User's Guide

Agilent 4070 Series Parametric Tester

Agilent Technologies

E3102-90000

January 2000

Legal Notice

The information contained in this document is subject to change without notice.

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  Agilent Technologies warrants Agilent Technologies hardware, accessories and supplies against defects in materials and workmanship for the period of one year from the warranty start date specified below. If Agilent Technologies receives notice of such defects during the warranty period, Agilent Technologies will, at its option, either repair or replace products which prove to be defective. Replacement products may be either new or like-new.

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To the extent allowed by local law, the above warranties are exclusive and no other warranty or condition, whether written or oral, is expressed or implied and Agilent Technologies specifically disclaims any implied warranties or conditions of merchantability, satisfactory quality, and fitness for a particular purpose.

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For consumer transactions in Australia and New Zealand: the warranty terms contained in this statement, except to the extent lawfully permitted, do not exclude, restrict or modify and are in addition to the mandatory statutory rights applicable to the sale of this product to you.

- **Assistance**

  Product maintenance agreements and other customer assistance agreements are available for Agilent Technologies products.

For any assistance, contact your nearest Agilent Technologies Sales Office.

- **Certification**

  Agilent Technologies Inc. certifies that this product met its published specifications at the time of shipment from the factory. Agilent further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology (NIST), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

- **Safety Summary**

  The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual may impair the protections provided by the equipment. In addition, it violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies Inc. assumes no liability for customer's failure to comply with these requirements.

NOTE

Agilent 4070 Complies with INSTALLATION CATEGORY II for mains input and INSTALLATION CATEGORY I for measurement input terminals, and POLLUTION DEGREE 2 defined in IEC 1010-1.

Agilent 4070 is CLASS 1 LASER and INDOOR USE product.

NOTE

When Agilent finds possible dangers associated with this product, you will be notified according to the Agilent internal standard.

- *GROUND THE INSTRUMENT*

  This is Safety Class I instrument. To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The power terminal and the power cable must meet International Electrotechnical Commission (IEC) safety standards.

- *DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE*

  Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

- *KEEP AWAY FROM LIVE CIRCUITS*

  Operation personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

- *DO NOT SERVICE OR ADJUST ALONE*

  Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

- *DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT*

  Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Agilent Technologies Sales and Service Office for services and repair to ensure that safety features are maintained.

- *DANGEROUS PROCEDURE WARNINGS*

  Warnings, such as example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING **Dangerous Voltage, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.**

- *CLEAN WITH DRY CLOTH*

  To prevent electrial shock, use a dry cloth or one slightly dampened with water to clean the external case parts.

- **Safety Symbols**

  The general definitions of safety symbols used on equipment or in manuals are listed below.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).

Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

~ Alternating current

⎓ Direct current

Electrical Shock

| ON (Supply)

○ OFF (Supply)

CAT 1 Means INSTALLATION CATEGORY I. Measurement terminals on the testhead comply with INSTALLATION CATEGORY I.

WARINIG The warning sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personal.

CAUTION

The caution sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

- **Electrical Work Types**

  The definisions of electrical work types are follows:

WorkType 3

Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposure does not exceed 30 Vrms, 42.4 Vpeak, 60 Vdc, and 240 VA.

WorkType 4

Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposure can exceed 30 Vrms, 42.4 Vpeak, 60 Vdc, 240 VA, or hazardous RF current.

Herstellerbescheinigung

GEÄUSCHEMISSION

Lpa < 70 dB

am Arbeitsplatz

normaler Betrieb

nach DIN 45635 T. 19

- **Manufacturer's Declaration**

  ACOUSTIC NOISE EMISSION

  Lpa < 70dB

  operator position

  normal operation

  per ISO 7779

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies Japan,Ltd.

Manufacturer's Address: 9-1, Takakura-cho, Hachioji-shi
Tokyo, 192-8510 Japan

Declares that the product:

Product Name: Semiconductor Parametric tester

Model Number: Agilent 4071A

Product Options: This declaration covers all options of the above product.

Conforms to the following product standards:

EMC: CISPR11(1990) / EN55011(1991) : Group 1, Class A
IEC 801-2(1991) / EN50082-1(1992) : 4kV CD, 8kV AD
IEC 801-3(1984) / EN50082-1(1992) : 3V/m
IEC 801-4(1988) / EN50082-1(1992) : 1kV Power Line / .5kV Signal Lines

Safety: IEC 1010-1(1990)+A2 / EN61010-1(1993)
CSA C22.2 No.1010.1(1992)

Conformity / Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Tokyo Japan, January 24, 2000

T. Kawaji
Toshiyuki Kawaji / QA Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor.

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies Japan, Ltd.

Manufacturer's Address: 9-1, Takakura-cho, Hachioji-shi
Tokyo, 192-8510 Japan

Declares that the product:

Product Name: Advanced parametric tester

Model Number: Agilent 4072A

Product Options: This declaration covers all options of the above product.

Conforms to the following product standards:

EMC: CISPR11(1990) / EN55011(1991) : Group 1, Class A
IEC 801-2(1991) / EN50082-1(1992) : 4kV CD, 8kV AD
IEC 801-3(1984) / EN50082-1(1992) : 3V/m
IEC 801-4(1988) / EN50082-1(1992) : 1kV Power Line / .5kV Signal Lines

Safety: IEC 1010-1(1990)+A2 / EN61010-1(1993)
CSA C22.2 No.1010.1(1992)

Conformity / Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Tokyo Japan, January 24, 2000

T. Kawaji

Toshiyuki Kawaji / QA Manager

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Printing History

Edition 1.	…	June 1999
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About This Manual

This manual consists of the following chapters:

- Chapter 1, “System Overview.”

  Provides information about system overview and specifications.

- Chapter 2, “Measurement Subsystems.”

  Provides information about the measurement subsystems.

- Chapter 3, “Measurement Types.”

  Provides information about I-V measurements, Search measurements, Capacitance measurements, and pulse generator output types.

- Chapter 4, “Operating the Agilent 4070.”

  Provides information about operating the hardware of Agilent 4070.

- Chapter 5, “Starting the 4070 System Software.”

  Provides information about starting the system software of Agilent 4070.

- Chapter 6, “Managing Your System.”

  Provides information about system management of Agilent 4070.

- Chapter 7, “Using Interactive Debugging Panel (IDP).”

  Provides information about operating the Interactive Debugging Panel.

- Chapter 8, “Error Messages.”

  Provides Agilent 4070 error messages.

In this manual, Agilent 4070 or 4070 means Agilent 4071A Semiconductor Parametric Tester and Agilent 4072A Advanced Parametric Tester.

Related Documents

In addition to this guide, you may want to read the following books to give you a more complete view of your system:

Table 1 Related Documents

Manual Title	Part Number
Programming Guide for BASIC Users	E3102-90010
Programming Reference for BASIC Users	E3102-90110
Programming Guide for C Users	E3102-90020
Programming Reference for C Users	E3102-90120
Maintenance Guide	E3102-90200

1 System Overview

The Agilent 4071A Semiconductor Parametric Tester and the Agilent 4072A Advanced Parametric Tester are the next generation testers of the Agilent 4062 Semiconductor Parametric Test System series, and is designed for semiconductor parametric test applications, semiconductor process monitoring applications, and so on.

This chapter describes the system overview of the 4070 and consists of the following sections:

- “Hardware Configuration”
- “System Software Overview”
- “Models and Options”
- “Available Accessories”
- “4071A Specifications”

Hardware Configuration

Agilent 4070 contains the following measurement resources:

- In system cabinet:
  - Agilent 4284A precision LCR meter for capacitance measurement (option)
  - Agilent 3458A multimeter for differential dc voltage measurement (option)
- In testhead:
  - Maximum 8 source monitor units (SMUs) for dc parameter measurement
  - Ground unit (GNDU) for dc parameter measurement zero volt force
  - Switching matrix: 10 input ports and maximum 48 outputs (measurement pins)
  - (4072A only) High frequency switching matrix (3 inputs x 48 outputs or two 3 inputs x 24 outputs): 6 input ports in total

The 4070 consists of a system cabinet and testhead as listed in Table 1-1, and shown in block diagrams of Figure 1-1 on page 1-5 and Figure 1-2 on page 1-6.

The system cabinet and testhead are connected via testhead power cable and an air duct. For controlling the testhead, optical fiber cables must be connected between the system controller and the testhead. Also, any measurement instruments and pulse generators (4072A only) in system cabinet must be connected by measurement cables to the testhead.

For the 4071A, there are two types of system cabinet are available, which are standard system cabinet and low height system cabinet.

Table 1-1 **Contents of Agilent 4070**

Description	Qty.
System cabinet	1
Testhead (with 3 SMUs and 12 pin boards)	1
Optical interface card	1
BNC cable for Chuck Connection Output connector	1

Description	Qty.
Triax(m)-BNC(f) adapter	1
Optical fiber cables	2
Air duct for testhead	1
Testhead power cable	1
Ground cable	1
Main power cable	1 (only for E3101A/B option 100 and 120)

The HP 9000 Series 700 Model 745i computer is used as the 4071A's system controller. For the 4072A, HP 745/132L computer is used as the standard controller. The controller should be installed with an optical interface card (for controlling the testhead) and GPIB interface cards (for controlling the instruments, automatic wafer prober, peripherals, and so on). If you system cabinet is standard type, the system controller can be rack mounted into the system cabinet.

The 4070 is usually used with an automatic wafer prober for fully automatic measurement. If so, the testhead should be installed on the automatic wafer prober as described in the *Pre-Installation Guide*.

Figure 1-1 **Agilent 4071A Block Diagram (Standard System Cabinet)**

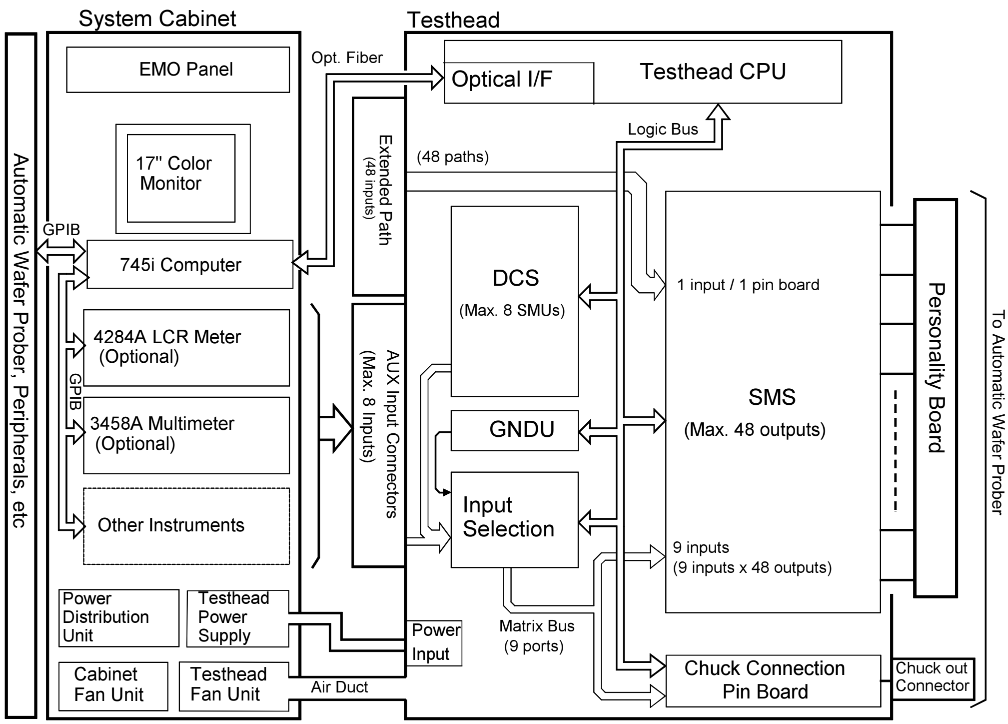
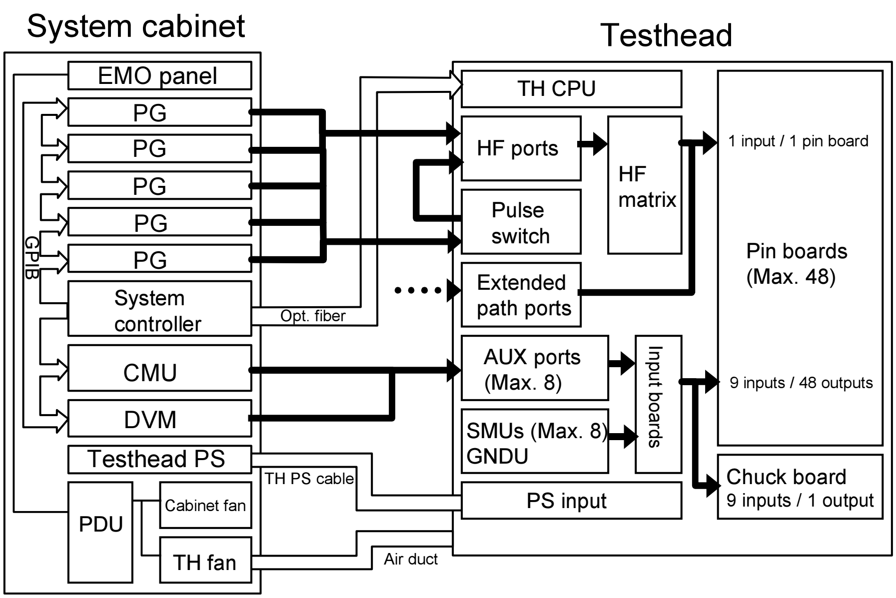


Figure 1-2 **Agilent 4072A Block Diagram**



- System Cabinet

  To fit your requirements for considering usability, floor space and safety, two kind of system cabinets are available for the 4071A. The 4072A (E3102A) provides standard cabinet (1.62 m).

  - Standard System Cabinet (Agilent E3101A)

    This taller cabinet allows you to install the system controller, display monitor for computer, your own additional instruments.

  - Low Height System Cabinet (Agilent E3101B)

    This lower height system cabinet can be located under the testhead which is rotated in 180 degree for maintenance and realize smaller foot print.

  Both types of system cabinet consists of the following functions and units:

  - Emergency Off (EMO) Panel

Capacitance Measurement Subsystem (CMS):
E3101A/E3101B/E3102A Option 011.

This is an Agilent 4284A Precision LCR Meter with option 001 and 006.

- DC Measurement Subsystem (DCS) for differential voltage measurement: E3101A/E3101B/E3102A Option 012.

  This is an Agilent 3458A Multimeter.

- (4072A only) Pulse Generator Subsystem (PGS) for forcing pulses: E3102A Option 500/550/552.

  This is Agilent 8110As, Agilent 8114As, or Agilent 81110A.

- Power Distribution Unit
- Testhead Power Supply Unit
- Cabinet Fan Unit
- Testhead Fan Unit

If you use standard system cabinet, you can also install system controller in the cabinet:

- System Controller:

  HP 9000 Series 700 Models 745i and 745/132L, or equivalent model with Optical interface card, GPIB interface card, and 17 inch color monitor

  Rack mount is optional: E3101A Option 020 and 021 for 4071A, E3102A Option 020 and 023 for 4072A

- Testhead
  - Testhead CPU with Optical I/F
  - DC Measurement Subsystem (DCS):

    Can install maximum 8 SMUs.

    - MPSMU (Medium Power SMU)

      100 mA/100 V max output

    - HPSMU (High Power Source Monitor Unit)

      1 A/200 V max output

      A maximum of 2 HPSMUs can be installed.

  - Ground Unit (GNDU)

- Switching Matrix Subsystem (SMS):

  Can connect ports to up to maximum 48 outputs (measurement pins)+1 pin for prober chuck connection.

  For high frequency switching marix, high frequency (HF) port 1 to 3 can be connected to pin 1 through 24, and HF4 to 6 can be connected to pin 25 through 48. By using 1 To 2 Adaptor, 3 high frequency inputs can be connected to maximum 48 outputs.

  One measurement pin is one pin board in switching matrix.

  Can configure minimum 12 to maximum 48 measurement pins.

System Software Overview

The system software creates an environment that makes the 4070 into an integrated system rather than a rack-and-stack set of instruments, which allows the instruments to perform at a higher level as a system.

The system software provides the following:

- Libraries of measurement subprograms and functions.
- Graphical user interface (GUI) tools for debugging measurement programs
- Diagnostics
- System resource management
- Other programs and subprogram libraries for creating measurement programs and viewing measurement results

Software Elements

The system software is composed of the following elements:

Test Instruction Set (TIS)

The Test Instruction Set (TIS) is a powerful software library designed to facilitate measurement programming.

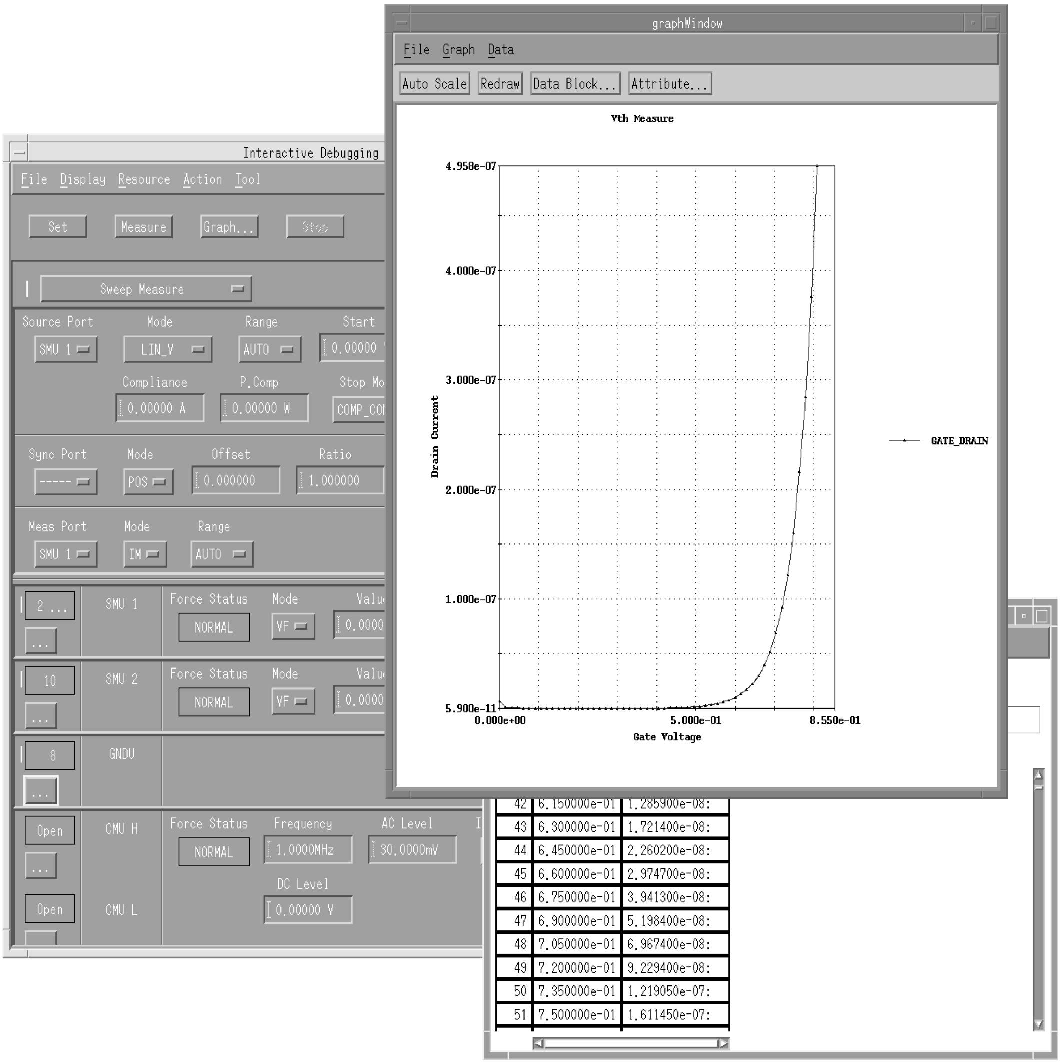
Agilent 4070 provides a TIS library for both the HP BASIC and C languages, so you can use TIS statements to quickly and easily create a measurement program as shown in the following example:

```
80 Connect (FNPort(0,9), 45, 46)
90 Connect (FNPort(0,1), 47, 48)
100 Force_v(FNPort(0,1), Vds, Vds, I_compl)
110 Measure_i(FNPort(0,1), Idsat)
```

Interactive Debugging Panel (idp4070)

Interactive Debugging Panel is an interactive interface, which allows you to make quick measurements and display the system settings while debugging measurement programs.

Figure 1-3 **Interactive Debugging Panel**



Diagnostics Program (diag4070)

Diagnostics program is used to verify normal system operation and as an aid when troubleshooting the 4070.

Diagnostics program is also a tool used for preventive maintenance. You should run it at least once a week.

For details about the diagnostics program, refer to the *Agilent 4071A /4072A Maintenance Guide*.

System Resource Management (Tester Manager)

Agilent 4070 manages and controls the following system resources to avoid any unexpected conflicts even if multiple users are using the 4070.

- System configuration
- Test sessions by users
- Hardware accesses from the test sessions
- System status including emergency state.

PARA Measurement Library

PARA library provides subprograms that make it easy to obtain complex dc semiconductor parameter measurement results.

Subprograms in PARA library are written in HP BASIC, and you can modify the subprograms to suit your requirements.

F_ROM Flash Memory Application Library (4072A only)

F_ROM library provides a set of application subprograms that make it easy to write and erase flash memories.

Subprograms in F_ROM library are writen in HP BASIC and C language, and you can modify the subprograms to suit your requirements.

XYGRAPH Graphical Library

XYGRAPH graphical library provides subprograms that let you plot a variety of graphs.

Subprograms in XYGRAPH library are written in HP BASIC, and you can modify the subprograms as desired.

Probing Pattern Generator Program (PPG)

Probing Pattern Generator (PPG) is an HP BASIC program that provides an interactive environment for defining the desired probing pattern for wafer measurements.

After you create a probing pattern data file by using PPG, you can read the file from your wafer measurement program by using Probing Control Library (PCL) subprograms.

Also, the probing pattern data file is used by Wafer Mapping Program (MAP) to create a wafer map.

Probing Control Library (PCL)

Probing Control Library (PCL) provides HP BASIC subprograms for controlling an automatic wafer prober.

PCL subprograms control an automatic wafer prober according to the information defined in a probing pattern data file created by PPG.

File Creation Library (FCL)

File Creation Library (FCL) provides HP BASIC subprograms for creating measurement data files that will be displayed by Wafer Mapping Program (MAP).

Wafer Mapping Program (MAP)

Wafer Mapping Program (MAP) is an HP BASIC program that uses the following data to create wafer maps:

- measurement data file created by FCL subprograms
- probing pattern data file created by PPG program

Models and Options

This section provides the tables that lists models and options of the 4070.

- "Models and Options for 4071A"
  - Table 1-2, "4071A Semiconductor Parametric Tester(Standard Cabinet)."
  - Table 1-3, "4071A Semiconductor Parametric Tester(Low Height Cabinet),"
  - Table 1-4, "4071A System Software and Operating System,"
- "Models and Options for 4072A"
  - Table 1-5, "Models and Options of 4072A Advanced Parametric Tester," on page 18
  - Table 1-6, "4072A System Software and Operating System," on page 20
- "Models and Options of 4070 Series System Controller"
  - Table 1-7, "4070 Series System Controller (Software Pre-installed),"

Models and Options for 4071A

Table 1-2 4071A Semiconductor Parametric Tester(Standard Cabinet)

Model No.	Option No.	Description
E3101A		4071A Semiconductor Parametric Tester Contents: - Standard system cabinet - Testhead - Pin boards (12) - 100mA/100V source monitor units (3) - Optical interface card - Optical fiber cables (2) - Air duct - Testhead power cable - License to Use for 4071A Software
	001	Add One Pin Board (E3121A)
	002	Add One 100 mA/100 V SMU (E3131A)
	003	Add One 1 A/200 V SMU (E3132A)
	005	Personality Board for non-Kelvin connection (E3145A)
	006	Personality Board for Kelvin connection (E3145B)
	007	Test Fixture Adapter (E3140A) and Universal Test Fixture (E3141A)
	009	Cable Extension Fixture (E3146A)
	011	Add 4284A Precision LCR Meter
	012	Add 3458A Multimeter
	020	Rack Mount Kit for 17 inch Monitor
	022	Rack Mount Kit for CD-ROM Drive
	023	Rack Mount Kit for HP 745/132L Controller
	050	50Hz Line Frequency
	060	60Hz Line Frequency
	100	100V Line Voltage

Model No.	Option No.	Description
E3101A	120	120V Line Voltage
	220	220V Line Voltage
	240	240V Line Voltage
	UK6	Commercial Certificate

Models and Options for 4071A

Table 1-3 4071A Semiconductor Parametric Tester(Low Height Cabinet)

Model No.	Option No.	Description
E3101B		Semiconductor Parametric Tester Contents: - Low height system cabinet - Testhead - Pin boards (12) - 100mA/100V source monitor units (3) - Optical interface card - Optical fiber cables (2) - Air duct - Testhead power cable - License to Use for 4071A Software
	001	Add One Pin Board (E3121A)
	002	Add One 100 mA/100 V SMU (E3131A)
	003	Add One 1 A/200 V SMU (E3132A)
	005	Personality Board for non-Kelvin connection (E3145A)
	006	Personality Board for Kelvin connection (E3145B)
	007	Test Fixture Adapter (E3140A) and Universal Test Fixture (E3141A)
	009	Cable Extension Fixture (E3146A)
	011	Add 4284A Precision LCR Meter
	012	Add 3458A Multimeter
	050	50Hz Line Frequency
	060	60Hz Line Frequency
	100	100V Line Voltage
	120	120V Line Voltage
E3101B	220	220V Line Voltage
	240	240V Line Voltage
	UK6	Commercial Certificate

Table 1-4 4071A System Software and Operating System

Model No.	Option No.	Description
E3113B		Software and manuals (English) for 4071A, HP-UX, HP BASIC/UX, C/ANSI C Contents: - 4071A software (CD-ROM) and manual - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual - C/ANSI C software (CD-ROM) and manual
E3113BJ		Software and manuals (Japanese) for 4071A, HP-UX, HP BASIC/UX, C/ANSI C Contents: - 4071A software (CD-ROM) and manual - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual - C/ANSI C software (CD-ROM) and manual
E3114B		Software and manuals (English) for 4071A, Agilent SPECS, HP-UX, HP BASIC/UX Contents: - 4071A software (CD-ROM) and manual - SPECS software (CD-ROM) and manual (E3180A with Option AAF) - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual
E3114BJ		Software and manuals (Japanese) for 4071A, SPECS, HP-UX, HP BASIC/UX Contents: - 4071A software (CD-ROM) and manual - SPECS software (CD-ROM) and manual (E3180AJ with Option AAF) - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual
E3161A		English manuals for 4071A.
E3161AJ		Japanese manuals for 4071A.

Models and Options for 4072A

Table 1-5 **Models and Options of 4072A Advanced Parametric Tester**

Model No.	Option No.	Description
E3102A		4072A Advanced Parametric Tester Contents: - Standard system cabinet - Testhead - Pin boards (12) - 100mA/100V source monitor units (3) - Optical interface card - Optical fiber cables (2) - Air duct - Testhead power cable - License to Use for 4072A Software
	001	Add One Pin Board (E3121A)
	002	Add One 100 mA/100 V SMU (E3131A)
	003	Add One 1 A/200 V SMU (E3132A)
	005	Personality Board for non-Kelvin connection (E3145A)
	006	Personality Board for Kelvin connection (E3145B)
	007	Test Fixture Adapter (E3140A) and Universal Test Fixture (E3141A)
	009	Cable Extension Fixture (E3146A)
	011	Add 4284A Precision LCR Meter
	012	Add 3458A Multimeter
	020	Rack Mount Kit for 17 inch Monitor
	022	Rack Mount Kit for CD-ROM Drive
	023	Rack Mount Kit for HP 745/132L Controller
	050	50Hz Line Frequency

Model No.	Option No.	Description
E3102A	060	60Hz Line Frequency
	200	200 V/ 20 A Line Voltage
	208	208 V/ 24 A Line Voltage
	220	220 V/ 20 A Line Voltage
	240	240 V/ 20 A Line Voltage
	500	Add Pulse Generator Integrator Kit
	550	Add One 8110A Pulse Generator (with 2 Output Channels)
	551	Add One 81110A Pulse Generator (with 2 Output Channels)
	552	Add One 8114A Pulse Generator (with 1 Output Channels)
	UK6	Commercial Certificate

Table 1-6 **4072A System Software and Operating System**

Model No.	Option No.	Description
E3113C		Software and manuals (English) for 4072A, HP-UX, HP BASIC/UX, C/ANSI C Contents: - 4072A software (CD-ROM) and manual - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual - C/ANSI C software (CD-ROM) and manual
E3113CJ		Software and manuals (Japanese) for 4072A, HP-UX, HP BASIC/UX, C/ANSI C Contents: - 4072A software (CD-ROM) and manual - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual - C/ANSI C software (CD-ROM) and manual
E3114C		Software and manuals (English) for 4072A, SPECS, HP-UX, HP BASIC/UX Contents: - 4072A software (CD-ROM) and manual - SPECS software (CD-ROM) and manual (E3180B with Option AAF) - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual
E3114CJ		Software and manuals (Japanese) for 4072A, SPECS, HP-UX, HP BASIC/UX Contents: - 4072A software (CD-ROM) and manual - SPECS software (CD-ROM) and manual (E3180BJ with Option AAF) - HP-UX OS software (CD-ROM) and manual - HP BASIC/UX software (CD-ROM) and manual
E3161B		English manuals for 4072A.
E3161BJ		Japanese manuals for 4072A.

Models and Options of 4070 Series System Controller

Table 1-7 4070 Series System Controller (Software Pre-installed)

Model No.	Option No.	Description
E3171A		System Controller for 4070 Series Contents: - HP 9000 Model HP 745/132L Computer with 4 Slot EISA -English Localization Kit - 17" Color Monitor - 128MB RAM, 4GB-HDD - High Speed GPIB Interface Card - License to Use for the pre-installed software
	001	Add CD-ROM Drive
	019	Replace with 19 inch Color Monitor
	AMB	Add 3.5 inch 1.4MB Flexible Disk Drive
	ATS	Add 4GB DDS DAT Drive
	ATW	Add Internal CD-ROM Drive
	A08	Add 4 GB SCSI Hard Disk Drive (8 GB Total)
E3171AJ		System Controller for 4070 Sereies Contents: - HP 9000 Model HP 745/132L with 4 Slot EISA, - Japanese Localization Kit - 17 inch Color Monitor - 128MB RAM , 4GB-HDD - High Speed GPIB Interface Card - License to Use for the pre-installed software
	001	Add CD-ROM Drive
	019	Replace with 19 inch Color Monitor
	AMB	Add 3.5 inch 1.4MB Floppy Disk Drive
	ATS	Add 4GB DDS DAT Drive
	ATW	Add Internal CD-ROM Drive
	A08	Add 4 GB SCSI Hard Disk Drive (8 GB Total)

Available Accessories

Table 1-8, “For Connecting Device Under Test (DUT),” on page 22 to Table 1-14 on page 25 list the available accessories of the 4070 series.

- For Connecting Device Under Test (DUT)
- For Connecting Instruments to Testhead
- For Expanding Measurement Capability or for Servicing
- Rack Mount Kit for System Cabinet
- Control Software
- Manual Set

Table 1-8 **For Connecting Device Under Test (DUT)**

Model No.	Option No.	Description
E3140A		Test Fixture Adapter
E3141A		Universal Test Fixture
E3145A		Personality Board for non-Kelvin Connection
E3145B		Personality Board for Kelvin Connection
E3146A		Cable Extension Fixture

Table 1-9 **For Connecting Instruments to Testhead**

Model No. or Agilent Part No.	Description
E3148A	Extended adapter Contents: - Extended adapter - Cables for pin connection (8)
16048E	Cable for connecting the 4284A (Cable is furnished with E3101A/E3101B/E3102A Opt 011)
1250-2405	BNC T-type (m-f-f) Adapter for connecting the 4284A (Two adapters are required to connect the 4284A. Two adapters are furnished with E3101A/E3101B/E3102A Opt 011.)
E3120-61683	Cable for connecting the 3458A (Cable is furnished with E3101A/E3101B/E3102A Opt 012.)
E3120-16000	Software configuration tool

Table 1-10 For Expanding Measurement Capability or for Servicing

Model No.	Option No.	Description
E3121A		Pin Board
E3131A		100 mA/100 V Source Monitor Unit
E3132A		1 A/200 V Source Monitor Unit

Table 1-11 Rack Mount Kit for System Cabinet

Model No.	Option No.	Description
E3151A		Rack Mount Kit for the 4284A LCR Meter
E3152A		Rack Mount Kit for the 3458A Multimeter
E3155A		Rack Mount Kit for HP A2284A 17 inch Monitor
E3155B		Rack Mount Kit for HP A4330A 17 inch Monitor

Models and Options of 4070 Series System Controller

Model No.	Option No.	Description
E3155C		Rack Mount Kit for HP A4490A 17 inch Monitor
E3155D		Rack Mount Kit for HP A4490A 17 inch Monitor (If this product is specified for the 4072A, this is available only when the 4072A does not have PGs.)
E3156A		Rack Mount Kit for 745i Computer
E3156B		Rack Mount Kit for 745/132L Computer
E3157A		Rack Mount Kit for CD-ROM Drive

Table 1-12 **4072A Pulse Equipment**

Model No.	Option No.	Description
E3153A		Pulse Generator Integration Kit
	001	For 1st Pulse Generator
	002	Rack Mount kit for the 8110A
	003	Rack Mount kit for the 81110A
	004	Rack Mount Kit for the 8114A

Table 1-13 Control Software

Model No.	Option No.	Description
E3180B		SPECS Software for HP 9000 Series 700
	AAH	Software (on DDS DAT) and manuals (English)
	AAF	Software (on CD-ROM) and manuals (English)
E3180BJ		SPECS Software for HP 9000 Series 700
	AAH	Software (on DDS DAT) and manuals (Japanese)
	AAF	Software (on CD-ROM) and manuals (Japanese)

Model No.	Option No.	Description
E3180L		License to Use for SPECS - Online and Offline
E3181L		License to Use for SPECS - Online only
E3183L		License to Use for SPECS - Offline only
E3165A		SPECS Manual Set (English)
E3165AJ		SPECS Manual Set (Japanese)

Table 1-14 **Manual Set**

Model No.	Option No.	Description
E3161A		4071A Manual Set (English) for users
E3161AJ		4071A Manual Set (Japanese) for users
E3165A		4072A Manual Set (English) for users
E3165AJ		4072A Manual Set (Japanese) for users

4071A Specifications

This section lists 4071A specifications and reference data.

The specifications are the performance standards or limits against which the 4071A was tested. When the 4071A is shipped from the factory, it meets the specifications.

"Reference Data" are not specifications, but are typical characteristics included as additional information for the operator.

General Description

The 4071A semiconductor parametric tester can perform precision dc and capacitance measurements. Refer to Figure 1-1 on page 1-5.

The testhead can contain up to 8 Source Monitor Units (SMUs), each of which is self-calibrating, and each SMU can force voltage or current, and measure voltage or current.

The testhead also has one 1.6 A ground unit.

External instruments can be connected to the testhead via 8 auxiliary (AUX) input ports. In addition, the Extended Path connector on testhead allows up to 48 wide bandwidth connections directly to switching matrix input.

The 4071A can have between 12 and 48 measurment pins, plus has an additional pin that can be connected to the prober chuck.

The low-leakage switching matrix can connect any SMU port, AUX port, Extended Path port, or ground unit port to any measurement pin, including the chuck pin.

Measurement Functions:

dc current, dc voltage, capacitance and conductance, differential voltage

- dc measurement:

  Spot Measurement, Sweep Measurement, Pulse Bias Measurement, and Pulse Sweep Measurement

Table 1-15 SMU Measurement Range

Measurement Unit	SMU
Measurement Range (SMU1 or SMU2)	10 fA to 100 mA, 2 µV to 100 V
Measurement Range (SMU3 to SMU8)	100fA to 1 A, 2 µV to 200 V[a]

a. Using optional HPSMU. If using MPSMU, 100 fA to 100 mA, 2 µV to 100 V

- Capacitance/Conductance Measurement (with or without dc bias voltage)

Table 1-16 CMU Measurement Range

Measurement Unit	4284A (CMU)
Measurement Frequency	1 kHz, 10 kHz, 100 kHz, 1 MHz
Measurement Range	1 fF to 100 nF, 0.1 nS to 7.5 mS
dc bias voltage	±40 V

- Two Terminal Differential Voltage Measurement:

Table 1-17 DVM Measurement Range

Measurement Unit	3458A (DVM)
Measurement Range	1 µV to 100 V

- Measurement Pins

  Minimum 12 pins, maximum 48 pins. (There is also an additional pin for connecting to wafer prober chuck)

- Switching Matrix Instrument Ports:
  - SMU ports (for up to 8 SMUs)
  - One ground unit (GNDU) port
  - AUX ports (for up to 8 external instruments)
  - Extended Path port (for up to 48 external connections)

General Specifications

Accuracy is specified at:

- Temperature: 23±5 °C
- Humidity: 5% to 70% RH
- Warm up: at least 40 minutes
- After Self-Calibration
- Integration Time: Medium or longer

NOTE

Temperature Change

The temperature change after calibration must be less than 3 °C. If more, the accuracy values in the following tables are doubled.

Isolation and Leakage current are specified separately.

- Operating Temperature Range: 5 °C to 40 °C
- Operating Humidity range: 5% to 70% (no-condensing)
- Storage Temperature Range: -20 °C to 60 °C (no-condensing)
- Warm up time: at least 40 minutes
- Regulatory compliance

Table 1-18

EMC:	EMC Directive 89/336/EEC, 92/31/EEC, 93/68/EEC
Safety:	Low Voltage Directive 73/23/EEC, 93/68/EEC CSA 1010, CSA Certified SEMI S2/93

- Dimensions:

  System Cabinet:

  - Standard Type: 600 mm (W) by 900 mm (D) by 1600 mm (H)
  - Low Height Type: 800 mm (W) by 900 mm (D) by 620 mm (H)

  Testhead: 640 mm (W) by 642 mm (D) by 250 mm (H)

- Weight:

  System Cabinet:

  - Standard Type: 120 kg
  - Low Height Type: 80 kg

  Testhead: 60 kg (for configuration of 4 SMUs and 48 pins)

Switching Matrix Subsystem

- Maximum Measurement Pins:

  48 pins + 1 pin for prober chuck connection

- Maximum Number of Instrument Ports:

  - SMU Ports: 8 SMU + GNDU

Table 1-19 Maximum Number of SMU Ports

Ports	Connection	Max. Number of Ports
Low current measurement ports	non-Kelvin	2 ports
Standard ports	Kelvin	4 ports
	non-Kelvin	2 ports
GNDU	Kelvin	1 port

  - Auxiliary (AUX) Ports:

    8 ports for external instruments (including CMU and DVM).

Table 1-20 Maximum Number of AUX Ports

Inputs	Max. Number of Ports
Tri-axial (Force/Guard/Common)	2 ports
2 BNC (Force/Common, Sense/Common)	4 ports
BNC (Force/Common)	2 ports

  - Extended Path:

    48 paths to the measurement pins. Each path can be connected to one measurement pin by an on/off relay switch.

- Maximum Voltage at Each Port:

Table 1-21 Maximum Voltage

Port	Maximum Voltage
SMU	±200 V
AUX1,2	±200 V
AUX3 - 8	±100 V
Extended path	±100 V

- Maximum Current at Each Port:

Table 1-22 Maximum Current

Port	Maximum Current
SMU	±1.0 A
GNDU	±1.6 A
AUX	±1.0 A
Extended path	±0.5 A

- Maximum Residual Resistance (AUX port):

Table 1-23 Maximum Residual Resistance (AUX)

Port	Resistance
Low current port	0.7 Ω (Force)
Kelvin port	1.0 Ω (Force)
	2.5 Ω (Sense)
Non-Kelvin port	1.0 Ω (Force)

- Maximum Stray Capacitance: ≤5 pF (between C measurement ports)
- Isolation Resistance:

  Low Current Port (with Guard): 5×10^{13} Ω

Source and Monitor Unit (SMU)

Table 1-24 Voltage Source/Monitor Range, Resolution, and Accuracy

Full Scale Voltage Range	Force Resolution	Measure Resolution: High Speed	Measure Resolution: Precision	Force Accuracy [a]	Measure Accuracy [b]
±2 V	100 μV	100 μV	2 μV	a: 0.05 % b: 0.05 % c: Rmat [c] × I_o [d]	a: 0.04 % b: 0.05 %
±20 V	1 mV	1 mV	20 μV		
±40 V	2 mV	2 mV	40 μV		
±100 V	5 mV	5 mV	100 μV		
±200 V [e]	10mV	10 mV	200 μV		

a. Force Accuracy is calculated as follows: a% of output setting value + b% of output voltage range + c volts
b. Measure Accuracy is calculated as follows: a% of measured value + b% of measurement range
c. Residual Resistance of Switching Matrix force port. See note below.
d. Output current
e. HPSMU only

NOTE

Rmat

Rmat is different at each port:

Low Current Port (SMU1, SMU2): 0.7 Ω

Kelvin Port (SMU3 to SMU6): 3 mΩ

Non-kelvin Port (SMU7, SMU8): 1.0 Ω

When using prober chuck connection pin, add 0.1 Ω to Rmat.

Table 1-25 Current Source/Monitor Range, Resolution, and Accuracy (SMU1, SMU2)

Full Scale Current Range	Force Resolution	Measure Resolution High Speed	Measure Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±100 mA	5 μA	5 μA	100 nA	a: 0.12 (%) b: 0.1+0.0005× V_o (%) c: 0	a: 0.1 (%) b: 0.05+0.0005× V_o (%) c: 0
±10 mA	500 nA	500 nA	10 nA		
±1 mA	50 nA	50 nA	1 nA		
±100 μA	5 nA	5 nA	100 pA		
±10 μA	500 pA	500 pA	10 pA		

Full Scale Current Range	Force Resolution	Measure Resolution High Speed	Measure Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±1 μA	50 pA	50 pA	1 pA	a: 0.2 (%) b: $0.1+0.0005\times V_o$ (%) c: $0.02\times 10^{-12}\times V_o$ (A)	a: 0.2 (%) b: $0.05+0.0005\times V_o$ (%) c: $0.02\times 10^{-12}\times V_o$ (A)
±100 nA	5 pA	5 pA	100 fA		
±10 nA	500 fA	500 fA	10 fA	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $3\times 10^{-12}+0.02\times 10^{-12}\times V_o$ (A)	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $3\times 10^{-12}+0.02\times 10^{-12}\times V_o$ (A)
±1 nA	50 fA	50 fA	10 fA		

a. Force Accuracy is calculated as follows: a% of output setting value + b% of output current range + *c* ampere V_o means output voltage.
b. Measure Accuracy is calculated as follows: a% of measured value + b% of current measurement range + *c* ampere V_o means output voltage.

Table 1-26 Current Source/Monitor Range, Resolution, and Accuracy (SMU3 to SMU8)

Full Scale Current Range	Force Resolution	Meas. Resolution High Speed	Meas. Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±1 A[c]	50 μA	50 μA	1 μA	a:0.5(%), b:0.1+0.005xVo, c: 0	a:0.5(%), b:0.05+0.005xVo, c: 0
±100 mA	5 μA	5 μA	100 nA	a: 0.12 (%) b: $0.1+0.0005\times V_o$ (%) c: 0	a: 0.1 (%) b: $0.05+0.0005\times V_o$ (%) c: 0
±10 mA	500 nA	500 nA	10 nA		
±1 mA	50 nA	50 nA	1 nA		
±100 μA	5 nA	5 nA	100 pA		
±10 μA	500 pA	500 pA	10 pA		
±1 μA	50 pA	50 pA	1 pA	a: 0.2 (%) b: $0.1+0.0005\times V_o$ (%) c: $300\times 10^{-12}+10\times 10^{-12}\times V_o$ (A)	a: 0.2 (%) b: $0.05+0.0005\times V_o$ (%) c: $300\times 10^{-12}+10\times 10^{-12}\times V_o$ (A)
±100 nA	5 pA	5 pA	100 fA		
±10 nA [d]	500 fA	500 fA	10 fA	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $303\times 10^{-12}+10\times 10^{-12}\times V_o$ (A)	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $303\times 10^{-12}+1\times 10^{-12}\times V_o$ (A)
±1 nA [d]	50 fA	50 fA	10 fA		

a. Force accuracy is calculated as follows: *a*% of reading + *b*% of range + *c* A V_o means output voltage.
b. Measure Accuracy is calculated as follows: *a*% of measured value + *b*% of current measurement range + *c* ampere V_o means output voltage.
c. Using HPSMU
d. Reference data when using Port 3 to Port 8

NOTE

Electromagnetic Fields and SMU Current Measure Accuracy

Current measurement accuracy of SMU may be affected by electromagnetic field strength over 3 V/m at frequency range of 26 MHz to 1 GHz.

Table 1-27 Other SMU Specifications

Output Power (MPSMU):	20 mA, 100 V 50 mA, 40 V 100 mA, 20 V
Output Power (HPSMU):	50 mA, 200 V 125mA, 100V 350 mA, 40 V 700 mA, 20 V 1A, 14V
Current Over Range:	15% of range (0% for 100 mA range)
Voltage Over Range (V Force):	0% of range
Voltage Over Range (V Measure):	10% of range (0% for 100 V range)
Current Compliance Setting Range:	1 pA to Maximum current
Accuracy of reverse polarity current limit [a] :	±2% of range (100 nA to 100 mA ranges) ±10% of range (1 nA and 10 nA ranges)
Maximum Capacitive Load:	≤1000 pF
Maximum Allowable Guard Capacitance:	≤250 pF (between signal and guard lines outside switching matrix)
Maximum Slew Rate:	0.2 V/μs

a. Reference Data

Ground Unit (GNDU)

This unit is used for ground when making measurements.

Table 1-28 Maximum Current, Offset Voltage, Maximum Capacitance Load

Output Voltage:	0 V
Maximum current:	±1.6 A
Offset Voltage:	±200 μV
Maximum Capacitance Load:	1 μF [a]

a. Reference Data

DVM (3458A)

Table 1-29 Voltage Measurement Range, Resolution, and Accuracy (NPLC≥1)

Full Scale Voltage Range	Resolution	Accuracy [a]
1 V	1 μV	a: 0.02 (%) b: 300 (μV)
10 V	10 μV	a: 0.02 (%) b: 300 (μV)
100 V	100 μV	a: 0.03 (%) b: 1 (mV)

a. Accuracy is calculated as follows: *a*% of measured value + *b* volts

Capacitance Measurement Unit (CMU)

The accuracy in following table is between any two measurement pins (except chuck connection pin) and for following conditions:

Table 1-30

Measurement range:	1 fF to 1.2 nF and 10 nS to 7.5 mS (1 MHz) 1 fF to 10 nF and 1 nS to 6.3 mS (100 kHz) 1 fF to 100 nF and 0.1 nS to 6.3 mS (10 kHz) 10 fF to 100 nF and 0.1 nS to 0.63 mS (1 kHz)
Measurement frequency:	1 kHz, 10 kHz, 100 kHz, and 1 MHz
dc bias voltage:	±40 V
Measurement speed:	MEDIUM or LONG
Test signal level:	30 mV_{rms}±5 mV_{rms}
Stray capacitance:	between force and guard must be under 5 pF.

And after calibration data measurement and offset cancel.

Table 1-31 **C/G Measurement Range, Resolution, and Accuracy**

Frequency	C Range	C Accuracy	G Range	G Accuracy
1 MHz	10 pF	a: 0.8(%), b: $1.0+0.6\times Gm/63\times 10^{-6}$(%)	63 µS	a: 0.8(%), b: $1.0+0.6\times Cm/10\times 10^{-12}$(%)
	100 pF	a: 0.8(%), b: $0.3+0.6\times Gm/630\times 10^{-3}$(%)	630 µS	a: 0.8(%), b: $0.3+0.6\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 1.5(%), b: $0.2+1.7\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 1.3(%), b: $0.2+2.2\times Cm/1\times 10^{-9}$(%)

Frequency	C Range	C Accuracy	G Range	G Accuracy
100 kHz	10 pF	a: 0.4(%), b: $1.0+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 μS	a: 0.4(%), b: $1.0+0.4\times Cm/10\times 10^{-12}$(%)
	100 pF	a: 0.3(%), b: $0.3+0.3\times Gm/63\times 10^{-6}$(%)	63 μS	a: 0.3(%), b: $0.3+0.3\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.2+0.4\times Gm/630\times 10^{-6}$(%)	630 μS	a: 0.3(%), b: $0.2+0.4\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.5(%), b: $0.2+1.0\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 0.7(%), b: $0.2+0.8\times Cm/10\times 10^{-9}$(%)
10 kHz	100 pF	a: 0.3(%), b: $0.2+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 μS	a: 0.3(%), b: $0.2+0.3\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.1+0.3\times Gm/63\times 10^{-6}$(%)	63 μS	a: 0.3(%), b: $0.1+0.3\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.3(%), b: $0.1+0.3\times Gm/630\times 10^{-6}$(%)	630 μS	a: 0.3(%), b: $0.1+0.3\times Cm/10\times 10^{-9}$(%)
	100 nF	a: 0.3(%), b: $0.1+1.0\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 0.7(%), b: $0.1+0.7\times Cm/100\times 10^{-9}$(%)
1 kHz	100 pF	a: 0.4(%), b: $0.5+0.4\times Gm/0.63\times 10^{-6}$	0.63 μS	a: 0.4(%), b: $0.5+0.4\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.1+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 μS	a: 0.3(%), b: $0.1+0.3\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.3(%), b: $0.1+0.3\times Gm/63\times 10^{-6}$(%)	63 μS	a: 0.3(%), b: $0.1+0.3\times Cm/10\times 10^{-9}$(%)
	100 nF	a: 0.3(%), b: $0.1+0.3\times Gm/630\times 10^{-6}$(%)	630 μS	a: 0.3(%), b: $0.1+0.3\times Cm/100\times 10^{-9}$(%)

- Accuracy is calculated as follows: *a*% of measured value + *b*% of measurement range.

  Gm is measured conductance. Cm is measured capacitance.

- The accuracy at the following ranges are reference data:
  - 10 pF range at 1 MHz and 10 kHz frequencies.
  - 100 pF range at 1 kHz frequency.
- When measurement speed is set to SHORT, calculate accuracy by adding 0.25% to % of measured value and 0.1% to % of measurement range.
- Accuracy of frequency: ±0.1%

System Controller

Supported Computer

HP 9000 Series 700 Model 745i or 745/132L

Operating System

HP-UX 10.20 (Needs some patches for Year 2000. Please contact your local sales representative.)

HP BASIC/UX 8.02 and SICL E.01.01 or G.01.02 (for 745/132L, only G.01.02 is supported), *or* C/ANSI C and SICL E.01.01

Required Memory

Minimum requirement is 64 MB (128 MB is recommended).

Required GPIB Interfaces

Agilent Technologies recommends the following:

- Use the built-in GPIB interface of system controller for controlling the system instruments (4284A and 3458A) if installed.
- Use an additional GPIB interface card as a separate GPIB interface for the Automatic Wafer Prober

Note that when you order the E3171A computer for the 4071A, an additional card (high speed GPIB interface card) is included.

System Software

Standard 4071A software provides the following capabilities:

- System Management
- Control of subsystems (TIS Library)
- Parameter measurement functions (PARA Library)
- Offline debugging
- Interactive Debugging Panel (IDP)
  Includes Flexible Algorithm Semiconductor Test Code (FASTCode) Generator.
- Probing Pattern generation and wafer map display (PPG, MAP)
- Prober Control Libraries: Electroglas, TEL, TSK
- Automatic Diagnostics

4072A Specifications

This section lists the 4072A specifications and reference data.

The specifications are the performance standards or limits against which the 4072A was tested. When the 4072A is shipped from the factory, it meets the specifications.

"Reference Data" are not specifications, but are typical characteristics included as additional information for the operator.

General Description

The 4072A Advanced Parametric Test System is designed to perform precision DC measure-ment, capacitance measurement, Flash memory cell testing, and other high-frequency applica-tions. The system supports up to eight source monitor units (SMUs), two of which may be high-power SMUs (HPSMUs). Each SMU is self-calibrating and may be individually configured to force either current or voltage, and simultaneously measure either voltage or current.

External instruments can be integrated into the system via the eight auxiliary input ports or 48 extended path inputs. The 48 extended path inputs allow the user to connect external signals directly to the DUT pins. A low-leakage switching matrix connects all of the inputs to fully guarded Kelvin output pins, which are customizable from 12 to 48 output pins. One special additional pin is dedicated as a chuck connection.

In addition, the 4072A has a high-frequency switching matrix with integrated pulse generator control. The high-frequency matrix is organized as two 3 x 24 matrices (6 inputs total), and furnished 1 TO 2 connectors may be used on each matrix pair to create one 3 x 48 matrix (3 inputs total). The system also has one 1.6 A ground unit.

Measurement Functions:

DC current, DC voltage, capacitance and conductance, differential voltage, pulse force

- dc measurement:

  Spot Measurement, Sweep Measurement, Pulse Bias Measurement, and Pulse Sweep Measurement

Table 1-32 SMU Measurement Range

Measurement Unit	MPSMU and HPSMU
Measurement Range (SMU1 or SMU2)	10 fA to 100 mA, 2 µV to 100 V
Measurement Range (SMU3 to SMU8)	100 fA to 1 A, 2 µV to 200 V[a]

a. Using optional HPSMU. Using MPSMU, 100 fA to 100 mA, 2 µV to 100 V.

- Capacitance/Conductance Measurement (with or without dc bias voltage)

Table 1-33 CMU Measurement Range

Measurement Unit	4284A (CMU)
Measurement Frequency	1 kHz, 10 kHz, 100 kHz, 1 MHz
Measurement Range	1 fF to 100 nF, 0.1 nS to 7.5 mS
dc bias voltage	±40 V

- Two Terminal Differential Voltage Measurement:

Table 1-34 DVM Measurement Range

Measurement Unit	3458A (DVM)
Measurement Range	1 µV to 100 V

- High-frequency Pulse Force

Table 1-35 PGU Output Range

Pulse Generator Unit	Agilent 8110A, 81110A, or 8114A (PGU)
Maximum Number of Installable Pulse Generators[a]	5 x 8110A or 5 x 81110A (without 8114A) 4 x 8110A or 4 x 81110A (with 1 x 8114A) 2 x 8110A or 2 x 81110A (with 2 x 8114A)
Pulse level (at open load)	± 19V (8110A, 81110A) - 49.9 V to + 50 V (8114A)
Pulse period	350 ns to 999.0 s (8110A, 81110A) 350 ns to 999 ms (8114A)
Pulse width	50 ns to 999 ms (8110A, 81110A) 150 ns to 150 ms (8114A)
Pulse delay	0 s to 998 ms
Transition time	20 ns to 200 ms (8110A, 81110A) 65 ns (8114A)

a. You cannot install both 8110A and 81110A in the system.

- Measurement Pins

  Minimum 12 pins, maximum 48 pins. (There is also an additional pin for connecting to wafer prober chuck)

- Switching Matrix Instrument Ports:
  - SMU ports (for up to 8 SMUs)
  - One ground unit (GNDU) port
  - AUX ports (for up to 8 external instruments)
  - HF ports (for up to 6 PGUs)
  - Extended Path port (for up to 48 external connections)
  - Pulse switch input/output ports

General Specifications

Accuracy is specified at:

- Temperature: 23±5 °C
- Humidity: 5% to 70% RH
- Warm up: at least 40 minutes
- After Self-Calibration: N/A
- Integration Time: Medium or longer

NOTE

Temperature Change

The temperature change after calibration must be less than 3 °C. If more, the accuracy values in the following tables are doubled.

Isolation and Leakage current are specified separately.

- Power Requirement:

Table 1-36

Normal Line Volatage[a]	Allowable Voltage Range	Requred Maximum Current
200 Vac	180 - 220 Vac	20 A
208 Vac	188 - 228 Vac	24 A
220 Vac	198 - 242 Vac	20 A
240 Vac	216 - 252 Vac	20 A
240 Vac	216 - 252 Vac	20 A

a. Line frequency must be 48 to 63 Hz

- Operating Temperature Range: 5 °C to 40 °C
- Operating Humidity range: 5% to 70% (no-condensing)
- Storage Temperature Range: -20 °C to 60 °C (no-condensing)
- Warm up time: at least 40 minutes
- Regulatory compliance

Table 1-37

EMC:	EMC Directive 89/336/EEC, 93/68/EEC
Safety:	Low Voltage Directive 73/23/EEC, 93/68/EEC CSA 1010, CSA Certified SEMI S2/93

- Dimensions:

  System Cabinet Type: 600 mm (W) by 900 mm (D) by 1600 mm (H)

  Testhead: 640 mm (W) by 642 mm (D) by 400 mm (H)

- Weight:

  System Cabinet: 250 kg (including 4284A, 3458A, 4 x 8110A and 8114A)

  Testhead: 70 kg (including 4 SMUs and 48 pins)

Switching Matrix Subsystem

- Maximum Measurement Pins:

  48 pins + 1 pin for prober chuck connection

- Maximum Number of Instrument Ports:

  - SMU Ports: 8 SMU + GNDU

Table 1-38 Maximum Number of SMU Ports

Ports	Connection	Max. Number of Ports
Low current measurement ports	non-Kelvin	2 ports
Standard ports	Kelvin	4 ports
	non-Kelvin	2 ports
GNDU	Kelvin	1 port

  - Auxiliary (AUX) Ports:

    8 ports for external instruments (including CMU and DVM).

Table 1-39 Maximum Number of AUX Ports

Inputs	Max. Number of Ports
Tri-axial (Force/Guard/Common)	2 ports
2 BNC (Force/Common, Sense/Common)	4 ports
BNC (Force/Common)	2 ports

  - High-frequency (HF) Ports:

    6 for pulse generator (8110A, 81110A, and 8114A) or other external instruments.

    HF ports 1 through 3 can access measurement pins 1 through 24, and HF ports 4 through 6 can access measurement pins 25 through 48. The user has the option of conecting any of the following HF port pairs together via a 1 TO 2 ADAPTER in order to access all (1 through 48) measurement pins:

ports 1 and 4, ports 2 and 5, ports 3 and 6.

- Extended Path:

  48 paths to the measurement pins. Each path can be connected to one measurement pin by an on/off relay switch.

- Pulse switch input/output ports:

- Maximum Voltage at Each Port:

Table 1-40 Maximum Voltage

Port	Maximum Voltage
SMU	±200 V
AUX1,2	±200 V
AUX3 - 8	±100 V
HF	±100 V (between force and common of each HF port) ±100 V (between two forces of all HF ports) ±100 V (between any force of HF ports and any force of extended paths)
Extended path	±100 V (between force and common of each extended port) ±100 V (between any force of HF ports and any force of extended paths)

- Maximum Current at Each Port:

Table 1-41 Maximum Current

Port	Maximum Current
SMU	±1.0 A
GNDU	±1.6 A
AUX	±1.0 A
HF	±0.5 A
Extended path	±0.5 A

- Maximum Residual Resistance (Reference Data):

Table 1-42 Maximum Residual Resistance (AUX)

Port	Resistance
Low current port	0.7 Ω (Force)
Kelvin port	1.0 Ω (Force)
	2.5 Ω (Sense)
Non-Kelvin port	1.0 Ω (Force)

Through HF port: 1.0 Ω

- Maximum Stray Capacitance between DUT pins (Reference Data)

  5 pF (between C meter ports)

- Isolation Resistance:

  Low Current Port (with Guard): 5×10^{13} Ω

- HF Port Bandwidth (@-3 dB) (Reference Data)

  60 MHz (50 Ω load impedance: from port to DUT pin, 3 x 24 configuration)

- HF Port Crosstalk between Pins (Reference Data)

  ±2 % (5 kΩ load impedance: from port to DUT pin, 20 ns pulse transition time)

Pulse Switch

The pulse switch includes seven semiconductor switching relays, for reliable and direct control of pulse shaping by the pulse generator or CPU. The pulse switch is integrated into the 4072A test head.

Number of Blocks:

2

Number of Switches for Each Block

Block 1: 3 relays (make or break, selectable type) and 1 relay (transfer type to create multi-level pulse)

Block 2: 1 relay (make or break, selectable type) and 2 relays (transfer type to create multi-level pulse)

Control Input Port:

One input per each block (PSC1 and PSC2)

Control Method

Both the PG and CPU can control all switches. PG or CPU control is independent for every block. In the case of PG control, block 1 can be controlled by the PSC1 input, and block 2 can be controlled by either PSC1 or PSC2 (selectable).

Mode of Relay Control

Make or break, selectable type relay: Normally open or normally closed modes are selectable.

Transfer type relay: Normally open and normally closed modes are not selectable.

Maximum Voltage

±60 V (between force and common of each switch)

±60 V (between PSI 21 and PSO 2, between PSI 31 and PSO 3, between PSI 41 and PSO 4, between PSI 51 and PSO 5)

±60 V (between PSI 11 (or PSI 12) and PSO 1, between PSI 11 and PSI 12, between PSI 61 (or PSI 62) and PSO 6, between PSI 61 and PSI 62, between PSI 71 (or PSI 72) and PSO 7, between PSI 71 and PSI 72)

Maximum Current:

±0.4 A (from input to output)

Residual Resistance (Reference Data):

Normal 2 Ω (from IN to OUT)

OFF Capacitance (Reference Data)

80 pF (between IN and OUT: Vin-Vout=0 V)
100 pF (force <-> common @ output of make or break, selectable type relay: Vin-Vout=0 V)

Operating Time of Switching (Reference Data):

max. 2 ms

Source and Monitor Unit (SMU)

Table 1-43 **Voltage Source/Monitor Range, Resolution, and Accuracy**

Full Scale Voltage Range	Force Resolution	Measure Resolution: High Speed	Measure Resolution: Precision	Force Accuracy [a]	Measure Accuracy [b]
±2 V	100 μV	100 μV	2 μV	a: 0.05 % b: 0.05 % c: Rmat [c] $\times$ I_o [d]	a: 0.04 % b: 0.05 %
±20 V	1 mV	1 mV	20 μV		
±40 V	2 mV	2 mV	40 μV		
±100 V	5 mV	5 mV	100 μV		
±200 V [e]	10mV	10 mV	200 μV		

a. Force Accuracy is calculated as follows: a% of output setting value + b% of output voltage range + c volts
b. Measure Accuracy is calculated as follows: a% of measured value + b% of measurement range
c. Residual Resistance of Switching Matrix force port. See note below.
d. Output current
e. HPSMU only

NOTE

Rmat

Rmat is different at each port:

Low Current Port (SMU1, SMU2): 0.7 Ω

Kelvin Port (SMU3 to SMU6): 3 mΩ

Non-kelvin Port (SMU7, SMU8): 1.0 Ω

When using prober chuck connection pin, add 0.1 Ω to Rmat.

Table 1-44 Current Source/Monitor Range, Resolution, and Accuracy (SMU1, SMU2)

Full Scale Current Range	Force Resolution	Measure Resolution High Speed	Measure Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±100 mA	5 μA	5 μA	100 nA	a: 0.12 (%) b: $0.1+0.0005\times V_o$ (%) c: 0	a: 0.1 (%) b: $0.05+0.0005\times V_o$ (%) c: 0
±10 mA	500 nA	500 nA	10 nA		
±1 mA	50 nA	50 nA	1 nA		
±100 μA	5 nA	5 nA	100 pA		
±10 μA	500 pA	500 pA	10 pA		
±1 μA	50 pA	50 pA	1 pA	a: 0.2 (%) b: $0.1+0.0005\times V_o$ (%) c: $0.02\times 10^{-12}\times V_o$ (A)	a: 0.2 (%) b: $0.05+0.0005\times V_o$ (%) c: $0.02\times 10^{-12}\times V_o$ (A)
±100 nA	5 pA	5 pA	100 fA		
±10 nA	500 fA	500 fA	10 fA	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $3\times 10^{-12}+0.02\times 10^{-12}\times V_o$ (A)	a: 1 (%) b: $0.1+0.0005\times V_o$ (%) c: $3\times 10^{-12}+0.02\times 10^{-12}\times V_o$ (A)
±1 nA	50 fA	50 fA	10 fA		

a. Force Accuracy is calculated as follows: a% of output setting value + b% of output current range + *c* ampere V_o means output voltage.
b. Measure Accuracy is calculated as follows: a% of measured value + b% of current measurement range + *c* ampere V_o means output voltage.

Table 1-45 Current Source/Monitor Range, Resolution, and Accuracy (SMU3 to SMU8)

Full Scale Current Range	Force Resolution	Meas. Resolution High Speed	Meas. Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±1 A[c]	50 μA	50 μA	1 μA	a:0.5(%), b:0.1+0.005xVo, c: 0	a:0.5(%), b:0.05+0.005xVo, c: 0
±100 mA	5 μA	5 μA	100 nA	a: 0.12 (%) b: $0.1+0.0005\times V_o$ (%) c: 0	a: 0.1 (%) b: $0.05+0.0005\times V_o$ (%) c: 0
±10 mA	500 nA	500 nA	10 nA		
±1 mA	50 nA	50 nA	1 nA		
±100 μA	5 nA	5 nA	100 pA		
±10 μA	500 pA	500 pA	10 pA		

Full Scale Current Range	Force Resolution	Meas. Resolution High Speed	Meas. Resolution Precision	Force Accuracy [a]	Measure Accuracy [b]
±1 μA	50 pA	50 pA	1 pA	a: 0.2 (%) b: 0.1+0.0005× V_o (%) c: 300× 10^{-12}+10× 10^{-12}× V_o (A)	a: 0.2 (%) b: 0.05+0.0005× V_o (%) c: 300× 10^{-12}+10× 10^{-12}× V_o (A)
±100 nA	5 pA	5 pA	100 fA		
±10 nA [d]	500 fA	500 fA	10 fA	a: 1 (%) b: 0.1+0.0005× V_o (%) c: 303× 10^{-12}+10× 10^{-12}× V_o (A)	a: 1 (%) b: 0.1+0.0005× V_o (%) c: 303× 10^{-12}+1× 10^{-12}× V_o (A)
±1 nA [d]	50 fA	50 fA	10 fA		

a. Force accuracy is calculated as follows: *a*% of reading + *b*% of range + *c* A V_o means output voltage.
b. Measure Accuracy is calculated as follows: *a*% of measured value + *b*% of current measurement range + *c* ampere V_o means output voltage.
c. Using HPSMU
d. Reference Data when using Port 3 to Port 8

NOTE

Electromagnetic Fields and SMU Current Measure Accuracy

Current measurement accuracy of SMU may be affected by electromagnetic field strength over 3 V/m at frequency range of 26 MHz to 1 GHz.

Table 1-46 Other SMU Specifications

Output Power (MPSMU):	20 mA, 100 V 50 mA, 40 V 100 mA, 20 V
Output Power (HPSMU):	50 mA, 200 V 125mA, 100V 350 mA, 40 V 700 mA, 20 V 1A, 14V
Current Over Range:	15% of range (0% for 100 mA range)
Voltage Over Range (V Force):	0% of range
Voltage Over Range (V Measure):	10% of range (0% for 100 V range)
Current Compliance Setting Range:	1 pA to Maximum current
Accuracy of reverse polarity current limit [a] :	±2% of range (100 nA to 100 mA ranges) ±10% of range (1 nA and 10 nA ranges)
Maximum Capacitive Load:	≤1000 pF
Maximum Allowable Guard Capacitance:	≤250 pF (between signal and guard lines outside switching matrix)
Maximum Slew Rate:	0.2 V/μs

a. Reference Data

Ground Unit (GNDU)

This unit is used for ground when making measurements.

Table 1-47 Maximum Current, Offset Voltage, Maximum Capacitance Load

Output Voltage:	0 V
Maximum current:	±1.6 A
Offset Voltage:	±200 μV
Maximum Capacitance Load:	1 μF [a]

a. Reference Data

DVM (3458A)

Table 1-48 Voltage Measurement Range, Resolution, and Accuracy (NPLC≥1)

Full Scale Voltage Range	Resolution	Accuracy [a]
1 V	1 μV	a: 0.02 (%) b: 300 (μV)
10 V	10 μV	a: 0.02 (%) b: 300 (μV)
100 V	100 μV	a: 0.03 (%) b: 1 (mV)

a. Accuracy is calculated as follows: *a*% of measured value + *b* volts

Capacitance Measurement Unit (CMU)

The accuracy in following table is between any two measurement pins (except chuck connection pin) and for following conditions:

Table 1-49

Measurement range:	1 fF to 1.2 nF and 10 nS to 7.5 mS (1 MHz) 1 fF to 10 nF and 1 nS to 6.3 mS (100 kHz) 1 fF to 100 nF and 0.1 nS to 6.3 mS (10 kHz) 10 fF to 100 nF and 0.1 nS to 0.63 mS (1 kHz)
Measurement frequency:	1 kHz, 10 kHz, 100 kHz, and 1 MHz
dc bias voltage:	±40 V
Measurement speed:	MEDIUM or LONG
Test signal level:	30 mV_{rms}±5 mV_{rms}
Stray capacitance:	between force and guard must be under 5 pF.

And after calibration data measurement and offset cancel.

