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Agilent 4155C
Semiconductor Parameter
Analyzer
Agilent 4156C
Precision Semiconductor
Parameter Analyzer

***VXIplug&play* Driver**
User's Guide



Agilent Technologies

Notices

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In This Manual

This manual provides information about the 4155/4156 *VXIplug&play* driver. This manual also explains two sample application programs using the Agilent VEE and the driver.

- Installation

This chapter describes system requirements to use the 4155/4156 *VXIplug&play* driver, and how to install the driver.

- Driver Functions

This chapter lists the all driver functions for the Agilent 4155/4156 and the Agilent E5250A Low Leakage Switch Mainframe.

- Programming Examples for Visual Basic Users

This chapter describes how to create measurement program using Microsoft Visual Basic, and provides programming examples.

- Programming Examples for Visual Basic .NET Users

This chapter describes how to create measurement program using Microsoft Visual Basic .NET, and provides programming examples.

- Programming Examples for C++ Users

This chapter describes how to create measurement program using Microsoft Visual C++, and provides programming examples.

- Programming Examples for VEE Users

This chapter describes how to create measurement program using Agilent VEE, and provides programming examples.

- Sample Application Programs

This chapter provides how to install, execute, and modify the sample application programs stored in the Agilent VEE Sample Program Disk furnished with the 4155/4156.

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1

Installation

Installation

This chapter explains the environment requirements and installation of the *VXIplug&play* driver for Agilent 4155/4156.

- “System Requirements”
- “Installing VXIplug&play Driver”

System Requirements

The following system environments are required.

- Operating System
Microsoft Windows XP Professional, Windows 2000, Windows NT 4.0, Windows 98, or Windows 95. It must be supported by the application development environment.
- Application Development Environment (or programming environment)
Microsoft Visual Basic, Microsoft Visual C++, Borland C++Builder, National Instruments LabWindows or LabVIEW, or Agilent VEE.
- Agilent T&M Programmers Toolkit for Visual Studio .NET
Agilent W1140A or equivalent. Needed for Visual Basic .NET users.
- GPIB (IEEE 488) Interface and 32-bit VISA I/O Library
Agilent 82357A USB/GPIB interface, E5810A LAN/GPIB gateway, 82350B GPIB interface, or equivalent. These models include Agilent VISA and SICL I/O libraries.
- Computer and peripherals
Required specifications depend on the application development environment. See manual of the software. The flexible disk drive (FDD) is required to install the *VXIplug&play* driver. The CD-ROM drive is required to install the software needed to use driver.
- Minimum disk space
2 MB for 4155/4156 driver
1 MB for E5250A driver

NOTE

If you use the sample application programs, stored in the VEE Sample Program Disk furnished with the 4155/4156, VEE software must be version 4.0 or later. See Chapter 7. Also, if you use the Cascade Microtech Summit series semi-auto prober, confirm the operating system supported by the prober control software (PCS) supplied from Cascade Microtech, Inc.

NOTE

The E5250A Plug&Play Driver Disk stores the *VXIplug&play* driver for Agilent E5250A. This driver is required to use the sample application programs.

Installing VXIplug&play Driver

The installation flow is shown below. If you have already installed the GPIB interface card, VISA I/O library, and programming software on your PC, skip steps 1 through 4.

1. Install the GPIB interface card into your PC.
See the interface card manual. Note the model number of the interface card, as you may need it when you configure the interface (in step 3).
2. Install VISA I/O library.
Follow the instructions in the I/O library's setup program.
3. Configure and check the GPIB interface.
See the I/O library manual.
4. Install the programming software.
Follow the setup program instructions.
5. If you use Microsoft Visual Basic .NET, install the Agilent T&M Programmers Toolkit.
6. Install the VXIplug&play driver as shown below.
 - a. Insert the 4155/4156 Plug&Play Driver Disk into FDD of your PC.
 - b. Execute SETUP.EXE stored on the diskette. The program automatically installs the following files in the folder \Vxipnp\Winxx\Hp4156b.
 - hp4156b.bas
 - hp4156b.c
 - hp4156b.def
 - hp4156b.fp
 - hp4156b.GID
 - hp4156b.h
 - hp4156b.hlp
 - readme.txt
 - DelsL1.isu

7. If you are also installing the driver for the E5250A, do the following.
 - a. Insert the E5250A Plug&Play Driver Disk into FDD of your PC.
 - b. Execute SETUP.EXE stored on the diskette. The program automatically installs the following files in the folder \Vxipnp\Winxx\Hpe5250a.
 - hpe5250a.bas
 - hpe5250a.c
 - hpe5250a.def
 - hpe5250a.fp
 - hpe5250a.GID
 - hpe5250a.h
 - hpe5250a.hlp
 - readme.txt
 - DelsL1.isu

NOTE

Winxx will be Winnt for Windows XP, Windows 2000, and Windows NT, or Win95 for others.

Installation

Installing VXIplug&play Driver

Driver Function Reference

This section explains all the driver functions available for Agilent 41555/4156 and Agilent E5250A.

- “4155/4156 Driver Functions”
- “E5250A Driver Functions”

NOTE

For additional information on each function, refer to the on-line help for the *VXIplug&play* drivers, or open the hp4156b.hlp or hpe5250a.hlp file in the folder the driver is installed. See “Installing VXIplug&play Driver” on page 1-4.

4155/4156 Driver Functions

This section provides the reference information of the Agilent 4155/4156 *VXIplug&play* driver functions.

Function List

Table 2-1 lists all the functions for the 4155/4156. You will see a brief description of the functions in the table.

For the description, syntax and parameters of the function, refer to the reference section following this table. The driver functions in the reference section will appear in the alphabetical order.

Table 2-1 4155/4156 Driver Function List

Category	Function	Description
Miscellaneous	hp4156b_init	Initializes the 4155/4156.
	hp4156b_close	Closes the connection with the 4155/4156.
	hp4156b_reset	Executes the 4155/4156 reset.
	hp4156b_self_test	Executes the 4155/4156 self-test.
	hp4156b_error_query	Queries the 4155/4156 for error code/message.
	hp4156b_error_message	Queries for the driver errors.
	hp4156b_revision_query	Queries for the 4155/4156 firmware/driver revisions.
	hp4156b_timeOut	Sets the timeout.
	hp4156b_timeOut_Q	Queries for the timeout setting.
	hp4156b_errorQueryDetect	Sets the automatic error checking.
	hp4156b_errorQueryDetect_Q	Queries for the automatic error checking setting.
	hp4156b_dcl	Sends the Device Clear.
	hp4156b_esr_Q	Queries the ESR status.
	hp4156b_readStatusByte_Q	Reads the 4155/4156 status byte.
	hp4156b_opc_Q	Checks the 4155/4156 operation completion status.

Driver Function Reference

Function List

Category	Function	Description
Primitive Measurement Functions	hp4156b_startMeasure	Starts a measurement.
	hp4156b_readData	Reads a measurement result.
	hp4156b_stopMode	Sets the measurement completion mode.
	hp4156b_abortMeasure	Aborts output or measurement.
Calibration	hp4156b_autoCal	Sets the auto calibration mode
	hp4156b_execCal	Executes the 4155/4156 calibration
Zero Offset Cancel	hp4156b_offsetCancel	Sets the zero offset cancel.
	hp4156b_execOffsetCancel	Executes the zero offset cancel.
Measurement Unit Setup	hp4156b_setSwitch	Sets the output switch.
	hp4156b_setFilter	Sets the output filter.
	hp4156b_setInteg	Sets the integration time.
	hp4156b_setVm	Sets the VMU measurement mode.
	hp4156b_setPguR	Sets the PGU output impedance.
Source Setup	hp4156b_force	Applies a dc current or voltage.
	hp4156b_forcePulse	Applies a pulse by using PGU.
	hp4156b_zeroOutput	Disables output.
	hp4156b_recoverOutput	Recovers output.
	hp4156b_setIv	Sets the sweep source.
	hp4156b_setPbias	Sets the pulsed bias source.
	hp4156b_setPiv	Sets the pulsed sweep source.
	hp4156b_setSweepSync	Sets the synchronous sweep source.
Measurement Execution	hp4156b_spotMeas	Executes a high speed spot measurement.
	hp4156b_measureM	Executes a multi-channel spot measurement.
	hp4156b_sweepIv	Executes a one channel sweep measurement.
	hp4156b_sweepMiv	Executes a multi-channel sweep measurement.
	hp4156b_measureP	Executes a pulsed spot measurement.
	hp4156b_sweepPiv	Executes a pulsed sweep measurement.
	hp4156b_sweepPbias	Executes a sweep measurement with pulsed bias.

Category	Function	Description
Sampling Measurements	hp4156b_setSample	Sets the timing parameters.
	hp4156b_addSampleSyncIv	Sets the dc source.
	hp4156b_addSampleSyncPulse	Sets the pulse source.
	hp4156b_sample	Executes a sampling measurement.
	hp4156b_clearSampleSync	Clears the source setup.
Stress Force	hp4156b_setStress	Sets the timing parameters.
	hp4156b_addStressSyncIv	Sets the dc stress source.
	hp4156b_addStressSyncPulse	Sets the pulse stress source.
	hp4156b_stress	Forces stress.
	hp4156b_clearStressSync	Clears the source setup.
Passthrough Functions	hp4156b_cmd	Sends a command.
	h4156b_cmdInt	Sends a command with an integer parameter.
	hp4156b_cmdReal	Sends a command with a real parameter.
	hp4156b_cmdData_Q	Sends a command to read any data.
	hp4156b_cmdString_Q	Sends a command to read string response.
	hp4156b_cmdInt16_Q	Sends a command to read 16 bit integer response.
	hp4156b_cmdInt16Arr_Q	Sends a command to read 16 bit integer array response.
	hp4156b_cmdInt32_Q	Sends a command to read 32 bit integer response.
	hp4156b_cmdInt32Arr_Q	Sends a command to read 32 bit integer array response.
	hp4156b_cmdReal64_Q	Sends a command to read 64 bit real response.
	hp4156b_cmdReal64Arr_Q	Sends a command to read 64 bit real array response.

Parameters

The parameters used by several functions are explained in this section.

- “range value and ranging mode”
- “VSU output voltage, resolution, and compliance”
- “SMU output voltage, resolution, and compliance by range”
- “SMU/VMU measurement voltage and resolution by range”
- “SMU output current, resolution, and compliance by range”
- “SMU measurement current and resolution by range”
- “PGU output voltage, resolution, and compliance by range”
- “PGU pulse period, pulse width, and delay time”
- “PGU leading transition time and trailing transition time”

NOTE

Macros

Some functions can use macros to set the parameter values. For details of functions and macros, refer to the help file (hp4156b.hlp) in the directory that the driver is installed.

Table 2-2 *range value and ranging mode*

Voltage or current	Available <i>range</i> values ^a	Ranging mode used for output/measurement
both	$range = 0$	Auto ranging ^b
voltage	$0 < range \leq 0.2 \text{ V}$ (for VMU in differential mode)	0.2 V limited auto ranging ^c
	$0 < range \leq 2 \text{ V}$	2 V limited auto ranging ^c
	$2 \text{ V} < range \leq 20 \text{ V}$	20 V limited auto ranging ^c
	$20 \text{ V} < range \leq 40 \text{ V}$	40 V limited auto ranging ^c
	$40 \text{ V} < range \leq 100 \text{ V}$	100 V limited auto ranging ^c
	$100 \text{ V} < range \leq 200 \text{ V}$ (for HPSMU)	200 V limited auto ranging ^c

Voltage or current	Available <i>range</i> values ^a	Ranging mode used for output/measurement
current	$0 < range \leq 10 \text{ pA}$ (for HRSMU)	10 pA limited auto ranging ^c
	$10 \text{ pA} < range \leq 100 \text{ pA}$ (for HRSMU)	100 pA limited auto ranging ^c
	$100 \text{ pA} < range \leq 1 \text{ nA}$	1 nA limited auto ranging ^c
	$1 \text{ nA} < range \leq 10 \text{ nA}$	10 nA limited auto ranging ^c
	$10 \text{ nA} < range \leq 100 \text{ nA}$	100 nA limited auto ranging ^c
	$100 \text{ nA} < range \leq 1 \text{ }\mu\text{A}$	1 μA limited auto ranging ^c
	$1 \text{ }\mu\text{A} < range \leq 10 \text{ }\mu\text{A}$	10 μA limited auto ranging ^c
	$10 \text{ }\mu\text{A} < range \leq 100 \text{ }\mu\text{A}$	100 μA limited auto ranging ^c
	$100 \text{ }\mu\text{A} < range \leq 1 \text{ mA}$	1 mA limited auto ranging ^c
	$1 \text{ mA} < range \leq 10 \text{ mA}$	10 mA limited auto ranging ^c
	$10 \text{ mA} < range \leq 100 \text{ mA}$	100 mA limited auto ranging ^c
	$100 \text{ mA} < range \leq 1 \text{ A}$ (for HPSMU)	1 A limited auto ranging ^c

- Negative *range* values are available for the functions used to start or execute measurements. The negative values set the ranging mode to the fix, not the limited auto.
- SMU uses the optimum range to force/measure voltage or current.
- SMU uses the optimum range to force/measure voltage or current. Then, the SMU never uses the range less than the specified range.

Table 2-3 VSU output voltage, resolution, and compliance

Output range (actually used)	Output voltage ^a	Setting resolution	<i>comp</i> value ^b
20 V	$0 \leq V \leq 20 \text{ V}$	1 mV	$\pm 100 \text{ mA}$

- Parameter name may be *base*, *bias*, *peak*, *stress*, *value*, *start*, *stop*, and so on.
- Set any value (e.g. 0.1) though the compliance is always 100 mA.

Driver Function Reference Parameters

Table 2-4 SMU output voltage, resolution, and compliance by range

Output range (actually used)	Output voltage ^a	Setting resolution	Maximum <i>comp</i> value ^b	
			HRSMU/ MPSMU	HPSMU
2 V	$0 \leq V \leq 2 \text{ V}$	100 μV	$\pm 100 \text{ mA}$	$\pm 1000 \text{ mA}$
20 V	$0 \leq V \leq 20 \text{ V}$	1 mV	$\pm 100 \text{ mA}$	$\pm 1000 \text{ mA}$
40 V	$0 \leq V \leq 20 \text{ V}$	2 mV	$\pm 100 \text{ mA}$	$\pm 1000 \text{ mA}$
	$20 \text{ V} < V \leq 40 \text{ V}$		$\pm 50 \text{ mA}$	$\pm 500 \text{ mA}$
100 V	$0 \leq V \leq 20 \text{ V}$	5 mV	$\pm 100 \text{ mA}$	$\pm 1000 \text{ mA}$
	$20 \text{ V} < V \leq 40 \text{ V}$		$\pm 50 \text{ mA}$	$\pm 500 \text{ mA}$
	$40 \text{ V} < V \leq 100 \text{ V}$		$\pm 20 \text{ mA}$	$\pm 125 \text{ mA}$
200 V	$0 \leq V \leq 20 \text{ V}$	10 mV	-	$\pm 1000 \text{ mA}$
	$20 \text{ V} < V \leq 40 \text{ V}$		-	$\pm 500 \text{ mA}$
	$40 \text{ V} < V \leq 100 \text{ V}$		-	$\pm 125 \text{ mA}$
	$100 \text{ V} < V \leq 200 \text{ V}$		-	$\pm 50 \text{ mA}$

a. Parameter name may be *base*, *bias*, *peak*, *stress*, *value*, *start*, *stop*, and so on.

b. This column shows the maximum value of the current compliance.

Table 2-5 SMU/VMU measurement voltage and resolution by range

Measurement range (actually used)	Measurement voltage	Measurement resolution			
		Integration time			High speed ^a sampling measurement
		1PLC or longer	640 μs to 1.92 ms	80 μs to 560 μs	
0.2 V (for VMU in differential mode)	$0 \leq V \leq 0.2 \text{ V}$	0.2 μV	2 μV	20 μV	200 μV
2 V	$0 \leq V \leq 2.2 \text{ V}$ (2 V for VMU)	2 μV	20 μV	200 μV	2 mV
20 V	$0 \leq V \leq 22 \text{ V}$ (20 V for VMU)	20 μV	200 μV	2 mV	20 mV
40 V	$0 \leq V \leq 44 \text{ V}$	40 μV	400 μV	4 mV	40 mV
100 V	$0 \leq V \leq 100 \text{ V}$ (110 V for HPSMU)	100 μV	1 mV	10 mV	100 mV
200 V (for HPSMU)	$0 \leq V \leq 200 \text{ V}$	200 μV	2 mV	20 mV	200 mV

a. This column is applied to the sampling measurement that *initial interval* is set to 480 μs or shorter.

Table 2-6 SMU output current, resolution, and compliance by range

Output range (actually used)	Output current ^a	Setting ^b resolution	Maximum <i>comp</i> value ^c		
			HRSMU	MPSMU	HPSMU
10 pA (for HRSMU)	$0 \leq I \leq 10 \text{ pA}$	10 fA	$\pm 100 \text{ V}$	-	-
100 pA (for HRSMU)	$0 \leq I \leq 100 \text{ pA}$	10 fA	$\pm 100 \text{ V}$	-	-
1 nA	$0 \leq I \leq 1 \text{ nA}$	100 fA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
10 nA	$0 \leq I \leq 10 \text{ nA}$	1 pA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
100 nA	$0 \leq I \leq 100 \text{ nA}$	10 pA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
1 μA	$0 \leq I \leq 1 \mu\text{A}$	100 pA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
10 μA	$0 \leq I \leq 10 \mu\text{A}$	1 nA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
100 μA	$0 \leq I \leq 100 \mu\text{A}$	10 nA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
1 mA	$0 \leq I \leq 1 \text{ mA}$	100 nA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
10 mA	$0 \leq I \leq 10 \text{ mA}$	1 μA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
100 mA	$0 \leq I \leq 20 \text{ mA}$	10 μA	$\pm 100 \text{ V}$	$\pm 100 \text{ V}$	$\pm 200 \text{ V}$
	$20 \text{ mA} < I \leq 50 \text{ mA}$		$\pm 40 \text{ V}$	$\pm 40 \text{ V}$	$\pm 200 \text{ V}$
	$50 \text{ mA} < I \leq 100 \text{ mA}$		$\pm 20 \text{ V}$	$\pm 20 \text{ V}$	$\pm 100 \text{ V}$
1 A (for HPSMU)	$0 \leq I \leq 50 \text{ mA}$	100 μA	-	-	$\pm 200 \text{ V}$
	$50 \text{ mA} < I \leq 125 \text{ mA}$		-	-	$\pm 100 \text{ V}$
	$125 \text{ mA} < I \leq 500 \text{ mA}$		-	-	$\pm 40 \text{ V}$
	$500 \text{ mA} < I \leq 1 \text{ A}$		-	-	$\pm 20 \text{ V}$

a. Parameter name may be *base*, *bias*, *peak*, *stress*, *value*, *start*, *stop*, and so on.

b. Minimum resolution is $\text{range} \times 5\text{E-}5$. However, the setting accuracy is not guaranteed for the resolution less than the value shown in the table.

c. This column shows the maximum value of the voltage compliance.

Table 2-7 SMU measurement current and resolution by range

Measurement range (actually used)	Measurement current	Measurement resolution			
		Integration time			High speed ^a sampling measurement
		1PLC or longer	640 μ s to 1.92 ms	80 μ s to 560 μ s	
10 pA (for HRSMU)	$0 \leq I \leq 10.5 \text{ pA}$	1 fA	1 fA	1 fA	10 fA
100 pA (for HRSMU)	$0 \leq I \leq 115 \text{ pA}$	1 fA	1 fA	10 fA	100 fA
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	10 fA	10 fA	100 fA	1 pA
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	10 fA	100 fA	1 pA	10 pA
100 nA	$0 \leq I \leq 115 \text{ nA}$	100 fA	1 pA	10 pA	100 pA
1 μ A	$0 \leq I \leq 1.15 \text{ } \mu\text{A}$	1 pA	10 pA	100 pA	1 nA
10 μ A	$0 \leq I \leq 11.5 \text{ } \mu\text{A}$	10 pA	100 pA	1 nA	10 nA
100 μ A	$0 \leq I \leq 115 \text{ } \mu\text{A}$	100 pA	1 nA	10 nA	100 nA
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	1 nA	10 nA	100 nA	1 μ A
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	10 nA	100 nA	1 μ A	10 μ A
100 mA	$0 \leq I \leq 100 \text{ mA}$ (115 mA for HPSMU)	100 nA	1 μ A	10 μ A	100 μ A
1 A (for HPSMU)	$0 \leq I \leq 1 \text{ A}$	1 μ A	10 μ A	100 μ A	1 mA

a. This column is applied to the sampling measurement that *initial interval* is set to 480 μ s or shorter.

Table 2-8 PGU output voltage, resolution, and compliance by range

Output range (actually used)	Output voltage ^a	Setting resolution	<i>comp</i> value ^b
20 V	$0 \leq V \leq 20 \text{ V}$	4 mV	$\pm 100 \text{ mA}$
40 V	$0 \leq V \leq 40 \text{ V}$	8 mV	$\pm 100 \text{ mA}$

a. Parameter name may be *base*, *bias*, *peak*, *stress*, *value*, *start*, *stop*, and so on.

b. Set any value (e.g. 0.1) though the compliance is always 100 mA.

Table 2-9 PGU pulse period, pulse width, and delay time

<i>period</i> value	<i>width</i> value	<i>delay</i> value ^a	Resolution
2.0 μs to 100.0 μs	1.0 μs to 99.9 μs	0 to 100.0 μs	0.1 μs
100 μs to 1000 μs	1 μs to 999 μs	0 to 1000 μs	1 μs
1.00 ms to 10.00 ms	0.01 ms to 9.99 ms	0 to 10.00 ms	10 μs
10.0 ms to 100.0 ms	0.1 ms to 99.9 ms	0 to 100.0 ms	100 μs
100 ms to 1000 ms	1 ms to 999 ms	0 to 1000 ms	1 ms
1.00 s to 10.00 s	0.01 s to 9.99 s	0 to 10.00 s	10 ms

a. The value must be $0 \leq \text{delay} \leq \text{period value}$.

Table 2-10 PGU leading transition time and trailing transition time

Leading transition time (<i>rise</i>)	Trailing transition time (<i>fall</i>)	Resolution
100 ns to 1000 ns	100 ns to 1000 ns	1 ns
0.50 μs to 10.00 μs	0.50 μs to 10.00 μs	10 ns
5.0 μs to 100.0 μs	5.0 μs to 100.0 μs	100 ns
50 μs to 1000 μs	50 μs to 1000 μs	1 μs
0.5 ms to 10.00 ms	0.5 ms to 10.00 ms	10 μs

Status Code

After measurement is performed, the Agilent 4155/4156 returns a status code to notify you if the measurement has been completed successfully. The status code will be returned with the measurement data by the following functions that perform measurement. Available status values are listed in Table 2-11.

- “hp4156b_spotMeas”
- “hp4156b_measureM”
- “hp4156b_measureP”
- “hp4156b_sweepIv”
- “hp4156b_sweepMiv”
- “hp4156b_sweepPiv”
- “hp4156b_sweepPbias”
- “hp4156b_sample”
- “hp4156b_stress”
- “hp4156b_readData”

Table 2-11

Status Values

Value	Description
0	No error.
1	A/D converter overflowed.
2	One or more channels are oscillating.
4	Another channel reached its compliance setting.
8	This channel reached its compliance setting.
16	PGU reached its compliance setting.
32	The sweep measurement was stopped by the stop function.
64	Invalid data was returned.
128	EOD (End of Data).

NOTE

If multiple status conditions are found, sum of the status values is returned. For example, if an A/D converter overflow occurred, and an SMU was oscillating during the measurements, the returned value is 3 (=1+2).

hp4156b_abortMeasure

This function aborts the 4155/4156's present operation, such as the measurement executed by the hp4156b_startMeasure function, the pulse output by the hp4156b_forcePulse function, the stress force by the hp4156b_stress function, and so on.

Syntax ViStatus _VI_FUNC hp4156b_abortMeasure(ViSession vi);

Parameters vi Instrument handle returned from hp4156b_init().

hp4156b_addSampleSyncIv

This function specifies dc voltage/current source and sets the parameters. The dc source is used for the sampling measurements. Source output starts at the beginning of the sampling measurement (beginning of the hold time), and stops at the end of the last sampling measurement point.

Sampling measurement channels are defined by the hp4156b_sample function, and sampling measurement timing is defined by the hp4156b_setSample function.

Syntax ViStatus _VI_FUNC hp4156b_addSampleSyncIv(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 base, ViReal64 bias, ViReal64 comp);

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the source unit. 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 27 (PGU1), or 28 (PGU2).
mode	Source output mode. 1 (current, only for SMU) or 2 (voltage).
range	Output ranging mode. 0 (auto) or positive value (limited auto).
base	Source output value before measurement trigger (in A or V).
bias	Source output value after measurement trigger (in A or V).
comp	Compliance value (in V or A). It must be voltage for the current source, or current for the voltage source.

NOTE range, base, bias, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

hp4156b_addSampleSyncPulse

This function specifies pulse voltage source and sets the parameters. The pulse source is used for the sampling measurements. Pulse outputs start at the beginning of the sampling measurement (beginning of the hold time), and stop at the end of the last sampling measurement point or stop at the last pulse if it comes earlier than the last sampling measurement point.

Sampling measurement channels are defined by the hp4156b_sample function, and sampling measurement timing is defined by the hp4156b_setSample function.

If you want to let the pulse output synchronize with the sampling measurement timing, you should define carefully both the hp4156b_addSampleSyncPulse timing parameters (count, period, width, delay, rise and fall) and the hp4156b_setSample timing parameters.

Syntax

```
ViStatus _VI_FUNC hp4156b_addSampleSyncPulse(ViSession vi, ViInt32 channel, ViReal64 base, ViReal64 peak, ViInt32 count, ViReal64 period, ViReal64 width, ViReal64 delay, ViReal64 rise, ViReal64 fall);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the pulse source. 27 (PGU1) or 28 (PGU2).
base	Pulse base value (in V). See Table 2-8.
peak	Pulse peak value (in V). See Table 2-8.
count	Pulse count (number of pulses, 1 to 65535) or 0 (pulse output free run mode).
period	Pulse period (in seconds). See Table 2-9.
width	Pulse width (in seconds). See Table 2-9.
delay	Pulse delay time (in seconds). See Table 2-9.
rise	Pulse leading transition time (in seconds). See Table 2-10.
fall	Pulse trailing transition time (in seconds). See Table 2-10.

hp4156b_addStressSyncIv

This function specifies dc stress source and sets the parameters. Up to 4 stress sources can be used at once. Use this function and/or hp4156b_addStressSyncPulse to set the stress sources.

Syntax	ViStatus _VI_FUNC hp4156b_addStressSyncIv(ViSession vi, ViInt32 source, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 base, ViReal64 stress, ViReal64 comp);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	source	Reference number of the stress source. 1, 2, 3, or 4.
	channel	Channel number of the stress source. 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 27 (PGU1), or 28 (PGU2).
	mode	Source output mode. 1 (current, only for SMU) or 2 (voltage).
	range	Output ranging mode. 0 (auto) or positive value (limited auto).
	base	Source output value before stress start trigger (in A or V).
	stress	Source output value after stress start trigger (in A or V).
	comp	Compliance value (in V or A). It must be voltage for the current source, or current for the voltage source.

NOTE

range, base, stress, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

hp4156b_addStressSyncPulse

This function specifies pulse stress source and sets the parameters. Up to 4 stress sources can be used at once. Use this function and/or hp4156b_addStressSyncIv to set the stress sources.

Syntax	ViStatus _VI_FUNC hp4156b_addStressSyncPulse(ViSession vi, ViInt32 source, ViInt32 channel, ViReal64 base, ViReal64 stress, ViReal64 width, ViReal64 delay, ViReal64 rise, ViReal64 fall);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	source	Reference number of the stress source. 1, 2, 3, or 4.
	channel	Channel number of the pulse source. 27 (PGU1) or 28 (PGU2)
	base	Stress pulse base value (in V). See Table 2-8.
	stress	Stress pulse peak value (in V). See Table 2-8.
	width	Pulse width (in seconds). See Table 2-9.

Driver Function Reference

hp4156b_autoCal

delay	Pulse delay time (in seconds). See Table 2-9.
rise	Pulse leading transition time (in seconds). See Table 2-10.
fall	Pulse trailing transition time (in seconds). See Table 2-10.

hp4156b_autoCal

This function enables or disables the auto calibration function.

Syntax ViStatus _VI_FUNC hp4156b_autoCal(ViSession vi, ViInt32 state);

Parameters

vi	Instrument handle returned from hp4156b_init().
state	Auto calibration mode. 0 (off) or 1 (on).

hp4156b_clearSampleSync

This function clears the channel setup defined by the hp4156b_addSampleSyncIv function and the hp4156b_addSampleSyncPulse function.

Syntax ViStatus _VI_FUNC hp4156b_clearSampleSync(ViSession vi);

Parameters

vi	Instrument handle returned from hp4156b_init().
----	---

hp4156b_clearStressSync

This function clears the channel setup defined by the hp4156b_addStressSyncIv function and the hp4156b_addStressSyncPulse function.

Syntax ViStatus _VI_FUNC hp4156b_clearStressSync(ViSession vi);

Parameters

vi	Instrument handle returned from hp4156b_init().
----	---

hp4156b_close

This function terminates the software connection to the instrument and deallocates system resources. It is generally a good programming habit to close the instrument handle when the program is done using the instrument.

Syntax ViStatus _VI_FUNC hp4156b_close(ViSession vi);

Parameters

vi	Instrument handle returned from hp4156b_init().
----	---

hp4156b_cmd

This function passes the cmd_str string to the instrument. Must be a NULL terminated C string.

Syntax ViStatus _VI_FUNC hp4156b_cmd(ViSession vi, ViString cmd_str);

Parameters

vi	Instrument handle returned from hp4156b_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).

Example

```
ViSession vi;
ViStatus ret;
ret = hp4156b_cmd(vi, "AB");    /* sends the AB command */
```

hp4156b_cmdData_Q

This function passes the cmd_str string to the instrument. This entry point will wait for a response which may be any data. You specify the cmd_str and size parameters, and get result[].

Syntax ViStatus _VI_FUNC hp4156b_cmdData_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViChar _VI_FAR result[]);

Parameters

vi	Instrument handle returned from hp4156b_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
size	Length of result in bytes. 2 to 32767.
result[]	Response from instrument.

hp4156b_cmdInt

This function passes the cmd_str string to the instrument. This entry point passes the string in cmd_str followed by a space and then the integer in value. Note that either an Int16 or 32 can be passed as the Int16 will be promoted.

Syntax ViStatus _VI_FUNC hp4156b_cmdInt(ViSession vi, ViString cmd_str, ViInt32 value);

Parameters

vi	Instrument handle returned from hp4156b_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).

value Parameter for command. -2147483647 to 2147483647.

hp4156b_cmdInt16Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 16 bit integers. You specify the cmd_str and size parameters, and get result[] and count.

Syntax ViStatus _VI_FUNC hp4156b_cmdInt16Arr_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViInt16 _VI_FAR result[], ViPInt32 count);

Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Size of result[] (number of items in the array). 1 to 2147483647.
	result[]	Response from instrument.
	count	Count of valid items in result[]. Returned data.

hp4156b_cmdInt16_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 16 bit integer.

Syntax ViStatus _VI_FUNC hp4156b_cmdInt16_Q(ViSession vi, ViString cmd_str, ViPInt16 result);

Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	result	Response from instrument.

hp4156b_cmdInt32Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 32 bit integers. You specify the cmd_str and size parameters, and get result[] and count.

Syntax ViStatus _VI_FUNC hp4156b_cmdInt32Arr_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViInt32 _VI_FAR result[], ViPInt32 count);

Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Size of result[] (number of items in the array). 1 to 2147483647.
	result[]	Response from instrument.
	count	Count of valid items in result[]. Returned data.

hp4156b_cmdInt32_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 32 bit integer.

Syntax ViStatus_VI_FUNC hp4156b_cmdInt32_Q(ViSession vi, ViString cmd_str, ViPInt32 result);

Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	result	Response from instrument.

hp4156b_cmdReal

This function passes the cmd_str string to the instrument. This entry point passes the string in cmd_str followed by a space and then the real in value. Note that either an Real32 or 64 can be passed as the Real32 will be promoted.

Syntax ViStatus_VI_FUNC hp4156b_cmdReal(ViSession vi, ViString cmd_str, ViReal64 value);

Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	value	Parameter for command. -1E+300 to 1E+300.

hp4156b_cmdReal64Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 64 bit real. You specify the cmd_str and size parameters, and get result[] and count.

Driver Function Reference

hp4156b_cmdReal64_Q

Syntax	ViStatus _VI_FUNC hp4156b_cmdReal64Arr_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViReal64 _VI_FAR result[], ViPInt32 count);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Size of result[] (number of items in the array). 1 to 2147483647.
	result[]	Response from instrument.
	count	Count of valid items in result[]. Returned data.

hp4156b_cmdReal64_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 64 bit real.

Syntax	ViStatus _VI_FUNC hp4156b_cmdReal64_Q(ViSession vi, ViString cmd_str, ViPReal64 result);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	result	Response from instrument.

hp4156b_cmdString_Q

This function passes the cmd_str string to the instrument. This entry point will wait for a response which must be a string (character data). You specify the cmd_str and size parameters, and get result[].

Syntax	ViStatus _VI_FUNC hp4156b_cmdString_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViChar _VI_FAR result[]);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Length of result in bytes. 2 to 32767.
	result[]	Response from instrument.

hp4156b_dcl

This function sends a device clear (DCL) to the instrument.

A device clear will abort the present operation and enable the instrument to accept a new command or query. This is particularly useful in situations where it is not possible to determine the instrument state. In this case, it is customary to send a device clear before issuing a new instrument driver function. The device clear ensures that the instrument will be able to begin processing the new commands.

Syntax ViStatus _VI_FUNC hp4156b_dcl(ViSession vi);

Parameters vi Instrument handle returned from hp4156b_init().

hp4156b_error_message

This function translates the error code from an instrument driver function to a readable string.

Syntax ViStatus _VI_FUNC hp4156b_error_message(ViSession vi, ViStatus error_number, ViChar _VI_FAR message[]);

Parameters

vi	Instrument handle returned from hp4156b_init().
error_number	Error code from the driver function.
message[]	Error message string. Returned data. This is limited to 256 characters.

hp4156b_error_query

This function returns the error codes and corresponding error messages in the error queue of an instrument. See *If You Have a Problem* manual for a listing of the instrument error codes and messages.

Instrument errors may occur when you places the instrument in a bad state such as sending an invalid sequence of coupled commands. Instrument errors can be detected by polling. Automatic polling can be accomplished by using the hp4156b_errorQueryDetect function.

Syntax ViStatus _VI_FUNC hp4156b_error_query(ViSession vi, ViPInt32 error_number, ViChar _VI_FAR error_message[]);

Parameters vi Instrument handle returned from hp4156b_init().

error_number	Instrument's error code. Returned data.
error_message[]	Instrument's error message. Returned data. Up to 256 characters.

hp4156b_errorQueryDetect

This function enables or disables automatic instrument error checking.

If automatic error checking is enabled then the driver will query the instrument for an error at the end of each function call.

Syntax

```
ViStatus _VI_FUNC hp4156b_errorQueryDetect(ViSession vi,  
ViBoolean errorQueryDetect);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
errorQueryDetect	Error checking enable (VI_TRUE) or disable (VI_FALSE).

hp4156b_errorQueryDetect_Q

This function indicates if automatic instrument error detection is enabled or disabled.

Syntax

```
ViStatus _VI_FUNC hp4156b_errorQueryDetect_Q(ViSession vi,  
ViPBoolean pErrDetect);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
pErrDetect	Error checking enable (VI_TRUE) or disable (VI_FALSE). Returned data.

hp4156b_esr_Q

This function returns the contents of the ESR register. The driver returns the equivalent messages.

Syntax

```
ViStatus _VI_FUNC hp4156b_esr_Q(ViSession vi, ViChar _VI_FAR errstr[ ]);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
errstr[]	Response from instrument. 1 (ESR_OPC), 2 (ESR_RQL), 4 (ESR_QYE), 8 (ESR_DDE), 16 (ESR_EXE), 32 (ESR_CME), 64 (ESR_URQ), or 128 (ESR_PON).

hp4156b_execCal

This function executes the calibration and returns the calibration result. The parameter “result” returns the calibration result.

Syntax ViStatus _VI_FUNC hp4156b_execCal(ViSession vi, ViInt32 result);

Parameters

vi	Instrument handle returned from hp4156b_init().
result	Calibration result. Returned data. Numeric number. 0: No error (calibration succeed).

hp4156b_execOffsetCancel

This function measures the zero offset data, and sets the zero offset function to on.

The parameter ‘channel’ specifies the measurement channel (SMU or VMU). If you define SMU for ‘channel’, the SMU must be set to the voltage force mode by using the hp4156b_force function, before executing this function.

If you define VMU for ‘channel’, the VMU must be set to the differential voltage measurement mode by using the hp4156b_setVm function, before executing this function.

Syntax ViStatus _VI_FUNC hp4156b_execOffsetCancel(ViSession vi, ViInt32 channel, ViInt32 range);

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the unit to measure the zero offset data. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
range	Measurement range to measure the zero offset data. 0, 1, 2, or 3. 0: 10 pA range for SMU 1: 100 pA range for SMU 2: 1 nA range for SMU 3: 0.2 V range for VMU

hp4156b_force

This function specifies dc current/voltage source and forces the specified output immediately. To stop the output, use the hp4156b_force function with zero output.

Driver Function Reference

hp4156b_forcePulse

Syntax ViStatus _VI_FUNC hp4156b_force(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 value, ViReal64 comp, ViInt32 polarity);

NOTE range, value, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

Parameters	vi	Instrument handle returned from hp4156b_init().
	channel	Channel number of the source unit. 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 27 (PGU1), or 28 (PGU2).
	mode	Source output mode. 1 (current, only for SMU) or 2 (voltage).
	range	Output ranging mode. 0 (auto) or positive value (limited auto).
	value	Source output value (in A or V).
	comp	Compliance value (in V or A). It must be voltage for the current source, or current for the voltage source.
	polarity	Compliance polarity (only for SMU). 0 (auto) or 1 (manual). If <i>polarity</i> =0, the compliance polarity is automatically set to the same polarity as <i>value</i> , regardless of the specified <i>comp</i> polarity. The compliance polarity is positive if <i>value</i> =0. If <i>polarity</i> =1, the specified <i>comp</i> polarity is kept.

hp4156b_forcePulse

This function specifies pulse voltage source and forces the specified pulse immediately. To stop the pulse output, use hp4156b_abortMeasure function.

Syntax ViStatus _VI_FUNC hp4156b_forcePulse(ViSession vi, ViInt32 channel, ViInt32 count, ViReal64 base, ViReal64 peak, ViReal64 width, ViReal64 period, ViReal64 delay, ViReal64 rise, ViReal64 fall);

Parameters	vi	Instrument handle returned from hp4156b_init().
	channel	Channel number of the pulse source. 27 (PGU1) or 28 (PGU2).
	count	Pulse count (number of pulses, 1 to 65535) or 0 (pulse output free run mode).
	base	Pulse base value (in V). See Table 2-8.
	peak	Pulse peak value (in V). See Table 2-8.

width	Pulse width (in seconds). See Table 2-9.
period	Pulse period (in seconds). See Table 2-9.
delay	Pulse delay time (in seconds). See Table 2-9.
rise	Pulse leading transition time (in seconds). See Table 2-10.
fall	Pulse trailing transition time (in seconds). See Table 2-10.

NOTE

Pulse Count and Pulse Period

Pulse count (*count*) and pulse period (*period*) settings are effective for both PGU1 and PGU2. If you use a PGU as a pulse source set by this function and another PGU as a stress source set by the `hp4156b_setStress` function, check the setting of these parameters. The parameter values must be the same as shown below.

`hp4156b_forcePulse's count = hp4156b_setStress's duration` (pulse count)

`hp4156b_forcePulse's period = hp4156b_setStress's period`

hp4156b_init

This function initializes the software connection to the instrument and optionally verifies that instrument is in the system. In addition, it may perform any necessary actions to place the instrument in its reset state.

This function is not required for the Visual Basic .NET and Agilent VEE environments.

If the `hp4156b_init` function encounters an error, then the value of the `vi` output parameter will be `VI_NULL`.

Syntax

```
ViStatus _VI_FUNC hp4156b_init(ViRsrc InstrDesc, ViBoolean id_query,
ViBoolean do_reset, ViSession vi);
```

Parameters

<code>InstrDesc</code>	Instrument description. Examples; GPIB0::1::INSTR.
<code>id_query</code>	<code>VI_TRUE</code> (to perform system verification), or <code>VI_FALSE</code> (do not perform system verification).
<code>do_reset</code>	<code>VI_TRUE</code> (to perform reset operation), or <code>VI_FALSE</code> (do not perform reset operation).
<code>vi</code>	Instrument handle. This is <code>VI_NULL</code> if an error occurred during the init.

hp4156b_measureM

This function executes a multi channel spot measurement by the specified units, and returns the measurement result data and the measurement status.

Syntax

```
ViStatus _VI_FUNC hp4156b_measureM(ViSession vi, ViInt32 channel[ ],  
ViInt32 mode[ ], ViReal64 range[ ], ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel[]	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2). Enter 0 to the last element of channel[]. For example, if you use two channels, set the array size to 3, specify the channels to the first and second elements, and enter 0 to the third element.
mode[]	Measurement mode. 1 (current) or 2 (voltage).
range[]	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

Example

```
ViSession vi;  
ViStatus ret;  
ViReal64 v1 = 3; /* output voltage */  
ViInt32 vmode = 2; /* voltage output mode */  
ViInt32 mch[3]; /* source and measurement channels */  
mch[0] = 1; /* SMU1 for the 1st measurement channel */  
mch[1] = 2; /* SMU2 for the 2nd measurement channel */  
mch[2] = 0;  
ret = hp4156b_setSwitch(vi, mch[0], 1);  
ret = hp4156b_setSwitch(vi, mch[1], 1);  
ret = hp4156b_force(vi, mch[0], vmode, 0, 0, 0.1, 0);  
ret = hp4156b_force(vi, mch[1], vmode, 0, v1, 0.1, 0);  
  
ViInt32 mode[2]; /* measurement mode */  
mode[0] = 1; /* current measurement for 1st channel */  
mode[1] = 1; /* current measurement for 2nd channel */  
ViReal64 range[2]; /* measurement range */  
range[0] = 0; /* auto ranging for 1st channel */  
range[1] = 0; /* auto ranging for 2nd channel */  
ViReal64 md[2]; /* measurement value */  
ViInt32 st[2]; /* measurement status */  
ret = hp4156b_measureM(vi, mch, mode, range, &md[0], &st[0]);
```

hp4156b_measureP

This function executes a pulsed spot measurement by the specified channel, and returns the measured value and the measurement status.

Syntax ViStatus _VI_FUNC hp4156b_measureP(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViPReal64 value, ViPInt32 status);

Parameters	vi	Instrument handle returned from hp4156b_init().
	channel	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
	mode	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
	range	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
	value	Measurement data. Returned data.
	status	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

hp4156b_offsetCancel

This function enables or disables the zero offset cancel function.

Syntax ViStatus _VI_FUNC hp4156b_offsetCancel(ViSession vi, ViInt32 channel, ViInt32 state);

Parameters	vi	Instrument handle returned from hp4156b_init().
	channel	Channel number of the unit to set the offset cancel function. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
	state	Function state. 0 (off) or 1 (on).

hp4156b_opc_Q

This function does the *OPC? common command.

Syntax ViStatus _VI_FUNC hp4156b_opc_Q(ViSession vi, ViPBoolean result);

Parameters	vi	Instrument handle returned from hp4156b_init().
-------------------	----	--

Driver Function Reference

hp4156b_readData

result *OPC? command execution result. Returned data. VI_TRUE (Operation complete), or VI_FALSE (Operation is pending).

Example

```
ViSession vi;  
ViStatus ret;  
ViPBoolean result;  
ret = hp4156b_opc_Q(vi,&result);
```

hp4156b_readData

This function reads and returns the source setup data or the data measured by the hp4156b_startMeasure function.

Syntax

```
ViStatus _VI_FUNC hp4156b_readData(ViSession vi, ViPInt32 eod,  
ViPInt32 data_type, ViPReal64 value, ViPInt32 status, ViPInt32 channel);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
eod	End of data flag. Returned data. 1 (end of data) or 0 (not EOD).
data_type	Data type of “value”. Returned data. 0, 1, 3, 8, 9, 11, 14, or 15. 0: Voltage setup data 1: Current setup data 3: Time setup data 8: Voltage measurement data 9: Current measurement data 11: Time measurement data 14: Sampling index data 15: Stress status data
value	Measurement data or source setup data. Returned data.
status	Measurement status or source status. Returned data. For the status value, see “Status Code” on page 2-12.
channel	Channel number of the unit for measurement or output. Returned data. 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 23 (VMU1), 24 (VMU2), 27 (PGU1), or 28 (PGU2).

hp4156b_readStatusByte_Q

This function returns the contents of the status byte register.

Syntax	<code>ViStatus _VI_FUNC hp4156b_readStatusByte_Q(ViSession vi, ViPInt16 statusByte);</code>	
Parameters	<code>vi</code>	Instrument handle returned from <code>hp4156b_init()</code> .
	<code>statusByte</code>	Contents of the status byte. Returned data.

hp4156b_recoverOutput

This function returns the specified channel to the settings that are stored by the `hp4156b_zeroOutput` function, and clears the stored settings.

Syntax	<code>ViStatus _VI_FUNC hp4156b_recoverOutput(ViSession vi, ViInt32 channel);</code>	
Parameters	<code>vi</code>	Instrument handle returned from <code>hp4156b_init()</code> .
	<code>channel</code>	Channel number of the unit to return the settings. 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 27 (PGU1), or 28 (PGU2).

hp4156b_reset

This function places the instrument in a default state. Before issuing this function, it may be necessary to send a device clear to ensure that the instrument can execute a reset. A device clear can be issued by invoking `hp4156b_dcl` function.

Syntax	<code>ViStatus _VI_FUNC hp4156b_reset(ViSession vi);</code>	
Parameters	<code>vi</code>	Instrument handle returned from <code>hp4156b_init()</code> .

hp4156b_revision_query

This function returns the driver revision and the instrument firmware revision.

Syntax	<code>ViStatus _VI_FUNC hp4156b_revision_query(ViSession vi, ViChar _VI_FAR driver_rev[], ViChar _VI_FAR instr_rev[]);</code>	
Parameters	<code>vi</code>	Instrument handle returned from <code>hp4156b_init()</code> .
	<code>driver_rev[]</code>	Instrument driver revision. Returned data. This is limited to 256 characters.
	<code>instr_rev[]</code>	Instrument firmware revision. Returned data. This is limited to 256 characters.

hp4156b_sample

This function executes a sampling measurement by the specified channels, and returns the number of measurement points, measurement data index, measurement data, and the measurement status.

Before executing this function, set the sampling timing by the `hp4156b_setSample` function. The synchronous dc sources used with the sampling measurement units are defined by the `hp4156b_addSampleSyncIv` function. And the synchronous pulsed sources used with the sampling measurement units are defined by the `hp4156b_addSampleSyncPulse` function.

Syntax

```
ViStatus _VI_FUNC hp4156b_sample(ViSession vi, ViInt32 channel[ ],  
ViInt32 mode[ ], ViReal64 range[ ], ViPInt32 point, ViInt32 index[ ],  
ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

vi	Instrument handle returned from <code>hp4156b_init()</code> .
channel[]	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2). Enter 0 to the last element of <code>channel[]</code> . For example, if you use two channels, set the array size to 3, specify the channels to the first and second elements, and enter 0 to the third element.
mode[]	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range[]	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
point	Number of measurement points. Returned data.
index[]	Measurement data index. Returned data.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

hp4156b_self_test

This function causes the instrument to perform a self-test and returns the result of that self-test. This is used to verify that an instrument is operating properly. A failure may indicate a potential hardware problem.

Syntax	ViStatus _VI_FUNC hp4156b_self_test(ViSession vi, ViInt16 test_result, ViChar_VI_FAR test_message[]);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	test_result	Numeric result from self-test operation. Returned data. If no error is detected, 0 is returned.
	test_message[]	Self-test status message. Returned data. This is limited to 256 characters.

hp4156b_setFilter

This function sets the output filter of the specified SMU.

Syntax	ViStatus _VI_FUNC hp4156b_setFilter(ViSession vi, ViInt32 channel, ViInt32 state);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	channel	Channel number of the unit. 1 (SMU1), 2, 3, 4, 5, or 6 (SMU6).
	state	SMU filter state. 0 (off) or 1 (on).

hp4156b_setInteg

This function sets the integration time and sets the number of samples that are taken and averaged for the measurement.

Syntax	ViStatus _VI_FUNC hp4156b_setInteg(ViSession vi, ViInt32 table, ViReal64 time, ViInt32 average);	
Parameters	vi	Instrument handle returned from hp4156b_init().
	table	Integration time table. 1 (short), 2 (medium), or 3 (long).
	time	Integration time (in seconds). For <i>table</i> =1: 80 μ s to 10.16 ms. For <i>table</i> =2: Any value is ok (e.g. 1). The value will be ignored. For <i>table</i> =3: 16.7 ms to 2.0 s
	average	Number of samples for averaging, 1 to 1023. Or enter 0 to use the last setting.

hp4156b_setlv

This function specifies staircase sweep source and sets the parameters. The sweep source is used for the staircase sweep measurements and the staircase sweep with pulsed bias measurements.

For the staircase sweep with pulsed bias measurements, the sweep output synchronizes with the pulse output by the hp4156b_setPbias function.

Syntax

ViStatus _VI_FUNC hp4156b_setlv(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 start, ViReal64 stop, ViInt32 point, ViReal64 hold, ViReal64 delay, ViReal64 s_delay, ViReal64 comp, ViReal64 p_comp);

NOTE

range, start, stop, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the sweep source. 1 to 6 (SMU1 to SMU6), 21 (VSU1), or 22 (VSU2).
mode	Output mode. 1, 2, 3, 4, -1, -2, -3, or -4. For the log sweep mode, <i>start</i> and <i>stop</i> must be the same polarity. 1: Voltage-Single-Linear sweep 2: Voltage-Single-Log sweep 3: Voltage-Double-Linear sweep 4: Voltage-Double-Log sweep -1: Current-Single-Linear sweep (only for SMU) -2: Current-Single-Log sweep (only for SMU) -3: Current-Double-Linear sweep (only for SMU) -4: Current-Double-Log sweep (only for SMU)
range	Output ranging mode. 0 (auto) or positive value (limited auto).
start	Sweep start value (in A or V).
stop	Sweep stop value (in A or V).
point	Number of sweep steps. 1 to 1001.
hold	Hold time. 0 to 655.35 seconds, in 0.01 seconds resolution.
delay	Delay time. 0 to 65.535 seconds, in 0.0001 seconds resolution.
s_delay	Step delay time. 0 to 1.0 seconds, in 0.0001 seconds resolution.

comp	Compliance value (in V or A). It must be voltage for the current sweep source, or current for the voltage sweep source. Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified <i>comp</i> polarity. The compliance polarity is positive if the output value is 0.
p_comp	Power compliance. Available values are listed below. If you enter the other value, the power compliance is not set. 0.001 to 2.0 VA (for 4155/4156 and MPSMU in 41501) 0.001 to 14.0 VA (for HPSMU in 41501) Setting resolution: 0.001 VA

hp4156b_setPbias

This function specifies pulse source and sets the parameters. The pulse source is used for the pulsed spot measurements and the staircase sweep with pulsed bias measurements.

Filter of the pulse source must be set to off by using the hp4156b_setFilter function.

For the staircase sweep with pulsed bias measurements, the pulse output synchronizes with the staircase sweep output by the hp4156b_setIv function.

Syntax

ViStatus _VI_FUNC hp4156b_setPbias(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 base, ViReal64 peak, ViReal64 width, ViReal64 period, ViReal64 hold, ViReal64 comp);

NOTE

range, base, peak, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the pulse source. 1 to 6 (SMU1 to SMU6), 21 (VSU1), or 22 (VSU2).
mode	Pulse output mode. 1 (current, only for SMU) or 2 (voltage). For the current output, <i>base</i> and <i>peak</i> must be the same polarity.
range	Output ranging mode. 0 (auto) or positive value (limited auto).
base	Pulse base value (in A or V).
peak	Pulse peak value (in A or V).

Driver Function Reference
hp4156b_setPguR

width	Pulse width (in seconds). 0.5 ms to 0.1 s. 0.1 ms resolution.
period	Pulse period (in seconds). 5 ms to 1.0 s. 0.1 ms resolution. The value must be <i>width</i> + 4 ms or more.
hold	Hold time (in seconds). 0.0 to 655.35 s. 0.01 s resolution.
comp	Compliance value (in V or A). It must be voltage for the current source, or current for the voltage source. Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified <i>comp</i> polarity. The compliance polarity is positive if the output value is 0. For <i>mode</i> = 1, if <i>base</i> or <i>peak</i> is within 10 μ A and not 0, <i>comp</i> must be 2 V or less. For <i>mode</i> = 2, the minimum <i>comp</i> value must be as shown in Table 2-12.

Table 2-12 Minimum Compliance Value for Voltage Pulse Output

Voltage pulse ^a	<i>comp</i> (current compliance)
$0 < V_{p-p} < 2 \text{ V}$	$ comp > 2 \text{ nA}$
$2 \text{ V} < V_{p-p} < 20 \text{ V}$	$ comp > V_{p-p} \times 1.111 \times 10^{-6} - 2.22 \times 10^{-6}$
$20 \text{ V} < V_{p-p} $	$ comp > 20 \text{ } \mu\text{A}$

a. $|V_{p-p}|$ is the voltage from the pulse base value to the pulse peak value.

hp4156b_setPguR

This function sets the PGU output impedance.

Syntax ViStatus _VI_FUNC hp4156b_setPguR(ViSession vi, ViInt32 channel, ViInt32 state);

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of PGU. 27 (PGU1) or 28 (PGU2).
state	Status. 0 (approx. 0 ohm low impedance) or 1 (50 ohm).

hp4156b_setPiv

This function specifies pulsed sweep source and sets the parameters. The pulsed sweep source is used for the pulsed sweep measurements.

Filter of the pulse source must be set to off by using the hp4156b_setFilter function.

Syntax

ViStatus _VI_FUNC hp4156b_setPiv(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViReal64 base, ViReal64 start, ViReal64 stop, ViInt32 point, ViReal64 hold, ViReal64 width, ViReal64 period, ViReal64 comp);

NOTE

range, base, start, stop, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the pulse sweep source. 1 to 6 (SMU1 to SMU6), 21 (VSU1), or 22 (VSU2).
mode	Output mode. 1, 2, 3, 4, -1, -2, -3, or -4. For the current mode or log sweep mode, <i>base</i> , <i>start</i> , and <i>stop</i> must be the same polarity. 1: Voltage-Single-Linear sweep 2: Voltage-Single-Log sweep 3: Voltage-Double-Linear sweep 4: Voltage-Double-Log sweep -1: Current-Single-Linear sweep (only for SMU) -2: Current-Single-Log sweep (only for SMU) -3: Current-Double-Linear sweep (only for SMU) -4: Current-Double-Log sweep (only for SMU)
range	Output ranging mode. 0 (auto) or positive value (limited auto).
base	Pulse sweep base value (in A or V).
start	Pulse sweep start value (in A or V).
stop	Pulse sweep stop value (in A or V).
point	Number of sweep steps. 1 to 1001.
hold	Hold time (in seconds). 0.0 to 655.35 s. 0.01 s resolution.
width	Pulse width (in seconds). 0.5 ms to 0.1 s. 0.1 ms resolution.
period	Pulse period (in seconds). 5 ms to 1.0 s. 0.1 ms resolution. The value must be <i>width</i> + 4 ms or more.

Driver Function Reference

hp4156b_setSample

comp Compliance value (in V or A). It must be voltage for the current source, or current for the voltage source. Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *comp* polarity. The compliance polarity is positive if the output value is 0.

For the current output, if *base*, *start*, or *stop* is within 10 μ A and not 0, *comp* must be 2 V or less.

For the voltage output, the minimum *comp* value must be as shown in Table 2-12.

hp4156b_setSample

This function specifies the measurement timing of the sampling measurements. The sampling measurement units are defined by the `hp4156b_sample` function.

Syntax

```
ViStatus _VI_FUNC hp4156b_setSample(ViSession vi, ViReal64 hold, ViReal64 interval, ViInt32 point);
```

Parameters

vi	Instrument handle returned from <code>hp4156b_init()</code> .
hold	Hold time (in seconds). -30 ms to 655.35 s. 100 μ s resolution.
interval	Sampling interval (in seconds). 60 μ s to 480 μ s (20 μ s resolution), 480 μ s to 1 s (80 μ s resolution), or 1 s to 65.534 s (2 ms resolution).
point	Number of sampling points. 1 to 10001.

hp4156b_setStress

This function sets the timing parameters of the stress.

Syntax

```
ViStatus _VI_FUNC hp4156b_setStress(ViSession vi, ViReal64 hold, ViInt32 mode, ViReal64 duration, ViReal64 period);
```

Parameters

vi	Instrument handle returned from <code>hp4156b_init()</code> .
hold	Hold time (in seconds). 0 to 655.35 s.
mode	Stress mode. 1 (pulse count mode) or 2 (duration mode).
duration	Meaning of this parameter depends on the mode setting: If <i>mode</i> =1, this is the number of pulse count. 1 to 65535.

If *mode*=2, this is the stress time (in seconds). 500 μ s to 655.0 s.

period Pulse period (in seconds). 2 μ s to 10.0 s. Only for pulse stress.

The *period* value must match the *width* and *delay* values of the hp4156b_addStressSyncPulse function. See Table 2-9.

For *mode*=1, if you set the automatic abort function by using the hp4156b_stopMode function, the pulse output must be more than 10 seconds ($duration \times period > 10$ s).

NOTE

Pulse Count and Pulse Period

Pulse count (*duration*) and pulse period (*period*) settings are effective for both PGU1 and PGU2. If you use a PGU as a stress source set by this function and another PGU as a pulse source set by the hp4156b_forcePulse function, check the setting of these parameters. The parameter values must be the same as shown below.

hp4156b_setStress's *duration* (pulse count) = hp4156b_forcePulse's *count*

hp4156b_setStress's *period* = hp4156b_forcePulse's *period*

hp4156b_setSweepSync

This function specifies synchronous sweep source and sets the parameters. The synchronous sweep source will be the additional staircase sweep source for the staircase sweep measurements, the pulsed sweep measurements, or the staircase sweep with pulsed bias measurements. The hp4156b_setLv or hp4156b_setPiv function must be executed before this function.

For the staircase sweep measurements, the output synchronizes with the staircase sweep output by the hp4156b_setLv function.

For the pulsed sweep measurements, the output synchronizes with the pulsed sweep output by the hp4156b_setPiv function.

For the staircase sweep with pulsed bias measurements, the output synchronizes the staircase sweep output by the hp4156b_setLv function and the pulse output by the hp4156b_setPbias function.

Syntax

```
ViStatus _VI_FUNC hp4156b_setSweepSync(ViSession vi, ViInt32 channel,
ViInt32 mode, ViReal64 range, ViReal64 start, ViReal64 stop, ViReal64 comp,
ViReal64 p_comp);
```

Parameters

vi Instrument handle returned from hp4156b_init().

Driver Function Reference

hp4156b_setSwitch

channel	Channel number of the sweep source. 1 to 6 (SMU1 to SMU6), 21 (VSU1), or 22 (VSU2).
mode	Source output mode. 1 (current, only for SMU) or 2 (voltage). Set 1 if the hp4156b_setIv or hp4156b_setPiv function sets the current output mode. Or, set 2 if the function sets the voltage output mode.
range	Output ranging mode. 0 (auto) or positive value (limited auto).
start	Sweep start value (in A or V).
stop	Sweep stop value (in A or V).
comp	Compliance value (in V or A). It must be voltage for the current sweep source, or current for the voltage sweep source. Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified <i>comp</i> polarity. The compliance polarity is positive if the output value is 0.
p_comp	Power compliance. Available values are listed below. If you enter the other value, the power compliance is not set. 0.001 to 2.0 VA (for 4155/4156 and MPSMU in 41501) 0.001 to 14.0 VA (for HPSMU in 41501) Setting resolution: 0.001 VA

NOTE

range, start, stop, comp parameters

Available values depend on the unit. See “Parameters” on page 2-6.

Sweep type, linear or log, is set by the hp4156b_setIv or hp4156b_setPiv function. If the function sets the log sweep, *start* and *stop* must be the same polarity.

hp4156b_setSwitch

This function sets the output switch of the specified channel.

Syntax

```
ViStatus _VI_FUNC hp4156b_setSwitch(ViSession vi, ViInt32 channel,  
ViInt32 state);
```

Parameters

vi Instrument handle returned from hp4156b_init().

channel	Channel number of the unit. 0 (all channels), 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 23 (VMU1), 24 (VMU2), 26 (GNDU), 27 (PGU1) or 28 (PGU2).
state	Output switch setting. 0 (off) or 1 (on).

hp4156b_setVm

This function sets VMU1 and VMU2 to the normal mode that can use two VMUs individually or the differential voltage measurement mode that uses two VMUs to measure voltage between two terminals.

Syntax ViStatus _VI_FUNC hp4156b_setVm(ViSession vi, ViInt32 mode);

Parameters

vi	Instrument handle returned from hp4156b_init().
mode	Measurement mode. 1 (normal) or 2 (differential).

hp4156b_spotMeas

This function executes a high speed spot measurement by the specified channel, and returns the measured value and the measurement status.

Syntax ViStatus _VI_FUNC hp4156b_spotMeas(ViSession vi, ViInt32 channel, ViInt32 mode, ViReal64 range, ViPReal64 value, ViPInt32 status);

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
mode	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
value	Measurement data. Returned data.
status	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

hp4156b_startMeasure

This function starts the specified measurement by the specified channels. You can read the measured data by using the hp4156b_readData function. The measurement data is entered to the 4155/4156 output buffer in the measurement order. If you want to abort the measurement, use the hp4156b_abortMeasure function.

Syntax

```
ViStatus _VI_FUNC hp4156b_startMeasure(ViSession vi, ViInt32 meas_type,
ViInt32 channel[ ], ViInt32 mode[ ], ViReal64 range[ ], ViInt32 source);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
meas_type	Measurement type. 1 (multi spot), 2 (staircase sweep), 3 (pulse spot), 4 (pulse sweep), 5 (sweep with pulsed bias), 10 (sampling), or 11 (stress force).
channel[]	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2). Enter 0 to the last element of channel[]. For example, if you use two channels, set the array size to 3, specify the channels to the first and second elements, and enter 0 to the third element.
mode[]	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range[]	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
source	Source data output mode. 0 (measurement data output without source data) or 1 (measurement data output with source data).

