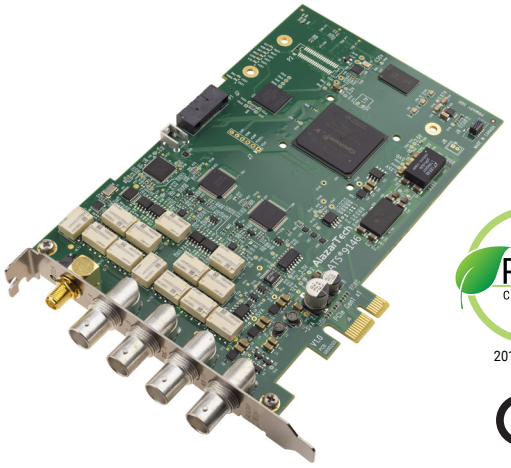
# ATS9146
## 125 MS/s 14-Bit PCIe Digitizer

- 2 channels sampled at 14-bit resolution
- 125 MS/s simultaneous real-time sampling rate on each input
- Up to 128 Million samples of on-board acquisition memory per channel
- ±20 mV to ±10 V input range
- Asynchronous DMA device driver
- AlazarDSO® Oscilloscope Software
- Software Development Kit supports C/C++, C#, Python, MATLAB®, LabVIEW®
- Support for Windows® & Linux®



RoHS 3 COMPLIANT
2015/863/EU

CE

| Product | Bus | Operating System | Channels | Max. Sample Rate | Bandwidth | Memory Per Channel | Resolution |
|---|---|---|---|---|---|---|---|
| ATS9146 | PCIe x1 Gen 1 | 64-bit Windows & 64-bit Linux | 2 | 125 MS/s | 65 MHz (for 50 Ω input) | 128 Megasamples | 14 bits |

## Overview

AlazarTech ATS®9146 is a dual-channel, 14-bit, 125 MS/s waveform digitizer card capable of storing up to 128 Million samples per channel of acquired data in its on-board memory or streaming acquired data to PC memory. ATS9146 is a single-lane PCI Express (PCIe x1) Gen 1 card, which supports up to 200 MB/s bus throughput.

Users can capture data from one trigger or a burst of triggers. Users can also stream very large datasets continuously to motherboard memory or hard disk.

ATS9146 PCI Express digitizers are an ideal solution for cost-sensitive OEM applications that require a digitizer to be embedded into the customer's equipment.

ATS9146 is supplied with AlazarDSO oscilloscope software that lets the user get started immediately without having to write any software.

Users who need to integrate the ATS9146 in their own program can purchase a software development kit, ATS-SDK, for C/C++, C#, Python, MATLAB, and LabVIEW for both Windows and Linux operating system.

All of this advanced functionality is packaged in a low power, half-length PCI Express card.

## Applications

**Optical Coherence Tomography (OCT)**

**Ultrasonic & Eddy Current NDT/NDE**

**Radar/RF Signal Recording & Analysis**

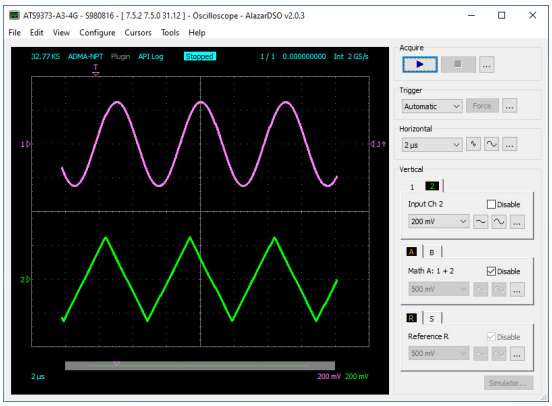
**Terabyte Storage Oscilloscope**

**High-Resolution Oscilloscope**

**Lidar**

**Spectroscopy**

**Multi-Channel Transient Recording**



## PCI Express Bus Interface

ATS9146 interfaces to the host computer using a 1-lane PCI Express bus, operating at 2.5 Gbps.

According to PCIe specification, a 1-lane board can be plugged into any PCIe slot. ATS9146 requires at least one free slot on the motherboard. Electrically, ATS9146 is compatible with Gen 1, Gen 2, and Gen 3 slots.

The physical and logical PCIe x1 interface is provided by an on-board FPGA, which also integrates acquisition control functions, memory management functions and acquisition datapath. This very high degree of integration maximizes product reliability.

The AlazarTech® 200 MB/s benchmark was done using an ASUS® X299-A motherboard. The same performance can be expected from virtually all other motherboards.

## Analog Input

An ATS9146 features two analog input channels with extensive functionality. Each channel has 65 MHz of full power analog input bandwidth for 50 Ω input and 10 MHz bandwidth for 1 MΩ input. With software-selectable attenuation, you can achieve an input voltage range of ±20 mV to ±10 V.

Software-selectable AC or DC coupling further increases the signal measurement capability. Software-selectable 50 Ω input impedance makes it easy to interface to high-speed RF signals.

