

AstroFft2 System

2019-08-05

Introduction

This contains some info on a second generation AstroFFT system. This will be based on using a fast FFT algorithm running on a multi-processor PC type system with a suitable ADC board installed.

Components

PCIE-1840	https://www.advantech.com/products/1-2mlk8i/pcie-1840/mod_a4a811bb-bc81-422f-a76e-15932ed6bc96 . This would do 2 x IQ channels at 125 MSPS with 16bits. £3577
PCIE-1840L	This would do 2 x IQ channels at 80 MSPS with 16bits. £1855.
ATS9440, 4ch, 14bit 125Msps	https://www.alazartech.com/Product/ATS9440
ATS9462, 4ch, 16bit 180Msps	http://www.alazartech.com/product/ats9462
Oscar Express CSE4447 4ch, 16bit, 100Msps	http://www.gage-applied.com/digitizers/16-bit/pcie/compuSCOPE-oscar-44xx-express.htm
PCIE-9852, 2ch, 14bits, 200 Msps	https://www.adlinktech.com/Products/GPIB_Modular_Instruments/Digitizers_Oscilloscopes/PCIE-9852?lang=en , £4906
USRP N300	https://www.ettus.com/all-products/USRP-N300/
General GNU radio front ends	https://wiki.gnuradio.org/index.php/Hardware#Commercially_Available_SDR_Platforms
Anti-aliasing filters	Assume -40db at 62.6 MHz is enough for this system
BLP-50+	https://www.minicircuits.com/WebStore/dashboard.html?model=BLP-50%2B \$35, 20 dB at 62.5MHz. Could use two in series for -40dB.
CLPFL-0050-BNC	https://www.digikey.co.uk/product-detail/en/crystek-corporation/CLPFL-0050-BNC/744-1736-ND/5137592 9th order Chebyshev but at 50MHz only -7dB at 60MHz. £30.65. They may do one with a lower cutoff frequency.
	http://tte.com/products/passive-filters/lowpass-filters/
	https://www.wainwright-filters.com
Servers	

HPE DL360 gen10	https://www.serversdirect.co.uk/p/1303167/hpe-proliant-dl360-gen10-xeon-silver-4110-16gb-no-hdd-hot-swap-2.5-rack-server CPU Needs disks. How about Graphics and faster CPU (8 core)? £1262
HPE DL20 gen10	https://www.serversdirect.co.uk/p/1345066/hpe-proliant-dl20-gen10-performance-server CPU E-2126 6-core, 3.3GHz, AVX2. Needs disks. How about Graphics and faster CPU Xeon (D-2100 which as AVX-512?) £745
	https://miatlantic.com/p03631-b21?gclid=CjwKCAjwnMTqBRAzEiwAEF3nds7HLg7HtNvPj1AkhGprzQSsB7vZdt0A9s03ikneYRApJcbOYvbhYBoC1R0QAvDBwE Needs disks. How about Graphics and faster CPU (10 core)? £1332.

Software

The following assumes the use of the 4 channel 125 MSPS at 16bits ADC front end.

The FPGA processing engine can be able to be set into one of a number of modes as listed below.

FFT Mode: In this mode a single ATD converter samples a single analogue data stream at 125Mhz. The ATD samples are fed into the real inputs of a 8192 point FFT using fixed point math. The FFT generates 8192 complex frequency samples. The following integrator will integrate all 8192 samples although only the first 4096 are useful. The magnitude of each complex frequency sample, formed by squaring the real and imaginary parts separately and then adding them, is added to an integrating buffer. After a given number of FFT runs have been processed and added to the integrator the integrated results are passed to the host.

QFFT Mode: In this mode the twin ATD converters sample the two analogue data streams at 125Mhz. The ATD samples are fed into the real and imaginary inputs of a 8192 point FFT using fixed point math. The FFT generates 8192 complex frequency samples. The following integrator integrates all of the 8192 samples separately. The magnitude of each complex frequency sample, formed by squaring the real and imaginary parts separately and then adding them, is added to the integrating buffer. After a given number of FFT runs have been processed and added to the integrator the integrated results are passed to the host.

RFFT Mode: In this mode a single ATD convertor samples the single analogue data stream at 125Mhz. Alternate ATD samples are fed into the real and imaginary inputs of a 8192 point FFT using fixed point math. The FFT will generate 8192 mixed complex frequency samples. A following post processing filter takes these samples and produces the genuine 8192 frequency samples. The following integrator takes all of the 8192 samples. The magnitude of each complex frequency sample, formed by squaring the real and imaginary parts separately and then adding them, is added to the integrating buffer. After a given number of FFT runs have been processed and added to the integrator the integrated results are passed to the host.

Analogue Mode: In this mode both ATD converters sample at 125Mhz. The two 16 bit values are combined into a 32 bit value and fed to the host. The software also calculates the RMS power and the number of ATD peak values of each data stream and passes this to the host with each set of samples.

Performance

On a Xeon E3-1245 v5 @ 3.50GHz we get the following performance figures:

FFT Type	FFT Time	Data rate
fftw_plan_dft_r2c_1d, 8192	15us	525 Msps
fftw_plan_dft_r2c_1d, 16384	35us	465 Msps
fftw_plan_dft_c2c_1d, 8192	32us	256 Msps

FOPS needed is approximately: $FOPS = (5/2) * N \log_2(N)$

From <http://www.fftw.org/speed/E31220V3-3.1GHz> this CPU can manage about 16000 MFlops with an 8192 point FFT. So this can operate at a sample rate of about 500Msps which matches the results obtained.

ADC Performance

The PCIE-1840 can sample at 125 Msps on 4 x 16bit channels. It can also do: 2 x 16bits at 250 Msps. SNR is about 65dB with +-1V input, THD -82 dB, BW 65MHz.

- <https://spectrum-instrumentation.com/en/m4i4420-x8>
- <https://spectrum-instrumentation.com/en/m4i4421-x8>
- <https://www.alazartech.com/en/product/ats9440/16/>
- <https://www.alazartech.com/en/product/ats9625/11/>
- <https://www.gage-applied.com/digitizers/16-bit/pcie/digitizer-compuscope-razorplus-express.htm>
- <https://www.acquitek.com/product/razorplus-express/>

Host

2 x 3.5inch drive days, RAM 16 GBytes, CPU Xeon E-2224 – 3.4GHz. 6 core is E-2236.

CPU: E-2124 4 core 4 Threads

- <https://buy.hpe.com/uk/en/servers/proliant-dl-servers/proliant-dl20-servers/proliant-dl20-server/hpe-proliant-dl20-gen10-server/p/1011028697>

£750 + 3.5” Disks

CPU E-2136 6 core 12 Threads

- £896 + 2.5” Disks

Other

- https://www.serversdirect.co.uk/p/1510186/hewlett-packard-hpe-proliant-dl20-gen10-performance-server-rack-mountable-1u-1-way-1-x-xeon-e-2224-3.4-ghz-ram-16-gb-sata-3.5-bays-no-hdd-matrox-g200-gige-monitor_-none
- <https://www.ebuyer.com/947611-hpe-proliant-dl20-gen10-performance-rack-mountable-xeon-e-2224-3-4-ghz-p17080-b21>

CPU: 4210R 10 core 20 Threads

- <https://buy.hpe.com/uk/en/servers/proliant-dl-servers/proliant-dl100-servers/proliant-dl160-server/hpe-proliant-dl160-gen10-server/hpe-proliant-dl160-gen10-4210r-1p-16gb-r-s100i-4lff-500w-ps-server/p/P35515-B21>

£1084 + disks