Table 1-50 **C/G Measurement Range, Resolution, and Accuracy**

Frequency	C Range	C Accuracy	G Range	G Accuracy
1 MHz	10 pF	a: 0.8(%), b: $1.0+0.6\times Gm/63\times 10^{-6}$(%)	63 µS	a: 0.8(%), b: $1.0+0.6\times Cm/10\times 10^{-12}$(%)
	100 pF	a: 0.8(%), b: $0.3+0.6\times Gm/630\times 10^{-3}$(%)	630 µS	a: 0.8(%), b: $0.3+0.6\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 1.5(%), b: $0.2+1.7\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 1.3(%), b: $0.2+2.2\times Cm/1\times 10^{-9}$(%)
100 kHz	10 pF	a: 0.4(%), b: $1.0+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 µS	a: 0.4(%), b: $1.0+0.4\times Cm/10\times 10^{-12}$(%)
	100 pF	a: 0.3(%), b: $0.3+0.3\times Gm/63\times 10^{-6}$(%)	63 µS	a: 0.3(%), b: $0.3+0.3\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.2+0.4\times Gm/630\times 10^{-6}$(%)	630 µS	a: 0.3(%), b: $0.2+0.4\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.5(%), b: $0.2+1.0\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 0.7(%), b: $0.2+0.8\times Cm/10\times 10^{-9}$(%)

Frequency	C Range	C Accuracy	G Range	G Accuracy
10 kHz	100 pF	a: 0.3(%), b: $0.2+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 µS	a: 0.3(%), b: $0.2+0.3\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.1+0.3\times Gm/63\times 10^{-6}$(%)	63 µS	a: 0.3(%), b: $0.1+0.3\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.3(%), b: $0.1+0.3\times Gm/630\times 10^{-6}$(%)	630 µS	a: 0.3(%), b: $0.1+0.3\times Cm/10\times 10^{-9}$(%)
	100 nF	a: 0.3(%), b: $0.1+1.0\times Gm/6.3\times 10^{-3}$(%)	6.3 mS	a: 0.7(%), b: $0.1+0.7\times Cm/100\times 10^{-9}$(%)
1 kHz	100 pF	a: 0.4(%), b: $0.5+0.4\times Gm/0.63\times 10^{-6}$	0.63 µS	a: 0.4(%), b: $0.5+0.4\times Cm/100\times 10^{-12}$(%)
	1 nF	a: 0.3(%), b: $0.1+0.3\times Gm/6.3\times 10^{-6}$(%)	6.3 µS	a: 0.3(%), b: $0.1+0.3\times Cm/1\times 10^{-9}$(%)
	10 nF	a: 0.3(%), b: $0.1+0.3\times Gm/63\times 10^{-6}$(%)	63 µS	a: 0.3(%), b: $0.1+0.3\times Cm/10\times 10^{-9}$(%)
	100 nF	a: 0.3(%), b: $0.1+0.3\times Gm/630\times 10^{-6}$(%)	630 µS	a: 0.3(%), b: $0.1+0.3\times Cm/100\times 10^{-9}$(%)

- Accuracy is calculated as follows: *a*% of measured value + *b*% of measurement range.

  Gm is measured conductance. Cm is measured capacitance.

- The accuracy at the following ranges are reference data:
  - 10 pF range at 1 MHz and 10 kHz frequencies.
  - 100 pF range at 1 kHz frequency.
- When measurement speed is set to SHORT, calculate accuracy by adding 0.25% to % of measured value and 0.1% to % of measurement range.
- Accuracy of frequency: ±0.1%

Pulse Force Unit

Supported Pulse Generators:	Agilent 8110A, 81110A, and 8114A
Maximum Number of Installable Pulse Generators:	5 x 8110A or 5 x 81110A (without 8114A)
	4 x 8110A or 4 x 81110A (with 1 x 8114A)
	2 x 8110A or 2 x 8110A (with 2 x 8114A)

Pulse Force Mode

Pulse signal:	2-level and 3-level output
Burst count:	10^9(max.) or infinite
Output mode:	Normal mode or Pattern mode
	Normal mode All pulse generators (up to 5) can force in synchronization.
	Pattern mode All pulse generators except a master pulse generator can force in synchronization. (more accurate pulse width and pulse delay than normal mode).
	Note: 8114A does not support pattern mode.
Load impedance:	999 kΩ (default), selectable from 2.5 Ω to 999 kΩ (8110A, 81110A) selectable from 10Ω to 999 kΩ (8114A)

Pulse Setting Range

Pulse Period

Mode	PGU	Range
Normal mode	8110A, 81110A	350 ns to 999 s Resolution: 4 digits (min. 100 ps)
	8114A	350 ns to 999 ms, Resolution: 3 digits (min. 1 ns)
Pattern mode	8110A or 81110A in a master unit	120 μs to 999 s Resolution: 4 digits (min. 100 ns)
	8114A in a master unit	120 ns to 999 ms Resolution: 3 digits (min. 1 μs)

Pulse Width

Mode	PGU	Range
Normal mode	8110A	50 ns to 999 ms Resolution: 3 digits (min. 100 ps)
	81110A	50 ns to 999 ms Resolution: 3.5 digits (min. 50 ps)
	8114A	150 ns to150 ms, Resolution: 3 digits (min. 1 ns)

Mode	PGU	Range
Pattern mode	8110A or 81110A in a master unit	50 ns to 999 ms Resolution: 3 digits (min. 100 ps)
	8114A in a master unit	150 ns to 150 ms Resolution: 3 digits (min. 1 ns)
	8110A or 81110A in a slave unit	100 ns to 999 ms Resolution: 1×10^{-n} (at $1000 \times 10^{-n} < T \leq 4000 \times 10^{-n}$) 2×10^{-n} (at $4000 \times 10^{-n} < T \leq 8000 \times 10^{-n}$) 2.5×10^{-n} (at $8000 \times 10^{-n} < T \leq 10000 \times 10^{-n}$) T means the maximum value of (pulse width + delay time) among all the channels. For example, if T is 250 us, then according to above table, the resolution is 0.1 μs (1×10^{-7}) because T= 250 x 10 - 6 = 2500×10^{-7}

Pulse Delay

Mode	PGU	Range
Normal mode	8110A, 8114A	0 to 998 ms Resolution: 3 digits (min. 10 ps)
	81110A	0 ns to 998 ms Resolution: 3.5 digits (min. 5 ps)
Pattern mode	8110A, 81110A, or 8114A in a master unit	0 to 998 ms Resolution: 3 digits (min. 10 ps)
	8110A or 81110A in a slave unit	0 to 998 ms Resolution: 1×10^{-n} (at $1000 \times 10^{-n} < T \leq 4000 \times 10^{-n}$) 2×10^{-n} (at $4000 \times 10^{-n} < T \leq 8000 \times 10^{-n}$) 2.5×10^{-n} (at $8000 \times 10^{-n} < T \leq 10000 \times 10^{-n}$) T means the maximum value of (pulse width + delay time) among all the channels. For example, if T is 250 us, then according to above table, the resolution is 0.1 μs (1×10^{-7}) because T= 250 x 10 - 6 = 2500×10^{-7}

Transition Time

20 ns to 200 ms (8110A, 81110A)

65 ns (fixed) (8114A)

Pulse Level (at open load)

8110A, 81110A	+ 19 V (at 2 level) + 19 V (at 3 level)[a]
8114A	-49.9 V to +50 V (at 2 level) -49.9 V to +50 V (at 3 level)[b]
(8110A or 81110A) + 8114A	-49.9 V to +50 V (at 3 level)

a. Restriction for "3-level pulse with one PG" output mode: the sum of the absolute values of both amplitudes cannot exceed 20 V.

b. There is no "3-level pulse with one PG" output mode on the 8114A because it has only one output.

Pulse Level Accuracy (at open load)

8110A and 81110A level	± ((2 % of amplitude) + 150 mV)
8114A amplitude	± ((2 % of amplitude) + 200 mV)
8114A baseline	± ((2 % of baseline) + (1 % of amplitude) + 200 mV)

Pulse Shape Accuracy (at 50 Ω load impedance)

8110A width	± (5 % of setting + 2 ns) (in normal mode, width ≥ 50 ns)
81110A width	± (3 % of setting + 2 ns) ± (0.5 % of setting + 2 ns)[a] after timing calibration (in normal mode, width ≥ 50 ns)
8110A delay	± (5 % of setting + 1 ns) (in normal mode)
81110A delay	± (3 % of setting + 1 ns) ± (0.5 % of setting + 1 ns)[a] after timing calibration (in normal mode, width ≥ 50 ns)
8110A and 81110A transition	(-10 % of setting) to (+10 % of setting + 20 ns) (transition time ≥ 20 ns)
8110A and 81110A overshoot	± (5 % of amplitude + 20 mV) (transition time ≥ 20 ns)
8114A width	± (5 % of setting + 3.5 ns) (width >= 200 ns) ± (5 % of setting + 6.0 ns) (width >= 150 ns)
8114A delay	± (5 % of setting + 1 ns)
8114A transition	65 ns ± 20 ns
8114A overshoot	± (5 % of amplitude + 50 mV)

a. Reference data.

Pulse Shape Accuracy (at 5 kΩ load impedance: reference data)

8110A and 81110A overshoot/ringing	± (5 % of amplitude + 20 mV)
8114A overshoot/ringing	(-8% of amplitude) to (+4% of amplitude)
8110A and 81110A transition time	± (10 % of setting + 5 ns)
8114A transition time	56 ns ± 5 ns
Skew between pins	± 10 ns

System Controller

Supported Computer

HP 9000 Series 700 Model 745/132L and 745i

Operating System

HP-UX 10.20 (Needs some patches for Year 2000. Please contact your local sales representative.)

HP BASIC/UX 8.02 and SICL E.01.01or G.01.02 (for 745/132L, only G.01.02 is supported), *or* C/ANSI C and SICL

Required Memory

Minimum requirement is 64 MB (128 MB is recommended).

Required GPIB Interfaces

Agilent Technologies recommends two external GPIB interface card for use with:

Instruments controlled by the 4072A TIS commands (e.g. 4284A, 3458A)

Automatic Wafer Prober

System Software

Standard 4072A software provides the following capabilities:

- System Management
- Control of subsystems (TIS Library)
- Parameter measurement functions (PARA Library)
- Offline debugging
- Interactive Debugging Panel (IDP)
  Includes Flexible Algorithm Semiconductor Test Code (FASTCode) Generator.
- Probing Pattern generation and wafer map display (PPG, MAP)
- Prober Control Libraries: Electroglas, TEL, TSK
- Application program (Sample program): flash memory cell evaluation, charge pumping method
- Automatic Diagnostics

2 Measurement Subsystems

This chapter describes the fundamental operating theory of the Agilent 4071Aor Agilent 4072A's measurement subsystems to provide you with a better understanding of the system's hardware and operation.

This chapter consists of the following sections that describe each subsystem:

- “Switching Matrix Subsystem (SMS)” on page 2-3

  The SMS is in the testhead. Consists of switching matrix (SWM) and testhead CPU and is for connecting the ports for DCS, CMS, and PGS (4072A only) measurement subsystems to the measurement pins.

- “DC Subsystem (DCS)” on page 2-16

  Consists of the Source Monitor Units (SMUs) in the testhead and Agilent 3458A multimeter (if installed) in system cabinet.

- “Capacitance Measurement Subsystem (CMS)” on page 2-29

  Consists of Agilent 4284A Precision LCR Meter (if installed) in system cabinet.

- “Pulse Generator Subsystem (PGS)” on page 2-34

  Consists of the Pulse Generator Units (PGUs), if installed, in system cabinet and pulse switch in the testhead.

  Note that PGS is only available for 4072A system.

Switching Matrix Subsystem (SMS)

SMS consists of the following:

- Switching matrix (SWM)

  For connecting the ports (for DCS, CMS, and PGS measurement subsystems and extended path) to the measurement pins.

- Testhead CPU

  For controlling relays of SWM.

Table 2-1 on page 4 shows a simplified diagram of the SMS.

SWM can connect any of the following ports to up to 48 measurement pins.

- Testhead internal ports: up to eight SMUs, one GNDU, and three guard ports.
- External ports:
  - Up to eight AUX ports and three guard ports.
  - Up to six High Frequency (HF) ports for pulse signals from PGUs. (4072A only)
  - Extended path

For more about these ports, refer to next section, “Ports” on page 2-5.

NOTE

Chuck Connection Pin

In addition to the standard measurement pins, SWM provides a special pin for prober chuck connection. This pin is connected to the Chuck Connection Output connector on the side panel of testhead. So, you can connect any of the ports to the prober chuck from this pin.

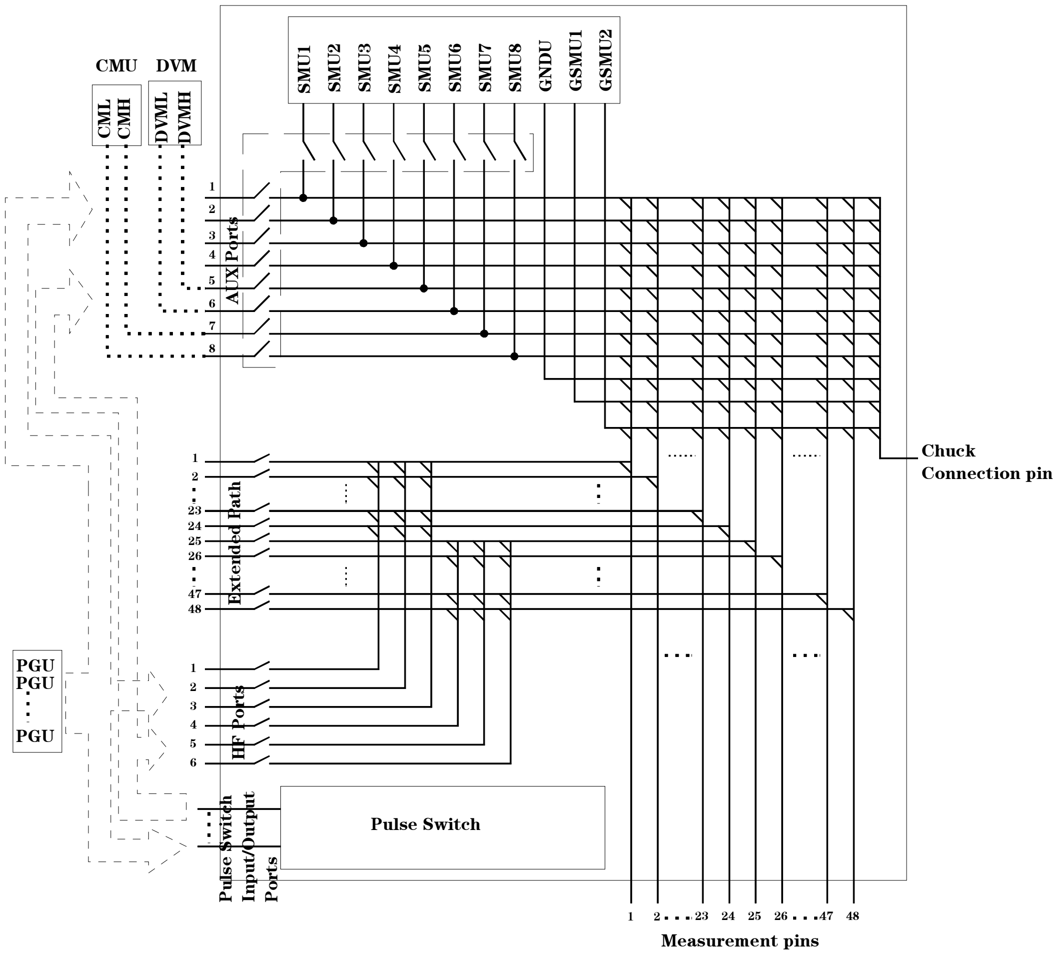
For more about Chuck Connection Pin, refer to “Chuck Connection Pin” on page 2-11.

Any measurement pin can be connected or disconnected to almost any port except HF ports by software control (TIS statements). So, you can control the 4071A's subsystem components as if they are built into the SWM.

As for the HF ports, HF1 to HF3 ports can connect or disconnect to any pins of pin 1 to pin 24, and HF3 to HF6 ports can connect or disconnect to any pins of pin 25 to pin 48.

You can connect the SWM to a wafer prober (using the Personality Board and prober's probe card) or to one of the furnished test fixtures.

Figure 2-1 **Simplified Diagram of SMS**



Ports

The switching matrix is for connecting the ports (for DCS, CMS, and PGS measurement subsystems, Extended Path, and unsupported equipment) to the measurement pins.

Port 10 is for instruments connected to Extended Path connector on side panel of testhead. Refer to “Extended Path” on page 2-12.

Pulse Switch ports are for open/close or multiplex switching for pulse signals from PGUs to HF or AUX ports. Refer to “Pulse Switch (4072A only)” on page 2-14

Testhead Internal ports and AUX ports

The following two tables show the testhead internal ports and AUX ports.

AUX ports are for instruments connected to AUX connectors on side of the testhead, such as 3458A, 4284A, or pulse generators in the system cabinet or unsupported user-connected instruments.

The AUX and internal ports (except for the GNDU, which is port 9) use the same port numbers: 1 to 8, −1, and −2. So, these ports go through an input selection block to select internal *or* external port before going to SWM.

Table 2-1 **Testhead Internal Ports**

Port Name	Description	Port Number
SMU1	For low current measurement (if installed)	1
SMU2	For low current measurement	2
SMU3 [a]	For general dc measurement	3 [a]
SMU4 [a]	For general dc measurement	4 [a]
SMU5	For general dc measurement (if installed)	5
SMU6	For general dc measurement (if installed)	6
SMU7	For general dc measurement (if installed)	7
SMU8	For general dc measurement (if installed)	8
GNDU	DC ground unit (for keeping 0 potential)	9

Port Name	Description	Port Number
GSMU1	SMU1 guard terminal (guarding for low current measurements)	-1
GSMU2	SMU2 guard terminal (guarding for low current measurements)	-2
GCMU	Guarding for capacitance measurements (circuit common)	11

a. You can install HPSMU in this port.

Table 2-2 **AUX Port**

Port Name	Description	Port Number
AUX1	For AUX1 terminal external equipment (if connected)	1
AUX2	For AUX2 terminal external equipment (if connected)	2
AUX3	For AUX3 terminal external equipment (if connected)	3
AUX4	For AUX4 terminal external equipment (if connected)	4
DVMH (AUX5)	HIGH terminal for differential V measurements (if Agilent 3458A DVM is installed)	5
DVML (AUX6)	LOW terminal for differential V measurements (if Agilent 3458A DVM is installed)	6
CMH (AUX7)	HIGH terminal for C measurements (if Agilent 4284A CMS is installed)	7
CML (AUX8)	LOW terminal for C measurements (if Agilent 4284A CMS is installed)	8
GAUX1	AUX1 guard terminal	-1
GAUX2	AUX2 guard terminal	-2

Ports for Guarding

The GSMU1 and GSMU2 ports are connected to the guard terminals of SMU1 and SMU2 respectively. These ports can be used as guard terminals for other pins, such as for a guard pattern around the test device. Refer to “Guarding” on page 2-23.

The GCMU port connects to the chassis ground (circuit common). This port can be used as the guard when measuring capacitance.

When a DVM is connected to the AUX5 and AUX6 outputs, the connections for DVMH and DVML are as shown above because the DVM is not connected to the Sense line. The AUX5 and AUX6 outputs are the same as the AUX3 and AUX4 outputs.

HF Port (4072A only)

The HF ports are for the pulse signals from the PGUs or for the Pulse Switch Output ports that connect to the HF connectors on the side of the testhead.

Although the pulse signal can be forced through the AUX port, the HF port is specially designed for passing high-frequency pulse signals. You can force higher speed pulse signals to your DUT through the HF ports than you can through the AUX ports.

HF1 to HF3 ports can connect or disconnect to any pins of pin 1 to pin 24, and HF3 to HF6 ports can connect or disconnect to any pins of pin 25 to pin 48.

If you would like to force pulse signals to any pin from 1 to 48, you can use the THF port. The THF port consists of two HF ports that you connect using the 1-to-2 adapter to enable forcing pulse signals to any pin from 1 to 48.

Table 2-3 **HF Port**

Port Name	Description	Port Number
HF1	HF1 terminal for the pulse output from the pulse generator. This port can only connect to pins 1–24.	1
HF2	HF2 terminal for the pulse output from the pulse generator. This port can only connect to pins 1–24.	2
HF3	HF3 terminal for the pulse output from the pulse generator. This port can only connect to pins 1–24.	3

Port Name	Description	Port Number
HF4	HF4 terminal for the pulse output from the pulse generator. This port can only connect to pins 25–48.	4
HF5	HF5 terminal for the pulse output from the pulse generator. This port can only connect to pins 25–48.	5
HF6	HF6 terminal for the pulse output from the pulse generator. This port can only connect to pins 25–48.	6

Table 2-4 THF Port

Port Name	Description	Port Number
THF1	This port is realized by connecting the HF1 terminal and HF4 terminal by the 1-to-2 adapter. The pulse to this port is distributed to both HF terminals and can be forced to any pin from 1–48.	1
THF2	This port is realized by connecting the HF2 terminal and HF5 terminal by the 1-to-2 adapter. The pulse to this port is distributed to both HF terminals and can be forced to any pin from 1–48.	2
THF3	This port is realized by connecting the HF3 terminal and HF6 terminal by the 1-to-2 adapter. The pulse to this port is distributed to both HF terminals and can be forced to any pin from 1–48.	3

Measurement Pins

One measurement pin is realized by one pin board in the SWM.

One measurement pin is actually a set of three spring-loaded pins — SENSE, FORCE, and GUARD — on the pin board:

SENSE: For SMU3, AUX3, SMU4, AUX4, SMU5, AUX5, SMU6, or AUX6 port, SENSE pin is an input terminal for Kelvin connection.

For the SMU1, AUX1, SMU2, AUX2, DVMH, DVML, SMU7, AUX7(CMH), SMU8, AUX8 (CML) port, SENSE pin is open-terminated, so has no function.

FORCE: For the SMU3, AUX3, SMU4, AUX4, SMU5, AUX5, SMU6, or AUX6 port, FORCE pin is an output terminal for Kelvin connection.

For the SMU1, AUX1, SMU2, AUX2, SMU7, AUX7(CMH), SMU8, AUX8(CML) port, the FORCE pin is an input/output terminal.

For the DVMH or DVML port, the FORCE pin is an input terminal.

For the HF1 to 6 or THF1 to3 port, the FORCE pin is an output terminal.

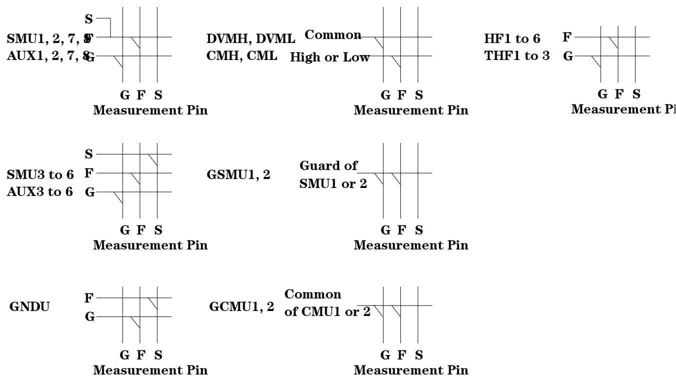
GUARD: For the SMU1 to SMU8, AUX1 to AUX8, CMH, or CML port, GUARD pin is guard terminal.

Measurement Pins

Measurement pins are completely isolated from each other to prevent leakage current between pins and to maximize measurement accuracy.

Figure 2-2 on page 2-10 shows SWM pin-port connections.

Figure 2-2 **SWM Pin-Port Connections**

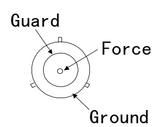


Chuck Connection Pin

In addition to the standard measurement pins, SWM provides a special pin for prober chuck connection. This pin is connected to the Chuck Connection Output connector on the side panel of testhead. So, you can connect any of the ports to the prober chuck via this pin.

Actually the Chuck Connection Output connector is connected to the measurement path in testhead as follows:

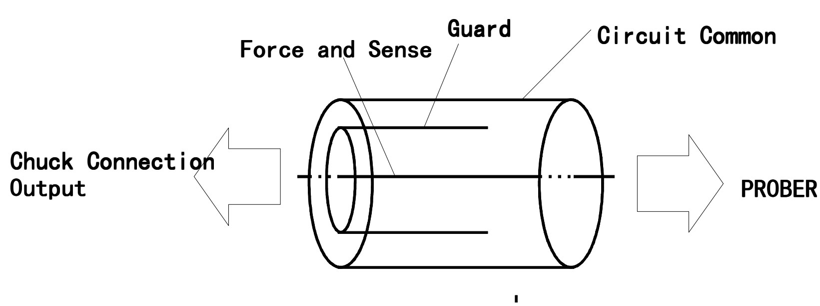
Figure 2-3 **Chuck Connection Output connector**



- The center conductor of the Chuck Connection Output connector is connected to Force and Sense lines.
- The inner shield of the Chuck Connection Output connector is connected to Guard.
- The outer shield of the Chuck Connection Output connector is connected to Circuit Common.

Agilent 4070 provides tri-axial to co-axial conversion connector (Agilent Part Number: 1250-2610) for the Chuck Connection Output connector.

This conversion connector converts the Chuck Connection Output connector on the side-panel of the testhead to the BNC co-axial connector as follows:



Extended Path

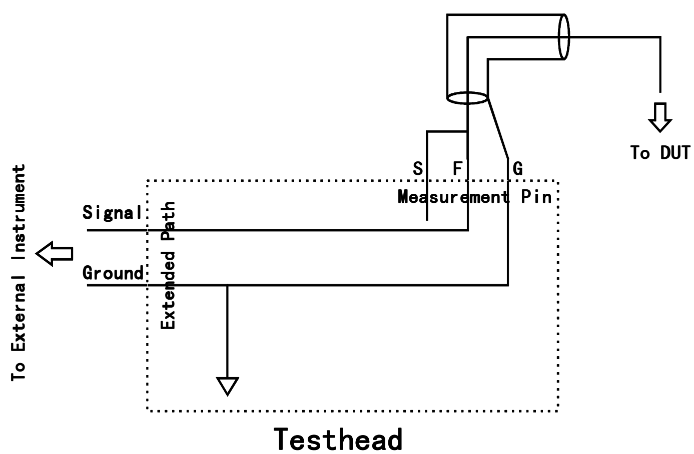
Extended Path connector (on the side panel of testhead) is for directly connecting an instrument to an individual pin board of switching matrix (SWM) *without passing through the input selection block.*

By using this path, an external instrument (for example Pulse Generator) can be connected to any of the 48 measurement pins of the switching matrix and this path can handle higher frequency signals than the other ports.

Extended Path in Testhead

Each signal pin of extended path connector is connected to Force pin of the corresponding measurement pin.

Each ground pin of extended path connector is connected to the chassis ground and connected to Guard pin of the corresponding measurement pin.



Agilent E3148A Extended Adapter

Agilent E3148A Extended Adapter is available as an optional accessory for 4070. The E3148A is for attaching to the Extended Path connector, so that you can easily connect an external instrument via BNC connector.

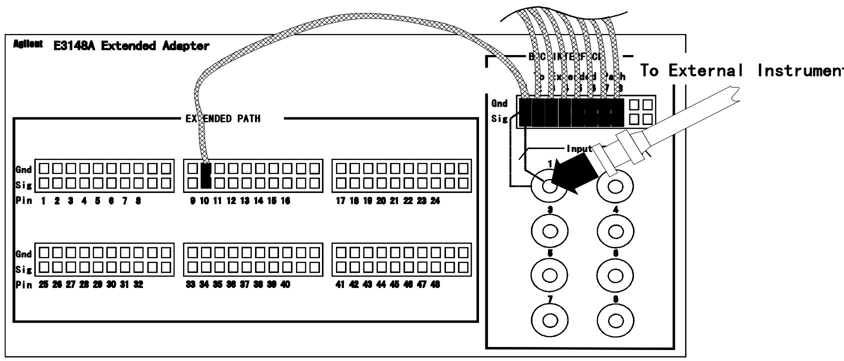
You can connect an external instrument to the E3148A as follows:

- Directly connect to any of the 48 pins in the EXTENDED PATH block

- If the external instrument has a BNC connector, connect to any of the eight Input (BNC) connectors on the BNC INTERFACE block. These eight BNC connectors are connected internally to the pins related to the Output connector.

The E3148A is furnished with a connector adapter and eight cables. You can connect this adapter to the Output connector of the BNC INTERFACE block. Then you can use the eight cables to connect the desired pins of the Output connector to any eight of the 48 pins of the EXTENDED PATH block.

For example, if an instrument output is connected to BNC connector 1, and Output pin 1 is connected to EXTENDED PATH pin 10, then the instrument output will be directly connected to pin board 10 (measurement pin 10 of testhead) of the switching matrix.



Refer to *E3148A Extended Adapter Operating Guide* for more detail about connections.

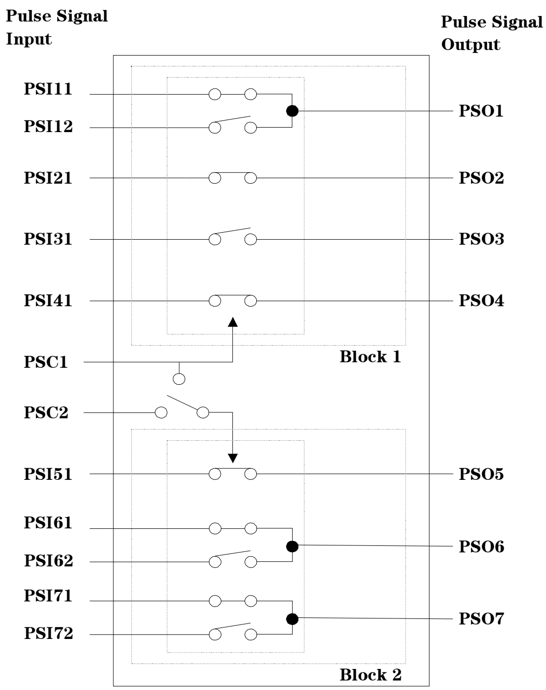
Pulse Switch (4072A only)

The pulse switch provides three multiplexer switches and four open/close switches for pulse signals from the PGUs and to the HF or AUX ports.

The semiconductor switching relays used for the switches allow reliable and direct control of the pulse signal from the pulse generator, the GUI window, or a TIS subprogram in your measurement program. You can easily force and control pulse signals to the DUT. This is especially useful when testing a flash memory device.

The following figure shows the block diagram of the pulse switch:

Figure 2-4 **Simplified Diagram of Pulse Switch**



The pulse switch is divided into two blocks. You can control the switch using a pulse signal from the pulse generator or from a TIS subprogram in your measurement program. Each block can be controlled independently. For example, if you are controlling the switch using a pulse signal from the pulse generator, block 1 can be controlled by the signal to PSC1 input and block 2 can be controlled by the signal to PSC1 or PSC2 (selectable).

The open/close switch is used to open or force the pulse signal to the device terminal. You can select the switch position to be normally open or normally closed.

The multiplexer switch allows forcing a higher voltage 3-level pulse or a multi-level pulse of up to 5-levels.

Safety Features

DC voltages up to ±100 V can be present at the measurement pins of the SWMs. The 4070 provides several safety features to protect operators against potential shock hazards.

To perform a measurement, *one* of following conditions must be true:

- The SWM must be firmly installed on a wafer prober

  or

- The SWMA must have a test fixture adapter installed with the lid closed.

The testhead CPU monitors the following conditions:

If *both* of these conditions are false, the testhead CPU disables the SWM output (the OUTPUT ENABLED lamp on the SWM is turned off).

If *one* of these conditions is true, the testhead CPU enables the SWM output (the OUTPUT ENABLED lamp lights).

If the required condition becomes false during a measurement, the output is disabled immediately. The measurement can continue only *after* the required condition becomes true again.

DC Subsystem (DCS)

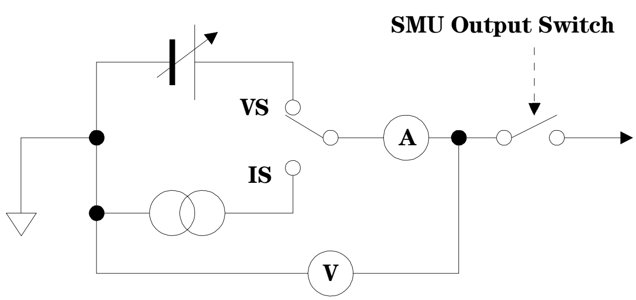
The DCS consists of the SMUs in the testhead and 3458A multimeter (if installed) in system cabinet.

Source/Monitor Units (SMUs)

You can program each SMU to function as either a voltage source (V source mode) or as a current source (I source mode). In both modes, the SMU can perform voltage or current measurement.

Figure 2-5 shows a simplified SMU circuit diagram.

Figure 2-5 **Simplified SMU Circuit Diagram**



The Output V or I can be held constant, swept linearly or logarithmically, or pulsed. These functions are described in Chapter 3, “Measurement Types,”.

Only SMU3, 4, 5, and 6 can implement Kelvin connections. Refer to “Kelvin Connection” on page 2-22 for more information.

The following tables shows the output and measurement ranges of the SMU.

Table 2-5 **SMU Output Voltage Ranges and Resolution**

Output Range	Setting Resolution
2 V	100 µV
20 V	1 mV
40 V	2 mV
100 V	5 mV

Table 2-6 **SMU Voltage Measurement Ranges and Resolution**

Measurement Range	Measurement Resolution High-speed ADC	Measurement Resolution High-resolution ADC
2 V	100 μV	2 μV
20 V	1 mV	20 μV
40 V	2 mV	40 μV
100 V	5 mV	100 μV

Table 2-7 **SMU Output Current Ranges and Resolution**

Output Range	Setting Resolution
1 nA	50 fA
10 nA	500 fA
100 nA	5 pA
1 μA	50 pA
10 μA	500 pA
100 μA	5 nA
1 mA	50 nA
10 mA	500 nA
100 mA	5 μA

Table 2-8 SMU Current Measurement Ranges and Resolutions

Measurement Range	Resolution	
	High-speed ADC	**High-resolution ADC**
1 nA	50 fA	10 fA
10 nA	500 fA	10 fA
100 nA	5 pA	100 fA
1 μA	50 pA	1 pA
10 μA	500 pA	10 pA
100 μA	5 nA	100 pA
1 mA	50 nA	1 nA
10 mA	500 nA	10 nA
100 mA	5 μA	100 nA

Compliance

To prevent test device damage, you can specify voltage and current compliance values to limit SMU output. If an SMU reaches compliance, it acts as a constant source, and cannot exceed the specified compliance value.

You can monitor compliance by using the `Port_status` TIS statements. Refer to the *Programming Reference* for details on `Port_status` usage.

For sweep measurements, you can also specify power compliance. Refer to “Power Compliance” on page 2-21.

Figure 2-6 shows an example bipolar transistor measurement setup and Figure 2-7 on page 2-19 shows the I-V curve obtained when compliance is reached.

Figure 2-6 **Example Setup for Compliance**

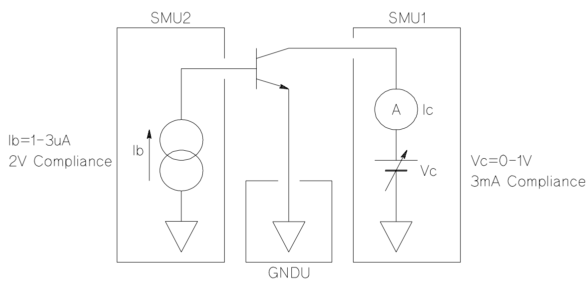
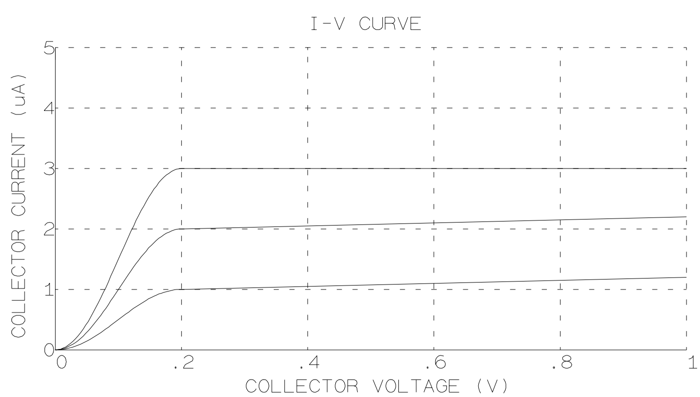


Figure 2-7 **Upper Curve has Reached Current Compliance**



As shown in this example, the upper curve has reached compliance, so current becomes constant at 3 mA. The two lower curves have not reached compliance, so continue to gradually increase.

Actual limit depends on the polarity of output voltage or current.

- V compliance

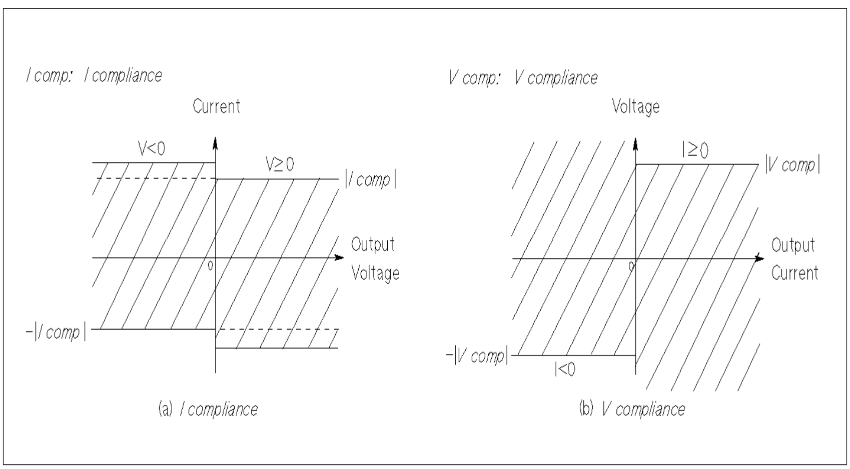
  SMU automatically sets the V compliance polarity to the same polarity as the output current, regardless of the specified V compliance polarity. There is no compliance for the opposite polarity.

- I compliance

  SMU automatically sets I compliance for both the positive and negative polarity, regardless of the I compliance polarity.

  However, if the output voltage and output current are opposite polarity, the *I compliance* value is increased by an amount that is 2.5% to 12% of the range value in the lowest range that includes *I compliance*. The following figure shows the relation of the compliance and output.

Figure 2-8 **Relation of Compliance and Output**



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When setting compliance:

- Do not set I compliance too low.

  An undesired current, in series with an SMU's output, may be generated as a result of dirty contacts — caused by an electrochemical reaction or a temperature difference between contacts.

  If I compliance is too low, this undesired current may cause SMU to reach I compliance, which would cause a voltage greater than the specified output V to be applied to the test device.

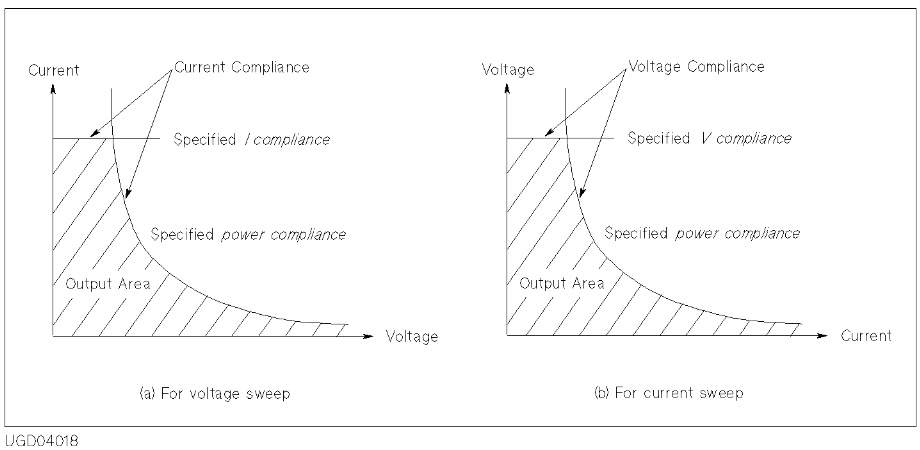
Power Compliance

In addition to V compliance or I compliance, you can set power compliance for a sweep source unit. You *cannot* set power compliance for a *pulsed* staircase sweep source.

If you specify I compliance and power compliance for a V sweep source, the SMU changes the I compliance at every voltage step. The I compliance is set to smaller value of *I compliance* and *power compliance/step voltage*, as shown in the following figure (a).

If you specify V compliance and power compliance for an I sweep source, the SMU changes the V compliance at every current step. V compliance is set to smaller value of *V compliance* and *power compliance/step current* as shown in figure (b).

Figure 2-9 **Power Compliance Output Area**



Kelvin Connection

When you measure low resistance, high current flows through the test device. This high current increases the measurement error caused by the residual resistance of test leads and contacts.

To eliminate this problem, you can implement a Kelvin (4-wire) connection by using SMU3, 4, 5, or 6, and the GNDU. For a Kelvin connection, the sense and force test leads are extended separately to the test device.

NOTE Non-kelvin SMUs

The force and sense lines of SMU1, SMU2, SMU7, SMU8 are connected inside the testhead, so *cannot* be used for Kelvin connections.

When compared to 2- or 3- wire connections, Kelvin connections provide a distinct advantage when performing low resistance measurements, for example, forward biased pn junctions.

Kelvin Connection Applications

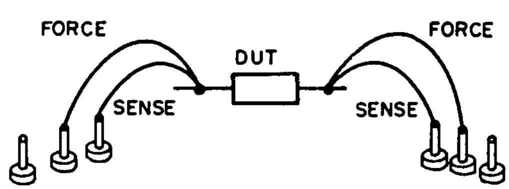
You can implement Kelvin connections when using the universal fixture or the extension cable fixture.

To implement a Kelvin connection when you use test fixtures, connect the force and sense leads.

Figure 2-10 shows the example of kelvin connection by using Extension Cable Fixture.

To cancel the effects of residual resistance, test leads should be connected as close as possible to the test device. Note that cable length should not exceed 1 m.

Figure 2-10 **Kelvin Connection using Universal Low Leakage Fixture**



Guarding

Guarding allows accurate low current measurements by eliminating the effects of leakage current and associated measurement errors.

Each SMU has a guard line, which is connected internally to the SMU's force line via a buffer amplifier.

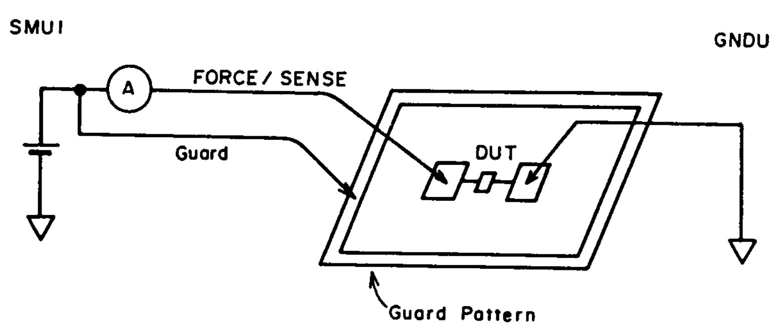
The guard line completely surrounds all force/sense lines, including the cables between the SMUs and SWM, and printed circuits on the SWM's pin boards. So, the force/sense lines are guarded all the way to the measurement pins on the pin boards.

The guard line is same potential as the force/sense lines, so current does not flow between force/sense lines and guard lines. Therefore, leakage current and associated errors are negligible, which allows accurate low current measurements.

The GSMU1 and GSMU2 ports of SWM are connected to guard line of SMU1 and SMU2 respectively. This is useful for guarding test devices (DUTs) on the wafer as shown in Figure 2-11.

As shown in this example, one prober needle connects force/sense of SMU1 to the DUT, and another prober needle connects the GSMU1 port (guard of SMU1) to the guard pattern on wafer.

Figure 2-11 **Example of GSMU Use**



Also refer to Figure 2-2 on page 2-10.

Selecting A/D Converter

For voltage or current measurement, two types of A/D converters are available for each SMU in the testhead:

- *High-speed A/D converter*

  This is a successive-approximation type A/D converter, which can perform measurement *faster*, but with lower resolution, than high-resolution A/D converter.

  Results are the *measured* average of the number of samples determined by the integration time.

- *High-resolution A/D converter*

  This is an integration type A/D converter which can perform measurement with *higher resolution*, but slower, than a high-speed A/D converter.

  Results are the integrated average during the specified integration time, so this ADC also works as a low-pass filter to cut noise.

You can select which A/D converter each SMU uses by using the `Set_smu_ch` TIS statement.

For the integration time of the ADCs, refer to “Integration Time” on page 2-26.

Self-Calibration and Auto Zero Function

To minimize output drift and measurement fluctuations, caused primarily by ambient temperature changes, SMU provides the function to cancel offsets of its control circuit (including A/D converters).

When you execute SMU self-calibration function, SMU measures offsets of its control circuit (including A/D converters), then 4071A automatically cancel measured offsets.

Auto Zero function only cancels offsets of high-resolution A/D converter if the integration time setting is greater than approximate 10 ms.

SMU Ranging Mode

SMU provides the following ranging modes:

- Output
  - auto ranging
  - limit auto ranging
  - fixed range
- Measurement
  - auto ranging
  - limited auto ranging

The source or measurement unit searches for the range that provides the best resolution, then outputs or measures.

You specify a range, which is the lowest possible range at which you want to measure or output.

Measurement time for limited auto ranging is less than for auto ranging because unit does not search below specified range, thus reducing number of range changes. So, specify highest range that gives you satisfactory results.

The source unit outputs at the specified range only.

Integration Time

By using the `Set_adc` TIS statement, you can select the SMU digital integration time setting: SHORT, MEDIUM, LONG, and MANUAL.

High-speed A/D Converter (measured average)

Integration mode	Integration time (number of samples)
Manual	You specify the number of samples to average.
Short	The number of samples to average is calculated as follows: system pre-defined number of samples × your specified value.
Medium	Integration time is set to 1 Power Line Cycle (PLC).
Long	Integration time is set to your specified number of PLCs.

High-resolution A/D Converter (integrated average)

Integration mode	Integration time
Manual	You specify integration time in seconds or number of PLCs.
Short	The integration time is calculated as follows: system pre-defined factor × your specified value in seconds.
Medium	Integration time is set to 1 Power Line Cycle (PLC).
Long	Integration time is set to your specified number of PLCs.

If MEDIUM or LONG integration mode setting is selected, measurement is performed in synchronization with the power line frequency to minimize line frequency noise errors. For correct digital integration operation, line frequency setting in your 4070 must be correct. Refer to *Installation Guide* for setting line frequency.

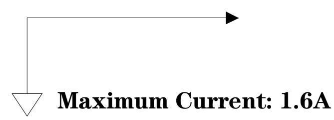
Ground Unit (GNDU)

The GNDU provides a measurement ground reference, can output 0 V, and can sink up to ±1.6 A. To cancel the effects of the SWM's residual resistance, you can use the GNDU with SMU3, 4, 5, or 6 to implement Kelvin connections.

Refer to “Kelvin Connection” on page 2-22 for details on Kelvin connections.

Figure 2-12 shows a simplified GNDU circuit diagram.

Figure 2-12 **Simplified GNDU Circuit Diagram**



Agilent 3458A (DVM)

DVM provides differential voltage measurement function. Figure 2-13 shows a simplified DVM circuit diagram.

Figure 2-13 **Simplified DVM Circuit Diagram**

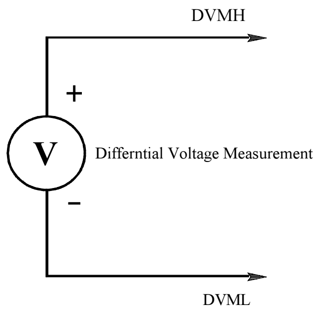


Table 2-9 shows the connection between DVM's measurement terminals and SWM's ports.

Table 2-9 **DVM Measurement Terminals and Port Connections**

Measurement Terminal	Port
HIGH	DVMH (AUX5)
LOW	DVML (AUX6)

Table 2-10 **DVM Voltage Measurement Ranges and Resolutions**

Measurement range	Resolution
1 V	1 µV
10 V	10 µV
100 V	100 µV

Integration Time

By using the `Set_adc3458` TIS statement, you can specify the DVM digital integration time setting in seconds or number of power line cycles.

Capacitance Measurement Subsystem (CMS)

The 4070 can use 4284A Precision LCR Meter (optional) as a capacitance measurement unit (CMU).

This section describes the following:

- "Capacitance Measurement Unit (CMU)"
- "CMU Error Compensation"

For more information on 4284A, refer to *Agilent 4284A Operation Manual.*

Capacitance Measurement Unit (CMU)

The CMU (4284A) is an LCR meter with a 20 Hz to 1 MHz signal source and a dc bias source. The CMU's measurement terminals — UNKNOWN Hcur and Hpot, and Lcur and Lpot — connect to the SWM's CMH and CML ports, respectively.

For complete information on CMU, refer to Agilent 4284A *Operation Manual*.

Test Signal

The CMU can output a test signal with frequency of 20 Hz to 1 MHz (with 8610 frequency steps) and with output levels from 5 mVrms to 20 Vrms.

NOTE

Measurement Accuracy Specifications

The 4070 guarantees the measurement accuracy only for frequencies 1 kHz, 10 kHz, 100 kHz, and 1 MHz, and output level 30 mVrms.

Measurement Modes and Functions

The 4071A uses only the Cp-G function.

Measurement Ranges

You can set the capacitance measurement range value of the CMU and specified range value is converted to an impedance range according to the following equation, and CMU performs an impedance measurement:

$$\text{impedance range} = 1/(2\pi f|range|)$$

Where,

f is the measurement frequency and measurement *range* is specified capacitance range.

Refer to the *Agilent 4284A Precision LCR Meter Operation Manual* for more information on the impedance range.

The specified *measurement range* (capacitance range) and corresponding impedance ranges are shown in following table:

Table 2-11 Capacitance Range and Corresponding Impedance Range

	Measurement Frequencies and Corresponding Impedance Ranges			
Allowed *measurement range* in F	1 kHz	10 kHz	100 kHz	1 MHz
0 ≤ |*range*| ≤1.592E-12	100 kΩ	100 kΩ	100 kΩ	100 kΩ
1.592E-12 < |*range*| ≤5.305E-12	100 kΩ	100 kΩ	100 kΩ	30 kΩ
5.305E-12 < |*range*| ≤1.592E-11	100 kΩ	100 kΩ	100 kΩ	10 kΩ
1.592E-11 < |*range*| ≤5.305E-11	100 kΩ	100 kΩ	30 kΩ	3 kΩ
5.305E-11 < |*range*| ≤1.592E-10	100 kΩ	100 kΩ	10 kΩ	1 kΩ
1.592E-10 < |*range*| ≤5.305E-10	100 kΩ	30 kΩ	3 kΩ	300 Ω
5.305E-10 < |*range*| ≤1.592E-9	100 kΩ	10 kΩ	1 kΩ	100 Ω
1.592E-9 < |*range*| ≤5.305E-9	30 kΩ	30 kΩ	300 Ω	100 Ω
5.305E-9 < |*range*| ≤1.592E-8	10 kΩ	1 kΩ	100 Ω	100 Ω
1.592E-8 < |*range*| ≤5.305E-8	3 kΩ	300 Ω	100 Ω	10 Ω
5.305E-8 < |*range*| ≤1.592E-7	1 kΩ	100 Ω	100 Ω	10 Ω
1.592E-7 < |*range*| ≤5.305E-7	300 Ω	100 Ω	10 Ω	1 Ω
5.305E-7 < |*range*| ≤1.592E-6	100 Ω	100 Ω	10 Ω	1 Ω
1.592E-6 < |*range*| ≤1.592E-5	100 Ω	10 Ω	1 Ω	1 Ω
1.592E-5 < |*range*| ≤1.592E-4	10 Ω	1 Ω	1 Ω	1 Ω
1.592E-4 < |*range*|	1 Ω	1 Ω	1 Ω	1 Ω

The conductance measurement range (G range) is automatically set to capacitance measurement range $\times\ 1.0 \times 10^7$.

Auto ranging or limited auto ranging is used for ranging mode.

Integration Time

The integration time is the time required to perform an A-D conversion. Generally, a longer conversion time results in more stable and accurate measurement results. SHORT, MEDIUM, or LONG integration times can be selected.

Internal DC Bias

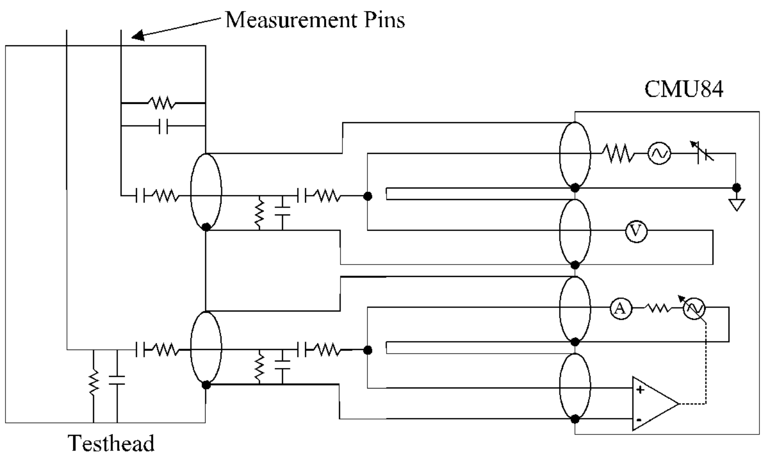
The CMU is equipped with a ±40 V dc bias source. When CMU applies dc bias, the dc bias appears across the CMH and CML ports. The dc bias source can output a staircase sweep as described in “Capacitance Measurements” on page 3-20.

CMU Error Compensation

When using the CMU to perform capacitance measurements, stray capacitances and residual resistances in the testhead and in connection cables between the CMS and testhead can affect measurement results.

Also, refer to “Measuring Error Compensation Data for CMU” on page 6-19.

Figure 2-14 **Stray Capacitances and Residual Resistances of CMS**



The 4070 automatically compensates the measurement data by performing calculations using the following:

- Error compensation data (for CMU connection cables to testhead) is stored in 4284A at the factory.

  You can re-measure and re-store this data by using cal4070 utility or, Open_corr84 and Short_corr84 TIS statements executed in measurement program.

- Error compensation data for testhead is measured and stored in a system file at system installation.

  You can re-measure and re-store this data by using cal4070 utility.

NOTE

If you Change the Measurement Pin Configuration

If you change the measurement pin configuration of testhead, you should execute `cal4070` utility to re-measure and re-store the error compensation data for testhead.

Error Correction up to Probe Needles or Test Fixture

By default, error correction is performed up to the measurement pins only.

The 4070 provides the function to compensate error factors beyond any two capacitance measurement pins, but not the chuck connection pin. For example, error correction can extend to the probe needles.

By using the cal4070 utility or TIS statements, the 4070:

- Measures OPEN and SHORT error factors up to any two specified probe needles.
- Automatically performs error compensation for the capacitance measurement on the specified measurement pins after the OPEN and SHORT measurements.
- Applies measured compensation data during the current test session.
- Stores measured compensation data into a file and re-loads the data for error compensation later, or in another test session.

NOTE

You must re-measure if the conditions change

When conditions change, re-measure the error compensation data. If you do not re-measure, the 4070 incorrectly performs error compensation.

For example, if the probe card is changed, you must re-measure the error compensation data.

Pulse Generator Subsystem (PGS)

The 4072A can optionally use 8110A, 81110A, or 8114A Pulse Generators as pulse sources.

The allowable number of pulse generators installed in a system is:

- Maximum of five 8110As or five 81110A, and no 8114A
- Maximum of four 8110As or four 81110A, and one 8114A
- Maximum of two 8110As or two 81110A, and two 8114As

Note that you cannot install both 8110A and 81110A in the system.

The following table shows the major differences between the 8110A, 81110A, and 8114A:

Table 2-12 Major Differences between 8110A, 81110A, and 8114A

	8110A, 81110A	8114A
Number of output channel (PGUs)	2[a]	1
Trigger Mode[b]	Normal or Pattern	Normal
Pulse Period[c]	350 ns to 999.0 s	350 ns to 999 ms
Pulse Width[d]	50 ns to 999 ms	150 ns to 150 ms
Transition Time	20 ns to 200 ms	65 ns
Pulse Level	-19 to 19 V[e]	-49.9 to 50 V

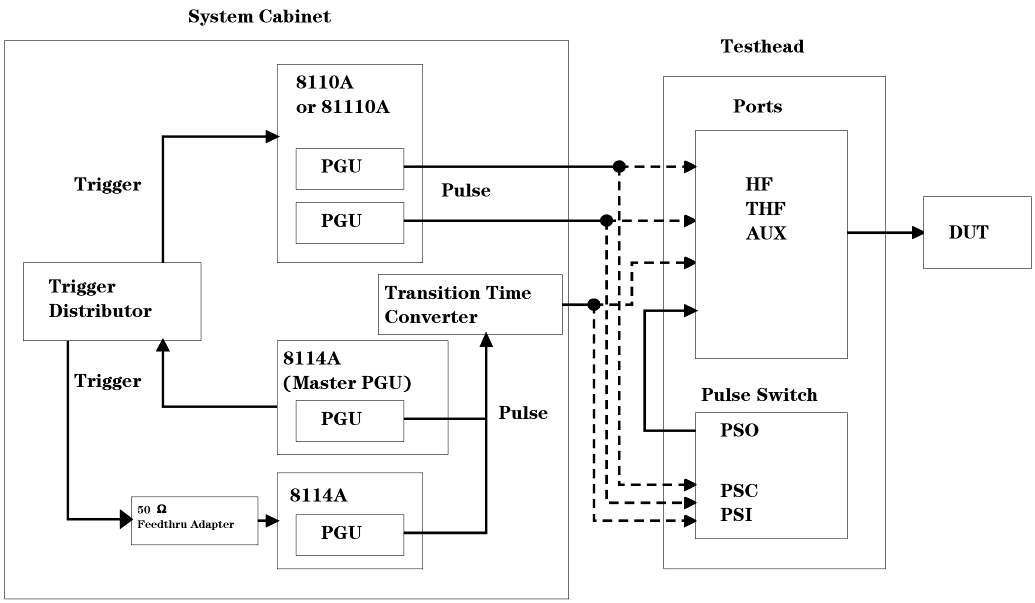
a. If the 8110A or 81110A is set to 3-level pulse mode, the second PGU is disabled.
b. Refer to “Synchronization between PGUs” on page 2-37 for details on the trigger mode.
c. In normal trigger mode
d. In normal trigger mode
e. The amplitude of the 3-level pulse when using one pulse generator cannot exceed 20 V.

A pulse signal forced from the PGU:

- goes through the HF port, THF, or AUX port, then to your DUT.
- goes through the HF port, THF, or AUX port by way of the pulse switch, then to your DUT.
- goes to PSC port of the pulse switch to control the pulse switch.

An overview of the pulse generator connections are shown in the following figure.

Figure 2-15 **Pulse Generator Connection**



Note that 8114A requires a 50 Ω feedthru adapter to input a trigger from the Trigger Distributor and Transition Time Converter to fix the transition time to 65 ns.

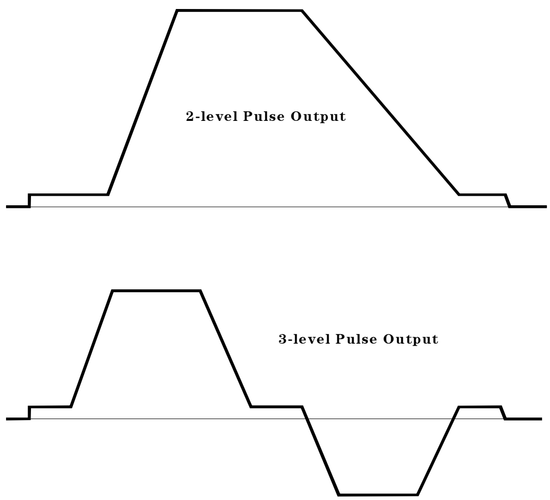
Pulse Generator Unit (PGU)

Each output channel of the pulse generator corresponds to one Pulse Generator Unit (PGU). The 8110A and 81110A have two PGUs (output channels). The 8114A has only one PGU (output channel).

Pulse Waveform from PGU

The first PGU (PGx1) of the 8110A and 81110A can force two types of pulses; a 2-level pulse output and a 3-level pulse output. The two types of pulses are shown in the following figure.

Figure 2-16 **Pulses Forced from the PGU**



The 8110A and 81110A actually use two output channels (PGUs) to output a 3-level pulse signal. So the second PGU of the 8110A or 81110A is disable when the first PGU outputs a 3-level pulse signal.

The second PGU (PGx2) of the 8110A and 81110A, and the PGU of the 8114A can force only 2-level pulse output.

The actual output pulse forced to the measurement pin depends on the specified port and pulse generator configuration. For example, if you use the multiplexer pulse switch port, you can force a 3-level pulse with a higher pulse level or a 4-level or 5-level pulse. Refer to “Forcing Pulse from PGU” on page 3-22 for more detail.

Synchronization between PGUs

The 4072A system software has two trigger modes for synchronizing pulse signals from several pulse generators; normal mode and pattern mode.

Normal mode uses the PGU's pulse mode to force the pulse signals. The trigger signal output from the TRIGGER OUT terminal of the master PGU (PG1) is transferred to the EXT INPUT terminal of the slave PGUs by way of the trigger distributor, causing all PGUs to synchronously force pulse signals. If your system includes an 8114A, it must be the master PGU (PG1).

If the pulse period is comparatively long, the time accuracy of the normal mode is inferior to that of the pattern mode.

Pattern mode uses the pattern mode of the PGU (8110A or 81110A) to force pulse signals. In this mode, the master PGU and the PGU of the 8114A are not used. The trigger signal output from the TRIGGER OUT terminal of the first slave PGU (PG2), which must be 8110A or 81110A, is transferred to the CLK INPUT terminal of the other slave PGUs except 8114A by way of the trigger distributor, and all connected PGUs synchronously produce pulse signals.

3 Measurement Types

This chapter describes the following types of measurements that can be performed using the Agilent 4071A or Agilent 4072A:

- "I-V Measurements"
- "Search Measurements", which are also a type of I-V measurement
- "Capacitance Measurements"
- "Forcing Pulse from PGU"

Also, for more information abut the various measurement types, refer to "Executing Measurement" on page 7-49.

I-V Measurements

This section describes the following I-V measurements that can be performed by the DC system of the 4070 series:

- “Staircase Sweep Measurements”
- “Synchronous Sweep Measurements”
- “Pulsed Bias Spot Measurements”
- “Pulsed Bias Sweep Measurements”
- “Pulsed Sweep Measurements”

Staircase Sweep Measurements

An SMU can be set up to perform staircase sweep measurements by using a TIS statement: BASIC (Set_iv) or C (set_iv). In the statement, specify the following parameters:

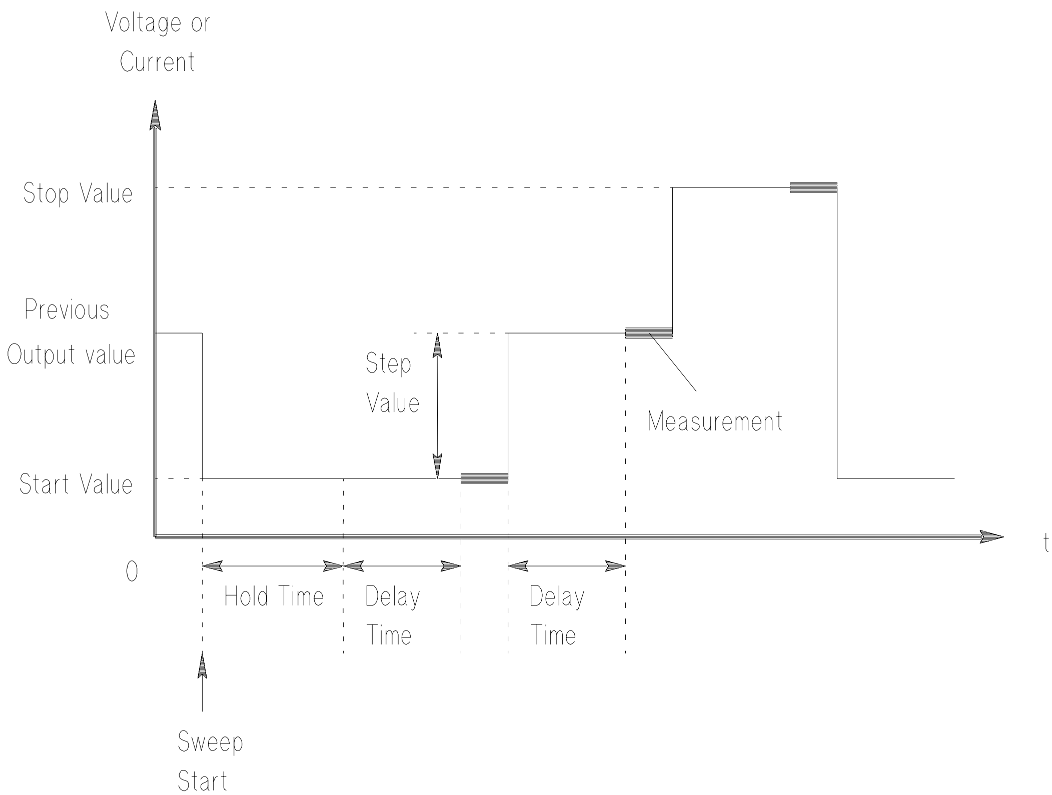
Sweep Mode:	Linear or log, single or double, voltage or current sweep.
Start Value:	Output value at which sweep begins.
Stop Value:	Output value at which sweep ends.
No. of Steps:	Number of sweep steps (up to 1001 steps). The step value is determined by the Start Value, Stop Value, and No. of Steps. For a single sweep, No. of Steps steps are performed from Start Value to Stop Value. For a double sweep, No. of Steps steps are performed from Start Value to Stop Value, then No. of Steps steps are performed from Stop Value to Start Value.
Hold Time:	Wait time before a sweep begins.
Delay Time:	Wait time before a measurement is made at each step point in the sweep.
Stop Mode:	Selects whether to continue or abort the sweep if an error occurs or if an SMU reaches compliance.

NOTE

Output after sweep

After the sweep finishes, the SMU output returns to the specified *Start Value*. To protect test devices, you may need to reset the output of the SMU to 0 (V or A) after the sweep finishes.

Figure 3-1 **Staircase Sweep Measurement Output**



A second SMU can be set up as a sweep source that has the output synchronized with the staircase sweep, as described in “Synchronous Sweep Measurements” on page 3-6. In this case, the staircase sweep is the primary sweep source.

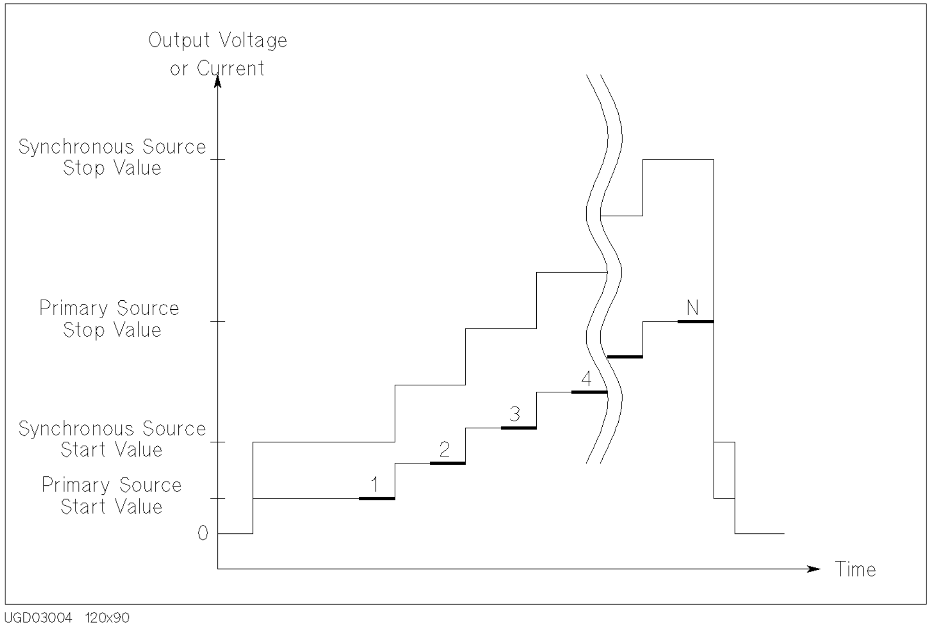
Synchronous Sweep Measurements

An SMU can be set up as a synchronous sweep source or search source. The output of the SMU will be synchronoized to the output of the primary sweep source or search source.

The following parameters are used to set up a synchronous source when using a TIS statement: BASIC (Set_sync) or C (set_sync).

mode	Determines output relationship between primary and synchronous sources: sync_output=offset+(ratio× primary_output) or sync_output=offset-(ratio× primary_output) For search measurements, ratio is always 1.
offset	Offset between outputs of primary and synchronous sources.
ratio	Ratio between outputs of primary and synchronous sources.

Figure 3-2 **Synchronous Sweep Measurement**



A synchronous source can be set up for the following types of measurements:

- Staircase sweep measurements
- Pulsed bias sweep measurements
- Pulsed sweep measurements
- Binary search measurements
- Linear search measurements

The synchronous sweep output is always a normal (non-pulse) staircase sweep.

Pulsed Bias Spot Measurements

An SMU can be set up to output pulses for spot measurements using a TIS statement: BASIC (Set_pbias) or C (set_pbias).

In the statement, specify the following parameters:

Pulse Base:	Base value of pulse.
Pulse Peak:	Peak value of pulse.
Pulse Width:	Time from the beginning of the pulse to the completion of the measurement during the output of the pulse.
Pulse Period:	Time from the beginning of one pulse to the beginning of the next pulse.
Hold Time:	Wait time before pulse output begins.

Each pulse is triggered by the TIS statement (BASIC: Measure_p or C: measure_p). The beginning of the pulse is usually *Hold Time* after the trigger statement.

