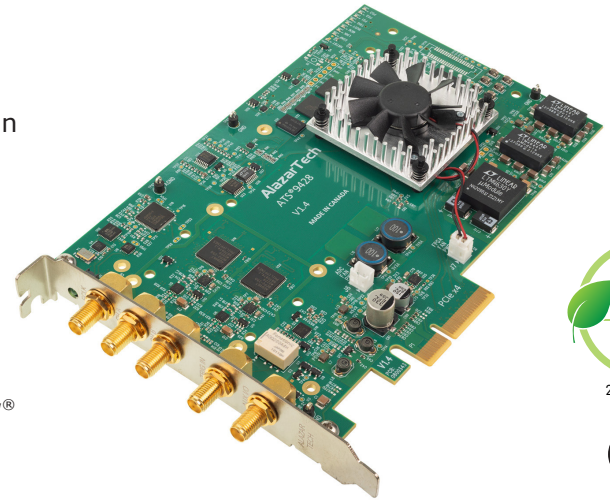
ATS9428

250 MS/s 14-Bit DC-coupled PCIe Digitizer

- 2 channels sampled at 14-bit resolution
- 250 MS/s real-time sampling rate
- 256 Megasamples of on-board acquisition memory per channel
- PCI Express Gen 2 x4 (4-lane) interface
- Continuous streaming mode
- 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
ATS9428	PCIe x4	64-bit Windows & 64-bit Linux	2	250 MS/s	DC-120 MHz	256 Megasamples	14 bits

Overview

AlazarTech ATS®9428 is a 4-lane PCI Express Gen 2, dual-channel, high-speed, 14-bit, 250 MS/s wave-form digitizer card with DC-coupled inputs capable of streaming acquired data to PC memory at rates up to 1.6 GB/s or storing it in its deep on-board dual-port acquisition memory buffer of 256 Megasamples.

Unlike other products on the market, ATS9428 does not use interleaved sampling. Each input has its own 14-bit, 250 MSPS ADC chip.

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

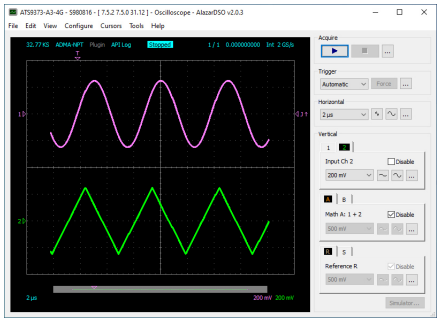
ATS9428 is supplied with AlazarDSO software that lets the user get started immediately without having to go through a software development process.

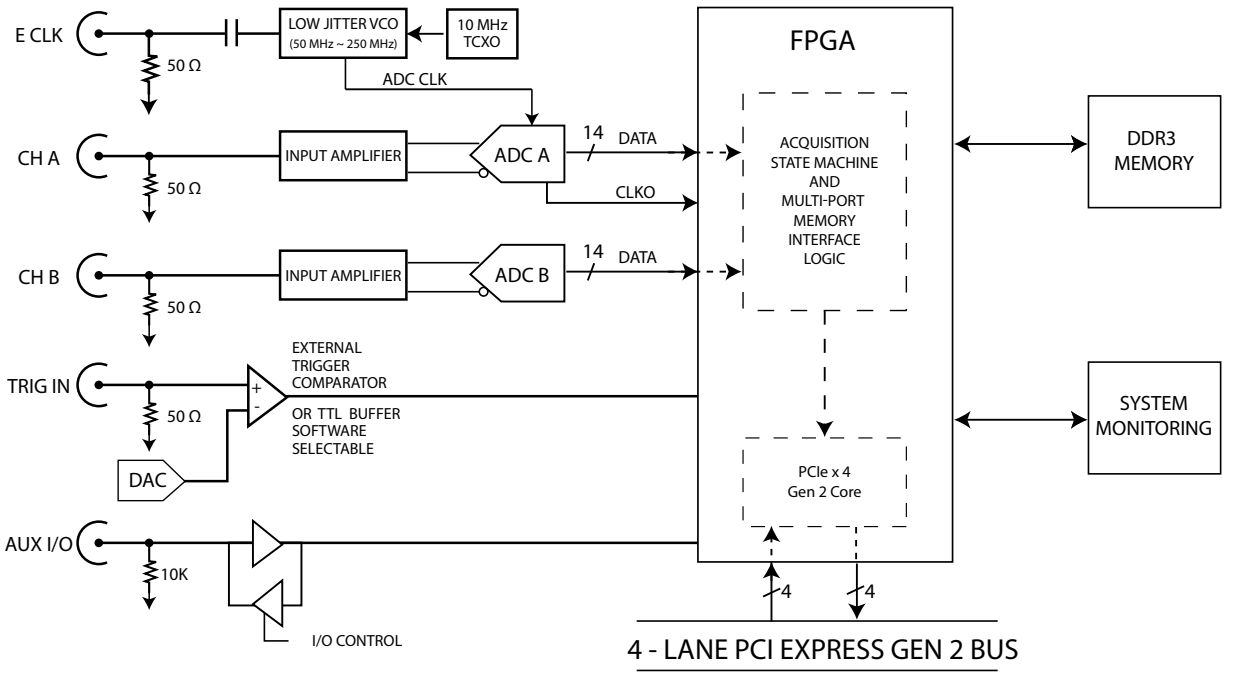
Users who need to integrate the ATS9428 in their own program can purchase a software development kit, ATS-SDK, for C/C++, C#, Python, MATLAB and LabVIEW for both Windows and Linux operating systems.

