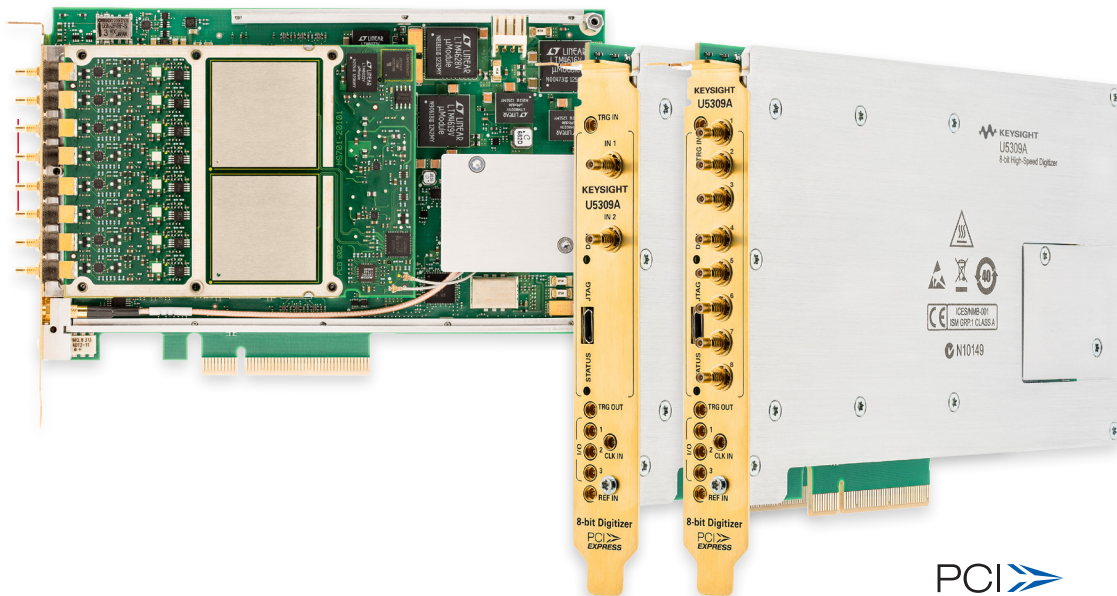# Keysight U5309A
PCIe High-Speed Digitizer with On-Board Processing

2 or 8 channels, 8-bit, up to 2 GS/s, DC to 500 MHz bandwidth, with custom firmware support
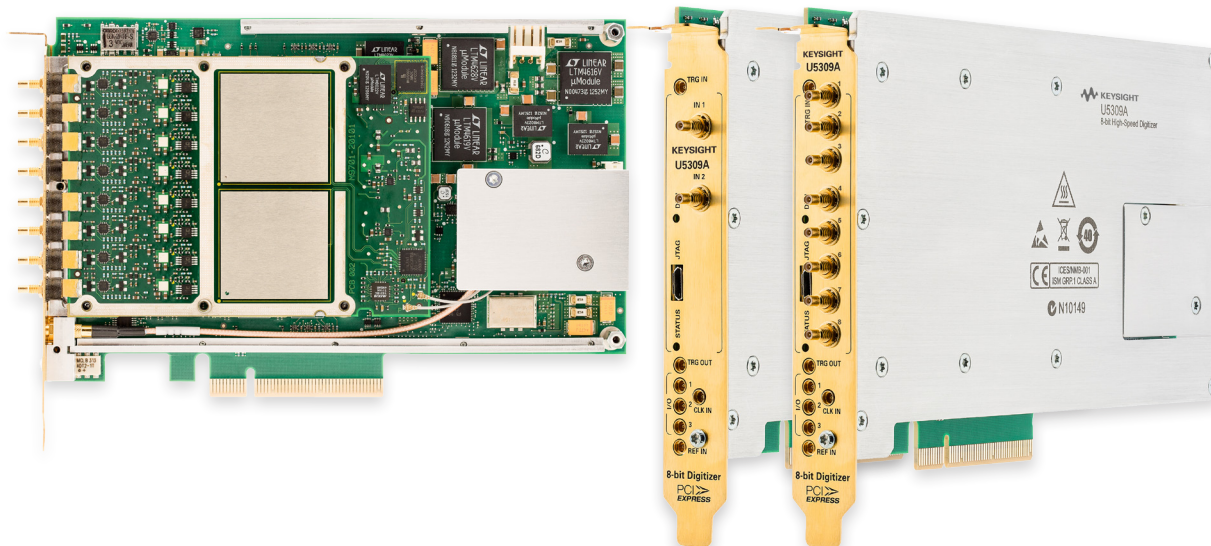
Data Sheet

