Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices

User's Guide

Agilent Technologies

Notices

Manual Part Number

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CAUTION

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

WARNING

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

Safety Information

The following general safety precautions must be observed during all phases of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies, Inc. assumes no liability for the customer's failure to comply with these requirements.

Regulatory Markings

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.
ICES/NMB-001	ICES/NMB-001 indicates that this ISM device complies with Canadian ICES-001.
SA ® 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.
c UL US LISTED	The UL Mark is a registered trademark of Underwriters Laboratories Inc. UL listing mark with the indicators "C" and "US" indicates the product compliance with both Canadian and U.S. requirements.
N10149	The C-tick mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australian EMC Framework regulations under the terms of the Radio Communications Act of 1992.

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.

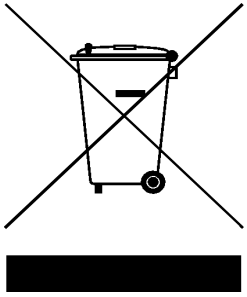
Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

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 instructions on how to get started with U2500A Series DAQ devices that begins from system requirements checking to installations of 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

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

19-October-2007
Date

Mack Soh
Quality Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor, or Agilent Technologies Deutschland GmbH, Herrenberger Straße 130, 71034 Böblingen, Germany.

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 conforme 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

Contents

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Tables

1 Getting Started

This chapter contains instructions on how to get started with U2500A Series DAQ devices that begins from system requirements checking to installations of hardware and software to the 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) are high performance and user friendly devices. It can be used as a standalone or 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:

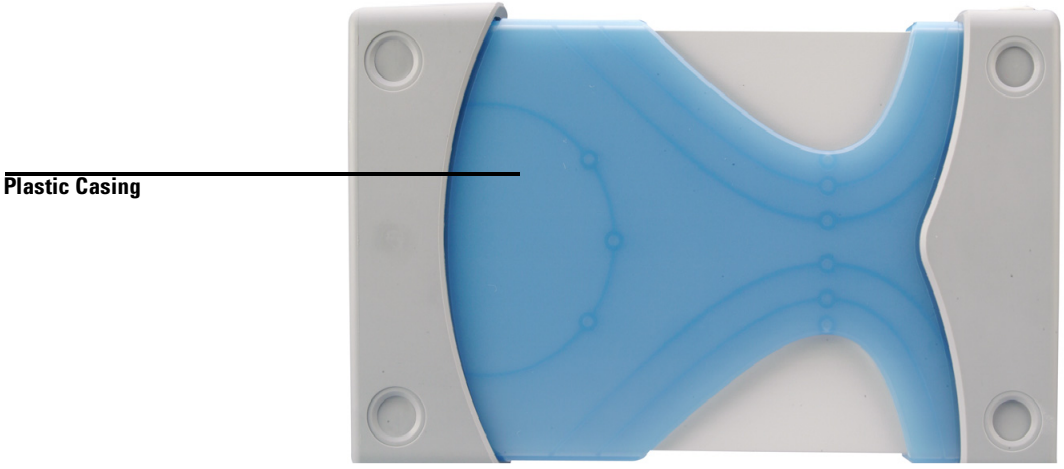
- U2531A: 4 channels SS multifunction DAQ 14 bits 2 MSa/s
- U2541A: 4 channels SS multifunction DAQ 16 bits 250 kSa/s
- U2542A: 4 channels SS multifunction DAQ 16 bits 500 kSa/s

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.

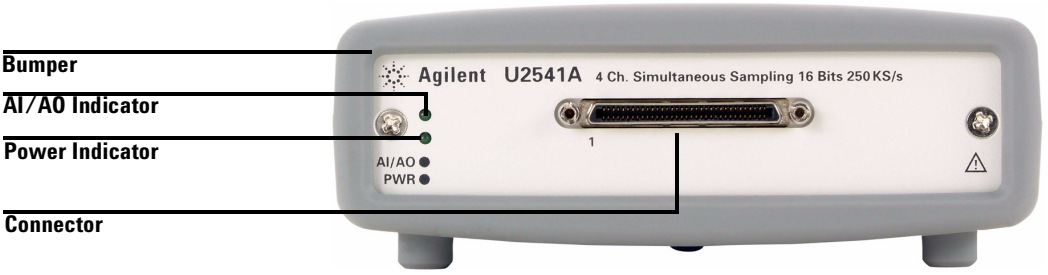
Product Overview

Product Outlook

Top View



Front View

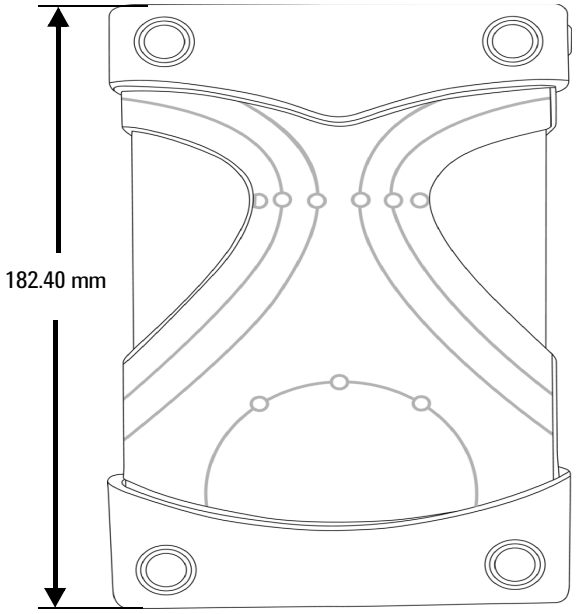


Rear View

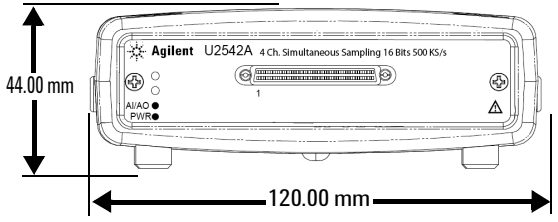
Product Dimension

With Plastic Casing

Top View

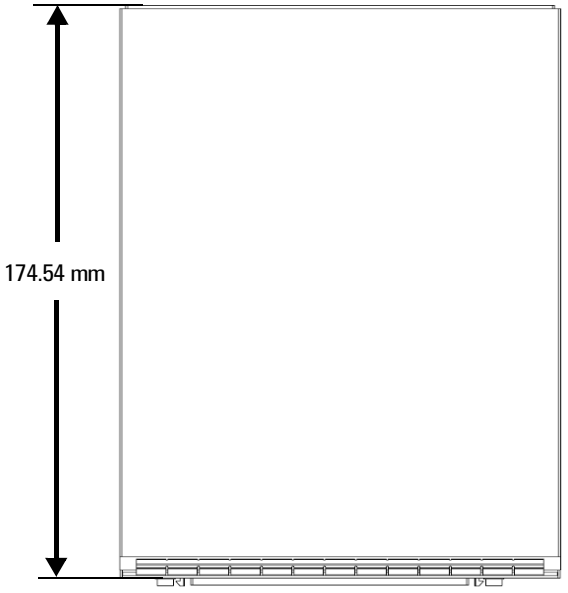


Front View

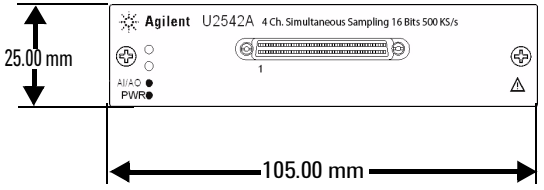


Without Plastic Casing

Top View



Front View



Standard Purchase Items Checklist

Inspect and verify that you have all the following items upon standard purchase of U2500A Series DAQ devices. If there are missing items, contact the nearest Agilent Sales Office.

