

Service Guide

Agilent E5260/E5270 Series of Parametric Measurement Solutions

Edition 2



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Printing History

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition is published. No information is incorporated into a reprinting unless it appears as a prior update; the edition does not change when an update is incorporated.

The software revision code printed before the date indicates the version level of the software product at the time the manual or update was issued. Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one to one correspondence between product updates and manual updates.

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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.

GROUND THE 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 in the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

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

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.



Protective conductor terminal.

It is intended for connection to an external protective conductor for protection against electric shock in case of a fault or the terminal of a protective earth electrode.



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).

WARNING

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 personnel.

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.

NOTE

The note sign denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

Preface

Contents

WARNING The information in this manual is provided for use by service trained personnel only. To avoid electrical shock, do not perform any procedures in this manual, unless you are qualified to do so.

This manual contains information relating to the calibration and repair of the Agilent E5260A/E5270A/E5270B 8 slot parametric measurement mainframe, Agilent E5262A/E5272A 2 channel (medium power, medium power) source/monitor unit, and Agilent E5263A/E5273A 2 channel (high power, medium power) source/monitor unit. The manual consists of the following chapters:

Chapter 1 , “Overview” describes the product configurations, accessories, and service tools for the E5260/E5270.

Chapter 2 , “Calibration” contains the information and instructions for the performance verification and ADC/SMU calibrations.

Chapter 3 , “Troubleshooting” contains the information and instructions for the troubleshooting.

Chapter 4 , “Replacement Procedure” contains the assembly removal procedures and installation procedures.

Chapter 5 , “Replaceable Parts” contains the replaceable parts and assembly location information.

Chapter 6 , “Theory of Operation” contains the theory of operation to aid in the troubleshooting.

Chapter 7 , “Error Messages” contains meanings of the error codes.

Other Manuals

See the following user's manuals for more detailed information on the above topics, user operation, and programming.

User's Guide (part number E5260-90000)

Programming Guide (part number E5260-90010)

The following manuals contain service information for the Agilent 16440A, Agilent 16441A, and Agilent 16442A.

Agilent 16440A SMU/Pulse Generator Selector User's Guide (part number 16440-90000)

Agilent 16441A R-Box User's Guide (part number 16441-90000)

Agilent 16442A Test Fixture User's Guide (part number 16442-90000)

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1 Overview

Product Overview

This section describes product overview for the mainframe, accessories, and calibration tool kit.

Mainframe

The Agilent E5260/E5270 series are electronic instruments for applying DC voltage or current, and measuring DC current or voltage. The Agilent E5260/E5270 series consists of the following products:

- Agilent E5270A 8 slot parametric measurement mainframe : obsolete at November 2004
The E5270A is the mainframe for parametric measurement modules, and consists of a ground unit (GNDU) and eight empty slots to install the source/monitor unit (SMU) modules. The LCD and front panel keys are also provided to control the modules.
The E5270A accommodates up to eight medium power SMUs (MPSMUs), up to four high-power SMUs (HPSMUs), or any physically allowable combination thereof.
- Agilent E5272A 2 channel source/monitor unit (SMU): obsolete at November 2004
The E5272A is a fixed-configuration dual SMU instrument, and consists of a GNDU and two MPSMUs. LCD and front panel keys are also provided to control the modules.
- Agilent E5273A 2 channel source/monitor unit (SMU): obsolete at November 2004
The E5273A is a fixed-configuration dual SMU instrument, and consists of a GNDU, an HPSMU, and an MPSMU. The LCD and front panel keys are also provided to control the modules.
- Agilent E5280A high power source/monitor unit (HPSMU) module: obsolete at November 2004
The E5280A is the HPSMU module for the E5270A, and occupies two slots. The E5280A can force and measure 1 A/200 V maximum.
- Agilent E5281A medium power source/monitor unit (MPSMU) module: obsolete at November 2004
The E5281A is the MPSMU module for the E5270A, and occupies one slot. The E5281A can force and measure 200 mA/100 V maximum.
- Agilent E5260A 8 slot high speed parametric measurement mainframe
The E5260A is the mainframe for high speed parametric measurement modules, and consists of a ground unit (GNDU) and eight empty slots to install the high speed source/monitor unit (SMU) modules. The LCD and front panel keys are also provided to control the modules.
The E5260A accommodates up to eight high speed medium power SMUs (MPSMUs), up to four high speed high-power SMUs (HPSMUs), or any physically allowable combination thereof.
- Agilent E5262A 2 channel high speed source/monitor unit (SMU)
The E5262A is a fixed-configuration dual SMU instrument, and consists of a GNDU and two high speed MPSMUs.
LCD and front panel keys are also provided to control the modules.
- Agilent E5263A 2 channel high speed source/monitor unit (SMU)
The E5263A is a fixed-configuration dual SMU instrument, and consists of a GNDU, an high speed HPSMU, and an high speed MPSMU. The LCD and front panel keys are also provided to control the modules.

- Agilent E5290A high speed high power source/monitor unit (HPSMU) module
The E5290A is the high speed HPSMU module for the E5260A, and occupies two slots. The E5290A can force and measure 1 A/200 V maximum.
- Agilent E5291A high speed medium power source/monitor unit (MPSMU) module
The E5291A is the high speed MPSMU module for the E5260A, and occupies one slot. The E5291A can force and measure 200 mA/100 V maximum.
- Agilent E5270B 8 slot precision parametric measurement mainframe
The E5270B is the mainframe for precision parametric measurement modules, and consists of a ground unit (GNDU) and eight empty slots to install the precision source/monitor unit (SMU) modules. The LCD and front panel keys are also provided to control the modules.
The E5270B accommodates up to eight precision medium power SMUs (MPSMUs), up to four precision high-power SMUs (HPSMUs), up to eight high-resolution SMUs (HRSMUs), or any physically allowable combination thereof.
- Agilent E5280B high power source/monitor unit (HPSMU) module
The E5280B is the HPSMU module for the E5280B, and occupies two slots. The E5280B can force and measure 1 A/200 V maximum.
- Agilent E5281B medium power source/monitor unit (MPSMU) module
The E5281B is the MPSMU module for the E5270B, and occupies one slot. The E5281B can force and measure 100 mA/100 V maximum.
- Agilent E5287A atto level high resolution source/monitor unit (HRSMU) module
The E5287A is the atto level HRSMU module for the E5270B, and occupies one slot. The E5287A can force and measure 100 mA/100 V maximum and 1 fA/0.5 uV resolution. If you attach the optional E5288A atto sense and switch unit (ASU), measurement resolution will be 0.1 fA/0.5 uV.
- Agilent E5288A atto sense and switch unit (ASU)
The E5288A is optional switch unit for E5287A HRSMU. E5288A provide measurement resolution as 0.1 fA/0.5 uV.

Figure 1-1 E5260/E5270 series



Agilent E5260A/E5270A/E5270B



Agilent E5262A/E5263A/E5272A/E5273A

Product Overview

Accessories

- Test fixture

The Agilent 16442B is the test fixture for the E5260/E5270 series. You can mount a device under test (DUT) on the 16442B, and measure the device characteristics.

- Cables and adapters

The Agilent 16435A, Agilent 16493G/J/K/L/M, Agilent 16494A/B, and Agilent N1253A/N1254A are cables and adapters for the E5270 series. You can connect the E5270 series to other instruments, test fixture, connector plate, or prober by using these cables and adapters.

- Connector plates

The Agilent 16495F/G/H/J/K is the connector plate for the E5260/E5270 series, and is the interface for connecting the E5260/E5270 series, Agilent 4155C/4156C, Agilent E5250A, and Agilent B2200A/B2201A to the prober or test fixture.

Calibration tool set

Agilent E5299B is a calibration tool set for the E5260/E5270 series, and consists of calibration software, cables, adapters, and operation guide.

NOTE

E5299B includes new revision of PV software and low current calibration adapter. If you have E5299A and need to calibrate E5270B, order the E5299-65001 (Low Current Calibration Adapter) and 16353H (100 Gohm calibration standard box).

Products and Options

Table 1-1 lists Agilent product numbers and option items for Agilent E5260/E5270 series..

Table 1-1 Mainframes and modules

Product number	Option item	Description
E5260A		8 slot high speed parametric measurement mainframe
	E5260A-050	50 Hz power line frequency
	E5260A-060	60 Hz power line frequency
	E5260A-A6J	ANSI Z540 compliant calibration
	E5260A-UK6	Commercial cal. certificate w/ test data
	E5260A-ABA	Manual set, English
	E5260A-ABJ	Manual set, Japanese
E5262A		2 channel source/monitor unit (MPSMU/MPSMU)
	E5262A-050	50 Hz power line frequency
	E5262A-060	60 Hz power line frequency
	E5262A-A6J	ANSI Z540 compliant calibration
	E5262A-UK6	Commercial cal. certificate w/ test data
	E5262A-ABA	Manual set, English
	E5262A-ABJ	Manual set, Japanese
E5263A		2 channel source/monitor unit (HPSMU/MPSMU)
	E5263A-050	50 Hz power line frequency
	E5263A-060	60 Hz power line frequency
	E5263A-A6J	ANSI Z540 compliant calibration
	E5263A-UK6	Commercial cal. certificate w/ test data
	E5263A-ABA	Manual set, English
	E5263A-ABJ	Manual set, Japanese

Table 1-2 Mainframes and modules

Product number	Option item	Description
E5270B		8 slot precision parametric measurement mainframe
	E5270B-050	50 Hz power line frequency
	E5270B-060	60 Hz power line frequency
	E5270B-A6J	ANSI Z540 compliant calibration
	E5270B-UK6	Commercial cal. certificate w/ test data
	E5270B-ABA	Manual set, English
	E5270B-ABJ	Manual set, Japanese
E5280B		High power source/monitor unit module for E5270B
E5281B		Medium power source/monitor unit module for E5270B
E5287A		High resolution source/monitor unit module for E5270B
E5288A		Atto sense and switch unit for E5287A
E5290A		high speed HPSMU module for E5260A
E5291A		high speed MPSMU module for E5260A

Available Accessories

Table 1-3 through Table 1-5 list the available accessories for E5270 series.

Table 1-3 Test fixture

Product number	Option item	Description
16442B		Test fixture
	16442B-010	Add 1.5 m triaxial cables, 4 ea.
	16442B-011	Add 3.0 m triaxial cables, 4 ea.
	16442B-800	Extra blank teflon board
	16442B-801	Universal socket module, 0.1 inch pitch, with 10 pins
	16442B-802	Universal socket module, 0.075 inch pitch, with 10 pins
	16442B-803	Universal socket module, 0.05 inch pitch, with 10 pins
	16442B-810	Extra pin set (for universal socket module, 10 pins.)
	16442B-811	Extra wire set (mini banana to pin plug, 6 ea.)
	16442B-812	Extra wire set (pin plug to pin plug, 6 ea.)
	16442B-813	Extra wire set (mini banana to mini clip, 6 ea.)
	16442B-814	Extra wire set (mini banana to mini banana, 6 ea.)
	16442B-821	Socket module, 4-pin TO package
	16442B-822	Socket module, 18-pin DIP package
	16442B-823	Extra socket module, 28-pin DIP package
16442B-890	Extra accessory case	

Table 1-4 Cables and adapters

Product number	Option item	Description
16435A		Interlock cable adapter (E5270 type to BNC)
16493G		Digital I/O Connection Cable
	16493G-001	1.5 m length
	16493G-002	3.0 m length
16493J		Interlock cable
	16493J-001	1.5 m length
	16493J-002	3.0 m length
16493G		Digital I/O connection cable
	16493G-001	1.5 m length
	16493G-002	3.0 m length
16493K		Kelvin triaxial cable (E5270 Kelvin to E5270 Kelvin)
	16493K-001	1.5 m length
	16493K-002	3.0 m length
16493L		GNDU cable for E5270 series
	16493L-001	1.5 m length
	16493L-002	3.0 m length
16493M		Triaxial and D-sub Cable for ASU
	16493M-001	1.5 m length
	16493M-002	3.0 m length
16494A		Triaxial cable
	16494A-001	1.5 m length
	16494A-002	3 m length
	16494A-003	80 cm length
16494B		Kelvin triaxial cable (E5270 Kelvin to E5250 Kelvin)
	16494B-001	1.5 m length
	16494B-002	3 m length
	16494B-003	80 cm length
N1253A		Digital I/O accessories
	N1253A-100	Digital I/O T-cable
	N1253A-200	Digital I/O BNC box
N1254A		Accessories
	N1254A-100	GNDU to Kelvin adapter
16435A		Interlock Cable Adapter (E5260/E5270 type to BNC)

Table 1-5 Connector plates

Product number	Option item	Description
16495F		Connector plate w/ 12×triax., interlock, GNDU
	16495F-001	Bulkhead feed through connectors (female to female)
	16495F-002	Connectors to contacts for soldering
16495G		Connector plate w/ 24×triax., interlock, GNDU
	16495G-001	Bulkhead feed through connectors (female to female)
	16495G-002	Connectors to contacts for soldering
16495H		Connector plate w/ 6×triax., 6×coax., interlock, GNDU
	16495H-001	Bulkhead feed through connectors (female to female)
	16495H-002	Connectors to contacts for soldering
16495J		Connector plate w/ 8×triax., 4×coax., Interlock, GNDU
	16495J-001	Bulkhead feed through connectors (female to female)
	16495J-002	Connectors to contacts for soldering
16495K		Connector plate for ASU
	16495K-001	Bulkhead feedthrough connectors (female to female)

Service Tools

The Agilent E5299B is the calibration tool set for the E5260/E5270 series, and consists of the items as listed in Table 1-6. Table 1-7 and Table 1-8 list the required equipment for servicing the E5260/E5270 series.

Table 1-6 E5299B contents

Product number/ part number	Description	Quantity
04142-61641	Triaxial cable, 1 m	1
04155-60007	Module extractor	1
04155-61614	Interlock cable	1
04155-61648	Mini pin plug to banana plug cable	1
04155-65041	Calibration adapter	1
04155-65042	Shorting box for calibration adapter	1
04155-65043	Interlock test adapter	1
1250-0929	BNC shorting cap	1
11058A	Banana plug to banana plug cable ^a	1
E5299-16001	Calibration software for E5260/E5270 series	1
E5299-65001	Low current calibration adapter	1

a. The 11058A consists of red and black banana plug to banana plug cables.

Table 1-7 Required equipment for calibration

Product number/ part number	Description	Quantity
16353A	Standard resistor set	1
16353H	100 Gohm calibration standard box	1
3458A	Digital multimeter	1
E5299B	Calibration tool set for E5260/E5270 series	1
–	PC as a controller: CPU Intel® Pentium® or compatible processor 300 MHz or higher clock speed Memory 128 Mbyte Hard disk 20 Mbyte free space OS Microsoft® Windows® NT 4.0, 2000, or XP GPIB card Agilent 82350A PCI GPIB interface card, Agilent 82357A USB-GPIB interface card, National Instruments® PCI-GPIB interface card, or other GPIB interface cards that are supported by VISA.	1

NOTE The Agilent 3458A, Agilent 16353A, and Agilent 16353H should be calibrated by an instrument traceable to the National Institute of Standards and Technologies (NIST) or an equivalent standard; or calibrated directly by an authorized calibration organization such as NIST. The calibration cycle should be in accordance with the stability specifications of each component.

Table 1-8 Required equipment for troubleshooting

Description	Quantity
Torx® screwdriver (No. 25)	1
Hex wrench (H2.5 mm)	1
Nut drivers or spanners (H5.5 mm, H7 mm, H 1/2", and H 1/4")	4
Flat-tip screwdriver	1
Pozidrive screwdrivers (No. 1 and No. 2)	2

NOTE Calibration equipment is also needed for troubleshooting.

2 Calibration

Calibration

This chapter gives the information about the Agilent E5260/E5270 calibration, and consists of the following sections:

- “Calibration Overview”
- “Getting Started”
- “Performance Verification Procedure for E5270A/E5272A/E5273A”
- “Performance Verification Procedure for E5260A/E5262A/E5263A/E5270B”
- “ADC/SMU Calibration Procedure”
- “Performance Verification Theory”
- “ADC/SMU Calibration Theory”
- “Printing Test Result”

Calibration Overview

This section describes definition of calibration, calibration flow, requirements, operating conditions, and so on.

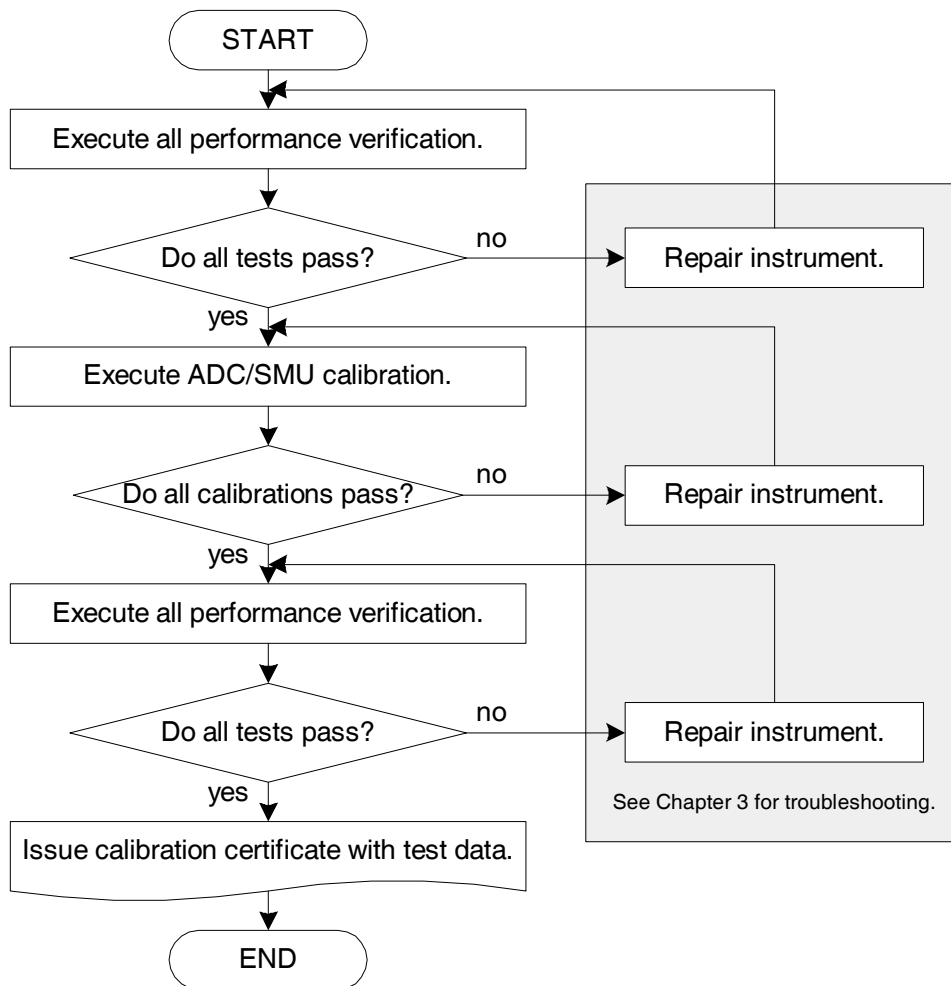
Definition of calibration

Calibration is defined as the action that confirms the equipment performance, compares it with commercial specifications, and adjusts the reference resistors and voltages values that affect the measurement and output values. The calibration consists of the performance verification and ADC/SMU calibration.

Calibration flow

You must perform the calibration as shown in Figure 2-1.

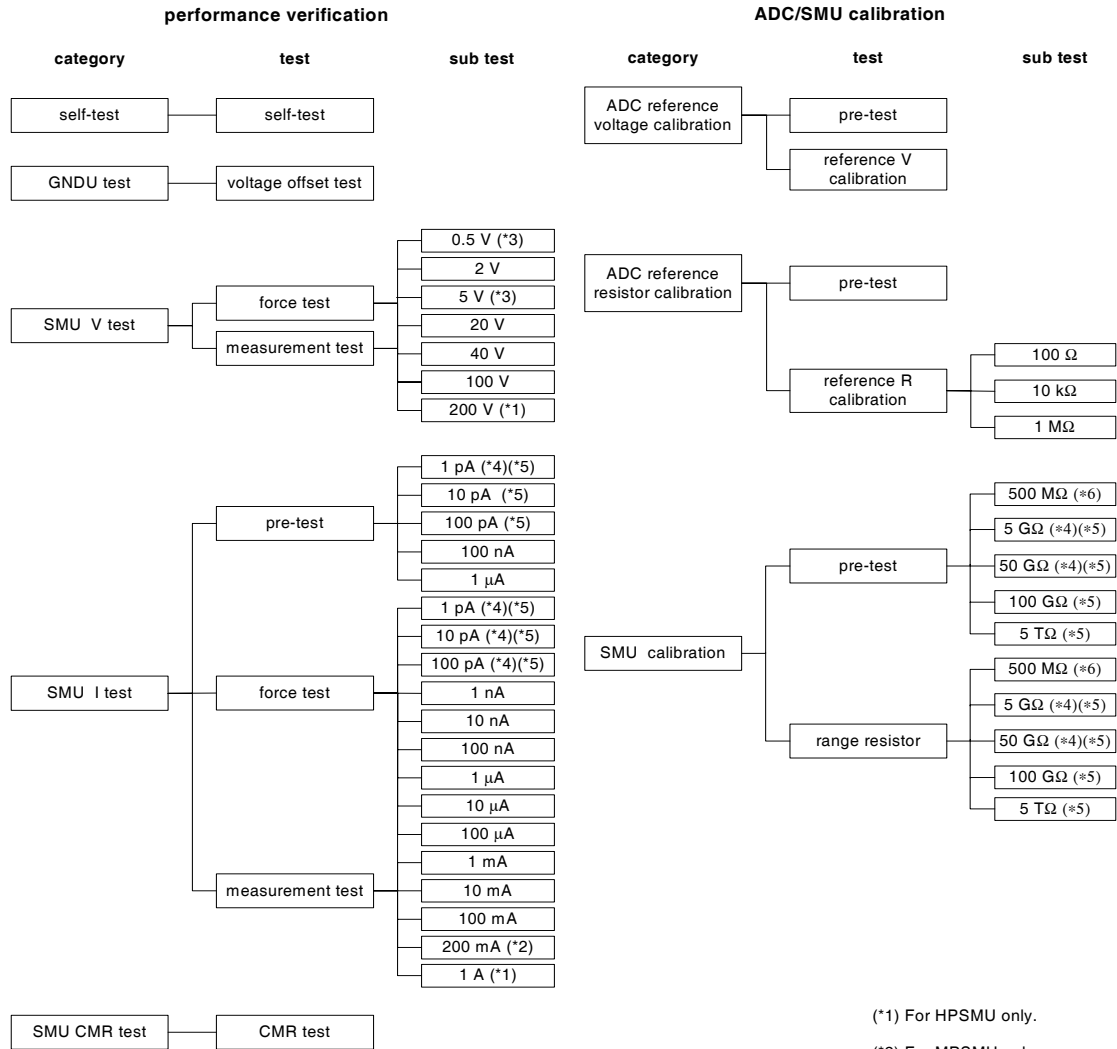
Figure 2-1 Calibration flow



Calibration structure

Figure 2-2 shows the performance verification and ADC/SMU calibration structure.

Figure 2-2 Calibration structure



(*1) For HPSMU only.
 (*2) For MPSMU only.
 (*3) For E5281B/E5287A/E5288A only.
 (*4) For E5287A only.
 (*5) For E5287A+E5288A only.
 (*6) E5290A/E5291A are not available.

Required equipment

Table 1-7 lists the required equipment for the calibration.

Operating conditions

Perform all calibration in the following conditions:

- Ambient temperature is $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$
- E5260/E5270 series are warmed up at least 40 minutes.
- Agilent 3458A is periodically calibrated and is warmed up for four hours. Also, **ACAL** is performed after the warm-up time.
- Temperature change is within $1\text{ }^{\circ}\text{C}$ after the **ACAL**.
- At least one SMU is installed in the mainframe for the ADC calibration.

Calibration cycle

The E5260/E5270 series require the periodic calibration. The frequency of the calibration depends on the operating and environmental conditions under which the instrument is used. Agilent Technologies recommends that the calibration is performed at least once a year.

Also, a part of calibration should be performed to guarantee the instrument specification when you repair a part of the E5260/E5270 series that is related to the specification. The required performance verification and ADC/SMU calibration are shown in Chapter 5 , “Replaceable Parts,”.

Getting Started

This section describes how to install, set up, and run the performance verification and calibration software. Perform steps 1 through 6 in this section.

NOTE Before you perform steps 1 through 6, check if the GPIB interface card and I/O library are properly installed.

Step 1. Software and hardware setup

The following is the hardware and software (calibration software for Agilent E5270 series) installation and set up procedure.

1. Connect the GPIB cable between a PC and the E5260/E5270 series mainframe.
2. Turn on the PC and E5260/E5270 series mainframe.
3. Confirm that the GPIB interface and I/O library are installed in the PC and are working.
4. Install the E5270 series calibration software as follows:
 - a. Insert the software CD-ROM into your CD-ROM drive.
 - b. Close all running applications.
 - c. Click **Start > Run**.
 - d. Enter the setup file name with the path (ex. D:\setup), and then click **OK**.
 - e. Follow the instructions displayed on the screen to install the calibration software.

When the installation is complete, a program group is added on the **Start** menu labeled **Agilent E5299B > Calibration Software for Agilent E5260/E5270 Series**.

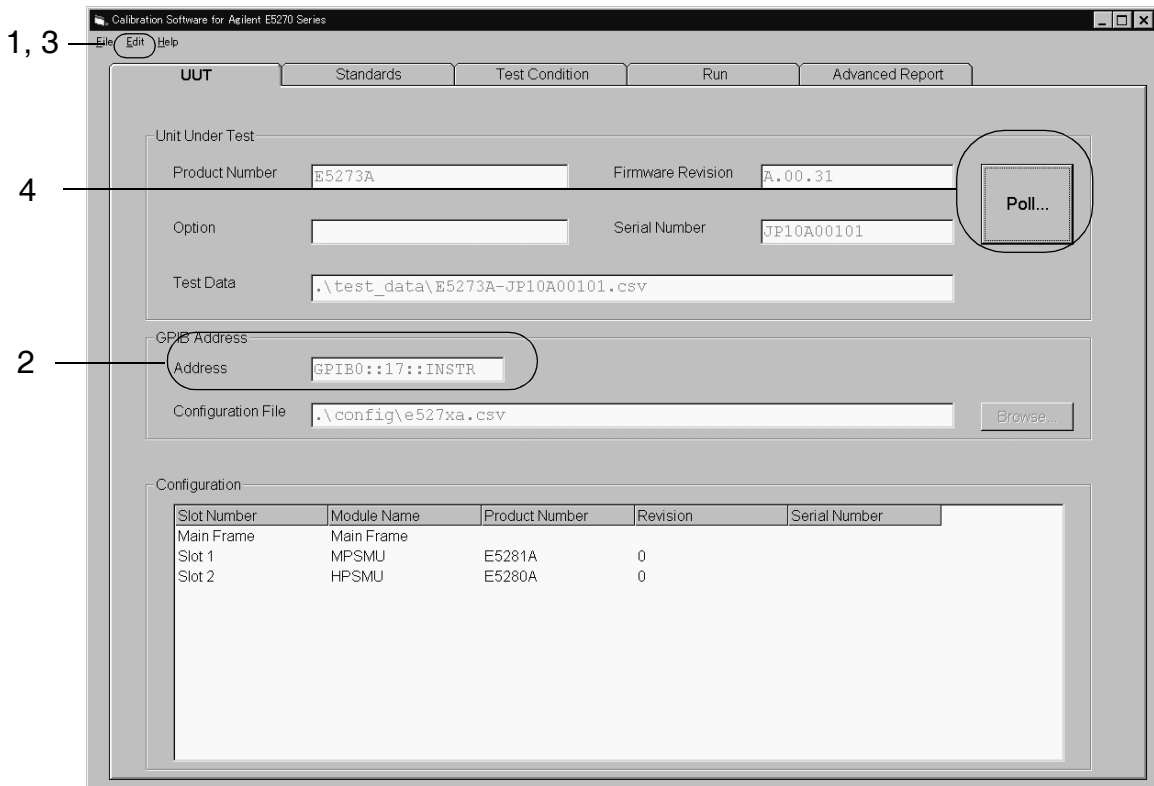
Step 2. Configuring UUT information

Run the calibration software by selecting **Start > Agilent E5299B > Calibration Software for Agilent E5260/E5270 Series**. This opens the calibration software graphical user interface (GUI) as shown in Figure 2-3. The calibration software is grouped into four tabs: UUT, Standards, Test Condition, and Run. The unit under test (UUT) configuration is done on the UUT tab.

Follow these steps to configure the UUT information.

1. Click **Edit > Edit Data**. The check mark is displayed beside the **Edit Data**.
2. Enter the GPIB address in the blank of the GPIB Address area. For example, if the GPIB interface name is GPIB0 and the E5270 GPIB address is 17, type GPIB0::17::INSTR.. This information is confirmable by using the VISA Assistant.
3. Click **Edit > Edit Data**, and then save the configuration into the file specified in Configuration File.

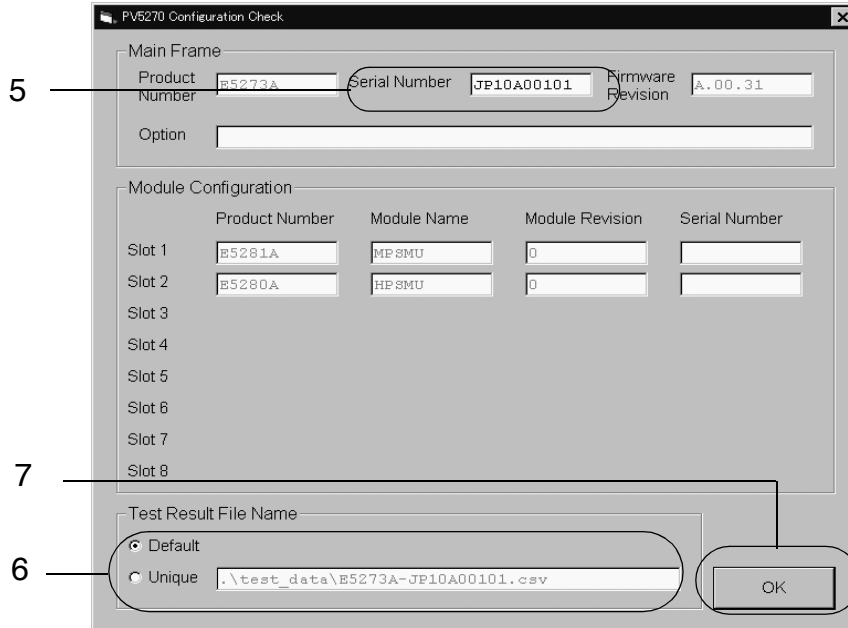
Figure 2-3 UUT tab



Calibration
Getting Started

- Click **Poll**. The calibration software retrieves the UUT configuration (model number, firmware revision, and module configuration), and displays this on the PV5260/E5270 Configuration Check window as shown in Figure 2-4.

Figure 2-4 PV5270 Configuration Check window



- Enter the E5260/E5270 serial number.
- Enter the test result file name. The default setting of the test result file name is made by the serial number. If you want to change the test result file name, select **Unique**, then enter the file name.

NOTE When you execute the performance verification after the ADC/SMU calibration, Agilent Technologies recommends that you change the test result file name for easy test data administration. For details, see “Printing Test Result”.

- Click **OK**.

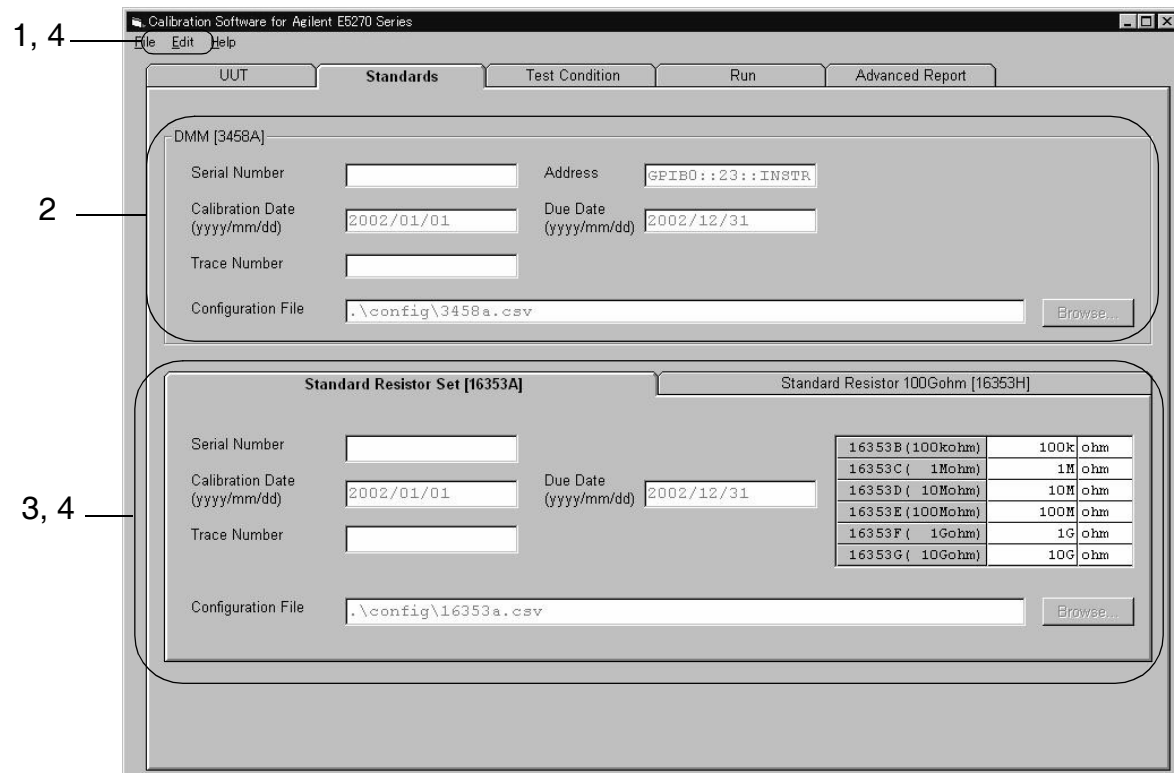
Step 3. Setting calibration standards

Open the Standards tab by clicking the tab, and then follow these steps to set up the calibration standards (Agilent 3458A, Agilent 16353A, and Agilent 16353H).

1. Click **Edit > Edit Data**. The check mark is displayed beside **Edit Data**.
2. Enter the serial number, GPIB address, calibrated date, due date, and trace number of Agilent 3458A (DMM).
3. Enter the serial number, calibrated date, due date, trace number, and resistance values of Agilent 16353A (standard resistor set) and 16353H.
4. (Optional only for E5270B HRSMU with ASU)
Select the 16353H tab, and enter the serial number, calibrated date, due date, trace number, and resistance values of Agilent 16353H (100 Gohm calibration standard box).
5. Click **Edit > Edit Data**, and then save the data into the files specified in the Configuration File.

NOTE Once you enter the information and save it into the files, you can load the information by clicking **Load or Create File**. In default setting, the standard setting files are made in the C:\Program Files\Agilent Technologies\E5299\config folder, but you can put the setting files in another folder and share them with other networked PCs.

Figure 2-5 Standards tab

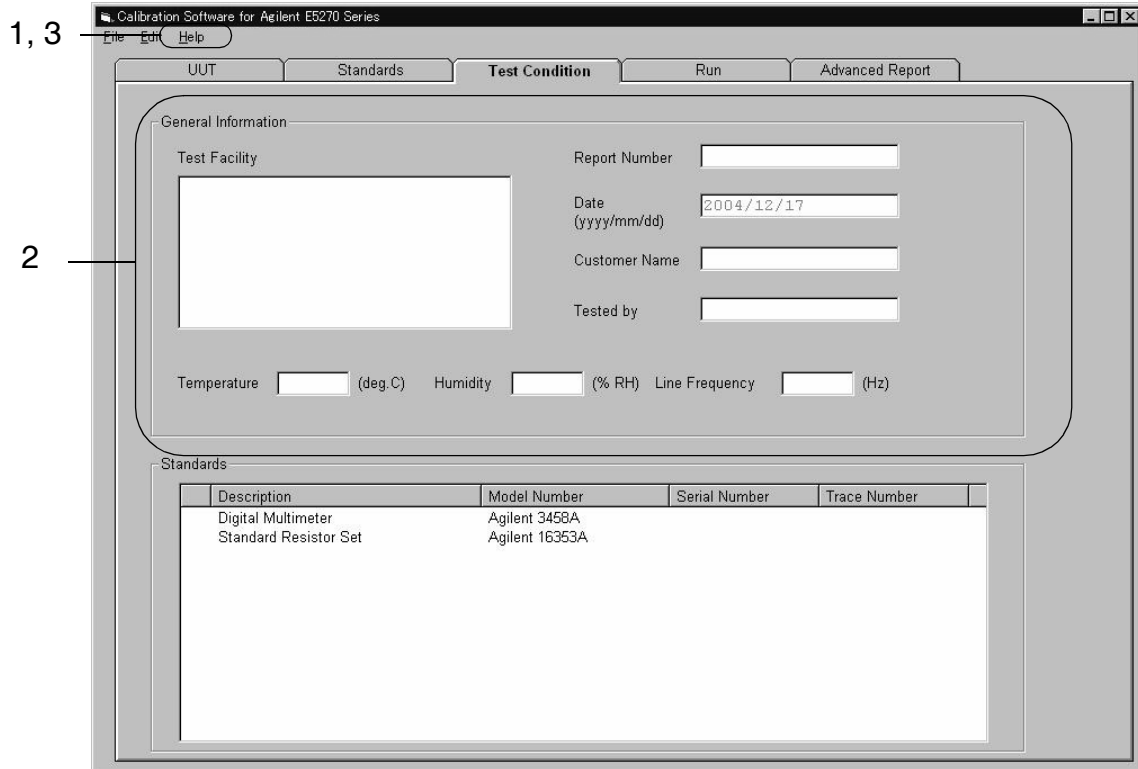


Step 4. Entering test conditions

Open the Test Condition tab by clicking the tab, and then follow these steps to enter test conditions.

1. Click **Edit > Edit Data**. The check mark is displayed beside **Edit Data**.
2. Enter the test facility name, report number, calibration date, customer name, tested by, temperature, humidity, and line frequency. These data are used for the first page of calibration report.
3. Click **Edit > Edit Data**, and then save the data into result file specified in the Test Condition tab.

Figure 2-6 Test Condition tab



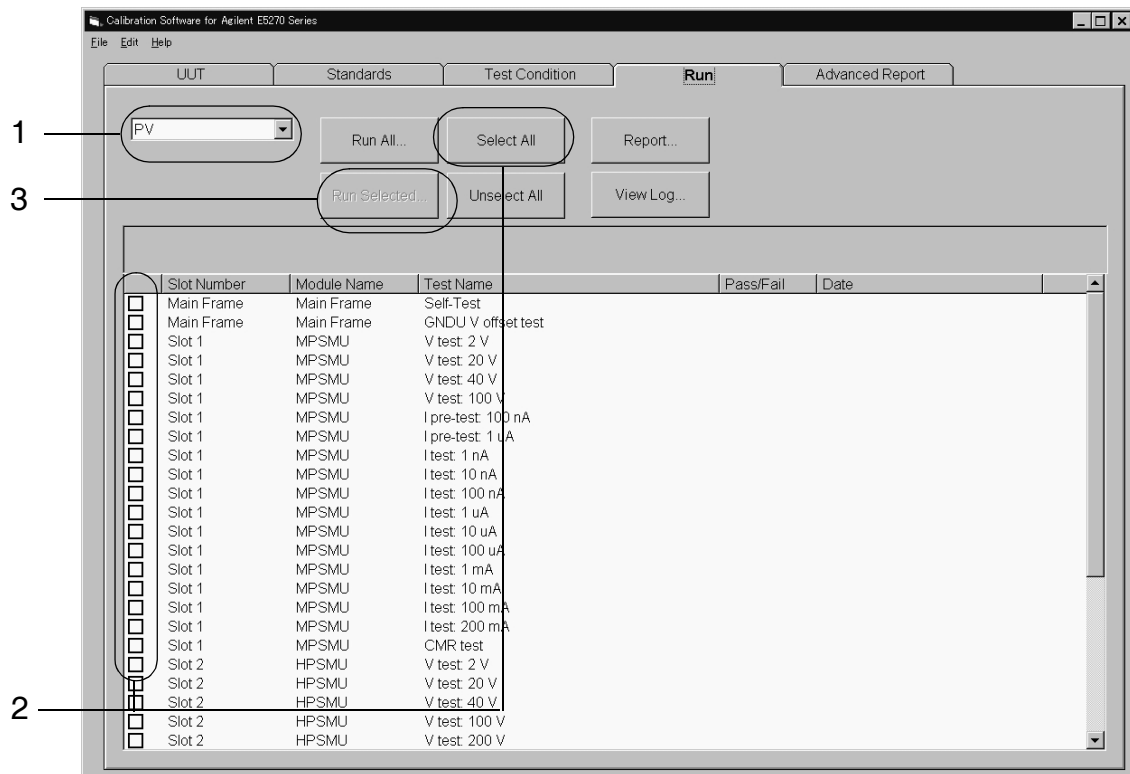
Step 5. Selecting tests

Open the Run tab by clicking the tab, and then follow these steps to execute the performance verification or ADC/SMU calibration.

1. If you want to execute the performance verification, select **PV**. If you want to execute the ADC/SMU calibration, select **Calibration**. The executable tests are displayed in the window.
2. Select tests or calibrations that you want to execute by clicking the check box or **Select All**.
3. Click **Run Selected**.

NOTE If you are executing the performance verification after the ADC/SMU calibration. Agilent Technologies recommends that you change the result file name in step 2-4 for easy test data administration. See also “Printing Test Result”.

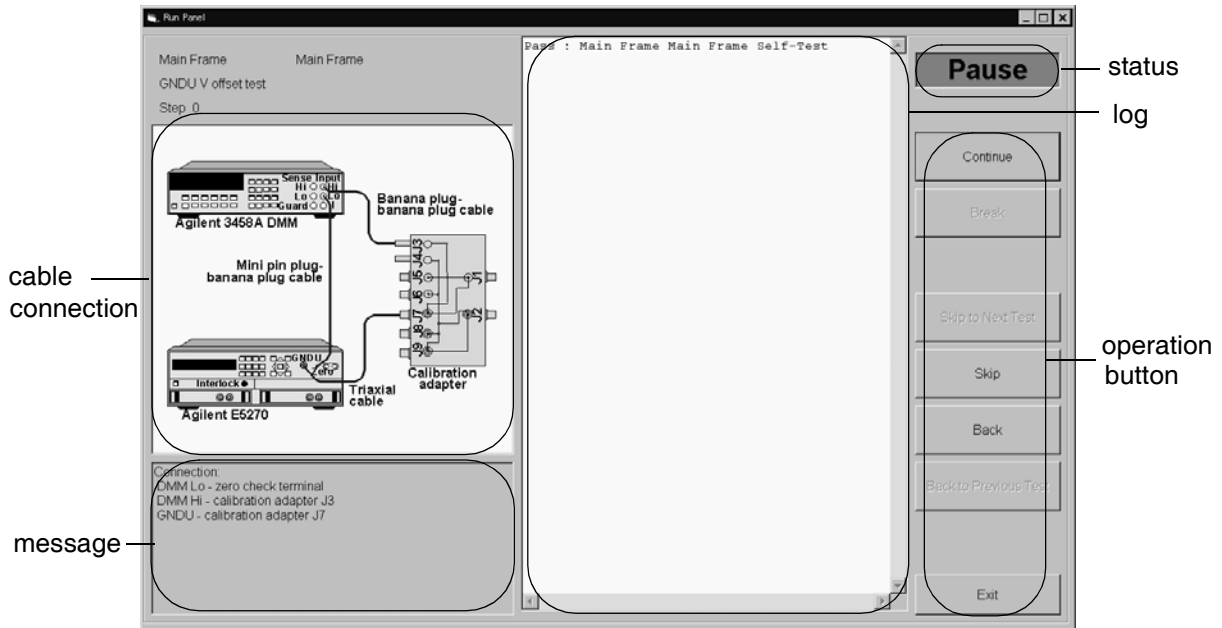
Figure 2-7 Run tab



Step 6. Executing tests or calibrations

Run the selected tests or calibrations by clicking **Run Selected**. This opens the run panel and test introduction window as shown in figure 2-8.

Figure 2-8 Run panel



The following lists the functions of the Run Panel.

- Continue** Goes to next step.
- Break** Stops executing tests or calibrations.
- Skip to Next Test** Skips the current test or calibration, then goes to the next test.
- Skip** Skips the current step, then goes to the next step.
- Back** Returns to the previous step.
- Back to Previous Test** Returns to the previous test or calibration.
- Exit** Quits the performance verification or calibration, then closes the Run Panel.
- Cable connection** Displays the cable connection.
- Message** Displays the connection or test name.
- Log** Displays logs for performance verification and calibration. This information is also stored in the result file that you specified in the Configuration tab.
- Status** Displays the test and calibration status.

Performance Verification Procedure for E5270A/E5272A/E5273A

This section describes the performance verification procedure, required equipment, and cable connections for each tests.

Self-test

Required equipment

None

Procedure

1. Disconnect all cables and plugs from the SMU. (Set the SMU to “open” condition.)
2. Click **Continue**. The self-test is executed.

GNDU voltage offset test

This test verifies the ground unit (GNDU) voltage offset accuracy.

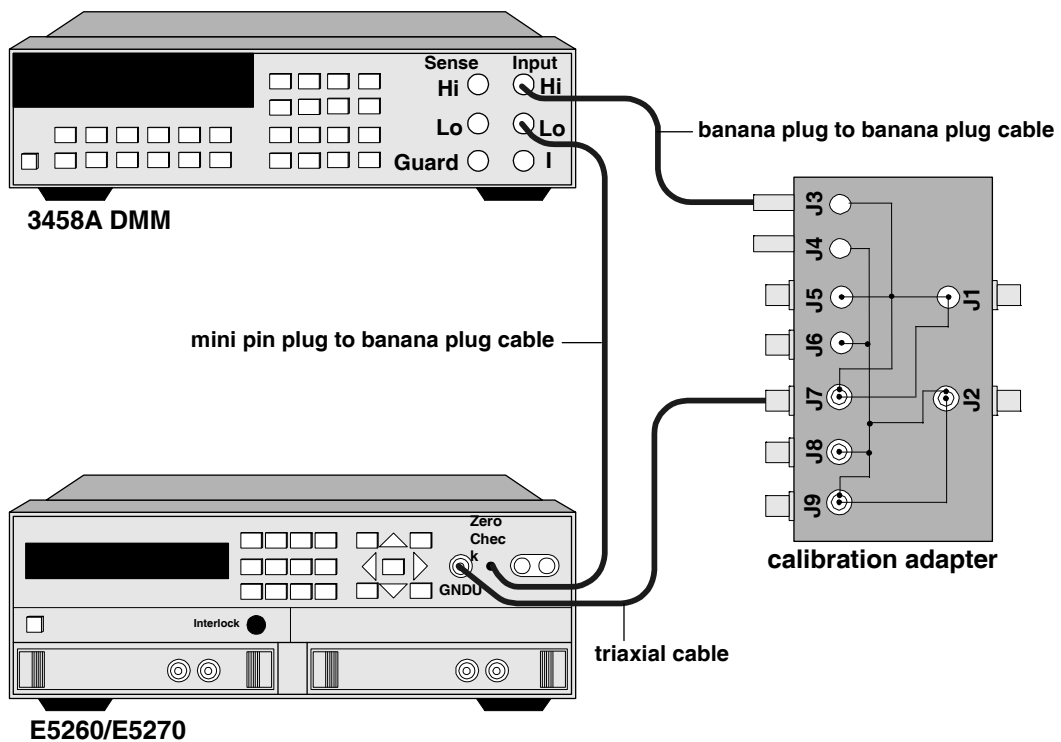
Required equipment

- Triaxial cable (04142-61641)
- Mini pin plug to banana plug cable (04155-61648)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the zero check terminal on the mainframe front panel.
2. Connect DMM-Hi to the calibration adapter J3.
3. Connect the GNDU to the calibration adapter J7.
4. Click **Continue**. The GNDU voltage offset test is executed.

Figure 2-9 Connection for GNDU voltage offset test



SMU voltage test

This test consists of the voltage setting test and voltage measurement test; it verifies the SMU voltage setting and measurement accuracy.

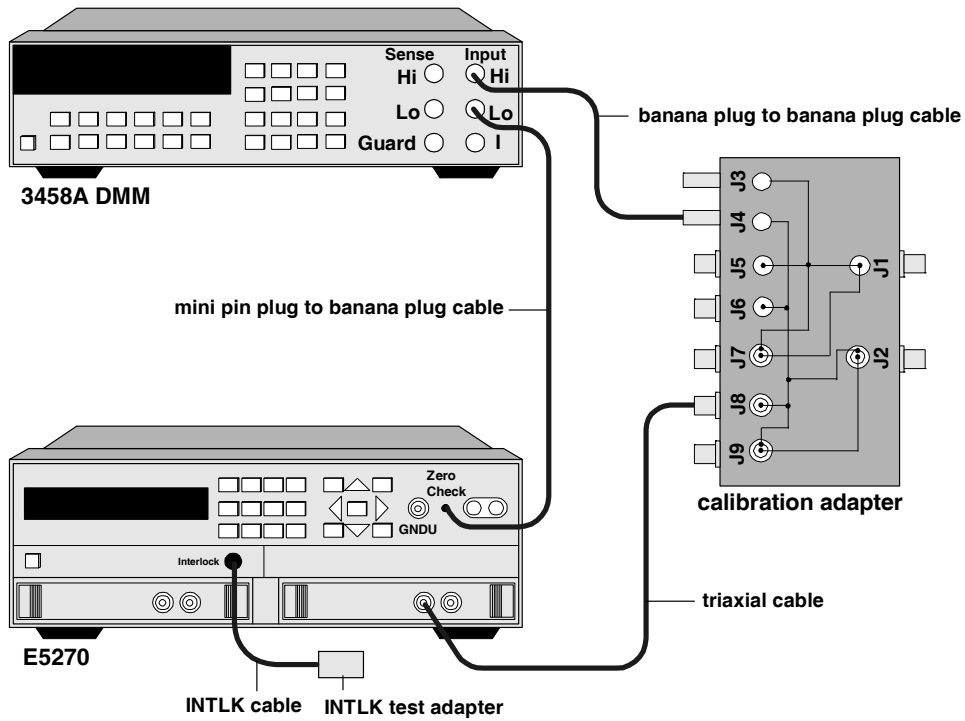
Required equipment

- Triaxial cable (04142-61641)
- INTLK cable (04155-61614)
- Mini pin plug to banana plug cable (04155-61648)
- Calibration adapter (04155-65041)
- Low current calibration adapter (E5299-65001: For E5270B HRSMU only)
- INTLK test adapter (04155-65043)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the zero check terminal on the E5260/E5270 front panel.
2. Connect DMM-Hi to the calibration adapter J4.
3. Connect the INTLK test adapter to the Interlock terminal on the E527xA front panel with the INTLK cable.
4. Set the INTLK test adapter switch to 1 (ON).
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J8 according to the displayed instruction.
7. Click **Continue**. The voltage setting test and voltage measurement test are executed.
8. Steps 6 and 7 are repeated until all of the selected SMUs are tested.

Figure 2-10 Connection for SMU voltage test



SMU current pre-test

This test is the pre-measurement for the SMU current test, and verifies the guard potential offset voltage.

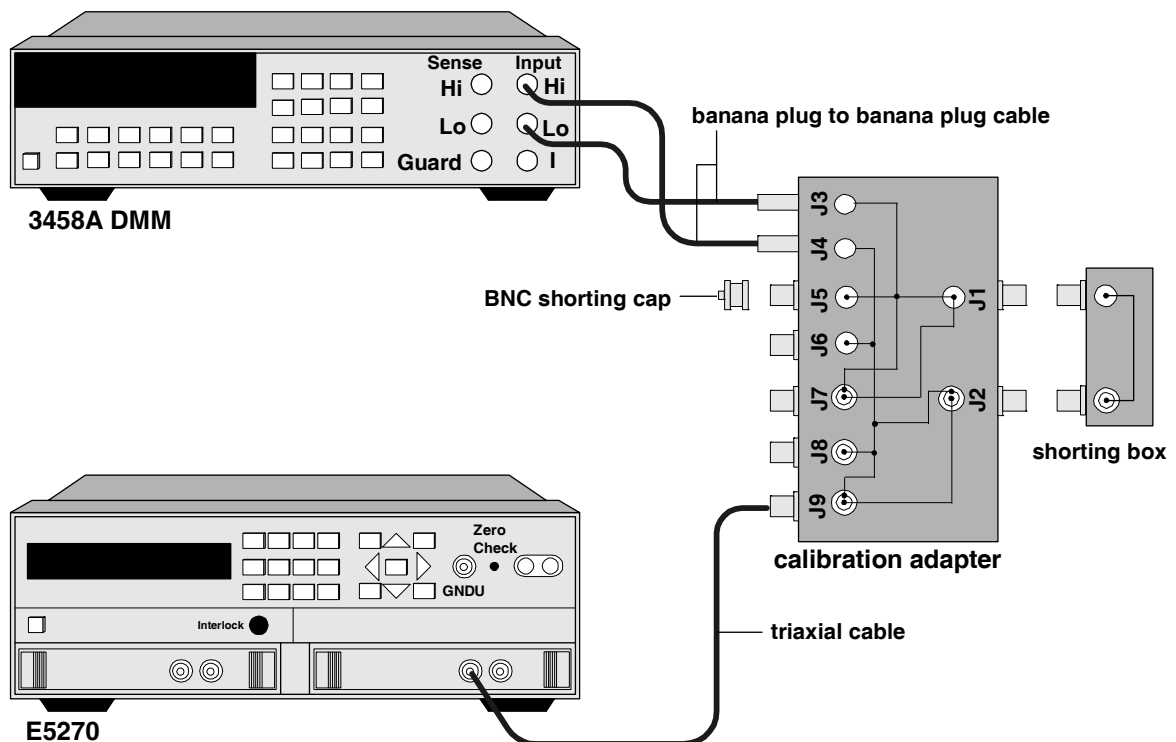
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Shorting box (04155-65042)
- Banana plug to banana plug cable (Agilent 11058A)
- BNC shorting cap (1250-0929)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the calibration adapter J3.
2. Connect DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the shorting box to the calibration adapter J1 and J2.
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J9 according to the displayed instruction.
7. Click **Continue**. The SMU current pre-test is executed.
8. Steps 6 and 7 are repeated until all SMUs are tested.

Figure 2-11 Connection for SMU current pre-test



SMU current test (for 1 nA to 10 μ A ranges)

This test consists of the current setting test and current measurement test; it verifies the current setting and measurement accuracy. Note that the SMU current pre-test must pass before this test.

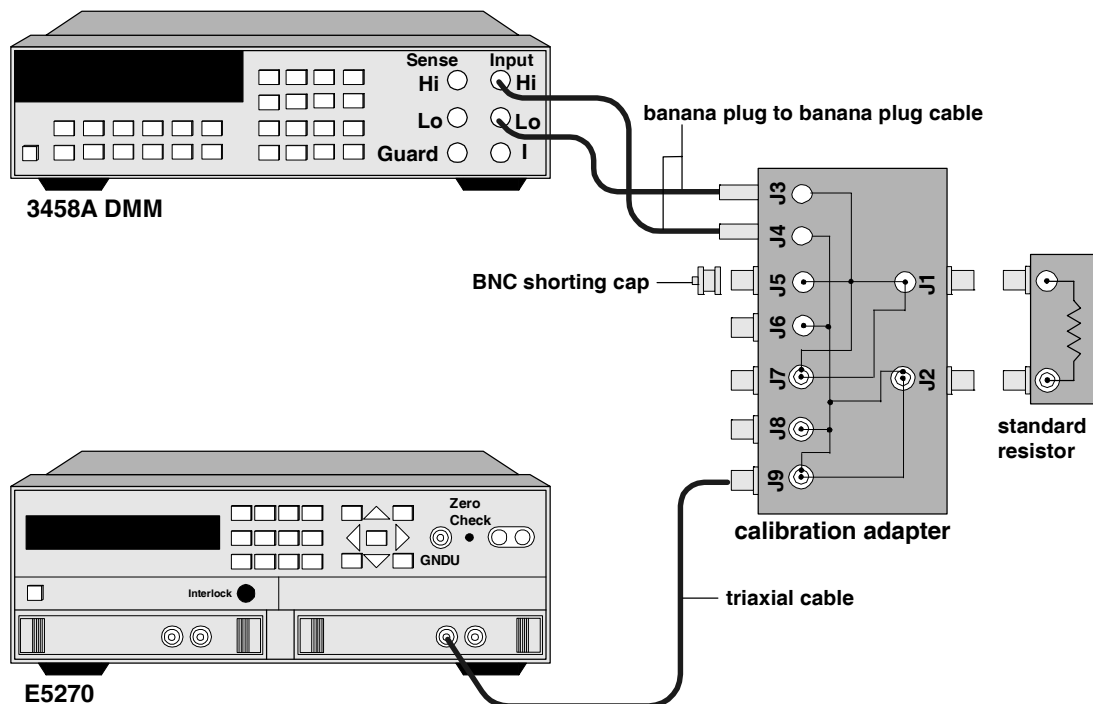
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- BNC shorting cap (1250-0929)
- Standard resistor set (Agilent 16353A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the calibration adapter J3.
2. Connect DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the standard resistor to the calibration adapter J1 and J2 according to the displayed instruction.
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J9.
7. Click **Continue**. The current setting test and current measurement test are executed.
8. Steps 6 and 7 are repeated until all of the selected SMUs are tested.
9. Steps 1 through 8 are repeated until all of the selected current ranges are tested.

Figure 2-12 Connection for SMU Current test (for 1 nA to 10 μ A ranges)



Performance Verification Procedure for E5270A/E5272A/E5273A

SMU current test (for 100 μ A to 1 A ranges)

This test consists of the current setting accuracy test and current measurement accuracy test; it verifies the current setting and measurement accuracy.

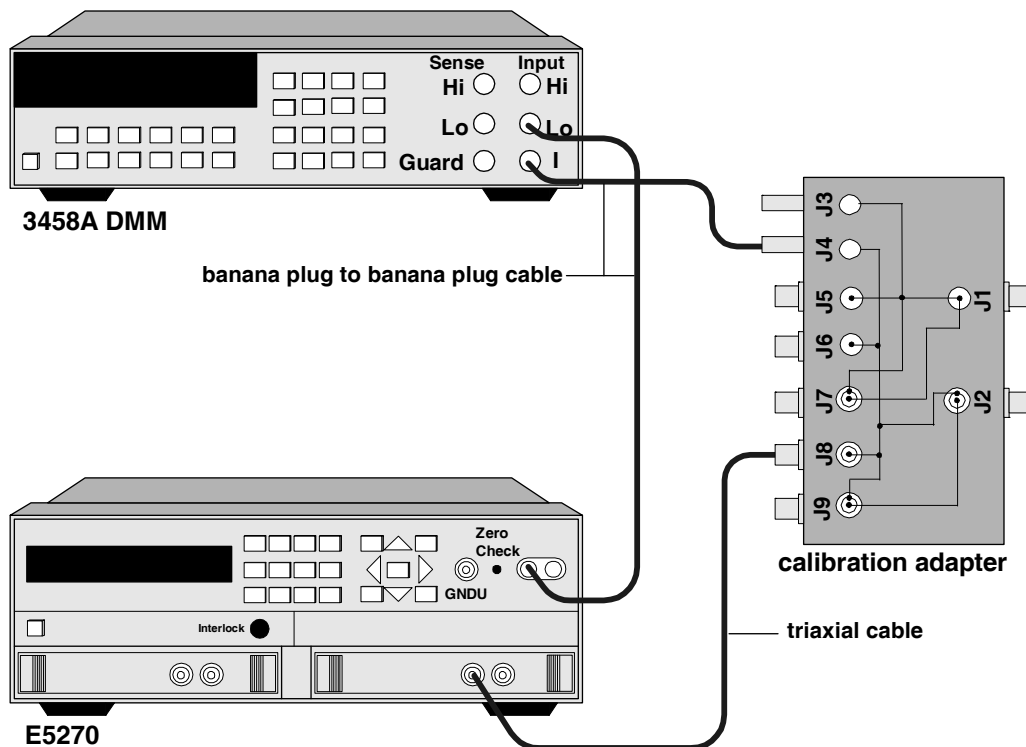
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Test procedure

1. Connect DMM-Lo to the circuit common terminal on the mainframe front panel.
2. Connect DMM-I to the calibration adapter J4.
3. Click **Continue**.
4. Connect the SMU Force to the calibration adapter J8 according to the displayed instruction.
5. Click **Continue**. The SMU current setting test and current measurement test are executed.
6. Steps 4 and 5 are repeated until all of the selected SMUs are tested.
7. Steps 1 through 6 are repeated until all of the selected current ranges are tested.

Figure 2-13 Connection for SMU current test (for 100 μ A to 1 A ranges)



Performance Verification Procedure for E5270A/E5272A/E5273A

SMU CMR test

This test verifies the SMU common mode rejection accuracy.

