Keysight U2300A Series USB Multifunction Data Acquisition Devices

KEYSIGHT TECHNOLOGIES

User's Guide

Notices

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Safety Symbols

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

⎓	Direct current	⚠	Warning

Safety Considerations

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. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

WARNING

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

CAUTION

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

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	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.		The CSA mark is a registered trademark of the Canadian Standards Association.
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	This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.		This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
	This symbol is a South Korean Class A EMC Declaration. This is a Class A instrument suitable for professional use and in electromagnetic environment outside of the home.		

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This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or 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 as shown below.

Do not dispose in domestic household waste.

To return this unwanted instrument, contact your nearest Keysight Service Center, or visit http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.

Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

- www.keysight.com/find/U2300A
  (product-specific information and support, software and documentation updates)
- www.keysight.com/find/assist
  (worldwide contact information for repair and service)

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1 Getting Started

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 Keysight Measurement Manager application software.

Introduction

The Keysight 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.

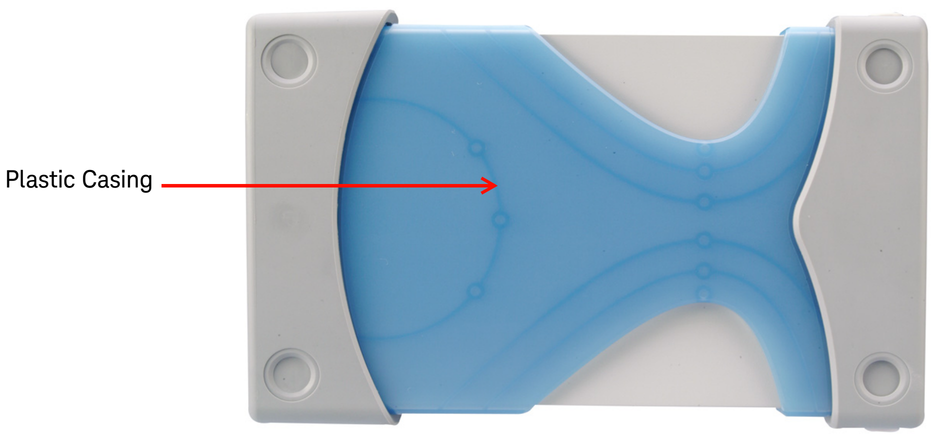
The U2300A series DAQ also features a 24-bit programmable digital I/O and two independent 31-bit general purpose digital counter. In addition to that, the U2300A is able to perform analog and digital functions at full speed. It has a resolution range of 12 to 16 bits, with no missing codes. It comes 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 Keysight VEE, LabVIEW and Microsoft Visual Studio. Bundled with the purchase of every device is an easy-to-use data logging software, the Keysight Measurement Manager.

