



# **Agilent B1500A Semiconductor Device Analyzer**

## **Self-paced Training Manual, 2**



**Agilent Technologies**

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## Manual Part Number

B1500-90041

## Edition

Edition 1, September 2005  
Edition 2, May 2006  
Edition 3, January 2007  
Edition 4, June 2007  
Edition 5, February 2008

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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.

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### CAUTION

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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 $\mu$ 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 $\mu$ 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 $\mu$ 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

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**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.

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**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.

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**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.

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## 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



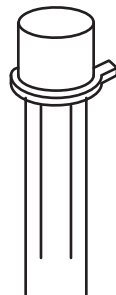
Test Setup Name	Description
Trng List	MOSFET Vth-gmmax measurement using I/V List Sweep
Trng Multi	Multi Channel I/V Sweep (Bipolar transistor and LED)
Trng Sampling	0.1 $\mu$ F sampling measurement
Trng Switch	B2200/E5250 switch setup, Input 1-3-5-7 to Output 1-3-5-7
Zero-check	SMU open measurement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

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## 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.

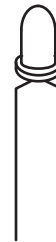
Description	Quantity
N-channel MOSFET	2 ea.
NPN Bipolar Transistor	1 ea.
Red Miniature LED	1 ea.
0.1 $\mu$ F Capacitor 50 V	1 ea.
1.0 $\Omega$ Resistor 1/8 W	1 ea.
1.1 k $\Omega$ Resistor 1/8 W	1 ea.
511 k $\Omega$ Resistor 1/8 W	1 ea.



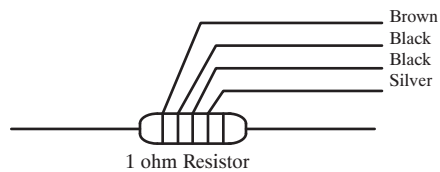
N-ch MOSFET



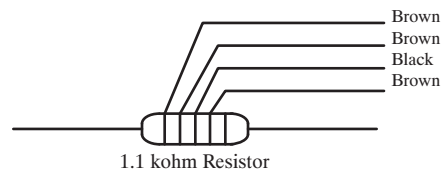
NPN bipolar Transistor



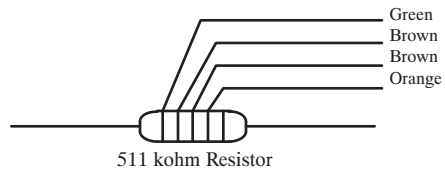
LED



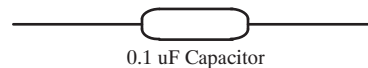
1 ohm Resistor



1.1 kohm Resistor



511 kohm Resistor



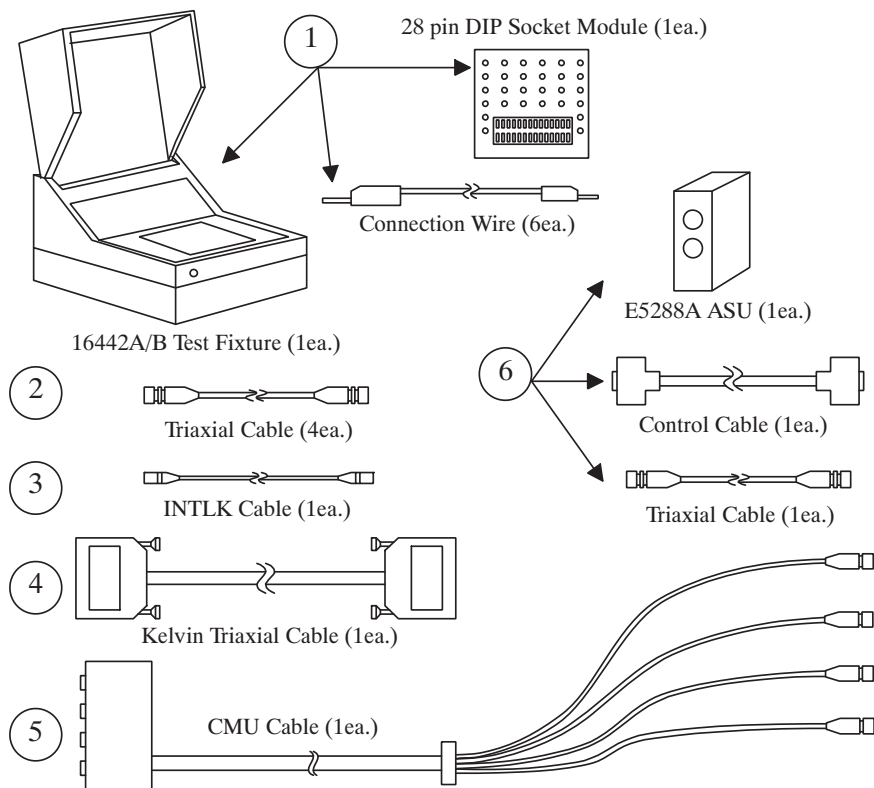
0.1 uF Capacitor

## 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 <sup>a</sup>	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.

<b>Description</b>	<b>Model No.</b>	<b>Qty.</b>
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.

<b>Description</b>	<b>Model No.</b>	<b>Qty.</b>
SMU/PG selector with control cable <sup>a</sup>	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**



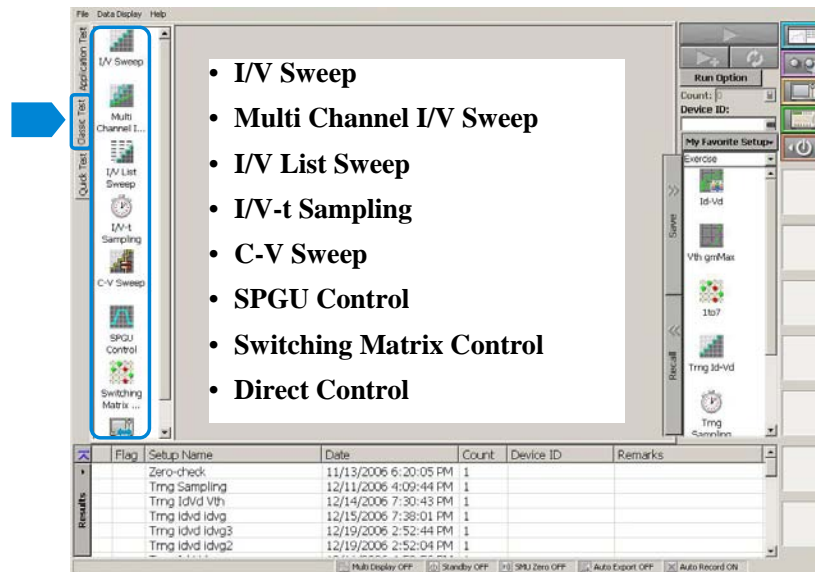
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## **In This Module**

- **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**

Note:

## Classic Test Execution Mode

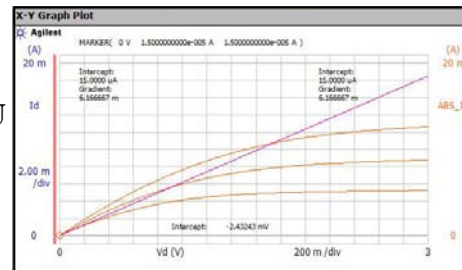
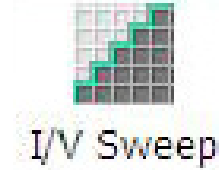


To use the classic test mode, click the Classic Test tab. And select the execution mode. The following modes are available.

- **I/V Sweep:** For X-Y characteristics measurement of I or V.
- **Multi Channel I/V Sweep:** For simultaneous multi channel (up to 10) sweep measurement of I or V.
- **I/V List Sweep:** For multi channel (up to 10) I/V sweep measurement using list data.
- **I/V-t Sampling:** For time-Y characteristics measurement of I or V.
- **C-V Sweep:** For DC bias-impedance characteristics measurement.
- **SPGU Control:** For voltage pulse output. See Module 13.
- **Switching Matrix Control:** For B2200/E5250 switching matrix control.
- **Direct Control:** For various measurements (e.g. C-f measurement, Quasi-Static C-V measurement) using Agilent FLEX commands.

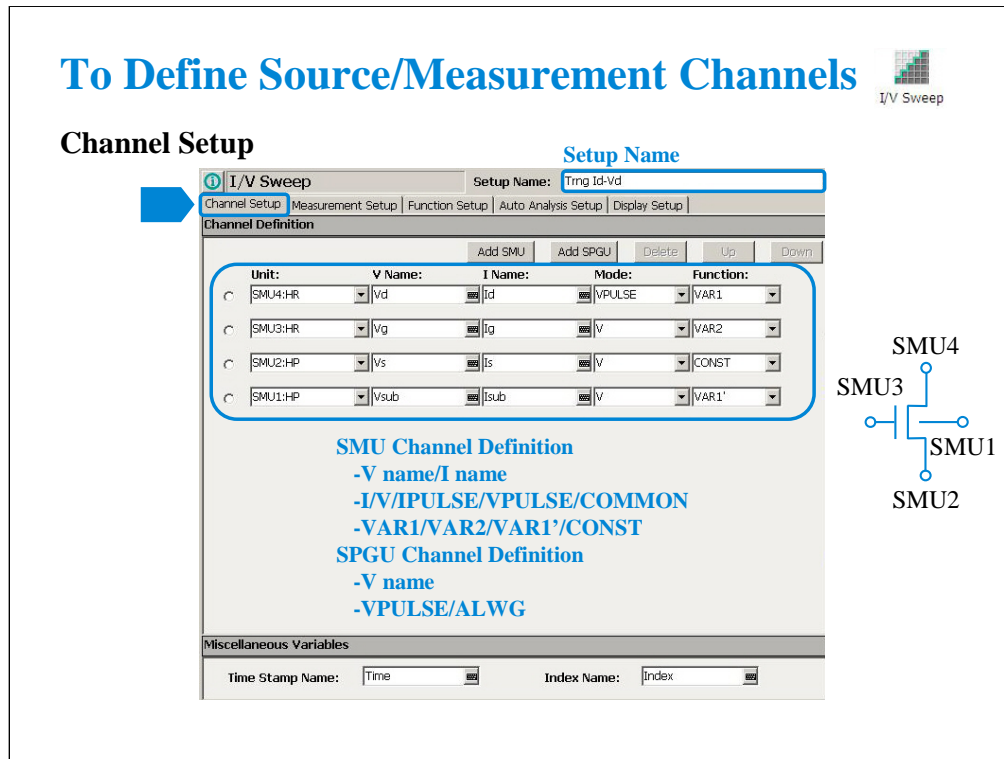
## I/V Sweep Measurement

- To Define Source/Measurement Channels
- To Read Time Stamp Data and Data Index
- To Set Source Outputs (VAR1, VAR2, VAR1', Pulse, CONST)
- To Set Timing Parameters
- To Set Sweep Abort Function
- Range, ADC, Advanced, SPGU
- To Set User Functions
- To Set Analysis Functions
- To Set Auto Analysis Function
- To Set Display Parameters (X-Y Graph, Data List, Parameter)



This section explains how to perform I/V sweep measurement. You will perform the above tasks to execute the I/V sweep measurement.





Click the I/V Sweep icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

1. Enter the Setup Name for the test setup to be defined on the setup editor.
2. List SMUs used for source output or measurement, and set the following parameters.
  - Unit: SMU name or number. The GNDU (ground unit) can be set instead of a SMU.
  - V Name: Variable name for the voltage measurement or source data
  - I Name: Variable name for the current measurement or source data
  - Mode: Source output mode, V (voltage), I (current), VPULSE (voltage pulse), IPULSE (current pulse), or COMMON (ground)
  - Function: Source output function, VAR1 (primary sweep), VAR2 (secondary sweep), VAR1' (synchronous sweep), CONST (constant)

V Name and I Name are used to specify the parameters displayed on the Data Display window. The display parameters are selected on the Display Setup tab screen. For the GNDU, 0 V is returned to the V variable and no data is returned to the I variable.

To use the SPGU channels, click the Add SPGU button. The SPGU channel setup row will appear. Then set the following parameters.

- Unit: SPGU name or number
- V Name: Variable name for the voltage data. No data is returned to the variable.
- Mode: SPGU output mode. VPULSE (voltage pulse) or ALWG (arbitrary linear waveform voltage) for all SPGU.

## To Read Time Stamp Data and Index



### Channel Setup

**I/V Sweep** Setup Name: Trng Id-Vd

Channel Setup | Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

**Channel Definition**

	Unit:	V Name:	I Name:	Mode:	Function:
<input type="radio"/>	SMU4:HR	Vd	Id	VPULSE	VAR1
<input type="radio"/>	SMU3:HR	Vg	Ig	V	VAR2
<input type="radio"/>	SMU2:HP	Vs	Is	V	CONST
<input type="radio"/>	SMU1:HP	Vsub	Isub	V	VAR1'

**Miscellaneous Variables**

Time Stamp Name:  Index Name:

Variable name for time stamp data

Variable name for data index

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

Note:

The time stamp is the time the measurement is started for each measurement point.

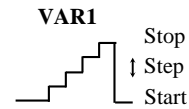
The index is the index number for each measurement data.

## To Set Primary Sweep Source



### Measurement Setup

Unit	V Name	I Name	Mode	Source	Compliance
SMU2:HP	Vs	Is	V	0 V	50 mA



The Measurement Setup tab screen is used to set the source output value and timing parameters. At the VAR1 area, you set the primary sweep source output.

- Unit: SMU name or number
- Name: Variable name of source output
- Direction: Single (start to stop) or Double (start to stop to start)
- Linear/Log: Linear sweep or Log sweep
- Start: Source output start value
- Stop: Source output stop value
- Step: Source output incremental step value
- No of Step: Number of sweep steps
- Compliance: SMU compliance value
- Pwr Comp: SMU power compliance value

## To Set Secondary Sweep Source



### Measurement Setup

**I/V Sweep** Setup Name: Trng Id-Vd

Channel: [ ] Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

VAR1		VAR2		VAR1'	
Unit: SMU4:HR	Unit: SMU3:HR	Unit: SMU1:HP	Range:		
Name: Vd	Name: Vg	Name: Vsub	ADC / Integ:		
Direction: Single		Offset: 0 V	Ad- vanced:		
Linear/Log: LINEAR		Ratio: 0	SPGU Pulse Setup		
Start: 0 V	Start: 1 V	Compliance: 100 mA			
Stop: 3 V	Stop: 2 V	Pwr Comp: OFF			
Step: 60 mV	Step: 500 mV	SMU Pulse			
No of Step: 51	No of Step: 3	Unit: SMU4:HR	Period: 10 ms		
Compliance: 10 mA	Compliance: 1 mA	Width: 1 ms	Base: 0 V		
Pwr Comp: OFF	Pwr Comp: OFF				

Timing

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

Constants

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU2:HP	Vs	Is	V	0 V	50 mA



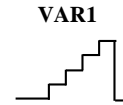
At the VAR2 area, you set the secondary sweep source output.

- Unit: SMU name or number
- Name: Variable name of source output
- Start: Source output start value
- Stop: Source output stop value
- Step: Source output incremental step value
- No of Step: Number of sweep steps
- Compliance: SMU compliance value
- Pwr Comp: SMU power compliance value

## To Set Synchronous Sweep Source



### Measurement Setup



At the VAR1' area, you set the synchronous sweep source output.

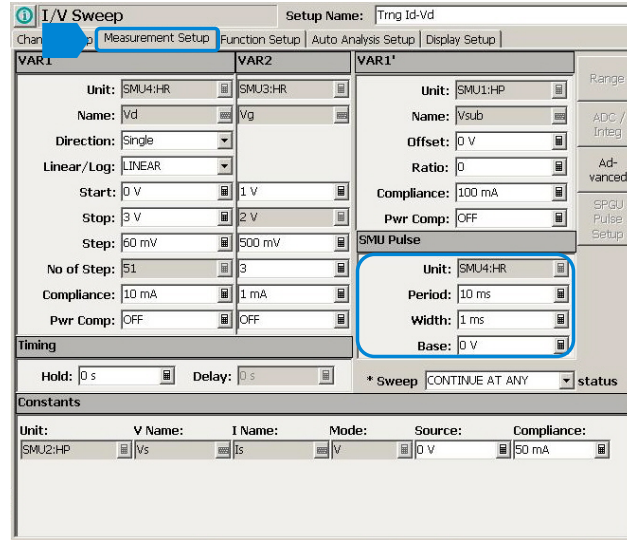
- Unit: SMU name or number
- Name: Variable name of source output
- Offset: B value of the above formula.
- Ratio: A value of the above formula.
- Compliance: SMU compliance value
- Pwr Comp: SMU power compliance value

The VAR1' output is expressed by the following formula.

$$\text{VAR1' output} = A \times (\text{VAR1 output}) + B$$

## To Set Pulse Output

### Measurement Setup



**I/V Sweep** Setup Name: Trng Id-Vd

Channel: Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

VAR1	VAR2	VAR1'
Unit: SMU4:HR	Unit: SMU3:HR	Unit: SMU1:HP
Name: Vd	Name: Vg	Name: Vsub
Direction: Single		Offset: 0 V
Linear/Log: LINEAR		Ratio: 0
Start: 0 V	Start: 1 V	Compliance: 100 mA
Stop: 3 V	Stop: 2 V	Pwr Comp: OFF
Step: 60 mV	Step: 500 mV	
No of Step: 51	No of Step: 3	
Compliance: 10 mA	Compliance: 1 mA	
Pwr Comp: OFF	Pwr Comp: OFF	

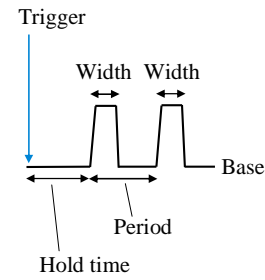
**SMU Pulse**

Unit: SMU4:HR  
Period: 10 ms  
Width: 1 ms  
Base: 0 V

Timing  
Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU2:HP	Vs	Is	V	0 V	50 mA



Delay time cannot be set.

At the SMU Pulse area, you set the SMU pulse timing parameter and the pulse base value.

- Unit: SMU name or number
- Period: Pulse period
- Width: Pulse width
- Base: Pulse base value

Only a SMU can be set to the pulse source.

## To Set Constant Output



### Measurement Setup

The screenshot shows the 'I/V Sweep' Measurement Setup dialog box. The 'Constants' section at the bottom is highlighted with a blue border. It contains the following fields:

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU2:HP	Vs	Is	V	0 V	50 mA

At the Constants area, you set the SMU constant output.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), VPULSE (voltage pulse), IPULSE (current pulse), or COMMON (ground)
- Source: SMU output value
- Compliance: SMU compliance value

## To Set Timing Parameters

### Measurement Setup

**I/V Sweep** Setup Name: Trng Id-Vd

Channel: Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

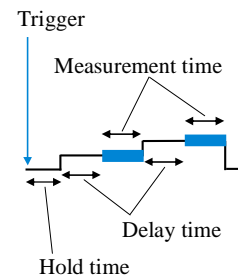
VAR1		VAR2		VAR1'	
Unit: SMU4:HR	SMU3:HR	Unit: SMU1:HP			
Name: Vd	Vg	Name: Vsub			
Direction: Single		Offset: 0 V			
Linear/Log: LINEAR		Ratio: 0			
Start: 0 V	1 V	Compliance: 100 mA			
Stop: 3 V	2 V	Pwr Comp: OFF			
Step: 60 mV	500 mV	SMU Pulse			
No of Step: 51	3	Unit: SMU4:HR			
Compliance: 10 mA	1 mA	Period: 10 ms			
Pwr Comp: OFF	OFF	Width: 1 ms			
		Base: 0 V			

**Timing**

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU2:HP	Vs	Is	V	0 V	50 mA



At the Timing area, you set the source output and measurement timing.

- Hold: Source output hold time. Time after the measurement trigger until starting delay time.
- Delay: Measurement start delay time. Time after the hold time until starting measurement.

When a SMU forces pulse, the delay time is ignored. Source output and measurement timing will be controlled by the pulse width and pulse period.



## To Set Sweep Abort Function

### Measurement Setup

The screenshot shows the 'I/V Sweep' Measurement Setup dialog box. The 'Sweep' dropdown menu is highlighted with a blue box, showing 'CONTINUE AT ANY' and 'status' options. The dialog includes sections for VAR1, VAR2, VAR1', Timing, and Constants.

VAR1	VAR2	VAR1'
Unit: SMU4:HR	Unit: SMU3:HR	Unit: SMU1:HP
Name: Vd	Name: Vg	Name: Vsub
Direction: Single		Offset: 0 V
Linear/Log: LINEAR		Ratio: 0
Start: 0 V	Start: 1 V	Compliance: 100 mA
Stop: 3 V	Stop: 2 V	Pwr Comp: OFF
Step: 60 mV	Step: 500 mV	SMU Pulse
No of Step: 51	No of Step: 3	Unit: SMU4:HR
Compliance: 10 mA	Compliance: 1 mA	Period: 10 ms
Pwr Comp: OFF	Pwr Comp: OFF	Width: 1 ms
		Base: 0 V

Timing

Hold: 0 s Delay: 0 s

\* Sweep CONTINUE AT ANY status

Constants

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU2:HP	Vs	Is	V	0 V	50 mA

CONTINUE AT ANY  
STOP AT ANY ABNORMAL  
-Range overflow  
-SMU compliance  
-SMU oscillation

This field sets the sweep abort function.

When this field is CONTINUE AT ANY, the sweep measurement is not aborted.

When this field is STOP AT ANY ABNORMAL, the sweep measurement will be aborted when one of the following conditions is detected.

