

Agilent U2300A Series USB Multifunction Data Acquisition Devices

User's Guide

Agilent Technologies

Notices

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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.

Safety Symbols

The following symbols indicate the precautions taken to maintain safe operation of the instrument.

	Direct current
	Warning

Regulatory Markings

	The CE mark shows that the product complies with all the relevant European Legal Directives (if accompanied by a year, it signifies when the design was proven).
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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.

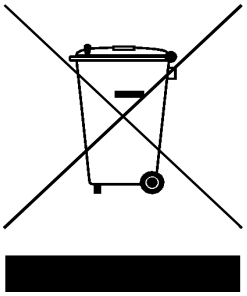
Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

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** provides an overview of the U2300A Series, the product outlook, product dimension, and product layout. This chapter also contains the instructions on getting started with the U2300A Series from system requirements checking to installations of hardware and software to the launching of the Agilent Measurement Manager application software.

2 **Connector Pins Configuration** describes the connector pins configuration of the U2300A Series USB DAQ and the signal connection between the U2300A and external devices.

3 **Features and Functions** includes the information for better understanding on the features and functions of the U2300A series USB DAQ. This includes the operations of the analog input, analog output, digital input/output, and digital counter subsystems.

4 **Characteristics and Specifications** specifies the characteristics, environmental conditions, and specifications of the U2300A DAQ devices.

5 **Calibration** introduces the procedures to perform the calibration process for the U2300A Series DAQ devices to minimize A/D measurement errors and D/A output errors.

Agilent Technologies	**DECLARATION OF CONFORMITY** According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014	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 U2300A Series Multifunction USB Data Acquisition(DAQ) device
Models Number:	U2331A, U2351A, U2352A, U2353A, U2354A, U2355A, U2356A
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 (73/23/EEC, amended by 93/68/EEC)
EMC Directive (89/336/EEC, amended by 93/68/EEC)

and conforms with the following product standards:

	Standard	Limit
EMC	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1990 / EN55011:1991	Class A Group 1
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	4 kV CD, 8 kV AD
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	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-001:1998
Australia/New Zealand: AS/NZS 2064.1

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

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

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

20-October-2006
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, D 71034 Böblingen, Germany.

Template: A5971-5302-2, Rev. B.01 U2300 series Rev 1.0

Product Regulations

		Performance Criteria
EMC	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	U2331A, U2351A, U2352A U2353A, U2354A, U2355A, U2356A
	CISPR 11:1990 / EN 55011:1991 – Group 1 Class A	
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995 (ESD 4kV CD, 8kV AD)	B
	IEC 61000-4-3:1995 / EN 61000-4-3:1995 (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)	B
	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%)	C
	Canada: ICES-001:1998	
	Australia/New Zealand: AS/NZS 2064.1	
Safety	IEC 61010-1:2001 / EN 61010-1:2001 Canada: CSA C22.2 No. 61010-1:2004 USA: UL 61010-1: 2004	

Additional Information:

The product herewith complies with the essential requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) 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

Models Description:

U2331A – USB 64SE/32DI, 12bits, 3MSa/s Multifunction USB DAQ
U2351A – USB 16SE/8DI, 16bits, 250kSa/s Multifunction USB DAQ
U2352A – USB 16SE/8DI, 16bits, 250kSa/s Multifunction USB DAQ (without Analog output)
U2353A – USB 16SE/8DI, 16bits, 500kSa/s Multifunction USB DAQ
U2354A – USB 16SE/8DI, 16bits, 500kSa/s Multifunction USB DAQ (without Analog output)
U2355A – USB 64SE/32DI, 16bits, 250kSa/s Multifunction USB DAQ
U2356A – USB 64SE/32DI, 16bits, 500kSa/s Multifunction USB DAQ

Notes:

Regulatory Information for Canada

ICES/NMB-001:1998
This ISM device complies with Canadian ICES-001.
Cet appareil ISM est conformre à la norme NMB-001 du Canada.

Regulatory Information for Australia/New Zealand

This ISM device complies with Australian/New Zealand AS/NZS 2064.1

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This chapter provides an overview of the U2300A series, the product outlook, product dimension, and product layout. This chapter also contains instructions on how to get started with the U2300A series that begins from system requirements checking to installations of hardware and software to the launching of the Agilent Measurement Manager application software.

Introduction

The Agilent U2300A series USB multifunction data acquisition (DAQ) devices can operate as a standalone unit or modular unit (when used in a chassis). The U2300A series consists of basic multifunction models (U2351A, U2352A, U2353A, and U2354A) and high density multifunction models (U2355A, U2356A, and U2331A). The basic multifunction DAQ can sample up to 500 kSa/s with a resolution of 16 bits. Whereas, the high density multifunction DAQ is able to sample up to 3 MSa/s for a single channel and up to 1 MSa/s for multiple channels. This makes it ideal when dealing with high-density analog input/output signals and different input ranges.

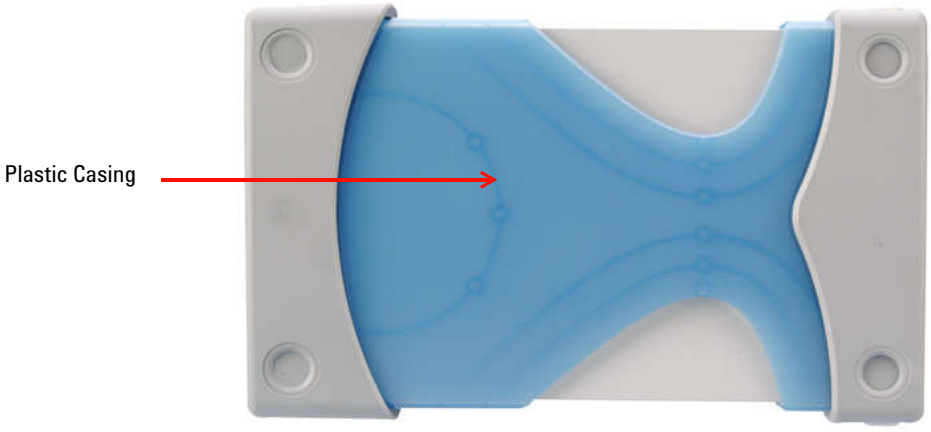
The U2300A series DAQ also features a 24-bit programmable digital I/O and two independent 31-bit general purpose digital counter. In addition to that, the U2300A is able to perform analog and digital functions at full speed. It has a resolution range of 12 to 16 bits, with no missing codes. It comes with self calibration capability. This enables the device to readjust its offset within the specified accuracies and ranges.

The U2300A series DAQ devices are compatible with a wide range of Application Development Environment (ADE), such as Agilent VEE, LabVIEW and Microsoft Visual Studio. Bundled with the purchase of every device is an easy-to-use data logging software, the Agilent Measurement Manager.