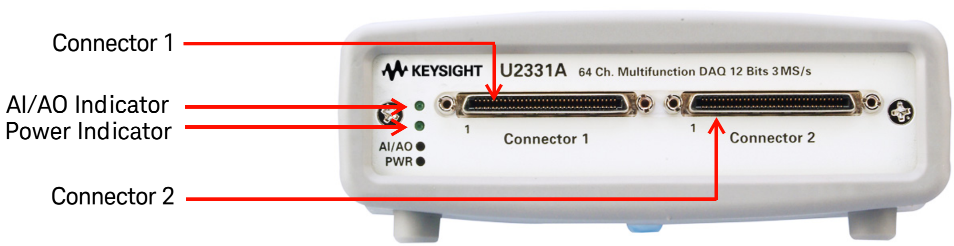
Product Overview

Product outlook

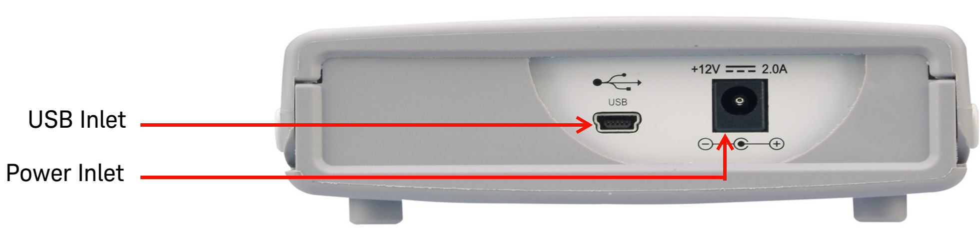
Top view



Front view



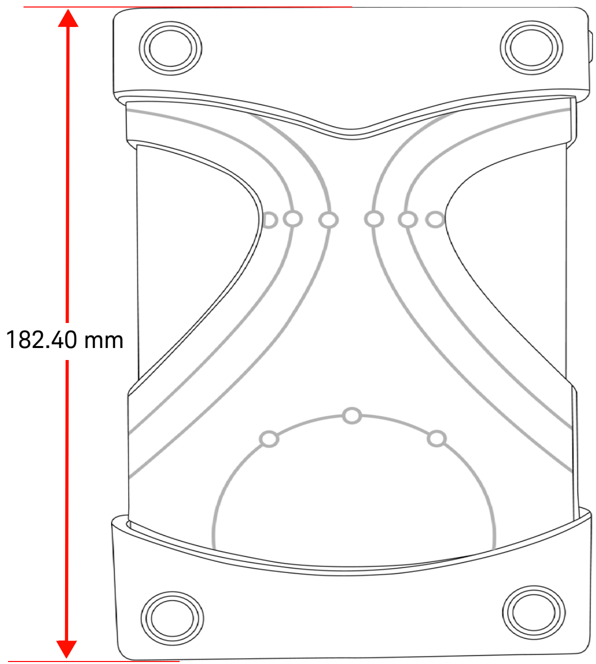
Rear view



Product dimension

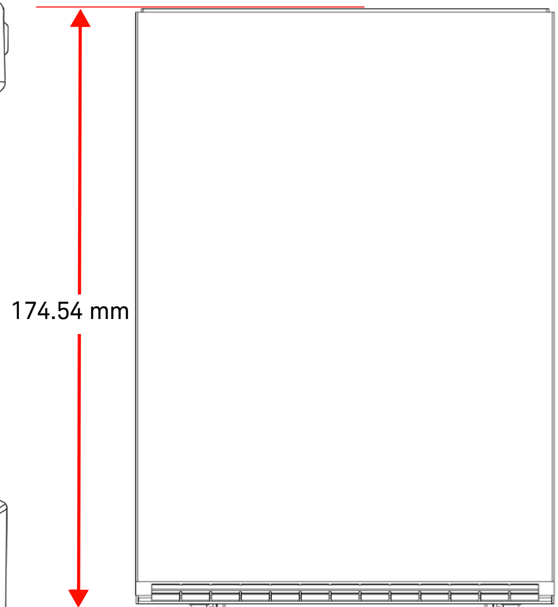
With plastic casing

Top view

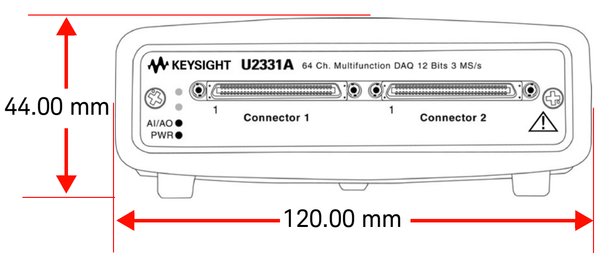


Without plastic casing

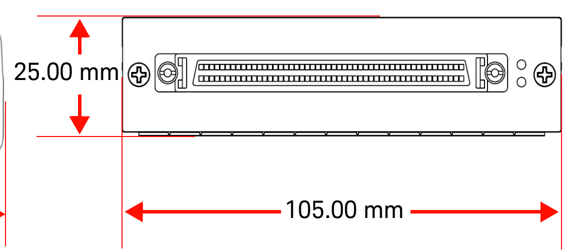
Top view



Front view

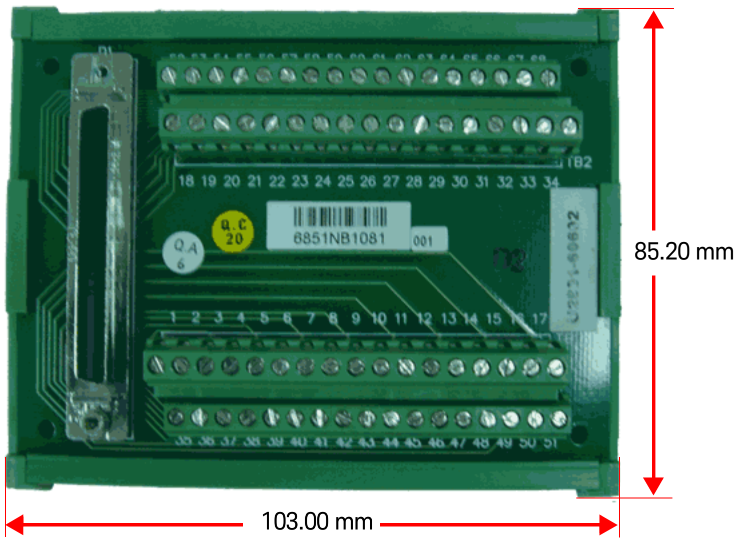


Front view

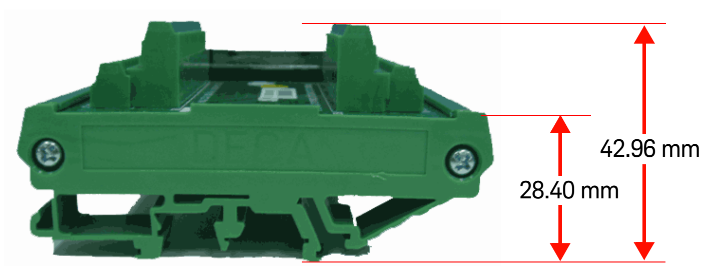


Terminal Block Overview

Front view



Side view



Standard Purchase Items Checklist

Inspect and verify the following items for the standard purchase of U2300A series. If there are missing items, contact the nearest Keysight Sales Office.

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

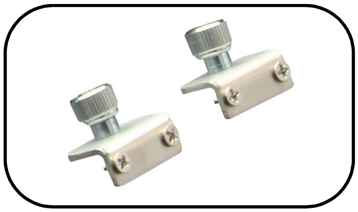
Software Installation

If you would like to use the U2300A series USB DAQ devices with the Keysight Measurement Manager application software, follow the step-by-step instructions as shown in the *Keysight USB Modular Products and Systems Quick Start Guide*.

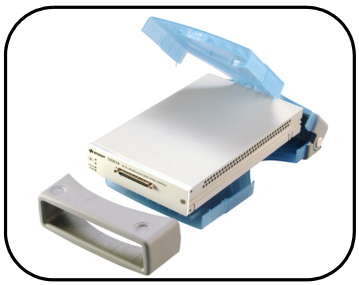
NOTE You may be required to install the IVI-COM driver before using the U2300A series with other ADEs.

L-Mount Kit Installation

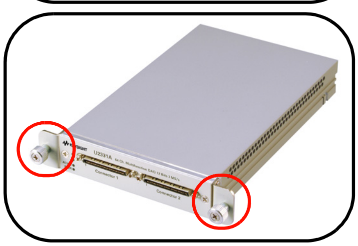
The L-Mount kit is to be used with Keysight U2781A USB modular instrument chassis. The following instructions describes simple procedures of installing the L-Mount kit to a U2300A DAQ device.



