Keysight E4981B 120 Hz/ 1kHz/ 1MHz Capacitance Meter

This is the User's Guide for E4981B 120Hz/ 1kHz/ 1MHz Capacitance Meter.

USER'S GUIDE

Notices

Trademark Acknowledgments

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Safety Notices

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

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1 Unpacking and Preparation

This chapter describes how to set up and start the Keysight E4981B Capacitance Meter.

Contents of this Chapter

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Checking the Shipment

After you receive the E4981B, carry out checks during unpacking according to the following procedure.

WARNING   **If the external face of the Capacitance meter (such as the cover, front/rear panel, LCD screen, power switch, and port connectors) appears to have been damaged during transport, do not turn on the power switch. Otherwise, you may get an electrical shock.**

Step 1.   Check that the packing box or shock-absorbing material used to package the Capacitance meter has not been damaged.

NOTE   If the packing box or shock-absorbing material has been damaged, leave the packing box and shock-absorbing material as is until other inspection items are checked as follows.

Step 2.   Check the packaged items supplied with the Capacitance meter for any damage or defects.

Step 3.   By referring to the packing list, check that all packaged items supplied with the Capacitance meter have been provided as per the specified options.

Step 4.   After checking, if one of the following applies, contact your nearest Keysight Technologies sales and service office.

·   The packing box or shock-absorbing material used to package the Capacitance meter has been damaged or the shock-absorbing material displays traces of where extreme pressure has been applied.

·   A packaged item supplied with the Capacitance meter has mechanical damage or defects.

·   A packaged item supplied with the Capacitance meter is missing.

·   A fault has been detected in the subsequent operation check of the Capacitance meter.

If an abnormality is detected in Step 1, contact the company that transported the Capacitance meter as well as your nearest Keysight Technologies sales and service office. For inspection by the transport company, save the packing box, shock-absorbing material, and packaged items as you received them.

Environmental Requirements

Set up the E4981B where the following environmental requirements are satisfied.

Operating environment

Ensure that the operating environment meets the following requirements.

Table 1-1   Operating environment requirements

Temperature	0 °C to 45 °C
Temperature range at calibration	23 °C ± 5 °C (|1 °C deviation from the temperature when performing calibration)
Humidity (~40 °C, no condensation)	15% to 85% RH
Altitude	0 to 2,000 m (0 to 6,561 feet)
Vibration	Max. 0.5 G, 5 Hz to 500 Hz

CAUTION   The environmental requirements listed above are NOT for the specifications and measurement accuracy of the E4981B, but for its operating environment.

Ventilation requirements

To ensure that the safety requirements, the specifications, and the measurement accuracy of the Capacitance meter are met, you must maintain the environmental temperature to within the specified range by providing an appropriate cooling clearance around the Capacitance meter or, for the rack-mounted type, by forcefully air-cooling inside the rack housing. For more information on environmental temperatures that satisfy the specifications and measurement accuracy of the Capacitance meter, see Chapter 10, "Specifications and Supplemental Information," on page 165.

The Capacitance meter conforms to the requirements of the safety standard.When the environmental temperature around the Capacitance meter is kept within the temperature range of the operating environment specifications ("Operating environment" on page 13).

The Capacitance meter still conforms to the requirements of the safety standard it is installed with the following cooling clearance:

Requirements	
Back	180 mm
Sides	60 mm (both right and left)

Figure 1-1   Ventilation space at installation
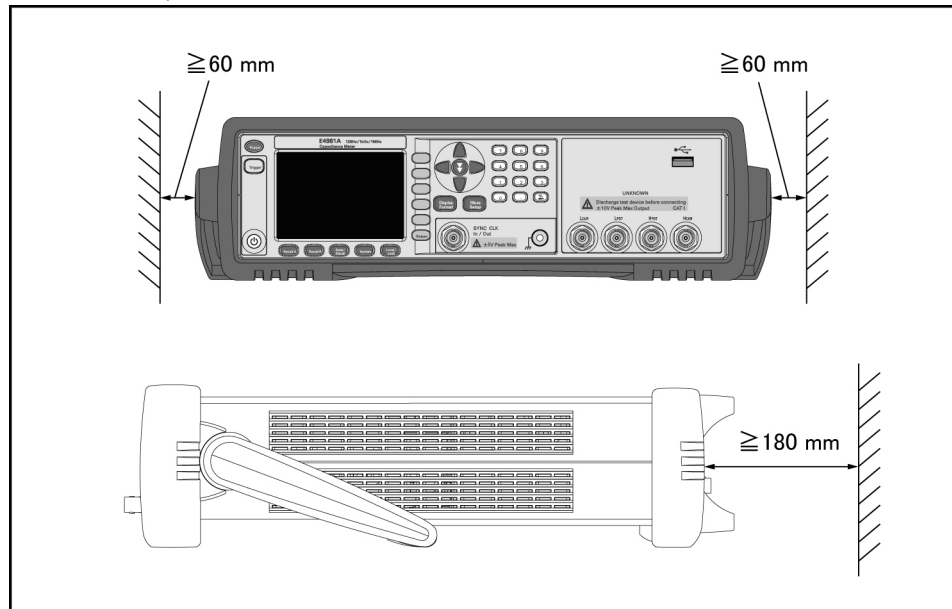
Protection against electrostatic discharge (ESD)

Figure 1-2 shows the setup for a static-safe work station to protect the electronic components from damage by electrostatic discharge (ESD).

Figure 1-2   Example of a static-free work station
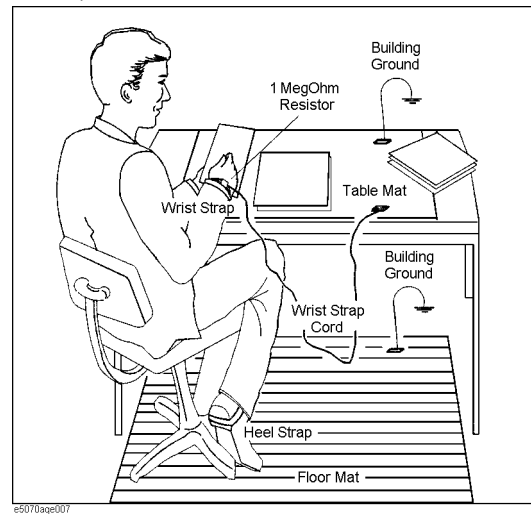
Ensuring adequate free space around the capacitance meter for immediate disconnection of the power cable in case of emergency

As described in "Disconnecting from the supply source" on page 22, the plug attached to the power cable serves as the disconnecting device (device that cuts off the power supply) for the E4981B. When installing the E4981B, ensure that there is sufficient free space around the unit to permit quick disconnection of the plug (from the AC outlet or the E4981B unit) in case of emergency.

How to Remove the Handle

A handle kit is attached to the E4981B Option 600. When using the E4981B with the rack-mount kit, remove the handle according to the following steps.

Figure 1-3   How to remove the handle
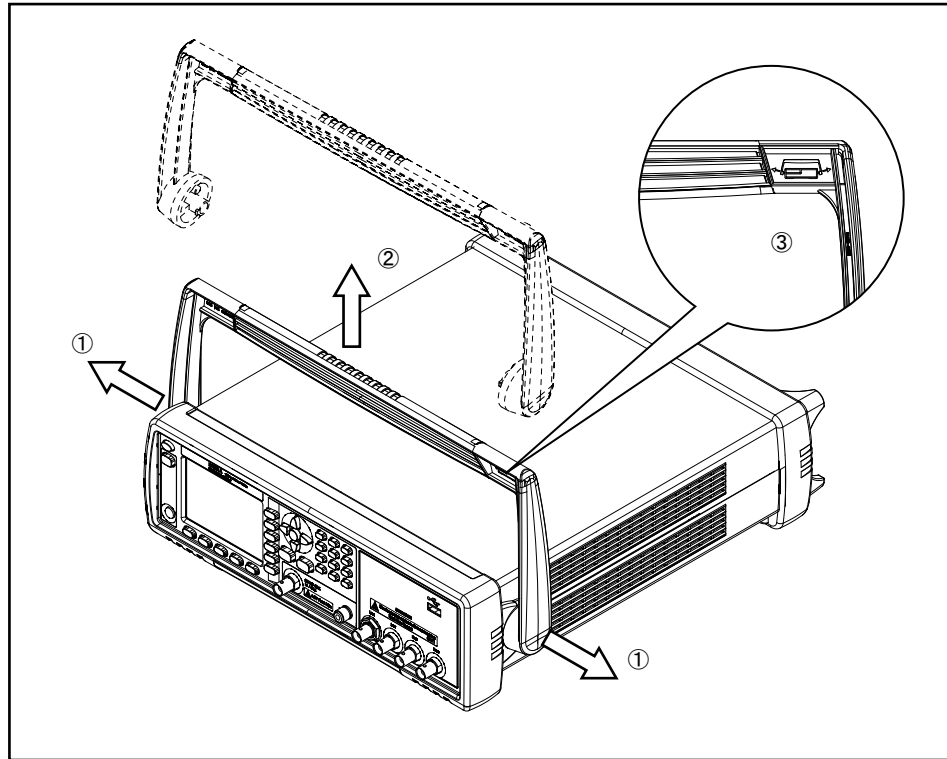
Step 1.   Lift the handle perpendicular to the unit while pulling it in the direction of 1.

Step 2.   While pulling the handle in the direction of 1, lift towards 2.

NOTE   Install the handle with 3 facing toward the front. Installing the handle the other way around may damage it.

Caution when using the handle

Follow the instructions below when using the E4981B's handle, otherwise you may get your fingers caught in the handle or the E4981B may fall and be damaged

- When the handle is set up as shown in **Figure 1-4**, do not put any additional weight onto the E4981B or lift it suddenly.

- Do not touch the handle while the DUT is attached.

Figure 1-4   The handle in the set-up position
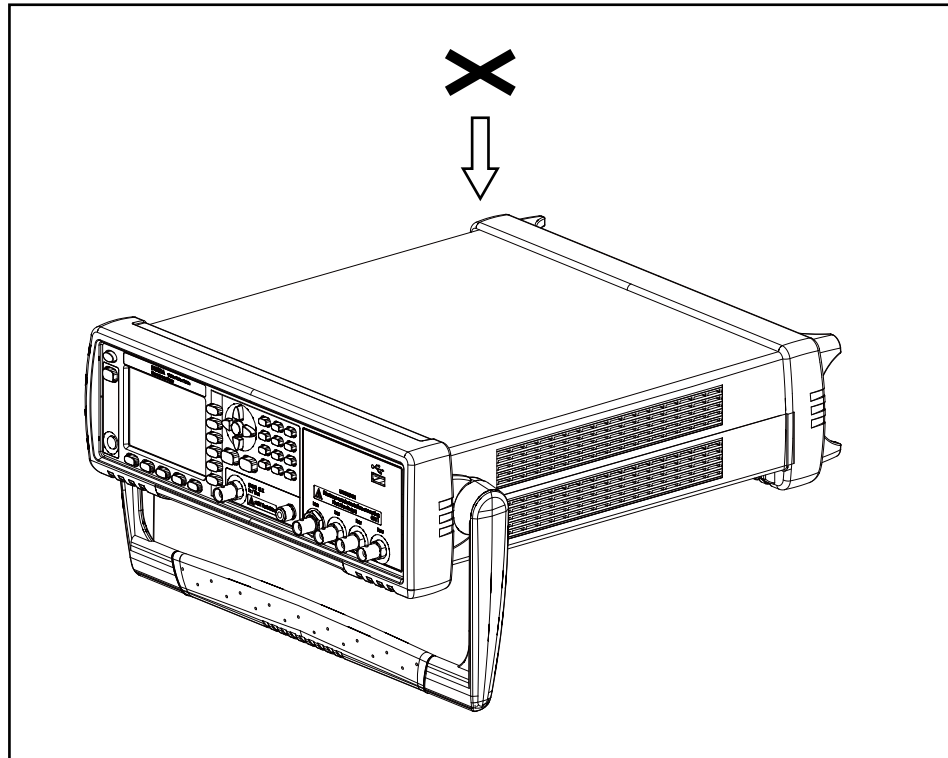
Mounting front flanges for rackmount

You can use the E4981B on a workbench or mounted in a rack. This section described how to mount it into a rack as part of a measurement system (Option 1CM119A).

Table 1-2   Contents of option 1CM119A kit

Option	Contents	Quantity
1CM119A	Adapter Assembly	1
	Rack Flange	1
	Screw	4
	Nut	4
	Dress Screw	4

Figure 1-5   Mounting the rackmount kit
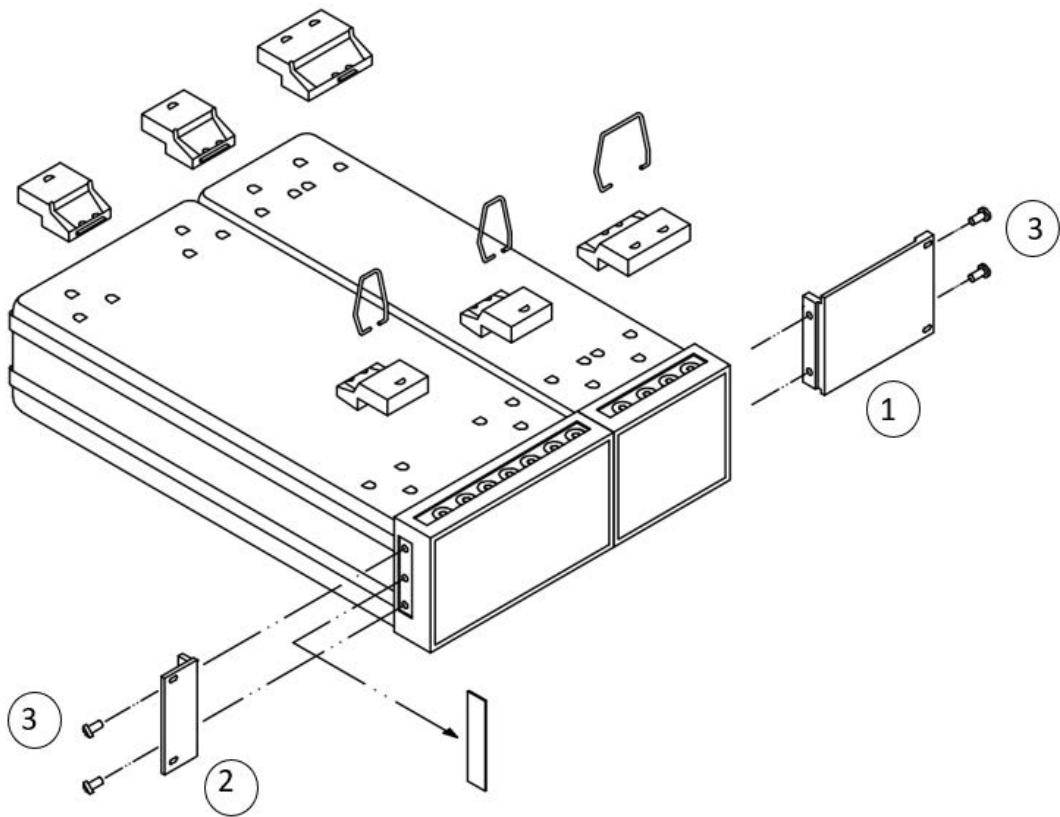
Mounting rackmount kit (Option 1CM119A)

The rackmount kit is a kit that contains 2 flanges (side plates for securing) to mount the E4981B into the standard rack 88.1H. Follow these steps to mount it, referring to the Figure 1-5.

Step 1. Attach Adapter Assembly (1) to left or right side with 2 screws (3).

Step 2. Attach Rack Flange (2) to opposite side withe 2 screws (3).

Step 3. Mount the E4981B into rack with dress screws.

Preparations Before Use

Verifying the power supply

Confirm that the power supplied to the E4981B meets the following requirements:

Table 1-3   Power supply requirements

	Requirements
Rated voltage	100 - 240 VAC
Voltage	90 - 264 VAC
Rated Frequency	50 / 60 Hz
Frequency range	47 - 63 Hz
Maximum power consumption	150 VA

⚠ Setting up the fuse

Please use the following fuse type.

UL/CSA type, Slo-Blo, 5×20-mm miniature fuse, 3 A, 250 V (Keysight part number 2110-1017)

When you need a fuse, contact your nearest Keysight Technologies sales and service office. To verify and replace the fuse, remove the power cable and pull out the fuse holder.

Verifying and connecting the power cable

The three-wire power cable attached to the E4981B has one wire serving as a ground. Using this power cable allows the E4981B to be grounded, thereby protecting you against electrical shock from the power outlet.

Step 1.   Confirm that the power cable is not damaged.

WARNING	**Never use a power cable showing any sign of damage. Faulty cables can cause electric shock.**

Step 2.   Use the supplied cable to connect the power cable receptacle on the real panel of the E4981B to a three-wire power outlet with the grounding prong firmly held in the ground slot.

WARNING	**Use the supplied three-wire power cable with a grounding wire to securely ground the** E4981B**.**

NOTE	A 3p-2p conversion adapter is not supplied with the Capacitance meter. When you need a 3p-2p conversion adapter, contact your nearest Keysight Technologies sales and service office listed in the back of this manual.

For power cord list, refer to https://www.keysight.com/find/powercords which shows the power cable options.

Starting the E4981B

This section describes how to turn on/off the E4981B power and how to cut off the power supply in an emergency.

Turning the power ON and OFF

Turning the power ON

The ON and OFF status of the power switch ⏻ is confirmed by the color of the ⏻ switch.

Table 1-4   Power switch status indicator

Color of the light	Status of the power
Orange	Power off
Yellow-green	Power on
Light off	Power off (The power supply is cut off)

Step 1.   Confirm that the power switch light ⏻ in the lower-left part of the front panel is lit in orange. If the light is off, the power supply may also be off.

Step 2.   Press the power switch. When the light of the power switch turns yellow-green, the power is turned ON and the E4981B starts the self-test.

The self-test takes approx. 30 seconds.

Step 3.   Confirm that the self-test indicates normal operation.

Normal operation is confirmed by the self-test if no error message appears.

Turning the power OFF

Follow the method below to turn the power OFF.

Step 1.   Press the power switch ⏻ in the lower-left part of the front panel.

NOTE   Do not turn the power OFF while saving into or recalling from the internal memory of the E4981B or the USB memory. Doing so may clear the contents from the memory.

Disconnecting from the supply source

The plug attached to the power cable (on the power outlet side or device side of the cable) serves as the disconnecting device (device that cuts off the power supply) of the E4981B. When the power supply must be cut off to avoid such danger as electric shock, pull out the power cable's plug (on the power outlet side or device side of the cable).

NOTE	To allow this operation to be performed smoothly, be sure to follow the guidelines in "Ensuring adequate free space around the capacitance meter for immediate disconnection of the power cable in case of emergency" on page 14.
	When turning the power OFF under normal circumstances, always follow the methods described in "Turning the power OFF" on page 21.

2 Overview

This chapter provides the basic procedures for operating the E4981B and describes names and functions of the front panel, rear panel, and screen display.

Product Introduction

The Keysight E4981B is a capacitance meter for ceramic capacitor production tests. The E4981B is used for evaluating ceramic capacitance at frequencies 120 Hz, 1 kHz to 1 MHz and test signal levels (0.1 mV to 1 V).

The E4981B offers C-D measurement with a basic accuracy of ±0.07% (C), ±0.0005 (D) at all frequencies with seven-digit resolution (the dissipation factor resolution is 1×10^{-6}) in every range.

With its built-in comparator, the E4981B can output comparison/decision results for sorting components into a maximum of ten bins. Furthermore, by using the handler interface and scanner interface, the E4981B can be easily combined with a component handler, a scanner, and a system controller to fully automate component testing, sorting, and quality-control data processing.

The GPIB/LAN/USB interfaces are standard on the E4981B and enable automatic testing.

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Front Panel: Names and Functions of Parts

This section describes the names and functions of the parts on the E4981B's front panel. For more details on the functions displayed on the LCD screen, see "Screen Area: Names and Functions of Parts" on page 30.

Figure 2-1   Front panel
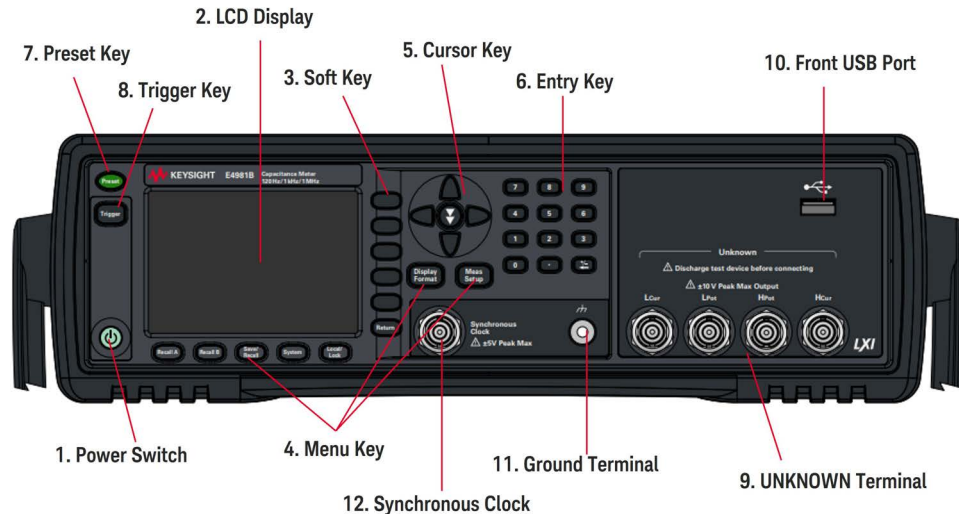
1. Power switch

Used for choosing between power-on and -off states of the E4981B. When turned on, the switch lights up in yellow-green and all operating voltages are applied to the instrument. When turned off, the switch lights up in orange and no operating voltages are applied to the instrument.

2. LCD

The Liquid Crystal Display (LCD) displays measurement results, test conditions, etc.

NOTE   Occasionally there are missing pixels or constantly lit pixels, but this is not a malfunction and does not affect the performance of your product.

3. Softkeys

Five softkeys are used to select measurement conditions and parameter functions. Each softkey has a softkey label along its left side.

4. Menu keys

Menu selection keys are used to access the corresponding selection of instrument controls.

Table 2-1   Menu keys description

[Display Format] key	Displays measurement results and selections.
[Meas Setup] key	Sets measurement conditions, a correction function, contact check function, and limit values for BIN sorting.
[Recall A] key	Recalls the setting information on internal memory 0.
[Recall B] key	Recalls the setting information on internal memory 1.
[Save/Recall] key	Saves and recalls the setting information. Saves measurement results and screen images.
[System] key	Sets the system. Sets the GPIB/LAN/USB interface. Performs a self-test.
[Local/Lock] key	Locks and unlocks hard keys and softkeys on the front panel.

5. Cursor keys

Keys used to move the field select cursor from field to field on a displayed page. When the cursor is moved to a certain field, that field changes to an inverse video image of the original field. The cursor can only be moved from field to field.

For the skip key, refer to the "How to use skip keys" on page 33.

6. Entry keys

Keys used to enter numeric data into the E4981B. The entry keys comprise the digits 0 to 9, a period (.), and a plus/minus (+/−) sign. Entered values are displayed on the input line (second line from the bottom of the LCD screen), and pressing the softkey terminates numeric input. The plus/minus key deletes the last character of the input value.

7. Preset key

A key used to return the Capacitance meter to the initial setup state. There are three methods for initialization. For details, refer to "Initializing the Instrument" on page 39.

8. Trigger key

A key used to manually trigger the E4981B when it is set to the manual trigger mode.

9. UNKNOWN terminals

These are the UNKNOWN terminals used to connect a four-terminal pair test fixture or test leads for measuring the device under test (DUT).

NOTE	When using a four-terminal pair test fixture or test leads with a stopper, remove the stopper or the bumper of the E4981B.

CAUTION	Do not apply DC voltage or current to the UNKNOWN terminals. Applying DC voltage or current may lead to device failure. Connect the measurement sample (DUT) to the test port (or the test fixture, cables, etc. connected to the test port) after the Capacitance meter has been completely discharged.

The maximum load the UNKNOWN terminals can withstand is 10 kg (nominal).

The test ports comply with Installation Category I of IEC 61010-1.

10. Front USB port

This port is used to save data in a USB memory.

Connector types: Universal Serial Bus (USB) Jack, Type A (four contact points), Female.

Compliance Standards: USB 2.0

NOTE	Do not connect any device other than a USB memory to the USB port. We do not support connections to the USB port of printers, devices with a built-in HDD, or USB hubs. To print a screen, refer to "Saving a screenshot into USB memory" on page 89.

NOTE	Do not unplug the USB memory while the USB indicator is on.

USB memory type

Use USB memory that is USB mass-storage-class compliant and formatted with FAT32 or NTFS. For points to notice, refer to "USB memory notes" on page 78.

Interface: USB 2.0

11. Ground terminal

Connected to the chassis of the E4981B.

12. Synchronous clock

The internal clock signal is outputted.

Rear Panel: Names and Functions of Parts

This section describes the names and functions of the parts on the E4981B's rear panel.

Figure 2-2   Rear panel
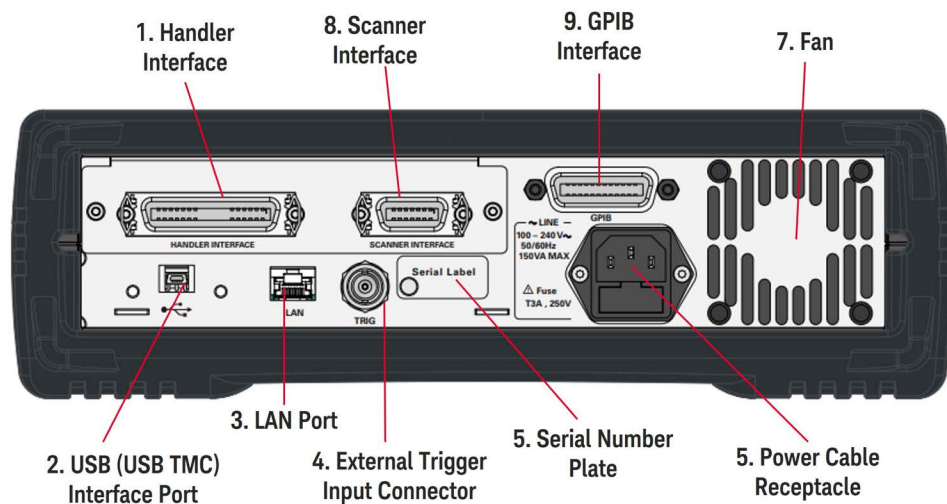
1. Handler interface

This interface is for data exchange with an automatic machine (handler) used on a production line.

Connector type: 36-pin Centronics

2. USB (USBTMC) interface port

Through this port, you can control the E4981B via external controllers.

Connector Types: Universal Serial Bus (USB) jack, type mini-B (five contact points), Female Compliance Standards: USBTMC-USB488 and USB2.0

The USB port of the E4981B provides (screw holes) to secure the USB cable with a custom make bracket. The figure describes the dimension required for the custom bracket. The distance between the surfaces of the rear panel and USB connector is 2 mm. The length of the screw should be less than 10 mm.
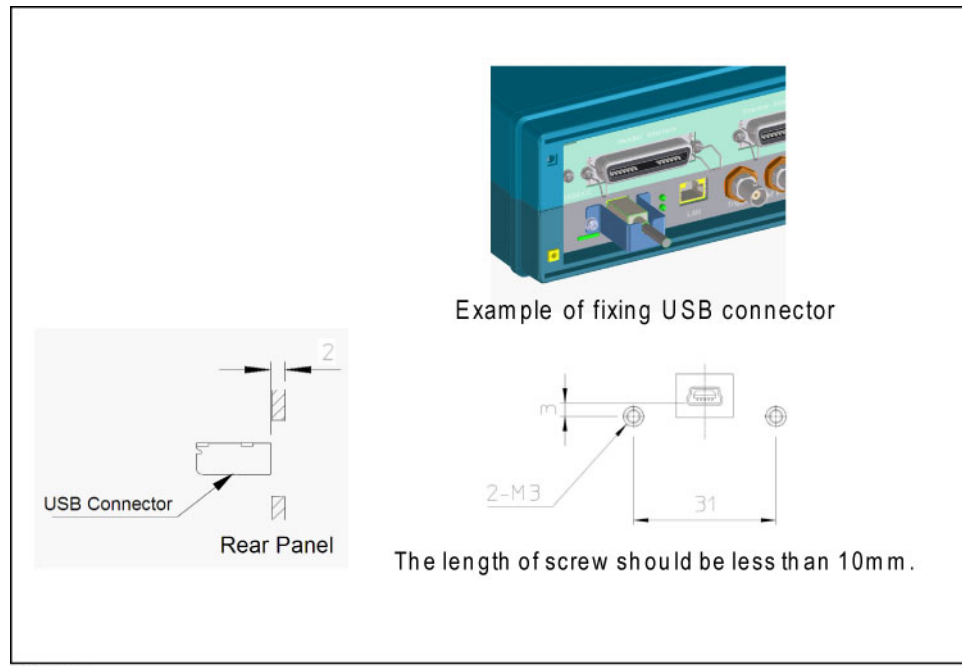
3. LAN port

The port to connect the E4981B to a LAN (Local Area Network). Connecting this instrument to a LAN enables you to control this instrument by using SICL-LAN or telnet, or from an external PC via a Web server.

This is compliant with LXI standard (LAN eXtensions for Instrumentation): version 1.5 LXI Device Specification 2016.

Connector type: 8-pin RJ-45 connector
Compliance Standard: 10 Base-T/100 Base-T/1000 Base-T Ethernet (automatic data rate selection)

4. External trigger input connector

The BNC connector to input the positive/negative TTL pulse to trigger the E4981B with external trigger signals.(The trigger mode must be set to EXTernal.)

5. Serial number plate

The seal showing the product's serial number.

6. Power cable receptacle (to LINE)

The receptacle (outlet) to which the power cable is connected.

NOTE   To connect the device to a power source (outlet), use the supplied three-prong power cable with a ground conductor.

The plug attached to the power cable (on the power outlet side or device side of the cable) serves as the E4981B's disconnecting device (device that cuts off the power supply). When the power supply must be cut off to avoid such danger as electric shock, pull out the power cable plug (on the power outlet side or device side of the cable). For the procedure for turning off the power in normal use, see the description in "1. Power switch" on page 24.

For more on the power supply, see "Verifying the power supply" on page 19.

7. Fan

The cooling fan for controlling the temperature inside the E4981B. This fan extracts heated air from inside the Capacitance meter.

8. Scanner interface

The interface to connect a scanner to perform up to 256 sets of multi-channel corrections and measurements.

Connector type: 14-pin Amphenol

9. GPIB interface connector

General Purpose Interface Bus (GPIB). The connection of an external controller and other devices through this connector allows you to configure an automatic measurement system.

Screen Area: Names and Functions of Parts

This section describes the names and functions of parts on the E4981B's LCD screen.

Figure 2-3   Screen display

e4981aue0017
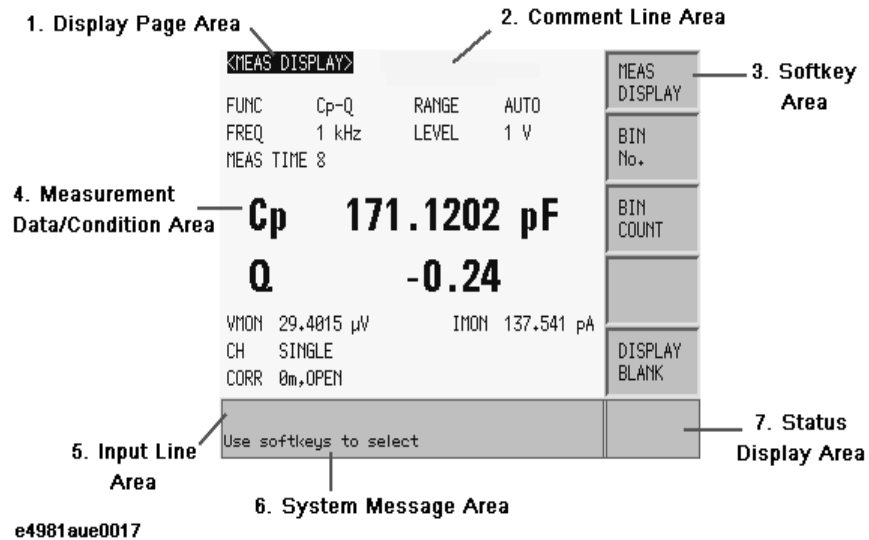
1. Display page area

Shows a display page name of the current display page.

2. Comment line area

You can input up to 30 characters in ASCII format by using the front panel or the DISPlay:LINE command of the SCPI command. The first 22 characters are displayed in this area.

Comment line is displayed on MEAS DISPLAY, BIN No. DISPLAY, BIN COUNT DISPLAY and MEAS SETUP display page.

For the input method in the comment line, refer to **"Inputting Comment Line" on page 53**.

3. Softkey area

Displays softkey labels corresponding to the field.

A ▶ displayed to the right of a softkey indicates that pressing that softkey will display the softkey label one level lower.

Pressing the **Return** key when the lower level softkey label is displayed will display the softkey label one level higher. In this case, a ◄ is displayed on the label to the left of the **Return** key.

Figure 2-4   Softkey area
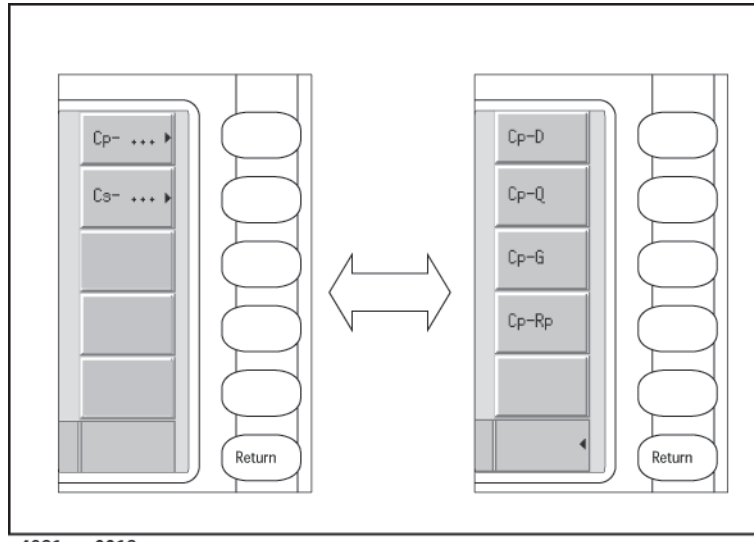
4. Measurement data/Conditions area

Displays measurement conditions and measurement results.

5. Input line area

Displays numeric values entered with the entry key.

6. System message area

Displays a system message, warning, and an error message.

7. Status display area

When the front panel key is locked, "LOCK" is displayed in this area. When sending SCPI commands from an external controller, "RMT" is displayed and the front panel keys are locked. When E4981B accesses the USB memory, "USB" is displayed in this area.

Basic Operation

The E4981B's basic operations are described below:

1. Display the desired page using both the MENU keys and softkeys.

2. Move the cursor to the desired field using the cursor keys. When the cursor is moved to a certain field, the field changes to an inverse video image of the original. The cursor can be moved from field to field (right and left or up and down).

3. The softkey labels corresponding to the field indicated by the cursor are displayed automatically. Press the desired softkey.

   Use the entry keys to input numeric data. When one of the entry keys is pressed, the softkeys will change to the available unit softkeys. Pressing these unit softkeys terminates numeric input.

   The unit changes according to the field selected.

How to use cursor keys

Move the cursor to the desired field using the cursor keys as shown in **Figure 2-5**.

Figure 2-5   Cursor keys and a field operation example
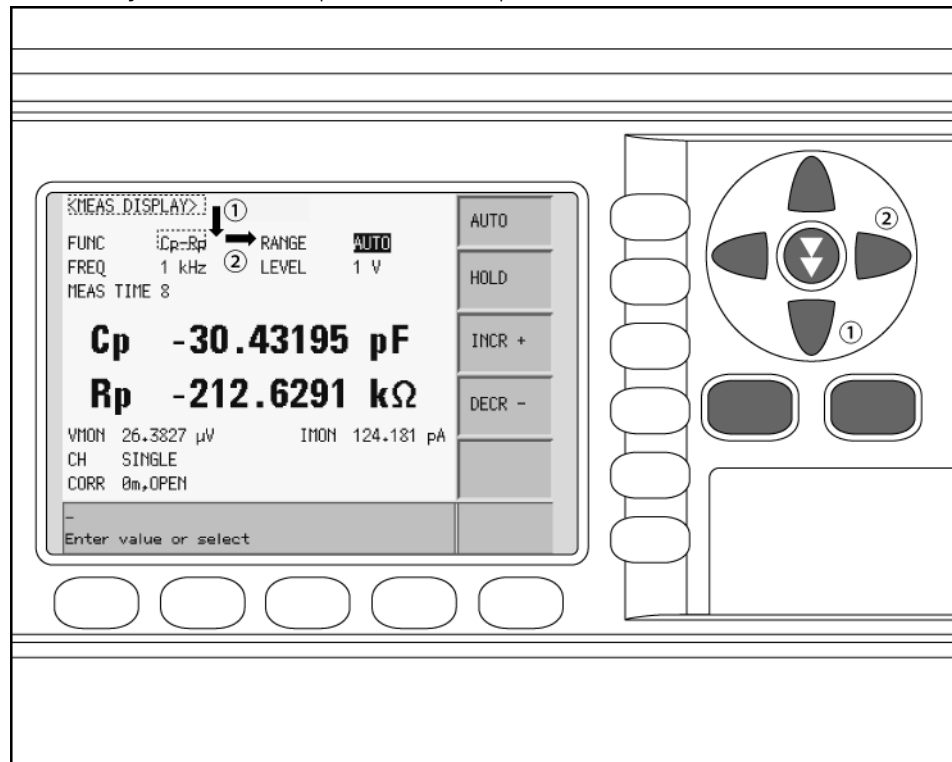
How to use skip keys

The following describes how to use a skip key.

