A PXI-based, Multi-channel Ultra-fast Data Acquisition System for Transient Pulsed Signal

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1. Overview

This work presents a high speed, high resolution data acquisition system(DAS) with 1Gsps sampling rate and 12 bit resolution, mainly applying to nuclear and particle physics experiments. The system consists of one NI PXIe-1085 chassis, containing a PXIe controller card and 16 data acquisition cards at most. For every single card, the signal conditioning module incorporates one high precision Op Amps converting single-ended signals to differential signals(LVDS) with low additional noise level, and the data acquisition module combines a 12-bit folding interpolating ADC with a Xilinx Kintex-7 FPGA, implementing controls of A/D conversion and high speed data transmission through SFP interface using Aurora protocol. All these cards in the chassis can be synchronized easily using timing and triggering with PXI resources. Besides, a simple software of our system is designed to display the captured waveform signal and communicate with the host PC for remote controlling.

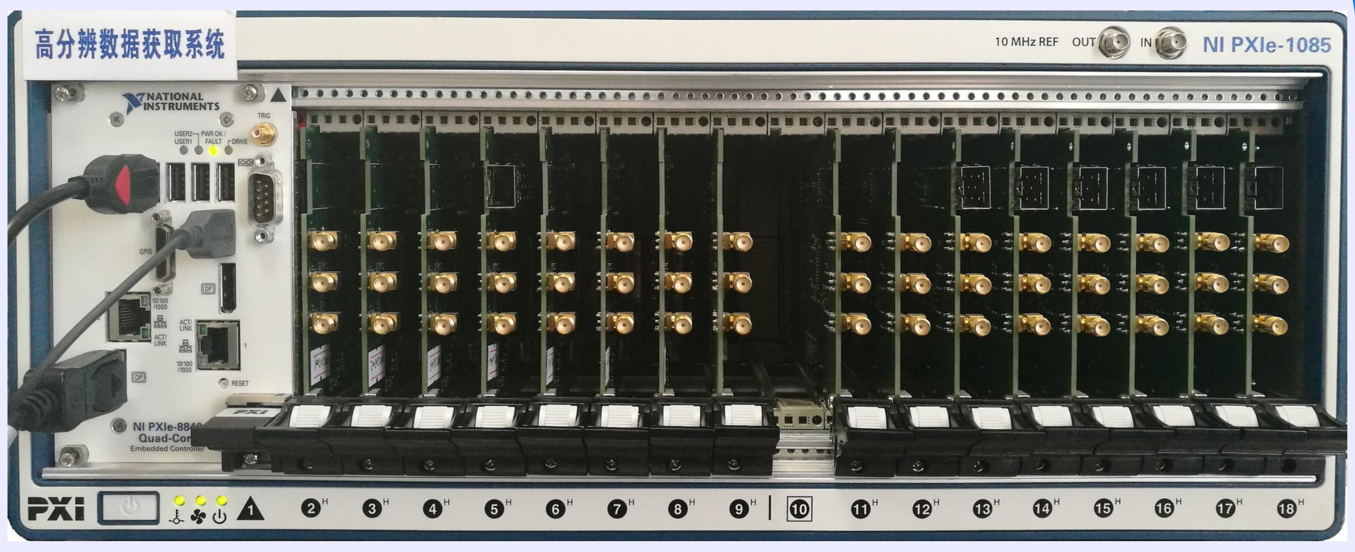

Fig.1: A photo of the PXI-based, Multi-channel Ultra-fast DAS for Transient Pulsed Signal. (Note: The NI PXIe-1085 18-slot chassis features a high-bandwidth, all-hybrid backplane to meet a wide range of high-performance test .)

