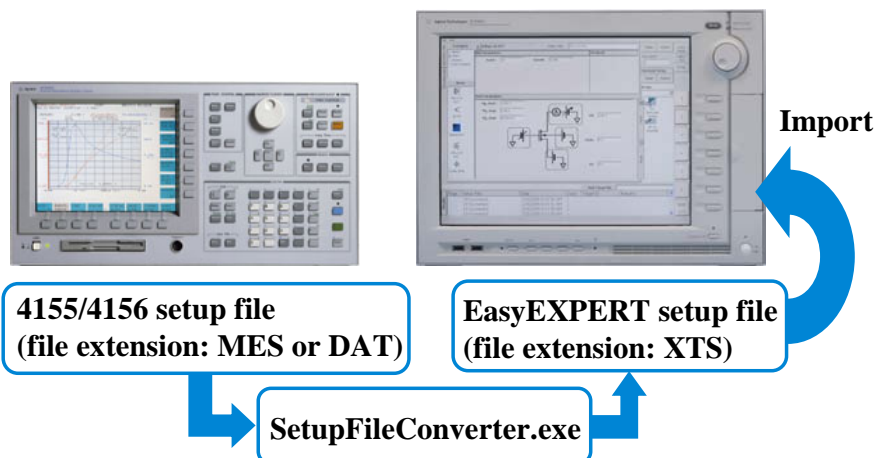
To launch Desktop EasyEXPERT, click the Start EasyEXPERT button.

Note: Desktop EasyEXPERT supports most of the EasyEXPERT functions. However, some functions are not supported on an external computers due to differences in hardware and so on.

Note: For the installation procedure, see the readme file stored in the Desktop EasyEXPERT CD-ROM.

Note: For the offline mode. To use the same module configuration as the B1500A, copy the UnitConfigB1500A.xml file to your PC which the Desktop EasyEXPERT runs. The file is stored in the B1500A hard disk drive. The location is shown in the slide. The file must be copied to the same location in your PC.

To Use 415x Setup File Converter



Execution example:

```
C:\Mydata>SetupFileConverter.exe setup1.dat
C:\Mydata>SetupFileConverter.exe *.mes
```

You can reuse the 4155/4156 setup file (MES file or DAT file) for the test using EasyEXPERT. This is realized by Setup File Converter which has the function to create the XTS file by converting the MES or DAT file to the EasyEXPERT format. This executable file is stored in the following folder.

C:\Program Files\Agilent\B1500A\EasyEXPERT\Utilities

You can execute the setup file converter on the Command Prompt as shown below. If you want to use the Windows desktop instead of the Command Prompt, see the next page.

1. Create your working folder (for example, C:\415xdata).
2. Copy your MES or DAT files to this folder.
3. Copy SetupFileConverter.exe file to this folder.
4. Launch the Command Prompt.
5. Go to your working folder (for example, C:\> cd 415xdata).
6. Execute SetupFileConverter.exe as shown in the following example.

```
C:\415xdata> SetupFileConverter.exe *.MES
```

This example converts all MES files in your working folder to the EasyEXPERT setup file format, and creates the XTS files in this folder.

Note: If you execute the setup file converter without the parameter, the help message will be displayed.

Note: The setup file converter provides some options. See User's Guide or online help for the options.

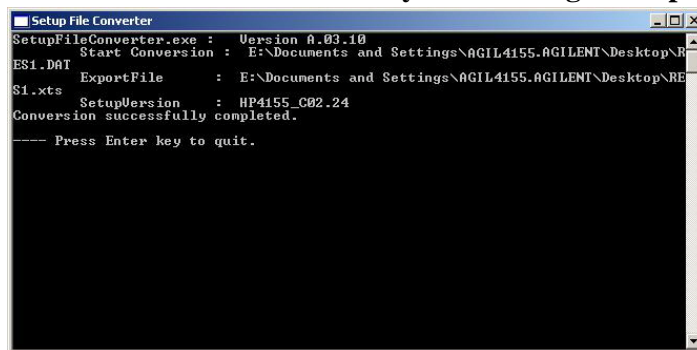
To Use 415x Setup File Converter

1. Drag and drop the shortcuts of the MES/DAT file on the shortcut of the Setup File Converter.



3. XTS file and shortcut are created.

2. File conversion is executed and system message is displayed.



You can perform the file conversion on the Windows desktop as follows.

1. Create a shortcut of the SetupFileConverter.exe on the desktop.
2. Copy your MES/DAT files to the desktop.
3. Drag and drop the shortcuts of the MES/DAT files on the shortcut of SetupFileConverter.

This starts the file conversion and displays the system message. And if the conversion is completed successfully, the setup file converter creates the XTS files and the shortcuts on the desktop.

Note: The setup file converter provides some options. See User's Guide or online help for the options.

In This Module

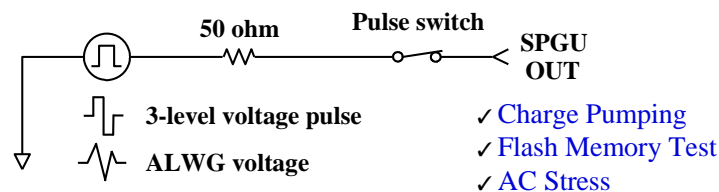
- **High Voltage SPGU**
- **SPGU Control**
- **Pulse Generator Mode**
- **Charge Pumping**
- **Flash Memory Test**
- **ALWG Mode**

Note:

High Voltage SPGU

High Voltage Semiconductor Pulse Generator Unit

- 2 channels per module
- Output impedance: 50 ohm
- Amplitude: +/-40 V (open load), +/-20 V (50 ohm load)
- PG mode or ALWG mode
- Free run, duration, or count
- 2- or 3-level pulse output for each channel in PG mode
- Pulse switch
- Automatic voltage level adjustment

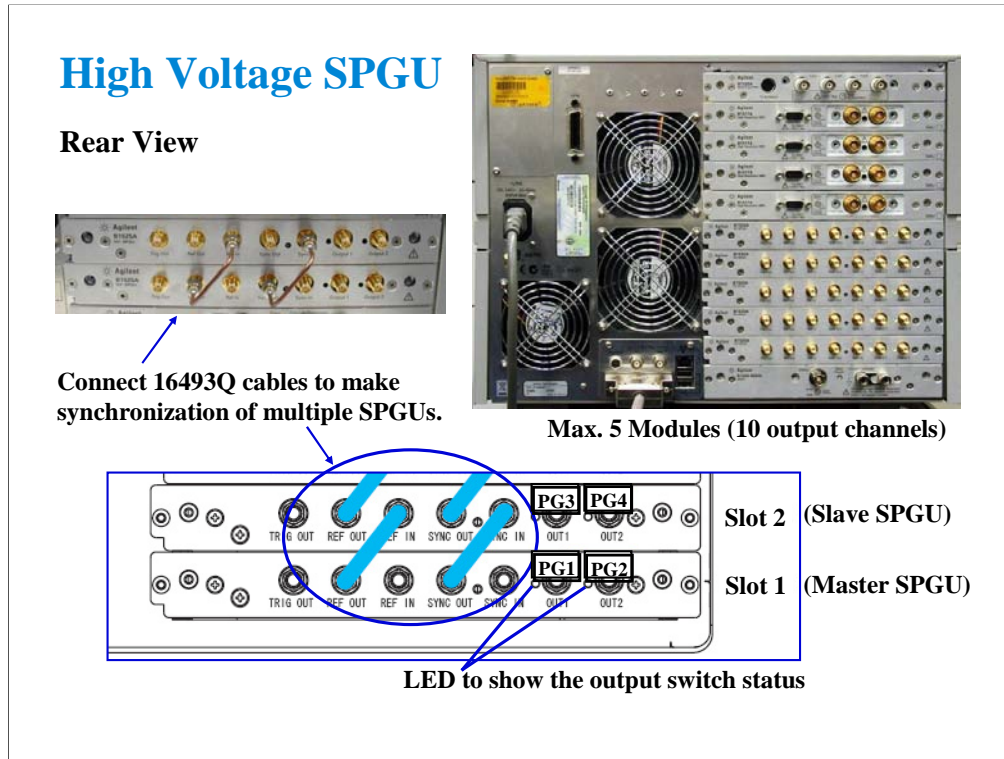


High Voltage Semiconductor Pulse Generator Unit (HVSPGU) is specially designed for semiconductor test. Most pulse generators' output voltage is less than 10 V with 50 ohm impedance. However, in semiconductor test (especially reliability test) 30 to 40 V capability is required for the flash memory write/erase cycle test. The HVSPGU output voltage is 40 V at open load.

The HVSPGU provides two output mode, PG mode and ALWG mode. In the PG mode, the HVSPGU can output 2- or 3-level voltage pulse. And in the ALWG mode, it can output an arbitrary linear waveform voltage.

The pulse switch is built into the SPGU channel for performing the endurance test of the NOR type flash memory effectively. The SPGU channel can output the drain pulse for the write operation and make the open status for the erase operation in one pulse period.

The output impedance of the SPGU is fixed to 50 ohm. However, the SPGU channel can output the voltage close to the setting value if you specify the load impedance of DUT properly. Because the channel automatically adjusts the output level by using the specified load impedance value.



The B1500A can install the maximum of five SPGUs. The SPGUs must be installed in the contiguous slots from the slot 1. Where the SPGU installed in the slot 1 is the master SPGU. The channel number PG1 is assigned for the Output 1 of the master SPGU. And the following numbers are assigned for the subsequent channels.