Example

```
ViSession vi;
ViStatus ret;
ViInt32 mch[3];      /* channel */
mch[0] = 1;          /* SMU1 for the 1st measurement channel*/
mch[1] = 2;          /* SMU2 for the 2nd measurement channel*/
mch[2] = 0;
ret = hp4156b_setSwitch(vi, mch[0], 1);
ret = hp4156b_setSwitch(vi, mch[1], 1);
ret = hp4156b_setFilter(vi, mch[0], 0);

ViInt32 om = 2;      /* output mode: voltage */
ViReal64 or = 0;     /* output range: auto */
ViReal64 v1 = 0;     /* base voltage */
ViReal64 v2 = 1.5;   /* peak voltage */
ViReal64 tw = 0.001; /* width */
ViReal64 tp = 0.01;  /* period */
ViReal64 th = 0;     /* hold time */
ViReal64 ic = 0.01;  /* current compliance */
ret= hp4156b_setPbias(vi, mch[0], om, or, v1, v2, tw, tp, th, ic);
```

```
ret= hp4156b_force(vi, mch[1], om, or, v1, ic, 0);

ViInt32 type = 3;      /* pulsed spot measurement */
ViInt32 mode[2];      /* measurement mode */
ViReal64 range[2];    /* measurement range */
mode[0] = 1;          /* current for 1st measurement channel */
mode[1] = 1;          /* current for 2nd measurement channel */
range[0] = 0;          /* auto for 1st measurement channel */
range[1] = 0;          /* auto for 2nd measurement channel */
ret = hp4156b_startMeasure(vi, type, mch, mode, range, 0);

ViInt32 eod;           /* eod */
ViInt32 dtype;         /* data type */
ViReal64 md;           /* measurement value */
ViInt32 st;            /* measurement status */
ViInt32 ch;            /* channel */
ret = hp4156b_readData(vi, &eod, &dtype, &md, &st, &ch);
printf("I1 = %9.6f mA \n", md * 1000);
ret = hp4156b_readData(vi, &eod, &dtype, &md, &st, &ch);
printf("I2 = %9.6f mA \n", md * 1000);
```

hp4156b_stopMode

This function specifies the stop condition which enables the automatic abort function for the sweep measurement, sampling measurement, or stress force. Also this function specifies the sweep source output of the measurement unit after the sweep measurement is aborted.

Syntax

```
ViStatus _VI_FUNC hp4156b_stopMode(ViSession vi, ViInt32 occ_stop,
ViInt32 tcc_stop, ViInt32 ovf_stop, ViInt32 osc_stop, ViInt32 last_mode);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
occ_stop	Automatic abort function by compliance of another unit. 0 (disables this abort mode) or 1 (enables this abort mode).
tcc_stop	Automatic abort function by compliance of this unit. 0 (disables this abort mode) or 1 (enables this abort mode).
ovf_stop	Automatic abort function by overflow of AD converter. 0 (disables this abort mode) or 1 (enables this abort mode).
osc_stop	Automatic abort function by oscillation of unit(s). 0 (disables this abort mode) or 1 (enables this abort mode).
last_mode	Source output value after abort condition. 1 (returns to start value), or 2 (keeps the value when aborted).

hp4156b_stress

This function forces the stress defined by the hp4156b_setStress, hp4156b_addStressSyncIv, and/or hp4156b_addStressSyncPulse functions.

Syntax

```
ViStatus _VI_FUNC hp4156b_stress(ViSession vi, ViInt32 status);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
status	Stress output status. Returned data. For the status value, see “Status Code” on page 2-12.

hp4156b_sweepIv

This function executes a staircase sweep measurement by the specified channel, and returns the number of measurement steps, sweep source data, measurement data and the measurement status.

Before executing this function, execute the hp4156b_setIv function to set the sweep source. Also, execute the hp4156b_setSweepSync function to set the synchronous sweep source.

Syntax

```
ViStatus _VI_FUNC hp4156b_sweepIv(ViSession vi, ViInt32 channel,  
ViInt32 mode, ViReal64 range, ViInt32 point, ViReal64 source[ ],  
ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
mode	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
point	Number of measurement steps. Returned data.
source[]	Sweep source setup data. Returned data.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

Example

```
ViSession vi;
ViStatus ret;
ViInt32 sch = 1; /* SMU1 for sweep channel */
ViInt32 mch = 2; /* SMU2 for measurement channel */
ViInt32 sm = 1; /* sweep mode: voltage-single-linear */
ViInt32 om = 2; /* output mode: voltage */
ViReal64 or = 0; /* output range: auto */
ViReal64 vl = 0; /* start voltage */
ViReal64 v2 = 1.5; /* stop voltage */
ViInt32 pts = 11; /* point */
ViReal64 th = 0.01; /* hold time */
ViReal64 td = 0.001; /* delay time */
ViReal64 ts = 0.001; /* step delay time */
ViReal64 icip = 0.1; /* current compliance */
ViReal64 pcomp = 0.2; /* power compliance */
ViInt32 mm = 1; /* measurement mode: current */
ViReal64 mr = 0; /* measurement range: auto */
ViInt32 mpts; /* number of measurement steps */
ViReal64 sc[11]; /* source data */
ViReal64 md[11]; /* measurement data */
ViInt32 st[11]; /* status */

ret = hp4156b_setSwitch(vi, sch, 1);
ret = hp4156b_setSwitch(vi, mch, 1);
ret = hp4156b_force(vi, mch, om, or, vl, icip, 0);
ret = hp4156b_setIv(vi, sch, sm, or, vl, v2, pts, th, td, ts,
icip, pcomp);
ret = hp4156b_sweepIv(vi, mch, mm, mr, &mpts, &sc[0], &md[0],
&st[0]);
```

For the above example, the array variables `sc[]`, `md[]`, and `st[]` will contain the following data.

`sc[n]`: Sweep source setup data (voltage).

`md[n]`: Measurement data (current).

`st[n]`: Status for the `md[n]` data.

where, `n` = 0 to 10 (integer).

hp4156b_sweepMiv

This function executes a multi channel staircase sweep measurement by the specified channels, and returns the number of measurement steps, sweep source data, measurement data and the measurement status.

Before executing this function, execute the `hp4156b_setIv` function to set the sweep source. Also, execute the `hp4156b_setSweepSync` function to set the synchronous sweep source.

Driver Function Reference

hp4156b_sweepMiv

Syntax

```
ViStatus _VI_FUNC hp4156b_sweepMiv(ViSession vi, ViInt32 channel[ ],
ViInt32 mode[ ], ViReal64 range[ ], ViInt32 point, ViReal64 source[ ],
ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel[]	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2). Enter 0 to the last element of channel[]. For example, if you use two channels, set the array size to 3, specify the channels to the first and second elements, and enter 0 to the third element.
mode[]	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range[]	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
point	Number of measurement steps. Returned data.
source[]	Sweep source setup data. Returned data.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

Example

```
ViSession vi;
ViStatus ret;
ViInt32 mch[3];          /* measurement channels */
mch[0] = 1;
mch[1] = 2;
mch[2] = 0;
ret = hp4156b_setSwitch(vi, mch[0], 1);
ret = hp4156b_setSwitch(vi, mch[1], 1);

ViInt32 om = 2;          /* output mode: voltage */
ViInt32 sm = 1;          /* sweep mode: voltage-single-linear mode */
ViReal64 or = 0;         /* output range: auto */
ViReal64 v1 = 0;          /* start voltage */
ViReal64 v2 = 1.5;        /* stop voltage */
ViInt32 pts = 11;         /* point */
ViReal64 th = 0.01;       /* hold time */
ViReal64 td = 0.001;      /* delay time */
ViReal64 ts = 0.001;      /* step delay time */
ViReal64 icomp = 0.1;     /* current compliance */
ViReal64 pcomp = 0.2;     /* power compliance */
ret = hp4156b_force(vi, mch[0], om, or, v1, icomp, 0);
ret = hp4156b_setIv(vi, mch[1], sm, or, v1, v2, pts, th, td, ts,
icomp, pcomp);

ViInt32 mm[2];           /* measurement mode */
ViReal64 mr[2];          /* measurement range */
```

```
mm[0] = 1;          /* current mode for mch[0] */
mm[1] = 1;          /* current mode for mch[1] */
mr[0] = 0;          /* auto range for mch[0] */
mr[1] = 0;          /* auto range for mch[1] */
ViInt32 mpts;       /* number of measurement steps */
ViReal64 sc[11];    /* source data */
ViReal64 md[22];    /* measurement data */
ViInt32 st[22];     /* status */
ret = hp4156b_sweepMiv(vi, mch, mm, mr, &mpts, &sc[0], &md[0],
&st[0]);
```

For the above example, the array variables `sc[]`, `md[]`, and `st[]` will contain the following data.

`sc[n]`: Sweep source setup data (voltage).

`md[2*n]`: Data (current) measured by the `mch[0]` channel.

`md[2*n+1]`: Data (current) measured by the `mch[1]` channel.

`st[2*n]`: Status for the `md[2*n]` data.

`st[2*n+1]`: Status for the `md[2*n+1]` data.

where, `n = 0 to 10 (integer)`.

hp4156b_sweepPbias

This function executes a staircase sweep with pulsed bias measurement by the specified channel, and returns the number of measurement steps, sweep source data, measurement data, and the measurement status.

Before executing this function, execute the `hp4156b_setIv` function and the `hp4156b_setPbias` function to set the staircase sweep source and the pulsed bias source respectively. Also, execute the `hp4156b_setSweepSync` function to set the synchronous sweep source.

Syntax

```
ViStatus _VI_FUNC hp4156b_sweepPbias(ViSession vi, ViInt32 channel,
ViInt32 mode, ViReal64 range, ViInt32 point, ViReal64 source[ ],
ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

<code>vi</code>	Instrument handle returned from <code>hp4156b_init()</code> .
<code>channel</code>	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
<code>mode</code>	Measurement mode. 1 (current, only for SMU) or 2 (voltage).

Driver Function Reference

hp4156b_sweepPbias

range	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
point	Number of measurement steps. Returned data.
source[]	Sweep source setup data. Returned data.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

Example

```
ViSession vi;
ViStatus ret;
ViInt32 pch = 1;          /* SMU1 for pulse source channel */
ret = hp4156b_setSwitch(vi, pch, 1);
ret = hp4156b_setFilter(vi, pch, 0);

ViInt32 om = 2;           /* output mode: voltage */
ViReal64 or = 0;          /* output range: auto */
ViReal64 th = 0;          /* hold time */
ViReal64 tw = 0.001;      /* pulse width */
ViReal64 tp = 0.01;       /* pulse period */
ViReal64 vl = 0;          /* pulse base voltage */
ViReal64 v2 = 1.5;        /* pulse peak voltage */
ViReal64 ic = 0.05;       /* pulse source current compliance */
ret = hp4156b_setPbias(vi, pch, om, or, vl, v2, tw, tp, th, ic);

ViInt32 sch = 2;          /* SMU2 for sweep source channel */
ViInt32 sm = 1;           /* sweep mode: voltage-single-linear */
ViInt32 pts = 11;         /* number of sweep steps */
ViReal64 td = 0;          /* delay time */
ViReal64 ts = 0;          /* step delay time */
ViReal64 s1 = 0;          /* sweep start voltage */
ViReal64 s2 = 3;          /* sweep stop voltage */
ViReal64 icomp = 0.1;     /* sweep source current compliance */
ViReal64 pcomp = 0.5;     /* sweep source power compliance */
ret = hp4156b_setSwitch(vi, sch, 1);
ret = hp4156b_setIv(vi, sch, sm, or, s1, s2, pts, th, td, ts,
    icomp, pcomp);

ViInt32 mm = 1;           /* measurement mode: current */
ViReal64 mr = 0;          /* measurement range: auto */
ViInt32 mpts;             /* number of measurement steps */
ViReal64 sc[11];          /* source data */
ViReal64 md[11];          /* measurement data */
ViInt32 st[11];           /* status */
ret = hp4156b_sweepPbias(vi, sch, mm, mr, &mpts, &sc[0], &md[0],
    &st[0]);
```

For the above example, the array variables `sc[]`, `md[]`, and `st[]` will contain the following data.

`sc[n]`: Sweep source setup data (voltage).

md[n]: Measurement data (current).

st[n]: Status for the md[n] data.

where, n = 0 to 10 (integer).

hp4156b_sweepPiv

This function executes a pulsed sweep measurement by the specified channel, and returns the number of measurement steps, sweep source data, measurement value and the measurement status.

Before executing this function, execute the hp4156b_setPiv function to set the pulsed sweep source. Also, execute the hp4156b_setSweepSync function to set the synchronous sweep source.

Syntax

```
ViStatus_VI_FUNC hp4156b_sweepPiv(ViSession vi, ViInt32 channel,
ViInt32 mode, ViReal64 range, ViInt32 point, ViReal64 source[ ],
ViReal64 value[ ], ViInt32 status[ ]);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the measurement unit. 1 to 6 (SMU1 to SMU6), 23 (VMU1), or 24 (VMU2).
mode	Measurement mode. 1 (current, only for SMU) or 2 (voltage).
range	Measurement ranging mode. 0 (auto), positive value (limited auto), or negative value (fixed range). For the available values, see Table 2-2 and Table 2-5 or Table 2-7.
point	Number of measurement steps. Returned data.
source[]	Sweep source setup data. Returned data.
value[]	Measurement data. Returned data.
status[]	Measurement status. Returned data. For the status value, see “Status Code” on page 2-12.

Example

```
ViSession vi;
ViStatus ret;
ViInt32 pch = 1;      /* SMU1 for pulse sweep source */
ret = hp4156b_setSwitch(vi, pch, 1);
ret = hp4156b_setFilter(vi, pch, 0);

ViInt32 sm = 1;      /* sweep mode: voltage-single-linear mode */
ViReal64 or = 0;     /* output range: auto */
ViReal64 v0 = 0;     /* pulse base voltage */
ViReal64 v1 = 0;     /* pulse sweep start voltage */
```

Driver Function Reference

hp4156b_sweepPiv

```
ViReal64 v2 = 10;      /* pulse sweep stop voltage */
ViInt32 pts = 11;      /* number of sweep steps */
ViReal64 th = 0;       /* hold time */
ViReal64 tw = 0.001;   /* pulse width */
ViReal64 tp = 0.01;    /* pulse period */
ViReal64 ic = 0.05;    /* sweep source current compliance */
ret = hp4156b_setPiv(vi, pch, sm, or, v0, v1, v2, pts, th, tw, tp,
ic);

ViInt32 mm = 1;        /* measurement mode: current */
ViReal64 mr = 0;       /* measurement range: auto */
ViInt32 mpts;          /* number of measurement steps */
ViReal64 sc[11];       /* source data */
ViReal64 md[11];       /* measurement data */
ViInt32 st[11];        /* status */
ret = hp4156b_sweepPiv(vi, pch, mm, mr, &mpts, &sc[0], &md[0],
&st[0]);
```

For the above example, the array variables `sc[]`, `md[]`, and `st[]` will contain the following data.

`sc[n]`: Sweep source setup data (voltage).

`md[n]`: Measurement data (current).

`st[n]`: Status for the `md[n]` data.

where, $n = 0$ to 10 (integer).

hp4156b_timeOut

This function sets a minimum timeout value for driver I/O transactions in milliseconds. The default timeout period is 5 seconds.

Syntax

```
ViStatus_VI_FUNC hp4156b_timeOut(ViSession vi, ViInt32 timeOut);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
timeOut	I/O timeout value for all functions in the driver. in milliseconds. 0 to 2147483647.

hp4156b_timeOut_Q

This function returns the timeout value for driver I/O transactions in milliseconds.

Syntax

```
ViStatus_VI_FUNC hp4156b_timeOut_Q(ViSession vi, ViPInt32 pTimeOut);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
pTimeOut	Minimum timeout period that the driver can be set to, in milliseconds.

hp4156b_zeroOutput

This function stores the measurement setup of the units, and sets the units to 0 V output. To recover the setup, execute hp4156b_recoverOutput function.

Syntax

```
ViStatus_VI_FUNC hp4156b_zetoOutput(ViSession vi, ViInt32 channel);
```

Parameters

vi	Instrument handle returned from hp4156b_init().
channel	Channel number of the unit to set to the zero output. 0 (all channels), 1 to 6 (SMU1 to SMU6), 21 (VSU1), 22 (VSU2), 27 (PGU1), or 28 (PGU2).

E5250A Driver Functions

This section provides the reference information of the Agilent E5250A *VXIplug&play* driver functions.

Function List

Table 2-13 lists all the functions for the E5250A. You will see a brief description of the functions in the table.

For the description, syntax and parameters of the function, refer to the reference section following this table. The driver functions in the reference section will appear in the alphabetical order.

Table 2-13 **E5250A Driver Function List**

Category	Function	Description
Miscellaneous	hpe5250a_init	Initializes the E5250A.
	hpe5250a_close	Closes the connection with the E5250A.
	hpe5250a_reset	Executes the E5250A reset.
	hpe5250a_self_test	Executes the E5250A self-test.
	hpe5250a_error_query	Queries for the E5250A error code/message.
	hpe5250a_error_message	Queries for the driver error.
	hpe5250a_revision_query	Queries for the E5250A firmware/driver revisions.
	hpe5250a_timeOut	Sets the timeout.
	hpe5250a_timeOut_Q	Queries for the timeout setting.
	hpe5250a_errorQueryDetect	Sets the automatic error checking.
	hpe5250a_errorQueryDetect_Q	Queries for the automatic error checking setting.
	hpe5250a_dcl	Sends the Device Clear.
	hpe5250a_esr_Q	Queries for the ESR status.
	hpe5250a_readStatusByte_Q	Reads the E5250A status byte.
	hpe5250a_opc_Q	Checks the E5250A operation completion status.
Mode Control	hpe5250a_func	Sets the configuration mode.
	hpe5250a_connRuleSeq	Sets the connection rule/sequence.

Category	Function	Description
Bias Mode	hpe5250a_biasPort	Selects the input bias port.
	hpe5250_biasChanCard	Selects the card for bias mode.
	hpe5250_biasChanList	Selects the channel list for bias mode.
	hpe5250a_biasState	Sets the bias port state.
	hpe5250a_biasChanList_Q	Queries for the bias channel list.
Couple Port	hpe5250a_couplePort	Selects the couple port.
	hpe5250a_coupleState	Sets the couple port state.
Route Control	hpe5250a_closeList	Closes the channel list.
	hpe5250a_openList	Opens the channel list.
	hpe5250a_openCard	Opens all output on the card.
	hpe5250a_closeList_Q	Queries for the channel list status.
	hpe5250a_openList_Q	
	hpe5250a_closeCard_Q	Queries for the closed channel list on the card.
C/G Compensation	hpe5250a_CompenC	Executes the C/G compensation.
	hpe5250a_selectCompenFile	Selects the compensation data file.
Diagnostics	hpe5250a_testExec_Q	Executes the relay/front-panel/controller test.
	hpe5250a_testClear	Clears the test result.
Passthrough Functions	hpe5250a_cmd	Sends a command.
	hpe5250a_cmdInt	Sends a command with an integer parameter.
	hpe5250a_cmdReal	Sends a command with a real parameter.
	hpe5250a_cmdData_Q	Sends a command to read any data.
	hpe5250a_cmdString_Q	Sends a command to read string response.
	hpe5250a_cmdInt16_Q	Sends a command to read 16 bit integer response.
	hpe5250a_cmdInt16Arr_Q	Sends a command to read 16 bit integer array response.
	hpe5250a_cmdInt32_Q	Sends a command to read 32 bit integer response.
	hpe5250a_cmdInt32Arr_Q	Sends a command to read 32 bit integer array response.
	hpe5250a_cmdReal64_Q	Sends a command to read 64 bit real response.
	hpe5250a_cmdReal64Arr_Q	Sends a command to read 64 bit real array response.

hpe5250a_biasChanCard

This function will enable or disable bias on all the output ports of the specified card.

Syntax

```
ViStatus _VI_FUNC hpe5250a_biasChanCard(ViSession vi,  
ViInt16 disable_enable, ViInt16 bias_cardno);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
disable_enable	Bias status. 0 (sets bias enabled card) or 1 (sets bias disabled card).
bias_cardno	Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.

hpe5250a_biasChanList

This function will enable or disable bias on all the output ports specified by the biaschan_list.

The parameter 'biaschan_list' is an array of integers with each integer representing one channel. The last number of the 'biaschan_list' should be "0"(numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

Syntax

```
ViStatus _VI_FUNC hpe5250a_biasChanList(ViSession vi,  
ViInt16 biaschan_disen, ViInt32 _VI_FAR biaschan_list[ ]);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
biaschan_disen	Bias status. 0 (sets bias enabled port) or 1 (sets bias disabled port).
biaschan_list[]	Channel numbers. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.

hpe5250a_biasChanList_Q

This function will query the instrument for the bias status for the channels given in the list.

The parameter 'biaschan_list' is an array of integers with each integer representing one channel. The last number of the 'biaschan_list' should be "0" (numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

The 'bias_status' parameter is an array of integers containing the return values of the query. The 'bias_status' array returned will correspond one to one with 'biaschan_list' parameter.

Syntax

```
ViStatus _VI_FUNC hpe5250a_biasChanList_Q(ViSession vi, ViInt16 bias_disen,
ViInt32 _VI_FAR biaschan_list[ ], ViInt32 _VI_FAR bias_status[ ]);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
bias_disen	Bias status for the query. 0 (confirms if the port is the bias enabled) or 1 (confirms if the port is the bias disabled).
biaschan_list[]	Channel numbers to know the bias status. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.
bias_status[]	Bias status of the channels given in the biaschan_list. Returned value depends on the setting of bias_disen as shown below: when <i>bias_disen</i> =0, 0 means bias disabled, 1 means enabled. when <i>bias_disen</i> =1, 0 means bias enabled, 1 means disabled.

hpe5250a_biasPort

This function will select which input port is the bias port on the specified card. For each card, you can specify the same or different Bias Port. This function applies only to the E5252A card.

Syntax

```
ViStatus _VI_FUNC hpe5250a_biasPort(ViSession vi, ViInt16 biasport_cardno,
ViInt16 bias_port);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
biasport_cardno	Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.

Driver Function Reference

hpe5250a_biasState

bias_port Input port number to be set to the bias port. 1 to 10 (input port 1 to input port 10).

hpe5250a_biasState

This function controls the bias mode for the specified card. When Bias Mode is on, the input Bias Port is connected to all bias enabled output ports that are not connected to any other input ports. Bias disabled output ports are never connected to the input Bias Port when Bias Mode is on.

Syntax ViStatus _VI_FUNC hpe5250a_biasState(ViSession vi, ViInt16 biasstate_cardno, ViInt16 state);

Parameters

vi	Instrument handle returned from hpe5250a_init().
biasstate_cardno	Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.
state	Bias mode. 0 (off) or 1 (on).

hpe5250a_close

This function terminates the software connection to the instrument and deallocates system resources. It is generally a good programming habit to close the instrument handle when the program is done using the instrument.

Syntax ViStatus _VI_FUNC hpe5250a_close(ViSession vi);

Parameters vi Instrument handle returned from hpe5250a_init().

hpe5250a_closeCard_Q

This function will query the card for the channels closed of the specified card.

The parameter 'closechan_list' contains the channel numbers returned by the instrument. This will be an array of integers terminated by 'zero' to identify the end of the list. Array of enough length should be passed to the function.

Syntax ViStatus _VI_FUNC hpe5250a_closeCard_Q(ViSession vi, ViInt16 close_card, ViInt32 _VI_FAR closechan_list[]);

Parameters

vi	Instrument handle returned from hpe5250a_init().
close_card	Card number. 1 (card 1), 2 (card 2), 3 (card 3), or 4 (card 4) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.
closechan_list[]	Channels closed of the specified card.

hpe5250a_closeList

This function will connect the input ports to the output ports specified by the channel list.

The parameter 'closechan_list' is an array of integers with each integer representing one channel. The last number of the 'closechan_list' should be "0" (numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

Syntax

```
ViStatus _VI_FUNC hpe5250a_closeList(ViSession vi,
ViInt32 _VI_FAR closechan_list[ ]);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
closechan_list[]	Channel numbers to connect. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.

hpe5250a_closeList_Q

This function will query the instrument for the channels closed given in the 'closechan_list'.

The parameter 'closechan_list' is an array of integers with each integer representing one channel. The last number of the 'closechan_list' should be "0" (numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

The 'close_status' parameter is an array of integers containing the return values of the query. The 'close_status' array returned will correspond one to one with 'closechan_list' parameter.

Driver Function Reference

hpe5250a_cmd

Syntax	<pre>ViStatus _VI_FUNC hpe5250a_closeList_Q(ViSession vi, ViInt32 _VI_FAR closechan_list[], ViInt32 _VI_FAR close_status[]);</pre>	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	closechan_list[]	Channel numbers to know the close status. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.
	close_status[]	Status of the channels given in the closechan_list. 0 (opened) or 1 (closed).

hpe5250a_cmd

This function passes the cmd_str string to the instrument. Must be a NULL terminated C string.

Syntax	<pre>ViStatus _VI_FUNC hpe5250a_cmd(ViSession vi, ViString cmd_str);</pre>	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).

hpe5250a_cmdData_Q

This function passes the cmd_str string to the instrument. This entry point will wait for a response which may be any data. You specify the cmd_str and size parameters, and get result[].

Syntax	<pre>ViStatus _VI_FUNC hpe5250a_cmdData_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViChar _VI_FAR result[]);</pre>	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Length of result in bytes. 2 to 32767.
	result[]	Response from instrument.

hpe5250a_cmdInt

This function passes the cmd_str string to the instrument. This entry point passes the string in cmd_str followed by a space and then the integer in value. Note that either an Int16 or 32 can be passed as the Int16 will be promoted.

Syntax ViStatus _VI_FUNC hpe5250a_cmdInt(ViSession vi, ViString cmd_str, ViInt32 value);

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
value	Parameter for command. -2147483647 to 2147483647.

hpe5250a_cmdInt16Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 16 bit integers. You specify the cmd_str and size parameters, and get result[] and count.

Syntax ViStatus _VI_FUNC hpe5250a_cmdInt16Arr_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViInt16 _VI_FAR result[], ViInt32 count);

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
size	Size of result[] (number of items in the array). 1 to 2147483647.
result[]	Response from instrument.
count	Count of valid items in result[].

hpe5250a_cmdInt16_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 16 bit integer.

Syntax ViStatus _VI_FUNC hpe5250a_cmdInt16_Q(ViSession vi, ViString cmd_str, ViPInt16 result);

Parameters

vi	Instrument handle returned from hpe5250a_init().
----	---

cmd_str	Instrument command (cannot exceed 256 bytes in length).
result	Response from instrument.

hpe5250a_cmdInt32Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 32 bit integers. You specify the cmd_str and size parameters, and get result[] and count.

Syntax

```
ViStatus _VI_FUNC hpe5250a_cmdInt32Arr_Q(ViSession vi, ViString cmd_str,  
ViInt32 size, ViInt32 _VI_FAR result[ ], ViInt32 count);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
size	Size of result[] (number of items in the array). 1 to 2147483647.
result[]	Response from instrument.
count	Count of valid items in result[].

hpe5250a_cmdInt32_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 32 bit integer.

Syntax

```
ViStatus _VI_FUNC hpe5250a_cmdInt32_Q(ViSession vi, ViString cmd_str,  
ViInt32 result);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
result	Response from instrument.

hpe5250a_cmdReal

This function passes the cmd_str string to the instrument. This entry point passes the string in cmd_str followed by a space and then the real in value. Note that either an Real32 or 64 can be passed as the Real32 will be promoted.

Syntax ViStatus _VI_FUNC hpe5250a_cmdReal(ViSession vi, ViString cmd_str, ViReal64 value);

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
value	Parameter for command. -1E+300 to 1E+300.

hpe5250a_cmdReal64Arr_Q

This function passes the cmd_str string to the instrument. This command expects a response that is a definite arbitrary block of 64 bit real. You specify the cmd_str and size parameters, and get result[] and count.

Syntax ViStatus _VI_FUNC hpe5250a_cmdReal64Arr_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViReal64 _VI_FAR result[], ViPInt32 count);

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
size	Size of result[] (number of items in the array). 1 to 2147483647.
result[]	Response from instrument.
count	Count of valid items in result[].

hpe5250a_cmdReal64_Q

This function passes the cmd_str string to the instrument. This command expects a response that can be returned as a 64 bit real.

Syntax ViStatus _VI_FUNC hpe5250a_cmdReal64_Q(ViSession vi, ViString cmd_str, ViPReal64 result);

Parameters

vi	Instrument handle returned from hpe5250a_init().
cmd_str	Instrument command (cannot exceed 256 bytes in length).
result	Response from instrument.

hpe5250a_cmdString_Q

This function passes the cmd_str string to the instrument. This entry point will wait for a response which must be a string (character data). You specify the cmd_str and size parameters, and get result[].

Syntax ViStatus _VI_FUNC hpe5250a_cmdString_Q(ViSession vi, ViString cmd_str, ViInt32 size, ViChar _VI_FAR result[]);

Parameters	vi	Instrument handle returned from hpe5250a_init().
	cmd_str	Instrument command (cannot exceed 256 bytes in length).
	size	Length of result in bytes. 2 to 32767.
	result[]	Response from instrument.

hpe5250a_compenC

This function compensates capacitance/conductance data measured by using Agilent 4284A C meter, and returns compensation results. If you change the compensation data, create the compensation data file, and specify the data file using hpe5250a_selectCompenFile function before executing this function.

Syntax ViStatus _VI_FUNC hpe5250a_compenC(ViSession vi, ViReal64 frequency, ViReal64 len_hptrx, ViReal64 len_usrtrx_h, ViReal64 len_usrtrx_l, ViReal64 len_usrcoax_h, ViReal64 len_usrcoax_l, ViReal64 raw_c, ViReal64 raw_g, ViPReal64 compen_c, ViPReal64 compen_g);

Parameters	vi	Instrument handle returned from hpe5250a_init().
	frequency	Measurement frequency. 1E3 to 1E6 Hz.
	len_hptrx	Agilent 16494A triaxial cable. 1.5 or 3.0 m.
	len_usrtrx_h	Triaxial cable length (in m) between connector plate and DUT high terminal. If you do not use triaxial cable, enter 0 (zero).
	len_usrtrx_l	Triaxial cable length (in m) between connector plate and DUT low terminal. If you do not use triaxial cable, enter 0 (zero).
	len_usrcoax_h	Coaxial cable length (in m) between connector plate and DUT high terminal. If you do not use coaxial cable, enter 0 (zero).
	len_usrcoax_l	Coaxial cable length (in m) between connector plate and DUT low terminal. If you do not use coaxial cable, enter 0 (zero).

raw_c	Capacitance value (in F) measured by the 4284A.
raw_g	Conductance value (in S) measured by the 4284A.
compen_c	Capacitance compensation result (in F).
compen_g	Conductance compensation result (in S).

Example

```
Sub Main()
    Dim Ag5250 As Hpe5250a = New Hpe5250a("GPIB0::22::INSTR", True,
    True)
    Ag5250.Reset()
    Ag5250.Timeout(60000)

    Dim closelist() As Integer = {40101, 40202, 40303, 0}
    'path: in1-out1, in2-out2, in3-out3 of card4
    Ag5250.Func(Hpe5250a.ChannelConfigEnum.NormalConfiguration)
    Ag5250.ConnRuleSeq(0, 1, 1)
    Ag5250.CloseList(closelist)

    Dim freq As Double = 1000000 ' measurement frequency: 1 (MHz)
    Dim c_len As Double = 3 ' 16494A cable length: 3 (m)
    Dim tri_h As Double = 0 ' HI side triax cable length in m
    Dim tri_l As Double = 0 ' LO side triax cable length in m
    Dim co_h As Double = 0 ' HI side coax cable length in m
    Dim co_l As Double = 0 ' LO side coax cable length in m
    Dim cr As Double = 0.0000000001 ' C value by 4284A: 100 (pF)
    Dim gr As Double = 0.0005 ' G value by 4284A: 0.5 (mS)
    Dim cc As Double
    Dim gc As Double
    Ag5250.CompenC(freq, c_len, tri_h, tri_l, co_h, co_l, cr, gr, cc,
    gc)

    Dim result As String = "C = " & cc * 1000000000000.0 & " (pF)"
    result = result & Chr(10) & "G = " & gc * 1000 & " (mS)" & Chr(10)
    Console.WriteLine(result)

    Ag5250.Close()
End Sub
```

hpe5250a_connRuleSeq

The function sets connection rule and connection sequence for the specified card.

Syntax

```
ViStatus _VI_FUNC hpe5250a_connRuleSeq(ViSession vi,
ViInt16 cardno_ruleseq, ViInt16 rule, ViInt16 sequence);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
cardno_ruleseq	Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.

Driver Function Reference

hpe5250a_couplePort

rule	Connection rule. 0 (free route) or 1 (single route).
sequence	Connection sequence. 0 (no sequence), 1 (break before make), or 2 (make before break)

hpe5250a_couplePort

This function sets the couple ports which are used for making kelvin connections on the specified card. The specified input port number will be coupled with the next input port and two output ports. For each card, you may setup the same or different couple ports. This command overwrites the previous couple port setting for the card. This command applies only to the E5252A card.

The couple port mode is controlled by the hpe5250a_coupleState function.

Syntax

```
ViStatus _VI_FUNC hpe5250a_couplePort(ViSession vi,  
ViInt16 coupleport_cardno, ViInt16 port1, ViInt16 port3, ViInt16 port5,  
ViInt16 port7, ViInt16 port9);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
coupleport_cardno	Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.
port1	Couple port by the input ports 1 and 2. 0 (disable) or 1 (enable).
port3	Couple port by the input ports 3 and 4. 0 (disable) or 1 (enable).
port5	Couple port by the input ports 5 and 6. 0 (disable) or 1 (enable).
port7	Couple port by the input ports 7 and 8. 0 (disable) or 1 (enable).
port9	Couple port by the input ports 9 and 10. 0 (disable) or 1 (enable).

hpe5250a_coupleState

This function controls the couple port mode for the specified card. This function applies only to the E5252A card.

Syntax

```
ViStatus _VI_FUNC hpe5250a_coupleState(ViSession vi,  
ViInt16 couplestate_cardno, ViInt16 couple_state);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
----	---

`couplestate_cardno` Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see `hpe5250a_func`.

`couple_state` Couple port mode. 0 (off) or 1 (on).

hpe5250a_dcl

This function sends a device clear (DCL) to the instrument.

A device clear will abort the present operation and enable the instrument to accept a new command or query.

This is particularly useful in situations where it is not possible to determine the instrument state. In this case, it is customary to send a device clear before issuing a new instrument driver function. The device clear ensures that the instrument will be able to begin processing the new commands.

Syntax

```
ViStatus _VI_FUNC hpe5250a_dcl(ViSession vi);
```

Parameters

`vi` Instrument handle returned from `hpe5250a_init( )`.

hpe5250a_error_message

This function translates the error return value from an instrument driver function to a readable string.

Syntax

```
ViStatus _VI_FUNC hpe5250a_error_message(ViSession vi, ViStatus  
error_number, ViChar _VI_FAR message[ ] );
```

Parameters

`vi` Instrument handle returned from `hpe5250a_init( )`.

`error_number` Error return value from the driver function.

`message[ ]` Error message string. This is limited to 256 characters.

hpe5250a_error_query

This function returns the error numbers and corresponding error messages in the error queue of a instrument. See *Agilent E5250A User's Guide* for a listing of the instrument error numbers and messages.

Instrument errors may occur when you places the instrument in a bad state such as

sending an invalid sequence of coupled commands. Instrument errors can be detected by polling. Automatic polling can be accomplished by using the hpe5250a_errorQueryDetect function.

Syntax	ViStatus _VI_FUNC hpe5250a_error_query(ViSession vi, ViInt32 error_number, ViChar _VI_FAR error_message[]);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	error_number	Instrument's error code.
	error_message[]	Instrument's error message. This is limited to 256 characters.

hpe5250a_errorQueryDetect

This function enables or disables automatic instrument error checking.

If automatic error checking is enabled then the driver will query the instrument for an error at the end of each function call.

Syntax	ViStatus _VI_FUNC hpe5250a_errorQueryDetect(ViSession vi, ViBoolean errorQueryDetect);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	errorQueryDetect	Error checking enable (VI_TRUE) or disable (VI_FALSE).

hpe5250a_errorQueryDetect_Q

This function indicates if automatic instrument error detection is enabled or disabled.

Syntax	ViStatus _VI_FUNC hpe5250a_errorQueryDetect_Q(ViSession vi, ViPBoolean pErrDetect);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	pErrDetect	Error checking enable (VI_TRUE) or disable (VI_FALSE).

hpe5250a_esr_Q

This function returns the contents of the ESR register. The driver returns the equivalent messages.

Syntax	ViStatus _VI_FUNC hpe5250a_esr_Q(ViSession vi, ViChar _VI_FAR errstr[]);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	errstr[]	Response from instrument. 1, 2, 4, 8, 16, 32, 64, 128 or others. 1 (ESR_OPC), 2 (ESR_RQL), 4 (ESR_QYE_ERROR), 8 (ESR_DEVICE_DEPENDENT_ERROR), 16 (ESR_EXECUTION_ERROR), 32 (ESR_COMMAND_ERROR), 64 (ESR_URQ), 128 (ESR_PON), or others (ESR_MULTI_EVENT).

hpe5250a_func

This function is used to set the channel configuration to the auto configuration mode or the normal configuration mode.

Syntax	ViStatus _VI_FUNC hpe5250a_func(ViSession vi, ViInt16 channel_config);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	channel_config	Configuration mode. 0 (auto) or 1 (normal).

hpe5250a_init

This function initializes the software connection to the instrument and optionally verifies that instrument is in the system. In addition, it may perform any necessary actions to place the instrument in its reset state.

If the hpe5250a_init function encounters an error, then the value of the vi output parameter will be VI_NULL.

Syntax	ViStatus _VI_FUNC hpe5250a_init(ViRsrc InstrDesc, ViBoolean id_query, ViBoolean do_reset, ViPSession vi);	
Parameters	InstrDesc	Instrument description. Examples; GPIB0::1::INSTR.
	id_query	VI_TRUE (to perform In-System Verification), or VI_FALSE (do not perform In-System Verification).
	do_reset	VI_TRUE (to perform reset operation), or VI_FALSE (do not perform reset operation).

vi Instrument handle. This is VI_NULL if an error occurred during the init.

hpe5250a_opc_Q

This function does the *OPC? common command.

Syntax

```
ViStatus _VI_FUNC hpe5250a_opc_Q(ViSession vi, ViPBoolean result);
```

Parameters

vi Instrument handle returned from hpe5250a_init().

result VI_TRUE (Operation complete), or
 VI_FALSE (Operation is pending).

hpe5250a_openCard

This function will disconnect all input ports from all output ports for the specified card. Then if bias mode is on, connects the input bias port to all bias enabled output ports.

Syntax

```
ViStatus _VI_FUNC hpe5250a_openCard(ViSession vi, ViInt16 open_cardno);
```

Parameters

vi Instrument handle returned from hpe5250a_init().

open_cardno Card number. 1 (card 1), 2 (card 2), 3 (card 3), 4 (card 4), or 5 (all card) in the normal configuration mode, or 0 (all card in the automatic configuration mode). For the configuration mode, see hpe5250a_func.

hpe5250a_openList

This function will disconnect the input ports from the output ports specified by the channel list.

The parameter 'openchan_list' is an array of integers with each integer representing one channel. The last number of the 'openchan_list' should be "0" (numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

Syntax

```
ViStatus _VI_FUNC hpe5250a_openList(ViSession vi,  
ViInt32 _VI_FAR openchan_list[ ]);
```

Parameters

vi Instrument handle returned from hpe5250a_init().

openchan_list[] Channel numbers to disconnect. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.

hpe5250a_openList_Q

This function will query the instrument for the channels open given in the 'openchan_list'.

The parameter 'openchan_list' is an array of integers with each integer representing one channel. The last number of the 'openchan_list' should be "0" (numeric zero) to identify the end of the list. The maximum number of channels that can be specified by the list is 100.

The 'open_status' parameter is an array of integers containing the return values of the query. The 'open_status' array returned will correspond one to one with 'openchan_list' parameter.

Syntax

```
ViStatus _VI_FUNC hpe5250a_openList_Q(ViSession vi,  
ViInt32 _VI_FAR openchan_list[ ], ViInt32 _VI_FAR open_status[ ]);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
openchan_list[]	Channel numbers to know the open status. 5 digits integer. ABCDE. where A: card number, BC: input port number, DE: output port number. Top zero(s) can be ignored. For example, if A=0, BC=01, and DE=01, channel number should be 101 instead of 00101.
open_status[]	Status of the channels given in the openchan_list. 1 (opened) or 0 (closed).

hpe5250a_readStatusByte_Q

This function returns the contents of the status byte register.

Syntax

```
ViStatus _VI_FUNC hpe5250a_readStatusByte_Q(ViSession vi,  
ViPInt16 statusByte);
```

Parameters

vi	Instrument handle returned from hpe5250a_init().
statusByte	The contents of the status byte are returned in this parameter.

hpe5250a_reset

This function places the instrument in a default state. Before issuing this function, it may be necessary to send a device clear to ensure that the instrument can execute a reset. A device clear can be issued by invoking hpe5250a_dcl function.

Syntax ViStatus _VI_FUNC hpe5250a_reset(ViSession vi);

Parameters vi Instrument handle returned from hpe5250a_init().

hpe5250a_revision_query

This function returns the driver revision and the instrument firmware revision.

Syntax ViStatus _VI_FUNC hpe5250a_revision_query(ViSession vi,
ViChar _VI_FAR driver_rev[], ViChar _VI_FAR instr_rev[]);

Parameters vi Instrument handle returned from hpe5250a_init().
driver_rev[] Instrument driver revision. This is limited to 256 characters.
instr_rev[] Instrument firmware revision. This is limited to 256 characters.

hpe5250a_selectCompenFile

This function specifies capacitance/conductance compensation data file used to compensate C/G by using hpe5250a_compenC.

Syntax ViStatus _VI_FUNC hpe5250a_selectCompenFile(ViSession vi,
ViString file_name);

Parameters vi Instrument handle returned from hpe5250a_init().
file_name Compensation data file name. Use absolute path. If the value is NULL string, the default data is used.

Remarks If you change the compensation data, copy the default data shown below, and modify the data for your measurement cable. You will need to change the data for DATA05 and 06, and/or DATA07 and 08 corresponding to your cables. To measure and change the compensation data, refer to Agilent E5250A *User's Guide*. To get

the R, L, and C value, measure R, L, and C of the cable using the 4284A, and divide them by cable length (in m). Compensation data must be the value for 1 m length. Do not change the data format in the file.

```
# E5250A C Compensation coefficient data table
#
# CAUTION : Do not add or delete "REVISION" line and "DATAxx" line.
#           Change the value for R,L,C of DATA05,06,07 or 08.
#
REVISION    A. 03.00
#           R [ohm]      L [H]      C [F]
DATA00      74.65E-3     140.00E-9    58.44E-12   # Frame Path 1
DATA01      75.41E-3     90.00E-9     67.13E-12   # Frame Path 2
DATA02      231.41E-3    450.00E-9    178.85E-12   # Card Path High
DATA03      177.56E-3    390.00E-9    135.45E-12   # Card Path Low
DATA04      100.70E-3    400.00E-9     80.00E-12   # Triax Cable [m]
DATA05      100.70E-3    400.00E-9     80.00E-12   # User Triax Cbl H [m]
DATA06      100.70E-3    400.00E-9     80.00E-12   # User Triax Cbl L [m]
DATA07      114.00E-3    544.00E-9    130.00E-12   # User Coax Cbl H [m]
DATA08      114.00E-3    544.00E-9    130.00E-12   # User Coax Cbl L [m]
DATA09      0.00E-3      0.00E-9      1.20E-12     # Stray Capacitance
# END of Data
```

hpe5250a_self_test

This function causes the instrument to perform a self-test and returns the result of that self-test. This is used to verify that an instrument is operating properly. A failure may indicate a potential hardware problem.

Syntax

```
ViStatus _VI_FUNC hpe5250a_self_test(ViSession vi, ViInt16 test_result,
ViChar _VI_FAR test_message[ ] );
```

Parameters

vi Instrument handle returned from hpe5250a_init().

test_result Numeric result from self-test operation. 0: No error.

test_message[] Self-test status message. This is limited to 256 characters.

hpe5250a_testClear

This function clears the test result for the specified relay card or the front panel or the controller.

Syntax

```
ViStatus _VI_FUNC hpe5250a_testClear(ViSession vi, ViInt16 framecard_clear);
```

Parameters

vi Instrument handle returned from hpe5250a_init().

framecard_clear Test result to be cleared. 0 (test result of all test), 1 (card 1 relay test result), 2 (card 2 relay test result), 3 (card 3 relay test result), 4 (card 4 relay test result), 5 (relay test result of all card), 6 (front panel test result), or 7 (controller test result).

hpe5250a_testExec_Q

This function executes the controller test, the front panel test, or the relay test for the specified card. You must attach the relay test adapter before executing the relay test. The Front Panel test requires the key to be pressed within 10 seconds else the test will fail.

Syntax	ViStatus_VI_FUNC hpe5250a_testExec_Q(ViSession vi, ViInt16 framecard_exec, ViPInt16 exec_result);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	framecard_exec	Test to be executed. 1 (card 1 relay test) to 4 (card 4 relay test), 5 (relay test for all card), 6 (front panel test), or 7 (controller test).
	exec_result	Test result. 0: No error.

hpe5250a_timeOut

This function sets a minimum timeout value for driver I/O transactions in milliseconds. The default timeout period is 2 seconds.

Syntax	ViStatus_VI_FUNC hpe5250a_timeOut(ViSession vi, ViInt32 timeOut);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	timeOut	I/O timeout value for all functions in the driver. in milliseconds. 0 to 2147483647.

hpe5250a_timeOut_Q

This function returns the timeout value for driver I/O transactions in milliseconds.

Syntax	ViStatus_VI_FUNC hpe5250a_timeOut_Q(ViSession vi, ViPInt32 pTimeOut);	
Parameters	vi	Instrument handle returned from hpe5250a_init().
	pTimeOut	Minimum timeout period that the driver can be set to, in milliseconds.

Programming Examples for Visual Basic Users

This chapter describes how to create measurement programs using the Agilent 4155/4156 and the 4155/4156 VXi*plug&play* driver, and provides programming examples using Microsoft Visual Basic. This chapter contains the following sections:

- “Programming Basics”
- “High-Speed Spot Measurements”
- “Multi-Channel Spot Measurements”
- “Staircase Sweep Measurements”
- “Synchronous Sweep Measurements”
- “Multi-Channel Sweep Measurements”
- “Pulsed Spot Measurements”
- “Multi-Channel Pulsed Spot Measurements”
- “Pulsed Sweep Measurements”
- “Multi-Channel Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Sampling Measurements”
- “Stress Force”

NOTE

About Program Code

Programming examples are provided as subprograms that can be run with the project template shown in Table 3-1. The subprograms include the code to perform measurement, to display the measurement data, or to store the data. To execute the program, insert the subprograms instead of the perform_meas subprogram in the template.

Programming Basics

This section provides the basic information for programming using the Agilent 4155/4156 VXI*plug&play* driver.

- “To Create Your Project Template”
- “To Create Measurement Program”

To Create Your Project Template

This section explains how to create a project template using Microsoft Visual Basic. Before starting programming, create your project template, and keep it as your reference. It will remove the conventional task in the future programming.

Step 1. Connect instrument (e.g. Agilent 4155/4156) to computer via GPIB.

Step 2. Launch Visual Basic and create a new project.

Step 3. Import the following file to the project.

- hp4156b.bas (e.g. \Program Files\VISA\winnt\include\hp4156b.bas)
- visa32.bas (e.g. \Program Files\VISA\winnt\include\visa32.bas)

Step 4. Open a form (e.g. Form1) in the project.

Step 5. Enter a program code as template. See Table 3-1 for example. The example code is written in Visual Basic 6.0.

Step 6. Save the project as your template (e.g. \test\my_temp).

NOTE

To Start Program

If you create the measurement program by modifying the example code shown in Table 3-1, the program can be run by clicking the Run button on the Visual Basic main window. After that, a message box will appear. Then click OK to continue.

Programming Examples for Visual Basic Users

Programming Basics

Table 3-1 Example Template Program Code for Visual Basic 6.0

<pre> Sub Main() 'Starting the session ***** Dim vi As Long Dim ret As Long Dim msg As String Dim err_msg As String * 256 ret = hp4156b_init("GPIB::17::INSTR", VI_TRUE, VI_TRUE, vi) If ((vi = VI_NULL) Or (ret < VI_SUCCESS)) Then msg = "Initialization failure." & Chr(10) & Chr(10) & "Status Code: " & ret MsgBox msg, vbOKOnly, "" If (vi <> VI_NULL) Then ret = hp4156b_error_message(vi, ret, err_msg) msg = "Error: " & ret & Chr(10) & Chr(10) & err_msg MsgBox msg, vbOKOnly, "" End If End If ret = hp4156b_reset(vi) ret = hp4156b_timeOut(vi, 60000) ret = hp4156b_errorQueryDetect(vi, VI_TRUE) msg = "Click OK to start measurement." MsgBox msg, vbOKOnly, "" perform_meas vi, ret 'ret = hp4156b_cmd(vi, "aa") 'check_err vi, ret </pre>		<pre> '1 '7 '17 '19 25 </pre>
Line	Description	
1	Beginning of the Main subprogram.	
3 to 6	Declares variables used in this program.	
7	Establishes the software connection with the Agilent 4155/4156. The above example is for the Agilent 4155/4156 on the GPIB address 17. Confirm the GPIB address of your 4155/4156, and set the address correctly instead of "17".	
8 to 17	Checks the status returned by the hp4156b_init function. If an error status is returned, displays a message box to show the error message, and stops the program execution.	
19 to 23	Resets the Agilent 4155/4156, sets the driver I/O time out to 60 seconds, and enables the automatic instrument error checking. Also opens a message box to confirm start of measurement.	
25	Calls the perform_meas subprogram (line 38).	
26 to 27	Should be deleted or commented out before executing the program. The lines are just used to check the operation of the check_err subprogram.	

```

'Closing the session *****
ret = hp4156b_close(vi)                                     ' 30
check_err vi, ret
msg = "Click OK to stop the program."
MsgBox msg, vbOKOnly, ""

End Sub
'-----                                                    36

Sub perform_meas(vi As Long, ret As Long)
'insert program code
End Sub
'-----                                                    41

Sub check_err(vi As Long, ret As Long)
Dim inst_err As Long
Dim err_message As String * 250
Dim msg As String
Dim retStatus As Long
If VI_SUCCESS > ret Then
    If (hp4156b_INSTR_ERROR_DETECTED = ret) Then
        retStatus = hp4156b_error_query(vi, inst_err, err_message)
        msg = "Instrument Error: " & inst_err & Chr(10) & Chr(10) & err_message
        MsgBox msg, vbOKOnly, ""
    Else
        retStatus = hp4156b_error_message(vi, ret, err_message)
        msg = "Driver Error: " & ret & Chr(10) & Chr(10) & err_message
        MsgBox msg, vbOKOnly, ""
    End If
End If
End Sub

```

Line	Description
30	Disables the software connection with the Agilent 4155/4156.
31	Calls the check_err subprogram to check if an error status is returned for the line 30.
32 to 33	Opens a message box to confirm end of program.
35	End of the Main subprogram.
38 to 40	This is just the declaration of the perform_meas subprogram. Complete the subprogram that controls the 4155/4156, performs measurement, and displays/saves the results.
41 to last	Checks if the passed “ret” value indicates normal status, and returns to the line that called this subprogram. If the value indicates an instrument error status or a device error status, a message box will be displayed to show the error message.

To Create Measurement Program

Create the measurement program as shown below. The following procedure needs your project template. If the procedure does not fit your programming environment, arrange it to suit your environment.

Step 1. Plan the automatic measurements. Then decide the following items:

- Measurement devices
Discrete, packaged, on-wafer, and so on.
- Parameters/characteristics to be measured
 h_{FE} , V_{th} , sheet resistance, and so on.
- Measurement method
Spot measurement, staircase sweep measurement, and so on.

Step 2. Make a copy of your project template (e.g. \test\my_temp to \test\dev_a\my_temp).

Step 3. Rename the copy (e.g. \test\dev_a\my_temp to \test\dev_a\spot_id).

Step 4. Launch Visual Basic.

Step 5. Open the project (e.g. \test\dev_a\spot_id).

Step 6. Open the form that contains the template code as shown in Table 3-1. On the code window, complete the perform_meas subprogram. Then use the Agilent 4155/4156 *VXIplug&play* driver functions:

- hp4156b_setSwitch to enable/disable the source/measurement channels
- hp4156b_force, hp4156b_setIv, etc. to set source outputs
- hp4156b_spotMeas, hp4156b_sweepIv, etc. to perform measurements
- hp4156b_zeroOutput to disable source outputs

Step 7. Insert the code to display, store, or calculate data into the subprogram.

Step 8. Save the project (e.g. \test\dev_a\spot_id).

High-Speed Spot Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform high speed spot measurement (spot_meas), and display measurement result data (display_data). This example measures MOSFET drain current.

Table 3-2

High-Speed Spot Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim pins(4) As Long 'SMU port numbers ' 3 pins(0) = 1 'SMU1: drain pins(1) = 2 'SMU2: gate pins(2) = 3 'SMU3: source pins(3) = 4 'SMU4: substrate ret = hp4156b_setSwitch(vi, pins(3), 1) ' 9 ret = hp4156b_setSwitch(vi, pins(2), 1) ret = hp4156b_setSwitch(vi, pins(1), 1) ret = hp4156b_setSwitch(vi, pins(0), 1) check_err vi, ret ' 13 spot_meas vi, ret, pins() ' 15 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 17 check_err vi, ret End Sub ' 20 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 7	Declares variables, and defines the value.
9 to 12	Enables measurement channels.
15	Calls the spot_meas subprogram (next page) to perform spot measurement.
17	Disables measurement channels.
13 and 18	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
20	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

High-Speed Spot Measurements

```

Sub spot_meas(vi As Long, ret As Long, pins() As Long)                                '1

Dim vd As Double                                                                    '3
Dim vg As Double
Dim idcomp As Double
Dim igcomp As Double
Dim meas As Double
Dim status As Long
vd = 0.5
idcomp = 0.05
vg = 0.5
igcomp = 0.01                                                                    '12

ret = hp4156b_force(vi, pins(3), hp4156b_VF_MODE, 0, 0, 0.05, 0)                    '14
ret = hp4156b_force(vi, pins(2), hp4156b_VF_MODE, 0, 0, 0.05, 0)
ret = hp4156b_force(vi, pins(1), hp4156b_VF_MODE, 2, vg, igcomp, 0)
ret = hp4156b_force(vi, pins(0), hp4156b_VF_MODE, 2, vd, idcomp, 0)                '17
check_err vi, ret

ret = hp4156b_spotMeas(vi, pins(0), hp4156b_IM_MODE, 0, meas, status)                '20
check_err vi, ret
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                       '22
check_err vi, ret

display_data meas, status, vi, ret, pins()
End Sub

```

Line	Description
1	Beginning of the spot_meas subprogram.
3 to 12	Declares variables, and defines the value.
14 to 17	Applies voltage to device.
20	Performs the high speed spot measurement.
22	Sets the specified port to the zero output state.
18, 21, and 23	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
25	Calls the display_data subprogram (next page) to display measurement data.
26	End of the spot_meas subprogram.