- Measurement range overflow
- SMU compliance
- SMU oscillation

## To Set Ranging Mode

### Measurement Setup



Range

ADC /  
Integ

Ad-  
vanced

SPGU  
Pulse  
Setup

Not available when a SMU pulse is used.

**SMU Range Setup**

Measurement Range

Up Down

Unit:	Name:	Mode:	Range:	Range Change Rule:	Rate:
<input type="radio"/> SMU1:HP	I1	LIMITED	1nA	BY FULL RANGE	NaN
<input type="radio"/> SMU2:HR/AS	I2	LIMITED	1nA	BY FULL RANGE	NaN
<input type="radio"/> SMU3:HR/AS	I3	LIMITED	1nA	BY FULL RANGE	NaN
<input type="radio"/> SMU4:HR	I4	LIMITED	1nA	BY FULL RANGE	NaN

Close

The Range button opens the SMU Range Setup dialog box. The dialog box is used to set the measurement ranging mode. This button is not available when a pulse source is used.

- Unit: SMU name or number
- Name: Variable name for the measurement data
- Mode: Ranging mode, AUTO, LIMITED, or FIXED
- Range: Range value
- Range Change Rule: BY FULL RANGE, GO UP AHEAD, or UP AND DOWN AHEAD
- Rate: Value used for range changing. See the following formula.

For the AUTO or LIMITED, SMU automatically selects the minimum range that covers the measurement value, and performs the measurement by using the range. For the limited auto ranging, the instrument does not use the range lower than the specified range value. For example, if you select the 100 nA limited auto ranging, the instrument never uses the 10 nA range and below.

BY FULL RANGE performs normal auto ranging operation.

For the GO UP AHEAD and UP AND DOWN AHEAD rules, specify the *Rate* value, 11 to 100, which fixes the boundary of the ranging. The ranging occurs when the measurement data goes across the *boundary* values shown below.

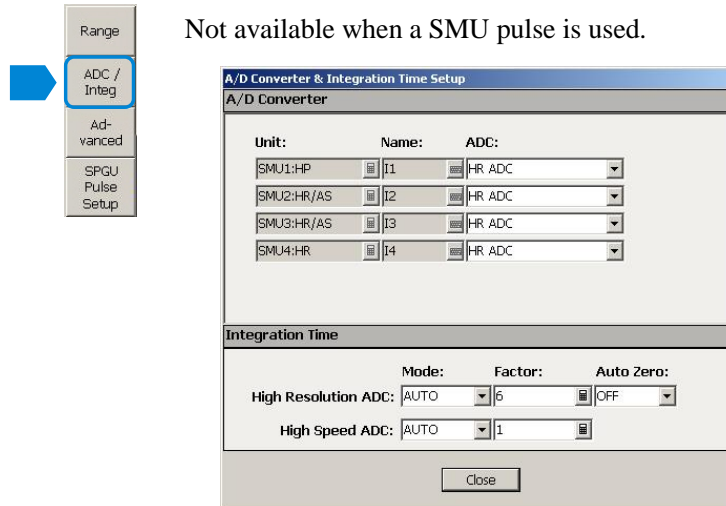
$$go\ up\ boundary = present\ measurement\ range \times Rate / 100$$

$$go\ down\ boundary = present\ measurement\ range \times Rate / 1000$$

The *go down boundary* is available only for the UP AND DOWN AHEAD rule.

## To Set ADC/Integration Time

### Measurement Setup



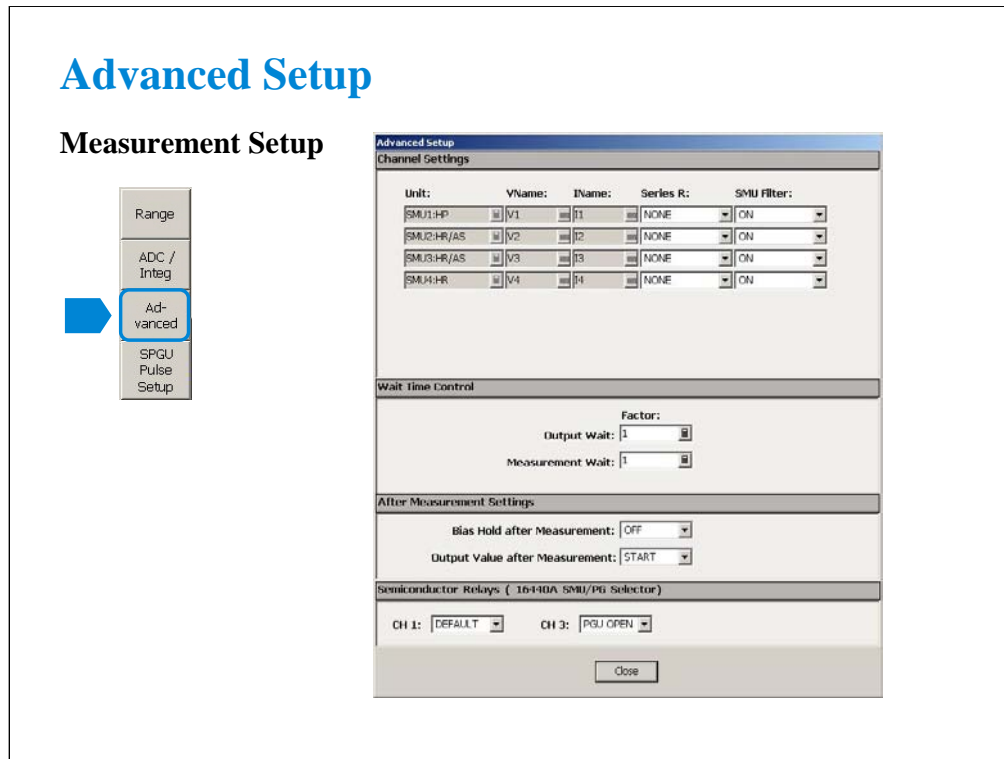
The ADC/Integ button opens the A/D Converter & Integration Time Setup dialog box. The dialog box is used to select the ADC for each SMU and set the integration time for each ADC (high resolution or high speed). This button is not available when a pulse source is used.

A/D Converter:

- Unit: SMU name or number
- Name: Variable name of the measurement data
- ADC: ADC type, HR ADC (high resolution) or HS ADC (high speed)

Integration Time:

- Mode: AUTO, MANUAL, or PLC. Rule to decide the integration time. For details, see online help or User's Guide.
- Factor: Coefficient for the reference value of the integration time.
- Auto Zero: Auto Zero function ON or OFF. For HR ADC.



The Advanced button opens the Advanced Setup dialog box. The dialog box is used to set the SMU filter and SMU series resistor settings, the wait time, the after measurement settings, and the 16440A selector semiconductor relay setting.

Channel Settings:

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Series R: SMU series resistor NONE or 1MOHM (1000000 ohm)
- SMU Filter: SMU filter ON or OFF

Wait Time Control:

- Factor: Coefficient for the reference value of the wait time. For details, see online help or User's Guide.

After Measurement Settings:

- Bias Hold after Measurement: Bias hold function ON or OFF.
- Output Value after Measurement: Source output value after measurement. START (sweep start value), STOP (sweep stop value), SOURCE (sampling output source value), or BASE (sampling output base value)

Note: Pulse channel output after measurement is always Base value.

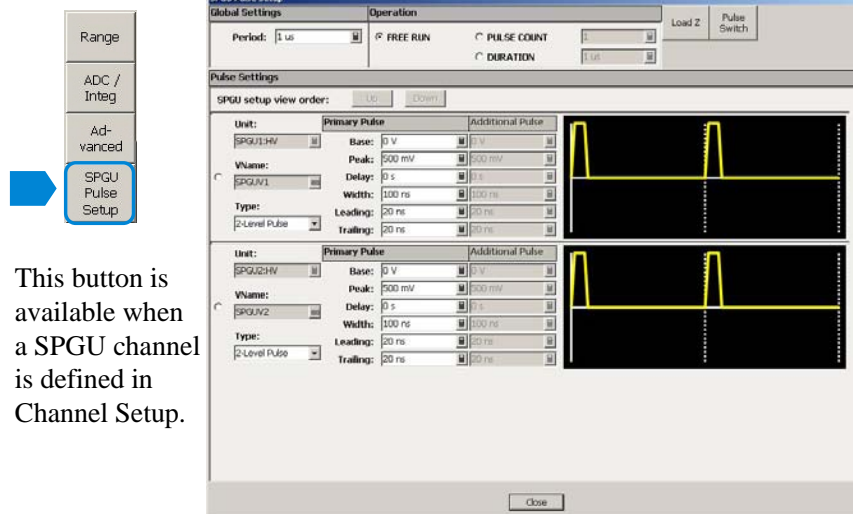
Semiconductor Relays (16440A SMU/PG Selector):

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

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

## SPGU Pulse Setup

### Measurement Setup

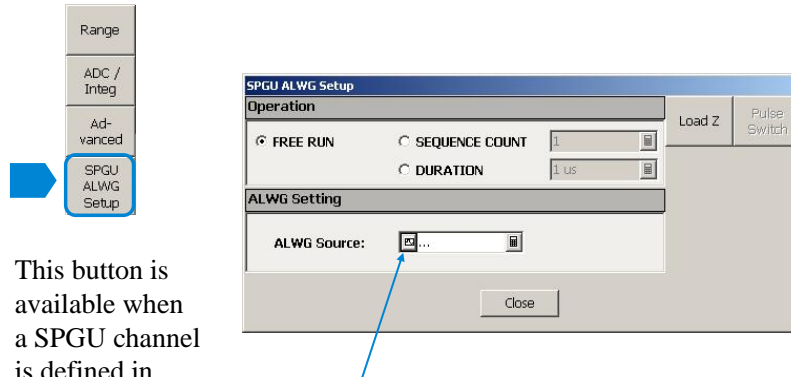


This button is available when a SPGU channel is defined in Channel Setup.

If a SPGU channel is defined and set to the VPULSE mode on the Channel Setup screen, the SPGU Pulse Setup button is effective. This button opens the SPGU Pulse Setup window which is used to define the voltage pulse output by the specified SPGU channels. Maximum 10 SPGU channels can be used. For details, see Module 13.

## SPGU ALWG Setup

### Measurement Setup



This button is available when a SPGU channel is defined in Channel Setup.

This button opens the Define ALWG Waveform window used to define the arbitrary linear waveform.

If a SPGU channel is defined and set to the ALWG mode on the Channel Setup screen, the SPGU ALWG Setup button is effective. This button opens the SPGU ALWG Setup window which is used to define the arbitrary linear waveform voltage output by the specified SPGU channels. Maximum 10 SPGU channels can be used. For details, see Module 13.

## To Set User Functions

### Function Setup

**Function Setup**

Setup Name: Trng Id-Vd

Channel Setup | Measurement Setup | **Function Setup** | Auto Analysis Setup | Display Setup

**User Function**

Name:	Unit:	Definition:
ABS_ID	A	abs(Id)

**Data calculation**  
-Measurement data/source data  
-Built-in function, etc.

**Analysis Function**

Name:	Unit:	Definition:
Slope	A	@L1G1

Click the Function Setup tab to display the User Function/Analysis Function setup screen. The user functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

Name: Function name

Unit: Unit of the function

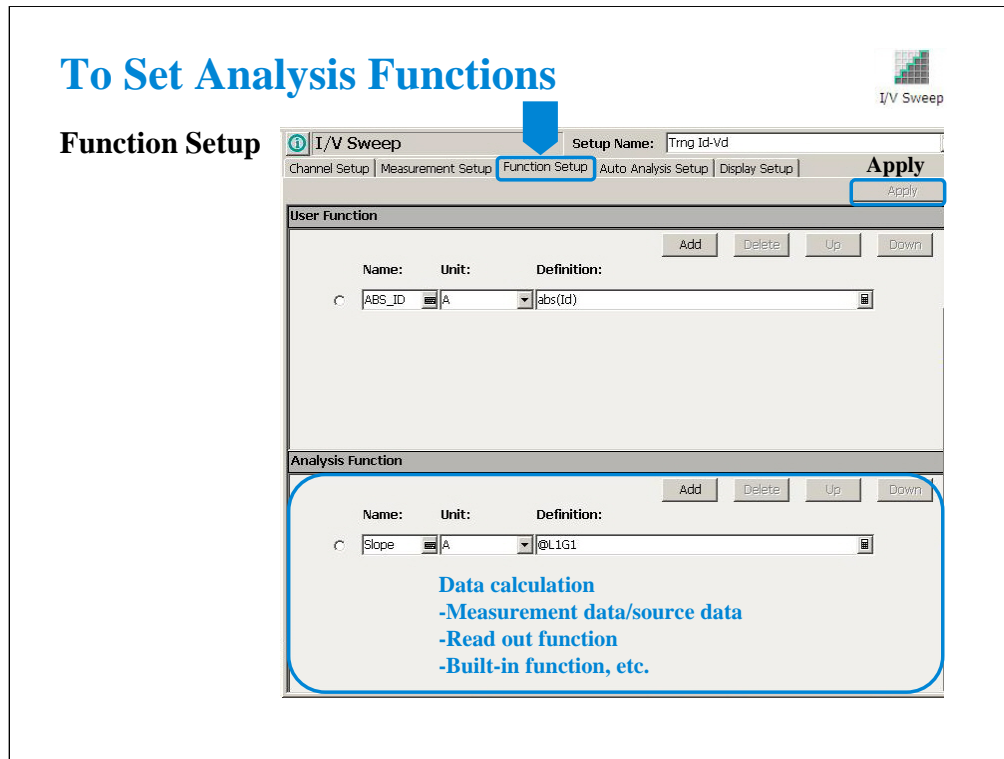
Definition: Definition of the function. The following identifiers can be used.

- Variables for the measurement/output data used in this test
- Functions defined in the above lines
- Local variables passed from the application test that calls this test as a component
- Built-in functions and global variables

For details, see online help or User's Guide.

Note:

The Apply button performs calculation of the definition in this screen. If this button is clicked when the Data Display window associated with this test has been opened, the display is also updated. The associated Data Display window will be the Data Display window that displays the last measurement data or that is recalled at last.



The analysis functions can be displayed on the Parameters area of the Data Display window. Up to 20 functions can be set.

Name: Function name

Unit: Unit of the function

Definition: Definition of the function. The following identifiers can be used.

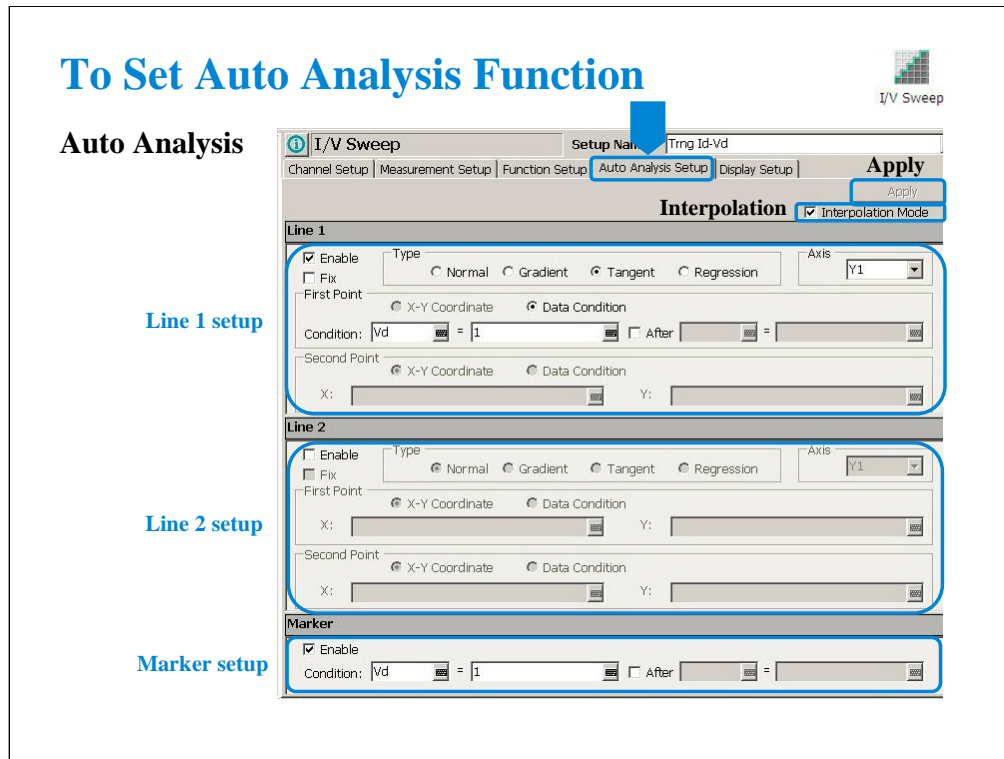
- Variables for the measurement/output data used in this test
- Functions defined in the above lines
- Local variables passed from the application test that calls this test as a component
- Built-in functions and global variables
- Read out functions

For details, see online help or User's Guide.

Note:

The Apply button performs calculation of the definition in this screen. If this button is clicked when the Data Display window associated with this test has been opened, the display is also updated. The associated Data Display window will be the Data Display window that displays the last measurement data or that is recalled at last.





Click the Auto Analysis Setup tab to display the auto analysis setup screen. The auto analysis capability allows you to display/move the marker/line on the data graph automatically after measurement. The above example displays marker at  $V_d=1$  V point and draw a tangent line for this point.

**Interpolation Mode:** Check this box to enable the interpolation mode. You can position marker between measurement points.

**Line 1, Line 2:** This area sets the line 1 or line 2 automatically displayed and moved to the specified position after the measurement. Check Enable box to enable the line.

For Type, select a line type, Normal, Gradient, Tangent, or Regression.

For Axis, select the axis effective for the line.

In First Point and Second Point, specify the cursor points used to draw line.

In Gradient, specify the slope of the Gradient line.

**Marker:** This area sets the marker automatically displayed and moved to the specified position after the measurement. Check Enable box to enable the marker.

For Condition, enter a variable name and a condition expression to specify where you want the marker to display.

For After, check this box to enable the additional condition. And enter a second variable and condition expression. This sets up a search start condition for finding specified point.

For example, you can specify the following expressions to search for a measurement point that satisfies the first condition after the second condition is satisfied.

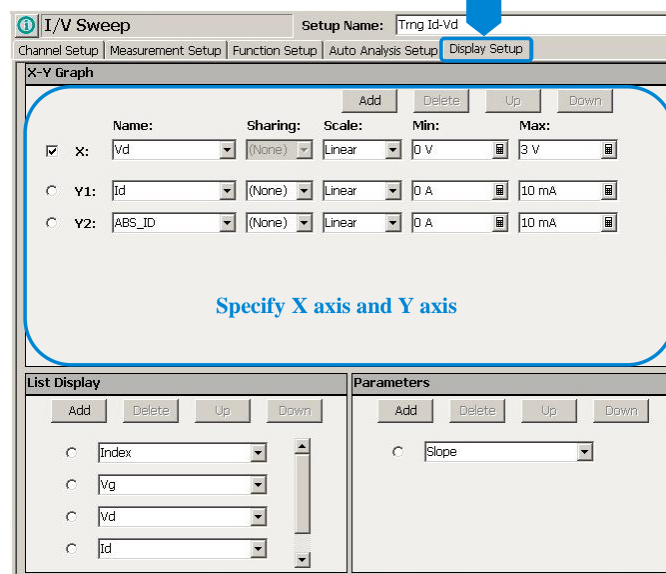
Condition:  $[DGM] = [MAX(DGM)*0.01]$  [x] After  $[DGM] = [MAX(DGM)]$

**Note:**

The Apply button performs calculation of the definition in this screen. If this button is clicked when the Data Display window associated with this test has been opened, the display is also updated. The associated Data Display window will be the Data Display window that displays the last measurement data or that is recalled at last.