Required equipment

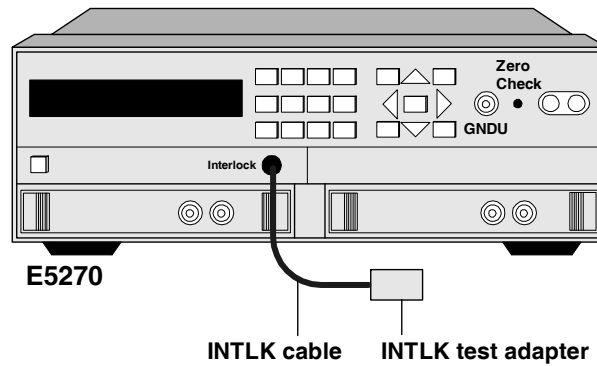
INTLK cable (04155-61614)

INTLK test adapter (04155-65043)

Test procedure

1. Disconnect all cables and plugs from the SMU. (Set the SMU to “open” condition.)
2. Connect the INTLK test adapter to the Interlock terminal on the E527xA front panel with the INTLK cable.
3. Set the INTLK test adapter switch to 1 (ON).
4. Click **Continue**. The SMU CMR test is executed.

Figure 2-14 Connection for SMU CMR test



Performance Verification Procedure for E5260A/E5262A/E5263A/E5270B

This section describes the performance verification procedure, required equipment, and cable connections for each tests.

NOTE

When you execute the performance verification for E5270B, you need to disconnect ASU (Atto Sense Unit) before power on E5270B. After finish the performance verification without ASU, then you need to execute the performance verification with ASU connected. Power off the E5270B, connect ASU to HRSMU, and power on E5270B and continue the performance verification from Self-test for the HRSMU channels with ASUs only.

Please see E5260/E5270 User Guide about how to connect ASU with HRSMU.

Figure 2-15 shows example of connection between ASU, low current calibration adapter, and calibration standard.

Figure 2-15 ASU connection for low current calibration adapter and calibration standard



Self-test

Required equipment

None

Procedure

1. Disconnect all cables and plugs from the SMU. (Set the SMU to “open” condition. If you test HRSMU with ASU, don’t disconnect it.)
2. Click **Continue**. The self-test is executed.

GNDU voltage offset test

This test verifies the ground unit (GNDU) voltage offset accuracy.

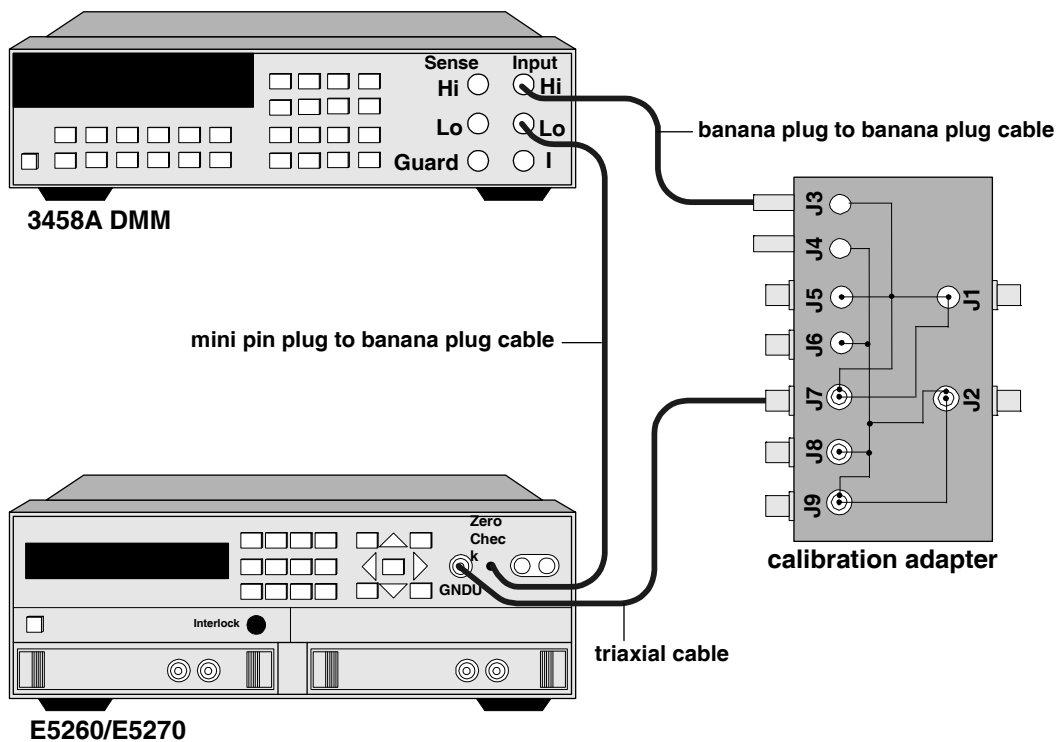
Required equipment

- Triaxial cable (04142-61641)
- Mini pin plug to banana plug cable (04155-61648)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the zero check terminal on the mainframe front panel.
2. Connect DMM-Hi to the calibration adapter J3.
3. Connect the GNDU to the calibration adapter J7.
4. Click **Continue**. The GNDU voltage offset test is executed.

Figure 2-16 Connection for GNDU voltage offset test



Performance Verification Procedure for E5260A/E5262A/E5263A/E5270B

SMU voltage test

This test consists of the voltage setting test and voltage measurement test; it verifies the SMU voltage setting and measurement accuracy.

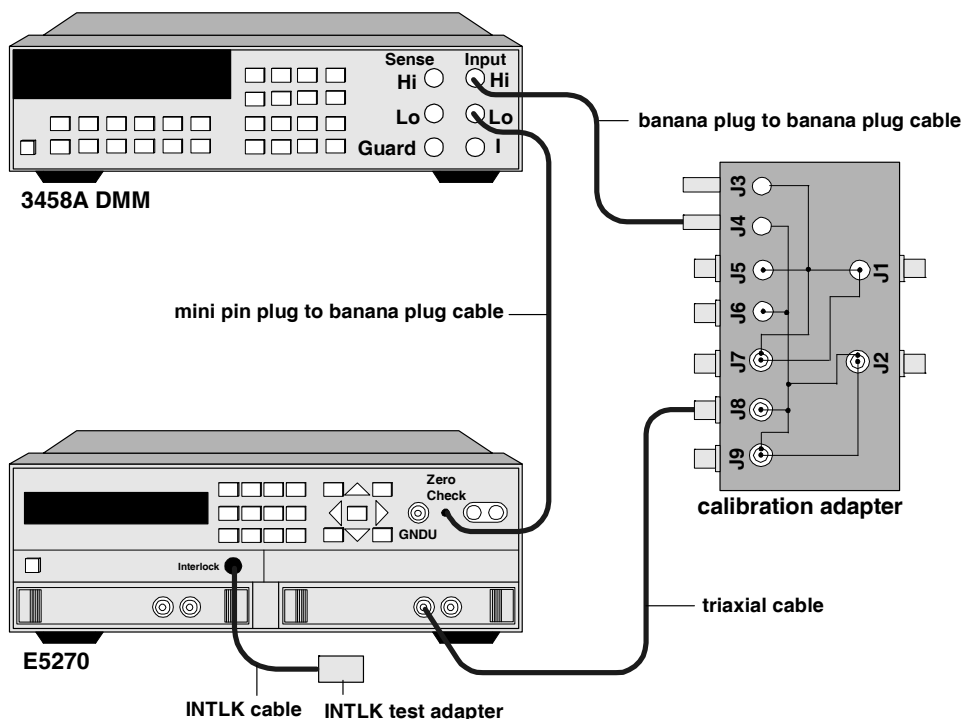
Required equipment

- Triaxial cable (04142-61641)
- INTLK cable (04155-61614)
- Mini pin plug to banana plug cable (04155-61648)
- Calibration adapter (04155-65041)
- INTLK test adapter (04155-65043)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the zero check terminal on the E5260/E5270 front panel.
2. Connect DMM-Hi to the calibration adapter J4.
3. Connect the INTLK test adapter to the Interlock terminal on the E527xA front panel with the INTLK cable.
4. Set the INTLK test adapter switch to 1 (ON).
5. Click **Continue**.
6. Connect the SMU Force or ASU Force to the calibration adapter J8 according to the displayed instruction.
7. Click **Continue**. The voltage setting test and voltage measurement test are executed.
8. Steps 6 and 7 are repeated until all of the selected SMUs are tested.

Figure 2-17 Connection for SMU voltage test



SMU current pre-test

This test is the pre-measurement for the SMU current test, and verifies the guard potential offset voltage.

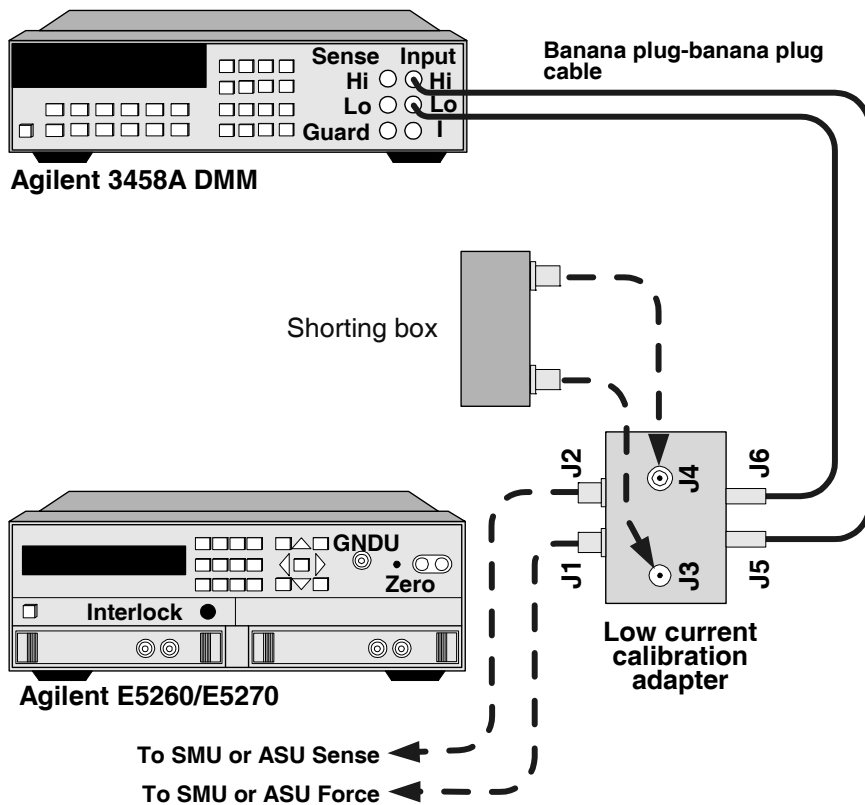
Required equipment

- Triaxial cable (04142-61641)
- Low current calibration adapter (E5299-65001)
- Shorting box (04155-65042)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the low current calibration adapter J6.
2. Connect DMM-Hi to the low current calibration adapter J5.
3. Connect the shorting box to the calibration adapter J3 and J4.
4. Click **Continue**.
5. Connect the SMU Force or ASU Force to the calibration adapter J1, SMU Sense or ASU Sense to the J2 according to the displayed instruction.
6. Click **Continue**. The SMU current pre-test is executed.
7. Steps 6 and 7 are repeated until all SMUs are tested.

Figure 2-18 Connection for SMU current pre-test



Performance Verification Procedure for E5260A/E5262A/E5263A/E5270B

SMU current test (Lower than 10 μ A ranges)

This test consists of the current setting test and current measurement test; it verifies the current setting and measurement accuracy. Note that the SMU current pre-test must pass before this test.

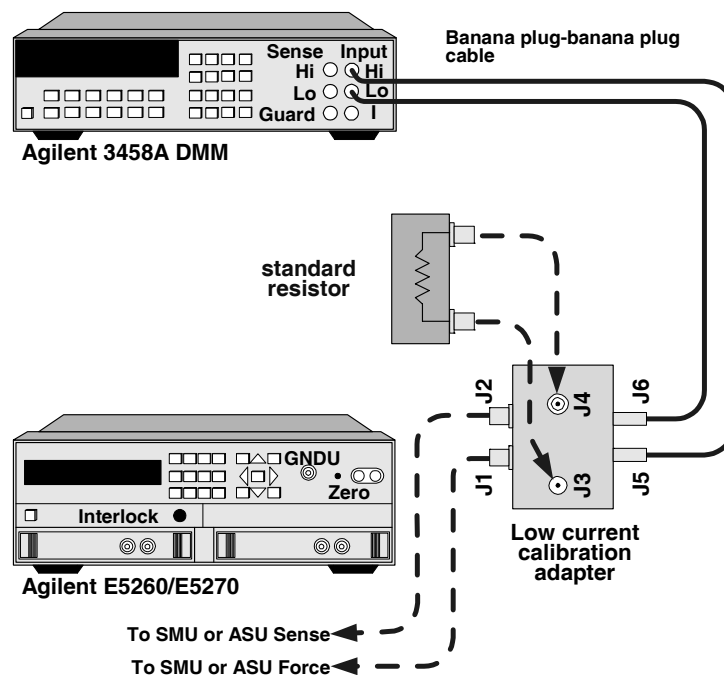
Required equipment

- Triaxial cable (04142-61641)
- Low current calibration adapter (E5299-65001)
- Banana plug to banana plug cable (Agilent 11058A)
- Standard resistor set (Agilent 16353A)
- 100 Gohm standard resistor (Agilent 16353H: Only for E5270B HRSMU or ASU)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the calibration adapter J6.
2. Connect DMM-Hi to the calibration adapter J5.
3. Connect the standard resistor to the calibration adapter J3 and J4 according to the displayed instruction.
4. Click **Continue**.
5. Connect the SMU Force or ASU Force to the calibration adapter J1, SMU Sense or ASU Sense to J2.
6. Click **Continue**. The current setting test and current measurement test are executed.
7. Steps 3 and 4 are repeated until all of the selected current ranges are tested.
8. Steps 1 through 8 are repeated until all of the SMUs are tested.

Figure 2-19 Connection for SMU Current test (Lower than 10 μ A ranges)



SMU current test (for 100 μ A to 1 A ranges)

This test consists of the current setting accuracy test and current measurement accuracy test; it verifies the current setting and measurement accuracy.

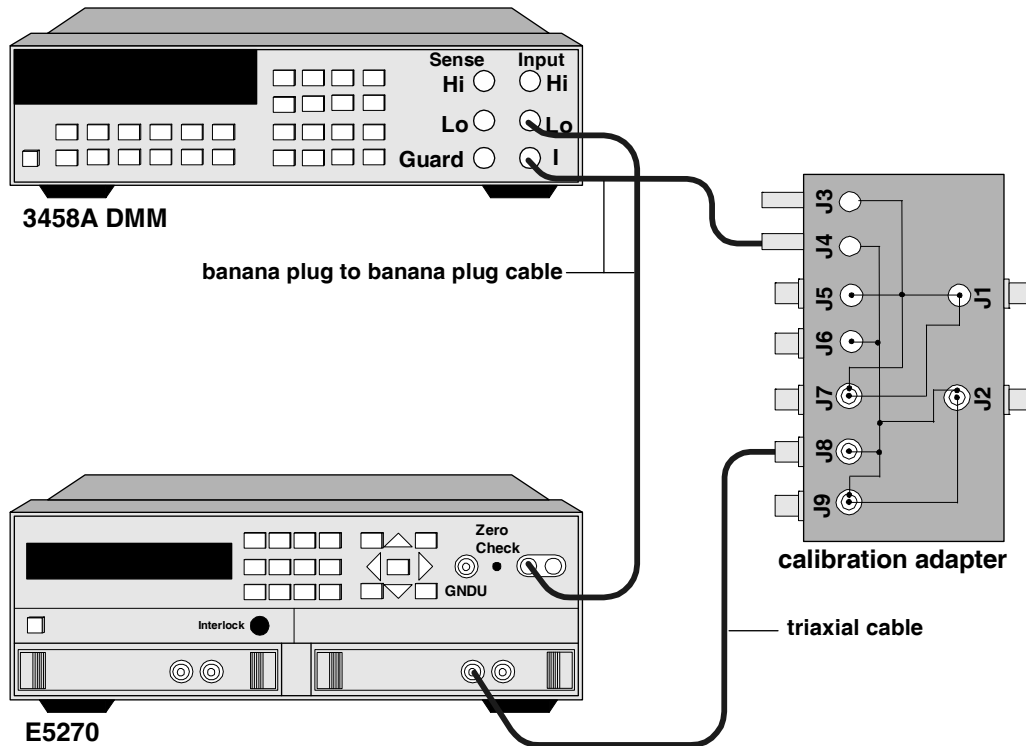
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Test procedure

1. Connect DMM-Lo to the circuit common terminal on the mainframe front panel.
2. Connect DMM-I to the calibration adapter J4.
3. Click **Continue**.
4. Connect the SMU Force or ASU Force to the calibration adapter J8 according to the displayed instruction.
5. Click **Continue**. The SMU current setting test and current measurement test are executed.
6. Steps 4 and 5 are repeated until all of the selected SMUs are tested.
7. Steps 1 through 6 are repeated until all of the selected current ranges are tested.

Figure 2-20 Connection for SMU current test (for 100 μ A to 1 A ranges)



Performance Verification Procedure for E5260A/E5262A/E5263A/E5270B**SMU CMR test**

This test verifies the SMU common mode rejection accuracy.

Required equipment

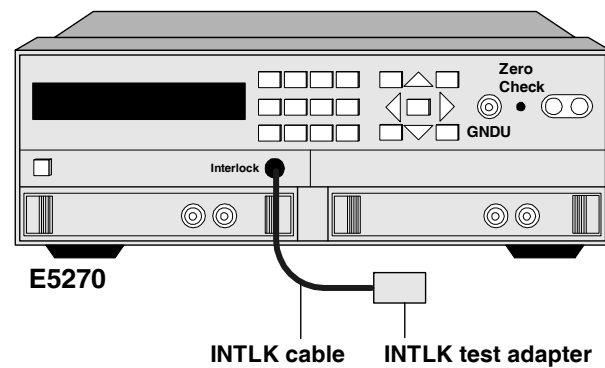
INTLK cable (04155-61614)

INTLK test adapter (04155-65043)

Test procedure

1. Disconnect all cables and plugs from the SMU. (Set the SMU to “open” condition.)
2. Connect the INTLK test adapter to the Interlock terminal on the E526xA/E5270B front panel with the INTLK cable.
3. Set the INTLK test adapter switch to 1 (ON).
4. Click **Continue**. The SMU CMR test is executed.

Figure 2-21 Connection for SMU CMR test



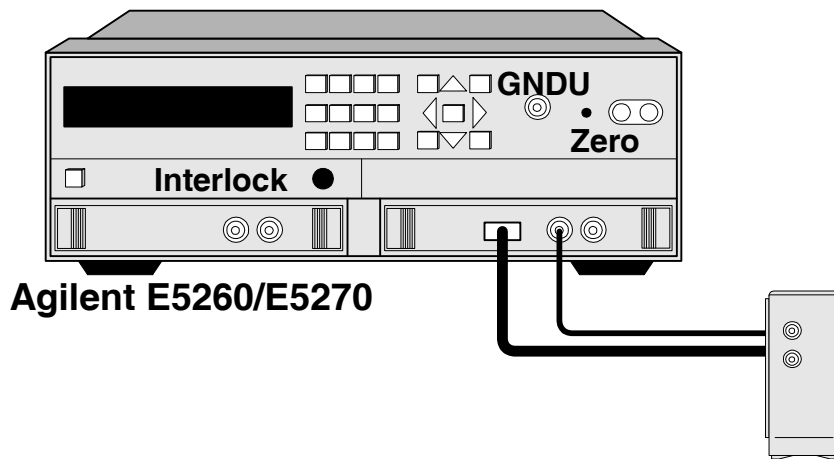
Serial interchange

After pass the all test items, serial number will be interchanged between E5287A HRSMU and E5288A ASU. The serial number of E5287A will be written on EEPROM of E5288A, the one of E5288A will be written on EEPROM of E5287A.

Test procedure

1. Disconnect all cables and plugs from the SMU. (Set the SMU to “open” condition.)
2. Click **Continue**. The SMU CMR test is executed.

Figure 2-22 Connection for serial interchange



ADC/SMU Calibration Procedure

This section describes the ADC/SMU calibration procedure, required equipment, and cable connections for each calibration.

- NOTE** The ADC/SMU calibration must be done in the following order:
1. ADC reference voltage calibration
 2. ADC reference resistor calibration
 3. SMU range resistor calibration
-

ADC/SMU Calibration Procedure

ADC reference voltage calibration

This calibration confirms the reference voltage values and updates them in the EEPROM of the GNDU/ADC module.

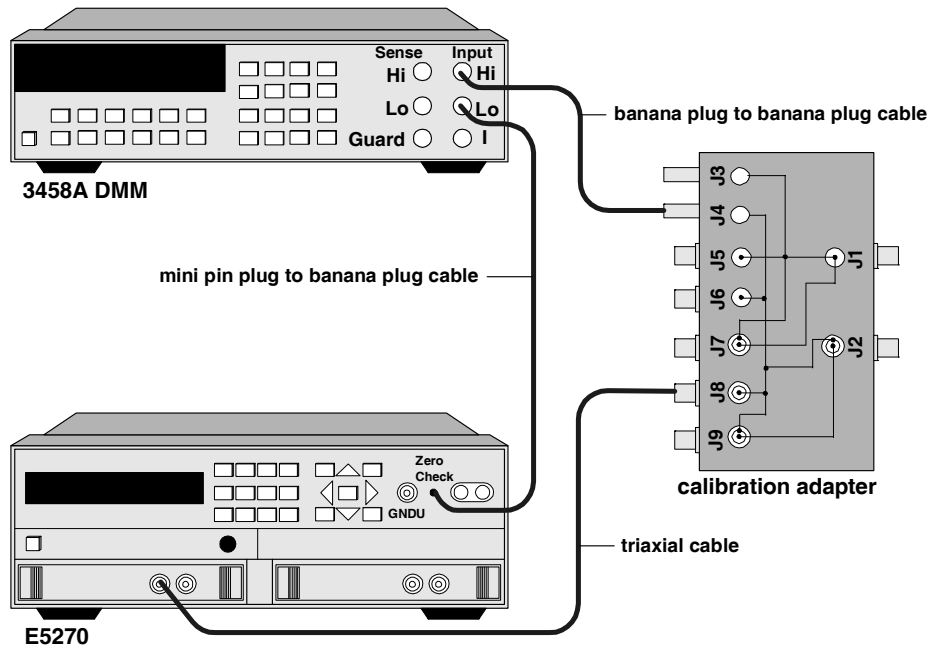
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Mini pin plug to banana plug cable (04155-61648)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect DMM-Lo to the zero check terminal on the mainframe front panel.
2. Connect DMM-Hi to the calibration adapter J4.
3. Click **Continue**. The ADC reference voltage calibration pre-test is executed.
4. Connect the SMU Force to the calibration adapter J8.
5. Click **Continue**. The ADC reference voltage calibration is executed.

Figure 2-23 Connection for reference voltage calibration



ADC reference resistor calibration

This calibration confirms the reference resistor values and updates them in the EEPROM of the GNDU/ADC module.

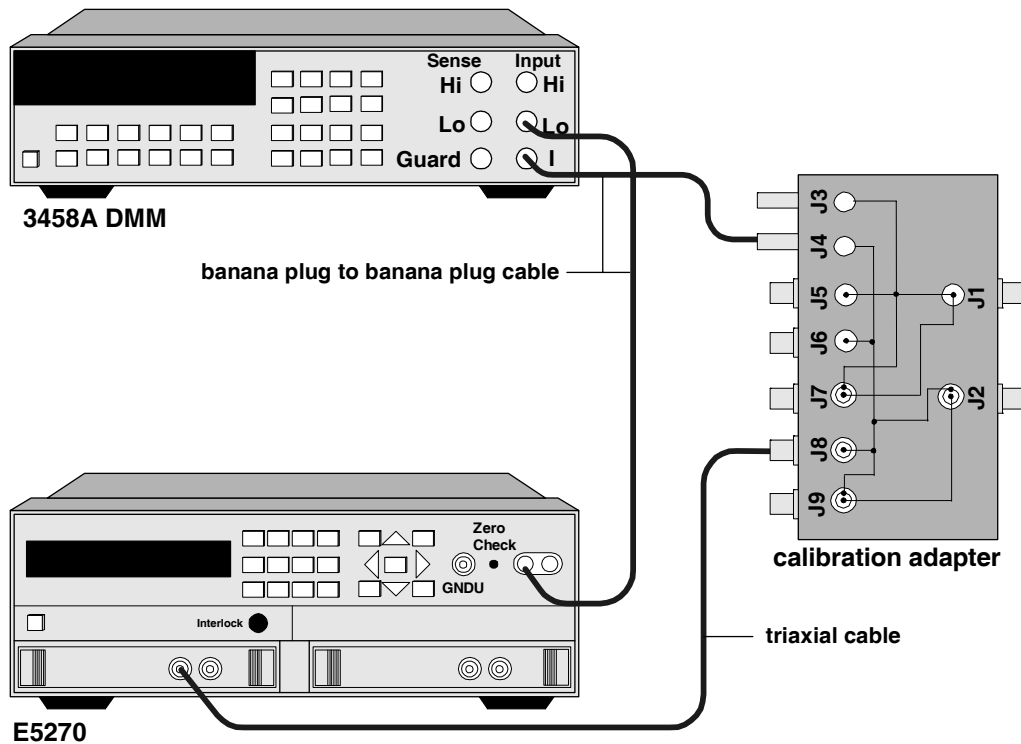
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect DMM-Lo to the circuit common terminal on the mainframe front panel.
2. Connect DMM-Hi to the calibration adapter J4.
3. Click **Continue**. The ADC reference resistor calibration pre-test is executed.
4. Connect the SMU Force to the calibration adapter J8.
5. Click **Continue**. The ADC reference resistor calibration is executed.

Figure 2-24 Connection for reference resistor calibration



SMU range resistor calibration (For E527xA)

This calibration confirms the 500 M Ω range resistor value on each SMU and updates them in the EEPROM of each SMU.

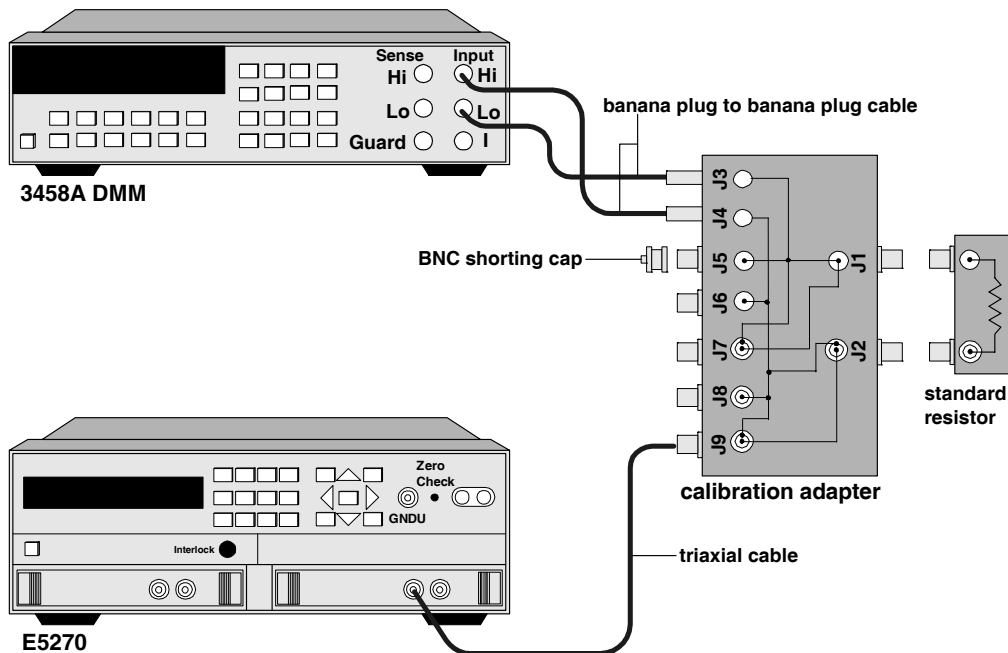
Required equipment

- Triaxial cable (04142-61641)
- Calibration adapter (04155-65041)
- Banana plug to banana plug cable (Agilent 11058A)
- BNC shorting cap (1250-0929)
- Standard resistor set (Agilent 16353A)
- Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect DMM-Lo to the calibration adapter J3.
2. Connect DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the 1 G Ω standard resistor to the calibration adapter J1 and J2.
5. Connect the SMU Force to the calibration adapter J9.
6. Click **Continue**. The SMU range resistor calibration is executed.
7. Steps 5 and 6 are repeated until all of the selected SMUs are calibrated.

Figure 2-25 Connection for SMU range resistor calibration for E527xA



SMU range resistor calibration pre-test (For E5270B)

This test is the pre-measurement for the SMU range resistor calibration test, and verifies the guard potential offset voltage.

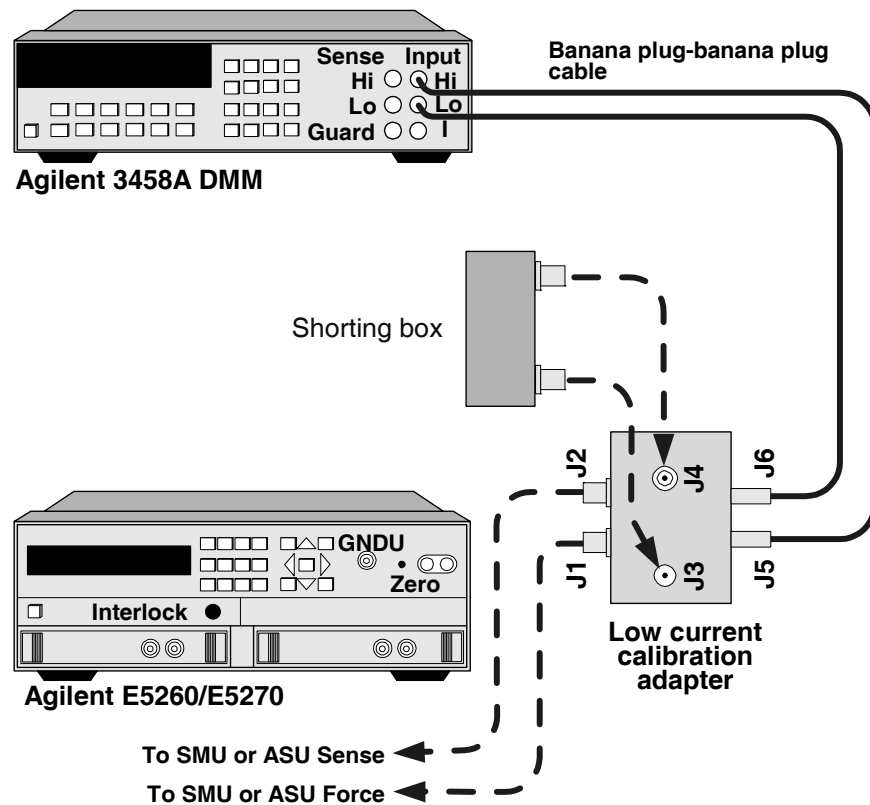
Required equipment

- Triaxial cable (04142-61641)
- Low current calibration adapter (E5299-65001)
- Shorting box (04155-65042)
- Banana plug to banana plug cable (Agilent 11058A)
- Digital multimeter (Agilent 3458A)

Procedure

1. Connect DMM-Lo to the low current calibration adapter J6.
2. Connect DMM-Hi to the low current calibration adapter J5.
3. Connect the shorting box to the calibration adapter J3 and J4.
4. Click **Continue**.
5. Connect the SMU Force or ASU Force to the calibration adapter J1, SMU Sense or ASU Sense to the J2 according to the displayed instruction.
6. Click **Continue**. The SMU current pre-test is executed.
7. Steps 6 and 7 are repeated until all SMUs are tested.

Figure 2-26 Connection for SMU range resistor calibration pre-test



ADC/SMU Calibration Procedure**SMU range resistor calibration (For E5270B)**

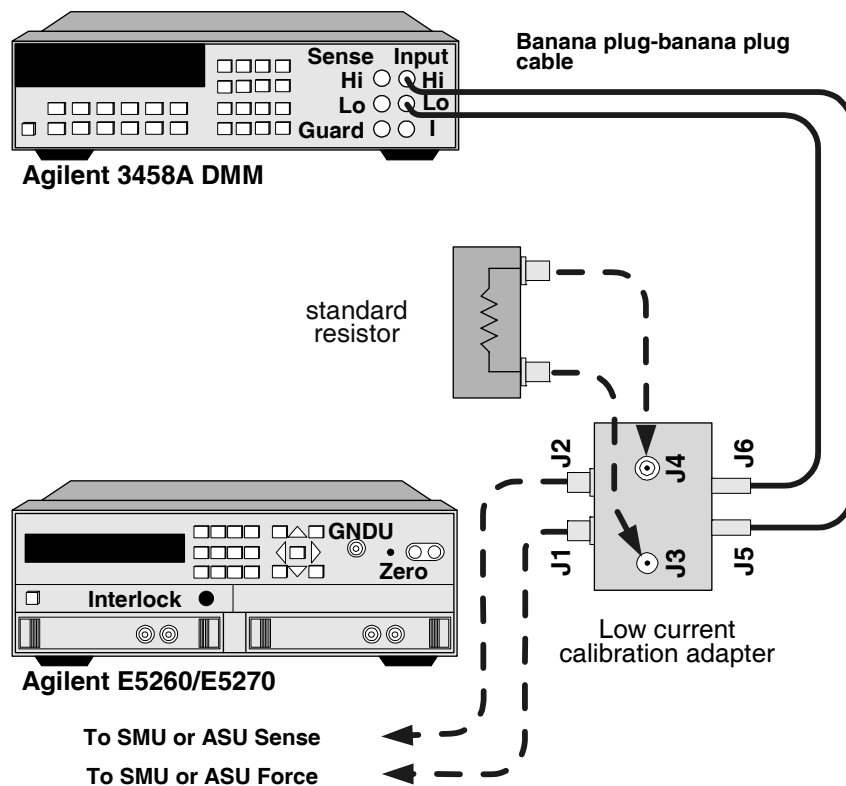
This calibration confirms the 500 M Ω , 5 G Ω , and 50 G Ω range resistor value on each SMU and updates them in the EEPROM of each SMU. If E5270B has ASU connected, 100 G Ω and 5 T Ω range resistor will be added to this calibration.

Required equipment

- Triaxial cable (04142-61641)
- Low current calibration adapter (E5299-65001)
- Banana plug to banana plug cable (Agilent 11058A)
- BNC shorting cap (1250-0929)
- Standard resistor set (Agilent 16353A)
- Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect DMM-Lo to the calibration adapter J6.
2. Connect DMM-Hi to the calibration adapter J5.
3. Connect the standard resistor to the calibration adapter J3 and J4.
4. Connect the SMU Force or ASU Force to the calibration adapter J1, SMU Sense or ASU Sense to J2.
5. Click **Continue**. The SMU range resistor calibration is executed.
6. Steps 5 and 6 are repeated until all of the selected SMUs are calibrated.

Figure 2-27 Connection for SMU range resistor calibration for E5270B

Performance Verification Theory

This section covers the operating theory, block diagrams, and test limits for the performance verification.

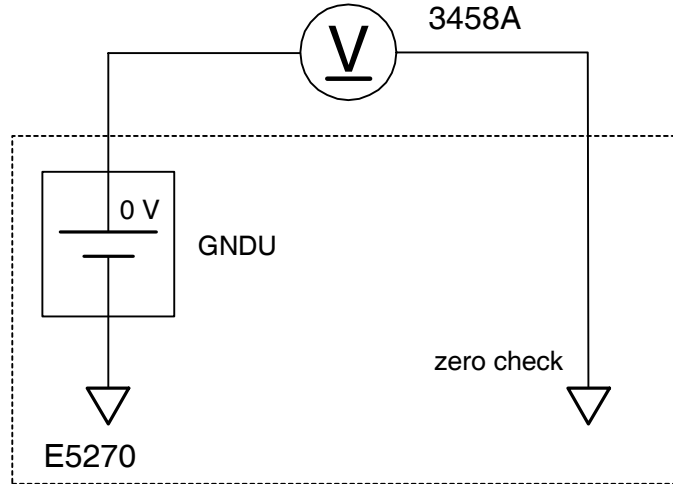
Self-test

The self-test operating theory is described in Chapter 3. See “Troubleshooting Reference” in Chapter 3.

GNDU voltage offset test

This test verifies the ground unit (GNDU) voltage offset accuracy.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	100 mV
Auto zero	On
NPLC	10
2. The GNDU is set as follows:
3. The GNDU forces 0 V.
4. The 3458A waits for 100 milliseconds and measures the GNDU output voltage.
5. The 3458A measurement value is compared to the test limit.

Test limit

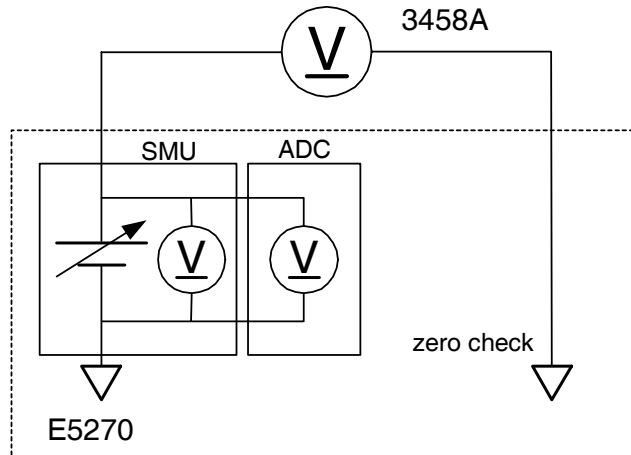
Table 2-1 GNDU voltage offset test limit

Nominal value	Accuracy	Uncertainty
0 V	$\pm 100 \mu\text{V}$	$2.82 \mu\text{V}$

SMU voltage test

This test consists of the voltage force test and voltage measurement test; they verify the SMU voltage setting and measurement accuracy.

Block diagram



Performance Verification Theory**Operating theory**

1. The 3458A is set as follows:

Function	DCV
Range	10 V (for SMU 2 V range) 100 V (for SMU 20 V, 40 V, and 100 V ranges) 1000 V (for HPSMU 200 V range)

Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	VFVM
Range	0.5 V, 2 V, 5V, 20 V, 40 V, 100 V, or 200 V (0.5 V, 5 V: E5281B/E5287A/E5288A only, 200V: HPSMU only)

Output current 0 V, \pm FS (full scale), \pm FS \times 1.1

Current compliance 100 μ A

Filter On

Averaging samples 1

Integration time Medium (NPLC = 1)

3. The SMU forces a certain voltage.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure SMU output voltage.
5. The 3458A measurement value is compared to the voltage force test limit. The measured value is also used as the reference for the voltage measurement test.
6. The high-speed ADC and high-resolution ADC measurement values are compared to the measurement test limit that is calculated by using the 3458A measurement value.
7. Steps 1 through 6 are repeated until all of the selected ranges are tested.
8. Steps 1 through 6 are repeated until all of the selected SMUs are tested.

Test limit

Table 2-2 SMU voltage force test limit (for E5260A/E5270A series MPSMU, all model HPSMU)

Voltage range	Nominal value	Force accuracy	Uncertainty
2 V	0 V	±900 µV	3.28 µV
	±2 V	±1.5 mV	21.5 µV
	±2.2 V	±10.6 mV	23.4 µV
20 V	0 V	±4 mV	39.1 µV
	±20 V	±10 mV	243 µV
	±22 V	±13.6 mV	267 µV
40 V	0 V	±7 mV	39.1 µV
	±40 V	±19 mV	480 µV
	±44 V	±32.6 mV	527 µV
100 V	0 V	±15 mV	39.1 µV
	±100 V	±55 mV	1.19 mV
	±110 V ^a	±79.5 mV	1.32 mV
200 V ^a	0 V	±30 mV	133 µV
	±200 V	±120 mV	2.39 mV

a. HPSMU only

Table 2-3 SMU voltage force test limit (for E5270B MPSMU)

Voltage range	Nominal value	Force accuracy	Uncertainty
0.5 V	0 V	±350 µV	2.82 µV
	±0.5 V	±0.5 mV	7.23 µV
	±0.55 V	±1.065 mV	7.7 µV
2 V	0 V	±900 µV	3.28 µV
	±2 V	±1.5 mV	21.5 µV
	±2.2 V	±2.66 mV	23.4 µV
5 V	0 V	±2 mV	3.28 µV
	±5 V	±3.5 mV	50.1 µV
	±5.5 V	±5.65 mV	54.8 µV
20 V	0 V	±4 mV	39.1 µV
	±20 V	±10 mV	243 µV
	±22 V	±13.6 mV	267 µV
40 V	0 V	±7 mV	39.1 µV
	±40 V	±19 mV	480 µV
	±44 V	±32.6 mV	527 µV
100 V	0 V	±15 mV	39.1 µV
	±100 V	±55 mV	1.19 mV
	±110 V ^a	±59 mV	1.32 mV

Table 2-4 SMU voltage force test limit (for E5270B HRSMU/ASU)

Voltage range	Nominal value	Force accuracy	Uncertainty
0.5 V	0 V	$\pm 350 \mu\text{V}$	$2.82 \mu\text{V}$
	$\pm 0.5 \text{ V}$	$\pm 500 \mu\text{V}$	$7.23 \mu\text{V}$
	$\pm 0.55 \text{ V}$	$\pm 810 \mu\text{V}$	$7.7 \mu\text{V}$
2 V	0 V	$\pm 900 \mu\text{V}$	$3.28 \mu\text{V}$
	$\pm 2 \text{ V}$	$\pm 1.5 \text{ mV}$	$21.5 \mu\text{V}$
	$\pm 2.2 \text{ V}$	$\pm 2.44 \text{ mV}$	$23.4 \mu\text{V}$
5 V	0 V	$\pm 2 \text{ mV}$	$3.28 \mu\text{V}$
	$\pm 5 \text{ V}$	$\pm 3.5 \text{ mV}$	$50.1 \mu\text{V}$
	$\pm 5.5 \text{ V}$	$\pm 5.1 \text{ mV}$	$54.8 \mu\text{V}$
20 V	0 V	$\pm 4 \text{ mV}$	$39.1 \mu\text{V}$
	$\pm 20 \text{ V}$	$\pm 10 \text{ mV}$	$243 \mu\text{V}$
	$\pm 22 \text{ V}$	$\pm 13.5 \text{ mV}$	$267 \mu\text{V}$
40 V	0 V	$\pm 7 \text{ mV}$	$39.1 \mu\text{V}$
	$\pm 40 \text{ V}$	$\pm 19 \text{ mV}$	$480 \mu\text{V}$
	$\pm 44 \text{ V}$	$\pm 32.6 \text{ mV}$	$527 \mu\text{V}$
100 V	0 V	$\pm 15 \text{ mV}$	$39.1 \mu\text{V}$
	$\pm 100 \text{ V}$	$\pm 55 \text{ mV}$	1.19 mV
	$\pm 110 \text{ V}^{\text{a}}$	$\pm 59 \text{ mV}$	1.32 mV

Table 2-5 SMU voltage measurement test limit (for E5260A/E5270A series MPSPMU)

Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
2 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{dmm}^a \times 0.0002 + 700 \mu\text{V})$	7.52 μV
	V_{dmm}^a at SMU ± 2 V	$\pm(V_{dmm}^a \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{dmm}^a \times 0.0002 + 700 \mu\text{V})$	22.2 μV
	V_{dmm}^a at SMU ± 2.2 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	24.0 μV
20 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	52.4 μV
	V_{dmm}^a at SMU ± 20 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	246 μV
	V_{dmm}^a at SMU ± 22 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	269 μV
40 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	59.7 μV
	V_{dmm}^a at SMU ± 40 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	482 μV
	V_{dmm}^a at SMU ± 44 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	529 μV
100 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	130 μV
	V_{dmm}^a at SMU ± 100 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	1.20 mV

a. Measurement value of standard digital multimeter

Table 2-6 SMU voltage measurement test limit (for E5260/E5270 series HPSMU)

Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
2 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{dmm}^a \times 0.0002 + 700 \mu\text{V})$	8.11 μV
	V_{dmm}^a at SMU ± 2 V	$\pm(V_{dmm}^a \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{dmm}^a \times 0.0002 + 700 \mu\text{V})$	22.3 μV
	V_{dmm}^a at SMU ± 2.2 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	24.2 μV
20 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	40.8 μV
	V_{dmm}^a at SMU ± 20 V	$\pm(V_{dmm}^a \times 0.0003 + 4 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 2 \text{ mV})$	244 μV
	V_{dmm}^a at SMU ± 22 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	267 μV
40 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	42.2 μV
	V_{dmm}^a at SMU ± 40 V	$\pm(V_{dmm}^a \times 0.0003 + 8 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0002 + 3 \text{ mV})$	480 μV
	V_{dmm}^a at SMU ± 44 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	528 μV
100 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	51.1 μV
	V_{dmm}^a at SMU ± 100 V	$\pm(V_{dmm}^a \times 0.0004 + 20 \text{ mV})$	$\pm(V_{dmm}^a \times 0.0003 + 5 \text{ mV})$	1.19 mV
	V_{dmm}^a at SMU ± 110 V	$\pm(V_{dmm}^a \times 0.00045 + 40 \text{ mV})$	$\pm(V_{dmm}^a \times 0.00035 + 10 \text{ mV})$	1.31 mV
200 V	V_{dmm}^a at SMU 0 V	$\pm(V_{dmm}^a \times 0.00045 + 40 \text{ mV})$	$\pm(V_{dmm}^a \times 0.00035 + 10 \text{ mV})$	147 μV
	V_{dmm}^a at SMU ± 200 V	$\pm(V_{dmm}^a \times 0.00045 + 40 \text{ mV})$	$\pm(V_{dmm}^a \times 0.00035 + 10 \text{ mV})$	2.39 mV

Performance Verification Theory

- a. Measurement value of standard digital multimeter

Table 2-7 SMU voltage measurement test limit (for E5270B MPSMU)

Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
0.5 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 250 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 250 \mu\text{V})$	5.91 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 0.5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 250 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 250 \mu\text{V})$	8.34 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 0.55 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 700 \mu\text{V})$	8.73 μV
2 V	$V_{\text{dmm}}^{\text{b}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 700 \mu\text{V})$	6.24 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 2 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 700 \mu\text{V})$	21.9 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 2.2 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 1 \text{ mV})$	23.7 μV
5 V	$V_{\text{dmm}}^{\text{c}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 1 \text{ mV})$	6.79 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 1 \text{ mV})$	50.3 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 5.5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 2 \text{ mV})$	55 μV
20 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 2 \text{ mV})$	47.6 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 20 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 2 \text{ mV})$	245 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 22 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 3 \text{ mV})$	268 μV
40 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 3 \text{ mV})$	50.6 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 40 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 3 \text{ mV})$	481 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 44 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0004 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 5 \text{ mV})$	529 μV
100 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0004 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 5 \text{ mV})$	70.4 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 100 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0004 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0003 + 5 \text{ mV})$	1.19 mV

- a. Measurement value of standard digital multimeter
- b. Measurement value of standard digital multimeter
- c. Measurement value of standard digital multimeter

Table 2-8 SMU voltage measurement test limit (for E5270B HRSMU/ASU)

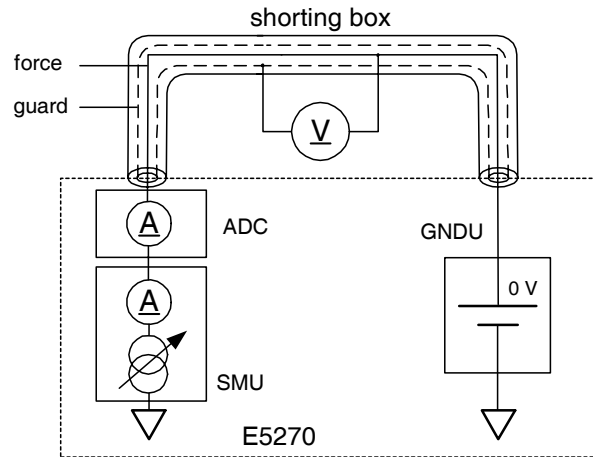
Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
0.5 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 250 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 150 \mu\text{V})$	5.91 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 0.5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 250 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 150 \mu\text{V})$	8.34 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 0.55 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 200 \mu\text{V})$	8.73 μV
2 V	$V_{\text{dmm}}^{\text{b}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 200 \mu\text{V})$	6.24 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 2 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 700 \mu\text{V})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 200 \mu\text{V})$	21.9 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 2.2 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 250 \mu\text{V})$	23.7 μV
5 V	$V_{\text{dmm}}^{\text{c}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 250 \mu\text{V})$	6.79 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 2 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 250 \mu\text{V})$	50.3 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 5.5 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 1 \text{ mV})$	55 μV
20 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 1 \text{ mV})$	47.6 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 20 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 4 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0001 + 1 \text{ mV})$	245 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 22 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 2 \text{ mV})$	268 μV
40 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 2 \text{ mV})$	50.6 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 40 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 8 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00015 + 2 \text{ mV})$	481 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 44 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00025 + 5 \text{ mV})$	529 μV
100 V	$V_{\text{dmm}}^{\text{a}}$ at SMU 0 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00025 + 5 \text{ mV})$	70.4 μV
	$V_{\text{dmm}}^{\text{a}}$ at SMU ± 100 V	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.0002 + 20 \text{ mV})$	$\pm(V_{\text{dmm}}^{\text{a}} \times 0.00025 + 5 \text{ mV})$	1.19 mV

- a. Measurement value of standard digital multimeter
b. Measurement value of standard digital multimeter
c. Measurement value of standard digital multimeter

SMU current pre-test

This test is the premeasurement for the SMU current test; it verifies the guard potential offset voltage.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	100 mV
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	100 pA, 10 pA, 1 pA, 100 nA or 1 μ A (100 pA, 10 pA, 1pA: HRSMU + ASU only)
Output current	\pm FS \times 1.15, \pm FS, and \pm FS/10
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

3. The SMU forces a certain current.
4. The 3458A waits for 100 milliseconds and measures the voltage difference between force and guard lines.
5. Steps 1 through 4 are repeated until all of the selected ranges are tested.
6. Steps 1 through 5 are repeated until all of the selected SMUs are tested.

Test limit

Table 2-9 SMU current pre-test limit (E5260A/E5270A series MPSMU, and all series HPSMU)

Current range	Output current	Nominal value	Accuracy	Uncertainty
100 nA	±115 nA	0 V	±1.0 mV	None
	±100 nA			
	±10 nA			
1 nA	±1.15 µA			
	±1 µA			
	±100 nA			

Table 2-10 SMU current pre-test limit (E5270B MPSMU and HRSMU)

Current range	Output current	Nominal value	Accuracy	Uncertainty
100 nA	±115 nA	0 V	±3 mV	None
	±100 nA			
	±10 nA			
1 nA	±1.15 µA			
	±1 µA			
	±100 nA			

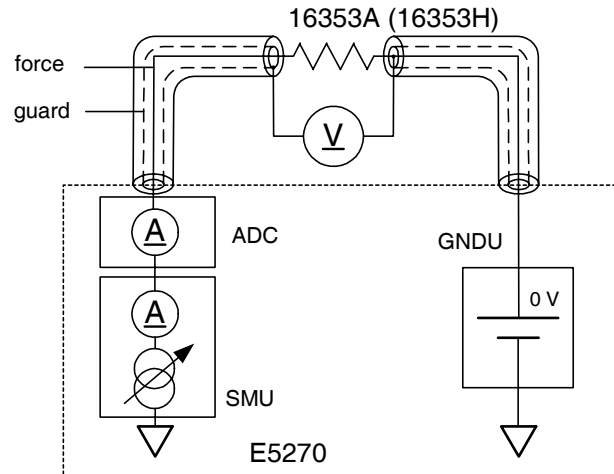
Table 2-11 SMU current pre-test limit (E5288A ASU)

Current range	Output current	Nominal value	Accuracy	Uncertainty
1 pA	±1.15 pA	0 V	±4.2 mV	None
	±1 pA			
	±100 fA			
10 pA	±11.5 pA			
	±10 pA			
	±1 pA			
100 pA	±115 pA			
	±100 pA			
	±10 pA			
100 nA	±115 nA			
	±100 nA			
	±10 nA			
1 nA	±1.15 μA			
	±1 μA			
	±100 nA			

SMU current test (Lower than 10 μA ranges)

This test consists of the current force test and current measurement test; they verify the current force and measurement accuracy. Note that the SMU current pre-test must pass before this test.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	1 V
Auto zero	On
NPLC	10, 50 (only for 1 pA, 10 pA range for HRSMU/HRSMU+ASU calibration)

2. The SMU is set as follows:

Function	IFIM
Range	1 nA, 10 nA, 100 nA, 1 μ A, or 10 μ A (Additionally, 1 pA, 10 pA, and 100 pA for ASU calibration)
Output current	\pm FS \times 1.15, \pm FS, and \pm FS/10
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1), NPLC=20 (100 pA for HRSMU calibration), NPLC=50 (1 pA and 10 pA for HRSMU calibration)

3. The SMU forces a certain current.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure the voltage drop of the guard line (3458A) and SMU output current (ADCs).
5. The SMU output current is calculated by the 3458A measurement value and known resistance, and is compared to the current force test limit. The calculated value is also used as the reference for the current measurement test.
6. The high-speed ADC and high-resolution ADC measurement values are compared to the measurement test limit that is calculated by using the calculated SMU output value.
7. Steps 1 through 6 are repeated until all of the selected SMUs are tested.
8. Steps 1 through 8 are repeated until all of the selected ranges are tested.

NOTE The measurement and comparison of high-resolution ADC is only for E5270 series.

Test limit

Table 2-12 SMU current force test limit (E5260A/E5270A series MPSMU/HPSMU)

Current range	Nominal value	Force accuracy	Uncertainty
1 nA	±100 pA	±3.5 pA	69.7 fA
	±1 nA	±8 pA	561 fA
	±1.15 nA	±8.75 pA	643 fA
10 nA	±1 nA	±12 pA	690 fA
	±10 nA	±57 pA	6.42 pA
	±11.5 nA	±64.5 pA	7.38 pA
100 nA	±10 nA	±62 pA	2.44 pA
	±100 nA	±170 pA	12.0 pA
	±115 nA	±188 pA	13.7 pA
1 µA	±100 nA	±520 pA	29.6 pA
	±1 µA	±1.6 nA	207 pA
	±1.15 µA	±1.78 nA	238 pA
10 µA	±1 µA	±6.2 nA	223 pA
	±10 µA	±17 nA	729 pA
	±11.5 µA	±18.8 nA	829 pA

Table 2-13 SMU current force test limit (E5270B MPSMU)

Current range	Nominal value	Force accuracy	Uncertainty
1 nA	±100 pA	±3.5 pA	58.3 fA
	±1 nA	±8 pA	552 fA
	±1.15 nA	±8.75 pA	634 fA
10 nA	±1 nA	±12 pA	643 fA
	±10 nA	±57 pA	6.16 pA
	±11.5 nA	±64.5 pA	7.08 pA
100 nA	±10 nA	±62 pA	1.64 pA
	±100 nA	±170 pA	11.7 pA
	±115 nA	±188 pA	13.4 pA
1 µA	±100 nA	±520 pA	14.9 pA
	±1 µA	±1.6 nA	97.0 pA
	±1.15 µA	±1.78 nA	111 pA
10 µA	±1 µA	±6.2 nA	131 pA
	±10 µA	±17 nA	684 pA
	±11.5 µA	±18.8 nA	784 pA

Table 2-14 SMU current force test limit (E5270B HPSMU)

Current range	Nominal value	Force accuracy	Uncertainty
1 nA	±100 pA	±3.5 pA	69.7 fA
	±1 nA	±8 pA	561 fA
	±1.15 nA	±8.75 pA	643 fA
10 nA	±1 nA	±12 pA	690 fA
	±10 nA	±57 pA	6.42 pA
	±11.5 nA	±64.5 pA	7.38 pA
100 nA	±10 nA	±62 pA	2.44 pA
	±100 nA	±170 pA	12.0 pA
	±115 nA	±188 pA	13.7 pA
1 μA	±100 nA	±520 pA	29.6 pA
	±1 μA	±1.6 nA	207 pA
	±1.15 μA	±1.78 nA	238 pA
10 μA	±1 μA	±6.2 nA	223 pA
	±10 μA	±17 nA	729 pA
	±11.5 μA	±18.8 nA	829 pA

Table 2-15 SMU current force test limit (E5270B HRSMU)

Current range	Nominal value	Force accuracy	Uncertainty
10 pA	±1 pA	±45 fA	2.66 fA
	±10 pA	±90 fA	14.3 fA
	±11.5 pA	±97.5A	16.3 fA
100 pA	±10 pA	±170 fA	14.2 fA
	±100 pA	±620 fA	133 fA
	±115 pA	±695 fA	152 fA
1 nA	±100 pA	±650 fA	30.8 fA
	±1 nA	±2.9 pA	275 fA
	±1.15 nA	±3.27 pA	315 fA
10 nA	±1 nA	±6.5 pA	504 fA
	±10 nA	±29 pA	4.78 pA
	±11.5 nA	±32.7 pA	5.49 pA
100 nA	±10 nA	±52 pA	1.31 pA
	±100 nA	±160 pA	6.73 pA
	±115 nA	±178 pA	7.71 pA
1 μA	±100 nA	±520 pA	12.5 pA
	±1 μA	±1.6 nA	55.5 pA
	±1.15 μA	±1.78 nA	63.5 pA
10 μA	±1 μA	±4.7 nA	116 pA
	±10 μA	±11 nA	340 pA
	±11.5 μA	±12 nA	368 pA

Table 2-16 SMU current force test limit (E5270B HRSMU + ASU)

Current range	Nominal value	Force accuracy	Uncertainty
1 pA	±100 fA	±16.8 fA	1.10 fA
	±1 pA	±33 fA	2.58 fA
	±1.15 pA	±35.7 fA	2.83 fA
10 pA	±1 pA	±45 fA	2.66 fA
	±10 pA	±90 fA	14.3 fA
	±11.5 pA	±97.5A	16.3 fA
100 pA	±10 pA	±170 fA	14.2 fA
	±100 pA	±620 fA	133 fA
	±115 pA	±695 fA	152 fA
1 nA	±100 pA	±650 fA	30.8 fA
	±1 nA	±2.9 pA	275 fA
	±1.15 nA	±3.27 pA	315 fA
10 nA	±1 nA	±6.5 pA	504 fA
	±10 nA	±29 pA	4.78 pA
	±11.5 nA	±32.7 pA	5.49 pA
100 nA	±10 nA	±52 pA	1.31 pA
	±100 nA	±160 pA	6.73 pA
	±115 nA	±178 pA	7.71 pA
1 μA	±100 nA	±520 pA	12.5 pA
	±1 μA	±1.6 nA	55.5 pA
	±1.15 μA	±1.78 nA	63.5 pA
10 μA	±1 μA	±4.7 nA	116 pA
	±10 μA	±11 nA	340 pA
	±11.5 μA	±12 nA	368 pA

Table 2-17 SMU current measurement test limit (for E5260A/E5270A series MPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
1 nA	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	76.8 fA
	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	562 fA
	I_{dmm}^a at SMU ± 1.15 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	644 fA
10 nA	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	693 fA
	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	6.42 pA
	I_{dmm}^a at SMU ± 11.5 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	7.38 pA
100 nA	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	2.63 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	12.0 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	13.7 pA
1 μ A	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	29.8 pA
	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	207 pA
	I_{dmm}^a at SMU ± 1.15 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	238 pA
10 μ A	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	242 pA
	I_{dmm}^a at SMU ± 10 μ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	735 pA
	I_{dmm}^a at SMU ± 11.5 μ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	835 pA

a. Measurement value of standard digital multimeter

Table 2-18 SMU current measurement test limit (for HPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
1 nA	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	75.9 fA
	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	562 fA
	I_{dmm}^a at SMU ± 1.15 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	644 fA
10 nA	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	69.3 fA
	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	6.42 pA
	I_{dmm}^a at SMU ± 11.5 nA	$\pm(I_{dmm}^a \times 0.005 + 5 \text{ pA})$	7.38 pA
100 nA	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	2.60 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	12.0 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	13.7 pA
1 μ A	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	29.7 pA
	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	207 pA
	I_{dmm}^a at SMU ± 1.15 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	238 pA

Table 2-18 SMU current measurement test limit (for HPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
10 μ A	I_{dmm}^a at SMU $\pm 1 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	236 pA
	I_{dmm}^a at SMU $\pm 10 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	733 pA
	I_{dmm}^a at SMU $\pm 11.5 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	833 pA

a. Measurement value of standard digital multimeter

Table 2-19 SMU current measurement test limit (for E5270B MPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
1 nA	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	63.4 fA
	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	552 fA
	I_{dmm}^a at SMU ± 1.15 nA	$\pm(I_{dmm}^a \times 0.005 + 3 \text{ pA})$	635 fA
10 nA	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.002 + 5 \text{ pA})$	64.5 fA
	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.002 + 5 \text{ pA})$	6.16 pA
	I_{dmm}^a at SMU ± 11.5 nA	$\pm(I_{dmm}^a \times 0.002 + 5 \text{ pA})$	7.08 pA
100 nA	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	1.81 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	17.1 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 30 \text{ pA})$	13.5 pA
1 μ A	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	15.3 pA
	I_{dmm}^a at SMU $\pm 1 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	97.1 pA
	I_{dmm}^a at SMU $\pm 1.15 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	111 pA
10 μ A	I_{dmm}^a at SMU $\pm 1 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	145 pA
	I_{dmm}^a at SMU $\pm 10 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	687 pA
	I_{dmm}^a at SMU $\pm 11.5 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 3 \text{ nA})$	786 pA

a. Measurement value of standard digital multimeter

Table 2-20 SMU current measurement test limit (for E5270B HRSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
10 pA	I_{dmm}^a at SMU ± 1 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	3.71 fA
	I_{dmm}^a at SMU ± 10 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	14.5 fA
	I_{dmm}^a at SMU ± 11.5 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	16.5 fA
100 pA	I_{dmm}^a at SMU ± 10 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	16.0 fA
	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	133 fA
	I_{dmm}^a at SMU ± 115 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	153 fA
1 nA	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	39.7 fA
	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	276 fA
	I_{dmm}^a at SMU ± 1.15 nA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	316 fA
10 nA	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	506 fA
	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	4.78 pA
	I_{dmm}^a at SMU ± 11.5 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	5.49 pA
100 nA	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	1.52 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	6.77 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	7.74 pA
1 μ A	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	12.9 pA
	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	55.6 pA
	I_{dmm}^a at SMU ± 1.15 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	63.6 pA
10 μ A	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	131 pA
	I_{dmm}^a at SMU ± 10 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	345 pA
	I_{dmm}^a at SMU ± 11.5 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	390 pA

a. Measurement value of standard digital multimeter

Table 2-21 SMU current measurement test limit (for E5270B HRSMU+ASU)

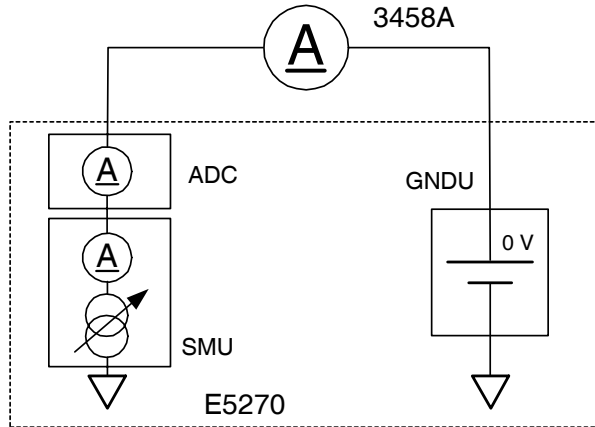
Current range	Nominal value	Measurement accuracy	Uncertainty
1 pA	I_{dmm}^a at SMU ± 100 fA	$\pm(I_{dmm}^a \times 0.018 + 12 \text{ fA})$	2.08 fA
	I_{dmm}^a at SMU ± 1 pA	$\pm(I_{dmm}^a \times 0.018 + 12 \text{ fA})$	2.96 fA
	I_{dmm}^a at SMU ± 1.15 pA	$\pm(I_{dmm}^a \times 0.018 + 12 \text{ fA})$	3.17 fA
10 pA	I_{dmm}^a at SMU ± 1 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	3.92 fA
	I_{dmm}^a at SMU ± 10 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	14.9 fA
	I_{dmm}^a at SMU ± 11.5 pA	$\pm(I_{dmm}^a \times 0.005 + 15 \text{ fA})$	16.9 fA
100 pA	I_{dmm}^a at SMU ± 10 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	15.6 fA
	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	133 fA
	I_{dmm}^a at SMU ± 115 pA	$\pm(I_{dmm}^a \times 0.005 + 40 \text{ fA})$	153 fA
1 nA	I_{dmm}^a at SMU ± 100 pA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	39.7 fA
	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	276 fA
	I_{dmm}^a at SMU ± 1.15 nA	$\pm(I_{dmm}^a \times 0.002 + 300 \text{ fA})$	316 fA
10 nA	I_{dmm}^a at SMU ± 1 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	506 fA
	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	4.78 pA
	I_{dmm}^a at SMU ± 11.5 nA	$\pm(I_{dmm}^a \times 0.002 + 2 \text{ pA})$	5.49 pA
100 nA	I_{dmm}^a at SMU ± 10 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	1.52 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	6.77 pA
	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ pA})$	7.74 pA
1 μ A	I_{dmm}^a at SMU ± 100 nA	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	12.9 pA
	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	55.6 pA
	I_{dmm}^a at SMU ± 1.15 μ A	$\pm(I_{dmm}^a \times 0.001 + 200 \text{ pA})$	63.6 pA
10 μ A	I_{dmm}^a at SMU ± 1 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	131 pA
	I_{dmm}^a at SMU ± 10 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	345 pA
	I_{dmm}^a at SMU ± 11.5 μ A	$\pm(I_{dmm}^a \times 0.005 + 2 \text{ nA})$	390 pA

a. Measurement value of standard digital multimeter

SMU current test (for 100 μ A to 1 A ranges)

This test consists of the current force test and current measurement test; they verify the current force and measurement accuracy.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCI
Range	100 μ A (for SMU 100 μ A range) 1 mA (for SMU 1 mA range) 10 mA (for SMU 10 mA range) 100 mA (for SMU 100 mA range) 1 A (for SMU 200 mA and 1 A ranges)
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	100 μ A, 1 mA 10 mA, 100 mA, 200 mA (MPSMU only), or 1 A (HPSMU only)
Output current	\pm FS \times 1.15 (except 200 mA and 1 A ranges), \pm FS, and \pm FS/10
Voltage compliance	2 V (for 100 μ A, 1 mA 10 mA, 100 mA, and 200 mA ranges) 5 V (for 1 A range)
Filter	On
Averaging samples	1
Integration time	medium (NPLC = 1)

3. The SMU forces a certain current.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure the SMU output current.
5. The 3458A measurement value is compared to the current force test limit. The measured value is also used as the reference for the current measurement test.
6. The high-speed ADC and high-resolution ADC measurement value is compared to the measurement test limit that is calculated by using 3458A measurement value.
7. Steps 1 through 6 are repeated until all of the selected ranges are tested.
8. Steps 1 through 6 are repeated until all of the selected SMUs are tested.

