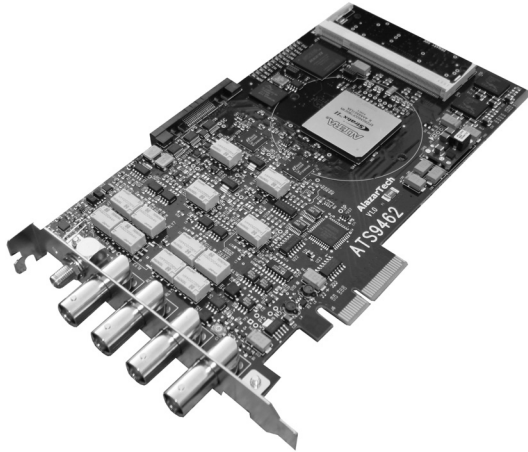


AlazarTech

ATS9462 User Manual

16 Bit, 180 MS/s
Waveform Digitizer for PCI Express Bus



Written for Hardware Version 1.1
November 2008 Edition
Part Number: 9462-USR-2

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AlazarTech Contact Information

AlazarTech, Inc.
6600 Trans-Canada Highway
Suite 310
Pointe-Claire, QC
Canada H9R 4S2

Telephone: (514) 426-4899
Fax: (514) 426-2723

E-mail: info@alazartech.com
Web site: www.alazartech.com

To comment on the documentation for ATS9462, send e-mail to support@alazartech.com.

Information required when contacting AlazarTech for technical support:

Owned by: _____

Serial Number: _____

Purchase Date: _____

Purchased From: _____

Software Driver Version: _____

SDK Version: _____

AlazarDSO Version: _____

Operating System: _____

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Compliance

FCC/Canada Radio Frequency Interference Compliance*

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark.

Consult the FCC web site <http://www.fcc.gov> for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by AlazarTech Inc. could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations. *Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.*

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at <http://www.alazartech.com/support/documents.htm>. This web page lists all DoCs by product family. Select the appropriate product to download or read the DoC.

- * Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.
- ** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Environmental Compliance

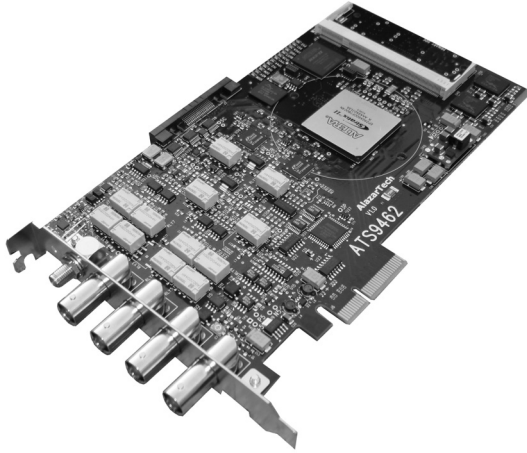
Alazar Technologies Inc., hereby certifies that this product is RoHS compliant, as defined by *Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment*. All manufacturing has been done using RoHS-compliant components and lead-free soldering.

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Chapter 1 - Introduction

This chapter describes the ATS9462 and lists additional equipment.



About Your ATS9462

Thank you for your purchase of an ATS9462. This PCI Express (PCIe x4) based waveform digitizer has the following features:

- Two 16-bit resolution analog input channels
- Real-time sampling rate of 180 MS/s to 1 KS/s
- Streaming of acquired data to PC host memory at 720 MB/s (exact rate is motherboard dependent)
- 65 MHz analog input bandwidth
- DIP switch selectable Amplifier Bypass Mode for optimum signal integrity
- Half length PCI Express (4 lane) card
- Analog trigger channel with software-selectable level and slope
- Software-selectable AC/DC coupling and $1\text{M}\Omega/50\Omega$ input impedance
- Software-selectable bandwidth limit switch, independent for each channel
- Pre-trigger and Post-Trigger Capture with Multiple Record capability
- NIST traceable calibration
- Dual DMA engines for best latency protection against Windows and Linux operating systems
- Fully asynchronous software driver for fastest DMA with least CPU overhead

All ATS9462 digitizers follow industry-standard Plug and Play specifications on all platforms and offer seamless integration with compliant systems.

If your application requires more than two channels for data acquisition, you can synchronize multiple digitizers on all platforms using a Master/Slave SyncBoard 460.

- Note that firmware version 23 or higher is needed for Master/Slave operation.

Detailed specifications of the ATS9462 digitizers are listed in Appendix A, Specifications.

Acquiring Data with Your ATS9462

You can acquire data either programmatically by writing an application for your ATS9462 or interactively with the AlazarDSO software.

If you want to integrate the ATS9462 in your test and measurement or embedded OEM application, you can program the digitizer using C/C++, Visual BASIC or LabVIEW for Windows or C for Linux operating systems.

- Windows operating systems supported are Windows Vista 32 bit, Windows Vista 64 bit, Windows XP 32 bit and Windows XP 64 bit

- Note that Windows 98SE is not supported.

For programming in C/C++ or Visual BASIC, you must purchase the ATS-SDK software development kit that comes with sample programs and a reference manual describing the API.

For programming in LabVIEW, you must purchase the ATS-VI virtual instrument library that comes with a high-level, easy-to-use VI that makes integrating the ATS9462 into your own system very simple.

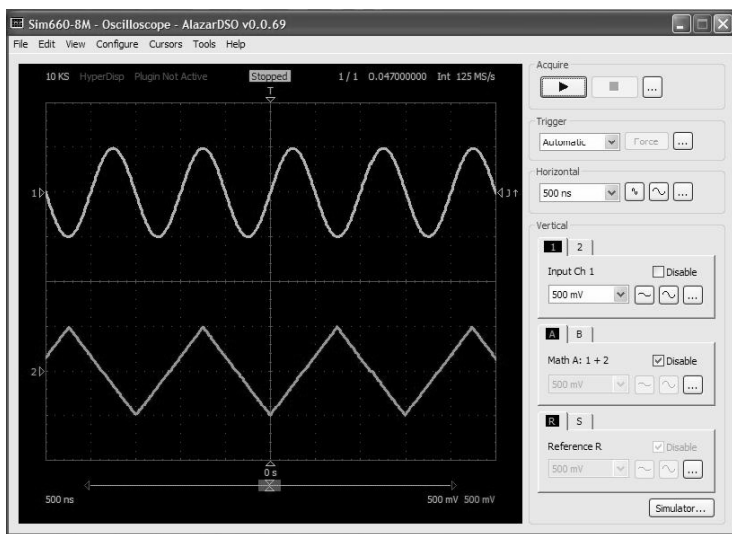
With the recent release of Linux drivers for ATS9462, it is possible to program your ATS9462 under Linux operating system. You will need to sign a Non-Disclosure Agreement with AlazarTech and purchase the ATS-Linux software development kit that comes with source files for the driver (Fedora Core 9 - kernel 2.6) and C source code for a sample program. Also supplied is the AlazarLinuxDSO graphical user interface for the ATS9462.

Interactively Controlling your ATS9462 with AlazarDSO

The AlazarDSO Soft Front Panel allows you to interactively control your ATS9462 as you would a desktop oscilloscope. To launch the Scope Soft Front Panel, select

Start » Programs » AlazarTech » AlazarDSO

The following screen will be displayed. If you connect the input to a signal generator and click on **Start** button, you should see the signal on the screen.