## To Set X-Y Graph Display

### Display Setup



**I/V Sweep** Setup Name: Trng Id-Vd

Channel Setup | Measurement Setup | Function Setup | Auto Analysis Setup | **Display Setup**

**X-Y Graph**

Add Delete Up Down

	Name:	Sharing:	Scale:	Min:	Max:
<input checked="" type="checkbox"/> X:	Vd	(None)	Linear	0 V	3 V
<input type="checkbox"/> Y1:	Id	(None)	Linear	0 A	10 mA
<input type="checkbox"/> Y2:	ABS_ID	(None)	Linear	0 A	10 mA

Specify X axis and Y axis

**List Display**

Add Delete Up Down

- ☐ Index
- ☐ Vg
- ☐ Vd
- ☐ Id

**Parameters**

Add Delete Up Down

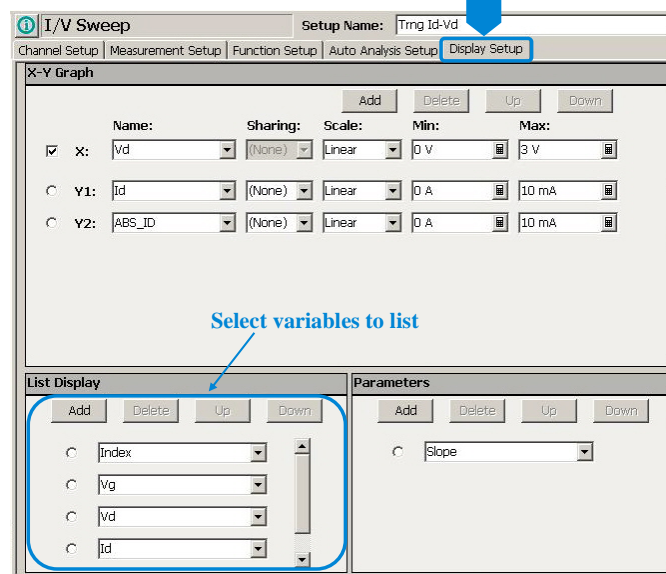
- ☐ Slope

Click the Display Setup tab to display the display setup screen. The X-Y Graph area is used to set the X axis and Y axis of the X-Y Graph Plot area in 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

## To Set Data List Display

### Display Setup



**I/V Sweep** Setup Name: Trng Id-Vd

Channel Setup | Measurement Setup | Function Setup | Auto Analysis Setup | **Display Setup**

**X-Y Graph**

Add Delete Up Down

Name: Sharing: Scale: Min: Max:

☒ X: Vd (None) Linear 0 V 3 V

☐ Y1: Id (None) Linear 0 A 10 mA

☐ Y2: ABS\_ID (None) Linear 0 A 10 mA

**List Display**

Add Delete Up Down

☐ Index

☐ Vg

☐ Vd

☐ Id

**Parameters**

Add Delete Up Down

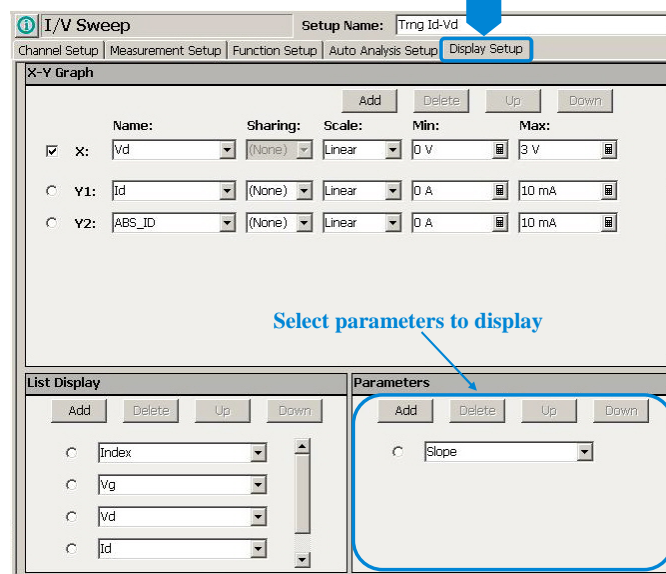
☐ Slope

Select variables to list

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

## To Set Parameters Display

### Display Setup



**I/V Sweep** Setup Name: Trng Id-Vd

Channel Setup | Measurement Setup | Function Setup | Auto Analysis Setup | **Display Setup**

**X-Y Graph**

Add Delete Up Down

	Name:	Sharing:	Scale:	Min:	Max:
<input checked="" type="checkbox"/> X:	Vd	(None)	Linear	0 V	3 V
<input type="checkbox"/> Y1:	Id	(None)	Linear	0 A	10 mA
<input type="checkbox"/> Y2:	ABS_ID	(None)	Linear	0 A	10 mA

Select parameters to display

**List Display**

Add Delete Up Down

- ☐ Index
- ☐ Vg
- ☐ Vd
- ☐ Id

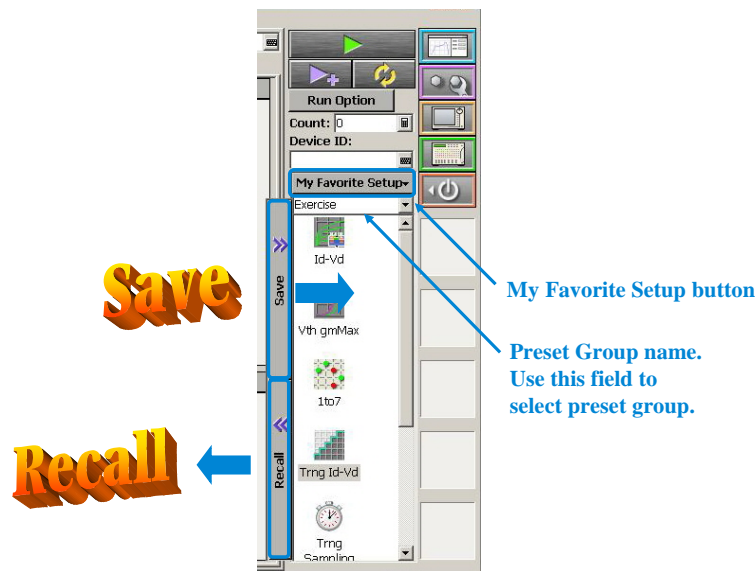
**Parameters**

Add Delete Up Down

- ☐ Slope

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

## To Save Test Setup



The test setups you create **MUST** be saved to the internal hard disk drive as “My Favorite Setup”.

To save the setup, click the Save button.

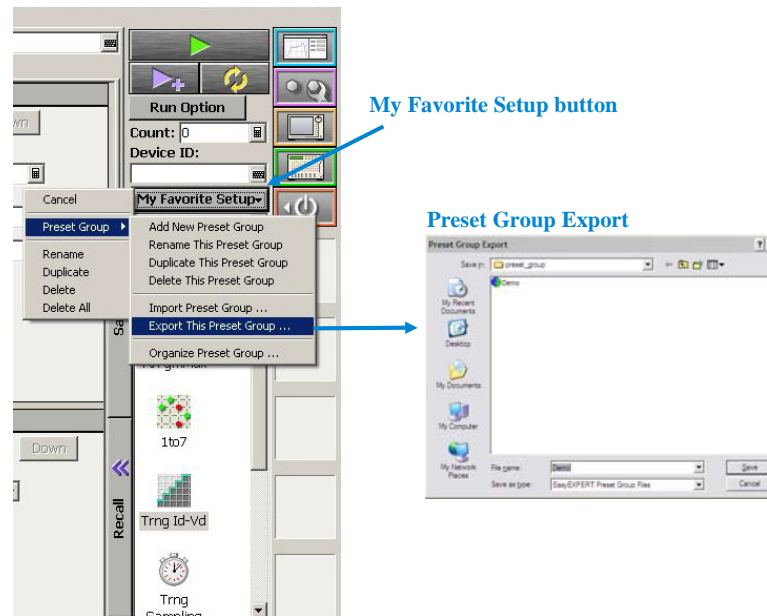
To recall the setup, click the Recall button.

You can organize the setups by using Preset Group. In the above example, the Demo group is selected and listed in the “My Favorite Setup”.

To create a new preset group, click the My Favorite Setup button to display the function menu, and select Add New Preset Group.

To select the available preset group, use the field below the My Favorite Setup button.

## To Export/Import Your Preset Group



You can export/import your preset group.

To export the present preset group, click the My Favorite Setup button, select Export, and specify the folder and the name of the preset group to export.

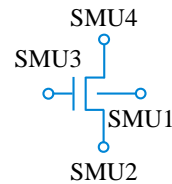
To import the preset group, click the My Favorite Setup button, select Import, and specify the preset group to import.

## Class Exercise



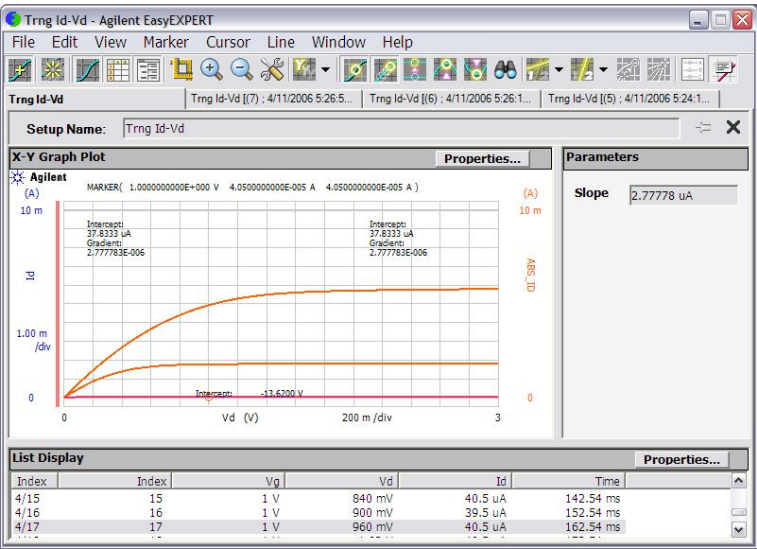
### Define test setup and perform test.

1. Click I/V Sweep icon and open setup editor.
2. Define test setup as shown in the previous pages.
3. Save it as Trng Id-Vd.
4. Connect device, and perform test.
5. Export preset group, and import it.



Note:

## Measurement Result Example



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

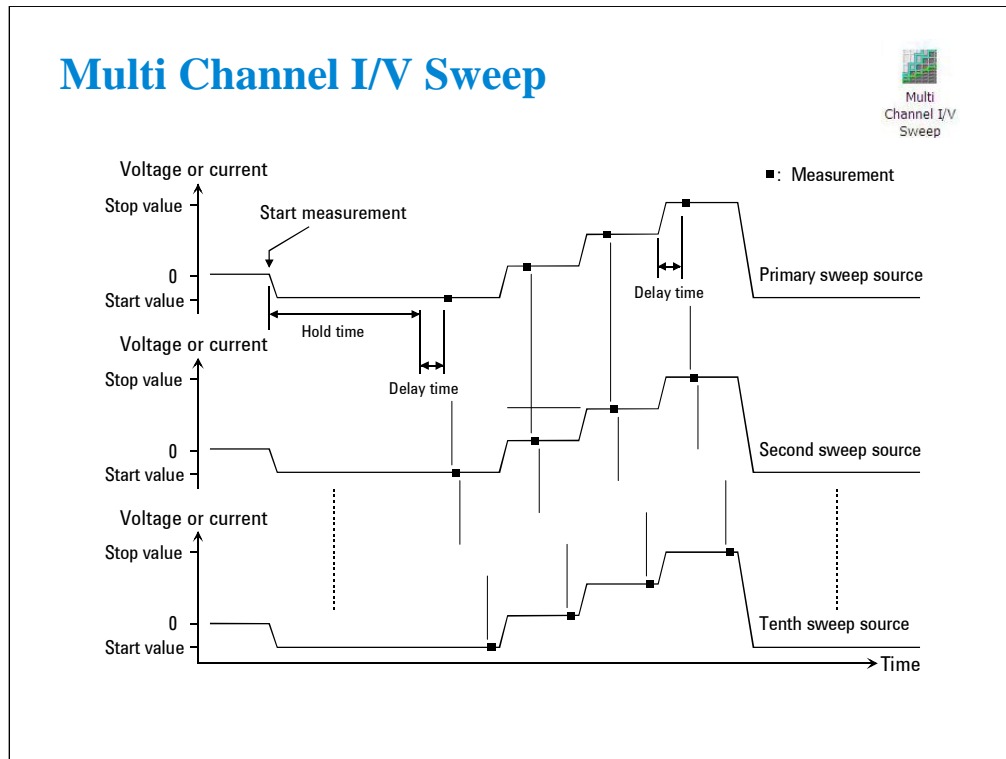


## Multi Channel I/V Sweep

- **To Define Channel Setup Screen**
- **To Set VAR1 Sweep Sources**
- **To Set Constant Output**
- **Other Measurement Setup Parameters**
- **To Set User Functions**
- **To Set Data Display**



This section explains how to perform the Multi Channel I/V sweep measurement. You will perform the above tasks to execute the Multi Channel I/V sweep measurement.

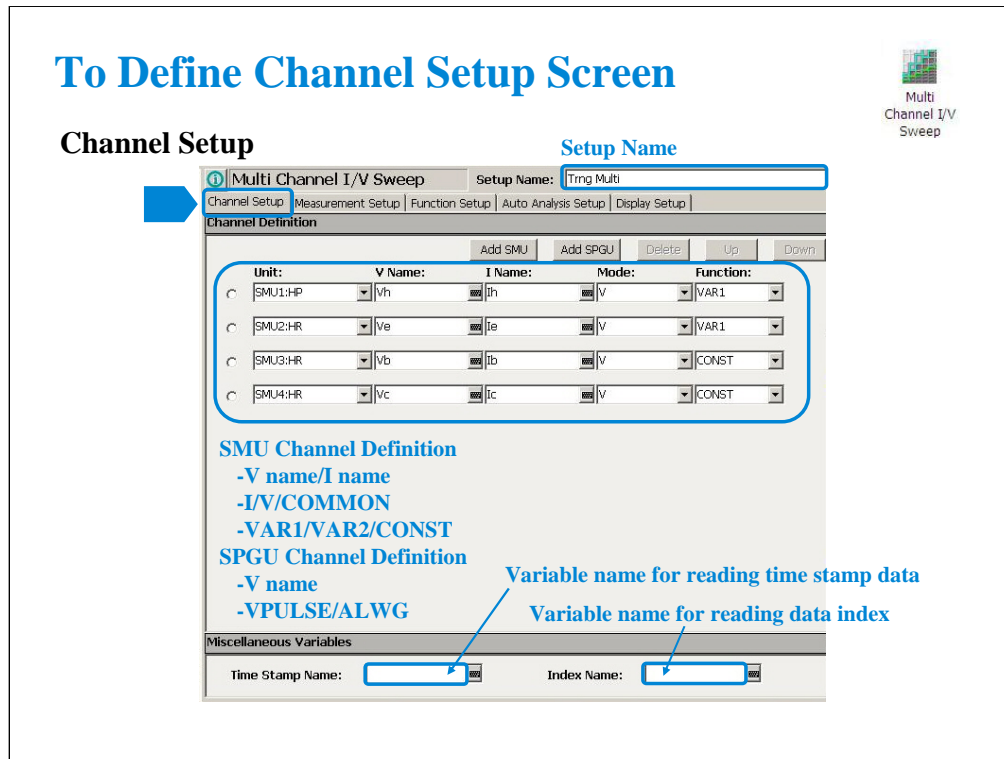


Multi Channel I/V Sweep measurement is similar to I/V Sweep measurement.

Changes from I/V Sweep are listed below.

- All SMU can be set to the VAR1 sweep source (up to 10 channels)
- Both voltage mode and current mode are available for the VAR1 sweep output
- VAR1' sweep output is not available
- SMU pulse output is not available

The output channels start to output in the order in which they are listed on the Channel Setup screen.



Click the Multi Channel I/V Sweep icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

1. Enter the Setup Name for the test setup to be defined on the setup editor.
2. List SMUs used for source output or measurement, and set the following parameters.
  - Unit: SMU name or number. The GNDU (ground unit) can be set instead of a SMU.
  - V Name: Variable name for the voltage measurement or source data
  - I Name: Variable name for the current measurement or source data
  - Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
  - Function: Source output function, VAR1 (primary sweep), VAR2 (secondary sweep), CONST (constant). Up to 10 sources can be set to VAR1.

V Name and I Name are used to specify the parameters displayed on the Data Display window. The display parameters are selected on the Display Setup tab screen. For the GNDU, 0 V is returned to the V variable and no data is returned to the I variable.

To use the SPGU channels, click the Add SPGU button. The SPGU channel setup row will appear. Then set the following parameters.

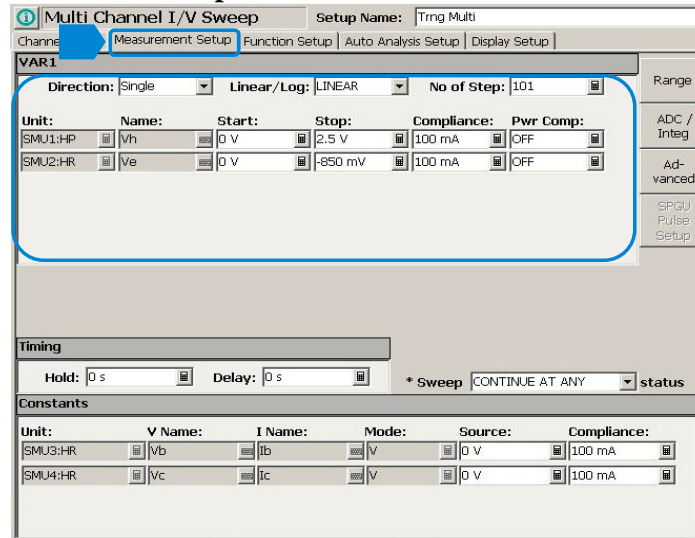
- Unit: SPGU name or number
- V Name: Variable name for the voltage data. No data is returned to the variable.
- Mode: SPGU output mode. VPULSE (voltage pulse) or ALWG (arbitrary linear waveform voltage) for all SPGU.

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

Note: The time stamp is the time the measurement is started for each measurement point. The index is the index number for each measurement data.

## To Set VAR1 Sweep Sources

### Measurement Setup



**Multi Channel I/V Sweep** Setup Name: Trng Multi

Channel: **Measurement Setup** Function Setup Auto Analysis Setup Display Setup

**VAR1**

Direction: Single Linear/Log: LINEAR No of Step: 101

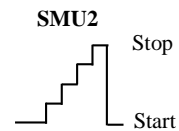
Unit:	Name:	Start:	Stop:	Compliance:	Pwr Comp:
SMU1:HP	Vh	0 V	2.5 V	100 mA	OFF
SMU2:HR	Ve	0 V	-850 mV	100 mA	OFF

Timing

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU3:HR	Vb	Ib	V	0 V	100 mA
SMU4:HR	Vc	Ic	V	0 V	100 mA



The Measurement Setup tab screen is used to set the source output value and timing parameters.

At the VAR1 area, you set VAR1 sweep sources.

Follows are common parameters for all VAR1 sweep sources.

- Direction: Single (start to stop) or Double (start to stop to start)
- Linear/Log: Linear sweep or Log sweep
- No of Step: Number of sweep steps

Following parameters can be set for each VAR1 sweep sources.

- Unit: SMU name or number
- Name: Variable name of source output
- Start: Source output start value
- Stop: Source output stop value
- Compliance: SMU compliance value
- Pwr Comp: SMU power compliance value

## To Set Constant Output

### Measurement Setup



**Multi Channel I/V Sweep** Setup Name: Trng Multi

Channel: **Measurement Setup** Function Setup Auto Analysis Setup Display Setup

**VARI**

Direction: Single Linear/Log: LINEAR No of Step: 101

Unit:	Name:	Start:	Stop:	Compliance:	Pwr Comp:
SMU1:HP	Vh	0 V	2.5 V	100 mA	OFF
SMU2:HR	Ve	0 V	-850 mV	100 mA	OFF

Timing

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU3:HR	Vb	Ib	V	0 V	100 mA
SMU4:HR	Vc	Ic	V	0 V	100 mA

At the Constants area, you set the SMU constant output.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
- Source: SMU output value
- Compliance: SMU compliance value

## Other Measurement Setup Parameters



### Measurement Setup

**Multi Channel I/V Sweep** Setup Name: Trng Multi

Channel: **Measurement Setup** Function Setup Auto Analysis Setup Display Setup

**VARI**

Direction: Single Linear/Log: LINEAR No of Step: 101

Unit:	Name:	Start:	Stop:	Compliance:	Pwr Comp:
SMU1:HP	Vh	0 V	2.5 V	100 mA	OFF
SMU2:HR	Ve	0 V	-850 mV	100 mA	OFF

Range  
ADC / Integ  
Ad-  
vanced  
SPGU  
Pulse  
Setup

**Timing**

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU3:HR	Vb	Ib	V	0 V	100 mA
SMU4:HR	Vc	Ic	V	0 V	100 mA

For the functions of Timing, Sweep status, Range, ADC/Integ, Advanced, SPGU Pulse Setup, and SPGU ALWG Setup, see the following pages respectively in the I/V Sweep section of this module.

- To Set Timing Parameters
- To Set Sweep Abort Function
- To Set Ranging Mode
- To Set ADC/Integration Time
- Advanced Setup
- SPGU Pulse Setup
- SPGU ALWG Setup

## To Set User Functions

### Function Setup

Multi Channel I/V Sweep

Setup Name: Trng Multi

Channel Setup | Measurement Setup | **Function Setup** | Auto Analysis Setup | Display Setup

Apply

**User Function**

Name:	Unit:	Definition:
Vbe	V	Vb-Ve

Add Delete Up Down

**Data calculation**  
-Measurement data/source data  
-Built-in function, etc.

**Analysis Function**

Name:	Unit:	Definition:
To add a function parameter, press the [Add] button in this area.		

Add Delete Up Down

Click the Function Setup tab to display the User Function/Analysis Function setup screen. The user functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

Name: Function name

Unit: Unit of the function

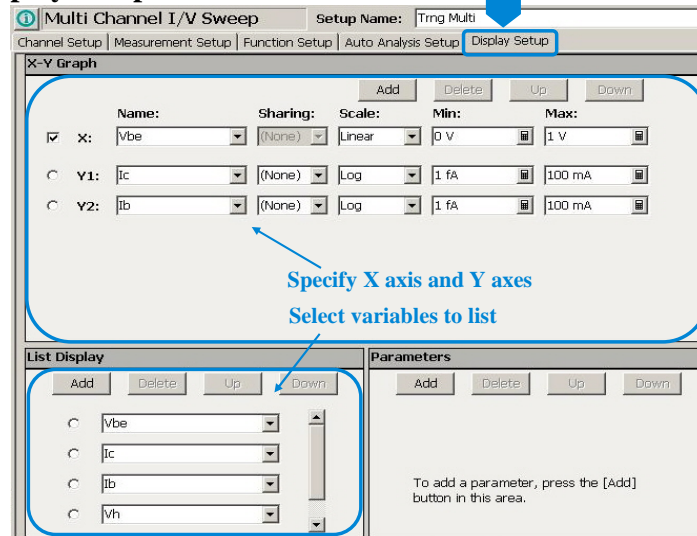
Definition: Definition of the function. The following identifiers can be used.