## Acquisition System

ATS9146 PCI digitizers use a pair of 125 MS/s, 14-bit ADCs to digitize the input signals. The real-time internal sampling rate ranges from 125 MS/s down to 1 KS/s. The two channels are guaranteed to be simultaneous, as they share the exact same clock.

An acquisition can consist of multiple records, with each record being captured as a result of one trigger event. A record can contain both pre-trigger and post-trigger data.

Infinite number of triggers can be captured by ATS9146, when it is operating using dual-port memory.

In between the multiple triggers being captured, the acquisition system is re-armed by the hardware within 32 sampling clock cycles.

This mode of capture, sometimes referred to as Multiple Record, is very useful for capturing data in applications with a very rapid or unpredictable trigger rate. Examples of such applications include medical imaging, ultrasonic testing, OCT and NMR spectroscopy.

## Recommended Motherboards or PCs

Many different types of motherboards and PCs have been benchmarked by AlazarTech. The ones that have produced the best throughput results are listed here: www.alazartech.com/images-media/2246-AlazarTechRecommendedMotherboards.pdf.

## On-Board Acquisition Memory

ATS9146 provides 128 Million samples per channel of on-board dual-port memory that can be used for signal storage.

Data is acquired into the on-board memory before being transferred to the host PC memory. This transfer is performed using an advanced custom DMA engine that can stream data to PC host memory at up to 200 MB/s (exact rate is motherboard dependent).

This on-board dual-port memory allows loss-less data transfer even if the computer is temporarily interrupted by other tasks.

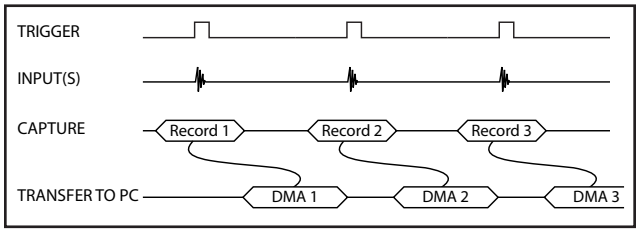
## Maximum Sustained Transfer Rate

Virtually all modern motherboards support the specified 200 MB/s throughput.

ATS9146 users can quickly determine the maximum sustained transfer rate for their motherboard by inserting their card in a PCIe slot and running the bus benchmarking tool provided in AlazarDSO for Windows or AlazarFrontPanel for Linux.

## Traditional AutoDMA

In order to acquire both pre-trigger and post-trigger data in a dual-ported memory environment, users can use Traditional AutoDMA.




Data is returned to the user in buffers, where each buffer can contain from 1 to 8191 records (triggers). This number is called RecordsPerBuffer.

A BUFFER_OVERFLOW flag is asserted if more than 512 buffers have been acquired by the acquisition system, but not transferred to host PC memory by the AutoDMA engine.

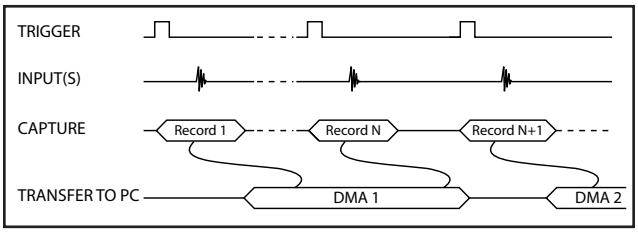
In other words, a BUFFER_OVERFLOW can occur if more than 512 triggers occur in very rapid succession, even if all the on-board memory has not been used up.

ATS9146 features a high-performance memory management firmware that allows much faster data throughput in Traditional mode than previous generation digitizers. Traditional AutoDMA is the fastest way to move data into user buffers. It is the recommended method.

## No Pre-Trigger (NPT) AutoDMA

Many ultrasonic scanning and medical imaging applications do not need any pre-trigger data: only post-trigger data is sufficient.

NPT AutoDMA is designed specifically for these applications. By only storing post-trigger data, the memory bandwidth is optimized.




NPT AutoDMA buffers do not include headers, so it is not possible to get trigger time-stamps.

More importantly, a BUFFER_OVERFLOW flag is asserted if the on-board memory overflows, i.e. the amount of memory that has been written into but not read out to PCIe bus exceeds the on-board memory size.

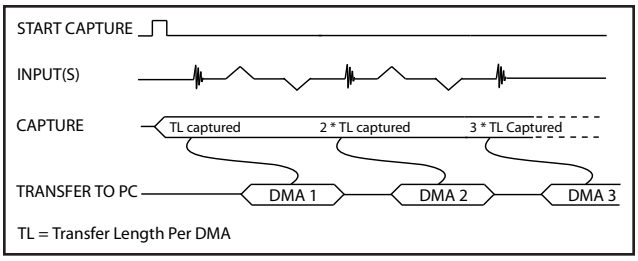
NPT AutoDMA can easily acquire data to PC host memory at the maximum sustained transfer rate of the motherboard without causing an overflow.