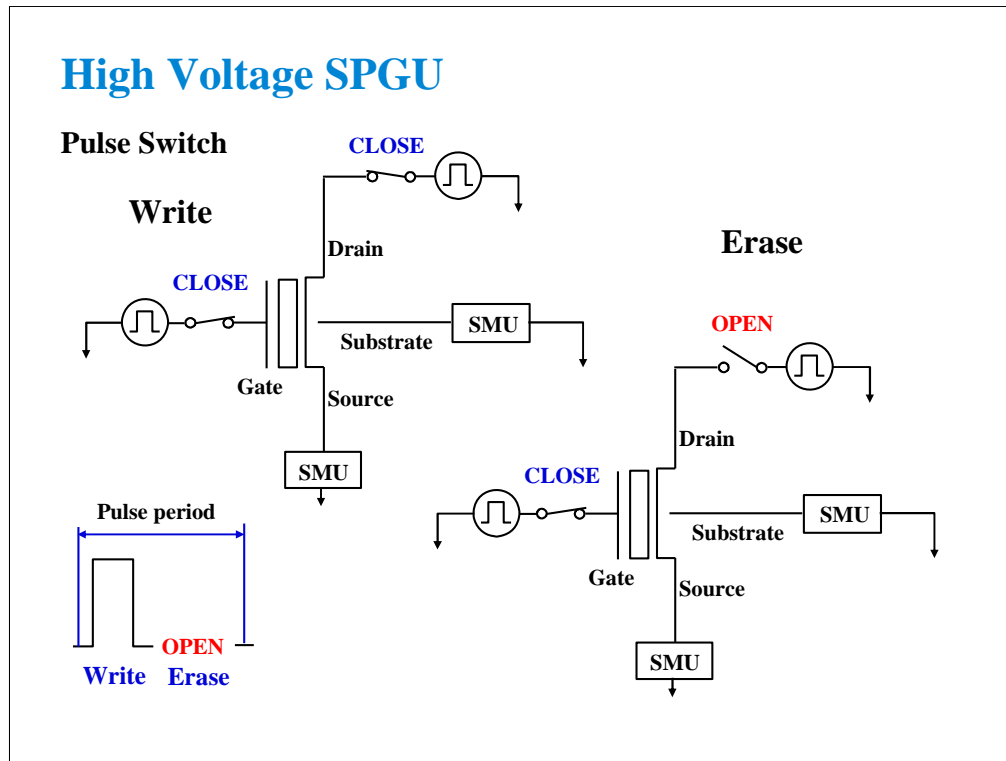
The SPGU has seven connectors.

The Output connectors are for the SPGU signal output.

The Ref In/Out and Sync In/Out connectors are for making synchronization of multiple modules.

The Trig Out connector outputs the trigger signal used to make synchronization with the external instruments.

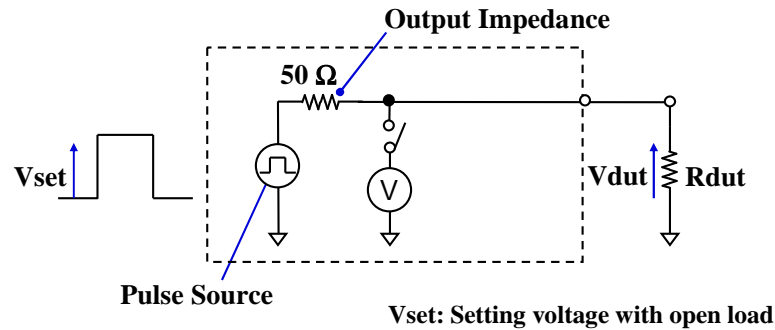
If the multiple SPGU modules are installed, the 16493Q cables must be connected between the Ref Out connector and the Ref In connector and between the Sync Out connector and the Sync In connector as shown above. This is necessary to synchronize the module outputs.



The pulse switch is the built-in high speed analog switch to open/close the SPGU output for each channel. This switch is used in the write/erase cycle of the NOR type flash memory cell test. This dramatically improves throughput of the endurance test (write/erase lifetime reliability test). The SPGU channel can output the drain pulse for the write operation and make the open status for the erase operation in one pulse period.

High Voltage SPGU

Effects of Load Impedance



$$V_{dut} = V_{set} \times \frac{R_{dut}}{R_{dut} + 50}$$

The voltage actually applied to the DUT depends on its impedance. This behavior is very common among the instrumentations like DC power supply and pulse generators. In this meaning, SMU is very special because the output of SMU is controlled by the feedback loop from the voltage monitored by the sense terminal.

If R_{dut} is large enough (ex. gate terminal) compared with 50 ohm output impedance, V_{dut} is almost equal to V_{set} .

If R_{dut} is not so large (ex. drain terminal at the ON state), the difference between V_{dut} and V_{set} is not negligible. In the case of 1 mA current with 1 V bias (= 1 kohm), the difference will be about 5 %.

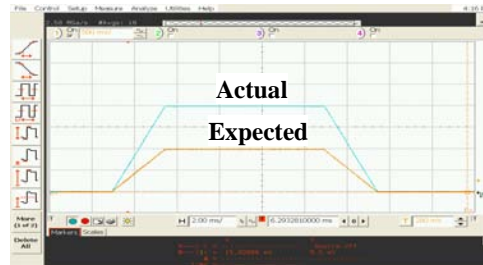
The SPGU provides the function to adjust the output voltage automatically. To use this function properly, the load impedance of DUT must be registered and it must be accurate. Then the SPGU can apply the voltage near the setting value to the DUT.

High Voltage SPGU

Effects of Load Impedance

Mismatch of load impedance setting may cause the error of applied voltage to the DUT.

Setup: 1 V output, 50 Ω load
Actual load: 1 M Ω \rightarrow 2 V output



Setup: 1 V output, 1 M Ω load
Actual load: 50 Ω \rightarrow 0.5 V output

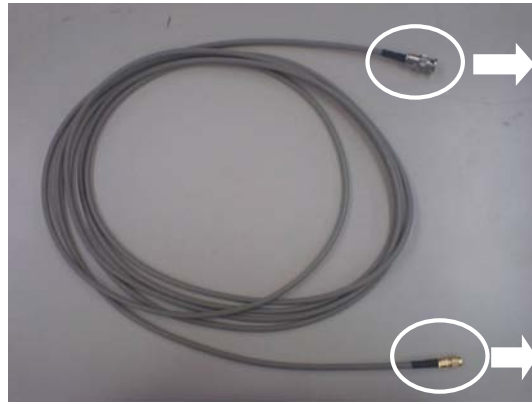


Here is the example of the voltage error due to the mismatch of the load impedance setting.

If the load impedance is set to 50 ohm when the actual load impedance is 1 Mohm, the voltage actually applied to the DUT is about double the setting value. If the load impedance is set to 1 Mohm when the actual load impedance is 50 ohm, the voltage actually applied to the DUT is about half the setting value. So the load impedance value must be accurate to apply the voltage near the setting value to the DUT.

High Voltage SPGU

Agilent 16493P BNC (m) - SMA (m) Cable



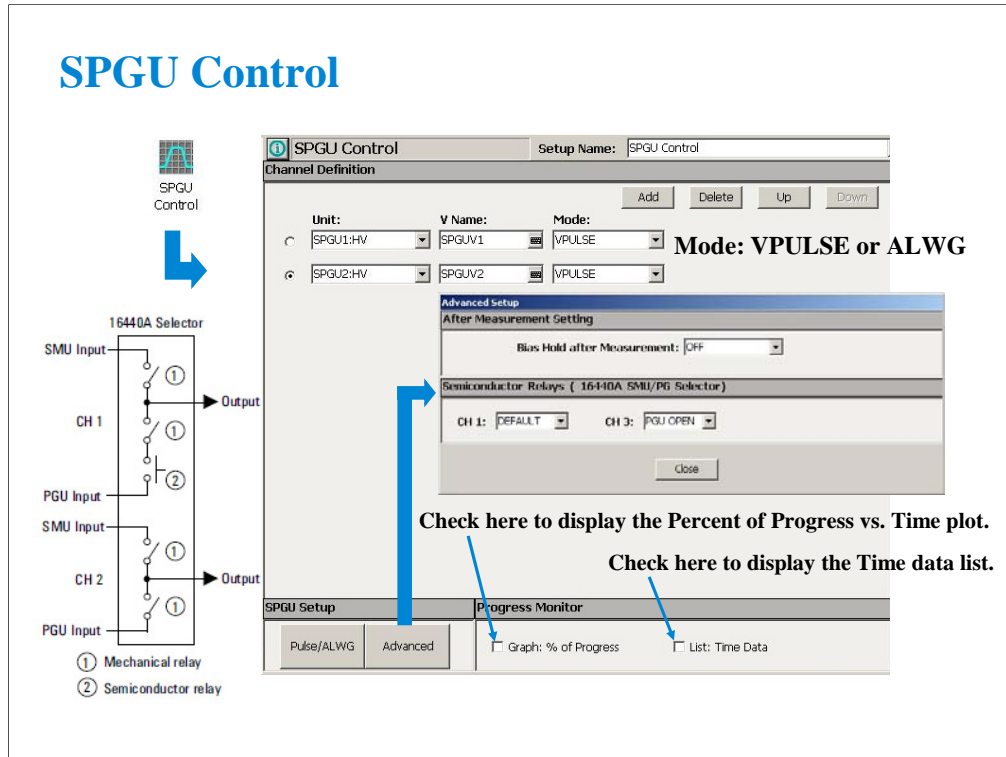
BNC (m) connector:

- To connector plate
- To 16442A/B test fixture
- To 16440A SMU/PGU selector
- To E5288A ASU
(Atto Sense and Switch Unit)

SMA (m) connector:

- To SPGU output

Agilent 16493P is the connection cable for the SPGU outputs.



