Acqiris U5303A
PCIe High-Speed ADC Card with FPGA Signal Processing

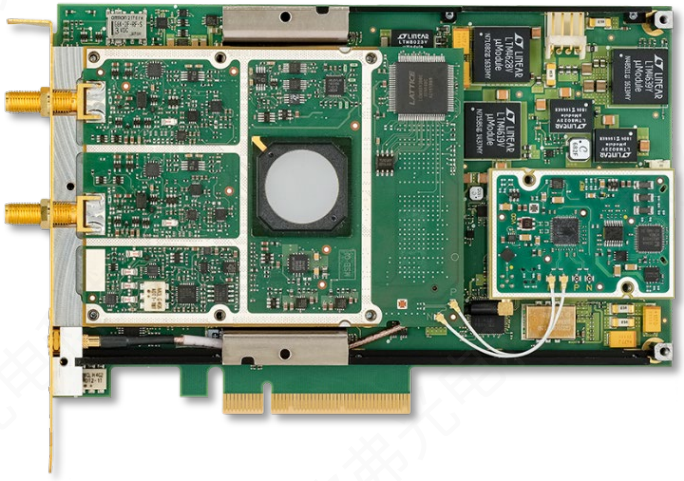
2 channels, 12-bit, from 500 MS/s to 4 GS/s,
DC up to 2 GHz bandwidth

Datasheet

acqiris

PCI EXPRESS

Overview



Introduction

The U5303A is a fast 12-bit PCIe signal acquisition card with programmable on-board processing, making it ideal for biotechnology, semiconductors, and physics. Providing excellent measurement accuracy and high dynamic range, the U5303A is particularly suited for OEM applications.

Product description

The U5303A ADC card occupies a single full-length PCIe slot of the host computer and captures signal on 2 channels, from DC to 2 GHz at 2 GS/s, 1.6 GS/s, 1 GS/s or 500 MS/s, depending on the model.

An interleaving option allows the two channels to be combined to acquire up to 4 GS/s in single channel mode.

Featuring DDR3 acquisition memory up to 4 GB, the U5303A includes a Xilinx FPGA allowing the implementation of custom real-time processing algorithms.

The digitizer firmware included allows signal acquisition to the on-board memory and subsequent transfer to the host computer via the PCIe bus.

Applications

- Medical research instrumentation
- Environmental monitoring with laser scanning (LiDAR)
- Analytical time-of-flight (TOF)
- Ultrasonic non-destructive testing (NDT)
- Semiconductor Test
- Distributed strain and temperature sensors (DSTS)

Features

- 1 channel with 12-bit resolution up to 4 GS/s sampling rate
- 2 channels up to 2 GS/s simultaneous sampling rate
- DC up to 2 GHz bandwidth
- 50 Ω input impedance, DC coupled
- Selectable 1 V or 2 V full scale range (FSR)
- ± 200 fs channel-to-channel skew stability
- 15 ps RMS trigger time interpolator (TTI) precision
- Up to 4 GB DDR3 on-board memory
- On-board data processing unit using a Xilinx FPGA
- Support for loading custom real-time processing
- Real-time averaging firmware options (-AVG)
- Real-time peak detection firmware options (-PKD)

Customer values

- Fast PCIe 12-bit ADC Card with on-board processing
- Capture wide bandwidth signals
- High dynamic range for better measurement fidelity
- Accurate long-term measurement
- Custom firmware implementation
- Capable of switching between multiple firmware programs
- Software support including multiple programmable interfaces for easy integration into existing environments
- Reduced development time, fast time to market
- Self-trigger mode for unequaled synchronous noise reduction
- Continuous data streaming (-CSR)

For information on other firmware options please contact us:
hello@acqiris.com

Hardware platform

Integration

The U5303A 12-bit ADC Card occupies a single full length PCIe x8 slot in a host computer or in an external chassis. It is compliant with PCI Express 2.0 standard, and benefits from the very fast data interface, making it an ideal platform for many OEM applications.

