Keysight U5310A
PCIe High-Speed Digitizer/ADC Card with FPGA Signal Processing
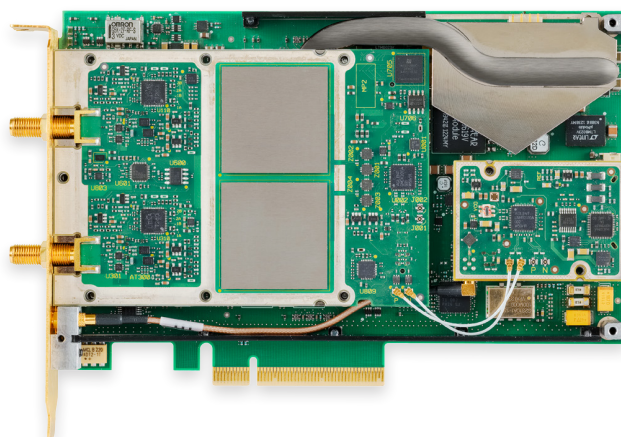
2 channels, 10-bit, up to 10 GS/s,
DC to 2.5 GHz bandwidth

Data Sheet

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See Deeper and Sharper than Before

Introduction

The U5310A is a true two channel PCIe, DC coupled 10-bit digitizer providing sample rates up to 10 GS/s. With 10-bit resolution across a wide 2.5 GHz bandwidth, and real-time processing capabilities, this high-speed digitizer is designed for embedded OEM applications in a variety of advanced imaging and processing systems.

Featuring unique spurious-free dynamic range (SFDR) and signal noise ratio (SNR) performances in high frequencies, especially at 250mV full scale range (FSR), the U5310A PCIe digitizer is particularly suited for embedded OEM applications requiring digitizer sampling at wide bandwidth and high dynamic range. Overall performance enables final products to more precisely measure time of flight in several end system applications.

Product description

The U5310A is a unique 10-bit ADC card, capturing signals from DC up to 2.5 GHz at 5 GS/s or 10 GS/s. It provides excellent measurement accuracy and high dynamic range. Optimized response enables few hundred picoseconds pulse analysis. An interleaving option allows the two channels to be combined to acquire at 10 GS/s in single channel mode, keeping excellent measurement fidelity. Featuring very long acquisition memory options up to 4 GB, the U5310A includes a Xilinx FPGA offering real-time data processing capability. The U5310A digitizer occupies a single full length PCIe slot of the host computer.

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 (Laser and LiDAR scanning)
- Analytical time-of-flight (TOF)
- Ultrasonic non-destructive testing (NDT)
- Semiconductor
- Distributed strain and temperature sensors (DSTS)

Features

- 1 channel with 10-bit resolution up to 10 GS/s sampling rate with interleaving enabled
- 2 channels with 10-bit resolution up to 5 GS/s simultaneously sampling rate per channel
- DC up to 2.5 GHz bandwidth
- 50 Ω input impedance, DC coupled
- Selectable 250 mV or 1 V full scale range (FSR)
- 15 ps RMS trigger time interpolator (TTI) precision
- Low noise density and low distortion
- Optimized frequency response flatness
- Excellent and flat SFDR over a large analysis bandwidth (> 56 dBc typical)
- Up to 4 GB DDR3 on-board memory
- On-board data processing unit using a Xilinx FPGA
- IVI-COM and IVI-C drivers available
- Support for Windows and Linux
- Real-time averaging option (-AVG)
- Streaming option (-CST)

Customer values

- Dual channel
- Fast PCIe 10-bit digitizer with on-board real-time processing
- See deeper with better resolution
- Capture wide bandwidth signals
- High dynamic range acquisition for better measurement fidelity
- Accurate measurement
- Large on-board memory
- Capable of 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

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

Hardware platform

Product overview

Benefitting from the very high data transfer rates of the PCIe interface, and occupying a single slot in a host computer, the U5310A digitizer offers high performance in a small footprint, making it an ideal platform for many commercial, industrial and aerospace & defense embedded systems.

