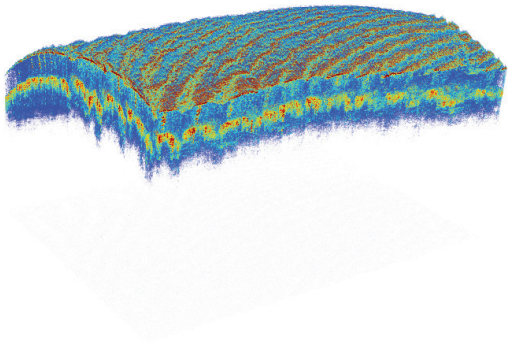
ATS-GPU-OCT

OCT Signal Processing Library

- Very High-Speed Floating Point FFT
- Dispersion Compensation and Windowing Functions
- Requires ATS-GPU-BASE
- Transfer A/D data to GPU at high speed
- Up to 6.9 GB/s transfer rate for PCIe Gen 3 digitizer boards
- Supports CUDA® compute capability 3.0+
- Designed to work with AlazarTech® PCI Express waveform digitizers
- Compatible with Windows® & Linux®



Product	GPU Compatibility	Operating System	Throughput to GPU	FFT Length	Max. FFTs Per Second
ATS-GPU-OCT	CUDA compute capability 3.0+	32-bit/64-bit Windows & 64-bit Linux	Up to 6.9 GB/s	Up to 8 M Points	1,900,000 (2048 pt FFTs, see benchmark table below for more details)

Overview

ATS-GPU-OCT is an OCT Signal Processing Library developed by AlazarTech that provides very high-speed floating point FFT capability for data acquired by AlazarTech's PCI Express waveform digitizers or for user-supplied data. ATS-GPU-OCT must be used with ATS-GPU-BASE.

ATS-GPU-BASE allows users do real-time data transfer from AlazarTech PCI Express waveform digitizers to a CUDA-enabled Graphical Processing Unit (GPU) at rates up to 6.9 GB/s.

ATS-GPU-OCT contains floating point FFT routines that have 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.

Benchmarks

An AlazarTech ATS®9373 in an Intel i9-7900X 10-Core @ 3.3 GHz system with an ASUS® x299 motherboard, 32 GB DDR4, and NVIDIA® Quadro® P5000 GPU had the following benchmarks:

GPU Buffer Size (MB)	FFT Length	FFTs per second
1	2048	1,900,000
	4096	950,000
	8192	485,000
	65536	45,000
4	2048	1,900,000
	4096	950,000
	8192	485,000
	65536	50,000
	1048576	2,500
16	2048	1,900,000
	4096	950,000
	8192	485,000
	65536	55,000
	1048576	2,600

Tests in an Intel i7 5930k 6-core @ 3.5 GHz system with an ASUS x99 Deluxe motherboard, 64 GB DDR4, and the same NVIDIA Quadro P5000 GPU produced very similar results.

Modular API

ATS-GPU-OCT has a unique, modular API that allows users to easily customize their signal processing algorithms. The modularity provides many hooks into the GPU data path, where customers can add their own signal processing code.

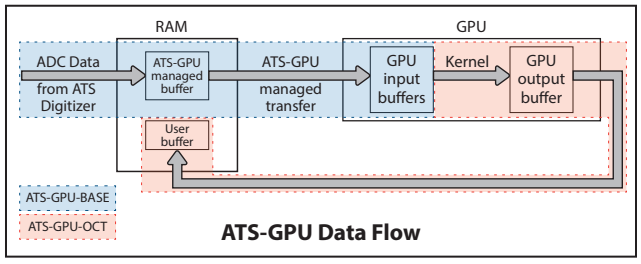
ATS-GPU and CUDA Runtime Library

ATS-GPU is shipped with a specific version of CUDA runtime library and links statically to it.

Programmers are allowed to use a different version of CUDA runtime library for their custom kernel code. NVIDIA guarantees that the two versions of CUDA runtime libraries will be interoperable.