Product Overview

Product outlook

Top view



Front view



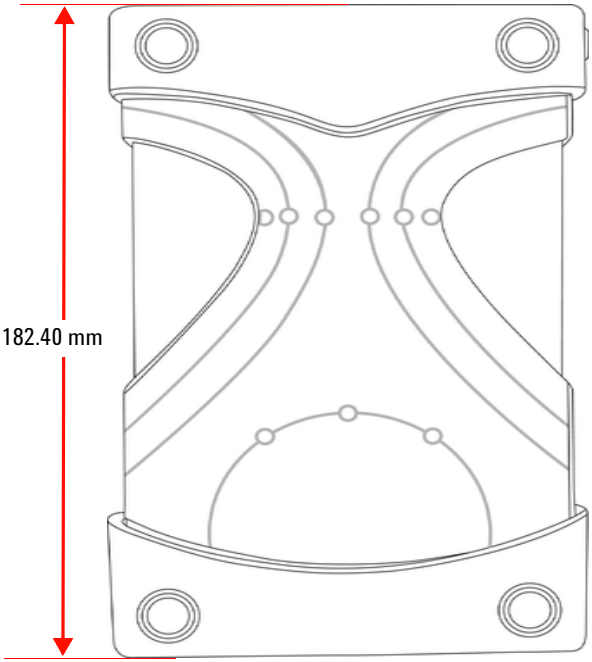
Rear view



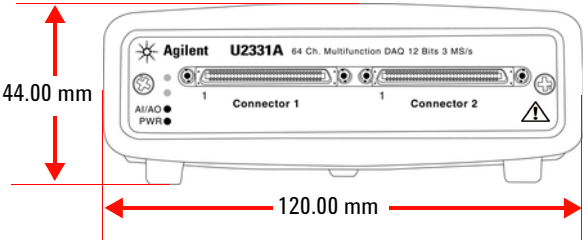
Product dimension

With plastic casing

Top view

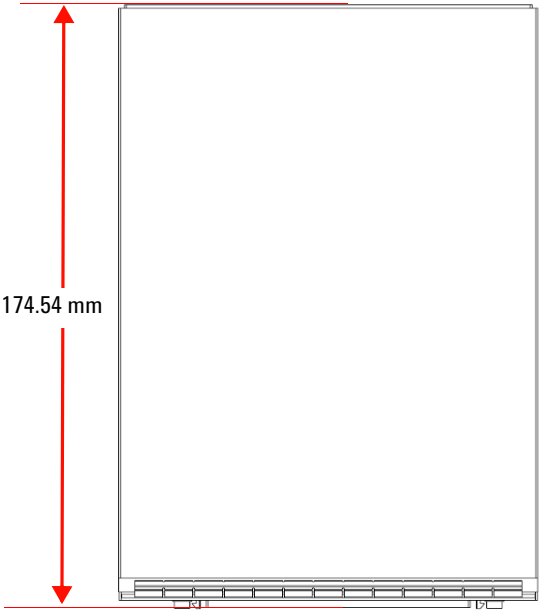


Front view

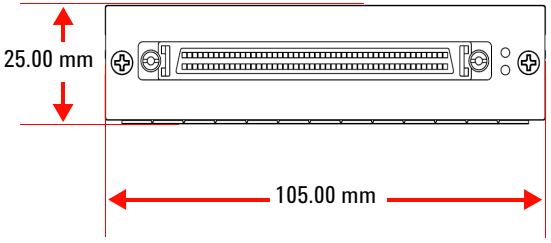


Without plastic casing

Top view

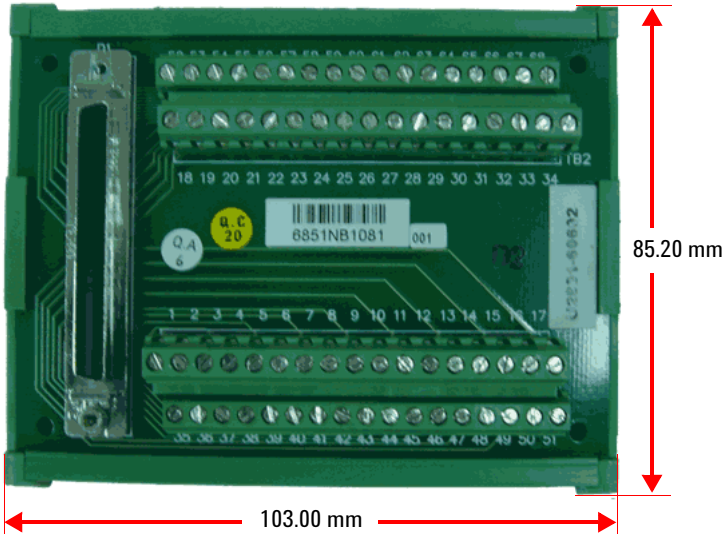


Front view

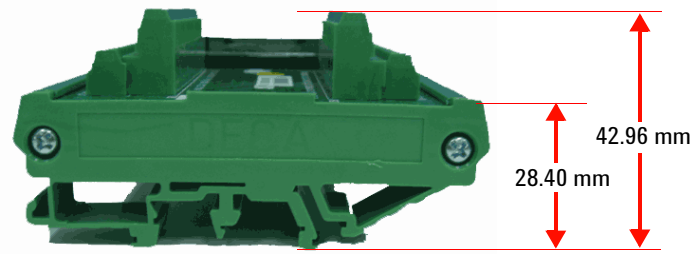


Terminal Block Overview

Front view



Side view



Standard Purchase Items Checklist

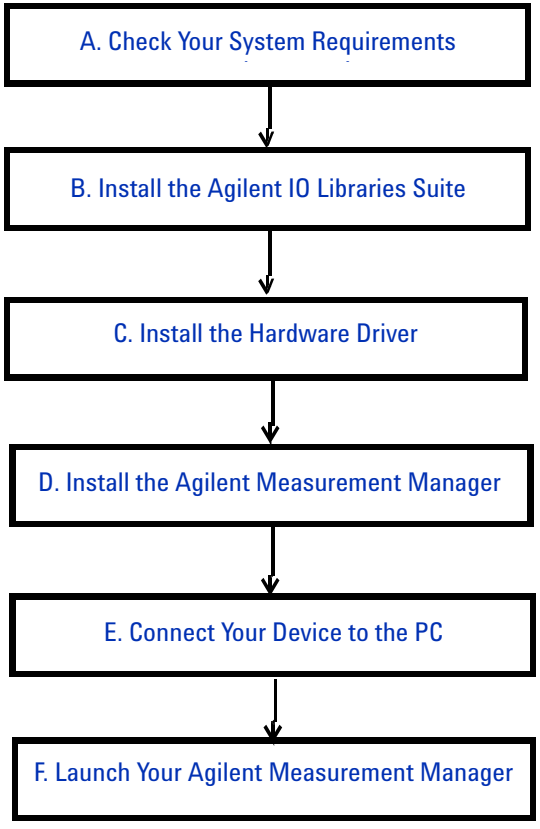
- ✔ AC/DC power adapter
- ✔ Power cord
- ✔ USB extension cable
- ✔ L–Mount kit (used with modular instrument chassis)
- ✔ Agilent U2300A Series Data Acquisition Devices and Agilent Measurement Manager Quick Start Guide
- ✔ Agilent USB Modular Instrument U2300A & U2700A Series Product Reference CD-ROM
- ✔ Agilent Automation-Ready CD (contains the Agilent IO Libraries Suite)
- ✔ Certificate of Calibration

Software Installation

If you would like to use the U2300A series USB DAQ devices with the Agilent Measurement Manager application software, follow the step-by-step instructions as shown in the following flowchart.

NOTE

- Agilent VEE, LabVIEW, MATLAB or Microsoft Visual Studio), you can skip steps D and F in the following flowchart.
- You may be required to install the IVI-COM driver before using the U2300A series with other ADEs.



A. Check Your System Requirements

Before installing the hardware driver and the Agilent Measurement Manager software, ensure that 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 1.1 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 "A. Check Your System Requirements" on page 8.)
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.

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**".

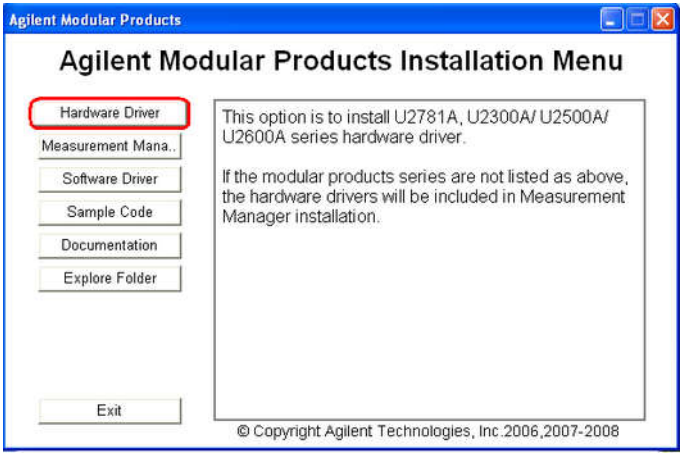
C. Install the Hardware Driver

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.

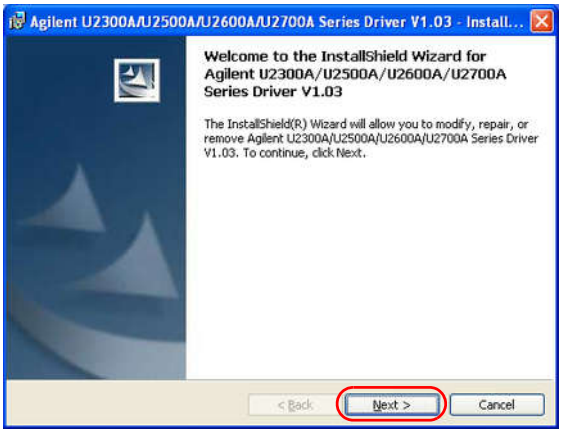
1 Insert the *Agilent USB Modular Instrument Product Reference CD- ROM* into the CD- ROM drive of your PC.

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

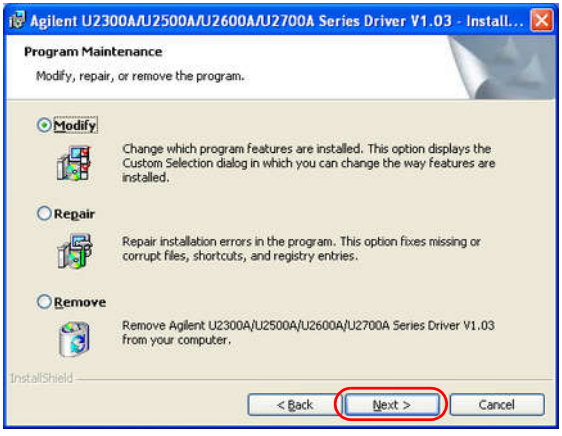


3 If the menu does not launch automatically, go to **Start > Run** (on the Windows Start menu) and type `<drive>:\Driver\Hardware\setup_hw.exe`, where `drive` is your CD- ROM drive. Click **OK** to begin installation.

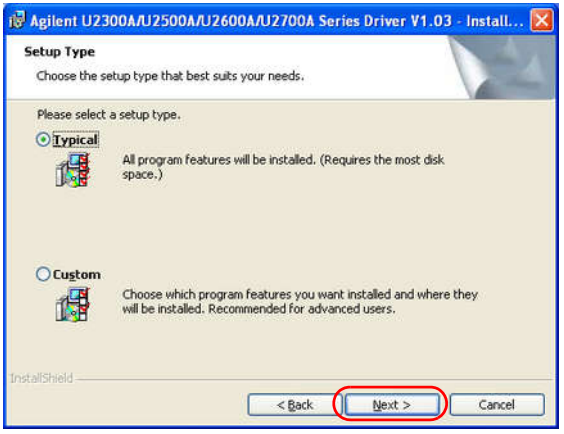
4 The following dialog will appear. Click **Next >** to begin the installation.



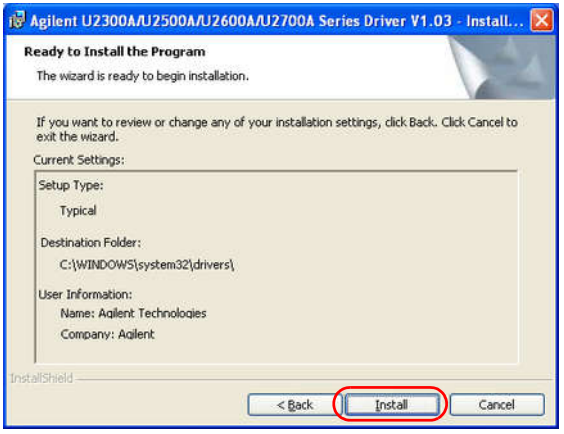
5 If you have previous hardware driver version, the dialog box will have the Modify, Repair and Remove options as shown below. Choose the option you like and click **Next >** to proceed.



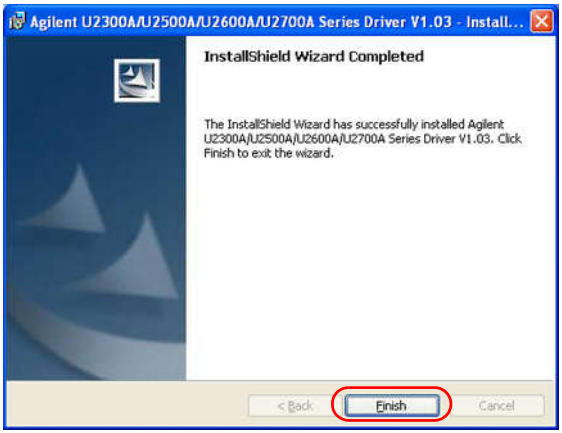
6 If you do not previously install any hardware driver, the following dialog box will be shown. Select **Typical** to install the all the features, otherwise select **Custom** to choose which program features you want to install. Click **Next >** to proceed.



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.



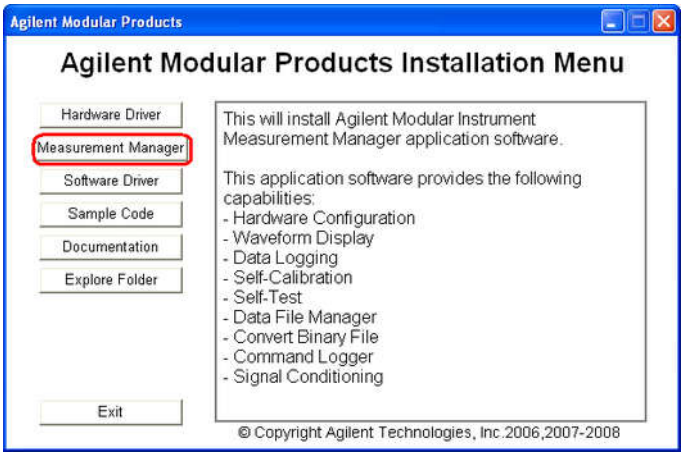
D. Install the Agilent Measurement Manager

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.

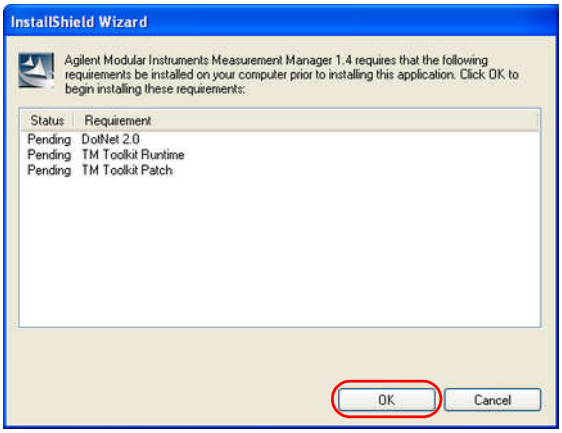
2 Select **Measurement Manager** on the Agilent Modular Products Installation Menu to begin the installation.



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 1.1 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.

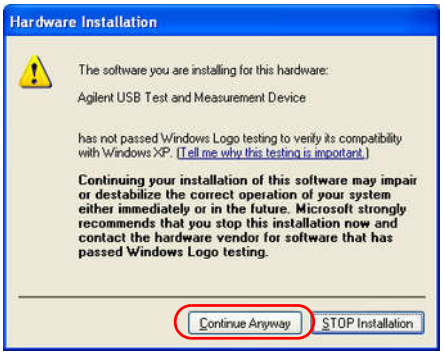
3 Connect any of the U2300A series instrument to any USB ports on your PC with the USB cable.

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.



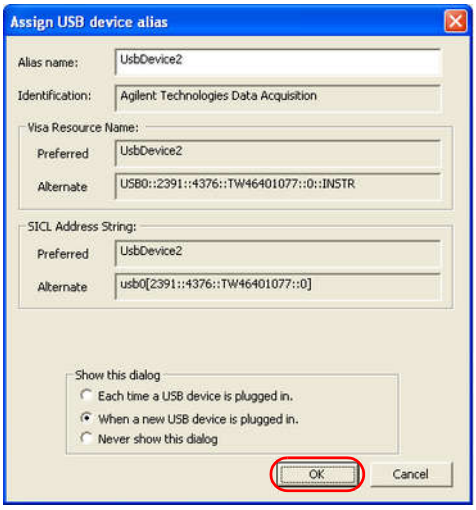
NOTE

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.

