Keysight Technologies E5260/E5270 Series of Parametric Measurement Solutions

Programming Guide

Notices

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In This Manual

This manual provides the information to control the Keysight E5260A/E5262A/E5263A/E5270B via GPIB interface using an external computer, and consists of the following chapters:

1. "Programming Basics"

   This chapter provides basic information to control the Keysight E5260/E5270.

2. "Remote Mode Functions"

   This chapter explains the functions of the Keysight E5260/E5270 in the remote mode.

3. "Programming Examples"

   This chapter lists the GPIB commands and explains the programming examples for each measurement mode or function. The examples have been written in the Microsoft Visual Basic .NET or the HP BASIC language.

4. "Command Reference"

   This chapter provides the complete reference of the GPIB commands of the Keysight E5260/E5270.

5. "Error Messages"

   This chapter lists the error codes, and explains them.

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1. Programming Basics

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Contents

1 Programming Basics

This chapter describes basic information to control the Keysight E5260/E5270, and contains the following sections:

- "Before Starting"
- "Getting Started"
- "Command Input Format"
- "Data Output Format"
- "GPIB Interface Capability"
- "Status Byte"
- "Programming Tips"

Before Starting

Before starting the programming, connect an external computer, and set the GPIB address of the Keysight E5260/E5270 as shown below.

1. Connect a GPIB cable between the GPIB interface of the external computer and the GPIB connector on the rear panel of the E5260/E5270.
2. Turn on the E5260/E5270, and set the GPIB address as shown below.
   a. Press the **Menu** key.
   b. Select the CONFIG menu, and press the **Enter** key.
   c. Select the ADDRESS menu, and press the **Enter** key.
   d. Press the arrow key to set the GPIB address of the E5260/E5270, then press the **Enter** key.
   e. Press the **Exit** key twice to close the setup menu.

NOTE

Command execution examples

In this section, command execution examples are written in HP BASIC. See the following instructions for your guidance.

1. Use the ASSIGN statement to assign the I/O path for controlling instruments.

   In the next example, the select code of the external computer is 7 and the GPIB address of the E5260/E5270 is 17.

```
10 ASSIGN @E5270 TO 717
```

2. Use the OUTPUT statement to send commands to instruments, as shown below.

```
OUTPUT @E5270;"*RST"
```

   It is available to send multiple commands as shown below.

```
OUTPUT @E5270;"*CN;MM2,1"
```

3. Use the ENTER statement to get a query response or data from instruments.

Getting Started

This section explains the following basic operations. In this section, the HP BASIC language is used for the examples.

- "To Reset the Keysight E5260/E5270"
- "To Read Query Response"
- "To Perform Self-Test"
- "To Perform Self-Calibration"
- "To Perform Diagnostics"
- "To Enable Source/Measurement Channels"
- "To Select the Measurement Mode"
- "To Force Voltage/Current"
- "To Set the Integration Time"
- "To Set the Measurement Range"
- "To Pause Command Execution"
- "To Start Measurement"
- "To Force 0 V"
- "To Disable Source/Measurement Channels"
- "To Control ASU"
- "To Read Error Code/Message"
- "To Read Spot Measurement Data"
- "To Read Sweep Measurement Data"
- "To Read Time Stamp Data"
- "To Perform High Speed Spot Measurement"

To Reset the Keysight E5260/E5270

The E5260/E5270 returns to the initial settings by the *RST command.

Example

```
OUTPUT @E5270;"*RST"
```

For the initial settings, refer to "Initial Settings" on page 2-42.

To Read Query Response

If you enter a query command such as the *TST?, ERR? and so on, the E5260/E5270 puts an ASCII format response to the query buffer that can store only one response. Read the response as soon as possible after entering a query command.

Example

```
OUTPUT @E5270;"NUB?"
ENTER @E5270;A
```

This example returns the number of data stored in the data output buffer.

To Perform Self-Test

The E5260/E5270 starts the self-test by the *TST? command. The *TST? command also returns the test result.

Example

```
OUTPUT @E5270;"*TST?"
ENTER @E5270;Code
IF Code<>0 THEN DISP "FAIL: SELF-TEST"
```

This example starts the self-test, and reads the test result code. For the test result code, refer to "*TST?" on page 4-123.

To Perform Self-Calibration

The E5260/E5270 starts the self-calibration by the *CAL? command.

Example

```
OUTPUT @E5270;"*CAL?"
ENTER @E5270;Result
IF Result<>0 THEN DISP "FAIL: CALIBRATION"
```

This example starts the self-calibration, and reads the result, pass or fail. For details, refer to "*CAL?" on page 4-42.

To Perform Diagnostics

The E5260/E5270 starts the diagnostics by the DIAG? command, and returns the result. You must specify the diagnostics item by using the first parameter. Available parameter values are:

1: Trigger In/Out diagnostics

2: Front panel key diagnostics

3: High voltage LED diagnostics

4: Digital I/O diagnostics

5: Beeper diagnostics

To perform diagnostics 1, connect a BNC cable between the Ext Trig In terminal and the Ext Trig Out terminal before starting the diagnostics.

To perform diagnostics 4, disconnect any cable from the digital I/O port.

For diagnostics 1 and 4, the second parameter is available. Available parameter values are:

0: E5260/E5270 starts diagnostics immediately.

1: E5260/E5270 starts diagnostics when the **Enter** key is pressed.

Example

```
OUTPUT @E5270;"DIAG? 1,0"
ENTER @E5270;Result
IF Result<>0 THEN DISP "FAIL: DIAGNOSTICS"
```

This example starts the Trigger In/Out diagnostics, and reads the result, pass or fail. For details, refer to "DIAG?" on page 4-49.

To Enable Source/Measurement Channels

The measurement channels or source channels can be enabled by closing the output switch. To close the switch, send the CN command. The E5260/E5270 closes the output switch of the specified channels.

Example

```
OUTPUT @E5270;"CN 1"
```

This example enables channel 1 (the module installed in slot 1 of the E5260/E5270). If you do not specify the channel, the CN command enables all channels.

To Select the Measurement Mode

The E5260/E5270 provides the following measurement modes. To select the measurement mode, send the MM command.

Measurement Mode	Mode No.
Spot Measurement	1
Staircase Sweep Measurement	2
Pulsed Spot Measurement	3
Pulsed Sweep Measurement	4
Staircase Sweep with Pulsed Bias Measurement	5
Quasi-Pulsed Spot Measurement	9
Linear Search Measurement	14
Binary Search Measurement	15
Multi Channel Sweep Measurement	16
High Speed Spot Measurement	NA

In the table, Mode No. means a command parameter of the MM command.

Syntax

```
MM Mode#,Ch#[,Ch#] ...
```

where, Mode# specifies the Mode No., and Ch# specifies the measurement channel. The available number of measurement channels depends on the measurement mode. For details, refer to “MM” on page 4-82.

Example

```
OUTPUT @E5270;"MM 2,1"
```

This example sets the staircase sweep measurement, and assigns channel 1 (the module installed in slot 1 of the E5260/E5270) as the measurement channel.

NOTE

The Mode No. is not assigned for the high speed spot measurement. Refer to “To Perform High Speed Spot Measurement” on page 1-18. The high speed spot measurement does not need the MM command.

For the source output commands available for each measurement mode, see Table 1-1 on page 1-9.

To Force Voltage/Current

The E5260/E5270 provides the following commands to enable the voltage/current output. For the commands available for each measurement mode, see Table 1-1.

Command	Description
DV, TDV	Forces the constant voltage immediately.
DI, TDI	Forces the constant current immediately.
WV	Sets the staircase sweep voltage source.
WSV	Sets the synchronous sweep voltage source.
WI	Sets the staircase sweep current source.
WSI	Sets the synchronous sweep current source.
PV / PT	Sets the pulsed voltage source.
PI / PT	Sets the pulsed current source.
PWV / PT	Sets the pulsed sweep voltage source.
PWI / PT	Sets the pulsed sweep current source.
WNX	Sets a sweep source for the multi sweep measurement.
BDV	Sets the quasi-pulsed voltage source.
LSV	Sets the linear search voltage source.
LSSV	Sets the linear search synchronous voltage source.
LSI	Sets the linear search current source.
LSSI	Sets the linear search synchronous current source.
BSV	Sets the binary search voltage source.
BSSV	Sets the binary search synchronous voltage source.
BSI	Sets the binary search current source.
BSSI	Sets the binary search synchronous current source.

where, the PT command is used to set the timing parameters of the pulsed bias source or pulsed sweep source.

Table 1-1 Measurement Mode and Available Source Output Commands

Measurement Mode	Command
Spot Measurement	DV, DI, TDV, TDI
Staircase Sweep Measurement	DV, DI, TDV, TDI, and WV(/WSV) or WI(/WSI)
Pulsed Spot Measurement	DV, DI, TDV, TDI, and PV/PT or PI/PT
Pulsed Sweep Measurement	DV, DI, TDV, TDI, and PWV/PT(/WSV) or PWI/PT(/WSI)
Staircase Sweep with Pulsed Bias Measurement	DV, DI, TDV, TDI, and WV(/WSV) or WI(/WSI), and PV/PT or PI/PT
Quasi-Pulsed Spot Measurement	DV, DI, TDV, TDI, BDV
Linear Search Measurement	DV, DI, TDV, TDI, and LSV(/LSSV) or LSI(/LSSI)
Binary Search Measurement	DV, DI, TDV, TDI, and BSV(/BSSV) or BSI(/BSSI)
Multi Channel Sweep Measurement	DV, DI, TDV, TDI, WNX, and WV or WI
High Speed Spot Measurement	DV, DI, TDV, TDI

The DV, DI, TDV, and TDI commands start to force the voltage or current immediately when the command is executed. The other commands just set the source channel condition, and the source channel starts the output by the start trigger, such as the XE command. For more details of the commands, refer to Chapter 4, “Command Reference.”

Example

```
OUTPUT @E5270;"DV 1,0,5"
```

This example just forces 5 V using channel 1 (the module installed in slot 1 of the E5260/E5270) with auto ranging.

To Set the Integration Time

To adjust the balance of the measurement accuracy and the measurement speed, change the integration time or the number of averaging samples of the A/D converter (ADC) by using the AV command. The AV command is compatible with the AV command of the Keysight 4142B.

For accurate and reliable measurement, set the integration time longer or set the number of samples larger. For details about the integration time settings, refer to Chapter 4, “Command Reference.”

The Keysight E5270B has the following two types of the A/D converter. Use the AAD command to select the type of ADC, and use the AIT command to set the integration time or the number of samples.

Type of ADC	Description
High-speed ADC	Effective for the high speed measurement. In the multi channel sweep measurement mode (MM16), multiple measurement channels can perform synchronous measurements. The number of averaging samples must be set by the AIT or AV command.
High-resolution ADC	Effective for the accurate measurement. Cannot be used for the pulsed measurement channel and the simultaneous measurement channel. The integration time must be set by the AIT command.

Example

The following example sets the number of samples to 10 for the A/D converter (high-speed ADC for the Keysight E5270B).

```
OUTPUT @E5270;"AV 10,1"
```

The following example is for the Keysight E5270B, and sets the power line cycle mode (PLC) for both the high-speed ADC and the high-resolution ADC. And channel 1 uses the high-resolution ADC and other channels use the high-speed ADC.

```
OUTPUT @E5270;"*RST"
OUTPUT @E5270;"AIT 0,2,1"
OUTPUT @E5270;"AIT 1,2"
OUTPUT @E5270;"AAD 1,1"
```

To Set the Measurement Range

To set the measurement range, send the following command. For details, refer to Chapter 4, "Command Reference."

Command	Description
RI	Sets the current measurement range. Available for measurement except for the high speed spot measurement.
RV	Sets the voltage measurement range. Available for measurement except for the high speed spot measurement.
TI, TTI	Sets the current measurement channel and the measurement range, and performs the high speed spot measurement.
TV, TTV	Sets the voltage measurement channel and the measurement range, and performs the high speed spot measurement.

Example

The following example sets the voltage measurement ranging mode of channel 1 to auto.

```
OUTPUT @E5270;"RV 1,0"
```

The following example sets the current measurement ranging mode of channel 1 to auto, and sets the current measurement auto ranging operation by using the RM command.

```
OUTPUT @E5270;"RI 1,0"
OUTPUT @E5270;"RM 1,3,90"
```

NOTE

To use 1 pA range of ASU

Set the 1 pA limited auto ranging mode or the 1 pA fixed range mode. Or enable the 1 pA range for the auto ranging mode by using the SAR command. See "SAR" on page 4-103.

NOTE

Range change at state change

Measurement range setting is stored independently for the local state and the remote state. So the range change may be caused by the state change.

To Pause Command Execution

To pause command execution until the specified wait time has elapsed, send the PA command.

Example

```
OUTPUT @E5270;"PA 5"
```

If this command is sent, the E5260/E5270 waits 5 seconds before executing the next command.

To Start Measurement

To start measurement other than the high speed spot measurement, send the XE command.

Example

```
OUTPUT @E5270;"XE"
```

This starts the measurement specified by the MM command.

For the high speed spot measurement, refer to "To Perform High Speed Spot Measurement" on page 1-18.

To Force 0 V

To force 0 V immediately, send the DZ command. The E5260/E5270 memorizes the present source output settings of the specified channel, and changes the specified channel output to 0 V. If you do not specify the channel, the DZ command function is effective for all channels.

Example

```
OUTPUT @E5270;"DZ 1"
```

If this command is sent, the E5260/E5270 memorizes the current settings of channel 1 (the module installed in slot 1 of the E5260/E5270), and changes channel 1 output to 0 V.

To restore the settings stored by the DZ command, send the RZ command. For details, refer to Chapter 4, "Command Reference."

To Disable Source/Measurement Channels

To disable the channels, send the CL command. The E5260/E5270 opens the output switch of the specified channels. Opening the output switch disables the channel.

Example

```
OUTPUT @E5270;"CL 1"
```

This example disables channel 1 (the module installed in slot 1 of the E5260/E5270). If you do not specify the channel, the CL command disables all channels.

To Control ASU

This function is available for the E5270B that is installed with the high resolution SMU (HRSMU). Atto Sense and Switch Unit (ASU) has two inputs, SMU input for the HRSMU and AUX input for the other instrument. And the ASU input to output connection can be controlled by the following commands. When the instrument is turned on, the SMU input will be connected to the ASU output. However, the SMU output switch will be off at this time.

Table 1-2 ASU Input Output Connection Control

<table>
<tr><th>Previous Connection</th><th>Command</th><th>Subsequent Connection</th></tr>
<tr><td>SMU side, Output on/off</td><td>SAP slot, 1</td><td>AUX side</td></tr>
<tr><td rowspan="2">SMU side, Output off</td><td>CN slot</td><td rowspan="4">SMU side, Output on</td></tr>
<tr><td>SAP slot, 0</td></tr>
<tr><td rowspan="3">AUX side</td><td>CN slot</td></tr>
<tr><td>SAP slot, 0</td></tr>
<tr><td>CL [slot]</td><td rowspan="2">SMU side, Output off</td></tr>
<tr><td>SMU side, Output on</td><td>CL [slot]</td></tr>
</table>

where, *slot* must be the slot number assigned to the slot that installs the HRSMU connected to the ASU. See "SAL", "SAP", and "SAR" on page 4-103 for the other function and control commands of the ASU.

When the SMU side is connected to the ASU output, the source output on/off can be controlled by the CN/CL command. And then the SAP *slot*, 1 command is used to change the output connection to the AUX side. When the AUX side is connected, the output of the instrument connected to the AUX input is appeared to the ASU output immediately.

To Read Error Code/Message

If any error occurs, the E5260/E5270 will not put the measurement data into the data output buffer. Hence, confirm that no error has occurred before reading the measurement data. To read the error code, enter the ERR? command, and to read the error message, enter the EMG? command.

Example

```
OUTPUT @E5270;"ERR? 1"
ENTER @E5270;Code
IF Code<>0 THEN
  OUTPUT @E5270;"EMG? ";Code
  ENTER @E5270;Msg$
  PRINT "ERROR: ";Msg$
ELSE
 :    :
```

This example checks the error buffer, and prints the error message on the computer screen if any error code is stored in the error buffer.

To Read Spot Measurement Data

After the spot measurements, the E5260/E5270 puts the measurement data into its output data buffer. You can read the data as shown below. The examples read the header information and the measurement data included in the ASCII data set by the FMT5 command. For the data output format, see “Data Output Format” on page 1-22. The example uses the HP BASIC or Microsoft Visual Basic .NET language.

Example 1

For the HP BASIC users, use the ENTER statement.

```
ENTER @E5270 USING "#,3A,12D,X";Head$,Mdata
```

Example 2

For the VISA library users, use the viScanf, viRead, or another function.

```
Dim ret_rd As System.Text.StringBuilder = _
           New System.Text.StringBuilder(3 + 12 + 1)
ret = viScanf(vi, "%t", ret_rd)
ret_val = ret_rd.ToString()
head = Left(ret_val, 3)
mdata = Val(Mid(ret_val, 4, 12))
```

Example 3

For the VISA COM library users, use the ReadString or another method.

```
ret_val = E5270.ReadString(3 + 12 + 1)
head = Left(ret_val, 3)
mdata = Val(Mid(ret_val, 4, 12))
```

To Read Sweep Measurement Data

For the sweep measurements, the measurement data will be put into the data output buffer after every step measurement. You can read the data as shown below. The examples use the VISA COM library and Microsoft Visual Basic .NET language. For the data output format, see "Data Output Format" on page 1-22.

- To read data after sweep measurement

  This way waits for the measurement completion by using the *OPC? command after the XE command, and reads the sweep data (all step measurement data) at once after the sweep measurement is completed. For the specific example, see Table 3-5 on page 3-19.

  Example:

```
E5270.WriteString("FMT 5,0" & vbLf)     'terminator=comma
E5270.WriteString("XE" & vbLf)
E5270.WriteString("*OPC?" & vbLf)
rep = E5270.ReadString(1 + 2)           'Response+CRLF
ret_val = E5270.ReadString(16 * nop)
For i = 0 To nop - 1            'nop=number of sweep steps
  head = Mid(ret_val, 16 * i + 1, 3)
  mdata = Val(Mid(ret_val, 16 * i + 4, 12))
  ddata = "Data = " & mdata & ", Header = " & head
  Console.WriteLine(ddata)
Next i
```

- To read data after every step measurement

  This way starts to read the data after the XE command. You do not need to wait for the sweep measurement completion. So you can check the result data before the sweep measurement is completed. For the specific example, see Table 3-6 on page 3-22.

  Example:

```
E5270.WriteString("FMT 5,0" & vbLf)       'terminator=comma
E5270.TerminationCharacter = Chr(44)      'Chr(44)=comma
E5270.TerminationCharacterEnabled = True 'enables comma
E5270.WriteString("XE" & vbLf)
For i = 0 To nop - 1            'nop=number of sweep steps
  ret_val = E5270.ReadString(3 + 12 + 1)
  head = Left(ret_val, 3)
  mdata = Val(Mid(ret_val, 4, 12))
  ddata = "Data = " & mdata & ", Header = " & head
  Console.WriteLine(ddata)
Next i
```

To Read Time Stamp Data

NOTE

This function is *not* available for the quasi-pulsed spot measurement (MM 9), search measurement (MM 14 or 15), and the binary data output format (FMT 3 or 4).

To read the time data with the best resolution (100 μs), clear the timer every 100 s or less (for FMT 1, 2, or 5), or 1000 s or less (for FMT 11, 12, 15, 21, 22, or 25).

The time stamp function records the time from when the timer count is cleared until the measurement is started. This function is enabled by the TSC command.

For example, in the staircase sweep measurement, the output data will be as follows:

Block1 [,*Block2*] . . . . <terminator>

where, *BlockN* (*N*: integer) = *Time1*,*Data1* [,*Time2*,*Data2*] ... [,*Source_data*], then *TimeN* (*N*: integer) is the time when the *DataN* measurement is started.

Without the TSC command, you can get the time data by the following commands:

- TSR: Resets the timer count (*Time*=0 s).
- TDV (for voltage output), TDI (for current output):

  Applies DC voltage or current, and returns the output start time.

  Example:

  ```
  OUTPUT @E5270;"TDV 1,0,20"
  ENTER @E5270 USING "#,5X,13D,X";Time
  PRINT "Time=";Time;"sec"
  ```

- TTV (for voltage measurement), TTI (for current measurement):

  Executes the high speed spot measurement, and returns the measurement data and the time data for the time from when the timer count is cleared until the measurement is started.

  Example:

  ```
  OUTPUT @E5270;"TTV 1,0"
  ENTER @E5270 USING "#,5X,13D,X";Time
  ENTER @E5270 USING "#,5X,13D,X";Mdata
  PRINT "Data=";Mdata;" at ";Time;"sec"
  ```

- TSQ: Returns the time when this command is entered.

  Example:

  ```
  OUTPUT @E5270;"TSR"            !Resets count
        :
  OUTPUT @E5270;"TSQ"            !Returns time data
  ENTER @E5270 USING "#,5X,13D,X";Time
  PRINT "Time=";Time;"sec"
  ```

To Perform High Speed Spot Measurement

The high speed spot measurement does not need the MM and XE commands to set the measurement mode and start measurement. To start and perform the high speed spot measurement immediately, send the TI/TTI command for the current measurement, or the TV/TTV command for the voltage measurement. The following example program measures current by using the TI command, and displays the measurement result data on the computer screen.

Example

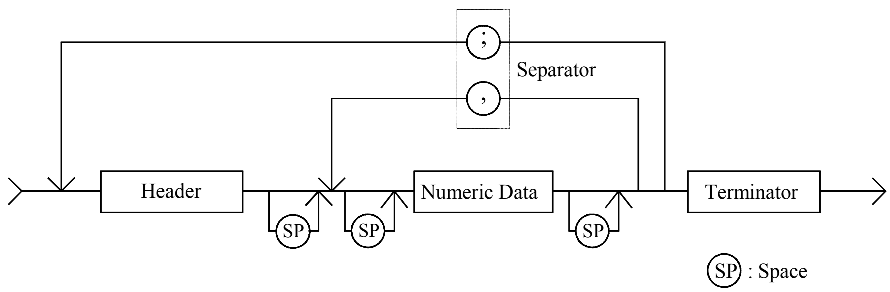
```
10    ASSIGN @E5270 TO 717
20    OUTPUT @E5270;"*RST"
30    OUTPUT @E5270;"FMT 5"
40    OUTPUT @E5270;"CN 1,2,3,4"
50    OUTPUT @E5270;"DV 1,0,0"
60    OUTPUT @E5270;"DV 2,0,0"
70    OUTPUT @E5270;"DV 3,0,2"
80    OUTPUT @E5270;"DV 4,0,5"
90    OUTPUT @E5270;"TI 4,0"
100   ENTER @E5270 USING "#,3A,12D,X";Head$,Data
110   PRINT Head$,Data
120   OUTPUT @E5270;"DZ"
130   OUTPUT @E5270;"CL"
140   END
```

Line Number	Description
10	Assigns the I/O path to control the E5260/E5270.
20	Initializes the E5260/E5270.
30	Sets the data output format (ASCII with header and <,>).
40	Enables channels 1, 2, 3, and 4.
50 to 80	Forces the DC voltage. Channel 1 and 2 force 0 V, channel 3 forces 2 V, and channel 4 forces 5 V with auto ranging.
90	Performs the high speed spot measurement using channel 4 with auto ranging.
100 to 110	Prints the header data and measurement data on the screen.
120	Forces 0 V. All channels force 0 V.
130	Disables all channels.

Command Input Format

The GPIB commands of the Keysight E5260/E5270 are composed of a header, numeric data, and terminator, as shown in the syntax diagram in the following figure.

E5260/E5270 Control Command Syntax Diagram



NOTE

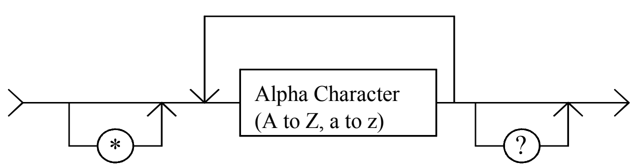
Terminator

Terminator is necessary to enter the command to the Keysight E5260/E5270. For the available terminators, see “Terminator” and “Special Terminator” on page 1-21.

Header

The header is the command name, always contains alpha characters, and is not upper or lowercase sensitive. Some command names also contain an asterisk (*) or question mark (?). The following figure shows the syntax diagram for a header.

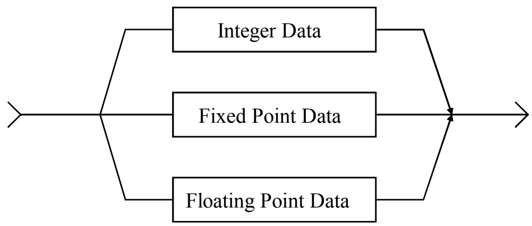
Header Syntax Diagram



Numeric Data

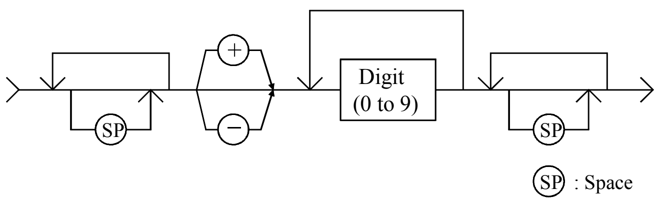
Numeric data are the command parameters. You can enter numeric data directly after the header or insert spaces between the header and numeric data. Some parameters require integer data. The following figure shows the syntax diagram for numeric data.

Numeric Data Syntax Diagram

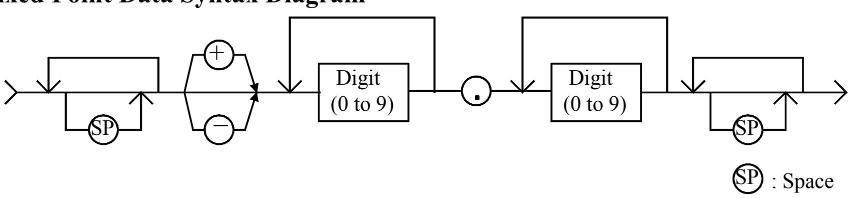


The following 3 figures show the syntax diagrams for integer, fixed point, and floating point data, respectively.

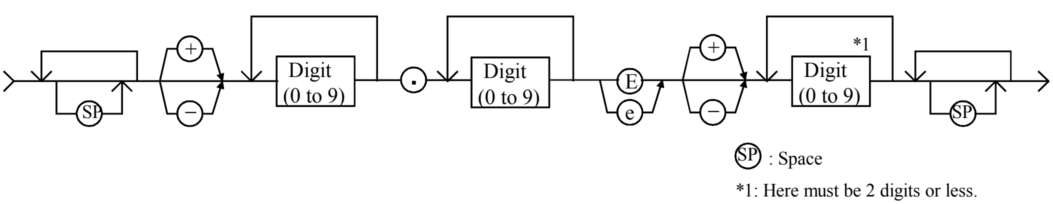
Integer Data Syntax Diagram



Fixed Point Data Syntax Diagram



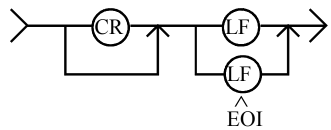
Floating Point Data Syntax Diagram



Terminator

The terminator completes the GPIB command entry and starts command execution. The following figure shows the terminator syntax diagram.

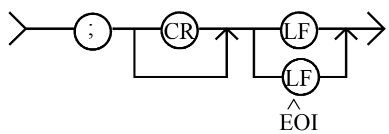
Terminator Syntax Diagram



Special Terminator

If a semicolon (;) is inserted before the terminator, as shown in the following figure, the preceding commands are not executed until the next command line is input and another terminator is input, without a preceding semicolon. The command lines are then executed together.

Special Terminator Syntax Diagram



Separator

If you enter multiple commands, use semicolons (;) to separate the commands. Spaces are allowed before and after the semicolons. Command execution starts when the terminator is received, not when the semicolon is received. You can input multiple commands of up to a total of 256 characters (including the terminator). If you input more than 256 characters, the input buffer overflows, and an error is indicated.

Use commas (,) to separate numeric data entries.

NOTE

Do not include the reset command (*RST) or the abort command (AB) in multiple command strings (example: `OUTPUT @E5270;"*RST;CN"`). If you do, the other commands in the string (example: `CN`) are not executed.

Data Output Format

Keysight E5260/E5270 provides the following data output formats:

- "ASCII Data Output Format"

  The E5260/E5270 supports ASCII format of the Keysight 4155B/4156B/4155C/4156C Parameter Analyzer in the Keysight FLEX command control mode and ASCII format of the Keysight 4142B Modular DC Source/Monitor.

  ASCII format provides better data resolution than binary format. You can read the data without calculation.

- "Binary Data Output Format"

  The E5260/E5270 supports binary format of the Keysight 4142B. Binary format enables faster data transfer time than ASCII format.

To select the data output format, use the FMT command. See "FMT" on page 4-59.

For the query response, the returned data is always stored in the query buffer in ASCII format, regardless of the FMT command setting.

A minimum of 17×1001×2 (34034) measurement data can be stored in the data output buffer.

Conventions

The following conventions are used in this section.

Data	Output data that the E5260/E5270 sends after a measurement.
[*Data*]	Optional output data sent when there are multiple output data items. For example, source data will be sent with measurement data after the staircase sweep measurements when the source data output is enabled by the FMT command.
<terminator>	Terminator. <CR/LF^EOI> (two bytes) or <,> (one byte) for ASCII data. <CR/LF^EOI> (two bytes) or <^EOI> (0 byte) for binary data. You can select by using the FMT command.

ASCII Data Output Format

This section describes the ASCII data output format, and the elements of the data.

- "Data Format"
- "Time Stamp"
- "Data Elements"

Data Format

The data output format depends on the measurement mode as shown below.

High Speed Spot

Data <terminator> (by TI or TV command)

Time,*Data* <terminator> (by TTI or TTV command)

Data is the value measured by the channel you specify by using the TI, TV, TTI, or TTV command. *Time* is the time from when the timer count is cleared until the measurement is started.

Spot

Data1 [,*Data2*] . . . . <terminator>

DataN (*N*: integer) is the value measured by a channel. The order of *Data* is defined by the MM command.

Pulsed Spot, Quasi-Pulsed Spot

Data <terminator>

Data is the value measured by the channel you specify by using the MM command.

Staircase Sweep, Multi Channel Sweep

Block1 [,*Block2*] . . . . <terminator>

Block1 is the block of data measured at the first sweep step. *Block2* is the block of data measured at the second sweep step.

where *Block* consists of the following data:

Data1 [,*Data2*] . . . . [,*Source_data*]

DataN (*N*: integer) is the value measured by a channel. The order of *Data* is defined by the MM command.

Source_data is the sweep source output value. It is sent if the data output is enabled by the FMT command.

Pulsed Sweep, Staircase Sweep with Pulsed Bias

Block1 [,*Block2*] . . . . <terminator>

Block1 is the block of data measured at the first sweep step. *Block2* is the block of data measured at the second sweep step.

where *Block* consists of the following data:

Data [,*Source_data*]

Data is the value measured by the channel you specify by using the MM command.

Source_data is the sweep source output value. It is sent if the data output is enabled by the FMT command.

Linear Search, Binary Search

Data_search [,*Data_sense*]<terminator>

This is the data at the measurement point closest to the search target.

Data_search is the value forced by the search output channel.

Data_sense is the value measured by the search monitor channel. It is sent if data output is enabled by the BSVM command for the binary search, or the LSVM command for the linear search.

TDI, TDV command

Time <terminator>

Time is the time from when the timer count is cleared until the output is started.

Time Stamp

NOTE

This function is *not* available for the quasi-pulsed spot measurement (MM9) and the search measurement (MM14 and MM15).

The E5260/E5270 can record the time when the measurement is started, and sends the time data (*Time*). This function is enabled by the TSC command.

The time data will be sent just before the measurement data. For example, in the staircase sweep measurements, the data will be as shown below.

Block1 [,*Block2*] . . . . <terminator>

where, *BlockN* (*N*: integer) = *Time1*,*Data1* [,*Time2*,*Data2*] ... [,*Source_data*], then *TimeN* (*N*: integer) is the time from when the timer count is cleared until the *DataN* measurement is started.

The timer count is cleared (*Time*=0) by the TSR command.

Data Elements

The measurement data (*Data*), source output data (*Source_data*), time data (*Time*), and search data (*Data_search* and *Data_sense*) are the string as shown below.

Data	FMT command
ABCDDDDDDDDDDDD	FMT1 or FMT5
ABCDDDDDDDDDDDDD	FMT11 or FMT15
EEEFGDDDDDDDDDDDDD	FMT21 or FMT25
DDDDDDDDDDDD	FMT2
DDDDDDDDDDDDD	FMT12 or FMT22

The data elements depends on the FMT command setting. Details of the elements are described on the following pages.

A: Status. One character.

B: Channel number. One character.

C: Data type. One character.

D: Data. Twelve digits or 13 digits.

E: Status. Three digits.

F: Channel number. One character.

G: Data type. One character.

A Status. One character.

- Status for *Source_data*:

  Priority of appearance is W<E.

A	Explanation
W	Data is for the first or intermediate sweep step.
E	Data is for the last sweep step.

- Status for *Data*, *Data_search*, or *Data_sense*: See Table 1-3 on page 1-29.

  Priority of appearance is as follows:

  - For the quasi-pulsed spot measurement: N<T<C<V<X<G or S
  - For other measurement: N<G<S<T<C<V<X<F

B Channel number of the measurement/source channel. One character.

B	Explanation
A	Channel 1.
B	Channel 2.
C	Channel 3.
D	Channel 4.
E	Channel 5.
F	Channel 6.
G	Channel 7.
H	Channel 8.

C Data type. One character.

C	Explanation
V	Voltage measurement data (*Data*).
I	Current measurement data (*Data*).
T	Time data (*Time*).

D

Value of *Data*, *Source_data*, Data_search, *Data_sense*, or *Time*.
Twelve or 13 digits depends on FMT setting, which may be one of the following:

- *sn.nnnnn*E*snn* or *sn.nnnnnn*E*snn*
- *snn.nnnn*E*snn* or *snn.nnnnn*E*snn*
- *snnn.nnn*E*snn* or *snnn.nnnn*E*snn*

where,

s: Sign, + or -.

n: Digit, 0 to 9.

E: Exponent symbol.

E

Status. Three digits. Ignore status for the *Time* value.

- Status for *Data*, *Data_search*, or *Data_sense*:

EEE	Explanation
1	A/D converter overflowed.
2	One or more units are oscillating.
4	Another unit reached its compliance setting.
8	This unit reached its compliance setting.
16	Target value was not found within the search range.
32	Search measurement was automatically stopped.
64	Invalid data is returned. *D* is not used.
128	EOD (End of Data).

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

- Status for *Source_data*: Priority of appearance is W<E.

EEE	Explanation
W	Data is for the first or intermediate sweep step.
E	Data is for the last sweep step.

F

Channel number of the measurement/source unit. One character.

F	Explanation
A	Channel 1.
B	Channel 2.
C	Channel 3.
D	Channel 4.
E	Channel 5.
F	Channel 6.
G	Channel 7.
H	Channel 8.
V	GNDU.
Z	Status code for extraneous data in the channel. TSQ command response or invalid data is returned.

G

Data type. One character.

G	Explanation
V	Voltage measurement data (*Data*).
v	Voltage source setup data (*Setup_data*).
I	Current measurement data (*Data*).
i	Current source setup data (*Setup_data*).
T	Time data (*Time*).
Z	Invalid data is returned.
z	

Table 1-3 **Status for Data, Data_search, or Data_sense**

A	Explanation
N	No status error occurred.
T	Another channel reached its compliance setting.
C	This channel reached its compliance setting.
V	Measurement data is over the measurement range. Or the sweep measurement was aborted by the automatic stop function or power compliance. *D* will be the meaningless value 199.999E+99.
X	One or more channels are oscillating. Or source output did not settle before measurement.[a]
G	For linear or binary search measurement, the target value was not found within the search range. Returns the source output value. For quasi-pulsed spot measurement, the detection time was over the limit (3 s for Short mode, 12 s for Long mode).[b]
S	For linear or binary search measurement, the search measurement was stopped. Returns the source output value. See status of *Data_sense*. For quasi-pulsed spot measurement, output slew rate was too slow to perform the settling detection.[c] Or quasi-pulsed source channel reached the current compliance before the source output voltage changed 10 V from the start voltage.[d]

a. Make the wait time or delay time longer. Or make the current compliance larger. For pulsed measurement, make the pulse width longer, or make the pulse base value closer to the pulse peak value. For current output by limited auto ranging, make the output range lower.
b. Make the current compliance or start voltage larger. Or set the detection interval to Long. If this status occurs with the Long mode, perform the spot measurement.
c. Make the current compliance larger. Or set the detection interval to Long. If this status occurs with the Long mode, perform the spot measurement or pulsed spot measurement.
d. Perform the pulsed spot measurement or spot measurement.

Binary Data Output Format

This section describes the binary data output format, and the elements of the data.

- "Data Format"
- "Data Elements"

NOTE

Data resolution

The resolution of binary data is as shown below.

- Measurement data: Measurement range / 50000
- Output data: Output range / 20000

Note that the resolution of the measurement data is larger than the resolution of the high resolution A/D converter.

Data Format

The data output format depends on the measurement mode as shown below.

High Speed Spot

Data <terminator>

Data is the value measured by the channel you specify by using the TI or TV command.

Spot

Data1 [*Data2*] . . . . <terminator>

DataN (*N*: integer) is the value measured by a channel. The order of *Data* is defined by the MM command.

Pulsed Spot, Quasi-Pulsed Spot

Data <terminator>

Data is the value measured by the channel you specify by using the MM command.

Staircase Sweep, Multi Channel Sweep

Block1 [*Block2*] . . . . <terminator>

Block1 is the block of data measured at the first sweep step. *Block2* is the block of data measured at the second sweep step.

where *Block* consists of the following data:

Data1 [*Data2*] . . . . [*Source_data*]

DataN (*N*: integer) is the value measured by a channel. The order of *Data* is defined by the MM command.

Source_data is the sweep source output value. It is sent if the data output is enabled by the FMT command.

Pulsed Sweep, Staircase Sweep with Pulsed Bias

Block1 [*Block2*] . . . . <terminator>

Block1 is the block of data measured at the first sweep step. *Block2* is the block of data measured at the second sweep step.

where *Block* consists of the following data:

Data [*Source_data*]

Data is the value measured by the channel you specify by using the MM command.

Source_data is the sweep source output value. It is sent if the data output is enabled by the FMT command.

Linear Search, Binary Search

Data_search [*Data_sense*]<terminator>

This is the data at the measurement point closest to the search target.

Data_search is the value forced by the search output channel.

Data_sense is the value measured by the search monitor channel. It is sent if data output is enabled by the BSVM command for the binary search, or the LSVM command for the linear search.

Data Elements

The measurement data (*Data*), source output data (*Source_data*), and search data (*Data_search* and *Data_sense*) are the 4 byte data as shown below.

<table>
<tr><td colspan="8">Byte 1</td><td colspan="8">Byte 2</td><td colspan="8">Byte 3</td><td colspan="8">Byte 4</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>A</td><td>B</td><td colspan="5">C</td><td colspan="17">D</td><td colspan="3">E</td><td colspan="5">F</td></tr>
</table>

There are 6 data elements. Details of the elements are described in the following pages.

A: Measurement or source output data type. One bit.

B: Data type. One bit.

C: Measurement or output range. Five bits.

D: Data. 17 bits.

E: Status. Three bits.

F: Channel number. Five bits.

A Measurement or source output data type. One bit.

A	Explanation
0	Source output data.
1	Measurement data.

B Data type. One bit.

B	Explanation
0	Voltage data.
1	Current data.

C Measurement or output range. Five bits.

C	Explanation
01000 (8)	0.5 V or 1 pA range.
01001 (9)	5 V or 10 pA range.
01010 (10)	100 pA range.
01011 (11)	2 V or 1 nA range.
01100 (12)	20 V or 10 nA range.
01101 (13)	40 V or 100 nA range.
01110 (14)	100 V or 1 μA range.
01111 (15)	200 V or 10 μA range.
10000 (16)	100 μA range.
10001 (17)	1 mA range.
10010 (18)	10 mA range.
10011 (19)	100 mA range.
10100 (20)	1 A range for E5280B/E5290A HPSMU or 200 mA range for E5291A MPSMU.
11111 (31)	Invalid data is returned.

D

Value of *Data*, *Source_data*, *Data_search*, or *Data_sense*.
This value is expressed in 17-bit binary data. The value can be calculated by the following formula.

Measurement data = $Count \times Range$ /50000

Source data = $Count \times Range$ /20000

where, *Count* is the decimal value of *D*, and *Range* is the measurement range or output range indicated by *C*.

For the current data, the measurement range or output range value can be calculated by the following formula:

Current measurement/output range (A) = 10^(*C*-20)

If the top bit of the binary data is 0, *Count* is positive and equal to the decimal value of the 16-bit binary data that follows the top bit.

If the top bit is 1, *Count* is negative. Calculate *Count* by subtracting 65536 (10000000000000000 in binary) from the decimal value of the 16-bit binary data.

Example:

If the output binary data is:

11010110000100111000100000000001

then,

Data type:	Current measurement data (*A*=1, *B*=1)
***Range*:**	1 nA=1E–9 A (*C*=01011)
***Count*:**	5000 (*D*=00001001110001000)
Status:	Normal condition (*E*=000)
Channel:	SMU1 (channel number 1) (*F*=00001)

Measurement data = 5000 × 1E–9/5E+4 = 100 pA

NOTE

B=1 and *C*=10100 means that HPSMU used 1 A range or MPSMU used 200 mA range. Then use *Range*=1 to calculate the data for both HPSMU and MPSMU. *Range*=0.2 is not available even if the range value is 200 mA.

E

Status. Three bits.

- Status for *Source_data*:

  Priority of appearance is 001<010.

E	Explanation
001	Data is for the first or intermediate sweep step.
010	Data is for the last sweep step.

- Status for *Data*, *Data_search*, or *Data_sense*. See Table 1-4.

  Priority of appearance is as follows:

  - For the quasi-pulsed spot measurement: 0<1<2<3<4<6 or 7
  - For other measurement: 0<6<7<1<2<3<4<5

F

Channel number of the measurement/source channel. Five bits.

F	Explanation
00001 (1)	Channel 1.
00010 (2)	Channel 2.
00011 (3)	Channel 3.
00100 (4)	Channel 4.
00101 (5)	Channel 5.
00110 (6)	Channel 6.
00111 (7)	Channel 7.
01000 (8)	Channel 8.
11111 (31)	Invalid data is returned.

Table 1-4 **Status for Data, Data_search, or Data_sense**

E	Explanation
000 (0)	No status error occurred.
001 (1)	Another channel reached its compliance setting.
010 (2)	This channel reached its compliance setting.
011 (3)	Measurement data is over the measurement range. *D* will be the meaningless value 1111111111111111 (65535).
100 (4)	One or more channels are oscillating. Or source output did not settle before measurement.[a]
110 (6)	For linear or binary search measurement, the target value was not found within the search range. Returns the source output value. For quasi-pulsed spot measurement, the detection time was over the limit (3 s for Short mode, 12 s for Long mode).[b]
111 (7)	For linear or binary search measurement, the search measurement was stopped. Returns the source output value. See status of *Data_sense*. For quasi-pulsed spot measurement, output slew rate was too slow to perform the settling detection.[c] Or quasi-pulsed source channel reached the current compliance before the source output voltage changed 10 V from the start voltage.[d]

a. Make the wait time or delay time longer. Or make the current compliance larger. For pulsed measurement, make the pulse width longer, or make the pulse base value closer to the pulse peak value. For current output by limited auto ranging, make the output range lower.
b. Make the current compliance or start voltage larger. Or set the detection interval to Long. If this status occurs with the Long mode, perform the spot measurement.
c. Make the current compliance larger. Or set the detection interval to Long. If this status occurs with the Long mode, perform the spot measurement or pulsed spot measurement.
d. Perform the pulsed spot measurement or spot measurement.

GPIB Interface Capability

The following table lists the GPIB capabilities and functions of the Keysight E5260/E5270. These functions provide the means for an instrument to receive, process, and transmit, commands, data, and status over the GPIB bus.

Interface Function	Code	Description
Source Handshake	SH1	Complete capability
Acceptor Handshake	AH1	Complete capability
Talker	T6	Basic Talker: YES Serial Poll: YES Talk Only Mode: NO Unaddress if MLA (my listen address): YES
Listener	L4	Basic Listener: YES Unaddress if MTA (my talk address): YES Listen Only Mode: NO
Service Request	SR1	Complete capability
Remote/Local	RL1	Complete capability (with local lockout)
Parallel Poll	PP0	No capability
Device Clear	DC1	Complete capability
Device Trigger	DT1	Complete capability
Controller Function	C0	No capability
Driver Electronics	E1	Open Collector

The E5260/E5270 responds to the following HP BASIC statements:

- ABORT (IFC)
- CLEAR (DCL or SDC. same as AB command)
- LOCAL (GTL)
- LOCAL LOCKOUT (LL0)
- REMOTE
- SPOLL (Serial Poll)
- TRIGGER (GET. same as XE command)

NOTE

If You Use LOCAL Statement

If the LOCAL statement is sent to GPIB devices, they can receive the GPIB command even in the local state. This allows you to confirm the E5260/E5270 GPIB command operation on the front panel LCD although it makes the operation time longer. Execute the following statement to get this feature without making the operation time longer.

The following example is for the computer with the GPIB interface logical unit 7 and the E5260/E5270 with the GPIB address 17.

```
LOCAL 7
REMOTE 717
OUTPUT 717;"RED 1"
```

Status Byte

Status byte bits are turned off or on (0 or 1) to represent the instrument operation status. When you execute a serial poll, an external computer (controller) reads the contents of the status byte, and responds accordingly. When an unmasked status bit is set to “1”, the instrument sends an SRQ to the controller, causing the controller to perform an interrupt service routine.

Bit	Decimal Value	Description
0	1	Data Ready Indicates whether the output buffer is empty. If an unread data or query response exists, this bit is set to “1”. It is set to “0” when all the stored data has been transferred to the controller, or when the E5260/E5270 receives a *RST, BC, FMT, or device clear command.
1	2	Wait Indicates whether the instrument is in the wait status. This bit is set to “1” when the E5260/E5270 has been set to the wait state by the PA, WS, PAX, or WSX command. It is set to “0” when the waiting condition is complete, or when the E5260/E5270 receives a *RST or device clear command.
2	4	Not used. This bit is always set to “0”.
3	8	Interlock Open If the interlock circuit is open, and a voltage output or voltage compliance setup value exceeds ±42 V, this bit is set to “1” . It is set to “0” when the E5260/E5270 receives a serial poll, *RST, or device clear command.
4	16	Set Ready If the E5260/E5270 receives a GPIB command or a trigger signal, this bit is set to “0”. It is set to “1” when its operation is completed. This bit is also set to “0” when the self-test or calibration is started by front panel operation, and set to “1” when it is completed.

Bit	Decimal Value	Description
5	32	Error Indicates whether any error has occurred. If an error occurred, this bit is set to “1”. It is set to “0” when the E5260/E5270 receives a serial poll, *RST, ERR?, CA, *TST?, *CAL?, DIAG? or device clear command.
6	64	RQS (You cannot mask this bit.) Indicates whether an SRQ (Service Request) has occurred. This bit is set to “1” whenever any other unmasked bit is set to “1”. This causes the E5260/E5270 to send an SRQ to the controller. It is set to “0” when the E5260/E5270 receives a serial poll, *RST, or device clear command.
7	128	Shutdown If the E5260/E5270 turned off by itself to avoid damage, or an instantaneous power down occurred on the site power line, this bit is set to “1”. It is set to “0” when the E5260/E5270 receives a serial poll, *RST, or device clear command.

The status byte register can be read with either a serial poll or the *STB? query command. Serial poll is a low-level GPIB command that can be executed by the `SPOLL` command in HP BASIC, for example `Status=SPOLL(@E5270)`.

In general, use serial polling (not *STB?) inside interrupt service routines. Use *STB? in other cases (not in interrupt service routine) when you want to know the value of the Status Byte.

NOTE

If Bit 3, Bit 5, or Bit 7 are masked, they are not set to “0” by a serial poll. Also, if these bits are masked, set to “1”, and then unmasked, a serial poll does not set them to “0”.

After a masked bit is set to “1”, removing the mask does not set Bit 6 to “1”. That is, the E5260/E5270 does not send an SRQ to the controller. Therefore, if you remove a mask from a bit, it is usually best to do it at the beginning of the program.

Programming Tips

This section provides the following additional information on creating measurement programs. It is useful for checking the operation status, improving the measurement speed, and so on.

- "To Confirm the Operation"
- "To Confirm the Command Completion"
- "To Disable the Auto Calibration"
- "To Optimize the Measurement Range"
- "To Optimize the Integration Time"
- "To Disable the ADC Zero Function"
- "To Optimize the Source/Measurement Wait Time"
- "To Use the Internal Program Memory"
- "To Get Time Data with the Best Resolution"
- "To Use Sweep Source as a Constant Source"
- "To Start Measurements Simultaneously"
- "To Interrupt Command Execution"
- "To Use Programs for Keysight 4142B"
- "To Use Programs for Keysight 4155/4156"
- "To Use Programs for Keysight E5270A"

To Confirm the Operation

To complete the measurement program, you can insert statements to check the E5260/E5270 operation status as shown below. This example starts the measurement, checks the status caused by the statements before the ERR? command, reads and displays the measurement data without errors, or displays an error message when an error occurs.

```
OUTPUT @E5270;"XE"
OUTPUT @E5270;"ERR? 1"
ENTER @E5270;Code
IF Code=0 THEN
  ENTER @E5270 USING "#,3X,12D,X";Mdata
  PRINT "I(A)=";Mdata
ELSE
  OUTPUT @E5270;"EMG? ";Code
  ENTER @E5270;Msg$
  PRINT "ERROR: ";Msg$
END IF
```

To Confirm the Command Completion

To check the completion of the previous command execution, use the *OPC? query command. Entering the *OPC command before sending a command to other equipment serves to delay its operation until the E5260/E5270 has completed its operation. The *OPC? command is useful to control equipments sequentially.

For example, the following program segment waits until the E5260/E5270 completes the DI command execution, and sends the *DCV* command to equipment identified by *@Address*.

```
OUTPUT @E5270;"DI";1,0,1.0E-10,1
OUTPUT @E5270;"*OPC?"
ENTER @E5270; A$
OUTPUT @Address;"DCV"
```

To Disable the Auto Calibration

The auto calibration function triggers self-calibration automatically every 30 minutes after measurement. When the function is enabled, open the measurement terminals frequently because calibration requires open terminals.

If you execute automatic measurements as a batch job that might leave the device connected for over 30 minutes after the measurements, disable auto calibration. Otherwise, the calibration might not be performed properly, or unexpected output might appear at the measurement terminals, and it could even damage the device. To disable auto calibration, send the `CM 0` command.

To Optimize the Measurement Range

The most effective way to improve measurement speed is to reduce the number of range changes. The limited auto ranging mode is more effective than the auto ranging mode. The fixed range mode is the most effective.

Check the typical value of the measurement data, select the optimum range, and perform measurement using the fixed range mode.

To Optimize the Integration Time

For best reliability and repeatability of the measurement data, the integration time or the number of averaging samples of the A/D converter must be increased. This increases the measurement time.

A long integration time and numerous samples are required for low current/ voltage measurements. However, the values can be decreased for medium or high current/voltage measurements. Enter the following commands:

AV Sets the number of averaging samples of the A/D converter. This command is compatible with the AV command of the Keysight 4142B.

AAD Selects the type of the A/D converter (high-speed ADC or high-resolution ADC) of the Keysight E5270B.

AIT Sets the integration time of the high-resolution ADC or the number of averaging samples of the high-speed ADC of the Keysight E5270B. The AIT command covers the function of the AV command. The last command setting is available for the measurement.

For more information regarding these commands, refer to Chapter 4, “Command Reference.” The AAD/AIT commands are available only for the Keysight E5270B.

To Disable the ADC Zero Function

This information is effective only for the Keysight E5270B and when the high resolution A/D converter is used for the measurement. If measurement speed is given top priority or is more important than reliability, disable the ADC zero function by sending the `AZ 0` command. This roughly halves integration time.

NOTE The ADC zero function is the function to cancel offset of the high resolution ADC. This function is especially effective for low voltage measurements.

To Optimize the Source/Measurement Wait Time

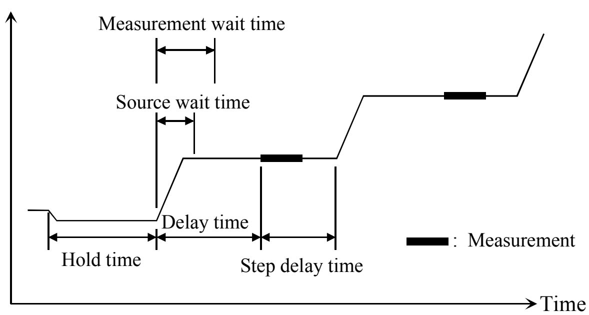
If measurement speed is given top priority or is more important than reliability, set the wait time shorter by using the WAT command. The source wait time is the time the source channel always waits before changing the source output value. The measurement wait time is the time the measurement channel always waits before starting measurement. The time is given by the following formula:

wait time = *initial wait time* × *A*+*B*

where, *initial wait time* is the time the E5260/E5270 automatically sets and you cannot change. The *initial source wait time* is not the same as the *initial measurement wait time*. *A* and *B* are the command parameters of the WAT command.

The wait time settings are effective for all modules.

Figure 1-1 **Source/Measurement Wait Time**



NOTE

The wait time can be ignored if it is shorter than the delay time.

It is not easy to determine the best wait time. If you specify it too short, the measurement may start before device characteristics stable. If too long, time will be wasted.

The initial wait time may be too short for measurements of high capacitance or slow response devices. Then set the wait time longer.