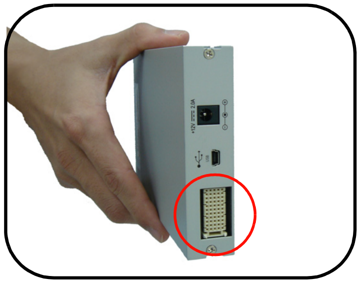
1 Unpack the L-Mount kit from the packaging.



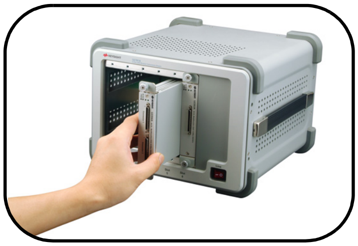
2 Remove your DAQ device from its plastic casing by pulling the bumper (front end of the casing) in an outward direction. Then, lift the plastic body casing and remove it from your DAQ device.



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

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

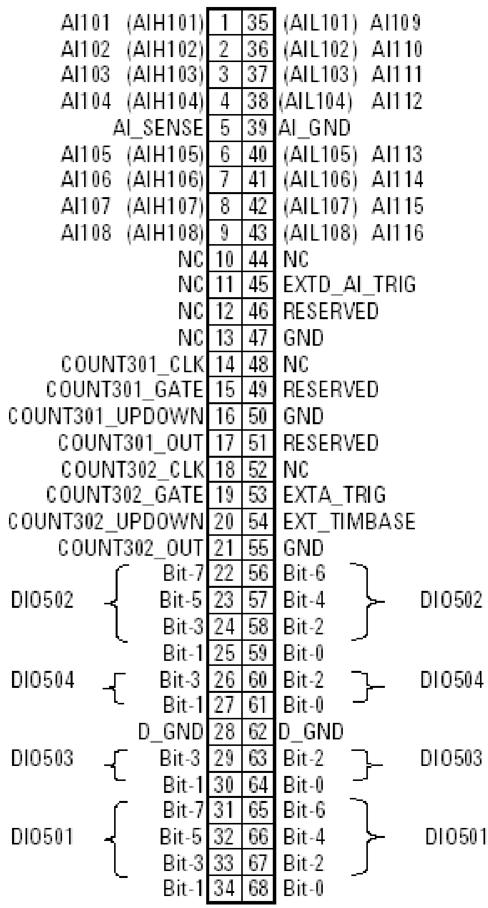
AI101	(AIH101)	1	35	(AIL101)	AI133
AI102	(AIH102)	2	36	(AIL102)	AI134
AI103	(AIH103)	3	37	(AIL103)	AI135
AI104	(AIH104)	4	38	(AIL104)	AI136
AI105	(AIH105)	5	39	(AIL105)	AI137
AI106	(AIH106)	6	40	(AIL106)	AI138
AI107	(AIH107)	7	41	(AIL107)	AI139
AI108	(AIH108)	8	42	(AIL108)	AI140
AI109	(AIH109)	9	43	(AIL109)	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

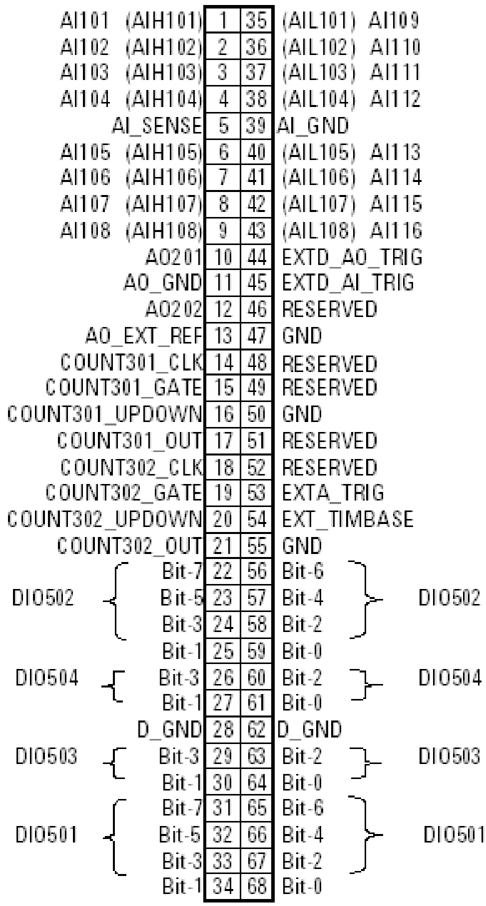
	AO201	1	35	AO_GND	
	AO202	2	36	AO_GND	
	AO_EXT_REF	3	37	AO_GND	
	NC	4	38	NC	
	D_GND	5	39	D_GND	
	EXTD_AO_TRIG	6	40	D_GND	
	EXTD_AI_TRIG	7	41	D_GND	
	RESERVED	8	42	RESERVED	
	RESERVED	9	43	RESERVED	
	RESERVED	10	44	RESERVED	
	RESERVED	11	45	RESERVED	
	RESERVED	12	46	D_GND	
	COUNT301_CLK	13	47	D_GND	
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

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

Table 2-1 68-pin VHDCI connector pins descriptions (continued)

Signal Name	Direction	Reference Ground	Description
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
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 *Keysight 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
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.