2. Design and Test

Hardware Design

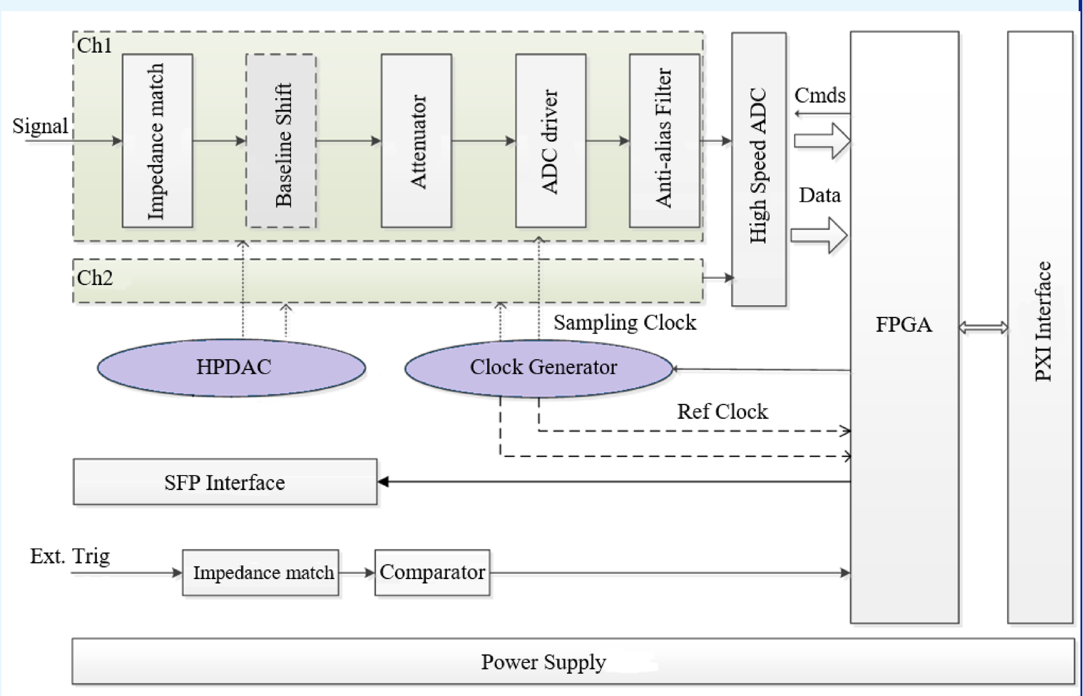

Fig.2: The block diagram of a single DAQ board.

- We deploy serval orders of input range to cover some hundreds of milli-voltages to hundreds of voltages.
- To improve SNR, a three-order Butterworth filter as anti-alias filter is used.
- A baseline shift module is designed for unipolar signals to fully display in the virtual oscilloscope.
- This design chooses TI's LMK04821 as the frequency Synthesizer chip

Fig.3: A photo of a single DAQ board.