Unique proprietary technology

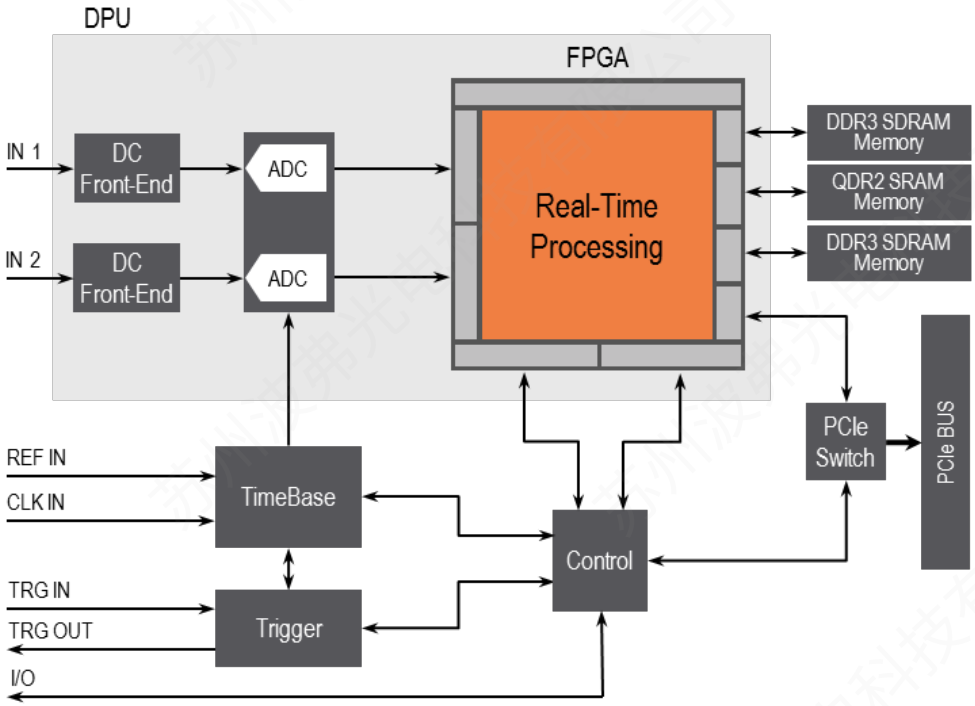
Our engineers team developed exclusive proprietary circuits enabling excellent signal performances. Indeed, the U5303A incorporates low noise signal conditioning amplifier to drive interleaved ADCs and thanks to a specific clock distribution, it minimizes the clock jitter and spurious.

On-board real-time processing

At the heart of the U5303A ADC card is a data processing unit (DPU) based on the Xilinx Virtex-6 FPGA. This DPU controls the digitizer functionality by implementing digitization of the signal, data storage in the DDR3 SDRAM memory and transfer through the PCIe connection to the host computer.

Moreover, this powerful feature allows real time signal processing and data reduction to be carried out onboard, minimizing transfer volumes and speeding-up analysis.

Block diagram



Award earned by the U5303A

ECN iMPACT 2014 Winner Awards

ACE AWARDS 2014 WINNER EE Times EDN

BEST IN TEST 2014 WINNER

Software Platform

Drivers

The ADC card comes with the Acqiris MD3 Software for Signal Acquisition Cards. It includes IviDigitizer class compliant IVI.NET and IVI-C drivers that work in the most popular development environments including Visual C/C++, C#, VB.NET.

Linux is also supported using a supplied IVI-C driver.

The software End User License Agreement is available for information at https://www.acqiris.com/SoftwareEULA.

Easy software integration

To help you get started and complete complex tasks quickly, the U5303A ADC card is supplied with a comprehensive portfolio of module drivers, documentation, examples, and software tools.

Software applications

The U5303A also includes the MD3 soft front panel (SFP) graphical user interface.

This software application can be initially used to explore the ADC Card capabilities and serves as a friendly and convenient tool for capturing and displaying the acquired data in time or frequency domain.