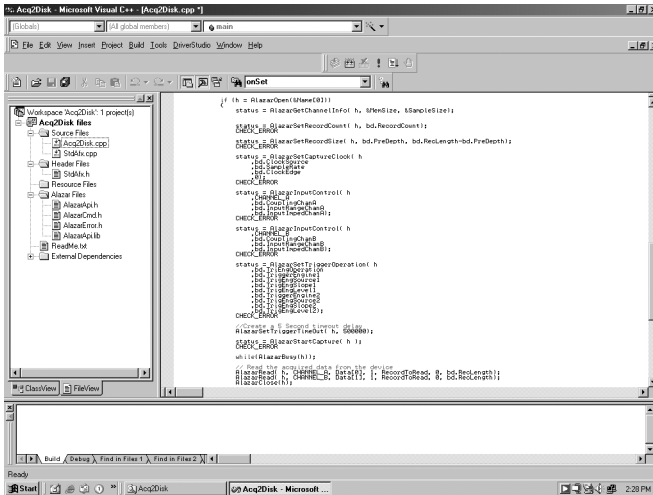


AlazarDSO has been designed to be very intuitive and uses a user interface similar to most of today's digital oscilloscopes.

ATS-SDK API

The ATS-SDK API is used for programming the ATS9462 in C/C++ or Visual BASIC. It provides the exact same API that is used for writing AlazarDSO software. To help you get started, ATS-SDK comes with examples you can use or modify.

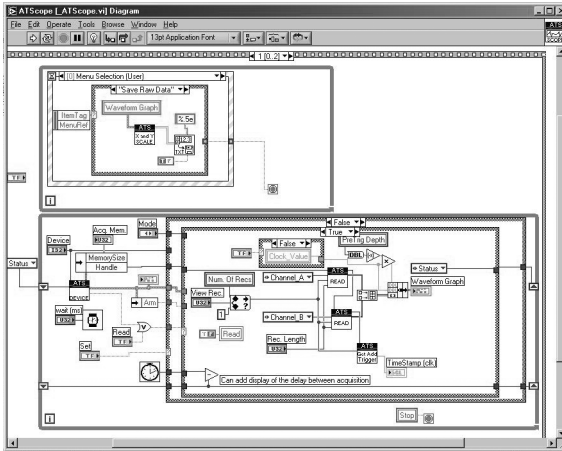
Note that only the Asynchronous API functions should be used when programming the ATS9462. Traditional API and AutoDMA API is not supported.



ATS-VI LabVIEW VI

ATS-VI allows you to integrate the ATS9462 into your own LabVIEW program. A high level VI is supplied that requires very few controls to get started.

Note that only the AsyncDMA.vi virtual instrument (vi) should be used when programming the ATS9462. Traditional vi's and synchronous AutoDMA vi's are not supported.



ATS-Linux for ATS9462

The ATS-Linux for ATS9462 can be used for programming the ATS9462 under Linux operating system. A source code driver is supplied that has been compiled for Fedora Core 9 (Kernel 2.6) running on an i386 platform. Sample program is supplied in C. The API is identical to the Windows API.

Note that you will need to sign a Non-Disclosure Agreement with AlazarTech in order for the source code of the drivers to be shared with you.

Optional Upgrades

AlazarTech offers the following upgrades and accessories for use with your ATS9462 digitizer:

- ATS9462: External Clock Upgrade
- ATS9462: Master/Slave SyncBoard 2 position
- ATS9462: Master/Slave SyncBoard 4 position
- ATS9462: Master/Slave SyncBoard 8 position
- AlazarDSO – Stream To Disk Module
- AlazarDSO – Plug-In Development Kit

Chapter 2 - Installation and Configuration

This chapter describes how to unpack, install, and configure your ATS9462.

What You Need to Get Started

To set up and use your ATS9462, you will need the following:

- One or more ATS9462 digitizers



- ATS9462 Install Disk

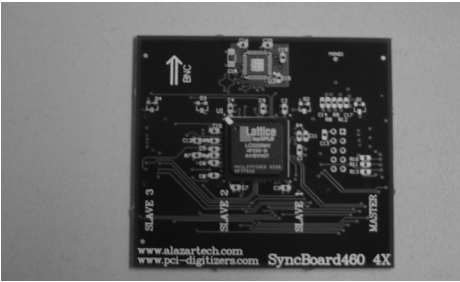


- For Master/Slave operation only:
SyncBoard of appropriate width

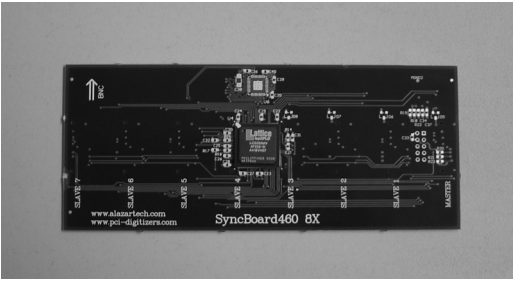
SyncBoard 2X for up to 2 digitizers



SyncBoard 4X for up to 4 digitizers



SyncBoard 8X for up to 8 digitizers



Unpacking

Your digitizer is shipped in an antistatic package to prevent electrostatic damage to the digitizer. Electrostatic discharge can damage several components on the digitizer. To avoid such damage in handling the digitizer, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the digitizer from the package.
- Remove the digitizer from the package and inspect the digitizer for loose components or any other sign of damage. Notify AlazarTech if the digitizer appears damaged in any way. Do *not* install a damaged digitizer into your computer.
- *Never* touch the exposed pins of the connectors.

Installing the ATS9462

There are four main steps involved in installation:

1. Physically install the digitizer(s) and SyncBoard, if any, in your computer.
2. Install ATS9462 software driver
3. Install AlazarDSO software that allows you to setup the hardware, acquire signals and view and archive them
4. Optionally, install the ATS-SDK software development kit or ATS-VI LabVIEW VI, which enables you to programmatically control the ATS9462

Thanks to the flexible nature of AlazarTech's driver installation software, you can either install the hardware first or install the software driver first.

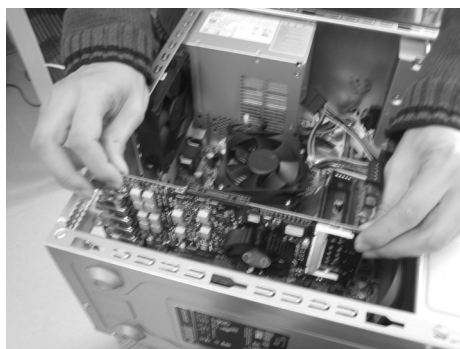
The following paragraphs will guide you through this process in a step-by-step manner.

1. Physically install the digitizer in your computer

Identify an unused PCI Express slot on your motherboard. As per PCI Express specification, the 4-lane ATS9462 card is compatible with any 4-lane, 8-lane or 16-lane connector on the motherboard.

Make sure that your computer is powered off before you attempt to insert the ATS9462 digitizer in one of the free PCI Express slots.

For best noise performance, leave as much room as possible between your ATS9462 and other hardware.