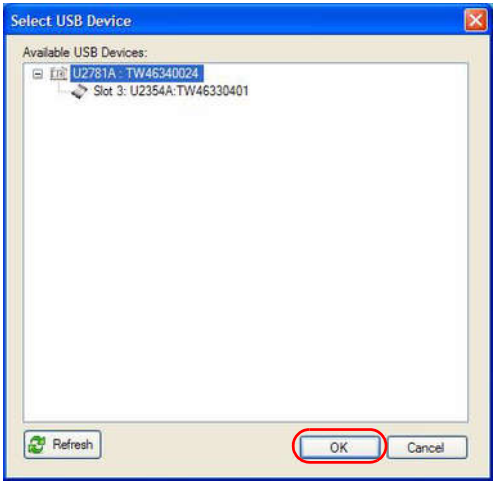
F. Launch Your Agilent Measurement Manager

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 Products > 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

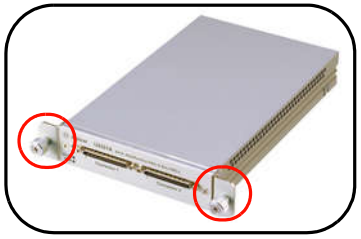
The L-Mount kit is to be used with Agilent U2781A USB modular instrument chassis. The following instructions describes simple procedures of installing the L-Mount kit to a U2300A DAQ device.



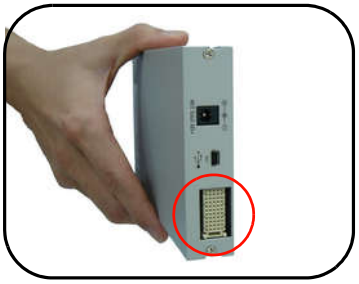
1 Unpack the L-Mount kit from the packaging.



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



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



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



5 Your DAQ 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 DAQ device, follow the instructions below.

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

2
Connector Pins Configuration

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Types of signal sources 33
Input configurations 34

This chapter describes the connector pins configuration of the U2300A series USB DAQ and the signal connection between the U2300A and external devices.

Connector Pins Configuration

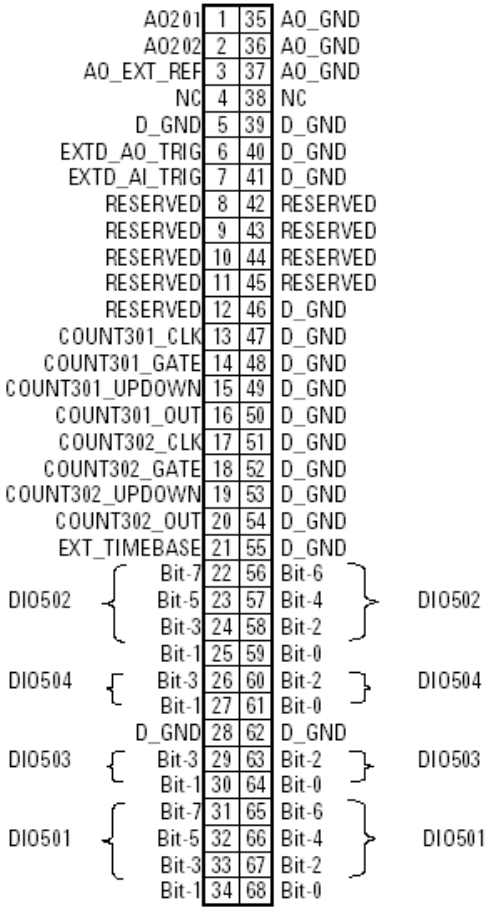
The U2300A series DAQ is equipped with 68–pin very high density cable interconnect (VHDCI) type connectors. These connector pins are used for digital input/output, analog input/output, counters and other external reference/trigger signal.

Pins Configuration of Connector 1 for U2331A, U2355A, U2356A

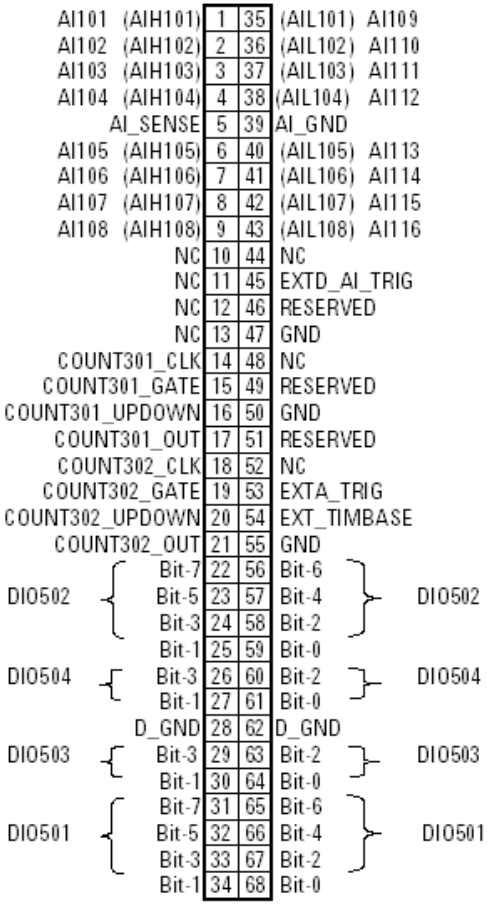
AI101	(AIH101)	1	35	(AIL101)	AI133
AI102	(AIH102)	2	36	(AIL102)	AI134
AI103	(AIH103)	3	37	(AIL103)	AI135
AI104	(AIH104)	4	38	(AIL104)	AI136
AI105	(AIH105)	5	39	(AIL105)	AI137
AI106	(AIH106)	6	40	(AIL106)	AI138
AI107	(AIH107)	7	41	(AIL107)	AI139
AI108	(AIH108)	8	42	(AIL108)	AI140
AI109	(AIH109)	9	43	(AIL109)	AI141
AI110	(AIH110)	10	44	(AIL110)	AI142
AI111	(AIH111)	11	45	(AIL111)	AI143
AI112	(AIH112)	12	46	(AIL112)	AI144
AI113	(AIH113)	13	47	(AIL113)	AI145
AI114	(AIH114)	14	48	(AIL114)	AI146
AI115	(AIH115)	15	49	(AIL115)	AI147
AI116	(AIH116)	16	50	(AIL116)	AI148
	AI_SENSE	17	51	AI_GND	
AI117	(AIH117)	18	52	(AIL117)	AI149
AI118	(AIH118)	19	53	(AIL118)	AI150
AI119	(AIH119)	20	54	(AIL119)	AI151
AI120	(AIH120)	21	55	(AIL120)	AI152
AI121	(AIH121)	22	56	(AIL121)	AI153
AI122	(AIH122)	23	57	(AIL122)	AI154
AI123	(AIH123)	24	58	(AIL123)	AI155
AI124	(AIH124)	25	59	(AIL124)	AI156
AI125	(AIH125)	26	60	(AIL125)	AI157
AI126	(AIH126)	27	61	(AIL126)	AI158
AI127	(AIH127)	28	62	(AIL127)	AI159
AI128	(AIH128)	29	63	(AIL128)	AI160
AI129	(AIH129)	30	64	(AIL129)	AI161
AI130	(AIH130)	31	65	(AIL130)	AI162
AI131	(AIH131)	32	66	(AIL131)	AI163
AI132	(AIH132)	33	67	(AIL132)	AI164
	EXTA_TRIG	34	68	AI_GND	

NOTE (AIH101..132) and (AIL101..132) are for differential mode connection pair.

Pins Configuration of Connector 2 for U2355A, U2356A, U2331A

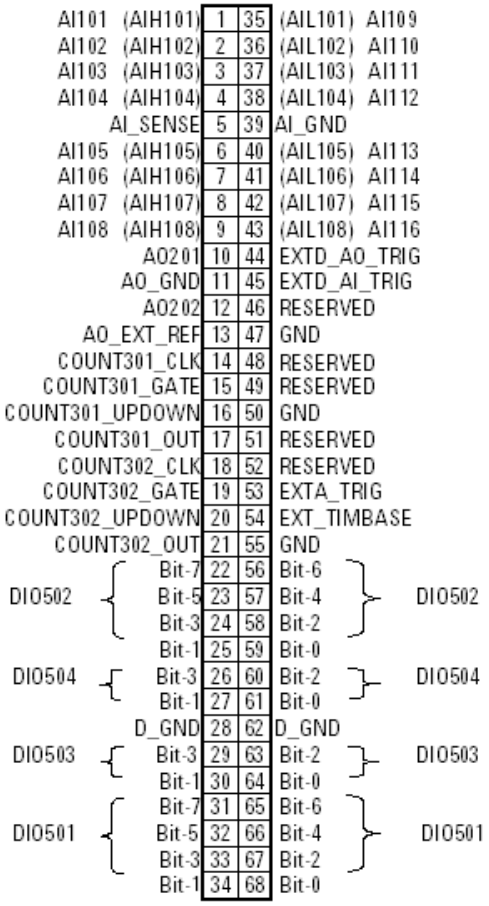


Pins Configuration for U2352A, U2354A



NOTE (AIH101..108) and (AIL101..108) are for differential mode connection pair.

Pins Configuration for U2351A, U2353A



NOTE (AIH101..108) and (AIL101..108) are for differential mode connection pair.

Table 2-1 68-pin VHDCI connector pins descriptions

Signal Name	Direction	Reference Ground	Description
AI_GND	N/A	N/A	Analog input (AI) ground. All three ground references (AI_GND, AO_GND, and D_GND) are connected together on board.
For 16 Channels: AI<101..116>	Input	AI_GND	**U2351A/U2352A/U2353A/U2354A** Analog input channels 101~116. Each channel pair, AI<i, i+8>(i = 101..108), can be configured either as two single-ended inputs or one differential input (marked as AIH<101..108> and AIL<101..108>).
For 64 Channels: AI<101..164>			**U2331A/U2356A/U2355A** Analog input channels 101~164). Each channel pair, AI<i, i+32> (i = 101..132), is configured either as two single-ended inputs or one differential input (marked as AIH<101..132> and AIL<101..132>)
AI_SENSE	Input	AI_GND	Analog input sense. The reference pin for any AI<101..116> or AI<101..164> channels in NRSE input configuration.
EXTA_TRIG	Input	AI_GND	External AI analog trigger
AO201	Output	AO_GND	Analog output channel 1
AO202	Output	AO_GND	Analog output channel 2
AO_EXT_REF	Input	AO_GND	External reference for AO channels
AO_GND	N/A	N/A	Analog ground for AO
EXTD_AO_TRIG	Input	D_GND	External AO waveform trigger
EXTD_AI_TRIG	Input	D_GND	External AI digital trigger
RESERVED	Output	N/A	Reserved pins. Do not connect them to any signal.
COUNT<301,302>_CLK	Input	D_GND	Source of counter <301,302>
COUNT<301,302>_GATE	Input	D_GND	Gate of counter <301,302>
COUNT<301,302>_OUT	Input	D_GND	Output of counter <301,302>
COUNT<301,302>_UPDOWN	Input	D_GND	Up/Down of counter <301,302>
EXT_TIMEBASE	Input	D_GND	External Timebase
D_GND	N/A	N/A	Digital ground
DIO501<7,0>	PIO	D_GND	Programmable DIO of Channel 501
DIO502<7,0>	PIO	D_GND	Programmable DIO of Channel 502

Table 2-1 68-pin VHDCI connector pins descriptions

DIO503<4,0>	PIO	D_GND	Programmable DIO of Channel 503
DIO504<4,0>	PIO	D_GND	Programmable DIO of Channel 504

55-Pin Backplane Connector Pins Configuration

11	GND	+12V	+12V	GND	USB_D+	USB_D-	GND
10	GND	+12V	+12V	+12V	GND	GND	GND
9	GND	+12V	+12V	+12V	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

NOTE The 55-pin backplane connector is used when the DAQ devices are used as modular with the modular instrument chassis. For more detail, refer to *Agilent U2781A USB Modular Instrument Chassis User's Guide*.

Table 2-2 SSI connector pins descriptions

SSI timing signal	Functionality
+12V	+12 V power from backplane
GND	Ground
BRSV	Reserved pin
TRIG0~TRIG7	Trigger bus 0 ~ 7
STAR_TRIG	Star trigger
CLK10M	10MHz reference clock
USB_VBUS	USB bus power, +5 V
USB_D+, USB_D-	USB differential pair

Table 2-2 SSI connector pins descriptions

LBL <0..7> and LBR <0..7>	Reserved pin
GA0, GA1, GA2	Geographical address pin

Analog Input Signal Connection

The U2300A series DAQ provides up to 64 single–ended (SE) or 32 differential analog input (DI) channels. The analog signal is converted to digital represented value by the A/D converter. In order to obtain a more accurate measurement from the A/D conversion, it is important to understand the type of signal source of analog input modes RSE, NRSE, and DIFF.

