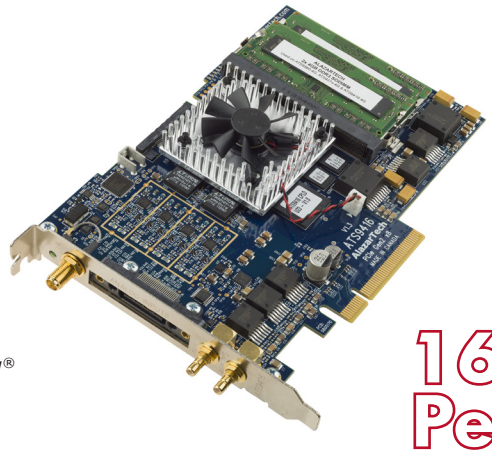
ATS9416

100 MS/s 16 channel PCIe Digitizer

- 16 analog channels per card
- Sample rate of 100 MS/s per channel
- 14-bit vertical resolution
- PCI Express Gen 2 interface
- 3.5 GB/s sustained throughput
- Up to 4 Gigasample dual-port memory
- 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

16 Inputs Per Card

Product	Bus	Operating System	Channels	Max. Sample Rate	Bandwidth	Memory Per Channel	Resolution
ATS9416	PCIe Gen 2 x8	32-bit/64-bit Windows & 64-bit Linux	16	100 MS/s	65 MHz Optional 100 MHz	Up to 4 Gig in single channel mode	14 bits

Overview

AlazarTech ATS®9416 is an 8-lane PCI Express Gen 2, 16-channel, high-speed, 14-bit, 100 MS/s waveform digitizer card capable of streaming acquired data to PC memory at rates up to 3.5 GB/s or storing it in its deep on-board dual-port acquisition memory buffer of up to 4 Gigasamples.

Each ATS9416 board has 16 Analog-to-Digital converters (ADCs) that are clocked simultaneously using a low-jitter VCO to provide absolute synchronization.

A high-density RF connector is used to increase the I/O density on the back-panel of ATS9416.

Up to four ATS9416 boards can be configured as a Leader/Follower system to create a simultaneous sampling system of up to 64 input channels.

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.

ATS9416 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 ATS9416 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

Fiber Sensing

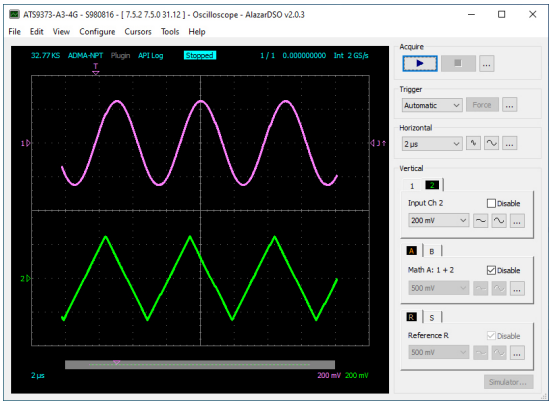
Microscopy

Multi-Channel RF Recording

Terabyte Storage Oscilloscope

High-Resolution Oscilloscope

Spectroscopy



PCI Express Bus Interface

ATS9416 interfaces to the host computer using an 8-lane PCI Express bus. Each lane operates at 5 Gbps (Gen 2). By definition, ATS9416 is also compatible with PCI Express Gen 1 and Gen 3.

According to PCIe specification, an 8-lane board can be plugged into any 8-lane or 16-lane slot, but not into a 4-lane or 1-lane slot. As such, ATS9416 requires at least one free 8-lane or 16-lane slot on the motherboard.

The physical and logical PCIe x8 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® 3.5 GB/s bus throughput benchmark was done on an ASUS® WS X299 SAGE motherboard.

Other motherboards, such as Asus P9X79 and ASROCK X79 Extreme 11, produced similar results. Older machines, such as the Dell T7400, also supported 3.5 GB/s.

Users must always be wary of throughput specifications from manufacturers of waveform digitizers. Some unscrupulous manufacturers tend to specify the raw, burst-mode throughput of the bus. AlazarTech, on the other hand, specifies the benchmarked sustained throughput. To achieve such high throughput, a great deal of proprietary memory management logic and kernel mode drivers have been designed.