KEYSIGHT
TECHNOLOGIES

Unlocking Measurement Insights

Overview

Introduction

The Keysight U5309A is a fast 8-bit multi-channel PCIe® digitizer with programmable on-board processing, making it ideal for commercial, industrial, and aerospace & defense. The U5309A is particularly suited for OEM applications with its fast PCI Express 2.0 eight lanes connection.

Product description

The U5309A occupies a single full-length PCIe slot of the host controller. Featuring two or eight high-speed channels with an analog bandwidth of DC to 500 MHz, and a large DDR3 memory for long acquisition time, the U5309A also includes a Xilinx Virtex-6 FPGA allowing implementation of custom real-time processing algorithms using the available FPGA development kit.

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

For information on other firmware options please contact Keysight Technologies, Inc.: **digitizers@keysight.com**

Example applications

– Emission monitoring
– Analytical time-of-flight
– Laser ranging
– Ultrasonic imaging
– Pulsed radar
– Advanced research experiments

Product features

– Up to 8 channels with 8-bit resolution
– Up to 2 GS/s sampling rate
– DC to 500 MHz analog bandwidth
– 50 Ω input impedance
– Selectable 250 mV to 5 V input full scale range (FSR)
– ±0.5x FSRmax input voltage offset range
– Up to 2 GB DDR3 on-board memory
– On-board data processing unit using a Xilinx Virtex-6 FPGA
– Support for loading custom real-time processing
– PCI Express 2.0 eight lanes (x8)
– IVI-C and IVI-COM drivers available
– Support for Windows and Linux

Uncompromising values

– Eight-channel (dual-channel option available)
– Fast PCIe 8-bit digitizer with on-board processing
– Capture wide bandwidth signals
– Large on-board memory
– Accurate measurements
– Custom firmware implementation
– Capable of fast switching between multiple firmware programs
– Very high digitized data throughput
– Software support including multiple programmable interfaces for easy integration into existing environments
– Reduced development time, fast time to market

Hardware Platform

Product overview

Benefitting from the very high data transfer rates of the PCIe 2.0 interface, and occupying a single x8 slot in a host PC, the U5309A offers high performance in a small footprint, making it an ideal platform for many commercial, industrial and aerospace & defense embedded systems.