On a display page, three lines are collected together as one. By using a skip key, you can select the desired field quickly as the selected field moves from area to area.

Figure 2-6   Skip key and a field operation example

Keysight E4981B 120 Hz/1 kHz/1 MHz Capacitance Meter
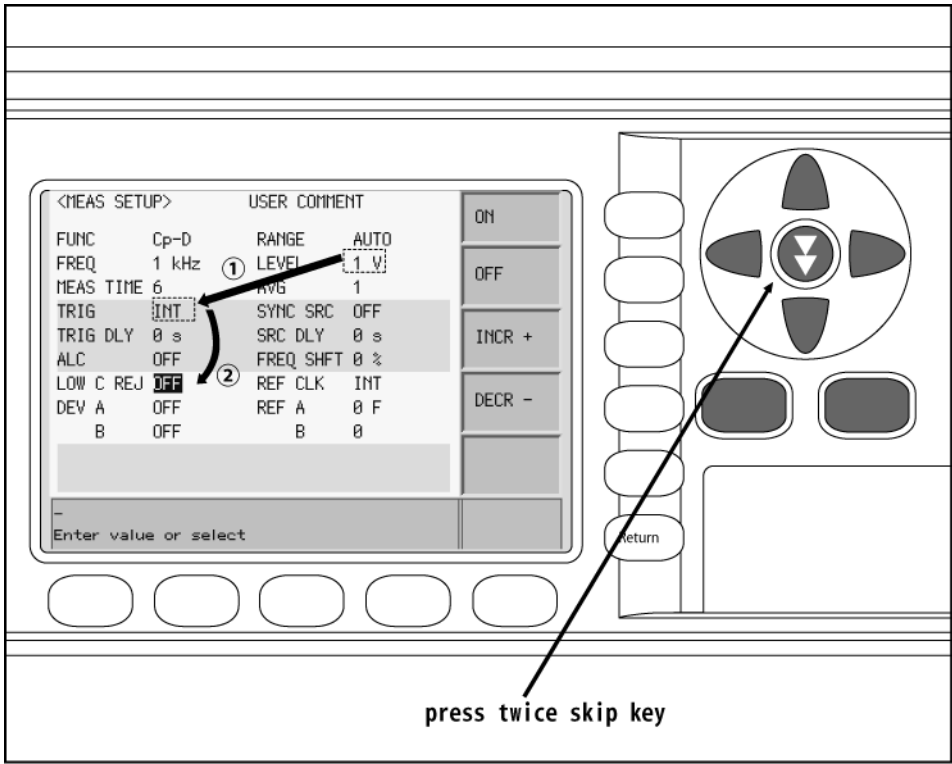
3 Getting Started

This chapter describes the basic operations of the Keysight E4981B. "Key Operation Basics" on page 35 explains how to use the basic key operations. "Learning Basic Measurement Procedure" on page 38 describes how to take basic measurements of capacitors (capacitance) with the E4981B.

Key Operation Basics

Three types of operations can take place when you press a front panel key of the E4981B:

- A single key press completes the operation.

- A menu (for item selection) appears on the screen.

- A value entry screen appears.

The basic operation for each case is described below:

A single key press completes the operation

Single-key operation turns ON/OFF the function or changes the setup. Specifically, each key press turns the setup ON/OFF. Two examples are given below:

- Pressing the **[Recall A]** key recalls configuration states from register 0.

- Pressing the **[Local/Lock]** key locks and unlocks hard keys and softkeys on the front panel.

A menu (for item selection) appears on the screen

In this case, pressing a key changes the display of softkey area for selecting items. Use the cursor keys or menu keys to change the selection. When the desired item is selected, press the softkey to confirm the selection. An example is given below.

Step 1. Press the **[Meas Setup]** key.

Step 2. Use the cursor keys to select the **TRIG** field.

Step 3. Press the **MAN** softkey to set the trigger type to manual.

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A value entry screen appears

In this case, pressing a key changes the screen display from the measurement screen to the value entry screen. Use the following keys to enter a value:

- Entry (**[0]**, **[1]**, **[2]**, **[3]**, **[4]**, **[5]**, **[6]**, **[7]**, **[8]**, **[9]**, **[.]** (decimal point), and **[+/–]** (plus/minus)) keys

- Softkeys

How to use each key is described below.

Entry keys

Keys used to enter a value. The **[+/- <-]** key deletes the last character of the input value.

Softkeys

Use this key to terminate the input.

NOTE	You can enter values by using only the entry keys and the softkeys. However, depending on the instrument setup state when you try to enter a value, some of these keys may be unavailable.

Example of operation used to enter a value

To learn how to enter a value, follow the steps below to change the measurement range setup the measurement range of 220 pF (when the measurement frequency is 1 kHz) in the following two ways:

- entry using the numeric keys and softkey, and

- entry using only the softkeys.

Each procedure is described below.

Step 1. Press the [Meas Setup] key.

Step 2. Use the cursor keys to select the **RANGE** field, as shown in Figure 3-1.

Figure 3-1   Measurement setup screen

Step 3. Enter 220 pF.

Entry using the numeric entry keys and softkeys:

> When data is entered with the numeric entry keys, the softkeys change to units labels (pF, nF, mF, mF, F).

> Press the **[2]** key, **[2]** key, and **[0]** key. Then, press the **pF** softkey.

Entry using only the softkeys:

Softkey	Description
INCR+	Increments the measurement range in the HOLD mode.
DECR-	Decrements the measurement range in the HOLD mode.

Learning Basic Measurement Procedure

This section describes the procedure used to measure a capacitor with the test fixture. This description is intended to help you learn the basic measurement procedure of the E4981B.

Connecting test fixture

CAUTION To avoid failure, do not apply DC voltage or current to the UNKNOWN terminal. Special care must be taken for capacitors because they may be charged. Fully discharge DUTs before connecting them to the UNKNOWN terminal (or the test fixture).

It is difficult to connect the DUT (capacitor) directly to the E4981B. Therefore, a test fixture is generally used to connect the DUT to the E4981B. Use the test fixture that is suitable for the shape of the DUT. Figure 3-2 shows an example of making a connection by using the 16034G, which is suitable for measuring chip capacitors.

Figure 3-2   Connecting test fixture (16034G)
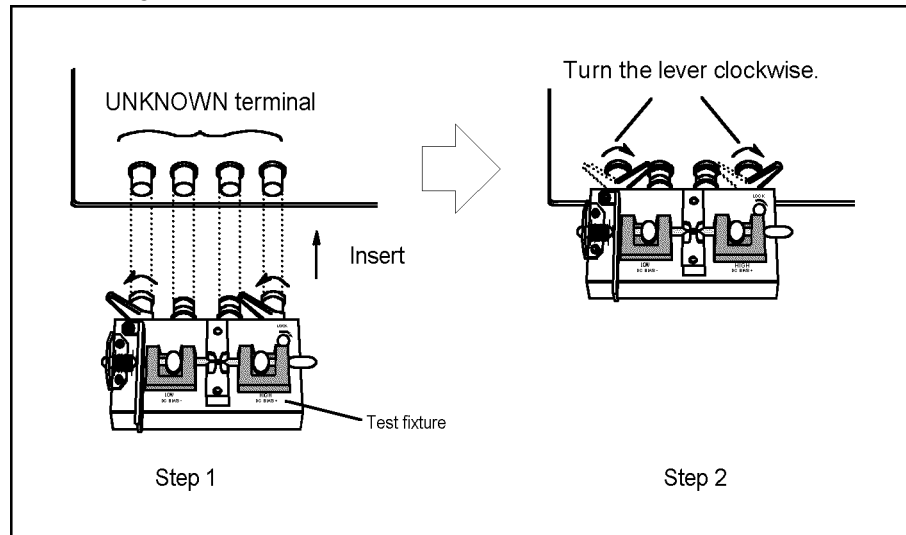
Setting up basic measurement conditions

This section describes how to set up basic measurement conditions for capacitor measurement. For an actual measurement (for example, measurement that provides better accuracy or measurement based on measurement time), you need to set up measurement conditions that are appropriate to the task, not necessarily those described here.

Initializing the Instrument

This section describes how to return the settings of the E4981B to their preset values.

Step 1.   Press the **[Preset]** key.

Step 2.   Use the softkeys to select one of the following four default states:

Table 3-1   Four default states of E4981B and how it is initialized

Default state	How the instrument is initialized
CLEAR SETTING	When you initialize the instrument into this state, all basic parameters configurable through the front panel and SCPI commands are cleared. (You get the same result by issuing the :SYST:PRES command).
CLEAR SET&CORR	When you initialize the instrument into this state, calibration data listed in the initial setting list are all cleared.[1] (You can get the same result by issuing the *RST command).
FACTORY DEFAULT	When you initialize the instrument into this state, it reverts to factory default settings with all user-configurable data cleared.
LAN RESET	When you initialize the instrument into this state, the LAN setting is returned to the factory default state.

1. It takes a few seconds for the initialization to complete.

For more information on each default state and affected settings, see Appendix C , "Initial Settings," on page 189.

Setting up measurement parameters

Set up the primary parameter and secondary parameter you want to measure. The E4981B allows you to select the parameters from the following combinations.

Primary parameter	Secondary parameter
Cp	D, Q, G, Rp
Cs	D, Q, Rs

Each parameter is described below.

Cp: Capacitance value when considering equivalent parallel resistance

Cs: Capacitance value when considering equivalent series resistance

D: Dissipation factor

Q: Quality factor (inverse of D)

G: Equivalent parallel conductance

Rp: Equivalent parallel resistance

Rs: Equivalent series resistance

The procedure to set up the measurement parameters is described below.

Step 1.   Press the **[Display format]** key.

Step 2. Press the **MEAS DISPLAY** softkey.

Step 3. Use the cursor key to select the **FUNC** field (as shown in Figure 3-3).

Step 4. Press the **Cp** or **Cs** softkey to select the primary parameter.

Figure 3-3   Primary parameter selection menu screen
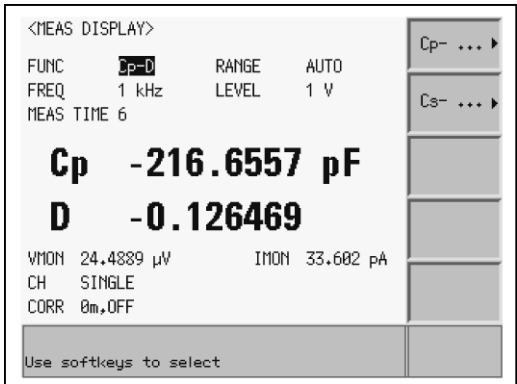
Step 5.   Press the softkey to select the secondary parameter (as shown in Figure 3-4).

Figure 3-4   Secondary parameter selection menu screen
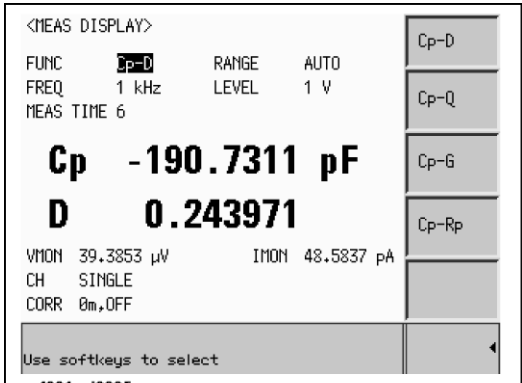
Setting up measurement signal frequency

Set up the frequency of the signal applied to the DUT (capacitor) during measurement.

Step 1.   Press the **[Display Format]** key.

Step 2. Press the **MEAS DISPLAY** softkey.

Step 3. Use the cursor key to select the **FREQ** field.

Step 4.   Use the softkeys or entry keys to enter the frequency. When data is entered with the numeric entry keys, the softkeys change to unit labels (Hz, kHz, MHz) for Option 001 and (Hz, kHz) for Option 002.

Figure 3-5   Measurement signal frequency selection menu screen
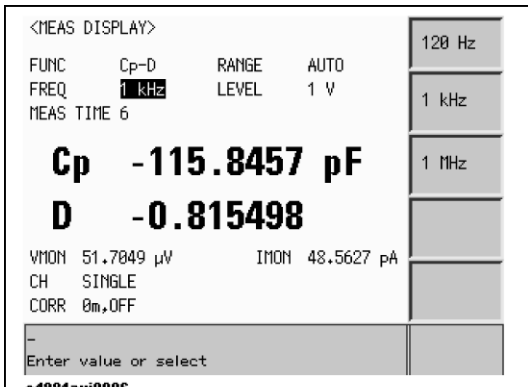
NOTE   In Option 002, 1 MHz frequency is not available.

Setting up measurement signal level

Set up the voltage level of the signal applied to the DUT (capacitor) during measurement.

Step 1. Press the **[Display Format]** key.

Step 2. Press the **MEAS DISPLAY** softkey.

Step 3. Use the cursor key to select the **LEVEL** field.

Step 4. Use the softkeys or entry keys to enter the test signal level. When data is entered with the entry keys, the softkeys change to units labels (mV, V).

Softkey	Description
INCR++	Increments the oscillator voltage level in steps of 100 mV, 500 mV, 1 V.
INCR+	Increases the oscillator voltage level with a resolution of 10 mV.
DECR-	Decreases the oscillator voltage level with a resolution of 10 mV.
DECR--	Decrements the oscillator voltage level in steps of 1 V, 500 mV, 100 mV.

Figure 3-6   Measurement signal level setup screen
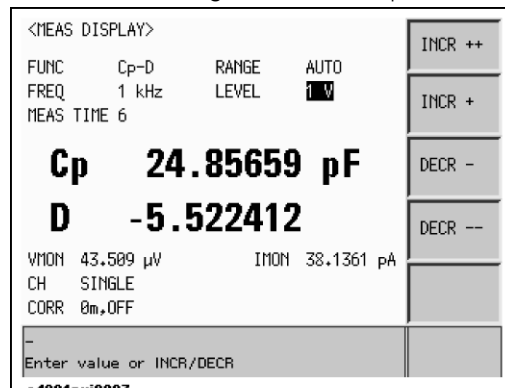
Setting up cable length

Select the length of the measurement cable from 0 m, 1 m, or 2 m, depending on the test set lead you use.

0 m   When you do not use the test lead (in other words, when you connect the test fixture directly to the UNKNOWN terminal).

1 m   When you use the Keysight 16048A/B test lead.

2 m   When you use the Keysight 16048D test lead.

The procedure used to set up the length of the measurement cable is described below.

Step 1.   Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **CABLE** field.

Step 4. Use the following softkeys:

Softkey	Description
0 m	Sets the cable length to 0 meter.
1 m	Sets the cable length to 1 meter.
2 m	Sets the cable length to 2 meter.

Figure 3-7   Cable length selection menu screen
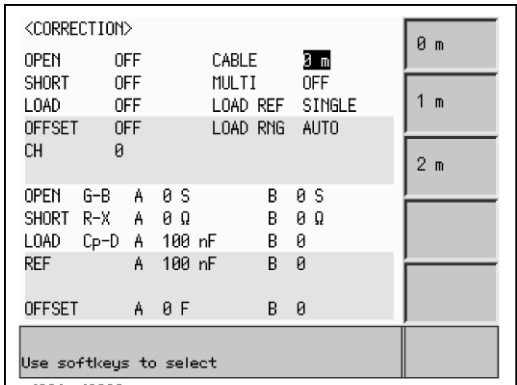
Executing measurement to compensate errors

You can compensate for errors in the measurement caused by disturbances such as stray admittance and residual impedance of the test fixture and cable.

Corrections should be performed before actually connecting the DUT to the test fixture.

Measuring data for OPEN correction

The OPEN correction is provided to remove stray admittance parallel to the DUT. The procedure to measure the data for OPEN correction is described below.

Step 1. Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey. The CORRECTION display page as shown in Figure 3-8 appears.

Figure 3-8   Correction screen
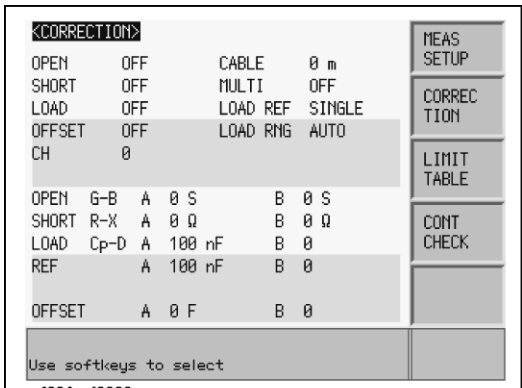
Step 3. Use the cursor keys to select the **OPEN** field.

Step 4. Connect the UNKNOWN terminal and the test fixture with no DUT connected.

Step 5. Press the **MEAS OPEN** softkey. The data for the OPEN correction is then measured.

- During the measurement, an "OPEN measurement in progress" message is shown on the display.

- When the measurement has finished, the "OPEN measurement in progress" message disappears.

- During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort open correction.

NOTE	The data for OPEN correction is stored as data for all the measurement frequencies.

Step 6. When measurement of the data for OPEN correction is successfully
completed, the OPEN correction turns to ON (as shown in Figure 3-9).

Figure 3-9   Screen upon completion of measuring data for OPEN correction
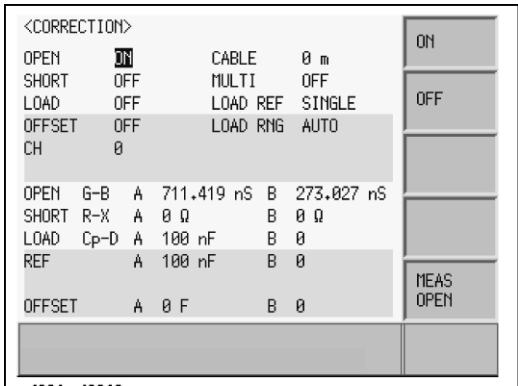
Description of softkeys

To enable/disable or otherwise control the behavior of open correction, use the
following softkeys:

Softkey	Description
ON	Enables open correction.
OFF	Disables open correction.
MEAS OPEN	Starts open correction.

If open admittance |Yo| $(=\sqrt{G^2 + B^2})$ is greater than 20 μS (an unsuitable level for
the data used in OPEN correction), the warning message "Out of limit" appears
on the System message area on the screen.

NOTE   Even if this warning message appears, the data for OPEN correction is still
used. However, you should recheck the connection between the test fixture
and the UNKNOWN terminal and confirm that the OPEN correction
procedure was done correctly.

If a measurement failure occurs while measuring the data for correction, the
error message "OPEN Measurement incomplete" occurs.

NOTE   If this error occurs, the data for correction before the measurement remains
without change.

Checking data for OPEN correction

You can check the measured open admittance value (data for the OPEN correction). The procedure is given below.

Step 1.   Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **OPEN G-B** field.

Figure 3-10   OPEN Correction Data


```
<CORRECTION>
                                           G-B
OPEN      ON          CABLE     0 m
SHORT     OFF         MULTI     OFF
LOAD      OFF         LOAD REF  SINGLE       Cp-G
OFFSET    OFF         LOAD RNG  AUTO
CH        0


OPEN   G-B   A  711.419 nS  B  273.027 nS
SHORT  R-X   A  0 Ω         B  0 Ω
LOAD   Cp-D  A  100 nF      B  0
REF          A  100 nF      B  0

OFFSET       A  0 F         B  0


Use softkeys to select
```
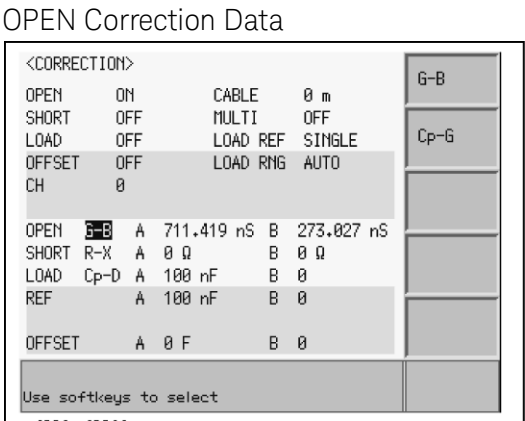
Step 4.   Use the following softkeys:

Softkey   Description

G-B   Displays the measured G-B value on the screen.

Cp-G   Displays the measured Cp-G value on the screen.

Measuring data for SHORT correction

The SHORT correction removes residual impedance in series with the DUT. The procedure to measure the data for SHORT correction is described below.

Step 1. Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey. The CORRECTION display page as shown in Figure 3-8 appears.

Step 3. Use the cursor keys to select the **SHORT** field.

Step 4. Connect the UNKNOWN terminal and the test fixture and short-circuit the high and low test terminals

Step 5. Press the **MEAS SHORT** softkey. The data for the SHORT correction is then measured.

- During the measurement, a "SHORT measurement in progress" message is shown on the display.

- When the measurement has finished, the "SHORT measurement in progress" message disappears.

- During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort short correction.

NOTE	The data for SHORT correction is stored as data for all the measurement frequencies.

Step 6. When measurement of the data for SHORT correction is successfully completed, the SHORT correction turns to **ON** (as shown in Figure 3-11).

Figure 3-11   Screen upon completion of measuring data for SHORT correction
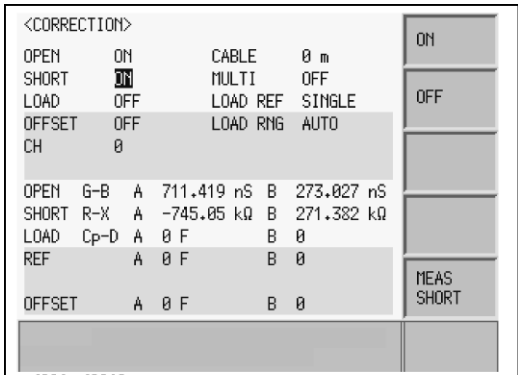
Description of softkeys

To enable/disable or otherwise control the behavior of short correction, use the following softkeys:

Softkey	Description
ON	Enables short correction.
OFF	Disables short correction.
MEAS SHORT	Starts short correction.

If SHORT impedance |Zs| ($= \sqrt{R^2 + X^2}$) is greater than 20 Ω (an unsuitable level for the data used in SHORT correction), the warning message "Out of limit" appears on the System message area on the screen

NOTE   **Even if this warning message appears, the data for SHORT correction is still used. However, you should recheck the connection between the test fixture and the UNKNOWN terminal and confirm that the SHORT correction procedure was done correctly.**

If a measurement failure occurs while measuring the data for correction, an error message appears on the screen.

NOTE   **If an error occurs, the data for correction before the measurement remains without change.**

Checking data for SHORT correction

You can check the measured SHORT impedance value (the data for SHORT correction). The procedure is given below.

Step 1.   Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **SHORT R-X** field (as shown in Figure 3-12).

Figure 3-12   SHORT correction data
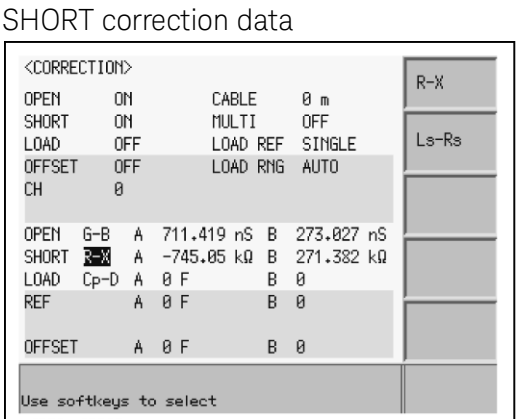
Step 4.   Use the following softkeys:

Softkey	Description
R-X	Displays the measured R-X value on the screen.
Ls-Rs	Displays the measured Ls-Rs value on the screen.

NOTE   For information on measuring data for Load correction, refer to "Obtaining (measuring) data for LOAD correction" on page 102.

For checking data for Load correction, refer to "Checking displaying/setting up data for LOAD correction" on page 111.

Connecting the DUT (capacitor)

Mount a capacitor on the test fixture. The measurement result for the parameter selected in "Setting up measurement parameters" on page 40 is displayed. Figure 3-13 shows an example when the primary parameter is Cp and the secondary parameter is D.

Figure 3-13   Measurement result display screen (when primary parameter is Cp and secondary parameter is D)

4   Setting up Measurement Conditions and Display

This chapter describes how to initialize the instrument, set up the measurement conditions and display. It also describes how to save/recall the instrument setup state, including the measurement conditions.

Selecting Measurement Parameters

You can select one of the measurement parameter combinations shown in Table 4-1.

Table 4-1   Measurement parameters

Primary parameter	Secondary parameter
Cp	D, Q, G, Rp
Cs	D, Q, Rs

Each parameter is described below.

Cp: Capacitance value measured using the parallel equivalent circuit model

Cs: Capacitance value measured using the series equivalent circuit model

D: Dissipation factor

Q: Quality factor (inverse of D)

G: Equivalent parallel conductance measured using the parallel equivalent circuit model

Rp: Equivalent parallel resistance measured using the parallel equivalent circuit model

Rs: Equivalent series resistance measured using the series equivalent circuit model

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Figure 4-1   Relationship between equivalent circuit model and measurement parameters

Parallel equivalent circuit model

Cp

Rp

$$D = \frac{1}{2\pi f\, Cp\, Rp}$$

$$Q = \frac{1}{D} = 2\pi f\, Cp\, Rp$$

$$G = \frac{1}{Rp}$$

Series equivalent circuit model

Cs Rs

$$D = 2\pi f\, Cs\, Rs$$

$$Q = \frac{1}{D} = \frac{1}{2\pi f\, Cs\, Rs}$$

f: Measurement signal frequency (120 Hz / 1 kHz / 1 MHz)
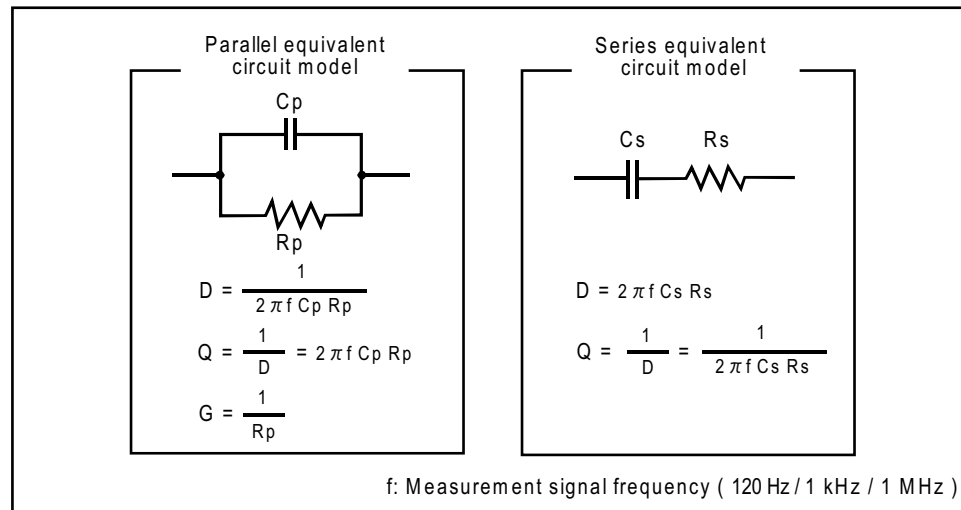
For information on the selection criteria for the equivalent circuit model, refer to "Selection criteria of parallel/series equivalent circuit models" on page 209.

Setup procedure

For details on setup procedure, refer to "Setting up measurement parameters" on page 40.

Inputting Comment Line

You can enter a comment in the comment line by using the softkeys to enter letters and the entry keys to enter numbers from 0 through 9, +, -, and period (.). Your entered comment is saved in the internal memory or external USB memory along with the control settings of the E4981B. When you load the control settings, your saved comment is loaded as well.

The comment can be up to 30 characters in length. However, only the first 22 characters are displayed in the area.

Until you enter a comment into the comment line, the default text "USER COMMENT" appears in the comment line.

NOTE   You can also use the :DISPlay:LINE command to enter ASCII characters into the comment line.

To enter a comment into the comment line:

Step 1.   Press the **[Meas Setup]**.

Step 2.   Press **MEAS SETUP** softkey.

Step 3.   Using the cursor keys, select the **USER COMMENT** field.

NOTE   If there is already a comment, select that comment (field).

Step 4.   To input a letter, use the following softkeys to cycle through letters in alphabetical order and then select your desired letter:

Softkey	Description
NEXT	Displays the next letter to the letter currently displayed in the **ADD CHAR** softkey.
PREV	Displays the previous letter to the letter currently displayed in the **ADD CHAR** softkey.

NOTE   To input a number, use the entry keys.

Step 5.   Press the **ADD CHAR** softkey.Your selected single character appears in the input line area.

Step 6.   Repeat Step 4 and Step 5 to input subsequent characters.

Step 7.   Press the **ENTER** softkey to enter your text in the USER COMMENT field.

Setting Up Measurement Signals (Frequency And Level)

Setting up frequency

You can set the frequency of the measurement signal applied to the DUT as either
120 Hz, 1 kHz, or 1 MHz.

NOTE	In Option 002, 1 MHz frequency is not available.

Setup procedure

For details on setup procedure, refer to "Setting up measurement signal frequency" on page 41.

Setting up level

You can set up the level of the measurement signal applied to the DUT within a range of 0.1 V to 1.0 V in steps of 10 mV.

Setup procedure

For details on setup procedure, refer to "Setting up measurement signal level" on page 42.

Setting up signal level compensation (SLC) function

Functional description

If the impedance of DUT is small, then the output resistance of the signal source, the resistance of the measurement cable can cause the voltage applied to the DUT to decrease below the specified voltage of the signal source. The signal level compensation feature adjusts the voltage across the DUT to the same level as the signal voltage level setting. Using this feature, you can maintain a constant level (voltage) of measurement signals applied to the DUT.

NOTE	SLC is available on:

- 120 Hz: 220 µF, 470 µF, 1 mF range
- 1 kHz: 22 µF, 47 µF, 100 µF range

For all other range/frequency SLC is not executed even if LVL COMP is ON.

To set up the signal level compensation feature:

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **LVL COMP** field.

Step 3.   Use the following softkeys:

Softkey	Description
ON	Turns ON the signal level compensation feature.
OFF	Turns OFF the signal level compensation feature.

Level error of the signal level compensation function

Even if you use the signal level compensation function, signal level drop occurs at larger capacitance with larger D (refer to "Signal Level Compensation (SLC) function" on page 191).

NOTE	In E4981B, the AC level monitor is always ON.

The status in which capacity further increases and the output current of the signal source approaches the limit (approximately 1 Arms) is judged as overload. In this case, OVLD appears on the display.

Executing signal level check

When level error becomes over 10%. If the applied signal level for DUT is dropped more than 10% from the setting level the following error occurs:

· When both SLC and contact check are ON, generates contact check error.

· When SLC is ON and contact check is OFF, generates OVLD (overload) error.

For more information on contact check, refer to "Setting up Contact Check" on page 66.

Selecting Measurement Range

Setting measurement range to be automatically selected (auto ranging)

Two modes can be used to select the measurement range as shown in Table 4-2. To enable automatic selection, select the auto range mode.

Table 4-2   Measurement range mode

Mode	Function overview	Advantage	Disadvantage
Auto range (auto selection)	The instrument automatically selects a proper measurement range depending on the value of the DUT and performs measurement.	You do not need to select the measurement range.	The measurement time is longer due to the ranging time.
Hold (fixed) range (manual selection)	Measurement is performed with a fixed measurement range regardless of the value of the DUT.	No ranging time is required.	You need to select a proper range depending on the value of the DUT.

Selecting your desired measurement range (hold range)

The selectable measurement ranges are shown in Table 4-3. As this table shows, selectable measurement ranges differ depending on the measurement signal frequency. Therefore, if a newly selected measurement frequency conflicts with the current measurement range setting, the setting is automatically changed to cover the allowable range.

Table 4-3   Selectable measurement ranges

For 120 Hz measurement signal frequency:			For 1 kHz measurement signal frequency:			For 1 MHz measurement signal frequency:		
						1 pF	2.2 pF	4.7 pF
						10 pF	22 pF	47 pF
			100 pF	220 pF	470 pF	100 pF	220 pF	470 pF
			1 nF	2.2 nF	4.7 nF	1 nF		
10 nF	22 nF	47 nF	10 nF	22 nF	47 nF			
100 nF	220 nF	470 nF	100 nF	220 nF	470 nF			
1 μF	2.2 μF	4.7 μF	1 μF	2.2 μF	4.7 μF			
10 μF	22 μF	47 μF	10 μF	22 μF	47 μF			
100 μF	220 μF	470 μF	100 μF					
1 mF								

The procedure to set up the measurement range mode is described below.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor key to select the **RANGE** field.

Step 3.   Use the numeric keys or following softkeys:

Softkey	Description
AUTO	Sets the measurement range mode to AUTO.
HOLD	Sets the measurement range mode to HOLD.
INCR+	Increments the measurement range in the HOLD mode.
DECR-	Decrements the measurement range in the HOLD mode.

Selecting Measurement Time

NOTE Measurement time of 1, 2, 4, 6 and 8 are available in E4981B.

For details on the actual measurement time, refer to "Measurement time" on page 186.

Setup procedure

Step 1. Press **[Meas Setup]**.

Step 2. Use the cursor keys to select the **MEAS TIME** field.

Step 3. Use the numeric keys or following softkeys:

Softkey	Description
INCR+	Increments the measurement time.
DECR-	Decrements the measurement time.

Selecting Cable Length

Set up the length of the measurement cable to compensate errors due to the extension of the measurement cable. The E4981B lets you select the length from 0 m, 1 m, or 2 m, depending on the measurement cable you use.

0 m	When you do not use the test lead (in other words, when you connect the test fixture directly to the UNKNOWN terminal).
1 m	When you use the Keysight 16048A/B Keysight test lead.
2 m	When you use the Keysight 16048D test lead.

Setup procedure

For details on setup procedure, refer to "Setting up cable length" on page 43.

NOTE Cable length information is saved in internal FLASH memory when power is OFF with backup function enabled.

Setting Up Averaging Count

Functional description

The averaging feature of the E4981B allows you to obtain moving average values of successive measurement results.

You can specify the averaging factor within the range of 1 to 256 in steps of 1.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **AVG** field

Step 3.   Use the numeric keys or following softkeys:

Softkey	Description
ON	Turns ON the averaging feature.
OFF	Turns OFF the averaging feature.
INCR+	Increments the averaging factor in steps of 1.
DECR-	Decrements the averaging factor in steps of 1.

Setting Up Trigger Delay Time

You can set up a wait time (trigger delay time) between when a trigger is detected and when the measurement is started. You can set up the trigger delay time within the range of 0 s to 1 s in steps of 100 µs.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **TRIG DLY** field.

Step 3.   Use the numeric keys or following softkeys:

Softkey	Description
INCR++	Increments the trigger delay time in steps of 1 msec.
INCR+	Increments the trigger delay time in steps of 0.1 msec.
DECR-	Decrements the trigger delay time in steps of 0.1 msec.
DECR--	Decrements the trigger delay time in steps of 1 msec.

Setting up Measurement Conditions and Display
Outputting the Measurement Signal Only During the Measurement to Protect the
Contact Pin (Synchronous Source Function)

NOTE	When source delay is available, trigger delay executes after source delay time.

Outputting the Measurement Signal Only During the Measurement to Protect the Contact Pin (Synchronous Source Function)

You can use this function to prevent large current from flowing through the contact pin at the moment of contact with DUT to avoid damaging the contact pin. This function, after a trigger, outputs the measurement signal so that it is applied only during measurement (synchronous source function).

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **SYNC SRC** field.

Step 3.   Use the following softkeys:

Softkey	Description
ON	Turns ON the synchronous source function.
OFF	Turns OFF the synchronous source function.

Step 4.   Use the cursor keys to select the **SRC DLY** field.

Step 5.   Use the following softkeys:

Softkey	Description
INCR++	Increments the source delay in steps of 1 ms.
INCR+	Increments the source delay in steps of 0.1 ms.
DECR-	Decrements the source delay in steps of 0.1 ms.
DECR--	Decrements the source delay in steps of 1 ms.

NOTE	The specified source delay time (to delay the start of signal output) is valid only when the synchronous source function is ON.