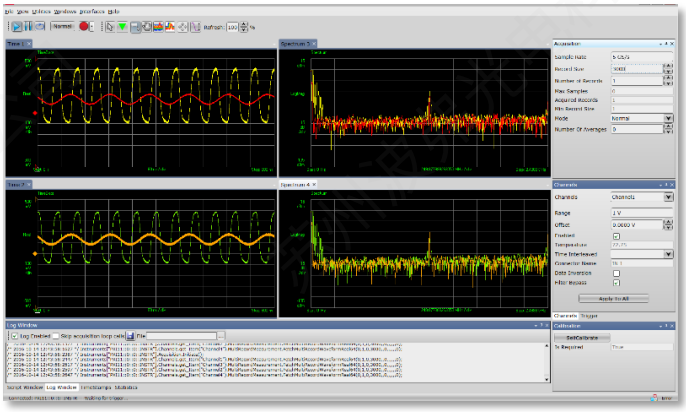


Figure 2. MD3 software front panel (SFP) interface.

Figure 3. U5303A front panel with analog inputs and multiple I/Os signals.

Figure 4. The Acqiris U5303A PCIe 12-bit ADC card with on-board processing offers a small size for easy integration.

Firmware Options

The U5303A PCIe high-speed ADC Card provides several firmware options:

- DGT: Digitizer firmware
- INT: Interleaved channel sampling functionality
- FDK[1]: Custom firmware capability
- AVG[1]: Firmware for real-time sampling and averaging
- PKD[1]: Firmware for real-time signal peak detection
- TSR: Triggered simultaneous acquisition and readout
- CSR[2]: Continuous simultaneous acquisition and readout

Table 1. Firmware options versus sampling rate.

	Sampling rate			
Firmware	-SR0	-SR1	-SR2	-SR3
-DGT	√	√	√	√
-INT	√	√	√	√
-FDK	√	√	√	√
-AVG	-	√	√	√
-PKD	-	√	√	√
-TSR	-	√	√	√
-CSR	-	√	√	-
-AVG/TSR/INT	-	√	-	-

Easy firmware switch

A simple call to the configuration function will enable to switch to the required option.

DGT digitizer firmware

The digitizer firmware:

- Allows standard data acquisition, including: digitizer initialization, setting of the acquisition and clocking modes, management of channel triggering for best synchronization, storing data in the internal memory and/or transferring them through the backplane bus.
- Implements multi-record acquisition functionality.
- Supports fixed internal clocking frequency with internal or external reference, and variable frequency external clock.
- Includes programmable binary decimation available with SR1, SR2 and SR3 options to lower the sample rate by a factor of 2^n where n is defined in the range of 1 to 10 for single record. For example, with U5303A-SR2 you can select from 3.2 GS/s (with interleaving) down to 3.125 MS/s.

Lastly, the implemented trigger time interpolator (TTI) is a high precision integrated time to digital converter, guarantying time measurement accuracy.

1. A calibration digitizer function is available with each firmware.
2. Only available with DGT option.
3. On the Xilinx LX195T DPU FPGA.

INT interleaved channel sampling functionality

This interleave option allows two channels to be combined and to reach 4 GS/s (SR3 option), 3.2 GS/s (SR2 option) or 2 GS/s (SR1 option), in one channel acquisition mode.

This option can be combined with digitizer firmware (-DGT), firmware for real-time sampling and averaging (-AVG) or, firmware for real-time peak detection (-PKD).

FDK custom firmware capability

This option enables loading[3] custom firmware. Contact support at support@acqiris.com for additional information.

AVG firmware for real-time sampling and averaging

Averaging signals reduces random noise effects, improving the signal-to-noise ratio, as well as increasing resolution and dynamic range.

This option enables synchronous real-time sampling and accumulation up to 4 GS/s on single-channel and 2 GS/s in dual-channel, featuring:

- Accumulation of 1 up to 520,000 triggers.
- Effective acquisition length of up to 480 kSamples in single channel or 240 kSamples per channel in dual-channel.
- Noise suppressed accumulation (NSA).
- Self-trigger mode for minimal synchronous noise.
- Baseline stabilization algorithm and digital offset.

PKD firmware for real-time signal peak detection

The peak detection firmware allows real-time acquisition and peak detection with the possibility to generate a histogram of peak versus time for successive acquisitions.

Synchronous real-time sampling and peak detection up to 4 GS/s on single-channel and 2 GS/s dual-channel with:

- Accumulation of 1 up to 520,000 triggers.
- Effective acquisition length from 1 to 480 kSamples in single channel or 240 kSamples per channel in dual-channel.
- Self-trigger mode for minimal synchronous noise.
- Baseline stabilization algorithm and digital offset.