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

Applications

Optical Coherence Tomography (OCT)
Radar/RF Signal Recording & Analysis
Ultrasonic & Eddy Current NDT/NDE
Terabyte Storage Oscilloscope
High Resolution Oscilloscope
Lidar
Spectroscopy
Digital Down Conversion (DDC)
Multi-Channel Transient Recording





PCI Express Bus Interface

ATS9428 interfaces to the host computer using a 4-lane PCI Express bus. Each lane operates at 5 Gbps (Gen 2).

The physical and logical PCIe x4 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.

Some PCIe slots use open-ended sockets to allow for longer cards. As such, ATS9428 requires at least one free 4-lane, 8-lane or 16-lane, or an open-ended slot on the motherboard.

The number of lanes actually connected to a PCIe slot may be fewer than the number supported by the physical slot size. In other words, a 4-lane slot may not provide a x4 electrical connection. Users must ensure that the slot is electrically x4 and Gen 2 or higher to achieve maximum sustained transfer rates; data throughput will be halved if ATS9428 is plugged into a Gen1 slot.

The AlazarTech® 1.6 GB/s benchmark was done using an ASUS® WS X299 SAGE motherboard.

The same performance can be expected from virtually all other motherboards.

Analog Input

ATS9428 has two DC-coupled analog input channels. Each channel has analog input bandwidth from DC to 120 MHz. Input impedance of both channels is fixed at 50 Ω. The full scale input range is fixed at ±1.25 V.

For applications that require capture of small signals, customers can purchase the ATS9428-014 upgrade that allows the input range to be permanently changed to ±200 mV. It should be noted that the analog input bandwidth is limited to 100 MHz with this upgrade. Furthermore, this upgrade must be done at the factory and must be ordered at the time of placing the ATS9428 order.

Acquisition System

ATS9428 PCI Express digitizers use state of the art 250 MSPS, 14-bit ADCs to digitize the input signals. The real-time sampling rate of the ADCs ranges from 250 MS/s down to 50 MS/s.

The two channels are guaranteed to be simultaneous, with a maximum clock skew of 10 ps. Additive jitter of the clock distributor circuit is less than 225 fs_{rms}.

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 ATS9428, 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 256 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.

On-Board Acquisition Memory

ATS9428 provides 256 Million samples per channel of on-board dual-port memory that can be used for signal storage.

This on-board memory is used as a very deep FIFO to temporarily store acquired ADC data before transferring it to motherboard memory using proprietary DMA engines. This on-board buffer allows loss-less data transfer even if the computer is temporarily interrupted by other tasks.

Maximum Sustained Transfer Rate

PCI Express support on different motherboards is not always the same, resulting in significantly different sustained data transfer rates. The reasons behind these differences are complex and varied and will not be discussed here.