For measurements of low capacitance or fast response devices, if measurement speed has top priority or is more important than reliability and accuracy, set the wait time shorter.

To Use the Internal Program Memory

If your program repeats the setup and measurement for a number of devices, use the internal program memory. For these measurements, using the internal program memory reduces the command transfer time, and improves the program execution speed.

You can enter a maximum of 2,000 programs (total 40,000 commands) into the internal program memory. Refer to Chapter 2, “Remote Mode Functions.”

To Get Time Data with the Best Resolution

To read the time data with the best resolution (100 μs), the timer must be cleared within the following interval:

- 100 sec or less (for FMT1, 2, or 5 data output format)
- 1000 sec or less (for FMT 11, 12, 15, 21, 22, or 25 data output format)

Send the TSR command to clear the timer.

To Use Sweep Source as a Constant Source

The following setup enables sweep source to force a constant current or voltage.

- Sweep start value = Sweep stop value (for WI, WV, or WNX).

Also, setting number of sweep steps to 1 enables to perform a spot measurement.

To Start Measurements Simultaneously

Spot measurement, staircase sweep measurement, and multi channel sweep measurement enable to use multiple measurement channels. Then the measurement channels perform measurement in the order defined in the MM command. However, the measurement channels with the following setup start measurements simultaneously.

- To set the multi channel sweep measurement mode (MM 16).
- To set the measurement ranging mode to fixed (for RI or RV).
- For the Keysight E5270B, to use the high-speed ADC (use AV).

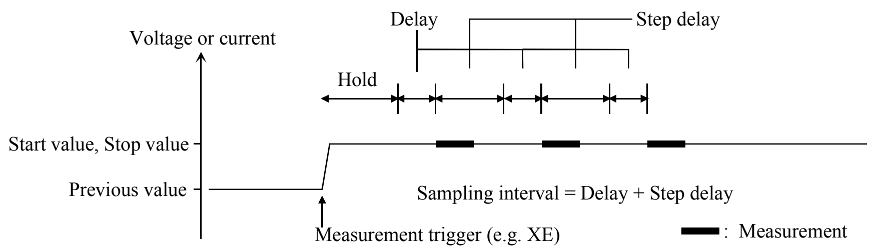
NOTE

Measurement setup is independent from source output setup. So, this simultaneous measurement cannot be broken by the source output setup. Any setting of the output ranging mode is effective for the simultaneous measurement.

To Perform Quasi-Sampling Measurement

The following setup enables to perform a quasi-sampling measurement. Then the sampling interval will be sum of delay time and step delay time.

- Sets the sweep measurement mode (MM 2 or MM 16).
- Sweep start value = Sweep stop value (for WI, WV, or WNX).
- Sets hold time, delay time, and step delay time (WT).



To Interrupt Command Execution

The E5260/E5270 executes commands in the received order. However, only the following commands can interrupt the command execution.

Table 1-5 **Interrupt Commands**

Command	Description
AV	Changes the number of averaging samples during the measurement.
AIT	Changes the integration time during the measurement.
AB	Aborts the command execution.
*RST	Resets the E5260/E5270 during the command execution.
XE	If the E5260/E5270 has been set to the wait status by the PA or PAX command, the XE command can be used to release the wait status. For details, refer to Chapter 4, “Command Reference.”

To Use Programs for Keysight 4142B

Keysight E5260/E5270 supports most of the commands and the data output format supported by the Keysight 4142B Modular DC Source/Monitor. To reuse the programs created for the Keysight 4142B, confirm the following and modify the programs if necessary.

- To remove all unsupported commands

  Some commands are not supported owing to differences in the modules supported by each instrument. Refer to Table 1-6 that shows the commands not supported by the E5260/E5270. Do not use these commands.

  Perform the linear search or binary search measurement as a substitute for the analog search measurement that needs the analog feedback unit (AFU).

  Use a source/monitor unit (SMU) instead of the voltage source/voltage monitor unit (VS/VMU). Note that the SMU cannot perform the differential voltage measurements.

- FL command

  The initial setting of the FL command is different. It is ON for the Keysight 4142B, and OFF for the E5260/E5270.

  Add the FL1 command to use the filter.

- AV command

  This command is used to set the A/D converter of the E5260/E5270.

  To set the high resolution ADC installed in the E5270B, use the AAD and AIT commands.

Table 1-6 **Modules and Commands Unsupported**

Plug-in Module	Commands
Analog Feedback Unit	ASM, AT, ASV, AIV, AVI
High Current Unit	PDM, PDI, PDV
High Voltage Unit	POL
Voltage Source/Voltage Monitor Unit	VM

To Use Programs for Keysight 4155/4156

Keysight E5260/E5270 supports commands similar to the FLEX command of the Keysight 4155B/4156B/4155C/4156C Parameter Analyzer. However, not all command sets are fully compatible. To reuse the programs created for the Keysight 4155/4156, the following modifications are required.

- To remove all unsupported commands

  Table 1-7 shows the commands not supported by the E5260/E5270. You cannot use these commands. The SCPI commands and 4145 syntax commands are not supported either.

  The E5260/E5270 does not need the US and :PAGE commands that are necessary to change the control mode of the Keysight 4155/4156.

- To check and correct the command syntax

  Even if the command name is the same, the available parameters and values may be different. Check and correct the command parameters.

- To change the FMT command parameter

  Use the FMT 21, FMT 22, or FMT 25 command that sets the data output format compatible with the 4155/4156 ASCII format.

- To delete RMD?

  The E5260/E5270 does not need the RMD? command that is necessary to put the measurement data into the output data buffer of the Keysight 4155/4156.

- FL command

  The initial setting of the FL command is different. It is ON for the Keysight 4155/4156, and OFF for the E5260/E5270.

  Add the FL1 command to use the filter.

- AV command

  This command is used to set the A/D converter of the E5260/E5270.

  To set the high resolution ADC installed in the E5270B, use the AAD and AIT commands.

- To replace TI?/TV?/TTI?/TTV? with TI/TV/TTI/TTV respectively
- To replace WM with LSM for the linear search measurement
- To replace TSQ? with TSQ

- If you reuse the built-in IBASIC programs:
  - Change the GPIB address.
  - Remove the statements to use the built-in flexible disk drive.

Table 1-7 **FLEX Commands Unsupported**

Category	Command
Control mode	:PAGE, US, US42
Measurement mode	VM, VMD
Staircase/pulsed sweep source setup	ESC
Sampling source setup	MCC, MI, MP, MSC, MV
Quasi-static CV measurement setup	QSL, QSM, QSR, QST, QSV, QSZ, QSZ?
PGU control	POR, SPG, SPP, SRP
Stress source setup	STC, STI, STM, STP, STT, STV
Measurement setup	MT
Integration time	SIT, SLI
Measurement execution	TI?, TTI?, TTV?, TV?
Time stamp	TSQ?
Output data	RMD?
Abort/pause/wait	*WAI
Zero offset cancel	GOC, SOC
SMU/PGU selector	SSP
R-box	RBC
External trigger	STG
Network operation	CLOSE, OPEN, PRN, RD?, SDSK, SPL, SPR, WR
Status byte	*CLS, *ESE(?), *ESR?
Query	CMD?, *OPT?, :SYST:ERR?

To Use Programs for Keysight E5270A

Keysight E5270B supports all of the commands and the data output format supported by the Keysight E5270 series.

Keysight E5260 series supports most of the commands and the data output format supported by the Keysight E5270 series. To reuse the programs created for the Keysight E5270 series, confirm the following and modify the programs if necessary.

- To remove all unsupported commands

  The following commands are not supported by the Keysight E5260 series. Do not use the commands.

  - AAD

    E5260 series does not have the function corresponding to this command.

  - AIT

    Use the AV command instead of this command.

  - AZ

    E5260 series does not have the function corresponding to this command.

- Measurement range

  Keysight E5260 series does not have the 1 nA range and the 10 nA range. Use the 100 nA range or above.

2 Remote Mode Functions

KEYSIGHT TECHNOLOGIES

This chapter describes the functions of the Keysight E5260/E5270 in the remote mode, and the initial settings.

- “Measurement Modes”
- “Synchronous Output”
- “Automatic abort Function”
- “Program Memory”
- “Digital I/O Port”
- “Trigger Function”
- “Initial Settings”

NOTE

Synchronous Output

You can use synchronous output that will be synchronized to the output of the primary sweep or search source. The output is available for the following measurement modes:

- “Staircase Sweep Measurements”
- “Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Binary Search Measurements”
- “Linear Search Measurements”

The synchronous source supports the output mode (voltage or current) same as the primary source, and does not support the pulsed output.

Measurement Modes

The Keysight E5260/E5270 provides the following measurement modes.

- “Spot Measurements”
- “Pulsed Spot Measurements”
- “Staircase Sweep Measurements”
- “Multi Channel Sweep Measurements”
- “Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Quasi-Pulsed Spot Measurements”
- “Binary Search Measurements”
- “Linear Search Measurements”

NOTE

About Search Measurements

The E5260/E5270 supports search measurement to find a point on an I-V curve where a specified condition is satisfied. For example, it searches for a breakdown voltage or threshold voltage at a specified current.

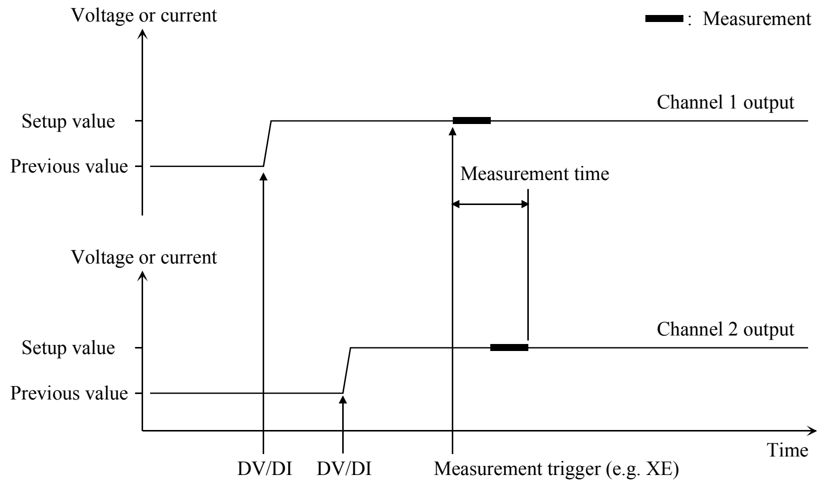
Search measurements are performed by one or two SMUs. For two SMUs, one is the search channel, and the other is a sense channel. When one SMU is used, it serves as both search and sense channel.

Basically, the search channel forces voltage or current until the search stop condition is satisfied.

Spot Measurements

Spot measurement is performed as shown below. The measurement channel performs one point measurement.

Figure 2-1 **Spot Measurements**



1. The source channel starts output by the DV or DI command.

   You can use up to eight channels for the 8-ch mainframe, two channels for the 2-ch mainframe.

2. The measurement channel starts measurement by a trigger, such as the XE command. If the trigger is received during the settling time of the source channels, measurement starts after the settling time.

   You can use up to eight channels for the 8-ch mainframe, two channels for the 2-ch mainframe. If you use multiple measurement channels, the channels perform measurement in the order defined in the MM command.

3. After measurement, the source channels continue the source output.

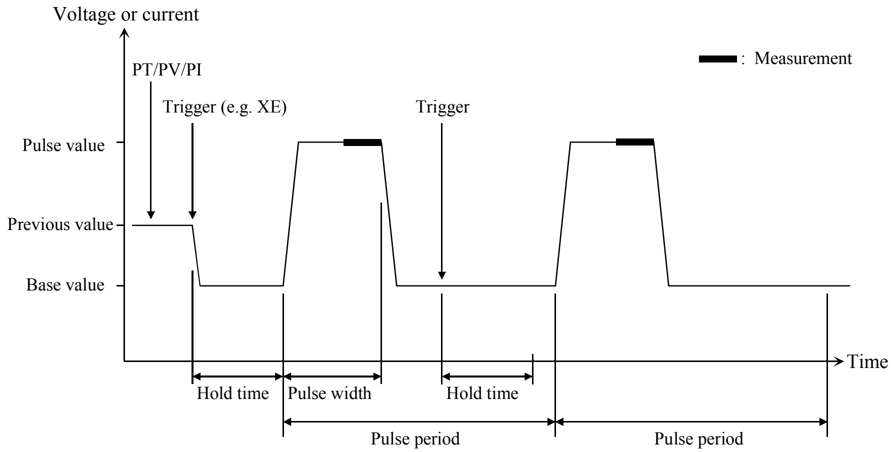
   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE The DV command is used to force voltage, and the DI command is used to force current.

Pulsed Spot Measurements

Pulsed spot measurement is performed as shown below. The measurement channel performs one point measurement while the source channel is forcing a pulse.

Figure 2-2 **Pulsed Spot Measurements**



1. The pulse source channel sets output by the PT command and the PV or PI command. Only one channel can be used for the pulse source.
2. The pulse source channel starts output by a trigger, such as the XE command.
3. The measurement channel starts measurement as shown in Figure 2-2.
   The channel performs measurement so that the pulse width and pulse period are kept (the integration time setting is ignored). Only one channel can be used for measurement.
4. After measurement, the pulse source channel forces the pulse base value.

   If the next trigger occurs within the pulse period, and if the rest of the pulse period is longer than the hold time as shown in Figure 2-2, the pulse source waits for the rest, then starts the pulse output immediately. If the rest of the pulse period is shorter than the hold time, the pulse source waits for the hold time since the last trigger, then starts the pulse output.

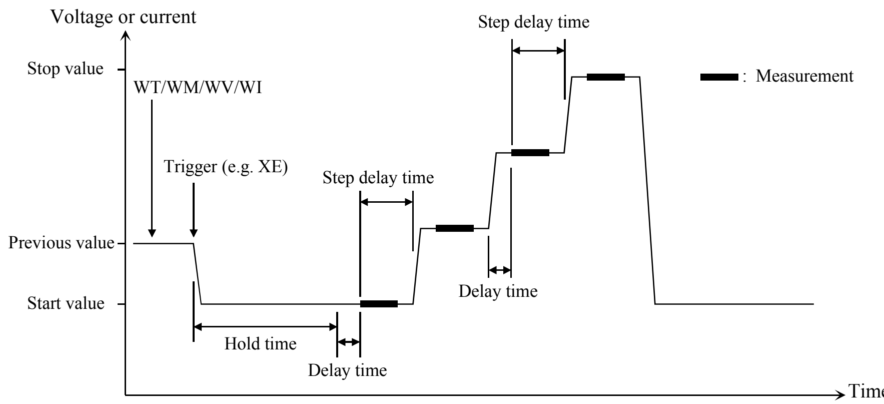
   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE The PT command sets the pulse timing parameters, such as pulse width and pulse period. The PV command sets voltage pulse, and the PI command sets current pulse.

Staircase Sweep Measurements

Staircase sweep measurement is performed as shown below. The source channel forces staircase sweep voltage or current, and the measurement channel performs one point measurement at each sweep step.

Figure 2-3 **Staircase Sweep Measurements**



1. The staircase sweep source sets output by the WT, WM, and WV or WI commands. Only one channel can be used for the sweep source.
2. The sweep source starts output by a trigger, such as the XE command.
3. After the hold time, the sweep source waits for the delay time.
4. After the delay time, the measurement channel starts measurement.

   You can use up to eight channels for the 8-ch mainframe, two channels for the 2-ch mainframe. If you use multiple measurement channels, the channels perform measurement in the order defined in the MM command.
5. After measurement, the sweep source waits for the rest of the step delay time if it is set, and the sweep source changes the output value.
6. The E5260/E5270 repeats 4 and 5 for all sweep steps.
7. After the sweep measurement, the sweep source forces the start or stop value, as specified by the WM command, and keeps it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

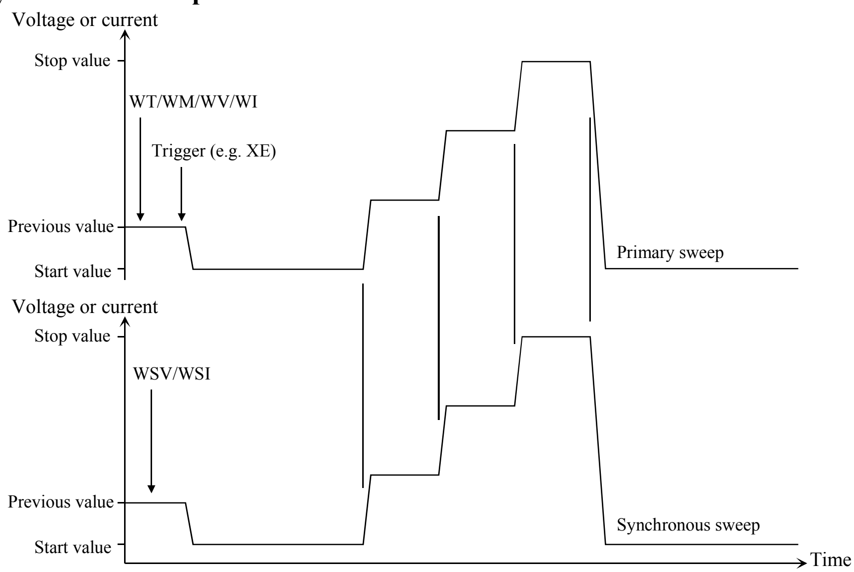
NOTE

The WT command sets the hold time, delay time, and step delay time. The WM command sets the automatic abort function and the output after measurement. The WV command sets the sweep voltage, and the WI command sets the sweep current. The start and stop values must have the same polarity for log sweep.

To Use Synchronous Sweep Source

One more channel can be set up as a sweep source that has the output synchronized with the staircase sweep. Refer to "Synchronous Output" on page 2-21. After the measurement, the synchronous sweep source forces the start or stop value, as specified by the WM command, and keeps it.

Figure 2-4 **Synchronous Sweep**



NOTE

The WSV command sets the sweep voltage, and the WSI command sets the sweep current. You can use the same output mode (voltage or current) as the primary sweep. The start and stop values must have the same polarity for log sweep.

To Stop Sweep Output

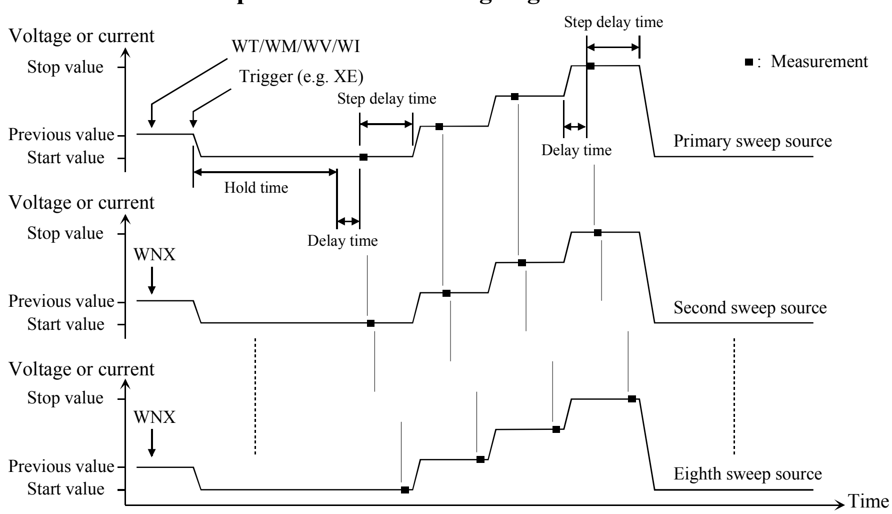
An automatic abort function is available. Refer to "Automatic abort Function" on page 2-23.

Even if the automatic abort function is disabled, the E5260/E5270 automatically stops measurement if power compliance is enabled for the sweep source and the power compliance or an automatic abort condition is detected.

Multi Channel Sweep Measurements

Multi channel sweep measurement is performed as shown below. The source channel forces staircase sweep voltage or current, and the measurement channel performs one point measurement at each sweep step. Up to eight channels can be used for both sweep output and measurement. Both voltage output mode and current output mode are available for the sweep sources regardless of the output mode of the primary sweep source.

Figure 2-5 **Multi Channel Sweep Measurements using High-Resolution A/D Converter**



1. The primary sweep source sets output by the WV or WI commands. And the *n*th (*n*=2 to 8) sweep source sets output by the WNX command.
2. The sweep sources simultaneously start output by a trigger, such as the XE command. However, if a sweep source sets power compliance or forces logarithmic sweep current, the sweep sources start output in the order specified by the *n* value. Then the first output is forced by the channel set by the WI or WV command.
3. After the hold time, the sweep sources wait for the delay time.
4. After the delay time, the measurement channel starts measurement. If you use multiple measurement channels, the channels that use the fixed measurement ranging mode start measurement simultaneously, then other channels perform measurement in the order defined in the MM command.

   For the Keysight E5270B, note that the high-resolution ADC cannot perform simultaneous measurement.

5. After measurement, the sweep source waits for the rest of the step delay time if it is set, and the sweep source changes the output value.
6. The E5260/E5270 repeats 4 and 5 for all sweep steps.
7. After the sweep measurement, the sweep sources force the start or stop value, as specified by the WM command, and keep it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE

The WT command sets the hold time, delay time, and step delay time. The WM command sets the automatic abort function and the output after measurement. The WV/WI command sets the output of the first sweep source, and the WNX command sets the output of the *n*th (*n*=2 to 8) sweep source. The start and stop values must have the same polarity for log sweep.

To Stop Sweep Output

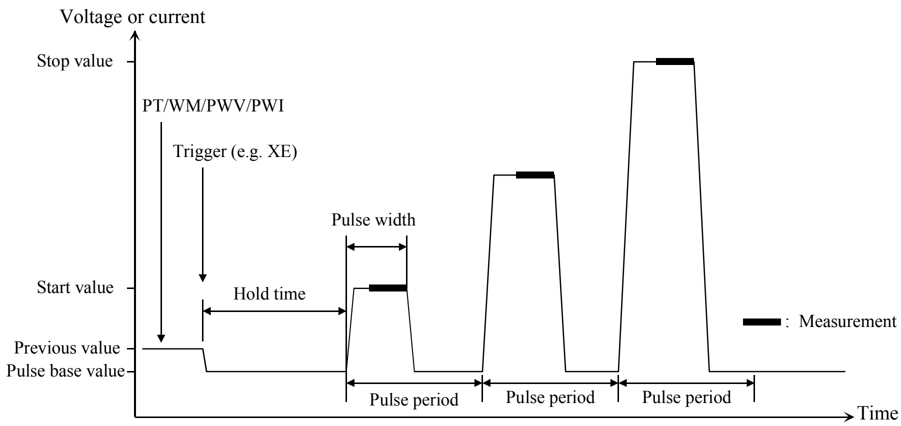
An automatic abort function is available. Refer to "Automatic abort Function" on page 2-23.

Even if the automatic abort function is disabled, the E5260/E5270 automatically stops measurement if power compliance is enabled for the sweep source and the power compliance or an automatic abort condition is detected.

Pulsed Sweep Measurements

Pulsed sweep measurement is performed as shown below. The source channel forces pulsed sweep voltage or current, and the measurement channel performs one point measurement at each sweep step.

Figure 2-6 **Pulsed Sweep Measurements**



1. The pulsed sweep source sets output by the PT, WM, and PWV or PWI commands. Only one channel can be used for the pulsed sweep source.
2. The pulsed sweep source starts output by a trigger, such as the XE command.
3. After the hold time, the measurement channel starts measurement as shown in Figure 2-6. The channel performs measurement so that the pulse width and pulse period are kept (the integration time setting is ignored). Only one channel can be used for measurement.
4. After measurement, the pulsed sweep source forces the pulse base value, and waits for the rest of the pulse period. Then the pulsed sweep source changes the output value.
5. The E5260/E5270 repeats 3 and 4 for all sweep steps.
6. After the pulsed sweep measurement, the pulsed sweep source forces the pulse base value, and keeps it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

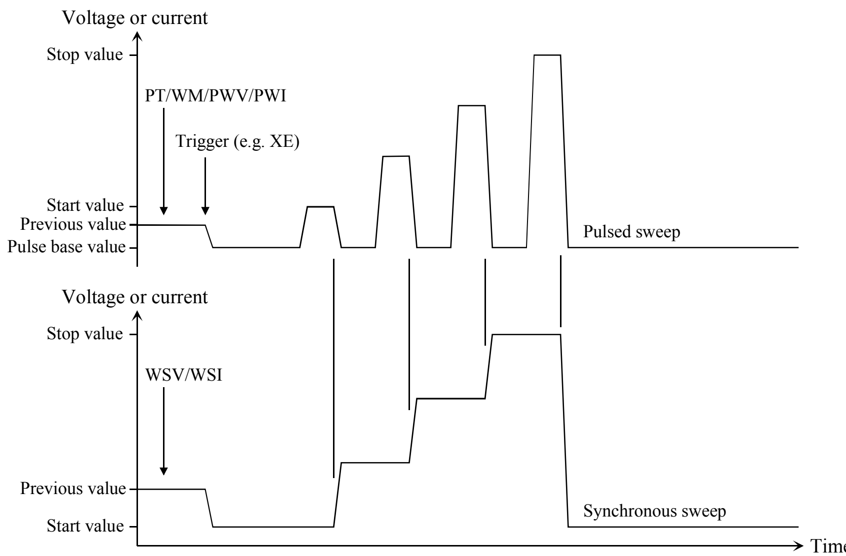
NOTE

The PT command sets the hold time, pulse width, and pulse period. The WM command sets the automatic abort function and the output after measurement. The PWV sets the pulsed sweep voltage, and the PWI sets the pulsed sweep current. The start, stop, and pulse base values must have the same polarity for log sweep.

To Use Synchronous Sweep Source

One more channel can be set up as a staircase sweep source that has the output synchronized with the pulsed sweep. Refer to "Synchronous Output" on page 2-21. After the measurement, the synchronous sweep source forces the start value, and keeps it.

Figure 2-7 **Synchronous Sweep**



NOTE

The WSV command sets the sweep voltage, and the WSI command sets the sweep current. You can use the same output mode (voltage or current) as the pulsed sweep. The start and stop values must have the same polarity for log sweep.

To Stop Sweep Output

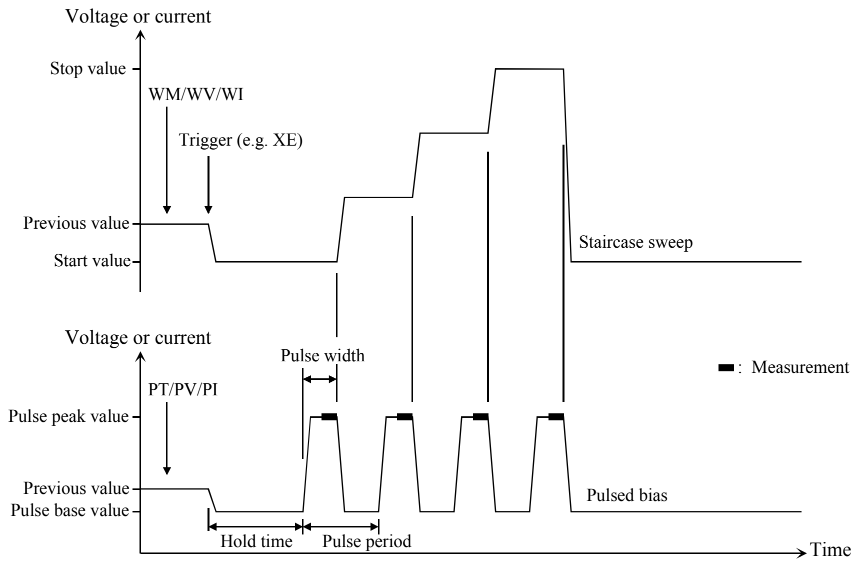
An automatic abort function is available. Refer to "Automatic abort Function" on page 2-23.

Even if the automatic abort function is disabled, the E5260/E5270 automatically stops measurement if power compliance is enabled for the sweep source and the power compliance or an automatic abort condition is detected.

Staircase Sweep with Pulsed Bias Measurements

Staircase sweep with pulsed bias measurement is performed as shown below. The source channel forces staircase sweep voltage or current, the pulse channel forces pulsed bias, and the measurement channel performs one point measurement at each sweep step.

Figure 2-8 **Staircase Sweep with Pulsed Bias Measurements**



1. The staircase sweep source sets output by the WM, and WV or WI commands. Only one channel can be used for the sweep source.
2. The pulsed source sets output by the PT, and PV or PI commands. Only one channel can be used for the pulsed source.
3. The source channels start output by a trigger, such as the XE command.
4. After the hold time, the measurement channel starts measurement as shown in Figure 2-8. The channel performs measurement so that the pulse width and pulse period are kept (the integration time setting is ignored). Only one channel can be used for measurement.
5. After the measurement, the sweep source changes the output value. Then the pulsed source forces the pulse base value, and waits for the rest of the pulse period until the next pulse output.
6. The E5260/E5270 repeats 4 and 5 for all sweep steps.

7. After the sweep measurement, the pulsed source forces the pulse base value, and the sweep source forces the start or stop value, as specified by the WM command, and keeps it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE

The WM command sets the automatic abort function and the output after measurement. The WV command sets the sweep voltage, and the WI command sets the sweep current. The start and stop values must have the same polarity for log sweep.

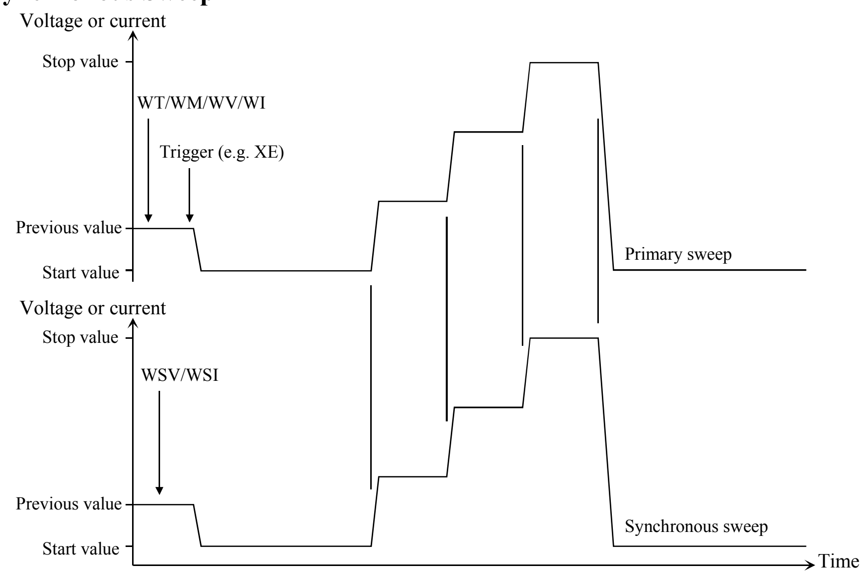
The PT command sets the pulse timing parameters, such as pulse width and pulse period. The PV command sets the voltage pulse, and the PI command sets current pulse.

To Use Synchronous Sweep Source

One more channel can be set up as a sweep source that has the output synchronized with the staircase sweep. Refer to "Synchronous Output" on page 2-21.

After the measurement, the synchronous sweep source forces the start or stop value, as specified by the WM command, and keeps it.

Figure 2-9 **Synchronous Sweep**



NOTE

The WSV command sets the sweep voltage, and the WSI command sets the sweep current. You can use the same output mode (voltage or current) as the primary sweep. The start and stop values must have the same polarity for log sweep.

To Stop Sweep Output

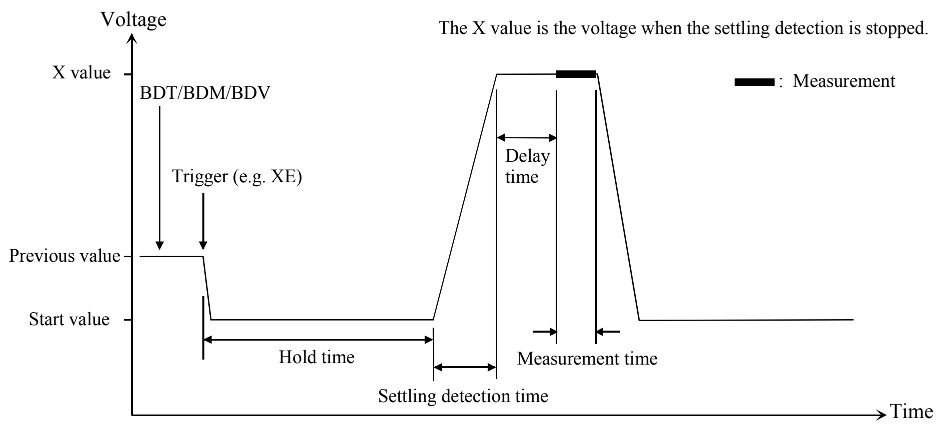
An automatic abort function is available. Refer to "Automatic abort Function" on page 2-23.

Even if the automatic abort function is disabled, the E5260/E5270 automatically stops measurement if power compliance is enabled for the sweep source and the power compliance or an automatic abort condition is detected.

Quasi-Pulsed Spot Measurements

Quasi-pulsed spot measurement is performed as shown below. The measurement channel performs one point measurement while the source channel forces a quasi-pulse voltage. This measurement mode can minimize the output time of the measurement voltage. So it is effective for the breakdown voltage measurement and the reliability test.

Figure 2-10 **Quasi-Pulsed Spot Measurements**



1. The quasi-pulse source channel sets output by the BDT, BDM, and BDV commands. Only one channel can be used for the quasi-pulse source.
2. The quasi-pulse source starts output by a trigger, such as the XE command.
3. After the hold time, the quasi-pulse source starts the voltage transition to the stop value (settling detection time). Also, it performs voltage measurement (settling detection) in the interval set by the BDM command. The voltage transition and settling detection continue until the output voltage slew rate becomes half of the rate when settling detection started. The slew rate depends on the cabling and the characteristics of the device. You cannot define it directly. In normal operation, the slew rate will be slower in the following conditions:
   - When the quasi-pulse source applies voltage close to the stop value.
   - When the quasi-pulse source reaches its current compliance due to the breakdown condition of the device under test.

NOTE If the slew rate was too slow when settling detection started or if the settling detection time was too long, an error occurs and the source returns its output to the start value immediately. See "BDM" on page 4-26.

4. After the settling detection stops, the quasi-pulse source keeps the output.
5. After the delay time, the measurement channel starts measurement.
   Only one channel can be used for measurement.
6. After measurement, the quasi-pulse source immediately returns the output to the start value and keeps it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE

If there is noise or skew on the output voltage, settling detection might stop at an unexpected voltage.

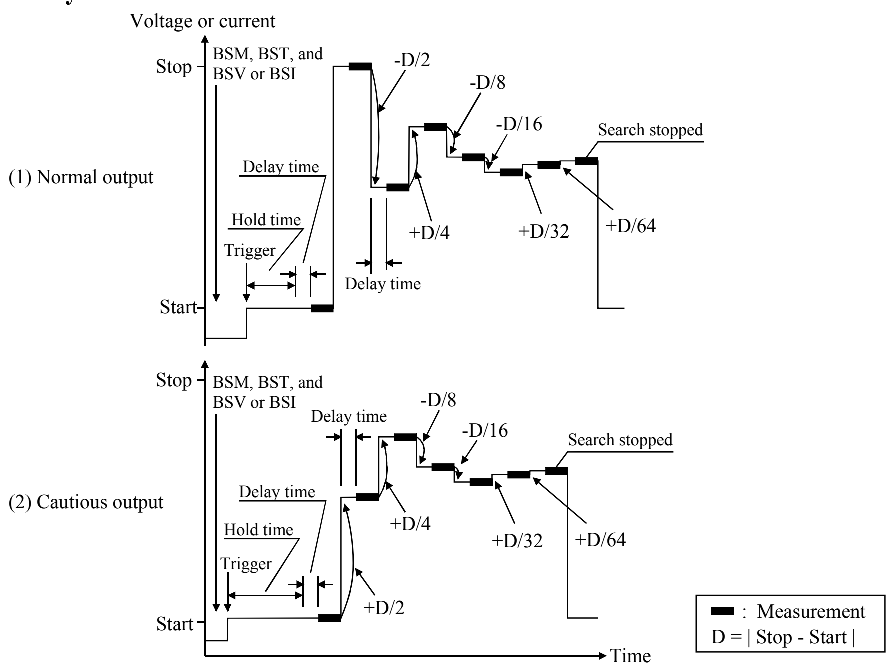
NOTE

The BDT command sets the hold time and delay time, and the BDM command sets the settling detection interval and measurement mode (voltage or current); the BDV command sets the output. Also |start - stop| must be 10 V or more.

Binary Search Measurements

Binary search measurement is performed as shown below. The source channel forces voltage or current, and the measurement channel performs one point measurement. The E5260/E5270 repeats this until the search stop condition is satisfied, and returns the source's last output value. The last measurement data is also returned if it is set by the BSVM command.

Figure 2-11 **Binary Search Measurements**



1. The search source sets output by the BSM, BST, and BSV or BSI commands. Only one channel can be used for the search source.
2. The search source starts output by a trigger, such as the XE command.
3. After the hold time, the measurement channel waits for the delay time, and starts measurement as shown in Figure 2-11. The measurement channel can be set by the BGI or BGV command. Only one channel can be used for measurement.
4. After measurement, the search source changes the output value. The output value depends on the output control mode, normal or cautious, selected by the BSM command. See Figure 2-11.

5. The E5260/E5270 repeats 3 and 4 until the search stop condition is satisfied. The search stop condition is one of the following conditions selected by the BGI or BGV command.
    - Measured value = Search target value ± limit
    - Number of measurement points > limit
6. After the search measurement, the search source forces the start value, the stop value, or the last output value, as specified by the BSM command, and keeps it.

    For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

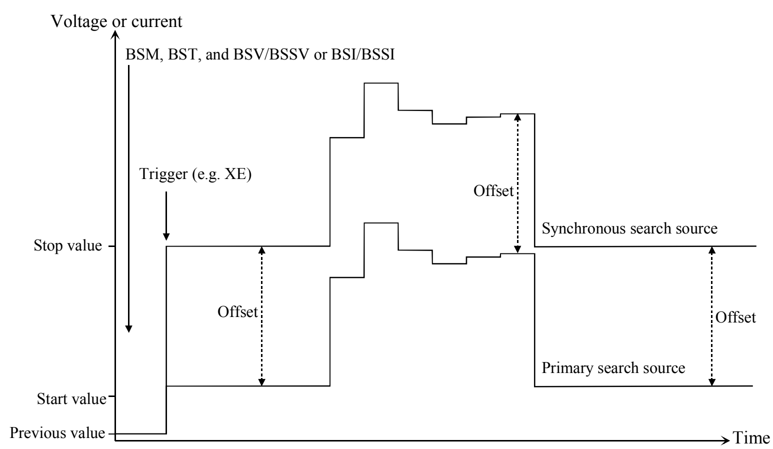
NOTE

The BSM command sets the search control mode, the automatic abort function, and the output after search. The BST command sets the hold time and delay time. The BSV/BSI command sets the search output, and the BGI/BGV command sets the measurement channel.

To Use Synchronous Output Channel

You can use the synchronous output channel that provides the output synchronized with the search source. Refer to "Synchronous Output" on page 2-21. After measurement, the synchronous channel forces the start+offset, stop+offset, or the last output value, as specified by the BSM command, and keeps it.

Figure 2-12 **Synchronous Output**



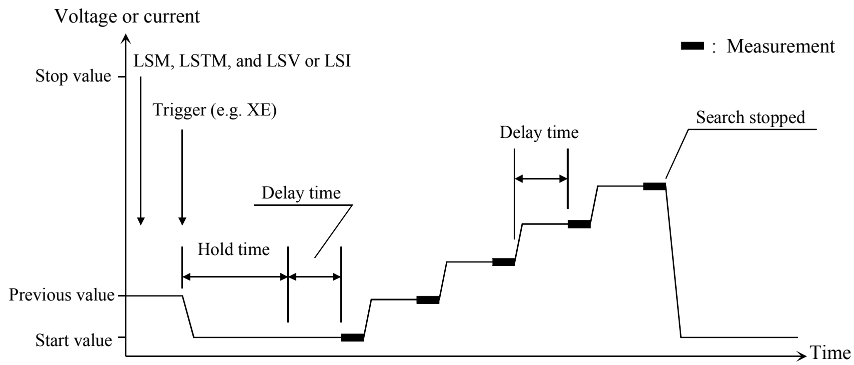
NOTE

The BSSV/BSSI command sets the synchronous output. You can use the same output mode (voltage or current) as the search source. All output values must be covered by the output range of the search source.

Linear Search Measurements

Linear search measurement is performed as shown below. The source channel sweeps voltage or current, and the measurement channel performs one point measurement at each sweep step. The E5260/E5270 stops sweep and measurement when the search stop condition is satisfied, and returns the source's last output value. The last measurement data is also returned if it is set by the LSVM command.

Figure 2-13 **Linear Search Measurements**



1. The search source sets output by the LSM, LSTM, and LSV or LSI commands. Only one channel can be used for the search source.
2. The search source starts output by a trigger, such as the XE command.
3. After the hold time, the measurement channel waits for the delay time, and starts measurement as shown in Figure 2-13. The measurement channel can be set by the LGI or LGV command. Only one channel can be used for the measurement.
4. After measurement, the search source changes the output value.
5. The E5260/E5270 repeats 3 and 4 until the search stop condition is satisfied. The search stop condition is one of the following conditions selected by the LGV or LGI command.
    - Measured value is over the search target value.
    - Measured value breaks the search target value.
6. After the search measurement, the search source forces the start value, the stop value, or the last output value, as specified by the LSM command, and keeps it.

   For 0 V output, enter the DZ command that is used to memorize the present settings of the channel and change the output to 0 V.

NOTE

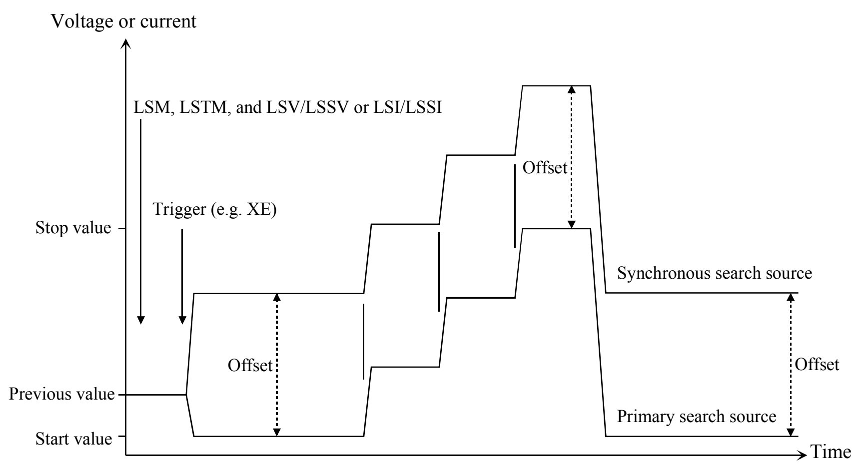
The LSM command sets the automatic abort function and the output after search. The LSTM command sets the hold time and delay time. The LSV/LSI command sets the search output, and the LGI/LGV command sets the measurement channel.

To Use Synchronous Output Channel

You can use the synchronous output channel that provides output synchronized with the search source. Refer to "Synchronous Output" on page 2-21.

After measurement, the synchronous channel forces the start+offset, stop+offset, or the last output value, as specified by the LSM command, and keeps it.

Figure 2-14 **Synchronous Output**



NOTE

The LSSV/LSSI command sets the synchronous output. You can use the same output mode (voltage or current) as the search source. All output values must be covered by the output range of the search source.

Synchronous Output

You can use synchronous output that will be synchronized to the output of the primary sweep or search source. See Figure 2-15 and Figure 2-16. Synchronous output is available for the following measurement modes and set by the following commands:

Measurement Mode	Command
"Staircase Sweep Measurements"	WSI or WSV
"Pulsed Sweep Measurements"	WSI or WSV
"Staircase Sweep with Pulsed Bias Measurements"	WSI or WSV
"Binary Search Measurements"	BSSI or BSSV
"Linear Search Measurements"	LSSI or LSSV

The synchronous source supports the same output mode (voltage or current) as the primary source, and does not support pulsed output.

Parameters

The following parameters are used to set up a synchronous output. For details of the commands, refer to Chapter 4, "Command Reference."

- For the WSI and WSV commands:

  start Synchronous sweep start value.

  stop Synchronous sweep stop value.

  The start and stop values must have the same polarity for logarithmic sweep.

- For the BSSI, BSSV, LSSI, and LSSV commands:

  offset Offset value from the search source output.

  polarity Polarity (+ or -) of the synchronous source output.

  Synchronous output is given by one of the following formulas:

  - *Synchronous output = primary source output + offset*
  - *Synchronous output* = -1× *primary source output + offset*

  All output values must be covered by the output range of the search source.

Figure 2-15 **Synchronous Sweep Output Example for Staircase Sweep**

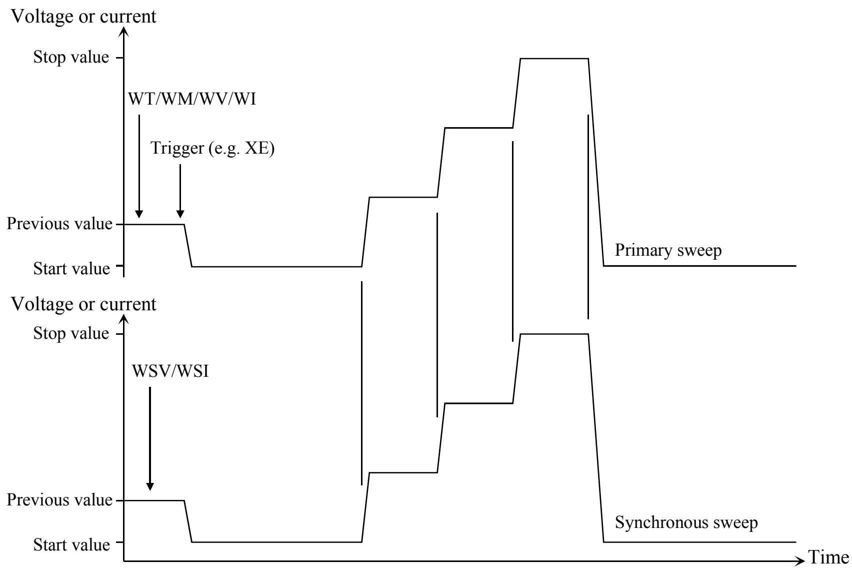
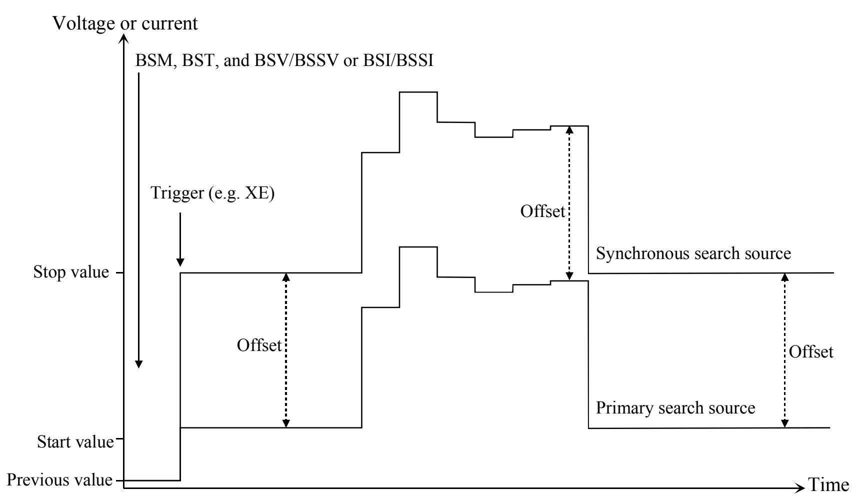


Figure 2-16 **Synchronous Output Example for Binary Search**



Automatic abort Function

The automatic abort function stops measurement (increasing or decreasing source output value) when one of the following conditions occurs. This function is useful to reduce source output time and to prevent damage to the device during measurement.

- The output reaches voltage compliance or current compliance
- A measurement value exceeds the specified measurement range
- An SMU oscillates

The automatic abort function is enabled by using the WM, LSM, or BSM command. This function is available for the following measurement modes:

- "Staircase Sweep Measurements"
- "Staircase Sweep with Pulsed Bias Measurements"
- "Multi Channel Sweep Measurements"
- "Pulsed Sweep Measurements"
- "Linear Search Measurements" and "Binary Search Measurements"

When abort occurs

After measurement is aborted, the source forces the following value. And then the dummy data (199.999E+99) is returned for measurement points not reached.

- Start value (for staircase sweep source and search source)
- Pulse base value (for pulsed source and pulsed sweep source)

Output after measurement

You can specify the post measurement condition for normal measurement end. The source output value is set by the WM, LSM, or BSM command, and it can be one of the following values:

- Start value
- Stop value
- Last output value (for search measurement)

The setting is not effective for the pulsed sweep measurement.

NOTE

Even if the post measurement value is set, the source forces the start value if output is stopped by the automatic abort function, power compliance, or AB command.

Program Memory

The program memory is a volatile memory that is used to store command strings temporarily. The Keysight E5260/E5270 has a built-in program memory that can store 2,000 programs maximum, and a total of 40,000 commands.

The program memory can eliminate several processes in the program execution, such as transferring commands, checking command syntax, and converting commands to the internal codes. Thus, using the program memory speeds up program execution. If frequently used command strings are stored in the program memory, GPIB/computer activity is minimized.

Using Program Memory

You can store, execute, read, and delete programs in the program memory as shown below. For details on each command, refer to Chapter 4, "Command Reference."

To store programs

Send the ST and END commands to store a program. The following procedure stores a program (program number *n*) in the program memory. A multiple command string is also available.

1. `OUTPUT @E5270;"ST` *n*`"`

   where, *n* is the program number for the program now stored in the program memory. The value must be an integer, 1 to 2000.

2. `OUTPUT @E5270;"`*XXXX*`"`

   where, *XXXX* must be the command you want to store in the program memory. Repeat this until all required commands are stored.

   Table 2-1 lists the invalid commands for the program memory.

3. `OUTPUT @E5270;"END"`

NOTE

The program must be complete and free of errors.

An error occurs if the program memory overflows while a program is being stored.

If you store a new program using an existing program number, the old program is deleted and the new program is stored.

To call programs from a memory program

A memory program can invoke another memory program by storing the DO or RU command in the memory program. Up to eight levels of nesting are available. The first level is always the DO or RU command sent by the external computer.

To execute programs

Send the RU or DO command to execute the memory program.

- `OUTPUT @E5270;"RU 1,5"`

  This example executes the programs numbered 1 through 5 sequentially. These programs must be stored in the memory.

- `OUTPUT @E5270;"DO 1,2,3,4,5"`

  This example executes programs 1, 2, 3, 4, and 5 in this order. These programs must be stored in the memory. A maximum of eight numbers can be specified.

To use variables

You can use variables in the memory programs. To enter the value to the variable, send the VAR command. If the variable is referred by multiple programs or commands, set or change the value carefully so that the program works fine without errors. Format of the variable is %*tn* (*t*: integer I or real R, *n*: integer, 1 to 99).

In the following example, the first line stores a program (program 99) which uses the `%I50` variable. The second line enters 2 to `%I50`, and executes the program 99.

```
OUTPUT @E5270;"ST99;CN%I50;DV%I50,0,2;TI%I50;CL%I50;END"
OUTPUT @E5270;"VAR0,50,2;DO99"
```

To read programs

To read the program numbers of the memory programs, send the LST? command without a command parameter.

To read the contents of a memory program, send the LST? command with the program number as shown below. Up to 3000 commands can be read by one command execution.

```
OUTPUT @E5270;"LST? 100"
```

To delete programs

To delete all memory programs, send the SCR command without a parameter.

To delete a memory program, send the SCR command with the program number as shown below.

```
OUTPUT @E5270;"SCR 100"
```

NOTE

Turning off the instrument also clears the program memory. The device clear and *RST commands do not clear the program memory.

Table 2-1 Invalid Commands for Program Memory

Category	GPIB Command
Reset	*RST
Diagnostics	DIAG?
Self-test	*TST?
Self Calibration	CA
	*CAL?
	CM
Abort	AB
Channel Control	RCV
	WZ?
Program Memory	ST
	END
	SCR
	VAR?
	LST?
16 bit Control Port	ERS?
Query	ERR?
	EMG?
	*IDN?
	LOP?
	*LRN?
	NUB?
	*OPC?
	UNT?
	WNU?
Status Byte	*SRE?
	*STB?

Digital I/O Port

The digital I/O port is used for the trigger input/output terminals or an interface to control an external relay circuit and so on. For the trigger input/output, refer to "Trigger Function". For another usage, the following commands are available:

ERM Changes the digital I/O port assignments.

ERS? Returns the digital I/O port status.

ERC Changes the output status of the digital I/O port

Connector type of the digital I/O port is D-Sub 25-pin. The pin assignment is shown in Table 2-2. In the initial setting, the all port forces TTL high level (approx. 2.4 V. TTL low is approx. 0.8 V). The above commands are available for non trigger ports from DIO 1 to DIO 16.

Table 2-2 **Digital I/O Pin Assignment**

Description	Pin Number		Description
GND	25	13	GND
Do not use	24	12	Do not use
Do not use	23	11	Do not use
DIO 15 (bit 15)	22	10	DIO 16 (bit 16)
DIO 13 (bit 13)	21	9	DIO 14 (bit 14)
DIO 11 (bit 11)	20	8	DIO 12 (bit 12)
DIO 9 (bit 9)	19	7	DIO 10 (bit 10)
DIO 7 (bit 7)	18	6	DIO 8 (bit 8)
DIO 5 (bit 5)	17	5	DIO 6 (bit 6)
DIO 3 (bit 3)	16	4	DIO 4 (bit 4)
DIO 1 (bit 1)	15	3	DIO 2 (bit 2)
Do not use	14	2	Do not use
		1	Do not use

Accessories

The following accessories are available to connect the Digital I/O port.