However, the actual time from the beginning of a pulse to the beginning of next pulse is calculated as follows:

$t1$ = MAX(t+*Hold Time*, *Pulse Period*)

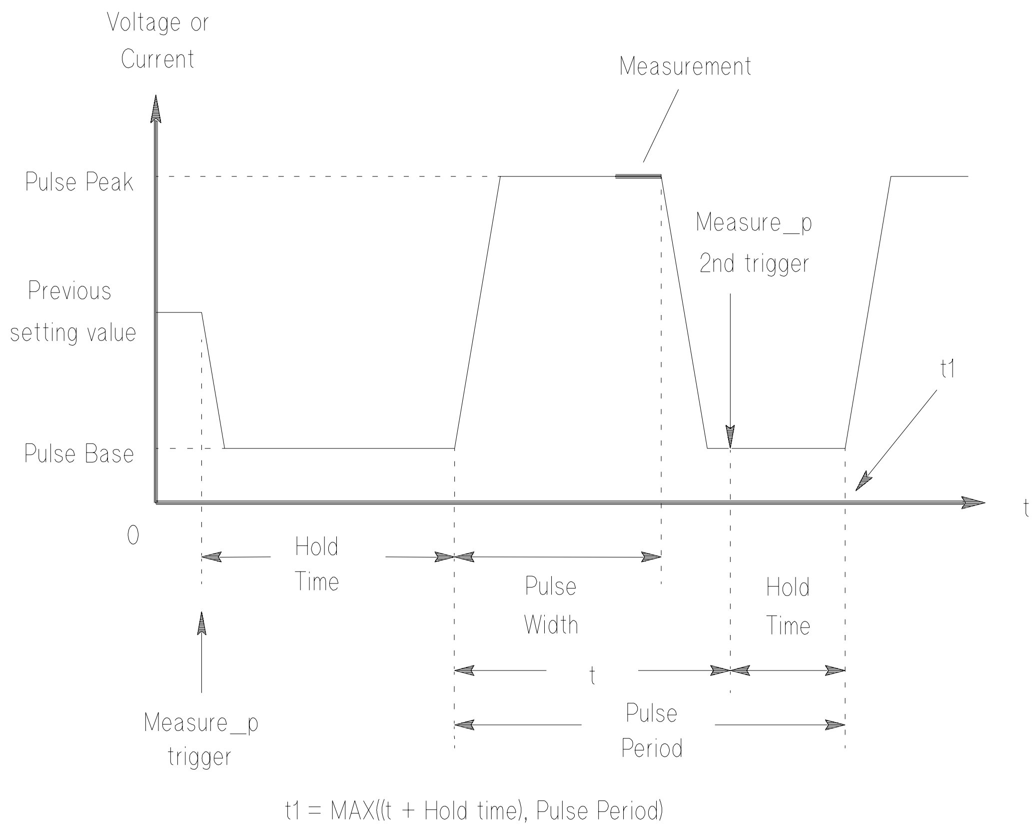
where t is the time from the beginning of the pulse to the next trigger statement.

NOTE

Output after measurement

After a pulsed measurement, the SMU output returns to the specified *Pulse Base* value. To protect test devices, you may need to reset the output of the SMU to 0 (V or A) after each pulsed measurement.

Figure 3-3 **Pulsed Bias Spot Measurement Output**



Pulsed Bias Sweep Measurements

One SMU can be set up as a staircase sweep source and another SMU can be set up as a pulsed bias source to perform a staircase sweep with pulsed bias measurements using TIS statements: BASIC (Set_iv and Set_pbias), or C (set_iv and set_pbias).

Set the following using Set_iv or set_iv:

Start Value:	Output value at which the sweep begins.
Stop Value:	Output value at which the sweep ends.
No. of Steps:	Number of sweep steps (up to 1001 steps).

Set the following by using Set_pbias or set_pbias:

Pulse Base:	Base value of pulse.
Pulse Peak:	Peak value of pulse.
Pulse Width:	Time from the beginning of the pulse to the completion of the measurement during that pulse's output.
Pulse Period:	Time from the beginning of one pulse to the beginning of the next pulse.
Hold Time:	Wait time before the sweep and pulse output begins.

The sweep source is synchronized with the pulsed bias source, and ignores the hold time and delay time settings of Set_iv or set_iv.

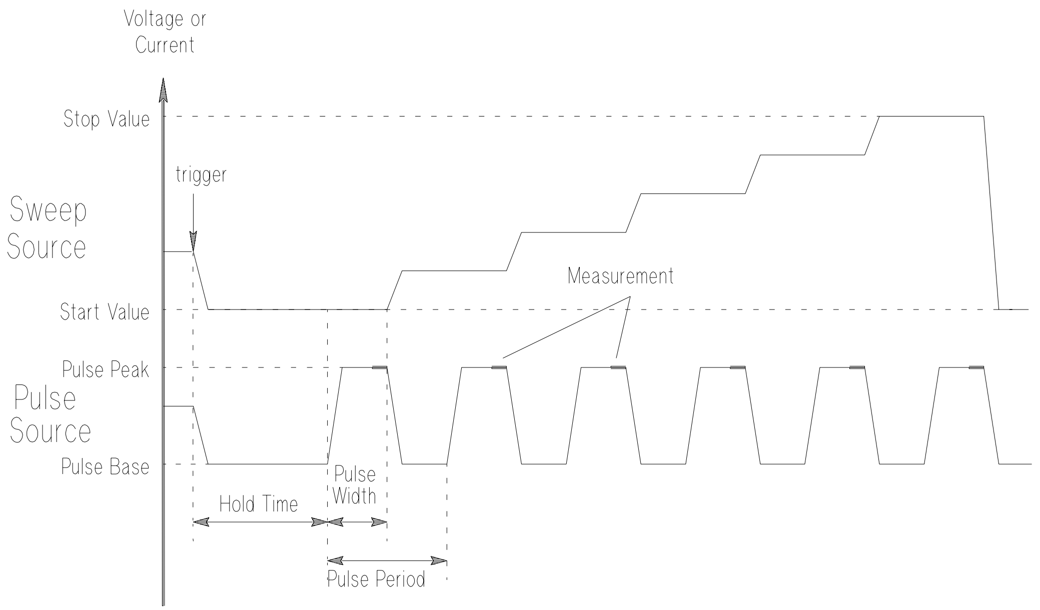
NOTE

Outputs after measurement

After the pulsed bias sweep is finished, the output of the pulsed bias source SMU returns to the specified *Pulse Base* value, and the output of the sweep source SMU returns to the specified *Start Value*.

To protect test devices, you may need to reset the outputs of the SMU to 0 (V or A) after the sweep is finished.

Figure 3-4 **Pulsed Bias Measurement Sweep Output**



Also, you can set up another SMU as a synchronous sweep source to be output synchronously with the staircase sweep and pulsed bias sources, as described in "Synchronous Sweep Measurements" on page 3-6.

Pulsed Sweep Measurements

You can set up an SMU to perform *pulsed* staircase sweep measurements by using a TIS statement: BASIC (Set_piv) or C (set_piv). In the statement, you specify the following parameters:

Pulse Sweep Mode: Linear or log, single or double, voltage or current sweep.

Pulse Base: Base value of pulse.

Start Value: Output value at which sweep begins.

Stop Value: Output value at which sweep ends.

No. of Steps: Number of sweep steps (up to 1001 steps).

For a single sweep, No. of Steps steps are performed from Start Value to Stop Value.

For a double sweep, No. of Steps steps are performed from Start Value to Stop Value, then No. of Steps steps are performed from Stop Value to Start Value.

Pulse Width: Time from beginning of pulse to completion of measurement during that pulse's output.

Pulse Period: Time from beginning of one pulse to beginning of next pulse.

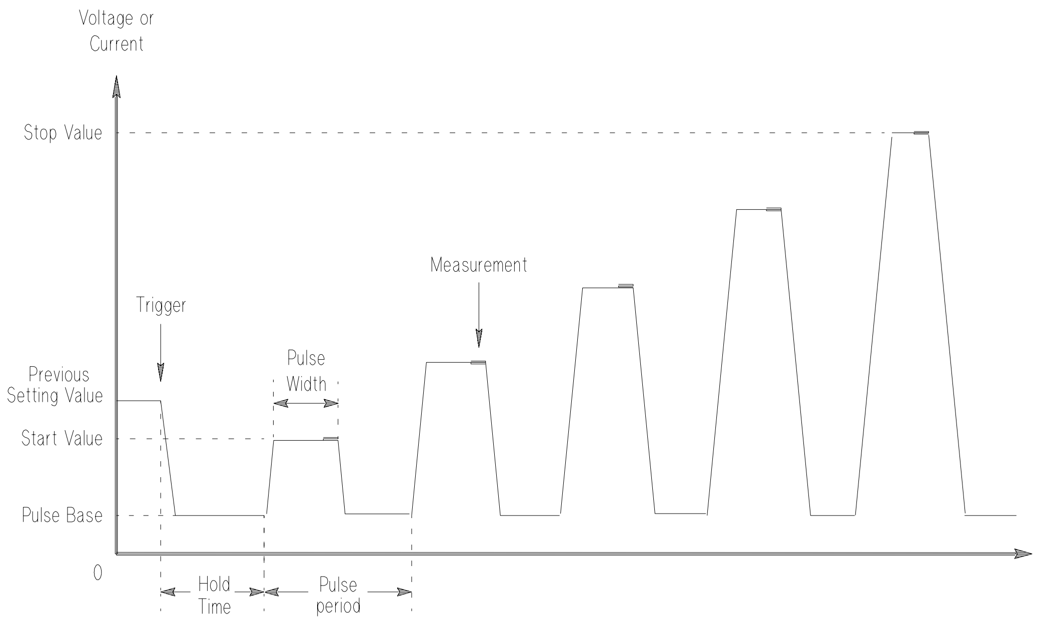
Hold Time: Wait time before the pulsed sweep begins.

NOTE

Output after measurement

After a the pulsed sweep is finished, SMU output returns to the specified *Pulse Base* value. To protect test devices, you may need to set SMU output to 0 (V or A) after the sweep is finished.

Figure 3-5 Pulsed Sweep Measurement Output



Also, you can set up another SMU as a synchronous sweep source to be output synchronously with the pulsed sweep, as described in "Synchronous Sweep Measurements" on page 3-6. In this case, the pulsed sweep is the primary sweep source.

Search Measurements

DC subsystem of 4070 series can perform a search measurement to find a point on an I-V curve where a specified condition is satisfied. For example, search for a breakdown voltage or threshold voltage at a specified current.

Search measurements are performed by one or two SMUs. In case of using two SMUs, one SMU is search unit, and other SMU is a sense unit. In case of using one SMU, one SMU is used as both search and sense unit.

Basically, the search unit outputs voltages or currents until the sense unit measures a voltage or current that is close to the specified target value.

This section describes two types of search measurements:

- "Binary Search Measurements"
- "Linear Search Measurements"

Binary Search Measurements

For a binary search, the search unit outputs voltages or currents according to a binary search algorithm while the sense unit make measurements and compares to target value.

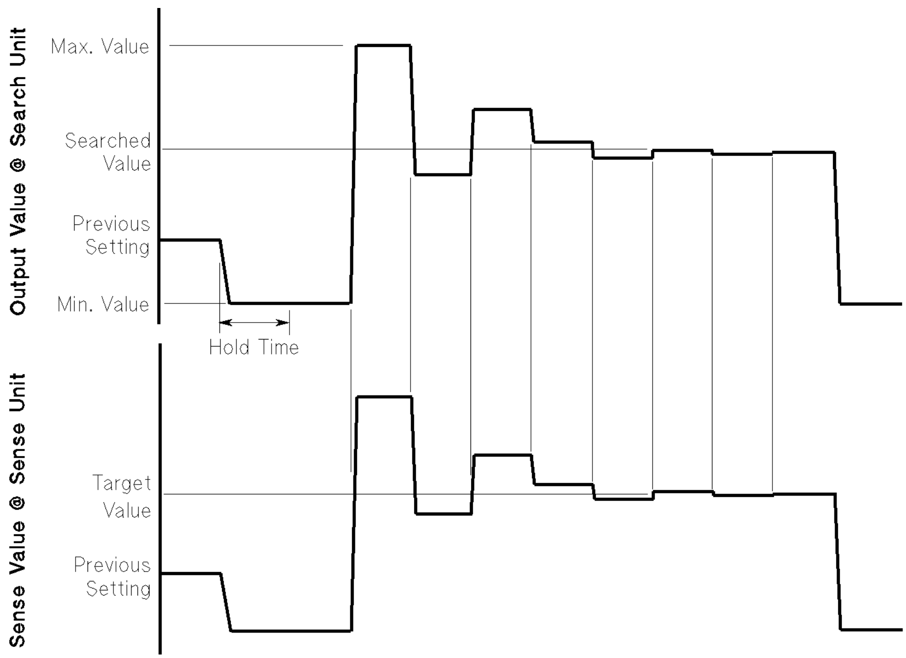
You can set up a binary search measurement by using a TIS statement: BASIC (Set_bsearch) or C (set_bsearch). In the statement, you specify the following parameters:

Mode:	Defines the search unit mode (voltage or current force), and convergence mode (accuracy or times).
Minimum Search Value:	Minimum value to be output by the search unit during the binary search.
Maximum Search Value:	Maximum value to be output by the search unit during the binary search.
Target Value:	Voltage or current value that is compared to measurements made by the sense unit.
Delay Time	Time between output from search unit and measurement by sense unit.

Convergence Condition: For the accuracy mode, specify %. The search continues until measurement made by sense unit is within the specified % of the target value. For the times mode, specify the total number of times to force/measure.

The search unit outputs the *minimum search value*, then outputs the *maximum search value* while the sense unit measures and compares to the *target value*. The search unit continues to output up or down in smaller increments until the *convergence condition* is satisfied.

Figure 3-6 **Binary Search Measurement Waveforms**



Also, you can set up another SMU as a source to be output synchronously with the search unit, as described in "Synchronous Sweep Measurements" on page 3-6.

Linear Search Measurements

For a linear search, the search unit outputs voltages or currents according to a linear search algorithm while the sense unit makes measurements and compares to target value.

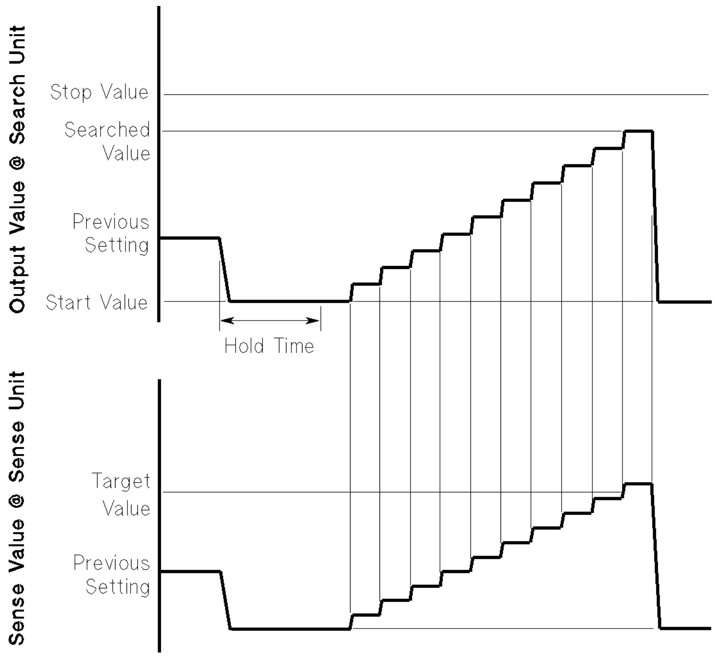
You can set up a linear search measurement by using a TIS statement: BASIC (Set_lsearch) or C (set_lsearch). In the statement, you specify the following parameters:

Mode:	Defines the search unit mode (voltage or current force), stop mode (measured value is greater or less than Target Value), and sense mode (measurement or compliance). For measurement mode, the sense unit measures for every step and compares to the Target Value. For compliance mode, the sense unit compliance is set to the specified Target Value. No measurement is performed and search stops when sense unit reaches the compliance value.
Start Value:	Start output value for search unit during the linear search.
Stop Value:	Stop output value for search unit during the linear search.
Step Value:	Step value for the search unit output.
Target Value:	Voltage or current value that is compared to measurements made by the sense unit.
Delay Time:	Time between the output from search unit and measurement by the sense unit.

The search unit sweeps from the *start value* to the *stop value* while the *sense unit* determines if the *target value* has been reached.

Figure 3-7 shows an example waveform of the linear search.

Figure 3-7 Linear Search Measurement Waveforms



Also, you can set up another SMU as a source to be output synchronously with the search unit, as described in “Synchronous Sweep Measurements” on page 3-6.

Step Skipping

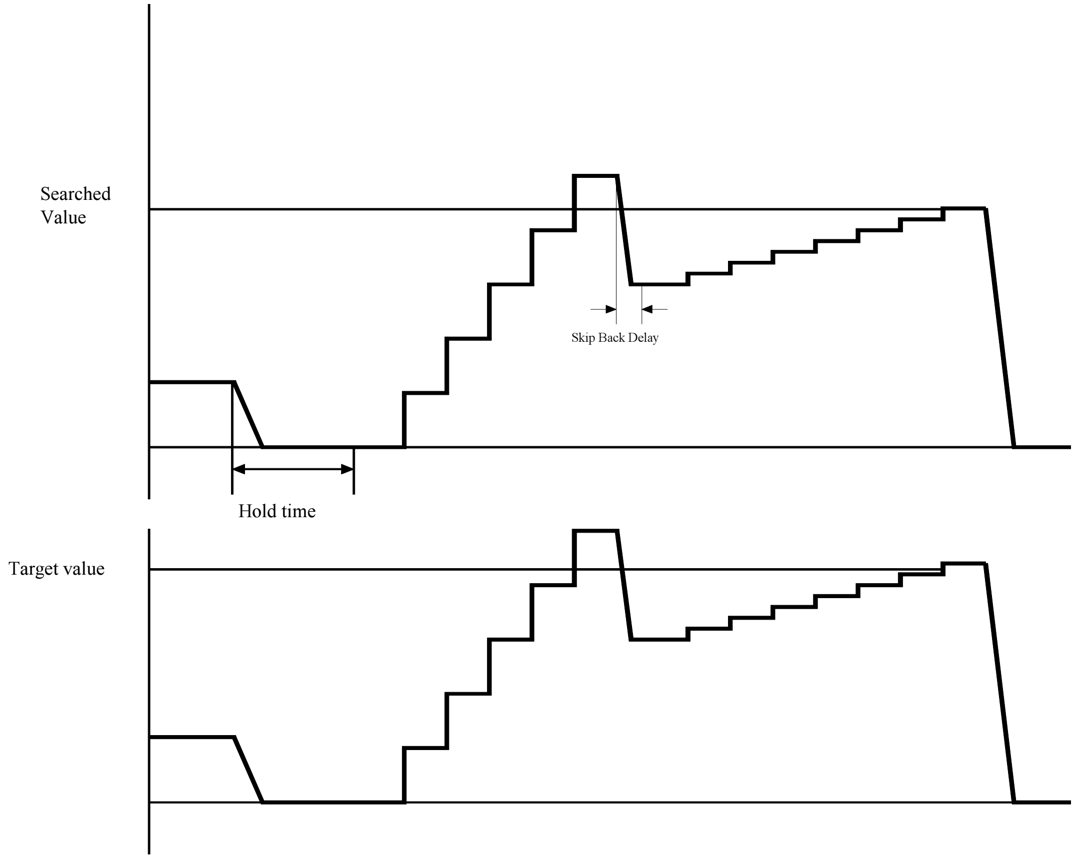
To search faster, you can use step skipping method, which performs the following:

1. Search unit starts to sweep with large steps until sense unit coarsely finds the *Target Value*. Large step size is *Skip*×*Step Value*.
2. Search unit goes back the specified number (*Skip Back*) of large steps, waits *Skip Back Delay* seconds, then starts to sweep with small steps (*Step Value*) until sense unit accurately finds the *Target Value*.

To use step skipping, you need to specify the following parameters in Set_lsearch or set_lsearch:

Skip	Skip is used to calculate the size of large step: Skip × Step Value.
Skip Back	Number of large steps to go back after sense unit coarsely finds the target value.
Skip Back Delay	Time to wait before starting fine sweep.

Figure 3-8 **Step Skipping**



Capacitance Measurements

This section describes “C-V Measurements” using CMU.

For more information on CMU, also refer to “Capacitance Measurement Subsystem (CMS)” on page 2-29.

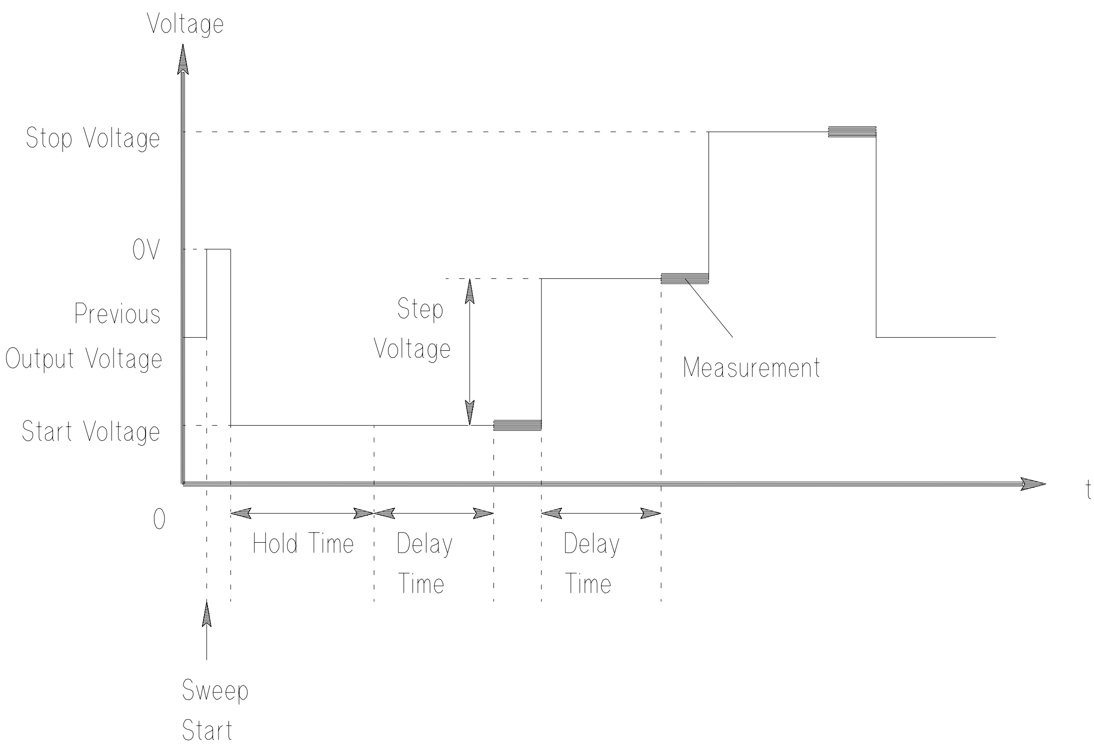
C-V Measurements

For easy test device C-V characterization, you can set up the CMU's internal dc bias source to output a staircase sweep by using a TIS statement: BASIC (Set_cv84) or C (set_cv84). In the statement, you specify the following parameters:

Start Voltage:	Voltage at which sweep begins.
Stop Voltage:	Voltage at which sweep ends.
No. of Steps:	Number of sweep steps. The step voltage is determined by the Start Voltage, Stop Voltage, and No. of Steps.
Hold Time:	Wait time before sweep begins.
Delay Time:	Wait time before a measurement is made at each step.

Figure 3-9 on page 3-21 shows an example of the dc bias sweep from the CMU.

Figure 3-9 **C-V Sweep Measurement Output**



Forcing Pulse from PGU

This section describes on forcing pulse signals from PGU to your DUT and covers the following topics:

- "Pulse Waveform Types"
- "Pulse Parameters"

Pulse Waveform Types

The PGU itself can force 2-level pulse and 3-level pulse (except 8114A). But the pulse signals forced to the DUT depends on the configuration of pulse generators and their connected ports.

The 4072A system software manages the configuration of pulse generators in system and their connections between ports and controls the pulse generator based on managed information.

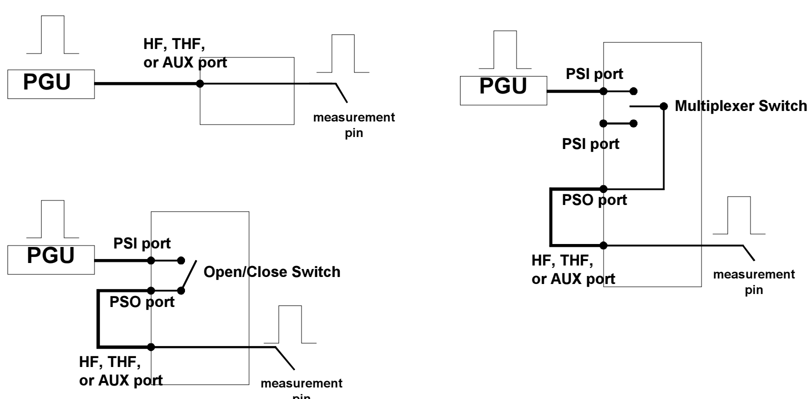
The following shows various types of pulse waveform to the DUT:

- 2-level pulse

  Specify HF, THF, or AUX port that connects to one of the following port or PGU:

  - directly connecting to a PGU
  - connecting to the PSO port of available open/close pulse switch
  - connecting to the PSO port of multiplexer switch and only one PSI port of which is available

  and set the connected PGU to “2-level pulse” output mode.

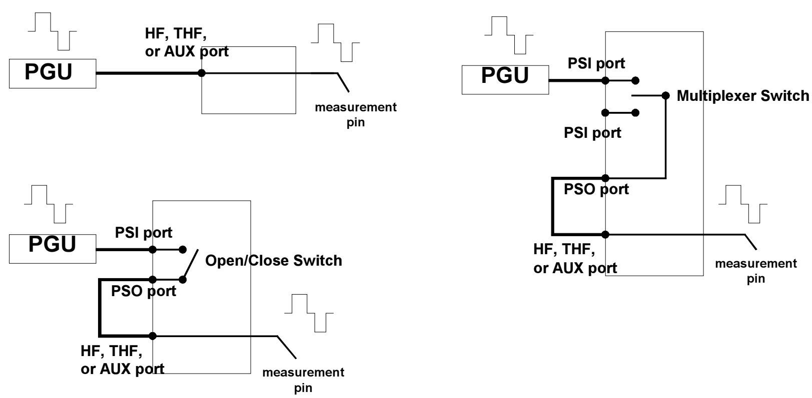


- 3-level pulse with one PGU

  Sepcify HF, THF, or AUX port that connects to one of the following port or PGU:

  - directly connecting to a PGU.
  - connecting to the PSO port of available open/close pulse switch
  - connecting to the PSO port of multiplexer switch and only one PSI port of which is available

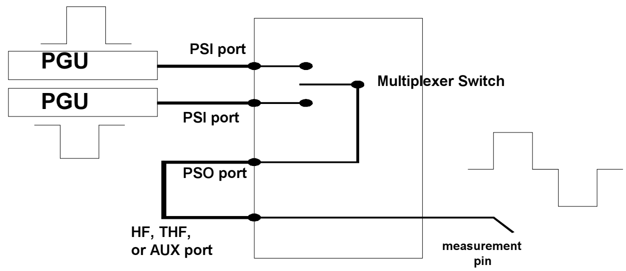
  and set the connected PGU to “3-level pulse” output mode. Note that the PGU which is the first channel of the 8110A or 81110A can be set to “3-level pulse” output mode.



- 3-level pulse using two PGUs and multiplexer pulse switch

  This method can force higher level of pulse signals than that of “3-level pulse with one PGU” method.The timing accuracy is worse than “3-level pulse with one PGU”, though.

  Specify HF, THF, or AUX port that connects to PSO port of multiplexer switch and then connects to two PGUs, and set both PGUs to “2-level pulse” output mode:

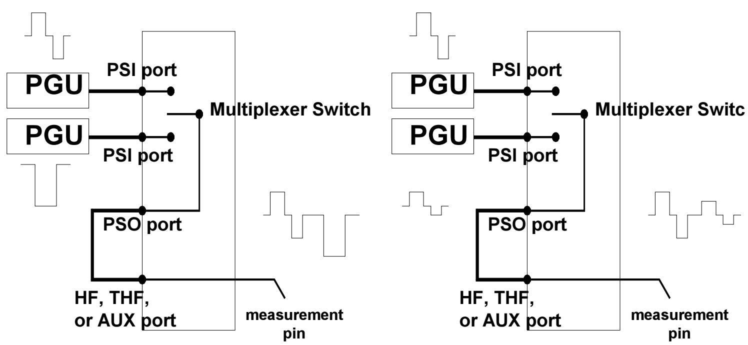


And the specified port forces the 3-level pulse output by using two PGUs in "2-level pulse" output mode and the pulse multiplexer switch.

NOTE

4-level and 5-level pulse

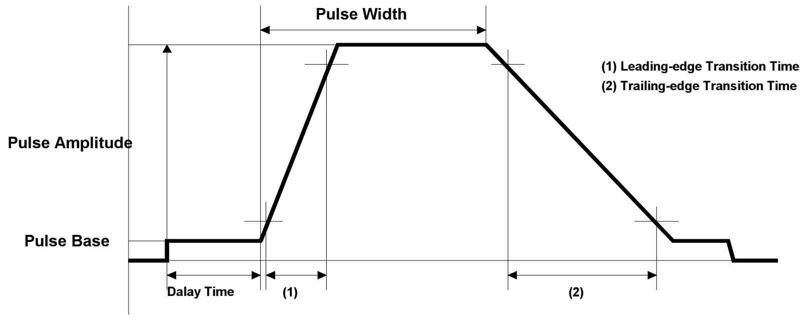
By directly specifying PSI port that connects to the multiplexer pulse switch port, you can individually set the output mode of each PGU and you can force 4-level or 5-level pulse output.

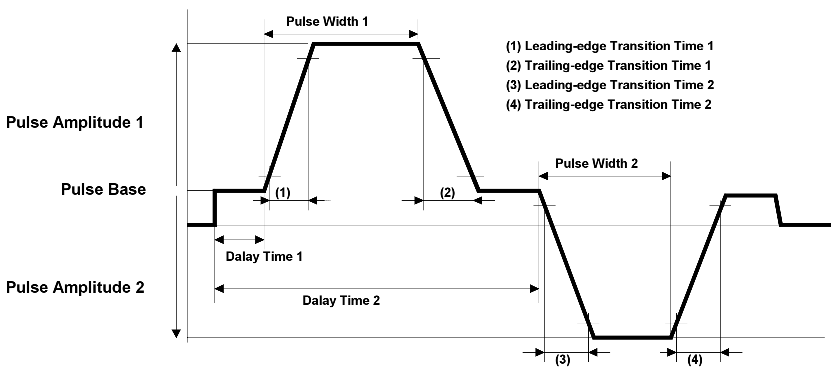


Pulse Parameters

The following figure shows the parameters of 2-level and 3-level pulse signals:

Figure 3-10 **Pulse Parameters**





Pulse amplitude	Pulse amplitude is the amplitude from the base voltage (pulse base) to the peak voltage.
Pulse width	Time from the start of pulse amplitude of leading-edge to the start of pulse amplitude of trailing-edge.
Delay time	Time from the start of a pulse period to the start of the leading-edge of the pulse.
Leading-edge transition time	The transition time measured from 10% to 90% of pulse amplitude.
Trailing-edge transition time	The transition time measured from 90% to 10% of pulse amplitude.

4 Operating the Agilent 4070

This chapter describes how to operate the Agilent 4071A or Agilent 4072A hardware and contains the following sections:

- “Panel Features”
- “Turning your System On and Off”
- “Recovering from Power Line Problems”
- “Theory of PDU and EMO Circuit Operation”

Panel Features

This section explains important panel features of 4071A or 4072A:

- “System Cabinet (Front)”
- “System Cabinet (Rear)”
- “Testhead”
- “Capacitance Measurement Unit (CMU) — 4284A”
- **“Digital Voltage Multimeter (DVM) — 3458A”**
- “Pulse Generator Unit (PGU) — 8110A, 81110A, or 8114A”

System Cabinet (Front)

Figure 4-1 **Standard System Cabinet (front)**

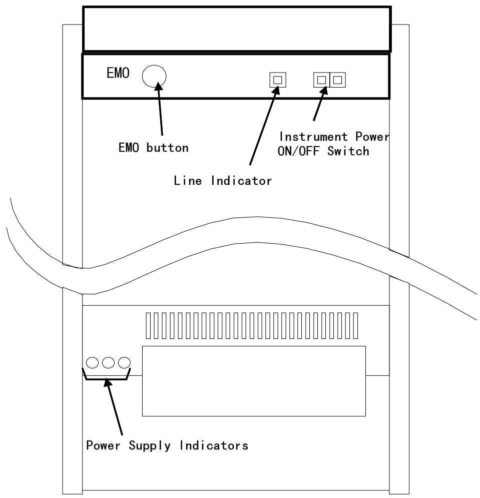
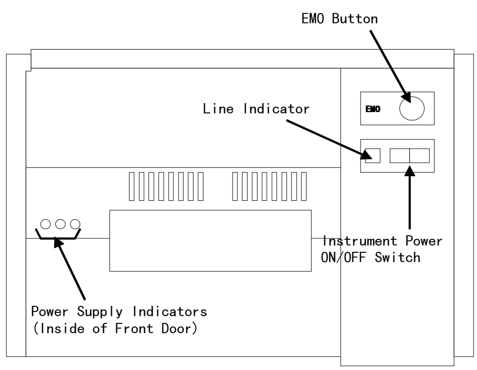


Figure 4-2 **Low Height System Cabinet - 4071A Only (Front)**



EMO Button

EMO button (which is on EMO panel) is used to turn off all power to the 4071A or 4072A. If EMO button is normal position, ac power is applied to the 4071A or 4072A. But if EMO button is pressed, the emergency breaker is opened. This turns off all ac power, and LINE indicator turns off.

Instrument Power ON Switch

Instrument power ON switch is used to turn on power to the power outlets for instruments. If you press this switch when the LINE indicator is lit, power is applied to power outlets for instruments and testhead, and the green LED in this switch is turned on.

Instrument Power OFF Switch

Instrument power OFF switch is used to turn off power to the power outlets for instruments. If you press this switch, power to power outlets for instruments and testhead is stopped, and green LED in the instrument power ON switch is turned off.

LINE Indicator

For a 4071A product that has a serial number JP10Dxxxxx, LINE indicator is turned on when the main breaker and the emergency breaker are set to on. This means that ac power is applied to the power outlets for controller. If the Instrument Power ON switch is set to on, power is also applied to the power outlets for instruments and testhead.

For a 4072A or 4071A product that has a serial number of JP20Dxxxxx, the LINE indicator is turned on when the main breaker, the emergency breaker, and the main switch are turned on. The ac power is applied to the power outlet for the controller by pressing the system switch on the PDU controller.

For position of main and emergency breakers, refer to Figure 4-4 on page 4-7.

Power Supply Indicators

Front panel of the testhead power supply has three LEDs listed below:

Power LED	Indicates that condition of testhead power supply is normal.
Caution LED	Turns on if one of the followings occurs: • Testhead fan stops or slows down • Testhead fan speed sensor cable is disconnected or broken. • Testhead fan protector is set to “Out” (extended) position.
Error LED	Turns of if one of the followings occurs: • Output is over voltage • Output is under voltage • Temperature inside the testhead power supply is too high

System Cabinet (Rear)

Figure 4-3 **4072A System Cabinet (Inside of Rear Door)**

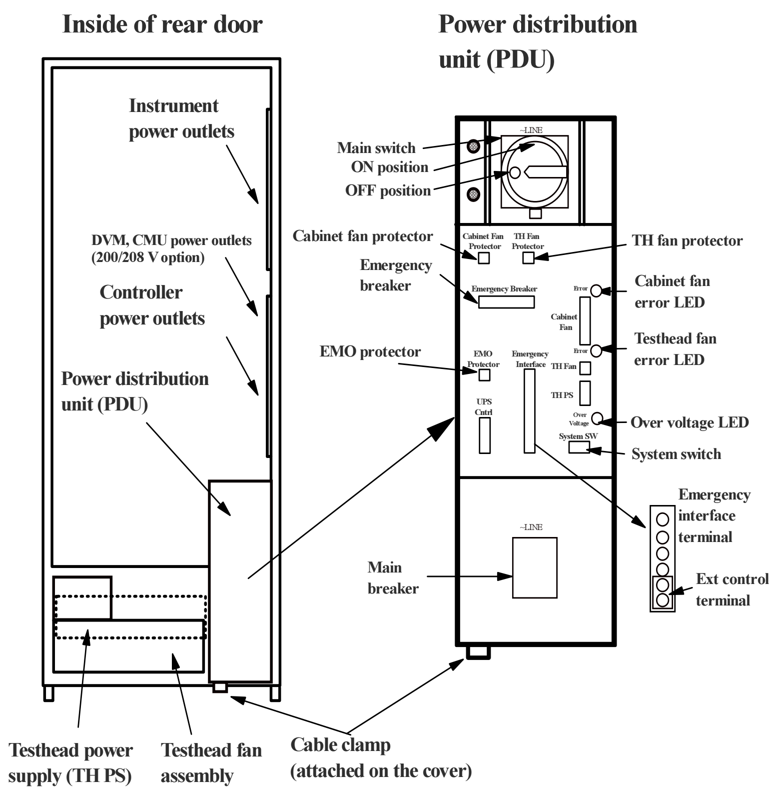


Figure 4-4 **4071A Standard System Cabinet for JP10Dxxxxx (Inside of Rear Door)**

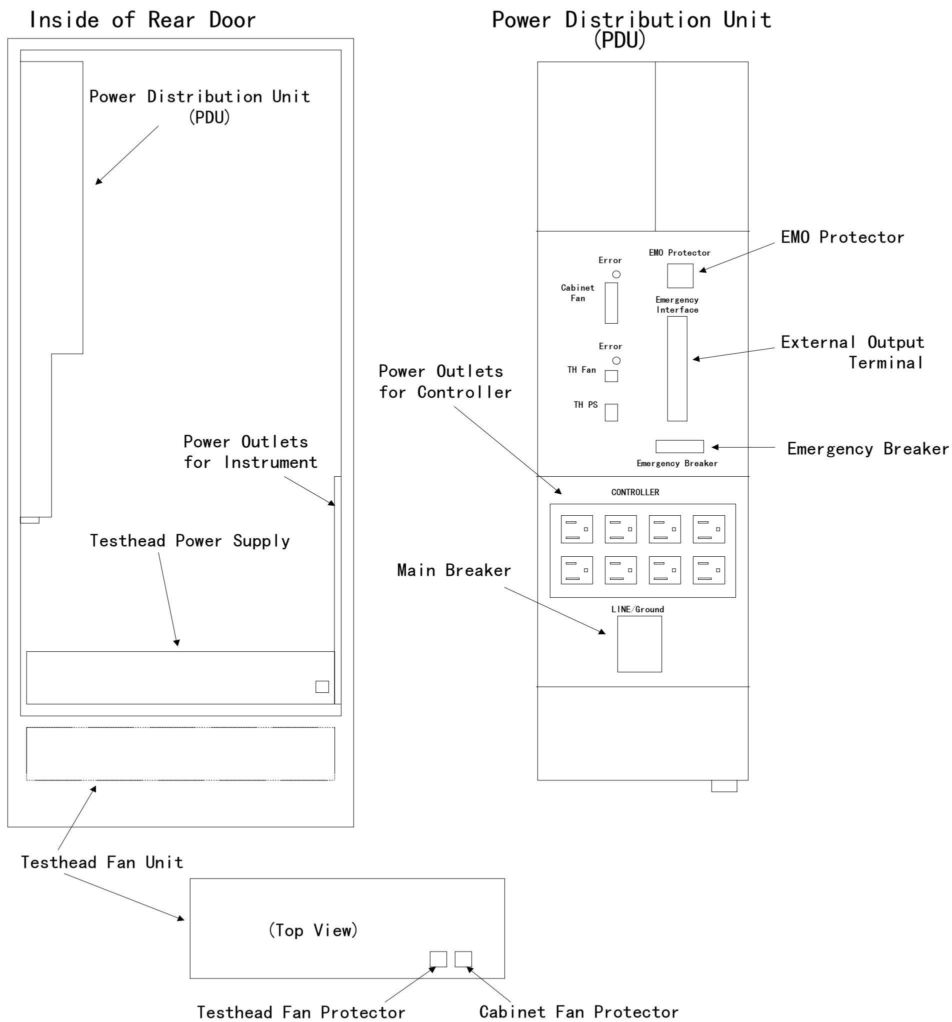


Figure 4-5 **4071A Low Hight System Cabinet for JP10Dxxxxx (Inside of Rear Door)**

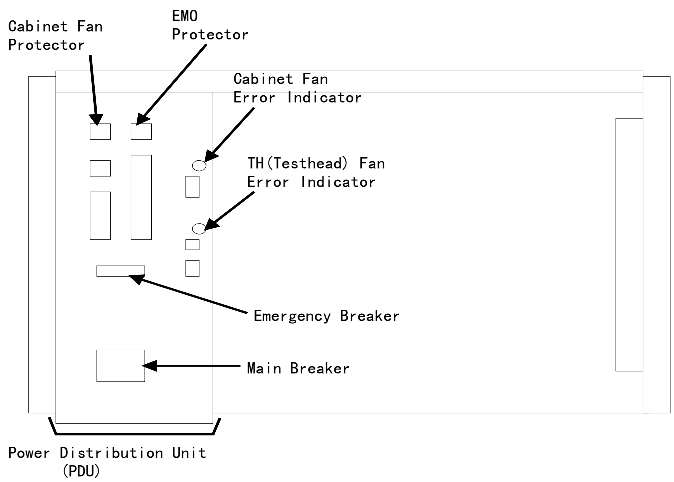
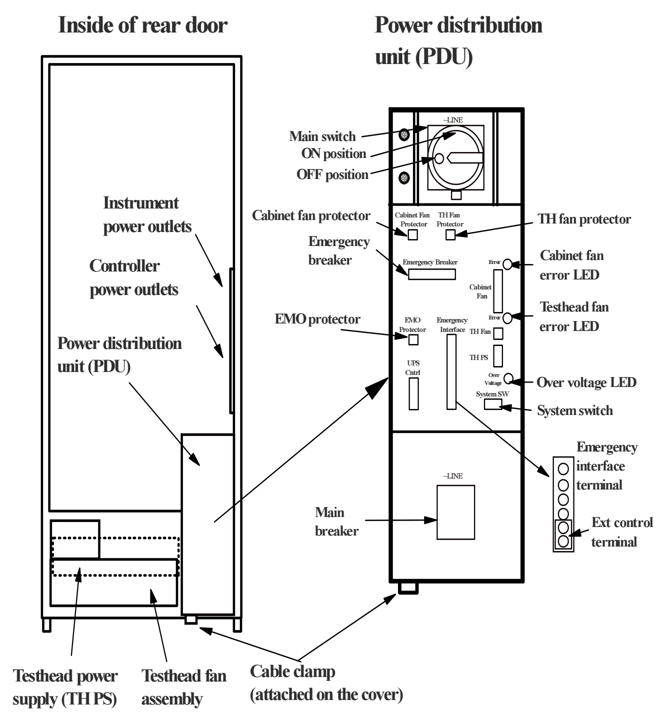


Figure 4-6 **4071A Standard System Cabinet for JP20Dxxxxx (Inside of Rear Door)**



Power Distribution Unit (PDU)

The PDU gets line (ac) power from a power switchboard or outlet at the installation site and distributes ac power to following in the system cabinet:

- Power outlets (for controller and for instruments)
- Cooling fans (Testhead Fan Unit and Cabinet Fan Unit)
- Testhead Power Supply (TH PS) unit via power outlet for instruments

Main Breaker

Main breaker turns on or off ac power to PDU.

Emergency Breaker

Emergency breaker for turns on or off ac power to the power outlets for controller.

For a 4071A with a serial number of JP10Dxxxxx, when the emergency breaker is closed, LINE indicator is turned on. This means that ac power is applied to the power outlets for controller. Then if the instrument power ON switch is pressed, green LED in the ON switch is turned on. This means that power is applied to the power outlets for instrument and testhead.

For a 4072A or 4071A with a serial number of JP20Dxxxxx, when the emergency breaker is closed, the LINE indicator is turned on after the system switch is pressed. This means the ac power is applied to the power outlets for the controller. Then if the instrument power ON switch is pressed, a green LED in the ON switch lights. This means that power is applied to the power outlets for the instrument and the testhead.

EMO Protector

EMO protector prevents the flow of excessive current (over 3 A) from the External Control terminal.

Main Switch (4072A or 4071A JP20Dxxxxx)

The Main switch turns the ac power to PDU on or off. When this switch is turned on, the LINE indicator lights. The main switch has a lockout function. For details on the lockout function, refer to Chapter 1 " General Information" of the 4071A or 4072A Pre-Installation Guide.

System Switch (4072A or 4071A JP20Dxxxxx)

The System switch turns the ac power to the power outlet for the controller on or off. When the System switch is active, the indicator in the switch lights.

Cabinet Fan Protector

Cabinet fan protector prevents the flow of excessive current to the cabinet fan.

Testhead (TH) Fan Protector

The TH fan protector prevents the flow of excessive current to the testhead fan.

External Output Terminals

These terminals allow you to connect an extra emergency off switch, alarm, or signal lamp to let you know when an emergency happens.

Teathead Power Supply

Testhead power supply gets ac power from the power outlet for instruments in the system cabinet and applies dc voltage to the testhead.

Testhead

Figure 4-7 **4072A Testhead (Side View)**

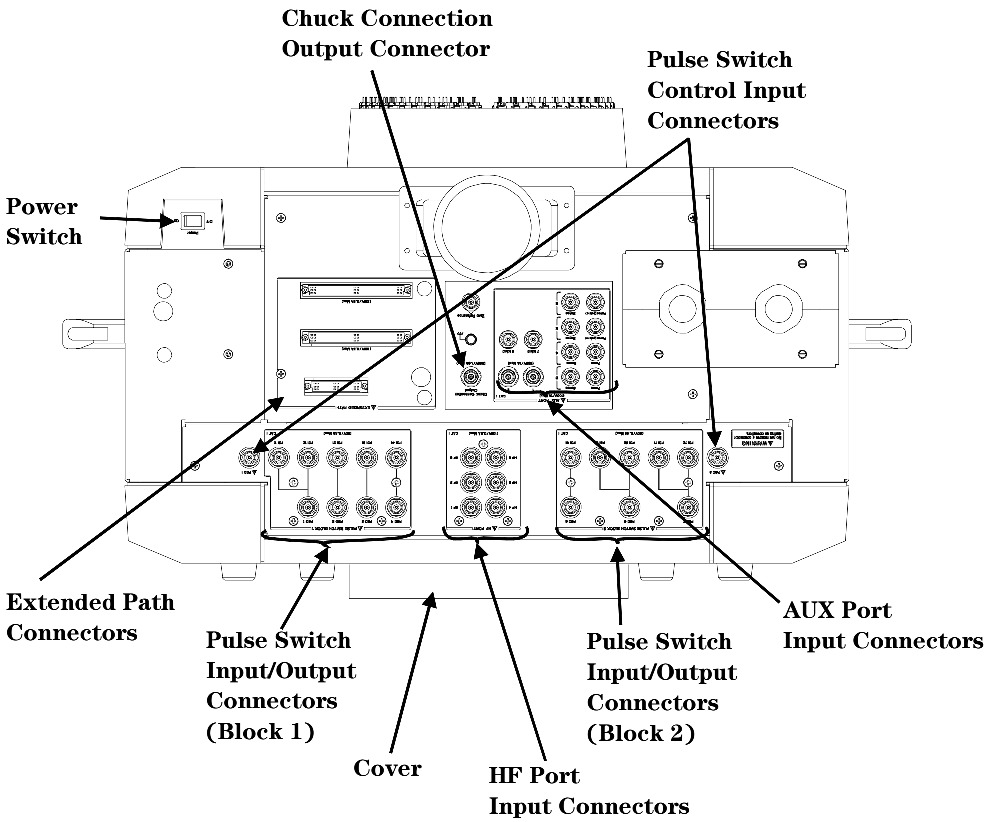


Figure 4-8 4071A Testhead (Side View)

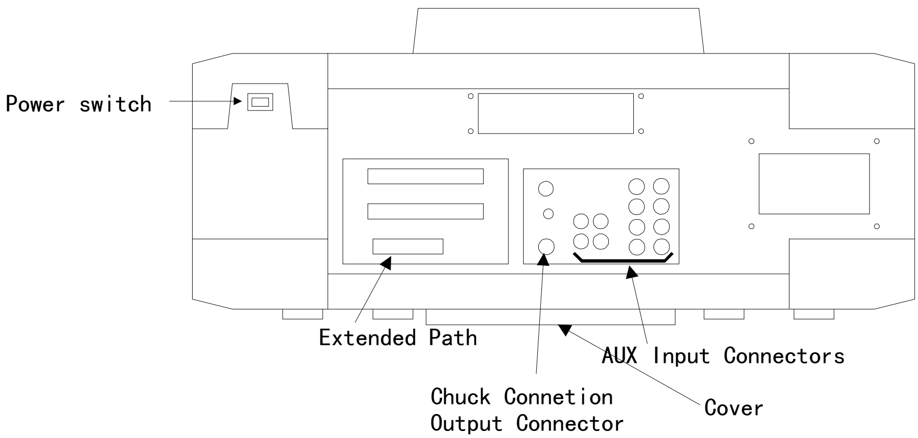
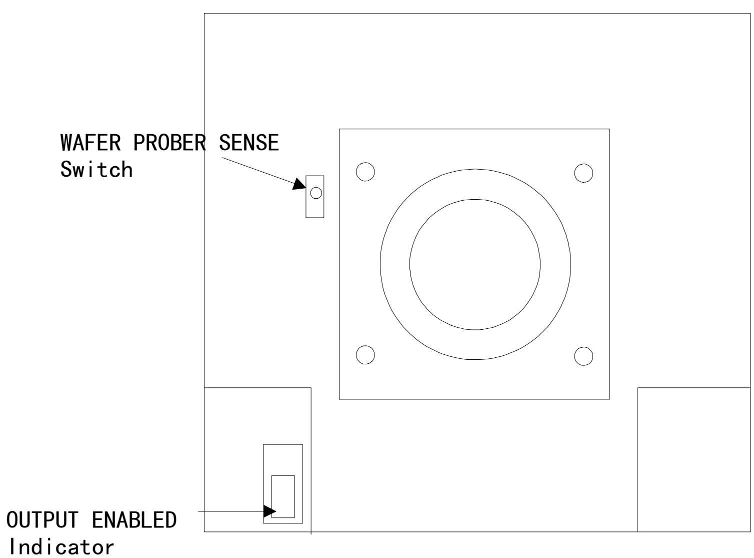


Figure 4-9 Testhead (Top View)



Power Switch

Power switch of the testhead.

OUTPUT ENABLED Indicator

Lights when the WAFER PROBER SENSE switch is closed. When lit, programmed pin-port connections are made.

WARNING **Potentially hazardous voltage may be present at the measurement pins when the OUTPUT ENABLED indicator on the testhead is lit.**

WAFER PROBER SENSE Switch

Detects if the testhead is positioned on a wafer prober or if the test fixture adapter's cover is open or closed.

WARNING **If WAFER PROBER SENSE switch is closed, dangerous dc voltage exceeding ±40 V may be present at the measurement pins. You will be severely shocked if you touch the measurement pins.**

AUX Input Connectors

Auxiliary input connectors are used to connect CMU (4284A) and DVM (3458A) to the testhead. Or you can use these connectors to connect other instruments to the testhead.

WARNING **Potentially hazardous voltage may be present at the auxiliary input connectors when the OUTPUT ENABLED indicator on the testhead is lit.**

HF Port Input Connectors

HF port input connectors are used to connect PGU directly or through the pulse switch to the testhead. Or you can use these connectors to connect other instruments to the testhead. HF port is specially designed for passing high-frequency pulse signals. You can force higher speed pulse signals to your DUT through the HF ports than you can through the AUX ports.

WARNING **Potentially hazardous voltage may be present at the HF input connectors when the OUTPUT ENABLED indicator on the testhead is lit.**

Pulse Switch Input/Output Connectors

The pulse switch provides three multiplexer switches and four open/close switches for pulse signals from the PGUs and to the HF or AUX ports.

WARNING **Potentially hazardous voltage may be present at the pulse switch input/output connectors when the OUTPUT ENABLED indicator on the testhead is lit.**

Pulse Switch Control Input Connectors

Pulse Switch Control Input connectors is for control pulse to synchronize pulse switches.

Extended Path Connectors

Extended Path connector (on the side panel of testhead) is for directly connecting an instrument to an individual measurement pin. An external instrument can be connected to any of the 48 pin boards.

Chuck Connection Output Connector

Chuck Connection Output connector (on the side panel of testhead) is for prober chuck connection.

WARNING

Potentially hazardous voltage may be present at the Chuck Connection Output connector when the OUTPUT ENABLED indicator on the testhead is lit.

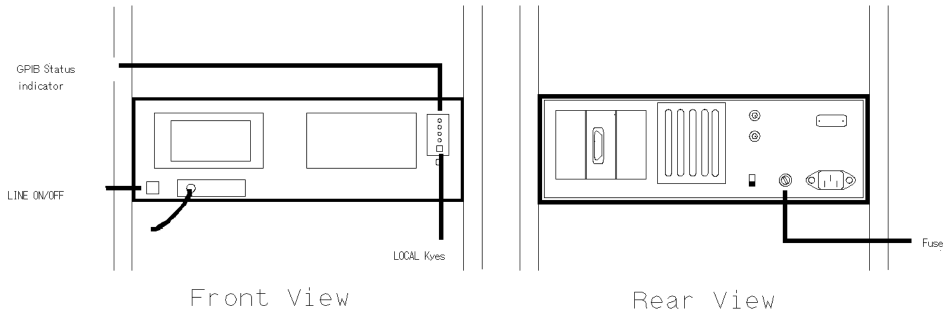
Cover

This Cover (Agilent part number: E3120-60011) is installed in 4072A or 4071A that has a serial number of JP20Dxxxxx. The cover protects you from the potentially hazardous voltage at the output source in the testhead. Use a screw driver to fasten the screws on the cover.

The cover can also be installed on the testhead of an 4071A that has a serial number of JP10Dxxxxx.

Capacitance Measurement Unit (CMU) — 4284A

Figure 4-10 **Front and Rear Panels of 4284A (CMU)**



LINE ON/OFF Switch

Line switch of the CMU.

GPIB Status Indicators

LEDs that show the GPIB status of the CMU.

LCL Key

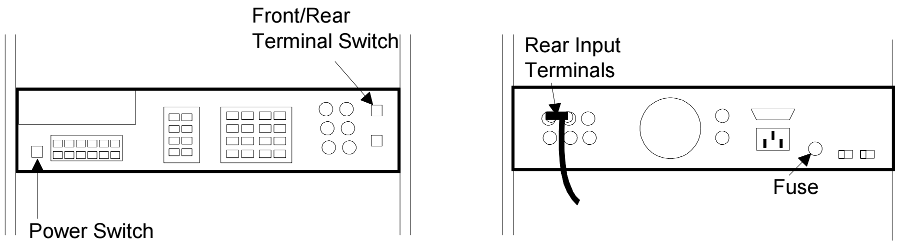
Pressing this key returns the CMU to local control (RMT lamp goes out), which enables all front panel keys for manual operation.

Fuse

- 3 A, Time Delay (Agilent part number 2110-0381) for 100 Vac or 120 Vac
- 2 A, Time Delay (Agilent part number 2110-0303) for 220 Vac or 240 Vac

Digital Voltage Multimeter (DVM) — 3458A

Figure 4-11 **Front and Rear Panels of 3458A (DVM)**



Power Switch

Power switch of the DVM.

Front/Rear Terminal Switch

3458A has both front and rear terminals for measurement connections. The position of this switch determines which terminals are used:

In:	Rear Terminals
Out:	*Front Terminals*

For 4070 series use, this switch must be at In position.

Rear Input Terminals

DVM connection cable is connected to HI and LO terminals of Input.

Fuse

Fuse for the DVM. When replacing the fuse, use the following:

- 1.5 A, Non-Time-Delay (Agilent Part Number 2110-0043) for 100 Vac or 120 Vac
- 500 mA, Slow-Blow (Agilent Part Number 2110-0202) for 220 Vac or 240 Vac

Pulse Generator Unit (PGU) — 8110A, 81110A, or 8114A

Figure 4-12 Front and Rear Panel of PGU (8110A)

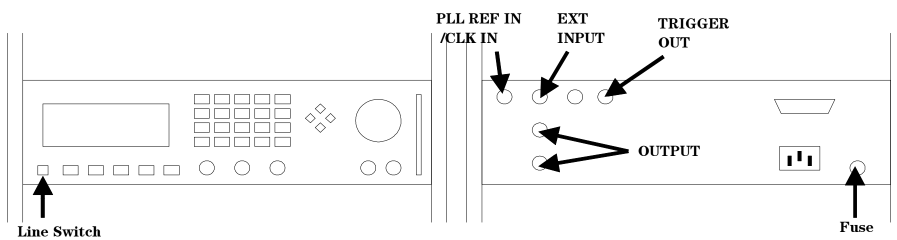


Figure 4-13 Front and Rear Panel of PGU (81110A)

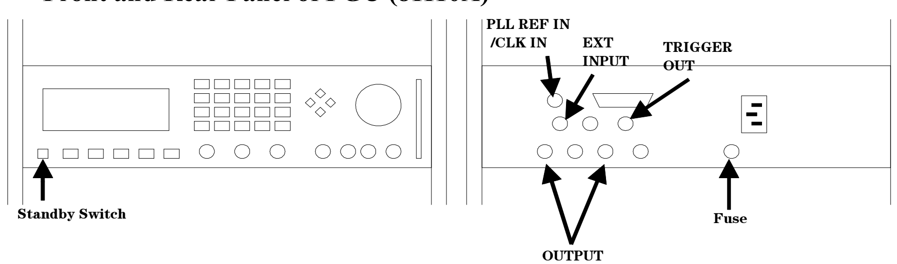
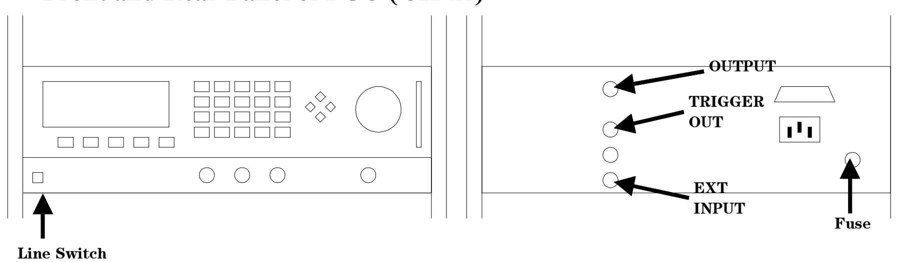


Figure 4-14 Front and Rear Panel of PGU (8114A)



Line Switch or Standby Switch (81110A)

The Line switch of 8110A or 8114A turns the ac power to the PGU on or off.

When the Standby switch of 81110A is off, the PGU is in Standby mode. You can turn off the ac power of the 81110A only by disconnecting the power code.

Rear OUTPUT Terminal

Pulse Output.

Rear TRIGGER OUT, EXT INPUT, and PLL REFIN/CLK IN Terminals

To synchronize pulse signals between PGUs, these connectors connects to the trigger distributor using the trigger signal cables.

Fuse

Fuse for the PGU. When replacing the fuse, use the following:

8110A	250 V, T 3 A (Agilent Part Number 2110-0029
81110A	250 V, T 10 A (Agilent Part Number 2110-0720)
8114A	250 V, T 4 A (Agilent Part Number 2110-0014)

Turning your System On and Off

This section describes how to turn on or off your system:

- "To Turn On your System"
- "To Turn Off your System (in Normal Situation)"
- "To Turn Off your System (in Emergency Situation)"
- "To Reset EMO Button"

WARNING

Electrical Work Type 3:

24 V is forced to the uninsulated parts of the EMO rear panel. Do not touch these parts.

To Turn On your System

The basic procedure for turning on your 4071A or 4072A consists of turning on the system components, and allowing the system to warm-up.

The procedure for turning on your system is as follows:

- For a 4071A with serial number of JP10Dxxxxx

  1. Open the cabinet's front door, and confirm that LINE ON/OFF switches of all cabinet-mounted instruments, system controller, and testhead are turned on.
  2. Confirm that the emergency breaker is set to on, then turn on the main breaker, which is located on the left panel, which you can access by opening the rear door of the system cabinet.

     The LINE Indicator on the front panel of the system cabinet should light, which means ac power is applied to the system controller.
  3. Press the Instrument Power ON switch on the front panel of the system cabinet. The green LED in the Instrument Power ON switch turns on, which means power is applied to the instruments and testhead.

- For a 4072 A or 4071A with serial number of JP20Dxxxxx

  1. Open the cabinet's front door, and confirm that LINE ON/OFF switches of all cabinet-mounted instruments, system controller, and testhead are turned on.

2. Confirm that the emergency breaker is set to on, then turn on the main breaker of the PDU. It can be accessed by opening the rear door of the system cabinet.
3. Opening the rear door of the system cabinet and turn on the main switch of the PDU. The LINE indicator on the front panel of the system cabinet lights.
4. To supply ac power to the controller, press the system switch on the PDU within 20 seconds after the main switch of the PDU in on. The green LED in the switch lights.

NOTE

If you donot turn on the system switch within 20 seconds after the main switch is on:

Cabinet fan error indicator lights and the Instrument Power ON switch is ineffective.

To recover this problem, perform turn off procedure and then perform turn on procedure again.

5. Press the Instrument Power ON switch on the front panel of the system cabinet. The green LED in the Instrument Power ON switch turns on, which means power is applied to the instruments and testhead.

To Turn Off your System (in Normal Situation)

1. Press Instrument Power OFF switch on the front panel of the system cabinet. This stops power to the instruments and testhead.
2. Perform the shutdown procedure for your system controller and turn off its LINE switch.
3. (For 4072A or 4071A with JP20Dxxxxx only) Turn off the main switch.
4. Turn off the main breaker, which is on left panel that is accessed by opening the rear door. This stops ac power to the system controller.

WARNING **If you turn off the main breaker without shutting down your system controller, the file system of the controller will be corrupted.**

To Turn Off your System (in Emergency Situation)

The 4071A or 4072A provides the emergency off (EMO) system that can automatically or manually stop power to the system instruments, system controller, and testhead in an emergency situation.

For example, if an earthquake occurs, you can press the EMO button. Power supply to the system stops immediately, thus preventing a potential fire caused by an electrical short circuit.

To turn off your system in an emergency:

1. Press EMO button, which is the large red button on upper front of the system cabinet.

   The EMO button is locked to the In position, which stops all power to system instruments, system controller, and testhead.

To Reset EMO Button

NOTE

Before resetting the EMO button

Before resetting the EMO button, make sure that no system instruments are damaged or have recovered from any problems.

To reset the EMO button, you must unlock the EMO button as follows:

1. Rotate the button counter-clockwise until the button moves to the Out position.
2. Turn on the emergency breaker on the PDU, which you access via the rear door of the system cabinet.
3. (For 4072A or 4071A with JP20Dxxxxx only)Turn on the system switch on the PDU.

Recovering from Power Line Problems

The PDU has protectors to detect power line problems and protect the system from damage. These protectors stop the supply of power from the PDU to instruments and system controller.

This section describes the following:

- "When Main Breaker Activates"
- "When Emergency Breaker Activates"
- "When Testhead Fan Protector Activates"

When Main Breaker Activates

When excessive current flows to the main breaker, the main beaker opens (moves to OFF position), which turns off ac power to the PDU.

Excessive current means as follows:

- over 30 A for 100 V or 120 V line voltage
- over 15 A for 220 V or 240 V line voltage

After fixing the problem, do as follows:

1. Set the main breaker switch to the ON position.
2. (For 4072A or 4071A with JP20Dxxxxx only) Turn on the system switch.

NOTE

For 100 Vac Power Line Systems Only

100 Vac systems have the GFCI function. If GFCI indicator is at Out position, set the main breaker switch to the OFF position, then set it to the ON position. See the following for details.

For 100 Vac Power Line Systems Only (GFCI)

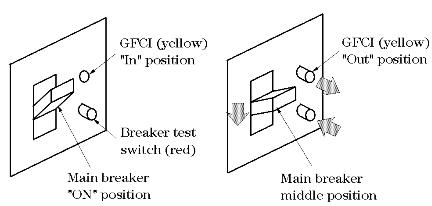
100 Vac systems have the Ground Fault Circuit Interrupter (GFCI) function, which means the main breaker opens to a position that is between ON and OFF when excessive current flows.

The GFCI function allows the main breaker to also detect excessive current caused by earth leakage. If breaker opens because of excessive earth leakage current, a yellow button next to the main breaker, moves to Out position. If breaker opens because of other excessive current, the button stays at In position.

After fixing the problem, do as follows:

- If yellow button is in In position, set the main breaker switch to ON position.
- If yellow button is in Out position:
  1. Set the main breaker switch to the OFF position. The GFCI indicator moves to In position.
  2. Set the main breaker switch to the ON position.
  3. (For 4071A with JP20Dxxxxx only) Turn on the system switch.

Figure 4-15 **GFCI Indicator**



When Emergency Breaker Activates

Main reasons that cause the emergency breaker to activate:

- Excessive current flows to the emergency breaker:
  - Over 20 A for 100 V or 120 V line voltage
  - Over 10 A for 220 V or 240 V line voltage
- EMO protector opens.

  EMO protector opens when excessive current (over 3 A) flows from the External Control terminal.
- Cabinet Fan protector opens.

  Cabinet Fan protector opens when excessive current (over 2 A) flows to cabinet fan. The Cabinet Fan Error indicator will light.
- Cabinet Fan stops or slows down.

  Cabinet Fan Error indicator will light.

After fixing problem, use following procedure to reset Emergency Breaker:

1. If EMO protector is opened, press EMO protector switch.
2. If Cabinet Fan protector is opened, press Cabinet Fan protector switch.
3. Turn on the emergency breaker.
4. (For 4072A or 4071A with JP20Dxxxxx only) Turn on the system switch.

NOTE

If you turn on the emergency breaker within five seconds after the emergency breaker activates, Cabinet fan error occurs.

Wait at least five seconds to turn on the emergency breaker after the emergency breaker activates

When Testhead Fan Protector Activates

When excessive current flows to the testhead fan, testhead fan protector opens, which stops the testhead fan and turns off the testhead power supply.

Excessive current means:

- over 5 A for 100 V or 120 V line voltage
- over 3 A for 220 V or 240 V line voltage

After fixing the problem, turn on the Testhead Fan Protector.

Theory of PDU and EMO Circuit Operation

This section explains how PDU and EMO circuit operates, which will help you understand how to solve power line problems.

Also, this section provides an example for implementing an emergency lamp by using External Output terminal of EMO circuit. Refer to “Example: Implementing an Emergency Lamp”.

Figure 4-16 **Power Distribution Unit Circuit Diagram (for 4071A JP10Dxxxxx)**

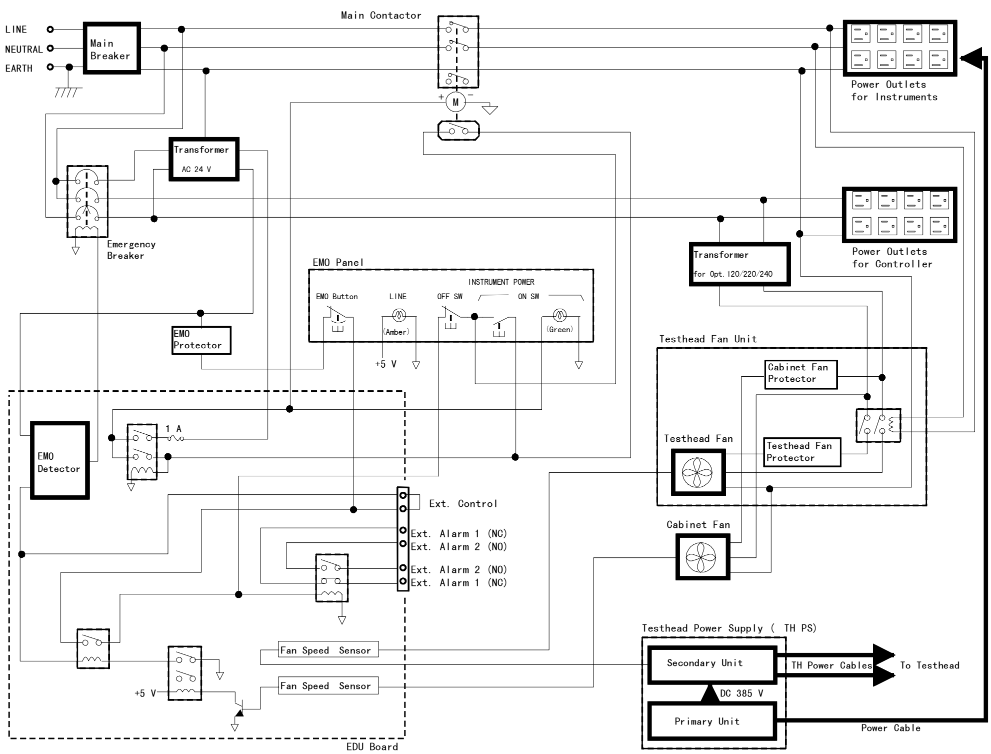
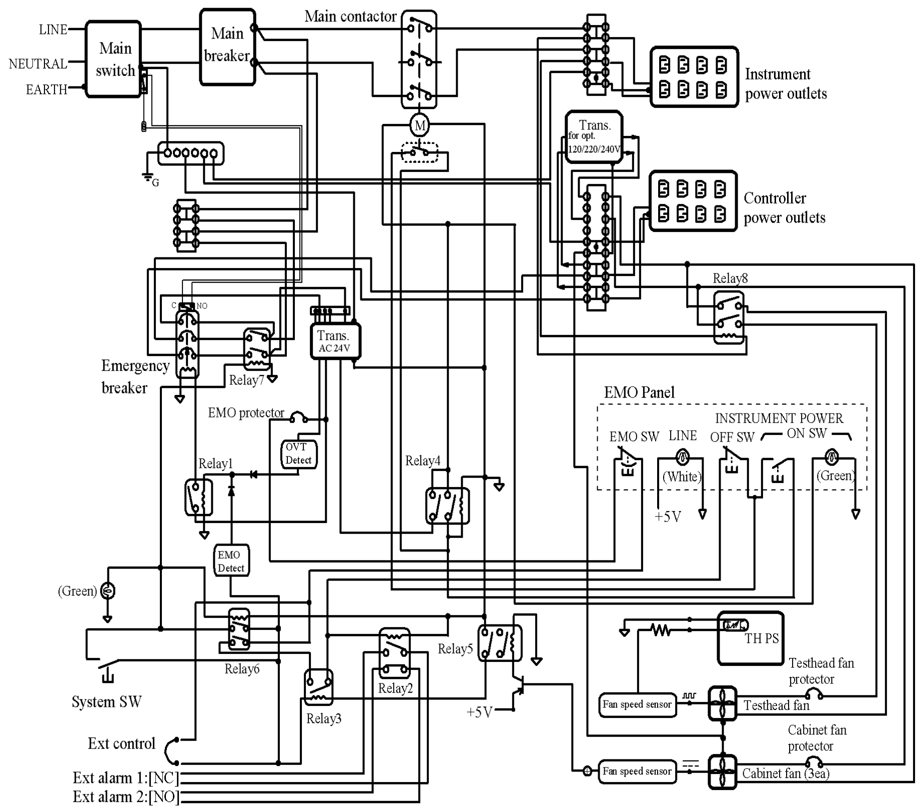


Figure 4-17 **Power Distribution Unit Circuit Diagram (for 4072A or 4071A JP20Dxxxxx)**



- Main Switch (4072A or 4071A with JP20Dxxxxx only)

  The main switch turns on or off ac power to the PDU. The main switch can be operated without opening the rear door.