- ✔ DC Power Adapter
- ✔ Power Cord
- ✔ USB Extension Cable
- ✔ L–Mount Kit (used with Agilent U2781A modular instrument chassis)
- ✔ Agilent U2500A Series USB Simultaneous Sampling Multifunction Data Acquisition Devices Quick Start Guide
- ✔ Agilent Measurement Manager for U2500A Series Quick Start Guide
- ✔ Agilent USB Modular Instrument Product Reference CD-ROM
- ✔ Agilent Automation-Ready CD (contains the Agilent IO Libraries Suite)
- ✔ Certificate of Calibration

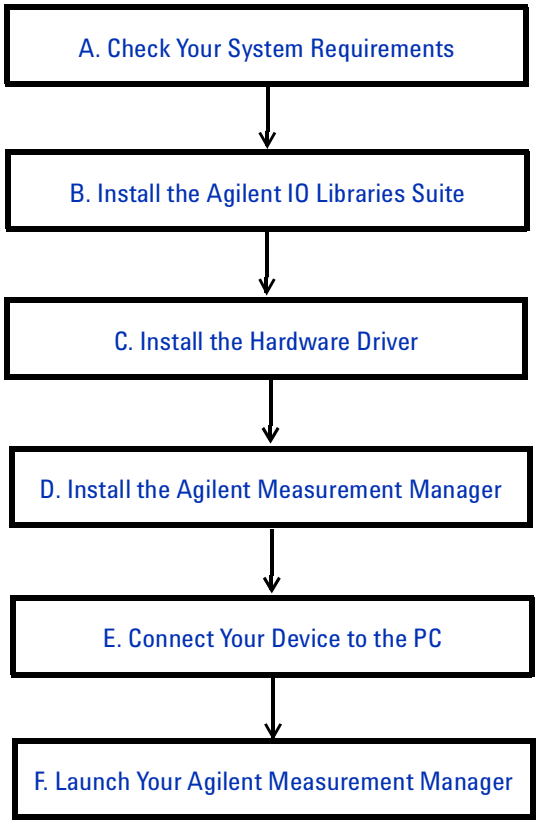
WARNING **Use only power adaptor provided by manufacturer to avoid unexpected hazard.**

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 following flowchart.

NOTE

- If you do not wish to specifically use the device with the Agilent Measurement Manager software but to use it on other ADE (e.g. Agilent VEE, LabVIEW, MATLAB or Microsoft Visual Studio), you can skip steps D and F in the following flowchart.
- You may require to install IVI-COM driver before using the U2500A Series with other ADE.



A. Check Your System Requirements

Before installing the hardware driver and the Agilent Measurement Manager software, make sure your PC meets the following minimum system requirements for installation.

Processor	1.6 GHz Pentium IV or higher
Operating system	Windows XP Professional or Home Edition (Service Pack 1 or later), Windows 2000 Professional (Service Pack 4 or later)
Browser	Microsoft Internet Explorer 5.01 or higher
Available RAM	512 MB or higher recommended
Hard disk space	1 GB
Prerequisite	• Agilent IO Libraries Suite 14.2[1] or higher • Agilent T&M Toolkit 2.1 Runtime version[2] • Microsoft.NET Framework version 1.0 and 2.0[2] • Agilent T&M Toolkit Redistributable Package 2.1 patch[2]
Video	Super VGA (800x600) 256 colors or higher

1 Available in Agilent Automation-Ready CD.

2 Bundled with Agilent Measurement Manager application software installer

B. Install the Agilent IO Libraries Suite

It is recommended to install the latest version of Agilent IO Libraries.

NOTE You must have Administrator privileges to install Agilent IO Libraries Suite and to run Connection Expert.

1. Verify that your PC meets the minimum system requirements. (See Chapter 1, "A. Check Your System Requirements".)
2. If you are upgrading to IO Libraries Suite from a previous version of IO Libraries, you must remove the instruments and interfaces listed below before you upgrade your software. This step is necessary in order for these devices to obtain the correct drivers to work with Agilent IO Libraries Suite.
   a. Disconnect any USB instruments from your PC.
   b. Disconnect any Agilent 82357 USB/GPIB interface converters from your PC.
   c. Disconnect any Agilent E8491 IEEE 1394 PC Link to VXI interfaces from your PC.
3. Close all other applications on your PC.
4. Insert the *Agilent Automation-Ready CD* with Agilent IO Libraries Suite into the CD-ROM drive of your PC. Wait a few seconds for the auto-run window to appear. If the auto-run window does not appear automatically,
   - Click **Start** > **Run...** and type `<drive>:\autorun\auto.exe`, where `<drive>` is your CD drive letter.
5. When the auto-run window appears, click **Install Software** once, and wait for the InstallShield Wizard to appear.
6. When the InstallShield Wizard appears, click **Next** > to begin the IO Libraries Suite software installation. Follow the instructions in the InstallShield Wizard and choose the options according to your preferences.
7. For more information to install the Agilent IO Libraries Suite, refer to *Agilent Technologies USB/LAN/GPIB Interfaces Connectivity Guide* available in the *Agilent Automation-Ready CD* with the file name called "**connectivity_guide.pdf**".

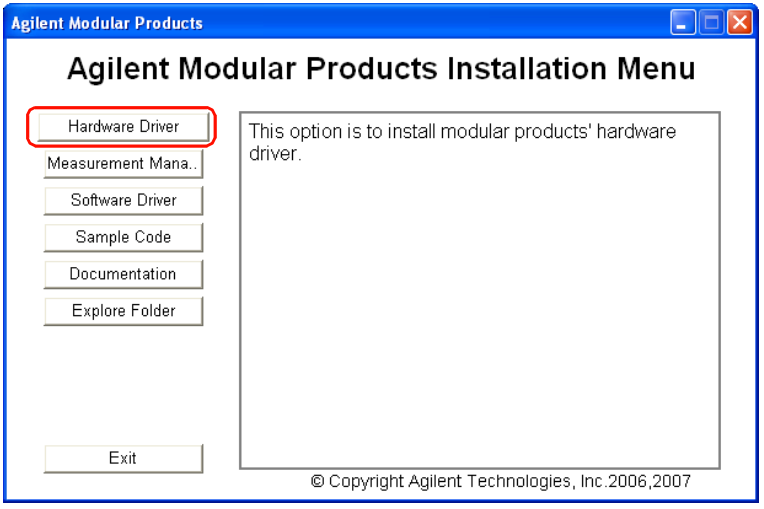
C. Install the Hardware Driver

NOTE

- Ensure that the USB device is disconnected from your PC before installing the driver.
- Ensure that the Agilent IO Libraries Suite version 14.2 or higher is installed before proceeding.

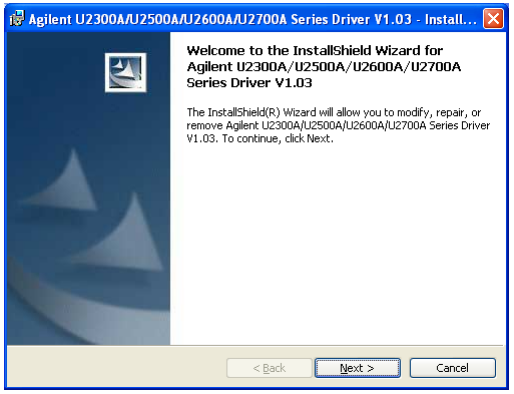
1 Insert the *Agilent USB Modular Instrument Product Reference CD-ROM* into the CD-ROM drive of your PC.

2 The installer will automatically launch the Agilent Modular Products Installation Menu. Select **Hardware Driver** to begin the hardware driver installation.

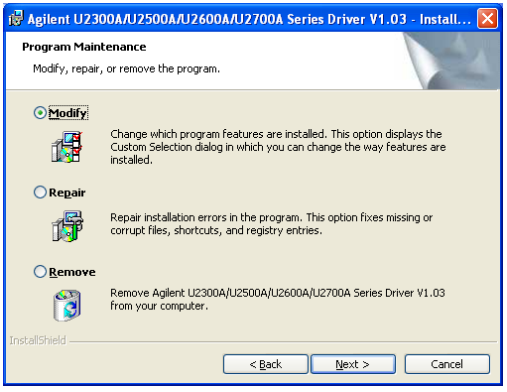


3 If the menu does not launch automatically, go to **Start > Run** (on the Windows Start menu) and type `<drive>:\Driver\Hardware\setup_hw.exe`, where `drive` is your CD-ROM drive. Click **OK** to begin installation.