- Keysight 16493G Digital I/O connection cable

  Used to connect the Digital I/O port to a D-Sub (f) 25-pin connector. This cable should be connected between two E5260/E5270s, or between the E5260/E5270 and the N1253A-200 BNC box. Cable length depends on the following option items:

  16493G-001: Approx. 1.5 m

  16493G-002: Approx. 3 m

- Keysight N1253A-100 Digital I/O T-cable

  Used to connect the Digital I/O port to a D-Sub (f) 25-pin connector and a D-Sub (m) 25-pin connector. This cable must be used to connect three or more E5260/E5270s. Cable length is as following:

  - D-Sub (m) to D-Sub (m): Approx. 1.5 m

    Both connectors should be connected to the Digital I/O ports.

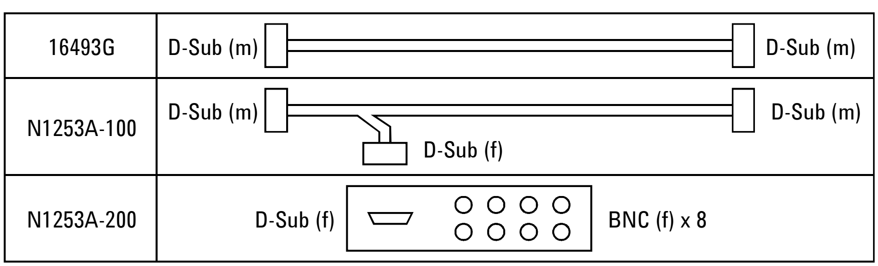
  - D-Sub (m) to D-Sub (f): Approx. 30 cm

    The D-Sub (f) connector should be connected to the additional N1253A-100 or the 16493G cable to connect the third or following E5260/E5270.

- Keysight N1253A-200 Digital I/O BNC box

  Used to convert the D-Sub connector to the BNC connectors. Only the DIO 1 to DIO 8 are connected to the BNC (f) connectors individually. To use the BNC box, connect the 16493G cable between the Digital I/O port and the BNC box.

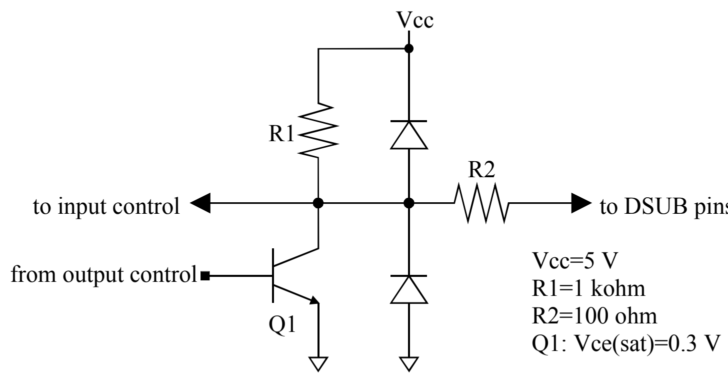
Figure 2-17 **Accessories for Digital I/O Port**



Digital I/O Internal Circuit

The following figure shows the input/output circuits internally connected to each port/pin of the Digital I/O connector.

Figure 2-18 **Digital I/O Internal Circuit**



Trigger Function

The Keysight E5260/E5270 can be synchronized with other equipment, such as capacitance meters, voltmeters, ammeters, probers, handlers and so on, by using the following terminals:

- Ext Trig In

  BNC connector. Only for trigger input (to receive trigger).

- Ext Trig Out

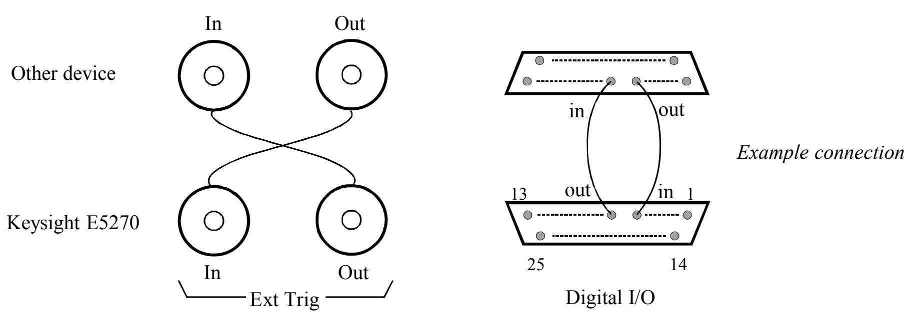
  BNC connector. Only for trigger output (to send trigger).

- Digital I/O

  D-Sub 25-pin connector. Sixteen paths are available for the trigger port. Each path can be used for either input or output. For the pin assignment and accessories, refer to "Digital I/O Port".

Figure 2-19 shows a connection example of the E5260/E5270 and another device.

Figure 2-19 **Connecting Trigger Input/Output**



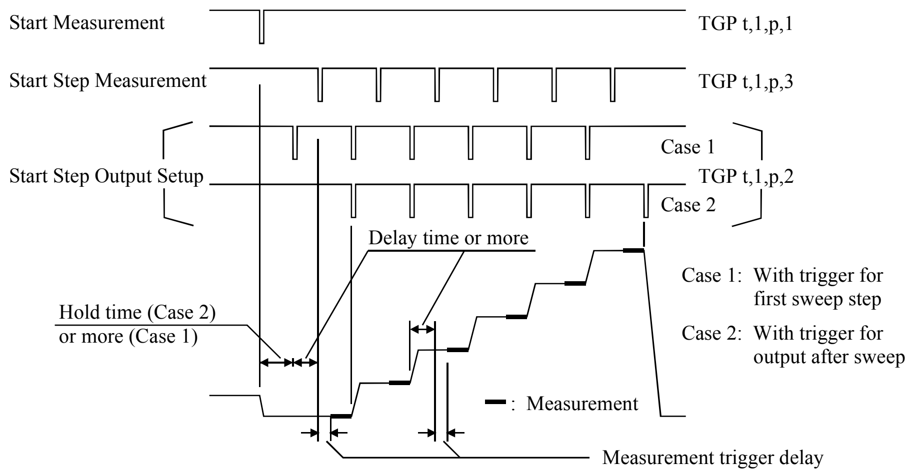
NOTE

To use the digital I/O port for the trigger input/output port, send the TGP command. DIO 1 to DIO 16 can be used for the trigger input/output port. See Table 2-2.

Trigger Input

A trigger input operation example is shown in Figure 2-20. Measurement or source output can be started by the input trigger sent through the port specified by the TGP command. See Table 2-3.

Figure 2-20 **Trigger Input Example, Staircase Sweep Measurement, Negative Logic**



Initial Settings

The following functions are available in the initial settings:

- Trigger port: Ext Trig In
- Trigger type: Start Measurement (type 1)
- Commands for the trigger wait: WS, TM3, or PA with TM3

Input Trigger

The E5260/E5270 responds to the input trigger (minimum pulse width 10 µs) that changes the signal level from high (approx. 2.4 V) to low (approx. 0.8 V). This is negative logic. You can change it to positive logic by using the third parameter of the TGP command.

Measurement Trigger Delay

Delay time from a trigger input to starting a step measurement. The delay time is available for the Start Step Measurement trigger (type 3). You can set the delay time value by using the WT command.

PA/PAX/WS/WSX Commands

The commands put the E5260/E5270 in the trigger wait state. The E5260/E5270 can recover from the wait state if an external trigger is sent to a trigger input port. You can use the commands regardless of the trigger type.

If you use the PA or PAX command to put the E5260/E5270 in the trigger wait state, send the TM3 command before the PA or PAX command.

Table 2-3 Type of Trigger Input

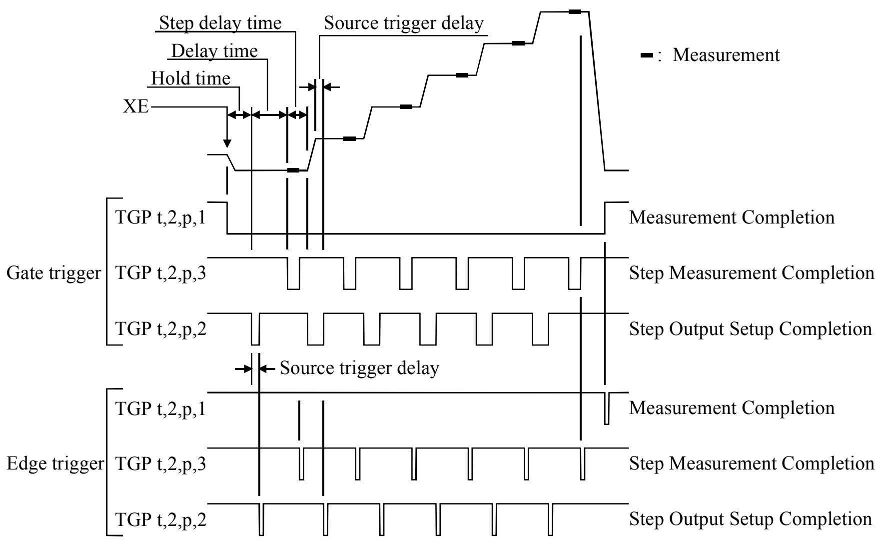
Type	E5260/E5270 Operation by Input Trigger	Command[a]
1	Starts the measurement specified by the MM command.	TGP *t*,1,*p*,1 TM3
2	The sweep source starts to set the sweep step output. The pulse source starts to set the pulsed output. This trigger type is available for the staircase sweep, pulsed spot, pulsed sweep, staircase sweep with pulsed bias, or multi channel sweep measurement.	TGP *t*,1,*p*,2 TGSI *m*
3	Waits for the measurement trigger delay, and starts the sweep step measurement. This trigger type is available for the staircase sweep and multi channel sweep measurement.	TGP *t*,1,*p*,3

a. *t* selects trigger input terminal, Ext Trig In or a digital I/O path.
p selects positive or negative logic of the trigger.
m selects Case 1 or Case 2 of the trigger type 2 (see Figure 2-20).

Trigger Output

A trigger output operation example is shown in Figure 2-21. When the measurement or source output setup is completed, the output trigger is sent through the port specified by the TGP command. See Table 2-4.

Figure 2-21 Trigger Output Example, Staircase Sweep Measurement, Negative Logic



Initial Settings

The following functions are available in the initial settings:

- Trigger port: Ext Trig Out
- Trigger type: Measurement Completion (type 1)
- Commands for the trigger output: OS

Output Trigger

An edge trigger or a gate trigger will be sent when an operation is completed (see Figure 2-22). Initially, the negative edge trigger is sent.

Source Trigger Delay

Delay time from when the source output setup is completed until an edge trigger is sent or a gate trigger level is returned. The delay time is available for the Step Output Setup Completion trigger (type 2). You can set the delay time value by using the WT command.

OS/OSX Commands

The command is used to send a trigger immediately from a trigger output terminal. You can use the commands regardless of the trigger type.

Using Multiple Channels

If you use the multiple measurement channels, an edge trigger will be sent or a gate trigger level will be returned when the measurement is completed by all channels.

For the multi channel sweep measurement, an edge trigger will be sent or a gate trigger level will be returned when the source output setup is completed by all channels, or when the measurement is completed by all channels.

Figure 2-22 **Output Trigger**

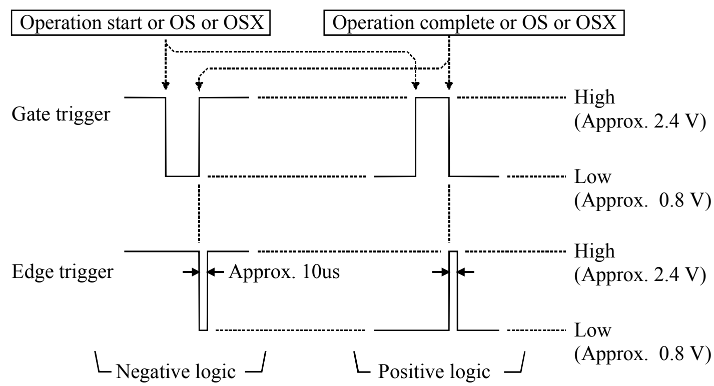


Table 2-4 **Type of Trigger Output**

Type	Timing of Trigger Output by E5260/E5270	Command[a]
1	When the measurement specified by the MM command is completed.	TGP *t*,2,*p*,1 TGXO *m* TM3
2	When the source trigger delay time is elapsed after the sweep step output setup or pulse output setup is completed. Available for the staircase sweep, pulsed spot, pulsed sweep, staircase sweep with pulsed bias, and multi channel sweep measurement.	TGP *t*,2,*p*,2 TGSO *m*
3	When the measurement is completed at each sweep step for the staircase sweep or multi channel sweep measurement.	TGP *t*,2,*p*,3 TGMO *m*

a. *t* selects the trigger output terminal, Ext Trig Out or a digital I/O. *p* selects positive or negative logic. *m* selects edge or gate trigger.

Using Trigger Function

To Make Wait State Using PA/PAX

The PA or PAX command puts the E5260/E5270 into a wait state. The E5260/E5270 can be recovered from the wait state when the specified wait time elapses, or when an event selected by the TM command occurs. Then the E5260/E5270 executes the commands following the PA/PAX command. The event only releases the wait state set by the PA/PAX command.

The wait time parameter is available for the PA/PAX command. If you specify the wait time, the wait state continues until the time has elapses or until the event occurs.

Available value: -99.9999 to 99.9999 s, in 100 μs resolution.

If you set a negative value, the wait state is kept until the event occurs.

You can select the event by using the TM command. If you want to use an external trigger as the event, enter the TM3 command. Then the PA/PAX command waits for the XE command execution, or:

- PA waits for a trigger sent to the Ext Trig In terminal.
- PAX waits for a trigger sent to the specified terminal.

In the initial setting, negative logic is available. To change it to positive, send the TGP command.

NOTE

The TM command is used to select the event effective for starting measurement, or releasing the wait time set by the PA or PAX command. Enter the TM command before the PA or PAX command.

To Make Wait State Using WS/WSX

The WS or WSX command puts the E5260/E5270 into a wait state. The E5260/E5270 can be recovered from the wait state by an external trigger. Then the E5260/E5270 executes the commands following the WS/WSX command. The external trigger only releases the wait state set by the WS/WSX command.

- WS waits for a trigger sent to the Ext Trig In terminal.
- WSX waits for a trigger sent to the specified terminal.

In the initial setting, the negative logic is available. To change it to the positive, send the TGP command.

If you want to end a wait state before receiving an external trigger, enter the AB or *RST command, or use the device clear (HP BASIC CLEAR statement) if any other commands have already been entered.

NOTE For easy programming, do not enter the TM command, or use the TM1, TM2, or TM4 event mode. The TM3 event mode will complicate programming.

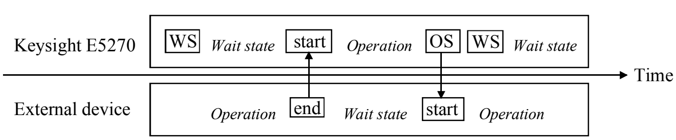
To Send Trigger Using OS/OSX

To trigger an external device from the E5260/E5270, use the OS or OSX command.

- OS sends an edge trigger to the Ext Trig Out terminal.
- OSX sends a trigger to the specified terminal.

In the initial setting, negative logic is available. To change it to positive, send the TGP command.

Enter the WS/WSX command immediately after the OS/OSX command. Then the E5260/E5270 triggers an external device to start its operation by the OS/OSX, and waits for an operation complete trigger from the external equipment. This scenario ensures that the E5260/E5270 and external equipment operations do not overlap.



To Receive Measurement Trigger

To use an external trigger just for starting measurement, instead of the XE command, perform the next step. This is not effective for the high speed spot measurement.

1. Connect a BNC cable between the Ext Trig In connector and a trigger output connector of an external device.

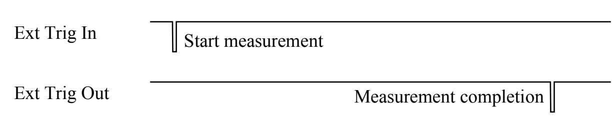
2. Create a control program. Then the TM3 command and HP BASIC ENTER statement should be entered as shown in the following example:

```
       :
OUTPUT @E5270;"MM1"     ! Sets spot measurement mode
       :                ! Sets measurement condition
       :
OUTPUT @E5270;"TM3"     ! Uses external trigger
ENTER @E5270 USING "#,3X,12D,2X";M_data
       :
```

3. Execute the control program.

   The E5260/E5270 sets the measurement conditions, and waits for an external trigger (negative trigger) sent to the Ext Trig In connector.

   When the trigger is received, the E5260/E5270 starts measurement. When measurement is completed, the E5260/E5270 sends a negative edge trigger to the Ext Trig Out connector, and puts the measurement data in the data output buffer.



NOTE The HP BASIC ENTER statement pauses program execution until measurement data is put in the data buffer, reads the data from the buffer, and then continues program execution.

To Specify Trigger Port and Receive Trigger

To use an external trigger just for starting measurement, instead of the XE command, perform the next step. This is not effective for the high speed spot measurement.

This example specifies the trigger input/output ports and uses the gate trigger for the output trigger.

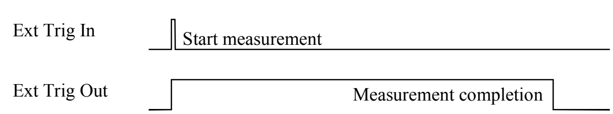
1. Connect a BNC cable between the Ext Trig In connector and a trigger output connector of an external device.
2. Create a control program. Then the TM3 and TGP commands and HP BASIC ENTER statement should be entered as shown in the following example:

```
       :
OUTPUT @E5270;"MM1"              ! Sets spot measurement mode
       :                         ! Sets measurement condition
       :
OUTPUT @E5270;"TM3"              ! Uses external trigger
OUTPUT @E5270;"TGP -1,1,1,1"     ! Sets trigger input
OUTPUT @E5270;"TGP -2,2,1,1"     ! Sets trigger output
OUTPUT @E5270;"TGXO 2"           ! Enables gate trigger
ENTER @E5270 USING "#,3X,12D,2X";M_data
       :
```

3. Execute the control program.

   The E5260/E5270 sets the measurement conditions, and waits for an external trigger (positive trigger) sent to the Ext Trig In connector.

   When the trigger is received, the E5260/E5270 starts measurement and sends a positive gate trigger to the Ext Trig Out connector. When measurement is completed, the E5260/E5270 returns the gate trigger level to logical low, and puts the measurement data in the data output buffer.



NOTE

The HP BASIC ENTER statement pauses program execution until measurement data is put in the data buffer, reads the data from the buffer, and then continues program execution.

To Control Measurement Timing Using External Trigger

Multiple trigger terminals will be used to control measurement timing. Refer to the following example that controls the staircase sweep measurement timing.

The example below uses the following triggers and terminals:

Trigger Name or Trigger Type	Terminal	TGP Command [a]
Start Measurement	Ext Trig In	`TGP -1,1,2,1`
Start Step Measurement	DIO 2	`TGP 2,1,2,3`
Start Step Output Setup	DIO 1	`TGP 1,1,2,2`
Measurement Completion	Ext Trig Out	`TGP -2,2,2,1`
Step Measurement Completion	DIO 12	`TGP 12,2,2,3`
Step Output Setup Completion	DIO 11	`TGP 11,2,2,2`

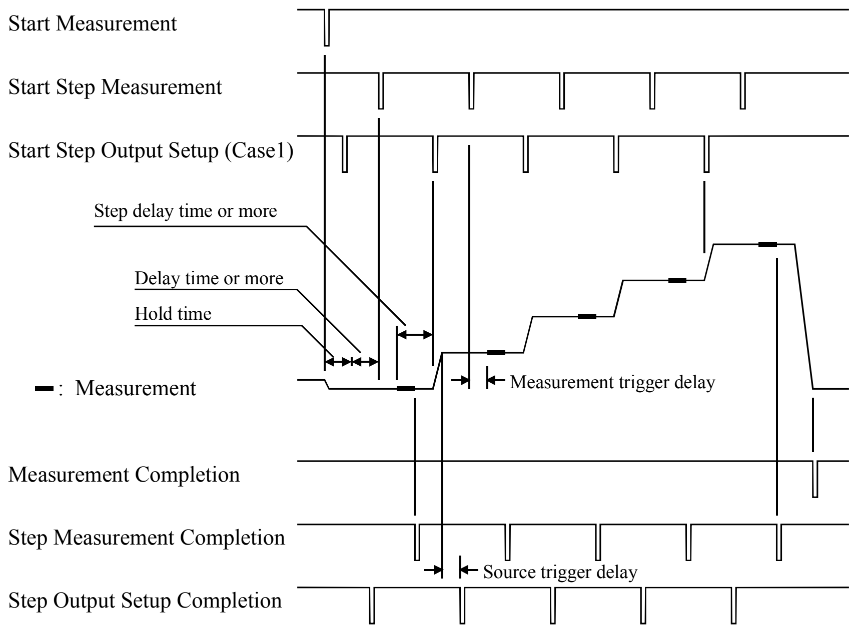
a. Parameters mean the port number, trigger input/output, positive/negative logic, and trigger type in this order from left.

Example

This example uses the negative edge trigger (set by the TGP and TGXO/TGMO/TGSO commands), and the Case 1 Start Step Output Setup trigger (set by the TGSI command). The WT command sets the hold time, delay time, step delay time, source trigger delay time, and the measurement trigger delay time.

```
       :
OUTPUT @E5270;"MM2"      ! Sets staircase sweep measurement mode
       :                 ! Sets measurement condition
       :
OUTPUT @E5270;"TM3"           !Uses external trigger
OUTPUT @E5270;"TGP -1,1,2,1" !Start Measurement trigger
OUTPUT @E5270;"TGP 2,1,2,3"  !Start Step Measurement trigger
OUTPUT @E5270;"TGP 1,1,2,2"  !Start Step Output Setup trigger
OUTPUT @E5270;"TGP -2,2,2,1" !Measurement Completion trigger
OUTPUT @E5270;"TGP 12,2,2,3" !Step Measurement Completion trigger
OUTPUT @E5270;"TGP 11,2,2,2" !Step Output Setup Completion trigger
OUTPUT @E5270;"TGXO 1"       !1:Edge trigger
OUTPUT @E5270;"TGMO 1"       !1:Edge trigger
OUTPUT @E5270;"TGSO 1"       !1:Edge trigger
OUTPUT @E5270;"TGSI 1"       !1:Case 1
OUTPUT @E5270;"WT";Hold,Delay,Sdelay,Tdelay,Mdelay
       :
FOR N=1 TO No_step
  ENTER @E5270 USING "#,3X,12D,2X";M_data
  PRINT "DATA";N;"=";M_data
NEXT N
       :
```

Figure 2-23 **Trigger Input/Output Example, Staircase Sweep, Negative Logic**



The E5260/E5270 sets the measurement conditions, sets the trigger ports, and waits for a Start Measurement trigger.

By the Start Measurement trigger, the E5260/E5270 starts the staircase sweep measurement.

By the Start Step Output Setup trigger, the E5260/E5270 waits until the source trigger delay is elapsed, and sends the Step Output Setup Completion trigger. If the trigger is received during the hold time, the E5260/E5270 performs this after the hold time.

By the Start Step Measurement trigger, the E5260/E5270 waits until the measurement trigger delay is elapsed, executes a step measurement, and sends the Step Measurement Completion trigger. If the trigger is received during the delay time, the E5260/E5270 performs this after the delay time.

By the next Start Step Output Setup trigger, the E5260/E5270 changes the source output value, and waits until the source trigger delay is elapsed, and sends the Step Output Setup Completion trigger. If the trigger is received during the step delay time, the E5260/E5270 performs this after the step delay time.

After the staircase sweep measurement, the E5260/E5270 sends the Step Measurement Completion trigger and the Measurement Completion trigger, and puts the measurement data in the data output buffer.

Trig In/Out Internal Circuit

The following figures show the trigger input/output circuits internally connected to the Trig In/Out connectors.

Figure 2-24 **Trigger Input Internal Circuit**

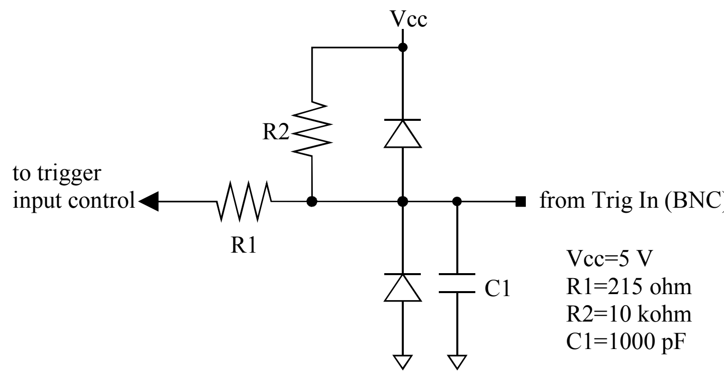
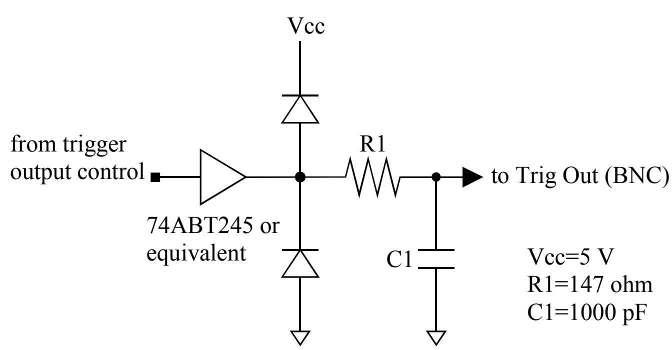


Figure 2-25 **Trigger Output Internal Circuit**



Initial Settings

Keysight E5260/E5270 is initialized by turning the E5260/E5270 on, the *RST command, or the device clear. Initial settings of the E5260/E5270 are shown in Table 2-5 and Table 2-6. Table 2-6 fits into one page, and lists all initial settings.

Table 2-5 Initial Settings

Setup Item	Initial Setting		Commands
Measurement channel	Channel assigned the lowest number.		MCH
Measurement data to be displayed	Data 1	Compliance side data	MPA
	Data 2	none	MPA
Output channel	Channel assigned the lowest number.		SCH
Output data to be displayed	Data 1	OUT	SPA
	Data 2	CPL	SPA
Data display format	ENGINEERING		DFM
Remote mode data display	off		RED
Remote mode key lock/unlock	unlock		KLC
Auto calibration	on		CM
ADC zero function (for E5270B)	off		AZ
SMU output switch	open		CN, CL
ASU path/1 pA auto range/indicator	SMU side/disabled/enabled		SAP/SAR/SAL
Filter	off		FL
Series resistor	off		SSR
A/D converter	High speed ADC		AAD
Integration time (High resolution ADC is available for E5270B)	High speed ADC: auto		AIT
	High resolution ADC: auto		AIT

Setup Item	Initial Setting		Commands
AV command parameter	*number*=1, *mode*=0		AV
Current measurement range	with pulse	Compliance range	RI
	without pulse	auto	
Voltage measurement range	with pulse	Compliance range	RV
	without pulse	auto	
Sweep source parameters	cleared		WV, WSV, WI, WSI
Automatic abort function	off		WM
Output after sweep measurement	Start value		WM
Pulse source parameters	cleared		PV, PI
Pulse sweep source parameters	cleared		PWV, PWI
Pulse width	0.001 s		PT
Pulse period	0.01 s		PT
Search source parameters	cleared		BSV, BSSV, BSI, BSSI, LSV, LSSV, LSI, LSSV
Search monitor parameters	cleared		BGV, BGI, LGV, LGI
Output after search measurement	Start value		BSM, LSM
Search measurement data	Source output value only		BSVM, LSVM
Quasi-pulse source parameters	cleared		BDV
Quasi-pulsed spot measurement mode	Voltage		BDM
Quasi-pulse settling detection interval	Short		BDM
Hold time	0 s		WT, PT, BDT, BST, LSTM
Delay time	0 s		WT, PT, BDT, BST, LSTM

<table>
<tr><th>Setup Item</th><th colspan="2">Initial Setting</th><th>Commands</th></tr>
<tr><td>Step delay time</td><td colspan="2">0 s</td><td>WT</td></tr>
<tr><td>Trigger delay time</td><td colspan="2">0 s</td><td>WT, PT</td></tr>
<tr><td>Trigger mode</td><td colspan="2">XE, TV, TI, or GET</td><td>TM</td></tr>
<tr><td rowspan="3">Trigger port</td><td>Ext Trig In</td><td>Start Measurement trigger input</td><td>TGP</td></tr>
<tr><td>Ext Trig Out</td><td>Measurement Completion trigger output</td><td>TGP</td></tr>
<tr><td>Digital I/O</td><td>cleared</td><td>TGP</td></tr>
<tr><td>Trigger condition of
Start Step Output Setup trigger</td><td colspan="2">with trigger for first sweep step</td><td>TGSI</td></tr>
<tr><td>Type of output trigger</td><td colspan="2">Edge trigger</td><td>TGXO, TGSO, TGMO</td></tr>
<tr><td>Digital I/O port</td><td colspan="2">Output for all port</td><td>ERM</td></tr>
<tr><td>Program memory</td><td colspan="2">cleared [a]</td><td>SCR</td></tr>
<tr><td>Value of internal variable (%In, %Rn)</td><td colspan="2">0</td><td>VAR</td></tr>
<tr><td>Data output format</td><td colspan="2">ASCII with header, CR/LF^EOI</td><td>FMT</td></tr>
<tr><td>Data output buffer</td><td colspan="2">cleared</td><td>BC</td></tr>
<tr><td>Status byte</td><td colspan="2">Only bit 6 is enabled.</td><td>*SRE</td></tr>
<tr><td>Error code register</td><td colspan="2">cleared</td><td>ERR?</td></tr>
</table>

a. Program memory is not cleared by the *RST command or the device clear.

Table 2-6 Initial Settings

Setup Item	Initial Setting		Commands
Measurement channel	Channel assigned the lowest number.		MCH
Measurement data to be displayed	Data 1	Compliance side data	MPA
	Data 2	none	MPA
Output channel	Channel assigned the lowest number.		SCH
Output data to be displayed	Data 1	OUT	SPA
	Data 2	CPL	SPA
Data display format	ENGINEERING		DFM
Remote mode data display	off		RED
Remote mode key lock/unlock	unlock		KLC
Auto calibration	on		CM
ADC zero function (for E5270B)	off		AZ
SMU output switch	open		CN, CL
ASU path/1 pA auto range/indicator	SMU side/disabled/enabled		SAP/SAR/SAL
Filter/Series resistor	off/off		FL/SSR
A/D converter	High speed ADC		AAD
Integration time (High resolution ADC is available for E5270B)	High speed ADC: auto		AIT
	High resolution ADC: auto		AIT
AV command parameter	*number*=1, *mode*=0		AV
Current measurement range	with pulse	Compliance range	RI
	without pulse	auto	
Voltage measurement range	with pulse	Compliance range	RV
	without pulse	auto	
Sweep source parameters	cleared		WV, WSV, WI, WSI
Automatic abort function	off		WM
output after sweep measurement	Start value		WM
Pulse source parameters	cleared		PV, PI
Pulse sweep source parameters	cleared		PWV, PWI
Pulse width	0.001 s		PT
Pulse period	0.01 s		PT
Search source parameters	cleared		BSV, BSSV, BSI, BSSI, LSV, LSSV, LSI, LSSV
Search monitor parameters	cleared		BGV, BGI, LGV, LGI
Output after search measurement	Start value		BSM, LSM
Search measurement data	Source output value only		BSVM, LSVM
Quasi-pulse source parameters	cleared		BDV
Quasi-pulsed spot measurement mode	Voltage		BDM
Quasi-pulse settling detection interval	Short		BDM
Hold time	0 s		WT, PT, BDT, BST, LSTM
Delay time	0 s		WT, PT, BDT, BST, LSTM
Step delay time	0 s		WT
Trigger delay time	0 s		WT, PT
Trigger mode	XE, TV, TI, or GET		TM
Trigger port	Ext Trig In	Start Measurement trigger input	TGP
	Ext Trig Out	Measurement Completion trigger output	TGP
	Digital I/O	cleared	TGP
Trigger condition of Start Step Output Setup trigger	with trigger for first sweep step		TGSI
Type of output trigger	Edge trigger		TGXO, TGSO, TGMO
Digital I/O port	Output for all port		ERM
Program memory	cleared. Not cleared by *RST command or device clear.		SCR
Value of internal variable (%In, %Rn)	0		VAR
Data output format	ASCII with header, CR/LF^EOI		FMT
Data output buffer	cleared		BC
Status byte	Only bit 6 is enabled.		*SRE
Error code register	cleared		ERR?

3 Programming Examples

This chapter lists the GPIB commands required for each measurement mode, and provides the programming examples.

Refer to Chapter 4, “Command Reference,” for the command syntax and descriptions of the Keysight E5260/E5270 GPIB commands.

The following command conventions are used in this chapter.

command	Required command for measurement execution.
[command]	Optional command for measurement execution.
parameter	Required command parameter. A value or variable *must* be specified.
[*parameter*]	Optional command parameter. A value may be specified.

NOTE

About Example Program Code

Example programs described in this section have been written in the Microsoft Visual Basic .NET or the HP BASIC language. Most of the examples written in the Visual Basic .NET are provided as a subprogram that can be run with the project template shown in Table 3-1. To run the program, insert the example subprogram or your subprogram instead of the perform_meas subprogram in the template.

NOTE

To Start Program

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

NOTE

After the Automatic Measurement

After the automatic measurements, open the measurement terminals or disconnect the device under test from the measurement terminals. If you leave the connection with the device, the device may be damaged by unexpected operations.

Do not leave the connection over 30 minutes after measurement if the auto calibration is set to ON. Then, the Keysight E5260/E5270 performs the self-calibration automatically every 30 minutes after measurement. The calibration requires to open the measurement terminals.

To disable the auto calibration, enter the `CM 0` command.

Programming Basics for Visual Basic .NET Users

This section provides the basic information for programming of the automatic measurement using the Keysight E5260/E5270, Keysight IO Library, and Microsoft Visual Basic .NET.

- "To Create Your Project Template"
- "To Create Measurement Program"

NOTE To execute the example programs in this chapter, you need to install Keysight GPIB interface, Keysight IO Library, VISA COM Library, and Microsoft Visual Basic .NET on your computer. The VISA COM Library is included in the IO Library.

To Create Your Project Template

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

Step 1. Connect Keysight E5260/E5270 (ex. GPIB address 17) to the computer via GPIB.

Step 2. Launch Visual Basic .NET and create a new project. The project type should be Console Application to simplify the programming.

Step 3. Add VISA COM library (VisaComLib) to the reference.

Step 4. Open a module (e.g. Module1.vb) in the project. And enter a program code as template. See Table 3-1 for example.

Step 5. Save the project as your template (e.g. \test\my_temp).

To Create Measurement Program

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

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

- Measurement devices

  Discrete, packaged, on-wafer, and so on.

- Parameters/characteristics to be measured

  h_{FE}, Vth, sheet resistance, and so on.

- Measurement method

  Spot measurement, staircase sweep measurement, and so on.

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

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

Step 4. Launch Visual Basic .NET.

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

Step 6. Open the module that contains the template code as shown in Table 3-1. On the code window, complete the perform_meas subprogram.

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

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

Table 3-1 Example Template Program Code for Visual Basic .NET

```
Imports Ivi.visa.interop

Module Module1

  Sub Main()                                                              '5
    Dim E5270 As IResourceManager
    Dim session As IMessage
    E5270 = New ResourceManager
    session = E5270.Open("GPIB0::17::INSTR")
    session.WriteString("*RST" & vbLf)
    MsgBox("Click OK to start measurement.", vbOKOnly, "")
    Console.WriteLine("Measurement in progress. . ." & Chr(10))

    Dim t() As Integer = {5, 4, 3, 1}  'Drain,  Gate, Source, Sub        '14
    Dim term As String = t(0) & "," & t(1) & "," & t(2) & "," & t(3)
    session.WriteString("CN " & term & vbLf)
    perform_meas(session, t)

    session.WriteString("CL" & vbLf)                                     '19
    session.Close()
    MsgBox("Click OK to stop the program.", vbOKOnly, "")
    Console.WriteLine("Measurement completed." & Chr(10))
  End Sub                                                                '23
```

Line	Description
1	This line is required to use the VISA COM library.
5 to 23	Main subprogram establishes the software connection with the Keysight E5260/E5270, resets the E5260/E5270, opens a message box to confirm the start of measurement, and pauses program execution until OK is clicked on the message box. By clicking OK, the program displays a message on the console window, enables the SMUs, and calls the perform_meas subprogram that will be used to perform measurement. After the measurement, the program disables all SMUs, disables the software connection with the E5260/E5270, and opens a message box to confirm the end of the program. Finally, by clicking OK on the message box, the program displays a message on the console window.
9	The above example is for the E5260/E5270 of the GPIB address 17 on the interface GPIB0. "GPIB0" is the VISA name. Confirm your GPIB settings, and set them properly.
14 to 15	The above example uses the SMUs installed in the E5260/E5270 slots 1, 3, 4, and 5. Change the slot numbers for matching your configuration.

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)           '25
  Dim i As Integer = 0 : Dim j As Integer = 0
  Dim nop1 As Integer = 1 : Dim nop2 As Integer = 1
  Dim data(nop2 - 1, nop1 - 1) As String
  Dim value As String = "Enter data header"
  Dim fname As String = "C:\enter_file_name.txt"
  Dim title As String = "Measurement Result"
  Dim msg As String = "No error." : Dim err As Integer = 0

  ' insert measurement program code                                          34

  session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
  If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err

  session.WriteString("DZ" & vbLf)
  save_data(fname, title, value, data, nop1, nop2, session, t)              '40
  Exit Sub

 Check_err:
  session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
  MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub                                                                     '46
```

Line	Description
25	Beginning of the perform_meas subprogram.
26 to 32	Declares variables used in this program template. The values are dummy. You must change the values to match your program. If you find unnecessary variables, delete them. *i* and *j*: Variables used to specify the element of the *data* array. *nop1* and *nop2*: Number of measurement steps. Also used to declare the *data* array. *data*: String data array used to store the measurement result data. *val*: String data variable to store the header (first line) of the displayed data. *fname*: Full path name of the measurement result data file. *title*: Title of the message box used to display the measurement result data. *msg* and *err*: Variables used to store an error message and an error code.
34	The line is placed as dummy. Remove the line and insert your program code to control the instruments and perform measurement.
36 to 37	Checks if the instrument causes an error, and goes to Check_err if an error is detected.
39 to 40	Applies 0 V from all channels and calls the save_data subprogram (lines 48 to 70).
43 to 45	Opens a message box to display error message if an error is detected.
46	End of the perform_meas subprogram.

```
  Sub save_data(ByVal fname As String, ByVal title As String, ByVal value As
String, ByVal data(,) As String, ByVal nop1 As Integer, ByVal nop2 As Integer,
ByVal session As IMessage, ByVal t() As Integer)                               '48
    Dim i As Integer = 0
    Dim j As Integer = 0
    FileOpen(1, fname, OpenMode.Output, OpenAccess.Write, OpenShare.LockReadWrite)
    Print(1, value)
    For j = 0 To nop2 - 1
        For i = 0 To nop1 - 1
            Print(1, data(j, i))
        Next i
    Next j
    FileClose(1)

    Dim rbx As Integer                                                         '60
    For j = 0 To nop2 - 1
        For i = 0 To nop1 - 1
            value = value & data(j, i)
        Next i
    Next j
    value = value & Chr(10) & Chr(10) & "Data save completed."
    value = value & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
    rbx = MsgBox(value, vbYesNo, title)
    If rbx = vbYes Then perform_meas(session, t)
  End Sub                                                                      '70

End Module
```

Line	Description
48	Beginning of the save_data subprogram.
49 to 50	Declares loop counters used to specify the element of the *data* array.
51 to 58	Saves measurement result data into a file specified by the *fname* variable.
60 to 68	Displays the data and a message on a message box.
69	If Yes is clicked on the message box, calls the perform_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.
70	End of the save_data subprogram.

High-Speed Spot Measurements

To perform high-speed spot measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Forces constant voltage	DV, TDV	*chnum*,*vrange*,*output* [,*comp*[,*polarity*[,*irange*]]]
Forces constant current	DI, TDI	*chnum*,*irange*,*output* [,*comp*[,*polarity*[,*vrange*]]]
Measures current	TI, TTI	*chnum*[,*range*]
Measures voltage	TV, TTV	*chnum*[,*range*]
Resets the time stamp	TSR	
Returns the time stamp at this time	TSQ	

You can use the above commands regardless of the measurement mode (MM command settings).

A program example of a high-speed spot measurement is shown below. This example measures MOSFET drain current. This program uses the TTI command to measure the current and read the time stamp data.

Table 3-2 High-Speed Spot Measurement Example

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)               '1
    Dim i As Integer = 0                         't(0): Drain
    Dim j As Integer = 0                         't(1): Gate
    Dim nop1 As Integer = 1                      't(2): Source
    Dim nop2 As Integer = 1                      't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Id (uA), Status, Meas Time (msec)"
    Dim fname As String = "C:\Keysight\prog_ex\data1.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd As Double = 3                                                          '13
    Dim vg As Double = 1
    Dim idcomp As Double = 0.05
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 0
    Dim mrng As Integer = 0

    session.WriteString("FMT 1" & vbLf)                                           '20
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(1) & "," & orng & "," & vg & "," & igcomp & vbLf)
    session.WriteString("DV " & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err           '28
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 18	Declares variables and sets the value.
20 to 22	Sets the data output format and A/D converter. Also sets the SMU filter off.
23 to 28	Applies voltage to device and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.

```
    session.WriteString("TSR" & vbLf)                                         '30
    session.WriteString("TTI " & t(0) & "," & mrng & vbLf)
    session.WriteString("TSQ" & vbLf)
    Dim mret As String = session.ReadString(16 + 17)  'data+comma+data+terminator
    Dim tret As String = session.ReadString(17)       'data+terminator
    Dim tcal As String = Mid(mret, 4, 12)
    tret = Mid(tret, 4, 12)
    Dim mtime As Double = Val(tret) - Val(tcal)
    Dim status As String = Mid(mret, 17, 3)
    Dim meas As Double = Val(Mid(mret, 20, 12))

    data(j, i) = Chr(13) & Chr(10) & meas * 1000000 & ", " & status & ", " & mtime
* 1000

    session.WriteString("DZ" & vbLf)                                          '43
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                  '47
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
30 to 41	Resets time stamp and performs the high-speed spot measurement. And stores the returned data into the *mret* and *tret* string variables. Finally, stores the measured data into the *data* array.
43 to 45	Applies 0 V from the all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
48 to 49	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Id (uA), Status, Meas Time (msec)
23.69, NEI, 14.05

Data save completed.

Do you want to perform measurement again?
```

Spot Measurements

To perform spot measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Forces constant voltage	DV, TDV	*chnum*,*vrange*,*output* [,*comp*[,*polarity*[,*irange*]]]
Forces constant current	DI, TDI	*chnum*,*irange*,*output* [,*comp*[,*polarity*[,*vrange*]]]
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	1,*chnum*[,*chnum* ... [,*chnum*] ...]
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

NOTE If you use multiple measurement channels, the channels start measurement in the order defined in the MM command.

A program example of a spot measurement is shown below. This example measures MOSFET drain current.

Table 3-3 **Spot Measurement Example**

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              '1
    Dim i As Integer = 0                         't(0): Drain
    Dim j As Integer = 0                         't(1): Gate
    Dim nop1 As Integer = 1                      't(2): Source
    Dim nop2 As Integer = 1                      't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Id (uA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data2.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd As Double = 3                                                      '13
    Dim vg As Double = 1
    Dim idcomp As Double = 0.05
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 0
    Dim mrng As Integer = 0
    session.WriteString("FMT 1" & vbLf)                                       '19
    session.WriteString("TSC 1" & vbLf)       'enables time stamp output
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(1) & "," & orng & "," & vg & "," & igcomp & vbLf)
    session.WriteString("DV " & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("MM 1," & t(0) & vbLf)         '1: spot measurement
    session.WriteString("CMM " & t(0) & ",1" & vbLf)   '1: current measurement
    session.WriteString("RI " & t(0) & "," & mrng & vbLf)                     '29
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 18	Declares variables and sets the value.
19 to 22	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
23 to 26	Applies voltage to device.
27 to 29	Sets the measurement mode, channel measurement mode, and measurement range.
30 to 31	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.

```
    session.WriteString("TSR" & vbLf)                                            '33
    session.WriteString("XE" & vbLf)
    session.WriteString("TSQ" & vbLf)
    Dim mret As String = session.ReadString(16 + 17)    'data+comma+data+terminator
    Dim tret As String = session.ReadString(17)         'data+terminator
    Dim tcal As String = Mid(mret, 4, 12)
    tret = Mid(tret, 4, 12)
    Dim mtime As Double = Val(tret) - Val(tcal)
    Dim status As String = Mid(mret, 17, 3)
    Dim meas As Double = Val(Mid(mret, 20, 12))

    data(j, i) = Chr(13) & Chr(10) & meas * 1000000 & ", " & status & ", " & mtime
* 1000

    session.WriteString("DZ" & vbLf)                                             '46
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                     '50
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
33 to 44	Resets time stamp and performs the spot measurement. And stores the returned data into the *mret* and *tret* string variables. Finally, stores the measured data into the *data* array.
46 to 48	Applies 0 V from the all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
51 to 52	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Id (uA), Status, Meas Time (msec)
23.495, NEI, 14.28

Data save completed.

Do you want to perform measurement again?
```

Pulsed Spot Measurements

To perform pulsed spot measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Forces constant voltage	DV, TDV	*chnum*,*vrange*,*output* [,*comp*[,*polarity*[,*irange*]]]
Forces constant current	DI, TDI	*chnum*,*irange*,*output* [,*comp*[,*polarity*[,*vrange*]]]
Sets pulse timing parameters	PT	*hold*,*width*[,*period* [,*tdelay*]]
Forces pulse voltage	PV	*chnum*,*range*,*base*,*pulse*[,*comp*]
Forces pulse current	PI	*chnum*,*range*,*base*,*pulse* [,*comp*]
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	3,*chnum*
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

NOTE

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

A program example of a pulsed spot measurement is shown below. This example measures MOSFET drain current.

Table 3-4 Pulsed Spot Measurement Example

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)             '1
    Dim i As Integer = 0                        't(0): Drain
    Dim j As Integer = 0                        't(1): Gate
    Dim nop1 As Integer = 1                     't(2): Source
    Dim nop2 As Integer = 1                     't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Id (uA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data3.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd As Double = 3                                                      '13
    Dim vg As Double = 1
    Dim idcomp As Double = 0.05
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 0
    Dim mrng As Integer = 0
    session.WriteString("FMT 1" & vbLf)                                       '19
    session.WriteString("TSC 1" & vbLf)       'enables time stamp output
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("AV 1,1" & vbLf)      'sets number of samples for 1 data
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    Dim g_pt As String = "0.1,0.01,0.02"      'hold, width, period in sec
    session.WriteString("PT " & g_pt & vbLf)
    Dim v0 As Double = 0                      '0 V: pulse base voltage
    session.WriteString("PV " & t(1) & "," & orng & "," & v0 & "," & vg & "," &
igcomp & vbLf)
    session.WriteString("DV " & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("MM 3," & t(0) & vbLf)         '3: pulsed spot measurement
    session.WriteString("CMM " & t(0) & ",1" & vbLf)   '1: current measurement
    session.WriteString("RI " & t(0) & "," & mrng & vbLf)                     '32
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 18	Declares variables and sets the value.
19 to 22	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
23 to 29	Applies DC voltage to device, and sets the voltage pulse source.
30 to 32	Sets the measurement mode, channel measurement mode, and measurement range.
33 to 34	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.

```
    session.WriteString("TSR" & vbLf)                                        '35
    session.WriteString("XE" & vbLf)
    session.WriteString("TSQ" & vbLf)
    Dim mret As String = session.ReadString(16 + 17)    'data+comma+data+terminator
    Dim tret As String = session.ReadString(17)         'data+terminator
    Dim tcal As String = Mid(mret, 4, 12)
    tret = Mid(tret, 4, 12)
    Dim mtime As Double = Val(tret) - Val(tcal)
    Dim status As String = Mid(mret, 17, 3)
    Dim meas As Double = Val(Mid(mret, 20, 12))

    data(j, i) = Chr(13) & Chr(10) & meas * 1000000 & ", " & status & ", " & mtime
* 1000

    session.WriteString("DZ" & vbLf)                                         '48
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                 '52
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
35 to 46	Resets time stamp and performs the pulsed spot measurement. And stores the returned data into the *mret* and *tret* string variables. Finally, stores the measured data into the *data* array.
48 to 50	Applies 0 V from the all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
53 to 54	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Id (uA), Status, Meas Time (msec)
25, NEI, 17.58

Data save completed.

Do you want to perform measurement again?
```

Staircase Sweep Measurements

To perform staircase sweep measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Sets sweep source timing parameter	[WT]	*hold*,*delay* [,*sdelay*[,*tdelay*[,*mdelay*]]]
Sets auto abort function	[WM]	*abort*[,*post*]
Sets voltage sweep source	WV	*chnum*,*mode*,*range*,*start*,*stop*,*step* [,*comp*[,*Pcomp*]]
Sets current sweep source	WI	
Sets synchronous sweep source [a]	[WSV]	*chnum*,*range*,*start*,*stop* [,*comp*[,*Pcomp*]]
	[WSI]	
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	2,*chnum*[,*chnum* ... [,*chnum*] ...]
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

a. The WSV/WSI command must be entered after the WV/WI command.

NOTE

If you use multiple measurement channels, the channels start measurement in the order defined in the MM command.

A program example of a staircase sweep measurement is shown below. This example measures MOSFET Id-Vd characteristics.

Table 3-5 **Staircase Sweep Measurement Example 1**

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)            '1
    Dim i As Integer = 0                         't(0): Drain
    Dim j As Integer = 0                         't(1): Gate
    Dim nop1 As Integer = 11                     't(2): Source
    Dim nop2 As Integer = 3                      't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vg (V), Vd (V), Id (mA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data4.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd1 As Double = 0                                                   '13
    Dim vd2 As Double = 3
    Dim idcomp As Double = 0.05
    Dim vg1 As Double = 1
    Dim vg2 As Double = 3
    Dim igcomp As Double = 0.01
    Dim vg As Double = vg1              'secondary sweep output value
    Dim d_vg As Double = 0              'secondary sweep step value (delta)
    If nop2 <> 1 Then d_vg = (vg2 - vg1) / (nop2 - 1)
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim p_comp As Double = 0.3
    Dim rep As Integer = nop1
    Dim mret As String                                                      '27
    Dim sc(nop1) As Double
    Dim md(nop1) As Double
    Dim st(nop1) As String
    Dim tm(nop1) As Double
    session.WriteString("FMT 1,1" & vbLf)'ASCII,<CRLF EOI>,w/sweep source data '32
    session.WriteString("TSC 1" & vbLf)       'enables time stamp output
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 26	Declares variables used to set the source output, and sets the value.
27 to 31	Declares variables used to read the measurement data.
32 to 35	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
36 to 37	Applies voltage to device.

```
    session.WriteString("MM 2," & t(0) & vbLf)    '2: staircase sweep measurement
    session.WriteString("CMM " & t(0) & ",1" & vbLf) '1: current measurement
    session.WriteString("RI " & t(0) & ",0" & vbLf)  '0: auto ranging
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)     '41
    session.WriteString("WM 2,1" & vbLf)             'stops any abnormal
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err

    For j = 0 To nop2 - 1                                                     '46
      session.WriteString("WV " & t(0) & ",1,0," & vd1 & "," & vd2 & "," & nop1 &
"," & idcomp & "," & p_comp & vbLf)
      session.WriteString("DV " & t(1) & ",0" & "," & vg & "," & igcomp & vbLf)
      session.WriteString("TSR" & vbLf)
      session.WriteString("XE" & vbLf)
      session.WriteString("*OPC?" & vbLf) : rep = session.ReadString(1 + 2)
      session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
      If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
      session.WriteString("NUB?" & vbLf) : rep = session.ReadString(3 + 2)     '54
      If rep <> nop1 * 3 Then session.WriteString("DZ" & vbLf) : GoTo Check_nop

      mret = session.ReadString(16 * 3 * nop1 + 1)
      For i = 0 To nop1 - 1
        tm(i) = Val(Mid(mret, 4 + 16 * 3 * i, 12))
        st(i) = Mid(mret, 17 + 16 * 3 * i, 3)
        md(i) = Val(Mid(mret, 20 + 16 * 3 * i, 12))
        sc(i) = Val(Mid(mret, 36 + 16 * 3 * i, 12))
        data(j, i) = Chr(13) & Chr(10) & vg & ", " & sc(i) & ", " & md(i) * 1000 &
", " & tm(i) & ", " & st(i)                                                   '63
      Next i
      vg = vg + d_vg
    Next j
    session.WriteString("DZ" & vbLf)                                          '67
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub
```

Line	Description
38 to 40	Sets the measurement mode, channel measurement mode, and measurement range.
41 to 44	Sets the timing parameters and sweep mode of the staircase sweep source. And checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
46 to 66	Sets the sweep source, applies voltage to device, resets time stamp, and performs the staircase sweep measurement. And stores the returned data into the *mret* string variable. Finally, stores the measured data into the *data* array.
54 to 55	Checks number of returned data. If it is not correct, forces 0 V and goes to Check_nop.
63	Stores the measured data into the *data* array.
67 to 69	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.