```

Sub display_data(meas As Double, status As Long, vi As Long, ret
As Long, pins() As Long)

Dim title As String                                ' 3
Dim value As String
Dim rbx As Integer
title = "Spot Measurement Result"                  ' 6

If status = 0 Then                                  ' 8
    value = "Id = " & meas * 1000 & " (mA)" & Chr(10) & Chr(10)
    value = value & "Do you want to perform measurement again?"
    rbx = MsgBox(value, vbYesNo + vbQuestion, title)
    If rbx = vbYes Then
        spot_meas vi, ret, pins()
    End If
Else
    value = "Status error. Code = " & status
    MsgBox value, vbOKOnly, title
End If                                             ' 18

End Sub

```

Line	Description
1	Beginning of the display_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 18	Displays measurement data on a message box if the measurement status is normal. If Yes is clicked on the message box, performs the spot_meas subprogram again. If No is clicked, returns to the perform_meas subprogram. Or displays error message on a message box if the status is abnormal.
20	End of the display_data subprogram.

Measurement Result Example

Id = 4.0565 (mA)

Do you want to perform measurement again?

Multi-Channel Spot Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform multi channel spot measurement (mspot_meas), and display measurement result data (display_data). This example measures bipolar transistor collector current and base current.

Table 3-3

Multi-Channel Spot Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim pins(3) As Long 'SMU port numbers ' 3 pins(0) = 1 'SMU1: emitter pins(1) = 2 'SMU2: base pins(2) = 4 'SMU4: collector ret = hp4156b_setSwitch(vi, pins(2), 1) ' 8 ret = hp4156b_setSwitch(vi, pins(1), 1) ret = hp4156b_setSwitch(vi, pins(0), 1) check_err vi, ret ' 11 mspot_meas vi, ret, pins() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the mspot_meas subprogram (next page) to perform multi channel spot measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

```

Sub mspot_meas(vi As Long, ret As Long, pins() As Long)                                '1

Dim vc As Double                                                                    '3
Dim vb As Double
Dim ve As Double
Dim iccomp As Double
Dim ibcomp As Double
Dim iecomp As Double
ve = 0
iecomp = 0.1
vb = 0.7
ibcomp = 0.01
vc = 3
iccomp = 0.1

Dim mch(3) As Long                                                                '16
mch(0) = pins(2)      'collector
mch(1) = pins(1)      'base
mch(2) = 0
Dim mode(2) As Long
mode(0) = 1            'current measurement
mode(1) = 1            'current measurement
Dim range(2) As Double
range(0) = 0           'auto range
range(1) = 0           'auto range

Dim md(2) As Double                                                                '27
Dim st(2) As Long

ret = hp4156b_force(vi, pins(0), hp4156b_VF_MODE, 0, ve, iecomp, 0)                '30
ret = hp4156b_force(vi, pins(1), hp4156b_VF_MODE, 0, vb, ibcomp, 0)
ret = hp4156b_force(vi, pins(2), hp4156b_VF_MODE, 0, vc, iccomp, 0)
ret = hp4156b_measureM(vi, mch(0), mode(0), range(0), md(0), st(0))
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                       '36
display_data md(), st(), vi, ret, pins()
End Sub

```

Line	Description
1	Beginning of the mspot_meas subprogram.
3 to 28	Declares variables used in the subprogram, and defines the value.
30 to 35	Applies voltage to device, and performs the multi channel spot measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
36	Sets the specified port to the zero output state.
37	Calls the display_data subprogram (next page) to display measurement data.
38	End of the mspot_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Spot Measurements

```

Sub display_data(md() As Double, st() As Long, vi As Long, ret As Long, pins() As
Long) '1

Dim title As String '3
Dim value As String
Dim rbx As Integer
title = "Spot Measurement Result" '6

If st(0) = 0 Then '8
    value = "Ic = " & md(0) * 1000 & " (mA)"
    If st(1) = 0 Then
        value = value & Chr(10) & Chr(10) & "Ib = " & md(1) * 1000 & " (mA)"
        value = value & Chr(10) & Chr(10) & "hfe = " & md(0) / md(1)
        value = value & Chr(10) & Chr(10) & "Do you want to perform measurement
again?"
        rbx = MsgBox(value, vbYesNo + vbQuestion, title)
        If rbx = vbYes Then
            mspot_meas vi, ret, pins()
        End If
    Else
        value = "Base channel status error. Code = " & st(1)
        MsgBox value, vbOKOnly, title
    End If
Else
    value = "Collector channel status error. Code = " & st(0)
    MsgBox value, vbOKOnly, title
End If '25
End Sub

```

Line	Description
1	Beginning of the display_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 25	Displays measurement data on a message box if the measurement status is normal. If Yes is clicked on the message box, performs the mspot_meas subprogram again. If No is clicked, returns to the perform_meas subprogram. Or displays error message on a message box if the status is abnormal.
26	End of the display_data subprogram.

Measurement Result Example

```

Ic = 3.808 (mA)

Ib = 0.01883 (mA)

hfe = 202.230483271375

Do you want to perform measurement again?

```

Staircase Sweep Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform staircase sweep measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures MOSFET Id-Vd characteristics.

Table 3-4

Staircase Sweep Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(4) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: drain m(1) = 2 'SMU2: gate m(2) = 3 'SMU3: source m(3) = 4 'SMU4: substrate ret = hp4156b_setSwitch(vi, m(3), 1) ' 9 ret = hp4156b_setSwitch(vi, m(2), 1) ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret ' 13 sweep_meas vi, ret, m() ' 15 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 17 check_err vi, ret End Sub ' 20 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 7	Declares variables, and defines the value.
9 to 12	Enables measurement channels.
15	Calls the sweep_meas subprogram (next page) to perform staircase sweep measurement.
17	Disables measurement channels.
13 and 18	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
20	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Staircase Sweep Measurements

<pre> Sub sweep_meas(vi As Long, ret As Long, m() As Long) '1 Dim vd1 As Double '3 Dim vd2 As Double Dim idcomp As Double Dim vg1 As Double Dim vg2 As Double Dim igcomp As Double Dim hold As Double Dim delay As Double Dim s_delay As Double Dim p_comp As Double Dim nop1 As Long Dim nop2 As Long vd1 = 0 vd2 = 3 idcomp = 0.05 vg1 = 1 vg2 = 3 igcomp = 0.01 hold = 0 delay = 0 s_delay = 0 p_comp = 0 nop1 = 11 nop2 = 3 Dim i As Integer Dim j As Integer Dim n As Long n = nop1 * nop2 '30 Dim msg As String Dim rep As Long '33 Dim sc() As Double 'primary sweep output data Dim md() As Double 'sweep measurement data Dim st() As Long 'status data at each step Dim dvg() As Double 'secondary sweep output data ReDim Preserve sc(n) As Double ReDim Preserve md(n) As Double ReDim Preserve st(n) As Long ReDim Preserve dvg(nop2) As Double '41 ret = hp4156b_force(vi, m(3), hp4156b_VF_MODE, 0, 0, 0.05, 0) ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, 0, 0.05, 0) </pre>	
Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 30	Declares variables, and defines the value.
33 to 41	Declares variables used to keep source data, measurement data and status data. Also defines array size.
43 to 44	Applies voltage to device.

```

Dim d_vg As Double           'secondary sweep step value (delta)           ' 46
If nop2 = 1 Then
    d_vg = 0
Else
    d_vg = (vg2 - vg1) / (nop2 - 1)
End If

Dim vg As Double             'secondary sweep source output               ' 54
vg = vg1

i = 0                        'array counter for sweepIv returned data         ' 56
For j = 1 To nop2            'array counter for secondary sweep output data
    dvg(j - 1) = vg
    ret = hp4156b_force(vi, m(1), hp4156b_VF_MODE, 0, vg, igcomp, 0)
    ret = hp4156b_setIv(vi, m(0), hp4156b_SWP_VF_SGLLIN, 0, vd1, vd2, nop1, hold,
delay, s_delay, idcomp, p_comp)
    ret = hp4156b_sweepIv(vi, m(0), hp4156b_IM_MODE, 0, rep, sc(i), md(i), st(i))
    check_err vi, ret
    vg = vg + d_vg
    If rep = nop1 Then
        i = i + nop1
    Else
        msg = rep & " measurement steps were returned. It must be " & nop1 & "
steps.
        MsgBox msg, vbOKOnly, ""
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
        GoTo Bottom_sub
    End If
Next j                        ' 72

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
save_data nop1, nop2, dvg(), md(), st(), sc(), vi, ret, m()           ' 75

Bottom_sub:
End Sub

```

Line	Description
46 to 54	Declares variables, and defines the value. They are used for the secondary sweep source, d_vg is the step value and vg is the output value.
56 to 72	Performs the staircase sweep measurement (MOSFET Id-Vd characteristics).
59 to 62	Applies voltage to device, and sets the voltage sweep source. And performs the staircase sweep measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
64 to 71	Displays a message box to notify error, disables the source outputs, and stops the program execution if the number of returned data is not equal to the nop1 value.
75	Calls the save_data subprogram (next page) to save measurement data.
78	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Staircase Sweep Measurements

```

Sub save_data(nop1 As Long, nop2 As Long, dvg() As Double, md() As Double, st() As
Long, sc() As Double, vi As Long, ret As Long, m() As Long)

Dim i      As Integer      'array counter for primary sweep          ' 3
Dim j      As Integer      'array counter for secondary sweep
Dim val    As String       'data to be saved to a file
val = "Vg (V), Vd (V), Id (mA), Status"

For j = 1 To nop2          ' 8
    For i = nop1 * (j - 1) To nop1 * j - 1
        val = val & Chr(13) & Chr(10) & dvg(j - 1) & "," & sc(i) & "," & md(i) *
1000 & "," & st(i)
    Next i
Next j                      ' 12

Dim fname  As String       'data file name                          ' 14
Dim fnum   As Integer      'file number
fname = "C:\Agilent\data\data1.txt"
fnum = 1

'saves data into the file specified by fname
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum                  ' 22

'displays data on a MsgBox
Dim title  As String       ' 25
Dim rbx    As Integer
title = "Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m() 'returns to sweep_meas if Yes is clicked.
End If                      ' 33

End Sub

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 12	Creates data to be saved and displayed on a message box.
14 to 22	Saves measurement data into a file (C:\Agilent\data\data1.txt, CSV file).
25 to 33	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
35	End of the save_data subprogram.

**Measurement
Result Example**

```
Vg (V), Vd (V), Id (mA), Status
1,0,-0.00011721,0
1,0.3,3.1915,0
1,0.6,5.8795,0
1,0.9,8.1215,0
1,1.2,10.004,0
1,1.5,11.64,0
1,1.8,13.09,0
1,2.1,14.385,0
1,2.4,15.57,0
1,2.7,16.63,0
1,3,17.6,0
2,0,-0.000117215,0
2,0.3,4.178,0
2,0.6,7.9075,0
2,0.9,11.193,0
2,1.2,14.035,0
2,1.5,16.49,0
2,1.8,18.59,0
2,2.1,20.44,0
2,2.4,22.095,0
2,2.7,23.575,0
2,3,24.94,0
3,0,0.00050875,0
3,0.3,5.0385,0
3,0.6,9.6655,0
3,0.9,13.88,0
3,1.2,17.65,0
3,1.5,21.005,0
3,1.8,23.935,0
3,2.1,26.515,0
3,2.4,28.775,0
3,2.7,30.77,0
3,3,32.575,0
```

Data save completed.

Do you want to perform measurement again?

Synchronous Sweep Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform staircase sweep measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures MOSFET Id-Vg characteristics. The subprogram uses the synchronous sweep source.

Table 3-5

Synchronous Sweep Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(4) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: drain m(1) = 2 'SMU2: gate m(2) = 3 'SMU3: source m(3) = 4 'SMU4: substrate ret = hp4156b_setSwitch(vi, m(3), 1) ' 9 ret = hp4156b_setSwitch(vi, m(2), 1) ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret ' 13 sweep_meas vi, ret, m() ' 15 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 17 check_err vi, ret End Sub ' 20 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 7	Declares variables, and defines the value.
9 to 12	Enables measurement channels.
15	Calls the sweep_meas subprogram (next page) to perform staircase sweep measurement.
17	Disables measurement channels.
13 and 18	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
20	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Synchronous Sweep Measurements

```

Sub sweep_meas(vi As Long, ret As Long, m() As Long)           '1

Dim vpri1      As Double                                       '3
Dim vpri2      As Double
Dim vsyn1      As Double
Dim vsyn2      As Double
Dim vcon1      As Double
Dim vcon2      As Double
Dim ilcomp     As Double
Dim i2comp     As Double
Dim hold       As Double
Dim delay      As Double
Dim s_delay    As Double
Dim plcomp     As Double
Dim p2comp     As Double
Dim nop        As Long

vpri1 = 0
vpri2 = 3
ilcomp = 0.01
vsyn1 = 0
vsyn2 = 3
i2comp = 0.05
hold = 0
delay = 0
s_delay = 0
plcomp = 0
p2comp = 0
nop = 11                                                         '29

Dim rep        As Long                                         '31
Dim sc()       As Double 'primary sweep output data
Dim md()       As Double 'sweep measurement data
Dim st()       As Long   'status data at each step

ReDim Preserve sc(nop) As Double
ReDim Preserve md(nop) As Double
ReDim Preserve st(nop) As Long                                   '38

```

Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 29	Declares variables, and defines the value.
31 to 38	Declares variables used to keep source data, measurement data and status data. Also defines array size.

Programming Examples for Visual Basic Users

Synchronous Sweep Measurements

```

ret = hp4156b_force(vi, m(3), hp4156b_VF_MODE, 0, vcon1, 0.05, 0) '40
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, vcon2, 0.05, 0)
ret = hp4156b_setIv(vi, m(1), hp4156b_SWP_VF_SGLLIN, 0, vpri1, vpri2, nop, hold,
delay, s_delay, ilcomp, plcomp)
check_err vi, ret
ret = hp4156b_setSweepSync(vi, m(0), hp4156b_VF_MODE, 0, vsyn1, vsyn2, i2comp,
P2comp)
check_err vi, ret

ret = hp4156b_sweepIv(vi, m(0), hp4156b_IM_MODE, 0, rep, sc(0), md(0), st(0)) '47
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL) '50

Dim msg As String
If rep = nop Then '53
    save_data nop, md(), st(), sc(), vi, ret, m()
Else
    msg = rep & " measurement steps were returned. It must be " & nop & " steps. "
    MsgBox msg, vbOKOnly, ""
End If '58
End Sub '60

```

Line	Description
40 to 41	Applies voltage to device.
42	Sets the primary sweep source.
44	Sets the synchronous sweep source.
47	Performs the staircase sweep measurement.
50	Sets the specified port to the zero output state.
43, 45, and 48	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
53 to 58	Calls the save_data subprogram to save measurement data. Or, displays a message box if the number of returned data is not equal to the nop value.
60	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Synchronous Sweep Measurements

```

Sub save_data(nop As Long, md() As Double, st() As Long, sc() As Double, vi As Long, ret As Long, m() As Long) ' 1

Dim i As Integer 'array counter for primary sweep ' 3
Dim val As String 'data to be saved to a file
val = "Vg (V), Id (mA), Status"

For i = 0 To nop - 1 ' 7
    val = val & Chr(13) & Chr(10) & sc(i) & "," & md(i) * 1000 & "," & st(i)
Next i

Dim fname As String 'data file name ' 11
Dim fnum As Integer 'file number
fname = "C:\Agilent\data\data2.txt"
fnum = 1

'saves data into the file specified by fname
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum

'displays data on a MsgBox ' 22
Dim title As String
Dim rbx As Integer
title = "Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m() 'returns to sweep_meas if Yes is clicked. ' 30
End If

End Sub

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 5	Declares variables, and defines the value.
7 to 9	Creates data to be saved and displayed on a message box.
11 to 19	Saves measurement data into a file (C:\Agilent\data\data2.txt, CSV file).
22 to 30	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
32	End of the save_data subprogram.

Programming Examples for Visual Basic Users

Synchronous Sweep Measurements

Measurement Result Example

```
Vg (V), Id (mA), Status
0,-0.000098485,0
0.3,2.338,0
0.6,4.9295,0
0.9,7.7645,0
1.2,10.8095,0
1.5,14.05,0
1.8,17.465,0
2.1,21.045,0
2.4,24.755,0
2.7,28.59,0
3,32.54,0
```

Data save completed.

Do you want to perform measurement again?

Multi-Channel Sweep Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform multi channel sweep measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures bipolar transistor Ic-Vb and Ib-Vb characteristics.

Table 3-6

Multi-Channel Sweep Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(3) As Long 'SMU port numbers ' 3 m(0) = 2 'SMU2: base m(1) = 4 'SMU4: collector m(2) = 1 'SMU1: emitter ret = hp4156b_setSwitch(vi, m(2), 1) ' 8 ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret sweep_meas vi, ret, m() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the sweep_meas subprogram (next page) to perform multi channel sweep measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Sweep Measurements

```

Sub sweep_meas(vi As Long, ret As Long, m() As Long)      '1

Dim vc           As Double                                '3
Dim ve           As Double
Dim vb1          As Double
Dim vb2          As Double
Dim iccomp       As Double
Dim ibcomp       As Double
Dim iecomp       As Double
Dim hold         As Double
Dim delay        As Double
Dim s_delay      As Double
Dim pcomp        As Double
Dim nop          As Long
Dim n            As Long
vc = 3
iccomp = 0.1
ve = 0
iecomp = 0.1
vb1 = 0.3
vb2 = 0.8
ibcomp = 0.001
hold = 0
delay = 0
s_delay = 0
pcomp = 0
nop = 11
n = nop * 2

Dim mch(3)       As Long
Dim mode(2)      As Long
Dim range(2)     As Double
mch(0) = m(0)    'base
mch(1) = m(1)    'collector
mch(2) = 0
mode(0) = 1      'current measurement
mode(1) = 1      'current measurement
range(0) = -0.001 ' 1 mA range fixed
range(1) = -0.1  '100 mA range fixed
Dim rep          As Long
Dim sc()         As Double 'primary sweep output data
Dim md()         As Double 'sweep measurement data
Dim st()         As Long   'status data at each step
ReDim Preserve sc(nop) As Double
ReDim Preserve md(n)   As Double
ReDim Preserve st(n)   As Long

```

Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 46	Declares variables used in this subprogram, and defines the value.

<pre> ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2) ' 48 check_err vi, ret ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, ve, iecomp, 0) ' 51 ret = hp4156b_force(vi, m(1), hp4156b_VF_MODE, 0, vc, iccomp, 0) ret = hp4156b_setIv(vi, m(0), hp4156b_SWP_VF_SGLLIN, 0, vb1, vb2, nop, hold, delay, s_delay, ibcomp, pcomp) check_err vi, ret ret = hp4156b_sweepMiv(vi, mch(0), mode(0), range(0), rep, sc(0), md(0), st(0)) check_err vi, ret ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL) ' 59 Dim msg As String If rep = nop Then ' 62 save_data nop, md(), st(), sc(), vi, ret, m() Else msg = rep & " measurement steps were returned. It must be " & nop & " steps." MsgBox msg, vbOKOnly, "" End If ' 67 End Sub ' 69 </pre>	
Line	Description
48	Sets the A/D converter integration time.
51 to 52	Applies voltage to device.
53	Sets the staircase sweep source.
56	Performs multi channel sweep measurement.
59	Sets the specified port to the zero output state.
49, 54, and 57	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
62 to 67	Calls the save_data subprogram to save measurement data. Or, displays a message box if the number of returned data is not equal to the nop value.
69	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Sweep Measurements

```

Sub save_data(nop As Long, md() As Double, st() As Long, sc() As Double, vi As Long, ret As Long, m() As Long) '1

Dim i As Integer 'array counter for primary sweep '3
Dim val As String 'data to be saved to a file
val = "Vb (V), Ib (mA), Ic (mA), Status_b, Status_c"

For i = 0 To nop - 1 '7
val = val & Chr(13) & Chr(10) & sc(i) & "," & md(2 * i) * 1000 & ","
val = val & md(2 * i + 1) * 1000 & "," & st(2 * i) & "," & st(2 * i + 1)
Next i

Dim fname As String 'data file name '12
Dim fnum As Integer 'file number
fname = "C:\Agilent\data\data3.txt"
fnum = 1

'saves data into the file specified by fname
Open fname For Output Access Write Lock Read Write As fnum '18
Print #fnum, val
Close fnum

'displays data on a MsgBox
Dim title As String '23
Dim rbx As Integer
title = "Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m()
End If '31

End Sub

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 5	Declares variables, and defines the value.
7 to 10	Creates data to be saved and displayed on a message box.
12 to 20	Saves measurement data into a file (C:\Agilent\data\data3.txt, CSV file).
23 to 31	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
33	End of the save_data subprogram.

**Measurement
Result Example**

```
Vb (V), Ib (mA), Ic (mA), Status_b, Status_c  
0.3,0,-0.005,0,0  
0.35,0,-0.005,0,0  
0.4,0,-0.005,0,0  
0.45,0,-0.005,0,0  
0.5,0,0,0,0  
0.55,0.0001,0.015,0,0  
0.6,0.0005,0.085,0,0  
0.65,0.00305,0.605,0,0  
0.7,0.01915,3.89,0,0  
0.75,0.09975,19.625,0,0  
0.8,0.34745,59.38,0,0
```

Data save completed.

Do you want to perform measurement again?

Pulsed Spot Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform pulsed spot measurement (spot_meas), and display measurement result data (display_data). This example measures MOSFET drain current.

Table 3-7 Pulsed Spot Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim pins(4) As Long 'SMU port numbers ' 3 pins(0) = 1 'SMU1: drain pins(1) = 2 'SMU2: gate pins(2) = 3 'SMU3: source pins(3) = 4 'SMU4: substrate ret = hp4156b_setSwitch(vi, pins(3), 1) ' 9 ret = hp4156b_setSwitch(vi, pins(2), 1) ret = hp4156b_setSwitch(vi, pins(1), 1) ret = hp4156b_setSwitch(vi, pins(0), 1) check_err vi, ret ' 13 spot_meas vi, ret, pins() ' 15 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 17 check_err vi, ret End Sub ' 20 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 7	Declares variables, and defines the value.
9 to 12	Enables measurement channels.
15	Calls the spot_meas subprogram (next page) to perform pulsed spot measurement.
17	Disables measurement channels.
13 and 18	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
20	End of the perform_meas subprogram.

```

Sub spot_meas(vi As Long, ret As Long, pins() As Long)                                '1
Dim vd As Double                                                                    '3
Dim vg As Double
Dim idcomp As Double
Dim igcomp As Double
Dim base As Double
Dim width As Double
Dim period As Double
Dim hold As Double
vd = 0.5
idcomp = 0.05
vg = 0.5
igcomp = 0.01
base = 0
width = 0.001
period = 0.01
hold = 0.1
Dim meas As Double
Dim status As Long                                                                '20

ret = hp4156b_setFilter(vi, pins(1), hp4156b_FLAG_OFF)                            '22
ret = hp4156b_setPbias(vi, pins(1), hp4156b_VF_MODE, 2, base, vg, width, period,
hold, igcomp)
ret = hp4156b_force(vi, pins(3), hp4156b_VF_MODE, 0, 0, 0.05, 0)
ret = hp4156b_force(vi, pins(2), hp4156b_VF_MODE, 0, 0, 0.05, 0)
ret = hp4156b_force(vi, pins(0), hp4156b_VF_MODE, 2, vd, idcomp, 0)
ret = hp4156b_measureP(vi, pins(0), hp4156b_IM_MODE, 0, meas, status)            '27
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                       '30
display_data meas, status, vi, ret, pins()
End Sub

```

Line	Description
1	Beginning of the spot_meas subprogram.
3 to 20	Declares variables used in this subprogram, and defines the value.
22 to 23	Sets the SMU filter off for the pulsed bias channel, and set the pulsed bias source.
24 to 26	Applies voltage to device.
27 to 28	Performs the pulsed spot measurement, and calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
30	Sets the specified port to the zero output state.
31	Calls the display_data subprogram (next page) to display measurement data.
32	End of the spot_meas subprogram.

Programming Examples for Visual Basic Users

Pulsed Spot Measurements

```

Sub display_data(meas As Double, status As Long, vi As Long, ret As
Long, pins() As Long)                                '1

Dim title As String                                  '3
Dim value As String
Dim rbx As Integer
title = "Spot Measurement Result"                    '6

If status = 0 Then                                    '8
    value = "Id = " & meas * 1000 & " (mA)" & Chr(10) & Chr(10)
    value = value & "Do you want to perform measurement again?"
    rbx = MsgBox(value, vbYesNo + vbQuestion, title)
    If rbx = vbYes Then
        spot_meas vi, ret, pins()
    End If
Else
    value = "Status error. Code = " & status
    MsgBox value, vbOKOnly, title
End If                                                '18

End Sub

```

Line	Description
1	Beginning of the display_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 18	Displays measurement data on a message box if the measurement status is normal. If Yes is clicked on the message box, performs the spot_meas subprogram again. If No is clicked, returns to the perform_meas subprogram. Or displays error message on a message box if the status is abnormal.
20	End of the display_data subprogram.

Measurement Result Example

```

Id = 4.075 (mA)
Do you want to perform measurement again?

```

Multi-Channel Pulsed Spot Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform multi channel pulsed spot measurement (mspot_meas), and display measurement result data (display_data). This example measures bipolar transistor collector current and base current.

Table 3-8

Multi-Channel Pulsed Spot Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim pins(3) As Long 'SMU port numbers ' 3 pins(0) = 1 'SMU1: emitter pins(1) = 2 'SMU2: base pins(2) = 4 'SMU4: collector ret = hp4156b_setSwitch(vi, pins(2), 1) ' 8 ret = hp4156b_setSwitch(vi, pins(1), 1) ret = hp4156b_setSwitch(vi, pins(0), 1) check_err vi, ret ' 11 mspot_meas vi, ret, pins() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the mspot_meas subprogram (next page) to perform multi channel pulsed spot measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Pulsed Spot Measurements

```

Sub mspot_meas(vi As Long, ret As Long, pins() As Long)                                '1

Dim vc          As Double                                                            '3
Dim vb          As Double
Dim iccomp      As Double
Dim ibcomp      As Double
vc = 0
vb = 0
iccomp = 0.1
ibcomp = 0.1
Dim mch(3)      As Long
mch(0) = pins(2)      'collector
mch(1) = pins(1)      'base
mch(2) = 0
Dim mode(2)     As Long
mode(0) = 1           'current measurement
mode(1) = 1           'current measurement
Dim range(2)    As Double
range(0) = 0          'auto range
range(1) = 0          'auto range
Dim eod         As Long
Dim dtype       As Long
Dim mdata       As Double
Dim stat        As Long
Dim ch          As Long
Dim md(2)       As Double
Dim st(2)       As Long                                                            '27

ret = hp4156b_setFilter(vi, pins(0), hp4156b_FLAG_OFF)                             '29
ret = hp4156b_cmd(vi, "PT 0,0.005,0.01,0,1")                                     'sets pulse timing parameters
ret = hp4156b_cmd(vi, "PV 1,0,0,-0.8,0.1")                                       'sets pulse voltage source
ret = hp4156b_force(vi, pins(1), hp4156b_VF_MODE, 0, vb, ibcomp, 0)              '32
ret = hp4156b_force(vi, pins(2), hp4156b_VF_MODE, 0, vc, iccomp, 0)
ret = hp4156b_startMeasure(vi, hp4156b_MM_PSPOT, mch(0), mode(0), range(0), hp4156b_FLAG_OFF)
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                       '37
ret = hp4156b_readData(vi, eod, dtype, mdata, stat, ch)
md(0) = mdata
st(0) = stat
ret = hp4156b_readData(vi, eod, dtype, mdata, stat, ch)
md(1) = mdata
st(1) = stat
display_data md(), st(), vi, ret, pins()
End Sub                                                                            '45

```

Line	Description
1	Beginning of the mspot_meas subprogram.
3 to 27	Declares variables used in this subprogram, and defines the value.
29 to 31	Sets the SMU filter off for the pulsed bias channel, and set the pulsed bias source.
32 to 35	Applies voltage to device, and performs multi channel pulsed spot measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
37 to 43	Sets all channels to zero output state, and read the measurement result data.
44	Calls the display_data subprogram (next page) to display measurement data.
45	End of the mspot_meas subprogram.


```

Sub display_data(md() As Double, st() As Long, vi As Long, ret As Long, pins() As Long)

Dim title As String
Dim value As String
Dim rbx As Integer
title = "Spot Measurement Result"

If st(0) = 0 Then
    value = "Ic = " & md(0) * 1000 & " (mA)" & Chr(10) & Chr(10)
    If st(1) = 0 Then
        value = value & "Ib = " & md(1) * 1000 & " (mA)" & Chr(10) & Chr(10)
        value = value & "hfe = " & md(0)/md(1) & Chr(10) & Chr(10)
        value = value & "Do you want to perform measurement again?"
        rbx = MsgBox(value, vbYesNo + vbQuestion, title)
        If rbx = vbYes Then
            mspot_meas vi, ret, pins()
        End If
    Else
        value = "Base channel status error. Code = " & st(1)
        MsgBox value, vbOKOnly, title
    End If
Else
    value = "Collector channel status error. Code = " & st(0)
    MsgBox value, vbOKOnly, title
End If
End Sub

```

Line	Description
1	Beginning of the display_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 25	Displays measurement data on a message box if the measurement status is normal. If Yes is clicked on the message box, performs the mspot_meas subprogram again. If No is clicked, returns to the perform_meas subprogram. Or displays error message on a message box if the status is abnormal.
26	End of the display_data subprogram.

Measurement Result Example

```

Ic = 42.1918 (mA)

Ib = 0.321449 (mA)

hfe = 131.255035791059

Do you want to perform measurement again?

```

Pulsed Sweep Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform pulsed sweep measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures bipolar transistor Ic-Vc characteristics.

Table 3-9

Pulsed Sweep Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(3) As Long 'SMU port numbers ' 3 m(0) = 4 'SMU4: collector m(1) = 2 'SMU2: base m(2) = 1 'SMU1: emitter ret = hp4156b_setSwitch(vi, m(2), 1) ' 8 ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret sweep_meas vi, ret, m() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the sweep_meas subprogram (next page) to perform pulsed sweep measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

```

Sub sweep_meas(vi As Long, ret As Long, m() As Long)                                '1

Dim vc1          As Double                                                         '3
Dim vc2          As Double
Dim iccomp       As Double
Dim ib1          As Double
Dim ib2          As Double
Dim vbcomp       As Double
Dim hold         As Double
Dim width        As Double
Dim period       As Double
Dim base         As Double
Dim nop1         As Long
Dim nop2         As Long
vc1 = 0
vc2 = 3
iccomp = 0.05
ib1 = 0.00005    ' 50 uA
ib2 = 0.00015    '150 uA
vbcomp = 5
hold = 0.1
width = 0.001
period = 0.01
base = 0
nop1 = 11
nop2 = 3
Dim i As Integer
Dim j As Integer
Dim n As Long
n = nop1 * nop2
Dim rep          As Long
Dim sc()         As Double 'primary sweep output data
Dim md()         As Double 'sweep measurement data
Dim st()         As Long   'status data at each step
Dim dib()        As Double 'secondary sweep output data
ReDim Preserve sc(n) As Double
ReDim Preserve md(n) As Double
ReDim Preserve st(n) As Long
ReDim Preserve dib(nop2) As Double

ret = hp4156b_setFilter(vi, m(0), hp4156b_FLAG_OFF)                                '41
ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2)
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, 0, 0.05, 0)

```

Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 39	Declares variables used in this subprogram, and defines the value.
41	Sets the SMU filter off for the pulse output channel.
42	Sets the A/D converter integration time.
43	Applies voltage to device.

Programming Examples for Visual Basic Users

Pulsed Sweep Measurements

```

Dim d_ib As Double      'secondary sweep step value (delta)          ' 45
If nop2 = 1 Then
    d_ib = 0
Else
    d_ib = (ib2 - ib1) / (nop2 - 1)
End If

Dim ibo As Double       'secondary sweep source output              ' 53
ibo = ib1

Dim msg As String
i = 0                   'array counter for sweepIv returned data
For j = 1 To nop2
    dib(j - 1) = ibo
    ret = hp4156b_force(vi, m(1), hp4156b_IF_MODE, 0, ibo, vbcomp, 0) ' 59
    ret = hp4156b_setPiv(vi, m(0), hp4156b_SWP_VF_SGLLIN, 0, base, vc1, vc2, nop1,
hold, width, period, iccomp)
    ret = hp4156b_sweepPiv(vi, m(0), hp4156b_IM_MODE, 0, rep, sc(i), md(i), st(i))
    check_err vi, ret
    ibo = ibo + d_ib
    If rep = nop1 Then
        i = i + nop1
        ' 64
    Else
        msg = rep & " measurement steps were returned. It must be " & nop1 & " steps."
        MsgBox msg, vbOKOnly, ""
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
        GoTo Bottom_sub
    End If
Next j
' 72

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
save_data nop1, nop2, md(), st(), sc(), dib(), vi, ret, m()
' 74
Bottom_sub:
End Sub
' 77

```

Line	Description
45 to 53	Declares variables, and defines the value. They are used for the secondary sweep source, d_ib is the step value and ibo is the output value.
59 to 62	Applies current to device, sets the pulsed sweep voltage source, and performs the pulsed sweep measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
64 to 71	Disables the channels and stops the program execution if the number of returned data is not equal to the nop1 value.
74	Sets the specified port to the zero output state.
75	Calls the save_data subprogram (next page) to save measurement data.
77	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Pulsed Sweep Measurements

```

Sub save_data(nop1 As Long, nop2 As Long, md() As Double, st() As Long, sc() As
Double, dib() As Double, vi As Long, ret As Long, m() As Long) '1

Dim i      As Integer      'array counter for sweepPiv returned data      '3
Dim j      As Integer      'array counter for secondary sweep output data
Dim val    As String      'data to be saved to a file
val = "Ib (uA), Vc (V), Ic (mA), Status"

For j = 1 To nop2 '8
    For i = nop1 * (j - 1) To nop1 * j - 1
        val = val & Chr(13) & Chr(10) & dib(j - 1) * 1000000# & "," & sc(i) & "," &
md(i) * 1000 & "," & st(i)
    Next i
Next j

Dim fname  As String      'data file name '14
Dim fnum   As Integer      'file number
fname = "C:\Agilent\data\data4.txt"
fnum = 1
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum

Dim title  As String      '22
Dim rbx    As Integer
title = "Pulsed Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m()
End If

End Sub '32

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 6	Declares variables, and defines the value.
8 to 12	Creates data to be saved and displayed on a message box.
14 to 20	Saves measurement data into a file (C:\Agilent\data\data4.txt, CSV file).
22 to 30	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
32	End of the save_data subprogram.

Programming Examples for Visual Basic Users

Pulsed Sweep Measurements

Measurement Result Example

Ib (uA), Vc (V), Ic (mA), Status

```
50,0,-0.05,0
50,0.3,8.965,0
50,0.6,9.705,0
50,0.9,9.735,0
50,1.2,9.765,0
50,1.5,9.805,0
50,1.8,9.83,0
50,2.1,9.835,0
50,2.4,9.85,0
50,2.7,9.9,0
50,3,9.915,0
100,0,-0.1,0
100,0.3,15.725,0
100,0.6,18.115,0
100,0.9,18.715,0
100,1.2,18.84,0
100,1.5,18.925,0
100,1.8,19.015,0
100,2.1,19.045,0
100,2.4,19.12,0
100,2.7,19.175,0
100,3,19.215,0
150,0,-0.15,0
150,0.3,21.065,0
150,0.6,24.54,0
150,0.9,26.47,0
150,1.2,27.19,0
150,1.5,27.405,0
150,1.8,27.605,0
150,2.1,27.71,0
150,2.4,27.795,0
150,2.7,27.885,0
150,3,27.955,0
```

Data save completed.

Do you want to perform measurement again?

Multi-Channel Pulsed Sweep Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform multi channel pulsed sweep measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures bipolar transistor Ic-Vb and Ib-Vb characteristics.

Table 3-10

Multi-Channel Pulsed Sweep Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(3) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: emitter m(1) = 2 'SMU2: base m(2) = 4 'SMU4: collector ret = hp4156b_setSwitch(vi, m(0), 1) ' 8 ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(2), 1) check_err vi, ret sweep_meas vi, ret, m() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the sweep_meas subprogram (next page) to perform multi channel pulsed sweep measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Pulsed Sweep Measurements

<pre> Sub sweep_meas(vi As Long, ret As Long, m() As Long) '1 Dim vc As Double '3 Dim vb As Double Dim iccomp As Double Dim ibcomp As Double Dim nop As Long vc = 0 vb = 0 iccomp = 0.1 ibcomp = 0.1 nop = 11 Dim mch(3) As Long Dim mode(2) As Long Dim range(2) As Double mch(0) = m(2) 'measurement channel: collector mch(1) = m(1) 'measurement channel: base mch(2) = 0 mode(0) = 1 'current measurement mode mode(1) = 1 'current measurement mode range(0) = 0 'auto range range(1) = 0 'auto range Dim rep As Long Dim sc() As Double 'primary sweep output data Dim md1() As Double 'sweep measurement data Dim md2() As Double 'sweep measurement data ReDim Preserve sc(nop) As Double ReDim Preserve md1(nop) As Double ReDim Preserve md2(nop) As Double Dim eod As Long Dim dtype As Long Dim mdata As Double Dim stat As Long Dim ch As Long '34 </pre>	
Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 34	Declares variables used in this subprogram, and defines the value.

Programming Examples for Visual Basic Users

Multi-Channel Pulsed Sweep Measurements

```

ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2) '36
ret = hp4156b_setFilter(vi, m(0), hp4156b_FLAG_OFF)
ret = hp4156b_cmd(vi, "PT 0,0.005,0.01,0,1") 'sets pulse timing parameters
ret = hp4156b_cmd(vi, "PWV 1,1,0,0,0,-0.8,11,0.1,0") 'sets pulsed sweep source
check_err vi, ret '40

ret = hp4156b_force(vi, m(1), hp4156b_VF_MODE, 0, vb, ibcomp, 0) '42
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, vc, iccomp, 0)
ret = hp4156b_startMeasure(vi, hp4156b_MM_PSWEAP, mch(0), mode(0), range(0),
hp4156b_FLAG_ON)
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL) '47
Dim i As Integer
For i = 1 To nop
    ret = hp4156b_readData(vi, eod, dtype, mdata, stat, ch)
    md1(i) = mdata ' Data measured by mch(0) = collector
    ret = hp4156b_readData(vi, eod, dtype, mdata, stat, ch)
    md2(i) = mdata ' Data measured by mch(1) = base
    ret = hp4156b_readData(vi, eod, dtype, mdata, stat, ch)
    sc(i) = mdata ' Pulsed sweep source output data
Next i

save_data nop, m(), sc(), md1(), md2(), vi, ret
End Sub '59

```

Line	Description
36 to 40	Sets the A/D converter integration time, sets the SMU filter off for the pulsed sweep source, sets the pulse timing parameters, and sets the pulsed sweep source. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
42 to 45	Applies voltage to device, and performs multi channel pulsed sweep measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
47 to 56	Sets all channels to zero output state, and reads the measurement result data.
58	Calls the save_data subprogram to save measurement data.
59	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Multi-Channel Pulsed Sweep Measurements

```

Sub save_data(nop As Long, m() As Long, sc() As Double, md1() As Double, md2() As Double,
vi As Long, ret As Long)                                     '1
Dim i As Integer                                             'array counter for primary sweep      '2
Dim val As String                                           'data to be saved to a file
val = "Ve (V), Ic (mA), Ib (mA)"
For i = 1 To nop
    val = val & Chr(13) & Chr(10) & sc(i) & "," & md1(i) * 1000 & "," & md2(i) * 1000
Next i
Dim fname As String                                         'data file name                                     '8
Dim fnum As Integer                                         'file number
fname = "C:\Agilent\data\data5.txt"
fnum = 1
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum
Dim title As String                                         '15
Dim rbx As Integer
title = "Pulsed Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m()
End If
End Sub                                                         '24

```

Line	Description
1	Beginning of the save_data subprogram.
2 to 7	Declares variables, and creates data to be saved and displayed on a message box.
8 to 14	Saves measurement data into a file (C:\Agilent\data\data5.txt, CSV file).
15 to 23	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
24	End of the save_data subprogram.

Measurement Result Example

```

Vb (V), Ib (mA), Ic (mA), Status_b, Status_c
0.3,0,-0.005,0,0
0.35,0,-0.005,0,0
0.4,0,-0.005,0,0
0.45,0,-0.005,0,0
0.5,0,0,0,0
0.55,0.0001,0.015,0,0
0.6,0.0005,0.085,0,0
0.65,0.00305,0.605,0,0
0.7,0.01915,3.89,0,0
0.75,0.09975,19.625,0,0
0.8,0.34745,59.38,0,0

```

Data save completed.

Do you want to perform measurement again?

Staircase Sweep with Pulsed Bias Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform staircase sweep with pulsed bias measurement (sweep_meas), and save measurement result data into a file (save_data). This example measures MOSFET Id-Vd characteristics.

Table 3-11

Staircase Sweep with Pulsed Bias Measurement Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(4) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: drain m(1) = 2 'SMU2: gate m(2) = 3 'SMU3: source m(3) = 4 'SMU4: substrate ret = hp4156b_setSwitch(vi, m(3), 1) ' 9 ret = hp4156b_setSwitch(vi, m(2), 1) ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret sweep_meas vi, ret, m() ' 15 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 17 check_err vi, ret End Sub ' 20 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 7	Declares variables, and defines the value.
9 to 12	Enables measurement channels.
15	Calls the sweep_meas subprogram (next page) to perform staircase sweep with pulsed bias measurement.
17	Disables measurement channels.
13 and 18	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
20	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Staircase Sweep with Pulsed Bias Measurements

<pre> Sub sweep_meas(vi As Long, ret As Long, m() As Long) ' 1 Dim vd1 As Double ' 3 Dim vd2 As Double Dim idcomp As Double Dim vg1 As Double Dim vg2 As Double Dim igcomp As Double Dim hold As Double Dim delay As Double Dim s_delay As Double Dim p_comp As Double vd1 = 0 vd2 = 3 idcomp = 0.05 vg1 = 1 vg2 = 3 igcomp = 0.01 hold = 0 delay = 0 s_delay = 0 p_comp = 0 Dim nop1 As Long Dim nop2 As Long nop1 = 11 nop2 = 3 ' 27 Dim i As Integer Dim j As Integer Dim n As Long n = nop1 * nop2 Dim msg As String Dim rep As Long ' 35 Dim sc() As Double 'primary sweep output data Dim md() As Double 'sweep measurement data Dim st() As Long 'status data at each step Dim dvg() As Double 'secondary sweep output data ReDim Preserve sc(n) As Double ReDim Preserve md(n) As Double ReDim Preserve st(n) As Long ReDim Preserve dvg(nop2) As Double ' 43 ret = hp4156b_setFilter(vi, m(1), hp4156b_FLAG_OFF) ' 45 ret = hp4156b_force(vi, m(3), hp4156b_VF_MODE, 0, 0, 0.05, 0) ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, 0, 0.05, 0) </pre>	
Line	Description
1	Beginning of the sweep_meas subprogram.
3 to 32	Declares variables for source channels, and defines the value.
35 to 43	Declares variables used to keep source data, measurement data and status data. Also defines array size.
45 to 47	Sets the SMU filter off for the pulsed bias channel, and applies voltage to device.

Programming Examples for Visual Basic Users

Staircase Sweep with Pulsed Bias Measurements

```

Dim d_vg As Double 'secondary sweep step value (delta) ' 49
If nop2 = 1 Then
    d_vg = 0
Else
    d_vg = (vg2 - vg1) / (nop2 - 1)
End If
Dim vg As Double 'secondary sweep source output
vg = vg1

Dim width As Double ' 58
Dim period As Double
Dim p_hold As Double
width = 0.001
period = 0.01
p_hold = 0.1
i = 0 'array counter for sweepIv returned data
For j = 1 To nop2 'array counter for secondary sweep output data ' 65
    dvg(j - 1) = vg
    ret = hp4156b_setPbias(vi, m(1), hp4156b_VF_MODE, 0, 0, vg, width, period, p_hold, igcomp)
    ret = hp4156b_setIv(vi, m(0), hp4156b_SWP_VF_SGLLIN, 0, vd1, vd2, nop1, hold, delay,
s_delay, idcomp, p_comp)
    ret = hp4156b_sweepPbias(vi, m(0), hp4156b_IM_MODE, 0, rep, sc(i), md(i), st(i))
    check_err vi, ret

    vg = vg + d_vg
    If rep = nop1 Then ' 73
        i = i + nop1
    Else
        msg = rep & " measurement steps were returned. It must be " & nop1 & " steps."
        MsgBox msg, vbOKOnly, ""
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
        GoTo Bottom_sub
    End If ' 80
Next j
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)
save_data nop1, nop2, dvg(), md(), st(), sc(), vi, ret, m()
Bottom_sub:
End Sub ' 85

```

Line	Description
49 to 56	Declares variables, and defines the value. They are used for the secondary sweep source, d_vg is the step value and vg is the output value.
67 to 70	Sets the pulsed source, sets the voltage sweep source, and performs the staircase sweep with pulsed bias measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
73 to 80	Disables the channels and stops the program execution if the number of returned data is not equal to the nop1 value.
82 to 83	Sets all channels to zero output state, and calls the save_data subprogram (next page) to save measurement data.
85	End of the sweep_meas subprogram.

Programming Examples for Visual Basic Users

Staircase Sweep with Pulsed Bias Measurements

```

Sub save_data(nop1 As Long, nop2 As Long, dvg() As Double, md() As Double, st() As
Long, sc() As Double, vi As Long, ret As Long, m() As Long) '1

Dim i As Integer 'array counter for primary sweep '3
Dim j As Integer 'array counter for secondary sweep
Dim val As String 'data to be saved to a file
val = "Vg (V), Vd (V), Id (mA), Status"
For j = 1 To nop2
    For i = nop1 * (j - 1) To nop1 * j - 1
        val = val & Chr(13) & Chr(10) & dvg(j - 1) & "," & sc(i) & "," & md(i) *
1000 & "," & st(i)
    Next i
Next j

Dim fname As String 'data file name '13
Dim fnum As Integer 'file number
fname = "C:\Agilent\data\data6.txt"
fnum = 1
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum

Dim title As String '21
Dim rbx As Integer
title = "Sweep Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sweep_meas vi, ret, m()
End If

End Sub '31

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 11	Declares variables, and creates data to be saved and displayed on a message box.
13 to 19	Saves measurement data into a file (C:\Agilent\data\data6.txt, CSV file).
21 to 29	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sweep_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
31	End of the save_data subprogram.

Programming Examples for Visual Basic Users

Staircase Sweep with Pulsed Bias Measurements

Measurement Result Example

Vg (V), Vd (V), Id (mA), Status

```
1,0,0,0
1,0.3,3.205,0
1,0.6,5.9,0
1,0.9,8.15,0
1,1.2,10.035,0
1,1.5,11.68,0
1,1.8,13.13,0
1,2.1,14.425,0
1,2.4,15.61,0
1,2.7,16.675,0
1,3,17.65,0
2,0,-0.005,0
2,0.3,4.205,0
2,0.6,7.955,0
2,0.9,11.245,0
2,1.2,14.11,0
2,1.5,16.55,0
2,1.8,18.67,0
2,2.1,20.52,0
2,2.4,22.185,0
2,2.7,23.67,0
2,3,25.02,0
3,0,0,0
3,0.3,5.07,0
3,0.6,9.73,0
3,0.9,13.965,0
3,1.2,17.76,0
3,1.5,21.115,0
3,1.8,24.07,0
3,2.1,26.64,0
3,2.4,28.91,0
3,2.7,30.925,0
3,3,32.71,0
```

Data save completed.

Do you want to perform measurement again?

Sampling Measurements

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform sampling measurement (sampling_meas), and save measurement result data into a file (save_data). This example measures current of a device that has two high terminals and a low terminal, and calculates the resistance.

Table 3-12 **Sampling Measurement Example**

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(3) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: t1 m(1) = 2 'SMU2: t2 m(2) = 3 'SMU3: low ret = hp4156b_setSwitch(vi, m(2), 1) ' 8 ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret sampling_meas vi, ret, m() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the sampling_meas subprogram (next page) to perform sampling measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

<pre> Sub sampling_meas(vi As Long, ret As Long, m() As Long) '1 Dim base As Double '3 Dim bias As Double Dim icomp As Double Dim vlout As Double Dim ilcomp As Double Dim hold As Double Dim interval As Double Dim nop As Long base = 0 bias = 0.1 icomp = 0.1 vlout = 0 ilcomp = 0.1 hold = 0.1 interval = 0.05 nop = 30 Dim mch(3) As Long Dim mode(2) As Long Dim range(2) As Double Dim n As Long n = nop * 2 mch(0) = m(0) ' t1 mch(1) = m(1) ' t2 mch(2) = 0 mode(0) = 1 mode(1) = 1 range(0) = 0 range(1) = 0 Dim point As Long '33 Dim index() As Long Dim value() As Double Dim status() As Long ReDim Preserve index(nop) As Long ReDim Preserve value(n) As Double ReDim Preserve status(n) As Long '39 </pre>	
Line	Description
1	Beginning of the sampling_meas subprogram.
3 to 31	Declares variables, and defines the value.
33 to 39	Declares variables used to keep index data, measurement data, and status data. Also defines array size.

Programming Examples for Visual Basic Users

Sampling Measurements

```

ret = hp4156b_setFilter(vi, hp4156b_CH_ALL, hp4156b_FLAG_ON) '41
ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2)

ret = hp4156b_setSample(vi, hold, interval, nop) '44
ret = hp4156b_addSampleSyncIv(vi, m(0), hp4156b_VF_MODE, 0, base, bias, icomp)
ret = hp4156b_addSampleSyncIv(vi, m(1), hp4156b_VF_MODE, 0, base, bias, icomp)
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, 0, vlout, ilcomp, 0)

ret = hp4156b_sample(vi, mch(0), mode(0), range(0), point, index(0), value(0), '49
status(0))
check_err vi, ret

ret = hp4156b_clearSampleSync(vi) '52
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)

Dim msg As String '55
If point <> nop Then
    msg = point & " measurement steps were returned. It must be " & nop & " steps."
    MsgBox msg, vbOKOnly, ""
Else
    save_data vi, ret, nop, index(), bias, value(), status(), m()
End If

End Sub '63

```

Line	Description
41 to 42	Sets the SMU filter on for the all channels, and sets the A/D converter integration time.
44 to 47	Sets the sampling timing parameters, sets the voltage sources that operate synchronously with the measurement trigger, and applies voltage to device.
49 to 50	Performs the sampling measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
52 to 53	Clears the setting of the voltage sources defined by the hp4156b_addSampleSyncIv function, and sets all channels to zero output state.
55 to 61	Calls the save_data subprogram (next page) to save the measurement result data. However, if the number of returned data is not equal to the nop value, the program disables the source/measurement channels and stops program execution without saving the measurement data.
63	End of the sampling_meas subprogram.

```

Sub save_data(vi As Long, ret As Long, nop As Long, index() As Long, bias As Double, value() As Double, status() As Long, m() As Long) '1

Dim i As Integer '3
Dim data1 As Double
Dim data2 As Double
Dim r1 As Double
Dim r2 As Double
Dim val As String

val = "Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status"
For i = 0 To nop - 1
    data1 = Round(value(2 * i) * 1000, 3)
    data2 = Round(value(2 * i + 1) * 1000, 3)
    r1 = Round(bias / value(2 * i), 2)
    r2 = Round(bias / value(2 * i + 1), 2)
    val = val & Chr(13) & Chr(10) & index(i) & "," & data1 & "," & r1
    val = val & "," & data2 & "," & r2 & "," & status(i)
Next i

Dim fname As String 'data file name '20
Dim fnum As Integer 'file number
fname = "C:\Agilent\data\data7.txt"
fnum = 1
Open fname For Output Access Write Lock Read Write As fnum
Print #fnum, val
Close fnum

Dim title As String '28
Dim rbx As Integer
title = "Sampling Measurement Result"
val = val & Chr(10) & Chr(10) & "Data save completed."
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    sampling_meas vi, ret, m()
End If

End Sub '38

```

Line	Description
1	Beginning of the save_data subprogram.
3 to 18	Declares variables, and creates data to be saved and displayed on a message box.
20 to 26	Saves measurement data into a file (C:\Agilent\data\data7.txt, CSV file).
28 to 36	Displays measurement data on a message box. If Yes is clicked on the message box, performs the sampling_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
38	End of the save_data subprogram.

Programming Examples for Visual Basic Users

Sampling Measurements

Measurement Result Example

```
Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status
1,11.136,8.98,10.755,9.29,0
2,11.136,8.98,10.759,9.29,0
3,11.147,8.97,10.766,9.28,0
4,11.136,8.98,10.762,9.29,0
5,11.136,8.98,10.759,9.29,0
6,11.147,8.97,10.762,9.29,0
7,11.143,8.97,10.755,9.29,0
8,11.143,8.97,10.769,9.28,0
9,11.136,8.98,10.752,9.31,0
10,11.133,8.98,10.759,9.29,0
11,11.147,8.97,10.752,9.31,0
12,11.136,8.98,10.759,9.29,0
13,11.136,8.98,10.755,9.29,0
14,11.147,8.97,10.766,9.28,0
15,11.141,8.97,10.755,9.29,0
16,11.143,8.97,10.762,9.29,0
17,11.153,8.96,10.762,9.29,0
18,11.147,8.97,10.759,9.29,0
19,11.143,8.97,10.755,9.29,0
20,11.143,8.97,10.755,9.29,0
21,11.141,8.97,10.762,9.29,0
22,11.141,8.97,10.755,9.29,0
23,11.141,8.97,10.759,9.29,0
24,11.136,8.98,10.759,9.29,0
25,11.133,8.98,10.749,9.31,0
26,11.136,8.98,10.762,9.29,0
27,11.136,8.98,10.755,9.29,0
28,11.136,8.98,10.766,9.28,0
29,11.133,8.98,10.755,9.29,0
30,11.147,8.97,10.759,9.29,0
```

Data save completed.

Do you want to perform measurement again?

Stress Force

This section explains example subprograms that enable/disable measurement channels (perform_meas), perform stress measurement (stress_meas), and display measurement result data (disp_data1 and disp_data2). This example measures current of a device that has two high terminals and a low terminal.

Table 3-13

Stress Force Example

<pre> Sub perform_meas(vi As Long, ret As Long) ' 1 Dim m(3) As Long 'SMU port numbers ' 3 m(0) = 1 'SMU1: t1 m(1) = 2 'SMU2: t2 m(2) = 3 'SMU3: low ret = hp4156b_setSwitch(vi, m(2), 1) ' 8 ret = hp4156b_setSwitch(vi, m(1), 1) ret = hp4156b_setSwitch(vi, m(0), 1) check_err vi, ret stress_meas vi, ret, m() ' 13 ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0) ' 15 check_err vi, ret End Sub ' 18 </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 6	Declares variables, and defines the value.
8 to 10	Enables measurement channels.
13	Calls the stress_meas subprogram (next page) to perform stress measurement.
15	Disables measurement channels.
11 and 16	Calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
18	End of the perform_meas subprogram.

Programming Examples for Visual Basic Users

Stress Force

```

Sub stress_meas(vi As Long, ret As Long, m() As Long)                                '1

Dim range      As Double                                                            '3
Dim base       As Double
Dim stress     As Double
Dim bias       As Double
Dim icomp      As Double
Dim vlout      As Double
Dim ilcomp     As Double
Dim hold       As Double
Dim duration   As Double
Dim period     As Double
Dim status     As Long
Dim md(4)      As Double
Dim st(4)      As Long

range = 0
base = 0
stress = 2
bias = 0.1
icomp = 0.1
vlout = 0
ilcomp = 0.1
hold = 0
duration = 5
period = 0.01

ret = hp4156b_setFilter(vi, hp4156b_CH_ALL, hp4156b_FLAG_ON)                      '28
ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2)
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, range, vlout, ilcomp, 0)
ret = hp4156b_force(vi, m(1), hp4156b_VF_MODE, range, bias, icomp, 0)
ret = hp4156b_force(vi, m(0), hp4156b_VF_MODE, range, bias, icomp, 0)
ret = hp4156b_spotMeas(vi, m(0), hp4156b_IM_MODE, range, md(0), st(0))
ret = hp4156b_spotMeas(vi, m(1), hp4156b_IM_MODE, range, md(1), st(1))
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                      '37
disp_data1 vi, ret, m(), md(), st(), stress, duration

```

Line	Description
1	Beginning of the stress_meas subprogram.
3 to 26	Declares variables, and defines the value.
28 to 35	Sets the SMU filter on for the all channels, sets the A/D converter integration time, applies voltage to device, and performs spot measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
37 to 38	Sets all channels to zero output state, and calls the disp_data1 subprogram to display measurement data.

```

ret = hp4156b_setStress(vi, hold, hp4156b_STT_TIME, duration, period)           ' 40
ret = hp4156b_force(vi, m(2), hp4156b_VF_MODE, range, vout, ilcomp, 0)
ret = hp4156b_addStressSyncIv(vi, 1, m(0), 2, range, base, stress, icomp)
ret = hp4156b_addStressSyncIv(vi, 2, m(1), 2, range, base, stress, icomp)
ret = hp4156b_stress(vi, status)
check_err vi, ret

ret = hp4156b_clearStressSync(vi)                                             ' 47

ret = hp4156b_force(vi, m(1), hp4156b_VF_MODE, range, bias, icomp, 0)         ' 49
ret = hp4156b_force(vi, m(0), hp4156b_VF_MODE, range, bias, icomp, 0)
ret = hp4156b_spotMeas(vi, m(0), hp4156b_IM_MODE, range, md(2), st(2))
ret = hp4156b_spotMeas(vi, m(1), hp4156b_IM_MODE, range, md(3), st(3))
check_err vi, ret

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL)                                 ' 55
disp_data2 vi, ret, m(), md(), st(), stress, duration

End Sub                                                                       ' 58

```

Line	Description
40 to 45	Sets the stress timing parameters, applies voltage to the device, sets the stress sources that operate synchronously with the stress trigger, and applies the stress to the device. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
47	Clears the setting of the stress sources defined by the hp4156b_addStressSyncIv function.
49 to 53	Applies voltage to the device, and performs spot measurement. After that, calls the check_err subprogram (shown in Table 3-1) to check if an error status is returned for the previous line.
55 to 56	Sets all channels to zero output state, and calls the disp_data2 subprogram to display measurement data.
58	End of the stress_meas subprogram.

Programming Examples for Visual Basic Users

Stress Force

```

Sub disp_data1(vi As Long, ret As Long, m() As Long, md() As Double, st() As Long,
stress As Double, duration As Double)                                '1

Dim title As String                                                  '3
Dim val As String
Dim rbx As Integer
title = "Measurement Result"
val = "Data before stress:"
val = val & Chr(13) & Chr(10) & "T1 current = " & md(0) * 1000 & " [mA]"
val = val & ", Status = " & st(0)
val = val & Chr(13) & Chr(10) & "T2 current = " & md(1) * 1000 & " [mA]"
val = val & ", Status = " & st(1)
val = val & Chr(10) & Chr(10) & "Do you want to CANCEL stress force?"
val = val & Chr(10) & Chr(10) & "Stress: " & stress & " [V], Duration: " & duration
& " [sec]"

Dim msg As String                                                    '15
rbx = MsgBox(val, vbYesNo, title)
If rbx = vbYes Then
    ret = hp4156b_close(vi)
    msg = "Click OK to stop the program."
    MsgBox msg, vbOKOnly, ""
End
End If

End Sub                                                                '24

```

Line	Description
1	Beginning of the disp_data1 subprogram.
3 to 13	Declares variables, and creates data to be displayed on a message box.
15 to 22	Displays the message box. If Yes is clicked, stops the program execution.
24	End of the disp_data1 subprogram.


```

Sub disp_data2(vi As Long, ret As Long, m() As Long, md() As Double, st() As Long,
stress As Double, duration As Double)                                '1

Dim title As String                                                '3
Dim val As String
Dim rbx As Integer
title = "Measurement Result"
val = "Data before stress:"
val = val & Chr(13) & Chr(10) & "T1 current = " & md(0) * 1000 & " [mA]"
val = val & ", Status = " & st(0)
val = val & Chr(13) & Chr(10) & "T2 current = " & md(1) * 1000 & " [mA]"
val = val & ", Status = " & st(1)
val = val & Chr(10) & Chr(10) & "Stress: " & stress & " [V], Duration: " & duration
& " [sec]"
val = val & Chr(10) & Chr(10) & "Data after stress:"
val = val & Chr(13) & Chr(10) & "T1 current = " & md(2) * 1000 & " [mA]"
val = val & ", Status = " & st(2)
val = val & Chr(13) & Chr(10) & "T2 current = " & md(3) * 1000 & " [mA]"
val = val & ", Status = " & st(3)
val = val & Chr(10) & Chr(10) & "Do you want to perform measurement AGAIN?"

rbx = MsgBox(val, vbYesNo, title)                                    '20
If rbx = vbYes Then
    stress_meas vi, ret, m()
End If

End Sub                                                            '25

```

Line	Description
1	Beginning of the disp_data2 subprogram.
3 to 18	Declares variables, and creates data to be displayed on a message box.
20 to 23	Displays the message box. If Yes is clicked, calls the stress_meas subprogram.
25	End of the disp_data2 subprogram.

Measurement Result Example

```

Data before stress:
T1 current = 11.09860 [mA], Status = 0
T2 current = 10.75880 [mA], Status = 0

Stress: 2 [V], Duration: 5 [sec]

Data after stress:
T1 current = 11.10200 [mA], Status = 0
T2 current = 10.76220 [mA], Status = 0

Do you want to perform measurement AGAIN?

```

Programming Examples for Visual Basic Users
Stress Force

This chapter describes how to create measurement programs using the Agilent 4155/4156 and the 4155/4156 VXi*plug&play* driver, and provides programming examples using Microsoft Visual Basic .NET. This chapter contains the following sections:

- “Programming Basics”
- “High-Speed Spot Measurements”
- “Multi-Channel Spot Measurements”
- “Staircase Sweep Measurements”
- “Synchronous Sweep Measurements”
- “Multi-Channel Sweep Measurements”
- “Pulsed Spot Measurements”
- “Multi-Channel Pulsed Spot Measurements”
- “Pulsed Sweep Measurements”
- “Multi-Channel Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Sampling Measurements”
- “Stress Force”

NOTE

About Program Code

Programming examples are provided as subprograms that can be run with the project template shown in Table 4-1. To execute the program, insert the subprograms instead of the perform_meas subprogram in the template.

NOTE

Driver function name and instrument handle vi

Function name is different from the original name. And you do not need to specify the instrument handle vi for a function parameter. For example, hp4156b_reset(vi) must be entered as Ag415x.Reset() if you declare your 4155/4156 as Ag415x.

For the available functions, see the function input aid of the driver. It will appear when you type the declared instrument name and a period (e.g. Ag415x. _) on the code window. Also see the parameter input aid to know the parameters needed for the function. It will appear when you additionally type the function name and front-parenthesis (e.g. Ag415x.Force(_)).

Programming Basics

This section provides the basic information for programming using the Agilent 4155/4156 *VXIplug&play* driver.

- “To Create Your Project Template”
- “To Create Measurement Program”

NOTE

To Start Program

If you create the measurement program by modifying the example code shown in Table 4-1, the program can be run by clicking the Run button on the Visual Basic main window. After that, a message box will appear. Then click OK to continue.

