Keysight B2961B/B2962B
Low Noise Power Source

Programming Guide

Notices

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In This Manual

This manual provides the information for controlling the Keysight Technologies B2961B/B2962B by using an external computer, and consists of the following chapters.

1. "Controlling the Keysight B2961B/B2962B"

   Describes how to control the B2961B/B2962B on a task basis.

2. "Programming Examples"

   Introduces example programs for controlling the B2961B/B2962B.

See *Keysight B2961B/B2962B User's Guide* for information about the B2961B/B2962B itself.

Refer to *Keysight B2961B/B2962B SCPI Command Reference* for the SCPI messages and conventions, data output format, error code, and the details on Keysight B2961B/B2962B SCPI commands.

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1 Controlling the Keysight B2961B/B2962B

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This chapter describes basic information to control the Keysight B2961B/B2962B.

Table 1-1 Conventions Used in This Document for Expressing SCPI Commands

Convention	Description
Angle brackets < >	Items within angle brackets are parameter abbreviations. For example, <NR1> indicates a specific form of numerical data.
Vertical bar |	Vertical bars separate alternative parameters. For example, <VOLT|CURR> indicates that either VOLT or CURR must be placed there.
Square brackets [ ]	Items within square brackets are optional. The representation [SOURce:]VOLTage means that SOURce: may be omitted.
Parentheses ( )	Items within parentheses are used in place of the usual parameter types to specify a channel list. The notation (@1:3) specifies a channel list that includes channels 1, 2, and 3. The notation (@1,3) specifies a channel list that includes only channels 1 and 3.
Braces { }	Braces indicate parameters that may be repeated zero or more times. It is used especially for representing arrays. The notation <A>{,<B>} shows that parameter “A” must be entered, while parameter “B” omitted or may be entered one or more times.

Before Starting

This section describes the information needed before starting programming.

- "Software Requirements"
- "Connecting to the Interface"
- "Starting the Instrument Control"

Software Requirements

Programming examples described in this manual use the following software. Install the software to your computer to execute the programming examples.

- Keysight IO Libraries Suite software
- Microsoft Visual Basic .NET software

Connecting to the Interface

Keysight B2961B/B2962B supports GPIB, LAN, and USB interfaces. All three interfaces are live at power-on. Select the interface used for controlling the B2961B/B2962B. Connect your interface cable to the appropriate interface connector.

For the information on configuring the interfaces, see *Keysight B2961B/B2962B User's Guide*.

Starting the Instrument Control

The following program code is one of the simple program template for starting and ending the communication between the computer and the instrument. For using the code, the instrument address must be set to the `address` variable correctly.

```
Sub Main()
  Dim rm As Ivi.Visa.Interop.ResourceManager
  Dim ioObj As Ivi.Visa.Interop.FormattedIO488
  Dim address As String = "enter address of your instrument"

  rm = New Ivi.Visa.Interop.ResourceManager
  ioObj = New Ivi.Visa.Interop.FormattedIO488
  ioObj.IO = rm.Open(address)
      ’ insert your code for instrument control
  ioObj.IO.Close()
End Sub
```

The `address` value depends on the interface as shown below.

- For using the GPIB interface

  The `address` value is the VISA GPIB Connect String displayed on the GPIB Configuration dialog box opened by pressing the More > I/O > GPIB function keys.

  Example:

  `address = "GPIB0::23::INSTR"`

- For using the USB interface

  The `address` value is the VISA USB Connect String displayed on the USB Status dialog box opened by pressing the More > I/O > USB function keys.

  Example:

  `address = "USB0::10893::12345::XY00001234::0::INSTR"`

- For using the LAN interface

  The `address` value is as follows.

  `address = "TCPIP0::`*xxx.yyy.zzz.aaa*`::5025::SOCKET"`

  Where, *xxx.yyy.zzz.aaa* is the IP Address displayed on the LAN Configuration dialog box opened by pressing the More > I/O > LAN > Config function keys.

  Example:

  `address = "TCPIP0::192.168.0.1::5025::SOCKET"`

Controlling Various Functions

This section describes how to control various functions apart from the source output and measurement functions.

- “Setting the Power Frequency”
- “Resetting to the Initial Settings”
- “Setting the Beeper”
- “Setting the Date and Time”
- “Performing the Self-Test”
- “Performing the Self-Calibration”
- “Setting the Operations at Power On”
- “Reading an Error Message”
- “Clearing the Error Buffer”
- “Reading Timestamp”
- “Clearing Timestamp”
- “Setting the Automatic Clear of Timestamp”
- “Confirming the Firmware Revision”
- “Setting the Remote Display Mode”
- “Making a Screen Dump”
- “Performing a File Operation”

Setting the Power Frequency

Power line frequency is set by the :SYST:LFR command.

Example

```
ioObj.WriteString(":SYST:LFR 50") '50 Hz
ioObj.WriteString(":SYST:LFR 60") '60 Hz
```

Resetting to the Initial Settings

The initial settings are applied by the *RST command

Example

```
ioObj.WriteString("*RST")
```

For the initial settings, see *SCPI Command Reference*.

Setting the Beeper

Beeper is enabled/disabled by the :SYST:BEEP:STAT command. And a beep sound of the specified frequency and duration is generated by the :SYST:BEEP command.

Example

```
ioObj.WriteString(":SYST:BEEP:STAT ON") 'Enables beep

ioObj.WriteString(":SYST:BEEP 200,1")   '200 Hz, 1 s
```

Setting the Date and Time

Date is set by the :SYST:DATE command. And time is set by the :SYST:TIME command.

Example

```
ioObj.WriteString(":SYST:DATE 2012,7,1")   'Y,M,D

ioObj.WriteString(":SYST:TIME 23,59,59")   'H,M,S
```

Performing the Self-Test

Self-test is performed by the *TST? command. The *TST? command also returns the execution result. Before performing the self-test, disconnect test leads and cables from the channel terminals.

Example

```
ioObj.WriteString("*TST?")
Dim d As String = ioObj.ReadString()
If d = 0 Then
  Console.WriteLine("PASS")
Else
  Console.WriteLine("FAIL")
End If
```

This example performs the self-test, and displays the test result, pass or fail.

Performing the Self-Calibration

Self-calibration is performed by the *CAL? command. The *CAL? command also returns the execution result. Before performing the self-calibration, disconnect test leads and cables from the channel terminals.

Example

```
ioObj.WriteString("*CAL?")
Dim d As String = ioObj.ReadString()
If d = 0 Then
  Console.WriteLine("PASS")
Else
  Console.WriteLine("FAIL")
End If
```

This example performs the self-calibration, and displays the result, pass or fail.

Setting the Operations at Power On

Operations at power-on are decided by the memory program specified by the :PROG:PON:COPY command. And the power-on program execution is enabled/disabled by the :PROG:PON:RUN command. The specified program must be previously defined in the program memory.

Example

```
ioObj.WriteString(":PROG:PON:COPY ""program1""")
ioObj.WriteString(":PROG:PON:RUN ON")
```

This example sets *program1* to the power-on program and enables the function.

Reading an Error Message

Error message is read one by one by using the :SYST:ERR? command. This command reads and removes the top item in the error buffer, and returns the code and message.

Example

```
ioObj.WriteString(":SYST:ERR?")
Dim d As String = ioObj.ReadString()
Console.WriteLine(d)
```

If the error buffer is empty, the response is +0,“No error”.

Clearing the Error Buffer

Error buffer is cleared by the :SYST:ERR:ALL? command. This command reads and returns all items in the error buffer, and clears the buffer.

Example

```
ioObj.WriteString(":SYST:ERR:ALL?")
Dim d As String = ioObj.ReadString()
Console.WriteLine(d)
```

If the error buffer is empty, the response is +0,“No error”.

Reading Timestamp

Timestamp is read by the :SYST:TIME:TIM:COUN? command.

Example

```
ioObj.WriteString(":SYST:TIME:TIM:COUN?")
Dim d As String = ioObj.ReadString()
Console.WriteLine(d)
```

Clearing Timestamp

Timestamp is cleared by the :SYST:TIME:TIM:COUN:RES command.

Example

```
ioObj.WriteString(":SYST:TIME:TIM:COUN:RES")
```

Setting the Automatic Clear of Timestamp

Automatic clear of timestamp is enabled/disabled by the :SYST:TIME:TIM:COUN:RES:AUTO command. If this function is enabled, the timestamp is cleared when the initiate action occurs.

Example

```
ioObj.WriteString(":SYST:TIME:TIM:COUN:RES:AUTO ON")
```

Confirming the Firmware Revision

Instrument’s (mainframe) identification and firmware revision are read by the *IDN? command.

Example

```
ioObj.WriteString("*IDN?")
Dim d As String = ioObj.ReadString()
Console.WriteLine(d)
```

The returned value will be as follows.

`Keysight Technologies,`*`model`*`,`*`serial`*`,`*`revision`*

model: mainframe model number

serial: mainframe serial number

revision: firmware revision number

Setting the Remote Display Mode

Front panel display under remote operation is enabled or disabled by the :DISP:ENAB command.

Example

```
ioObj.WriteString(":DISP:ENAB ON")
```

Making a Screen Dump

Screen dump of the front panel display is made by the :HCOP:SDUM commands.

Example

```
ioObj.WriteString(":DISP:ENAB ON")
ioObj.WriteString(":DISP:VIEW GRAP")
ioObj.WriteString(":HCOP:SDUM:FORM JPG")
ioObj.WriteString("*OPC?") : s = ioObj.ReadString()
ioObj.WriteString(":HCOP:SDUM:DATA?")

Dim data As Object
data = ioObj.ReadIEEEBlock(Ivi.Visa.Interop.IEEEBinaryType.BinaryType_UI1,
False, True)

Dim dataSize As Integer = data.Length
Dim dumpname As String = "C:/temp/screendump1.jpg"
Using stream As New FileStream(dumpname, FileMode.Create, FileAccess.Write)
  stream.Write(data, 0, dataSize)
End Using
```

Performing a File Operation

File operation is effective for the USB memory connected to the front panel USB connector, and performed by the :MMEM commands. Error occurs if an USB memory is not connected.

Example

```
ioObj.WriteString(":MMEM:CAT?")    'Gets file catalog
s = ioObj.ReadString()

ioObj.WriteString(":MMEM:STOR:DATA ""test.dat""") 'Saves data
ioObj.WriteString("*OPC?") : s = ioObj.ReadString()

ioObj.WriteString(":MMEM:STOR:STAT ""test.sta""") 'Saves status
ioObj.WriteString("*OPC?") : s = ioObj.ReadString()

ioObj.WriteString(":MMEM:LOAD:STAT ""test.sta""")  'Loads status
```

Controlling the Source Output

This section describes how to control the source output of Keysight B2961B/B2962B.

- "Enabling the Source Output"
- "Setting the Source Output Mode"
- "Applying the DC Voltage/Current"
- "Stopping the Source Output"
- "Setting the Limit/Compliance Value"
- "Setting the Output Range"
- "Setting the Pulse Output"
- "Setting the Arbitrary Waveform Output"
- "Setting the Sweep Operation"
- "Setting the Sweep Output"
- "Setting the Ranging Mode of the Sweep Source"
- "Setting the List Sweep Output"
- "Setting the Source Output Trigger"
- "Setting the Source Wait Time"
- "Setting the Output Filter"
- "Setting the External Filter"
- "Setting the Connection Type"
- "Setting the Low Terminal State"
- "Enabling or Disabling the High Capacitance Mode"
- "Enabling or Disabling the Over Voltage/Current Protection"
- "Specifying the Output-Off Status"
- "Enabling or Disabling the Automatic Output-On Function"

- "Enabling or Disabling the Automatic Output-Off Function"
- "Using the Programmable Output Resistance Function"

NOTE The string :SOUR in the command string described in this manual can be omitted. For example, :SOUR:VOLT can be :VOLT.

Enabling the Source Output

Source output is enabled by the :OUTP ON command.

Example

```
ioObj.WriteString(":OUTP ON")
```

Setting the Source Output Mode

Source output mode is set by the :SOUR:FUNC:MODE command.

Example

```
ioObj.WriteString(":SOUR:FUNC:MODE CURR") 'Current output

ioObj.WriteString(":SOUR:FUNC:MODE VOLT") 'Voltage output
```

Applying the DC Voltage/Current

DC current/voltage is immediately applied by the :SOUR:<CURR|VOLT> command during the source output is enabled.

If you want to control the DC current/voltage output timing using a trigger, use the :SOUR:<CURR|VOLT>:TRIG command. See Figure 1-4.

Example

```
ioObj.WriteString(":SOUR:FUNC:MODE CURR")
ioObj.WriteString(":SOUR:CURR 1E-3")     'Outputs 1 mA immediately

ioObj.WriteString(":SOUR:FUNC:TRIG:CONT 1")
ioObj.WriteString(":SOUR:FUNC:MODE VOLT")
ioObj.WriteString(":SOUR:VOLT:MODE FIX")
ioObj.WriteString(":SOUR:VOLT:TRIG 1")   'Outputs 1 V by a trigger
```

Stopping the Source Output

Source output is stopped and disabled by the :OUTP OFF command.

Example

```
ioObj.WriteString(":OUTP OFF")
```

Setting the Limit/Compliance Value

Limit/compliance is set by the :SENS:<CURR|VOLT>:PROT command.

Example

```
ioObj.WriteString(":SENS:CURR:PROT 0.1") '100 mA compliance

ioObj.WriteString(":SENS:VOLT:PROT 10")  '10 V compliance
```

NOTE

To set the positive limit and the negative limit individually

Use the :SENS:<CURR|VOLT>:PROT:POS command to set the positive limit and the :SENS:<CURR|VOLT>:PROT:NEG command to set the negative limit. Do not use the :SENS:<CURR|VOLT>:PROT command.

Setting the Output Range

Output range is set by the :SOUR:<CURR|VOLT>:RANG command. And the auto range operation is enabled/disabled by the :SOUR:<CURR|VOLT>:RANG:AUTO command. The lower limit for the auto range operation is set by the :SOUR:<CURR|VOLT>:RANG:AUTO:LLIM command.