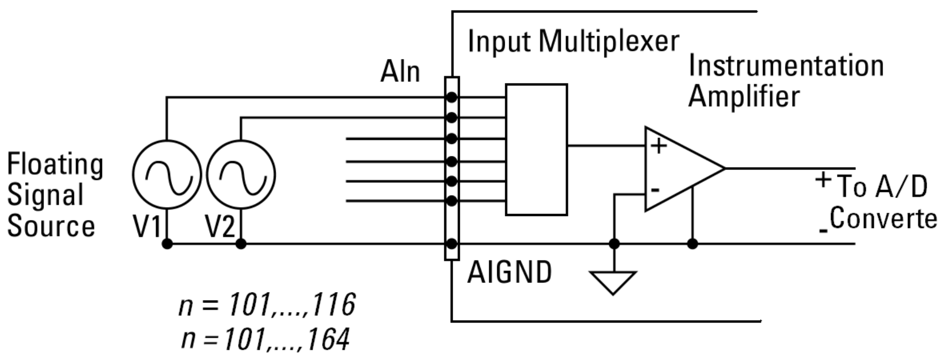


Figure 2-1 Floating source and RSE input connections

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.

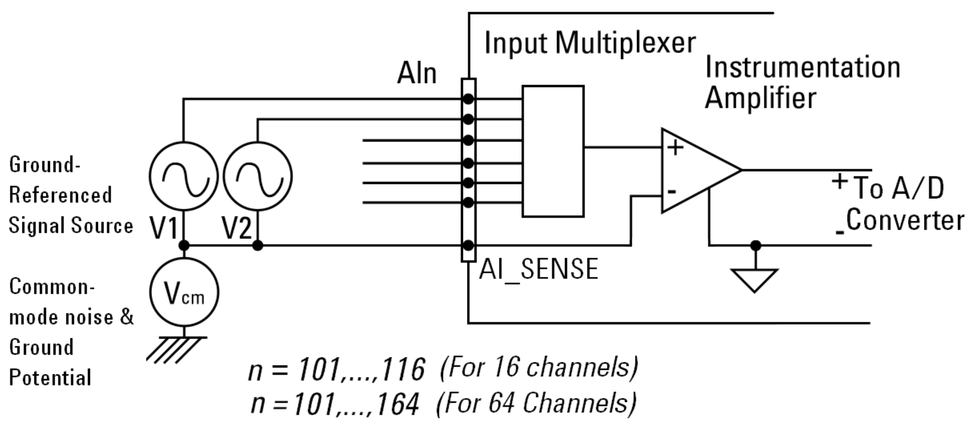


Figure 2-2 Ground-referenced sources and NRSE input connections

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.

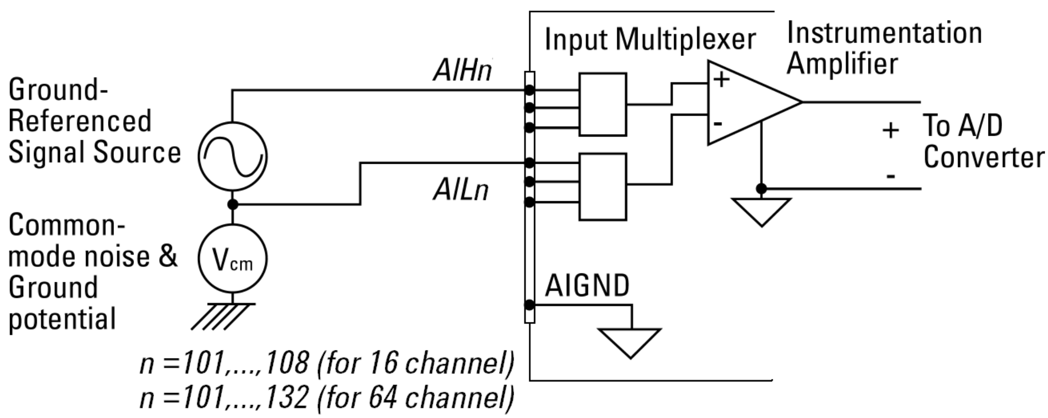


Figure 2-3 Ground-referenced source and differential input mode

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.

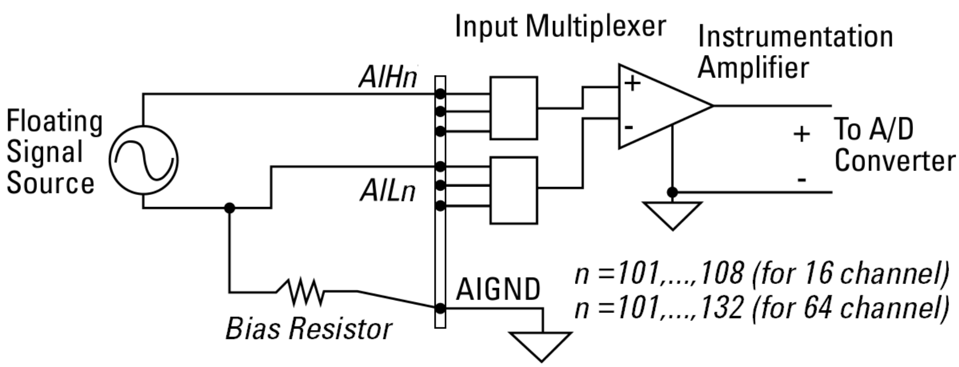


Figure 2-4 Floating source and differential input

NOTE

- Keysight 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.

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3 Features and Functions

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.