Types of signal sources

Ground-referenced signal sources

A ground-referenced signal source is defined as a signal source that is connected in some way to the building's grounding system. This means that the signal source is connected to a common ground point with respect to the U2300A series DAQ (assume the host PC which is connected with DAQ is in the same power ground).

Floating signal sources

A floating signal source is a signal that is not connected to the building's grounding system. It is also a device with an isolated output. Example of floating signal sources are optical isolator output, transformer output, and thermocouple.

Input configurations

Single-ended connections

A single-ended connection is applicable when the analog input signal is referenced to a ground and can be shared with other analog input signals. There are two different types of single-ended connections, which are RSE and NRSE configuration.

- **Referenced Single-Ended (RSE) mode**
  In referenced single-ended mode, all the input signals are connected to the ground provided by the U2300A series DAQ and suitable for connections with floating signal sources. The following figure illustrates the RSE mode.

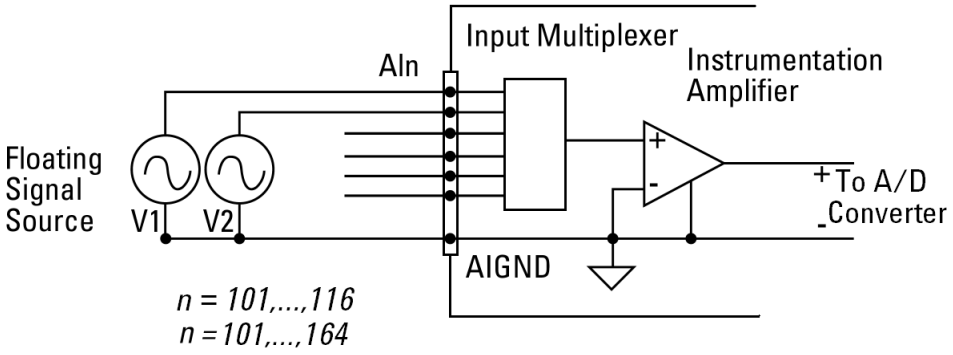


Figure 2-1 Floating source and RSE input connections

NOTE When more than two floating sources are connected, these sources are referenced to the same common ground.

- **Non-Referenced Single-Ended (NRSE) Mode**
  In NRSE mode, the DAQ device does not provide the grounding point. The ground reference point is provided by the external analog input signal. You can connect the signals in NRSE mode to measure ground-referenced signal sources, which are connected to the same grounding point. The following figure illustrates the connection. The signal local ground reference is connected to the negative input of the instrumentation Amplifier (AI_SENSE pin on connector1). Hence, any potential difference of the common mode ground between signal ground and the signal ground on DAQ board will be rejected by the instrumentation amplifier.

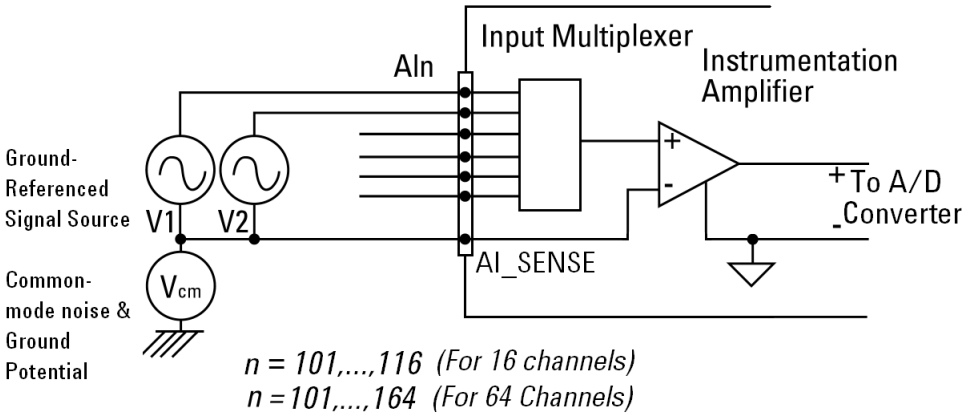


Figure 2-2 Ground-referenced sources and NRSE input connections

Differential Input Mode

The differential input mode provides two inputs that respond to the difference of the signal voltage. The analog input of the U2300A series DAQ has its own reference ground or signal return path. The differential mode can be used for the common-mode noise rejection if the signal source is ground-referenced. The following figure shows the connection of ground-referenced signal sources under differential input mode.

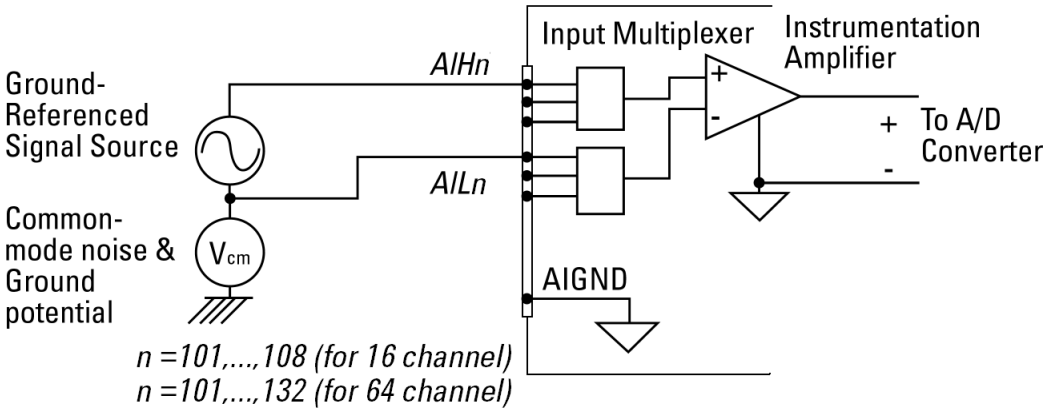


Figure 2-3 Ground-referenced source and differential input mode

The following figure illustrates the connection of a floating signal source to the U2300A series DAQ in differential input mode. For floating signal sources, additional resistor is needed at each channel to provide a bias return path. The resistor value is equivalent to about 100 times the source impedance. If the source impedance is less than 100 Ω, you can connect the negative polarity of the signal directly to AI_GND, as well as the negative input of the Instrumentation Amplifier. The noise couples in differential input mode are less compared to the single-ended mode.

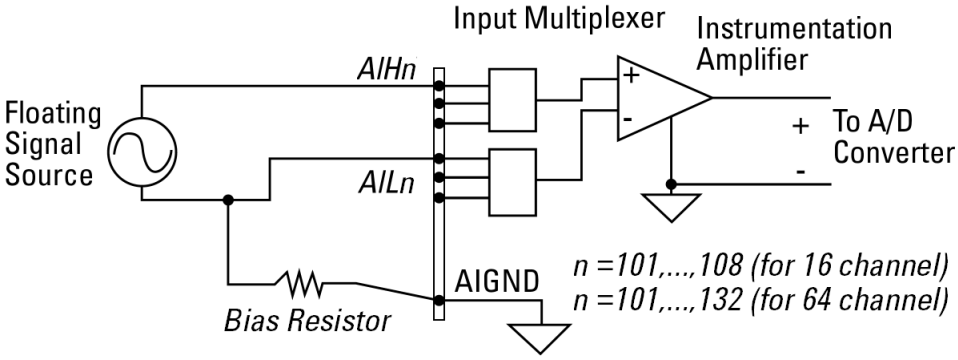


Figure 2-4 Floating source and differential input

NOTE

- Agilent U2300A series DAQ is designed with high input impedance. Please ensure that all the connection are connected properly before acquiring any data. Failing to do so may cause data fluctuation or erroneous readings.
- Unused pins at multiplexing DAQ inputs can be treated as floating source with infinite output impedance. Therefore, necessary grounding system is required in user application system.

3
Features and Functions

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This chapter describes the features and functions of the U2300A series USB 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.

Features Overview

U2351A/U2352A/U2355A	16-bit analog input resolution with sampling rate of 250 kSa/s
U2353A/U2354A/U2356A	16-bit analog input resolution with sampling rate of 500 kSa/s
U2331A	12-bit analog input resolution with sampling rate up to 3 MSa/s per single channel

- Resolution of 12-bit and 16-bit with no missing codes.
- Up to 64 single-ended (SE) inputs or 32 differential inputs (DI).
- Up to 100 selectable analog input channels for sequencing scanning.
- Programmable bipolar and unipolar analog input.
- Self-calibration supported.
- USBTMC 488.2 compliant.
- Hi-Speed USB 2.0 interface.
- Multiple trigger sources none (intermediate trigger), external analog/digital trigger, and SSI/star trigger (used with modular chassis).

Analog Input Operation Mode

Analog-to-Digital (A/D) conversion converts analog voltage into digital information, which enables the computer to process or to store the signals. Before using an A/D converter, you should define the properties of the measured signals, which are the range, polarity (Unipolar/Bipolar) and signal type. You can also set the desired channels.

The A/D acquisition requires a trigger source. Once the trigger condition is matched, only then the data acquisition begins. The measured signal is buffered in a data FIFO. buffer. The analog inputs are able to provide input voltages between ±1.25 V to ±10 V (16-bit ADC), except for U2331A with ±0.05 V to ±10 V (12-bit ADC). The following diagram illustrates the functional block diagram of the U2300A series DAQ device.

According to the functional block diagram, when the U2300A series DAQ device is switched on, the calibration constants is loaded from the on-board EEPROM to ensure both the Calibration DACs and PGA circuit are functioning correctly. Users are required to set the input configuration in the Scan List, trigger source, and trigger mode using SCPI commands. The DAQ will start with different scan data acquisition timings, and when the trigger condition is matched, a trigger event will take place. The data will be transferred to the system memory using suitable data transfer mode. The input signal types are single-ended and differential.

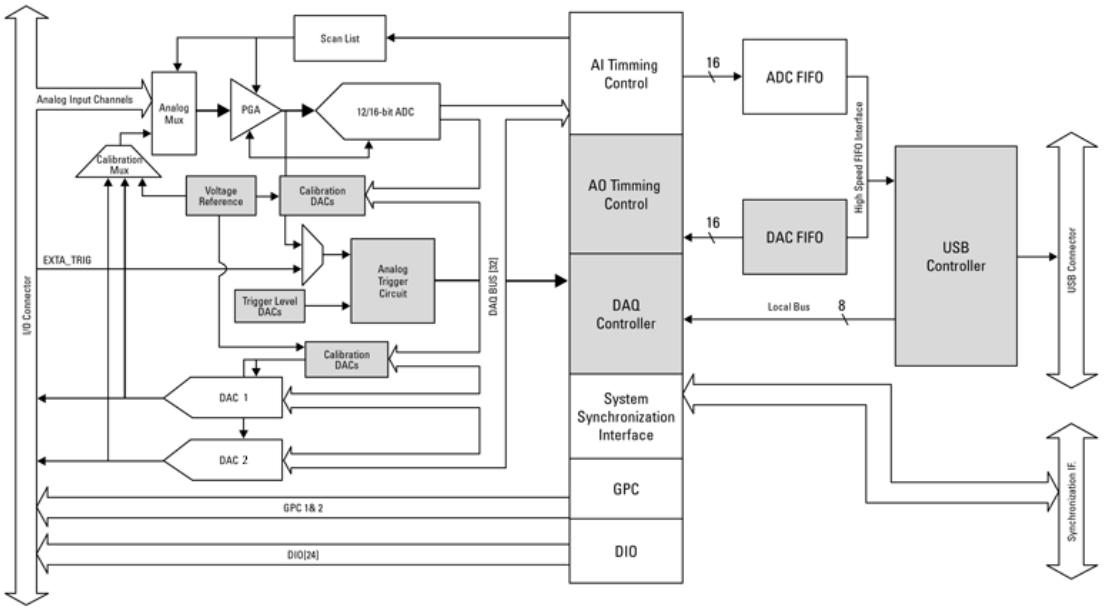


Figure 3-1 Functional block diagram of U2300A series DAQ device

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 data. The A/D converter starts converting one reading whenever the dedicated SCPI command is executed. This mode is well suited in applications that needs to process A/D data in real time. In this mode, the timing of the A/D conversion is fully controlled by the software. However, it is difficult to control the A/D conversion rate.