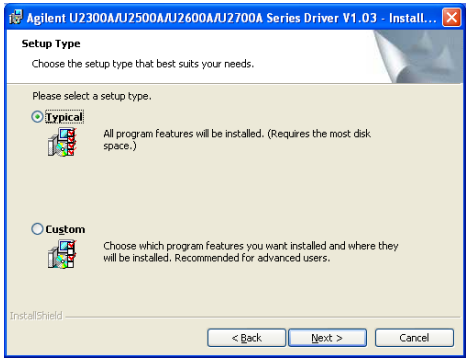
4 The following dialog will appear. Click **Next >** to begin the installation.



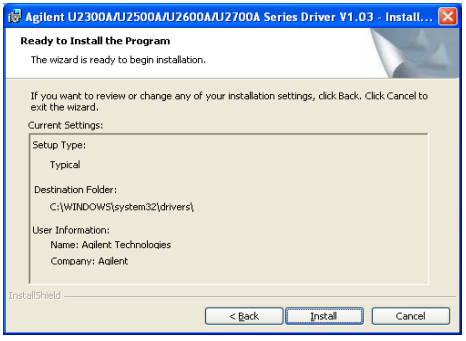
5 If you have previous hardware driver version, the dialog box will have the Modify, Repair and Remove options as shown below. Choose the option you like and click **Next >** to proceed.



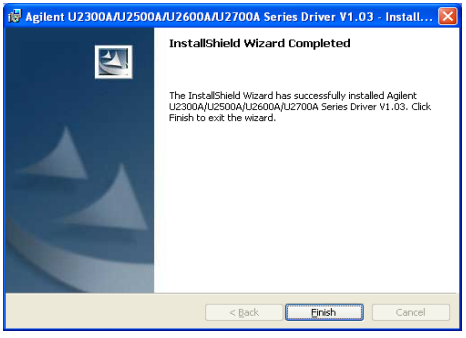
6 If you do not previously install any hardware driver, the following dialog box will be shown. Select **Typical** to install the all the features, otherwise select **Custom** to choose which program features you want to install. Click **Next >** to proceed.



7 Choose the option you like and the following dialog will appear showing all the components that will be installed. Click **Install** to begin installation.



8 Click **Finish** when the installation has completed.



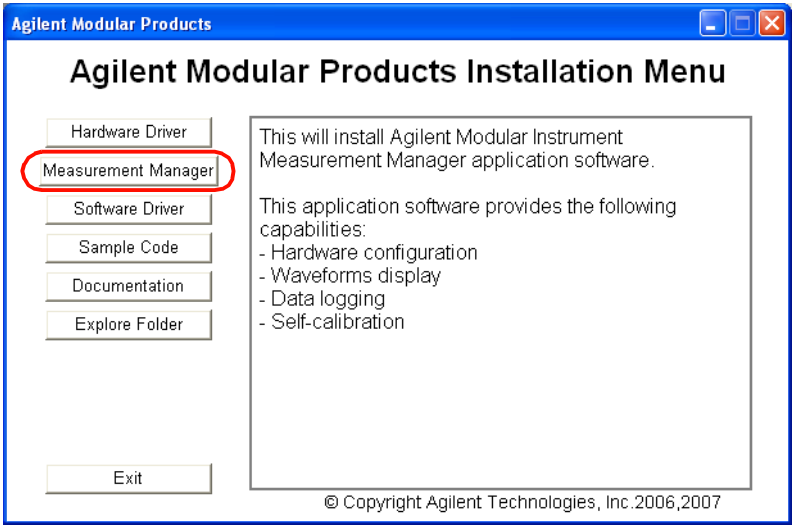
D. Install the Agilent Measurement Manager

NOTE

- Ensure that the Agilent IO Libraries Suite version 14.2 or higher is installed before proceeding.
- You must have Administrator privileges to install Agilent IO Libraries Suite and to run Connection Expert.

1 Verify that you have the hardware driver installed.

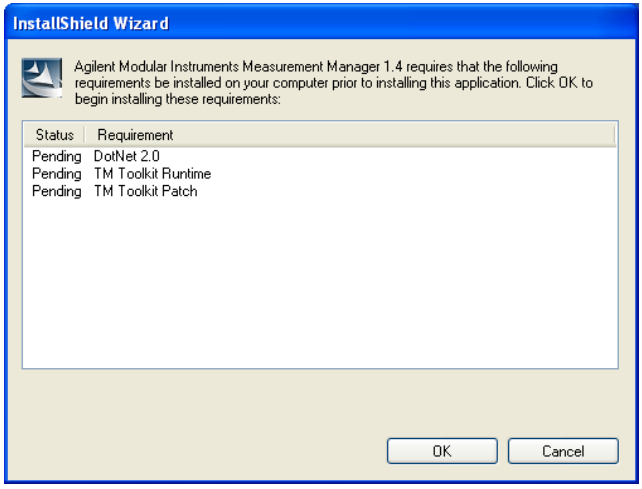
2 Select **Measurement Manager** on the Agilent Modular Products Installation Menu to begin the installation.



3 If the installation menu does not appear after a few seconds, go to **Start > Run** (on the Windows Start menu) and type `<drive>:\Application\Modular Instruments Measurement Manager\setup.exe`, where `drive` is your CD-ROM drive.

4 Click **OK** to begin installation.

5 If you do not have the Agilent T&M Toolkit 2.1 Runtime version, Microsoft .NET Framework version 1.0 and 2.0, and Agilent T&M Toolkit Redistributable Package 2.1 patch installed, the InstallShield Wizard software pre-requisite will appear as shown in the following figure.



6 Click **OK** to begin installation of the listed missing software.

NOTE

If you have Agilent VEE installed, you may need to install the Agilent T&M Toolkit 2.1 Runtime version manually.

- Click **Start** > **Run...**
- Type `<drive>:Utilities\Agilent T&M Toolkit Redistributable Package 2.1\setup.exe`, where `<drive>` is your CD drive letter.

7 Once the above installation is completed, installation of the Agilent Measurement Manager software will proceed as normal.

8 Follow the instructions on your screen to proceed with the Agilent Measurement Manager software installation.

9 When the InstallShield Wizard appears, click **Next >** to begin the Agilent Measurement Manager installation.

10 Read the License Agreement carefully. If you accept the terms, select the radio button that labeled **I accept the terms in the license agreement** and click **Next >** to continue.

11 Type in your user name in the User Name text box and organization name in the Organization text box. If there are more than one person using the same computer, select the radio button that labeled **Anyone who uses this computer**, otherwise select radio button labeled **Only for me.**

12 The default location to install the software is `C:\Program Files\Agilent\Measurement Manager 1.4\`. If you prefer to install the software to other location, click **Change...** to change the destination of the folder. When you are done, Click **Next >** to continue.

13 If you are ready to install the Agilent Measurement Manager, click **Install** to begin installation.

14 Click **Finish** when the installation has completed. A shortcut for this software will be created on your desktop.

NOTE USING THE LICENSED MATERIALS INDICATES YOUR ACCEPTANCE OF THE LICENSE TERMS. IF YOU DO NOT AGREE TO ALL OF THESE TERMS, YOU MAY RETURN ANY UNOPENED LICENSED MATERIALS FOR A FULL REFUND. IF THE LICENSED MATERIALS ARE BUNDLED OR PRE-LOADED WITH ANOTHER PRODUCT, YOU MAY RETURN THE ENTIRE UNUSED PRODUCT FOR A FULL REFUND.