Example

```
ioObj.WriteString(":SOUR:VOLT:RANG:AUTO OFF")
ioObj.WriteString(":SOUR:VOLT:RANG 20")         '20 V range fix

ioObj.WriteString(":SOUR:VOLT:RANG:AUTO ON")
ioObj.WriteString(":SOUR:VOLT:RANG:AUTO:LLIM 2") '2 V range limit
```

Setting the Pulse Output

Pulse output is set by the :SOUR:FUNC:SHAP PULS, :SOUR:PULS:DEL, and :SOUR:PULS:WIDT commands. See Figure 1-4.

Pulse base and peak values are set by the :SOUR:<CURR|VOLT> command and the :SOUR:<CURR|VOLT>:TRIG command respectively.

Example

```
ioObj.WriteString(":SOUR:FUNC:SHAP PULS")
ioObj.WriteString(":SOUR:PULS:DEL 1E-3")  'Delay time 1 ms
ioObj.WriteString(":SOUR:PULS:WIDT 1E-3") 'Pulse width 1 ms
ioObj.WriteString(":SOUR:VOLT 0")         'Base 0 V
ioObj.WriteString(":SOUR:VOLT:TRIG 1")     'Peak 1 V
```

NOTE

Outputting the pulse voltage/current

Execute the :OUTP ON command to start outputting the pulse base value.

Execute the :INIT to perform the specified pulse output and measurement.

Setting the Arbitrary Waveform Output

Arbitrary waveform output is enabled by the :<CURR|VOLT>:MODE ARB command. And the output waveform is set by the :SOUR:ARB commands. See Figures 1-1 and 1-2 for various waveforms and associated setup commands.

Waveform count is set by the :SOUR:ARB:COUN command.

Example

```
ioObj.WriteString(":SOUR:VOLT:MODE ARB")
ioObj.WriteString(":SOUR:ARB:FUNC SIN")         'Sinusoidal wave
ioObj.WriteString(":SOUR:ARB:VOLT:SIN:AMPL 1")  'Amplitude 1 V
ioObj.WriteString(":SOUR:ARB:VOLT:SIN:OFFS 0")  'Offset 0 V
ioObj.WriteString(":SOUR:ARB:VOLT:SIN:FREQ 1")  'Frequency 1 Hz
```

NOTE

To define your desired waveform

Use the :SOUR:ARB:<CURR|VOLT>:UDEF commands.

The :SOUR:ARB:<CURR|VOLT>:UDEF[:LEV] commands set the output level.

The :SOUR:ARB:<CURR|VOLT>:UDEF:TIME command sets the step time between adjacent points in a waveform.

Figure 1-1 Variety of Arbitrary Waveforms, EXP, RAMP, SIN

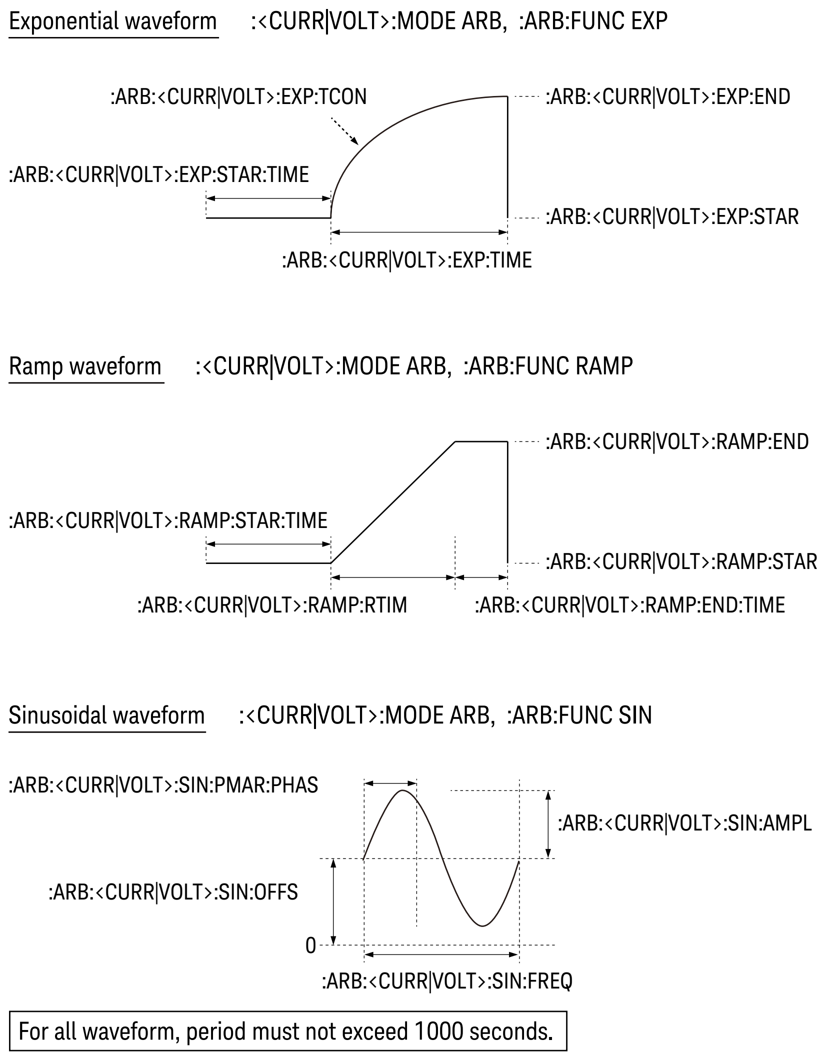
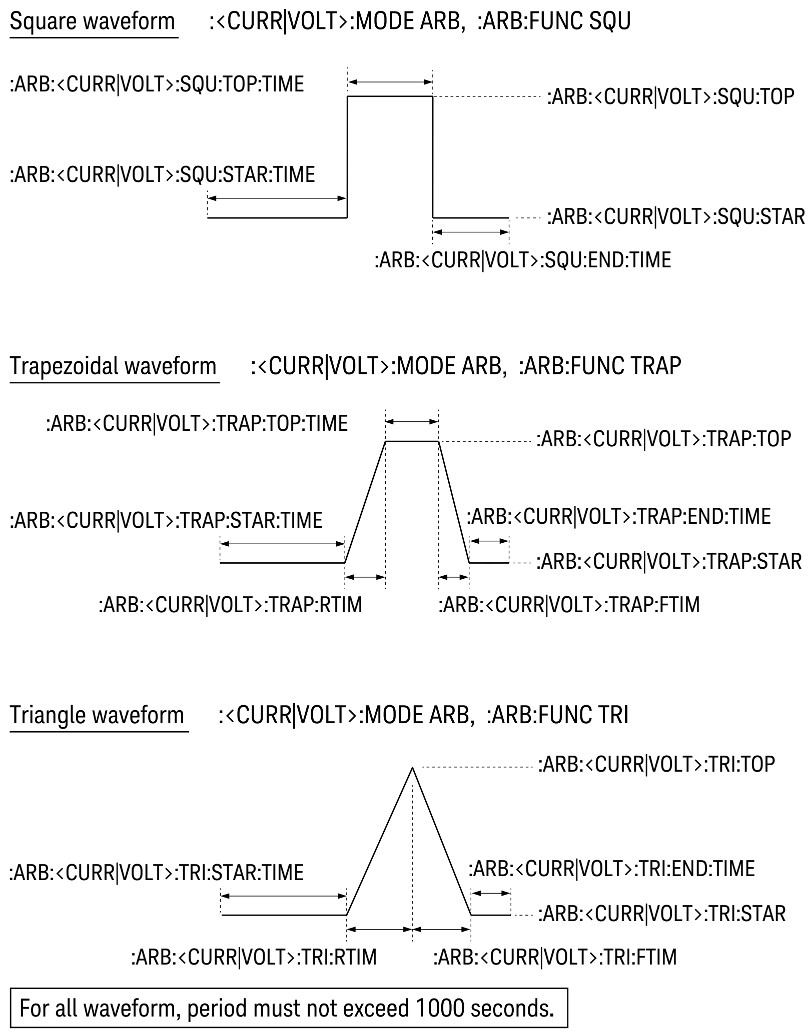


Figure 1-2 Variety of Arbitrary Waveforms, SQU, TRAP, TRI



Setting the Sweep Operation

For the variety of sweep output operation, see Figure 1-3.

Sweep direction, upward or downward is set by the :SOUR:SWE:DIR command.

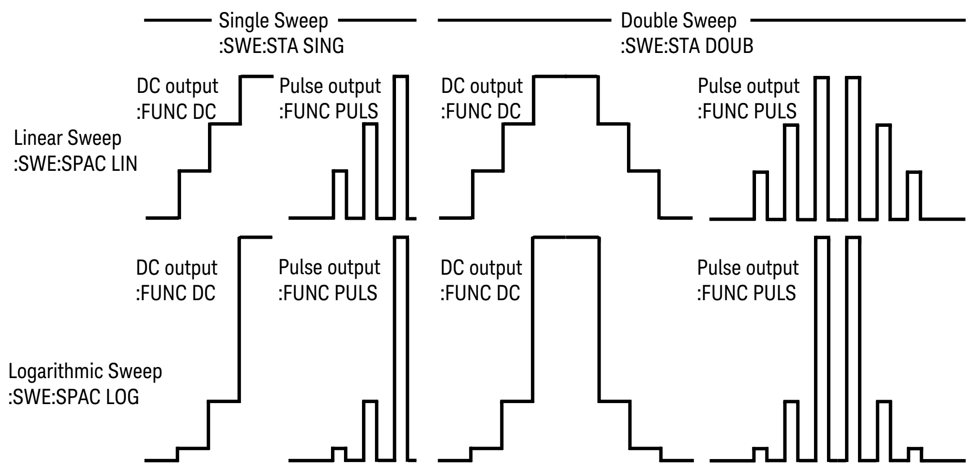
Sweep mode, single or double is set by the :SOUR:SWE:STA command.

Sweep spacing, linear or log is set by the :SOUR:SWE:SPAC command.

Example

```
ioObj.WriteString(":SOUR:SWE:DIR DOWN")
ioObj.WriteString(":SOUR:SWE:STA DOUB")
ioObj.WriteString(":SOUR:SWE:SPAC LOG")
```

Figure 1-3 Variety of Sweep Outputs



Setting the Sweep Output

Staircase sweep output is set by the :SOUR:<CURR|VOLT>:MODE SWE command, the :SOUR:<CURR|VOLT>:<POIN|STEP> or :SOUR:SWE:POIN command, and the :SOUR:<CURR|VOLT>:<STAR|STOP> or :SOUR:<CURR|VOLT>:<CENT|SPAN> command. See Figure 1-5.

Before performing the pulsed sweep output, it is necessary to set the staircase sweep output and pulse output. For details on setting the pulse output, see “Setting the Pulse Output” on page 19. Also see Figure 1-6.

Example

```
ioObj.WriteString(":SOUR:VOLT:MODE SWE")
ioObj.WriteString(":SOUR:VOLT:STAR 0")  'Start 0 V
ioObj.WriteString(":SOUR:VOLT:STOP 1")  'Stop 1 V
ioObj.WriteString(":SOUR:VOLT:POIN 11")  '11 points
```

NOTE

Outputting the sweep voltage/current

Execute the :OUTP ON command to start outputting the value set by the :SOUR:<CURR|VOLT> command.

Execute the :INIT to perform the specified sweep output and measurement.

Setting the Ranging Mode of the Sweep Source

Ranging mode of sweep source is set by the :SOUR:SWE:RANG command.

Example

```
ioObj.WriteString(":SOUR:SWE:RANG BEST")  'Covers all LIN steps

ioObj.WriteString(":SOUR:SWE:RANG FIX")   'Not change

ioObj.WriteString(":SOUR:SWE:RANG AUTO")  'Auto for each step
```

Setting the List Sweep Output

List sweep output is set by the :SOUR:<CURR|VOLT>:MODE LIST command and the :SOUR:LIST:<CURR|VOLT> command

Example

```
ioObj.WriteString(":SOUR:VOLT:MODE LIST")
ioObj.WriteString(":SOUR:LIST:VOLT 0,2,4,6,8,10,0")
```

NOTE

Outputting the list sweep voltage/current

Execute the :OUTP ON command to start outputting the value set by the :SOUR:<CURR|VOLT> command.

Execute the :INIT to perform the specified list sweep output and measurement.

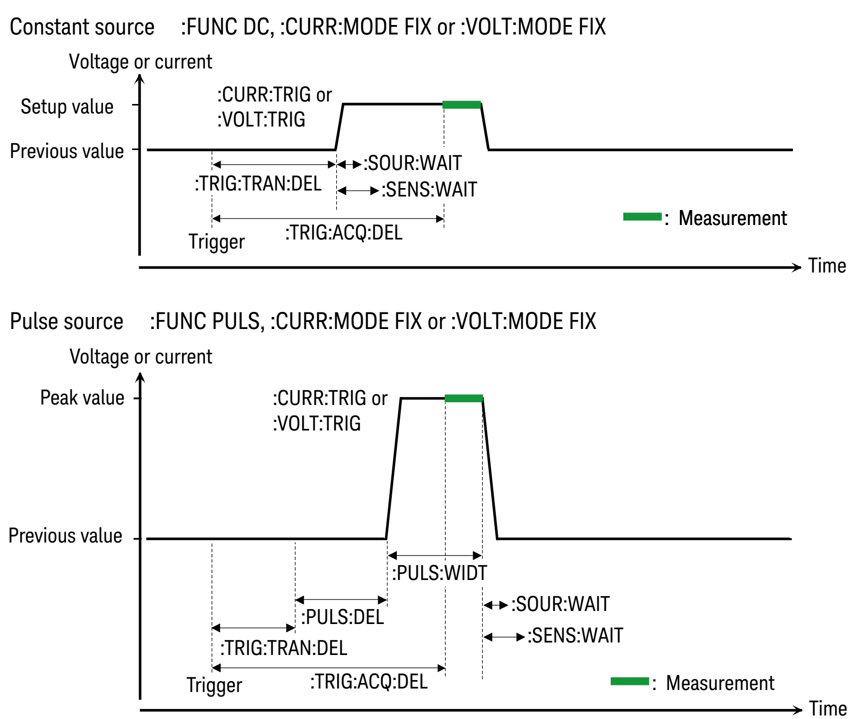
Setting the Source Output Trigger

Source output trigger is simply set by the :TRIG<:TRAN | [:ALL]>:SOUR, :TRIG<:TRAN | [:ALL]>:TIM, :TRIG<:TRAN | [:ALL]>:COUN, and :TRIG<:TRAN | [:ALL]>:DEL commands. See Figure 1-4.