When the source delay time and trigger delay time are both specified, the source delay time precedes the trigger execution.

Figure 4-2 shows the measurement signal output timing.

Figure 4-2   Measurement signal output timing
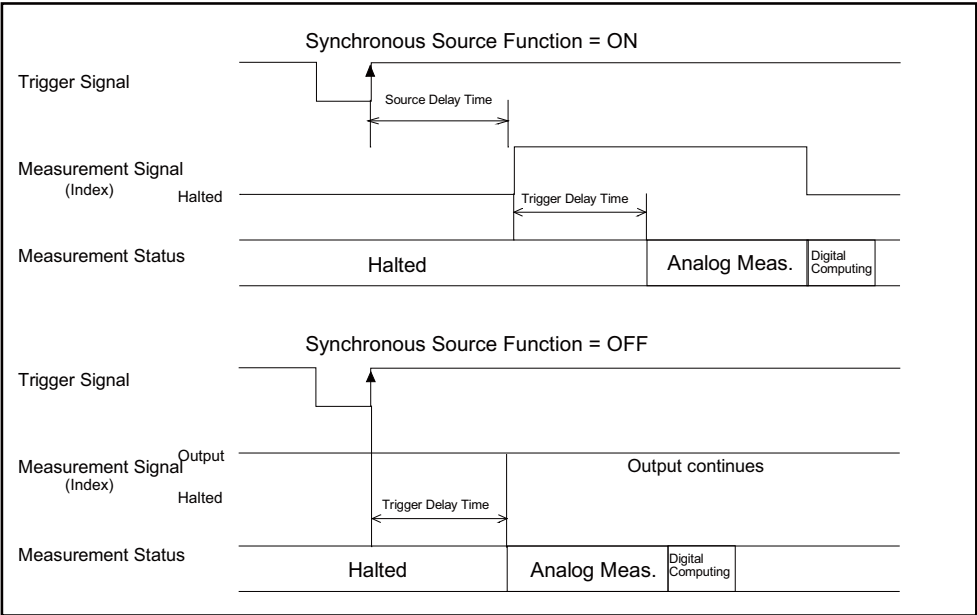
Setting Up Frequency Shift

When two or more E4981B units are integrated into a single system, you can shift the 1 MHz measurement frequency by +1%, –1%, 0%, –2%, or +2% to avoid interference between the measurement signals.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **FREQ SHFT** field.

Step 3.   Use the following softkeys:

Softkey	Description
+1%	Shifts the 1 MHz measurement frequency by +1%.
–1%	Shifts the 1 MHz measurement frequency by –1%.
0%	Shifts the 1 MHz measurement frequency by 0%.
–2%	Shifts the 1 MHz measurement frequency by –2%.
+2%	Shifts the 1 MHz measurement frequency by +2%.

NOTE   For Option 002, the frequency shift function is not available.

Setting Up Display

Turning ON/OFF display

You can turn ON/OFF the display with the **[Display Format]** key.

If you turn OFF the display, **DISPLAY NORMAL** is always displayed in the display area for the above items, and you cannot read the measurement result. However, the measurement time is shortened because no additional time is required for updating the display.

Setup procedure

Step 1.   Press **[Display Format]**.

Step 2.   Press the **DISPLAY BLANK** softkey.

Step 3.   If you turn OFF the display, **DISPLAY NORMAL** is always displayed in the display area. To return to normal display press the **DISPLAY NORMAL** softkey.

Using fixed point display for measurement result

The following two display modes can be used to display the measurement result of the measurement parameter.

	Description
Floating point display (default setup)	The value displayed at each digit is not fixed and changes depending on the measured value.
Fixed point display	The value displayed at each digit is fixed to the value defined by the user.

NOTE	The fixed point display is always used to display the deviation percentage (refer to "Displaying measurement result in deviation from reference value (deviation measurement mode)" on page 63) as well as to display D and Q.

Setup procedure

Selecting floating/fixed point display

Step 1. Press **[Display Format]**.

Step 2. Use the cursor keys to select the field in which a measurement result of primary parameter or secondary parameter is displayed.

Step 3. Use the following softkeys:

Softkey	Description
D.P. AUTO	Automatically sets the decimal point
D.P. FIX	Fixes the decimal point position
D.P. POS INCR+	Increments the position of decimal point
D.P. POS DECL-	Decrements the position of decimal point

Displaying measurement result in deviation from reference value (deviation measurement mode)

Functional description

The deviation measurement feature allows you to display deviation values instead of actual measurements. A deviation is expressed as the difference between the actual measurement and the stored reference value. The deviation measurement feature is useful when you observe how a particular value of a device/component changes under varying conditions of temperature, frequency, bias, and other influences.

You can apply the deviation measurement feature to the primary or secondary parameter or both. The deviation measurement feature supports the following two modes:

· ΔABS (absolute value) deviation measurement

   Identifies and displays the difference between the actual measurement of the DUT and the stored reference value. This value is calculated based on the following formula:

   $\Delta ABS = X - Y$

   X   actual measurement of the DUT

   Y   stored reference value

· Δ% (percentage) deviation measurement

Identifies the difference between the actual measurement of the DUT and the stored reference value and displays it as a percentage of the reference value. This percentage deviation value is calculated based on the following formula:

Δ%   = (X-Y)/Y×100 (%)

X   actual measurement of the DUT

Y   stored reference value

To set up the deviation measurement feature:

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **REF A** field.

Step 3.   Enter the reference value using the softkeys or entry keys. If you use the entry keys to enter the value, the softkey labels change to unit labels (p, n, u, m, x1, k).

Softkey	Description
MEASURE	If you want to use a particular device/component as the reference, connect the DUT and press this key. Then the instrument measures the DUT once and automatically fills the REF A and REF B fields with the measured values, which now serve as the reference values.

Step 4.   Use the cursor keys to select the **DEV A** field.

Step 5.   Use the softkey to select the deviation mode for the primary parameter:

Softkey	Description
ABS	Displays the deviation as the difference from the reference value.
%	Displays the deviation as a percentage of the reference value.
OFF	Turns OFF deviation measurement.

Step 6.   Using the cursor keys, select the **DEV B** field.

Step 7.   Select the deviation mode for the primary parameter using the softkeys described in .

Difference between deviation measurement mode and offset correction

The offset correction function is similar to the deviation measurement mode with respect to the behavior when a predefined value is subtracted from the measured value. On the other hand, the two functions differ as explained below.

	Purpose	Effect on comparator
Deviation measurement mode	Used when calculating the deviation of the measured value from any given value (for example, nominal value).	Not affected. The absolute value of the measurement result is always used for sorting judgment.
Offset correction	Used to bring the measured value close to any given value (for example, to compensate variations of the measured value among instruments for the same DUT).	Affected. Values compensated by this function are used for sorting judgment.

If the deviation measurement mode and the offset correction are both ON, the offset correction is executed first and then, using the result as the measurement result, the value calculated is displayed. (Refer to Figure 5-1 on page 92.)

Setting up Contact Check

The E4981B contact check function can be used to check for contact failure between the E4981B connector and the DUT.

When contact failure is detected, N.C. will appear on the display and a fixed value (9.9E37) is always read out via GPIB/LAN/USB as the measurement value, and the /LOWC_OR_NC signal of the handler interface goes Low.

> **NOTE** The contact check function is available only at 120 Hz and 1 kHz measurement frequency. This function does not works when range is set as AUTO.

Setup procedure

Step 1. Press **[Meas Setup]**.

Step 2. Press the **CONT CHECK** softkey.

Step 3. Use the cursor keys to select the **CONT CHK1** field.

Step 4. Use the following softkeys:

Softkey	Description
ON	Turns ON the contact check function to detect loose connection
OFF	Turns OFF the contact check function

Step 5. Use the cursor keys to select the **CC1 TH1** field. TH1 is a parameter proportional to the contact resistance of Hp or Hc.

Step 6. Use the recommended setting value 0.1 (default value) for **CC1 TH1**.

Table 4-4   Recommended setting value for TH1 and TH2

Range		TH1	TH2
120 Hz	**1 kHz**		
10 nF	100 pF - 1 nF		0.08
22 nF - 100 nF	2.2 nF - 10 nF		0.08
220 nF - 1 µF	22 nF - 100 nF		0.08
2.2 µF - 10 µF	220 nF - 1 µF	0.1[1]	0.1
22 µF - 100 µF	2.2 µF - 10 µF		0.15[1]
220 µF - 1 mF	22 µF - 100 µF		N/A

1. Default value.

Step 7.   Use the cursor keys to select the **CC1 TH2** field. TH2 is a parameter proportional to the contact resistance of Lp or Lc.

Step 8.   Use the softkeys or entry keys to enter the TH2 value according to Table 4-4. When data is entered with the entry keys, the softkeys change to units labels (m, x1).

Softkey	Description
INCR++	Increments the threshold value as 0, 10 m, 20 m, 50 m, 100 m, 200 m, 500 m, 1.
INCR+	Increments the threshold value in steps of 10.
DECR−	Decrements the threshold value in steps of 10.
DECR−−	Decrements the threshold value 1, 500 m, 200 m, 100 m, 50 m, 20 m, 10 m, 0.

Setting Up Condition To Make A Beep

The condition to make a beep sound differs depending on the beep mode, as shown in Table 4-5.

Table 4-5   Condition to make a beep

Mode	Condition to make a beep	
Off	Never makes a beep.	
Fail	When wrong key operation is performed.	When the sorting judgment result of the comparator is OUT_OF_BIN, AUX_BIN, No contact or OVLD.
Pass	When an error, alarm, or other message is outputted.	When the sorting judgment result of the comparator is from BIN1 to BIN9.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **BEEP** field.

Turning On/Off the Beep Feature

Functional description

The E4981B has a beep feature that generates beeps when one or more of the following conditions occur:

- An error message or warning message has appeared.

- The instrument has completed open/short correction.

- The instrument has completed open/short/load correction at user-specified frequency points.

- The DUT has failed the limit test or has been sorted as OUT_OF_BIN, AUX_BIN, OVLD or No contact by the comparator. [1]

- The DUT has passed the limit test or has been sorted into one of bins 1 through 9 by the comparator. [1]

- You have turned on/off the key lock.

Regardless of whether the beep feature is on or off, beeps are generated whenever:

- E4981B starts up.

- You change the beep tone through the front panel.

NOTE   The beep feature does not support volume control.

To set up the beep feature:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Use the cursor keys to select the **BEEPER ENABLED** field.

Step 4.   Turn on or off the beep feature by pressing the appropriate softkey:

Softkey	Description
ON	Turns ON the beep feature.
OFF	Turns OFF the beep feature.

---

1. You can use the BEEP field on the LIMIT TABLE SETUP page or the
   :CALC:COMP:BEEP command to turn on/off the beep feature for the comparator.

Changing the Beep Tone

Functional description

The E4981B allows you to change the beep tone to one of five levels.

To change the beep tone:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Use the cursor keys to select the **BEEPER TON**E field.

Step 4.   Change the beep tone by pressing the appropriate softkey:

Softkey	Description
TONE 1	Selects tone 1.
TONE 2	Selects tone 2.
TONE 3	Selects tone 3.
TONE 4	Selects tone 4.
TONE 5	Selects tone 5.

Configuring the Time Zone

Functional description

The E4981B allows you to set a time zone."Configuring the System Date" on page 71 changes whenever the time zone is changed.

Set the time difference from Greenwich Mean Time, GMT.

To configure the time zone:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Use the cursor keys to select the **TIME ZONE** field.

Step 4.   Use the following softkey:

Softkey	Description
HOUR INCR++	Increases the time up to +15 in steps of 1.
MINUTE INCR+	When the time is plus (+), increments the time from 0 to 45 in steps of 15.
	When the time is minus (–), increments the time from –45 to 0 in steps of 15.
MINUTE DECR–	When the time is plus (+), decrements the time from 45 to 0 in steps of 15.
	When the time is minus (–), decrements the time from 0 to –45 in steps of 15.
HOUR DECR—	Decreases the time up to –12 in steps of 1.

NOTE   When the E4981B is returned to the factory default settings, the time zone setting is also initialized.

Configuring the System Date

Functional description

The E4981B features a built-in clock.

NOTE	Configure the system date after "Configuring the Time Zone" on page 70.

To configure the system date:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Use the cursor keys to select the **DATE/TIME** field.

Step 4.   Use the following softkey:

Softkey	Description
DATE	Selects the date field so that you can change the year, month, and day.
TIME	Selects the time field so that you can change the hour, minute, and seconds digit.

Step 5.   If you have selected the date field, use the following keys to edit the year, month, and day. If you have selected the time field, proceed to Step 7.

Softkey	Description
YEAR	Allows you to change the year digit.
MONTH	Allows you to change the month digit.
DAY	Allows you to change the day digit.

Step 6.   Enter the year/month/day using the softkeys or entry keys. If you use the entry keys to enter the value, the softkey labels change to unit labels (x1).

Softkey	Description
YEAR INCR+	Increments the year in steps of 1.
YEAR DECR-	Decrements the year in steps of 1.
MONTH INCR+	Increments the month in steps of 1.
MONTH DECR-	Decrements the month in steps of 1.
DAY INCR+	Increments the day in steps of 1.

Softkey	Description
DAY DECR-	Decrements the day in steps of 1.

NOTE When you enter the year through the entry keys, use a four-digit value.

Step 7. If you have selected the time field, use the following keys to edit the hour, minute, and second digits.

Softkey	Description
HOUR	Allows you to change the hour digit.
MINUTE	Allows you to change the minute digit.
SECOND	Allows you to change the second digit.

Step 8. Enter the hour/minute/second using the softkeys or entry keys. If you use the entry keys to enter the value, the softkey labels change to unit labels (x1).

Softkey	Description
HOUR INCR+	Increments the hour in steps of 1.
HOUR DECR-	Decrements the hour in steps of 1.
MINUTE INCR+	Increments the minute in steps of 1.
MINUTE DECR-	Decrements the minute in steps of 1.
SECOND INCR+	Increments the second in steps of 1.
SECOND DECR-	Decrements the second in steps of 1.

NOTE When you enter the hour with the entry keys, use a value within the range of 0 (midnight) through 23 (11:00 pm).

Configuring the GPIB Address

Functional description

Before you can control the E4981B by issuing SCPI commands from an external controller connected via its GPIB connector, you have to configure the GPIB address of your E4981B. For information on the concept and implementation of automatic configuration by use of GPIB, refer to *Programming Manual*.

To configure the GPIB address:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Use the cursor keys to select the **GPIB ADDR** field.

Step 4.   Enter a value with the entry keys in the range of 0 through 30.

Configuring the LAN IP Address

Functional description

To enable the E4981B to communicate over a local area network (LAN), you have to configure its IP address and connect a LAN cable. The IP address can be either automatically obtained or manually configured.

When the IP address is set to **AUTO**, AUTO-IP address is set. When the IP address is set to **MANUAL**, the address manually configured is set.

For information on the concept and implementation of automatic configuration by use of a LAN, refer to *Programming Manual*.

Softkey	Description
AUTO	Automatically obtains the IP address.
MANUAL	Manually configures the IP address.

Table 4-6   IP address configuration methods

Method	Description
AUTO-IP	You can automatically obtain an available IP address.
MANUAL	You can manually configure the IP address as well as subnet mask and gateway settings. [1]

1. Consult your network administrator for relevant settings of your network.

Once you have automatically obtained an IP address, you can check the
following monitor areas in the SYSTEM CONFIG page to see the address,
subnet mask, and gateway:

- · CURRENT IP ADDR

- · CURRENT SUBNET MASK

- · CURRENT GATEWAY

To automatically obtain the IP address:

Step 1. Press **[System]**.

Step 2. Press the **SYSTEM CONFIG** softkey.

Step 3. When you want to obtain the IP address automatically, select the **IP CONFIG**
field using the cursor keys and then press the **AUTO** softkey.

To manually configure the IP address:

Step 1. Press **[System]**.

Step 2. Press the **SYSTEM CONFIG** softkey.

Step 3. Use the cursor keys to select the **IP CONFIG** field and then press the **MANUAL**
softkey.

Step 4. Use the cursor keys to select the **MANUAL IP ADDR** field.

Step 5. Enter the IP address using the entry keys.

Example: 192.168.1.101

Step 6. Press the **ENTER** softkey.

Step 7. Use the cursor keys to select the **MANUAL SUBNET MASK** field.

Step 8. Enter the subnet mask using the entry keys.

Step 9. Press the **ENTER** softkey.

Step 10. Use the cursor keys to select the **MANUAL GATEWAY** field.

Step 11. Enter the gateway using the entry keys.

Step 12. Press the **ENTER** softkey.

Step 13. Press the **RESTART NETWORK** softkey.

Checking the LAN connection status

You can check the **CURRENT LAN STATUS** monitor area to see the LAN connection status of the E4981B. The status is expressed as one of the following:

Table 4-7   LAN connection status

Status	Description
NORMAL	LAN connection is OK.
FAILED	Disconnected from the LAN or LAN connection has failed.
IDENTIFY	LAN connection is being initialized.

To reconnect to the network:

Step 1.   Press **[System]**.

Step 2.   Press the **SYSTEM CONFIG** softkey.

Step 3.   Press the **RESTART NETWORK** softkey on the **IP CONFIG** field, **MANUAL IP ADDR** field, **MANUAL SUBNET MASK** field, or **MANUAL GATEWAY** field.

Saving/Recalling Instrument Setup State (Save/Recall Function)

You can save/recall up to 20 instrument setup states into/from the built-in FLASH memory (0 through 9) and external USB memory (10 through 19).

NOTE The ninth instrument setting corresponds to Auto Recall. Auto recall is not executed when power is ON, by pressing the **[Preset]** key.

Overview of save/recall functionality

Configurations and measurement results can be saved into, and recalled from, the E4981B's internal memory or external USB memory through the save/recall functionality.

Save methods and their uses

Table 4-8 shows available save methods and their uses:

Table 4-8   Save methods and their uses

Save method		Recallable	Use
Type	File format (extension)		
Configuration Save (internal memory)	-----------	Yes	To save E4981B's configuration states into the internal memory.
Configuration Save (USB memory)	(.sta)	Yes	To save E4981B's configuration states into USB memory.
Data Save (USB memory)	CSV format (.csv)	No	To save measurement results into USB memory.
Screen Save (USB memory)	GIF format (.gif)	No	To save E4981B's screenshot into USB memory.

NOTE For information on configuration states that can be saved, see Table C-1, "Initial settings, settings that can be saved/recalled, settings that can be backed up," on page C-190.

Folder/File structure on USB memory

When you save information into USB memory, a predetermined structure scheme is used to organize folders and files on the memory, as shown in Figure 4-3.

Folder	Max. number of files	Description
data	999	Contains measurement results as .csv files.
image	999	Contains screenshots as .gif files.
state	10	Contains instrument configuration states.
system[1]	1	This single file, whose name is always "system," contains the system information.

1. This folder can be operated from the SYSTEM page.

NOTE   These folders are automatically created in the memory.

Figure 4-3   Folder/File structure on USB memory
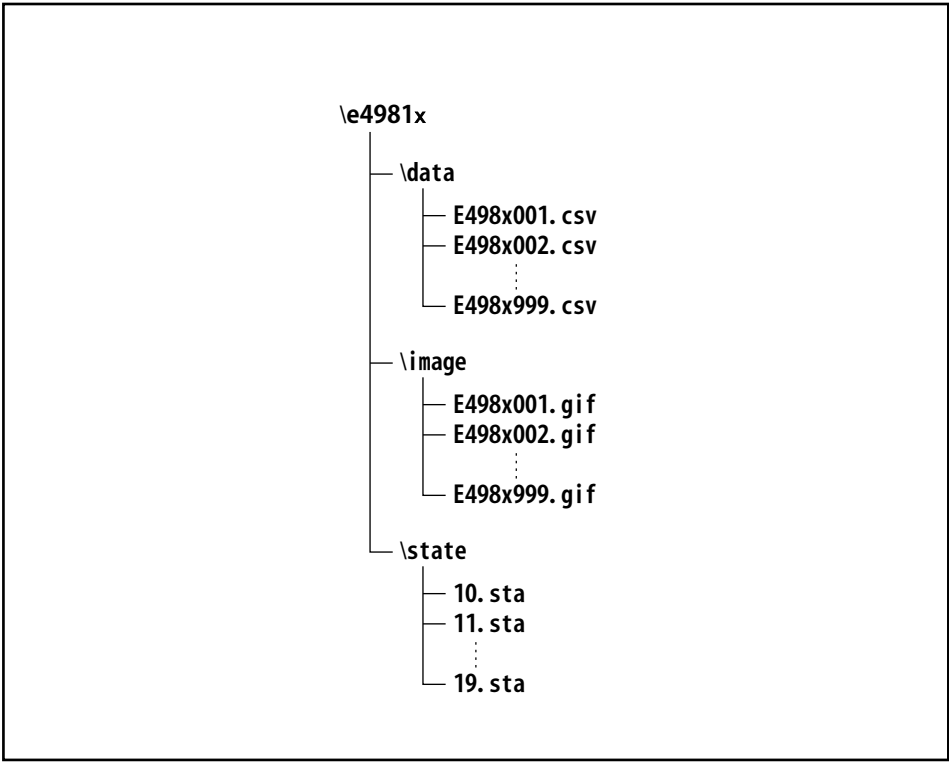
USB memory notes

Attention should be given to the following points when using a USB memory device with the E4981B

- Use a USB memory whose interface is USB 2.0.

- Use a USB memory that is USB mass storage class compliant and formatted with FAT32 or NTFS.

- Use the USB memory solely for the E4981B. Otherwise, other data previously saved in the USB memory could be erased.

- If you cannot save into or recall from the USB memory, use another USB memory device.

- Keysight Technologies shall not be responsible for nor assume any liability for data loss in your USB memory device after using it with the E4981B.

Saving/Recalling instrument configuration states

Overview of instrument configurations

Pressing the [Save/Recall] opens the CATALOG page. You can save/recall instrument configuration states in either of two ways:

- Save into the internal memory

- Save into USB memory

You can save up to 10 registers into the internal memory and into a single USB memory device. Also, register numbers have extensions as shown in Table 4-9:

Table 4-9   Extensions for register numbers

Classification	Register number (No. field)	Extension
Internal memory	0	Recalled when the [Recall A] key is pressed.
	1	Recalled when the [Recall B] key is pressed.
	2 through 8	-
	9	Auto recall
USB memory	10 through 19	-

In this page, you can configure each of the following controls with the cursor placed in the corresponding field (denoted in parentheses).

- Medium mode (MEDIA field)

- Register number (No. field)

Figure 4-4   CATALOG page
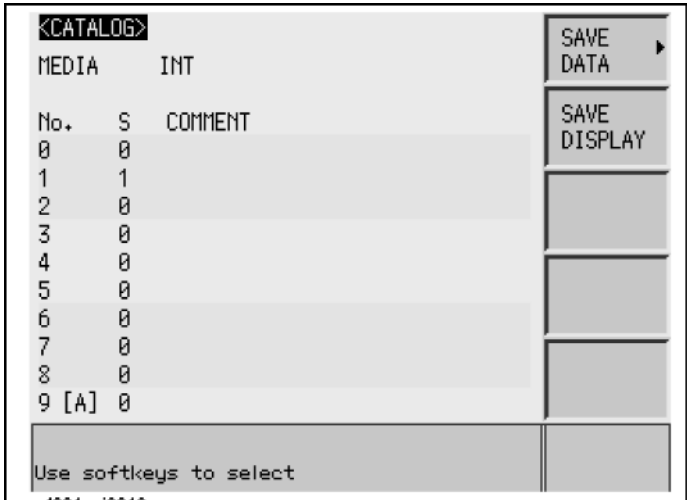
Medium mode

Functional description

You have to specify the medium type of the destination or source before saving or recalling instrument configurations.

To select the medium mode:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **MEDIA** field.

Step 3.   Select the medium mode by pressing the appropriate softkey:

Softkey	Description
INT	Uses the internal memory as the destination or source. Once you have selected this mode, the register numbers (in the No. field) change to 0 through 9.
EXT	Uses USB memory as the destination or source. Once you have selected this mode, the register numbers (in the No. field) change to 10 through 19.

Choosing a register number

Functional description

You have to choose one of the register numbers (in the No. field) before saving or recalling instrument configurations.

Available choices include 0 through 9 when the medium mode is INT (internal memory), or 10 through 19 when the medium mode is EXT (USB memory).

To choose a register number and save/recall the configurations:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **No.** field of your desired register number.

Step 3.   Select your desired action by pressing the appropriate softkey:

Softkey	Description
RECALL	Recalls the configurations previously saved in the register that corresponds to your specified register number.
SAVE	Saves the configurations into the register that corresponds to your specified register number.
DELETE	Deletes the configurations previously saved in the register that corresponds to your specified register number.

Memory status information

Functional description

Each register number is associated with one of the following memory status values:

Status value	Description
−1	The register contains non-E4981B configuration information. [1]
0	The register contains no configurations.
1	The register does contain configurations.
2	The register contains any configuration that was saved under a different firmware version or from another E4981B with a different option(s) equipped. [2]

1. This value is not applicable when the medium mode is INT (internal memory).
2. An "Incompatible state file" warning message is displayed. Status information may fail to be correctly recalled.

NOTE   The ninth instrument setting corresponds to Auto Recall. Auto recall is not executed when power is ON, by pressing the **[Preset]** key.

Comment information

Functional description

You can view comments entered into the comment line (USER COMMENT field) on the Measurement Conditions screen. For information on how to enter a comment, see "Inputting Comment Line" on page 53.

Saving/Recalling instrument configuration states into/from the internal memory

Figure 4-5 shows the fields available on this page along with the softkeys corresponding to them.

Figure 4-5   CATALOG page (when saving instrument configurations into the internal memory)

To save configuration states into the internal memory:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **MEDIA** field.

Step 3.   Press the **INT** softkey.

Step 4.   Use the cursor keys to select the **No.** field (0 through 9) for your desired register.

Step 5.   Press the **SAVE** softkey to save configuration states into the internal memory.

> **NOTE**   If you have selected the No. field for a register that already contains configuration states, new configuration states overwrite the existing ones.

To recall configuration states from the internal memory:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **MEDIA** field.

Step 3.   Press the **INT** softkey.

Step 4.   Use the cursor keys to select the **No.** field (0 through 9) for your desired register.

Step 5.   Press the **RECALL** softkey to recall configurations from the internal memory.

Using a hard key to recall states from the internal memory

You can also recall configuration states from a particular register in the internal memory by pressing one of the following hard keys:

Hard key	Description
Recall A	Recalls configuration states from register 0 (#0 in the No. field).
Recall B	Recalls configuration states from register 1 (#1 in the No. field).

Saving/Recalling instrument configuration states into/from USB memory

Figure 4-6 shows the fields available on this page along with the softkeys corresponding to them.

Figure 4-6   CATALOG page (when saving instrument configurations into USB memory)
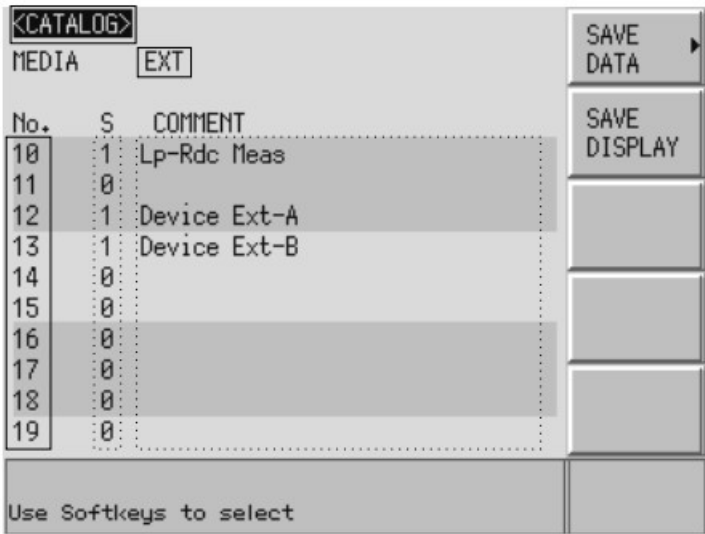
Functional description

When you save configuration states into USB memory, they are saved as predefined files in predefined locations. You cannot manually define the file names or locations.

Each state file is assigned a file name in the format of "register number.sta".

To save configuration states into USB memory:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **MEDIA** field.

Step 3.   Press the **EXT** softkey.

Step 4.   Use the cursor keys to select the **No.** field (10 through 19) for your desired register.

Step 5.   Press the **SAVE** softkey to save configuration states into the USB memory.

NOTE	If you have selected the No. field for a register that already contains configuration states, the new configuration states overwrite the existing ones.

To recall configuration states from USB memory:

Step 1.   Press **[Save/Recall]**.

Step 2.   Use the cursor keys to select the **MEDIA** field.

Step 3.   Press the **EXT** softkey.

Step 4.   Use the cursor keys to select the **No.** field (10 through 19) for your desired register.

Step 5.   Press the **RECALL** softkey to recall configurations from the USB memory.

NOTE	State files are automatically assigned file names 10.sta through 19.sta, and you cannot change the file names.

If you attempt to recall configuration states under any of the following conditions, an "Incompatible state file" warning message is displayed.

·   The configuration states were saved under a different firmware version.

·   The configuration states were saved from another E4981B with a different option(s) equipped.

Using the auto recall feature

Functional description

You can have the E4981B, at start-up, automatically recall the configuration states previously saved in register number 9 on Internal memory.

To use the auto recall feature:

Step 1. Press **[Save/Recall]**.

Step 2. Use the cursor keys to select the **No. 9 [A]** field.

Step 3. Press the **RECALL** softkey, to configure the instrument using the instrument configuration information previously saved in register 9 on the Internal memory.

Transferring auto recall setting to another E4981B

Using external USB memory

Step 1. Perform auto recall.

Step 2. Connect external USB memory.

Step 3. Press **[Save/Recall]**.

Step 4. Use the cursor keys to select **MEDIA** to **EXT**.

Step 5. Use the cursor keys to select memory location from 10 to 19.

Step 6. Press the **SAVE** softkey to save the data in the USB memory.

Step 7. Connect the USB memory to another E4981B, recall the saved state.

Step 8. After recalling the state, save it to internal memory **No. 9[A]**.

Using *LRN? command

Step 1. Perform auto recall.

Step 2. Retrieve the instrument configuration using *LRN? command via GPIB/LAN/USB.

Step 3. Send the instrument configurations (retrieved in Step 2) to another E4981B.

Step 4. Save the data to internal memory **No. 9[A]**.

Saving measurement results into USB memory

You can save measurement results obtained by the E4981B into USB memory as .CSV files. You can later load your saved files into an application program running on a PC.

NOTE	Data buffer 3 is used to perform save data operation through front panel and web server. Also, it is not possible to load data through web server.

Before saving measurement results into USB memory, you need to complete some tasks preparatory to initiating measurement so that the data buffer memory contains the necessary data. For more information, see "To save measurement results into USB memory:" on page 88.

NOTE	You cannot load measurement results from USB memory into the E4981B.

Measurement result format

Measurement results are output in the format shown in Table 4-10.

The Data A and Data B fields of a measurement result file differ depending on whether the "effective digits" setting is on or off (controlled by the :FORMat:ASCii:LONG command).

Table 4-10   Measurement result format

Measurement Screen	Comparator	Result Format
one point	OFF	‹Data A›,‹Data B›,‹Status›
one point	ON	‹Data A›,‹Data B›,‹Status›,‹BIN No.›

Data A

Outputs the measurement data for the primary parameter.

The Data A field uses the following two different fixed-length ASCII formats:

When the "effective digits" setting is off: (:FORMat:ASCii:LONG OFF)	SN.NNNNNESNN (S:+/-, N:0 to 5, E: exponent character)
When the "effective digits" setting is on: (:FORMat:ASCii:LONG ON)	SN.NNNNNNNNNESNN (S:+/-, N:0 to 9, E: exponent character)

Data B

Outputs the measurement data for the secondary parameter.

The Data B field uses the following two different fixed-length ASCII formats:

When the "effective digits" setting is off: (:FORMat:ASCii:LONG OFF)	SN.NNNNNESNN (S:+/-, N:0 to 5, E: exponent character)
When the "effective digits" setting is on: (:FORMat:ASCii:LONG ON)	SN.NNNNNNNNNESNN (S:+/-, N:0 to 9, E: exponent character)

Status

Represents the measurement result status by using one of the following status values:

0	Measurement successfully completed.
+1	Overload.
+2	Low C or No contact.

The Status field uses the following two-character fixed-length ASCII format:

SN   (S:+/-, N:0 to 2)

NOTE   If the value is 1, the measurement data is 9.9E37; if the value is 0 or 2, the actual measurement data is output.

NOTE   The data buffer memory contains a measurement result with no data (as represented by the status value of –1), but it is excluded when the data is saved into USB memory.

Bin no. (IN/OUT)

Represents the bin sorting results as well as IN/OUT evaluation results, as shown below:

0	OUT_OF_BINS
+1 to +9	BIN 1 through BIN 9
+10	AUX_BIN
+11	BIN_NA

The <BIN No.> data output format is either 2- or 3-character fixed-length ASCII format:

SN or SNN   (S:+/-, N:0 to 9)

Example 4-1   Example of saved measurement result data

+1.059517689E-24,+1.954963777E+00,+0,+0

+9.706803904E-25,+2.095857894E-01,+0,+0

+2.172725184E-24,+2.072965495E-01,+0,+0

+3.660460872E-25,+7.172688291E+00,+0,+0

+1.135428381E-24,+6.490636201E-01,+0,+0

+1.384790632E-24,+2.193020669E+00,+0,+0

+3.829879310E-26,+2.788435221E+01,+0,+0

To save measurement results into USB memory:

Step 1.   Plug a USB memory stick into the front USB port.

Step 2.   Press [**Save/Recall**].

Step 3.   Press the **SAVE DATA** softkey.

Step 4.   Press the **START LOG** softkey and then press the following softkeys to enter the measurement results into the data buffer memory.

Softkey	Description
START LOG	Starts logging the measurement results into the data buffer memory.
SAVE & STOP	Copies the data from the data buffer memory into the USB memory. Then stops saving the measurement results into the data buffer memory and clears the data buffer memory.

NOTE	The above mentioned steps stores the data in buffer 3, enabling to save the data to USB memory.

Step 5.   Start measurement. The data buffer memory is filled with up to 1000 sets of measurement results.

Step 6.   Press the **SAVE & STOP** softkey to save results into the USB memory.

Step 7.   When the data has been saved into the USB memory, a "Storing data completed. : E498xXXX.csv" message appears in the system message area.

Figure 4-7   Saving measurement results into USB memory
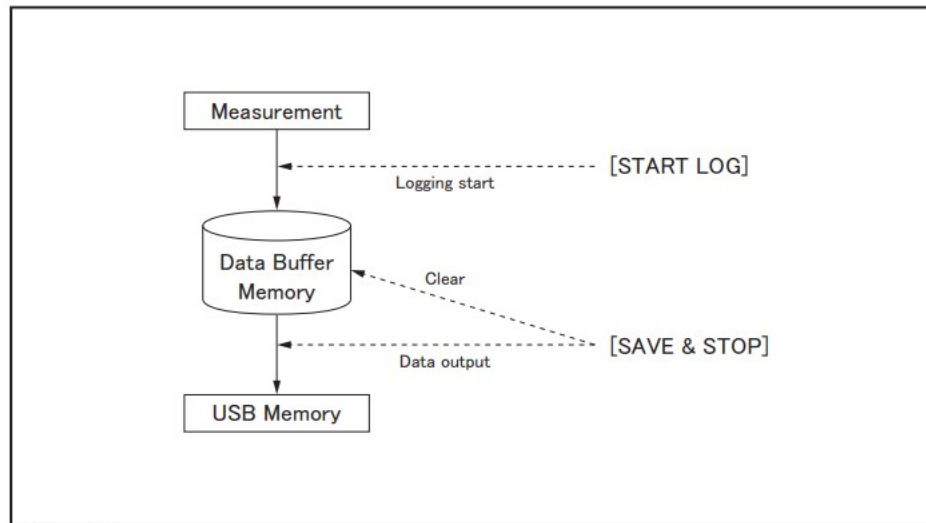
NOTE	Measurement result files are automatically assigned file names E498x001.csv through E498x999.csv, and you cannot change the file names.

Saving a screenshot into USB memory

You can save a screenshot of the E4981B's display into USB memory as a .GIF file. You can later load your saved file into an application program running on a PC.

To save a screenshot into USB memory

Step 1.   Display the screen you want to save.

Step 2.   Plug a USB memory device into the front USB port.

Step 3.   Press **[Save/Recall]**.

Step 4.   Press the **SAVE DISPLAY** softkey.

Step 5.   When the data has been saved into the USB memory device, a "Storing image completed. : E498xXXX.gif" message appears in the system message area.

NOTE	Screenshot files are automatically assigned file names E498x001.gif through E498x999.gif, and you cannot change the file names.

Keysight E4981B 120 Hz/1 kHz/1 MHz Capacitance Meter

5   Preparation for Accurate Measurement (Executing Correction)

This chapter gives an overview and the operational procedures of the different types of correction function available in the E4981B.