This is the recommended mode of operation for most ultrasonic scanning, OCT and medical imaging applications.

## Continuous AutoDMA

Continuous AutoDMA is also known as the data streaming mode.

In this mode, data starts streaming across the PCIe bus as soon as the ATS9146 is armed for acquisition. It is important to note that triggering is disabled in this mode.




Continuous AutoDMA buffers do not include headers, so it is not possible to get trigger time-stamps.

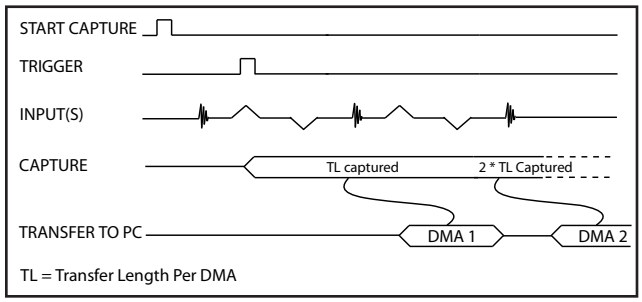
A BUFFER_OVERFLOW flag is asserted if the on-board memory overflows, i.e. the amount of memory that has been written into but not read out to PCIe bus exceeds the on-board memory size.

The amount of data to be captured is controlled by counting the number of buffers acquired. Acquisition is stopped by an AbortCapture command.

Continuous AutoDMA can easily acquire data to PC host memory at the maximum sustained transfer rate of the motherboard without causing an overflow. This is the recommended mode for very long signal recording.

## Triggered Streaming AutoDMA

Triggered Streaming AutoDMA is virtually the same as Continuous mode, except the data transfer across the bus is held off until a trigger event has been detected.




Triggered Streaming AutoDMA buffers do not include headers, so it is not possible to get trigger time-stamps.

A BUFFER_OVERFLOW flag is asserted if the on-board memory overflows, i.e. the amount of memory that has been written into but not read out to PCIe bus exceeds the on-board memory size.

As in Continuous mode, the amount of data to be captured is controlled by counting the number of buffers acquired. Acquisition is stopped by an AbortCapture command.

Triggered Streaming AutoDMA can easily acquire data to PC host memory at the maximum sustained transfer rate of the motherboard without causing an overflow.

## Asynchronous DMA Driver

AlazarTech's dual-port memory and AutoDMA schemes discussed above provide hardware support for optimal data transfer. However, a corresponding high-performance software mechanism is also required to make sure sustained data transfer can be achieved.

This proprietary software mechanism is called Async DMA (short for Asynchronous DMA).

A number of data buffers are posted by the application software. Once a data buffer is filled, i.e. a DMA has been completed, ATS9146 hardware generates an interrupt, causing an event message to be sent to the application so it can start consuming data. Once the data has been consumed, the application can post the data buffer back on the queue. This can go on indefinitely.

One of the great advantages of Async DMA is that almost 95% of CPU cycles are available for data processing, as all DMA arming is done on an event-driven basis.

## Output Data Format

By default, ATS9146 data comes out as unsigned binary, where code 0 represents the negative full scale, code ($2^{n-1}$-1) represents the positive full scale with zero being $2^{n-2}$.

It is possible to change the data format to signed binary using an API call. In signed binary format, zero is represented by code 0, positive full scale is represented by ($2^{n-2}$-1) and negative full scale is represented by ($2^{n-2}$).

## Triggering

The ATS9146 is equipped with sophisticated analog and digital triggering options, such as programmable trigger thresholds and slope on any of the input channels or the External Trigger input.

While most oscilloscopes offer only one trigger engine, ATS9146 offers two trigger engines (called Engines J and K). This allows the user to combine the two engines using a logical OR operand.

The user can specify the number of records to capture in an acquisition, the length of each record and the amount of pre-trigger data.

A programmable trigger delay can also be set by the user. This is very useful for capturing the signal of interest in a pulse-echo application, such as ultrasound, radar, lidar etc.

## External Trigger Input

ATS9146 external trigger input (TRIG IN) can be set as an analog input with ±2.5 V full scale input range and 50 Ω input impedance, or a 3.3 V TTL input.

When TTL input is selected, the input impedance increases to approximately 6 kΩ, making it easier to drive the TRIG IN input from high output impedance sources.

## Trigger Time Stamp

A 40-bit time stamp counter comes standard with the ATS9146. By default, this counter is initialized to a zero value when an acquisition session is started and increments once for every sample captured, thus providing a 2-clock timing accuracy. At 125 MS/s sample rate, this counter will not roll over for well over 30 minutes.

The value of this counter is latched each time a trigger is detected and the latched value is included in Traditional AutoDMA Header.

This allows the user to find out the timing of each trigger in a multiple record acquisition relative to the start of the acquisition.