The SPGU can be used in the classic test other than the C-V Sweep and the Switching Matrix Control. So you can use the SPGU output while a measurement is performed. If you need the SPGU output only, use the SPGU Control classic test. In this classic test, the single button triggers the SPGU outputs, and the Data Display works as the progress monitor.

The SPGU provides two output mode, VPULSE (pulse generator mode) and ALWG (arbitrary linear waveform generator mode). And the same mode must be set to the all output channels. The B1500A can have the maximum of ten SPGU output channels.

The Advanced button opens the Advanced Setup dialog box. The dialog box is used to set the after measurement settings and the 16440A selector semiconductor relay setting.

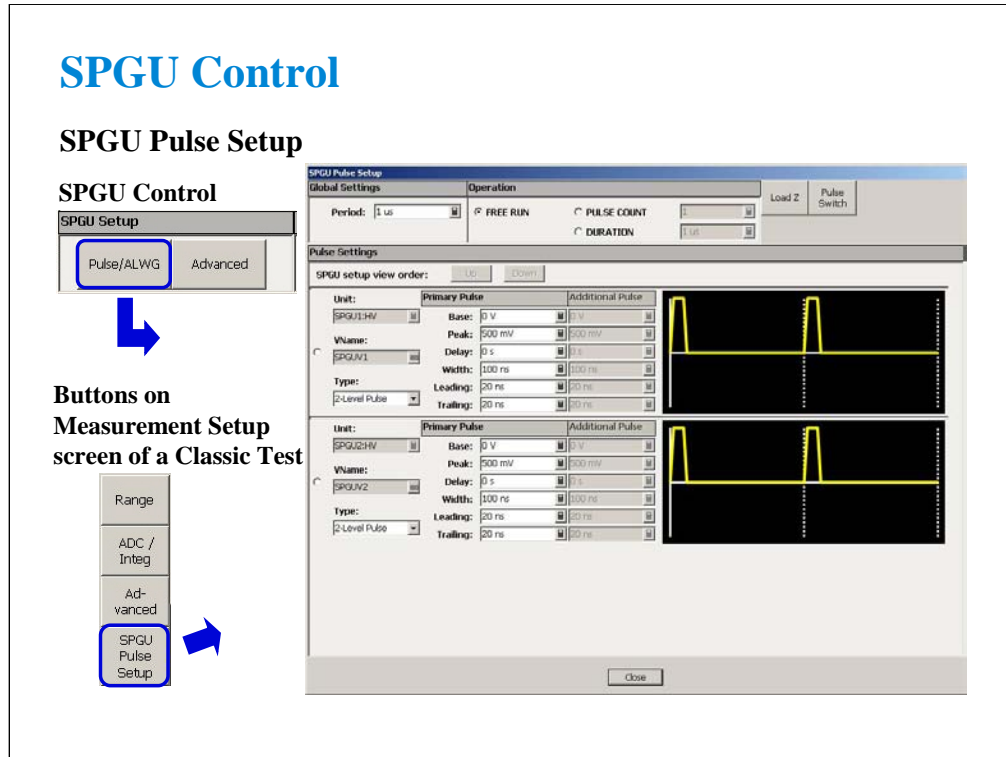
After Measurement Setting:

- Bias Hold after Measurement: Bias hold function ON or OFF.

Semiconductor Relays (16440A SMU/PG Selector):

- CH1: Default or PGU OPEN
- CH3: Default or PGU OPEN

The fields define the selector channel's switch condition during the measurement. Default means the setting defined on the SMU/PG Selector screen of the Configuration window.



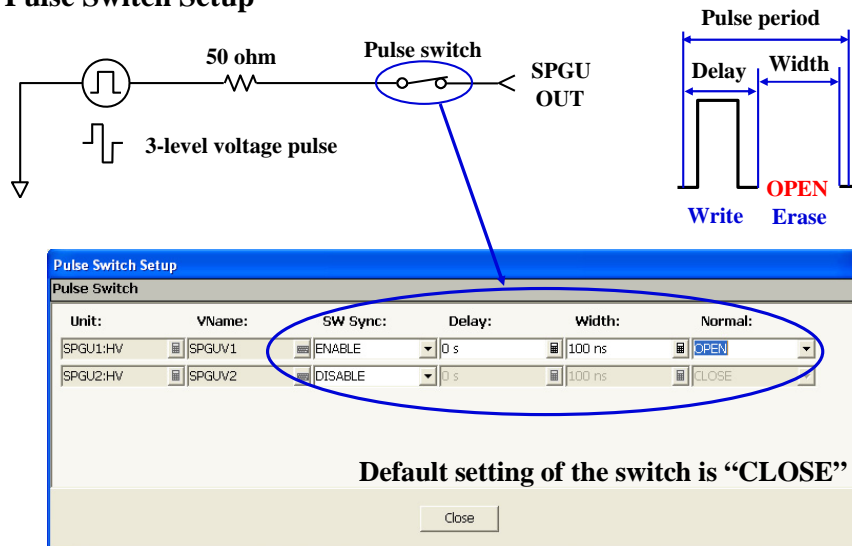
If the SPGU output mode is set to VPULSE, the Pulse/ALWG button opens the SPGU Pulse Setup window. This window is used to define the voltage pulses applied by the specified SPGU channels. For the setup parameters, see later page titled Pulse Setup Parameters of Pulse Generator Mode. In the other classic test, this window is opened by the SPGU Pulse Setup button on the Measurement Setup screen.

The Pulse Switch button opens the dialog box used to set the pulse switch operation.

The Load Z button opens the dialog box used to set the load impedance of the DUT.

SPGU Control

Pulse Switch Setup



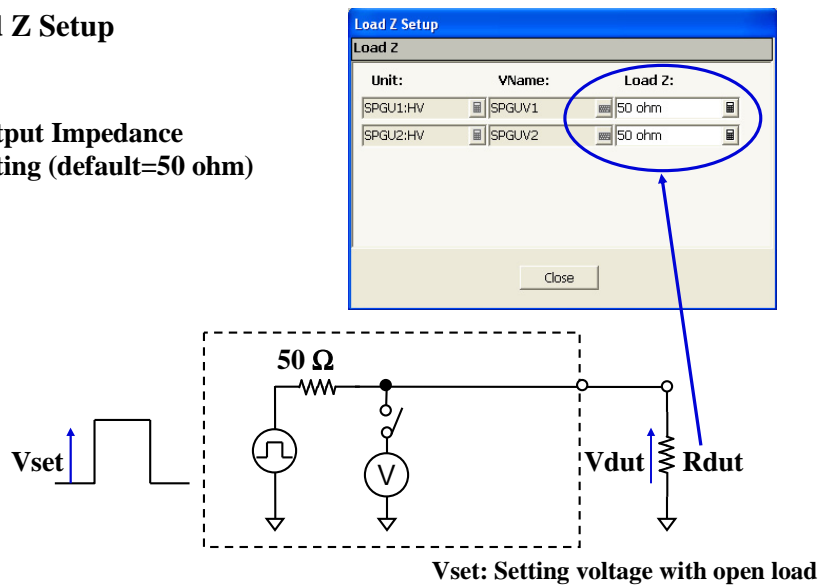
You can set the pulse switch operation on the Pulse Switch Setup dialog box. Set the SW Sync to ENABLE to use the pulse switch. The delay time is the time from start of pulse output to changeover of pulse switch. The width is the duration to hold the switched state of the pulse switch. And the normal field specifies the pulse switch status OPEN or CLOSE at the normal state which is not the switched state.

Recommended width value is more than 100 us because of the time lag for changeover.

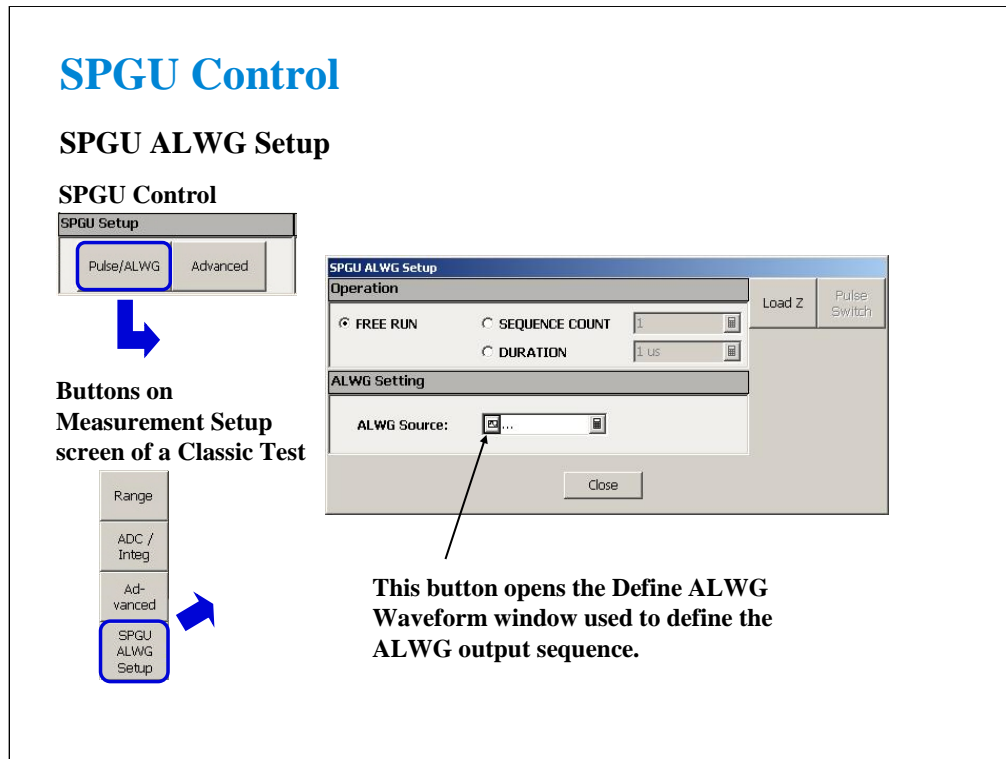
SPGU Control

Load Z Setup

**Output Impedance
Setting (default=50 ohm)**



You can specify the load impedance of DUT on the Load Z Setup dialog box. By setting the load impedance value accurately, the SPGU can apply the voltage near the setting value to the DUT.