- Variables for the measurement/output data used in this test
- Functions defined in the above lines
- Local variables passed from the application test that calls this test as a component
- Built-in functions and global variables

For details, see online help or User's Guide.

## To Set Data Display

### Display Setup



Multi Channel I/V Sweep Setup Name: Trng Multi

Channel Setup | Measurement Setup | Function Setup | Auto Analysis Setup | **Display Setup**

**X-Y Graph**

	Name:	Sharing:	Scale:	Min:	Max:
<input checked="" type="checkbox"/>	X: Vbe	(None)	Linear	0 V	1 V
<input type="checkbox"/>	Y1: Ic	(None)	Log	1 fA	100 mA
<input type="checkbox"/>	Y2: Ib	(None)	Log	1 fA	100 mA

Specify X axis and Y axes  
Select variables to list

**List Display**

	Name:
<input type="checkbox"/>	Vbe
<input type="checkbox"/>	Ic
<input type="checkbox"/>	Ib
<input type="checkbox"/>	Vh

**Parameters**

To add a parameter, press the [Add] button in this area.

Click the Display Setup tab to display the display setup screen.

The X-Y Graph area is used to set the X axis and Y axes of the X-Y Graph Plot area in 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 in the List Display area of the Data Display window. Up to 20 variables can be set.

For example, following variables are set for the Class Exercise.

Vbe, Ic, Ib, Vh, Ih



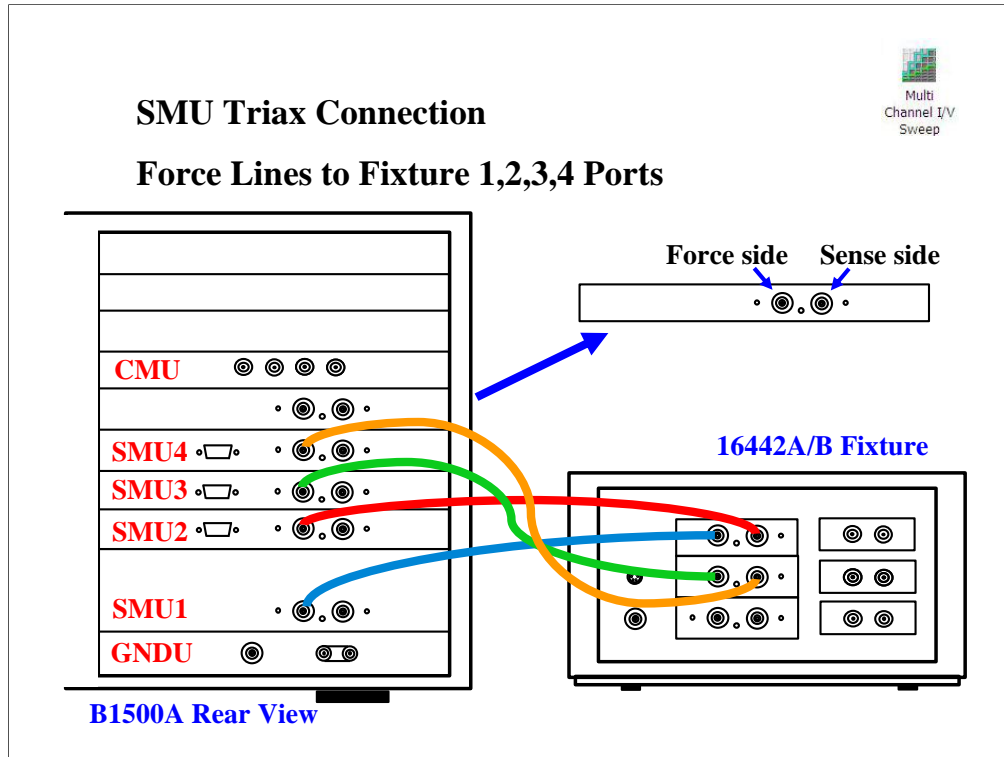
## Class Exercise



### Define test setup and perform test.

1. **Click Multi Channel I/V Sweep icon and open setup editor.**
2. **Define test setup as shown in the previous pages.**
3. **Save it as Trng Multi.**
4. **Connect devices (NPN Bipolar Transistor and Red Miniature LED) as shown in next several pages, and perform test.**
5. **Export preset group, and import it.**

Note:

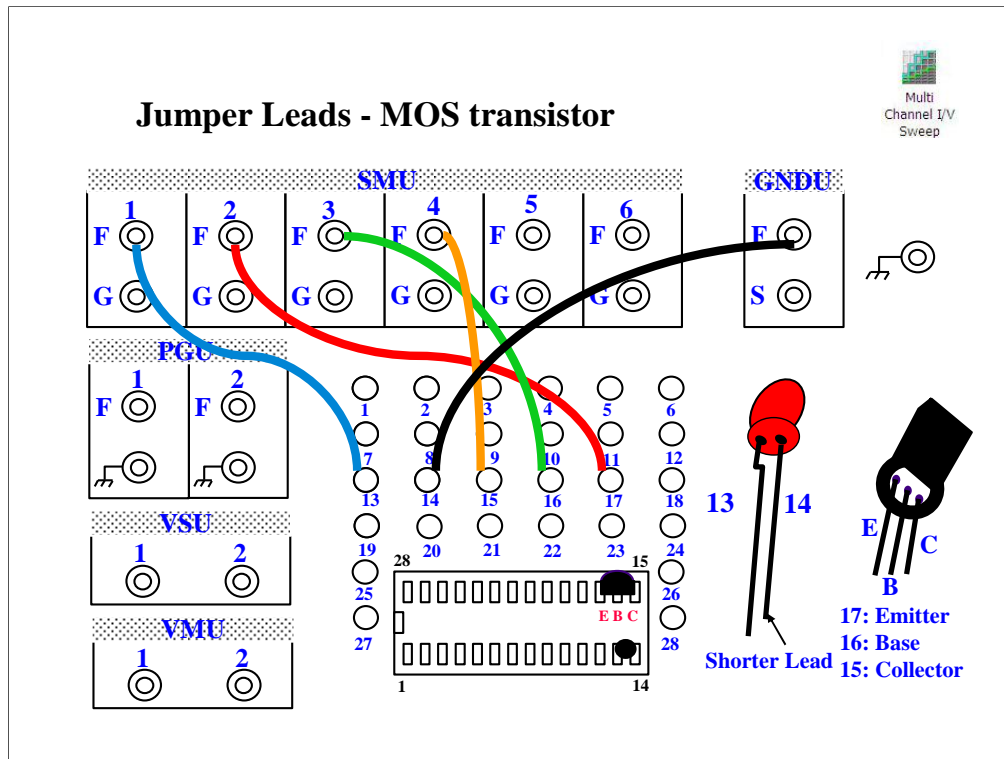


For the non-Kelvin connections, connect only the Force lines, leaving the Sense lines open.

Connect corresponding numbers. On the 16442A/B fixture use the numbers labeled 1 - 6, not 1 - 3.

Your B1500A may not match the SMU configuration shown in this figure. Note that SMU1 is the module top of the GNDU (ground unit). The SMU number become large from bottom to top as shown.

This is the SMU cable setup that will be used in the remainder of the class exercises.



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.

With the 16442A/B fixture, note that there are two SMU numbering schemes....3 SMUs with force and sense, or six SMUs with force only. For this class example we will use the six (6) SMU scheme.

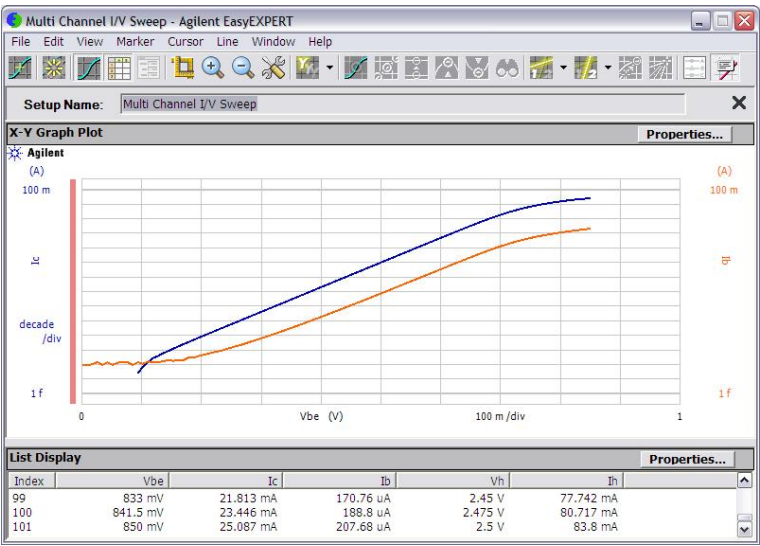
Connect jumper leads as follows.

- Terminal 13 : SMU1 F terminal
- Terminal 14 : GNDU F terminal
- Terminal 15 : SMU4 F terminal
- Terminal 16 : SMU3 F terminal
- Terminal 17 : SMU2 F terminal

Locate the bipolar transistor in the corner of the 28-pin dual in line socket as shown, with the flat side of the device facing toward you. Unlike the MOS device, the bipolar transistor is not static sensitive. You may touch the leads without using a ground strap.

Locate the LED between terminals 13 and 14 of the 28-pin dual in line socket.

## Measurement Result Example



This is a test result example displayed on the Data Display window.  
At the start of measurement, LED lights off. Beyond the threshold voltage, the LED lights on.

## I/V List Sweep



- **To Define Channel Setup Screen**
- **To Set VAR1 Sweep Sources**
- **To Set Constant Output**
- **Other Measurement Setup Parameters**
- **To Set User/Analysis Functions**
- **Auto Analysis Setup**
- **To Set Data Display**

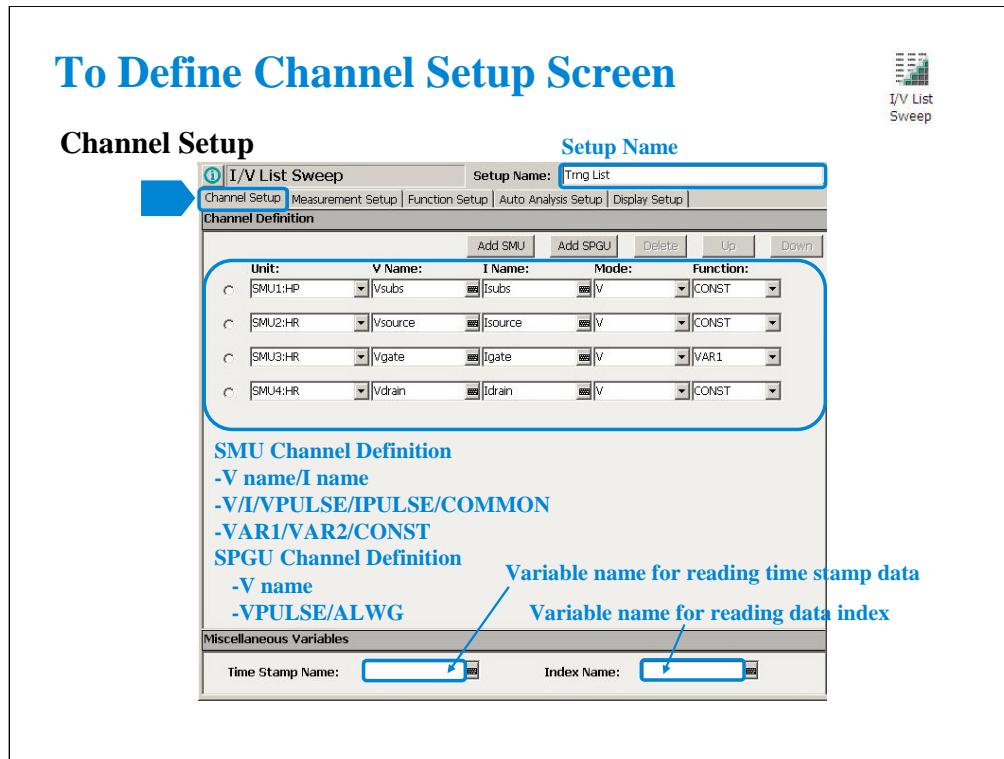
This section explains how to perform I/V List sweep measurement. You will perform the above tasks to execute the I/V List sweep measurement.

I/V List Sweep measurement is similar to I/V Sweep measurement.

Changes from the I/V Sweep are listed below.

- VAR1/VAR2 step output values are set by using a vector data. Vector data from a spreadsheet software, either tab separated or comma separated can be copied to the Define vector data dialog box via the Windows clipboard.
- All SMU installed in the B1500A can be set to VAR1.
- VAR1' is not supported.

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



Click the I/V List Sweep icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

1. Enter the Setup Name for the test setup to be defined on the setup editor.
2. List SMUs used for source output or measurement, and set the following parameters.
  - Unit: SMU name or number. The GNDU (ground unit) can be set instead of a SMU.
  - V Name: Variable name for the voltage measurement or source data
  - I Name: Variable name for the current measurement or source data
  - Mode: Source output mode, V (voltage), I (current), VPULSE (voltage pulse), IPULSE (current pulse), or COMMON (ground)
  - Function: Source output function, VAR1 (primary sweep), VAR2 (secondary sweep), or CONST (constant). Note: Up to 10 sources can be set to VAR1.

V Name and I Name are used to specify the parameters displayed on the Data Display window. The display parameters are selected on the Display Setup tab screen. For the GNDU, 0 V is returned to the V variable and no data is returned to the I variable.

To use the SPGU channels, click the Add SPGU button. The SPGU channel setup row will appear. Then set the following parameters.

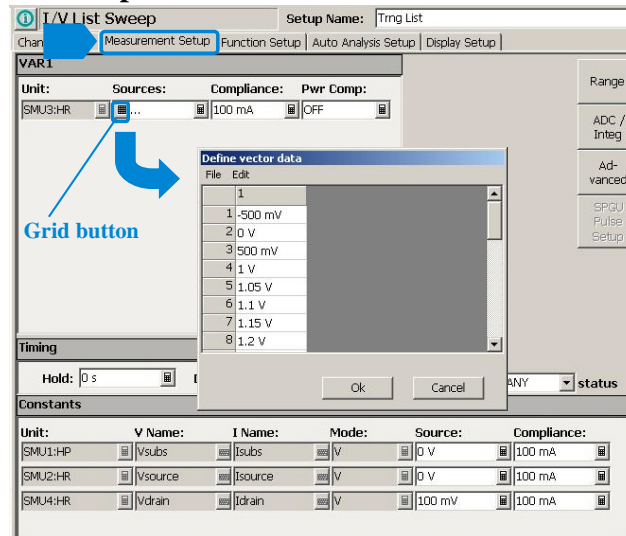
- Unit: SPGU name or number
- V Name: Variable name for the voltage data. No data is returned to the variable.
- Mode: SPGU output mode. VPULSE (voltage pulse) or ALWG (arbitrary linear waveform voltage) for all SPGU.

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

Note: The time stamp is the time the measurement is started for each measurement point. The index is the index number for each measurement data.

## To Set VAR1 Sweep Sources

### Measurement Setup



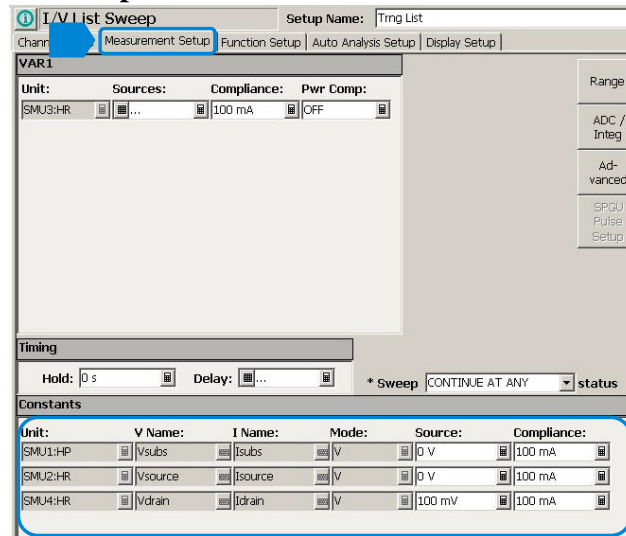
The Measurement Setup tab screen is used to set the source output value and timing parameters.

At the VAR1 area, you set VAR1 sweep sources.

- Unit: SMU name or number
- Source: Click the grid button to open the Define vector data dialog box. Enter the vector data of VAR1. For example, -500 m, 0, 500 m, 1, 1,05,1.1, 1.15, 1.2, 1.25, 1.3, 1.35, 1.4, 1.45, 1.5, 1.55, 1.6, 1.65, 1.7, 1.75, 1.8, 1.85, 1.9, 1.95, 2, 2.5, and 3 V are set for the Vth-gmMax. Step voltages near the gmMax are set to 50 mV and others are set to 500 mV.
- Compliance: SMU compliance value
- Pwr Comp: SMU power compliance value

## To Set Constant Output

### Measurement Setup



**I/V List Sweep** Setup Name: Trng List

Chann: Measurement Setup Function Setup Auto Analysis Setup Display Setup

**VAR1**

Unit:	Sources:	Compliance:	Pwr Comp:
SMU3:HR	100 mA	100 mA	OFF

Range  
ADC / Integ  
Ad-  
vanced  
SPGU  
Pulse  
Setup

**Timing**

Hold: 0 s Delay: ... \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU1:HP	Vsubs	Isubs	V	0 V	100 mA
SMU2:HR	Vsource	Isource	V	0 V	100 mA
SMU4:HR	Vdrain	Idrain	V	100 mV	100 mA

At the Constants area, you set the SMU constant output.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), VPULSE (voltage pulse), IPULSE (current pulse), or COMMON (ground)
- Source: SMU output value. For example, Vdrain is set to 100 mV for the Vth-gmMax.
- Compliance: SMU compliance value



## Other Measurement Setup Parameters



### Measurement Setup

Unit:	Sources:	Compliance:	Pwr Comp:
SMU3:HR	...	100 mA	OFF

Timing

Hold: 0 s      Delay: ...

\* Sweep: CONTINUE AT ANY      status

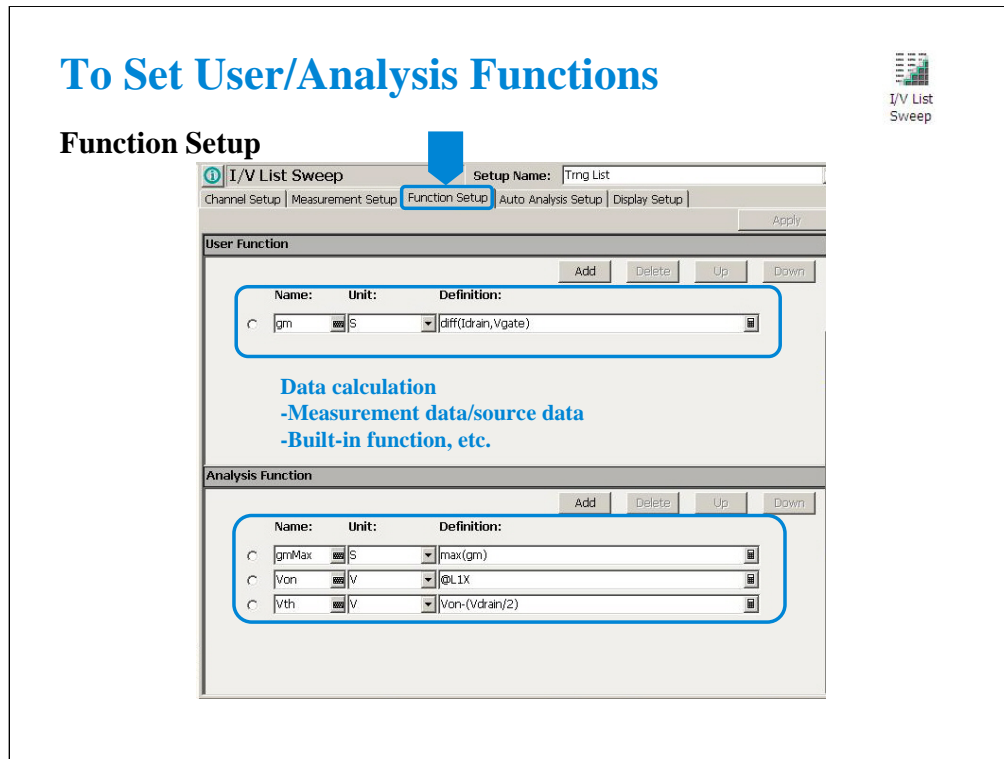
  

Constants

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
SMU1:HP	Vsubs	Isubs	V	0 V	100 mA
SMU2:HR	Vsource	Isource	V	0 V	100 mA
SMU4:HR	Vdrain	I drain	V	100 mV	100 mA

For the functions of Timing, Sweep status, Range, ADC/Integ, Advanced, SPGU Pulse Setup, and SPGU ALWG Setup, see the following pages respectively in the I/V Sweep section of this module.

- To Set Timing Parameters
- To Set Sweep Abort Function
- To Set Ranging Mode
- To Set ADC/Integration Time
- Advanced Setup
- SPGU Pulse Setup
- SPGU ALWG Setup



Click the Function Setup tab to display the User Function/Analysis Function setup screen. The user/analysis functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

Name: Function name

Unit: Unit of the function

Definition: Definition of the function. The following identifiers can be used.

- Variables for the measurement/output data used in this test
- Functions defined in the above lines
- Local variables passed from the application test that calls this test as a component
- Built-in functions and global variables

For details, see online help or User's Guide.

For example, following user/analysis functions are set for the Vth-gmMax.