ATS9428 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.

ATS9428, which is equipped with dual-port on-board memory, will be able to achieve this maximum sustained transfer rate.

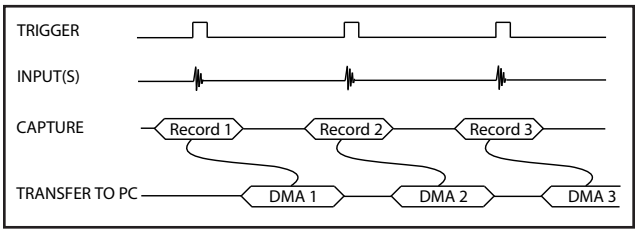
Recommended Motherboards or PCs

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.

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 8192 records (triggers). This number is called RecordsPerBuffer.



Users can also specify that each record should come with its own header that contains a 40-bit trigger timestamp.

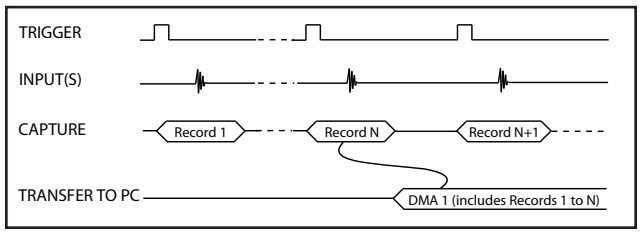
While Traditional AutoDMA can acquire data to PC host memory at the maximum sustained transfer rate of the motherboard, a BUFFER_OVERFLOW can occur if more than 512 triggers occur in very rapid succession, even if all the on-board memory has not been used up.

ATS9428 features a high-performance memory management firmware that allows much faster data throughput in Traditional mode than previous generation digitizers.

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 and the entire on-board memory acts like a very deep FIFO.



Note that a DMA is not started until RecordsPerBuffer number of records (triggers) have been acquired and written to the on-board memory.

NPT AutoDMA buffers do not include headers or footers.

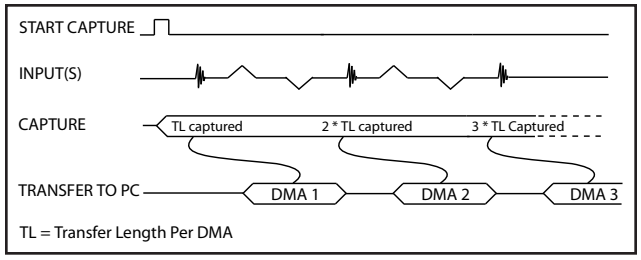
More importantly, a BUFFER_OVERFLOW flag is asserted only if the entire on-board memory is used up. This provides a very substantial improvement over Traditional AutoDMA.

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

Continuous AutoDMA

Continuous AutoDMA is also known as the data streaming mode.

In this mode, data starts streaming across the PCIe Express bus as soon as the ATS9428 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 only if the entire on-board memory is used up.

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.

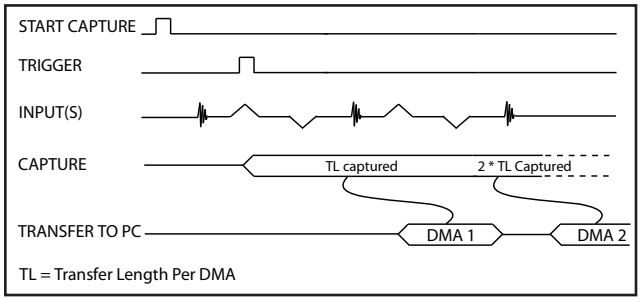
Triggered Streaming AutoDMA

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 only if the entire on-board memory is used up.

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.

This is the recommended mode for RF signal recording that has to be started at a specific time, e.g. based on a GPS pulse.

Multi-board Systems using ATS 4X1G

ATS9428: Sync 4X1G is a device that allows simultaneous sampling across multiple independent ATS9428 waveform digitizers. This is achieved by providing common clock and trigger signals to each digitizer.

Sync 4X1G supports Trigger Enable and Trigger Disable so that users can delay triggering until all digitizers are armed; this is a distinct advantage over passive signal splitters.