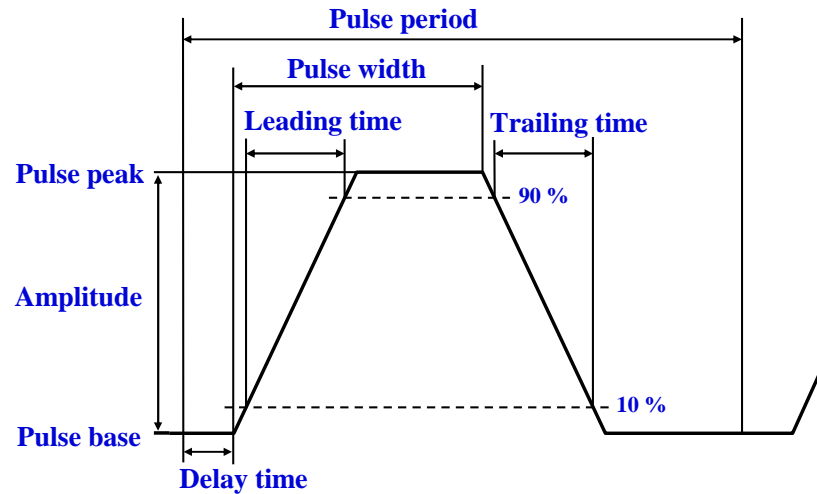


If the SPGU output mode is set to ALWG, the Pulse/ALWG button opens the SPGU ALWG Setup window. This window is used to define the arbitrary linear waveform voltage applied by the specified SPGU channels. In the other classic test, this window is opened by the SPGU ALWG Setup button on the Measurement Setup screen.

The Load Z button opens the dialog box used to set the load impedance of the DUT.

Pulse Generator Mode

Pulse Setup Parameters

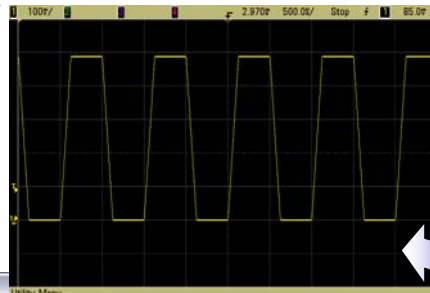


The pulse setup parameters are defined as shown above.

The pulse leading time and trailing time are defined as the voltage transition time between 10 % and 90 % of the amplitude. Minimum setting value is 8 ns.

Pulse Generator Mode

Pulse output example:



2. SPGU Pulse Setup window

SPGU Pulse Setup															
Global Settings	Operation														
Period: 1 ms	<input type="radio"/> FREE RUN <input checked="" type="radio"/> PULSE COUNT: 10 <input type="radio"/> DURATION: 1 us														
Pulse Settings SPGU setup view order: Up Down															
Unit: SPGU1:HV VName: SPGUV1 Type: 2-Level Pulse	<table border="1"> <thead> <tr> <th>Primary Pulse</th> <th>Additional Pulse</th> </tr> </thead> <tbody> <tr> <td>Base: 0 V</td> <td>Base: 0 V</td> </tr> <tr> <td>Peak: 500 mV</td> <td>Peak: 500 mV</td> </tr> <tr> <td>Delay: 0 s</td> <td>Delay: 0 s</td> </tr> <tr> <td>Width: 500 us</td> <td>Width: 100 ns</td> </tr> <tr> <td>Leading: 100 us</td> <td>Leading: 20 ns</td> </tr> <tr> <td>Trailing: 100 us</td> <td>Trailing: 20 ns</td> </tr> </tbody> </table>	Primary Pulse	Additional Pulse	Base: 0 V	Base: 0 V	Peak: 500 mV	Peak: 500 mV	Delay: 0 s	Delay: 0 s	Width: 500 us	Width: 100 ns	Leading: 100 us	Leading: 20 ns	Trailing: 100 us	Trailing: 20 ns
Primary Pulse	Additional Pulse														
Base: 0 V	Base: 0 V														
Peak: 500 mV	Peak: 500 mV														
Delay: 0 s	Delay: 0 s														
Width: 500 us	Width: 100 ns														
Leading: 100 us	Leading: 20 ns														
Trailing: 100 us	Trailing: 20 ns														

3. Pulse setup parameters

To apply the SPGU pulse output, set the pulse setup parameters, specify the Operation, and click the Single button.

The following operations are available.

PULSE COUNT: SPGU outputs the specified number of pulses. Specify a number within the range of 1 to 1000000.

DURATION: SPGU continues the output until the specified time elapses. Specify a time within the range of 1 us to 31556926 s (1 year).

FREE RUN: SPGU continues the output until the measurement is completed or stopped. This operation is not available for the SPGU Control classic test.

To set the pulse setup parameters,

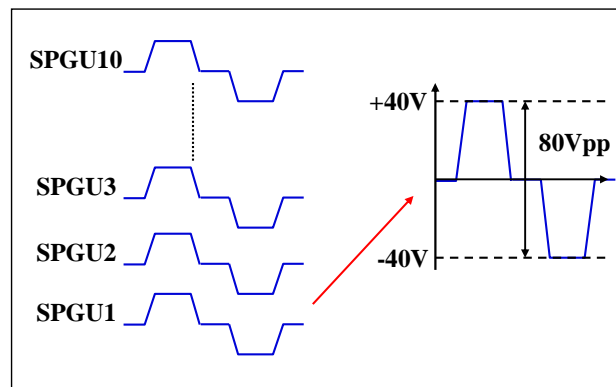
1. Display the SPGU Control classic test screen or the Measurement Setup screen of the other classic test.
2. Open the SPGU Pulse Setup window by clicking the Pulse/ALWG button on the SPGU Control classic test screen or the SPGU Pulse Setup button on the Measurement Setup screen.
3. Set the Type, Period, and Primary Pulse parameters. For the pulse setup parameters, see the previous page.

For the 3-level pulse, select the 3-Level Pulse type. Then the Additional Pulse fields will be active. The 3-level pulse is defined as sum of two 2-level pulses, Primary Pulse and Additional Pulse.

Pulse Generator Mode

3-Level Pulses

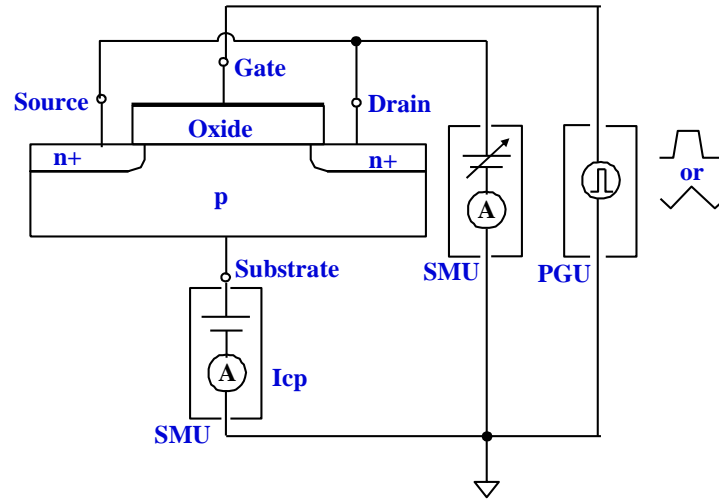
- Every channel can output 3-level pulse
80 Vp-p within +/-40 V window (at open load)
- Pulse width and level of each channel can be set individually.



Up to 10 output channels can be installed in one B1500A and each channel can output 3-level pulse with a maximum output voltage.

The channels are independent. So the channels can apply the different pulses. However, the pulse period value is common for all channels.

Charge Pumping



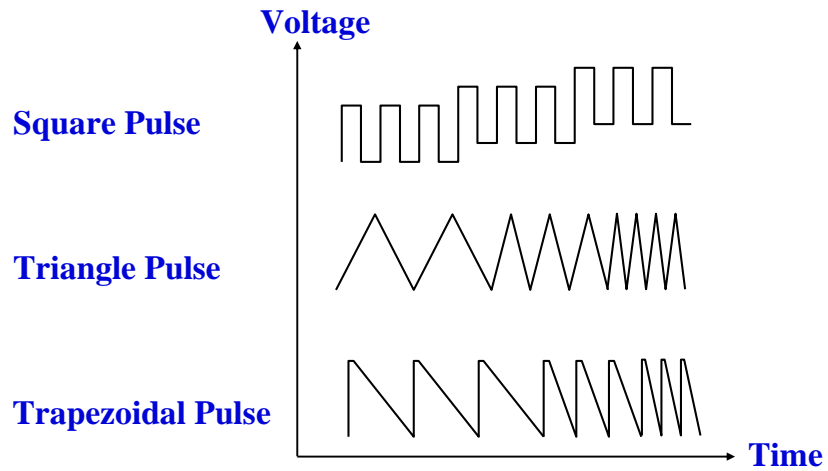
Charge pumping is a type of hot carrier measurement. It provides direct measurement of interface states and an indication of electron and hole trapping.