Example

```
ioObj.WriteString(":TRIG:SOUR TIM")
ioObj.WriteString(":TRIG:TIM 4E-3")        'Interval 4 ms
ioObj.WriteString(":TRIG:COUN 11")         '11 points
ioObj.WriteString(":TRIG:TRAN:DEL 1E-3")   'Source delay 1 ms
```

Figure 1-4 To Perform DC and Pulse Output and Spot Measurement



NOTE If you want to use arm trigger, use the :ARM<:TRAN | [:ALL]>:SOUR, :ARM<:TRAN | [:ALL]>:TIM, :ARM<:TRAN | [:ALL]>:COUN, and :ARM<:TRAN | [:ALL]>:DEL commands. For more details, see *SCPI Command Reference*.

NOTE If source channels are set as shown below, the source output starts simultaneously.

- Trigger source is set to the same mode.
- Delay time is set to the same value.
- Source output ranging mode is set to the fixed mode.
- Source wait time control is set to OFF.
- Measurement wait time control is set to OFF.
- Measurement ranging mode is set to the fixed mode.

Setting the Source Wait Time

Source wait time is set by the :SOUR:WAIT commands. See Figures 1-5 and 1-6 for the wait time.

Example

```
ioObj.WriteString(":SOUR:WAIT OFF")        'Wait = 0 s

ioObj.WriteString(":SOUR:WAIT ON")
ioObj.WriteString(":SOUR:WAIT:AUTO OFF")
ioObj.WriteString(":SOUR:WAIT:OFFS 10E-3") 'Wait = 10 ms

ioObj.WriteString(":SOUR:WAIT ON")
ioObj.WriteString(":SOUR:WAIT:AUTO ON")
ioObj.WriteString(":SOUR:WAIT:OFFS 10E-3")
ioObj.WriteString(":SOUR:WAIT:GAIN 1")'Wait = 10 ms + initial wait
```

Setting the Output Filter

Output filter is set by the :OUTP:FILT[:LPAS] commands.

Example

```
ioObj.WriteString(":OUTP:FILT ON")
ioObj.WriteString(":OUTP:FILT:AUTO OFF")
ioObj.WriteString(":OUTP:FILT:FREQ 10E+3")  '10 kHz
```

Setting the External Filter

To use the N1294A-020/021/022 external filter, specify the filter type HCULNF (N1294A-020 high current ultra low noise filter), ULNF (N1294A-021 ultra low noise filter), or LNF (N1294A-022 low noise filter) by using the :OUTP:FILT:EXT:TYPE command and enable the external filter by using the :OUTP:FILT:EXT:STAT command.

Example
```
ioObj.WriteString(":OUTP:FILT:EXT:TYPE LNF")  'N1294A-022 filter
ioObj.WriteString(":OUTP:FILT:EXT:STAT ON")    'Enables filter
```

Setting the Connection Type

Connection type, 2-wire or 4-wire is set by the :SENS:REM command.

Example
```
ioObj.WriteString(":SENS:REM ON")         '4-wire
```

Setting the Low Terminal State

Low terminal state, ground or floating is set by the :OUTP:LOW command.

Example
```
ioObj.WriteString(":OUTP OFF")
ioObj.WriteString(":OUTP:LOW GRO")       'Ground
ioObj.WriteString(":OUTP ON")
```

Enabling or Disabling the High Capacitance Mode

High capacitance mode is set by the :OUTP:HCAP command.

Example
```
ioObj.WriteString(":OUTP:HCAP ON")
```

Enabling or Disabling the Over Voltage/Current Protection

Over voltage/current protection is set by the :OUTP:PROT command.

Example
```
ioObj.WriteString(":OUTP:PROT ON")
```

Specifying the Output-Off Status

Output-off status is set by the :OUTP:OFF:MODE command.

Example

```
ioObj.WriteString(":OUTP:OFF:MODE ZERO")  'Zero volt
ioObj.WriteString(":OUTP:OFF:MODE HIZ")   'High impedance
ioObj.WriteString(":OUTP:OFF:MODE NORM")  'Normal
```

Enabling or Disabling the Automatic Output-On Function

Automatic output-on function is set by the :OUTP:ON:AUTO command.

Example

```
ioObj.WriteString(":OUTP:ON:AUTO ON")
```

Enabling or Disabling the Automatic Output-Off Function

Automatic output-off function is set by the :OUTP:OFF:AUTO command.

Example

```
ioObj.WriteString(":OUTP:OFF:AUTO ON")
```

Using the Programmable Output Resistance Function

The programmable output resistance function is set by the :OUTP:RES commands.

Example

```
ioObj.WriteString(":OUTP:RES:MODE FIX")  'Sets fix mode
ioObj.WriteString(":OUTP:RES:SER 1")     'Sets 1 ohm series R
ioObj.WriteString(":OUTP:RES:STAT ON")   'Enables function

ioObj.WriteString(":OUTP:RES:MODE FIX")  'Sets fix mode
ioObj.WriteString(":OUTP:RES:SHUN 50")   'Sets 50 ohm shunt R
ioObj.WriteString(":OUTP:RES:STAT ON")   'Enables function

ioObj.WriteString(":OUTP:RES:MODE EMUL") 'Sets emulation mode
ioObj.WriteString(":OUTP:RES:EMUL:VOLT 0.1,0.2,0.3,0.4,0.5,0.6,0.7")
     'Sets voltage list data for emulation table
ioObj.WriteString(":OUTP:RES:EMUL:CURR 0.075,0.075,0.07,0.06,0.05,0.03,0.01
")   'Sets current list data for emulation table
ioObj.WriteString(":OUTP:RES:EMUL:MODE CURR,CURR,CURR,VOLT,VOLT,VOLT")
     'Sets source type list data for emulation table
ioObj.WriteString(":OUTP:RES:STAT ON")   'Enables function
```

Controlling the Measurement Function

This section describes how to control the measurement function of Keysight B2961B/B2962B.

- "Enabling the Measurement Channel"
- "Setting the Measurement Mode"
- "Enabling or Disabling the Resistance Compensation"
- "Performing Spot Measurement"
- "Setting the Measurement Speed"
- "Setting the Measurement Trigger"
- "Setting the Measurement Wait Time"
- "Performing Sweep Measurement"
- "Stopping Measurement"

Enabling the Measurement Channel

Measurement channel is enabled by the :OUTP ON command.

Example

```
ioObj.WriteString(":OUTP ON")
```

Setting the Measurement Mode

Measurement mode is set by the :SENS:FUNC commands.

Example

```
ioObj.WriteString(":SENS:FUNC:ALL")
ioObj.WriteString(":SENS:FUNC:OFF ""RES""")

ioObj.WriteString(":SENS:FUNC:OFF:ALL")
ioObj.WriteString(":SENS:FUNC ""RES""")
```

Enabling or Disabling the Resistance Compensation

Resistance compensation is set by the :SENS:RES:OCOM command.

Example

```
ioObj.WriteString(":SENS:RES:OCOM ON")    'Enables compensation
```

Performing Spot Measurement

Spot measurement is performed by the :MEAS:<CURR|VOLT|RES>? command or the :MEAS? command. See Figure 1-4 for the spot measurement.

Example

```
ioObj.WriteString(":MEAS:RES?")

ioObj.WriteString(":FORM:ELEM:SENS RES,STAT")
ioObj.WriteString(":MEAS?")
```

NOTE For the :MEAS? command, the measurement parameters are specified by :SENS:FUNC and the returned data is specified by :FORM:ELEM:SENS.

Setting the Measurement Speed

Measurement speed is set by the :SENS:<CURR|VOLT>:APER or :SENS:<CURR|VOLT>:NPLC command.

Example

```
ioObj.WriteString(":SENS:CURR:APER 1E-4")    '0.1 ms

ioObj.WriteString(":SENS:CURR:NPLC 1")       '1 Power Line Cycle
```

Setting the Measurement Trigger

Measurement trigger is simply set by the :TRIG<:ACQ | [:ALL]>:SOUR, :TRIG<:ACQ | [:ALL]>:TIM, :TRIG<:ACQ | [:ALL]>:COUN, and :TRIG<:ACQ | [:ALL]>:DEL commands. See Figures 1-4, 1-5, and 1-6.

Example

```
ioObj.WriteString(":TRIG:SOUR TIM")
ioObj.WriteString(":TRIG:TIM 4E-3")       'Interval 4 ms
ioObj.WriteString(":TRIG:COUN 11")        '11 points
ioObj.WriteString(":TRIG:ACQ:DEL 2E-3")    'Meas delay 2 ms
```

NOTE

If measurement channels are set as shown below, the measurement starts simultaneously.

- Trigger source is set to the same mode.
- Delay time is set to the same value.
- Measurement wait time control is set to OFF.
- Measurement ranging mode is set to the fixed mode.

NOTE

If you want to use arm trigger, use the :ARM<:ACQ | [:ALL]>:SOUR, :ARM<:ACQ | [:ALL]>:TIM, :ARM<:ACQ | [:ALL]>:COUN, and :ARM<:ACQ | [:ALL]>:DEL commands. For more details, see *SCPI Command Reference*.

Figure 1-5 To Perform Staircase Sweep Output and Measurement

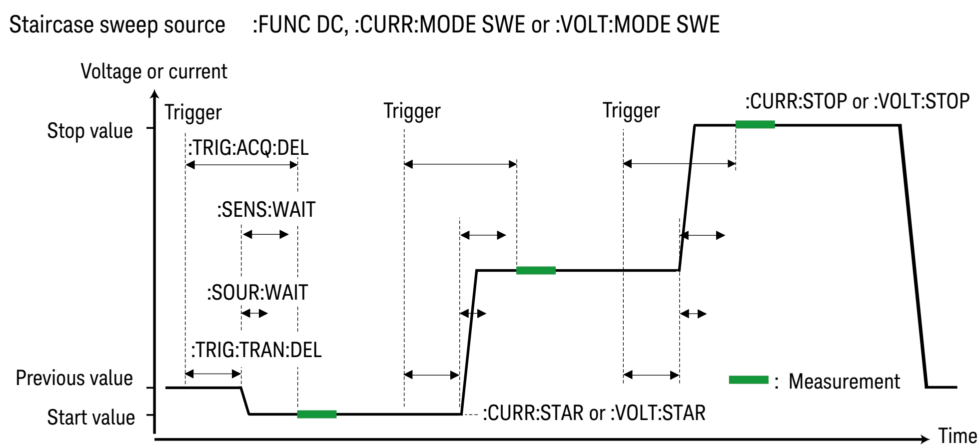
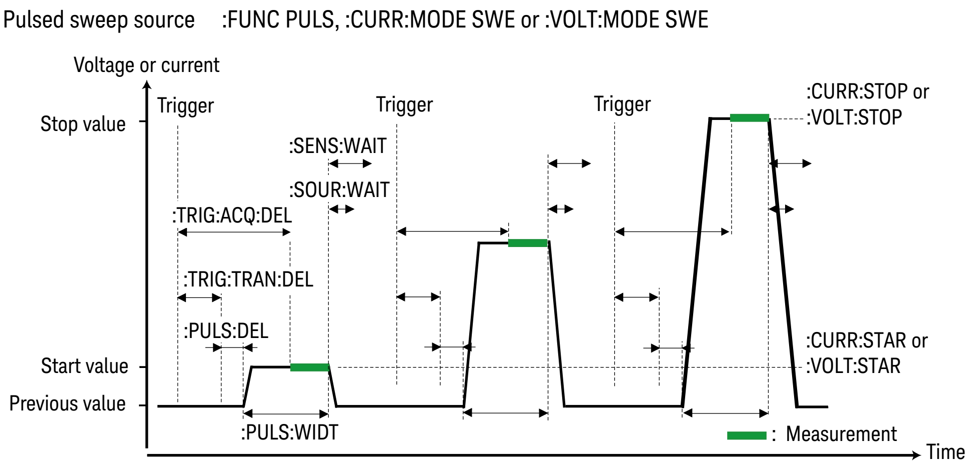


Figure 1-6 To Perform Pulsed Sweep Output and Measurement



Setting the Measurement Wait Time

Measurement wait time is set by the :SENS:WAIT commands. See Figures 1-5 and 1-6 for the wait time.

Example

```
ioObj.WriteString(":SENS:WAIT OFF")        'Wait = 0 s

ioObj.WriteString(":SENS:WAIT ON")
ioObj.WriteString(":SENS:WAIT:AUTO OFF")
ioObj.WriteString(":SENS:WAIT:OFFS 10E-3") 'Wait = 10 ms

ioObj.WriteString(":SENS:WAIT ON")
ioObj.WriteString(":SENS:WAIT:AUTO ON")
ioObj.WriteString(":SENS:WAIT:OFFS 10E-3")
ioObj.WriteString(":SENS:WAIT:GAIN 1")'Wait = 10 ms + initial wait
```

Performing Sweep Measurement

Staircase sweep measurement is performed as follows.

1. Set the staircase sweep source and the required source functions. For details, see “Controlling the Source Output” on page 17.
2. Set the required measurement functions. For details, see previous topics in this section.
3. Set the trigger condition. See “Setting the Source Output Trigger” on page 25 and “Setting the Measurement Trigger” on page 30.
4. Enable the channel. See “Enabling the Measurement Channel” on page 29.

