Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices

User's Guide

Agilent Technologies

Notices

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CE ISM 1-A	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.
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C US	The CSA mark is a registered trademark of the Canadian Standards Association. A CSA mark with the indicators "C" and "US" means that the product is certified for both the U.S. and Canadian markets, to the applicable American and Canadian standards.
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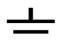
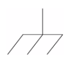
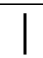
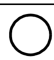
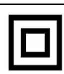
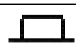
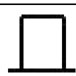
Safety Symbols

	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	Equipment protected throughout by double insulation or reinforced insulation
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger (See note.)
	In position of a bi-stable push control
	Out position of a bi-stable push control

General Safety Information

WARNING

- Do not use the device if it is damaged. Before you use the device, inspect the case. Look for cracks or missing plastic. Do not operate the device around explosive gas, vapor, or dust.
- Do not apply more than the rated voltage (as marked on the device) between terminals, or between terminal and external ground.
- Always use the device with the cables provided.
- Observe all markings on the device before connecting to the device.
- Turn off the device and application system power before connecting to the I/O terminals.
- When servicing the device, use only specified replacement parts.
- Do not operate the device with the removable cover removed or loosened.
- Do not connect any cables and terminal block prior to performing self-test process.
- Use only the power adapter supplied by the manufacturer to avoid any unexpected hazards.

CAUTION

- Do not load the output terminals above the specified current limits. Applying excessive voltage or overloading the device will cause irreversible damage to the circuitry.
- Applying excessive voltage or overloading the input terminal will damage the device permanently.
- If the device is used in a manner not specified by the manufacturer, the protection provided by the device may be impaired.
- Always use dry cloth to clean the device. Do not use ethyl alcohol or any other volatile liquid to clean the device.
- Do not permit any blockage of the ventilation holes of the device.

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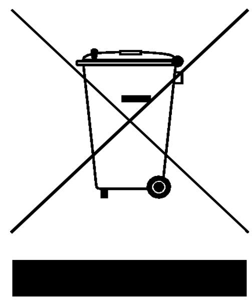
This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category:

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is shown as below:



Do not dispose in domestic household waste

To return this unwanted instrument, contact your nearest Agilent office, or visit:

http://www.agilent.com/environment/product

for more information.

In This Guide...

1 Getting Started

This chapter provides an overview of the U2500A series USB simultaneous sampling multifunction DAQ devices, product outlook and product layout. This chapter also contains the instructions on getting started with the U2500A series from checking your system requirements to the installations of the device's hardware and software.

2 Connector Pins Configuration

This chapter describes the connector pins configuration of all the U2500A series DAQ devices.

3 Features and Functions

In this chapter you are provided with information for better understanding on the features and functions of U2500A series USB DAQ. This includes the operations of the analog input/output, digital input/output and digital counter.

4 Characteristics and Specifications

This chapter specifies the characteristics, and specifications of the U2500A series DAQ devices.

5 Calibration

This chapter introduces the procedures to perform calibration process to the U2500A series DAQ devices to minimize A/D measurement errors and D/A output errors.

Agilent Technologies	**DECLARATION OF CONFORMITY** According to EN ISO/IEC 17050-1:2004	CE

Manufacturer's Name: Agilent Technologies Microwave Products (M) Sdn. Bhd
Manufacturer's Address: Bayan Lepas Free Industrial Zone,
11900, Bayan Lepas, Penang, Malaysia

Declares under sole responsibility that the product as originally delivered:

Product Name: Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices
Models Number: U2531A, U2541A, U2542A
Product Options: This declaration covers all options of the above product(s)

complies with the essential requirements of the following applicable European Directives, and carries the CE marking accordingly:

Low Voltage Directive (2006/95/EC)
EMC Directive (2004/108/EC)

and conforms with the following product standards:

EMC

Standard	Limit
IEC 61326:2002 / EN 61326:1997+A1:1998+A2:2001+A3:2003	
CISPR 11:1990 / EN55011:1990	Class A Group 1
IEC 61000-4-2:1995 / EN 61000-4-2:1995	4 kV CD, 8 kV AD
IEC 61000-4-3:1995 / EN 61000-4-3:1996	3 V/m, 80-1000 MHz
IEC 61000-4-4:1995 / EN 61000-4-4:1995	0.5 kV signal lines, 1 kV power lines
IEC 61000-4-5:1995 / EN 61000-4-5:1995	0.5 kV line-line, 1 kV line-ground
IEC 61000-4-6:1996 / EN 61000-4-6:1996	3 V, 0.15-80 MHz
IEC 61000-4-11:1994 / EN 61000-4-11:1994	1 cycle / 100%

Canada: ICES-001:2004
Australia/New Zealand: AS/NZS CISPR11:2004

The product was tested in a typical configuration with Agilent Technologies test systems.

Safety
IEC 61010-1:2001 / EN 61010-1:2001
Canada: CAN/CSA-C22.2 No. 61010-1-04
USA: ANSI/UL 61010-1:2004

c UL us   SP® 206349

This DoC applies to above-listed products placed on the EU market after:

19-October-2007
Date

Mack Soh

Mack Soh
Quality Manager

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Template: A5971-5302-2, Rev. E.00 U2500A series DoC Revision 1.0

Product Regulations

EMC

	Performance Criteria
IEC 61326-1:2002 / EN 61326-1:1997+A1:1998+A2:2001+A3:2003	
CISPR 11:1990 / EN 55011:1990 – Group 1 Class A	
IEC 61000-4-2:1995 / EN 61000-4-2:1995 (ESD 4kV CD, 8kV AD)	B
IEC 61000-4-3:1995 / EN 61000-4-3:1996 (3V/m, 80% AM)	A
IEC 61000-4-4:1995 / EN 61000-4-4:1995 (EFT 0.5kV line-line, 1kV line-earth)	B
IEC 61000-4-5:1995 / EN 61000-4-5:1995 (Surge 0.5kV line-line, 1kV line-earth)	A
IEC 61000-4-6:1996 / EN 61000-4-6:1996 (3V, 0.15~80 MHz, 80% AM, power line)	A
IEC 61000-4-11:1994 / EN 61000-4-11:1994 (Dips 1 cycle, 100%)	B
Canada: ICES-001:2004	
Australia/New Zealand: AS/NZS CISPR11:2004	

Safety IEC 61010-1:2001 / EN 61010-1:2001
Canada: CAN/CSA-C22.2 No. 61010-1-04
USA: ANSI/UL 61010-1:2004

Additional Information:

The product herewith complies with the essential requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive (2004/108/EC) and carries the CE Marking accordingly (European Union).

[1]Performance Criteria:

A Pass - Normal operation, no effect.
B Pass - Temporary degradation, self recoverable.
C Pass - Temporary degradation, operator intervention required.
D Fail - Not recoverable, component damage.
N/A – Not applicable due to the product is a battery operated device

Models Description:
U2531A: 4 channels Simultaneous Sampling Multifunction DAQ 14-bits 2MSa/s.
U2541A: 4 channels Simultaneous Sampling Multifunction DAQ 16-bits 250kSa/s.
U2542A: 4 channels Simultaneous Sampling Multifunction DAQ 16-bits 500kSa/s.

Notes:

Regulatory Information for Canada

ICES/NMB-001:2004
This ISM device complies with Canadian ICES-001.
Cet appareil ISM est confomre à la norme NMB-001 du Canada.

Regulatory Information for Australia/New Zealand

This ISM device complies with Australian/New Zealand AS/NZS CISPR11:2004

N10149

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1
Getting Started

This chapter contains instructions on how to get started with the U2500A series DAQ devices that includes a system requirement check, installations of the device's hardware and software, and launching of the Agilent Measurement Manager application software.

Introduction to U2500A Series DAQ Devices

The Agilent U2500A Series USB Simultaneous Sampling (SS) Multifunction Data Acquisition (DAQ) is a high performance and user friendly device. It can be used as a standalone unit or as a modular unit. However, if used as modular unit, the module needs to be installed in the Agilent U2781A USB modular instrument chassis. The U2500A series consists of three models:

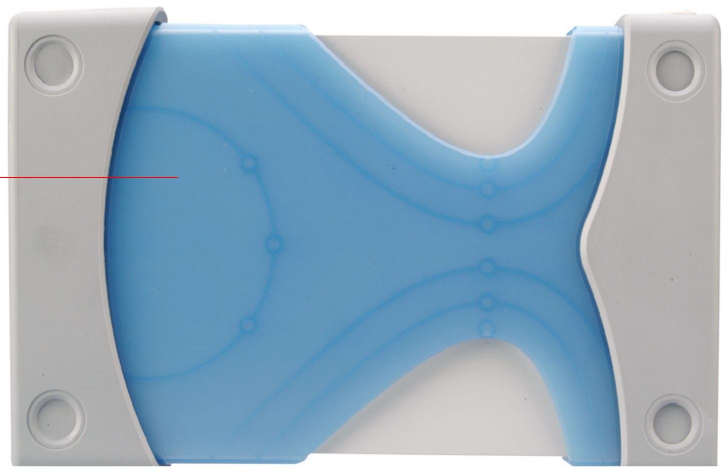
- U2531A: 4 channel SS multifunction DAQ 14 bits 2 MSa/s
- U2541A: 4 channel SS multifunction DAQ 16 bits 250 kSa/s
- U2542A: 4 channel SS multifunction DAQ 16 bits 500 kSa/s

The U2500A series DAQ devices are compatible with a wide range of Application Development Environment (ADE), such as Agilent VEE, LabVIEW, MATLAB, and Microsoft Visual Studio. Bundled with the purchase of every device is an easy-to-use application software, the Agilent Measurement Manager.