Test limit

Table 2-22 SMU current force test limit

Current range	Nominal value	Force accuracy	Uncertainty
100 μ A	$\pm 10 \mu\text{A}$	$\pm 52 \text{ nA}$	975 μA
	$\pm 100 \mu\text{A}$	$\pm 160 \text{ nA}$	2.56 nA
	$\pm 115 \mu\text{A}$	$\pm 178 \text{ nA}$	2.90 nA
1 mA	$\pm 100 \mu\text{A}$	$\pm 620 \text{ nA}$	6.56 nA
	$\pm 1 \text{ mA}$	$\pm 1.8 \mu\text{A}$	24.6 nA
	$\pm 1.15 \text{ mA}$	$\pm 1.88 \mu\text{A}$	28.0 nA
10 mA	$\pm 1 \text{ mA}$	$\pm 5.2 \mu\text{A}$	65.6 nA
	$\pm 10 \text{ mA}$	$\pm 16 \mu\text{A}$	246 nA
	$\pm 11.5 \text{ mA}$	$\pm 17.8 \mu\text{A}$	280 nA
100 mA	$\pm 10 \text{ mA}$	$\pm 62 \mu\text{A}$	735 nA
	$\pm 100 \text{ mA}$	$\pm 170 \mu\text{A}$	4.13 μA
	$\pm 115 \text{ mA}$	$\pm 188 \mu\text{A}$	4.73 μA
200 mA ^a	$\pm 20 \text{ mA}$	$\pm 124 \mu\text{A}$	12.0 μA
	$\pm 200 \text{ mA}$	$\pm 340 \mu\text{A}$	28.0 μA
1 A ^b	$\pm 100 \text{ mA}$	$\pm 1 \text{ mA}$	17.3 μA
	$\pm 1 \text{ A}$	$\pm 5.5 \text{ mA}$	128 μA

a. MPSMU only (not available for E5270B)

b. HPSMU only

Table 2-23 SMU current measurement test limit (for E5260A/E5270A series MPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
100 μ A	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 20 \text{ nA})$	1.10 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 20 \text{ nA})$	2.61 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 115 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 20 \text{ nA})$	2.94 nA
1 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 300 \text{ nA})$	11.0 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 300 \text{ nA})$	26.1 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1.15 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 300 \text{ nA})$	29.4 nA
10 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 2 \mu\text{A})$	72.1 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 2 \mu\text{A})$	248 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 11.5 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 2 \mu\text{A})$	282 nA
100 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 30 \mu\text{A})$	1.15 μA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 30 \mu\text{A})$	4.22 μA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 115 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 30 \mu\text{A})$	4.82 μA
200 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 20 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 60 \mu\text{A})$	12.4 μA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 200 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.001 + 60 \mu\text{A})$	28.2 μA

a. Measurement value of standard digital multimeter

Table 2-24 SMU current measurement test limit (HPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
100 μ A	I_{dmm}^a at SMU $\pm 10 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	993 pA
	I_{dmm}^a at SMU $\pm 100 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	2.57 nA
	I_{dmm}^a at SMU $\pm 115 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	2.90 nA
1 mA	I_{dmm}^a at SMU $\pm 100 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	9.59 nA
	I_{dmm}^a at SMU ± 1 mA	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	25.6 nA
	I_{dmm}^a at SMU ± 1.15 mA	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	28.9 nA
10 mA	I_{dmm}^a at SMU ± 1 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	67.7 nA
	I_{dmm}^a at SMU ± 10 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	246 nA
	I_{dmm}^a at SMU ± 11.5 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	281 nA
100 mA	I_{dmm}^a at SMU ± 10 mA	$\pm(I_{dmm}^a \times 0.001 + 30 \mu\text{A})$	1.03 μ A
	I_{dmm}^a at SMU ± 100 mA	$\pm(I_{dmm}^a \times 0.001 + 30 \mu\text{A})$	4.19 μ A
	I_{dmm}^a at SMU ± 115 mA	$\pm(I_{dmm}^a \times 0.001 + 30 \mu\text{A})$	4.79 μ A
1 A	I_{dmm}^a at SMU ± 100 mA	$\pm(I_{dmm}^a \times 0.005 + 300 \mu\text{A})$	17.4 μ A
	I_{dmm}^a at SMU ± 1 A	$\pm(I_{dmm}^a \times 0.005 + 300 \mu\text{A})$	128 μ A

a. Measurement value of standard digital multimeter

Table 2-25 SMU current measurement test limit (for E5270B MPSPMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
100 μ A	I_{dmm}^a at SMU $\pm 10 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	1.02 nA
	I_{dmm}^a at SMU $\pm 100 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	2.58 nA
	I_{dmm}^a at SMU $\pm 115 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 20 \text{ nA})$	2.91 nA
1 mA	I_{dmm}^a at SMU $\pm 100 \mu$ A	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	8.87 nA
	I_{dmm}^a at SMU ± 1 mA	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	25.3 nA
	I_{dmm}^a at SMU ± 1.15 mA	$\pm(I_{dmm}^a \times 0.001 + 300 \text{ nA})$	28.7 nA
10 mA	I_{dmm}^a at SMU ± 1 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	68.4 nA
	I_{dmm}^a at SMU ± 10 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	247 nA
	I_{dmm}^a at SMU ± 11.5 mA	$\pm(I_{dmm}^a \times 0.001 + 2 \mu\text{A})$	281 nA
100 mA	I_{dmm}^a at SMU ± 10 mA	$\pm(I_{dmm}^a \times 0.001 + 30 \mu\text{A})$	964 nA
	I_{dmm}^a at SMU ± 100 mA	$\pm(I_{dmm}^a \times 0.001 + 30 \mu\text{A})$	4.17 μ A

a. Measurement value of standard digital multimeter

Table 2-26 SMU current measurement test limit (for E5270B HRSMU/ASU)

Current range	Nominal value	Measurement accuracy	Uncertainty
100 μ A	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.005 + 20 \text{ nA})$	1.02 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.005 + 20 \text{ nA})$	2.58 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 115 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.005 + 20 \text{ nA})$	2.91 nA
1 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \mu\text{A}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 200 \text{ nA})$	8.87 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 200 \text{ nA})$	25.3 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1.15 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 200 \text{ nA})$	28.7 nA
10 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 1 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 2 \mu\text{A})$	68.4 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 2 \mu\text{A})$	247 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 11.5 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 2 \mu\text{A})$	281 nA
100 mA	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 10 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 20 \mu\text{A})$	964 nA
	$I_{\text{dmm}}^{\text{a}}$ at SMU $\pm 100 \text{ mA}$	$\pm(I_{\text{dmm}}^{\text{a}} \times 0.004 + 20 \mu\text{A})$	4.17 μA

a. Measurement value of standard digital multimeter

SMU CMR test

This test is a part of SMU CMR test, and verifies the SMU common mode rejection accuracy.

Operating theory

1. The SMU is set as follows:

Function	VFIM
Range	100 V
Output voltage	±100 V
Current compliance	10 mA
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

2. The SMU forces the -100 V.
3. The SMU waits for 10 seconds and measures its own output (leakage) current (SMU_{im}).
4. The SMU forces the +100 V.
5. The SMU waits for 10 seconds and measures its own output (leakage) current (SMU_{ip}).
6. The CMR is calculated as follows, and the calculated CMR is compared to the test limit.

$$CMR = SMU_{im} - SMU_{ip}$$

Test limit

Table 2-27 SMU CMR test limit

Nominal value	Accuracy	Uncertainty	SMU P/N
0 A	±2 μA	None	E5287A, E5288A
	±4 μA	None	E5280A, E5281A, E5280B, E5281B, E5290A, E5291A

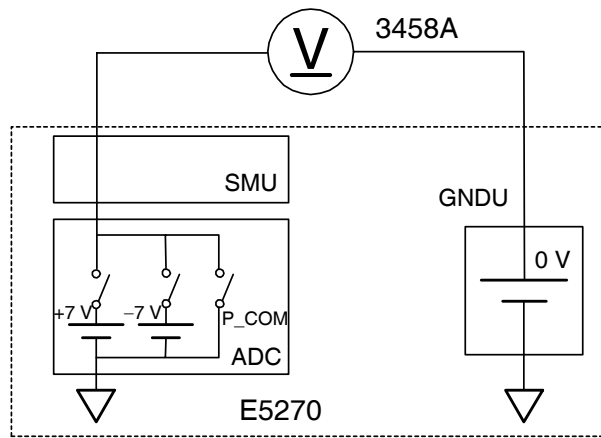
ADC/SMU Calibration Theory

This section covers the operating theory, block diagrams, and calibration limits for the ADC/SMU calibration.

ADC reference voltage calibration

There are two reference voltages, +7 V and -7 V, on the GNDU/ADC board. This calibration confirms the reference voltage values and updates the values in the EEPROM on the GNDU/ADC module.

Block diagram



Operating theory

1. The calibration program executes the self-test for each SMU, and uses one of the SMUs for connecting reference voltage in the reference voltage calibration.
2. The 3458A is set as follows:

Function	DCV
Range	10 V
Auto zero	On
NPLC	100
3. The reference potential common of the circuit (P_COM) is connected to the SMU1 port, and the 3458A measures the voltage of the reference potential common (V_{com}).
4. The +7 V reference voltage is connected to the SMU port, and the 3458A measures the output voltage (V_p).
5. The -7 V reference voltage is connected to the SMU port, and the 3458A measures the output voltage (V_n).
6. The voltages of ± 7 V are calculated as follows:

$$V_{refp} = V_p - V_{com}$$

$$V_{refn} = V_n - V_{com}$$

7. Steps 3 through 6 are repeated three times.
8. The average value of the three measurements is compared to the accuracy limit.
9. The dispersion of the three measurements is compared to the dispersion limit.
10. After the calibration completes, the calibrated values and date are updated in the EEPROM of the GNDU/ADC module.

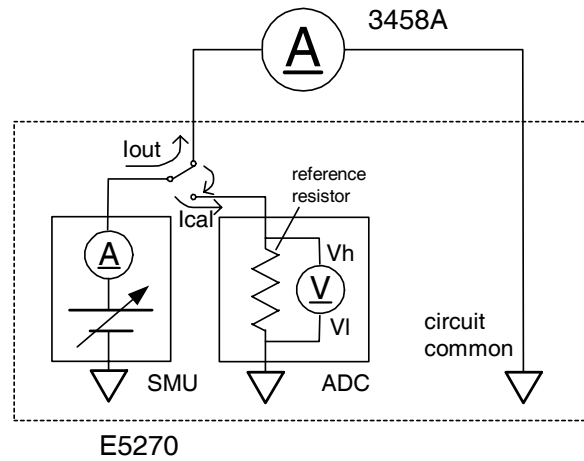
Calibration limit**Table 2-28 ADC reference voltage calibration limit**

Reference voltage	Nominal value	Accuracy	Dispersion
+7 V	6.95 V	± 0.42 V	$\leq 30 \mu\text{V}$
-7 V	-6.95 V	± 0.42 V	$\leq 30 \mu\text{V}$

ADC reference resistor calibration

There are five reference resistors: 100 Ω , 10 k Ω , 1 M Ω , and 100 M Ω , on the GNDU/ADC board. This calibration confirms the reference resistor values and updates the values in the EEPROM on the GNDU/ADC module.

Block diagram



ADC/SMU Calibration Theory**Operating theory**

1. The calibration program executes the CMR test for each SMU, and uses the best CMR accuracy SMU for the voltage source of the reference resistor calibration.

2. The 3458A is set as follows:

Function	DCI
Range	100 mA
Auto zero	On
NPLC:	100

3. The SMU is connected to the SMU output, and forces a certain voltage.

4. The 3458A and SMU measure the output current (I_{dmm} and I_{out}).

5. The SMU is connected to the reference resistor, and forces a certain voltage.

6. The SMU measures its own current (I_{cal}).

7. The high-resolution ADC measures the voltage of the reference resistor high side (V_h).

8. The high-resolution ADC measures the voltage of the reference resistor low side (V_l).

9. The resistance value is calculated as follows:

$$R = \frac{(V_h - V_l) \times I_{out}}{I_{dmm} \times I_{cal}}$$

10. Steps 2 through 9 are repeated three times.

11. The average value of the three measurements is compared to the calibration limit.

12. The dispersion of the three measurements is compared to the calibration limit.

13. Steps 1 through 11 are repeated until all of the reference resistors are calibrated.

14. After the calibration completes, the calibrated values and date are updated in the EEPROM on the GNDU/ADC module.

Calibration limit**Table 2-29 ADC reference resistor calibration pre-test (CMR test) limit**

Nominal value	Accuracy
0 A	±1 nA

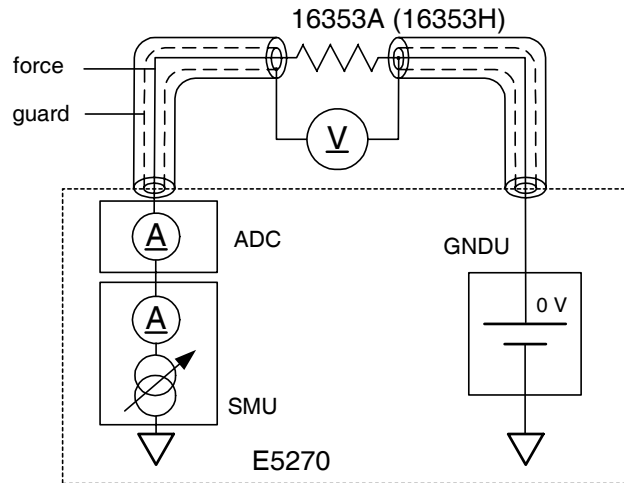
Table 2-30 ADC reference resistor calibration limit

Reference resistor	Nominal value	Accuracy	Dispersion
100 Ω	100 Ω	±500 mΩ	≤10 mΩ
10 kΩ	10 kΩ	±50 Ω	≤500 mΩ
1 MΩ	1 MΩ	±5 kΩ	≤50 Ω
100 MΩ	100 MΩ	±1 MΩ	≤50 kΩ

SMU range resistor calibration

This calibration confirms the 500 M Ω or higher SMU range resistor value, which is used for ranges lower than 10 nA, and updates them in the EEPROM of the SMU module.

Block diagram



Operation theory

1. The 3458A is set as follows:

Function	DCV
Range	10 V
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	10 nA
Output current	10 nA
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Long (NPLC=5)

3. The 3458A and high-resolution ADC wait for 5 seconds and measure the guard offset voltage (V_2) and the SMU output current (I_2).

ADC/SMU Calibration Theory

4. The SMU is set as follows:

Function	IFIM
Range	10 nA
Output current	10 nA
Voltage compliance	20 V
Filter	On
Averaging samples	1
Integration time	Long (NPLC=5)

5. The 3458A and high-resolution ADC wait for 5 seconds and measure the voltage drop of 1 G Ω standard resistor (V_{20}) and SMU output current (I_{20}).

6. The measurement values are compared to the calibration limit.

7. The gain of the SMU measurement and 3458A is calculated as follows:

$$Gain = \frac{V_{20} - V_2}{(I_{20} - I_2) \times R}$$

8. Steps 1 through 9 are repeated until all of the selected SMUs are calibrated.

9. After the calibration completes, the calibrated values (gain) and date are updated in the EEPROM on the SMU.

Calibration limit**Table 2-31 SMU range resistor calibration limit**

Variable	Nominal value	Accuracy
V_2	2.0 V	± 0.20 V
V_{20}	20 V	± 2 V
I_2	2 nA	± 0.2 nA
I_{20}	10 nA	± 1 nA

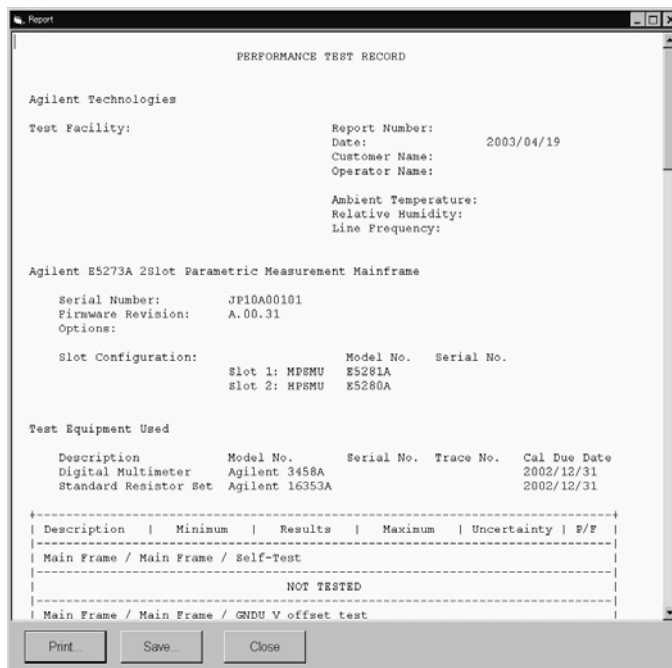
Printing Test Result

The test results can be printed out on paper or can be shown on the display. To report the test results, use the following procedure.

NOTE This report function formats and displays the latest test result only. If you execute the performance verification repeatedly, use the **Advanced Report** tab.

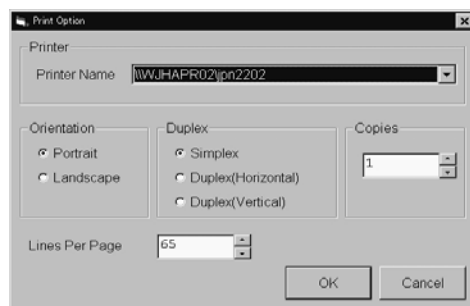
1. Click **Report** on the Run tab. The Report Window appears as shown in Figure 2-28.

Figure 2-28 Report window



2. Click **Print**. The Print Option window appears as shown in Figure 2-29.

Figure 2-29 Print Option window



3. Enter or select appropriate print options.
4. Click **OK**. The test report is printed out to the specified printer with the specified print options.

Advanced test data edit

This section describes the advanced test data edit function provided by the calibration software.

To store formatted data in a text file

1. Click **Save** on Report window.
2. Enter the file name you want to store the data.
3. Click **OK**. The formatted data is stored in the specified file.

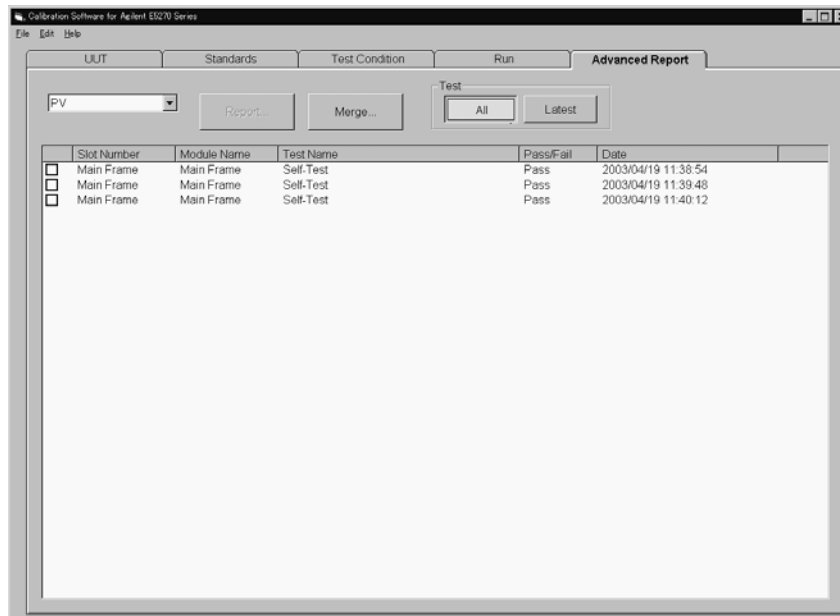
To merge two test data

1. Open the Advanced Report tab by clicking the tab.
2. Click **Merge** in the Advanced Report tab.
3. Enter the file name you want to merge.
4. Click **OK**. The specified file is merged into the file specified in Result File.

To print out a part of test data

1. Open the Advanced Report tab by clicking the tab.
2. Click **All** in the Advanced Report tab. All test results included in the result file appears in the window.

Figure 2-30 Advanced Report tab



3. Select a test name in the Advanced Report tab.
4. Click **Report** in the Advance Report tab. The Report window appears and displays selected test data.

To edit test report format

The test result file is stored in CSV format. If you use an editor that can read CSV format, you can format the test data as you like.

Test data example

Figure 2-31 through Figure 2-41 shows an example of the formatted test data.

Figure 2-31 E5270A test record example (1/11)

E5270A JP10A00101 Page 1/11				
PERFORMANCE TEST RECORD				
Agilent Technologies				
Test Facility:		Report Number:		
		Date:	2003/05/14	
		Customer Name:		
		Operator Name:		
		Ambient Temperature:		
		Relative Humidity:		
		Line Frequency:		
Agilent E5270A 8Slot Parametric Measurement Mainframe				
Serial Number:	JP10A00101			
Firmware Revision:	A.00.31			
Options:				
Slot Configuration:		Model No.	Serial No.	
	Slot 1:			
	Slot 2:	HPSMU	E5280A	
	Slot 3:			
	Slot 4:	MPSMU	E5281A	
	Slot 5:			
	Slot 6:			
	Slot 7:			
	Slot 8:			
Test Equipment Used				
Description	Model No.	Serial No.	Trace No.	Cal Due Date
Digital Multimeter	Agilent 3458A			2003/12/31
Standard Resistor Set	Agilent 16353A			2003/12/31

Calibration
 Printing Test Result

Figure 2-32 E5270A test record example (2/11)

E5270A JP10A00101 Page 2/11

Description	Minimum	Results	Maximum	Uncertainty	P/F
Main Frame / Main Frame / Self-Test					
					Pass
Main Frame / Main Frame / GNDU V offset test					
	-100.00000 uV	14.90678 uV	100.00000 uV	2.82000 uV	Pass
Slot 2 / HPSMU / V test: 2 V					
-2.2V DMM	-2.20466 V	-2.20022 V	-2.19534 V	0.00002 V	Pass
-2.2V HRADC	-2.20136 V	-2.20013 V	-2.19908 V	0.00002 V	Pass
-2.2V HSADC	-2.20158 V	-2.20030 V	-2.19886 V	0.00002 V	Pass
-2V DMM	-2.00150 V	-2.00018 V	-1.99850 V	0.00002 V	Pass
-2V HRADC	-2.00128 V	-2.00005 V	-1.99908 V	0.00002 V	Pass
-2V HSADC	-2.00148 V	-2.00020 V	-1.99888 V	0.00002 V	Pass
0V DMM	-900.00000 uV	-15.81826 uV	900.00000 uV	3.28000 uV	Pass
0V HRADC	-715.81826 uV	44.00000 uV	684.18174 uV	8.11000 uV	Pass
0V HSADC	-715.81826 uV	100.00000 uV	684.18174 uV	8.11000 uV	Pass
2V DMM	1.99850 V	2.00014 V	2.00150 V	0.00002 V	Pass
2V HRADC	1.99904 V	2.00012 V	2.00124 V	0.00002 V	Pass
2V HSADC	1.99884 V	2.00030 V	2.00144 V	0.00002 V	Pass
2.2V DMM	2.19534 V	2.20012 V	2.20466 V	0.00002 V	Pass
2.2V HRADC	2.19898 V	2.20012 V	2.20126 V	0.00002 V	Pass
2.2V HSADC	2.19876 V	2.20030 V	2.20148 V	0.00002 V	Pass
Slot 2 / HPSMU / V test: 20 V					
-22V DMM	-22.01360 V	-22.00147 V	-21.98640 V	0.00027 V	Pass
-22V HRADC	-22.00787 V	-22.00050 V	-21.99507 V	0.00027 V	Pass
-22V HSADC	-22.01207 V	-22.00200 V	-21.99087 V	0.00027 V	Pass
-20V DMM	-20.01000 V	-20.00172 V	-19.99000 V	0.00024 V	Pass
-20V HRADC	-20.00772 V	-20.00090 V	-19.99572 V	0.00024 V	Pass
-20V HSADC	-20.01172 V	-20.00200 V	-19.99172 V	0.00024 V	Pass
0V DMM	-4.00000 mV	-0.00192 mV	4.00000 mV	0.03910 mV	Pass
0V HRADC	-2.00192 mV	0.02000 mV	1.99808 mV	0.04080 mV	Pass
0V HSADC	-4.00192 mV	0.00000 mV	3.99808 mV	0.04080 mV	Pass
20V DMM	19.99000 V	20.00164 V	20.01000 V	0.00024 V	Pass
20V HRADC	19.99564 V	20.00076 V	20.00764 V	0.00024 V	Pass
20V HSADC	19.99164 V	20.00200 V	20.01164 V	0.00024 V	Pass
22V DMM	21.98640 V	22.00203 V	22.01360 V	0.00027 V	Pass
22V HRADC	21.99563 V	22.00102 V	22.00843 V	0.00027 V	Pass
22V HSADC	21.99143 V	22.00300 V	22.01263 V	0.00027 V	Pass
Slot 2 / HPSMU / V test: 40 V					
-44V DMM	-44.03260 V	-44.00387 V	-43.96740 V	0.00053 V	Pass
-44V HRADC	-44.01567 V	-44.00340 V	-43.99207 V	0.00053 V	Pass
-44V HSADC	-44.02507 V	-44.00600 V	-43.98267 V	0.00053 V	Pass
-40V DMM	-40.01900 V	-40.00136 V	-39.98100 V	0.00048 V	Pass
-40V HRADC	-40.01236 V	-40.00096 V	-39.99036 V	0.00048 V	Pass
-40V HSADC	-40.02136 V	-40.00400 V	-39.98136 V	0.00048 V	Pass
0V DMM	-7.00000 mV	0.15581 mV	7.00000 mV	0.03910 mV	Pass
0V HRADC	-2.84419 mV	0.20000 mV	3.15581 mV	0.04220 mV	Pass
0V HSADC	-7.84419 mV	0.00000 mV	8.15581 mV	0.04220 mV	Pass
40V DMM	39.98100 V	40.00150 V	40.01900 V	0.00048 V	Pass
40V HRADC	39.99050 V	40.00104 V	40.01250 V	0.00048 V	Pass
40V HSADC	39.98150 V	40.00400 V	40.02150 V	0.00048 V	Pass
44V DMM	43.96740 V	44.00326 V	44.03260 V	0.00053 V	Pass
44V HRADC	43.99146 V	44.00264 V	44.01506 V	0.00053 V	Pass
44V HSADC	43.98206 V	44.00600 V	44.02446 V	0.00053 V	Pass

Figure 2-33 E5270A test record example (3/11)

E5270A JP10A00101 Page 3/11						
Description	Minimum	Results	Maximum	Uncertainty	P/F	
Slot 2 / HPSMU / V test: 100 V						
-110V DMM	-110.07950 V	-110.00272 V	-109.92050 V	0.00132 V	Pass	
-110V HRADC	-110.04072 V	-110.00080 V	-109.96472 V	0.00131 V	Pass	
-110V HSADC	-110.05572 V	-110.01000 V	-109.94972 V	0.00131 V	Pass	
-100V DMM	-100.05500 V	-100.00588 V	-99.94500 V	0.00119 V	Pass	
-100V HRADC	-100.04088 V	-100.00500 V	-99.97088 V	0.00119 V	Pass	
-100V HSADC	-100.05588 V	-100.01000 V	-99.95588 V	0.00119 V	Pass	
0V DMM	-15.00000 mV	0.56580 mV	15.00000 mV	0.03910 mV	Pass	
0V HRADC	-4.43420 mV	0.60000 mV	5.56580 mV	0.05110 mV	Pass	
0V HSADC	-19.43420 mV	0.00000 mV	20.56580 mV	0.05110 mV	Pass	
100V DMM	99.94500 V	100.00615 V	100.05500 V	0.00119 V	Pass	
100V HRADC	99.97115 V	100.00440 V	100.04115 V	0.00119 V	Pass	
100V HSADC	99.95615 V	100.01500 V	100.05615 V	0.00119 V	Pass	
110V DMM	109.92050 V	109.99778 V	110.07950 V	0.00132 V	Pass	
110V HRADC	109.95978 V	109.99570 V	110.03578 V	0.00131 V	Pass	
110V HSADC	109.94478 V	110.00500 V	110.05078 V	0.00131 V	Pass	
Slot 2 / HPSMU / V test: 200 V						
-200V DMM	-200.12000 V	-199.99406 V	-199.88000 V	0.00239 V	Pass	
-200V HRADC	-200.07406 V	-199.99300 V	-199.91406 V	0.00239 V	Pass	
-200V HSADC	-200.10406 V	-200.01000 V	-199.88406 V	0.00239 V	Pass	
0V DMM	-30.00000 mV	1.26121 mV	30.00000 mV	0.13300 mV	Pass	
0V HRADC	-8.73879 mV	1.40000 mV	11.26121 mV	0.14700 mV	Pass	
0V HSADC	-38.73879 mV	0.00000 mV	41.26121 mV	0.14700 mV	Pass	
200V DMM	199.88000 V	199.99375 V	200.12000 V	0.00239 V	Pass	
200V HRADC	199.91375 V	199.98960 V	200.07375 V	0.00239 V	Pass	
200V HSADC	199.88375 V	200.00000 V	200.10375 V	0.00239 V	Pass	
Slot 2 / HPSMU / I pre-test: 100 nA						
-115nA DMM	-1.00000 mV	0.00429 mV	1.00000 mV		Pass	
-115nA SMU	-116.00000 nA	-115.02000 nA	-114.00000 nA		Pass	
-100nA DMM	-1.00000 mV	0.00490 mV	1.00000 mV		Pass	
-100nA SMU	-101.00000 nA	-100.01000 nA	-99.00000 nA		Pass	
-10nA DMM	-1.00000 mV	0.00496 mV	1.00000 mV		Pass	
-10nA SMU	-11.00000 nA	-10.00500 nA	-9.00000 nA		Pass	
10nA DMM	-1.00000 mV	0.00525 mV	1.00000 mV		Pass	
10nA SMU	9.00000 nA	10.00000 nA	11.00000 nA		Pass	
100nA DMM	-1.00000 mV	0.00587 mV	1.00000 mV		Pass	
100nA SMU	99.00000 nA	100.01000 nA	101.00000 nA		Pass	
115nA DMM	-1.00000 mV	0.00630 mV	1.00000 mV		Pass	
115nA SMU	114.00000 nA	115.01500 nA	116.00000 nA		Pass	
Slot 2 / HPSMU / I pre-test: 1 uA						
-1.15uA DMM	-1.00000 mV	-0.01105 mV	1.00000 mV		Pass	
-1.15uA SMU	-1.16000 uA	-1.15020 uA	-1.14000 uA		Pass	
-1uA DMM	-1.00000 mV	-0.00692 mV	1.00000 mV		Pass	
-1uA SMU	-1.01000 uA	-1.00005 uA	-0.99000 uA		Pass	
-100nA DMM	-1.00000 mV	0.00341 mV	1.00000 mV		Pass	
-100nA SMU	-110.00000 nA	-99.95000 nA	-90.00000 nA		Pass	
100nA DMM	-1.00000 mV	0.00508 mV	1.00000 mV		Pass	
100nA SMU	90.00000 nA	100.00000 nA	110.00000 nA		Pass	
1uA DMM	-1.00000 mV	0.01123 mV	1.00000 mV		Pass	
1uA SMU	0.99000 uA	1.00005 uA	1.01000 uA		Pass	
1.15uA DMM	-1.00000 mV	0.01484 mV	1.00000 mV		Pass	
1.15uA SMU	1.14000 uA	1.15015 uA	1.16000 uA		Pass	
Slot 2 / HPSMU / I test: 1 nA						
-1.15nA DMM	-1.15875 nA	-1.15003 nA	-1.14125 nA	0.00064 nA	Pass	
-1.15nA HRADC	-1.15878 nA	-1.15009 nA	-1.14128 nA	0.00064 nA	Pass	

Calibration
Printing Test Result

Figure 2-34 E5270A test record example (4/11)

E5270A JP10A00101 Page 4/11						
Description	Minimum	Results	Maximum	Uncertainty	P/F	
-1.15nA HSADC	-1.15878 nA	-1.15020 nA	-1.14128 nA	0.00064 nA	Pass	
-1nA DMM	-1.00800 nA	-0.99994 nA	-0.99200 nA	0.00056 nA	Pass	
-1nA HRADC	-1.00794 nA	-1.00002 nA	-0.99194 nA	0.00056 nA	Pass	
-1nA HSADC	-1.00794 nA	-1.00010 nA	-0.99194 nA	0.00056 nA	Pass	
-100pA DMM	-103.50000 pA	-99.93037 pA	-96.50000 pA	0.06970 pA	Pass	
-100pA HRADC	-103.43037 pA	-100.00400 pA	-96.43037 pA	0.07590 pA	Pass	
-100pA HSADC	-103.43037 pA	-100.00000 pA	-96.43037 pA	0.07590 pA	Pass	
100pA DMM	96.50000 pA	100.04768 pA	103.50000 pA	0.06970 pA	Pass	
100pA HRADC	96.54768 pA	100.01100 pA	103.54768 pA	0.07590 pA	Pass	
100pA HSADC	96.54768 pA	100.00000 pA	103.54768 pA	0.07590 pA	Pass	
1nA DMM	0.99200 nA	1.00002 nA	1.00800 nA	0.00056 nA	Pass	
1nA HRADC	0.99202 nA	1.00002 nA	1.00802 nA	0.00056 nA	Pass	
1nA HSADC	0.99202 nA	1.00010 nA	1.00802 nA	0.00056 nA	Pass	
1.15nA DMM	1.14125 nA	1.15007 nA	1.15875 nA	0.00064 nA	Pass	
1.15nA HRADC	1.14132 nA	1.15006 nA	1.15882 nA	0.00064 nA	Pass	
1.15nA HSADC	1.14132 nA	1.15015 nA	1.15882 nA	0.00064 nA	Pass	
Slot 2 / HPSMU / I test: 10 nA						
-11.5nA DMM	-11.56450 nA	-11.49962 nA	-11.43550 nA	0.00738 nA	Pass	
-11.5nA HRADC	-11.54112 nA	-11.50044 nA	-11.45812 nA	0.00738 nA	Pass	
-11.5nA HSADC	-11.54112 nA	-11.50150 nA	-11.45812 nA	0.00738 nA	Pass	
-10nA DMM	-10.05700 nA	-9.99739 nA	-9.94300 nA	0.00642 nA	Pass	
-10nA HRADC	-10.03739 nA	-9.99993 nA	-9.95739 nA	0.00642 nA	Pass	
-10nA HSADC	-10.03739 nA	-10.00100 nA	-9.95739 nA	0.00642 nA	Pass	
-1nA DMM	-1.01200 nA	-0.99825 nA	-0.98800 nA	0.00069 nA	Pass	
-1nA HRADC	-1.02925 nA	-0.99975 nA	-0.96725 nA	0.00069 nA	Pass	
-1nA HSADC	-1.02925 nA	-1.00000 nA	-0.96725 nA	0.00069 nA	Pass	
1nA DMM	0.98800 nA	1.00024 nA	1.01200 nA	0.00069 nA	Pass	
1nA HRADC	0.96924 nA	1.00007 nA	1.03124 nA	0.00069 nA	Pass	
1nA HSADC	0.96924 nA	1.00000 nA	1.03124 nA	0.00069 nA	Pass	
10nA DMM	9.94300 nA	9.99918 nA	10.05700 nA	0.00642 nA	Pass	
10nA HRADC	9.95918 nA	10.00015 nA	10.03918 nA	0.00642 nA	Pass	
10nA HSADC	9.95918 nA	10.00100 nA	10.03918 nA	0.00642 nA	Pass	
11.5nA DMM	11.43550 nA	11.49849 nA	11.56450 nA	0.00738 nA	Pass	
11.5nA HRADC	11.45699 nA	11.50076 nA	11.53999 nA	0.00738 nA	Pass	
11.5nA HSADC	11.45699 nA	11.50150 nA	11.53999 nA	0.00738 nA	Pass	
Slot 2 / HPSMU / I test: 100 nA						
-115nA DMM	-115.18800 nA	-115.00580 nA	-114.81200 nA	0.01370 nA	Pass	
-115nA HRADC	-115.15080 nA	-115.00950 nA	-114.86080 nA	0.01370 nA	Pass	
-115nA HSADC	-115.15080 nA	-115.02000 nA	-114.86080 nA	0.01370 nA	Pass	
-100nA DMM	-100.17000 nA	-99.99753 nA	-99.83000 nA	0.01200 nA	Pass	
-100nA HRADC	-100.12753 nA	-100.00060 nA	-99.86753 nA	0.01200 nA	Pass	
-100nA HSADC	-100.12753 nA	-100.01000 nA	-99.86753 nA	0.01200 nA	Pass	
-10nA DMM	-10.06200 nA	-10.00061 nA	-9.93800 nA	0.00244 nA	Pass	
-10nA HRADC	-10.04061 nA	-10.00210 nA	-9.96061 nA	0.00260 nA	Pass	
-10nA HSADC	-10.04061 nA	-10.00500 nA	-9.96061 nA	0.00260 nA	Pass	
10nA DMM	9.93800 nA	10.00209 nA	10.06200 nA	0.00244 nA	Pass	
10nA HRADC	9.96209 nA	10.00130 nA	10.04209 nA	0.00260 nA	Pass	
10nA HSADC	9.96209 nA	10.00000 nA	10.04209 nA	0.00260 nA	Pass	
100nA DMM	99.83000 nA	100.00117 nA	100.17000 nA	0.01200 nA	Pass	
100nA HRADC	99.87117 nA	100.00240 nA	100.13117 nA	0.01200 nA	Pass	
100nA HSADC	99.87117 nA	100.01000 nA	100.13117 nA	0.01200 nA	Pass	
115nA DMM	114.81200 nA	115.00740 nA	115.18800 nA	0.01370 nA	Pass	
115nA HRADC	114.86240 nA	115.00890 nA	115.15240 nA	0.01370 nA	Pass	
115nA HSADC	114.86240 nA	115.01500 nA	115.15240 nA	0.01370 nA	Pass	
Slot 2 / HPSMU / I test: 1 uA						
-1.15uA DMM	-1.15178 uA	-1.15007 uA	-1.14822 uA	0.00024 uA	Pass	
-1.15uA HRADC	-1.15142 uA	-1.15008 uA	-1.14872 uA	0.00024 uA	Pass	
-1.15uA HSADC	-1.15142 uA	-1.15020 uA	-1.14872 uA	0.00024 uA	Pass	

Figure 2-35 E5270A test record example (5/11)

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Description	Minimum	Results	Maximum	Uncertainty	P/F
-1uA DMM	-1.00160 uA	-0.99999 uA	-0.99840 uA	0.00021 uA	Pass
-1uA HRADC	-1.00119 uA	-1.00000 uA	-0.99879 uA	0.00021 uA	Pass
-1uA HSADC	-1.00119 uA	-1.00010 uA	-0.99879 uA	0.00021 uA	Pass
-100nA DMM	-100.52000 nA	-99.98938 nA	-99.48000 nA	0.02960 nA	Pass
-100nA HRADC	-100.28938 nA	-99.99800 nA	-99.68938 nA	0.02970 nA	Pass
-100nA HSADC	-100.28938 nA	-100.00000 nA	-99.68938 nA	0.02970 nA	Pass
100nA DMM	99.48000 nA	100.02022 nA	100.52000 nA	0.02960 nA	Pass
100nA HRADC	99.72022 nA	100.01500 nA	100.32022 nA	0.02970 nA	Pass
100nA HSADC	99.72022 nA	100.00000 nA	100.32022 nA	0.02970 nA	Pass
1uA DMM	0.99840 uA	1.00001 uA	1.00160 uA	0.00021 uA	Pass
1uA HRADC	0.99881 uA	1.00000 uA	1.00121 uA	0.00021 uA	Pass
1uA HSADC	0.99881 uA	1.00005 uA	1.00121 uA	0.00021 uA	Pass
1.15uA DMM	1.14822 uA	1.15006 uA	1.15178 uA	0.00024 uA	Pass
1.15uA HRADC	1.14871 uA	1.15006 uA	1.15141 uA	0.00024 uA	Pass
1.15uA HSADC	1.14871 uA	1.15010 uA	1.15141 uA	0.00024 uA	Pass
Slot 2 / HPSMU / I test: 10 uA					
-11.5uA DMM	-11.51880 uA	-11.49976 uA	-11.48120 uA	0.00083 uA	Pass
-11.5uA HRADC	-11.51426 uA	-11.50084 uA	-11.48526 uA	0.00083 uA	Pass
-11.5uA HSADC	-11.51426 uA	-11.50150 uA	-11.48526 uA	0.00083 uA	Pass
-10uA DMM	-10.01700 uA	-9.99947 uA	-9.98300 uA	0.00073 uA	Pass
-10uA HRADC	-10.01247 uA	-10.00042 uA	-9.98647 uA	0.00073 uA	Pass
-10uA HSADC	-10.01247 uA	-10.00150 uA	-9.98647 uA	0.00073 uA	Pass
-1uA DMM	-1.00620 uA	-1.00000 uA	-0.99380 uA	0.00022 uA	Pass
-1uA HRADC	-1.00400 uA	-1.00010 uA	-0.99600 uA	0.00024 uA	Pass
-1uA HSADC	-1.00400 uA	-1.00000 uA	-0.99600 uA	0.00024 uA	Pass
1uA DMM	0.99380 uA	0.99987 uA	1.00620 uA	0.00022 uA	Pass
1uA HRADC	0.99587 uA	0.99996 uA	1.00387 uA	0.00024 uA	Pass
1uA HSADC	0.99587 uA	1.00000 uA	1.00387 uA	0.00024 uA	Pass
10uA DMM	9.98300 uA	9.99928 uA	10.01700 uA	0.00073 uA	Pass
10uA HRADC	9.98628 uA	10.00018 uA	10.01228 uA	0.00073 uA	Pass
10uA HSADC	9.98628 uA	10.00100 uA	10.01228 uA	0.00073 uA	Pass
11.5uA DMM	11.48120 uA	11.49970 uA	11.51880 uA	0.00083 uA	Pass
11.5uA HRADC	11.48520 uA	11.50072 uA	11.51420 uA	0.00083 uA	Pass
11.5uA HSADC	11.48520 uA	11.50150 uA	11.51420 uA	0.00083 uA	Pass
Slot 2 / HPSMU / I test: 100 uA					
-115uA DMM	-115.17800 uA	-114.99476 uA	-114.82200 uA	0.00290 uA	Pass
-115uA HRADC	-115.12976 uA	-115.00820 uA	-114.85976 uA	0.00290 uA	Pass
-115uA HSADC	-115.12976 uA	-115.02000 uA	-114.85976 uA	0.00290 uA	Pass
-100uA DMM	-100.16000 uA	-99.98886 uA	-99.84000 uA	0.00256 uA	Pass
-100uA HRADC	-100.10886 uA	-100.00080 uA	-99.86886 uA	0.00257 uA	Pass
-100uA HSADC	-100.10886 uA	-100.01000 uA	-99.86886 uA	0.00257 uA	Pass
-10uA DMM	-10.05200 uA	-10.00051 uA	-9.94800 uA	0.00098 uA	Pass
-10uA HRADC	-10.03051 uA	-10.00140 uA	-9.97051 uA	0.00099 uA	Pass
-10uA HSADC	-10.03051 uA	-10.00000 uA	-9.97051 uA	0.00099 uA	Pass
10uA DMM	9.94800 uA	9.99942 uA	10.05200 uA	0.00098 uA	Pass
10uA HRADC	9.96942 uA	10.00100 uA	10.02942 uA	0.00099 uA	Pass
10uA HSADC	9.96942 uA	10.00000 uA	10.02942 uA	0.00099 uA	Pass
100uA DMM	99.84000 uA	99.98650 uA	100.16000 uA	0.00256 uA	Pass
100uA HRADC	99.86650 uA	99.99920 uA	100.10650 uA	0.00257 uA	Pass
100uA HSADC	99.86650 uA	100.00500 uA	100.10650 uA	0.00257 uA	Pass
115uA DMM	114.82200 uA	114.99408 uA	115.17800 uA	0.00290 uA	Pass
115uA HRADC	114.85908 uA	115.00790 uA	115.12908 uA	0.00290 uA	Pass
115uA HSADC	114.85908 uA	115.01500 uA	115.12908 uA	0.00290 uA	Pass
Slot 2 / HPSMU / I test: 1 mA					
-1.15mA DMM	-1.15188 mA	-1.15008 mA	-1.14812 mA	0.00003 mA	Pass
-1.15mA HRADC	-1.15153 mA	-1.15010 mA	-1.14863 mA	0.00003 mA	Pass
-1.15mA HSADC	-1.15153 mA	-1.15020 mA	-1.14863 mA	0.00003 mA	Pass
-1mA DMM	-1.00170 mA	-1.00002 mA	-0.99830 mA	0.00002 mA	Pass

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Figure 2-36 E5270A test record example (6/11)

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Description	Minimum	Results	Maximum	Uncertainty	P/F
-1mA HRADC	-1.00132 mA	-1.00004 mA	-0.99872 mA	0.00003 mA	Pass
-1mA HSADC	-1.00132 mA	-1.00010 mA	-0.99872 mA	0.00003 mA	Pass
-100uA DMM	-100.62000 uA	-100.01388 uA	-99.38000 uA	0.00656 uA	Pass
-100uA HRADC	-100.41388 uA	-100.01600 uA	-99.61388 uA	0.00959 uA	Pass
-100uA HSADC	-100.41388 uA	-100.05000 uA	-99.61388 uA	0.00959 uA	Pass
100uA DMM	99.38000 uA	100.00183 uA	100.62000 uA	0.00656 uA	Pass
100uA HRADC	99.60183 uA	100.00800 uA	100.40183 uA	0.00959 uA	Pass
100uA HSADC	99.60183 uA	100.00000 uA	100.40183 uA	0.00959 uA	Pass
1mA DMM	0.99830 mA	1.00001 mA	1.00170 mA	0.00002 mA	Pass
1mA HRADC	0.99871 mA	1.00002 mA	1.00131 mA	0.00003 mA	Pass
1mA HSADC	0.99871 mA	1.00010 mA	1.00131 mA	0.00003 mA	Pass
1.15mA DMM	1.14812 mA	1.15004 mA	1.15188 mA	0.00003 mA	Pass
1.15mA HRADC	1.14859 mA	1.15006 mA	1.15149 mA	0.00003 mA	Pass
1.15mA HSADC	1.14859 mA	1.15015 mA	1.15149 mA	0.00003 mA	Pass
Slot 2 / HPSMU / I test: 10 mA					
-11.5mA DMM	-11.51780 mA	-11.50166 mA	-11.48220 mA	0.00028 mA	Pass
-11.5mA HRADC	-11.51516 mA	-11.50060 mA	-11.48816 mA	0.00028 mA	Pass
-11.5mA HSADC	-11.51516 mA	-11.50150 mA	-11.48816 mA	0.00028 mA	Pass
-10mA DMM	-10.01600 mA	-10.00115 mA	-9.98400 mA	0.00025 mA	Pass
-10mA HRADC	-10.01315 mA	-10.00042 mA	-9.98915 mA	0.00025 mA	Pass
-10mA HSADC	-10.01315 mA	-10.00150 mA	-9.98915 mA	0.00025 mA	Pass
-1mA DMM	-1.00520 mA	-1.00019 mA	-0.99480 mA	0.00007 mA	Pass
-1mA HRADC	-1.00319 mA	-1.00015 mA	-0.99719 mA	0.00007 mA	Pass
-1mA HSADC	-1.00319 mA	-1.00050 mA	-0.99719 mA	0.00007 mA	Pass
1mA DMM	0.99480 mA	0.99998 mA	1.00520 mA	0.00007 mA	Pass
1mA HRADC	0.99698 mA	1.00006 mA	1.00298 mA	0.00007 mA	Pass
1mA HSADC	0.99698 mA	1.00000 mA	1.00298 mA	0.00007 mA	Pass
10mA DMM	9.98400 mA	10.00066 mA	10.01600 mA	0.00025 mA	Pass
10mA HRADC	9.98866 mA	10.00025 mA	10.01266 mA	0.00025 mA	Pass
10mA HSADC	9.98866 mA	10.00100 mA	10.01266 mA	0.00025 mA	Pass
11.5mA DMM	11.48220 mA	11.50127 mA	11.51780 mA	0.00028 mA	Pass
11.5mA HRADC	11.48777 mA	11.50055 mA	11.51477 mA	0.00028 mA	Pass
11.5mA HSADC	11.48777 mA	11.50100 mA	11.51477 mA	0.00028 mA	Pass
Slot 2 / HPSMU / I test: 100 mA					
-115mA DMM	-115.18800 mA	-115.00933 mA	-114.81200 mA	0.00473 mA	Pass
-115mA HRADC	-115.15433 mA	-115.00800 mA	-114.86433 mA	0.00479 mA	Pass
-115mA HSADC	-115.15433 mA	-115.02000 mA	-114.86433 mA	0.00479 mA	Pass
-100mA DMM	-100.17000 mA	-100.00439 mA	-99.83000 mA	0.00413 mA	Pass
-100mA HRADC	-100.13439 mA	-100.00370 mA	-99.87439 mA	0.00419 mA	Pass
-100mA HSADC	-100.13439 mA	-100.01500 mA	-99.87439 mA	0.00419 mA	Pass
-10mA DMM	-10.06200 mA	-10.00446 mA	-9.93800 mA	0.00074 mA	Pass
-10mA HRADC	-10.04446 mA	-10.00410 mA	-9.96446 mA	0.00103 mA	Pass
-10mA HSADC	-10.04446 mA	-10.00500 mA	-9.96446 mA	0.00103 mA	Pass
10mA DMM	9.93800 mA	9.99891 mA	10.06200 mA	0.00074 mA	Pass
10mA HRADC	9.95891 mA	9.99960 mA	10.03891 mA	0.00103 mA	Pass
10mA HSADC	9.95891 mA	10.00000 mA	10.03891 mA	0.00103 mA	Pass
100mA DMM	99.83000 mA	100.00263 mA	100.17000 mA	0.00413 mA	Pass
100mA HRADC	99.87263 mA	100.00190 mA	100.13263 mA	0.00419 mA	Pass
100mA HSADC	99.87263 mA	100.01000 mA	100.13263 mA	0.00419 mA	Pass
115mA DMM	114.81200 mA	115.00989 mA	115.18800 mA	0.00473 mA	Pass
115mA HRADC	114.86489 mA	115.00770 mA	115.15489 mA	0.00479 mA	Pass
115mA HSADC	114.86489 mA	115.01500 mA	115.15489 mA	0.00479 mA	Pass
Slot 2 / HPSMU / I test: 1 A					
-1A DMM	-1.00550 A	-0.99995 A	-0.99450 A	0.00013 A	Pass
-1A HRADC	-1.00525 A	-1.00001 A	-0.99465 A	0.00013 A	Pass
-1A HSADC	-1.00525 A	-1.00010 A	-0.99465 A	0.00013 A	Pass
-100mA DMM	-101.00000 mA	-100.01939 mA	-99.00000 mA	0.01730 mA	Pass
-100mA HRADC	-100.81939 mA	-100.01700 mA	-99.21939 mA	0.01740 mA	Pass

Figure 2-37 E5270A test record example (7/11)

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Description	Minimum	Results	Maximum	Uncertainty	P/F	
-100mA HSADC	-100.81939 mA	-100.05000 mA	-99.21939 mA	0.01740 mA	Pass	
100mA DMM	99.00000 mA	100.02085 mA	101.00000 mA	0.01730 mA	Pass	
100mA HRADC	99.22085 mA	100.03200 mA	100.82085 mA	0.01740 mA	Pass	
100mA HSADC	99.22085 mA	100.05000 mA	100.82085 mA	0.01740 mA	Pass	
1A DMM	0.99450 A	0.99994 A	1.00550 A	0.00013 A	Pass	
1A HRADC	0.99464 A	1.00002 A	1.00524 A	0.00013 A	Pass	
1A HSADC	0.99464 A	1.00010 A	1.00524 A	0.00013 A	Pass	
Slot 2 / HPSMU / CMR test						
	-4.00000 uA	-0.05000 uA	4.00000 uA		Pass	
Slot 4 / MPSMU / V test: 2 V						
-2.2V DMM	-2.20466 V	-2.20070 V	-2.19534 V	0.00002 V	Pass	
-2.2V HRADC	-2.20184 V	-2.20061 V	-2.19956 V	0.00002 V	Pass	
-2.2V HSADC	-2.20206 V	-2.20070 V	-2.19934 V	0.00002 V	Pass	
-2V DMM	-2.00150 V	-2.00021 V	-1.99850 V	0.00002 V	Pass	
-2V HRADC	-2.00131 V	-2.00013 V	-1.99911 V	0.00002 V	Pass	
-2V HSADC	-2.00151 V	-2.00020 V	-1.99891 V	0.00002 V	Pass	
0V DMM	-900.00000 uV	-52.43762 uV	900.00000 uV	3.28000 uV	Pass	
0V HRADC	-752.43762 uV	-34.00000 uV	647.56238 uV	7.52000 uV	Pass	
0V HSADC	-752.43762 uV	-100.00000 uV	647.56238 uV	7.52000 uV	Pass	
2V DMM	1.99850 V	2.00011 V	2.00150 V	0.00002 V	Pass	
2V HRADC	1.99901 V	2.00005 V	2.00121 V	0.00002 V	Pass	
2V HSADC	1.99881 V	2.00020 V	2.00141 V	0.00002 V	Pass	
2.2V DMM	2.19534 V	2.20036 V	2.20466 V	0.00002 V	Pass	
2.2V HRADC	2.19922 V	2.20029 V	2.20150 V	0.00002 V	Pass	
2.2V HSADC	2.19900 V	2.20050 V	2.20172 V	0.00002 V	Pass	
Slot 4 / MPSMU / V test: 20 V						
-22V DMM	-22.01360 V	-22.00200 V	-21.98640 V	0.00027 V	Pass	
-22V HRADC	-22.00840 V	-22.00106 V	-21.99560 V	0.00027 V	Pass	
-22V HSADC	-22.01260 V	-22.00200 V	-21.99140 V	0.00027 V	Pass	
-20V DMM	-20.01000 V	-20.00185 V	-19.99000 V	0.00024 V	Pass	
-20V HRADC	-20.00785 V	-20.00112 V	-19.99585 V	0.00025 V	Pass	
-20V HSADC	-20.01185 V	-20.00200 V	-19.99185 V	0.00025 V	Pass	
0V DMM	-4.00000 mV	-0.19982 mV	4.00000 mV	0.03910 mV	Pass	
0V HRADC	-2.19982 mV	-0.22000 mV	1.80018 mV	0.05240 mV	Pass	
0V HSADC	-4.19982 mV	0.00000 mV	3.80018 mV	0.05240 mV	Pass	
20V DMM	19.99000 V	20.00150 V	20.01000 V	0.00024 V	Pass	
20V HRADC	19.99550 V	20.00056 V	20.00750 V	0.00025 V	Pass	
20V HSADC	19.99150 V	20.00300 V	20.01150 V	0.00025 V	Pass	
22V DMM	21.98640 V	22.00180 V	22.01360 V	0.00027 V	Pass	
22V HRADC	21.99540 V	22.00076 V	22.00820 V	0.00027 V	Pass	
22V HSADC	21.99120 V	22.00300 V	22.01240 V	0.00027 V	Pass	
Slot 4 / MPSMU / V test: 40 V						
-44V DMM	-44.03260 V	-44.00494 V	-43.96740 V	0.00053 V	Pass	
-44V HRADC	-44.01674 V	-44.00480 V	-43.99314 V	0.00053 V	Pass	
-44V HSADC	-44.02614 V	-44.00600 V	-43.98374 V	0.00053 V	Pass	
-40V DMM	-40.01900 V	-40.00126 V	-39.98100 V	0.00048 V	Pass	
-40V HRADC	-40.01226 V	-40.00120 V	-39.99026 V	0.00048 V	Pass	
-40V HSADC	-40.02126 V	-40.00200 V	-39.98126 V	0.00048 V	Pass	
0V DMM	-7.00000 mV	0.51027 mV	7.00000 mV	0.03910 mV	Pass	
0V HRADC	-2.48973 mV	0.52000 mV	3.51027 mV	0.05970 mV	Pass	
0V HSADC	-7.48973 mV	0.00000 mV	8.51027 mV	0.05970 mV	Pass	
40V DMM	39.98100 V	40.00096 V	40.01900 V	0.00048 V	Pass	
40V HRADC	39.98996 V	40.00072 V	40.01196 V	0.00048 V	Pass	
40V HSADC	39.98096 V	40.00400 V	40.02096 V	0.00048 V	Pass	
44V DMM	43.96740 V	44.00174 V	44.03260 V	0.00053 V	Pass	
44V HRADC	43.98994 V	44.00128 V	44.01354 V	0.00053 V	Pass	