   The channel starts output set by the :SOUR:<CURR|VOLT> command.
5. Execute the :INIT command to start measurement.

For the programming example, see “Staircase Sweep Output” on page 81.

NOTE To get measurement result data, use a :FETC subsystem command. For example, the :FETC:CURR? command returns the latest current measurement data. The :FETC?command returns the latest data for the parameters specified by the :FORM:ELEM:SENS command.

For details on the :FETC subsystem commands, see *SCPI Command Reference*.

Stopping Measurement

Measurement is stopped by the :OUTP OFF command.

Example

```
ioObj.WriteString(":OUTP OFF")
```

Using the Math Function

This section describes how to use the math function.

- "Defining a Math Expression"
- "Deleting an User Defined Math Expression"
- "Enabling or Disabling the Math Function"
- "Reading Math Result Data"

Defining a Math Expression

Math expression is defined by the :CALC:MATH[:EXPR] commands.

Example

```
ioObj.WriteString(":CALC:MATH:NAME ""DiffV""")
ioObj.WriteString(":CALC:MATH:DEF (SOUR-VOLT)")
ioObj.WriteString(":CALC:MATH:UNIT ""V""")
```

Deleting an User Defined Math Expression

Math expression is deleted by the :CALC:MATH[:EXPR]:DEL commands. The commands do not delete the predefined math expression.

Example

```
ioObj.WriteString(":CALC:MATH:DEL ""DiffV""")   'Deletes DiffV

ioObj.WriteString(":CALC:MATH:DEL:ALL")         'Deletes all
```

Enabling or Disabling the Math Function

Math function is set by the :CALC:MATH:STAT command.

Example

```
ioObj.WriteString(":CALC:MATH:STAT ON")
```

Reading Math Result Data

Math result data is read by the :CALC:MATH:DATA? commands.

Example

```
ioObj.WriteString(":CALC:MATH:DATA:LAT?")   'Latest data

ioObj.WriteString(":CALC:MATH:DATA?")       'All data
```

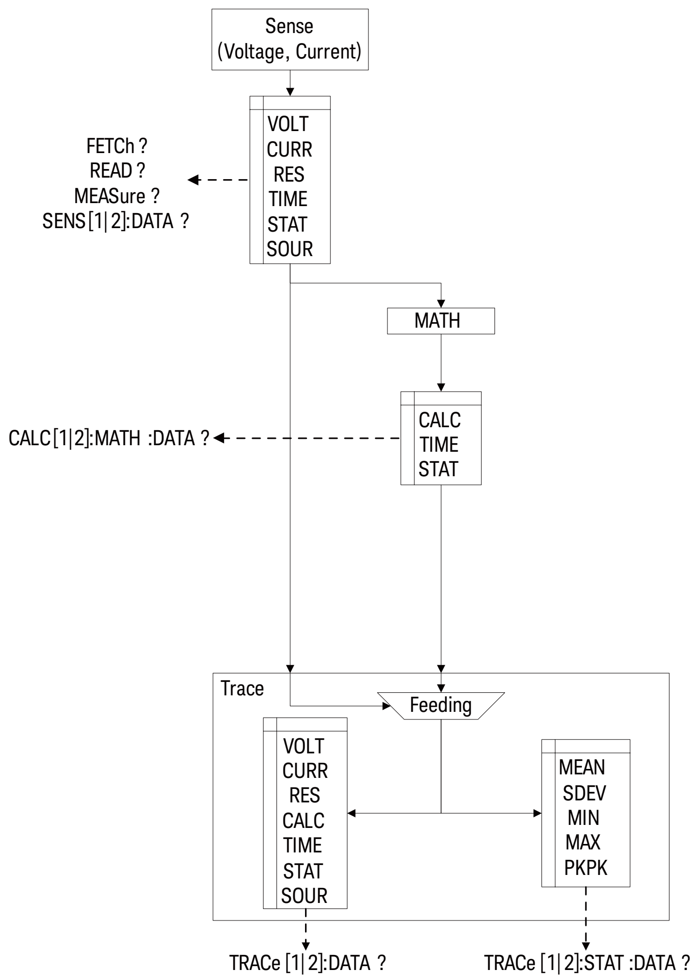
NOTE To specify the data to obtain, use the :FORM:ELEM:CALC command.

Using the Trace Buffer

This section describes how to use the trace buffer.

- "Setting the Trace Buffer"
- "Reading the Trace Data"

Figure 1-7 Trace Buffer and Data Flow



Setting the Trace Buffer

Trace buffer is set by the :TRAC commands.

Example

```
ioObj.WriteString(":TRAC:CLE")            'Clears trace buffer
ioObj.WriteString(":TRAC:POIN 1000")      'Sets buffer size
ioObj.WriteString(":TRAC:FEED SENS")      'Specifies data to feed
ioObj.WriteString(":TRAC:FEED:CONT NEXT") 'Enables write buffer
ioObj.WriteString(":TRAC:TST:FORM DELT")
```

NOTE

The :TRAC:TST:FORM command is used to specify the timestamp data format, delta (DELT) or absolute (ABS).

To specify the data to collect, use the :FORM:ELEM:SENS command for the measurement data or the :FORM:ELEM:CALC command for the calculation data.

Reading the Trace Data

All data in the trace buffer is read by the :TRAC:DATA? command.

Statistical data of the data stored in the trace buffer is read by the :TRAC:STAT:DATA? command. Previously, the type of the statistical data to read must be selected by the :TRAC:STAT:FORM command.

The :TRAC:STAT:FORM command selects one from the following statistical data.

- MEAN: Mean value
- SDEV: Standard deviation
- PKPK: Peak to peak value
- MIN: Minimum value
- MAX: Maximum value

Example

```
ioObj.WriteString(":TRAC:DATA?")           'Reads all data

ioObj.WriteString(":TRAC:STAT:FORM MEAN")
ioObj.WriteString(":TRAC:STAT:DATA?")      'Reads statistical data
```

Using Program Memory

This section describes how to use program memory.

- "Defining a Memory Program"
- "Deleting a Program"
- "Controlling the Program Operation"

Defining a Memory Program

Memory program is defined by the :PROG:NAME and :PROG:DEF commands.

Example

```
ioObj.WriteString(":PROG:NAME ""sample""")
ioObj.WriteString(":PROG:DEF #213:OUTP:STAT ON") 'Definite length

ioObj.WriteString(":PROG:NAME ""sample1""")
ioObj.WriteString(":PROG:DEF #0:OUTP:STAT ON") 'Indefinite length
```

Deleting a Program

Memory program is deleted by the :PROG:DEL commands.

Example

```
ioObj.WriteString(":PROG:DEL:ALL")          'Deletes all

ioObj.WriteString(":PROG:NAME ""sample1""")
ioObj.WriteString(":PROG:DEL")              'Deletes sample1
```

Controlling the Program Operation

Memory program is controlled by the :PROG:NAME command and the :PROG:EXEC or :PROG:STAT command. The :PROG[:SEL]:STAT command needs a parameter used to control the operation or change the status. The parameter must be RUN to change the status to running, PAUS to change it to paused, CONT to change it from paused to running, STOP to change it to stopped, or STEP to perform step execution.

Example

```
ioObj.WriteString(":PROG:NAME ""sample""")
ioObj.WriteString(":PROG:EXEC")
ioObj.WriteString("*OPC?") : s = ioObj.ReadString()

ioObj.WriteString(":PROG:NAME ""sample""")
ioObj.WriteString(":PROG:STAT RUN")
ioObj.WriteString("*OPC?") : s = ioObj.ReadString()
ioObj.WriteString(":PROG:STAT STOP")
```

2 Programming Examples

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This chapter explains programming example.

NOTE

About Numeric Suffix

Command header may be accompanied by a numeric suffix *c* for specifying the instrument channel. *c* must be 1 for using the channel 1, or 2 for using the channel 2. Abbreviating *c* gives the same result as specifying 1.

For example, the :OUTP ON command and the :OUTP1 ON command enable the channel 1, and the :OUTP2 ON command enables the channel 2.

NOTE

About Example Program Code

Example programs described in this section have been written in the Microsoft Visual Basic .NET language. The examples are provided as a subprogram that can be run with the project template shown in Table 2-2. To run the program, insert the example subprogram or your subprogram instead of the B2960control subprogram in the template.

Preparations

This section provides the basic information for programming of the automatic measurement using the Keysight B2961B/B2962B, Keysight IO Libraries, and Microsoft Visual Basic .NET.

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

NOTE To execute the example programs in this chapter, you need to install Keysight GPIB interface, Keysight IO Libraries Suite, and Microsoft Visual Basic .NET on your computer.

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 B2961B/B2962B (e.g. GPIB address 23) 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 the following references to the project.

- VISA COM 3.0 Type Library
- Ivi.Visa.Interop
- System.IO

Step 4. Open a module (e.g. Module1.vb) in the project. And enter a program code as template. See Table 2-2 for example.

Step 5. Save the project as your template (e.g. \B2960\my_temp).

NOTE

To Start Program

If you create the control program by using the example code shown in Table 2-2, the program can be run by clicking the Run button on the Visual Basic main window.

To Create Control Program

Create the control 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:

- Source mode, voltage or current
- Source function

  Arbitrary waveform, DC output, pulsed output, staircase sweep, your desired waveform, and so on.
- Number of waves/repetitions, and trigger timing
- Device under test and parameters/characteristics to measure, optional

Step 2. Make a copy of your project template (e.g. \B2960\my_temp to \B2960\source\my_temp).

Step 3. Rename the copy (e.g. \B2960\source\my_temp to \B2960\source\wave1).

Step 4. Launch Visual Basic .NET.

Step 5. Open the project (e.g. \B2960\source\wave1).

Step 6. Open the module that contains the template code as shown in Table 2-2. On the code window, complete the B2960control subprogram.

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

Step 8. Save the project (e.g. \B2960\source\wave1).

Table 2-2 Example Template Program Code

```
Module Module1

  Sub Main()                                                                   '1
    Dim rm As Ivi.Visa.Interop.ResourceManager
    Dim ioObj As Ivi.Visa.Interop.FormattedIO488
    Dim ifAddress As String = "23"
    Dim filename As String = ""
    Dim filedata As String = "Result: "
    Dim s As String = ""

    Try                                                                        '9
      rm = New Ivi.Visa.Interop.ResourceManager
      ioObj = New Ivi.Visa.Interop.FormattedIO488
      Try
        ioObj.IO = rm.Open("GPIB0::" + ifAddress + "::INSTR")
        ioObj.IO.Timeout = 60000
        ioObj.IO.TerminationCharacter = 10
        ioObj.IO.TerminationCharacterEnabled = True
      Catch ex As Exception
        Console.WriteLine("An error occurred: " + ex.Message)
      End Try

      B2960control(ioObj, s, filename)                                        '21
      Console.Write(filedata + s)
      MsgBox("Click OK to close the console window.", vbOKOnly, "")

      FileOpen(1, filename, OpenMode.Output, OpenAccess.Write, OpenShare.LockReadWrite)
                                                                              '25
      Print(1, filedata + s)
      FileClose(1)

      ioObj.IO.Close()                                                        '29
      System.Runtime.InteropServices.Marshal.ReleaseComObject(ioObj)
      System.Runtime.InteropServices.Marshal.ReleaseComObject(rm)
    Catch ex As Exception
      Console.WriteLine("An error occurred: " + ex.Message)
    End Try
  End Sub

  Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String,
ByRef filename As String)                                                     '37
  filename = "C:/temp/exdata1.txt"
  End Sub

End Module
```

Line	Description
1 to 8	Beginning of the Main subprogram. And defines the variables used in this program.
9 to 20	Establishes the connection with the instrument specified by the GPIB address ifAddress = 23 on the interface GPIB0.

```
Module Module1

  Sub Main()                                                                  '1
    Dim rm As Ivi.Visa.Interop.ResourceManager
    Dim ioObj As Ivi.Visa.Interop.FormattedIO488
    Dim ifAddress As String = "23"
    Dim filename As String = ""
    Dim filedata As String = "Result: "
    Dim s As String = ""

    Try                                                                       '9
      rm = New Ivi.Visa.Interop.ResourceManager
      ioObj = New Ivi.Visa.Interop.FormattedIO488
      Try
        ioObj.IO = rm.Open("GPIB0::" + ifAddress + "::INSTR")
        ioObj.IO.Timeout = 60000
        ioObj.IO.TerminationCharacter = 10
        ioObj.IO.TerminationCharacterEnabled = True
      Catch ex As Exception
        Console.WriteLine("An error occurred: " + ex.Message)
      End Try

      B2960control(ioObj, s, filename)                                       '21
      Console.Write(filedata + s)
      MsgBox("Click OK to close the console window.", vbOKOnly, "")

      FileOpen(1, filename, OpenMode.Output, OpenAccess.Write, OpenShare.LockReadWrite)
                                                                             '25
      Print(1, filedata + s)
      FileClose(1)

      ioObj.IO.Close()                                                       '29
      System.Runtime.InteropServices.Marshal.ReleaseComObject(ioObj)
      System.Runtime.InteropServices.Marshal.ReleaseComObject(rm)
    Catch ex As Exception
      Console.WriteLine("An error occurred: " + ex.Message)
    End Try
  End Sub

  Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String,
ByRef filename As String)                                                    '37
  filename = "C:/temp/exdata1.txt"
  End Sub

End Module
```

Line	Description
21 to 23	Calls the B2960control subprogram. And displays the example data in a console window.
25 to 27	Saves the data to a file specified by filename.
29 to 35	Breaks the connection with the instrument specified by ifAddress = 23.
37 to 39	B2960control subprogram. Instrument control program code should be entered here.

DC Output

A program example of DC output is shown in Table 2-4. This example is used to apply voltage and measure current.