Overview of Correction Function

The E4981B provides several types of corrections such as OPEN, SHORT, LOAD, OFFSET, and Cable correction. This section explains various types of corrections available in the E4981B.

OPEN/SHORT/LOAD/OFFSET correction

The E4981B provides four types of correction functions: OPEN correction, SHORT correction, LOAD correction, and OFFSET correction. The following table gives a brief description of each correction function:

Type of correction	Description
OPEN correction	Corrects errors caused by parallel stray admittance of the test fixture. This correction is based on the results of admittance measurement in the OPEN state which is performed in advance.
	OPEN correction can be performed at any frequency (120 Hz/ 1 kHz/1 MHz) and the correction data remains valid for all measurement frequencies.
SHORT correction	Corrects errors caused by series residual impedance of the test fixture. This correction is based on the results of impedance measurement in the SHORT state which is performed in advance.
	SHORT correction can be performed at any frequency (120 Hz/ 1 kHz/1 MHz) and the correction data remains valid for all measurement frequencies.
LOAD correction	Corrects complex errors related to amplitude/phase errors, the scanner, and other factors caused by the cable and test fixture. This correction is based on the results of impedance measurement of the standard having a known value which is performed in advance.
	LOAD correction is frequency dependent and the correction data remains valid only for the measurement frequency at which the LOAD correction is applied. If the frequency is changed, the LOAD correction needs to be performed again.

Type of correction	Description
OFFSET correction	Corrects errors between the actual measured value and the ideal value that the user desires. This is done by subtracting any value that the user enters from the measured result (for example, difference between a known standard value and its measured value, or instrument-by-instrument differences in the measured values of the same DUT).

NOTE   In Option 002, there is no correction for 1 MHz frequency.

As shown in the data processing flow of Figure 5-1, the OPEN/SHORT/LOAD correction is first performed for the measured impedance result (complex number), and the result is converted to the primary/secondary parameters. Then, for the primary/secondary parameter values (real number), the OFFSET correction is performed.

Figure 5-1   Data processing flow

c4981auu0038
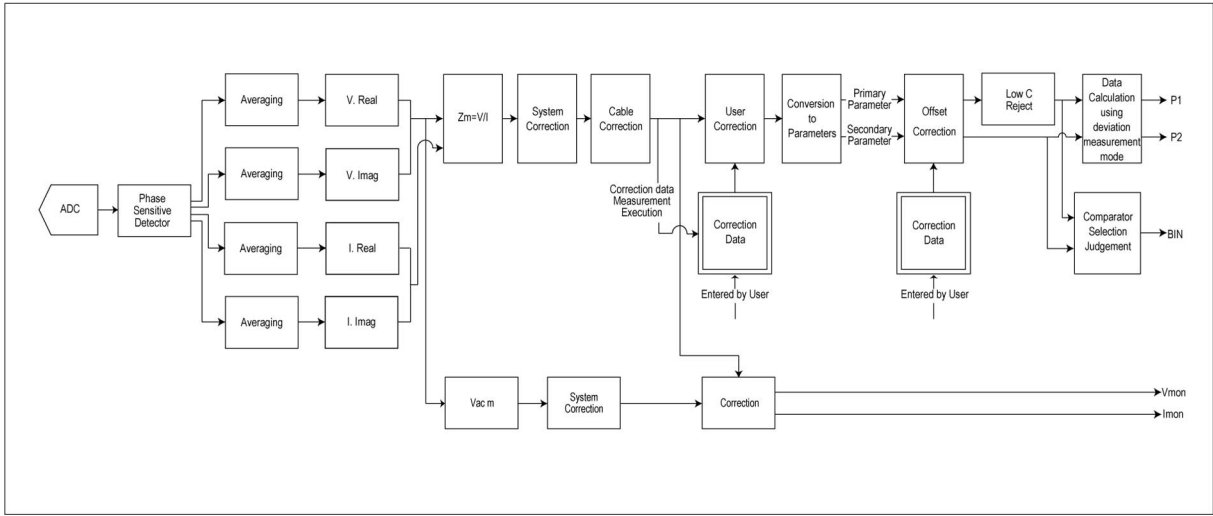
NOTE   The measurement value displayed for correction or LOAD REF uses the internal data for calculation. The value is set depending upon the state of MULTI CORRECTION, LOAD REF, or CHANNEL.

Cable correction

Cable correction avoids measurement error due to the differences of each cable when you use a cable length of 1 m or 2 m in 1 MHz.

> **NOTE** In Option 002, 1 MHz frequency is not available.

Measurement error due to an individual cable is proportional to the square of the test frequency. Accordingly, the difference of each test cables may not be ignored at high frequencies, such as 1 MHz. When the E4981B is shipped from the factory, it contains typical correction data for both 1 m and 2 m cables. Cable correction can compensate the error for your own cable.

The following equipment are required for cable correction:

Open Termination   42090A Open termination (do not use BNC adapter as an alternative)

Load Standard   6383A 100 pF (capacitor) or 42037A 1 kΩ (resistor)

> **NOTE** Cable correction is not required in the following conditions:
>
> · For 120 Hz and 1 kHz measurement frequency.
>
> · When Open, Short, and Load correction is executed at 1 MHz measurement frequency.

Turning ON/OFF Correction Functions

You can turn ON/OFF each correction function separately.

Turning on OPEN correction

Use one of the following two ways to set the OPEN correction to ON.

Measuring data for OPEN correction

Execute measurement of the data for the OPEN correction. When the measurement finishes successfully, the OPEN correction is automatically set to ON. For information on the measurement procedure for the data used in the OPEN correction, refer to "Measuring data for OPEN correction" on page 44.

Setting up ON/OFF directly

Use the following procedure to set the OPEN correction to ON/OFF.

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **OPEN** field.

Step 4.   Press the **ON** softkey to turn ON the OPEN correction function.

NOTE	If you change the setup of the cable length or frequency shift (1 MHz) with the OPEN correction ON, the warning message "Need corr meas" appears and the OPEN correction is automatically set to OFF. Along with OPEN correction, SHORT and LOAD correction is set to OFF as well.

NOTE	If you set the OPEN correction to ON by using the above procedure when the setup of the cable length or frequency shift differs from that during measurement of the data for OPEN correction, the warning message "Need open meas" appears. Even if this warning message appears, the OPEN correction is set to ON. However, you must again measure the data for OPEN correction to ensure accurate measurement.

NOTE	When the measurement result becomes overload, "Measurement failed" error is displayed and OPEN correction data is not updated.

Turning on SHORT correction

Use one of the following two ways to set the SHORT correction to ON.

Measuring data for SHORT correction

Execute measurement of the data for the SHORT correction. When the measurement finishes successfully, the SHORT correction is automatically set to ON. For information about the measurement procedure for the data used in the SHORT correction, refer to "Measuring data for SHORT correction" on page 47.

Setting up ON/OFF directly

Use the following procedure to set the SHORT correction to ON/OFF.

Step 1. Press **[Meas Setup]**.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **SHORT** field.

Step 4. Press the **ON** softkey to turn ON the SHORT correction function.

NOTE	If you change the setup of the cable length or frequency shift (1 MHz) with the SHORT correction ON, the warning message "Need corr meas" appears and the SHORT correction is automatically set to OFF. Along with SHORT correction, OPEN and LOAD correction is set to OFF as well.

NOTE	If you set the SHORT correction to ON using the above procedure when the setup of the cable length or frequency shift differs from that during measurement of the data for SHORT correction, the warning message "Need short meas" appears. Even if this warning message appears, the SHORT correction is set to ON. However, you must again measure the data for SHORT correction to ensure accurate measurement.

NOTE	When the measurement result becomes overload, "Measurement failed" error is displayed and SHORT correction data is not updated.

Turning on LOAD correction

Use one of the following two ways to set the LOAD correction to ON.

Measuring LOAD correction data

Execute measurement of the data for the LOAD correction. When the measurement finishes successfully, the LOAD correction is automatically set to ON. For information about the measurement procedure for the data used in the LOAD correction, refer to "Obtaining (measuring) data for LOAD correction" on page 102.

Setting up ON/OFF directly

Use the following procedure to set the LOAD correction to ON/OFF.

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **LOAD** field.

Step 4.   Press the **ON** softkey to turn ON the LOAD correction function.

NOTE	If you change the setup of the cable length or frequency shift (1 MHz) with the LOAD correction ON, the warning message "Need corr meas" appears and the LOAD correction is automatically set to OFF. Along with LOAD correction, OPEN and SHORT correction is set to OFF as well.

NOTE	If you set up the LOAD correction to ON using the above procedure when the setup of the cable length or frequency shift differs from that during measurement of the data for LOAD correction, the warning message "Need load meas" appears. Even if this warning message appears, the LOAD correction is set to ON. However, you must again measure the data for the LOAD correction to ensure accurate measurement.

NOTE	When the measurement result becomes overload, "Measurement failed" error is displayed and LOAD correction data is not updated.

Turning on OFFSET correction

Use the following procedure to set the OFFSET correction to ON/OFF.

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **OFFSET** field.

Step 4.   Press the **ON** softkey to turn ON the OFFSET correction function.

NOTE	If you change the setup of the measurement parameter with the OFFSET correction ON, the OFFSET correction is automatically set to OFF.

NOTE	You cannot separately set the ON and OFF states as the primary parameter and secondary parameter. However, if you set the correction value to 0, the state is effectively the same as OFF even if the OFFSET correction is ON. Therefore, you can set up separate ON/OFF states by setting the correction value of either parameter to 0.

Obtaining Correction Data

Obtaining (measuring) data for OPEN correction

Data structure

The 120 Hz, 1 kHz, and 1 MHz data used in the OPEN correction is divided into the data for normal operation and the data of each channel (256 channels) for multi-correction, as shown in Figure 5-2.

Figure 5-2   Structure of data for OPEN correction
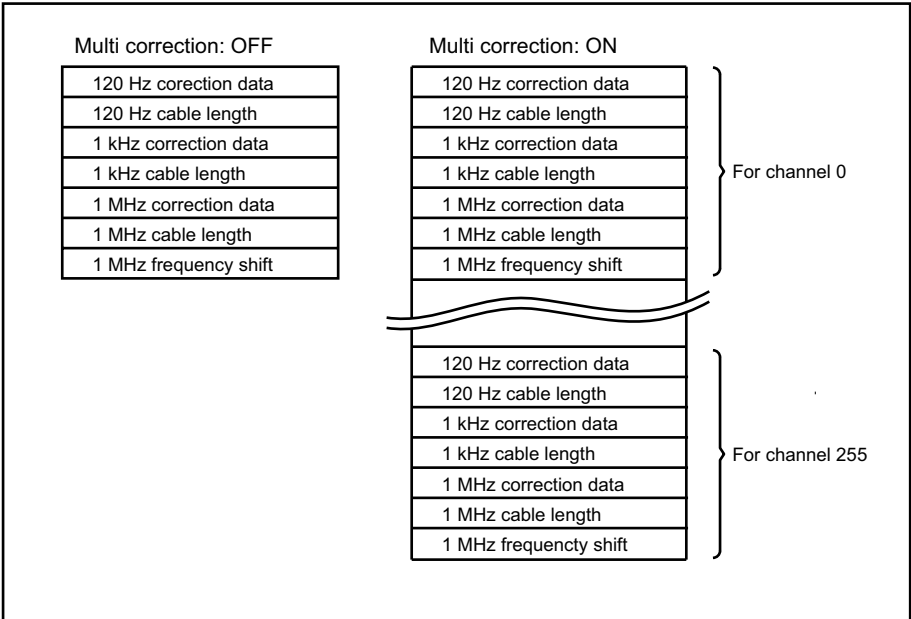
Measured data

For Open correction, 120 Hz, 1 kHz, and 1 MHz are measured and each data frequency is saved. Therefore, even if the measurement frequency is changed there is no need to reset the correction. The result is set up as the data for normal operation when the multi-correction function is OFF and as the data for multi-correction when the function is ON (for the channel that has been selected at execution).

The table below summarizes how data is set up, depending on the setup at execution.

Multi-correction	Setup of measurement signal frequency	Data
OFF	120 Hz	120 Hz correction data and 120 Hz cable length for normal operation
	1 kHz	1 kHz correction data and 1 kHz cable length for normal operation
	1 MHz	1 MHz correction data, 1 MHz cable length, and 1 MHz frequency shift for normal operation
ON	120 Hz	120 Hz correction data and 120 Hz cable length for the channel selected at the time of multi-correction measurement
	1 kHz	1 kHz correction data and 1 kHz cable length for the channel selected at the time of multi-correction measurement
	1 MHz	1 MHz correction data, 1 MHz cable length and 1 MHz frequency shift for the channel selected at the time of multi-correction measurement

Measurement conditions during data measurement

The data for the OPEN correction is measured under the following conditions:

· Measurement range mode: auto range mode

· Measurement time mode: 8

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

Measurement procedure

For more information on the measurement procedure for the data used in the OPEN correction, refer to "Measuring data for OPEN correction" on page 44.

Obtaining (measuring) data for SHORT correction

Data structure

The 120 Hz, 1 kHz, and 1 MHz data used in the SHORT correction is divided into the data for normal operation and the data of each channel (256 channels) for multi-correction, as shown in Figure 5-3.

Figure 5-3   Structure of data for SHORT correction

Multi correction: OFF	Multi correction: ON	
120 Hz corection data	120 Hz correction data	
120 Hz cable length	120 Hz cable length	
1 kHz correction data	1 kHz correction data	
1 kHz cable length	1 kHz cable length	For channel 0
1 MHz correction data	1 MHz correction data	
1 MHz cable length	1 MHz cable length	
1 MHz frequency shift	1 MHz frequency shift	
	120 Hz correction data	
	120 Hz cable length	
	1 kHz correction data	
	1 kHz cable length	For channel 255
	1 MHz correction data	
	1 MHz cable length	
	1 MHz frequencty shift	

Measured data

For SHORT correction, 120 Hz, 1 kHz, and 1 MHz are measured and each data frequency is saved. Therefore, even if the measurement frequency is changed there is no need to reset the correction. The result is set up as the data for normal operation when the multi-correction function is OFF and as the data for multi-correction when the function is ON (for the channel that has been selected at execution).

The table below summarizes how data is set up, depending on the setup at execution.

Multi correction	Setup of measurement signal frequency	Data
OFF	120 Hz	120 Hz correction data and 120 Hz cable length for normal operation
	1 kHz	1 kHz correction data and 1 kHz cable length for normal operation
	1 MHz	1 MHz correction data, 1 MHz cable length, and 1 MHz frequency shift for normal operation
ON	120 Hz	120 Hz correction data and 120 Hz cable length for the channel selected at the time of multi-correction measurement
	1 kHz	1 kHz correction data and 1 kHz cable length for the channel selected at the time of multi-correction measurement
	1 MHz	1 MHz correction data, 1 MHz cable length and 1 MHz frequency shift for the channel selected at the time of multi-correction measurement

Measurement conditions during data measurement

The data for the SHORT correction is measured under the following measurement conditions:

- Measurement range mode: auto range mode
- Measurement time mode: 8
- Output impedance of measurement signal source: 20 Ω

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

Measurement procedure

For more information about the measurement procedure for the data used in the SHORT correction, refer to "Measuring data for SHORT correction" on page 47.
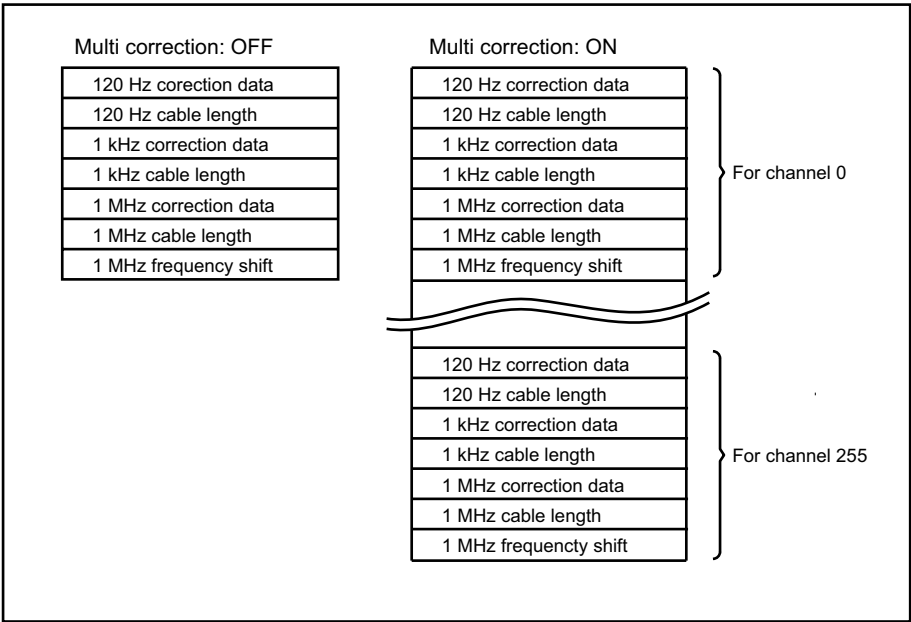
Obtaining (measuring) data for LOAD correction

Preparing the standard for LOAD correction

To measure the data for the LOAD correction, you must first prepare a device as the standard used for this measurement. You can use any device that has a stable known value as the standard. Also, the type of standard and the type of DUT can be different. For example, even if you measure a capacitor, you can use a resistor as the standard.

When using an existing standard:

Any device that has an accurate value (guaranteed as the specification) can be used as the standard.

When using a general purpose capacitance component as the standard:

If you cannot prepare an existing standard, value a general purpose device (capacitor, resistor, and so on) by using a Capacitance meter and use it as the standard. Notes on selecting a device to use as the standard are given below.

- When you measure DUTs with a fixed impedance value, use a device with an impedance close to the fixed value. On the other hand, when you measure DUTs of several different values, use a device whose impedance can be valued accurately within a range of approximately 100 to 1 kΩ.

- Use a stable device that is not sensitive to factors of the measuring environment such as temperature and magnetic field.

You must value the standard as accurately as possible. The valuing procedure is described below.

Step 1. Connect the direct coupled test fixture to a Capacitance meter and execute OPEN/SHORT correction.

Step 2. Set the measurement frequency of the Capacitance meter to the frequency (120 Hz/1 kHz/1 MHz) actually used when measuring the data for the LOAD correction.

Step 3. Set up the Capacitance meter under measurement conditions that allow high-accuracy valuing (measurement) (for example, setting up the measurement time to 8 or increasing the averaging count).

Step 4. Connect a device you use as the standard to the direct coupled test fixture and perform the measurement. Use the obtained measured value as the standard for the LOAD correction.

Defining standard for LOAD correction (setting up LOAD reference value)

Before measuring the data for the LOAD correction, you must define the value of the standard used in LOAD correction. You can define the standard for the LOAD correction by using one the following parameter combinations.

Table 5-1   Definition parameters of the standard for LOAD correction

Primary parameter	Secondary parameter
Cp	D, Q, G, Rp
Cs	D, Q, Rs

Defining parameters when using a resistance standard

When using a resistance standard (a standard that has been valued in the *R-X* format) as the standard for LOAD correction, you must convert it to the *Cs-Rs* format because the E4981B does not allow you to enter a value directly in the *R-X* format as the definition value. The conversion expression is given below.

Equation 5-1   Conversion expression for a standard valued in the R-X format

$$Rs = R$$

$$Cs = -\frac{1}{2\pi fX}$$

where *f* denotes the measurement frequency.

Definition procedure

The procedure to define the standard value for the LOAD correction is described below.

Step 1.   Press the **[Meas Setup]** key.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **LOAD Cp-D** field.

Step 4.   Press the appropriate softkey (**Cp-...**/**Cs-...**) to select the primary parameter.

Step 5.   Press the appropriate softkey to select the secondary parameter.

Step 6.   Use the cursor keys to select the **REF A/B** field.

Step 7.   Use the entry keys to enter the reference value for load.

Measuring data for LOAD correction

Data structure

The 120 Hz, 1 kHz, and 1 MHz data used in the LOAD correction is divided into the data for normal operation and the data of each channel (256 channels) for multi-correction, as shown in Figure 5-4. Each set of data consists of the correction data, cable length, standard definition value, and frequency shift (only for 1 MHz).

Figure 5-4   Structure of data for LOAD correction

Multi correction: OFF

| 120 Hz correction data |
| 120 Hz cable length |
| 120 Hz standard definition value |
| 1 kHz correction data |
| 1 kHz cable length |
| 1 kHz standard definition value |
| 1 MHz correction data |
| 1 MHz cable length |
| 1 MHz standard definition value |
| 1 MHz frequency shift |

Multi correction: ON

For channel 0
| 120 Hz correction data |
| 120 Hz cable length |
| 120 Hz standard definition value |
| 1 kHz correction data |
| 1 kHz cable length |
| 1 kHz standard definition value |
| 1 MHz correction data |
| 1 MHz cable length |
| 1 MHz standard definition value |
| 1 MHz frequency shift |

For channel 255
| 120 Hz correction data |
| 120 Hz cable length |
| 120 Hz standard definition value |
| 1 kHz correction data |
| 1 kHz cable length |
| 1 kHz standard definition value |
| 1 MHz correction data |
| 1 MHz cable length |
| 1 MHz standard definition value |
| 1 MHz frequency shift |

For all channels
| 120 Hz standard definition value |
| 1 kHz standard definiton value |
| 1 MHz standard defition value |

Measured data

The data for the LOAD correction can only be measured at the measurement frequency set by the user (120 Hz, 1 kHz or 1 MHz) at the time of execution. The result is set up as the data for normal operation when the multi-correction function is OFF and as the data for multi-correction when the function is ON (for the channel that has been selected at execution).

The table below summarizes how data is set up, depending on the setup at execution.

Multi correction	Setup of measurement signal frequency	Data
OFF	120 Hz	120 Hz correction data and 120 Hz cable length for normal operation
	1 kHz	1 kHz correction data and 1 kHz cable length for normal operation
	1 MHz	1 MHz correction data, 1 MHz cable length, and 1 MHz frequency shift for normal operation
ON	120 Hz	120 Hz correction data and 120 Hz cable length for the channel selected at the time of multi-correction measurement
	1 kHz	1 kHz correction data and 1 kHz cable length for the channel selected at the time of multi-correction measurement
	1 MHz	1 MHz correction data, 1 MHz cable length and 1 MHz frequency shift for the channel selected at the time of multi-correction measurement

Measurement conditions during data measurement

The data for the LOAD correction is measured under the following measurement conditions.

· Measurement range mode: auto range mode or fixed range mode

· Measurement time mode: 8

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

NOTE	Auto Range during the measurement of Load Standard can be also be set to ON/OFF by **LOAD RNG** under the **CORRECTION** softkey.

Measurement procedure

Step 1. Connect the standard for the LOAD correction to the test fixture.

Step 2. Press **[Meas Setup]**.

Step 3. Press the **CORRECTION** softkey to display the correction page.

Step 4. Use the cursor keys to select the **LOAD** field.

Step 5. Press the **MEAS LOAD** softkey. The data for the LOAD correction is then measured.

- During the measurement, an "LOAD measurement in progress" message is shown on the display.

- When the measurement has finished, the "LOAD measurement in progress" message disappears.

- During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort load correction.

Step 6. When measurement of the data for LOAD correction is successfully completed, the LOAD correction turns to **ON**.

If the difference between the measured value and definition value of the standard for the LOAD correction exceeds 10% (not suitable for the data for LOAD correction), the warning message "Out of limit" appears.

NOTE Even if this warning message appears, data for the LOAD correction is still used. However, it is recommended to confirm that the connection between the test fixture and the UNKNOWN terminal as well as the measurement procedure are correct.

If a measurement failure occurs while measuring the data for correction, the error message "Correction Meas Aborted" appears.

NOTE If this error occurs, the data used for correction before the measurement remains without change.

Step 7. Use the cursor keys to select the **LOAD RNG** field.

Step 8. Use the following softkeys:

Softkey	Function
AUTO	Turns ON the auto-ranging function when load correction is executed.
FIX	Turns OFF the auto-ranging function.

NOTE When the load range is set at FIX, the selected measurement range is used at the LOAD measurement.

Description of softkeys

To enable/disable or otherwise control the behavior of load correction, use the following softkeys:

Softkey	Description
ON	Enables load correction.
OFF	Disables load correction.
MEAS LOAD	Starts load correction.

Selecting single/multiple correction mode

Functional description

E4981B can store up to 256 sets of OPEN/SHORT/LOAD correction data. In addition, it can store one set of the standard's reference value data at a specified frequency point. In multiple correction mode, you can switch among up to 256 data sets to carry out correction.

> **NOTE**   The correction features default to single correction mode.

In multiple correction mode, the channel number for which correction data is selected.

To set up single/multiple correction mode:

Step 1. Press **[Meas Setup]**.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **MULTI** field.

Step 4. Use the following softkeys:

Softkey	Description
ON	Turns ON the multiple correction mode.
OFF	Turns OFF the multiple correction mode.

> **NOTE**   For more information on measurement parameters, see "Setting up measurement parameters" on page 40.

Step 5. Use the cursor keys to select the **CH** field.

Step 6.   Use the numeric entry keys to enter the number of channels or use the
following softkeys

Softkey	Description
INCR++	Increments the channel number in steps of 10.
INCR+	Increments the channel number in steps of 1.
DECR-	Decrements the channel number in steps of 1.
DECR--	Decrements the channel number in steps of 10.

Step 7.   Use the cursor keys to select the **LOAD REF** field.

Step 8.   Use the following softkeys:

Softkey	Description
SINGLE	Defines a single LOAD correction standard value commonly applied to all channels.
MULTI	Defines a LOAD correction standard value for each channel.

Setting up data for OFFSET correction

You can define a certain value and set it up as the data for OFFSET correction.

When the OFFSET correction is ON, taking the measured value before correction as $Meas$ and the data for the OFFSET correction as $Offset$, the measured value is corrected as $Meas - Offset$. Therefore, to correct the measurement result to your desired value, set up the difference between the desired value and the measurement result as the data for the OFFSET correction. For example, to correct the current measured value of the primary parameter of 1.012 nF to the measured value of 1.000 nF, set up the data for the OFFSET correction for the primary parameter to 12 pF.

The data for the OFFSET correction consists of 120 Hz, 1 kHz, and 1 MHz data for both the primary and secondary parameters, as shown in Table 5-2.

Table 5-2   Structure of data for OFFSET correction

For primary parameter	For secondary parameter
120 Hz correction data	120 Hz correction data
1 kHz correction data	1 kHz correction data
1 MHz correction data	1 MHz correction data

Setup procedure

Step 1. Press **[Meas Setup]**.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **OFFSET** field.

Step 4. Use the following softkeys:

Softkey	Description
ON	Turns ON the OFFSET correction function
OFF	Turns OFF the OFFSET correction function

Step 5. Use the cursor keys to select the **OFFSET A/B** field

Step 6. Use the numeric entry keys to enter the correction value for primary and secondary parameter.

The entered values are set up as the data for the OFFSET correction for the measurement frequency at the time of data entry.

Checking Displaying/Setting Up Correction Data

Checking displaying/setting up data for OPEN correction

Displaying data/Selecting parameter format for OPEN correction

For information on the procedure to display the data for OPEN correction, refer to "Checking data for OPEN correction" on page 46.

Setting up data for OPEN correction

You can setup the data for OPEN correction by the following procedure.

Step 1.   Press the **[Meas Setup]** key.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **OPEN G-B** field.

Step 4.   Select the **G-B** or **Cp-G** which you required.

Step 5.   Use the right cursor keys to select the **A** field.

Step 6.   Input your desired value for the primary parameter for OPEN.

Step 7.   Use the right cursor keys to select the **B** field.

Step 8.   Input your desired value for the secondary parameter for OPEN.

Checking displaying/setting up data for SHORT correction

Displaying data/Selecting parameter format for SHORT correction (6 digits)

For information on the procedure to display the data for SHORT correction, refer to "Checking data for SHORT correction" on page 49.

Setting up data for SHORT correction

You can setup the data for SHORT correction by the following procedure.

Step 1.   Press the **[Meas Setup]** key.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **SHORT R-X** field.

Step 4.   Select **R-X** or **Ls-Rs** which you required.

Step 5.   Use the right cursor keys to select the **A** field.

Step 6.   Input your desired value for the primary parameter for SHORT.

Step 7.   Use the right cursor keys to select the **B** field.

Step 8.   Input your desired value for the secondary parameter for SHORT.

Checking displaying/setting up data for LOAD correction

Displaying data/Selecting parameter format for LOAD correction

The parameter format of LOAD correction data depends on the parameter format of the standard value for the LOAD correction and cannot be selected independently.

Refer to "Defining standard for LOAD correction (setting up LOAD reference value)" on page 103.

Setting up data for LOAD correction

You can setup the data for LOAD correction by the following procedure.

Step 1. Press the **[Meas Setup]** key.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **LOAD Cp-D** field.

Step 4. Select **Cp- ...** or **Cs- ...** which you required.

Step 5. Use the right cursor keys to select the **A** field.

Step 6. Input your desired value for the primary parameter for LOAD.

Step 7. Use the right cursor keys to select the **B** field.

Step 8. Input your desired value for the secondary parameter for LOAD.

Avoiding Mistakes Related to Work in Obtaining Correction Data

To avoid simple work-related mistakes in measuring the data for OPEN/SHORT/LOAD correction (for example, setting up the OPEN state and SHORT state inversely), it is important to confirm that the measured data is correct.

Using warning messages

If the measured data is out of the valid range shown in Table 5-3 when measuring the data for OPEN/SHORT/LOAD correction, the warning message "Out of limit" appears, which allows you to detect an error of the measured data.

NOTE	The valid ranges are fixed and cannot be changed. Even after the warning message is displayed, the correction data is used as is.

Table 5-3   Valid ranges of correction data

Type of correction	Valid range
OPEN correction	$|Y| < 20\ \mu S$
SHORT correction	$|Z| < 20\ \Omega$
LOAD correction	$|Z_{ref}| \times 0.9 < |Z| \mid |Z_{ref}| \times 1.1$

In Table 5-3, Y is the measured admittance value, Z is the measured impedance value, and Zref is the definition value of the standard for the LOAD correction.

Obtaining Cable Correction Data

The procedure to obtain cable correction is described below.

Step 1.   Press **[System]**.

Step 2.   Press the **CABLE CORR** softkey.

> **NOTE**   In Option 002, the **CABLE CORR** softkey is not available on the SYSTEM INFO page.

Step 3.   Use the cursor keys to select from cable length of **1m** or **2m**.

Step 4.   Connect a 100 pF capacitor (16383A) or 1 kΩ resistor (42037A) to the UNKNOWN terminals.

Step 5.   Press the **MEAS REF** softkey. The data for the reference correction is then measured.

- During the measurement, the "REF measurement in progress" message is shown on the display.

- When the measurement has finished, the "REF measurement in progress" message disappears.

- During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort reference correction.

Step 6.   Remove the standard capacitor/resistor from UNKNOWN terminals. Connect the cable length of 1 m or 2 m.

Step 7.   Connect the OPEN termination 42090A at the end of cable.

Step 8.   Press the **MEAS OPEN** softkey. The data for the OPEN correction is then measured.

- During the measurement, an "OPEN measurement in progress" message is shown on the display.

- When the measurement has finished, the "OPEN measurement in progress" message disappears.

- During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort open correction.

Step 9.   Remove the OPEN termination and connect LOAD standard 16383A (100 pF) or 42037A (1 kΩ) to the end terminal of the cable.

Step 10.   Press the **MEAS LOAD** softkey. The data for the LOAD correction is then measured.

- During the measurement, the "LOAD measurement in progress" message is shown on the display.

·   When the measurement has finished, the "LOAD measurement in progress" message disappears.

·   During the measurement, the **ABORT** softkey is shown. Use this key when you want to abort load correction.

Step 11.   Press the **SAVE** softkey, when the measurement of reference, open and load is successfully completed to turn ON the correction function.

NOTE	When measurement is executed, the correction function including OFFSET correction turns OFF automatically.

NOTE	If cable correction is ON, when the measurement is being executed it turns OFF automatically.

Description of softkeys

To enable/disable the cable correction function use the following softkeys:

Softkey	Function
MEAS REF	Measures the cable correction reference value.
MEAS OPEN	Measures the cable correction open value.
MEAS LOAD	Measures the cable correction load value.
SAVE	Saves the cable correction data.
CLEAR	Clears the cable correction data.

NOTE	When overload occurs during the measurement and measurement is aborted an error occurs.

Measurement results are valid even if warning message is displayed in the following condition:

·   Reference/Load measurement: when auto range is not executed in 100 pF or 220 pF range.

·   Open measurement: when measurement value is not in |Y| ⎸ 20 μS range.

6   Executing Measurement

This chapter describes how to generate a trigger to start measurement. It also provides helpful information for measurement.

Starting (Triggering) Measurement

The method used to start (trigger) measurement varies depending on the setup of the trigger mode, as shown in Table 6-1 below:

Table 6-1   Trigger mode

Trigger mode	Method to generate a trigger
Internal trigger (INT)	The internal trigger is used to generate a trigger.
Manual trigger (MAN)	Pressing the [Trigger] key on the front panel generates a trigger.
External trigger (EXT)	Inputting an external trigger signal through the Ext Trig terminal, handler interface, or scanner interface generates a trigger.
BUS trigger (BUS)	The E4981B performs one cycle of measurement each time it receives a trigger command sent via GPIB/LAN/USB.

NOTE   E4981B ignores any trigger that is input during the measurement cycle. Be sure to trigger the instrument when it is not in a measurement cycle.

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Setting the trigger mode

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor keys to select the **TRIG** field.

Step 3.   Select the desired trigger mode by pressing the appropriate softkey

Softkey	Function
INT	Puts the instrument into internal trigger (INT) mode.
MAN	Puts the instrument into manual trigger (MAN) mode.
EXT	Puts the instrument into external trigger (EXT) mode.
BUS	Puts the instrument into bus trigger (GPIB/USB/LAN) mode.

Perform successive measurements automatically

Select the internal trigger mode according to the procedure in "Setting the trigger mode" on page 116. In this mode, measurements are automatically repeated, triggered by the internal trigger signal.

Specifying measurement timing

Generating a trigger manually

Step 1.   Select the manual trigger mode according to the procedure in "Setting the trigger mode" on page 116.

Step 2.   Press the **[Display Format]** key.

Step 3.   Press the **[Trigger]** key to make a single measurement.

Generating a trigger with an external signal

Step 1. Select external trigger mode according to the procedure in "Setting the trigger mode" on page 116.

Step 2. Press the **[Display Format]** key.

Step 3. Input a trigger signal (TTL pulse signal) from the Ext Trig terminal on the rear panel or input EXT_TRIG through the handler/scanner interface to perform a single measurement.

The trigger signal input from the Ext Trig terminal on the rear panel must meet the following requirements (input voltage and pulse width).

High level input voltage: 2 - 5 V

Low level input voltage: 0 - 0.5 V

Trigger pulse width: longer than 100 μsec
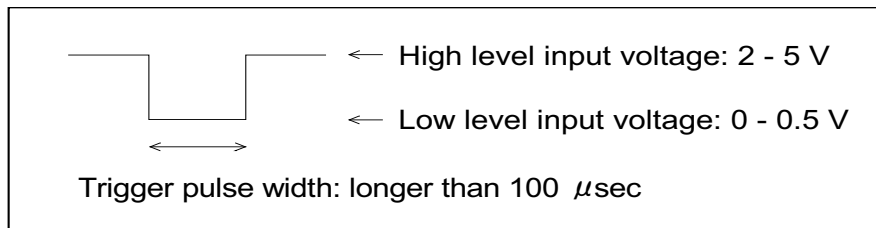
Step 4. To repeat measurement, repeat Step 3.

Selecting polarity for BNC external trigger

Step 1. Press the **[System]** key.

Step 2. Use the cursor keys to select the **EXT TRIG POL** field.

Step 3. Use the following softkeys:

Softkey	Description
POS	Specifies positive edge trigger
NEG	Specifies negative edge trigger

NOTE	Setting the trigger polarity for BNC external trigger on the rear panel does not affects the trigger signal on handler/scanner interface.

Notes on inputting a trigger signal

A trigger signal is not recognized until measurement with the previous input trigger is finished (the EOM signal turns to LOW).

· If a trigger is input twice (double trigger), only the first one is valid.

Tips for More Accurate Measurement

You can use the following techniques to increase measurement accuracy.

Setting measurement time to 8

Set the measurement time to 8, which provides better measurement accuracy.

For the setup procedure, refer to "Selecting Measurement Time" on page 58.

Selecting an appropriate measurement range

When making a measurement in the fixed range mode, select the measurement range so that measurement is performed within the recommended range (refer to Table 10-2 on page 10-169, Table 10-3 on page 10-170 and Table 10-4 on page 10-171).

For the setup procedure, refer to "Selecting Measurement Range" on page 56.

Using the correction functions

The OPEN correction eliminates the error due to the parallel stray admittance of the measurement cable and test fixture.