To Create Your Project Template

This section explains how to create a project template using Microsoft Visual Basic .NET. Before starting programming, create your project template, and keep it as your reference. It will remove the conventional task in the future programming.

Step 1. Connect instrument (e.g. Agilent 4155/4156) to computer via GPIB.

Step 2. Launch Visual Basic .NET and create a new project. The project type must be Agilent T&M Toolkit Projects.

Follow the Agilent T&M Toolkit New Project Wizard to create the project. Then select the following libraries to be imported additionally.

- Agilent.TMFramework.InstrumentDriverInterop
- Agilent.TMFramework.InstrumentDriverInterop.Design

Step 3. Click T&M Toolkit > Instrument Explorer to open Agilent Instrument Explorer. On the explorer, click Find Instrument icon to detect the instrument automatically.

Step 4. Click T&M Toolkit > Driver Wrapper Wizard to open Agilent Driver Wrapper Wizard. And follow the wizard to enable your desired *VXIplug&play* driver (e.g. HP4156B - *VXIplug&play*).

Step 5. Right-click on the instrument icon (e.g. HP 4156C (:17) icon) in the Agilent Instrument Explorer, and click on Add Instrument Session to open Agilent Instrument Session Wizard. And follow the wizard to add the *VXIplug&play* session for the instrument (e.g. HP4156C).

Step 6. Open a module (e.g. Module1.vb) in the project.

Step 7. Enter a program code as template. See Table 4-1 for example.

Step 8. Save the project as your template (e.g. \test\my_temp).

To Create Measurement Program

Create the measurement program as shown below. The following procedure needs your project template. If the procedure does not fit your programming environment, arrange it to suit your environment.

Step 1. Plan the automatic measurements. Then decide the following items:

- Measurement devices:
Discrete, packaged, on-wafer, and so on.
- Parameters/characteristics to be measured:
 h_{FE} , V_{th} , sheet resistance, and so on.
- Measurement method:
Spot measurement, staircase sweep measurement, and so on.

Step 2. Make a copy of your project template (e.g. \test\my_temp to \test\dev_a\my_temp).

Step 3. Rename the copy (e.g. \test\dev_a\my_temp to \test\dev_a\spot_id).

Step 4. Launch Visual Basic .NET.

Step 5. Open the project (e.g. \test\dev_a\spot_id).

Step 6. Open the module that contains the template code as shown in Table 4-1. On the code window, complete the perform_meas subprogram. Then use the Agilent 4155/4156 *VXIplug&play* driver functions:

- *name.SetSwitch* to enable/disable the source/measurement channels
- *name.Force*, *SetIv*, etc. to set source outputs
- *name.SpotMeas*, *SweepIv*, etc. to perform measurements
- *name.ZeroOutput* to disable source outputs

where, *name* must be the declared instrument name (e.g. Ag415x).

Step 7. Insert the code to display, store, or calculate data into the subprogram.

Step 8. Save the project (e.g. \test\dev_a\spot_id).

Table 4-1 Example Template Program Code for Visual Basic .NET

<pre>Imports Agilent.TMFramework ' 1 Imports Agilent.TMFramework.DataAnalysis Imports Agilent.TMFramework.DataVisualization Imports Agilent.TMFramework.InstrumentIO Imports Agilent.TMFramework.InstrumentDriverInterop Imports Agilent.TMFramework.InstrumentDriverInterop.Design Imports Agilent.TMFramework.InstrumentDriverInterop.VxipnpWrappers Module Module1 Sub Main() ' 11 Dim Ag415x As Hp4156b = New Hp4156b("GPIB0::17::INSTR", True, True) Ag415x.Reset() Ag415x.Timeout(60000) MsgBox("Click OK to start measurement.", vbOKOnly, "") Console.WriteLine("Measurement in progress. . ." & Chr(10)) perform_meas(Ag415x) Ag415x.SetSwitch(0, 0) Ag415x.Close() MsgBox("Click OK to stop the program.", vbOKOnly, "") Console.WriteLine("Measurement completed." & Chr(10)) End Sub ' 24</pre>	
Line	Description
1 to 7	These lines are necessary to use the Agilent 4155/4156 VXiplug&play driver.
11 to 24	Main subprogram establishes the software connection with the Agilent 4155/4156, resets the 4155/4156, sets the driver I/O time out to 60 seconds, opens a message box to confirm the start of measurement, and pauses program execution until OK is clicked on the message box. By clicking OK, the program displays a message on the console window and calls the perform_meas subprogram that is used to perform measurement. After the measurement, the program disables all channels, disables the software connection with the 4155/4156, and opens a message box to confirm the end of the program. Finally, the program displays a message on the console window by clicking OK on the message box.
12	The above example is for the 4155/4156 on the GPIB address 17. Confirm the GPIB address of your 4155/4156, and set the address correctly instead of "17".

Programming Examples for Visual Basic .NET Users

Programming Basics

```

Sub perform_meas(ByVal Ag415x As Hp4156b)                                ' 26
    Dim i As Integer = 0
    Dim j As Integer = 0
    Dim nop1 As Integer = 1
    Dim nop2 As Integer = 1
    Dim data(nop2, nop1) As String
    Dim val As String = "enter data header"
    Dim fname As String = "C:\enter_file_name.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Ag415x.SetSwitch(1, 1)          'this is dummy.                    ' 38
    ' insert measurement program code

    Ag415x.ErrorQuery(err, msg)                                           ' 41
    If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    Ag415x.ZeroOutput(0)                                                 ' 44
    save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err:                                                                ' 47
    If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly,
    "")
End Sub                                                                    ' 49

```

Line	Description
26	Beginning of the perform_meas subprogram.
27 to 36	Declares variables used in this program template. The values are dummy. You must change the values to match your program. If you find unnecessary variables, delete them. <i>i</i> and <i>j</i>: Variables used to specify the element of the <i>data</i> array. <i>nop1</i> and <i>nop2</i>: Number of measurement steps. Also used to declare the <i>data</i> array. <i>data</i>: String data array used to store the measurement result data except for the header. <i>val</i>: String data variable to store the header (first line) of the measurement result data. <i>fname</i>: Full path name of the measurement result data file to be saved. <i>title</i>: Title of the message box used to display the measurement result data. <i>msg</i> and <i>err</i>: Variables used to display an error message.
38 to 39	The lines are placed as dummy. Remove the lines and insert your program code to control the instruments and perform measurement.
41 to 42	Checks if the 4155/4156 causes an error, and goes to Check_err if an error is detected.
44 to 45	Applies 0 V from all channels and calls the save_data subprogram (lines 51 to 73).
47 to 48	Opens a message box to display error message if an error is detected.
49	End of the perform_meas subprogram.


```

Sub save_data(ByVal fname As String, ByVal title As String, ByVal val As String,
ByVal data(,) As String, ByVal nop1 As Integer, ByVal nop2 As Integer, ByVal Ag415x
As Hp4156b) ' 51
    Dim i As Integer = 0
    Dim j As Integer = 0
    FileOpen(1, fname, OpenMode.Output, OpenAccess.Write, OpenShare.LockReadWrite)
    Print(1, val)
    For j = 0 To nop2 - 1
        For i = 0 To nop1 - 1
            Print(1, data(j, i))
        Next
    Next
    FileClose(1)

    Dim rbx As Integer
    For j = 0 To nop2 - 1
        For i = 0 To nop1 - 1
            val = val & data(j, i)
        Next
    Next
    val = val & Chr(10) & Chr(10) & "Data save completed."
    val = val & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
    rbx = MsgBox(val, vbYesNo, title)
    If rbx = vbYes Then perform_meas(Ag415x)
End Sub ' 73

End Module

```

Line	Description
51 to 73	Save_data subprogram saves measurement result data into a file specified by the <i>fname</i> variable and displays the data and a message on a message box. If Yes is clicked on the message box, calls the perform_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.

High-Speed Spot Measurements

This section explains an example subprogram that performs high speed spot measurement. This example measures MOSFET drain current.

Table 4-2 High-Speed Spot Measurement Example

<pre> Sub perform meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 1 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Id (mA), Status" Dim fname As String = "C:\Agilent\data\data1.txt" Dim title As String = "Spot Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3, 4} ' 13 Ag415x.SetSwitch(t(3), 1) 'SMU4: substrate Ag415x.SetSwitch(t(2), 1) 'SMU3: source Ag415x.SetSwitch(t(1), 1) 'SMU2: gate Ag415x.SetSwitch(t(0), 1) 'SMU1: drain Dim vd As Double = 0.5 ' 19 Dim vg As Double = 0.5 Dim idcomp As Double = 0.05 Dim igcomp As Double = 0.01 Dim meas As Double Dim status As Integer Ag415x.Force(t(3), 2, 0, 0, 0.1, 0) 'out= 0 V, comp= 0.1 A 26 Ag415x.Force(t(2), 2, 0, 0, 0.1, 0) 'out= 0 V, comp= 0.1 A Ag415x.Force(t(1), 2, 2, vg, igcomp, 0) 'out= vg V, comp= igcomp A Ag415x.Force(t(0), 2, 2, vd, idcomp, 0) 'out= vd V, comp= idcomp A Ag415x.ErrorQuery(err, msg) If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 17	Enables measurement channels.
19 to 24	Declares variables and sets the value.
26 to 31	Applies voltage to device and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.

Ag415x.SpotMeas(t(0), 1, 0, meas, status)	'current measurement	33
data(j, i) = Chr(13) & Chr(10) & meas * 1000 & ", " & status		
Ag415x.ZeroOutput(0)		'36
save_data(fname, title, val, data, nop1, nop2, Ag415x)		
Check_err:		'39
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")		
End Sub		

Line	Description
33 to 34	Performs spot measurement. And stores the measured data into the <i>data</i> variable.
36 to 37	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data1.txt file (CSV) and displays the data on a message box.
39 to 40	Displays a message box to show an error message if the error is detected.

Measurement Result Example

Id (mA), Status
3.91571, 0

Data save completed.

Do you want to perform measurement again?

Multi-Channel Spot Measurements

This section explains an example subprogram that performs multi channel spot measurement. This example measures bipolar transistor collector current and base current.

Table 4-3 Multi-Channel Spot Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 1 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Ic (mA), Status_c, Ib (mA), Status_b, hfe" Dim fname As String = "C:\Agilent\data\data2.txt" Dim title As String = "Spot Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3} ' 13 Ag415x.SetSwitch(t(2), 1) 'SMU3: collector Ag415x.SetSwitch(t(1), 1) 'SMU2: base Ag415x.SetSwitch(t(0), 1) 'SMU1: emitter Dim vc As Double = 3 ' 18 Dim vb As Double = 0.7 Dim ve As Double = 0 Dim iccomp As Double = 0.1 Dim ibcomp As Double = 0.01 Dim iecomp As Double = 0.1 Dim mch() As Integer = {t(2), t(1), 0} Dim mode() As Integer = {1, 1} 'current measurement Dim range() As Double = {0, 0} 'auto range Dim md(2) As Double Dim st(2) As Integer Ag415x.Force(t(0), Hp4156b.ModeEnum.VoltageOutput, 0, ve, iecomp, 0) ' 30 Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, vb, ibcomp, 0) Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, vc, iccomp, 0) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 16	Enables measurement channels.
18 to 28	Declares variables and sets the value.
30 to 32	Applies voltage to device.

```

Ag415x.ErrorQuery(err, msg) ' 34
If err <> 0 Then Ag415x.ZeroOutput(0): GoTo Check_err

Ag415x.MeasureM(mch, mode, range, md, st) ' 37
data(j, i) = Chr(13) & Chr(10) & md(0) * 1000 & ", " & st(0) & ", "
data(j, i) = data(j, i) & md(1) * 1000 & ", " & st(1) & ", " & md(0) / md(1)

Ag415x.ZeroOutput(0) ' 41
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: ' 44
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub

```

Line	Description
34 to 35	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
37 to 39	Performs multi channel spot measurement. And stores the measured data into the <i>data</i> variable.
41 to 42	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data2.txt file (CSV) and displays the data on a message box.
44 to 45	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Ic (mA), Status_c, Ib (mA), Status_b, hfe
3.79141, 0, 0.0187544, 0, 202.161092863541

```

Data save completed.

Do you want to perform measurement again?

Staircase Sweep Measurements

This section explains an example subprogram that performs staircase sweep measurement. This example measures MOSFET Id-Vd characteristics.

Table 4-4 Staircase Sweep Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 3 Dim data(nop2, nop1) As String Dim val As String = "Vg (V), Vd (V), Id (mA), Status" Dim fname As String = "C:\Agilent\data\data3.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3, 4} ' 13 Ag415x.SetSwitch(t(3), 1) 'SMU4: substrate Ag415x.SetSwitch(t(2), 1) 'SMU3: source Ag415x.SetSwitch(t(1), 1) 'SMU2: gate Ag415x.SetSwitch(t(0), 1) 'SMU1: drain Dim vd1 As Double = 0 ' 19 Dim vd2 As Double = 3 Dim idcomp As Double = 0.05 Dim vg1 As Double = 1 Dim vg2 As Double = 3 Dim igcomp As Double = 0.01 Dim vg As Double = vg1 'secondary sweep output value Dim d_vg As Double = 0 'secondary sweep step value (delta) If nop2 <> 1 Then d_vg = (vg2 - vg1) / (nop2 - 1) Dim hold As Double = 0 Dim delay As Double = 0 Dim s_delay As Double = 0 Dim p_comp As Double = 0 Dim rep As Integer = nop1 Dim sc(nop1) As Double 'primary sweep output data Dim md(nop1) As Double 'sweep measurement data Dim st(nop1) As Integer 'status data at each step ' 36 </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 17	Enables measurement channels.
19 to 36	Declares variables and sets the value.

Programming Examples for Visual Basic .NET Users

Staircase Sweep Measurements

```

Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)           '38
Ag415x.Force(t(3), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)

For j = 0 To nop2 - 1                                                         '41
    Ag415x.SetIv(t(0), Hp4156b.ModeEnum4.SingleLinearV, 0, vd1, vd2, nop1, hold,
delay, s_delay, idcomp, p_comp)
    Ag415x.ErrorQuery(err, msg)
    If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, vg, igcomp, 0)       '46
    Ag415x.SweepIv(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, 0, rep, sc, md, st)
    If rep <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    For i = 0 To nop1 - 1                                                       '50
        data(j, i) = Chr(13) & Chr(10) & vg & "," & sc(i) & "," & md(i) * 1000 & "," &
st(i)
    Next i

    vg = vg + d_vg
Next j

Ag415x.ZeroOutput(0)                                                         '57
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err:                                                                    '60
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If rep <> nop1 Then MsgBox("No. of data: " & rep & " (not " & nop1 & ")", vbOKOnly,
"")
End Sub

```

Line	Description
38 to 39	Applies voltage to device.
42	Sets the primary sweep source.
43 to 44	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
46 to 48	Applies voltage to the device and performs staircase sweep measurement. After that, checks the number of returned data. If it was not rep= nop1, forces 0 V and goes to Check_err.
50 to 52	Stores the measured data into the <i>data</i> variable.
57 to 58	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data3.txt file (CSV) and displays the data on a message box.
60 to 62	Displays a message box to show an error message if the error is detected.

Programming Examples for Visual Basic .NET Users

Staircase Sweep Measurements

Measurement Result Example

Vg (V), Vd (V), Id (mA), Status

```
1,0,-0.00115744,0
1,0.3,3.05372,0
1,0.6,5.61719,0
1,0.9,7.74477,0
1,1.2,9.53146,0
1,1.5,11.07517,0
1,1.8,12.4335,0
1,2.1,13.654,0
1,2.4,14.7489,0
1,2.699,15.7364,0
1,3,16.6246,0
2,0,-0.00174059,0
2,0.3,4.03733,0
2,0.6,7.63927,0
2,0.9,10.80673,0
2,1.2,13.5329,0
2,1.5,15.8655,0
2,1.8,17.8811,0
2,2.1,19.642,0
2,2.4,21.2001,0
2,2.699,22.6005,0
2,3,23.8623,0
3,0,-0.00185628,0
3,0.3,4.89763,0
3,0.6,9.39135,0
3,0.9,13.4735,0
3,1.2,17.1346,0
3,1.5,20.3616,0
3,1.8,23.1928,0
3,2.1,25.6613,0
3,2.4,27.8118,0
3,2.699,29.7103,0
3,3,31.4002,0
```

Data save completed.

Do you want to perform measurement again?

Synchronous Sweep Measurements

This section explains an example subprogram that performs staircase sweep measurement. This example measures MOSFET Id-Vg characteristics. The subprogram uses the synchronous sweep source.

Table 4-5 Synchronous Sweep Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Vg (V), Id (mA), Status" Dim fname As String = "C:\Agilent\data\data4.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3, 4} ' 13 Ag415x.SetSwitch(t(3), 1) ' SMU4: substrate Ag415x.SetSwitch(t(2), 1) ' SMU3: source Ag415x.SetSwitch(t(1), 1) ' SMU2: gate Ag415x.SetSwitch(t(0), 1) ' SMU1: drain Dim vpri1 As Double = 0 Dim vpri2 As Double = 3 Dim vsyn1 As Double = 0 Dim vsyn2 As Double = 3 Dim vcon1 As Double = 0 Dim vcon2 As Double = 0 Dim ilcomp As Double = 0.01 Dim i2comp As Double = 0.05 Dim hold As Double = 0 Dim delay As Double = 0 Dim s_delay As Double = 0 Dim plcomp As Double = 0 Dim p2comp As Double = 0 Dim rep As Integer = nop1 Dim sc(nop1) As Double 'primary sweep output data Dim md(nop1) As Double 'sweep measurement data Dim st(nop1) As Integer 'status data at each step ' 34 Ag415x.SetIv(t(1), Hp4156b.ModeEnum4.SingleLinearV, 0, vpri1, vpri2, nop1, hold, delay, s_delay, ilcomp, plcomp) Ag415x.SetSweepSync(t(0), Hp4156b.ModeEnum.VoltageOutput, 0, vsyn1, vsyn2, i2comp, p2comp) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 34	Enables measurement channels. And declares variables and sets the value.
36 to 37	Sets the primary sweep source and the synchronous sweep source.

Programming Examples for Visual Basic .NET Users

Synchronous Sweep Measurements

```

Ag415x.ErrorQuery(err, msg) '38
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

Ag415x.Force(t(3), Hp4156b.ModeEnum.VoltageOutput, 0, vcon1, 0.05, 0) '41
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, vcon2, 0.05, 0)
Ag415x.SweepIv(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, 0, rep, sc, md, st)
If rep <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

For i = 0 To nop1 - 1 '46
    data(j, i) = Chr(13) & Chr(10) & sc(i) & "," & md(i) * 1000 & "," & st(i)
Next i

Ag415x.ZeroOutput(0) '50
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: '53
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If rep <> nop1 Then MsgBox("No. of data: " & rep & " (not " & nop1 & ")", vbOKOnly, "")
End Sub

```

Line	Description
38 to 39	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
41 to 44	Applies voltage to device and performs sweep measurement. After that, checks the number of returned data. If it was not rep= nop1, forces 0 V and goes to Check_err.
46 to 48	Stores the measured data into the <i>data</i> variable.
50 to 51	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data4.txt file (CSV) and displays the data on a message box.
53 to 55	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Vg (V), Id (mA), Status
0,-0.000172985,0
0.3,2.25005,0
0.6,4.73989,0
0.9,7.47392,0
1.2,10.42244,0
1.5,13.5558,0
1.8,16.877,0
2.1,20.3577,0
2.4,23.9656,0
2.699,27.7044,0
3,31.5447,0

```

Data save completed.

Do you want to perform measurement again?

Multi-Channel Sweep Measurements

This section explains an example subprogram that performs multi channel sweep measurement. This example measures bipolar transistor Ic-Vb and Ib-Vb characteristics.

Table 4-6 Multi-Channel Sweep Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Vb (V), Ib (mA), Status_b, Ic (mA), Status_c, hfe" Dim fname As String = "C:\Agilent\data\data5.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {2, 3, 1} ' 13 Ag415x.SetSwitch(t(2), 1) 'SMU1: emitter Ag415x.SetSwitch(t(1), 1) 'SMU3: collector Ag415x.SetSwitch(t(0), 1) 'SMU2: base Dim vc As Double = 3 Dim ve As Double = 0 Dim vb1 As Double = 0.3 Dim vb2 As Double = 0.8 Dim icomp As Double = 0.1 Dim ibcomp As Double = 0.001 Dim iecomp As Double = 0.1 Dim hold As Double = 0 Dim delay As Double = 0 Dim s_delay As Double = 0 Dim pComp As Double = 0 Dim mch() As Integer = {t(0), t(1), 0} 'base, collector Dim mode() As Integer = {1, 1} 'current measurement Dim range() As Double = {0.0001, 0.001} 'limited auto ranging (0.1 mA, 1 mA) Dim rep As Integer = nop1 Dim sc(nop1) As Double 'primary sweep output data Dim md(nop1 * 2) As Double 'sweep measurement data Dim st(nop1 * 2) As Integer 'status data at each step ' 35 Ag415x.SetInteg(Hp4156b.TableEnum.IntegTimeShort, 0.0001, 2) Ag415x.SetIv(t(0), Hp4156b.ModeEnum4.SingleLinearV, 0, vb1, vb2, nop1, hold, delay, s_delay, ibcomp, pcomp) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 35	Enables measurement channels. And declares variables and sets the value.
37 to 38	Sets the A/D converter integration time, and sets the primary sweep source.

Programming Examples for Visual Basic .NET Users

Multi-Channel Sweep Measurements

```

Ag415x.ErrorQuery(err, msg) ' 39
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, ve, iecomp, 0) ' 42
Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, vc, iccomp, 0)
Ag415x.SweepMiv(mch, mode, range, rep, sc, md, st)
If rep <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

For i = 0 To nop1 - 1 ' 47
    data(j, i) = Chr(13) & Chr(10) & sc(i) & ", " & md(2 * i) * 1000 & ", "
    data(j, i) = data(j, i) & st(2 * i) & ", " & md(2 * i + 1) * 1000 & ", "
    data(j, i) = data(j, i) & st(2 * i + 1) & ", " & md(2 * i + 1) / md(2 * i)
Next i

Ag415x.ZeroOutput(0) ' 53
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: ' 56
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If rep <> nop1 Then MsgBox("No. of data: " & rep & " (not " & nop1 & ")", vbOKOnly, "")
End Sub

```

Line	Description
39 to 40	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
42 to 45	Applies voltage to device and performs sweep measurement. After that, checks the number of returned data. If it was not rep= nop1, forces 0 V and goes to Check_err.
47 to 51	Stores the measured data into the <i>data</i> variable.
53 to 54	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data5.txt file (CSV) and displays the data on a message box.
56 to 58	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Vb (V), Ib (mA), Status_b, Ic (mA), Status_c, hfe
0.2999, -3E-06, 0, -6E-06, 0, 2
0.3499, -3E-06, 0, -3.3E-05, 0, 11
0.4, 2.3E-06, 0, -6E-06, 0, -2.60869565217391
0.45, 5.1E-06, 0, 0.00021, 0, 41.1764705882353
0.5, 1.33E-05, 0, 0.001864, 0, 140.15037593985
0.55, 6.8E-05, 0, 0.012705, 0, 186.838235294118
0.6, 0.0004727, 0, 0.087561, 0, 185.235878993019
0.65, 0.003016, 0, 0.597003, 0, 197.945291777188
0.7, 0.0188088, 0, 3.81314, 0, 202.731700055293
0.75, 0.0953332, 0, 18.5294, 0, 194.364607502948
0.8, 0.318431, 0, 54.3315, 0, 170.622521048516

```

Data save completed.

Do you want to perform measurement again?

Pulsed Spot Measurements

This section explains an example subprogram that performs pulsed spot measurement. This example measures MOSFET drain current.

Table 4-7 Pulsed Spot Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 1 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Id (mA), Status" Dim fname As String = "C:\Agilent\data\data6.txt" Dim title As String = "Spot Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3, 4} ' 13 Ag415x.SetSwitch(t(3), 1) 'SMU4: substrate Ag415x.SetSwitch(t(2), 1) 'SMU3: source Ag415x.SetSwitch(t(1), 1) 'SMU2: gate Ag415x.SetSwitch(t(0), 1) 'SMU1: drain Dim vd As Double = 0.5 Dim vg As Double = 0.5 Dim idcomp As Double = 0.05 Dim igcomp As Double = 0.01 Dim base As Double = 0 Dim width As Double = 0.001 Dim period As Double = 0.01 Dim hold As Double = 0.1 Dim meas As Double Dim status As Integer Ag415x.SetFilter(t(1), Hp4156b.StateEnum2.FilterOff) ' 30 Ag415x.SetPbias(t(1), Hp4156b.ModeEnum5.VoltagePulse, 2, base, vg, width, period, hold, igcomp) Ag415x.ErrorQuery(err, msg) If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 28	Enables measurement channels. And declares variables and sets the value.
30 to 31	Sets the filter off for the pulse output channel and sets the pulse voltage source.
32 to 33	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.

Programming Examples for Visual Basic .NET Users

Pulsed Spot Measurements

```

Ag415x.Force(t(3), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)           '35
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)
Ag415x.Force(t(0), Hp4156b.ModeEnum.VoltageOutput, 2, vd, idcomp, 0)
Ag415x.MeasureP(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, 0, meas, status)

data(j, i) = Chr(13) & Chr(10) & meas * 1000 & ", " & status                '40

Ag415x.ZeroOutput(0)                                                         '42
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err:                                                                    '45
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub

```

Line	Description
35 to 38	Applies voltage to device and performs pulsed spot measurement.
40	Stores the measured data into the <i>data</i> variable.
42 to 43	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the <i>save_data</i> subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data6.txt file (CSV) and displays the data on a message box.
45 to 46	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Id (mA), Status
3.8789, 0

Data save completed.

Do you want to perform measurement again?

```

Multi-Channel Pulsed Spot Measurements

This section explains an example subprogram that performs multi channel pulsed spot measurement. This example measures bipolar transistor collector current and base current.

Table 4-8 Multi-Channel Pulsed Spot Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 1 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Ic (mA), Status_c, Ib (mA), Status_b, hfe" Dim fname As String = "C:\Agilent\data\data7.txt" Dim title As String = "Spot Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3} ' 13 Ag415x.SetSwitch(t(2), 1) 'SMU3: collector Ag415x.SetSwitch(t(1), 1) 'SMU2: base Ag415x.SetSwitch(t(0), 1) 'SMU1: emitter Dim vc As Double = 0 Dim vb As Double = 0 Dim icomp As Double = 0.1 Dim ibcomp As Double = 0.1 Dim mch() As Integer = {t(2), t(1), 0} 'collector, base Dim mode() As Integer = {1, 1} 'current measurement Dim range() As Double = {0, 0} 'auto range Dim eod As Integer Dim dtype As Integer Dim mdata As Double Dim stat As Integer Dim ch As Integer Dim md(2) As Double Ag415x.SetFilter(t(0), Hp4156b.StateEnum2.FilterOff) ' 32 Ag415x.Cmd("PT 0,0.005,0.01,0,1") 'sets pulse timing parameters Ag415x.Cmd("PV 1,0,0,-0.8,0.1") 'sets pulse voltage source </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 30	Enables measurement channels. And declares variables and sets the value.
32 to 34	Sets the filter off for the pulse output channel and sets the pulse voltage source.

Programming Examples for Visual Basic .NET Users

Multi-Channel Pulsed Spot Measurements

```

Ag415x.ErrorQuery(err, msg)                                     ' 36
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, vb, ibcomp, 0) ' 39
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, vc, iccomp, 0)
Ag415x.StartMeasure(Hp4156b.MeasTypeEnum.MmPspot, mch, mode, range,
Hp4156b.SourceEnum.WithoutSourceDataOutput)

Ag415x.ReadData(eod, dtype, mdata, stat, ch)                   ' 43
md(0) = mdata
data(j, i) = Chr(13) & Chr(10) & mdata * 1000 & ", " & stat
Ag415x.ReadData(eod, dtype, mdata, stat, ch)
md(1) = mdata
data(j, i) = data(j, i) & ", " & mdata * 1000 & ", " & stat
data(j, i) = data(j, i) & ", " & md(0) / md(1)

Ag415x.ZeroOutput(0)                                           ' 51
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err:                                                      ' 54
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub

```

Line	Description
36 to 37	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
39 to 41	Applies voltage to device and performs multi channel pulsed spot measurement.
43 to 49	Reads measurement data, and stores the data into the <i>data</i> variable.
51 to 52	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data7.txt file (CSV) and displays the data on a message box.
54 to 55	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Ic (mA), Status_c, Ib (mA), Status_b, hfe
42.8595, 0, 0.330382, 0, 129.72710377684
```

Data save completed.

Do you want to perform measurement again?

Pulsed Sweep Measurements

This section explains an example subprogram that performs pulsed sweep measurement. This example measures bipolar transistor Ic-Vc characteristics.

Table 4-9 Pulsed Sweep Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 3 Dim data(nop2, nop1) as String Dim val As String = "Ib (uA), Vc (V), Ic (mA), Status" Dim fname As String = "C:\Agilent\data\data8.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {3, 2, 1} ' 13 Ag415x.SetSwitch(t(2), 1) ' SMU1: emitter Ag415x.SetSwitch(t(1), 1) ' SMU2: base Ag415x.SetSwitch(t(0), 1) ' SMU3: collector Dim vc1 As Double = 0 Dim vc2 As Double = 3 Dim iccomp As Double = 0.05 Dim ib1 As Double = 0.00005 ' 50 uA Dim ib2 As Double = 0.00015 ' 150 uA Dim vbcomp As Double = 5 Dim ibo As Double = ib1 ' secondary sweep output value Dim d_ib As Double ' secondary sweep step value (delta) If nop2 <> 1 Then d_ib = (ib2 - ib1) / (nop2 - 1) Dim hold As Double = 0.1 Dim width As Double = 0.001 Dim period As Double = 0.01 Dim base As Double = 0 Dim rep As Integer Dim sc(nop1) As Double ' primary sweep output data Dim md(nop1) As Double ' sweep measurement data Dim st(nop1) As Integer ' status data at each step Ag415x.SetFilter(t(0), Hp4156b.StateEnum2.FilterOff) ' 36 Ag415x.SetInteg(Hp4156b.TableEnum.IntegTimeShort, 0.0001, 2) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 34	Enables measurement channels. And declares variables and sets the value.
36 to 37	Sets the filter off for the pulse output channel and sets the A/D converter integration time.

Programming Examples for Visual Basic .NET Users

Pulsed Sweep Measurements

```

Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0) '39
Ag415x.ErrorQuery(err, msg)
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

For j = 0 To nop2 - 1
    Ag415x.SetPiv(t(0), Hp4156b.ModeEnum3.SingleLinearV, 0, base, vc1, vc2, nop1,
hold, width, period, iccomp) '44
    Ag415x.ErrorQuery(err, msg)
    If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    Ag415x.Force(t(1), Hp4156b.ModeEnum.CurrentOutput, 0, ibo, vbcomp, 0) '48
    Ag415x.SweepPiv(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, 0, rep, sc, md, st)
    If rep <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    For i = 0 To nop1 - 1 '52
        data(j, i) = Chr(13) & Chr(10) & ibo * 1000000 & "," & sc(i)
        data(j, i) = data(j, i) & "," & md(i) * 1000 & "," & st(i)
    Next i

    ibo = ibo + d_ib
Next j

Ag415x.ZeroOutput(0) '60
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: '63
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If rep <> nop1 Then MsgBox("No. of data: " & rep & " (not " & nop1 & ")", vbOKOnly,
"")
End Sub

```

Line	Description
39 to 41	Applies voltage to device and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
44 to 46	Sets the pulsed sweep source and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
48 to 50	Applies voltage to the device and performs pulsed sweep measurement. After that, checks the number of returned data. If it was not rep= nop1, forces 0 V and goes to Check_err.
52 to 55	Stores the data into the <i>data</i> variable.
60 to 61	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data8.txt file (CSV) and displays the data on a message box.
63 to 65	Displays a message box to show an error message if the error is detected.

**Measurement
Result Example**

```
Ib (uA), Vc (V), Ic (mA), Status
50,0,-0.0503,0
50,0.3,8.5514,0
50,0.6,9.5932,0
50,0.9,9.7166,0
50,1.2,9.7714,0
50,1.5,9.7919,0
50,1.8,9.8262,0
50,2.1,9.8057,0
50,2.4,9.8673,0
50,2.699,9.881,0
50,3,9.8536,0
100,0,-0.0846,0
100,0.3,15.4259,0
100,0.6,18.0373,0
100,0.9,18.6679,0
100,1.2,18.8804,0
100,1.5,18.9351,0
100,1.8,19.0448,0
100,2.1,19.1202,0
100,2.4,19.1339,0
100,2.699,19.1957,0
100,3,19.2094,0
150,0,-0.1394,0
150,0.3,20.4911,0
150,0.6,24.3156,0
150,0.9,26.1593,0
150,1.2,27.0709,0
150,1.5,27.3793,0
150,1.8,27.6741,0
150,2.1,27.6467,0
150,2.4,27.8659,0
150,2.699,27.9139,0
150,3,27.9824,0
```

Data save completed.

Do you want to perform measurement again?

Multi-Channel Pulsed Sweep Measurements

This section explains an example subprogram that performs multi channel pulsed sweep measurement. This example measures bipolar transistor Ic-Vb and Ib-Vb characteristics.

Table 4-10 Multi-Channel Pulsed Sweep Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 3 Dim data(nop2, nop1) as String Dim val As String = "Ic (mA), Status_c, Ib (mA), Status_b, Ve (V)" Dim fname As String = "C:\Agilent\data\data9.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3} ' 13 Ag415x.SetSwitch(t(0), 1) 'SMU1: emitter Ag415x.SetSwitch(t(1), 1) 'SMU2: base Ag415x.SetSwitch(t(2), 1) 'SMU3: collector Dim vc As Double = 0 Dim vb As Double = 0 Dim iccomp As Double = 0.1 Dim ibcomp As Double = 0.1 Dim mch() As Integer = {t(2), t(1), 0} 'measurement channels Dim mode() As Integer = {1, 1} 'current measurement mode Dim range() As Double = {0, 0} 'auto ranging Dim eod As Integer Dim dtype As Integer Dim mdata As Double Dim stat As Integer Dim ch As Integer Ag415x.SetFilter(t(0), Hp4156b.StateEnum2.FilterOff) ' 31 Ag415x.SetInteg(Hp4156b.TableEnum.IntegTimeShort, 0.0001, 1) Ag415x.Cmd("PT 0,0.005,0.01,0,1") 'sets pulse timing parameters Ag415x.Cmd("PWV 1,1,0,0,0,-0.8,11,0.1,0") 'sets pulsed sweep source </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 29	Enables measurement channels. And declares variables and sets the value.
31 to 34	Sets the filter off for the pulse output channel and sets the A/D converter integration time. Also sets the pulse voltage source.

Programming Examples for Visual Basic .NET Users

Multi-Channel Pulsed Sweep Measurements

```

Ag415x.ErrorQuery(err, msg) ' 36
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err
Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, vb, ibcomp, 0) ' 38
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, vc, iccomp, 0)
Ag415x.StartMeasure(Hp4156b.MeasTypeEnum.MmPsweep, mch, mode, range,
Hp4156b.SourceEnum.SourceDataOutput)

For i = 0 To nop1 - 1 ' 42
    Ag415x.ReadData(eod, dtype, mdata, stat, ch)
    data(j, i) = Chr(13) & Chr(10) & mdata * 1000 & "," & stat 't(2)=collector
    Ag415x.ReadData(eod, dtype, mdata, stat, ch)
    data(j, i) = data(j, i) & "," & mdata * 1000 & "," & stat 't(1)=base
    Ag415x.ReadData(eod, dtype, mdata, stat, ch)
    data(j, i) = data(j, i) & "," & mdata 't(0)=emitter
Next i

Ag415x.ZeroOutput(0) ' 51
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: ' 54
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub

```

Line	Description
36 to 37	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
38 to 40	Applies voltage to device and performs multi channel pulsed sweep measurement.
42 to 49	Stores the data into the <i>data</i> variable.
51 to 52	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data9.txt file (CSV) and displays the data on a message box.
54 to 55	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Ic (mA), Status_c, Ib (mA), Status_b, Ve (V)
-1.21572E-09,0,-3.3938E-10,0,0
7.9188E-10,0,4.3032E-10,0,-0.08
2.9592E-09,0,1.19947E-09,0,-0.16
1.23562E-07,0,9.6629E-09,0,-0.24
1.74463E-06,0,2.70753E-08,0,-0.32
3.76546E-05,0,3.66487E-07,0,-0.4
0.000832422,0,5.73051E-06,0,-0.48
0.0183221,0,0.000107577,0,-0.56
0.400051,0,0.00207699,0,-0.64
7.22489,0,0.0366662,0,-0.72
42.8737,0,0.330252,0,-0.8

```

Data save completed.

Do you want to perform measurement again?

Staircase Sweep with Pulsed Bias Measurements

This section explains an example subprogram that performs staircase sweep with pulsed bias measurement. This example measures MOSFET Id-Vd characteristics.

Table 4-11 Staircase Sweep with Pulsed Bias Measurement Example

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 11 Dim nop2 As Integer = 3 Dim data(nop2, nop1) As String Dim val As String = "Vg (V), Vd (V), Id (mA), Status" Dim fname As String = "C:\Agilent\data\data10.txt" Dim title As String = "Sweep Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3, 4} ' 13 Ag415x.SetSwitch(t(3), 1) 'SMU4: substrate Ag415x.SetSwitch(t(2), 1) 'SMU3: source Ag415x.SetSwitch(t(1), 1) 'SMU2: gate Ag415x.SetSwitch(t(0), 1) 'SMU1: drain Dim vd1 As Double = 0 Dim vd2 As Double = 3 Dim idcomp As Double = 0.05 Dim vg1 As Double = 1 Dim vg2 As Double = 3 Dim igcomp As Double = 0.01 Dim vg As Double = vg1 'secondary sweep output value Dim d_vg As Double = 0 'secondary sweep step value (delta) If nop2 <> 1 Then d_vg = (vg2 - vg1) / (nop2 - 1) Dim hold As Double = 0 Dim delay As Double = 0 Dim s_delay As Double = 0 Dim p_comp As Double = 0 Dim width As Double = 0.001 Dim period As Double = 0.01 Dim p_hold As Double = 0.1 Dim rep As Integer = nop1 Dim sc(nop1) As Double 'primary sweep output data Dim md(nop1) As Double 'sweep measurement data Dim st(nop1) As Integer 'status data at each step </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 39	Enables measurement channels. And declares variables and sets the value.

Programming Examples for Visual Basic .NET Users

Staircase Sweep with Pulsed Bias Measurements

```

Ag415x.SetFilter(t(1), Hp4156b.StateEnum2.FilterOff) ' 41
Ag415x.Force(t(3), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, 0, 0.05, 0)

For j = 0 To nop2 - 1
    Ag415x.SetPbias(t(1), Hp4156b.ModeEnum5.VoltagePulse, 0, 0, vg, width, period,
p_hold, igcomp) ' 46
    Ag415x.SetIv(t(0), Hp4156b.ModeEnum4.SingleLinearV, 0, vd1, vd2, nop1, hold,
delay, s_delay, idcomp, p_comp)
    Ag415x.ErrorQuery(err, msg)
    If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    Ag415x.SweepPbias(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, 0, rep, sc, md,
st) ' 51
    If rep <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

    For i = 0 To nop1 - 1
        data(j, i) = Chr(13) & Chr(10) & vg & "," & sc(i) & "," & md(i) * 1000 & "," &
st(i) ' 54
    Next i

    vg = vg + d_vg
Next j

Ag415x.ZeroOutput(0) ' 61
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err: ' 64
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If rep <> nop1 Then MsgBox("No. of data: " & rep & " (not " & nop1 & ")", vbOKOnly,
"")
End Sub

```

Line	Description
41 to 43	Sets the filter off for the pulse output channel and applies voltage to device.
46 to 49	Sets the pulse source and the primary sweep source, and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
51 to 52	Performs sweep measurement. After that, checks the number of returned data. If it was not rep= nop1, forces 0 V and goes to Check_err.
54 to 56	Stores the measured data into the <i>data</i> variable.
61 to 62	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data10.txt file (CSV) and displays the data on a message box.
64 to 66	Displays a message box to show an error message if the error is detected.

Programming Examples for Visual Basic .NET Users

Staircase Sweep with Pulsed Bias Measurements

Measurement Result Example

Vg (V), Vd (V), Id (mA), Status

```
1,0,-0.0003,0
1,0.3,3.0016,0
1,0.6,5.5649,0
1,0.9,7.6691,0
1,1.2,9.4168,0
1,1.5,10.9109,0
1,1.8,12.316,0
1,2.1,13.3578,0
1,2.4,14.6257,0
1,2.699,15.5852,0
1,3,16.6064,0
2,0,-0.0071,0
2,0.3,3.92,0
2,0.6,7.3332,0
2,0.9,10.4586,0
2,1.2,13.3852,0
2,1.5,15.3453,0
2,1.8,17.4015,0
2,2.1,19.115,0
2,2.4,21.0135,0
2,2.699,21.7194,0
2,3,23.1929,0
3,0,-0.0071,0
3,0.3,4.6945,0
3,0.6,9.122,0
3,0.9,13.1864,0
3,1.2,17.0314,0
3,1.5,19.7592,0
3,1.8,22.6515,0
3,2.1,25.0435,0
3,2.4,26.7638,0
3,2.699,29.615,0
3,3,30.5882,0
```

Data save completed.

Do you want to perform measurement again?

Sampling Measurements

This section explains an example subprogram that performs sampling measurement. This example measures current of a device that has two high terminals and a low terminal, and calculates the resistance.

Table 4-12 **Sampling Measurement Example**

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 30 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status" Dim fname As String = "C:\Agilent\data\data11.txt" Dim title As String = "Sampling Measurement Result" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3} ' 13 Ag415x.SetSwitch(t(0), 1) ' SMU1: t1 Ag415x.SetSwitch(t(1), 1) ' SMU2: t2 Ag415x.SetSwitch(t(2), 1) ' SMU3: low Dim base As Double = 0 Dim bias As Double = 0.1 Dim icomp As Double = 0.1 Dim vlout As Double = 0 Dim ilcomp As Double = 0.1 Dim hold As Double = 0.1 Dim interval As Double = 0.05 Dim mch() As Integer = {t(0), t(1), 0} Dim mode() As Integer = {1, 1} Dim range() As Double = {0, 0} Dim n As Integer = nop1 * 2 Dim point As Integer Dim index(nop1) As Integer Dim value(n) As Double Dim status(n) As Integer Ag415x.SetFilter(Hp4156b.ChannelEnum4.AllSmu, Hp4156b.StateEnum2.FilterOn) ' 34 Ag415x.SetInteg(Hp4156b.TableEnum.IntegTimeShort, 0.0001, 2) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 32	Enables measurement channels. And declares variables and sets the value.
34 to 35	Sets the filter on for the all channels and sets the A/D converter integration time.

Programming Examples for Visual Basic .NET Users

Sampling Measurements

```

Ag415x.SetSample(hold, interval, nop1)                                     ' 37
Ag415x.AddSampleSyncIv(t(0), Hp4156b.ModeEnum.VoltageOutput, 0, base, bias,
icomp)
Ag415x.AddSampleSyncIv(t(1), Hp4156b.ModeEnum.VoltageOutput, 0, base, bias,
icomp)
Ag415x.ErrorQuery(err, msg)
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err

Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, 0, vlout, ilcomp, 0)    ' 43
Ag415x.Sample(mch, mode, range, point, index, value, status)
Ag415x.ClearSampleSync()
If point <> nop1 Then Ag415x.ZeroOutput(0) : GoTo Check_err

For i = 0 To nop1 - 1                                                    ' 48
    Dim r1 As Double = Math.Round(bias / value(2 * i), 3)
    Dim r2 As Double = Math.Round(bias / value(2 * i + 1), 3)
    data(j, i) = Chr(13) & Chr(10) & index(i) & "," & value(2 * i) * 1000
    data(j, i) = data(j, i) & "," & r1 & "," & value(2 * i + 1) * 1000
    data(j, i) = data(j, i) & "," & r2 & "," & status(i)
Next i

Ag415x.ZeroOutput(0)                                                    ' 56
save_data(fname, title, val, data, nop1, nop2, Ag415x)

Check_err:                                                                ' 59
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
If point <> nop1 Then MsgBox("No. of data: " & point & " (not " & nop1 & ")",
vbOKOnly, "")
End Sub

```

Line	Description
37 to 41	Sets the timing parameters, sets the dc voltage sources for sampling measurement, and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
43 to 46	Applies voltage to device and performs sampling measurement. After the measurement, clears the setup of the dc voltage sources for the sampling measurement. And then, checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
48 to 54	Stores the measured data into the <i>data</i> variable.
56 to 57	Applies 0 V from the all channels. And transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data11.txt file (CSV) and displays the data on a message box.
59 to 61	Displays a message box to show an error message if the error is detected.

**Measurement
Result Example**

```
Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status
1,9.64451,10.369,9.15948,10.918,0
2,9.64641,10.367,9.16111,10.916,0
3,9.64641,10.367,9.16003,10.917,0
4,9.6456,10.367,9.16112,10.916,0
5,9.64587,10.367,9.1603,10.917,0
6,9.64668,10.366,9.16057,10.916,0
7,9.64669,10.366,9.15976,10.917,0
8,9.64533,10.368,9.16057,10.916,0
9,9.64506,10.368,9.15976,10.917,0
10,9.64614,10.367,9.15894,10.918,0
11,9.6456,10.367,9.15976,10.917,0
12,9.6456,10.367,9.16084,10.916,0
13,9.64641,10.367,9.15976,10.917,0
14,9.6456,10.367,9.16112,10.916,0
15,9.64614,10.367,9.15976,10.917,0
16,9.64505,10.368,9.16003,10.917,0
17,9.64587,10.367,9.16003,10.917,0
18,9.64614,10.367,9.1603,10.917,0
19,9.64669,10.366,9.15948,10.918,0
20,9.6456,10.367,9.16003,10.917,0
21,9.64614,10.367,9.15922,10.918,0
22,9.64505,10.368,9.1603,10.917,0
23,9.64614,10.367,9.15895,10.918,0
24,9.64641,10.367,9.1603,10.917,0
25,9.64668,10.366,9.15895,10.918,0
26,9.64533,10.368,9.15976,10.917,0
27,9.6456,10.367,9.15948,10.918,0
28,9.64587,10.367,9.16084,10.916,0
29,9.64587,10.367,9.16003,10.917,0
30,9.64533,10.368,9.16003,10.917,0
```

Data save completed.

Do you want to perform measurement again?

Stress Force

This section explains an example subprogram that performs stress measurement. This example measures current of a device that has two high terminals and a low terminal.

Table 4-13 **Stress Force Example**

<pre> Sub perform_meas(ByVal Ag415x As Hp4156b) ' 1 Dim i As Integer = 0 Dim j As Integer = 0 Dim nop1 As Integer = 2 Dim nop2 As Integer = 1 Dim data(nop2, nop1) As String Dim val As String = "Condition, I1 (mA), Status1, I2 (mA), Status2" Dim fname As String = "C:\Agilent\data\data12.txt" Dim title As String = "Stress Test Result:" Dim msg As String = "No error." Dim err As Integer = 0 Dim t() As Integer = {1, 2, 3} ' 13 Ag415x.SetSwitch(t(0), 1) ' SMU1: t1 Ag415x.SetSwitch(t(1), 1) ' SMU2: t2 Ag415x.SetSwitch(t(2), 1) ' SMU3: low Dim range As Double = 0 Dim base As Double = 0 Dim stress As Double = 2 Dim bias As Double = 0.1 Dim icomp As Double = 0.1 Dim vlout As Double = 0 Dim ilcomp As Double = 0.1 Dim hold As Double = 0 Dim duration As Double = 5 Dim period As Double = 0.01 Dim status As Integer Dim md(4) As Double Dim st(4) As Integer Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, range, vlout, ilcomp, 0) ' 32 Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, range, bias, icomp, 0) Ag415x.Force(t(0), Hp4156b.ModeEnum.VoltageOutput, range, bias, icomp, 0) Ag415x.SpotMeas(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, range, md(0), st(0)) Ag415x.SpotMeas(t(1), Hp4156b.ModeEnum1.CurrentMeasurement, range, md(1), st(1)) Ag415x.ZeroOutput(0) </pre>	
Line	Description
2 to 11	Declares variables used in the program template. And sets the proper values.
13 to 30	Enables measurement channels. And declares variables and sets the value.
32 to 37	Applies voltage to device, performs spot measurement, and applies 0 V from the all channels.

```

data(j, 0) = Chr(13) & Chr(10) & "Before stress, " & md(0) * 1000 & ", " & st(0) '38
data(j, 0) = data(j, 0) & ", " & md(1) * 1000 & ", " & st(1)

Ag415x.SetStress(hold, Hp4156b.ModeEnum6.DurationMode, duration, period) '41
Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, range, vlout, ilcomp, 0)
Ag415x.AddStressSyncIv(1, t(0), 2, range, base, stress, icomp)
Ag415x.AddStressSyncIv(2, t(1), 2, range, base, stress, icomp)
Ag415x.ErrorQuery(err, msg)
If err <> 0 Then Ag415x.ZeroOutput(0) : GoTo Check_err
Ag415x.Stress(status)
Ag415x.ZeroOutput(0)
Ag415x.ClearStressSync()

Ag415x.Force(t(2), Hp4156b.ModeEnum.VoltageOutput, range, vlout, ilcomp, 0) '51
Ag415x.Force(t(1), Hp4156b.ModeEnum.VoltageOutput, range, bias, icomp, 0)
Ag415x.Force(t(0), Hp4156b.ModeEnum.VoltageOutput, range, bias, icomp, 0)
Ag415x.SpotMeas(t(0), Hp4156b.ModeEnum1.CurrentMeasurement, range, md(2), st(2))
Ag415x.SpotMeas(t(1), Hp4156b.ModeEnum1.CurrentMeasurement, range, md(3), st(3))
Ag415x.ZeroOutput(0)
data(j, 1) = Chr(13) & Chr(10) & "After stress, " & md(2) * 1000 & ", " & st(2)
data(j, 1) = data(j, 1) & ", " & md(3) * 1000 & ", " & st(3)

save_data(fname, title, val, data, nop1, nop2, Ag415x) '60

Check_err: '62
If err <> 0 Then MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub

```

Line	Description
38 to 39	Stores the measured data into the <i>data</i> variable.
41 to 49	Sets the stress timing parameters, applies voltage to the device, sets the dc voltage sources used for the stress force, and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err. And then, applies the stress to the device. After the stress, applies 0 V from the all channels and clears the setup of the dc voltage sources for the stress.
51 to 58	Applies voltage to the device, performs spot measurement, applies 0 V from the all channels, and stores the measured data into the <i>data</i> variable.
60	Transfers the data stored in the <i>data</i> variable to the save_data subprogram (see Table 4-1). And the subprogram will save the data into the C:\Agilent\data\data12.txt file (CSV) and displays the data on a message box.
62 to 63	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```

Condition, I1 (mA), Status1, I2 (mA), Status2
Before stress, 9.80588, 0, 9.27516, 0
After stress, 9.80886, 0, 9.3245, 0

```

Data save completed.

Do you want to perform measurement again?

Programming Examples for Visual Basic .NET Users
Stress Force

This chapter describes how to create measurement programs using the Agilent 4155/4156 and the 4155/4156 VXi*plug&play* driver, and provides programming examples using Microsoft Visual C++. This chapter contains the following sections:

- “Programming Basics”
- “High-Speed Spot Measurements”
- “Multi-Channel Spot Measurements”
- “Staircase Sweep Measurements”
- “Synchronous Sweep Measurements”
- “Multi-Channel Sweep Measurements”
- “Pulsed Spot Measurements”
- “Multi-Channel Pulsed Spot Measurements”
- “Pulsed Sweep Measurements”
- “Multi-Channel Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Sampling Measurements”
- “Stress Force”

NOTE

About Program Code

Programming examples are provided as a subprogram that can be run with the project template shown in Table 5-1. The subprograms include the code to perform measurement and to display/save the measurement data. To execute the program, insert the subprogram instead of the perform_meas subprogram in the template.

Programming Basics

This section provides the basic information for programming using the Agilent 4155/4156 VXi*plug&play* driver.

- “To Create Your Project Template”
- “To Create Measurement Program”

To Create Your Project Template

This section explains how to create a project template in the C language. Before starting programming, create your project template, and keep it as your reference. It will remove the conventional task in the future programming.

- Step 1.** Connect instrument (e.g. Agilent 4155/4156) to computer via GPIB.
- Step 2.** Launch the programming software and create a new project. Then, select the Win32 project or the console application for the new project template selection. They will simplify the programming. Of course, other project template can be used.
- Step 3.** Define the followings to the project properties or the project options. See manual or on-line help of the programming software for defining them.
1. Additional include file search path:
 - directory (e.g. \Program Files\VISA\winnt\include) that stores the hp4156b.h file and the VISA related include files
 2. Additional library search path:
 - directory (e.g. \Program Files\VISA\winnt\lib\msc for Microsoft Visual C++ or \Program Files\VISA\winnt\lib\bc for Borland C++Builder) that stores the hp4156b.lib file and the VISA related library files
 3. Additional project link library:
 - hp4156b.lib
- Step 4.** Open a source file (.cpp) in the project, and enter a program code as template. See Table 5-1 for example. The example uses Microsoft Visual C++.
- Step 5.** Save the project as your template (e.g. \test\my_temp).

Programming Examples for C++ Users

Programming Basics

Table 5-1 **Example Template Program Code for Visual C++**

```

#include    <stdio.h>                                /* 1 */
#include    <stdlib.h>
#include    <visa.h>
#include    "hp4156b.h"

void check_err (ViSession vi, ViStatus ret) {          /* 6 */
    ViInt32    inst_err;
    ViChar     err_msg[256];

    if (VI_SUCCESS > ret) {
        if ( hp4156b INSTR_ERROR_DETECTED == ret ) {
            hp4156b_error_query(vi, &inst_err, err_msg);
            printf("Instrument Error: %ld\n %s\n", inst_err, err_msg);
        }
        else {
            hp4156b_error_message(vi, ret, err_msg);
            printf("Driver Error: %ld\n %s\n", ret, err_msg);
        }
    }
}                                                     /* 20 */

void perform_meas (ViSession vi, ViStatus ret) {      /* 22 */
    /* insert program code */
}

ViStatus main ( )                                    /* 26 */
{
    ViStatus    ret;                                  /* 28 */
    ViSession   vi;
    ViChar      err_msg[256];                         /* 30 */

```

Line	Description
1 to 4	Required to use the Agilent 4155/4156 <i>VXIplug&play</i> driver. The header files contain various necessary information such as function declaration and macro definitions. You may add the include statements to call another header files that may be needed by the codes you added. Also, the include statements may be written in a header file that will be called by the source file (e.g. #include <stdio.h> may be written in the stdafx.h header file that will be called by the source file).
6 to 20	Checks if the passed “ret” value indicates normal status, and returns to the line that called this subprogram. If the value indicates an instrument error status or a device error status, the error message will be displayed.
22 to 24	Complete the perform_meas subprogram to perform measurement.
26	Beginning of the main program.
28 to 30	Declares variables used in the main program.