Table 2-3 DC Output and Measurement Commands

Function	Command
Selects source function	[:SOUR[*c*]]:FUNC:MODE *v-or-c*
Sets source output range	[:SOUR[*c*]]:*v-or-c*:RANG:AUTO <ON | OFF>
	[:SOUR[*c*]]:*v-or-c*:RANG *value*
Sets source output value	[:SOUR[*c*]]:*v-or-c* *value*
Sets measurement function	:SENS[*c*]:FUNC "*func*"[, "*func*"[, "*func*"]]
Sets aperture time in seconds or by using NPLC value	:SENS[*c*]:*func2*:APER *time*
	:SENS[*c*]:*func2*:NPLC *value*
Sets limit (compliance) value	:SENS[*c*]:*v-or-c*:PROT *value*
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates measurement and reads result data (latest data)	:MEAS? [*chanlist*]
	:MEAS:*func*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-4 DC Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/FixedDc1.txt"                                                   '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output to 0.1 V                                                   '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt 0.1")

    ' Set 100 mA fixed-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                         '11
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                                      '20

  Try ' Initiate measurement and retrieve measurement result                         '22
    ioObj.WriteString(":meas:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 8	Sets the voltage source function. And sets the source value to 0.1 V.
11 to 13	Sets the current measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
20	Enables the channel. And starts DC output.
22 to 24	Performs measurement and reads the measurement result data.

Measurement Result Example

```
Result: +9.000000E-05
```

Pulse Output

A program example of pulse output is shown in Table 2-6. This example is used to apply pulsed voltage and measure current three times.

Table 2-5 Pulse Output and Measurement Commands

Function	Command
Selects source function	[:SOUR[*c*]]:FUNC:MODE *v-or-c*
Sets pulse output	[:SOUR[*c*]]:FUNC[:SHAP] PULS
Sets source output range	[:SOUR[*c*]]:*v-or-c*:RANG:AUTO <ON | OFF>
	[:SOUR[*c*]]:*v-or-c*:RANG *value*
Sets source output value	[:SOUR[*c*]]:*v-or-c value*
Sets pulse peak value	[:SOUR[*c*]]:*v-or-c*:TRIG *value*
Sets pulse delay time	[:SOUR[*c*]]:PULS:DEL *time*
Sets pulse width	[:SOUR[*c*]]:PULS:WIDT *time*
Sets measurement function	:SENS[c]:FUNC "*func*"[, "*func*"[, "*func*"]]
Sets aperture time in seconds or by using NPLC value	:SENS[*c*]:*func2*:APER *time*
	:SENS[*c*]:*func2*:NPLC *value*
Sets limit (compliance) value	:SENS[*c*]:*v-or-c*:PROT *value*
Selects trigger source	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:SOUR *source*
Sets interval of timer trigger	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:TIM *time*
Sets trigger count	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:COUN *value*
Sets trigger delay time	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:DEL *time*
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]

Function	Command
Reads result data (latest data)	:FETC[:SCAL]? [*chanlist*]
	:FETC[:SCAL]:*type*? [*chanlist*]
Reads result data (array data)	:FETC:ARR? [*chanlist*]
	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-6 Pulse Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/FixedPulse1.txt"                                                    ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ’ Set voltage pulse output
    ioObj.WriteString(":sour:func:mode volt")                                             ’7
    ioObj.WriteString(":sour:func:shap puls")

    ’ Set base/peak voltages to 0.0/0.1 V
    ioObj.WriteString(":sour:volt 0")                                                     ’11
    ioObj.WriteString(":sour:volt:trig 0.1")

    ’ Set delay/width to 500 us/1 ms
    ioObj.WriteString(":sour:puls:del 0.5e-3")                                            ’15
    ioObj.WriteString(":sour:puls:widt 1.0e-3")

    ’ Set 100 mA fixed-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                              ’19
    ioObj.WriteString(":sens:curr:aper 1e-4")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ’ Adjust trigger timing parameters
    ioObj.WriteString(":trig:tran:del 1.5e-3")                                            ’24
    ioObj.WriteString(":trig:acq:del 2.9e-3")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
7 to 8	Sets the voltage source function. And sets the pulse output function.
11 to 12	Sets the pulse base voltage and the pulse peak voltage.
15 to 16	Sets the pulse delay time and the pulse width.
19 to 21	Sets the current measurement function. And sets the aperture time to 0.1 ms and the current limit (compliance) value to 0.1 A.
24 to 25	Sets the transient (source) delay time and the acquire (measurement) delay time.

```
    ’ Generate 3 triggers in 4 ms period
    ioObj.WriteString(":trig:sour tim")                                     ’28
    ioObj.WriteString(":trig:tim 4e-3")
    ioObj.WriteString(":trig:coun 3")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ’ Turn on output switch
  ioObj.WriteString(":outp on")                                             ’37

  ’ Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                           ’40

  Try ’ Retrieve measurement result                                         ’42
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
28 to 30	Sets the timer trigger source. And sets the trigger interval to 4 ms, and the trigger count to 3. The B2961B/B2962B will perform the pulsed spot measurement three times.
37	Enables the channel. And starts source output.
40	Starts pulse output and pulsed spot measurement.
42 to 44	Reads the measurement result data.

Measurement Result Example

```
Result: +9.000000E-05,+9.000000E-05,+9.000000E-05
```

Exponential Wave Output

A program example of exponential wave output is shown in Table 2-8. This example is used to apply exponential wave voltage and monitor the output voltage.

Table 2-7 Commands for Applying and Monitoring the Exponential Wave

Function	Command
Selects source function	[:SOUR[*c*]]:FUNC:MODE *v-or-c*
Selects arbitrary waveform output	[:SOUR[*c*]]:*v-or-c*:MODE ARB
Selects exponential wave output	[:SOUR[*c*]]:ARB:FUNC EXP
Sets exponential wave start level	[:SOUR[*c*]]:ARB:*v-or-c*:EXP:STAR *level*
Sets exponential wave end level	[:SOUR[*c*]]:ARB:*v-or-c*:EXP:END *level*
Sets exponential wave start time	[:SOUR[*c*]]:ARB:*v-or-c*:EXP:STAR:TIME *time*
Sets time constant	[:SOUR[*c*]]:ARB:*v-or-c*:EXP:TCON *value*
Sets exponential wave output time	[:SOUR[*c*]]:ARB:*v-or-c*:EXP:TIME *time*
Sets measurement function	:SENS[*c*]:FUNC "*func*"[, "*func*"[, "*func*"]]
Sets aperture time in seconds or by using NPLC value	:SENS[*c*]:*func2*:APER *time*
	:SENS[*c*]:*func2*:NPLC *value*
Sets limit (compliance) value	:SENS[*c*]:*v-or-c*:PROT *value*
Selects trigger source	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:SOUR *source*
Sets interval of timer trigger	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:TIM *time*
Sets trigger count	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:COUN *value*
Sets trigger delay time	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:DEL *time*

Function	Command
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-8 Exponential Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/ExponentialWaveform1.txt"                                           ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set exponential wave voltage output                                               ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func exp")
    ioObj.WriteString(":sour:arb:volt:exp:star 0")
    ioObj.WriteString(":sour:arb:volt:exp:end 5")
    ioObj.WriteString(":sour:arb:volt:exp:star:time 0.1")
    ioObj.WriteString(":sour:arb:volt:exp:tcon 0.2")
    ioObj.WriteString(":sour:arb:volt:exp:time 0.9")

  ' Set voltage measurement                                                              ’16
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                    ’21
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 14	Sets the exponential wave output voltage from 0 V to 5 V and the time parameters. See Figure 1-1 for the relation between the commands and the waveform.
16 to 19	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
22 to 23	Sets the transient trigger. Source output will be triggered once.
24 to 26	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                   '28
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                           '33

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                         '36

  Try ' Retrieve measurement result                                       '38
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
33	Enables the channel. And starts source output (0 V with the default setting).
36	Starts the exponential wave output and monitor.
38 to 40	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+1.800000E-02,+2.610000E-01,+4.920000E-01,+7.120000E-01,+
9.210000E-01,+1.120000E+00,+1.309000E+00,+1.489000E+00,+1.660000E+00,+1.823
000E+00,+1.978000E+00,+2.125000E+00,+2.266000E+00,+2.399000E+00,+2.526000E+
00,+2.646000E+00,+2.761000E+00,+2.870000E+00,+2.974000E+00,+3.073000E+00,+3
.167000E+00,+3.256000E+00,+3.341000E+00,+3.422000E+00,+3.499000E+00,+3.5720
00E+00,+3.642000E+00,+3.708000E+00,+3.771000E+00,+3.831000E+00,+3.888000E+0
0,+3.942000E+00,+3.994000E+00,+4.043000E+00,+4.090000E+00,+4.134000E+00,+4.
176000E+00,+4.217000E+00,+4.255000E+00,+4.291000E+00,+4.326000E+00,+4.35900
0E+00,+4.390000E+00,+4.420000E+00,+4.448000E+00,+4.475000E+00,+4.500000E+00
,+4.525000E+00,+4.548000E+00,+4.570000E+00,+4.591000E+00,+4.611000E+00,+4.6
30000E+00,+4.648000E+00,+4.665000E+00,+4.681000E+00,+4.697000E+00,+4.712000
E+00,+4.726000E+00,+4.739000E+00,+4.752000E+00,+4.764000E+00,+4.776000E+00,
+4.786000E+00,+4.797000E+00,+4.807000E+00,+4.816000E+00,+4.825000E+00,+4.83
4000E+00,+4.842000E+00,+4.850000E+00,+4.857000E+00,+4.864000E+00,+4.870000E
+00,+4.877000E+00,+4.883000E+00,+4.889000E+00,+4.894000E+00,+4.899000E+00,+
4.904000E+00,+4.909000E+00,+4.913000E+00,+4.917000E+00,+4.921000E+00,+4.925
000E+00,+4.929000E+00,+4.932000E+00,+4.936000E+00
```

Ramp Wave Output

A program example of ramp wave output is shown in Table 2-10. This example is used to apply ramp wave voltage and monitor the output voltage.

Table 2-9 Commands for Applying and Monitoring the Ramp Wave

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[c]]:v-or-c:MODE ARB</td></tr>
<tr><td>Selects ramp wave output</td><td>[:SOUR[c]]:ARB:FUNC RAMP</td></tr>
<tr><td>Sets ramp wave start level</td><td>[:SOUR[c]]:ARB:v-or-c:RAMP:STAR level</td></tr>
<tr><td>Sets ramp wave end level</td><td>[:SOUR[c]]:ARB:v-or-c:RAMP:END level</td></tr>
<tr><td>Sets ramp wave start time</td><td>[:SOUR[c]]:ARB:v-or-c:RAMP:STAR:TIME time</td></tr>
<tr><td>Sets ramp wave ramp time</td><td>[:SOUR[c]]:ARB:v-or-c:RAMP:RTIM time</td></tr>
<tr><td>Sets ramp wave end time</td><td>[:SOUR[c]]:ARB:v-or-c:RAMP:END:TIME time</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
</table>

Function	Command
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-10 Ramp Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/RampWaveform1.txt"                                                  ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set ramp wave voltage output                                                      ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func ramp")
    ioObj.WriteString(":sour:arb:volt:ramp:star 0")
    ioObj.WriteString(":sour:arb:volt:ramp:end 5")
    ioObj.WriteString(":sour:arb:volt:ramp:star:time 0.2")
    ioObj.WriteString(":sour:arb:volt:ramp:rtime 0.4")
    ioObj.WriteString(":sour:arb:volt:ramp:end:time 0.4")

  ' Set voltage measurement                                                              ’16
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                    ’21
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 14	Sets the ramp wave output voltage from 0 V to 5 V and the time parameters. See Figure 1-1 for the relation between the commands and the waveform.
16 to 19	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
22 to 23	Sets the transient trigger. Source output will be triggered once.
24 to 26	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                  '28
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                         '33