Always screw the digitizer bracket to the chassis in order to create a stable and robust connection to chassis ground.

In the absence of such a connection, ATS9462 is not guaranteed to operate within the specifications listed elsewhere in this manual.

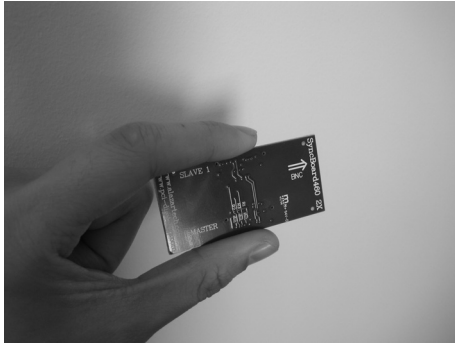
Some motherboards may have a 16-lane connector, but only one of the lanes is connected to the motherboard chipset. Motherboard manufacturers refer to this as “Mechanically 16-lane, electrically 1 lane”. ATS9462 is fully compatible with such motherboards, but the data throughput across PCI Express bus will be limited by the number of lanes.

For Master/Slave Installation

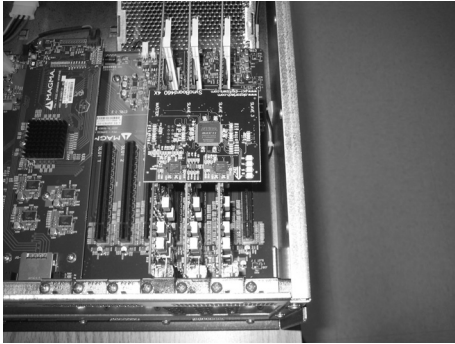
If you are installing multiple ATS9462 digitizers that will be configured as a Master/Slave system, make sure that you insert all cards in adjacent slots.



The connector on the SyncBoard that is labeled as “M” (Master), must be inserted into the Master/Slave connector of the left-most digitizer, if you are facing the BNC connectors of the ATS9462 digitizers.



If you are installing fewer than the maximum number of digitizers supported by your SyncBoard, the unused SyncBoard connectors must be on the right-hand side of the digitizers, if you are facing the BNC connectors of the ATS9462 digitizers.



Once you have completed this step, you should power the computer on.

2. **Install ATS9462 software driver**

The following instructions guide you through the process of installing the ATS9462 in a computer running Windows Vista, Windows XP or Windows 2000 operating systems.

Other operating systems, such as Windows NT, Windows 95 and Windows 98SE are not covered here.

Note that the images of the dialog boxes shown below were taken from a Windows XP computer. Computers running Vista may have slightly different dialog boxes.

Installation of Multiple ATS9462 Digitizers

If you are installing multiple ATS9462 digitizers, the operating system will detect one card at a time and you will have to go through the driver installation setup as many times as you have cards.

Installing ATS9462 Hardware First

If you decided to install the ATS9462 hardware before installing the ATS9462 software driver, then when you first boot up the computer, the plug-n-play Windows operating system will detect the presence of a new PCI card and ask you to provide the device driver.

- a) When you power on for the first time, Windows will display the **Welcome to the Found New Hardware Wizard**



Click **Cancel**.

- b) Insert the installation CD. If it does not auto-run, manually run the Setup.exe program on the ATS9462 Driver Disk.



Click **Next**.

- c) The following dialog box will be displayed showing the progress of installation of ATS9462 driver files in the operating system driver store.



- a) The following final screen will confirm that the driver has been installed.



Now your ATS9462 is fully installed and is ready to use.

Installing ATS9462 Driver First

If you decided to install the ATS9462 software driver before installing the ATS9462 hardware, then you must follow the following sequence to make sure your operating system recognizes ATS9462 as an installed device.

- b) Insert the installation CD. If it does not auto-run, manually run the Setup.exe program on the ATS9462 Driver Disk.



Click **Next**.

- c) The following dialog box will be displayed showing the progress of installation of ATS9462 driver files in the operating system driver store.



- d) The following final screen will confirm that the driver has been installed.



- e) Click **Finish** and power down your computer
- f) Physically install your ATS9462 card(s).

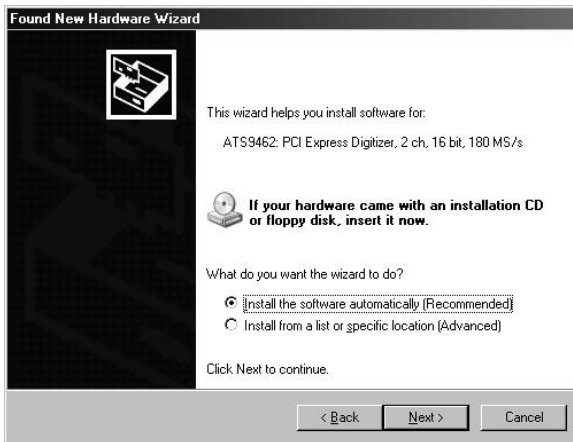
If you are installing a Master/Slave system, also install the SyncBoard.

- g) Power on your computer
- h) Windows will display the **Welcome to the Found New Hardware Wizard**



Click **Next**

- i) The following dialog box will be displayed:



- j) Choose to install the software automatically. Click **Next**

Operating system will copy the appropriate files to its system folders. The following dialog box will be displayed:



- k) Operating system will display the **Completing the Found New Hardware Wizard** message.



Click **Finish**. Now your ATS9462 is fully installed and is ready to use.

3. **Install AlazarDSO software that allows you to setup the hardware, acquire signals and view and archive them**

If you are installing from the CD shipped with the ATS9462 digitizer:

- Insert the ATS9462 Install disk
- Use Windows Explorer to navigate to the AlazarDSO folder on the ATS9462 Install Disk. Run Setup.exe program
- Follow the instructions on the screen.

If you are installing AlazarDSO after having downloaded the installation file from AlazarTech web site:

- Download AlazarDSO installation file from www.alazartech.com/support/downloads.htm
- Unzip the file downloaded in the previous step.
- Browse to the folder that contains the unzipped file, Setup.exe
- Run this executable file and follow the instructions on the screen.

4. **Optionally, install the ATS-SDK software development kit or ATS-VI LabVIEW VI, which enables you to programmatically control the ATS9462**

Insert the ATS-SDK or ATS-VI CD. Software installation will start automatically.

If, for any reason, installation does not start automatically, run the SETUP.EXE program.

Follow the instructions on the screen.

Note that you must have already installed the ATS9462 drivers for any of the sample programs included with the ATS-SDK or ATS-VI to work properly.

Installing the ATS9462 in a Linux System

ATS9462 is fully compatible with the popular Linux operating system.

AlazarTech supplies source code Linux drivers that have been tested under Fedora Core 9 (kernel 2.6).

- Note that a Non-Disclosure Agreement must be signed between AlazarTech and your company before any source code can be released to you.

AlazarTech does not provide software support for compiling drivers for other versions of Linux, i.e. customers will be fully responsible for compiling drivers for their own Linux operating system.

To install Linux drivers in a Fedora Core 9 system, follow the instructions listed below:

1. Copy the supplied RPM file to the target machine
2. Double-click on the RPM icon. This will install the driver as well as associated applications.
3. Reboot the PC.
Note that if you do not reboot the PC, the driver will not be loaded.