The gate of the MOS transistor is connected to a pulse generator. The current (I_{cp}) is caused by the repetitive recombination of minority carriers with majority carriers at the silicon-silicon oxide interface.

Charge Pumping

Three Methods of Charge Pumping

Gate Waveforms



Square Pulse

The base of the pulse is stepped from well below gate threshold to well above. At each step, the substrate leakage current is monitored. The flat part of the resultant curve is proportional to interface-state density.

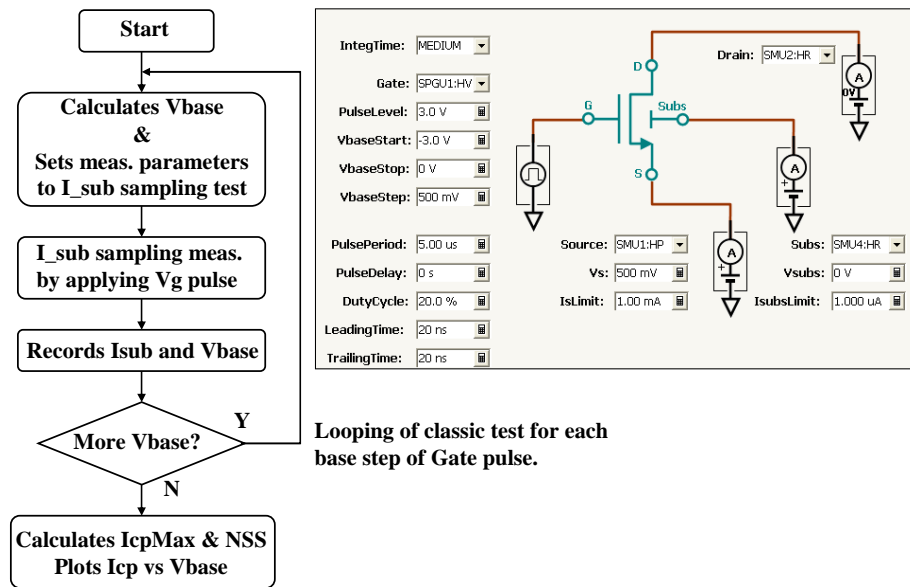
Triangle Pulse

The frequency of a constant height triangle pulse is increased in steps. At each step, substrate leakage is measured. Average interface state density and capture cross-section are measured by this method.

Trapezoidal Pulse

A fixed height pulse is applied to the gate. By varying the leading/trailing edge of the pulse, you can plot interface-state density vs energy.

Charge Pumping



I_{cp} is measured after each increment of the gate pulse base value. A curve of I_{cp} vs base value is plotted. The maximum I_{cp} value is noted. At this point:

$$I_{cp} = f * Q_{ss}$$

$$= f * A_g * q * D_{it}$$

where

f : pulse frequency

Q_{ss} : recombined charge per pulse period

A_g : channel area of the transistor

q : electron charge

D_{it} : interface state density

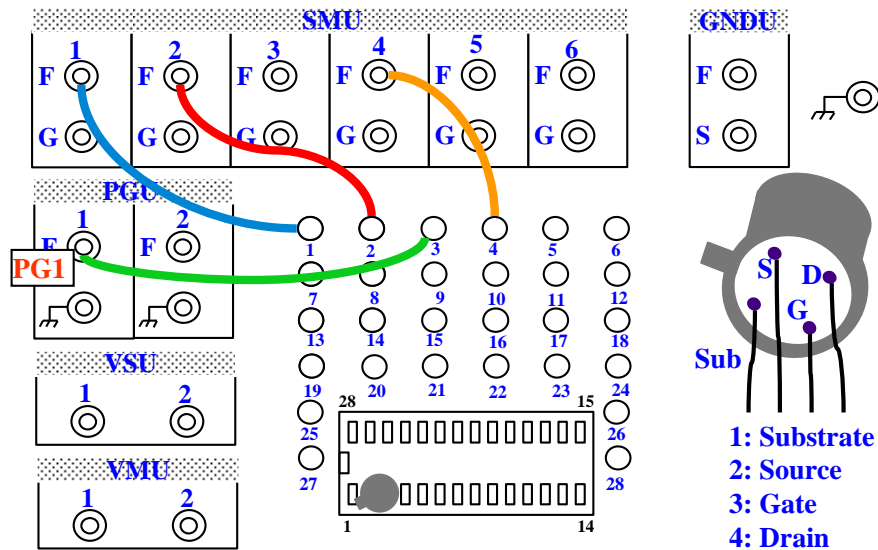
Class Exercise

Square Pulse Charge Pumping

1. **Recall the Charge Pumping 4T 0.1V step test record.**
2. **Connect the DUT (MOS FET) as shown in the next page.**
3. **Specify the module (SMU and PGU) connected to DUT terminal properly.**
4. **Perform the test.**

Note:

Jumper Leads – MOS transistor



For all class exercises, you need the 28-pin dual in line socket which comes standard with the 4145 fixture (16058A) or the newer fixture (16442A/B). Either fixture works fine.

This class exercise requires four jumper leads to connect the DUT. Connect the jumper leads between the following terminals.

SMU1 : terminal 1

SMU2 : terminal 2

SMU4 : terminal 4

PGU1 : terminal 3

Then, the modules must be connected to the fixture as shown below.

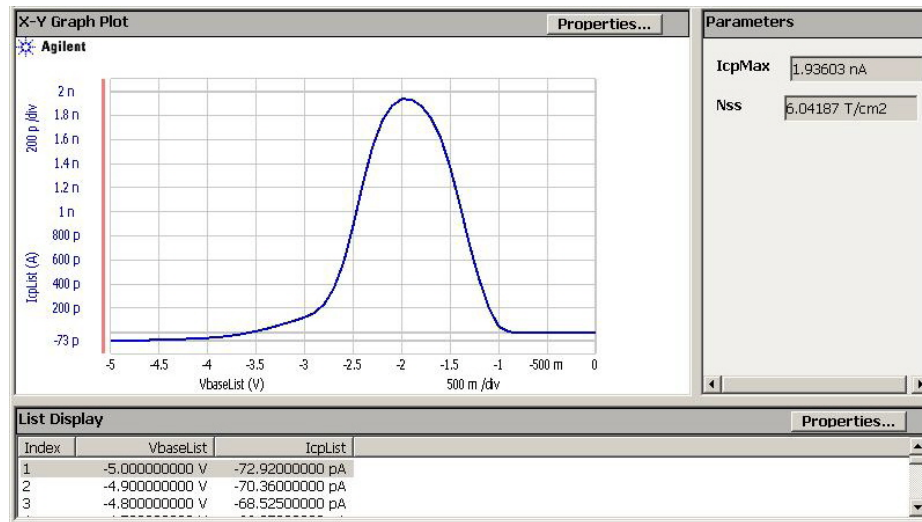
B1500A SMU1 -> Fixture SMU1 connector

B1500A SMU2 -> Fixture SMU2 connector

B1500A SMU4 -> Fixture SMU4 connector

B1500A PGU1 -> Fixture PGU1 connector

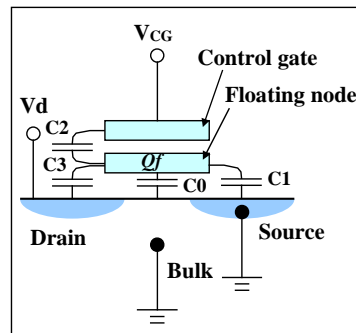
Measurement Result Example



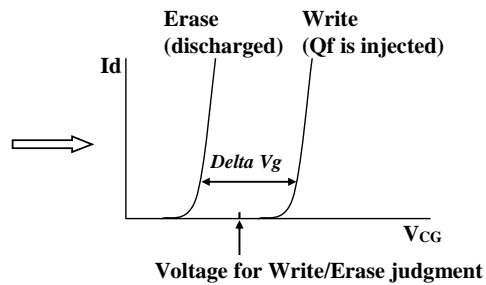
Here we see the result of plotting I_{cp} vs pulse base voltage.

Flash Memory

Basic Flash memory Cell Structure



Q_f is injected (by a pulse) to write the memory

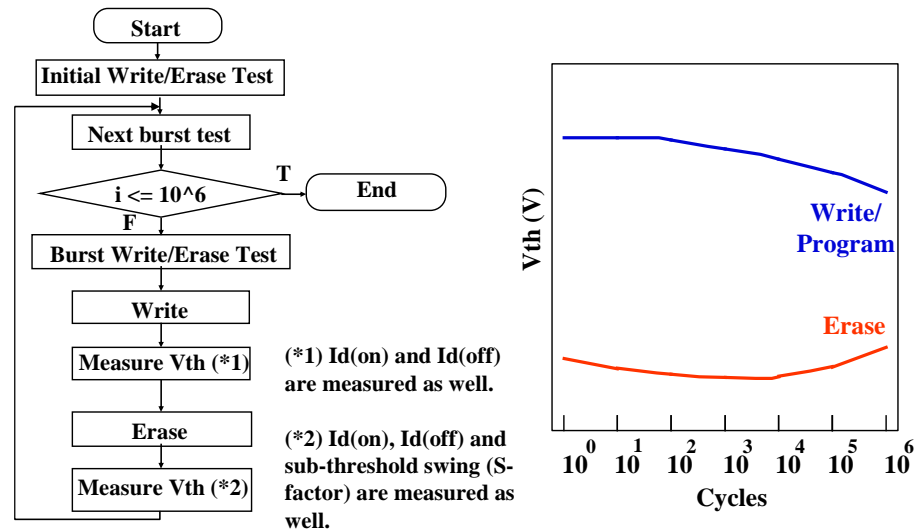


Effective gate voltage shifts $\Delta V_g = Q_f/C_f$.
 C_f is effective floating gate capacitance.