In polling mode, the properties of the measured signal should be defined. The properties are range, polarity (unipolar/bipolar) and signal type. Signal type consists of RSE, NRSE and DIFF.

The default polarity is bipolar. The SCPI command for performing the polling mode measurement is under MEASure subsystem.

NOTE For more information on MEASure subsystem, refer to the *Agilent U2300A Series Multifunction USB Data Acquisition Programming Guide*.

Continuous mode

Continuous mode is divided into two types, single-shot and continuous acquisition. In single-shot acquisition, the data is acquired at a specified sample points and processed once. On the other hand, the continuous acquisition allows you to acquire data continuously 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:

Sampling rate

Specify the sampling rate of each AI channel. Since the U2300A series DAQ devices comes with multiplexing analog input, the maximum sampling rate depends on the ADC's sampling rate and the entry number in the scan list.

For example, if four channels are specified in the scan list of the U2356A, the maximum sampling rate is actually 500 kSa/s divided by four, which is 125 kSa/s for each channel. However, in the U2331A, the maximum sampling rate is only up to 1 MSa/s when switching of multiple channels is enabled.

Sample points

Specify the number of acquisition points for the channel. For example, if 800 sample points and four channels are specified in the scan list, there will be total of 3200 samples to be acquired.

NOTE The maximum sample points for single-shot acquisition are 8 MSa and for continuous acquisition is 4 MSa, where both types of acquisitions are of continuous input mode.

Scan list (for continuous mode only)

You are required to set up the scan list to include all desired analog input channels. By default, the U2300A series scans only CH 101 with the following settings.

- Range: ±10 V
- Input signal type: Single-ended
- Polarity: Bipolar

The settings in channel configuration entry remain unchanged when the desired data is sampled. You do not need to reconfigure the channel configuration entry if you wish to sample new data using the same order and settings. The maximum number of entries you can set is 100. Table below shows the structure of a scan list.

Table 3-2 Structure of a scan list with four entries

CHANNEL	RANGE	POLARITY	SIGNAL TYPE
108	10	UNIP	SING
101	±5	BIP	NRS
103	±10	BIP	NRS
102	±2.5	BIP	DIFF

To build a scan list

To build a scan list, follow the steps below:

- Use the `ROUTe:SCAN` command to define the list of channels in the scan list. To determine what channels are currently in the scan list, use the `ROUTe:SCAN?` query command.
- Use the `ROUTe:SCAN` command if you wish to overwrite the initial setting of the scan list.
- To initiate a scan sequence, use either the `DIGitize` or `RUN` command.

To stop a scan initiated by the `RUN` command, use the `STOP` command.

Burst mode

The DAQ device is equipped with BURST mode. This mode enables the DAQ device to simulate in simultaneous mode. It would perform sampling measurement in the highest speed of the product capabilities. The following figure illustrates an example of burst mode.

Example:

Sampling rate: 1 kSa/s
Number of sampling channels: three
Scan list sequence: 101, 102, 103

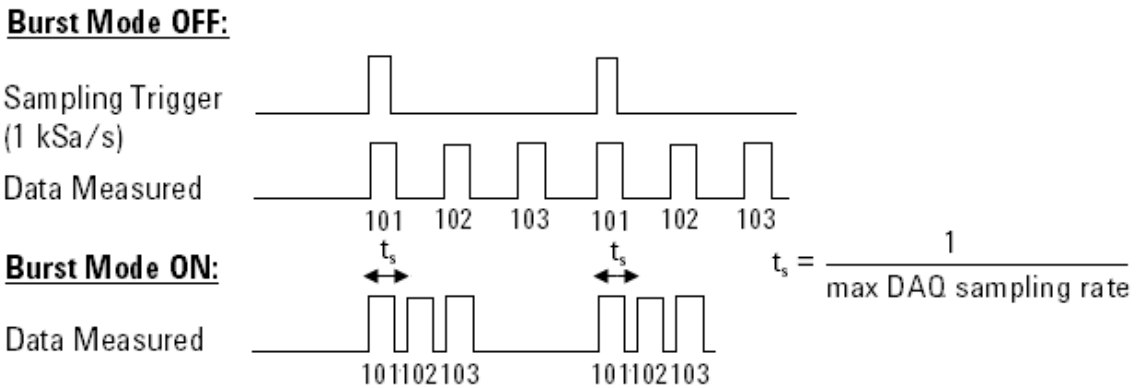


Figure 3-2 Burst mode enabled and disabled during data acquisition

A/D data conversion

A/D data conversion converts analog voltage into digital information. The following section illustrates the format of acquired raw data for the A/D conversion.

Below is the illustrated example of the acquired raw data scan list for CH 101, CH 102, and CH 103.

#800000200	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	...
Data length indicator, The next 8 bytes (0000 0200) specifying the actual data length only, not actual data. Data length (200 bytes long)	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		...

16-bit Data Format

LSB	MSB
DDDD DDDD	DDDD DDDD

12-bit Data Format

LSB	MSB
DDDD XXXX	DDDD DDDD

D - Data bits

X - Unused bits

Raw data conversion

To convert the data into an 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 the U2356A as an example. The resolution of U2356A is 16 bits and the range is taken as 10 V. The Int16b value calculated using conversion algorithm is 12768.

Hence, the 16 bits binary read back calculation will be as follows.

LSB MSB
<11100000> <00110001>
= 12768

NOTE The raw data provided by U2300A series DAQ devices is in the byte order of LSB first.

Bipolar:

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

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

Unipolar:

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

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

NOTE

- The converted value is of float type. As such, you may need to type cast the Int16 value to float in your programming environment.
- For the U2331A, there is a need to perform a 4-bit right shift operation. This is because it is equipped with 12-bit ADC, and the last 4 bits are truncated.

AI data format

12-bit AI range

The following Table 3-3 and Table 3-4 describes the U2331A ideal transfer characteristics of the bipolar and unipolar analog input ranges.

NOTE The AI resolution of the U2331A is 12 bits. The four lowest bits are truncated. In the tables below, X refers to four unused bits.

Table 3-3 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)	4.88 mV	2.44 mV	1.22 mV	0.61 mV	
FSR–1LSB	9.9951 V	4.9976 V	2.4988 V	1.2494 V	7FFX
Midscale +1LSB	4.88 mV	2.44 mV	1.22 mV	0.61 mV	001X
Midscale	0 V	0 V	0 V	0 V	000X
Midscale –1LSB	–4.88 mV	–2.44 mV	–1.22 mV	–0.61 mV	FFFX
–FSR	–10 V	–5 V	–2.5 V	–1.25 V	800X

Table 3-4 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	
Least significant bit (LSB)	2.44 mV	1.22 mV	0.61 mV	
FSR–1LSB	9.9976 V	4.9988 V	2.9994 V	7FFX
Midscale +1LSB	5.00244 V	2.50122 V	1.25061 V	001X
Midscale	5 V	2.5 V	1.25 V	000X
Midscale –1LSB	4.9976 V	2.4988 V	1.2494 V	FFFX
–FSR	0 V	0 V	0 V	800X

16-bit AI range

The following Table 3-5 and Table 3-6 describes the ideal transfer characteristics of bipolar and unipolar input ranges of the U2351A, U2352A, U2353A, U2354A, U2355A, and U2356A models.

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

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

Table 3-6 Analog input range and digital code output for unipolar

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

Analog Output Operation Mode

There are two D/A channels that are available in the U2300A series DAQ devices. The two analog outputs are capable of supplying output voltages in the range of 0 to 10 V and ±10 V (12-bit for U2355A, U2356A, U2331A and 16-bit for U2351A, U2353A). 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 to this, the analog outputs are also used to output pre-defined function generators or any arbitrary waveform.

Analog output operation mode consists of voltage output and continuous output. Continuous output mode is divided into function generator and arbitrary.

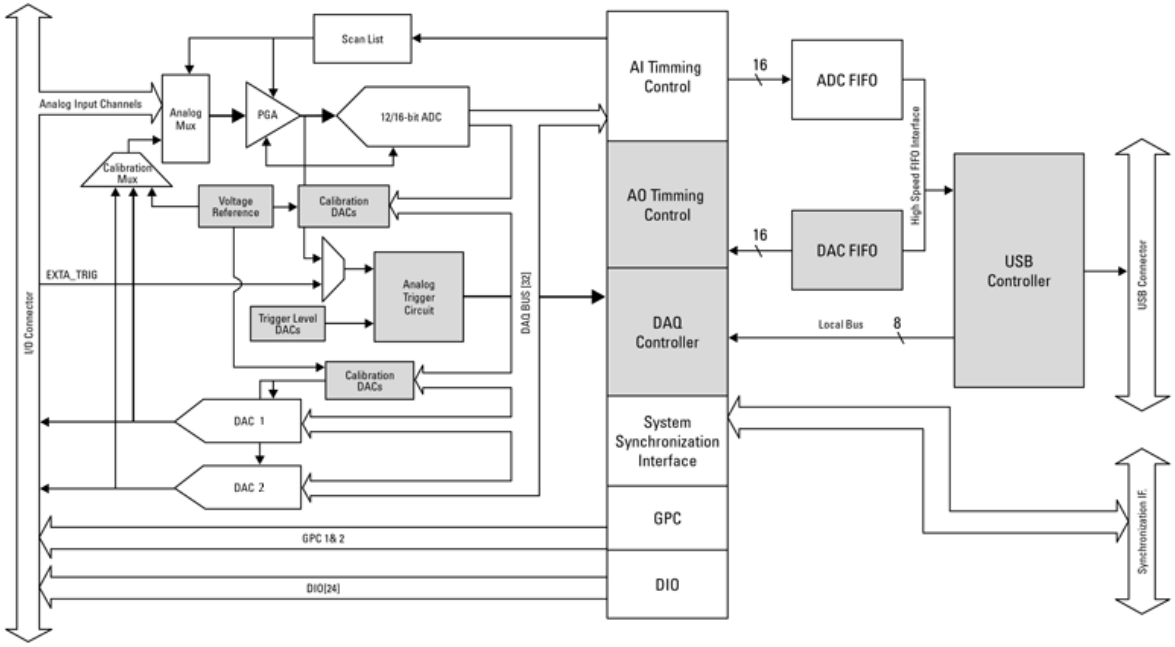


Figure 3-3 Analog output operation mode

Table 3-7 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 show the sample output of a DC voltage level for the specified DA channels.

Example 1, To output a DC voltage via CH 201

```
-> *RST;*CLS                    // 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,              // Changes output from 3.2 VDC to –3.2
(@201)                          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

```
-> *RST;*CLS                 // 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 U2300A Series USB Multifunction Data Acquisition Programming Guide*.

Example 3, To output a sine wave via CH 201

```
-> *RST;*CLS                 // 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

```
-> *RST;*CLS                     // 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
-> ROUT: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)

#800000200	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**<byte>**	**...**
Data length indicator, The next 8 bytes (0000 0200) specifying the actual data length only, not actual data. Data length (200 bytes long)	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 201/202		CH 201/202		CH 201/202		CH 201/202		...

Data format for two channels arbitrary AO (when two channels are enabled and USER mode)

#800000200	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	<byte>	...
Data length indicator, The next 8 bytes (0000 0200) specifying the actual data length only, not actual data. Data length (200 bytes long)	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		...