- Main breaker

  Main breaker turns on or off ac power to PDU. If excessive current (over 30 A for 100 V or 120 V line voltage, or over 15 A for 220 V or 240 V line voltage) flows to the main breaker, ac power to PDU will be turned off.

- Emergency Breaker, and System Switch

  The emeregency breaker turns on or off ac power to the controller power outlets.

  (4072A or 4071A with JP20Dxxxxx)To turn on the ac power to the controller power outlets, perform the following:

  1. Set the main breaker to ON.
  2. Set the emergency breakder to ON.
  3. Set the main switch to ON. (The LINE indicator lights.)
  4. Press the system switch.

  (4071A with JP10Dxxxxx)To turn on the ac power to the controller power outlets:

  1. Set the main breaker to ON.
  2. Set the emergency breaker to ON. Then the LINE indicator ligths.

  Main reasons that cause the emergency breaker to open:

  - 130 % or higher input voltage is detected (4072A or 4071A with JP20Dxxxxxx only)
  - Excessive current flows to the emergency breaker:

    Over 20 A for 100 V or 120 V line voltage

    Over 10 A for 220 V or 240 V line voltage
  - EMO button is pressed
  - EMO protector opens
  - Cabinet Fan protector opens
  - Cabinet Fan stops or slows down

- Main Contactor

  Main contactor turns on or off power to the power outlets for instrument and testhead. The main contactor is closed if the emergency breaker is closed and instrument power ON switch is set to ON.

  Main reasons that cause the main contactor to open:

  - Emergency breaker opens
  - Instrument power OFF switch is pressed

  - Cabinet Fan protector opens
  - Cabinet Fan stops or slows down
  - Cabinet Fan Speed Sensor cable is disconnected or broken

- EMO Button

  EMO button (which is large red button on EMO panel) is used to turn off power to all power outlets. If EMO button is in normal position, ac power is applied to the emergency breaker. But if EMO button is pressed, the emergency breaker opens. This turns off ac power to all power outlets, and LINE indicator turns off.

- Instrument Power ON Switch

  The INSTRUMENT POWER ON switch on the EMO panel is used to apply power to the instrument power outlets.

  (4072A or 4071A JP20Dxxxxx) When the system switch is pressed, and the main breaker, the emergency breaker, and the main switch are set to ON, pressing the INSTRUMENT POWER ON switch sets the main contactor to ON. This applies ac power to the instrument power outlets, and turns on the green LED in this switch.

  (4071A JP10Dxxxxx) When the main breaker and emergency breaker are set to ON, that is, the LINE indicator is lit, pressing the INSTRUMENT POWER ON switch sets the main contactor to ON. This supplies ac power to the instrument power outlets, and turns on the green LED in this switch.

- Instrument Power OFF Switch

  Instrument power OFF switch (which is in EMO panel) is used to turn off power to the power outlets for instruments and testhead. When this switch is pressed, the main contactor opens, and green LED in the instrument power ON switch turns off.

- LINE Indicator

  (4072A or 4071A JP20Dxxxxx) The LINE indicator is turned on when the main switch, main breaker, and the emergency breaker are set to ON. This means that when the system switch is pressed ac power is applied to the controller power outlets. If the INSTRUMENT POWER ON switch is pressed, ac power is also applied to the instrument power outlets.

  (4071A JP10Dxxxxx) The LINE indicator is turned on when the main breaker and the emergency breaker are set to ON. This means that ac power is applied to the controller power outlets. If the INSTRUMENT POWER ON switch is pressed, ac power is also applied to the instrument power outlets.

When Testhead Fan Protector Activates

- Over Voltage Error Indicator (4072A or 4071A with JP20Dxxxxx Only)

  This LED indicator will be lit if an input voltage 118%, or higher, of the specified voltage is detected. Also, if an input voltage 130%, or higher, of the specified voltage is detected the emergency breaker turns power to the system off. If this LED is lit, check the ac input voltage.

- EMO Protector

  EMO protector opens when excessive current (over 3 A) flows from the External Control terminal. This causes the emergency breaker to open. This turns off ac power to all power outlets, and turns off the LINE indicator. This is same condition as after the EMO button is pressed.

- Cabinet Fan Protector

  Cabinet fan protector opens when excessive current (over 2 A) flows to cabinet fan. The cabinet fan stops, and the emergency breaker opens. This turns off ac power to all power outlets, and turns off the LINE indicator. This is same condition as after the EMO button is pressed.

- Cabinet Fan Error indicator

  When the cabinet fan is stopped or the cabinet fan protector is opened, this LED will be lit.

- Testhead(TH) Fan Protector

  The TH fan protector is set to the "Out" (extended) position if excessive current flows into the testhead fan. The testhead fan then stops and turns off the testhead power supply.

  4072A: over 2A for 220/240V

  4071A JP20Dxxxxx: over 3 A for 100/120 V line voltage; over 2 A for 220/240 V

  4071A JP10Dxxxxx: over 5 A for 100/120 V line voltage; over 3 A for 220/240 V

- Testhead Fan Error indicator

  When the testhead fan is stopped, or testhead fan protector is opened, this red LED will be lit.

- External Output Terminals

  These terminals allow you to connect an extra emergency off switch, alarm, or signal lamp to let you know when an emergency happens.

Ext. Control — You can connect these terminals to an extra emergency off switch outside the 4071A or 4072A.

Ext. Alarm 1 (NC) — You can connect these terminals to a device, such as a signal lamp or alarm, to indicate that the 4071A or 4072A has emergency. The terminals are internally connected to a normally-closed relay.

Ext. Alarm 2 (NO) — You can connect these terminals to a device, such as a signal lamp or alarm, to indicate that the 4071A or 4072A has emergency. The terminals are internally connected to a normally-opened relay.

The following table shows the I/O specifications for External Output terminals:

Table 4-1 I/O Reference Data

Ext. Control	Steady current: 56±11.2mA (50 Hz); 50±10mA (60 Hz) at 24 Vac Transient current: 2 to 3 times that of the steady current.
Ext. Alarm 1	Maximum current: 3 A at 250 Vac, 2 A at 30 Vdc (For JP10Dxxxxx) Maximum current: 3 A at 24 Vac, 2 A at 30 Vdc (For 4072A or 4071A with JP20Dxxxxx)
Ext. Alarm 2	Maximum current: 3 A at 250 Vac, 2 A at 30 Vdc (For JP10Dxxxxx) Maximum current: 3 A at 24 Vac, 2 A at 30 Vdc (For 4072A or 4071A with JP20Dxxxxx)

Refer to “Example: Implementing an Emergency Lamp” for example using Ext. Alarm terminal.

- Testhead Power Supply

  Testhead power supply gets ac power from the power outlet for instruments in the system cabinet and applies dc voltage to the testhead.

  Testhead power supply consists of primary unit and secondary unit. Primary unit gets ac power and applies dc voltage (385 V) to secondary unit. Secondary unit regulates dc voltage and applies the dc voltage to the testhead.

  The testhead power supply is turned off if one of the following conditions occurs:

When Testhead Fan Protector Activates

- The testhead fan stops or slows down.
- The testhead fan speed sensor cable is disconnected or broken.
- The testhead fan protector is set to the "Out" (extended) position
- The testhead cover is removed.
- The Power switch for the testhead is set to Off.
- The Line switch on the rear of the testhead power supply is set to Off
- The INSTRUMENT POWER switch is set to OFF.
- The testhead power supply is in over current protection status.
- The testhead power supply is in over voltage protection status.
- The testhead power supply is in under voltage protection status.
- The testhead power supply is in overheat protection status
- The temperature difference between the two temperature sensors in the testhead (in the air-cooled area where SMUs, CPU, and ADC are installed) exceeds 20 °C.
- The SMU output is in over voltage (approximately 130 V).
- The signal cable between the testhead and the testhead power supply is broken or disconnected
- The control cable between the PDU and the testhead power supply is broken or disconnected.

Front panel of the testhead power supply secondary unit has three LEDs:

Power LED: Indicates that condition of testhead power supply is normal.

Caution LED: Turns on if one of following occur:

- Testhead fan protector is opened
- Testhead fan is stopped
- Testhead fan is slowed down
- Testhead fan speed sensor cable is disconnected or broken
- Testhead power supply output is over current

- Temperature difference between two testhead temperature sensors is greater than 20 °C
- SMU output is in over voltage (approximately 130 V) status
- Signal cable between the testhead and the testhead power supply is broken or disconnected
- Control cable between the PDU and the testhead power supply is broken or disconnected

Error LED: Turns on if one of following occur:

- Output current is excessive.
- Output voltage is excessive.
- Output voltage is insufficient.
- Temperature in the testhead power supply is too high

Example: Implementing an Emergency Lamp

The procedure below describes how to implement a lamp (by using External Output terminals on PDU) that turns on when the EMO button is pressed.

Connect the Ext. Alarm 2 terminals (normally open) to an emergency lamp as follows:

1. Connect the NEUTRAL side of power line outlet to a terminal of emergency lamp.
2. Connect the LINE side of power outlet to one terminal of Ext. Alarm 2.
3. Connect the other terminal of Ext. Alarm 2 to the other terminal of the emergency lamp.

Note that you *must not* use a power line outlet of the system cabinet because power to these outlets stops when EMO button is pressed.

5 Starting the 4070 System Software

To control Agilent 4070 from system software, you must start (login to) a test session.

This chapter contains the following main sections:

- "Starting and Ending a Test Session"
- "Problems when Starting a Test Session"

A test session has a unique session ID from PCS_SESSION_ID environment variable. By default, PCS_SESSION_ID is determined by process ID of login shell.

All 4070 control processes in the test session must have same session ID as the test session.

This chapter explains how to start and end a test session. There are two types of test sessions:

- Online test session, which can control 4070 hardware resources
- Offline test session, which cannot control 4070 hardware resources

Up to five offline test sessions can be started simultaneously, but only one online test session can be started.

- Online Test Session

  When you start an online test session, the following occurs:

  - Initializes 4070 hardware resources (SMUs, PGUs, CMU, DVM, and SWM) and Prober can be initialized.
  - Executes self-calibration of SMUs
  - Displays system configuration

  Then, you can control 4070 hardware resources.

- Offline Test Session

  If you start an offline test session, you cannot control 4070 hardware resources.

  But an offline test session can simulate hardware resources and return simulated data to your program.

  An offline test session is useful for program debugging.

Starting and Ending a Test Session

There are two methods to start a test session.

- Executing /opt/hp4070/bin/hp4070 from HP-UX command prompt

  Use this method if you want to execute measurement programs written in C language or HP BASIC measurement programs that links TIS4070 library, which can not be used with 4070 supplied prober-related subprograms.

  Refer to “To Start a Test Session by using hp4070”.

- Executing /opt/hp4070/bin/START from HP BASIC/UX

  Use this method if you want to execute an HP BASIC measurement program that linksTIS library, which can be used with 4070 supplied prober-related HP BASIC subprograms (EGX, EGY, TEL,TSK, MJC,or WAFER).

  Refer to “To Start a Test Session by using START”.

To Start a Test Session by using hp4070

NOTE

For HP BASIC program that controls prober

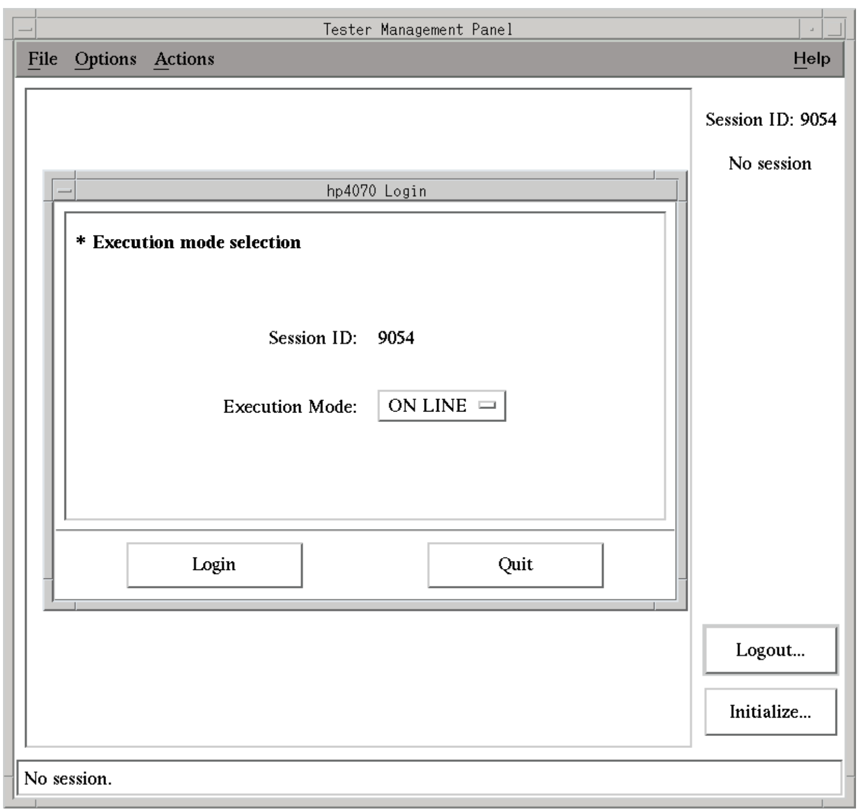
If the measurement program links TIS library, which can be used with 4070 supplied prober-related HP BASIC subprograms (EGX, EGY, TEL, TSK, MJC, or WAFER), you must start the test session as described in “To Start a Test Session by using START”.

1. Execute /opt/hp4070/bin/hp4070 as follows:

   $ hp4070 &

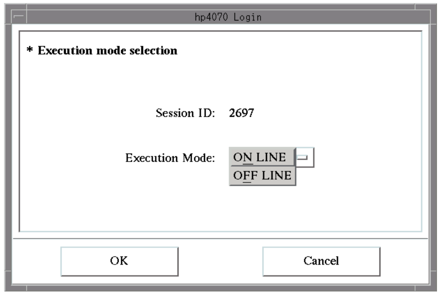
   The "hp4070 Login" window and "Tester Management Panel" window are displayed.

Figure 5-1 **Starting a Test Session**



2. Select the desired Execution Mode in the "hp4070 Login" window:

Figure 5-2 Selecting the Execution Mode



- If you need to control 4070 hardware resources, select ON LINE.
- If you do not need to control 4070 hardware resources, select OFF LINE.

3. Click the OK button in "hp4070 Login" window.

   The test session starts and present system configuration is displayed on "Tester Management Panel" window as shown in following figure.

Figure 5-3 Displaying the System Configuration (4071A)

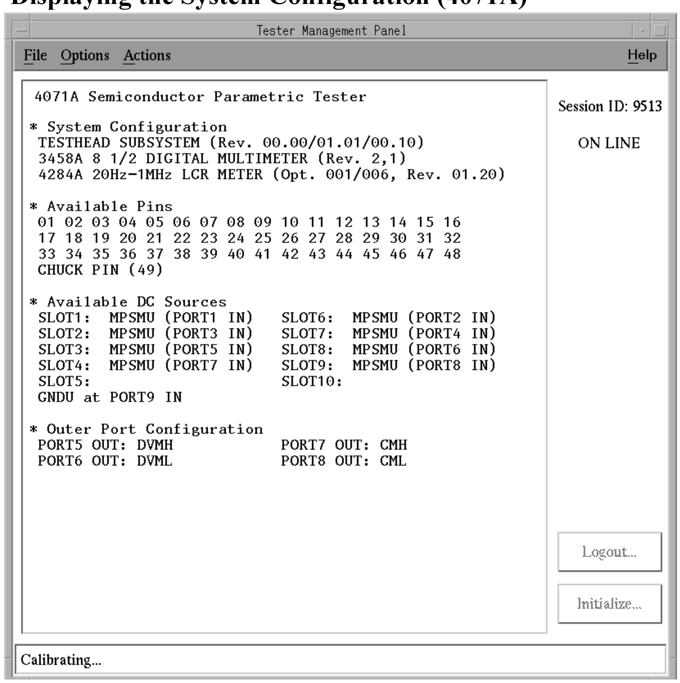
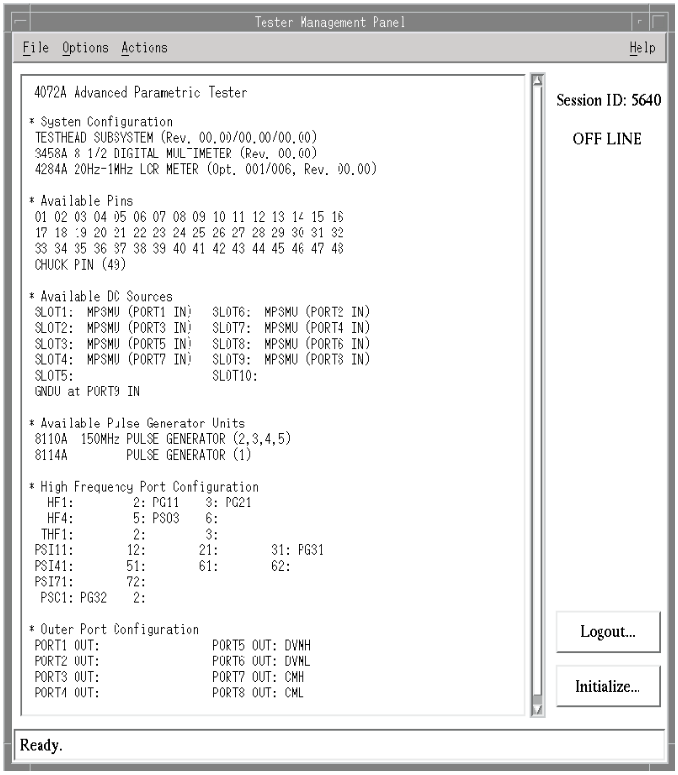


Figure 5-4 **Displaying the System Configuration (4072A)**



When you start an offline test session, the following system configuration is used:

SMU	8 SMUs are available
Measurement Pins	1 to 48 measurement pins are available
DVM	depending on the 4070 hardware configuration.
CMU	depending on the 4070 hardware configuration.
PGU	depending on the 4072A hardware configuration.
HF Port Configuration	depending on the default information file created by the PG Cable Connection window in the 4072A.

Without GUI

If you do not have a Graphical User Interface (GUI) window, you can start a test session as follows:

- To start an *online* test session:

  $ hp4070 -login online

- To start an *offline* test session:

  $ hp4070 -login offline

You can also use the following options with -login option.

-no-smucal	SMU calibration is not executed.
-no-show	System configuration is not displayed.

For example:

$ hp4070 -login -no-show online

This example starts an online test session, and system configuration is not displayed.

To Start a Test Session by using START

NOTE

For C or non-prober HP BASIC measurement programs

For following types of measurement programs, you should start the test session as described in “To Start a Test Session by using hp4070”.

- C measurement program to control 4070
- HP BASIC measurement program that links TIS4070 library, which can not be used with 4070 supplied prober-related subprograms.

1. Start HP BASIC/UX as follows:

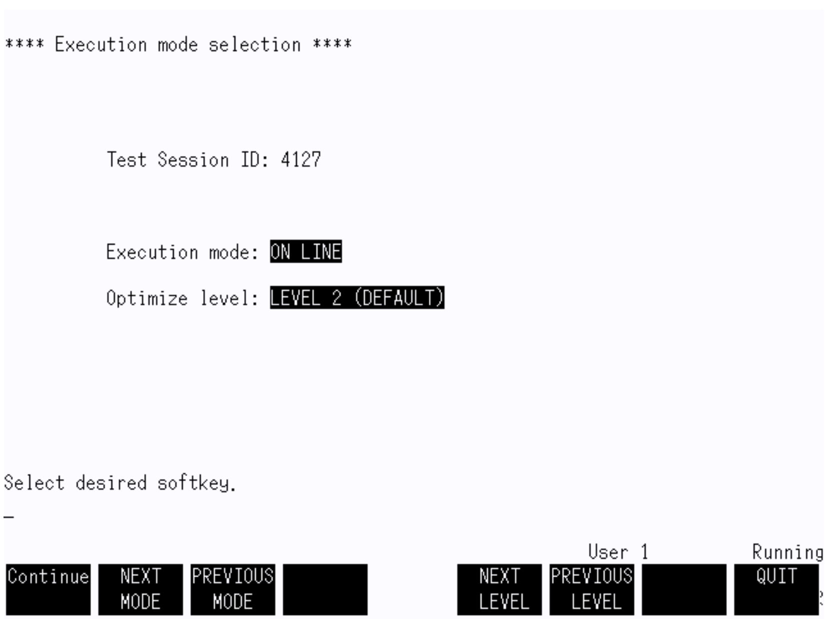
   $ rmb

2. Load and execute the following from HP BASIC/UX:

   LOAD “/opt/hp4070/bin/START”,1

   The following window is displayed.

Figure 5-5 Selecting the Execution Mode



3. Select the execution mode of test session by using NEXT CHOICE or PREVIOUS CHOICE softkey.

4. Press Continue to start the test session.

   System configuration is displayed and /etc/opt/hp4070/KEY4070 file is loaded. The KEY4070 file defines function keys, which you can use to load (link) or delete TIS subprograms for your measurement program.

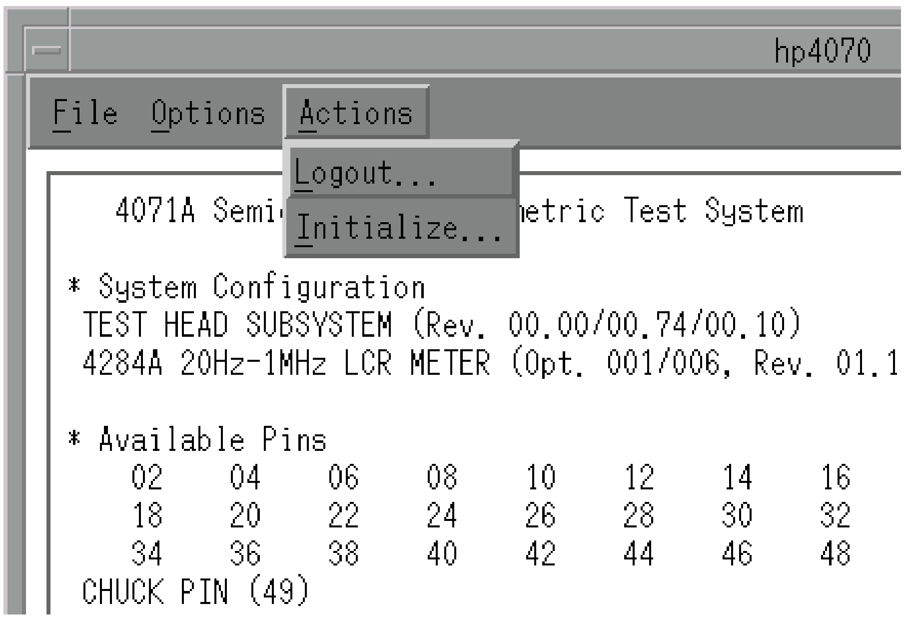
To End a Test Session

The following describes how to end (logout from) a test session:

- If you started the test session by using "Tester Management Panel" window:

  1. Choose Action : Logout…menu of "Tester Management Panel" window

Figure 5-6



  2. Test session ends and the "hp4070 Login" window displays again.

     You can select Login button to start test session again or Quit button to close "Tester Management Panel" window.

- If you started the test session by executing hp4070 -login:

  - Execute the following:

    $ hp4070 -logout

- If you started the test session by executing START program from HP BASIC/UX:

  - Quit from HP BASIC/UX window. The test session ends automatically.

Problems when Starting a Test Session

This section provides solutions to the following problems that may occur when starting a test session:

- You cannot start an online test session and an error occurs.

  Refer to "You Cannot Start an Online Test Session".

- You can start a test session, but displayed 4070 system configuration is different from present configuration.

  Refer to "System Configuration was Changed".

You Cannot Start an Online Test Session

If you cannot start an online test session, and following error message is displayed:

'FATAL ERROR 1-10012 Faild to call connect().'

Perform the following:

1. Confirm that process tis_online -ioff -e -a is running.

   $ ps -ef | grep tis_online

   If the process is running, a line similar to following should be displayed:

   glacier 5036 1 91 11:01:42 ? 0:06 tis_online -ioff -e -a

2. If tis_online -ioff -e -a process is *not* running, execute the following:

   $ hp4070 -start

3. Try to start the test session again.

System Configuration was Changed

The 4070 system software confirms the system configuration of 4070 when you boot up the system controller.

If you change the system configuration or turn on system instruments *after* booting up your system controller, you need to perform the following procedure so that 4070 system software can confirm the present system configuration:

1. Execute /opt/hp4070/bin/hp4070 as follows:

   $ hp4070 -shutdown

2. Execute the following:

   $ hp4070 -start

Now when you start the test session, the displayed system configuration should match the present system configuration.

6 Managing Your System

This chapter explains how to manage Agilent 4070 system software and has the following sections:

- “Managing Basic Operation of System”
- “Executing SMU Self-Calibration”
- “Executing PGU Calibration (4072A only)”
- “Measuring Error Compensation Data for CMU”
- “Changing Port Mapping Table”
- “Setting Cable Connection Information (4072A only)”
- “Setting the Default Pulse Switch Condition (4072A only)”

Managing Basic Operation of System

This section describes the following administration tasks:

- "To Initialize the System"
- "To Change the Optimization Level"
- "To Recover from an Abnormal Condition"

Initial Settings of System Resources

The following describes the initial setting of the system resources and the optimization level.

Initializing system resources clears all previous settings and sets the main functions of the systems (except the wafer prober) as follows:

Table 6-1 **SWM Settings**

—	Force	Sense	Guard
Pin board	Open	Open	Open or circuit common[a]
Chuck connection	Open	Open	Open or circuit common [b]
SMU 1 or 2 port	Open	—	Open
SMU 3 to 8 port	Open	Open	Open
GNDU port	Open	Open	—
AUX 1 or 2 port	Open	—	Open
AUX 3 to 8 port	Open	Open	Open

a. If optimization level is 0 or 1: Open. If optimization level is 2 or 3: depends on setting of previously executed Gnd_open_guard subprogram.
b. If optimization level is 0 or 1: Open. If optimization level is 2 or 3: depends on setting of previously executed Gnd_open_guard subprogram.

Table 6-2 **SMU Settings**

Mode	Voltage Source / Current Monitor
V output	0 V at 20 V range
I compliance	100 μA at 100 μA range
A/D converter	Depends on the optimization level setting [a]
Integration time	SHORT
Auto zero	Depends on the optimization level setting [b]
SMU filter	Depends on the optimization level setting. [c]
Wait time	1 s

a. If optimization level is 0 or 1, high-resolution ADC is selected. If optimization level is 2 or 3, high-speed ADC is selected.
b. If optimization level is 0 or 1, auto zero function is enabled. If optimization level is 2 or 3, auto zero function is disabled.
c. If optimization level is 0 or 1, SMU filter is enabled. If optimization level is 2 or 3, SMU filter is disabled.

Table 6-3 **CMU Settings**

Measurement range	AUTO
Signal level	30 mV_{rms}
DC bias	0 V
Frequency	1 MHz
Open correction	Enabled
Short correction	Enabled

Table 6-4 **DVM Settings**

Measurement range	AUTO
Integration time	1 PLC
Auto zero	Enabled

Table 6-5 PGU Settings (8110A and 81110A)

Output Switch	Open
Time Accuracy Mode	Normal
Output Mode	2-level Pulse Output
Pulse Base	0 V
Pulse Amplitude	0.2 V
Pulse Width	10 ns
Delay Time	0 s
Leading-edge Transition Time	20 ns
Trailing-edge Transition Time	20 ns
Load Impedance	999 kΩ

Table 6-6 PGU Settings (8114A)

Output Switch	Open
Time Accuracy Mode	Normal
Output Mode	2-level Pulse Output
Pulse Base	0 V
Pulse Amplitude	2 V
Pulse Width	10 ns
Delay Time	0 s
Leading-edge Transition Time	n.a.
Trailing-edge Transition Time	n.a.
Load Impedance	999 kΩ

Init_system resets the following variables and parameters set by TIS and COM blocks used by prober control subprograms:

- The measurement parameters set by Set_iv, Set_piv, Set_pbias, Set_cv84, Set_bsearch, Set_lsearch, Set_sync, Set_bdv, Set_ileak, Set_vth, Set_cmu84, Set_freq, Stand_by_port, Set_type_pg, Set_level_pg, Set_time_pg, and Set_mode_pg.
- The probing sequence loaded by Wget.
- The index values set by Pscale.
- The probing wafer chip coordinates.

Optimization Level

You set the optimization level depending on the following:

- Desired default values of TIS statements and initial hardware settings.

  You choose the level according to whether you want to use settings compatible with 4062 or 4070.

- Desired synchronization between measurement program and testhead operation.

  For 4070, the measurement program sends a statement that control testhead resources (SMUs and switching matrix) to the testhead and go to the next step even if the testhead CPU has not completed the corresponding operation. So, this synchronization is an issue.

You mainly use optimization level 0 or 1 for running a 4062 measurement program on 4070 with less modification. And level 2 and 3 are for running measurement programs developed for the 4070.

- Level 0:

  Uses default values of TIS statements and initial settings of hardware resources that are as compatible as possible with 4062.

  Measurement program statements and testhead operation are fully synchronized. That is, TIS statements that control testhead resources wait for the testhead CPU operation to complete, then measurement program proceeds to the next step.

  For this optimization level, the measurement program runs slower. So, you should use this level only if you want to execute a 4062 measurement program that controls system instruments and unsupported instruments, or that contains HP BASIC statements that control the program timing, such as a "WAIT" statement.

- Level 1:

Uses default values of TIS statements and initial settings of hardware resources that are as compatible as possible with the 4062.

Basically, measurement program statements and testhead operation are not synchronized. However, TIS statements that control the CMU and DVM, TIS statements to execute measurements, and TIS statements to disconnect *all* measurement pins and disable *all* measurement ports wait for completion of all previous statements sent to the testhead CPU. So, you only need to worry about timing considerations if your measurement program contains timing control statements or statements that control unsupported instruments.

Some default values of 4062 and initial settings cause measurement program to run slower. So, you should use this optimization level only if you would want to execute a 4062 measurement program on the 4070 with less modification.

- Level 2:

  Uses default values of TIS statements and initial settings of hardware resources that are optimized for 4070.

  The synchronization between testhead CPU and measurement program execution is same as optimization level 1.

- Level 3:

  Uses default values of TIS statements and initial settings of hardware resources that are optimized for 4070.

  There is no synchronization between measurement program and testhead CPU operation. So, even when a TIS statement is executed to disconnect *all* measurement pins or disable *all* measurement ports, the measurement program does not wait for completion of previous statements sent to testhead CPU.

  So, with good programming, this level will be the fastest, but you must be very careful to consider the timing between testhead operation and measurement program, especially for prober control.

To Initialize the System

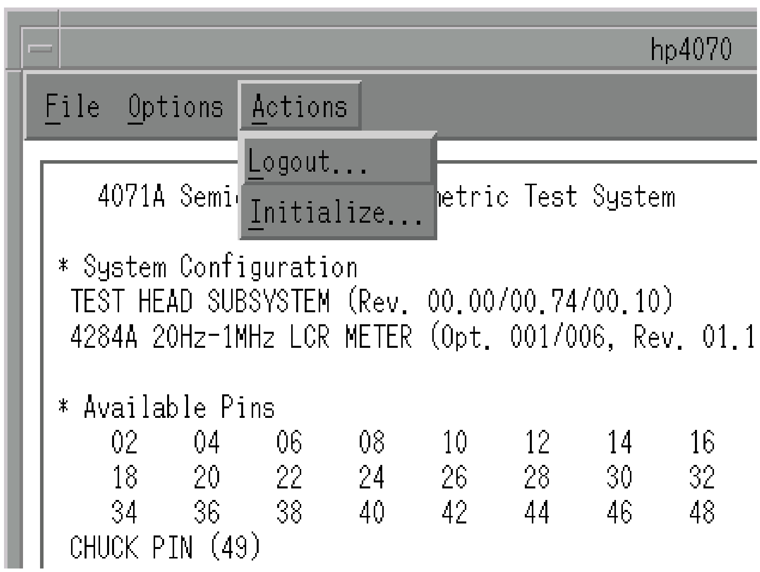
You can initialize system resources by using as follows:

From Tester Management Panel

If you logged into an online test session by using the "Tester Management Panel" window, perform the following procedure in the "Tester Management Panel" window to initialize the 4070:

1. Choose `Actions: Initialize` menu of "Tester Management Panel" window.

Figure 6-1



2. Confirmation dialog opens. Do one of following:
   - Click OK to initialize 4070 system.
   - Click No to cancel initializing procedure.

From command line

1. Execute the `/opt/hp4070/bin/hp4070` command as follows:

```
$ hp4070 -init
```

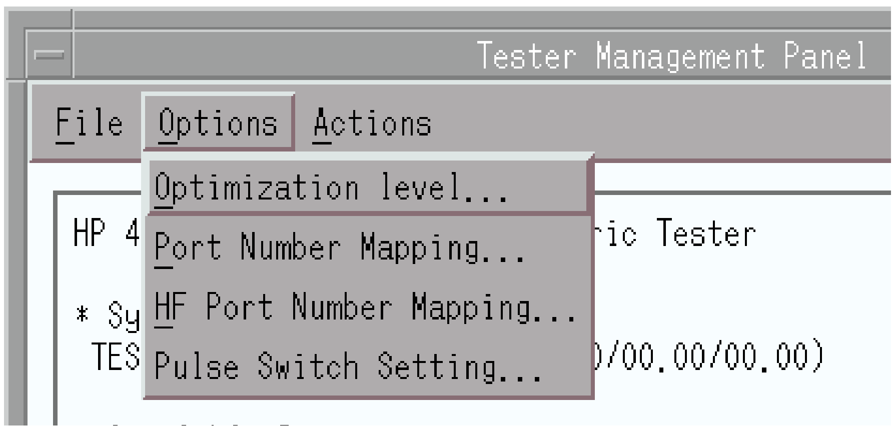
To Change the Optimization Level

From Tester Management Panel

If you logged into an online test session by using the "Tester Management Panel" window, perform the following procedure in the "Tester Management Panel" window to change the optimization level:

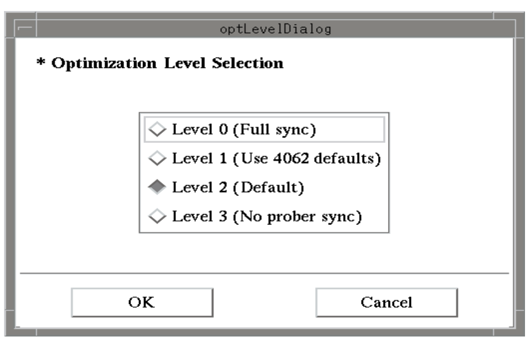
1. Choose `Options: Optimization level` menu of the "Tester Management Panel" window.

Figure 6-2



2. The "optLevelDialog" dialog opens.

Figure 6-3



3. Click button for desired optimization level.
4. Click OK button.

From command line

1. Execute the `/opt/hp4070/bin/hp4070` command as follows:

   `$ hp4070 -optimize` *level*

   Where, *level* is the desired optimization level: `0`, `1`, `2`, or `3`

To Recover from an Abnormal Condition

The 4070 always monitors the following abnormal conditions during measurement:

- Testhead Prober Sense or Fixture Open (Interlock function)

  Testhead is not firmly installed on a wafer prober, test fixture adapter is not installed on the testhead, or lid of the test fixture adapter is open.

- Testhead Emergency

  Emergency condition occurs at the testhead. For example, the testhead fan stops.

- Testhead Power Fail

If one of the above conditions occurs, the 4070 initializes the system after the following:

- For Testhead Prober Sense or Fixture Open

  You can execute the measurement again after you solve the abnormal condition, for example, you close the lid of the test fixture adapter.

- Testhead Emergency or Testhead Power Fail

  The 4071A shutdowns the system. So you need to re-start the system after solving the problem. To re-start the system software, do the following:

  1. Execute the `/opt/hp4070/bin/hp4070` command as follows:

     ```
     $ hp4070 -start
     ```

  2. Start a test session:

     ```
     $ hp4070 -login online
     ```

NOTE

To Display a Message when Abnormal Condition Occurs

If you want a message to be displayed when a Testhead Emergency or Testhead Power Fail abnormal condition occurs, do as follows:

1. Execute the `/opt/hp4070/bin/exph4070` command as follows:

   ```
   $ exph4070 &
   ```

   Now, when one of these abnormal conditions occurs, a related message will be displayed as in following example.

Figure 6-4

2. After solving the problem, click OK.

Executing SMU Self-Calibration

You should execute SMU self-calibration at least once a day or when the temperature changes more than 3° C since SMU self-calibration.

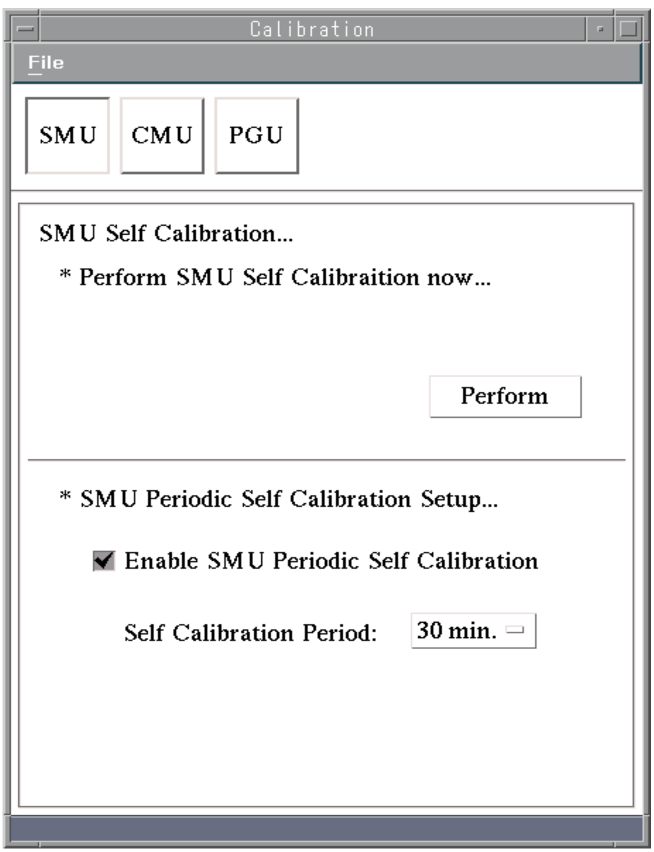
To execute SMU self-calibration or set up periodic SMU self-calibration, do the following

1. Execute the following from a command line:

   ```
   $ /opt/hp4070/bin/cal4070
   ```

   The following window is displayed:

Figure 6-5



2. *To Execute SMU Self-calibration:*

   a. Click SMU button on the "Calibration" window.

   b. Click Perform button.

   To Set up Periodic Self-calibration of SMU:

   a. Click SMU button on the "Calibration" window.

   b. Click button for `Enable SMU Periodic Self Calibration`.

   c. Choose desired period from `Self Calibration Period` option menu.

   Or `/opt/hp4070/bin/hp4070` command with `-smucal` option immediately execute SMU self-calibration.

```
$ hp4070 -smucal
```

Executing PGU Calibration (4072A only)

There are two ways to calibrate the PGU output voltage level; auto calibration and manual calibration. You should execute this calibration when you change the PGU configuration.

- auto calibration

  An auto calibration calibrates the PGUs directly connected to the HF ports and AUX ports. It also calibrates the PGUs connected to HF ports and AUX ports through pulse switches.

  This calibration cannot calibrate PGUs connected to the PSC, or PGUs that are not connected to any ports. Execute the manual calibration to calibrate these PGUs .

- manual calibration

  The manual calibration calibrates the PGU connected to the HF1 port. For PGUs that are not calibrated during the auto calibration, connect the PGU to the HF1 port and calibrate it, then disconnect the PGU and re-connect it to the original port. Repeat this procedure for each PGU you want to calibration.

If your system has a 81110A for PGU, you can also execute the calibration for pulse timing.

- timing calibration

  The timing calibration calibrates the delay time and width time of the PGU (81110A).

To Execute Auto Calibration

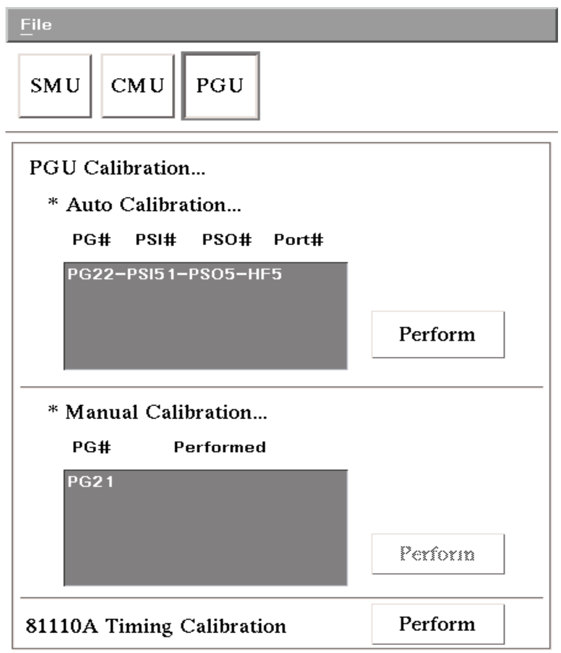
Use the following procedure to perform an auto calibration for the PGU output voltage level.

1. From the command line, execute the following command:

   `$/opt/hp4070/bin/cal4070`

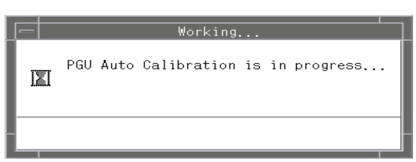
   Select the PGU button in the Calibration window. The following window is displayed:

Figure 6-6



2. Select the Perform action button in the Auto Calibration area. The following message is displayed, and the calibration is executed.

Figure 6-7



To Execute a Manual Calibration

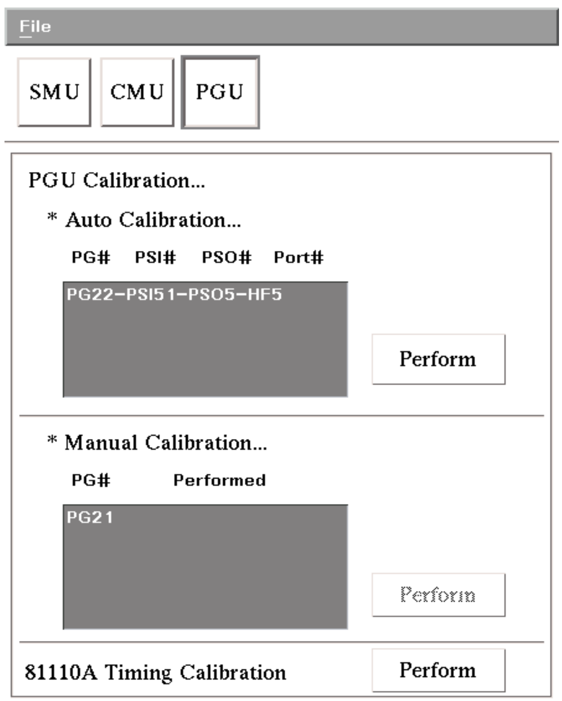
Use the following procedure to perform a manual calibration for the PGU output voltage level.

1. From the command line, execute the following command:

   `$/opt/hp4070/bin/cal4070`

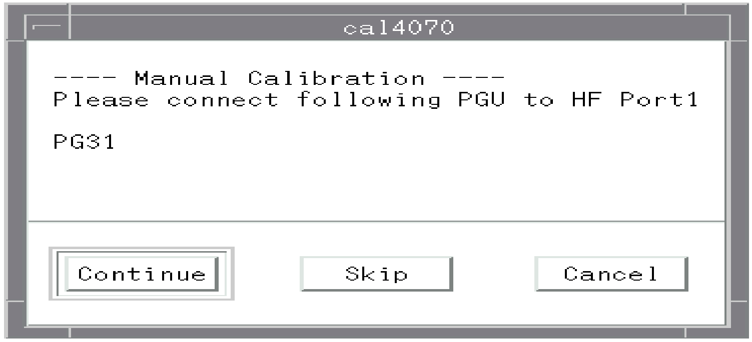
   Select the PGU button in the Calibration window. The following window is displayed:

Figure 6-8



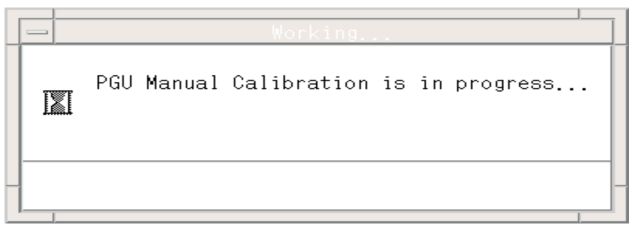
2. Select the PG output channels you want to calibrate by clicking the PG channel numbers in the Manual Calibration area.
3. Click the Perform button in the Manual Calibration area. The following is displayed.

Figure 6-9



4. Connect the indicated PG output channel to theHF1 port. Click the Continue button. Tthe following message window is displayed and the calibration is executed.

Figure 6-10



5. When the calibration is finished the following window is displayed. Disconnect the PG output channel and re-connect it to the original port.

Figure 6-11

6. Click OK. An asterisk (*) is displayed next to the PG channel in the Manual Calibration area of the Calibration window to indicate the channel has been calibrated.

7. Repeat steps 3 to 5 for each of the PG output channels you selected in step 2.

To Execute Timing Calibration for 81110A

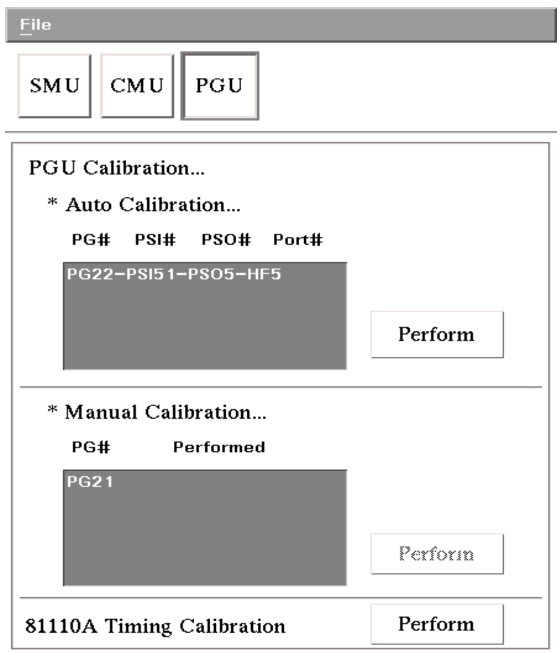
Use the following procedure to perform a timing calibration for the PGU (81110A) output pulse delay and width.

1. From the command line, execute the following command:

   ```
   $/opt/hp4070/bin/cal4070
   ```

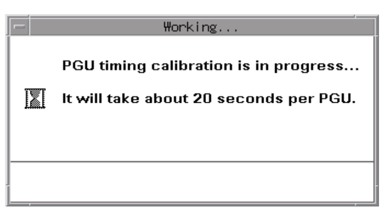
   Select the PGU button in the Calibration window. The following window is displayed:

Figure 6-12



2. Select the Perform action button in the 81110A Timing Calibration area. The following message is displayed, and the calibration is executed.

Figure 6-13



Measuring Error Compensation Data for CMU

The following error compensation data for CMU is measured and stored at the factory:

- Data for cables that connect the CMU to the testhead is stored in 4284A.
- Data for the CMU measurement path (switching matrix) in the testhead is stored in a 4070 system file.

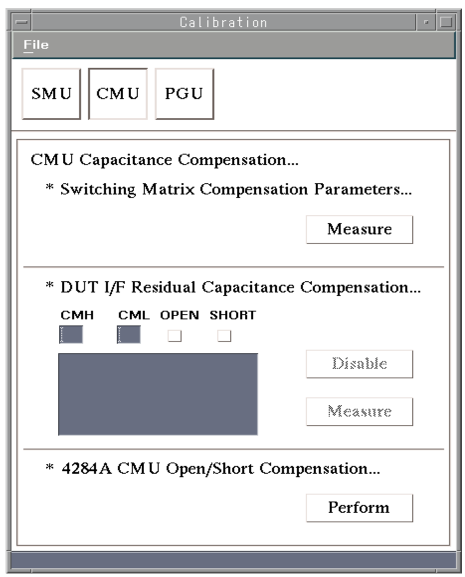
Also 4070 provides the function to measure the capacitance compensation data beyond any two capacitance measurement pins other than chuck connection pin.

You can re-measure and re-store the compensation data by doing the following:

1. Open the "Calibration" window by executing the following command:

```
$ /opt/hp4070/bin/cal4070
```

Figure 6-14



2. Then you can perform one of the following:
   - “To Measure Error Compensation Data of CMU Connection Cable”
   - “To Measure CMU Error Compensation Data of Switching Matrix”

- “To Measure CMU Error Compensation Data of DUT Connection”

Also, refer to “CMU Error Compensation” on page 2-32.

To Measure Error Compensation Data of CMU Connection Cable

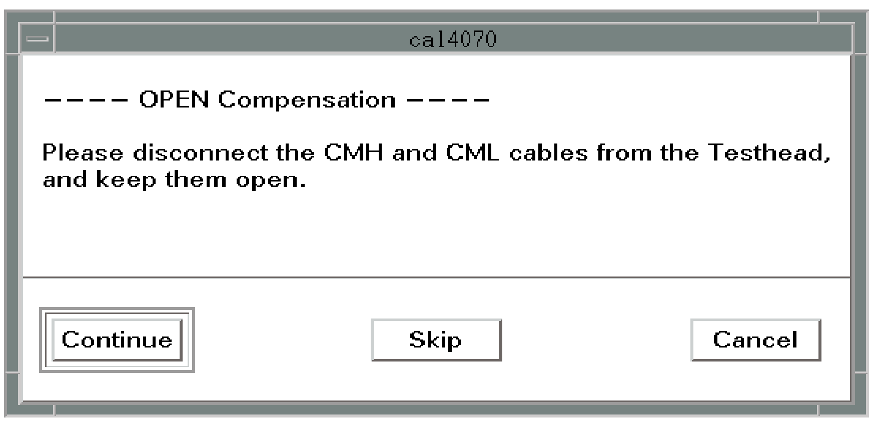
The following describes the procedure for measuring and storing open and short error compensation data for the cables that connect the CMU to the testhead.

Note that you need a BNC shorting adapter (Agilent part number: 1250-0080) for this procedure.

1. Click CMU button of the "Calibration" window.
2. Click Perform button in the `4284 CMU Open/Short Compensation` area.

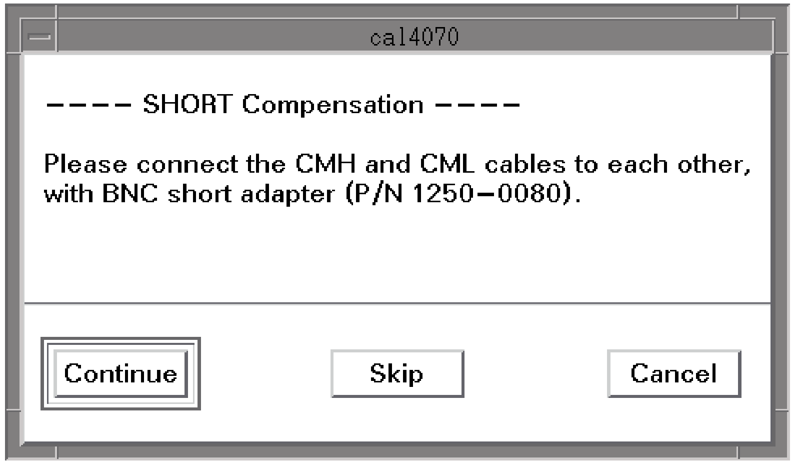
   The following dialog opens:

Figure 6-15



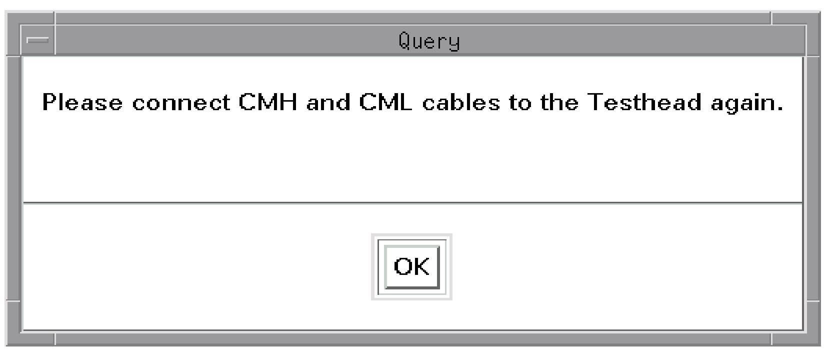
3. Disconnect CMU connection cables from the testhead.
4. Click Continue button. This measures the open compensation data, and the following dialog opens.

Figure 6-16



5. Use the shorting adapter (Agilent part number: 1250-0080) to connect CMH cable to CML cable.
6. Click Continue button. This measures the short compensation data, and the following dialog opens:

Figure 6-17



7. Re-connect CMU connection cables to the testhead, then click OK.

The error compensation data is stored into 4284A, which will be used to automatically compensate measurement data.

To Measure CMU Error Compensation Data of Switching Matrix

1. Click CMU button of the "Calibration" window.
2. Click Measure button in `Switching Matrix Compensation Parameters` area.

   The CMU error compensation data is measured.

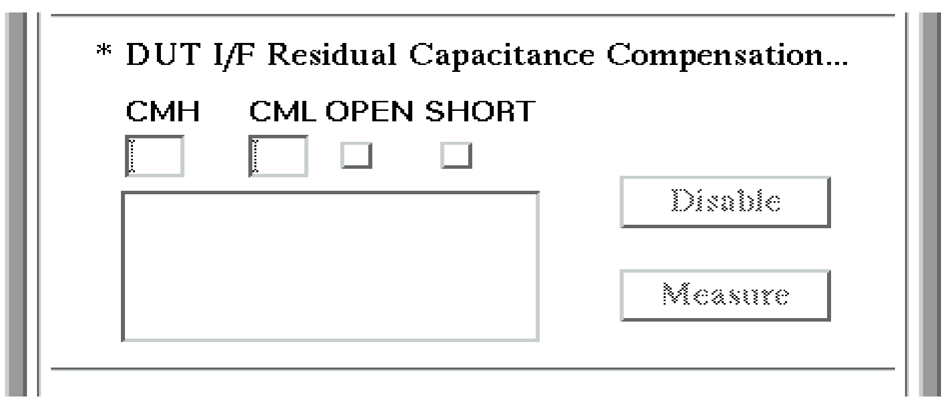
The error compensation data is stored into a 4070 system file, which will be used to automatically compensate measurement data.

To Measure CMU Error Compensation Data of DUT Connection

The following describes the procedure for measuring and storing open and/or short error compensation data for the measurement path beyond any two measurement pins of switching matrix, for example probing needles.

1. Click CMU button of the "Calibration" window.
2. In `DUT I/F Residual Capacitance Compensation...` area, enter pin number of CMH at CMH field and pin number of CML at CML field respectively.

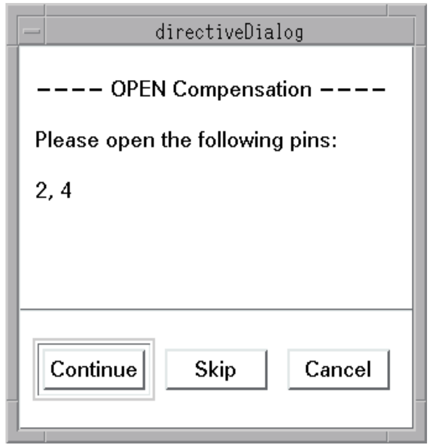
Figure 6-18



3. Make probe needles to open (nothing is connected to needles).
4. Click OPEN button and SHORT button.
5. Click Measure button.

6. The following dialog opens:

Figure 6-19



7. Make corresponding probe pins open (nothing connected) and then click Continue.

8. After measuring open compensation data, the following dialog opens:

Figure 6-20

9. Shorten corresponding probe pins and then click Continue.

10. Repeat same procedure for all combination of measurement pins which you will use for capacitance measurement.

You can measure compensation data for maximum 500 combination of measurement pins.

11. All measured pins are displayed lower left area in `DUT I/F Residual Capacitance Compensation...` area.

You can save measured compensation data into a file and re-store the data from a file later.

To Save Measured Compensation Data

To save a measured compensation data:

1. Choose `File: Save C Compensation Table...` menu.
2. The Compensation Table File…dialog opens.
3. Enter file name in Selection field.
4. Click OK. All measured compensation data is saved to the file.

To load a measured compensation data:

1. Choose `File: Load C Compensation Table...` menu.
2. The Compensation Table File…dialog opens.
3. Enter file name in Selection field.
4. Click OK. Saved measured compensation data is loaded from the file.

Or execute `/opt/hp4070/bin/hp4070` command as follows:

```
$ hp4070 -ccomp file
```

Changing Port Mapping Table

Because of the differences of system architecture, the port numbering and semantics are different between 4062 and 4070.

To solve this incompatibility, TIS statements of 4070 can accept the port address of 4062, which is then translated to 4070's port address according to the pre-defined port mapping information.

For the 4072A environment, in addition to the port mapping table to define the ports both 4062UX and 4062F have, there is HF port mapping table to define the HF ports of 4062F ports' mapping to the 4072A HF/THF/AUX ports.

Actually, port mapping information is stored into a file and you can edit the port mapping table, which defines the port address translation rules between 4062 and 4070, by using hp4070 utility, which is provided by 4070.

This mapping table is also used to redirect the accessing of system resource that 4070 does not have, to an equivalent measurement resource of 4070, if possible.

For example, accessing VS1 port of 4062 is redirected to SMU6 of 4070 according to the default port mapping table.

This section consists of the followings:

- "To Change Port Mapping"
- "To Load 4062 Unit Configuration from DUMCONFIG"
- "To Save Port Mapping Table into File"
- "To Load Port Mapping Table from File"

NOTE

Default Port Mapping Table

By default, 4070 provides the following port mapping table:

Table 6-7 **Default Port Mapping Table**

4062		4070	
Port Address	**Port**	**Port Address**	**Port**
32701	SMU1	20002	SMU2
32702	SMU2	20003	SMU3
32703	SMU3	20004	SMU4
32704	SMU4	20005	SMU5
32705	AUX1(VS1)	20006	SMU6
32706	AUX2(VM1)	20006	SMU6
32707	GNDU	20009	GNDU
32708	CMH	20107	CMH
32709	CML	20108	CML
32710	GSMU	20110	GSMU2
32711	GCMU	20113	GCMU

Table 6-8 **Default HF Port Mapping Table (4072A only)**

4062F		4072A	
Port Address	**Port**	**Port Address**	**Port**
32741	HF1	20201	HF1
32742	HF2	20201	HF1
32743	HF3	20202	HF2
32744	HF4	20202	HF2
32745	HF5	20203	HF3
32746	HF6	20203	HF3
32747	HF7	20204	HF4
32748	HF8	20204	HF4
32749	HF9	20205	HF5
32750	HF10	20205	HF5
32751	HF11	20206	HF6
32752	HF12	20206	HF6

To Change Port Mapping

This section describes how to change port mapping table.

- If you logged into a test session by using hp4070 command, "Tester Management Panel" must have been started and perform the following procedure in the "Tester Management Panel" window to change the port mapping table.
- If you logged into a test session by executing `/opt/hp4070/bin/START` from HP BASIC/UX, execute `/opt/hp4070/bin/hp4070` to open "Tester Management Panel" and perform the following procedure in the "Tester Management Panel" window to change the port mapping table.

  ```
  $ hp4070
  ```

  Note that "Tester Management Panel" must have the same PCS_SESSION_ID as HP BASIC/UX window that is used to log into a test session.

1. Choose `Options: Port Number Mapping`... menu of the "Tester Management Panel" window. For displaying the HF port mapping table, choose `Option: HF Port Number Mapping...`menu.
2. The "hp4070 Port Number Mapping" or “hp4070 HF Port Number Mapping” window opens.

Figure 6-21 “hp4070 Port Number Mapping” Window

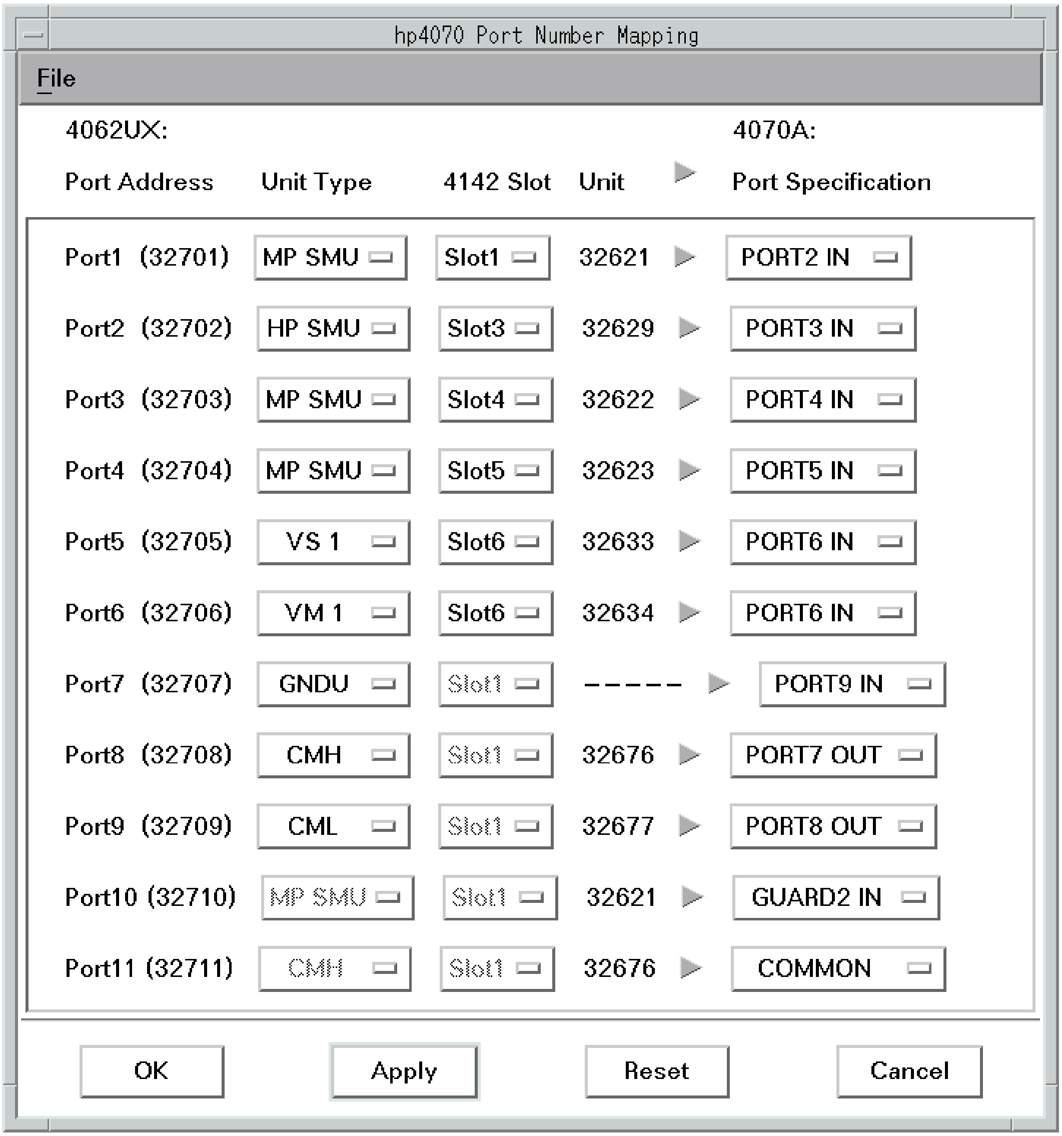
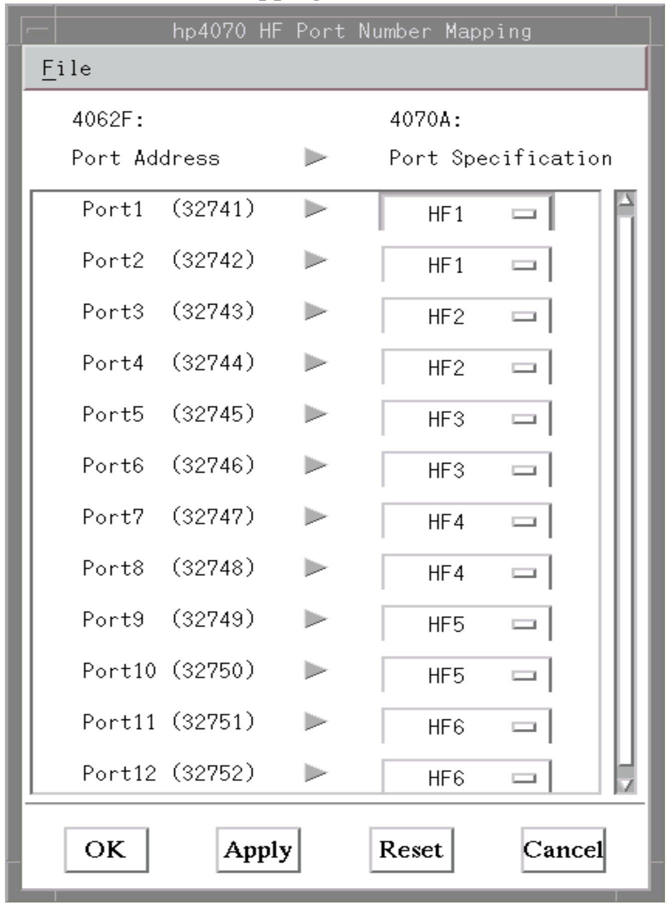


Figure 6-22 **"hp4070 HF Port Number Mapping" Window**



The "hp 4070 Port Number Mapping" and "hp 4070 HF Port Mapping" window display present port mapping table and you can change the table as follows:

- 4062UX: Port Addresses and 4062F: Port Address

  The 4062UX: Port Address column shows 4062's ports other than HF ports of 4062F and the port address of each port.

  The 4062F: Port Address column (4072A only) shows HF ports of 4062F and the port address of each port.

- 4062UX: Unit Type and 4062UX: 4142 Slot

  The selection buttons on these column show the unit configuration of 4142B in the 4062 and the connection between the unit and the port of 4062.

Change the unit type or slot number of 4142 by using the selection button if your 4062 has the different configuration.

Instead of manually changing 4062 unit configuration of port mapping, you can load the 4062 unit configuration from the DUMCONFIG file of 4062. Refer to “To Load 4062 Unit Configuration from DUMCONFIG”.

- 4062UX: Unit

  This column shows the 4062 unit address of each port. 4062 unit address is determined by Unit Type and 4142 Slot.

- 4070A: Port Specification

  The selection buttons on this column in the “hp4070 Port Number Mapping “ window shows the corresponding 4070 port other than HF and THF ports as shown inTable 6-9 and Table 6-10.

  The selection buttons on this column in the “hp4070 HF Port Number Mapping” window shows the corresponding 4072A HF, THF, and AUX ports as shown in Table 6-11.

Table 6-9 4070 Port Selection (1 of 2)

Selection	Port Name	Port Address
PORT1 IN	SMU1	20001
PORT2 IN	SMU2	20002
PORT3 IN	SMU3	20003
PORT4 IN	SMU4	20004
PORT5 IN	SMU5	20005
PORT6 IN	SMU6	20006
PORT7 IN	SMU7	20007
PORT8 IN	SMU8	20008
PORT9 IN	GNDU	20009

Table 6-10 **4070 Port Selection (2 of 2)**

Selection	Port Name	Port Address
PORT1 OUT	AUX1	20101
PORT2 OUT	AUX2	20102
PORT3 OUT	AUX3	20103
PORT4 OUT	AUX4	20104
PORT5 OUT	AUX5 (DVMH)	20105
PORT6 OUT	AUX6 (DVML)	20106
PORT7 OUT	AUX7 (CMH)	20107
PORT8 OUT	AUX8 (CML)	20108
GUARD1 IN	GSMU1	20109
GUARD2 IN	GSMU2	20110
COMMON	GCMU	20113

Table 6-11 4072A HF Port Selection

Selection	Port Name	Port Address
HF1	HF1	20201
HF2	HF2	20202
HF3	HF3	20203
HF4	HF4	20204
HF5	HF5	20205
HF6	HF6	20206
THF1	THF1	20211
THF2	THF2	20212
THF3	THF3	20213
PORT1 OUT	AUX1	20101
PORT2 OUT	AUX2	20102
PORT3 OUT	AUX3	20103
PORT4 OUT	AUX4	20104
PORT5 OUT	AUX5 (DVMH)	20105
PORT6 OUT	AUX6 (DVML)	20106
PORT7 OUT	AUX7 (CMH)	20107
PORT8 OUT	AUX8 (CML)	20108

The 4062's port address and unit address are converted to the port address of the 4070's port on this column.