On-board real-time processing

At the heart of the U5309A is a data processing unit (DPU) based on the powerful Xilinx Virtex-6 FPGA. This DPU is responsible for controlling the module functionality, data flow and real-time signal processing. This powerful feature allows data reduction and storage to be carried out at the digitizer level, minimizing transfer volumes and speeding-up analysis.
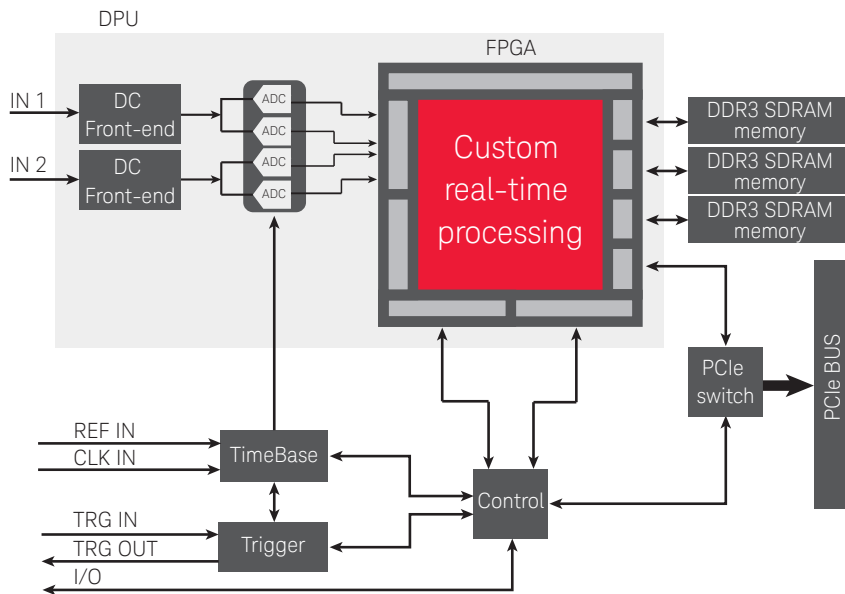
U5340A - FPGA Development Kit [1]

The FPGA development kit is primarily intended to open the design of the FPGA to specific user requirements by providing a development framework that interfaces to the underlying hardware.

The FPGA development kit combines capabilities to:
– Achieve multi GS/s real-time processing on a full digitizer framework by leveraging the full density and speed of the FPGA.
– Shorten time-to-market with turn-key, easy-to-use development flow and debug.

There are several rationales to consider developing custom signal processing such as:
– Data throughput optimization
– Real time processing
– Implementation of custom IP and OEM technical know-how
– Re-usability and upgradability

The FPGA development kit includes everything you need: source code, ready-to-use base design, a set of cores to easily interface to the underlying hardware, a test-bench environment for design and simulation, and automated building script.

Block Diagram 2 channels

Figure 1. Simplified block diagram of the U5309A 2 channels PCIe high-speed digitizer with on-board processing.

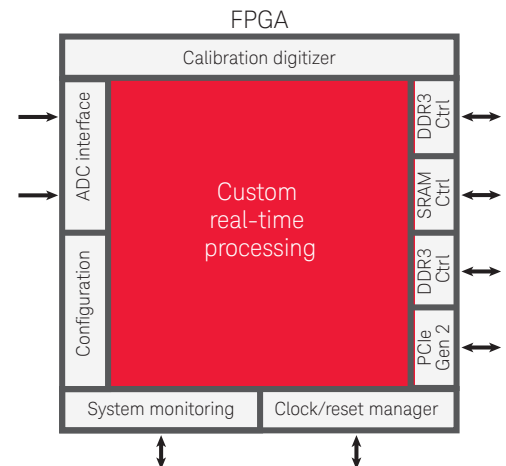Figure 2. Enlarged block diagram of the FPGA Xilinx Virtex-6

☐ Predefined Keysight IP cores

■ Custom real-time processing (using the FPGA development kit)

For more information:
Keysight U5340A - FPGA Development Kit for High-Speed Digitizers
Keysight product brochure 5991-2424EN
http://literature.cdn.keysight.com/litweb/pdf/5991-2424EN.pdf

1. This standalone software package must be acquired separately.

Software Platform

Keysight Software Suite

Keysight IO Libraries Suite offers FAST and EASY access to the U5309A using a standardized interface and ensuring compatibility and upgradability of the software applications.

Drivers

The module comes with the Keysight MD2 IVI-COM and IVI-C standard software drivers that work in the most popular development environments including Visual C/C++, C#, VB.NET, MATLAB, and LabVIEW. Linux is also supported using the IVI-C driver.