E. Connect Your Device to the PC

1. After all installations have been successfully completed, connect the power cord to the AC/DC power adapter. The AC/DC power adapter requirements are 110 V/240 VAC, 50/60 Hz, with output voltage of +12 VDC.
2. Insert the DC output plug from the AC/DC power adapter to the power jack on the rear panel of the USB device.
3. Connect any of the U2500A Series instrument to any USB ports on your PC with the USB cable.
4. If this is the first time you connect the instrument to your PC, the Found New Hardware Wizard window will appear as shown below. Select **Yes, this time only** and click **Next** to proceed.

5. Select **Install the software automatically (Recommended)** and click **Next**.
6. A warning message will appear in Hardware Installation window, as shown below. Click **Continue Anyway** to proceed with the installation of the driver.

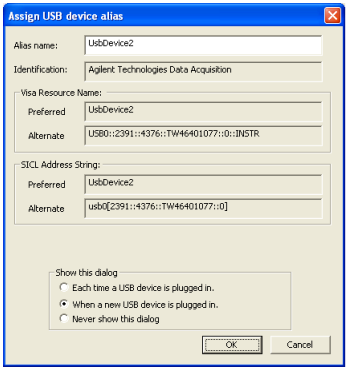
NOTE

If you do not wish to receive similar warning message in future, follow the instructions below.

1 Go to **Start > Control Panel** and double-click **System**.
2 Select **Hardware** tab and on the Drivers panel click **Driver Signing**. The Driver Signing Options dialog box will appear.
3 Select **Ignore** to disable the warning message.

7 Click **Finish** to complete the installation.

8 When installation has been completed, the Assign USB device alias window will appear. Each time a USB device is plugged in, this dialog box will appear. To configure or disable this dialog, select an option in the **Show this dialog** panel and click **OK**.



9 The USB device is now ready for usage.

NOTE

Before proceeding, you may verify your connected device using Agilent Connection Expert.

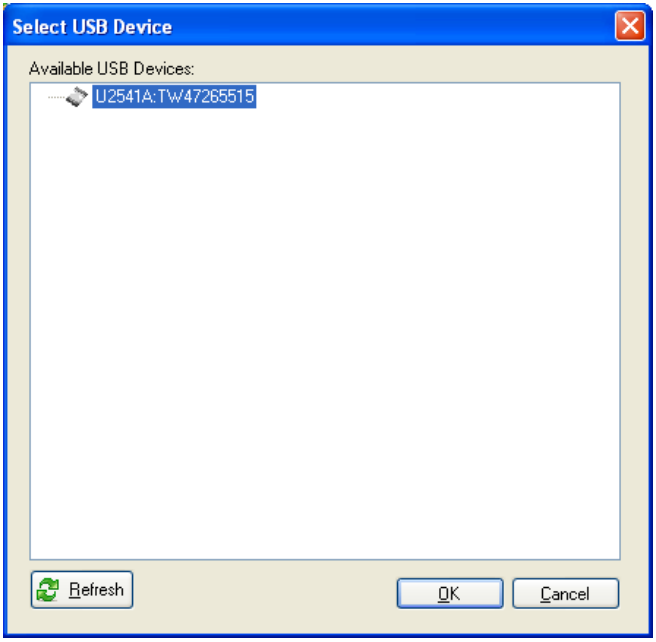
F. Launch Your Agilent Measurement Manager

NOTE

- Agilent IO Control will launch automatically when you start your PC.
- Launching Agilent Measurement Manager without Agilent IO Control running will cause Agilent Measurement Manager to fail from detecting or establishing any connection with the USB device connected to your PC.
- To launch Agilent IO Control, go to **Start > All Programs > Agilent IO Libraries Suite > Agilent Connection Expert**.

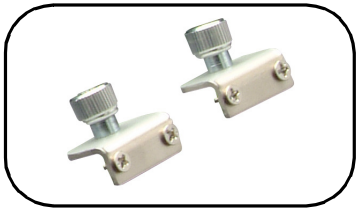
1 Double-click the Agilent Measurement Manager software icon on your desktop or go to **Start > All Programs > Agilent > Modular Instruments > Measurement Manager** to launch the software.

2 The Select USB Device dialog box will appear. It will show all the devices that are connected to your PC. To start the application, select a DAQ device and click **OK** to establish the connection.

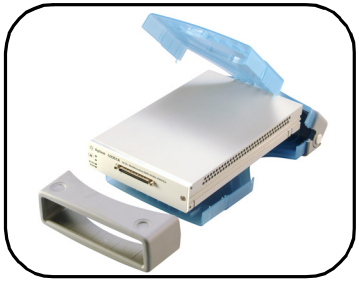


L-Mount Kit Installation

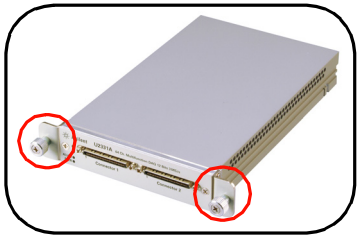
The L-Mount kit is to be used with Agilent U2781A USB modular instrument chassis.The following instructions describes simple procedures of installing the L-Mount kit to a U2600A USB devices.



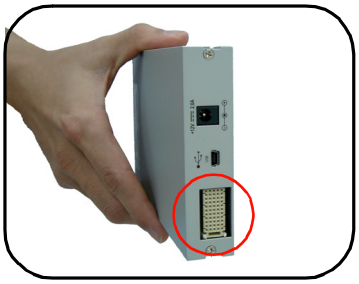
1 Unpack the L-Mount kit from the packaging.



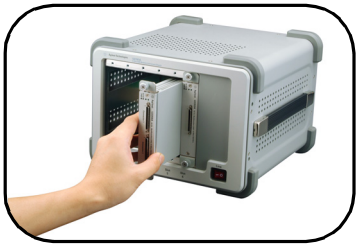
2 Remove your USB device from its plastic casing by pulling the bumper (front end of the casing) outward direction. Then, lift the plastic body casing and remove it from your USB device.



3 Using the *Philip* 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 of 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) 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.

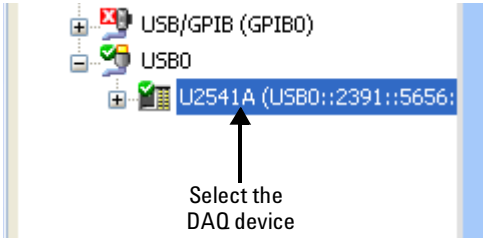
Additional Information

Hardware Verification

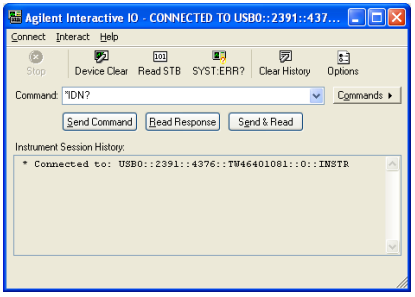
Agilent Connection Expert is one of the utilities of Agilent IO Libraries. It can automatically detects the USB devices that were connected to the PC and enables the communication between the USB device and the PC. To verify that your USB device has established a connection with your PC, do the following 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 indicate successful hardware installation and connection establishment.

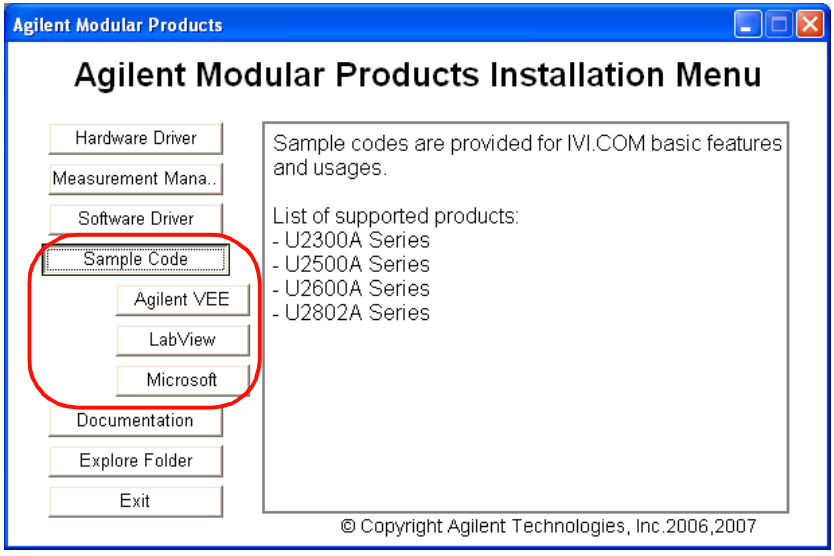
Sample code

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.