It is also possible to configure the timestamp counter to reset for the first acquisition only and never again, until a software reset is issued. This feature enables users to obtain precise timing information about multiple acquisitions. This feature is not supported by the standard API, but can be configured using special register reads and writes.

## Optional External Clock

While the ATS9146 features a 10 MHz TCXO as the source of the timebase system, there may be occasions when digitizing has to be synchronized to an external clock source.

ATS9146 External Clock option (order number ATS9146-005) provides an SMA input for an external clock signal with a frequency between 125 MHz and 1 MHz.

Users can also set a decimation factor for the external clock. For example, if the user wants to digitize the input signal on every tenth clock edge, this factor can be set to 10. Minimum decimation value is 1 and maximum is 100,000.

There are three types of External Clock supported by ATS9146. These are described below.

### Fast External Clock

A new sample is taken by the on-board ADCs for each rising (or falling) edge of this External Clock signal.

In order to satisfy the clocking requirements of the ADC chips being used, Fast External Clock frequency must always be higher than 1 MHz and lower than 125 MHz.

### Slow External Clock

This type of clock should be used when the clock frequency is either too slow or is a burst-type clock. Both these types of clock do not satisfy the minimum clock requirements listed above for Fast External Clock.

In this mode, the ATS9146 ADCs are run at a preset internal clock frequency. The user-supplied Slow External Clock signal is then monitored for low-to-high transitions. Each time there is such a transition, a new sample is stored into the on-board memory.

It should be noted that there can be a 0 to +8 ns sampling jitter when Slow External Clock is being used, as the internal ADC clock is not synchronized to the user-supplied clock.

### 10 MHz Reference Clock

It is possible to generate the sampling clock based on an external 10 MHz reference input. This is useful for RF systems that use a common 10 MHz reference clock.

In this mode, ATS9146 uses an advanced clock generator circuit consisting of a VCO and PLL to generate the sampling clock.

## AUX Connector

ATS9146 provides an AUX (Auxiliary) BNC connector that is configured as a Trigger Output connector by default.

When configured as a Trigger Output, AUX BNC connector outputs a 5 Volt TTL signal synchronous to the ATS9146 Trigger signal, allowing users to synchronize

their test systems to the ATS9146 Trigger. Note that the Trigger output is synchronized to a divide-by-2 clock.

When combined with the Trigger Delay feature of the ATS9146, this option is ideal for ultrasonic and other pulse-echo imaging applications.

AUX connector can also be used as a Trigger Enable Input and programmable Clock Output.

## Calibration

Every ATS9146 digitizer is factory calibrated for gain and offset accuracy to NIST- or CNRC-traceable standards, using an oscilloscope calibrator. To recalibrate an ATS9146, the digitizer must be shipped back to the factory.

## RoHS Compliance

ATS9146 units are fully RoHS compliant, as defined by Directive 2015/863/EU (RoHS 3) of the European Parliament and of the Council of 31 March 2015 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

All manufacturing is done using RoHS-compliant components and lead-free soldering.

## On-Board Monitoring

Adding to the reliability offered by ATS9146 are the on-board diagnostic circuits that constantly monitor over 15 different voltages, currents and temperatures. LED alarms are activated if any of the values surpass the limits.

## AlazarDSO Software

ATS9146 is supplied with the powerful AlazarDSO software that allows the user to setup the acquisition hardware and capture, display and archive the signals.

The Stream-To-Memory command in AlazarDSO allows users to stream a large dataset to motherboard memory.

AlazarDSO software also includes powerful tools for benchmarking the computer bus and disk drive.

## Software Development Kits

AlazarTech provides easy-to-use software development kits for customers who want to integrate the ATS9146 into their own software.

A Windows-compatible software development kit, called ATS-SDK, includes headers, libraries and source code sample programs written in C/C++, C#, Python, MATLAB, and LabVIEW.

A Linux-compatible software development kit, called ATS-devel, includes headers, libraries and source code sample programs written in C++ and Python.

These programs can fully control the ATS9146 and acquire data in user buffers.

The purchase of an ATS-SDK license includes a subscription that allows users to download ATS-SDK updates from the AlazarTech website for period of 12 months from the date of purchase.

Customers who want to download new releases beyond this 12 month period should purchase extended maintenance (order number ATS-SDK-1YR).

## ATS-GPU

ATS-GPU is a software library developed by AlazarTech to allow users to do real-time data transfer from ATS9146 to a CUDA®-enabled GPU card at full bus speed.

Interfacing waveform digitizers to GPUs involves creating a software mechanism to move data from one to the other and back to user buffers. The standard techniques used most often can get the job done, but feature very low data throughput due to software overheads.

AlazarTech designed ATS-GPU to eliminate this software bottleneck so that data can be moved from AlazarTech digitizers to GPUs and from GPUs to user buffers at full PCIe bus speeds. Once the data is available in GPU memory, many types of digital signal processing (DSP) can be done on this data at near-hardware speeds.