Unique proprietary technology

Keysight developed exclusive proprietary integrated circuits. In particular, the digitizer incorporates low noise and low distortion signal conditioning amplifier to drive interleaved ADCs and specific clock distribution to minimize the clock jitter and spurious. Moreover, optimized frequency response flatness provides enhanced measurement accuracy on a wide bandwidth.

On-board real-time processing

At the heart of the U5310A ADC card is a data processing unit (DPU) based on the Xilinx Virtex-6 FPGA. This DPU implements full digitizer functionality firmware, allowing digitization of the signal, storage of the resulting data in the onboard memory and transfer through the PCIe connection to the Host computer. This powerful feature allows data reduction, real time signal processing and storage to be carried out at the digitizer level, minimizing transfer volumes and speeding-up analysis.

Compliance

The U5310A is compliant with PCI Express 2.0 standard. Designed to benefit from fast data interfaces, the product can be integrated into PCI Express slots.
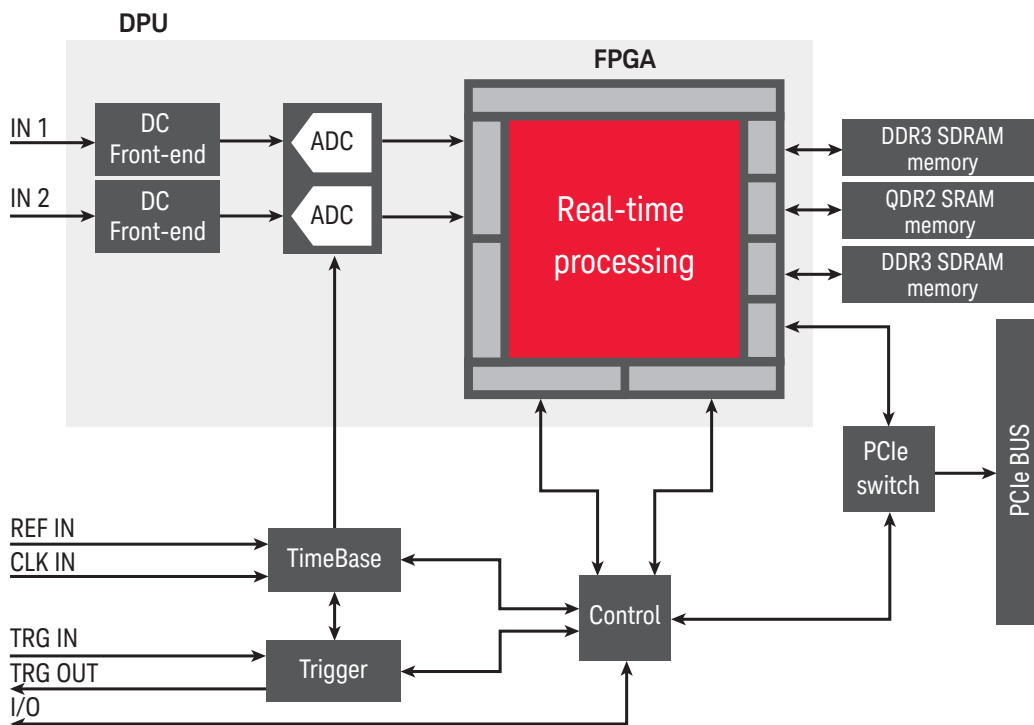
Block diagram

Figure 1. Simplified block diagram of the U5310A PCIe high-speed digitizer with on-board real-time processing.

Software Platform

Keysight Software Suite

Keysight IO Libraries Suite offers fast and easy access to the U5310A digitizer using a standardized interface and ensuring compatibility and upgradability of the software applications.

All of the modules in your system are displayed. You can view information about the installed software or launch the modules' soft front panel directly from Keysight Connection Expert (KCE). In addition, KCE offers an easy way to find the correct driver for your instrument.

Drivers

The module comes with the IviDigitizer class compliant Keysight MD2 IVI-COM and IVI-C 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 U5310A ADC card is supplied with a comprehensive portfolio of module drivers, documentation, examples, and software tools to help you quickly develop test systems with your software platform of choice.