The SHORT correction eliminates the error due to the series residual impedance of the measurement cable and test fixture.

The LOAD correction eliminates the complex error due to the amplitude/phase error of the measurement cable and test fixture, scanner, and so on.

For details, refer to Chapter 5, "Preparation for Accurate Measurement (Executing Correction)" on page 91.

Making stable measurement

In a high-noise measurement environment, you can obtain more reliable measurement results by performing averaging.

For the setup procedure, refer to "Setting Up Averaging Count" on page 59.

Making measurements using a four-terminal pair

You can use four-terminal pair measurement to eliminate measurement errors.

For details, refer to "Principle of four-terminal pair measurement" on page 210.

Using frequency shift

When two or more E4981Bs are integrated into a single system, you can shift the 1 MHz measurement frequency (by +1%, −1%, 0%, −2%, or +2%) to avoid interference between the measurement signals. You can specify the amount of shift the signal frequency actually applies to the DUT relative to 1 MHz as a percentage of 1 MHz. If the specified value is out of allowable setup range, the maximum value or minimum value is set.

For setup procedure, refer to "Setting Up Frequency Shift" on page 61.

Tips for Increasing Measurement Speed (Throughput)

You can use the following methods to increase the measurement speed.

Setting measurement time to 1

Set the measurement time to 1, which provides a shorter measurement time.

For the setup procedure, refer to "Selecting Measurement Time" on page 58.

Setting measurement range mode to the fixed range

If you set the measurement range mode to the auto range, the measurement time is lengthened because a ranging time is required. Therefore, specify the fixed range for quicker measurements.

For the setup procedure, refer to "Selecting Measurement Range" on page 56.

Turning OFF display

Turning OFF display can shorten the measurement computation time (EOM). The display time is shown in "Measurement time" on page 186.

For the procedure to turn ON/OFF the measurement result display, refer to "Turning ON/OFF display" on page 62.

Decreasing averaging count

If you use the averaging function, set the averaging count to as small a value as possible.

For the setup procedure, refer to "Setting Up Averaging Count" on page 59.

Setting the trigger delay time to 0

If you do not need to use the trigger delay function, confirm that the trigger delay time is set to 0.

For the setup procedure, refer to "Setting Up Trigger Delay Time" on page 59.

Reducing the waiting time for analog measurement

E4981B has the capability to reduce the waiting time for analog measurement. The waiting time is included in the analog measurement time. This is a system default measurement delay time.

When waiting time is reduced, the measurement accuracy is not applied. To set the waiting time, use the [:SENSe]:DETector:DELay[1-3] command. Refer to the *E4981B Programming Manual*.

Turning off the status register update

When the status register is not used, the measurement computation time can be reduced to 0.7 ms (the measurement computation time is 1 ms when status register is ON).

To turn OFF the register, use the :STATus:OPERation:UPDate command. Refer to the *E4981B Programming Manual*.

7 Sorting Based on Measured Results (Comparator Function)

This chapter describes how to use the function that performs sorting based on the measured results (comparator function).

Overview of Comparator Function

The E4981B's comparator function lets you set up to 9 limit ranges for the primary parameter (BIN1 to BIN9) and 1 limit range for the secondary parameter and sort DUTs into up to 11 categories: BIN1 to BIN9, OUT_OF_BINS or AUX_BIN. If you need only simple pass/fail judgment and do not need BIN sorting, use the comparator function while setting up only 1 limit range for the primary parameter (BIN1) (and, if necessary, 1 limit range for the secondary parameter) to judge whether the measured result of the DUT falls into the specified limit range.

You can specify the upper and lower limit values for the primary parameter with not only absolute values but also relative values (deviation) from the reference value (nominal value).

The sorting judgment result of the comparator function is displayed on the screen and also output from the handler interface. In addition, you can read out the sorting judgment result from an external controller by using the SCPI command together with the measured value.

You can use the BIN count function to count the number of DUTs sorted into each BIN, display the counts on the screen, and read them out with the SCPI command.

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Turning ON/OFF Comparator Function

The ON/OFF state of the comparator function also controls the ON/OFF state of the output of the handler interface signal.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **COMP** field.

Step 4.   Use the following softkeys:

Softkey	Function
ON	Turns ON the comparator function.
OFF	Turns OFF the comparator function.

Setting Up Sorting Judgment Conditions

Clearing (resetting) limit ranges

Clearing the limit ranges returns the settings of the following items to the factory-default preset values (refer to).

- ON/OFF, lower limit value, and upper limit value of all limit ranges (BIN1 to BIN9 and secondary parameter limit range)
- Limit range designation method
- Reference value for the tolerance mode

Execution procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **BIN** field.

Step 4.   Press the **CLEAR TABLE** softkey, to clear the limit ranges.

```
<LIMIT TABLE SETUP>                           CLEAR
                                              TABLE
FUNC  Cp-D   NOM  1 nF         BEEP   FAIL
⊿MODE  ⊿%      AUX  ON          COMP   ON
BIN          LOW [ % ]   HIGH [ % ]
 1    ON    -1           1
 2    ON    -2           2
 3    ON    -3           3
 4    OFF    0           0
 5    OFF    0           0
 6    OFF    0           0
 7    OFF    0           0
 8    OFF    0           0
 9    OFF    0           0
2nd   ON     0           100 m        [ - ]

Use softkeys to select
```

Selecting a limit range designation method

Two methods can be used to designate the limit ranges for the primary parameter (BIN1 to BIN9). One is to designate the limit boundary value using an absolute value (absolute mode) and the other is to designate it using a relative value (deviation) from the reference value (nominal value) (tolerance mode). The tolerance mode is further divided into a method to designate the deviation using an absolute value (absolute tolerance mode) and a method to designate the deviation using the percentage of the reference value (percent tolerance mode).

NOTE   Only the absolute mode can be used to designate the secondary parameter limit range.

Mode		
Off	Absolute mode	
∆ABS	Tolerance mode	Absolute tolerance mode
∆%		Percent tolerance mode

Setup procedure for the limit range designation method and reference value

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **MODE** field.

Step 4.   Use the following softkeys:

Softkey	Function
OFF	Switches the comparator into absolute mode.
∆ABS	Switches the comparator into tolerance mode based on absolute value.
∆%	Switches the comparator into tolerance mode based on deviation percentages.

Step 5.   Use the cursor keys to select the **NOM** field, to set the reference value for absolute tolerance mode or percent tolerance mode.

Step 6.   Enter the nominal value using the softkeys or entry keys. If you use the entry keys to enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

Softkey	Function
INCR++	Increments the nominal value in steps of your selected number (1, 2, 5, 10, 20, 50, 100, 200, 500)
INCR+	Increments the nominal value in steps of 1.
DECR-	Decrements the nominal value in steps of 1.
DECR--	Decrements the nominal value in steps of your selected number (1, 2, 5, 10, 20, 50, 100, 200, 500)

Relationship between the limit range designation method and the setup value

Table 7-1 and Table 7-2 compare the setup values between the limit designation methods when setting up the limit ranges shown in Figure 7-1 and Figure 7-2, respectively.

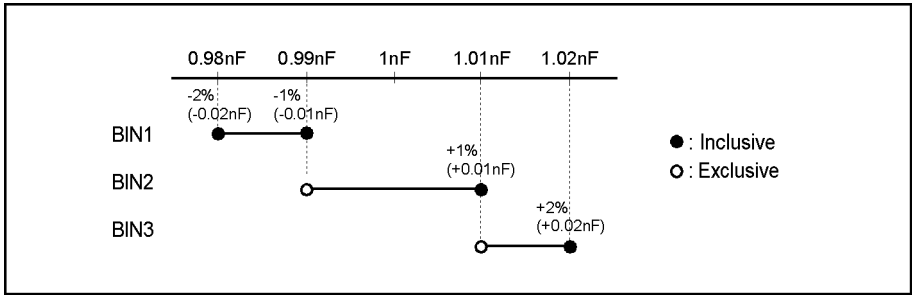Figure 7-1   Example of limit range settings (case 1)

Table 7-1   Lower and upper limit values of limit ranges for Figure 7-1 (comparison of modes)

| | Absolute mode | | Tolerance mode (reference value: 1 nF) | | | |
| | | | Absolute | | Percent | |
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	0.98 nF	0.99 nF	–0.02 nF	–0.01 nF	–2%	–1%
BIN2	0.99 nF	1.01 nF	–0.01 nF	0.01 nF	–1%	1%
BIN3	1.01 nF	1.02 nF	0.01 nF	0.02 nF	1%	2%

Figure 7-2   Example of limit range settings (case 2)
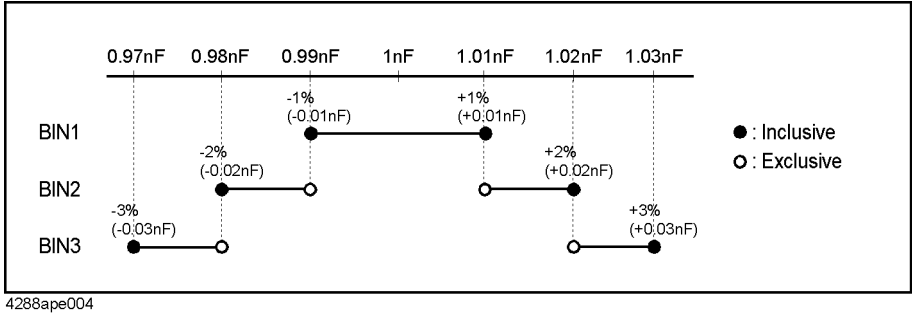

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Table 7-2   Lower and upper limit values of limit ranges for Figure 7-2 (comparison of modes)

| | Absolute mode | | Tolerance mode (reference value: 1 nF) | | | |
| | | | Absolute | | Percent | |
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	0.99 nF	1.01 nF	−0.01 nF	0.01 nF	−1%	1%
BIN2	0.98 nF	1.02 nF	−0.02 nF	0.02 nF	−2%	2%
BIN3	0.97 nF	1.03 nF	−0.03 nF	0.03 nF	−3%	3%

Setting up limit ranges

Notes on setup

- If you set up the upper limit value to a value equal to or less than the lower limit value, the limit range is not used. This operation is equivalent to setting the limit range to OFF.

- If BINs overlap, the resulting measurement is sorted into the BIN of the smallest number (refer to Figure 7-5, "Sorting judgment flow," on page 133). Therefore, you need to set up the limit ranges starting from the narrowest to the widest as shown in Figure 7-2.

- For the tolerance mode, the reference value is not required to be within the limit range (between the lower limit value and upper limit value).

- Gaps between the limit ranges are allowed. Therefore, you can set up the limit ranges as shown in Figure 7-3.

Figure 7-3   Example of gap between limit ranges
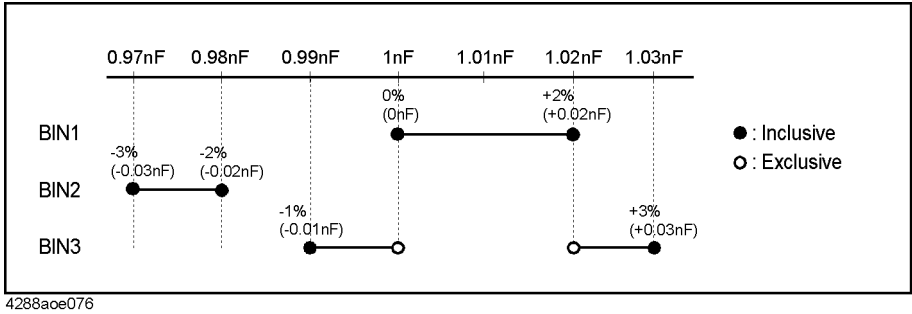

Table 7-3   Lower and upper limit values of limit ranges for Figure 7-3

| | Absolute mode | | Tolerance mode (reference value: 1 nF) | | | |
| | | | Absolute | | Percent | |
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	1 nF	1.02 nF	0 nF	0.02 nF	0%	2%
BIN2	0.97 nF	0.98 nF	–0.03 nF	–0.02 nF	–3%	–2%
BIN3	0.99 nF	1.03 nF	–0.01 nF	0.03 nF	–1%	3%

WARNING   **When the low limit value is greater than the upper limit, a warning message "Improper high/low limits" is displayed.**

Procedure to set up BIN1 to BIN9 (ON/OFF and lower and upper limit values)

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **BIN 1** field.

Step 4.   Use the following softkeys:

Softkey	Function
ON	Turns ON the bin function.
OFF	Turns OFF the bin function.

Step 5.   Repeat Step 3 to Step 4 using the cursor keys until you have turned ON the bin 9.

Step 6.   Use the cursor keys to select the BIN 1 **LOW** field.

Step 7.   Enter the limit value using the entry keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

- You can clear your selected lower limit value by pressing the **CLEAR** softkey.

- You can enter the lower limit value using the **HIGHx(-1)** softkey.

- You can clear all the limit values and sets the status to OFF for your selected bin by pressing the **CLEAR LINE** softkey.

Step 8.   Use the cursor keys to select the BIN 1 **HIGH** field.

Step 9.   Enter the limit value using the entry keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

- You can clear your selected upper limit value by pressing the **CLEAR** softkey.

- You can enter the upper limit value using the **LOWx(-1)** softkey.

- You can clear all the limit values and sets the status to OFF for your selected bin by pressing the **CLEAR LINE** softkey.

Step 10.   Repeat Step 6 to Step 9 using the cursor keys until you have entered the lower and upper limit values for bin 9.

Procedure to set up secondary parameter limit range (ON/OFF and lower and upper limit values)

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the BIN **2nd** (secondary parameter) field.

Step 4.   Use the following softkeys:

Softkey	Function
ON	Turns ON the bin function of secondary parameter.
OFF	Turns OFF the bin function of secondary parameter.

Step 5.   Use the cursor keys to select the 2nd **LOW** field.

Step 6.   Enter the limit value using the entry keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

- You can clear your selected lower limit value by pressing the **CLEAR** softkey.

- You can enter the lower limit value using the **HIGHx(-1)** softkey.

- You can clear all the limit values and sets the status to OFF for your selected bin by pressing the **CLEAR LINE** softkey.

Step 7.   Use the cursor keys to select the 2nd **HIGH** field.

Step 8.   Enter the limit value using the entry keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

- You can clear your selected upper limit value by pressing the **CLEAR** softkey.

- You can enter the upper limit value using the **LOWx(-1)** softkey.

- You can clear all the limit values and sets the status to OFF for your selected bin by pressing the **CLEAR LINE** softkey.

Setting up AUX function

If the secondary parameter limit range is ON, the sorting result varies when it exceeds the secondary parameter limit range, depending on the ON/OFF state of the AUX function (Table 7-4).

Table 7-4   **Sorting result when measured secondary parameter value exceeds limit range**

Primary parameter sorting result	AUX BIN function	Sorting result
One of BIN1 to BIN9	OFF	OUT_OF_BINS
One of BIN1 to BIN9	ON	AUX_BIN
Not sorted to any BINs	No relation	OUT_OF_BINS

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **LIMIT TABLE** softkey.

Step 3.   Use the cursor keys to select the **AUX** field.

Step 4.   Use the following softkeys:

Softkey	Function
ON	Turns ON the auxiliary function.
OFF	Turns OFF the auxiliary function.

Rejecting Excessively Low Measured Results (Low C reject function)

The E4981B has a function to detect extremely low measured primary parameter values (Cp or Cs) that are equal to or less than the preset boundary value as Low C (abnormal measurement status). This is called the Low C reject function.

NOTE	When the comparator function is ON, normal sorting judgment will be performed even if Low C is detected. However, the sorting judgment result displayed on the screen is LOWC and, on the handler interface, the /LOWC_OR_NC signal becomes active (low level) in addition to the sorting judgment signal.

NOTE	Handler output shares the line for No Contact & Low C Reject and becomes active when primary parameter is lower than the border value.

Turning ON/OFF Low C reject function

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor key to select the **LOW C REJ** field.

Step 3.   Use the following softkeys:

Softkey	Function
ON	Turns ON the Low C Reject function.
OFF	Turns OFF the Low C Reject function.

Setting up limit (boundary value) of Low C reject function

Set up the limit of the Low C reject function (boundary value of the range to detect Low C) as a percentage of the measurement range (full scale). The applicable measurement range varies depending on the setting of the measurement range mode:

- For the auto range mode

  The minimum measurement range is applicable regardless of whether the measurement is actually performed. Specifically, it is one of the following measurement ranges:

  When measurement frequency is 120 Hz: $10E^{-9}$ F (10 nF) range

  When measurement frequency is 1 kHz: $100E^{-12}$ F (100 pF) range

  When measurement frequency is 1 MHz: $1E^{-12}$ F (1 pF) range

- For the fixed range mode

  The measurement range currently selected is applicable, that is, it is the range in which the measurement is actually performed.

For example, if you make a measurement with the 1 μF range fixed and set the limit to 1%, Low C is detected when the measured primary parameter value (Cs or Cp) is equal to or less than 10 nF.

Setup procedure

Step 1.   Press **[Meas Setup]**.

Step 2.   Use the cursor key to select the **LOW C REJ** field.

Step 3.   Use the entry keys or softkeys to enter the limit value. When you enter the value with the entry keys, the softkey unit label changes to (%).
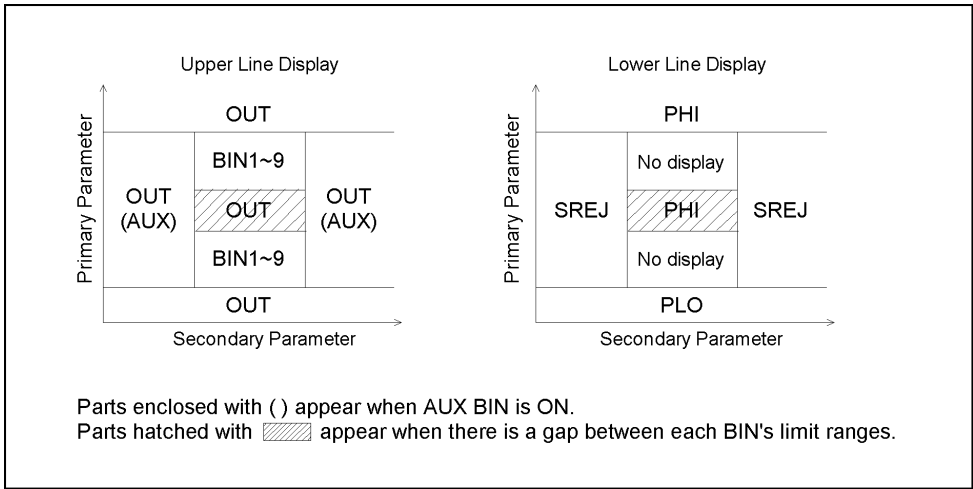
Softkey	Function
INCR+	Increments the Low C Reject value in steps of 0.001%.
DECR-	Decrements the Low C Reject value in steps of 0.001%.

Reading out Sorting Judgment Result

The sorting judgment is obtained through the comparator function according to the flow shown in **Figure 7-5**.

Figure 7-4 shows the relationship between the screen display and the sorting result.

Figure 7-4   Relationship between display output and comparator sorting result

Parts enclosed with ( ) appear when AUX BIN is ON.
Parts hatched with ▨ appear when there is a gap between each BIN's limit ranges.

NOTE   If an overload is detected, the sorting judgment cannot be performed and therefore ---- is displayed in the upper row. If Low C reject is detected, normal sorting judgment is performed but LOWC is displayed in the upper row instead of the sorting judgment result (OUT, AUX, or BIN1 to BIN9).
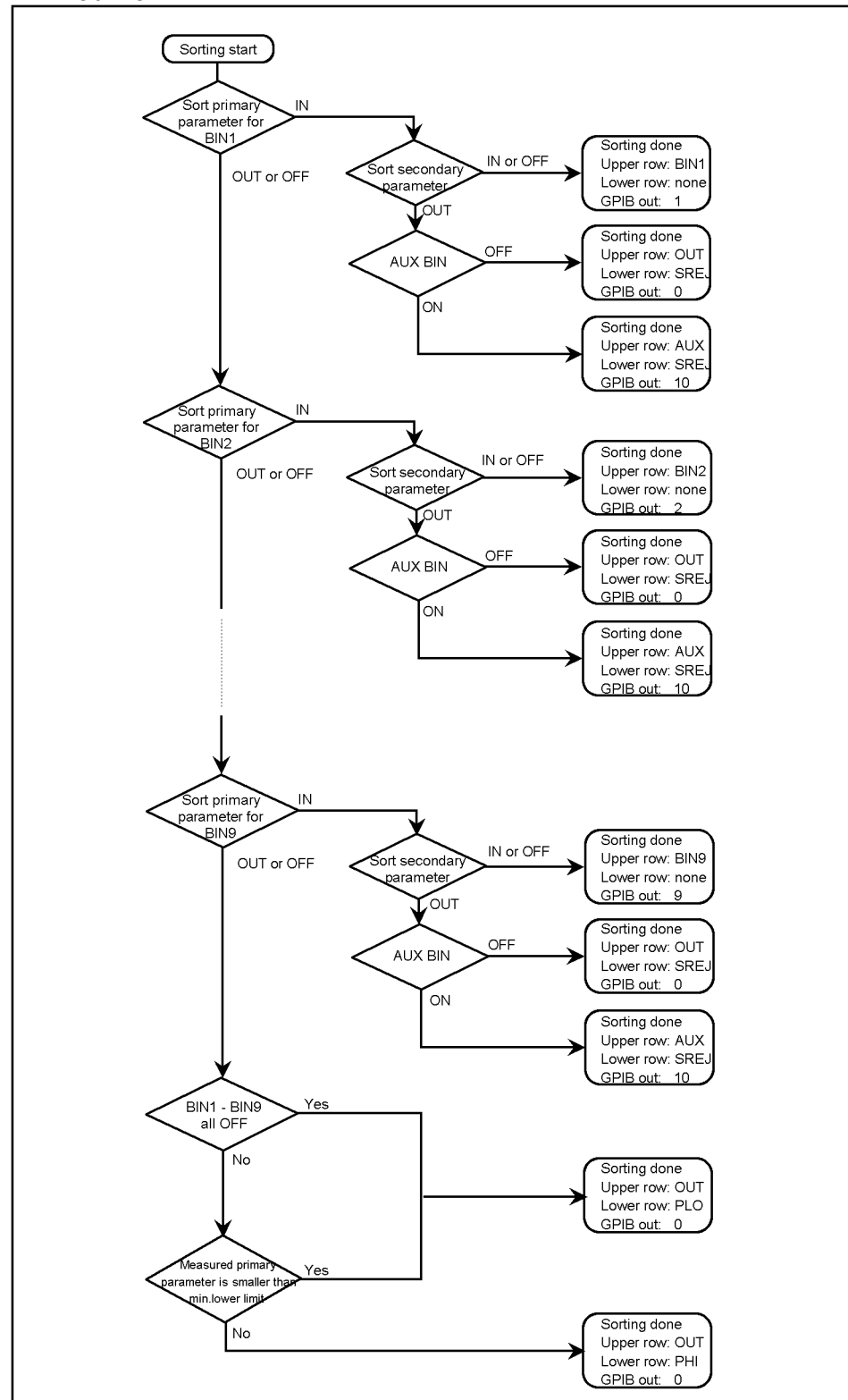
NOTE   The sorting judgment result can be read out through the SCPI command.

Figure 7-5   Sorting judgment flow

Reading out Sort Count of Each BIN (BIN count function)

You can count the number of DUTs sorted into each BIN by turning ON the BIN count function. The maximum value of the count is 999999. If this value is exceeded, the count will not increase but remain at 999999 (it does not return to 0).

When the MULTI correction function is ON, channel-by-channel count is performed separately from the usual count (total of all channels). You can read out the result by using the SCPI command.

NOTE	You can read all the BIN count values with the :CALCulate1:COMParator:COUNt:DATA? command. For more information, refer to the *Programming Manual*.

NOTE	The overload count value can be read only through the SCPI command and cannot be displayed on the screen.

Setup procedure

The BIN count value is displayed in the BIN COUNT DISPLAY page.

The setup procedure is given below.

Step 1. Press **[Display Format]**.

Step 2. Press the **BIN COUNT** softkey.

Step 3. Use the following softkeys:

Softkey	Function
COUNT ON	Turns ON the count function.
COUNT OFF	Turns OFF the count function.
RESET COUNT	Resets the count function.

NOTE	Clearing the BIN count values initializes all of the count values to 0.

NOTE	The BIN count value for each channel when the MULTI correction function is ON can be checked only through SCPI command and cannot be displayed on the screen.

NOTE	The overload count value of each channel when the MULTI correction function is ON, can be read with the :CALCulate1:COMParator:COUNT:MULTi:OVLD? command. For more information, refer to the *Programming Manual*.

Making a Beep Based on Sorting Judgment Result

You can set the conditions for making a beep sound, based on the sorting judgment result, to one of the following.

- Makes a beep when the sorting judgment result is OUT_OF_BINS, AUX_BIN or OVLD and LOWC_OR_NC.

- Makes a beep when the sorting judgment result is BIN1 to BIN9.

You can also disable the beep sound.

For the procedure on how to set up the beep output, refer to **"Setting Up Condition To Make A Beep" on page 67**.

Keysight E4981B 120 Hz/1 kHz/1 MHz Capacitance Meter

8   Using Handler Interface

You can output the measurement end signal, the sorting result of the comparator function, and other data from the Keysight E4981B, as well as input an external trigger signal or a key lock signal to the E4981B, through the handler interface. This chapter also gives information required to configure an auto-sorting system that combines the E4981B and a handler in using the handler interface and the comparator function.

Output of Comparator Sorting Result

When the comparator function is ON, the comparator sorting result is output through the handler interface. Figure 8-1 and Table 8-1 show the relationship between the comparator sorting result and the output signals of the handler interface (/BIN1 - /BIN9, /AUX_BIN, /OUT_OF_BINS, /PHI, /PLO, and /SREJ).

NOTE	When the comparator function is OFF, no signals are output, except for /INDEX, /EOM, and /ALARM. /INDEX and /EOM stay LOW. /ALARM, as when the comparator is ON, is output when an error occurs.
	EXT_TRIG, regardless of the ON/OFF state of the comparator function, is active when the trigger mode is set to the external trigger (EXT). When /KEY_LOCK is LOW, regardless of the ON/OFF state of the comparator function, the key lock state remains unchanged.

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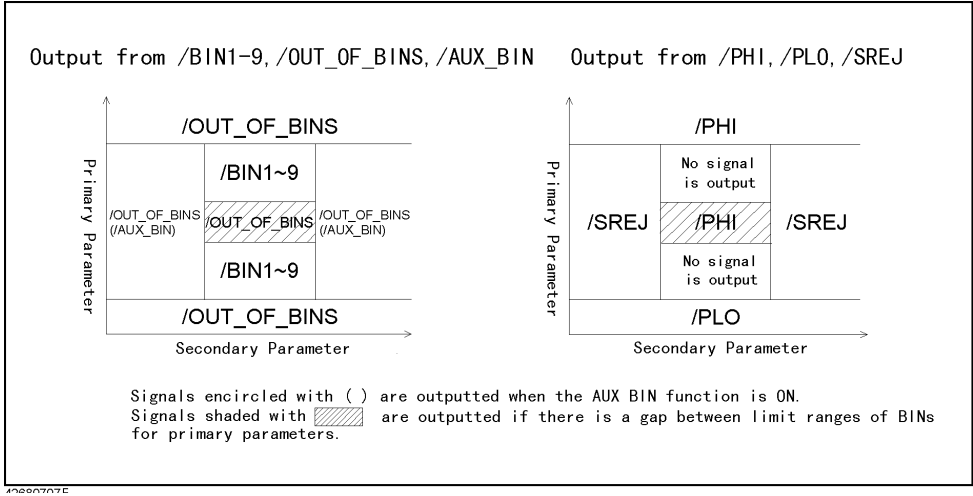Figure 8-1   Output of comparator sorting result to the handler interface

Table 8-1   Relationship between comparator sorting result and output signals of the handler interface

Mea-surement status	Judgment result			Handler interface signals that become active	GPIB output		
	Primary parameter	Secondary parameter			Mea-surement status	Mea-sured value	BIN sorting result
No error	IN	BIN1	IN	/BIN1	0	Mea-sured value	1
		BIN2		/BIN2			2
		BIN3		/BIN3			3
		BIN4		/BIN4			4
		BIN5		/BIN5			5
		BIN6		/BIN6			6
		BIN7		/BIN7			7
		BIN8		/BIN8			8
		BIN9		/BIN9			9
		One of BIN1 to BIN9	OUT	AUX BIN: OFF	/OUT_OF_BINS /SREJ			0
				AUX BIN: ON	/AUX_BIN /SREJ			10
	OUT	Less than the mini-mum lower limit	N/A	/OUT_OF_BINS /PLO			0
		Other than above		/OUT_OF_BINS /PHI			
Overload	Cannot be sorted.			/OVLD	1	9.9E37	11
Low C				/LOW-C_OR_NC[1]	2	Mea-sured value	0 - 10

Table 8-1   Relationship between comparator sorting result and output signals of the handler interface

Mea-surement status	Judgment result		Handler interface signals that become active	GPIB output		
	Primary parameter	Secondary parameter		Mea-surement status	Mea-sured value	BIN sorting result
No Con-tact	Cannot be sorted		/LOW-C_OR_NC	2	9.9E37	11

1. /LOWC becomes active together with the signal that corresponds to the result of normal sorting judgment (judgment result when no error occurs).

Input/Output Signal Pin Assignment

Figure 8-2 shows the input/output signal pin assignment of the handler interface connector. Table 8-2 gives a description of the input/output signals.

NOTE	A slash (/) symbol preceding signal names means that they are negative logic (active low).

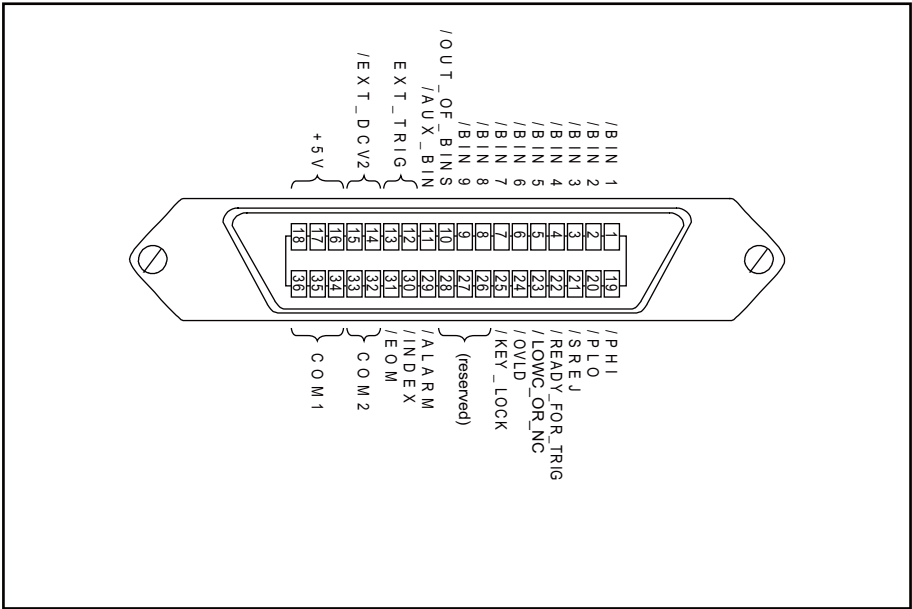Figure 8-2   Pin assignment of the handler interface connector

Table 8-2   Description of the handler interface input/output signals

Pin number	Signal name	Input/output	Description
1	/BIN1		
2	/BIN2		
3	/BIN3		
4	/BIN4		
5	/BIN5		Sorting judgment signals. A BIN signal of the sorting result (one of pin numbers 1 - 11) becomes LOW. These signals do not become LOW if measurement is not possible (overload).
6	/BIN6	Output	
7	/BIN7		
8	/BIN8		
9	/BIN9		
10	/OUT_OF_BINS		
11	/AUX_BIN		
12, 13	EXT_TRIG	Input	External trigger signal. This is active when the trigger mode is set to the external trigger (Ext). The trigger is generated at the rising edge of a pulse. When this trigger pin is not used, the pin should be connected with GND (LO).

Table 8-2   Description of the handler interface input/output signals

Pin number	Signal name	Input/ output	Description
14, 15	EXT_DCV2	Input	External dc voltage. This supplies the voltage to the input signals (EXT_TRIG and /KEY_LOCK) and the operation output signals (/ALARM, /INDEX, /EOM, and /READY_FOR_TRIG). The input voltage range is between +5 V and +24 V.
16, 17, 18	+5 V		Internal dc voltage.
19	/PHI		Primary-parameter-upper-limit-exceeded signal. When the upper limit of BIN1 - BIN9 is exceeded, this becomes LOW.
20	/PLO		Primary-parameter-lower-limit-not-reached signal. When the lower limit of BIN1 - BIN9 is not reached, this becomes LOW.
21	/SREJ		Secondary-parameter-out-of-limit signal. If the secondary parameter is out of the limit, this becomes LOW.
22	/READY_FOR_TRIG	Output	Trigger-acceptable signal. When a trigger-signal-acceptable state is established, this becomes LOW. When the handler receives this signal, an external trigger signal can be input.
23	/LOWC_OR_NC		Low-C-reject-detection signal occurs at 120 Hz, 1 kHz and 1 MHz and No_Contact is available at 120 Hz and 1 kHz. For Low-C-Reject, if the measured Cp or Cs result is equal to or less than the preset boundary value (percentage of the measurement range), Pin 23 value becomes LOW. For No-Contact detection, if the measurement value becomes very less i.e 9.99E37, Pin 23 becomes LOW.
24	/OVLD		Measurement-impossible signal. If measurement is impossible in the analog measurement part (overload), this becomes LOW.
25	/KEY_LOCK	Input	Key-lock signal. If you set this signal to LOW, the front panel keys of the E4981B are disabled.
26	(reserved)	———	Not used in the current release. Do not connect anything.
27, 28	EXT_DCV1	———	External dc voltage for judgemental system is not used in E4981B as PullUp resistors are not mounted inside the E4981B.

Table 8-2   Description of the handler interface input/output signals

Pin number	Signal name	Input/ output	Description
29	/ALARM	Output	Error-occurrence signal. If a problem (an error in the self test result, power supply interruption, malfunction of a specific circuit, etc.) occurs, this becomes LOW. For power supply interruption, this stays LOW only while the power is down.
30	/INDEX		Analog measurement end signal. When an analog measurement finishes, this becomes LOW. When the handler receives this signal, you can connect the next DUT. You cannot obtain the measurement data until the /EOM signal is received.
31	/EOM		Measurement cycle end signal. When a series of measurement processes finishes and the measured data sorting judgment result becomes available, this becomes LOW.
32, 33	COM2		Common pins for the external dc voltage EXT_DCV2 (pin numbers 14 and 15).
34, 35, 36	COM1		Common pins for the external dc voltage EXT_DCV1 (pin numbers 27 and 28).

Timing Chart

Figure 8-3 shows the timing chart. The section where /Data is unpredictable in the figure indicates that the E4981B is processing data after analog measurement and the output signals are invalid. For details on measurement time, refer to Table 8-3 on page 144.
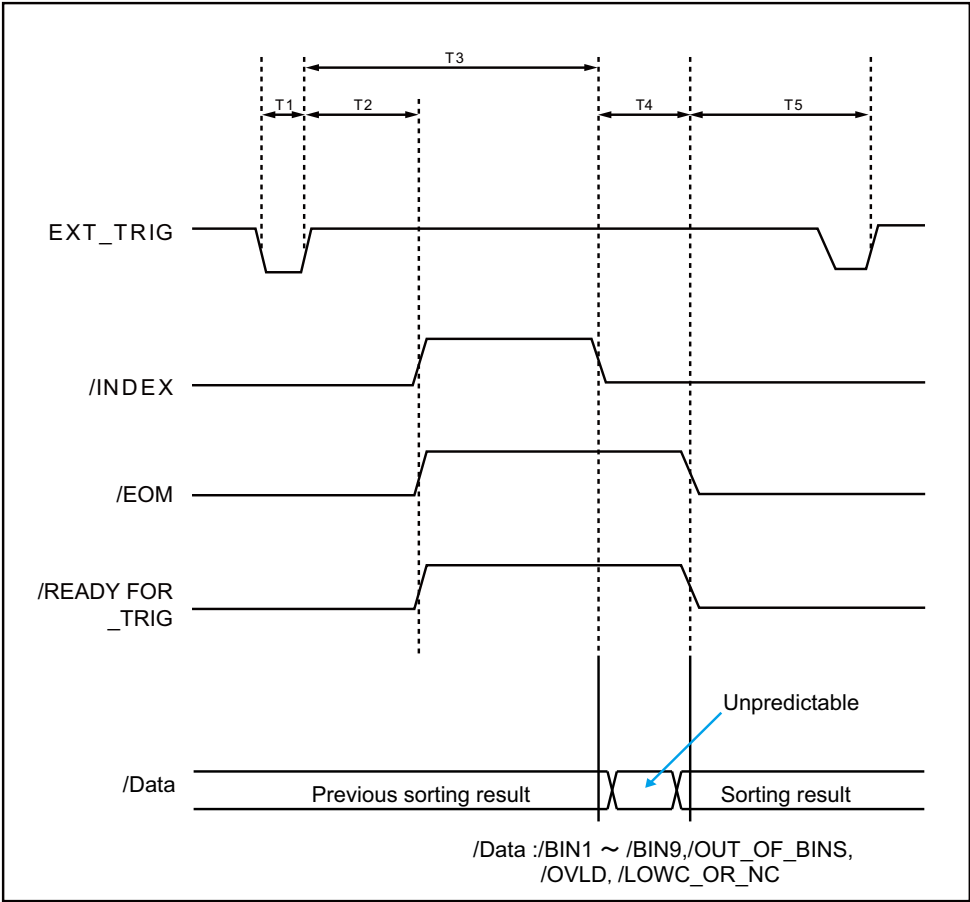
Figure 8-3   Timing chart for handler interface

/Data :/BIN1 ~ /BIN9,/OUT_OF_BINS,
/OVLD, /LOWC_OR_NC

Table 8-3   Values of T1–T5

		MEAS TIME	Minimum value	Typical value
T1	Trigger pulse width	NA	1 µs	—
T2	Trigger response time of /READY_FOR_TRIG, /INDEX and /EOM	NA	—	40 µs

Table 8-3   Values of T1–T5

			MEAS TIME	Minimum value	Typical value
T3 + T4	Measurement time	T3 Analog measurement time	1(120 Hz)	—	10.0 ms
			1(1 kHz)	—	2.0 ms
			1(1 MHz)	—	1.3 ms
		T4 Measurement computation time	N/A	—	1.0 ms
T5	Trigger wait time		N/A	0 µs	—

Electrical Characteristics

Output signals

The output signals are available as open collector outputs with photo coupler isolated. You can obtain each voltage output by connecting a pull-up resistor (refer to Table 8-4) to the exterior of the E4981B.