The RPM file will also install an application called AlazarLinuxDSO. This is a Graphical User Interface (GUI) using which you can setup and acquire data from the ATS9462.

Note that AlazarLinuxDSO has been compiled using GTK 2.4 libraries. If you intend to use an operating system other than Fedora Core 9, make sure that the GTK 2.4 libraries have been installed on your machine.

- 1.

Compiling the ATS9462 Linux Driver

If you need to compile the ATS9462 driver for a version of Linux other than Fedora Core 9, follow the following steps:

2. Install the Linux kernel header files.
3. Extract the driver sources using the command "tar xvzf PlxLinux-2006.01.10.tgz". This will create a folder names "PlxLinux" with the driver files inside.
4. Set the shell environment variable PLX_SDK_DIR to the root location where the "PlxLinux" directory was created. For example, if using bash and the PlxLinux directory is in your home directory, then add the following line to the ~/.bashrc :

```
declare -x PLX_SDK_DIR=$HOME/PlxLinux
```

5. To build the ATS9462 driver, type

```
cd PlxLinux/linux/driver  
./make
```

This will create the file ATS9462.ko, the loadable driver file. You can change build defines in PlxLinux/linux/makefiles/Gcc.def. Copy the driver to /usr/local/AlazarTech/bin.

6. Load the driver by rebooting the computer or typing:

```
cd /usr/local/AlazarTech/bin  
ATS9462.rc start
```

The customer should be able to run the AlazarLinuxDSO application or Acq2Disk sample in /usr/local/AlazarTech/samples/ATS9462.

7. If it is necessary to rebuild the library, type

```
cd PlxLinux/linux/api  
make
```

This will create SharedLibrary/libPlxApi.so.0.0. Copy the file to /usr/local/AlazarTech/lib and then run ldconf

Updating ATS9462 Driver

From time to time, AlazarTech updates the device drivers for its products. These updates may be required for product enhancements or for bug fixes.

This section of the manual takes you through the steps required to update the device driver for the ATS9462 PCI Express waveform digitizer.

In other words, this section shows you how to install a newer version of the driver, when you already have a previous version of the driver installed on your machine.

1. Download the latest driver from AlazarTech's web site:
www.alazartech.com/support/downloads.htm
2. Unzip the downloaded file to a local folder
3. Run the resulting installation file (*.exe extension). For example, the installation file for driver version 5.6.9 is called **ATS9462_Driver_V5.6.9.exe**.

The following welcome screen will be displayed:



Click **Next**.

4. The following dialog box will be displayed showing the progress of installation of ATS9462 driver files.



5. The following final screen will confirm that the driver has been installed.

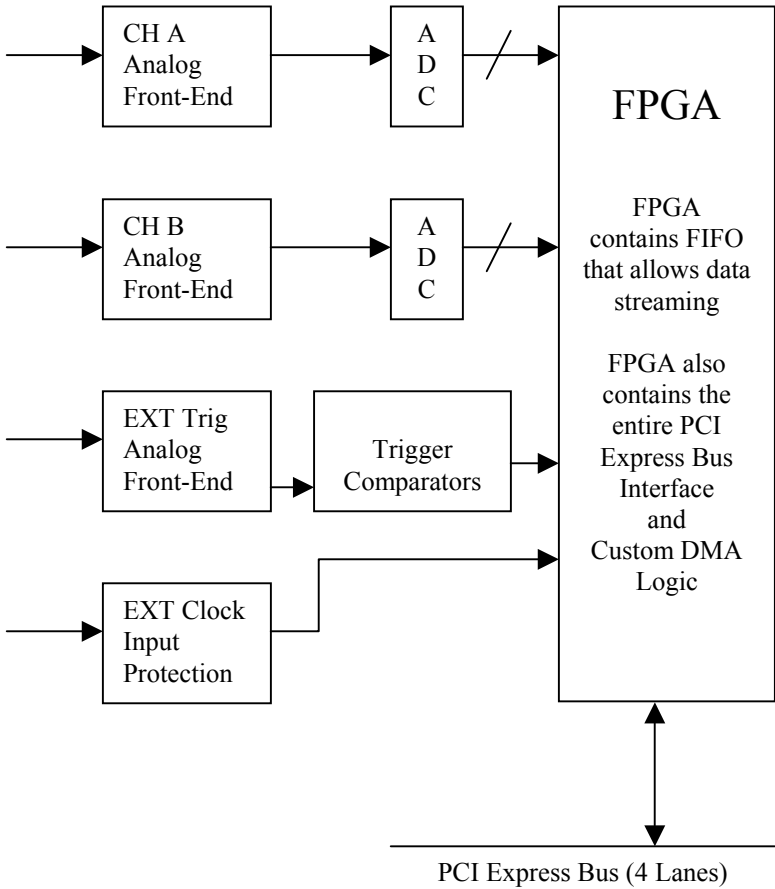


- a. Click **Finish**.

ATS9462 driver has now been updated

Chapter 3 - Hardware Overview

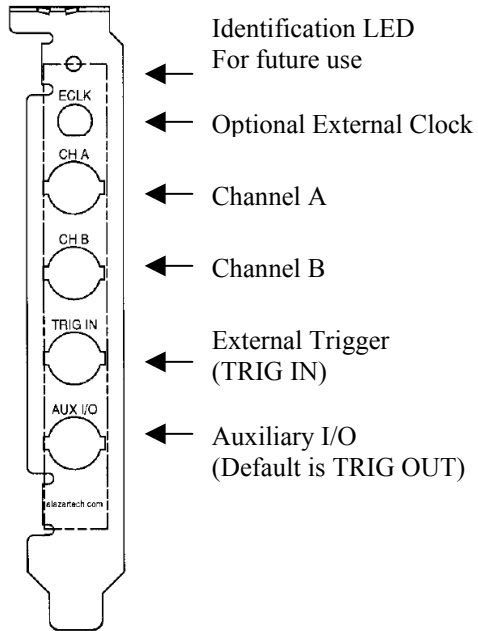
This chapter includes an overview of the ATS9462, explains the operation of each functional unit making up your ATS9462, and describes the signal connections. Following is a high-level block diagram of ATS9462.



Input Connectors

ATS9462 digitizers have one SMA connector for ECLK (External Clock) Input, two standard BNC female connectors for CH A and CH B analog input connections, one standard BNC female connector for the TRIG IN (External Trigger) input and one standard BNC female connector for AUX I/O (Auxiliary Input or Output).

The following pictorial shows the various connectors available on the digitizer bracket.



Signal Connections

You can use CH A and CH B to digitize data as well as to trigger an acquisition.

Use the EXT input for an external analog trigger only; data on the TRIG channel cannot be digitized.

If External Clock Upgrade is installed on your ATS9462, use the ECLK input for clocking the ATS9462 in applications that require an external clock. Consult the chapter [Optional External Clock](#) for details on various types of clocking schemes available.

AUX I/O connector can be used for outputting TRIG OUT signal, a 5 V TTL signal synchronous with the on-board trigger signal and the sampling clock.

- Note that the Trigger Output connector can also be configured as a Trigger Enable Input through a software command. Contact factory for details.