Flash memory is one type of floating gate memory. The left figure shows the structure of the floating gate memory cell. There is a metal floating node on the top of transistor channel region. Any stored charge in this floating node shifts its threshold voltage as shown in the right figure.

Flash Memory – Endurance Test

1 million Write/Erase cycle test



Endurance test is a kind of reliability tests. Repetitive write (program) and erase pulses are applied to the cell and the Vth of the cell is monitored after certain number of pulses are applied. This test is important because the flash memory is used for the data and file storage application. Then the failure rate must be less than one percent for one million write/erase cycles. Therefore, for device development, the endurance test is the critical test to make sure that the durability of the cell can meet the target.

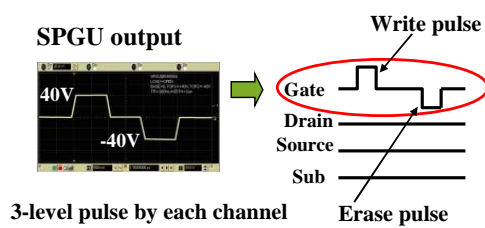
When measuring characteristics after certain number of write-erase cycling, Id(on) and Id(off) are measured besides Vth depending on the cell type. In case of the cell types which use the F-N tunneling between substrate and floating gate, sub-threshold swing is also measured after erasing the cell.

Flash Memory – Endurance Test

NAND Cell Test

- Burst write/erase reduces test time dramatically

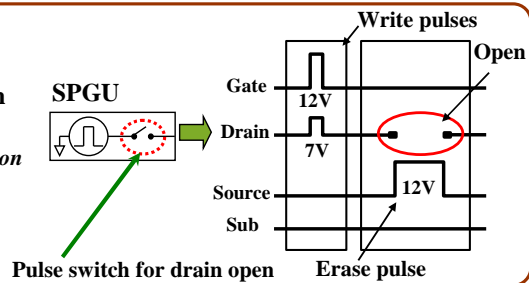
In an example, the test time was less than 2 hours for 1 million cycle test. It will be about 1/70 compared with 4155/4156 solution.



NOR Cell Test

- Drain open can be made by opening the analog switch in the HVSPGU.

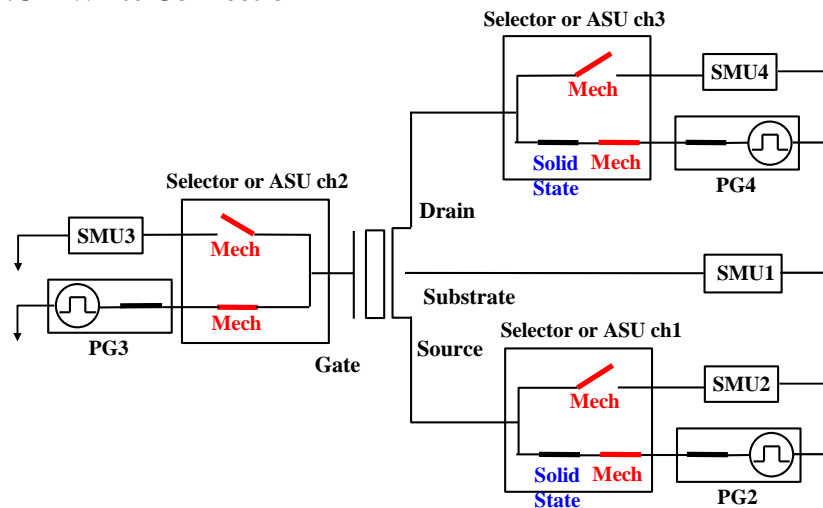
For 1 million cycle test, 2PG solution improves the test time about 1/4 compared with 4155/4156 solution. 3PG solution improves it about 1/4 compared with 2PG solution.



Note:

Flash Memory – Endurance Test

NOR Write Connection



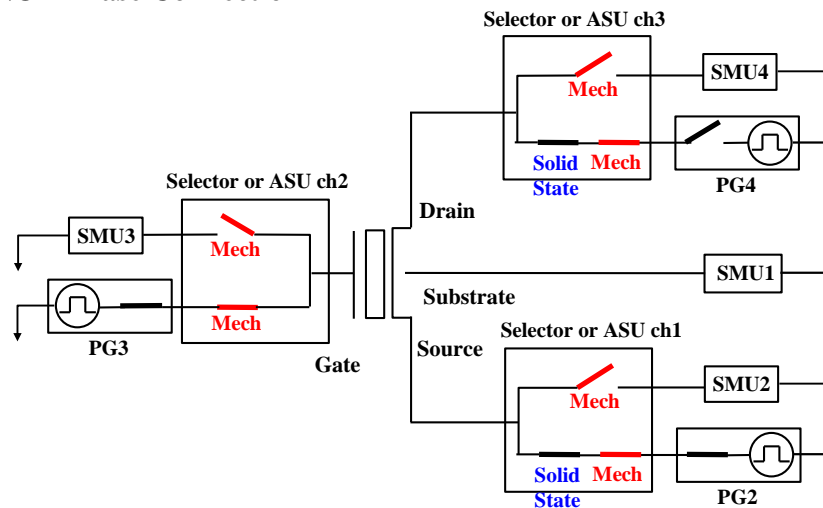
This is an example setup to perform the write operation of the NOR type flash memory cell. This setup uses three sets of the SMU, SPGU, and selector/ASU. This setup is used by the Demo-S-NorFlash Endurance test shown in Class Exercise.

To perform the write operation, all of the selector/ASU channels must make the path to the PG.

Note: The solid state relay is installed in the selector, but not installed in the ASU.

Flash Memory – Endurance Test

NOR Erase Connection

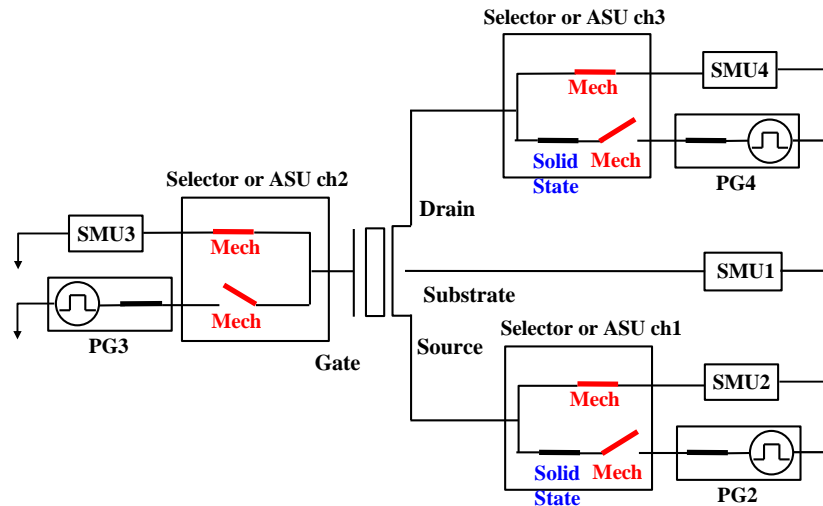


This is an example setup to perform the erase operation of the NOR type flash memory cell. To perform the erase operation, all of the selector/ASU channels must make the path to the PG and the PG3 internal pulse switch must be opened. The pulse switch is also a solid state relay.

Note that the solid state relay in the selector is not used. The relay must be always close.

Flash Memory – Endurance Test

Measure V_{th} Connection



V_{th} must be measured after writing or erasing. To perform the V_{th} measurement, all of the selector/ASU channels must make the path to the SMU. V_{th} is measured at each decade, so a mechanical relay will be used, not the solid state relay. The mechanical relay has low leakage specifications to better match the capabilities of the SMUs.

Class Exercise

Flash Memory Endurance Test

1. **Recall the Demo-S-NorFlash Endurance test record.**
2. **Connect the DUT (MOS FET, not flash memory) as shown in the next page.**
3. **Specify the module (SMU and PGU) connected to DUT terminal properly.**
4. **Perform the test.**

To perform this class exercise, you need the following equipment.

16440A Selector with control cable, 2 sets

16445A Selector adapter with control cable, 1 set

B1500A installed with two SPGU modules and four SMU modules

Test fixture

Triaxial cable, 7 ea.

BNC-SMA cable, 3 ea.