Analog Input

An ATS9416 features 16 analog input channels. Each channel has up to 65 MHz of full power analog input bandwidth. Note that the bandwidth can be increased to 100 MHz by purchasing the Wideband Input Upgrade.

Channels 1 to 8 have a common gain control. Similarly, Channels 9 to 16 have a common gain control, i.e. if you change the gain of, say, Channel 3, it will change the gain for Channels 1 to 8.

The full scale input range is fixed at ±1 V.

Input impedance of all channels is fixed at 50 Ω. Input coupling of all channels is fixed at DC coupling.

High-Density Input Connector

ATS9416 uses a high-density, high-bandwidth connector to connect to the outside world. This connector is SAMTEC QSS-025-01-L-D-RA-MTI.

More information on this connector can be found at http://www.samtec.com/ftppub/pdf/qss_ra.pdf

All 16 analog input channels pass through this connector. External Trigger, AUX I/O and External clock signals use their own coaxial connectors. This was done to minimize crosstalk between these signals and the 16 analog inputs.

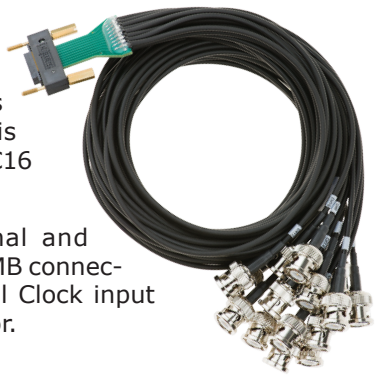
AlazarTech can supply a number of different cables that mate with this connector. Alternatively, customers can order their own cables from SAMTEC.

ATS9416 CONNECTOR PINOUT

Pin	Signal	Pin	Signal
1	Not Connected	2	AGND
3	AGND	4	CH 16 (P)
5	CH 13 (M)	6	AGND
7	AGND	8	AGND
9	AGND	10	CH 14 (N)
11	CH 15 (O)	12	AGND
13	AGND	14	AGND
15	AGND	16	CH 12 (L)
17	CH 9 (I)	18	AGND
19	AGND	20	AGND
21	AGND	22	CH 10 (J)
23	CH 11 (K)	24	AGND
25	AGND	26	AGND
27	AGND	28	CH 8 (H)
29	CH 5 (E)	30	AGND
31	AGND	32	AGND
33	AGND	34	CH 6 (F)
35	CH 7 (G)	36	AGND
37	AGND	38	AGND
39	AGND	40	CH 4 (D)
41	CH 1 (A)	42	AGND
43	AGND	44	AGND
45	AGND	46	CH 2 (B)
47	CH 3 (C)	48	AGND
49	AGND	50	Not Connected
SHIELD		AGND	

RF cables

The most popular cable (sold separately) is one that terminates to 16 BNC plugs. This cable is called QSS-BNC16 cable.



External trigger signal and AUX I/O signals use SMB connectors. Optional External Clock input uses an SMA connector.

If customers want to design an identical QSS-025-01-L-D-RA-MTI connector on their circuit board, it is also possible to purchase a cable that can mate the two QSS connectors. This cable is called QSS-QSS cable.

Users should note that the maximum achievable bandwidth using the QSS-QSS cable is approximately 10 MHz. Due to its inferior frequency response, we do not recommend it for new designs.

Acquisition System

ATS9416 PCI Express digitizer board uses two state of the art octal (x8) 100 MSPS, 14-bit ADCs to digitize the input signals. This means there are a total of 16 individual A/D converters, each running at 100 MS/s.

The 16 channels are guaranteed to be simultaneous, as they use a common clock.

The real-time sampling rate ranges from 100 MS/s down to 100 KS/s for internal clock and 5 MS/s for external 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 ATS9416, 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 64 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 spectroscopy.

Channel Selection

ATS9416 supports the following channel selections:

# of channels to acquire	Channels selected
16	All channels are acquired
8	CH 1~8 are acquired. CH 9~16 cannot be acquired in 8 channel mode
4	CH 1~4 are acquired. CH 5~16 cannot be acquired in 4 channel mode
2	CH 1~2 are acquired. CH 3~16 cannot be acquired in 2 channel mode
1	Any channel can be selected

If user attempts to specify a different channel selection in any application, an error message will be generated.