Easy software integration

To help you get started and complete complex tasks quickly, the U5309A digitizer is supplied with a comprehensive portfolio of module drivers, documentation and examples, to help you quickly develop test systems with your software platform of choice.

Compliance

The U5309A is compliant with PCI Express 2.0 standard. Designed to benefit from fast data interfaces, the product can be integrated into PCI Express slots.

Calibration

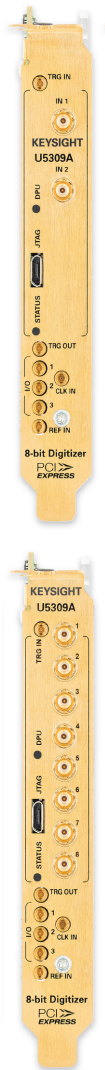The U5309A is factory calibrated and shipped with a certificate of calibration.

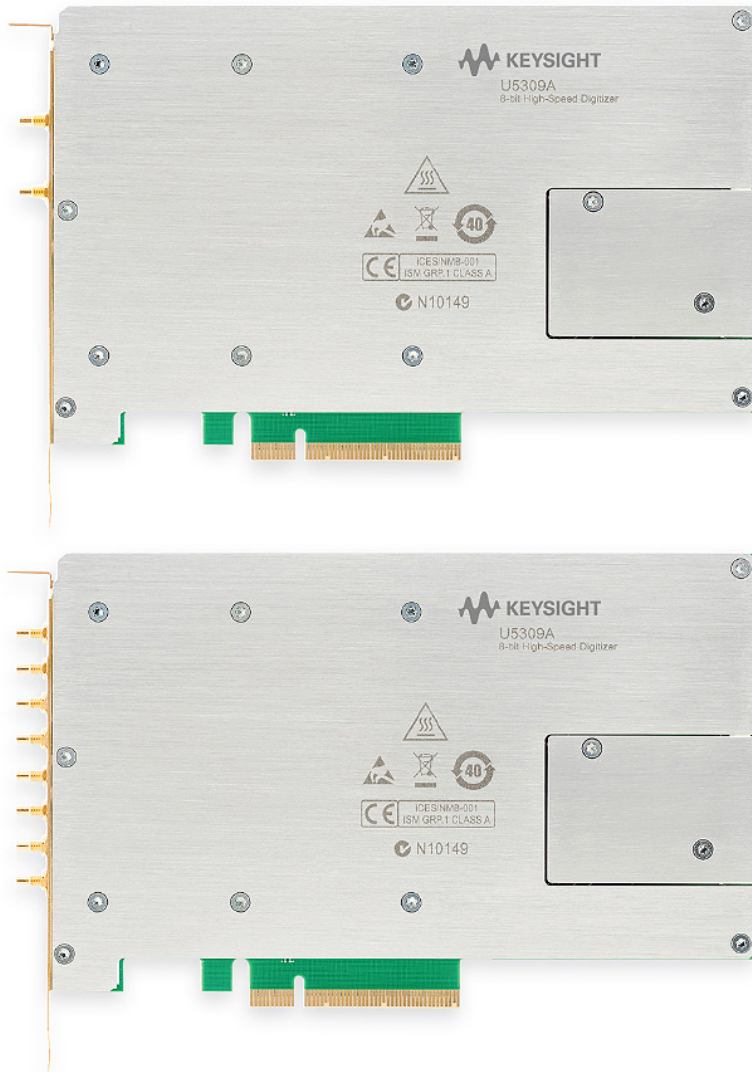Figure 3. 2 and 8 channels U5309A front panels with analog inputs and multiple I/O signals.

Figure 4. The Keysight 2 and 8 channels U5309A PCIe 8-bit digitizers with on-board processing offers a small size for easy integration.

Firmware options

The U5309A PCIe high-speed digitizer provides several firmware options:

- **DGT**: Digitizer firmware
- **FDK**[1]: Custom firmware capable
  (Required to load FPGA firmware created with U5340A)
- **AVG**[1]: Firmware for real-time sampling and averaging
- **PKD**[1]: Firmware for real-time signal peak detection
- **TSR**[1]: Firmware for triggered simultaneous acquisition and readout.