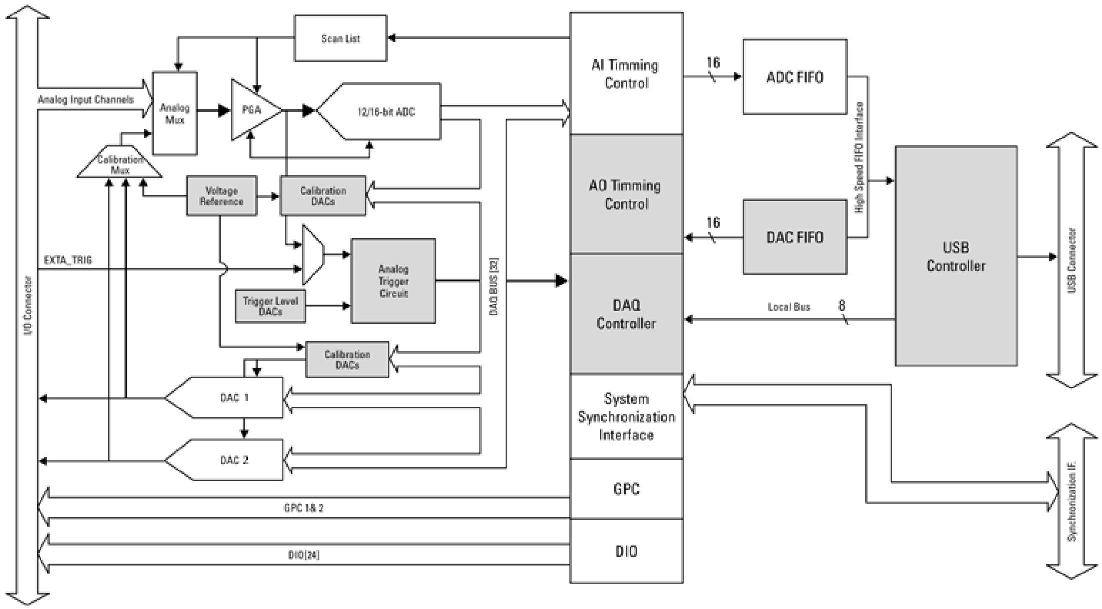

Figure 3-1 Functional block diagram of U2300A series DAQ device

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 *Keysight 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

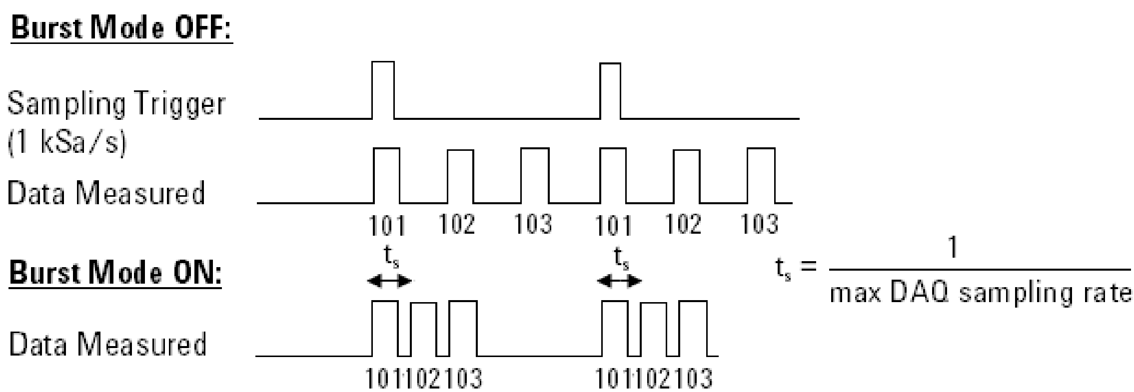

Figure 3-2 Burst mode enabled and disabled during data acquisition

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	X7FF
Midscale +1LSB	4.88 mV	2.44 mV	1.22 mV	0.61 mV	X001
Midscale	0 V	0 V	0 V	0 V	X000
Midscale –1LSB	–4.88 mV	–2.44 mV	–1.22 mV	–0.61 mV	XFFF
–FSR	–10 V	–5 V	–2.5 V	–1.25 V	X800

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	X7FF
Midscale +1LSB	5.00244 V	2.50122 V	1.25061 V	X001
Midscale	5 V	2.5 V	1.25 V	X000
Midscale –1LSB	4.9976 V	2.4988 V	1.2494 V	XFFF
–FSR	0 V	0 V	0 V	X800

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.