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Figure 2-38 E5270A test record example (8/11)

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Description	Minimum	Results	Maximum	Uncertainty	P/F	
44V HSADC	43.98054 V	44.00600 V	44.02294 V	0.00053 V	Pass	
Slot 4 / MPSMU / V test: 100 V						
-100V DMM	-100.05500 V	-100.00581 V	-99.94500 V	0.00119 V	Pass	
-100V HRADC	-100.04081 V	-100.00550 V	-99.97081 V	0.00120 V	Pass	
-100V HSADC	-100.05581 V	-100.01000 V	-99.95581 V	0.00120 V	Pass	
0V DMM	-15.00000 mV	0.52445 mV	15.00000 mV	0.03910 mV	Pass	
0V HRADC	-4.47555 mV	0.60000 mV	5.52445 mV	0.13000 mV	Pass	
0V HSADC	-19.47555 mV	0.00000 mV	20.52445 mV	0.13000 mV	Pass	
100V DMM	99.94500 V	100.00319 V	100.05500 V	0.00119 V	Pass	
100V HRADC	99.96819 V	100.00210 V	100.03819 V	0.00120 V	Pass	
100V HSADC	99.95319 V	100.01000 V	100.05319 V	0.00120 V	Pass	
Slot 4 / MPSMU / I pre-test: 100 nA						
-115nA DMM	-1.00000 mV	-0.00068 mV	1.00000 mV		Pass	
-115nA SMU	-116.00000 nA	-115.01500 nA	-114.00000 nA		Pass	
-100nA DMM	-1.00000 mV	0.00088 mV	1.00000 mV		Pass	
-100nA SMU	-101.00000 nA	-100.01000 nA	-99.00000 nA		Pass	
-10nA DMM	-1.00000 mV	0.00541 mV	1.00000 mV		Pass	
-10nA SMU	-11.00000 nA	-10.00000 nA	-9.00000 nA		Pass	
10nA DMM	-1.00000 mV	0.00759 mV	1.00000 mV		Pass	
10nA SMU	9.00000 nA	10.00000 nA	11.00000 nA		Pass	
100nA DMM	-1.00000 mV	0.01189 mV	1.00000 mV		Pass	
100nA SMU	99.00000 nA	100.01000 nA	101.00000 nA		Pass	
115nA DMM	-1.00000 mV	0.01279 mV	1.00000 mV		Pass	
115nA SMU	114.00000 nA	115.01000 nA	116.00000 nA		Pass	
Slot 4 / MPSMU / I pre-test: 1 uA						
-1.15uA DMM	-1.00000 mV	-0.05999 mV	1.00000 mV		Pass	
-1.15uA SMU	-1.16000 uA	-1.15010 uA	-1.14000 uA		Pass	
-1uA DMM	-1.00000 mV	-0.05332 mV	1.00000 mV		Pass	
-1uA SMU	-1.01000 uA	-1.00010 uA	-0.99000 uA		Pass	
-100nA DMM	-1.00000 mV	0.00148 mV	1.00000 mV		Pass	
-100nA SMU	-110.00000 nA	-99.90000 nA	-90.00000 nA		Pass	
100nA DMM	-1.00000 mV	0.01217 mV	1.00000 mV		Pass	
100nA SMU	90.00000 nA	100.00000 nA	110.00000 nA		Pass	
1uA DMM	-1.00000 mV	0.02440 mV	1.00000 mV		Pass	
1uA SMU	0.99000 uA	1.00005 uA	1.01000 uA		Pass	
1.15uA DMM	-1.00000 mV	0.02708 mV	1.00000 mV		Pass	
1.15uA SMU	1.14000 uA	1.15010 uA	1.16000 uA		Pass	
Slot 4 / MPSMU / I test: 1 nA						
-1.15nA DMM	-1.15875 nA	-1.14997 nA	-1.14125 nA	0.00064 nA	Pass	
-1.15nA HRADC	-1.15872 nA	-1.15003 nA	-1.14122 nA	0.00064 nA	Pass	
-1.15nA HSADC	-1.15872 nA	-1.15015 nA	-1.14122 nA	0.00064 nA	Pass	
-1nA DMM	-1.00800 nA	-0.99996 nA	-0.99200 nA	0.00056 nA	Pass	
-1nA HRADC	-1.00796 nA	-1.00002 nA	-0.99196 nA	0.00056 nA	Pass	
-1nA HSADC	-1.00796 nA	-1.00010 nA	-0.99196 nA	0.00056 nA	Pass	
-100pA DMM	-103.50000 pA	-99.96031 pA	-96.50000 pA	0.06970 pA	Pass	
-100pA HRADC	-103.46031 pA	-99.97800 pA	-96.46031 pA	0.07640 pA	Pass	
-100pA HSADC	-103.46031 pA	-100.00000 pA	-96.46031 pA	0.07640 pA	Pass	
100pA DMM	96.50000 pA	100.00290 pA	103.50000 pA	0.06970 pA	Pass	
100pA HRADC	96.50290 pA	99.97600 pA	103.50290 pA	0.07640 pA	Pass	
100pA HSADC	96.50290 pA	100.00000 pA	103.50290 pA	0.07640 pA	Pass	
1nA DMM	0.99200 nA	0.99999 nA	1.00800 nA	0.00056 nA	Pass	
1nA HRADC	0.99199 nA	1.00001 nA	1.00799 nA	0.00056 nA	Pass	
1nA HSADC	0.99199 nA	1.00005 nA	1.00799 nA	0.00056 nA	Pass	
1.15nA DMM	1.14125 nA	1.15000 nA	1.15875 nA	0.00064 nA	Pass	
1.15nA HRADC	1.14125 nA	1.15003 nA	1.15875 nA	0.00064 nA	Pass	
1.15nA HSADC	1.14125 nA	1.15010 nA	1.15875 nA	0.00064 nA	Pass	

Figure 2-39 E5270A test record example (9/11)

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Description	Minimum	Results	Maximum	Uncertainty	P/F
Slot 4 / MPSMU / I test: 10 nA					
-11.5nA DMM	-11.56450 nA	-11.49954 nA	-11.43550 nA	0.00738 nA	Pass
-11.5nA HRADC	-11.54104 nA	-11.50019 nA	-11.45804 nA	0.00738 nA	Pass
-11.5nA HSADC	-11.54104 nA	-11.50150 nA	-11.45804 nA	0.00738 nA	Pass
-10nA DMM	-10.05700 nA	-9.99734 nA	-9.94300 nA	0.00642 nA	Pass
-10nA HRADC	-10.03734 nA	-9.99986 nA	-9.95734 nA	0.00642 nA	Pass
-10nA HSADC	-10.03734 nA	-10.00050 nA	-9.95734 nA	0.00642 nA	Pass
-1nA DMM	-1.01200 nA	-0.99774 nA	-0.98800 nA	0.00069 nA	Pass
-1nA HRADC	-1.02874 nA	-0.99950 nA	-0.96674 nA	0.00069 nA	Pass
-1nA HSADC	-1.02874 nA	-0.99950 nA	-0.96674 nA	0.00069 nA	Pass
1nA DMM	0.98800 nA	0.99969 nA	1.01200 nA	0.00069 nA	Pass
1nA HRADC	0.96869 nA	0.99948 nA	1.03069 nA	0.00069 nA	Pass
1nA HSADC	0.96869 nA	0.99950 nA	1.03069 nA	0.00069 nA	Pass
10nA DMM	9.94300 nA	9.99939 nA	10.05700 nA	0.00642 nA	Pass
10nA HRADC	9.95939 nA	10.00014 nA	10.03939 nA	0.00642 nA	Pass
10nA HSADC	9.95939 nA	10.00050 nA	10.03939 nA	0.00642 nA	Pass
11.5nA DMM	11.43550 nA	11.49788 nA	11.56450 nA	0.00738 nA	Pass
11.5nA HRADC	11.45638 nA	11.50014 nA	11.53938 nA	0.00738 nA	Pass
11.5nA HSADC	11.45638 nA	11.50050 nA	11.53938 nA	0.00738 nA	Pass
Slot 4 / MPSMU / I test: 100 nA					
-115nA DMM	-115.18800 nA	-115.00157 nA	-114.81200 nA	0.01370 nA	Pass
-115nA HRADC	-115.14657 nA	-115.00540 nA	-114.85657 nA	0.01370 nA	Pass
-115nA HSADC	-115.14657 nA	-115.01500 nA	-114.85657 nA	0.01370 nA	Pass
-100nA DMM	-100.17000 nA	-99.99958 nA	-99.83000 nA	0.01200 nA	Pass
-100nA HRADC	-100.12958 nA	-100.00390 nA	-99.86958 nA	0.01200 nA	Pass
-100nA HSADC	-100.12958 nA	-100.01000 nA	-99.86958 nA	0.01200 nA	Pass
-10nA DMM	-10.06200 nA	-9.99883 nA	-9.93800 nA	0.00244 nA	Pass
-10nA HRADC	-10.03883 nA	-10.00050 nA	-9.95883 nA	0.00263 nA	Pass
-10nA HSADC	-10.03883 nA	-10.00000 nA	-9.95883 nA	0.00263 nA	Pass
10nA DMM	9.93800 nA	10.00144 nA	10.06200 nA	0.00244 nA	Pass
10nA HRADC	9.96144 nA	10.00040 nA	10.04144 nA	0.00263 nA	Pass
10nA HSADC	9.96144 nA	10.00000 nA	10.04144 nA	0.00263 nA	Pass
100nA DMM	99.83000 nA	100.00285 nA	100.17000 nA	0.01200 nA	Pass
100nA HRADC	99.87285 nA	100.00340 nA	100.13285 nA	0.01200 nA	Pass
100nA HSADC	99.87285 nA	100.01000 nA	100.13285 nA	0.01200 nA	Pass
115nA DMM	114.81200 nA	115.00466 nA	115.18800 nA	0.01370 nA	Pass
115nA HRADC	114.85966 nA	115.00520 nA	115.14966 nA	0.01370 nA	Pass
115nA HSADC	114.85966 nA	115.01000 nA	115.14966 nA	0.01370 nA	Pass
Slot 4 / MPSMU / I test: 1 uA					
-1.15uA DMM	-1.15178 uA	-1.14999 uA	-1.14822 uA	0.00024 uA	Pass
-1.15uA HRADC	-1.15134 uA	-1.15001 uA	-1.14864 uA	0.00024 uA	Pass
-1.15uA HSADC	-1.15134 uA	-1.15010 uA	-1.14864 uA	0.00024 uA	Pass
-1uA DMM	-1.00160 uA	-0.99997 uA	-0.99840 uA	0.00021 uA	Pass
-1uA HRADC	-1.00117 uA	-0.99999 uA	-0.99877 uA	0.00021 uA	Pass
-1uA HSADC	-1.00117 uA	-1.00010 uA	-0.99877 uA	0.00021 uA	Pass
-100nA DMM	-100.52000 nA	-99.94059 nA	-99.48000 nA	0.02960 nA	Pass
-100nA HRADC	-100.24059 nA	-99.94800 nA	-99.64059 nA	0.02980 nA	Pass
-100nA HSADC	-100.24059 nA	-99.95000 nA	-99.64059 nA	0.02980 nA	Pass
100nA DMM	99.48000 nA	99.94958 nA	100.52000 nA	0.02960 nA	Pass
100nA HRADC	99.64958 nA	99.94900 nA	100.24958 nA	0.02980 nA	Pass
100nA HSADC	99.64958 nA	99.95000 nA	100.24958 nA	0.02980 nA	Pass
1uA DMM	0.99840 uA	0.99998 uA	1.00160 uA	0.00021 uA	Pass
1uA HRADC	0.99878 uA	0.99999 uA	1.00118 uA	0.00021 uA	Pass
1uA HSADC	0.99878 uA	1.00005 uA	1.00118 uA	0.00021 uA	Pass
1.15uA DMM	1.14822 uA	1.14999 uA	1.15178 uA	0.00024 uA	Pass
1.15uA HRADC	1.14864 uA	1.15001 uA	1.15134 uA	0.00024 uA	Pass
1.15uA HSADC	1.14864 uA	1.15005 uA	1.15134 uA	0.00024 uA	Pass

Calibration
 Printing Test Result

Figure 2-40 E5270A test record example (10/11)

E5270A JP10A00101 Page 10/11

Description	Minimum	Results	Maximum	Uncertainty	P/F
Slot 4 / MPSMU / I test: 10 uA					
-11.5uA DMM	-11.51880 uA	-11.49921 uA	-11.48120 uA	0.00083 uA	Pass
-11.5uA HRADC	-11.51371 uA	-11.50030 uA	-11.48471 uA	0.00084 uA	Pass
-11.5uA HSADC	-11.51371 uA	-11.50150 uA	-11.48471 uA	0.00084 uA	Pass
-10uA DMM	-10.01700 uA	-9.99915 uA	-9.98300 uA	0.00073 uA	Pass
-10uA HRADC	-10.01215 uA	-10.00005 uA	-9.98615 uA	0.00074 uA	Pass
-10uA HSADC	-10.01215 uA	-10.00100 uA	-9.98615 uA	0.00074 uA	Pass
-1uA DMM	-1.00620 uA	-0.99961 uA	-0.99380 uA	0.00022 uA	Pass
-1uA HRADC	-1.00361 uA	-0.99977 uA	-0.99561 uA	0.00024 uA	Pass
-1uA HSADC	-1.00361 uA	-1.00000 uA	-0.99561 uA	0.00024 uA	Pass
1uA DMM	0.99380 uA	0.99980 uA	1.00620 uA	0.00022 uA	Pass
1uA HRADC	0.99580 uA	0.99981 uA	1.00380 uA	0.00024 uA	Pass
1uA HSADC	0.99580 uA	1.00000 uA	1.00380 uA	0.00024 uA	Pass
10uA DMM	9.98300 uA	9.99966 uA	10.01700 uA	0.00073 uA	Pass
10uA HRADC	9.98666 uA	10.00040 uA	10.01266 uA	0.00074 uA	Pass
10uA HSADC	9.98666 uA	10.00100 uA	10.01266 uA	0.00074 uA	Pass
11.5uA DMM	11.48120 uA	11.49944 uA	11.51880 uA	0.00083 uA	Pass
11.5uA HRADC	11.48494 uA	11.50026 uA	11.51394 uA	0.00084 uA	Pass
11.5uA HSADC	11.48494 uA	11.50100 uA	11.51394 uA	0.00084 uA	Pass
Slot 4 / MPSMU / I test: 100 uA					
-115uA DMM	-115.17800 uA	-114.98507 uA	-114.82200 uA	0.00290 uA	Pass
-115uA HRADC	-115.12007 uA	-114.99900 uA	-114.85007 uA	0.00294 uA	Pass
-115uA HSADC	-115.12007 uA	-115.01000 uA	-114.85007 uA	0.00294 uA	Pass
-100uA DMM	-100.16000 uA	-99.98787 uA	-99.84000 uA	0.00256 uA	Pass
-100uA HRADC	-100.10787 uA	-100.00020 uA	-99.86787 uA	0.00261 uA	Pass
-100uA HSADC	-100.10787 uA	-100.01000 uA	-99.86787 uA	0.00261 uA	Pass
-10uA DMM	-10.05200 uA	-9.99625 uA	-9.94800 uA	0.00098 uA	Pass
-10uA HRADC	-10.02625 uA	-9.99750 uA	-9.96625 uA	0.00110 uA	Pass
-10uA HSADC	-10.02625 uA	-10.00000 uA	-9.96625 uA	0.00110 uA	Pass
10uA DMM	9.94800 uA	9.99676 uA	10.05200 uA	0.00098 uA	Pass
10uA HRADC	9.96676 uA	9.99880 uA	10.02676 uA	0.00110 uA	Pass
10uA HSADC	9.96676 uA	10.00000 uA	10.02676 uA	0.00110 uA	Pass
100uA DMM	99.84000 uA	99.98822 uA	100.16000 uA	0.00256 uA	Pass
100uA HRADC	99.86822 uA	100.00080 uA	100.10822 uA	0.00261 uA	Pass
100uA HSADC	99.86822 uA	100.00500 uA	100.10822 uA	0.00261 uA	Pass
115uA DMM	114.82200 uA	114.98649 uA	115.17800 uA	0.00290 uA	Pass
115uA HRADC	114.85149 uA	114.99990 uA	115.12149 uA	0.00294 uA	Pass
115uA HSADC	114.85149 uA	115.00500 uA	115.12149 uA	0.00294 uA	Pass
Slot 4 / MPSMU / I test: 1 mA					
-1.15mA DMM	-1.15188 mA	-1.15002 mA	-1.14812 mA	0.00003 mA	Pass
-1.15mA HRADC	-1.15147 mA	-1.15001 mA	-1.14857 mA	0.00003 mA	Pass
-1.15mA HSADC	-1.15147 mA	-1.15010 mA	-1.14857 mA	0.00003 mA	Pass
-1mA DMM	-1.00170 mA	-1.00000 mA	-0.99830 mA	0.00002 mA	Pass
-1mA HRADC	-1.00130 mA	-0.99999 mA	-0.99870 mA	0.00003 mA	Pass
-1mA HSADC	-1.00130 mA	-1.00010 mA	-0.99870 mA	0.00003 mA	Pass
-100uA DMM	-100.62000 uA	-99.97825 uA	-99.38000 uA	0.00656 uA	Pass
-100uA HRADC	-100.37825 uA	-99.96800 uA	-99.57825 uA	0.01100 uA	Pass
-100uA HSADC	-100.37825 uA	-100.00000 uA	-99.57825 uA	0.01100 uA	Pass
100uA DMM	99.38000 uA	99.99128 uA	100.62000 uA	0.00656 uA	Pass
100uA HRADC	99.59128 uA	99.99700 uA	100.39128 uA	0.01100 uA	Pass
100uA HSADC	99.59128 uA	100.00000 uA	100.39128 uA	0.01100 uA	Pass
1mA DMM	0.99830 mA	1.00001 mA	1.00170 mA	0.00002 mA	Pass
1mA HRADC	0.99871 mA	1.00002 mA	1.00131 mA	0.00003 mA	Pass
1mA HSADC	0.99871 mA	1.00005 mA	1.00131 mA	0.00003 mA	Pass
1.15mA DMM	1.14812 mA	1.15008 mA	1.15188 mA	0.00003 mA	Pass
1.15mA HRADC	1.14863 mA	1.15008 mA	1.15153 mA	0.00003 mA	Pass
1.15mA HSADC	1.14863 mA	1.15015 mA	1.15153 mA	0.00003 mA	Pass

Figure 2-41 E5270A test record example (11/11)

Description	Minimum	Results	Maximum	Uncertainty	P/F
E5270A JP10A00101 Page 11/11					
Slot 4 / MPSMU / I test: 10 mA					
-11.5mA DMM	-11.51780 mA	-11.50089 mA	-11.48220 mA	0.00028 mA	Pass
-11.5mA HRADC	-11.51439 mA	-11.50020 mA	-11.48739 mA	0.00028 mA	Pass
-11.5mA HSADC	-11.51439 mA	-11.50150 mA	-11.48739 mA	0.00028 mA	Pass
-10mA DMM	-10.01600 mA	-10.00031 mA	-9.98400 mA	0.00025 mA	Pass
-10mA HRADC	-10.01231 mA	-9.99991 mA	-9.98831 mA	0.00025 mA	Pass
-10mA HSADC	-10.01231 mA	-10.00100 mA	-9.98831 mA	0.00025 mA	Pass
-1mA DMM	-1.00520 mA	-0.99962 mA	-0.99480 mA	0.00007 mA	Pass
-1mA HRADC	-1.00262 mA	-0.99961 mA	-0.99662 mA	0.00007 mA	Pass
-1mA HSADC	-1.00262 mA	-0.99950 mA	-0.99662 mA	0.00007 mA	Pass
1mA DMM	0.99480 mA	0.99964 mA	1.00520 mA	0.00007 mA	Pass
1mA HRADC	0.99664 mA	0.99968 mA	1.00264 mA	0.00007 mA	Pass
1mA HSADC	0.99664 mA	0.99950 mA	1.00264 mA	0.00007 mA	Pass
10mA DMM	9.98400 mA	10.00014 mA	10.01600 mA	0.00025 mA	Pass
10mA HRADC	9.98814 mA	9.99992 mA	10.01214 mA	0.00025 mA	Pass
10mA HSADC	9.98814 mA	10.00050 mA	10.01214 mA	0.00025 mA	Pass
11.5mA DMM	11.48220 mA	11.50074 mA	11.51780 mA	0.00028 mA	Pass
11.5mA HRADC	11.48724 mA	11.50026 mA	11.51424 mA	0.00028 mA	Pass
11.5mA HSADC	11.48724 mA	11.50100 mA	11.51424 mA	0.00028 mA	Pass
Slot 4 / MPSMU / I test: 100 mA					
-115mA DMM	-115.18800 mA	-115.00994 mA	-114.81200 mA	0.00473 mA	Pass
-115mA HRADC	-115.15494 mA	-115.00060 mA	-114.86494 mA	0.00482 mA	Pass
-115mA HSADC	-115.15494 mA	-115.01000 mA	-114.86494 mA	0.00482 mA	Pass
-100mA DMM	-100.17000 mA	-100.00933 mA	-99.83000 mA	0.00413 mA	Pass
-100mA HRADC	-100.13933 mA	-100.00030 mA	-99.87933 mA	0.00422 mA	Pass
-100mA HSADC	-100.13933 mA	-100.01000 mA	-99.87933 mA	0.00422 mA	Pass
-10mA DMM	-10.06200 mA	-9.99822 mA	-9.93800 mA	0.00074 mA	Pass
-10mA HRADC	-10.03822 mA	-9.99660 mA	-9.95822 mA	0.00115 mA	Pass
-10mA HSADC	-10.03822 mA	-9.99500 mA	-9.95822 mA	0.00115 mA	Pass
10mA DMM	9.93800 mA	9.99940 mA	10.06200 mA	0.00074 mA	Pass
10mA HRADC	9.95940 mA	9.99950 mA	10.03940 mA	0.00115 mA	Pass
10mA HSADC	9.95940 mA	10.00500 mA	10.03940 mA	0.00115 mA	Pass
100mA DMM	99.83000 mA	100.00962 mA	100.17000 mA	0.00413 mA	Pass
100mA HRADC	99.87962 mA	100.00270 mA	100.13962 mA	0.00422 mA	Pass
100mA HSADC	99.87962 mA	100.01000 mA	100.13962 mA	0.00422 mA	Pass
115mA DMM	114.81200 mA	115.01568 mA	115.18800 mA	0.00473 mA	Pass
115mA HRADC	114.87068 mA	115.00700 mA	115.16068 mA	0.00482 mA	Pass
115mA HSADC	114.87068 mA	115.01500 mA	115.16068 mA	0.00482 mA	Pass
Slot 4 / MPSMU / I test: 200 mA					
-200mA DMM	-200.34000 mA	-200.00370 mA	-199.66000 mA	0.02800 mA	Pass
-200mA HRADC	-200.26370 mA	-200.00240 mA	-199.74370 mA	0.02820 mA	Pass
-200mA HSADC	-200.26370 mA	-200.02000 mA	-199.74370 mA	0.02820 mA	Pass
-20mA DMM	-20.12400 mA	-20.00332 mA	-19.87600 mA	0.01200 mA	Pass
-20mA HRADC	-20.08332 mA	-20.00260 mA	-19.92332 mA	0.01240 mA	Pass
-20mA HSADC	-20.08332 mA	-20.00000 mA	-19.92332 mA	0.01240 mA	Pass
20mA DMM	19.87600 mA	20.00216 mA	20.12400 mA	0.01200 mA	Pass
20mA HRADC	19.92216 mA	20.00220 mA	20.08216 mA	0.01240 mA	Pass
20mA HSADC	19.92216 mA	20.00000 mA	20.08216 mA	0.01240 mA	Pass
200mA DMM	199.66000 mA	200.00696 mA	200.34000 mA	0.02800 mA	Pass
200mA HRADC	199.74696 mA	200.00860 mA	200.26696 mA	0.02820 mA	Pass
200mA HSADC	199.74696 mA	200.02000 mA	200.26696 mA	0.02820 mA	Pass
Slot 4 / MPSMU / CMR test					
	-4.00000 uA	0.55000 uA	4.00000 uA		Pass

3 Troubleshooting

Introduction

This chapter describes the Agilent E5260/E5270 troubleshooting procedures and the reference information, and consists of the following sections.

- “Introduction”
- “Troubleshooting Flow”
- “Troubleshooting Reference”

WARNING The information in this manual is provided for use by service trained personnel only. To avoid electrical shock, do not perform any procedures in this manual unless you are qualified to do so.

Potential shock hazard. Dangerous voltage may be present on the board assembly (including shield cover) for up to 10 seconds after you set the Line switch to off.

- **Power supply module: ± 300 V maximum**
 - **Other modules: ± 270 V maximum**
-

CAUTION Before you start the troubleshooting, clear any obstructions around the fans and cooling air holes. Before you access the inside of the instrument, make sure the power is turned off.

Troubleshooting tools

The troubleshooting in this chapter is performed by using the following tools:

- Built-in selftest and diagnostics
- Performance verification (PV) software

When you use the above tools, you may also perform the following to isolate the problem.

- Disconnect the connection between two assemblies, then perform the test.
- Remove an assembly, then perform the test.
- Swap on SMU module with another SMU module, then perform the test.
- Detach the power supply, and turn on the power supply only.

After repair

If you replace or swap a module or a board, you need to do the performance verification, calibration, and so on. See Chapter 5 for details.

Notes for troubleshooting

- Before an assembly replacement, try to reconnect the cable or reinstall the assembly to check the connections. Sometimes bad connections cause problems.
- Before you start the troubleshooting, confirm the GPIB address, line frequency, and firmware revision so that you can set them properly when the troubleshooting is done.
- The only difference between the E5262A/ E5272A and E5263A/E5273A is the SMU module configuration. When the power is turned on, the SMU module ID is checked and if both of the two SMUs are recognized as MPSMU, the instrument is identified as E5262A/E5272A. If MPSMU is recognized at slot 1 and HPSMSU at slot 2, the instrument is identified as E5263A/ E5273A.

CAUTION Do not block the ventilation opening on the side covers. Otherwise, thermal damage might occur.

Notes on E5260A/E5270A/E5270B modules and components

The following are notes for each module and component in the E5260A/E5270A/E5270B.

- Power supply module
 - ❑ The power supply module can operate with AC voltage 90 V to 260 V without any manual switching.
 - ❑ Each DC output line has the detection circuit for over load, over voltage, and under voltage. If any abnormal condition is detected, the power supply module shuts down by itself.
 - ❑ The power supply module detects the fan revolution speed. If the power supply fan slows down or stops, the power supply module detects it.
 - ❑ There is no serviceable part inside the power supply module. Do not open and access the inside.
 - ❑ The cable that connects the power supply module with the motherboard is set as a part of the power supply module.
 - ❑ The fuse is located inside the power supply module and is accessible from outside the module.
 - ❑ In the troubleshooting process, you may need to refer to the two LED error indicators on the instrument's rear panel. The picture below shows the location of the LEDs.

Figure 3-1 Rear panel LED error indicators



Introduction

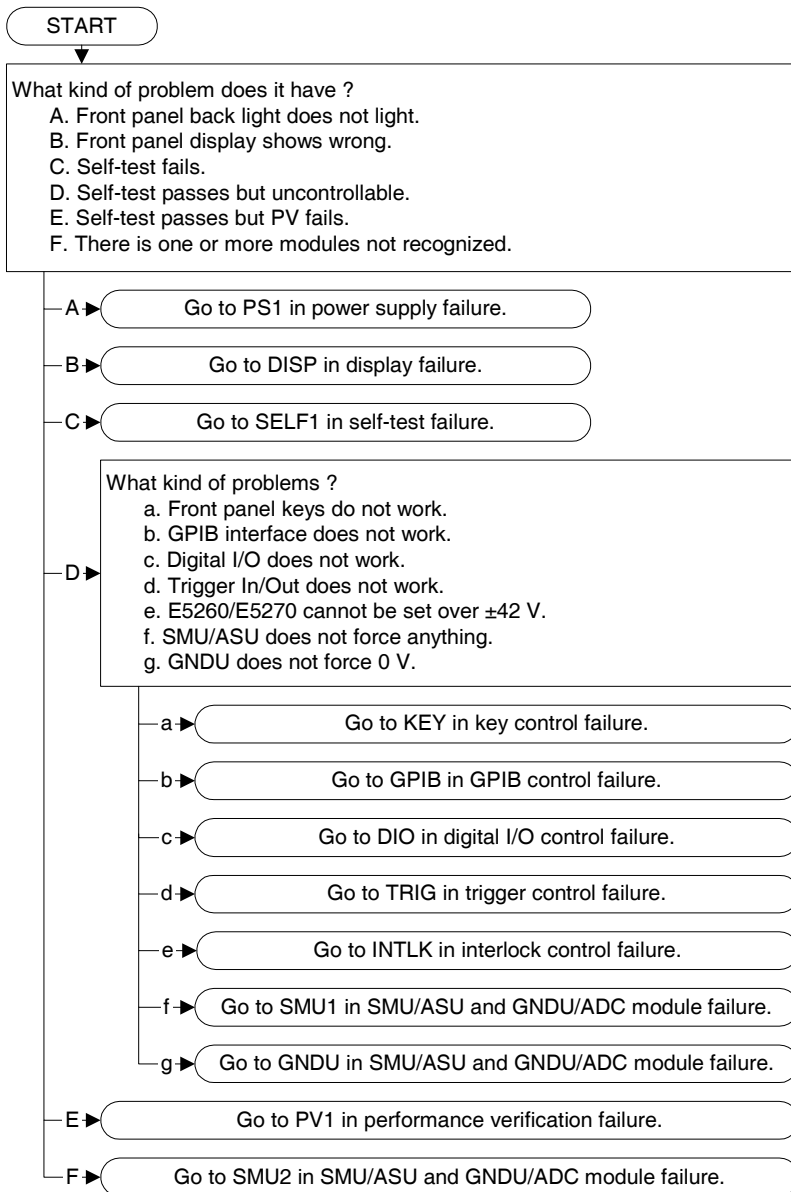
- Frame fan
 - ❑ The frame fan revolution is monitored by the CPU board. If the fans slow down or stop, this is detected as an error and shutdown occurs. It takes about 10 seconds before the shutdown is implemented.
 - ❑ If the fans are connected to the wrong connectors, shutdown occurs because the CPU board detects the error.
- LCD backlight
 - ❑ The LED array is used to provide power to the LCD backlight. No high voltage is used.
- GNDU/ADC module
 - ❑ If there are failures in ADC tests, the self-tests for the SMU will not be performed. However, if there are failures in the GNDU, the self-tests for the SMU will still be performed. If there are failures in the ADC tests, the self-tests for the SMU will not be performed. However, if there are failures in GNDU, the self-tests for the SMU will still be performed. If the self-test for the GNDU/ADC fails, the output relay will stay open, but the GNDU output will remain connected to the chassis common via the 11 k Ω resistor.
 - ❑ If the self-test for the GNDU/ADC fails, the output relay will stay open, but the GNDU output will remain connected to the chassis common via the 11 k Ω resistor.
- CPU module
 - ❑ If the CPU module has an error where the CPU module can still give an error code, the self-test for the GNDU/ADC module and the SMU module will be executed.
 - ❑ If the CPU module is installed but the front board is not installed, the CPU module fails the LCD read/write self-test, and the self-test error 716 occurs.
 - ❑ If the CPU module is installed but the GNDU/ADC module is not installed, the GNDU/ADC module fails the self-test, and the self-test error 720 occurs.
 - ❑ The SMU module for each mainframe has not compatibility. For example, MPSMU for E5260A does not work with E5270A or E5270B.

NOTE The SMU module for each mainframe has not compatibility. For example, MPSMU for E5260A does not work with E5270A or E5270B.

Troubleshooting Flow

This section describes the troubleshooting flow for the E5260/E5270 series. Start from START in Figure 3-2.

Figure 3-2 Troubleshooting start



Power supply failure

Figure 3-3 If power supply back light does not light

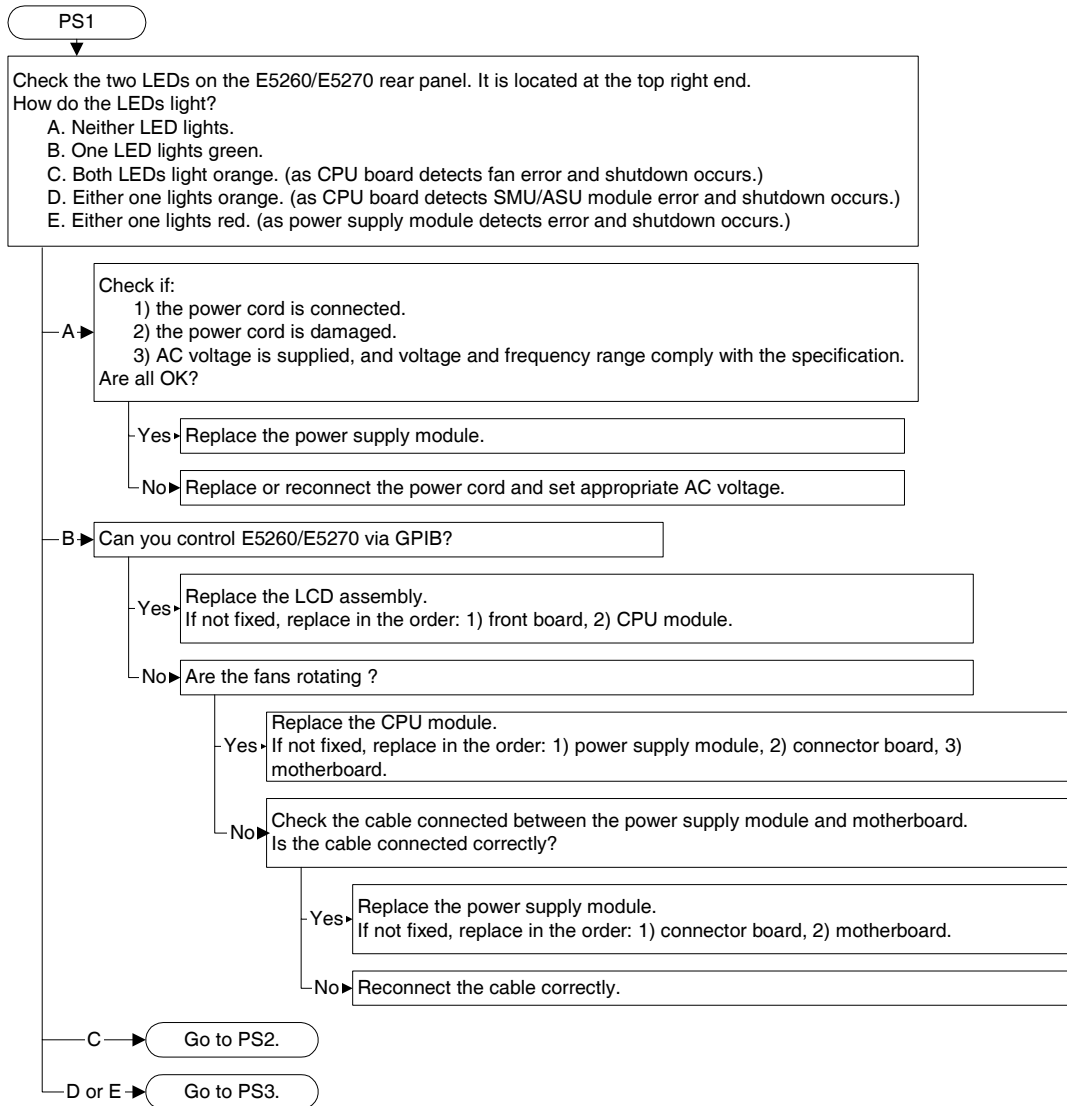


Figure 3-4 If both LEDs on rear panel light orange

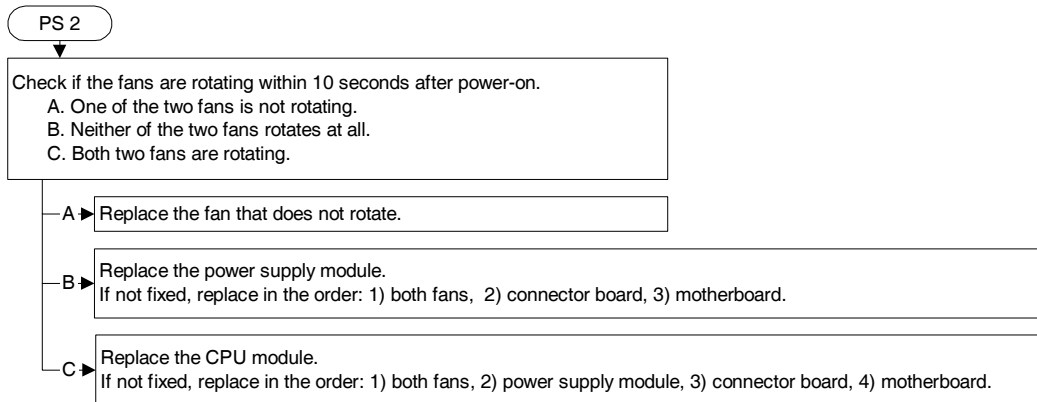


Figure 3-5 If one of LEDs on rear panel lights orange or red

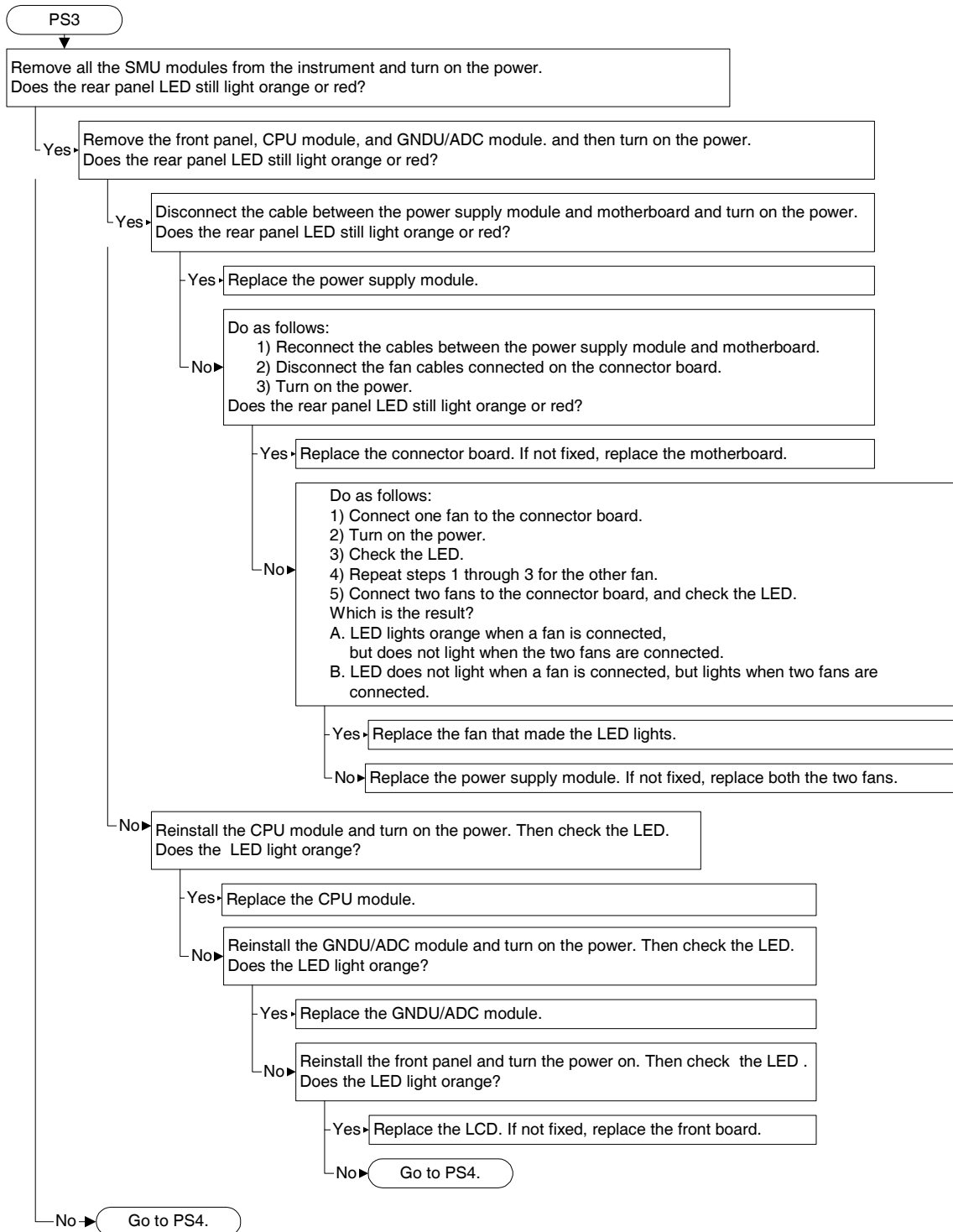
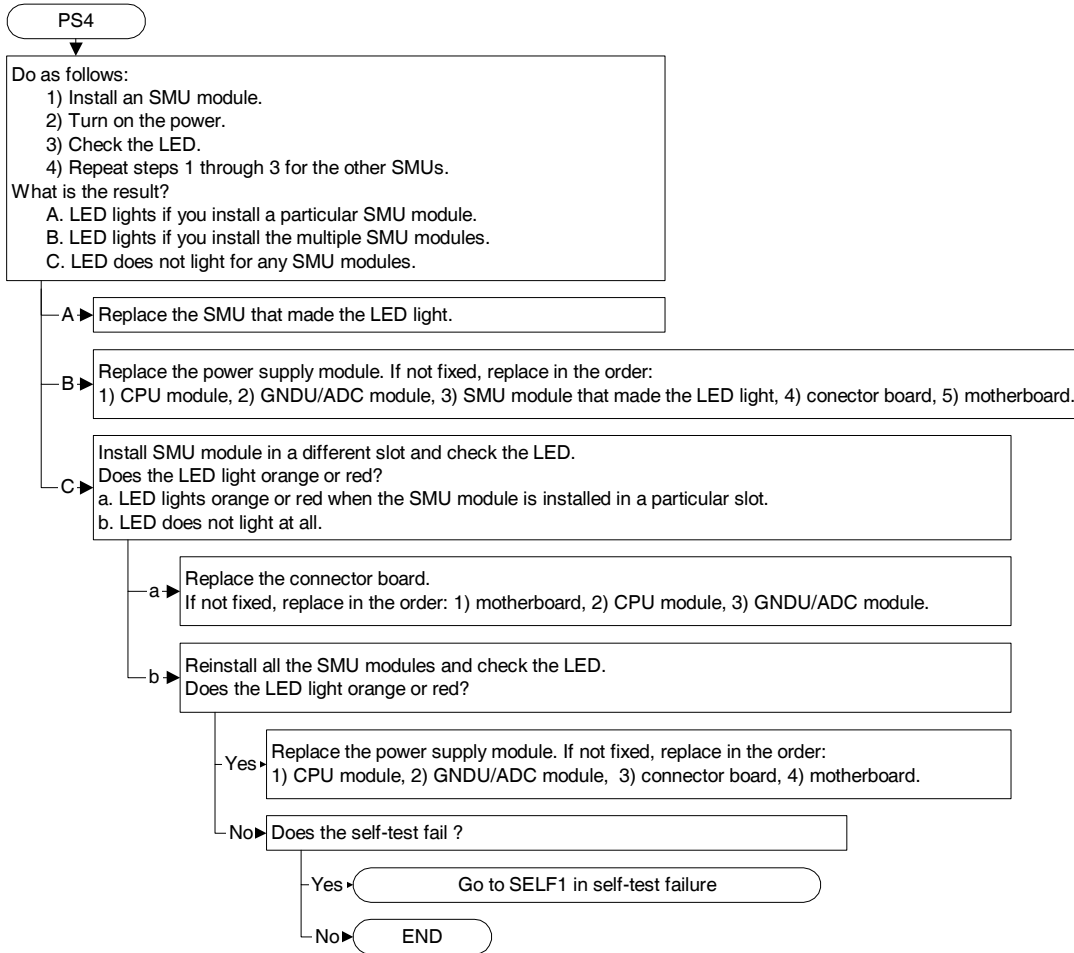
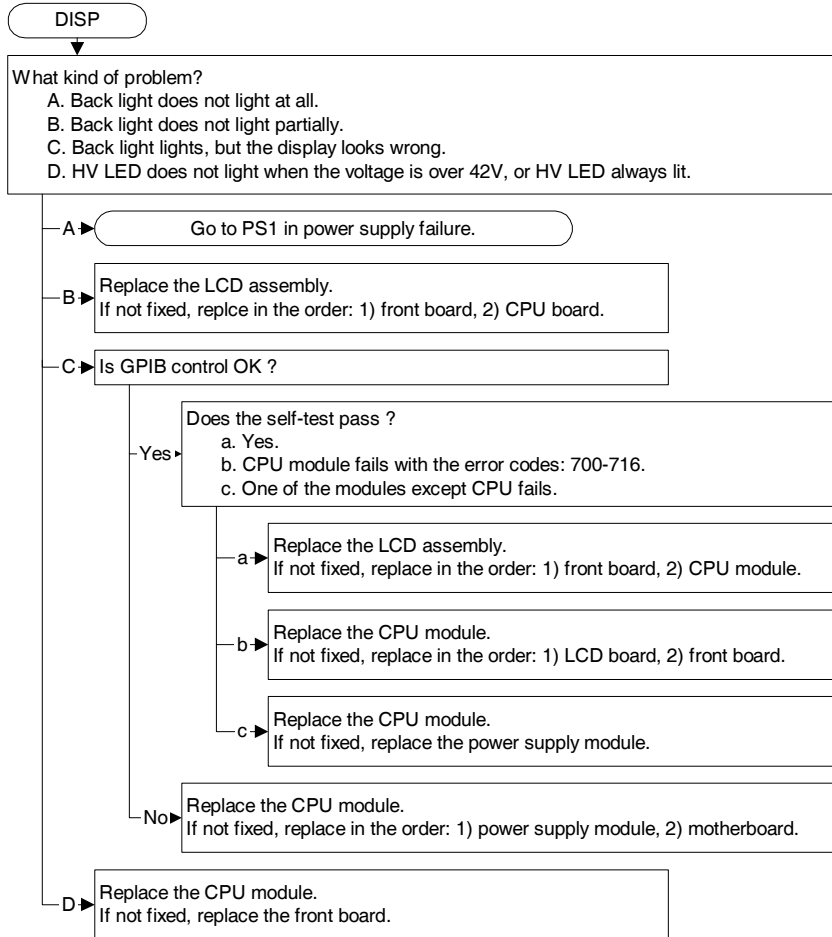


Figure 3-6 If one of rear panel LEDs lights orange or red when SMU/ASU module is installed



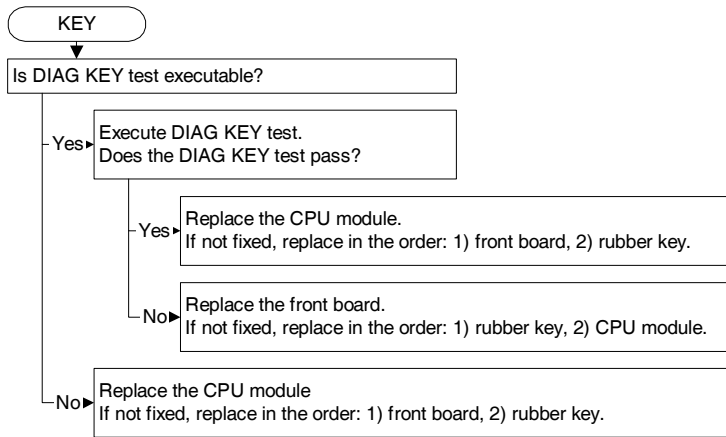
Front display failure

Figure 3-7 If front display looks wrong or back light does not light



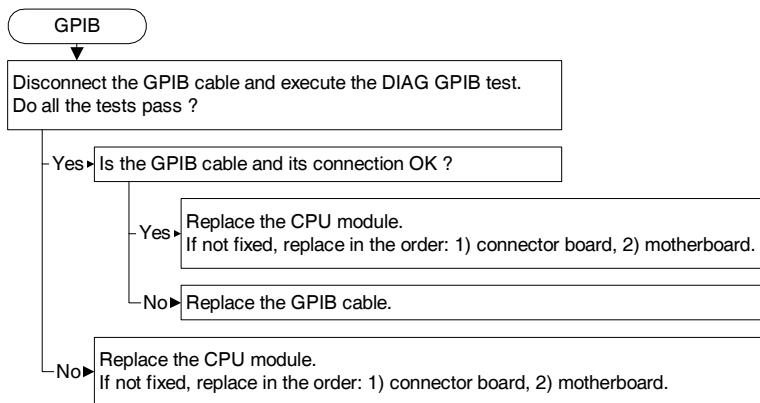
Front key failure

Figure 3-8 If front panel keys do not work



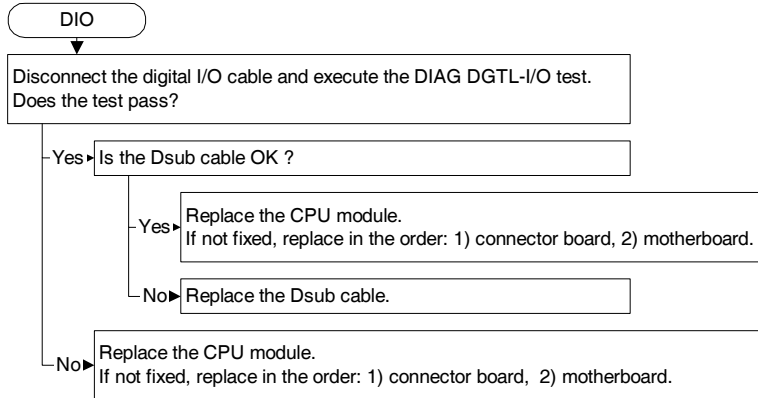
GPIB control failure

Figure 3-9 If GPIB control fails



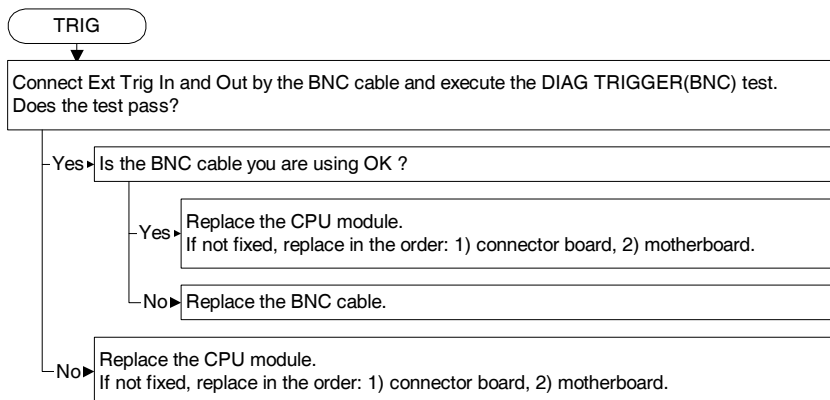
Digital I/O control failure

Figure 3-10 If digital I/O control fails



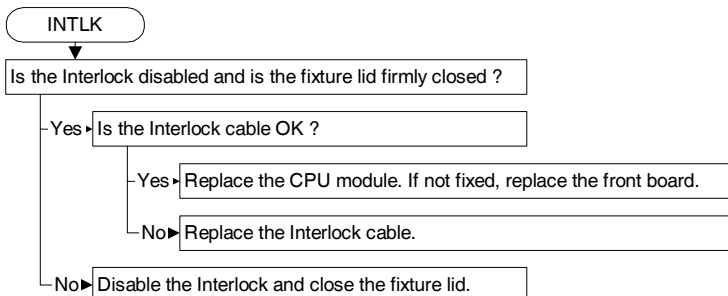
Trigger control failure

Figure 3-11 If trigger control fails but self-test passes



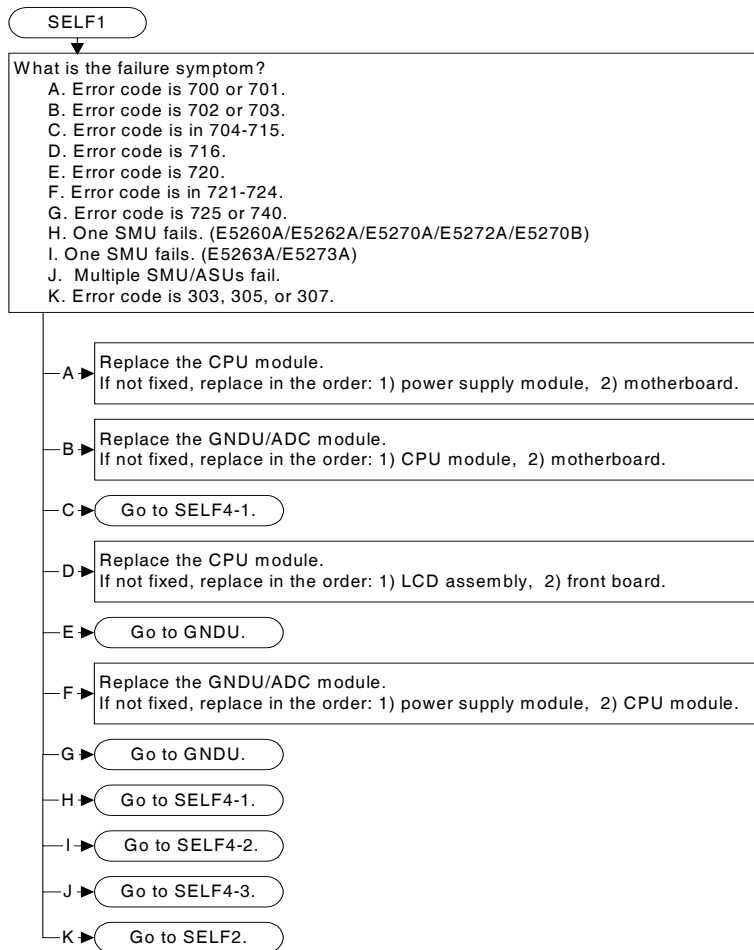
Interlock control failure

Figure 3-12 If interlock control fail (voltage over 42 V cannot be output)



Self-test failure

Figure 3-13 If the self-test fails



Troubleshooting
Troubleshooting Flow

Figure 3-14 If self-test fails with error code 303, 305, or 307

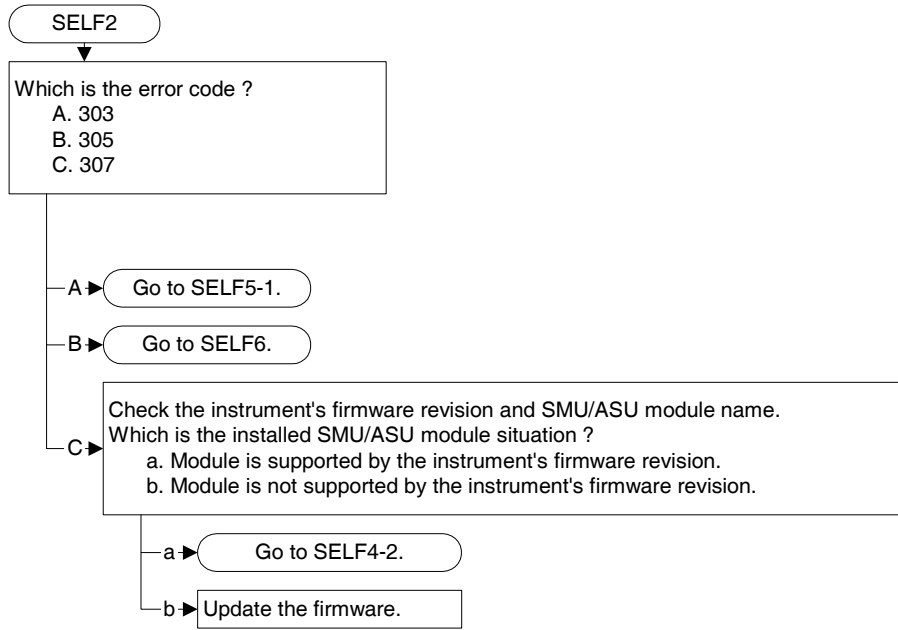
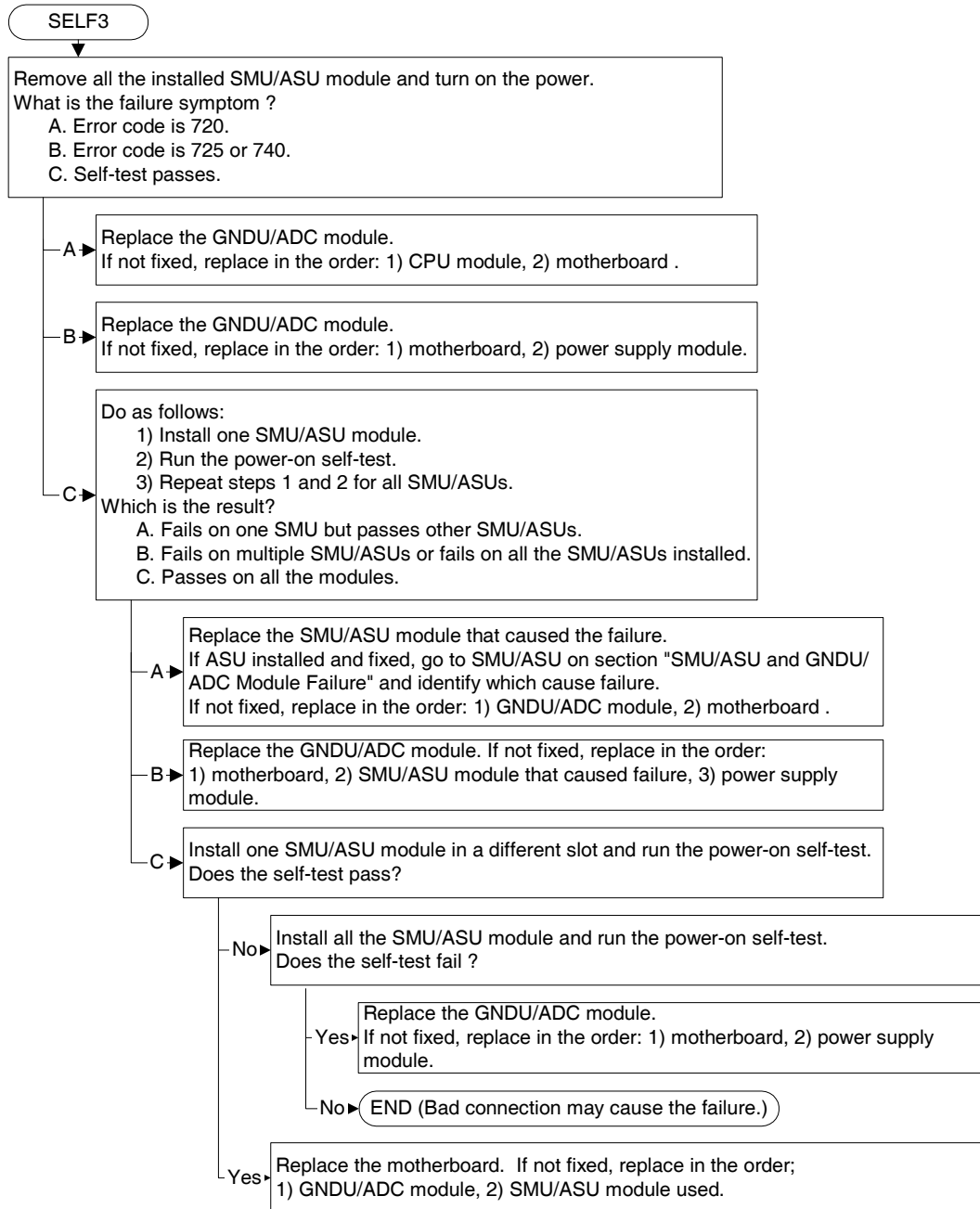


Figure 3-15 If GNDU or ADC self-test fails or ADC not installed; error code: 720, 725 or 740