ATS Sync 4X1G comes with a software library that allows user software to control it.

Sync 4X1G interfaces to AlazarTech digitizer cards using a proprietary high-frequency cable. The provided cable terminates in a ganged micro-miniature RF connector, which is used to connect to the Sync 4X1G.

The other end of the cable terminates in male SMA and BNC connectors, which are used to connect to the digitizer External Clock and External Trigger respectively.

Sync 4X1G connects to the host computer using a provided USB cable. Please refer to the ATS Sync 4X1G datasheet for full specifications.

Asynchronous DMA Driver

The various 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, ATS9428 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.

To the best of our knowledge, no other supplier of waveform digitizers provides asynchronous software drivers. Their synchronous drivers force the CPU to manage data acquisition, thereby slowing down the overall data acquisition process.

Output Data Format

By default, ATS9428 data comes out as unsigned binary, where code 0 represents the negative full scale, code (2^n-1) represents the positive full scale with zero being 2^{n-1}.

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-1}-1) and negative full scale is represented by (2^{n-1}).

Triggering

ATS9428 is equipped with sophisticated 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, ATS9428 offers two trigger engines (called Engines J and K).

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

The external trigger input on the ATS9428 is labeled TRIG IN on the face plate.

By default, the input impedance of this input is 50 Ω and the full scale input range is ±3 Volts. The trigger signal is treated as an analog signal in this situation and a high-speed comparator receives the signal.

It is also possible to trigger the ATS9428 using a 3.3 V TTL signal. Input impedance is approximately 6.3 kΩ in this mode. This is very useful in imaging applications that use a trigger signal that cannot drive a 50 Ω load.

Timebase

ATS9428 timebase can be controlled either by on-board low-jitter VCO or by External Clock.

On-board low-jitter VCO uses an on-board 10 MHz TCXO as a reference clock.

External Clock

While the ATS9428 features low-jitter VCO and 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.

ATS9428 External Clock provides an SMA input for an external clock signal, which should have a high slew rate. Signal levels, specified in detail on page 9, must be respected.

Input impedance for the External Clock input is fixed at 50 Ω. External clock input is always AC-coupled.

There are two types of External Clock supported by ATS9428: Fast External Clock, and 10 MHz Reference Clock.

Fast External Clock

A new sample is taken by the on-board ADCs for each rising 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 50 MHz and lower than 250 MHz.

This is the ideal clocking scheme for OCT applications

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.

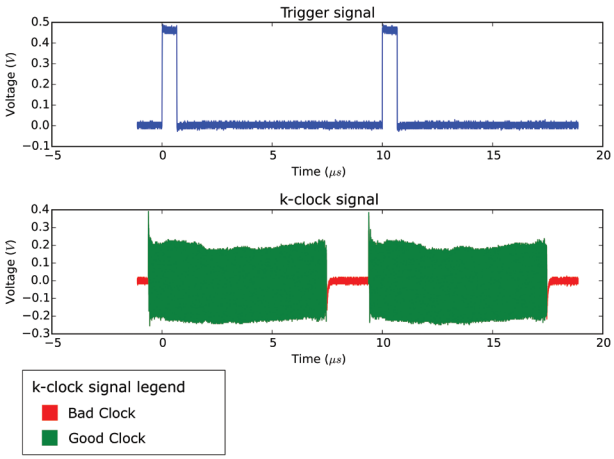
ATS9428 uses an on-board low-jitter VCO to generate the 250 MHz high frequency clock used by the ADC. This 250 MS/s sampled data can then be decimated by a factor of 1, 2, 5, 10 or any other integer value that is divisible by 5.

OCT Ignore Bad Clock

The ADCs used on the ATS9428 require the external clock frequency to be above 50 MHz and lower than 250 MHz. In OCT applications, these limits cannot always be respected due to the nature of the optical source.

AlazarTech's *OCT Ignore Bad Clock* technology, allows safe operation with these out-of-specification clocks without requiring the use of a dummy clock in the source.

Users must set the trigger source to be External Trigger input (TRIG IN) when using OCT Ignore Bad Clock. The External Trigger must be set in TTL input range. If these two conditions are not met, the OCT Ignore Bad Clock circuitry will not function.