Analog Input

The two analog input channels are referenced to common ground in bipolar mode. These settings are fixed; therefore, neither the reference nor the polarity of input channels can be changed. You cannot use CH A or CH B to make differential measurements or measure floating signals unless you subtract the digital waveforms in software.

For accurate measurements, make sure the signal being measured is referenced to the same ground as your AT9462 by attaching the probe's ground clip to the signal ground.

The EXTERNAL Trigger input (labeled TRIG IN) has a programmable input range of ± 5 V or ± 1 V.

The CH A, CH B, and EXT inputs have a software-programmable coupling selection between AC and DC. Use AC coupling when your AC signal contains a large DC component. Without AC coupling, it is difficult to view details of the AC component with a large DC offset and a small AC component, such as switching noise on a DC supply. If you enable AC coupling, you remove the large DC offset for the input amplifier and amplify only the AC component. This technique makes effective use of dynamic range to digitize the signal of interest.

The *low-frequency corner* in an AC-coupled circuit is the frequency below which signals are attenuated by at least 3 dB. The low-frequency corner is approximately 10 Hz with 1 M Ω input impedance and 100 KHz with 50 Ω input impedance.

Pipelined ADC

Each of the two ADCs on the ATS9462 is a pipelined flash converter with a maximum conversion rate of 180 MS/s.

If you use an external clock, you must provide a free-running clock to ensure reliable operation. You also must follow all the timing specifications on the external clock as described in Appendix A, Specifications.

Multiple Record Acquisition

The ATS9462 allows the capture of multiple records into the on-board memory. This allows you to capture rapidly occurring triggers in OCT, ultrasound or radar applications.

Note that pre-trigger data cannot be acquired using ATS9462.

Specifying Record Length

Record Length is specified in number of sample points. It must be a minimum of 128 points and can be specified with a 16-sample resolution.

Specifying Pretrigger Depth

ATS9462 cannot acquire pre-trigger data.

Specifying Record Count

User can specify the number of records that must be captured into host PC memory. The minimum value must be 1.

Since the data is streamed to PC memory, there is no upper limit on how many records you can capture in one acquisition.

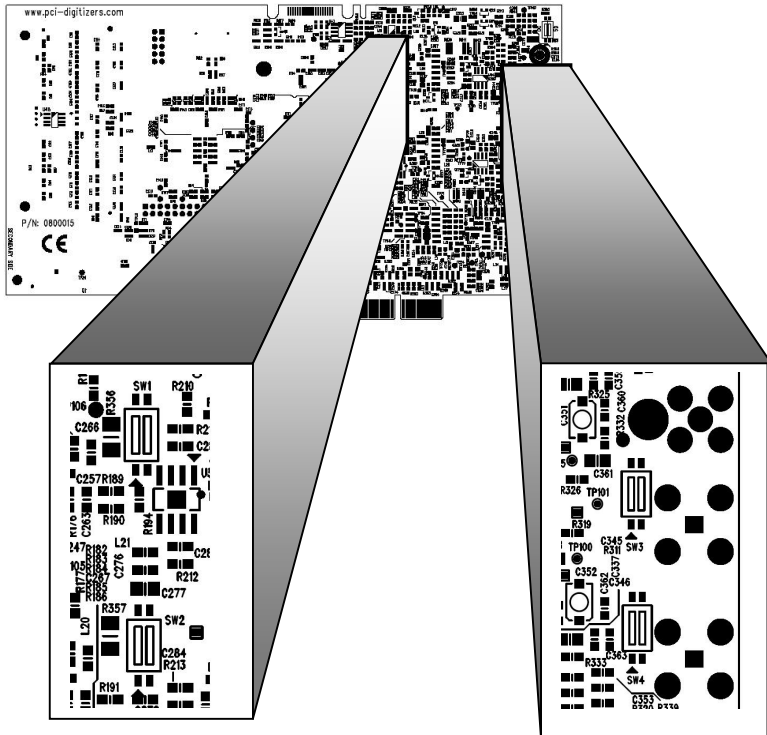
Amplifier Bypass Option

ATS9462 includes the capability to bypass the input amplifier in order to maximize dynamic performance.

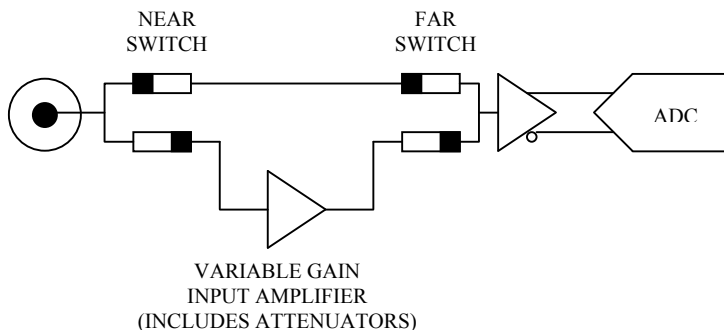
ATS9462 allows the user to set and reset the Amplifier Bypass Option using on-board DIP switches.

The user can bypass the amplifier on any one, or both, channels of ATS9462.

The following picture of the secondary side of ATS9462 board shows the location of four DIP switches used for this purpose (2 DIP switches per channel):



The concept behind Amplifier Bypass Option is very simple, as shown below:



There are two DIP switches per channel: the one closest to the input BNC connectors is called the “Near Switch” and the one closest to the ADC IC is called the “Far Switch”.

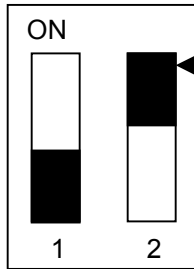
Each DIP switch, in turn, has two individual switches, called Switch 1 and Switch 2.

Under normal operating conditions, Switch 1 is always OFF (disconnected) and Switch 2 is always ON (connected). Thus, the input signal travels through the input amplifier and attenuator circuitry before being digitized by the ADC IC.

To select “Amplifier Bypass Mode”, the switch settings must be changed such that Switch 1 is always ON (connected) and Switch 2 is always OFF (disconnected). This would bypass all input amplifier circuitry and inject the signal directly into the driving amplifier of the ADC.

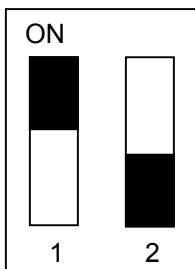
It is very important that the user set both the “Near Switch” and “Far Switch” with the same settings. Failure to do so can cause measurement errors.

The default setting of all four of the DIP switches is shown below:

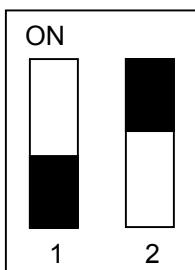


The black square represents the plastic tab for the switch. Note that the actual tab may not be black. It may, in fact, be white.

To set Amplifier Bypass Option for a channel, change the DIP Switch setting of the Near and Far switches for that particular channel to be as shown below:



To re-insert the input amplifier in the signal path, i.e. to remove Amplifier Bypass Option, change the DIP Switch setting of the Near and Far switches for that particular channel to be the same as the factory-set default:



NOTE THAT ANY SETTINGS OTHER THAN THE ONES SHOWN ABOVE ARE ILLEGAL, AND MAY CAUSE DAMAGE TO THE ATS9462 ANALOG CIRCUITRY

Calibration

Calibration is the process of minimizing measurement errors by making small circuit adjustments.