Troubleshooting
Troubleshooting Flow

Figure 3-16 If only one SMU/ASU self-test fails (E5260A/E5262A/E5270A/E5272A/E5270B only)

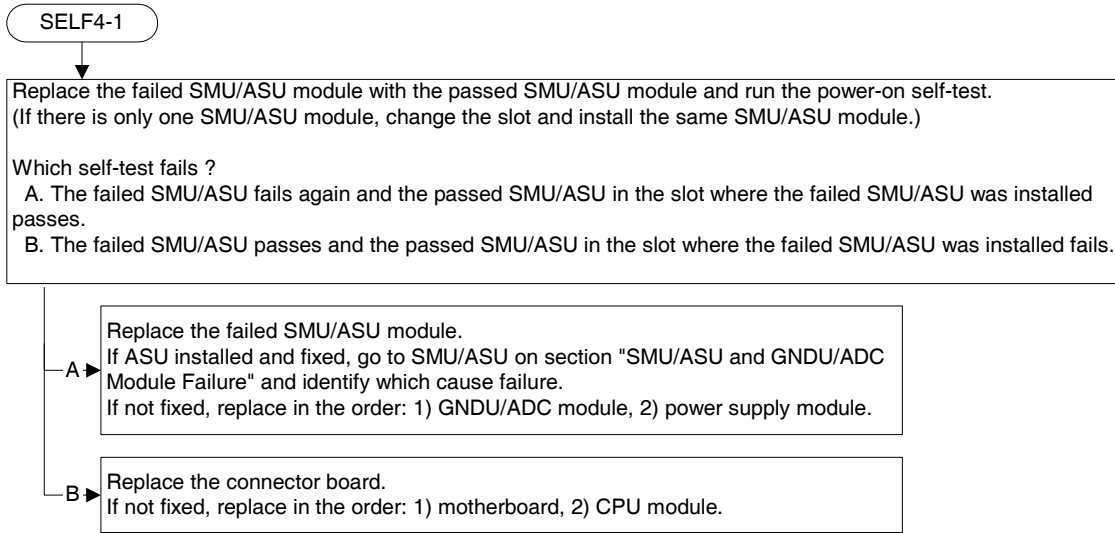


Figure 3-17 If only one SMU self-test fails (E5263A/E5273A only)

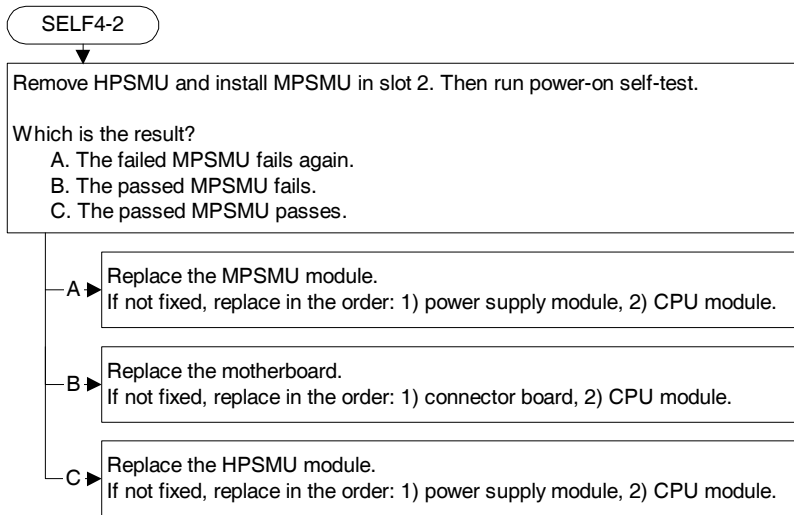
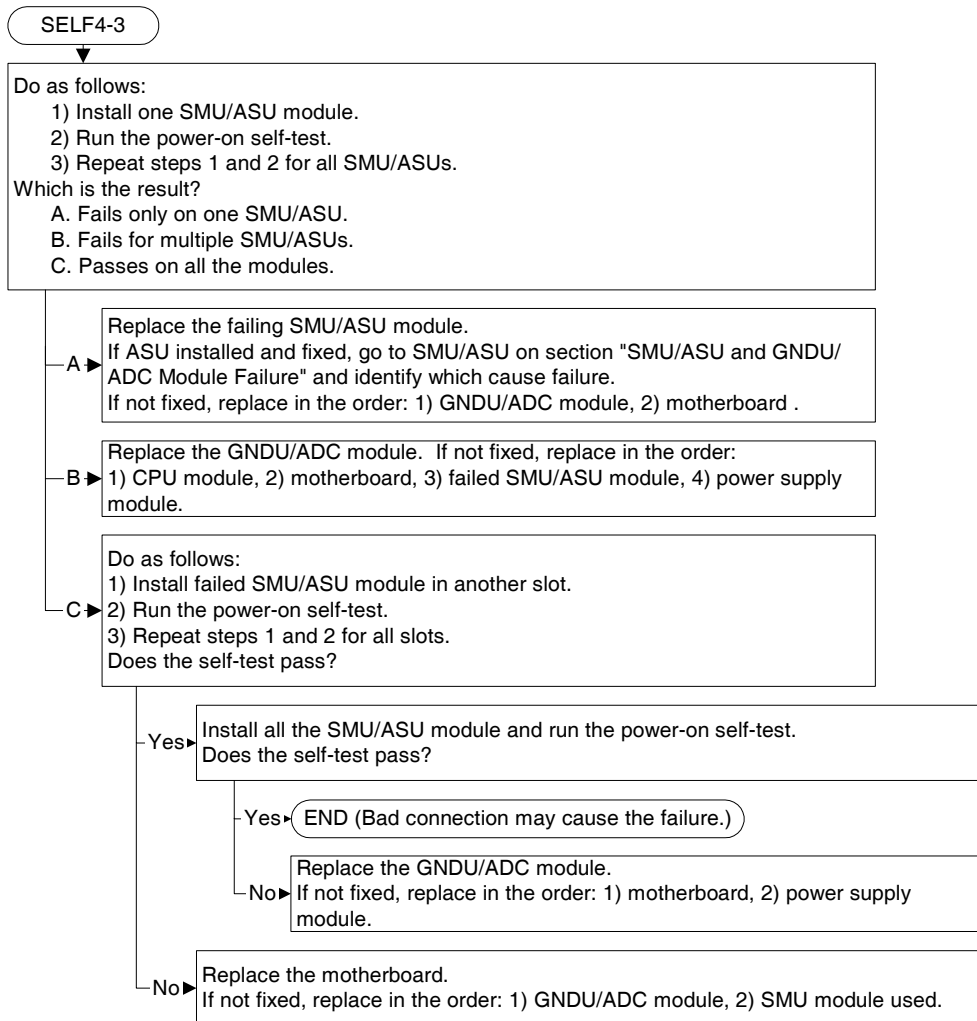


Figure 3-18 If CPU self-test fails with SMU/ASU status check fail 704-715 or multiple self-tests fail



Troubleshooting
Troubleshooting Flow

Figure 3-19 If self-test fails with an error code 303: excess voltage in MPSMU/HRSMU/ASU

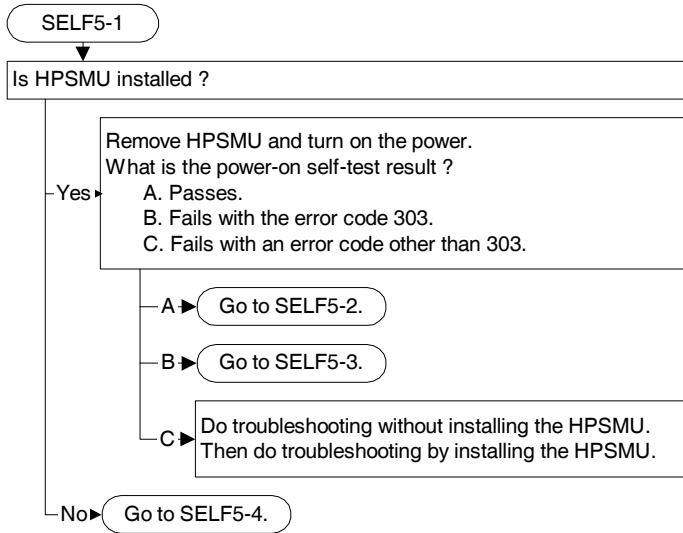


Figure 3-20 If SMU/ASU self-test fails when installing HPSMU with an error code 303

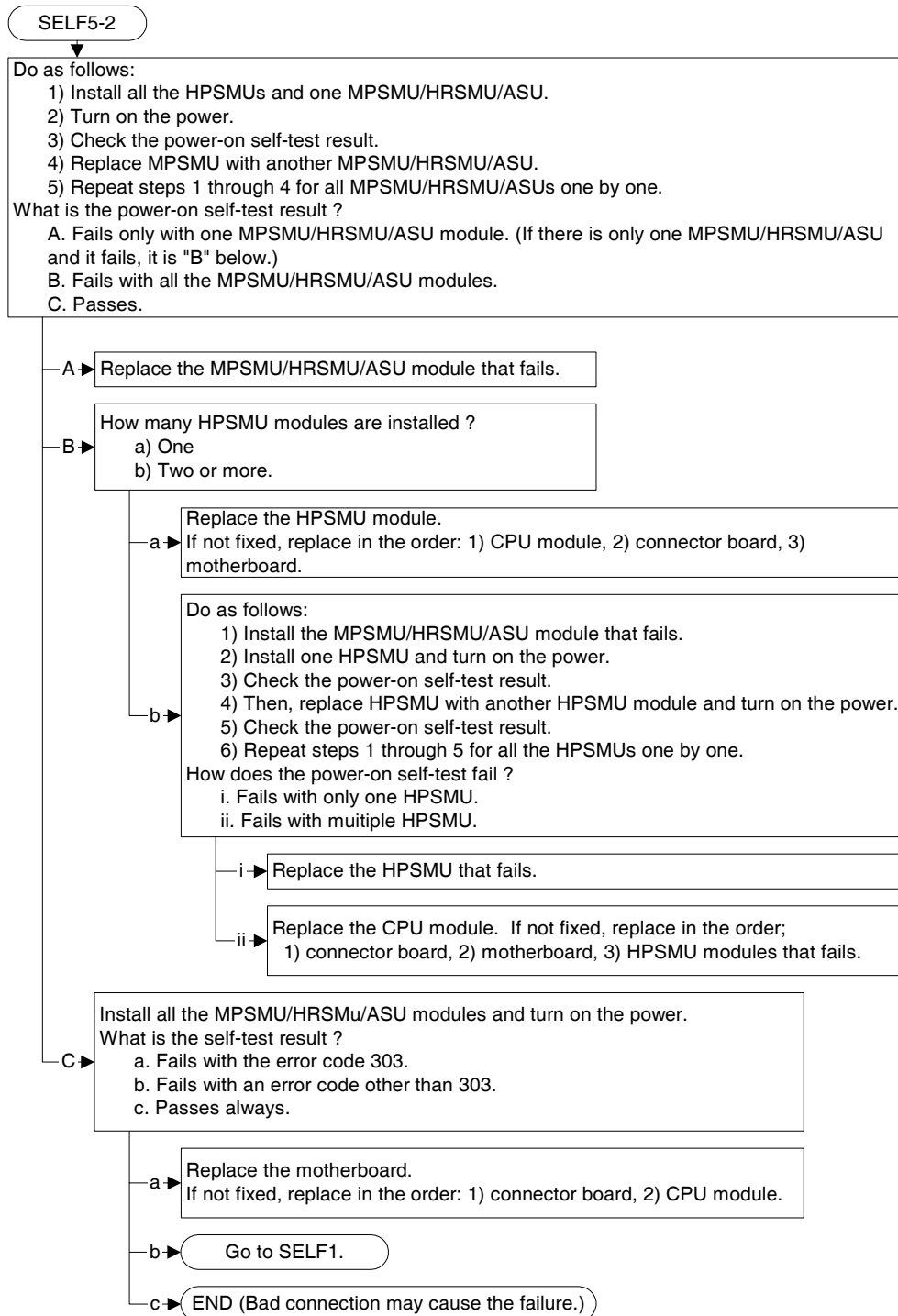


Figure 3-21 If SMU/ASU self-test fails when HPSMU is deinstalled with an error code 303

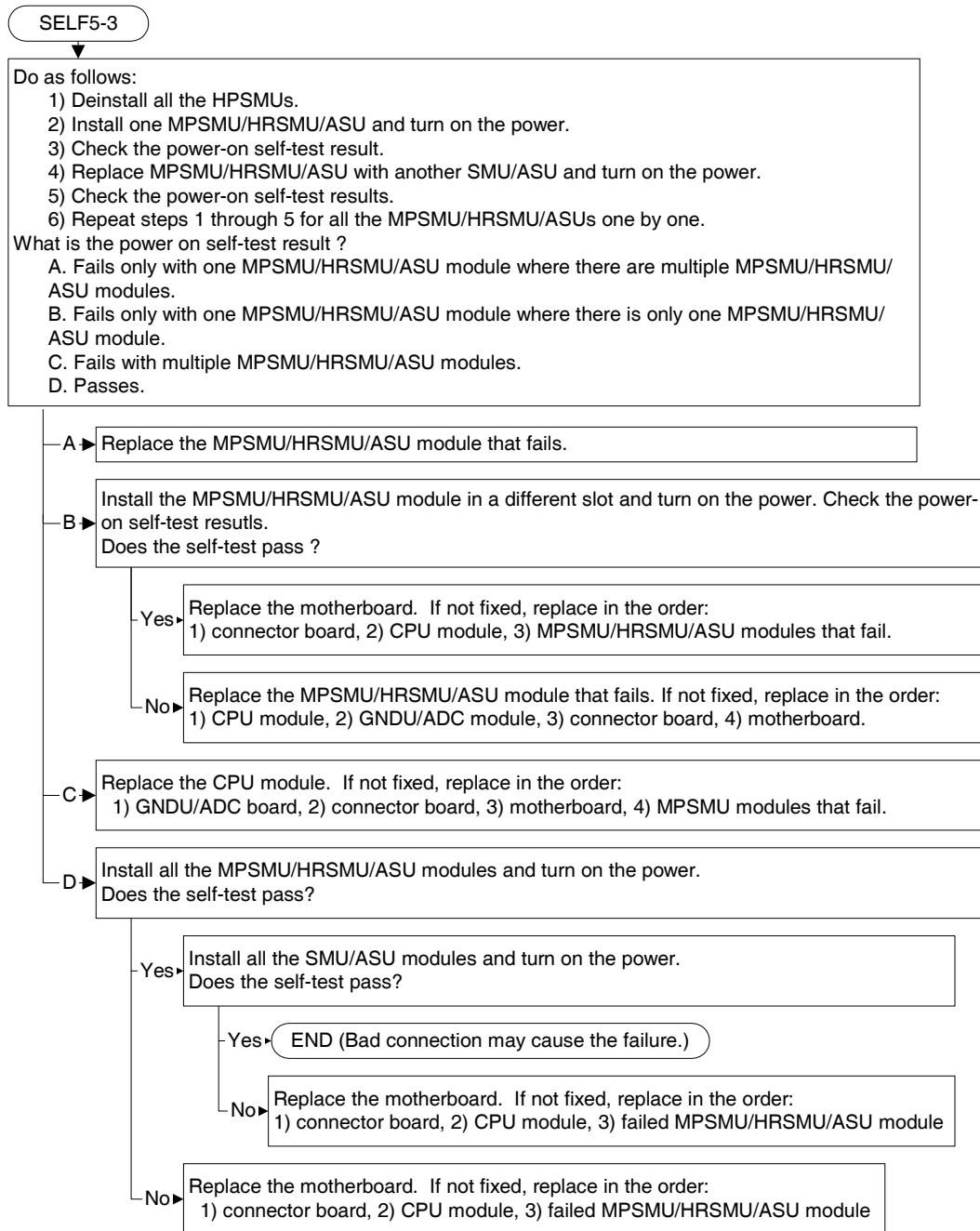


Figure 3-22 If SMU/ASU self-test fails with an error code 303: MPSMU/HRSMU/ASU install error only

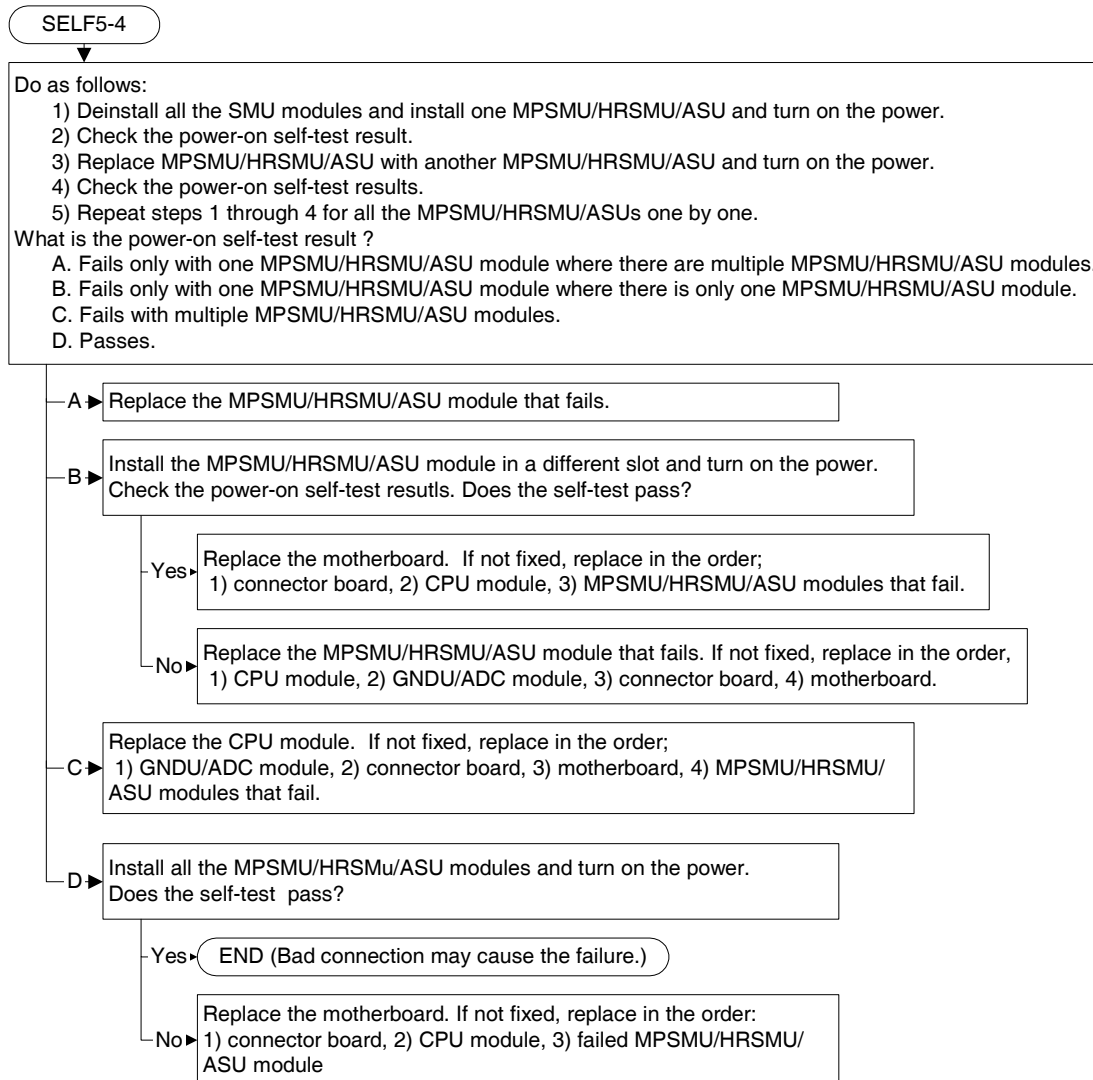
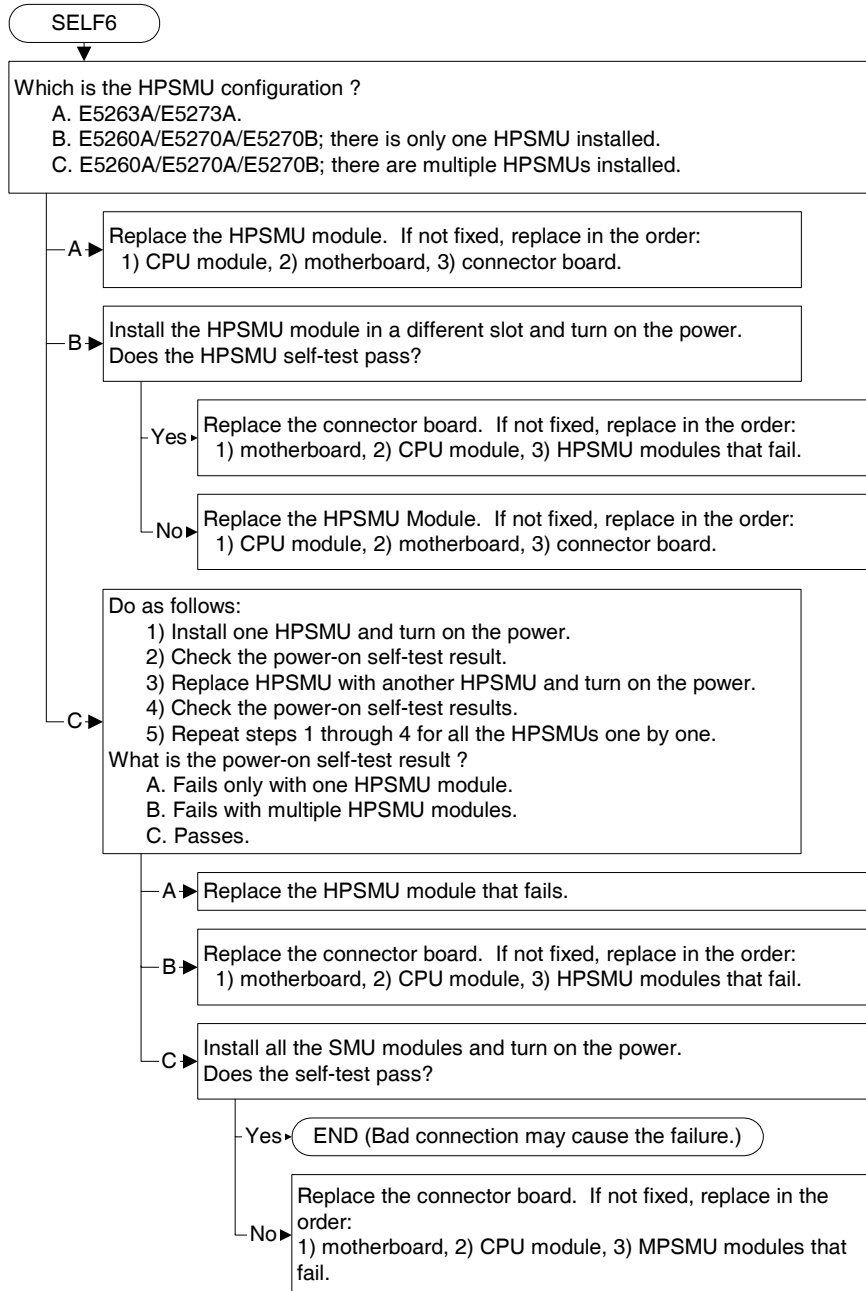


Figure 3-23 If SMU self-test fails with an error code 305: excess current in HPSMU



SMU/ASU and GNDU/ADC Module Failure

This section describes the troubleshooting procedure for SMU and GNDU/ADU module related failures.

Figure 3-24 If SMU/ASU module fails (there is no output from SMU/ASU)

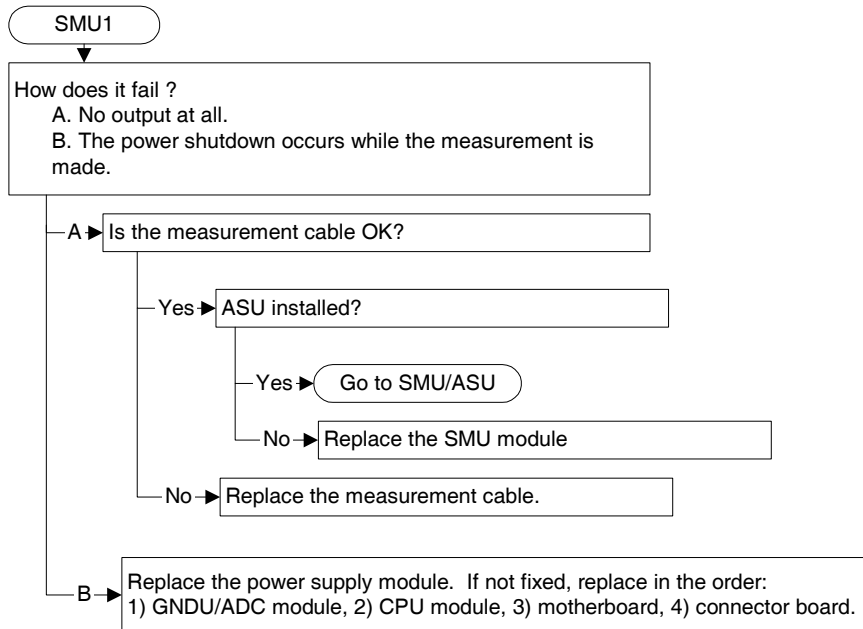


Figure 3-25 If SMU module fails (module not recognized by CPU)

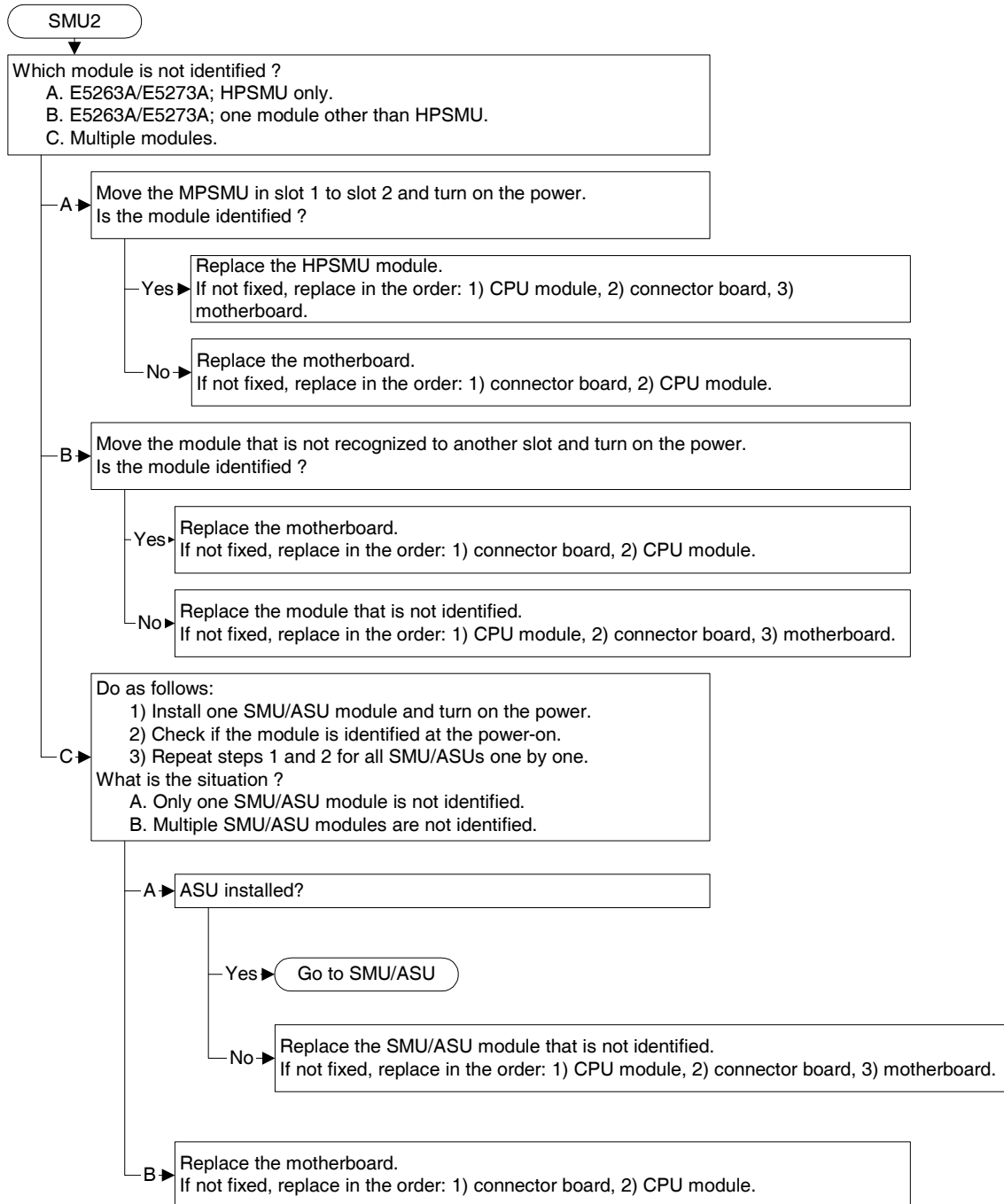


Figure 3-26 If HRSMU+ASU fails

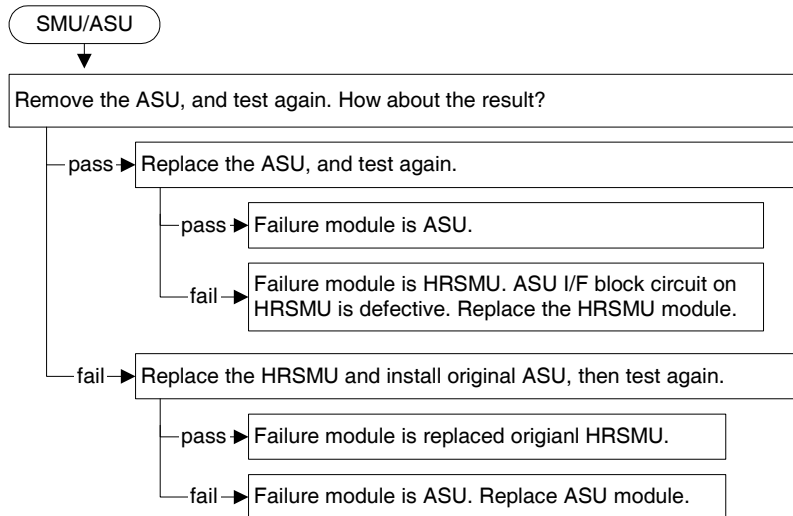
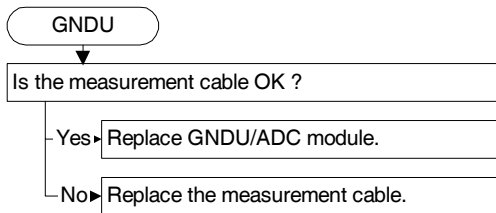
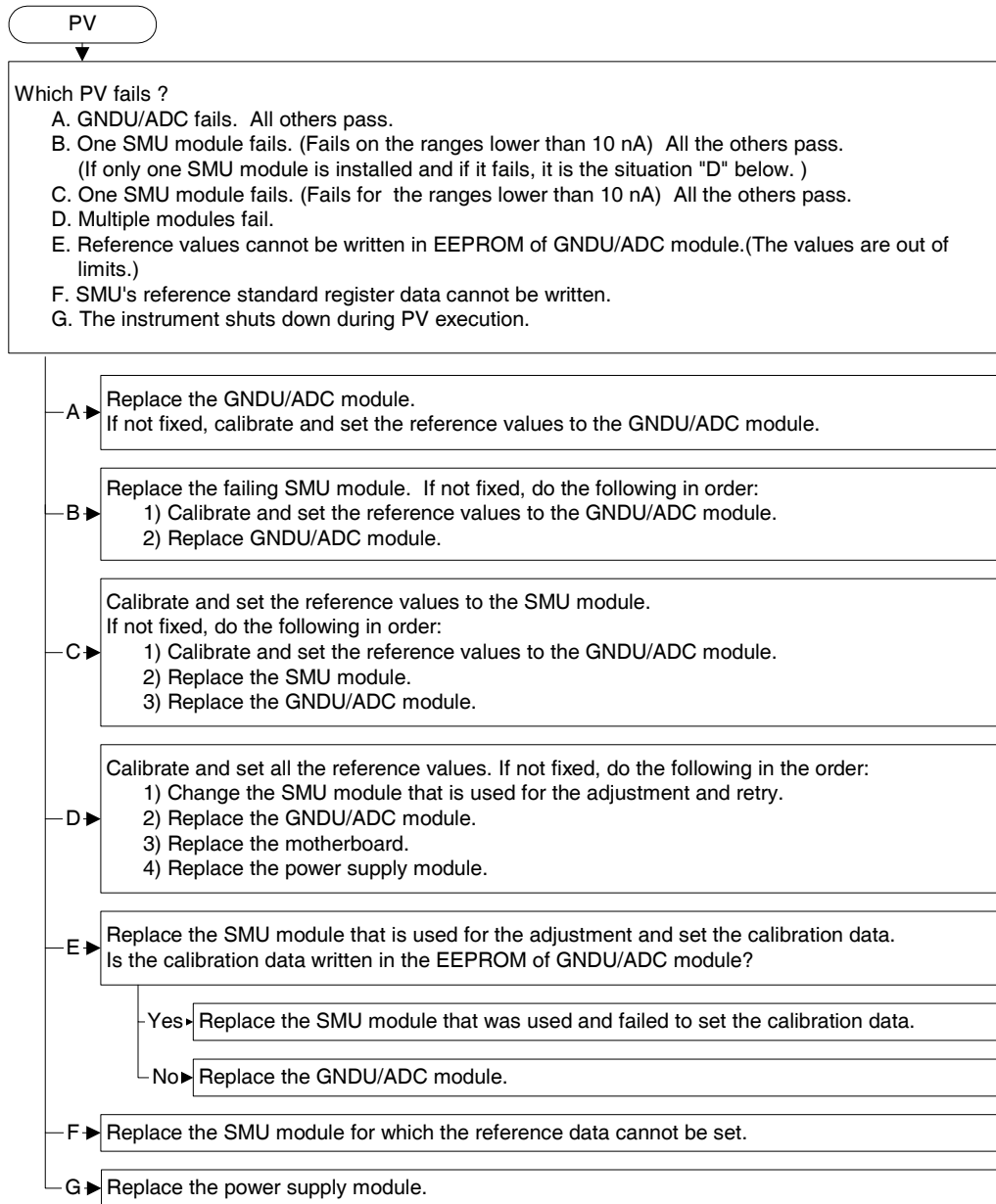


Figure 3-27 If ADC/GNDU fails but self-test passes



PV Failure

Figure 3-28 If PV fails



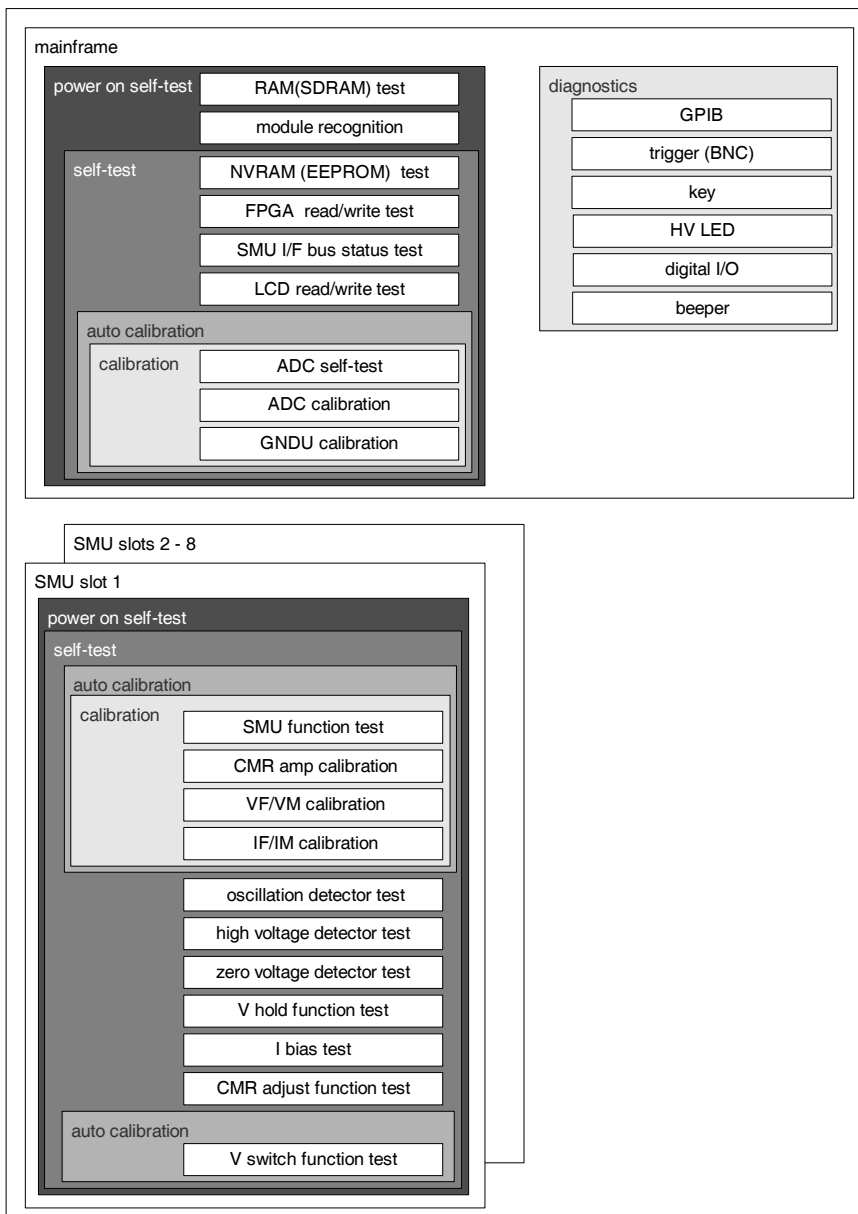
Troubleshooting Reference

This section describes the theory of the built-in self-test and diagnostics.

The Agilent E5260/E5270 has calibration, selftest and diagnostics functions. At turn-on, the power-on selftest is performed automatically without your assistance. The diagnostics' interactive test is performed with your assistance, such as cable connection and visual check. The selftest and the diagnostics verifies that the E5260/E5270 is operating but may not verify if the output and measurement are performed accurately. If you need to verify the output and measurement accuracy, use calibration and performance verification. See Chapter 2, "Calibration".

The selftest and diagnostics subtest structure are shown below.

Figure 3-29 Selftest and diagnostics structure



Self-test

This section describes the self-test procedure and internal operation of each self-test item.

To execute self-test from front panel

If you execute the self-test from the front panel, use the following procedure.

1. Disconnect all cables and adapters from the E5270 front panel.
2. Press **[Shift] [Menu]**.
3. Select `SELFTEST` using the arrow keys, then press **[Enter]**.
4. Select `EXECUTE` using the arrow keys, then press **[Enter]**.
5. Select the self-test item using the arrow keys, then press **[Enter]**.

The self-test starts. If you want to abort the self-test, press **[Exit]**.

To check self-test results

If you check the self-test results, use the following procedure.

1. Press **[Shift] [Menu]**.
2. Select `SELFTEST` using the arrow keys, then press **[Enter]**.
3. Select `RESULT` using the arrow keys, then press **[Enter]**.
4. Select the self-test item using the arrow keys. The test result is displayed for each item.

To use modules that failed self-test

The following procedure enables you to use a module that failed self-test or self-calibration.

1. Press **[Shift] [Menu]**.
2. Select `SELFTEST` using the arrow keys, then press **[Enter]**.
3. Select `RECOVER` using the arrow keys, then press **[Enter]**.
4. Select `YES` using the arrow keys, then press **[Enter]**. Module recovery is executed.

Self-test and power-on self-test internal operation

This section describes the self-test and power-on self-test internal operation of each self-test item.

- **FRAME: RAM (SDRAM) test**
This test sets “0” and “1” to its internal circuitry and checks if they are correctly set. If it fails, the LED on the CPU module lights.
- **FRAME: module recognition test**
This test checks the identification numbers of the installed modules and the boards.
- **FRAME: NVRAM (EEPROM) test**
This test performs write and read test of the NVRAM on the CPU module.
- **FRAME: FPGA write/read test**
This test performs the write and read test of the FPGA on the CPU module.
- **FRAME: SMU interface bus status test**
This test checks the status signals of the SMU interface bus.
- **FRAME: LCD write and read test**
This test performs the write and read test of the LCD assembly.
- **FRAME: ADC self-test**
This test checks the identification number of the GNDU/ADC module and performs the write and read test for the memory function of the GNDU/ADC module.
- **FRAME: ADC calibration**
This test sets the calibration data to the ADC and DAC of the GNDU/ADC module; if the calibration data is out of the specified range, it gives an error.
- **FRAME: GNDU calibration**
This test sets the offset calibration data. If the data is out of the specified range, it gives an error.
- **SMU SLOT 1-8: SMU function test**
This test performs the function tests of the voltage force, voltage measure, I force, I measure, and loop status.
- **SMU SLOT 1-8: CMR amplifier calibration**
This test sets the calibration data to the common mode rejection amplifier in the SMU modules. If the calibration data is out of the specified range, this gives an error.
- **SMU SLOT 1-8: VF/VM calibration**
This test sets the calibration data of the gain and the offset to the voltage force and the voltage measure function. If the calibration data is out of the specified range, it gives an error.
- **SMU SLOT 1-8: IF/IM calibration**
This test sets the calibration data of the gain and the offset to the I force and I measure function. If the calibration data is out of the specified range, it gives an error.

Troubleshooting Reference

- SMU SLOT 1-8: Oscillation detector test

This test checks if there is no oscillation occurring at the following cases, 0 V, when the voltage is changed from 0 V to 94 V, and when the voltage is changed from 94 V to 0V. If an oscillation is found, the error OSCOUT will be set.

- SMU SLOT 1-8: High voltage detector test

This test checks if the high voltage detector performs properly by setting the voltages to 0 V, 60 V, and -60 V. If it fails, the error HV_DET_ERR will be set.

- SMU SLOT 1-8: zero voltage detector test

This test checks if the zero voltage detector performs properly by setting the voltages to 0 V, 3 V, and -3 V. If it fails, the error ZVOUT will be set.

- SMU SLOT 1-8: V hold function test

This test checks if the V hold function performs properly by setting the voltage to 10 V, then setting V Hold to ON and changing the voltage to 0 V. If it fails, the error V_HOLD_ERR will be set.

- SMU SLOT 1-8: I bias test

This test checks if the I bias function, which prevents the SMU current limit values from being reversed, performs properly. If it fails, the error IBIAS_ERR will be set.

- SMU SLOT 1-8: CMR adjust function test

This test checks if the CMR adjust function performs properly.

- SMU SLOT 1-8: V switch function test (HPSMU only)

This test checks the voltage switching function in the SMU module. If it fails, the error VSW_FUNC_ERR will be set.

Self-calibration

This section describes the self-calibration procedure.

To execute self-calibration

To execute the self-calibration, use the following procedure.

1. Disconnect all cables and adapters from the E5260/E5270 front panel.
2. Press **[Shift] [Menu]**.
3. Select CAL using the arrow keys, then press **[Enter]**.
4. Select EXECUTE using the arrow keys, then press **[Enter]**.
5. Select the calibration item using the arrow keys, then press **[Enter]**.

The self-calibration starts. If you want to abort the self-calibration, press **[Exit]**.

To check calibration results

To check the self-calibration results, use the following procedure.

1. Press **[Shift] [Menu]**.
2. Select CAL using the arrow keys, then press **[Enter]**.
3. Select RESULT using the arrow keys, then press **[Enter]**.
4. Select the calibration item using the arrow keys, then press **[Enter]**. The calibration result is displayed for each calibration item.

Self-calibration internal operation

The self-calibration is a part of the self-test. For details, see “Self-test and power-on self-test internal operation”.

Diagnostics

This section describes the diagnostics procedure and internal operation of each diagnostics item.

To execute diagnostics

To execute the diagnostics, use the following procedure.

1. Press **[Shift] [Menu]**.
2. Select **DIAG** using the arrow keys, then press **[Enter]**.
3. Select **EXECUTE** using the arrow keys, then press **[Enter]**.
4. Select the diagnostics item using the arrow keys, then press **[Enter]**.

The diagnostics starts. If you want to abort the diagnostics, press **[Exit]**.

NOTE Before starting the diagnostics, do the following:

- For GPIB, disconnect the GPIB cable.
- For TRIGGER (BNC), connect a BNC cable between the Ext Trig In and Out connectors.
- For DGTL-I/O, disconnect any cable from the digital I/O port.

-
5. After starting the diagnostics, do the following.
 - For **KEY**, press any front panel key; then the LCD displays the key name. Repeat this for all front panel keys.
If all responses were good, press **[Enter]** twice to stop.
If any response was bad, press **[Exit]** twice to stop.
 - For **HV-LED**, confirm that the LED blinks.
If the LED is blinking, press **[Enter]** to stop.
If the LED does not blink, press **[Exit]** key to stop.
 - For **BEEPER**, confirm that the beeper makes two sounds every second.
If you hear it, press **[Enter]** to stop.
If you do not hear it, press **[Exit]** key to stop.
 - For other diagnostics, no action is required.

To check diagnostics results

To check the diagnostics results, use the following procedure.

1. Press **[Shift] [Menu]**.
2. Select **DIAG** using the arrow keys, then press **[Enter]**.
3. Select **RESULT** using the arrow keys, then press **[Enter]**.
4. Select the diagnostics item using the arrow keys. The diagnostics result is displayed for each diagnostics item.

Diagnostics internal operation

This section describes the diagnostics internal operation of each diagnostics item.

- GPIB test
This test sets the SRQ status and read back to check if the SRQ status is read correctly.
- Trigger (BNC) test
This test sends the BNC trigger signal from Ext Trig Out terminal and checks if the trigger is correctly received from the Ext Trig In terminal.
- Key test
This test displays the name of the key that is pushed in the LCD panel; visually check if it works.
- HV LED test
This test lights the HV LED; visually check if it works.
- Digital I/O test
This test sets each pin to “1” and “0” status and checks if they are set correctly.
- Beeper test
This test makes the beeper sound; listen to check if it works.

Operation error

The operation error is stored in the error buffer of the CPU module. This section describes how to read and clear the operation error.

To check operation error

If you check the operation error, use the following procedure.

1. Press **[Menu]**.
2. Select **ERROR** using the arrow keys, then press **[Enter]**.
3. Select **DISPLAY** using the arrow keys, then press **[Enter]**. The latest error is displayed.
4. Press the arrow keys to read another error. A maximum of four errors can be stored in the error buffer.

To clear errors

If you want to clear the operation errors, use the following procedure.

1. Press **[Menu]**.
2. Select **ERROR** using the arrow keys, then press **[Enter]**.
3. Select **CLEAR** using the arrow keys, then press **[Enter]**.
4. Select **YES** using the arrow keys, then press **[Enter]**. The error buffer is cleared.

Firmware revision

If you check the firmware revision, use the following procedure.

1. Press **[Menu]**.
2. Move the cursor to **CONFIG**, then press **[Enter]**.
3. Move the cursor to **REVISION**, then press **[Enter]**. The firmware revision is displayed.

4 Replacement Procedure

This chapter describes the assemblies replacement procedures. Each section explains how to remove the assemblies from Agilent E5260/E5270 series.

WARNING Only personnel with knowledge of electric circuitry and an awareness of the hazards involved should remove and install printed circuit board assemblies.

CAUTION

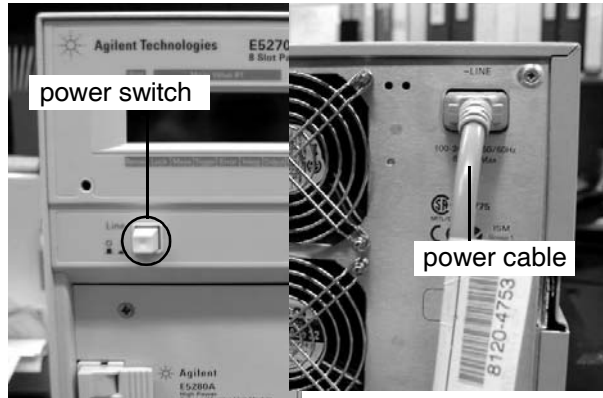
- To avoid electrostatic damage (ESD), use an anti-static mat and wrist strap.
 - After removing a module, hold the module so that the printed circuit board of the module does not bend. Bending the board can damage the printed patterns.
 - Oil, perspiration, fibrous dust, and dirt degrade the insulation of the circuit, thus lowering measurement accuracy. Wear rubber gloves when handling the print circuit boards.
-

The chapter contains the following sections:

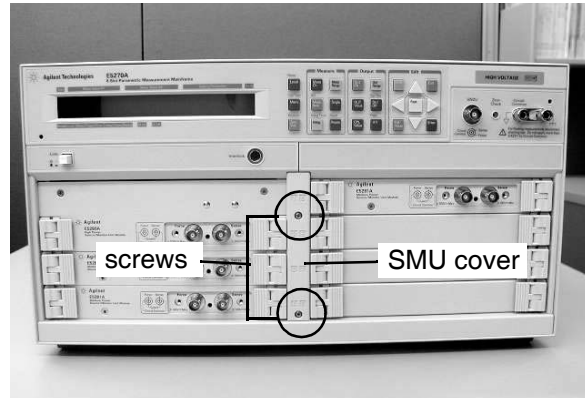
- “Removing SMU Module”
- “Removing GNDU/ADC Module”
- “Removing CPU Module”
- “Removing Keyboard and LCD Assemblies”
- “Removing Power Supply Module”
- “Removing Connector Board”
- “Removing Fans”
- “Removing Motherboard”
- “Updating Firmware”

Removing SMU Module

This section describes how to remove the SMU module.



1. Turn off the power, then disconnect the power cable.



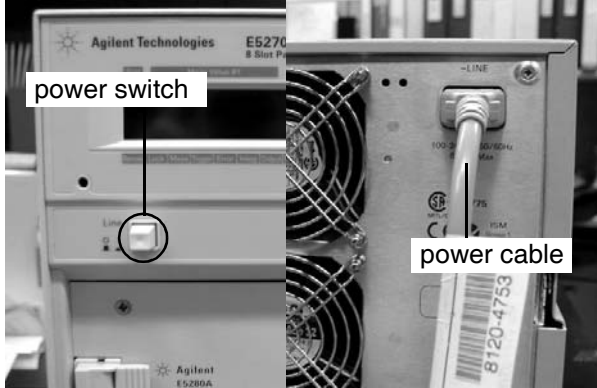
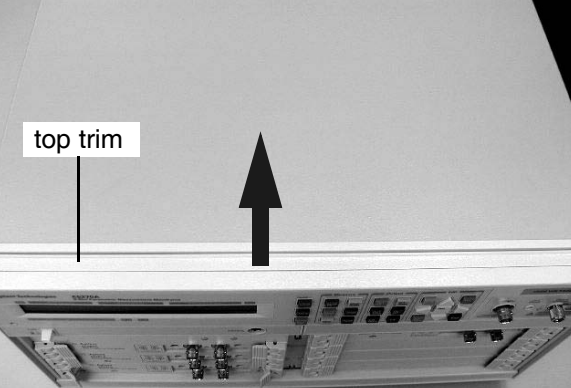
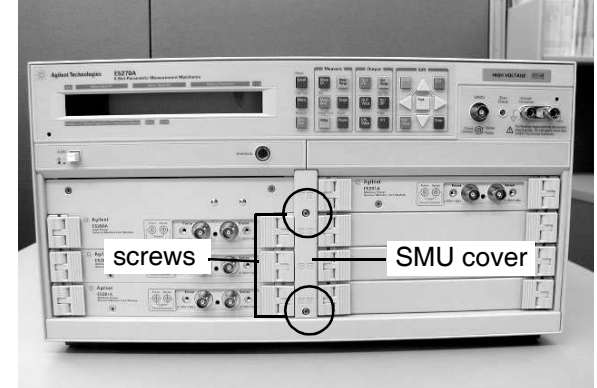

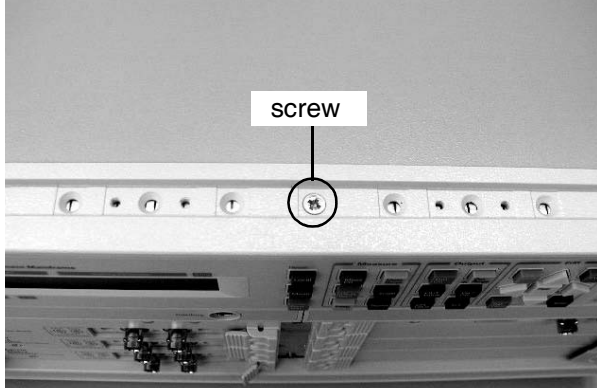

2. Loosen the screws on the SMU cover.
3. Remove the SMU cover.



4. While holding the module extractor, gently pull out the SMU module.

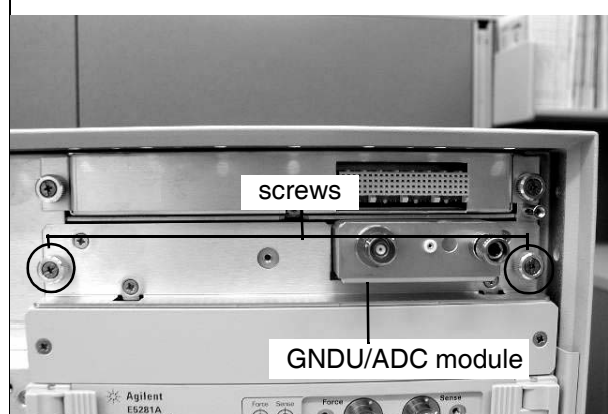
Removing GNDU/ADC Module

This section describes how to remove the GNDU/ADC module.

	
<p>1. Turn off the power, then disconnect the power cable.</p>	<p>2. Remove the top trim.</p>
	
<p>3. Loosen the screws on the SMU cover. 4. Remove the SMU cover.</p>	<p>5. Loosen the screw on the front of the mainframe.</p>
	
<p>6. Loosen the screw at the top of the mainframe.</p>	<p>7. Remove the shorting bar from the circuit common.</p>



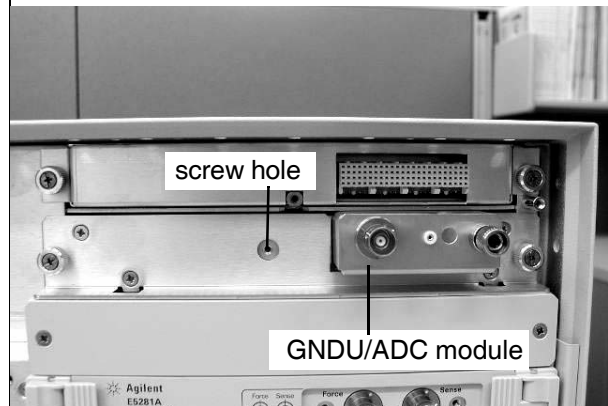
8. Use the H2.5 hex wrench to gently loosen the screws on the front panel. The front panel assembly is moved forward by the screws.



9. Loosen the screws on the GNDU/ADC module.



10. Remove the module extractor.



11. Screw the module extractor into the screw hole on the GNDU/ADC module.

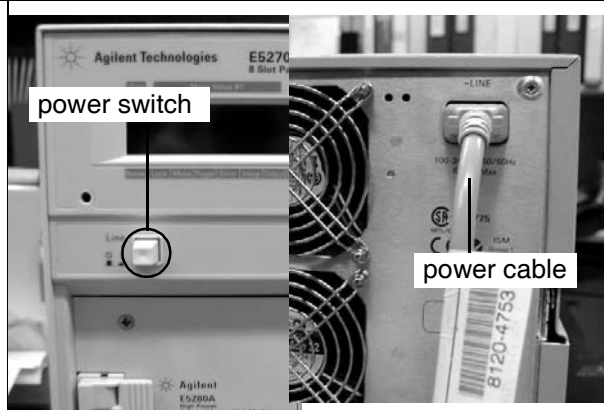


12. Pull the screwed-in module extractor.

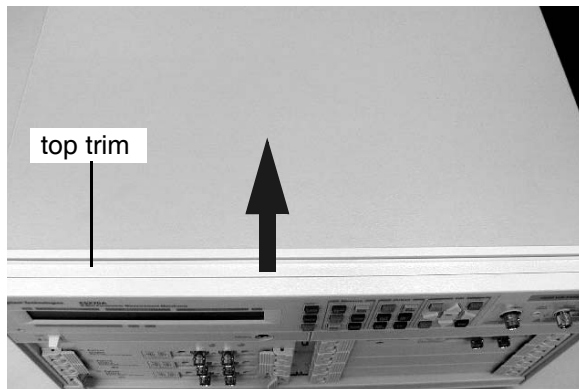
Removing CPU Module

This section describes how to remove the CPU module.

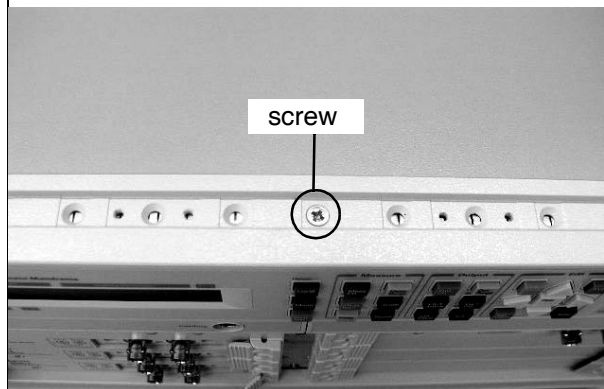
1. Turn on the power.
2. Confirm and jot down the present frequency setting using the following procedure.
 - a. Press **[Menu]**.
 - b. Select **CONFIG**, and press **[Enter]**.
 - c. Select **LINEFREQ**, and press **[Enter]**.
The present frequency setting is displayed.
3. Confirm and jot down the present firmware revision using the following procedure.
 - a. Select **VERSION**, and press **[Enter]**. The present firmware revision is displayed.



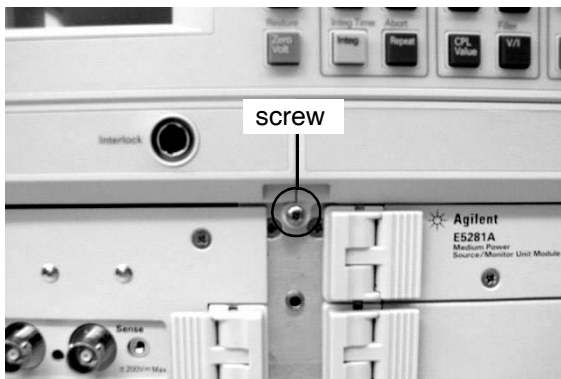
4. Turn off the power, then disconnect the power cable.



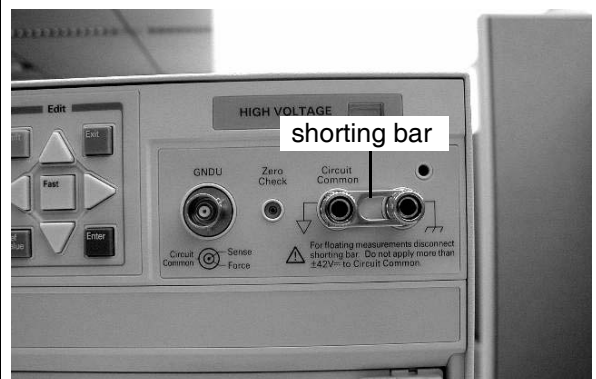
5. Remove the top trim.



6. Loosen the screw at the top of the mainframe.



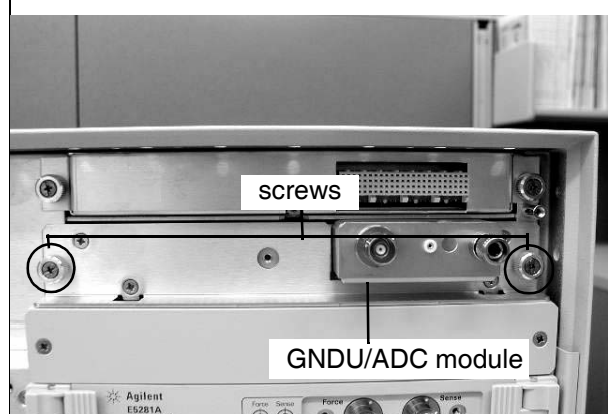
7. Loosen the screw at the front of the mainframe.



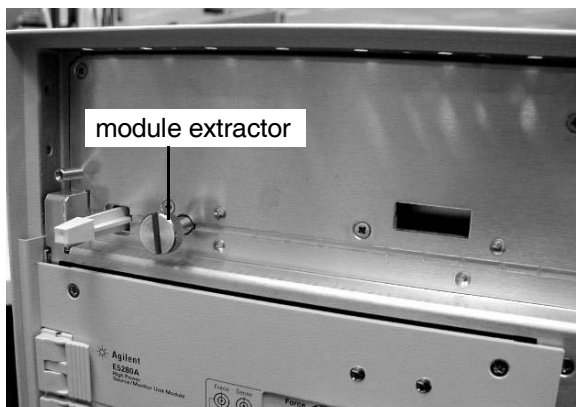
8. Remove the shorting bar from the circuit common.