On-Board Acquisition Memory

ATS9416 supports on-board memory buffer of 4 Gigasamples. Note that one sample is stored as two bytes, so 4 Gigasample means there is 8 GByte memory on-board.

Acquisition memory can be divided equally between the selected input channels.

For example, ATS9416 provides 4 Gigasamples of on-board memory when sampling in one-channel mode. In two-channel mode, it provides 2 Gigasamples per channel of on-board memory. In four-channel mode, it provides 1 Gigasamples per channel of on-board memory and so on.

When operated as dual-port memory, the on-board memory acts as a very deep FIFO between the Analog-to-Digital converters and PCI Express bus, allowing very fast sustained data transfers across the bus, even if the operating system or another motherboard resource temporarily interrupts DMA transfers.

Maximum Sustained Transfer Rate

PCI Express support on different motherboards is not always the same, resulting in significantly different sustained data transfer rates.

For example, it is possible that a motherboard may have an x8 PCI Express connector, but only one PCIe lane is connected on the motherboard. Motherboard documentation will refer to such a slot as "x8 mechanical, x1 electrical". In such a system, the maximum data throughput may be as low as 200 MB/s.

ATS9416 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.

ATS9416, which is equipped with dual-port on-board memory, will be able to achieve this maximum sustained transfer rate.

Recommended Motherboards or PCs

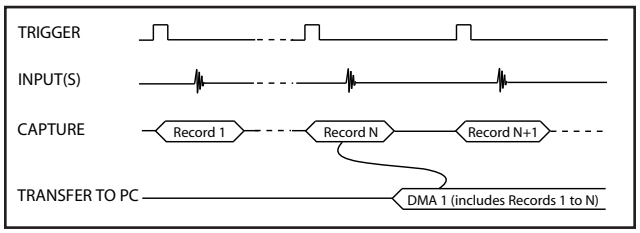
Many different types of motherboards and PCs have been benchmarked by AlazarTech. The ones that have produced the best throughput results (3.5 GB/s) are listed here: www.alazartech.com/images-media/2246-AlazarTechRecommendedMotherboards.pdf.

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.

More recently, some customer applications have required a limited amount of pre-trigger data to be available even in NPT AutoDMA. This capability has been added to ATS9416 and now it is possible to acquire up to 4096 points of pre-trigger data in NPT mode.



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 support footers, so it is possible to get a 40-bit timestamp as well as other information about the record. The footer is called NPT Footer.

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.

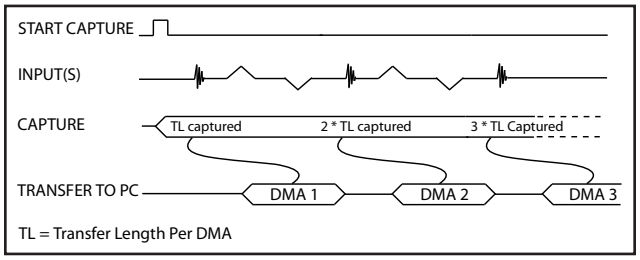
NPT AutoDMA can easily acquire data to PC host memory at the maximum sustained transfer rate of the motherboard without causing an overflow.

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

Continuous AutoDMA

Continuous AutoDMA is also known as data streaming mode.

In this mode, data starts streaming across the PCIe bus as soon as the ATS9416 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.

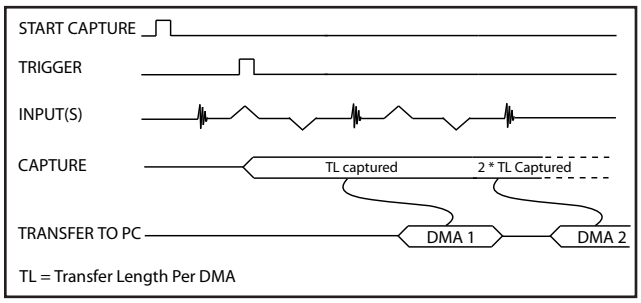
A BUFFER_OVERFLOW flag is asserted only if the entire on-board memory is used up.

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.

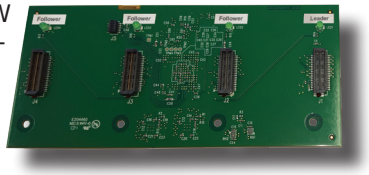
Triggered Streaming AutoDMA can easily acquire data to PC host memory at the maximum sustained transfer rate of the motherboard without causing an overflow. This is the recommended mode for RF signal recording that has to be started at a specific time, e.g. based on a GPS pulse.