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                      '36

  Try ' Retrieve measurement result                                      '38
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
33	Enables the channel. And starts source output (0 V with the default setting).
36	Starts the ramp wave output and monitor.
38 to 40	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+8.100000E-02,+2.060000E-01,+3.310000E-01,+4.560000E-
01,+5.810000E-01,+7.060000E-01,+8.310000E-01,+9.560000E-01,+1.081000E+00,+1
.206000E+00,+1.331000E+00,+1.456000E+00,+1.581000E+00,+1.706000E+00,+1.8310
00E+00,+1.956000E+00,+2.081000E+00,+2.206000E+00,+2.331000E+00,+2.456000E+0
0,+2.580000E+00,+2.705000E+00,+2.830000E+00,+2.955000E+00,+3.080000E+00,+3.
205000E+00,+3.330000E+00,+3.455000E+00,+3.580000E+00,+3.705000E+00,+3.83000
0E+00,+3.955000E+00,+4.080000E+00,+4.205000E+00,+4.330000E+00,+4.455000E+00
,+4.580000E+00,+4.705000E+00,+4.830000E+00,+4.955000E+00,+5.000000E+00,+5.0
00000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000
E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,
+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.00
0000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E
+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+
5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000
000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00
```

Sinusoidal Wave Output

A program example of sinusoidal wave output is shown in Table 2-12. This example is used to apply sinusoidal wave voltage and monitor the output voltage.

Table 2-11 **Commands for Applying and Monitoring the Sinusoidal Wave**

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[c]]:v-or-c:MODE ARB</td></tr>
<tr><td>Selects sinusoidal wave output</td><td>[:SOUR[c]]:ARB:FUNC SIN</td></tr>
<tr><td>Sets sinusoidal wave signal level</td><td>[:SOUR[c]]:ARB:v-or-c:SIN:AMPL level</td></tr>
<tr><td>Sets sinusoidal wave frequency</td><td>[:SOUR[c]]:ARB:v-or-c:SIN:FREQ frequency</td></tr>
<tr><td>Sets offset value</td><td>[:SOUR[c]]:ARB:v-or-c:SIN:OFFS value</td></tr>
<tr><td>Sets phase marker</td><td>[:SOUR[c]]:ARB:v-or-c:SIN:PMAR:PHAS value</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
<tr><td>Enables/disables channel</td><td>:OUTP[c] <ON | OFF></td></tr>
<tr><td>Initiates specified action</td><td>:INIT<:ACQ | :TRAN | [:ALL]> [chanlist]</td></tr>
<tr><td>Reads result data (array data)</td><td>:FETC:ARR:type? [chanlist]</td></tr>
</table>

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-12 Sinusoidal Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/SinusoidalWaveform1.txt"                                       ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set sinusoidal wave voltage output                                           ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func sin")
    ioObj.WriteString(":sour:arb:volt:sin:ampl 1")
    ioObj.WriteString(":sour:arb:volt:sin:freq 1")

  ' Set voltage measurement                                                         ’13
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                               ’18
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 11	Sets the sinusoidal wave output with the signal level 1 V and the frequency 1 Hz. See Figure 1-1 for the relation between the commands and the waveform.
13 to 16	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
19 to 20	Sets the transient trigger. Source output will be triggered once.
21 to 23	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                    '25
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                            '30

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                          '33

  Try ' Retrieve measurement result                                        '35
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
30	Enables the channel. And starts source output (0 V with the default setting).
33	Starts the sinusoidal wave output and monitor.
35 to 37	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+3.450000E-02,+9.720000E-02,+1.59
5000E-01,+2.212000E-01,+2.820000E-01,+3.417000E-01,+4.000000E-01,+4.568000E
-01,+5.117000E-01,+5.647000E-01,+6.154000E-01,+6.637000E-01,+7.093000E-01,+
7.522000E-01,+7.921000E-01,+8.288000E-01,+8.623000E-01,+8.924000E-01,+9.190
000E-01,+9.419000E-01,+9.612000E-01,+9.766000E-01,+9.882000E-01,+9.958000E-
01,+9.996000E-01,+9.994000E-01,+9.953000E-01,+9.872000E-01,+9.752000E-01,+9
.594000E-01,+9.398000E-01,+9.165000E-01,+8.896000E-01,+8.591000E-01,+8.2530
00E-01,+7.882000E-01,+7.480000E-01,+7.049000E-01,+6.590000E-01,+6.104000E-0
1,+5.595000E-01,+5.064000E-01,+4.512000E-01,+3.943000E-01,+3.358000E-01,+2.
760000E-01,+2.151000E-01,+1.534000E-01,+9.100000E-02,+2.830000E-02,-3.45000
0E-02,-9.720000E-02,-1.595000E-01,-2.212000E-01,-2.820000E-01,-3.417000E-01
,-4.000000E-01,-4.567000E-01,-5.117000E-01,-5.646000E-01,-6.153000E-01,-6.6
36000E-01,-7.093000E-01,-7.521000E-01,-7.920000E-01,-8.288000E-01,-8.623000
E-01,-8.924000E-01,-9.190000E-01,-9.419000E-01,-9.611000E-01,-9.766000E-01,
-9.882000E-01,-9.958000E-01,-9.996000E-01,-9.994000E-01,-9.953000E-01,-9.87
2000E-01,-9.752000E-01,-9.594000E-01,-9.398000E-01,-9.165000E-01,-8.896000E
-01,-8.592000E-01,-8.253000E-01,-7.883000E-01,-7.481000E-01,-7.049000E-01,-
6.590000E-01,-6.105000E-01,-5.595000E-01,-5.064000E-01,-4.512000E-01,-3.943
000E-01,-3.358000E-01,-2.760000E-01,-2.151000E-01
```

Square Wave Output

A program example of square wave output is shown in Table 2-14. This example is used to apply square wave voltage and monitor the output voltage.

Table 2-13 Commands for Applying and Monitoring the Square Wave

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[c]]:v-or-c:MODE ARB</td></tr>
<tr><td>Selects square wave output</td><td>[:SOUR[c]]:ARB:FUNC SQU</td></tr>
<tr><td>Sets square wave start level</td><td>[:SOUR[c]]:ARB:v-or-c:SQU:STAR level</td></tr>
<tr><td>Sets square wave top level</td><td>[:SOUR[c]]:ARB:v-or-c:SQU:TOP level</td></tr>
<tr><td>Sets square wave start time</td><td>[:SOUR[c]]:ARB:v-or-c:SQU:STAR:TIME time</td></tr>
<tr><td>Sets square wave top time</td><td>[:SOUR[c]]:ARB:v-or-c:SQU:TOP:TIME time</td></tr>
<tr><td>Sets square wave end time</td><td>[:SOUR[c]]:ARB:v-or-c:SQU:END:TIME time</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
</table>

Function	Command
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-14 Square Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/SquareWaveform1.txt"                                                 ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set square wave voltage output                                                     ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func squ")
    ioObj.WriteString(":sour:arb:volt:squ:star 0")
    ioObj.WriteString(":sour:arb:volt:squ:top 5")
    ioObj.WriteString(":sour:arb:volt:squ:star:time 0.2")
    ioObj.WriteString(":sour:arb:volt:squ:top:time 0.2")
    ioObj.WriteString(":sour:arb:volt:squ:end:time 0.2")

  ' Set voltage measurement                                                                ’16
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                      ’21
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 14	Sets the square wave output voltage and the time parameters. See Figure 1-2 for the relation between the commands and the waveform.
16 to 19	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
22 to 23	Sets the transient trigger. Source output will be triggered once.
24 to 26	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                   '28
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                           '33

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                         '36

  Try ' Retrieve measurement result                                       '38
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
33	Enables the channel. And starts source output (0 V with the default setting).
36	Starts the square wave output and monitor.
38 to 40	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+4.154000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+
00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5
.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.0000
00E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+8.440000E-0
1,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.
000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00000
0E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.0
00000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000
E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
```

Trapezoidal Wave Output

A program example of trapezoidal wave output is shown in Table 2-16. This example is used to apply trapezoidal wave voltage and monitor the output voltage.

Table 2-15 Commands for Applying and Monitoring the Trapezoidal Wave

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[*c*]]:FUNC:MODE *v-or-c*</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[*c*]]:*v-or-c*:MODE ARB</td></tr>
<tr><td>Selects trapezoidal wave output</td><td>[:SOUR[*c*]]:ARB:FUNC TRAP</td></tr>
<tr><td>Sets trapezoidal wave start level</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:STAR *level*</td></tr>
<tr><td>Sets trapezoidal wave top level</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:TOP *level*</td></tr>
<tr><td>Sets trapezoidal wave start time</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:STAR:TIME *time*</td></tr>
<tr><td>Sets trapezoidal wave rise time</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:RTIM *value*</td></tr>
<tr><td>Sets trapezoidal wave top time</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:TOP:TIME *time*</td></tr>
<tr><td>Sets trapezoidal wave fall time</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:FTIM *value*</td></tr>
<tr><td>Sets trapezoidal wave end time</td><td>[:SOUR[*c*]]:ARB:*v-or-c*:TRAP:END:TIME *time*</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[*c*]:FUNC “*func*”[, “*func*”[, “*func*”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[*c*]:*func2*:APER *time*</td></tr>
<tr><td>:SENS[*c*]:*func2*:NPLC *value*</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[*c*]:*v-or-c*:PROT *value*</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:SOUR *source*</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:TIM *time*</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:COUN *value*</td></tr>
</table>

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
<tr><td>Enables/disables channel</td><td>:OUTP[c] <ON | OFF></td></tr>
<tr><td>Initiates specified action</td><td>:INIT<:ACQ | :TRAN | [:ALL]> [chanlist]</td></tr>
<tr><td>Reads result data (array data)</td><td>:FETC:ARR:type? [chanlist]</td></tr>
</table>

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-16 Trapezoidal Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/TrapezoidalWaveform1.txt"                                        ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set trapezoidal wave voltage output                                             ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func trap")
    ioObj.WriteString(":sour:arb:volt:trap:star 0")
    ioObj.WriteString(":sour:arb:volt:trap:top 5")
    ioObj.WriteString(":sour:arb:volt:trap:star:time 0.2")
    ioObj.WriteString(":sour:arb:volt:trap:rtim 0.2")
    ioObj.WriteString(":sour:arb:volt:trap:top:time 0.2")
    ioObj.WriteString(":sour:arb:volt:trap:ftim 0.2")
    ioObj.WriteString(":sour:arb:volt:trap:end:time 0.2")

  ' Set voltage measurement                                                            ’18
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                  ’23
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 16	Sets the trapezoidal wave output voltage and the time parameters. See Figure 1-2 for the relation between the commands and the waveform.
18 to 21	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
24 to 25	Sets the transient trigger. Source output will be triggered once.
26 to 28	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                  '30
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                          '35

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                        '38

  Try ' Retrieve measurement result                                      '40
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
35	Enables the channel. And starts source output (0 V with the default setting).
38	Starts the trapezoidal wave output and monitor.
40 to 42	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+1.730000E-01,+4.230000E-01,+6.730000E-01,+9.230000E-
01,+1.173000E+00,+1.423000E+00,+1.673000E+00,+1.923000E+00,+2.173000E+00,+2
.423000E+00,+2.673000E+00,+2.923000E+00,+3.173000E+00,+3.423000E+00,+3.6730
00E+00,+3.923000E+00,+4.173000E+00,+4.423000E+00,+4.672000E+00,+4.922000E+0
0,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.
000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.00000
0E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00
,+5.000000E+00,+5.000000E+00,+5.000000E+00,+5.000000E+00,+4.828000E+00,+4.5
78000E+00,+4.328000E+00,+4.078000E+00,+3.828000E+00,+3.578000E+00,+3.328000
E+00,+3.078000E+00,+2.828000E+00,+2.578000E+00,+2.328000E+00,+2.078000E+00,
+1.828000E+00,+1.578000E+00,+1.328000E+00,+1.078000E+00,+8.280000E-01,+5.78
0000E-01,+3.290000E-01,+7.900000E-02,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
```

Triangle Wave Output

A program example of triangle wave output is shown in Table 2-18. This example is used to apply triangle wave voltage and monitor the output voltage.

Table 2-17 Commands for Applying and Monitoring the Triangle Wave

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[c]]:v-or-c:MODE ARB</td></tr>
<tr><td>Selects triangle wave output</td><td>[:SOUR[c]]:ARB:FUNC TRI</td></tr>
<tr><td>Sets triangle wave start level</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:STAR level</td></tr>
<tr><td>Sets triangle wave top level</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:TOP level</td></tr>
<tr><td>Sets triangle wave start time</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:STAR:TIME time</td></tr>
<tr><td>Sets triangle wave rise time</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:RTIM value</td></tr>
<tr><td>Sets triangle wave fall time</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:FTIM value</td></tr>
<tr><td>Sets triangle wave end time</td><td>[:SOUR[c]]:ARB:v-or-c:TRI:END:TIME time</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
</table>

Function	Command
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-18 Triangle Wave Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/TriangleWaveform1.txt"                                           ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set triangle wave voltage output                                               ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func tri")
    ioObj.WriteString(":sour:arb:volt:tri:star 0")
    ioObj.WriteString(":sour:arb:volt:tri:top 5")
    ioObj.WriteString(":sour:arb:volt:tri:star:time 0.2")
    ioObj.WriteString(":sour:arb:volt:tri:rtim 0.2")
    ioObj.WriteString(":sour:arb:volt:tri:ftim 0.2")
    ioObj.WriteString(":sour:arb:volt:tri:end:time 0.2")

  ' Set voltage measurement                                                           ’17
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                 ’22
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 15	Sets the triangle wave output voltage and the time parameters. See Figure 1-2 for the relation between the commands and the waveform.
17 to 20	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
23 to 24	Sets the transient trigger. Source output will be triggered once.
25 to 27	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
  Catch ex As Exception                                                   '29
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                           '34

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                         '37

  Try ' Retrieve measurement result                                       '39
    ioObj.WriteString(":fetc:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
34	Enables the channel. And starts source output (0 V with the default setting).
37	Starts the triangle wave output and monitor.
39 to 41	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+2.280000E-01,+4.780000E-01,+7.280000E-01,+9.780000E-
01,+1.228000E+00,+1.478000E+00,+1.728000E+00,+1.977000E+00,+2.227000E+00,+2
.477000E+00,+2.727000E+00,+2.977000E+00,+3.227000E+00,+3.477000E+00,+3.7270
00E+00,+3.977000E+00,+4.227000E+00,+4.477000E+00,+4.727000E+00,+4.977000E+0
0,+4.773000E+00,+4.523000E+00,+4.273000E+00,+4.023000E+00,+3.773000E+00,+3.
523000E+00,+3.273000E+00,+3.024000E+00,+2.774000E+00,+2.524000E+00,+2.27400
0E+00,+2.024000E+00,+1.774000E+00,+1.524000E+00,+1.274000E+00,+1.024000E+00
,+7.740000E-01,+5.240000E-01,+2.740000E-01,+2.400000E-02,+0.000000E+00,+0.0
00000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000
E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
```

User Defined Waveform Output

A program example of user defined waveform output is shown in Table 2-20. This example is used to apply voltage and monitor the output voltage.

Table 2-19 Commands for Applying and Monitoring the User Defined Waveform

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Selects arbitrary waveform output</td><td>[:SOUR[c]]:v-or-c:MODE ARB</td></tr>
<tr><td>Selects user defined waveform output</td><td>[:SOUR[c]]:ARB:FUNC UDEF</td></tr>
<tr><td>Sets data list used to create an user defined waveform</td><td>[:SOUR[c]]:ARB:v-or-c:UDEF list</td></tr>
<tr><td>Adds data to the list</td><td>[:SOUR[c]]:ARB:v-or-c:UDEF:APP list</td></tr>
<tr><td>Gets the number of data in the list</td><td>[:SOUR[c]]:ARB:v-or-c:UDEF:POIN value</td></tr>
<tr><td>Sets interval between each list data</td><td>[:SOUR[c]]:ARB:v-or-c:UDEF:TIME interval</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
</table>

Function	Command
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

list is data list used to create an user defined waveform. It must be a comma separated values, such as `0,1,0,-1,0`. This example contains five data.

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-20 User Defined Waveform Output Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/UserDefinedWaveform1.txt"                                          ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ' Set user defined waveform voltage output                                         ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode arb")
    ioObj.WriteString(":sour:arb:func udef")
    ioObj.WriteString(":sour:arb:volt:udef 0,1,0,-1,0")
    ioObj.WriteString(":sour:arb:volt:udef:time 0.2")

  ' Set voltage measurement                                                              ’13
    ioObj.WriteString(":sens:func ""volt""")
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

  ' Generate triggers                                                                    ’18
    ioObj.WriteString(":trig:tran:coun 1")
    ioObj.WriteString(":trig:tran:sour aint")
    ioObj.WriteString(":trig:acq:coun 100")
    ioObj.WriteString(":trig:acq:sour timer")
    ioObj.WriteString(":trig:acq:tim 0.01")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 11	Sets the the user defined waveform voltage output. The `:sour:arb:volt:udef` command sets the list of the output levels separated by a comma. The `:sour:arb:volt:udef:time` command sets the interval for changing the output level.
13 to 16	Sets the voltage measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A.
19 to 20	Sets the transient trigger. Source output will be triggered once.
21 to 23	Sets the acquire trigger. Output monitor will be triggered 100 times in 10 ms interval.