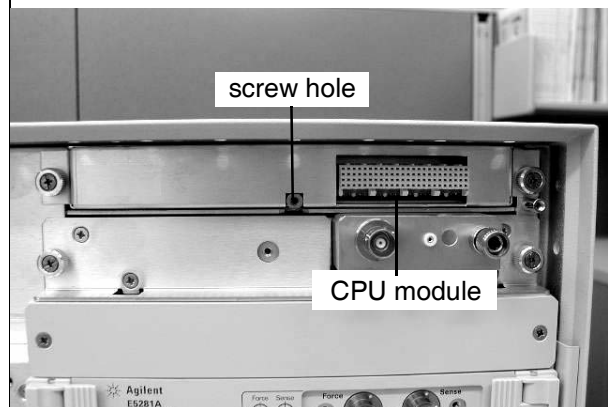
9. Use the H3 hex wrench to gently loosen the screws on the front panel.



10. Loosen the screws on the CPU module.



11. Remove the module extractor.



12. Screw the module extractor into the screw hole on the CPU module.



13. Pull the screwed-in module extractor.

14. Turn on the power.

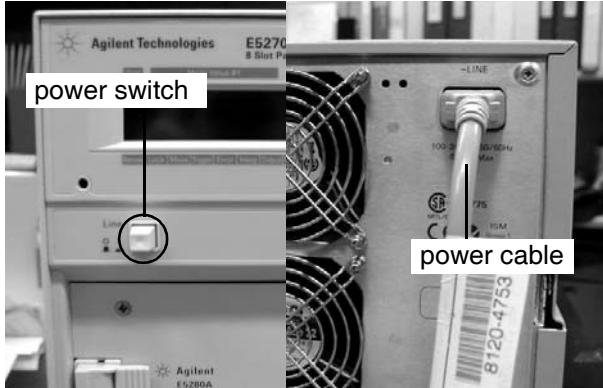
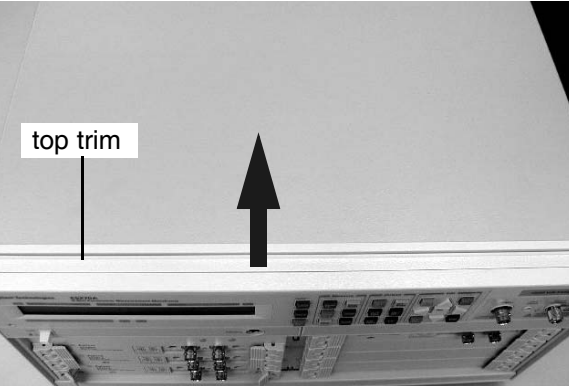
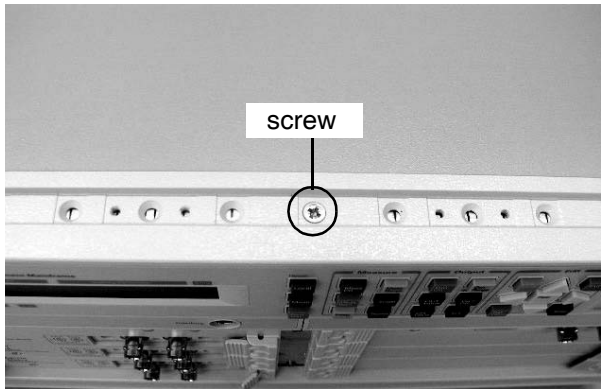
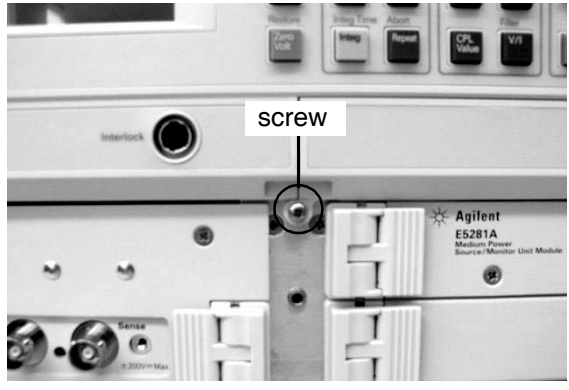


15. Set the power line frequency using the following procedure.

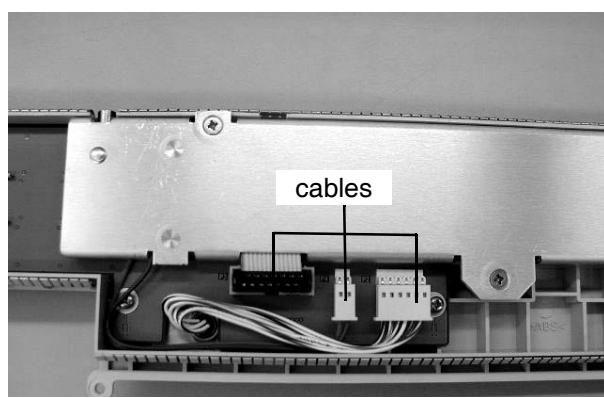
- a. Press **[Menu]**.
- b. Select **CONFIG**, and press **[Enter]**.
- c. Select **LINEFREQ**, and press **[Enter]**.
- d. Select the original frequency by using the arrow keys.

16. Confirm the firmware revisions. If the revisions are older than the original revisions, update the firmware. (See “Updating Firmware”.)

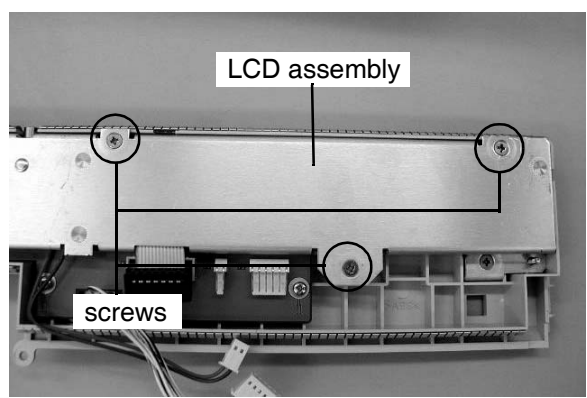
Removing Keyboard and LCD Assemblies

This section describes how to remove the keyboard and LCD assemblies.

 <p>power switch</p> <p>power cable</p>	 <p>top trim</p>
<p>1. Turn off the power, then disconnect the power cable.</p>	<p>2. Remove the top trim.</p>
 <p>screw</p>	 <p>screw</p>
<p>3. Loosen the screw at the top of the mainframe.</p>	<p>4. Loosen the screw on the front of the mainframe.</p>
 <p>shorting bar</p>	 <p>screws</p>
<p>5. Remove the shorting bar from the circuit common.</p>	<p>6. Use the H3 hex wrench to gently loosen the screws at the front panel.</p>

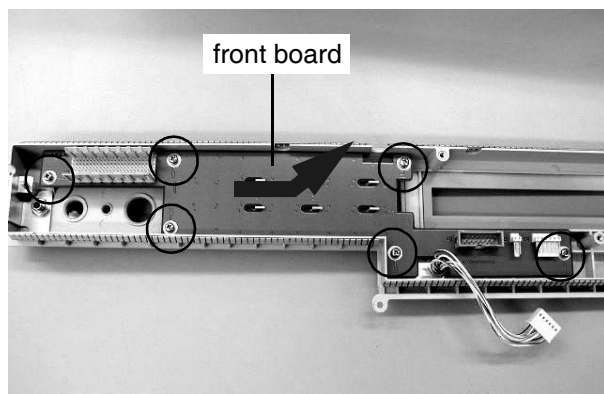


7. Disconnect the LCD and interlock cables.



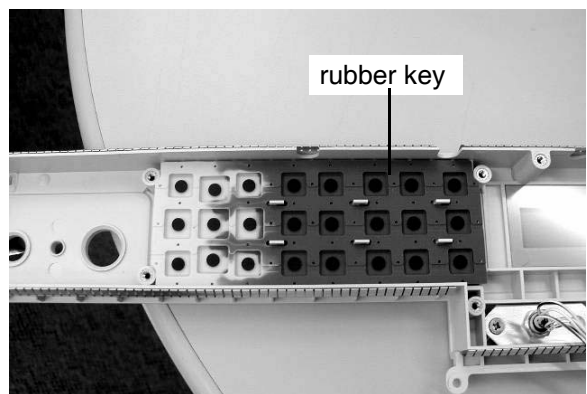
8. Loosen the screws on the LCD assembly.

9. Remove the LCD assembly from the front panel.



10. Loosen the screws on the front board.

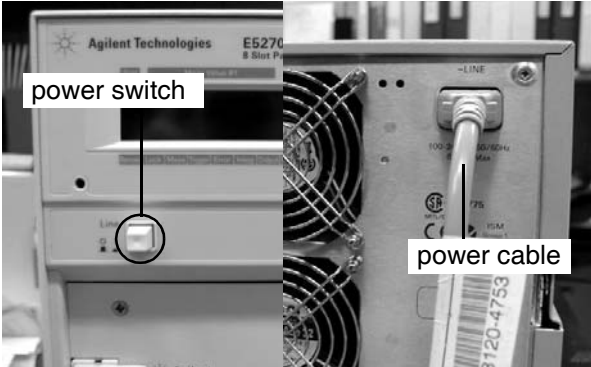
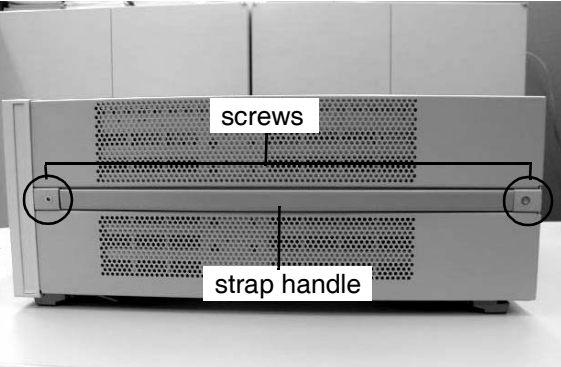
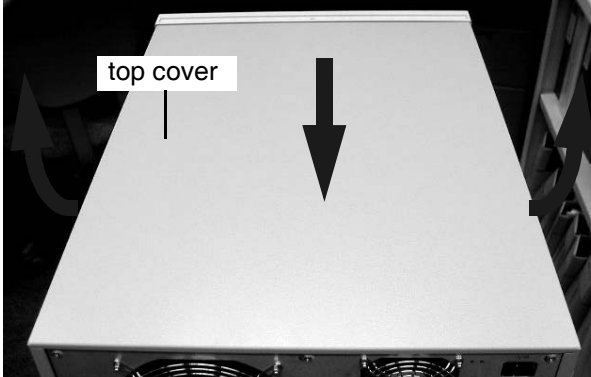
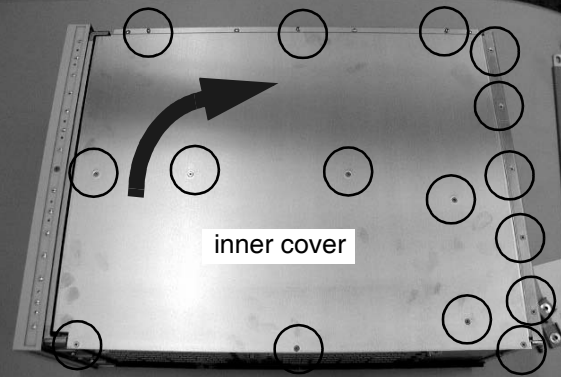
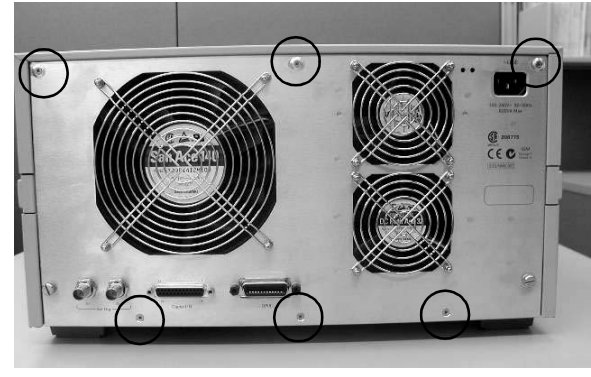
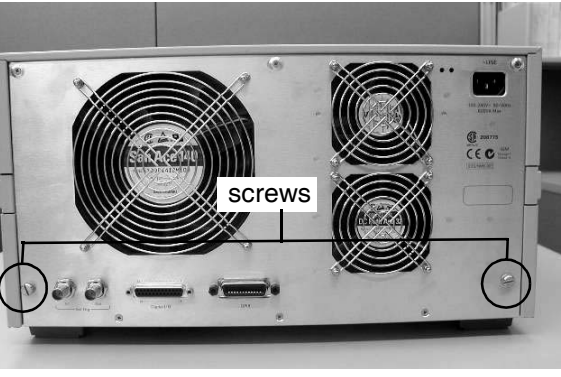
11. Slide and remove the front board.



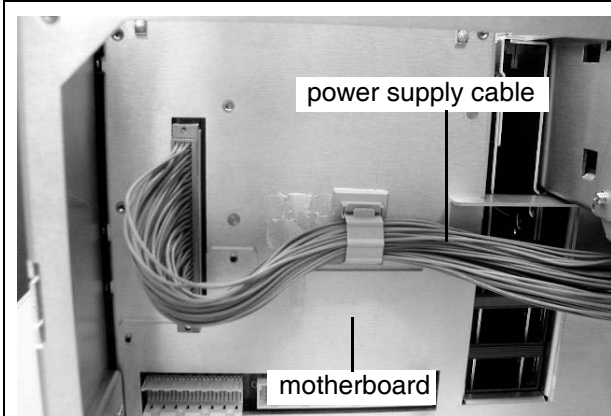
12. Remove the rubber key.

Removing Power Supply Module

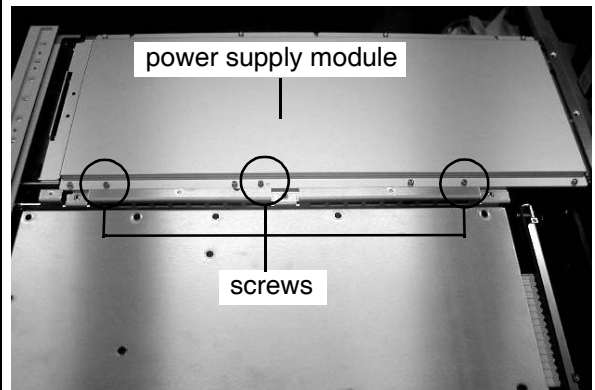
This section describes how to remove the power supply module.

 <p>power switch</p> <p>power cable</p>	 <p>screws</p> <p>strap handle</p>
<p>1. Turn off the power, then disconnect the power cable.</p>	<p>2. Loosen the screws of the strap handles. 3. Remove the strap handles.</p>
 <p>top cover</p>	 <p>inner cover</p>
<p>4. To remove the top cover, slide the cover back, splay the side of the cover, and then lift up the cover.</p>	<p>5. Loosen the screws on the inner cover. 6. Remove the inner cover.</p>
 <p>screws</p>	 <p>screws</p>
<p>7. (For E5270A only) Loosen the six screws on the rear panel.</p>	<p>8. (For E5270A only) Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.</p>

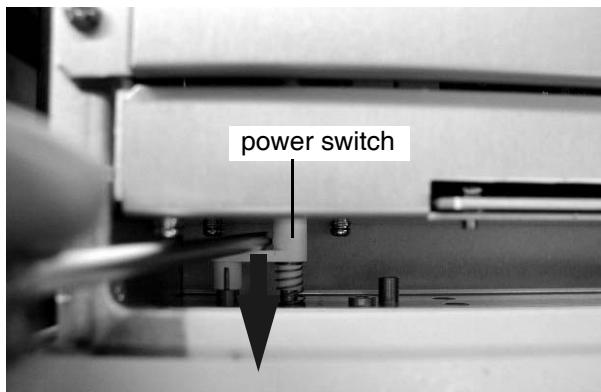
Replacement Procedure
Removing Power Supply Module



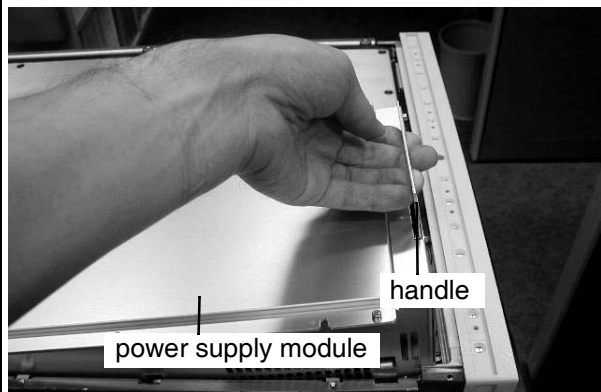
9. Disconnect the power supply cable from the motherboard.



10. Loosen the screws indicated.



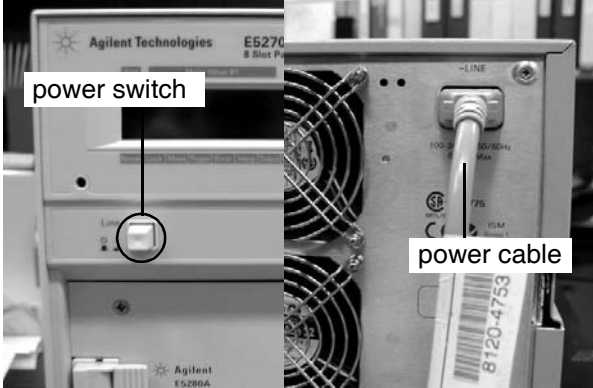
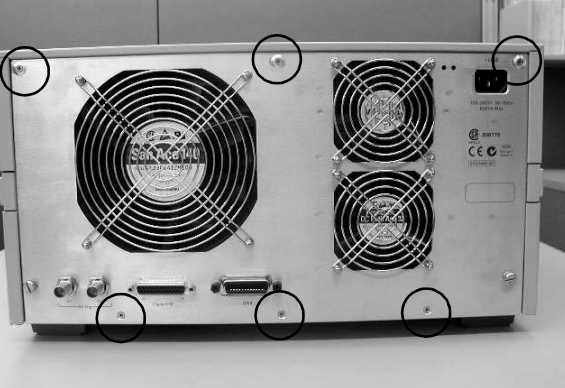
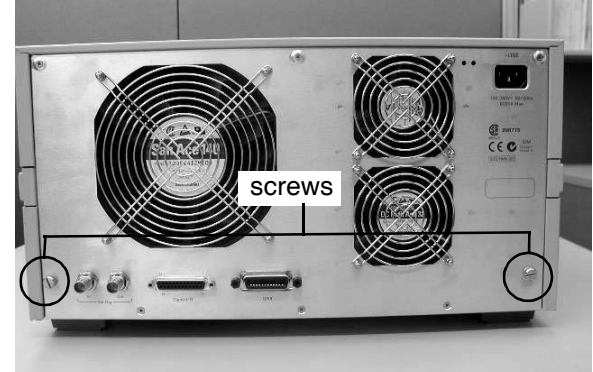


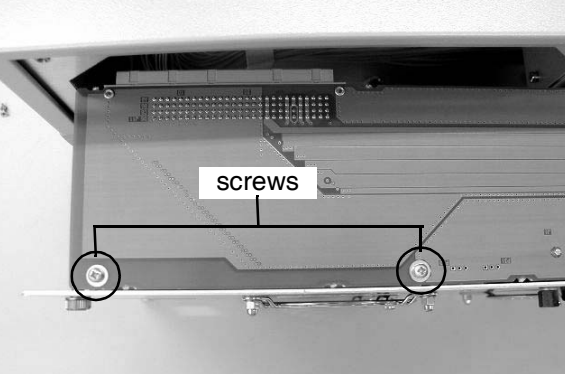
11. Move the power switch forward with a screwdriver. The power switch will be fixed in position.



12. Remove the power supply unit with the handle.

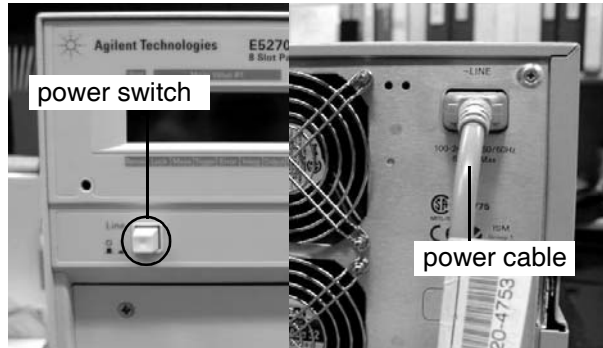
Removing Connector Board

This section describes how to remove the connector board.

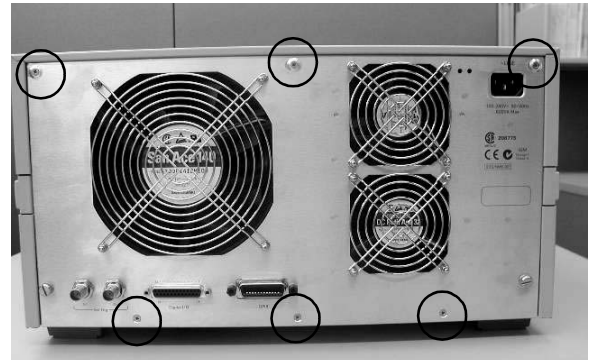
 <p>power switch</p> <p>power cable</p>	
<p>1. Turn off the power, then disconnect the power cable.</p>	<p>2. Loosen the six screws on the rear panel.</p>
 <p>screws</p>	 <p>fan connectors</p>
<p>3. Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.</p>	<p>4. Disconnect the fan cables.</p>
 <p>Ext Trig</p> <p>Digital I/O</p> <p>GPIB</p>	 <p>screws</p>
<p>5. Loosen the screws for the GPIB, trigger, and digital I/O interfaces.</p>	<p>6. Loosen the screws on the rear of the interface board, and remove the connector board from the rear panel.</p>

Removing Fans

This section describes how to remove the fans.



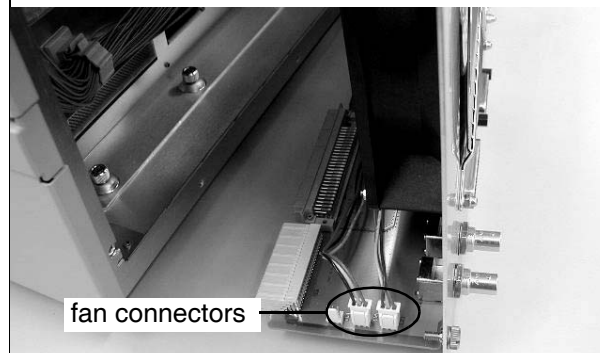
1. Turn off the power, then disconnect the power cable.



2. Loosen the six screws on the rear panel.



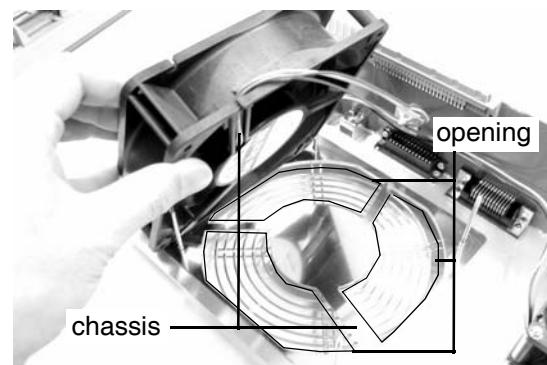
3. Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.



4. Disconnect the fan cables.



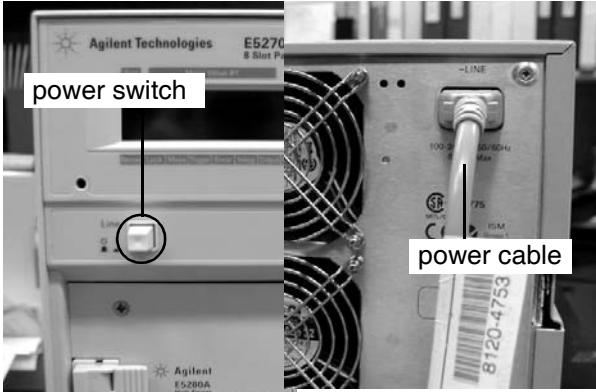
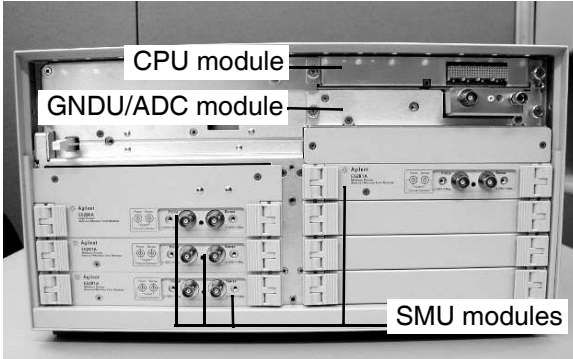
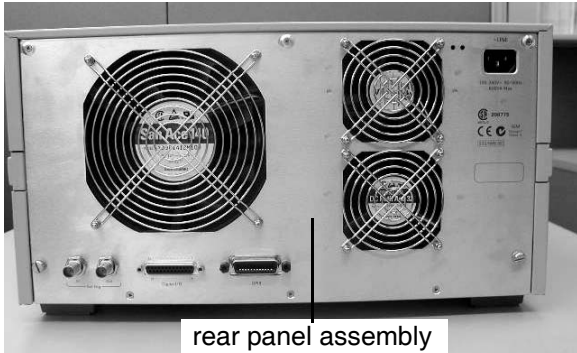
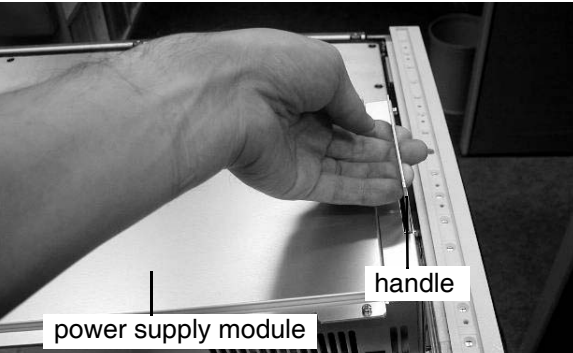
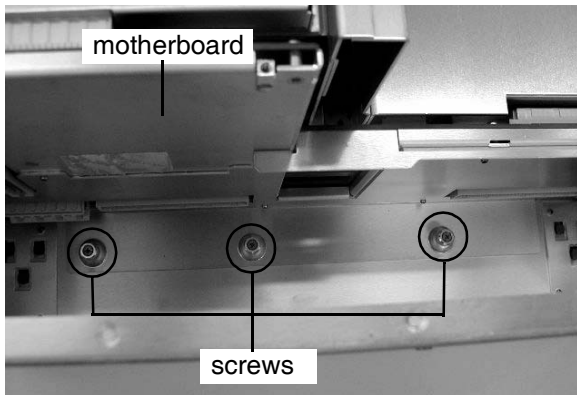
5. Loosen the screws on the fan, and remove the fan from the rear panel.



CAUTION When you reinstall the fan, fit the fan chassis to the rear panel and do not block the chassis opening. Otherwise, the SMU may be damaged because of overheating.

Removing Motherboard

This section describes how to remove the motherboard.

 <p>power switch</p> <p>power cable</p> <ol style="list-style-type: none">1. Turn off the power, then disconnect the power cable.	 <p>CPU module</p> <p>GNDU/ADC module</p> <p>SMU modules</p> <ol style="list-style-type: none">2. Remove the SMU, GNDU/ADC, and CPU modules. See “Removing SMU Module”, “Removing GNDU/ADC Module”, and “Removing CPU Module”.
 <p>rear panel assembly</p> <ol style="list-style-type: none">3. Remove the rear panel assembly. See “Removing Connector Board”.	 <p>handle</p> <p>power supply module</p> <ol style="list-style-type: none">4. Remove the power supply unit with the handle. See “Removing Power Supply Module”.
 <p>motherboard</p> <p>screws</p> <ol style="list-style-type: none">5. Loosen the screws.6. Remove the motherboard assembly.	

Updating Firmware

This section describes the firmware update procedure for the E5260/E5270.

NOTE To update the firmware, you need an Windows PC with an Agilent or National Instrument GPIB interface card and driver. Also, you need to download the latest firmware from the Agilent web (<http://www.agilent.com>).

1. Connect the PC to E5260/E5270 using GPIB cable.
2. Turn on the E5260/E5270.
3. Open the DOS window, then execute the `update_appl.exe` command. The following is an example for GPIB address 17 and GPIB card name GPIB0.

```
C:\TEMP> update_appl.exe -a 17 -g 'GPIB0' appl_B_01_01.bin
```

-a <gplib_address> Specify GPIB address 0 through 30 to be used communicate with the E5260/E5270. The default setting is 17.

-g <gplib_name> VISA GPIB interface name string that is used to open GPIB device on the system. The default setting is 'GPIB0'.

4. Firmware update starts, and the following message appears on the DOS window.

```
Changing operation mode to BOOTROM
Transferring data      .....
Erase Flash ROM      .....
Program Flash ROM    .....
Successfully F/W is updated.
Now rebooting, please wait for a while.
```

CAUTION Do not turn off the E5260/E5270 until the firmware update has been completed. If you turn off the E5260/E5270 while the firmware update is still in progress, the CPU board may have to be replaced.

5. After the firmware update is complete, E5260/E5270 automatically restarts with updated firmware.

5 Replaceable Parts

Replaceable Parts

This chapter describes the replaceable parts for the Agilent E5260/E5270 series, and its accessories. The tables in this section also contain the post repair action that must be performed when a part is replaced.

This chapter consists of the following sections:

- “Replaceable Parts for E5260/E5270”
- “Accessories”
- “Date Code and Revision History”

For the replacement procedure, see Chapter 4 , “Replacement Procedure,”.

Replaceable Parts for E5260/E5270

Table 5-1 through Table 5-3 list the replaceable parts for the E5260/E5270.

Figure 5-1 Front panel replaceable parts

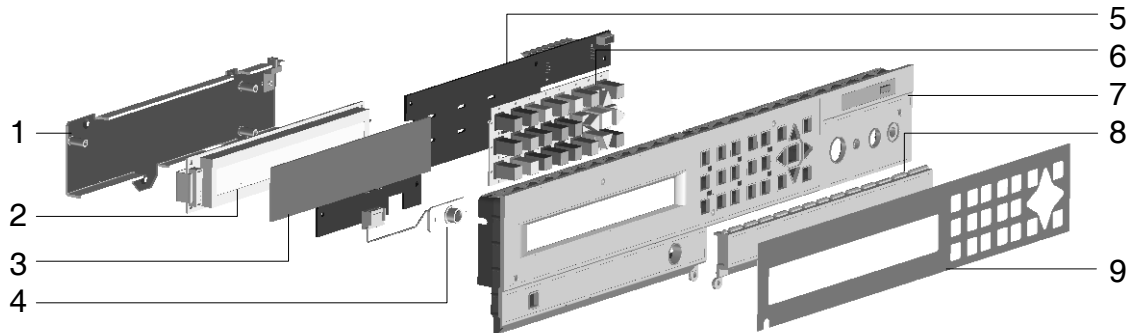


Table 5-1 Front panel replaceable parts

Reference designation	Part number	Quantity	Description
1	E5270-00602	1	LCD frame
2	E5270-61002	1	LCD assembly
3	04263-25003	1	Filter
4	E5270-61602	1	Interlock connector assembly
5	E5270-66503	1	Front board
6	E5270-40010	1	Rubber key
7	E5270-60013	1	Front panel assembly
8	E5270-60006	1	Front cover
9	E5260-87101	1	Label for E5260A front panel
	E5262-87101	1	Label for E5262A front panel
	E5263-87101	1	Label for E5263A front panel
	E5270-87101	1	Label for E5270A front panel
	E5270-87104	1	Label for E5270B front panel
	E5272-87101	1	Label for E5272A front panel
	E5273-87101	1	Label for E5273A front panel
–	0515-0914	3	Screw M3L6 flat (for fixing LCD frame)
–	0515-1076	2	Screw M3L9 (for fixing interlock connector assembly)
–	0515-1550	6	Screw M3L8 (for fixing front board assembly)

Table 5-1 Front panel replaceable parts

Reference designation	Part number	Quantity	Description
–	0515-1550	3	Screw M3L8 (for fixing LCD assembly)
–	0515-1551	1	Screw M3L10 (for fixing front cover)

Figure 5-2 Mainframe replaceable parts

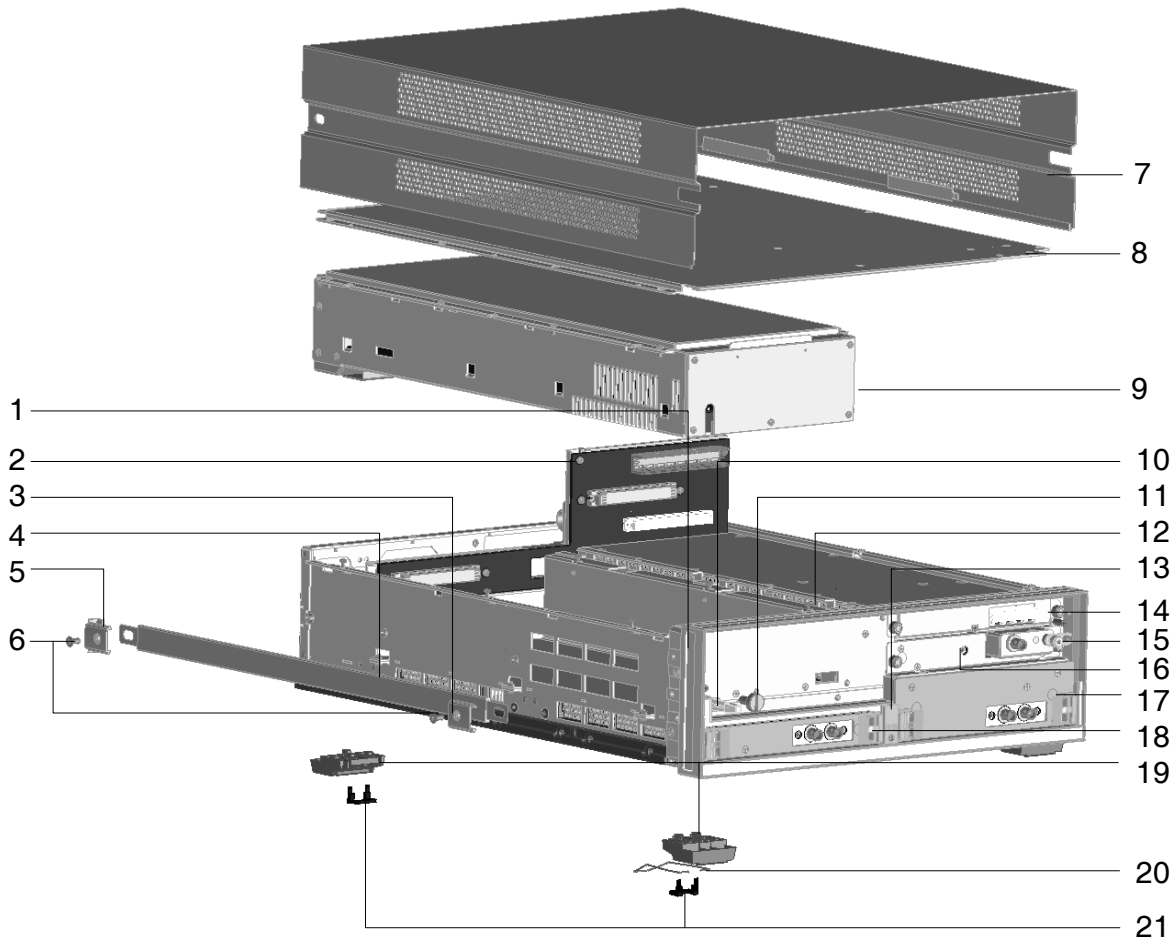


Table 5-2 Mainframe replaceable parts

Reference designation	P/N	Qty	Description	Post repair action
1	5041-9173	2	Side trim for E5260A/E5270A/E5270B	None
	5041-9171	2	Side trim for E5262A/E5263A/E5272A/E5273A	None
2	E5270-60002	1	Motherboard assembly for E5260A/E5270A/E5270B	GNDU test SMU V test
	E5271-60002	1	Motherboard assembly for E5262A/E5263A/E5272A/E5273A	SMU I test SMU CMR test
3	5041-9186	1	Front cap	None
4	5063-9211	2	Strap handle	None
5	5041-9187	2	Rear cap	None
6	0515-1384	4	Screw M5 (for fixing strap handle)	None

Replaceable Parts for E5260/E5270

Table 5-2 Mainframe replaceable parts

Reference designation	P/N	Qty	Description	Post repair action
7	E5270-04003	1	Top cover for E5260A/E5270A/E5270B	None
	E5271-04003	1	Top cover for E5262A/E5263A/E5272A/E5273A	None
8	E5240-04001	1	Inner cover	None
–	0515-1551	3	Screw M3L10 (for fixing inner cover)	None
–	0515-0914	13	Screw M3L6 flat (for fixing inner cover)	None
9	E5270-60012 (E5270-69012)	1	Power supply module for E5260A/E5270A/E5270B	None
	E5271-60012 (E5271-69012)	1	Power supply module for E5262A/E5263A/E5272A/E5273A	None
–	0515-1551	3	Screw M3L10 (for fixing PS module)	None
–	E5270-01203	1	Power supply cable guide ^a	None
–	E5270-61601	1	Power supply cable ^a	None
10	E5270-40013	1	Power switch	None
	1460-2360	1	Spring	None
11	04155-24012	1	Module extractor	None
12	5041-9176	1	Top trim	None
13	E5270-60005	1	SMU cover for E5260A/E5270A/E5270B	None
	E5271-60005	1	SMU cover for E5262A/E5263A/E5272A/E5273A	None
14	E5260-66532	1	CPU module for E5260A/E5262A/E5263A	Firmware update Frequency setting
	E5270-66502	1	CPU module for E5270A/E5272A/E5273A	
	E5270-66512	1	CPU module for E5270B	
15	5000-4206	1	Shorting bar	None
16	E5270-66505	1	GNDU/ADC module	Ref V calibration Ref R calibration GNDU test SMU V test SMU I test SMU CMR test
17	E5290-61001 (E5290-69001)	Up to 4	High power source monitor unit (HPSMU) for E5260A/E5263A	SMU R calibration ^b SMU V test ^b SMU I test ^b SMU CMR test ^b
	E5280-61001 (E5280-69001)	Up to 4	High power source monitor unit (HPSMU) for E5270A/E5273A	
	E5280-61011 (E5280-69011)	Up to 4	High power source monitor unit (HPSMU) for E5270B	

Table 5-2 Mainframe replaceable parts

Reference designation	P/N	Qty	Description	Post repair action
18	E5291-66501 (E5291-69501)	Up to 8	Medium power source monitor unit (MPSMU) for E5260A/E5262A/E5263A	SMU R calibration ^b SMU V test ^b SMU I test ^b SMU CMR test ^b
	E5281-66501 (E5281-69501)	Up to 8	Medium power source monitor unit (MPSMU) for E5270A/E5272A/E5273A	
	E5281-61001 (E5281-69001)	Up to 8	Medium power source monitor unit (MPSMU) for E5270B	
19	E5287-66501 (E5287-69501)	Up to 8	High resolution source monitor unit (HRSMU) for E5270B	
–	E5288-61001	Up to 8	Atto sense and switch unit	
21	5041-9167	4	Foot	None
22	1460-1345	2	Tilt stand	None
23	5021-2840	4	Foot lock	None

- a. This is included in the power supply module.
- b. Only for the repaired board.

Replaceable Parts for E5260/E5270

Figure 5-3 Rear panel replaceable parts

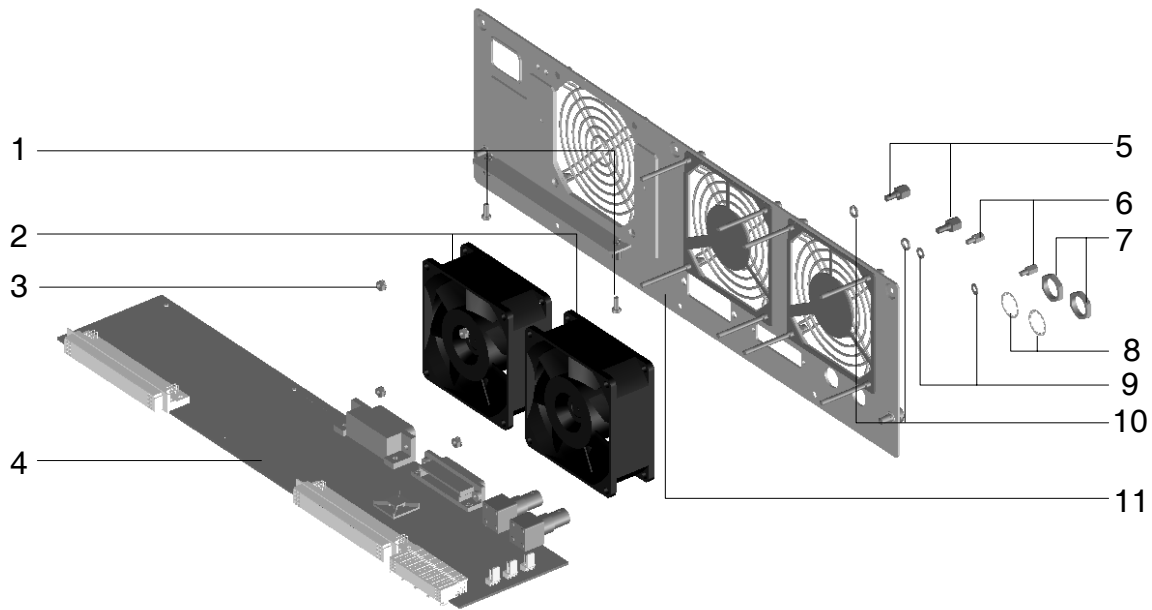


Table 5-3 Rear panel replaceable parts

Reference designation	Part number	Quantity	Description
1	0150-1550	2	Screw M3L8
2	3160-4151	1	Fan, large (for E5260A/E5270A/E5270B only)
	3160-4152	Up to 2	Fan, small
3	0535-0031	8	Nut
4	E5270-66504	1	Connector board
5	0380-0643	2	Stud (for GPIB)
6	0380-3070	2	Stud (for Digital I/O)
7	2950-0054	2	Nut (for Ext Trigger)
8	2190-0054	2	Washer (for Ext Trigger)
9	3050-0891	2	Washer (for Digital I/O)
10	2190-0577	2	Washer (for GPIB)
11	E5270-00201	1	Rear panel plate for E5260A/E5270A/E5270B
	E5271-00201	1	Rear panel plate for E5262A/E5263A/E5272A/E5273A

Accessories

This section describes the accessories replaceable parts. Table 5-4 through Table 5-7 list the replaceable parts for Agilent 16495H and Agilent 16495J connector plate.

Figure 5-4 16495H connector plate replaceable parts (1 of 2)

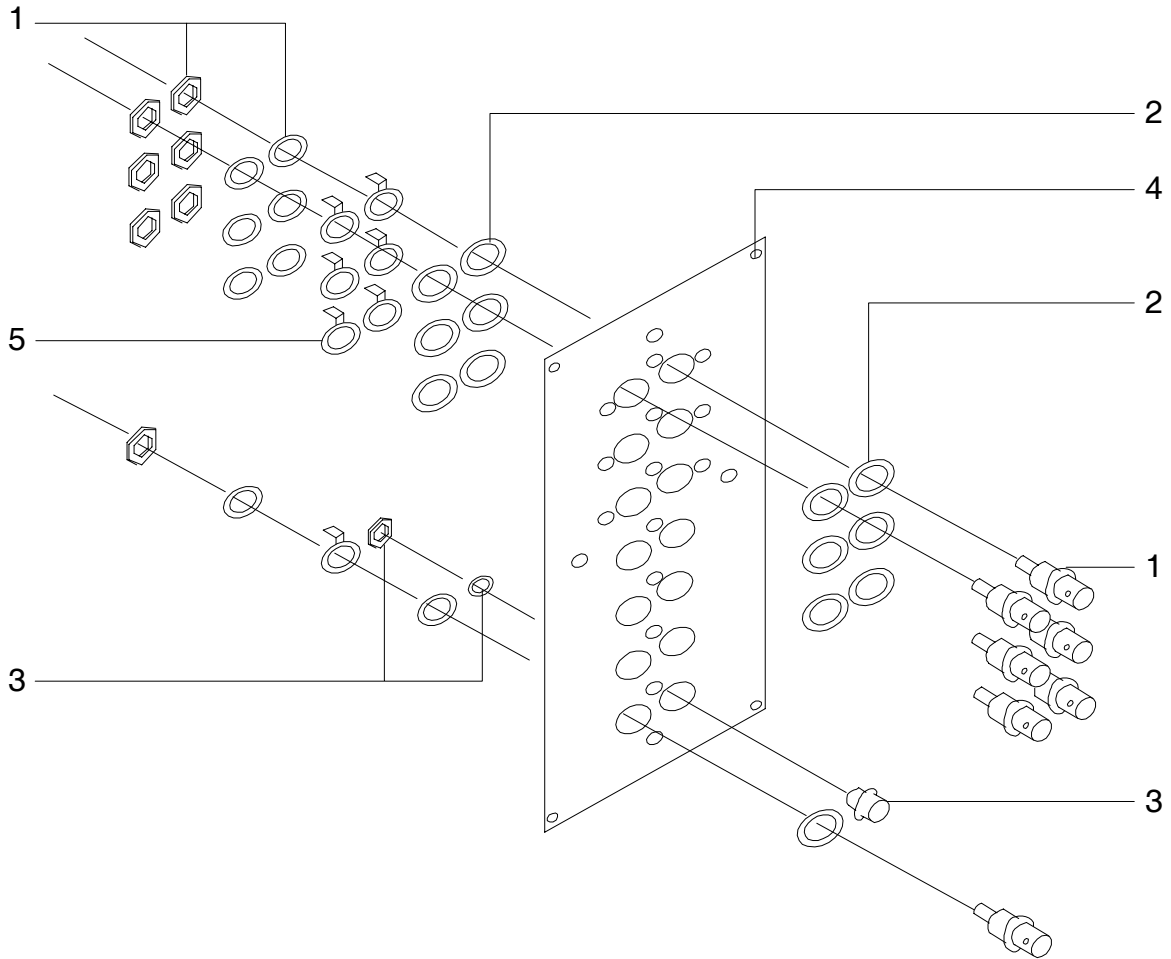


Table 5-4 16495H connector plate replaceable parts (1 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2618	1250-2457	7	Triax connector
2	16495-40011	16495-40012	14	Insulator
3	1252-1419	1252-1419	1	Connector
4	16495-00313	16495-00315	1	Panel
5	04284-01211	5000-4218	7	Terminal lug

Figure 5-5 16495H connector plate replaceable parts (2 of 2)

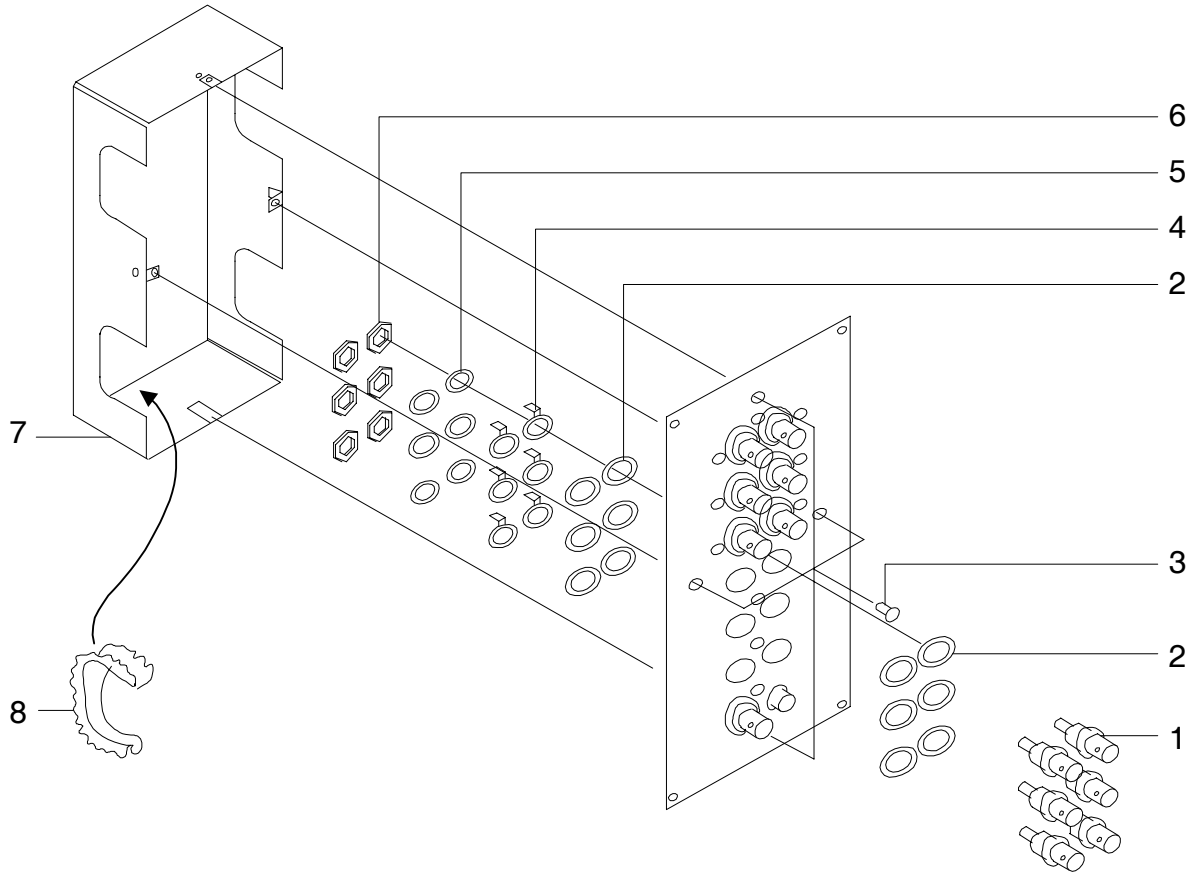


Table 5-5 16495H connector plate replaceable parts (2 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2617	1250-0118	6	BNC connector
2	16495-40011	5040-0345	12	Insulator
3	–	0515-0914	4	M3 screw L6
4	04284-01211	0360-1190	6	Terminal lug
5	–	2190-0016	6	Washer lock
6	–	2950-0001	6	Nut
7	–	16495-04003	1	Cover
8	–	0400-0254	4	Edge guard (9 cm)

Figure 5-6 16495J connector plate replaceable parts (1 of 2)

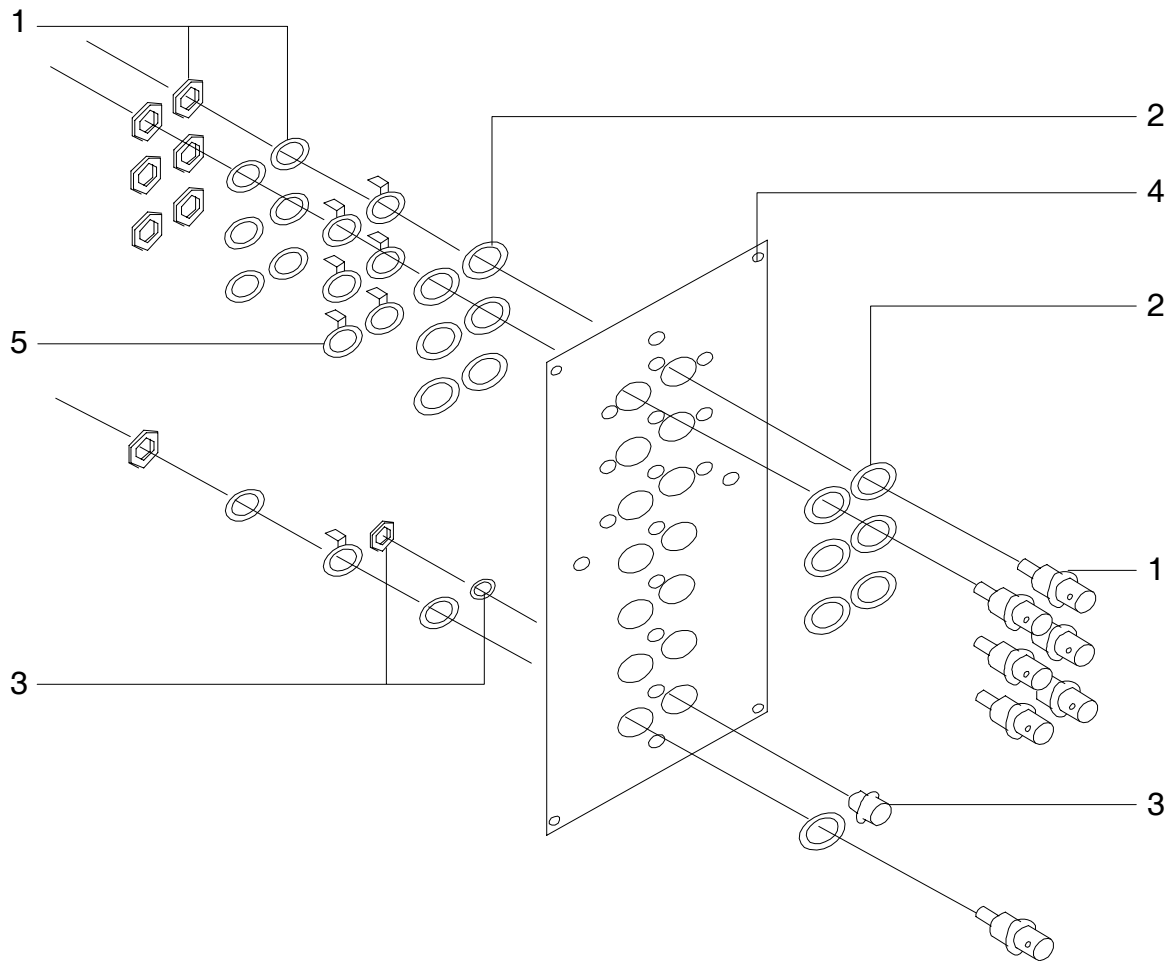


Table 5-6 16495J connector plate replaceable parts (1 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2618	1250-2457	9	Triax connector
2	16495-40011	16495-40012	18	Insulator
3	1252-1419	1252-1419	1	Connector
4	16495-00314	16495-00316	1	Panel
5	04284-01211	5000-4218	9	Terminal lug

Figure 5-7 16495J connector plate replaceable parts (2 of 2)

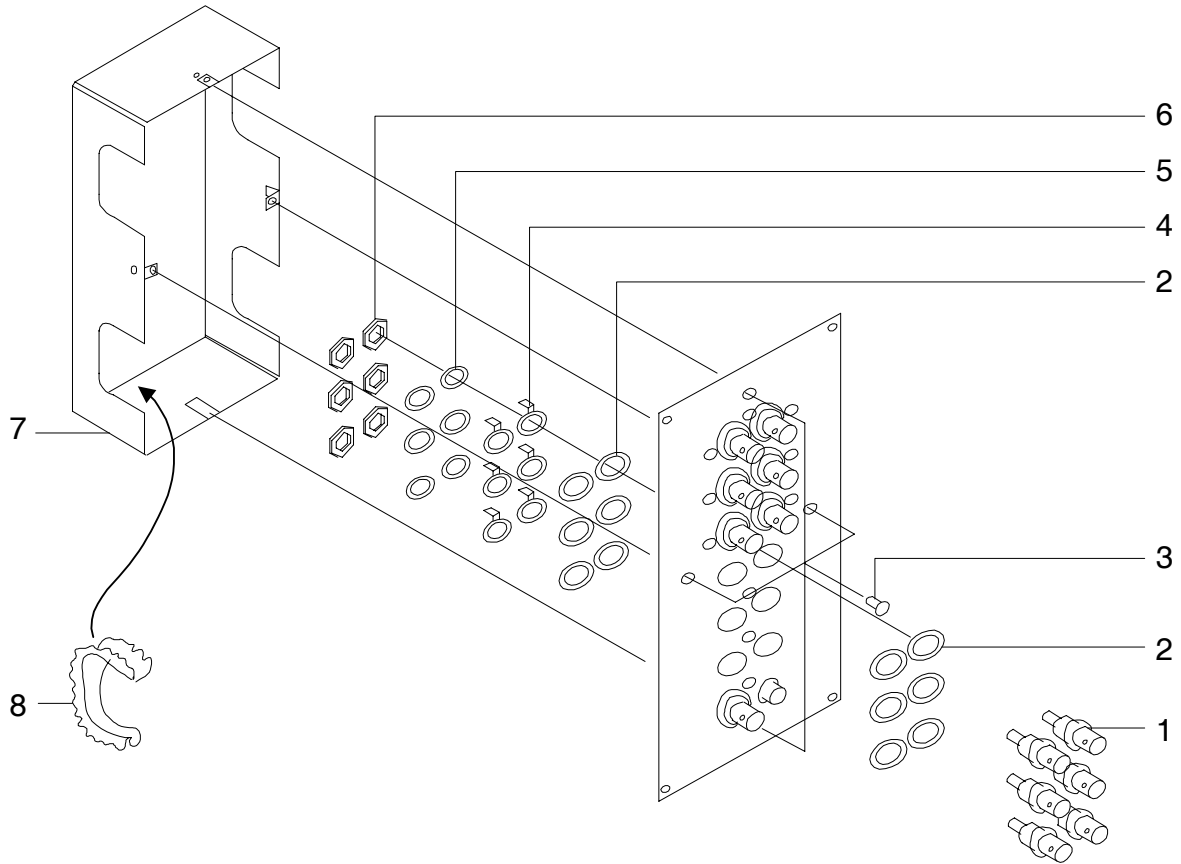


Table 5-7 16495J connector plate replaceable parts (2 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2617	1250-0118	4	BNC connector
2	16495-40011	5040-0345	8	Insulator
3	–	0515-0914	4	M3 screw L6
4	04284-01211	0360-1190	4	Terminal lug
5	–	2190-0016	4	Washer lock
6	–	2950-0001	4	Nut
7	–	16495-04003	1	Cover
8	–	0400-0254	4	Edge guard (9 cm)

Figure 5-8 16495K connector plate replaceable parts

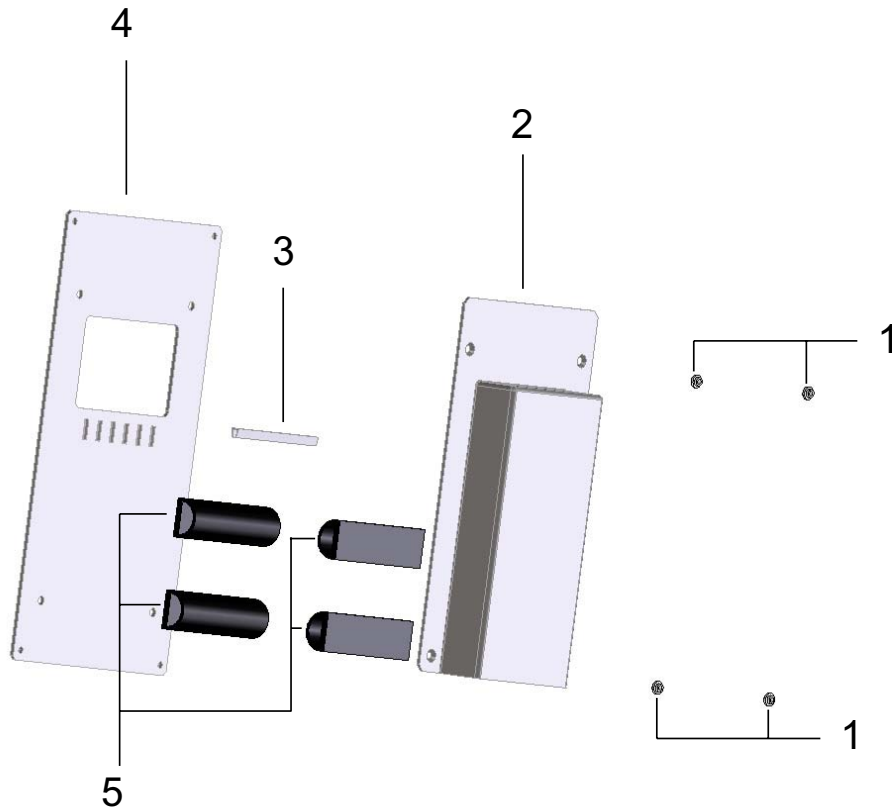


Table 5-8 16495K connector plate replaceable parts

Reference designation	Part number (option 002)	Quantity	Description
1	0515-0914	4	M3 screw L0.5
2	16495-00221	1	Panel
3	0400-0163	1	Grommet chain plain
4	16495-04004	1	Cover
5	16495-40003	4	Gasket rubber

Date Code and Revision History

Agilent Technologies uses the date code to control the module revision. The date code label shown in Figure 5-9 is labeled on each module. The first line shows the part number of the module. The second line shows the engineering date code. The engineering date code changes if the module mechanical design, circuit artwork, or characteristics are changed. The third line shows the manufacturing date code. The manufacturing date code consists of the unique serial number and manufacturing date.

Figure 5-9 Date code label sample

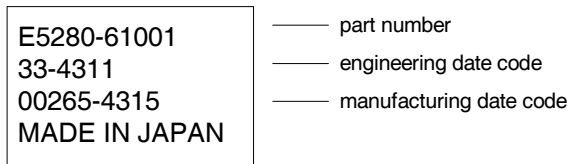


Table 5-9 lists the revision history of each module.