Table 8-4   Guide for pull-up resistor values

Pull-up voltage [V]	Resistance value [Ω]	Typical resistance	
		Resistance value [Ω]	Keysight part number
5	1.7 k (5 V / 3 mA)	1.78 k	0757-0278
9	3.0 k (9 V / 3 mA)	3.16 k	0757-0279
12	4.0 k (12 V / 3 mA)	4.22 k	0698-3154
15	5.0 k (15 V / 3 mA)	5.11 k	0757-0438
24	8.0 k (24 V / 3 mA)	8.25 k	0757-0441

The output signals are divided into two groups: judgment output signals and operation output signals. You can specify a different pull-up voltage for each of them. Table 8-5 shows the electrical characteristics of the output signals. Figure 8-4 and Figure 8-5 show the circuit diagrams of the judgment output signals and operation output signals, respectively.

Table 8-5   Electrical characteristics of the handler interface output signals

Output signal	Output voltage [V]		Maximum current [mA]
	LOW	HIGH	
Judgment output signals: /BIN1 - /BIN9, /AUX_BIN, /OUT_OF_BINS, /PHI, /PLO, /SREJ, /OVLD, /LOWC_OR_NC	0 - 0.5	+5 V to +24 V	6
Operation output signals: /INDEX, /EOM, /READY_FOR_TRIG, /ALARM	0 - 0.5	+5 V to +24 V	6

Figure 8-4   Circuit diagram of judgment output signals of the handler interface
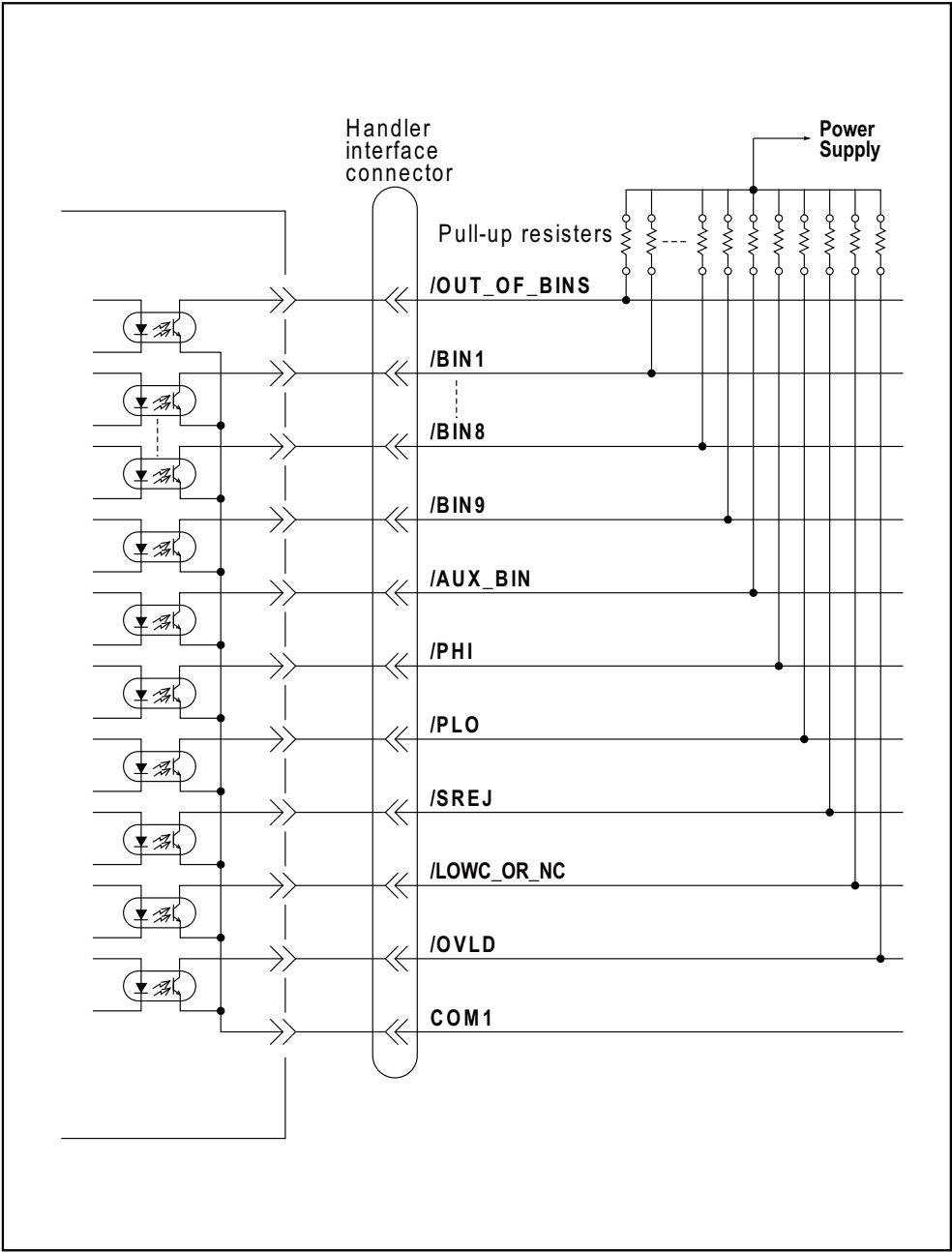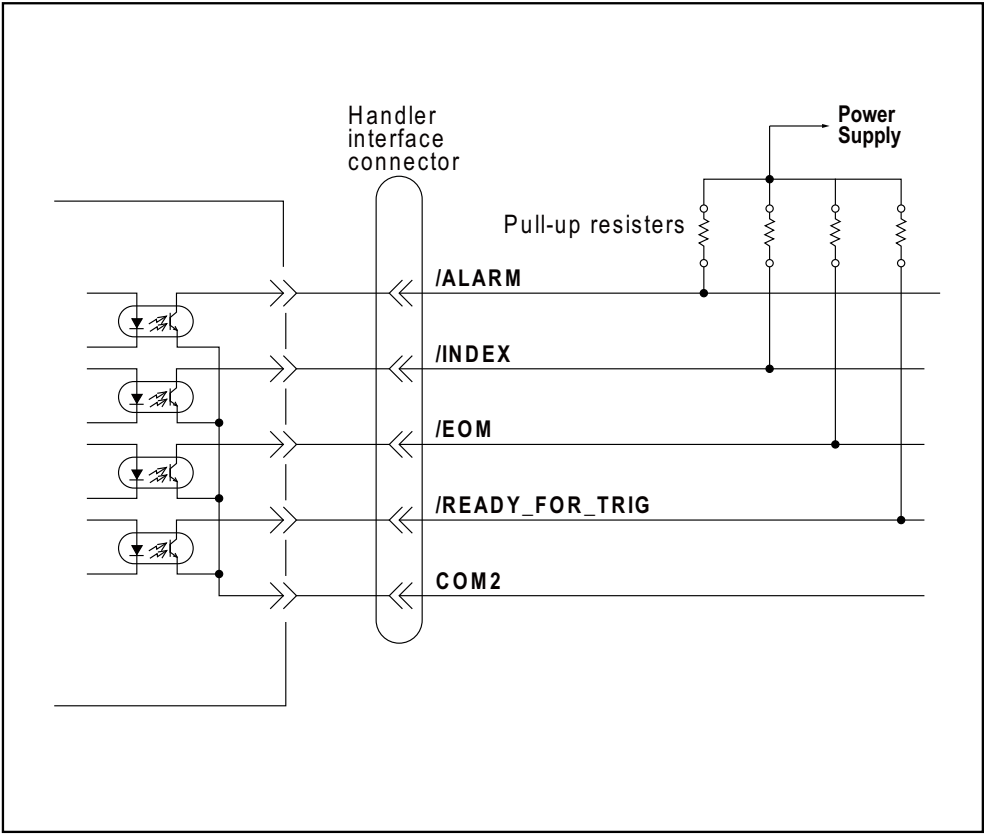
Figure 8-5   Circuit diagram of operation output signals of the handler interface

Input signal

Each input signal is supplied to the cathode of the photo coupler LED. The anode of the LED is connected to the drive source voltage. Table 8-6 shows the electrical characteristics of the input signals. Figure 8-6 shows the circuit diagram of the input signals. The amount of current flowing through the LED depends on the setups of the drive source voltage and the input signal resistor.

The S1, S2, S3 switches belongs to electrical switches that can be control by the following SCPi command **:SYSTem:HANDler:TRIGger:VOLTage <para>**

Table 8-6   Electrical characteristics of the handler interface input signals

Input signal	Input voltage [V]		Input current (LOW) [mA] (typical)			
			Drive source voltage: DCV2			
	LOW	HIGH	5 V	12 V	15 V	24 V
EXT_TRIG	0 - 1	DCV2	2.7	3.6	4.4	6.3
/KEY_LOCK			2.8	7.0	9.0	14.5

Figure 8-6   Circuit diagram of the handler interface input signals
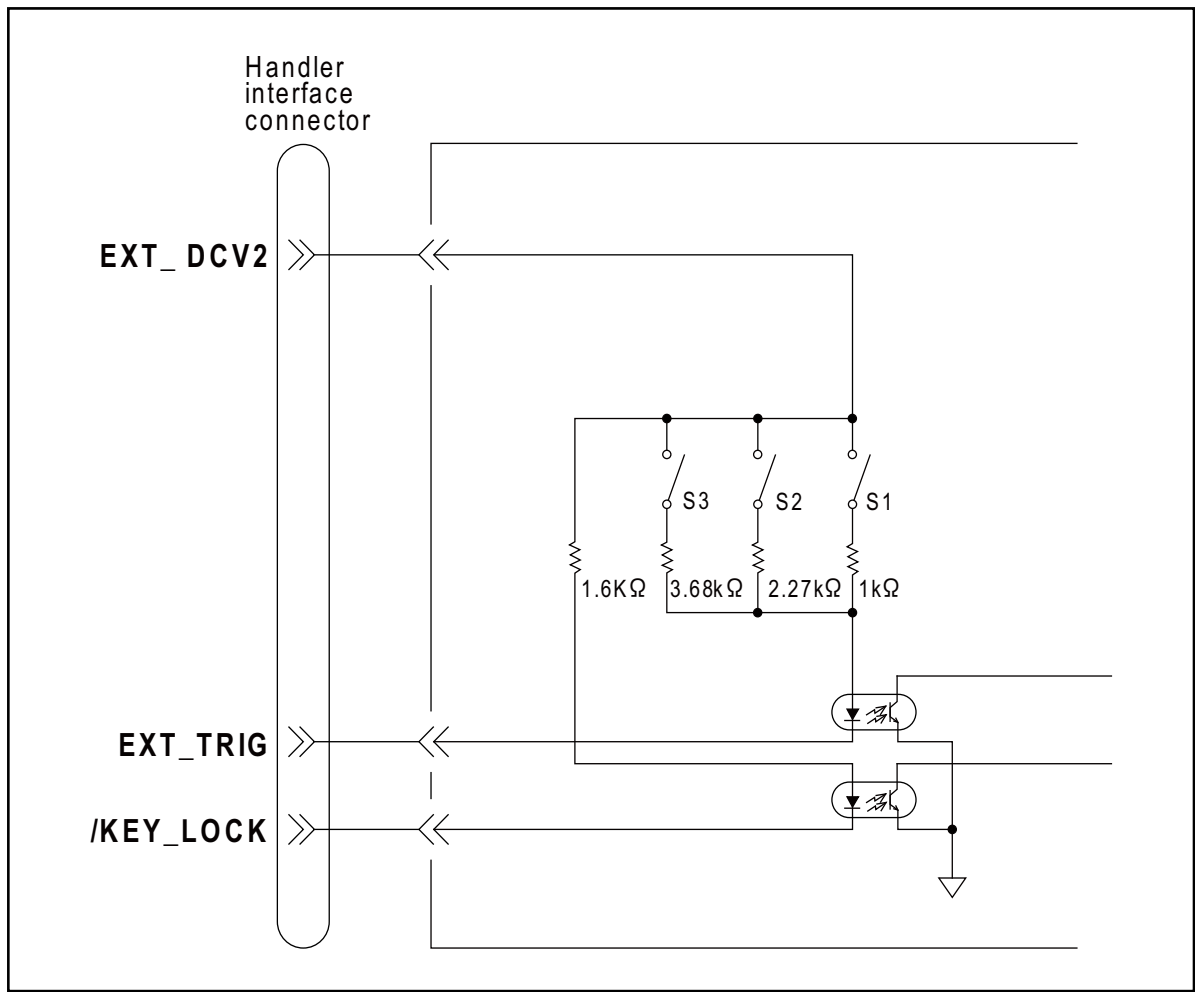
Table 8-7   Selection of handler input trigger voltage

	:SYSTem:HANDler:TRIGger:VOLTage ‹para›		
	5 V ~ para | 9 V	9 V ~ para | 15 V	15 V ~ para ≤ 24 V
S1	ON	OFF	OFF
S2	OFF	ON	OFF
S3	OFF	OFF	ON

NOTE   The S1, S2, S3 switches belongs to electrical switches that can be control by SCPi command **:SYSTem:HANDler:TRIGger:VOLTage ‹para›**

When the drive source voltage is between 5 V - 9 V, the switch S1 is ON (closed) and current flows through the input signal resistor of 1 kΩ.

When the source voltage is between 9 V - 15 V, the switch S2 is ON (closed) and current flows through the input signal resistor of 2.27 kΩ.

When the drive source voltage is between 15 V - 24 V, the switch S3 is ON (closed) and current flows through the input signal resistor of 3.68 kΩ.

NOTE
If the source voltage exceeds the available range, the analog circuit in the hardware might be damaged.

Control/Check the Handler Interface for Maintenance

To control/check the Handler interface, the Keysight E4981B provides several test commands related to various operations of handler interface. This section explains the various test commands available in E4981B to check/trouble the handler interface.

Starting Handler interface test

Handler interface can be set into test mode by using the :TEST:HANDler:MODE command. When this command value is set to ON, the handler interface pin signal value can be controlled/read by :TEST:HAND:xxxx commands.

Using Handler interface test commands

After setting the :TEST:HANDler:MODE command value to ON, the following commands can be used to control/read the handler interface pin signal value:

- :TEST:HANDler:BIN sets the Handler Bin No.

- :TEST:HANDler:COMP sets the Handler Comparator Function value.

- :TEST:HANDler:KEYLock? gets the Handler/Key_Lock signal level as HIGH/LOW.

- :TEST:HANDler:STATus:ALARm sets the Handler Alarm signal to HIGH/LOW.

- :TEST:HANDler:STATus:EOM sets the Handler End of Measurement (EOM) status to HIGH/LOW.

- :TEST:HANDler:STATus:INDex sets the Handler Index value to HIGH/LOW.

- :TEST:HANDler:STATus:NC sets the Handler No Contact/Low C Reject signal to HIGH/LOW.

- :TEST:HANDler:STATus:OVLD sets the Handler Overload signal status to HIGH/LOW.

- :TEST:HANDler:STATus:RDYTrig sets the Handler Ready for Trigger signal to HIGH/LOW.

- :TEST:HANDler:TRIGger? gets the Handler Trigger signal status as HIGH/LOW.

NOTE For more information about Handler Test commands, refer to the *Keysight E4981B Programming Manual*.

Ending Handler interface test

When the Handler interface test is finished, close the E4981B Handler interface test mode by setting :TEST:HANDler:MODE command value to OFF so that handler interface pin signal is generated according to the actual measurement result.

9   Using Scanner Interface

You can select correction data for each channel (up to 256 sets, multi-correction function) or input/output a timing control signal for measurement and scanner operation through the scanner interface. This chapter gives information required to configure a scanning system using the scanner interface and multi-correction function.

Using Multi-correction Function

The E4981B provides a function that lets you select a data set from up to 256 correction data sets measured and stored in advance and use it (multi-correction function). This function performs OPEN/SHORT/LOAD correction for each channel of the scanner to cancel variations in measured values caused by a different measurement path for each channel. Consequently, the function can provide highly reliable measurement.

This section describes how to use the multi-correction function.

Turning ON/OFF multi-correction function

When you turn ON the multi-correction function, the correction data for each channel, which has been measured in advance according to the procedure described in "Measuring multi-correction data", is used to perform error correction.

NOTE	The ON/OFF state of the multi-correction function is dependent on the ON/OFF state of the scanner interface. When the multi-correction function is OFF, the channel number inputs (/CH0 - /CH7 and /CH_VALID) from the scanner interface are ignored and /INDEX and /EOM stay LOW. Regardless of the ON/OFF state of the multi-correction function, /EXT_TRIG is valid when the trigger mode is set to the external trigger (EXT).

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The procedure to turn ON/OFF the multi-correction function is given below.

Step 1.   Press [Meas Setup].

Step 2.   Press **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **MULTI** field.

Step 4.   Use the following softkeys:

Softkey	Function
ON	Turns ON the multi-correction function.
OFF	Turns OFF the multi-correction function.

Selecting a channel

Making a selection using the front panel

The procedure to select a channel using the front panel keys is given below.

Step 1.   Press **[Meas Setup]**.

Step 2.   Press the **CORRECTION** softkey.

Step 3.   Use the cursor keys to select the **CH** field.

Step 4.   Use the softkeys or numeric entry keys to enter the channel number. When data is entered using the numeric keys, the softkeys change to units labels (x1).

Softkey	Function
INCR++	Increments the channel number in steps of 10.
INCR+	Increments the channel number in steps of 1.
DECR-	Decrements the channel number in steps of 1.
DECR--	Decrements the channel number in steps of 10.

Making a selection using the scanner interface

To select a channel through the scanner interface, use the /CH0 – /CH7 and /CH_VALID signals. For information on these signals, refer to "Input/Output Signal Pin Assignment" on page 158.

A channel number is expressed in binary notation by the HIGH level (0)/LOW level (1) of the /CH0 – /CH7 signals. The /CH7 signal is the most significant bit and the /CH0 signal is the least significant bit. For example, if the /CH7 signal is LOW and the /CH0 – /CH6 signals are HIGH, the expressed number is 128; if the /CH0 – /CH1 signals are LOW and the CH2 – /CH7 signals are HIGH, the expressed number is 3.

The /CH_VALID signal enables/disables the setting of the signals from /CH0 to /CH7. If the /CH_VALID signal is LOW, a trigger will set the channels of the E4981B to the channel numbers specified by the signals from /CH0 to /CH7.

The procedure to set the channel is given below.

Step 1.   Set the /CH_VALID signal to HIGH.

Step 2.   Set up a channel number using the /CH0 – /CH7 signals.

Step 3.   Set the /CH_VALID signal to LOW.

Step 4.   Generate a trigger.

NOTE	**Difference in execution timing depending on the channel selection method**

When the front panel or SCPI command is used to select a channel, the selection is executed immediately. On the other hand, when the /CH0 to /CH7 and /CH_VALID signals of the scanner interface are used, the channel selection is not executed immediately after setting the signals but when a trigger is generated.

For information on the setup timing of the /CH0 – /CH7 and /CH_VALID signals, refer to Figure 9-3 on page 160.

Measuring multi-correction data

Figure 9-1 shows the basic flow of measuring the OPEN/SHORT/LOAD correction data for the multi-correction.

NOTE You cannot initialize the correction data for the multi-correction function. Even if you trigger a reset or turn OFF the power, the values are maintained.

Figure 9-1   Flow of measuring correction data for the multi-correction
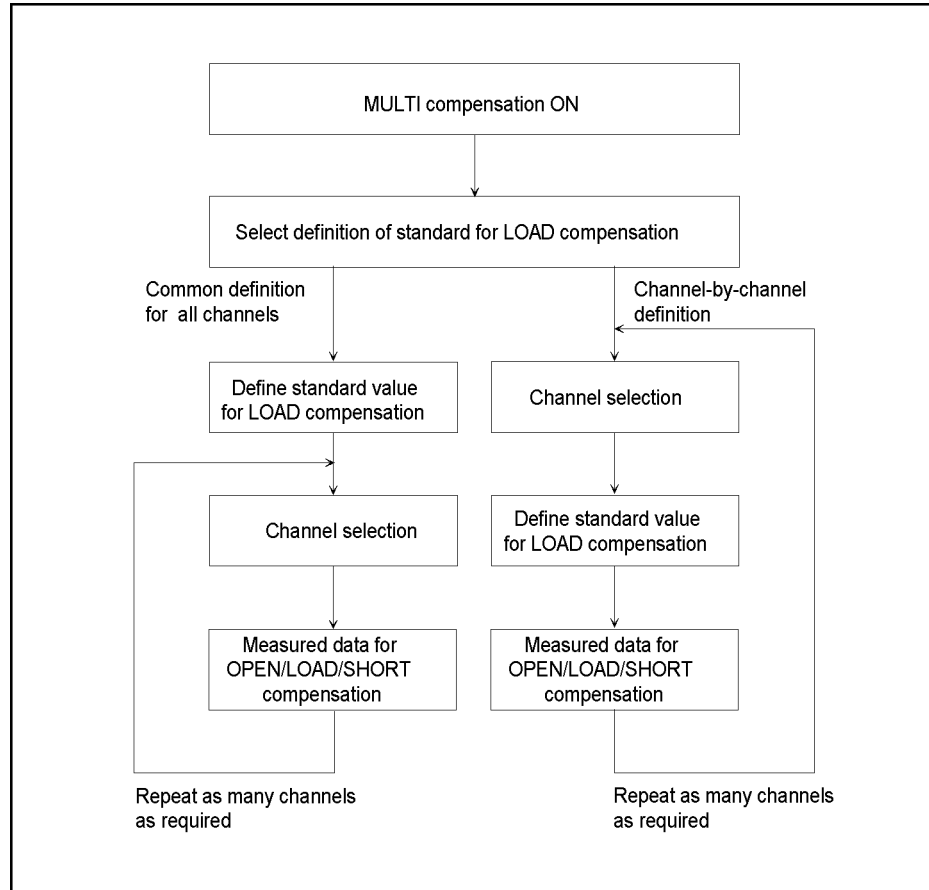
Selecting definition method of the LOAD correction standard

You can select how to define the LOAD correction standard value (LOAD correction reference value): either defining a value for each channel or defining a common value for all channels. If you select the channel-by-channel definition, the value is set up as the reference value for the channel selected when you enter the reference value. If you select defining a common value for all channels, the value is stored as the value for all channels regardless of the channel selected when setting up the value. Refer to "Structure of data for LOAD correction" on page 104.

The procedure to select the definition method of the LOAD correction standard value (LOAD correction reference value) is given below.

Step 1. Press **[Meas Setup]**.

Step 2. Press the **CORRECTION** softkey.

Step 3. Use the cursor keys to select the **LOAD REF** field.

Step 4. Use the following softkeys:

Softkey	Function
SINGLE	Defines a single LOAD correction standard value commonly applied to all channels.
MULTI	Defines a LOAD correction standard value for each channel.

Measuring OPEN/SHORT/LOAD correction data

The procedure to measure OPEN/SHORT/LOAD correction data for multi-correction is the same as that for the usual correction data, except that you need to select a proper channel before the measurement. For more information, refer to "Obtaining Correction Data" on page 98.

When you measure the OPEN/SHORT/LOAD correction data with the multi-correction function ON, the measured value is stored as the correction data for the channel selected at the time of measurement. For information on the structure of the correction data, refer to "Structure of data for OPEN correction" on page 98, "Structure of data for SHORT correction" on page 100, and "Structure of data for LOAD correction" on page 104.

Checking OPEN/SHORT/LOAD correction data

The procedure to check OPEN/SHORT/LOAD correction data for multi-correction is the same as that for the usual correction data, except that you need to select a proper channel before the measurement. For more information, refer to "Checking Displaying/Setting Up Correction Data" on page 110.

Input/Output Signal Pin Assignment

Figure 9-2 shows the pin assignment of the input/output signals of the scanner interface connector. Table 9-1 gives a description of the input/output signals.

NOTE	A slash (/) symbol preceding signal names means that they are negative logic (active low).

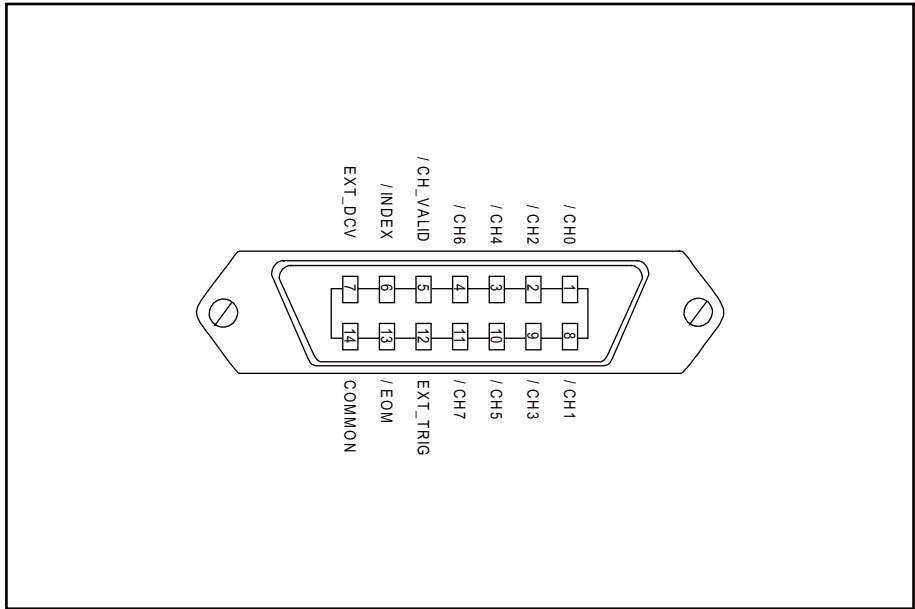Figure 9-2   Pin assignment of the scanner interface connector

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Table 9-1   Description of input/output signals of the scanner interface

Pin number	Signal name	Input/ Output	Description
1	/CH0	Input	Channel number selection signal (8-bit binary input). Selects the correction data for each channel of the scanner. The most significant bit is /CH7 (pin number 11). The least significant bit is /CH0 (pin number 1).
2	/CH2		
3	/CH4		
4	/CH6		
5	/CH_VALID	Input	Channel number identification signal. If the /CH_VALID signal is LOW, a trigger will set the channels of the E4981B to the channel numbers specified by the signals from /CH0 to /CH7.

Table 9-1   Description of input/output signals of the scanner interface

Pin number	Signal name	Input/ Output	Description
6	/INDEX	Output	Analog measurement end signal. When an analog measurement finishes, this becomes LOW. When this signal is received, you can change the channel of the scanner. You cannot obtain the measured data until the /EOM signal is received.
7	EXT_DCV	Input	External power input. Supplies the voltage to the output signals (/INDEX and /EOM) and input signals (EXT_TRIG, /CH0 - /CH7, and /CH_VALID). The input voltage range is between +5 V and +15 V.
8	/CH1		Channel number selection signal (8-bit binary input). Selects the correction data for each channel of the scanner. The most significant bit is /CH7 (pin number 11). The least significant bit is /CH0 (pin number 1).
9	/CH3		
10	/CH5		
11	/CH7		
12	EXT_TRIG	Input	External trigger signal. This is available when the trigger mode is set to the external trigger (Ext). The trigger is generated at the rising edge of a pulse. When this trigger pin is not used, the pin should be connected with GND (LO).
13	/EOM	Output	Measurement cycle end signal. When a series of measurement processes finishes and the measured data becomes available, this becomes LOW.
14	COMMON	–––	Common pin for the external DC voltage EXT_DCV (pin number 7).

Timing Chart

Figure 9-3 shows the timing chart. The time periods of T1-T5 in the figure are described in the following table.

		Minimum value	Typical value
T1	Trigger pulse width	1 µs	-
T2	Trigger response time of /INDEX and /EOM	-	60 µs
T3	Channel number input hold time	-	0 µs
T4	Channel number input setup time	-	0 µs
T5	Trigger wait time	-	0 µs

Figure 9-3   Timing chart of the scanner interface

Ch(n)   : Channel Number at Nth measurement
Ch(n+1) : Channel Number at (N+1)th measurement
Ch(n+1) : Channel Number at (N-1)th measurement
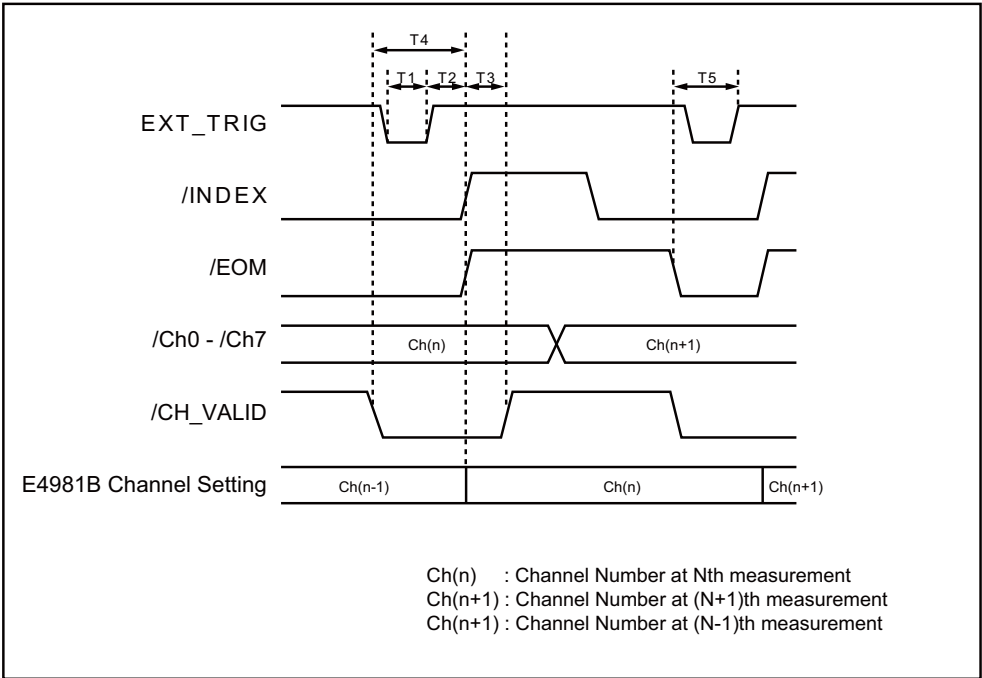
Electrical Characteristics

Output signal

The output signals (/INDEX and /EOM) are available as open collector outputs with photo coupler isolated. You can obtain each voltage output by connecting a pull-up resistor (refer to Table 9-2) to the exterior of the E4981B.

Table 9-2   Guide for pull-up resistor values

Pull-up voltage [V]	Resistance value [Ω]	Typical resistance	
		Resistance value [Ω]	Keysight part number
5	1.7 k (5 V/3 mA)	1.78 k	0757-0278
9	3.0 k (9 V/3 mA)	3.16 k	0757-0279
12	4.0 k (12 V/3 mA)	4.22 k	0698-3154
15	5.0 k (15 V/3 mA)	5.11 k	0757-0438

Table 9-3 shows the electrical characteristics of the output signals. Figure 9-4 shows the circuit diagram of the output signals.

Table 9-3   Electrical characteristics of the scanner interface output signals

Output signal	Output voltage [V]		Maximum current [mA]
	LOW	HIGH	
/INDEX, /EOM	0 - 0.5	EXT_DCV[1]	6

1. EXT_DCV: +5 V – +15 V

Figure 9-4   Circuit diagram of the scanner interface output signals
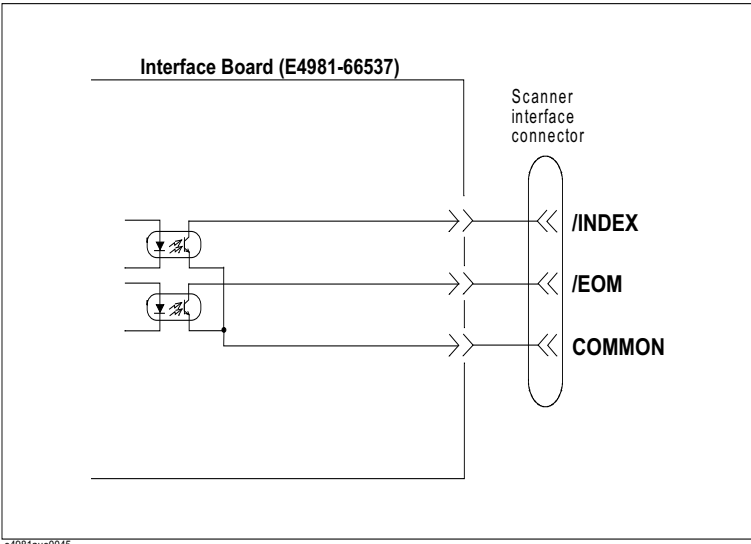
Input signal

Each input signal is connected to the cathode side of the photo coupler LED. The anode side of the LED is connected to the drive source voltage.

Table 9-4 shows the electrical characteristics of the input signals. Figure 9-5 and Figure 9-6 show the circuit diagram of the input signals. The amount of current flowing through the LED depends on the setups of the drive source voltage, and the external trigger (EXT_TRIG) signal resistance setup switch (S1, S2).