All ATS9462 digitizers come factory calibrated to the levels indicated in Appendix A, Specifications. Note that AlazarTech calibration is fully NIST traceable.

However, your digitizer needs to be periodically recalibrated in order to maintain its specified accuracy. This calibration due date is listed on the CALIBRATION sticker affixed to your ATS9462 digitizer.

Externally recalibrate the ATS9462 when this calibration interval has expired.

This requires three very simple steps:

1. Verify whether or not ATS9462 is still within its specifications. If it is, then your calibration can be extended by another one-year period
2. If not, perform calibration, i.e. make adjustments to the circuit until it is within specifications again
3. If any adjustments have been made, verify if the ATS9462 is within specifications

Verification and Calibration procedures are available to all registered users of ATS9462 upon request.

Master/Slave Operation

You can use two or more ATS9462 digitizers in one system to increase the number of channels for your application by synchronizing digitizers using the appropriate SyncBoard.

The main trick in using multiple ATS9462 boards as Master/Slave is to find a motherboard with the required number of slots.

Currently, up to 16 channel (8 board) systems are supported for ATS9462. For higher channel counts, contact the factory for special system configuration.

Unlike other products on the market, ATS9462 does not suffer from clock jitter between master and slave digitizers.

The unique design of the ATS9462 clock circuit provides a buffered copy of the Master digitizer's clock to itself and all the slave digitizers, thereby maintaining a very low skew between Master and Slave digitizer clocks.

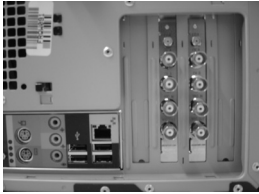
Note that an ATS9462 Master/Slave system is capable of triggering from any one of its input channels. This is valuable in multi-channel detector applications that cannot predict the input channel that is going to receive the first pulse.

With fully synchronous A/D conversion, arming and triggering, an ATS9462 based Master/Slave system is an ideal multi-channel transient analyzer.

Restrictions

To ensure proper master/slave operation of your ATS9462 digitizers, you must observe the following restrictions:

- All Master/Slave digitizers must be installed in adjacent slots, i.e. there should be no gap between the digitizers that are to be configured as a Master/Slave system



Good Installation



Bad Installation

- You must connect the appropriate SyncBoard to all of the ATS9462 digitizers in your system. Note that all SyncBoards are polarized, so you cannot make a mistake in inserting them
- If you are using fewer than the maximum number of digitizers allowed by the SyncBoard, make sure that the connector labeled “M” (Master) on the SyncBoard is connected to one of the ATS9462 digitizers. Any over-hang of the SyncBoard should be beyond the last slave board in your system

The presence of a SyncBoard is detected by the ATS9462 driver when the ATSApi DLL is loaded. This DLL gets loaded when you run any application program written for ATS9462. Examples of such application programs are AlazarDSO, one of the sample programs supplied with ATS-SDK or ATS-VI or any custom software written using ATS-SDK or ATS-VI.

If you run AlazarDSO or your own software that loads the ATSApi DLL, after having installed a SyncBoard, the ATS9462 driver will automatically recognize that the digitizers are now configured as Master/Slave.

As such, there is no need to have your hardware upgraded or modified in any way to go from a set of independent boards to Master/Slave and vice-versa.

Optional External Clock

ATS9462 PCI Digitizer optionally allows you to supply the ADC clock. This option is extremely important in many RF applications in which phase measurements must be made between the inputs themselves or between the inputs and an external event.

Driving high performance ADCs must be done carefully, as any injection of phase jitter through ADC clocks will result in reduction in data conversion quality.

Aside from phase noise, the clock signal for a pipelined ADC must also have a duty cycle close to 50%. This maximizes the dynamic performance of the ADC. See Fast External Clock section below for more details.

External clock input impedance is fixed at 50 Ohms.

External clock input coupling can be set to AC or DC, under software control.

There are three types of External Clock supported by ATS9462:

- Fast External Clock
- Slow External Clock
- 10 MHz Clock Reference

The following paragraphs describe the three types of External Clock input and outline the restrictions on each of them.

Fast External Clock

This setting must be used when the external clock frequency is in the range of 1 MHz to 180 MHz.

- If you are experiencing intermittent problems while using Fast External Clock that has rapidly changing frequency, contact the factory to disable the on-board Clock Duty Cycle Stabilization circuit. For hardware version 1.1, this modification can only be done at the factory.

It is highly recommended that the Fast External Clock signal have a duty cycle of 50% +/- 5%.

If the External Clock supplied is lower than 1 MHz, measurement quality will be compromised. Measurement errors may include gain errors, signal discontinuities and general signal distortion.

If you want to clock slower than the lower limit of Fast External Clock, you must use the Slow External Clock range.

Slow External Clock

This setting must be used when the external clock frequency is slower than the lower limit of Fast External Clock.

In this range, the input clock is tracked by the 125 MHz internal clock and a sample is taken on every rising or falling clock edge. As such, there will be a timing error of 0 to 8 nanoseconds. For low bandwidth signals, this error can be considered to be negligible.

10 MHz Clock Reference

ATS9462 allows the user to synchronize the sampling clock to an external 10 MHz reference signal. This is useful in many RF applications.

Reference clock frequency must be 10 MHz +/- 0.5 MHz.

It should be noted that the user can set the sampling frequency from 150 MHz to 180 MHz, with 1 MHz resolution.

Streaming Using Data FIFO

One of the most unique features of the ATS9462 is its on-FPGA Data FIFO and the associated Dual-DMA engine. This combined by the advanced, fully asynchronous software driver allows data transfer to host PC memory without any appreciable “in-process” software involvement.

These features are particularly useful for applications that require:

a) Continuous, gapless data capture. Also known as “Data Streaming” to PC host memory or hard disk

or

b) Data capture from rapidly occurring triggers, also known as Pulse Repeat Frequency Captures or PRF Captures.

In order to understand these sophisticated features, let us first review some of the issues involved in transferring data under Windows or Linux operating systems.

The Effects of the Operating System

Windows and Linux are not real-time operating systems, i.e. the operating system cannot guarantee a deterministic response time to an event, such as an interrupt or a software generated event.

This means that if software has to play any appreciable part in data transfer, then the data throughput cannot be guaranteed, as the operating system will have the last say as to when the data collection application will get the CPU cycles to execute the necessary commands.

Note that the above is true even if the digitizer claims to use Direct Memory Access (DMA) to do the actual transfer, but uses software commands to re-arm the digitizer. It is the re-arm command that will determine the overall data throughput.

For example, it is very common for PCI digitizers that boast very fast throughput to slow down considerably when capturing pulsed radar or ultrasonic signals at Pulse Repeat

Frequency (PRF) of 1 KHz or so, even though each capture is only 2048 bytes (a paltry 2 MB/s throughput).

In other words, digitizers that specify raw data throughput of 100 MB/s can hardly handle 2MB/s effective throughput due to operating system related delays in issuing re-arm commands.

Real-Time Operating Systems

Some vendors claim that switching to a real-time operating system (RTOS) can solve the problems involved in PRF data capture.

Before switching to an expensive RTOS (such as VxWorks, QNX or PharLap ETS), ask the vendor of the operating system, the supplier of your PC system and manufacturer of the digitizer board if they are all guaranteed to be 100% compatible and interoperable with each other with deterministic interrupt latencies and if you will get your money back if the system does not work at your PRF rates with your software.