3. Click OK to enable changed port mapping table in current test session.

To Load 4062 Unit Configuration from DUMCONFIG

Instead of manually changing the 4062 unit configuration of port mapping, you can load the 4062 unit configuration from the DUMCONFIG file of 4062.

To load the DUMCONFIG file:

1. Choose `File: Read DUMCONFIG` menu of the "hp4070 Port Number Mapping" window.
2. The "File Selection" dialog opens.
3. Enter DUMCONFIG with full path in selection field.
4. Click OK.

To Save Port Mapping Table into File

You can save the present port mapping table to a file.

1. Choose `File: Save as`… menu of the "hp4070 Port Number Mapping" window. To save HF port mapping table, choose `File: Save as...`menu of the "hp4070 HF Port Number Mapping" window.
2. File Selection dialog opens.
3. Enter a file name in selection field.
4. Click OK.

To Save as Default

You can save the present port mapping table as a default port mapping table, when starting a test session.

To save the present port mapping table as a default port mapping table:

1. Choose `File: Save as Default` menu of the "hp4070 Port Number Mapping" window. To save HF port mapping table, choose `File: Save as ...`menu of the "hp4070 HF Port Number Mapping" window.
2. Query dialog opens.
3. Click OK.

To Load Port Mapping Table from File

To load a port mapping table from a file:

From Port Number Mapping window,

1. Choose `File: Load`... menu of the "hp4070 Port Number Mapping" window. To load HF port mapping table, choose `File: Load...`menu of the "hp4070 HF Port Number Mapping" window.
2. File Selection dialog opens.
3. Enter a file name of the port mapping table in a selection field.
4. Click OK.

To Load Default Port Mapping Table

You can load the default port mapping table by only choosing `File: Load Default` menu of the "hp4070 Port Number Mapping" window. To load the default HF port mapping table, choose `File: Load Default` menu of the "hp4070 HF Port Number Mapping" window.

NOTE

From command line

- To load port mapping file, execute `/opt/hp4070/bin/hp4070` command as follows:

  `$ hp4070 -portmap` *file*

- (4072A only) To load HF port mapping file, execute `/opt/hp4070/bin/hp4070` command as follows:

`$ hp4070 -hfportmap` *file*

Setting Cable Connection Information (4072A only)

When you connect cables to the PGUs, or when you change the cable connections to the PGUs, you need to set the hardware connection information and send it to the test session in which the connection is used.

This section consists of the followings:

- "To Set PG Cable Connection Information"
- "To Save the PG Cable Connection Information into File"
- "To Load the PG Cable Connection Information from File"
- "To Print PG Cable Connection Information"

To Set PG Cable Connection Information

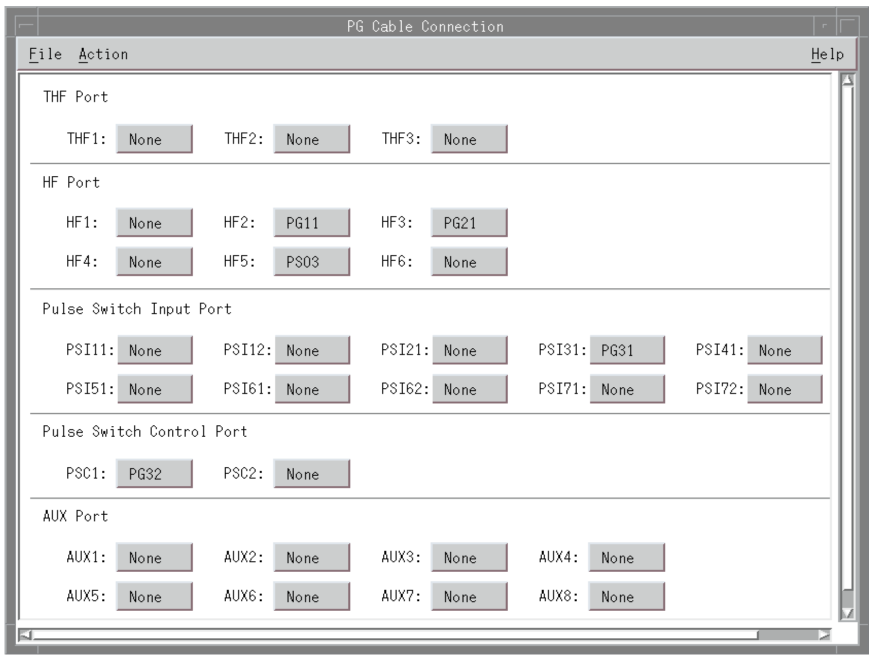
After checking if PGUs cable connections are proper, perform the following procedure:

1. Start a test session and execute the /opt/hp4070/bin/pgconn4070 program.

   ```
   $ pgconn4070
   ```

   The PG Cable Connection window is displayed.

Figure 6-23



2. In the PG Cable Connection window, set the connection lists using one of the following procedures:

   a. If you use the default file for hardware connection information(/etc/opt/hp4070/config/pgconnection file), select the File:Defaut menu.

      If the default file has the connection for the PGUs which does not exist, the selection button changed to display "None", and a vertical line is displayed to left of the field.

To Set PG Cable Connection Information

The pgconn4070 command with the -view option displays the PG Cable Connection window and the default information forthe PG connection. The pgconn4070 command with the -view option displays only the default information, which does not include the pulse generator product models. If your configuration includes a 8114A, be sure to verify the information is correct for your actual hardware. You cannot modify the displayed window using the pgconn4070 with the -view option.

```
$ pgconn4070 -view
```

b. If you use a connection setup from a previously saved file, select the File: Load... menu.

c. If you update the window by searching the actual hardware cable connections, select the Action: Search Actual Connection menu. The search operation takes a few minutes.

NOTE

When you execute the search operation, be sure to verify the matrix pins are opened. The search operation outputs voltage to the matirx pins. If there are any devices connected to matrix pins or if any of the matrix pins are shorted the search operation can cause incorrect connection information to be displayed.

You can manually set the connection information by pressing the selection button for each port field in the PG Cable Connection window.

3. Use the Action: Send Connection to Test Session menu to send the connection setup lists to the test session running on the hp4070 system with the same session ID as the one in the PG Cable Connection window. This operation initializes the 4072A system and then uses the connection information in each TIS statement.

The Load_pg_conf subprogram can also be used to load the default pgconnection file, load a previously saved connection information file, and to initialize the system.

To Save the PG Cable Connection Information into File

You can save the present PG cable connection information to a file.

1. Choose `File: Save as`... menu of the "PG Cable Connection" window.
2. File Selection dialog opens.
3. Enter a file name in selection field.
4. Click OK.

To Save as the Default

You can save the present PG cable connection information as the default used when starting a test session.

To save the present connection information as the default:

1. Choose the `File: Save as Default` selection in the "PG Cable Connection" window.
2. The Query dialog box opens.
3. Click OK.

To Load the PG Cable Connection Information from File

To load the PG cable connection information from a file:

1. Choose `File: Load`... menu of the "PG Cable Connection" window.
2. The File Selection dialog opens.
3. Enter the file name in the selection field.
4. Click OK.

To Load Default PG Cable Connection Information

You can load the default cable connection information by choosing the `File: Load Default` menu of the "PG Cable Connection" window.

To Print PG Cable Connection Information

To print out the PG cable connection information in the PG Cable Connection window,:

1. Choose the `File: Print...`nemu of the "PG Cable Connection" window.
2. The Print Dialog opens.
3. Enter print command.
4. Click OK.

Setting the Default Pulse Switch Condition (4072A only)

When you use a pulse switch, the default switching condition for the pulse switch has to be defined before you begin forcing pulses. The default switching condition of the pulse switch is set in the Pulse Switch Setting window.

In the Pulse Switch Setting window, you can set the default conditions for :

- the open/close switch condition of the PSO2 to PSO5 ports.
- whether or not the control pulse for the pulse switch is common to both PSC ports or independent for each PSC port.

The default condition file of the pulse switch can be changed only in the Pulse Switch Setting window. The Set_sr_mode or Set_sr_control TIS statements change the default switching conditions only for the test session with the same session ID as the executed TIS statements. The Init_system TIS statement does not change the default switching condition, but the hp4070 command uses the default file settings for the switch conditions.

This section consists of the following:

- "To Set the Default Pulse Switch Condition"
- "To Save Default Pulse Switch Condition"
- "To Load Default Pulse Switch Condition"

To Set the Default Pulse Switch Condition

This section describes how to change the default switching condition for the pulse switch.

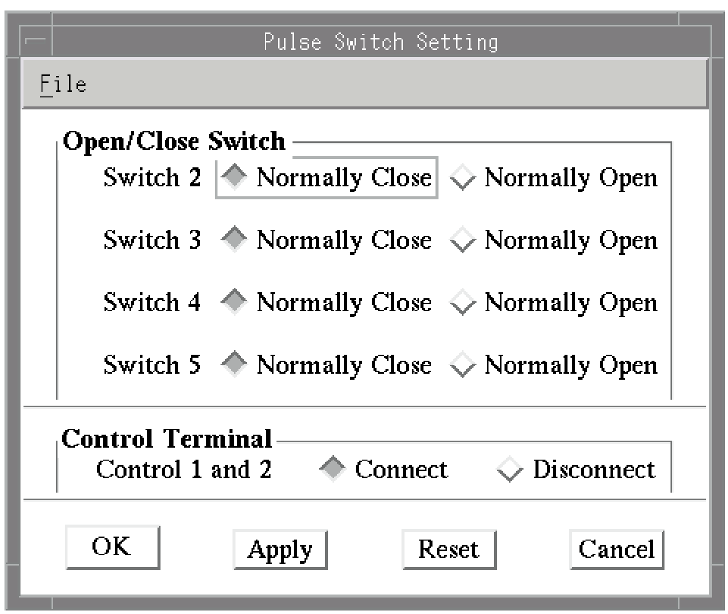
- The "Tester Management Panel" was opened if you logged into a test session using the hp4070 command. Perform the following procedure to change the default switching condition for the pulse switch.
- If you logged into a test session by executing `/opt/hp4070/bin/START` from HP BASIC/UX, then execute `/opt/hp4070/bin/hp4070` to open the "Tester Management Panel". Perform the following procedure.

  ```
  $ hp4070
  ```

  Note that the "Tester Management Panel" must have the same PCS_SESSION_ID as the HP BASIC/UX window used to log onto a test session.

1. Choose the `Options: Pulse Switch Setting...` menu of the "Tester Management Panel".
2. The Pulse Switch Setting window opens.

Figure 6-24



The Pulse Switch Setting window displays the default switching condition file for the pulse switch.

3. In the Open/Close switch setup area, select the Normally Close or Normally Open selection button.
4. To make the PSC1 and PSC2 ports independent of each other, in the Control Terminal setup area, select the Disconnect button. To have the PSC1 control all of the switches, select the Connect button .
5. Click OK to accept the switch conditions in the current test session.

To Reset the Modified Default Setting

The modified settings do not take effect until the Apply button is clicked. If you wish to return to the settings that existed when this window was first opened, click the Reset button or choose the File:Reset menu.

To Save Default Pulse Switch Condition

You can save the present default switch condition for pulse switch to a file.

1. Choose the `File: Save as`... menu of the Pulse Switch Setting window.
2. The File Selection dialog opens.
3. Enter a file name in the selection field.
4. Click OK.

To Save as Default

You can save the current pulse switch settings as the default conditions used when starting a test session.

1. Choos the `File: Save as Default` selection in the Pulse Switch Setting window.
2. Thr Query dialog box opens.
3. Click OK.

To Load Default Pulse Switch Condition

To load the default setting of the default pulse switch condition from a file:

1. Choose the `File: Load`... menu of the Pulse Switch Setting window.
2. The File Selection dialog opens.
3. Enter a file name in the selection field.
4. Click OK.

NOTE

From the command line

- Execute the /opt/hp4070/bin/hp4070 command as follows:

`$ hp4070 -pmux` *file*

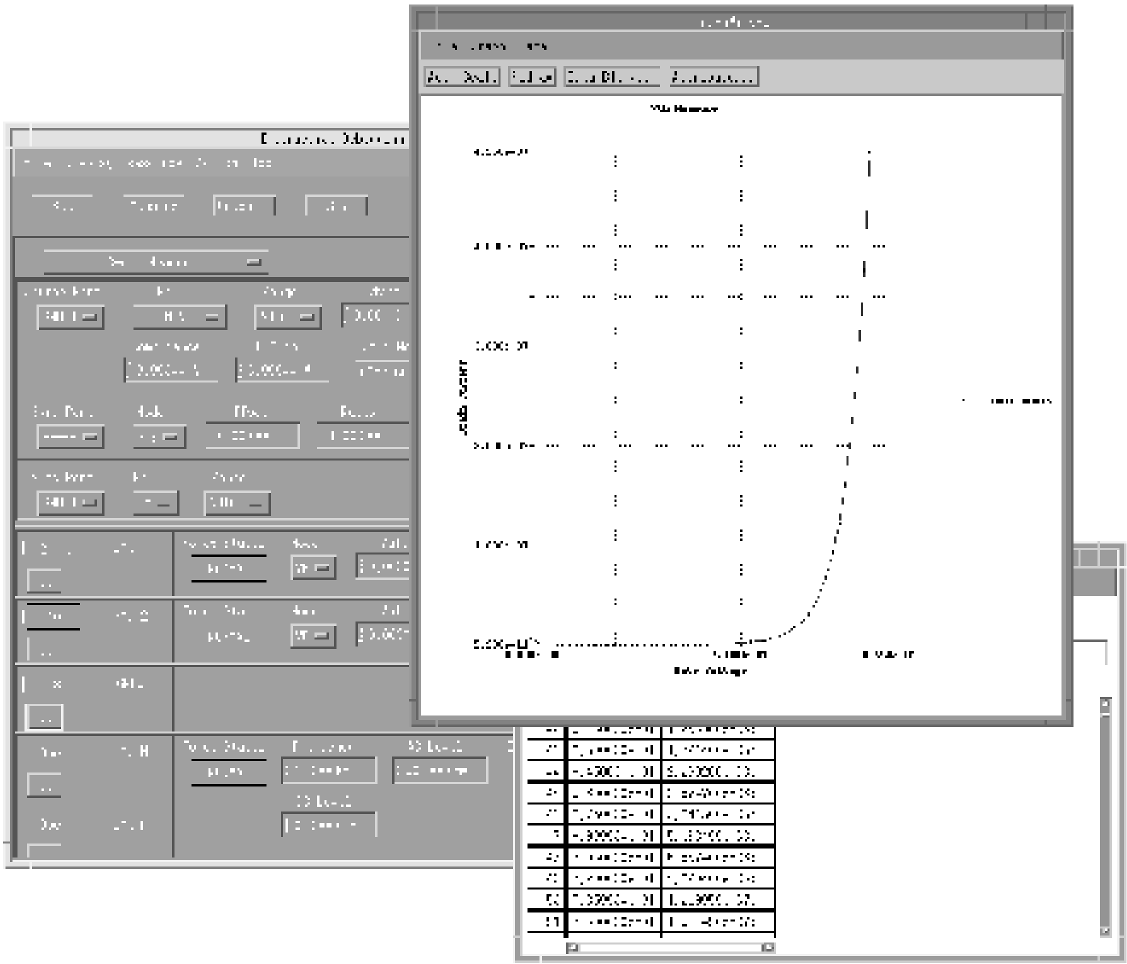
7 Using Interactive Debugging Panel (IDP)

The chapter explains the Interactive Debugging Panel (IDP) of Agilent 4070 system software and has the following main sections:

- "Starting and Stopping IDP"
- "Connecting Ports to Pins"
- "Forcing DC Bias and Setting Test Signal"
- "Forcing Pulses (4072A only)"
- "Executing Measurement"
- "Storing and Loading Measurement Setups"
- "Viewing Measurement Results"
- "Changing System Settings"

Interactive Debugging Panel window

Figure 7-1 **Interactive Debugging Panel window**



The following describes the main areas of this window:

- Menu Bar and Action buttons

  From this area, you can do the following:

  - Execute measurement or forcing according to the setup area.

    For some measurements, a Graph Window opens to display the measurement results. You can also list the results in a List Window.

  - Change system-wide settings (for example, optimization level, ADC).
  - Load or save setting information from or to a file
  - (4072A only) Displays the Pulse Generator Setup window for setting and forcing pulses by PGUs. In the Pulse Generator Setup window, program code for PGUs can be generated.
  - Displays the Switching Matrix Window for setting connections between instruments ports and switching matrix pins.
  - Generate program code according to the setup in the IDP. Refer to the *Programming Guide*.

- Measurement Setup and Monitor Area

  From this area, you can do the following:

  - Set up various measurements that can be executed from the IDP's action buttons
  - Change each field name to a desired field name by setting the Parameter Name Entry Dialog displayed after clicking each field name.
  - Monitor these settings as they are set by an executing measurement program. Refer to the *Programming Guide*.

- Force Setup and Monitor Area

  From this area, you can do the following:

  - Set up the following: connections between instrument ports and switching matrix pins, dc bias source for SMUs and CMU, and test signal of CMU. These settings can be executed from the IDP's action buttons.
  - Change each field name to a desired field name by setting the Parameter Name Entry Dialog displayed after clicking each field name.
  - Monitor these settings as they are set by an executing measurement program. Refer to the *Programming Guide*.

Starting and Stopping IDP

This section explains how to start or stop IDP:

- "To Start IDP"
- "To Stop IDP"

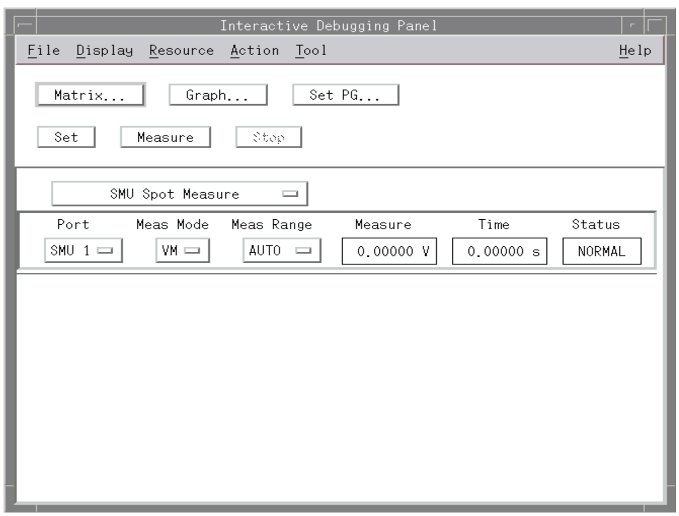
To Start IDP

1. Execute the `/opt/hp4070/bin/idp4070` command as follows:

   `$ idp4070 &`

2. The Interactive Debugging Panel window opens as shown in the following figure:

Figure 7-2



You can start IDP from either an online or offline test session, but only one IDP can be started from one test session (usually one user).

To Stop IDP

1. Choose `File: Exit` menu of the Interactive Debugging Panel window.
2. Confirmation dialog opens. Click YES to exit.

Connecting Ports to Pins

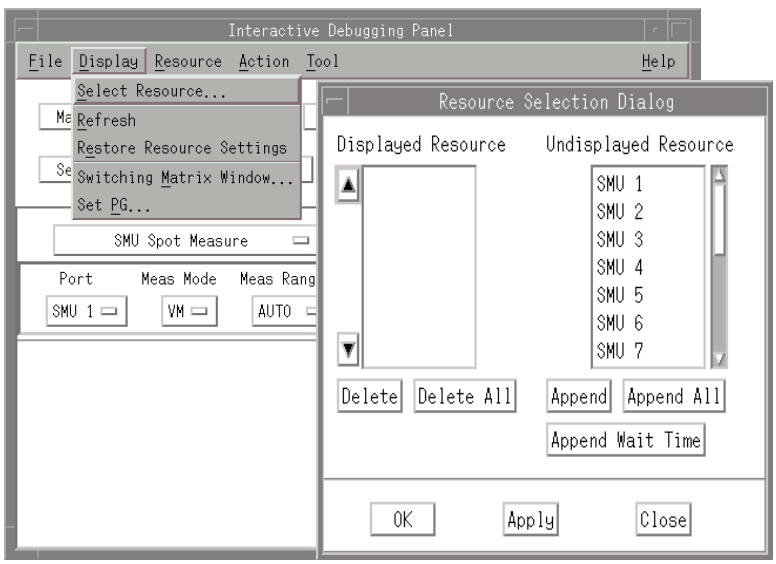
This section explains how to connect instrument ports to switching matrix pins.

You must connect the desired ports to the desired pins before executing measurement as follows:

1. Select the ports that you want to connect to switching matrix pins:

   a. Choose `Display: Select Resource` menu. The Resource Selection Dialog is displayed. If you use PGUs of 4072A, choose `Display: Set PG` menu to display Pulse Generator Setup window, then choose `Display: Select PG Resource` menu in the Pulse Generator Setup window.

Figure 7-3



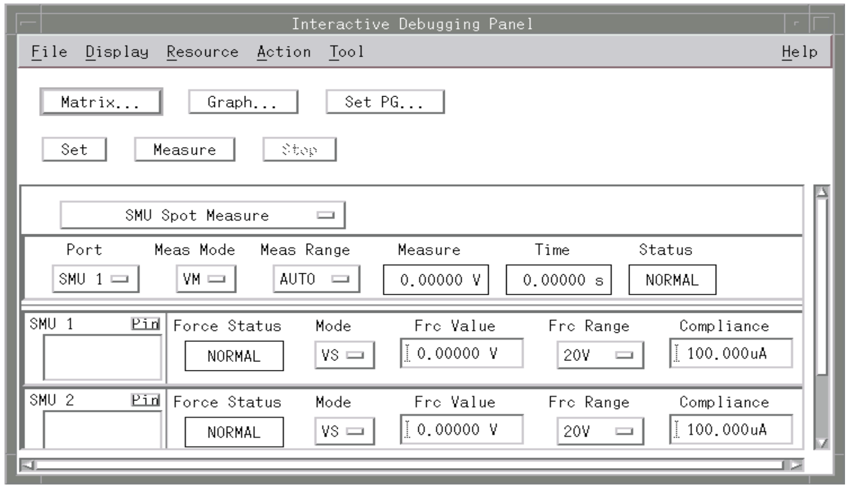
   b. Click desired port name in the Undisplayed Resource area. The port name is highlighted.

   c. Click Append button. The port name appears in the Displayed Resource area.

   d. Repeat this for all desired ports.

   e. After selecting the desired ports, click OK. The desired ports are displayed in Force Setup and Monitor Area as in following figure.

Figure 7-4

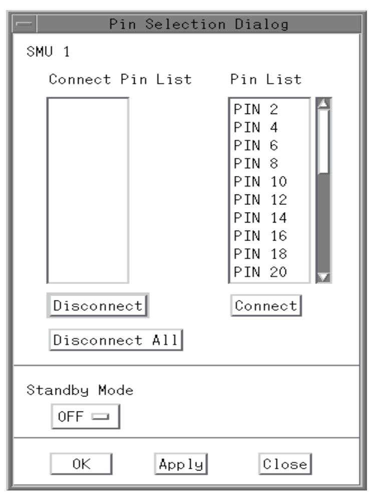


2. Select the switching matrix pins that you want to connect to each port by clicking Pin or Matrix button:

- By Using Pin Button

a. Click Pin button at desired port to open the Pin Selection Dialog.

Figure 7-5



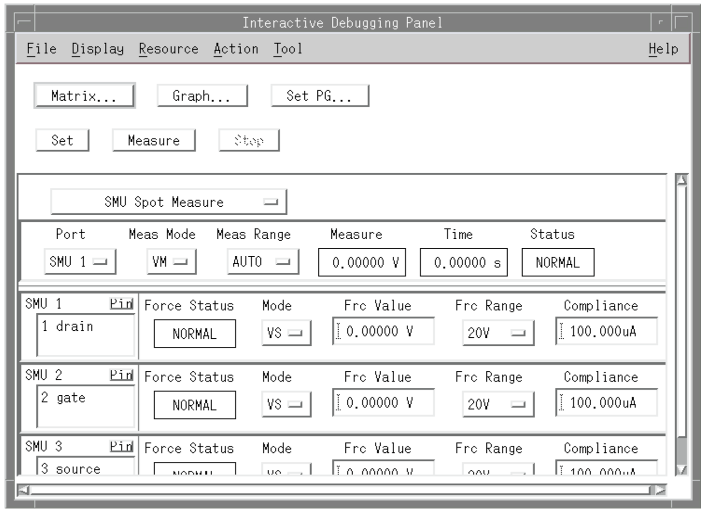
b. Click desired pin name in Pin List. The pin name is highlighted.

c. Click Connect button. The pin name appears in the Connect Pin List area.

d. Repeat this for all pins that you want to connect to the port.

e. Click OK. The selected pin numbers appear in display bellow the Pin button as shown in the following figure.

Figure 7-6



At this time, selected pins are not connected to port, and a vertical line is displayed to left of the display field.

f. Repeat this for each port that you will use.

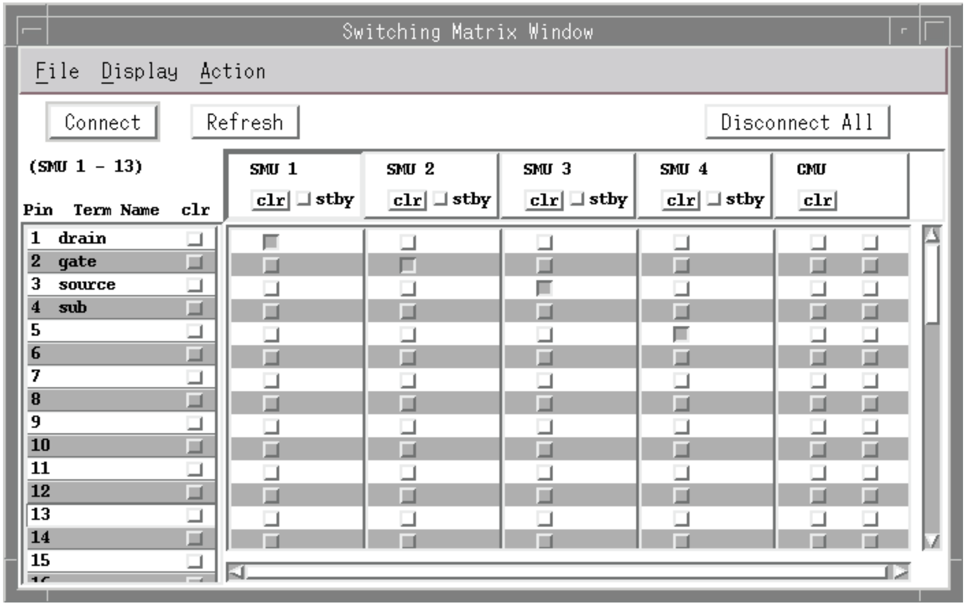
- By Using Matrix Button

a. Click Matrix... button in the IDP main window or in the Pulse Generator Setup window, or choose Display: Switching Matrix Window... menu. The Switching Matrix Window is displayed.

b. Click desired button to be connected. When mouse cursor is placed on a button, corresponding connection of the port and the pin is displayed below the Connect button like: “(SMU2-3)”.

For CMU connection, the left buttons are for the CMH port and the right buttons are for the CML port.

Figure 7-7



c. Repeat for all buttons that you want to connect ports and pins.

d. (Optional) Set desired terminal name in the Term Name field.

3. To actually connect selected pins to a port, click the Set button in the IDP main window, Connect button in the Switching Matrix Window, or Force action button in the Pulse Generator Setup window.

Forcing DC Bias and Setting Test Signal

This section explains how to do the following:

- "To Force Voltage or Current from SMU"
- "To Set Test Signal and DC Bias of CMU"
- "To Set Wait Time"

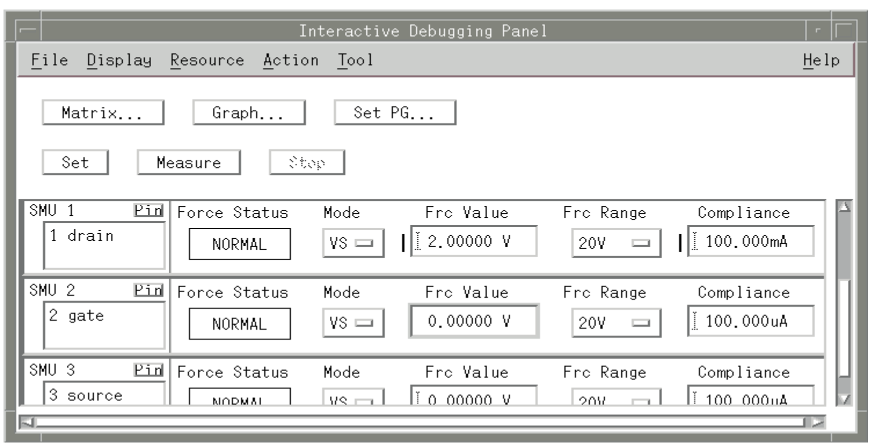
To Force Voltage or Current from SMU

This section explains how to force voltage or current from an SMU that will be used as a bias source.

Before forcing, you need to connect each force port to desired measurement pins. Refer to "Connecting Ports to Pins" on page 7-6.

You can set the force parameters of desired ports in the Force Setup and Monitor Area.

Figure 7-8



1. Select the force mode by using Mode option menu:

   VF: Voltage Force

   IF: Current Force

2. Enter the force value in Value field.

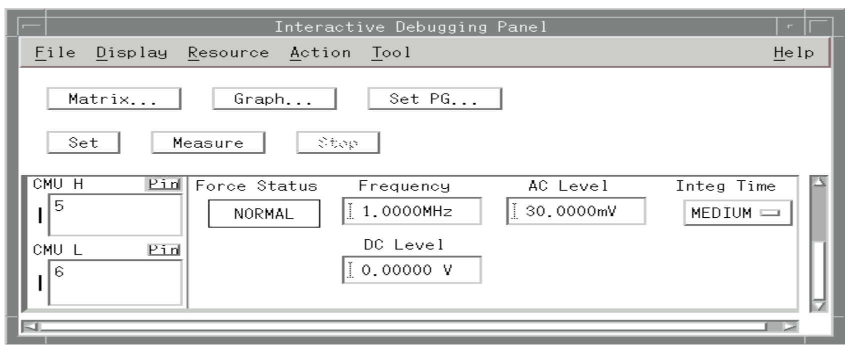
3. Select output range by using Range option menu.
4. Enter compliance value in Compliance field.
5. To force output from the SMU ports, click Set button at upper left of Interactive Debugging Panel.

To Set Test Signal and DC Bias of CMU

To force dc bias from CMU, you need to connect CMH port to switching matrix pins. Refer to “Connecting Ports to Pins” on page 7-6.

To set the parameters of the test signal or force bias voltage, you use the Force Setup and Monitor Area for CMH and CML.

Figure 7-9



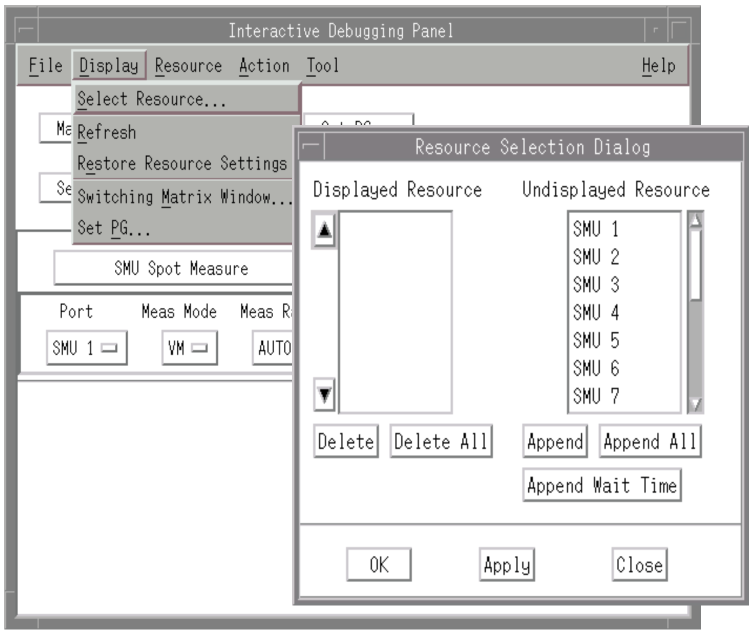
1. Specify parameters of test signal as follows:
   - Enter desired frequency of test signal in the Frequency field.
   - Enter desired voltage of test signal in the AC Level field.
   - Select desired integration time (SHORT, MEDIUM, or LONG) in Integ Time option menu.
2. Enter desired dc bias voltage in DC Level field.
3. To become the setting of the test signal and dc bias effective, click Set button at upper left of Interactive Debugging Panel.

To Set Wait Time

This section explains how to set wait time.

1. Choose Display: Select Resource menu. The resource Selection Dialog is displayed.

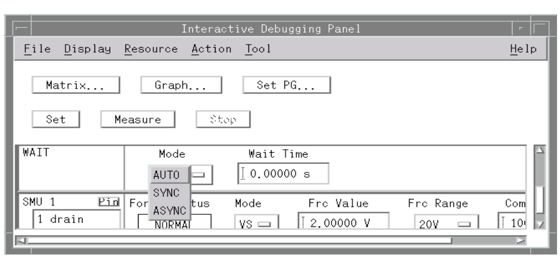
Figure 7-10



2. Select Append Wait Time button between resources in which to take wait time, then click OK. If you place choose Append Wait Time in the last of the selected resources, wait time is taken before measurement.

3. Set the parameters or wait time.

Figure 7-11



Mode: Selects wait time mode by using this option menu.

- Auto

  If any resources except for SMUs and GNDU are not selected below this wait time field, and if SMUs are specified as measurement units, “Async” mode is used. In other cases, “Sync” mode is used.

- Sync

  Wait time is set by using “Sync_th” TIS statement. Specified wait time is taken after all operations are completed by testhead, even if SMU are specified before WAIT time field. For details of Sync_th, refer to Programming Reference.

- Async

  Wait time is set by using “Wait_th” TIS statement. Testhead CPU waits specified wait time after previous SMU operation. So for CMU and DVM, this setup does nothing.

Time: Sets wait time

Forcing Pulses (4072A only)

This section explains how to force pulses by using PGUs from IDP.

- “Before Setting and Forcing Pulses”
- “To Select Pulse Operation Type”
- “To Force General Pulse”
- “To Write NAND Type Flash Memory”
- “To Erase NAND Type Flash Memory”
- “To Repeat Write and Erase of NAND Type Flash Memory”
- “To Write NOR Type Flash Memory”
- “To Erase NOR Type Flash Memory”
- “To Repeat Write and Erase of NOR Type Flash Memory”
- “To Write Low-power NOR Type Flash Memory”
- “To Erase Low-power NOR Type Flash Memory”
- “To Repeat Write and Erase of Low-power NOR Type Flash Memory”
- “To Write Low-power NOR Type Flash Memory with Multiplexer”
- “To Erase Low-power NOR Type Flash Memory with Multiplexer”
- “To Repeat Write and Erase of Low-power NOR Type Flash Memory with Multiplexer”
- “To View Setup Pulse Waveform”

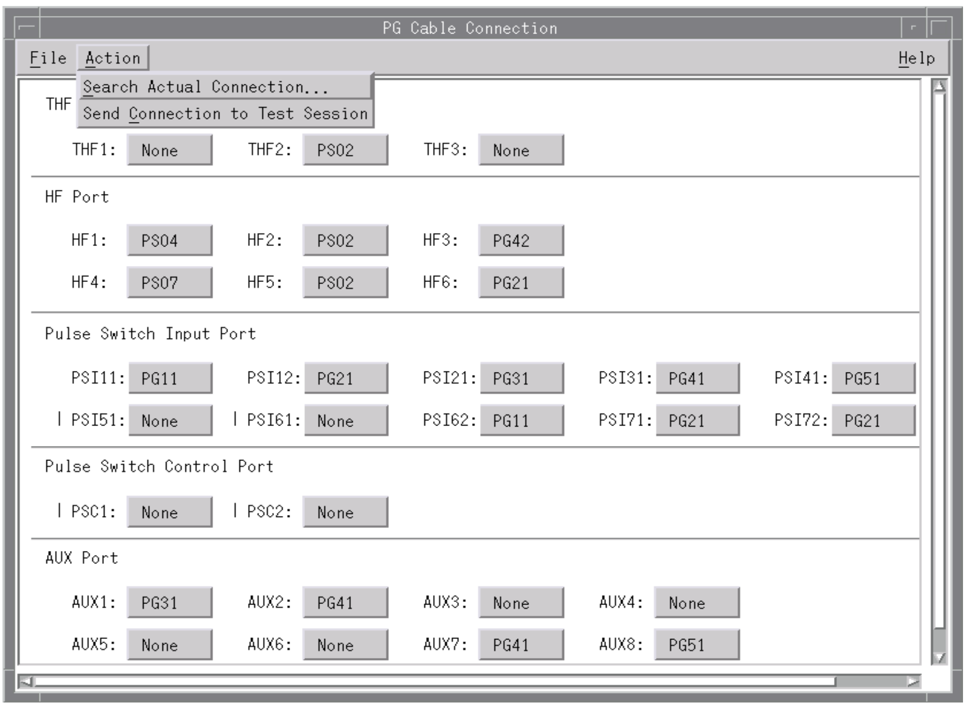
Before Setting and Forcing Pulses

Before setting and forcing pulses in the Pulse Generation Setup window in the IDP, do the following procedure:

1. Connect PGUs and Ports by using cables.
2. Set the hardware connection and send the connection information to the Test session as follows:

    a. Execute /opt/hp4070/bin/pgconn4070 to display the PG Cable Connection window.

Figure 7-12



    b. Select Action: Search Actual Connection menu. Or Select File: Load... menu, if you use connection setup from previously saved file. You can also set the connection information in each field manually.

    c. Select: Action Send Connection to Test Session menu to send the connection setup lists in the window to the test session running in the hp4070 system that has the same session ID of the PG Cable Connection window.

3. Set default condition for pulse switch as following proceedure, if you use pulse switch.

   a. Select Option: Pulse Switch Setting menu in the Tester Management Panel. Then the Pulse Switch Setting window is displayed.

   b. Set the default condition, then select OK.

4. Connect each port to pin. For details, refer to “Connecting Ports to Pins” on page 7-6.

To Select Pulse Operation Type

1. Display the Pulse Generator Setup window by choosing Display:Set PG... menu, or selecting Set PG... action button in the IDP main window.

2. Select desired pulse operation type option menu:

Figure 7-13

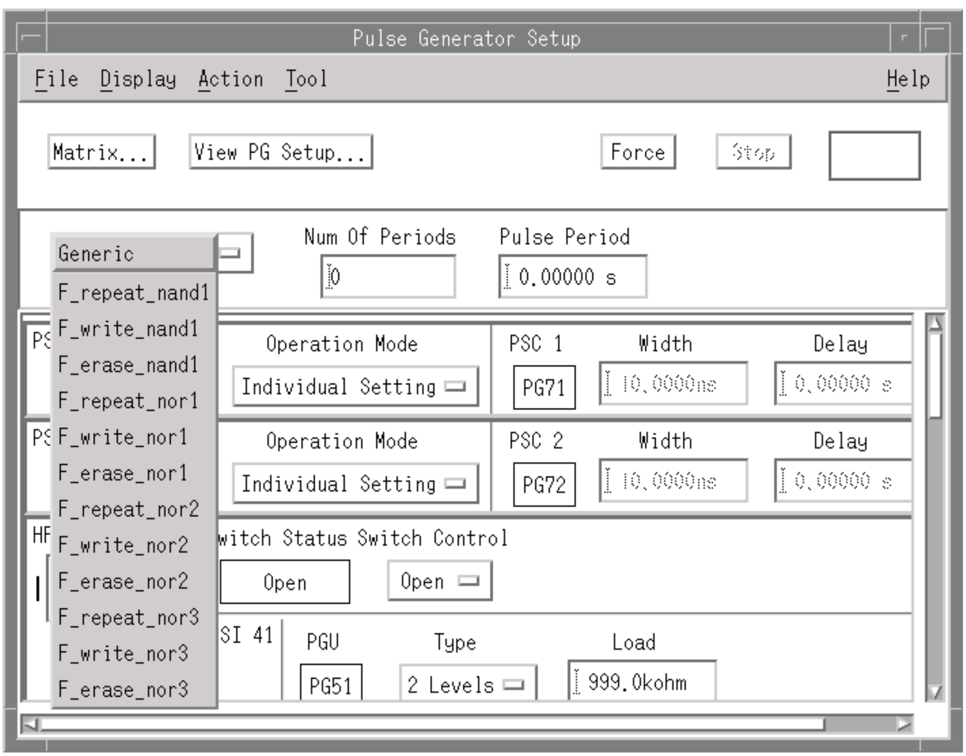


Table 7-1

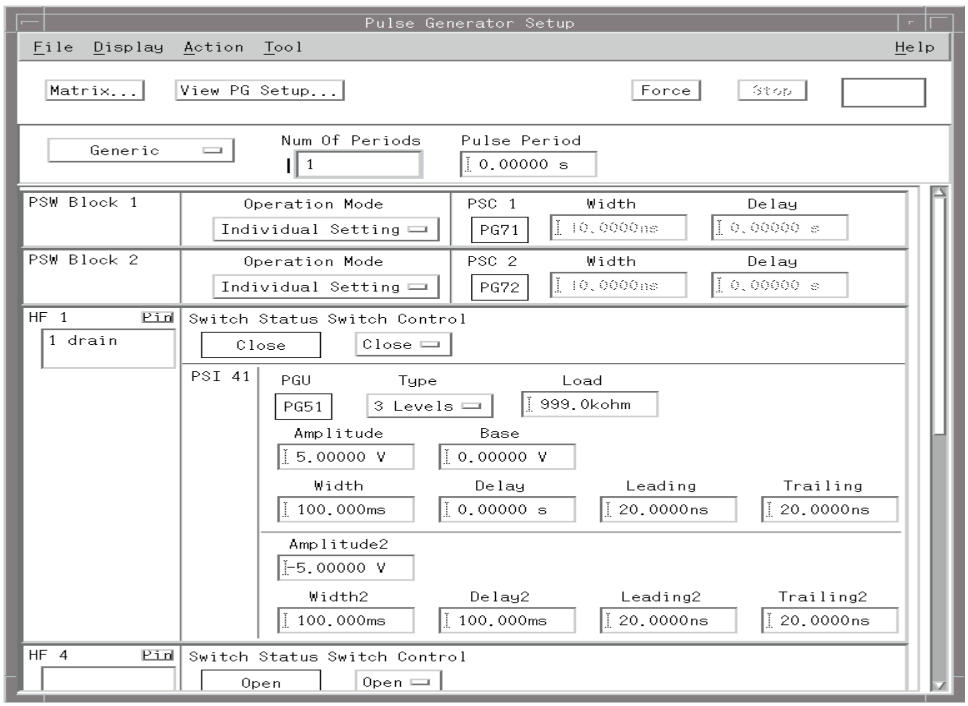
Menu	Desctiption
Generic	General pulses.
F_repeat_nand1	Continuous write and erase operation of the NAND type flash memory cell. Corresponding to F_repeat_nand1, f_repeat_nand1 for BASIC and C F_ROM library, respectively.
F_write_nand1	Write operation of the NAND type flash memory cell. Corresponding to F_wtire_nand1, f_write_nand1 for BASIC and C F_ROM library, respectively.
F_erase_nand1	Erase operation of the NAND type flash memory cell. Corresponding to F_erase_nand1, f_erase_nand1 for BASIC and C F_ROM library, respectively.
F_repeat_nor1	Continuous write and erase operation of the NOR type flash memory cell. Corresponding to F_repeat_nor1, f_repeat_nor1 for BASIC and C F_ROM library, respectively.
F_write_nor1	Write operation of the NOR type flash memory cell. Corresponding to F_wtire_nor1, f_write_nor1 for BASIC and C F_ROM library, respectively.
F_erase_nor1	Erase operation of the NOR type flash memory cell. Corresponding to F_erase_nor1, f_erase_nor1 for BASIC and C F_ROM library, respectively.
F_repeat_nor2	Continuous write and erase operation of the NOR type low-power flash memory cell. Corresponding to F_repeat_nor2, f_repeat_nor2 for BASIC and C F_ROM library, respectively.
F_write_nor2	Write operation of the NOR type low-power flash memory cell. Corresponding to F_wtire_nor2, f_write_nor2 for BASIC and C F_ROM library, respectively.

Menu	Desctiption
F_erase_nor2	Erase operation of the NOR type low-power flash memory cell. Corresponding to F_erase_nor2, f_erase_nor2 for BASIC and C F_ROM library, respectively.
F_repeat_nor3	Continuous write and erase operation of the NOR type low-power flash memory cell using multiplexer. Corresponding to F_repeat_nor3, f_repeat_nor3 for BASIC and C F_ROM library, respectively.
F_write_nor3	Write operation of the NOR type low-power flash memory cell using multiplexer. Corresponding to F_wtire_nor3, f_write_nor3 for BASIC and C F_ROM library, respectively.
F_erase_nor3	Erase operation of the NOR type low-power flash memory cell using multiplexer. Corresponding to F_erase_nor3, f_erase_nor3 for BASIC and C F_ROM library, respectively.

To Force General Pulse

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `Generic` pulse operation type from option menu:

Figure 7-14



3. If you use pulse switches, sett parameters for the pulse switch control:

PSW Block *x* Set the following parameters in each column for controling block 1 of the pulse switch (pulse switches for PSO 1 to 4) :

- PSW Block 1: Sets pulse switch control of the block 1 (pulse switches for PSO1 to 4)
- PSW Block 2: Sets pulse switch control of the block 2 (pulse switches for PSO5 to 7)

To Force General Pulse

Operation Mode	Select pulse switch control mode by using this option menu: • Individual Setting: Controls each pulse switch directly by setting at each port connected to each pulse switch. • PSC1 Synchro: Setting PSC1 Synchro in both PSW Block 1 and 2 fields controls pulse switches synchroniously with the pulse signal from PGU connected to PSC1. If you select this mode in the PSW Block 2 column, the pulse switches of block 1 and 2 are synchrously controlled by the PGU connected to PSC1. • (PSW Block 2 only) PSC2 Synchro: Controls pulse switches synchroniously with the pulse signal from PGU connected to PSC2.
PSC *x*	Displays the PGU connected to each PSC port.
Width	Pulse width for PSC port.
Delay	Pulse delay time for PSC port.

4. Set parameters for each pulse source:

Switch Status	(PSO ports only) Displays the current pulse switch condition.
Switch Control	(PSO ports only) Select pulse switch control by using this option menu: • Open: Connects the pulse switch. • Close: Disconnects the pulse switch.
PGU	Displays the output terminal of PG connected to corresponding port.
Type	Select 2-level or 3-level pulse type by using this Type option menu.
Load	Load impedance value.
Amplitude	Pulse amplitude value.
Base	Pulse base value.
Width	Pulse width value.
Delay	Pulse delay time.

Leading	Pulse leading-edge transition time. (Ignored if 8114A)
Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)

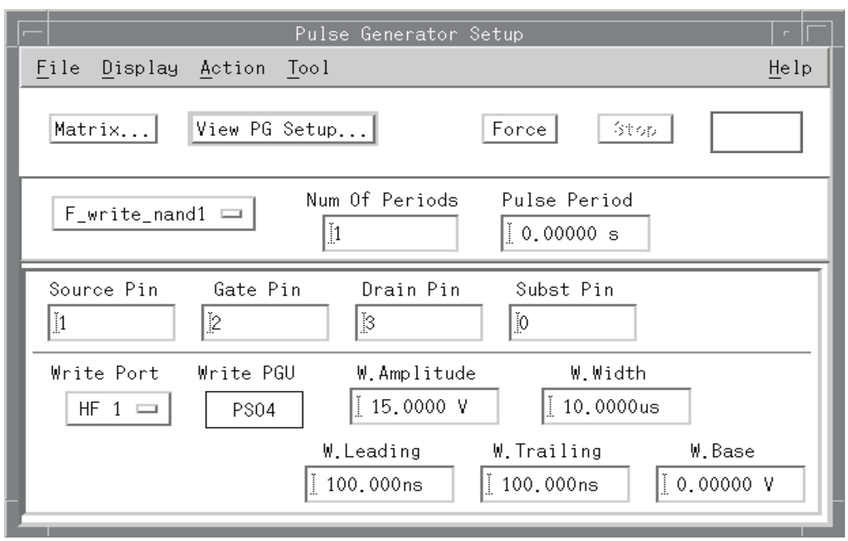
If you select 3-level pulse type by the Type option menu, set Amplitude2, Width2, Delay2, Leading2, and Trailing2 fields, too.

5. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
6. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Write NAND Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_write_nand1` pulse operation type from option menu:

Figure 7-15



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.

To Write NAND Type Flash Memory

Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source:

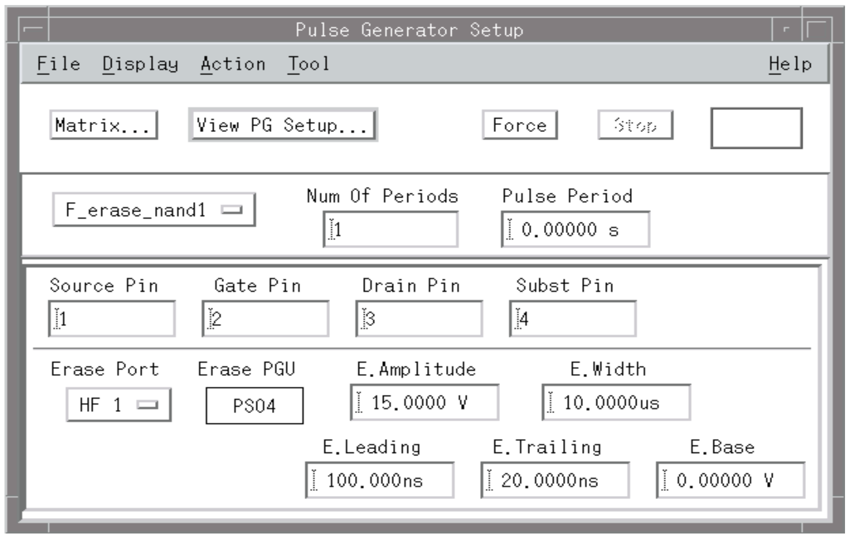
Write Port	Select HF, THF, or AUX port number connected to write terminal (Gate) by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch.)
Write PGU	Displays the output terminal of PGU connected to write terminal.
W.Amplitude	Pulse amplitude value.
W.Width	Pulse width value.
W.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
W.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
W.Base	Pulse base value.

5. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
6. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Erase NAND Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_erase_nand1` pulse operation type from option menu:

Figure 7-16



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source:

Erase Port	Select HF, THF, or AUX port number connected to erase terminal (Source, Drain, and Substrate) by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch.)

To Erase NAND Type Flash Memory

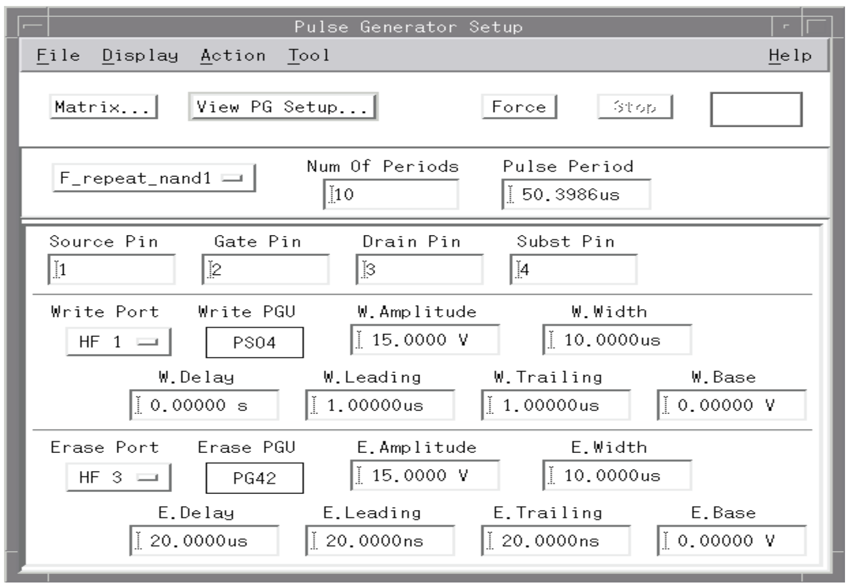
Erase PGU	Displays the output terminal of PGU connected to erase terminal.
E.Amplitude	Pulse amplitude value.
E.Width	Pulse width value.
E.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
E.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
E.Base	Pulse base value.

5. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
6. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Repeat Write and Erase of NAND Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_repeat_nand1` pulse operation type from option menu:

Figure 7-17



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to write terminal:

Write Port	Select HF, THF, or AUX port number connected to write terminal (Gate) by using this option menu. Must be different from source port. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Write PGU	Displays the output terminal of PGU connected to write terminal.
W.Amplitude	Pulse amplitude value.
W.Delay	Pulse delay value.
W.Width	Pulse width value.
W.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
W.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
W.Base	Pulse base value.

5. Set parameters for pulse source connected to erase terminal:

Erase Port	Select HF, THF, or AUX port number connected to erase terminal (Source, Drain, and Substrate) by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch) . Must be different from gate port.
Erase PGU	Displays the output terminal of PGU connected to erase terminal.
E.Amplitude	Pulse amplitude value.
E.Width	Pulse width value.
E.Delay	Pulse delay value.
E.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
E.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
E.Base	Pulse base value.

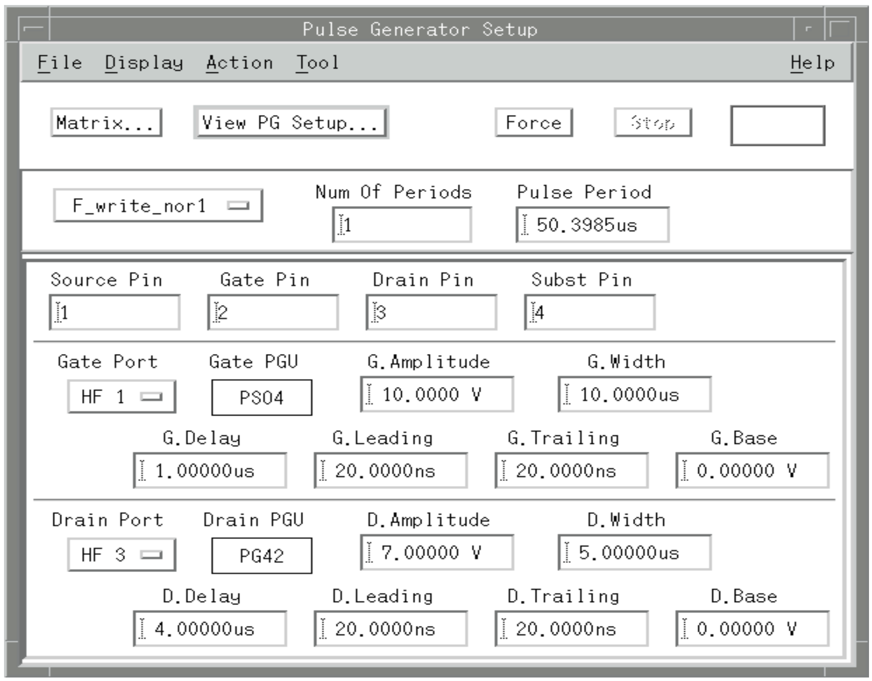
6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.

7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Write NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_write_nor1` pulse operation type from option menu:

Figure 7-18



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to write terminal (Gate) by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Gate PGU	Displays the output terminal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.
G.Width	Pulse width value.
G.Delay	Pulse delay value.
G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to drain terminal:

Drain Port	Select HF, THF, or AUX port number connected to write terminal (Drain) by using this option menu. The port must not connect to PSIx2 (input 2 of multiplexer switch). Must be different from gate port.
Drain PGU	Displays the output terminal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Delay	Pulse delay value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
D.Base	Pulse base value.

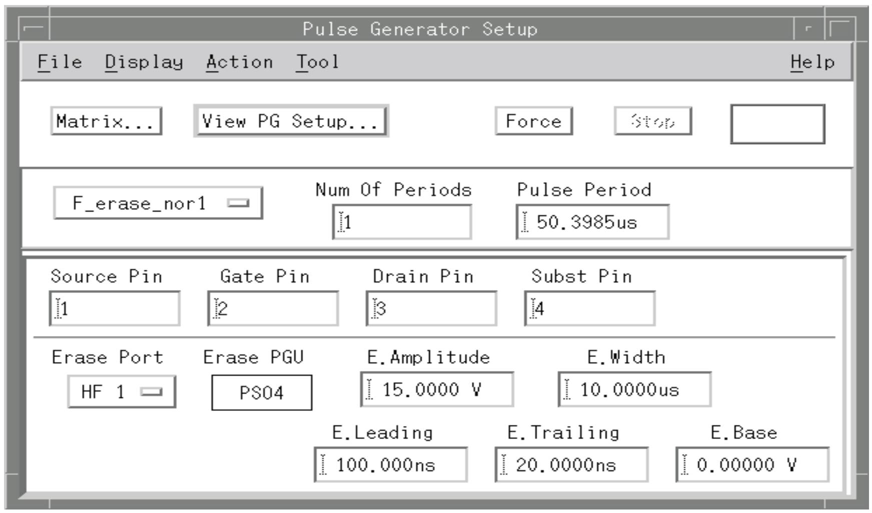
6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.

7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Erase NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_erase_nor1` pulse operation type from option menu:

Figure 7-19



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source:

Erase Port	Select HF, THF, or AUX port number connected to erase terminal (Source) by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch).

To Erase NOR Type Flash Memory

Erase PGU	Displays the output terminal of PGU connected to erase terminal.
E.Amplitude	Pulse amplitude value.
E.Width	Pulse width value.
E.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
E.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
E.Base	Pulse base value.

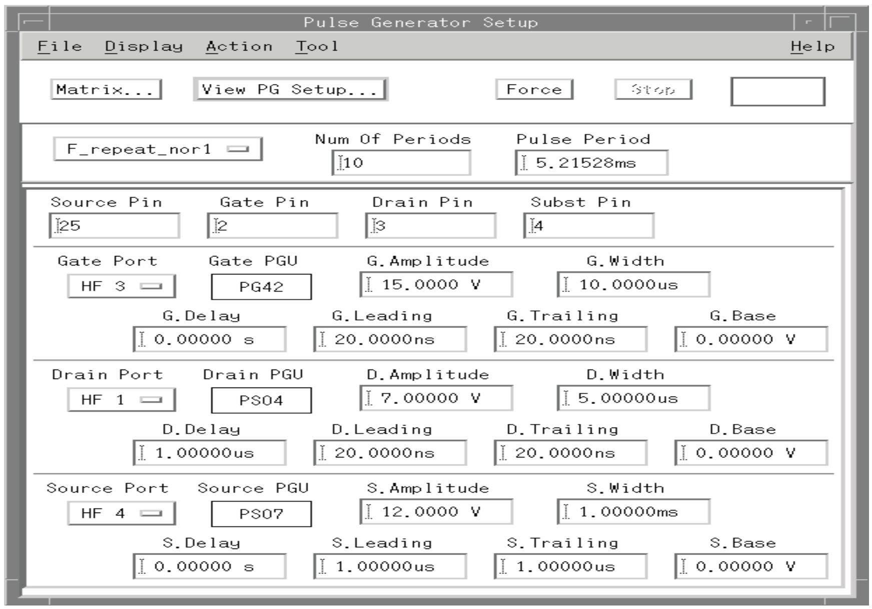
5. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
6. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Repeat Write and Erase of NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.

2. Select `F_repeat_nor1` pulse operation type from option menu:

Figure 7-20



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

To Repeat Write and Erase of NOR Type Flash Memory

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. Must be different from drain or source port. The port must not be connected to the pulse switch port or not be connected to PSIx1 in different control block of drain port.
Gate PGU	Displays the output terminal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.
G.Width	Pulse width value.
G.Delay	Pulse delay value.
G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to drain terminal:

Drain Port	Select HF, THF, or AUX port number connected to drain terminal by using this option menu. Must be connected to open/close switch.
Drain PGU	Displays the output terminal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Delay	Pulse delay value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
D.Base	Pulse base value.

6. Set parameters for pulse source connected to source terminal:

Source Port	Select HF, THF, or AUX port number connected to source terminal by using this option menu. Must be different from gate or drain port. The port must not be connected to the pulse switch port or not be connected to PSIx1 in different control block of drain port.
Source PGU	Displays the output terminal of PGU connected to source terminal.

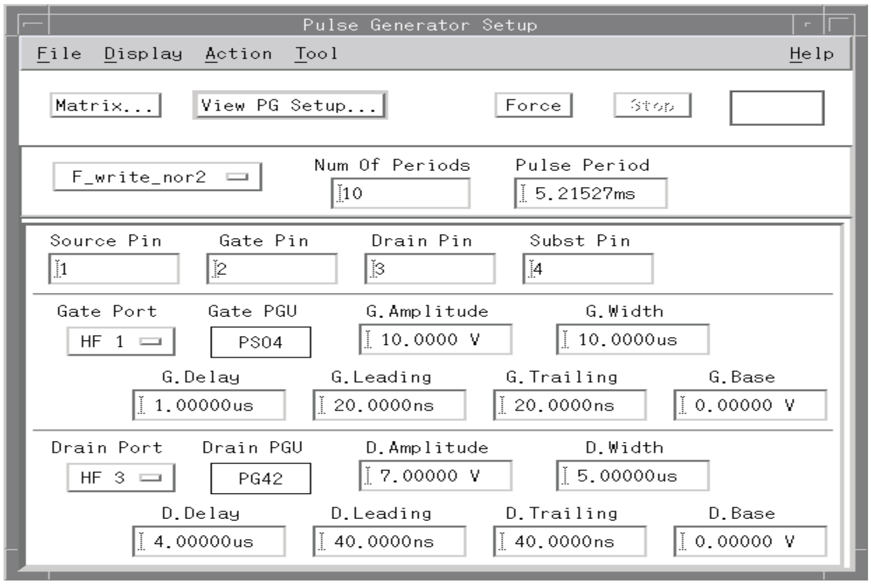
S.Amplitude	Pulse amplitude value.
S.Width	Pulse width value.
S.Delay	Pulse delay value.
S.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
S.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
S.Base	Pulse base value.

7. Set Num of Periods (number of period) or Pulse Period field. If you set 0 in the Num of Periods field, pulse output continues till Stop action button is clicked.
8. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Write Low-power NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_write_nor2` pulse operation type from option menu:

Figure 7-21



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. The port must not connect to PSIx2 (input 2 of multiplexer switch).
Gate PGU	Displays the output terninal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.
G.Width	Pulse width value.
G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to drain terminal:

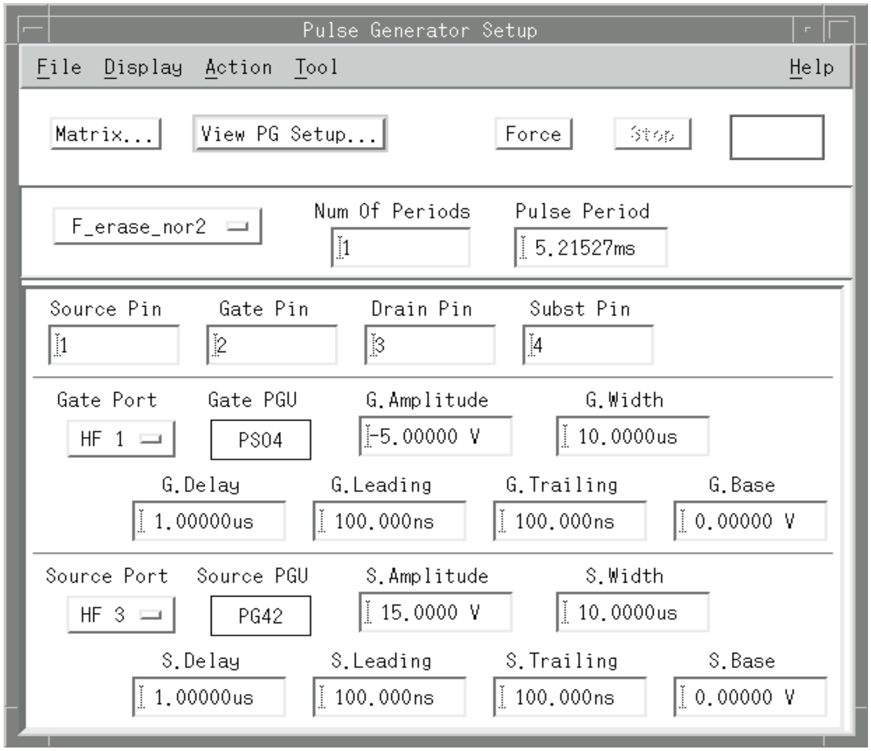
Drain Port	Select HF, THF, or AUX port number connected to drain terminal by using this option menu. The port must not connect to PSIx2 (input 2 of multiplexer switch). Must be different from gate port.
Drain PGU	Displays the output terninal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
D.Base	Pulse base value.

6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Erase Low-power NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_erase_nor2` pulse operation type from option menu:

Figure 7-22



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. Must be different from drain or source port. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Gate PGU	Displays the output terninal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.
G.Width	Pulse width value.
G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to source terminal:

Source Port	Select HF, THF, or AUX port number connected to source terminal by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Source PGU	Displays the output terminal of PGU connected to source terminal.
S.Amplitude	Pulse amplitude value.
S.Width	Pulse width value.
S.Delay	Pulse delay value.
S.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
S.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
S.Base	Pulse base value.

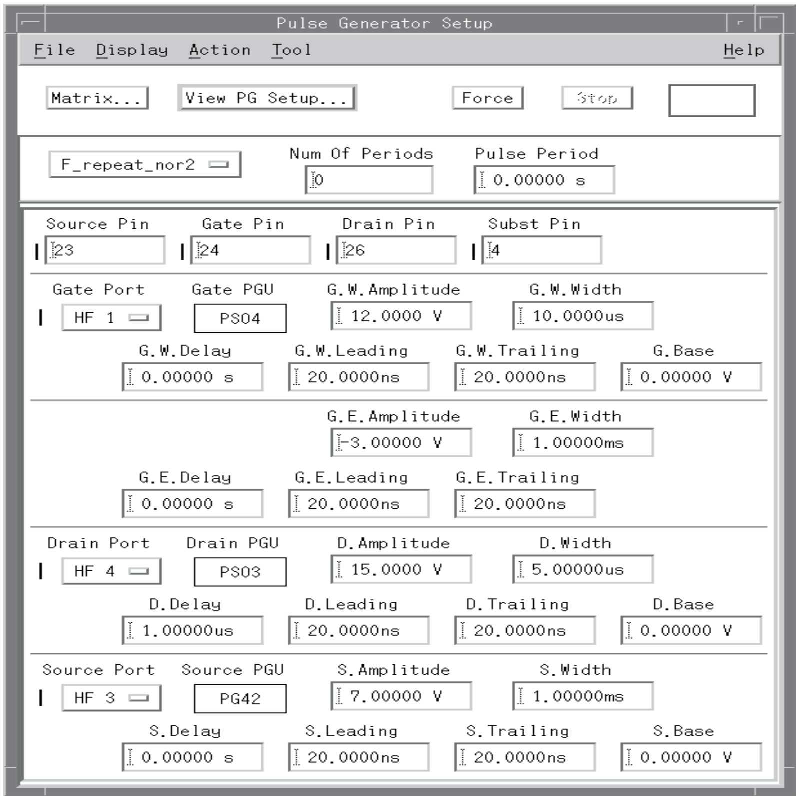
6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Repeat Write and Erase of Low-power NOR Type Flash Memory

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.

2. Select `F_repeat_nor2` pulse operation type from option menu:

Figure 7-23



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. The port cannot be connected to the pulse switch port or connected to PSIx1 in different control block of drain port. A connected PGU must be PGx1 (channel 1 of PG) and PG must not be 8114A.
Gate PGU	Displays the output temninal of PGU connected to gate terminal.
G.W.Amplitude	Write pulse amplitude value.
G.W.Width	Write pulse width value.
G.W.Delay	Write pulse delay value.
G.W.Weading	Write pulse leading-edge transition time. (Ignored if 8114A)
G.W.Trailing	Write pulse trailing-edge transition time. (Ignored if 8114A)
G.W.Base	Write pulse base value.
G.E.Amplitude	Erase pulse amplitude value.
G.E.Width	Erase pulse width value.
G.E.Delay	Erase pulse delay value.
G.E.Weading	Erase pulse leading-edge transition time. (Ignored if 8114A)
G.E.Trailing	Erase pulse trailing-edge transition time. (Ignored if 8114A)

5. Set parameters for pulse source connected to drain terminal:

Drain Port	Select HF, THF, or AUX port number connected to drain terminal by using this option menu. Must connect to open/close switch.
Drain PGU	Displays the output terminal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)

D.Base	Pulse base value.

6. Set parameters for pulse source connected to source terminal:

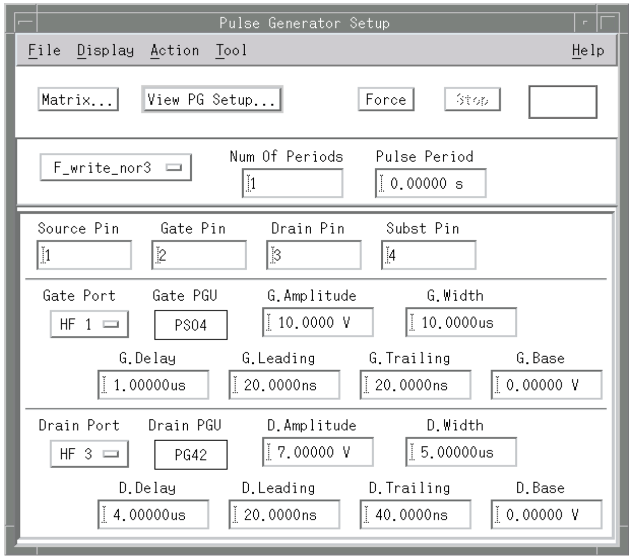
Source Port	Select HF, THF, or AUX port number connected to source terminal by using this option menu. Must be different from gate or drain port. The port cannot be connected to the pulse switch port or connected to PSIx1 in different control block of drain port.
Source PGU	Displays the output terminal of PGU connected to source terminal.
S.Amplitude	Pulse amplitude value.
S.Width	Pulse width value.
S.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
S.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
S.Base	Pulse base value.

7. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
8. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Write Low-power NOR Type Flash Memory with Multiplexer

1. Check if you finish all required procedure in the "Before Setting and Forcing Pulses" on page 7-15.
2. Select `F_write_nor3` pulse operation type from option menu:

Figure 7-24



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. Must be different from drain port.
Gate PGU	Displays the output terminal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.
G.Width	Pulse width value.
G.Delay	Pulse delay value.

G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to drain terminal:

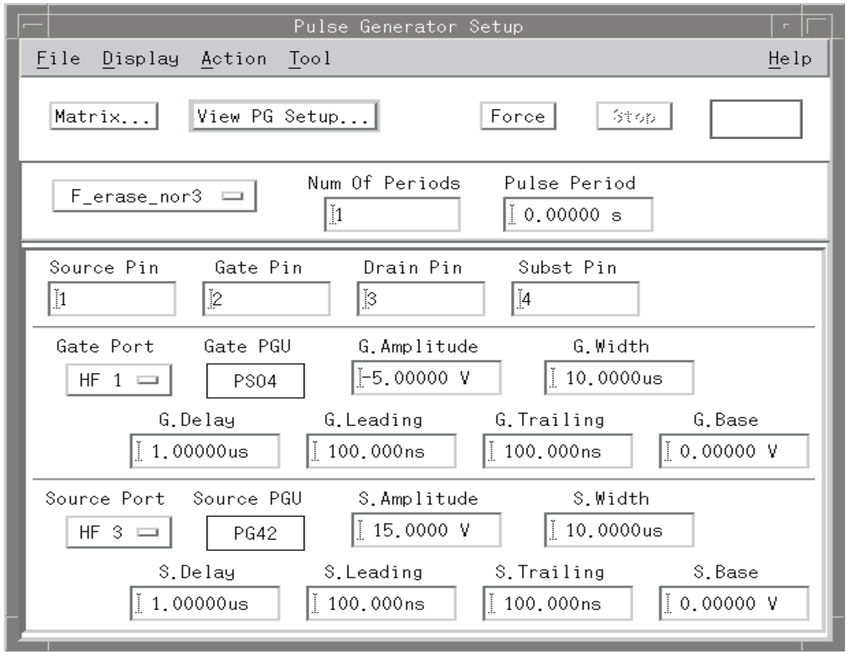
Drain Port	Select HF, THF, or AUX port number connected to drain terminal by using this option menu. Must be different from gate port. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Drain PGU	Displays the output terminal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Delay	Pulse delay value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
D.Base	Pulse base value.

6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Erase Low-power NOR Type Flash Memory with Multiplexer

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_erase_nor3` pulse operation type from option menu:

Figure 7-25



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. Must be different from source port.
Gate PGU	Displays the output terminal of PGU connected to gate terminal.
G.Amplitude	Pulse amplitude value.

G.Width	Pulse width value.
G.Delay	Pulse delay value.
G.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
G.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.

5. Set parameters for pulse source connected to source terminal:

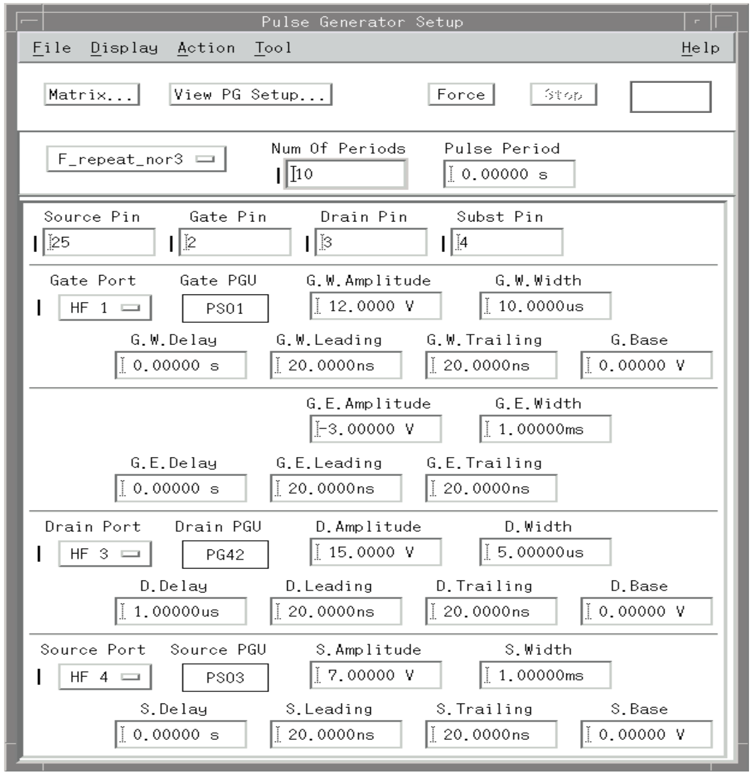
Source Port	Select HF, THF, or AUX port number connected to source terminal by using this option menu. The port must not be connected to PSIx2 (input 2 of multiplexer switch).
Source PGU	Displays the output terminal of PGU connected to source terminal.
S.Amplitude	Pulse amplitude value.
S.Width	Pulse width value.
S.Delay	Pulse delay value.
S.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
S.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
S.Base	Pulse base value.

6. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
7. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To Repeat Write and Erase of Low-power NOR Type Flash Memory with Multiplexer

1. Check if you finish all required procedure in the “Before Setting and Forcing Pulses” on page 7-15.
2. Select `F_repeat_nor3` pulse operation type from option menu:

Figure 7-26



3. Set parameters for measurement pins:

Source	Set measurement pin that is connected to the source terminal of device under test.
Gate	Set measurement pin that is connected to the gate terminal of device under test.
Drain	Set measurement pin that is connected to the drain terminal of device under test.
Subst	Set measurement pin that is connected to the substrate terminal of device under test. If 0 is specified, this terminal is not connected to port.

4. Set parameters for pulse source connected to gate terminal:

Gate Port	Select HF, THF, or AUX port number connected to gate terminal by using this option menu. The port must be connected to the mutliplexer port. Both PSI ports of the multiplexer port must be connected to a PGU.
Gate PGU	Displays the output terminal of PGU connected to gate terminal.
G.W.Amplitude	Write pulse amplitude value.
G.W.Width	Write pulse width value.
G.W.Delay	Write pulse delay value.
G.W.Leading	Write pulse leading-edge transition time. (Ignored if 8114A)
G.W.Trailing	Write pulse trailing-edge transition time. (Ignored if 8114A)
G.Base	Pulse base value.
G.E.Amplitude	Erase pulse amplitude value.
G.E.Width	Erase pulse width value.
G.E.Delay	Erase pulse delay value.
G.E.Leading	Erase pulse leading-edge transition time. (Ignored if 8114A)
G.E.Trailing	Erase pulse trailing-edge transition time. (Ignored if 8114A)

5. Set parameters for pulse source connected to drain terminal:

Drain Port	Select HF, THF, or AUX port number connected to drain terminal by using this option menu. Must connect to open/close switch.
Drain PGU	Displays the output terminal of PGU connected to drain terminal.
D.Amplitude	Pulse amplitude value.
D.Width	Pulse width value.
D.Delay	Pulse delay value.
D.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
D.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)

D.Base	Pulse base value.

6. Set parameters for pulse source connected to source terminal:

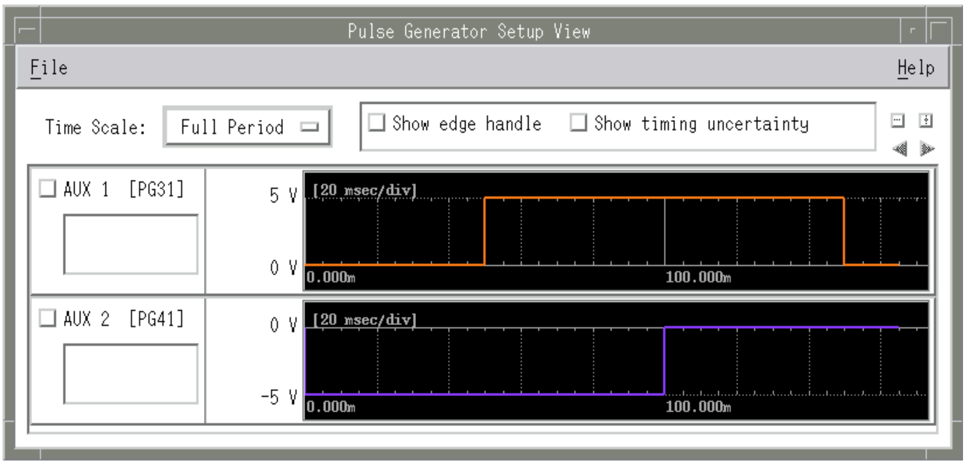
Source Port	Select HF, THF, or AUX port number connected to source terminal by using this option menu. Must be different from gate or drain port. The port must not be connected to the pulse switch port or connected to PSIx1 in different control block of drain port.
Source PGU	Displays the output terminal of PGU connected to source terminal.
S.Amplitude	Pulse amplitude value.
S.Width	Pulse width value.
S.Delay	Pulse delay value.
S.Leading	Pulse leading-edge transition time. (Ignored if 8114A)
S.Trailing	Pulse trailing-edge transition time. (Ignored if 8114A)
S.Base	Pulse base value.

7. Set Num of Periods (number of period) field. If you set 0 in the Num of Periods field, error occurs.
8. Click Force button in upper part of Pulse Generator Setup window to force pulse.

To View Setup Pulse Waveform

1. Check if all required parameters are set in the Pulse Generator Setup window.
2. Click View PG Setup... action button in the Pulse Generator Setup window. Then the setup pulse waveform is displayed in the Pulse Generator Setup View window.

Figure 7-27



Executing Measurement

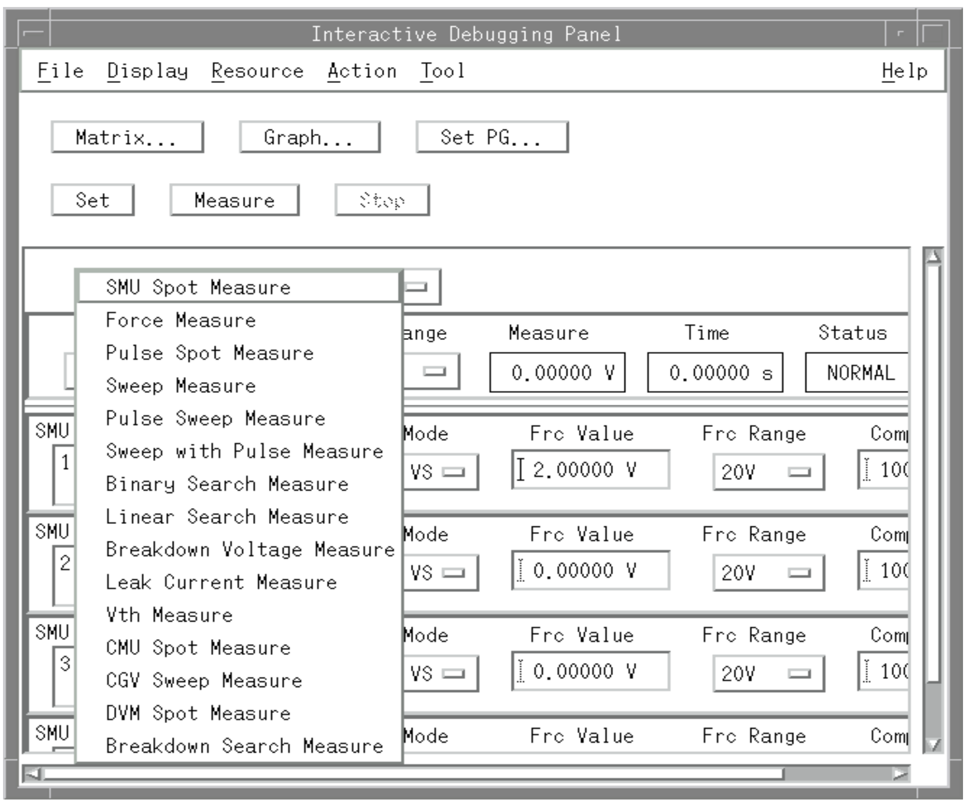
This section explains how to execute a measurement from IDP.

Before executing a measurement, you must connect each instrument port to desired switching matrix pins. Refer to “Connecting Ports to Pins” on page 7-6. If you want to force a dc bias not included in following measurements, or set up test signal for CMU, refer to “Forcing DC Bias and Setting Test Signal” on page 7-10.

To Select Measurement Type

1. Select desired measurement from measurement type option menu:

Figure 7-28 **Measurement Type**



To Select Measurement Type

The following describes each measurement type:

Table 7-2

SMU Spot Measure:	Voltage or current spot measurement by using SMU.
Force Measure:	Force voltage or current, then measure voltage or current by using SMU. You can specify hold time between force and measurement.
Pulse Spot Measure:	Pulsed spot measurement.
Sweep Measure:	Staircase sweep I-V measurement. You can also set synchronous sweep source.
Pulse Sweep Measure:	Pulsed sweep I-V measurement. You can also set synchronous sweep source.
Sweep with Pulse Measure:	Staircase sweep I-V measurement with pulsed bias. You can also set synchronous sweep source.
Binary Search Measure:	Binary search measurement. You can also set synchronous sweep source.
Linear Search Measure:	Linear search measurement. You can also set synchronous sweep source.
Breakdown Voltage Measure:	Breakdown voltage measurement by using quasi-pulse.
Leak Current Measure:	Leakage current measurement by using quasi-pulse.
Vth Measure:	FET gate-source threshold voltage measurement by using linear search with step skipping and least squares method.
CMU Spot Measure:	Capacitance measurement.
CGV Sweep Measure:	Sweep C-V or G-V measurement.
DVM Spot Measure:	Differential voltage measurement by using 3458.
Breakdown Search Measure:	Breakdown voltage measurement by using breakdown voltage search.

The following table shows the measurement types and corresponding setup statements of TIS.

Table 7-3

Unit	Measurement Type	TIS (BASIC)	TIS (C)
SMU	SMU Spot Measure	Measure_v, Measure_i, Measure_m	measure_v, measure_vt, measure_i, measure_it, measure_m
	Force Measure	Force_meas	force_meas, force_meas_t
	Pulse Spot Measure	Set_pbias, Measure_p	set_pbias, measure_p
	Sweep Measure	Set_iv, Set_sync, Sweep_iv, Sweep_miv, Rsweep_iv, Rsweep_miv	set_iv, set_sync, sweep_iv, sweep_miv, rsweep_iv, rsweep_ivt, rsweep_miv, rsweep_mivt
	Pulse Sweep Measure	Set_piv, Set_sync, Sweep_iv, Rsweep_iv	set_piv, set_sync, sweep_iv, rsweep_iv, rsweep_ivt
	Sweep with Pulse Measure	Set_iv, Set_pbias, Set_sync, Sweep_iv, Rsweep	set_iv, set_pbias, set_sync, sweep_iv, rsweep_iv, rsweep_ivt
	Binary Search Measure	Set_bsearch, Set_sync, Search, Rsearch	set_bsearch, set_sync, search_iv, rsearch_iv
	Linear Search Measure	Set_lsearch, Set_sync, Search, Rsearch	set_lsearch, set_sync, search_iv, rsearch_iv
	Breakdown Voltage Measure	Set_bdv, Measure_bdv	set_bdv, measure_bdv
	Leak Current Measure	Set_ileak, Measure_ileak	set_ileak, measure_ileak
	Vth Measure	Set_vth, Measure_vth	set_vth, measure_vth
	Breakdown Search Measure	Set_bdv_search, Search	set_bdv_search, search_iv
CMU	CMU Spot Measure	Measure_cmu84	measure_cmu84
	CGV	Set_cv84, Sweep_cv84	set_cv84, sweep_cv84
DVM	Differential Voltage	Measure_v3458	measure_v3458

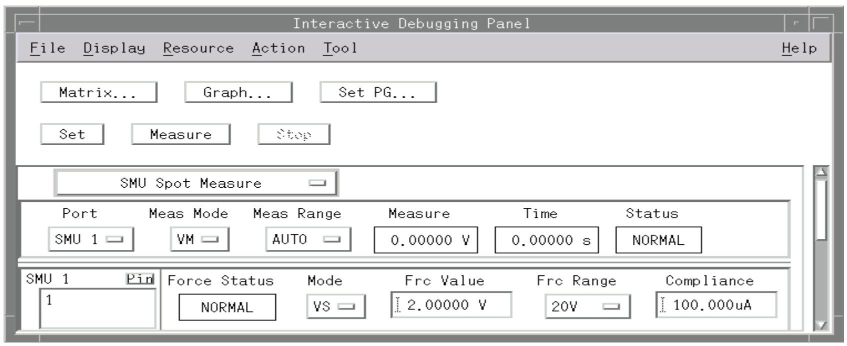
The following sections describe how to execute each measurement type.

Also, for more information abut the various measurement types, refer toChapter 3, “Measurement Types,”.

To Execute SMU Spot Measurement

1. Select SMU Spot Measure from option menu:

Figure 7-29



2. Select SMU measurement port by using Port option menu.
3. Select VM (voltage measurement) or IM (current measurement) by using Meas Mode option menu.
4. Select measurement range by using Meas Range option menu.
5. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.
    - Measured value is returned to Measure field.
    - Time stamp is returned to Time field
    - Measurement status is returned to Status field.

NOTE

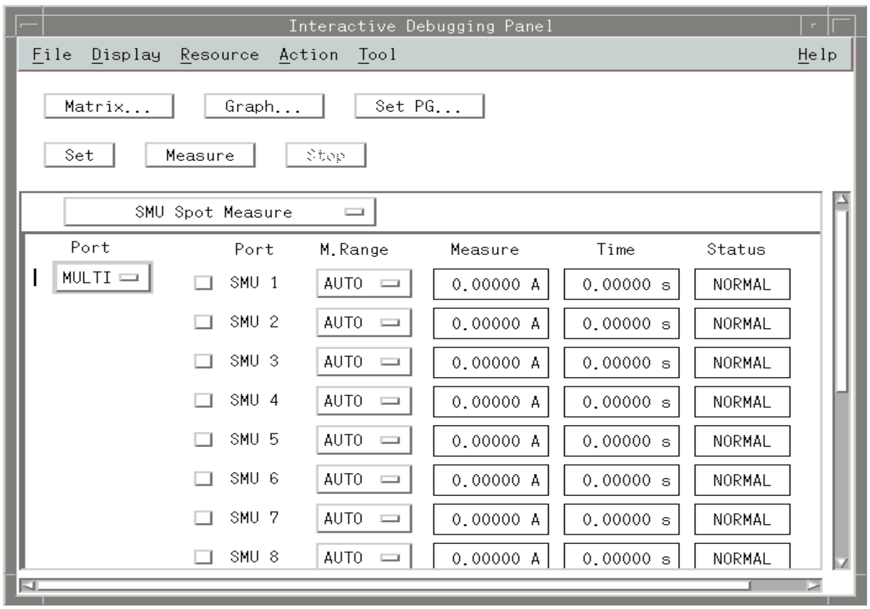
Multichannel SMU Spot Measurement

You can specify multiple SMU measurement ports:

1. Select MULTI in Port option menu.

   The measurement setup area expands as follows, so you can set up multiple measurement ports:

Figure 7-30



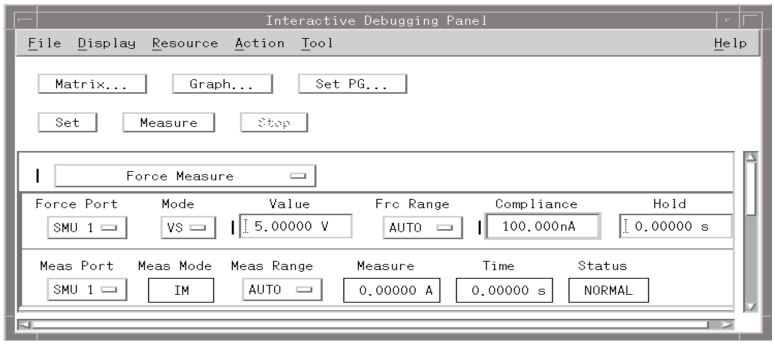
2. Select the check buttons of desired measurement ports.

3. Select the measurement range for each port by using the M.Range option menu.

To Execute SMU Forcing and Measurement

1. Select Force Measure from option menu:

Figure 7-31



2. Select SMU force port by using Force Port option menu.
3. Select VF (voltage force) or IF (current force) by using Mode option menu.
4. Enter force voltage or current in the Value field.
5. Select output range by using Range option menu.
6. Enter voltage or current compliance value in Compliance field.
7. Enter hold time between force and measure in Hold field.
8. Select SMU measurement port by using Meas Port option menu.

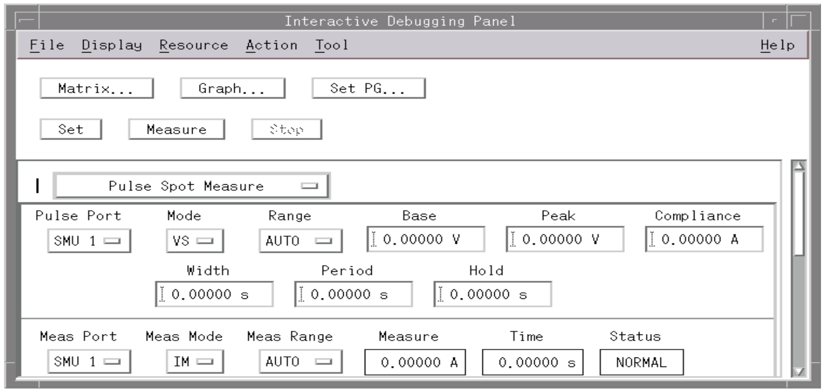
   Measurement mode of selected SMU measure port is determined by present force mode (VF or IF) of SMU. If VF mode, measurement mode is IM, and if IF mode, measurement mode is VM. If force and measure port are the same, changing force port mode automatically changes measure port mode. If different ports, set force mode of measure port to give desired measure mode as described in “To Force Voltage or Current from SMU” on page 7-10.
9. Select measurement range by using the Meas Range option menu.
10. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

    - Measured value is returned to Measure field.
    - Time stamp is returned to Time field.
    - Measurement status is returned to Status field.

To Execute SMU Pulsed Spot Measurement

1. Select Pulse Spot Measure from option menu:

Figure 7-32

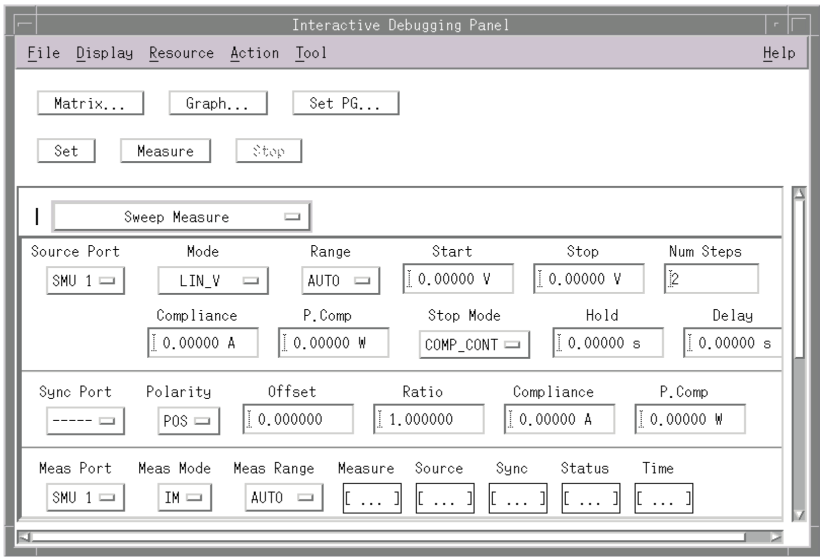


2. Select pulse source port by using Pulse Port option menu.
3. Select VF (voltage pulse force) or IF (current pulse force) by using Mode option menu.
4. Select output range for pulse source by using Range option menu.
5. Enter pulse base value in Base field, and pulse peak in Peak field.
6. Enter compliance of pulse source in Compliance field.
7. Enter pulse width in Width field, and pulse period in Period field.
8. Enter hold time in Hold field.
9. Select measurement port by using Meas Port option menu.
10. Select measurement mode (VM: voltage measurement, or IM: current measurement) by using Mode option menu.
11. Select measurement range by using Meas Range option menu.
12. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.
    - Measured value is returned to Measure field.
    - Time stamp is returned to Time field.
    - Measurement status is returned to Status field.

To Execute SMU Sweep Measurement

1. Select Sweep Measure from option menu:

Figure 7-33



2. Set parameters for sweep source:

Source Port	Select sweep source SMU by using this option menu.
Mode	Select sweep mode by using this option menu:

- LIN_V: Linear single voltage sweep
- LIN_I: Linear single current sweep
- LOG_V: Log single voltage sweep
- LOG_I: Log single current sweep
- LIN_V_DOUBLE: Linear double voltage sweep
- LIN_I_DOUBLE: Linear double current sweep
- LOG_V_DOUBLE: Log double voltage sweep
- LOG_I_DOUBLE: Log double current sweep

Range	Output range of sweep source.

Start	Start value of sweep.
Stop	Stop value of sweep.
Step	Number of steps from start to stop.
Compliance	Compliance value of sweep source.
P. Comp	Power compliance value of sweep source.
Stop Mode	Select stop mode at reaching compliance by using this option menu: • COMP_STOP: Sweep aborts when an SMU reaches compliance. • COMP_CONT: Sweep continues to the last specified step even if an SMU reaches compliance.
Hold	Hold time.
Delay	Delay time.

3. You can optionally set the parameters for a synchronous sweep port:

Sync Port	Select synchronous sweep source SMU by using this option menu.
Polarity	Select calculation mode for start and stop values of synchronous sweep source: • POS $sync\_start = offset + ratio \times primary\_start$ $sync\_stop = offset + ratio \times primary\_stop$ • NEG $sync\_start = offset - ratio \times primary\_start$ $sync\_stop = offset - ratio \times primary\_stop$
Offset	Offset value. Refer to Mode.
Ratio	Ratio value. Refer to Mode.
Compliance	Compliance value of synchronous sweep source.
P. Comp	Power compliance value of synchronous sweep source.

4. Set the parameters for measurement SMU.

Meas port	Select measurement SMU by using this option menu.

Meas Mode	Select measurement mode (IM: current measurement, or VM: voltage measurement) by using this option menu.
Meas Range	Select the measurement range.

5. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during measurement execution.

NOTE

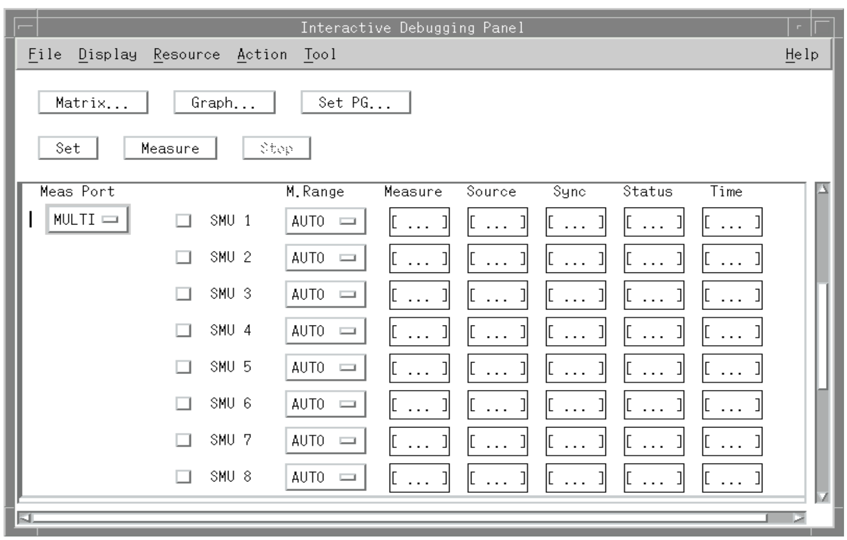
Multichannel Measurement

You can specify multiple SMU measurement ports:

1. Select MULTI in Meas Port option menu.

   The measurement setup area expands as follows, and you can set up multiple measurement ports:

Figure 7-34

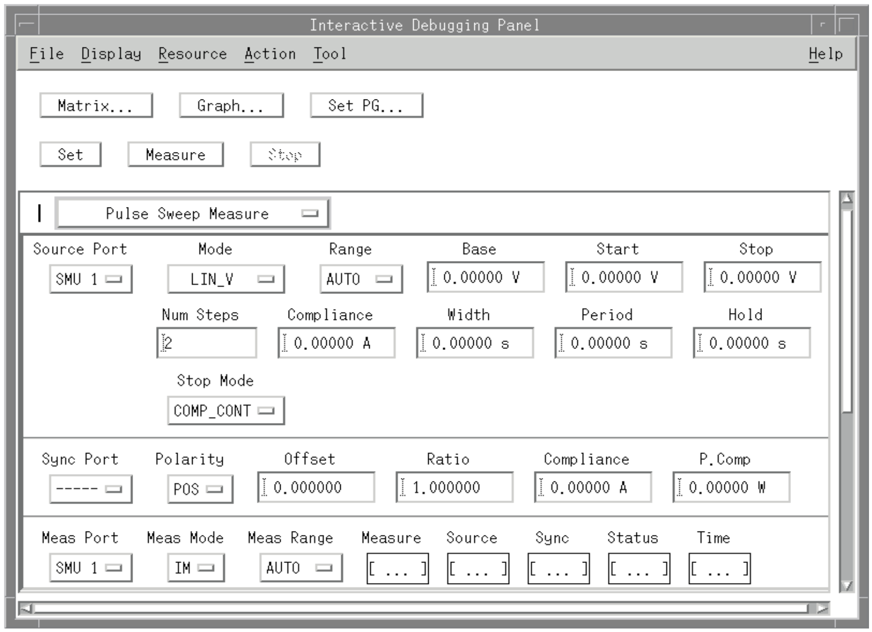


2. Select the check buttons of desired measurement ports.
3. Select the measurement range for each port by using the M.Range option menu.

To Execute Pulsed Sweep Measurement

1. Select Pulse Sweep Measure from option menu:

Figure 7-35



2. Set parameters for pulsed sweep source:

Source Port — Select pulsed sweep source SMU by using this option menu.

Mode — Select sweep mode by using this option menu:

- LIN_V: Linear single pulsed voltage sweep
- LIN_I: Linear single pulsed current sweep
- LOG_V: Log single pulsed voltage sweep
- LOG_I: Log single pulsed current sweep
- LIN_V_DOUBLE: Linear double pulsed voltage sweep
- LIN_I_DOUBLE: Linear double pulsed current sweep
- LOG_V_DOUBLE: Log double pulsed voltage sweep
- LOG_I_DOUBLE: Log double pulsed current sweep

Base	Pulse base value.
Start	Start value of sweep.
Stop	Stop value of sweep.
Step	Number of steps from start to stop.
Compliance	Compliance value of sweep source.
Width	Pulse width.
Period	Pulse period.
Hold	Hold time.
Stop Mode	Select stop mode at reaching compliance by using this option menu: • COMP_STOP: Sweep aborts when an SMU reaches compliance. • COMP_CONT: Sweep continues to the last specified step even if an SMU reaches compliance.

3. You can optionally set the parameters for a synchronous sweep port:

Sync Port	Select synchronous sweep source SMU by using this option menu.
Polarity	Select calculation mode for start and stop values of synchronous sweep source: • POS $sync\_start = offset + ratio \times primary\_start$ $sync\_stop = offset + ratio \times primary\_stop$ • NEG $sync\_start = offset - ratio \times primary\_start$ $sync\_stop = offset - ratio \times primary\_stop$
Offset	Offset value. Refer to Mode.
Ratio	Ratio value. Refer to Mode.
Compliance	Compliance value of synchronous sweep source.
P. Comp	Power compliance value of synchronous sweep source.

4. Set the parameters for measurement SMU.

Meas port	Select measurement SMU by using this option menu.
Meas Mode	Select measurement mode (IM: current measurement, or VM: voltage measurement) by using this option menu.
Meas Range	Select the measurement range.

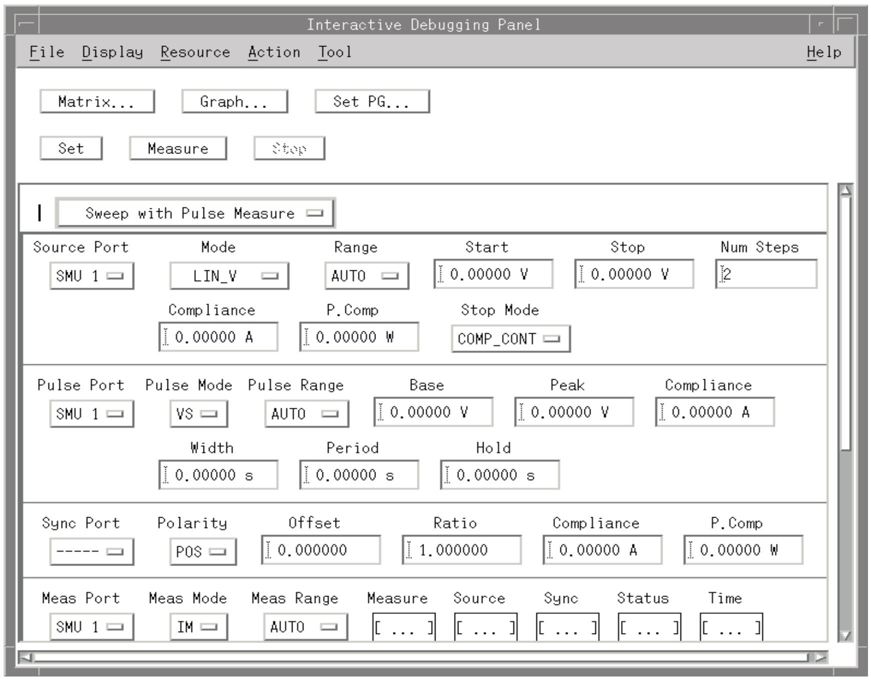
5. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during measurement execution.

To Execute Sweep with Pulsed Bias Measurement

1. Select Sweep with Pulse Measure from option menu:

Figure 7-36



2. Set parameters for sweep source:

Source Port	Select sweep source SMU by using this option menu.
Mode	Select sweep mode by using this option menu:

- LIN_V: Linear single voltage sweep
- LIN_I: Linear single current sweep
- LOG_V: Log single voltage sweep
- LOG_I: Log single current sweep
- LIN_V_DOUBLE: Linear double voltage sweep
- LIN_I_DOUBLE: Linear double current sweep

- LOG_V_DOUBLE: Log double voltage sweep
- LOG_I_DOUBLE: Log double current sweep

Range	Output range of sweep source.
Start	Start value of sweep.
Stop	Stop value of sweep.
Step	Number of steps from start to stop.
Compliance	Compliance value of sweep source.
P. Comp	Power compliance value of sweep source.
Stop Mode	Select stop mode at reaching compliance by using this option menu:

- COMP_STOP: Sweep aborts when an SMU reaches compliance.
- COMP_CONT: Sweep continues to the last specified step even if an SMU reaches compliance.

3. Set the parameters for pulse bias source:

Pulse Port	Select pulse bias source SMU by using this option menu.
Pulse Mode	Select VF (voltage pulse) or IF (current pulse) by using this option menu.
Pulse Range	Output range of pulse source.
Base	Pulse base value.
Peak	Pulse peak value.
Compliance	Compliance value of pulse source.
Width	Pulse width.
Period	Pulse period.
Hold	Hold time.

4. You can optionally set the parameters for a synchronous sweep port:

Sync Port	Select synchronous sweep source SMU by using this option menu.
Polarity	Select calculation mode for start and stop values of synchronous sweep source:

- POS

  $sync\_start = offset + ratio \times primary\_start$ $sync\_stop = offset + ratio \times primary\_stop$

- NEG

  $sync\_start = offset - ratio \times primary\_start$ $sync\_stop = offset - ratio \times primary\_stop$

Offset	Offset value. Refer to Mode.
Ratio	Ratio value. Refer to Mode.
Compliance	Compliance value of synchronous sweep source.
P. Comp	Power compliance value of synchronous sweep source.

5. Set the parameters for measurement SMU:

Meas port	Select measurement SMU by using this option menu.
Meas Mode	Select measurement mode (IM: current measurement, or VM: voltage measurement) by using this option menu.
Meas Range	Select the measurement range.

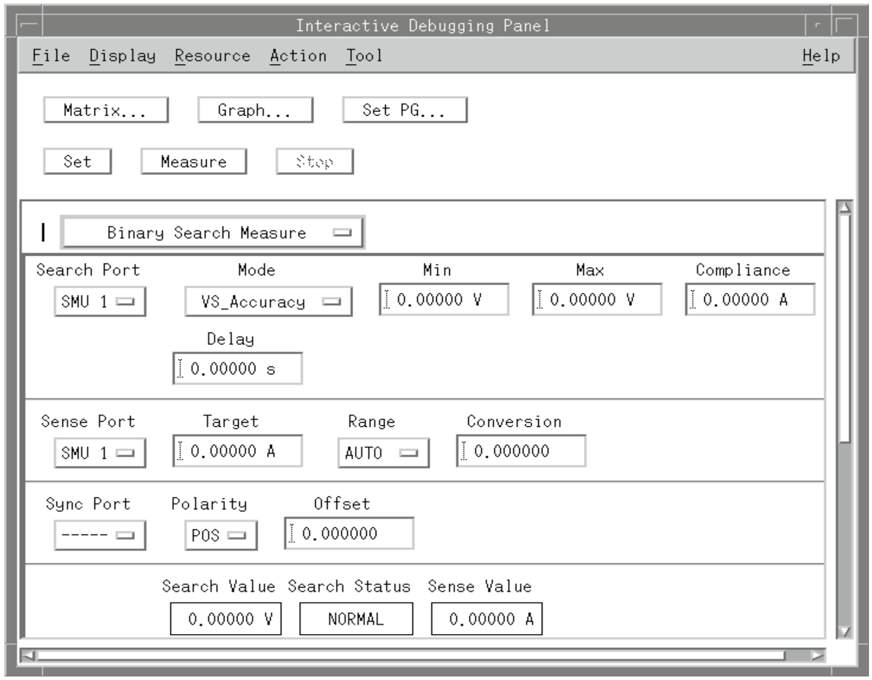
6. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during measurement execution.

To Execute Binary Search Measurement

1. Select Binary Search Measure from option menu:

Figure 7-37



2. Set the parameters for search port:

Search Port	Select search port SMU by using this option menu.
Mode	Select search mode:

- VS_Accuracy

  Search port is set to voltage source, and search convergence mode is set to Accuracy.

- IS_Accuracy

  Search port is set to current source, and search convergence mode is set to Accuracy.

- VS_Times

Search port is set to voltage source, and search convergence mode is set to Times.

- IS_Times

  Search port is set to current source, and search convergence mode is set to Times.

Min	Minimum value that will be output by search port during the search.
Max	Maximum value that will be output by search port during the search.
Compliance	Compliance of search port.
Delay	Time between the output from search port and measurement by the sense port.

3. Set the parameters for sense port:

Sense Port	Select sense port SMU by using this option menu.
Target	Target value for search. The sense port measures, and compares the measurement value to this target value.
Meas Range	Measurement range of sense port.
Conversion	Specify convergence condition for search:

- For Accuracy convergence mode, specify a %. The search continues until the value measured by the sense port is within the specified % of the target value.
- For Times convergence mode, specify the number of binary comparisons to perform. The maximum number is 16.

4. You can optionally set the parameters for a synchronous sweep port:

Sync Port	Select synchronous source SMU by using this option menu.
Polarity	Select calculation mode for output values of synchronous source:

- POS

  sync output = offset + search output

- NEG

  sync output = offset –search output

Offset	Offset value. Refer to Mode.

5. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during search measurement.

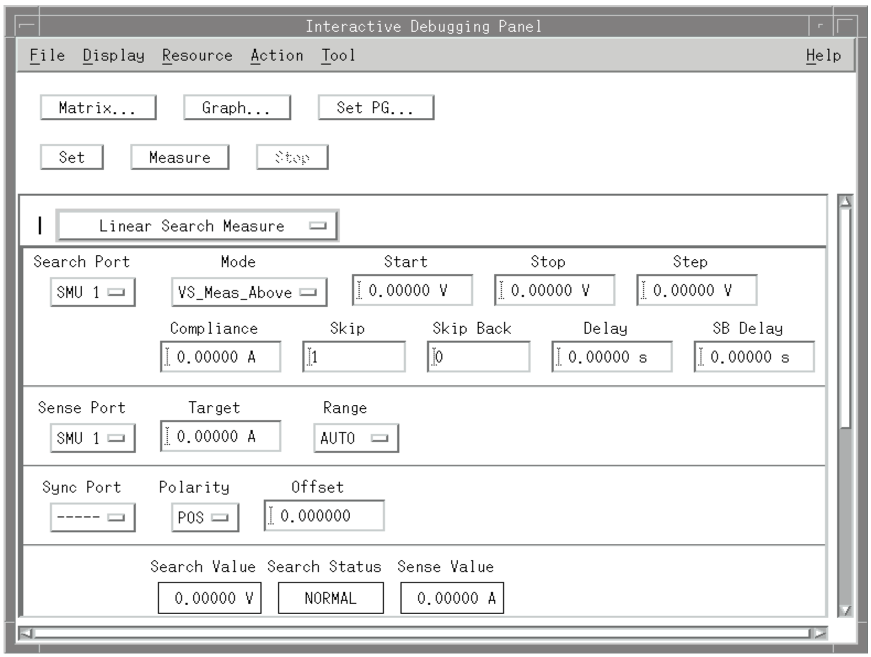
   And after search measurement is completed:

   - The value output by Search unit (when sense unit measures target value within convergence conditions) is returned to Search Value field.
   - Search status is returned to Search Status field.
   - Target value measured by sense port is returned to Sense Value field.

To Execute Linear Search Measurement

1. Select Linear Search Measure from option menu:

Figure 7-38



2. Set the parameters for search port:

Search Port	Select search port SMU by using this option menu.
Mode	Select search mode:

- VS_Meas_Above

  Search port is set to voltage source, and search continues until sense value is greater than target value.

- IS_Meas_Above

  Search port is set to current source, and search continues until sense value is greater than target value.

- VS_Meas_Below

  Search port is set to voltage source, and search continues until sense value is less than target value.

- IS_Meas_Below

  Search port is set to current source, and search continues until sense value is less than target value.

- VS_Comp

  Search port is set to voltage source, compliance of sense port is set to target value, and search will continue until sense port reaches the compliance.

- IS_Comp

  Search port is set to current source, compliance of sense port is set to target value, and search will continue until sense port reaches the compliance.

Start	Start value of search.
Stop	Stop value of search.
Step	Step value of fine search, and used to calculate large step.
Compliance	Compliance of search port.
Skip	Search port's large step size for step skipping method is calculated by skip \\times step.
Skip Back	Number of large steps for search port to go back after coarsely finding the target.
Delay	Delay time.
SB Delay	Delay time between coarse search and fine search.

3. Set the parameters for sense port:

Sense Port	Select sense port SMU by using this option menu.
Target	Target value for search.
Meas Range	Measurement range of sense port.

4. You can optionally set the parameters for a synchronous port:

Sync Port	Select synchronous source SMU by using this option menu.

Polarity	Select calculation mode for output values of synchronous source: • POS *sync output = offset + search output* • NEG *sync output = offset –search output*
Offset	Offset value. Refer to Mode.

5. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during search measurement.

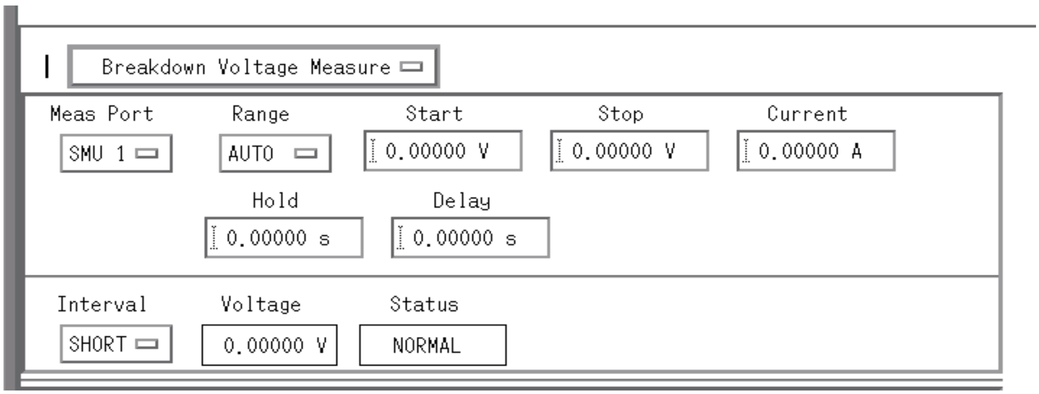
   And after search measurement is completed:

   - The value output by Search unit (when sense unit measures target value or reaches compliance) is returned to Search Value field.
   - Search status is returned to Search Status field.
   - Target value measured by sense port is returned to Sense Value field.

To Execute Breakdown Voltage Measurement (quasi-pulse)

1. Select Breakdown Voltage Measurement from option menu:

Figure 7-39

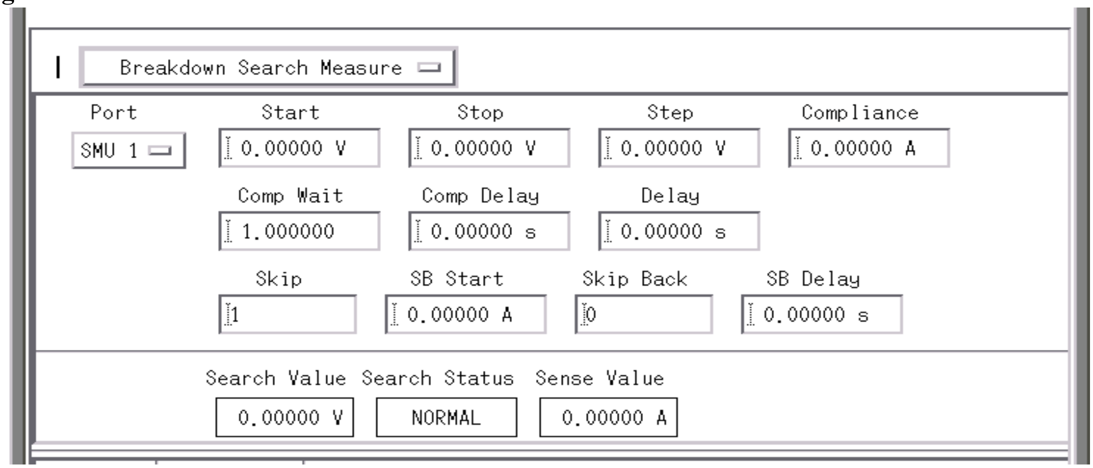


2. Select measurement port by using Meas Port option menu.
3. Select the output voltage range of the measurement port by using Range option menu.
4. Enter the start output voltage in Start field. Difference between start and stop output voltages must be at least 10 V.
5. Enter the stop output voltage in Stop field.
6. Enter the breakdown current in the Current field. The current compliance of the measurement port is set to this current.
7. Enter hold time in Hold field.
8. Enter delay time in Delay field.
9. Select the detection interval (SHORT or LONG) by using the Interval option menu. This determines how often to monitor (calculate) the voltage gradient, which determines when breakdown occurs.
10. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.
    - Measured breakdown voltage is returned to Voltage field.
    - Measurement status is returned to Status field.

To Execute Breakdown Voltage Measurement (Breakdown Voltage Search)

1. Select Breakdown Search Measure from option menu:

Figure 7-40



2. Select search port by using Port option menu.
3. Set the parameters for search port:

Start	Start voltage of search.
Stop	Stop voltage of search.
Step	Step voltage of fine search, and used to calculate large step..
Compliance	Compliance of search port. This current value is used to determine if the breakdown occurs.
Comp Wait, Comp Delay	For a reliable search measurement, adequate delay time is necessary for the SMU to step up next voltage and stabilize its output before compliance check. You can optimize the compliance check wait time by using these field.
Delay	Delay time for measurement.
Skip	Search port's large step size for step skipping method is calculated by skip x step.
SB Start	Current for fine search start.

Skip Back	Number of large steps for search port to go back after finding the fine search start point.
SB Delay	Delay time between end of coarse search (large steps), and start of fine search.

4. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

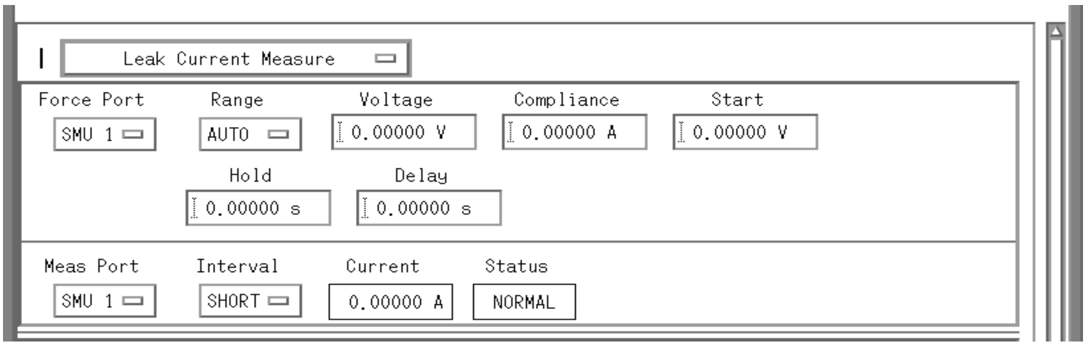
   And after search measurement is completed:

   - Breakdown voltage is returned to Search Value field, and measurement status is returned to Status field.
   - Measured current of search port is returned to Sense Value field.

To Execute Leakage Current Measurement

1. Select Leak Current Measure from option menu:

Figure 7-41



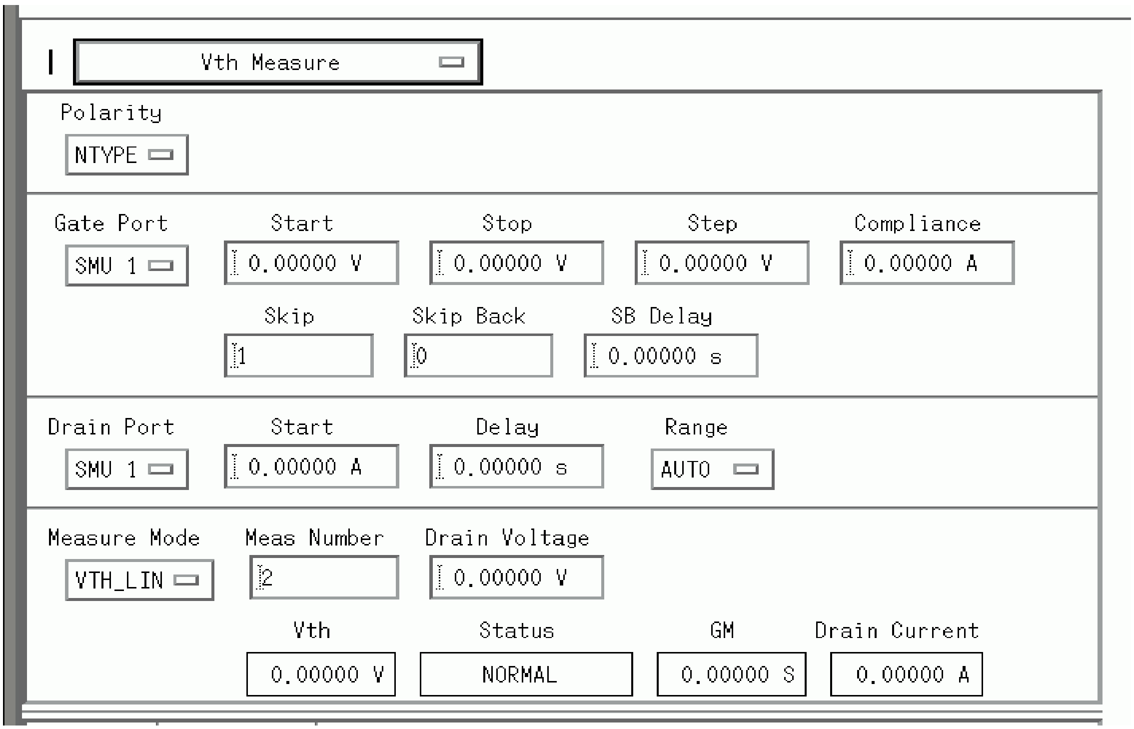
2. Select voltage force port by using Force Port option menu.
3. Select output voltage range of force port by using Range option menu.
4. Enter output voltage (at which to measure leakage current) in Voltage field.
5. Enter current compliance of voltage force port in Compliance field.
6. Enter start output voltage in Start field.
7. Enter hold time in Hold field.
8. Enter delay time in Delay field.
9. Select leakage current measurement port by using Meas Port option menu.
10. Select the detection interval (SHORT or LONG) by using the Interval option menu. This determines how often to monitor (calculate) the voltage gradient, which determines when to measure the current.
11. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

    - Measured leakage current is returned to Current field.
    - Measurement status is returned to Status field.

To Execute Vth Measurement

1. Select Vth Measure from option menu:

Figure 7-42



2. Select the MOSFET channel type (NTYPTE or PTYPE) by using Polarity option menu.

3. Set the parameters for gate port:

Gate Port	Select gate port SMU by using this option menu.
Start	Gate start voltage for search.
Stop	Gate stop voltage for search.
Step	Gate step voltage for search. This determines the large step voltage (Skip× Step) used to search for the fine search start point, and is also the step voltage used during the fine search for the drain current.

Compliance	Gate current compliance.
Skip	This determines the large step voltage used to search for the fine search start point. Large step size is: Skip$\times$Step.
Skip Back	Number of large steps for gate port to go back after finding the fine search start point.
SB Delay	Delay time between end of coarse search (large steps), and start of fine search.

4. Set the parameters for drain port:

Drain Port	Select drain port SMU by using this option menu.
Start	Drain current for fine search start. Specified drain current must be before FET reaches threshold. To make measurement faster, you need to specify this value close to, but before the threshold.
Delay	Delay time before performing measurement at each search step.
Range	Measurement range for drain current.

5. Set the parameters for Vth measurement:

Measure Mode	Select measurement region (VTH_LIN: linear region, or VTH_SAT: saturated region) of FET.
Meas Number	Number of samples used to calculate and find maximum gradient of $Vgs - Ids$ or $Vgs - \sqrt{Ids}$ curve. Least squares method is used for this calculation.
Drain Voltage	Used to calculate threshold voltage: If Measure Mode is VTH_LIN (linear region) and you specify Drain Voltage, the following is returned to Vth: *X-intercept of tangent line* $-$(*Drain Voltage*/2) If Measure Mode is VTH_SAT (saturated region), or you do not specify Drain Voltage, *X-intercept of tangent line* is returned to Vth.

6. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

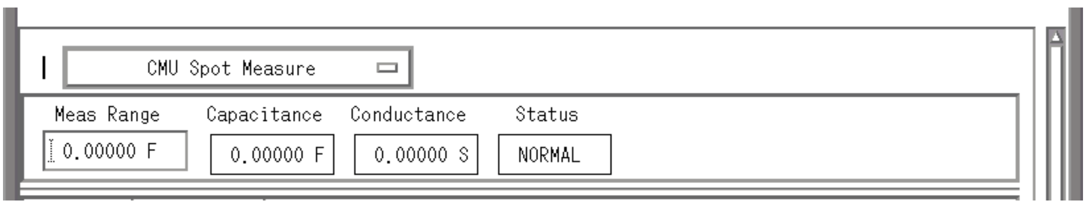
   And after search measurement is completed:

- Threshold voltage is returned to Vth field (see Drain Voltage above), and measurement status is returned to Status field.
- Maximum gradient (*Gm*) of $Vgs - Ids$ or $Vgs - \sqrt{Ids}$ curve is returned to GM field.
- Drain current for threshold voltage is returned to Drain Current field.
- Measurement results of search are plotted on Graph Window.

To Execute Capacitance Measurement

1. Select CMU Spot Measure from option menu:

Figure 7-43



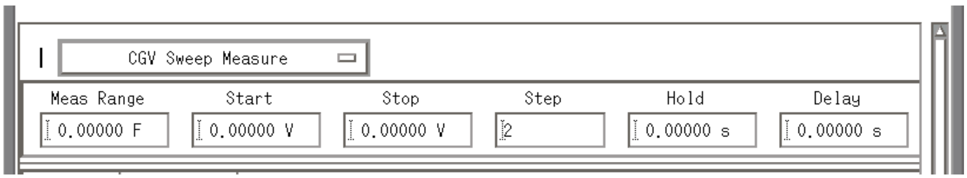
2. You can enter a capacitance measurement range (for limited auto ranging) in Meas Range field. For default (0), Auto ranging is used.
3. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   - Measured capacitance value is returned to Capacitance field.
   - Measured conductance value is returned to Conductance field.
   - Measurement status is returned to Status field.

To Execute C-V/G-V Sweep Measurement

1. Select CGV Sweep Measure from option menu:

Figure 7-44



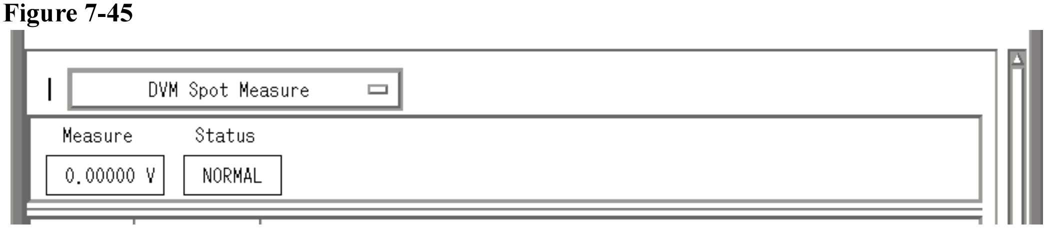
2. You can enter a capacitance measurement range (for limited auto ranging) in Meas Range field. For default (0), Auto ranging is used.
3. Enter start voltage value for sweep in Start field.
4. Enter stop voltage value for sweep in Stop field.
5. Enter number of steps from start to stop in Step field.
6. Enter hold time in Hold field.
7. Enter delay time in Delay field.
8. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.

   Graph Window automatically opens, and measured values are plotted during measurement.

To Execute Voltage Measurement By Using DVM

1. Select DVM Spot Measure from option menu:

Figure 7-45



2. Click Measure button in upper part of Interactive Debugging Panel to execute measurement.
   - Measured voltage value is returned to Measure field.
   - Measurement status is returned to Status field.

Storing and Loading Measurement Setups

You can save measurement or PG setups that you set on the IDP to a file, or load a saved setup file into the IDP.

To Save Measurement Setup to a File

1. Choose `File: Save File` menu on the Interactive Debugging Panel. The Save Dialog opens.
2. Enter a file name in selection field.
3. Click OK.

To Load Measurement Setup from a File

1. Choose `File: Load Setup` menu on the Interactive Debugging Panel.
2. The Load Dialog opens.
3. Enter file name to load in selection field.
4. Click OK.

Viewing Measurement Results

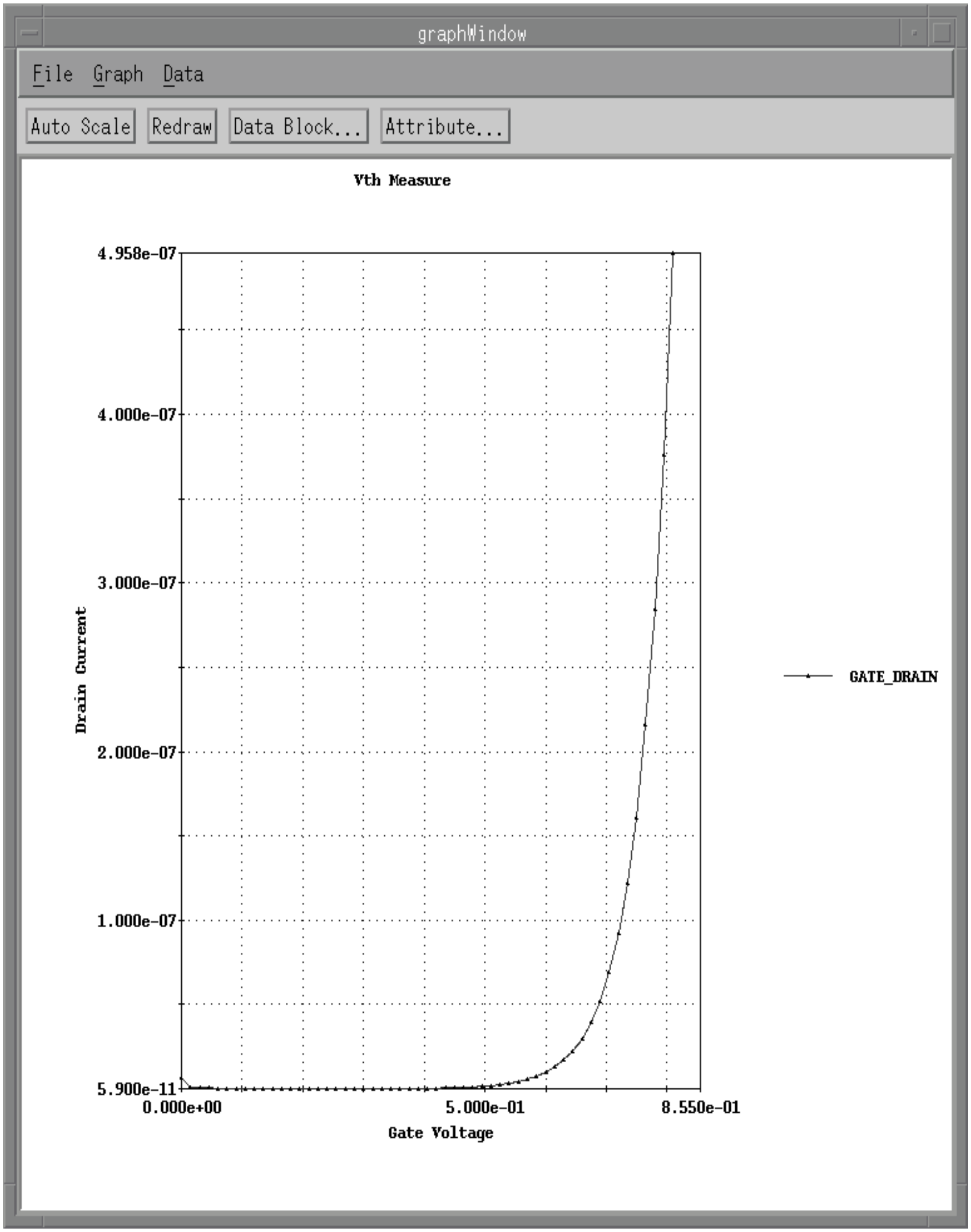
When you execute the following measurements from IDP, Graph Window automatically opens and measurement results for each step are plotted in real-time:

- SMU Sweep Measurement
- Pulsed Sweep Measurement
- Sweep with Pulsed Bias Measurement
- Binary Search Measurement
- Linear Search Measurement
- C-V/G-V Sweep Measurement
- Vth Measurement (not real-time, plotted after measurement is finished)

This section explains how to operate Graph Window and display measurement results in List Window:

- "To Select Data to Display"
- "To Set Graph Attributes"
- "To Save Displayed Data"
- "To Load Saved Data"
- "To Print Displayed Data"
- "To Display Data as a List"
- "To Save List Data to an ASCII file"

Figure 7-46


graphWindow
File
Graph
Data
Auto Scale
Redraw
Data Block...
Attribute...
Vth Measure
4.958e-07
4.000e-07
3.000e-07
2.000e-07
1.000e-07
5.900e-11
Drain Current
0.000e+00
5.000e-01
8.550e-01
Gate Voltage
GATE_DRAIN

To Select Data to Display

You can display the following data on Graph Window for each measurement:

Table 7-4

Measurement mode	X axis	Y axis
SMU Sweep Pulsed Sweep Sweep with Pulsed Bias	Sweep unit force values Synchronous unit force values Time stamp values	Measured values [a]
Binary Search Linear Search	Search unit force values Synchronous unit force values Time stamp values	Sense unit monitor values
Vth	Gate voltage values Time stamp values	Drain current values
C-V/G-V	Sweep unit force values	Measured capacitance values Measured conductance values

a. If you execute an SMU sweep that makes multichannel measurements, the measurement results of each channel are saved in separate data blocks.

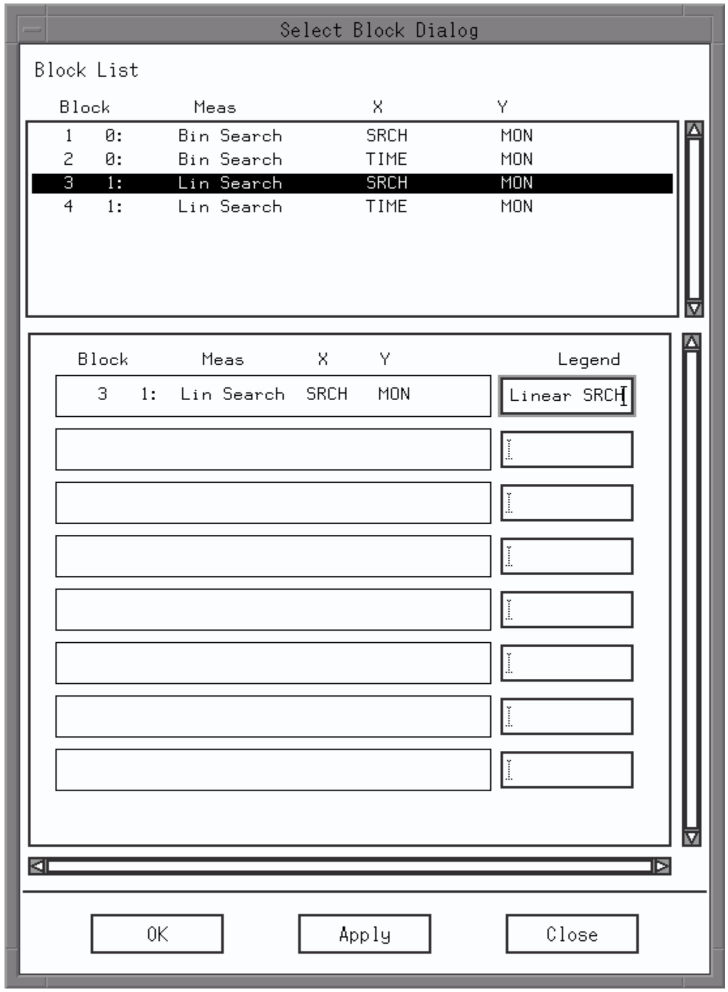
You can select a maximum eight data blocks and display them simultaneously.

To select the data blocks to display:

1. Choose the Data Block button in the Graph Window. The Select Block Dialog opens:

   The Block List area lists the available data blocks.

Figure 7-47



2. Click to select the desired data block. The data block is highlighted and displayed in lower area of Select Block Dialog.

3. Repeat this to select all data blocks that you want to display on Graph Window. You can display a maximum eight data blocks.

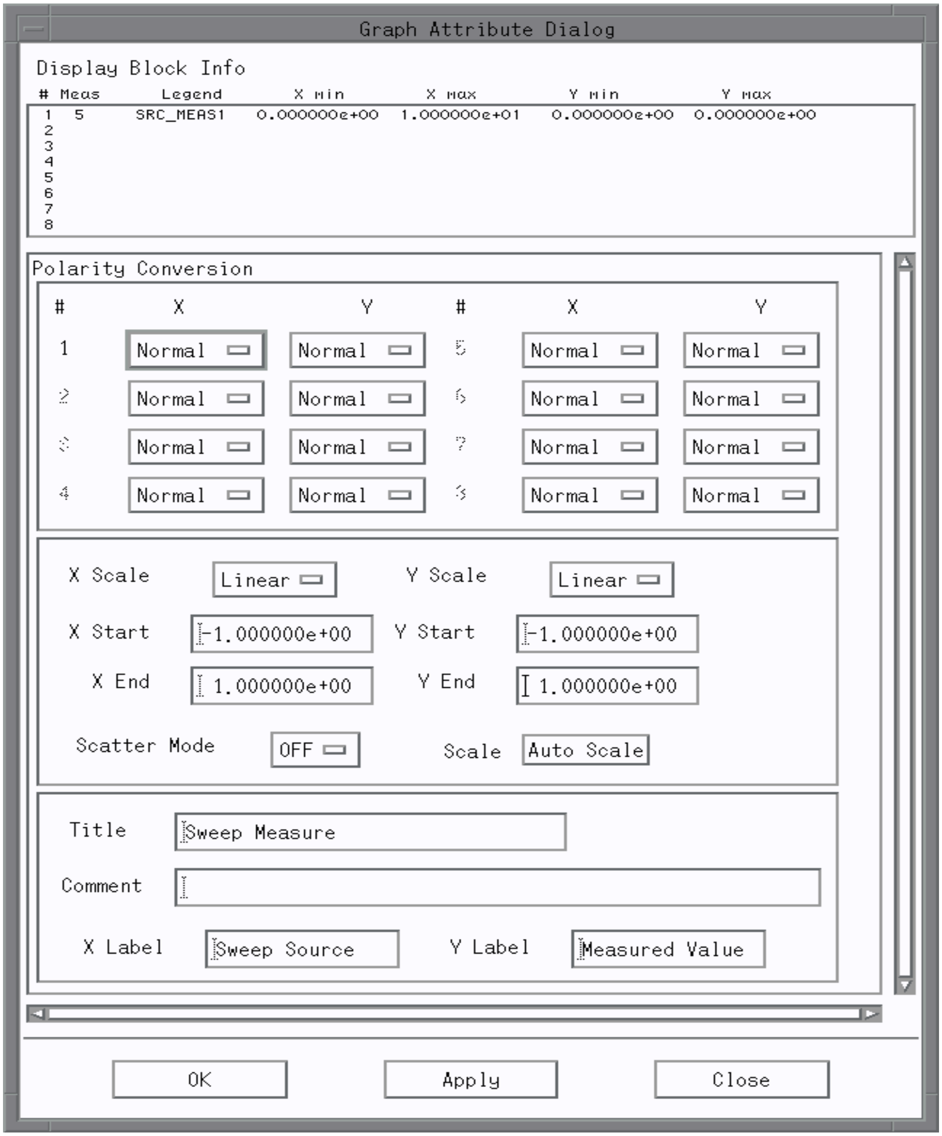
   To cancel a data block to display, click the desired data block in Block List area again.