Or,

B1500A installed with two SPGU modules, three pairs of HRSMU and ASU, and a SMU module

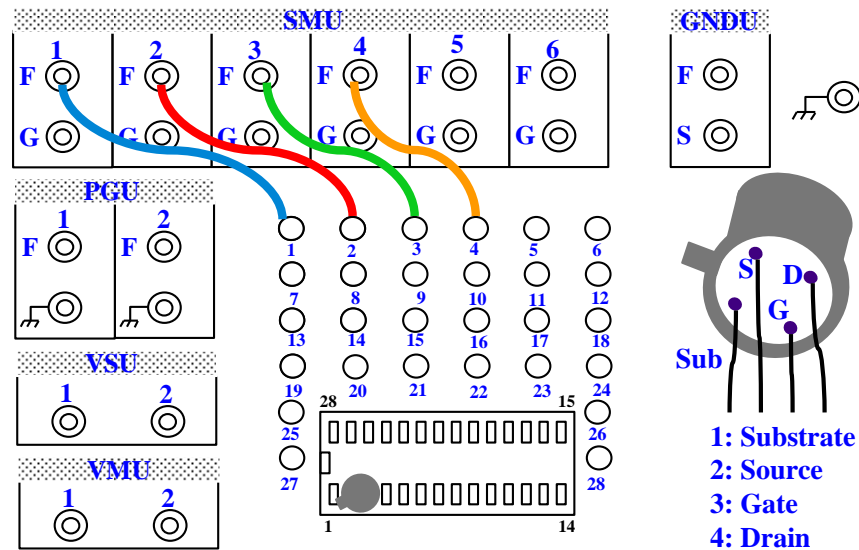
Test fixture

Triaxial cable, 7 ea.

BNC-SMA cable, 3 ea.

ASU control cable, 3 ea.

Jumper Leads – MOS transistor



For all class exercises, you need the 28-pin dual in line socket which comes standard with the 4145 fixture (16058A) or the newer fixture (16442A/B). Either fixture works fine.

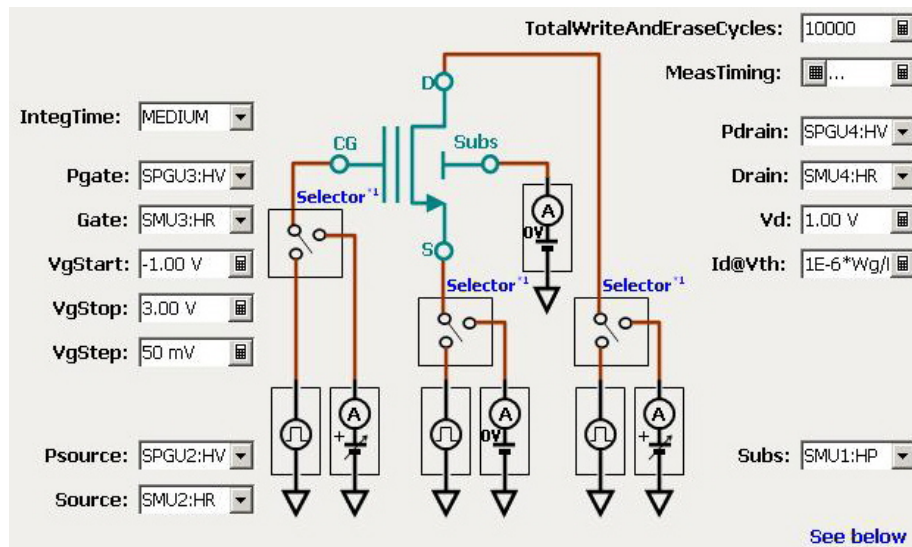
This class exercise requires four jumper leads to connect the DUT. Connect the jumper leads between the following terminals.

SMU1 : terminal 1
SMU2 : terminal 2
SMU3 : terminal 3
SMU4 : terminal 4

Then, the modules must be connected to the fixture as shown below.

B1500A SMU1 -> Fixture SMU1 connector
B1500A SMU2 -> Selector ch1 SMU input or ASU ch1 Force
B1500A SMU3 -> Selector ch2 SMU input or ASU ch2 Force
B1500A SMU4 -> Selector ch3 SMU input or ASU ch3 Force
B1500A PG2 -> Selector ch1 PGU input or ASU ch1 AUX In
B1500A PG3 -> Selector ch2 PGU input or ASU ch2 AUX In
B1500A PG4 -> Selector ch3 PGU input or ASU ch3 AUX In
Selector/ASU ch1 output -> Fixture SMU2 connector
Selector/ASU ch2 output -> Fixture SMU3 connector
Selector/ASU ch3 output -> Fixture SMU4 connector

Demo-S-NorFlash Endurance Test Setup



For the instrument connection shown in the previous pages, change the value as follows.

Pgate -> SPGU3

Gate -> SMU3

Psource -> SPGU2

Source -> SMU2

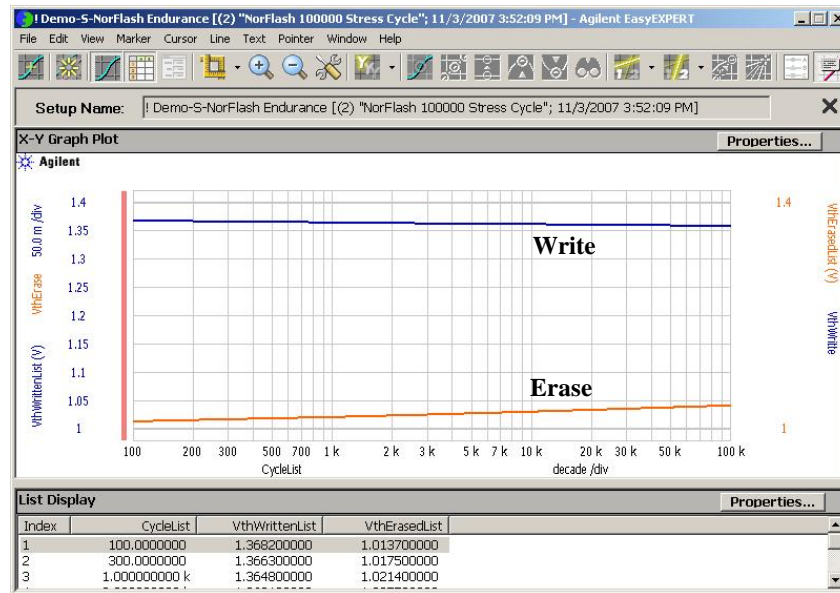
Pdrain -> SPGU4

Drain -> SMU4

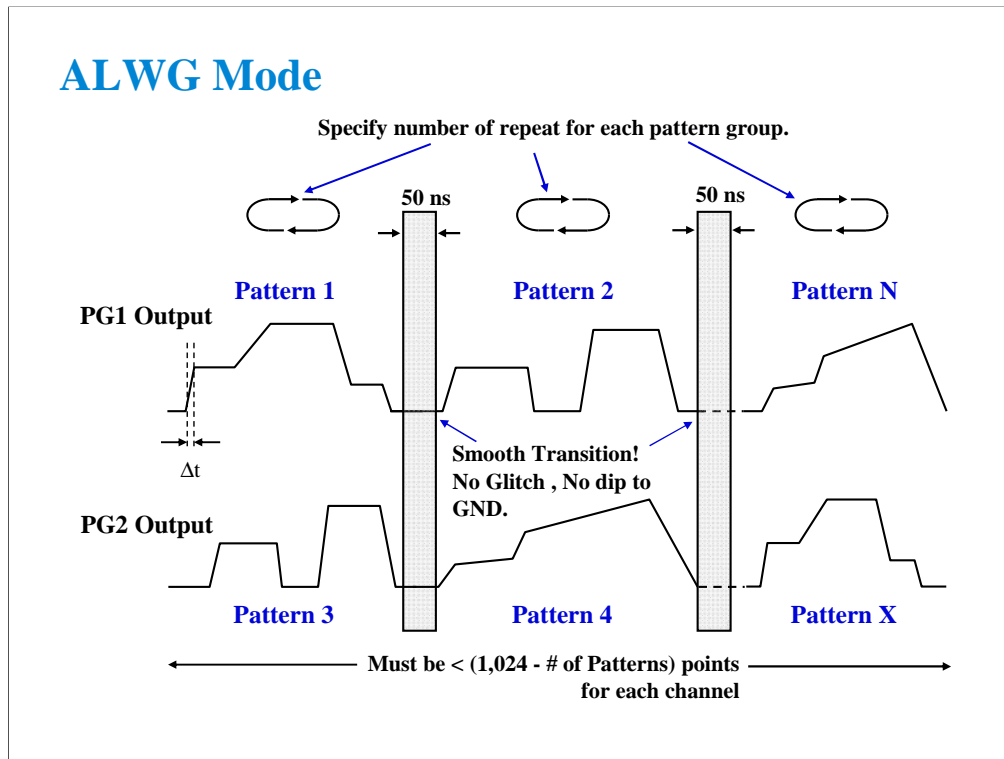
Subs -> SMU1

Also, set a small TotalWriteAndEraseCycles value, for example 1000. If you set one million, you will have to wait long time over several hours until the test is completed.

Measurement Result Example



This is a test result example displayed on the Data Display window.



ALWG stands for Arbitrary Linear Waveform Generator. This function is similar to the AWG (Arbitrary Waveform Generator), but specialized for a semiconductor parametric test. The ALWG describes the pulse wave by the combination of the line segment described as the differential time and absolute voltage.