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.

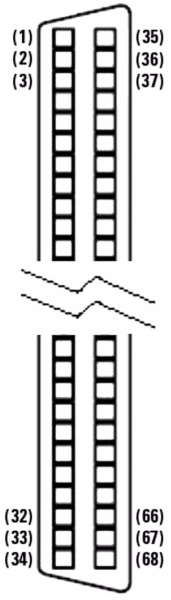


Figure 2-1 Connector in vertical view

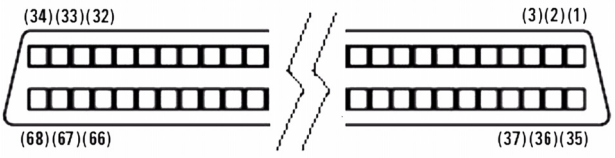


Figure 2-2 Connector in horizontal view

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
Bit-7	22	56	Bit-6
Bit-5	23	57	Bit-4
Bit-3	24	58	Bit-2
Bit-1	25	59	Bit-0
Bit-3	26	60	Bit-2
Bit-1	27	61	Bit-0
D_GND	28	62	D_GND
Bit-3	29	63	Bit-2
Bit-1	30	64	Bit-0
Bit-7	31	65	Bit-6
Bit-5	32	66	Bit-4
Bit-3	33	67	Bit-2
Bit-1	34	68	Bit-0

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 devices. 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 3-1 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 Figure3-1, 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 level for digital analog converter (DAC) have to be defined if 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.

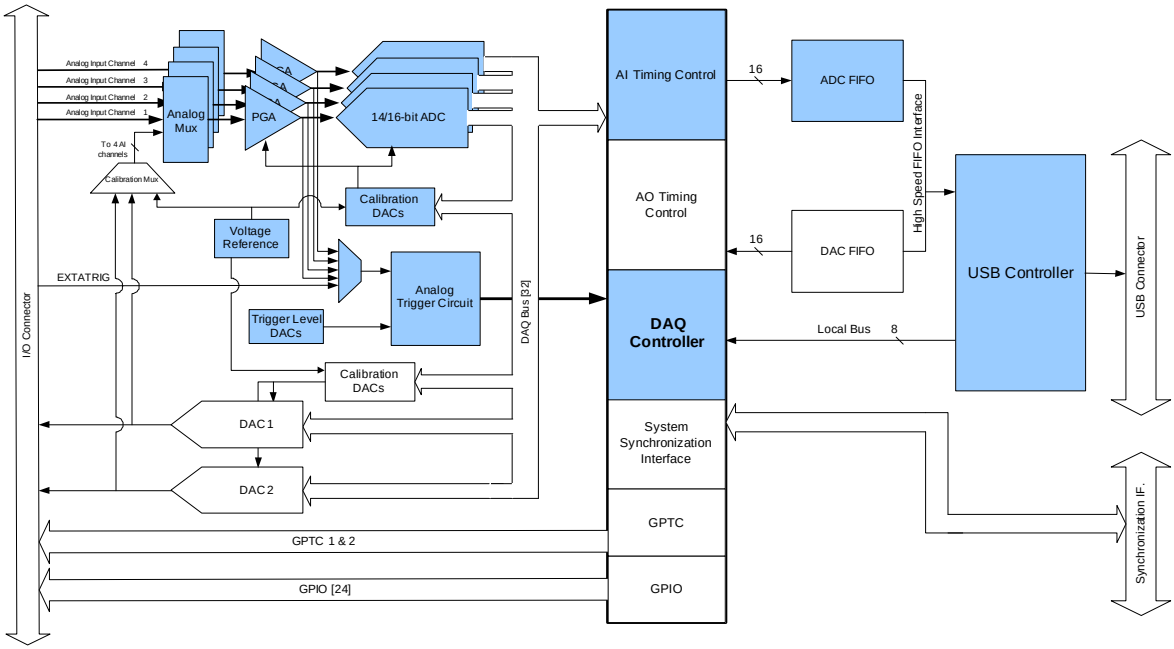


Figure 3-1 Functional block diagram of U2500A Series DAQ device

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 `MEAS?` 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 `MEAS? (@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 UNIPolar measurement
                                     to CH 101,103

-> 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** ►

#800001000	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	...
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.	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		...

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:

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

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

$$= 3.896\ \text{V}$$

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.
- 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	FFFF
Midscale+1LSB	305.2 µV	152.6 µV	76.3 µV	38.15 µV	8001
Midscale	0 V	0 V	0 V	0 V	8000
Midscale–1LSB	–305.2 µV	–152.6 µV	–76.3 µV	–38.15 µV	7FFF
–FSR	–10 V	–5 V	–2.5 V	–1.25 V	0000

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	FFFF
Midscale +1LSB	5.000153 V	2.500076 V	1.250038 V	0.625019 V	8001
Midscale	5 V	2.5 V	1.25 V	0.625 V	8000
Midscale –1LSB	4.999847 V	2.499924 V	1.249962 V	0.624981 V	7FFF
–FSR	0 V	0 V	0 V	0 V	0000

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 3.2 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, while 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.

#800001000	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**...**
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.	1st data LSB	1st data MSB	2nd data LSB	2nd data MSB	3rd data LSB	3rd data MSB	4th data LSB	4th data MSB	...
	CH 201 or 202		CH 201 or 202		CH 201 or 202		CH 201 or 202		...

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

#800001000	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	...
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.	1st data LSB	1st data MSB	1st data LSB	1st data MSB	2nd data LSB	2nd data MSB	2nd data LSB	2nd data MSB	...
	CH 201		CH 202		CH 201		CH 202		...

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.

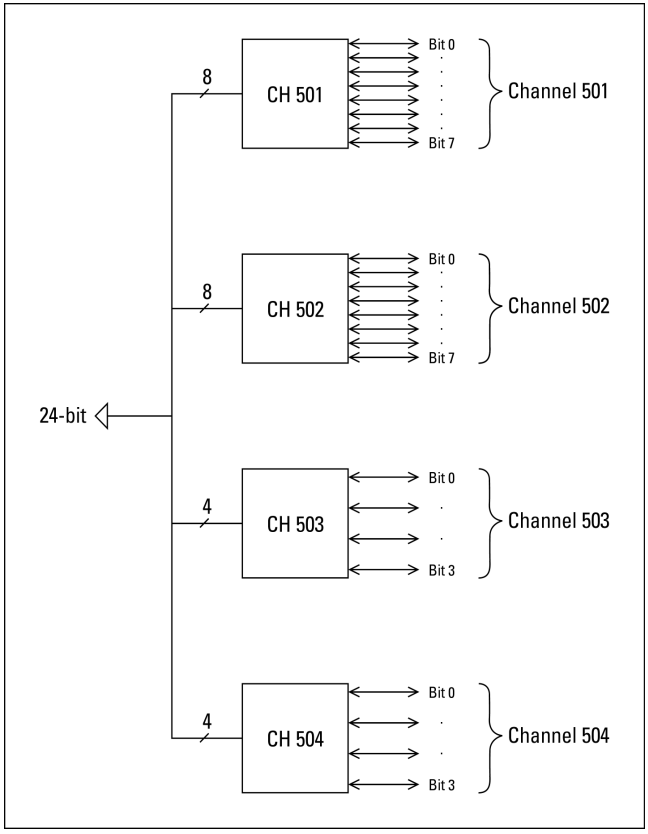


Figure 3-2 General purpose digital I/O of Agilent U2500A Series DAQ

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 (GPC)

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 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.