ATS-GPU-BASE is supplied with an example user application in source code. The application includes GPU kernels that use ATS-GPU to receive data, do very simple signal processing (data inversion), and copy the processed (inverted) data back to a user buffer. All this is done at the highest possible data transfer rate.

Programmers can replace the data inversion code with application-specific signal processing kernels to develop custom applications.

ATS-GPU-OCT is the optional OCT Signal Processing library for ATS-GPU. It contains floating point FFT routines that have also been optimized to provide the maximum number of FFTs per second. Kernel code running on the GPU can do zero-padding, apply a windowing function, do a floating point FFT, calculate the amplitude and convert the result to a log scale. It is also possible to output phase information.

ATS-GPU-NUFFT is an extension of ATS-GPU-OCT that allows non-uniform FFTs to be performed on data acquired uniformly in time domain using a fixed sampling rate. For SS-OCTs where the wavelength does not vary linearly in time, a fixed sampling rate results in data that is non-uniformly distributed in frequency domain. ATS-GPU-NUFFT allows linearized FFTs to be performed on such data.

ATS-GPU supports 64-bit Windows and 64-bit Linux for CUDA®-based development.

## Support for Windows

Windows support for ATS9146 includes Windows 11, Windows 10, Windows Server® 2019, and Windows Server 2016. As Windows Server 2019 and 2016 are seldom used by our customers, they are expected to work but are not regularly tested with each software release. If there are issues related to Windows Server 2016 or 2019, tech support may not be as rapid as for other operating systems.

Only 64-bit Windows operating systems are supported.

Microsoft mainstream support ended in 2018 for Windows 8.1 and Windows Server 2012 R2. As such, AlazarTech has ceased development on these operating systems. Current software and driver releases may work with these operating systems but they are not officially supported.

Due to lack of demand and due to the fact that Microsoft no longer supports these operating systems, AlazarTech no longer supports Windows 8, Windows 7, Windows XP, Windows Vista, Windows Server 2012, Windows Server 2008 R2, and Windows Server 2008.

## Linux Support

AlazarTech offers Dynamic Kernel Module Support (DKMS) drivers for the following Linux distributions: Ubuntu, Debian, and RHEL®.

AlazarTech DKMS drivers may work for other Linux distributions but they have not been tested and technical support may be limited.

Users can download the DKMS driver and associated library for their specific distribution here:
www.alazartech.com/en/linux-drivers/ats9146/17/

Only 64-bit Linux operating systems are supported.

A GUI application called AlazarFrontPanel that allows simple data acquisition and display is also provided.

ATS-SDK includes source code example programs for Linux, which demonstrate how to acquire data programmatically using a C compiler. Note that example programs are only provided for Python and C++.

Based on a minimum annual business commitment, the Linux driver source code license (order number ATS9146-LINUX) may be granted to qualified OEM customers for a fee. For release of driver source code, a Non-Disclosure Agreement must be executed between the customer's organization and AlazarTech.

All such source code disclosures are made on an as-is basis with limited support from the factory.

## Upgrading Your Digitizer in The Field

It is always recommended to get upgrades installed at the factory with the initial digitizer purchase.

If the digitizer is still under warranty, it may be possible to add certain upgrades in the field, but there is a small chance that the upgrade will not work, in which case the digitizer would need to be returned to the factory to complete the upgrade.

If the digitizer is no longer under warranty, the upgrade must be done at the factory and there will be a minimum service charge in addition to the cost of the upgrade. This is so that AlazarTech can verify that the digitizer meets basic performance levels prior to any upgrade.

## Technical Support

AlazarTech is known for its world-class technical support. Customers receive free technical support on hardware products that are under warranty.

AlazarTech digitizers come with a standard one (1) year parts and labor warranty. This warranty can be extended for a fee (more information can be found in the Extended Warranty section below).

If your waveform digitizer is out of warranty, you will not be eligible for free technical support on AlazarTech hardware or software products and you will need to purchase technical support hours (order number SUPPORT-HR5) to obtain assistance.

In addition, any necessary repairs to your out-of-warranty hardware products will carry a minimum bench charge.

## Extended Warranty

The purchase of an ATS9146 includes a standard one (1) year parts and labor warranty. Customers may extend their warranty by ordering an Extended Warranty (order number ATS9146-061).

This must be purchased before expiration of the standard warranty (or before expiration of an Extended Warranty). Extended Warranties can only be purchased while there is a valid warranty in place.

Users can purchase up to 4 (four) additional years of warranty extensions for a maximum total of 5 years of warranty.

Get your warranty end date by registering your product at: www.alazartech.com/en/my-account/my-products/.

## Export Control Classification

According to the Export Controls Division of Government of Canada, ATS9146 is currently not controlled for export from Canada. Its export control classification is N8, which is equivalent to ECCN EAR99. ATS9146 can be shipped freely outside of Canada, with the exception of countries listed on the *Area Control List* and *Sanctions List*. Furthermore, if the end-use of ATS9146, in part or in its entirety, is related to the development or deployment of weapons of mass destruction, AlazarTech is obliged to apply for an export permit.