	Channel Configuration			
	-CH2			**-CH8**
	Sampling Rate			Sampling Rate
Firmware	-SR0	-SR1	-SR2	-SR1
-DGT	✓	✓	✓	✓
-FDK	✓	✓	✓	-
-AVG	✓	✓	✓ [2]	-
-PKD	✓	✓	✓ [2]	-
-TSR	✓	✓	✓	-

Table 1. Firmware options versus sampling rate.

DGT digitizer firmware

This is the standard digitizer firmware which:

- 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.
- Programmable binary decimation 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). e.g. for a U5309A-SR2 you can select from 2 GS/s (with interleaving) down to 1.953125 MS/s.

FDK custom firmware capable

This option enables loading of custom firmware created with the U5340A FPGA development kit.

AVG firmware for real-time sampling and averaging [3]

Synchronous real-time sampling and accumulation up to 2 GS/s on single-channel and 1 GS/s on dual-channel with:

- Accumulation of 1 up to 520,000 triggers per record in steps of 8 triggers [4].
- Effective acquisition length of up to 480 KSamples in single channel or 240 KSamples per channel in dual-channel.
- Noise suppressed accumulation (NSA).

PKD firmware for real-time signal peak detection [3]

Synchronous real-time sampling and peak detection up to 2 GS/s on single-channel and 1 GS/s on dual-channel with:

- Accumulation of 1 up to 520,000 triggers per record in steps of 8 triggers [4].
- Effective acquisition length of up to 480 KSamples in single channel or 240 KSamples per channel in dual-channel.

TSR firmware for triggered simultaneous acquisition and readout

The triggered simultaneous acquisition and readout concept guarantees no lost triggers at high repetition rate for specific configuration [5]:

- Larger memory size increases the maximum margin for host PC processing time, and allows for short to very long record size.
- The architecture allows to continuously acquire new records while reading previous ones.
- PCIe 2.0 with 8 lanes allows fast data throughput.
- High precision integrated time to digital converter can be used to increase time measurement accuracy.

Easy firmware switch

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

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1. A calibration digitizer function is available with each firmware.
2. On 1 channel only.
3. -AVG and -PKD are not available with the combination of -CH2 and -SR2 options.
4. Expected for 8 first triggers.
5. Please contact Keysight to find out the repetition rate that can be achieved in your application.

Technical Specifications and Characteristics

Analog Input (SSMC Connectors)		
Number of channels		2 or 8 (simultaneously sampled)
Impedance		50 Ω ±2% [1]
Coupling		DC
Full scale range (FSR)	Standard	250 mV, 500 mV, 1 V, 2.5 V, and 5 V
	-LVR	50 mV, 100 mV, 200 mV, 500 mV, and 1 V
Maximum input voltage		±3.4 V
Input voltage offset		±0.5x FSR
Frequency Range (–3 dB Bandwidth)	-F05	DC to 500 MHz *(nominal)*
	-F03	DC to 300 MHz *(nominal)*
Effective Number Of Bits (ENOB) [2]	@ 100 MHz	6.8 *(typical)*
Signal-to-Noise Ratio (SNR) [2]	@ 100 MHz	43 dB *(typical)*
Spurious-Free Dynamic Range (SFDR) [2]	@ 100 MHz	50 dB *(typical)*
Total Harmonic Distortion (THD) [2]	@ 100 MHz	–48 dB *(typical)*