Software applications

In addition, the U5310A includes the Keysight MD2 soft front panel (SFP) graphical interface. This software application can be used to explore the capabilities of the Keysight modular high-speed digitizers.

Figure 2. Keysight MD2 software front panel (SFP) interface.
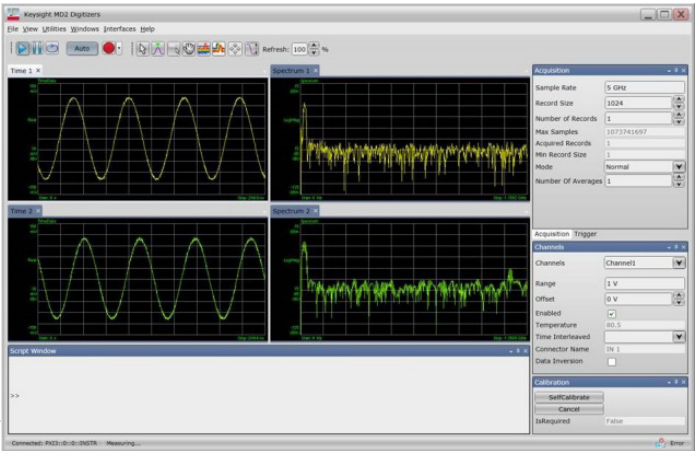
For advanced measurement analysis, the U5310A can be combined with Keysight's 89600 Vector Signal Analysis software, the industry's standard for signal analysis and demodulation.

Figure 3. U5310A front panel with analog inputs and multiple I/O signals.

Figure 4. The Keysight U5310A PCIe 10-bit digitizer with on-board processing offers a small size for easy integration.

Firmware Options

The U5310A PCIe high-speed digitizer provides several firmware options:
- **DGT**: Digitizer firmware
- **INT**: Interleaved channel sampling functionality
- **AVG**[1]: Firmware for real-time sampling and averaging
- **CST**: Continuous simultaneous acquisition and readout, with triggers

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.
- Delivers fixed internal clocking frequency with internal or external reference, and external clock.
- Supports a programmable binary decimation to lower the sample rate by a factor of 2, 4, 8, 16 or 32; enabling decimated sampling rates at 2.5 GS/s, 1.25 GS/s, 625 MS/s, 312.5 MS/s and 156.25 MS/s.

Moreover, the U5310A includes frequency equalization capabilities. Two equalization modes can be selected:
- The "smooth roll off" mode minimizes the overshoot and ringing.
- The "sharp roll off" mode optimizes the frequency response flatness.

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

INT interleaved channel sampling functionality

This interleave option allows two channels to be combined and to reach 10 GS/s in one channel acquisition mode.

This option can be used with both digitizer (DGT) or real-time sampling and averaging (AVG) firmware.

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 at 5 GS/s on dual-channel or at 10 GS/s on single channel with INT option, featuring:
- Accumulation from 1 to 16,384 triggers.
- Effective acquisition length up to 655 kSamples in single channel with interleave option or up to 325 kSamples per channel in dual-channel.
- Noise suppressed accumulation (NSA).
- Self-trigger mode for minimal synchronous noise.

The AVG firmware allows decimation factors from 2 to 256 and associated low pass filters:
- Decimated sampling rates: 2.5 GS/s, 1.25 GS/s, 625 MS/s, 312.5 MS/s, 156.25 MS/s, 78.125 MS/s, 39.06 MS/s and 19.53 MS/s.
- Filters in dual channel mode:
  1 GHz, 500 MHz, 250 MHz and 125 MHz.
- Filter in single channel mode, with interleave (-INT):
  1 GHz, 500 MHz, 250 MHz and 180 MHz.

CST Continuous simultaneous acquisition and readout, with triggers

The -CST firmware option enables simultaneous acquisition and readout and supports multiple record acquisition functionality.

Using this feature, acquired records are streamed to the host computer while the digitizer is acquiring the next records. This mode supports triggered multiple records of same length. Enabling gaps between the triggered records, CST mode allows longer acquisition duration, compared with standard DGT digitizer firmware.