```
  Check_err:                                                                                   '71
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
    Exit Sub

  Check_nop:                                                                                   '76
    MsgBox("No. of data: " & rep & " (not " & nop1 * 3 & ")", vbOKOnly, "")
End Sub
```

Line	Description
71 to 74	Displays a message box to show an error message if the error is detected.
76 to 77	Displays a message box to show an error message if the number of returned data is not correct.

Measurement Result Example

```
Vg (V), Vd (V), Id (mA), Time (sec), Status
1, 0, 0.0001123, 0.05631, NEI
1, 0.3, 0.02327, 0.09489, NEI
1, 0.6, 0.0235, 0.12746, NEI
1, 0.9, 0.0235, 0.16004, NEI
1, 1.2, 0.0235, 0.19262, NEI
1, 1.5, 0.0235, 0.22518, NEI
1, 1.8, 0.02351, 0.25775, NEI
1, 2.1, 0.0235, 0.29032, NEI
1, 2.4, 0.02353, 0.32288, NEI
1, 2.7, 0.02351, 0.35545, NEI
1, 3, 0.02353, 0.38802, NEI
2, 0, 0.001794, 0.03458, NEI
2, 0.3, 2.085, 0.05779, NEI
2, 0.6, 3.5975, 0.07353, NEI
2, 0.9, 4.5655, 0.08926, NEI
2, 1.2, 5.0875, 0.10499, NEI
2, 1.5, 5.316, 0.12073, NEI
2, 1.8, 5.4045, 0.13646, NEI
2, 2.1, 5.4455, 0.15219, NEI
2, 2.4, 5.474, 0.16794, NEI
2, 2.7, 5.4935, 0.18367, NEI
2, 3, 5.513, 0.19941, NEI
3, 0, 0.0027225, 0.03542, NEI
3, 0.3, 3.4465, 0.05861, NEI
3, 0.6, 6.4185, 0.07436, NEI
3, 0.9, 8.904, 0.09011, NEI
3, 1.2, 10.9, 0.10008, NEI
3, 1.5, 12.425, 0.10527, NEI
3, 1.8, 13.51, 0.11046, NEI
3, 2.1, 14.215, 0.11566, NEI
3, 2.4, 14.63, 0.12085, NEI
3, 2.7, 14.875, 0.12605, NEI
3, 3, 15.04, 0.13124, NEI
Data save completed.
Do you want to perform measurement again?
```

The following program performs the same measurement as the previous program (Table 3-5). This program starts to read measurement data before the sweep measurement is completed.

Table 3-6 Staircase Sweep Measurement Example 2

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)            '1
    Dim i As Integer = 0                               't(0): Drain
    Dim j As Integer = 0                               't(1): Gate
    Dim nop1 As Integer = 11                           't(2): Source
    Dim nop2 As Integer = 3                            't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vg (V), Vd (V), Id (mA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data4r.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd1 As Double = 0                                                   '13
    Dim vd2 As Double = 3
    Dim idcomp As Double = 0.05
    Dim vg1 As Double = 1
    Dim vg2 As Double = 3
    Dim igcomp As Double = 0.01
    Dim vg As Double = vg1              'secondary sweep output value
    Dim d_vg As Double = 0              'secondary sweep step value (delta)
    If nop2 <> 1 Then d_vg = (vg2 - vg1) / (nop2 - 1)
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim p_comp As Double = 0.3

    session.WriteString("FMT 5,1" & vbLf)  'ASCII,<comma>,w/sweep source data  '27
    session.WriteString("TSC 1" & vbLf)       'enables time stamp output
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("MM 2," & t(0) & vbLf)   '2: staircase sweep measurement
    session.WriteString("CMM " & t(0) & ",1" & vbLf) '1: current measurement
    session.WriteString("RI " & t(0) & ",0" & vbLf)  '0: auto ranging
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)
    session.WriteString("WM 2,1" & vbLf)             'stops any abnormal
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err      '39
```

Line	Description
1 to 25	Declares variables and set the value. Almost same as the previous program. Only the fname value is different.
27	Sets the data output format. A comma will be sent as the data terminator.
28 to 39	Sets the measurement condition. Same as the lines 33 to 44 of the previous program.

```
    Dim ret_val As String : Dim status As String : Dim chan As String          '41
    Dim type As String : Dim rdata As Double : Dim tdata As Double
    Dim sdata As Double : Dim mdata As Double : Dim mstat As String
    Dim disp_data As String : Dim k As Integer = 0
    session.TerminationCharacter = 44           'terminator=comma              '45
    session.TerminationCharacterEnabled = True

    For j = 0 To nop2 - 1                                                      '48
       session.WriteString("WV " & t(0) & ",1,0," & vd1 & "," & vd2 & "," & nop1 &
"," & idcomp & "," & p_comp & vbLf)
       session.WriteString("DV " & t(1) & ",0" & "," & vg & "," & igcomp & vbLf)
       session.WriteString("TSR" & vbLf)
       session.WriteString("XE" & vbLf)
       For i = 0 To nop1 - 1
          For k = 0 To 2                                                       '54
             ret_val = session.ReadString(16)
             status = Left(ret_val, 1)        'status
             chan = Mid(ret_val, 2, 1)        'channel
             type = Mid(ret_val, 3, 1)        'data type
             rdata = Val(Mid(ret_val, 4, 12)) 'data
             If type = "T" Then tdata = rdata                    'time data
             If type = "I" Then mdata = rdata : mstat = status   'meas data, status
             If type = "V" Then sdata = rdata                    'source data
          Next k                                                               '63
          If mstat <> "N" Then session.WriteString("DZ" & vbLf) : GoTo Check_err
          disp_data = "Vg = " & vg & " (V), "
          disp_data = disp_data & "Vd = " & sdata & " (V), "
          disp_data = disp_data & "Id = " & mdata * 1000 & " (mA), "
          disp_data = disp_data & "Time = " & tdata & " (sec), "
          disp_data = disp_data & "Status = " & mstat
          Console.WriteLine(disp_data)
          data(j, i) = Chr(13) & Chr(10) & vg & ", " & sdata & ", " & mdata * 1000
& ", " & tdata & ", " & mstat                                                  '71
       Next i
       vg = vg + d_vg
    Next j
```

Line	Description
41 to 44	Declares the variables used to read and save the measurement data.
45 to 46	Declares that a comma is the data terminator needed to read data, and enables it.
49 to 52	Sets the sweep source, applies voltage to device, resets time stamp, and triggers the staircase sweep measurement. Same as the lines 47 to 50 of the previous program.
54 to 63	Reads data and picks up the status, channel, data type, and data. And stores the time data, measurement data, and source data into the variables, *tdata*, *mdata*, and *sdata*.
64	Checks the status of the measurement channel. And applies 0 V and goes to Check_err if an error is detected.
65 to 71	Displays the data on the console window. And stores the data into the *data* array.

```
    session.WriteString("DZ" & vbLf)                                          '76
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                  '80
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
76 to 78	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
80 to 82	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Vg (V), Vd (V), Id (mA), Time (sec), Status
1, 0, 0.00011485, 0.0595, N
1, 0.3, 0.02333, 0.09706, N
1, 0.6, 0.02351, 0.12941, N
1, 0.9, 0.023545, 0.16096, N
1, 1.2, 0.02356, 0.19251, N
1, 1.5, 0.02357, 0.22487, N
1, 1.8, 0.02356, 0.25643, N
1, 2.1, 0.02356, 0.28798, N
1, 2.4, 0.02356, 0.31978, N
1, 2.7, 0.02359, 0.35134, N
1, 3, 0.02357, 0.3829, N
2, 0, 0.001744, 0.0327, N
2, 0.3, 2.085, 0.05511, N
2, 0.6, 3.597, 0.07008, N
2, 0.9, 4.5645, 0.08505, N
2, 1.2, 5.0875, 0.10057, N
2, 1.5, 5.3175, 0.11609, N
2, 1.8, 5.4055, 0.131, N
2, 2.1, 5.4445, 0.14653, N
2, 2.4, 5.4725, 0.16147, N
2, 2.7, 5.4925, 0.17629, N
2, 3, 5.512, 0.19182, N
3, 0, 0.002838, 0.04035, N
3, 0.3, 3.445, 0.06253, N
3, 0.6, 6.416, 0.07754, N
3, 0.9, 8.8995, 0.09331, N
3, 1.2, 10.895, 0.10238, N
3, 1.5, 12.425, 0.10732, N
3, 1.8, 13.51, 0.11182, N
3, 2.1, 14.215, 0.11484, N
3, 2.4, 14.63, 0.11813, N
3, 2.7, 14.88, 0.12139, N
3, 3, 15.045, 0.12469, N
Data save completed.
Do you want to perform measurement again?
```

The following program example executes the synchronous sweep measurement using two sweep sources. This example measures MOSFET Id-Vg characteristics.

Table 3-7 Staircase Sweep Measurement Example 3

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              '1
    Dim i As Integer = 0                          't(0): Drain
    Dim j As Integer = 0                          't(1): Gate
    Dim nop1 As Integer = 11                      't(2): Source
    Dim nop2 As Integer = 1                       't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vg (V), Id (mA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data5.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd1 As Double = 0                                                     '13
    Dim vd2 As Double = 2
    Dim idcomp As Double = 0.05
    Dim pd_comp As Double = 0.1
    Dim vg1 As Double = vd1
    Dim vg2 As Double = vd2
    Dim igcomp As Double = 0.01
    Dim pg_comp As Double = 0.05
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim rep As Integer = nop1
    Dim mret As String                                                        '25
    Dim sc(nop1) As Double
    Dim md(nop1) As Double
    Dim st(nop1) As String
    Dim tm(nop1) As Double
    session.WriteString("FMT 1,1" & vbLf)'ASCII,<CRLF EOI>,w/sweep source data '30
    session.WriteString("TSC 1" & vbLf)       'enables time stamp output
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 24	Declares variables used to set the source output, and sets the value.
25 to 29	Declares variables used to read the measurement data.
30 to 33	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
34 to 35	Applies voltage to device.

```
    session.WriteString("MM 2," & t(0) & vbLf)    '2: staircase sweep measurement
    session.WriteString("CMM " & t(0) & ",1" & vbLf) '1: current measurement
    session.WriteString("RI " & t(0) & ",0" & vbLf)  '0: auto ranging
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)     '40
    session.WriteString("WM 2,1" & vbLf)             'stops any abnormal
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err

    session.WriteString("WV " & t(0) & ",1,0," & vd1 & "," & vd2 & "," & nop1 & ","
& idcomp & "," & pd_comp & vbLf)                                               '45
    session.WriteString("WSV " & t(1) & ",0," & vg1 & "," & vg2 & "," & igcomp & ","
& pg_comp & vbLf)
    session.WriteString("TSR" & vbLf)
    session.WriteString("XE" & vbLf)
    session.WriteString("*OPC?" & vbLf) : rep = session.ReadString(1 + 2)
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("NUB?" & vbLf) : rep = session.ReadString(3 + 2)       '52
    If rep <> nop1 * 3 Then session.WriteString("DZ" & vbLf) : GoTo Check_nop

    mret = session.ReadString(16 * 3 * nop1 + 1)                               '55
    For i = 0 To nop1 - 1
      tm(i) = Val(Mid(mret, 4 + 16 * 3 * i, 12))
      st(i) = Mid(mret, 17 + 16 * 3 * i, 3)
      md(i) = Val(Mid(mret, 20 + 16 * 3 * i, 12))
      sc(i) = Val(Mid(mret, 36 + 16 * 3 * i, 12))
      data(j, i) = Chr(13) & Chr(10) & sc(i) & ", " & md(i) * 1000 & ", " & tm(i) &
", " & st(i)
    Next i

    session.WriteString("DZ" & vbLf)                                           '64
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub
```

Line	Description
37 to 39	Sets the measurement mode, channel measurement mode, and measurement range.
40 to 43	Sets the timing parameters and sweep mode of the staircase sweep source. And checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
45 to 62	Sets the sweep sources, applies voltage to device, resets time stamp, and performs the staircase sweep measurement. And stores the returned data into the *mret* string variable. Finally, stores the measured data into the *data* array.
52 to 53	Checks number of returned data. If it is not correct, forces 0 V and goes to Check_nop.
61	Stores the measured data into the *data* array.
64 to 66	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.

```
  Check_err:                                                                '68
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
    Exit Sub

  Check_nop:                                                                '73
    MsgBox("No. of data: " & rep & " (not " & nop1 * 3 & ")", vbOKOnly, "")
End Sub
```

Line	Description
68 to 70	Displays a message box to show an error message if the error is detected.
73 to 74	Displays a message box to show an error message if the number of returned data is not correct.

Measurement Result Example

```
Vg (V), Id (mA), Time (sec), Status
0, -3.685E-10, 5.44653, NEI
0.2, 1.6695E-08, 5.67838, NEI
0.4, 5.2305E-07, 5.77096, NEI
0.6, 1.8995E-05, 5.84304, NEI
0.8, 0.00078485, 5.90087, NEI
1, 0.023885, 5.94082, NEI
1.2, 0.2708, 5.96907, NEI
1.4, 1.035, 5.98927, NEI
1.6, 2.261, 6.00637, NEI
1.8, 3.7695, 6.02346, NEI
2, 5.43, 6.04055, NEI
Data save completed.
Do you want to perform measurement again?
```

Pulsed Sweep Measurements

To perform pulsed sweep measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets pulse timing parameters	PT	*hold*,*width*,*period* [,*tdelay*]
Sets auto abort function	[WM]	*abort*[,*post*]
Sets pulsed sweep source	PWV	*chnum*,*mode*,*range*,*base*,*start*, *stop*, *step*[,*comp*]
	PWI	
Sets synchronous sweep source [a]	[WSV]	*chnum*,*range*,*start*,*stop* [,*comp*[,*Pcomp*]]
	[WSI]	
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	4,*chnum*
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

a. The WSV/WSI command must be entered after the PWV/PWI command.

NOTE

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

A program example of a pulsed sweep measurement is shown below. This example measures the bipolar transistor Ic-Vc characteristics.

Table 3-8 **Pulsed Sweep Measurement Example**

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              '1
    Dim i As Integer = 0                         't(0): Emitter
    Dim j As Integer = 0                         't(1): Base
    Dim nop1 As Integer = 11                     't(2): Collector
    Dim nop2 As Integer = 3                      't(3): not use
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Ib (mA), Vc (V), Ic (mA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data6.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim v0 As Double = 0                                                        '13
    Dim vc1 As Double = 0
    Dim vc2 As Double = 5
    Dim iccomp As Double = 0.05
    Dim ib1 As Double = 0.003
    Dim ib2 As Double = 0.007
    Dim vbcomp As Double = 5
    Dim ib As Double = ib1             'secondary sweep output value
    Dim d_ib As Double = 0             'secondary sweep step value (delta)
    If nop2 <> 1 Then d_ib = (ib2 - ib1) / (nop2 - 1)
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim rep As Integer = nop1
    Dim mret As String                                                          '27
    Dim sc(nop1) As Double
    Dim md(nop1) As Double
    Dim st(nop1) As String
    Dim tm(nop1) As Double
    session.WriteString("FMT 1,1" & vbLf)   'ASCII, <CRLF EOI>, w/sweep source data
    session.WriteString("TSC 1" & vbLf)     'enables time stamp output
    session.WriteString("FL 1" & vbLf)      'sets filter on
    session.WriteString("AV 10,1" & vbLf)   'sets number of samples for 1 data
    session.WriteString("CL " & t(3) & vbLf)                                    '36
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 26	Declares variables used to set the source output, and sets the value.
27 to 31	Declares variables used to read the measurement data.
32 to 35	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
36	Disables SMU assigned to t(3) that is not needed.

```
    session.WriteString("DV " & t(0) & ",0,0,0.1" & vbLf) 'out=0 V, comp=0.1 A '38
    Dim b_pt As String = "0.1,0.01,0.02"       'hold, width, period in sec
    session.WriteString("PT " & b_pt & vbLf)
    session.WriteString("MM 4," & t(2) & vbLf) '4: pulsed sweep measurement
    session.WriteString("CMM " & t(2) & ",1" & vbLf)
    session.WriteString("RI " & t(2) & ",0" & vbLf)
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)
    session.WriteString("WM 2,1" & vbLf)             'stops any abnormal
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)     '46
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err

    For j = 0 To nop2 - 1                                                      '49
      session.WriteString("PWV " & t(2) & ",1,0," & v0 & "," & vc1 & "," & vc2 & ","
& nop1 & "," & iccomp & vbLf)
      session.WriteString("DI " & t(1) & ",0," & ib & "," & vbcomp & vbLf)
      session.WriteString("TSR" & vbLf)
      session.WriteString("XE" & vbLf)
      session.WriteString("*OPC?" & vbLf) : rep = session.ReadString(1 + 2)
      session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
      If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
      session.WriteString("NUB?" & vbLf) : rep = session.ReadString(3 + 2)     '57
      If rep <> nop1 * 3 Then session.WriteString("DZ" & vbLf) : GoTo Check_nop

      mret = session.ReadString(16 * 3 * nop1 + 1)                             '60
      For i = 0 To nop1 - 1
        tm(i) = Val(Mid(mret, 4 + 16 * 3 * i, 12))
        st(i) = Mid(mret, 17 + 16 * 3 * i, 3)
        md(i) = Val(Mid(mret, 20 + 16 * 3 * i, 12))
        sc(i) = Val(Mid(mret, 36 + 16 * 3 * i, 12))
        data(j, i) = Chr(13) & Chr(10) & ib * 1000 & ", " & sc(i) & ", " & md(i) *
1000 & ", " & tm(i) & ", " & st(i)
      Next i
      ib = ib + d_ib
    Next j                                                                     '69
```

Line	Description
38 to 45	Applies voltage to device. And sets the pulse timing parameters, measurement mode, channel measurement mode, measurement range, and sweep mode.
46 to 47	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
49 to 69	Sets the pulsed sweep source, applies voltage to device, resets time stamp, and performs the pulsed sweep measurement. And stores the returned data into the *mret* string variable. Finally, stores the measured data into the *data* array.
57 to 58	Checks number of returned data. If it is not correct, forces 0 V and goes to Check_nop.

```
    session.WriteString("DZ" & vbLf)                                            '71
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                    '75
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
    Exit Sub

  Check_nop:                                                                    '80
    MsgBox("No. of data: " & rep & " (not " & nop1 * 3 & ")", vbOKOnly, "")
End Sub
```

Line	Description
71 to 72	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
75 to 77	Displays a message box to show an error message if the error is detected.
80 to 81	Displays a message box to show an error message if the number of returned data is not correct.

Measurement Result Example

```
Ib (mA), Vc (V), Ic (mA), Time (sec), Status
3, 0, -0.375, 0.1437, NCI
3, 0.5, 5.28, 0.1637, NCI
3, 1, 5.39, 0.1837, NCI
3, 1.5, 5.48, 0.2037, NCI
3, 2, 5.57, 0.2237, NCI
3, 2.5, 5.66, 0.2437, NCI
3, 3, 5.785, 0.2637, NCI
3, 3.5, 5.97, 0.2837, NCI
3, 4, 6.305, 0.3037, NCI
3, 4.5, 6.895, 0.3237, NCI
3, 5, 7.97, 0.3437, NCI
5, 0, -0.985, 0.12189, NCI
5, 0.5, 9.68, 0.14189, NCI
5, 1, 9.845, 0.16189, NCI
5, 1.5, 9.985, 0.18189, NCI
5, 2, 10.12, 0.20189, NCI
5, 2.5, 10.255, 0.22189, NCI
5, 3, 10.46, 0.24189, NCI
5, 3.5, 10.775, 0.26189, NCI
5, 4, 11.375, 0.28189, NCI
5, 4.5, 12.46, 0.30189, NCI
5, 5, 14.47, 0.32189, NCI
7, 0, -1.565, 0.12387, NCI
7, 0.5, 13.8, 0.14387, NCI
7, 1, 14.005, 0.16387, NCI
7, 1.5, 14.18, 0.18387, NCI
7, 2, 14.34, 0.20387, NCI
7, 2.5, 14.53, 0.22387, NCI
7, 3, 14.785, 0.24387, NCI
7, 3.5, 15.22, 0.26387, NCI
7, 4, 16.045, 0.28387, NCI
7, 4.5, 17.565, 0.30387, NCI
7, 5, 20.355, 0.32387, NCI

Data save completed.
```

```
Do you want to perform measurement again?
```

Staircase Sweep with Pulsed Bias Measurements

To perform staircase sweep with pulsed bias measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets auto abort function	[WM]	*abort*[,*post*]
Sets voltage sweep source	WV	*chnum*,*mode*,*range*,*start*,*stop*, *step*[,*comp*[,*Pcomp*]]
Sets current sweep source	WI	
Sets synchronous sweep source [a]	[WSV]	*chnum*,*range*,*start*,*stop* [,*comp*[,*Pcomp*]]
	[WSI]	
Sets pulse timing parameters	PT	*hold*,*width*,*period* [,*tdelay*]
Forces pulse voltage	PV	*chnum*,*range*,*base*,*pulse*[,*comp*]
Forces pulse current	PI	*chnum*,*range*,*base*,*pulse* [,*comp*]
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	5,*chnum*
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

a. The WSV/WSI command must be entered after the WV/WI command.

NOTE

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

A program example of a staircase sweep with pulsed bias measurement is shown below. This example measures the bipolar transistor Ic-Vc characteristics.

Table 3-9 Staircase Sweep with Pulsed Bias Measurement Example

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              '1
    Dim i As Integer = 0                         't(0): Emitter
    Dim j As Integer = 0                         't(1): Base
    Dim nop1 As Integer = 11                     't(2): Collector
    Dim nop2 As Integer = 3                      't(3): not use
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Ib (mA), Vc (V), Ic (mA), Time (sec), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data7.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0
    Dim vc1 As Double = 0                                                     '12
    Dim vc2 As Double = 5
    Dim iccomp As Double = 0.05
    Dim pccomp As Double = 0.2
    Dim i0 As Double = 0
    Dim ib1 As Double = 0.003
    Dim ib2 As Double = 0.007
    Dim vbcomp As Double = 5
    Dim ib As Double = ib1              'secondary sweep output value
    Dim d_ib As Double = 0              'secondary sweep step value (delta)
    If nop2 <> 1 Then d_ib = (ib2 - ib1) / (nop2 - 1)
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim rep As Integer = nop1
    Dim mret As String                                                        '27
    Dim sc(nop1) As Double
    Dim md(nop1) As Double
    Dim st(nop1) As String
    Dim tm(nop1) As Double
    session.WriteString("FMT 1,1" & vbLf)   'ASCII, <CRLF EOI>, w/sweep source data
    session.WriteString("TSC 1" & vbLf)     'enables time stamp output
    session.WriteString("FL 1" & vbLf)      'sets filter on
    session.WriteString("AV 10,1" & vbLf)   'sets number of samples for 1 data
    session.WriteString("CL " & t(3) & vbLf)                                  '36
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
12 to 26	Declares variables used to set the source output, and sets the value.
27 to 31	Declares variables used to read the measurement data.
32 to 35	Sets the data output format, time stamp data output mode, SMU filter, and averaging.
36	Disables SMU assigned to t(3) that is not needed.

```
    session.WriteString("DV " & t(0) & ",0,0,0.1" & vbLf)                         '37
    Dim b_pt As String = "0.1,0.01,0.02"       'hold, width, period in sec
    session.WriteString("PT " & b_pt & vbLf)
    session.WriteString("MM 5," & t(2) & vbLf) '5: staircase sweep w/pulsed bias
    session.WriteString("CMM " & t(2) & ",1" & vbLf)
    session.WriteString("RI " & t(2) & ",0" & vbLf)
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)
    session.WriteString("WM 2,1" & vbLf)
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)     '45
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err

    For j = 0 To nop2 - 1                                                       '48
      session.WriteString("WV " & t(2) & ",1,0," & vc1 & "," & vc2 & "," & nop1 &
"," & iccomp & "," & pccomp & vbLf)
      session.WriteString("PI " & t(1) & ",0," & i0 & "," & ib & "," & vbcomp &
vbLf)
      session.WriteString("TSR" & vbLf)
      session.WriteString("XE" & vbLf)
      session.WriteString("*OPC?" & vbLf) : rep = session.ReadString(1 + 2)
      session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
      If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
      session.WriteString("NUB?" & vbLf) : rep = session.ReadString(3 + 2)     '56
      If rep <> nop1 * 3 Then session.WriteString("DZ" & vbLf) : GoTo Check_nop

      mret = session.ReadString(16 * 3 * nop1 + 1)                              '59
      For i = 0 To nop1 - 1
        tm(i) = Val(Mid(mret, 4 + 16 * 3 * i, 12))
        st(i) = Mid(mret, 17 + 16 * 3 * i, 3)
        md(i) = Val(Mid(mret, 20 + 16 * 3 * i, 12))
        sc(i) = Val(Mid(mret, 36 + 16 * 3 * i, 12))
        data(j, i) = Chr(13) & Chr(10) & ib * 1000 & ", " & sc(i) & ", " & md(i) *
1000 & ", " & tm(i) & ", " & st(i)
      Next i
      ib = ib + d_ib
    Next j                                                                      '68
```

Line	Description
37 to 44	Applies voltage to device. And sets the pulse timing parameters, measurement mode, channel measurement mode, measurement range, and sweep mode.
45 to 46	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
48 to 68	Sets the sweep source and the pulsed bias source, resets time stamp, and performs the staircase sweep with pulsed bias measurement. And stores the returned data into the *mret* string variable. Finally, stores the measured data into the *data* array.
56 to 57	Checks number of returned data. If it is not correct, forces 0 V and goes to Check_nop.

```
    session.WriteString("DZ" & vbLf)                                         '70
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)  '75
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
    Exit Sub

  Check_nop:
    MsgBox("No. of data: " & rep & " (not " & nop1 * 3 & ")", vbOKOnly, "")    '80
End Sub
```

Line	Description
70 to 72	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
75 to 76	Displays a message box to show an error message if the error is detected.
80	Displays a message box to show an error message if the number of returned data is not correct.

Measurement Result Example

```
Ib (mA), Vc (V), Ic (mA), Time (sec), Status
3, 0, -0.39, 0.14938, NCI
3, 0.5, 5.28, 0.16938, NCI
3, 1, 5.39, 0.18938, NCI
3, 1.5, 5.48, 0.20938, NCI
3, 2, 5.57, 0.22938, NCI
3, 2.5, 5.66, 0.24938, NCI
3, 3, 5.78, 0.26938, NCI
3, 3.5, 5.97, 0.28938, NCI
3, 4, 6.305, 0.30938, NCI
3, 4.5, 6.89, 0.32938, NCI
3, 5, 7.97, 0.34938, NCI
5, 0, -0.98, 0.12291, NCI
5, 0.5, 9.685, 0.14291, NCI
5, 1, 9.845, 0.16291, NCI
5, 1.5, 9.985, 0.18291, NCI
5, 2, 10.12, 0.20291, NCI
5, 2.5, 10.26, 0.22291, NCI
5, 3, 10.455, 0.24291, NCI
5, 3.5, 10.78, 0.26291, NCI
5, 4, 11.37, 0.28291, NCI
5, 4.5, 12.46, 0.30291, NCI
5, 5, 14.47, 0.32291, NCI
7, 0, -1.59, 0.12552, NCI
7, 0.5, 13.795, 0.14552, NCI
7, 1, 14.005, 0.16552, NCI
7, 1.5, 14.18, 0.18552, NCI
7, 2, 14.345, 0.20552, NCI
7, 2.5, 14.53, 0.22552, NCI
7, 3, 14.785, 0.24552, NCI
7, 3.5, 15.22, 0.26552, NCI
7, 4, 16.045, 0.28552, NCI
7, 4.5, 17.56, 0.30552, NCI
7, 5, 20.365, 0.32552, NCI

Data save completed.

Do you want to perform measurement again?
```

Quasi Pulsed Spot Measurements

To perform quasi-pulsed spot measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Sets detection interval	[BDM]	*interval*[,*mode*]
Sets timing parameters	[BDT]	*hold*,*delay*
Sets quasi-pulsed source	BDV	*chnum*,*range*,*start*,*stop*[,*comp*]
Forces constant voltage	DV, TDV	*chnum*,*vrange*,*output* [,*comp*[,*polarity*[,*irange*]]]
Forces constant current	DI, TDI	*chnum*,*irange*,*output* [,*comp*[,*polarity*[,*vrange*]]]
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	9[,*chnum*]
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

A program example of a spot measurement is shown below. This measures the breakdown voltage of bipolar transistor.

Table 3-10 Quasi Pulsed Spot Measurement Example

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              '1
    Dim i As Integer = 0                        't(0): Emitter
    Dim j As Integer = 0                        't(1): Base
    Dim nop1 As Integer = 1                     't(2): Collector
    Dim nop2 As Integer = 1                     't(3): not use
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "BVceo (V), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data8.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vc1 As Double = 0                                                     '13
    Dim vc2 As Double = 100
    Dim iccomp As Double = 0.005
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim interval As Double = 0
    Dim mmode As Double = 0
    Dim mrng As Integer = 0

    session.WriteString("FMT 1" & vbLf)                                       '22
    session.WriteString("CL " & t(1) & "," & t(3) & vbLf)
    session.WriteString("MM 9," & t(2) & vbLf)             '9: quasi pulsed spot
    session.WriteString("BDT " & hold & "," & delay & vbLf)
    session.WriteString("BDM " & interval & "," & mmode & vbLf)
    session.WriteString("BDV " & t(2) & "," & mrng & "," & vc1 & "," & vc2 & "," &
iccomp & vbLf)
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)     '28
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("DV " & t(0) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("XE" & vbLf)
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 20	Declares variables, and sets the value.
22 to 23	Sets the data output format. And disables SMUs assigned to t(1) and t(3) that are not needed.
24 to 27	Sets the measurement mode, measurement timing parameters, measurement conditions, and source output conditions.
28 to 29	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
30 to 31	Applies voltage to device, and performs the quasi pulsed spot measurement.

```
    Dim data1 As String = session.ReadString(17)                          '33
    Dim status As String = Left(data1, 3)
    data1 = Mid(data1, 4, 12)
    Dim meas As Double = Val(data1)
    data(j, i) = Chr(13) & Chr(10) & meas & ", " & status

    session.WriteString("DZ" & vbLf)                                      '39
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                              '43
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
33 to 37	Reads the returned data and stores it into the *data1* string variable. Finally, stores the measured data into the *data* array.
39 to 41	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
43 to 45	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
BVceo (V), Status
7.759, CCV

Data save completed.

Do you want to perform measurement again?
```

Linear Search Measurements

To perform linear search measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Sets measurement mode	MM	14
Selects output data	[LSVM]	*output_data*
Sets timing parameters	[LSTM]	*hold*,*delay*
Sets auto abort function	[LSM]	*abort*[,*post*]
Sets current search or voltage search condition	LGI or LGV	*chnum*,*mode*,*range*,*target*
Sets voltage source or current source	LSV or LSI	*chnum*,*range*,*start*,*stop*,*step* [,*comp*]
Sets synchronous voltage source or current source	[LSSV] or [LSSI]	*chnum*,*polarity*,*offset*[,*comp*]
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Executes measurement	XE	

The LSV and LSI commands clear the previous source settings.

Send the LSI command before sending the LSSI command.

Send the LSV command before sending the LSSV command.

The LSI/LSSV commands or LSV/LSSI commands cannot be used together.

A program example of a linear search measurement is shown below. This example measures the MOSFET threshold voltage.

Table 3-11 **Linear Search Measurement Example**

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)             '1
    Dim i As Integer = 0                         't(0): Drain
    Dim j As Integer = 0                         't(1): Gate
    Dim nop1 As Integer = 1                      't(2): Source
    Dim nop2 As Integer = 1                      't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vth (V), Id (mA), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data9.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd1 As Double = 0                                                     '13
    Dim vd2 As Double = 3
    Dim vdel As Double = 0.01
    Dim idcomp As Double = 0.01
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 12    '12: 20 V limited auto ranging
    Dim mrng As Integer = 13    '13: 100 nA limited auto ranging
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim judge As Integer = 1    ' 1: result>=target
    Dim tgt As Double = 0.001   ' target current
    Dim posneg As Integer = 1   ' 1: positive
    Dim offset As Double = 0    ' offset voltage

    session.WriteString("FMT 1" & vbLf)                                       '27
    session.WriteString("MM 14" & vbLf)    'linear search measurement
    session.WriteString("LSM 2,3" & vbLf)  'stops by any abnormal
    session.WriteString("LSVM 1" & vbLf)   'returns search data and sense data
    session.WriteString("LSTM " & hold & "," & delay & vbLf)
    session.WriteString("LGI " & t(0) & "," & judge & "," & mrng & "," & tgt & vbLf)
    session.WriteString("LSV " & t(1) & "," & orng & "," & vd1 & "," & vd2 & "," &
vdel & "," & idcomp & vbLf)
    session.WriteString("LSSV " & t(0) & "," & posneg & "," & offset & "," & igcomp
& vbLf)                                                                       '34
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 25	Declares variables, and sets the value.
27 to 28	Sets the data output format and the measurement mode.
29 to 32	Sets the linear search measurement conditions.
33 to 34	Sets the linear search sources, primary source and synchronous source.

```
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)     '36
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf) 'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)
    session.WriteString("XE" & vbLf)                                           '40

    Dim mret As String = session.ReadString(16 + 17)    'data+comma+data+terminator
    Dim dsearch As Double = Val(Mid(mret, 4, 12))
    Dim status As String = Mid(mret, 17, 3)
    Dim dsense As Double = Val(Mid(mret, 20, 12))
    data(j, i) = Chr(13) & Chr(10) & dsearch & ", " & dsense * 1000 & ", " & status

    session.WriteString("DZ" & vbLf)                                           '48
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                   '52
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
36 to 37	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
38 to 40	Applies voltage to device, and performs the linear search measurement.
42 to 46	Reads the returned data and stores it into the *mret* string variable. Finally, stores the measured data into the *data* array.
48 to 50	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
52 to 54	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Vth (V), Id (mA), Status
1.4, 1.03545, NEI

Data save completed.

Do you want to perform measurement again?
```

Binary Search Measurements

To perform binary search measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Sets measurement mode	MM	15
Selects output data	[BSVM]	*output_data*
Sets timing parameters	[BST]	*hold*,*delay*
Sets source control mode	BSM	*mode*,*abort*[,*post*]
Sets current search or voltage search condition	BGI or BGV	*chnum*,*mode*,*condition*,*range*, *target*
Sets voltage source or current source	BSV or BSI	*chnum*,*range*,*start*,*stop*[,*comp*]
Sets synchronous voltage source or current source	[BSSV] or [BSSI]	*chnum*,*polarity*,*offset*[,*comp*]
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Executes measurement	XE	

The BSV and BSI commands clear the previous source settings.

Send the BSI command before sending the BSSI command.

Send the BSV command before sending the BSSV command.

The BSI/BSSV commands or BSV/BSSI commands cannot be used together.

A program example of a binary search measurement is shown below. This example measures the MOSFET threshold voltage.

Table 3-12 **Binary Search Measurement Example**

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)              ’1
    Dim i As Integer = 0                         ’t(0): Drain
    Dim j As Integer = 0                         ’t(1): Gate
    Dim nop1 As Integer = 1                      ’t(2): Source
    Dim nop2 As Integer = 1                      ’t(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vth (V), Id (mA), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data10.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd1 As Double = 0                                                     ’13
    Dim vd2 As Double = 3
    Dim idcomp As Double = 0.01
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 12        ’12: 20 V limited auto ranging
    Dim mrng As Integer = 13        ’13: 100 nA limited auto ranging
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim mode As Integer = 0         ’ 0: limit, 1: repeat
    Dim judge As Double = 0.000001  ’ limit value in A
    Dim tgt As Double = 0.001       ’ target current
    Dim posneg As Integer = 1       ’ 1: positive
    Dim offset As Double = 0        ’ offset voltage

    session.WriteString("FMT 1" & vbLf)                                       ’27
    session.WriteString("MM 15" & vbLf)    ’binary search measurement
    session.WriteString("BSM 1,1" & vbLf)  ’cautious mode, abort off
    session.WriteString("BSVM 1" & vbLf)   ’returns search data and sense data
    session.WriteString("BST " & hold & "," & delay & vbLf)
    session.WriteString("BGI " & t(0) & "," & mode & "," & judge & "," & mrng & ","
& tgt & vbLf)
    session.WriteString("BSV " & t(1) & "," & orng & "," & vd1 & "," & vd2 & "," &
idcomp & vbLf)
    session.WriteString("BSSV " & t(0) & "," & posneg & "," & offset & "," & igcomp
& vbLf)
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 25	Declares variables, and sets the value.
27 to 28	Sets the data output format and the measurement mode.
29 to 32	Sets the binary search measurement conditions.
33 to 34	Sets the binary search sources, primary source and synchronous source.

```
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)     '36
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)    'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)    'out= 0 V, comp= 0.1 A
    session.WriteString("XE" & vbLf)                                            '40

    Dim mret As String = session.ReadString(16 + 17)    'data+comma+data+terminator
    Dim dsearch As Double = Val(Mid(mret, 4, 12))
    Dim status As String = Mid(mret, 17, 3)
    Dim dsense As Double = Val(Mid(mret, 20, 12))
    data(j, i) = Chr(13) & Chr(10) & dsearch & ", " & dsense * 1000 & ", " & status

    session.WriteString("DZ" & vbLf)                                            '48
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                    '52
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
End Sub
```

Line	Description
36 to 37	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
38 to 40	Applies voltage to device, and performs the binary search measurement.
42 to 46	Reads the returned data and stores it into the *mret* string variable. Finally, stores the measured data into the *data* array.
48 to 50	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
52 to 54	Displays a message box to show an error message if the error is detected.

Measurement Result Example

```
Vth (V), Id (mA), Status
1.393, 1.0004, NEI

Data save completed.

Do you want to perform measurement again?
```

Multi Channel Sweep Measurements

To perform multi channel sweep measurements, use the following commands.

Function	Command	Parameters
Enables channels	CN	[*chnum* ... [,*chnum*] ...]
Disables channels	CL	[*chnum* ... [,*chnum*] ...]
Sets filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets series resistor ON/OFF	[SSR]	*chnum*[,*mode*]
Sets integration time (Keysight E5270B can use AAD/AIT instead of AV.)	[AV]	*number*[,*mode*]
	[AAD]	*chnum*[,*type*]
	[AIT]	*type*,*mode*[,*N*]
Sets sweep source timing parameter	[WT]	*hold*,*delay* [,*sdelay*[,*tdelay*[,*mdelay*]]]
Sets auto abort function	[WM]	*abort*[,*post*]
Sets voltage sweep source	WV	*chnum*,*mode*,*range*,*start*,*stop*,*step* [,*comp*[,*Pcomp*]]
Sets current sweep source	WI	
Sets synchronous sweep source [a]	WNX	*N*,*chnum*,*mode*,*range*,*start*,*stop* [,*comp*[,*Pcomp*]]
Forces constant voltage	DV, TDV	*chnum*,*range*,*output* [,*comp*[,*polarity*[,*crange*]]]
Forces constant current	DI, TDI	
Sets voltage measurement range	[RV]	*chnum*,*range*
Sets current measurement range	[RI]	*chnum*,*range*
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	16,*chnum*[,*chnum* ... [,*chnum*] ...]
Sets SMU operation mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	

a. The WNX command must be entered after the WV/WI command.

NOTE

Sweep sources simultaneously start output by a trigger such as the XE command. However, if a sweep source sets power compliance or forces logarithmic sweep current, the sweep sources start output in the order specified by the WNX's *N* value. Then the first output is forced by the channel set by the WI or WV command.

If you use multiple measurement channels, the channels that use the fixed ranging mode start measurement simultaneously, then other channels start measurement in the order defined in the MM command. For the Keysight E5270B, note that the high-resolution ADC cannot perform simultaneous measurement.

A program example of a multi channel sweep measurement is shown below. This example measures the bipolar transistor Ib-Vb and Ic-Vb characteristics.

Table 3-13 Multi Channel Sweep Measurement Example

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)                '1
    Dim i As Integer = 0                         't(0): Emitter
    Dim j As Integer = 0                         't(1): Base
    Dim nop1 As Integer = 11                     't(2): Collector
    Dim nop2 As Integer = 1                      't(3): not use
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Vb (V), Ib (mA), Tb (sec), Stat_b, Ic (mA), Tc (sec), 
Stat_c"
    Dim fname As String = "C:\Keysight\prog_ex\data11.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vc As Double = 3                                                          '13
    Dim vb1 As Double = 0.1
    Dim vb2 As Double = 0.9
    Dim ibcomp As Double = 0.1
    Dim pbcomp As Double = 0.1
    Dim hold As Double = 0
    Dim delay As Double = 0
    Dim s_delay As Double = 0
    Dim rep As Integer = nop1
    Dim mret As String                                                            '22
    Dim sc(nop1) As Double
    Dim md1(nop1) As Double
    Dim st1(nop1) As String
    Dim tm1(nop1) As Double
    Dim md2(nop1) As Double
    Dim st2(nop1) As String
    Dim tm2(nop1) As Double                                                       '29
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 21	Declares variables used to set the source output, and sets the value.
22 to 29	Declares variables used to read the measurement data.

```
    session.WriteString("FMT 1,1" & vbLf)'ASCII,<CRLF EOI>,w/sweep source data '31
    session.WriteString("TSC 1" & vbLf)  'enables time stamp output
    session.WriteString("FL 1" & vbLf)   'sets filter on
    session.WriteString("AV 10,1" & vbLf)'sets number of samples for 1 data
    session.WriteString("MM 16," & t(1) & "," & t(2) & vbLf) '16: m-ch sweep
    session.WriteString("CMM" & t(1) & ",1" & vbLf)
    session.WriteString("CMM" & t(2) & ",1" & vbLf)
    session.WriteString("RI" & t(1) & ",-19" & vbLf) '-19: 100 mA fixed range
    session.WriteString("RI" & t(2) & ",-19" & vbLf)
    session.WriteString("WT " & hold & "," & delay & "," & s_delay & vbLf)
    session.WriteString("WM 2,1" & vbLf) 'stops any abnormal
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err         '43

    session.WriteString("WV" & t(1) & ",1,0," & vb1 & "," & vb2 & "," & nop1 & ","
& ibcomp & "," & pbcomp & vbLf)
    session.WriteString("DV" & t(2) & ",0," & vc & ",0.1" & vbLf)
    session.WriteString("DV" & t(0) & ",0,0,0.1" & vbLf)    'out= 0 V, comp= 0.1 A
    session.WriteString("TSR" & vbLf)
    session.WriteString("XE" & vbLf)
    session.WriteString("*OPC?" & vbLf) : rep = session.ReadString(1 + 2)      '50
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("NUB?" & vbLf) : rep = session.ReadString(3 + 2)
    If rep <> nop1 * 5 Then session.WriteString("DZ" & vbLf) : GoTo Check_nop

    mret = session.ReadString(16 * 5 * nop1 + 1)                                '56
```

Line	Description
31 to 43	Sets the data output format, time stamp data output mode, A/D converter, SMU filter, measurement mode, channel measurement mode, and measurement range. Also sets the timing parameters and sweep mode of the staircase sweep source. And checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
45 to 49	Sets the sweep sources, applies voltage to device, resets time stamp, and performs the multi channel sweep measurement.
50 to 54	Waits until the measurement is completed, and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err. Also checks number of returned data. If it is not correct, forces 0 V and goes to Check_nop.
56	Stores the returned data into the *mret* string variable.

```
    For i = 0 To nop1 - 1                                                    '58
    tm1(i) = Val(Mid(mret, 4 + 16 * 5 * i, 12))
    st1(i) = Mid(mret, 17 + 16 * 5 * i, 3)
    md1(i) = Val(Mid(mret, 20 + 16 * 5 * i, 12))
    tm2(i) = Val(Mid(mret, 36 + 16 * 5 * i, 12))
    st2(i) = Mid(mret, 49 + 16 * 5 * i, 3)
    md2(i) = Val(Mid(mret, 52 + 16 * 5 * i, 12))
    sc(i) = Val(Mid(mret, 68 + 16 * 5 * i, 12))
    data(j, i) = Chr(13) & Chr(10) & sc(i) & ", " & md1(i) * 1000 & ", " & tm1(i) &
", " & st1(i) & ", " & md2(i) * 1000 & ", " & tm2(i) & ", " & st2(i)
    Next

    session.WriteString("DZ" & vbLf)                                         '69
    save_data(fname, title, value, data, nop1, nop2, session, t)
    Exit Sub

  Check_err:                                                                 '73
    session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
    Exit Sub

  Check_nop:
    MsgBox("No. of data: " & rep & " (not " & nop1 * 5 & ")", vbOKOnly, "")    '79
End Sub
```

Line	Description
58 to 67	Picks the measurement data out and stores it into the *data* array.
69 to 71	Applies 0 V from all channels and transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
73 to 79	Displays a message box to show an error message if the error is detected. Also displays a message box to show an error message if the number of returned data is not correct.

Measurement Result Example

```
Vb (V), Ib (mA), Tb (sec), Stat_b, Ic (mA), Tc (sec), Stat_c
0.1, 0.01, 0.02949, NDI, -0.025, 0.02949, NCI
0.18, 0.01, 0.03788, NDI, -0.03, 0.03788, NCI
0.26, 0.01, 0.04628, NDI, -0.03, 0.04628, NCI
0.34, 0.01, 0.05468, NDI, -0.025, 0.05468, NCI
0.42, 0.01, 0.06308, NDI, -0.025, 0.06308, NCI
0.5, 0.02, 0.07148, NDI, -0.025, 0.07148, NCI
0.58, 0.105, 0.07987, NDI, 0.005, 0.07987, NCI
0.66, 0.585, 0.08825, NDI, 0.5, 0.08825, NCI
0.74, 2.635, 0.09664, NDI, 4.885, 0.09664, NCI
0.82, 9.96, 0.10505, NDI, 20.5, 0.10505, NCI
0.9, 27.84, 0.11345, NDI, 45.75, 0.11345, NCI
Data save completed.
Do you want to perform measurement again?
```

Using Program Memory

The program memory can store approximately 2,000 programs or 40,000 commands. Storing programs and executing them will improve the program execution speed. The following commands are available to use program memory.

Command	Function and Syntax

ST and END	Stores the program in the memory.
	`ST` *pnum*`;`*command*`[ ... [;`*command*`] ..];END`
	or
	`ST` *pnum*
	`[`*command*`]`
	`:`
	`[`*command*`]`
	`END`

[SCR]	Scratches the program. `SCR [`*pnum*`]`
[LST?]	Gets a catalog of program numbers or a specific program listing (up to 3000 commands). `LST? [`*pnum*`[,`*index*`[,`*size*`]]]`
DO	Executes specified programs. `DO` *pnum*`[,`*pnum ...* `[,`*pnum*`] ...]`
RU	Executes programs sequentially. `RU` *start*`,`*stop*
[PA]	Pauses command execution or internal memory program execution. `PA [`*wait*`]`
[VAR]	Defines an internal memory variable, and sets the value. `VAR` *Type*`,`*N*`,`*Value*
[VAR?]	Reads the value of the internal memory variable. `VAR?` *Type*`,`*N*

Table 3-14 and Table 3-15 show the example program that uses the internal program memory, and does the following:

- stores a high-speed spot measurement program in the memory 1, and displays it.
- stores a pulsed spot measurement program in the memory 2, and displays it.
- executes the internal memory program 1 and 2.
- displays the measurement results on the console window.

The example program shown in Table 3-15 uses the internal variables available for the internal program memory. The program code is given as the replaceable code of the lines 13 to 39 shown in Table 3-14. To run the program, delete the lines 13 to 39 from the program of Table 3-14, and insert the program lines 1 to 37 of Table 3-15. Also insert Table 3-15's lines 39 to 49 between Table 3-14's lines 53 and 54. The code shown in Table 3-15 cannot run by itself.

NOTE

Running example programs in this section

To run the programs, the project template (Table 3-1) is not needed. To run the program of Table 3-15, see the above paragraph.

Tips to use program memory

1. Completes program:

   Before storing the program in the program memory, verify that the program is complete and free of errors. Command parameter check will be performed when the program is executed.

   If the program being stored makes changes to the present measurement setup, verify that these changes are correct and compatible with the present setup.

2. For the invalid commands in the internal memory program, refer to Table 2-1 on page 2-26.

Table 3-14 Program Memory Programming Example 1

```
Imports Ivi.visa.interop                                                    '1

Module Module1
Sub Main()
    Dim E5270 As IResourceManager                                           '5
    Dim session As IMessage
    E5270 = New ResourceManager
    session = E5270.Open("GPIB0::17::INSTR")
    session.WriteString("*RST" & vbLf)
    Dim fmt As Integer = 1 : session.WriteString("FMT" & fmt & vbLf)
    Dim t() As Integer = {5, 4, 3, 1}  'Drain, Gate, Source, Substrate
    Dim v0 As Double = 0 : Dim vd As Double = 1 : Dim idcomp As Double = 0.1   '12
    Dim vg As Double = 0.8 : Dim igcomp As Double = 0.05
    Dim orng As Integer = 0 : Dim mrng As Integer = 0 : Dim hold As Double = 0.1
    Dim width As Double = 0.01 : Dim period As Double = 0.02

    Dim mem As Integer = 1                                                  '17
    session.WriteString("ST" & mem & vbLf)
    session.WriteString("DV" & t(3) & ",0,0,0.1" & vbLf)
    session.WriteString("DV" & t(2) & ",0,0,0.1" & vbLf)
    session.WriteString("DV" & t(1) & "," & orng & "," & vg & "," & igcomp & vbLf)
    session.WriteString("DV" & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("TI" & t(0) & "," & mrng & vbLf)
    session.WriteString("END" & vbLf)
    display_mem(session, mem)

    mem = 2                                                                 '27
    session.WriteString("ST" & mem & vbLf)
    session.WriteString("PT" & hold & "," & width & "," & period & vbLf)
    session.WriteString("DV" & t(3) & ",0,0,0.1" & vbLf)
    session.WriteString("DV" & t(2) & ",0,0,0.1" & vbLf)
    session.WriteString("PV" & t(1) & "," & orng & "," & v0 & "," & vg & "," &
igcomp & vbLf)
    session.WriteString("DV" & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("MM3," & t(0) & vbLf)
    session.WriteString("RI" & t(0) & "," & mrng & vbLf)
    session.WriteString("XE" & vbLf)
    session.WriteString("END" & vbLf)
    display_mem(session, mem)                                               '38
```

Line	Description
1	This line is required to use the VISA COM library.
5 to 11	Establishes the connection with the Keysight E5260/E5270, resets the E5260/E5270, and sets the data output format. Also declares the SMUs used for measurement.
12 to 15	Declares variables used to set measurement conditions and sets the value.
17 to 25	Stores program in the internal memory 1, and displays it on the console window.
27 to 38	Stores program in the internal memory 2, and displays it on the console window.

```
    Dim term As String = t(0) & "," & t(1) & "," & t(2) & "," & t(3)           '40
    session.WriteString("CN" & term & vbLf)
    Dim i As Integer : Dim ret As Integer : Dim msg As String
    Dim value As String : Dim status As String : Dim meas As Double
    For i = 1 To 2
     session.WriteString("DO" & i & vbLf)
     session.WriteString("*OPC?" & vbLf) : ret = session.ReadString(1 + 2)
     session.WriteString("ERR? 1" & vbLf) : ret = session.ReadString(4 + 2)
     If ret <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
     value = session.ReadString(17) : status = Left(value, 3)
     value = Mid(value, 4, 12) : meas = Val(value)
     Console.WriteLine("Memory " & i & ": Id = " & meas & " (A), Status = " & status
& Chr(10))
    Next
    session.WriteString("DZ" & vbLf)                                           '53
    session.WriteString("CL" & vbLf)
    session.Close()
    Exit Sub

Check_err:                                                                     '58
    session.WriteString("EMG? " & ret & vbLf) : msg = session.ReadString(256)
    MsgBox("Instrument error: " & ret & Chr(10) & msg, vbOKOnly, "")
    Exit Sub
End Sub

Sub display_mem(ByVal session As IMessage, ByVal mem As Integer)              '64
    session.WriteString("LST?" & mem & vbLf)
    Dim prog_list As String = session.ReadString(256)
    Console.WriteLine("Memory " & mem & ":")
    Console.WriteLine(prog_list & Chr(10))
End Sub

End Module
```

Line	Description
40 to 52	Enables SMUs and performs the measurement. After that, checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err. Also reads the measured data and displays it on the console window.
53 to 56	Applies 0 V from all channels, disables SMUs, and closes the connection with the Keysight E5260/E5270.
58 to 62	Displays a message box to show an error message if the error is detected.
64 to 69	Reads the program lists stored in the internal program memory, and displays it on the console window.