Table 5-9 Revision history

Part number	Description	Engineering date code	Changes
E5270-60002	Motherboard for E5270A	33-4249	Initial release
E5270-66532	CPU module for E526xA	33-4450	Initial release
E5270-66502	CPU module for E527xA	33-4249	Initial release
		33-4312	Firmware revision A.01.01
		33-4439	Firmware revision B.01.00
E5270-66512	CPU module for E5270B	33-4450	Initial release
E5270-66503	Front board	33-4249	Initial release
E5270-66504	Connector board	33-4249	Initial release
E5270-66505	GNDU/ADC module	33-4249	Initial release
E5271-60002	Motherboard for E5272A/73A	33-4249	Initial release
E5280-61001	HPSMU for E527xA	33-4249	Initial release
		33-4311	SN E5270A-01/E5272A-01/E5273A-01
E5280-61011	HPSMU for E5270B	33-4427	Initial release
E5281-66501	MPSMU for E527xA	33-4249	Initial release
		33-4311	SN E5270A-01/E5272A-01/E5273A-01
E5281-66511	MPSMU for E5270B	33-4427	Initial release
E5287-66501	HRSMU for E5270B	33-4427	Initial release
		33-4503	Bug fix for Service Note E5270B-01
E5288-61001	Atto-Ampere Sense Unit	33-4427	Initial release
E5290-61001	HPSMU for E526xA	33-4427	Initial release
E5291-66501	MPSMU for E526xA	33-4427	Initial release

6 Theory of Operation

Theory of Operation

This chapter provides a simplified explanation of E5260/E5270 circuit operation to aid when troubleshooting them. Included are the following sections.

- “Overall Product Architecture”
- “Measurement Unit”
- “Digital Control”
- “Power Supply”
- “Abnormal Condition Detectors”
- “External Instrument Control”

Overall Product Architecture

This section describes the overall product architecture, and consists of the block diagram and configuration information.

Configuration

The E5260/E5270 series have one CPU module, one GNDU/ADC module, and power supply module. Also, the following SMUs are installed in the E5260/E5270.

- E5260A/E5270A/E5270B

The medium power source/monitor unit (MPSMU) and high resolution source/monitor unit (HRSMU) occupy one slot. Hence, the MPSMU/HRSMU can be installed in any slot. Also, the channel number is the same as the slot number. The HRSMU is only for E5270B.

The high power source/monitor unit (HPSMU) occupies two slots. Thus, the HPSMU can be installed in slots 1 to 2, 2 to 3, 3 to 4, 5 to 6, 6 to 7, or 7 to 8. The channel number is the larger slot number for the slots the HPSMU occupies. For example, if a HPSMU occupies slots 5 and 6, the channel number for the module must be 6. Channel numbers 1 and 5 are not available for the HPSMU.

- E5262A/E5272A

The E5262A/E5272A has two MPSMUs, and the SMU configuration cannot be modified.

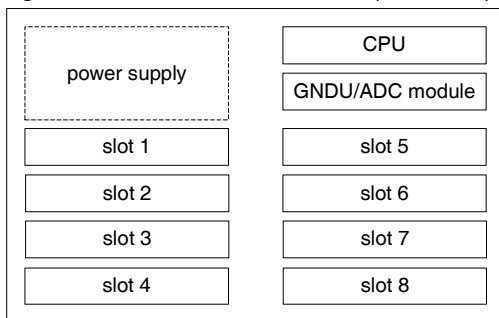
- E5263A/E5273A

The E5263A/E5273A has one HPSMU and one MPSMU, and the SMU configuration cannot be modified.

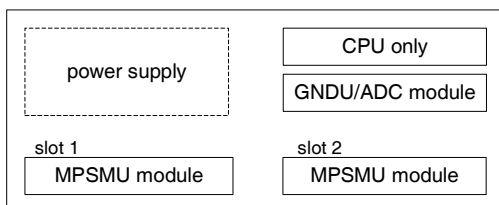
NOTE In the E5263A/E5273A, the MPSMU can be installed in slot 2 for troubleshooting purposes only.

Figure 6-1 SMU installable slots

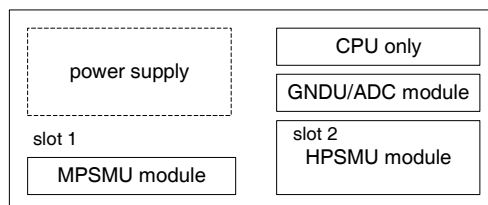
Agilent E5260A/E5270A/E5270B (front view)



Agilent E5262A/E5272A (front view)



Agilent E5263A/E5273A (front view)



Overall block diagram

Figure 6-2 through Figure 6-4 are the overall measurement, control, and power destination diagrams.

Figure 6-2 Overall measurement diagram for E5260/E5270 series

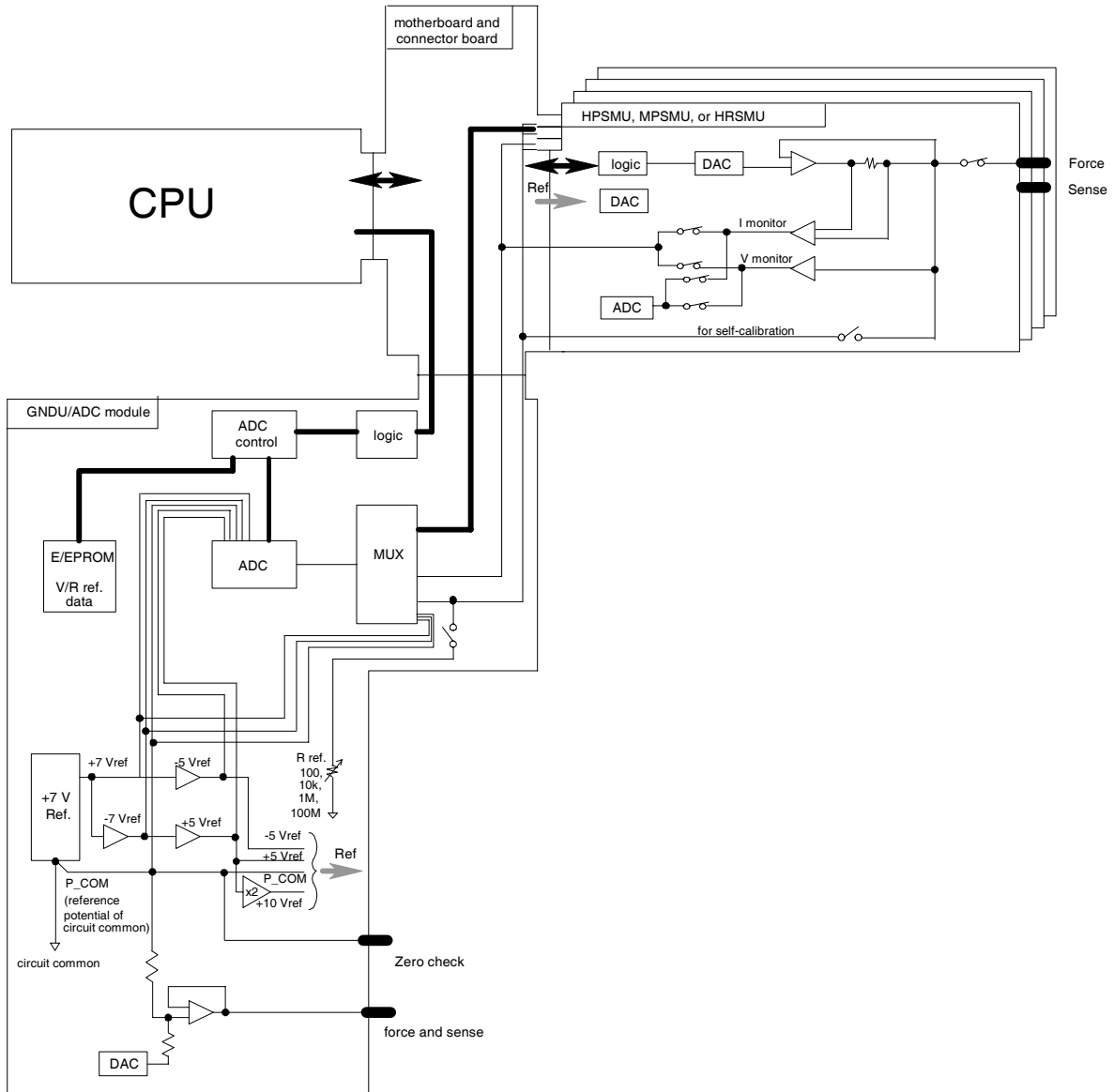


Figure 6-3 Overall control and power destination diagram for E5260A/E5270A/E5270B

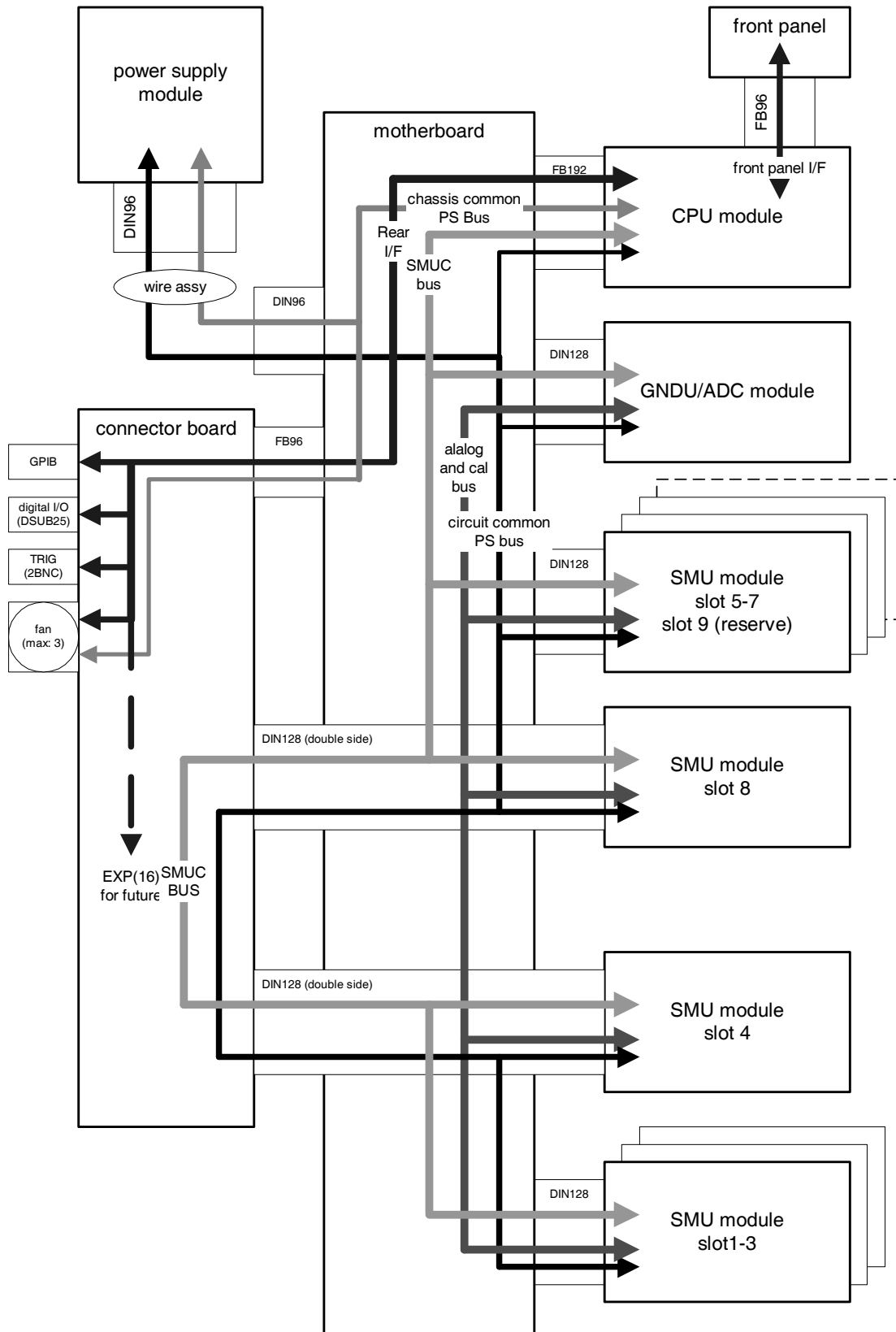
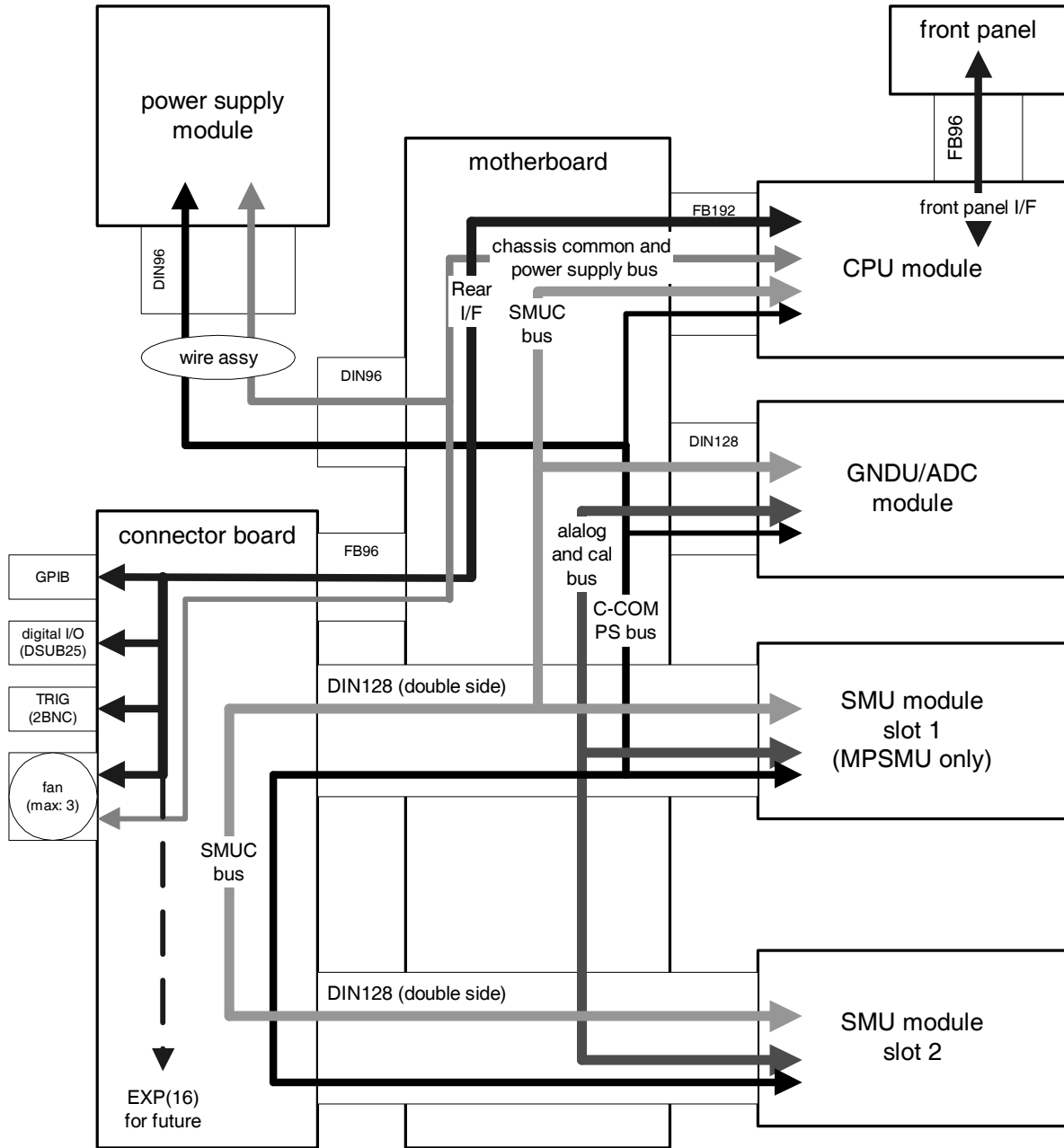


Figure 6-4 Overall control and power destination diagram for E5262A/E5263A/E5272A/E5273A



Measurement Unit

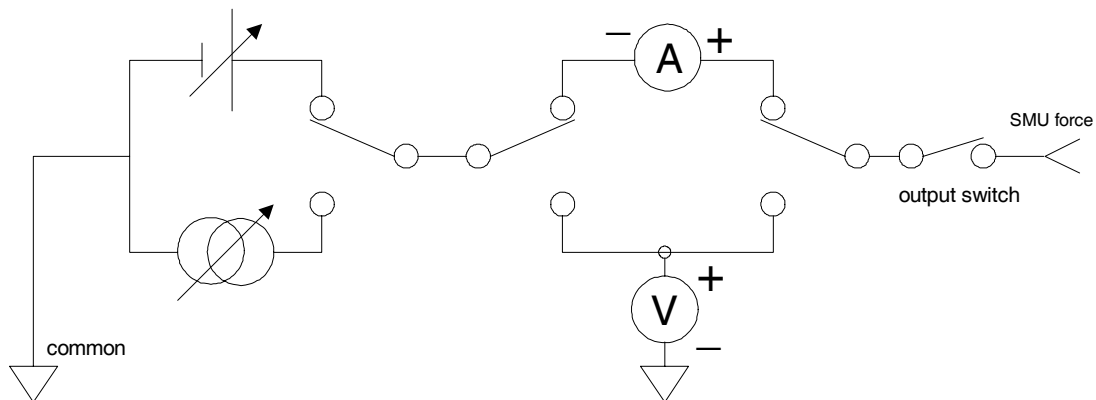
This section gives a simplified explanation of the circuit operation the measurement units to help in troubleshooting.

Source monitor unit (SMU)

There are three types of SMUs. The medium power SMU (MPSMU) is available for all E5260/E5270 series. The high power SMU (HPSMU) is available for the E5260A/E5263A/E5270A/E5273A/E5270B. Additionally, high resolution SMU (HRSMU) and atto sense and switch unit (ASU) are available for the E5270B. The SMUs can force a constant voltage, constant current, pulse voltage, or pulse current, and can measure a DC current or DC voltage. Only one SMU can be set to the pulsed source. Figure 6-5 is a simplified SMU circuit diagram. The SMU has the following three modes:

- Voltage force and current monitor mode (VFIM)
- Current force and voltage monitor mode (IFVM)
- source common mode

Figure 6-5 Simplified SMU circuit diagram



Each SMU has high-speed ADC to force and measure the DC voltage and current. Also, the SMU can force and measure the DC voltage and current using the high-resolution ADC, which is on the GNDU/ADC module.

Theory of Operation
Measurement Unit

Medium power SMU (MPSMU)

The following are the typical specifications of the MPSMU.

- Force and measure up to ± 100 V or ± 200 mA.
- Maximum output power is 4 W.
- Output and measurement range and resolution are shown in Figure 6-6 and Table 6-1 through Table 6-4.

Figure 6-6 MPSMU output and measurement ranges

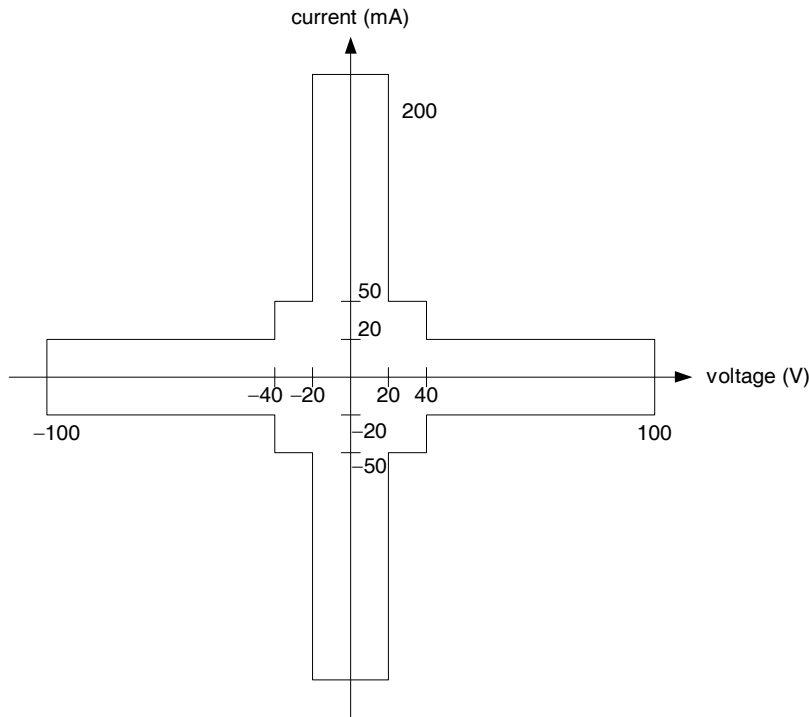


Table 6-1 MPSMU output voltage ranges and resolution

Range	Output value	Setting resolution	Maximum current
2 V	$0 \leq V \leq 2$ V	100 μ V	± 200 mA
20 V	$0 \leq V \leq 20$ V	1 mV	± 200 mA
40 V	$0 \leq V \leq 20$ V	2 mV	± 200 mA
	20 V < $ V \leq 40$ V	2 mV	± 50 mA
100 V	$0 \leq V \leq 20$ V	5 mV	± 200 mA
	20 V < $ V \leq 40$ V	5 mV	± 50 mA
	40 V < $ V \leq 100$ V	5 mV	± 20 mA

Table 6-2 MPSMU measurement voltage ranges and resolution

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
2 V	$0 \leq V \leq 2.2 \text{ V}$	100 μV	2 μV
20 V	$0 \leq V \leq 22 \text{ V}$	1 mV	20 μV
40 V	$0 \leq V \leq 44 \text{ V}$	2 mV	40 μV
100 V	$0 \leq V \leq 100 \text{ V}$	5 mV	100 μV

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

Table 6-3 MPSMU output current ranges and resolution

Range	Output value	Setting resolution	Maximum voltage
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	$\pm 100 \text{ V}$
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	$\pm 100 \text{ V}$
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	$\pm 100 \text{ V}$
1 μA	$0 \leq I \leq 1.15 \mu\text{A}$	50 pA	$\pm 100 \text{ V}$
10 μA	$0 \leq I \leq 11.5 \mu\text{A}$	500 pA	$\pm 100 \text{ V}$
100 μA	$0 \leq I \leq 115 \mu\text{A}$	5 nA	$\pm 100 \text{ V}$
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	$\pm 100 \text{ V}$
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	$\pm 100 \text{ V}$
100 mA	$0 \leq I \leq 20 \text{ mA}$	5 μA	$\pm 100 \text{ V}$
	$20 \text{ mA} < I \leq 50 \text{ mA}$	5 μA	$\pm 40 \text{ V}$
	$50 \text{ mA} < I \leq 115 \text{ mA}$	5 μA	$\pm 20 \text{ V}$
200 mA	$0 \leq I \leq 20 \text{ mA}$	10 μA	$\pm 100 \text{ V}$
	$20 \text{ mA} < I \leq 50 \text{ mA}$	10 μA	$\pm 40 \text{ V}$
	$50 \text{ mA} < I \leq 200 \text{ mA}$	10 μA	$\pm 20 \text{ V}$

Table 6-4 MPSMU measurement current ranges and resolution

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	10 fA
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	10 fA
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	100 fA
1 μA	$0 \leq I \leq 1.15 \mu\text{A}$	50 pA	1 pA
10 μA	$0 \leq I \leq 11.5 \mu\text{A}$	500 pA	10 pA
100 μA	$0 \leq I \leq 115 \mu\text{A}$	5 nA	100 pA
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	1 nA
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	10 nA
100 mA	$0 \leq I \leq 115 \text{ mA}$	5 μA	100 nA
200 mA	$0 \leq I \leq 200 \text{ mA}$	10 μA	200 nA

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

High power SMU (HPSMU)

The following are the typical specifications of the MPSMU.

- Force and measure up to ± 200 V or ± 1 A.
- Maximum output power is 20 W.
- Output and measurement range and resolution are shown in Figure 6-7 and Table 6-5 through Table 6-8.

Figure 6-7 HPSMU output and measurement ranges

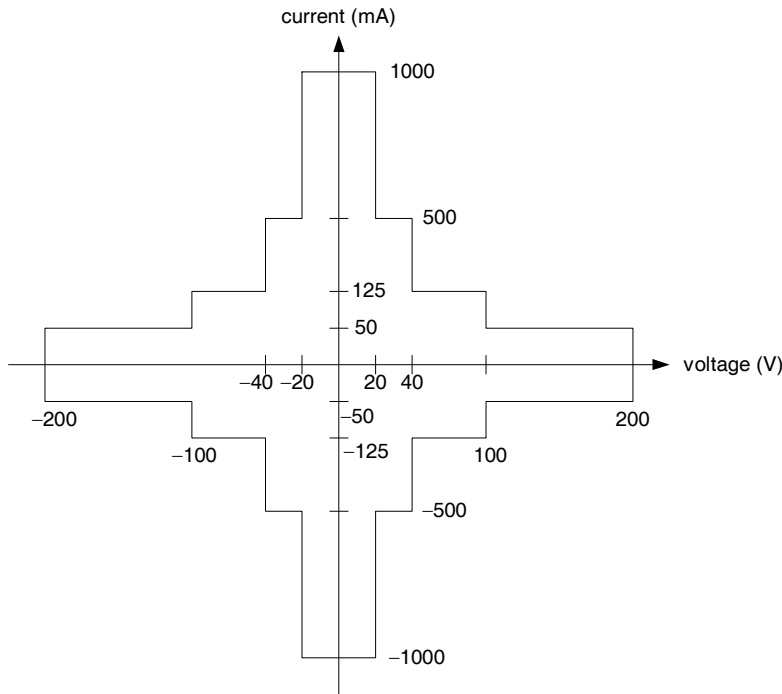


Table 6-5 HPSMU output voltage ranges and resolution

Range	Output value	Setting resolution	Maximum current
2 V	$0 \leq V \leq 2$ V	100 μ V	± 1000 mA
20 V	$0 \leq V \leq 20$ V	1 mV	± 1000 mA
40 V	$0 \leq V \leq 20$ V	2 mV	± 500 mA
	20 V < $ V \leq 40$ V	2 mV	± 125 mA
100 V	$0 \leq V \leq 20$ V	5 mV	± 1000 mA
	20 V < $ V \leq 40$ V	5 mV	± 500 mA
	40 V < $ V \leq 100$ V	5 mV	± 125 mA
200 V	$0 \leq V \leq 20$ V	10 mV	± 1000 mA
	20 V < $ V \leq 40$ V	10 mV	± 500 mA
	40 V < $ V \leq 100$ V	10 mV	± 125 mA
	100 V < $ V \leq 200$ V	10 mV	± 50 mA

Table 6-6 HPSMU measurement voltage ranges and resolution

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
2 V	$0 \leq V \leq 2.2 \text{ V}$	100 μV	2 μV
20 V	$0 \leq V \leq 22 \text{ V}$	1 mV	20 μV
40 V	$0 \leq V \leq 44 \text{ V}$	2 mV	40 μV
100 V	$0 \leq V \leq 110 \text{ V}$	5 mV	100 μV
200 V	$0 \leq V \leq 200 \text{ V}$	10 mV	200 μV

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

Table 6-7 HPSMU output current ranges and resolution

Range	Output value	Setting resolution	Maximum voltage
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	$\pm 200 \text{ V}$
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	$\pm 200 \text{ V}$
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	$\pm 200 \text{ V}$
1 μA	$0 \leq I \leq 1.15 \mu\text{A}$	50 pA	$\pm 200 \text{ V}$
10 μA	$0 \leq I \leq 11.5 \mu\text{A}$	500 pA	$\pm 200 \text{ V}$
100 μA	$0 \leq I \leq 115 \mu\text{A}$	5 nA	$\pm 200 \text{ V}$
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	$\pm 200 \text{ V}$
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	$\pm 200 \text{ V}$
100 mA	$0 \leq I \leq 50 \text{ mA}$	5 μA	$\pm 200 \text{ V}$
	$50 \text{ mA} < I \leq 115 \text{ mA}$	5 μA	$\pm 100 \text{ V}$
1 A	$0 \leq I \leq 50 \text{ mA}$	50 μA	$\pm 200 \text{ V}$
	$50 \text{ mA} < I \leq 125 \text{ mA}$	50 μA	$\pm 100 \text{ V}$
	$125 \text{ mA} < I \leq 500 \text{ mA}$	50 μA	$\pm 40 \text{ V}$
	$500 \text{ mA} < I \leq 1 \text{ A}$	50 μA	$\pm 20 \text{ V}$

Table 6-8 HPSMU measurement current ranges and resolution

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	10 fA
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	10 fA
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	100 fA
1 μA	$0 \leq I \leq 1.15 \mu\text{A}$	50 pA	1 pA
10 μA	$0 \leq I \leq 11.5 \mu\text{A}$	500 pA	10 pA
100 μA	$0 \leq I \leq 115 \mu\text{A}$	5 nA	100 pA
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	1 nA
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	10 nA
100 mA	$0 \leq I \leq 115 \text{ mA}$	5 μA	100 nA
1 A	$0 \leq I \leq 1 \text{ A}$	50 μA	1 μA

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

Theory of Operation
Measurement Unit

High resolution SMU (HRSMU) (without ASU)

The following are the typical specifications of the HRSMU.

- Force and measure up to ± 100 V or ± 100 mA.
- Maximum output power is 2 W.
- Output and measurement range and resolution are shown in Figure 6-8 and Table 6-9 through Table 6-12.

Figure 6-8 HRSMU output and measurement ranges (without ASU)

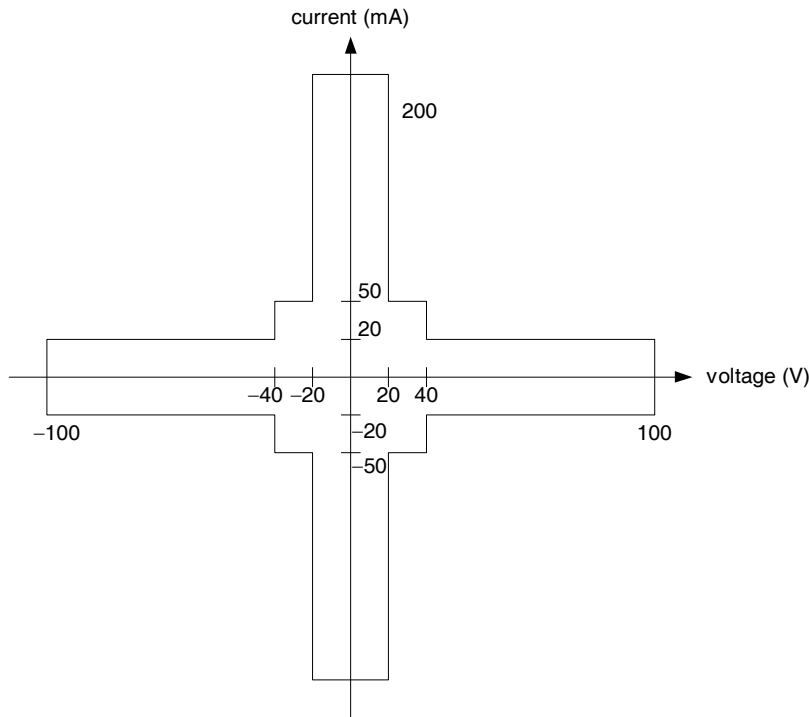


Table 6-9 HRSMU output voltage ranges and resolution (without ASU)

Range	Output value	Setting resolution	Maximum current
0.5 V	$0 \leq V \leq 0.5$ V	25 μ V	± 100 mA
2 V	$0 \leq V \leq 2$ V	100 μ V	± 100 mA
5 V	$0 \leq V \leq 5$ V	250 μ V	± 100 mA
20 V	$0 \leq V \leq 20$ V	1 mV	± 100 mA
40 V	$0 \leq V \leq 20$ V	2 mV	± 100 mA
	20 V < $ V \leq 40$ V	2 mV	± 50 mA
100 V	$0 \leq V \leq 20$ V	5 mV	± 100 mA
	20 V < $ V \leq 40$ V	5 mV	± 50 mA
	40 V < $ V \leq 100$ V	5 mV	± 20 mA

Table 6-10 HRSMU measurement voltage ranges and resolution (without ASU)

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
0.5 V	$0 \leq V \leq 0.55 \text{ V}$	25 μV	0.5 μV
2 V	$0 \leq V \leq 2.2 \text{ V}$	100 μV	2 μV
5 V	$0 \leq V \leq 5.5 \text{ V}$	250 μV	5 μV
20 V	$0 \leq V \leq 22 \text{ V}$	1 mV	20 μV
40 V	$0 \leq V \leq 44 \text{ V}$	2 mV	40 μV
100 V	$0 \leq V \leq 100 \text{ V}$	5 mV	100 μV

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

Table 6-11 HRSMU output current ranges and resolution (without ASU)

Range	Output value	Setting resolution	Maximum voltage
10 pA	$0 \leq I \leq 11.5 \text{ pA}$	5 fA	$\pm 100 \text{ V}$
100 pA	$0 \leq I \leq 115 \text{ pA}$	5 fA	$\pm 100 \text{ V}$
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	$\pm 100 \text{ V}$
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	$\pm 100 \text{ V}$
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	$\pm 100 \text{ V}$
1 μA	$0 \leq I \leq 1.15 \mu\text{A}$	50 pA	$\pm 100 \text{ V}$
10 μA	$0 \leq I \leq 11.5 \mu\text{A}$	500 pA	$\pm 100 \text{ V}$
100 μA	$0 \leq I \leq 115 \mu\text{A}$	5 nA	$\pm 100 \text{ V}$
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	$\pm 100 \text{ V}$
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	$\pm 100 \text{ V}$
100 mA	$0 \leq I \leq 20 \text{ mA}$	5 μA	$\pm 100 \text{ V}$
	$20 \text{ mA} < I \leq 50 \text{ mA}$	5 μA	$\pm 40 \text{ V}$
	$50 \text{ mA} < I \leq 110 \text{ mA}$	5 μA	$\pm 20 \text{ V}$

Table 6-12 HRSMU measurement current ranges and resolution (without ASU)

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
10 pA	$0 \leq I \leq 11.5 \text{ pA}$	1 fA	1 fA
100 pA	$0 \leq I \leq 115 \text{ pA}$	5 fA	2 fA
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	10 fA
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	10 fA
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	100 fA
1 μA	$0 \leq I \leq 1.15 \text{ } \mu\text{A}$	50 pA	1 pA
10 μA	$0 \leq I \leq 11.5 \text{ } \mu\text{A}$	500 pA	10 pA
100 μA	$0 \leq I \leq 115 \text{ } \mu\text{A}$	5 nA	100 pA
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	1 nA
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	10 nA
100 mA	$0 \leq I \leq 110 \text{ mA}$	5 μA	100 nA

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

High resolution SMU (HRSMU) (with ASU)

The following are the typical specifications of the HRSMU.

- Force and measure up to $\pm 100 \text{ V}$ or $\pm 100 \text{ mA}$.
- Maximum output power is 2 W.
- Output and measurement range and resolution are shown in Figure 6-9 and Table 6-13 through Table 6-16.

Figure 6-9 HRSMU output and measurement ranges (with ASU)

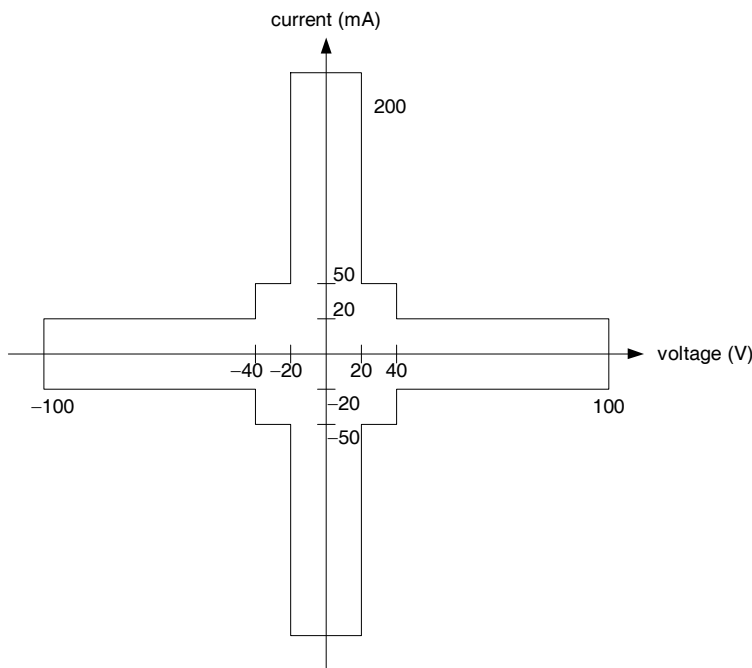


Table 6-13 HRSMU output voltage ranges and resolution (with ASU)

Range	Output value	Setting resolution	Maximum current
0.5 V	$0 \leq V \leq 0.5 \text{ V}$	25 μV	$\pm 100 \text{ mA}$
2 V	$0 \leq V \leq 2 \text{ V}$	100 μV	$\pm 100 \text{ mA}$
5 V	$0 \leq V \leq 5 \text{ V}$	250 μV	$\pm 100 \text{ mA}$
20 V	$0 \leq V \leq 20 \text{ V}$	1 mV	$\pm 100 \text{ mA}$
40 V	$0 \leq V \leq 20 \text{ V}$	2 mV	$\pm 100 \text{ mA}$
	$20 \text{ V} < V \leq 40 \text{ V}$	2 mV	$\pm 50 \text{ mA}$
100 V	$0 \leq V \leq 20 \text{ V}$	5 mV	$\pm 100 \text{ mA}$
	$20 \text{ V} < V \leq 40 \text{ V}$	5 mV	$\pm 50 \text{ mA}$
	$40 \text{ V} < V \leq 100 \text{ V}$	5 mV	$\pm 20 \text{ mA}$

Table 6-14 HRSMU measurement voltage ranges and resolution (with ASU)

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
0.5 V	$0 \leq V \leq 0.55 \text{ V}$	25 μV	0.5 μV
2 V	$0 \leq V \leq 2.2 \text{ V}$	100 μV	2 μV
5 V	$0 \leq V \leq 5.5 \text{ V}$	250 μV	5 μV
20 V	$0 \leq V \leq 22 \text{ V}$	1 mV	20 μV
40 V	$0 \leq V \leq 44 \text{ V}$	2 mV	40 μV
100 V	$0 \leq V \leq 100 \text{ V}$	5 mV	100 μV

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

Table 6-15 HRSMU output current ranges and resolution (with ASU)

Range	Output value	Setting resolution	Maximum voltage
1 pA	$0 \leq I \leq 1.15 \text{ pA}$	1 fA	$\pm 100 \text{ V}$
10 pA	$0 \leq I \leq 11.5 \text{ pA}$	5 fA	$\pm 100 \text{ V}$
100 pA	$0 \leq I \leq 115 \text{ pA}$	5 fA	$\pm 100 \text{ V}$
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	$\pm 100 \text{ V}$
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	$\pm 100 \text{ V}$
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	$\pm 100 \text{ V}$
1 μA	$0 \leq I \leq 1.15 \text{ } \mu\text{A}$	50 pA	$\pm 100 \text{ V}$
10 μA	$0 \leq I \leq 11.5 \text{ } \mu\text{A}$	500 pA	$\pm 100 \text{ V}$
100 μA	$0 \leq I \leq 115 \text{ } \mu\text{A}$	5 nA	$\pm 100 \text{ V}$
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	$\pm 100 \text{ V}$
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	$\pm 100 \text{ V}$
100 mA	$0 \leq I \leq 20 \text{ mA}$	5 μA	$\pm 100 \text{ V}$
	$20 \text{ mA} < I \leq 50 \text{ mA}$	5 μA	$\pm 40 \text{ V}$
	$50 \text{ mA} < I \leq 110 \text{ mA}$	5 μA	$\pm 20 \text{ V}$

Table 6-16 HRSMU measurement current ranges and resolution (with ASU)

Range	Measurement value ^a	Measurement resolutions	
		High-speed ADC	High-resolution ADC
1 pA	$0 \leq I \leq 1.15 \text{ pA}$	100 aA	100 aA
10 pA	$0 \leq I \leq 11.5 \text{ pA}$	1 fA	400 aA
100 pA	$0 \leq I \leq 115 \text{ pA}$	5 fA	500 aA
1 nA	$0 \leq I \leq 1.15 \text{ nA}$	50 fA	10 fA
10 nA	$0 \leq I \leq 11.5 \text{ nA}$	500 fA	10 fA
100 nA	$0 \leq I \leq 115 \text{ nA}$	5 pA	100 fA
1 μ A	$0 \leq I \leq 1.15 \text{ } \mu\text{A}$	50 pA	1 pA
10 μ A	$0 \leq I \leq 11.5 \text{ } \mu\text{A}$	500 pA	10 pA
100 μ A	$0 \leq I \leq 115 \text{ } \mu\text{A}$	5 nA	100 pA
1 mA	$0 \leq I \leq 1.15 \text{ mA}$	50 nA	1 nA
10 mA	$0 \leq I \leq 11.5 \text{ mA}$	500 nA	10 nA
100 mA	$0 \leq I \leq 110 \text{ mA}$	5 μ A	100 nA

a. This column is applied to auto ranging or limited auto ranging. For fixed ranging, the maximum measurement value is the Range column value.

GNDU/ADC module

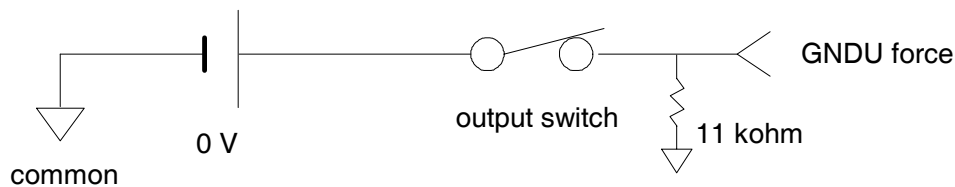
The ground unit and analog digital converter (GNDU/ADC) module consists of the following sub functions:

- GNDU
- High-resolution ADC
- Reference voltage
- Reference resistor
- Zero check terminal
- Circuit common and chassis ground

GNDU

The GNDU is a 0 V constant voltage source, used for the reference of the measurement ground. Also, the GNDU can sink up to ± 4 A in the E5270A and ± 2.2 A in the E5272A and E5273A, so it is effective for using the HPSMU. Figure 6-10 is a simplified circuit diagram of GNDU.

Figure 6-10 Simplified GNDU circuit diagram



High-resolution ADC

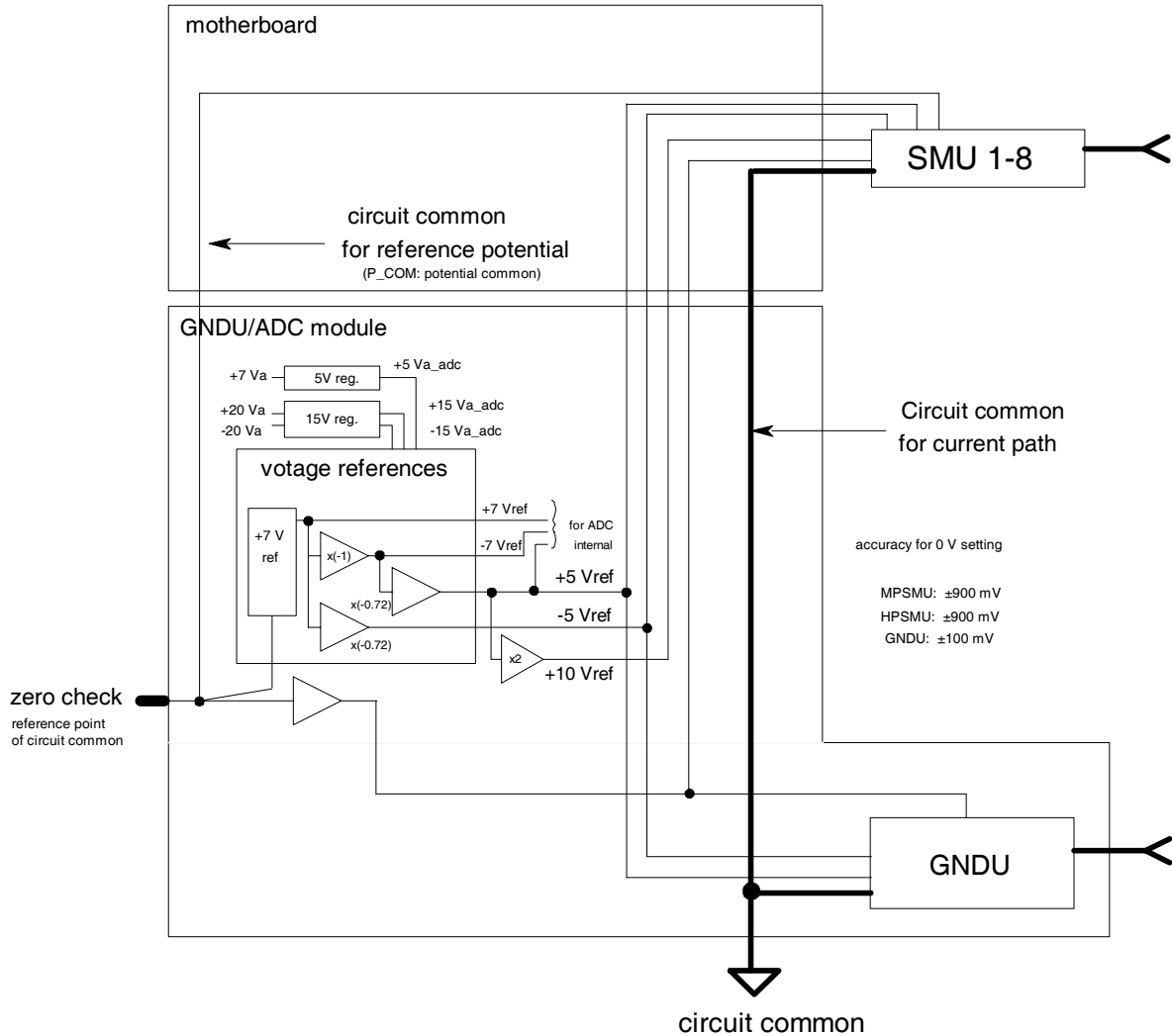
The GNDU/ADC module has one high-resolution ADC. The high-resolution ADC is used for high-resolution and high-accuracy measurement.

Reference voltage

There are six reference voltages on the GNDU/ADC module: +7 Vref, -7 Vref, +5 Vref, -5 Vref, +10 Vref, and potential common (zero check). The high-resolution ADC uses +7 Vref, -7 Vref, +5 Vref, and potential common (zero check) as the voltage references. The SMU and GNDU use +5 Vref, -5 Vref, +10 Vref, and potential common (zero check) as the reference voltages. (high-speed ADC on each SMU uses +10 Vref.)

The voltage references are supplied from the voltage regulator on the GNDU/ADC module. Figure 6-11 is a simplified circuit diagram of the reference voltage.

Figure 6-11 Reference voltages and zero check terminal



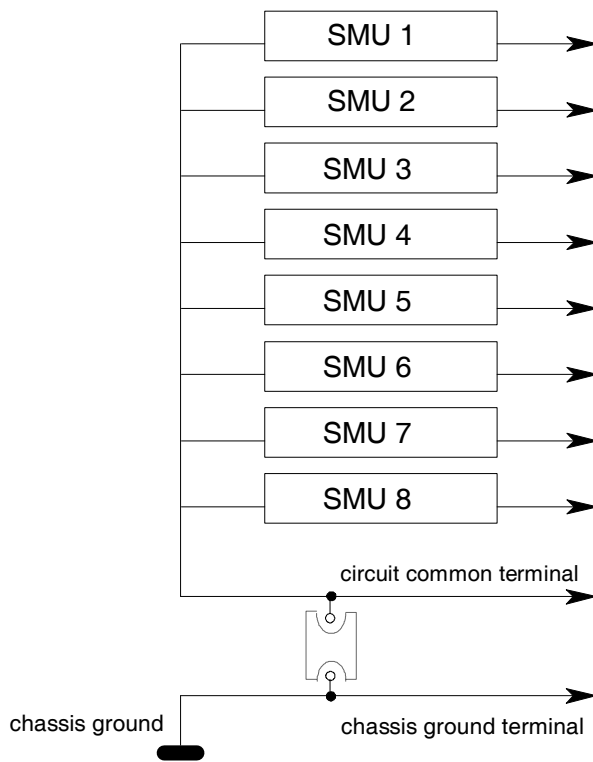
Circuit common and chassis ground

The circuit common and chassis ground terminals on the front panel are used during floating or grounded measurements. When the test device is grounded by an external instrument (wafer-prober or external sources, etc.), use the floating measurements to prevent noise from ground loops. The E5260/E5270 forces and measures voltage or current referenced to external ground (± 42 V maximum). If the external ground is greater than ± 42 V referenced to chassis ground, the E5260/E5270 might be damaged as a consequence. Note that the voltage appears on the outer conductor of the force terminals, which are the circuit common.

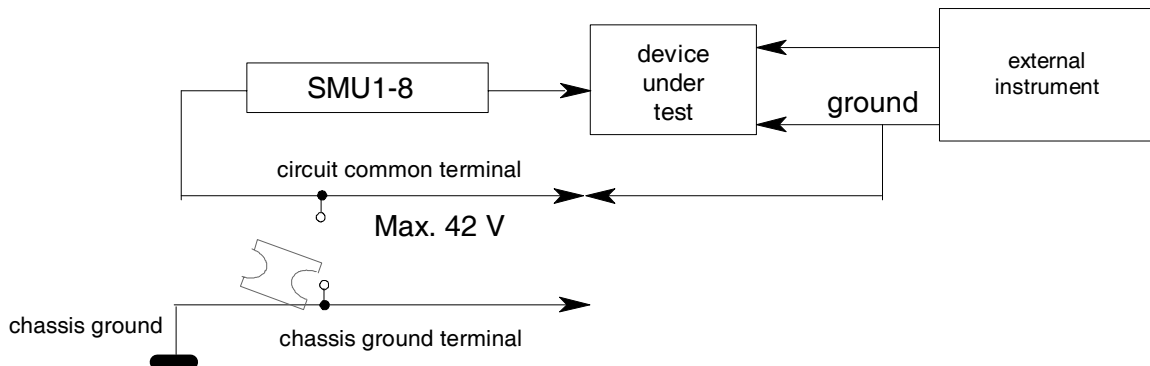
When you do not perform the floating measurements, connect the chassis ground and circuit common with the shorting-bar for noise reduction and safety.

Figure 6-13 Circuit common and chassis ground terminals

grounded measurements (circuit common = chassis ground):



floating measurements (circuit common = external ground):



Output and Measurement Mechanism

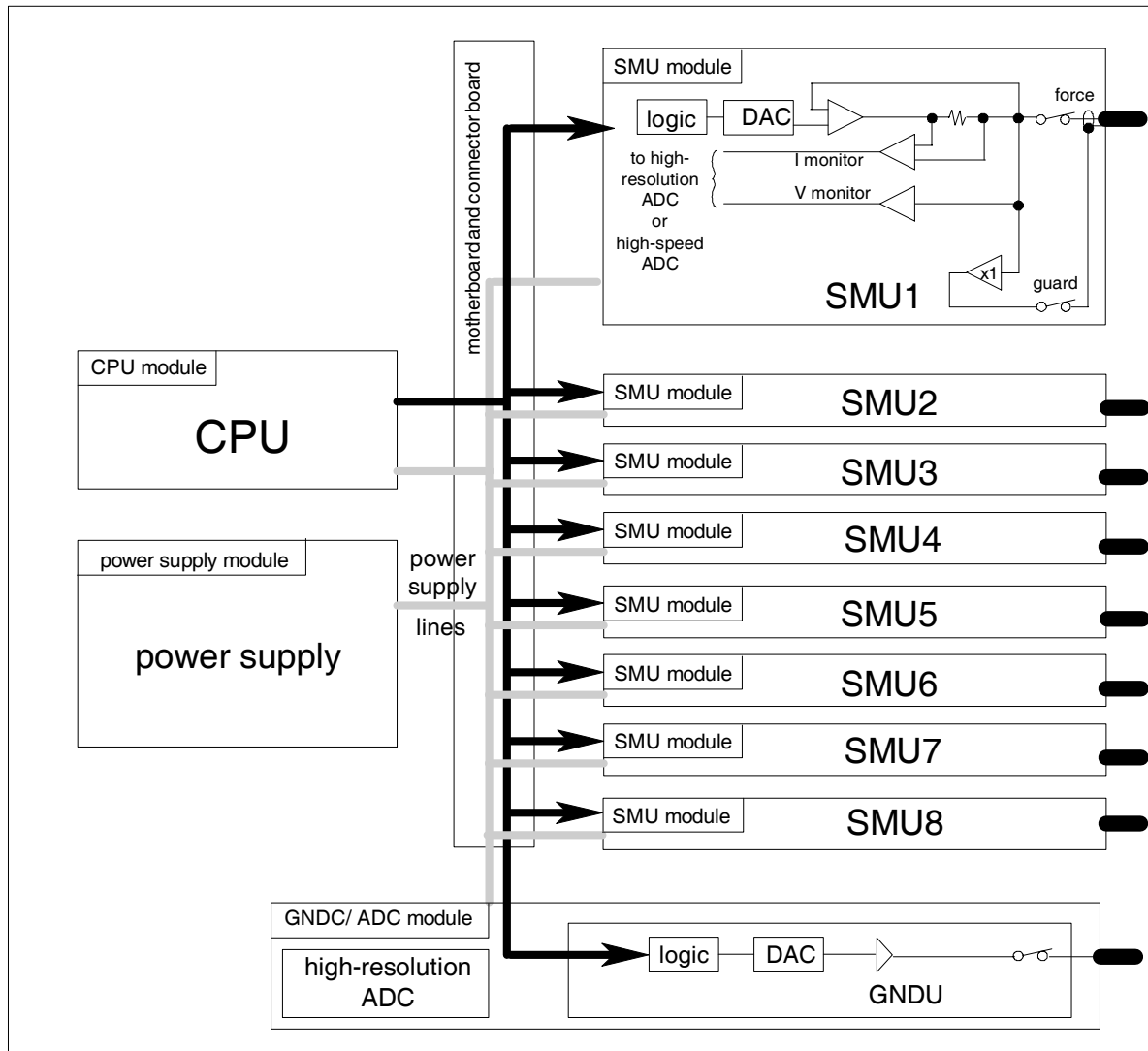
This section describes the SMU output and measurement flow and auto ranging mechanism.

Output diagram

In the E5260/E5270, each measurement-unit module (SMU and GNDU) includes all circuits for the output. That is, each module has everything from the digital analog converter (DAC) to the output terminal. Therefore, the output circuit of each module is independent of the other modules.

Figure 6-14 is the output flow diagram. The CPU (CPU module) controls all measurement-unit modules, and the CPU module is connected to each measurement unit through the motherboard and the connector board.

Figure 6-14 Output flow diagram



Measurement diagram

There are two kinds of ADCs, a high-resolution ADC on the GNDU/ADC module and the high-speed ADCs on the SMU modules. The inputs to the high-resolution ADC are switched by the multiplexer on the SMU module. When you perform multi-channel measurements by using the high-resolution ADC, the timing for each channel is different. The time difference consists of the measurement integration time and measurement range change time by auto ranging. Figure 6-15 shows an example of the measurement timing for multichannel measurement.

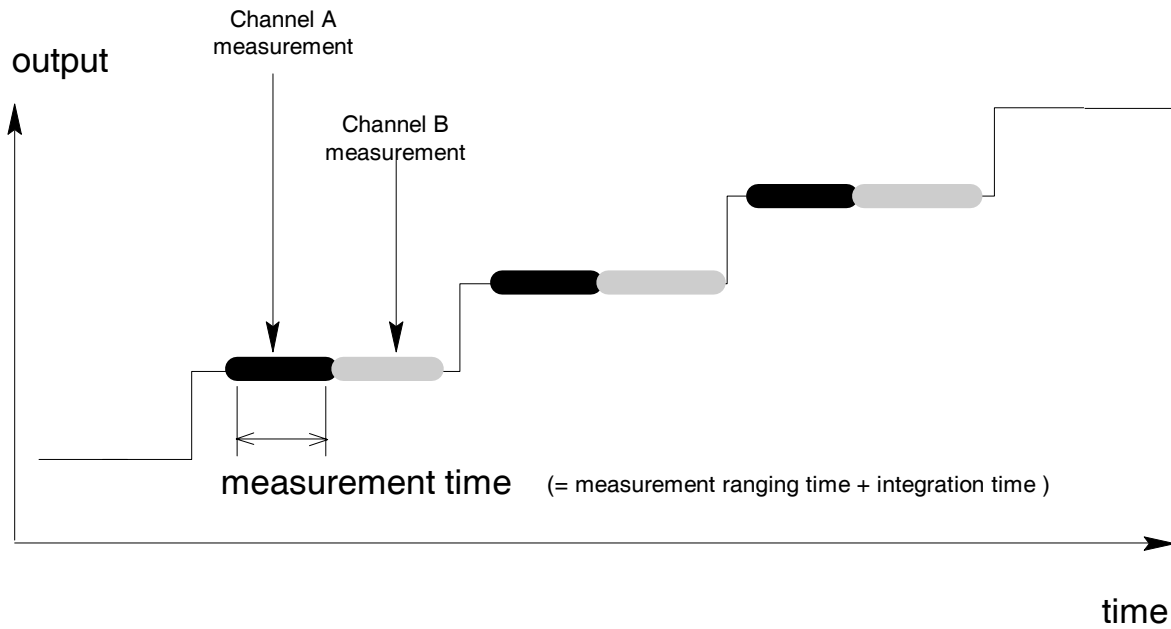
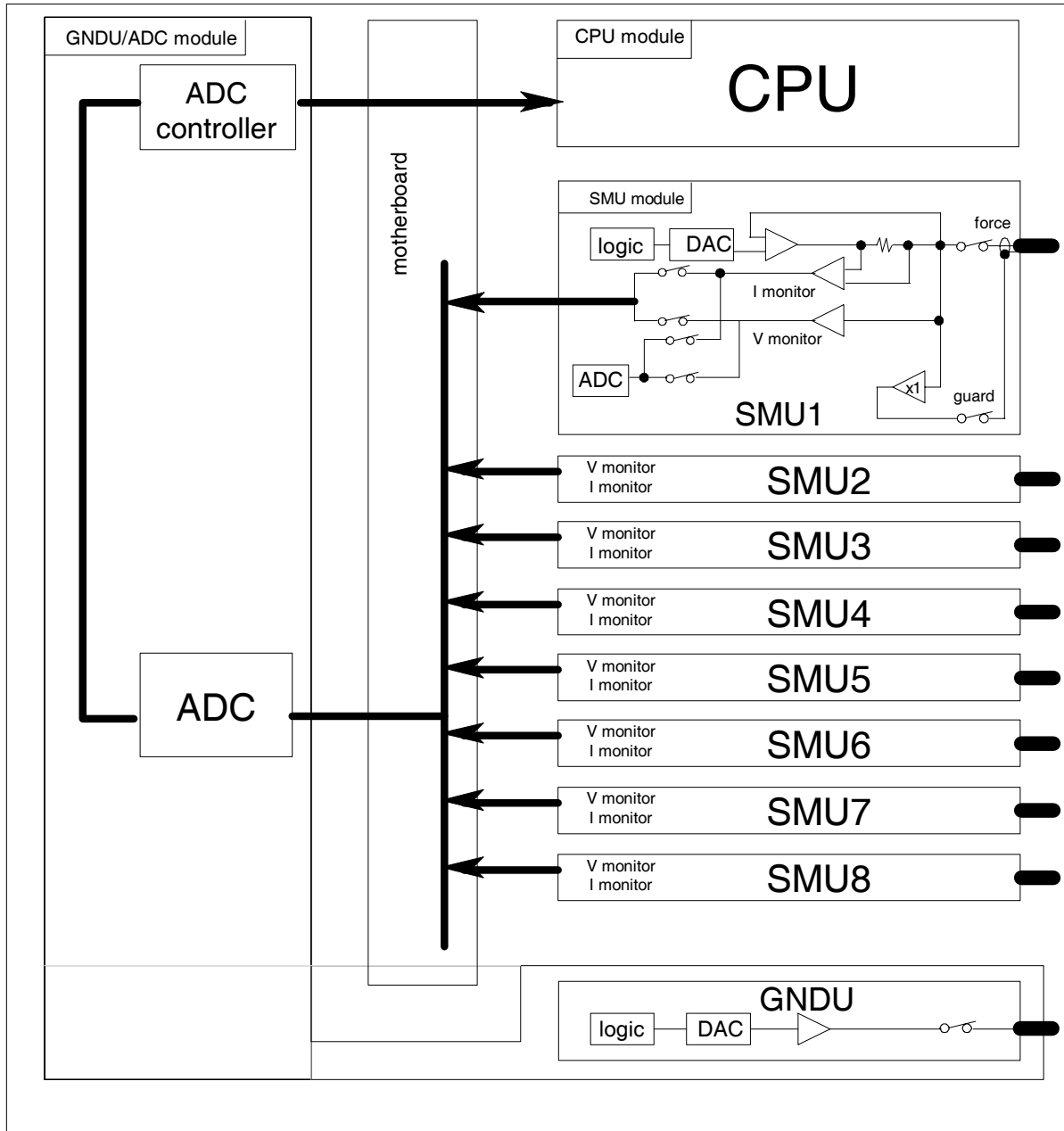
Figure 6-15 Multichannel measurement in output sweep

Figure 6-16 is the measurement flow diagram. The monitor amplifier in each measurement-unit module normalizes the input voltage/current to 0 to ± 8 and the polarity is reversed for the voltage measurement. The normalized voltage is sent to the GNDU/ADC module. For example, if the SMU voltage measurement range is 100 V and the ADC-converted value is 8 V, the measurement voltage is -100 V.