The -CST firmware option manages the streaming of 10-bit raw output data. Using raw data output, trigger position is known with the accuracy of a sample. For applications requiring trigger position at sub-sample, the information is available on a separated marker stream providing absolute trigger position.

This option is especially dedicated to applications requiring no trigger loss. Depending on the settings and trigger rate, the streaming can be sustained endlessly without overflow. The maximum duration of the acquisition only depends on the size of the storage device of the host computer.

1. A calibration digitizer function is available with each firmware.

Technical Specifications and Characteristics

Analog input (IN1 and IN2 SMA connectors)		
Number of channels		2 (without INT option) 2 or 1 (with INT option)
Impedance		50 Ω ±4 %
Coupling		DC
Full scale ranges (FSR)		250 mV and 1V
Maximum input voltage		250 mV FSR: ±0.5 Vpk 1 V FSR: ±1.5 Vpk
Input voltage offset		±FSR
Input frequency range (-3 dB bandwidth)	-F25	DC to 2.5 GHz **(typical)**
Bandwidth limit filters (BWL)		2 GHz **(nominal)**
Channel to Channel skew [1]		± 30 ps
Effective numbers of bits (ENOB) [2]		@ 100 MHz 7.0 **(7.3 typical)** @ 648 MHz 7.0 **(7.2 typical)** @ 924 MHz 6.9 **(7.2 typical)** @ 1.9 GHz 6.6 **(6.9 typical)**
Signal to noise distortion (SNR) [2]		@ 100 MHz 44 dB **(46 dB typical)** @ 648 MHz 44 dB **(45 dB typical)** @ 924 MHz 44 dB **(45 dB typical)** @ 1.9 GHz 41 dB **(44 dB typical)**
Spurious free dynamic range (SFDR) [2]		@ 100 MHz **58 dBc (typical)** @ 648 MHz **57 dBc (typical)** @ 924 MHz **57 dBc (typical)** @ 1.9 GHz **56 dBc (typical)**
Total harmonic distortion (THD) [2]		@ 100 MHz **-61 dB (typical)** @ 648 MHz **-57 dB (typical)** @ 924 MHz **-57 dB (typical)** @ 1.9 GHz **–55 dB (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. The measurement results from a sine-fit method of a 100 k samples using sinusoid signal whose frequency is swept over 50 MHz to 2 GHz, and is an average of 5 measurements.
2. Measured for a –1 dBFS input signal in internal clock mode at 5.0 GS/s (-SR4)

Technical Specifications and Characteristics *(continued)*

Digital conversion		
Resolution		10 bits
Acquisition memory (total)	-M02	256 MB (100 MSamples/ch)
	-M40	4 GB (1.6 GSamples/ch)
Sample clock sources		Internal or external
Internal clock source		Internal, external reference
Real-time sampling rates		5 GS/s per channel
Sampling clock jitter		80 fs **(nominal)** [1]
Clock accuracy		±1.5 ppm
External clock source (CLK IN MMCX connector)		
Impedance		50 Ω **(nominal)**
Frequency range [2]		5 GHz
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
Maximum number of records		131072
Maximum record length	-M02	100 MSamples/ch (or 200 MSamples with –INT option)
	-M40	1.6 GSamples/ch (or 3.2 GSamples with –INT option)

1. Jitter figure based on phase noise integration from 100 Hz to 100 MHz in internal reference.
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 2.6 GHz **(nominal)**
External trigger (TRG IN MMCX connector)	

	Coupling	DC
	Impedance	50 Ω **(nominal)**
	Level range	± 5 V **(nominal)**
	Minimum amplitude	0.5 V pk-pk **(nominal)**
	Frequency range	DC to 2 GHz **(nominal)**

Maximum time stamp duration	20 days
Trigger time interpolator resolution	8 ps **(nominal)**
Trigger time interpolator precision	15 ps RMS **(nominal)**
Rearm time (deadtime)	0.8 µs **(nominal)**
Trigger out (TRG OUT MMCX connector)	1 (programmable), 50 Ω source

	Signal level [1]	0.8 Vpp ±2.5 Voffset **(nominal)** into high impedance

Control IO (I/O 1 and 2 MMCX connectors)		
Output functions		Acquisition active
		Trigger is armed
		Trigger accept resynchronization
		100 MHz reference clock divided by 2 [2]
		Sampling clock divided by 128 [2]
		Low level
		High level
	-AVG	SelfTrigger [3]
	-AVG	Accumulation active [4]
Input function	-AVG	Accumulation enable [2]

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1. At 10 MHz on a 50 Ω load.
2. Only on I/O 1.
3. Only on I/O 3.
4. Only on I/O 2.