4. Choose OK. The selected data blocks are plotted on Graph Window.

To Set Graph Attributes

1. Choose Attribute button on Graph Window. Graph Attribute Dialog opens:

Figure 7-48

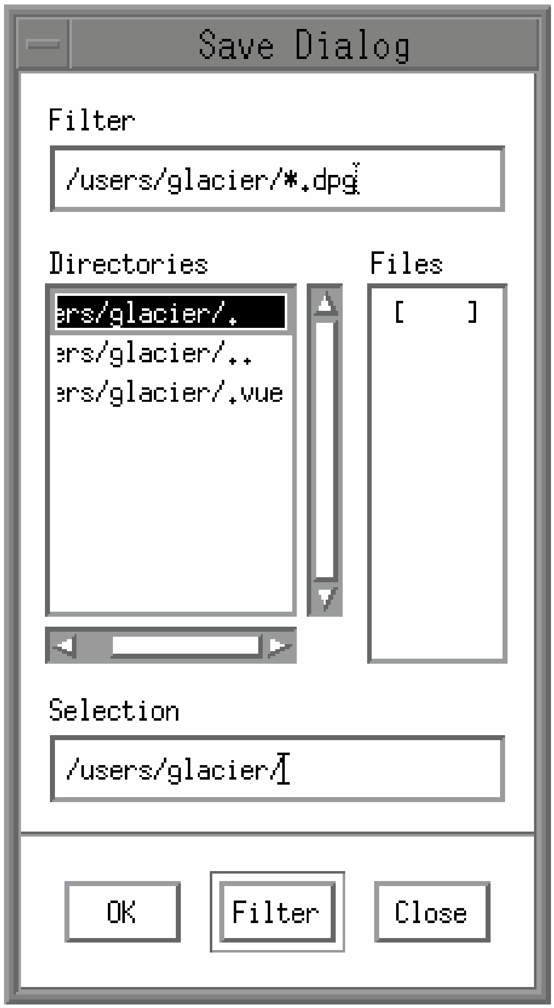


2. In the Polarity Conversion area, you can select the following:
   - Normal
   - Inverse Opposite polarity of the values is used. For example, negative values are changed to positive. This is useful if you need to display negative values in log scale.
3. In X Scale and Y Scale option menu, you can choose the following:
   - Linear
   - Log
4. You can set minimum and maximum values of X and Y axes as follows:
   - Specify the values directly in the X Start, X End, Y Start, and Y End fields.
   - Click the Auto Scale button. The fields are set to the minimum and maximum values in the data block.
5. If you select ON in the Scatter Mode option menu, lines will not be drawn between data points in the Graph Window.
6. You can specify graph title, comment, and labels for X and Y axes.
7. Click OK.

To Save Displayed Data

1. Choose `File: Save` menu in Graph Window. The Save Dialog opens:

Figure 7-49



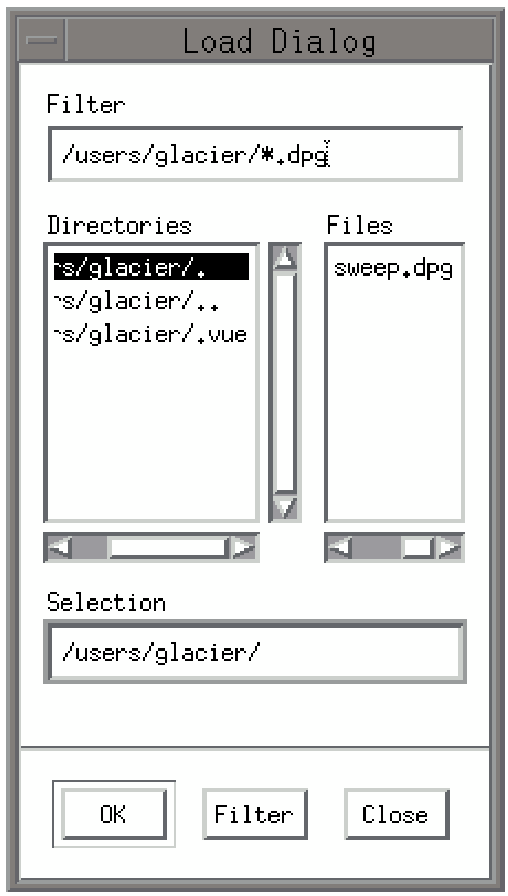
2. Enter file name in Selection field.
3. Click OK. Displayed data including graph attributes is saved to the file.

To Load Saved Data

If you want to load saved data and display on the Graph Window *with saved graph attributes*, choose `Graph: Clear` menu on Graph Window to clear present data blocks. If not, the loaded data is just appended to the available data blocks and saved graph attributes are not used.

1. Choose `File: Load` menu on the Graph Window. The Load Dialog opens:

Figure 7-50



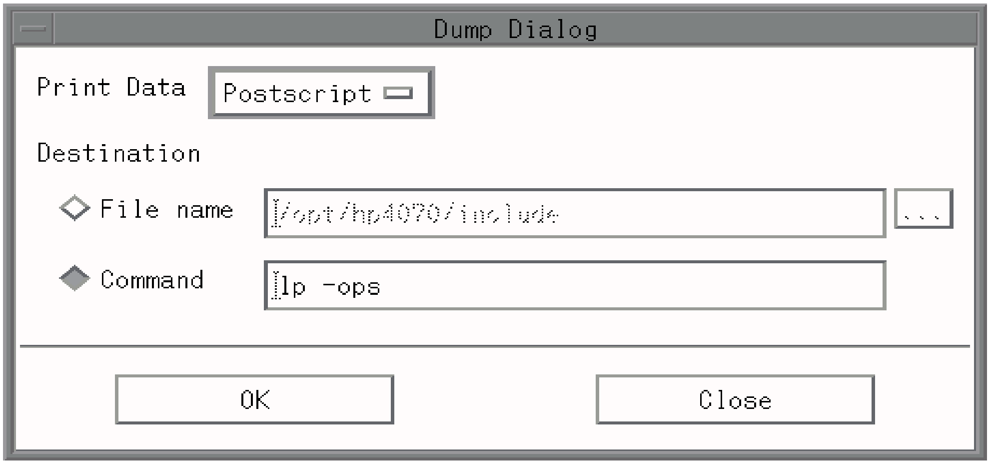
2. Enter file name to load in Selection field.

3. Click OK.

To Print Displayed Data

1. Choose `File: Dump` menu on the Graph Window. The Dump Dialog opens:

Figure 7-51

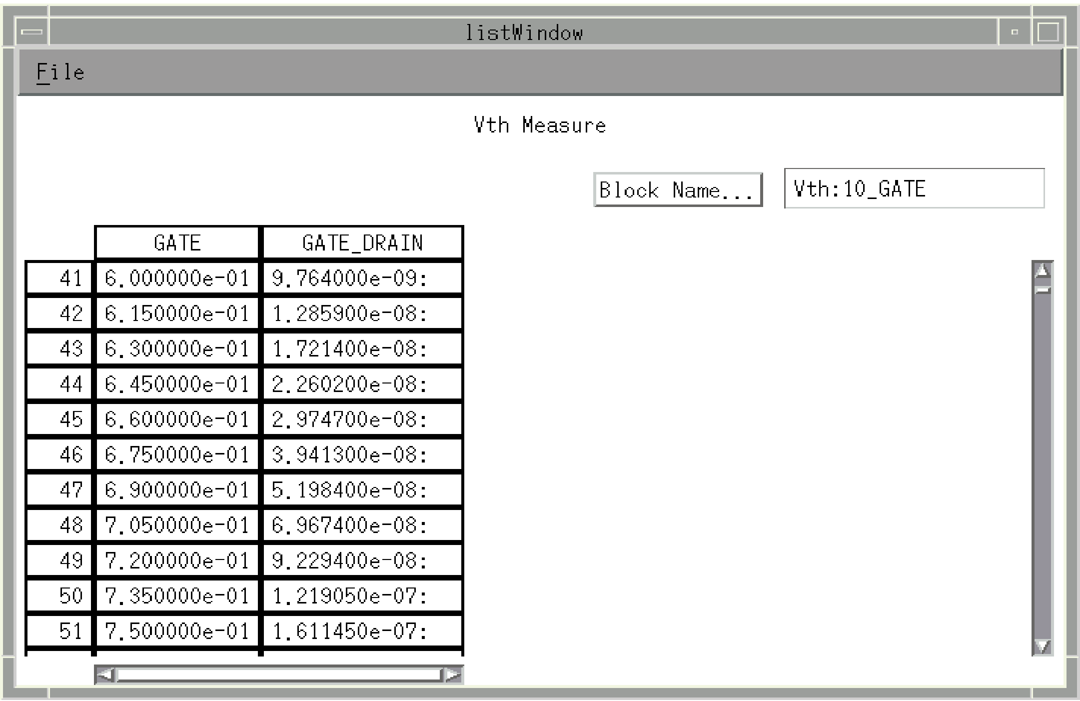


2. Select printer language as Postscript or Image (PCL) by using Print Data option menu.
3. You can print out graph or save graph data to a file:
    - Print out
        - Click the Command radio button. You can enter your desired print option in Command field.
    - Save to a file
        - Click File name radio button, then enter the desired file name in the File name field.
4. Click OK.

To Display Data as a List

1. Choose `Data: List` menu on the Graph Window.
2. The List Window opens and first selected data block in Select Block Dialog is listed:

Figure 7-52



	GATE	GATE_DRAIN
41	6.000000e-01	9.764000e-09:
42	6.150000e-01	1.285900e-08:
43	6.300000e-01	1.721400e-08:
44	6.450000e-01	2.260200e-08:
45	6.600000e-01	2.974700e-08:
46	6.750000e-01	3.941300e-08:
47	6.900000e-01	5.198400e-08:
48	7.050000e-01	6.967400e-08:
49	7.200000e-01	9.229400e-08:
50	7.350000e-01	1.219050e-07:
51	7.500000e-01	1.611450e-07:

3. To list another data block, use the Block Name button.
4. If the data has abnormal measurement status, one of the following labels is added to right of measurement data:

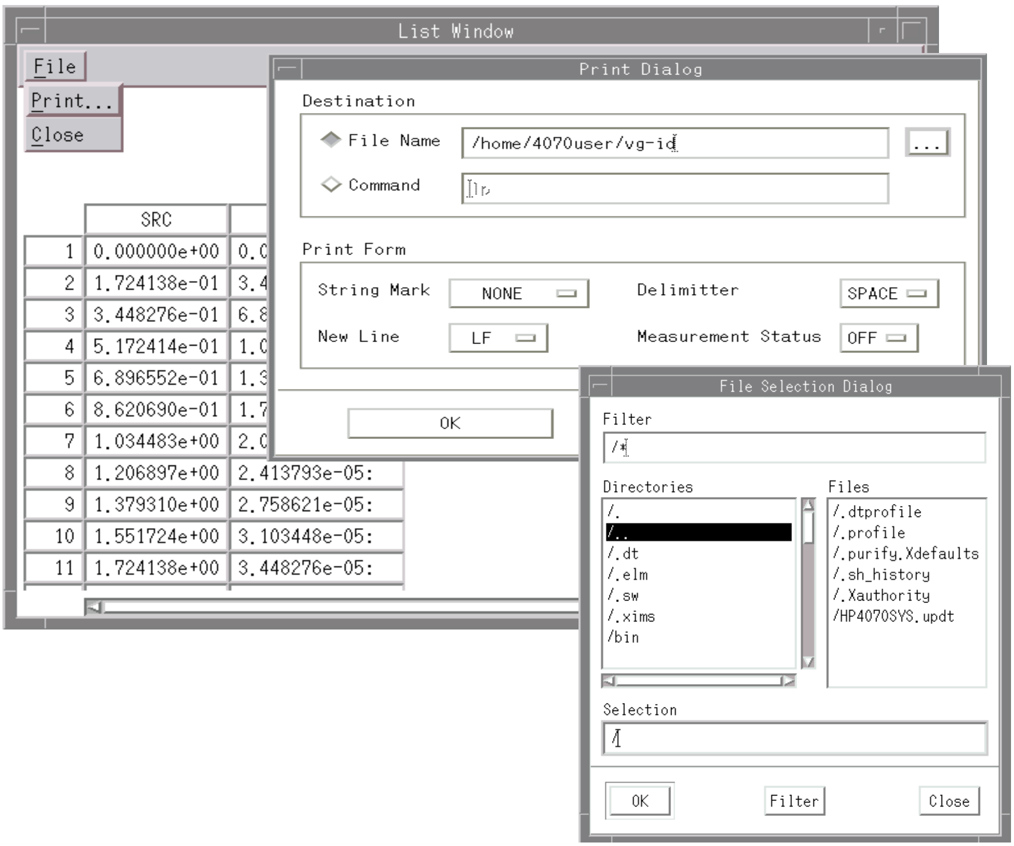
Table 7-5

Label	Status
CO	Another unit has reached compliance.
C	This unit has reached compliance.
OS	This unit is oscillating.
OF	Measurement overflow.
ST	Sweep or search aborted or completed.
DO	Search value not found.
AB	Abnormal data.
F or NG	Sense unit cannot find target value within specified accuracy (Binary Search) Abnormal compliance loop (Linear Search, Vth)
NP	Vth search ended (reached *Vg stop* before measuring *number of samples* measurement points).
MG	No maximum gradient found (Vth).
ZG	Maximum gradient is 0 (Vth).
UB	Analog bridge is unbalanced.
AD	A/D converter is not working.
OL	Signal source is overloaded.
AL	Automatic Level Control (ALC) is unable to keep constant level.

To Save List Data to an ASCII file

1. Display the measured result in the List Window. Refer to “To Display Data as a List” in this chapter.
2. Choose `File: Print...` menu on the List Window. The Print Dialog opens.

Figure 7-53



3. Set file name and the directory in which to save the measured data in the File Name field. “...” button opens dialog for assisting to set the file and the directory. Or you can set command line to make the ASCII file in the Command field, such as lp, cat commands.
4. Set desired format in the Print Form setup area. In this area, you can also select if you save Measured Status with the measured data or not.
5. Click OK in the Print Dialog.

Changing System Settings

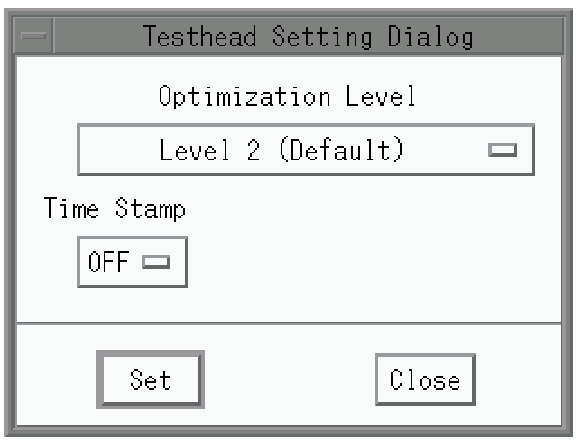
This section describes how to do the following from the IDP:

- "To Change Optimization Level"
- "To Change Time Stamp Setting"
- "To Setup the ADCs for SMU Measurement"
- "To Set Connection for Unused Pins"
- "To Initialize System"

To Change Optimization Level

1. Choose `Resource:Testhead`. The Testhead Setting Dialog opens:

Figure 7-54



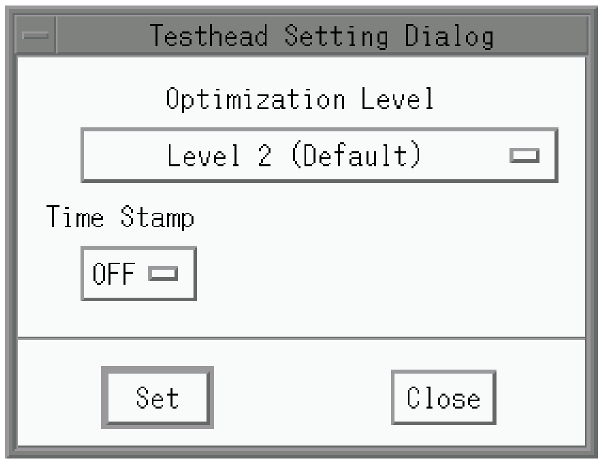
2. Select optimization level from option menu:
   - Level 0 (Full sync)
   - Level 1 (Use 4062 defaults)
   - Level 2 (Default)
   - Level 3 (No prober sync)
3. Click the Set button to change optimization level.

To Change Time Stamp Setting

You can select whether measurement statements will return the time stamp with the measurement data.

1. Choose `Resource: Testhead` on the Interactive Debugging Panel. The Testhead Setting Dialog opens:

Figure 7-55

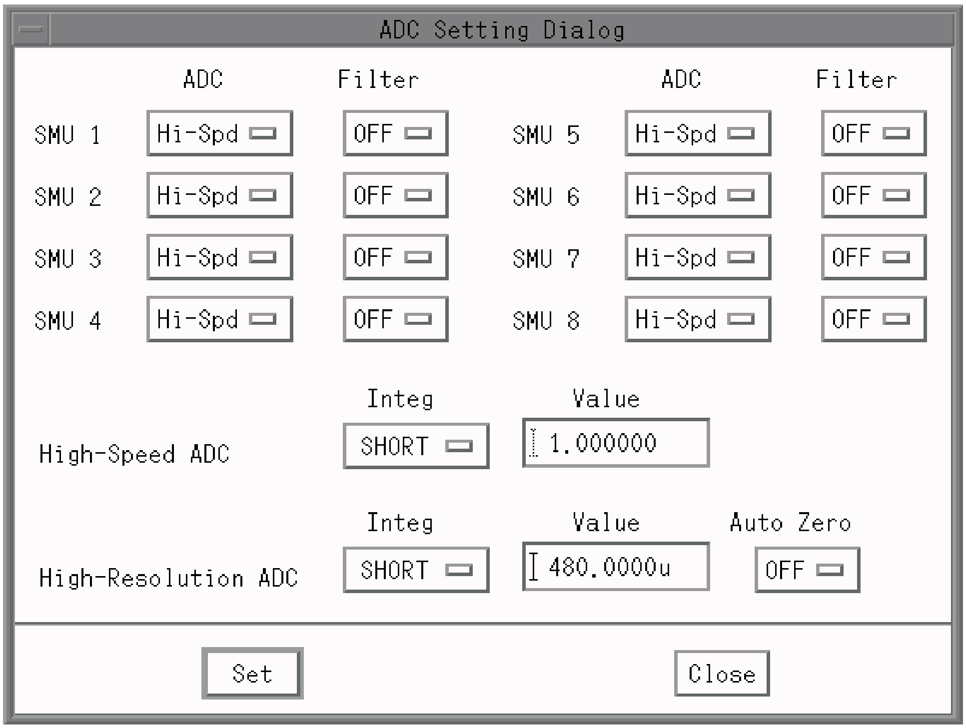


2. Select OFF (do not return time stamp) or ON (return time stamp) by using Time Stamp option menu.
3. Click the Set button.

To Setup the ADCs for SMU Measurement

1. Choose `Resource: ADC` menu on the Interactive Debugging Panel. The ADC Setting Dialog opens:

Figure 7-56



2. You can select the ADC (to use for each SMU) by using ADC option menu:

Hi-Res	high-resolution ADC
Hi-Spd	high-speed ADC

3. You can set the filter setting (of each selected ADC) to ON or OFF by using Filter option menu.

4. You can set integration time setting (for each ADC) by using Integ option menu and specifying the *Value* field as follows:

- High-speed ADC

Table 7-6

Integration mode	Integration time
MANUAL	*Value* specifies the number of samples to average.
SHORT	Number of samples to average is calculated as follows: system pre-defined number of samples × *Value*.
MEDIUM	Integration time is set to 1 Power Line Cycle (PLC). *Value* is ignored.
LONG	Integration time is set to *Value* PLCs.

- High-resolution ADC

Table 7-7

Integration mode	Integration time
MANUAL	If *Value* is in range from 80E-6 and 20E-3, integration time is set to *Value* seconds. If *Value* is in range from 1 to 100, integration time is set to *Value* PLCs.
SHORT	Integration time is calculated as follows: system pre-defined factor × *Value* (in seconds).
MEDIUM	Integration time is set to 1 Power Line Cycle (PLC). *Value* is ignored.
LONG	Integration time is set to *Value* PLCs.

5. You can set the auto-zero function for high-resolution A/D converter to ON or OFF by using Auto Zero option menu.
6. Click the Set button.

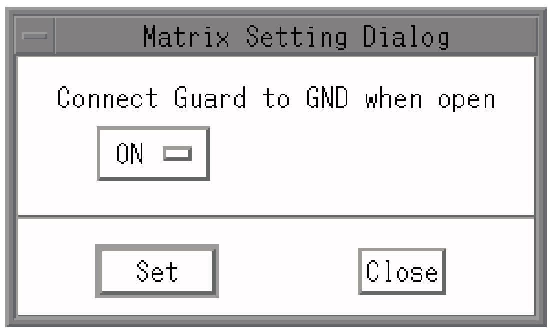
To Set Connection for Unused Pins

You can specify that guard terminals of open (*unused*) switching matrix pins will automatically be connected to circuit common.

The guard terminals of used pins (pins that are currently connected to a port) are not affected by this setting. But after a pin is disconnected from the port, the guard terminal of pin will be connected or disconnected to circuit common as was specified by this setting.

1. Choose `Resource: Matrix` menu on the Interactive Debugging Panel. The Matrix Setting Dialog opens:

Figure 7-57



2. Select ON (guard connect to circuit common) or OFF (guard open) by using `Connect Guard to GND when open` option menu.
3. Click the Set button.

To Initialize System

1. Choose `Action: Initialize` menu on Interactive Debugging Panel. Confirmation dialog opens.
2. Click YES to initialize system.

8 Error Messages

This chapter lists Agilent 4070 error messages and provides solutions.

Error Messages

1-xxxxx

- **1-10001 System software inconsistency discovered.**
  1-10002 System software inconsistency discovered in session login mechanism.
  1-10003 System software inconsistency discovered in session logout mechanism.

  Unknown error occurred during the 4070 system software execution, or login/logout session. Cannot continue the session. Execute hp4070 -logout , then execute hp4070 -login again.

- **1-10004 Cannot allocate memory.**

  Could not allocate enough memory. Execute hp4070 -logout , then execute hp4070 -login again.

- **1-10006 Cannot set socket buffer size.**
  1-10007 Failed to call socket().
  1-10008 Failed to call bind().
  1-10009 Failed to call listen().
  1-10010 Failed to call symlink().
  1-10011 Failed to call accept().
  1-10012 Failed to call connect().
  1-10013 Failed to call shmget().
  1-10014 Failed to call shmat().

  Unknown error occurred in the 4070 system software. Execute hp4070 -logout , then execute hp4070 -login again. Or reboot HP-UX.

- **1-10015 Cannot open hardware configuration file(in /etc/opt/hp4070/config/).**
  1-10016 Cannot fstat() hardware configuration file(in /etc/opt/hp4070/config/).
  1-10017 Cannot mmap() hardware configuration file(in /etc/opt/hp4070/config/).1
  10018 Cannot read() hardware configuration file(in /etc/opt/hp4070/config/).
  1-10019 Cannot unmmap() hardware configuration file(in /etc/opt/hp4070/config/).

  Could not open the configuration file (/etc/opt/hp4070/config/1). Check the configuration file. If problem is not found in the data, permission and so on, re-install the 4070 system software.

- **1-10020 Cannot allocate event handler table.**

  Too many test programs are running. Or too many events are registered by Wait_event command. Stop unnecessary test programs.

- **1-10021 Cannot read Optical Interface Special Data Register 0.**
  1-10022 Cannot ioctl() Optical Interface Card.
  1-10023 Cannot ioctl() Optical Interface Card.
  1-10024 Cannot ioctl() Optical Interface Card.
  1-10025 Cannot read Optical Interface Special Data Register N.
  1-10029 Cannot ioctl() Optical Interface Card.

  Error occurred when accessing the optical interface card. Execute hp4070 -logout, then execute hp4070 -login again. Or the optical interface card may be defective.

- **1-10026 Power Fail occurred. TIS Daemon process is going to die.**

  Testhead was turned off. Turn the testhead on. And execute hp4070 -login.

- **1-10027 Another online TIS Daemon is running.**

  Another online test session is already running. Only one online TIS Daemon can be running.

- **1-10028 Cannot open optical interface device file.**

  Could not open the optical interface device file. Check the following device files. If problem is not found in the data, permission and so on, re-install the 4070 system software. The permission of the file must be crw-rw-rw-.

  - /dev/hp4070/opt_sN
  - /dev/hp4070/opt_sNf0
  - /dev/hp4070/opt_sNf1
  - /dev/hp4070/opt_sNf2
  - /dev/hp4070/opt_sNs0
  - /dev/hp4070/opt_sNs1
  - /dev/hp4070/opt_sNs2

  where, *N* is the ISA slot number (1, 2, 3, or 4) where the optical interface card is installed.

- **1-10031 Cannot fork expmon4070 (errno=*N*).**

  Could not execute expmon4070. Check /opt/hp4070/lbin/expmon4070. The permission must be -r-xr-xr-x. If too many processes are running, kill unnecessary processes.

  where, *N* is the error number returned by the HP-UX kernel or system call.

- **1-10032 OptCard selftest(register r/w test) error.**
  1-10033 OptCard selftest(FIFO memory r/w test) error.
  1-10034 OptCard selftest(communication test) error.

  Failed on the self-test of the optical interface card installed in the system controller. Replace the optical interface card.

- **1-10035 Test Head is not in normal mode. Cannot continue TIS Daemon.**

  Unknown problem occurred in the testhead. Turn off the power of the testhead and on again. Then restart the TIS server again.

- **1-20001 Client Table full. Please quit some applications that use TIS library.**

  Too many test programs or test algorithms are running. Stop unnecessary programs or algorithms.

- **1-20003 Error in iclear() on accessing GPIB device.**
  1-20004 Error in itimeout() on accessing GPIB device.
  1-20005 Error in igpibllo() on accessing GPIB device.
  1-20006 Error in iprintf() on accessing GPIB device.
  1-20007 Error in iopen() on accessing GPIB device.
  1-20008 Error in iwrite() on accessing GPIB device.
  1-20009 Error in iread() on accessing GPIB device.
  1-20022 Error in igpibbusstatus().

  Error occurred in accessing GPIB interface. Check the GPIB interface card or the system instruments.

- **1-20010 Error in ioctl() on accessing optical interface.**
  1-20011 Error in write() on accessing optical interface.
  1-20012 Error in read() on accessing optical interface.
  1-20014 Error in select() on accessing optical interface (errno=*N*).
  1-20015 Error in select() on accessing optical interface.

  Error occurred in accessing the optical interface. Check the optical interface card.

  where, *N* is the error number returned by the HP-UX kernel or system call.

- **1-20013 Optical Interface Timeout.**

  Time out occurred when accessing the testhead. Check the test program. Or turn off the testhead.

- **1-20020 Cannot load C compensation data file.**

  Could not read the capacitance compensation data. Check the data and permission of the /etc/opt/hp4070/ccdata file and /etc/opt/hp4070/ccdata0 file.

- **1-20021 C compensation data is not loaded.**

  TIS command needs the capacitance compensation data. Related to error No. 1-20020. Solve error No. 1-20020.

- **1-20085 CMU GPIB error occurred.**

  GPIB error occurred during communication with the 4284A. Check the GPIB interface card, GPIB cable, and 4284A.

- **1-20086 DVM GPIB error occurred.**

  GPIB error occurred during communication with the 3458A. Check the GPIB interface card, GPIB cable, and 3458A.

- **1-30001 Cannot make connection because no session is logged in now.**

  No session is logged in now. Execute hp4070 -login.

- **1-30002 Cannot make connection because of wrong session id.**

  Wrong session ID was specified. Use correct session ID, or log out of unnecessary session.

- **1-30003 Request was refused because the TIS Daemon is not in the normal state. Current state is *N*.**

  where, *N* (=1 to 6) means the following status.

  - 1 : Testhead power fail occurred.
  - 2 : Testhead emergency (Over Current or Over voltage) occurred.
  - 3 : Test fixture is open.
  - 4 : Interlock is open.
  - 5 : Testhead firmware is abnormal. Replace Testhead CPU board.
  - 6 : Another client program (test algorithm, etc.) is in abort process.

  This error message appears because of the above status. Solve the problem corresponding to the status.

- **1-30004 Optical Interface timeout.**

  Time out occurred during communication with the testhead. Check the optical interface card and the optical fiber cables.

- **1-30005 GPIB timeout.**

  Time out occurred during communication with the system instruments. Check the GPIB interface card, GPIB cable, and the system instruments.

- **1-30006 Hardware Exception occurred and cannot accept any request.**

  Sub-message for error No. 1-30003.

- **1-30007 A client is in aborting sequence.**

  Sub-message for error No. 1-30003.

- **1-30008 SICL error occurred: *N*.**

  Error occurred during communication with the system instruments. Check the GPIB interface card, GPIB cable, and the system instruments.

- **1-30009 Cannot make connection. Only one Debugging Panel may run at a time.**

  Tried to open a second Interactive Debugging Panel in same session. You can open only one debugging panel at a time in same session.

- **1-30010 Cannot make connection. Another Diagnostics is running.**

  Only one Diagnostics program can run at a time. Use the Diagnostics program that is already running. Or stop the program that is already running to newly run the Diagnostics program.

- **1-30011 Cannot make connection. Another Performance Verification is running.**

  Only one Performance Verification (PV) program can run at a time. Use the program that is already running. Or stop the program that is already running to newly run the PV program.

- **1-30012 Request was refused because Diagnostics or PV is running.**

  Test program using TIS cannot be executed when the Diagnostics program or the Performance Verification (PV) program is running. Stop the Diagnostics program or the PV program to run the test program using TIS.

- **1-30013 TIS command cannot be executed because the testhead is in power failure.**

  TIS command cannot be executed because a power failure was detected in the testhead. Turn on the power to the testhead again, then restart the TIS server.

- **1- 30014 TIS command cannot be executed because over voltage or current is forced to SMUs.**

  The TIS command cannot be executed because over voltage or over current is being forced to the SMUs from external instruments or SMUs.

- **1-30015 TIS command cannot be executed because the fixture is open.**

  The TIS command cannot be executed because the test fixture lid is open. Close the lid of test fixture.

- **1-30016 TIS command cannot be executed because the interlock is open.**

  The TIS command cannot be executed because the interlock circuit is open. Close the interlock circuit.

- **1-30017 TIS command cannot be executed because the testhead cannot work properly.**

  The TIS command cannot be executed because the testhead cannot work proerly. There is something wrong with the optical interface communication, or something wrrong with the testhead. Contact the nearest Agilent Technologies Sales and Service office if the system cannot be restarted.

- **1-30018 TIS command cannot be executed because the system is running an internal process.**

  The TIS command cannot be executed because the system is running an internal process.

- **1-30019 TIS command cannot be executed because an abnormal condition exists.**

  The TIS command cannot be executed because an abnormal condition in the system. Remove the abnormal condition before executing the TIS command again.

2-xxxxx

- **2-10002 Cannot open file. filename:** *File*

  Could not open the file specified by *File*. Confirm the file name and permission of the file.

- **2-10004 An illegal format data exists. filename:** *File*, **data:** *Data*

  Tried to open file with invalid data format. Change the data format of the data *Data* in the file *File*.

- **2-10008 An improper option is specified. option:** *Option*

  Improper value (*Option*) was specified for the option. Specify the option properly.

- **2-10009 An improper argument is specified. option:** *Option*, **argument:** *Argument*

  Argument value (*Argument*) invalid for the option (*Option*) was specified. Specify the argument properly.

- **2-10014 Cannot execute command. command path:** *Path*

  Could not execute the command path *Path*. Re-install the 4070 system software.

- **2-10019 Cannot get character input.**

  Could not read the character input. Maximum 1024 characters.

- **2-11001 Failed to write the test selection file. Check permission.**

  Un-specifiable error occurred in write operation of the test selection file. Check the permission of the file.

- **2-13002 An error occurred in TIS.**

  Error occurred in TIS. Refer to the additional messages.

- **2-14001 Cannot open Optical Interface Card device file.**

  Could not open the device file for the optical interface card. Check the configuration file (/etc/opt/hp4070/config/1) and specify the proper slot number for the optical interface card. Or kill the unnecessary process that opened the optical interface card device file.

- **2-14003 An error occurred in Optical Interface Card Loopback test.**

  Optical interface card failed the loopback test. Check the optical fiber cables or the optical interface card.

- **2-21001 No test is selected. Please select at least one test.**

  No test is selected in the "Test Selection" field. Select at least one test.

- **2-21002 No SMU is selected. Please select at least one SMU.**

  No SMU is selected in the "Test Selection" field. Select at least one SMU.

- **2-21003 No Pin is selected. Please select at least one pin, chuck or input board.**

  No pin is selected in the "Test Selection" field. Select at least one pin, chuck pin, or input board.

- **2-21004 Only a numeric value is allowed here.**

  Invalid character (non-numeric) is entered in the input field for numeric character. Enter a numeric value.

- **2-21005 Only an integer value is allowed here.**

  Invalid character (non-integer) is entered in the input field for integer. Enter an integer value.

- **2-21006 Invalid repeat count. Must be 1 to 999999 (integer).**

  Wrong value is specified for how many times to repeat the test. The value must be 1 to 999999.

- **2-21007 Invalid margin ratio. Must be 0.0 to 1.0 (float).**

  Wrong value is specified for the marginal ratio used to define the marginal test limit. The value must be 0.0 to 1.0.

- **2-21008 Can't read the file. The file does not exist or no read permission.**

  The file could not be read. The file does not exist or does not have read permission. Check if the file exists or check the permission of the file.

- **2-21009 Can't write the file. The file or directory has no write permission, or the directory does not exist.**

  The file could not be written. The file or directory for the file does not have write permission. Or the directory does not exist. Check that the directory exists, and check the permission of the directory and the file.

- **2-21012 Failed to start diagnostics (errno = *N*).**

  HP-UX kernel error No. *N* occurred in starting diagnostics. Check if the /opt/hp4070/lbin/diagBody4070 program exists and check the permission of the program. If the program does not exist, re-install the 4070 system software. Or check the number of processes in progress, and kill unnecessary process.

- **2-21013 Can't preserve the result data file (errno = *N*). Check permission or maybe diagnostics was not executed yet.**

  HP-UX kernel error No. *N* occurred in preserving the result data file by File: Preserve data... menu on the Diagnostics window. Execute diagnostics once at least. Or check the permission of the file and /var/opt/hp4070/diag directory.

- **2-21014 Failed to write the result data (errno = *N*). Check permission.**

  HP-UX kernel error No. *N* occurred in writing the result data. Check the permission of the file and /var/opt/hp4070/diag directory.

- **2-21015 Failed to read result data file (errno = *N*). Check permission.**

  HP-UX kernel error No. *N* occurred in reading the result data. Check the permission of the file and /var/opt/hp4070/diag directory.

- **2-21016 Failed to write to result data file (errno = *N*). Check permission or free disk space.**

  HP-UX kernel error No. *N* occurred in writing the result data file. Check the permission of the file and /var/opt/hp4070/diag directory. Or check the free disk space. File system full may cause this error.

- **2-23001 ADC Board is malfunctioning or not installed.**

  The high-resolution ADC board is not installed or may be defective. Install or replace the board.

- **2-23002 GNDU is malfunctioning or not installed.**

  The GNDU board is not installed or may be defective. Install or replace the board.

- **2-23003 Chuck Connection Board is malfunctioning or not installed.**

  The chuck connection pin board is not installed or may be defective. Install or replace the board.

- **2-23004 LC Input Board (Port *Port_No.*) is malfunctioning or not installed.**

  The low current input board is not installed or may be defective. Install or replace the board.

- **2-23005 Kelvin Input Board is malfunctioning or not installed.**

  The kelvin input board is not installed or may be defective. Install or replace the board.

- **2-23006 CMU Input Board is malfunctioning or not installed.**

  The CMU input board is not installed or may be defective. Install or replace the board.

- **2-23007 Relay Test Board (Block** *Block_No.***) is malfunctioning or not installed.**

  The relay test board is not installed or may be defective. Install or replace the board.

- **2-23011 ADC Board attenuation factor measurement failed. port:** *Port***, expected:** *Data1***, measured:** *Data2*

  High-resolution ADC board failed the attenuation factor measurement test. If all ports failed this test, replace the high-resolution ADC board, otherwise follow the diagnostics execution results.

- **2-23012 ADC Board guard amp offset measurement failed. port:** *Port***, measured:** *Data*

  High-resolution ADC board failed the guard amplifier offset measurement test. Follow the diagnostics execution results. If all ports failed this test, replace the high-resolution ADC board.

- **2-23021 Status error occurred in SMU. port:** *Port***, status:** *Status*

  Status error occurred in the SMU specified by *Port*. Check the SMU if the 4070 failed the diagnostics.

- **2-23022 Status error occurred in CMU. status:** *Status*

  Status error occurred in the CMU. Check the CMU if the 4070 failed the diagnostics.

- **2-23023 Status error occurred in DVM. status:** *Status*

  Status error occurred in the DVM. Check the DVM if the 4070 failed the diagnostics.

- **2-23031 HF Matrix Board N is malfunctioning or not installed.**

  Reference configuration file */etc/opt/hp4070/config/refconfig1* shows the existence of HF matrix board N, but it is not detected by the testhead firmware. HF matrix board may not be installed or may be defective. Install or replace the board.

- **2-23032 HF Matrix Addressing Board is malfunctioning or not installed.**

  Reference configuration file */etc/opt/hp4070/config/refconfig1refconfig1* shows the existence of HF matrix addressing board, but it is not detected by the testhead firmware. HF matrix addressing board is not installed or may be defective. Install or replace the board.

- **2-23033 Pulse Switch N Board is malfunctioning or not installed.**

  Reference configuration file */etc/opt/hp4070/config/refconfig1* shows the existence of pulse switch board N, but it is not detected by the testhead firmware. Pulse switch board N is not installed or may be defective. Install or replace the board.

- **2-31001 File already exists. Do you want to replace it?**

  If you want to replace the data, select **OK** button. Or else, select **Cancel** button.

- **2-31002 The test(s) requested on non-existent resources will be ignored.**

  Invalid test item, SMU, or pin number is selected. The selection is ignored.

- **2-33001 Cannot identify Pin Board. pin:** *Pin*

  Actual pin board configuration did not match the configuration file (/etc/opt/hp4070/config/1). Check the configuration file and define the actual configuration.

- **2-33002 Cannot identify SMU Board. port:** *Port*

  Actual SMU configuration did not match the configuration file (/etc/opt/hp4070/config/1). Check the configuration file and define the actual configuration.

- **2-33003 Cannot identify CMU.**

  Actual CMU configuration did not match the configuration file (/etc/opt/hp4070/config/1). Check the configuration file and define the actual configuration.

- **2-33004 Cannot identify DVM.**

  Actual DVM configuration did not match the configuration file (/etc/opt/hp4070/config/1). Check the configuration file and define the actual configuration.

- **2-33005 Testhead Power Line Cycle is mismatching. reference:** *Ref* **[Hz], actual:** *Act* **[Hz]**

  Actual line frequency did not match the configuration file (/etc/opt/hp4070/config/1). Check the configuration file and define the actual frequency.

- **2-33006 Cannot identify HF Matrix.**

  The command attempts to control the HF matrix, even though the reference configuration file */etc/opt/hp4070/config/refconfig1* has the information of no MF matrix installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **2-33007 Cannot identify Pulse Switch.**

  The command attempts to control the pulse switch, even though the reference configuration file */etc/opt/hp4070/config/refconfig1* has the information of no pulse switch installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **2-33008 Cannot identify PG***n.*

  The command attempts to control the PGn, even though the reference configuration file */etc/opt/hp4070/config/refconfig1* has the information of no PGn installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **2-33009 PGn type or GPIB address mismatch.**

  The PGn definition in the reference configuration file */etc/opt/hp4070/config/refconfig1* is not correct. Check if the reference configuration file includes the correct system configuration information.

- **2-33011Cannot find pin for connection test. Port:** *Port.*

  Cannot execute the connection test. At least one pin board must be installed in:

  - Slot 1 to 24 for the HF ports 1, 2, and 3.
  - Slot 25 to 48 for the HF ports 4, 5, and 6.
  - Slot 1 to 48 for the AUX ports 1 to 8.

- **2-41001 Margin detection disabled.**

  Detection mode for the marginal limit was disabled.

- **2-45001 Relay contact check failed.**
  description: *Test case*
  measured: *Data1*, **offset:** *Offset*, **Rmeas:** *Data2*,
  Rlimit: *Limit*

  Failed in the contact check of the HF Matrix Relay Test. Check the connection of the short adapter. Or do troubleshooting and replace defective part.

- **2-45002Relay stuck check failed. description:** *Test case*
  board: *board*, **relay:** *relay*, **measured:** *Data1*, **expected:** *Data2*

  Failed in the open check of the HF Matrix Relay Test. Do troubleshooting and replace defective part.

- **2-45101PG selftest failed. description: PG***n* **Status code:** *Code*
  Message: *Message from PG*

  Failed in the selftest of the PG. Do troubleshooting and replace defective part.

- **2-45201PG connection test failed. description: PG***n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Failed in the PG connection test. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45202 PG connection test marginally passed.**
  description: PG*n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Passed in the PG connection test but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45301Pulse switch test failed.**
  description: PG*n* **port:** *port* **control: TH**
  expected: *Data1* **measured:** *Data2*

  Failed in the testhead controlled pulse switch test. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45302 Pulse switch test marginally passed.**
  description: PG*n* **port:** *port* **control: TH**
  expected: *Data1* **measured:** *Data2*

  Passed in the testhead controlled pulse switch test but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45303Pulse switch test failed.**
  description: PG*n* **port:** *port* **control:** *N* **switch:** *switch*
  expected: *Data1* **measured:** *Data2*

  Failed in the PG controlled pulse switch test (multiplexer switch). Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45304Pulse switch test marginally passed.**
  description: PG*n* **port:** *port* **control:** *N* **switch:** *switch*
  expected: *Data1* **measured:** *Data2*

  Passed in the PG controlled pulse switch test (multiplexer switch) but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45305Pulse switch test failed.**
  description: PG*n* **port:** *port* **control:** *N* **switch:** *switch*
  expected: *Data1* **measured:** *Data2*

  Failed in the PG controlled pulse switch test (open/close switch). Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45306 Pulse switch test marginally passed.**
  description: PG*n* **port:** *port* **control:** *N* **switch:** *switch*
  expected: *Data1* **measured:** *Data2*

  Passed in the PG controlled pulse switch test (open/close switch) but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45401 PG output level test failed.**
  description: PG*n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Failed in the PG output level test. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45402 PG output level test marginally passed.**
  description: PG*n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Passed in the PG output level test but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45501 PG trigger test failed.**
  description: PG*n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Failed in the PG trigger test. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

- **2-45502 PG trigger test marginally passed.**
  description: PG*n* **port:** *port*
  expected: *Data1* **measured:** *Data2*

  Passed in the PG trigger test but the result is nearly test limit. Check the cable connection and connect properly. Or do troubleshooting and replace defective part.

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- **3-10001 System software inconsistency discovered.**

  Unknown error occurred during the 4070 system software execution. Cannot continue the session.

- **3-10002 Cannot open file. filename:** *File.*

  Could not open the file specified by *File.* Check the file name and permission of the file.

- **3-10004 An illegal format data exists. filename:** *File.***data:** *Data*

  Tried to open file with invalid data format. Change the data format of the data *Data* in the *FIle* or remake datafile.

- **3-10006 Cannot write data to file. filename:** *Filename*

  Could not write data to *Filename*. Check the permission of file or directory. Or check the free disk space. File system full may cause this error.

- **3-10015 Cannot execute command. command path:** *Path*

  Check the *Path* command. The command may not have execute permission. If problem is not found, re-install 4070 system software.

- **3-10023 Failed to open Standard Set calibration data directory.**

  Could not open /etc/opt/hp4070/diag/caldata directory. Check the data directory. If problem is not found in the directory, permission and so on, re-install the 4070 system software.

- **3-10024 Cannot rename file. filename:** *Filename*

  Could not rename the file. Check the permission of file or directory. If problem is not found, re-install the 4070 system software.

- **3-11001 Failed to write the test selection file.**

  Un-specifiable error occurred during write operation of the test selection file. Check the permission of file.

- **3-11002 Failed to open temporary PVheader file.**

  Could not open /var/opt/hp4070/daig/PVheader file. Check the free disk space. File system full may cause this error. If problem is not found, re-install the 4070 system software.

- **3-11003 pvBody4070 process is alreay running. Something is wrong.**

  The pvBody4070 process has been started. Check the pvBody process.

- **3-11004 Failed to open pipe (errno = *N*).**

  HP-UX kernel error No. *N* occurred during communication with diagnostics program. Exit from the 4070 system software environment, then log into it again. Then execute diagnostics program.

- **3-11005 Failed to invoke diagBody4070 program (errno = *N*).**

  HP-UX kernel error No. *N* occurred when starting diagnostics. Check if the diagBody4070 program exists and check the permission of the program. If the program does not exist, re-install the 4070 system software. Or check the number of processes in progress, and kill unnecessary process.

- **3-13002 An error occurred in TIS.**

  Error occurred in TIS. Refer to the additional messages.

- **3-16001 Memory exhausted.**

  The measurement data could not be loaded because of small free memory space. Stop unnecessary applications and close windows to increase free memory.

- **3-16010 Failed to open the file. Check permission or diskette.**

  The file was not loaded/saved because error occurred during load/save of file. Check the permission of the file. Or check the diskette.

- **3-16011 Failed to read the file. Check permission or diskette.**

  The file was not loaded because error occurred during load of file. Check the permission of the file. Or check the diskette.

- **3-16012 Failed to write the file. Check permission or diskette.**

  The file was not saved because error occurred during save of file. Check the permission of the file. Or check the diskette.

- **3-16013 Failed to end printing (errno = *N*).**

  Error No. *N* occurred at end of printing. Cannot close the pipe for LP command.

- **3-20001 Failed to read Standard Set calibration data.**

  Could not read the data file in /etc/opt/hp4070/diag/caldata directory. Check the permission of the data file and directory.

- **3-20002 Failed to write Standard Set calibration data.**

  Could not write the data file in /etc/opt/hp4070/diag/caldata directory. Check the permission of the data file and directory.

- **3-20003 Failed to remove Standard Set calibration data.**

  Could not remove the data file in /etc/opt/hp4070/diag/caldata directory. Check the permission of the data file and directory.

- **3-21001 No test is selected. Please select at least one test.**

  No test is selected in the "Test Selection" field. Select at least one test.

- **3-21002 No SMU is selected. Please select at least one SMU.**

  No SMU is selected in the "SMU Selection" field. Select at least one SMU.

- **3-21003 No Pin is selected. Please select at least one pin, chuck or input board.**

  No pin is selected in the "Pin Selection" field. Select at least one pin or chuck pin.

- **3-21004 Failed to open the profile data file.**

  Could not open the profile data file. Check if the file exists and permission of file or directory. If this message is displayed when you open the system default file, check the /etc/opt/hp4070/diag/PVprofile.

- **3-21005 Failed to read the profile data file.**

  Could not read the profile data file. Check if the file exists and permission of file or directory.

- **3-21006 Failed to write to the profile data file.**

  Could not write the profile data file. Check if the file exists and permission of file or directory. If this message is displayed when you write the system default file, check the /etc/opt/hp4070/diag/PVprofile.

- **3-21008 Can't read the file. The file does not exist or no read permission, or the directory does not exist.**

  The file could not be read. The file or directory for the file does not have read permission. Or the directory does not exist. Check that the directory exists, and check the permission of the directory and the file.

- **3-21009 Can't write the file. The file or directory does not have write permission, or the directory does not exist.**

  The file could not be written. The file or directory for the file does not have write permission. Or the directory does not exist. Check that the directory exists, and check the permission of the directory and the file.

- **3-21010 The DMM address for PV is not specified. Specify GPIB address in Configuration Window.**
- **3-21011 Standard C/R set to be used is not specified. Specify their serial numbers in Configuration Window.**
- **3-21012 Specified value for** *Equipment_Name* **exceeds the ±5% range limit against the nominal value. Set the correct value.**
- **3-21013 GPIB address must be integer value. Specify an integer value for DMM address.**

  A non-integer value is specified for GPIB address. Specify an integer value.
- **3-21022 The Oscilloscope address for PV is not specified. Specify GPIB address in Configuration Window.**

  No GPIB address for the 54750A Oscilloscope is specified in the Standard Selection window. Specify the GPIB address of the 54750A.
- **3-21023 Specified Oscilloscope GPIB address is an integer. Specify an integer value.**

  Specified GPIB address value for the 54750A Oscilloscope is not integer. Specify a proper integer value for the GPIB address of the 54750A.
- **3-23001 ADC Board is malfunctioning or not installed.**

  The high-resolution ADC board is not installed or may be defective. Install or replace the board.
- **3-23002 GNDU Board is malfunctioning or not installed.**

  The GNDU board is not installed or may be defective. Install or replace the board.
- **3-23003 Chuck Connection Pin Board is malfunctioning or not installed.**

  The chuck connection pin board is not installed or may be defective. Install or replace the board.
- **3-23004 LC Input Board (Port** *Port_No.***) is malfunctioning or not installed.**

  The low current input board is not installed or may be defective. Install or replace the board.
- **3-23005 Kelvin Input Board is malfunctioning or not installed.**

  The Kelvin input board is not installed or may be defective. Install or replace the board.

- **3-23006 CMU Input Board is malfunctioning or not installed.**

  The CMU input board is not installed or may be defective. Install or replace the board.

- **3-23007 Relay Test Board (Block** *Block_No.*) **is malfunctioning or not installed.**

  The relay test board is not installed or may be defective. Install or replace the board.

- **3-23011 ADC Board attenuation factor measurement failed.**
  port: *Port*, **expected:** *Data1*, **measured:** *Data2*

  The high-resolution ADC board failed the attenuation factor measurement test. Follow the performance verification execution results. If all ports failed this test, replace the high-resolution ADC board.

- **3-23012 ADC Board guard amp offset measurement failed.**
  port: *port* **, measured:** *Data*

  The high-resolution ADC board failed the guard amplifier offset measurement test. Follow the diagnostics execution results. If all ports failed this test, replace the high-resolution ADC board.

- **3-23021 Status error occurred in SMU. port:** *port*, **status:** *Data*

  Status error occurred in the SMU specified by *Port*. Check the SMU if the 4070 failed the performance verification.

- **3-23022 Status error occurred in CMU. status:** *Status*

  Status error occurred in the CMU. Check the CMU if the 4070 failed the performance verification.

- **3-23023 Status error occurred in DVM. status:** *Status*

  Status error occurred in the DVM. Check the DVM if the 4070 failed the performance verification.

- **3-23030 Error in iopen() on GPIB device (DMM for PV).**

  An error in iopen() occurred when the PV4070 program tries to communicate the DMM (3458A). Confirm if the specified logical unit of the DMM is correct or if the SICL configuration has the specified logical unit entry.

- **3-23031 DMM for PV is not found.**

  The DMM (3458A) for PV is not responsed by the serial polling on the specified logical unit+GPIB address. Check the following items:

  - If the GPIB address setting of the DMM is correct.
  - If another GPIB device other than the DMM is on the specified GPIB address.
  - If the GPIB cable is not broken.

- **3-23032 The DMM address must specify both logical unit and GPIB address.**

  Logical unit or GPIB address of the DMM is not specified in the Standard Selection window. Specify both the logical unit and GPIB address of the DMM.

- **3-23034 Error in iread()/iwrite() on GPIB device (DMM for PV).**

  An error occurred during the HP-UX communication between the computer and the DMM (3458A). Check the following items:

  - If the GPIB cable is not broken.
  - If the GPIB interface of the computer is not broken.
  - If the GPIB interface of the DMM (3458A) is not broken.

- **3-23036 Each test pin must be connected to different connector pin.**

  Multiple test pins are connected to the same connector. Change the pin assignment.

- **3-23051 HF Matrix Board *N* is malfunctioning or not installed.**

  Reference configuration file “/etc/opt/hp4070/config/refconfig1” shows the existence of HF matrix board *N*, but it is not detected by the testhead firmware. HF matrix board may not be installed or may be defective. Install or replace the board.

- **3-23052 HF Matrix Addressing Board is malfunctioning or not installed.**

  Reference configuration file “/etc/opt/hp4070/config/refconfig1” shows the existence of HF matrix addressing board, but it is not detected by the testhead firmware. HF matrix addressing board is not installed or may be defective. Install or replace the board.

- **3-23053 Pulse Switch *N* Board is malfunctioning or not installed.**

  Reference configuration file "/etc/opt/hp4070/config/refconfig1" shows the existence of pulse switch board *N*, but it is not detected by the testhead firmware. Pulse switch board *N* is not installed or may be defective. Install or replace the board.

- **3-23054 Error in iopen() on GPIB device (Oscilloscope for PV).**

  An error in iopen() occurred when the PV4070 program tried to communicate the 54750A. Confirm if the specified logical unit of the 54750A is correct or if the SICL configuration has the specified logical unit entry.

- **3-23055 Oscilloscope for PV is not found.**

  The oscilloscope (54750A) for PV is not responsed by the serial polling on the specified logical unit+GPIB address. Check the following items:

  - If the GPIB address setting of the oscilloscope is correct.
  - If another GPIB device other than the oscilloscope is on the specified GPIB address.
  - If the GPIB cable is not broken.

- **3-23056 The Oscilloscope address must specify both logical unit and GPIB address.**

  Logical unit or GPIB address of the oscilloscope is not specified in the Standard Selection window. Specify both the logical unit and GPIB address of the oscilloscope.

- **3-23057 Error in iread()/iwrite() on GPIB device (Oscilloscope for PV).**

  An error occurred during the HP-UX communication between the computer and the oscilloscope (54750A). Check the following items:

  - If the GPIB cable is not broken.
  - If the GPIB interface of the computer is not broken.
  - If the GPIB interface of the oscilloscope is not broken.

- **3-23070 Error in itimeout() on GPIB device (DMM for PV).**
  3-23071 Error in iclear() on GPIB device (DMM for PV).
  3-23072 Error in itermchr() on GPIB device (DMM for PV).

  An error occurred when the computer tried to initialize the DMM (3458A). Check the following items:

  - If the GPIB cable is not broken.
  - If the GPIB interface of the computer is not broken.
  - If the GPIB interface of the DMM is not broken.
  - If the DMM is working correctly.

- **3-23080 Error in itimeout() on GPIB device (Oscilloscope for PV).**
  3-23081 Error in iclear() on GPIB device (Oscilloscope for PV).
  3-23082 Error in itermchr() on GPIB device (Oscilloscope for PV).

  An error occurred when the computer tried to initialize the oscilloscope (54750A). Check the following items:

  - If the GPIB cable is not broken.
  - If the GPIB interface of the computer is not broken.
  - If the oscilloscope is working correctly.
  - If the GPIB interface of the oscilloscope is not broken.

- **3-24302 Cannot find available SMU. Please check using DIAG4070.**

  Could not find available SMU for calibrating the relay test board. Check the testhead configuration by using DIAG4070.

- **3-24303 Failed to calibrate a relay test board. Please check using DIAG4070.**

  Could not calibrate a relay test board and could not check of measurement pin position is correct. Check the relay test board by using DIAG4070.

- **3-24501 Each test pin must be connected to different connector pin.**

  Multiple test pins are connected to the same connector. Change the pin assignment.

- **3-24801 Cannot specify chuck connection pin for test pin.**

  Chuck connection pin was specified to be CMU bias test pin. Set CMU bias test pin to other pin.

- **3-24901 One of 1/2/3/4/48 pin should be available for SMU Output Resistance Test.**

  Check the pin board 1, 2, 3, 4 and 48 by using DIAG4070.

- **3-24902 Pin *N* is malfunctioning or not installed. SMU Output Resistance Test needs this pin board.**

  The pin *N* is not installed or may be defective. Check the pin *N* by using DIAG4070.

- **3-24903 The SMU Output Resistance Test requires at least two SMUs.**

  SMU is malfunctioning or at least two SMUs are not installed. Check the SMU function and configuration by using DIAG4070.

- **3-24951 Each test pin must be in different block.**

  Pulse level test and pulse parameter test require that at least one pin board is installed in each matrix block of the testhead. One pin board must be installed in the slot numbers 1 to 24, and another pin board must be in the numbers 25 to 48.

- **3-24952 Each test pin must be a multiple of 4.**

  Test pins specified for the pulse parameter test must be multiples of 4. That is, they are 4, 8, 12, 16, ... , 48. Check the pin configuration.

- **3-25001 Calibration Bus(block: *N*) does not have enough performance. Please check using DIAG4070**.

  The calibration is discontinued because calibration bus does not have enough performance. Check the calibration bus by using DIAG4070 and calibrate again.

- **3-25002 SMU *N* does not have enough performance. Please check using DIAG4070. (*V* [V]: *I* [A], *V* [V]: *I* [A])**

  The calibration is discontinued because SMU *N* does not have enough performance. Check the SMU *N* by using DIAG4070 and calibrate again.

- **3-25003 Failed to measure Reference Resistor.**
  (measured: *Measured_R* [ohm], expected: *Expected_R* [ohm])

  3-25004 Failed to measure Reference Resistor.
  (expected: *R1* [ohm], min: *R2* [ohm], max: *R3* [ohm])

  Could not measure the reference resistor. Check the cable connections, DMM for PV, and high-resolution ADC board.

- **3-25011 ADC Reference Volt measurement failed. (measured:** *Measured_V* **[V], expected:** *Expected_V* **[V]).**

  3-25012 ADC B-COM Volt measurement failed.(B-COM: *V* **[V])**

  Check the high-resolution ADC board by using DIAG4070. Or check the cable connections.

- **3-25021 ADC R Ref Calibration must be executed before SMU R Calibration.**

  The R Ref Calibration was not executed before SMU Ref Calibration. Re-calibrate SMU reference by using **Cal SMU**.

- **3-25031 Vtop/Vbase measurement for skew calibration was failed. Check PG*n*-HF*m* connection.**

  Failed to measure Vtop or Vbase value for the skew calibration. Check the cable connections between the PG*n* and HF*m*. If the skew calibration still fails with this error, check the cable connections between the PV pulse fixture and signal input connector of the oscilloscope.

- **3-25032 PG*n* delay time measurement for skew calibration was failed.**

  Failed to measure delay times for the skew calibration. Check the cable connections between the PG*n* and HF*m*. If the skew calibration still fails with this error, check the cable connections between the PV pulse fixture and signal input connector of the oscilloscope.

- **3-26001 Can't read the file.The file does not exist or no read permission or illegal path name is specified. Check the path name.**

- **3-26002 Can't write the file. The file or directory has no write permission, or an illegal path name is specified. Check the path name.**

- **3-26003 Failed to initiate spooler command. Check the specified command.**

- **3-26004 Failed to print (errno =** *Error***).**

  Could not send the data to spooler command. Check the spooler setting.

- **3-26006 Failed to open diskette directory. Check the following:**
  DOS format diskette is inserted into the disk drive.
  The specified disk drive path name is correct.
  The scsifloppy device driver is present in the HP-UX kernel.
  The DOS-UTIL fileset is installed.
- **3-26010 File format error. Specified field delimiter is not found. Check the file format and delimiter specification.**
- **3-26011 File format error. Specified string quotation mark is not found. Check the file format and quotation specification.**
- **3-26012 File format error. Numerical value is not found in a numeric field.**
- **3-26013 File format error. No valid data.**
- **3-27001 An error occurred in Testhead. status:** *Status*

  Testhead timeout occurred when ADC board was calibrated. Check the ADC board, CPU board and so on.
- **3-31001 File already exists. Do you want to overwrite it?**

  If you want to overwrite the data, select **OK** button. If not, select **Cancel** button.
- **3-31002 The test(s) requested on non-existent resources will be ignored.**

  Invalid test item, SMU, or pin number is selected. The selection is ignored.
- **3-33001 Cannot identify Pin Board. pin:** *Pin*

  Actual pin board configuration did not match the configuration file (/etc/opt/hp4070/config/refconfig1). Check the configuration file and define the actual configuration.
- **3-33002 Cannot identify SMU Board. port:** *Port*

  Actual SMU configuration did not match the configuration file (/etc/opt/hp4070/config/refconfig1). Check the configuration file and define the actual configuration.
- **3-33003 Cannot identify CMU.**

  Actual CMU configuration did not match the configuration file (/etc/opt/hp4070/config/refconfig1). Check the configuration file and define the actual configuration.

- **3-33004 Cannot identify DVM.**

  Actual DVM configuration did not match the configuration file (/etc/opt/hp4070/config/refconfig1). Check the configuration file and define the actual configuration.

- **3-33005 Testhead Power Line Cycle in config file does not match actual line frequency. reference:** *Ref* **[Hz], actual:** *Act* **[Hz]**

  Actual line frequency did not match the configuration file (/etc/opt/hp4070/config/refconfig1). Check the configuration file and define the actual frequency.

- **3-33006 Cannot identify HF Matrix.**

  The command attempts to control the HF matrix, even though the reference configuration file "/etc/opt/hp4070/config/refconfig1" has the information of no MF matrix installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **3-33007 Cannot identify Pulse Switch.**

  The command attempts to control the pulse switch, even though the reference configuration file "/etc/opt/hp4070/config/refconfig1" has the information of no pulse switch installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **3-33008 Cannot identify PG*n*.**

  The command attempts to control the PG*n*, even though the reference configuration file "/etc/opt/hp4070/config/refconfig1" has the information of no PG*n* installed. Check the following items:

  - If the command that you execute is correct.
  - If the reference configuration file includes the correct system configuration information.

- **3-36001 File already exists. Do you want to overwrite it?**

  If you want to overwrite the data, select **OK** button. If not, select **Cancel** button.

- **3-41001 Is it ok to remove the Standard Set calibration data? Note that this operation is not recoverable.**

  If you want to remove the data, select **OK** button. If not, select **Cancel** button.

- **3-41002 Do you want to discard all unsaved changes? Note that this operation is not recoverable.**

  If you want to discard all unsaved changes, select **OK** button. If not, select **Cancel** button.

- **3-41003 The currently modified data will be lost. Do you want to save them before loading the new Standard Set data?**

  If you want to save the data, select **OK** button. If not, select **Cancel** button.

- **3-45701Relay contact check failed. description:** *Test case* **measured:** *Data1*, **offset:** *Offset*, **Rmeas:** *Data2*, **Rlimit:** *Limit*

  Failed in the contact check of the HF Matrix Relay Test. Check the connection of the short adapter. Or do troubleshooting and replace defective part.

- **3-45702 Relay stuck check failed.**
  description: *Test case*
  board: *board*, **relay:** *relay*, **measured:** *Data1*, **expected:** *Data2*

  Failed in the open check of the HF Matrix Relay Test. Do troubleshooting and replace defective part.

- **3-45801 Pulse switch test failed.**
  description: *Description*
  measured: *Data*

  Failed in the pulse switch test (on/off test). Check the test lead connections and connect properly. Or do troubleshooting and replace defective part.

- **3-45901 Pulse level test failed.**
  description: *Test case*
  measured: *Data*

  Failed in the pulse level test. Check the connection from PGU and HF port to the signal input port of the oscilloscope. And connect properly. Or do troubleshooting and replace defective part.

- **3-45921 Pulse parameter test failed.**
  description: *Description*
  measured: *Data*

  Failed in the pulse parameter test (except for overshooting). Check the connection from PGU and HF port to the signal input port of the oscilloscope. And connect properly. Or do troubleshooting and replace defective part.

- **3-45922 Pulse parameter test failed due to overshoot.**
  description: *Description*
  measured: *Data*

  Failed in the pulse parameter test due to overshoot. Check the connection from PGU, HF port to 54751A. And connect properly. Or do troubleshooting and replace defective part.

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- **4-110001 Cannot make connection because no session is logged in now.**

  Before starting up the IDP, you need to log in to the 4070 operating environment. Execute hp4070 -login command before executing idp4070 command.

- **4-110004 Break connection because TIS Daemon process was down.**

  TIS daemon was down during IDP operation. Log in to the 4070 again, and execute idp4070 command.

- **4-110005 Cannot send event data to idp4070.**

  IDP was down abnormally. Exit IDP by choosing File: Exit menu on the IDP window.

- **4-120001 Cannot allocate memory for reading last measurement data.**

  The measurement data could not be loaded when choosing File: Open Last Test menu on the Graph window of IDP because of small free memory space. Stop unnecessary applications and close windows to increase free memory size.

- **4-202004 Allocation size is too large. Ignored.**

  Tried to load data file that was edited or broken. Internal error. Number of vector data is larger than the allocated size. Excess data is not set.

- **4-202005 Data size is larger than allocated size. The data is ignored.**

  Tried to load data file that was edited or broken. Internal error. Tried to set number of vector data that was negative number. No action.

- **4-202006 Invalid block number is selected. Ignored.**

  Internal error. Block number of the data block to be cleared is a negative number or over the maximum number. No action.

- **4-202007 Selected block size is too large. Last selected block is ignored.**

  Tried to load data file that was edited or broken. Internal error. Too large block size was specified for block selection. The block is not selected.

- **4-202009 Measurement vector number is invalid. The vector is ignored.**

  Tried to load data file that was edited or broken. Internal error. Tried to set number of the vector data that is negative number, zero, or over the number of registered data. The vector data is not set.

- **4-205011 Warning: Illegal data format in data file. Ignored. Too long line. Line =** *Line_No.***.**

  Data file to be loaded was edited or broken. Number of characters in line *Line_No.* of data file to be loaded was over 128 characters. The line is ignored. Delete the line or edit the line so that it is 128 or less characters.

- **4-205012 Warning: Too many data in one data block: <= 2002 data per data block. Used only the first 2002 data.**

  Data file to be loaded was edited or broken. Number of data in a vector data is over 2002. Only the first 2002 data are loaded. Delete the excess data so that number of data is 2002 or less.

- **4-205013 Warning: Bad data Tag found in data file. Ignored. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Invalid specifier was used in line *Line_No.* of the data file. The line is ignored. Delete the line. Or edit the data file. Use ": (colon)", for example, "BX:", "BY:" and so on, to indicate the specifiers.

- **4-205014 Warning: Cannot use Attributes Tag in data block portion. Ignored. Use this Tag in header portion of data file. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Attribute tag is inserted in line *Line_No.* of the data file to be loaded. The line is ignored. Delete the line.

- **4-205015 Warning: Illegal data format in data file. Ignored. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Non-numeric data is included in line *Line_No.*. The line is ignored. Delete the non-numeric data, or exchange it with the numeric data.

- **4-205016 Warning: Illegal range format in data file for** *Data***. Ignored. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Could not get the data from the lines #XI, #X and #Y for graph in the data file. The line *Line_No.* is ignored. Delete the line. Or edit the file and insert the proper value.

- **4-205018 Warning: Illegal Character in data file for** *Data*. **Used NULL String. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Invalid character was used in line *Line_No.*. The line is ignored. Edit the file. Numeric characters, and '–' (minus), '+' (plus), '_' (underscore), ' ' (space), '.' (period) and ',' (comma) are allowed for the data.

- **4-205019 Warning: Illegal string description in data file. Ignored. Line =** *Line_No.*.

  Data file to be loaded was edited or broken. Strings are not enclosed by double quotations ('). The line *Line_No.* is ignored. Edit the file and properly enclose the strings by double quotations.

- **4-205101 Warning: Bad data range for Log scale;***Axis*. **Turned off log scale mode.**

  Tried to set minimum value or maximum value of X axis or Y axis in log scale to 0 or negative value. Graph scale is set to linear scale automatically. The data must be positive value for log scale.

- **4-205102 Warning: Bad data for Log scale. Turned off log scale mode.**

  Tried to set X-axis data or Y-axis data in log scale to negative value. Graph scale is set to linear scale automatically. The data must be positive value for log scale.

- **4-205103 Warning: Bad range for scale. Set previous value.**

  Difference between maximum value and minimum value of the graph is almost 0. Minimum value and maximum value are set to the previous values automatically. Specify a bigger difference.

- **4-205112 Warning: No Y data. Cannot plot any data.**

  Data file to be loaded was edited or broken. Internal error. Y vector data does not exist although X vector data exists. Graph does not plot any data. Create one Y vector data at least.

- **4-211000 Can't open file.**

  Error occurred during loading/saving the IDP data file. The data file is not loaded/saved. Confirm that the directory for the data file exists, and the permission of the directory and the data file.

- **4-211001 Can't write file.**

  Error occurred while saving the IDP data file. The data file is not saved. Confirm that there is sufficient free disk space. Prepare approx. 10 KByte for one IDP data file.

- **4-211002 Can't read file.**

  Size of the data file is less than the size of IDP data file. The data file is not loaded. Specify the IDP data file name properly. If the file was edited, the file cannot be loaded.

- **4-211003 Saving to a file is not allowed when some resource fields are modified.**

  Tried to save the IDP data file before setup was completed (clicking **Set** button) on the IDP window. The data file is not saved. Close the Save Dialog and click **Set** button. Then save the data file.