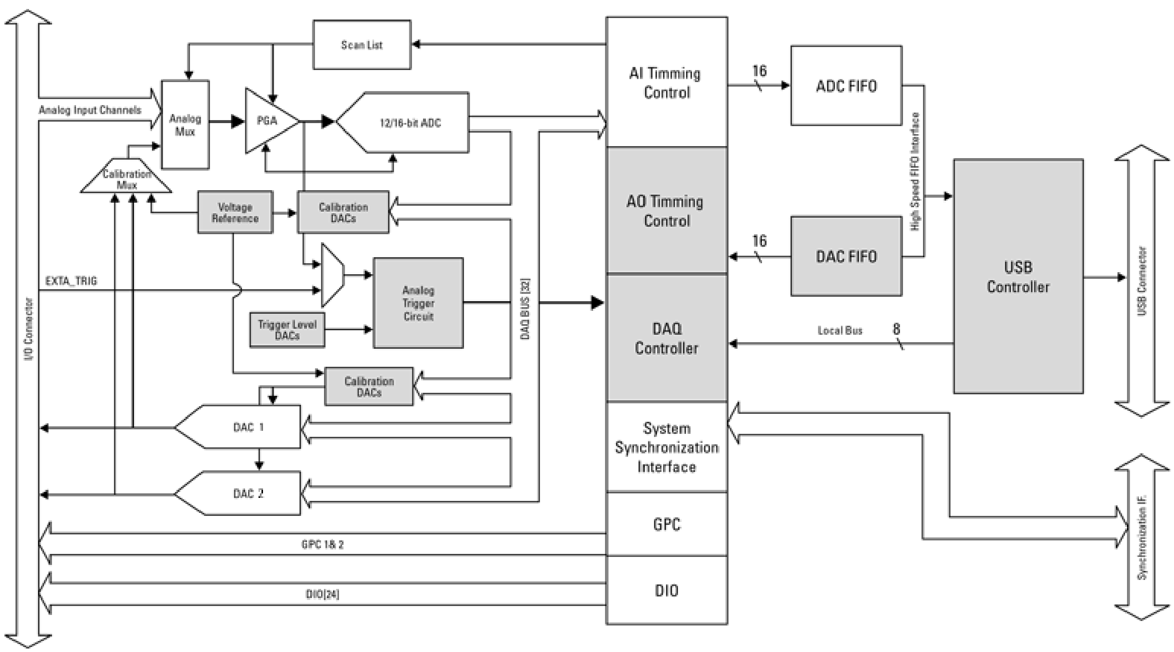

Figure 3-3 Analog output operation mode

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, (@201)`	*// Changes output from 3.2 VDC to –3.2 VDC*
`-> SOUR:VOLT? (@202)`	*// To query the state of CH 202*
`<- 0`	*// By default, CH 202 is 0 VDC*

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

`-> *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 *Keysight 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 O 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.

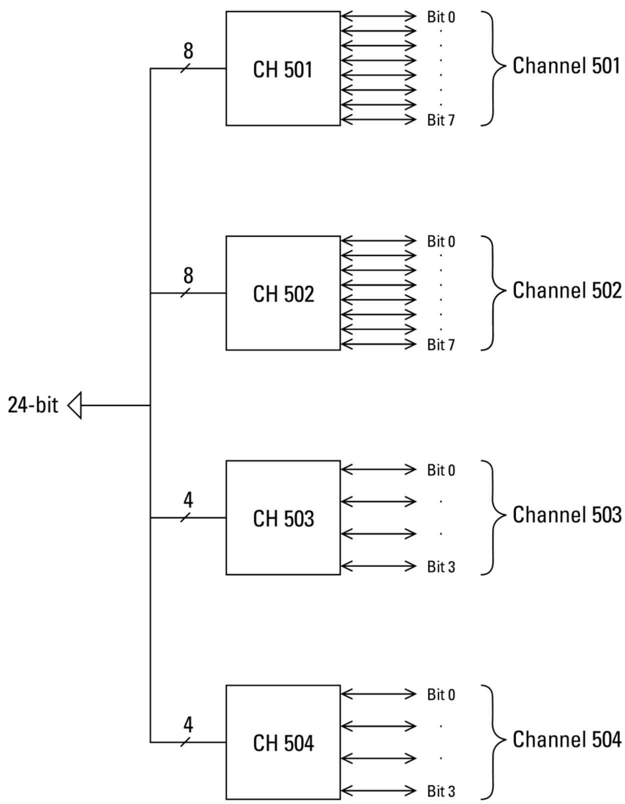

Figure 3-4 General purpose digital I/O of Keysight U2300A series DAQ

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.

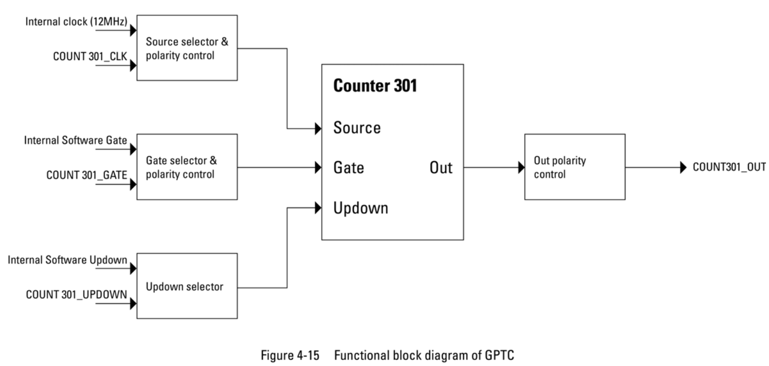

Figure 3-5 General purpose digital counter

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.

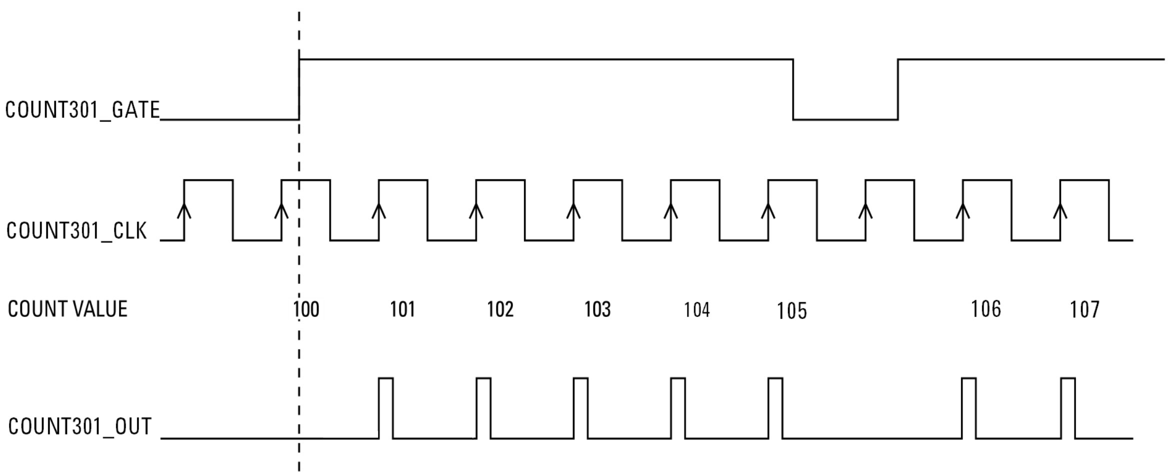

Figure 3-6 Totalizer mode

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 Up mode
-> 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 Keysight 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.