Leader/Follower Systems

Users can create a multi-board Leader/Follower system by synchronizing up to four ATS9416 boards using an appropriate SyncBoard-9416.

SyncBoard-9416 is a mezzanine board that connects to the Leader/Follower connector along the top edge of the ATS9416 and sits parallel to the motherboard. For additional robustness, users can secure the SyncBoard-9416 to a bracket mounted on each of the ATS9416 boards.

SyncBoard-9416 is available in different widths:2x, 4x, 2x-W, 3x-W or 4x-W.



SyncBoards with the -W suffix provide 2-slot spacing between ATS9416 cards to support some of the newer motherboards that space out the on-board x8 or x16 slots by two slots. The -W SyncBoards are also a better solution from thermal point of view, as there is better air flow with 2-slot spacing.

The 2x and 2x-W models allow a 2-board Leader/Follower system; the 3x-W model allows a 2 or 3-slot Leader/Follower system; and the 4x and 4x-W models allow 2, 3 or 4 board Leader/Follower systems.

The Leader board's clock, trigger and initialization signals are copied by the SyncBoard-9416 and supplied to all the Follower boards. This guarantees complete synchronization between the Leader board and all Follower boards.

It should be noted that SyncBoard-9416 does not use a PLL-based clock buffer, allowing the use of variable frequency clocks in Leader/Follower configuration.

A Leader/Follower system samples all inputs simultaneously, triggers all boards simultaneously and also starts the acquisition simultaneously on all board (on the same clock edge).

For optimal trigger accuracy, only the Leader board is allowed to trigger the acquisition system.

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, ATS9416 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.

Triggering

ATS9416 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, ATS9416 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 ATS9416 is labeled TRIG IN.

External trigger is a digital 3.3 V TTL input with 6.7 kΩ impedance. Note that external trigger input cannot accept an analog signal.

Timebase

ATS9416 timebase can be controlled either by on-board low-jitter VCO or by optional Fast External Clock or by an external 10 MHz REF IN.

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

Optional Fast External Clock

While the ATS9416 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.

ATS9416 External Clock option 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.

A new sample is taken by the on-board ADCs for each rising edge of this Fast 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 5 MHz and lower than 100 MHz.

It should be noted that ATS9416 does not support variable frequency external clocking. In other words, external clock frequency must remain constant during an acquisition.

Optional 10 MHz Reference Clock Input

With the optional external clock upgrade, it is also 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.

ATS9416 uses an on-board low-jitter VCO to generate the sampling clock used by the ADC. This sampling clock can be set to any value between 5 MHz and 100 MHz with a 1 MHz resolution.

Reference clock frequency must be 10 MHz ±0.1 MHz. It should be a high slew rate signal and signal levels, specified in detail on page 9, must be respected.

Auxiliary (AUX) I/O

ATS9416 provides an AUX (Auxiliary) I/O signal that can be used to input or output various signals.

When configured as a Trigger Output, AUX connector outputs a 5 Volt TTL signal synchronous to the ATS9416 Trigger signal, allowing users to synchronize their test systems to the ATS9416 Trigger.

When combined with the Trigger Delay feature of the ATS9416, this option is ideal for ultrasonic and other pulse-echo imaging applications.

AUX connector can also be used as a Trigger Enable Input that can be used for frame capture applications.

Wideband Input Upgrade

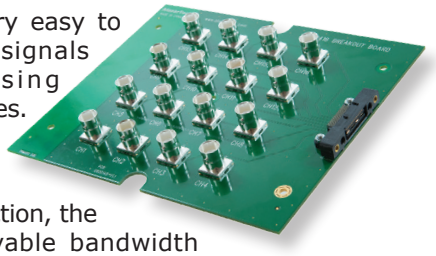
ATS9416 Wideband Input option provides up to 100 MHz analog input on each of the 16 channels on the ATS9416. Input impedance of all channels is fixed at 50 Ω.

It should be noted that 100 MHz bandwidth can only be achieved with the use of the QSS-BNC16 cable and not the breakout board or the QSS-QSS cable. The maximum bandwidth achievable using the breakout board and/or the QSS-QSS cable is 10 MHz.