Measurement Result Example

```
Memory 1: Id = 0.021945 (A), Status = NAI

Memory 2: Id = 0.022095 (A), Status = NAI

Press any key to continue
```

Table 3-15 Program Memory Programming Example 2

```
session.WriteString("VAR0,0," & t(0) & vbLf) '%I0=t(0)                    ’1
session.WriteString("VAR0,1," & t(1) & vbLf) '%I1=t(1)
session.WriteString("VAR0,2," & t(2) & vbLf) '%I2=t(2)
session.WriteString("VAR0,3," & t(3) & vbLf) '%I3=t(3)
session.WriteString("VAR0,4,0" & vbLf)       '%I4=mrng
session.WriteString("VAR0,5,0" & vbLf)       '%I5=orng
session.WriteString("VAR1,0,1" & vbLf)       '%R0=vd
session.WriteString("VAR1,1,0.8" & vbLf)     '%R1=vg
session.WriteString("VAR1,2,0.1" & vbLf)     '%R2=idcomp
session.WriteString("VAR1,3,0.05" & vbLf)    '%R3=igcomp
session.WriteString("VAR1,4,0" & vbLf)       '%R4=v0
session.WriteString("VAR1,5,0.1" & vbLf)     '%R5=hold
session.WriteString("VAR1,6,0.01" & vbLf)    '%R6=width
session.WriteString("VAR1,7,0.02" & vbLf)    '%R7=period

Dim mem As Integer = 1                                                    ’16
session.WriteString("ST" & mem & vbLf)
session.WriteString("DV %I3,0,0,0.1" & vbLf)
session.WriteString("DV %I2,0,0,0.1" & vbLf)
session.WriteString("DV %I1,%I5,%R1,%R3" & vbLf)
session.WriteString("DV %I0,%I5,%R0,%R2" & vbLf)
session.WriteString("TI %I0,%I4" & vbLf)
session.WriteString("END" & vbLf)
display_mem(session, mem)

mem = 2                                                                   ’26
session.WriteString("ST" & mem & vbLf)
session.WriteString("PT %R5,%R6,%R7" & vbLf)
session.WriteString("DV %I3,0,0,0.1" & vbLf)
session.WriteString("DV %I2,0,0,0.1" & vbLf)
session.WriteString("PV %I1,%I5,%R4,%R1,%R3" & vbLf)
session.WriteString("DV %I0,%I5,%R0,%R2" & vbLf)
session.WriteString("MM3,%I0" & vbLf)
session.WriteString("RI %I0,%I4" & vbLf)
session.WriteString("XE" & vbLf)
session.WriteString("END" & vbLf)
display_mem(session, mem)                                                 ’37
```

Line	Description
1 to 14	Declares variables used to set measurement conditions and sets the value. To run the program, replace the code with the lines 12 to 15 of the program shown in Table 3-14.
16 to 24	Stores program in the internal memory 1, and displays it on the console window. To run the program, replace the code with the lines 17 to 25 of the program shown in Table 3-14.
26 to 37	Stores program in the internal memory 2, and displays it on the console window. To run the program, replace the code with the lines 27 to 38 of the program shown in Table 3-14.

```
'changes vd and vg and performs measurement again                              '39
session.WriteString("VAR1,0,3" & vbLf)      '%R0=vd
For i = 1 To 2
session.WriteString("DO" & i & vbLf)
session.WriteString("*OPC?" & vbLf) : ret = session.ReadString(1 + 2)
session.WriteString("ERR? 1" & vbLf) : ret = session.ReadString(4 + 2)
If ret <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
value = session.ReadString(17) : status = Left(value, 3)
value = Mid(value, 4, 12) : meas = Val(value)
Console.WriteLine("Memory " & i & ": Id = " & meas & " (A), Status = " & status &
Chr(10))
Next                                                                           '49
```

Line	Description
39 to 49	Changes the value of the internal variable %R0, and performs measurement again. Can be inserted between line 52 and line 53 of the program shown in Table 3-14.

Measurement Result Example

```
Memory 1: Id = 0.021955 (A), Status = NAI

Memory 2: Id = 0.021975 (A), Status = NAI

Memory 1: Id = 0.023085 (A), Status = NAI

Memory 2: Id = 0.023335 (A), Status = NAI

Press any key to continue
```

Using Trigger Function

The Keysight E5260/E5270 can be equipped with eight trigger ports that will be used for different purpose individually. The Keysight E5260/E5270 can synchronize the operation with other equipment by using the trigger function. For details about the trigger input/output operation, see "Trigger Function" on page 2-30. The following commands are available for the trigger function.

Command	Function and Syntax
TGP	Sets the trigger port for the specified terminal. `TGP` *port*`,`*terminal*`,`*polarity*`[,`*type*`]`
TGPC	Clears the trigger setting of the specified ports. `TGPC [`*port* `... [,`*port*`] ... ]`
TGSI	Selects the sweep step first or last that ignores the Start Step Output Setup trigger input set by the `TGP` *port*`,1,`*polarity*`,2` command. `TGSI` *mode*
TGSO	Selects the trigger type, edge or gate, for the Step Output Setup Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,2` command. `TGSO` *mode*
TGXO	Selects the trigger type, edge or gate, for the Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,1` command. `TGXO` *mode*
TGMO	Selects the trigger type, edge or gate, for the Step Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,3` command. `TGMO` *mode*
TM3	Enables the trigger set by the `TGP` *port*`,`*terminal*`,`*polarity*`,1` command.

The following commands are also available to send a trigger or wait for an external trigger input. Refer to "Using Trigger Function" on page 2-35.

Command	Function and Syntax
OS	Causes the Keysight E5260/E5270 to send a trigger signal from the Ext Trig Out terminal. `OS`
OSX [a]	Causes the Keysight E5260/E5270 to send a trigger signal from the specified port. `OSX` *port* [, *level*]
WS	Enters a wait state until the Keysight E5260/E5270 receives an external trigger via the Ext Trig In terminal. `WS` [*mode*]
WSX [a]	Enters a wait state until the Keysight E5260/E5270 receives an external trigger via the specified port. `WSX` *port* [, *mode*]
PA	Pauses command execution or internal memory program execution until the specified wait time has elapsed, or until a trigger is received from the Ext Trig In terminal if the TM3 command has been entered. `PA` [*wait*]
PAX [a]	Pauses command execution or internal memory program execution until the specified wait time has elapsed, or until a trigger is received from the specified port if the TM3 command has been entered. `PAX` *port* [, *wait*]
TGP	Sets trigger port to the specified terminal. `TGP` *port*, *terminal*, *polarity* [, *type*]
TM3	Uses an external trigger to release the PA/PAX command state or to start measurement when the E52570 is not in the PA/PAX/WS/WSX command state.

a. Enter the TGP command to set the trigger port.

Programming examples using the trigger function are explained below. The examples use a couple within the available couples of the Keysight B1500A and the Keysight E5260/E5270 series. In this section, they are assigned as Unit1 (address 717) and Unit2 (address 722).

NOTE

To run the programs shown in this section, you do not need the example code shown in Table 3-1 (template of a project).

The following program performs a MOSFET drain current measurement. Unit2 applies voltage to the source and substrate terminals. Unit1 applies voltage to the gate and drain terminals, and measures the drain current. Before running the program, connect a BNC cable between the following terminals.

- Unit2's Ext Trig Out to Unit1's Ext Trig In

Table 3-16 Trigger Programming Example 1

```
Imports Ivi.visa.interop                                                       '1

Module Module1
Sub Main()
 Dim B1500 As IResourceManager : Dim unit1 As IMessage                         '5
 B1500 = New ResourceManager
 unit1 = B1500.Open("GPIB0::17::INSTR")
 Dim E5270 As IResourceManager : Dim unit2 As IMessage
 E5270 = New ResourceManager
 unit2 = E5270.Open("GPIB0::22::INSTR")
 unit1.WriteString("*RST" & vbLf)
 unit2.WriteString("*RST" & vbLf)
 MsgBox("Click OK to start measurement.", vbOKOnly, "")
 Console.WriteLine("Measurement in progress. . ." & Chr(10))
 Dim t() As Integer = {1, 2, 1, 2}              'unit1[1,2], unit2[1,2]
 Dim term1 As String = t(0) & "," & t(1)
 Dim term2 As String = t(2) & "," & t(3)
 unit1.WriteString("CN " & term1 & vbLf)
 unit2.WriteString("CN " & term2 & vbLf)
 perform_meas(unit1, unit2, t)                                                 '20
```

Line	Description
1	This line is required to use the VISA COM library.
5 to 20	Main subprogram establishes the connection with Unit1 and Unit2, resets them, opens a message box to confirm the start of measurement, and pauses program execution until OK is clicked on the message box. By clicking OK, the program displays a message on the console window, enables the SMUs (in the slots 1 and 2 of both Unit1 and Unit2), and calls the perform_meas subprogram that will be used to perform measurement.

```
 unit1.WriteString("CL" & vbLf)                                              '22
 unit2.WriteString("CL" & vbLf)
 unit1.Close()
 unit2.Close()
 MsgBox("Click OK to stop the program.", vbOKOnly, "")
 Console.WriteLine("Measurement completed." & Chr(10))
 End Sub                                                                     '28

Sub perform_meas(ByVal unit1 As IMessage, ByVal unit2 As IMessage, ByVal t() As
Integer)                                                                     '30
 Dim i As Integer = 0                          't(0): Drain
 Dim j As Integer = 0                          't(1): Gate
 Dim nop1 As Integer = 1                       't(2): Source
 Dim nop2 As Integer = 1                       't(3): Substrate
 Dim data(nop2 - 1, nop1 - 1) As String
 Dim value As String = "Id (mA), Status"
 Dim fname As String = "C:\Keysight\prog_ex\data14.txt"
 Dim title As String = "Measurement Result"
 Dim msg As String = "No error."
 Dim err As Integer = 0

 Dim vg As Double = 0.8 : Dim igcomp As Double = 0.05                        '42
 Dim vd As Double = 2.5 : Dim vs As Double = 0 : Dim icomp As Double = 0.1
 Dim ret As Integer

 unit1.WriteString("FMT 1" & vbLf)
 unit1.WriteString("TM 1" & vbLf)
 unit1.WriteString("AV -1" & vbLf)
 unit1.WriteString("MM 1," & t(0) & vbLf)
 unit2.WriteString("DV" & t(3) & ",0," & vs & "," & icomp & vbLf)
 unit2.WriteString("DV" & t(2) & ",0," & vs & "," & icomp & vbLf)
 unit1.WriteString("DV" & t(0) & ",0," & vd & "," & icomp & vbLf)
 unit1.WriteString("DV" & t(1) & ",0," & vg & "," & igcomp & vbLf)           '53
```

Line	Description
22 to 28	After the measurement, the program disables all SMUs, closes the connection with Unit1 and Unit2, and opens a message box to confirm the end of the program. Finally, by clicking OK on the message box, the program displays a message on the console window.
31 to 40	Declares variables used through the project. And sets the proper values.
42 to 44	Declares variables used to perform measurement, and sets the value.
46 to 49	Sets the data output format, trigger mode, A/D converter, and measurement mode.
50 to 51	Unit2 applies voltage to the source and substrate terminals of a device.
52 to 53	Unit1 applies voltage to the gate and drain terminals of a device.

```
unit1.WriteString("WS 2" & vbLf)                                                  '55
unit1.WriteString("XE" & vbLf)
unit2.WriteString("OS" & vbLf)

'unit1.WriteString("TM 3" & vbLf)                                                 '59
'unit1.WriteString("*OPC?" & vbLf) : ret = unit1.ReadString(1 + 2)
'unit2.WriteString("OS" & vbLf)
'unit1.WriteString("PA" & vbLf)                                                   '62
'unit2.WriteString("OS" & vbLf)
'unit1.WriteString("XE" & vbLf)

unit1.WriteString("*OPC?" & vbLf) : ret = unit1.ReadString(1 + 2)                 '66
unit1.WriteString("ERR? 1" & vbLf) : err = unit1.ReadString(4 + 2)
If err <> 0 Then
   unit1.WriteString("DZ" & vbLf) : unit2.WriteString("DZ" & vbLf)
   GoTo Check_err
End If

Dim mret As String = unit1.ReadString(17)                                         '73
Dim status As String = Left(mret, 3)
Dim meas As Double = Val(Mid(mret, 4, 12))

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

unit1.WriteString("DZ" & vbLf) : unit2.WriteString("DZ" & vbLf)                   '79
save_data(fname, title, value, data, nop1, nop2, unit1, unit2, t)
Exit Sub
```

Line	Description
55 to 57	Unit1 waits for a trigger sent to the Ext Trig In terminal, and starts measurement by receiving a trigger sent by Unit2.
59 to 61	The lines can be replaced with 55 to 57. Delete ’ at the top of the lines 59 to 61, and delete lines 55 to 57, then run the program. Unit1 will start measurement when a trigger is received via the Ext Trig In terminal.
62 to 64	The lines can be replaced with 55 to 57. Delete ’ at the top of the lines 59 to 64, and delete lines 55 to 57, and 61, then run the program. Unit1 will start measurement when a trigger is received via the Ext Trig In terminal.
66 to 71	Waits for the operation complete and checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
73 to 77	Reads measurement data and stores it into the *data* array.
79 to 81	Applies 0 V from all channels and transfers the data stored in the *data* variable to the save_data subprogram. And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.

```
Check_err:                                                                      '83
 unit1.WriteString("EMG? " & err & vbLf) : msg = unit1.ReadString(256)
 MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
 Exit Sub

End Sub                                                                         '88

Sub save_data(ByVal fname As String, ByVal title As String, ByVal value As String,
ByVal data(,) As String, ByVal nop1 As Integer, ByVal nop2 As Integer, ByVal unit1
As IMessage, ByVal unit2 As IMessage, ByVal t() As Integer)                     '90
 Dim i As Integer = 0
 Dim j As Integer = 0
 FileOpen(1, fname, OpenMode.Output, OpenAccess.Write, OpenShare.LockReadWrite)
 Print(1, value)
 For j = 0 To nop2 - 1
    'Print(1, Chr(13) & Chr(10) & "Unit" & j + 1)                                '96
    For i = 0 To nop1 - 1
       Print(1, data(j, i))
    Next i
 Next j
 FileClose(1)

 Dim rbx As Integer
 For j = 0 To nop2 - 1
    'value = value & Chr(10) & "Unit" & j + 1                                   '105
    For i = 0 To nop1 - 1
       value = value & data(j, i)
    Next i
 Next j
 value = value & Chr(10) & Chr(10) & "Data save completed."
 value = value & Chr(10) & Chr(10) & "Do you want to perform measurement again?"
 rbx = MsgBox(value, vbYesNo, title)
 If rbx = vbYes Then perform_meas(unit1, unit2, t)
End Sub                                                                        '114

End Module
```

Line	Description
83 to 86	Displays a message box to show an error message if the error is detected.
90 to 114	Save_data subprogram saves measurement result data into a file specified by the *fname* variable and displays the data and a message on a message box. If Yes is clicked on the message box, calls the perform_meas subprogram again. If No is clicked, returns to the perform_meas subprogram.

Measurement Result Example

```
Id (mA), Status
22.475, NAI

Data save completed.

Do you want to perform measurement again?
```

The following program controls two units and performs I-V measurement of two-terminal devices. Each unit measures a different device and performs one point measurement alternately at each sweep step. Before running the program, connect a BNC cable between the following terminals.

- Unit1's Ext Trig Out to Unit2's Ext Trig In
- Unit2's Ext Trig Out to Unit1's Ext Trig In

NOTE

The program needs the example code shown in Table 3-16 to run. Delete apostrophe (') at the beginning of the lines 96 and 105 shown in Table 3-16. And delete the lines 30 to 88 shown in Table 3-16, and insert the code shown in Table 3-17 into there.

Table 3-17 Trigger Programming Example 2

```
Sub perform_meas(ByVal unit1 As IMessage, ByVal unit2 As IMessage, ByVal t() As
Integer)                                                                       '1
 Dim i As Integer = 0                            't(0): Low1
 Dim j As Integer = 0                            't(1): High1
 Dim nop1 As Integer = 5                         't(2): High2
 Dim nop2 As Integer = 2                         't(3): Low2
 Dim data(nop2 - 1, nop1 - 1) As String
 Dim value As String = "I (mA), Time (msec), Status"
 Dim fname As String = "C:\Keysight\prog_ex\data15.txt"
 Dim title As String = "Measurement Result"
 Dim msg As String = "No error."
 Dim err As Integer = 0
 Dim v1 As Double = 0.1 : Dim v2 As Double = 0.5                               '12
 Dim vs As Double = 0 : Dim icomp As Double = 0.1
 Dim ret As Integer
 unit1.WriteString("FMT 1" & vbLf)
 unit1.WriteString("AV -1" & vbLf)
 unit1.WriteString("WT 0, 0.01" & vbLf)
 unit1.WriteString("TM 3" & vbLf)
 unit1.WriteString("TGP -1, 1, 2, 1" & vbLf)
 unit1.WriteString("TGP -2, 2, 2, 3" & vbLf)
 unit1.WriteString("TGMO 1" & vbLf)                                            '21
```

Line	Description
1 to 11	Declares variables used in the Main of Table 3-16. And sets the proper values.
12 to 14	Declares variables used to perform measurement, and sets the value.
15 to 17	Unit1 sets the data output format, A/D converter, and sweep delay time.
18 to 19	Unit1 sets the Start Measurement trigger input for the Ext Trig In terminal.
20 to 21	Unit1 sets the Step Measurement Completion trigger output for the Ext Trig Out terminal.

```
unit1.WriteString("DV" & t(1) & ",0," & vs & "," & icomp & vbLf)              '22
unit1.WriteString("WV" & t(0) & ",1,0," & v1 & "," & v2 & "," & nop1 & "," & icomp
& vbLf)
unit1.WriteString("MM 2," & t(0) & vbLf)
unit1.WriteString("TSC 1" & vbLf)

unit2.WriteString("FMT 1" & vbLf)                                             '27
unit2.WriteString("AV -1" & vbLf)
unit2.WriteString("WT 0, 0.01" & vbLf)
unit2.WriteString("TM 3" & vbLf)                                              '30
unit2.WriteString("TGP -2, 2, 2, 1" & vbLf)
unit2.WriteString("TGXO 2" & vbLf)
unit2.WriteString("TGP -1, 1, 2, 2" & vbLf)
unit2.WriteString("TGSI 2" & vbLf)                                            '34
unit2.WriteString("DV" & t(3) & ",0," & vs & "," & icomp & vbLf)
unit2.WriteString("WV" & t(2) & ",1,0," & v1 & "," & v2 & "," & nop1 & "," & icomp
& vbLf)
unit2.WriteString("MM 2," & t(2) & vbLf)
unit2.WriteString("TSC 1" & vbLf)
unit1.WriteString("TSR" & vbLf) : unit2.WriteString("TSR" & vbLf)
unit2.WriteString("XE" & vbLf)

unit1.WriteString("*OPC?" & vbLf) : ret = unit1.ReadString(1 + 2)             '42
unit1.WriteString("ERR? 1" & vbLf) : err = unit1.ReadString(4 + 2) : ret = 1
If err <> 0 Then GoTo Check_err
unit2.WriteString("ERR? 1" & vbLf) : err = unit2.ReadString(4 + 2) : ret = 2
If err <> 0 Then GoTo Check_err
```

Line	Description
22 to 25	Unit1 applies voltage to device, and sets the sweep source, the measurement mode, and the time stamp data output.
27 to 29	Unit2 sets the data output format, A/D converter, and sweep delay time.
30 to 32	Unit2 sets the Measurement Completion trigger output for the Ext Trig Out terminal, and specifies the gate trigger. Unit1 will start measurement when this trigger is sent to its Ext Trig In terminal.
33 to 34	Unit2 sets the Start Step Output Setup trigger input for the Ext Trig In terminal. Unit2 will start step output setup when the Step Measurement Completion trigger is sent by Unit1.
35 to 38	Unit2 applies voltage to device, and sets the sweep source, the measurement mode, and the time stamp data output.
39	Resets the time stamp.
40	Unit2 starts measurement, and sends a gate trigger to the Ext Trig Out terminal. Then Unit1 starts measurement.
42 to 46	Waits for the operation complete. Goes to Check_err if an error is detected.

```
 Dim mret1 As String = unit1.ReadString(16 * 2 * nop1 + 1)                     '48
 Dim mret2 As String = unit2.ReadString(16 * 2 * nop1 + 1)
 Dim time As Double : Dim status As String : Dim meas As Double
 For i = 0 To nop1 - 1
   time = Val(Mid(mret1, 4 + i * 16 * 2, 12))
   status = Mid(mret1, 17 + i * 16 * 2, 3)
   meas = Val(Mid(mret1, 20 + i * 16 * 2, 12))
   data(0, i) = Chr(13) & Chr(10) & meas * 1000 & ", " & time * 1000 & ", " & status
 Next i
 For i = 0 To nop1 - 1
   time = Val(Mid(mret2, 4 + i * 16 * 2, 12))
   status = Mid(mret2, 17 + i * 16 * 2, 3)
   meas = Val(Mid(mret2, 20 + i * 16 * 2, 12))
   data(1, i) = Chr(13) & Chr(10) & meas * 1000 & ", " & time * 1000 & ", " & status
 Next i

 unit1.WriteString("DZ" & vbLf) : unit2.WriteString("DZ" & vbLf)               '64
 save_data(fname, title, value, data, nop1, nop2, unit1, unit2, t)
 Exit Sub

Check_err:                                                                     '68
 unit1.WriteString("DZ" & vbLf) : unit2.WriteString("DZ" & vbLf)
 If ret = 1 Then unit1.WriteString("EMG? " & err & vbLf) : msg =
unit1.ReadString(256)
 If ret = 2 Then unit2.WriteString("EMG? " & err & vbLf) : msg =
unit2.ReadString(256)
 MsgBox("Unit" & ret & " error: " & err & Chr(10) & msg, vbOKOnly, "")
 Exit Sub
End Sub
```

Line	Description
48 to 62	Reads measurement data and stores it into the *data* array.
64 to 65	Applies 0 V from all channels and transfers the data stored in the *data* variable to the save_data subprogram. And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
68 to 73	Applies 0 V from all channels and displays a message box to show an error message.

Measurement Result Example

```
I (mA), Time (msec), Status
Unit1
11.345, 18.8, NAI
22.685, 50, NAI
34.035, 81.2, NAI
45.385, 112.4, NAI
56.73, 143.5, NAI
Unit2
10.98, 13.6, NAI
21.98, 47.1, NAI
32.98, 78.2, NAI
43.965, 109.6, NAI
54.965, 140.7, NAI
```

This is a program written in the HP BASIC language, and performs the following.

1. Sets the Keysight E5260/E5270 for the bipolar transistor Ib-Ic measurement
2. Triggers a sweep measurement
3. Performs a step measurement and sends the Step Measurement Completion output gate trigger
4. Waits for the Start Step Output Setup input trigger
5. Displays a measurement data (Ic)
6. Repeats 3 to 5 the number of times specified by Ib_num
7. Disables the Keysight E5260/E5270 channel output

This is a part of the program used to synchronize the E5260/E5270 operation with the other instrument. However this program does not include the program code to control the instrument. So add the program code to control it before running the program. For the timing of the trigger, refer to the comments in the following program listing.

```
10      ASSIGN @E5270 TO 717
20      OPTION BASE 1
30      INTEGER Collector,Base,Ib_num,Vc_num
40     !
50      Collector=2
60      Base=1
70      Ib_start=.0001
80      Ib_stop=.001
90      Ib_num=10
100     Ib_step=(Ib_stop-Ib_start)/(Ib_num-1)
110     Vb_comp=1
120     Vc=2.5
130     Ic_comp=.1
140    !
150    !Other instrument should be initialized and set up.
160    !
```

Line No.	Description
10	Assigns the I/O path to control the E5260/E5270.
50 to 130	Sets the value of the variables for source setup and so on.
140 to 160	Add program lines to perform initialization and measurement setup of the other instrument.

```
170    OUTPUT @E5270;"FMT 5"        ! ASCII w/header<,>
180    OUTPUT @E5270;"AV -1"        ! Averaging=1PLC
190    OUTPUT @E5270;"WT 0,.01"     ! Hold Time, Delay Time
200    OUTPUT @E5270;"CN";Collector,Base
210    OUTPUT @E5270;"TGP -2,2,2,3" ! StepMeasEndTrg Output
220    OUTPUT @E5270;"TGMO 2"       ! Gate Trigger
230    OUTPUT @E5270;"TGP -1,1,2,2" ! StartStepSetupTrg Input
240    OUTPUT @E5270;"TGSI 2" ! Ignore TRG for 1st step setup
250    OUTPUT @E5270;"DV";Collector,0,Vc,Ic_comp
260    OUTPUT @E5270;"WI";Base,1,0,Ib_start,Ib_stop,Ib_num,Vb_comp
270    OUTPUT @E5270;"MM";2,Collector
280   !
290   !Other instrument must be set to the measurement ready and
300   !trigger wait condition.
310   !
```

Line No.	Description
170	Specifies the data output format.
180	Sets the number of averaging samples of the ADC.
190	Sets the hold time and delay time.
200	Enables the source/measurement channels.
210 to 220	Sets the Step Measurement Completion trigger output for the Ext Trig Out terminal, and specifies the gate trigger.
230 to 240	Sets the Start Step Output Setup trigger input for the Ext Trig In terminal, also disables the input trigger for the first sweep step.
250	Forces voltage.
260	Sets the staircase sweep source.
270	Sets the measurement mode and the measurement channel.
280 to 310	To synchronize the Keysight E5260/E5270 operation with the operation of the other instrument, add program lines to set it to the measurement ready and trigger wait condition.

```
320    OUTPUT @E5270;"XE"
330   !
340   !E5270 starts measurement. Then E5270 sends negative gate
350   !trigger to the other instrument.
360   !Then the instrument should start measurement.
370   !
380    FOR I=1 TO Ib_num
390      ENTER @E5270 USING "#,3X,12D,X";Ic
400      PRINT "Ic= ";Ic*1000;" [mA]"
410   !
420   !Measurement data of the other instrument should be read.
430   !And the data should be displayed.
440   !
450   !The instrument must be set to the measurement ready and
460   !trigger wait condition.
470   !
480   !The instrument must send trigger to E5270. E5270 will
490   !start a step source output by the trigger, and perform
500   !a step measurement.
510   !
520    NEXT I
530   !
540    OUTPUT @E5270;"CL"
550    END
```

Line No.	Description
320	Starts sweep measurement, and performs a step measurement. When the Keysight E5260/E5270 starts a step measurement, it sends a negative gate trigger. Then the other instrument should start measurement.
390 to 400	Reads the measurement data, and displays the measurement data.
410 to 510	To synchronize the Keysight E5260/E5270 operation with the operation of other instrument, add program lines to do following: • To read and display the data measured by the instrument • To set it to the measurement ready and trigger wait condition • To send a trigger from the instrument When the Keysight E5260/E5270 receives the trigger, it starts a step measurement and sends negative gate trigger.
520	Repeats 390 to 510 the number of times specified by Ib_num.
540	Disables the source/measurement channels.

Reading Time Stamp Data

Time stamp function outputs a time data with a measurement result data. For example of reading the time stamp data, see programs in the previous sections.

NOTE

This function is not available for binary data output format (FMT 3 and 4).

This function is not available for the quasi-pulsed spot measurement (MM 9) and the search measurement (MM 14 and 15).

To read the time data with the best resolution (100 µs), reset the time stamp every 100 sec or less for the FMT 1, 2, or 5 data output format, or every 1000 sec or less for the FMT 11, 12, 15, 21, 22, or 25 data output format.

Enter the MM command to define the measurement mode and enter the TSC command to set the time stamp function ON. You can get the time data with the measurement data. The time data is the time from when the time stamp is cleared until the measurement is started.

Function	Command	Parameters
Sets the time stamp function	TSC	*onoff*

The following commands returns the time data regardless of the TSC command setting. The time data is the time from when the time stamp is cleared until the following command is entered.

Function	Command	Parameters
Forces voltage	TDV	*chnum*,*range*,*output*[,*Icomp*]
Forces current	TDI	*chnum*,*range*,*output*[,*Vcomp*]
Performs high speed spot current measurement	TTI	*chnum*,*range*
Performs high speed spot voltage measurement	TTV	*chnum*,*range*
Just returns the time data	TSQ	

To clear the time stamp, enter the TSR command.

Reading Binary Output Data

This section provides the example to read binary data. The following program example:

1. executes high-speed spot measurements
2. reads the measurement data in binary data format
3. rearranges the data and calculates the measured data
4. prints the measured data on the screen

NOTE

Data resolution

The resolution of binary data is as shown below.

- Measurement data: Measurement range / 50000
- Output data: Output range / 20000

Note that the resolution of the measurement data is larger than the resolution of the high resolution A/D converter.

Measurement Result Example

```
Id (uA), Status
status = 0
type = 1
mode = 1
channel = 5
sign = 0
range = 0.0001
count = 12010

24.02, 0

Data save completed.

Do you want to perform measurement again?
```

Table 3-18 High-Speed Spot Measurement Example to read binary data

```
Sub perform_meas(ByVal session As IMessage, ByVal t() As Integer)                   '1
    Dim i As Integer = 0                         't(0): Drain
    Dim j As Integer = 0                         't(1): Gate
    Dim nop1 As Integer = 1                      't(2): Source
    Dim nop2 As Integer = 1                      't(3): Substrate
    Dim data(nop2 - 1, nop1 - 1) As String
    Dim value As String = "Id (mA), Status"
    Dim fname As String = "C:\Keysight\prog_ex\data16.txt"
    Dim title As String = "Measurement Result"
    Dim msg As String = "No error."
    Dim err As Integer = 0

    Dim vd As Double = 3                                                             '13
    Dim vg As Double = 1
    Dim idcomp As Double = 0.05
    Dim igcomp As Double = 0.01
    Dim orng As Integer = 0
    Dim mrng As Integer = 0

    session.WriteString("FMT 3" & vbLf)
    session.WriteString("AV 10,1" & vbLf)     'sets number of samples for 1 data
    session.WriteString("FL 0" & vbLf)        'sets filter off
    session.WriteString("DV " & t(3) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(2) & ",0,0,0.1" & vbLf)   'out= 0 V, comp= 0.1 A
    session.WriteString("DV " & t(1) & "," & orng & "," & vg & "," & igcomp & vbLf)
    session.WriteString("DV " & t(0) & "," & orng & "," & vd & "," & idcomp & vbLf)
    session.WriteString("ERR? 1" & vbLf) : err = session.ReadString(4 + 2)          '28
    If err <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    session.WriteString("TI " & t(0) & "," & mrng & vbLf)
    Dim dat() As Byte = session.Read(4 + 2) '4 byte data + terminator               '31

    Dim status As Integer = dat(3) And 224 : status = status / 32  '224=128+64+32
    If status <> 0 Then session.WriteString("DZ" & vbLf) : GoTo Check_err
    Dim type As Integer = dat(0) And 128 : type = type / 128  '0:source, 1:meas
    Dim mode As Integer = dat(0) And 64 : mode = mode / 64    '0:voltage, 1:current
    Dim sign As Integer = dat(0) And 1                         '0:positive, 1:negative
    Dim rng As Integer = dat(0) And 62 : rng = rng / 2         '62=32+16+8+4+2
    Dim count As Integer = dat(1) * 256 + dat(2)
    Dim chan As Integer = dat(3) And 31                        '31=16+8+4+2+1
    If sign = 1 Then count = count - 65536 '65536 = 10000000000000000 (17 bits)
```

Line	Description
2 to 11	Declares variables used through the project. And sets the proper values.
13 to 18	Declares variables and sets the value.
20 to 22	Sets the data output format and A/D converter. Also sets the SMU filter off.
23 to 26	Applies voltage to device.
28 to 29	Checks if an error occurred. If an error is detected, forces 0 V and goes to Check_err.
30 to 31	Performs the high-speed spot measurement. And stores the returned binary data (four bytes) into the *dat* array variable.
33 to 41	Picks up the elements, status, type, mode, sign, rng, count, and chan, included in the returned binary data.

```
 Dim range As Double                                                      '43
 If mode = 1 Then              ' current range
   range = 10 ^ (rng - 20)
   If rng = 20 Then
     session.WriteString("UNT? 1" & vbLf)
     Dim unt As String = session.ReadString(256)
     Dim mdl(8) As String : Dim c As String
     Dim a As Integer : Dim b As Integer = 0 : Dim d As Integer = 0
     For a = 1 To Len(unt)
       c = Mid(unt, a, 1)
       If c = "," Then mdl(d) = Mid(unt, b + 1, a - b - 1) : d = d + 1
       If c = ";" Then b = a
     Next
     If mdl(chan) = "E5291A" Then range = 0.2   'for E5260/E5270
   End If
 Else                          ' voltage range
   If rng = 8 Then range = 0.5
   If rng = 9 Then range = 5
   If rng = 11 Then range = 2
   If rng = 12 Then range = 20
   If rng = 13 Then range = 40
   If rng = 14 Then range = 100
   If rng = 15 Then range = 200
 End If                                                                   '66

   'value = value & Chr(13) & Chr(10) & "status = " & status              '68
   'value = value & Chr(13) & Chr(10) & "type = " & type
   'value = value & Chr(13) & Chr(10) & "mode = " & mode
   'value = value & Chr(13) & Chr(10) & "channel = " & chan
   'value = value & Chr(13) & Chr(10) & "sign = " & sign
   'value = value & Chr(13) & Chr(10) & "range = " & range
   'value = value & Chr(13) & Chr(10) & "count = " & count & Chr(13) & Chr(10)

   Dim meas As Double                                                     '76
   If type = 0 Then meas = count * range / 20000 'source data
   If type = 1 Then meas = count * range / 50000 'measurement data

   data(j, i) = Chr(13) & Chr(10) & meas * 1000 & ", " & status           '80

   session.WriteString("DZ" & vbLf)                                       '82
   save_data(fname, title, value, data, nop1, nop2, session, t)
   Exit Sub

Check_err:                                                                '86
   session.WriteString("EMG? " & err & vbLf) : msg = session.ReadString(256)
   MsgBox("Instrument error: " & err & Chr(10) & msg, vbOKOnly, "")
   Exit Sub

End Sub
```

Line	Description
43 to 66	Checks the measurement range or output range setting.
68 to 74	If you want to display and save the binary data elements, delete ’ at the top of the lines.
76 to 80	Calculates the measurement data or source output data. And, stores the data into the *data* array.
82 to 84	Applies 0 V from all channels. And transfers the data stored in the *data* variable to the save_data subprogram (see Table 3-1). And the subprogram will save the data into a CSV file specified by the *fname* variable and displays the data on a message box.
86 to 89	Displays a message box to show an error message if the error is detected.

Using Programs for 4142B

This section describes the program modification example to use a program created for the Keysight 4142B Modular DC Source/Monitor. To use the program:

1. change the GPIB address, if necessary.
2. enter the ACH command to translate the channel numbers, if necessary.
3. remove the unsupported command, or replace it with the command supported by the E5260/E5270.

For more information, refer to "To Use Programs for Keysight 4142B" on page 1-47.

The following program examples show a modified measurement program, which performs a high-speed spot measurement.

The original 4142B program:

```
10     ASSIGN @Hp4142 TO 717
20     INTEGER G_ch,D_ch,S_ch
30   !
40   !         !Source:    GNDU
50     G_ch=2  !Gate:      HPSMU (SLOT2)
60     D_ch=3  !Drain:     MPSMU (SLOT3)
70     S_ch=4  !Substrate: MPSMU (SLOT4)
80   !
90     OUTPUT @Hp4142;"FMT5"
100    OUTPUT @Hp4142;"CN";D_ch,G_ch,S_ch
110    OUTPUT @Hp4142;"DV";S_ch;",0,0,.1"
120    OUTPUT @Hp4142;"DV";G_ch;",0,3,.01"
130    OUTPUT @Hp4142;"DV";D_ch;",0,5,.1"
140    OUTPUT @Hp4142;"TI";D_ch;",0"
150    ENTER @Hp4142 USING "#,3X,12D,X";Mdata
160    PRINT "Id(A)=";Mdata
170    OUTPUT @Hp4142;"CL"
180    END
```

Line No.	Description
10	Assigns the I/O path to control the 4142B.

Line No.	Description
90	Specifies the data output format.
100 to 130	Enables the source/measurement channels, and forces voltage.
140 to 180	Executes the measurement, reads and displays the measurement data, and disables channels.

The program modified to control the E5260/E5270:

```
10     ASSIGN @Hp4142 TO 717                 !<<<<
20     INTEGER G_ch,D_ch,S_ch
21     INTEGER Sub                           !<<<<
30    !
40    !        !Source:    GNDU
50     G_ch=2  !Gate:      HPSMU (SLOT2)
60     D_ch=3  !Drain:     MPSMU (SLOT3)
70     S_ch=4  !Substrate: MPSMU (SLOT4)
80    !
81     Sub=5                                 !<<<<
82     OUTPUT @Hp4142;"ACH";Sub,S_ch         !<<<<
83     OUTPUT @Hp4142;"*OPC?"                !<<<<
84     ENTER @Hp4142;A                       !<<<<
85    !
90     OUTPUT @Hp4142;"FMT5"
100    OUTPUT @Hp4142;"CN";D_ch,G_ch,S_ch
110    OUTPUT @Hp4142;"DV";S_ch;",0,0,.1"
120    OUTPUT @Hp4142;"DV";G_ch;",0,3,.01"
130    OUTPUT @Hp4142;"DV";D_ch;",0,5,.1"
140    OUTPUT @Hp4142;"TI";D_ch;",0"
150    ENTER @Hp4142 USING "#,3X,12D,X";Mdata
160    PRINT "Id(A)=";Mdata
170    OUTPUT @Hp4142;"CL"
180    END
```

Line No.	Note
10	Change GPIB address, if necessary.
21, 81	Add program lines if the module configuration is different from the 4142B. This example adds the variable Sub, and uses the SMU in slot 5 instead of slot 4 for substrate.
82 to 84	Add program line to set the channel map. This example transfers the Sub value to the variable S_ch used in the original program.

Using Programs for 4155B/4156B/4155C/4156C

This section describes the program modification example to use a FLEX command program created for the Keysight 4155B/4156B/4155C/4156C Parameter Analyzer. To use the program:

1. change the GPIB address, if necessary.
2. enter the ACH command to translate the channel numbers, if necessary.
3. change the FMT command parameter value to use the data output format compatible with the 4155/4156 output data, or change the program lines to read the measurement data.
4. remove the US command.
5. remove the RMD? command.
6. remove the unsupported command, or replace the command with the corresponding command supported by the E5260/E5270.

For more information, refer to "To Use Programs for Keysight 4155/4156" on page 1-48.

The following program examples show a modified measurement program, which performs a high-speed spot measurement.

The original 4156C program:

```
10      ASSIGN @Hp415x TO 717
20      INTEGER G_ch,D_ch,S_ch,B_ch
30    !
40      S_ch    !Source:    SMU1
50      G_ch=2  !Gate:      SMU2
60      D_ch=3  !Drain:     SMU3
70      B_ch=4  !Substrate: SMU4
80    !
90      OUTPUT @Hp415x;"US"
100     OUTPUT @Hp415x;"FMT 5"
110     OUTPUT @Hp415x;"CN ";D_ch,G_ch,S_ch,B_ch
120     OUTPUT @Hp415x;"DV ";S_ch;",0,0,.1"
130     OUTPUT @Hp415x;"DV ";B_ch;",0,0,.1"
140     OUTPUT @Hp415x;"DV ";G_ch;",0,3,.01"
150     OUTPUT @Hp415x;"DV ";D_ch;",0,5,.1"
160     OUTPUT @Hp415x;"TI ";D_ch;",0"
170     OUTPUT @Hp415x;"RMD? 1"
180     ENTER @Hp415x USING "#,5X,13D,X";Mdata
190     PRINT "Id(A)=";Mdata
200     OUTPUT @Hp415x;"CL"
210     END
```

Line No.	Description
10	Assigns the I/O path to control the 4155/4156.
90	Enters the FLEX command mode.
100	Specifies the data output format.
110 to 150	Enables the source/measurement channels, and forces voltage.
160 to 210	Executes the measurement, reads and displays the measurement data, and disables channels.

The program modified to control the E5260/E5270:

```
10     ASSIGN @Hp415x TO 717                    !<<<<
20     INTEGER G_ch,D_ch,S_ch,B_ch
21     INTEGER Sub                              !<<<<
30   !
40   ! S_ch=1  !Source:    SMU1 <<<< replaced with GNDU
50     G_ch=2  !Gate:      SMU2
60     D_ch=3  !Drain:     SMU3
70     B_ch=4  !Substrate: SMU4
80   !
81     Sub=5                                    !<<<<
82     OUTPUT @Hp415x;"ACH ";Sub,B_ch           !<<<<
83   !
90   ! OUTPUT @Hp415x;"US"                       <<<<
100    OUTPUT @Hp415x;"FMT 25"                  !<<<<
110    OUTPUT @Hp415x;"CN ";D_ch,G_ch,B_ch      !<<<<
120  ! OUTPUT @Hp415x;"DV ";S_ch;",0,0,.1"       <<<<
130    OUTPUT @Hp415x;"DV ";B_ch;",0,0,.1"
140    OUTPUT @Hp415x;"DV ";G_ch;",0,3,.01"
150    OUTPUT @Hp415x;"DV ";D_ch;",0,5,.1"
160    OUTPUT @Hp415x;"TI ";D_ch;",0"
170  ! OUTPUT @Hp415x;"RMD? 1"                    <<<<
180    ENTER @Hp415x USING "#,5X,13D,X";Mdata
190    PRINT "Id(A)=";Mdata
200    OUTPUT @Hp415x;"CL"
210    END
```

Line No.	Note
10	Change GPIB address, if necessary.
21, 81	Add program lines if the module configuration is different from the 415x. This example adds the Sub variable, and uses the SMU in slot 5 instead of slot 4 for substrate.
82	Add program line to set the channel map. This example transfers the Sub value to the variable B_ch used in the original program.
90	Remove the US command. This command is not required.
100	Change the FMT command parameter value.
40, 110, 120	This example uses the GNDU instead of the SMU1. So remove the program lines that include the variable S_ch (SMU1).
170	Remove the RMD? command. This command is not required.

4 Command Reference

This chapter is the complete reference of the GPIB commands of the Keysight E5260/E5270:

- "Command Summary"
- "Command Parameters"
- "Command Reference"

NOTE

Module model number and description

In this chapter, plug-in modules and accessory for the Keysight E5260/E5270 will be expressed by the model number or the following abbreviation as shown below.

E5280B: HPSMU (high power SMU, for E5270B)

E5281B: MPSMU (medium power SMU, for E5270B)

E5287A: HRSMU (high resolution SMU, for E5270B)

E5288A: ASU (atto sense and switch unit, for E5270B)

E5290A: HPSMU (high power SMU, for E5260 series)

E5291A: MPSMU (medium power SMU, for E5260 series)

Command Summary

The following table summarizes the GPIB commands.

Category	Command	Summary
Reset	*RST	Resets the E5260/E5270 to the initial settings.
Diagnostics	DIAG?	Performs diagnostics, and returns the result.
Self-test	*TST?	Performs the self-test, and returns the result.
Self Calibration	CA	Performs self calibration.
	*CAL?	Performs self calibration, and returns the result.
	CM	Sets auto-calibration ON or OFF.
Abort	AB	Aborts the present operation and subsequent command execution.
Pause/ Continue	PA/PAX	Pauses command execution or internal memory program execution, until the specified wait time has elapsed or until an event specified by the TM command is received.
	TM	Sets the event to start measurement or to release the E5260/E5270 from the paused status set by the PA or PAX command.
Channel Control	ACH	Translates a channel number to another channel number.
	CN	Enables the specified channels by setting the output switches to ON.
	CL	Disables the specified channels by setting the output switches to OFF.
	IN	Sets the specified channels to 0 V.
	DZ	Stores the setup of the channels, and sets the output to 0 V.
	RZ	Returns the channel to the settings that are stored by the DZ command and clears the stored channel settings.
	SAL	Only for E5270B. Disables the connection status indicator of the ASU.
	SAP	Only for E5270B. Controls the input-output path of the ASU.
	SAR	Only for E5270B. Sets the auto ranging operation.
	RCV	Enables the channels that fail self-test.

Category	Command	Summary
Series Resistor	SSR	Sets the SMU series resistor of the specified channel to ON or OFF.
Filter	FL	Sets the filter of the specified channels to ON or OFF.
Integration Time and Averaging	AV	For the E5260 series and the high-speed ADC of the E5270B. Sets the number of samples for averaging of the ADC (A/D converter).
	WAT	Sets the source wait time and the measurement wait time.
	AAD	Only for E5270B. Selects the type of ADC, high-speed or high-resolution ADC.
	AIT	Only for E5270B. Selects the number of samples for averaging or the integration time of the ADC.
	AZ	Only for E5270B. Enables or disables the ADC zero function.
Output Data	FMT	Specifies the measurement data output format and the data terminator.
	BC	Clears the E5260/E5270 output data buffer that stores measurement data and/or query command response data.
Source Setup	DI	Forces current from the specified channel.
	DV	Forces voltage from the specified channel.
High speed spot measurement	TI	Executes the current measurement, and returns the measured data.
	TV	Executes the voltage measurement, and returns the measured data.
Time Stamp	TDI TDV	Forces current (TDI) or voltage (TDV), and returns the time data from when the timer is cleared until source output is started.
	TSC	Enables the time stamp function for the MM 1, 2, 3, 4, 5, or 16 mode.
	TSQ	Returns the time data from when TSR is given until TSQ is given.
	TSR	Clears the timer count.
	TTI TTV	Measures current (TTI) or voltage (TTV), and returns the measurement data and the time data for the time from when the timer is cleared until the measurement is started.
Measurement Mode	MM	Sets the measurement mode and measurement channels.

Category	Command	Summary
Measurement Execution	XE	Performs measurements, and returns the measurement data; or recovers from the paused state if the PA/PAX command has been sent. Not available for the high speed spot measurement.
Staircase Sweep Source Setup	WT	Sets the hold time, delay time, step delay time, and trigger delay time.
	WI	Sets the staircase current sweep source.
	WV	Sets the staircase voltage sweep source.
	WM	Sets the automatic sweep abort function.
Synchronous Sweep Source Setup	WSI	Sets the synchronous current sweep source used with the WI or PWI command.
	WSV	Sets the synchronous voltage sweep source used with the WV or PWV command.
Multi channel Sweep Source Setup	WNX	Sets the synchronous current sweep source or synchronous voltage sweep source used with the WI or WV command.
Pulsed Source Setup	PT	Sets the hold time, pulse width, pulse period, and trigger delay time.
	PI	Sets the pulsed current source.
	PV	Sets the pulsed voltage source.
Pulsed Sweep Source Setup	PT	Sets the hold time, pulse width, pulse period, and trigger delay time.
	PWI	Sets the pulsed current sweep source.
	PWV	Sets the pulsed voltage sweep source.
	WM	Sets the automatic sweep abort function.
Quasi-pulsed Voltage Source Setup	BDM	Specifies the detection interval, and either voltage or current measurement.
	BDT	Specifies the hold time and delay time.
	BDV	Sets the quasi-pulsed voltage source.

Category	Command	Summary
Binary Search Measurement Setup	BSM	Sets the source output control mode and the automatic abort function.
	BST	Specifies the hold time and delay time.
	BSVM	Selects the data output mode.
	BSI	Sets the current source channel.
	BSSI	Sets the synchronous current source channel.
	BGV	Sets the voltage monitor channel.
	BSV	Sets the voltage source channel.
	BSSV	Sets the synchronous voltage source channel.
	BGI	Sets the current monitor channel.
Linear Search Measurement Setup	LSTM	Specifies the hold time and delay time.
	LSVM	Selects the data output mode.
	LSI	Sets the current source channel.
	LSSI	Sets the synchronous current source channel.
	LGV	Sets the voltage monitor channel.
	LSV	Sets the voltage source channel.
	LSSV	Sets the synchronous voltage source channel.
	LGI	Sets the current monitor channel.
	LSM	Sets the automatic abort function.
Measurement Setup	CMM	Sets the SMU measurement operation mode.
	RI	Specifies the current measurement ranging mode for measurement other than the high speed spot measurement that uses TI/TTI command.
	RV	Specifies the voltage measurement ranging mode for measurement other than the high speed spot measurement that uses TV/TTV command.
	RM	Sets the range selection rule for the auto ranging current measurement.
Internal Variable	VAR	Sets the value to the internal variable.
	VAR?	Returns the value set to the internal variable.

Category	Command	Summary
Program Memory	ST	Used with END command to store a program in the internal program memory. The ST command indicates the beginning of the program.
	END	Used with the ST command to store a program in the internal program memory. The END command indicates the end of the program.
	SCR	Scratches the specified program from the internal program memory.
	LST?	Returns a catalog of internal memory programs or a specific program listing (3000 commands maximum).
	DO	Executes internal memory programs in the order specified.
	RU	Executes internal memory programs sequentially.
Query	ERR?	Returns error codes.
	EMG?	Returns error message for the specified error code.
	*IDN?	Returns the instrument model number and the ROM version number.
	LOP?	Returns the operation status of all modules.
	*LRN?	Returns channel settings or the E5260/E5270 command parameter settings.
	NUB?	Returns the number of measurement data items in the output data buffer.
	*OPC?	Starts to monitor pending operations, or asks the OPC bit setting.
	UNT?	Returns the model and revision numbers of all modules.
	WNU?	Returns the number of sweep steps specified by the sweep command.
	WZ?	Returns 0 if all channel output is ± 2 V or less, or 1 if any channel applies more than ± 2 V.
Status Byte	*SRE	Enables the specified bits of the status byte register.
	*SRE?	Returns which bits of the status byte register are enabled.
	*STB?	Returns the status byte setting.

Category	Command	Summary
External Trigger	TGP	Enables the trigger function for a terminal.
	TGPC	Clears the trigger setting of the specified ports.
	TGSI	Selects the sweep step first or last that ignores the Start Step Output Setup trigger input set by the `TGP` *port*`,1,`*polarity*`,2` command.
	TGSO	Selects the trigger type, edge or gate, for the Step Output Setup Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,2` command.
	TGXO	Selects the trigger type, edge or gate, for the Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,1` command.
	TGMO	Selects the trigger type, edge or gate, for the Step Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,3` command.
	OS/OSX	Causes the E5260/E5270 to send a trigger signal from a trigger output terminal.
	WS/WSX	Enters a wait state until the E5260/E5270 receives an external trigger via a trigger input terminal.
	TM3	Enables use of an external trigger to release the PA/PAX state, or to start measurement if the E5260/E5270 has not been set to the PA/PAX/WS/WSX state. Or enables trigger set by the TGP *port*,*terminal*,*polarity*,1.
Digital I/O port	ERM	Changes the digital I/O port assignments.
	ERS?	Returns the digital I/O port status.
	ERC	Changes the output status of the digital I/O port.
Display and keyboard	RED	Enables or disables the measurement data display and the setup data display in the remote mode.
	DFM	Selects the data display format, scientific or engineering.
	SPA	Selects the parameter displayed in the Source Data display area.
	MPA	Selects the parameter displayed in the Measurement Data display area.
	SCH	Selects the source channel for the data is displayed on the LCD.
	MCH	Selects the measurement channel for the data is displayed on the LCD.
	KLC	Locks or unlocks the front panel keys.

Command Parameters

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

- "Channel Number"
- "Voltage Measurement Ranging Type"
- "Current Measurement Ranging Type"
- "Voltage Output Ranging Type"
- "Current Output Ranging Type"
- "Voltage Source Setup Parameters for DV/TDV/BDV/WV/WSV/WNX/PV/PWV/LSV/BSV Commands"
- "Current Source Setup Parameters for DI/TDI/WI/WSI/WNX/PI/PWI/LSI/BSI Commands"

In the following tables, the command parameters are put in italics such as *chnum*.

Table 4-1 Channel Number

Mainframe	*chnum*	Description
E5270B	2, 3, 4, 6, 7, 8	HPSMU[a] in the slot specified by *chnum*.
	1 to 8	MPSMU in the slot specified by *chnum*.
	1 to 8	HRSMU in the slot specified by *chnum*.
E5260A	2, 3, 4, 6, 7, 8	HPSMU[a] in the slot specified by *chnum*.
	1 to 8	MPSMU in the slot specified by *chnum*.
E5262A	1	MPSMU in slot 1.
	2	MPSMU in slot 2.
E5263A	1	MPSMU in slot 1.
	2	HPSMU.

a. HPSMU uses two slots. Then *chnum* must be the greater slot number. For example, if it is installed in slot 3 and 4, *chnum* must be 4.

Table 4-2 Voltage Measurement Ranging Type

range [a]	Ranging type	
	for measurement mode without pulse	**for measurement mode that uses pulse**
0	Auto ranging	Measurement channel uses the minimum range that covers the compliance value.
5, for E5281B/E5287A	0.5 V limited auto ranging	
50, for E5281B/E5287A	5 V limited auto ranging	
20 or 11	2 V limited auto ranging	
200 or 12	20 V limited auto ranging	
400 or 13	40 V limited auto ranging	
1000 or 14	100 V limited auto ranging	
2000 or 15, for E5280B/E5290A	200 V limited auto ranging	
-5, for E5281B/E5287A	0.5 V range fixed	
-50, for E5281B/E5287A	5 V range fixed	
-20 or -11	2 V range fixed	
-200 or -12	20 V range fixed	
-400 or -13	40 V range fixed	
-1000 or -14	100 V range fixed	
-2000 or -15, for E5280B/E5290A	200 V range fixed	

a. If the measurement channel forces voltage, the channel uses the voltage output range regardless of the *range* value.

Table 4-3 Current Measurement Ranging Type

range [a]	Ranging type	
	for measurement mode without pulse	**for measurement mode that uses pulse**
0	Auto ranging	Measurement channel uses the minimum range that covers the compliance value.
8, for E5287A+E5288A ASU	1 pA limited auto ranging	
9, for E5287A	10 pA limited auto ranging	
10, for E5287A	100 pA limited auto ranging	
11, for E5280B/E5281B/E5287A	1 nA limited auto ranging	
12, for E5280B/E5281B/E5287A	10 nA limited auto ranging	
13	100 nA limited auto ranging	
14	1 µA limited auto ranging	
15	10 µA limited auto ranging	
16	100 µA limited auto ranging	
17	1 mA limited auto ranging	
18	10 mA limited auto ranging	
19	100 mA limited auto ranging	
20, for E5291A	200 mA limited auto ranging	
20, for E5280B/E5290A	1 A limited auto ranging	
-8, for E5287A+E5288A ASU	1 pA range fixed	
-9, for E5287A	10 pA range fixed	
-10, for E5287A	100 pA range fixed	
-11, for E5280B/E5281B/E5287A	1 nA range fixed	
-12, for E5280B/E5281B/E5287A	10 nA range fixed	
-13	100 nA range fixed	
-14	1 µA range fixed	
-15	10 µA range fixed	
-16	100 µA range fixed	
-17	1 mA range fixed	
-18	10 mA range fixed	
-19	100 mA range fixed	
-20, for E5291A	200 mA range fixed	
-20, for E5280B/E5290A	1 A range fixed	

a. If the measurement channel forces current, the channel uses the current output range regardless of the *range* value.

NOTE

Measurement Ranging (Auto and Limited auto)

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

NOTE

Before using 1 pA range (only for E5270B)

The measurement channel connected to the ASU (Atto Sense and Switch Unit) supports the 1 pA range. To use the 1 pA range, set the 1 pA fixed range or the 1 pA limited auto ranging.