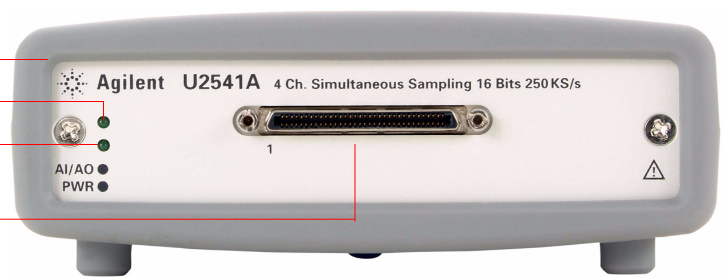
Product Overview

Product outlook

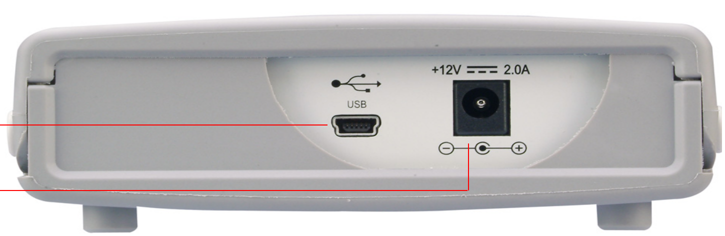
Top view



Front view



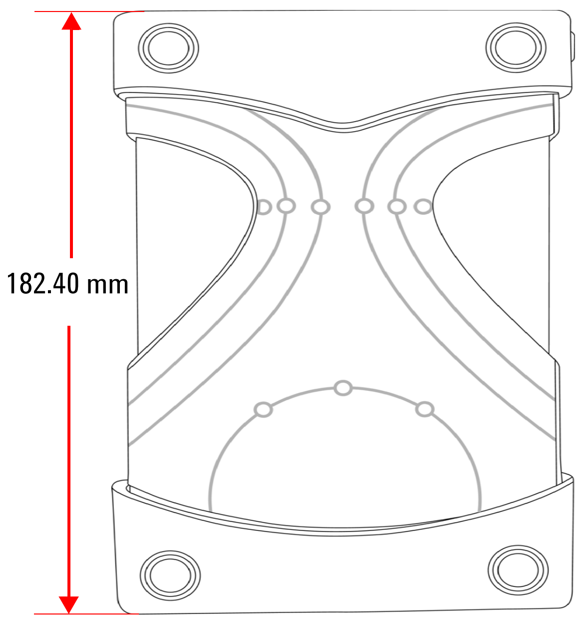
Rear view



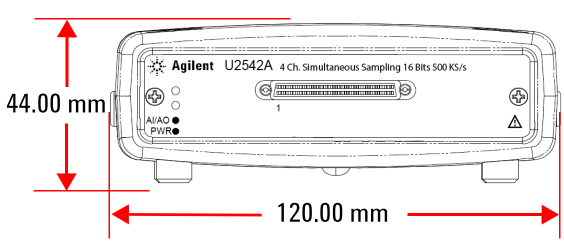
Product dimensions

With plastic casing

Top view

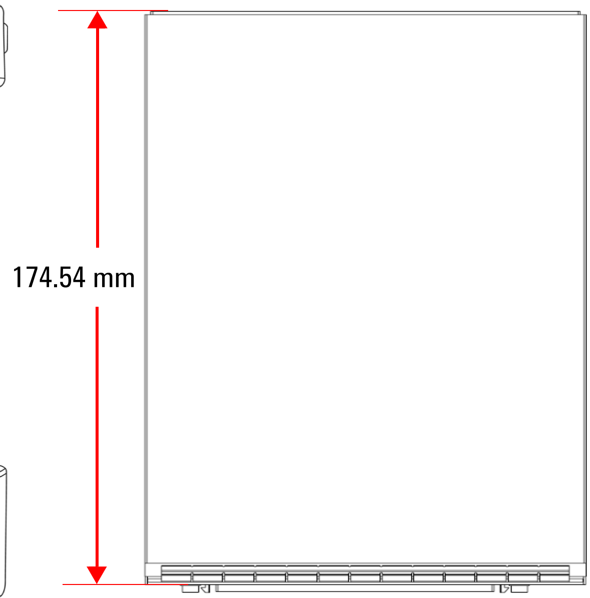


Front view

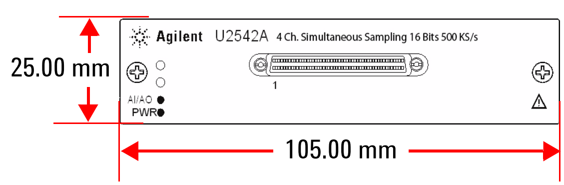


Without plastic casing

Top view

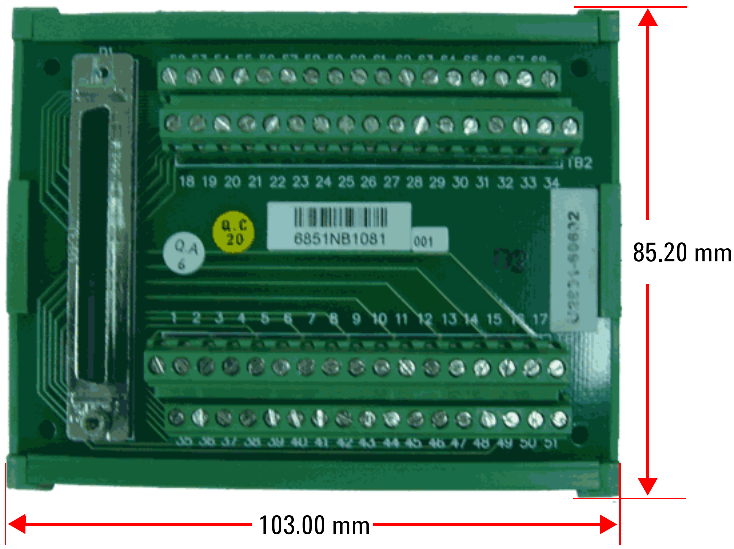


Front view

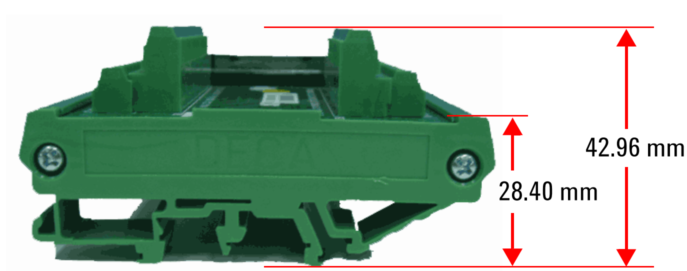


Terminal Block Overview

Top view



Side view



Standard Purchase Items Checklist

Inspect and verify that you have all the following items upon the purchase of your U2500A series DAQ device. If there are missing items, please contact the nearest Agilent Sales Office.

- ✔ AC/DC power adapter
- ✔ Power cord
- ✔ USB extension cable
- ✔ L–Mount kit (used with Agilent U2781A modular instrument chassis)
- ✔ Agilent USB Modular Products and Systems Quick Start Guide
- ✔ Agilent USB Modular Products and Systems Product Reference DVD-ROM
- ✔ Agilent Automation-Ready CD-ROM (contains the Agilent IO Libraries Suite)
- ✔ Certificate of Calibration

WARNING **Use only power adaptor provided by manufacturer to avoid unexpected hazard.**

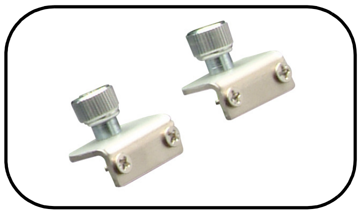
Software Installation

If you would like to use the U2500A series DAQ devices with the Agilent Measurement Manager application software, follow the step-by-step instructions as shown in the *Agilent USB Modular Products and Systems Quick Start Guide*.

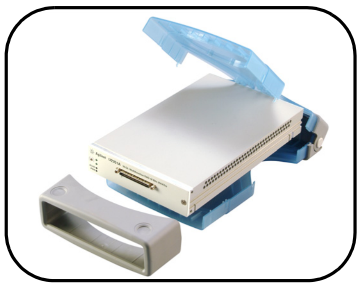
NOTE You may be required to install the IVI-COM driver before using the U2500A series with other ADEs.

L-Mount Kit Installation

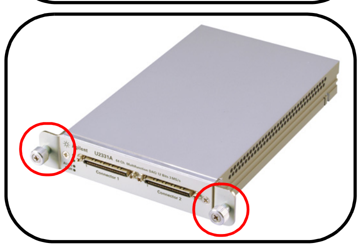
The L-Mount kit is to be used with Agilent U2781A USB modular instrument chassis.The following instructions describes simple procedures of installing the L-Mount kit to a U2600A USB devices.



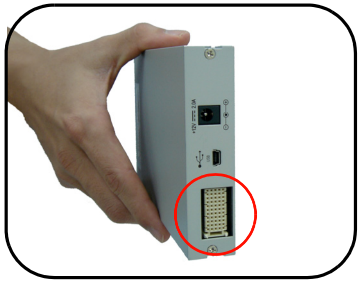
1 Unpack the L-Mount kit from the packaging.



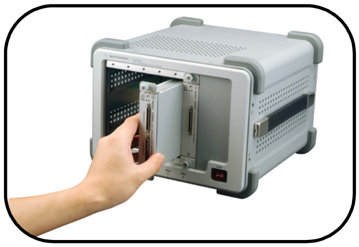
2 Remove your USB device from its plastic casing by pulling the bumper (front end of the casing) in an outward direction. Then, lift the plastic body casing and remove it from your USB device.



3 Using the *Philips* screw driver, screw the L-Mount kit to your USB device.



4 To slot in the USB module to your chassis, turn your module perpendicularly and ensure that the 55-pin backplane connector is at the bottom side of the USB module.



5 Your USB device is now ready to be plug into an instrument chassis.

General Maintenance

NOTE Repair or service which are not covered in this manual should only be performed by qualified personnel.

To remove the dirt or moisture from the USB device, follow the instructions below.

1 Power off the USB device and remove the AC/DC adapter cord and USB cable from your device.
2 Remove your USB device from its plastic casing by pulling at the bumper (front end of the casing) in an outward direction. Then, lift the plastic body casing and remove it from your USB device.
3 Holding your USB device, shake out any dirt that may have accumulated on the panel of your USB device.
4 Wipe your USB device with a dry clean cloth.

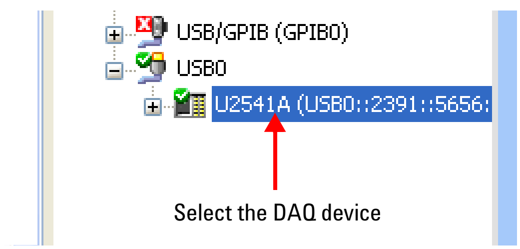
Additional Information

Hardware verification

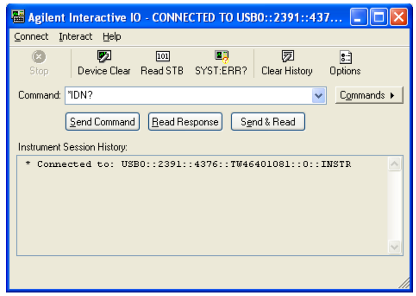
Agilent Connection Expert is one of the utilities of Agilent IO Libraries. It automatically detects the USB devices that are connected to the PC and enables communication between the USB device and the PC. To verify that your USB device has established a connection with your PC, perform the following steps.

1 Go to **Start > All Programs > Agilent IO Libraries Suite > Agilent Connection Expert** to launch the Agilent Connection Expert.

2 The connected USB device will be visible in the **Instrument I/O on this PC** panel as indicated in the following. Select the DAQ connection interface and right-click.



3 A context menu will appear. Click **Send Commands To This Instrument**. The Agilent Interactive IO dialog box will appear as shown below. Click **Send & Read** to send the `*IDN?` default SCPI command. The instrument's response will be displayed in the **Instrument Session History** panel.



4 Successful communication between the PC and the connected hardware indicates successful hardware installation and connection establishment.

Sample code

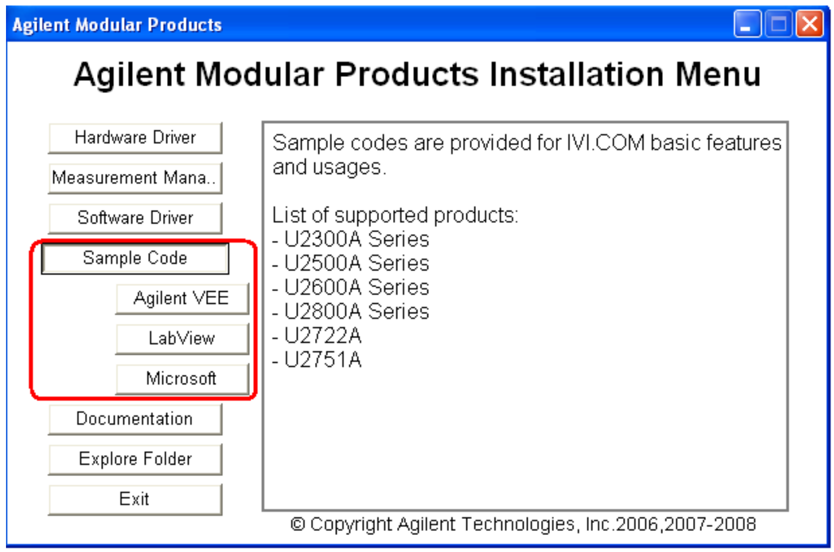
Sample codes for Agilent VEE, LabView and Microsoft (C#, C++, VB7, and VB6) are provided to help you get started and familiarized with the instrument. The sample codes provided for each language are as follows.

- **Example1**: Demonstrates the initialization of the instrument.
- **DigitalIO:** Read data from instrument and write data to instrument.
- **OneShot:** Acquire data from measurement and return it to user.
- **Counter:** Perform basic counter functionality such as configure the counter and measure frequency.
- **ArbWav:** Generation of arbitrary waveform.
- **StdWav:** Generation of standard waveform.

To view the sample code

Select **Sample Code** on the Agilent Modular Products Installation Menu and choose the type of language.

See the following figure.



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2
Connector Pins Configuration

This chapter describes the U2500A series USB simultaneous sampling multifunction data acquisition devices pins configuration and the 55-pin backplane connector pins configuration.

Introduction

The U2500A series USB simultaneous sampling multifunction data acquisition (DAQ) devices were equipped with 68-pin female VHDCI type connector. The connector pins configuration for all of the U2500A series DAQ devices are provided in this chapter.

When the DAQ module is used in a modular instrument chassis (U2781A), see Figure 2-1 for the pins numbering. When the DAQ module is used as a standalone unit, see Figure 2-2.

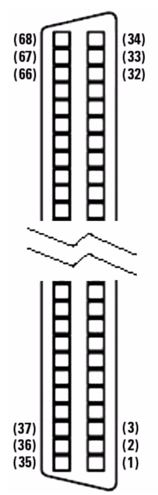

Figure 2-1 Connector in vertical view

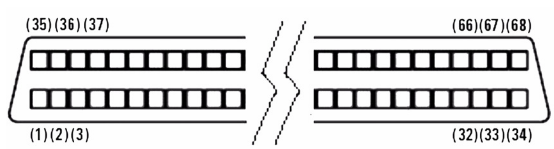

Figure 2-2 Connector in horizontal view

Connector Pins Configuration for U2531A/U2541A/U2542A

	AIH101	1	35	AIL 101	
	AIH102	2	36	AIL 102	
	AIH103	3	37	AIL 103	
	AIH104	4	38	AIL 104	
	EXTA_TRIG	5	39	AI_GND	
	AO202	6	40	AO_GND	
	AO201	7	41	AO_GND	
	AO_EXT_REF	8	42	AO_GND	
	RESERVED	9	43	RESERVED	
	RESERVED	10	44	RESERVED	
	RESERVED	11	45	RESERVED	
	RESERVED	12	46	RESERVED	
	RESERVED	13	47	EXTD_AO_TRIG	
	RESERVED	14	48	EXTD_AI_TRIG	
	COUNT302_CLK	15	49	D_GND	
	COUNT301_CLK	16	50	D_GND	
	COUNT301_GATE	17	51	COUNT302_GATE	
	COUNT301_OUT	18	52	COUNT302_OUT	
	COUNT301_UPDOWN	19	53	COUNT302_UPDOWN	
	EXT_TIMEBASE	20	54	D_GND	
	RESERVED	21	55	RESERVED	
DIO502	Bit-7	22	56	Bit-6	DIO502
DIO502	Bit-5	23	57	Bit-4	DIO502
DIO502	Bit-3	24	58	Bit-2	DIO502
DIO502	Bit-1	25	59	Bit-0	DIO502
DIO504	Bit-3	26	60	Bit-2	DIO504
DIO504	Bit-1	27	61	Bit-0	DIO504
	D_GND	28	62	D_GND	
DIO503	Bit-3	29	63	Bit-2	DIO503
DIO503	Bit-1	30	64	Bit-0	DIO503
DIO501	Bit-7	31	65	Bit-6	DIO501
DIO501	Bit-5	32	66	Bit-4	DIO501
DIO501	Bit-3	33	67	Bit-2	DIO501
DIO501	Bit-1	34	68	Bit-0	DIO501

Figure 2-3 Pins configuration for U2531A/U2541A/U2542A

Table 2-1 Pins legend for U2531A/U2541A/U2542A

Pin	Signal Name	Direction	Reference	Description
1 to 4	AIH<101...104>	Input	AIL<101...104>	Differential positive input for AI channel <101...104>
5	EXTA_TRIG	Input	AI_GND	External AI analog trigger
6	AO202	Output	AO_GND	AO channel 2
7	AO201	Output	AO_GND	AO channel 1
8	AO_EXT_REF	Input	AO_GND	External reference for AO channels
9 to 12	RESERVED	Input	N/A	RESERVED
13, 14	RESERVED	Output	D_GND	RESERVED
15	COUNT<302>_CLK	Input	D_GND	Source of counter <302>
16	COUNG<301>_CLK	Input	D_GND	Source of counter <301>
17, 51	COUNT<301,302>_ GATE	Input	D_GND	Gate of counter <301,302>
18, 52	COUNT<301,302>_ OUT	Input	D_GND	Output of counter <301,302>
19, 53	COUNT<301,302>_ UPDOWN	Input	D_GND	Up/Down of counter <301,302>
20	EXT_TIMEBASE	Input	D_GND	External TIMEBASE
21, 28, 49, 50, 54, 62	D_GND	N/A	N/A	Digital ground
22, 56, 23, 57, 24, 58, 25, 59	DIO502<7,0>	PIO	D_GND	Programmable DIO of Channel 502
26, 60, 27, 61	DIO504<3,0>	PIO	D_GND	Programmable DIO of Channel 504
29, 63, 30, 64	DIO503<3,0>	PIO	D_GND	Programmable DIO of Channel 503
31, 65, 32, 66, 33, 67, 34, 68	DIO501<7,0>	PIO	D_GND	Programmable DIO of Channel 501
35 to 38	AIL<101...104>	Input	N/A	Differential negative input for AI channel<101...104>
39	AI_GND	N/A	N/A	Analog ground for AI
40 to 42	AO_GND	N/A	N/A	Analog ground for AO
43 to 46	RESERVED	Input	N/A	RESERVED
47	EXTD_AO_TRIG	Input	D_GND	External AO waveform trigger
48	EXTD_AI_TRIG	Input	D_GND	External AI digital trigger
21, 55	RESERVED	Input	N/A	RESERVED