Optional Breakout Board

ATS9416 Breakout Board connects to the ATS9416 using a QSS-QSS cable and provides a separate female BNC connector for each analog input.

This makes it very easy to connect analog signals to ATS9416 using standard BNC cables.



As mentioned in the *Wideband Input Upgrade* section, the maximum achievable bandwidth using a breakout board and QSS-QSS cable is 10 MHz.

Calibration

Every ATS9416 digitizer is factory calibrated to NIST- or CNRC-traceable standards. To recalibrate an ATS9416, the digitizer must be shipped back to the factory.

On-Board Monitoring

Adding to the reliability offered by ATS9416 are the on-board diagnostic circuits that constantly monitor over 20 different voltages, currents and temperatures. LED alarms are activated if any of the values surpass the limits.

AlazarDSO Software

ATS9416 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 ATS9416 into their own software.

A Windows and Linux compatible software development kit, called ATS-SDK, includes headers, libraries and source code sample programs written in C/C++, C#, Python, MATLAB, and LabVIEW. These programs can fully control the ATS9416 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 ATS9416 to a GPU card at rates up to 3.5 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.

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 780,000 FFTs per second when capturing data in 16-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 ATS9416 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.

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 for their specific distribution by choosing from the available drivers here: ftp://release@ftp.alazartech.com/outgoing/linux

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.

Based on a minimum annual business commitment, the Linux driver source code license (order number ATS9416-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.

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 ATS9416 includes a standard one (1) year parts and labor warranty. Customers may extend their warranty by ordering an Extended Warranty (order number ATS9416-061).

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, ATS9416 is currently not controlled for export from Canada. Its export control classification is N8, which is equivalent to ECCN EAR99. ATS9416 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 ATS9416, 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

ATS9416 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.

EC Conformity

ATS9416 conforms to the following standards:

Electromagnetic Emissions:
CISPR 32:2015/EN 55032:2015 (Class A):
Multimedia Equipment (MME) Radio disturbance characteristics. Limits and method of measurement: EN 61000-3-2:2014, EN 61000-3-3:2013, EN 61000-6-3:2007.

Electromagnetic Immunity:
EN 55035:2017/A11:2020:
Multimedia Equipment (MME) Immunity characteristics — Limits and methods of measurement: EN 61000-4-3:2006 + A1:2008 + A2:2010.

Safety:
IEC 62368-1:2020 / EN IEC 62368-1:2020+A11:2020:
Audio/video, information and communication technology equipment - Part 1: Safety requirements.

ATS9416 also follows the provisions of the following directives: 2014/35/EU (Low Voltage Equipment); 2014/30/EU (Electromagnetic Compatibility).

FCC & ICES-003 Compliance

ATS9416 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 6 2016.

System Requirements

Personal computer with at least one free x8 or x16 PCI Express 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	1.8 A, typical
+3.3 V	2.0 A, typical

Physical

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

I/O Connector

Analog connector	SAMTEC QSS-025-01-L-D-RA-MTI
External Trigger connector	SMB - female
Auxiliary I/O connector	SMB - female
External Clock connector	SMA - female

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
Bandwidth (-3 dB)	
DC-coupled, 50 Ω	DC - 65 MHz, typical for all input ranges With wideband option, the bandwidth increases to DC - 100 MHz
Number of channels	16, simultaneously sampled
Maximum Sample Rate	100 MS/s single shot
Minimum Sample Rate	100 KS/s single shot for internal clocking
Full Scale Input range	
50 Ω Input impedance:	±1 V, fixed
DC accuracy	±2% of full scale in all ranges
Input coupling	DC coupling only
Input impedance	50 Ω ±5%
Absolute maximum input	±4 V (DC + peak AC)

Acquisition Memory System

Memory size	4 GigaSamples
Record length	Software-selectable with 128-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 8176 for single channel From 0 to 4088 for dual channel From 0 to 2044 for quad channel From 0 to 1022 for 8 channels From 0 to 511 for 16 channels
Post-trigger depth	Record Length – Pre-Trigger Depth

Timebase System

Timebase options	Internal Clock or External Clock (Optional)
Internal Sample Rates	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
Internal Clock accuracy	±2 ppm

Dynamic Parameters

Typical values measured on CH 1 of a randomly selected ATS9416. Input signal was provided by an SRS SG384 signal generator, followed by a 9-pole, 10 MHz band-pass filter (TTE Q36T-10M-1M-50-720BMF). Input frequency was set at 10 MHz and output amplitude was 0.670 Vrms, which was approximately 95% of the full scale input. FFT was averaged.