```

/* Starting the session */
ret = hp4156b_init("GPIB::17::INSTR", VI_TRUE, VI_TRUE, &vi);          /* 33 */
if ( ( ret < VI_SUCCESS ) || ( vi == VI_NULL ) ) {
    printf("Initialization failure.\n Status code: %d.\n", ret);
    if ( vi != VI_NULL ) {
        hp4156b_error_message(vi, ret, err_msg);
        printf("Error: %ld\n %s\n", ret, err_msg);
    }
    exit (ret);
}                                                                    /* 41 */

ret = hp4156b_reset(vi);                                              /* resets 4155/4156      43 */
ret = hp4156b_timeOut(vi, 60000);                                    /* sets 60 second timeout */
ret = hp4156b_errorQueryDetect(vi, VI_TRUE);                        /* turns on error detection */

perform_meas(vi, ret);                                              /* calls perform_meas subprogram 47 */
/* ret = hp4156b_cmd(vi, "aa");                                     sends an invalid command */
/* check_err(vi, ret);                                             checks check_err subprogram operation */

/* Closing the session
ret = hp4156b_close(vi);                                            52 */
check_err(vi, ret);

return VI_SUCCESS;                                                  /* 55 */
}

```

Line	Description
33	Establishes the software connection with the Agilent 4155/4156. The above example is for the Agilent 4155/4156 on the GPIB address 17. Confirm the GPIB address of your 4155/4156, and set the address correctly instead of “17”.
34 to 41	Checks the status returned by the hp4156b_init function. Displays the error message and stops the program execution if an error status is returned.
43 to 45	Resets the Agilent 4155/4156, sets the driver I/O time out to 60 seconds, and enables the automatic instrument error checking.
47	Calls the perform_meas subprogram (line 22).
48 to 49	Should be deleted or commented out before executing the program. The lines are just used to check the operation of the check_err subprogram.
52	Disables the software connection with the Agilent 4155/4156.
53	Calls the check_err subprogram to check if an error status is returned for the line 52.
55 to 56	End of the main program.

To Create Measurement Program

Create the measurement program as shown below. The following procedure needs your project template. If the procedure does not fit your programming environment, arrange it to suit your environment.

Step 1. Plan the automatic measurements. Then decide the following items:

- Measurement devices
Discrete, packaged, on-wafer, and so on.
- Parameters/characteristics to be measured
 h_{FE} , V_{th} , sheet resistance, and so on.
- Measurement method
Spot measurement, staircase sweep measurement, and so on.

Step 2. Make a copy of your project template (e.g. `\test\my_temp` to `\test\dev_a\my_temp`).

Step 3. Rename the copy (e.g. `\test\dev_a\my_temp` to `\test\dev_a\spot_id`).

Step 4. Launch the programming software.

Step 5. Open the project (e.g. `\test\dev_a\spot_id`).

Step 6. Open the source file that contains the template code as shown in Table 5-1, and complete the `perform_meas` subprogram. Then use the Agilent 4155/4156 *VXIplug&play* driver functions:

- `hp4156b_setSwitch` to enable/disable the source/measurement channels
- `hp4156b_force`, `hp4156b_setIv`, etc. to set source outputs
- `hp4156b_spotMeas`, `hp4156b_sweepIv`, etc. to perform measurements
- `hp4156b_zeroOutput` to disable source outputs

Step 7. Insert the code to display, store, or calculate data into the subprogram.

Step 8. Save the project (e.g. `\test\dev_a\spot_id`).

High-Speed Spot Measurements

This section explains an example subprogram that performs high speed spot measurement. The following subprogram will apply voltage to a MOSFET, measure drain current, and display the measurement result data.

Table 5-2 **High-Speed Spot Measurement Example**

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 drain; /* 3 */ ViInt32 gate; ViInt32 source; ViInt32 bulk; drain = 1; /* SMU1 */ gate = 2; /* SMU2 */ source = 3; /* SMU3 */ bulk = 4; /* SMU4 */ /* 11 */ ret = hp4156b_setSwitch(vi, drain, 1); /* 13 */ ret = hp4156b_setSwitch(vi, gate, 1); ret = hp4156b_setSwitch(vi, source, 1); ret = hp4156b_setSwitch(vi, bulk, 1); check_err (vi, ret); /* 17 */ ViReal64 vd; /* 19 */ ViReal64 vg; ViReal64 idcomp; ViReal64 igcomp; ViReal64 meas; ViInt32 status; vd = 1.5; idcomp = 0.05; vg = 1.5; igcomp = 0.01; /* 29 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 11	Declares variables, and defines the value.
13 to 16	Enables measurement channels.
17	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
19 to 29	Declares variables, and defines the value.

Programming Examples for C++ Users

High-Speed Spot Measurements

```

ret = hp4156b_force(vi, bulk, hp4156b_VF_MODE, 0, 0, 0.1, 0);          /* 31 */
ret = hp4156b_force(vi, source, hp4156b_VF_MODE, 0, 0, 0.1, 0);
ret = hp4156b_force(vi, gate, hp4156b_VF_MODE, 2, vg, igcomp, 0);
ret = hp4156b_force(vi, drain, hp4156b_VF_MODE, 2, vd, idcomp, 0);    /* 35 */
check_err (vi, ret);

ret = hp4156b_spotMeas(vi, drain, hp4156b_IM_MODE, 0, &meas, &status); /* 38 */
check_err (vi, ret);

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                         /* 40 */
check_err (vi, ret);                                                  /* 41 */

printf("Id = %9.6f mA (at %3.1f V)\n", meas * 1000, vd);             /* 43 */
printf("Vg = %3.1f V\n", vg);

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);                      /* 46 */
check_err (vi, ret);                                                  /* 47 */
}

```

Line	Description
31 to 34	Applies voltage to device.
37	Performs high speed spot measurement for the drain terminal.
40	Sets the specified port to the zero output state.
43 to 44	Displays the measurement result data.
46	Disables all ports.
35, 38, 41, and 47	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
48	End of the perform_meas subprogram.

Measurement Result Example

```

Id = 13.441500 mA (at 1.5 V)
Vg = 1.5 V

```

Multi-Channel Spot Measurements

This section explains an example subprogram that performs multi channel spot measurement. The following subprogram will apply voltage to a bipolar transistor, measure Ic and Ib, calculate hfe value, and display the measurement result data.

Table 5-3

Multi-Channel Spot Measurement Example

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 emitter; /* 3 */ ViInt32 base; ViInt32 collector; emitter = 1; /* SMU1 */ base = 2; /* SMU2 */ collector = 4; /* SMU4 */ /* 8 */ ret = hp4156b_setSwitch(vi, emitter, 1); /* 10 */ ret = hp4156b_setSwitch(vi, base, 1); ret = hp4156b_setSwitch(vi, collector, 1); check_err (vi, ret); /* 13 */ ViReal64 vc; /* 15 */ ViReal64 vb; ViReal64 iccomp; ViReal64 ibcomp; vc = 3; iccomp = 0.1; vb = 0.7; ibcomp = 0.01; ViInt32 mch[3]; ViInt32 mode[2]; ViReal64 range[2]; ViReal64 md[2]; ViInt32 st[2]; /* 29 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 8	Declares variables, and defines the value.
10 to 12	Enables measurement channels.
13	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
15 to 29	Declares variables, and defines the value.

Programming Examples for C++ Users

Multi-Channel Spot Measurements

```

mch[0] = collector; /* 31 */
mch[1] = base;
mch[2] = 0;
mode[0] = 1;
mode[1] = 1;
range[0] = 0;
range[1] = 0;

ret = hp4156b_force(vi, emitter, hp4156b_VF_MODE, 0, 0, 0.1, 0); /* 38 */
ret = hp4156b_force(vi, base, hp4156b_VF_MODE, 0, vb, ibcomp, 0);
ret = hp4156b_force(vi, collector, hp4156b_VF_MODE, 0, vc, iccomp, 0);
check_err (vi, ret); /* 42 */

ret = hp4156b_measureM(vi, mch, mode, range, &md[0], &st[0]); /* 45 */
check_err (vi, ret); /* 47 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL); /* 48 */
check_err (vi, ret);

printf("Ic = %8.6f mA\n", md[0] * 1000);
printf("Ib = %8.6f mA\n", md[1] * 1000);
printf("hfe = %10.6f \n", md[0]/md[1]); /* 52 */

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0); /* 54 */
check_err (vi, ret); /* 55 */
}

```

Line	Description
31 to 37	Defines the value for the variables used for the measurement channel.
39 to 41	Applies voltage to device.
44	Performs multi channel spot measurement.
47	Sets the specified port to the zero output state.
50 to 52	Displays the measurement result data.
54	Disables all ports.
42, 45, 48 and 55	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
56	End of the perform_meas subprogram.

Measurement Result Example

```

Ic = 3.846500 mA
Ib = 0.018970 mA
hfe = 202.767528

```


Staircase Sweep Measurements

This section explains an example subprogram that performs staircase sweep measurement. The following subprogram performs I-V measurement and save the measurement results (MOSFET Id-Vd characteristics) into a file.

Table 5-4 **Staircase Sweep Measurement Example**

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 drain = 1; /* SMU1 */ /* 4 */ ViInt32 gate = 2; /* SMU2 */ ViInt32 source = 3; /* SMU3 */ ViInt32 bulk = 4; /* SMU4 */ ViReal64 vd = 3; ViReal64 vg = 3; ViReal64 idcomp = 0.05; ViReal64 igcomp = 0.01; ViReal64 hold = 0; ViReal64 delay = 0; ViReal64 s_delay = 0; ViReal64 p_comp = 0; ViInt32 nop1 = 11; ViInt32 nop2 = 3; ViInt32 rep; ViReal64 sc[33]; ViReal64 md[33]; ViInt32 st[33]; ViReal64 dv[3]; ViInt32 i = 0; ViInt32 j; ViInt32 n; ViChar f_name[] = "C:\Agilent\data\data1.txt"; ViChar head1[] = "Vg (V), Vd (V), Id (mA), Status"; ViChar msg1[] = "Saving data..."; ViChar msg2[] = "Data save completed."; ViChar c = '\n'; /* 36 */ }</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
4 to 36	Declares variables, and defines the value.

Programming Examples for C++ Users

Staircase Sweep Measurements

```

ret = hp4156b_setSwitch(vi, drain, 1);                                /* 38 */
ret = hp4156b_setSwitch(vi, gate, 1);
ret = hp4156b_setSwitch(vi, source, 1);
ret = hp4156b_setSwitch(vi, bulk, 1);
check_err (vi, ret);                                                /* 42 */

                                                                    /* 44 */

ret = hp4156b_force(vi, bulk, hp4156b_VF_MODE, 0, 0, 0.1, 0);
ret = hp4156b_force(vi, source, hp4156b_VF_MODE, 0, 0, 0.1, 0);

for (j = 0; j < nop2; j++){                                          /* 48 */
    dvg[j] = (j + 1) * vg / nop2;
    ret = hp4156b_force(vi, gate, hp4156b_VF_MODE, 0, dvg[j], igcomp, 0);
    ret = hp4156b_setIv(vi, drain, hp4156b_SWP_VF_SGLLIN, 0, 0, vd, nop1, hold,
delay, s_delay, idcomp, p_comp);
    check_err (vi, ret);

    ret = hp4156b_sweepIv(vi, drain, hp4156b_IM_MODE, 0, &rep, &sc[i], &md[i],
&st[i]);
    check_err (vi, ret);

    if ( rep = nop1 ) {
        i = i + nop1;
    }
    else {
        printf ("%d measurement steps were returned.\nIt must be %d steps.\n", rep,
nop1);
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
        ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
        check_err (vi, ret);
        exit (ret);
    }
}                                                                    /* 67 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                      /* 69 */
check_err (vi, ret);

```

Line	Description
38 to 41	Enables measurement channels.
45 to 46	Applies voltage to device.
48 to 67	Applies dc voltage and sweep voltage, and performs staircase sweep measurement. After that, disables all ports and stops the program execution if the number of returned data is not equal to the nop1 value.
69	Sets the specified port to the zero output state.
42 and 70	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

```
printf(" Vg (V),  Vd (V),  Id (mA)\n");                                /* 72 */
for (j = 0; j < nop2; j++){
    n = j * nop1;
    for (i = n; i < n + nop1; i++){
        printf(" %4.2f,      %4.2f,      %9.6f \n", dvg[j], sc[i], md[i] * 1000);
    }
}                                                                    /* 79 */
FILE *stream;                                                         /* 81 */

if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (j = 0; j < nop2; j++){
        n = j * nop1;
        for (i = n; i < n + nop1; i++){
            fprintf( stream, "%4.2f, %4.2f, %9.6f, %d\n", dvg[j], sc[i], md[i] * 1000,
st[i]);
        }
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}                                                                    /* 100 */

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);                      /* 102 */
check_err (vi, ret);

}
```

Line	Description
72 to 79	Displays the measurement result data.
81 to 100	Saves the measurement results into a file (C:\Agilent\data\data1.txt, CSV file).
102	Disables all ports.
103	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
105	End of the perform_meas subprogram.

Programming Examples for C++ Users

Staircase Sweep Measurements

Measurement Result Example

```
Vg (V), Vd (V), Id (mA), Status
1.00, 0.00, -0.000114, 0
1.00, 0.30, 3.180000, 0
1.00, 0.60, 5.850000, 0
1.00, 0.90, 8.085500, 0
1.00, 1.20, 9.972000, 0
1.00, 1.50, 11.625000, 0
1.00, 1.80, 13.085000, 0
1.00, 2.10, 14.410000, 0
1.00, 2.40, 15.595000, 0
1.00, 2.70, 16.690000, 0
1.00, 3.00, 17.680000, 0
2.00, 0.00, -0.000117, 0
2.00, 0.30, 4.168000, 0
2.00, 0.60, 7.882000, 0
2.00, 0.90, 11.150500, 0
2.00, 1.20, 13.975000, 0
2.00, 1.50, 16.425000, 0
2.00, 1.80, 18.540000, 0
2.00, 2.10, 20.420000, 0
2.00, 2.40, 22.080000, 0
2.00, 2.70, 23.580000, 0
2.00, 3.00, 24.950000, 0
3.00, 0.00, -0.000114, 0
3.00, 0.30, 5.028500, 0
3.00, 0.60, 9.638000, 0
3.00, 0.90, 13.825000, 0
3.00, 1.20, 17.570000, 0
3.00, 1.50, 20.905000, 0
3.00, 1.80, 23.830000, 0
3.00, 2.10, 26.405000, 0
3.00, 2.40, 28.670000, 0
3.00, 2.70, 30.695000, 0
3.00, 3.00, 32.505000, 0
```

Synchronous Sweep Measurements

The following subprogram performs I-V measurement and saves the measurement results (MOSFET Id-Vg characteristics) into a file. The subprogram uses the synchronous sweep source set by the hp4156b_setSweepSync function.

Table 5-5

Synchronous Sweep Measurement Example

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 drain = 1; /* SMU1 */ /* 3 */ ViInt32 gate = 2; /* SMU2 */ ViInt32 source = 3; /* SMU3 */ ViInt32 bulk = 4; /* SMU4 */ ViReal64 vd = 3; ViReal64 vg = 3; ViReal64 idcomp = 0.05; ViReal64 igcomp = 0.01; ViReal64 hold = 0; ViReal64 delay = 0; ViReal64 s_delay = 0; ViReal64 pdcomp = 0; ViReal64 pgcomp = 0; ViInt32 nop = 11; ViInt32 rep; ViReal64 sc[11]; ViReal64 md[11]; ViInt32 st[11]; ViInt32 i; ViChar f_name[] = "C:\Agilent\data\data2.txt"; ViChar head1[] = "Vg (V), Id (mA), Status"; ViChar msg1[] = "Saving data..."; ViChar msg2[] = "Data save completed."; ViChar c = '\n'; /* 26 */ ret = hp4156b_setSwitch(vi, drain, 1); /* 27 */ ret = hp4156b_setSwitch(vi, gate, 1); ret = hp4156b_setSwitch(vi, source, 1); ret = hp4156b_setSwitch(vi, bulk, 1); check_err (vi, ret); /* 31 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 26	Declares variables, and defines the value.
27 to 30	Enables measurement channels.
31	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

Programming Examples for C++ Users

Synchronous Sweep Measurements

```

ret = hp4156b_force(vi, bulk, hp4156b_VF_MODE, 0, 0, 0.1, 0);          /* 33 */
ret = hp4156b_force(vi, source, hp4156b_VF_MODE, 0, 0, 0.1, 0);

ret = hp4156b_setIv(vi, gate, hp4156b_SWP_VF_SGLLIN, 0, 0, vg, nop, hold, delay,
s_delay, igcomp, pgcomp);
check_err (vi, ret);                                                  /* 37 */

ret = hp4156b_setSweepSync(vi, drain, hp4156b_VF_MODE, 0, 0, vd, idcomp, pdcomp);
check_err (vi, ret);

ret = hp4156b_sweepIv(vi, drain, hp4156b_IM_MODE, 0, &rep, &sc[0], &md[0], &st[0]);
check_err (vi, ret);                                                  /* 43 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                        /* 45 */
ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);                                                  /* 47 */

if ( rep != nop ) {                                                  /* 49 */
    printf ("%d measurement steps were returned.\nIt must be %d steps.\n", rep, nop);
    exit (ret);
}                                                                      /* 52 */

printf(" Vg (V), Id (mA)\n");                                         /* 54 */
for (i = 0; i < nop; i++){
    printf(" %4.2f, %9.6f \n", sc[i], md[i] * 1000);
}                                                                      /* 57 */

```

Line	Description
33 to 34	Applies voltage to device.
36	Sets the primary sweep source.
39	Sets the synchronous sweep source by using the hp4156b_setSweepSync function.
42	Performs staircase sweep measurement by using the hp4156b_sweepIv function.
45	Sets the specified port to the zero output state.
46	Disables all ports.
37, 40, 43, and 47	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
49 to 52	Stops the program execution if the number of returned data is not equal to nop.
54 to 57	Displays the measurement result data.

```
FILE *stream; /* 59 */

if( ( stream = fopen( f_name, "w+" ) ) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (i = 0; i < nop; i++){
        fprintf( stream, "%4.2f, %9.6f, %d\n", sc[i], md[i] * 1000, st[i]);
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
} /* 75 */
}
```

Line	Description
59 to 75	Saves the measurement results into a file (C:\Agilent\data\data2.txt, CSV file).
76	End of the perform_meas subprogram.

**Measurement
Result Example**

```
Vg (V), Id (mA), Status
0.00, 0.004043, 0
0.30, 2.330500, 0
0.60, 4.904000, 0
0.90, 7.723500, 0
1.20, 10.753000, 0
1.50, 13.975000, 0
1.80, 17.385000, 0
2.10, 20.955000, 0
2.40, 24.660000, 0
2.70, 28.500000, 0
3.00, 32.450000, 0
```

Multi-Channel Sweep Measurements

This section explains an example subprogram that performs multi channel sweep measurement. The following subprogram performs I-V measurement and saves the measurement results (bipolar transistor Ic-Vb and Ib-Vb characteristics) into a file.

Table 5-6

Multi-Channel Sweep Measurement Example

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 emitter = 1; /* SMU1 */ /* 3 */ ViInt32 base = 2; /* SMU2 */ ViInt32 collector = 4; /* SMU4 */ ViReal64 vb1 = 0.3; ViReal64 vb2 = 0.8; ViReal64 vc = 3; ViReal64 ve = 0; ViReal64 ibcomp = 0.01; ViReal64 iccomp = 0.1; ViReal64 iecomp = 0.1; ViReal64 pcomp = 0; ViInt32 nop = 11; ViReal64 hold = 0; ViReal64 delay = 0; ViReal64 s_delay = 0; ViReal64 p_comp = 0; ViReal64 width = 0.001; ViReal64 period = 0.01; ViReal64 p_hold = 0.1; ViInt32 mch[3]; ViInt32 mode[2]; ViReal64 range[2]; ViInt32 rep; ViReal64 sc[11]; ViReal64 md[22]; ViInt32 st[22]; mch[0] = collector; mch[1] = base; mch[2] = 0; mode[0] = 1; mode[1] = 1; range[0] = 0; range[1] = 0; /* 37 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 37	Declares variables, and defines the value.


```

ret = hp4156b_setSwitch(vi, emitter, 1);                                /* 39 */
ret = hp4156b_setSwitch(vi, base, 1);
ret = hp4156b_setSwitch(vi, collector, 1);
check_err (vi, ret);                                                  /* 42 */

ret = hp4156b_force(vi, emitter, hp4156b_VF_MODE, 0, ve, iecomp, 0);    /* 44 */
ret = hp4156b_force(vi, collector, hp4156b_VF_MODE, 0, vc, icomp, 0);

ret = hp4156b_setIv(vi, base, hp4156b_SWP_VF_SGLLIN, 0, vb1, vb2, nop, hold, delay,
s_delay, ibcomp, pcomp);
check_err (vi, ret);                                                  /* 48 */

ret = hp4156b_sweepMiv(vi, mch, mode, range, &rep, &sc[0], &md[0], &st[0]);
check_err (vi, ret);                                                  /* 51 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                          /* 53 */
ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);                                                  /* 55 */

if ( rep != nop ) {                                                  /* 57 */
    printf ("%d measurement steps were returned.\nIt must be %d steps.\n", rep, nop);
    exit (ret);
}

```

Line	Description
39 to 41	Enables measurement channels.
44 to 45	Applies voltage to device.
47	Sets the staircase sweep source.
50	Performs measurement by using the hp4156b_sweepMiv function.
53	Sets the specified port to the zero output state.
54	Disables all ports.
42, 48, 51, and 55	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
57 to 60	Stops the program execution if the number of returned data is not equal to the nop value.

Programming Examples for C++ Users

Multi-Channel Sweep Measurements

```

ViInt32    i;                                     /* 67 */
ViInt32    n;
printf(" Vb (V), Ic (mA), Ib (mA)\n");
for (i = 0; i < nop; i++){
    printf(" %4.2f, %11.8f, %11.8f\n", sc[i], md[2*i] * 1000, md[2*i+1] * 1000);
}

ViChar     f_name[] = "C:\Agilent\data\data3.txt";          /* 74 */
ViChar     head1[] = "Vb (V), Ic (mA), Ib (mA), hfe, Status_c, Status_b";
ViChar     msg1[] = "Saving data...";
ViChar     msg2[] = "Data save completed.";
ViChar     c = '\n';
FILE *stream;
if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (i = 0; i < nop; i++){
        fprintf( stream, "%4.2f, %11.8f, %11.8f, %12.8f, %d, %d\n", sc[i], md[2*i] *
1000, md[2*i+1] * 1000, md[2*i]/md[2*i+1], st[2*i], st[2*i+1]);
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}
}
/* 96 */

```

Line	Description
67 to 72	Displays the measurement result data.
74 to 95	Saves the measurement results into a file (C:\Agilent\data\data3.txt, CSV file).
96	End of the perform_meas subprogram.

Measurement Result Example

```

Vb (V), Ic (mA), Ib (mA), hfe, Status_c, Status_b
0.30, 0.00000083, -0.00000001, -59.41935484, 0, 0
0.35, 0.00000557, 0.00000005, 123.29646018, 0, 0
0.40, 0.00003837, 0.00000032, 119.64452760, 0, 0
0.45, 0.00026580, 0.00000190, 140.15291326, 0, 0
0.50, 0.00185550, 0.00001155, 160.64935065, 0, 0
0.55, 0.01274500, 0.00007378, 172.73158501, 0, 0
0.60, 0.08796500, 0.00047225, 186.26786660, 0, 0
0.65, 0.60135000, 0.00303550, 198.10574864, 0, 0
0.70, 3.84650000, 0.01897000, 202.76752768, 0, 0
0.75, 18.79500000, 0.09735000, 193.06625578, 0, 0
0.80, 55.71000000, 0.33300000, 167.29729730, 0, 0

```

Pulsed Spot Measurements

This section explains an example subprogram that performs pulsed spot measurement. The following subprogram will apply voltage to a MOSFET, measure drain current, and display the measurement result data.

Table 5-7 Pulsed Spot Measurement Example

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 drain; /* 3 */ ViInt32 gate; ViInt32 source; ViInt32 bulk; drain = 1; /* SMU1 */ gate = 2; /* SMU2 */ source = 3; /* SMU3 */ bulk = 4; /* SMU4 */ ViReal64 vd; ViReal64 vg; ViReal64 idcomp; ViReal64 igcomp; ViReal64 base; ViReal64 width; ViReal64 period; ViReal64 hold; ViReal64 meas; ViInt32 status; /* 21 */ ret = hp4156b_setSwitch(vi, drain, 1); /* 23 */ ret = hp4156b_setSwitch(vi, gate, 1); ret = hp4156b_setSwitch(vi, source, 1); ret = hp4156b_setSwitch(vi, bulk, 1); ret = hp4156b_setFilter(vi, gate, hp4156b_FLAG_OFF); check_err (vi, ret); /* 28 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 21	Declares variables, and defines the value.
23 to 27	Enables measurement channels, and sets the filter off for the SMU used for the pulse source.
28	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

Programming Examples for C++ Users

Pulsed Spot Measurements

```

vd =      1.5;                                /* 30 */
idcomp = 0.05;
vg =      1.5;
igcomp = 0.01;
base =    0;
width =   0.001;
period =  0.01;
hold =    0.1;                                /* 37 */

ret = hp4156b_force(vi, bulk, hp4156b_VF_MODE, 0, 0, 0.1, 0);
ret = hp4156b_force(vi, source, hp4156b_VF_MODE, 0, 0, 0.1, 0);
ret = hp4156b_setPbias(vi, gate, hp4156b_VF_MODE, 2, base, vg,
width, period, hold, igcomp);
ret = hp4156b_force(vi, drain, hp4156b_VF_MODE, 2, vd, idcomp, 0);
check_err (vi, ret);                          /* 43 */

ret = hp4156b_measureP(vi, drain, hp4156b_IM_MODE, 0, &meas, &status);
check_err (vi, ret);                          /* 46 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
check_err (vi, ret);                          /* 49 */

printf("Id = %9.6f mA (at %3.1f V)\n", meas * 1000, vd);
printf("Vg = %3.1f V\n", vg);                /* 52 */

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);                          /* 55 */
}

```

Line	Description
30 to 37	Defines the variable values for the source channels.
39 to 42	Applies voltage to device, and sets the pulsed bias source.
45	Performs pulsed spot measurement.
48	Sets the specified port to the zero output state.
51 to 52	Displays the measurement result data.
54	Disables all ports.
43, 46, 49 and 55	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
56	End of the perform_meas subprogram.

Measurement Result Example

```

Id = 14.255000 mA (at 1.5 V)
Vg = 1.5 V

```

Multi-Channel Pulsed Spot Measurements

This section explains an example subprogram that performs multi channel pulsed spot measurement. The following subprogram will apply voltage to a bipolar transistor, measure I_c and I_b , and display the measurement result data.

Table 5-8

Multi-Channel Pulsed Spot Measurement Example

<pre> void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 emitter; /* 3 */ ViInt32 base; ViInt32 collector; emitter = 1; /* SMU1 */ base = 2; /* SMU2 */ collector = 4; /* SMU4 */ ViReal64 vc; ViReal64 vb; ViReal64 iccomp; ViReal64 ibcomp; vc = 0; vb = 0; iccomp = 0.1; ibcomp = 0.1; ViInt32 mch[3]; ViInt32 mode[2]; ViReal64 range[2]; ViReal64 md[2]; ViInt32 st[2]; ViInt32 eod; ViInt32 type; ViReal64 mdata; ViInt32 stat; ViInt32 ch; ret = hp4156b_setSwitch(vi, emitter, 1); /* 27 */ ret = hp4156b_setSwitch(vi, base, 1); ret = hp4156b_setSwitch(vi, collector, 1); ret = hp4156b_setFilter(vi, emitter, hp4156b_FLAG_OFF); /* 30 */ check_err (vi, ret); </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 26	Declares variables, and defines the value.
27 to 30	Enables measurement channels, and sets the filter off for the SMU used for the pulse source.
31	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

Programming Examples for C++ Users

Multi-Channel Pulsed Spot Measurements

```

mch[0] = collector; /* 32 */
mch[1] = base;
mch[2] = 0;
mode[0] = 1;
mode[1] = 1;
range[0] = 0;
range[1] = 0;
ret = hp4156b_cmd(vi, "PT 0,0.005,0.01,0,1"); /* 39 */
ret = hp4156b_cmd(vi, "PV 1,0,0,-0.8,0.1");
ret = hp4156b_force(vi, base, hp4156b_VF_MODE, 0, vb, ibcomp, 0); /* 41 */
ret = hp4156b_force(vi, collector, hp4156b_VF_MODE, 0, vc, iccomp, 0);
check_err(vi, ret); /* 43 */
ret = hp4156b_startMeasure(vi, hp4156b_MM_PSPOT, mch, mode, range,
hp4156b_FLAG_OFF);
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL); /* 45 */
check_err(vi, ret);
ret = hp4156b_readData(vi, &eod, &type, &mdata, &stat, &ch); /* 47 */
md[0]=mdata;
st[0]=stat;
ret = hp4156b_readData(vi, &eod, &type, &mdata, &stat, &ch);
md[1]=mdata;
st[1]=stat;
check_err(vi, ret);
printf("Ic = %9.6f mA\n", md[0] * 1000);
printf("Ib = %9.6f mA\n", md[1] * 1000);
ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0); /* 56 */
check_err(vi, ret);
}

```

Line	Description
32 to 38	Defines the value for the variables used for the measurement channel.
39 to 40	Sets the pulse source timing parameters and voltage output parameters.
41 to 42	Applies voltage to device.
44	Performs multi channel pulsed spot measurement.
45	Sets the specified port to the zero output state.
47 to 55	Reads the measurement data, and displays the result.
56	Disables all ports.
43, 46, 53 and 57	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
58	End of the perform_meas subprogram.

Measurement Result Example

```

Ic = 43.357000 mA
Ib = 0.336762 mA

```

Pulsed Sweep Measurements

This section explains an example subprogram that performs pulsed sweep measurement and saves the measurement results (bipolar transistor Ic-Vc characteristics) into a file.

Table 5-9 Pulsed Sweep Measurement Example

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 emitter = 1; /* SMU1 */ ViInt32 base = 2; /* SMU2 */ ViInt32 collector = 4; /* SMU4 */ ViReal64 vc = 3; ViReal64 ib = 150E-6; ViReal64 iccomp = 0.05; ViReal64 vbcomp = 5; ViReal64 hold = 0.1; ViReal64 width = 0.001; ViReal64 period = 0.01; ViInt32 nop1 = 11; ViInt32 nop2 = 3; ViInt32 rep; ViReal64 sc[33]; ViReal64 md[33]; ViInt32 st[33]; ViReal64 dib[3]; ViInt32 i = 0; ViInt32 j; ViInt32 n; ViChar f_name[] = "C:\Agilent\data\data4.txt"; ViChar head1[] = "Ib (uA), Vc (V), Ic (mA), Status"; ViChar msg1[] = "Saving data..."; ViChar msg2[] = "Data save completed."; ViChar c = '\n'; ret = hp4156b_setSwitch(vi, emitter, 1); /* 31 */ ret = hp4156b_setSwitch(vi, base, 1); ret = hp4156b_setSwitch(vi, collector, 1); check_err (vi, ret); /* 34 */</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 29	Declares variables, and defines the value.
31 to 33	Enables measurement channels.

Programming Examples for C++ Users

Pulsed Sweep Measurements

```

ret = hp4156b_setFilter(vi, collector, hp4156b_FLAG_OFF);
ret = hp4156b_force(vi, emitter, hp4156b_VF_MODE, 0, 0, 0.1, 0);

for (j = 0; j < nop2; j++){                                     /* 39 */
    dib[j] = (j + 1) * ib / nop2;
    ret = hp4156b_force(vi, base, hp4156b_IF_MODE, 0, dib[j], vbcomp, 0);
    ret = hp4156b_setPiv(vi, collector, hp4156b_SWP_VF_SGLLIN, 0, base, 0, vc, nop1,
hold, width, period, iccomp);
    check_err (vi, ret);

    ret = hp4156b_sweepPiv(vi, collector, hp4156b_IM_MODE, 0, &rep, &sc[i], &md[i],
&st[i]);
    check_err (vi, ret);

    if ( rep = nop1 ) {
        i = i + nop1;
    }
    else {
        printf ("%d measurement steps were returned.\nIt must be %d steps.\n", rep,
nop1);
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
        ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
        check_err (vi, ret);
        exit (ret);
    }
}                                                                 /* 58 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                  /* 60 */
check_err (vi, ret);

```

Line	Description
36	Sets the filter off for the SMU used for the pulse source.
37	Applies voltage to device.
39 to 58	Applies dc current and pulsed sweep voltage, and performs pulsed sweep measurement. After that, disables all ports and stops the program execution if the number of returned data is not equal to the nop1 value.
60	Sets the specified port to the zero output state.
34, 43, 46, 55, and 61	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.


```

printf(" Ib (uA),  Vc (V),  Ic (mA)\n");                                /* 63 */
for (j = 0; j < nop2; j++){
    n = j * nop1;
    for (i = n; i < n + nop1; i++){
        printf(" %5.1f,      %4.2f,      %9.6f \n", dib[j] * 1E6, sc[i], md[i] * 1000);
    }
}                                                                    /* 70 */

FILE *stream;                                                         /* 72 */

if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (j = 0; j < nop2; j++){
        n = j * nop1;
        for (i = n; i < n + nop1; i++){
            fprintf( stream, "%5.1f, %4.2f, %9.6f, %d\n", dib[j] * 1E6, sc[i], md[i] *
1000, st[i]);
        }
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}                                                                    /* 91 */

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);                       /* 93 */
check_err (vi, ret);

}

```

Line	Description
63 to 70	Displays the measurement result data.
72 to 91	Saves the measurement results into a file (C:\Agilent\data\data4.txt, CSV file).
93	Disables all ports.
94	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
96	End of the perform_meas subprogram.

Programming Examples for C++ Users

Pulsed Sweep Measurements

Measurement Result Example

Ib (uA)	Vc (V)	Ic (mA)	Status
50.0	0.00	-0.050000	0
50.0	0.30	9.015000	0
50.0	0.60	9.760000	0
50.0	0.90	9.825000	0
50.0	1.20	9.840000	0
50.0	1.50	9.875000	0
50.0	1.80	9.905000	0
50.0	2.10	9.950000	0
50.0	2.40	9.935000	0
50.0	2.70	9.970000	0
50.0	3.00	10.010000	0
100.0	0.00	-0.095000	0
100.0	0.30	15.765000	0
100.0	0.60	18.245000	0
100.0	0.90	18.910000	0
100.0	1.20	19.030000	0
100.0	1.50	19.105000	0
100.0	1.80	19.200000	0
100.0	2.10	19.250000	0
100.0	2.40	19.310000	0
100.0	2.70	19.385000	0
100.0	3.00	19.420000	0
150.0	0.00	-0.145000	0
150.0	0.30	21.140000	0
150.0	0.60	24.710000	0
150.0	0.90	26.660000	0
150.0	1.20	27.505000	0
150.0	1.50	27.800000	0
150.0	1.80	27.935000	0
150.0	2.10	28.050000	0
150.0	2.40	28.205000	0
150.0	2.70	28.285000	0
150.0	3.00	28.330000	0

Multi-Channel Pulsed Sweep Measurements

This section explains an example subprogram that performs multi channel pulsed sweep measurement. The following subprogram performs I-V measurement and saves the measurement results (bipolar transistor Ic-Ve and Ib-Ve characteristics) into a file.

Table 5-10

Multi-Channel Pulsed Sweep Measurement Example

<pre> void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 emitter = 1; /* SMU1 */ /* 3 */ ViInt32 base = 2; /* SMU2 */ ViInt32 collector = 4; /* SMU4 */ ViReal64 vb = 0; ViReal64 vc = 0; ViReal64 ibcomp = 0.1; ViReal64 iccomp = 0.1; ViInt32 nop = 11; ViInt32 mch[3]; ViInt32 mode[2]; ViReal64 range[2]; ViInt32 rep; ViReal64 sc[11]; ViReal64 md1[11]; ViReal64 md2[11]; ViInt32 eod; ViInt32 type; ViReal64 mdata; ViInt32 stat; ViInt32 ch; mch[0] = collector; mch[1] = base; mch[2] = 0; mode[0] = 1; mode[1] = 1; range[0] = 0; range[1] = 0; </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 33	Declares variables, and defines the value.

Programming Examples for C++ Users

Multi-Channel Pulsed Sweep Measurements

```

ret = hp4156b_setSwitch(vi, emitter, 1);                                /* 35 */
ret = hp4156b_setSwitch(vi, base, 1);
ret = hp4156b_setSwitch(vi, collector, 1);
ret = hp4156b_setFilter(vi, emitter, hp4156b_FLAG_OFF);
ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, hp4156b_INTEG_TIME_MIN, 2);
check_err (vi, ret);                                                  /* 40 */

ret = hp4156b_cmd(vi, "PT 0,0.005,0.01,0,1");                        /* 42 */
ret = hp4156b_cmd(vi, "PWV 1,1,0,0,0,-0.8,11,0.1,0");
ret = hp4156b_force(vi, base, hp4156b_VF_MODE, 0, vb, ibcomp, 0);    /* 44 */
ret = hp4156b_force(vi, collector, hp4156b_VF_MODE, 0, vc, iccomp, 0);

ret = hp4156b_startMeasure(vi, hp4156b_MM_PSWEPT, mch, mode, range,
hp4156b_FLAG_ON);
check_err (vi, ret);                                                  /* 48 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                        /* 50 */
ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);                                                  /* 52 */

ViInt32    i;                                                         /* 54 */
for (i = 0; i < nop ; i++){
    ret = hp4156b_readData(vi, &eod, &type, &mdata, &stat, &ch);
    md1[i] = mdata;           /* Data measured by mch[0] = collector */
    ret = hp4156b_readData(vi, &eod, &type, &mdata, &stat, &ch);
    md2[i] = mdata;           /* Data measured by mch[1] = base */
    ret = hp4156b_readData(vi, &eod, &type, &mdata, &stat, &ch);
    sc[i] = mdata;           /* Pulsed sweep source output data */
}                                                                      /* 62 */

```

Line	Description
35 to 37	Enables measurement channels.
38	Sets the filter off for the SMU used for the pulse source.
39	Sets the A/D converter integration time.
42 to 43	Sets the pulsed sweep source timing parameters and voltage output parameters.
44 to 45	Applies voltage to device.
47	Performs multi channel pulsed sweep measurement.
50	Sets the specified port to the zero output state.
51	Disables all ports.
40, 48, and 52	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
54 to 62	Reads measurement data.

```

printf(" Ve (V), Ic (mA), Ib (mA)\n");
for (i = 0; i < nop; i++){
    printf(" %5.2f, %11.8f, %11.8f\n", sc[i], mdl[i] * 1000, md2[i] * 1000);
}

ViChar    f_name[] = "C:\Agilent\data\data5.txt";          /* 74 */
ViChar    head1[] = "Ve (V), Ic (mA), Ib (mA)";
ViChar    msg1[] = "Saving data...";
ViChar    msg2[] = "Data save completed.";
ViChar    c = '\n';
FILE *stream;
if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (i = 0; i < nop; i++){
        fprintf( stream, "%5.2f, %11.8f, %11.8f\n", sc[i], mdl[i] * 1000, md2[i] *
1000);
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}
}
/* 96 */

```

Line	Description
67 to 72	Displays the measurement result data.
74 to 95	Saves the measurement results into a file (C:\Agilent\data\data5.txt, CSV file).
96	End of the perform_meas subprogram.

Measurement Result Example

```

Ve (V), Ic (mA), Ib (mA)
0.00, 0.00000000, 0.00000000
-0.08, 0.00000000, 0.00000000
-0.16, 0.00000000, 0.00000000
-0.24, 0.00000008, 0.00000000
-0.32, 0.00000169, 0.00000003
-0.40, 0.00003758, 0.00000035
-0.48, 0.00083207, 0.00000569
-0.56, 0.01834160, 0.00010753
-0.64, 0.40003000, 0.00207454
-0.72, 7.24961000, 0.03680280
-0.80, 43.35560000, 0.33661400

```

Staircase Sweep with Pulsed Bias Measurements

This section explains an example subprogram that performs staircase sweep with pulsed bias measurement and saves the measurement results (MOSFET Id-Vd characteristics) into a file.

Table 5-11

Staircase Sweep with Pulsed Bias Measurement Example

<pre> void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 drain = 1; /* SMU1 */ /* 4 */ ViInt32 gate = 2; /* SMU2 */ ViInt32 source = 3; /* SMU3 */ ViInt32 bulk = 4; /* SMU4 */ ViReal64 vd = 3; ViReal64 vg = 3; ViReal64 idcomp = 0.05; ViReal64 igcomp = 0.01; ViReal64 hold = 0; ViReal64 delay = 0; ViReal64 s_delay = 0; ViReal64 p_comp = 0; ViReal64 width = 0.001; ViReal64 period = 0.01; ViReal64 p_hold = 0.1; ViInt32 nop1 = 11; ViInt32 nop2 = 3; ViInt32 i = 0; ViInt32 j; ViInt32 n; ViInt32 rep; ViReal64 sc[33]; ViReal64 md[33]; ViInt32 st[33]; ViReal64 dvg[3]; ViChar f_name[] = "C:\Agilent\data\data6.txt"; ViChar head1[] = "Vg (V), Vd (V), Id (mA), Status"; ViChar msg1[] = "Saving data..."; ViChar msg2[] = "Data save completed."; ViChar c = '\n'; /* 36 */ </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
4 to 36	Declares variables, and defines the value.

Programming Examples for C++ Users

Staircase Sweep with Pulsed Bias Measurements

```

ret = hp4156b_setSwitch(vi, drain, 1);                                /* 38 */
ret = hp4156b_setSwitch(vi, gate, 1);
ret = hp4156b_setSwitch(vi, source, 1);
ret = hp4156b_setSwitch(vi, bulk, 1);
check_err (vi, ret);                                                /* 42 */

ret = hp4156b_setFilter(vi, gate, hp4156b_FLAG_OFF);                /* 44 */
ret = hp4156b_force(vi, bulk, hp4156b_VF_MODE, 0, 0, 0.1, 0);
ret = hp4156b_force(vi, source, hp4156b_VF_MODE, 0, 0, 0.1, 0);

for (j = 0; j < nop2; j++){                                          /* 48 */
    dvg[j] = (j + 1) * vg / nop2;
    ret = hp4156b_setPbias(vi, gate, hp4156b_VF_MODE, 0, 0, dvg[j], width, period,
p_hold, igcomp);
    ret = hp4156b_setIv(vi, drain, hp4156b_SWP_VF_SGLLIN, 0, 0, vd, nop1, hold,
delay, s_delay, Idcomp, p_comp);
    check_err (vi, ret);

    ret = hp4156b_sweepPbias(vi, drain, hp4156b_IM_MODE, 0, &rep, &sc[i], &md[i],
&st[i]);
    check_err (vi, ret);

    if ( rep = nop1 ) {
        i = i + nop1;
    }
    else {
        printf ("%d measurement steps were returned.\nIt must be %d steps.\n", rep,
nop1);
        ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
        ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
        check_err (vi, ret);
        exit (ret);
    }
}                                                                    /* 67 */

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);                      /* 69 */
check_err (vi, ret);

```

Line	Description
38 to 41	Enables measurement channels.
44	Sets the filter off for the SMU used for the pulse source.
45 to 46	Applies voltage to device.
48 to 67	Applies pulsed voltage and sweep voltage, and performs staircase sweep measurement. After that, disables all ports and stops the program execution if the number of returned data is not equal to the nop1 value.
69	Sets the specified port to the zero output state.
42 and 70	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

Programming Examples for C++ Users

Staircase Sweep with Pulsed Bias Measurements

```

printf(" Vg (V),  Vd (V),  Id (mA)\n");                                /* 72 */

for (j = 0; j < nop2; j++){
    n = j * nop1;
    for (i = n; i < n + nop1; i++){
        printf(" %4.2f,      %4.2f,      %9.6f \n", dvg[j], sc[i], md[i] * 1000);
    }
}                                                                    /* 79 */

FILE *stream;                                                         /* 81 */

if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (j = 0; j < nop2; j++){
        n = j * nop1;
        for (i = n; i < n + nop1; i++){
            fprintf( stream, "%4.2f, %4.2f, %9.6f, %d\n", dvg[j], sc[i], md[i] * 1000,
st[i]);
        }
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}                                                                    /* 100 */

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);                      /* 102 */
check_err (vi, ret);

}

```

Line	Description
72 to 79	Displays the measurement result data.
81 to 100	Saves the measurement results into a file (C:\Agilent\data\data6.txt, CSV file).
102	Disables all ports.
103	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
105	End of the perform_meas subprogram.

Programming Examples for C++ Users

Staircase Sweep with Pulsed Bias Measurements

Measurement Result Example

Vg (V)	Vd (V)	Id (mA)	Status
1.00	0.00	0.005000	0
1.00	0.30	3.170000	0
1.00	0.60	5.835000	0
1.00	0.90	8.040000	0
1.00	1.20	9.905000	0
1.00	1.50	11.530000	0
1.00	1.80	12.965000	0
1.00	2.10	14.270000	0
1.00	2.40	15.425000	0
1.00	2.70	16.495000	0
1.00	3.00	17.460000	0
2.00	0.00	0.005000	0
2.00	0.30	4.165000	0
2.00	0.60	7.875000	0
2.00	0.90	11.135000	0
2.00	1.20	13.945000	0
2.00	1.50	16.370000	0
2.00	1.80	18.470000	0
2.00	2.10	20.320000	0
2.00	2.40	21.950000	0
2.00	2.70	23.430000	0
2.00	3.00	24.780000	0
3.00	0.00	0.000000	0
3.00	0.30	5.035000	0
3.00	0.60	9.650000	0
3.00	0.90	13.835000	0
3.00	1.20	17.575000	0
3.00	1.50	20.895000	0
3.00	1.80	23.810000	0
3.00	2.10	26.355000	0
3.00	2.40	28.615000	0
3.00	2.70	30.615000	0
3.00	3.00	32.410000	0

Sampling Measurements

This section explains an example subprogram that measures current of a device with two high terminals and a low terminal, and saves the measurement results data.

Table 5-12 **Sampling Measurement Example**

<pre> void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 t1 = 1; /* SMU1 */ ViInt32 t2 = 2; /* SMU2 */ ViInt32 low = 3; /* SMU3 */ ViReal64 base = 0; ViReal64 bias = 0.1; ViReal64 icomp = 0.1; ViReal64 vlout = 0; ViReal64 ilcomp = 0.1; ViReal64 hold = 0.1; ViReal64 interval = 0.05; ViInt32 nop = 30; ViInt32 mch[3]; ViInt32 mode[2]; ViReal64 range[2]; ViInt32 point; ViInt32 index[30]; ViReal64 value[60]; ViInt32 status[60]; mch[0] = t1; mch[1] = t2; mch[2] = 0; mode[0] = 1; mode[1] = 1; range[0] = 0; range[1] = 0; /* 27 */ ret = hp4156b_setSwitch(vi, t1, 1); ret = hp4156b_setSwitch(vi, t2, 1); ret = hp4156b_setSwitch(vi, low, 1); ret = hp4156b_setFilter(vi, hp4156b_CH_ALL, hp4156b_FLAG_ON); ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, 0.0001, 2); </pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 27	Declares variables, and defines the value.
28 to 30	Enables measurement channels.
31	Sets the filter on for the all SMUs.
32	Sets the A/D converter integration time.

```

ret = hp4156b_setSample(vi, hold, interval, nop); /* 34 */
ret = hp4156b_addSampleSyncIv(vi, t1, hp4156b_VF_MODE, 0, base, bias, icom);
ret = hp4156b_addSampleSyncIv(vi, t2, hp4156b_VF_MODE, 0, base, bias, icom);
ret = hp4156b_force(vi, low, hp4156b_VF_MODE, 0, vlout, ilcomp, 0);
check_err (vi, ret);

ret = hp4156b_sample(vi, mch, mode, range, &point, &index[0], &value[0],
&status[0]); /* 40 */
check_err (vi, ret);

ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
check_err (vi, ret);

if ( point != nop ) { /* 46 */
    printf ("%d measurement data were returned.\nIt must be %d data.\n", point,
nop);
    ret = hp4156b_clearSampleSync(vi);
    ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
    check_err (vi, ret);
    exit (ret);
}

ViInt32 i; /* 54 */
ViChar f_name[] = "C:\\Agilent\\data\\data7.txt";
ViChar head1[] = "Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status";
ViChar msg1[] = "Saving data...";
ViChar msg2[] = "Data save completed.";
ViChar c = '\n';

```

Line	Description
34	Sets the sampling measurement timing parameters and the number of samples.
35 to 36	Sets the constant voltage sources for the sampling measurement.
37	Applies voltage to the low terminal of the device.
40	Performs the sampling measurement using the channels specified by mch.
43	Sets the specified port to the zero output state.
46 to 52	Clears the sampling source setup information, disables all ports, and stops the program execution if the number of returned data is not equal to the nop value.
38, 41, 44, and 50	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
54 to 59	Declares variables, and defines the value.

Programming Examples for C++ Users

Sampling Measurements

```

printf(" Index,  R1 (ohm),  R2 (ohm)\n");                                /* 61 */
for (i = 0; i < nop; i++){
    printf("   %2d,   %6.3f,   %6.3f \n", index[i], bias/value[2 * i], bias/value[2
* i + 1]);
}                                                                    /* 64 */

FILE *stream;                                                         /* 66 */

if( ( stream = fopen( f_name, "w+" )) == NULL ){
    printf( "Data file was not opened\n" );
}
else {
    printf( "%s%c", msg1, c );
    fprintf( stream, "%s%c", head1, c );
    for (i = 0; i < nop; i++){
        fprintf(stream,"%2d,%7.3f,%6.3f,%7.3f,%6.3f, %d\n",index[i],value[2 * i] *
1000, bias/value[2 * i], value[2 * i + 1] * 1000, bias/value[2 * i + 1], status[i]);
    }
    printf( "%s%c", msg2, c );
}

if( fclose( stream ) ){
    printf( "Data file was not closed\n" );
}                                                                    /* 82 */

ret = hp4156b_clearSampleSync(vi);
ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);
}

```

Line	Description
61 to 64	Displays the measurement result data.
66 to 82	Saves the measurement results into a file (C:\Agilent\data\data7.txt, CSV file).
84	Clears the source setup information for the sampling measurement.
85	Disables all ports.
86	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
87	End of the perform_meas subprogram.

**Measurement
Result Example**

```
Index, I1 (mA), R1 (ohm), I2 (mA), R2 (ohm), Status
1, 11.136, 8.980, 10.755, 9.298, 0
2, 11.136, 8.980, 10.759, 9.295, 0
3, 11.147, 8.971, 10.766, 9.289, 0
4, 11.136, 8.980, 10.762, 9.292, 0
5, 11.136, 8.980, 10.759, 9.295, 0
6, 11.147, 8.971, 10.762, 9.292, 0
7, 11.143, 8.974, 10.755, 9.298, 0
8, 11.143, 8.974, 10.769, 9.286, 0
9, 11.136, 8.980, 10.752, 9.301, 0
10, 11.133, 8.982, 10.759, 9.295, 0
11, 11.147, 8.971, 10.752, 9.301, 0
12, 11.136, 8.980, 10.759, 9.295, 0
13, 11.136, 8.980, 10.755, 9.298, 0
14, 11.147, 8.971, 10.766, 9.289, 0
15, 11.140, 8.977, 10.755, 9.298, 0
16, 11.143, 8.974, 10.762, 9.292, 0
17, 11.153, 8.966, 10.762, 9.292, 0
18, 11.147, 8.971, 10.759, 9.295, 0
19, 11.143, 8.974, 10.755, 9.298, 0
20, 11.143, 8.974, 10.755, 9.298, 0
21, 11.140, 8.977, 10.762, 9.292, 0
22, 11.140, 8.977, 10.755, 9.298, 0
23, 11.140, 8.977, 10.759, 9.295, 0
24, 11.136, 8.980, 10.759, 9.295, 0
25, 11.133, 8.982, 10.749, 9.304, 0
26, 11.136, 8.980, 10.762, 9.292, 0
27, 11.136, 8.980, 10.755, 9.298, 0
28, 11.136, 8.980, 10.766, 9.289, 0
29, 11.133, 8.982, 10.755, 9.298, 0
30, 11.147, 8.971, 10.759, 9.295, 0
```

Stress Force

This section explains an example subprogram that performs current measurement of a device with two high terminals and a low terminal, applies stress, performs current measurement again, and displays the measurement result data.

Table 5-13 **Stress Force Example**

<pre>void perform_meas (ViSession vi, ViStatus ret) /* 1 */ { ViInt32 t1 = 1; /* SMU1 */ ViInt32 t2 = 2; /* SMU2 */ ViInt32 low = 3; /* SMU3 */ ViReal64 range = 0.0; ViReal64 base = 0.0; ViReal64 stress = 2.0; ViReal64 bias = 0.1; ViReal64 icomp = 0.1; ViReal64 vlout = 0; ViReal64 ilcomp = 0.1; ViReal64 hold = 0.0; ViReal64 duration = 5.0; ViReal64 period = 0.01; ViInt32 status; ViReal64 md[2]; ViInt32 st[2]; /* 18 */ ret = hp4156b_setSwitch(vi, t1, 1); ret = hp4156b_setSwitch(vi, t2, 1); ret = hp4156b_setSwitch(vi, low, 1); ret = hp4156b_setFilter(vi, hp4156b_CH_ALL, hp4156b_FLAG_ON); ret = hp4156b_setInteg(vi, hp4156b_INTEG_TBL_SHORT, hp4156b_INTEG_TIME_MIN, 2); check_err (vi, ret);</pre>	
Line	Description
1	Beginning of the perform_meas subprogram.
3 to 18	Declares variables, and defines the value.
20 to 22	Enables measurement channels.
23	Sets the filter on for the all SMUs.
24	Sets the A/D converter integration time.
25	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

```

ret = hp4156b_force(vi, low, hp4156b_VF_MODE, range, vlout, ilcomp, 0); /* 27 */
ret = hp4156b_force(vi, t1, hp4156b_VF_MODE, range, bias, icomp, 0);
ret = hp4156b_force(vi, t2, hp4156b_VF_MODE, range, bias, icomp, 0);
ret = hp4156b_spotMeas(vi, t1, hp4156b_IM_MODE, range, &md[0], &st[0]);
ret = hp4156b_spotMeas(vi, t2, hp4156b_IM_MODE, range, &md[1], &st[1]);
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
check_err (vi, ret);

printf("Data before stress:\n"); /* 35 */
printf("T1 current = %8.5f [mA], Status = %d \n", md[0] * 1000, st[0]);
printf("T2 current = %8.5f [mA], Status = %d \n", md[1] * 1000, st[1]);
printf("\n");

ret = hp4156b_setStress(vi, hold, hp4156b_STT_TIME, duration, period); /* 40 */
check_err (vi, ret);
ret = hp4156b_force(vi, low, hp4156b_VF_MODE, range, vlout, ilcomp, 0);
ret = hp4156b_addStressSyncIv(vi, 1, t1, 2, range, base, stress, icomp);
check_err (vi, ret);
ret = hp4156b_addStressSyncIv(vi, 2, t2, 2, range, base, stress, icomp);
check_err (vi, ret);

printf("Stress force in progress: %3.1f [V], %3.1f [sec]\n", stress, duration);
printf("\n");

ret = hp4156b_stress(vi, &status); /* 51 */
check_err (vi, ret);

ret = hp4156b_clearStressSync(vi);

```

Line	Description
27 to 32	Applies voltage to device, performs spot measurement, and sets the specified port to the zero output state.
35 to 38	Displays the measurement result data.
40	Sets the stress source timing parameters.
42	Applies voltage to the low terminal of the device.
43 and 45	Sets the stress source outputs.
51	Applies stress to the device.
54	Clears the stress source setup information.
33, 41, 44, 46, and 52	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.

Programming Examples for C++ Users

Stress Force

```

ret = hp4156b_force(vi, t1, hp4156b_VF_MODE, range, bias, icomp, 0);          /* 56 */
ret = hp4156b_force(vi, t2, hp4156b_VF_MODE, range, bias, icomp, 0);
ret = hp4156b_spotMeas(vi,t1, hp4156b_IM_MODE, range, &md[0], &st[0]);
ret = hp4156b_spotMeas(vi,t2, hp4156b_IM_MODE, range, &md[1], &st[1]);
ret = hp4156b_zeroOutput(vi, hp4156b_CH_ALL);
check_err (vi, ret);

printf("Data after stress:\n");                                           /* 63 */
printf("T1 current = %8.5f [mA], Status = %d \n", md[0] * 1000, st[0]);
printf("T2 current = %8.5f [mA], Status = %d \n", md[1] * 1000, st[1]);

ret = hp4156b_setSwitch(vi, hp4156b_CH_ALL, 0);
check_err (vi, ret);
}

```

Line	Description
56 to 60	Applies voltage to device, performs spot measurement, and sets the specified port to the zero output state.
63 to 65	Displays the measurement result data.
67	Disables all ports.
61 and 68	Calls the check_err subprogram (shown in Table 5-1) to check if an error status is returned for the previous line.
69	End of the perform_meas subprogram.

Measurement Result Example

```

Data before stress:
T1 current = 11.09860 [mA], Status = 0
T2 current = 10.75880 [mA], Status = 0

Stress force in progress: 2.0 [V], 5.0 [sec]