The S1, S2 switches belongs to electrical switches that can be control by the following SCPi command **:SYSTem:SCANner:TRIGger:VOLTage <para>**

Table 9-4   Electrical characteristics of the scanner interface input signals

Input signal	Input voltage [V]		Input current (LOW) [mA] (typical)		
			Pull-up source voltage: EXT_DCV		
	LOW	HIGH	5 V	9 V	15 V
/CH0 - /CH7, /CH_VALID	0 - 1	EXT_DCV	4.8	13.3	17.0
EXT_TRIG			3.7	4.7	6.0

The current can be calculated by the following formula:
$I = (DCV-Vf-Low)/R$
Low = 0 V
EXT_TRIG Vf = 1.3 V (typical)
\CH0 -\CH7 \CH_VALID Vf = 1.1 V (typical)

Figure 9-5   Circuit diagram of scanner interface input signals (channel control signals)
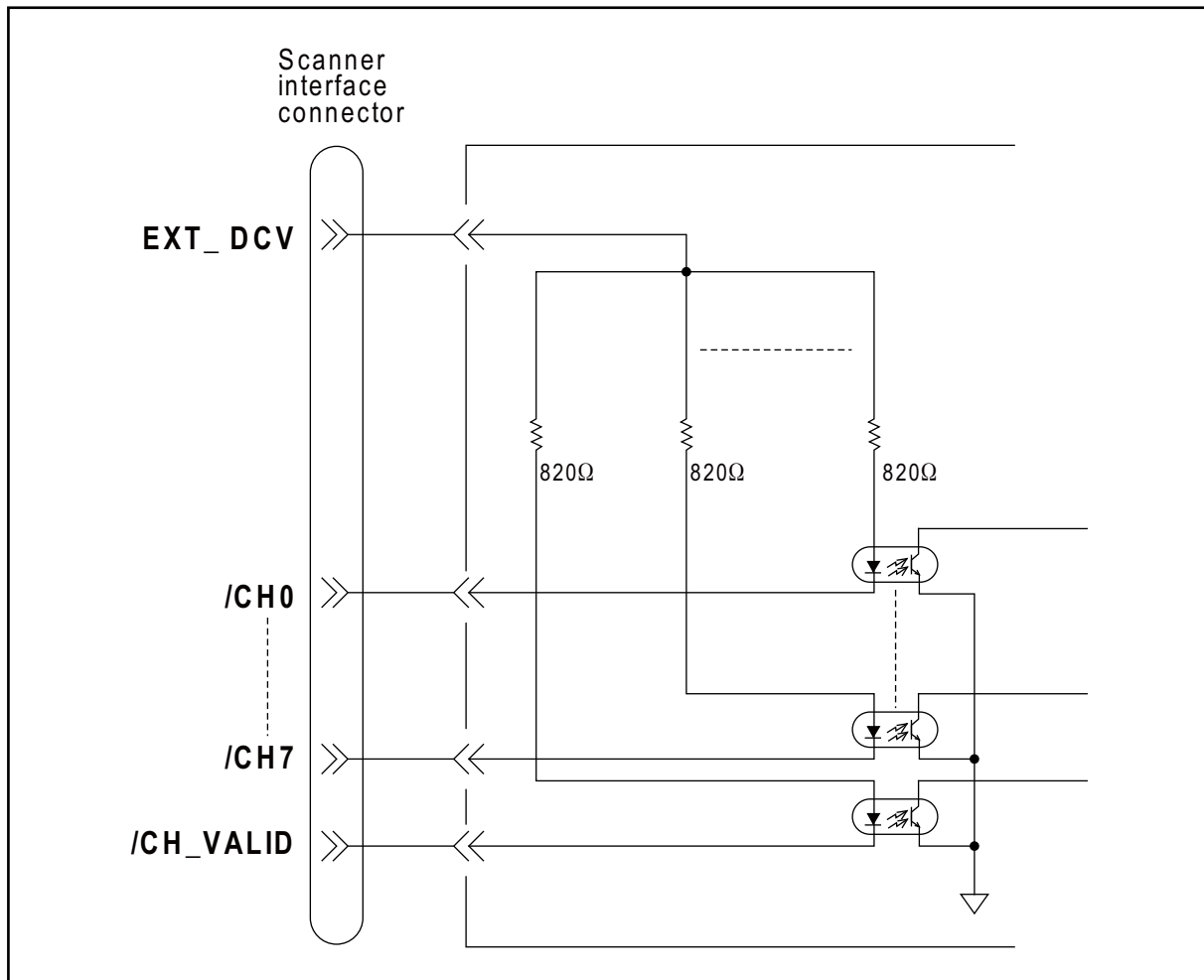
Figure 9-6   Circuit diagram of scanner interface input signals (external trigger signal)
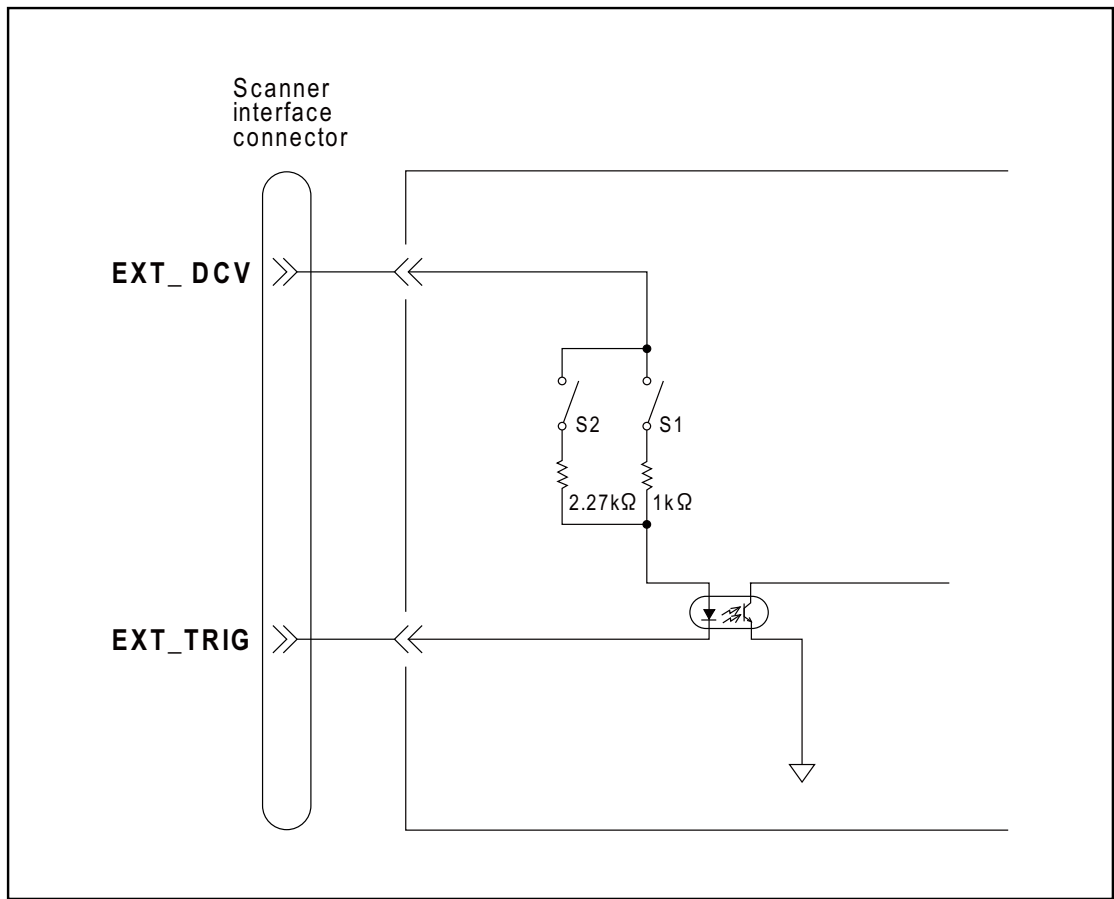
Table 9-5   Selection of scanner input trigger voltage

	:SYSTem:SCANner:TRIGger:VOLTage ‹para›	
	5 V ~ para | 9 V	9 V ~ para | 15 V
S1	ON	OFF
S2	OFF	ON

NOTE   The S1, S2 switches belongs to electrical switches that can be control by the following SCPi command **:SYSTem:SCANner:TRIGger:VOLTage ‹para›**

When the source voltage is between 5 V - 9 V, switch S1 is ON (closed) and current flows through the input signal resistance of 1 kΩ.

When the source voltage is between 9 V - 15 V, switch S2 is ON (closed) and current flows through the input signal resistance of 2.27 kΩ.

NOTE If the parameter set is out of range, an error is generated.

Power source

You can use only the external power source (EXT_DCV). Set its power output within the following voltage range.

	Voltage range [V]
EXT_DCV	+5 to +15

Control/Check the Scanner Interface for Maintenance

To control/check the Scanner interface, the Keysight E4981B provides several test commands related to various operations of scanner interface. This section explains the various test commands available in E4981B to check/trouble the scanner interface.

Starting Scanner interface test

Scanner interface can be set into test mode by using the :TEST:SCANner:MODE command. When this command value is set to ON, the scanner interface pin signal value can be controlled/read by :TEST:SCAN:xxxx commands.

Using Scanner interface test commands

After setting the :TEST:SCANner:MODE command value to ON, the following commands can be used to control/read the scanner interface pin signal value:

- :TEST:SCANner:CH sets the Scanner Channel No.

- :TEST:SCANner:EOM sets the Scanner End of Measurement (EOM) status to HIGH/LOW.

- :TEST:SCANner:INDex sets the Scanner Index value to HIGH/LOW.

- :TEST:SCANner:VALid? gets the Scanner/CH_VALID signal status as HIGH/LOW.

- :TEST:SCANner:TRIGger? gets the Scanner Trigger signal status as HIGH/LOW.

NOTE For more information about Scanner Test commands, refer to the *Keysight E4981B Programming Manual*.

Ending Scanner interface test

When the Scanner interface test is finished, close the E4981B Scanner interface test mode by setting :TEST:SCANner:MODE command value to OFF so that scanner interface pin signal is generated according to the actual measurement result.

10 Precautions for Use and Daily Checks

This chapter describes precautions to take when using the E4981B and explains how to perform regular maintenance on the device.

Precautions for Use

This section describes the precautions to take in using the E4981B.

Avoiding improper input from the front panel (key lock function)

When you do not need to operate the keys on the front panel, you can disable entry from the front panel keys (key lock function) to avoid improper input caused by touching the front panel keys accidentally.

The ON/OFF state of the key lock function is indicated by whether **LOCK** is displayed in the status display area. When **LOCK** is displayed, as indicated by 1 in Figure 10-1, the function is ON.

Figure 10-1   ON/OFF display of the key lock function (when ON)
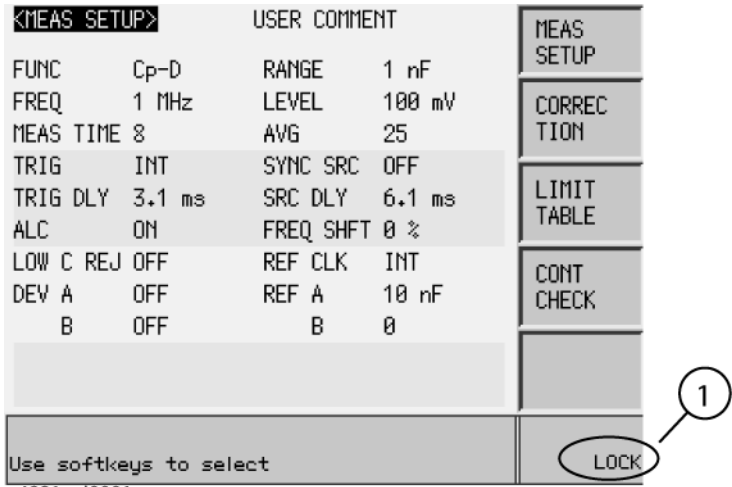
Setup procedure

Step 1. Press the **[Local/Lock]** key on the front panel.

Step 2. Confirm that **LOCK** is displayed in the status display area in the lower-right corner of the LCD display.

NOTE	During the cable correction, correction or reference measurement all the key operations are invalid except the **ABORT** softkey and **[Local/Lock]**.

Daily Checks (Executing the Self-test)

This section describes the daily checks required for the E4981B.

Self-test at power on

The E4981B provides a function that executes a self-test automatically at power-on. When the self-test detects any malfunction at power-on, an error message "Power on test failed" is displayed in the system message area. If this happens, refer to "Check Items When Trouble Occurs" on page 173.

Executing the self-test from the front panel

The self-test of the E4981B can be executed from the front panel. The steps are given below.

Self-test procedure

Step 1. Press the **[System]** key.

Step 2. Press the **SELF TEST** softkey.

Step 3. Use the cursor key to select the right of "TEST No." (1 in Figure 10-2)

Step 4. Select the number corresponding to the test that you want to perform by using the **INCR+** and **DECR-** softkeys.

Step 5. Press the **EXECUTE** softkey (2 in Figure 10-2)

Step 6. Press the **TEST START** softkey (2 in Figure 10-2) to execute the selected test item.

Figure 10-2   Self-test screen and procedure
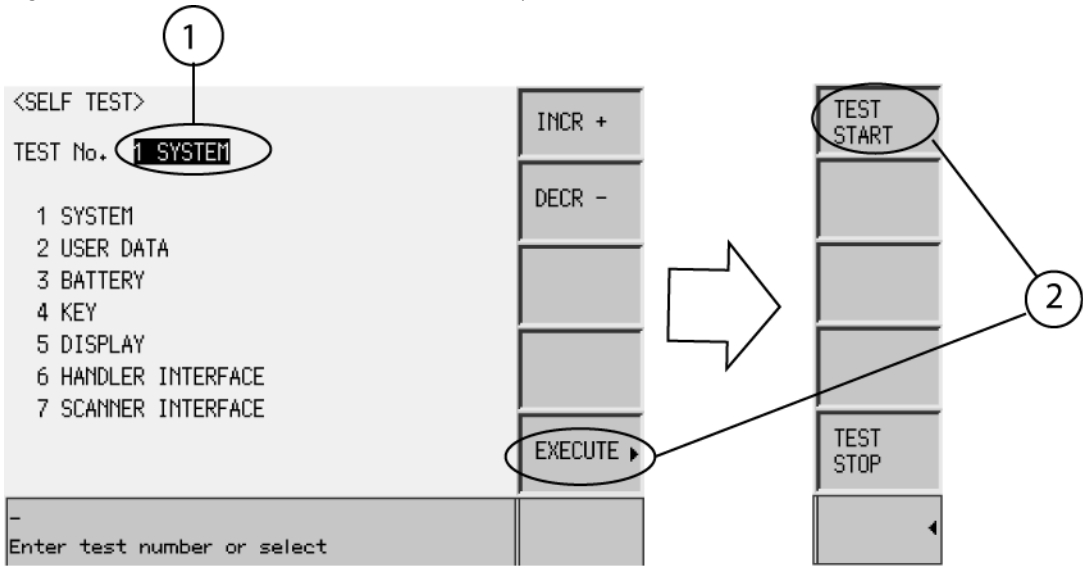
The following test items can be checked by using the self-test.

Self-test items

1 SYSTEM	Checks the system, A1/A2/A3 boards, and system correction data.
2 USER DATA	Checks the settings of GPIB and LAN, instrument setup information, correction data, and scanner's correction data.
3 BATTERY	Checks the internal batteries.
4 KEY	Checks the front panel keys. (Visual confirmation only; no pass/fail result shown on screen.)
5 DISPLAY	Checks the LED/LCD on the front panel. (Visual confirmation only; no pass/fail result shown on screen.)
6 HANDLER INTERFACE	Checks the handler interface. (Visual confirmation only; no pass/fail result shown on screen.)
7 SCANNER INTERFACE	Checks the scanner interface. (Visual confirmation only; no pass/fail result shown on screen.)

NOTE	For more information, on self test of Handler and Scanner Interface refer to the *E4981B Service Guide*.

Cleaning this Instrument

This section explains how to clean the instrument.

WARNING   **To protect yourself from electrical shock, be sure to unplug the power cable from the outlet before cleaning the instrument.**

Never clean the internal components of the instrument.

Unknown terminals

Unknown terminals on the front panel of the E4981B are fitted with BNC Type connectors (m).Stains or other damage to these connectors would significantly affect the measurement accuracy. Please give attention to the following precautions.

· Always keep the connectors free from stains or dust.

· Do not touch the contact surface on the connectors.

· Do not plug damaged or scratched connectors into the test ports.

· Use compressed air to clean connectors. Do not use abrasives under any circumstance.

Cleaning parts other than unknown terminals

To remove stains on parts other than the unknown terminals, wipe them gently with a soft cloth that is dry or one that is wet with a small amount of water and wrung tightly.

Updating the Firmware

Firmware update is available for E4981B. When a new firmware is released, it will be posted on the Keysight website. Please refer to https://www.keysight.com/support/e4981b for the firmware update and details.

Cautions Applicable to Requesting Repair, Replacement, Regular Calibration, Etc.

Caution when sending the unit

If it is necessary to send the unit to a Service Center of Keysight Technologies, please follow the instructions below.

Equipment to be sent

When requesting repair or regular calibration of the unit at our Service Center, send only the E4981B main unit without any installed option. Unless specifically instructed, it is not necessary to send accessories.

Packing

Use the original package and shock absorbers, or equivalent antistatic packing materials, when sending the unit.

Shipping address

For the address of the nearest Keysight Technologies Service Center, direct inquiries to www.keysight.com/support.

Recommended calibration period

The recommended interval between calibrations of this instrument is one year. Keysight recommends that you request our Service Center to perform regular calibration every year.

11 Troubleshooting

This chapter lists items to check if you encounter a problem while using the Keysight E4981B. All of these items should be carefully investigated before you determine that your E4981B instrument is faulty.

Check Items When Trouble Occurs

The instrument does not start up (nothing is displayed).

· Check if the power cable is disconnected.

· Check if the fuse is blown.

If normal operation does not resume after taking the above measures, there is the possibility of a failure. Unplug the power cable immediately and contact Keysight Technologies' Customer Contact, listed at www.keysight.com/support, or the company from which you bought the device.

The system starts up, but the normal measurement screen does not appear (Service Mode)

The Service Mode is a state that occurs when the power-on test fails. Here, the characters on the display turn yellow and all of the front panel keys are unavailable.

· Confirm that the power-on test or a self test has failed.

When the power-on test at start-up fails, the error message "Power on test failed" is displayed in the system message area.

For details on the Service Mode, refer to the *Service Guide*.

When the normal measurement screen does not appear, there is the possibility of a failure. Contact Keysight Technologies' Customer Contact, listed at www.keysight.com/support, or the company from which you bought the device.

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An overload message (OVLD) is displayed (when nothing is connected to the UNKNOWN terminal).

This is normal operation. An overload is often detected by the E4981B when nothing is connected to the UNKNOWN terminal.

Beeping persists when turning ON the comparator function.

- Check if the limit range is set up properly.

  When the beep is set up to sound when the comparator function is ON (initial setup), the beep sounds on every completion of measurement if the limit range is set up improperly.

The front panel keys are unavailable.

o Check if the keys are locked.

  When the keys are locked, **LOCK** is displayed in the status display area in the lower-right corner of the screen.

  Press the **[Local/Lock]** key to unlock the keys.

| **NOTE** | If the keys have been locked through the handler interface, you cannot unlock them by using the front panel keys. Set the /KEY_LOCK signal of the handler interface to HIGH. |

- Check if the instrument is in the remote mode.

  If the E4981B is in the remote mode, **RMT** is displayed in the status display area in the lower-right corner of the screen.

  Press the **[Local/Lock]** key to clear the remote mode.

The measured value is abnormal.

- The measurement of correction data may have failed.

  Measure the correction data again. For how to measure the correction data, refer to "Obtaining Correction Data" on page 98.

- When the MULTI correction is ON, check that the channel and the definition method of the LOAD standard value are selected correctly.

Saving to USB memory fails

Some USB memory does not work with the E4981B. For more information on USB memory, refer to "USB interface port" on page 193.

An error message or warning message is displayed.

For information on error messages and warning messages, refer to Appendix D.

Check Items When Trouble Occurs During Remote Control

The instrument does not respond to the external controller or malfunctions.

- Check that the GPIB address for a GPIB connection or the IP address for a LAN connection is set up correctly on the SYSTEM CONFIG screen of the E4981B.

- Check that the GPIB cable, USB cable, and LAN cable are not disconnected.

- Check whether another instrument connected by the GPIB or LAN cable has the same GPIB address or IP address.

- Check that the GPIB cable connection is not looped.

You cannot read out the measured value.

- Check that the data transfer format is set up correctly.

An error message is displayed.

- Check that the program is correct.

  For details on error messages, refer to **Appendix D**.

A Manual Changes

This appendix contains the information required to adapt this manual to earlier versions or configurations of the Keysight E4981B than that indicated by the current printing date of this manual. The information in this manual applies directly to the E4981B model that has the serial number prefix listed on the title page of this manual.

Manual Changes

If your E4981B has firmware or serial number shown in Table A-1 and Table A-2, see the corresponding manual changes.

Table A-1   Manual changes by serial number

Serial Prefix or Number	Make Manual Changes

Table A-2   Manual changes by firmware version

Version	Make Manual Changes

The ten-character serial number is stamped on the serial number plate on the rear panel.

NOTE	You can check the firmware version by pressing the [**System**] key.

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Keysight E4981B 120 Hz/1 kHz/1 MHz Capacitance Meter

B Information for Replacing 4268A, 4288A with E4981B

This appendix provides a functional comparison between the Keysight 4268A and 4288A with Keysight E4981B. See Keysight 4268A, 4288A *Operation Manual* for more detailed information on the 4268A, 4288A.

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Functional Comparison between 4268A, 4288A, and E4981B

Table B-3 compares the functions of the 4268A, 4288A, and E4981B.

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function			E4981B	4268A	4288A
Measurement condition	Reset		Can be executed using the front panel or SCPI command.	Can be executed using the front panel or GPIB command.	Can be executed using the front panel or GPIB command.
	Measurement parameter setup		Selectable from Cp-D, Cp-Q, Cp-G,Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.	Selectable from Cp-D, Cp-Q, Cp-G,Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.	Selectable from Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.
	Measurement signal setup	Frequency	Selectable from 120 Hz, 1 kHz or 1 MHz.	Selectable from 120 Hz or 1 kHz.	Selectable from 1 kHz or 1 MHz.
		1 MHz frequency shift	Can be changed to +2%, −2%, +1%, −1%, or 0% .	N/A	Can be changed to +2%, +1%, or −1% .
		OSC Level	Can be set up within the range of 0.1 to 1 V in steps of 0.01 V.	Can be set up within the range of 0.1 to 1 V in steps of 0.01 V.	Can be set up within the range of 0.1 to 1 V in steps of 0.1 V.
		Level monitor function	AC Level monitor is always ON.	Voltage value and current value can be monitored.	Voltage value and current value can be monitored.
		Signal level compensation (SLC)	Available at 120 Hz or 1 kHz.	ALC is available	N/A
		Output mode	Continuous, Synchronous.	Continuous, Synchronous.	N/A
	Measurement range mode		Selectable from the auto range or hold range.	Selectable from the auto range or hold range.	Selectable from the auto range or hold range.
	Measurement time (integration time)	Mode	Selectable from Short, Medium, or Long (Using SCPI command only).	Selectable from Short, Medium, or Long.	Selectable from Short or Long.
		Time	Selectable from 1, 2, 4, 6, or 8.	N/A	N/A
	Averaging count		Can be set up freely within the range of 1 to 256.	Can be set up freely within the range of 1 to 256.	Can be set up freely within the range of 1 to 256.
	Cable length setup		Selectable from 0 m, 1 m, or 2 m.	Selectable from 0 m, 1 m, or 2 m.	Selectable from 0 m, 1 m, or 2 m.
	Source delay setup		Can be set within 0 - 1 sec in steps of 100 µs.	Can be set within 0 - 1 sec in steps of 1 µs.	N/A

Table B-3 Functional comparison between 4268A, 4288A, and E4981B

Function		E4981B	4268A	4288A
	Trigger delay setup	Can be set within 0 - 1 sec in steps of 100 µs.	Can be set within 0 - 1 sec in steps of 1 ms.	Can be set within 0 - 1 sec in steps of 1 ms.
	Analog convergence waiting time setup	Can be setup within the range of 0 to 1 s in steps of 100 µs.	N/A	N/A
Correction	OPEN correction ON/OFF	OPEN correction, SHORT correction, and LOAD correction can be turned ON/OFF separately.	Entire correction ON/OFF.	OPEN correction, SHORT correction, and LOAD correction can be turned ON/OFF separately.
	SHORT correction ON/OFF		Entire correction ON/OFF.	
	LOAD correction ON/OFF		LOAD correction can be turned ON/OFF separately.	
	OPEN correction data parameter format	Selectable from G-B, or Cp-G.	N/A	Selectable from G-B, or Cp-G.
	SHORT correction data parameter format	Selectable from R-X, or Ls-Rs.	N/A	Selectable from R-X, or Ls-Rs.
	Definition parameter of the value for LOAD standard correction	Selectable from Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.	Selectable from Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.	Selectable from Cp-D, Cp-Q, Cp-G, Cp-Rp, Cs-D, Cs-Q, or Cs-Rs.
	Measurement Range on Load correction	Auto Range can be set ON/OFF when LOAD measurement is done.	N/A	Auto Range can be set ON/OFF when LOAD measurement is done
Correction data	Measurement	Measures the OPEN/SHORT/LOAD correction and turns on the correction function.	Measures the OPEN/SHORT/LOAD correction and turns on the correction function	Measures the OPEN/SHORT/LOAD correction and turns on the correction function
	Setup and read out	Can setup and readout the correction data by both SCPI command and front panel.	GPIB command is available for readout and setup.	GPIB command is available for readout and setup.
	Offset correction	Can be turned ON/OFF for both the primary and secondary parameters simultaneously.	N/A	Can be turned ON/OFF for both the primary and secondary parameters simultaneously.

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function		E4981B	4268A	4288A
Scanner (multi correction)	ON/OFF	Can be turned ON/OFF.	Can be turned ON/OFF.	Can be turned ON/OFF.
	Channel setup	256 channels are available.	64 channels are available (option).	64 channels are available.
	LOAD standard correction method setup	A single reference value is shared by all of the channels, or a different reference value is used for each channel.	A single reference value is shared by all of the channels, or a different reference value is used for each channel.	A single reference value is shared by all of the channels, or a different reference value is used for each channel.
Cable Correction	Correct the error of individual test cable	Available	N/A	N/A
Trigger	Trigger mode	Selectable from the internal trigger (INT), external trigger (EXT), GPIB/LAN/USB trigger (BUS), or manual trigger (MAN).	Selectable from the internal trigger (INT), external trigger (EXT), GPIB trigger (BUS), or manual trigger (MAN).	Selectable from the internal trigger (INT), external trigger (EXT), GPIB trigger (BUS), or manual trigger (MAN).
	External Trigger Slope	Selectable from POSitive or NEGative slope for BNC connector.	N/A	N/A

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function			E4981B	4268A	4288A
Measurement Data	Data transfer format setup	Binary/ASCII	Selectable from ASCII format or binary (64-bit) format.	Selectable from ASCII format or binary (64-bit) format.	Selectable from ASCII format or binary (64-bit) format.
		Binary data byte order	Selectable from NORmal or SWAPped transfer order.	N/A	N/A
		ASCII long format	Can turn ON/OFF the long format.	N/A	N/A
	Data readout	Measurement result	Measurement status, measured primary/secondary parameter value, comparator sorting result, BIN count value, or measurement signal level monitor value.	Measurement status, measured primary/secondary parameter value, comparator sorting result, BIN count value, or measurement signal level monitor value.	Measurement status, measured primary/secondary parameter value, comparator sorting result, BIN count value, or measurement signal level monitor value.
	Data buffer setup		Data for 1000 measurements can be outputted in batch.	Data for 2000 measurements can be outputted in batch.	Data for 1000 measurements can be outputted in batch.
Comparator	ON/OFF		Can turn ON/OFF the comparator function.	Can turn ON/OFF the comparator function.	Can turn ON/OFF the comparator function.
	Limit range reset		Clears the ON/OFF state and range of every limit range.	N/A	Clears the ON/OFF state and range of every limit range.
	Primary parameter limit range setup	ON/OFF	Can turn ON/OFF BIN1 to BIN9 of the comparator function.	Can turn ON/OFF BIN1 to BIN9 of the comparator function.	Can turn ON/OFF BIN1 to BIN9 of the comparator function.
		Range setup	Can set low and high limit ranges of BIN1 to BIN9.	Can set low and high limit ranges of BIN1 to BIN9.	Can set low and high limit ranges of BIN1 to BIN9.
		Limit range designation method (mode selection)	Selectable from DEV/ABS/PCNT	Selectable from DEV/ABS/PCNT	Selectable from DEV/ABS/PCNT
		Reference (nominal) value	Specifies the reference value when specifying the primary parameter limit range for the comparator function.	Specifies the reference value when specifying the primary parameter limit range for the comparator function.	Specifies the reference value when specifying the primary parameter limit range for the comparator function.

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function			E4981B	4268A	4288A
Comparator	Secondary parameter limit range setup	ON/OFF	Can turn ON/OFF sorting judgement for measurement result of secondary parameter when using the comparator function.	Can turn ON/OFF sorting judgement for measurement result of secondary parameter when using the comparator function.	Can turn ON/OFF sorting judgement for measurement result of secondary parameter when using the comparator function.
		Range setup	Can set low and high limit ranges of BIN1 to BIN9.	Can set low and high limit ranges of BIN1 to BIN9.	Can set low and high limit ranges of BIN1 to BIN9.
	AUX BIN function ON/OFF		Can turn ON/OFF the AUX BIN sorting of comparator function.	Can turn ON/OFF the AUX BIN sorting of comparator function.	Can turn ON/OFF the AUX BIN sorting of comparator function.
	Low C reject function		The detection limit value can be freely set within the range of 1 to 10%.	N/A	The detection limit value can be freely set within the range of 1 to 10%.
	BIN count function	ON/OFF	Can turn ON/OFF the BIN counter function.	Can turn ON/OFF the BIN counter function.	Can turn ON/OFF the BIN counter function.
		Resets count values	Clears the count value of each BIN to 0.	Clears the count value of each BIN to 0.	Clears the count value of each BIN to 0.
		Readout of count values	Reads the value of BIN1 to BIN9, AUX_BIN, and OUT_OF_BINS.	Reads the value of BIN1 to BIN9, AUX_BIN, and OUT_OF_BINS.	Reads the value of BIN1 to BIN9, AUX_BIN, and OUT_OF_BINS.
		Readout of count value of overload	Reads out each overload count value.	N/A	Reads out each overload count value.
		Readout of count values for each channel	Reads out the count value of BIN1 to BIN9, OUT_OF_BINS, and AUX_BIN of selected channel.		Reads out the count value of BIN1 to BIN9, OUT_OF_BINS, and AUX_BIN of selected channel.
		Readout of count value of overload for each channel	Reads out the overload count value of the selected channel.		Reads out the overload count value of the selected channel.
Measurement signal monitor	Current/ Voltage monitor	Monitor value readout	Always ON	Can be turned ON/OFF.	Can be turned ON/OFF.

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function		E4981B	4268A	4288A
Save/Recall	Save/Recall	10 setups can be stored in Flash memory and 10 setups can be stored in external USB memory.	10 setups can be stored in EEPROM.	10 setups can be stored in EEPROM.
	Delete	Deletes the states from the memory.	N/A	N/A

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function		E4981B	4268A	4288A
Display	ON/OFF	Can enable/disable the display of the measurement result.	Can enable/disable the display of the measurement result.	Can enable/disable the display of the measurement result.
	Number of digits setup	N/A	Selectable from 4, 5, or 6 digits.	Selectable from 4, 5, or 6 digits.
	Fixed point display setup	Selectable from fixed point display or floating point display.	N/A	Selectable from fixed point display or floating point display.
	Deviation measurement mode setup	Display mode	For the measured primary/ secondary parameter value: Selectable from Deviation measurement mode OFF (the measured value is displayed as it is) or Deviation measurement mode ON (displayed in a deviation relative to any reference value).	For the measured primary/ secondary parameter value: Selectable from Deviation measurement mode OFF (the measured value is displayed as it is) or Deviation measurement mode ON (displayed in a deviation relative to any reference value).	For the measured primary/ secondary parameter value: Selectable from Deviation measurement mode OFF (the measured value is displayed as it is) or Deviation measurement mode ON (displayed in a deviation relative to any reference value).
		Reference value	Sets the reference value for primary/secondary parameter.	Sets the reference value for primary/secondary parameter.	Sets the reference value for primary/secondary parameter.
	Setup of displayed page	Only 1 display format/area.	Only 1 display format but 2 distinct display areas: the main display area on the left shows measured values and instrument settings, which are indicated by the _ symbol; the display area on the right can be used to show a variety of other measurement settings.	Only 1 display format but 2 distinct display areas: the main display area on the left shows measured values and instrument settings, which are indicated by the _ symbol; the display area on the right can be used to show a variety of other measurement settings.
	Reset of displayed error/message	Clears errors/caution messages from the display.	N/A	N/A
	Input the comment lines	Can enter arbitrary comment containing upto 30 ASCII characters.	N/A	N/A

Table B-3   Functional comparison between 4268A, 4288A, and E4981B

Function			E4981B	4268A	4288A
Display	Output the displayed image to controller/external USB memory		Outputs the screen image display in gif format.	N/A	N/A
Contact Check	ON/OFF		Available	Available	N/A
Key lock	ON/OFF		Available	Available	Available
Beeper	ON/OFF		Can turn ON/OFF the beep output.	Can turn ON/OFF the beep output.	Can turn ON/OFF the beep output.
	Beep mode setup		Selectable from beep tone 1 to 5.	N/A	N/A
	Beep		Produces beep sound.	N/A	N/A
	Comparator beep condition		Sets the condition for producing beep sound.	Sets the condition for producing beep sound.	Sets the condition for producing beep sound.
External Connector	GPIB Address		Sets the GPIB address.	N/A	N/A
	LAN setup	Fixed IP address, gateway, subnet mask	Sets the static IP address, gateway address and subnet mask address.	N/A	N/A
		AUTO IP	Selectable from AUTO/MANUAL IP configuration setup method.	N/A	N/A
	LAN address, gateway, subnet mask status		Returns the value of current IP address, gateway address and subnet mask address.	N/A	N/A
	MAC Address		Returns the MAC address.	N/A	N/A
	Reconnect after reset to factory state		Presets the network settings and restarts the network.	N/A	N/A
	Reconnection		Restarts the network.	N/A	N/A
	Socket Control Port number		Returns the SOCKET control port number.	N/A	N/A
Internal Clock	Date, time, time zone		Sets the date, time in the internal clock and configures the time zone.	N/A	

C   Initial Settings

This appendix provides initial settings, settings that can be saved/recalled, and settings that can be backed up.

Initial Settings, Settings That Can Be Saved/recalled, Settings That Can Be Backed Up

The columns of Table C-1 show the following items.

- Initial settings (factory settings)

- Settings reset from the front panel or the GPIB by the **:SYStem:PRESet** command

- Settings reset from the GPIB by the ***RST** command

- Settings that can be saved/recalled

  Table C-1 uses the following symbols.

    ^: Settings that can be saved/recalled

    ×: Settings that cannot be saved/recalled

- Settings that can be backed up

  Table C-1 uses the following symbols.

    ^: Settings that can be backed up in the Flash memory

    ×: Settings that cannot be backed up

The symbol "]" in Table C-1 indicates that the value is the same as that indicated to the left.