Firmware Options *(continued)*

TSR triggered simultaneous acquisition and readout

The triggered simultaneous acquisition and readout architecture allows to continuously acquire new records while reading previous ones.

TSR solution is dedicated to applications requiring no trigger loss, achieving longer recording time when compares with standard digitizer (-DGT).

TSR option main features:

- High trigger rate with guaranteed no lost trigger for specific configuration[1].
- Easy to use solution, implementing an optimal and automated control of memory addressing.
- Selecting larger memory size option allows longer record size and provides larger buffer for data transfer to host computer, especially useful for applications with non-periodic trigger or very high trigger rate during a limited period.

AVG/TSR/INT Combining real-time averaging and streaming

Combining -AVG and -TSR firmware allows signal acquisition, real time averaging and data readout simultaneously, on a single channel. This acquisition mode performs multiples and successive averaging sequences at up to 2 GS/s, without missing any trigger.

Featuring the similar capabilities than -AVG firmware (baseline correction, triggering, …), the addition of -TSR enables simultaneous real-time averaging and streaming of average records to host computer. The readout can be performed as soon an “averager record” is acquired and during the next averager accumulation, minimizing the dead time between accumulations.

This acquisition mode comes with INT/AVG/TSR option selection and is compatible with sampling rate at up to 2 GS/s, on a single channel[2] (-SR1).

CSR continuous simultaneous acquisition and readout

The continuous simultaneous acquisition and readout implements a firmware function and a software API which allows the user to readout multiple streams while the acquisition is still running. A stream is defined as a sequence of data elements made available over time. The data elements can be samples, timestamps information, real time measurements, etc. Each stream can be read independently and in a time multiplexed manner allowing a fine tuning of the system and application performance.

The acquisition data rate is adapted to the target application by several mechanisms:

- Downsampling: Allows to reduce the acquisition sample rate by performing a binary decimation.
- Truncation and compression: It truncates the samples on fewer bits and packs them continuously to reduce total volume.
- External clock: Allows a fine tuning of the incoming sample rate.

Depending on the settings, the streaming can be sustained endlessly without overflow.

1. Please contact Acqiris to find out the repetition rate that can be achieved in your application.
2. Dual channel not supported.

Technical Specifications and Characteristics

Analog input (IN 1 and IN 2 SMA connectors)		
Number of channels		2 (without INT option) 2 or 1 (with INT option)
Impedance		50 Ω ± 2 %
Coupling		DC
Full scale ranges (FSR)		1 V and 2 V
Maximum input voltage		1 V FSR: Clamp at ± 3.6 V, absolute maximum DC voltage rating ± 4.6 V 2 V FSR: Clamp at ± 6.3 V, absolute maximum DC voltage rating ± 5.0 V
Input voltage offset		± 2 x FSR
Input frequency range (-3 dB bandwidth)		See table below
DC gain accuracy		± 0.5 % *(typical)* in 1 V FSR ± 0.7 % *(typical)* in 2 V FSR
Offset accuracy		± 0.5 % in 1 V FSR ± 1.5 % in 2 V FSR
Time skew[1]	Skew between channels[2]	± 50 ps (*nominal*)
	Channel-to-channel skew stability[3]	± 200 fs pk *(nominal)* 75 fs RMS *(nominal)*
Bandwidth limit filters (BWL)	-SR1, -SR2, -SR3	650 MHz (*nominal*) for -SR1, -SR2 and -SR3
	-SR0	no BWL
Effective number of bits (ENOB)[4]	-SR0	@ 100 MHz 9.0 (9.3 *typical)*
	-SR1, -SR2	@ 410 MHz 8.7 (9.1 *typical)*
	-SR3	@ 410 MHz 8.5 (typical)
Signal to noise ratio (SNR)[4]	-SR0	@ 100 MHz 56 dB (58 dB *typical*)
	-SR1, -SR2	@ 410 MHz 55 dB (57 dB *typical*)
	-SR3	@ 410 MHz 54 dB (*typical*)
Spurious free dynamic range (SFDR)[4]	-SR0	@ 100 MHz 55 dBc (63 dBc *typical*)
	-SR1, -SR2	@ 410 MHz 56 dBc (64 dBc *typical*)
	-SR3	@ 410 MHz 59 dBc (*typical*)
Total harmonic distortion (THD)[4]	-SR0	@ 100 MHz -55 dB (-63 dB *typical*)
	-SR1, -SR2	@ 410 MHz -56 dB (-64 dB *typical*)
	-SR3	@ 410 MHz -60 dB (*typical*)

Table 2. Input frequency range versus options and full-scale range.