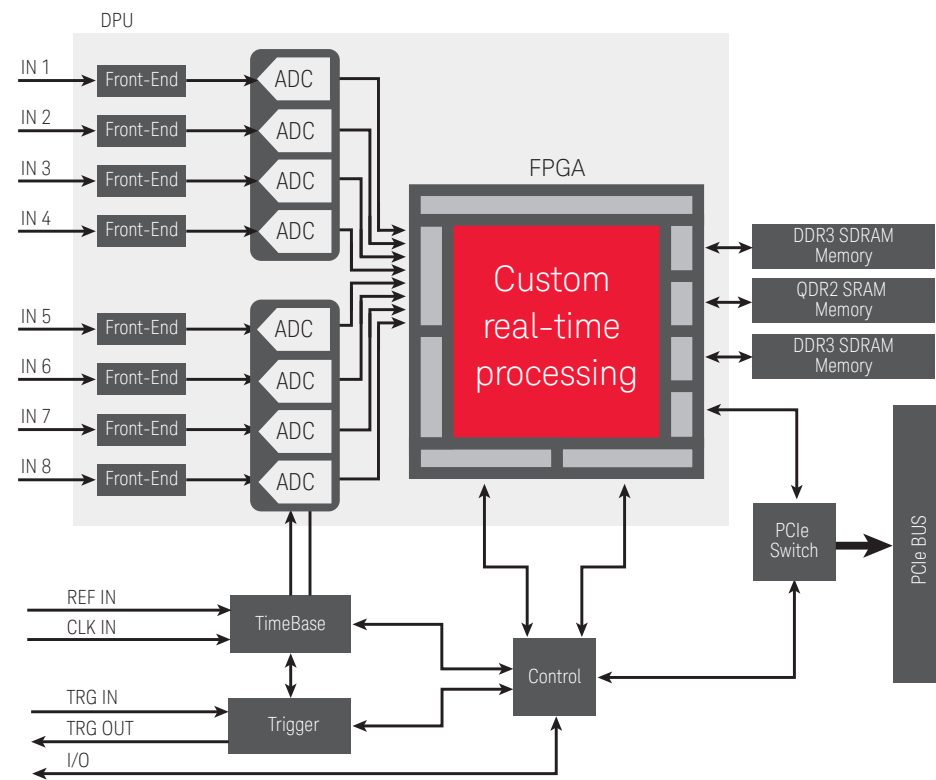# Block Diagram 8 channels

Figure 4. Simplified block diagram of the U5309A 8 channels PCIe high-speed digitizer with on-board processing.

1. Input impedance is 150 Ω during the calibration process.
2. Measured at 2.0 GS/s and 1 V FSR for a –1 dBFS input signal in internal clock mode with -F05 option.

Technical Specifications and Characteristics *(continued)*

Digital Conversion		
Resolution		8 bits
Acquisition memory (total)	-M01	128 MB
	-M05	512 MB
	-M20	2 GB
		When using the -AVG or -PKD option exclusively, it is recommended to select the smallest memory option.
Sample clock sources		Internal or external
Internal clock source		Internal, external reference
	Real-time sampling rates	See the table 2 below
	Sampling jitter	500 fs *(nominal)*
	Clock accuracy	±1.5 ppm
External clock source (CLK IN MMCX connector)		
	Impedance	50 Ω *(nominal)*
	Frequency range (F_{ext})	See the table 3 below
	Signal level	+5 dBm to +15 dBm *(nominal)*, 0 V DC
	Coupling	AC
External reference clock source (REF IN MMCX connector)		
	Impedance	50 Ω *(nominal)*
	Frequency range	100 MHz to ±100 kHz *(nominal)*
	Signal level	–3 dBm to +3 dBm *(nominal)*
	Coupling	AC
Acquisition modes		Single shot, sequence (up to 131072 records. Record maximum length = memory size/number of channels)

	Max Sampling Rate		
Channel Configuration	-SR0	-SR1	-SR2
-CH2	0.5 GS/s	1 GS/s	2 GS/s
-CH8	–	1 GS/s	–

Table 2. Real-time sampling rates with internal clock source.