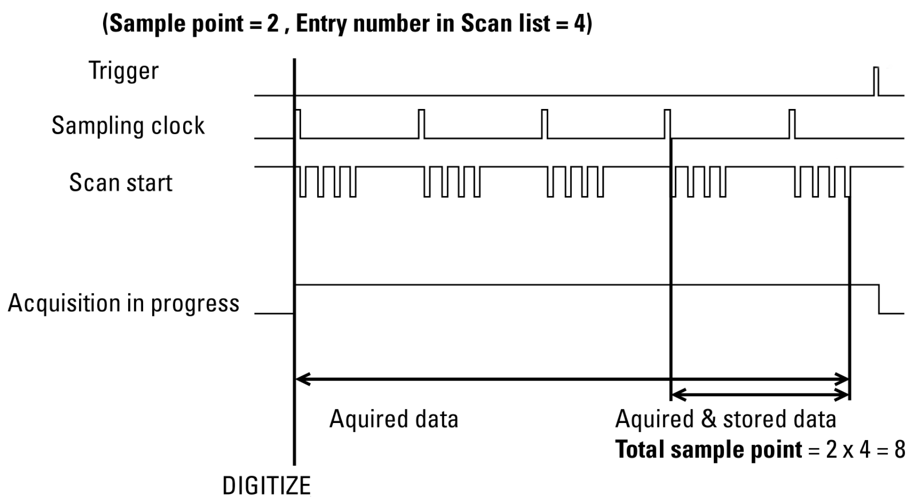

Figure 3-7 Pre-trigger

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.

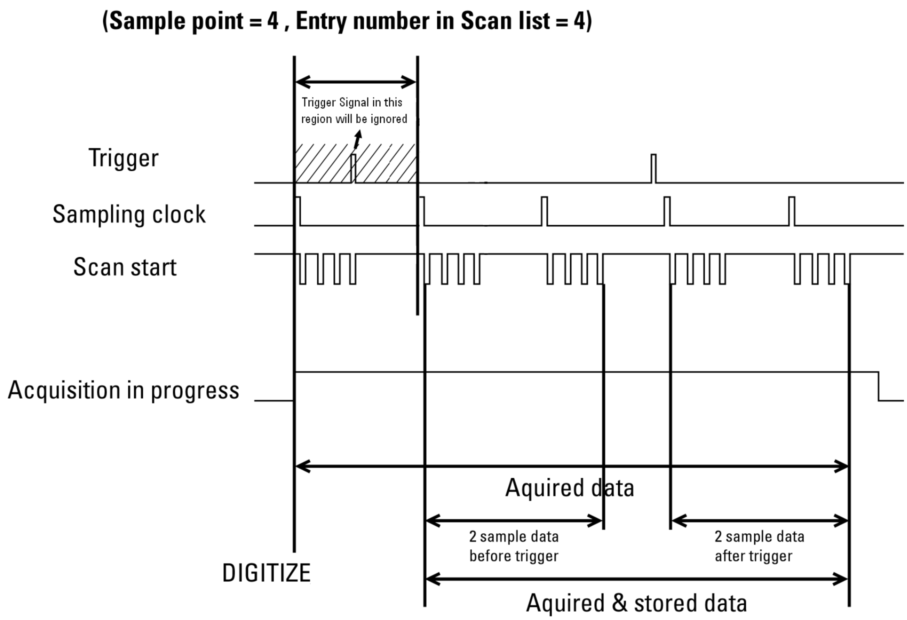

Figure 3-8 Middle-trigger

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.

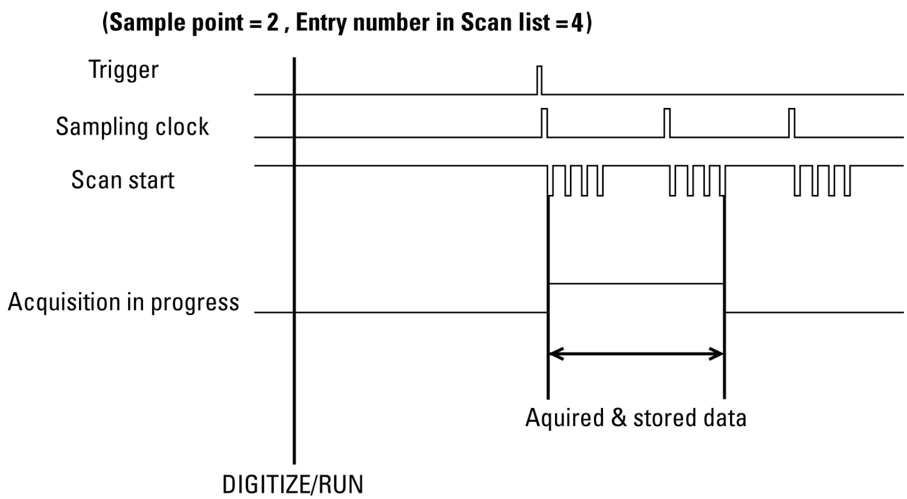

Figure 3-9 Post-trigger

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.

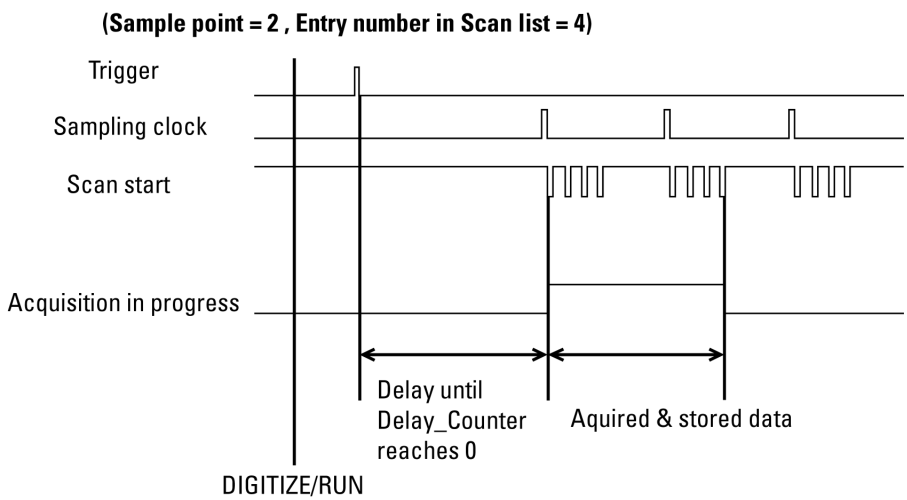

Figure 3-10 Delay-trigger

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.