Table C-1   Initial settings, settings that can be saved/recalled, settings that can be backed up

Setting items			Initial settings (factory settings)	Reset		Save/ Recall	Backup
				Front panel key (:SYST:PRES)	*RST		
Measurement parameter	Primary parameter		CP	]	]	^	×
	Secondary parameter		D	]	]	^	×
Measurement signal	Frequency		1 kHz	]	]	^	×
	1 MHz frequency shift		0%	No effect	]	×	^
	Level		1 V	]	]	^	×
	Signal level compensation (SLC)		OFF	]	]	^	×
	Output mode		CONT	]	]	^	×
Measurement range	Auto		ON	]	]	^	×
	Range setup		100 nF	]	]	^	×
Measurement time mode	N		6	]	]	^	×
Averaging	ON/OFF		ON	]	]	^	×
	Number of counts		1	]	]	^	×
Cable length			0	No effect	0	×	^
Analog convergence waiting time setup			1.67 m	]	]	×	×
			1 m	]	]	×	×
			270 μ	]	]	×	×
Trigger	Triggering			No effect		×	×
	Mode		INTernal	]	]	^	×
	Trigger delay time		0	]	]	^	×
	Trigger system	Reset		No effect		×	×
		Initiates		No effect		×	×
		Continuous activation ON/OFF	ON	]	OFF	^	×
	BNC External trigger slope		POSitive	No effect	]	×	^
OPEN correction	ON/OFF		OFF	No effect	OFF	×	^
	Parameter type		GB	No effect	GB	×	^
SHORT correction	ON/OFF		OFF	No effect	OFF	×	^
	Parameter type		RX	No effect	RX	×	^

Table C-1   Initial settings, settings that can be saved/recalled, settings that can be backed up

Setting items		Initial settings (factory settings)	Reset		Save/ Recall	Backup
			Front panel key (:SYST:PRES)	*RST		
LOAD correction	ON/OFF	OFF	No effect	OFF	×	^
	Measurement range	ON	No effect	ON	×	^
	LOAD standard definition — Definition value	100 nF	No effect	100 nF	×	^
	LOAD standard definition — Parameter type	CPD	No effect	CPD	×	^
Cable correction	Correction data — OPEN	-	No effect	]	×	×
	Correction data — LOAD	-	No effect	]	×	×
	Correction data — 0m standard	-	No effect	]	×	×
	Correction coefficient clear	-	No effect	]	×	×
	Correction coefficient calculation and save	-	No effect	]	×	×
	ON/OFF on correction function	-	No effect	]	×	^
Offset correction	ON/OFF	OFF	No effect	OFF	×	^
	Data Setup	0	No effect	0	×	^
Multi correction	ON/OFF	OFF	No effect	OFF	×	^
	Channel setup	0	]	]	^	×
	LOAD standard definition method (Single/Multi)	OFF	No effect	OFF	×	^
Data transfer format	Binary/ASCII	ASCii	]	]	^	×
	Binary Data Byte order	NORmal	]	]	^	×
	ASCII Long format	OFF	]	]	^	×
Data buffer	Feeding target parameter	""	]	]	×	×
	Control (feed/not feed)	NEVer	]	]	×	×
	Buffer size — BUF1|BUF2	200	]	]	×	×
	Buffer size — BUF3	1000	]	]	×	×

Table C-1   Initial settings, settings that can be saved/recalled, settings that can be backed up

Setting items			Initial settings (factory settings)	Reset		Save/ Recall	Backup
				Front panel key (:SYST:PRES)	*RST		
Comparator		ON/OFF	OFF	]	]	^	×
	Limit range reset			No effect	]	×	×
	Limit range ON/OFF	Primary parameter	ON	]	]	^	×
		Secondary parameter	ON	]	]	^	×
	Limit range setting	Primary limit range setup	0	]	]	^	×
		Secondary limit range setup	0	]	]	^	×
		Primary Limit range designation method (mode selection)	ABS	]	]	^	×
		Primary Reference (nominal) value	0	]	]	^	×
	AUX BIN ON/OFF		OFF	]	]	^	×
	Low C reject	ON/OFF	OFF	]	]	^	×
		Limit value	0%	]	]	^	×
	BIN count	ON/OFF	OFF	]	]	^	×
		Reset Count value		No effect	]	×	×
		Readout of Count value	0	]	]	×	×
		Readout of Count value at overload	-	]	]	×	×
		Readout of Count value for each channel	0	]	]	×	×
		Readout of Count valueon overload per channel	-	]	]	×	×
Measurement Signal Monitor[1]	Current monitor	ON/OFF	ON	]	]	^	×
		Monitor value readout	-	No effect	]	×	×
	Voltage monitor	ON/OFF	ON	]	]	^	×
		Monitor value readout	-	No effect	]	×	×

Table C-1   Initial settings, settings that can be saved/recalled, settings that can be backed up

Setting items			Initial settings (factory settings)	Reset		Save/ Recall	Backup
				Front panel key (:SYST:PRES)	*RST		
Display	ON/OFF		ON	]	]	^	×
	Fixed point display	ON/OFF	OFF	]	]	^	×
		Value of the highest digit (Msd)	1 nF	]	]	^	×
	Deviation measurement mode	Primary parameter ON/OFF	OFF	]	]	^	×
		Primary parameter Mode	DEV	]	]	^	×
		Secondary parameter ON/OFF	OFF	]	]	^	×
		Secondary parameter Mode	DEV	]	]	^	×
		Reference value	0	]	]	^	×
	Page number of instrument setup display area		MEAS	]	]	^	×
	Input the comment line		""	]	]	^	×
	Output the displayed image to controller		-	No effect	]	×	×
Contact Check ON/OFF			OFF	]	]	^	×
Key lock ON/OFF			OFF	]	]	×	×
Beeper	ON/OFF		ON	]	]	^	×
	Mode		3	No effect	]	×	^
	Comparator Beeper condition		FAIL	]	]	^	×
Status Report Function	Clear			No effect	]	×	×
	Status Byte register value readout		-	No effect	]	×	×
	Service request enable register value		-	No effect	]	×	×
	Standard event status register	Register reading	-	No effect	]	×	×
		OPC ON		No effect	]	×	×
		Valid register setup	-	No effect	]	×	×
	Operation event status register	Clear		No effect	]	×	×
		Register reading	0	No effect	]	×	×
		OPC ON	0	No effect	]	×	×
		Valid register setup	0	No effect	]	×	×

Table C-1   Initial settings, settings that can be saved/recalled, settings that can be backed up

Setting items			Initial settings (factory settings)	Reset		Save/ Recall	Backup
				Front panel key (:SYST:PRES)	*RST		
External Controller	GPIB Address		17	No effect	]	×	^
	LAN setup	Fixed IP	"196.168.1.101"	No effect	]	×	^
		Fixed Gateway	"0.0.0.0"	No effect	]	×	^
		Fixed Subnet mask	"255.255.255.0"	No effect	]	×	^
		Auto IP	AUTO	No effect	]	×	^
	LAN status	Address	-	No effect	]	×	×
		Gateway	-	No effect	]	×	×
		Subnet Mask	-	No effect	]	×	×
	MAC Address		-	No effect	]	×	×
	Reconnect after reset to factory state			No effect	]	×	×
	Reconnection			No effect	]	×	×
	Socket port number		0	No effect	]	×	×
Internal Clock	Date		-	No effect	]	×	×
	Time		-	No effect	]	×	×
	Time zone		0	No effect	]	×	^

1. In E4981B the signal monitor is always ON.

D   Error Messages

The Keysight E4981B provides error messages to indicate its operating status. This appendix describes the error messages of the E4981B in alphabetical order.

Error Messages (Alphabetical Order)

Error messages are displayed in the lower row of the E4981B's display. You can read them out by using the SCPI command. This section provides a description of each error message and its remedy.

NOTE	Errors with a negative error number are basically general errors defined by IEEE488.2 for GPIB instruments. On the other hand, errors with a positive error number are defined specifically for the E4981B.

1 – 100

21   **1 MHz opt. not installed**

This error occurs when cable correction commands are sent to E4981B with Option 002, via GPIB/LAN/USB. This error is not generated with front panel operation.

A

1103   **A1 EEPROM write error**

An error is generated while writing data to A1 EEPROM.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

B

-168   **Block data not allowed**

A block data element has been received where the E4981B does not accept any block data element.

C

| 41 | **Correction Measurement Aborted** |

This error occurs when the correction data measurement is aborted.

| 1200 | **CPU bd FLASH ROM write error** |

An error is generated while writing data to FLASH.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

| 1201 | **CPU bd EEPROM write error** |

An error is generated while writing data to EEPROM.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

| -100 | **Command error** |

A comprehensive syntax error has occurred for which the E4981B cannot detect further details of the error. This error code simply indicates the occurrence of a command error that is defined in IEEE488.2,11.5.1.1.4.

| -140 | **Character data error** |

An error not included in the error numbers between -141 and -149 has occurred during the syntax analysis of a character data element.

| -148 | **Character data not allowed** |

Character data not allowed for this operation.

D

| -104 | **Data type error** |

The parser has recognized impossible data elements. For example, numeric value or string data is expected, but block data is sent.

| -222 | **Data out of range** |

A data element (that does not violate the standard) has been received out of the range defined for the E4981B.

| -230 | **Data corrupt or stale** |

The data is invalid or a newly initiated read operation has not been completed since the latest access.

E

-123 **Exponent too large**

The absolute value of the exponent has exceeded 32,000. (Refer to IEEE488.2,7.7.2.4.1.)

-170 **Expression error**

An error not included in the error numbers between -171 and -179 has occurred during the syntax analysis of equation data.

-178 **Expression data not allowed**

An equation data element has been received where the E4981B does not accept any equation data element.

-200 **Execution error**

A comprehensive execution error has occurred for which the E4981B cannot detect further details. This error code simply indicates the occurrence of an execution error that is defined in IEEE488.2,11.5.1.1.5.

F

1070 **Fan failed**

Cooling fan hardware failure is detected.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

G

-105 **GET not allowed**

A group execution trigger (GET) has been received in a program message. (Refer to IEEE488.2,7.7.)

H

-114 **Header suffix out of range**

The header suffix is out of range.

I

-101 **Invalid character**

Invalid characters have been found in the program message string. For example, in a correct program message ":CALC1:FORM CP", an ampersand (&) is inserted by mistake to give ":CALC1:FORM&CP".

-103 **Invalid separator**

The parser (syntax analysis program) expects a separator, but a character other than a separator has been sent. For example, although the correct way is to use ";" to separate two sent program messages such as ":CALC1:FORM CP;*OPC?", the semicolon (;) needed to separate the program messages is missing to give ":CALC1:FORM CP *OPC?".

-121 **Invalid character in number**

An invalid character for the data type of the syntax analysis target has been received. For example, alphabetical characters exist in a decimal value or "9" exists in octal data.

-131 **Invalid suffix**

The suffix does not meet the syntax defined in IEEE488.2,7.7.3.2 or is inappropriate for the E4981B.

-141 **Invalid character data**

A character data element has been recieved where the E4981B does not accepts any character data element.

-151 **Invalid string data**

Character string data are expected, but the string data received are invalid for some reason. (Refer to IEEE488.2,7.7.5.2.) For example, the END message is received before the end quotation mark character appears.

-161 **Invalid block data**

Block data are expected, but the block data received are invalid for some reason. (Refer to IEEE488.2,7.7.6.2.) For example, the END message is received before the length of the block data is reached.

-171 **Invalid expression**

The equation data element is invalid. (Refer to IEEE488.2,7.7.7.2.) For example, parentheses are not paired or a character violates the standard.

-213 **Init ignored**

Another measurement has been being executed and the measurement start request (**:INITiate[:IMMediate]** command) has been ignored.

-224   **Illegal parameter value**

The parameter recieved is not correct. For example, though a correct program message was ":CALC1:FORM CP," a wrong program message, ":CALC1:FORM RP," was received.

L

46   **LOAD measurement incomplete**

This error occurs when the cable correction LOAD measurement is incomplete.

M

43   **Measurement failed**

A measurement failure has occurred during measuring the correction data.

-109   **Missing parameter**

The number of parameters is less than required by the command. For example, although the :CREJ:LIM command requires one parameter such as ":CREJ:LIM 3", no parameter is added to give ":CREJ:LIM".

-250   **Mass storage error**

An error occurred while accessing the external mass storage device.

N

83   **No data to load**

There is no setup data for the selected number or no external mass storage device is connected.

-120   **Numeric data error**

Numeric data is improper.

-128   **Numeric data not allowed**

A numeric value data element (that does not violate the standard) has been received where the E4981B does not accept any numeric value data element.

O

47	**OPEN measurement incomplete**

This error occurs when the cable correction OPEN measurement is incomplete.

-321	**Out of memory**

The E4981B has insufficient memory to perform the requested operation.

P

1080	**Power failed**

Power unit hardware failure is detected.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

-108	**Parameter not allowed**

The number of parameters is larger than required by the command. For example, although the :CREJ:LIM command requires one parameter such as ":CREJ:LIM 3", two parameters are added to give ":CREJ:LIM 0,3".

-112	**Program mnemonic too long**

The length of the header exceeds 12 characters. (Refer to IEEE488.2,7.6.1.4.1.)

Q

-350	**Queue overflow**

The queue contains a certain code other than the code that caused this error. This indicates that an error has occurred due to insufficient space in the queue but has not been recorded.

-400	**Query error**

A comprehensive Query error has occurred for which the E4981B cannot detect further details. This code simply indicates the occurrence of a Query error that is defined in IEEE488.2,11.5.1.1.7 and 6.3.

-410	**Query INTERRPUTED**

This indicates the status that causes an "INTERRUPTED" Query error. (Refer to IEEE488.1,6.3.2.3.) This error occurs, for example, when data byte (DAB) or GET is received after Query but before the response has been completely sent.

-420	**Query UNTERMINATED**

This indicates the status that causes an "UNTERMINATED" Query error. (Refer to IEEE488.2,6.3.2.) This error occurs, for example, when the E4981B is specified as a talker and an incomplete program message is received.

| -430 | **Query DEADLOCKED** |

This indicates the status that causes a "DEADLOCKED" Query error. (Refer to IEEE488.2,6.3.1.7.) This error occurs, for example, when both input and output buffers become full and the E4981B cannot continue processing.

| -440 | **Query UNTERMINATED after indefinite response** |

In a certain program message, a Query that requests an ambiguous response has not yet been completely executed when a different Query is received. (Refer to IEEE488.2,6.5.7.5.7.)

R

| 16 | **Reference Measurement Aborted** |

This error occurs when REF data measurement is aborted.

| 48 | **REF measurement incomplete** |

This error occurs when the cable correction REF measurement is incomplete.

S

| 82 | **Store failed** |

This error occurs when external mass storage device fails or internal FLASH ROM hardware fails.

Contact Keysight Technology's Sales and Service Office or the company from which you purchased the device.

| -102 | **Syntax error** |

There is a command or data type that cannot be recognized. For example, in the program message ":SYST:PRES", a colon (:) is inserted by mistake to give ":SYST::PRES".

| -134 | **Suffix too long** |

The length of suffix is long.

| -138 | **Suffix not allowed** |

A suffix is added to a numeric value element that does not permit a suffix.

| -150 | **String data error** |

An error not included in the error numbers between –151 and –159 has occurred during the syntax analysis of a string data element.

| -158 | **String data not allowed** |

A string data element has been received where the E4981B does not accept any string data element. For example, a parameter must be enclosed with double quotation marks ("...") but they are missing.

T

-124   **Too many digits**

The number of digits of the mantissa of the decimal value data element exceeds 255 except for preceding 0s. (Refer to IEEE488.27.7.2.4.1.)

-211   **Trigger ignored**

A trigger command or trigger signal has been received and recognized by the E4981B, but it is ignored due to the timing relationship with the E4981B. For example, this happens when the E4981B's trigger system is not in the Waiting for Trigger state.

-214   **Trigger deadlock**

Indicates that the **:READ?** command was ignored because the trigger source setting was MAN or BUS.

-223   **Too much data**

The received block, equation, or string type program data complies with the standard, but the amount of data exceeds the limit that the E4981B can handle due to memory or device-specific conditions related to memory.

U

-113   **Undefined header**

A header not defined for the E4981B has been received. For example, "*XYZ", which is not defined for the E4981B, is received.

Warning Messages (WARNING)

Warning messages are displayed to warn users. They are displayed in the lower row of the display of the E4981B. You cannot read them out using the GPIB command.

WARNING: Need corr meas

When the OPEN correction, SHORT correction or LOAD correction is ON, this is displayed when you change the setup of the cable length or measurement frequency shift (1 MHz). In this case, the OPEN correction, SHORT correction and LOAD correction are automatically turned OFF.

WARNING: Need load meas

This is displayed when you turn ON the LOAD correction from the front panel although the setups of the cable length and measurement frequency shift (1 MHz) differ from those when measuring/setting up the LOAD correction data. In this case, the LOAD correction is turned ON, but you need to measure the LOAD correction data again for accurate measurement.

WARNING: Need open meas

This is displayed when you turn ON the OPEN correction from the front panel although the setups of the cable length and measurement frequency shift (1 MHz) differ from those when measuring/setting up the OPEN correction data. In this case, the OPEN correction is turned ON, but you need to measure the OPEN correction data again for accurate measurement.

WARNING: Need short meas

This is displayed when you turn ON the SHORT correction from the front panel although the setups of the cable length and measurement frequency shift (1 MHz) differ from those when measuring/setting up the SHORT correction data. In this case, the SHORT correction is turned ON, but you need to measure the SHORT correction data again for accurate measurement.

WARNING: Out of limit

This is displayed if the correction data is out of the valid range when measuring the correction data. The valid range for each type of correction is as follows.

Type of correction	Valid range
OPEN correction	$|Y| < 20\ \mu S$
SHORT correction	$|Z| < 20\ \Omega$
LOAD correction	$|Zref| \times 0.9 < |Z| < |Zref| \times 1.1$

In the above table, Y is the measured admittance value, Z is the measured impedance value, and Zref is the LOAD correction standard definition value.

WARNING: Improper high/low limits

The upper limit value is less than the lower limit value. Set the lower limit value to less than the upper limit value.

WARNING: Incompatible state file

The setting file recalled from external mass storage device has been saved using an E4981B with a different firmware version or different options. There may be some parameters set up incorrectly. Check the setting.

This message may appear due to option mismatch, firmware mismatch, check-sum error or state format mismatch.

E   Technical Information

This chapter provides technical information on the operating principles of the E4981B and the basic principles of capacitance measurement.

Measurement Principle

This section explains the underlying principle of how the E4981B is used to measure the impedance of a DUT.

Figure E-1   Circuit model of impedance measurement

L7003016
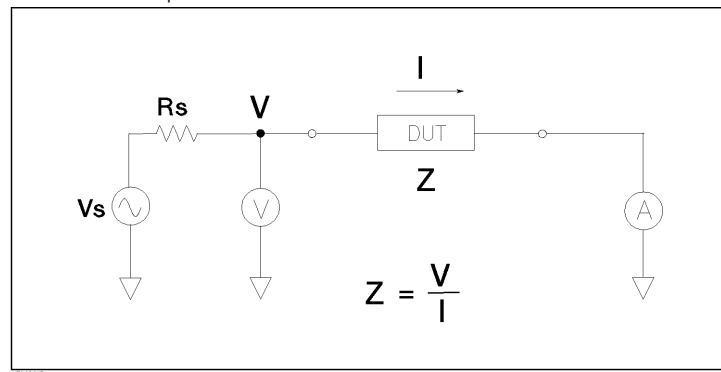
Figure E-1 illustrates the circuit model of impedance measurement using the E4981B. Vs is the measurement power supply voltage, and Rs is the output resistance of the E4981B. When voltage applied to a DUT is V and current flowing through the DUT is I, impedance Z is expressed by the equation Z = V/I.

Z consists of a real part and an imaginary part. Figure E-2 shows the vector diagram of impedance.

Figure E-2   Vector diagram of impedance
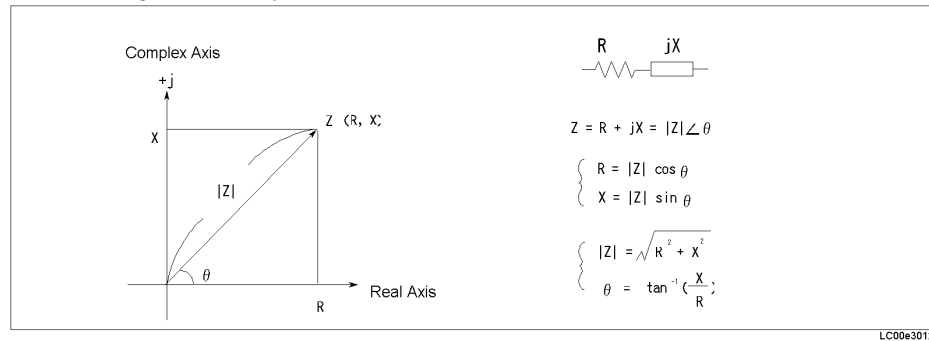
Symbols used in **Figure E-2** have the following meanings:

R   Resistance

X   Reactance

|Z| Absolute value of impedance

?   Phase of impedance

Another way to express impedance Z is the use of admittance Y. The relationship between admittance Y and impedance Z is Y = 1/Z.

Figure E-3   Relationship between impedance and admittance
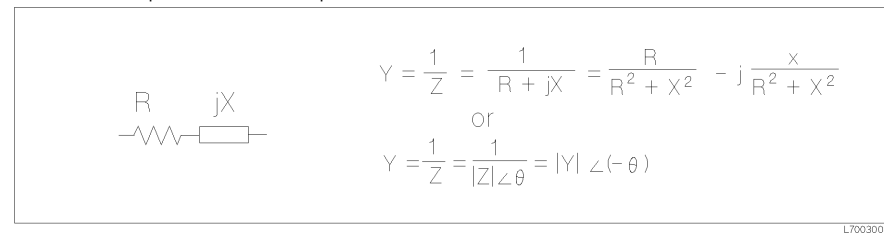
For a parallel connection, using admittance Y is more convenient.

Figure E-4　　　　　Vector diagram of admittance

$$Y = \frac{1}{Z} = \frac{1}{R + jX} = \frac{R}{R^2 + X^2} - j\frac{X}{R^2 + X^2}$$

or

$$Y = \frac{1}{Z} = \frac{1}{|Z|\angle\theta} = |Y|\angle(-\theta)$$

$$Z = \frac{jRX}{R + jX} = \frac{RX^2}{R^2 + X^2} + j\frac{R^2 X}{R^2 + X^2}$$

(Introducing impedance yields complicated expression.)

$$G \left(= \frac{1}{R}\right)$$
$$jB \left(= \frac{1}{jX}\right)$$

$$Y = G + jB$$

(Introducing admittance yields simplified expression.)

LC00e3014
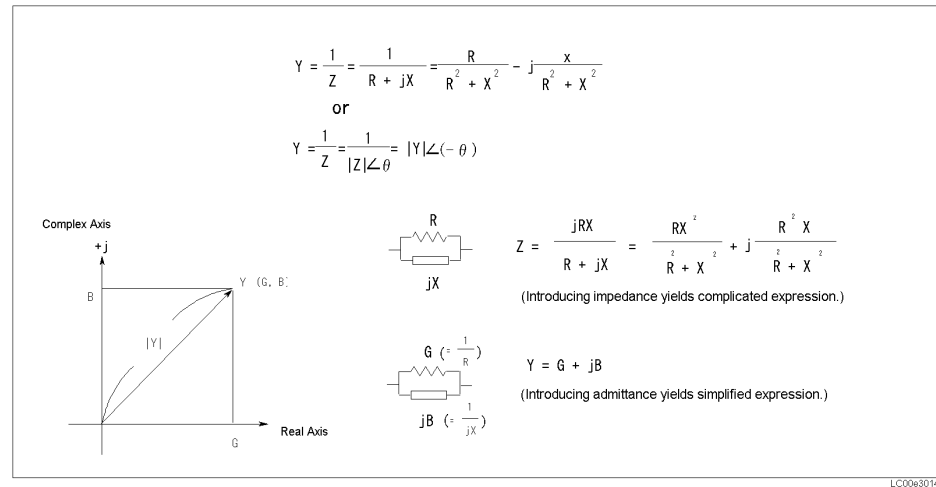
Symbols in **Figure E-4** have the following meanings:

G　　　　　　　　Conductance

B　　　　　　　　Susceptance

|Y|　　　　　　　　Absolute value of admittance

The E4981B measures the vector value of a DUT's impedance Z and indicates the result as the circuit constants of the equivalent circuit shown in **Figure E-5**.

Figure E-5　　　　　Relationship between measurement parameters

$$Z = Rs + jX = |Z|\angle$$

$$X = -\frac{1}{\omega Cs}$$

$$Z = Rs - j\frac{1}{\omega Cs}$$

where, $\omega = 2\pi f$
(f: Measurement frequency)

$$Y = G + jB$$

$$B = \omega Cp$$

$$Y = G - j\omega Cp$$

where, $\omega = 2\pi f$
(f: Measurement frequency)

$$Q = \frac{1}{D} = \tan\theta = \frac{|X|}{R} = \frac{|B|}{G}$$
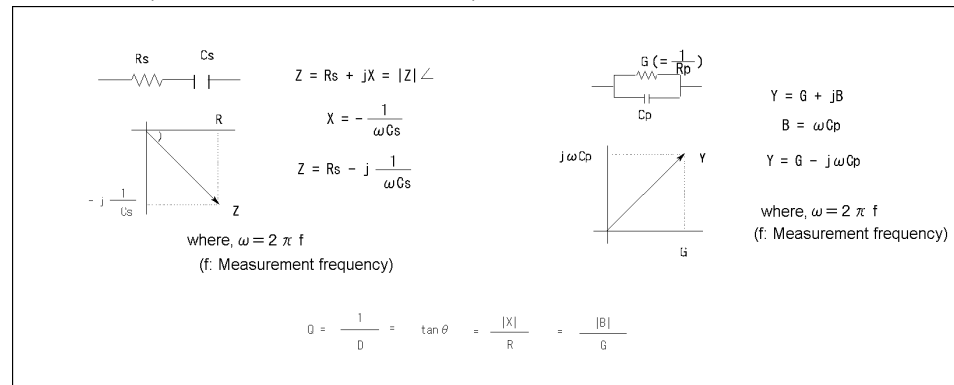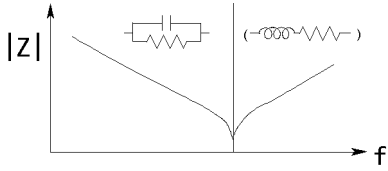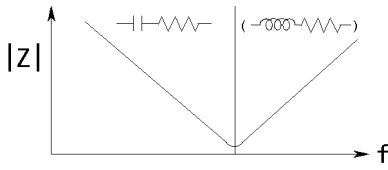
Basic Principles of Capacitance Measurement

This section explains the useful basics when measuring capacitance with the E4981B.

Typical characteristics of capacitance DUT

As shown in Table E-1, the impedance characteristics of capacitance components change depending on the actual operating conditions. Therefore, to measure impedance accurately, it is necessary to take measurements under the actual operating conditions in which the component is used.

Table E-1   **Typical characteristics of capacitance DUT**

DUT	Example of Characteristics	Measurement function
Small C		Cp-D, Cp-Q, Cp-G, Cp-Rp
Large C		Cs-D, Cs-Q, Cs-Rs

Selection criteria of parallel/series equivalent circuit models

There are two equivalent circuit models used for capacitance measurement: parallel mode and series mode, as shown in Table E-2. You must select one of these before measurement, depending on the magnitude of reactance and the effect of the equivalent parallel resistance (Rp) and equivalent series resistance (Rs) on it.

Table E-2   Parallel/Series equivalent circuit models and measurement functions of the E4981B

Circuit model	Measurement function of E4981B	Definition of D, Q, G
Parallel equivalent circuit model	Cp-D, Cp-Q, Cp-G, Cp-Rp	$D = 1/(|2?fCp|Rp)$ $Q = 1/D = |2?fCp|Rp$ $G = 1/Rp$
Series equivalent circuit model	Cs-D, Cs-Q, Cs-Rs	$D = |2?fCs|Rs$ $Q = 1/D = 1/(|2?fCs|Rs)$

· When capacitance is small:

When capacitance is small, reactance is large. Therefore, the effect of Rp is greater than that of Rs. When Rs is small, its effect can be neglected compared to capacitive reactance. In this case, use the parallel equivalent circuit model shown in Figure E-6 (a).

· When capacitance is large:

When capacitance is large, reactance is small. Therefore, the effect of Rs is greater than that of Rp. In this case, use the series equivalent circuit model shown in Figure E-6 (b).

Figure E-6   Selection of capacitance measurement circuit model
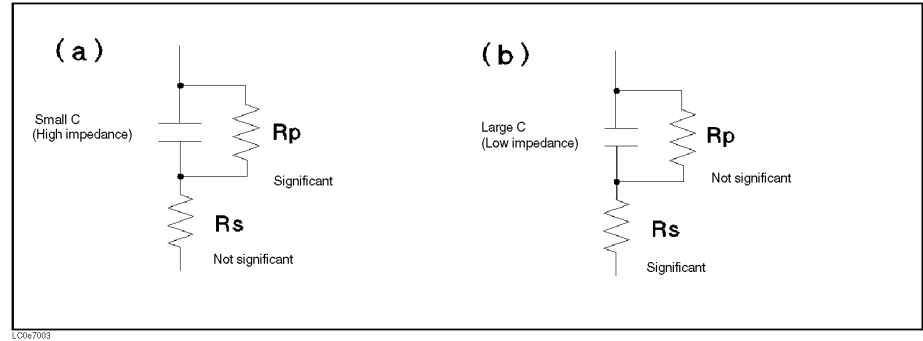
Principle of four-terminal pair measurement

Generally, in connection methods using common terminal structures, mutual inductance, interference between measurement signals, and unnecessary residual elements (especially at higher frequencies) significantly affect measurements.

The E4981B adopts a four-terminal pair structure to reduce the limitations on measurements due to these factors and to facilitate stable and accurate measurements.

Figure E-7 illustrates the principle of four-terminal pair measurement. The UNKNOWN terminals are four coaxial connector terminals.

- H_{CUR}: Current high terminal
- H_{POT}: Voltage high terminal
- L_{POT}: Voltage low terminal
- L_{CUR}: Current low terminal

Figure E-7   Principle of four-terminal pair measurement
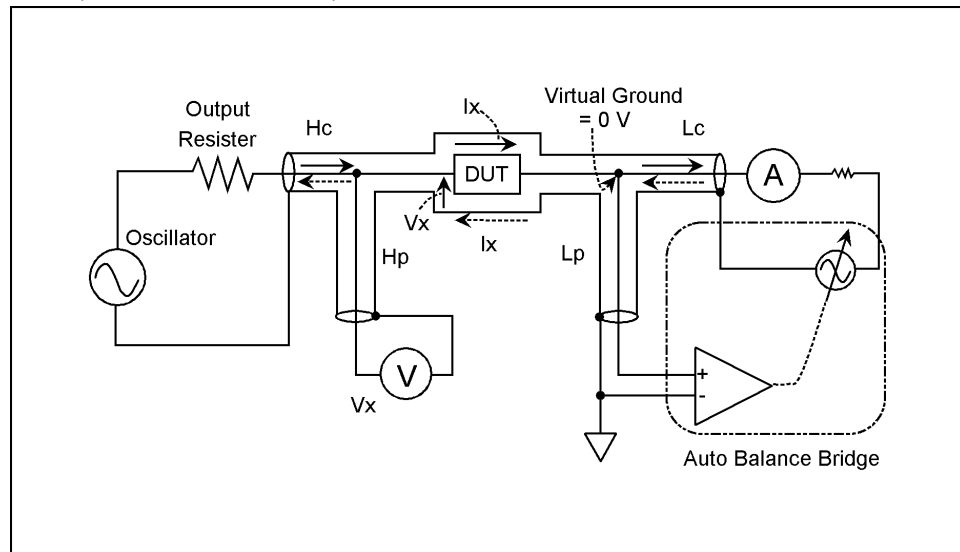
The four-terminal pair measurement method has advantages in both low- and high-impedance measurements. The outer shield conductors serve as the return path of the measurement signal current (not grounded). Current of the same amplitude flows through the core conductor and the surrounding shield conductor in opposite directions, and therefore no external magnetic field occurs around either conductor. In other words, the magnetic field caused by the inner conductor and that caused by the outer conductor cancel each other completely. The measurement signal current does not cause any induction field and, therefore, the test leads do not increase the error due to their self-inductance or the mutual inductance between different leads.

Precautions for four-terminal pair measurement

This section describes general precautions and techniques for using the four-terminal structure efficiently.

Measurement contacts

To ensure high accuracy when using the four-terminal pair measurement, the measurement contacts must meet the following requirements.

- Make the signal path between the capacitance meter and the DUT (indicated by 1 in **Figure E-8**) as short as possible.

- For a four-terminal pair measurement circuit configuration, the outer shields of the H_{CUR}, H_{POT}, L_{CUR}, and L_{POT} terminals must all be connected at the nearest possible point to the DUT. (Refer to 2 in **Figure E-8**.)

Figure E-8   Measurement contacts
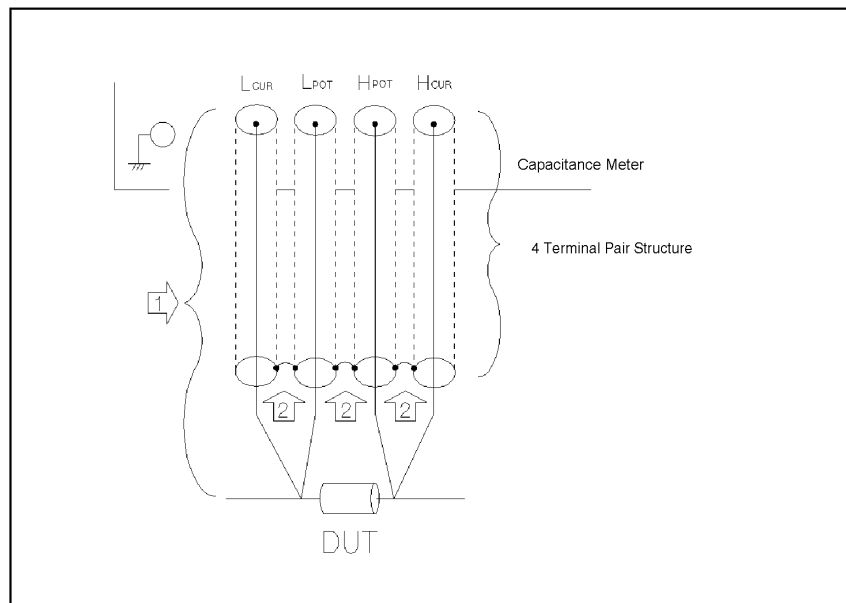
Contact resistance

Due to contact resistance between the DUT contacts and the DUT itself, a measurement error occurs when measuring large capacitance values, especially for measurement of D (dissipation factor).

For measurement of large capacitance values, the four-terminal pair measurement method has an advantage over the two-terminal method in that measurement errors are smaller. Select a four-terminal measurement test fixture that can secure the DUT to stabilize the connection and minimize contact resistance.

Figure E-9   Configuration of contacts

(A) 2 Terminal Pair Measurement Method   (B) 4 Terminal Pair Measurement Method
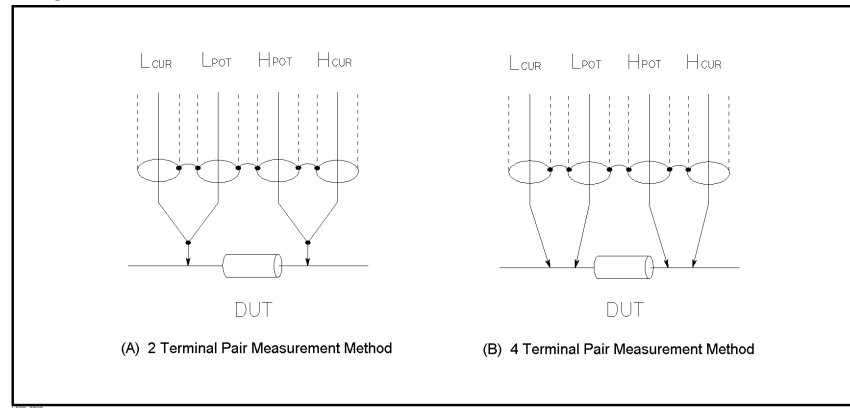
Extending the test leads

If you cannot make measurement contact with the four-terminal pair structure, use the connection method shown in **Figure E-10**.

Figure E-10   Measurement contacts when test leads are extended
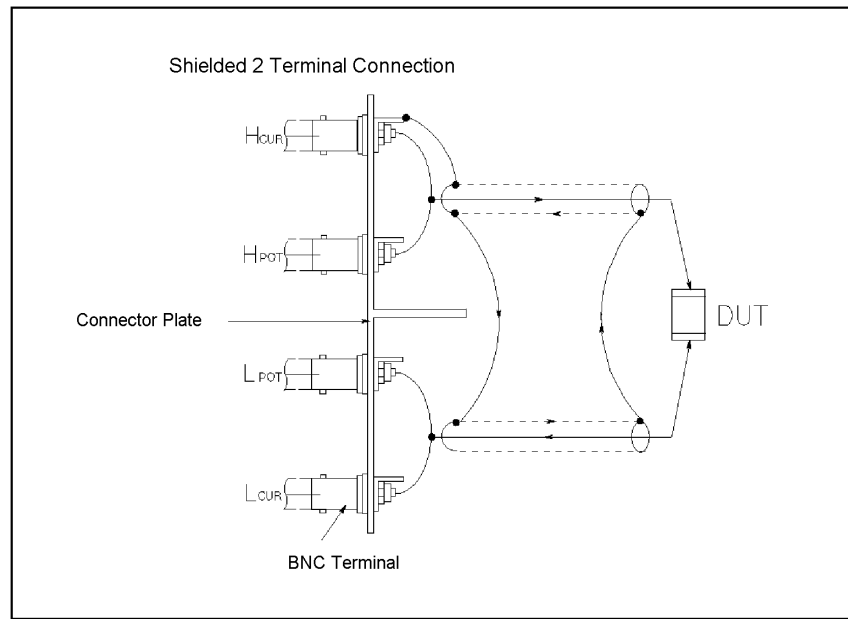
Guarding when measuring small capacitance

When measuring small capacitance values, for example those of small-capacitance chip capacitors, use a guard plate to minimize measurement errors caused by stray capacitance. Figure E-11 shows an example of using a guard plate with the measurement contacts of a four-terminal pair structure.

Figure E-11   Example of connecting guard plate to DUT

Ground

L_{CUR} L_{POT} H_{POT} H_{CUR}

Capacitance Meter

4TP Test Lead

Shielded Contact of
Test Lead

Contact here

Guard Plate
(Not grounded)

DUT

4288aoe136
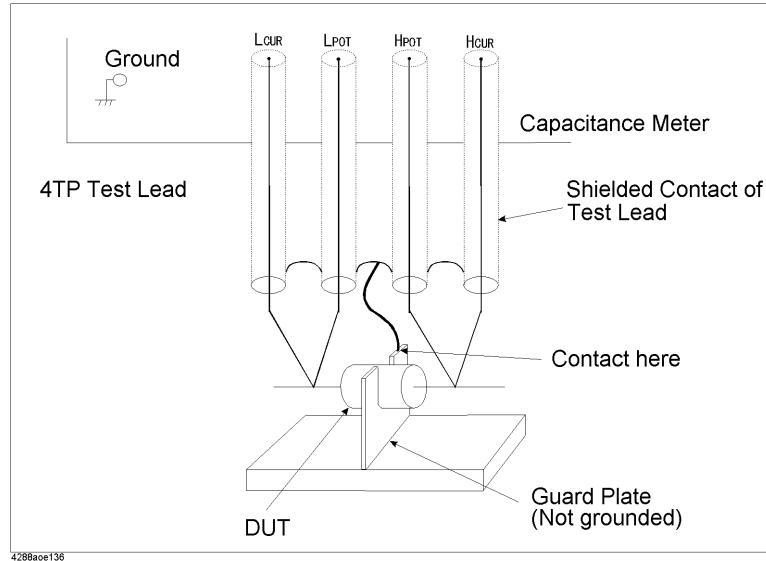
Shield

By using a shield, the effect of electrical noise picked up by the test leads can be significantly decreased. Therefore, prepare a shield plate and connect it to the outer shield conductor of the four-terminal pair test leads, as shown in Figure E-12.

Figure E-12   Guard shield

LC00e7013

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KEYSIGHT