Data after stress:
T1 current = 11.10200 [mA], Status = 0
T2 current = 10.76220 [mA], Status = 0

```

6 Programming Examples for VEE Users

Programming Examples for VEE Users

This chapter describes how to create measurement programs using the 4155/4156 VXIplug&play driver and Agilent VEE, and provides programming examples. This chapter contains the following sections:

- “Programming Basics”
- “High-Speed Spot Measurements”
- “Multi-Channel Spot Measurements”
- “Staircase Sweep Measurements”
- “Synchronous Sweep Measurements”
- “Multi-Channel Sweep Measurements”
- “Pulsed Spot Measurements”
- “Multi-Channel Pulsed Spot Measurements”
- “Pulsed Sweep Measurements”
- “Multi-Channel Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Sampling Measurements”
- “Stress Force”

Programming Basics

This section covers the following topics.

- “Registrating the Driver on Agilent VEE”
- “Basic Objects to Control the Instrument”
 - “To display the To/From object”
 - “To define transactions in the To/From object”
 - “To set input parameters”
 - “To use the Help function”
 - “To use input variables”
 - “To create output terminals in the To/From object”
 - “To display/connect the Data object”
 - “To display/connect the Display object”
- “Debugging Your Program”
- “Restrictions When Using the Driver with Agilent VEE”

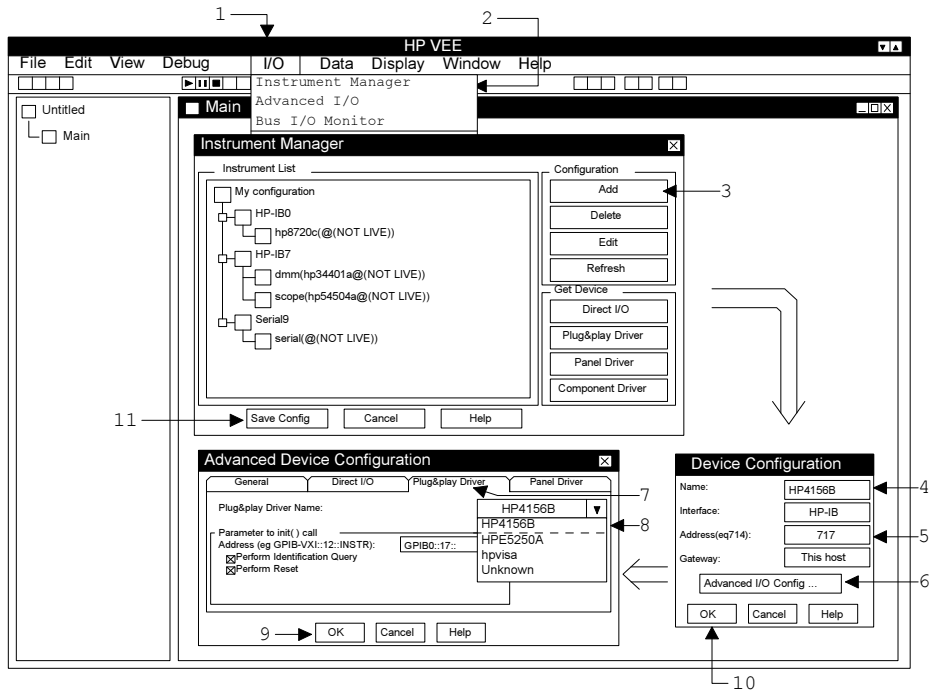
Registrating the Driver on Agilent VEE

To use the *VXIplug&play* driver on Agilent VEE, register the driver as described below and as shown in Figure 6-1 on page 6-5.

1. Click the I/O menu.
2. Select Instrument Manager from the I/O menu. The Instrument Manager dialog box is displayed. The dialog box lists the available devices (instruments). If this is the first time using Agilent VEE, only off-line (NOT LIVE) devices are shown in the Instrument List.
3. Click Add. The Device Configuration dialog box is displayed.
4. Enter the device name in the Name field. The example shown in Figure 6-1 sets "HP4156B".
5. Enter the GPIB address for the device in the Address field. The example shown in Figure 6-1 sets "717".
6. Click Advanced I/O Config. The Advanced Device Configuration dialog box is displayed.
7. Click the Plug&play Driver tab.
8. Select HP4156B in the Plug&play Driver Name field to configure the 4155/4156 driver. If the driver is not installed properly, "HP4156B" is not available in this field. Install the driver properly at this time.
9. Click OK to close the Advanced Device Configuration dialog box.
10. Click OK to close the Device Configuration dialog box.
11. Click Save Config to save the configuration of the drivers. The Instrument Manager dialog box is closed.

You can now use the *VXIplug&play* driver for the 4155/4156.

Figure 6-1 Registering the Driver on Agilent VEE



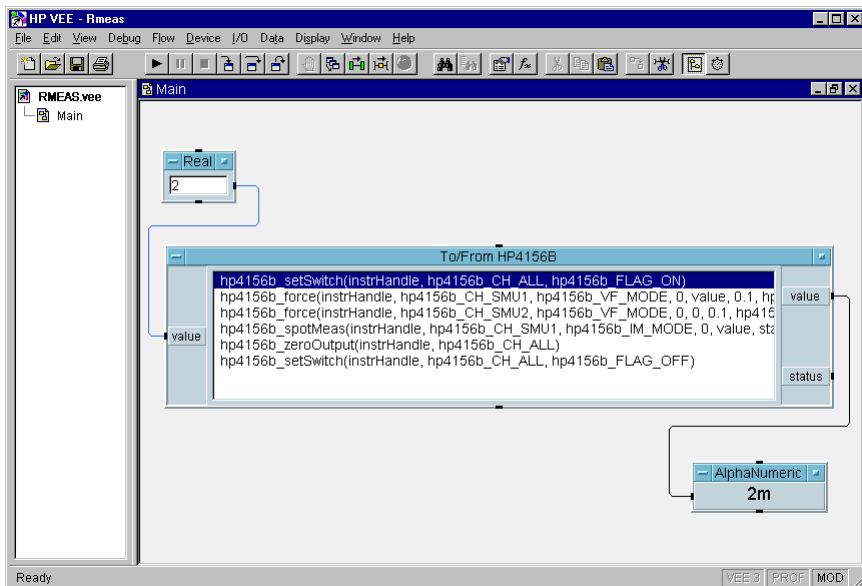
Basic Objects to Control the Instrument

You can create programs using Agilent VEE and the *VXIplug&play* driver, as shown in the following steps. In this procedure you use only three objects; To/From, Data, and Display, shown in Figure 6-2.

1. Display the To/From object for the *VXIplug&play* driver.
2. Define the transactions (functions of the driver) in the To/From object.
3. Set the input parameters for the transaction.
4. (Optional: Use a variable for the input parameter.)
5. Repeat steps 2, 3, and 4 to complete the To/From object.
6. Connect the input terminals of the To/From object to the Data object.
7. Connect the output terminals of the To/From object to the Display object.
8. Complete the Agilent VEE program.

Figure 6-2

Basic Objects of Agilent VEE



The To/From HP4156B object, in Figure 6-2, defines the following transactions (functions of the *plug&play* driver) to measure the current flow to a resistor.

- hp4156b_setSwitch This function controls the 4155/4156 output switch.
- hp4156b_force This function forces dc voltage or current.
- hp4156b_spotMeas This function executes a spot measurement.
- hp4156b_zeroOutput This function disables the 4155/4156 output.

To display the To/From object

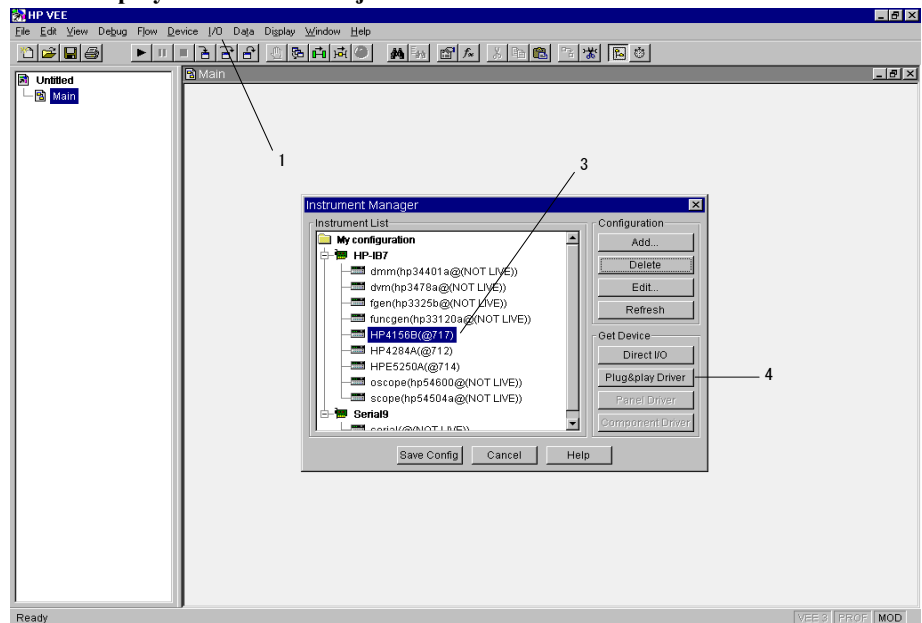
You can display the To/From object as shown below.

1. Click I/O menu.
2. Select Instrument Manager to display the Instrument Manager dialog box.
3. Select HP4156B in the Instrument List.
4. Click Plug&play Driver.

The Instrument Manager dialog box is then closed, and the To/From HP4156B object will be displayed by moving the mouse pointer to the appropriate point, then clicking the left mouse button.

Figure 6-3

To Display the To/From Object

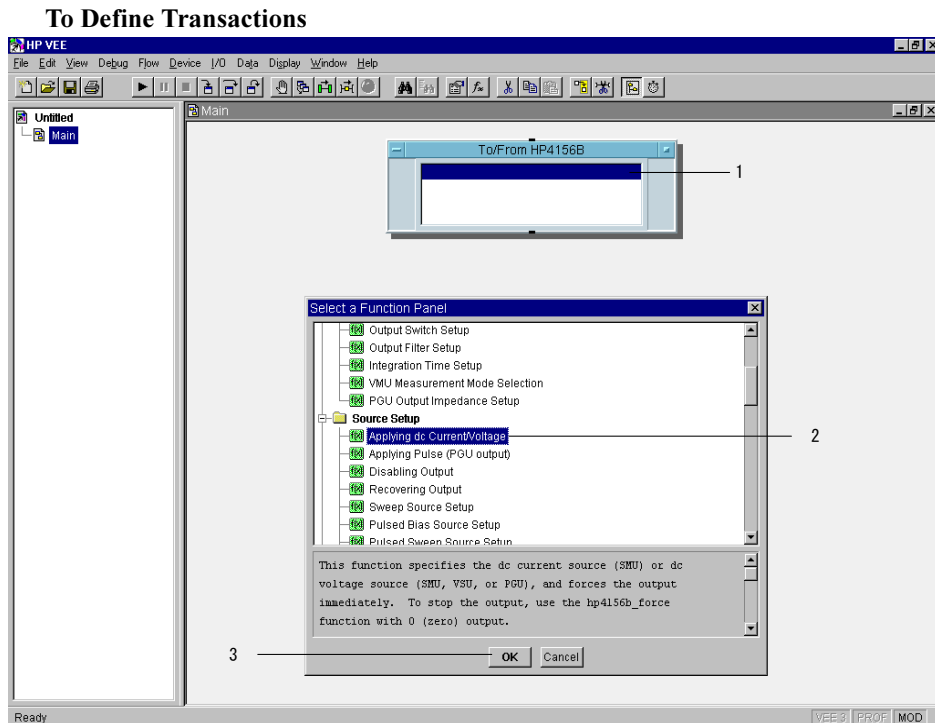


To define transactions in the To/From object

You can define transactions (functions of *plug&play* driver) as shown in the following example.

1. Double click the blue stripe on the To/From object. The Select a Function Panel dialog box is displayed. The dialog box lists the functions available for the instrument, and displays the Help message for the selected function.
2. Select the function you want to add to the To/From object. Figure 6-4 selects the “Applying dc Current/Voltage” function, and displays the Help message for that function.
3. Click OK. The Select a Function Panel dialog box is closed, and the Edit Function Panel dialog box is displayed. See Figure 6-5 on page 6-9.

Figure 6-4



NOTE

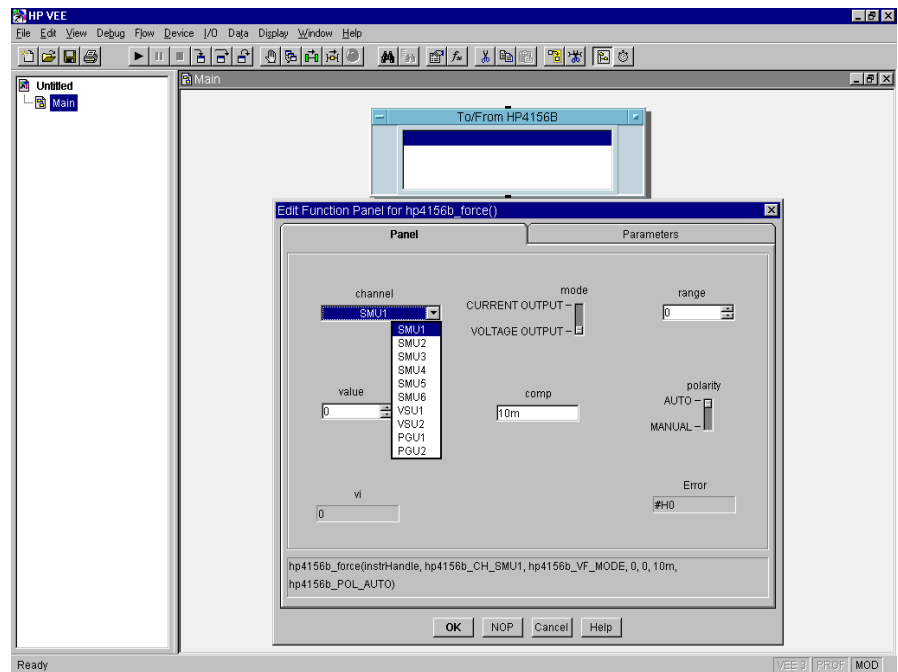
To add, insert, cut, copy, or paste the transaction, click the right mouse button on the To/From object, then select Add Trans, Insert Trans, Cut Trans, Copy Trans, or Paste Trans.

To set input parameters

You can set the input parameter value using the Edit Function Panel dialog box. Figure 6-5 sets the following values for the input parameters of the hp4156b_force function, which forces dc current or voltage.

channel	SMU1
mode	VOLTAGE OUTPUT
range (output range)	0 (auto range)
value	0 V
compliance	10 mA
polarity	AUTO

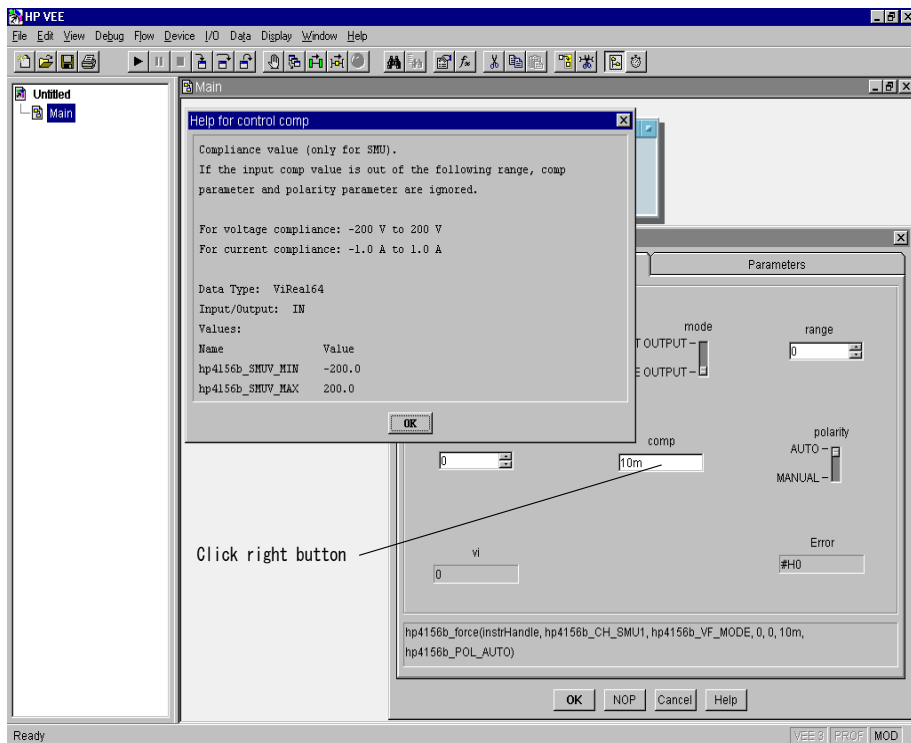
Figure 6-5 To Set Input Parameters



To use the Help function

If you need to know the details for each parameter in order to enter the parameter value, move the mouse pointer to the appropriate entry field, then click the right mouse button. The context-based Help function will be displayed. Figure 6-6 shows the Help message for the *comp* entry field.

Figure 6-6 Help Function



NOTE

To open on-line Help for the *plug&play* driver, click the right mouse button in the To/From object, then select “Instrument Help”.

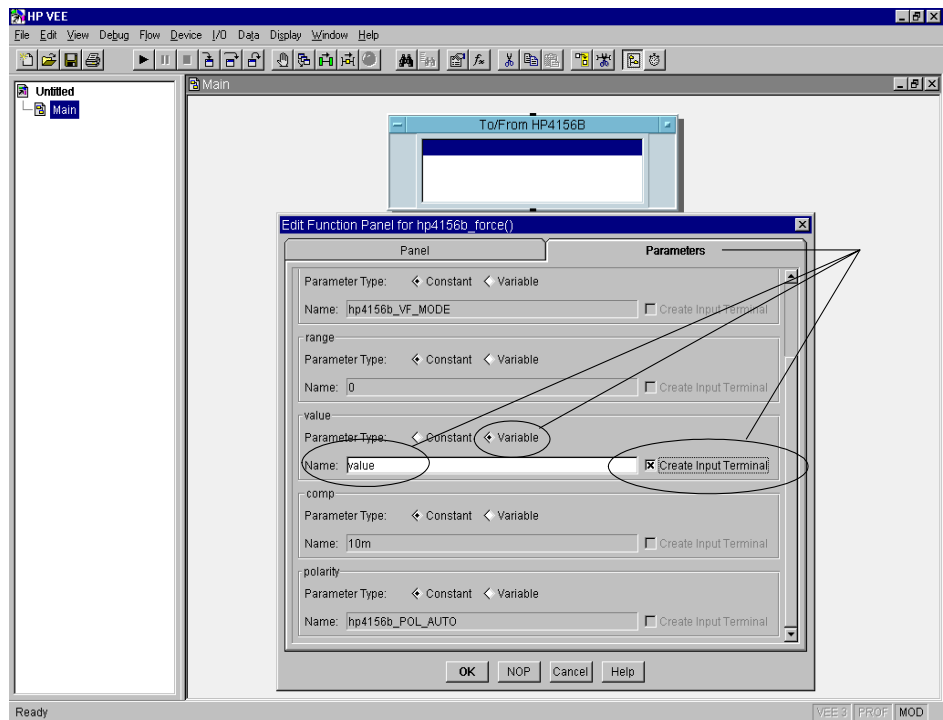
To use input variables

Most of the Edit Function Panel dialog boxes have two tabs, Panel and Parameters. To change the value, enter the value in the Panel tab.

If you pass the value from another object, such as Data-Real object, click the Parameters tab, and use Variable (not Constant). See Figure 6-7.

Figure 6-7

To Use Input Variables



NOTE

You can add terminals, after closing the dialog box, by placing the mouse pointer on the terminal area in the object and pressing Ctrl-A. You can also delete terminals by placing the mouse pointer on the terminal name you want to delete, and pressing Ctrl-D.

To create output terminals in the To/From object

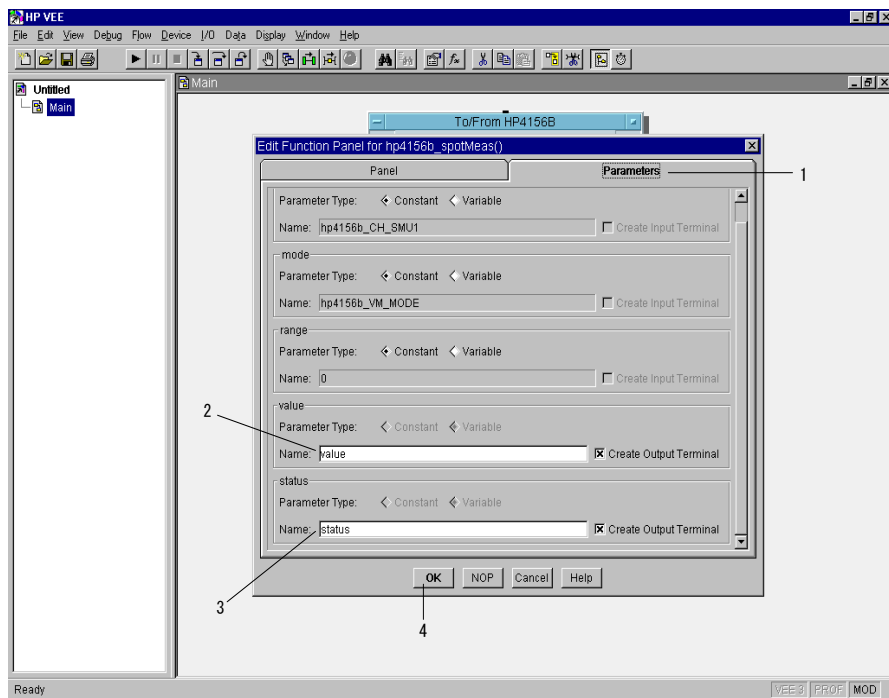
Figure 6-8 shows the Edit Function Panel dialog box of the hp4156b_spotMeas function. These measurement transactions need the output terminals in the To/From object. You can create the output terminal as shown in the following example.

1. Click the Parameters tab.
2. Enter the Name (output terminal name) for the output variable *value*.
3. Enter the Name (output terminal name) for the output variable *status*.
4. Click OK. The dialog box is closed, the transaction is added to the To/From object, and the output terminals are created in the object.

The output terminal will be created with the default name if steps 2 and 3 are omitted.

Figure 6-8

To Create Output Terminals



To display/connect the Data object

In Figure 6-9, the Data-Real object is used to pass the input parameter value to the *value* input variable of the hp4156b_force transaction.

You can display the Data-Real object by clicking the Data menu, selecting Constant, and then selecting Real. To pass the value, connect the output terminal of the Data-Real object to the input terminal of the To/From HP4156B object.

NOTE

Confirm the data type of the input variable. The data type of the Data object must be the same as the data type for the input parameter.

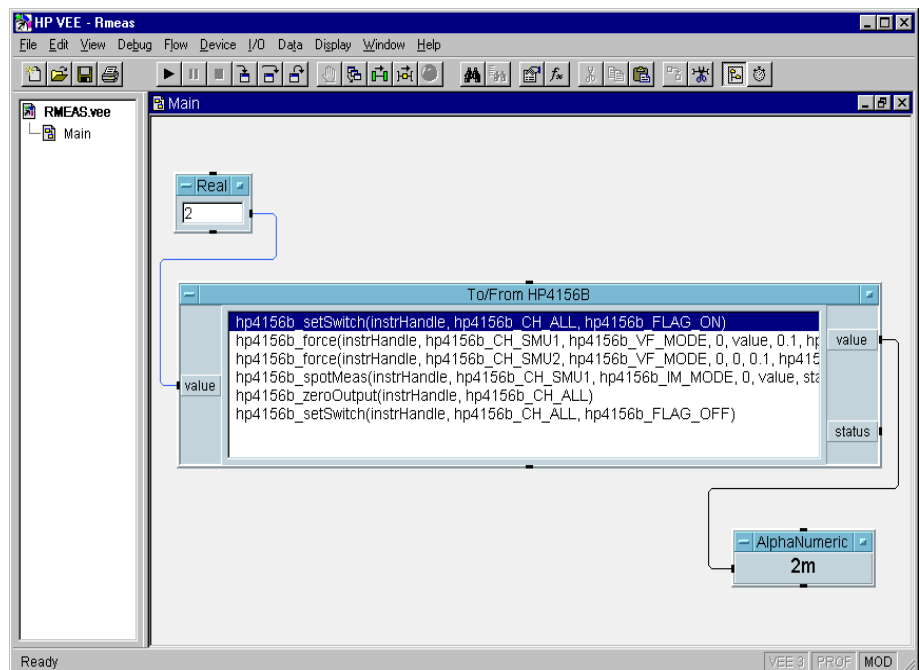
To display/connect the Display object

In Figure 6-9, the Display-AlphaNumeric object is used to display the measurement data (*result* output variable) from the hp4156b_spotMeas transaction.

You can display the Display-AlphaNumeric object by clicking the Display menu, and selecting AlphaNumeric. To display the value, connect the output terminal of the To/From HP4156B object to the input terminal of the Display-AlphaNumeric object.

Figure 6-9

To Connect Input/Output Terminals



Debugging Your Program

You may encounter problems when creating programs to control the 4155/4156. In the program development or debugging phase, insert the following transactions (functions of the driver) in the To/From object. Do not forget to remove the functions after completing the program. These functions will cause increased program execution time.

- `hp4156b_cmd(instrHandle,"US")`
- `hp4156b_errorQueryDetect`

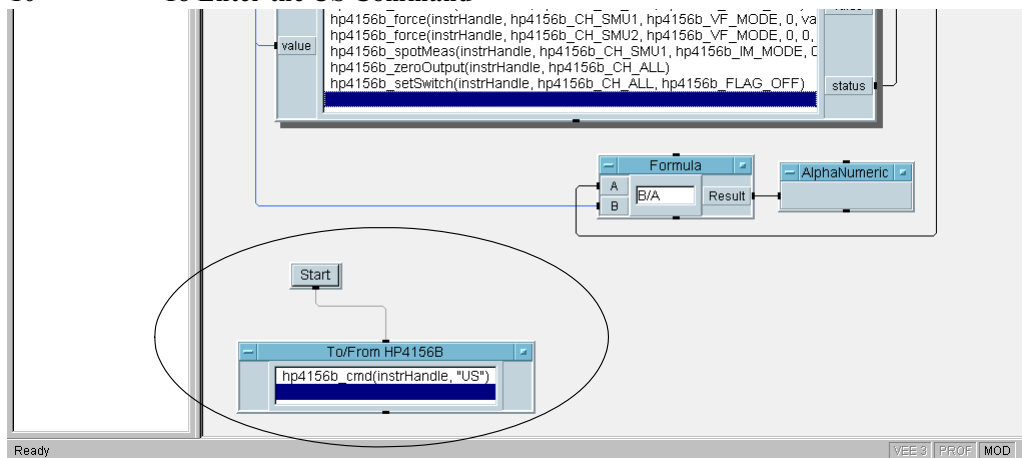
To recover control mode

When using Agilent VEE, the 4155/4156 control mode is controlled by the `hp4156b_init` function, which is automatically called and executed by Agilent VEE when the program first runs after loading.

However, if you press any PAGE CONTROL key or LOCAL softkey on the 4155/4156 front panel after program execution, the control mode is changed. Also, if an unexpected I/O error has occurred, you may need to do a hardware reset which changes the control mode. Once the control mode is changed, the program cannot run without reloading it.

To recover the control mode without reloading the program, enter the US command using the `hp4156b_cmd` function as shown in Figure 6-10. The command recovers the effective control mode for the *plug&play* driver.

Figure 6-10



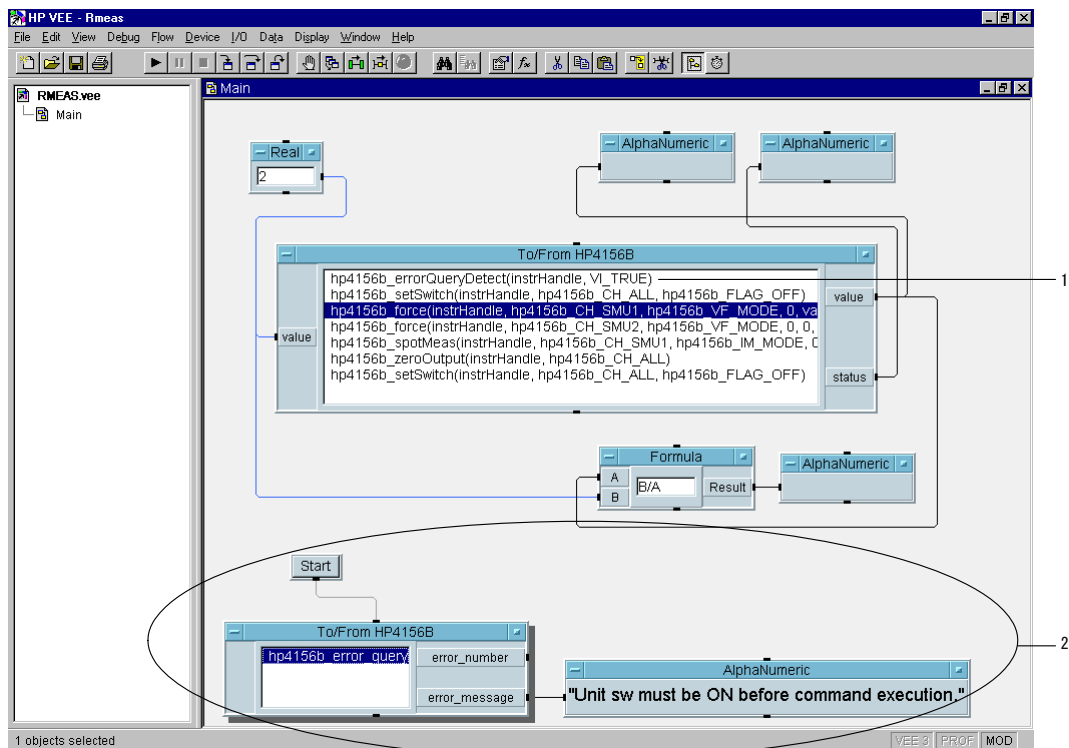
To check for instrument error

The `hp4156b_errorQueryDetect` function enables or disables automatic instrument error checking. If automatic error checking is enabled, the driver will query the instrument for an error at the end of each function call.

If this function is enabled (1 of Figure 6-11) and if an error occurs in the function call, Agilent VEE stops the program execution and displays an error dialog box. You must then enter the `hp4156b_error_query` function (see 2 of Figure 6-11). The `hp4156b_error_query` function returns the instrument error code and error message.

In this example, an error occurred in the `hp4156b_force` function call. The cause of the error was an improper parameter setting for the `hp4156b_setSwitch` function.

Figure 6-11 To Use the `hp4156b_error_query` Function



Restrictions When Using the Driver with Agilent VEE

When using Agilent VEE and any of the following functions for Agilent 4155/4156 and Agilent E5250A, certain restrictions will apply.

Invalid functions in the VEE program

- `hp4156b_init`, `hpe5250a_init`
Agilent VEE calls and executes these functions automatically when the program first runs after loading. These functions cannot be called in a program using Agilent VEE.
- `hp4156b_close`, `hpe5250a_close`
Agilent VEE calls and executes these functions automatically when you close the program or Agilent VEE. These functions cannot be called in a program using Agilent VEE.
- `hp4156b_error_message`, `hpe5250a_error_message`
These functions receive the error status of the plug&play driver function, and returns the error message. However, these functions are invalid in a program using Agilent VEE, because Agilent VEE does not pass the error status to the function.

Invalid use of the NULL pointer

The measurement functions listed below allow you to use the NULL pointer to restrict the number of parameters returned from the function. However, the NULL pointer is not available for Agilent VEE programming.

- `hp4156b_spotMeas`
- `hp4156b_sweepIv`
- `hp4156b_sweepMiv`
- `hp4156b_sweepPiv`
- `hp4156b_sweepPbias`
- `hp4156b_measureM`
- `hp4156b_measureP`
- `hp4156b_sample`
- `hp4156b_readData`

High-Speed Spot Measurements

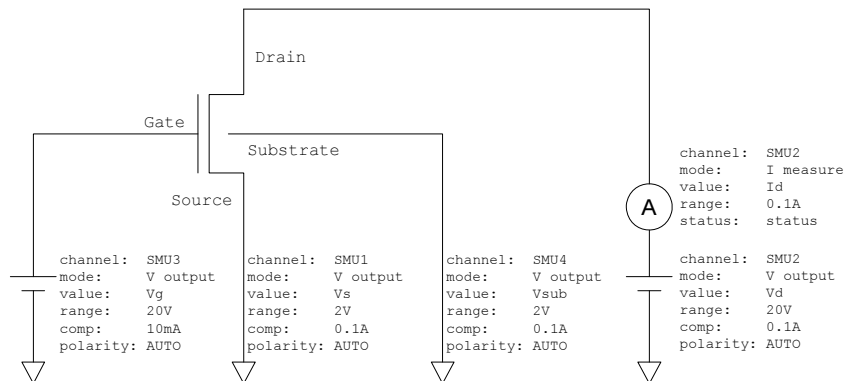
To make high-speed spot measurements, use the following functions.

Table 6-1 Functions for High-Speed Spot Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Executes measurement	hp4156b_spotMeas	channel,mode,range,value,status
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-13 on page 6-18. This program measures MOSFET drain current. The measurement setup is shown in Figure 6-12.

Figure 6-12 Device Connection and Source Setup for Example Program



Programming Examples for VEE Users

High-Speed Spot Measurements

Figure 6-13 Program Example of High-Speed Spot Measurement

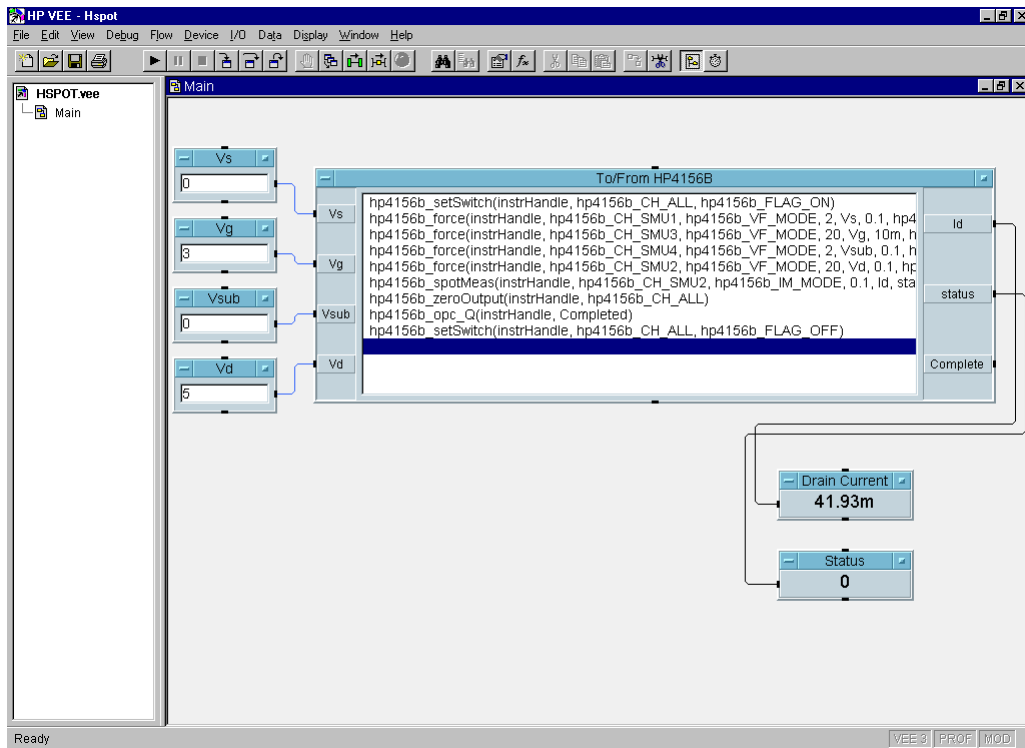


Table 6-2 Program Explanation

Object Title	Menu	Explanation
Vs,Vg,Vsub,Vd	Data-Constant-Real	Enters input parameters of hp4156b_force.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement.
Drain Current	Display-AlphaNumeric	Displays Id. (hp4156b_spotMeas value parameter)
Status	Display-AlphaNumeric	Displays status. (hp4156b_spotMeas status parameter)

Multi-Channel Spot Measurements

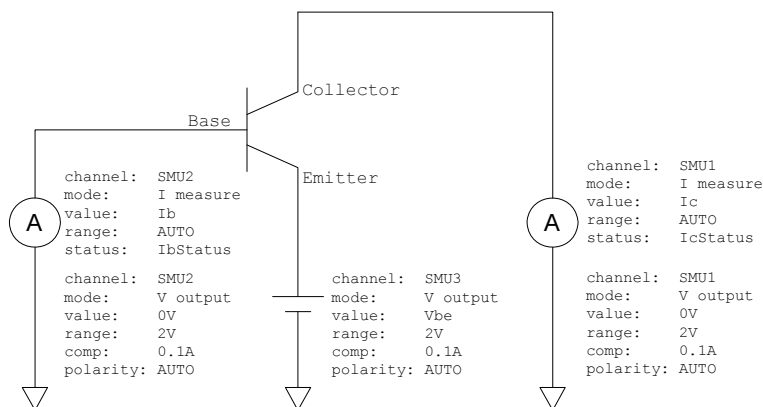
To make multi-channel spot measurements, use the following functions.

Table 6-3 Functions for Multi-Channel Spot Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Executes measurement	hp4156b_measureM	channel[],mode[],range[],value[],status[]
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-15 on page 6-20. This program measures bipolar transistor collector current and base current. The example uses the User object of the Agilent VEE. See Figure 6-16 on page 6-21. The measurement setup is shown in Figure 6-14.

Figure 6-14 Device Connection and Source Setup for Example Program



Programming Examples for VEE Users

Multi-Channel Spot Measurements

Figure 6-15

Program Example of Multi-Channel Spot Measurement

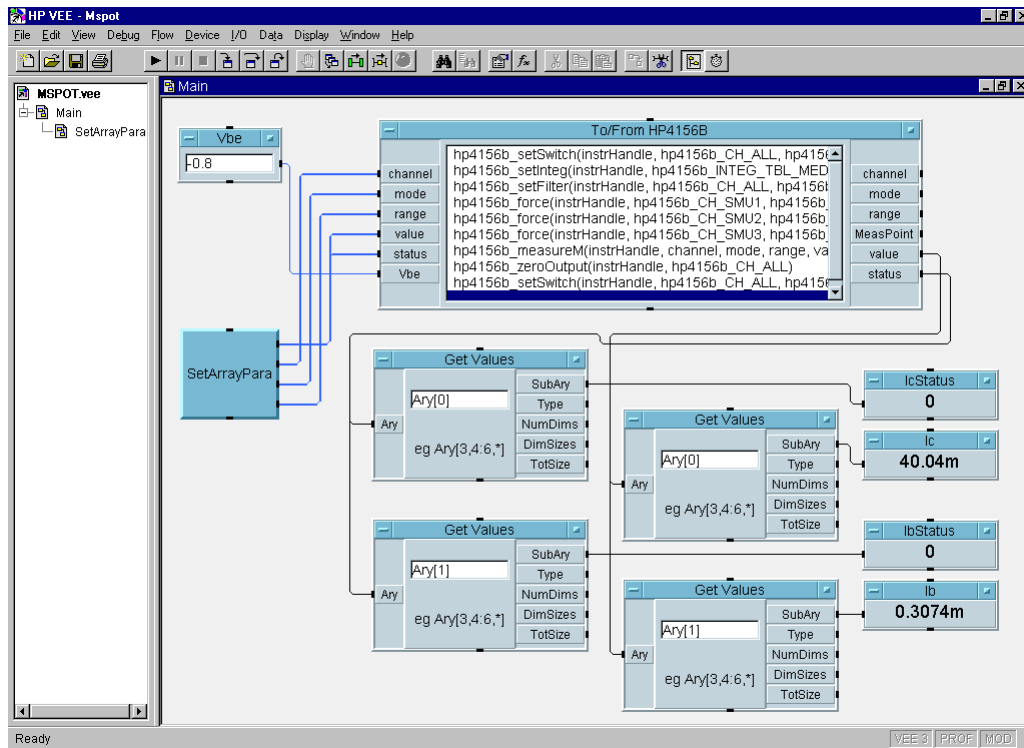


Table 6-4

Program Explanation

Object Title	Menu	Explanation
Vbe	Data-Constant-Real	Enters input parameters of hp4156b_force.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement.
GetValues	Data-AccessArray-GetValues	Gets data from Array (value[], status[]).
IcStatus,Ic, IbStatus,Ib	Display-AlphaNumeric	Displays measurement data/status. (hp4156b_measureM output parameters)

Figure 6-16 SetArrayPara User Object

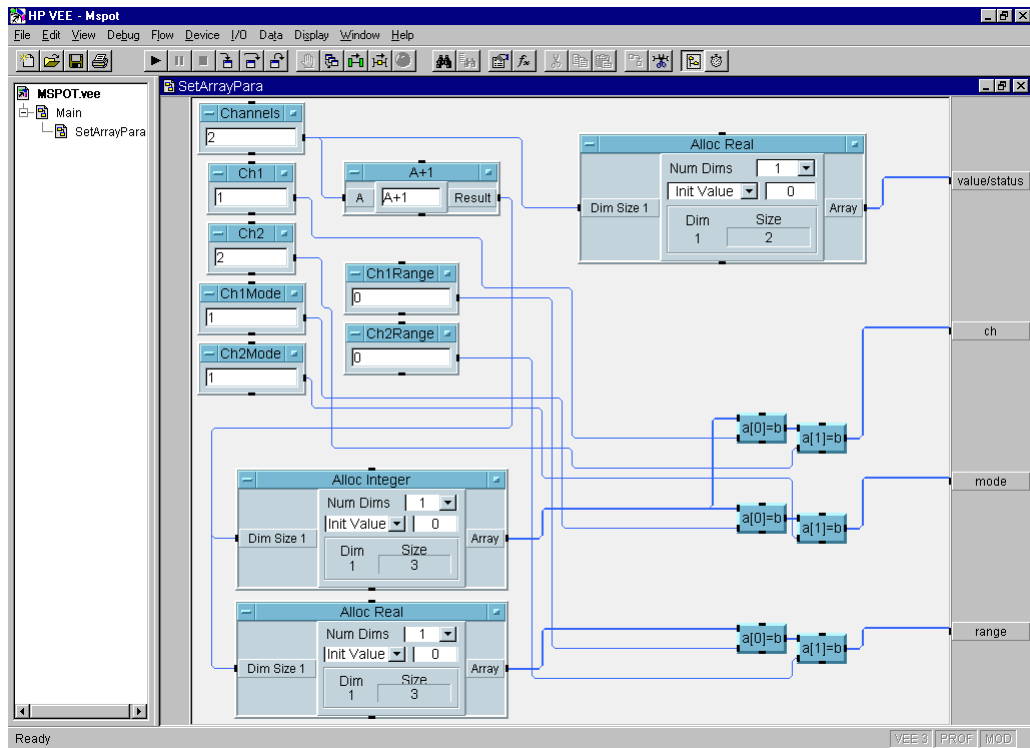


Table 6-5 Program Explanation

Object Title	Menu	Explanation
Channels, Ch1, Ch2, Ch1Mode, Ch2Mode, Ch1Range, Ch2Range	Data-Constant-Integer Data-Constant-Real	Enters data to allocate array, and array element for channel[], mode[], range[] of hp4156b_measureM.
A+1	Device-Formula	Calculates A+1 to allocate array.
AllocReal, AllocInteger	Data-AllocateArray-Real Data-AllocateArray-Integer	Allocates array for channel[], mode[], range[] of hp4156b_measureM.
a[0]=b, a[1]=b	Data-AccessArray-SetValues	Sets data of array (array element).

Staircase Sweep Measurements

To make staircase sweep measurements, use the following functions.

Table 6-6 Functions for Staircase Sweep Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sweep Source Setup	hp4156b_setIv	channel,mode,range,start,stop,point,hold,delay,s_delay,comp,p_comp
Executes measurement	hp4156b_sweepIv	channel,mode,range,point,source[],value[],status[]
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-18 on page 6-23. This program measures MOSFET Id-Vd characteristics. The measurement setup is shown in Figure 6-17.

Figure 6-17 Device Connection and Source Setup for Example Program

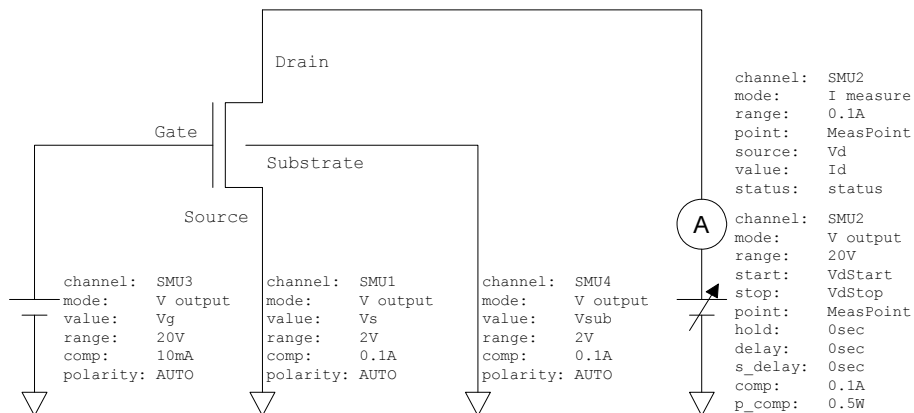


Figure 6-18 Program Example of Staircase Sweep Measurement

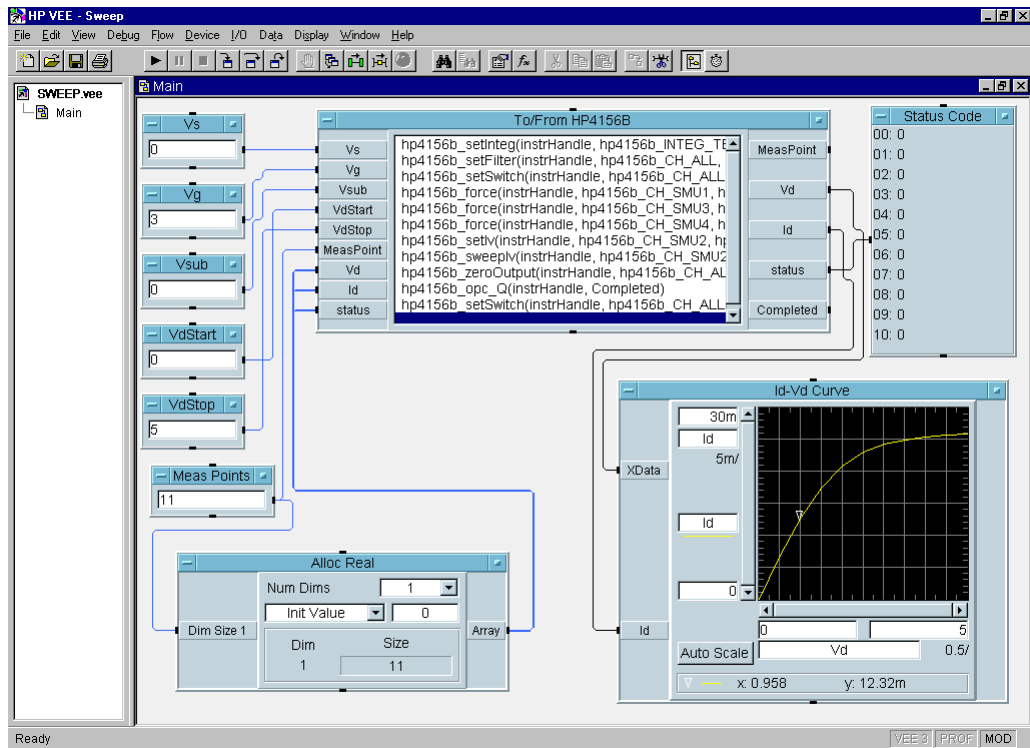


Table 6-7 Program Explanation

Object Title	Menu	Explanation
Vs,Vg,Vsub VdStart,VdStop MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_force, hp4156b_setIv, and hp4156b_sweepIv.
To/From HP4156B	I/O-InstrumentManager- Plug&play	Executes measurement.
AllocReal	Data-AllocateArray-Real	Allocates array for Vd[],Id[],status[] of hp4156b_sweepIv.
Status Code	Display-AlphaNumeric	Displays status[].
Id-Vd Curve	Display-XvsYPlot	Plots Id-Vd curve.

Synchronous Sweep Measurements

To make synchronous sweep measurements, use the following function with the functions shown in “Staircase Sweep Measurements” on page 22, or “Pulsed Sweep Measurements” on page 34.

The hp4156b_setSweepSync function must be placed after the hp4156b_setIv function or the hp4156b_setPiv function in the To/From object.

Table 6-8 Function for Synchronous Sweep Measurements

Description	Function	Parameters
Synchronous Source Setup	hp4156b_setSweepSync	channel,mode,range,start,stop,comp, p_comp

A program example is shown in Figure 6-20 on page 6-25. This program measures MOSFET Id-Vg characteristics. The measurement setup is shown in Figure 6-19.

Figure 6-19 Device Connection and Source Setup for Example Program

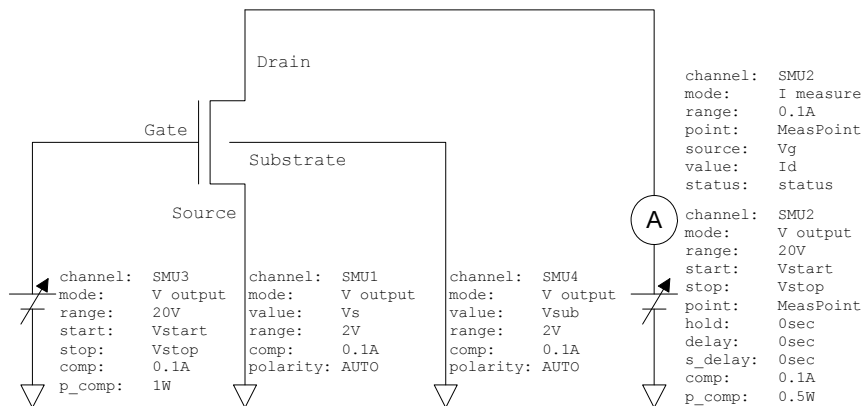


Figure 6-20 Program Example of Synchronous Sweep Measurement

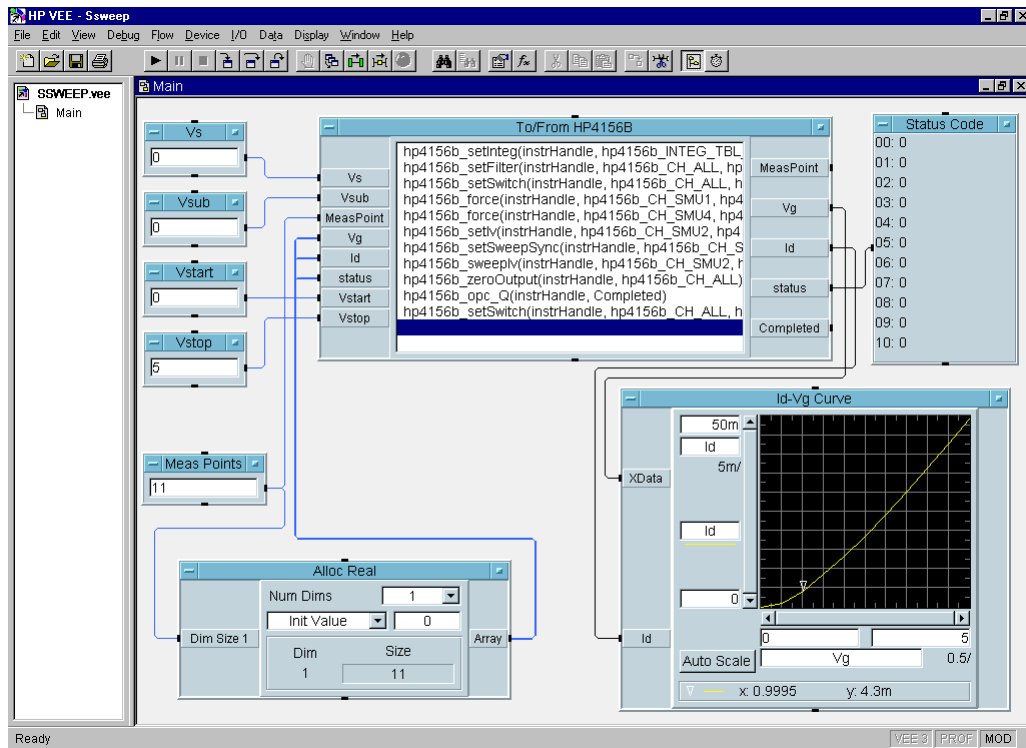


Table 6-9 Program Explanation

Object Title	Menu	Explanation
Vs,Vsub Vstart,Vstop MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_force, hp4156b_setIv, and hp4156b_setSweepSync.
To/From HP4156B	I/O-InstrumentManager- Plug&play	Executes measurement.
AllocReal	Data-AllocateArray-Real	Allocates array for Vg[],Id[],status[] of hp4156b_sweepIv.
Status Code	Display-AlphaNumeric	Displays status[].
Id-Vg Curve	Display-XvsYPlot	Plots Id-Vg curve.

Multi-Channel Sweep Measurements

To make multi-channel sweep measurements, use the following functions.

Table 6-10 Functions for Multi-Channel Sweep Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sweep Source Setup	hp4156b_setIv	channel,mode,range,start,stop,point,hold,delay,s_delay,comp,p_comp
Executes measurement	hp4156b_sweepMiv	channel[],mode[],range[],point,source[],value[], status[]
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-22 on page 6-27. This program measures bipolar transistor I_c , I_b - V_{be} characteristics. The example uses the User Object of the Agilent VEE. See Figure 6-23 on page 6-28 and Figure 6-24 on page 6-29. The measurement setup is shown in Figure 6-21.

Figure 6-21 Device Connection and Source Setup for Example Program

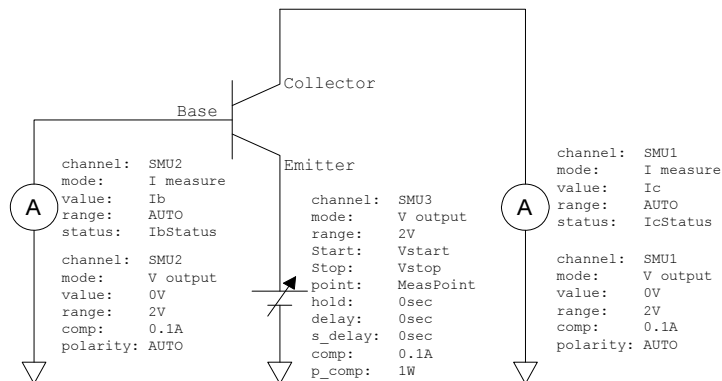


Figure 6-22 Program Example of Multi-Channel Sweep Measurement

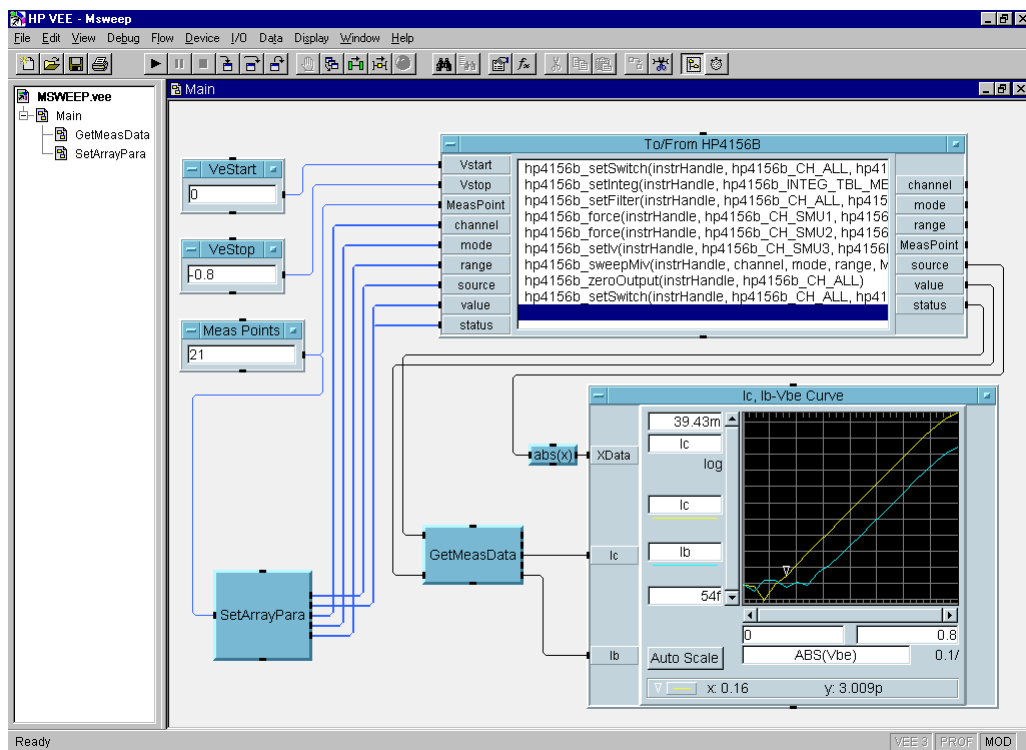


Table 6-11 Program Explanation

Object Title	Menu	Explanation
VeStart, VeStop MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_setlv and hp4156b_sweepMiv.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement.
abs(x)	Device-Formula	Calculates absolute value of Vbe (source).
Ic, Ib-Vbe Curve	Display-XvsYPlot	Plots Ic-Vbe and Ib-Vbe curves.

Programming Examples for VEE Users

Multi-Channel Sweep Measurements

Figure 6-23 **SetArrayPara User Object**

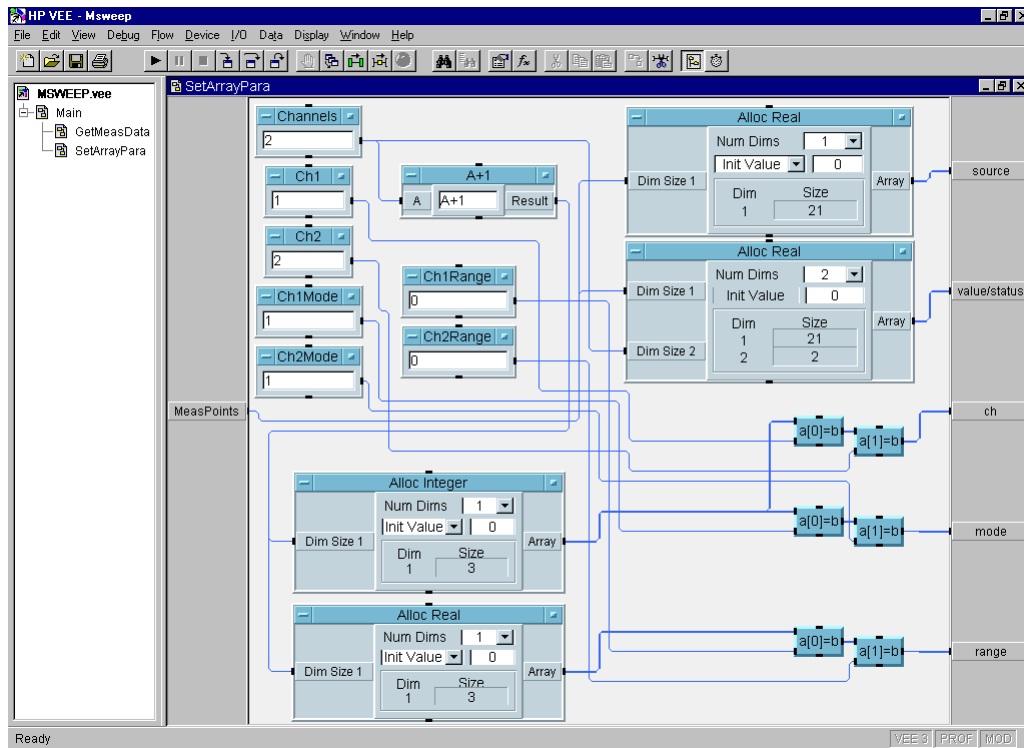


Table 6-12 Program Explanation

Object Title	Menu	Explanation
Channels,Ch1,Ch2, Ch1Mode,Ch2Mode, Ch1Range,Ch2Range	Data-Constant-Integer Data-Constant-Real	Enters data to allocate array, and array element for channel[], mode[], range[] of hp4156b_sweepMiv.