To enable the 1 pA range for the auto ranging mode, execute the SAR command.

The E5270B automatically performs the compensation of the data measured by the 1 pA range and returns the compensated data. You can use either the pre-stored offset data or the pre-measured offset data.

To measure the offset data, execute the CA command before starting the measurement for a DUT. This offset data is temporarily memorized until the E5270B is turned off.

NOTE

Output Ranging

The instrument automatically selects the minimum range that covers the output value, and applies voltage or current by using the range. For the limited auto ranging, the instrument does not use the range lower than the specified range value. For example, if you select the 100 nA limited auto ranging, the instrument never uses the 10 nA range and below.

Table 4-4 **Voltage Output Ranging Type**

range or *vrange*	Ranging type
0	Auto ranging
5	0.5 V limited auto ranging, for E5281B/E5287A
50	5 V limited auto ranging, for E5281B/E5287A
20 or 11	2 V limited auto ranging
200 or 12	20 V limited auto ranging
400 or 13	40 V limited auto ranging
1000 or 14	100 V limited auto ranging
2000 or 15	200 V limited auto ranging, for E5280B/E5290A

Table 4-5 **Current Output Ranging Type**

range or *irange*	Ranging type
0	Auto ranging
8	1 pA limited auto ranging, for E5287A+E5288A, not available for pulsed output
9	10 pA limited auto ranging, for E5287A, not available for pulsed output
10	100 pA limited auto ranging, for E5287A, not available for pulsed output
11	1 nA limited auto ranging, for E5280B/E5281B/E5287A, not available for pulsed output
12	10 nA limited auto ranging, for E5280B/E5281B/E5287A
13	100 nA limited auto ranging
14	1 μA limited auto ranging
15	10 μA limited auto ranging
16	100 μA limited auto ranging
17	1 mA limited auto ranging
18	10 mA limited auto ranging
19	100 mA limited auto ranging
20	200 mA limited auto ranging, for E5291A
	1 A limited auto ranging, for E5280B/E5290A

Table 4-6 Voltage Source Setup Parameters for DV/TDV/BDV/WV/WSV/WNX/PV/PWV/LSV/BSV Commands

Output range (actually used)	Setting resolution in V	*voltage*, *start*, *stop*, *base*, or *pulse* in V	Maximum *Icomp* value in A				
			E5280B	E5281B	E5287A	E5290A	E5291A
0.5 V	25E-6	0 to ± 0.5	NA	±100E-3	±100E-3	NA	NA
2 V	100E-6	0 to ± 2	±1	±100E-3	±100E-3	±1	±200E-3
5 V	250E-6	0 to ± 5	NA	±100E-3	±100E-3	NA	NA
20 V	1E-3	0 to ± 20	±1	±100E-3	±100E-3	±1	±200E-3
40 V	2E-3	0 to ± 20	±500E-3	±100E-3	±100E-3	±500E-3	±200E-3
		to ± 40		±50E-3	±50E-3		±50E-3
100 V	5E-3	0 to ± 20	±125E-3	±100E-3	±100E-3	±125E-3	±200E-3
		to ± 40		±50E-3	±50E-3		±50E-3
		to ± 100		±20E-3	±20E-3		±20E-3
200 V	10E-3	0 to ± 200	±50E-3	NA	NA	±50E-3	NA

Table 4-7 Current Source Setup Parameters for DI/TDI/WI/WSI/WNX/PI/PWI/LSI/BSI Commands

Output range (actually used)	Setting resolution in A	*current*, *start*, *stop*, *base*, or *pulse* in A	Maximum *Vcomp* value in V				
			E5280B	E5281B	E5287A	E5290A	E5291A
1 pA	1E-15	0 to ± 1.15 E-12	NA	NA	±100	NA	NA
10 pA	5E-15	0 to ± 11.5 E-12			±100		
100 pA	5E-15	0 to ± 115 E-12			±100		
1 nA	50E-15	0 to ± 1.15 E-9	±200	±100	±100		
10 nA	500E-15	0 to ± 11.5 E-9	±200	±100	±100		
100 nA	5E-12	0 to ± 115 E-9	±200	±100	±100	±200	±100
1 µA	50E-12	0 to ± 1.15E-6	±200	±100	±100	±200	±100
10 µA	500E-12	0 to ± 11.5E-6	±200	±100	±100	±200	±100
100 µA	5E-9	0 to ± 115E-6	±200	±100	±100	±200	±100
1 mA	50E-9	0 to ± 1.15E-3	±200	±100	±100	±200	±100
10 mA	500E-9	0 to ± 11.5E-3	±200	±100	±100	±200	±100
100 mA	5E-6	0 to ± 20E-3	±200	±100	±100	±200	±100
		to ± 50E-3	±200	±40	±40	±200	±40
		to ± 100E-3	±100	±20	±20	±100	±20
		to ± 115E-3	±100	NA	NA	±100	±20
200 mA	10E-6	0 to ± 20E-3	NA			NA	±100
		to ± 50E-3					±40
		to ± 200E-3					±20
1 A	50E-6	0 to ± 50E-3	±200			±200	NA
		to ± 125E-3	±100			±100	
		to ± 500E-3	±40			±40	
		to ± 1	±20			±20	

Command Reference

This section contains detailed descriptions of all GPIB commands. The commands are listed in alphabetical order. Each entry:

1. Defines one GPIB command
2. Describes the execution conditions, if any exist
3. Describes the syntax
4. Lists the parameters
5. Shows the query response after command execution, if there is a query command
6. Explains any additional information
7. Provides examples

The following conventions are used in this section.

parameter	Required command parameters, for which you must substitute a value or variable.
[*parameter*]	Optional command parameters, for which you may substitute a value or omit it.

Command Reference

AAD

This command is available for the Keysight E5270B, and is used to specify the A/D converter (ADC) type, high-speed or high-resolution, for each measurement channel.

This command setting is ignored by the pulsed spot, pulsed sweep, and staircase sweep with pulsed bias measurements.

Execution Conditions

Enter the AIT command to set up the ADC.

This command is not available for the Keysight E5260 series.

Syntax

`AAD` *`chnum`*`[,`*`type`*`]`

Parameters

chnum **:** Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

type **:** Type of the A/D converter. Integer expression. 0 or 1.

- 0: High-speed ADC (default setting). For high speed measurement.
- 1: High-resolution ADC. For high accurate measurement.

Example Statements

```
OUTPUT @E5270;"AAD 1,0"
OUTPUT @E5270;"AAD 1,1"
```

Command Reference

AB

The AB command aborts the present operation and subsequent command execution.

This command stops the operation now in progress, such as the measurement execution, source setup changing, and so on. But this command does not change the present condition. For example, if the E5260/E5270 just keeps to force the DC bias, the AB command does not stop the DC bias output.

Syntax

```
AB
```

Conditions after Execution

The AB command sets the E5260/E5270 as listed in the following table.

Operation before AB	Setting after AB
Staircase sweep measurement	Sets specified start value.
Pulsed spot measurement	Sets specified base value.
Pulsed sweep measurement	Sets specified base value.
Staircase sweep with pulsed bias measurement	Sets specified start value and base value.
Quasi-pulsed spot measurement	Sets specified start value.
Linear search measurement	Sets specified start value.
Binary search measurement	Sets specified start value.
Multi channel sweep measurement	Sets specified start value.
Self-test	Same as set by CL command.
Self-calibration	Same as set by CL command.
Wait state (PA/PAX/WS/WSX command)	Settings do not change.
Program execution (RU or DO command)	Settings do not change.

Example Statements

```
OUTPUT @E5270;"AB"
```

Command Reference

Remarks

If you start an operation that you may want to abort, do not send any command after the command or command string that starts the operation. If you do, the AB command cannot enter the command input buffer until the intervening command execution starts, so the operation cannot be aborted. In this case, use the device clear (HP BASIC CLEAR command) to end the operation.

If the AB command is entered in a command string, the other commands in the string are not executed. For example, the CN command in the following command string is not executed.

OUTPUT @E5270;"AB;CN"

During sweep measurement, if the E5260/E5270 receives the AB command, it returns only the measurement data obtained before abort. Then the dummy data is not returned.

For the quasi-pulsed spot measurement, the E5260/E5270 cannot receive any command during the settling detection. So the AB command cannot abort the operation, and it will be performed after the settling detection.

Command Reference

ACH

The ACH command translates the specified *program* channel number to the specified *actual* channel number at the program execution. This command is useful when you use a control program created for an instrument, such as the 4142B, 4155B/4155C/4156B/4156C, and E5260/E5270, that has a module configuration different from the E5260/E5270 actually you use. After the ACH command, enter the *OPC? command to confirm that the command execution is completed.

Syntax

`ACH [actual[,program]]`

Parameter

actual : Channel number actually used for measurement instead of *program*. The value must be slot number where the module has been installed in the E5260/E5270. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

program : Channel number used in a program and will be replaced with *actual*. Integer expression.

If you do not set *program*, this command is the same as ACH *n*,*n*.

If you do not set *actual* and *program*, the all channel number mapping is cleared.

For parameter settings, you cannot use the variables set by the VAR command.

Remarks

The ACH commands must be put at the beginning of the program or before the command line that includes a *program* channel number. In the program lines that follow the ACH command, you must leave the *program* channel numbers. The measurement data is returned as the data of the channel *program*, not *actual*.

Example Statements

If you want to use channels 1 to 3 instead of channels 5 to 7 respectively, enter the following statements. The measurement data is returned as the data of channel 5, not channel 1.

```
OUTPUT @E5270;"ACH 1,5"     !uses ch1 instead of ch5
OUTPUT @E5270;"ACH 2,6"     !     ch2            ch6
OUTPUT @E5270;"ACH 3,7"     !     ch3            ch7
OUTPUT @E5270;"*OPC?"
ENTER @E5270;A
!
OUTPUT @E5270;"CN 5,6,7"             !leave prog ch No.
!                                            |
OUTPUT @E5270;"DV 5,0,3"             !       |
OUTPUT @E5270;"DV 6,0,0"             !       |
OUTPUT @E5270;"DV 7,0,0"             !       |
!                                            |
OUTPUT @E5270;"TI 5,0"               !       |
ENTER @E5270 USING "#,3X,12D,X";Data!        |
PRINT "I=";Data                      !       |
!                                            |
OUTPUT @E5270;"CL 5,6,7"             !       V
```

Command Reference

AIT

This command is available for the Keysight E5270B, and is used to set the integration time or the number of averaging samples of the A/D converter (ADC) for each ADC type.

This command setting is ignored by the pulsed spot, pulsed sweep, and staircase sweep with pulsed bias measurements.

Execution Conditions

Enter the AAD command to specify the ADC type for each measurement channel.

This command is not available for the Keysight E5260 series.

Syntax

`AIT type,mode[,N]`

Parameters

***type* :** A/D converter type. Integer expression.

0: High-speed A/D converter.

1: High-resolution A/D converter.

***mode* :** ADC operation mode. Integer expression. Initial value is 0.

0: Auto mode.

1: Manual mode.

2: Power line cycle (PLC) mode.

***N* :** Coefficient used to define the integration time or the number of averaging samples. Integer expression. See Table 4-8.

Example Statements

```
OUTPUT @E5270;"AIT 0,2,1"
OUTPUT @E5270;"AIT 1,1,10"
```

Command Reference

Table 4-8 **Available Parameter Values**

type	*mode*	*N*
0	0	Value that defines the number of averaging samples given by the following formula. 1 to 1023. Default value is 1. *Number of averaging samples* = $N \times$ *initial averaging* where *initial averaging* is the number of averaging samples automatically set by Keysight E5270B and you cannot change.
	1	Number of averaging samples. 1 to 1023. Default value is 1.
	2	Value that defines the number of averaging samples given by the following formula. 1 to 100. Default value is 1. *Number of averaging samples* = $N \times 128$ The Keysight E5270B gets 128 samples in a power line cycle, repeats this for the times you specify, and performs averaging to get the measurement data.
1	0	Value that defines the integration time given by the following formula. 1 to 127. Default value is 6. *Integration time* = $N \times$ *initial integration time* where *initial integration time* is the integration time automatically set by Keysight E5270B and you cannot change.
	1	Value that defines the integration time given by the following formula. 1 to 127. Default value is 3. *Integration time* = $N \times 80$ μsec
	2	Value that defines the integration time given by the following formula. 1 to 100. Default value is 1. *Integration time* = N / *power line frequency*

Command Reference

AV

This command sets the number of averaging samples of the ADC (A/D converter).

This command is effective for the ADC of the E5260 series and the high-speed ADC of the E5270B, and not effective for the high-resolution ADC of the E5270A.

This command setting is ignored by the pulsed spot, pulsed sweep, and staircase sweep with pulsed bias measurements.

Syntax

`AV` *`number`*`[,`*`mode`*`]`

Parameters

***number* :** 1 to 1023, or –1 to –100. Initial value is 1.

For *positive* number input, this value specifies the number of samples depended on the *mode* value. See below.

For *negative* number input, this parameter specifies the number of power line cycles (PLC) for one point measurement. The Keysight E5260/E5270 gets 128 samples in 1 PLC. Ignore the *mode* parameter.

***mode* :** Averaging mode. Integer expression. This parameter is meaningless for negative *number*.

0: Auto mode (default setting).

Number of samples = *number* × *initial number*

1: Manual mode.

Number of samples = *number*

where *initial number* means the number of samples the Keysight E5260/E5270 automatically sets and you cannot change. For voltage measurement, *initial number*=1. For current measurement, see Table 4-9.

If you select the manual mode, *number* must be *initial number* or more to satisfy the specifications.

Example Statements

```
OUTPUT @E5270;"AV 10"

OUTPUT @E5270;"AV -50"

OUTPUT @E5270;"AV 100,1"
```

Command Reference

Table 4-9 **Initial Number for Current Measurement**

Current Measurement Range	Voltage Output Range [a]		
	to 40 V	100 V	200 V
to 10 μA	4	10	25
100 μA to 1 A	1	1	1

a. For measurement channels that force current, this is the minimum range that covers the voltage compliance value.

Command Reference

AZ

This command is available for the Keysight E5270B, and is used to enable or disable the ADC zero function that is the function to cancel offset of the high-resolution A/D converter. This function is especially effective for low voltage measurements. Power on, *RST command, and device clear disable the function.

This command is effective for the high-resolution A/D converter, not effective for the high-speed A/D converter.

Execution Conditions

This command is not available for the Keysight E5260 series.

Syntax

`AZ` *`mode`*

Parameters

mode **:** Mode ON or OFF.

0: OFF. Disables the function. Initial setting.

1: ON. Enables the function.

Remarks

Set the function to OFF in cases that the measurement speed is more important than the measurement accuracy. This roughly halves the integration time.

Example Statements

```
OUTPUT @E5270;"AZ 0"
```

BC

The BC command clears the output data buffer that stores measurement data and query command response data. This command does not change the measurement settings.

NOTE

Multi command statement is not allowed for this command.

Syntax

```
BC
```

Example Statements

```
OUTPUT @E5270;"BC"
```

Command Reference

BDM

The BDM command specifies the settling detection interval and the measurement mode; voltage or current, for the quasi-pulsed measurements.

Syntax

`BDM interval[,mode]`

Parameters

***interval* :** Settling detection interval. Numeric expression.

0: Short. Initial setting.
1: Long. For measurements of the devices that have the stray capacitance, or the measurements with the compliance less than 1 μA

***mode* :** Measurement mode. Numeric expression.

0: Voltage measurement mode. Default setting.
1: Current measurement mode.

Remarks

The following conditions must be true to perform the measurement successfully:

When *interval*=0: A > 1 V/ms and B ≤ 3 s

When *interval*=1: A > 0.1 V/ms and B ≤ 12 s

where A means the slew rate when source output sweep was started, and B means the settling detection time. See "Quasi-Pulsed Spot Measurements" on page 2-15. These values depend on the conditions of cabling and device characteristics. And you cannot specify the values directly.

Example Statements

```
OUTPUT @E5270;"BDM 0,1"
```

BDT

The BDT command specifies the hold time and delay time for the quasi-pulsed measurements.

Syntax

`BDT hold,delay`

Parameters

***hold* :** Hold time (in sec). Numeric expression.
0 to 655.35 s, 0.01 s resolution. Initial setting is 0.

***delay* :** Delay time (in sec). Numeric expression.
0 to 6.5535 s, 0.0001 s resolution. Initial setting is 0.

Example Statements

```
OUTPUT @E5270;"BDT 0.1,1E-3"
```

Command Reference

BDV

The BDV command specifies the quasi-pulsed voltage source and its parameters.

Syntax

```
BDV chnum,range,start,stop[,Icomp]
```

Parameters

***chnum* :** Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Ranging type for quasi-pulsed source. Integer expression. The output range will be set to the minimum range that covers both *start* and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

***start*, *stop* :** Start or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14.

0 to ±100, or 0 to ±200 for E5280B/E5290A

|*start* - *stop*| must be 10 V or more.

***Icomp* :** Current compliance (in A). Numeric expression. See Table 4-6 on page 4-14.

If you do not set *Icomp*, the previous value is used.

The compliance polarity is automatically set to the same polarity as the *stop* value, regardless of the specified *Icomp* value. If *stop*=0, the polarity is positive.

Remarks

The time forcing the *stop* value will be approximately 1.5 ms to 1.8 ms with the following settings:

- BDM, BDT command parameters: *interval*=0, *mode*=0, *delay*=0
- AV or AAD/AIT command parameters: initial setting

Example Statements

```
OUTPUT @E5270;"BDV 1,0,0,100,0.01"
```

Command Reference

BGI

The BGI command specifies the current monitor channel and its search parameters for the binary search measurement. This command ignores the RI command setting. This command setting is cleared by the BGV command.

Syntax

BGI *chnum*,*mode*,*condition*,*range*,*target*

Parameters

chnum **:** Search monitor channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode*, *condition **:** Search mode (0: limit mode or 1: repeat mode) and search stop condition. The meaning of *condition* depends on the *mode* setting:

mode	*condition*
0	Limit value for the search target (*target*). The search stops when the monitor data reaches *target* ± *condition*. Numeric expression. Positive value. in A. Setting resolution: *range*/20000. where *range* means the measurement range actually used for the measurement.
1	Repeat count. The search stops when the repeat count of the operation that changes the source output value is over the specified value. Numeric expression. 1 to 16.

range **:** Measurement ranging type. Integer expression. The measurement range will be set to the minimum range that covers the *target* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-3 on page 4-11.

target **:** Search target current (in A). Numeric expression.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"BGI 1,0,1E-8,14,1E-6"
```

See Also

“BSM”

Command Reference

Remarks

In the limit search mode, if search cannot find the search target and the following two conditions are satisfied, the E5260/E5270 repeats the binary search between the last source value and the source *start* value.

- *target* is between the data at source *start* value and the last measurement data.
- *target* is between the data at source *stop* value and the data at:
  source value = | *stop* – *start* | / 2.

If the search cannot find the search target and the following two conditions are satisfied, the E5260/E5270 repeats the binary search between the last source value and the source *stop* value.

- *target* is between the data at source *stop* value and the last measurement data.
- *target* is between the data at source *start* value and the data at:
  source value = | *stop* – *start* | / 2.

Command Reference

BGV

The BGV command specifies the voltage monitor channel and its search parameters for the binary search measurement. This command ignores the RV command setting. This command setting is cleared by the BGI command.

Syntax

`BGV` *`chnum,mode,condition,range,target`*

Parameters

***chnum* :** Search monitor channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***mode*, *condition* :** Search mode (0: limit mode or 1: repeat mode) and search stop condition. The meaning of *condition* depends on the *mode* setting:

mode	***condition***
0	Limit value for the search target (*target*). The search stops when the monitor data reaches *target* ± *condition*. Numeric expression. Positive value. in V. Setting resolution: *range*/20000. where *range* means the measurement range actually used for the measurement.
1	Repeat count. The search stops when the repeat count of the operation that changes the source output value is over the specified value. Numeric expression. 1 to 16.

***range* :** Measurement ranging type. Integer expression. The measurement range will be set to the minimum range that covers the *target* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-2 on page 4-10.

***target* :** Search target voltage (in V). Numeric expression.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"BGV 1,0,0.1,12,5"
```

See Also

"BSM"

Command Reference

Remarks

In the limit search mode, if search cannot find the search target and the following two conditions are satisfied, the E5260/E5270 repeats the binary search between the last source value and the source *start* value.

- *target* is between the data at source *start* value and the last measurement data.
- *target* is between the data at source *stop* value and the data at:
  source value = | *stop* – *start* | / 2.

If the search cannot find the search target and the following two conditions are satisfied, the E5260/E5270 repeats the binary search between the last source value and the source *stop* value.

- *target* is between the data at source *stop* value and the last measurement data.
- *target* is between the data at source *start* value and the data at:
  source value = | *stop* – *start* | / 2.

Command Reference

BSI

The BSI command specifies and sets the current search source for the binary search measurement. This command setting is cleared by the BSV command. After search stops, the search channel forces the value specified by the BSM command.

Syntax `BSI chnum,range,start,stop[,Vcomp]`

Parameters

***chnum* :** Search source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Output ranging type. Integer expression. The output range will be set to the minimum range that covers both *start* and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

***start*, *stop* :** Search start or stop current (in A). Numeric expression. See Table 4-7 on page 4-15. The *start* and *stop* must have different values.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

***Vcomp* :** Voltage compliance value (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not specify *Vcomp,* the previous value is set.

Example Statements

```
OUTPUT @E5270;"BSI 1,0,1E-12,1E-6,10"
```

Command Reference

BSM

The BSM command specifies the search source control mode in the binary search measurement (MM15), and enables or disables the automatic abort function. The automatic abort function stops the measurement when one of the following conditions occurs:

- Compliance on the measurement channel
- Compliance on the non-measurement channel
- Overflow on the AD converter
- Oscillation on any channel

This command also sets the post search condition for the binary search sources. After the search measurement is normally completed, the binary search sources force the value specified by the *post* parameter.

If the search operation is stopped by the automatic abort function, the binary search sources force the start value after search.

Syntax

`BSM mode,abort[,post]`

Parameters

mode **:** Source output control mode, 0 (normal mode) or 1 (cautious mode). If you do not enter this command, the normal mode is set. See Figure 4-1.

abort **:** Automatic abort function. Integer expression.

1: Disables the function. Initial setting.

2: Enables the function.

post **:** Source output value after the measurement is normally completed. Integer expression.

1: Start value. Initial setting.

2: Stop value.

3: Output value when the search target value is get.

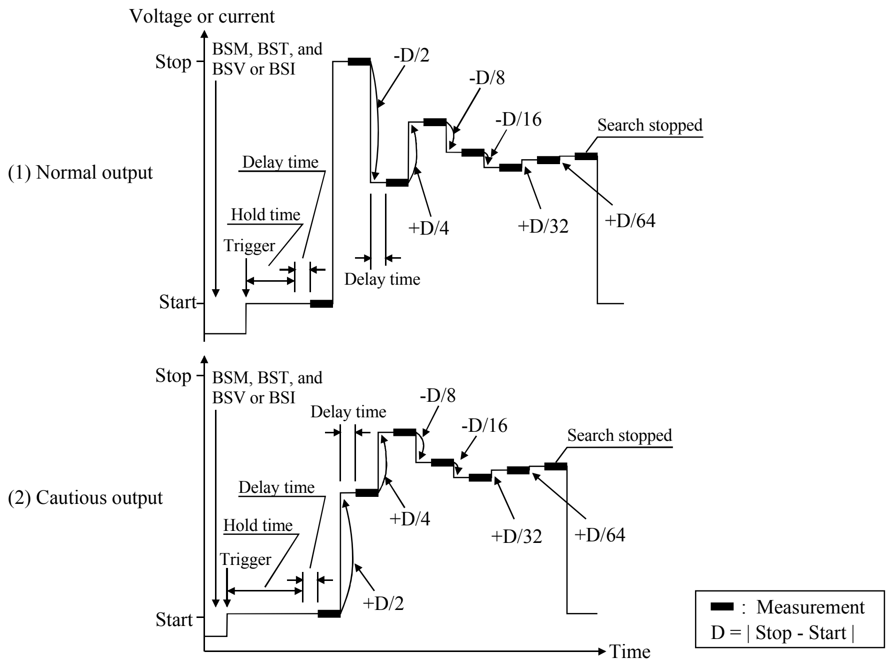
If you do not specify *post*, the search source forces the start value.

Example Statements

```
OUTPUT @E5270;"BSM 1,2,3"
```

Command Reference

Figure 4-1 **Binary Search Source Output Control Mode**



Normal mode

The operation of the normal mode is explained below:

1. The source channel forces the Start value, and the monitor channel executes a measurement.
2. The source channel forces the Stop value, and the monitor channel executes a measurement.

   If the search target value is out of the range between the measured value at the Start value and the measured value at the Stop value, the search stops.
3. The source channel forces the Stop - D/2 value (or Stop+D/2 if Start>Stop), and the monitor channel executes a measurement.

   If the search stop condition is not satisfied, the measured data is used to decide the direction (+ or –) of the next output change. The value of the change is always half of the previous change.
4. Repeats the output change and measurement until the search stop condition is satisfied.

   For information on the search stop condition, see “BGI” or “BGV”. If the output change value is less than the setting resolution, the search stops.

Command Reference

Cautious mode

The operation of the cautious mode is explained below:

1. The source channel forces the Start value, and the monitor channel executes a measurement.
2. The source channel forces the Start+D/2 value (or Start-D/2 if Start>Stop), and the monitor channel executes a measurement.

   If the search stop condition is not satisfied, the measured data is used to decide the direction (+ or –) of the next output change. The value of the change is always half of the previous change.
3. Repeats the output change and measurement until the search stop condition is satisfied.

   For information on the search stop condition, see "BGI" or "BGV". If the output change value is less than the setting resolution, the search stops.

Command Reference

BSSI

The BSSI command specifies and sets the synchronous current source for the binary search measurement. The synchronous source output will be:

Synchronous source output = *polarity* × BSI source output + *offset*

where BSI source output means the output set by the BSI command.

This command setting is cleared by the BSV/BSI command.

Execution Conditions

The BSI command must be sent *before* sending this command.

Syntax

`BSSI chnum,polarity,offset[,Vcomp]`

Parameters

chnum **:** Synchronous source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

polarity **:** Polarity of the BSSI output for the BSI output.

0: Negative. BSSI output = –BSI output + *offset*

1: Positive. BSSI output = BSI output + *offset*

offset **:** Offset current (in A). Numeric expression.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Both primary and synchronous search sources will use the same output range. So check the output range set to the BSI command to determine the synchronous source outputs.

Vcomp **:** Voltage compliance value (in V). Numeric expression. If you do not specify *Vcomp,* the previous value is set.

Example Statements

```
OUTPUT @E5270;"BSSI 1,0,1E-6,10"
```

See Also

Refer to Table 4-7 on page 4-15 for the source output value, output range, and the available compliance values.

Command Reference

BSSV

The BSSV command specifies the synchronous voltage source for the binary search measurement. The synchronous source output will be:

Synchronous source output = *polarity* × BSV source output + *offset*

where BSV source output means the output set by the BSV command.

This command setting is cleared by the BSI/BSV command.

Execution Conditions

The BSV command must be sent *before* sending this command.

Syntax

BSSV *chnum*,*polarity*,*offset*[,*Icomp*]

Parameters

chnum **:** Synchronous source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

polarity **:** Polarity of the BSSV output for the BSV output.

0: Negative. BSSV output = –BSV output + *offset*

1: Positive. BSSV output = BSV output + *offset*

offset **:** Offset voltage (in V). Numeric expression.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Both primary and synchronous search sources will use the same output range. So check the output range set to the BSV command to determine the synchronous source outputs.

Icomp **:** Current compliance value (in A). Numeric expression. If you do not specify *Icomp*, the previous value is set. Zero amps (0 A) is not a valid value for the *Icomp* parameter.

Example Statements

```
OUTPUT @E5270;"BSSV 1,0,5,1E-6"
```

See Also

Refer to Table 4-6 on page 4-14 for the source output value, output range, and the available compliance values.

Command Reference

BST

The BST command sets the hold time and delay time for the binary search measurement.

If you do not enter this command, all parameters are set to 0.

Syntax

`BST hold,delay`

Parameters

hold **:** Hold time (in seconds) that is the wait time after starting the search measurement and before starting the delay time for the first search point. Numeric expression.

0 to 655.35 sec. 0.01 sec resolution.

delay **:** Delay time (in seconds) that is the wait time after starting to force a step output value and before starting a step measurement. Numeric expression.

0 to 65.535 sec. 0.0001 sec resolution.

Example Statements

```
OUTPUT @E5270;"BST 5,0.1"
```

Command Reference

BSV

The BSV command specifies and sets the voltage search source for the binary search measurement. This command setting is cleared by the BSI command. After search stops, the search channel forces the value specified by the BSM command.

Syntax

`BSV chnum,range,start,stop[,Icomp]`

Parameters

chnum **:** Search source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range **:** Output ranging type. Integer expression. The output range will be set to the minimum range that covers both *start* and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

start*, *stop **:** Search start or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14. The *start* and *stop* parameters must have different values.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Icomp **:** Current compliance value (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not specify *Icomp*, the previous value is set. Zero amps (0 A) is not allowed for *Icomp*.

Example Statements

```
OUTPUT @E5270;"BSV 1,0,0,20,1E-6"
```

Command Reference

BSVM

The BSVM command selects the data output mode for the binary search measurement.

Syntax

`BSVM` *`mode`*

Parameters

mode **:** Data output mode. Integer expression.

0 : Returns *Data_search* only (initial setting).

1 : Returns *Data_search* and *Data_sense*.

where

Data_search is the value forced by the search output channel set by the BSV or BSI command.

Data_sense is the value measured by the search monitor channel set by the BGI or BGV command.

For data output format, refer to "Data Output Format" on page 1-22.

Example Statements

```
OUTPUT @E5270;"BSVM 1"
```

CA

The CA command performs the self-calibration.

Modules that fail the self-calibration are disabled, and can only be enabled by the RCV command.

After the CA command, enter the *OPC? command to confirm that the command execution is completed.

Execution Conditions

No channel may be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V).

To perform the self-calibration correctly, the measurement terminals should be opened.

Syntax

```
CA [slotnum]
```

Parameters

slotnum : Slot number that specifies the module to perform the self-calibration. Integer expression. 1 to 8.

For HPSMU that uses two slots, set the greater slot number. For example, if it is installed in slot 3 and 4, *slotnum* must be 4.

If you do not specify *slotnum*, this command performs the self-calibration for the mainframe and all modules.

If *slotnum* specifies the slot that installs no module, this command causes an error.

Example Statements

```
OUTPUT @E5270;"CA"
OUTPUT @E5270;"*OPC?"
ENTER @E5270;A
```

NOTE

To send CA command to Keysight E5270B installed with ASU

If you send the CA command to the E5270B installed with the ASU (Atto Sense and Switch Unit), the E5270B executes the self-calibration and the 1 pA range offset measurement for the measurement channels connected to the ASUs. The offset data is temporarily memorized until the E5270B is turned off, and is used for the compensation of the data measured by the 1 pA range of the channels. The E5270B performs the data compensation automatically and returns the compensated data.

Since the E5270B is turned on, if you do not send the CA command, the E5270B performs the data compensation by using the pre-stored offset data.

Command Reference

*CAL?

The CAL? query command performs the self-calibration, and returns the results in ASCII format. Modules that fail the self-calibration are disabled, and can only be enabled by the RCV command.

After the *CAL? command, read the results soon.

Execution Conditions

No module may be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V).

To perform the self-calibration correctly, the measurement terminals should be opened.

Syntax

`*CAL? [slotnum]`

Parameters

***slotnum* :** Specifies the module to perform the self-calibration. Integer expression. 0 to 9.

0: Mainframe and all modules. Default setting.

1 to 8: Module installed in the slot specified by *slotnum*.

9: Mainframe.

For HPSMU that uses two slots, set the greater slot number. For example, if it is installed in slot 3 and 4, *slotnum* must be 4.

If *slotnum* specifies the slot that installs no module, this command causes an error.

Query Response

`results<CR/LF^EOI>`

results returns the sum of the following values corresponding to the failures.

results	Description	*results*	Description
0	Passed. No failure detected.	16	Slot 5 module failed.
1	Slot 1 module failed.	32	Slot 6 module failed.
2	Slot 2 module failed.	64	Slot 7 module failed.
4	Slot 3 module failed.	128	Slot 8 module failed.
8	Slot 4 module failed.	256	Mainframe failed.

Example Statements

```
OUTPUT @E5270;"*CAL?"
ENTER @E5270;A
```

Command Reference

CL

The CL command disables the specified channels by setting the output switches to OFF. Then the channel output is opened, and the power consumption is 0 W.

Execution Conditions

No channel may be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V). However, if you do not specify *chnum* for CL command, there are no restrictions on the execution conditions.

Syntax

```
CL [chnum[,chnum...[,chnum]...]]
```

A maximum of eight channels can be set.

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you specify multiple *chnum*s, the E5260/E5270 sets the channels to 0 V in the specified order.

If you do not specify *chnum*, this command sets all channels to 0 V in order from higher voltage range (output or measurement range) to lower voltage range.

Remarks

The CL command sets the specified channels to the following conditions:

Item	Setting	Item	Setting
Output Switch	OFF	I Compliance	100 µA
Source Mode	Voltage	I Range	100 µA
Output Voltage	0 V	Filter	OFF
V Range	20 V	Series Resistor	Not changed

Example Statements

```
OUTPUT @E5270;"CL"
OUTPUT @E5270;"CL 1,2,3,5"
```

Command Reference

CM

The CM command sets the auto-calibration function to ON or OFF. If the following two conditions are satisfied, the E5260/E5270 automatically calibrates all channels every 30 minutes.

- Auto-calibration is ON
- Output switches of all channels have been OFF for 30 minutes

Syntax

`CM` *`mode`*

Parameters

mode **:** Auto-calibration ON or OFF. Integer expression.

0: OFF

1: ON (initial setting)

Remarks

To perform the calibration correctly, the measurement terminals should be opened before starting the calibration.

If the auto-calibration is enabled, do not forget to open the measurement terminals after measurements.

Example Statements

```
OUTPUT @E5270;"CM 0"
OUTPUT @E5270;"CM 1"
```

Command Reference

CMM

The CMM command sets the SMU measurement operation mode. This command is not available for the high speed spot measurement.

Syntax

`CMM` *`chnum`*`,`*`mode`*

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** SMU measurement operation mode. Integer expression.

- 0: Compliance side measurement (initial setting).
- 1: SMU always performs current measurement.
- 2: SMU always performs voltage measurement.
- 3: Force side measurement.

If *mode*=0, SMU measures current when it forces voltage, or measures voltage when it forces current.

If *mode*=3, SMU measures current when it forces current, or measures voltage when it forces voltage.

The *mode* setting is kept until the *mode* is changed by this command. If you want to return it to the initial setting, enter the CMM command with *mode*=0.

Example Statements

```
OUTPUT @E5270;"CMM 1,1"
```

Command Reference

CN

This command enables the specified channels by setting the output switches to ON. Then the power consumption is 0 W.

WARNING

SETTING THE OUTPUT SWITCH TO "ON" ENABLES THE CHANNEL TO FORCE DANGEROUS VOLTAGES.

WHEN THE CHANNEL IS NOT IN USE, SET THE OUTPUT SWITCH TO "OFF" WHENEVER POSSIBLE.

Execution Conditions

No channel may be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V).

Syntax

`CN [chnum[,chnum...[,chnum]...]]`

A maximum of eight channels can be set.

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you specify multiple *chnum*s, the E5260/E5270 sets the output switches to ON, in the specified order.

If you do not specify *chnum*, the E5260/E5270 sets all output switches to ON, in the order from lower to higher slot number.

Remarks

The CN command sets the specified channels to the following conditions:

Item	Setting	Item	Setting
Output Switch	ON	I Compliance	100 μA
Source Mode	Voltage	I Range	100 μA
Output Voltage	0 V	Filter	Not changed
V Range	20 V	Series Resistor	Not changed

If the output switch of the specified channel is already set to ON, no action is performed by the CN command.

Example Statements

```
OUTPUT @E5270;"CN"
OUTPUT @E5270;"CN 1,2,3,5"
```

Command Reference

DFM

The DFM command selects the data display format on the front panel LCD.

The *RST command or the device clear selects scientific.

Syntax

`DFM format`

Parameters

format : Data display format. Integer expression.

format	Description
0	Engineering. +/– sign, 6 digits numeric value with arithmetic point, and unit. Example: `+123.456mA`
1	Scientific. +/– sign, 4 digits numeric value with arithmetic point, exponential part (E, +/– sign, and 1 or 2 digits numeric value), and unit. Example: `+1.234E-1A`

Example Statements

```
OUTPUT @E5270;"DFM 0"
```

Command Reference

DI

The DI command forces current from the specified channel.

Execution Conditions

The CN command has been executed for the specified channel.

If the voltage compliance is greater than ±42 V, the interlock circuit must be shorted.

Syntax

`DI chnum,irange,current[,Vcomp[,comp_polarity[,vrange]]]`

Parameters

chnum **:** Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

irange **:** Ranging type for current output. Integer expression. The output range will be set to the minimum range that covers *current* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

current **:** Output current value (in A). Numeric expression. See Table 4-7 on page 4-15.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Vcomp **:** Voltage compliance value (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not specify this parameter, *Vcomp* is set to the previous setting.

comp_polarity **:** Polarity of voltage compliance. Integer expression.

- **0:** Auto mode (default setting). The compliance polarity is automatically set to the same polarity as *current*, regardless of the specified *Vcomp*. If *current*=0 A, the polarity is set to positive.
- **1:** Manual mode. Uses the polarity of *Vcomp* you specified.

vrange **:** Voltage compliance ranging type. Integer expression. The compliance range will be set to the minimum range that covers *Vcomp* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

Example Statements

```
OUTPUT @E5270;"DI 1,0,1E-6"
OUTPUT @E5270;"DI 3,14,5E-7,20,0,0"
```

DIAG?

The DIAG? command starts the diagnostics, and returns the results in ASCII format.

Before starting the diagnostics, refer to Remarks below.

After the DIAG? command, read the results soon.

Syntax

`DIAG? item[,pause]`

Parameters

***item* :** Diagnostics item. Integer expression. 1 to 5.

item	Description	*pause*
1	Trigger In/Out diagnostics.	effective
2	Front panel key diagnostics.	n.a
3	High voltage LED diagnostics.	n.a
4	Digital I/O diagnostics.	effective
5	Beeper diagnostics.	n.a

***pause* :** Pauses before starting diagnostics or not. Integer expression. 0 or 1. This parameter is effective for *item*=1 and 4.

0: Keysight E5260/E5270 starts diagnostics immediately.

1: Keysight E5260/E5270 starts diagnostics when the **Enter** key is pressed.

If you do not specify *pause*, 1 is set.

For *pause*=1, you can abort execution of the diagnostics by pressing the **Exit** key while a message is being displayed on the LCD.

Query Response

result <CR/LF^EOI>

0: Passed.

1: Failed.

2: Aborted.

Example Statements

```
OUTPUT @E5270;"DIAG? 1,1"
ENTER @E5270;A
```

Command Reference

Remarks

- Before starting the trigger in/out diagnostics, connect a BNC cable between the Ext Trig In and Out connectors.
- After starting the front panel key diagnostics, press any key and confirm that the key name is displayed. Repeat this for all keys.

  If all response was good, press the **Enter** key twice to stop. *result* returns 0.

  If any response was bad, press the **Exit** key twice to stop. *result* returns 1.
- After starting the high voltage LED diagnostics:

  If the LED blinks, press the **Enter** key to stop. *result* returns 0.

  If the LED does not blink, press the **Exit** key to stop. *result* returns 1.
- Before starting the digital I/O diagnostics, disconnect any cable from the digital I/O port.
- After starting the beeper diagnostics:

  If you listen 2 types of beep sounds every 1 second, press the **Enter** key to stop. *result* returns 0.

  If you do not listen it, press the **Exit** key to stop. *result* returns 1.

DO

The DO command executes the E5260/E5270 internal memory programs (up to 8 programs) in the order specified.

Execution Conditions

The specified programs have been stored by using the ST and END commands.

Syntax

`DO` *`pnum`*`[,`*`pnum`*`[,`*`pnum`*`[,`*`pnum`*`[,`*`pnum`*`[,`*`pnum`*`[,`*`pnum`*`[,`*`pnum`*`]]]]]]]`

Parameters

pnum **:** Internal memory program number. Numeric expression. 1 to 2000.

Example Statements

```
OUTPUT @E5270;"DO 1,2,3,4,5,6,7,8"
OUTPUT @E5270;"DO 98,99"
```

Command Reference

DV

The DV command forces output voltage from the specified channel.

Execution Conditions

The CN command has been executed for the specified channel.

If the output voltage is greater than ±42 V, the interlock circuit must be shorted.

Syntax

`DV chnum,vrange,voltage[,Icomp[,comp_polarity[,irange]]]`

Parameters

chnum **:** Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

vrange **:** Ranging type for voltage output. Integer expression. The output range will be set to the minimum range that covers *voltage* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

voltage **:** Output voltage value (in V). Numeric expression. See Table 4-6 on page 4-14.

0 to ±100, or 0 to ±200 (for E5280B/E5290A)

Icomp **:** Current compliance value (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not set *Icomp*, the previous value is used. 0 A is not allowed for *Icomp*.

comp_polarity **:** Polarity of current compliance. Integer expression.

0: Auto mode (default setting). The compliance polarity is automatically set to the same polarity as *voltage*, regardless of the specified *Icomp*. If *voltage*=0 V, the polarity is set to positive.

1: Manual mode. Uses the polarity of *Icomp* you specified.

irange **:** Current compliance ranging type. Integer expression. The compliance range will be set to the minimum range that covers *Icomp* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

Example Statements

```
OUTPUT @E5270;"DV 1,0,20,1E-6,0,15"
OUTPUT @E5270;"DV 2,12,10"
```

Command Reference

DZ

The DZ command stores the settings (V/I output values, V/I output ranges, V/I compliance values, and series resistor setting) of the specified channels, and sets the channels to 0 V. The settings can be recovered by using the RZ command. The stored settings are cleared by using a device clear (HP BASIC CLEAR) command, *RST, RZ, CL, CA, or *TST?.

Syntax

`DZ [chnum[,chnum...[,chnum]...]]`

A maximum of eight channels can be set.

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you specify multiple *chnum*s, the E5260/E5270 sets the channels to 0 V in the specified order.

If you do not specify *chnum*, the DZ command applies 0 V to all channels where the output switch is set to ON, in order from higher (output or measurement range) to lower voltage range.

Remarks

The DZ command sets the specified channels to the following conditions:

Item	Setting	Item	Setting
Output Switch	ON	I Range	See next table
Source Mode	Voltage	Compliance	See next table
Output Voltage	0 V	Filter	Not changed
V Range	Not changed	Series Resistor	Not changed

Previous range [a]	I Range	I Compliance
1 nA to 100 μA	same as previous range	range value
over 100 μA	100 μA	100 μA

a. Range value that was set before the DZ command.

Example Statements

```
OUTPUT @E5270;"DZ 1,2,3"
```

Command Reference

EMG?

The EMG? query command returns error message corresponding to the specified error code.

Syntax

`EMG? *errcode*`

Parameters

errcode **:** Error code returned by the ERR? command. Numeric expression.

Query Response

Error message <CR/LF^EOI>

For the error codes and error messages, refer to Chapter 5, “Error Messages.”

Example Statements

```
OUTPUT @E5270;"EMG? 100"
ENTER @E5270;A$
```

END

The END command is used with the ST command to store a program in the internal program memory. See “ST” on page 4-109.

Syntax

`END`

Example Statements

```
OUTPUT @E5270;"ST1;CN1;DV1,0,5,1E-4;TI1,0;CL1"
OUTPUT @E5270;"END"
```

Command Reference

ERC

The ERC command changes the output status of the digital I/O port. This command does not change the status of the trigger ports and the input ports set by the ERM command.

The *RST command or the device clear sets the digital I/O port (total 16 paths) to the output port, and sets the port output level to TTL high.

Syntax

`ERC mode,value[,rule]`

Parameters

mode **:** Control mode. Integer expression. Set *mode* to 2.

2: Controls the digital I/O port.

If you set 1 that is effective for the Keysight 4142B, an error occurs.

value **:** Decimal value of the output status bit pattern. Integer expression. 0 to 65535. The bit pattern must comply with the following rule:

Bit value 0: TTL high level (approx. 2.4 V)

Bit value 1: TTL low level (approx. 0.8 V)

rule **:** Place holder to keep the same syntax as the ERC command of the Keysight 4142B. Input value is ignored.

Example Statements

If you want to set TTL low level for the output ports of the digital I/O port bit 0 to 7, enter the following command.

```
OUTPUT @E5270;"ERC 2,255"
```

where the decimal value 255 means binary bit pattern `0000000011111111`. This command does not change the status of the trigger ports and the input ports.

See Also

"ERM" and "ERS?"

ERM

The ERM command changes the input/output assignments of the digital I/O port (total 16 paths). This command does not change the trigger port assignments and settings.

The *RST command or the device clear sets the digital I/O port to the output port, and sets the port output level to TTL high.

Syntax

`ERM` *`iport`*

Parameters

iport **:** Decimal value of the port setting. Integer expression. 0 to 65535.

The setting of each port must be designated by 0 or 1 that has the following meaning:

0: Output port

1: Input port

Example Statements

If you want to use the non-trigger ports of the digital I/O ports 0 to 7 as the input port, enter the following statement.

```
OUTPUT @E5270;"ERM 255"
```

where the decimal value 255 means binary bit pattern `0000000011111111`.

Remarks

The ERM command sets the port level to TTL high for all ports where the port assignment is changed from output to input or from input to output.

The ERM command does not change the port assignment of the trigger ports.

See Also

"ERS?"

Command Reference

ERR?

The ERR? query command returns error codes from the E5260/E5270 error register to the output data buffer (query buffer).

This command clears the error register.

Syntax

`ERR? [`*`mode`*`]`

Parameters

mode **:** Error code output mode. Integer expression. 0 (default setting) or 1.

0: Returns up to four error codes in order from their occurrence.

1: Returns one error code.

If you do not specify *mode*, the ERR? command returns four error codes (same as *mode*=0).

Query Response

Error Code,*Error Code*,*Error Code*,*Error Code* <CR/LF^EOI>

or

Error Code <CR/LF^EOI>

For the error codes, refer to Chapter 5, “Error Messages.” If no error occurred, *Error Code* is 0.

Example Statements

```
OUTPUT @E5270;"ERR?"
ENTER @E5270;A$

OUTPUT @E5270;"ERR? 1"
ENTER @E5270;A
```

Command Reference

ERS?

The ERS? command returns the status of the digital I/O port (16 paths).

Syntax

```
ERS?
```

Query Response

pattern <CR/LF^EOI>

pattern returns the decimal value of the port status.

The status of each port is designated by 0 or 1 that has the following meaning:

0: TTL high level (approx. 2.4 V)

1: TTL low level (approx. 0.8 V)

Example Statements

```
OUTPUT @E5270;"ERS?"
ENTER @E5270;A
PRINT "Port Status=";A
```

For example, 255 (0000000011111111) is returned when the port 0 to 7 have been set to the TTL low level and the port 8 to 15 have been set to the TTL high level.

See Also

"ERM"

Command Reference

FL

This command sets the connection mode of a filter for each channel.

A filter is mounted on each module. It assures clean source output with no spikes or overshooting.

Syntax

`FL mode[,chnum[,chnum...[,chnum]...]]`

A maximum of eight channels can be set.

Parameters

mode : Status of the filter. Integer expression.

0: Disconnect (initial setting).

1: Connect.

chnum : Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you do not specify *chnum*, the FL command sets the same *mode* for all channels.

Example Statements

```
OUTPUT @E5270;"FL"
OUTPUT @E5270;"FL 0,1,3,5"
```

Command Reference

FMT

The FMT command clears the E5260/E5270 output data buffer, and specifies the data output format and the data terminator. For details about data output format, see "Data Output Format" on page 1-22.

Query command output data is always stored in the query buffer in ASCII format, regardless of this command.

If you do not enter this command, the data output format is same as the data format by the FMT1,0 command.

NOTE Multi command statement is not allowed for this command.

Syntax

`FMT format[,mode]`

Parameters

format **:** Data output format. Integer expression. 1 to 5, 11, 12, 15, 21, 22, or 25. See Table 4-11.

mode **:** Source data output mode. Integer expression. 0 to 8. See Table 4-10. You can select the source data returned with the measurement data. If you do not specify this parameter, no source data is returned.

Example Statements

```
OUTPUT @E5270;"FMT 1"

OUTPUT @E5270;"FMT 2,1"
```

Table 4-10 **FMT mode parameter**

mode	Source data returned with measurement data
0	None (default setting). Only the measurement data is returned.
1	Data of the primary sweep source set by the WI/WV/PWI/PWV command.
2	Data of the synchronous sweep source set by the WSI/WSV command.
2 to 8	For the multi channel sweep measurement: Data of the synchronous sweep source set by the WNX command. The *mode* value must be the sweep source number (2 to 8) you want to get data. For the sweep source number, refer to "WNX" on page 4-136.

Command Reference

Table 4-11 **FMT format parameter**

format	**Data format**	**Terminator**
1 [a]	ASCII (12 digits data with header)	<CR/LF^EOI>
2 [a]	ASCII (12 digits data without header)	<CR/LF^EOI>
3 [a]	binary	<CR/LF^EOI>
4 [a]	binary	<^EOI>
5 [a]	ASCII (12 digits data with header)	,
11	ASCII (13 digits data with header)	<CR/LF^EOI>
12	ASCII (13 digits data without header) [b]	<CR/LF^EOI>
15	ASCII (13 digits data with header)	,
21	ASCII (13 digits data with header) [b]	<CR/LF^EOI>
22	ASCII (13 digits data without header) [b]	<CR/LF^EOI>
25	ASCII (13 digits data with header) [b]	,

a. Compatible with the Keysight 4142B data output format.
b. Compatible with the Keysight 4155/4156 FLEX mode ASCII data.

12 digits data will be `sn.nnnnnEsnn`, `snn.nnnnEsnn`, or `snnn.nnnEsnn`.

13 digits data will be `sn.nnnnnnEsnn`, `snn.nnnnnEsnn`, or `snnn.nnnnEsnn`.

where, `s` is `+` or `-`, `E` is exponent symbol, and `n` means one digit number.

NOTE

For binary data output format, the time stamp function is not available. Refer to "Data Output Format" on page 1-22.

Command Reference

*IDN?

The *IDN? query command returns the instrument model number and the ROM version number, then stores the results in the output data buffer (query buffer).

Syntax

`*IDN?`

Query Response

`Agilent Technologies,`*`model`*`,0,`*`ROM rev`* <CR/LF^EOI>

Response	Explanation
model	`E5260A`, `E5262A`, `E5263A`, or `E5270B`
ROM rev	ROM version number

Example Statements

```
OUTPUT @E5270;"*IDN?"
ENTER @E5270;A$
```

Example Response

```
Agilent Technologies,E5270B,0,B.01.00
```

IN

The IN command sets the specified channel to 0 V with an output range change.

Syntax

`IN [chnum[,chnum...[,chnum]...]]`

A maximum of eight channels can be set.

Parameters

***chnum* :** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you specify multiple *chnum*s, the E5260/E5270 sets the channels to 0 V in the specified order.

If you do not specify *chnum*, this command sets all channels to 0 V in order from higher voltage range (output or measurement range) to lower voltage range.

Remarks

The IN command sets the specified channels to the following conditions, which are the same as the conditions after executing the CN command.

Item	SMU	GNDU
Source Mode	V	
Output Voltage	0 V	0 V
V Range	20 V	
I Compliance	100 μA	
I Range	100 μA	
Filter	Not changed	
Power Consumption	0 W	

Example Statements

```
OUTPUT @E5270;"IN"
OUTPUT @E5270;"IN 1,2,3,5,6"
```

Command Reference

KLC

The KLC command locks or unlocks the front panel keys.

The *RST command or the device clear unlocks the front panel keys.

Syntax

`KLC mode`

Parameters

mode **:** Front panel key lock or unlock. Integer expression.

0: Unlock.

1: Lock.

Example Statements

```
OUTPUT @E5270;"KLC 1"
```

Command Reference

LGI

The LGI command specifies the current monitor channel and its search parameters for the linear search measurement.

This command ignores the RI command setting.

This command setting is cleared by the LGV command.

Syntax

`LGI chnum,mode,range,target`

Parameters

***chnum* :** Search monitor channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***mode* :** Search mode. Integer expression.

0 : If the measured value ≤ *target*, it is the search result data.

1 : If the measured value ≥ *target*, it is the search result data.

***range* :** Measurement ranging type. Integer expression. The measurement range will be set to the minimum range that covers the *target* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-3 on page 4-11.

***target*:** Search target current (in A). Numeric expression.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"LGI 0,1,14,1E-6"
```

Command Reference

LGV

The LGV command specifies the voltage monitor channel and its search parameters for the linear search measurement.

This command ignores the RV command setting.

This command setting is cleared by the LGI command.

Syntax

```
LGV chnum,mode,range,target
```

Parameters

chnum **:** Search monitor channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** Search mode. Integer expression.

0 : If the measured value ≤ *target*, it is the search result data.

1 : If the measured value ≥ *target*, it is the search result data.

range **:** Measurement ranging type. Integer expression. The measurement range will be set to the minimum range that covers the *target* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-2 on page 4-10.

target **:** Search target voltage (in V). Numeric expression.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"LGV 1,2,12,3"
```

Command Reference

LOP?

The LOP? query command returns the operation status of all modules and stores the results in the output data buffer (query buffer).