55-pin Connector (J1) Pins Configuration

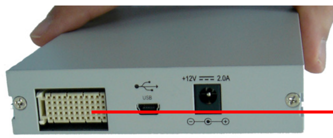

Figure 2-4 Connector (J1) 55-pin

Table 2-2 U2500A series J1 connector pin assignment

11	GND	+12 V	+12 V	GND	USB_D+	USB_D-	GND
10	GND	+12 V	+12 V	+12 V	GND	GND	GND
9	GND	+12 V	+12 V	+12 V	GND	USB_VBUS	GND
8	GND	LBL0	BRSV	GND	TRIG0	LBR0	GND
7	GND	LBL1	GA0	TRIG7	GND	LBR1	GND
6	GND	LBL2	GA1	GND	TRIG1	LBR2	GND
5	GND	LBL3	GA2	TRIG6	GND	LBR3	GND
4	GND	LBL4	STAR_TRIG	GND	TRIG2	LBR4	GND
3	GND	LBL5	GND	TRIG5	GND	LBR5	GND
2	GND	LBL6	CLK10M	GND	TRIG3	LBR6	GND
1	GND	LBL7	GND	TRIG4	GND	LBR7	GND
	Z	A	B	C	D	E	F

Table 2-3 U2500A series J1 connector legend

Pin	Descriptions
+12 V	+12 V power from backplane
GND	Ground
BRSV	Reserved pin
TRIG0 to TRIG7	Trigger bus 0 to 7
STAR_TRIG	Star trigger
CLK10M	10 MHz reference clock
USB_VBUS	USB bused power, +5 V
USB_D+, USB_D-	USB differential pair
LBL <0..7> and LBR <0...7>	Reserved pin
GA0, GA1, GA2	Geographical address pin

3
Features and Functions

This chapter describes the features and functions of the Agilent U2500A series USB simultaneous sampling multifunction DAQ device. This includes the operations of the analog input operation mode, analog output operation mode, digital I/O and General Purpose Digital Counter. This chapter also explains the trigger sources available for the device and some SCPI examples are provided to assist you in programming.

Features Overview

U2531A	14-bit analog input resolution with maximum sampling rate of 2 MSa/s
U2541A	16-bit analog input resolution with maximum sampling rate of 250 kSa/s
U2542A	16-bit analog input resolution with maximum sampling rate of 500 kSa/s

- Simultaneous sampling for analog input
- Resolution of 14-bit and 16-bit
- 4 simultaneous differential inputs (DI)
- Programmable bipolar and unipolar analog input
- Self-calibration supported
- USBTMC 488.2 compliant
- Hi-Speed USB 2.0 interface
- Multiple trigger sources† — none (immediate trigger), external analog/digital trigger, and SSI/star trigger (used with modular chassis)

Analog Input Operation Mode

The U2500A series DAQ devices have four simultaneous sampling (SS) analog input (AI) channels with programmable sampling rate. To measure analog signals, you should define the properties of the measured signals. The properties include the mode (polling/continuous), polarity (bipolar/ unipolar), and voltage range. You may also need to set the desired channels to input the analog signals. For all the SS models, the measuring configuration is in differential (DIFF) mode.

AI operations require a trigger source. Once the trigger condition is matched, the data acquisition will start. The measured signal is buffered in a Data FIFO. The analog inputs are able to measure input voltages between ±1.25 V to ±10 V. The diagram in Figure 3-5 illustrates the functional block diagram of the U2500A series DAQ devices.

When the U2500A series DAQ devices are switched on, the calibration constants are loaded from the on-board EEPROM to ensure both the calibration DACs and PGA circuit is functioning correctly. Refering to the functional block diagram in Figure 3-5, the AI signals will firstly get to the analog multiplexer and then to the PGA. Next, it will get through the analog digital converter (ADC), where the analog voltage will be converted into digital information for computer to process or store the signals. Note that the trigger levels for the digital analog converter (DAC) have to be defined beforehand if you want to use the analog trigger.

In this section, different types of analog input modes are described. The analog to digital data conversion for 16 bits and 14 bits will also be explained with formulas (bipolar and unipolar). Finally, the AI data format for U2500A series is provided.

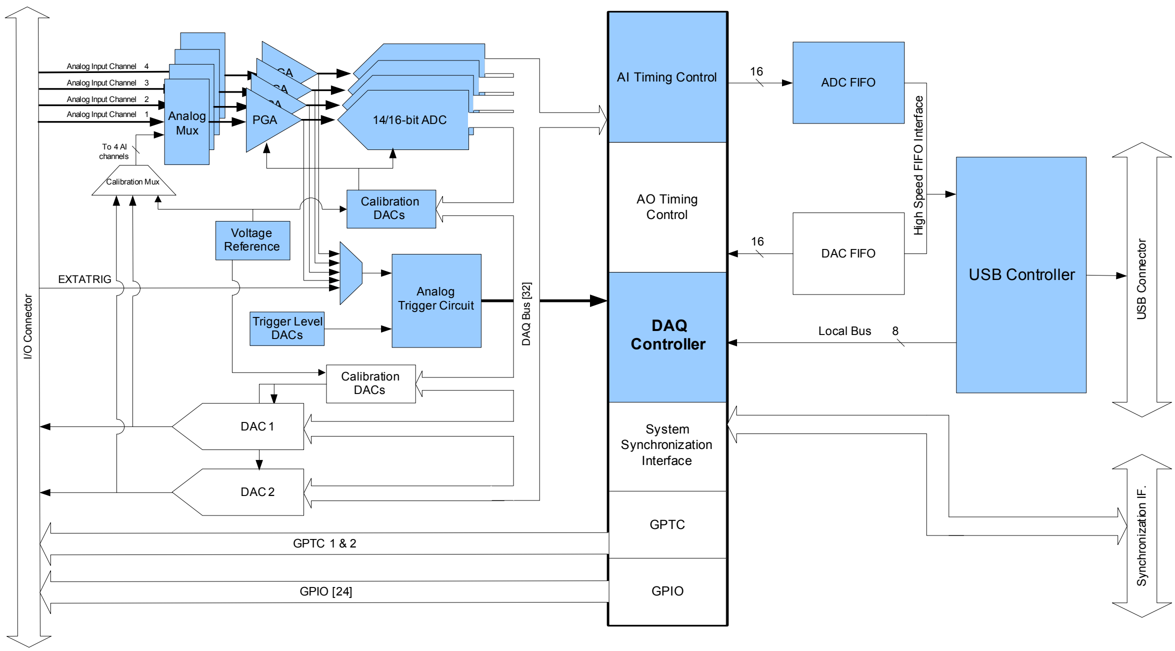

Figure 3-5 Functional block diagram of U2500A series DAQ device

There are two different modes of analog input operation, which are the polling and continuous.

Table 3-1 Analog input operation overview

Operation	Modes	Types of Acquisition
Analog Input	Polling Mode	Single A/D data acquisition
	Continuous Mode	• Single-shot acquisition • Continuous acquisition

Polling mode

This is the easiest way to acquire a single A/D measurement simultaneously for four different channels. The A/D converter starts converting one reading whenever the dedicated SCPI command is executed. The SCPI command for performing the polling mode measurement is under MEASure subsystem. In this mode, the timing of the A/D conversion is fully controlled by software.

Prior to using the polling mode, the properties of the measured signal should be defined. The properties that should be defined are voltage range (±10 V, ±5 V, ±2.5 V, ±1.25 V) and polarity (unipolar/bipolar). The default voltage range is ±10 V and the default polarity is bipolar. These properties can be set via SCPI commands under the SOURce subsystem. The signal type for U2500A series is in differential mode (DIFF).

By default, the polling mode measurement is made once the `MEASure?` query command is received by the devices. This behavior can be altered by instructing the device to average a range of measurements prior to returning the final value to users. For example, by setting the following SCPI command

```
[SENSe]:VOLTage:AVERage 10, (@101)
```

prior to the `MEASure? (@101)` query command, the device will make ten measurements; average them and returns the average value to the users.

NOTE For more information on MEASure subsystem, SOURce Subsystem and [SENSe:]VOLTage, refer to the *Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices Programmer's Reference*.

Example 1: Analog input polling

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> MEAS? (@101,102,103,104)`	*// AI polling with default condition*
`<-1.50123,5.0012,7.1234,9.1112`	*// Returned measurement*

Example 2: Analog input polling with settings

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> VOLT:RANG 10,(@101,103)`	*// Set 10 V range to CH 101, 103*
`-> VOLT:POL UNIP,(@101,103)`	*// Set polling to measure 100 times and return the average value*
`-> VOLT:AVER 100`	*// Set polling to measure 100 times and return the average value*
`-> MEAS? (@101,103)`	*// Ask AI polling to activate on above setting with 100 measurements and return the average value*
`<- 1.50123,5.3212`	*// Returned average value of 100 measurements from each channel*

Continuous mode

There are two types of continuous mode, single-shot and continuous acquisition. In single-shot acquisition, the data is acquired at a specified sample points and processed once. In continuous acquisition, the process of acquiring data is continuous until a `STOP` command is sent. The SCPI commands below are used to start the acquisition process:

- Single-shot acquisition:

  ```
  DIGitize
  ```

- Continuous acquisition:

  ```
  RUN
  ```

In continuous mode, there are two parameters that need to be specified:

a) Sampling rate

The maximum sampling rate depends on the ADC's sampling rate. For example, if you set the sampling rate to maximum, i.e. 500 kSa/s for U2542A, all the AI channels will sample data under the same sampling rate individually. The SCPI command to set the sampling rate for AI is:

```
ACQuire:SRATe <value>
```

The default sampling rate is 1 kHz.

b) Sample points

The sample points parameter is used to set the number of acquisition points for each channel. For example, if 800 sample points is set, measuring four AI channels simultaneously will require a total of 3200 samples to be acquired. The SCPI command to set the sample points for AI is:

```
ACQuire:POINts <value>
```

The default sample points is 500.

NOTE The maximum sample points for single-shot acquisition is 8 MSa divided by the number of channels enabled and for continuous acquisition is 4 MSa divided by the number of channels enabled.

Example1: Single-shot acquisition

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> ROUT:ENAB 1,(@101,103)`	*// To enable acquisition on CH 101 and 103*
`-> ROUT:CHAN:RANG 10,(@101,103)`	*// Set 10 V range to CH 101 and 103*
`-> ROUT:CHAN:POL BIP,(@101,103)`	*// Set BIPolar measuring mode to CH 101 and 103*
`-> ACQ:SRAT 10000`	*// Set acquisition with 10000 Sa/s sampling rate*
`-> ACQ:POIN 1000`	*// Set 1000 point for acquisition for each channel*
`-> DIG`	*// Activate single-shot acquisition*
`-> WAV:COMP?`	*// Check acquisition completion*
`<- NO`	*// Acquisition is not completed yet, it takes 1 sec to complete this acquisition*
`-> WAV:COMP?`	*// Check acquisition completion*
`<- YES`	*// Acquisition completed*
`-> WAV:DATA?`	*// Fetch data back to the user's PC*
`<- #800004000<data><data>...`	*// Raw data returned in binary block*

Example 2: Continuous acquisition

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> ROUT:ENAB 1,(@101,103)`	*// To enable acquisition on channel 101 and 103*
`-> ROUT:CHAN:RANG 10,(@101,103)`	*//Set 10 V range to CH 101 and 103*
`-> ROUT:CHAN:POL BIP,(@101,103)`	*// Set BIPolar measuring mode to CH 101 and 103*
`-> ACQ:SRAT 10000`	*// Set acquisition with 10000 Sa/s sampling rate*
`-> WAV:POIN 1000`	*// Set 1000 Sa point for acquisition for each data block*
`-> DIG`	*//Activate single-shot acquisition*
`-> WAV:STAT?`	*// Check acquisition status*
`<- FRAG`	*// Acquisition is not completed yet, it takes 1 sec to complete this block of acquisition*
`-> WAV:STAT?`	*// Check acquisition status*
`<- DATA`	*// This block of acquisition completed*
`-> WAV:DATA?`	*// Fetch data back to the user's PC*
`<- #800004000<data><data>….`	*// Raw data returned in binary block*

A/D data conversion

A/D data converter converts analog voltage into digital information. This section illustrates the format of acquired raw data from the A/D conversion.

The returned data is in a binary block format. Below is an example of the binary block format for three AI channels (CH 101, CH 102, and CH 103). The data arrangement in data buffer is from lower CH 101 to higher channel CH 103.

ASCII header **Numbers in hexadecimal**

<table>
<tr><th>#800001000</th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th>...</th></tr>
<tr><td rowspan="2">Data length indicator. “#8” means the following 8 bytes (0000 1000) indicates the actual data length, not actual data. E.g. for #800001000, “00001000” is the data length translated to 1000 bytes of raw data, which is 500 points of measured data.</td><td>1st data LSB</td><td>1st data MSB</td><td>1st data LSB</td><td>1st data MSB</td><td>1st data LSB</td><td>1st data MSB</td><td>2nd data LSB</td><td>2nd data MSB</td><td>...</td></tr>
<tr><td colspan="2">CH 101</td><td colspan="2">CH 102</td><td colspan="2">CH 103</td><td colspan="2">CH 101</td><td>...</td></tr>
</table>

The measured samples in continuous mode acquisition is stored in Little-Endian format. In other words, each measured sample is returned in a way that its least significant byte (LSB) is ordered first; following by its most significant byte (MSB).