			Input frequency range	
Options			1 V FSR	2 V FSR
-F05	-SR0	-	DC to 400 MHz *(typical)*	
		-INT		
	-SR1, -SR2	-	DC to 650 MHz *(typical)*	
		-INT		
-F10	-SR1, -SR2, -SR3	-	DC to 1.9 GHz *(typical)*	DC to 2.0 GHz *(typical)*
		-INT	DC to 1.3 GHz *(typical)*	

1. The channel-to-channel skew is defined as the magnitude of time delay difference between two digitized channel inputs, granted the same signal is provided to each channel at the exact same time.
2. The measurement represents the maximum time skew between 2 channels of a single unit, measured with a Sinefit method on 100 kSamples, for a sinusoid signal at 400 MHz and averaged 10 times.
3. Skew and offset stability are measured at 25 °C in a climatic chamber. The skew and offset between channels are measured every 5 minutes over 12 hours and after 1 hour stabilization time and the values represent the dispersion of the measurements.
4. Measured for a -1 dBFS input signal in internal clock mode with option -F10 at 2 GS/s (option -SR3), 1.6 GS/s (option -SR2) and 1 GS/s (option -SR1), and with option -F05 at 500 MS/s (option -SR0).

Technical Specifications and Characteristics *(Continued)*

Digital conversion		
Resolution		12 bits
Acquisition memory (total)	-M02 -M40	256 MB (64 MSamples/ch) 4 GB (1 GSamples/ch)
Sample clock sources		Internal or external
Internal clock source		Internal, external reference
Real-time sampling rates		See the table below
Sampling clock jitter[1]		225 fs *(nominal)*
Clock accuracy		± 1.5 ppm
External clock source (CLK IN MMCX connector)		
Impedance		50 Ω *(nominal)*
Frequency range[2]	-SR0 -SR1 -SR2 -SR3	500 MHz to 1 GHz 1.8 GHz to 2 GHz 1.8 GHz to 3.2 GHz 3 GHz to 4 GHz (External Clock not supported in interleaved mode)
Signal level		+5 dBm to +15 dBm *(nominal)*, 0 V DC
Coupling		AC
External reference clock (REF IN MMCX connector)		
Impedance		50 Ω *(nominal)*
Frequency range		100 MHz ± 1 kHz *(nominal)*
Signal level		- 3 dBm to + 3 dBm *(nominal)*
Coupling		AC
Acquisition modes		Single record, Multi-record, Continuous
Maximum number of records		131072
Maximum record length	-M02 -M40	64 MSamples/ch (or 128 MSamples/ch with INT option) 1 GSamples/ch (or 2 GSamples/ch with INT option)

Table 3. Real-time sampling rates with internal clock source.

	Maximum sampling rate			
Channel configuration	**-SR0**	**-SR1**	**-SR2**	**-SR3**
-CH2	500 MS/s	1 GS/s	1.6 GS/s	2 GS/s
-CH2 and -INT	1 GS/s	2 GS/s	3.2 GS/s	4 GS/s

1. Jitter figure based on phase noise integration from 100 Hz to 1600 MHz.
2. The sampling rate corresponds to the external clock frequency in 2-channel mode (non interleaved channels). In interleaved mode (only available with the INT option), the sampling rate corresponds to twice the frequency of the external clock signal.