Syntax

`LOP?`

Query Response

For E5262A/E5263A:

`LOP`*stat1*,*stat2* <CR/LF^EOI>

For E5260A/E5270B:

`LOP`*stat1*,*stat2*,*stat3*,*stat4*,*stat5*,*stat6*,*stat7*,*stat8* <CR/LF^EOI>

The variables *stat1* to *stat8* will indicate the status of the module installed in the slot 1 to 8 respectively, and will be the two-digit status code shown in the following table. For the HPSMU that occupies two slots, two variables will be returned. Then the first one is always 00, and the last one indicates the module status. For example, `LOP00,11,00,00,00,00,00,00` will be returned when only the HPSMU installed in the slot 1-2 is used and is in the voltage compliance condition.

Status code	Description
00	No module is installed, or the output switch is OFF.
01	SMU forces voltage, and does not reach current compliance.
02	SMU forces positive current, and does not reach voltage compliance.
03	SMU forces negative current, and does not reach voltage compliance.
10	Not applicable.
11	SMU reaches voltage compliance.
12	SMU reaches positive current compliance.
13	SMU reaches negative current compliance.
20	SMU is oscillating.
30	Not applicable.

Example Statements

```
OUTPUT @E5270;"LOP?"
ENTER @E5270;A$
```

Command Reference

*LRN?

The *LRN? (learn) query command returns information about the channel settings or the E5260/E5270 command parameter settings, and stores the results in the E5260/E5270 output data buffer (query buffer).

Syntax

`*LRN? type`

Example Statements

```
DIM A$[200]
OUTPUT @E5270;"*LRN? 1"
ENTER @E5270;A$
```

Parameters and Query Response

type **:** This parameter selects the type of query response. Available values are 0 to 60, but some numbers are not used. See below. Integer expression.

A description and the query response of each *type* is described below.

0 : Returns the output switch ON/OFF status:

CN[*chnum*[,*chnum* . . . [,*chnum*] . . .]]<CR/LF^EOI>

where *chnum* is the channel number for the channel whose output switch is set to ON.

If no output switches are ON, the query response is:

CL<CR/LF^EOI>

1 to 8 : Returns the SMU source status.

The *type* parameter corresponds to slot number where the module is installed.

If the output switch is ON, the query response is:

DV *chnum*,*range*,*voltage*[,*Icomp*[,*comp polarity*[,*irange*]]] <CR/LF^EOI>

or

DI *chnum*,*range*,*current*[,*Vcomp*[,*comp polarity*[,*vrange*]]] <CR/LF^EOI>

where *range* is the present setting of the output range.

If the output switch is OFF, the query response is:

CL *chnum* <CR/LF^EOI>

9 to 29 : Not used.

Command Reference

30 : Returns the filter ON/OFF status:

FL0 [*off ch*[,*off ch* . . . [,*off ch*] . . .];
FL1 [*on ch*[,*on ch* . . . [,*on ch*] . .] <CR/LF^EOI>

If all modules are Filter OFF, the query response is:

FL0<CR/LF^EOI>

If all modules are Filter ON, the query response is:

FL1<CR/LF^EOI>

31 : Returns the parameter values of the TM, AV, CM, FMT, and MM commands:

TM *trigger mode*;AV *number*[,*mode*];CM *auto calibration mode*;
FMT *output data format*,*output data mode*
[;MM *measurement mode*[,*chnum*[,*chnum*...[,*chnum*]...]]]
<CR/LF^EOI>

32 : Returns the measurement ranging status:

RI *chnum*,*Irange*;RV *chnum*,*Vrange*
[;RI *chnum*,*Irange*;RV *chnum*,*Vrange*]
:
[;RI *chnum*,*Irange*;RV *chnum*,*Vrange*]<CR/LF^EOI>

33 : Returns the staircase sweep measurement settings:

WM *automatic sweep abort function*,*output after sweep*;
WT *hold time*,*delay time*[,*step delay time*[,*S trig delay*[,*M trig delay*]]]
[;WV *chnum*,*mode*,*range*,*start*,*stop*,*nop*[,*Icomp* [,*pcomp*]]] or
[;WI *chnum*,*mode*,*range*,*start*,*stop*,*nop*[,*Vcomp*[,*pcomp*]]]
[;WSV *chnum*,*range*,*start*,*stop*[,*Icomp*[,*pcomp*]]] or
[;WSI *chnum*,*range*,*start*,*stop*[,*Vcomp*[,*pcomp*]]]<CR/LF^EOI>

34 : Returns the pulsed source settings:

PT *hold time*,*pulse width*[,*pulse period*[,*trig delay*]]
[;PV *chnum*,*output range*,*base voltage*,*pulse voltage* [,*Icomp*]] or
[;PI *chnum*,*output range*,*base current*,*pulse current* [,*Vcomp*]]
[;PWV *chnum*,*mode*,*range*,*base*,*start*,*stop*,*nop*[,*Icomp*]] or
[;PWI *chnum*,*mode*,*range*,*base*,*start*,*stop*,*nop*[,*Vcomp*]]<CR/LF^EOI>

35 to 36 : Not used.

Command Reference

37 : Returns the quasi-pulsed source settings:

BDM *detection interval*[,*mode*];
BDT *hold time*,*delay time*
[;BDV *chnum*,*range*,*start*,*stop*[,*Icomp*]]<CR/LF^EOI>

38 : Returns the digital I/O port information:

ERM *input pin*;ERC2,*value* <CR/LF^EOI>

39 : Not used.

40 : Returns channel mapping information:

If multiple channel numbers are translated to another numbers.

ACH *actual*,*program*
[;ACH *actual*,*program*]
:
[;ACH *actual*,*program*]<CR/LF^EOI>

If no channel number is defined by the ACH command.

ACH<CR/LF^EOI>

41 to 45 : Not used.

46 : Returns SMU measurement operation mode settings:

CMM *chnum*,*mode*
[;CMM *chnum*,*mode*]
:
[;CMM *chnum*,*mode*]<CR/LF^EOI>

47 to 49 : Not used.

50 : Returns the linear search measurement settings:

LSM *abort*,*post*;LSTM *hold*,*delay*;LSVM *mode*;
[;LGI *chnum*,*mode*,*Irange*,*Itarget*] or
[;LGV *chnum*,*mode*,*Vrange*,*Vtarget*]
[;LSV *chnum*,*range*,*start*,*stop*,*step*[,*Icomp*]] or
[;LSI *chnum*,*range*,*start*,*stop*,*step*[,*Vcomp*]]
[;LSSV *chnum*,*polarity*,*offset*[,*Icomp*]] or
[;LSSI *chnum*,*polarity*,*offset*[,*Vcomp*]]
<CR/LF^EOI>

Command Reference

51 : Returns the binary search measurement settings:

BSM *mode*,*past*;BST *hold*,*delay*;BSVM *mode*
[;BGI *chnum*,*mode*,*condition*,*Irange*,*Itarget*] or
[;BGV *chnum*,*mode*,*condition*,*Vrange*,*Vtarget*]
[;BSV *chnum*,*range*,*start*,*stop*[,*Icomp*]] or
[;BSI *chnum*,*range*,*start*,*stop*[,*Vcomp*]]
[;BSSV *chnum*,*polarity*,*offset*[,*Icomp*]] or
[;BSSI *chnum*,*polarity*,*offset*[,*Vcomp*]]
<CR/LF^EOI>

52 : Not used.

53 : Returns the SMU series resistor ON/OFF status:

SSR *chnum*,*mode*
[;SSR *chnum*,*mode*]
:
[;SSR *chnum*,*mode*]<CR/LF^EOI>

54 : Returns the auto ranging mode status:

RM *chnum*,*mode*[,*rate*]
[;RM *chnum*,*mode*[,*rate*]]
:
[;RM *chnum*,*mode*[,*rate*]]<CR/LF^EOI>

55 : Available only for the Keysight E5270B. Returns the A/D converter settings:

AAD *chnum*,*type*
[;AAD *chnum*,*type*]
:
[;AAD *chnum*,*type*]<CR/LF^EOI>

56 : Available only for the Keysight E5270B. Returns the ADC averaging or integration time setting:

AIT0,*mode*,*time*;AIT1,*mode*,*time*;
AZ *mode*<CR/LF^EOI>

57 : Returns the source/measurement wait time settings:

WAT0,*set_set*;WAT1,*set_meas*<CR/LF^EOI>

Command Reference

58 : Returns the trigger settings:

[TGP *port*,*terminal*,*polarity*,*type*]
[;TGP *port*,*terminal*,*polarity*,*type*]
:
[;TGP *port*,*terminal*,*polarity*,*type*]
TGSI *mode*;TGXO *mode*;TGSO *mode*;TGMO *mode*<CR/LF^EOI>

59 : Returns the multi channel sweep source settings:

WNX *n*,*chnum*,*mode*,*range*,*start*,*stop*[,*comp*[,*pcomp*]]
[;WNX *n*,*chnum*,*mode*,*range*,*start*,*stop*[,*comp*[,*pcomp*]]]
:
[;WNX *n*,*chnum*,*mode*,*range*,*start*,*stop*[,*comp*[,*pcomp*]]]
<CR/LF^EOI>

If no multi channel sweep source is set, the query response is:

WNX<CR/LF^EOI>

60 : Returns the time stamp setting:

TSC *enable*<CR/LF^EOI>

61 : Returns the display settings:

RED *enable*;
KLC *lock*;
DFM *format*;
SPA1,*param*;
SPA2,*param*;
MPA *param*;
SCH *chnum*;
MCH *chnum*<CR/LF^EOI>

62 : Available only for the Keysight E5270B with HRSMU and ASU. Returns the ASU connection path:

SAP *chnum*,*path*
[;SAP *chnum*,*path*]
:
[;SAP *chnum*,*path*]<CR/LF^EOI>

If no channel is connected to ASU.

SAP<CR/LF^EOI>

Command Reference

63 : Available only for the Keysight E5270B with HRSMU and ASU. Returns the 1 pA auto ranging operation mode:

SAR *chnum*,*mode*
[;SAR *chnum*,*mode*]
:
[;SAR *chnum*,*mode*]<CR/LF^EOI>

If no channel is connected to ASU.

SAR<CR/LF^EOI>

64 : Available only for the Keysight E5270B with HRSMU and ASU. Returns the operation mode of the ASU connection status indicator:

SAL *chnum*,*mode*
[;SAL *chnum*,*mode*]
:
[;SAL *chnum*,*mode*]<CR/LF^EOI>

If no channel is connected to ASU.

SAL<CR/LF^EOI>

Command Reference

LSI

The LSI command specifies and sets the current search source for the linear search measurement. This command setting is cleared by the LSV command. After search stops, the search channel forces the value specified by the LSM command.

Syntax

`LSI chnum,range,start,stop,step[,Vcomp]`

Parameters

chnum **:** Search source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range **:** Output ranging type. Integer expression. The output range will be set to the minimum range that covers both *start* and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

start**,** ***stop*** **:** Search start or stop current (in A). Numeric expression. See Table 4-7 on page 4-15. The *start* and *stop* must have different values.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

step**:** Step current (in A). Numeric expression.

If *start* < *stop*, *step* must be positive, and if *start* > *stop*, *step* must be negative. Maximum number of search steps is 1001.

Vcomp**:** Voltage compliance value (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not specify *Vcomp,* the previous value is set.

Example Statements

```
OUTPUT @E5270;"LSI 1,0,0,1E-6,1E-8,10"
```

Command Reference

LSM

The LSM command enables or disables the automatic abort function for the linear search measurement (MM14). The automatic abort function stops the measurement when one of the following conditions occurs:

- Compliance on the measurement channel
- Compliance on the non-measurement channel
- Overflow on the AD converter
- Oscillation on any channel

This command also sets the post search condition for the linear search sources. After the search measurement is normally completed, the linear search sources force the value specified by the *post* parameter.

If the search operation is stopped by the automatic abort function, the linear search sources force the start value after search.

Syntax

`LSM abort[,post]`

Parameters

abort **:** Automatic abort function. Integer expression.

1: Disables the function. Initial setting.

2: Enables the function.

post **:** Source output value after the measurement is normally completed. Integer expression.

1: Start value. Initial setting.

2: Stop value.

3: Output value when the search target value is obtained.

If this parameter is not specified, the search source forces the start value.

Example Statements

```
OUTPUT @E5270;"LSM 2"
OUTPUT @E5270;"LSM 2,3"
```

LSSI

The LSSI command specifies and sets the synchronous current source for the linear search measurement. The synchronous source output will be:

Synchronous source output = *polarity* × LSI source output + *offset*

where the LSI source output is the output set by the LSI command.

This command setting is cleared by the LSV/LSI command.

Execution Conditions

The LSI command must be entered before this command.

Syntax

`LSSI chnum,polarity,offset[,Vcomp]`

Parameters

chnum : Synchronous source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

polarity: Polarity of the LSSI output for the LSI output.

0 (negative): LSSI output = –LSI output + *offset*

1 (positive): LSSI output = LSI output + *offset*

offset: Offset current (in A). Numeric expression.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Both primary and synchronous search sources will use the same output range. So check the output range set to the LSI command to determine the synchronous source outputs.

Vcomp: Voltage compliance value (in V). Numeric expression. If you do not specify *Vcomp,* the previous value is set.

Example Statements

```
OUTPUT @E5270;"LSSI 1,1,1E-6,5"
```

See Also

Refer to Table 4-7 on page 4-15 for the source output value, output range, and the available compliance values.

LSSV

The LSSV command specifies and sets the synchronous voltage source for the linear search measurement. The synchronous source output will be:

Synchronous source output = *polarity* × LSV source output + *offset*

where the LSV source output is the value set by the LSV command.

This command setting is cleared by the LSI/LSV command.

Execution Conditions

The LSV command must be entered before this command.

Syntax

`LSSV chnum,polarity,offset[,Icomp]`

Parameters

chnum : Synchronous source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

polarity: Polarity of the LSSV output for the LSV output.

0 (negative): LSSV output = –LSV output + *offset*

1 (positive): LSSV output = LSV output + *offset*

offset: Offset voltage (in V). Numeric expression.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Both primary and synchronous search sources will use the same output range. So check the output range set to the LSV command to determine the synchronous source outputs.

Icomp: Current compliance value (in A). Numeric expression. If you do not specify *Icomp*, the previous value is set. Zero amps (0 A) is not a valid value for the *Icomp* parameter.

Example Statements

```
OUTPUT @E5270;"LSSV 1,0,5,1E-6"
```

See Also

Refer to Table 4-6 on page 4-14 for the source output value, output range, and the available compliance values.

Command Reference

LST?

The LST? query command stores a catalog of internal memory programs or a specific program listing in the output data buffer (query buffer) of the E5260/E5270.

Syntax `LST? [`*pnum*`[,`*index*`[,`*size*`]]]`

Parameters

pnum **:** Memory program number. Numeric expression. 0 to 2000. If you do not specify the value, 0 is set.

LST? 0 returns the catalog of the memory programs. This is same as the LST? command results. Then *index* and *size* are not required.

index **:** Command index that is the number of top command to read. Numeric expression. If you do not specify the value, 1 is set.

index=1 specifies the first command stored in the memory program. This command is always the ST command. And the last command is always the END command. If the *index* value is greater than the number of commands, the LST? returns the END only.

If you set *index*=0, the LST? returns the number of commands stored in the memory program. For empty memory programs, the LST? returns 2 (ST and END).

size **:** Number of commands to read. Numeric expression. 1 to 3000. If you do not specify the value, 3000 is set.

If you set the value greater than the number of commands from the command specified by *index* to the last command (END), the LST? command stops operation after reading the END command.

Query Response Response by LST? or LST? 0:

`Number of programs[,pnum[,pnum ... [,pnum]...]]<CR/LF^EOI>`

Response by LST? *pnum*[, *index*[, *size*]]:

```
ST pnum<CR/LF>
[saved command <CR/LF>]
[saved command <CR/LF>]
            :
[saved command <CR/LF>]
END<CR/LF^EOI>
```

The LST? command reads the command specified by the *index*, reads the command stored next, and repeats this operation until the *size* each of commands are read. If you do not specify the *index* and *size* values, the LST? command reads the first

Command Reference

stored command (ST *pnum*) to the 3000th stored command. If the number of commands are less than 3000, the LST? command reads the commands from ST to END. See Example Statements that show an HP BASIC programming example.

Example Statements

Example of LST? :

```
DIM A$[100]
OUTPUT @E5270;"LST?"
ENTER @E5270;A$
PRINT A$
```

Example of LST? *pnum*[, *index*[, *size*]] :

```
DIM A$[100]
P_num=1
!
OUTPUT @E5270;"LST?";P_num,0
ENTER @E5270;Num_c
Num_l=Num_c/3000
!
IF Num_c>3000 THEN
 C_index=1
 FOR I=1 TO INT(Num_l)
   OUTPUT @E5270;"LST?";P_num,C_index
   FOR N=1 TO 3000
     ENTER @E5270;A$
     PRINT A$
     C_index=C_index+1
   NEXT N
 NEXT I
 OUTPUT @E5270;"LST?";P_num,C_index
 LOOP
   ENTER @E5270;A$
   PRINT A$
 EXIT IF A$="END"
 END LOOP
ELSE
 OUTPUT @E5270;"LST?";P_num
 LOOP
   ENTER @E5270;A$
   PRINT A$
 EXIT IF A$="END"
 END LOOP
END IF
```

Command Reference

LSTM

The LSTM command sets the timing parameters for the linear search measurement.

If you do not enter this command, all parameters are set to 0.

Syntax

`LSTM` *`hold`*`,`*`delay`*

Parameters

***hold* :** Hold time (in seconds) that is the wait time after starting the search measurement and before starting the delay time for the first search point. Numeric expression.

0 to 655.35 sec. 0.01 sec resolution.

***delay* :** Delay time (in seconds) that is the wait time after starting to force a step output value and before starting a step measurement. Numeric expression.

0 to 65.535 sec. 0.0001 sec resolution.

Example Statements

```
OUTPUT @E5270;"LSTM 5,0.1"
```

Command Reference

LSV

The LSV command specifies and sets the voltage search source for the linear search measurement. This command setting is cleared by the LSI command. After search stops, the search channel forces the value specified by the LSM command.

Syntax

`LSV chnum,range,start,stop,step[,Icomp]`

Parameters

***chnum* :** Search source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Output ranging type. Integer expression. The output range will be set to the minimum range that covers both *start* and *stop* values. Range changing may cause 0 V output in a moment. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

***start*, *stop* :** Search start or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14. The *start* and *stop* parameters must have different values.

0 to ±100

0 to ±200 (for E5280B/E5290A)

***step* :** Step voltage (in V). Numeric expression.

If *start* < *stop*, *step* must be positive, and if *start* > *stop*, *step* must be negative. Maximum number of search steps is 1001.

***Icomp*:** Current compliance value (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not specify *Icomp*, the previous value is set. Zero amps (0 A) is not allowed for *Icomp*.

Example Statements

```
OUTPUT @E5270;"LSV 1,0,0,20,.5,1E-6"
```

LSVM

The LSVM command selects the data output mode for the linear search measurement.

Syntax

`LSVM mode`

Parameters

***mode* :** Data output mode. Integer expression. 0 (initial setting) or 1.

0 : Returns *Data_search* only.

1 : Returns *Data_search* and *Data_sense*.

where

Data_search is the value forced by the search output channel set by the LSV or LSI command.

Data_sense is the value measured by the search monitor channel set by the LGI or LGV command.

For data output format, refer to "Data Output Format" on page 1-22.

Example Statements

```
OUTPUT @E5270;"LSVM 1"
```

MCH

The MCH command selects the measurement channel for the data is displayed on the front panel LCD.

Syntax

`MCH chnum`

Parameters

***chnum* :** Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

Example Statements

```
OUTPUT @E5270;"MCH 1"
```

Command Reference

MM

The MM command specifies the measurement mode and the channels used for measurements. This command must be entered to specify the measurement mode. For the high speed spot measurements, do not enter the MM command.

Syntax

- For spot, staircase sweep, and multi channel sweep:

  `MM mode,chnum[,chnum[,chnum...[,chnum]...]]`

  A maximum of eight channels can be set.

- For pulsed spot, pulsed sweep, and staircase sweep with pulsed bias:

  `MM mode,chnum`

- For binary search and linear search:

  `MM mode`

- For quasi pulsed spot:

  `MM mode[,chnum]`

Parameters

mode : Measurement mode. Integer expression. 1 to 5, 9, and 14 to 16.

mode	Measurement mode	Related source setup command
1	Spot	DI, DV
2	Staircase sweep	WI, WV, WT, WM, WSI, WSV
3	Pulsed spot	PI, PV, PT
4	Pulsed sweep	PWI, PWV, PT, WM, WSI, WSV
5	Staircase sweep with pulsed bias	WI, WV, WM, WSI, WSV, PI, PV, PT
9	Quasi-pulsed spot	BDV, BDT, BDM
14	Linear search	LSV, LSI, LGV, LGI, LSM, LSTM, LSSV, LSSI, LSVM
15	Binary search	BSV, BSI, BGV, BGI, BSM, BST, BSSV, BSSI, BSVM
16	Multi channel sweep	WI, WV, WT, WM, WNX

chnum: Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

Command Reference

Remarks

The SMU operation mode is defined by the CMM command.

The measurement range is defined by the RI or RV command for the measurements except for the search measurement.

To execute the measurement, enter the XE command.

For the spot and staircase sweep measurements, if you use multiple measurement channels, the channels start measurement in the order defined in the MM command.

For the multi channel sweep measurement, if you use multiple measurement channels, the channels that use the fixed ranging mode start measurement simultaneously, then other channels start measurement in the order defined in the MM command. For the Keysight E5270B, note that the high-resolution ADC cannot perform simultaneous measurement.

For the quasi-pulsed spot measurement, if you do not specify *chnum*, the E5260/E5270 uses the channel specified by the BDV command to execute measurement.

For the quasi-pulsed spot measurement and the linear/binary search measurements, the time stamp function is not available. See "Data Output Format" on page 1-22.

Example Statements

```
OUTPUT @E5270;"MM 1,1"
OUTPUT @E5270;"MM 2,1,3"
```

MPA

The MPA command selects the data displayed in the measurement data display area on the front panel LCD.

The *RST command or the device clear sets the compliance side data only.

Syntax

MPA *item*

Parameters

***item* :** Measurement data displayed. Integer expression.

1: Compliance side data. Initial setting.

2: Compliance side data and force side data.

3: Resistance data. Displays "------" in the remote mode.

4: Power data. Displays "------" in the remote mode.

Command Reference

Example Statements

```
OUTPUT @E5270;"MPA 2"
```

Command Reference

NUB?

The NUB? query command checks the number of measurement data in the output data buffer, and stores the results in the output data buffer (query buffer).

Syntax `NUB?`

Query Response *`Number of measurement data`*`<CR/LF^EOI>`

Example Statements

```
OUTPUT @E5270;"NUB?"
ENTER @E5270;A
```

*OPC?

The *OPC? command monitors the pending operations, and places ASCII character `1` into the output queue when all pending operations are completed. Also this command sets/clears the operation complete (OPC) bit in the standard event status register as follows:

- If there are no pending operations, sets the OPC bit to 1.
- If there are any pending operations, sets the OPC bit to 0.
  The bit will be set to 1 when all pending operations are completed.

Syntax `*OPC?`

Query Response `1<CR/LF^EOI>`

No response will be returned until all pending operations are completed.

Example Statements

```
OUTPUT @E5270;"*OPC?"
ENTER @E5270;A
```

Command Reference

OS

The OS command causes the E5260/E5270 to send a edge trigger from the Ext Trig Out terminal. To set the trigger logic (initial value: negative), send the TGP command for the Ext Trig Out terminal.

Syntax

```
OS
```

Example Statements

```
OUTPUT @E5270;"OS"
```

OSX

The OSX command causes the E5260/E5270 to send a trigger from a trigger output terminal specified by the *port* parameter. To set the trigger logic (initial value: negative), send the TGP command for the specified port.

Syntax

OSX *port*[,*level*]

Parameters

***port* :** External trigger output port number. Integer expression. -2, or 1 to 16.

-2: Ext Trig Out terminal.

1 to 16: Port 1 to 16 of the digital I/O terminal.

To use a digital I/O port, send the TGP command. The *port* value must be same as the *port* value set to the TGP command.

***level* :** Trigger output level. Integer expression. 0, 1, or 2.

0: Logical low.

1: Logical high.

2: Edge trigger (default setting).

If *level* is not specified, the E5260/E5270 sends the edge trigger. For the gate trigger output, send OSX *port*,1 when starting trigger output, and send OSX *port*,0 when stopping trigger output.

Example Statements

```
OUTPUT @E5270;"OSX 1,1"
OUTPUT @E5270;"TI";1
ENTER @E5270 USING "#,3X,12D,X";Idata
OUTPUT @E5270;"OSX 1,0"
```

See Also

"TGP" and "TGPC"

Command Reference

PA

The PA command pauses the command execution or internal memory program execution, until the specified wait time has elapsed or until an event specified by the TM command is received. The event set by the TM command only releases the paused status. It does not start the measurement.

Syntax

`PA [wait time]`

Parameters

wait time **:** -99.9999 to 99.9999 seconds, with 100 µsec resolution. Numeric expression.

If *wait time* is not specified or negative *wait time* is set, the paused status is kept until receiving an event specified by the TM command.

Remarks

The TM3 command enables an external trigger from the Ext Trig In terminal as an event used to break the pause state set by the PA command.

The E5260/E5270 counts the *wait time* independent of the source wait time and the measurement wait time set by the WAT command. So the *wait time* can cover them as shown in the following program example:

```
OUTPUT @E5270;"CN";1
OUTPUT @E5270;"WAT";1,0,1E-3  !Source Wait Time =1ms
OUTPUT @E5270;"WAT";2,0,1E-3  !Meas Wait Time =1ms
OUTPUT @E5270;"DV";1,0,5,1E-2
OUTPUT @E5270;"PA";1E-3       !Wait Time =1ms
OUTPUT @E5270;"TI";1
ENTER @E5270 USING "#,3X,12D,X";Idata
```

Example Statements

```
OUTPUT @E5270;"PA 10"
```

See Also

"TM"

Command Reference

PAX

The PAX command pauses the command execution or internal memory program execution, until the specified wait time has elapsed or until an event specified by the TM command is received. The event set by the TM command only releases the paused status. It does not start the measurement.

Execution Conditions

The *port* parameter is meaningful only for the event (trigger input) set by the TM3 command. Set 1 (dummy) for the event set by the TM1, TM2, or TM4 command.

Syntax

`PAX port[,wait time]`

Parameters

***port* :** External trigger input port number. Integer expression. -1, or 1 to 16.

-1: Ext Trig In terminal.

1 to 16: Port 1 to 16 of the digital I/O terminal.

To use a digital I/O port, send the TGP command. The *port* value must be same as the *port* value set to the TGP command.

***wait time* :** -99.9999 to 99.9999 seconds, with 100 μsec resolution. Numeric expression.

If *wait time* is not specified or negative *wait time* is set, the paused status is kept until receiving an event specified by the TM command.

Remarks

The TM3 command enables an external trigger from a trigger input terminal specified by the *port* parameter as an event used to break the pause state set by the PA command.

The E5260/E5270 counts the *wait time* independent of the source wait time and the measurement wait time set by the WAT command. So the *wait time* can cover them as shown in the following program example:

```
OUTPUT @E5270;"CN";1
OUTPUT @E5270;"WAT";1,0,1E-3   !Source Wait Time =1ms
OUTPUT @E5270;"WAT";2,0,1E-3   !Meas Wait Time =1ms
OUTPUT @E5270;"DV";1,0,5,1E-2
OUTPUT @E5270;"PAX";-1,1E-3    !Wait Time =1ms
OUTPUT @E5270;"TI";1
ENTER @E5270 USING "#,3X,12D,X";Idata
```

Example Statements

```
OUTPUT @E5270;"PAX 1,10"
```

See Also

“TM”, “TGP”, and “TGPC”

Command Reference

PI

The PI command specifies the pulse current source and its parameters. This command also clears, and is cleared by, the PV command setting.

In the staircase sweep with pulsed bias measurement mode (set by the MM 5 command), the output forced by the PI command synchronized with the staircase sweep outputs forced by the WI or WV command.

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

Syntax

```
PI chnum,irange,base,pulse[,Vcomp]
```

Parameters

chnum : Pulsed source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

irange: Ranging type for pulse current output. Integer expression. The output range will be set to the minimum range that covers both *base* and *pulse* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

base, ***pulse*** : Pulse base current or pulse peak current (in A). Numeric expression. See Table 4-7 on page 4-15. *base* and *pulse* must have the same polarity.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Vcomp: Voltage compliance value (in V). Numeric expression. See Table 4-7 on page 4-15. If *Vcomp* is not specified, the previous value is set.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Vcomp*. If the output value is 0, the polarity is set to positive.

Example Statements

```
OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PI 1,16,0,5E-5,5"

OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PI 3,0,0,5E-6"
```

Command Reference

PT

The PT command sets the hold time, pulse width, and pulse period for a pulse source set by the PI, PV, PWI or PWV command. This command also sets the trigger delay time. Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

Syntax

For pulsed spot measurements:

`PT hold,width[,period[,Tdelay]]`

For pulsed sweep or staircase sweep with pulsed bias measurements:

`PT hold,width,period[,Tdelay]`

Parameters

hold **:** Hold time (in seconds). Numeric expression. 0 to 655.35 sec. 10 ms resolution. Initial setting = 0.

width **:** Pulse width (in seconds). Numeric expression. 0.5 ms to 2.0 s. 0.1 ms resolution. Initial setting = 1 ms.

period **:** Pulse period (in seconds). Numeric expression. 0, or 5 ms to 5.0 s. 0.1 ms resolution. Initial or default setting = 10 ms.

Restrictions:

- *period* ≥ *width* +2 ms (for *width* ≤ 100 ms)
- *period* ≥ *width* +10 ms (for *width* > 100 ms)

If you set *period* =0, the pulse period is automatically set as follows.

- *period* = 5 ms (for *width* ≤ 3 ms)
- *period* = *width* +2 ms (for 3 ms < *width* ≤ 100 ms)
- *period* = *width* +10 ms (for *width* > 100 ms)

If you do not specify *period*, 0 sec is set.

Tdelay **:** Trigger output delay time (in seconds). Numeric expression. 0 to *width* sec. 0.1 ms resolution. Default setting = 0.

This parameter is the time from pulse leading edge to timing of trigger output from a trigger output terminal. If you do not specify *Tdelay*, 0 is set.

Command Reference

PV

The PV command specifies the pulsed voltage source and its parameters. This command also clears, and is cleared by, the PI command setting.

In the staircase sweep with pulsed bias measurement mode (MM 5 command), the output forced by the PV command synchronized with the staircase sweep outputs forced by the WI or WV command.

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

Syntax

`PV` *`chnum,vrange,base,pulse`*`[,`*`Icomp`*`]`

Parameters

chnum **:** Pulsed source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***vrange*:** Ranging type for the pulsed voltage output. Integer expression. The output range will be set to the minimum range that covers both *base* and *pulse* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

base*, *pulse **:** Pulse base voltage or pulse peak voltage (in V). Numeric expression. See Table 4-6 on page 4-14.

0 to ±100, or 0 to ±200 for E5280B/E5290A

***Icomp*:** Current compliance value (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not set *Icomp*, the previous value is used.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Icomp*. If the output value is 0, the polarity is set to positive.

Example Statements

```
OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PV 1,12,0,5,1E-3"

OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PV 2,0,0,3"
```

Command Reference

PWI

The PWI command specifies the pulsed sweep current source and its parameters. This command clears the settings of the PWV, WSV and WSI commands.

The settings specified by this command are cleared by the PWV command.

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

Syntax

```
PWI chnum,mode,range,base,start,stop,step[,Vcomp]
```

Parameters

***chnum* :** Pulsed sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***mode* :** Sweep mode. Integer expression. 1 or 3.

1: Linear sweep (single stair, start to stop.)

3: Linear sweep (double stair, start to stop to start.)

***range* :** Ranging type for pulsed current sweep. Integer expression. The output range will be set to the minimum range that covers *base*, *start*, and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

***base*, *start*, *stop* :** Pulse base, start, or stop current (in A). Numeric expression. See Table 4-7 on page 4-15. *base*, *start* and *stop* must have the same polarity.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

***step* :** Number of steps for pulsed sweep. Numeric expression. 1 to 1001.

The E5260/E5270 can store approximately 16000 measurement data in ASCII format with header without source data, or approximately 64000 measurement data in binary format.

***Vcomp* :** Voltage compliance (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not specify *Vcomp*, the previous value is set.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Vcomp*. If the output value is 0, the polarity is set to positive.

Command Reference

Example Statements

```
OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PWI 1,1,0,0,0,0.1,101"

OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PWI 2,3,13,0,1E-7,1E-2,100,10"
```

Command Reference

PWV

The PWV command specifies the pulsed sweep voltage source and its parameters. This command also clears the settings of the PWI, WSV and WSI commands.

The settings specified by this command are cleared by the PWI command.

Measurement channel performs measurement so that the pulse width and pulse period are kept. The integration time is automatically set by the instrument, and you cannot change. For the Keysight E5270B, note that the high-resolution ADC cannot be used for the pulsed measurements. The AAD/AIT/AV/WT command settings are ignored.

Syntax

```
PWV chnum,mode,range,base,start,stop,step[,Icomp]
```

Parameters

chnum **:** Pulsed sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** Sweep mode. Integer expression. 1 or 3.

1: Linear sweep (single stair, start to stop.)

3: Linear sweep (double stair, start to stop to start.)

range**:** Ranging type for pulsed voltage sweep. Integer expression. The output range will be set to the minimum range that covers *base*, *start*, and *stop* values. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

base**,** ***start*****,** ***stop*** **:** Pulse base, start, or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14.

0 to ±100, or 0 to ±200 for E5280B/E5290A

step **:** Number of steps for pulsed sweep. Numeric expression. 1 to 1001.

The E5260/E5270 can store approximately 16000 measurement data in ASCII format with header without source data, or approximately 64000 measurement data in binary format.

Icomp **:** Current compliance (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not specify *Icomp*, the previous value is set.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Icomp*. If the output value is 0, the polarity is set to positive.

Command Reference

Example Statements

```
OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PWV 1,1,0,0,0,10,101"

OUTPUT @E5270;"PT 1,0.01"
OUTPUT @E5270;"PWV 2,3,14,0,1,10,100,0.1"
```

Command Reference

RCV

The RCV command enables the modules that fail the self-test or self-calibration so that it can receive commands again.

After the RCV command, enter the *OPC? command to confirm that the command execution is completed.

This command should only be used for servicing the E5260/E5270.

Syntax

```
RCV [slotnum]
```

Parameters

slotnum : Specifies the module to enable. Integer expression. 0 to 9.

0: All failed modules. Default setting.

1 to 8: Module installed in the slot specified by *slotnum*.

9: ADC module installed in the mainframe.

For HPSMU that uses two slots, set the greater slot number. For example, if it is installed in slot 3 and 4, *slotnum* must be 4.

If *slotnum* specifies the slot that installs no module, this command causes an error.

Example Statements

```
OUTPUT @E5270;"RCV 1"
OUTPUT @E5270;"*OPC?"
ENTER @E5270;A
```

RED

The RED command enables or disables the measurement data display and the setup data display in the remote mode.

The *RST command or the device clear disables the display.

Syntax

```
RED mode
```

Parameters

mode : Data display mode. Integer expression.

0: Disable.

1: Enable.

Example Statements

```
OUTPUT @E5270;"RED 1"
```

Command Reference

RI

The RI command specifies the current measurement range or ranging type. In the initial setting, the auto ranging is set. The range changing occurs immediately after the trigger (that is, during the measurements). Current measurement channel can be decided by the CMM command setting and the channel output mode (voltage or current).

For the high speed spot measurement, use the TI/TTI command.

The range setting is cleared by the CL, CA, IN, *TST?, *RST or a device clear (HP BASIC CLEAR) command.

Syntax

`RI chnum,range`

Parameters

***chnum* :** Current measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-3 on page 4-11.

For the measurement mode that uses pulse source, if you select the auto or limited auto ranging, the measurement channel uses the minimum range that covers the compliance value or current output range.

Example Statements

```
OUTPUT @E5270;"RI 1,0"

OUTPUT @E5270;"RI 2,-20"
```

NOTE

To use 1 pA range (only for E5270B)

The measurement channel connected to the ASU (Atto Sense and Switch Unit) supports the 1 pA range. To use the 1 pA range, set the 1 pA fixed range or the 1 pA limited auto ranging.

To enable the 1 pA range for the auto ranging mode, execute the SAR command.

Command Reference

RM

This command specifies the auto range operation for the current measurement.

Syntax

`RM chnum,mode[,rate]`

where the *rate* parameter is available for *mode*=2 or 3.

Parameters

***chnum* :** Current measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***mode* :** Range changing operation mode. Integer expression. 1, 2 or 3.

mode	Description
1	Initial setting. If you set *mode*=1, do not set *rate*.
2	If measured data ≥ *current1*, the range changes up after measurement.
3	If measured data ≤ *current2*, the range changes down immediately, and if measured data ≥ *current1*, the range changes up after measurement.

where *current1* and *current2* are given by the following formula:

$current1 = measurement\ range \times rate\ /100$
$current2 = measurement\ range \times rate\ /1000$

For 200 mA range, they must be:

$current1 = 200\ \mathrm{mA} \times rate\ /100$
$current2 = 100\ \mathrm{mA} \times rate\ /100$

For example, if *measurement range*=10 mA and *rate*=90, these values are as follows:

$current1 = 9\ \mathrm{mA}$
$current2 = 0.9\ \mathrm{mA}$

***rate*:** Parameter used to calculate the *current* value. Numeric expression. 11 to 100. Default value is 50.

Example Statements

```
OUTPUT @E5270;"RM 1,2"

OUTPUT @E5270;"RM 2,3,60"
```

Command Reference

*RST

The *RST command resets the E5260/E5270 to the initial settings. This command does not clear the program memory and the self calibration data.

Syntax

`*RST`

Remarks

If you want to reset channels while a sweep measurement is being performed, you must first send the AB command, then the *RST command.

Example Statement

```
OUTPUT @E5270;"*RST"
```

RU

The RU command sequentially executes the internal memory programs.

Execution Conditions

The specified programs have been stored by using the ST and END commands, from the start program number through the stop program number.

Syntax

RU *start*,*stop*

Parameters

start **:** Start program number. Numeric expression. 1 to 2000.

stop **:** Stop program number. Numeric expression. 1 to 2000.

where *stop* value must be greater than or equal to the *start* value.

Example Statements

```
OUTPUT @E5270;"RU 1,10"
OUTPUT @E5270;"RU 3,6"
```

Command Reference

RV

The RV command specifies the voltage measurement range or ranging type. In the initial setting, the auto ranging is set. The range changing occurs immediately after the trigger (that is, during the measurements). Voltage measurement channel can be decided by the CMM command setting and the channel output mode (voltage or current).

For the high speed spot measurement, use the TV/TTV command.

The range setting is cleared by the CL, CA, IN, *TST?, *RST or a device clear (HP BASIC CLEAR) command.

Syntax

`RV` *`chnum`*`,`*`range`*

Parameters

chnum **:** Voltage measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range **:** Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-2 on page 4-10.

For the measurement mode that uses pulse source, if you select the auto or limited auto ranging, the measurement channel uses the minimum range that covers the compliance value or voltage output range.

Example Statements

```
OUTPUT @E5270;"RV 2,-15"

OUTPUT @E5270;"RV 1,12"
```

Command Reference

RZ

The RZ command returns the channel to the settings that are stored by the DZ command and clears the stored settings.

The DZ command stores the channel settings (V/I output values, V/I output ranges, V/I compliance values, and series resistor setting), then sets the channel to 0 V.

Execution Conditions

The DZ command has been executed for the specified channel. And the CL, CA, *TST?, *RST or a device clear (HP BASIC CLEAR) command has not been executed for the specified channel.

Syntax

`RZ [`*`chnum`*`[,`*`chnum`*`...[,`*`chnum`*`]...]]`

A maximum of eight channels can be set.

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

If you do not specify this parameter, this command returns the settings for all channels that satisfy the conditions described in “Execution Conditions” above, in the order that the DZ command stored them.

You can specify up to eight channels at once using the RZ command. The E5260/E5270 returns the stored settings in the order specified.

Example Statements

```
OUTPUT @E5270;"RZ"

OUTPUT @E5270;"RZ 1,2,3"
```

SAL

The Keysight E5260 series does not support this command. This command is available for the Keysight E5270B installed with the high resolution SMU (HRSMU) and the Atto Sense and Switch Unit (ASU).

Disables or enables the connection status indicator (LED) of the ASU. This command is effective for the specified channel.

Syntax

`SAL` *`chnum,mode`*

Parameters

chnum **:** Slot number where the HRSMU has been installed. The ASU must be connected to the HRSMU. Integer expression. 1 to 8.

mode **:** 0: Disables the indicator.

1: Enables the indicator. Default setting.

Example Statements

```
OUTPUT @E5270;"SAL 1,0"
```

SAP

The Keysight E5260 series does not support this command. This command is available for the Keysight E5270B installed with the high resolution SMU (HRSMU) and the Atto Sense and Switch Unit (ASU). This command is not effective when the HIGH VOLTAGE indicator of the Keysight E5270B has been lighted.

Controls the connection path of the ASU. Switches the ASU input resource (HRSMU or the instrument connected to the AUX input) to be connected to the ASU output. This command is effective for the specified channel.

After the Keysight E5270B is turned on or the CL command is entered, the ASU output will be connected to the SMU connector side, but the HRSMU will not be enabled yet. After this command is entered with *path*=1, the HRSMU specified by *chnum* cannot be used. After this command is entered with *path*=0 or the CN command is entered, the HRSMU output will appear on the ASU output.Then the HRSMU output will be 0 V.

Syntax

`SAP` *`chnum,path`*

Parameters

chnum **:** Slot number where the HRSMU has been installed. The ASU must be connected to the HRSMU. Integer expression. 1 to 8.

path **:** 0: The ASU output will be connected to the SMU connector side.

Command Reference

1: The ASU output will be connected to the AUX connector side.

Example Statements

```
OUTPUT @E5270;"SAP 1,1"
```

NOTE

To use ASU

To use the ASU, connect it to the correct HRSMU properly before turning the Keysight E5270B on. For the connection, see *User's Guide*.

The ASU will add the connection switch function described above to the E5270B and the 1 pA measurement range to the HRSMU. Use the SAR function to enable/disable the 1 pA range for the auto ranging operation.

Remember that the series resistor in the HRSMU connected to the ASU cannot be used.

SAR

The Keysight E5260 series does not support this command. This command is available for the Keysight E5270B installed with the high resolution SMU (HRSMU) and the Atto Sense and Switch Unit (ASU).

Enables or disables the 1 pA range for the auto ranging operation. This command is effective for the specified channel only.

Syntax

`SAR` *`chnum`*`,`*`mode`*

Parameters

chnum **:** Slot number where the HRSMU has been installed. The ASU must be connected to the HRSMU. Integer expression. 1 to 8.

mode **:** 0: Enables 1 pA range for the auto ranging operation.

1: Disables 1 pA range for the auto ranging operation. Default setting.

Example Statements

```
OUTPUT @E5270;"SAR 1,0"
```

Command Reference

SCH

The SCH command selects the source channel for the data is displayed on the front panel LCD.

Syntax

`SCH` *`chnum`*

Parameters

***chnum* :** Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

Example Statements

```
OUTPUT @E5270;"SCH 1"
```

SCR

The SCR command scratches the specified program from the internal program memory.

Syntax

`SCR [`*`pnum`*`]`

Parameters

***pnum* :** Program number. Numeric expression. 1 to 2000.
If you do not specify this parameter, this command scratches all programs stored in the internal program memory.

Example Statements

```
OUTPUT @E5270;"SCR"
OUTPUT @E5270;"SCR 5"
```

Command Reference

SPA

The SPA command selects the parameter displayed in the source data display area on the front panel LCD.

The *RST command or the device clear sets the source force value in the first line and the source compliance value in the second line.

Syntax

`SPA line,item`

Parameters

line **:** Line or position the parameter value is displayed. Integer expression.

1: First line.

2: Second line.

item **:** Parameter displayed on the line specified by *line*. Integer expression.

item	Description
1	Source force value.
2	Source compliance value.
3	Voltage measurement range value.
4	Current measurement range value.
5	Latest error code or error number.

Example Statements

```
OUTPUT @E5270;"SPA 1,1"
OUTPUT @E5270;"SPA 2,5"
```

Command Reference

*SRE

The *SRE command enables the specified bits of the status byte register for SRQ (service requests), and masks (disables) the bits that are not specified.

Syntax

`*SRE bit`

Parameters

***bit* :** Sum of the decimal values corresponding to the bits to be enabled. Integer expression. 0 to 255. See the following table.

For example, to enable Bit 0, 4, and 7 for the SRQ, the *bit* value must be 145 (1 + 16 + 128).

If *bit*=0, all bits, except for Bit 6, will be masked (disabled for the SRQ). You cannot mask bit 6.

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
64	Bit 6	RQS
128	Bit 7	Shut Down

Example Statements

```
OUTPUT @E5270;"*SRE 6"
OUTPUT @E5270;"*SRE 128"
```

Command Reference

*SRE?

The *SRE? query command returns information about which bits of the status byte register are enabled for the SRQ (service requests), and stores the results in the output data buffer (query buffer).

Syntax

```
*SRE?
```

Query Response

enabled_bits<CR/LF^EOI>

enabled_bits are represented by the corresponding decimal values shown below.

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
64	Bit 6	RQS
128	Bit 7	Shut Down

For example, if Bit 0, 3, and 4 are enabled for the SRQ, 25 (1 + 8 + 16) will be returned. If all bits, except for Bit 6, are masked, *enabled_bits* will be 0.

Example Statements

```
OUTPUT @E5270;"*SRE?"
ENTER @E5270;A
```

Command Reference

SSR

This command sets the connection mode of a series resistor (approx. 1 MΩ) for each channel.

If the output switch is opened, the SSR command just sets the mode, and the CN command connects or disconnects the series resistor.

If the output switch is already closed, the SSR command connects the series resistor to the SMU output. Then the output forces 0 V one moment.

A series resistor is mounted on each module. If you use a series resistor, the voltage you set is applied to the near side of the series resistor. Thus, the voltage will be divided by the series resistor and the device under test.

Execution Conditions

The series resistor cannot be used for the measurements that use the high resolution SMU (HRSMU) connected to the Atto Sense and Switch Unit (ASU) or the measurements that use 1 A range of the high power SMU (HPSMU).

The channel must not be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V).

Syntax

`SSR chnum,mode`

Parameters

chnum **:** Channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** Status of the series resistor. Integer expression.

0: Disconnect (initial setting).

1: Connect.

Example Statements

```
OUTPUT @E5270;"SSR 1,1"

OUTPUT @E5270;"SSR 2,1"
```

ST

The ST command is used with the END command to store a program in the internal program memory that can store 2,000 programs maximum, and a total of 40,000 commands.

The ST command indicates the start of the program, and assigns the program number. If the assigned program number already exists, the E5260/E5270 deletes the old program, and stores the new one.

The END command indicates the end of the program. If the END command is not included, the E5260/E5270 stores the commands until the program memory is full.

Use the DO or RU command to execute stored programs.

Syntax

```
STpnum[;command[;command...[;command]...];END
```

or

```
ST pnum
[command]
[command]
    :
    :
[command]
END
```

Parameters

pnum **:** Program number. Integer expression. 1 to 2000.

command **:** Command stored in the internal program memory. Specify commands according to normal syntax – no special syntax is necessary.

For the commands that cannot stored in the program memory, refer to Table 2-1 on page 2-26.

Example Statements

Example 1:

```
OUTPUT @E5270;"ST1;CN1;DV1,0,5,1E-4;TI1,0;CL1"
OUTPUT @E5270;"END"
```

Example 2:

```
OUTPUT @E5270;"ST 1"
OUTPUT @E5270;"CN 1"
OUTPUT @E5270;"DV 1,0,5,1E-4"
OUTPUT @E5270;"TI 1,0"
OUTPUT @E5270;"CL 1"
OUTPUT @E5270;"END"
```

Command Reference

*STB?

The *STB? query command stores the decimal representation of the status byte in the output data buffer (query buffer).

The *STB? command is functionally identical to the SPOLL command of BASIC, however this command does not clear the status byte (the SPOLL command clears the status byte).

Syntax

```
*STB?
```

Query Response

status_byte<CR/LF^EOI>

status_byte value is a decimal number that indicates which bits of the status byte are ON (“1”).

For example, if *status_byte* is 40 (8 + 32), then Bit 3 and 5 are set to 1.

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
64	Bit 6	RQS
128	Bit 7	Shut Down

Example Statements

```
OUTPUT @E5270;"*STB?"
ENTER @E5270;A
```

Command Reference

TDI

Forces current and returns the time data from when the timer is cleared until output is started. This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Execution Conditions

The CN command has been executed for the specified channel.

If the voltage compliance is greater than ±42 V, the interlock circuit must be shorted.

Syntax

`TDI chnum,irange,current[,Vcomp[,comp_polarity[,vrange]]]`

Parameters

chnum : Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

irange: Ranging type for current output. Integer expression. The output range will be set to the minimum range that covers *current* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

current: Output current value (in A). Numeric expression. See Table 4-7 on page 4-15.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Vcomp: Voltage compliance value (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not specify this parameter, *Vcomp* is set to the previous setting.

comp_polarity: Polarity of voltage compliance. Numeric expression.

0: Auto mode (default setting). The compliance polarity is automatically set to the same polarity as *current*, regardless of the specified *Vcomp*. If *current*=0 A, the polarity is set to positive.

1: Manual mode. Uses the polarity of *Vcomp* you specified.

vrange: Voltage compliance ranging type. Integer expression. The compliance range will be set to the minimum range that covers *Vcomp* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

Example Statements

```
OUTPUT @E5270;"TDI 1,0,1E-6"
ENTER @E5270 USING "#,5X,13D,X";Time
```

Command Reference

TDV

Forces voltage and returns the time data from when the timer is cleared until output is started. This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Execution Conditions

The CN command has been executed for the specified channel.

If the output voltage is greater than ±42 V, the interlock circuit must be shorted.

Syntax

`TDV chnum,vrange,voltage[,Icomp[,comp_polarity[,irange]]`

Parameters

***chnum* :** Source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***vrange*:** Ranging type for voltage output. Integer expression. The output range will be set to the minimum range that covers *voltage* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-4 on page 4-13.

***voltage*:** Output voltage value (in V). Numeric expression. See Table 4-6 on page 4-14.

0 to ±100, or 0 to ±200 for E5280B/E5290A

***Icomp*:** Current compliance value (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not set *Icomp*, the previous value is used. 0 A is not allowed for *Icomp*.

***comp_ polarity*:** Polarity of current compliance. Integer expression.

0: Auto mode (default setting). The compliance polarity is automatically set to the same polarity as *voltage*, regardless of the specified *Icomp*. If *voltage*=0 V, the polarity is set to positive.

1: Manual mode. Uses the polarity of *Icomp* you specified.

***irange*:** Current compliance ranging type. Integer expression. The compliance range will be set to the minimum range that covers *Icomp* value. For the limited auto ranging, the instrument never uses the range less than the specified range. See Table 4-5 on page 4-13.

Example Statements

```
OUTPUT @E5270;"TDV 1,0,20,1E-6,0,15"
ENTER @E5270 USING "#,5X,13D,X";Time
```

TGMO

The TGMO command selects the edge trigger or the gate trigger for the Step Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,3` command. See Figure 4-2.

This command is available for the staircase sweep and multi channel sweep measurements.

Syntax

`TGMO` *`mode`*

Parameters

***mode* :** Edge trigger or gate trigger. Integer expression.

1: Edge trigger (initial setting).

2: Gate trigger.

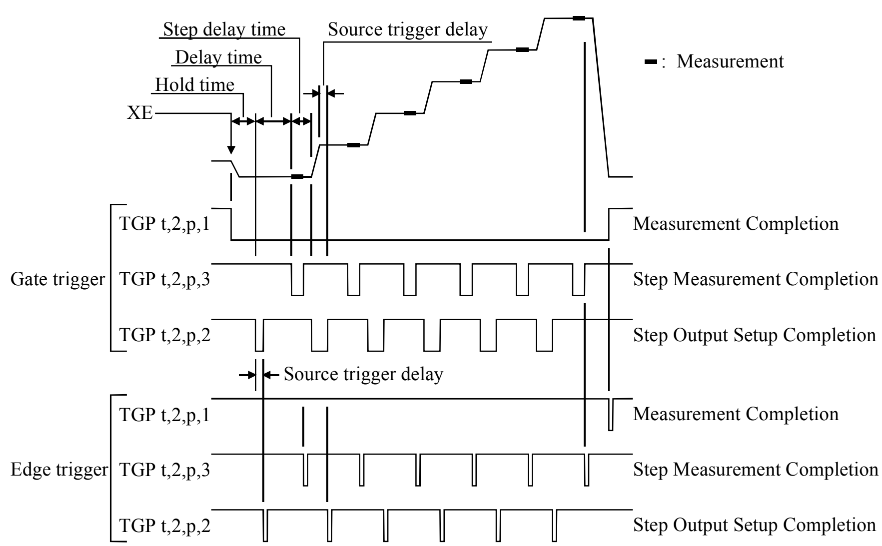
Example Statements

```
OUTPUT @E5270;"TGMO 2"
```

See Also

"TGP" and "TGPC"

Figure 4-2 **Trigger Output Example, Staircase Sweep Measurement, Negative Logic**



Command Reference

TGP

The TGP command enables the trigger function for the terminal specified by the *port* parameter. For the trigger function, refer to "Trigger Function" on page 2-30.

Syntax

`TGP port,terminal,polarity[,type]`

Parameters

port **:** Trigger port number. Integer expression. -1, -2, or 1 to 16.

-1: Ext Trig In terminal.

-2: Ext Trig Out terminal.

1 to 16: Port 1 to 16 of the digital I/O terminal.

terminal **:** Terminal type. Integer expression. 1 or 2.

1: Trigger input. Not available for *port*=-2.

2: Trigger output. Not available for *port*=-1.

polarity **:** Trigger logic. Integer expression. 1 or 2.

1: Positive logic.