## EC Conformity

ATS9146 conforms to the following standards:

Electromagnetic Emissions:
CISPR 32/EN 55032:2015/A11:2020 (Class A): Multimedia Equipment (MME). Radio disturbance characteristics. Limits and method of measurement: EN 61000-3-2:2014, EN 61000-3-3:2013.

Electromagnetic Immunity:
CISPR 35/EN 55035:2017:
Multimedia Equipment (MME) Immunity characteristics — Limits and methods of measurement.

Safety:
IEC 62368-1:2014 / EN 62368-1:2014+A11:2017: Information technology equipment — Safety — Part 1: General requirements.

ATS9146 also follows the provisions of the following directives: 2014/35/EU (Low Voltage Equipment); 2014/30/EU (Electromagnetic Compatibility).

## FCC & ICES-003 Compliance

ATS9146 has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15, subpart B of the FCC Rules, and the Canadian Interference-Causing Equipment Standard ICES-003 Issue 7 October 2020.

## System Requirements

Personal computer with at least one free PCIe slot, 16 GB RAM, 100 MB of free hard disk space, SVGA display adaptor and monitor with at least a 1024 x 768 resolution.

## Power Requirements

| | |
|---|---|
| +12 V | 1 A, typical |
| +3.3 V | 0.25 A, typical |

## Physical

| | |
|---|---|
| Size | Single slot, half length PCI Express card (4.38 inches x 6.5 inches excluding the connectors protruding from the front panel) |
| Weight | 142 g |

## I/O Connectors

| | |
|---|---|
| CH A, CH B, TRIG IN, AUX I/O | BNC female connectors |
| ECLK | SMA female connector |

## Environmental

| | |
|---|---|
| Operating temperature | 0 to 55 degrees Celsius |
| Storage temperature | -20 to 70 degrees Celsius |
| Relative humidity | 5 to 95%, non-condensing |

## Acquisition System

| | |
|---|---|
| Resolution | 14 bits<br>Data is returned as MSB-justified 16 bit unsigned integers |
| Bandwidth (-3 dB) | |
| DC-coupled, 1 MΩ | DC - 10 MHz |
| DC-coupled, 50 Ω | DC - 65 MHz |
| AC-coupled, 1 MΩ | 10 Hz - 10 MHz |
| AC-coupled, 50 Ω | 100 kHz - 65 MHz |
| Number of channels | 2, simultaneously sampled |
| Maximum sample rate | 125 MS/s single shot |
| Minimum sample rate | 1 KS/s single shot for internal clocking |
| Full scale input ranges | |
| 1 MΩ input impedance: | ±20 mV, ±40 mV, ±50 mV, ±80 mV, ±100 mV, ±200 mV, ±400 mV, ±500 mV, ±800 mV, ±1 V, ±2 V, ±4 V, ±5 V, ±8 V, and ±10 V, software-selectable |
| 50 Ω input impedance: | ±20 mV, ±40 mV, ±50 mV, ±80 mV, ±100 mV, ±200 mV, ±400 mV, ±500 mV, ±800 mV, ±1 V, ±2 V, and ±4 V, software-selectable |
| DC accuracy | ±2% of full scale in all input ranges |
| Input coupling | AC or DC, software-selectable |
| Input impedance | 50 Ω or<br>1 MΩ ±1% in parallel with 55 pF ±5 pF, software-selectable<br>For input ranges ≥2 V: 53 pF ±2 pF<br>For input ranges ≤1 V: 56 pF ±2 pF |
| Absolute maximum input | |
| 1 MΩ | ±28 V (DC + peak AC for CH A, CH B and EXT only without external attenuation) |
| 50 Ω | ±4 V (DC + peak AC for CH A, CH B and EXT only without external attenuation) |

## On-Board Acquisition Memory System

| | |
|---|---|
| On-board acq. memory | 512 Megabytes |
| Acquisition memory/ch | Up to 128 Million samples per channel |
| Record length | Software-selectable with 32-point resolution, specified in number of sample points. Must be a minimum of 128 points and must be a multiple of 32. |
| Number of records | Software-selectable from a minimum of 1 to a maximum of infinite number of records |
| Pre-trigger depth | 16 to (Record Length - 64) points, software-selectable, with 16-point resolution in traditional mode |
| Post-trigger depth | Record Length - Pre-Trigger Depth |

## Timebase System

| | |
|---|---|
| Timebase options | Internal Clock or<br>External Clock (Optional) |
| Internal sample rates | 125 MS/s, 100 MS/s, 50 MS/s, 20 MS/s, 10 MS/s, 5 MS/s, 2 MS/s, 1 MS/s, 500 KS/s, 200 KS/s, 100 KS/s, 50 KS/s, 20 KS/s, 10 KS/s, 5 KS/s, 2 KS/s, 1 KS/s |
| Internal clock accuracy | ±25 ppm |