SNR	66.8 dB
SINAD	65.6 dB
THD	-72.1 dB
SFDR	-73.5 dB

Note that these dynamic parameters may vary from one unit to another, with input frequency and with the full scale input range selected.

Optional ECLK (External Clock) Input

Signal Level	250 mV_{P-P} to 2 V_{P-P}
Input impedance	50 Ω
Input coupling	AC
Maximum frequency	100 MHz for Fast External Clock
Minimum frequency	5 MHz for Fast External Clock
Sampling Edge	Rising

Optional 10 MHz Reference PLL Input

Signal Level	300 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.	100 MHz

Triggering System

Mode	Edge triggering with hysteresis
Comparator Type	Digital comparators for internal (CH 1 ~ CH 16) triggering and TTL receiver 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	Any one of CH 1 ~ CH 16, 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	65 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 range	3.3 V TTL
Input impedance	6.7 kΩ ±10% for TTL input
Input Coupling	DC only
Bandwidth (-3 dB)	DC - 65 MHz
Min. pulse width	32 ADC sampling clocks
Min. pulse amplitude	2 Volts
Absolute maximum input	±5 V (DC + peak AC without external attenuation)

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. Divide-by-8 clock (dual channel mode) or divide-by-16 clock (single channel mode)
Input	
Amplitude:	3.3 Volt TTL (5 Volt compliant)
Input coupling:	DC

Materials Supplied

ATS9416 PCI Express Card
ATS9416 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

ATS9416-4G	ATS9416-002
ATS9416: External Clock Upgrade	ATS9416-005
SyncBoard-9416 2x	ATS9416-007
SyncBoard-9416 4x	ATS9416-008
ATS9416: Wideband Input Upgrade	ATS9416-009
SyncBoard-9416 2x-W	ATS9416-020
SyncBoard-9416 3x-W	ATS9416-021
SyncBoard-9416 4x-W	ATS9416-022
ATS9416: QSS-BNC16 Cable 36 inches (Purchased with board)	ATS9416-030
ATS9416: QSS-QSS Cable 60 inches (Purchased with board)	ATS9416-031
ATS9416: Breakout Board + Cable	ATS9416-032
ATS9416: QSS-BNC16 Cable 36 inches (Purchased separately)	ATS9416-033
ATS9416: QSS-QSS Cable 60 inches (Purchased separately)	ATS9416-034
ATS9416-4G: One Year Extended Warranty	ATS9416-061
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 OR 1-877-725-2927
TEL: (514) 426-4899 FAX: (514) 426-2723

E-MAIL: sales@alazartech.com

DATASHEET REVISION HISTORY

Changes from version 1.3I (Nov 2021) to version 1.3J

	Section, Page
Changes to maintenance subscription inclusions: removed technical support	Software Development Kits, pg. 6
Added Windows 11	Support for Windows, pg. 7
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. 7
Updated Electromagnetic Immunity standard number (product was retested)	EC Conformity, pg. 8
Updated specification name from *Input protection* to *Absolute maximum input* Actual value did not change.	Acquisition System, pg. 9
Updated specification name from *Input protection* to *Absolute maximum input* Actual value did not change.	TRIG IN (External Trigger) Input, pg. 10
Updated name for product *Software Development Kit* Now called: *ATS-SDK purchased with a digitizer board or ATS-GPU*	Ordering Information, pg. 10
Added products ATS-SDK-WOD and SUPPORT-HR5	Ordering Information, pg. 10

Changes from version 1.3H (Sept 2021) to version 1.3I

	Section, Page
Changed term for multi-board system to *Leader/Follower*	Leader/Follower Systems, pg. 4
Specified number of extended warranties that users may purchase	Extended Warranty, pg. 7
Updated terminology to match the standard: changed *Information Technology Equipment (ITE)* to *Multimedia Equipment (MME).* Moved *EN 61000-6-1:2007* from *Electromagnetic Emissions* to *Electromagnetic Immunity*	EC Conformity, pg. 7