16-bit Data Format

LSB	MSB
DDDD DDDD	DDDD DDDD

14-bit Data Format

LSB	MSB
DDDD DDXX	DDDD DDDD

D - Data bits

X - Unused bits

Raw data conversion

To convert the data into actual float number, we need the voltage range and polarity information. Below are the calculations on the raw data conversion for both bipolar and unipolar.

To perform a sample calculation of the conversion, take U2541A as example. Assume that the voltage level is set in the range from 0 V to 10 V for unipolar setting; and –10 V to 10 V for bipolar setting. Sample binary block is as follow.

#800001000	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**...**
	1st data LSB	1st data MSB	1st data LSB	1st data MSB	1st data LSB	1st data MSB	2nd data LSB	2nd data MSB	...
	CH 101		CH 102		CH 103		CH 101		...
Little Endian Format									
#800001000	e0	31	ff	cf	ff	ca	ff	c4	
Convert to Decimal Format									
#800001000	12768		53247		51967		50431		

The resolution for U2541A is 16 bits and the Int16 measured value return by DAQ is 12768. The binary number for 12768 is 00110001 11100000. However, since the data is stored in Little-Endian format, the 16 bits binary read back calculation will be as follow.

	LSB	**MSB**
Hex value :	**e0**	**31**
Binary value :	**<11100000>**	**<00110001>**
Decimal value :	**12768**	

NOTE The raw data provided by U2500A series DAQ devices is in the byte order of LSB first.

Bipolar:

$$\text{Converted value} = \left(\frac{2 \times \text{Int16 value}}{2^{\text{resolution}}}\right) \times \text{Range}$$

$$\text{Example of converted value} = \left(\frac{2 \times 12768}{2^{16}}\right) \times 10 = 3.896\text{ V}$$

Unipolar:

$$\text{Converted value} = \left(\frac{\text{Int16 value}}{2^{\text{resolution}}} + 0.5\right) \times \text{Range}$$

$$\text{Example of converted value} = \left(\frac{12768}{2^{16}} + 0.5\right) \times 10 = 6.948\text{ V}$$

NOTE The converted value is of float type. As such, you may need to type cast the Int16 value to float in your programming environment.

To perform a sample calculation of the conversion, take U2531A as example. Assume that the voltage level is set in the range from 0 V to 10 V for unipolar setting; and –10 V to 10 V for bipolar setting.

The resolution for U2531A is 14 bits and the Int12 measured value return by DAQ is 12768. The binary number for 12768 is 00110001 11100000. However, since the data is stored in Little-Endian format, the 14 bits binary read back calculation will be as follow.

	LSB	MSB
Hex value :	**e0**	**31**
Binary value :	**<11100000>**	**<00110001>**
Decimal value :	**12768**	

There are unused bits in the 14-bit data format. Therefore, there is a need to perform a 2-bit right shift operation. Hence, the 14 bits binary read back calculation will be as follows.

LSB MSB
<01111100> <00001100>
= 3192

NOTE The raw data provided by U2500A series DAQ devices is in the byte order of LSB first.

Bipolar:

$$\text{Converted value} = \left(\frac{2 \times \text{Int16 value}}{2^{\text{resolution}}}\right) \times \text{Range}$$

$$\text{Example of converted value} = \left(\frac{2 \times 3192}{2^{14}}\right) \times 10 = 3.896\ \text{V}$$

Unipolar:

$$\text{Converted value} = \left(\frac{\text{Int16 value}}{2^{\text{resolution}}} + 0.5\right) \times \text{Range}$$

$$\text{Example of converted value} = \left(\frac{3192}{2^{14}} + 0.5\right) \times 10 = 6.948\ \text{V}$$

NOTE

- The converted value is of float type. As such, you may need to type cast the Int14 value to float in your programming environment.
- For U2531A, there is a need to perform a 2-bit right shift operation. This is because it is equipped with 14-bit ADC and the last 2 bits are truncated.

AI data format

14-bit AI range

The following tables 3-2 and 3-3 describe the U2531A ideal transfer characteristics of the bipolar and unipolar analog input ranges. The digital code number is two complement number.

Table 3-2 Analog input range and digital code output for bipolar

Description	Bipolar analog input range				Digital code output
Full-scale Range (FSR)	±10 V	±5 V	±2.5 V	±1.25 V	
Least significant bit (LSB)	1.22 mV	0.61 mV	0.305 mV	0.153 mV	
FSR–1LSB	9.9988 V	4.9994 V	2.4997 V	1.2499 V	1FFF
Midscale +1LSB	1.22 mV	0.61 mV	0.305 mV	0.153 mV	0001
Midscale	0 V	0 V	0 V	0 V	0000
Midscale –1LSB	–1.22 mV	–0.61 mV	–0.305 mV	–0.153 mV	3FFF
–FSR	–10 V	–5 V	–2.5 V	–1.25 V	2000

Table 3-3 Analog input range and digital code output for unipolar

Description	Unipolar analog input range				Digital code output
Full-scale Range (FSR)	0 V to 10 V	0 V to +5 V	0 V to +2.5 V	0 to 1.25 V	
Least significant bit (LSB)	0.61 mV	0.305 mV	0.153 mV	76.3 μV	
FSR–1LSB	9.9994 V	4.9997 V	2.9999 V	1.2499 V	1FFF
Midscale +1LSB	5.00061 V	2.50031 V	1.25015 V	625.08 mV	0001
Midscale	5 V	2.5 V	1.25 V	625 mV	0000
Midscale –1LSB	4.99939 V	2.49970 V	1.24985 V	624.92 mV	3FFF
–FSR	0 V	0 V	0 V	0 V	2000

16-bit AI range

The following tables 3-4 and 3-5 describe the ideal transfer characteristics of bipolar and unipolar input ranges of U2541A and U2542A models.

Table 3-4 Analog input range and digital code output for bipolar

Description	Bipolar analog input range				Digital code output
Full-scale Range (FSR)	±10 V	±5 V	±2.5 V	±1.25 V	
Least significant bit (LSB)	305.2 µV	152.6 µV	76.3 µV	38.15 µV	
FSR–1LSB	9.999695 V	4.999847 V	2.499924 V	1.249962 V	7FFF
Midscale+1LSB	305.2 µV	152.6 µV	76.3 µV	38.15 µV	0001
Midscale	0 V	0 V	0 V	0 V	0000
Midscale–1LSB	–305.2 µV	–152.6 µV	–76.3 µV	–38.15 µV	FFFF
–FSR	–10 V	–5 V	–2.5 V	–1.25 V	8000

Table 3-5 Analog input range and digital code output for unipolar

Description	Unipolar analog input range				Digital code output
Full-scale Range (FSR)	0 V to 10 V	0 V to +5 V	0 V to +2.5 V	0 V to +1.25 V	
Least significant bit (LSB)	152.6 µV	76.3 µV	38.15 µV	19.07 µV	
FSR –1LSB	9.999847 V	4.999924 V	2.499962 V	1.249981 V	7FFF
Midscale +1LSB	5.000153 V	2.500076 V	1.250038 V	0.625019 V	0001
Midscale	5 V	2.5 V	1.25 V	0.625 V	0000
Midscale –1LSB	4.999847 V	2.499924 V	1.249962 V	0.624981 V	FFFF
–FSR	0 V	0 V	0 V	0 V	8000

Analog Output Operation Mode

There are two analog output (AO) channels (12 bits) available in the U2500A series DAQ devices. The two analog outputs are capable of supplying output voltages in the range of 0 to 10 V and ±10 V. Each DAC channel drives a maximum current of 5 mA. The two analog outputs can be used as voltage sources to your devices under test (DUT). In addition, the analog outputs are equipped with predefined function generators or any arbitrary waveform.

Analog output operation mode consists of voltage output and continuous output. The continuous output mode provided with two functions, which are function generator and arbitrary. The U2500A series DAQ is capable to generate sinusoidal, square, triangle, sawtooth waveforms and noise.

Table 3-6 Analog output operation overview

Operation	Modes	Types of Output
Analog Output	Single Voltage Output	DC Voltage Output
	Continuous Output	• Pre-defined Waveform ◦ Sine wave ◦ Square wave ◦ Triangle wave ◦ Sawtooth wave ◦ Noise wave
		• Arbitrary Wave

Single voltage output mode

The following SCPI commands perform sample output of a DC voltage level for the specified DA channels.

Example 1, To output a DC voltage via CH 201

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> SOUR:VOLT 2.5, (@201)`	*// Reference is AO_GND*
`-> SOUR:VOLT 3.2, (@201)`	*// Changes output from 2.5 VDC to 3.2 VDC*
`-> SOUR:VOLT -3.2,(@201)`	*// Changes output from 2.5 VDC to –3.2 VDC*
`-> SOUR:VOLT? (@202)`	*// To query the state of CH 202*
`<- 0`	*// By default, CH 202 is 0 VDC*

Example 2, To output two DC voltages via CH 201 and CH 202

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> SOUR:VOLT 3.5, (@201)`	*// Set 3.5 VDC output to CH 201*
`-> SOUR:VOLT 8.1, (@202)`	*// Set 8.1 VDC output to CH 202*

Continuous output mode

The continuous output mode consists of function generator and arbitrary. You can use the following SCPI commands in arbitrary mode:

```
DATA[:USER]
```

```
APPLy:USER
```

NOTE For further information, refer to the *Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices Programming Guide*.

Example 3, To output a sine wave via CH 201

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> ROUT:ENAB ON, (@201)`	*// Enable CH 201*
`-> APPL:SIN 5,0, (@201)`	*// Sine wave with 5 Vp (10 Vpp) and 0 VDC offset*
`-> SYST:ERR?`	*// To check for any error, this command can be ignored if this operations is not required*
`<- +0, "No Error"`	
`-> OUTP ON`	*// Turn on output*
`-> OUTP:WAV:FREQ? (@201)`	
`<- 4000`	*// Default output waveform is at 4 kHz*
`-> OUTP OFF`	*// Turn off output (both CH 201 and CH 202 at 0 VDC)*
`-> OUTP:WAV:FREQ 5000`	*// Change output frequency to 5 kHz*
`-> OUTP ON`	*// Turn on output*

Example 4, To output a sine wave and square wave via CH 201 and CH 202 respectively

`-> *CLS;*RST`	*// To reset DAQ to default power-on state, this command can be ignored if this operation is not required*
`-> ROUT:ENAB ON,(@201,202)`	*// Enable CH 201 and CH 202*
`-> APPL:SIN 5,0, (@201)`	*// Sine wave with 5 Vp (10 Vpp) and 0 VDC offset*
`-> APPL:SQU 3,-1, (@202)`	*// Square wave with 3 Vp (6 Vpp) and –1 VDC offset*
`-> OUTP:WAV:FREQ 3500`	*// Set both channel's output to 3.5 kHz*
`-> SYST:ERR?`	

`<- +0, "No Error"`	*// To check for any error, this command can be ignored if this operations is not required*
`-> OUTP ON`	*// Turn on output*

D/A reference voltage

By default, the internal reference voltage is 10 V. However, external reference can be supplied through the external reference input pin (AO_EXT_REF). The range of the DAC output is directly related to the reference. The analog output voltage can be generated by multiplying the digital codes that are updated with the 10 V as internal reference. Therefore, when 10 V is taken as the internal reference, the full range would be –10 V to +9.9951 V in bipolar output mode, and 0 V to 9.9976 V in unipolar output mode.

While using an external reference, the different output voltage ranges can be achieved by connecting different reference voltage. For example, if connecting a 5 VDC with the external reference (AO_EXT_REF), then the range from –4.9976 V to +5 V in the bipolar output can be achieved. The tables below illustrates the relationship between digital code and output voltages.

AO data format

Data format for single channels arbitrary AO (when either one channel is enabled and USER mode) is shown in the following table.

<table>
<tr><th>#800001000</th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th>...</th></tr>
<tr><td rowspan="2">Data length indicator. “#8” means the following 8 bytes (0000 1000) indicates the actual data length, not actual data. E.g. for #800001000, “00001000” is the data length translated to 1000 bytes of raw data, which is 500 points of output data.</td><td>1st data LSB</td><td>1st data MSB</td><td>2nd data LSB</td><td>2nd data MSB</td><td>3rd data LSB</td><td>3rd data MSB</td><td>4th data LSB</td><td>4th data MSB</td><td>...</td></tr>
<tr><td colspan="2">CH 201 or 202</td><td colspan="2">CH 201 or 202</td><td colspan="2">CH 201 or 202</td><td colspan="2">CH 201 or 202</td><td>...</td></tr>
</table>

Data format for two channels arbitrary AO (when two channels are enabled and USER mode) is shown in the following table.

<table>
<tr><th>#800001000</th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th><byte></th><th>...</th></tr>
<tr><td rowspan="2">Data length indicator. “#8” means the following 8 bytes (0000 1000) indicates the actual data length, not actual data. E.g. for #800001000, “00001000” is the data length translated to 1000 bytes of raw data, which is 500 points of output data.</td><td>1st data LSB</td><td>1st data MSB</td><td>1st data LSB</td><td>1st data MSB</td><td>2nd data LSB</td><td>2nd data MSB</td><td>2nd data LSB</td><td>2nd data MSB</td><td>...</td></tr>
<tr><td colspan="2">CH 201</td><td colspan="2">CH 202</td><td colspan="2">CH 201</td><td colspan="2">CH 202</td><td>...</td></tr>
</table>

12-bit data format

LSB	MSB
DDDD DDDD	XXXX DDDD

D - Data bits
X - Unused bits

Table 3-7 Digital code and voltage output table for bipolar setting (U2531A, U2541A and U2542A)

Digital Code (Hex)	Analog Output	Voltage output (with internal reference of +10 V)
0x0FFF	Vref * (2047/2048)	9.9951 V
0x0801	Vref * (1/2048)	0.0048 V
0x0800	0 V	0.0000 V
0x07FF	–Vref * (1/2048)	–0.0048 V
0x0000	–Vref	–10.000 V

Table 3-8 Digital code and voltage output table for unipolar setting (U2531A, U2541A and U2542A)

Digital Code (Hex)	Analog Output	Voltage output (with internal reference of +10 V)
0x0FFF	Vref * (4095/4096)	9.9976 V
0x0800	Vref * (2048/4096)	5.000 V
0x0001	Vref * (1/4096)	0.0024 V
0x0000	Vref * (0/4096)	0.000 V

Digital I/O

The U2500A series DAQ provides 24-bit of general purpose digital I/O (GPIO), which is TTL compatible.