## Optional ECLK (External Clock) Input

| | |
|---|---|
| Input impedance | 50 Ω for AC signals<br>10 kΩ for DC |
| Input coupling | AC |
| **Fast External Clock** | |
| Signal level | 500 $mV_{P-P}$ to 2 $V_{P-P}$ |
| Maximum frequency | 125 MHz with 50% ±5% duty cycle |
| Minimum frequency | 1 MHz with 50% ±5% duty cycle |
| Sampling edge | Rising |
| Decimation factor | Software-selectable from 1 to 100,000 |
| **Slow External Clock** | |
| Signal level | 3.3 V LVTTL |
| Maximum frequency | 10 MHz with minimum positive or negative pulse width of 8 ns |
| Minimum frequency | DC |

## Optional 10 MHz Reference Input

| | |
|---|---|
| Signal level | 500 $mV_{P-P}$ to 2 $V_{P-P}$ |
| Input impedance | 50 Ω |
| Input coupling | AC coupled |
| Input frequency | 10 MHz ± 0.1 MHz |
| Maximum frequency | 10.1 MHz |
| Minimum frequency | 9.9 MHz |
| Sampling clock freq. | 125 MHz, 100 MHz, 50 MHz, 20 MHz, 10 MHz, 5 MHz, 2 MHz, 1 MHz, 500 kHz, 200 kHz, 100 kHz, 50 kHz, 20 kHz, 10 kHz, 5 kHz, 2 kHz, 1 kHz, software-selectable |

## Triggering System

| | |
|---|---|
| Mode | Edge triggering with hysteresis |
| Comparator type | Analog comparators |
| Number of trigger engines | 2 |
| Trigger engine combination | Engine J, engine K, J OR K, software-selectable |
| Trigger engine source | CH A, CH B, EXT, Software or None, independently software-selectable for each of the two Trigger Engines |
| Hysteresis | ±5% of full scale input, typical |
| Trigger sensitivity | ±10% of full scale input range. This implies that the trigger system may not trigger reliably if the input has an amplitude less than ±10% of full scale input range selected |
| Trigger level accuracy | ±5%, typical, of full scale input range of the selected trigger source |
| Bandwidth | 65 MHz |
| Trigger delay | Software-selectable from 0 to 9,999,999 sampling clock cycles. Must meet alignment requirements (see ATS-SDK User Manual for more information). |
| Trigger timeout | Software-selectable with a 10 µs resolution. Maximum settable value is 3,600 seconds. Can also be disabled to wait indefinitely for a trigger event |

## TRIG IN (External Trigger) Input

| | |
|---|---|
| Input type | Analog or 3.3 V TTL, software-selectable |
| Input coupling | DC only |
| Analog input impedance | 1 MΩ |
| Analog bandwidth (-3 dB) | DC - 25 MHz |
| Analog input range | ±2.5 V |
| Analog DC accuracy | ±10% of full scale input |
| Analog absolute max. input | ±8 V (DC + peak AC without external attenuation) |
| TTL input impedance | 6 kΩ ±10% |
| TTL min. pulse width | 32 ADC sampling clocks |
| TTL min. pulse amplitude | 2 Volts |
| TTL absolute max. input | -0.7 V to +5.5 V |

## Auxiliary I/O (AUX I/O)

| | |
|---|---|
| Signal direction | Input or Output, software-selectable. Trigger Output by default |
| Output types: | Trigger Output, Pacer (programmable clock) Output, Software-controlled Digital Output |
| Input types: | Trigger Enable Software-readable Digital Input |
| Output | |
| Amplitude: | 5 Volt TTL |
| Synchronization: | Synchronized to a clock derived from the ADC sampling clock. |
| Input | |
| Amplitude: | 3.3 Volt TTL (5 Volt compliant) |
| Input coupling: | DC |

## Materials Supplied

ATS9146 PCIe Card

ATS9146 Installation Disk (on USB Flash Drive)

## Certification and Compliances

RoHS 3 (Directive 2015/863/EU) Compliance

CE Marking — EC Conformity

FCC Part 15 Class A / ICES-003 Class A Compliance

*All specifications are subject to change without notice*

## ORDERING INFORMATION

| | |
|---|---|
| ATS9146 | ATS9146-001 |
| ATS9146: External Clock Upgrade | ATS9146-005 |
| ATS9146: One Year Extended Warranty | ATS9146-061 |
| ATS-SDK purchased with a digitizer board or ATS-GPU: License + 1 Year Subscription (Supports C/C++, Python, MATLAB, and LabVIEW) | ATS-SDK |
| ATS-SDK purchased separately: License + 1 Year Subscription + 5 hours of technical support (Supports C/C++, Python, MATLAB, and LabVIEW) | ATS-SDK-WOD |
| ATS-GPU-BASE: GPU Streaming Library License + 1 Year Subscription | ATSGPU-001 |
| ATS-GPU-OCT: Signal Processing Library License + 1 Year Subscription (requires ATSGPU-001) | ATSGPU-101 |
| ATS-GPU-NUFFT: ATS-GPU-OCT Extension for fixed-frequency sampled data License + 1 Year Subscription (requires ATSGPU-001 & ATSGPU-101) | ATSGPU-201 |
| 5 Hours of technical support | SUPPORT-HR5 |