Here is an excerpt from a FAQ section of one such supplier of RTOS:

Question: How do system configuration and CPU selection impact the interrupt latency?

Answer: Hardware platforms and the configuration of the associated drivers that use the hardware do impact response times. Some of the common issues include:

Video cards - some of the higher-end cards lock-out (or busy-wait) the bus for extended periods of time to improve their performance.

DMA devices - devices which burst DMA for lengthy period.

Power management which cycles off the CPU during IDLE CPU periods.

Memory speeds, processor speeds, etc.

A PCI or PCI Express digitizer being used in a PRF or streaming application is, by definition, doing “burst DMA for lengthy period”, and is a type of product that can negatively impact response times of the RTOS.

As such, the claim that an RTOS can remove all timing uncertainties in PRF application is suspect, to say the least.

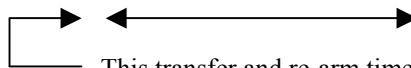
Furthermore, you may not be able to get software drivers for the selected RTOS for all the hardware components you need for your system.

In summary, moving to a real-time operating system will not guarantee data throughput, but will surely increase the overall system cost, increase the cost of software development and maintenance and limit the number of suppliers for other hardware components.

Dual Port Memory

The basic throughput problem faced by digitizers is that almost all of them use single-port memory, i.e. if you are reading data from the acquisition memory, you cannot capture into it and vice-versa.

This requires a software handshake which is heavily dependent on the operating system response time.



This transfer and re-arm time limits the maximum achievable PRF. Note that the operating system overheads are part of this delay

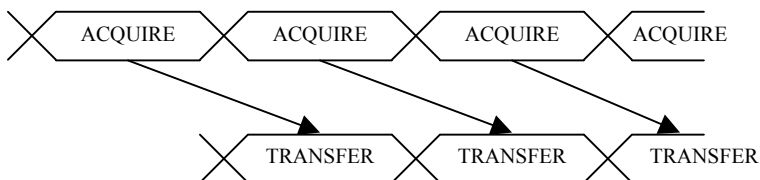
ATS9462 solves this problem by providing an on-FPGA dual-port FIFO and an advanced dual-DMA engine that can stream data to PC host memory at up to 720 MB/s (exact rate is motherboard dependent).

Bottom line is that software does not have to wait until the end of data capture to read the acquired data.

Asynchronous DMA

Just having dual-ported memory or a FIFO, on its own, does not solve the problem of PRF captures or streaming applications. Software still has to get involved in re-arming the hardware after every capture and again for reading the data from on-board acquisition memory.

ATS9462's proprietary AutoDMA circuitry allows the acquisition system to be re-armed by a hardware command and data transfer to be initiated by the hardware itself, thus removing virtually all "in-process" software involvement.



Of course, software still has to set up the DMA when one of the buffers fills up, but, thanks to the dual-DMA engine and fully asynchronous driver that uses overlapped IO, these tasks can be paralleled.

In other words, when software is re-arming DMA channel 0, DMA channel 1 is already transferring data to host memory.

At the fastest transfer rates, users must use large buffers (say, 8 Megabytes) to ensure that the DMA channel 1 does not finish before the DMA channel 0 is re-armed, and vice-versa.

Note that if data throughput is too high, a `DMA_OVERFLOW` flag gets set and is available to the programmer.

Consumption of the captured data is, of course, under the control of user-created software, and it is this that will determine the maximum PRF instead of the bus throughput.

The important thing to note is that if `AlazarAsyncRead` API function is used, CPU usage is almost 0% even when 720 MB/s DMA is going on.

No Pre-Trigger (NPT) AsyncDMA

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.

A `BUFFER_OVERFLOW` flag is asserted if the Data FIFO overflows.

Continuous AsyncDMA

Continuous AutoDMA is also known as the data streaming mode.

In this mode, data starts streaming across the PCI bus as soon as the ATS9462 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 Data FIFO overflows.

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 sustained rates up to 720 MB/s without causing an overflow. This is the recommended mode for very long signal recording.

Triggered Streaming AsyncDMA

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 Data FIFO overflows.

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 sustained rates up to 720 MB/s 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.

Stream To Disk

Any one of the AutoDMA modes can be combined with a fast disk drive to create a very efficient and low cost data streaming system.

AlazarDSO Stream To Disk module (sold separately) allows out-of-the-box disk streaming. No programming is required. Note, however, that the speed with which data can be stored to memory will be limited by the lower of:

1. ATS9462 Bus Throughput (720 MB/s)
2. PCI Express throughput supported by the motherboard
3. Sustained Throughput of the disk drive system

AlazarDSO version 1.0.19 and higher include a Disk Throughput Benchmarking tool, using which you can quickly and easily see how fast your disk drives are.

Files are saved as ATB format binary files, and can automatically be converted to text files or MATLAB compatible files.

For more information on complete disk streaming systems, please contact the factory or your local distributor.

Appendix A - Specifications

This appendix lists the specifications of the ATS9462. These specifications are typical at 25 °C unless otherwise stated. The operating temperature range is 0 to 50 °C.

System Requirements

Pentium based computer with at least one free x4, x8 or x16 PCI Express slot, 256 MB RAM, 20 MB of free hard disk space,

PCI Express revision	1.0a or higher
Transceiver speed	2.5 Gbps
Number of lanes	4
Compatibility - mechanical	x4, x8 and x16 slots
Compatibility - electrical	x1, x4, x8 and x16 slots

Power Requirements

+12V	1.5 A, typical for ATS9462
+3.3V	1.0 A, typical for ATS9462

Physical

Size	Single slot, half-length PCI card (4.2 inches x 7.5 inches)
Weight	500 g

I/O Connectors

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

Environmental

Operating temperature	0 to 55 °C
Storage temperature	-20 to 70 °C
Relative humidity	5 to 95%, non-condensing

Acquisition System

Resolution	16 bits
Bandwidth (-3dB)	
DC-coupled, 1M Ω	DC - 65 MHz
DC-coupled, 50 Ω	DC - 65 MHz
AC-coupled, 1M Ω	10 Hz - 65 MHz
AC-coupled, 50 Ω	100KHz - 65 MHz
Bandwidth flatness:	± 1 dB, from DC to 10 MHz with DC coupling ± 1 dB, from 50Hz to 10 MHz with AC, 1 M Ω ± 1 dB, from 200 KHz to 10 MHz with AC, 50 Ω
Bandwidth Limit	20 MHz, typical. Software selectable for each input channel independently
Number of channels	2 simultaneously sampled
Maximum Sample Rate	180 MS/s single shot (internal clock) 180 MS/s single shot (external clock)
Minimum Sample Rate	1 KS/s single shot (internal clock) 1 MS/s single shot (Fast External Clock)
Full Scale Input ranges	
1 M Ω :	± 200 mV, ± 400 mV, ± 800 mV, ± 2 V, ± 4 V, ± 8 V and ± 16 V, software selectable
50 Ω :	± 200 mV, ± 400 mV, ± 800 mV, ± 2 V and ± 4 V, software selectable
DC accuracy	$\pm 2\%$ of full scale in all input ranges
Input coupling	AC or DC, software selectable
Input impedance	50 Ω or 1M Ω $\pm 1\%$ in parallel with 30 pF ± 10 pF, software selectable
Input protection	
1M Ω	± 28 V (DC + peak AC for CH A, CH B and EXT only without external attenuation)
50 Ω	± 5 V (DC + peak AC for CH A, CH B and EXT only without external attenuation)