```
    Catch ex As Exception                                                      ’25
      Console.WriteLine("An error occurred: " + ex.Message)
    End Try

    ’ Turn on output switch
    ioObj.WriteString(":outp on")                                              ’30

    ’ Initiate transition and acquire
    ioObj.WriteString(":init (@1)")                                            ’33

    Try ’ Retrieve measurement result                                          ’35
      ioObj.WriteString(":fetc:arr:volt? (@1)")
      s = ioObj.ReadString()

    Catch ex As Exception
      Console.WriteLine("An error occurred: " + ex.Message)
    End Try
  End Sub
```

Line	Description
30	Enables the channel. And starts source output (0 V with the default setting).
33	Starts the user defined waveform output and monitor.
35 to 37	Reads the measurement result data.

Measurement Result Example

```
Result:
+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00
0000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+6.780000E-02,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+
00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1
.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.0000
00E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+1.000000E+00,+9.331000E-0
1,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.
000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.00000
0E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
,+0.000000E+00,+0.000000E+00,+0.000000E+00,-6.580000E-02,-1.000000E+00,-1.0
00000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000
E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,
-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.000000E+00,-1.00
0000E+00,-1.000000E+00,-9.353000E-01,+0.000000E+00,+0.000000E+00,+0.000000E
+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+
0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00,+0.000
000E+00,+0.000000E+00,+0.000000E+00,+0.000000E+00
```

Staircase Sweep Output

A program example of staircase sweep measurements is shown in Table 2-22. This example is used to apply sweep voltage and measure current at each sweep step.

Table 2-21 Staircase Sweep Measurement Commands

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Sets sweep output</td><td>[:SOUR[c]]:v-or-c:MODE SWE</td></tr>
<tr><td>Sets output range when starting sweep</td><td>[:SOUR[c]]:v-or-c:RANG value</td></tr>
<tr><td>Sets source output value</td><td>[:SOUR[c]]:v-or-c value</td></tr>
<tr><td>Sets sweep start or stop value</td><td>[:SOUR[c]]:v-or-c:<STAR | STOP> value</td></tr>
<tr><td>Sets sweep center or span value</td><td>[:SOUR[c]]:v-or-c:<CENT | SPAN> value</td></tr>
<tr><td>Sets sweep step value</td><td>[:SOUR[c]]:v-or-c:STEP value</td></tr>
<tr><td rowspan="2">Sets number of sweep steps</td><td>[:SOUR[c]]:v-or-c:POIN value</td></tr>
<tr><td>[:SOUR[c]]:SWE:POIN value</td></tr>
<tr><td>Selects sweep source ranging mode</td><td>[:SOUR[c]]:SWE:RANG <BEST | FIX | AUTO></td></tr>
<tr><td>Selects sweep direction</td><td>[:SOUR[c]]:SWE:DIR <UP | DOWN></td></tr>
<tr><td>Selects sweep linear or log</td><td>[:SOUR[c]]:SWE:SPAC <LIN | LOG></td></tr>
<tr><td>Selects sweep single or double</td><td>[:SOUR[c]]:SWE:STA <SING | DOUB></td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
</table>

Function	Command
Sets interval of timer trigger	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:TIM *time*
Sets trigger count	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:COUN *value*
Sets trigger delay time	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:DEL *time*
Enables/disables channel	:OUTP[*c*] <ON | OFF>
Initiates specified action	:INIT<:ACQ | :TRAN | [:ALL]> [*chanlist*]
Reads result data (array data)	:FETC:ARR? [*chanlist*]
	:FETC:ARR:*type*? [*chanlist*]

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Measurement Result Example

```
Result: +0.000000E+00,+2.000000E-05,+4.000000E-05,+6.000000E-05,+9.000000E-
05
```

Table 2-22 Staircase Sweep Measurement Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/StaircaseSweep1.txt"                                              '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output from 0 V to 0.1 V, 5 steps                                   '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode swe")
    ioObj.WriteString(":sour:volt:star 0")
    ioObj.WriteString(":sour:volt:stop 0.1")
    ioObj.WriteString(":sour:volt:poin 5")

    ' Set auto-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                           '14
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ' Generate 5 triggers by automatic internal algorithm
    ioObj.WriteString(":trig:sour aint")                                               '19
    ioObj.WriteString(":trig:coun 5")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                                        '27

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                                      '30

  Try ' Retrieve measurement result                                                    '32
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 11	Sets the voltage sweep output function. And sets the sweep output from 0 to 0.1 V in 0.02 V step (5 points).
14 to 16	Sets the current measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A. Auto range is ON with the default setting.

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/StaircaseSweep1.txt"                                              '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output from 0 V to 0.1 V, 5 steps                                   '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode swe")
    ioObj.WriteString(":sour:volt:star 0")
    ioObj.WriteString(":sour:volt:stop 0.1")
    ioObj.WriteString(":sour:volt:poin 5")

    ' Set auto-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                           '14
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ' Generate 5 triggers by automatic internal algorithm
    ioObj.WriteString(":trig:sour aint")                                               '19
    ioObj.WriteString(":trig:coun 5")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                                        '27

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                                      '30

  Try ' Retrieve measurement result                                                    '32
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
19 to 20	Sets the trigger source to AINT (automatic trigger). And sets the trigger count to 5 to perform a 5-step staircase sweep measurement.
27	Enables the channel. And starts source output (0 V with the default setting).
30	Starts staircase sweep measurement.
32 to 34	Reads the measurement result data.

Pulsed Sweep Output

A program example of pulsed sweep measurements is shown in Table 2-24. This example is used to apply pulsed sweep voltage and measure current at each sweep step.

Table 2-23 Pulsed Sweep Measurement Commands

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Sets pulse output</td><td>[:SOUR[c]]:FUNC[:SHAP] PULS</td></tr>
<tr><td>Sets sweep output</td><td>[:SOUR[c]]:v-or-c:MODE SWE</td></tr>
<tr><td>Sets output range when starting sweep</td><td>[:SOUR[c]]:v-or-c:RANG value</td></tr>
<tr><td>Sets source output value</td><td>[:SOUR[c]]:v-or-c value</td></tr>
<tr><td>Sets sweep start or stop value</td><td>[:SOUR[c]]:v-or-c:<STAR | STOP> value</td></tr>
<tr><td>Sets sweep center or span value</td><td>[:SOUR[c]]:v-or-c:<CENT | SPAN> value</td></tr>
<tr><td>Sets sweep step value</td><td>[:SOUR[c]]:v-or-c:STEP value</td></tr>
<tr><td rowspan="2">Sets number of sweep steps</td><td>[:SOUR[c]]:v-or-c:POIN value</td></tr>
<tr><td>[:SOUR[c]]:SWE:POIN value</td></tr>
<tr><td>Sets pulse delay time</td><td>[:SOUR[c]]:PULS:DEL time</td></tr>
<tr><td>Sets pulse width</td><td>[:SOUR[c]]:PULS:WIDT time</td></tr>
<tr><td>Selects sweep source ranging mode</td><td>[:SOUR[c]]:SWE:RANG <BEST | FIX | AUTO></td></tr>
<tr><td>Selects sweep direction</td><td>[:SOUR[c]]:SWE:DIR <UP | DOWN></td></tr>
<tr><td>Selects sweep linear or log</td><td>[:SOUR[c]]:SWE:SPAC <LIN | LOG></td></tr>
<tr><td>Selects sweep single or double</td><td>[:SOUR[c]]:SWE:STA <SING | DOUB></td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
</table>

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
<tr><td>Enables/disables channel</td><td>:OUTP[c] <ON | OFF></td></tr>
<tr><td>Initiates specified action</td><td>:INIT<:ACQ | :TRAN | [:ALL]> [chanlist]</td></tr>
<tr><td rowspan="2">Reads result data (array data)</td><td>:FETC:ARR? [chanlist]</td></tr>
<tr><td>:FETC:ARR:type? [chanlist]</td></tr>
</table>

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-24 Pulsed Sweep Measurement Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/StaircasePulsedSweep1.txt"                                       '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output from 0 V to 0.1 V, 5 steps                                   '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:func:shap puls")
    ioObj.WriteString(":sour:volt:mode swe")
    ioObj.WriteString(":sour:volt:star 0")
    ioObj.WriteString(":sour:volt:stop 0.1")
    ioObj.WriteString(":sour:volt:poin 5")

    ' Set delay/width to 500 us/1 ms
    ioObj.WriteString(":sour:puls:del 0.5e-3")                                         '15
    ioObj.WriteString(":sour:puls:widt 1.0e-3")

    ' Set 100 mA fixed-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                           '19
    ioObj.WriteString(":sens:curr:aper 1e-4")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ' Adjust trigger timing parameters
    ioObj.WriteString(":trig:tran:del 1.5e-3")                                         '24
    ioObj.WriteString(":trig:acq:del 2.9e-3")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 12	Sets the voltage pulse sweep output function. And sets the sweep output from 0 to 0.1 V in 0.02 V step (5 points).
15 to 16	Sets the pulse delay time and the pulse width.
19 to 21	Sets the current measurement function and the 100 mA fixed range measurement. And sets the aperture time to 0.1 ms and the current limit (compliance) value to 0.1 A.
24 to 25	Sets the transient (source) delay time and the acquire (measurement) delay time.

```
    ’ Generate 5 triggers in 4 ms period
    ioObj.WriteString(":trig:sour tim")                                    ’28
    ioObj.WriteString(":trig:tim 4e-3")
    ioObj.WriteString(":trig:coun 5")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ’ Turn on output switch
  ioObj.WriteString(":outp on")                                            ’37

  ’ Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                          ’40

  Try ’ Retrieve measurement result                                        ’42
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
28 to 30	Sets the timer trigger source. And sets the trigger interval to 4 ms, and the trigger count to 5 to perform a 5-step pulsed sweep measurement.
37	Enables the channel. And starts source output (0 V with the default setting).
40	Starts pulsed sweep measurement.
42 to 44	Reads the measurement result data.

Measurement Result Example

```
Result: +0.000000E+00,+2.000000E-05,+4.000000E-05,+6.000000E-05,+9.000000E-
05
```

List Sweep Output

A program example of list sweep measurements is shown in Table 2-26. This example is used to apply sweep voltage and measure current at each sweep step.

Table 2-25 List Sweep Measurement Commands

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Selects source function</td><td>[:SOUR[c]]:FUNC:MODE v-or-c</td></tr>
<tr><td>Sets list sweep output</td><td>[:SOUR[c]]:v-or-c:MODE LIST</td></tr>
<tr><td rowspan="2">Sets source output range</td><td>[:SOUR[c]]:v-or-c:RANG:AUTO <ON | OFF></td></tr>
<tr><td>[:SOUR[c]]:v-or-c:RANG value</td></tr>
<tr><td>Sets source output value</td><td>[:SOUR[c]]:v-or-c value</td></tr>
<tr><td>Sets list sweep output values</td><td>[:SOUR[c]]:LIST:v-or-c values</td></tr>
<tr><td>Adds list sweep output values to the end of the present setting</td><td>[:SOUR[c]]:LIST:v-or-c:APP values</td></tr>
<tr><td>Specifies the list sweep start point</td><td>[:SOUR[c]]:LIST:v-or-c:STAR start_index</td></tr>
<tr><td>Asks the number of sweep points</td><td>[:SOUR[c]]:LIST:v-or-c:POIN?</td></tr>
<tr><td>Sets measurement function</td><td>:SENS[c]:FUNC “func”[, “func”[, “func”]]</td></tr>
<tr><td rowspan="2">Sets aperture time in seconds or by using NPLC value</td><td>:SENS[c]:func2:APER time</td></tr>
<tr><td>:SENS[c]:func2:NPLC value</td></tr>
<tr><td>Sets limit (compliance) value</td><td>:SENS[c]:v-or-c:PROT value</td></tr>
<tr><td>Selects trigger source</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:SOUR source</td></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
</table>

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Enables/disables channel</td><td>:OUTP[c] <ON | OFF></td></tr>
<tr><td>Initiates specified action</td><td>:INIT<:ACQ | :TRAN | [:ALL]> [chanlist]</td></tr>
<tr><td rowspan="2">Reads result data (array data)</td><td>:FETC:ARR? [chanlist]</td></tr>
<tr><td>:FETC:ARR:type? [chanlist]</td></tr>
</table>

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-26 List Sweep Measurement Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/ListSweep1.txt"                                                    '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output to 0.03, 0.06, and 0.1 V                                      '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode list")
    ioObj.WriteString(":sour:list:volt 0.03,0.06,0.1")

    ' Set auto-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                            '12
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ' Generate 3 triggers by automatic internal algorithm
    ioObj.WriteString(":trig:sour aint")                                                '17
    ioObj.WriteString(":trig:coun 3")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ' Turn on output switch
  ioObj.WriteString(":outp on")                                                         '25

  ' Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                                       '28

  Try ' Retrieve measurement result                                                     '30
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 9	Sets the voltage list sweep output function. And sets the list sweep output 0.03 V, 0.06 V, and 0.1 V (3 points).
12 to 14	Sets the current measurement function. And sets the aperture time to 0.1 PLC and the current limit (compliance) value to 0.1 A. Auto range is ON with the default setting.
17 to 18	Sets the trigger source to AINT (automatic trigger). And sets the trigger count to 3 to perform a 3-point list sweep measurement.