The 24-bit GPIO are segmented into four channels (CH 501 to 504). Channel 501 and 502 consists of eight data bit while Channel 503 and 504 consists of four data bit. All four channels are programmable as input and output. As the system starts up and reset, all the I/O pins are reset to the input configuration and in high impedance.

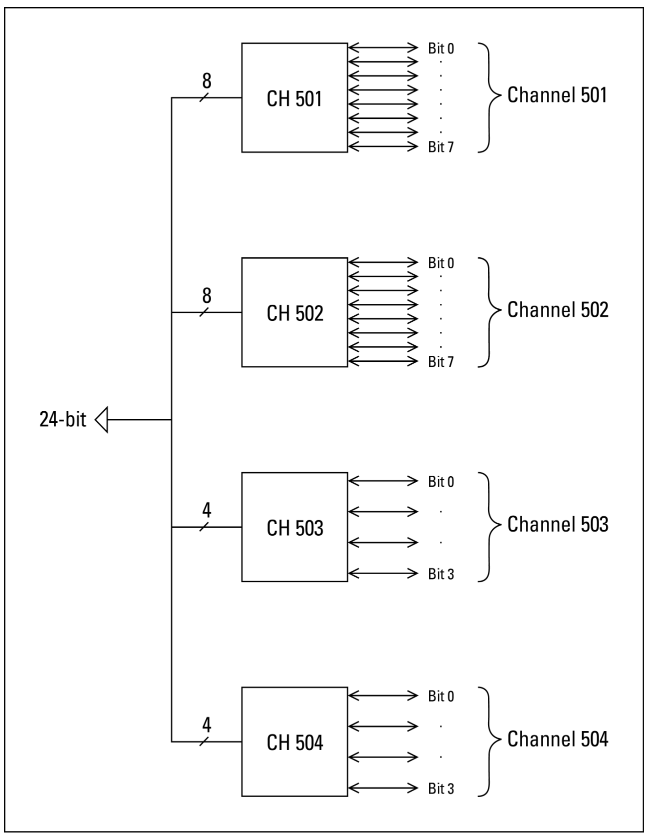

Figure 3-6 General purpose digital counter I/O of U2500A series DAQ device

The SCPI programming examples below will help you to configure the DIO and read a digital channel.

Configure the digital channel as OUTPUT and query/verify the output pattern data

Example 1:

```
-> CONF:DIG:DIR OUTP,(@501)
-> SOUR:DIG:DATA 123,(@501)
-> SOUR:DIG:DATA? (@501)
<- 123
```

Example 2:

`-> CONF:DIG:DIR OUTP,(@502)`	*//Configure the CH 502 to digital output state*
`-> SOUR:DIG:DATA:BIT 1,4,(@502)`	*//To set bit 4 of channel 502 to 1 immediately*
`-> SOUR:DIG:DATA:BIT? 4,(@502)`	*//Query status of bit 4 of CH 502*
`<- 1`	

Configure the digital channel to INPUT and read back the value

Example 1:

`-> CONF:DIG:DIR INP,(@501)`	*// Configure the CH 501 to digital input state*
`-> MEAS:DIG? (@501)`	*// To read back the digital value at channel 501*
`<- 23`	

Example 2:

```
-> CONF:DIG:DIR INP,(@501) // To read the logic state of bit 3 of channel 501
-> MEAS:DIG:BIT? 3,(@501)
<- 0
```

NOTE Input commands are not allow when channel is in Output mode, while output commands are not allow when channel is in Input mode.

Example 3:

```
-> CONF:DIG:DIR OUTP,(@501,503)
-> CONF:DIG:DIR INP,(@502,504)
-> CONF:DIG:DIR? (@501:504)
<- OUTP,INP,OUTP,INP
-> MEAS:DIG? (@501)            // CH 501 has been set to output state, hence, it cannot perform input activity
<-! VI_ERROR_TMO: A timeout occurred
-> SOUR:DIG:DATA? (@502)       // CH 502 has been set to input state, hence, it cannot perform output activity
<-! VI_ERROR_TMO: A timeout occurred
```

General Purpose Digital Counter

The U2500A series DAQ device has two independent 31-bit up/down counters to measure the input channels, which is TTL compatible. It has a programmable counter clock up to 12 MHz or clock generation. Refer to the following figure for further illustration.

The counter is designed with the following features:

- Count up/down capability
- Internal/external programmable counter clock source up to 12 MHz
- Programmable gate selection which can be triggered internally or externally
- Pre-loaded software initial count for Totalizer
- Read-back capability of current count, without affecting the counting process

This digital counter operates in two modes; totalizer and measurement modes.

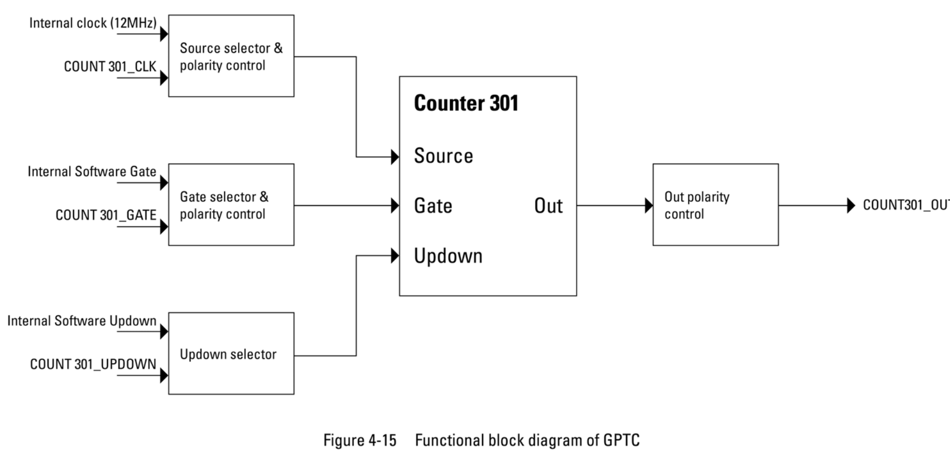

Figure 3-7 General purpose digital counter

Totalizer mode

In totalizer mode, the counter will start counting the number of pulses generated on COUNT_CLK. This is done after the GATE is enabled. The totalize count is measured with the following command:

```
MEASure:COUNter:TOTalize? (@301)
```

The example below illustrates the count up mode when the counter is configured as Totalize with initial count set to 0.

COUNT_GATE will enable the counting after Totalize function has been enabled and the COUNT_OUT pin will output a series of pulses as shown below.

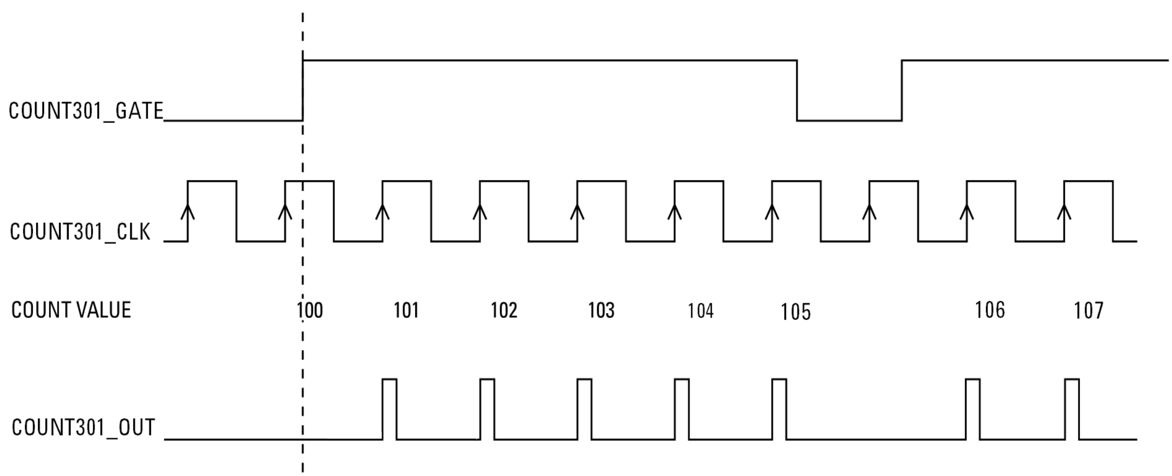

Figure3-8 Totalizer mode

NOTE The output pulse width is at 20.8 ns.

The following SCPI programming example shows how to set the counter mode.

```
// Supply the signal to COUNT301_CLK
// Counter mode setting
-> COUN:FUNC TOT,(@301)              // Set as Totalize function
-> COUN:GATE:SOUR INT,(@301)         // Set the GATE source as
                                     internal
-> COUN:CLK:POL AHI,(@301)           // Set the clock polarity as
                                     active high
-> COUN:CLK:SOUR EXT,(@301)          // Set the clock source as
                                     external
-> COUN:TOT:IVAL 100,(@301)          // Initial Count value
-> COUN:TOT:UDOW:DIR UP,(@301)       // Set as Count Upmode
-> COUN:TOT:UDOW:SOUR INT,(@301)     // Set the Up/Down source as
                                     internal
-> SOUR:COUN:OUTP:POL AHI,(@301)
-> COUN:TOT:INIT (@301)              // Initiate Totalize
-> MEAS:COUN:TOT? (@301)             // Initial value = 100
<- 100
-> MEAS:COUN:DATA? (@301)            // Return Totalize value
<- 100
-> COUN:GATE:CONT ENAB,(@301)        // Start Counting (for INT gate
                                     only)
-> COUN:GATE:CONT DIS,(@301)         // Stop Counting (for INT gate
                                     only)
-> MEAS:COUN:TOT? (@301)
<- 105
-> MEAS:COUN:DATA? (@301)
<- 105
-> COUN:ABOR (@301)                  // Abort all counter operation
-> COUN:TOT:CLE (@301)               // Clear Count value
-> MEAS:COUN:TOT? (@301)
<- 0
```

```
-> MEAS:COUN:DATA? (@301)
<- 0
```

Measurement mode

In the measurement mode, frequency, period and pulse width are measured. The intended measurement signal should be ported into COUNT301_GATE.

The gate source is set using the command below:

```
[SENSe:]COUNter:GATE:SOURce
```

Since all three measurements are derived from the same basic measurement, the measured frequency, period and pulse width can be easily retrieved from commands below:

```
MEAS:COUN:FREQ? (@<ch_list>
MEAS:COUN:PER? (@<ch_list>
MEAS:COUN:PWID? (@<ch_list>
```

The return value for frequency, period and pulse width measurements is a floating value.

NOTE

- The input frequency measurable range is from 0.1 Hz to 6 MHz, where measurement frequency resolution is:
  12 MHz/n, n = 2, 3, 4, 5, ..., 120M
  = 6 MHz, 4 MHz, 3 MHz, 2.4 MHz, 2.0 MHz, ..., 0.1 Hz (up to six decimal points)
- The pulse width measurement is in the range of 0.167 s to 178.956 s.

The following SCPI programming examples are for frequency, period and pulse width measurements.

Example 1:

```
// Supply the signal to COUNT301_GATE
// Counter mode setting
// Take 5.5 kHz with 70% duty cycle square wave as measurement
-> COUN:GATE:SOUR EXT,(@301)
-> COUN:GATE:POL AHI,(@301)
-> COUN:CLK:POL AHI,(@301)
-> COUN:CLK:SOUR INT,(@301)
-> COUN:CLK:INT?
<- 12000
-> SOUR:COUN:OUTP:POL AHI,(@301)
-> COUN:FUNC FREQ,(@301)
-> MEAS:COUN:DATA? (@301)          // Return value depend on
                                   function set
<- 5.499542                        // Frequency in kHz
-> COUN:FUNC PER,(@301)
-> MEAS:COUN:DATA? (@301)
<- 0.1818333                       // Period in ms
-> COUN:FUNC PWID,(@301)
-> MEAS:COUN:DATA? (@301)
<- 0.12725                         // Pulse width in ms
-> MEAS:COUN:FREQ? (@301)
<- 5.499542
-> COUN:FUNC? (@301)               // Function automatic set to
                                   FREQ
<- FREQ
-> MEAS:COUN:PER? (@301)
<- 0.1818333
-> COUN:FUNC? (@301)               // Function automatic set to
                                   PER
```

```
<- PER
-> MEAS:COUN:PWID? (@301)
<- 0.12725
-> COUN:FUNC? (@301)                    // Function automatic set to PWID
<- PWID
```

Example 2:

```
// Assume 10 MHz external Clock for FREQ,PER,PWID measurement
-> COUN:CLK:SOUR EXT,(@301)   // Must set the external Clock value (KHz)
-> COUN:CLK:EXT 10000,(@301)
-> COUN:CLK:EXT? (@301)
<- 10000
```

NOTE

Direction of the counter and the initial value of the counter are not important for this mode.

Trigger Sources

The Agilent U2500A series USB DAQ devices provide flexible trigger options for various applications. There are four types of trigger sources:

- none (immediate trigger)
- digital trigger
- analog trigger
- star trigger

Users can configure the trigger source for A/D and D/A operations remotely.

NOTE

- The D/A and A/D conversions share the same analog trigger.
- Star trigger is used when the DAQ is connected into the modular instrument chassis.

All four types of trigger sources are summarized in the following tables.

Table 3-9 Trigger type for single-shot acquisition of continuous mode

<table>
<tr><th>Trigger Source</th><th>Type</th><th>Condition</th><th>Pin Selection</th></tr>
<tr><td>None (immediate trigger)</td><td>• Post
• Delay</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Digital trigger</td><td rowspan="2">• Pre
• Middle
• Post
• Delay</td><td>Positive/Negative</td><td>EXTD_AI_TRIG, EXTD_AO_TRIG</td></tr>
<tr><td>Analog trigger</td><td>Above High/Below Low/Window</td><td>EXTA_TRIG, CH101, CH102, CH103, CH104</td></tr>
</table>

Table 3-10 Trigger type for continuous acquisition of continuous mode

Trigger Source	Type	Condition	Pin Selection
None (immediate trigger)	• Post • Delay	N/A	N/A
Digital trigger		Positive/Negative	EXTD_AI_TRIG, EXTD_AO_TRIG
Analog trigger		Above High/Below Low/Window	EXTA_TRIG, CH101, CH102, CH103, CH104

Trigger types

There are four types of trigger, which are pre-trigger, post-trigger, middle-trigger and delay-trigger.