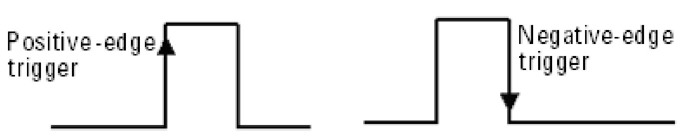

Figure 3-11 Positive and negative edge of digital trigger.

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 Keysight 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.

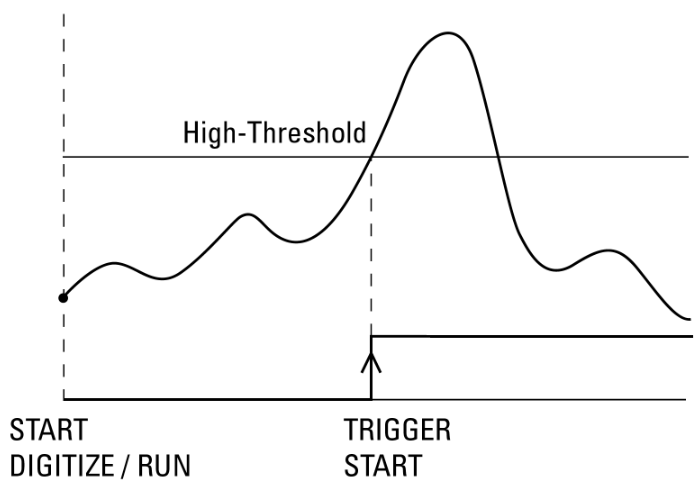

Figure 3-12 Above high trigger condition

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.

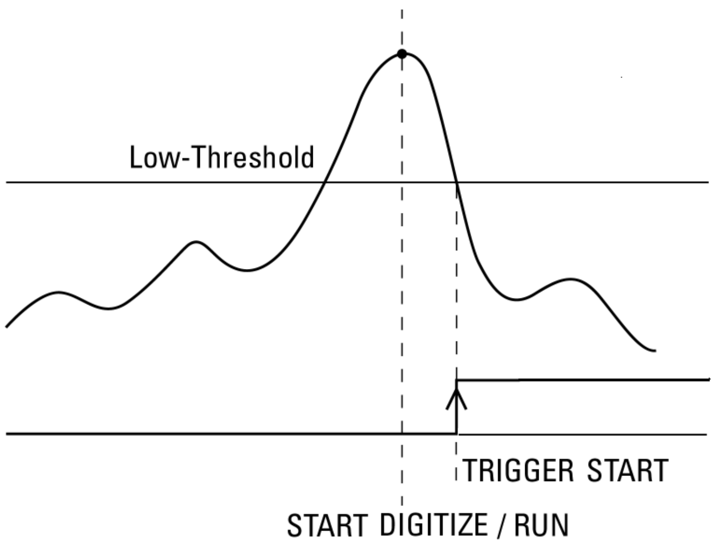

Figure 3-13 Below low trigger condition

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.

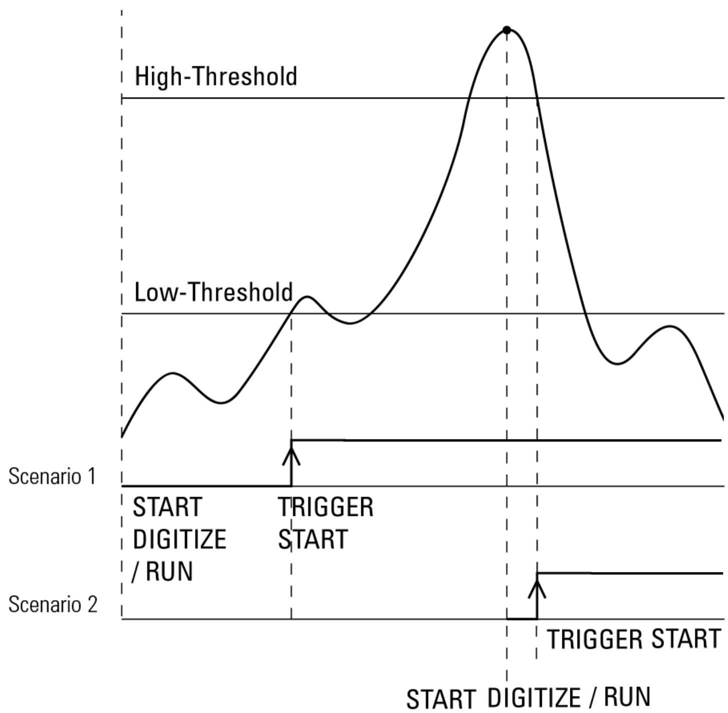

Figure 3-14 Window trigger condition

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.

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4 Characteristics and Specifications

For the characteristics and specifications of the U2300A Series USB Multifunction Data Acquisition Devices, refer to the datasheet at http://literature.cdn.keysight.com/litweb/pdf/5991-0566EN.pdf.

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5 Calibration

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

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

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

```
CALibration:BEGin
```

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

```
*OPC?
```

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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