			Max Sampling Rate		
Channel Configuration	Nominal Frequency	Frequency Range	-SR0	-SR1	-SR2
-CH2	2 GHz	1.8 GHz to 2.2 GHz [1]	Fext / 4	Fext / 2	Fext / 1
-CH8	4 GHz	3.6 GHz to 4.4 GHz [1]	–	Fext / 4	–

Table 3. External clock source frequency range.

1. Specifications guaranteed only at nominal frequency.

Technical Specifications and Characteristics *(continued)*

Trigger		
Trigger modes		Edge (positive, negative)
Trigger sources		External, Software, Channel (digital)
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		52 days
Trigger time interpolator resolution	External	8 ps [1] *(nominal)*
	Channel	1 sample
Trigger time interpolator precision	External	15 ps RMS [1] *(nominal)*
	Channel	1 sample
Rearm time (deadtime)		< 500 ns *(nominal)*
Trigger out (TRG OUT MMCX connector) [2]		1 (programmable), 50 Ω source
Signal level		0.8 Vpp amplitude ±2.5 V offset *(nominal)* into high impedance
Control IO (I/O 1 and 2 MMCX Connectors) [3]		
Output functions		Acquisition active Trigger is armed Trigger accept resynchronization 100 MHz reference clock divided by 2 [4] Sampling clock divided by 32 [4] Low level High level FPGA synchronization
Input/Output function		FPGA programmable I/O

1. For –CH2 option.
2. At 10 MHz on a 50 Ω load.
3. I/O 3 reserved for future use.
4. Only I/0 1.

Technical Specifications and Characteristics *(continued)*

Environmental and Physical [1]			
Temperature Range	Operating		0°C to +50°C (sea level to 10,000 feet) [2]
			0°C to +45°C (10,000 to 15,000 feet) [2]
	Non-operating		–40 °C to +70 °C
Altitude			Up to 15,000 feet (4'572 meters)
EMC			Complies with European EMC Directive 2004/108/EC
			– 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 2002/42/EC, 1.7.4.2u
			Acoustic noise emission
			LpA <70 dB
			Operator position
			Normal operation mode

Power Dissipation for CH2 [3]			
+ 3.3 V	+ 3.3 V$_{AUX}$	+ 12 V	Power on PCIe edge connector
0.8 A *(nominal)*	0.2 A *(nominal)*	2.7 A *(nominal)*	36 W *(nominal)*
+ 5 V		+ 12 V	Power on additional power cable [3]
1.8 A *(nominal)*		0.9 A *(nominal)*	20 W *(nominal)*
Power Dissipation for CH8 [3]			
+ 3.3 V	+ 3.3 V$_{AUX}$	+ 12 V	Power on PCIe edge connector
0.8 A *(nominal)*	0.2 A *(nominal)*	2.3 A *(nominal)*	31 W *(nominal)*
+ 5 V		+ 12 V	Power on additional power cable [3]
1.5 A *(nominal)*		2.3 A *(nominal)*	36 W *(nominal)*
Mechanical Characteristics			
Form Factor			PCIe x8 standard (full length with fan)
Size	Without fan [4]		17.6 mm W x 126.3 mm H x 169.5 mm D
	With fan [5]		40.6 mm W x 126.3 mm H x 252.1 mm D
Weight	With fan		0.575 kg (1.268 lbs)

1. Samples of this product have been type tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environ-mental 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. PC internal ambient temperature at intake of the digitizer's fan, operating temperature is respectively 0°C to +40°C and 0°C to +35°C for option –CH8.
3. Additional power cable mandatory to ensure adequate power distribution as per PCIe standard.
4. 60 m³/h airflow is required. The unit must be operated with the included fan.
5. Optional card retainer recommended to stabilize the PCIe card in the PC.