Changes from version 1.3G (Jan 2020) to version 1.3H

	Section, Page
Added maximum achievable bandwidth when using the QSS-QSS cable	RF Cables, pg. 3
Added section on supported channel selections	Channel Selection, pg. 3
Removed *5 V-compliant* from 3.3 V TTL input	External Trigger Input, pg. 5
Corrected maximum achievable bandwidth when using breakout board or QSS-QSS cable	Wideband Input Upgrade, pg. 6
Corrected maximum achievable bandwidth when using breakout board	Optional Breakout Board, pg. 6
Updated section *ATS-GPU* and added paragraph on ATS-GPU-NUFFT	ATS-GPU, pg. 6
Updated support status for Windows 8.x and Windows Server versions 2012 R2, 2016, 2019	Support for Windows, pg. 7
Updated Linux Support (RHEL) and added new DKMS drivers	Linux Support, pg. 7
Updated product registration URL	Extended Warranty, pg. 7
Updated standards and directives	EC Conformity, pg. 7
Updated year of FCC and ICES-003 standards	FCC & ICES-003 Compliance, pg. 8
Corrected TRIG IN Input type: removed (5 V compliant)	TRIG IN (External Trigger) Input, pg. 10
Added Auxiliary I/O input coupling (DC)	Auxiliary I/O (AUX I/O), pg. 10
Updated software descriptions and added order number for ATS-GPU-NUFFT	Ordering Information, pg. 10

Changes from version 1.3F (May 2019) to version 1.3G

	Section, Page
Changed *Sampling Rate* column to *Max. Sample Rate*	Feature Table, pg. 1
Added AlazarFrontPanel (for Linux) as benchmarking tool	Maximum Sustained Transfer Rate, pg. 3
Updated section title to indicate that External Clock is optional Replaced signal sine or square wave requirement with high slew rate, removed LVTTL signal, and replaced min. and max. amplitude with a note that signal levels specified on page 8 must be respected	Optional External Clock, pg. 5
Updated section title & text to show that 10 MHz Reference Clock is optional Replaced ref. clock amplitude with a note that signal levels specified on page 8 must be respected	Optional 10 MHz Reference Clock Input, pg. 5
Specified Windows 7 version support, re-ordered list of operating systems, and added end-of-support notice for Windows 7 and Windows Server 2008 R2	Support for Windows, pg. 6
Specified Linux distributions: CentOS, Debian, and Ubuntu	Linux Support, pg. 6

DATASHEET REVISION HISTORY

Changes from version 1.3F (May 2019) to version 1.3G (continued)	Section, Page
Changed signal level from "200 mV_{P-P} to 1 V_{P-P}" to "250 mV_{P-P} to 2 V_{P-P}" Removed maximum amplitude, as information is included in signal level	Optional ECLK (External Clock) Input, pg. 8
Changed signal level from "200 mV_{P-P} to 1 V_{P-P}" "500 mV_{P-P} to 2 V_{P-P}"	Optional 10 MHz Reference PLL Input, pg. 8
Corrected Output types (removed Busy Output and added Pacer Output)	Auxiliary I/O (AUX I/O), pg. 9
Corrected cable length to 60" for order numbers (ATS9416-031, ATS9416-034)	Ordering Information, pg. 9

Changes from version 1.3E (May 2019) to version 1.3F	Section, Page
Corrected input range: not user-selectable, it is fixed at ±1 V	Analog Input, pg. 2

Changes from version 1.3D (Jan 2019) to version 1.3E	Section, Page
Updated SyncBoard image	Master/Slave Systems, pg. 4
Updated ATS-GPU data transfer rate and benchmarks (FFTs/s, number of channels, and GPU)	ATS-GPU, pg. 6
Removed *ATS-GMA* section as this product is being discontinued	ATS-GMA, pg. 6
Added section *Extended Warranty*	Extended Warranty, pg. 7
Removed ATS-GMA order numbers (ATSGMA-001, ATSGMA-101)	Ordering Information, pg. 9
Updated Trademark information	pg. 9

Changes from version 1.3C (Sept 2018) to version 1.3D	Section, Page
Removed information about older CPUs that are no longer relevant	PCI Express Bus Interface, pg. 2
Moved *Analog Input* section from page 3 to page 2 for better document flow	Analog Input, pg. 2
Added corresponding letters to channels in *ATS9416 CONNECTOR PINOUT* table	High-Density Input Connector, pg. 2
Added external clock minimum signal level and maximum amplitude	Fast External Clock, pg. 5
Added reference clock frequency and amplitude	10 MHz Reference Clock Input, pg. 5
Updated *Sanctions List* URL	Export Control Classification, pg. 7
Updated Trademark information	pg. 9