16-bit Data Format

LSB	MSB
DDDD DDDD	DDDD DDDD

12-bit Data Format

LSB	MSB
DDDD DDDD	XXXX DDDD

D - Data bits
X - Unused bits

Table 3-8 Digital code and voltage output table for bipolar setting (U2331A, U2355A and U2356A)

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 3-9 Digital code and voltage output table for unipolar setting (U2331A, U2355A and U2356A)

Digital Code (Hex)	Analog Output	Voltage output (with internal reference of +10 V)
0x0FFF	Vref * (4095/4096)	9.9975 V
0x0800	Vref * (2048/4096)	5.000 V
0x0001	Vref * (1/4096)	0.0024 V
0x0000	Vref * (0/4096)	0.000 V

Table 3-10 Digital code and voltage output table for bipolar setting (U2351A and U2353A)

Digital Code (Hex)	Analog Output	Voltage output (with internal reference of +10 V)
0xFFFF	Vref * (32767/32768)	9.999694 V
0x8001	Vref * (1/32768)	0.000305 V
0x8000	0 V	0 V
0x7FFF	–Vref * (1/32768)	–0.000305 V
0x0000	–Vref	–10.000 V

Table 3-11 Digital code and voltage output table for unipolar setting (U2351A and U2353A)

Digital Code (Hex)	Analog Output	Voltage output (with internal reference of +10 V)
0xFFFF	Vref * (65535/65536)	9.999847 V
0x8000	Vref * (32768/65536)	5.00000 V
0x0001	Vref * (1/65536)	0.000152 V
0x0000	Vref * (0/65536)	0 V

Digital I/O

The U2300A 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.

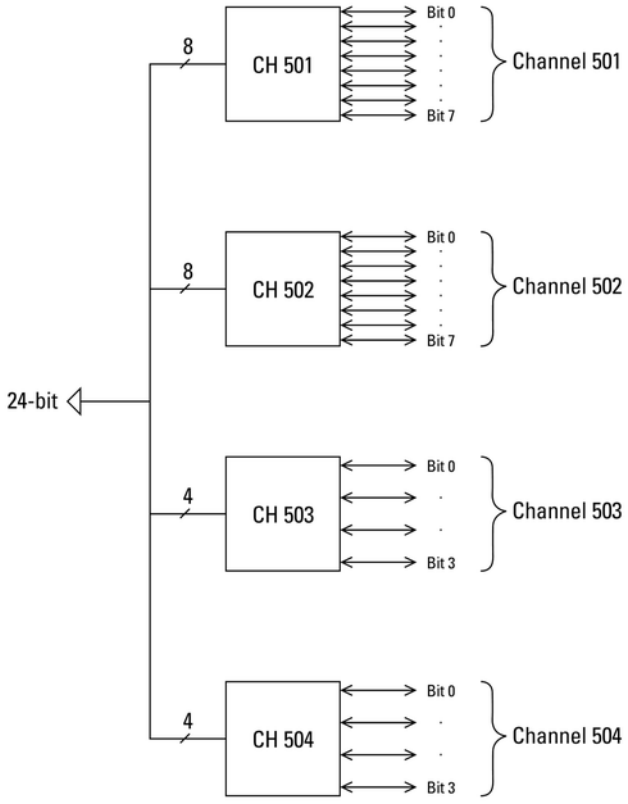


Figure 3-4 General purpose digital I/O of Agilent U2300A series DAQ

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

Configure the digital channel as OUTPUT and check the digital 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 the data bit 4 digital output line at channels 502 to 1 instantly
-> 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 output state
-> MEAS:DIG? (@501)          //To read back the digital value at channel 501
<- 23
```

Example 2:

```
-> CONF:DIG:DIR INP,(@501)
-> MEAS:DIG:BIT? 3,(@501)
<- 0
```

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

Example 3:

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

General Purpose Digital Counter

The U2300A series DAQ device has two independent 31–bit up/down counters to measure the input channels, which are TTL compatible. It has a programmable counter clock up to 12 MHz or clock generation. Refer to Figure 3-5 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. In either measurement mode or totalize mode, the signal source should be connected to the pin COUNT_GATE. In measurement mode, the signal that goes through the COUNT_GATE is the signal users wish to measure. In totalize mode, the signal that goes through the COUNT_GATE is the signal that enables the counter to start counting the clock.

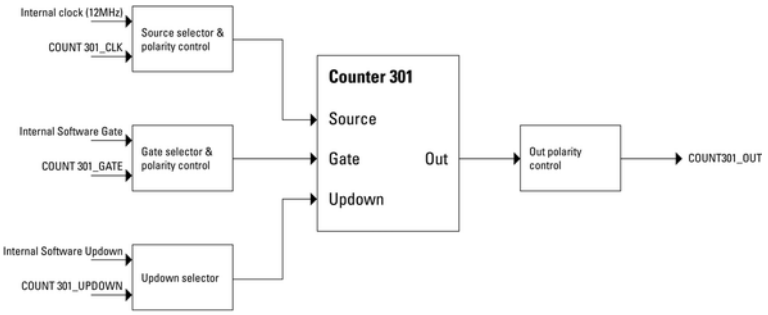


Figure 3-5 General purpose digital counter

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 the totalize function has been enabled and the COUNT_OUT pin will output a series of pulses as shown below.

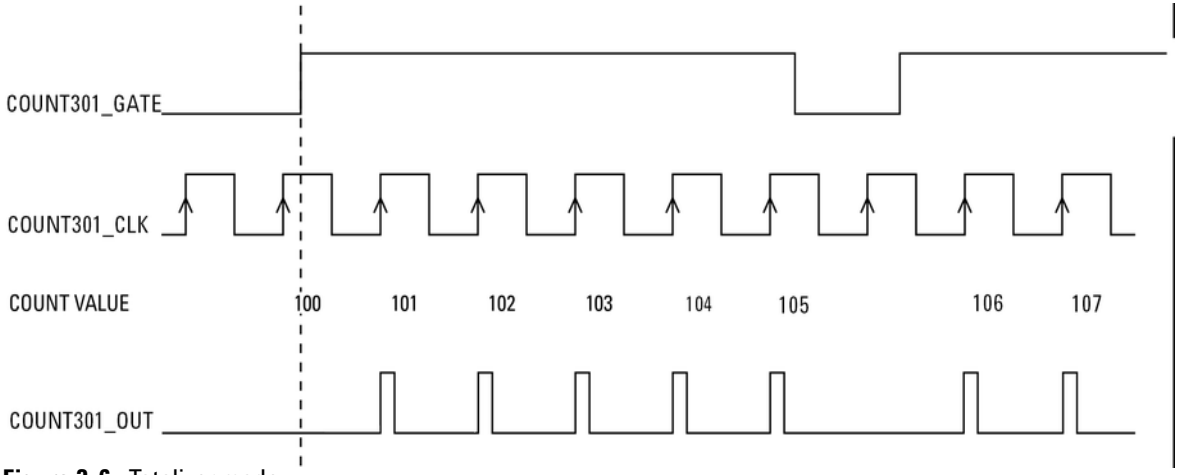


Figure 3-6 Totalizer mode

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 measurement is gated by either an internal or external gate source.

The gate source is set using the command below:

```
SENSe:COUNter: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:

```
MEASure:COUNter:FREQuency? (@<ch_list>)

MEASure:COUNter:PERiod? (@<ch_list>)

MEASure:COUNter:PWIDth? (@<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.
- 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)
<- FREQ                                        // Function automatic set to
                                               FREQ
-> MEAS:COUN:PER? (@301)
<- 0.1818333
-> COUN:FUNC? (@301)
<- PER                                         // Function automatic set to
                                               PER
-> MEAS:COUN:PWID? (@301)
<- 0.12725
```

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

Example 2:

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

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

Trigger Sources

The Agilent U2300A series USB DAQ devices provides 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 3-12 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, SONE

Table 3-13 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, SONE

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 points are converted. Refer to the following figure for further illustration.

NOTE Due to memory limitation on hardware, the maximum sample points is only up to 8 MSa.

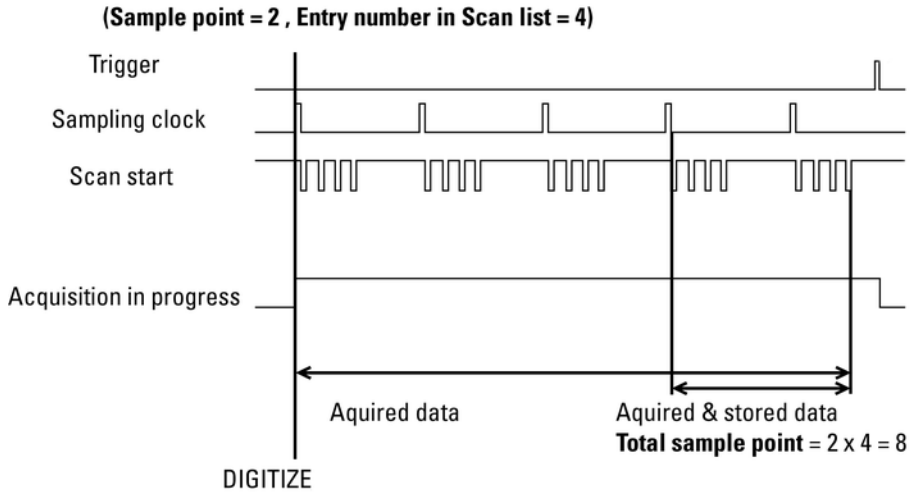


Figure 3-7 Pre-trigger

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. Refer to the following figure for further illustration.

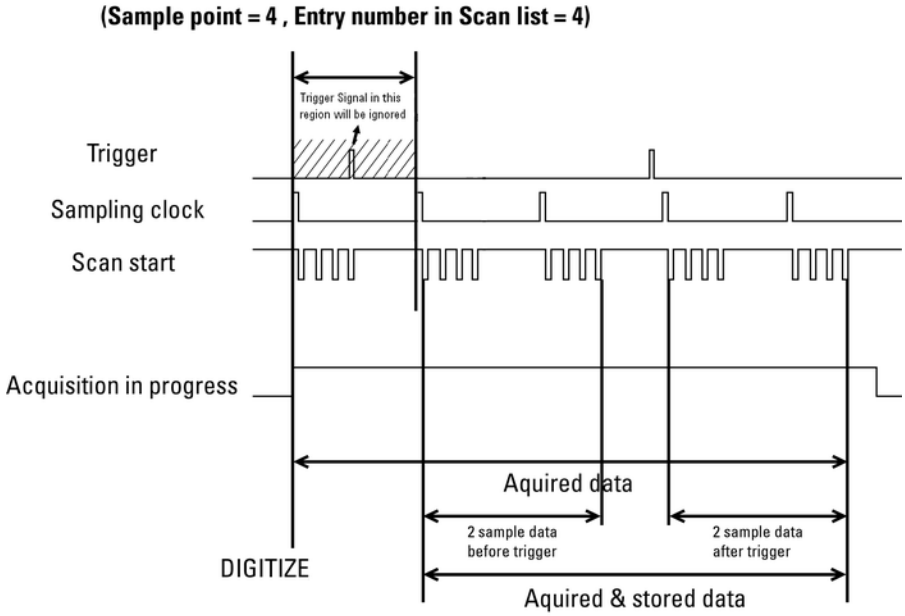


Figure 3-8 Middle-trigger

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.

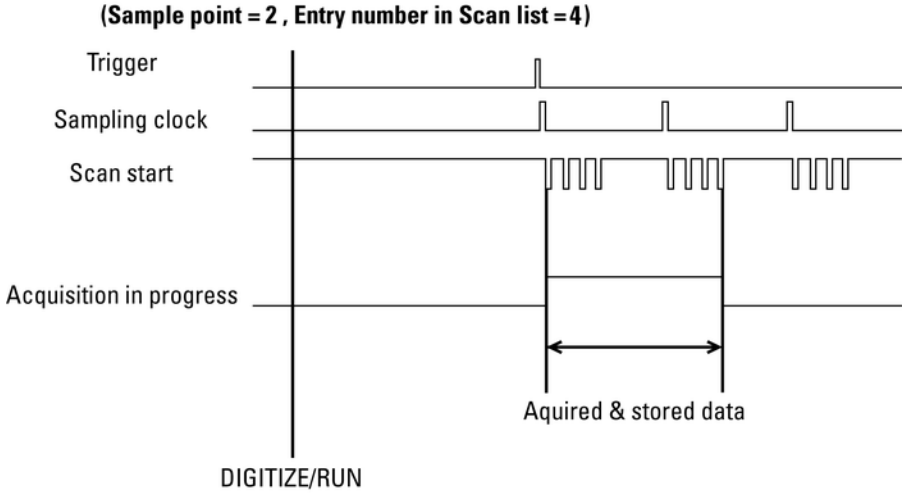


Figure 3-9 Post-trigger

Delay-trigger

This trigger acquisition is used in applications if you want to delay the data collecting process after a specified trigger event. The delay time is controlled by the value, which is pre-loaded in the Delay_counter (32-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.