Pre-trigger

This trigger type is used when you wish to collect data before a trigger event. The A/D conversion starts when you execute the specified function calls and stops when the trigger event occurs. For example, you specify four sample points and the analog trigger occurs after four sample point are converted. The SCPI command used to set the trigger type as pre-trigger is:

```
TRIG:TYPE PRE
```

Refer to Figure 3-9 for further illustration.

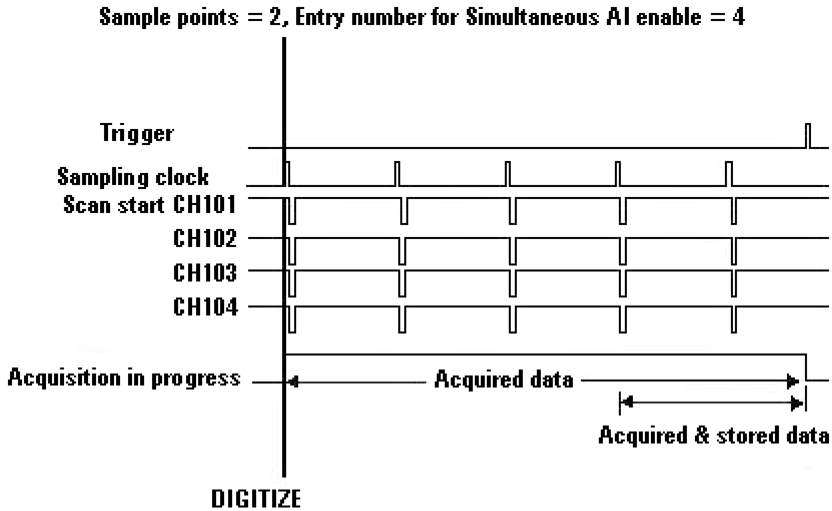

Figure 3-9 Pre-trigger

Middle-trigger

This trigger type is used when you want to collect data before and after a trigger event. The sampled data are equal before and after trigger. For example, if the user specify four sample points, the conversion only begins after the trigger event occurs. Two sample points before and after the trigger are taken. The SCPI command used to set the trigger type as middle-trigger is:

```
TRIG:TYPE MID
```

Refer to Figure 3-10 for further illustration.

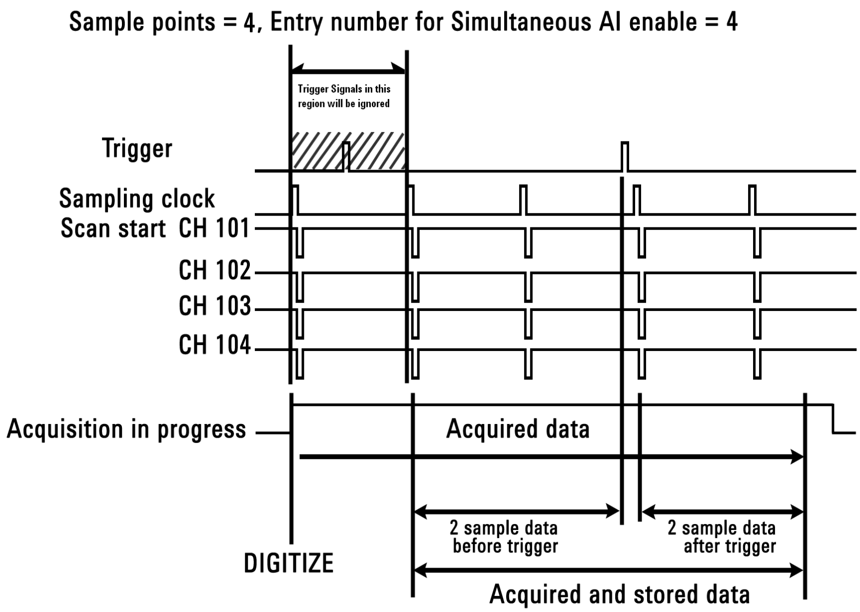

Figure 3-10 Middle-trigger

Post-trigger

The post-trigger is the default setting and used in applications when you want to collect data after a trigger event. As illustrated in the following figure, the sample point are set to two. Total of two sample points are taken after the trigger starts.

The SCPI command used to set the trigger type as post-trigger is:

```
TRIG:TYPE POST
```

Refer to Figure 3-11 for further illustration.

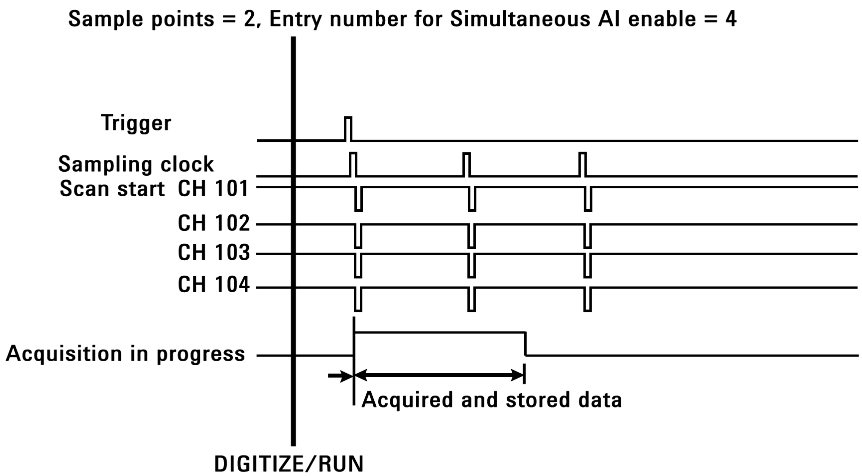

Figure 3-11 Post-trigger

Delay-trigger

This trigger acquisition is used in applications if you want to delay the data collecting process after a specified trigger event. The delay time is controlled by the value, which is pre-loaded in the Delay_counter (31-bit). The clock source is the Timebase clock. When the count reaches zero, the counter stops and the board start to acquire data. When the internal 48 MHz is set as Timebase clock, the delay time is in the range of 20.8 ns to 89.47 s. If the Timebase clock is from external clock (48 MHz to 1 MHz), the delay time can be varied by user's setting.

Refer to Figure 3-12 for further illustration.

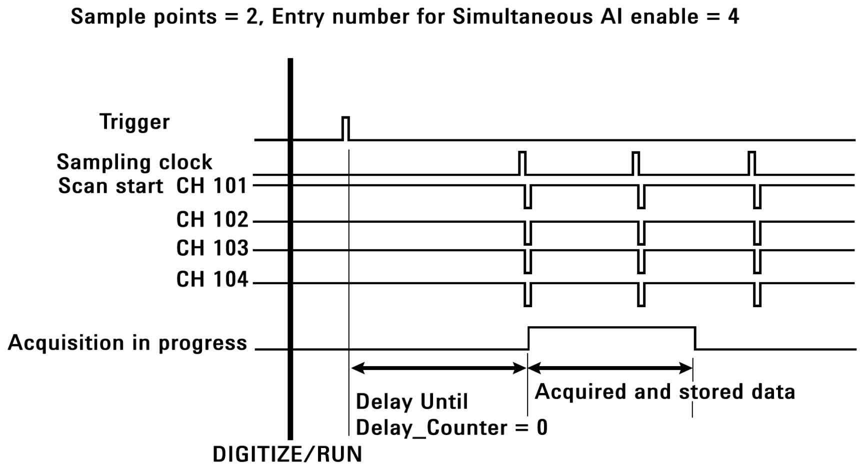

Figure 3-12 Delay-trigger

Digital trigger

There are positive and negative conditions in digital trigger. It is used when a rising or falling edge is detected on the digital signal. Positive condition is used when it triggers from low to high, while high to low when the negative condition is used.

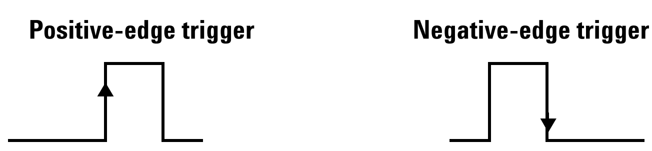

Figure 3-13 Positive and negative edge of digital trigger

Analog trigger

There are three analog trigger conditions in U2500A series DAQ and the trigger conditions are as follows:

- Above high
- Below low
- Window

It uses two threshold voltages, which are Low-Threshold and High-Threshold. Users can easily configure the analog trigger conditions using the Agilent Measurement Manager software.

Above high

The following figure illustrates the above high analog trigger condition. The trigger signal is generated when the analog input signal is higher than the High-Threshold voltage. In this trigger condition, the Low-Threshold voltage is not used.

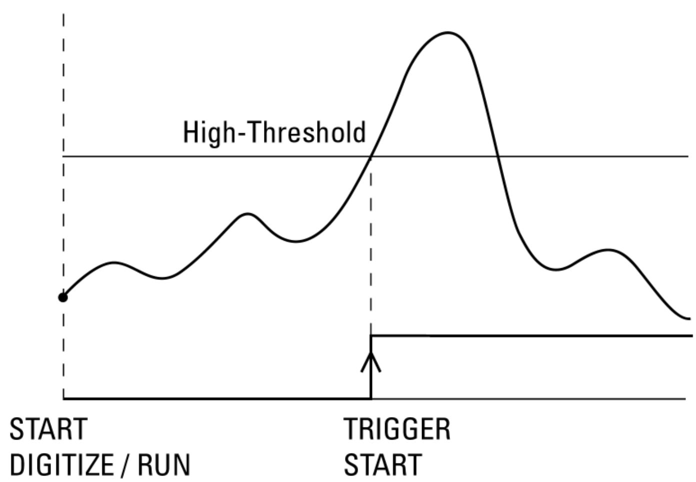

Figure 3-14 Above high trigger condition

Below low

In below low trigger condition, the trigger signal is generated when the analog input signal is lower than the Low-Threshold voltage. In this trigger condition, the High-Threshold voltage is not used. The following figure illustrates the below low analog trigger condition.

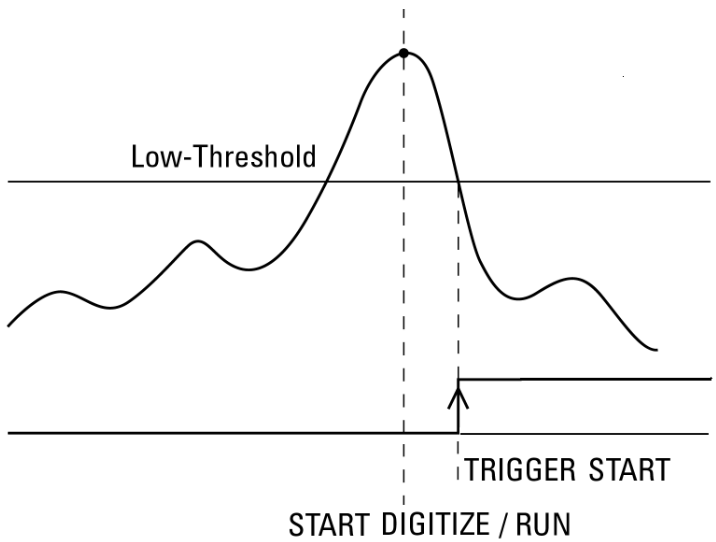

Figure 3-15 Below low trigger condition

Window

The window trigger condition is shown in the following diagram. The trigger signal is generated when the input analog signal falls within the voltage range of the High-Threshold and Low-Threshold.

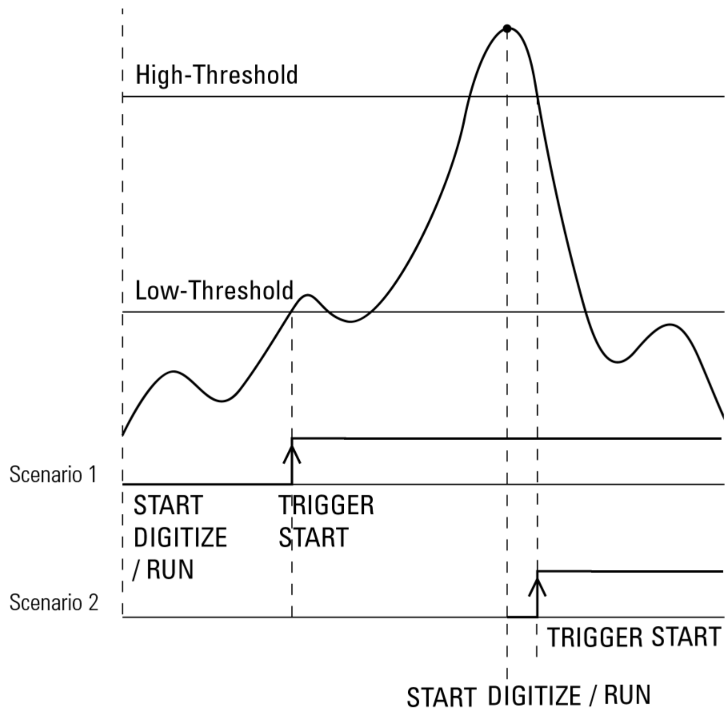

Figure 3-16 Window trigger condition

NOTE The High-Threshold voltage must be set higher than Low-Threshold.