Technical Specifications and Characteristics *(Continued)*

Trigger		
Trigger modes		Positive or negative edge
Trigger sources		External, Channel, Software
Channel trigger frequency range		DC to 250 MHz
External trigger (TRG IN MMCX connector)		
Coupling		DC
Impedance		50 Ω *(nominal)*
Level range		± 5 V *(nominal)*
Minimum amplitude		0.5 V pk-pk
Frequency range		DC to 2 GHz *(nominal)*
Maximum time stamp duration		See the table below
Trigger time interpolator		See the table below
Rearm time (deadtime)	-SR0, -SR1 -SR2, -SR3	800 ns *(nominal)* 500 ns *(nominal)*
Trigger out (TRG OUT MMCX connector)		1 (programmable), 50 Ω source
Signal level[1]		0.8 Vpp ± 2.5 V offset *(nominal)* into high impedance
Control IO (I/O 1, 2 and 3 MMCX connectors)		
Output functions		Acquisition active[3] Trigger is armed[3] Trigger accept resynchronization[3] 100 MHz reference clock divided by 2.[4] Sampling clock divided by 32.[4] Low level[3] High level[3]
	-AVG	Self-trigger[5]
	-AVG	Accumulation active[6]
Input function	-AVG	Accumulation enable[4]

Table 4. Trigger time parameters.

	Maximum sampling rate			
Channel configuration	-SR0	-SR1	-SR2	-SR3
Maximum time stamp duration	52 days	52 days	32 days	26 days
Trigger time interpolator resolution[2]	10.15 ps *(nominal)*	10.50 ps *(nominal)*	6.25 ps *(nominal)*	6.25 ps *(nominal)*
Trigger time interpolator precision[2]	19.75 ps RMS *(nominal)*	20.25 ps RMS *(nominal)*	15 ps RMS *(nominal)*	15 ps RMS *(nominal)*

1. At 10 MHz on a 50 Ω load.
2. At maximum sample rate or at decimated sampling rate down to 1/16 of the highest sample rate (1/32 of the highest sample rate with interleaving).
3. Only on I/O 1 or 2.
4. Only on I/O 1.
5. Only on I/O 3.
6. Only on I/O 2.

Technical Specifications and Characteristics *(Continued)*

Environmental and physical[1]			
Temperature range	Operating[2]	-SR0, -SR1, -SR2	0 to +50 °C (sea-level to 10,000 feet)
			0 to +45 °C (10,000 to 15,000 feet)
		-SR3	0 to +45 °C (sea-level to 10,000 feet)
	Non-operating	All versions	–40 to +70 °C
Altitude		-SR0, -SR1, -SR2	Up to 15,000 feet (4'572 meters)
		-SR3	Up to 10,000 feet (3'048 meters)
EMC			Complies with European EMC Directive – IEC/EN 61326-1 – CISPR Pub 11 Group 1, class A – AS/NZS CISPR 11 – ICES/NMB-001 This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.
Acoustic			European Machinery Directive Acoustic noise emission LpA < 70 dB Operator position Normal operation mode
Power dissipation[3]			
+ 3.3 V	+ 3.3 V_{AUX}	+ 12 V	Power on PCIe edge connector
0.8 A *(typical)*	0.2 A *(typical)*	2.3 A *(typical)*	31 W *(typical)*
+ 5 V		+ 12 V	Power on additional power cable[4]
1.5 A *(typical)*		1.5 A *(typical)*	26 W *(typical)*
Mechanical characteristics			
Form Factor			PCIe x8 standard (full length with fan)
Size		Without fan[5]	17.6 W x 126.3 H x 169.5 D mm
		With fan[6]	40.6 W x 126.3 H x 252.1 D mm
Weight			0.68 kg (1.49 lbs)

1. Samples of this product have been type tested to be robust against the environmental stresses of Storage, Transportation and End-use; those stresses include but are not limited to temperature, humidity, shock, vibration, altitude and power line conditions. Test Methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.
2. Host computer internal ambient temperature at intake of the ADC Card's fan.
3. With the DGT firmware.
4. Additional power cable mandatory to ensure adequate power distribution as per PCIe standard.
5. 60 m^3/h airflow is required. The unit must be operated with the included fan without obstruction of the airflow into the fans inlet and out of the card's sides.
6. Optional rail guide can be ordered to stabilize the PCIe card in the host computer.