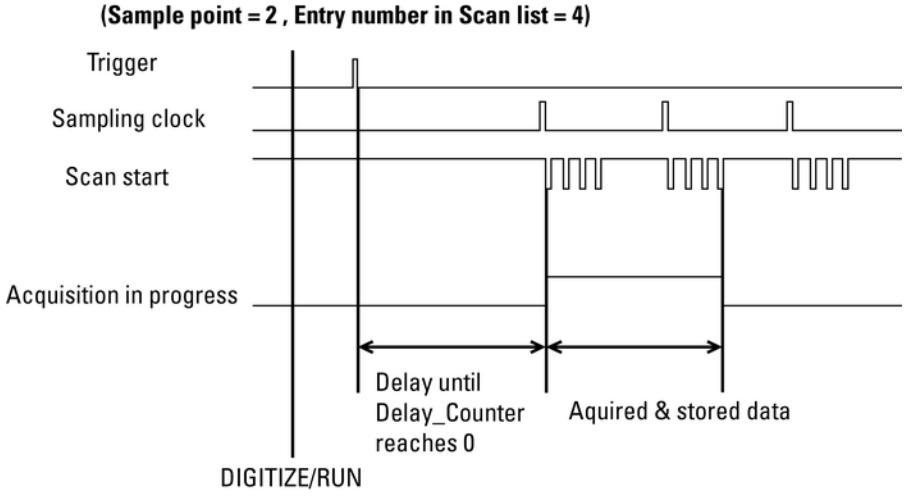


Figure 3-10 Delay-trigger

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.

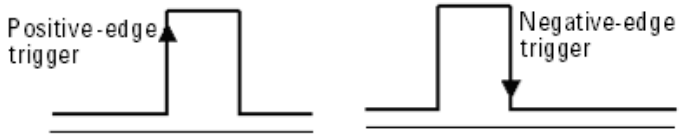


Figure 3-11 Positive and negative edge of digital trigger.

Analog trigger

There are three analog trigger conditions in U2300A 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.

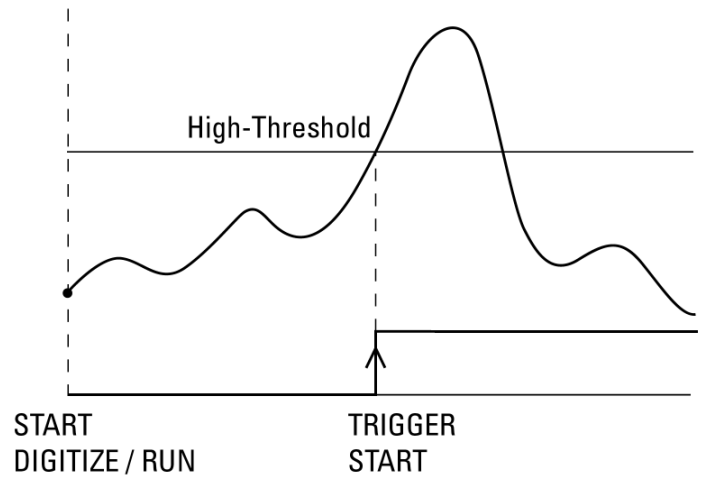


Figure 3-12 Above high trigger condition

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 above high analog trigger condition.

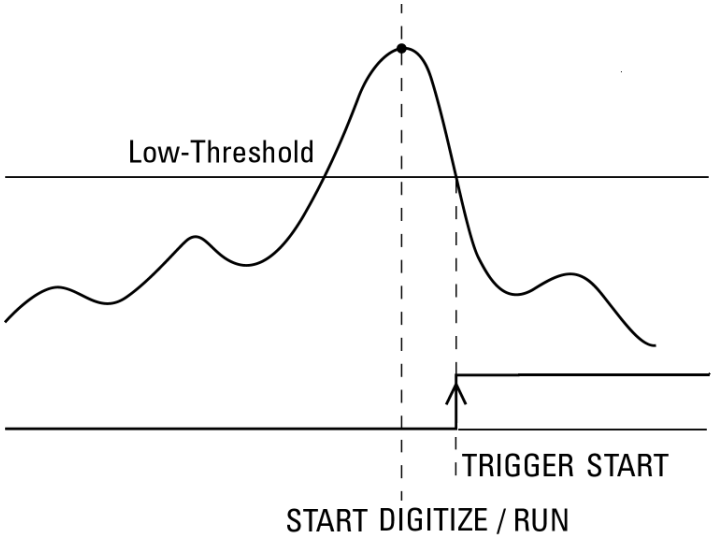


Figure 3-13 Below low trigger condition

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.

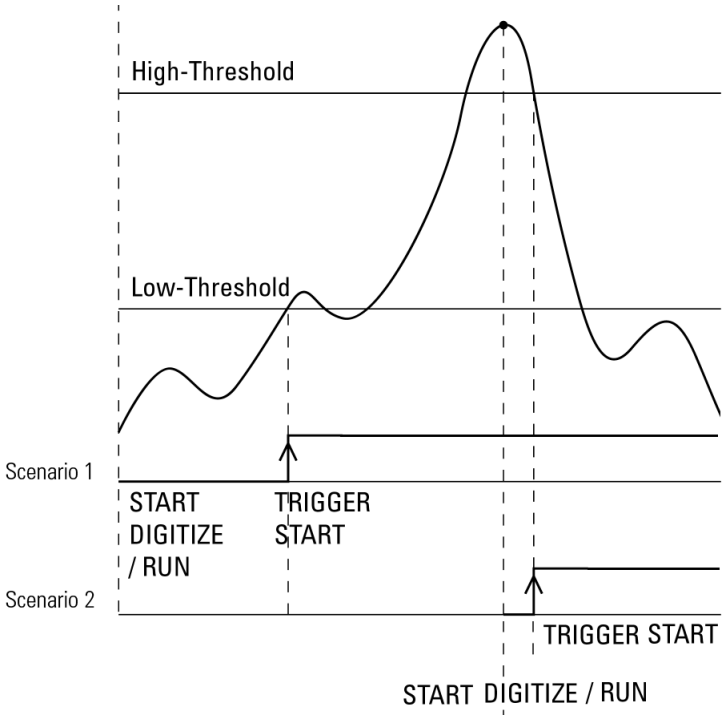


Figure 3-14 Window trigger condition

SCPI Programming Examples

Analog input

Example 1:

```
// Digital trigger with delay trigger type
// Supply Digital trigger signal to EXTD_AI_TRIG
-> 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 ~= 5 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             // Raw data returned by DAQ
<byte><byte>...
```

Example 2:

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

Example 4:

```
// Analog Trigger with first scan channel as trigger channel (SONE mode)
-> ACQ:POIN 1000                          // For "DIG" mode
-> ACQ:SRAT 1000
-> ROUT:SCAN (@133,101)                   // Use channel 133 as
                                          trigger channel
-> ROUT:CHAN:POL UNIP,(@133,101)
-> TRIG:SOUR EXTA
-> TRIG:ATRG:SOUR SONE
-> 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 and SONE 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 ~= 5 s
-> ROUT:ENAB ON,(@201)
-> OUTP ON
// Wait for trigger
// Output turn on after 5 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 first scan channel as trigger channel (SONE mode)
-> OUTP:TRIG:SOUR EXTA
-> ROUT:SCAN (@133)              // Use Channel 133 as trigger channel
-> OUTP:TRIG:ATRG:SOUR SONE      // Above High threshold Trigger condition
-> OUTP:TRIG:ATRG:COND AHIG
-> 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
-> OUTP ON                       // Important!
```

NOTE For SONE mode, execute the `RUN/DIG` command first before turning on the output. Channel 133 will only respond to trigger signal during acquisition.

4
Characteristics and Specifications

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This chapter specifies the characteristics, environmental conditions, and specifications of the U2300A DAQ device.

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, 550 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 (2nd Edition) ◦ USA: UL61010-1: 2004 ◦ Canada: CSA C22.2 No.61010-1:2004
EMC COMPLIANCE	• IEC/EN 61326-1 1998 • CISPR 11: 1990/EN55011:1991, Class A, Group 1 • CANADA: ICES-001: 1998 • Australia/New Zealand: AS/NZS 2064.1
SHOCK & VIBRATION	Tested to IEC/EN 60068-2
IO CONNECTOR	68-pin female VHDCI Type
DIMENSION (WxDxH)	Module dimension: ◦ 120.00 mm x 182.40 mm x 44.00 mm (with plastic casing) ◦ 105.00 mm x 174.54 mm x 25.00 mm (without plastic casing) Terminal block dimension: ◦ 103.00 mm x 85.20 mm x 42.96 mm
WEIGHT	• 565 g (with plastic casing) • 400 g (without plastic casing)
WARRANTY	Three years

Product Specifications

Basic multifunction DAQ device specifications

Table 4-1 Analog input product specifications for basic multifunction DAQ device

Analog Input				
Model Number	**U2351A**	**U2352A**	**U2353A**	**U2354A**
Resolution	16 bits, no missing codes			
Number of channels	16 SE/8 DI (software selectable/channel)			
Maximum sampling rate	250 kSa/s		500 kSa/s	
Scan list memory	Up to 100 selectable channels entries			
Programmable bipolar input range	±10 V, ±5 V, ±2.5 V, ±1.25 V			
Programmable unipolar input range	0 to 10 V, 0 to 5 V, 0 to 2.5 V, 0 to 1.25 V			
Input coupling	DC			
Input impedance	1 GΩ / 100 pF			
Operational common mode voltage range	±7.5 V maximum			
Overvoltage protection	Power on: Continuous ±30 V, Power off: Continuous ±15 V			
Trigger sources	External analog/digital trigger, SSI/star trigger [1]			
Trigger modes	Pre- trigger, delay-trigger, post-trigger, and middle-trigger			
FIFO buffer size	Up to 8 MSa			

Table 4-2 Analog output product specifications for basic multifunction DAQ device

Analog Output				
Model Number	**U2351A**	**U2352A**	**U2353A**	**U2354A**
Resolution	16 bits	N/A	16 bits	N/A
Number of channels	2	N/A	2	N/A
Maximum update rate	1 MSa/s	N/A	1 MSa/s	N/A
Output ranges	0 to 10 V, ±10 V, 0 to AO_EXT_REF, ±AO_EXT_REF [2]	N/A	0 to 10 V, ±10 V, 0 to AO_EXT_REF, ±AO_EXT_REF [2]	N/A
Output coupling	DC	N/A	DC	N/A
Output impedance	0.1 Ω Typical	N/A	0.1 Ω Typical	N/A
Stability	Any passive load up to 1500 pF	N/A	Any passive load up to 1500 pF	N/A
Power-on state	0 V steady state	N/A	0 V steady state	N/A
Trigger sources	External analog/digital trigger, SSI/star trigger [1]	N/A	External analog/digital trigger, SSI/star trigger [1]	N/A
Trigger modes	Post-trigger and delay-trigger	N/A	Post-trigger and delay-trigger	N/A
FIFO buffer size	1 channel: Maximum 8 MSa 2 channels: Maximum 4 MSa/ch	N/A	1 channel: Maximum 8 MSa 2 channels: Maximum 4 MSa/ch	N/A
Function generation mode	Sine-wave, square-wave, triangle, sawtooth, and noise waveform	N/A	Sine-wave, square-wave, triangle, sawtooth, and noise waveform	N/A

Table 4-3 Digital I/O product specifications for basic multifunction DAQ device

Digital I/O	
Model Number	**U2351A | U2352A | U2353A | U2354A**
Number of bits	24-bit programmable input/output
Compatibility	TTL
Input voltage	V_{IL} = 0.7 V maximum, I_{IL} = 10 µA maximum V_{IH} = 2.0 V minimum, I_{IH} = 10 µA maximum
Input voltage range	–0.5 V to +5.5 V
Output voltage	V_{OL} = 0.45 V maximum, I_{OL} = 8 mA maximum V_{OH} = 2.4 V minimum, I_{OH} = 400 µA maximum

Table 4-4 General purpose digital counter product specifications for basic multifunction DAQ device

General Purpose Digital Counter	
Model Number	**U2351A | U2352A | U2353A | U2354A**
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	0.1 Hz to 6 MHz at 50% duty cycle
Pulse width measurement range	0.167 µs to 178.956 s

Table 4-5 Analog trigger product specifications for basic multifunction DAQ device

Analog Trigger	
Model Number	**U2351A | U2352A | U2353A | U2354A**
Trigger source	All analog input channels, External analog trigger (EXTA_TRIG)
Trigger level	±Full Scale for internal; ±10 V for external
Trigger conditions	Above high, below low and window (software selectable)
Trigger level resolution	8 bits
Bandwidth	400 kHz
Input Impedance for EXTA_TRIG	20 kΩ
Coupling	DC
Overvoltage Protection	Continuous for ± 35 V maximum

Table 4-6 Digital trigger product specifications for basic multifunction DAQ device

Digital Trigger	
Model Number	**U2351A | U2352A | U2353A | U2354A**
Compatibility	TTL/CMOS
Response	Rising or falling edge
Pulse width	20 ns minimum

Table 4-7 Calibration product specifications for basic multifunction DAQ device

Calibration [3]	
Model Number	**U2351A | U2352A | U2353A | U2354A**
On board reference voltage	5 V
Temperature drift	±2 ppm/°C
Stability	±6 ppm/1000 hours

Table 4-8 General product specifications for basic multifunction DAQ device

General	
Model Number	**U2351A | U2352A | U2353A | U2354A**
Remote interface	Hi-Speed USB 2.0
Device class	USBTMC Class Device
Programmable interface	Standard Commands for Programmable Instruments (SCPI) and IVI-COM

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

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

[3] 20 minutes warm-up time is recommended.