- **4-211004 File format revision mismatch. Can't read the file.**

  Tried to load data file, but did not match the IDP data format. The data file is not loaded. Specify the file name of the IDP data. If the IDP data file was edited and changes made, the data file cannot be loaded.

- **4-211005 Can't close the resource display when some resource fields are modified.**

  Tried to delete a resource from the Resource Selection dialog before setup for the resource was completed (clicking **Set** button) on the IDP window. The resource is not deleted from the Resource Selection dialog. Close the Resource Selection dialog, click **Set** button. Then delete the resource from the Resource Selection dialog.

- **4-211006 Can't open last measurement data.** *Test_name* **doesn't create array data.**
  4-211007 Can't open last measurement data. No measurement has been performed.
  4-211008 Can't open last measurement data. There is no measurement data. The measurement might have been executed on offline system.

  Data on the Graph window does not change. Before choosing File: Open Last Test menu, you must execute measurement that makes array data.

  File: Open Last Test menu on the Graph window is used to display array data that was measured in the On-line mode.

- **4-212001 Cannot create measurement blocks.**

  Number of measurement data exceeds the maximum number. Measurement block is not created. Clear the data loaded on the Graph.

- **4-212002 Cannot create vector data blocks.**

  Tried to load data file that was edited or broken. Internal error. Number of data for vector data is zero, negative number, or exceeds the maximum number. No action.

- **4-212003 Cannot allocate data.**

  Tried to load data file that was edited or broken. Internal error. Tried to create data with negative number or over the maximum number.

- **4-215100 Error: Data block index value must be 1 to 7.**

  Tried to load data file that was edited or broken. Internal error. Data block index value must be 1 to 7.

- **4-215150 Error: Bad file name: May be too long file name or no suffix;***File_name*.

  Name of file to load is too long or no suffix. The file is not loaded. Enter the proper name for the file on the Load dialog, and try to load the file again.

- **4-215151 Error: Bad file suffix.**

  Suffix of the file name entered is not '.dpg' or '.dps'. The file is not loaded. Enter the proper name for the file in the Load Dialog, and try to load the file again.

- **4-215152 Error: Bad file type; not an ordinary file.**

  File is not ASCII file. The file is not loaded. Enter the proper name for the file in the Load Dialog, and try to load the file again.

- **4-215155 Error: Too long file path name. Maximum 1018 characters.**

  File name over 1018 characters was entered. The file is not saved. Use file name with 1018 or less characters and try to save the file again.

- **4-215156 Error: Specified path name is too long. Only the leading 1023 characters are used.**

  Path name over 1023 characters was entered. The file is not saved. Use path name with 1023 or less characters and try to save the file again.

- **4-215301 Error: Syntax error in dump command;** *Command*.

  Syntax error occurred in dump command. Enter the proper command for dump/print.

- **4-215303 Error: Cannot generate PostScript code.**

  Temporary PostScript file could not be created. Secure enough free disk space for temporary file.

- **4-225001 System Error: Cannot open data file;** *File_name*.

  Specified data file does not exist, improper directory is specified, or temporary file for dump cannot be created. Check the name of data file, or permission of the file and directory. Or secure enough free disk space for temporary file.

5-xxxxx

- **5-10001 Cannot make connection with TIS Daemon. No session or environment variable PCS_SESSION_ID is not properly set.**

  Execute hp4070 -login command. Or confirm the setting of the environmental variable PCS_SESSION_ID.

- **5-10002 Cannot allocate memory. Please quit and try again.**

  To allocate memory, stop the action and try it again.

- **5-10003 Environmental variable: PCS_SESSION_ID is not set.**

  Quit from the 4070 operating environment, set PCS_SESSION_ID, and then log in again.

6-xxxxx

- **6-20001 Cannot translate 4062 port address into 4070 port address.**

  Specified port address for the 4062 could not be translated to the 4070 port address. Check the port address, and specify the correct port address.

- **6-20002 Invalid port is assigned.**

  Specified port address is not correct. Confirm the port address.

- **6-20003 Invalid pin is assigned.**

  Specified pin number is not correct. Confirm the pin number.

- **6-20004 [F_ROM] Pin number must be 0 to 48.**

  Pin number must be 0 to 48. Enter a valid value.

- **6-20005 Specified pin board is malfunctioning or not installed.**

  Pin board for the specified pin number is not installed or defective. Confirm the pin board configuration. hp4070 -login command displays the 4070 system configuration.

- **6-20006 From_pin is out of range.**

  Pin number assigned for the *first pin* parameter of Connect_th command is not correct. Confirm the pin number.

- **6-20007 To_pin is out of range.**

  Pin number assigned for the *last pin* parameter of Connect_th command is not correct. Confirm the pin number.

- **6-20008 1st parameter must be 1 (connect) or 0 (disconnect).**

  Wrong value was specified for the first parameter of Tap_port command. The value must be 0 (disconnect) or 1 (connect). Check the value and specify the proper value.

- **6-20009 2nd parameter must be port address of SMU/AUX port 1 or 2.**

  Wrong value was specified for the second parameter of Tap_port command. The value must be the port address of SMU port 1 or 2, or AUX port 1 or 2. Check the value and specify the proper value.

- **6-20010 3nd parameter must be port address of SMU/AUX port 1 or 2.**

  Wrong value was specified for the third parameter of Tap_port command. The value must be the port address of SMU port 1 or 2, or AUX port 1 or 2. Check the value and specify the proper value.

- **6-20011 Improper SMU voltage range specified.**

  Voltage range setting for SMU is not correct. Check the value of the output voltage and the voltage range, and specify the proper value.

- **6-20012 Improper SMU voltage source, voltage output range, or compliance specified.**

  Output voltage value, voltage output range, or current compliance value are not correct. Verify the values of output voltage, voltage output range, and current compliance and then specify the correct value.

- **6-20013 Improper SMU current range specified.**

  Current range setting of SMU is not correct. Check the value of the output current and the current range, and specify the proper value.

- **6-20014 Improper SMU current source or compliance specified.**

  Value of output current or voltage compliance is not correct. Check the value of output current and voltage compliance, and specify the proper value.

- **6-20015 Specified SMU is malfunctioning or not installed.**

  Specified SMU board is not installed or defective. Confirm the SMU configuration. hp4070 -login command displays the 4070 system configuration.

- **6-20016 Source pin must be connected to an SMU.**

  Specified pin board is not connected to SMU. Check the measurement program. The program must have a program line that connects the SMU to the pin board *before* the program line that forces the output of the SMU specified by the pin number.

- **6-20017 Source port must be an SMU or a pin connected to an SMU.**

  Source port address used in the Force_meas command is not correct. Source port address must be SMU port address or the pin number of the pin board connected to the SMU. Check the port address and specify the proper value.

- **6-20018 Measure pin must be connected to an SMU.**

  Specified pin board is not connected to SMU. Check the measurement program. The program must have a program line that connects the SMU to the pin board *before* the program line that performs measurement using the SMU specified by the pin number.

- **6-20019 Measure port must be an SMU or a pin connected to an SMU.**

  Measurement port address is not correct. Measurement port address must be SMU port address or the pin number of the pin board connected to the SMU. Check the port address and specify the proper value.

- **6-20020 3rd parameter must be 1 (voltage source) or 2 (current source).**

  Wrong value was specified for the third parameter of Force_meas command. The value must be 1 (voltage source) or 2 (current source). Check the value and specify the proper value.

- **6-20021 Wait time must be 0 to 655.35 sec.**

  Specified value for the wait time is out of range. The value must be 0 to 655.35 seconds. Check the value and specify the proper value.

- **6-20022 Hold time must be 0 to 655.35 sec.**

  Specified value for the hold time is out of range. Available value for the hold time is 0 to 655.35 sec. Check the value and specify the proper value.

- **6-20023 Port must be CMH when forcing voltage on CMU.**

  Invalid port was specified for Force_v. When setting the dc bias of CMU, the CMH port address must be specified. Check the port address and specify the correct port.

- **6-20024 Wait time must be 0 to 655.35 sec.**

  Wait time value is not correct. Available value for the wait time is 0 to 655.35 sec. Check the value and specify the proper value.

- **6-20025 Size of port array must be greater than or equal to 1.**

  No port is defined for the array used to specify the multiple ports. Check the value and size of the array, and define the array properly.

- **6-20026 1st parameter must be an SMU port address or a pin connected to an SMU.**

  Wrong value was specified for the first parameter of Stand_by_port command. The value must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the value properly.

- **6-20027 2nd parameter must be an SMU port address or a pin connected to an SMU.**

  Wrong value was specified for the second parameter of Stand_by_port command. The value must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the value properly.

- **6-20028 3rd parameter must be an SMU port address or a pin connected to an SMU.**

  Wrong value was specified for the third parameter of Stand_by_port command. The value must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the value properly.

- **6-20029 *N*th parameter must be an SMU port address or a pin connected to an SMU.**

  Wrong value was specified for the *N*th parameter of Stand_by_port command. The value must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the value properly.

- **6-20030 Cannot connect Extended I/O port to the Chuck terminal.**

  Cannot specify Extended Path port for Connect_chuck command. Specify an SMU, GNDU, or AUX port address for the Connect_chuck command.

- **6-20031 Ports must be SMU or CMU.**

  Invalid port was specified for Disable_port command. Must specify an SMU or CMU port address, or the pin number of a pin board connected to the SMU or CMU. Check the port value and specify the port properly.

- **6-20032 Adc must be 0 (ADC_PERCH) or 1 (ADC_REF).**

  Wrong value was specified for the parameter to select ADC. The value must be 0 (high-speed ADC) or 1 (high-resolution ADC). Check the value and specify the value properly.

- **6-20033 Filter must be 0 (FILTER_OFF) or 1 (FILTER_ON).**

  Wrong value was specified for the parameter to select SMU filter status. The value must be 0 (filter off) or 1 (filter on). Check the value and specify the value properly.

- **6-20034 Wait time ratio must be 0.0 to 10.0.**

  Wrong value was defined for the wait time factor. The value must be 0 to 10. Check the value and specify the value properly.

- **6-20035 Integration time mode setting must be 0, 1, 2, or 3.**

  Wrong value was specified for the mode parameter of Set_smu or Set_adc command. The value must be 0 (manual), 1 (short), 2 (medium) or 3 (long). Check the value and specify the proper value.

- **6-20036 Averaging or integration time is out of range.**

  Wrong value was specified for the integration time or averaging parameter of Set_adc or Set_smu command, or the integration time parameter of the Set_adc3458 command. Check the value and specify the proper value.

- **6-20037 Autozero must be 0 (AUTOZERO_OFF) or 1 (AUTOZERO_ON).**

  Wrong value was specified for the auto zero parameter of Set_adc or Set_adc3458 command. The value must be 0 (auto zero off) or 1 (auto zero on). Check the value and specify the proper value.

- **6-20038 Port must be an SMU or a pin connected to an SMU.**

  Port address setting is not correct. The port address must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the proper value.

- **6-20039 Port must be an SMU or a pin connected to an SMU.**

  Port address setting is not correct. The port address must be the SMU port address or the pin number of the pin board connected to the SMU. Check the value and specify the proper value.

- **6-20040 Search mode must be 0 to 15 for Set_bsearch, 0 to 11 for Set_lsearch.**

  Wrong value was specified for the search mode parameter of the Set_lsearch or Set_bsearch command. The search mode value for Set_lsearch must be 0 to 11, and the value for Set_bsearch must be 0 to 15.

- **6-20041 Upper search boundary is equal to lower search boundary.**

  Same value was set for the start/stop parameters of Set_lsearch command or the min/max parameters of Set_bsearch command. Start (or min) value must be different from the stop (or max) value.

- **6-20042 Step value must be greater than 0 for Set_lsearch or Set_bdv_search.**

  Wrong value was specified for the step parameter for Set_lsearch or Set_bdv_search command. The value must be greater than 0.

- **6-20043 Target value must be less than measurement compliance.**

  Too large value was specified for the *target* parameter of Set_lsearch or Set_bsearch command. The value must be less than the value of the compliance parameter.

- **6-20044 Convergence condition in Accuracy mode must be 0 to 100.**

  Value of the convergence condition parameter of Set_bsearch command in the Accuracy mode is out of range. The value must be 0 to 100.

- **6-20045 Convergence condition in Times mode must be 0 to 16.**

  Value of the convergence condition parameter of Set_bsearch command in the Times mode is out of range. The value must be 1 to 16.

- **6-20046 Delay time must be 0 to 65.535 sec.**

  Setting value of the delay time is out of range. The value must be 0 to 65.535 sec. Check the value and specify the proper value.

- **6-20047 Skip_back value must be 0 to 100.**

  Wrong value was specified for the skip back parameter of Set_lsearch command. The value must be 0 to 100.

- **6-20048 Set_skip may not be used with Set_bsearch or Set_bdv_search.**

  Cannot use set_skip with set_bsearch or Set_bdv_search function in C language programming environment. Use set_skip with set_lsearch.

- **6-20049 Set_bsearch or Set_lsearch is not called before Search is called.**

  Before executing Search command, Set_lsearch or Set_bsearch command must be executed to define the search measurement setup. The setup defined by Set_lsearch or Set_bsearch command is canceled by the Init_system command.

- **6-20050 Compliance mode is not available for voltage measurement of Set_lsearch.**

  For the search mode 8 to 11 (compliance mode) of Set_lsearch command, the output mode of sense port SMU must be set to VF (voltage force) mode. Before executing Set_lsearch command, enter statement (for example, Force_v) to set the SMU output mode to VF mode.

- **6-20051 Sweep mode setting must be -4 to 4 (integer).**

  Improper sweep mode was specified for Set_iv or Set_piv command. The value must be -4 (Current, log, double), -3 (Voltage, log, double), -2 (Current, log, single), -1 (Voltage, log, single), 1 (Voltage, linear, single), 2 (Current, linear, single), 3 (Voltage, linear, double), or 4 (Current, linear, double). Check the sweep mode setting and set the proper mode.

- **6-20052 Number of steps must be 2 to 1001.**

  Improper number of steps was specified for Set_iv or Set_piv command. Value must be 2 to 1001. Check the value and set the proper value.

- **6-20053 Improper power compliance is specified.**

  Setting of the power compliance is out of range. Check the value and set the proper value.

- **6-20054 Sweep stop mode must be 1 (continue on error) or 2 (stop on error).**

  Improper stop mode was specified for the sweep measurement command. The value must be 1 (continue on error) or 2 (stop on error). Check the setting and set the proper value.

- **6-20056 Measurement mode must be 1 (voltage) or 2 (current).**

  Improper measurement mode was specified for Sweep_iv or Rsweep_iv command. The value must be 1 (voltage measurement mode) or 2 (current measurement mode).

- **6-20057 Start and stop values have different polarity.**

  In the logarithmic sweep measurement mode, polarity of the start and stop value must be the same.

- **6-20058 Hold time must be 0 to 655.35 sec.**

  Setting of hold time is wrong. The value must be 0 to 655.35.

- **6-20059 Difference of start and stop must be greater than** *Voltage*

  For Set_bdv command, the difference between the *start* value and the *stop* value must be 10 V or more.

  For Set_ileak command, the difference between the *output voltage* value and the *start* value must 10 V or more.

- **6-20060 Detection interval mode must be 0 (short) or 1 (long).**

  Improper *detection interval* was specified for Measure_bdv or Measure_ileak command. The value must be 0 (short mode) or 1 (long mode).

- **6-20061 Skip value must be 1 to 20000.**

  Improper *skip* value was specified for Set_lsearch command. The value must be 1 to 20000.

- **6-20062 Target value must be less than the sense port compliance.**

  Improper *target* value was specified for Set_lsearch command. The value must be less than compliance of sense port.

- **6-20063 Sync port must have the same V/I output mode as the control variable.**

  SMU output mode of the sync SMU defined for Set_sync command must be the same output mode of the search SMU defined for Set_bsearch or Set_lsearch command. Set the SMU output mode of the sync SMU by entering Force_v or Force_i command before entering Set_sync command.

  Force_v command is used to set the voltage output mode, and Force_i command is used to set the current output mode.

- **6-20064 Improper synchronous search offset value is specified.**

  Offset value of Set_sync command is out of range. Or the offset value is not correct for the settings of the start/stop values of Set_lsearch command or the min/max values of Set_bsearch command. Set the proper value.

- **6-20066 Offset value of synchronous search port or compliance is improper.**

  Sync port SMU output did not match to the compliance value. Check the offset and compliance values of Set_sync command, and the start/stop values of Set_lsearch command or the min/max values of Set_bsearch command, and set the proper value.

- **6-20067 Synchronization polarity mode must be 0 (positive) or 1 (negative).**

  Improper synchronization polarity mode was specified for Set_sync command. The value must be 0 (positive sync) or 1 (negative sync).

- **6-20068 Synchronous sweep ratio must be 0.01 to 10.0.**

  Improper synchronous sweep ratio value was specified for Set_sync command. The value must be 0.01 to 10.0.

- **6-20069 Improper synchronous sweep offset value specified.**

  Improper synchronous sweep offset value was specified for Set_sync command. Check the value and set the proper value.

- **6-20070 Calculated start, stop or compliance of synchronous sweep is improper.**

  Sync port SMU output is out of range, or does not match to the compliance value. Check the offset, ratio and compliance values of Set_sync command, or the start/stop values of the command for sweep measurement.

- **6-20071 Measurement mode must be 0 (linear) or 1 (saturation).**

  Invalid mode was specified for Measure_vth command. The mode must be 0 (linear region) or 1 (saturation region).

- **6-20072 Number of points must be 2 to 20.**

  Invalid number of points was specified for Measure_vth command. The number of points must be 2 to 20.

- **6-20073 Compliance must be specified when SMU V/I output mode is changed.**

  In the optimization level is 2 or 3, compliance value cannot be omitted for a command (Force_v, Force_i, etc.) that changes the the SMU output mode. Confirm the optimization level and set the compliance value properly.

- **6-20074 Invalid pin number specified for Hpin.**

  Invalid pin number was specified for the CMU high port of Corr_cmu command. Check the pin number and set the correct number.

- **6-20075 Invalid pin number specified for Lpin.**

  Invalid pin number was specified for the CMU low port of Corr_cmu command. Check the pin number and set the correct number.

- **6-20076 C Compensation file is not loaded.**

  TIS command requires that capacitance compensation was executed before loading the capacitance compensation data file. Check /etc/opt/hp4070/ccdata file and /etc/opt/hp4070/ccdata0 file, and the permission of the files.

- **6-20077 Cp should not be 0.**

  Cp value of Conv_mode command was set to zero. Cp value must not be zero.

- **6-20078 Proper sweep measurement is not done.**

  Status_miv command could not read the measurement status of the last sweep measurement. Sweep measurement was not done properly. Check the measurement program. Or sweep measurement may be now in progress.

- **6-20079 Current is too large.**

  Too large current value was set for Set_bdv command. Set the proper value.

- **6-20080 Vg_start and Vg_stop should not be same.**

  Same value was set for gate start and stop voltages of Set_vth command. The same value cannot be set for these parameters. Set the values properly.

- **6-20081 Gate step voltage value must be greater than 0 V.**

  Gate step voltage must be greater than 0 V for the Set_vth command. Set the value correctly.

- **6-20082 Id_start must be less than measurement port compliance.**

  Drain search start current of Set_vth command must be less than the compliance value of the measurement port. Set the value properly.

- **6-20083 Delay time must be 0 to 65.535 sec.**

  Delay time value of Set_vth command is out of range. Value must be 0 to 65.535 seconds. Set the value properly.

- **6-20084 Vg Skip_back value must be 0 to 100.**

  Vg Skip_back value of Set_vth command is out of range. Value must be 0 to 100. Set the value properly.

- **6-20085 Vg Skip value must be 1 to 20000.**

  Vg Skip value of Set_vth command is out of range. Value must be 1 to 20000. Set the value properly.

- **6-20086 Id_start value must be -0.1 to 0.1 A.**

  Drain start current value of Set_vth command is out of range. Value must be -0.1 to 0.1 A. Set the value properly.

- **6-20090 Sweep_miv or Rsweep_miv can be used with Set_iv, not Set_piv.**

  Sweep_miv and Rsweep_miv commands for the multi-channel sweep measurement can only be used for sweep that was set up by Set_iv command. The commands cannot be used with pulsed sweep, which is set up by Set_piv command. Check and change the program.

- **6-20100 Measurement port is not connected to any pins.**

  Measurement SMU port is not connected to any pin board. Connect the SMU to the measurement pin.

- **6-20101 Sweep port is not connected to any pins.**

  Sweep measurement SMU port is not connected to any pin board. Connect the SMU to the measurement pin.

- **6-20102 The synchronous sweep port is not set up.**

  An array was specified in Sweep_miv command for returning source values of synchronous sweep port, but synchronous port was not set up. Either delete the array name from Sweep_miv or set up synchronous sweep port by using Set_sync.

- **6-20103 The synchronous sweep port is not connected to any pins.**

  Synchronous sweep port is not connected to any pin board. Connect the SMU to the measurement pin.

- **6-20120 Force mode must be 1 (voltage force) or 2 (current force).**

  Improper mode was specified for the force mode of Set_pbias command. The value must be 1 (voltage force) or 2 (current force).

- **6-20121 Pulse sweep mode setting must be -4 to 4 (integer).**

  Improper *pulse sweep mode* was specified for Set_piv command. The value must be 1 (linear voltage), 2 (linear current), 3 (linear voltage double), 4 (linear current double), -1 (logarithmic voltage), -2 (logarithmic current), -3 (logarithmic voltage double), or -4 (logarithmic current double).

- **6-20122 Measurement mode must be 1 (voltage) or 2 (current).**

  Improper *measurement mode* was specified for Measure_p command. The value must be 1 (voltage measurement) or 2 (current measurement).

- **6-20123 Peak and base current must have the same polarity.**

  For current, the *pulse base* and *pulse peak* values must be the same polarity for Set_pbias command. Check the values and set the proper values.

- **6-20124 Peak, start and stop current must have the same polarity.**

  For current, *pulse base*, *start value*, and *stop value* must be the same polarity for Set_piv command. Check the values and set the proper values.

- **6-20125 Width value must be 0.0005 to 2 sec.**

  Pulse width value is out of range. Value must be 0.0005 to 2 sec with 0.0001 sec resolution. Set the correct value.

- **6-20126 Period value must be 0.005 to 5 sec.**

  Pulse period value is out of range. Value must be 0.005 to 5 sec with 0.0001 sec resolution. Set the correct value.

- **6-20128 Period value must be greater than width + 2ms.**

  Pulse period value must be greater than pulse width + 2 ms. Set the pulse period or pulse width value correctly.

- **6-20200 Set_pbias must be executed before Measure_p.**

  No setup for Measure_p command. Execute Set_pbias command before executing Measure_P command.

- **6-20201 Set_iv or Set_piv must be executed before Sweep_iv.**

  No setup for Sweep_iv command. Execute Set_iv or Set_piv command before executing Sweep_iv command.

- **6-20202 No measurement to stop by Rsweep_stop.**

  No real time sweep measurement to stop. Rsweep_stop is used for stopping *real-time* sweep measurements only.

- **6-20203 Set_iv or Set_piv must be executed before Rsweep_iv.**

  No setup for Rsweep_iv command. Execute Set_iv or Set_piv command before executing Rsweep_iv command.

- **6-20204 Set_iv must be executed before Rsweep_miv.**

  No setup for Rsweep_miv command. Execute Set_iv command before executing Rsweep_miv command.

- **6-20205 Set_iv must be executed before Sweep_miv.**

  No setup for Sweep_miv command. Execute Set_iv command before executing Sweep_miv command.

- **6-20206 Set_lsearch, Set_bsearch, or Set_bdv_search must be executed before Search or Search_iv.**

  No setup for Search or Search_iv command. Execute Set_lsearch, Set_bsearch, or Set_bdv_search command before executing Search or Search_iv.

- **6-20207 Synchronous port must be different from the primary sweep port.**

  Must use different SMU ports for the primary sweep port and synchronous port.

- **6-20208 Synchronous port must be different from the primary search port.**

  Must use different SMU ports for the primary search port and synchronous port.

- **6-20209 No sweep or search setup was set before Set_sync.**

  No setup for Set_sync command. Execute Set_iv, Set_piv, Set_bsearch, or Set_lsearch command before executing Set_sync command.

- **6-20210 Set_bdv must be executed before Measure_bdv.**

  No setup for Measure_bdv command. Execute Set_bdv command before executing Measure_bdv command.

- **6-20211 Set_ileak must be executed before Measure_ileak.**

  No setup for Measure_ileak command. Execute Set_ileak command before executing Measure_ileak command.

- **6-20212 Set_lsearch, Set_bsearch, or Set_bdv_search must be executed before Rsearch or Rsearch_iv.**

  No setup for Rsearch or Rsearch_iv command. Execute Set_lsearch , Set_bsearch, or Set_bdv_search command before executing Rsearch or Rsearch_iv.

- **6-20213 No measurement to stop by Rsearch_stop.**

  No real time search measurement to stop. Rsearch_stop is used for stopping *real-time* search measurements only.

- **6-20214 Set_vth must be executed before Measure_vth.**

  No setup for Measure_vth command. Execute Set_vth command before executing Measure_vth command.

- **6-20215 Synchronous port must be different from the pulse bias port.**

  Must use different SMU ports for the pulse bias port and synchronous port.

- **6-20216 Pulse bias port must be different from the Synchronous port.**

  Must use different SMU ports for the synchronous port and the pulse bias port.

- **6-20220 Cannot call Status_miv during a sweep measurement.**

  Cannot execute Status_miv command while *real-time* sweep measurement is executing.

- **6-20221 Fine search start current value must be smaller than breakdown current value.**

  The current value for fine search start must be smaller than the breakdown current value which sets compliance of an SMU in the Set_bdv_search command.

- **6-20222 Fine search start current and breakdown current must have the same polarity.**

  The setup current values for fine search start and breakdown current must be the same polarity for the Set_bdv_search command. Check the polarity and set the correct values.

- **6-20223 Cannot omit fine search start parameter.**

  Fine search start value must be specified when the skip parameter value is greater than 1 for the Set_bdv_search command.

- **6-20224 Compliance check delay time must be 0 to 65.535 sec.**

  Setting value for comp check delay is out of range. The value must be 0 to 65.535 sec. Check the value and specify it correctly.

- **6-21001 Specified pin is not connected to any ports.**

  Pins specified by `Disable_port` command are not connected to any port. Specify the pin number of a pin board that is connected to a port.

- **6-21002 SMU output voltage incompatible with set voltage range.**

  Wrong value was set for the SMU output voltage and voltage range. Set the values properly.

- **6-21003 SMU output current incompatible with set current range.**

  Wrong value was set for the SMU output current and current range. Set the values properly.

- **6-22001 CMU bias voltage must be -40 to 40 Vdc.**

  Wrong value was specified for the bias voltage of CMU. The value must be 0 to ±40 Vdc for 4284A equipped with option 001.

- **6-22002 CMU bias voltage must be -2, -1.5, 0, 1.5, or 2 Vdc.**

  Wrong value was specified for the bias voltage of CMU. The value must be 0, ±1.5, or ±2 Vdc for 4284A without option 001.

- **6-22003 CMU integration time mode setting must be 1, 2, or 3.**

  Invalid parameter was set for the integration time of Set_cmu84 command. The value must be 1 (short), 2 (medium) or 3 (long).

- **6-22004 CMU signal level must be 0.005 V or more.**

  Too small value was set for the signal level by Set_cmu84 command. The value must be greater than 0.005 V.

- **6-22005 CMU signal level must be 20.0 V or less.**

  Too large value was set for the signal level by Set_cmu84 command. The value must be 20 V or less for 4284A equipped with option 001.

- **6-22006 CMU signal level must be 2.0 V or less.**

  Too large value was set for the signal level by Set_cmu84 command. The value must be 2 V or less for 4284A without option 001.

- **6-22007 CMU frequency must be 19.8 Hz or more.**

  Too small value was set for the measurement frequency of CMU. The value must be 19.8 Hz or more.

- **6-22008 CMU frequency must be 1 MHz or less.**

  Too large value was set for the measurement frequency of CMU. The value must be 1 MHz or less.

- **6-22009 CMU is malfunctioning or not installed.**

  CMU (4284A) is not installed in the 4070, or may be defective. Execute hp4070 -login command and check the configuration of the 4070. If necessary, do the diagnostics.

- **6-22010 There is no capacitance and conductance data in buffer.**

  Capacitance/conductance measurement was not executed properly. CMU (4284A) may be defective. Do the diagnostics.

- **6-22011 Set_cv84 must be executed before Sweep_cv84.**

  No setup for Sweep_cv84 command. Execute Set_cv84 command before executing Sweep_cv84 command.

- **6-22012 Number of C-V sweep steps must be 2 to 1001.**

  Number of steps for Set_cv84 command is out of range. The value must be 2 to 1001.

- **6-22013 Hold time and delay time must be 0.0 to 650.0 sec.**

  Hold time or delay time value of Set_cv84 command is out of range. The value must be 0.0 to 650.0.

- **6-22014 4284A option 001 is not present.**

  C-V sweep measurement needs 4284A equipped with the option 001. Execute hp4070 -login command and check the configuration of the 4070.

- **6-23001 DVM is malfunctioning or not installed.**

  DVM (3458A) is not installed in the 4070, or may be defective. Execute hp4070 -login command and check the configuration of the 4070. If necessary, do the diagnostics.

- **6-23002 DVM is not set to DC voltage measurement mode.**

  DVM (3458A) is not in the DC voltage measurement mode. Set the mode correctly using front panel or GPIB command. Or DVM may be defective. If necessary, do the diagnostics.

- **6-23003 DVM GPIB address is not set or invalid.**

  Address3458 command was executed even though the DVM (3458A) is not installed in the 4070. Confirm the measurement program.

- **6-23100 Failed to call igpibbusstatus().**

  GPIB interface card may be defective.

- **6-24001 Testhead Power Fail state.**

  Testhead is turned off. Turn on the testhead. If testhead cannot turn on, check the testhead power supply.

- **6-24002 Testhead Emergency state.**

  Testhead is in the emergency status. Do the diagnostics.

- **6-25000** *Command* **is UNSUPPORTED.**

  The 4070 system software does not support the command specified by *Command*. Do not use *Command*.

- **6-25001 Improper PGU unit address** *Address*. **Enter correct value.**

  The available value depends on the configuration of the PGUs. To get the unit address from the port number, use FNPort or PORT.

- **6-25002 No PGU on the unit address. Enter correct value or check PGU.**

  There is no PGU on the unit address you specified, or the PGU is defective. Confirm the unit address and enter a valid value. Verify the PGU is operating correctly.

- **6-25003 Must specify unit address of PGU disconnected from testhead.**

  You must specify the unit address of the PGU disconnected from the testhead. Execute pgconn4070 and verify that the value in the PG connection file matches the actual PGU connection, then specify the unit address of the PGU disconnected from the testhead.

- **6-25004 Pin number must be 1 to 24 for the HF port. Enter correct value.**

  An invalid pin number was entered. Pin numbers 1 to 24 are available for the HF port you specified.

- **6-25005 Pin number must be 25 to 48 for the HF port. Enter correct value.**

  An invalid pin number was entered. Pin numbers 25 to 48 are available for the HF port you specified.

- **6-25006 Pin number must be 1 to 48 for the THF port. Enter correct value.**

  An invalid pin number was entered. Pin numbers 1 to 48 are available for the THF port you specified.

- **6-25007 Port address must be 20201 to 20206, or 20211 to 20213.**

  An invalid port address was entered. Addresses 20201 to 20206 are available for the HF port, and addresses 20211 to 20213 are available for the THF port. Enter a valid port address.

- **6-25008 Must specify the port connected to the PGU.**

  You must specify the port connected to the PGU. Execute pgconn4070 and verify that the value in the PG connection file matches the actual PGU conection, then specify the port connected to the PGU.

- **6-25009 Only CH1 is available for the PGU in 3-level pulse output mode.**

  The PGU specified is in the 3-level pulse output mode. Only CH1 is available for the PGU. Use CH1.

- **6-25010 Only CH1 is available for the PGU in 3-level pulse output mode.**

  The PGU specified is in the 3-level pulse output mode. Only CH1 is available for the PGU. Use CH1.

- **6-25011 Improper port address. Enter correct value.**

  Improper port address value is specified. You must specify the correct value for port connected to the PGU.

- **6-25012 Mode value must be 0 or 1. Enter correct value.**

  Set_sr_control TIS error. The mode parameter value must be 0 (independent) or 1 (synchronous).

- **6-25013 Port number must be PSC1, 2, or PSO1 to 5.**

  Set_sr_mode TIS error. The port address parameter must be PSC1, 2, or PSO2 to 5.

- **6-25014 Mode value must be 0 or 1. Enter correct value.**

  Set_sr_mode TIS error. The mode parameter value must be 0 (Normally Closed) or 1 (Normally Open).

- **6-25015 Port number must be PGU address, PSC1, 2, or PSO1 to 7.**

  Connect_sr TIS error. The port address parameter must be PGU address, PSC1, 2, or PSO1 to 7.

- **6-25016 PGU must be connected to the pulse switch control port 1 or 2.**

  Connect_sr TIS error. When a PGU unit address is specified for the port parameter the PGU must be connected to pulse switch control port 1 or 2. Specify a valid unit address and verify the PGU is connected correctly.

- **6-25017 To use Connect_sr/Switch_sr, independent mode must be set by Set_type_pg.**

  Set_sr_pg TIS error. To control switching by using Connect_sr or Switch_sr the mode parameter value must be 1 (independent mode).

- **6-25018 Port address must be HF, THF, AUX, PSI, or PGU address.**

  An illegal port address was specified. Port address must be HF, THF, AUX, PSI, or PGU address.

- **6-25019 Must specify the port connected to the PGU.**

  You must specify the port connected to the PGU. Execute pgconn4070 and verify that the value in the PG connection file matches the actual PGU conection, then specify the port connected to the PGU.

- **6-25020 Only CH1 is available for the PGU in 3-level pulse output mode.**

  Set_type_pg TIS error. The PGU you specified is in the 3-level pulse output mode. Only CH1 is available for the PGU. Use CH1.

- **6-25021 Mode value must be 1 to 3. Enter correct value.**

  Set_type_pg TIS error. The mode parameter value must be 1 (2-level pulse), 2 (3-level pulse by one PGU), or 3 (3-level pulse by multiplexer). Enter a a valid mode value.

- **6-25022 Only CH1 is available for the PGU in 3-level pulse output mode.**

  Set_type_pg TIS error. Mode=2 is available only for CH1 of the PGU. Use CH1.

- **6-25023 Mode value must be 1 or 3 for this port.**

  Set_type_pg TIS error. For the 8114A pulse generator. Mode 1 (2-level pulse) and 3 (3-level pulse by multiplexer) are available for this port. Enter a valid mode value.

- **6-25024 PGU must have two channels for 3-level pulse output.**

  The PGU you specified has only one channel. For 3-level pulse output use a PGU with two output channels.

- **6-25025 Must specify the port connected to the PGU.**

  You must specify the port connected to the PGU. Execute pgconn4070 and verify the value in the PG connection file matches the actual PGU conection, then specify the port connected to the PGU.

- **6-25026 Only CH1 is available for the PGU in 3-level pulse output mode.**

  Set_level_pg TIS error. The PGU specified is in the 3-level pulse output mode. Only CH1 is available for the PGU. Use CH1.

- **6-25027 Invalid port for using pulse switch.**

  Set_level_pg TIS error. The PGU specified is in the 3-level pulse output mode. Pulse switch is available for the port set to the 2-level pulse or 3-level pulse by the multiplexer. Enter a valid port value.

- **6-25028 Port address must be HF, THF, AUX, PSI, or PGU address.**

  An improper port address was specified. Port address must be HF, THF, AUX, PSI, or PGU address.

- **6-25029 Must specify the port connected to the PGU.**

  You must specify the port connected to the PGU. Execute pgconn4070, and verify the value in the PG connection file matches the actual PGU connection, then specify the port connected to the PGU.

- **6-25030 Only CH1 is available for the PGU in 3-level pulse output mode.**

  The PGU specified is in the 3-level pulse output mode. Only CH1 is available for the PGU. Use CH1.

- **6-25031 PGU must have two channels for 3-level pulse output.**

  The PGU specified has only one channel. Use a PGU with two output channels for 3-level pulse output.

- **6-25032 Invalid port for using pulse switch.**

  Set_time_pg TIS error. The PGU specified is in the 3-level pulse output mode. Pulse switch is available for the port which is set to the 2-level pulse or 3-level pulse by the multiplexer. Enter a a valid port value.

- **6-25033 Specify width2 parameter value.**

  Set_time_pg TIS error. A Width2 parameter must be specified. Values from 3.3 nsec to 999 msec, or 10.0 nsec to 900 msec (for the 8114A) are available. See the Set_time_pg command reference for the required parameters.

- **6-25034 Delay2 parameter value must equal width1 plus delay1 or more.**

  Set_time_pg TIS error. A Delay2 parameter value must equal width1 plus delay1 or more. Values from 0 to 999 msec, or 0 to 900 msec (for the 8114A) are available.

- **6-25035 Mode value must be 0, 1, or 2. Enter correct value.**

  Set_sr_pg TIS error. The mode parameter value must be 0 (reset), 1 (independent), or 2 (synchronous with pulse). Enter a a valid mode value.

- **6-25036 Specify width parameter value, if mode is set to 2.**

  Set_sr_pg TIS error. A width parameter must be specified. Values from 2 msec to 999 msec, or 2 msec to 900 msec (for the 8114A) are available. The width parameter is optional if the Set_sr_pg mode parameter is not 2.

- **6-25037 Must specify the PGU connected to the pulse switch control port.**

  Set_sr_pg TIS error. Connect the PGU to the pulse switch control port correctly and execute pgconn4070. Verify the value in the PG connection file matches the actual PGU conection, then specify the PGU connected to the pulse switch control port. See the Set_sr_pg command reference for restrictions on the PGU.

- **6-25038 period value too short.**

  Force_pg and Prep_pg TIS error. The period parameter must be more than or equal to the sum of the timing parameters defined by Set_time_pg. Enter a valid value.

- **6-25039 Cannot execute the TIS during pulse output.**

  During pulse output the 4072A reports this error by the TIS which controls the PGU setup or the switching matrix PGU path. The TIS stops the program with this error, and also stops pulse output.

- **6-25040 Count value must be 0 to 10000000.**

  Force_pg or Start_pg TIS error. The count parameter value must be from 0 to 10000000. If the count value is 1 to 10000000, Force_pg or Start_pg starts the pulse output, and waits for the last count of the pulse. For a count value of 0, the Force_pg or Start_pg triggers a continuous pulse output and finishes immediately. The pulse output continues until a Stop_pg TIS is received. During continuous pulse output the 4072A can receive TIS, but causes error 6-25039. See 6-25039.

- **6-25041 Install or turn on master PG.**

  Cannot detect the master PG. Install or turn on the master PG. The master PG is the pulse generator unit which has the PG logical number 1. See the configuration file (/etc/opt/hp4070/config/1) to specify the master PG. This file contains the PG name, PG logical number, bus address, and GPIB address.

- **6-25042 Time accuracy mode must be 0 or 1.**

  Set_mode_pg TIS error. The mode parameter value must be 0 (normal) or 1 (pattern). Mode=1 is not available for the 8114A.

- **6-25043 Define slave #1 PG.**

  Pattern mode (Set_mode_pg, mode=1) needs slave #1 PG. The slave #1 PG is the pulse generator unit which has the PG logical number 2. Edit the configuration file (/etc/opt/hp4070/config/1) and define the slave #1 PG. See 6-25044.

- **6-25044 Install or turn on slave #1 PG.**

  Pattern mode (Set_mode_pg, mode=1) needs slave #1 PG. Install and turn on the slave #1 PG. See 6-25043.

- **6-25045 For pattern mode, period value must be 120 usec or more.**

  In the pattern mode (Set_mode_pg, mode=1), the period parameter value must be 120 usec or more. Enter a a valid period value.

- **6-25046 Do not enter Set_level_pg for the pulse switch control port.**

  You cannot set the pulse output level of the PGU connected to the pulse switch control port. Do not enter Set_level_pg.

- **6-25047 Do not enter Set_type_pg for the pulse switch control port.**

  You cannot set the pulse mode of the PGU connected to the pulse switch control port. Do not enter Set_type_pg.

- **6-25048 Must specify the pulse switch control port connected to the PGU.**

  You must specify the pulse switch control port connected to the PGU. Execute pgconn4070 and verify the value in the PG connection file matches the actual PGU conection, then specify the pulse switch control port connected to the PGU.

- **6-25049 Do not use 8114A as the slave #1 PG.**

  When the time accuracy is set to pattern mode (Set_mode_pg, mode=1) the 8114A pulse generator cannot be used as slave #1. Use normal mode (Set_mode_pg, mode=0), or change the configuration by editing the configuration file /etc/opt/hp4070/config/1. See 6-25042 and 6-25043.

- **6-25050 Period value for 8114A must be *Max* msec or less.**

  The period value of the 8114A pulse generator must be *Max* msec or less. Enter a valid period value.

- **6-25051 Specify period value. The value for 8114A must be *Max* msec or less.**

  The 4072A automatically calculates the period parameter setting for the 8114A pulse generator in Force_pg or Prep_pg. If this automatically calculated value exceeds *Max* msec, then you must manually or explicitly specify the period value.

- **6-25052 PGU (*N*) is defective or not connected . Check PGU and enter correct port.**

  You must specify the port connected to to the PGU. Specify the correct port, and verify the PGU is installed and working correctly.

- **6-25053 Cannot execute *Command Name* during pulse output.**

  During pulse output, the 4072A causes this error by the TIS which controls the PGU setup or the switching matrix PGU path. The TIS stops the program with this error, and also stops pulse output.

- **6-25054 Output voltage of PGUs connected to PSO *N* must be same polarity or the difference must be 45 V or less.**

  When an 8110A and an 8114A are connected to PSO1, 6, or 7 using a multiplexer switch, the absolute value of the amplitude of the pulses must be 45 V or less. If the amplitude of the pulses must be 45 V the polarity of the pulses must be the same.

- **6-25055 PG Voltage exceeds the limit. Check the PG voltage connected to PSO *N* .**

  When using the 8110A and 8114A with a multiplexer, the signal was not output correctly. Verify that the 8110A and the 8114A are connected to PSO*N* and that amplitude of the pulse is set correctly. If this does not correct the error, reduce the amplitude of each pulse.

- **6-25056 PGU output voltage exceeds the limit. Check PG*XX* output amplitude.**

  Check the amplitude of the PG*XX* output. The limit is -19 V. If necessary, reduce the amplitude of the signal. If this does not correct the error, contact the nearest Agilent Technologies Sales and Service office.

- **6-25057 Mode value must be 0 to 2. Enter correct value.**

  Switch_sr TIS error. Mode must be 0, 1, or 2. Enter a valid mode number.

- **6-25058 Mode value must be 0 to 2. Enter correct value.**

  Connect_sr TIS error. Mode must be 0, 1, or 2. Enter a valid mode number.

- **6-25059 Port number must be PSC1, 2, or PSO1 to 7.**

  Switch_sr TIS error. The port address parameter must be PSC1, 2, or PSO1 to 7.

- **6-25501 PG Error.**

  An error occurred in the pulse generator unit. The pulse generator will provide detailed error messages.

- **6-25502 PG*N* pulse level is out of range.**

  The pulse level value is out of range. See the Set_level_pg command reference for the available range, and then enter a valid range.

- **6-25503 Load impedance value must be 2.5 ohm to 999 kilohm.**

  The load impedance value must be 2.5 ohm to 999 kilohm. Enter a valid impedance value.

- **6-25504 Load impedance value must be 10 ohm to 999 kilohm.**

  The load impedance value of the 8114A must be 10 ohm to 999 kilohm. Enter a valid impedance value.

- **6-25505 Amp*N* value is out of range.**

  Set_level_pg TIS error. The Amp*N* parameter value is out of range. See the Set_level_pg command reference for the available range, and then enter a valid value.

- **6-25506 3-level pulse output value (Amp*N*) is out of range.**

  Set_level_pg TIS error. The Amp*N* parameter value is out of range for the 3-level pulse output port (Set_type_pg, mode=2). See the Set_level_pg command reference for the available range, and then enter a valid value.

- **6-25507 Sum of 3-level pulse output value is out of range.**

  Set_level_pg TIS error. The sum of Amp1 and Amp2 is out of range for the 3-level pulse output port (Set_type_pg, mode=2). See the Set_level_pg command reference for the available range, and enter a valid value.

- **6-25508 Invalid setup combination of Amp and Base.**

  Set_level_pg TIS error. Cannot set the pulse level due to an invalid combination of the Amp value and Base value. See the Set_level_pg command reference for the available range, and then enter a valid combination.

- **6-25509 Pulse width (*Value*) is out of range.**

  Set_time_pg TIS error. The width parameter value must be 3.3 nsec to 999 msec, or 10 nsec to 900 msec for the 8114A. Enter a valid range value.

- **6-25510 Delay time (*Value*) plus skew is out of range.**

  Set_time_pg TIS error. The delay parameter value must be 0 to 999 msec, or 0 to 900 msec for 8114A. Enter a valid delay value. The skew between the PG outputs can cause this error.

- **6-25511 Invalid pulse leading time (*Value*). The value must be 2.0 nsec to 200 msec.**

  Set_time_pg TIS error. The leading edge transition time must be 2.0 nsec to 200 msec. Enter a valid transition value.

- **6-25512 Invalid pulse trailing time (*Value*). The value must be 2.0 nsec to 200 msec.**

  Set_time_pg TIS error. The trailing edge transition time must be 2.0 nsec to 200 msec. Enter a valid transition value.

- **6-25513 Leading time and trailing time must be in the same range.**

  Set_time_pg TIS error. Both the leading and trailing time must be in the same range. See the Set_time_pg command reference for available ranges and then enter a valid value.

- **6-25514 PG Error. Cannot change arming source.**

  Cannot change the arming source. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25515 PG Error. Cannot change pattern mode.**

  Cannot change the pattern mode. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25516 PG Error. Cannot measure trigger period.**

  The pulse generator cannot measure the trigger period. The trigger cable may be disconnected or defective. Or the PGU may be defective. Verify the trigger cable connection and the operation of the PGU.

- **6-25517 Cannot open file (errno =** *Error No.***) :** *File name*

  Cannot open the specified file. Check the file name, permission, and so on.

- **6-25518 Cannot write file (errno =** *Error No.***)**

  Cannot write the file. Check the file name, permission, and so on.

- **6-25519 Cannot read file (errno =** *Error No.***)**

  Cannot read the specified file. Check the file name, permission, and so on.

- **6-25520 PG setup file revision mismatch.**

  The PG setup file does not match the present revision.

- **6-25521 Configuration mismatch.**

  The current configuration does not match the configuration written in the PG setup file. The PG setup file is the file saved by Save_pg TIS.

- **6-25522 PG (*N*) Error. No response to combined channel query.**

  No response from the PGU for the combined channel query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25523 PG (*N*) Error. No response to arming source query.**

  No response from the PGU for the arming source query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25524 PG (*N*) Error. No response to period source query.**

  No response from the PGU for the period source query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25525 PG (*N*) Error. No response to trigger count query.**

  No response from the PGU for the trigger count query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25526 PG (*N*) Error. No response to pattern mode query.**

  No response from the PGU for the pattern mode query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25527 PG (*N*) Error. No response to period query.**

  No response from the PGU for the period query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25528 PG (*N*) Error. No response to switch query.**

  No response from the PGU for the switch query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25529 PG (*N*) Error. No response to rload query.**

  No response from the PGU for the rload query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25530 PG (*N*) Error. No response to delay query.**

  No response from the PGU for the delay query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25531 PG (*N*) Error. No response to width query.**

  No response from the PGU for the width query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25532 PG (*N*) Error. No response to leading edge query.**

  No response from the PGU for the leading edge query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25533 PG (*N*) Error. No response to trailing edge query.**

  No response from the PGU for the trailing edge query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25534 PG (*N*) Error. No response to complement query.**

  No response from the PGU for the complement query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25535 PG (*N*) Error. No response to voltage level query.**

  No response from the PGU for the voltage level query. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25536 PG Error. Cannot change period source.**

  Cannot change period source. The PGU may be defective or it may be a TIS fatal error. Verify the PGU is operating correctly.

- **6-25537 Set_level_pg Amp value is out of range.**

  Set_level_pg TIS error. For 8114A pulse generator. The Amp parameter value is out of range. See the Set_level_pg command reference for the available range, and then enter a valid value.

- **6-25901 [F_ROM] Port address (*Terminal Name*) must be unique.**

  Each terminal must be set to a unique port address. Set each terminal to a unique port address.

- **6-25902 [F_ROM] Relay mode must be enabled.**

  Relay mode must be enabled to use pulse switch. Execute F_set_relay_md(1) to enable the relay mode.

- **6-25903 [F_ROM] Port (*Terminal Name*) must be connected to pulse switch output.**

  A port must be connected to the pulse switch output. Connect the port and specify the correct port.

- **6-25904 [F_ROM] Port (*Terminal Name*) must be connected to pulse switch output 1, 6, or 7.**

  A port must be connected to the pulse switch output 1, 6, or 7. Connect the port and specify the correct port.

- **6-25905 [F_ROM] Port (*Terminal Name*) must be connected to pulse switch output 2, 3, 4, or 5.**

  A port must be connected to the pulse switch output 2, 3, 4, or 5. Connect the port and specify the correct port.

- **6-25906 Invalid count (*Value*). The value must be 1to 1000000000.**

  The count parameter value must be 1 to 1000000000. Enter a valid value.

- **6-25907 [F_ROM] PGU (*Terminal Name*) must be unique.**

  Each terminal must be connected to a unique PGU. Connect each terminal to a unique PGU.

- **6-25908 [F_ROM] Invalid port address for *Terminal Name*.**

  F_set_fport PARA error. The port address must be 20201 to 20206 for HF port, and 20211 to 20213 for THF port, and 20101 to 20108. Enter a valid port address.

- **6-25909 [F_ROM] Invalid PGU connection for *Terminal Name*.**

  The PGU must be connected to the specified port through the pulse switch. Connect the PGU to the pulse switch input and specify a valid port.

- **6-30002 SMU Calibration Fail.**

  SMU failed the calibration. Do the diagnostics, and do troubleshooting.

- **6-30003 Automatic SMU Calibration Fail.**

  SMU failed the automatic calibration. Do the diagnostics, and do troubleshooting.

- **6-30004 Automatic SMU Calibration Pass.**

  SMU passed the automatic calibration.

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- **7-10001 Power Fail occurred.**

  Testhead power fail occurred. Troubleshoot the testhead power supply and the testhead.

- **7-10002 Over Current or Voltage occurred.**

  Over current or over voltage occurred in the testhead. Troubleshoot the testhead.

- **7-10003 Fixture is opened.**

  Prober/Fixture Sense switch of the testhead is open. Close the sense switch of the testhead.

- **7-10004 Interlock is opened.**

  Interlock of the testhead is open. Close the interlock switch of the testhead.

- **7-10006 Hardware Status returned to the normal state.**

  The 4070 hardware status returned to the normal state. The 4070 can be used normally.

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- **8-10001 Failed to fork TIS Server (errno =** *Error_No.***).**

  hp4070 command or START program failed to start up the TIS server in fork().

  - If *Error_No.* is 11: Too many processes are running. Kill unnecessary processes or reconfigure kernel to extend maximum number of processes.
  - If *Error_No.* is 12: Too small swap space or memory to execute TIS server. Increase the swap space or memory.

- **8-10002 Failed to exec TIS Server (errno =** *Error_No.***).**

  hp4070 command or START program failed to start up the TIS server in execv().

  - If *Error_No.* is 13: Check the permission and directory path of tis_online or tis_offline file.
  - If *Error_No.* is 249: Too many symbolic links are made for directory path of tis_online or tis_offline file.
  - If *Error_No.* is 8: tis_online or tis_offline file is not set as an executable file. Set the file as an executable file.
  - If *Error_No.* is 12: Too small memory to execute TIS server.
  - If *Error_No.* is 26: tis_online or tis_offline file is opened without write protection.

- **8-11001 TIS server died.**

  hp4070 -shutdown command was executed, or testhead was turned off. Or fatal error occurred in testhead.

- **8-11002 Inconsistent exception (***Error_No.***).**

  TIS server detected illegal error that is not defined as 4070 error condition.

- **8-20001 Invalid parameter.**

  Improper command parameter was specified for hp4070 command. Check the parameter.

- **8-20002 Inconsistent parameters.**

  Invalid multiple command parameters were specified for hp4070 command. Check the parameter.

- **8-20003 Incomplete parameter specification.**

  Command parameter defined for hp4070 command is insufficient. Check the parameters.

- **8-20004 Already logged in.**

  You have already logged into the 4070 operating environment.

- **8-20005 No such session (*Error_No.*).**

  You have not logged into the 4070 operating environment yet. No session to log out.

- **8-20006 System busy (Used by session: *Session_ID*).**

  The 4070 has already been logged into as the on-line mode by another user specified by *Session_ID*. On-line mode allows one user to use the 4070.

- **8-20007 Session ID must be 1 to 999999.**

  Improper session ID was specified for the environmental parameter PCS_SESSION_ID. The value must be 1 to 999999.

- **8-20008 Optimization level setting must be 0, 1, 2 or 3.**

  Improper value was specified for hp4070 -optimize command. Value must be 0, 1, 2, or 3.

- **8-20009 Too many OFF LINE sessions.**

  Too many users logged into the 4070 off-line mode. Maximum 5 users can log into the 4070 off-line mode.

- **8-20010 Invalid unit on port *Port_No.*.**

  Invalid measurement unit is assigned for the 4062 port number *Port_No.* on the port map file. Maybe the port map file was edited incorrectly. Define the port number mapping properly.

- **8-20011 Invalid 4070 port selection on 4062 port *Port_No.*.**

  Improper 4070 port number is assigned for the 4062 port number *Port_No.* on the port map file. Maybe the port map file was edited incorrectly. Define the port number mapping properly.

- **8-20012 Duplicate 4142B slot specification on 4062 port *Port_No.*.**

  Multiple measurement units are assigned for the 4062 *Port_No.* on the port map file. Only one unit must be defined for one port. Define the port number mapping properly.

- **8-20013 41420A SMU is in slot 1 on 4062 port *Port_No.*.**

  Cannot assign the 41420A SMU for 4062 port *Port_No.* on the port map file because the 41420A uses two module slots of the 4142B. Define the port number mapping properly.

- **8-20014 Can't read the port map file. *Reason*.**

  Port map file could not be read because of the reason shown in *Reason*. Check the file name and the permission of the file and directory.

- **8-20015 Can't load the portmap file. File format incorrect.**

  Port map file could not be loaded because the file format is incorrect.

- **8-20016 Can't load the DUMCONFG file. File format incorrect.**

  The 4062UX DUMCONFIG file used for port mapping could not be loaded because the file format is incorrect.

- **8-20017 Can't read the DUMCONFIG file *Reason*.**

  The 4062UX DUMCONFIG file could not be read because of the reason shown in *Reason*. Check the file name, and the permission of the file and directory.

- **8-20018 Can't save the portmap file. *Reason*.**

  Port map file could not be saved because of the reason shown in *Reason*. Check the directory name, and the permission of the file and directory.

- **8-21001 Testhead Over Voltage.**

  SMU in testhead is over voltage. Testhead is automatically shut down.

- **8-22001 Insufficient args (Something's wrong).**
  8-22002 Invalid auto cal interval specified (Something's wrong).

  Error occurred in cal4070 command. Internal error.

- **8-22003 Failed at Matrix Mother Board C/G measurement (status: *Status*).**
  8-22004 Failed at Matrix Mother Board offset measurement (status: *Status*).
  8-22005 Failed at Matrix Mother Board R/L measurement (status: *Status*).
  8-22006 Failed at Testhead offset measurement (status: *Status*).

  Improper capacitance compensation data was returned by CMU (4284A). Check the measurement cable, or execute the relay test of testhead.

- **8-22008 Invalid configuration; Pin Board *Pin_No.* is not present.**
  8-22009 Invalid configuration; Chuck Connection Pin Board is not present.

  Cannot execute the capacitance compensation measurement, because the pin board specified by *Pin_No.* or the chuck connection pin board is not installed in the testhead, or defective. Check the configuration and install the pin board properly.

- **8-22010 Cannot read the file. The file does not exist or does not have read** permission.

  The specified file cannot be read because the file does not exist or does not have read permission.

- **8-22011 Cannot write the file. The file does not exist. Or the file or the directory does not have write permission.**

  The specified file cannot be written. Because the file does not exist, or the file or specified directory does not have write permission.

- **8-22021 Unable to use the same matrix Pin_No. for CMH and CML. Specify different pin number.**

  Unable to measure compensation data for level 2 capacitance measurement because the same matrix pin number shown as Pin_No. for CMH and CML is specified. Use a different pin number for each port.

- **8-22022 The specified matrix Pin_No. does not exist. Use a valid pin.**

  When executing compensation data measurement for level 2 capacitance measurement, a non-existing matrix pin was specified as Pin_No. Check available pins and use a valid pin number.

- **8-22030 Cannot find available SMU.**

  The system cannot find any SMUs to measure the PGU compensation data. To execute the PGU calibration, at least one SMU must be installed. Check the actual SMU configuration.

- **8-22031 Cannot find available Matrix Pin.**

  The system cannot find any pin boards for the PGU calibration. To execute the PGU calibration, at least one pin board must be installed for each matrix block. Check the actual pin board configuration.

- **8-22032 Can't save pg calibration data into "/etc/opt/hp4070/pgcaldata" file.**

  The compensation data cannot be saved in the /etc/opt/hp4070/pgcaldata file. Check the following items:

  - The /etc/opt/hp4070/pgcaldata must exist.
  - The permission, owner, and group of this file must be -rw-r--r--, “root”, and “sys”, respectively.

- **8-22033 Can't load pg calibration data file "/etc/opt/hp4070/pgcaldata".**

  The cal4070 program cannot load the PGU compensation data correctly because of the wrong data format. Copy the /etc/opt/hp4070/pgcaldata file from the /opt/hp4070/newconfig directory, then execute the cal4070 again.

- **8-22050 Failed at timing calibration PG*nn*. Error:** *Messages*

  The timing calibration for PGnn (81110A) from cal4070 program is failed.

- **8-23001 Can't open C compensation data file** *File_name* **for loading (errno =** *Error_No.***).**

  Capacitance compensation data file could not be open because of the reason specified by *Error_No.*.

- **8-23002 Can't open C compensation data file** *File_name* **for saving (errno =** *Error_No.***).**

  Capacitance compensation data file could not be saved because of the reason specified by *Error_No.*.

- **8-23003 Can't read C compensation data file** *File_name* **(errno =** *Error_No.***).**

  Capacitance compensation data file could not be read because of the reason specified by *Error_No.*.

- **8-23004 Invalid C compensation data file format.**

  Capacitance compensation data file could not be read because of invalid file format. Check the file name.

- **8-23005 C compensation data file does not match the present Pin Board configuration.**

  Pin board configuration might be changed. Cannot execute the capacitance compensation properly for the present pin board configuration.

- **8-23501 Cannot find HF Matrix board.**
  Check *Port* value in PG connection file.

  The HF matrix board is not installed or it is defective. Edit the PG connection file and delete the PG address set to the specified port (*Port*).

- **8-23502 One PG must be defined for the relative HF and THF ports.**
  Check *Port* value in PG connection file.

  Different PG addresses are defined for the relative HF and THF ports. A single PG address must be defined for the ports. Edit the PG connection file and set a sinlge PG or PSO address, or delete the address set to the specified port (*Port*).

- **8-23503 Invalid PG connection data on *Port*.**
  Specified PG or PSO does not exist.

  An invalid PG or PSO address is defined in the PG connection file. Set the available PG or PSO address to the specified port (*Port*).

- **8-23504 Cannot find Pulse Switch Block *N*.**
  Check *Port* value in PG connection file.

  Pulse switch block 1 or 2 is not installed or is defective. Edit the PG connection file and delete the PG address set to the specified port (*Port*) and to port PSI1/2/3/4 or PSI5/6/7.

- **8-23505 Invalid parameter for pgconn4070.**

  An invalid parameter was set for the pgconn4070 command execution. Set the parameter properly or execute pgconn4070 with no parameter.

- **8-23506 Syntax error in dump command.**

  An improper command is entered in the print dialog box. Enter the proper command.

- **8-23507 Cannot search connection for OFF LINE session.**

  Actual PG connection cannot be searched for offline session.

- **8-24001 Usage:** *Parameter*

  Improper command parameter was specified for setlf command. Specify the command parameter properly.

- **8-24002 Can't open Optical Interface device file (*Reason*).**

  Failed to open the optical interface device file by setlf command because of the reason shown in *Reason*.

- **8-24003 Can't open Optical Interface device file (*Reason*). Perhaps shutting down the system by hp4070 -shutdown is required.**

  Failed to open the optical interface device file by setlf command because the 4070 is used by another user (process ID).

  Execute hp4070 -shutdown before executing setlf command.

- **8-24004 Can't write to the Optical Interface device file (*Reason*).**

  Failed to write the optical interface device file by setlf command because of the reason shown in *Reason*.

- **8-24005 Can't read from the Optical Interface device file (*Reason*).**

  Failed to read the optical interface device file by setlf command because of the reason shown in *Reason*.

- **8-32002 File already exists. OK to overwrite the file?**

  The file name you specified already exists. Click OK to overwrite the file. Click No to cancel.

- **8-40004 The port map table has been modified. Is it OK to discard the changes?**

  The port map table was modified. Click OK to close the dialog box without saving the changes. Click NO to cancel.

- **8-40005 File already exists. Do you want to overwrite it?**

  The file name you specified already exists. Click OK to overwrite the file Click No to cancel.

- **8-40006 Is it OK to overwrite the default port map file?**

  You are going to overwrite the default port map file. Click OK to overwrite the file. Click No to cancel.

- **8-40007 HF port map table has been modified. Is it OK to discard the changes?**

  The HF port map table was modified. Click OK to close the dialog box without saving the changes. Click No to cancel.

- **8-40008 Is it OK to overwrite the default HF port map file?**

  You are going to overwrite the default HF port map file. Click OK to overwrite the file. Click No to cancel.

- **8-40009 Pulse switch table has been modified. Is it OK to discard the changes?**

  The pulse switch table was modified. Click OK to close the dialog box without saving the changes. Click No to cancel.

- **8-40010 Is it OK to overwrite the default pulse switch file?**

  You are going to overwrite the default pulse switch file. Click OK to overwrite the file. Click No to cancel.

- **8-42016 Failed to measure calibration data of following PGU.**
  PG*nn*, PG*nn*, PG*nn*
  Please check using diag4070.
  PG level calibration data will not be updated.

  Abnormal data is meadured for the PGnn. The level calibration data for the PG*nn* is not updated. Confirm the PG functions by using the diag4070.

- **8-43001 PG connection table was modified. OK to exit the program without saving?**

  The PG connection table was modified. Click OK to exit the program without saving the changes. Click No to cancel.

- **8-43002 OK to overwrite the default PG connection file?**

  You are going to overwrite the default PG connection file. Click OK to overwrite the file. Click No to cancel.

- **8-43003 PG connection table was modified. OK to open new file without saving?**

  The PG connection table was modified. Click OK to open the new file without saving the changes. Click No to cancel.

- **8-43004 OK to exit the program?**

  You are going to exit the program. Click OK to exit the program. Click No to cancel.

- **8-43005 Searching PGU connections.**

  This message is displayed while searching the PG connection.

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- **42-11020 Parameter name can consist of alphanumeric, space, underscore and period characters only.**
  42-11022 Parameter name must be 15 characters or less.

  Maximum number of characters for parameter name in the IDP setup window is 15.

- **42-11023 Failed to start idpcgen program (Reason).**

  Number of processes may be more than the limitation specified in kernel parameter, or available swap space or memory is not sufficient. The error message reported by the HP-UX kernel is shown in Reason.

- **42-11024 A directory name must be specified.**

  A directory name must be specified in the Code Directory field of the Generate Code window.

- **42-11025 A file name must be specified.**

  A file name must be specified in the Source Code Name field of the Generate Code window.

- **42-11026 BASIC line number and its incremental number must be positive.**

  The line number and the incremental number in the BASIC Program Line Numbering field of the Generate Code window must be positive.

- **42-11028 Must specify Algorithm Function Name.**

  An algorithm function name must be specified in the Code Generation Setup window.

- **42-11029 Algorithm function name must begin with an alpha character.**

- **42-23000 Syntax error.**
  Usage: idpcgen {-b|-c} [-mhpfvSP] [-t directory] [-i file] [-o name] [-l 0(TIS)|1(algorithm)|2(program)] [-L [begin_num[,increment_num]]]

-b	Generates BASIC program
-c	Generates C program
-m	Generates Makefile for C language compile
-h	Generates C language header (.h file extension) file
-p	Generates program code for IDP running in the same session idpcgen executed
-f	Forces the specified output file to be overwritten
-v	Displays warning messages
-S	Generates or overwrites SPECS algorithm library spec file
-P	Generates program code using template file for puless
-t *directory*	Specifies that directory template file exists
-i *file*	Specifies IDP setup file (.dps file extension) from which program code is generated
-o *name*	Specifies file name (without file extension) program is saved to
-l 0|1|2	Specifies code generation level
-L *begin num, increment_num*	Specifies BASIC line numbering

- **42-23001 Must specify one option: -b (BASIC) or -c (C)**

  Idpcgen command must be used with -b (BASIC) or -c (C) option to specify generated programming language.

- **42-23002 Unable to specify -b (BASIC) and -c (C) language options together.**

  Idpcgen command cannot specify both -b (BASIC) and -c (C) language options at the same time.

- **42-23003 Unable to specify -i and -p options together.**

  Idpcgen command cannot specify both -i (specifies .dps IDP setup file) and -p (specifies IDP setup window currently open) options at the same time.

- **42-23004 Failed to open input file File_name (Reason).**

  Idpcgen command failed to open specified File_name.dps IDP setup file. Cause of the error is shown in Reason.

- **42-23005 Must specify IDP setup file name with -i option.**

  Ipdcgen command must specify IDP setup file name from which the command generates the measurement program file.

- **42-23006 Failed to open output file File_name (Reason).**

  Idpcgen command failed to open output file specified as File_name. The cause of the error is shown in Reason.

- **42-23007 The specified file name already exists. Use -f option to overwrite it.**

  The output file name for measurement program generated by the idpcgen command already exists. To overwrite the file, specify the -f option with the idpcgen command, or if you do not want to overwrite the file, change the output filename.

- **42-23008 Must specify file name with -o option.**

  When -o option is specified, the idpcgen command must specify a file name without a file extension.

- **42-23009 Failed to open template directory Directory_name (Reason).**

  The idpcten command, used with the -t option, failed to open the specified directory Directory_name. The cause of the error is shown in Reason.

- **42-23010 Must specify directory name with -t option.**

  When -t option is specified, the idpcgen command must specify a directory name.

- **42-23011 Improper generation level Level_number. Specify 0, 1, or 2 with -l option.**

  Idpcgen command has the wrong Level_number setup for -l option (code generation level option). With -l option, specify 0, 1, or 2.

- **42-23012 Must specify 0, 1 or 2 with -l option.**

  When -l option is specified, the idpcgen command must specify a code generation level number.

- **42-23013 Failed to open IPC connection to IDP (Reason).**

  Idpcgen command with -p option failed to open IPC connection to IDP. The cause of the error is shown in Reason.

- **42-23014 Failed to connect IPC to IDP (Reason).**

  Idpcgen command with -p option failed to connect IPC to IDP. The cause of the error is shown in Reason.

- **42-23015 idpcgen failed to communicate with IDP process (Reason).**

  Idpcgen command with -p option failed to communicate with the process IDP generated because of the error shown in Reason.

- **42-23016 Possible incorrect IDP setup file. Record format mismatched.**

  The file specified by the idpcgen command includes an unrecognized record. May be using an incorrect or incorrectly modified IDP setup file.

- **42-23017 Unable to generate program coding for IDP file created by Rev. B.01.20 or earlier.**

  Idpcgen cannot generate program code for IDP setup file created by 4070 system rev. B.01.20 or earlier.   Load the IDP setup file in the 4070 rev. B.01.20 IDP setup window, then save the setup and execute the idpcgen command again. Or, after loading the IDP setup file in the rev. B.01.20 environment, generate program code in the IDP environment.

- **42-23018 Possible incorrect IDP setup file. Record format mismatched.**

  The file specified by the idpcgen command includes an unrecognized record. May be using an incorrect or incorrectly modified IDP setup file.

- **42-23100 Identical name (Parameter_name) cannot be used for different data** types.

  The IDP setup file, specified by the idpcgen command, has the identical parameter name setup shown in Parameter_name for a different data type. Change the parameter name in the IDP setup window.

- **42-23101 Failed to open template file File_name (Reason).**

  Idpcgen command failed to open the template file shown as File_name. The cause of the error is shown in Reason.

- **42-23102 Failed to read template file (Reason).**

  Idpcgen command failed to read the template file. The cause of the error is shown in Reason.

- **42-23200 Unknown Token. Replace `@’ with `@@’.**

  There is an unknown token starting with `@’ in the template file specified by the idpcgen command.   Replace `@’ with `@@’.

- **42-23301 Unknown variable type found: Variable_type (Variable_name); assumed REAL.**

  In the Algorithm Spec Editor, the setup for Variable_type shown in Variable_name is incorrect. The setup variable type is ignored and the code is generated as type real.

- **42-33000 Unrecognizable input record: Record**

  The IDP setup file specified by the idpcgen command, has an incorrect record that is not recognized by the code generation function. The IDP setup file may be modified incorrectly. The incorrect record is ignored.

- **42-33001 Duplicate Parameter_name exists. Change the Parameter_name .**

  The IDP setup file, specified by the idpcgen command, has a duplicate Parameter_name. Change the Parameter_name in the IDP setup window.

- **42-33002 Template file File_name is not in directory shown in Directory_name.**

  Template file File_name does not exist in the directory specified by Directory_name, when using idpcgen with the -t option.

- **42-33003 Unable to access the specified template directory. Default template File_name is loaded.**

  Unable to find the template file. The idpcgen command cannot access the specified template directory.