See www.alazartech.com/en/technology/oct-ignore-bad-clock/ for more information on this technology.

AUX Connector

ATS9428 provides an AUX (Auxiliary) SMA connector that is configured as a Trigger Output connector by default.

When configured as a Trigger Output, AUX SMA connector outputs a 5 Volt TTL signal synchronous to the ATS9428 Trigger signal, allowing users to synchronize their test systems to the ATS9428 Trigger.

When combined with the Trigger Delay feature of the ATS9428, this option is ideal for ultrasonic and other pulse-echo imaging applications.

AUX connector can also be used as a Trigger Enable Input, or "Frame Start" input, which can be used to acquire complete frames, or B-scans, in imaging applications. In fact, this is the most popular use of the AUX connector in OCT applications.

Calibration

Every ATS9428 digitizer is factory calibrated to NIST- or CNRC-traceable standards. To recalibrate an ATS9428, the digitizer must be shipped back to the factory.

Test Reports

AlazarTech thoroughly tests every digitizer that leaves the factory; each board must pass hundreds of tests before it is shipped to a customer.

In addition to an 8-hour burn-in, each digitizer undergoes a full Performance Verification Test (PVT) where functionality such as external trigger, internal & external clock are tested, and characteristics such as frequency response and bandwidth are measured to ensure that they are within specification.

Customers can obtain test reports for their AlazarTech digitizer (for a fee) by adding the following order number to their digitizer order: *TestReport*. When ordering test reports after the digitizer order, use: *TestReport-AO*.

AlazarDSO Software

ATS9428 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 ATS9428 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 ATS94628 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 ATS9428 to a GPU card at rates up to 1.6 GB/s.

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.

Version 23.1.0 and higher of ATS-GPU-BASE includes a Boxcar Averaging example kernel that provides the ability to perform real-time boxcar averaging on signals acquired by AlazarTech waveform digitizers. It uses optimized GPU routines that allow raw data acquisition rates up to 6.9 GB/s. This signal processing module can lead to a major improvement of signal-to-noise ratio without using CPU resources and without doing FPGA programming.

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.

FFTs can be done on triggered data or on continuous gapless stream of data. It is also possible to do spectral averaging. Our benchmarks showed that it was possible to do 240,000 FFTs per second when capturing data in dual-channel mode and using a NVIDIA® Quadro® P5000 GPU.

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 ATS9428 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/ats9428/665/

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 ATS9428-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 next section: *Extended Warranty*).

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 ATS9428 includes a standard one (1) year parts and labor warranty. AlazarTech hardware parts and labor warranty should be maintained to ensure uninterrupted access to technical support and warranty repair services.

Customers may extend their warranty by ordering the Extended Warranty (order number ATS9428-061).

This should be purchased before expiration of the standard warranty (or before expiration of an Extended Warranty).

If the warranty lapses, renewal at a later date will be subject to a reinstatement fee, to cover the administrative costs of warranty reinstatement, and a 6-month waiting period for repair claims. Furthermore, warranty must be extended at least 6 months past the current date.

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 the Government of Canada*, ATS9428 is currently not controlled for export from Canada. Its export control classification is N8, which is equivalent to ECCN EAR99. ATS9428 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 ATS9428, 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.

RoHS Compliance

ATS9428 is 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.

REACH Compliance

AlazarTech verifies its supply chain against the latest REACH requirements. A compliance statement is usually available within 6 months of release of the European Chemicals Agency (ECHA) updated substance of very high concern (SVHC), Authorizations, and Restrictions lists.

EC Conformity

ATS9428 conforms to the following standards:

Electromagnetic Emissions:
CISPR 32:2015/AMD1:2019 /
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:
EN 55035:2017/A11:2020 / CISPR 35:2016:
Multimedia Equipment (MME) Immunity characteristics — Limits and methods of measurement:
IEC 61000-4-2:2008 / EN 61000-4-2:2009,
IEC/EN 61000-4-3:2006/A2:2010,
IEC/EN 61000-4-4:2012,
IEC 61000-4-5:2005 / EN 61000-4-5:2006,
IEC 61000-4-6:2008 / EN 61000-4-6:2009,
IEC 61000-4-8:2009 / EN 61000-4-8:2010,
IEC/EN 61000-4-11:2004/A1:2017

Safety:
IEC 62368-1:2018 / EN 62368-1:2018: Audio/video, information and communication technology equipment - Part 1: Safety requirements.