Technical Specifications and Characteristics *(continued)*

System requirements (Contact us at digitizers@keysight.com for a list of recommended host computers)		
Topic	**Windows**	**Linux**
Operating Systems	Windows 7 (32-bit and 64-bit), All versions Windows 8.1 (32-bit and 64-bit), All versions	Linux Kernel 2.6 or higher (32 or 64-bit), Debian 7.0, CentOS 6
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	As per the minimum requirements of the chosen distribution

Available Disk Space [1]	1.5 GB available hard disk space, includes:
	  – 1 GB available for Microsoft .NET Framework 3.5 SP1 [2]
	  – 100 MB for Keysight IO Libraries Suite
		100 MB

Video	Support for DirectX 9 graphics with 128 MB graphics memory recommended (Super VGA graphics is supported)	No graphics required (for headless system), or X Windows
Browser	Microsoft Internet Explorer 7 or greater	Distribution supplied browser

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 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.

Note: All graphs contain measured data from several units at room temperature unless otherwise noted.

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1. Because of the installation procedure, less disk space may be required for operation than is required for installation. The amount of space listed above is required for installation.
2. NET Framework Runtime Components are installed by default with Windows 7. Therefore, you may not need this amount of available disk space.

Configuration and Ordering Information

Software information

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

Related products

Model	Description
U5340A	FPGA Development Kit for High-Speed Digitizers
Advantage Services: Calibration and Warranty	
Keysight Advantage Services is committed to your success throughout your equipment's lifetime.	
Included	3-year warranty (return to Keysight), standard
R-51B-001-5Z	5-year return to Keysight warranty assurance plan

Accesssories

Model	Description
U5300A-100	SSMC to BNC female cable, 1 m
U1092A-CB3	SSMC to SMA cable, 1 m
U1092A-WCK	SSMC torque wrench

Ordering information

	Model	Description
	U5309A	PCIe 8-bit Digitizer with on-board processing Includes:
		-Software, example programs and product information on CD
		-MMCX to BNC cable, 1 m (qty 1)
		-Additional power supply cables
		-Fan assembled on module
		-Return to Keysight Warranty extended to 3 years
Configurable Options		
Channel Configuration		
✓	U5309A-CH2	2 channels [1]
	U5309A-CH8	8 channels [1]
Sampling Rate		
	U5309A-SR0	500 MS/s sampling rate version [2]
✓	U5309A-SR1	1 GS/s sampling rate version
	U5309A-SR2	2 GS/s sampling rate version [2]
Bandwidth		
✓	U5309A-F03	DC to 300 MHz bandwidth version
	U5309A-F05	DC to 500 MHz bandwidth version
Memory		
	U5309A-M01	128 MB acquisition memory
✓	U5309A-M05	512 MB acquisition memory
	U5309A-M20	2 GB acquisition memory
Full Scale Range		
✓	Standard	Standard voltage range 5 V
	U5309A-LVR	Low voltage range 1 V
Data Processing Unit		
✓	U5309A-LX2	DPU FPGA: LX195T
Firmware		
✓	U5309A-DGT	Digitizer firmware
	U5309A-FDK	Custom firmware capable [2] (Required to load FPGA firmware created with the U5340A)
	U5309A-AVG	Real-time averager firmware
	U5309A-PKD	Real-time peak detection firmware
	U5309A-TSR	Triggered simultaneous acquisition and readout
Card Retainer		
✓	U5300A-001	With card retainer
	U5300A-002	No card retainer
	U5300A-003	Short card retainer

Please contact Keysight for other options not shown:
digitizers@keysight.com

✓ These options represent the standard configuration.
1. Please contact Keysight for other channel configuration.
2. Only available with –CH2 option.

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www.pxisa.org

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

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Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

Keysight Assurance Plans

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Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

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www.keysight.com/find/high-speed-digitizers
www.keysight.com/find/u5309a

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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Hong Kong	800 938 693
India	1 800 11 2626
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Singapore	1 800 375 8100
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For other unlisted countries:
www.keysight.com/find/contactus
(BP-04-23-15)

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TECHNOLOGIES
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