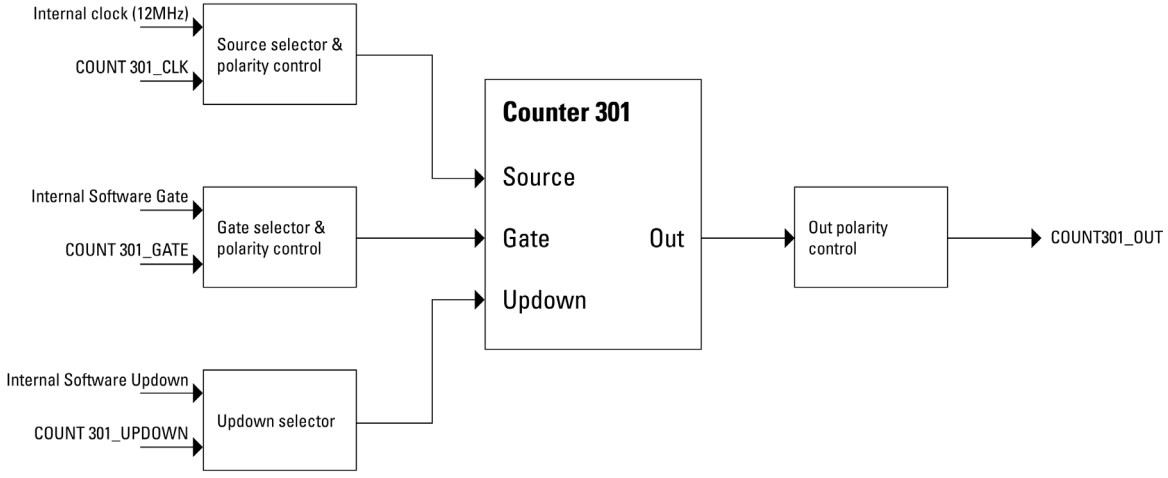


Figure 3-3 General purpose digital counter

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.

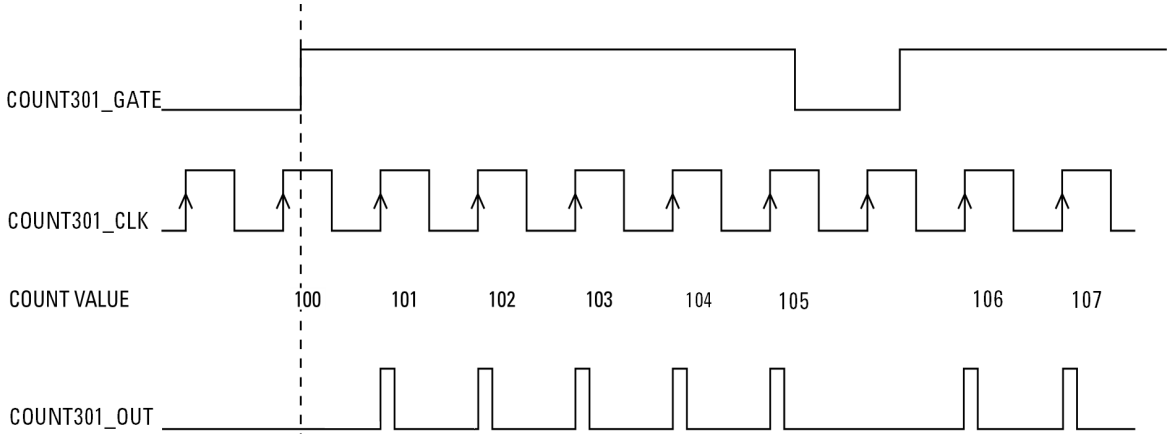


Figure3-4 Totalizer mode

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 KHz
-> 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)
-> COUN:CLK:EXT 10000,(@301)//Must set the external Clock
                              value (KHz)
-> 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

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

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 the following figure for further illustration.

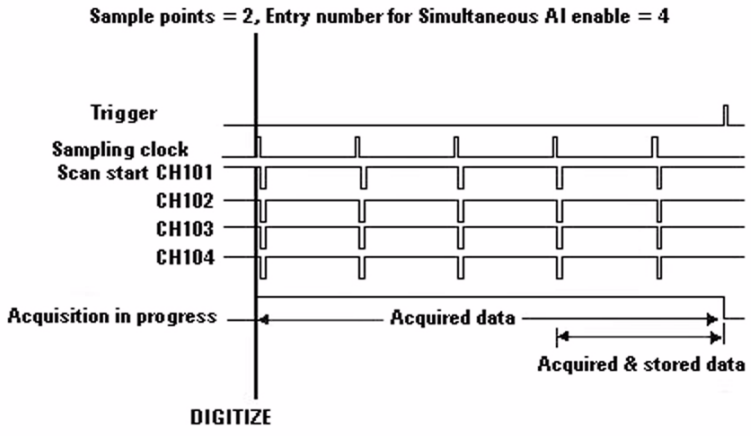


Figure 3-5 Pre-trigger

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 the following figure for further illustration.

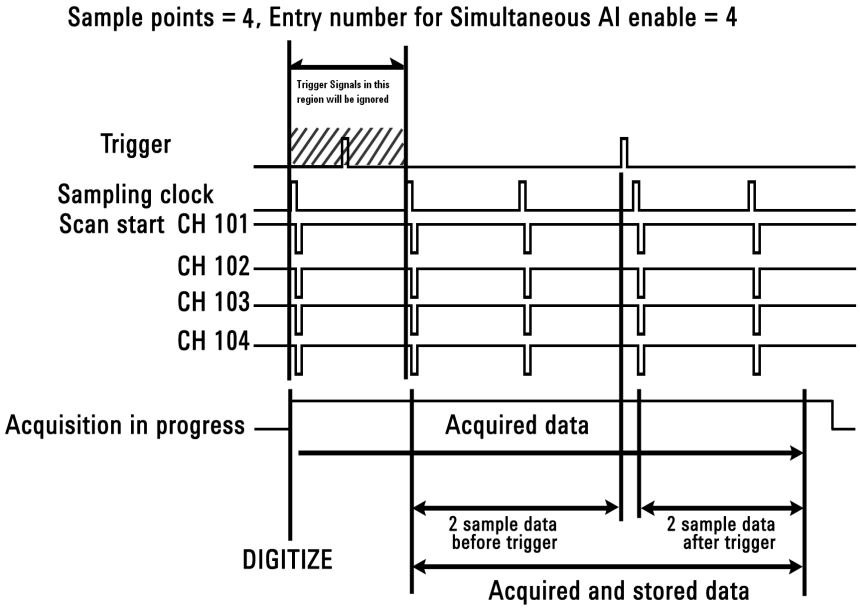


Figure 3-6 Middle-trigger

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.

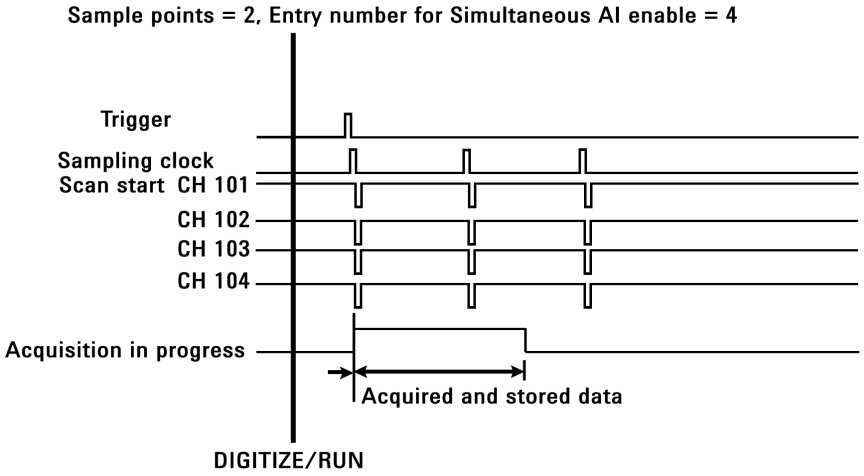


Figure 3-7 Post-trigger

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

```
TRIG:TYPE POST
```

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.