Amplifier Bypass Mode

DIP Switch Selectable	Yes, independently for each channel
Input Range	Approximately 550 mV rms
Input Coupling	DC, irrespective of input coupling setting for the channel
Input Impedance	50 Ω , irrespective of input impedance setting for the channel
Input Bandwidth (-3dB)	85 MHz

Acquisition Memory System

On-FPGA FIFO Size	8 kilobytes
Record Length	Software selectable with 16-point resolution. Record length must be a minimum of 128 points. There is no upper limit on the maximum record length. It is limited by host PC memory or disk size.
Number of Records	Software selectable from a minimum of 1 to a maximum of infinite number of records
Pre-trigger depth	Up to 2048 points with firmware version 23 and higher
Post-trigger depth	Record Length – Pre-Trigger Depth

Timebase System

Timebase options	Internal Clock or External Clock (Optional)
Internal Sample Rates	180 MS/s, 160 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, 500 KS/s, 200 KS/s, 100KS/s, 50 KS/s, 20KS/s, 10KS/s, 5 KS/s, 2 KS/s, 1 KS/s
Internal Clock accuracy	±25 ppm

Dynamic Parameters

Typical values measured using a randomly selected ATS9462 with Amplifier Bypass Mode. Input was provided by a HP8656A signal generator, followed by a 9-pole, 1 MHz band-pass filter (TTE Q36T-1M-100K-50-720B). Input frequency was set at 1 MHz and output amplitude was 520 mV rms, which is approximately 95% of the 550 mVrms full scale input in Amplifier Bypass Mode.

SNR	72.9 dB
SINAD	72.3 dB
THD	-83.2 dB
SFDR	-82.7 dB

Note that these measurements were made using raw data: no signal averaging was used to artificially improve the results.

Further 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	LVTTL levels or 200 mV sine wave
Input impedance	50 Ω
Input Coupling	AC or DC, software selectable
Maximum frequency	
Fast External Clock:	180 MHz with 50% \pm 5% duty cycle
Slow External Clock:	40 MHz with minimum positive or negative pulse width of 10 ns
10 MHz Clock Reference:	10.5 MHz
Minimum frequency	
Fast External Clock:	1 MHz with 50% \pm 5% duty cycle
Slow External Clock:	DC
10 MHz Clock Reference:	9.5 MHz
Decimation factor	Software selectable from 1 to 100,000 Fixed to 1 for Slow External Clock
Sampling Edge	Rising or Falling, software selectable
Sample Rates Available With 10 MHz Clock Reference:	150 MS/s, 151 MS/s, 152 MS/s, 153 MS/s, 154 MS/s, 155 MS/s, 156 MS/s, 157 MS/s, 158 MS/s, 159 MS/s, 160 MS/s, 161 MS/s, 162 MS/s, 163 MS/s, 164 MS/s, 165 MS/s, 166 MS/s, 167 MS/s, 168 MS/s, 169 MS/s, 170 MS/s, 171 MS/s, 172 MS/s, 173 MS/s, 174 MS/s, 175 MS/s, 176 MS/s, 177 MS/s, 178 MS/s, 179 MS/s, 180 MS/s

Note that the accuracy and stability of these sampling frequencies is dependent on the accuracy and stability of the 10 MHz Clock Reference input supplied by the user

Triggering System

Mode	Edge triggering with fixed hysteresis
Number of Trigger Engines	2
Trigger Engine Combination	OR, AND, XOR, software selectable
Trigger Engine Source	CH A, CH B, EXT, Software or None, independently software selectable for each of the two Trigger Engines
Hysteresis	\pm 5% of full-scale input, typical
Trigger sensitivity	\pm 10% of full scale input range. This implies that the trigger system may not trigger reliably if the input has an amplitude less than \pm 10% of full-scale input range selected
Trigger level accuracy	\pm 10%, 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 us resolution. Maximum settable value is 3,600 seconds. Can also be disabled to wait indefinitely for a trigger event

EXT (External Trigger) Input

Input impedance	1 M Ω in parallel with 30pF \pm 10pF
Bandwidth (-3dB)	
DC-coupled	DC - 25 MHz
AC-coupled	10 Hz - 25 MHz
Input range	\pm 5V or \pm 1V, software selectable
DC accuracy	\pm 10% of full-scale input
Input protection	\pm 28V (DC + peak AC without external attenuation)
Coupling	AC or DC, software selectable

Auxiliary I/O (AUX I/O)

Signal Direction	Input or Output, software selectable Output by default
Output Types:	Trigger Output Busy Output Software controlled Digital Output
Input Types:	Trigger Enable Software readable Digital Input
Output	
Amplitude:	5 Volt TTL
Synchronization:	Synchronized to rising edge of sampling clock
Input	
Amplitude:	5 Volt TTL or 3.3 Volt TTL

Certification and Compliances

CE Mark Compliance

Materials Supplied

One ATS9462 Digitizer
One ATS9462 Install Disk
One ATS9462 User Manual

All specifications are subject to change without notice

Appendix B - Benchmarks

This appendix lists the data throughput measured by our technicians on various computers and motherboards under different operating systems.

- Given the constantly changing nature of computers, these benchmarks are provided as a reference only and AlazarTech assumes no liability in case the computer you purchase behaves differently than what was observed in AlazarTech's laboratory.

Model	Chipset	Slot	O/S	Throughput
Intel S5000PSL	Intel 5000P	PCIe x8	Win XP 32-bit	720 MB/s
Intel S5000PSL	Intel 5000P	PCIe x8	Win XP 64-bit	720 MB/s
Intel S5000PSL	Intel 5000P	PCIe x8	Vista 32-bit	640 MB/s
Intel S5000PSL	Intel 5000P	PCIe x8	Vista 64-bit	640 MB/s
Tyan S2915-E	nVIDIA NPF3600 + NPF 3050	PCIe x8	Win XP 64-bit	720 MB/s
Dell T3400	Intel 975 Express	PCI e x4	Win XP 32-bit	720 MB/s
Dell T7400	Intel 5400	PCIe x8	Win XP 64-bit	600 MB/s
Dell T7400	Intel 5400	PCIe x8	Vista 64-bit	550 MB/s

SuperMicro X7DB3	Intel 5000P	PCIe x8	Win XP 32-bit	640 MB/s
HP xw9400	nVIDIA NFP3600 + NFP 2050	PCIe x8	Vista 32-bit	200 MB/s
Intel DG965RY	Intel 965	PCIe x16	Win XP 32-bit	400 MB/s
IBT MB899FX	Intel 945 + Modified BIOS	PCIe x16	Win XP 32-bit	640 MB/s



ALAZAR TECHNOLOGIES INC.

6600 Trans-Canada Highway
Suite 310
Pointe-Claire, QC
CANADA H9R 4S2

Tel: (514) 426-4899

Fax: (514) 426-2723

E-mail: info@alazartech.com

Web: www.alazartech.com