Technical Specifications and Characteristics *(Continued)*

System requirements (contact us at support@acqiris.com for a list of recommended host computers)		
Topic	**Windows**	**Linux**
Operating systems	Windows 10 (32-bit and 64-bit), All versions Windows 8.1 (32-bit and 64-bit), All versions Windows 7 (32-bit and 64-bit), All versions	Linux Kernel 2.6 or higher (32 or 64-bit), Debian 8, Ubuntu-16.04, CentOS-7
Processor speed	1 GHz 32-bit (x86), 1 GHz 64-bit (x64), no support for Itanium 64	As per the minimum requirements of the chosen distribution
Available memory	1 GB minimum[1]	As per the minimum requirements of the chosen distribution
Available disk space	2.5 GB available hard disk space, includes: 1 GB for Keysight IO Libraries Suite 1 GB for Microsoft .NET Framework	100 MB
Display	Minimum of 1024 x 768, 96 or 120 DPI	No display required

Definitions for specifications

Specifications describe the warranted performance of calibrated cards that have been stored for a minimum of 2 hours within the operating temperature range[2] of 0 to 50 °C, unless otherwise stated, and after a 45-minute warm-up period. Data represented in this document are specifications unless otherwise noted.

Characteristics describe product performance that is useful in the application of the product, but that is not covered by the product warranty. Characteristics are often referred to as Typical or Nominal values.

- *Typical* describes characteristic performance, which 80% of cards will meet when operated over a 20 to 30 °C temperature range. Typical performance is not warranted.
- *Nominal* describes representative performance that is useful in the application of the product when operated over a 20 to 30 °C temperature range. Nominal performance is not warranted.

Calibration

The U5303A is factory calibrated and shipped with a certificate of calibration.

1. On older host computers with minimum RAM, installation can take a long time when installing the IO Libraries Suite and the .NET Framework.
2. 0 to 45°C for card with SR3 option.

Configuration and Ordering Information

Software information

Supported operating systems and host computers	See system requirements
Standard compliant drivers	IVI.NET, IVI-C
Supported application development environments (ADE)	VisualStudio (VB.NET, C#, C/C++)

Related products

Model	Description
U5310A	PCIe 10-bit ADC Card with on-board processing
U5309A	PCIe 8-bit ADC Card with on-board processing
Advantage services: calibration and warranty	
Included	3-year warranty, standard
Optional	5-year warranty

Accessories

Model	Description
U5300A-101	MMCX male to SMA male cable, 1m
U5300A-102	MMCX male to BNC male cable, 1m
U5300A-001	Card retainer (recommended if the card is assembled horizontally or in harsh environment)
U5300A-003	Short card retainer
U5300A-KTA1	Kit: Startup Guide, Cable MMCX/BNC, 2x Power cables
U5300A-KTA2	Kit: Startup Guide, 2x Power cables

Ordering information

Model	Description
U5303A	PCIe 12-bit ADC Card with on-board processing Includes: – Fan assembled on module – 3-year warranty

Configurable options		
Sampling rate		
√	U5303A-SR0	500 MS/s sampling rate
	U5303A-SR1	1 GS/s sampling rate
	U5303A-SR2	1.6 GS/s sampling rate
	U5303A-SR3	2 GS/s sampling rate
Bandwidth		
√	U5303A-F05[1]	Bandwidth 650 MHz (SR2, SR1, SR3) or 400 MHz (SR0)
	U5303A-F10	Full bandwidth
Memory[2]		
√	U5303A-M02	256 MB (64 MS/ch) acquisition memory
	U5303A-M40	4 GB (1 GS/ch) acquisition memory
Firmware		
√	U5303A-DGT	Digitizer firmware
	U5303A-INT	Interleaved channel functionality
	U5303A-AVG	Real-time averager firmware
	U5303A-PKD	Real-time peak detection firmware
	U5303A-TSR	Triggered simultaneous acquisition and readout
	U5303A-CSR	Continuous simultaneous acquisition and readout

√ These options represent the standard configuration.

Ordering number format is U5303A-xxxx.

Please contact Acqiris for other options or specific requirements support@acqiris.com.

1. Not supported with SR3 sampling rate option.
2. When using the -AVG or -PKD option exclusively, it is recommended to select the smallest memory option which provides the same performance.

This information is subject to change without notice.

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