SCPI Programming Examples

Analog input

Example 1:

```
// Digital trigger with delay trigger type
// Supply Digital trigger signal to EXTD_AI_TRIG
-> *CLS; *RST
-> ROUT:ENAB 1, (@101)
-> ACQ:POIN 1000                 // For "DIG" mode
-> ACQ:SRAT 1000
-> TRIG:SOUR EXTD                // Digital Trigger
-> TRIG:DTRG:POL POS
-> TRIG:TYPE DEL
-> TRIG:DCNT 225000000           // Count value ~= 4.6875 s
-> WAV:STAT?
<- EMPT
-> WAV:COMP?
<- YES
-> DIG                           //Start single-shot acquisition
-> WAV:STAT?
<- FRAG
-> WAV:COMP?                     // To check acquisition completion
                                 for DIG
<- NO
// Wait for trigger. Five seconds delay after the trigger event
-> WAV:STAT?
<- DATA
-> WAV:COMP?
<- YES
<- WAV:DATA?
<- #800002000 <byte><byte>...// Raw data returned by DAQ
```

Example 2:

```
// Digital trigger with Middle trigger type
-> *CLS; *RST
-> ROUT:ENAB 1, (@101)
-> WAV:POIN 1000          // For "RUN" mode
-> ACQ:SRAT 1000
-> TRIG:SOUR EXTD         // Digital Trigger
-> TRIG:DTRG:POL POS
-> TRIG:TYPE MID
-> RUN
```

Example 3:

```
// Analog trigger with Pre trigger type
-> *CLS; *RST
-> ROUT:ENAB 1, (@101)
-> ACQ:POIN 1000               // For "DIG" mode

-> ACQ:SRAT 1000
-> ROUT:SCAN (@101)
-> ROUT:CHAN:POL BIP,(@101)
-> TRIG:SOUR EXTA              // Analog trigger
-> TRIG:ATRG:COND AHIG         // Above high Threshold trigger
                               condition
-> TRIG:ATRG:HTHR 3            // 3 V high Threshold
-> TRIG:ATRG:LTHR -3           // –3 V low Threshold
-> TRIG:TYPE PRE               // Pre trigger
-> DIG
// Trigger will happen when signal go above 3 V
```

Example 4:

```
// Analog Trigger as trigger channel (CH101)
-> *CLS; *RST
-> ROUT:ENAB 1, (@101)
-> ACQ:POIN 1000                    // For "DIG" mode
-> ACQ:SRAT 1000
-> ROUT:CHAN:POL UNIP,(@133,101)
-> TRIG:SOUR EXTA
-> TRIG:ATRG:SOUR CH101             // Set trigger source to
                                    CH101
-> TRIG:ATRG:COND BLOW              // Below Low Threshold
                                    trigger condition
-> TRIG:ATRG:HTHR 6                 // 6 V High Threshold
-> TRIG:ATRG:LTHR                   // 2 V Low Threshold
-> TRIG:TYPE POST                   // Post Trigger
-> DIG
// Trigger will take place when signal fall below 2 V at channel 133
```

NOTE Middle-trigger and pre-trigger are not allow in RUN mode, NONE trigger.

Analog output

Example 1:

```
// Digital trigger with delay trigger type
// Supply Digital trigger signal to EXTD_AO_TRIG
-> OUTP:TRIG:SOUR EXTD
-> OUTP:TRIG:DTRG:POL NEG
-> OUTP:TRIG:TYPE DEL
-> OUTP:TRIG:DCNT 225000000// Count value ~= 4.6875 s
-> ROUT:ENAB ON,(@201)
-> OUTP ON
// Wait for trigger
// Output turn on after 4.6875 s of delay (after trigger happen)
```

Example 2:

```
// Analog trigger with POST trigger type
-> OUTP:TRIG:SOUR EXTA
-> OUTP:TRIG:ATRG:COND WIND// Window trigger condition (–3 V to 3 V)
-> OUTP:TRIG:ATRG:HTHR 3     // 3 V high Threshold

-> OUTP:TRIG:ATRG:LTHR –3    // –3 V low Threshold
-> OUTP:TRIG:TYPE POST
-> ROUT:ENAB ON,(@201)
-> OUTP ON
```

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4
Characteristics and Specifications

This chapter specifies the characteristics, environmental conditions, and specifications of the U2500A DAQ devices.

Product Characteristics

REMOTE INTERFACE	• Hi-Speed USB 2.0 • USBTMC Class Device[1] [2]
POWER REQUIREMENT	• +12 VDC (TYPICAL) • 2 A (MAX) input rated current • Installation Category II
POWER CONSUMPTION	+12 VDC, 480 mA maximum
OPERATING ENVIRONMENT	• Operating temperature from 0 °C to +55 °C • Relative humidity at 15% to 85% RH (non-condensing) • Altitude up to 2000 meters • Pollution Degree 2 • For indoor use only
STORAGE COMPLIANCE	–20 °C to 70 °C
SAFETY COMPLIANCE	Certified with: • IEC 61010-1:2001/EN 61010-1:2001 • Canada: CAN/CSA-C22.2 No.61010-1-04 • USA: ANSI/UL61010-1: 2004
EMC COMPLIANCE	• IEC 61326-1:2002/EN 61326-1:1997+A1:1998+A2:2001+A3:2003 • CISPR 11: 1990/EN55011:1990 – Group 1 Class A • Canada: ICES-001: 2004 • Australia/New Zealand: AS/NZS CISPR11:2004
SHOCK & VIBRATION	Tested to IEC/EN 60068-2
IO CONNECTOR	68-pin female VHDCI Type
DIMENSION (WxDxH)	Module dimension: • 120.00 mm x 182.40 mm x 44.00 mm (with plastic casing) • 105.00 mm x 174.54 mm x 25.00 mm (without plastic casing) Terminal block dimension: • 103.00 mm x 85.20 mm x 42.96mm

WEIGHT	• 565 g (with plastic casing) • 400 g (without plastic casing)

WARRANTY	• Please refer to http://www.agilent.com/go/warranty_terms
	  ◦ Three years for the product
	  ◦ Three months for the product's standard accessories, unless otherwise specified
	• Please take note that for the product, the warranty does not cover:
	  ◦ Damage from contamination
	  ◦ Normal wear and tear of mechanical components
	  ◦ Manuals

1 Compatible with Microsoft Windows operating systems only.

2 Requires a direct USB connection to the PC so the appropriate driver can be installed in the USB modular instrument or USB DAQ module.

Product Specifications

Table 4-1 Analog input product specifications for U2500A series DAQ devices

Analog Input			
Model Number	**U2531A**	**U2541A**	**U2542A**
Resolution	14 bits	16 bits	
Number of channels	4 Differential Input Channels (software selectable/channel)		
Maximum sampling rate per channel	2 MSa/s	250 kSa/s	500 kSa/s
Programmable bipolar input range [1]	±10 V, ±5 V, ±2.5 V, ±1.25 V		
Programmable unipolar input range	0 to 10 V, 0 to 5 V, 0 to 2.5 V, 0 to 1.25 V		
Input coupling	DC		
Input impedance	1 GΩ / 100 pF		
Operational common mode voltage range	±7.5 V maximum[6]		
Overvoltage protection	Power on: Continuous ±30 V, Power off: Continuous ±15 V		
Trigger sources	External analog/digital trigger, SSI/star trigger [2]		
Trigger modes	Pre- trigger, delay-trigger, post-trigger and middle-trigger		
FIFO buffer size	Up to 8 MSa		

Table 4-2 Analog output product specifications for U2500A series DAQ devices

Analog Output	
Model Number	**U2531A | U2541A | U2542A**
Resolution	12 bits
Number of channels	2
Maximum update rate	1 MSa/s
Output ranges	0 to 10 V, ±10 V, 0 to AO_EXT_REF, ±AO_EXT_REF [3]
Output coupling	DC
Output impedance	0.1 Ω Typical
Stability	Any passive load up to 1500 pF
Power-on state	0 V steady state
Trigger sources	External analog/digital trigger, SSI/star trigger [2]
Trigger modes	Post-trigger and delay-trigger
FIFO buffer size	1 channel used: Maximum 8 MSa 4 channels used: Maximum 2 MSa/ch
Glitch Energy	5 ns-V [Typical] 80 ns-V [Maximum]
Driving Capability	5 mA
Function generation mode	Sine-wave, square-wave, triangle, sawtooth and noise waveform

Table 4-3 Digital I/O product specifications for U2500A series DAQ devices

Digital I/O	
Model Number	**U2531A | U2541A | U2542A**
Number of bits	24-bit programmable input/output
Compatibility	TTL
Input voltage	V_{IL} = 0.7 V maximum, I_{IL} = 10 μA maximum V_{IH} = 2.0 V minimum, I_{IH} = 10 μA maximum
Input voltage range	–0.5 V to +5.5 V
Output voltage	V_{OL} = 0.45 V maximum, I_{OL} = 8 mA maximum V_{OH} = 2.4 V minimum, I_{OH} = 400 μA maximum

Table 4-4 General purpose digital counter product specifications for U2500A series DAQ devices

General Purpose Digital Counter	
Model Number	**U2531A | U2541A | U2542A**
Maximum count	$(2^{31} – 1)$ bits
Number of channels	Two independent up/down counter
Compatibility	TTL
Clock source	Internal or external
Base clock available	48 MHz
Maximum clock source frequency	12 MHz
Input frequency range [4]	0.1 Hz to 6 MHz at 50% duty cycle
Pulse width measurement range	(0.167 μs to 178.956 s) ± 0.0833 μs

Table 4-5 Analog trigger product specifications for U2500A series DAQ devices

Analog Trigger	
Model Number	**U2531A | U2541A | U2542A**
Trigger source	All analog input channels, External analog trigger (EXTA_TRIG)
Trigger level	±Full scale for internal; ±10 V for external
Trigger conditions	Above high, below low and window (software selectable)
Trigger level resolution	8 bits
Bandwidth	400 kHz
Input impedance for EXTA_TRIG	20 kΩ
Coupling	DC
Overvoltage protection	Continuous for ± 35 V maximum

Table 4-6 Digital trigger product specifications for U2500A series DAQ devices

Digital Trigger	
Model Number	**U2531A | U2541A | U2542A**
Compatibility	TTL/CMOS
Response	Rising or falling edge
Pulse width	20 ns minimum

Table 4-7 Calibration product specifications for U2500A series DAQ devices

Calibration [5]	
Model Number	**U2531A | U2541A | U2542A**
On board reference voltage	5 V
Temperature drift	±2 ppm/°C
Stability	±6 ppm/1000 hours

Table 4-8 Physical product specifications for U2500A series DAQ devices

Physical	
Model Number	**U2531A | U2541A | U2542A**
Dimension	120 mm x 182.40 mm x 44 mm (W x D x H) with plastic cover 105 mm x 174.54 mm x 25 mm (W x D x H) without plastic cover
I/O connector	68-pin female VHDCI Type
Weight	565 g with plastic casing 400 g without plastic casing

Table 4-9 Power consumption product specifications for U2500A series DAQ devices

Power Consumption			
Model Number	**U2531A**	**U2541A**	**U2542A**
Input voltage (DC)	+12 VDC	+12 VDC	+12 VDC
Input current	480 mA maximum	390 mA maximum	390 mA maximum

Table 4-10 Enviroment product specifications for U2500A series DAQ devices

Environment	
Model Number	**U2531A | U2541A | U2542A**
Operating temperature	0 to 55 °C
Storage temperature	–20 °C to 70 °C
Relative humidity	15% to 85% RH (non condensing)

Table 4-11 General product specifications for U2500A series DAQ devices

General	
Model Number	**U2531A | U2541A | U2542A**
Remote interface	Hi-Speed USB 2.0
Device class	USBTMC Class Device
Programmable interface	Standard Commands for Programmable Instruments (SCPI) and IVI-COM

[1] Maximum input voltage for analog input is ±10 V.

[2] System Synchronous Interface (SSI) and star-trigger commands are used when modular devices are used in modular instrument chassis (U2781A).

[3] Maximum external reference voltage for analog output (AO_EXT_REF) is ±10 V.

[4] Measurement frequency's resolution = 12 MHz/n, n = 2, 3, 4, 5..., 120M

= 6 MHz, 4 MHz, 3 MHz, 2.4 MHz, 2.0 MHz, ..., 0.1 Hz (up to six decimal points)

[5] Recommended for 20 minutes warm-up time.

[6] Refer to Figure 4-1 for more information.

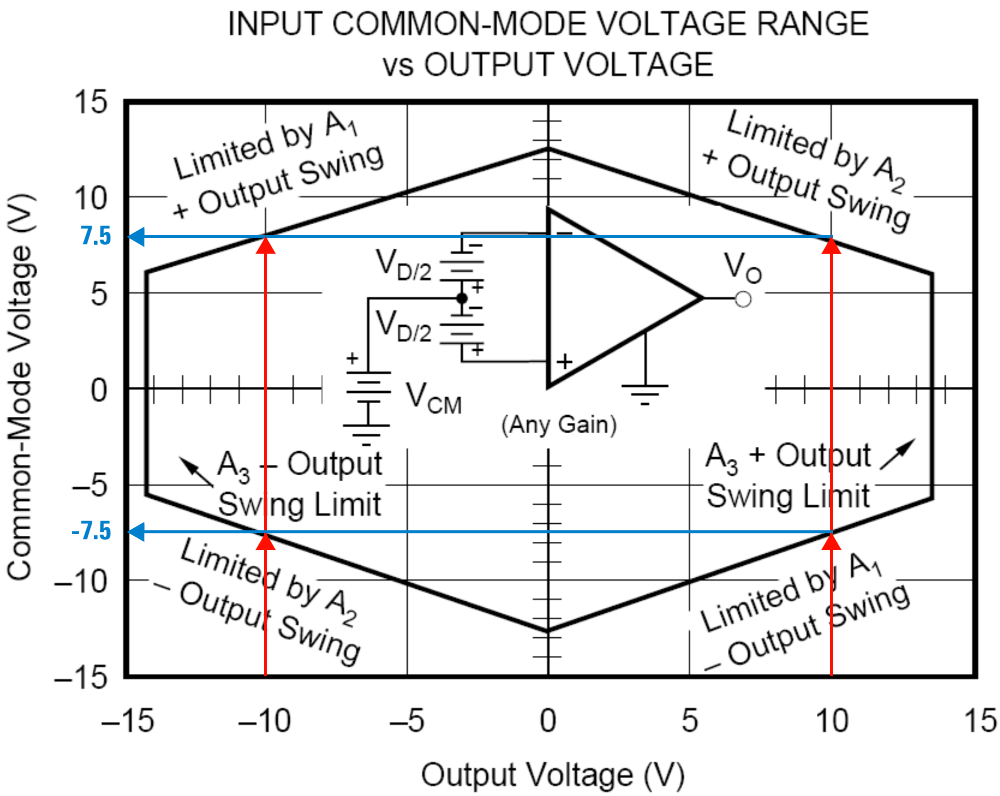

Figure 4-1 Operational common mode voltage range

This graph shows that the common mode voltage range is tightly linked with the output voltage. The output voltage range of the DAQ devices is ±10 V. Therefore, the common mode voltage range is ±7.5 V. Any operation beyond these voltage ranges may produce unexpected and unreliable results, and should be avoided.