<Name> <Unit> <Definition>

Gm S diff(Idrain,Vgate)

gmMax S max(gm)

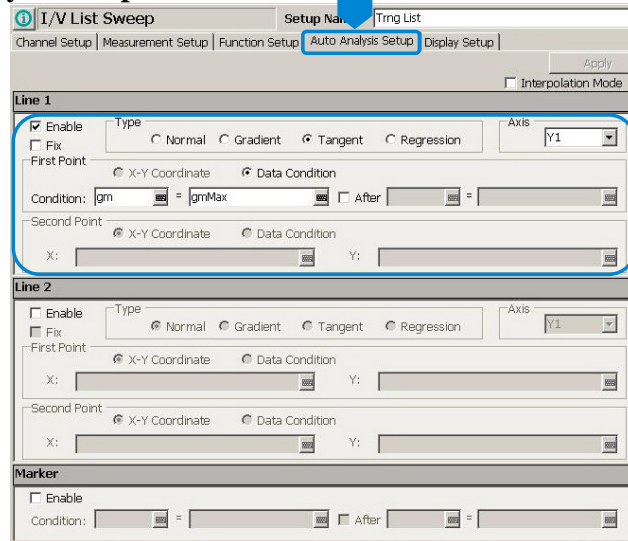
Von V @L1X

Vth V Von-(Vdrain/2)

For built-in functions, see online help or User's Guide.

## Auto Analysis Setup

### Auto Analysis Setup



**I/V List Sweep** Setup Name: Tmg List

Channel Setup | Measurement Setup | Function Setup | **Auto Analysis Setup** | Display Setup

Interpolation Mode: ☐ Interpolation Mode

**Line 1**

☒ Enable ☐ Fix Type: ☐ Normal ☐ Gradient ☒ Tangent ☐ Regression Axis: Y1

First Point: ☒ X-Y Coordinate ☒ Data Condition

Condition: gm = gmMax ☐ After =

Second Point: ☒ X-Y Coordinate ☐ Data Condition

X: Y:

**Line 2**

☐ Enable ☐ Fix Type: ☐ Normal ☐ Gradient ☐ Tangent ☐ Regression Axis: Y1

First Point: ☐ X-Y Coordinate ☐ Data Condition

X: Y:

Second Point: ☐ X-Y Coordinate ☐ Data Condition

X: Y:

**Marker**

☐ Enable

Condition: = ☐ After =

Click the Auto Analysis Setup tab to display the Auto Analysis setup screen. This screen is used to set the automatic analysis function. When a measurement finishes, the function automatically draws lines, a marker, or both on the X-Y Graph of the Data Display window.

You can set up two lines and one marker for the automatic analysis function.

In the Line 1 and Line 2 areas, you can set up the lines to be drawn.

In the Marker area, you can set up the marker.

For details, see online help or User's Guide.

For example, the Line 1 is set for the Vth-gmMax.

Type: Tangent

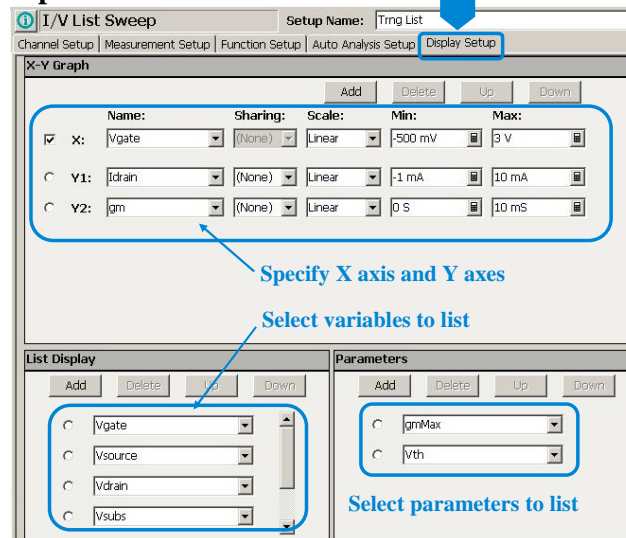
Axis: Y1

First Point: Data Condition

Condition: gm = gmMax

## To Set Data Display

### Display Setup



Click the Display Setup tab to display the display setup screen.

The X-Y Graph area is used to set the X axis and Y axes of the X-Y Graph Plot area in 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

For example, following axes are set for the Vth-gmMax.

	<Name>	<Sharing>	<Scale>	<Min>	<Max>
X	Vgate		Linear	-500 mV	3 V
Y1	Idrain	(None)	Linear	-1 mA	10 mA
Y2	gm	(None)	Linear	0 S	10 mS

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

For example, following variables are set for the Vth-gmMax.

Vgate, Vsource, Vdrain, Vsubs, Idrain, gm

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

For example, following parameters are set for the Vth-gmMax.

gmMax, Vth

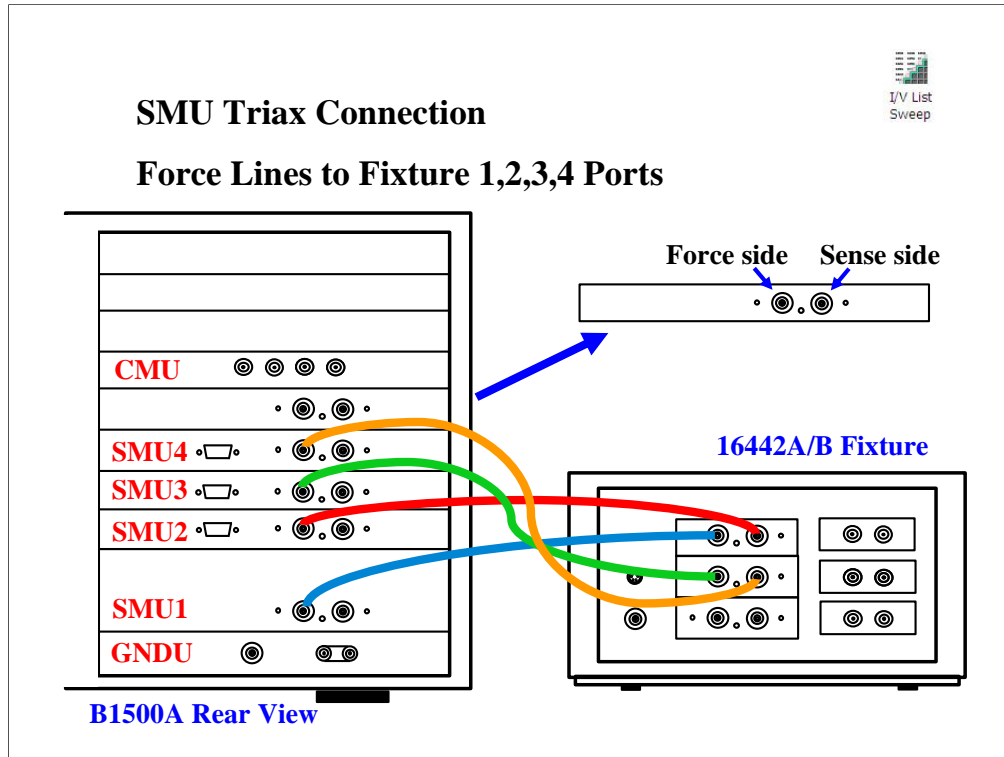
## Class Exercise



### Define test setup and perform test.

1. Click I/V List Sweep icon and open setup editor.
2. Define test setup as shown in the previous pages.
3. Save it as Trng List.
4. Connect an N-ch MOSFET as shown in next several pages, and perform test.
5. Export preset group, and import it.

Note:

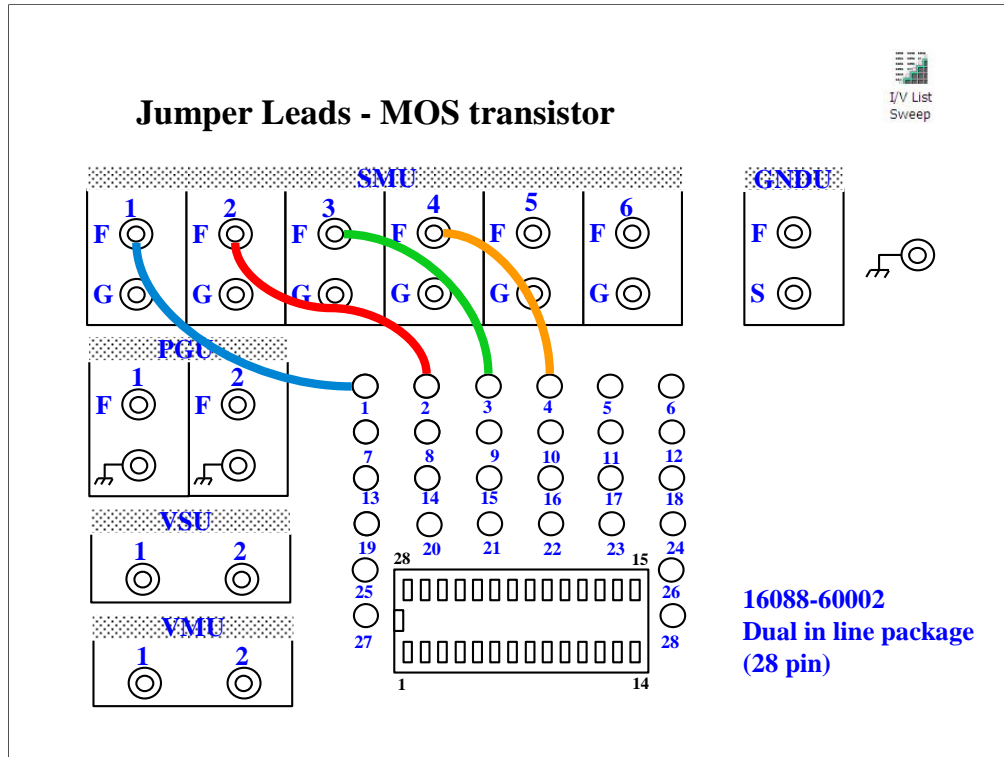


For the non-Kelvin connections, connect only the Force lines, leaving the Sense lines open.

Connect corresponding numbers. On the 16442A/B fixture use the numbers labeled 1 - 6, not 1 - 3.

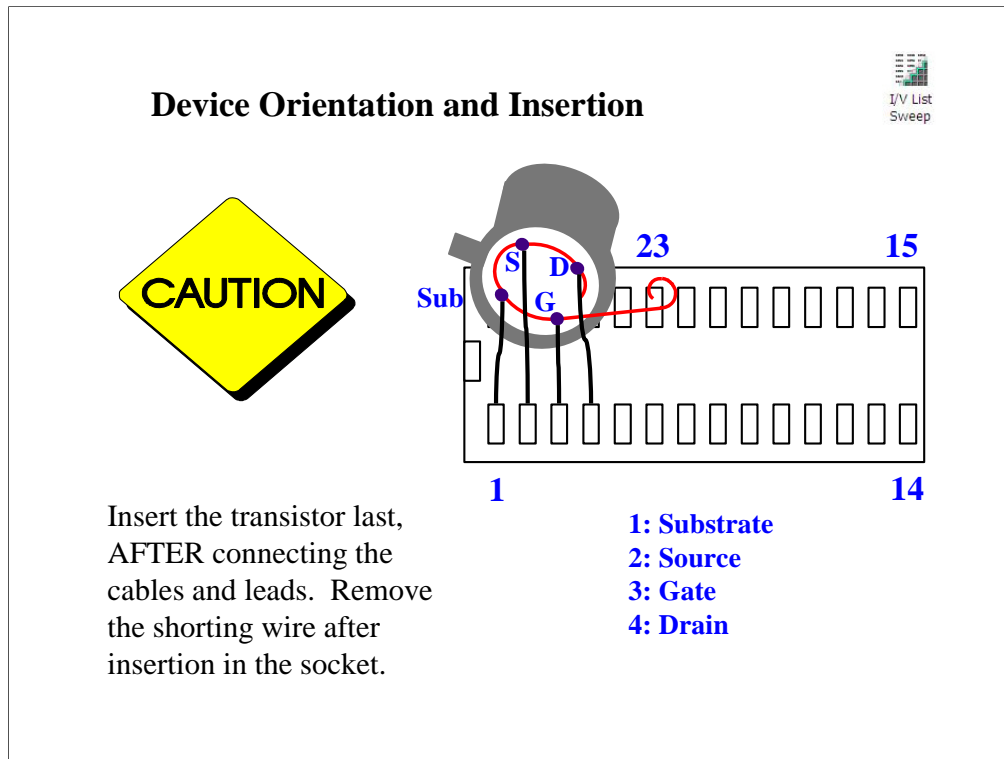
Your B1500A may not match the SMU configuration shown in this figure. Note that SMU1 is the module top of the GNDU (ground unit). The SMU number become large from bottom to top as shown.

This is the SMU cable setup that will be used in the remainder of the class exercises.



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.

With the 16442A/B fixture, note that there are two SMU numbering schemes....3 SMUs with force and sense, or six SMUs with force only. For this class example we will use the six (6) SMU scheme. On older fixtures, this scheme is shown in light blue lettering. In newer fixtures, this scheme is shown in white reverse background lettering.



The MOS FET leads must be re-arranged into a straight line as shown.

**IMPORTANT:**

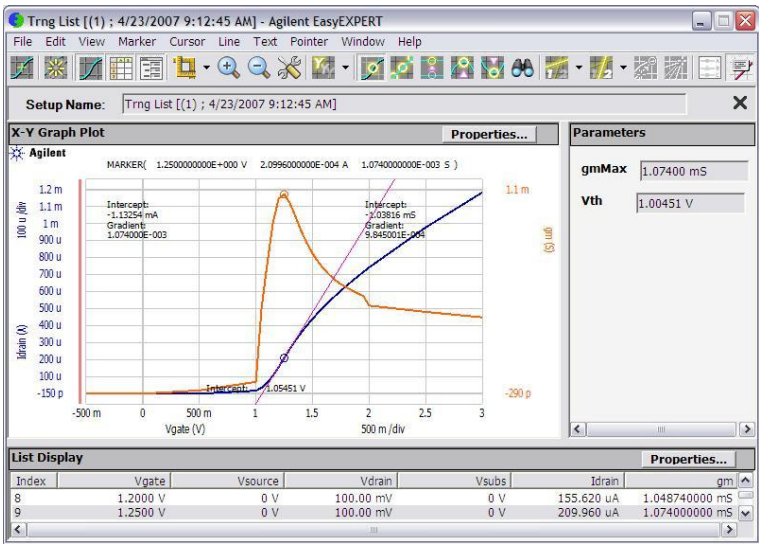
The MOS FET is highly sensitive to electrostatic damage. Touching the bare leads can definitely destroy the device. The device comes with a special shorting wire attached. Bend the leads the way you want, insert the device in the socket, and then remove the shorting wire. The wire has a tab. Just grab the tab and pull straight out. The wire will spiral out as you pull.

Once the shorting wire is removed, you must use a wrist strap when handling the device.



# Measurement Result Example

I/V List  
Sweep



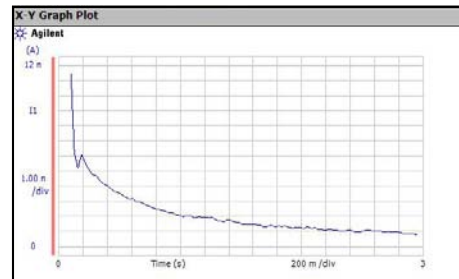
This is a test result example displayed on the Data Display window.

## I/V-t Sampling Measurement

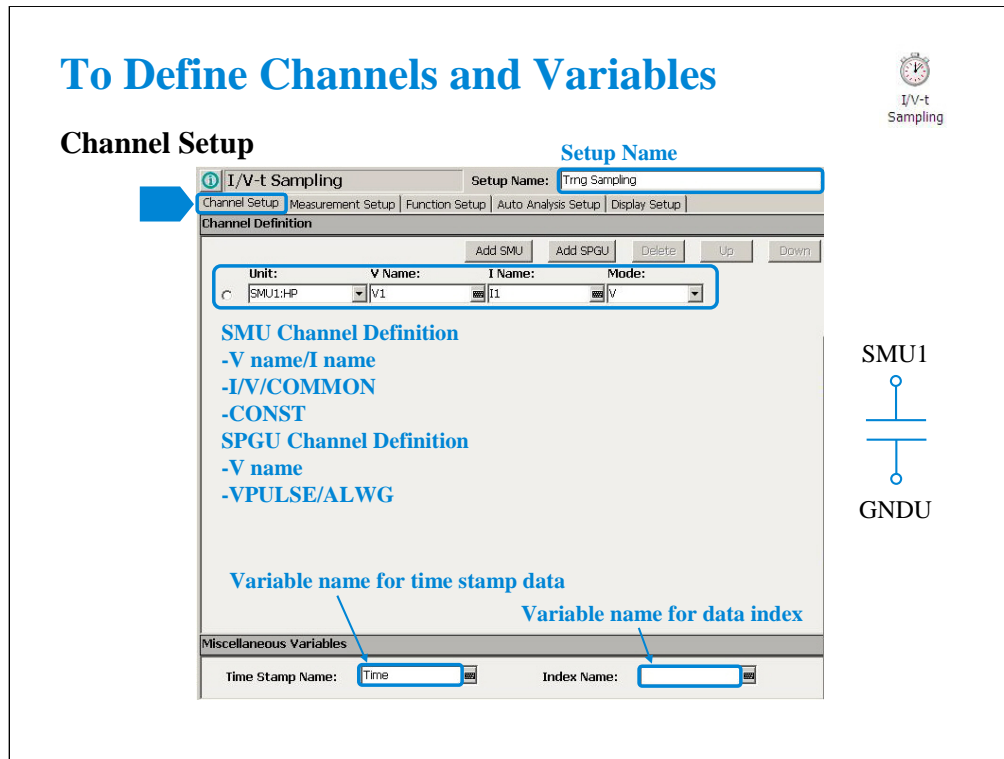


I/V-t  
Sampling

- To Define Channels and Variables
- To Set Sampling Parameters
- To Set Stop Condition
- To Set SMU Outputs (CONST)
- Range/ADC/Advanced/SPGU
- To Set User Functions/  
Analysis Functions
- To Set Data Display



This section explains how to perform I/V-t sampling measurement. You will perform the above tasks to execute the I/V-t sampling measurement.



Click the I/V-t Sampling icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

1. Enter the Setup Name for the test setup to be defined on the setup editor.
2. List SMUs used for source output or measurement, and set the following parameters.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
- Time Stamp Name: Variable name for the time stamp data
- Index Name: Variable name for the data index

V Name and I Name are used to specify the parameters displayed on the Data Display window. The display parameters are selected on the Display Setup tab screen. For the GNDU, 0 V is returned to the V variable and no data is returned to the I variable.

To use the SPGU channels, click the Add SPGU button. The SPGU channel setup row will appear. Then set the following parameters.

- Unit: SPGU name or number
- V Name: Variable name for the voltage data. No data is returned to the variable.
- Mode: SPGU output mode. VPULSE (voltage pulse) or ALWG (arbitrary linear waveform voltage) for all SPGU.

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

Note: The time stamp is the time the measurement is started for each measurement point. The index is the index number for each measurement data.

## To Set Sampling Parameters

### Measurement Setup

The diagram below the dialog illustrates the timing sequence for sampling:

- Trigger:** Indicated by a blue arrow pointing to the start of the measurement cycle.
- Hold time:** The duration before the measurement begins.
- Measurement time:** The duration of the actual measurement.
- Sampling interval:** The time between consecutive measurements.

Click the Measurement Setup tab to display the setup screen for the sampling timing parameters and the SMU source output parameters. At the Sampling Parameter area, you set the following sampling timing parameters.

**Linear/Log:**

Sampling mode. LINEAR for linear sampling. LOG10, LOG25, LOG50, LOG100, LOG250, or LOG500 for logarithmic sampling. For the logarithmic sampling, the number after LOG indicates the number of measurement data in a decade. For example, LOG10 mode is used to get 10 data/decade.

For the log sampling, the B1500A holds only the data that can be plotted on the log scale in the same distance as close as possible. Only the held data is counted in the number of measurement result data.

For the linear sampling with Interval < 2 ms, if the total measurement time runs over the specified time Interval × No of Samples, the sampling measurement will be stopped even if the number of measurement result data is less than the specified No of Samples.

**Interval:**

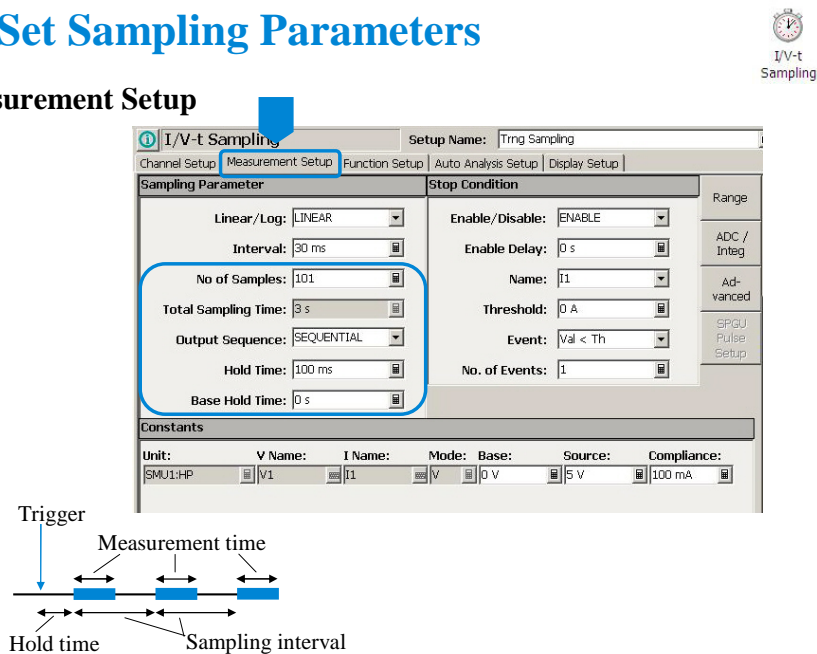
Interval of the sampling, in seconds. 0.002 to 65.535 s, 0.001 s resolution.