A+1	Device-Formula	Calculates A+1 to allocate array.
AllocReal, AllocInteger	Data-AllocateArray-Real Data-AllocateArray-Integer	Allocates array for channel, mode, range, source,value,status of hp4156b_sweepMiv.
a[0]=b, a[1]=b	Data-AccessArray-SetValues	Sets data of array (array element).

Figure 6-24 GetMeasData User Object

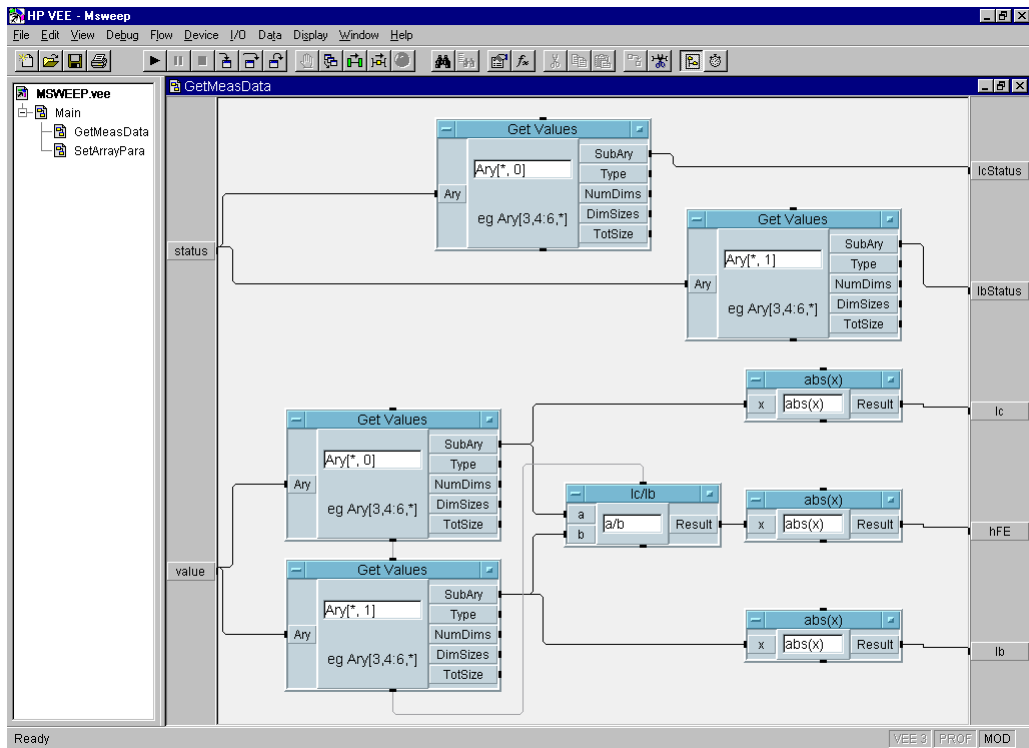


Table 6-13 Program Explanation

Object Title	Menu	Explanation
GetValues	Data-AccessArray-GetValues	Gets data from array (value[],status[]).
Ic/Ib	Device-Formula	Calculates a/b to get hFE value.
abs(x)	Device-Formula	Calculates absolute value of Ic,Ib,hFE.

Pulsed Spot Measurements

To make pulsed spot measurements, use the following functions.

Table 6-14 Functions for Pulsed Spot Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state (pulse channel must be set to OFF)
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Forces pulse bias	hp4156b_setPbias	channel,mode,range,base,peak,width,period,hold,compliance
Executes measurement	hp4156b_measureP	channel,mode,range,value,status
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-26 on page 6-31. This program measures MOSFET drain current. The measurement setup is shown in Figure 6-25.

Figure 6-25 Device Connection and Source Setup for Example Program

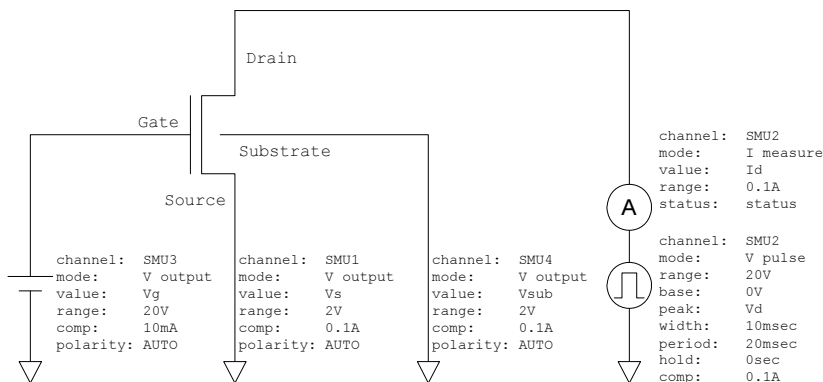


Figure 6-26 Program Example of Pulsed Spot Measurement

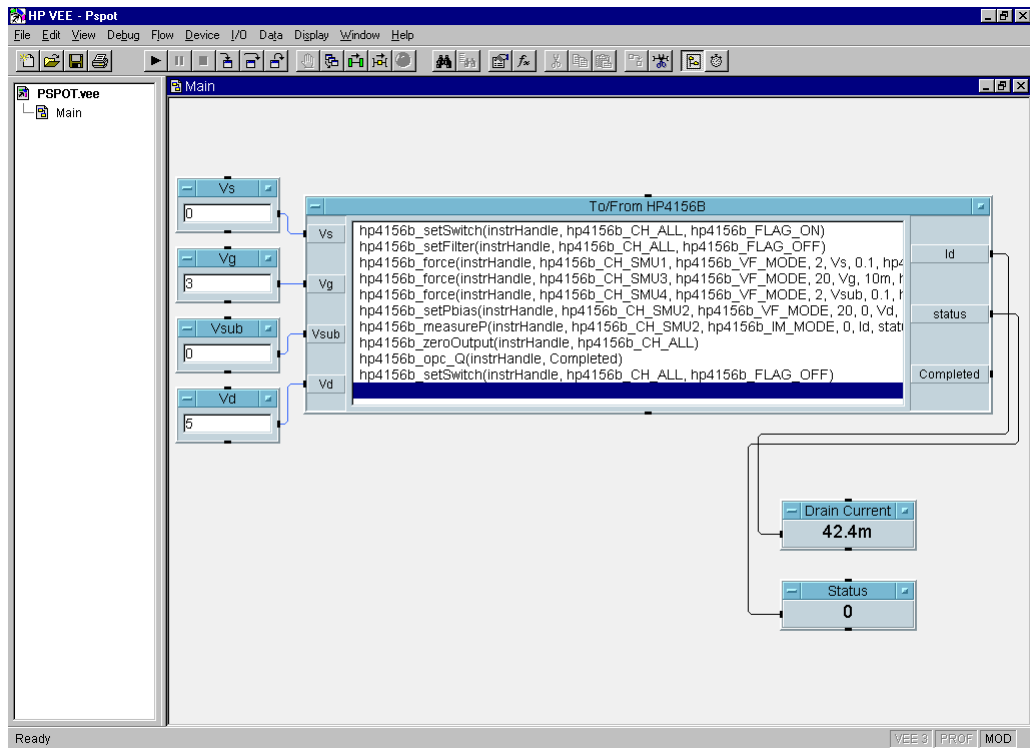


Table 6-15 Program Explanation

Object Title	Menu	Explanation
Vs,Vg,Vsub,Vd	Data-Constant-Real	Enters input parameters of hp4156b_force, and hp4156b_setPbias.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement.
Drain Current	Display-AlphaNumeric	Displays Id (hp4156b_measureP value parameter).
Status	Display-AlphaNumeric	Displays status (hp4156b_measureP status parameter).

Multi-Channel Pulsed Spot Measurements

To make multi-channel pulsed spot measurements, use the following functions.

Table 6-16 Functions for Multi-Channel Pulsed Spot Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state (pulse channel must be set to OFF)
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sends Command String	hp4156b_cmd	command (PT and PV commands are sent)
Executes measurement	hp4156b_startMeasure	meas_type,channel[],mode[],range[],source
Disables output	hp4156b_zeroOutput	channel
Reads measurement data	hp4156b_readData	eod,data_type,value,status,channel

A program example is shown in Figure 6-28 on page 6-33. This program measures bipolar transistor collector current and base current. The measurement setup is shown in Figure 6-27.

Figure 6-27 Device Connection and Source Setup for Example Program

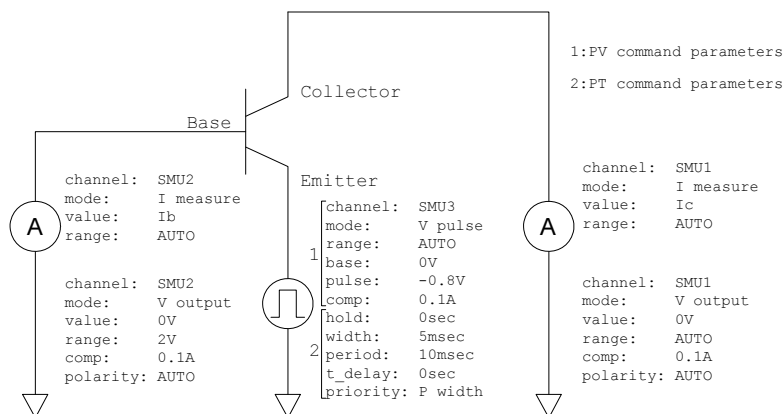


Figure 6-28

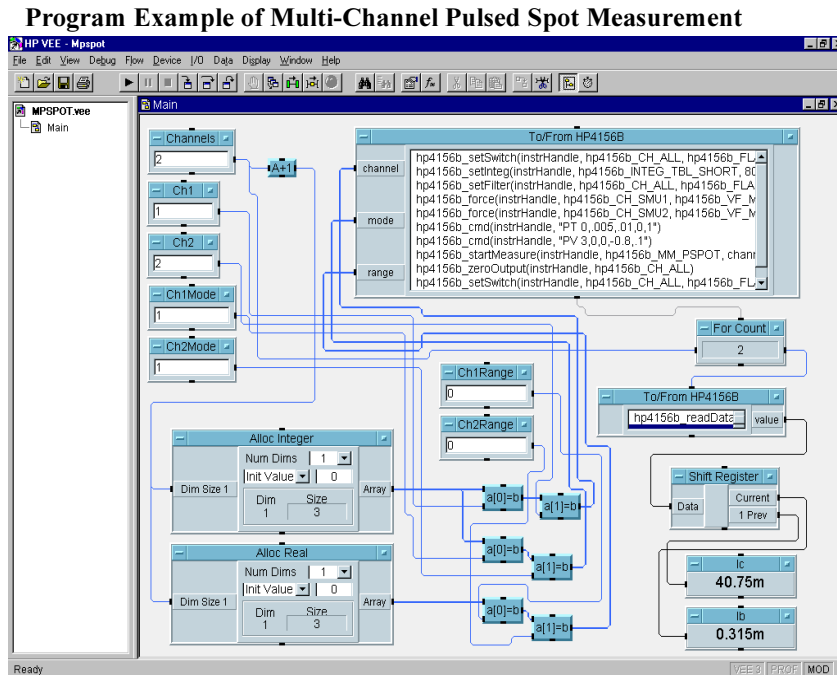


Table 6-17 Program Explanation

Object Title	Menu	Explanation
Channels, Ch1, Ch2, Ch1Mode, Ch2Mode, Ch1Range, Ch2Range	Data-Constant-Integer Data-Constant-Real	Enters data to allocate array, and array element for channel[], mode[], range[] of hp4156b_startMeasure.
A+1	Device-Formula	Calculates A+1 to allocate array.
AllocReal, AllocInteger	Data-AllocateArray-Real Data-AllocateArray-Integer	Allocates array for channel, mode, range of hp4156b_startMeasure.
a[0]=b, a[1]=b	Data-AccessArray-SetValues	Sets data of array (array element).
For Count	Flow-Repeat-ForCount	Repeats next action for specified count.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement or reads data.
Shift Register	Device-ShiftRegister	Outputs last data and 1 prev data.
Ic, Ib	Display-AlphaNumeric	Displays Ic and Ib.

Pulsed Sweep Measurements

To make pulsed sweep measurements, use the following functions.

Table 6-18 Functions for Pulsed Sweep Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state (pulse channel must be set to OFF)
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sweep Source Setup	hp4156b_setPiv	channel,mode,range,base,start,stop,point,hold,width,period,compliance
Executes measurement	hp4156b_sweepPiv	channel,mode,range,point,source[],value[],status[]
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-30 on page 6-35. This program measures MOSFET Id-Vd characteristics. The measurement setup is shown in Figure 6-29.

Figure 6-29 Device Connection and Source Setup for Example Program

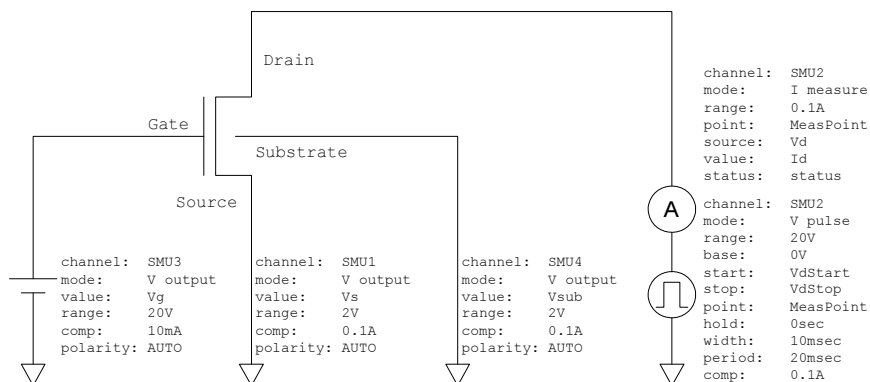


Figure 6-30 Program Example of Pulsed Sweep Measurement

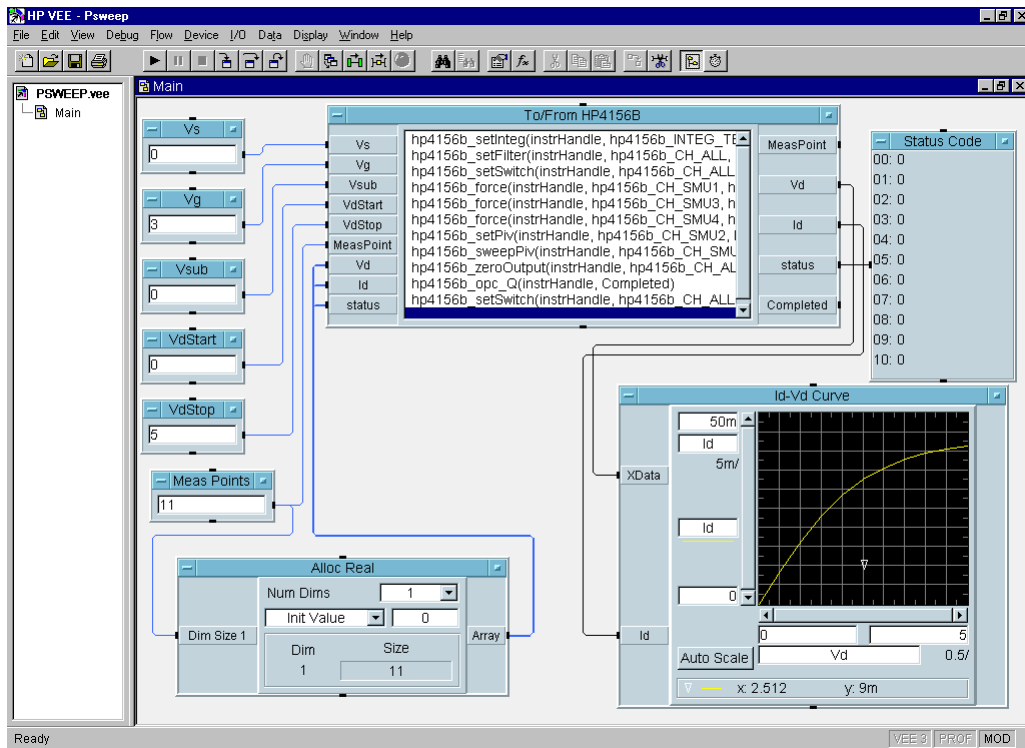


Table 6-19 Program Explanation

Object Title	Menu	Explanation
Vs,Vg,Vsub VdStart,VdStop MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_force, hp4156b_setPiv, and hp4156b_sweepPiv.
To/From HP4156B	I/O-InstrumentManager- Plug&play	Executes measurement.
AllocReal	Data-AllocateArray-Real	Allocates array for Vd[],Id[],status[] of hp4156b_sweepPiv.
Status Code	Display-AlphaNumeric	Displays status[].
Id-Vd Curve	Display-XvsYPlot	Plots Id-Vd curve.

Multi-Channel Pulsed Sweep Measurements

To make multi-channel pulsed sweep measurements, use the following functions.

Table 6-20 Functions for Multi-Channel Pulsed Sweep Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state (pulse channel must be set to OFF)
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sends Command String	hp4156b_cmd	command (PT and PWV commands are sent)
Executes measurement	hp4156b_startMeasure	meas_type,channel[],mode[],range[],source
Disables output	hp4156b_zeroOutput	channel
Reads measurement data	hp4156b_readData	eod,data_type,value,status,channel

A program example is shown in Figure 6-32 on page 6-37. This program measures bipolar transistor I_c , I_b - V_{be} characteristics. The example uses the User Function of the Agilent VEE. See Figure 6-33 on page 6-38. The measurement setup is shown in Figure 6-31.

Figure 6-31 Device Connection and Source Setup for Example Program

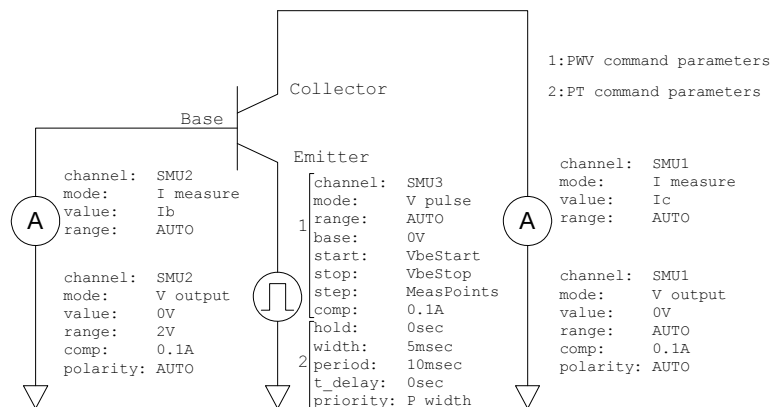


Figure 6-32 Program Example of Multi-Channel Pulsed Sweep Measurement

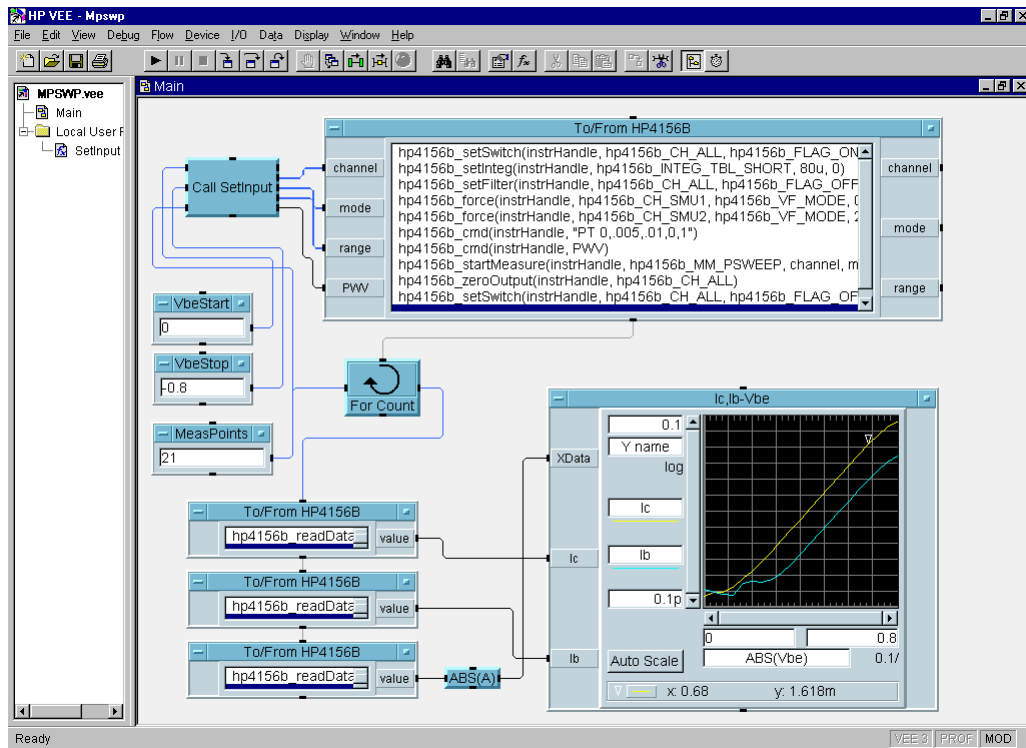


Table 6-21 Program Explanation

Object Title	Menu	Explanation
VbeStart,VbeStop MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters PWV command parameters.
For Count	Flow-Repeat-ForCount	Repeats next action for specified count.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement, or reads data.
ABS(A)	Device-Formula	Calculates absolute value of Vbe (source).
Ic,Ib-Vbe	Display-XvsYPlot	Plots Ic-Vbe and Ib-Vbe curves.

Programming Examples for VEE Users

Multi-Channel Pulsed Sweep Measurements

Figure 6-33 SetInput User Function

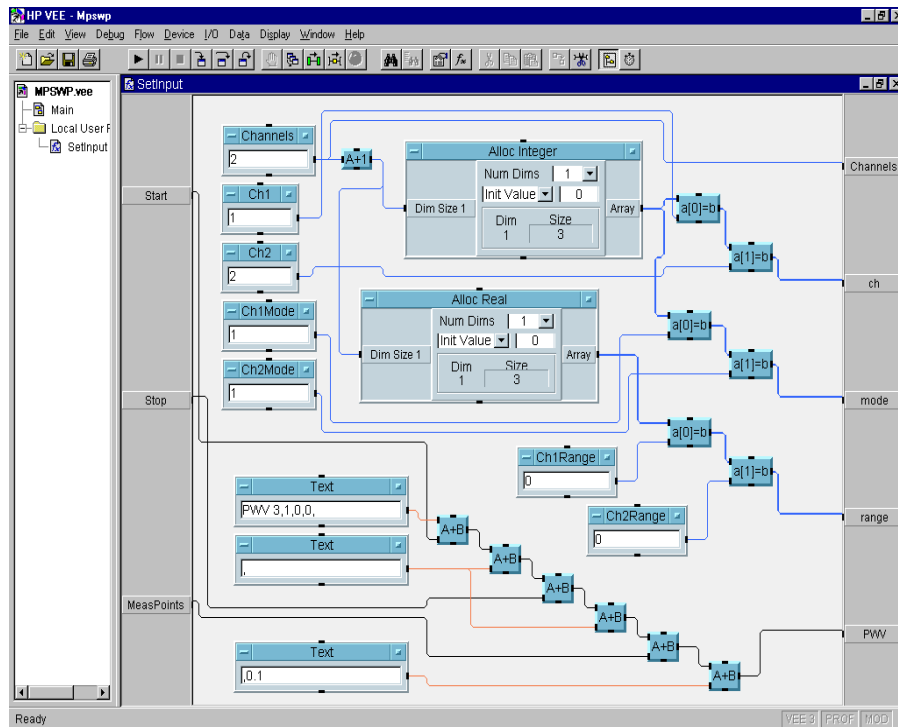


Table 6-22 Program Explanation

Object Title	Menu	Explanation
Channels, Ch1, Ch2, Ch1Mode, Ch2Mode, Ch1Range, Ch2Range	Data-Constant-Integer Data-Constant-Real	Enters data to allocate array, and array element for channel[], mode[], range[] of hp4156b_startMeasure.
A+1	Device-Formula	Calculates A+1 to allocate array.
AllocReal, AllocInteger	Data-AllocateArray-Real Data-AllocateArray-Integer	Allocates array for channel, mode, range, of hp4156b_startMeasure.
a[0]=b, a[1]=b	Data-AccessArray-SetValues	Sets data of array (array element).
Text	Data-Constant-Text	Enters PWV command parameters.
A+B	Device-Formula	Calculates A+B to create PWV command.

Staircase Sweep with Pulsed Bias Measurements

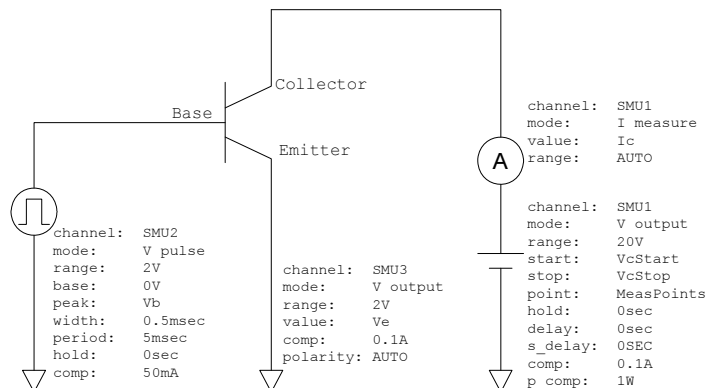
For staircase sweep with pulsed bias measurements, use the following functions.

Table 6-23 Functions for Staircase Sweep with Pulsed Bias Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state (pulse channel must be set to OFF)
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Forces pulse bias	hp4156b_setPbias	channel,mode,range,base,peak,width,period,hold,compliance
Sweep Source Setup	hp4156b_setIv	channel,mode,range,start,stop,point,hold,delay,s_delay,comp,p_comp
Executes measurement	hp4156b_sweepPbias	channel,mode,range,point,source[],value[],status[]
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-35 on page 6-40. This program measures bipolar transistor I_c - V_c characteristics. The measurement setup is shown in Figure 6-34.

Figure 6-34 Device Connection and Source Setup for Example Program



Programming Examples for VEE Users

Staircase Sweep with Pulsed Bias Measurements

Figure 6-35 Program Example of Staircase Sweep with Pulsed Bias Measurement

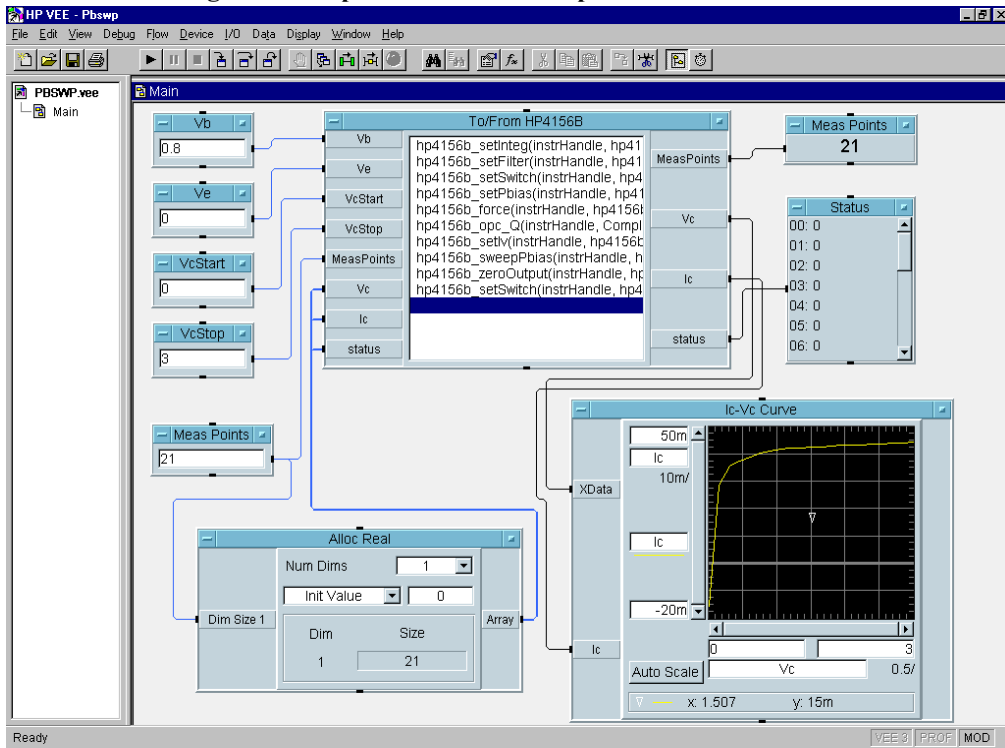


Table 6-24 Program Explanation

Object Title	Menu	Explanation
VcStart, VcStop Vb, Ve, MeasPoints	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_force, hp4156b_setPbias, and hp4156b_setV.
To/From HP4156B	I/O-InstrumentManager- Plug&play	Executes measurement.
AllocReal	Data-AllocateArray-Real	Allocates array for Vc[], Ic[], status[] of hp4156b_sweepPbias.
MeasPoints	Display-AlphaNumeric	Displays number of measurement points.
Status	Display-AlphaNumeric	Displays status[].
Ic-Vc Curve	Display-XvsYPlot	Plots Ic-Vc curve.

Sampling Measurements

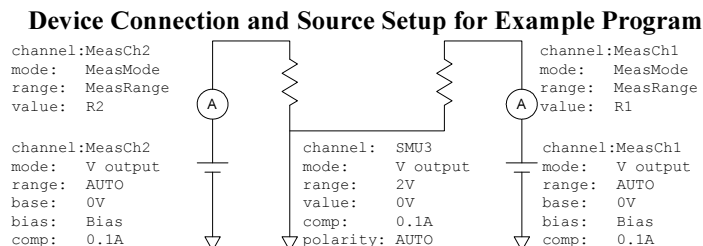
To make sampling measurements, use the following functions.

Table 6-25 Functions for Sampling Measurements

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
Output Filter Setup	hp4156b_setFilter	channel,state
Integration Time Setup	hp4156b_setInteg	table,time,average
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Sampling timing setup	hp4156b_setSample	hold,interval,point
Sampling dc source setup	hp4156b_addSampleSyncIv	channel,mode,range,base,bias,compliance
Sampling pulse source setup	hp4156b_addSampleSyncPulse	channel,base,peak,count,period,width,delay,rise,fall
Executes measurement	hp4156b_sample	channel[],mode[],range[],point,index[],value[],status[]
Clears sampling source setup	hp4156b_clearSampleSync	
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-37. This program measures resistance. The example uses the User function of the Agilent VEE. See Figure 6-38 on page 6-43 and Figure 6-39 on page 6-44. The measurement setup is shown in Figure 6-36.

Figure 6-36



Programming Examples for VEE Users

Sampling Measurements

Figure 6-37 Program Example of Sampling Measurement

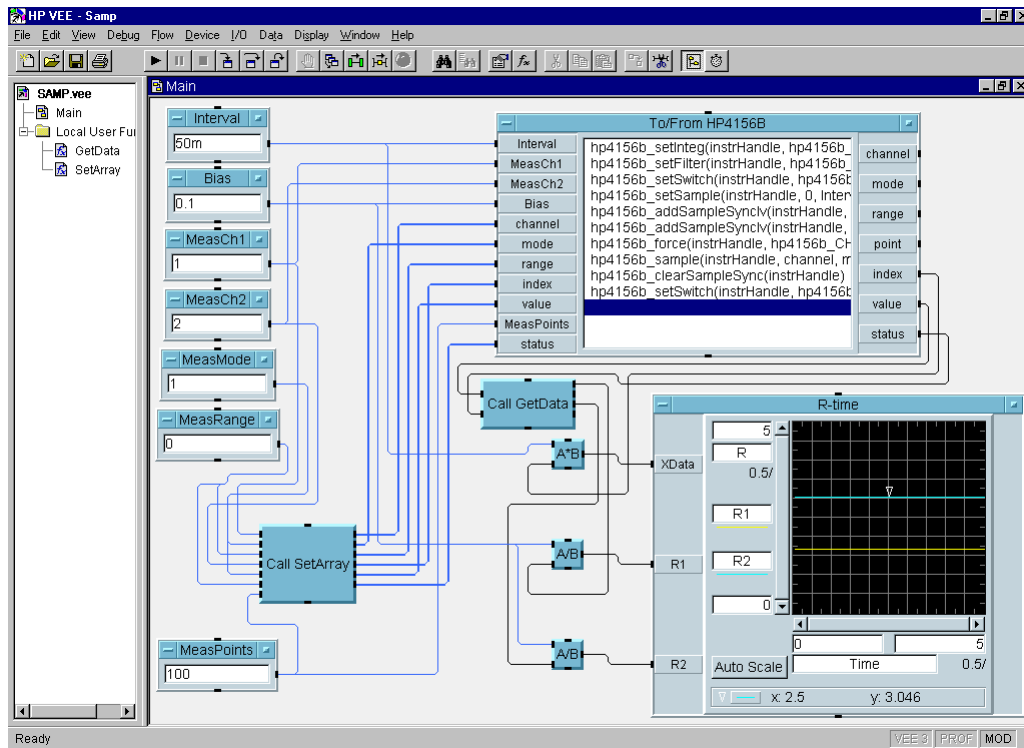


Table 6-26 Program Explanation

Object Title	Menu	Explanation
Interval,Bias, MeasCh1,MeasCh2 MeasMode, MeasRange, MeasPoints	Data-Constant-Integer, Data-Constant-Real	Enters input parameters of hp4156b_force, hp4156b_setSample, hp4156b_addSampleSyncIv, hp4156b_addSampleSyncPulse, hp4156b_sample
To/From HP4156B	I/O-InstrumentManager-Plug&play	Executes measurement.
A*B	Device-Formula	Calculates A*B to get Time value (X).
A/B	Device-Formula	Calculates A/B to get R1, R2 value (Y).
R-time	Display-XvsYPlot	Plots R-t curves.

Figure 6-38 SetArray User Function

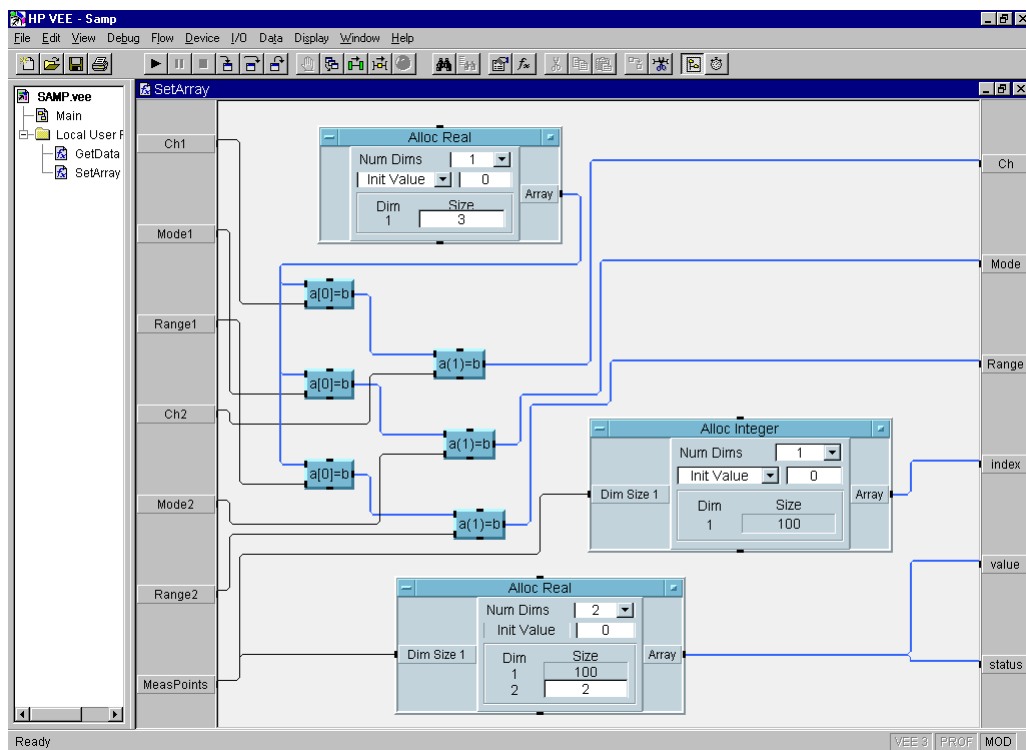


Table 6-27 Program Explanation

Object Title	Menu	Explanation
AllocReal, AllocInteger	Data-AllocateArray-Real Data-AllocateArray-Integer	Allocates array for channel, mode, range, index,value,status of hp4156b_sample.
a[0]=b, a[1]=b	Data-AccessArray-SetValues	Sets data of array (array element).

Programming Examples for VEE Users

Sampling Measurements

Figure 6-39 GetData User Function

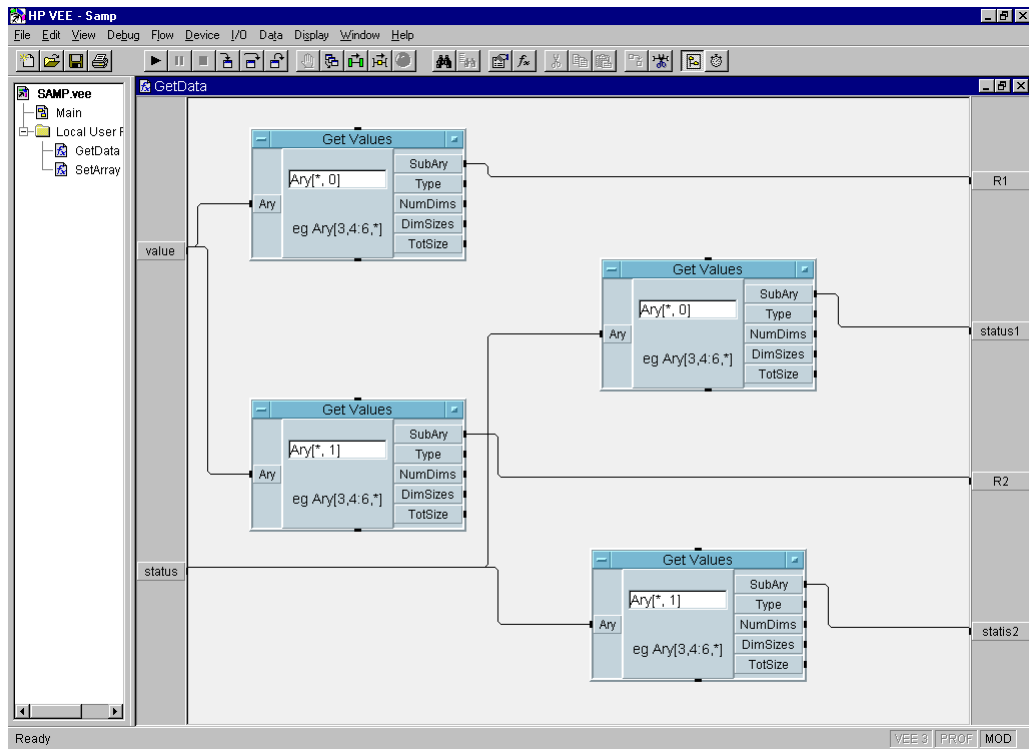


Table 6-28 Program Explanation

Object Title	Menu	Explanation
GetValues	Data-AccessArray-GetValues	Gets data from array (value[],status[]).

Stress Force

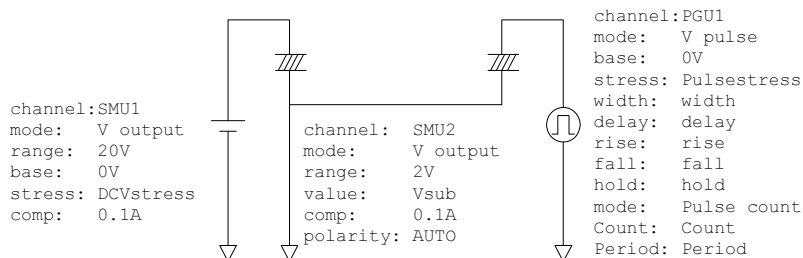
For stress force, use the following functions.

Table 6-29 Functions for Stress Force

Description	Function	Parameters
Output Switch Setup	hp4156b_setSwitch	channel,state
PGU output impedance setup	hp4156b_setPguR	channel,state
Forces dc bias	hp4156b_force	channel,mode,range,value,compliance,polarity
Stress timing setup	hp4156b_setStress	hold,mode,duration,period
dc stress setup	hp4156b_addStressSyncIv	source,channel,mode,range,base,stress,compliance
Pulse stress setup	hp4156b_addStressSyncPulse	source,channel,base,stress,width,delay,rise,fall
Forces stress	hp4156b_stress	status
Clears stress source setup	hp4156b_clearStressSync	
Disables output	hp4156b_zeroOutput	channel

A program example is shown in Figure 6-41 on page 6-46. This program forces dc stress and pulse stress to the DUTs (device under test). The measurement setup is shown in Figure 6-40.

Figure 6-40 Device Connection and Source Setup for Example Program



Programming Examples for VEE Users

Stress Force

Figure 6-41 Program Example of Stress Force

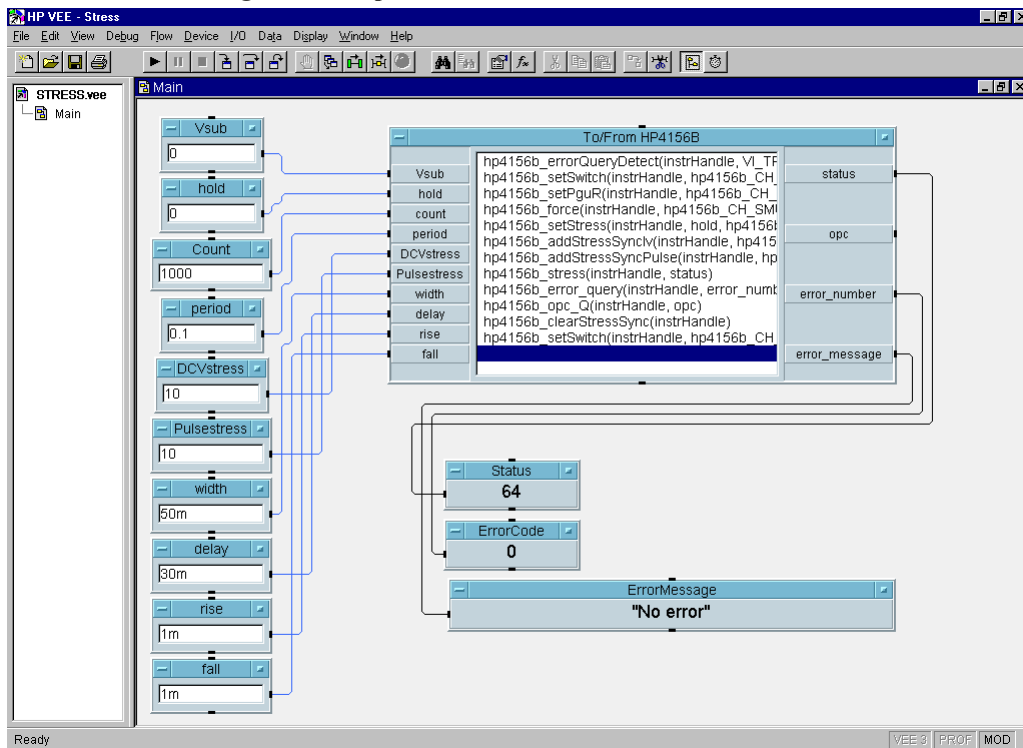


Table 6-30 Program Explanation

Object Title	Menu	Explanation
Vsub,hold,Count,period,DCVstress,Pulsestress,width,delay,rise,fall	Data-Constant-Real Data-Constant-Integer	Enters input parameters of hp4156b_force, hp4156b_setStress, hp4156b_addStressSyncIv, hp4156b_addStressSyncPulse, hp4156b_stress.
To/From HP4156B	I/O-InstrumentManager-Plug&play	Forces dc stress and pulse stress.
Status,ErrorCode,ErrorMessage	Display-AlphaNumeric	Displays measurement status, error code, error message. Ignore status code 64 which is meaningless as response of hp4156b_stress.

Sample Application Programs Using VEE

This chapter explains how to use the sample application programs stored on the Agilent VEE Sample Program Disk furnished with Agilent 4155/4156. This chapter consists of the following sections:

- “Introduction”
- “Installation”
- “Using sample1.vee”
- “Using sample2.vee”
- “Customizing Sample Programs”

CAUTION

The program and setup files stored on the Sample Program Disk are examples only, and may need to be customized for your specific application. Agilent Technologies is not responsible for any damage that may occur from the use of these sample programs.

NOTE

Copy the Agilent VEE Sample Program Disk, and keep the original disk as a backup. To store a program after modifying it, use a file name that is different than the original program name.

Introduction

This section introduces the sample application programs for Agilent VEE that are furnished with the 4155/4156, and covers the following sections:

- “Agilent VEE Sample Program Disk”
- “What are Sample Programs?”

Agilent VEE Sample Program Disk

The Agilent VEE Sample Program Disk stores sample application programs using Agilent VEE and *VXIplug&play* drivers for the 4155/4156 and the E5250A. The sample programs can control the 4155/4156, Agilent E5250A low leakage switch mainframe, and the Summit series semi-auto prober from Cascade Microtech, Inc.

The following files are stored on the disk.

- readme.txt

This is a text file with a brief introduction of the sample programs, installation information, and so on.

- sample1.vee and sample2.vee

These are program files that are executable on Agilent VEE (HP VEE version 4.0 or later). Refer to “What are Sample Programs?”.

- sample.ppd

This file is an example of data used to control the Summit series semi-auto prober from Cascade Microtech, Inc. The *.ppd files will be created and used by the prober control software (PCS) furnished with the prober or supplied from Cascade Microtech, Inc. The sample application programs require the *.ppd file and PCS to control the prober.

What are Sample Programs?

The Sample Program Disk stores two program files, sample1.vee and sample2.vee. Both programs control the 4155/4156, E5250A low leakage switch mainframe, and Cascade Summit series semi-auto prober, and do the following:

1. Probe two MOSFETs on a die
2. Measure Id-Vg characteristics of two MOSFETs
3. Extract the threshold voltage (Vth value) for two MOSFETs
4. Store the measured data into files, and display the results

The differences between the two programs are the probing control and the display, as shown in Table 7-1.

Table 7-1 **Differences Between sample1.vee and sample2.vee**

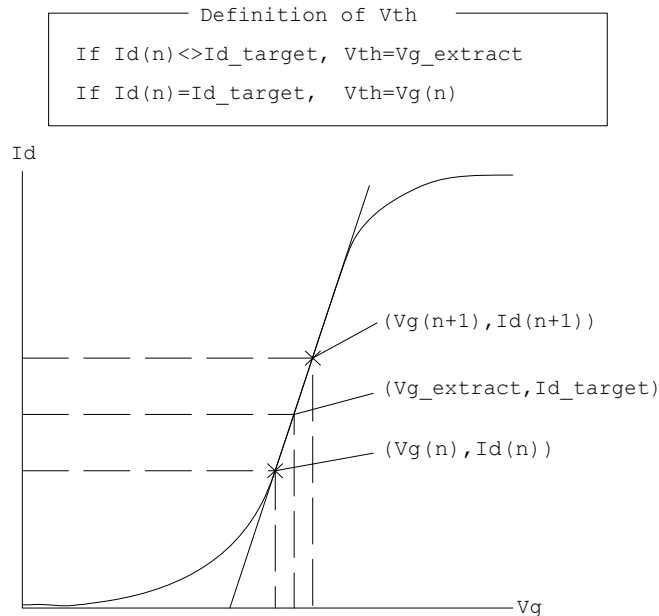
	sample1.vee	sample2.vee
Probing Control	Step-by-step Measurement. Probes the die where you specified the die position (x-y index) defined in the *.ppd file.	Sequential Measurement. Probes sequentially for the dies defined in the *.ppd file.
Display	Vth value, Vth pass/fail status on Wafer Map, X-Y (Vg-Id) Graph of device 1, X-Y (Vg-Id) Graph of device 2	Vth value, Vth pass/fail status on Wafer Map, Histogram of Vth value, X-Y (Vg-Id) Graph of the specified device

Definition of Vth

The threshold voltage (V_{th}) is extracted by a linear interpolation using two measurement points, which are the nearest from the targeted point for both higher and lower directions. The targeted point ($V_{g_extract}, Id_target$) is an ideal point, which indicates the Id_target value on the line through the two measurement points on the Id - V_g curve. See Figure 7-1.

Figure 7-1

Definition of Vth



Execution Mode

The sample1.vee and sample2.vee programs have five execution modes, as described below. The default is Offline mode.

NOTE

If you do not use the Cascade Summit series semi-auto prober, use sample1.vee with Online mode, standalone, or with the E5250A. The sample2.vee program is used for sequential test, using the semi-auto prober. The test results for sample2.vee will be meaningless in the Online mode without the prober.

- Offline mode
Select this mode if you do not use an instrument. After program execution, the demo (dummy) data is returned as the test result.
- Online mode, standalone (4155/4156 only)
Select this mode if you use the 4155/4156 only. The test device is a single MOSFET, as the 4155/4156 has four SMUs to connect and measure a 4-terminal device simultaneously. A test fixture or manual prober is required to connect the device.
- Online mode with E5250A
Select this mode if you use the 4155/4156 and E5250A. A test fixture or manual prober is required to connect the devices.
- Online mode with semi-auto prober
Select this mode if you use the 4155/4156 and the Cascade Microtech Summit series semi-auto prober. The test device is a single MOSFET, as the 4155/4156 has four SMUs to connect and measure a 4-terminal device simultaneously.
- Online mode, fully automatic
Select this mode if you use the 4155/4156, E5250A, and the Cascade Summit series semi-auto prober.

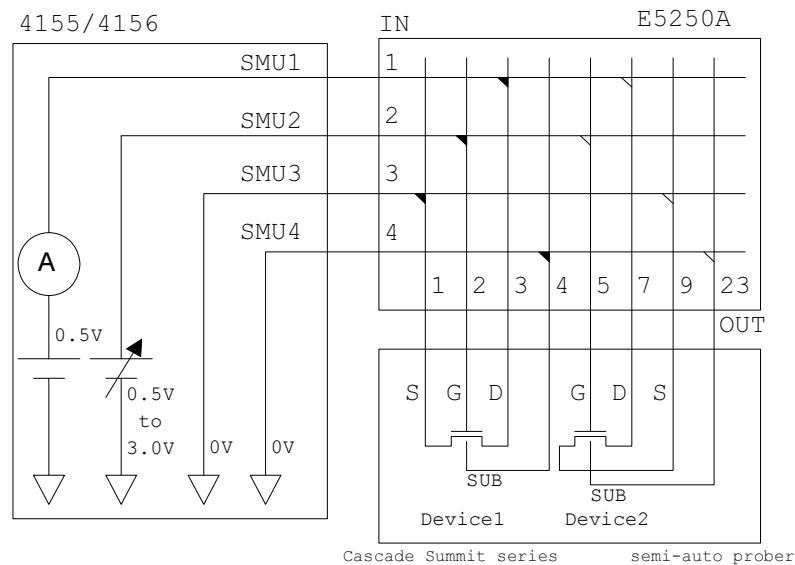
NOTE

The sample programs require that the E5250A be installed with two E5252A matrix cards. They must be installed in slots 1 and 2 of the E5250A mainframe.

Measurement Connection and Source Setup

Figure 7-2 shows the measurement connection for instruments, the probe and devices. This setup is for the fully automatic Online mode. For other modes, ignore the equipment not used. This figure also shows the default source setup.

Figure 7-2 Measurement Connection and Source Setup



NOTE

To avoid misconnection, pay close attention to the die (device1 and device2) and the pin assignment of the probe card, if used.

NOTE

In Figure 7-2, OUT 1 to 9 indicates output port 1 to 9 of the matrix card installed in slot 1 of the E5250A; OUT 23 indicates output port 11 of the card installed in slot 2 of the E5250A.

Sample Application Programs Using VEE

Introduction

Measurement Data Files

The sample programs create three types of data files, as shown below.

- info.txt Information file. Title, date, and comment are included.
- vthn.txt Vth data file. If 5 dies are tested, 5 data are included. For the file name, *n* is 1 or 2 (1 for device1, 2 for device2).
- dnvgidxy.txt Row measurement data file of Id-Vg curve. If 5 dies are tested, the program creates 10 data files (5 files/device). The file names *n*, *x*, and *y* indicate the following:
- n*: 1 or 2 (1 for device1, 2 for device2).
- x*: X-index of the die position.
- y*: Y-index of the die position.

Figure 7-3 Example of Data Files Created by Sample Programs

info.txt