Electrical Measurement Specifications

Table 4-12 Analog input electrical measurement specifications for U2500A series DAQ devices

Analog Input Measurement [1]						
Model Number	**U2531A**		**U2541A**		**U2542A**	
Function	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**
Offset Error [2]	±2 mV	±2 mV	±1 mV	±1mV	±1mV	±1 mV
Gain Error [2]	±6 mV	±6 mV	±2 mV	±2.5 mV	±2 mV	±2.5 mV
–3 dB small signal bandwidth	1.2 MHz		600 kHz		1.0 MHz	
1% THD large signal bandwidth	400 kHz		400 kHz		400 kHz	
System noise[3]	2 mVrms		0.5 mVrms		0.5 mVrms	
CMRR (DC to 60 HZ)	64 dB		80 dB		80 dB	
Spurious-free dynamic range (SFDR)	76 dB		88dB		86 dB	
Signal-to-noise and distortion ration (SINAD)	70 dB		82 dB		80 dB	
Total harmonic distortion (THD)	–72 dB		–86 dB		–84 dB	
Signal-to-noise ratio (SNR)	72 dB		84 dB		82 dB	
Effective number of bits (ENOB)	11.3-bit		13.3-bit		13.0-bit	
Channels Cross Talk [4]	66 dB		84 dB		80 dB	

Table 4-13 Analog output electrical measurement specifications for U2500A series DAQ devices

Analog Output Measurement [1]						
Model Number	**U2531A**		**U2541A**		**U2542A**	
Function	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 55 °C**
Offset error	±1 mV	±3 mV	±1 mV	±3 mV	±1 mV	±3mV
Gain error	±3 mV	±4 mV	±2 mV	±4 mV	±2 mV	±4 mV
Slew rate	15 V/µs	15 V/µs	15 V/µs	15 V/µs	15 V/µs	15 V/µs
Rise time	1.1 µs	1.2 µs	1.1 µs	1.2 µs	1.1 µs	1.2 µs
Fall time	1.1 µs	1.2 µs	1.1 µs	1.2 µs	1.1 µs	1.2 µs
Settling time to 1% output error	2 µs		2 µs		2 µs	

[1] Specification are for 20 minutes warm-up, self-calibration at temperature 23 °C and bipolar input voltage range of ±10 V.

[2] The measurement are calculated with 100 points averaging of data.

[3] The noise rms value is the standard deviation of 20k points.

[4] The cross talk measurement are tested up to input frequency at Fin = (Max Sampling) / 2.

Test Conditions

Table 4-14 Specifications are based on the following test conditions.Dynamic range test for U2500A series DAQ devices

Dynamic Range Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
SFDR, THD, SINAD, SNR, ENOB	U531A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental Input Voltage:	2 MSa/s 19.927 kHz 65536 FSR –1 dB FS
	U2541A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental Input Voltage:	250 kSa/s 2.4109 kHz 8192 FSR –1 dB FS
	U2542A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental Input Voltage:	500 kSa/s 4.974 kHz 16384 FSR –1 dB FS

Table 4-15 Bandwidth test for U2500Aseries DAQ devices

Bandwidth Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
–3 dB small signal bandwidth 1% THD large signal bandwidth	U531A	Sampling Rate: Input Voltage: –3 dB small signal bandwidth 1% THD large signal bandwidth	2 MSa/s 10% FSR FSR –1 dB FS
	U2541A	Sampling Rate: Input Voltage: –3 dB small signal bandwidth 1% THD large signal bandwidth	250 kSa/s 10% FSR FSR –1 dB FS
	U2542A	Sampling Rate: Input Voltage: –3 dB small signal bandwidth 1% THD large signal bandwidth	500 kSa/s 10% FSR FSR –1 dB FS

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5
Calibration

This chapter introduces the procedures to perform calibration process to the U2500A series DAQ devices to minimize A/D measurement errors and D/A output errors.

Self-Calibration

The Agilent U2500A series DAQ devices are factory-calibrated before shipment. The on-board reference voltage is calibrated and measured to ensure measurement accuracy. The device includes a self-calibration function to ensure accuracy of the measurement made under different environment usage.

For self-calibration, executing the calibration command will initiate a voltage adjustment in sequence for the specified DAC channel. This sequence sets a zero and gain adjustment constant for each DAC output.

Self-calibration can be initiated using the following SCPI command:

```
CALibration:BEGin
```

The functions of the DAQ will be halted until the self-calibration process is completed. You can query the status of calibration through the following SCPI command:

```
*OPC?
```

The two ways of performing self-calibration will be introduced in this section. The first option is by using the Agilent Connection Expert to send the related SCPI commands and the second option is to use the Agilent Measurement Manager application software.

Option 1: Self-calibration with Agilent Connection Expert

WARNING

- **Unplug all cables that are connected to the DAQ device before performing self-calibration.**
- **Any cables connected to the DAQ device will cause the failure of the self-calibration process.**

NOTE

It is recommended that the DAQ device is powered-up at least 20 minutes before performing self-calibration.

1 Power on the DAQ and disconnect all connections from the device. Warm it up for 20 minutes to ensure that it is operating in a stable condition.

2 Go to **Start > All Programs > Agilent IO Libraries Suite > Agilent Connection Expert** to launch the Agilent Connection Expert.

3 Connect the DAQ device to the PC with a mini-B type USB cable. The connected DAQ device will be visible in the **Instrument I/O on this PC** panel as illustrated in Figure 5-2.

4 Select the DAQ device that you wish to send the SCPI commands to and click the **Interactive IO** icon on the toolbar to launch the Agilent Interactive IO. See Figure 5-2.

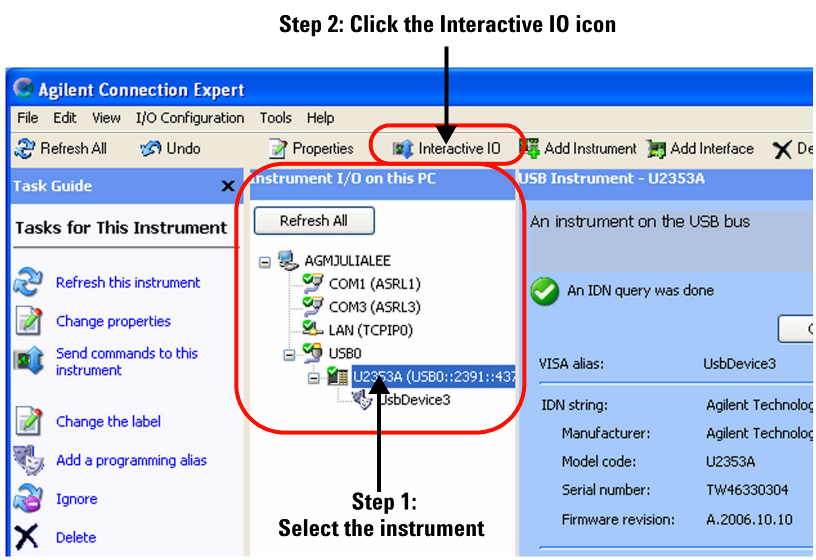

Figure 5-2 Launch the Interactive IO in Agilent Connection Expert

5 The **Agilent Interactive IO** dialog box will appear as shown in Figure 5-3. Click **Send & Read** to send the “*IDN?” default command. This instrument’s response should appear in the **Instrument Session History** panel.

6 Successful communication between the Agilent Connection Expert and the connected hardware will be shown in the **Instrument Session History** panel. The users may now send other SCPI commands to the instrument.

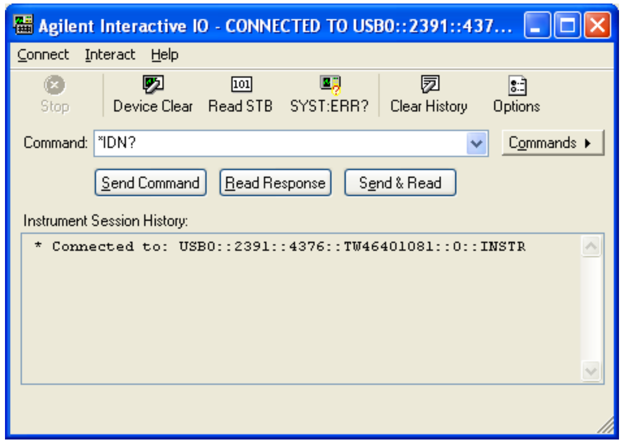

Figure 5-3 Interactive IO dialog box

7 Ensure that the DAQ device has been warmed up for 30 minutes. Send the SCPI commands "`*RST`" and "`*CLS`" to clear the register in DAQ device.

8 Send "`CAL:BEG`" to start the self-calibration process. This process may take a few minutes to complete.

9 Send "`*OPC?`" to check the operation complete status.

10 If "`*OPC?`" returns `1`, send "`SYST:ERR?`" to check if any system error has occurred during the self-calibration process. If there is no system error, the self-calibration process is done. Otherwise, the self-calibration process has failed.

Option 2: Self-calibration with Agilent Measurement Manager

WARNING

- **Unplug all cables that are connected to the DAQ device before performing self-calibration.**
- **Any cables connected to the DAQ device may cause the failure of the self-calibration process.**

1 Power on the DAQ device and disconnect all connections from it. Warm it up for 20 minutes to ensure that it is operating in a stable condition.

2 Connect the DAQ device to the PC with a mini-B type USB cable. Launch the Agilent Measurement Manager and select the DAQ device you wish to perform the self-calibration process on.

3 Go to **Tools** and select **Self Calibration**.

4 The **Self Calibration Form** dialog box will appear as shown below.

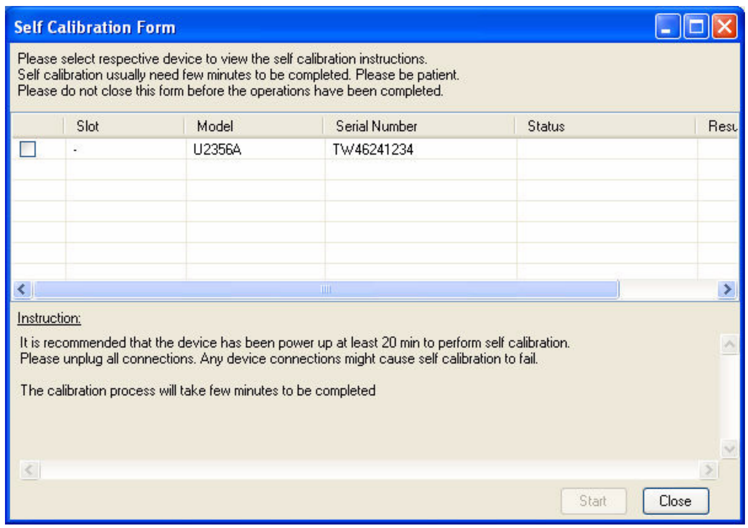

Figure 5-4 Self Calibration Form dialog box in Agilent Measurement Manager

5 Select the instrument that you would like to perform self-calibration and the **Start** button will be enabled. Click the **Start** button to proceed. See Figure 5-5.

6 The calibration process will take a few minutes to be completed. Once done, the status and results of the process will be displayed as shown in Figure 5-6.

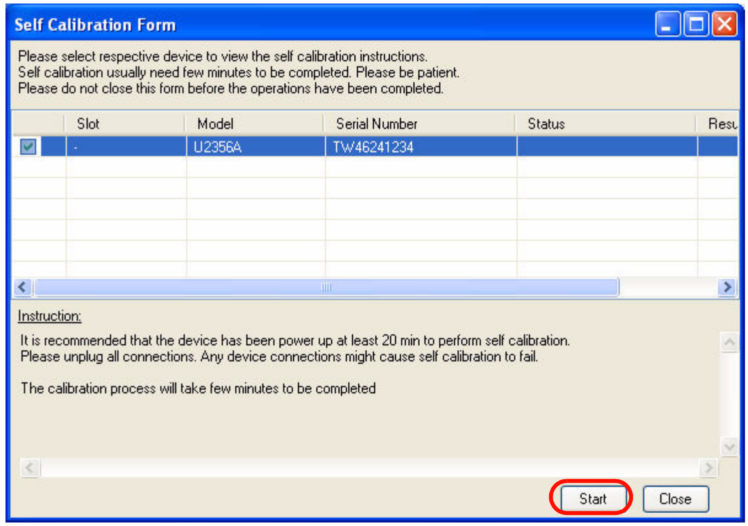

Figure 5-5 Self Calibration Form dialog box in Agilent Measurement Manager with a device being selected

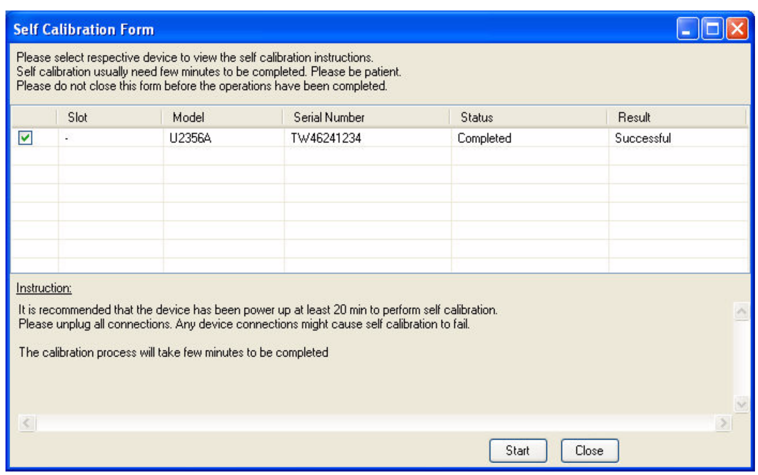

Figure 5-6 Self Calibration Form dialog box in Agilent Measurement Manaer showing the status and resultof the self-calibration process

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