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/ListSweep1.txt"                                              ’2

  ioObj.WriteString("*RST") ’ Reset

  Try ’ Set voltage output to 0.03, 0.06, and 0.1 V                                ’6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:volt:mode list")
    ioObj.WriteString(":sour:list:volt 0.03,0.06,0.1")

    ’ Set auto-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                      ’12
    ioObj.WriteString(":sens:curr:nplc 0.1")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ’ Generate 3 triggers by automatic internal algorithm
    ioObj.WriteString(":trig:sour aint")                                          ’17
    ioObj.WriteString(":trig:coun 3")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ’ Turn on output switch
  ioObj.WriteString(":outp on")                                                   ’25

  ’ Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                                 ’28

  Try ’ Retrieve measurement result                                               ’30
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
25	Enables the channel. And starts source output (0 V with the default setting).
28	Starts list sweep measurement.
30 to 32	Reads the measurement result data.

Measurement Result Example

```
Result: +2.000000E-05,+5.000000E-05,+9.000000E-05
```

Pulsed List Sweep Output

A program example of pulsed list sweep measurements is shown in Table 2-28. This example is used to apply pulsed sweep voltage and measure current at each sweep step.

Table 2-27 Pulsed List Sweep Measurement Commands

Function	Command
Selects source function	[:SOUR[*c*]]:FUNC:MODE *v-or-c*
Sets pulse output	[:SOUR[*c*]]:FUNC[:SHAP] PULS
Sets list sweep output	[:SOUR[*c*]]:*v-or-c*:MODE LIST
Sets source output range	[:SOUR[*c*]]:*v-or-c*:RANG:AUTO <ON | OFF>
	[:SOUR[*c*]]:*v-or-c*:RANG *value*
Sets source output value	[:SOUR[*c*]]:*v-or-c* *value*
Sets list sweep output values	[:SOUR[*c*]]:LIST:*v-or-c* *values*
Adds list sweep output values to the end of the present setting	[:SOUR[*c*]]:LIST:*v-or-c*:APP *values*
Specifies the list sweep start point	[:SOUR[*c*]]:LIST:*v-or-c*:STAR *start_index*
Asks the number of sweep points	[:SOUR[*c*]]:LIST:*v-or-c*:POIN?
Sets pulse delay time	[:SOUR[*c*]]:PULS:DEL *time*
Sets pulse width	[:SOUR[*c*]]:PULS:WIDT *time*
Sets measurement function	:SENS[*c*]:FUNC “*func*”[, “*func*”[, “*func*”]]
Sets aperture time in seconds or by using NPLC value	:SENS[*c*]:*func2*:APER *time*
	:SENS[*c*]:*func2*:NPLC *value*
Sets limit (compliance) value	:SENS[*c*]:*v-or-c*:PROT *value*
Selects trigger source	:TRIG[*c*]<:ACQ | :TRAN | [:ALL]>:SOUR *source*

<table>
<tr><th>Function</th><th>Command</th></tr>
<tr><td>Sets interval of timer trigger</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:TIM time</td></tr>
<tr><td>Sets trigger count</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:COUN value</td></tr>
<tr><td>Sets trigger delay time</td><td>:TRIG[c]<:ACQ | :TRAN | [:ALL]>:DEL time</td></tr>
<tr><td>Enables/disables channel</td><td>:OUTP[c] <ON | OFF></td></tr>
<tr><td>Initiates specified action</td><td>:INIT<:ACQ | :TRAN | [:ALL]> [chanlist]</td></tr>
<tr><td rowspan="2">Reads result data (array data)</td><td>:FETC:ARR? [chanlist]</td></tr>
<tr><td>:FETC:ARR:type? [chanlist]</td></tr>
</table>

v-or-c is VOLT for voltage source or limit (compliance), or CURR for current source or limit (compliance).

func is VOLT for voltage measurement, CURR for current measurement, or RES for resistance measurement.

func2 is VOLT for voltage measurement or CURR for current measurement.

source is AINT for the automatic trigger, BUS for the remote interface trigger command, TIM for the internal timer, INT*n* for a signal from the internal bus (*n* = 1 or 2), EXT*m* for a signal from the GPIO pin *m* (*m* = 1 to 14), or LAN for the LXI trigger.

type is VOLT for voltage data, CURR for current data, RES for resistance data, SOUR for source output data, STAT for status data, or TIME for time data.

chanlist is (@1) for selecting the channel 1 only, (@2) for selecting the channel 2 only, or (@1,2), (@1:2), (@2,1), or (@2:1) for selecting both channels 1 and 2. Abbreviating this parameter sets *chanlist* = (@1) for the 1-channel models, and *chanlist* = (@1,2) for the 2-channel models.

Table 2-28 Pulsed List Sweep Measurement Example

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/ListPulsedSweep1.txt"                                            '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Set voltage output to 0.03, 0.06, and 0.1 V                                   '6
    ioObj.WriteString(":sour:func:mode volt")
    ioObj.WriteString(":sour:func:shap puls")
    ioObj.WriteString(":sour:volt:mode list")
    ioObj.WriteString(":sour:list:volt 0.03,0.06,0.1")

    ' Set delay/width to 500 us/1 ms
    ioObj.WriteString(":sour:puls:del 0.5e-3")                                        '13
    ioObj.WriteString(":sour:puls:widt 1.0e-3")

    ' Set 100 mA fixed-range current measurement
    ioObj.WriteString(":sens:func ""curr""")                                          '17
    ioObj.WriteString(":sens:curr:aper 1e-4")
    ioObj.WriteString(":sens:curr:prot 0.1")

    ' Adjust trigger timing parameters
    ioObj.WriteString(":trig:tran:del 1.5e-3")                                        '22
    ioObj.WriteString(":trig:acq:del 2.9e-3")
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 10	Sets the voltage pulse list sweep output function. And sets the pulsed list sweep output 0.03 V, 0.06 V, and 0.1 V (3 points). Pulse base value is 0 V with the default setting.
13 to 14	Sets the pulse delay time and the pulse width.
17 to 19	Sets the current measurement function and the 100 mA fixed range measurement. And sets the aperture time to 0.1 ms and the current limit (compliance) value to 0.1 A.
22 to 23	Sets the transient (source) delay time and the acquire (measurement) delay time.

```
    ’ Generate 3 triggers in 4 ms period
    ioObj.WriteString(":trig:sour tim")                                  ’26
    ioObj.WriteString(":trig:tim 4e-3")
    ioObj.WriteString(":trig:coun 3")

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try

  ’ Turn on output switch
  ioObj.WriteString(":outp on")                                          ’35

  ’ Initiate transition and acquire
  ioObj.WriteString(":init (@1)")                                        ’38

  Try ’ Retrieve measurement result                                      ’40
    ioObj.WriteString(":fetc:arr:curr? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
26 to 28	Sets the timer trigger source. And sets the trigger interval to 4 ms, and the trigger count to 3 to perform a 3-point pulsed list sweep measurement.
35	Enables the channel. And starts source output (0 V with the default setting).
38	Starts pulsed list sweep measurement.
40 to 42	Reads the measurement result data.

Measurement Result Example

```
Result: +2.000000E-05,+5.000000E-05,+9.000000E-05
```

Using Program Memory

A program example for using program memory is shown in Table 2-30. This example is used to store a program in the program memory and execute it.

Table 2-29 Program Memory Commands

Function	Command
Returns the names of all programs defined in the program memory	:PROG:CAT?
Specifies memory program	:PROG:NAME "*name*"
Defines memory program [a]	:PROG:DEF *program_code*
Adds program code to the end of the memory program [a]	:PROG:APP *program_code*
Sets a value to the variable specified by *n* [b]	:PROG:VAR*n* "*value*"
Executes memory program [a]	:PROG:EXEC
Changes status of memory program [a]	:PROG:STAT *operation*
Blocks other commands until the program execution status changes to Paused or Stopped [a]	:PROG:WAIT? *timeout_in_seconds*
Deletes a memory program [a]	:PROG:DEL
Deletes all memory programs	:PROG:DEL:ALL

a. This function is effective for the memory program previously specified by the :PROG:NAME command.
b. Variables can be used in the memory program. They must be expressed as %*n*% (*n*: integer. 1 to 100) in the memory program.

operation is RUN to change to the running status, PAUS to change to the paused status, CONT to change to the running status, STOP to change to the stopped status, or STEP to perform step execution.

Table 2-30 Example to Use Program Memory

```
Sub B2960control(ByVal ioObj As Ivi.Visa.Interop.FormattedIO488, ByRef s As String, ByRef
filename As String)
  filename = "C:/temp/ProgramMemory1.txt"                                                   '2

  ioObj.WriteString("*RST") ' Reset

  Try ' Build program                                                                       '6
    Dim program As String = ""
    program = ":sour:func:mode curr\n"
    program += ":sour:curr:mode swe\n"
    program += ":sour:curr:star 0.0\n"
    program += ":sour:curr:stop 40e-3\n"
    program += ":sour:curr:poin 21\n"
    program += ":sens:func ""volt""\n"
    program += ":sens:curr:nplc 0.1\n"
    program += ":arm:coun 1\n"
    program += ":trig:coun 21\n"
    program += ":outp 1\n"
    program += ":init (@1)\n"

    ' Get program length
    Dim sProgramLength As String = String.Format("{0:#}", program.Length)                  '21

    ioObj.WriteString(":prog:name ""sample""")                                             '23
    ioObj.WriteString(":prog:def #" + sProgramLength.Length.ToString() + sProgramLength +
program)

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
```

Line	Description
2	Defines the file name used for saving the result data.
4	Resets the B2961B/B2962B.
6 to 18	Enters program code to the “program” variable. The program is for performing current source voltage measure sweep measurement from 0 A to 40 mA, 21 points, with the aperture time 0.1 PLC.
21	Gets the program length (number of characters in the “program” variable).
23 to 24	Stores the program code to the program memory as the program name “sample”.

```
  ’ Run program
  ioObj.WriteString(":prog:stat run")                                         ’31

  ’ Wait for operation complete
  ioObj.WriteString("*OPC?")                                                  ’34
  s = ioObj.ReadString()
  Console.Write("*OPC?: " + s)
  Console.WriteLine()

  Try ’ Retrieve measurement result                                           ’39
    ioObj.WriteString(":fetch:arr:volt? (@1)")
    s = ioObj.ReadString()

  Catch ex As Exception
    Console.WriteLine("An error occurred: " + ex.Message)
  End Try
End Sub
```

Line	Description
31	Executes the memory program.
34 to 37	Waits for operation complete. And write “*OPC?: 1” on the console window when the operation is completed.
39 to 41	Reads the measurement result data.

Measurement Result Example

```
Result: +5.200000E-03,+6.643000E-01,+1.931000E+00,+2.000000E+00,+2.000000E+
00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2
.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.0000
00E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+00,+2.000000E+0
0
```

Reading Binary Data

A program example for reading binary data is shown in Table 2-32. This example is used to read data in the ASCII format and the 8-byte binary format.

For performing a staircase sweep measurement, replace the program code from lines 32 to 38 shown in Table 2-22 with the code shown in Table 2-32.

Table 2-31 Data Output Format Commands

Function	Command
Sets the data output format	:FORM[:DATA] *format*
Sets byte order of binary data	:FORM:BORD *byte_order*

format is ASC for the ASCII data output format, REAL,32 for the IEEE-754 single precision format (4-byte data), or REAL,64 for the IEEE-754 double precision format (8-byte data).

byte_order is NORM for the normal byte order from byte 1 to byte 4 or 8, or SWAP for the reverse byte order from byte 4 or 8 to byte 1.

Measurement Result Example

```
Result: V (V), I (A), Time (sec), Status: 0,0,0.022718,41600.025,2E-05,0.02
5817,41600.05,4E-05,0.02878,41600.075,6E-05,0.031722,41600.1,9E-05,0.034668
,4160
```

Table 2-32 Example to Read Binary Data

```
’ Select measure data elements
ioObj.WriteString(":form:elem:sens volt,curr,time,stat")                        ’2

’ Retrieve measurement result & Output measurement result(Ascii format)         ’4
ioObj.WriteString(":form asc")
ioObj.WriteString(":fetch:arr? (@1)")
Dim numOfElem As Integer = 4 'V, I, Time, Status
Dim data(numOfElem * trigCount - 1)
data = ioObj.ReadList(Ivi.Visa.Interop.IEEEASCIIType.ASCIIType_Any, ",")

Dim value As String = "V (V), I (A), Time (sec), Status: "
s = value
Console.WriteLine("ASCII format")
Console.WriteLine(value)
For i = LBound(data) To UBound(data)
  If (i + 1) Mod numOfElem = 0 Then
    Console.WriteLine(data(i).ToString())
    s = s + data(i).ToString()
  Else
    Console.Write(data(i).ToString() + ",")
    s = s + data(i).ToString() + ","
  End If
Next

Console.WriteLine()

’ Retrieve measurement result & Output measurement result(Real64 format)        ’27
Console.WriteLine("REAL64 format")
Console.WriteLine(value)
ioObj.WriteString(":form real,64")
ioObj.WriteString(":fetch:arr? (@1)")
Dim data64
data64 = ioObj.ReadIEEEBlock(Ivi.Visa.Interop.IEEEBinaryType.BinaryType_R8, False, True)
For i = LBound(data64) To UBound(data64)
  If (i + 1) Mod numOfElem = 0 Then
    Console.WriteLine(data64(i).ToString())
  Else
    Console.Write(data64(i).ToString() + ",")
  End If
Next
Console.WriteLine()
```

Line	Description
2	Specifies the data to return. This example selects voltage measurement data, current measurement data, time data, and status data.
4 to 23	Reads the measurement result data in the ASCII format.
27 to 40	Reads the measurement result data in the REAL,64 format.

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