Interval < 0.002 s in 0.00001 s resolution is also available for the linear sampling. It must satisfy the following formula. For details, see online help or User's Guide.

Interval ≥ 0.0001 + 0.00002 × (number of measurement channels-1)

## To Set Sampling Parameters

### Measurement Setup



**No of Samples:**

Number of samples. Integer. 1 to the following value.

For linear:  $100001 / (\text{number of measurement channels})$

For logarithmic:  $1 + (\text{number of data for 11 decades})$

**Total Sampling Time:**

This field just displays the total sampling time that is the time from the measurement start time for the first point to the end of sampling measurement. It does not include the hold time.

$\text{Total Sampling Time} = \text{Interval} \times \text{No of Samples}$

**Output Sequence:**

Source output sequence. SIMULTANEOUS or SEQUENTIAL.

**Hold Time:**

Time since the Source value output until the first sampling point, in seconds. 0 to 655.35 s, resolution 0.01 s.

The following values are also available for Interval < 0.002 s. |Hold Time| will be the time since the sampling start until the Source value output.

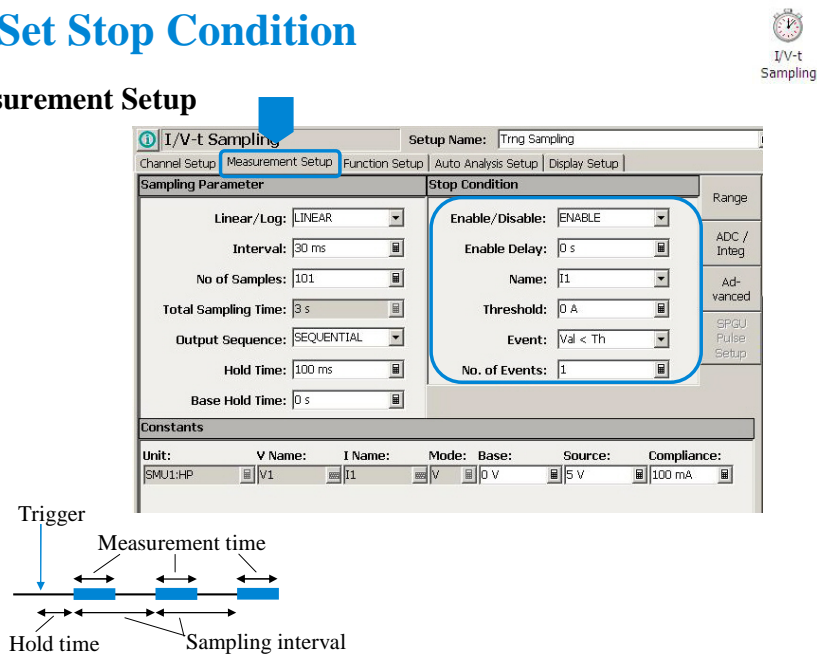
-0.09 to -0.0001 s, resolution 0.0001 s.

**Base Hold Time:**

Hold time of the Base value output until the Source value output, in seconds. 0 to 655.35 s, resolution 0.01 s.

## To Set Stop Condition

### Measurement Setup



The stop condition is defined by using the Stop Condition fields on the Measurement Setup screen. This function stops the measurement as shown below.

1. Compares the value of parameter set to the Name field and the value defined in the Threshold field.
2. Counts how many times the selected Event occurs.
3. When the count reaches the value defined in the No. of Events field, sampling is stopped immediately.

## To Set SMU Outputs (CONST)

### Measurement Setup



Sampling Parameter		Stop Condition		Range
Linear/Log:	LINEAR	Enable/Disable:	ENABLE	ADC / Integ
Interval:	30 ms	Enable Delay:	0 s	Ad- vanced
No of Samples:	101	Name:	I1	SPGU Pulse Setup
Total Sampling Time:	3 s	Threshold:	0 A	
Output Sequence:	SEQUENTIAL	Event:	Val < Th	
Hold Time:	100 ms	No. of Events:	1	
Base Hold Time:	0 s			

Constants						
Unit:	V Name:	I Name:	Mode:	Base:	Source:	Compliance:
SMU1:HP	V1	I1	V	0 V	5 V	100 mA

SMU constant output setup

At the Constants area, you set the SMU constant output.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
- Base and Source: SMU output value
- Compliance: SMU compliance value

Base value is available for all output channels for the SIMULTANEOUS mode and the last source channel for the SEQUENTIAL mode.

## Range/ADC/Advanced/SPGU Setup

### Measurement Setup



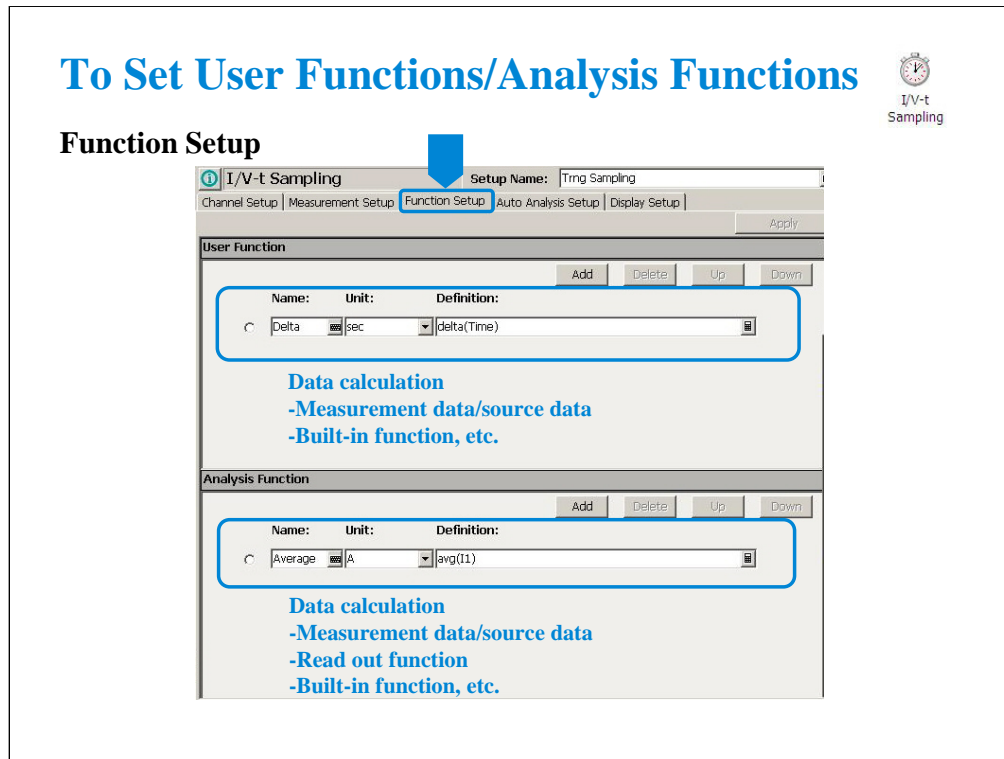
For the Range, ADC/Integ, Advanced, SPGU Pulse Setup, and SPGU ALWG Setup buttons, see the following pages respectively in the I/V Sweep section of this module.

- To Set Ranging Mode
- To Set ADC/Integration Time
- Advanced Setup
- SPGU Pulse Setup
- SPGU ALWG Setup

Note:

If the range changing occurs during measurement, the SMU may not complete measurement within the sampling interval. So use FIXED range if the sampling interval is top priority and the resolution/sensitivity is second priority.





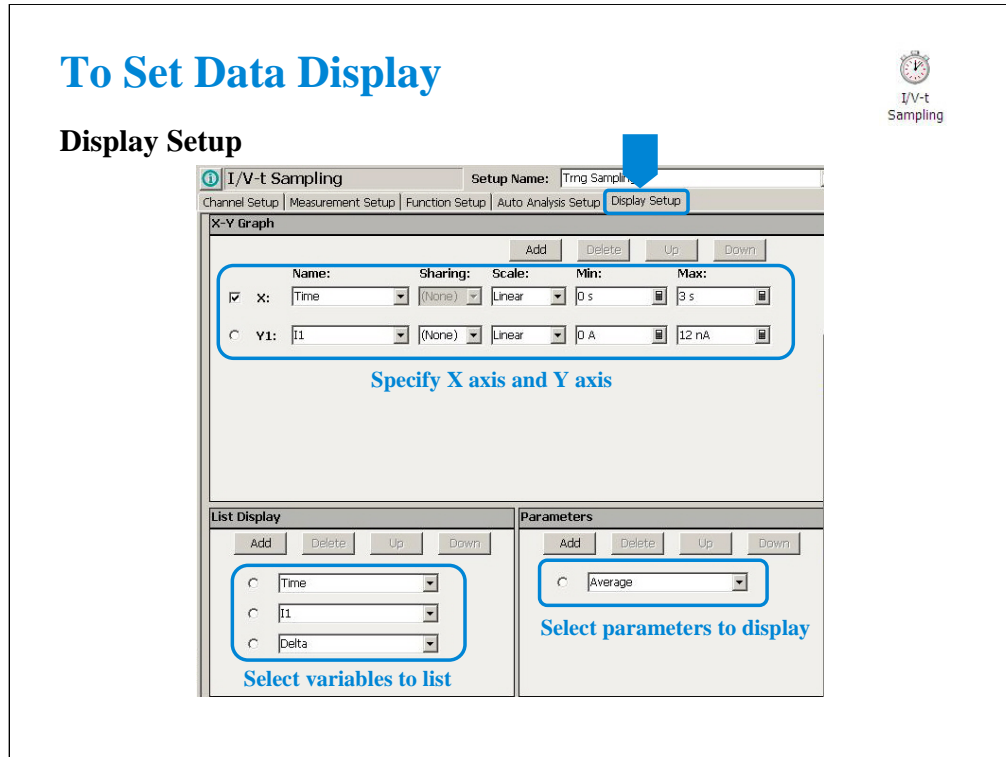
Click the Function Setup tab to display the User Function/Analysis Function setup screen.

The user functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

- Name: Function name
  - Unit: Unit of the function
  - Definition: Definition of the function. The following identifiers can be used.
    - Variables for the measurement/output data used in this test
    - Functions defined in the above lines
    - Local variables passed from the application test that calls this test as a component
    - Built-in functions and global variables
- For details, see online help or User's Guide.

The analysis functions can be displayed on the Parameters area of the Data Display window. Up to 20 functions can be set.

- Name: Function name
  - Unit: Unit of the function
  - Definition: Definition of the function. The following identifiers can be used.
    - Variables for the measurement/output data used in this test
    - Functions defined in the above lines
    - Local variables passed from the application test that calls this test as a component
    - Built-in functions and global variables
    - Read out functions
- For details, see online help or User's Guide.



Click the Display Setup tab to display the display setup screen. The X-Y Graph area is used to set the X axis and Y axis of the X-Y Graph Plot area in 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 in 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 in the Parameters area of the Data Display window. Up to 20 parameters can be set.

## Class Exercise



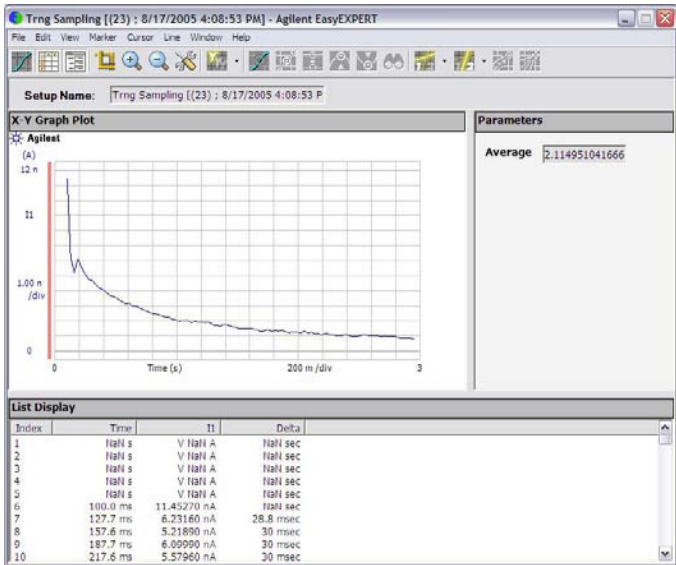
### Define test setup and perform test.

1. Click I/V-t Sampling icon and open setup editor.
2. Define test setup as shown in the previous pages.
3. Save it as Trng Sampling.
4. Connect device (capacitance), and perform test.
5. Export preset group, and import it.



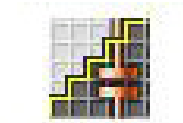
Note:

# Measurement Result Example



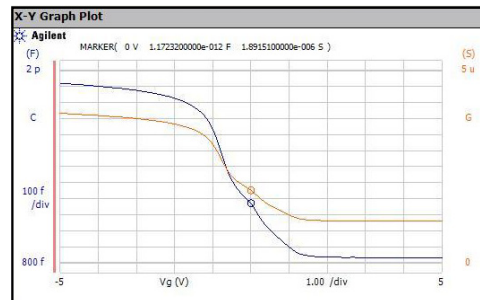
This is a test result example displayed on the Data Display window.

## C-V Sweep Measurement

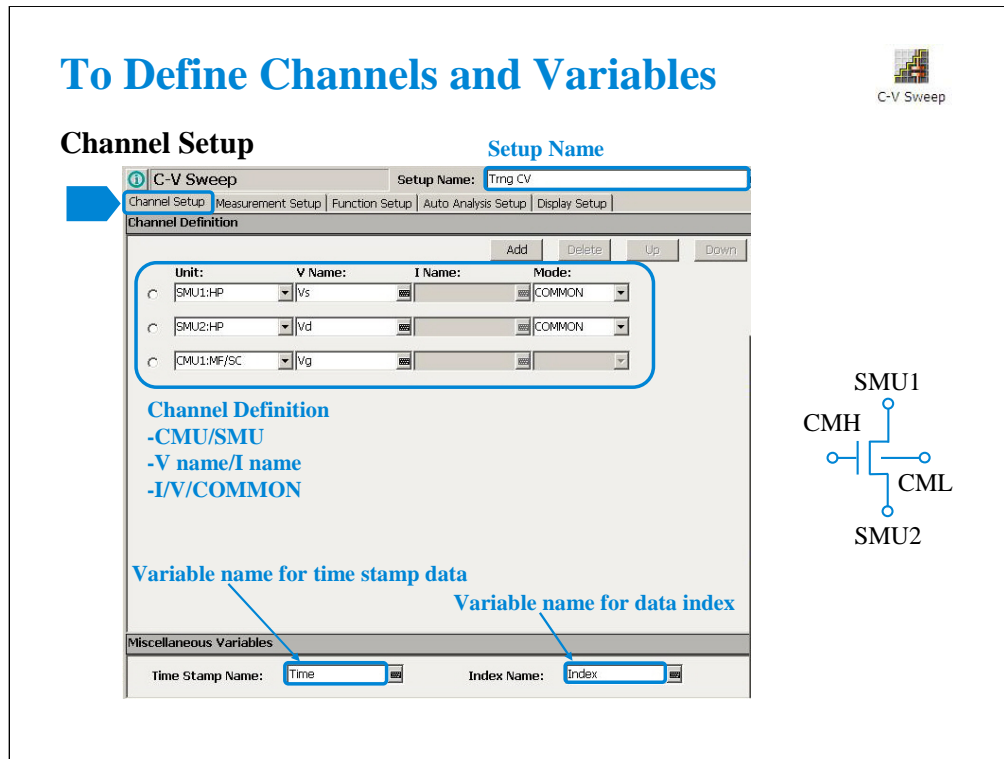


C-V Sweep

- To Define Channels and Variables
- To Set Sweep Source
- To Set Signal Source
- To Set Measurement Timing and Abort Function
- To Set SMU Outputs (CONST)
- Range/Advanced
- To Set User Functions/  
Analysis Functions
- To Set Data Display
- To Perform Compensation  
and Correction



This section explains how to perform C-V sweep measurement. You will perform the above tasks to execute the C-V sweep measurement.



Click the C-V Sweep icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

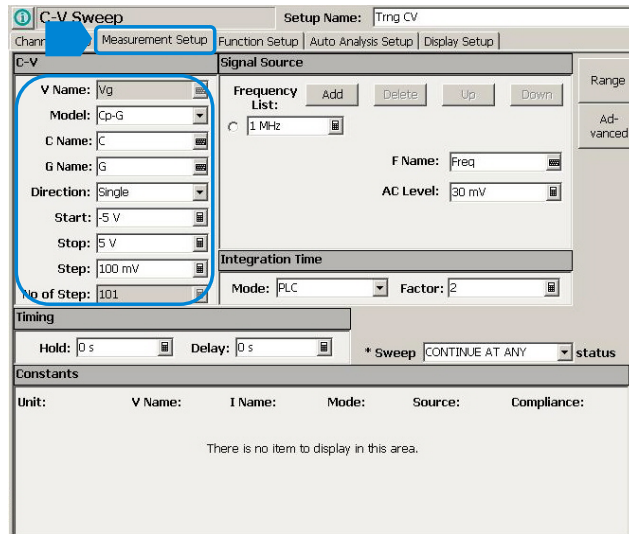
- Enter the Setup Name for the test setup to be defined on the setup editor.
- List units used for source output or measurement, and set the following parameters.
  - Unit: MFCMU/SMU name or number
  - V Name: Variable name for the voltage measurement or source data
  - I Name: Variable name for the current measurement or source data
  - Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
  - Time Stamp Name: Variable name for the time stamp data
  - Index Name: Variable name for the data index

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

Note: The time stamp is the time the measurement is started for each measurement point. The index is the index number for each measurement data.

## To Set Sweep Source

### Measurement Setup



**C-V Sweep** Setup Name: Trng CV

Chan: Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

**C-V**

V Name: Vg  
Model: Cp-G  
C Name: C  
G Name: G  
Direction: Single  
Start: -5 V  
Stop: 5 V  
Step: 100 mV  
No of Step: 101

**Signal Source**

Frequency List: Add Delete Up Down  
C 1 MHz  
F Name: Freq  
AC Level: 30 mV

**Integration Time**

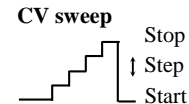
Mode: FLC Factor: 2

**Timing**

Hold: 0 s Delay: 0 s \* Sweep CONTINUE AT ANY status

**Constants**

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
There is no item to display in this area.					



The Measurement Setup tab screen is used to set the source output and timing parameters.

At the C-V area, you set the DC bias output of the MFCMU.

- V Name: Variable name of the MFCMU output
- Model: MFCMU measurement mode. Primary and secondary measurement parameters. Select one from the following four models.
  - Cp-G: Parallel capacitance (F) and Conductance (S)
  - Cp-D: Parallel capacitance (F) and Dissipation factor
  - Cs-Rs: Series capacitance (F) and Series resistance (ohm)
  - Z-Th: Impedance (ohm) and Phase (degree)
- C/Z Name: Variable name of the primary measurement parameter, C or Z
- G/D/R/Th Name: Variable name of the secondary measurement parameter, G, D, R, or Th
- Direction: Sweep direction, single (start to stop) or double (start to stop to start)
- Start: Source output start value
- Stop: Source output stop value
- Step: Source output incremental step value
- No of Step: Number of sweep steps

## To Set Signal Source



### Measurement Setup

**C-V Sweep** Setup Name: Trng CV

Chan: Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

**C-V**

V Name: Vg Model: Cp-G C Name: C G Name: G Direction: Single Start: -5 V Stop: 5 V Step: 100 mV No of Step: 101

**Signal Source**

Frequency List: Add Delete Up Down

C	F Name	AC Level
1 MHz	Freq	30 mV

Integration Time

Mode: FLC Factor: 2

Timing

Hold: 0 s Delay: 0 s \* Sweep: CONTINUE AT ANY status

Constants

Unit:	V Name:	I Name:	Mode:	Source:	Compliance:
There is no item to display in this area.					

At the Signal Source area, you set the MFCMU output frequency and oscillator level.

- Frequency List: MFCMU output frequency
- F Name: Variable name of MFCMU output frequency
- AC Level: MFCMU oscillator level, 10 mV to 250 mV, 1 mV resolution



## To Set Meas. Timing and Abort Function



### Measurement Setup

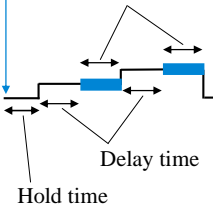
#### Sweep abort function

CONTINUE AT ANY  
STOP AT ANY ABNORMAL

- Range overflow
- MFCMU error
- SMU compliance
- SMU oscillation

#### Trigger

Measurement time



#### Timing parameters

At the Integration Time area, you set the integration time of the impedance measurement by the MFCMU.

- Mode: AUTO or PLC. Rule to decide the integration time. For details, see online help or User's Guide.
- Factor: Coefficient for the reference value of the integration time.

At the Timing area, you set the source output and measurement timing.

- Hold: Source output hold time. Time after the measurement trigger until starting delay time.
- Delay: Measurement start delay time. Time after the hold time until starting measurement.

The Sweep [ ] status field sets the sweep abort function.

When this field is CONTINUE AT ANY, the sweep measurement is not aborted.