Technical Specifications and Characteristics *(continued)*

Environmental and physical [1]		
Temperature range	Operating	0 to +40°C (sea-level to 10,000 feet) [2] 0 to +35°C (10,000 to 15,000 feet) [2]
	Non-operating	−40 to +70°C
Altitude		Up to 15,000 feet (4'572 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
1.7 A (nominal)	-	2.6 A (nominal)	37 W (nominal)
+ 5 V		+ 12 V	Power on additional power cable [4]
4.0 A (nominal)		2.6 A (nominal)	51 W (nominal)

Mechanical characteristics		
Form Factor		PCIe x8 standard (full length with fan)
Size	Without fan	17.6 W x 126.3 H x 169.5 D mm [5]
	With fan	40.6 W x 126.3 H x 252.1 D mm [6]
Weight		0.6 kg (1.32 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 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 digitizer's fan.
3. Power measured in digitizer mode.
4. Additional power cable mandatory to ensure adequate power distribution as per PCIe standard.
5. 60 m³/h airflow is required. The unit must be operated with the included fan.
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 acqiris_support@keysight.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: [2] – 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
Browser	Use a supported version of Internet Explorer; see http://support.microsoft.com/kb/969393	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 40°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.

Calibration

The U5310A is factory calibrated and shipped with a certificate of calibration.
Calibration is recommended every year in order to verify product performance.

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. 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. The .NET Framework Runtime Components are installed by default with most Windows installations, so 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
U5303A	PCIe 12-bit Digitizer with on-board processing
U5309A	PCIe 8-bit Digitizer with on-board processing
Advantage services: calibration	
Keysight Advantage Services is committed to your success throughout your equipment's lifetime.	
U5310A-A6J	ANSI Z540 Calibration

Accessories

Model	Description
U5300A-101	MMCX male to SMA male cable, 1m
U5300A-102	MMCX male to BNC male cable, 1m

Ordering information

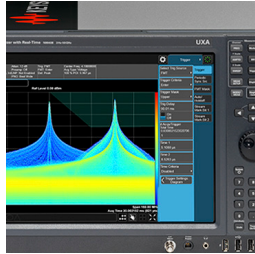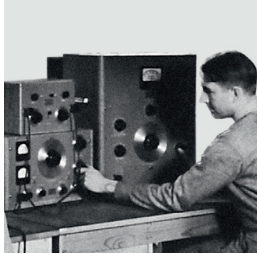| Model	Description
U5310A	PCIe 10-bit Digitizer with on-board processing Includes: – Software examples and product information on DVD – MMCX male to BNC male cable, 1 m (qty 1) – Additional power supply cables – Fan assembled on module
Configurable options	
Sampling rate	
✓ U5310A-SR4	5 GS/s sampling rate version
Bandwidth	
✓ U5310A-F25	DC to 2.5 GHz bandwidth
Memory	
✓ U5310A-M02	256 MB (100 MS/ch) acquisition memory
U5310A-M40	4 GB (1.6 GS/ch) acquisition memory
Firmware	
✓ U5310A-DGT	Digitizer firmware
U5310A-INT	Interleaved channel sampling functionality
U5310A-AVG	Real-time averager firmware
U5310A-CST	Continuous simultaneous acquisition and readout, with triggers
Card retainer	
✓ U5300A-001	With card retainer
U5300A-002	No card retainer
U5300A-003	Short card retainer

✓ These options represent the standard configuration.

Please contact Keysight for other options or specific requirements:
acqiris_support@keysight.com

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