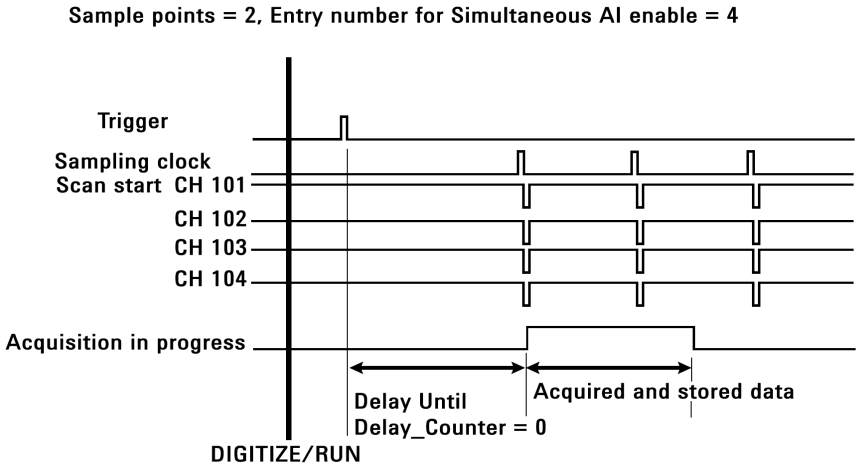


Figure 3-8 Delay-trigger

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.

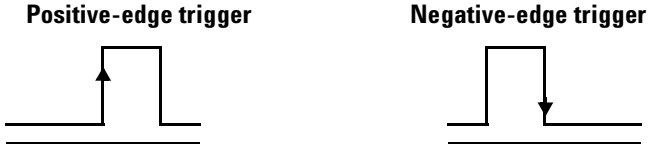


Figure 3-9 Positive and negative edge of digital trigger.

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.

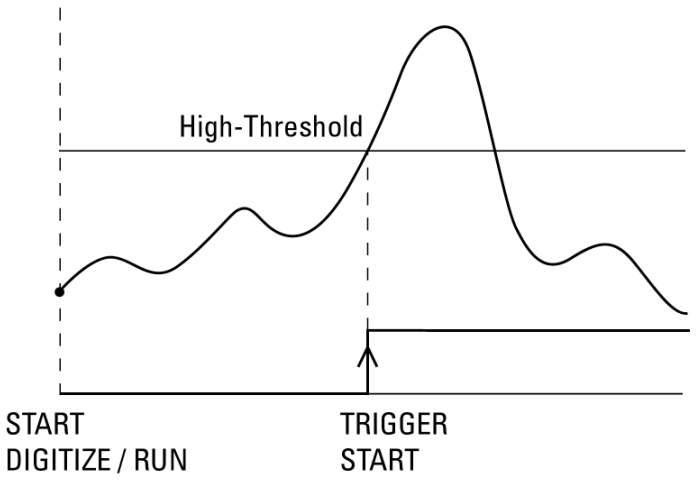


Figure 3-10 Above high trigger condition

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.

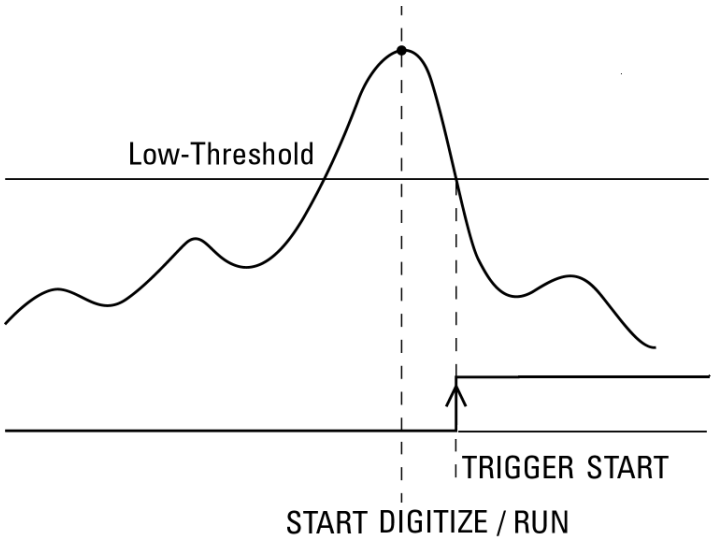


Figure 3-11 Below low trigger condition

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.

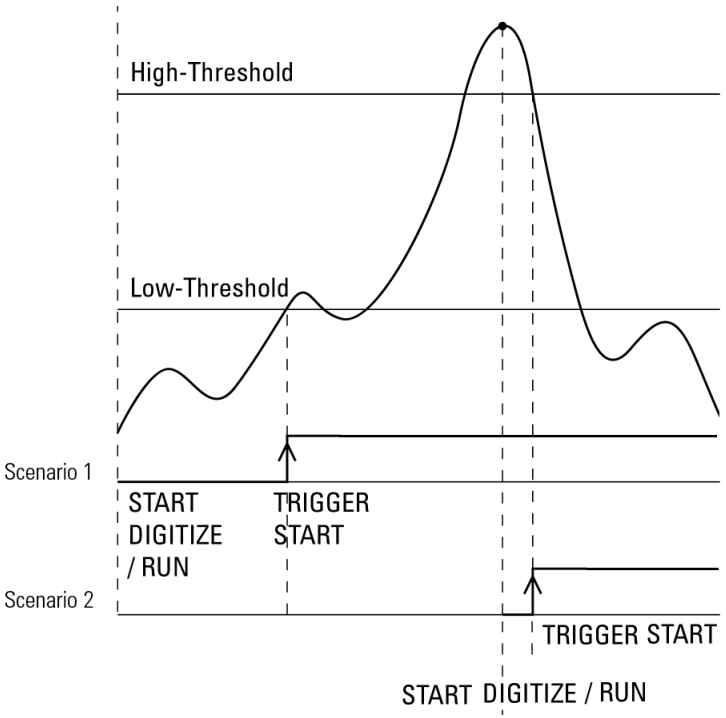


Figure 3-12 Window trigger condition

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
```

Example 3:

```
//Analog Trigger with as trigger channel (CH102)
-> OUTP:TRIG:SOUR EXTA
-> ROUT:ENAB 1,(@101)          //Use CH101 as trigger channel
-> OUTP:TRIG:ATRG:SOUR SONE
-> OUTP:TRIG:ATRG:COND AHIG //Above High threshold Trigger
                               condition
-> OUTP:TRIG:ATRG:HTHR 4      //4 V High Threshold
-> OUTP:TRIG:ATRG:LTHR 1      //1 V Low Threshold
-> OUTP:TRIG:TYPE POST
-> ROUT:ENAB ON,(@201)
-> RUN                        //Important!
-> OUTP ON
```

NOTE For CH101 to CH104, execute the `RUN/DIG` command first before turning on the output. CH101 will only respond to trigger signal during acquisition.

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

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)
- 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)

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

WARRANTY
- Three years

Product Specifications

Table 4-1 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	±8.0 V maximum		
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		

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

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

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

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

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

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

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

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

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)

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.

Electrical Measurement Specifications

Table 4-2 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	

Analog Output Measurement[1]						
Model Number	**U2531A**		**U2541A**		**U542A**	
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

Specifications are based on the following test conditions.

Table 4-3 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 4-4 Bandwidth Test for U2500A Series 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

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. It provides the self-calibration flexibility 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 operated using the following SCPI command:

```
CALibration:BEGin
```

The function of DAQ will not carry on until the self-calibration is completed. You can query the status of calibration through the following SCPI command:

```
*OPC?
```

Two ways of performing the self-calibration will be introduced in this section. The first option is to use the Agilent Connection Expert to send the 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 DAQ device. Warm it up for 20 minutes to ensure that it is operating at 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 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 5-1.

4 Select the DAQ device that you wish to send the SCPI commands to and then click the **Interactive IO** icon on the toolbar to launch the Agilent Interactive IO. See Figure 5-1.

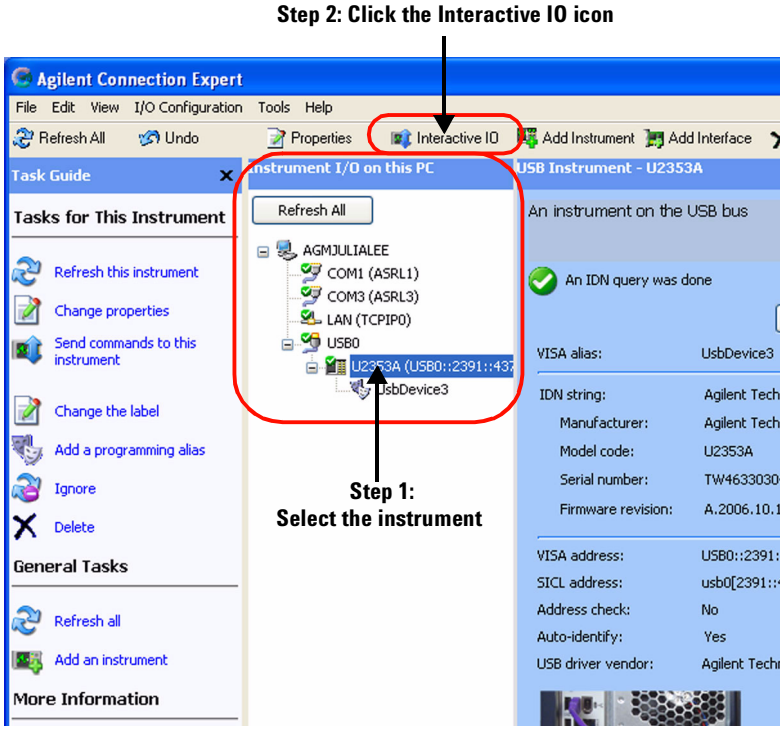


Figure 5-1 Launch the Interactive IO in Agilent Connection Expert

5 The **Agilent Interactive IO** dialog box will appear as shown in Figure 5-2. 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.

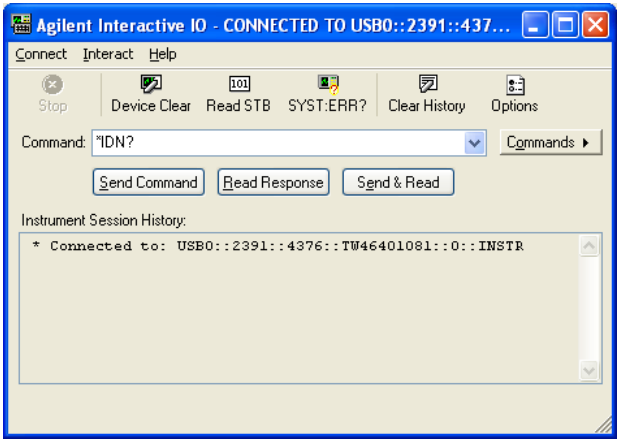


Figure 5-2 Interactive IO dialog box

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?`" return 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 is 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 at stable condition.

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

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

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

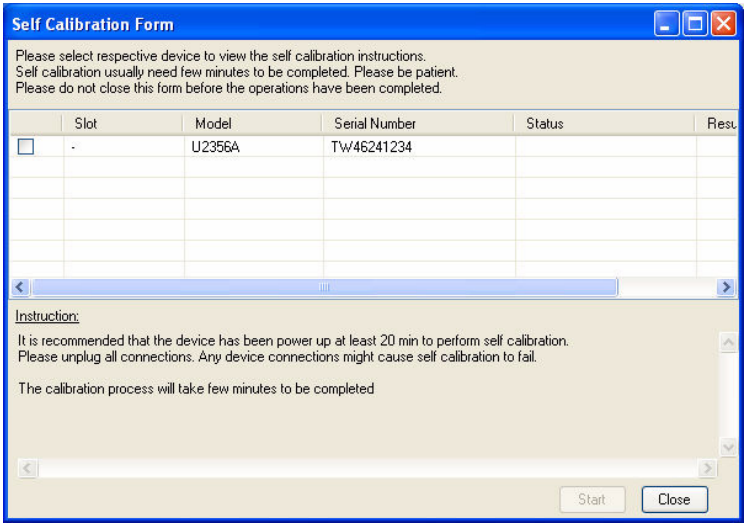


Figure 5-3 Self Calibration Form dialog box in Agilent Measurement Manager

5 Select the instrument that you would like to perform self-calibration and the **Start** button will be enabled. Click **Start** to proceed. See Figure 5-4.

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 5-5.

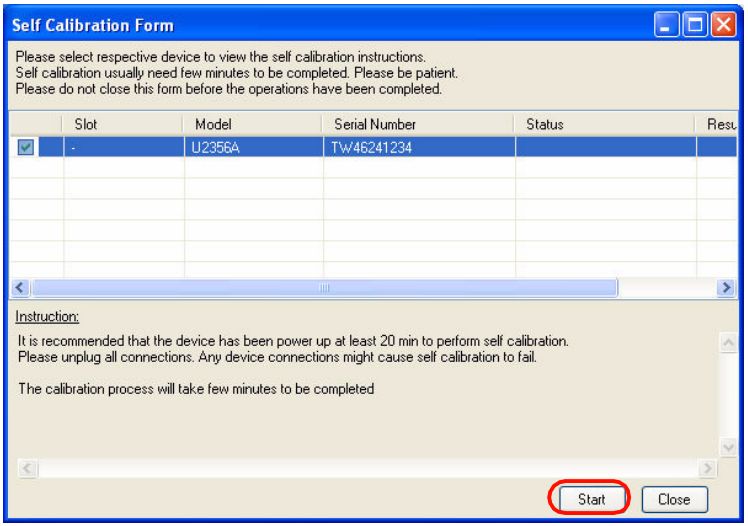


Figure 5-4 Self Calibration Form dialog box in Agilent Measurement Manager with a device being selected

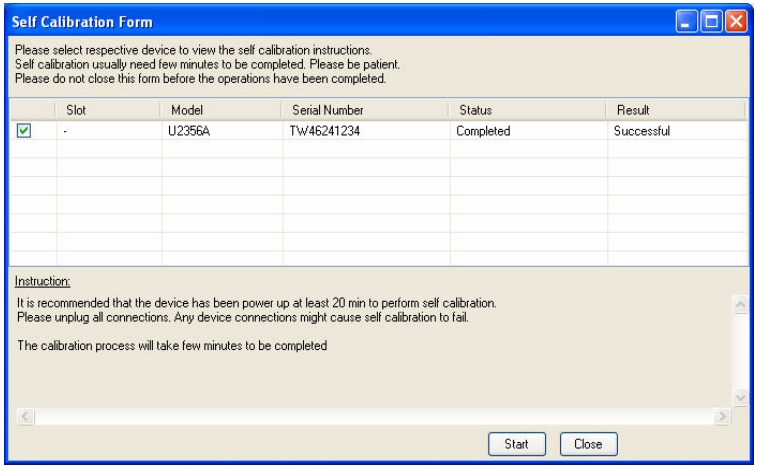


Figure 5-5 Self Calibration Form dialog box in Agilent Measurement Manaer showing the status and resultof the self-calibration process

5 Calibration

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