High density multifunction DAQ device specifications

Table 4-9 Analog input product specifications for high density multifunction DAQ device

Analog Input			
Model Number	**U2355A**	**U2356A**	**U2331A**
Resolution	16 bits, no missing codes		12 bits, no missing codes
Number of channels	64 SE/32 DI (software selectable/channel)		
Maximum sampling rate	250 kSa/s	500 kSa/s	3 MSa/s (single channel) 1 MSa/s (multi channels)
Scan list memory	Up to 100 selectable channels entries		
Programmable bipolar input range	±10 V, ±5 V, ±2.5 V, ±1.25 V		±10 V, ±5 V, ±2.5 V, ±1.25 V, ±1 V, ±0.5 V, ±0.25 V, ±0.2 V, ±0.05 V
Programmable unipolar input range	0 to 10 V, 0-5 V, 0-2.5 V, 0-1.25 V		0-10 V, 0-5 V, 0-4 V, 0-2.5 V, 0-2 V, 0-1 V, 0-0.5 V, 0-0.4 V, 0-0.1V
Input coupling	DC		
Input impedance	1 GΩ / 100 pF		
Operational common mode voltage range	±7.5 V maximum		
Overvoltage protection	Power on: Continuous ±30 V, Power off: Continuous ±15 V		
Trigger sources	External analog/digital trigger, SSI/star trigger [1]		
Trigger modes	Pre-trigger, delay-trigger, post-trigger and middle-trigger		
FIFO buffer size	Up to 8 MSa		

Table 4-10 Analog output product specifications for high density multifunction DAQ device

Analog Output	
Model Number	**U2355A | U2356A | U2331A**
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[2]
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[1]
Trigger modes	Post-trigger and delay-trigger
FIFO buffer size	1 channel: Maximum 8 MSa, 2 channels: Maximum 4 MSa/ch
Function generation mode	Sine-wave, square-wave, triangle, sawtooth and noise waveform

Table 4-11 Digital I/O product specifications for high density multifunction DAQ device

Digital I/O	
Model Number	**U2355A | U2356A | U2331A**
Number of bits	24-bit programmable input/output
Compatibility	TTL
Input voltage	V_{IL} = 0.7 V max, I_{IL} = 10 µA max V_{IH} = 2.0 V min, I_{IH} = 10 µA max
Input voltage range	–0.5 V to +5.5 V
Output voltage	V_{OL} = 0.45 V max, I_{OL} = 8 mA max V_{OH} = 2.4 V min, I_{OH} = 400 µA max

Table 4-12 General purpose digital counter product specifications for high density multifunction DAQ device

General Purpose Digital Counter	
Model Number	**U2355A | U2356A | U2331A**
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	0.1 Hz to 6 MHz at 50% duty cycle
Pulse width measurement range	0.167 µs to 178.956 s

Table 4-13 Analog trigger product specifications for high density multifunction DAQ device

Analog trigger	
Model Number	**U2355A | U2356A | U2331A**
Trigger source	All analog input channels, External analog trigger (EXTA_TRIG)
Trigger level	±Full Scale for internal; ±10 V for external
Trigger conditions	Above high, below low and window (software selectable)
Trigger level resolution	8 Bits
Bandwidth	400 kHz
Input Impedance for EXTA_TRIG	20 kΩ
Coupling	DC
Overvoltage Protection	Continuous for ±35 V maximum

Table 4-14 Digital trigger product specifications for high density multifunction DAQ device

Digital Trigger	
Model Number	**U2355A | U2356A | U2331A**
Compatibility	TTL/CMOS
Response	Rising or falling edge
Pulse width	20 ns minimum

Table 4-15 Calibration product specifications for high density multifunction DAQ device

Calibration [3]	
Model Number	**U2355A | U2356A | U2331A**
On board reference	5 V
Temperature drift	±2 ppm/°C
Stability	±6 ppm/1000 hours

Table 4-16 General product specifications for high density multifunction DAQ device

General	
Model Number	**U2355A | U2356A | U2331A**
Remote interface	Hi-Speed USB 2.0
Device class	USBTMC Class Device
Programmable interface	Standard Commands for Programmable Instruments (SCPI) and IVI-COM

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

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

[3] 20 minutes warm-up time is recommended.

Electrical Measurement Specifications

Basic multifunction USB DAQ device specifications

Table 4-17 Analog input electrical measurement specifications for basic multifunction USB DAQ device

Analog Input Measurement [1]				
Model Number	**U2351A | U2352A**		**U2353A | U2354A**	
Function	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**	**23°C ± 5°C**	**0°C to 18°C 28°C to 45°C**
Offset Error	±1 mV	±5mV	±1 mV	±5mV
Gain Error	±2 mV	±5mV	±2mV	±5mV
–3 dB small signal bandwidth[2]	760 kHz		1.5 MHz	
1% THD large signal bandwidth[2]	300 kHz		300 kHz	
System noise	1 mVrms	2 mVrms	1 mVrms	2.5 mVrms
CMRR	62 dB		62 dB	
Spurious-free dynamic range (SFDR) [3]	88 dB		82 dB	
Signal-to-noise and distortion ratio (SINAD) [3]	80 dB		78 dB	
Total harmonic distortion (THD) [3]	–90 dB		–82 dB	
Signal-to-noise ration (SNR) [3]	80 dB		78 dB	
Effective number of bits (ENOB) [3]	13		12.6	

Table 4-18 Analog output electrical measurement specifications for basic multifunction USB DAQ device

Analog Output Measurementv[1]		
Model Number	**U2351A | U2353A**	
Function	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**
Offset Error	±1 mV	±4 mV
Gain Error	±4mV	±5 mV
Slew rate	19 V/µs	
Rise time	0.9 µs	
Fall time	0.9 µs	
Settling time to 1% output error	4 µs	
Driving capability	5 mA	
Glitch energy	5 ns-V (Typical), 80 ns-V (Maximum)	

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

[2] Specifications are based on the following test conditions.

Bandwidth Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
• –3 dB small signal bandwidth • 1% THD large signal bandwidth	U2351A U2352A	Sampling Rate: Input voltage: • –3 dB small signal bandwidth • 1% THD large signal bandwidth	250 kSa/s 10% FSR FSR –1 dB FS
	U2353A U2354A	Sampling Rate: Input voltage: • –3 dB small signal bandwidth • 1% THD large signal bandwidth	500 kSa/s 10% FSR FSR –1 dB FS

[3] Specifications are based on the following test conditions.

Dynamic Range Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
SFDR, THD, SINAD, SNR, ENOB	U2351A U2352A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental input voltage:	250 kSa/s 2.4109 kHz 8192 FSR –1 dB FS
	U2353A U2354A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental input voltage:	500 kSa/s 4.974 kHz 16384 FSR –1 dB FS

High density multifunction USB DAQ device specifications

Table 4-19 Analog input electrical measurement specifications for high density multifunction USB DAQ device

Analog Input Measurement [1]						
Model Number	**U2355A | U2356A**				**U2331A**	
Function	**23 °C ± 5 °C**	**0 °C - 18 °C 28 °C - 45 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**
Offset Error	±1 mV	±2mV	±1 mV	±2mV	±2mV	±3mV
Gain Error	±2 mV	±3mV	±2mV	±6mV	±6mV	±7.5mV
–3 dB small signal bandwidth[2]	760 kHz		1.3 MHz		1.2 MHz	
1% THD large signal bandwidth[2]	400 kHz		400 kHz		N/A	
System noise	1 mVrms	2 mVrms	1 mVrms	4 mVrms	3 mVrms	5 mVrms
CMRR	64 dB		61 dB		62 dB	
Spurious-free dynamic range (SFDR)[3]	88 dB		86 dB		71 dB	
Signal-to-noise and distortion ratio (SINAD)[3]	80 dB		78 dB		72 dB	
Total harmonic distortion (THD)[3]	–90 dB		–84 dB		–76 dB	
Signal-to-noise ration (SNR)[3]	80 dB		78 dB		72 dB	
Effective number of bits (ENOB)[3]	13		12.6		11.6	

Table 4-20 Analog output electrical measurement specifications for high density multifunction USB DAQ device

Analog Output Measurement [1]				
Model Number	**U2355A | U2356A**		**U2331A**	
Function	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**	**23 °C ± 5 °C**	**0 °C to 18 °C 28 °C to 45 °C**
Offset Error	±1 mV	±4 mV	±1.5 mV	±3mV
Gain Error	±4 mV	±5 mV	±4 mV	±5 mV
Slew rate	19 V/µs		19 V/µs	
Rise time	0.9 µs		0.9 µs	
Fall time	0.9 µs		0.9 µs	
Settling time to 1% output error	4 µs		4 µs	
Driving capability	5 mA		5 mA	
Glitch energy	5 ns-V (Typical), 80 ns-V (Maximum)		5 ns-V (Typical), 80 ns-V (Maximum)	

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

[2] Specifications are based on the following test conditions.

Dynamic Range Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
• –3 dB small signal bandwidth • 1% THD large signal bandwidth	U2355A	Sampling Rate: Input voltage: • –3 dB small signal bandwidth • 1% THD large signal bandwidth	250 kSa/s 10% FSR FSR –1 dB FS
	U2356A	Sampling Rate: Input voltage: • –3 dB small signal bandwidth • 1% THD large signal bandwidth	500 kSa/s 10% FSR FSR –1 dB FS
	U2331A	Sampling Rate: Input voltage: • –3 dB small signal bandwidth • 1% THD large signal bandwidth	3 MSa/s 10% FSR FSR –1 dB FS

[3] Specifications are based on the following test conditions.

Dynamic Range Test	Model Number	Test Conditions (DUT setting at ±10 V bipolar)	
SFDR, THD, SINAD, SNR, ENOB	U2355A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental input voltage:	250 kSa/s 2.4109 kHz 8192 FSR –1 dB FS
	U2356A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental input voltage:	500 kSa/s 4.974 kHz 16384 FSR –1 dB FS
	U2331A	Sampling Rate: Fundamental Frequency: Number of points: Fundamental input voltage:	3 MSa/s 29.892 kHz 65536 FSR –1 dB FS

5 Calibration

Self-Calibration 96

This chapter introduces the procedures to perform calibration process to the U2300A series DAQ devices to minimize A/D measurement errors and D/A output errors.

Self-Calibration

The Agilent U2300A series USB data acquisition devices are factory-calibrated before shipment. The on-board reference voltage are calibrated and measured to ensure measurement accuracy. The device includes a self-calibration function to ensure accuracy of the measurement made under different environment usage.

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

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

```
CALibration:BEGin
```

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

```
*OPC?
```

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.

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