Changes from version 1.3B (Jan 2018) to version 1.3C	Section, Page
Updated RoHS Compliance to RoHS 3	Global change
Updated product image	pg. 1
Clarified Operating System Support	Features & Feature Table, pg. 1
Updated *Recommended Motherboards or PCs*	Recommended Motherboards or PCs, pg. 3
Correction of trigger engines: changed to J and K (instead of X and Y)	Triggering, pg. 4
Specified that External Trigger Input 3.3 V TTL input is 5 V-compliant	External Trigger Input, pg. 5
Added information on ATS-SDK license	Software Development Kits, pg. 6
Specified 64-bit version for Windows and Linux support	ATS-GPU, pg. 6
Added *ATS-GMA* section	ATS-GMA, pg. 6
Added list of supported Microsoft Windows versions	Support for Windows, pg. 7
Added *Acquisition Memory System* section	Acquisition Memory System, pg. 8
Added Maximum Amplitude: 2 V_{P-P}	Optional ECLK (External Clock) Input, pg. 8
Added "PLL" to section name for clarity, corrected Input Frequency tolerance, and added Max. and Min. Frequencies	Optional 10 MHz Reference PLL Input, pg. 8
Corrected Trigger Engine Combination	Triggering System, pg. 8
Added TTL min. pulse width, and TTL min. pulse amplitude	TRIG IN (External Trigger) Input, pg. 9
Added *Auxiliary I/O (AUX I/O)* section	Auxiliary I/O (AUX I/O), pg. 9
Added subscription length for ATS-SDK, ATSGPU-001, ATSGPU-101 Added products ATSGMA-001, ATSGMA-101	Ordering Information, pg. 9
Added Trademark information	pg. 9

DATASHEET REVISION HISTORY

Changes from version 1.3A (Oct 2017) to version 1.3B	Section, Page
Updated ATS9416 image	(Introduction), pg. 1
Added NPT AutoDMA buffer footer name	No Pre-Trigger (NPT) AutoDMA, pg. 4
Added CNRC as calibration standard	Calibration, pg. 6
Added -BASE and -OCT to ATS-GPU description for clarity	ATS-GPU, pg. 6
Corrected size of card	Physical, pg. 8
Updated email address	Manufactured By, pg. 9

Changes from version 1.3 (Sept 2017) to version 1.3A	Section, Page
Updated description for product ATSGPU-001 & ATSGPU-101	Ordering Information System, pg. 9

Changes from version 1.2A (July 2016) to version 1.3	Section, Page
Added connector types for External Trigger and Optional External Clock	RF Cables, pg. 2
Modified External Trigger Input description. External trigger is now digital TTL input only.	External Trigger Input, pg. 5
Added note: ATS9416 does not support variable frequency external clocking	Fast External Clock, pg. 5
Added section on Breakout Board	Breakout Board, pg. 6
Added section on Wideband Input Upgrade	Wideband Input Upgrade, pg. 6
Modified AlazarDSO description	AlazarDSO Software, pg. 6
Modified Software Development Kit description, added Linux support	Software Development Kit, pg. 6
Added section on ATS-GPU	ATS-GPU, pg. 6
Replaced section *ATS-Linux* with *Linux Support*; now includes download link & updated description	Linux Support, pg. 6
Added Export Control Classification information	Export Control Classification, pg. 7
Added section on RoHS compliance	RoHS Compliance, pg. 7
Added section on EC Conformity	EC Conformity, pg. 7
Added section on FCC & ICES-003 Compliance	FCC & ICES-003 Compliance, pg. 7
Updated Input Range and Input Impedance for External Trigger	TRIG IN (External Trigger) Input, pg. 9
Updated list of Certification and Compliances	Certification and Compliances, pg. 9
Corrected product names for ATS9416-030, ATS9416-031, and ATS-SDK	Ordering Information, pg. 9
Added products ATS9416-033, ATS9416-034, ATS9416-061, ATSGPU-001, ATSGPU-101	Ordering Information, pg. 9