```
Data Save Directory for HP4155B/4156B Sample Program
Mon 15/Jun/1998 14:14:30
Comment :
```

vth1.txt

Device 1 Vth Table		
X Index	Y Index	"Vth [V]"
5	7	9.21E-01
7	5	9.19E-01
5	5	7.32E-01
5	3	9.20E-01
5	3	9.22E-01

vth2.txt

Device 2 Vth Table		
X Index	Y Index	"Vth [V]"
5	7	9.10E-01
7	5	9.19E-01
5	5	9.06E-01
5	5	9.22E-01
5	3	9.09E-01

d1vgid55.txt

(5,5) Device 1 Vg-Id Data		
Vg [V]	Id [A]	Id Status
-5.00E-01	8.00E-15	0
-4.13E-01	8.00E-15	0
-3.25E-01	7.06E-15	0
-2.38E-01	6.06E-15	0
-1.50E-01	6.00E-15	0
-6.25E-02	6.00E-15	0
2.50E-02	5.06E-15	0
1.13E-01	6.89E-15	0
2.00E-01	2.87E-14	0
2.88E-01	4.61E-13	0
3.75E-01	9.17E-12	0
4.63E-01	1.66E-10	0
5.50E-01	2.91E-09	0

d2vgid55.txt

(5,5) Device 2 Vg-Id Data		
Vg [V]	Id [A]	Id Status
-5.00E-01	9.00E-15	0
-4.13E-01	8.00E-15	0
-3.25E-01	8.00E-15	0
-2.38E-01	8.00E-15	0
-1.50E-01	7.00E-15	0
-6.25E-02	6.00E-15	0
2.50E-02	6.00E-15	0
1.13E-01	6.00E-15	0
2.00E-01	5.00E-15	0
2.88E-01	6.99E-15	0
3.75E-01	2.99E-14	0
4.63E-01	4.85E-13	0
5.50E-01	9.67E-12	0

Installation

This section explains the equipment and accessories required to use the sample programs, and how to install the programs.

Required Equipment and Accessories

1. PC (AT-compatible) for Windows

Agilent VEE (HP VEE version 4.0 or later) and the *VXIplug&play* drivers for the 4155/4156 and E5250A must be installed in your PC and ready for use. See Chapter 1.

A 3.5 inch flexible disk drive must be connected to your PC to install the sample programs.

If you use the Cascade Microtech Summit series semi-auto prober, the prober control software (PCS) supplied by Cascade Microtech, Inc. must be installed in your PC and the prober must be connected to your PC via Cascade's interface. For the interface, and the operating system supported by the PCS, contact Cascade Microtech, Inc.

2. Agilent VEE Sample Program Disk

3. Agilent 4155 or 4156 Semiconductor Parameter Analyzer

4. Agilent E5250A Low Leakage Switch Mainframe

Two E5252A matrix cards are required and must be installed in slot 1 and 2 of the E5250A.

5. Cascade Microtech Summit Series Semi-Auto Prober

If you do not use the semi-auto prober, prepare the manual prober or test fixture, such as Agilent 16442A/B, to connect the test devices.

6. Connection Cables

Four triaxial cables are required to connect the 4155/4156 and E5250A.

Eight triaxial cables are required to connect the E5250A and the prober or test fixture. You will also need coaxial cables, probe card, manipulators, or wire to connect the test devices.

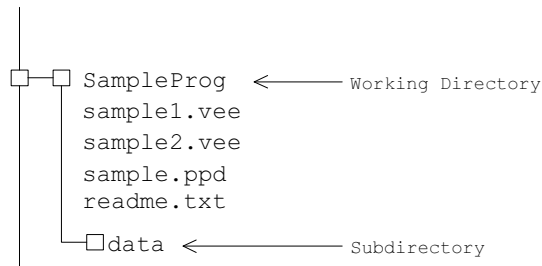
Two GPIB cables are required to connect the instruments and the PC.

Installing the Sample Programs

1. Make a working directory where you can install and execute the sample programs, using Windows Explorer.
2. Create a subdirectory in the working directory. The subdirectory will be used to save the measurement data files.
3. Insert the Agilent VEE Sample Program Disk into the flexible disk drive connected to your PC.
4. Copy all of the files on the disk to the working directory.

Figure 7-4

Installing Sample Programs



Using sample1.vee

This section covers the following topics.

- “Program Execution Flow”
- “Panel Display”
- “To Execute sample1.vee”

NOTE

For the wafer test using the Summit series semi-auto prober from Cascade Microtech, Inc., create your own probe plan file (*.ppd). The sample.ppd file stored on the Agilent VEE Sample Program Disk is an example only.

Sample Application Programs Using VEE Using sample1.vee

Program Execution Flow

The execution flow of the sample1.vee program is shown in Figure 7-5 and Table 7-2.

Figure 7-5 Execution Flow of sample1.vee

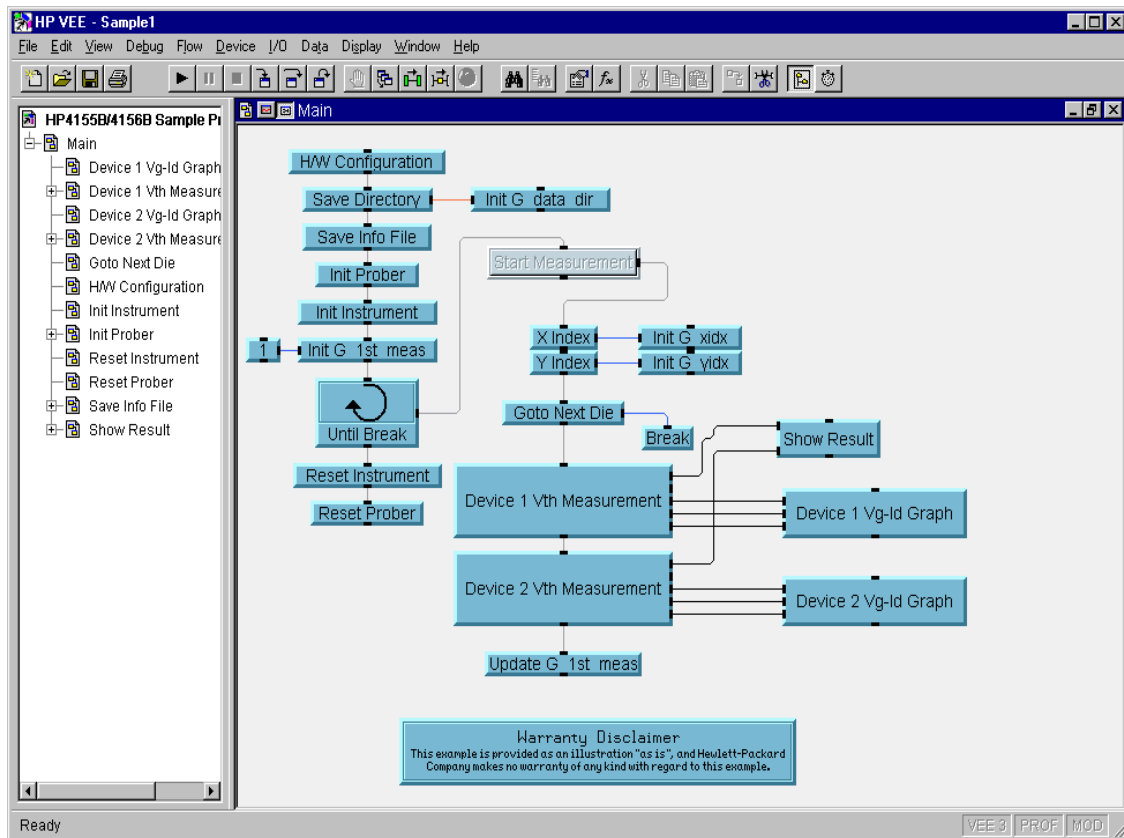


Table 7-2 Execution Flow of sample1.vee

	Object	Explanation
1	H/W Configuration	Defines execution mode. Set the mode before running sample1.vee.
2	Save Directory, Init G data dir	Defines name of the subdirectory to save the measurement result data. See “Installing the Sample Programs” on page 10.
3	Save Info File	Defines and saves the information file (info.txt) which contains title, date, and comments for the subdirectory. You can enter comments. See “Measurement Data Files” on page 8.
4	Init Prober	Initializes Cascade Summit series semi-auto prober, if used.
5	Init Instrument	Initializes instrument, if used.
6	1, Init G 1st meas	Sets G_1st_meas value. If G_1st_meas=1, header lines are written in vth1.txt and vth2.txt. See “Measurement Data Files” on page 8.
7	Until Break	Repeats the following sequence until a break occurs.
8	Start Measurement	Triggers the start of the measurement.
9	X Index, Init G xidx, Y Index, Init G yidx	Defines X and Y index of the die tested. The index must be defined in the *.ppd file used.
10	Goto Next Die, Break	Probes the die specified by the X-Y index. Breaks if X index < 0.
11	Device1 Vth Measurement Device2 Vth Measurement	Executes Id-Vg measurement, extracts Vth, and saves measurement results. See “Measurement Data Files” on page 8.
12	Device1 Vg-Id Graph Device2 Vg-Id Graph	Displays Id-Vg measurement result graphs of Device 1 and 2. See Figure 7-6.
13	Show Result	Displays Vth value and wafer map. See Figure 7-6. Dev1 Vth and Dev2 Vth show Vth value, and the field below shows wafer map.
14	Update G 1st meas	Sets G_1st_meas variable to 0.
15	Reset Instrument	Resets the instruments.
16	Reset Prober	Resets the prober.

Sample Application Programs Using VEE

Using sample1.vee

Panel Display

The sample1.vee program displays the following data and graph. See Figure 7-6.

Vth Displays Vth value of device 1 and 2. The data is in volts.

Vg-Id Graph Displays Id-Vg curve of device 1 and 2.

X, Y Index Displays wafer map of Vth value using the following characters.

∴ Both device 1 and 2 test data are within the allowable range.

F1: Device 1 test data is out of the allowable range.

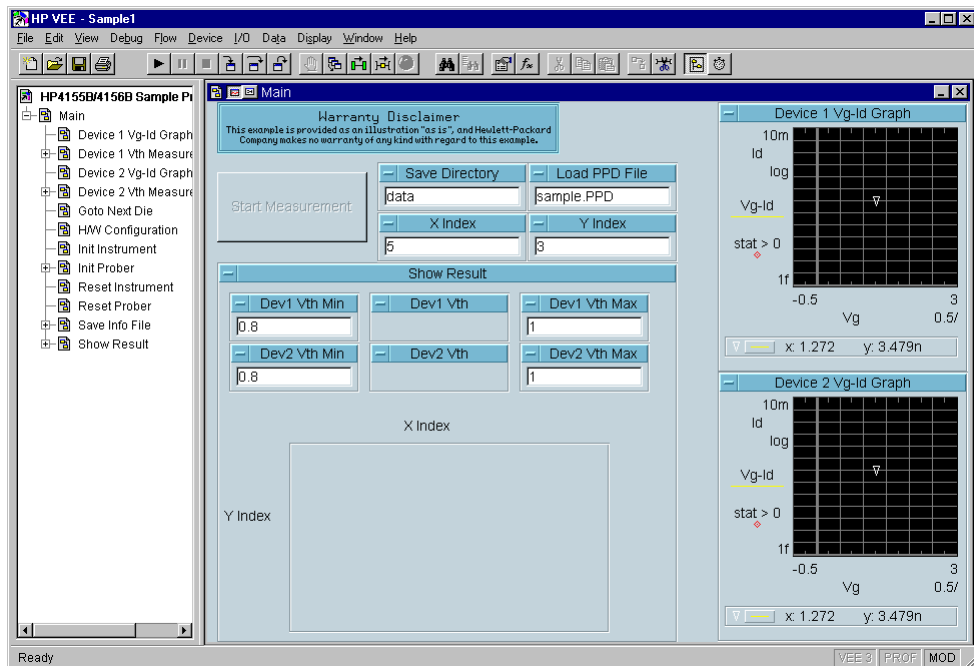
F2: Device 2 test data is out of the allowable range.

F3: Both device 1 and 2 test data are out of the allowable range.

The allowable range is specified by Dev1(2) Vth Min and Dev1(2) Vth Max input fields. Min field sets the lower limit, and Max field sets the upper limit.

Figure 7-6

Panel Display of sample1.vee



To Execute sample1.vee

Before executing the sample1.vee program, do the following.

NOTE

If you execute sample1.vee in Offline mode, skip steps 1 through 5.

1. Connect GPIB cables between your PC and the instruments being used.
2. Confirm that the semi-auto prober is connected to your PC via Cascade's interface, or connect the prober to your PC, if used.
3. Connect the measurement cables between the instruments and the prober or test fixture being used. See "Measurement Connection and Source Setup" on page 7.
4. Turn on the instruments and the semi-auto prober being used, if applicable.
5. Display the SYSTEM: MISCELLANEOUS screen on the 4155/4156. Select NOT SYSTEM CONTROLLER in the *4155C/4156C is* field.
6. Run Agilent VEE. If this is the first time using Agilent VEE and VXI*plug&play* drivers for the 4155/4156 and E5250A, register the drivers at this time. See "Programming Basics" on page 6-3.
7. Open the sample1.vee program.
8. Display the program (Figure 7-5) and double click the H/W Configuration object. The panel of this object is displayed.
9. On the panel, select the check button of the instruments being used and the semi-auto prober, if used. See Table 7-3.

Table 7-3

H/W Configuration Object Check Button Setup

Execution Mode	4155/56	E5250A	Semi-Auto Prober
Online, standalone	check		
Online, with E5250A	check	check	
Online, with prober	check		check
Online, fully automatic	check	check	check
Offline			

Sample Application Programs Using VEE

Using sample1.vee

To execute the sample1.vee program, do the following.

NOTE

If you execute sample1.vee in Offline mode, skip steps 3, 5, and 6.

1. Create a directory (Example: C:\lot1\test1\data) to be used to save the measurement data. To create a directory, use Windows Explorer. See “Installing the Sample Programs” on page 10.
2. Display the panel (Figure 7-6) and enter the following input fields.

Save Directory	Enter the name of the directory to save measurement data. Enter only the name if the directory is under the current directory which this program is stored, or enter the entire path to specify another directory, such as C:\lot1\test1\data.
Load PPD File	Enter the file name of the probe plan data file (*.ppd) for the Cascade Microtech Prober Control Software. Ignore this field if you do not use the semi-auto prober.
Dev1 Vth Min/Max	Enter the allowable range of device 1 Vth value. Min field sets the lower limit, Max field sets the upper limit.
Dev2 Vth Min/Max	Enter the allowable range of device 2 Vth value. Min field sets the lower limit, Max field sets the upper limit.
3. Connect the device.

If you use the semi-auto prober, load a wafer on the prober, and keep the platen handle up.

If you do not use the semi-auto prober, connect devices (two MOSFETs) to a test fixture, or load a wafer on a manual prober and probe a die tested.
4. Click the run button on the Agilent VEE menu bar. If you use the semi-auto prober, the Wait the DDE Server setup dialog box is displayed, and the Cascade Microtech prober control software is called. See Figure 7-7

If you do not use the semi-auto prober, skip steps 5 and 6.
5. Click Continue. A window for the prober control software is displayed as shown in Figure 7-8.

This example shows the SAMPLE.PPD window of the prober control software. The title of the window will be the file name you entered in the Load PPD File input field in step 2.
6. Move the wafer to align the probes over the probe plan alignment position, then click OK in the ALIGN PROBES dialog box.

Figure 7-7 Running sample1.vee with Cascade Microtech Prober Control Software (1)

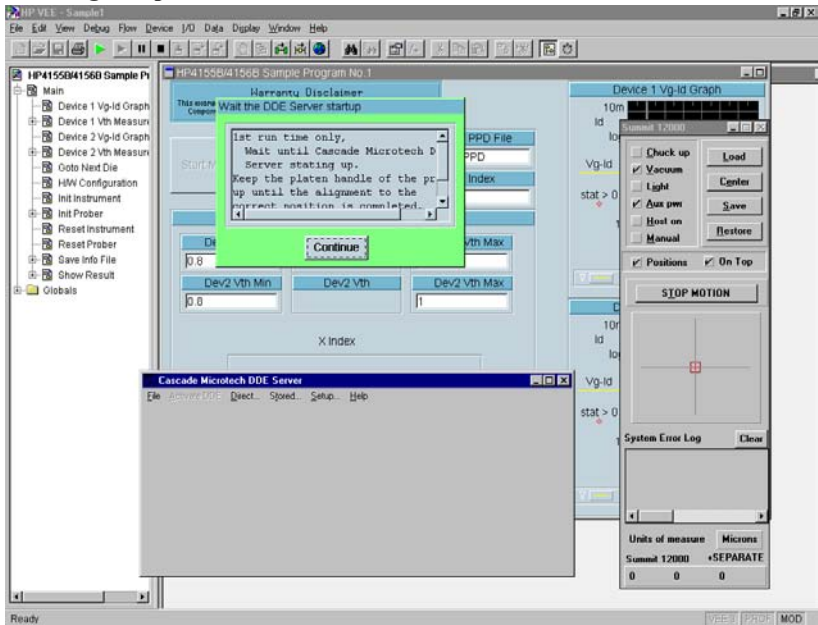
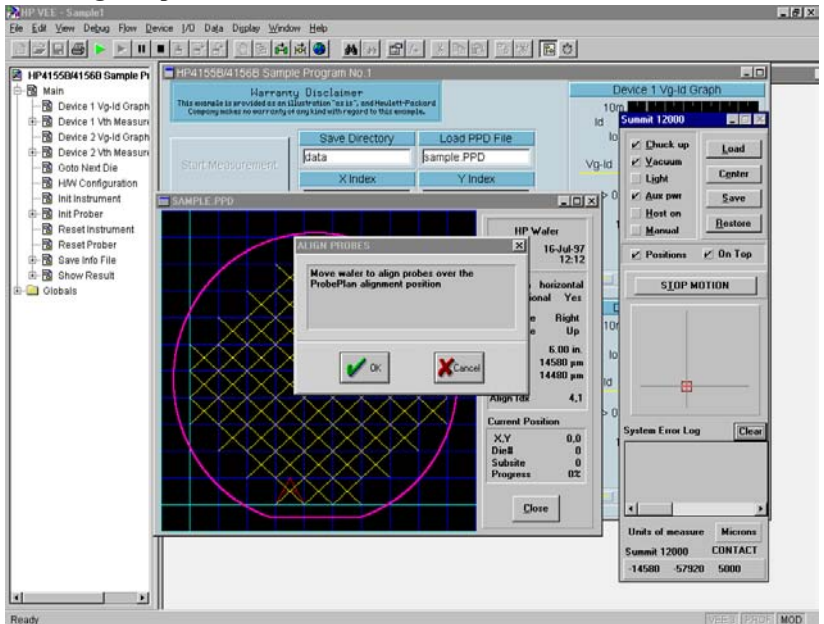


Figure 7-8 Running sample1.vee with Cascade Microtech Prober Control Software (2)

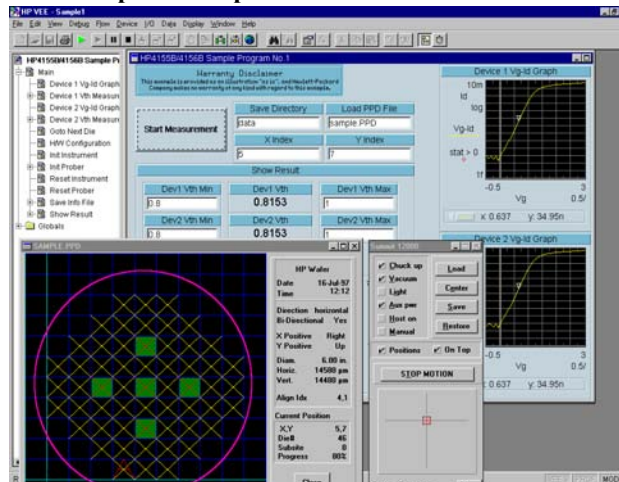


Sample Application Programs Using VEE

Using sample1.vee

- Enter the X-Y index of the die to be tested in the X Index and Y Index input fields. Only the index defined in the *.ppd file is effective for this test.
- Click Start Measurement. The program executes the Id-Vg measurement, extracts Vth value, displays the results, and stores the data into files. The program then waits for your input.

Figure 7-9 Execution Example of sample1.vee



- Repeat steps 7 and 8 for all dies to be tested.
- To stop the program, click the stop button on the Agilent VEE menu bar.

NOTE

In Offline mode, the program returns the dummy data instead of the raw measurement data in step 8.

NOTE

A wafer map is also displayed in the Cascade Microtech Prober Control Software *.ppd window. This window indicates results by using the following color scheme.

- Green: Both device 1 and 2 test data are within the allowable range.
- Yellow: Device 1 test data is out of the allowable range.
- Magenta: Device 2 test data is out of the allowable range.
- Red: Both device 1 and 2 test data are out of the allowable range.

NOTE

To exit the Cascade Microtech prober control software, select the File-Exit menu of the Cascade Microtech DDE Server window, then click Yes in the Halt Cascade DDE Server dialog box.

Using sample2.vee

This section covers the following topics.

- “Program Execution Flow”
- “Panel Display”
- “To Execute sample2.vee”

NOTE

For the wafer test using the Summit series semi-auto prober from Cascade Microtech, Inc., create your probe plan file (*.ppd). The sample.ppd file stored on the Agilent VEE Sample Program Disk is an example only.

Sample Application Programs Using VEE

Using sample2.vee

Program Execution Flow

The execution flow of the sample2.vee program is shown in Figure 7-10 and Table 7-4.

Figure 7-10 Execution Flow of sample2.vee

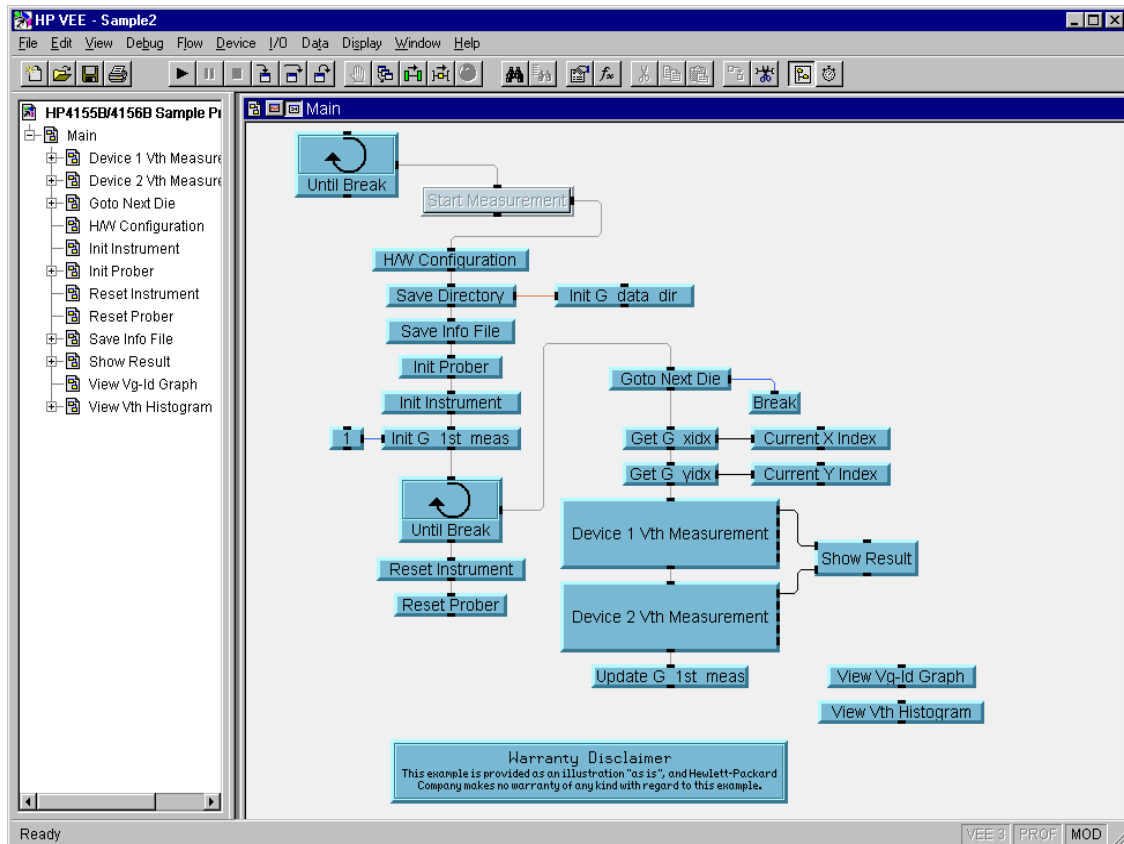


Table 7-4 Execution Flow of sample2.vee

	Object	Explanation
1	Until Break	Repeats the following sequence until a break occurs.
2	Start Measurement	Triggers the start of the wafer test.
3	H/W Configuration	Defines execution mode. Set the mode before running sample2.vee.
4	Save Directory, Init G data dir	Defines name of the subdirectory to save measurement result data. See “Installing the Sample Programs” on page 10.
6	Save Info File	Defines and saves the information file (info.txt) which contains title, date, and comments for the subdirectory. You can enter comments. See “Measurement Data Files” on page 8.
7	Init Prober	Initializes Cascade Summit series semi-auto prober, if used.
8	Init Instrument	Initializes instruments, if used.
9	1, Init G 1st meas	Sets G_1st_meas value. If G_1st_meas=1, the prober sets the first die to probe, and header lines are written in vth1.txt and vth2.txt. See “Measurement Data Files” on page 8.
10	Goto Next Die, Break	Probes the die to test. The die and probing sequence depend on the *.ppd file used. Breaks if the test was completed for all die.
11	Get G xidx, Get G yidx Current X, Y Index	Gets and displays the X-Y index of the die now tested.
13	Device1 Vth Measurement Device2 Vth Measurement	Executes Id-Vg measurement, extracts Vth, and saves measurement results. See “Measurement Data Files” on page 8.
14	Show Result	Displays Vth value and wafer map. See Figure 7-11. Dev1 Vth and Dev2 Vth show Vth value, and the field below shows wafer map.
15	Update G 1st meas	Sets G_1st_meas variable to 0.
16	Reset Instrument	Resets the instruments.
17	Reset Prober	Resets the prober.
--	View Vg-Id Graph	Displays Id-Vg curve of the device you select.
--	View Vth Histogram	Displays histogram for Vth of the device you select (device 1 or device 2).

Sample Application Programs Using VEE

Using sample2.vee

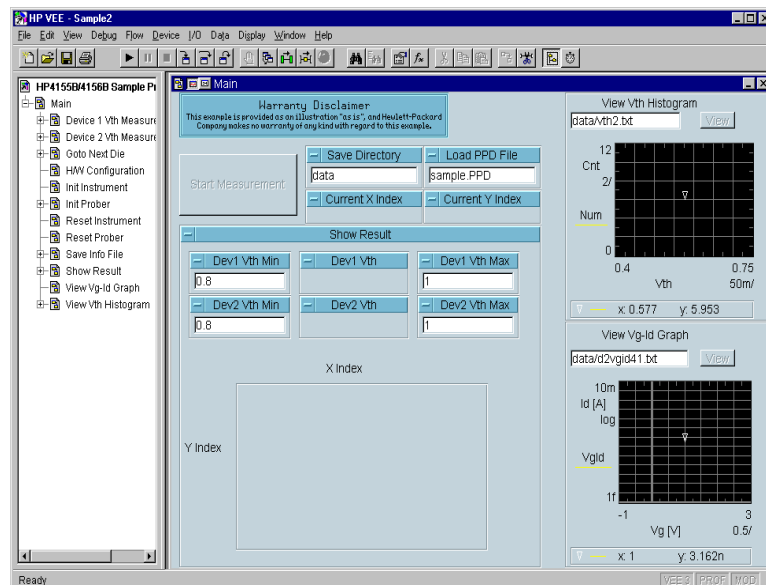
Panel Display

The sample2.vee program displays the following data and graph. See Figure 7-11.

Vth	Displays Vth value of device 1 and 2. The data is in volts.
Histogram	Displays histogram of Vth value for the device selected. Enter the file name, then click View to display the histogram.
Vg-Id Graph	Displays Id-Vg curve for the device selected. Enter the file name, then click View to display the graph.
X, Y Index	Displays wafer map of Vth value using the following characters. . : Both device 1 and 2 test data are within the allowable range. F1: Device 1 test data is out of the allowable range. F2: Device 2 test data is out of the allowable range. F3: Both device 1 and 2 test data are out of the allowable range. The allowable range is specified by Dev1(2) Vth Min and Dev1(2) Vth Max input fields. Min field sets the lower limit, and Max field sets the upper limit.

Figure 7-11

Panel Display of sample2.vee



To Execute sample2.vee

Before executing the sample2.vee program, do the following.

NOTE

If you execute sample2.vee in Offline mode, skip steps 1 through 5.

1. Connect the GPIB cables between your PC and the instruments being used.
2. Confirm that the semi-auto prober is connected to your PC via Cascade's interface, or connect the prober to your PC, if used.
3. Connect the measurement cables between the instruments and the prober or test fixture used. See "Measurement Connection and Source Setup" on page 7.
4. Turn on the instruments and the semi-auto prober being used, if applicable.
5. Display the SYSTEM: MISCELLANEOUS screen on the 4155/4156. Then select NOT SYSTEM CONTROLLER in the *4155C/4156C is* field.
6. Run Agilent VEE. If this is the first time using Agilent VEE and VXI*plug&play* drivers for the 4155/4156 and E5250A, register the drivers at this time. See "Programming Basics" on page 6-3.
7. Open the sample2.vee program.
8. Display the program (Figure 7-10) and double click the H/W Configuration object. The panel for the object is displayed.
9. On the panel, select the check button of the instruments and the semi-auto prober being used, if applicable. See Table 7-5.

Table 7-5

H/W Configuration Object Check Button Setup

Execution Mode	4155/56	E5250A	Semi-Auto Prober
Online, standalone	check		
Online, with E5250A	check	check	
Online, with prober	check		check
Online, fully automatic	check	check	check
Offline			

Sample Application Programs Using VEE

Using sample2.vee

To execute the sample2.vee program, do the following.

NOTE

If you execute sample2.vee in Offline mode, skip steps 4, 6, and 7.

1. Click the run button on the Agilent VEE menu bar.
2. Create a directory (Example: C:\lot1\test1\data) to save the measurement data. To create a directory, use Windows Explorer. See “Installing the Sample Programs” on page 10.
3. Enter the following input fields.

Save Directory	Enter the name of the directory to save measurement data. Enter only the name if the directory is under the current directory where this program is stored, or enter the entire path to specify a different directory, such as C:\lot1\test1\data.
Load PPD File	Enter the file name of the probe plan data (*.ppd) file for Cascade Microtech Prober Control Software. Ignore this field if the semi-auto prober is not used.
Dev1 Vth Min/Max	Enter the allowable range of Vth value for device 1. Min field sets the lower limit, Max field sets the upper limit.
Dev2 Vth Min/Max	Enter the allowable range of Vth value for device 2. Min field sets the lower limit, Max field sets the upper limit.
4. Connect the device.

If you use the semi-auto prober, load a wafer on the prober, and keep the platen handle up.

If you do not use the semi-auto prober, connect devices (two MOSFETs) to a test fixture, or load a wafer on a manual prober and probe a die tested.
5. Click Start Measurement. If you use the semi-auto prober, the Wait the DDE Server setup dialog box is displayed, and the Cascade Microtech prober control software is called. See Figure 7-12

If you do not use the semi-auto prober, skip steps 6 and 7.
6. Click Continue. A window of the prober control software is displayed as shown in Figure 7-13.

This example shows the SAMPLE.PPD window of the prober control software. The title of the window will be the file name you entered in the Load PPD File input field in step 3.

Figure 7-12 Running sample2.vee with Cascade Microtech Prober Control Software (1)

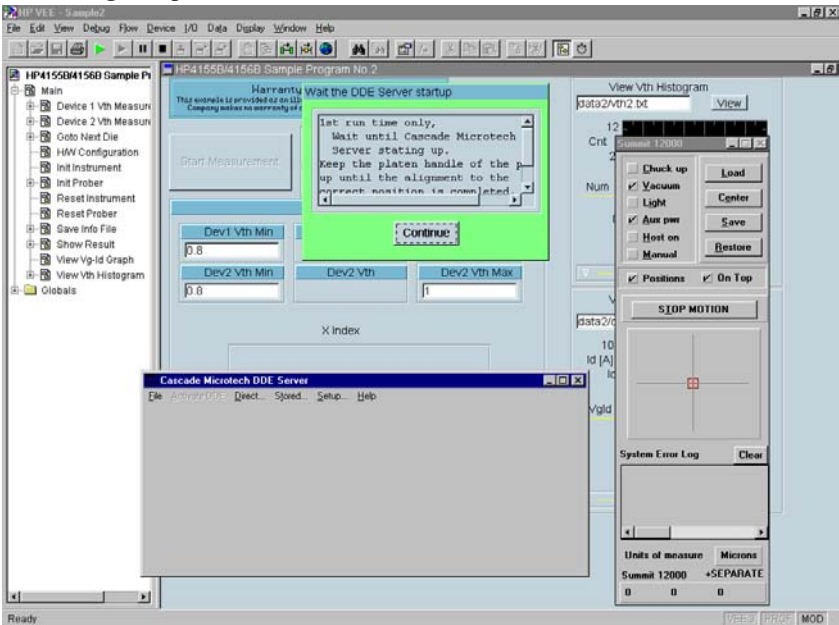
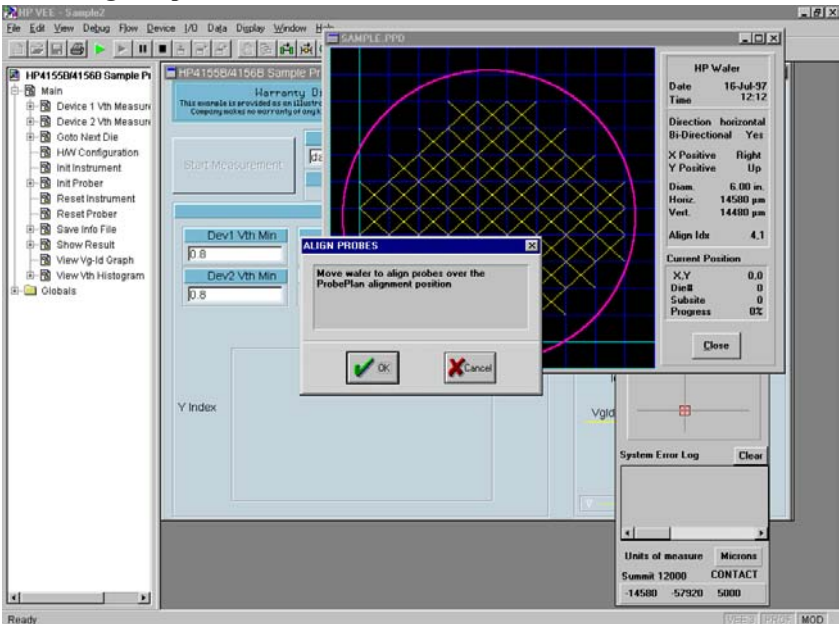


Figure 7-13 Running sample2.vee with Cascade Microtech Prober Control Software (2)

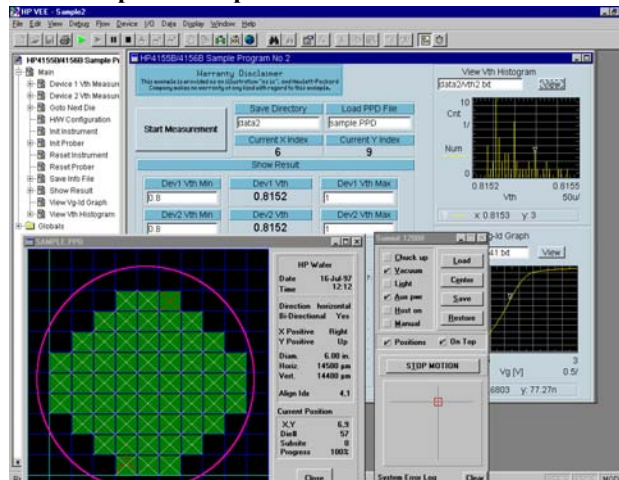


Sample Application Programs Using VEE

Using sample2.vee

7. Move the wafer to align the probes over the probe plan alignment position, then click OK in the ALIGN PROBES dialog box.
8. Wait until wafer test is completed. The program executes the Id-Vg measurement, extracts Vth value, displays the results, and stores the data into files. The program then waits for your input.

Figure 7-14 Execution Example of sample2.vee



9. Repeat step 2 through 8 for all wafers to be tested.
10. To stop the program, click the stop button on the Agilent VEE menu bar.

NOTE

In Offline mode, the program returns the dummy data instead of the raw measurement data in step 8.

NOTE

A wafer map is also displayed in the Cascade Microtech Prober Control Software *.ppd window. The window indicates the results by using the following color scheme.

- Green: Both device 1 and 2 test data are within the allowable range.
- Yellow: Device 1 test data is out of the allowable range.
- Magenta: Device 2 test data is out of the allowable range.
- Red: Both device 1 and 2 test data are out of the allowable range.

NOTE

To exit the Cascade Microtech Prober Control Software, select the File-Exit menu of the Cascade Microtech DDE Server window. Then click Yes in the Halt Cascade DDE Server dialog box.

Customizing Sample Programs

This section offers examples of modifications to the sample1.vee and sample2.vee programs:

- “To Change an GPIB Address”
- “To Change the Vth Measurement Setup”
- “To Remove a Test Device”
- “To Remove a Source Output”
- “To Add a Test Device”
- “To Add a Measurement Parameter”

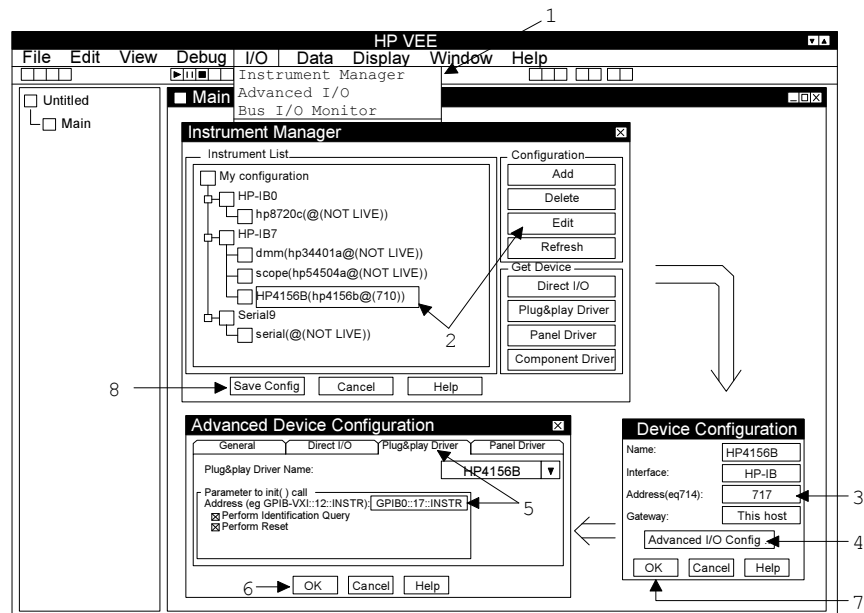
To Change an GPIB Address

You can change the GPIB address of the 4155/4156 and E5250A by using the Agilent VEE Instrument Manager.

1. Select the I/O-InstrumentManager menu from the Agilent VEE menu bar. The Instrument Manager dialog box is displayed.
2. Select the instrument (Example: HP4156B) from the Instrument Manager dialog box, and then click Edit. The Device Configuration dialog box is displayed.
3. Enter the new address in the Address field. For example, enter “717”.
4. Click Advanced I/O Config. The Advanced Device Configuration dialog box is displayed.
5. Select the Plug&play Driver Tab, and then enter the new address in the Address field. For example, enter “GPIB0::17::INSTR”.
6. Click OK in the Advanced Device Configuration dialog box.
7. Click OK in the Device Configuration dialog box.
8. Click Save Config in the Instrument Manager dialog box to register the new address.

Figure 7-15

To Change an GPIB Address



To Change the Vth Measurement Setup

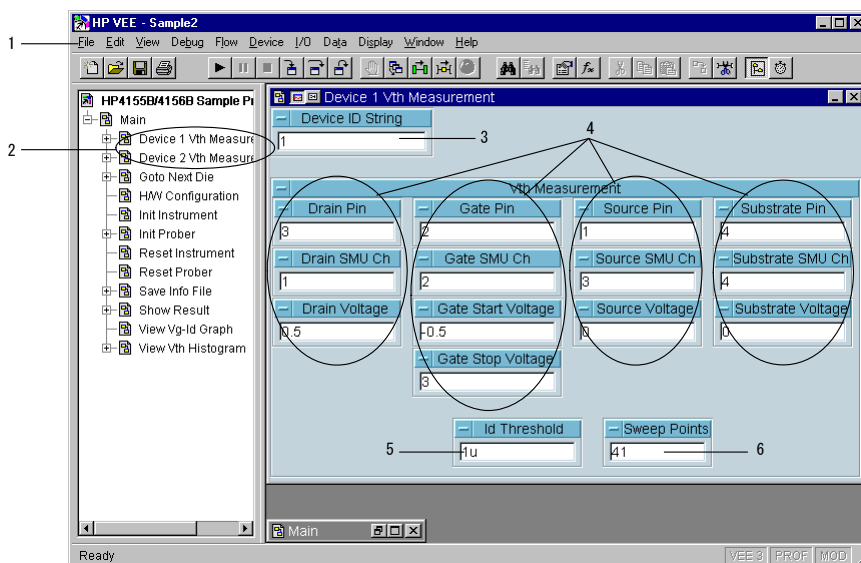
You can change the 4155/4156 source setup and the E5250A switching setup by editing the Device 1 (or 2) Vth Measurement object. See Figure 7-16.

1. Open the sample1.vee or sample2.vee program.
2. Double click Device 1 (or 2) Vth Measurement in the Agilent VEE program explorer. The Device 1 (or 2) Vth Measurement object is displayed.
3. Change the Device ID for MOSFET if needed, using a string format.
4. Change the setup for all terminals for MOSFET.

Pin	E5250A output channel number; 1 to 24 are available.
SMU Ch	4155/4156 SMU number; 1 to 4 are available.
Voltage	SMU output voltage (in volts).
Start, Stop Voltage	SMU output voltage for Vg sweep (in volts).
5. Change the target Id for extracting Vth. See “Definition of Vth” on page 5.
6. Change the number of measurement points in a sweep; 2 to 256 are available.

Figure 7-16

Vth Measurement Panel Display



Sample Application Programs Using VEE

Customizing Sample Programs

NOTE

If you want to change other source setup parameters, such as compliance, you will need to change the setup of the To/From object, by doing the following.

1. Display the program for the Device 1 (or 2) Vth Measurement object.
2. Open the Vth Measurement object, and display the program.
3. Open the Pre-Setup object, and then open the Setup4155 object.
4. Double click hp4156b_force and display the Edit Function Panel.
5. Change the setup value on the panel.

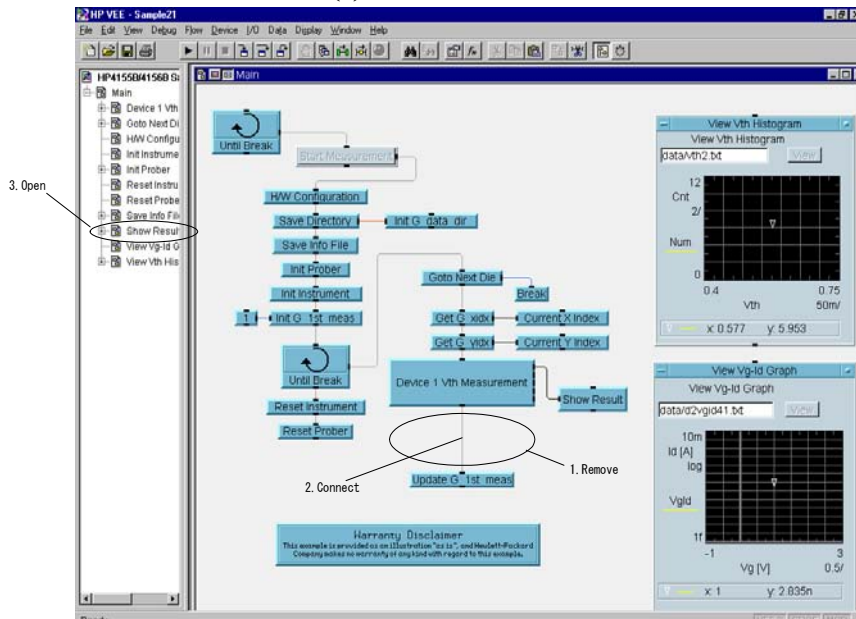
To Remove a Test Device

If your test die includes only one MOSFET, modify the program as shown below. This example modifies sample2.vee, and removes objects for device 2.

1. Cut the Device 2 Vth Measurement object from the Main program display.
2. Connect the control line between the Device 1 Vth Measurement object and the Update G 1st meas object.
3. Open the Show Result object using the Agilent VEE program explorer.

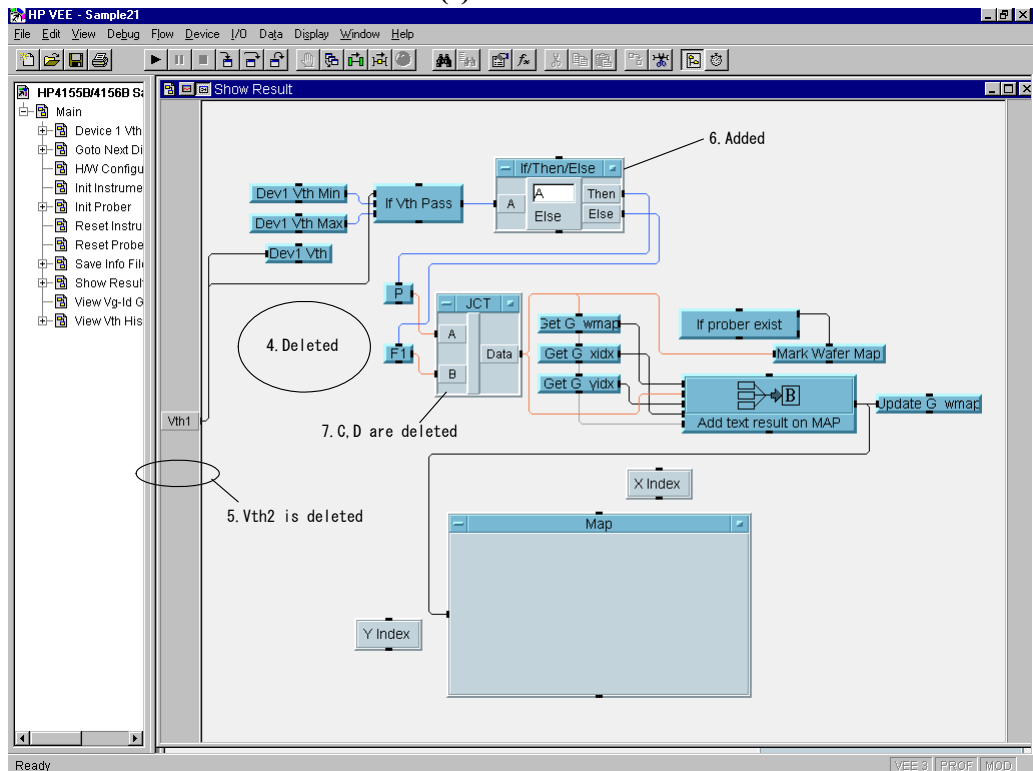
Figure 7-17

To Remove a Test Device (1)



4. Display the Show Result object program, and cut the following seven objects:
 - Dev2 Vth, Dev2 Vth Min, Dev2 Vth Max, If Vth Pass (for device2)
 - If/Then/Else
 - F2, F3
5. Delete the input terminal Vth2.
6. Add the Flow-If/Then/Else object, and enter A, then connect the lines:
 - between If Vth Pass and If/Then/Else A terminal
 - between If/Then/Else Then terminal and P
 - between If/Then/Else Else terminal and F1
7. Double click the JCT object, and delete the input terminals C and D.

Figure 7-18 To Remove a Test Device (2)

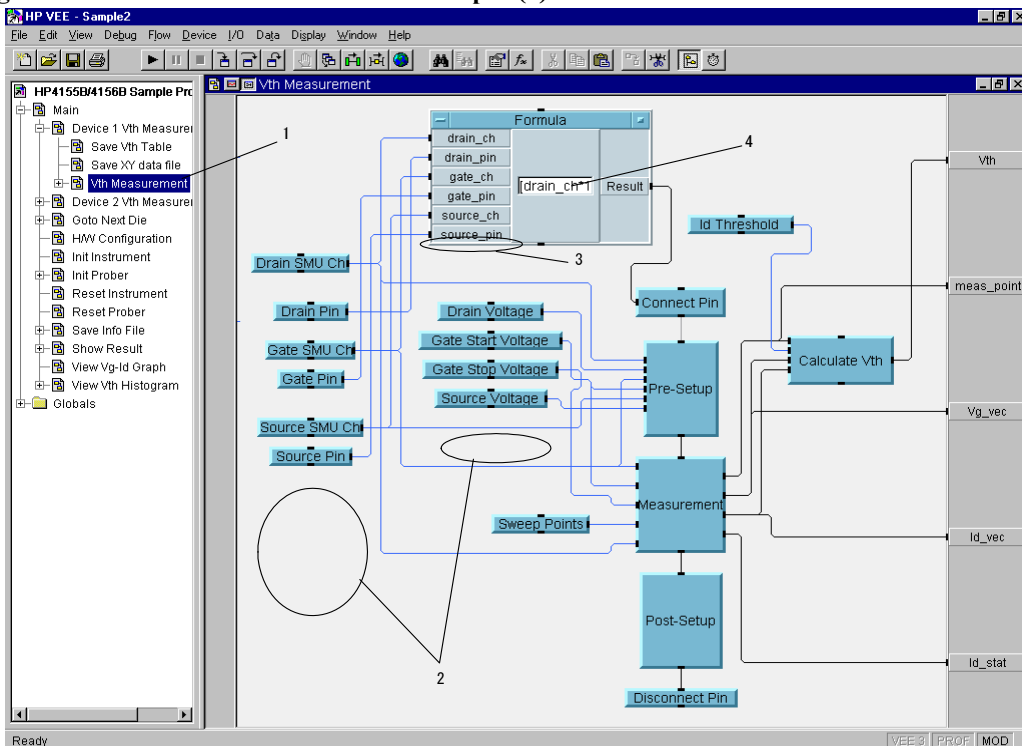


To Remove a Source Output

If the number of terminals for your device is less than four, modify the program as shown below. This example modifies `sample2.vee`, and removes objects for the substrate terminal of device 1 (the example does not modify the objects for device 2).

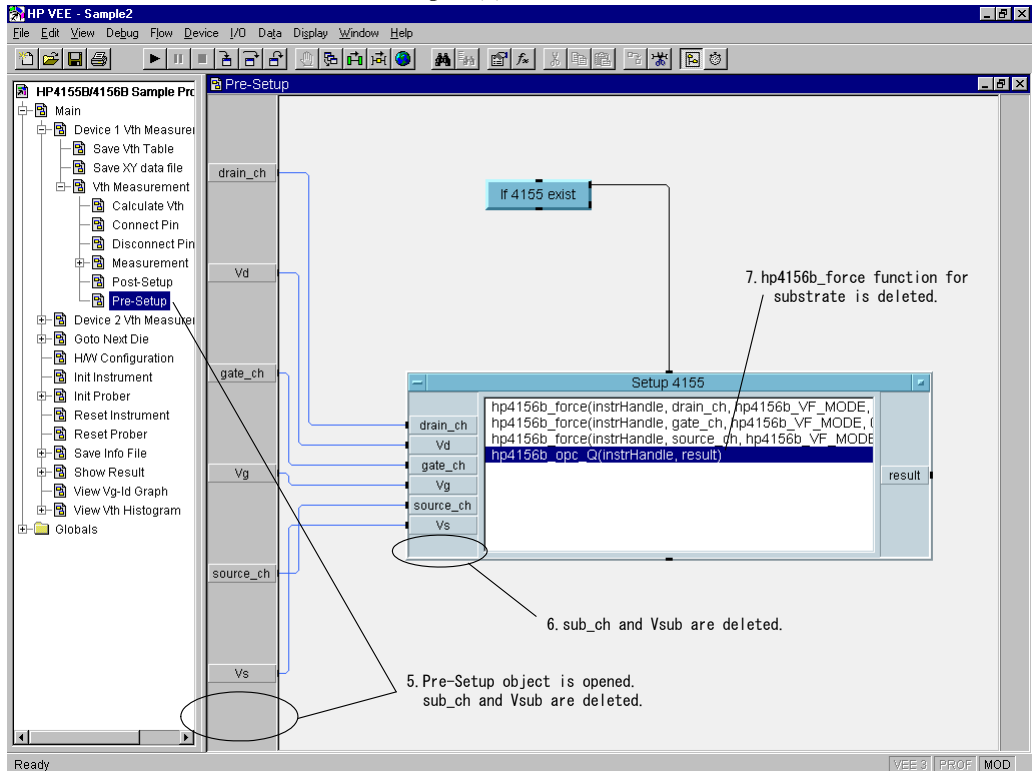
1. Open the Vth Measurement object using the Agilent VEE program explorer.
2. Display the program, and cut the following three objects.
 - Substrate SMU Ch
 - Substrate Pin
 - Substrate Voltage
3. Open the Formula object, and delete the sub_ch and sub_pin input terminals.
4. Change the formula, defined in the Formula object, as shown below.
$$[\text{drain_ch} \times 100 + \text{drain_pin}, \text{gate_ch} \times 100 + \text{gate_pin}, \text{source_ch} \times 100 + \text{source_pin}, 0]$$

Figure 7-19 To Remove a Source Output (1)



5. Open the Pre-Setup object, and delete the sub_ch and Vsub input terminals.
6. Open the Setup 4155 object, and delete the sub_ch and Vsub input terminals.
7. Delete the hp4156b_force(instrHandle,sub_ch,.....) function from the Setup 4155 object.

Figure 7-20 To Remove a Source Output (2)



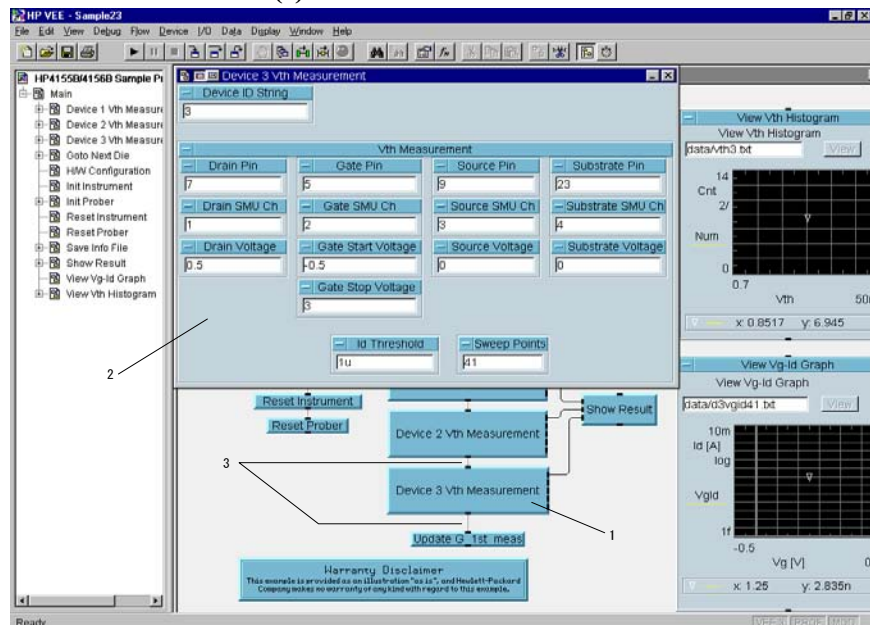
To Add a Test Device

If your test die includes three MOSFETs, modify the program as shown below. This example modifies sample2.vee, and adds the Vth measurement and display objects for the third MOSFET.

1. Copy and paste the Device 2 Vth Measurement object on the Main program display, and change the title to Device 3 Vth Measurement.
2. Change the measurement setup, Device ID String, pin, voltage, and so on, for the third device on the panel display of the Device 3 Vth Measurement object. See “To Change the Vth Measurement Setup” on page 29.
3. Cut the line between the Device 2 Vth Measurement object and Update G 1st meas object, then connect the lines as shown below.
 - between Device 2 Vth Measurement and Device 3 Vth Measurement
 - between Device 3 Vth Measurement and Update G 1st meas
4. Open the Show Result object program display, and add the Vth3 input terminal. See Figure 7-22.
5. Open the If/Then/Else object, and add the t3 input terminal.

Figure 7-21

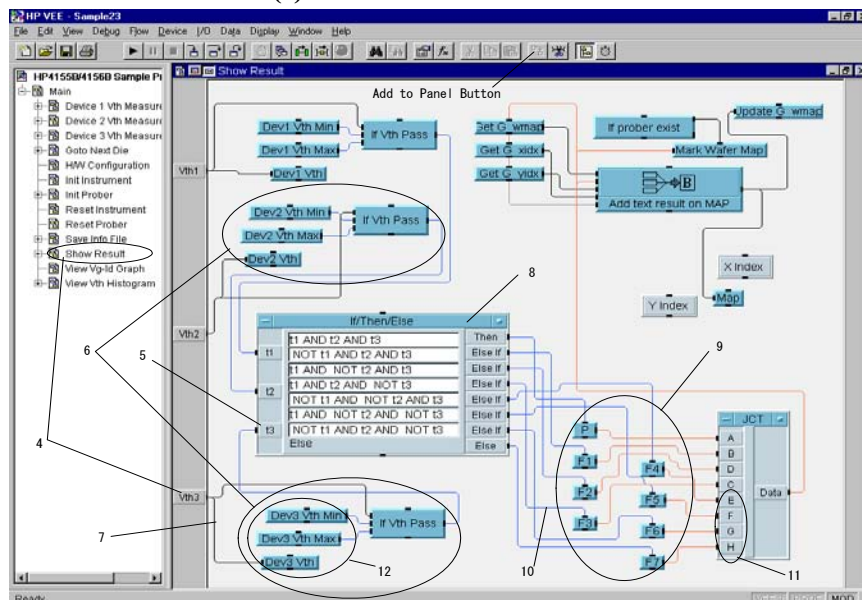
To Add a Test Device (1)



6. Copy and paste the following four objects, and change title Dev2 to Dev3.
 - Dev2 Vth Min, Dev2 Vth Max, Dev2 Vth, and If Vth Pass
7. Connect the lines shown below:
 - between Vth3 terminal and Dev3 Vth object
 - between Vth3 terminal and the data input terminal of If Vth Pass object
 - between If Vth Pass and t3 input terminal of If/Then/Else object
8. Change the definition of the If/Then/Else object as shown in Figure 7-22.
9. Copy and paste P, F1, F2 and F3 objects, and change the title and entry to F4, F5, F6, and F7, respectively.
10. Cut the line between Else and F3, and connect lines for F3, F4, F5, F6, and F7 as shown in Figure 7-22.
11. Open the JCT object, create an additional four input terminals, and connect the lines for E, F, G, and H as shown in Figure 7-22.
12. Open the Dev3 Vth, Dev3 Vth Min, and Dev3 Vth Max objects, and select them. Then click the Add to Panel button. The objects are added to the Show Result panel display. Adjust the position and size of the objects.

Figure 7-22

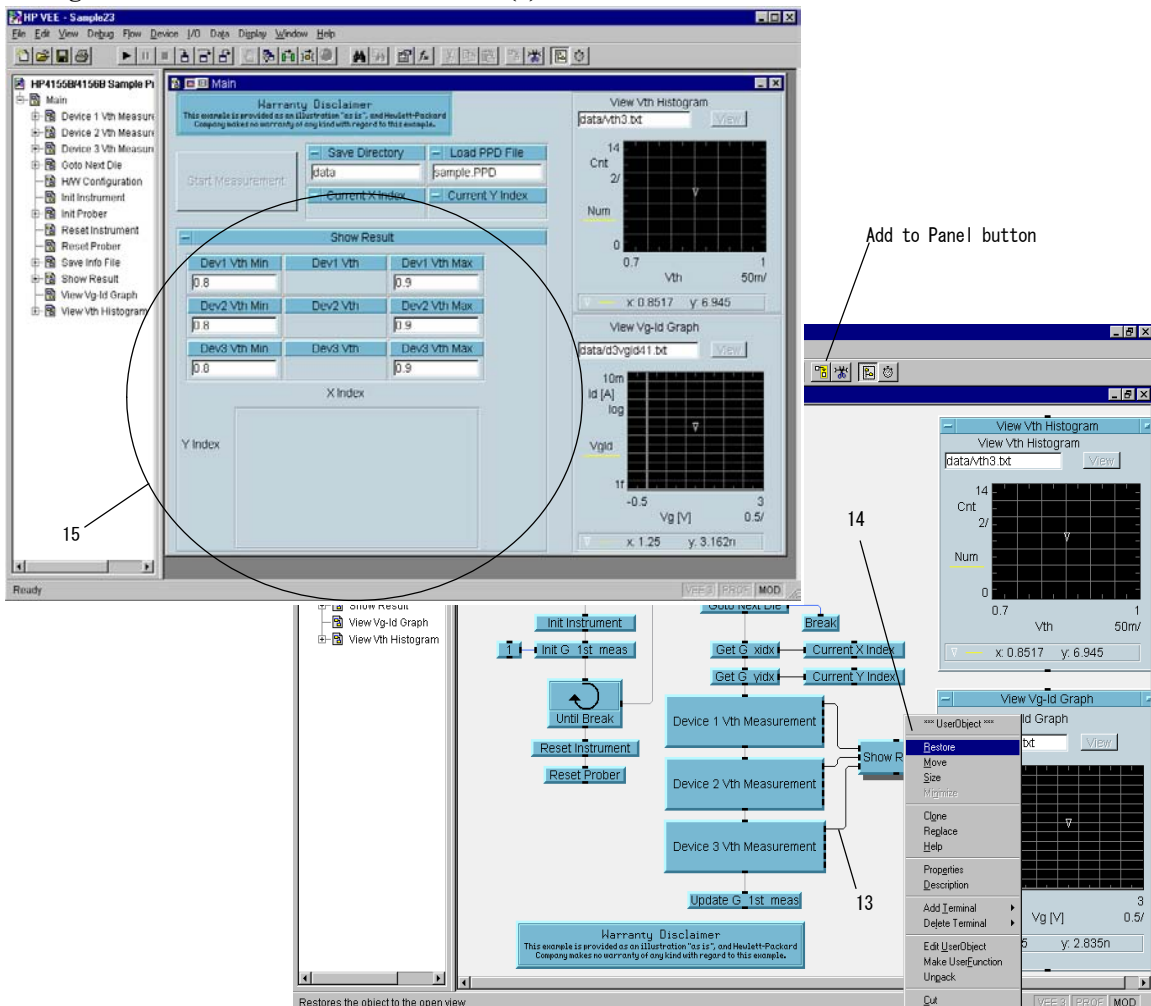
To Add a Test Device (2)



Sample Application Programs Using VEE Customizing Sample Programs

13. Open the Main program display, and connect the line between the Vth terminal of the Dev3 Vth Measurement object and the Vth3 terminal of the Show Result object.
14. Click the right mouse button on the Show Result object, and select the Restore menu. The Show Result object panel display is restored on the Main program display.
15. Select the restored Show Result object, and click the Add to Panel button. The object is added to the Main panel display. Delete the old Show Result object, and adjust the position and size of the new Show Result object.

Figure 7-23 To Add a Test Device (3)



NOTE

The modification example shown above changes the meaning of the wafer map result display as shown below.

P	Test results of all devices are within the allowable range.
F1	Device 1 test result is out of the allowable range.
F2	Device 2 test result is out of the allowable range.
F3	Device 3 test result is out of the allowable range.
F4	Test results of device 1 and 2 are out of the allowable range.
F5	Test results of device 2 and 3 are out of the allowable range.
F6	Test results of device 1 and 3 are out of the allowable range.
F7	Test results of all devices are out of the allowable range.

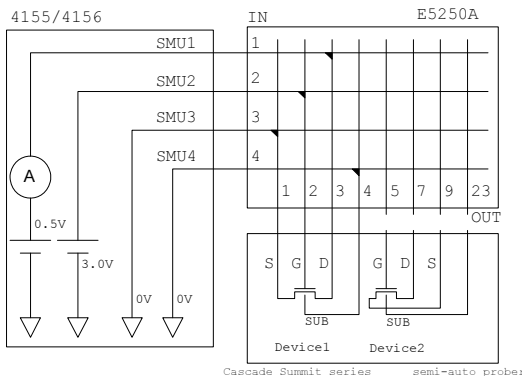
To Add a Measurement Parameter

If you want to add a measurement parameter, such as drain current I_d , modify the program as shown below. This example modifies sample2.vee for device 1 only (this example does not modify the objects for device 2).

- Adds the measurement function to the Measurement object.
- Adds the object to set the dummy data to the Meas 4155 (Offline) object.
- Adds the object to set the measurement source to the Vth Measurement object.
- Adds the object to save the measured data to the Device 1 Measurement object.
- Modifies the Show Result object and the Main panel display.

Figure 7-24

Id Measurement Setup



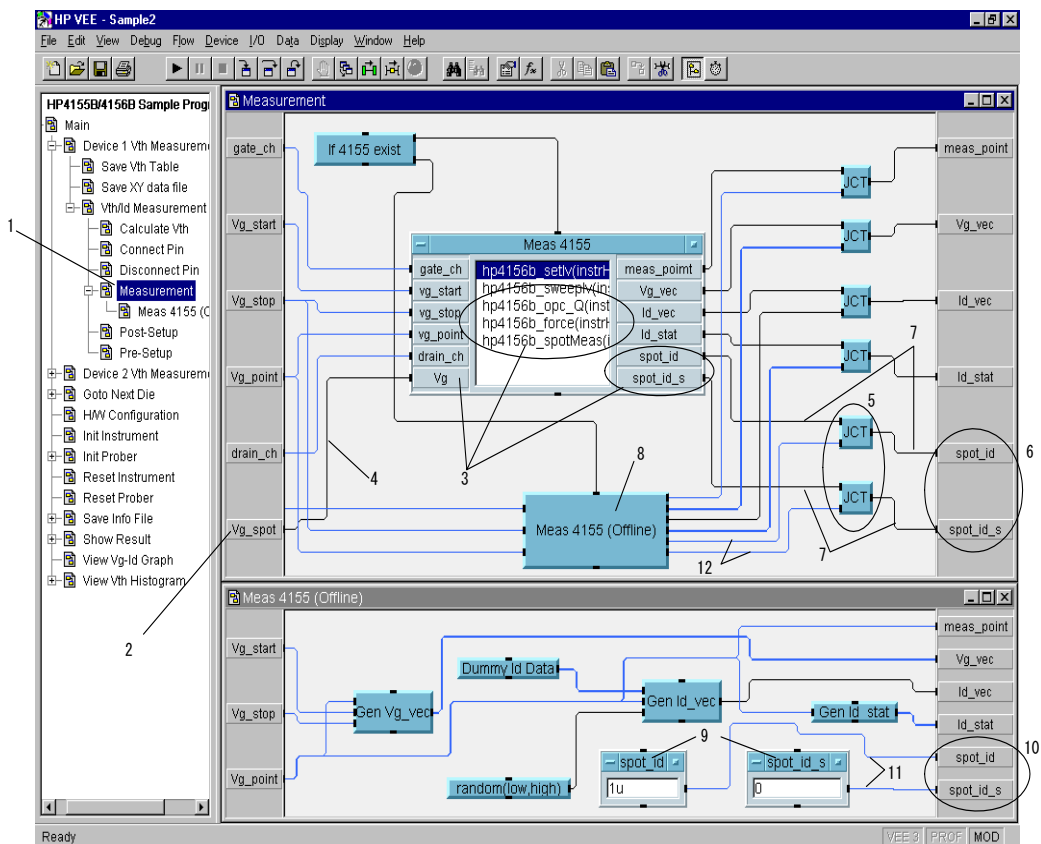
To Add the Measurement Function and Dummy Data

1. Open the Measurement object using the Agilent VEE program explorer.
2. Create the Vg_spot input terminal in the Measurement object as shown in Figure 7-25.
3. Open the Meas 4155 object, and add the following three functions. Then set the parameters shown using the Edit Function Panel of each function.
 - hp4156b_opc_Q function
 - hp4156b_force function
 - a. channel : Use gate_ch variable.
 - b. mode : VOLTAGE OUTPUT
 - c. range : 0
 - d. value : Use Vg variable, and create Vg input terminal.
 - e. comp : 1m
 - f. polarity : AUTO
 - hp4156b_spotMeas function
 - a. channel : Use drain_ch variable.
 - b. mode : CURRENT MEASUREMENT
 - c. range : 0
 - d. value : Use spot_id variable, and create spot_id output terminal.
 - e. status : Use spot_id_s variable, and create spot_id_s output terminal.
4. Connect the line between the Vg_spot input terminal and the Vg input terminal of the Meas 4155 object.
5. Add two Flow-Junction (JCT) objects.
6. Create the spot_id and spot_id_s output terminals in the Measurement object.
7. Connect the lines from the spot_id terminal of the Meas 4155 object to the spot_id terminal of the Measurement object via the JCT object.

Then connect the lines from the spot_id_s terminal of the Meas 4155 object to the spot_id_s terminal of the Measurement object via the JCT object.
8. Open the Meas 4155 (Offline) object.

9. Add the Data-Constant-Real and Data-Constant-Integer objects, and set the title to `spot_id` and `spot_id_s`, respectively. Then enter “1u” to the entry field of the `spot_id` object.
10. Create the `spot_id` and `spot_id_s` output terminals in the Meas 4155 (Offline) object.
11. Connect the line between the `spot_id` object and the `spot_id` terminal.
Then connect the line between the `spot_id_s` object and the `spot_id_s` terminal.
12. Connect the line between the `spot_id` terminal of the Meas 4155 (Offline) object and the JCT object connected to the `spot_id` terminal.
Then connect the line between the `spot_id_s` terminal of the Meas 4155 (Offline) object and the JCT object connected to the `spot_id_s` terminal.

Figure 7-25 **To Add the Measurement Function and Dummy Data**



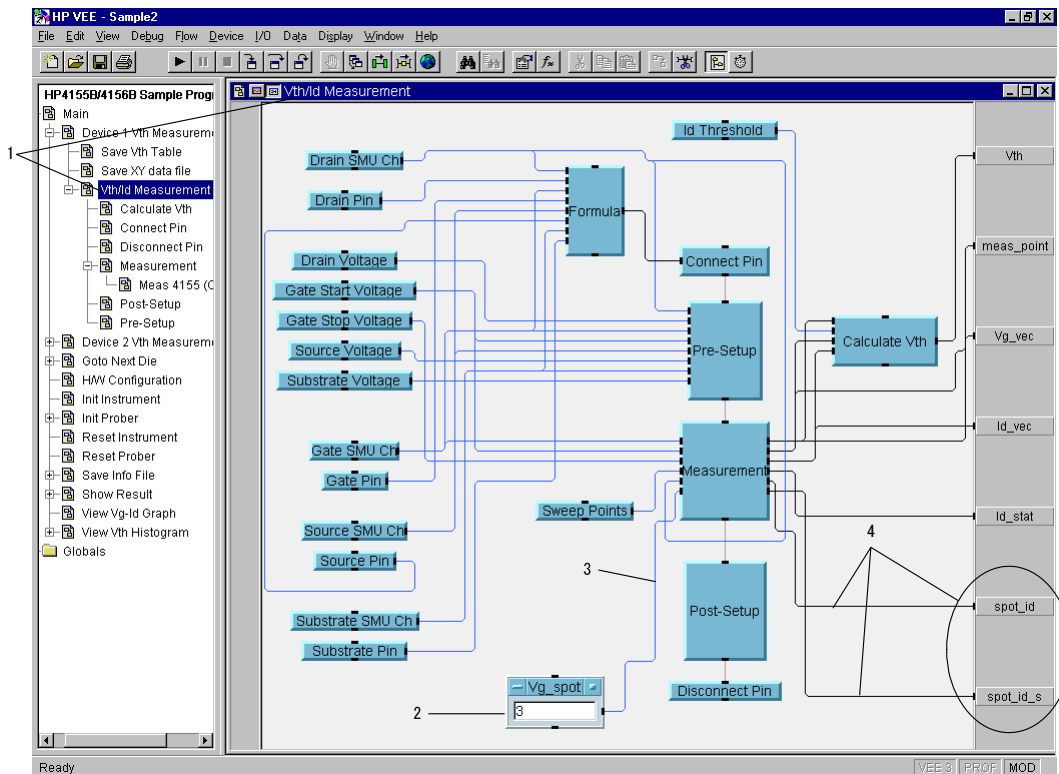
Sample Application Programs Using VEE Customizing Sample Programs

To Set the Id Measurement Source

1. Open the Vth Measurement object program display, and change the title to Vth/Id Measurement.
2. Add the Data-Constant-Real object, set the title to Vg_spot, and enter any value for gate voltage in volts. This example enters 3.
3. Connect the line between the Vg_spot object and the Vg_spot terminal of the Measurement object.
4. Create the spot_id and spot_id_s output terminals in Vth/Id Measurement object.

Then connect lines between the spot_id terminal of the Measurement object and the spot_id output terminal, and between the spot_id_s terminal of the Measurement object and the spot_id_s output terminal.

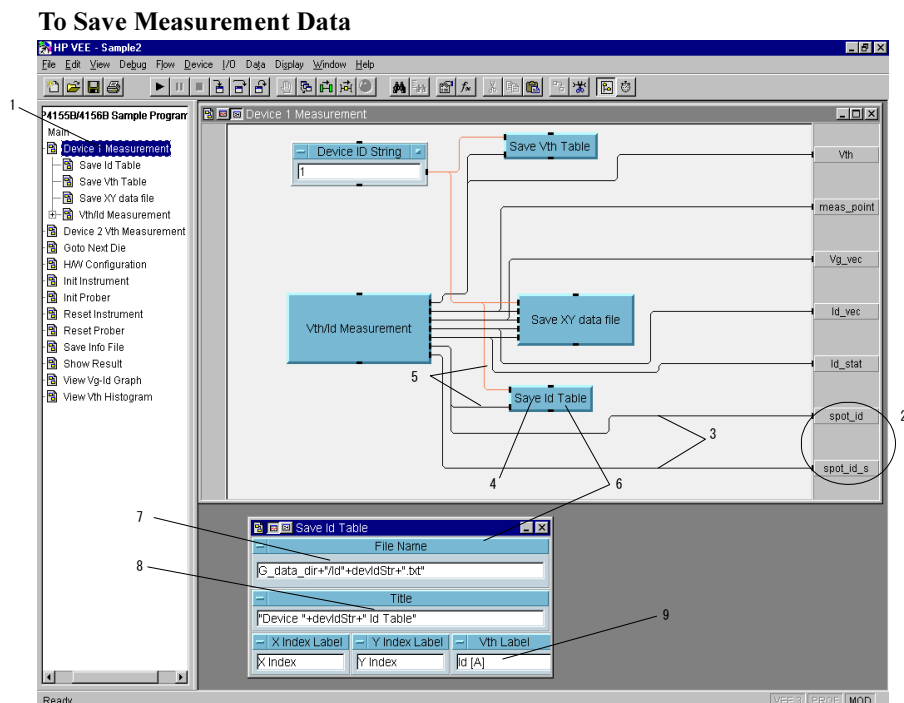
Figure 7-26 To Set the Id Measurement Source



To Save Measurement Data

1. Open the Device 1 Vth Measurement object program display, and change the title to Device 1 Measurement.
2. Create the spot_id and spot_id_s output terminals.
3. Connect the lines between the spot_id terminal of the Vth/Id Measurement object and the spot_id output terminal, and between the spot_id_s terminal of the Vth/Id Measurement object and the spot_id_s output terminal.
4. Copy and paste Save Vth Table, and change the title to Save Id Table.
5. Connect the lines between the Device Id String object and the devIdStr terminal of the Save Id Table object, and between the spot_id terminal of the Vth/Id Measurement object and the Vth terminal of the Save Id Table object.
6. Open the Save Id Table object panel display.
7. Change the characters *Vth* in the File Name entry field to *Id*.
8. Change the characters *Vth* in the Title entry field to *Id*.
9. Enter Id [A] into the Vth Label entry field.

Figure 7-27



Sample Application Programs Using VEE Customizing Sample Programs

To Modify the Show Result and Main Panel Displays

1. Open the Show Result object program display.
2. Add the Display-Alphanumeric object, and set the title to Dev1 Id.
3. Create the spot_id input terminal.
4. Connect the line between the spot_id terminal and the Dev1 Id object.
5. Click the Dev Id object, then click the Add to Panel button. The Dev Id object is added to the panel display of the Show Result object. Adjust the position and size of the object.
6. Open the Main program display, and connect the line between the Show Result object spot_id terminal and the Device 1 Measurement object spot_id terminal.
7. Click the right mouse button on the Show Result object, and select Restore menu. The restored Show Result object is displayed.
8. Click the restored Show Result object, and click the Add to Panel button. The object is added to the Main panel display. Delete the old Show Result object from the panel, and adjust the position and size of the new Show Result object.

Figure 7-28

To Modify Show Result and Main Panel