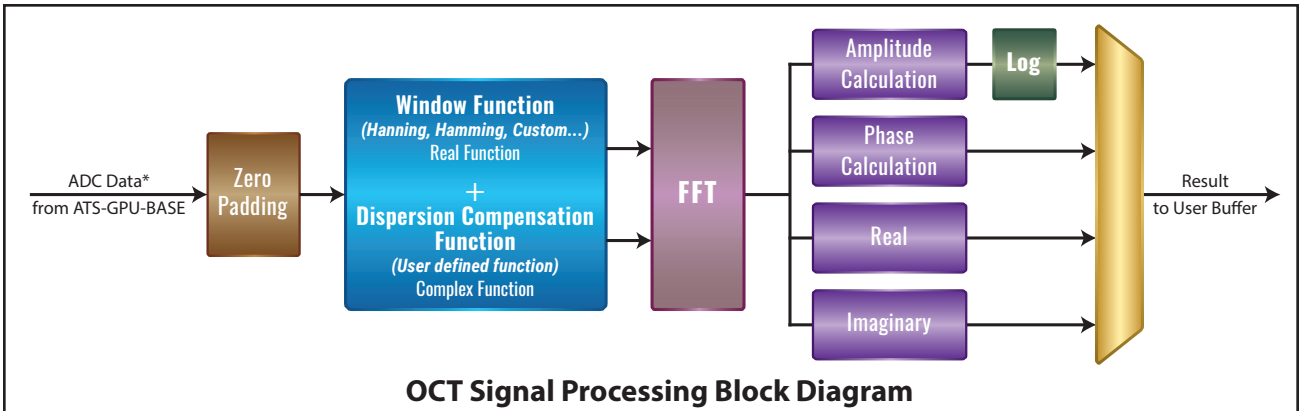
Note: ATS-GPU only supports Windows versions and Linux distributions that are supported by NVIDIA's CUDA Toolkit. 32-bit operating system support is also similarly limited by NVIDIA. In particular, the ATS-GPU-OCT cannot be built as a 32-bit library. We currently use CUDA toolkit 10.0, older versions are untested.

ATS-GPU Data Flow



ATS-GPU-BASE is supplied with an example user application in source code. The application includes GPU kernels that use ATS-GPU-BASE 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.

ATS-GPU-OCT
OCT Signal Processing Library



OCT Signal Processing Block Diagram

*Data can come from multiple channels

ATS-GPU-OCT is supplied with example programs in C/C++, Python, LabVIEW, and MATLAB that allows users to set-up the waveform digitizer parameters, set-up FFT parameters in the GPU, do the acquisition, and receive the FFT result buffer.

Programming with ATS-GPU-OCT

Users can use example programs in C/C++, Python, LabVIEW, or MATLAB to set-up the waveform digitizer parameters, set-up FFT parameters in the GPU, do the acquisition, and receive the FFT result buffer.

C/C++ example programs are provided with Visual Studio projects and CMake build files. Python code is tested under Python 2.7 and 3.6. LabVIEW 2009 or newer is necessary to use LabVIEW example codes. MATLAB code is developed under MATLAB 2015A, but is expected to work with most MATLAB versions.

Waveform digitizer data is transferred to the GPU in a buffer that will contain many records. This number, RecordsPerBuffer, is specified by the user. Users should make sure that they choose this number such that the buffer size is in the order of 1 MByte or larger. Smaller buffers can reduce overall data throughput.

If the number of samples per record is not a power-of-2, ATS-GPU FFT will perform zero-padding to the next power of 2. It will then apply a complex windowing function, do a single-precision floating point FFT, calculate the amplitude and phase, and convert the amplitude to logarithmic values.

Very Long FFTs

For some applications, it is necessary to perform very long FFTs (e.g. one million points).

Even if a waveform digitizer has an on-board FPGA, such very long FFTs do not fit inside an FPGA due to resource limitations of the FPGA.

With the ATS-GPU-OCT Signal Processing Library, ATS-GPU is fully capable of calculating such very long FFTs. Our benchmarks using an Intel i9-7900X 10-Core @ 3.3 GHz system with an ASUS x299 motherboard, and NVIDIA Quadro P5000 GPU have shown that ATS-GPU is capable of doing 2600 one million point FFTs per second in single channel mode (keep up with sample rate of up to 2600 MS/s).