ATS9428 also follows the provisions of the following directives: 2014/35/EU (Low Voltage Equipment); 2014/30/EU (Electromagnetic Compatibility).

FCC & ICES-003 Compliance

ATS9428 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 x4, x8, or x16 or open-ended PCI Express slot (must be Gen 2 [or higher] x4 slot to achieve full data throughput) and 16 GB RAM; if using AlazarDSO, 16 GB of free hard disk space is also required.

Power Requirements

+12 V	1.5 A, typical
+3.3 V	1.0 A, typical

Physical

Size	Single slot, half length PCI Express card (4.377 inches x 6.5 inches excluding the connectors protruding from the front panel)
Weight	250 g

I/O Connectors

ECLK, CH A, CH B, TRIG IN, AUX I/O	SMA female connectors

Environmental

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

Acquisition System

Resolution	14 bits
Bandwidth (-3 dB) DC-coupled, 50 Ω	Without ATS9428-014 upgrade: DC - 120 MHz With ATS9428-014 upgrade: DC - 100 MHz
Number of channels	2, simultaneously sampled
Maximum Sample Rate	250 MS/s single shot
Minimum Sample Rate	1 MS/s single shot for internal clocking
Full Scale Input range:	±1.25 V standard. Can be permanently changed to ±200 mV with ATS9428-014 upgrade
Input coupling	DC only
Input impedance	50 Ω ±1%
Absolute maximum input	±2 V (DC + peak AC for CH A, CH B and TRIG IN only without external attenuation)

Acquisition Memory System

Acquisition Memory/ch	256 Million samples per channel
Record length	Software selectable with 32-point resolution. Record length must be a minimum of 256 points. There is no upper limit on the maximum record length.
Number of records	Software selectable from a minimum of 1 to a maximum of infinite number of records
Pre-trigger depth	From 0 to 4080 for single channel in NPT mode From 0 to 2040 for dual channel in NPT mode
Post-trigger depth	Record Length – Pre-Trigger Depth

Timebase System

Timebase options	Internal Clock or External Clock
Internal Sample Rates	250 MS/s, 200 MS/s, 125 MS/s, 100 MS/s, 50 MS/s, 20 MS/s, 10 MS/s, 5 MS/s, 2 MS/s, 1 MS/s
Internal Clock accuracy	±2 ppm

Dynamic Parameters

Typical values measured on the 400 mV range of CH A of a randomly selected ATS9428. Input signal was provided by a Rohde & Schwarz SMB100A signal generator, followed by a 9-pole, 10 MHz band-pass filter (TTE Q36T-50M-5M-50-720BMF). Input frequency was set at 49.9 MHz at -0.5 dBFS, which was approximately 95% of the full scale input.

SNR	69.2 dB
SINAD	57.3 dB
SFDR	59.6 dBc

ECLK (External Clock) Input

Signal Level	500 mV_{P-P} to 3.3 V_{P-P}
Input impedance	50 Ω
Input coupling	AC
Maximum frequency	250 MHz for Fast External Clock
Minimum frequency	50 MHz for Fast External Clock
Sampling Edge	Rising
Maximum amplitude	2 V_{P-P}

10 MHz Reference PLL Input

Signal Level	500 mV_{P-P} to 3.3 V_{P-P}
Input impedance	50 Ω
Input Coupling	AC
Input frequency	10 MHz ± 0.1 MHz
Maximum frequency	10.1 MHz
Minimum frequency	9.9 MHz
Sampling Clock Freq.	250 MHz

Triggering System

Mode	Edge triggering with hysteresis
Comparator Type	Digital comparators for internal (CH A, CH B) triggering and analog comparators for TRIG IN (External) triggering
Number of Trigger Engines	2
Trigger Engine Combination	Engine J, engine K, J OR K, software selectable
Trigger Engine Source	CH A, CH B, TRIG IN, 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	50 MHz
Trigger Delay	Software selectable from 0 to 9,999,999 sampling clock cycles
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	50 Ω
Analog bandwidth (-3 dB)	DC - 250 MHz
Analog input range	±3 V
Analog DC accuracy	±10% of full scale input
Analog absolute max. input	±8 V (DC + peak AC without external attenuation)
TTL input impedance	6.3 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 1)