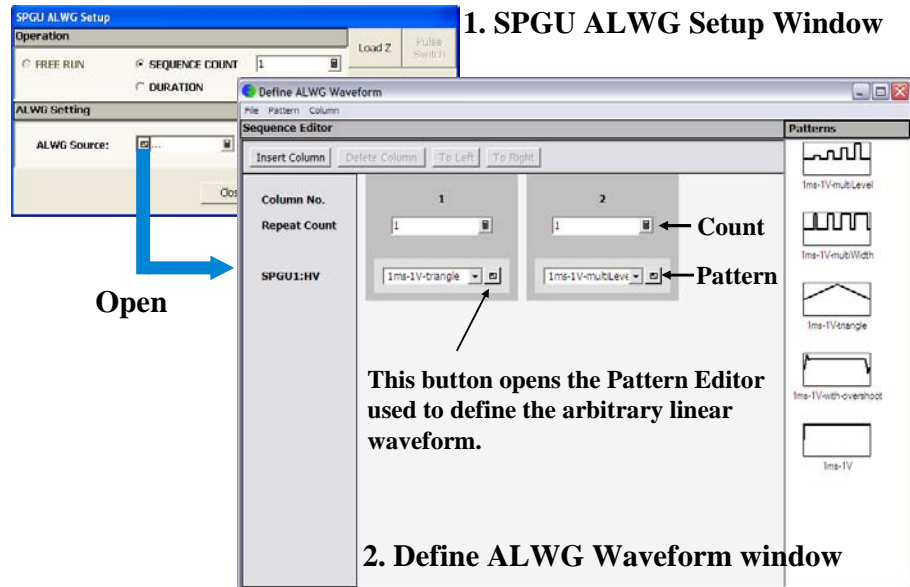
Key features are as follows.

- Number of patterns in a sequence: maximum 512 for a channel
- Number of vector data: maximum 1024-N (N: number of patterns) for defining all patterns to a channel
- Repeat count of a pattern group: maximum 1,048,576
- Time data (differential time, delta T): 10 ns to 671.088630 ms with 10 ns resolution
- Extremely short over head, 50 ns to change the pattern. No delay for the repetition of the same pattern.

Of course, +/-40 V and 80 Vpp feature of HVSPGU is available with this ALWG feature.

This function allows you to use more complicated waveform like the multiple level pulse more than 3-level, and step pulse or ramp voltage to characterize the novel flash memory like CTF.

ALWG Mode



To apply the ALWG output, define the ALWG output sequence, specify the Operation, and click the Single button.

The following operations are available.

PULSE COUNT: SPGU outputs the specified number of sequences. Specify a number within the range of 1 to 1000000.

DURATION: SPGU continues the output until the specified time elapses. Specify a time within the range of 1 us to 31556926 s (1 year).

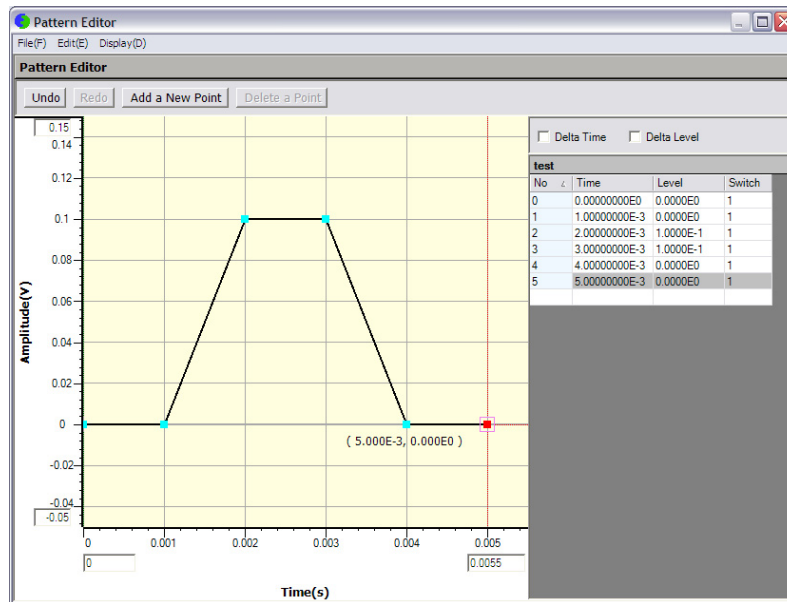
FREE RUN: SPGU continues the output until the measurement is completed or stopped. This operation is not available for the SPGU Control classic test.

To define the ALWG output sequence,

1. Open the SPGU ALWG Setup window by clicking the Pulse/ALWG button on the SPGU Control classic test screen or the SPGU ALWG Setup button on the Measurement Setup screen of the other classic test.
2. Open the Define ALWG Waveform window by clicking the button of the ALWG Source on the SPGU ALWG Setup window.

The ALWG output sequence can be defined by specifying the waveform pattern and the repeat count on the Define ALWG Waveform window. To create a new waveform pattern, use the Pattern Editor. See the next page.

ALWG Mode



A pattern can be defined by specifying the differential time and the absolute voltage. You can define it by using the left side GUI or the right side table on the window.

Class Exercise

Monitor ALWG output by the sampling measurement.

1. Click I/V-t Sampling icon and open setup editor.
2. Define the measurement setup with the ALWG output.
3. Save the test setup.
4. Connect a device (511 kohm resistor) as shown in the next page.
5. Perform the test.

Channel Setup:

SMU1 -> V1, I1, Mode=I
SMU2 -> V2, I2, Mode=COMMON
SPGU1 -> SPGUV1, Mode=ALWG

Measurement Setup:

Interval=2 ms
No of Samples=201
SMU1 -> Source=0 A, Compliance=2 V

Range:

SMU1 -> Mode=FIXED, Range=2 V

ADC/Integ:

SMU1 -> ADC=HS ADC

Advanced:

SMU1 -> SMU Filter=OFF

SPGU ALWG Setup:

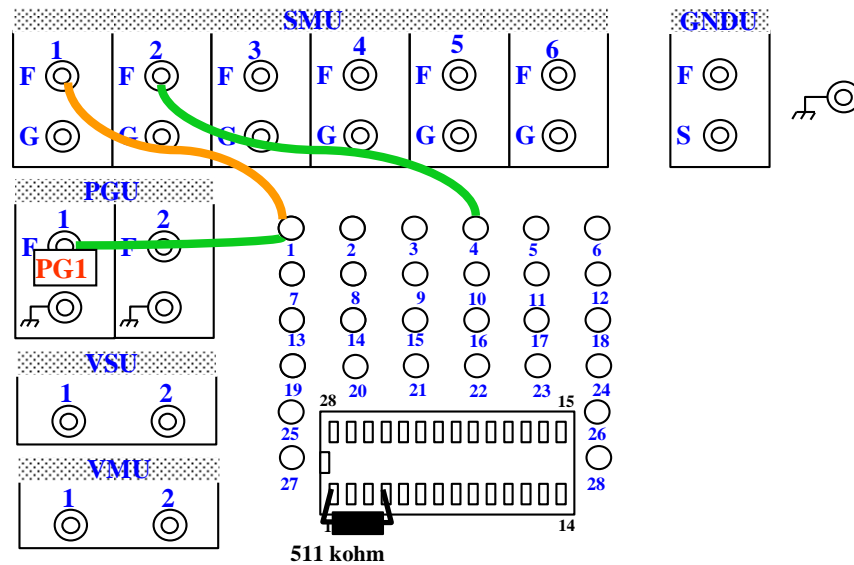
SPGU1 -> LoadZ=511 kohm
ALWG Source -> Define the waveform as you like.

Display Setup:

X-axis -> Time
Y1-axis -> V1

For the example setup, open the “ALWG monitor” test setup.

Jumper Leads – Capacitance



For all class exercises, you need the 28-pin dual in line socket which comes standard with the 4145 fixture (16058A) or the newer fixture (16442A/B). Either fixture works fine.

This class exercise requires three jumper leads to connect the DUT. Connect the jumper leads between the following terminals.

SMU1 : terminal 1

SMU2 : terminal 4

PGU1 : terminal 1

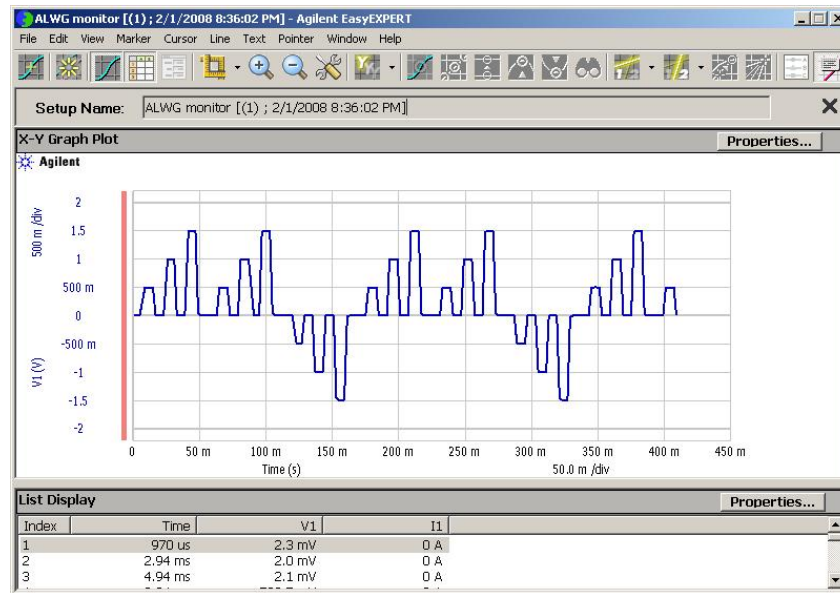
Then, the modules must be connected to the fixture as shown below.

B1500A SMU1 -> Fixture SMU1 connector

B1500A SMU2 -> Fixture SMU2 connector

B1500A PG1 -> Fixture PGU1 connector

Measurement Result Example



This is a test result example displayed on the Data Display window for the “ALWG monitor” test setup.