2: Negative logic.

type **:** Trigger type. Integer expression. 0, 1, 2, or 3. Selects the function of the trigger port. See Table 4-12.

If this parameter is not specified, *type* is set to 0.

Remarks

The function of type=0 is effective for all trigger ports regardless of the *type* value. Then the PA and WS commands are used for the Ext Trig In terminal, and the OS command is used for the Ext Trig Out terminal. Also the PAX and WSX commands are used for the trigger input ports set by the TGP command, and the OSX command is used for the trigger output ports set by the TGP command.

type=1 to 3 is available for a port only. If you send the command with the same *type* more than once, only the last command is effective. *type*=0 is set for another ports.

If you send the TGP command with *terminal*=1 and *port*=1 to 16, the signal level of the trigger input terminal is set to physical high.

If you send the TGP command with *terminal*=2, the signal level of the trigger output terminal is set to logical low.

Command Reference

Table 4-12 Trigger Type

type	*terminal*	**Description**
0	1	When a trigger is received, the E5260/E5270 recovers from the wait state set by the PA, PAX, WS, or WSX command.
	2	The E5260/E5270 sends a trigger by the OS or OSX command.
1 [a]	1	Start measurement trigger When a trigger is received, the E5260/E5270 starts the measurement.
	2	Measurement completion trigger The E5260/E5270 sends a trigger after measurement.
2	1	Start step output setup trigger When a trigger is received, the E5260/E5270 starts the output setup at each sweep step or the pulsed output setup. This function is available for the staircase sweep, pulsed sweep, staircase sweep with pulsed bias, multi channel sweep, or pulsed spot measurement.
	2	Step output setup completion trigger The E5260/E5270 sends a trigger when the output setup is completed at each sweep step or the pulsed output setup is completed. This function is available for the staircase sweep, pulsed sweep, staircase sweep with pulsed bias, multi channel sweep, or pulsed spot measurement.
3	1	Start step measurement trigger When a trigger is received, the E5260/E5270 starts the measurement at each sweep step. This function is available for the staircase sweep or multi channel sweep measurement.
	2	Step measurement completion trigger The E5260/E5270 sends a trigger after measurement at each sweep step. This function is available for the staircase sweep or multi channel sweep measurement.

a. TM3 command must be entered to use this trigger type.

Example Statements

```
OUTPUT @E5270;"TGP 1,1,1,2"
```

See Also

See Figure 4-2 on page 4-113 for a trigger output example and Figure 4-3 on page 4-117 for a trigger input example.

Command Reference

TGPC

The TGPC command clears the trigger setting of the specified ports.

Syntax

```
TGPC [port[,port...[,port]...]]
```

A maximum of 18 ports can be set. If no port is specified, the TGPC command clears the setting of the all ports; Ext Trig In, Ext Trig Out, and digital I/O ports 1 to 16.

Parameters

port **:** Trigger port number. Integer expression. -1, -2, or 1 to 16.

-1: Ext Trig In terminal.

-2: Ext Trig Out terminal.

1 to 16: Port 1 to 16 of the digital I/O terminal.

Remarks

The TGPC command sets the trigger ports as shown below.

Ext Trig In	Same as after TGP -1,1,2,0 command execution.
Ext Trig Out	Same as after TGP -2,2,2,0 command execution.
Digital I/O Ports	No trigger function is available. The ERS? and ERC commands are available for the port control.

This is not same as the condition set by the *RST command that sets the ports as shown below.

Ext Trig In	Same as after TGP -1,1,2,1 command execution.
Ext Trig Out	Same as after TGP -2,2,2,1 command execution.
Digital I/O Ports	No trigger function is available. The ERS? and ERC commands are available for the port control.

Example Statements

```
OUTPUT @E5270;"TGPC -1,-2,1,2"
```

See Also

"TGP"

Command Reference

TGSI

The TGSI command selects Case 1 or Case 2 effective for the Start Step Output Setup trigger input set by the `TGP` *port*`,1,`*polarity*`,2` command.

This command is available for the staircase sweep, pulsed spot, pulsed sweep, staircase sweep with pulsed bias, and multi channel sweep measurements.

Syntax

`TGSI mode`

Parameters

mode **:** Case 1 or Case 2. Integer expression. See Figure 4-3.

1: Case 1 (initial setting).

2: Case 2.

Case 1 waits for a trigger for the first sweep step, and does not wait for a trigger for the source output after sweep.

Case 2 does not wait for a trigger for the first sweep step, and waits for a trigger for the source output after sweep.

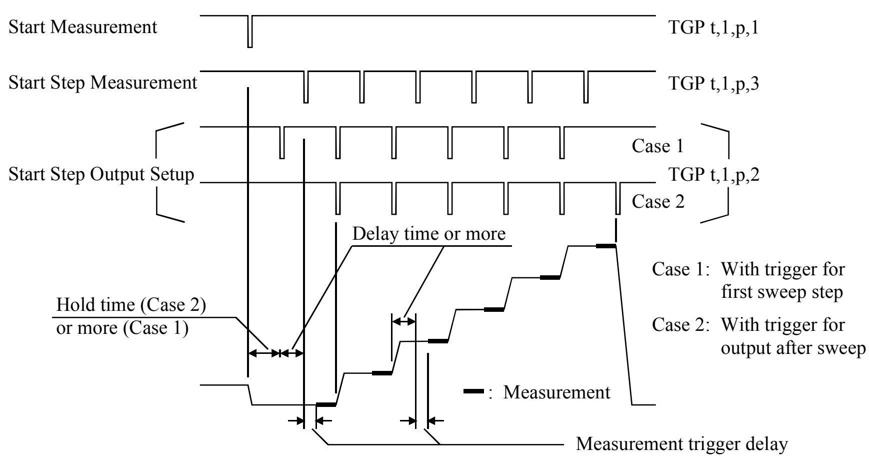
Example Statements

```
OUTPUT @E5270;"TGSI 2"
```

See Also

"TGP" and "TGPC"

Figure 4-3 **Trigger Input Example, Staircase Sweep Measurement, Negative Logic**



Command Reference

TGSO

The TGSO command selects the edge trigger or the gate trigger for the Step Output Setup Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,2` command. See Figure 4-2 on page 4-113

This command is available for the staircase sweep, pulsed spot, pulsed sweep, staircase sweep with pulsed bias, and multi channel sweep measurements.

Syntax

`TGSO` *mode*

Parameters

mode **:** Edge trigger or gate trigger. Integer expression.

1: Edge trigger (initial setting).

2: Gate trigger.

Example Statements

```
OUTPUT @E5270;"TGSO 2"
```

See Also

"TGP" and "TGPC"

TGXO

The TGXO command selects the edge trigger or the gate trigger for the Measurement Completion trigger output set by the `TGP` *port*`,2,`*polarity*`,1` command. See Figure 4-2 on page 4-113

Syntax

`TGXO` *mode*

Parameters

mode **:** Edge trigger or gate trigger. Integer expression.

1: Edge trigger (initial setting).

2: Gate trigger.

Example Statements

```
OUTPUT @E5270;"TGXO 2"
```

See Also

"TGP" and "TGPC"

Command Reference

TI

The TI command performs the high speed spot measurement, and returns the measurement data. The command starts a current measurement regardless of the SMU operation mode, trigger mode (TM command), and measurement mode (MM command).

Execution Conditions

CN command has been executed for the specified channel.

Syntax

`TI chnum[,range]`

Parameters

chnum : Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range : Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-3 on page 4-11.

If you do not specify the *range* parameter for voltage output channels, the channel uses the minimum range that covers the compliance value.

The *range* parameter is meaningless for current output channels. The measurement ranging type is always same as the output ranging type.

Example Statements

```
OUTPUT @E5270;"TI 1"
ENTER @E5270 USING "#,3X,12D,X";Idata
```

NOTE

To use 1 pA range (only for E5270B)

The measurement channel connected to the ASU (Atto Sense and Switch Unit) supports the 1 pA range. To use the 1 pA range, set the 1 pA fixed range or the 1 pA limited auto ranging.

To enable the 1 pA range for the auto ranging mode, execute the SAR command.

Command Reference

TM

The TM command specifies how events are effective for the following actions:

- Releasing the E5260/E5270 from the paused status set by the PA or PAX command
- Starting the measurement except for high speed spot measurement (when the E5260/E5270 is not in the paused status set by the PA, PAX, WS, or WSX command)

Syntax

`TM mode`

Parameters

***mode* :** Event mode. Integer expression. See below.

mode	Events
1	XE command and GPIB GET (Group Execute Trigger, TRIGGER command in HP BASIC). Initial setting.
2	XE command
3	XE command and external trigger
4	XE command and MM command (automatic trigger after the MM command execution)

To enable the trigger function set by the TGP *port*,*terminal*,*polarity*,1 command, the *mode* value must be 3.

Remarks

In the TM3 event mode, if the E5260/E5270 is not in the wait status set by the PA, PAX, WS, or WSX command, the E5260/E5270 can start the measurement by an external trigger input. After measurement, the E5260/E5270 sends a trigger to a trigger output terminal. In the initial setting, you can use the Ext Trig In and Out terminals. To use the digital I/O port, enter the TGP command to set the trigger input or output terminal.

To set the trigger logic (initial value: negative), send the TGP command for the trigger input terminal.

Example Statements

```
OUTPUT @E5270;"TM 1"
OUTPUT @E5270;"TM 3"
```

See Also

“PA”, “PAX”, “TGP”, “TGPC”, “WS”, and “WSX”

TSC

The TSC command enables or disables the time stamp function.

This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Execution Conditions

Time stamp function is not available for the following measurement modes:

- Quasi-pulsed spot measurement (MM 9)
- Linear search measurement (MM 14)
- Binary search measurement (MM 15)

Syntax

```
TSC mode
```

Parameters

mode : Time stamp function mode. Integer expression.

mode	Description
0	Disables the time stamp function. Initial setting.
1	Enables the time stamp function.

When the function is enabled, the E5260/E5270 returns the time data with the measurement data. The time data is the time from when the timer is cleared until the measurement is started. Refer to "Data Output Format" on page 1-22.

Remarks

To read the time data with the best resolution (100 µs), the timer must be cleared every 100 sec or less for the FMT1, 2, or 5 data output format, or every 1000 sec or less for the FMT 11, 12, 15, 21, 22, or 25 data output format.

Example Statements

```
OUTPUT @E5270;"TSC 1"
```

Command Reference

TSQ

The TSQ command returns the time data from when the TSR command is sent until this command is sent. The time data will be put in the data output buffer as same as the measurement data.

This command is effective for all measurement modes, regardless of the TSC setting.

This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Syntax

```
TSQ
```

Example Statements

```
OUTPUT @E5270;"TSQ"
ENTER @E5270 USING "#,5X,13D,X";Time
PRINT "Time=";Time;"s"
```

TSR

The TSR command clears the timer count.

This command is effective for all measurement modes, regardless of the TSC setting.

This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Syntax

```
TSR
```

Remarks

To read the time data with the best resolution (100 µs), the timer must be cleared every 100 sec or less for the FMT1, 2, or 5 data output format, or every 1000 sec or less for the FMT 11, 12, 15, 21, 22, or 25 data output format.

Example Statements

```
OUTPUT @E5270;"TSR"
```

Command Reference

*TST?

The *TST? query command performs the self-test and self-calibration, and returns the results in ASCII format. Modules that fail the self-test are disabled, and can only be enabled by the RCV command.

After the *TST? command, read the results soon.

Execution Conditions

No module may be in the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V).

To perform the self-test correctly, the measurement terminals should be opened.

Syntax

`*TST? [slotnum]`

Parameters

slotnum **:** Specifies the module to test. Integer expression. 0 to 9.

0: Mainframe and all modules. Default setting.

1 to 8: Module installed in the slot specified by *slotnum*.

9: Mainframe.

For HPSMU that uses two slots, set the greater slot number. For example, if it is installed in slot 3 and 4, *slotnum* must be 4.

If *slotnum* specifies the slot that installs no module, this command causes an error.

Query Response

results<CR/LF^EOI>

results returns the sum of the following values corresponding to the failures.

results	**Description**	***results***	**Description**
0	Passed. No failure detected.	16	Slot 5 module failed.
1	Slot 1 module failed.	32	Slot 6 module failed.
2	Slot 2 module failed.	64	Slot 7 module failed.
4	Slot 3 module failed.	128	Slot 8 module failed.
8	Slot 4 module failed.	256	Mainframe failed.

Example Statements

```
OUTPUT @E5270;"*TST?"
ENTER @E5270;A
```

Command Reference

TTI

The TTI command performs the high speed spot measurement, and returns the measurement data and the time data for the time from when the timer is cleared until the measurement is started. The command starts a current measurement regardless of the SMU operation mode, trigger mode (TM command), and measurement mode (MM command).

This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Execution Conditions

CN command has been executed for the specified channel.

Syntax

`TTI chnum[,range]`

Parameters

chnum **:** Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range **:** Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-3 on page 4-11.

If you do not specify the *range* parameter for voltage output channels, the channel uses the minimum range that covers the compliance value.

The *range* parameter is meaningless for current output channels. The measurement ranging type is always same as the output ranging type.

NOTE

To use 1 pA range (only for E5270B)

The measurement channel connected to the ASU (Atto Sense and Switch Unit) supports the 1 pA range. To use the 1 pA range, set the 1 pA fixed range or the 1 pA limited auto ranging.

To enable the 1 pA range for the auto ranging mode, execute the SAR command.

Command Reference

Remarks

To read the time data with the best resolution (100 μs), the timer must be cleared every 100 sec or less for the FMT1, 2, or 5 data output format, or
every 1000 sec or less for the FMT 11, 12, 15, 21, 22, or 25 data output format.

Example Statements

```
OUTPUT @E5270;"TTI 1"
ENTER @E5270 USING "#,5X,13D,X";Time
ENTER @E5270 USING "#,5X,13D,X";Idata
PRINT "Data=";Idata*1000;"mA, at";Time;"s"
```

Command Reference

TTV

The TTV command performs the high speed spot measurement, and returns the measurement data and the time data for the time from when the timer is cleared until the measurement is started. The command starts a voltage measurement regardless of the SMU operation mode, trigger mode (TM command), and measurement mode (MM command).

This command is effective for ASCII data output format. Refer to "FMT" on page 4-59.

Execution Conditions

CN command has been executed for the specified channel.

Syntax

`TTV chnum[,range]`

Parameters

chnum **:** Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range **:** Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-2 on page 4-10.

If you do not specify the *range* parameter for current output channels, the channel uses the minimum range that covers the compliance value.

The *range* parameter is meaningless for voltage output channels. The measurement ranging type is always same as the output ranging type.

Remarks

To read the time data with the best resolution (100 µs), the timer must be cleared every 100 sec or less for the FMT1, 2, or 5 data output format, or
every 1000 sec or less for the FMT 11, 12, 15, 21, 22, or 25 data output format.

Example Statements

```
OUTPUT @E5270;"TTV 1"
ENTER @E5270 USING "#,5X,13D,X";Time
ENTER @E5270 USING "#,5X,13D,X";Vdata
PRINT "Data=";Vdata*1000;"mV, at";Time;"s"
```

Command Reference

TV

The TV command performs the high speed spot measurement, and returns the measurement data. The command starts a voltage measurement regardless of the SMU operation mode, trigger mode (TM command), and measurement mode (MM command).

Execution Conditions

CN command has been executed for the specified channel.

Syntax

TV *chnum*[,*range*]

Parameters

chnum : Measurement channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

range : Measurement range or ranging type. Integer expression. If you select the fixed range, the instrument performs measurement by using the specified range. For the auto or limited auto ranging, the measurement range will be set to the minimum range that covers the measured values. However, the instrument never uses the range less than the specified range for the limited auto ranging. See Table 4-2 on page 4-10.

If you do not specify the *range* parameter for current output channels, the channel uses the minimum range that covers the compliance value.

The *range* parameter is meaningless for voltage output channels. The measurement ranging type is always same as the output ranging type.

Example Statements

```
OUTPUT @E5270;"TV 1"
ENTER @E5270 USING "#,3X,12D,X";Vdata
```

Command Reference

UNT?

This query command returns the model and revision numbers of all modules in the E5260/E5270, and stores the results in the E5260/E5270 output data buffer (query buffer).

Syntax

`UNT? [`*`mode`*`]`

Parameters

mode **:** Response type. Integer expression.

0: Returns information for all modules.

1: Returns information for all modules with control unit.

If you do not specify this parameter, the *mode* is set to 0.

Query Response

```
part number of control unit,revision number of control unit;
model number at slot 1,revision number at slot 1;
        ......                  ......
model number at slot 8,revision number at slot 8<CR/LF^EOI>
```

For *mode*=0, ignore the first line shown above. The E5260/E5270 does not return the information of the control unit.

Example Statements

```
DIM A$[50]
OUTPUT @E5270;"UNT?"
ENTER @E5270;A$
```

Command Reference

VAR

This command defines the Keysight E5260/E5270 internal variable, and sets the value. The variable name is automatically assigned by using the parameters you specify.

Syntax

`VAR` *`type`*`,`*`n`*`,`*`value`*

Parameters

type **:** Variable type. Integer expression. 0 or 1.

0: Integer variable. Variable name will be %I*n*.

1: Real variable. Variable name will be %R*n*.

n **:** Number *n* added to the variable name. Integer expression. 0 to 99.

value **:** Value entered in the variable. Numeric value. The value must be 6 digits or less. Available values are as follows:

For integer variables: -999999 to 999999

For real variables: -9999.9 to 9999.9

Example Statements

```
OUTPUT @E5270;"ST1;CN1;DV1,0,%R99,1E-4;TI1,0"
OUTPUT @E5270;"END"
OUTPUT @E5270;"VAR 1,99,2.5"
```

This example sets 2.5 to the real variable %R99.

VAR?

Returns the value of the variable set by the VAR command.

Syntax

`VAR?` *`type`*`,`*`n`*

Parameters

type **:** Variable type. Integer expression. 0 or 1.

0: Integer variable. For the variable %I*n*.

1: Real variable. For the variable %R*n*.

n **:** Number *n* added to the variable name. Integer expression. 0 to 99.

Query Response

value<CR/LF^EOI>

Example Statements

```
OUTPUT @E5270;"VAR? 1,99"
ENTER @E5270;A$
```

This example reads the %R99 real variable value.

Command Reference

WAT

This command sets the source wait time and the measurement wait time as shown in Figure 4-4. The wait time is given by the following formula:

$$wait\ time = N \times initial\ wait\ time + offset$$

where *initial wait time* is the time the Keysight E5260/E5270 initially sets and you cannot change. The *initial source wait time* is not same as the *initial measurement wait time*. The wait time settings are effective for all modules.

Syntax

`WAT type,N[,offset]`

Parameters

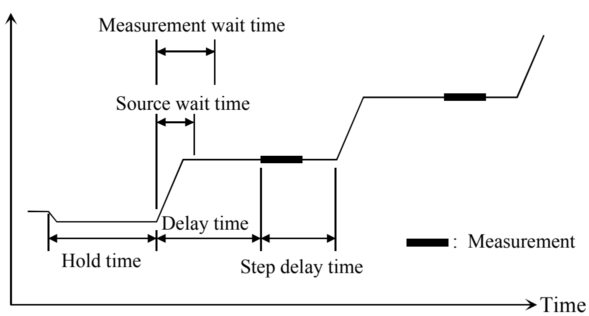
type	Type of the wait time. Integer expression. 1 or 2. 1: Source wait time (before changing the output value). 2: Measurement wait time (before starting the measurement).
N	Coefficient for *initial wait time*. Numeric expression. 0 to 10, resolution 0.1. Initial value is 1.
offset	Offset for the wait time. Numeric expression. 0 to 1 sec, resolution 0.0001. Default value is 0.

Example Statements

```
OUTPUT @E5270;"WAT 1,.7"

OUTPUT @E5270;"WAT 2,0,.01"
```

Figure 4-4 **Source/Measurement Wait Time**



NOTE The wait time can be ignored if it is shorter than the delay time.

Command Reference

NOTE

It is not easy to determine the best wait time. If you specify it too short, the measurement may start before device characteristics stable. If too long, time will be wasted.

The initial wait time may be too short for measurements of high capacitance or slow response devices. Then set the wait time longer.

For measurements of low capacitance or fast response devices, if measurement speed has top priority or is more important than reliability and accuracy, set the wait time shorter.

Command Reference

WI

The WI command specifies the staircase sweep current source and its parameters. This command also clears the WV, WSV, WSI, and WNX command settings.

This command setting is cleared by the WV command.

Syntax

- For Staircase Sweep Measurement:

  `WI chnum,mode,range,start,stop,step[,Vcomp[,Pcomp]]`

- For Staircase Sweep with Pulsed Bias Measurement:

  `WI chnum,mode,range,start,stop,step[,Vcomp]`

Parameters

chnum **:** Sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** Sweep mode. Integer expression. Only linear sweep (*mode*=1 or 3) is available for the staircase sweep with pulsed bias.

1: Linear sweep (single stair, start to stop.)

2: Log sweep (single stair, start to stop.)

3: Linear sweep (double stair, start to stop to start.)

4: Log sweep (double stair, start to stop to start.)

range **:** Ranging type for staircase sweep current output. Integer expression. See Table 4-5 on page 4-13.

For the linear sweep, the E5260/E5270 uses the minimum range that covers both *start* and *stop* values to force the staircase sweep current.

For the log sweep, the E5260/E5270 uses the minimum range that covers the output value, and changes the output range dynamically.

For the limited auto ranging, the instrument never uses the range less than the specified range.

start**,** ***stop*** **:** Start or stop current (in A). Numeric expression. See Table 4-7 on page 4-15. *start* and *stop* must have the same polarity for *log* sweep.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

Command Reference

step **:** Number of steps for staircase sweep. Numeric expression. 1 to 1001.

The E5260/E5270 can store approximately 16000 measurement data in ASCII format with header without source data, or approximately 64000 measurement data in binary format.

Vcomp **:** Voltage compliance (in V). Numeric expression. See Table 4-7.

If you do not set *Vcomp*, the previous value is used.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Vcomp*. If the output value is 0, the polarity is set to positive.

If you set *Pcomp*, the maximum *Vcomp* value for the module is allowed, regardless of the output range setting.

For the log sweep and without *Pcomp*, set the value available for the minimum range that covers *start* and *stop* values.

Pcomp **:** Power compliance (in W). Numeric expression. Resolution: 0.001 W. If the *Pcomp* value is not entered, the power compliance is not set.

0.001 to 2, 0.001 to 4 for E5291A, or 0.001 to 20 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"WI 1,1,11,0,0.1,100,10,1"
OUTPUT @E5270;"WI 2,2,15,1E-6,0.1,100"
```

Command Reference

WM

The WM command enables or disables the automatic abort function for the staircase sweep sources and the pulsed sweep source. The automatic abort function stops the measurement when one of the following conditions occurs:

- Compliance on the measurement channel
- Compliance on the non-measurement channel
- Overflow on the AD converter
- Oscillation on any channel

This command also sets the post measurement condition for the sweep sources. After the measurement is normally completed, the staircase sweep sources force the value specified by the *post* parameter, and the pulsed sweep source forces the pulse base value.

If the measurement is stopped by the automatic abort function, the staircase sweep sources force the start value, and the pulsed sweep source forces the pulse base value after sweep.

Syntax

`WM` *`abort`*`[,`*`post`*`]`

Parameters

abort **:** Automatic abort function. Integer expression.

1: Disables the function. Initial setting.

2: Enables the function.

post **:** Source output value after the measurement is normally completed. Integer expression.

1: Start value. Initial setting.

2: Stop value.

If this parameter is not specified, the sweep sources force the start value.

Output Data

The E5260/E5270 returns the data measured before any abort condition is detected. Dummy data 199.999E+99 will be returned for the data after abort.

Example Statements

```
OUTPUT @E5270;"WM 2"
OUTPUT @E5270;"WM 2,2"
```

Command Reference

WNU?

The WNU? query command returns the number of sweep steps specified by the sweep command (WI, WV, PWI or PWV), and stores the results in the output data buffer (query buffer).

Execution Conditions

If you want to know the number of steps for a pulsed sweep, you must execute an “MM 4” command before using this command, otherwise the number of steps for the staircase sweep is reported.

Syntax

`WNU?`

Query Response

number of sweep steps<CR/LF^EOI>

Example Statement

```
OUTPUT @E5270;"WNU?"
ENTER @E5270;A
```

WNX

The WNX command specifies the staircase sweep source (synchronous sweep source) that will be synchronized with the staircase sweep source (primary sweep source) set by the WI or WV command.

You can use the maximum of eight sweep sources. There is no restrictions for the output mode (voltage or current) of the sweep sources.

Execution Conditions

Available only for the multi channel sweep measurement (MM 16).

This command must be entered after the WI or WV command that clears the WNX command setting.

Syntax

`WNX N,chnum,mode,range,start,stop[,comp[,Pcomp]]`

Parameters

N **:** Sweep source number. Integer expression. 2 to 8. Sweep sources start output simultaneously or in number order. See Remarks below.

chnum **:** Sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

mode **:** Sweep source type. Integer expression. 1 or 2.

1: Voltage sweep source.

2: Current sweep source.

Sweep mode, linear or log, is set by the WI or WV command.

range **:** Ranging type for synchronous sweep output. Integer expression.

- For voltage source (*mode*=1): See Table 4-4 on page 4-13.

  The E5260/E5270 usually uses the minimum range that covers both *start* and *stop* values to force the staircase sweep voltage. However, if you set *Pcomp* and if the following formulas are true, the E5260/E5270 changes the output range dynamically (20 V range or above). Range changing may cause 0 V output in a moment. For the limited auto ranging, the instrument never uses the range less than the specified range.

  - *comp* > maximum current for the output range
  - *Pcomp*/output value > maximum current for the output range

Command Reference

- For current source (*mode*=2): See Table 4-5 on page 4-13.

  For the linear sweep, the E5260/E5270 uses the minimum range that covers both *start* and *stop* values to force the staircase sweep current.

  For the log sweep, the E5260/E5270 changes the output range dynamically.

  For the limited auto ranging, the instrument never uses the range less than the specified range.

***start*, *stop* :** Start or stop value (in V or A). Numeric expression.

- For voltage source (*mode*=1): See Table 4-6 on page 4-14.

  0 to ±100, or 0 to ±200 for E5280B/E5290A

- For current source (*mode*=2): See Table 4-7 on page 4-15.

  0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

start and *stop* must have the same polarity for *log* sweep.

Sweep mode, linear or log, and the number of sweep steps are set by the WI or WV command.

***comp* :** Compliance (in A or V). Numeric expression. If you do not set *comp*, the previous value is used.

If you set *Pcomp*, the maximum *comp* value for the module is allowed, regardless of the output range setting.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *comp*. If the output value is 0, the polarity is set to positive.

- For voltage source (*mode*=1): See *Icomp* in Table 4-6 on page 4-14.
- For current source (*mode*=2): See *Vcomp* in Table 4-7 on page 4-15.

  For the log sweep and without *Pcomp*, set the value available for the minimum range that covers *start* and *stop* values.

***Pcomp* :** Power compliance (in W). Numeric expression. Resolution: 0.001 W. If the *Pcomp* value is not entered, the power compliance is not set.

0.001 to 2, 0.001 to 4 for E5291A, or 0.001 to 20 for E5280B/E5290A

Command Reference

Remarks

To set multiple sweep sources, enter the WI or WV command at first, and enter the WNX command once or more. Then the *N* value and the *chnum* value must be unique for each WNX command. If you set the value used to the previous command, the previous command setting is cleared, and the last command setting is effective.

Sweep sources simultaneously start output by a trigger such as the XE command. However, if a sweep source sets power compliance or forces logarithmic sweep current, the sweep sources start output in the order specified by the *N* value. Then the first output is forced by the channel set by the WI or WV command.

If you use multiple measurement channels, the channels that use the high-speed A/D converter with the fixed ranging mode start measurement simultaneously, then other channels start measurement in the order defined in the MM command.

Example Statements

```
OUTPUT @E5270;"WNX 2,3,1,12,0,3,1E-3,2E-3"

OUTPUT @E5270;"WNX 3,4,2,0,1E-3,1E-2,3"
```

Command Reference

WS

The WS command causes the E5260/E5270 to enter a wait state until the E5260/E5270 receives an external trigger from the Ext Trig In terminal. To set the trigger logic (initial value: negative), send the TGP command for the Ext Trig In terminal.

To end a wait state before the trigger, execute the AB or *RST command.

Syntax

`WS [mode]`

Parameters

mode **:** Waiting mode. Integer expression. 1 or 2.

If this parameter is not specified, *mode* is set to 1.

mode	Description
1	Continues the operation if an external trigger was already received. Otherwise, the E5260/E5270 immediately goes into a wait state for an external trigger.
2	In any condition, the E5260/E5270 immediately goes into a wait state for an external trigger.

Remarks

The E5260/E5270 checks its trigger flag to confirm the present trigger status, received or none. To clear the trigger flag:

- Enter the *RST or device clear command (HP BASIC CLEAR statement).
- Enter the TM3 command.
- Enter the TM1, TM2, or TM4 command to change the mode from TM3.
- Enter the OS command.
- Trigger the E5260/E5270 to start measurement via the Ext Trig In terminal.
- Trigger the E5260/E5270 to recover from wait state set by the WS command via the Ext Trig In terminal.

Example Statements

```
OUTPUT @E5270;"WS 2"
```

Command Reference

WSI

The WSI command specifies the staircase sweep current source (synchronous sweep source) that will be synchronized with the staircase sweep current source (primary sweep source) set by the WI command, or the pulsed sweep current source (primary sweep source) set by the PWI command.

Execution Conditions

Available for the staircase sweep (MM 2), pulsed sweep (MM 4), or staircase sweep with pulsed bias (MM5) measurement.

This command must be entered after the WI or PWI command that clears the WSI command setting. The WV and PWV command also clears the WSI setting.

Syntax

`WSI chnum,range,start,stop[,Vcomp[,Pcomp]]`

Parameters

***chnum* :** Synchronous sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Ranging type for synchronous sweep current output. Integer expression. See Table 4-5 on page 4-13.

For the linear sweep, the E5260/E5270 uses the minimum range that covers both *start* and *stop* values to force the staircase sweep current.

For the log sweep, the E5260/E5270 uses the minimum range that covers the output value, and changes the output range dynamically.

Sweep mode, linear or log, is set by the WI or PWI command.

For the limited auto ranging, the instrument never uses the range less than the specified range.

***start*, *stop* :** Start or stop current (in A). Numeric expression. See Table 4-7 on page 4-15. *start* and *stop* must have the same polarity for *log* sweep. Sweep mode, linear or log, and the number of sweep steps are set by the WI or PWI command.

0 to ±0.1, 0 to ±0.2 for E5291A, or 0 to ±1 for E5280B/E5290A

***Vcomp* :** Voltage compliance (in V). Numeric expression. See Table 4-7 on page 4-15. If you do not set *Vcomp*, the previous value is used.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Vcomp*. If the output value is 0, the compliance polarity is positive.

Command Reference

If you set *Pcomp*, the maximum *Vcomp* value for the module is allowed, regardless of the output range setting.

For the log sweep and without *Pcomp*, set the value available for the minimum range that covers *start* and *stop* values.

***Pcomp* :** Power compliance (in W). Numeric expression. Resolution: 0.001 W. If the *Pcomp* value is not entered, the power compliance is not set.

0.001 to 2, 0.001 to 4 for E5291A, or 0.001 to 20 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"WSI 1,16,0,4E-5"
OUTPUT @E5270;"WSI 2,0,1E-3,1E-2,5,5E-2"
```

Command Reference

WSV

The WSV command specifies the staircase sweep voltage source (synchronous sweep source) that will be synchronized with the staircase sweep voltage source (primary sweep source) set by the WV command, or the pulsed sweep voltage source (primary sweep source) set by the PWV command.

Execution Conditions

Available for the staircase sweep (MM 2), pulsed sweep (MM 4), or staircase sweep with pulsed bias (MM5) measurement.

This command must be entered after the WV or PWV command that clears the WSV command setting. The WI and PWI command also clears the WSV setting.

Syntax

```
WSV chnum,range,start,stop[,Icomp[,Pcomp]]
```

Parameters

***chnum* :** Synchronous sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***range* :** Ranging type for synchronous sweep voltage output. Integer expression. See Table 4-4 on page 4-13.

The E5260/E5270 usually uses the minimum range that covers both *start* and *stop* values to force the staircase sweep voltage. However, if you set *Pcomp* and if the following formulas are true, the E5260/E5270 changes the output range dynamically (20 V range or above). Range changing may cause 0 V output in a moment. For the limited auto ranging, the instrument never uses the range less than the specified range.

- *Icomp* > maximum current for the output range
- *Pcomp*/output voltage > maximum current for the output range

***start*, *stop* :** Start or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14. *start* and *stop* must have the same polarity for *log* sweep. Sweep mode, linear or log, and the number of sweep steps are set by the WV or PWV command.

0 to ±100, or 0 to ±200 for E5280B/E5290A

***Icomp* :** Current compliance (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not set *Icomp*, the previous value is used.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Icomp*. If the output value is 0, the compliance polarity is positive.

Command Reference

If you set *Pcomp*, the maximum *Icomp* value for the module is allowed, regardless of the output range setting.

Pcomp **:** Power compliance (in W). Numeric expression. Resolution: 0.001 W. If the *Pcomp* value is not entered, the power compliance is not set.

0.001 to 2, 0.001 to 4 for E5291A, or 0.001 to 20 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"WSV 1,0,1,100,0.01,1"
OUTPUT @E5270;"WSV 2,12,0,10"
```

Command Reference

WSX

The WSX command causes the E5260/E5270 to enter a wait state until the E5260/E5270 receives an external trigger from a trigger input terminal specified by the *port* parameter. To set the trigger logic (initial value: negative), send the TGP command for the specified terminal. To end a wait state before the trigger, execute the AB or *RST command.

Syntax

`WSX port[,mode]`

Parameters

port : External trigger input port number. Integer expression. -1, or 1 to 16.

-1: Ext Trig In terminal.

1 to 16: Port 1 to 16 of the digital I/O terminal.

To use a digital I/O port, send the TGP command. The *port* value must be same as the *port* value set to the TGP command.

mode : Waiting mode. Integer expression. 1 or 2.
If this parameter is not specified, *mode* is set to 1.

mode	Description
1	Continues the operation if an external trigger was already received. Otherwise, the E5260/E5270 immediately goes into a wait state for an external trigger.
2	In any condition, the E5260/E5270 immediately goes into a wait state for an external trigger.

Remarks

The E5260/E5270 checks its trigger flag to confirm the present trigger status, received or none. To clear the trigger flag:

- Enter the *RST or device clear command (HP BASIC CLEAR statement).
- Enter the TM3 command.
- Enter the TM1, TM2, or TM4 command to change the mode from TM3.
- Enter the OS command.
- Trigger the E5260/E5270 to start measurement via the trigger input terminal.
- Trigger the E5260/E5270 to recover from wait state set by the WS command via the trigger input terminal.

Example Statements

```
OUTPUT @E5270;"WSX 2"
```

Command Reference

WT

The WT command sets the hold time, delay time, and step delay time for the staircase sweep or multi channel sweep measurement. This command is also used to set the step source trigger delay time effective for the step output setup completion trigger and the step measurement trigger delay time effective for the start step measurement trigger. For the trigger function, refer to "Trigger Function" on page 2-30.

If you do not enter this command, all parameters are set to 0.

This command setting is ignored by the following measurement mode.

- Pulsed spot measurements
- Pulsed sweep measurements
- Staircase sweep with pulsed bias measurements

Syntax

`WT hold,delay[,Sdelay[,Tdelay[,Mdelay]]]`

Parameters

***hold* :** Hold time (in seconds) that is the wait time after starting the sweep measurement and before starting the delay time for the first step value. Numeric expression.

0 to 655.35, with 10 ms resolution.

***delay* :** Delay time (in seconds) that is the wait time after starting to force a step output value and before starting a step measurement. Numeric expression.

0 to 65.535, with 0.1 ms resolution.

***Sdelay* :** Step delay time (in seconds) that is the wait time after starting a step measurement and before starting to force the next step output value. Numeric expression.

0 to 1.0, with 0.1 ms resolution.

If this parameter is not specified, *Sdelay* is set to 0.

If the specified *Sdelay* is shorter than the measurement time, the E5260/E5270 waits until the measurement completes, then forces the next step output value.

Command Reference

Tdelay **:** Step source trigger delay time (in seconds) that is the wait time after completing a step output setup and before sending a step output setup completion trigger. Numeric expression.

0 to *delay*, with 0.1 ms resolution.

If this parameter is not specified, *Tdelay* is set to 0.

Mdelay **:** Step measurement trigger delay time (in seconds) that is the wait time after receiving a start step measurement trigger and before starting a step measurement. Numeric expression.

0 to 65.535, with 0.1 ms resolution.

If this parameter is not specified, *Mdelay* is set to 0.

Example Statements

```
OUTPUT @E5270;"WT 5,0.1,0.1,0.1,0.1"
OUTPUT @E5270;"WT 5,0.2"
```

Command Reference

WV

The WV command specifies the staircase sweep voltage source and its parameters. This command also clears the WI, WSI, WSV, and WNX command settings.

This command setting is cleared by the WI command.

Syntax

- For Staircase Sweep Measurement:

  `WV chnum,mode,range,start,stop,step[,Icomp[,Pcomp]]`

- For Staircase Sweep with Pulsed Bias Measurement:

  `WV chnum,mode,range,start,stop,step[,Icomp]`

Parameters

***chnum* :** Sweep source channel number. The value must be slot number where the module has been installed. Integer expression. 1 to 8 (1 and 5 are not available for HPSMU). See Table 4-1 on page 4-9.

***mode* :** Sweep mode. Integer expression. Only linear sweep (*mode*=1 or 3) is available for the staircase sweep with pulsed bias.

1: Linear sweep (single stair, start to stop.)

2: Log sweep (single stair, start to stop.)

3: Linear sweep (double stair, start to stop to start.)

4: Log sweep (double stair, start to stop to start.)

***range* :** Ranging type for staircase sweep voltage output. Integer expression. See Table 4-4 on page 4-13.

The E5260/E5270 usually uses the minimum range that covers both *start* and *stop* values to force the staircase sweep voltage. However, if you set *Pcomp* and if the following formulas are true, the E5260/E5270 uses the minimum range that covers the output value, and changes the output range dynamically (20 V range or above). Range changing may cause 0 V output in a moment. For the limited auto ranging, the instrument never uses the range less than the specified range.

- *Icomp* > maximum current for the output range
- *Pcomp*/output voltage > maximum current for the output range

***start*, *stop* :** Start or stop voltage (in V). Numeric expression. See Table 4-6 on page 4-14. *start* and *stop* must have the same polarity for *log* sweep.

0 to ±100, or 0 to ±200 for E5280B/E5290A

Command Reference

step **:** Number of steps for staircase sweep. Numeric expression. 1 to 1001.

The E5260/E5270 can store approximately 16000 measurement data in ASCII format with header without source data, or approximately 64000 measurement data in binary format.

Icomp **:** Current compliance (in A). Numeric expression. See Table 4-6 on page 4-14. If you do not set *Icomp*, the previous value is used.

Compliance polarity is automatically set to the same polarity as the output value, regardless of the specified *Icomp*. If the output value is 0, the compliance polarity is positive.

If you set *Pcomp*, the maximum *Icomp* value for the module is allowed, regardless of the output range setting.

Pcomp **:** Power compliance (in W). Numeric expression. Resolution: 0.001 W. If the *Pcomp* value is not entered, the power compliance is not set.

0.001 to 2, 0.001 to 4 for E5291A, or 0.001 to 20 for E5280B/E5290A

Example Statements

```
OUTPUT @E5270;"WV 1,2,12,1E-6,10,100,0.1,1"
OUTPUT @E5270;"WV 2,1,0,0,20,101"
```

Command Reference

WZ?

This query command immediately confirms the all channel output, and returns the status 0 if it is within ±2 V or 1 if it is more than ±2 V.

Syntax

`WZ? [timeout]`

Parameters

timeout **:** Timeout. Numeric expression.

0 to 655.35 sec, with 0.01 sec resolution.

With *timeout* parameter, this command waits until the all channel output becomes within ±2 V or until the specified *timeout* elapses, and returns 0 or 1.

The `WZ? 0` command has the same effect as the `WZ?` command.

Query Response

`state<CR/LF^EOI>`

0: All channel output is within ±2 V.

1: Any output channel applies more than ±2 V.

Example Statement

```
OUTPUT @E5270;"WZ? 5.0"
ENTER @E5270;A
```

Command Reference

XE

The XE command triggers the E5260/E5270 to start measurement, or causes the E5260/E5270 to recover from the wait state set by the PA command.

This command is not available for the high-speed spot measurement.

NOTE

After measurement, the measurement data will be entered to the output data buffer. For data output format, refer to "Data Output Format" on page 1-22.

Execution Conditions

The following execution conditions are for you who use the XE command to start measurement. There is no execution condition when you use the XE command to recover from the wait state.

- If any channel is set to the HIGH VOLTAGE state (forcing more than ±42 V, or voltage compliance set to more than ±42 V) after the trigger (XE), the interlock terminal must be shorted.
- The following commands must be entered before the XE command.

Measurement Mode	Commands
Spot	CN, MM, DV or DI
Staircase sweep	CN, MM, WV or WI
Pulsed spot	CN, MM, PV or PI
Pulsed sweep	CN, MM, PWV or PWI
Staircase sweep with pulsed bias	CN, MM, WV or WI, PV or PI
Quasi-pulsed spot	CN, MM, BDV
Liner search	CN, MM, LSV or LSI, LGV or LGI
Binary search	CN, MM, BSV or BSI, BGV or BGI
Multi channel sweep	CN, MM, WI or WV, WNX

Syntax

```
XE
```

Example Statement

```
OUTPUT @E5270;"XE"
```

5 Error Messages

This chapter explains the channel status code and the error code of the Keysight E5260/E5270.

- "Channel Status Code"
- "Error Codes"

If error occurs, find solutions in the following sections and solve problems. However, if problems still remain, perform self-test.

If the E5260/E5270 fails self-test, contact your nearest Keysight Technologies Service Center.

Channel Status Code

The channel status code indicates the following statuses of the measurement channel, and is displayed in the channel status area on the LCD. No status code is displayed if the Keysight E5260/E5270 is in the normal condition.

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

The status priority is:

X > V > C > T

Error Codes

If errors occur, error codes are stored in the error buffer. To read the error code, execute the "ERR?" command. To read the error message, execute the "EMG?" command.

The output of the error codes is in the order that they occurred, and the first four error codes are stored in the buffer. If no errors occurred, "0, 0, 0, 0" is returned.

Operation Error

100 Undefined GPIB command.

Send the correct command.

102 Incorrect numeric data syntax.

Correct the data syntax.

103 Incorrect terminator position.

Correct the command syntax. The number of parameters will be incorrect.

120 Incorrect parameter value.

Correct the parameter value.

121 Channel number must be 1 to 2, or 1 to 8.

Correct the channel number. The channel number must be 1 to 2 for the Keysight E5262A/E5263A, or 1 to 8 for the Keysight E5260A/E5270B.

122 Number of channels must be corrected.

Check the MM, FL, CN, CL, IN, DZ, or RZ command, and correct the number of channels.

123 Compliance must be set correctly.

Incorrect compliance value was set. Set the compliance value correctly.

124 Incorrect range value for this channel.

Check the range value available for the channel, and correct the range value.

126 Pulse base and peak must be same polarity.

The polarity of the base and peak values must be the same in the PI command. Also the polarity of the base, start, and stop values must be the same in the PWI command.

130 Start and stop must be same polarity.

For a log sweep, the polarity of the start and stop values must be the same in the WV, WI, WSV, WSI, or WNX command. Also, 0 is not allowed for the start and stop values.

150 Command input buffer is full.

The Keysight E5260/E5270 can receive 256 characters maximum including the terminator at one time.

152 Cannot use failed module.

The channel number specifying the module failed the self-test or calibration. Specify another module that passed the self-test or calibration. For the service purpose, execute the RCV command to enable the module.

153 No module for the specified channel.

Module is not installed in the slot specified by the channel number.

160 Incorrect ST execution.

The internal memory programming can be started by the ST command and completed by the END command. Do not enter the ST command between the ST command and the END command.

161 Incorrect END execution.

The internal memory programming can be started by the ST command and completed by the END command. Do not send the END command before starting the programming.

162 Incorrect command for program memory.

Specified command cannot be stored in the program memory. For the incorrect commands, refer to Table 2-1 on page 2-26.

170 Incorrect usage of internal variable.

The internal variable must be %I*n* for integer data, or %R*n* for real data. where *n* is an integer, 0 to 99. Use %I*n* for the integer type command parameters; and use %R*n* for the real type command parameters. For the internal variables, refer to “VAR” on page 4-129.

171 Internal variable is not allowed.

The internal variables %I*n* and %R*n* are not available for the ACH, VAR, and VAR? commands. Do not use the internal variables for the commands.

200 Channel output switch must be ON.

To enter the specified command, set the channel output switch to ON.

201 Compliance must be set.

To change the source output mode (voltage or current), set the compliance value.

202 Interlock circuit must be closed.

To set the output voltage or the voltage compliance to more than ±42 V (high voltage state), close the interlock circuit. If the interlock circuit is opened in the high voltage state, outputs of all units will be set to 0 V.

203 Cannot enable channel.

The channel output switch cannot be set to ON in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to set the switch to ON.

204 Cannot disable channel.

The channel output switch cannot be set to OFF in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to set the switch to OFF. Or send the CL command with no parameter to set switches of all channels to OFF immediately.

205 DZ must be sent before RZ.

The RZ command is effective for the channels set to 0 V output by the DZ command.

206 Do not specify the channel recovered by RZ.

Specify the channels that have not been recovered yet by the RZ command after the DZ command. The RZ command cannot be executed if the specified channels include a channel that has already been recovered by the RZ command.

210 Ext trigger could not start measurement.

External trigger cannot start measurement because of busy condition.

211 TM1 must be sent to use GET.

Send the TM1 command to use the GPIB GET command (TRIGGER statement in HP BASIC).

212 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the DV, DI, PV, PI, PWV, PWI, TDV, TDI, LSV, LSI, LSSV, LSSI, BSV, BSI, BSSV, or BSSI command. Set the compliance value correctly.

213 Cannot perform self-test or calibration.

Self-test and calibration cannot be performed in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to perform the self-test or calibration.

214 Send MM before measurement trigger.

Before sending the measurement trigger, the MM command must be sent to set the measurement mode.

220 Send WV or WI to set primary sweep source.

Before triggering the staircase sweep measurement, triggering the staircase sweep with pulsed bias measurement, or sending the WSV, WSI, or WNX command to set the synchronous sweep source, send the WV or WI command to set the primary sweep source.

221 Send PWV or PWI to set pulse sweep source.

Before triggering the pulsed sweep measurement, or sending the WSV or WSI command to set the synchronous sweep source, send the PWV or PWI command to set the pulse sweep source.

222 Send PV or PI to set pulse source.

Before triggering the staircase sweep with pulsed bias measurement, send the PV or PI command to set the pulse source.

223 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the WV, WI, WSV, WSI, WNX, or BDV command. Set the compliance value correctly.

224 Sweep and sync output modes must be the same.

The primary sweep channel and the synchronous sweep channel must be different, and they must be set to the same output mode (voltage or current).

225 Send WSV, WSI, or WNX to get sync sweep data.

If you enable data output of the synchronous sweep source, do not forget to set the synchronous sweep source by the WSV, WSI, or WNX command. For data output, refer to "FMT" on page 4-59.

226 Set linear sweep for MM4 or MM5.

Only the linear sweep is available for the PWV or PWI command for the pulsed sweep measurement (MM4) or the WV or WI command for the staircase sweep with pulsed bias measurement (MM5).

227 Sweep measurement was aborted.

Sweep measurement was aborted by the automatic abort function or the power compliance.

230 Pulse source must be set.

To perform the pulsed spot measurement (MM3), send the PV or PI command to set the pulse source.

231 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the PV, PI, PWV, or PWI command. Set the correct compliance value effective for the pulse output.

238 Too large pulse width (max. 2 s).

The maximum value of the pulse width is 2 s. And the available value depends on the pulse period value. Refer to "PT" on page 4-90.

239 Pulse width must be 0.5 ms or more.

Set the pulse width to 0.5 ms or more. Refer to "PT" on page 4-90.

253 Program memory is full.

Maximum of 2000 programs or 40000 commands can be stored in the program memory. Refer to "ST" on page 4-109.

254 Invalid input for a memory program.

The GPIB GET command (TRIGGER statement in HP BASIC) and an external trigger input are not allowed in a memory program (between the ST and END commands).

255 Maximum nesting level is eight.

Nesting (one program calling another) of a memory program must be eight levels or less.

260 Data output buffer is full.

Maximum 34034 measurement data items can be stored in the data output buffer.

270 Search source channel must be set.

Before triggering the search measurement or sending the LSSV, LSSI, BSSV, or BSSI command to set the synchronous search source, send the LSV, LSI, BSV, or BSI command to set the primary search source.

271 Search monitor channel must be set.

Before triggering the search measurement, send the LGV, LGI, BGV, or BGI command to set the search monitor channel.

273 Search and sync output modes must be the same.

The primary search source channel and the synchronous source channel must be different, and they must be set to the same output mode (voltage or current).

274 Search sync source is overflow.

Set the search sources so that the same output range is set to both primary and synchronous search sources.

275 Search target must be compliance value or less.

The search target value must be less than or equal to the compliance value of the search monitor channel. Correct the search target value or the compliance value.

276 Start and stop must be different.

Set different values for the search start and stop values.

277 Step must be output resolution or more.

Set the search step value to the output resolution or more.

278 Search and sync channels must be different.

Set the search source and the synchronous source to different channels.

279 Search monitor mode must be compliance side.

Send the LGI/BGI command to set the voltage source search monitor channel, or send the LGV/BGV command to set the current source search monitor channel.

303 Excess voltage in MPSMU.

Voltage that exceeds maximum voltage at the present current range was detected by a MPSMU. All output switches were set to OFF.

305 Excess current in HPSMU.

Current that exceeds maximum current at the present voltage range was detected by a HPSMU. All output switches were set to OFF.

307 Unsupported module.

This module is not supported by this firmware version. Until you update the firmware, use the Keysight E5260/E5270 with this module removed.

310 Interlock open operation error. Initialized.

Initialization was automatically performed because the E5260/E5270 failed to set its output to 0 V when the interlock circuit was opened in the high voltage condition. Any module may be defective. Perform self-test.

311 ASU control cable was connected/disconnected.

The E5270B must be turned off when the Atto Sense and Switch Unit (ASU) is connected/disconnected.

603 Sweep and pulse channels must be different.

Set the sweep source and the pulse source to different channels for the staircase sweep with pulsed bias measurement (MM5).

610 Quasi-pulse source channel must be set.

Before triggering the quasi-pulsed spot measurement, send the BDV command to set the quasi-pulse source.

620 TGP specified incorrect I/O port.

Specify trigger input for the Ext Trig In port, or trigger output for the Ext Trig Out port by the TGP command. Refer to “TGP” on page 4-114.

621 Specify trigger input port for PAX/WSX.

No trigger input port was specified for the PAX or WSX command. Specify the trigger input port, or set the port as the trigger input port. Refer to “TGP” on page 4-114 to set trigger port.

622 Specify trigger output port for OSX.

No trigger output port was specified for the OSX command. Specify the trigger output port, or set the port as the trigger output port. Refer to “TGP” on page 4-114 to set trigger port.

630 Incorrect polarity of search step value.

For the linear search measurement. The step value must be positive if start<stop, or negative if start>stop.

631 Number of search steps must be 1001 or less.

For the linear search measurement. The number of search steps between start and stop must be 1001 or less. This means the |step| value must be |stop-start|/1001 or more.

632 Search measurement was aborted.

Search measurement was aborted by the automatic abort function.

640 Search limits must be range/20000 or more.

For the binary search measurement. The limit value for the search target must be *range*/20000 or more. where *range* means the measurement range actually used for the measurement.

650 Data format must be ASCII to get time data.

The time stamp function is not available for the binary data output format. To use the time stamp function, set the data output format to ASCII.

655 Cannot connect/disconnect series resistor.

The series resistor status cannot be changed in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to connect or disconnect the series resistor.

656 Series resistor must be OFF for 1 A range.

The series resistor cannot be set to ON for the measurement channels or the output channels that use 1 A range.

657 Series resistor cannot be used with ASU.

The series resistor is not available for the channel connected to the Atto Sense and Switch Unit (ASU).

670 Specified channel does not have ASU.

Specify the module that can be used with the ASU.

Self-test/Calibration Error

When the Keysight E5260/E5270 fails the self-test or self-calibration, the Keysight E5260/E5270 returns the following error code and error message.

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

700	CPU failed NVRAM read/write test.
701	CPU failed FPGA read/write test.
702	CPU failed H-RESOLN ADC end signal test.
703	CPU failed H-RESOLN ADC start signal test.
704	CPU failed emergency status signal test.
705	CPU failed SRQ status signal test.
706	CPU failed high voltage status signal test.
707	CPU failed low voltage status signal test.
708	CPU failed DAC settling status signal test.
709	CPU failed measure ready status signal test.
710	CPU failed set ready status signal test.
711	CPU failed measure end status signal test.
712	CPU failed measure trigger signal test.
713	CPU failed pulse trigger signal test.
714	CPU failed abort trigger signal test.
715	CPU failed DAC set trigger signal test.
716	CPU failed LCD read/write test.
720	H-RESOLN ADC is not installed.
721	H-RESOLN ADC failed ROM/RAM test.
722	H-RESOLN ADC failed B-COM offset DAC test.
723	H-RESOLN ADC failed sampling ADC test.
724	H-RESOLN ADC failed integrating ADC test.
725	H-RESOLN ADC failed bus function test.
740	GNDU failed calibration.

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

N789 SMU failed high voltage detector test.

N790 SMU failed zero voltage detector test.

N791 SMU failed V hold test.

N792 SMU failed V switch test.

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