**Manufactured By:**

**Alazar Technologies Inc.**

6600 TRANS-CANADA HIGHWAY, SUITE 310
POINTE-CLAIRE, QC, CANADA H9R 4S2

TOLL FREE: 1-877-7-ALAZAR
TEL: (514) 426-4899 FAX: (514) 426-2723

E-MAIL: sales@alazartech.com

# DATASHEET REVISION HISTORY

| Changes from version 1.3A (July 2022) to version 1.3B | Section, Page |
|---|---|
| Removed 32-bit Windows | Feature Table, pg. 1 |
| Added new section to specify default output data format is unsigned binary and that it can be changed to signed binary via an API call. | Output Data Format, pg. 3 |
| Separate description for Linux SDK to detail supported programming languages | Software Development Kits, pg. 5 |
| Noted that only 64-bit Windows is supported and that the last driver version that supports 32-bit Windows is 5.10.24. | Support for Windows, pg. 6 |
| Updated download link for the Linux driver and associated library, and added note: ATS-SDK example programs are only provided for Python and C++ | Linux Support, pg. 6 |
| Added new section to detail AlazarTech's upgrade policy | Upgrading Your Digitizer in The Field, pg. 6 |

| Changes from version 1.3 (Nov 2021) to version 1.3A | Section, Page |
|---|---|
| Changes to maintenance subscription inclusions: removed technical support | Software Development Kits, pg. 5 |
| Added Windows 11 | Support for Windows, pg. 5 |
| Added new section to specify how AlazarTech handles technical support: Customers receive free technical support on hardware products that are under warranty. Out-of-warranty support requires the purchase of support hours. | Technical Support, pg. 6 |
| Updated Electromagnetic Emissions standard number (revised report) | EC Conformity, pg. 6 |
| Updated specification name from *Input protection* to *Absolute maximum input* Actual value did not change. | Acquisition System, pg. 7 |
| Updated specification names (actual values did not change): *Analog input protection* to *Analog absolute max. input* *TTL input protection* to *TTL absolute max. input*. | TRIG IN (External Trigger) Input, pg. 8 |
| Updated name for product *Software Development Kit* Now called: *ATS-SDK purchased with a digitizer board or ATS-GPU* | Ordering Information, pg. 8 |
| Added products ATS-SDK-WOD and SUPPORT-HR5 | Ordering Information, pg. 8 |

| Changes from version 1.2b (Sept 2021) to version 1.3 | Section, Page |
|---|---|
| Removed mention of *NPT AutoDMA footer* as it is not supported | Trigger Time Stamp, pg. 4 |
| Specified number of extended warranties that users may purchase | Extended Warranty, pg. 6 |

| Changes from version 1.2a (March 2021) to version 1.2b | Section, Page |
|---|---|
| Updated support status for Windows 8.x and Windows Server versions 2012 R2, 2016, 2019 | Support for Windows, pg. 5 |
| Updated Linux Support (RHEL) | Linux Support, pg. 5 |
| Updated Electromagnetic Immunity and Safety standards | EC Conformity, pg. 6 |

| Changes from version 1.2 (June 2020) to version 1.2a | Section, Page |
|---|---|
| Corrected input voltage range with software-selectable attenuation to ±20 mV to ±10 V | Analog Input, pg. 2 |
| Edited section Traditional AutoDMA: removed sentence about Traditional AutoDMA being the recommended mode of operation (for ATS9146, both *Traditional AutoDMA* and *NPT AutoDMA* can acquire data to PC host memory at the maximum sustained transfer rate of the motherboard). | Traditional AutoDMA, pg. 3 |
| Updated section *No Pre-Trigger (NPT) AutoDMA*: removed paragraph about NPT AutoDMA being the recommended mode of operation. | No Pre-Trigger (NPT) AutoDMA, pg. 3 |
| Updated supported Windows versions - removed Windows 7 & Windows Server 2008 R2 | Support for Windows, pg. 5 |
| Corrected standards for Electromagnetic Emissions, Electromagnetic Immunity, and Safety; Corrected Low Voltage Equipment and Electromagnetic Compatibility directives | EC Conformity, pg. 7 |
| Corrected ICES-003 standard from ICES-003:2004 to ICES-003 Issue 7 October 2020 | FCC & ICES-003 Compliance, pg. 7 |
| Added Auxiliary I/O input coupling (DC) | Auxiliary I/O (AUX I/O), pg. 8 |
| Updated descriptions for ATS-SDK, ATSGPU-001, ATSGPU-101, ATSGPU-201 | Ordering Information, pg. 8 |