Similarly, the input to the high-speed ADC is normalized to 0 to ± 8 .

Figure 6-16 Measurement flow diagram



Auto ranging measurement

The SMU unit searches for and measures at the range that provides the highest resolution as follows:

- Voltage measurement

The unit changes ranges (up or down one range at a time) until the measurement value is between 100 % of the lower voltage range and 110 % of the present range; then the unit performs the measurement.

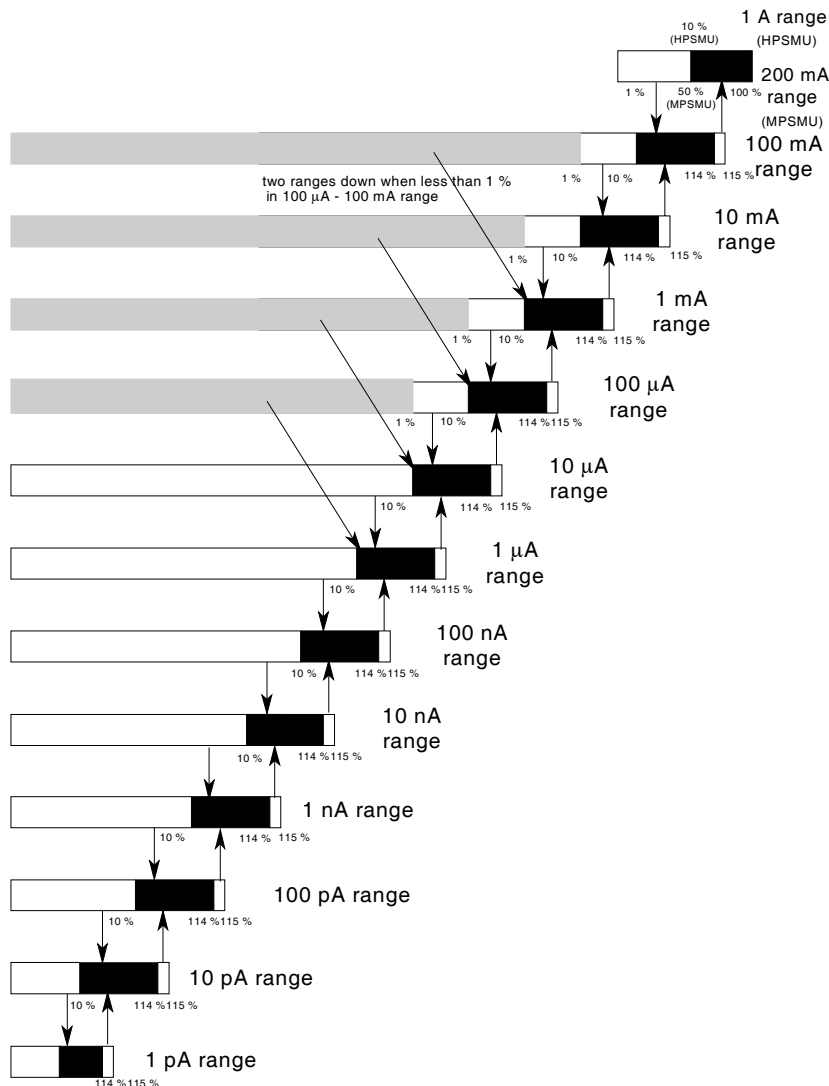
- Current measurement

The unit changes ranges (up or down one range at a time) until the measurement value is between 10 % and 114 % of the range; then the unit performs the measurement.

Exception: If the present range is 100 μ A to 100 mA and the measurement value is less than 1 % of the present range, the range changes down two ranges instead of one range.

If the unit is MPSMU and the present range is 200 mA, the unit changes to the 100 mA range when the measurement value is less than 50 % of the range.

Figure 6-17 SMU current measurement auto ranging



ADC Self-Calibration

This section describes the ADC self-calibration flow and block diagram of the ADC self-calibration path.

Calibration flow

The ADC self-calibration/self-test uses the +7 Vref, -7 Vref, and potential common.

The current output self-calibration is done in the following order:

1. SMU forces a current (I_{set}) to the reference resistor whose value is known by calibration, through the self-calibration bus.
2. ADC measures the V_{adc} , which is the voltage of reference resistor.
3. CPU calculates the following, which is the true value of I_{set} .

$$\frac{V_{adc}}{R_{ref}}$$

The current measurement self-calibration is done in the following order:

1. SMU forces a current (I_{set}).
2. SMU measures the current ($I_{monitor}$).
3. ADC measures the V_{adc} .
4. CPU calculates the following, which is the true value of $I_{monitor}$.

$$\frac{V_{adc}}{R_{ref}}$$

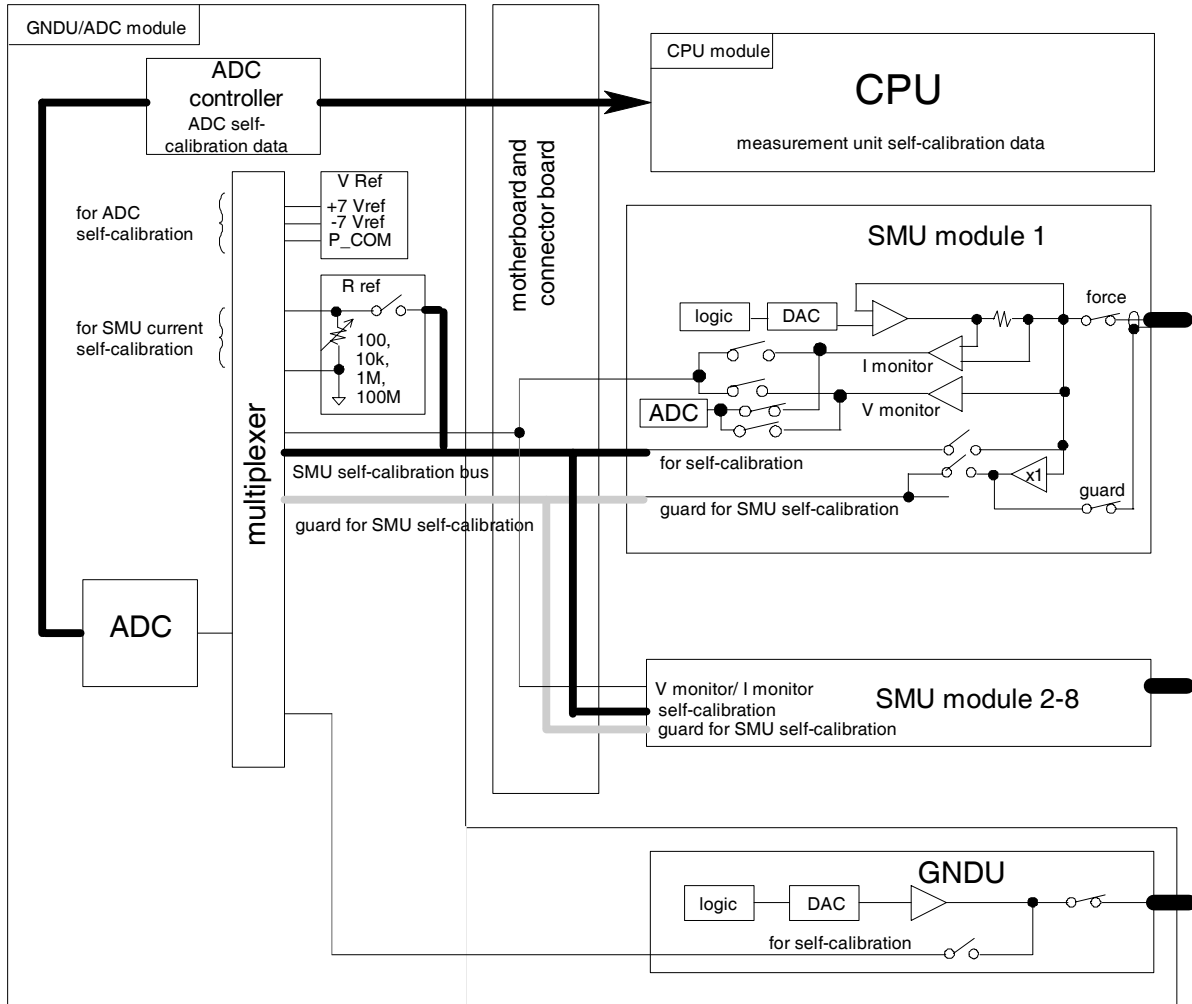
The reference resistors are not tested in the ADC self-calibration. Therefore, the ADC self-calibration and ADC self-test may pass and SMU self-test may fail if the reference resistors are defective.

Self-calibration path

The self-calibration is performed by using the measurement bus and self-calibration bus as shown in Figure 6-18. During the self-calibration, the outputs are not forced outside because all output switches are set to off. The self-calibration bus connects the SMU output to the ADC directly (without monitor amplifier) for accurate calibration

Maximum voltage is limited to 10 V because the maximum ADC input is 10 V. To self-calibrate the voltages greater than 10 V, the normal measurement bus (V/I monitor lines) is used.

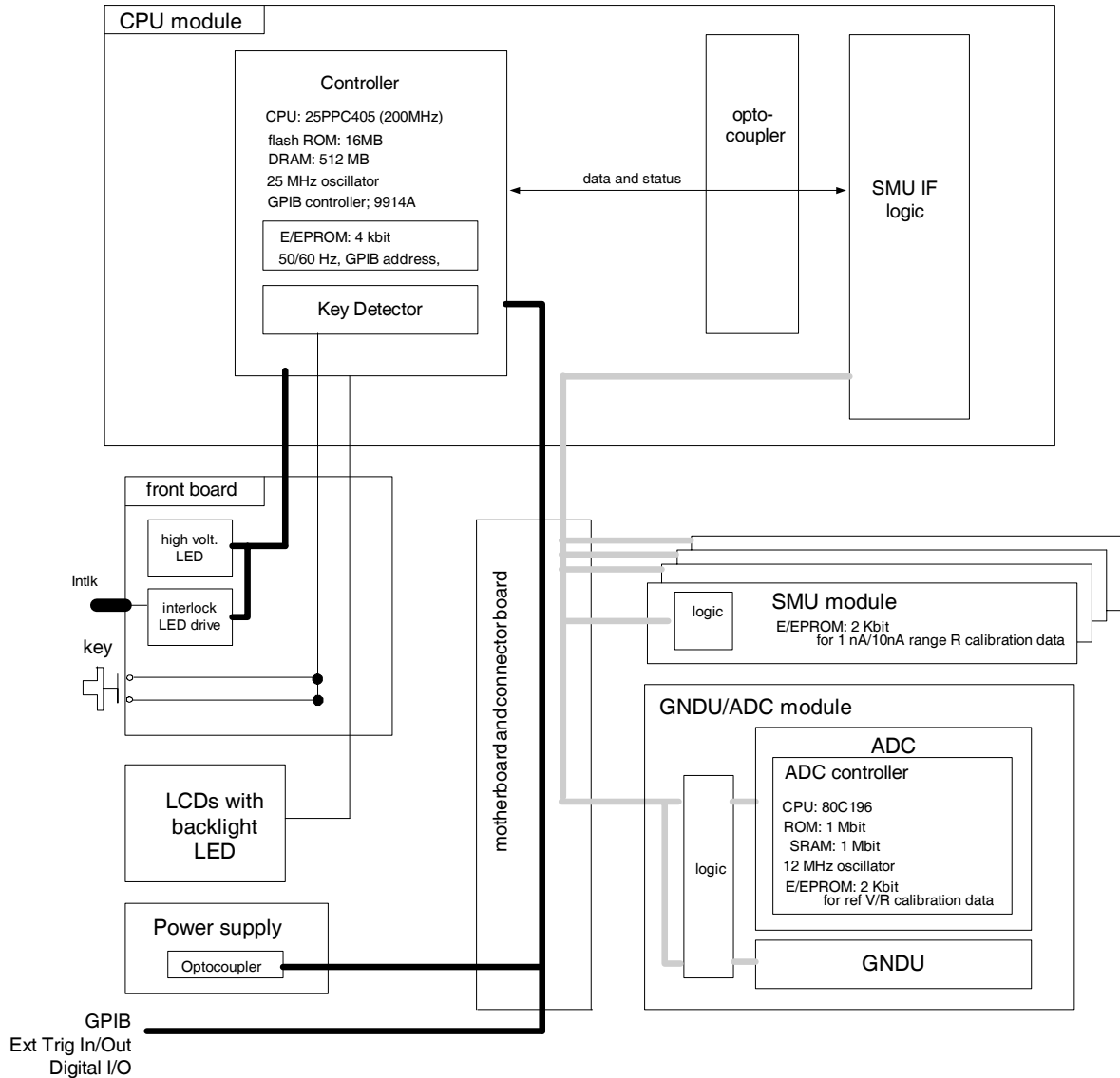
Figure 6-18 Self-calibration path (measurement bus and self-calibration bus)



Digital Control

This section describes the overall E5270 digital control architecture and function of related components such as the CPU module, LCD, and front key. Figure 6-19 is the E5270 digital control diagram.

Figure 6-19 E5270 control diagram



CPU module

The controller controls the front panel (including keys and LEDs), LCD, GPIB, digital I/O, trigger in/out, and interlock (Intlk), GNDU/ADC module, SMUs.

CPU module consists of the host controller and the SMU interface logic. The host controller controls and communicates with front board, power supply, and external I/O. The SMU interface logic controls the SMU and GNDU/ADC modules.

LCD

The LCD is a two-line, 40-character monochrome display with backlight LEDs.

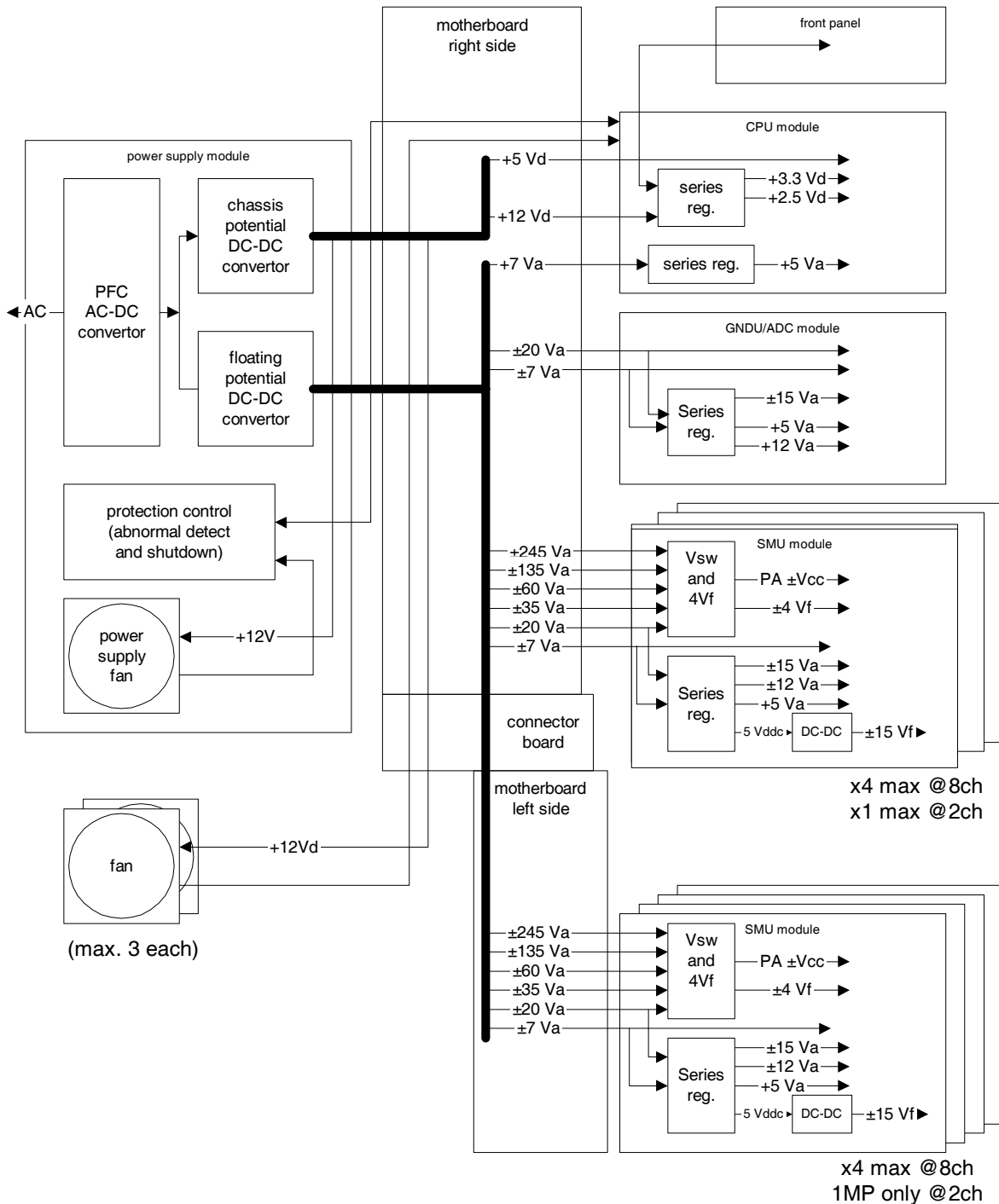
Front board and rubber key

The front board and rubber key are a part of the front panel assembly. Each front rubber key has a carbon pad behind the key, which is an electrical conductor. If a key is pressed, two points on the front board are closed. The closed points are detected by the key decoder on the CPU board.

Power Supply

This section describes the information about the power supply destination for each DC voltage in the E5270. Figure 6-20 is the mainframe block diagram for the power supply destination.

Figure 6-20 Power supply destination



DC voltages on power supply module

Table 6-17 and Table 6-18 list the DC voltages, which are forced from the power supply module, and the specifications. (Table 6-17 is for the power supply module of E5270A and Table 6-18 is for E5272A and E5273A. Table 6-19 and Figure 6-21 show the DC output voltage on the power supply module connectors and pin location of the connector.

Table 6-17 E5270A power supply output voltages and protection circuit

Signal	Output voltage	Current	Common	Built-in protection circuit		
				Over current	Over voltage	Under voltage
+5 Vd	+5.1 V _{DC} ± 3% (4.947 to 5.253 V)	0.1 to 3.5 A	Chassis	4.4 ± 0.5 A	6.0 ± 0.5 V	4.1 ± 0.4 V
+12 Vd	+12 V _{DC} ± 10% (10.8 to 13.2 V)	0.3 to 0.8 A	Chassis	1.0 ± 0.1 A	15 ± 1 V	9 ± 0.7 V
+7 Va	+7 V _{DC} ± 12% (6.16 to 7.84 V)	0.1 to 8 A	Circuit	9.8 ± 0.7 A	9.0 ± 0.7 V	5.3 ± 0.5 V
-7 Va	-7 V _{DC} ± 12% (-6.16 to -7.84 V)	0.1 to 7 A	Circuit	-8.7 ± 0.9 A	-9.0 ± 0.7 V	-5.3 ± 0.5 V
+20 Va	+20 V _{DC} ± 10% (18 to 22 V)	0.1 to 5.5 A	Circuit	6.5 ± 0.65 A	26 ± 2 V	15 ± 1.5 V
-20 Va	-20 V _{DC} ± 10% (-18 to -22 V)	0.1 to 5.5 A	Circuit	-6.5 ± 0.65 A	-26 ± 2 V	-15 ± 1.5 V
+35 Va	+34 V _{DC} ± 8% (31.28 to 36.72 V)	0 to 4.1 A	Circuit	5.2 ± 0.53 A	42 ± 3 V	26 ± 2 V
-35 Va	-34 V _{DC} ± 8% (-31.28 to -36.72 V)	0 to 4.1 A	Circuit	5.2 ± 0.53 A	42 ± 3 V	-26 ± 2 V
+60 Va	+56 V _{DC} ± 10% (-50.4 to -61.8 V)	0 to 2.1 A	Circuit	3.15 ± 0.75 A	71 ± 6 V	43 ± 4 V
-60 Va	-56 V _{DC} ± 10% (-50.4 to -61.8 V)	0 to 2.1 A	Circuit	3.15 ± 0.75 A	-71 ± 6 V	-43 ± 4 V
+135 Va	+134 V _{DC} ± 10% (120.6 to 147.4 V)	0 to 0.6 A	Circuit	1.02 ± 0.26 A	170 ± 13 V	103 ± 8 V
-135 Va	-134 V _{DC} ± 10% (-120.6 to -147.4 V)	0 to 0.6 A	Circuit	1.02 ± 0.26 A	-170 ± 13 V	-103 ± 8 V
+245 Va	+245 V _{DC} ± 10% (220.5 to 269.5 V)	0 to 0.3 A	Circuit	0.46 ± 0.11 A	290 ± 9 V	188 ± 14 V
-245 Va	-245 V _{DC} ± 10% (-220.5 to -269.5 V)	0 to 0.3 A	Circuit	0.46 ± 0.11 A	-290 ± 9 V	-188 ± 14 V

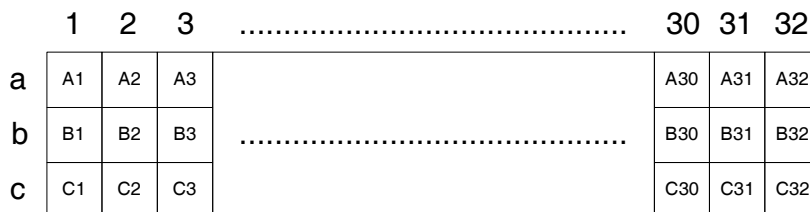
Table 6-18 E5272A/E5273A power supply output voltages and protection circuit

Signal	Output voltage	Current	Common	Built-in protection circuit		
				Over current	Over voltage	Under voltage
+5 Vd	+5.1 V _{DC} ± 3% (4.947 to 5.253 V)	0.1 to 3.5 A	Chassis	4.4 ± 0.5 A	6.0 ± 0.5 V	4.1 ± 0.4 V
+12 Vd	+12 V _{DC} ± 10% (10.8 to 13.2 V)	0.3 to 0.8 A	Chassis	1.0 ± 0.1 A	15 ± 1 V	9 ± 0.7 V
+7 Va	+7 V _{DC} ± 12% (6.16 to 7.84 V)	0.1 to 4.3 A	Circuit	5.3 ± 0.6 A	9.0 ± 0.7 V	5.3 ± 0.5 V
-7 Va	-7 V _{DC} ± 12% (- 6.16 to -7.84 V)	0.1 to 3.5 A	Circuit	4.3 ± 0.5 A	-9.0 ± 0.7 V	-5.3 ± 0.5 V
+20 Va	+20 V _{DC} ± 10% (18 to 22 V)	0.1 to 3.0 A	Circuit	3.8 ± 0.4 A	26 ± 2 V	15 ± 1.5 V
-20 Va	-0 V _{DC} ± 10% (-18 to -22 V)	0.1 to 3.0 A	Circuit	3.8 ± 0.4 A	-26 ± 2 V	-15 ± 1.5 V
+35 Va	+34 V _{DC} ± 8% (31.28 to 36.72 V)	0 to 2.5 A	Circuit	3.2 ± 0.4 A	42 ± 3 V	26 ± 2 V
-35 Va	-34 V _{DC} ± 8% (-31.28 to -36.72 V)	0 to 2.5 A	Circuit	3.2 ± 0.4 A	42 ± 3 V	-26 ± 2 V
+60 Va	+56 V _{DC} ± 10% (-50.4 to - 61.8 V)	0 to 0.6 A	Circuit	1.15 ± 0.3 A	71 ± 6 V	43 ± 4 V
-60 Va	-56V _{DC} ± 10% (-50.4 to -61.8 V)	0 to 0.6 A	Circuit	1.15 ± 0.3 A	-71 ± 6 V	-43 ± 4 V
+135 Va	+134 V _{DC} ± 10% (120.6 to 147.4 V)	0 to 0.22 A	Circuit	0.38 ± 0.1 A	170 ± 13 V	103 ± 8 V
-135 Va	-134 V _{DC} ± 10% (-120.6 to -147.4 V)	0 to 0.22 A	Circuit	0.38 ± 0.1 A	-170 ± 13 V	-103 ± 8 V
+245 Va	+245 V _{DC} ± 10% (220.5 to 269.5 V)	0 to 0.08 A	Circuit	0.14 ± 0.04 A	290 ± 9 V	188 ± 14 V
-245 Va	-245 V _{DC} ± 10% (-220.5 to -269.5 V)	0 to 0.08 A	Circuit	0.14 ± 0.04 A	-290 ± 9 V	-188 ± 14 V

Table 6-19 E5260/E5270 power supply pin assignment

Pin number	Signal
A1, B1, C1	Circuit common
A2, B2, C2	+60 Va
A3, B3, C3	+135 Va
A4, B4, C4	+245 Va
A5, B5, C5, A6, B6, C6	+35 Va
A7, B7, C7, A8, B8, C8	-35 Va
A9, B9, C9	-245 Va
A10, B10, C10	-135 Va
A11, B11, C11	-60 Va
A12, B12, C12, A13, B13, C13, A14, B14, C14, A15, B15, C15	Circuit common
A16, B16, C16, A17, B17, C17	+20 Va
A18, B18, C18, A19, B19, C19	-20 Va
A20, B20, C20, A21, B21, C21, A22, B22, C22	+7 Va
A23, B23, C23, A24, B24, C24, A25, B25, C25	-7 Va
A26, B26, C26	Circuit common
A27, B27, C27, A28, B28, C28	Digital common
A29, B29, C29	Not a power supply pin
A30, B30, C30, A31, B31, C31	+5 Vd
A32	+12 Vd
B32, C32	Digital common

Figure 6-21 E5270 power supply pin location (cable end)



DC voltages on CPU, GNDU/ADC, and SMU modules

The post regulator filters and regulates some outputs of the (switching regulator) power supply again.

- CPU module
 - +3.3 Vd, +2.5 Vd For controller
 - +5 Va For SMU interface logic
- GNDU/ADC module
 - ±15 Va For analog circuits
 - +12 Va For relay drive
 - +5 Va For GNDU/ADC controller logic
- SMU module
 - ±15 Va For analog circuits
 - ±15 Va For analog and relay drive
 - +5Va For logic circuits
 - ±15 Va For SMU floating circuits

Fuses

There are no replaceable fuses.

Abnormal Condition Detectors

The abnormal condition detectors monitor the power supply and SMU input and output status and shut down the E5270 if an abnormal condition occurs. This section describes the function of each detector and emergency shutdown function.

Power supply AC input monitor

If the AC line voltage drops to $80 V_{AC}$, the E5260/E5270 power supplies automatically turn off. If the voltage recovers and exceeds $80 V_{AC}$, the E5260/E5270 automatically turns on again.

If this occurs, monitor the AC line first. Usually, this means the supplying AC line is abnormal. For example, momentary power loss may occur, voltage sags may occur, or the tops of AC line waveform may be clipped. The sags and clipped tops tend to occur when the power used exceeds the supply capability of the AC line.

Power supply DC output monitor and fan stop detectors

If the power supply detects an overvoltage, overcurrent, undervoltage, or its fan stops, the power supply automatically shuts down by the emergency shutdown function. The overvoltage, overcurrent, and undervoltage limits are listed in Table 6-17 and Table 6-18.

The following is the shutdown sequence.

1. Detector notifies the CPU within 15 milliseconds after the detection.
2. The power supply starts turning off. The outputs can be kept at least three milliseconds after CPU notification.
3. The CPU sets all source unit outputs (DACs) to 0 V, and all source unit output switches to OFF. This step cannot always be performed because the power shutdown has already started. When source units are set to 0 V, the order is from higher voltage to lower voltage units.

To recover this, you must turn the E5270 off and on.

SMU output detectors

The MPSMU and HRSMU have an overvoltage detector, and the HPSMU has an overcurrent detector. The MPSMU overvoltage detector detection value is ± 120 V on voltage force. The HPSMU overcurrent detector detection values are as listed in Table 6-20.

Table 6-20 HPSMU overcurrent detector detection value

Voltage range (range max. current)	Current output or measurement range	Detection value
2 V, 20 V (1 A)	100 mA, 1 A	None
	≤ 10 mA	70 mA
40 V (500 mA)	100 mA, 1 A	650 mA
	≤ 10 mA	70 mA
100 V (125 mA)	100 mA, 1 A	170 mA
	≤ 10 mA	70 mA
200 V (50 mA)	All	75 mA

If the SMU detects an overvoltage or overcurrent:

1. The detector notifies the CPU.
2. The CPU starts to set all source unit outputs (DACs) to 0 V, and all source unit output switches to OFF.
3. Then the CPU waits for 15 milliseconds.
4. If the abnormal voltage or current is corrected, only an error message displayed, and the shutdown does not occur. If not corrected, the CPU turns the power supply OFF by the emergency shutdown function.

Emergency shutdown function

If any of the following occurs, the E5260/E5270 automatically shuts down to prevent damage (power is off, but LINE switch stays in ON position).

- The power supply detects an abnormal condition. (except detection by the AC input monitor).
- The measurement unit detects an overvoltage or overcurrent, and the abnormal condition is not corrected even if the output switches of all measurement units are set to off.
- The power supply detects the power supply fan slow down or stop.
- The CPU module detects the frame fan slow down or stop.

In this case, the power supply is locked into the power-off setting. To turn it back on, do as follows:

1. Set the LINE switch to OFF once.
2. Wait for 10 seconds or more.
3. Set the LINE switch to ON.

If the power supply AC input monitor detects an abnormal condition, the power supply is turned off, but is not locked into the power-off setting. Therefore, if the abnormal condition is corrected, the power supply (that is, E5260/E5270) automatically starts up.

An abnormal voltage or current on internal circuits can be caused by:

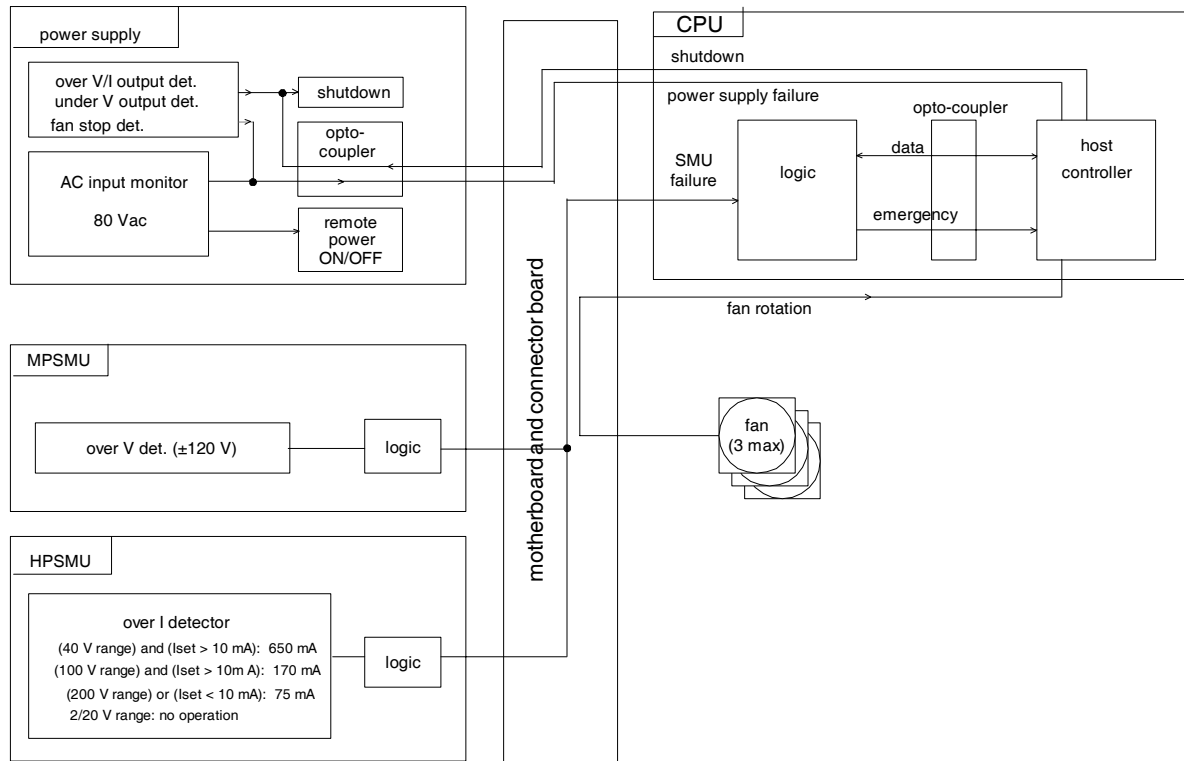
- Incorrect connection between the instrument and test devices
- Overvoltage or overcurrent input
- Closed circuit between an SMU guard output and another guard or output
- AC LINE having an abnormal voltage, impulses, surges
- Hardware failure

NOTE

An ADC failure can cause over voltages in the HPSMU/MPSMU.

For example, if the ADC module is not connected to the motherboard, the E5260/E5270 shuts down by overvoltage of the measurement units. This is because the SMU loses the voltage reference, and the amplifiers are saturated.

Figure 6-22 E5260/E5270 abnormal condition detectors



External Instrument Control

The E5260/E5270 has some interfaces to control and communicate with an external instrument. This section provides the information for the following interfaces.

- “Digital I/O”
- “Interlock”

Digital I/O

The digital I/O is for connecting other instruments. The digital I/O has an open collector with a 1 k Ω pull up resistor and 100 Ω series resistor. See Figure 6-23 for the block diagram. Figure 6-24 and Table 6-21 show the digital I/O pin assignment.

Figure 6-23 Digital I/O block diagram

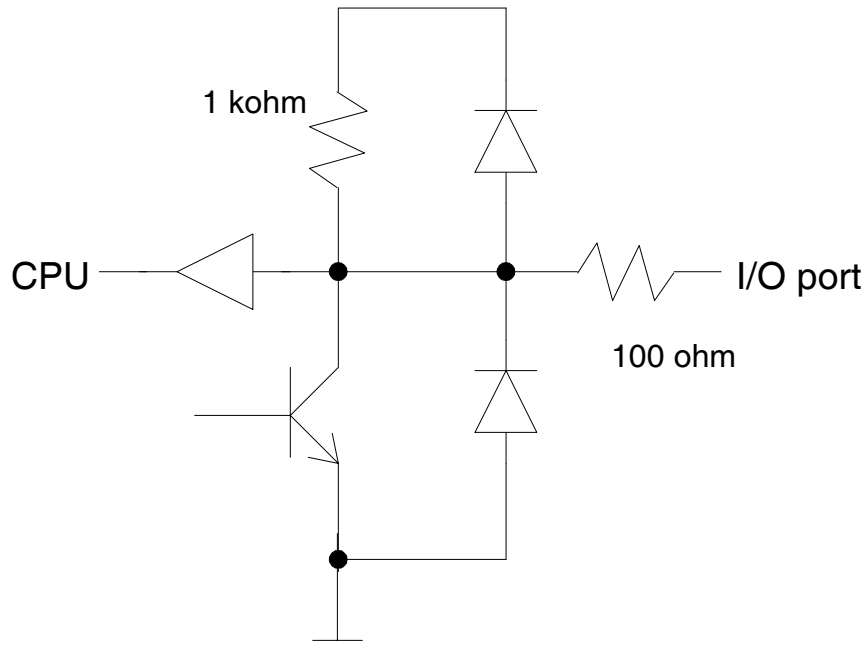


Figure 6-24 Digital I/O (25-Pin) connector pins

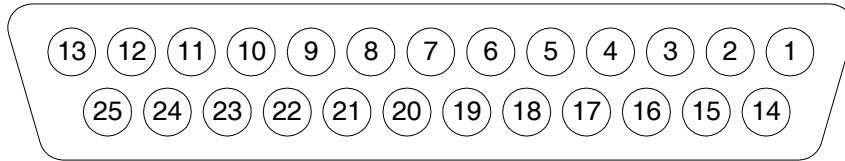


Table 6-21 Digital I/O (25-Pin) pin assignment

Pin number	Signal (direction)	Pin number	Signal (direction)
1	No connection	14	No connection
2	No connection	15	Digital I/O - 00
3	Digital I/O - 01	16	Digital I/O - 02
4	Digital I/O - 03	17	Digital I/O - 04
5	Digital I/O - 05	18	Digital I/O - 06
6	Digital I/O - 07	19	Digital I/O - 08
7	Digital I/O - 09	20	Digital I/O - 10
8	Digital I/O - 11	21	Digital I/O - 12
9	Digital I/O - 13	22	Digital I/O - 14
10	Digital I/O - 15	23	Do not connect
11	Do not connect	24	Do not connect
12	Do not connect	25	Ground
13	Ground		

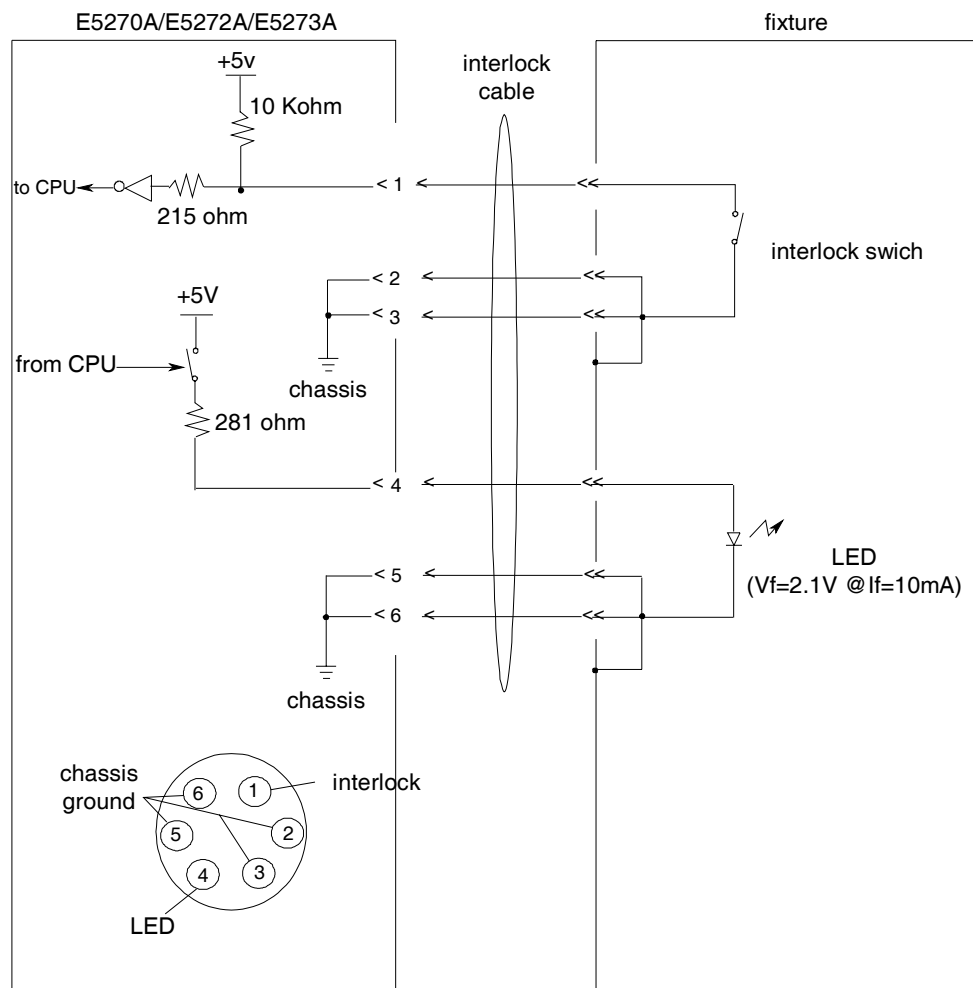
NOTE Do not connect and use pins 11, 12, 23, and 24. They are used for hardware development purposes.

Interlock

The interlock circuit is designed to prevent electrical shock when a user touches the measurement terminals. If the interlock pin 1 and chassis ground are not closed, the SMU output is limited, and the SMU can force a maximum 42 V. The following is information on each pin of the interlock connector, and Figure 6-25 is the block diagram of the interlock and fixture.

- Pin 1 Pin 1 is the interlock line. When the line is set to low (closed to chassis ground), E5260/E5270 can force a voltage greater than 42 V. If no voltage is applied to the interlock line, the interlock line is +5 V (serial resistance is 10 k Ω), and E5260/E5270 cannot force high voltages (greater than 42 V). In the 16442B test fixture, the interlock switch (interlock line) synchronizes with the fixture cover. When the fixture cover opens, the interlock switch also opens, and the E5260/E5270 cannot force high voltage. When the fixture cover closes, the interlock switch also closes, and the E5260/E5270 can force high voltage.
- Pin 4 Pin 4 is the external LED drive line. When the interlock line is shorted to ground, the external LED drive line is +5 V. The 16442B test fixture uses this line for the fixture LED.
- Pins 2, 3, 5, and 6 Pin 2, 3, 5, and 6 are chassis ground, and used for connecting pin 1 (interlock line) and pin 4 (LED drive line) to the ground.

Figure 6-25 Interlock block diagram



7 Error Messages

Error Messages

If Agilent E5270 series are not operated correctly, or if self-test/calibration fails, error codes and error messages are displayed. This chapter lists error codes and messages of the Agilent E5270.

This chapter consists of the following sections:

- “Self-Test/Calibration Errors”
- “Calibration Software Errors”
- “Operation Errors”
- “Channel Status Codes”

Self-Test/Calibration Errors

When the Agilent E5270 fails the self-test or self-calibration, the Agilent E5270 returns the following error code and error message.

CPU test

700	CPU failed NVRAM read/write test.
701	CPU failed FPGA read/write test.
702	CPU failed H-RESOLN ADC end signal test.
703	CPU failed H-RESOLN ADC start signal test.
704	CPU failed emergency status signal test.
705	CPU failed SRQ status signal test.
706	CPU failed high voltage status signal test.
707	CPU failed low voltage status signal test.
708	CPU failed DAC settling status signal test.
709	CPU failed measure ready status signal test.
710	CPU failed set ready status signal test.
711	CPU failed measure end status signal test.
712	CPU failed measure trigger signal test.
713	CPU failed pulse trigger signal test.
714	CPU failed abort trigger signal test.
715	CPU failed DAC set trigger signal test.
716	CPU failed LCD read/write test.

GNDU/ADC test

720	H-RESOLN ADC is not installed.
721	H-RESOLN ADC failed ROM/RAM test.
722	H-RESOLN ADC failed B-COM offset DAC test.
723	H-RESOLN ADC failed sampling ADC test.
724	H-RESOLN ADC failed integrating ADC test.
725	H-RESOLN ADC failed bus function test.
740	GNDU failed calibration.

SMU test

In the error code, N indicates the slot number. If the module is installed in slot 1, and it fails the function test, the error code will be 1760.

N760	SMU failed function test.
N761	SMU failed VF/VM function test.
N762	SMU failed IF/IM function test.
N763	SMU failed loop status test.
N764	SMU failed temperature sensor test.
N765	SMU failed CMR amplifier calibration.
N766	SMU failed CMR amplifier adjustment.
N767	SMU failed CMR 100 V range full output test.
N768	SMU failed VF/VM calibration.
N769	SMU failed VM offset calibration.
N770	SMU failed VM gain calibration.
N771	SMU failed VF offset calibration.
N772	SMU failed VF gain calibration.
N773	SMU failed VF gain calibration at 20 V range.
N774	SMU failed VF filter offset calibration.
N775	SMU failed H-SPEED ADC self-calibration.
N776	SMU failed H-SPEED ADC VM offset calibration.
N777	SMU failed H-SPEED ADC VM gain calibration.
N778	SMU failed IF/IM calibration.
N779	SMU failed calibration bus test.
N780	SMU failed IM offset calibration.
N781	SMU failed IM gain calibration.
N782	SMU failed IF offset calibration.
N783	SMU failed IF gain calibration.
N784	SMU failed IDAC filter offset calibration.
N785	SMU failed oscillation detector test.
N786	SMU failed I bias test.
N787	SMU failed common mode rejection test.
N789	SMU failed high voltage detector test.
N790	SMU failed zero voltage detector test.
N791	SMU failed V hold test.
N792	SMU failed V switch test.

Calibration Software Errors

This section lists the error codes, messages, and recovery action of the calibration software.

- 1001 Incorrect test item file format.**
- The calibration software cannot find the test item file (C:\Program Files\Agilent Technologies\E5299\limits\mainframe.csv, hpsmu.csv, or mpsmu.csv). Reinstall the software.
- 1002 Incorrect equipment file format.**
- The format of the equipment file (C:\Program Files\Agilent Technologies\E5299\config\e527xa.csv, 3458a.csv, and 16353a.csv) is incorrect. Reassign or remake the equipment file in the UUT or Standards tab.
- 1003 Incorrect test group file format.**
- The format of the test group file (C:\Program Files\Agilent Technologies\E5299\limits\testgrp.csv) is incorrect. Reinstall the software.
- 1004 Nonexistent slot is specified.**
- A nonexistent slot is specified in the calibration software. Contact your nearest Agilent office.
- 1005 Incorrect module file format.**
- The format of the module file (C:\Program Files\Agilent Technologies\E5299\limits\modules.csv) is incorrect. Reinstall the software.
- 1006 Incorrect module or equipment file format.**
- The format of the module or equipment file (C:\Program Files\Agilent Technologies\E5299\limits\modules.csv, C:\Program Files\Agilent Technologies\E5299\config\e527xa.csv, 3458a.csv, or 16353a.csv file) is incorrect. Reassign or remake the equipment file in the UUT or Standards tab. If not fixed, reinstall the calibration software.
- 1007 Cannot open test item file.**
- The calibration software cannot open the test item file (C:\Program Files\Agilent Technologies\E5299\limits\mainframe.csv, hpsmu.csv, and mpsmu.csv). The file might be locked by another application. Close the application that locking the file.
- 1008 Cannot find test item file.**
- The calibration software cannot find the test item file (C:\Program Files\Agilent Technologies\E5299\limits\mainframe.csv, hpsmu.csv, or mpsmu.csv). Reinstall the software.
- 1009 Incorrect test item file format.**
- The format of the test item file (C:\Program Files\Agilent Technologies\E5299\limits\mainframe.csv, hpsmu.csv, and mpsmu.csv) is incorrect. Reinstall the software.

Calibration Software Errors

- 100A Cannot open test group file.**
The calibration software cannot open the test group file
(C:\Program Files\Agilent Technologies\E5299\limits\testgrp.csv).
The file might be locked by another application. Close the application that is locking the file.
- 100B Cannot find test group file.**
The calibration software cannot find the test group file
(C:\Program Files\Agilent Technologies\E5299\limits\testgrp.csv).
Reinstall the software.
- 100C Incorrect test group file format.**
The format of the test group file
(C:\Program Files\Agilent Technologies\E5299\limits\testgrp.csv) is
incorrect. Reinstall the software.
- 100D Cannot open module file.**
The calibration software cannot open the module file
(C:\Program Files\Agilent Technologies\E5299\limits\modules.csv).
The file might be locked by another application. Close the application that is locking the file.
- 100E Cannot find module file.**
The calibration software cannot find the module file
(C:\Program Files\Agilent Technologies\E5299\limits\modules.csv).
Reinstall the software.
- 100F Incorrect module file format.**
The format of the module file
(C:\Program Files\Agilent Technologies\E5299\limits\modules.csv) is
incorrect. Reinstall the software.
- 1010 Cannot open equipment file.**
The calibration software cannot open the equipment file
(C:\Program Files\Agilent Technologies\E5299\config\e527xa.csv,
3458a.csv, or 16353a.csv). The file might be locked by another application. Close the
application that is locking the file.
- 1011 Cannot find equipment file.**
The calibration software cannot find the equipment file
(C:\Program Files\Agilent Technologies\E5299\config\e527xa.csv,
3458a.csv, or 16353a.csv). Reassign or remake the file in the UUT or Standards tab.
- 1012 Incorrect equipment file format.**
The format of the equipment file
(C:\Program Files\Agilent Technologies\E5299\config\e527xa.csv,
3458a.csv, or 16353a.csv) is incorrect. Reassign or remake the file in the UUT or
Standards tab.
- 1013 File revision mismatch.**
The revision of the files in the
C:\Program Files\Agilent Technologies\E5299\limits folder are mismatched.
Reinstall the calibration software.

- 1014 Incorrect test data format.**
The format of the test data file specified in the UUT tab is incorrect. Select another file in the UUT tab.
- 1016 Incorrect test item file format.**
The format of the test item file (C:\Program Files\Agilent Technologies\E5299\limits\mainframe.csv, hpsmu.csv, or mpsmu.csv) is incorrect. Reinstall the software.
- 1017 Cannot open test data file.**
The calibration software cannot open the test data file specified in the UUT tab. The file might be locked by another application. Close the application that is locking the file.
- 1019 Incorrect test data format.**
The format of the test data file specified in the UUT tab is incorrect. Select another file in the UUT tab.
- 1020 The UUT configuration is different from the actual configuration.**
Reconfigure the UUT configuration by clicking the **Poll** button.
- 3001-4001 Internal communication error occurred.**
The error codes from 3001 to 4001 are used for the software internal communication error. If this error occurs, try the following:
1. Close the calibration software and restart the software.
 2. Close other applications. Overloading and resource shortage of the operating system may affect the error.
 3. Turn off and restart the controller.
- If the error is not fixed, contact your nearest Agilent office.
- BFFF0000-BFFF00A6 Cannot communicate with the equipment.**
The error codes from BFFF0000 to BFFF00A6 are used for VISA GPIB communication. If this error occurs, the calibration software cannot communicate with the E5270 or 3458A. Check the following:
- VISA installation and setup
 - GPIB cable connection
 - GPIB address setting
 - Equipment power-on

Operation Errors

The following are the error codes and their messages that may occur when you operate the E5270 series.

- | | |
|-----|--|
| 100 | Undefined GPIB command.
Send the correct command. |
| 102 | Incorrect numeric data syntax.
Correct the data syntax. |
| 103 | Incorrect terminator position.
Correct the command syntax. The number of parameters will be incorrect. |
| 120 | Incorrect parameter value.
Correct the parameter value. |
| 121 | Channel number must be 1 to 2, or 1 to 8.
Correct the channel number. The channel number must be 1 to 2 for the Agilent E5272A/E5273A, or 1 to 8 for the Agilent E5270A. |
| 122 | Number of channels must be corrected.
Check the MM, FL, CN, CL, IN, DZ, or RZ command, and correct the number of channels. |
| 123 | Compliance must be set correctly.
Incorrect compliance value was set. Set the compliance value correctly. |
| 124 | Incorrect range value for this channel.
Check the range value available for the channel, and correct the range value. |
| 126 | Pulse base and peak must be same polarity.
The polarity of the base and peak values must be the same in the PI command. Also the polarity of the base, start, and stop values must be the same in the PWI command. |
| 130 | Start and stop must be same polarity.
For a log sweep, the polarity of the start and stop values must be the same in the WV, WI, WSV, WSI, or WNX command. Also, 0 is not allowed for the start and stop values. |
| 150 | Command input buffer is full.
The Agilent E5270 can receive 256 characters maximum including the terminator at one time. |
| 152 | Cannot use failed module.
The channel number specifying the module failed the self-test or calibration. Specify another module that passed the self-test or calibration. For the service purpose, execute the RCV command to enable the module. |
| 153 | No module for the specified channel.
Module is not installed in the slot specified by the channel number. |

- 160 Incorrect ST execution.
The internal memory programming can be started by the ST command and completed by the END command. Do not enter the ST command between the ST command and the END command.
- 161 Incorrect END execution.
The internal memory programming can be started by the ST command and completed by the END command. Do not send the END command before starting the programming.
- 162 Incorrect command for program memory.
Specified command cannot be stored in the program memory. For the incorrect commands, see chapter 2 of *Programming Guide*.
- 170 Incorrect usage of internal variable.
The internal variable must be $%In$ for integer data, or $%Rn$ for real data. where n is an integer, 0 to 99. Use $%In$ for the integer type command parameters; and use $%Rn$ for the real type command parameters. For the internal variables, see chapter 4 of *Programming Guide*.
- 171 Internal variable is not allowed.
The internal variables $%In$ and $%Rn$ are not available for the ACH, VAR, and VAR? commands. Do not use the internal variables for the commands.
- 200 Channel output switch must be ON.
To enter the specified command, set the channel output switch to ON.
- 201 Compliance must be set.
To change the source output mode (voltage or current), set the compliance value.
- 202 Interlock circuit must be closed.
To set the output voltage or the voltage compliance to more than ± 42 V (high voltage state), close the interlock circuit. If the interlock circuit is opened in the high voltage state, outputs of all units will be set to 0 V.
- 203 Cannot enable channel.
The channel output switch cannot be set to ON in the high voltage state. Set the output voltage or the voltage compliance to ± 42 V or less to set the switch to ON.
- 204 Cannot disable channel.
The channel output switch cannot be set to OFF in the high voltage state. Set the output voltage or the voltage compliance to ± 42 V or less to set the switch to OFF. Or send the CL command with no parameter to set switches of all channels to OFF immediately.
- 205 DZ must be sent before RZ.
The RZ command is effective for the channels set to 0 V output by the DZ command.
- 206 Do not specify the channel recovered by RZ.
Specify the channels that have not been recovered yet by the RZ command after the DZ command. The RZ command cannot be executed if the specified channels include a channel that has already been recovered by the RZ command.
- 210 Ext trigger could not start measurement.
External trigger cannot start measurement because of busy condition.

Error Messages

Operation Errors

- 211 TM1 must be sent to use GET.
Send the TM1 command to use the GPIB GET command (TRIGGER statement in HP BASIC).
- 212 Compliance must be set correctly.
Compliance was not set or an incorrect compliance value was set in the DV, DI, PV, PI, PWV, PWI, TDV, TDI, LSV, LSI, LSSV, LSSI, BSV, BSI, BSSV, or BSSI command. Set the compliance value correctly.
- 213 Cannot perform self-test or calibration.
Self-test and calibration cannot be performed in the high voltage state. Set the output voltage or the voltage compliance to ± 42 V or less to perform the self-test or calibration.
- 214 Send MM before measurement trigger.
Before sending the measurement trigger, the MM command must be sent to set the measurement mode.
- 220 Send WV or WI to set primary sweep source.
Before triggering the staircase sweep measurement, triggering the staircase sweep with pulsed bias measurement, or sending the WSV, WSI, or WNX command to set the synchronous sweep source, send the WV or WI command to set the primary sweep source.
- 221 Send PWV or PWI to set pulse sweep source.
Before triggering the pulsed sweep measurement, or sending the WSV or WSI command to set the synchronous sweep source, send the PWV or PWI command to set the pulse sweep source.
- 222 Send PV or PI to set pulse source.
Before triggering the staircase sweep with pulsed bias measurement, send the PV or PI command to set the pulse source.
- 223 Compliance must be set correctly.
Compliance was not set or an incorrect compliance value was set in the WV, WI, WSV, WSI, WNX, or BDV command. Set the compliance value correctly.
- 224 Sweep and sync output modes must be the same.
The primary sweep channel and the synchronous sweep channel must be different, and they must be set to the same output mode (voltage or current).
- 225 Send WSV, WSI, or WNX to get sync sweep data.
If you enable data output of the synchronous sweep source, do not forget to set the synchronous sweep source by the WSV, WSI, or WNX command. For data output, see chapter 4 of *Programming Guide*.
- 226 Set linear sweep for MM4 or MM5.
Only the linear sweep is available for the PWV or PWI command for the pulsed sweep measurement (MM4) or the WV or WI command for the staircase sweep with pulsed bias measurement (MM5).
- 227 Sweep measurement was aborted.
Sweep measurement was aborted by the automatic sweep abort function or the power compliance.

- 230 Pulse source must be set.
To perform the pulsed spot measurement (MM3), send the PV or PI command to set the pulse source.
- 231 Compliance must be set correctly.
Compliance was not set or an incorrect compliance value was set in the PV, PI, PWV, or PWI command. Set the correct compliance value effective for the pulse output.
- 238 Too large pulse width (max. 2 s).
The maximum value of the pulse width is 2 s. And the available value depends on the pulse period value. See chapter 4 of *Programming Guide*.
- 239 Pulse width must be 0.5 ms or more.
Set the pulse width to 0.5 ms or more. See chapter 4 of *Programming Guide*.
- 253 Program memory is full.
Maximum of 2000 programs or 40000 commands can be stored in the program memory. See chapter 4 of *Programming Guide*.
- 254 Invalid input for a memory program.
The GPIB GET command (TRIGGER statement in HP BASIC) and an external trigger input are not allowed in a memory program (between the ST and END commands).
- 255 Maximum nesting level is eight.
Nesting (one program calling another) of a memory program must be eight levels or less.
- 260 Data output buffer is full.
Maximum 34034 measurement data items can be stored in the data output buffer.
- 270 Search source channel must be set.
Before triggering the search measurement or sending the LSSV, LSSI, BSSV, or BSSI command to set the synchronous search source, send the LSV, LSI, BSV, or BSI command to set the primary search source.
- 271 Search monitor channel must be set.
Before triggering the search measurement, send the LGV, LGI, BGV, or BGI command to set the search monitor channel.
- 273 Search and sync output modes must be the same.
The primary search source channel and the synchronous source channel must be different, and they must be set to the same output mode (voltage or current).
- 275 Search target must be compliance value or less.
The search target value must be less than or equal to the compliance value of the search monitor channel. Correct the search target value or the compliance value.
- 276 Start and stop must be different.
Set different values for the search start and stop values.
- 277 Step must be output resolution or more.
Set the search step value to the output resolution or more.

Error Messages

Operation Errors

- 278 Search and sync channels must be different.
Set the search source and the synchronous source to different channels.
- 279 Search monitor mode must be compliance side.
Send the LGI/BGI command to set the voltage source search monitor channel, or send the LGV/BGV command to set the current source search monitor channel.
- 303 Excess voltage in MPSMU.
Voltage that exceeds maximum voltage at the present current range was detected by a MPSMU. All output switches were set to OFF.
- 305 Excess current in HPSMU.
Current that exceeds maximum current at the present voltage range was detected by a HPSMU. All output switches were set to OFF.
- 307 Unsupported module.
This module is not supported by this firmware version. Until you update the firmware, use the Agilent E5270 with this module removed.
- 310 Interlock open operation error. Initialized.
Initialization was automatically performed because the E5270 failed to set its output to 0 V when the interlock circuit was opened in the high voltage condition. Any module may be defective. Perform self-test.
- 311 ASU control cable was connected/disconnected.
The E5270B must be turned off when the Atto Sense and Switch Unit (ASU) is connected/disconnected.
- 603 Sweep and pulse channels must be different.
Set the sweep source and the pulse source to different channels for the staircase sweep with pulsed bias measurement (MM5).
- 610 Quasi-pulse source channel must be set.
Before triggering the quasi-pulsed spot measurement, send the BDV command to set the quasi-pulse source.
- 620 TGP specified incorrect I/O port.
Specify trigger input for the Ext Trig In port, or trigger output for the Ext Trig Out port by the TGP command. See chapter 4 of *Programming Guide*.
- 621 Specify trigger input port for PAX/WSX.
No trigger input port was specified for the PAX or WSX command. Specify the trigger input port, or set the port as the trigger input port. See chapter 4 of *Programming Guide* to set trigger port.
- 622 Specify trigger output port for OSX.
No trigger output port was specified for the OSX command. Specify the trigger output port, or set the port as the trigger output port. See chapter 4 of *Programming Guide* to set trigger port.
- 630 Incorrect polarity of search step value.
For the linear search measurement. The step value must be positive if start<stop, or negative if start>stop.

- 631 Number of search steps must be 1001 or less.
For the linear search measurement. The number of search steps between start and stop must be 1001 or less. This means the $|\text{step}|$ value must be $|\text{stop-start}|/1001$ or more.
- 632 Search measurement was aborted.
Search measurement was aborted by the automatic abort function.
- 640 Search limits must be $\text{range}/20000$ or more.
For the binary search measurement. The limit value for the search target must be $\text{range}/20000$ or more. where *range* means the measurement range actually used for the measurement.
- 650 Data format must be ASCII to get time data.
The time stamp function is not available for the binary data output format. To use the time stamp function, set the data output format to ASCII.
- 655 Cannot connect/disconnect series resistor.
The series resistor status cannot be changed in the high voltage state. Set the output voltage or the voltage compliance to ± 42 V or less to connect or disconnect the series resistor.
- 656 Series resistor must be OFF for 1 A range.
The series resistor cannot be set to ON for the measurement channels or the output channels that use 1 A range.
- 657 Series resistor cannot be used with ASU.
The series resistor is not available for the channel connected to the Atto Sense and Switch Unit (ASU).
- 670 Specified channel does not have ASU.
Specify the module that can be used with the ASU.

Channel Status Codes

The channel status code indicates the following statuses of the measurement channel, and is displayed in the channel status area on the LCD. No status code is displayed if the Agilent E5270 is in the normal condition.

X	One or more channels are oscillating.
V	Measurement data exceeds the measurement range.
C	This channel reached its compliance setting.
T	Another channel reached its compliance setting.

The status priority is:

$X > V > C > T$

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