When this field is STOP AT ANY ABNORMAL, the sweep measurement will be aborted when one of the following conditions is detected.

- Measurement range overflow
- MFCMU error
- SMU compliance
- SMU oscillation

## To Set SMU Outputs (CONST)



### Measurement Setup

**C-V Sweep** Setup Name: Trng CV

Chan: Measurement Setup | Function Setup | Auto Analysis Setup | Display Setup

**C-V**

V Name: Vg Model: Cp-G C Name: C G Name: G Direction: Single Start: -5 V Stop: 5 V Step: 100 mV No of Step: 101

**Signal Source**

Frequency List: Add Delete Up Down C 1 MHz F Name: Freq AC Level: 30 mV

**Integration Time**

Mode: FLC Factor: 2

**Timing**

Hold: 0 s Delay: 0 s \* Sweep: CONTINUE AT ANY status

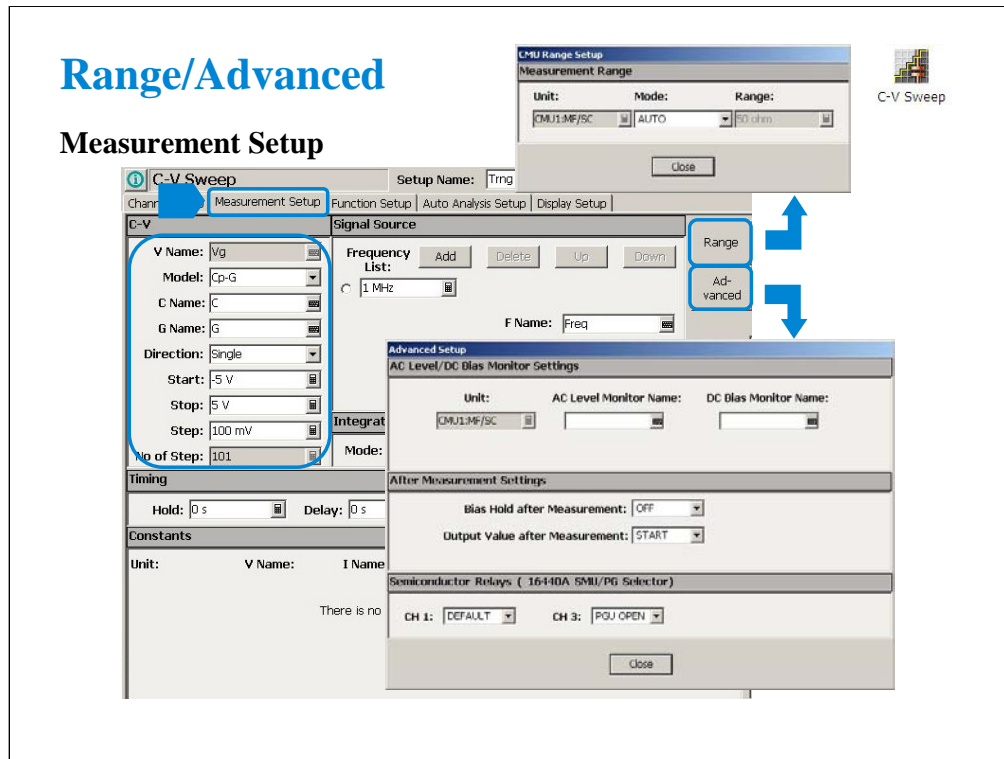
**Constants**

Unit	V Name	I Name	Mode	Source	Compliance
There is no item to display in this area.					

**SMU output setup**

At the Constants area, you set the SMU constant output.

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Mode: Source output mode, V (voltage), I (current), or COMMON (ground)
- Source: SMU output value
- Compliance: SMU compliance value



The Range button opens the CMU Range Setup dialog box. The dialog box is used to set the measurement ranging operation.

- Unit: CMU name or number
- Mode: Ranging mode, AUTO or FIXED
- Range: Measurement range. This field is effective when Mode=FIXED.  
Available values are 50 ohm, 100 ohm to 300 kohm ( $\leq 200$  kHz), 100 ohm to 30 kohm ( $\leq 2$  MHz), and 100 ohm to 3 kohm ( $\leq 5$  MHz) in 1, 3 step

The Advanced button opens the Advanced Setup dialog box used to set the following functions.

AC Level/DC Bias Monitor Settings:

Defines the variables for the AC level data and the DC bias data monitored by the MFCMU while the capacitance measurement is performed.

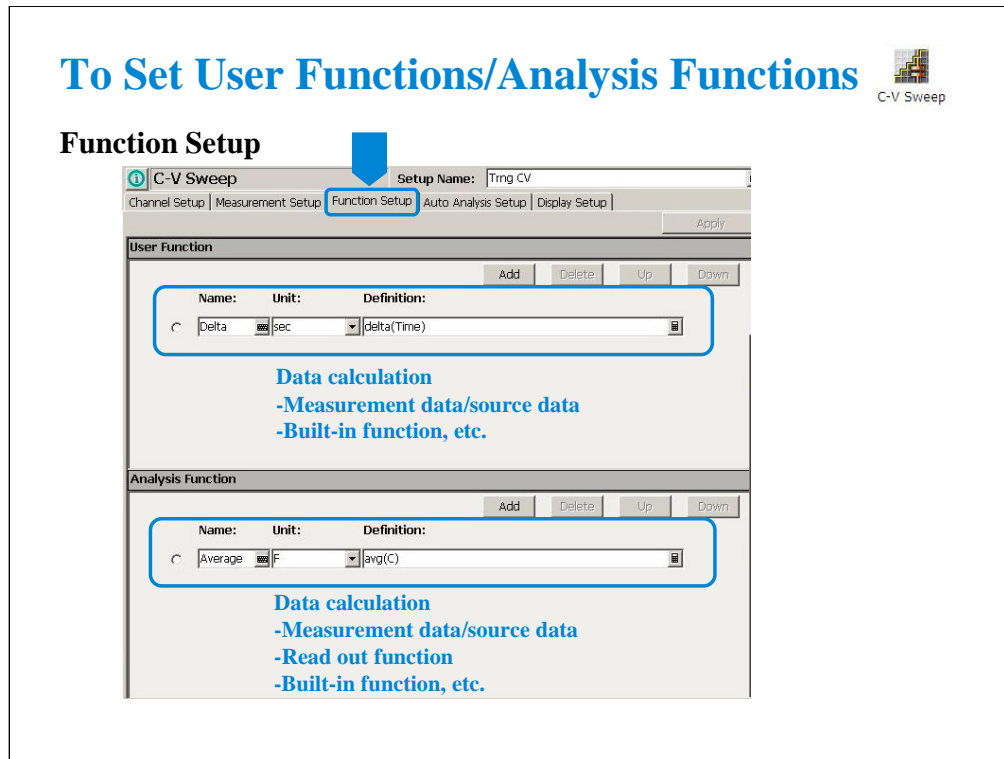
After Measurement Settings:

- Bias Hold after Measurement: Bias hold function ON or OFF.
- Output Value after Measurement: Source output value after measurement. START (sweep start value) or STOP (sweep stop value)

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 is the setting defined on the SMU/PG Selector screen of the Configuration window.



Click the Function Setup tab to display the User Function/Analysis Function setup screen.

The user functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

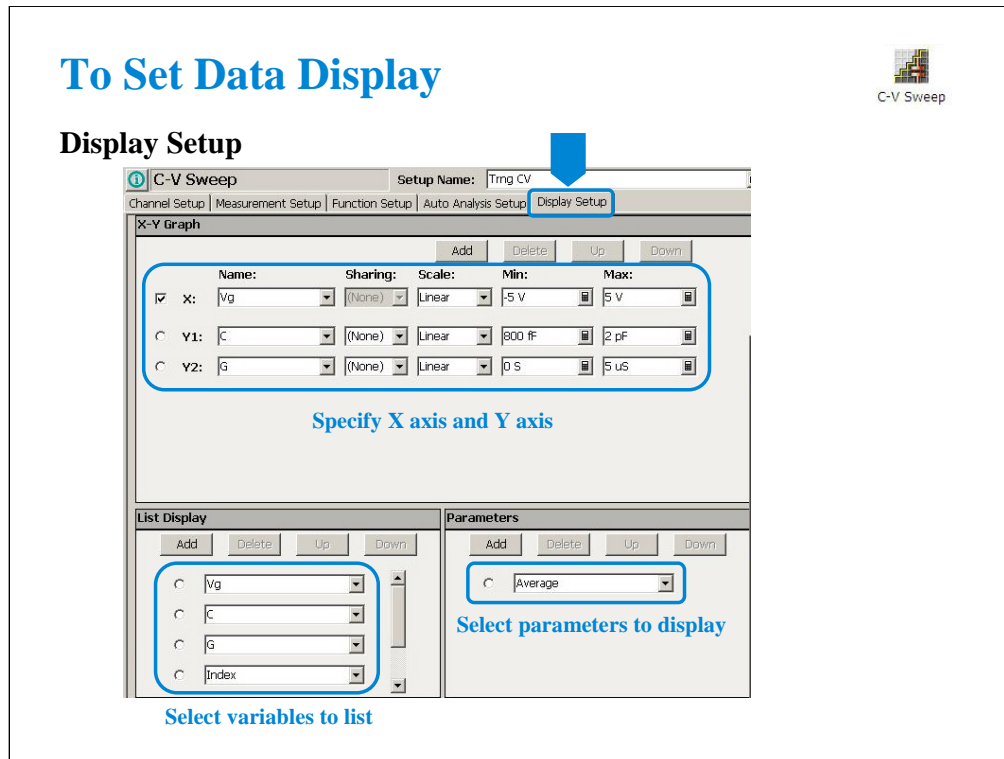
- Name: Function name
- Unit: Unit of the function
- Definition: Definition of the function. The following identifiers can be used.
  - Variables for the measurement/output data used in this test
  - Functions defined in the above lines
  - Local variables passed from the application test that calls this test as a component
  - Built-in functions and global variables

For details, see online help or User's Guide.

The analysis functions can be displayed on the Parameters area of the Data Display window. Up to 20 functions can be set.

- Name: Function name
- Unit: Unit of the function
- Definition: Definition of the function. The following identifiers can be used.
  - Variables for the measurement/output data used in this test
  - Functions defined in the above lines
  - Local variables passed from the application test that calls this test as a component
  - Built-in functions and global variables
  - Read out functions

For details, see online help or User's Guide.

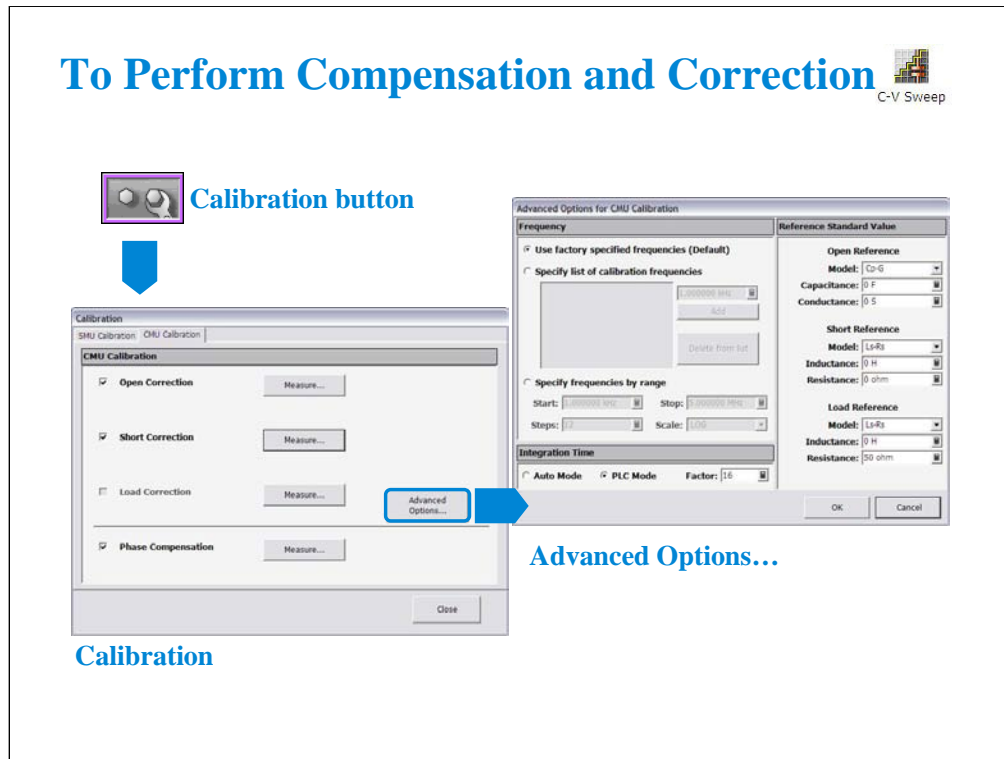


Click the Display Setup tab to display the display setup screen. The X-Y Graph area is used to set the X axis and Y axis of the X-Y Graph Plot area in the Data Display window.

- 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 in 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 in the Parameters area of the Data Display window. Up to 20 parameters can be set.



The MFCMU is equipped with the error correction function used to realize accurate impedance measurements. The correction function minimizes the effects of the error elements in the extension cables and the DUT interface such as manipulator and probe card.

- Phase compensation: Corrects phase error caused by extending measurement cables.
- Open correction: Corrects for stray admittance. Effective for high impedance measurements.
- Short correction: Corrects for residual impedance. Effective for low impedance measurements.
- Load correction: Corrects any error by using the working standard (load standard).

Click the Calibration button to open the Calibration window. And click the CMU calibration tab on the window to perform the compensation and correction data measurement.

- To measure the phase compensation data, open the measurement terminals at the end of the device side and click the Measure... button.
- To measure the open correction data, open the measurement terminals at the end of the device side and click the Measure... button.
- To measure the short correction data, connect the measurement terminals together at the end of the device side and click the Measure... button.
- To measure the load correction data, connect the load standard that has the reference value or calibration value. Then, click the Measure... button.

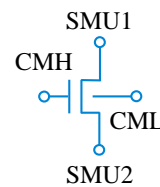
For details of the error correction (CMU calibration) and the Advanced Options, see online help or User's Guide. The Advanced Options window is used for the compensation/correction data measurement setup.

## Class Exercise



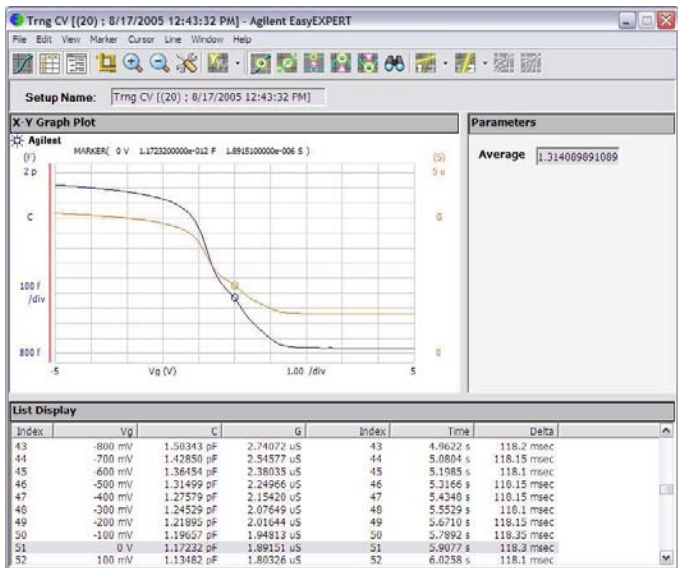
### Define test setup and perform test.

1. Click C-V Sweep icon and open setup editor.
2. Define test setup as shown in previous pages. And save it as Trng CV.
3. Open measurement terminals, and perform phase compensation and open correction.
4. Connect device, and perform test.
5. Export preset group, and import it.



Note:

## Measurement Result Example



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



## Switching Matrix Control

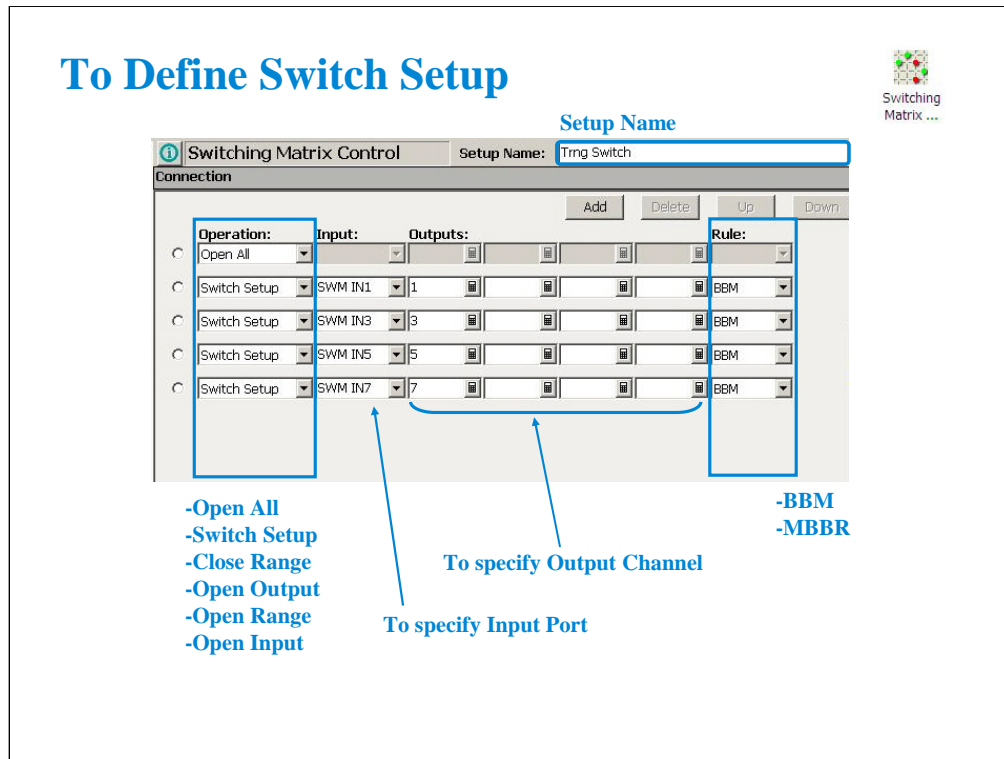
- To Define Switch Setup



This section explains how to define the switch setup for B2200/E5250 Switching Matrix.

Note: Standard revision of EasyEXPERT cannot support the E5250. The E5250 control is optional function of B1540A-002/B1541A-002.

Note: EasyEXPERT supports the E5250A installed with the E5252A matrix card.



This setup screen is used to create the relay control setup (switch setup) for Agilent B2200A/B2201A/E5250A Switching Matrix.

To send the switch setup to B2200/E5250, click the Single button. Before doing this, you have to establish the GPIB connection to B2200/E5250 by using the Switching Matrix tab screen of the Configuration window and B1500A is set to system controller. See Module 12.

This screen provides the following GUI.

Add: Adds a setup row for relay connection.

Delete: Deletes the setup row. To select the setup row, use the left radio button.

Up: Moves the selected setup row upward.

Down: Moves the selected setup row downward. The setup row provides the following entry fields.

Operation: Relay control operation. Open All, Switch Setup, Close Range, Open Output, Open Range, or Open Input. See the next page.

Input: B2200/E5250 input port number or label. Available for the Switch Setup, Close Range, and Open Input operations.

Outputs: B2200/E5250 output channel number or label. Four entry fields are available for the Switch Setup and Open Output operations to specify the output channels. Two entry fields are available for the Close Range and Open Range operations to specify the range of output channels.

Rule: Relay connection rule. BBM or MBBR.

- BBM: Breaks the previous connection and then makes the new connection for the specified outputs.
- MBBR: Makes the new connection and then breaks the previous connection for the specified outputs.

## Operation and number of Outputs



Operation	Description	Number of Outputs
Open All	Opens all relays.	0
Switch Setup	Makes the connection from the specified input port to the specified output channels. Up to four output channels can be specified at once.	4
Close Range	Makes the connection from the specified input port to the specified output channels. They are between two channels given by the Outputs fields.	2
Open Output	Opens the relays connected to the specified output channels. Up to four output channels can be specified at once.	4
Open Range	Opens the relays connected to the specified output channels. They are between two channels given by the Outputs fields.	2
Open Input	Opens the relays connected to the specified input port.	0

Note:

## Class Exercise



**Define switch setup and send it to B2200/E5250.**

- 1. Click Switching Matrix Control icon and open setup editor.**
- 2. Define switch setup as you want. And save it as Trng Switch.**
- 3. If B2200/E5250 is available, establish the GPIB connection between B1500 (must be set to system controller) and B2200/E5250, and apply your switch setup.**

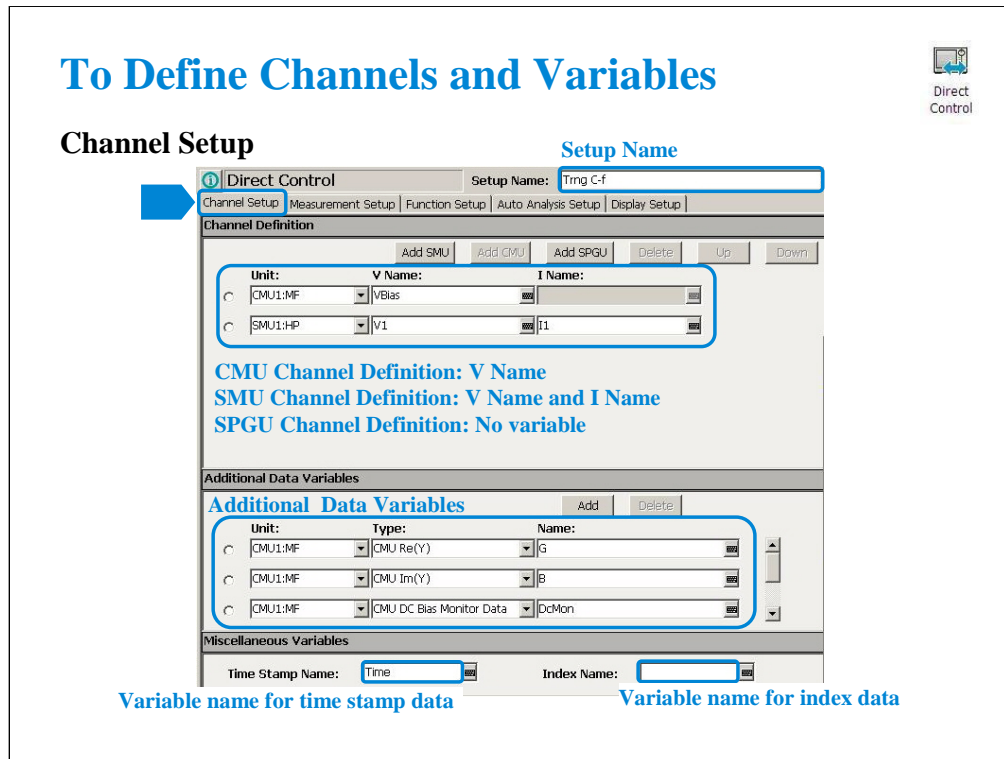
Note:

## Direct Control

- **To Define Channels and Variables**
- **To Set Measurement Conditions**
- **Advanced Setup**
- **To Set User Functions**
- **To Set Data Display**



This section explains how to use Direct Control to perform various measurements (e.g. C-f measurement, Quasi-Static C-V measurement) using Agilent FLEX commands.