Even longer FFTs are possible. We have measured 8 million (2^{23}) point FFTs but we have not fully tested the limits of FFT length with ATS-GPU.

Zero Padding

If the number of samples per record (A-scan) is not a power of 2, the OCT Signal Processing Library will perform zero-padding to the closest power of 2 before doing further signal processing.

Dispersion Compensation Function

Dispersion compensation is an essential part of any OCT signal processing system. ATS-GPU-OCT Signal Processing Library allows users to multiply the zero-padded data with a user-specified Dispersion Compensation Function (DCF). The DCF is a complex function.

Windowing Function

The windowing function in the ATS-GPU-OCT Signal Processing Library is used to ensure that there are no discontinuities in the FFT. Note that the length of the window function should be the same as the length of the A-Scan, e.g. if the A-scan is 1536 points long, the window function should also be 1536 points long, even though the FFT length will be 2048.

Amplitude and Phase Output

The FFT algorithm implemented in the OCT Signal Processing Library is capable of calculating both amplitude and phase outputs. All outputs are provided as single-precision floating point data (32 bits per data point).

Data Throughput to GPU

The data transfer rate to GPU is dependent on the generation of PCI Express digitizer board used:

PCIe Link Speed	Transfer Rate
Gen 3: ATS9373, ATS9371	Up to 6.9 GB/s
Gen 2: ATS9360, ATS9416	Up to 3.5 GB/s
Gen 1: ATS9870, ATS9350, ATS9351, ATS9120, ATS9625, ATS9626, ATS9440, ATS9462	Up to 1.6 GB/s (Exact rate is limited by digitizer sample rate)

Compatible Waveform Digitizers

All AlazarTech PCI Express waveform digitizers are compatible with ATS-GPU. Only single-board configurations are supported at this time.

AlazarTech's PCI bus waveform digitizers are not supported, as the host CPU is more than capable of handling data rates generated by PCI bus boards.

ATS-GPU cannot directly be interfaced with non-AlazarTech waveform digitizers.

ATS-GPU-OCT
OCT Signal Processing Library

Software Licensing Policy
Users are allowed to freely distribute the ATS-GPU-OCT library as long as there is an AlazarTech PCI Express waveform digitizer present in the same computer. If an AlazarTech PCI Express waveform digitizer is not present in the computer, users must purchase a separate license for each computer on which ATS-GPU-OCT is installed.

In no case is the user allowed to distribute or share the source code of ATS-GPU-OCT with other users.

Annual Subscriptions
The purchase of an ATS-GPU-OCT license includes a subscription that provides customers with the following benefits for a period of 1 year on ATS-GPU-OCT:

- Download ATS-GPU-OCT updates from the AlazarTech website;
- Receive new example programs as they become available;
- Receive technical support on ATS-GPU-OCT.

Note that support is provided for product bugs, and not for writing custom GPU kernels or for learning GPU programming.

ORDERING INFORMATION

ATS-GPU-BASE: GPU Streaming Library 1 Year Subscription	ATSGPU-001
ATS-GPU-BASE-1YR: 1 year extended support & maintenance for ATS-GPU-BASE	ATSGPU-002
ATS-GPU-OCT: Signal Processing Library 1 Year Subscription (requires ATSGPU-001)	ATSGPU-101
ATS-GPU-OCT-1YR: 1 year extended support & maintenance for ATS-GPU-OCT	ATSGPU-102

ATS-GPU-OCT main API functions

```
ATS_GPU_OCT_AbortCapture
ATS_GPU_OCT_AllocBuffer
ATS_GPU_OCT_EnableVerificationMode
ATS_GPU_OCT_FreeBuffer
ATS_GPU_OCT_GenerateWindowFunction
ATS_GPU_OCT_GetBuffer
ATS_GPU_OCT_PostBuffer
ATS_GPU_OCT_SetBuffer
ATS_GPU_OCT_Setup
ATS_GPU_OCT_SetWindowFunction
ATS_GPU_OCT_StartCapture
```


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