Signal direction	Input or Output, software-selectable. 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. Divide-by-4 clock (dual channel mode) or divide-by-8 clock (single channel mode)
Input	
Amplitude:	3.3 Volt TTL
Input coupling:	DC

Materials Supplied

ATS9428 PCI Express Card

ATS9428 Software Installer (downloadable from product page)

Certification and Compliances

RoHS 3 (Directive 2015/863/EU) Compliance

REACH 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

ATS9428	ATS9428-001
ATS9428: ±200mV Input Range Upgrade	ATS9428-014
ATS9428: One Year Extended Warranty	ATS9428-061
Test reports ordered with board	TestReport
Test reports ordered after board order	TestReport-AO
ATS9428: Sync 4X1G	ATS9428-025
ATS Sync xX1G: AC Wall Adapter	SYNC-X1G-PWR
ATS Sync 4X1G: GRF1-SMA/BNC cable	SYNC-4X1-CBL
SYNC-4X1G: One Year Extended Warranty	SYNC-4X1-061
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:

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DATASHEET REVISION HISTORY

Changes from version 1.0C (Feb 2024) to version 1.0D	Section, Page
Modified PCIe specification slot requirements to include open-ended slots	PCI Express Bus Interface, pg. 2
Added section	Test Reports, pg. 6
Updated system requirements	System Requirements, pg. 9
Replaced install disk on USB flash drive with downloadable content	Materials Supplied, pg. 10
Added test report order numbers	Ordering Information, pg. 10

Changes from version 1.0B (Dec 2023) to version 1.0C	Section, Page
Added section on ATS9428: Sync 4X1G	Multi-board Systems using ATS 4X1G, pg. 4
Modified warranty reinstatement fee information	Extended Warranty, pg. 7
Specified that Operating temperature is ambient	Environmental, pg. 9
Added Sync 4X1G, its accessories and extended warranty: ATS9428-025, SYNC-X1G-PWR, SYNC-4X1-CBL, SYNC-4X1-061	Ordering Information, pg. 10

Changes from version 1.0A (Apr 2023) to version 1.0B	Section, Page
Corrected unsigned binary positive full scale to 2^{n}-1 (was incorrectly stated as 2^{n-1}-1), corrected signed binary positive full scale to 2^{n-1}-1 (was incorrectly stated as 2^{n-2}-1) and negative full scale 2^{n-1} (was incorrectly stated as 2^{n-2}).	Output Data Format, pg. 4
Added note about trigger source	OCT Ignore Bad Clock, pg. 5
Added paragraph on Boxcar Averaging for *ATS-GPU-BASE*	ATS-GPU, pg. 6
Modified to include new warranty reinstatement policy	Extended Warranty, pg. 7
Added section for REACH Compliance	REACH Compliance, pg. 7
Added section for EC Conformity	EC Conformity, pg. 7
Added section for FCC & ICES-003 Compliance	FCC & ICES-003 Compliance, pg. 8
Removed *AUX I/O 2*; it was listed in error.	I/O Connectors, pg. 9
Absolute maximum input: Corrected label for External Trigger from EXT to TRIG IN	Acquisition System, pg. 9
Trigger Engine Source: Corrected label for External Trigger from EXT to TRIG IN	Triggering System, pg. 9
Added REACH Compliance, CE Marking, and FCC Part 15/ICES-003 to list	Certification and Compliances, pg. 10

Changes from version 1.0 (Sept 2022) to version 1.0A	Section, Page
Corrected signal level from 250 mV_{P-P} to 2 V_{P-P} to 500 mV_{P-P} to 3.3 V_{P-P}	ECLK (External Clock) Input, pg. 8
Corrected signal level from 200 mV_{P-P} to 2 V_{P-P} to 500 mV_{P-P} to 3.3 V_{P-P}	10 MHz Reference PLL Input, pg. 8