Click the Direct Control icon and open the setup editor. Then click the Channel Setup tab to display the channel definition screen.

1. Enter the Setup Name for the test setup to be defined on the setup editor.
2. List channels used for source output or measurement, and set the following parameters.

- Unit: Name or number of the channel
- V Name: Variable name for the voltage measurement or source data. For SMU and CMU.
- I Name: Variable name for the current measurement or source data. For SMU only.

V Name and I Name are used to specify the parameters displayed on the Data Display window. The display parameters are selected on the Display Setup tab screen.

You can read measurement data by using the Data Display window. Parameters displayed on the window are selected on the Display Setup tab screen. If you enter the variable name in the V Name, I Name, Additional Variable Name, Time Stamp Name, and/or Index Name entry fields, you can choose the variables as the display parameters.

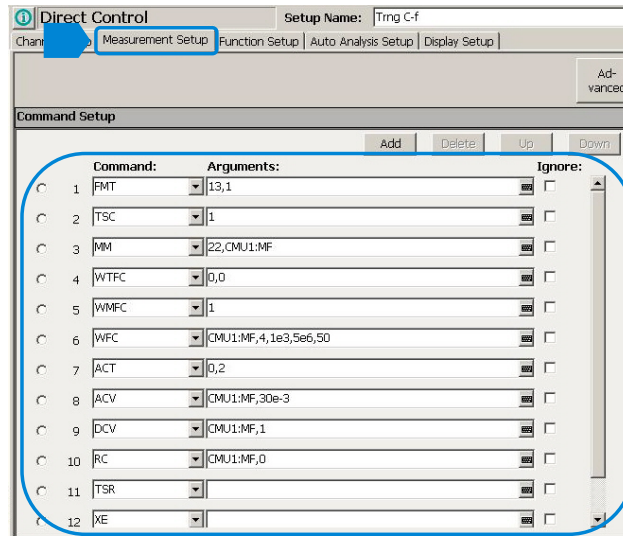
Note: The time stamp is the time the measurement is started for each measurement point. The index is the index number for each measurement data.

For example, the Trng C-f test setup has defined the following additional variables to monitor.

<Unit>	<Type>	<Name>
CMU1:MF	CMU Re(Y)	G
CMU1:MF	CMU Im(Y)	B
CMU1:MF	CMU DC Bias Monitor Data	DcMon
CMU1:MF	CMU AC Level Monitor Data	AcMon
CMU1:MF	CMU Frequency	Freq

## To Set Measurement Conditions

### Measurement Setup

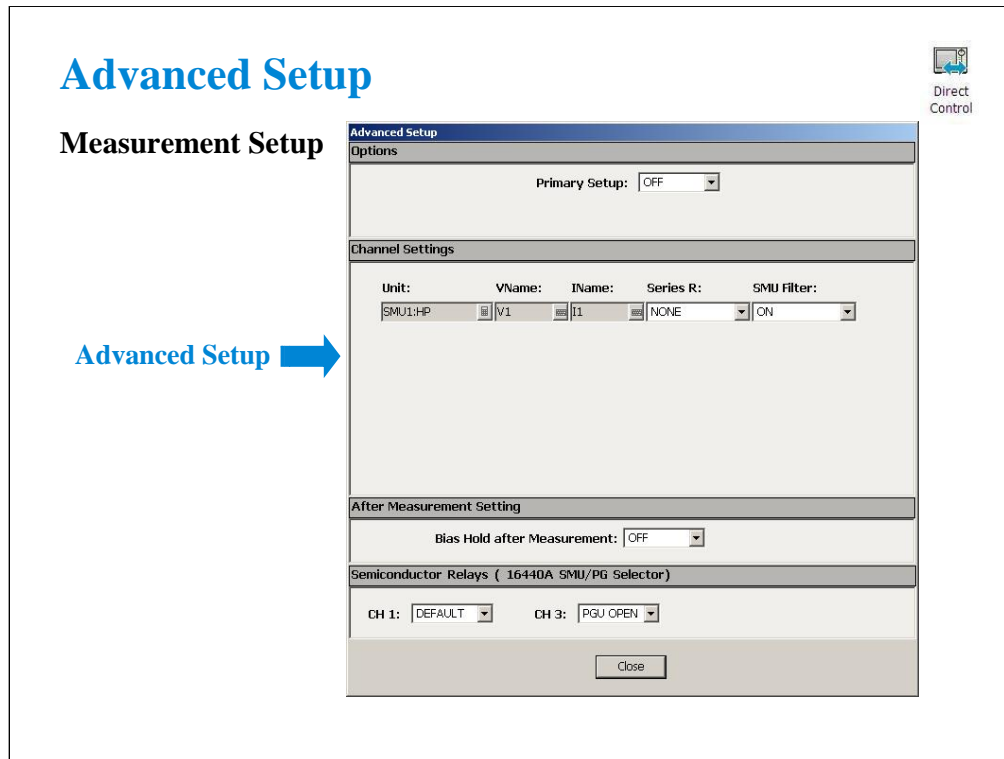


Command Setup

The Measurement Setup tab screen is used to set Agilent FLEX commands for measurement. For example, following FLEX commands are set for the C-f Sweep Measurement.

<Command>	<Arguments>
1 FMT	13,1
2 TSC	1
3 MM	22,CMU1:MF
4 WTFC	0,0
5 WMFC	1
6 WFC	CMU1:MF,4,1e3,5e6,50
7 ACT	0,2
8 ACV	CMU1:MF,30e-3
9 DCV	CMU1:MF,1
10 RC	CMU1:MF,0
11 TSR	
12 XE	
13 ReadDataBuffer	

See B1500A Programming Guide for more details about FLEX commands.



The Advanced button opens the Advanced Setup dialog box. The dialog box is used to set the option setting, the SMU filter and SMU series resistor settings, the after measurement settings, and the 16440A selector semiconductor relay setting.

Options:

- Primary Setup: ON or OFF.

If Primary Setup=ON, the primary setup is applied to the instrument when the Direct Control test is started. For the primary setup condition, see the online help or User's Guide.

Channel Settings:

- Unit: SMU name or number
- V Name: Variable name for the voltage measurement or source data
- I Name: Variable name for the current measurement or source data
- Series R: SMU series resistor NONE or 1MOHM (1000000 ohm)
- SMU Filter: SMU filter ON or OFF

After Measurement Settings:

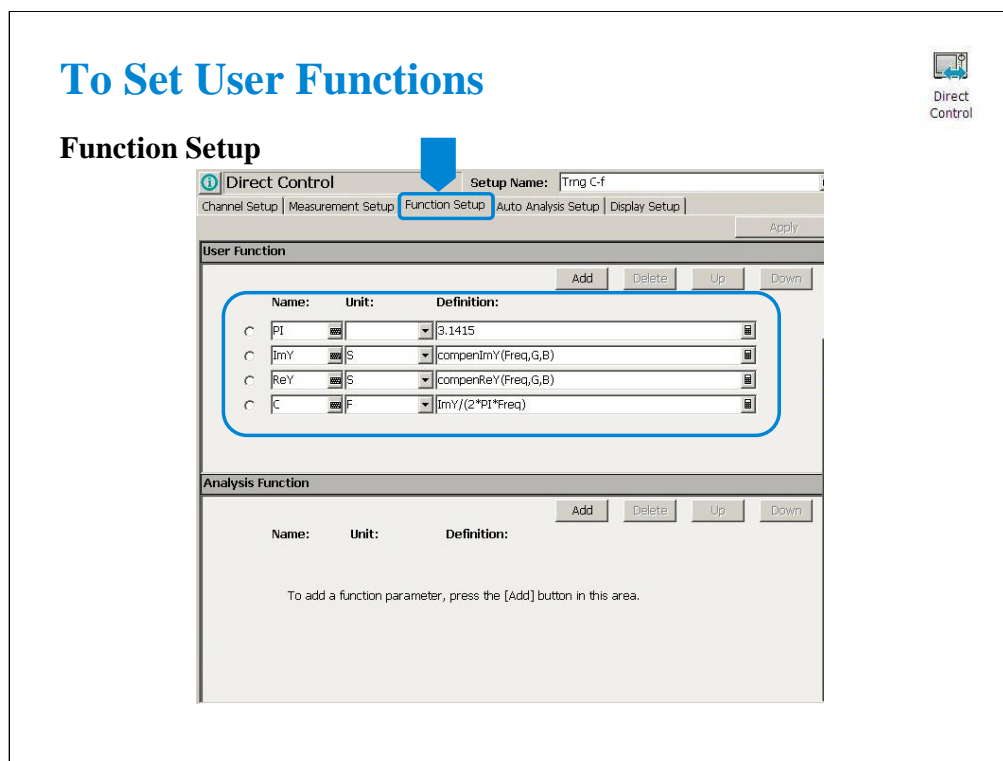
- Bias Hold after Measurement: Bias hold function ON or OFF.

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 is the setting defined on the SMU/PG Selector screen of the Configuration window.





Click the Function Setup tab to display the User Function/Analysis Function setup screen. The user functions can be displayed on the X-Y Graph Plot, List Display, and Parameters area of the Data Display window. Up to 20 functions can be set.

Name: Function name

Unit: Unit of the function

Definition: Definition of the function. The following identifiers can be used.

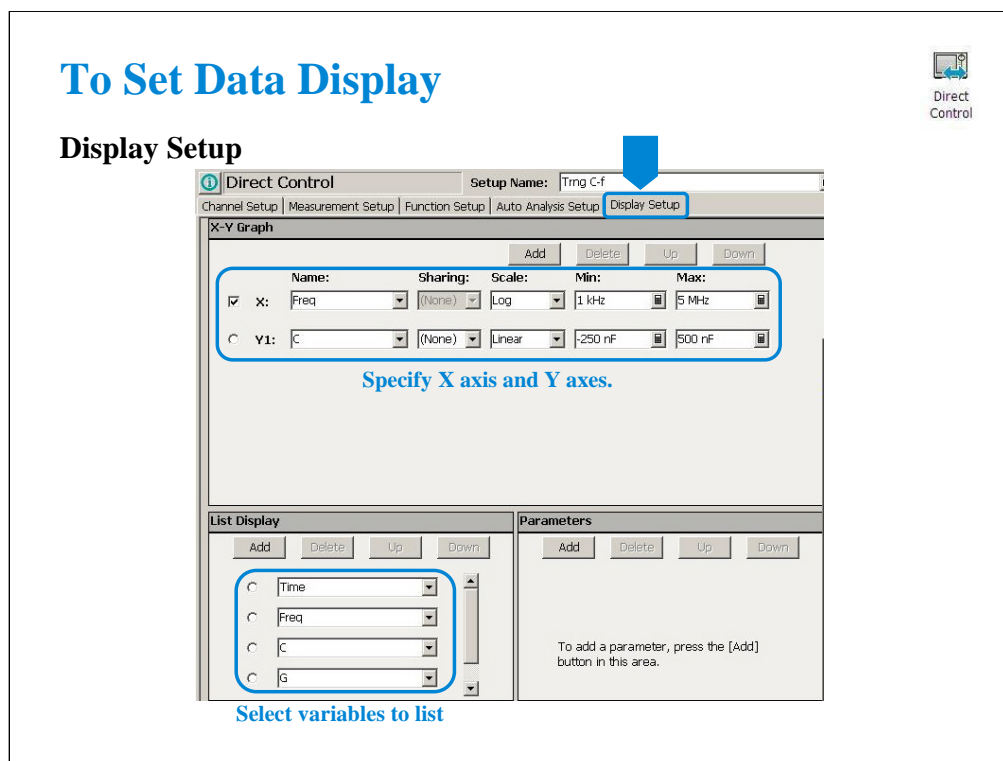
- Variables for the measurement/output data used in this test
- Functions defined in the above lines
- Local variables passed from the application test that calls this test as a component
- Built-in functions and global variables

For details, see online help or User's Guide.

For example, following user functions are set for C-f Sweep Measurement.

<Name> <Unit> <Definition>

PI		3.1415
ImY	S	compenImY(Freq,G,B)
ReY	S	compenReY(Freq,G,B)
C	F	ImY/(2*PI*Freq)



Click the Display Setup tab to display the display setup screen. The X-Y Graph area is used to set the X axis and Y axes of the X-Y Graph Plot area in the Data Display window.

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

For example, following axes are set for the C-f Sweep Measurement.

	<Name>	<Scale>	<Min>	<Max>
X	Freq	Linear	1 kHz	5 MHz
Y1	C	Linear	-250 nF	500 nF

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

For example, following variables are set for the C-f Sweep Measurement.

Time, Freq, C, G, B

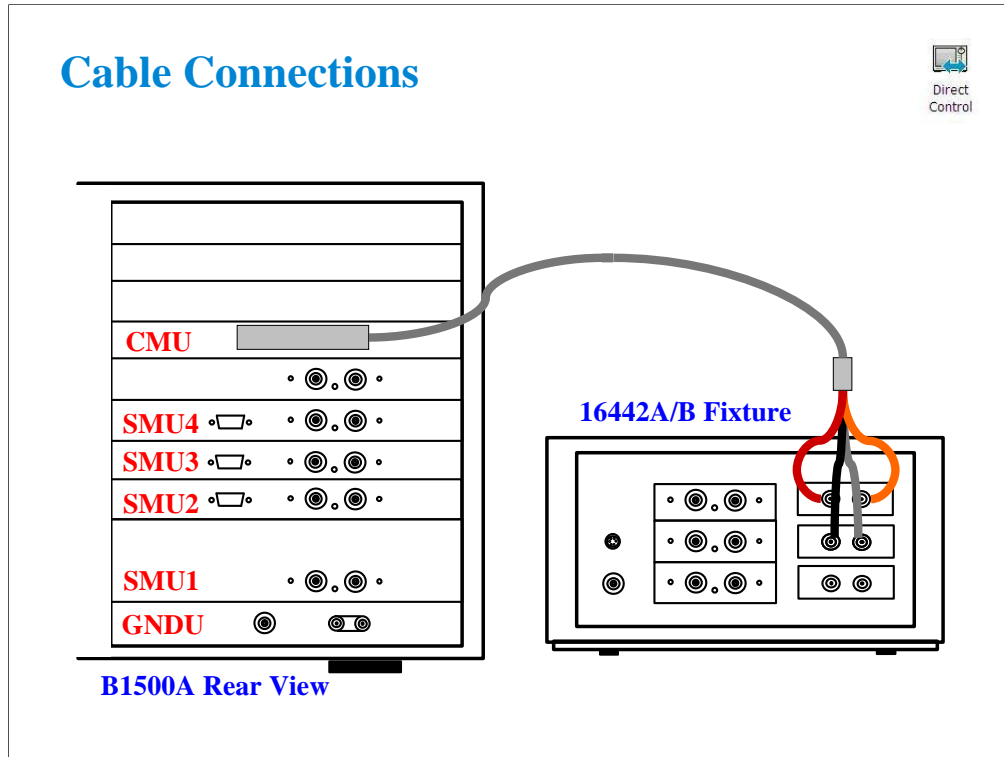
## Class Exercise



### Define test setup and perform test.

1. Click Direct Control icon and open setup editor.
2. Define test setup as shown in the previous pages.
3. Save it as Trng C-f.
4. Connect a device (capacitance) as shown in next several pages, and perform test.
5. Export preset group, and import it.

Note:



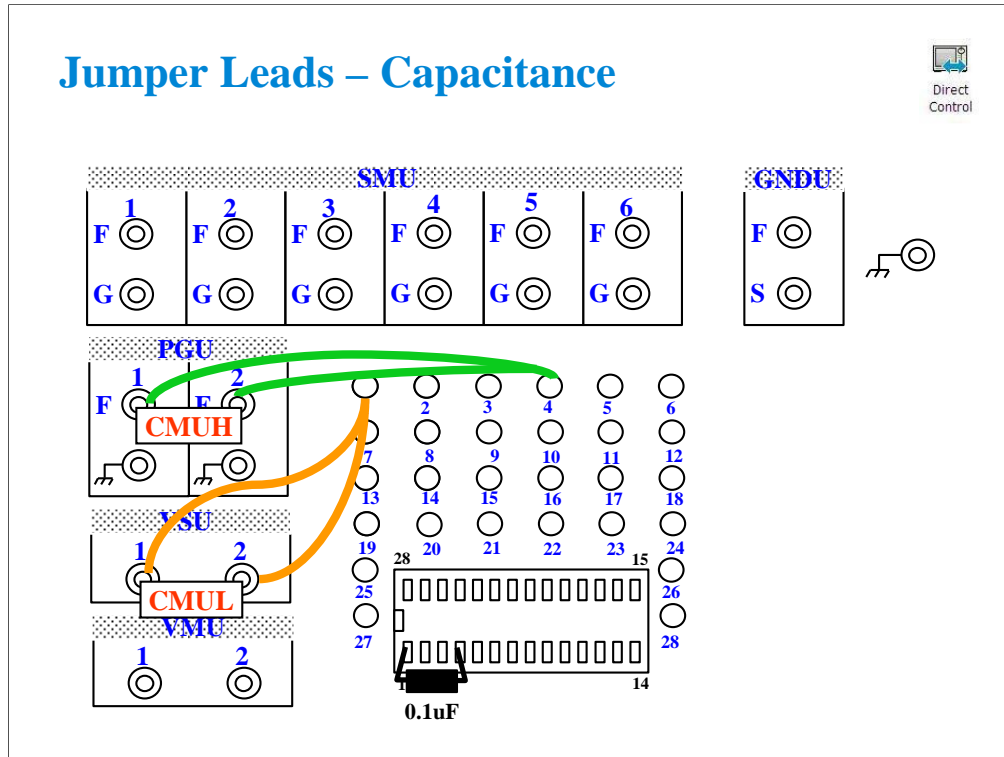
The following cables are required to perform this class exercise.

CMU cable (Agilent N1300A-001/002), 1 ea.

One side of the CMU cable forms the attachment used to join and fix it to the CMU. And the other side provides four BNC connectors used to connect the fixture as shown.

Connect the cables between the B1500A and the test fixture as follows.

Hcur : PGU1 (red)  
Hpot : PGU2 (orange)  
Lcur : VSU1 (black)  
Lpot : VSU2 (gray)

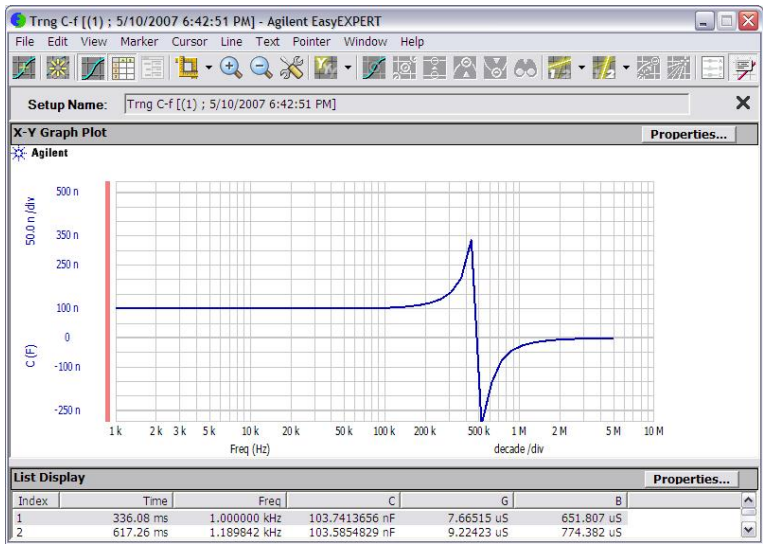


For all class exercises, you need the 28-pin dual in line socket which comes standard with the 4145 fixture (16058A) or the newer fixture (16442A/B). Either fixture works fine.

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

PGU1 : terminal 1  
PGU2 : terminal 1  
VSU1 : terminal 4  
VSU2 : terminal 4

## Measurement Result Example



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