Logic and Software Design

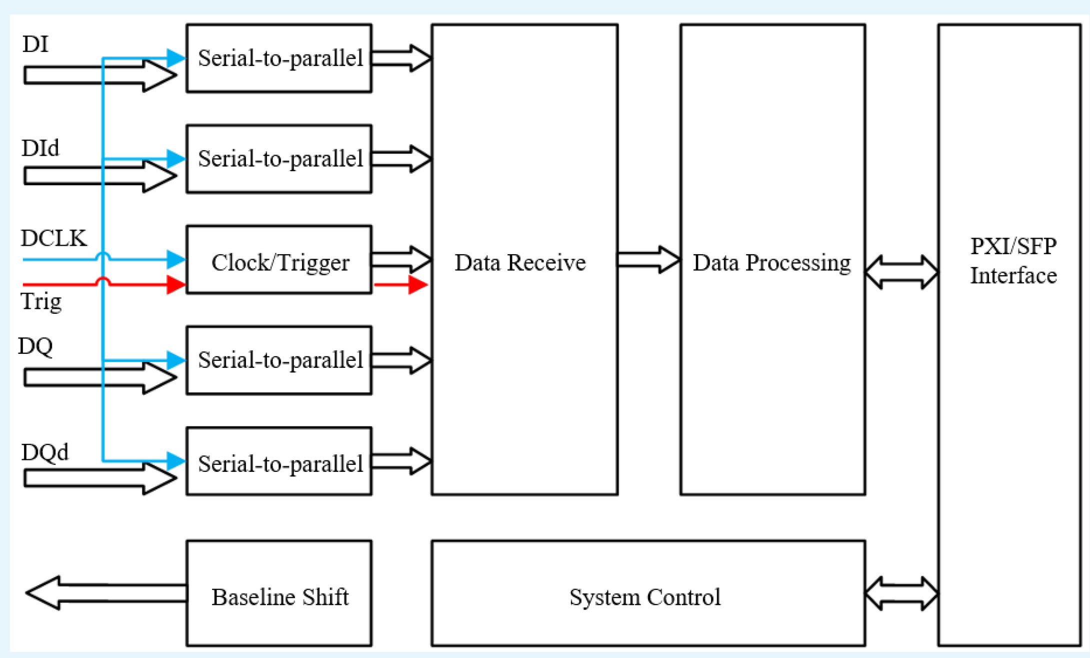

Fig.4: Main Procedures in logic design with Xilinx FPGA .

- Serial-to-parallel: lower date rate per lane
- We use integrated Block RAM IP core to instantiate a module to assemble the captured data
- The resulting data can be transmitted to remote server through SFP connector with optic fibers using Aurora Protocol.
- After creating the VISA-based driver and developing basic communication and DMA support, our control software is built.

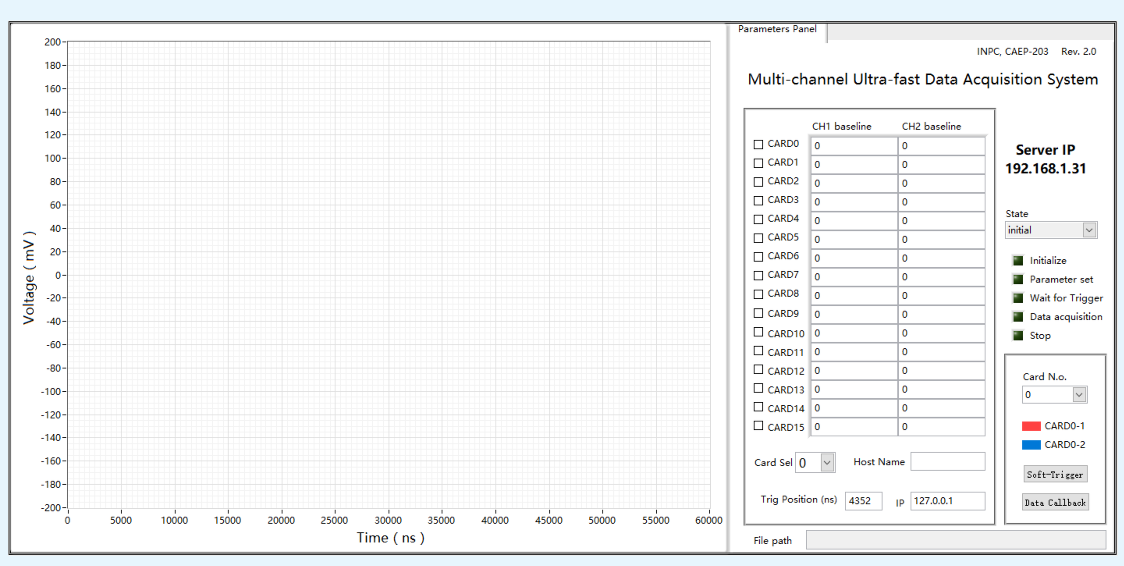

Fig.5: Interface of software designed in LabVIEW environment

Test Results

- Virtually oscilloscopes in a chassis.
- After calibration, primary test results show as followings

Tab.1: The primary test results of ENOB.

Anti-alias Filter	23.723MHz	58.541MHz	134.337MHz
Yes	9.3	9.3	9.2
No	9.3	9.2	9.1

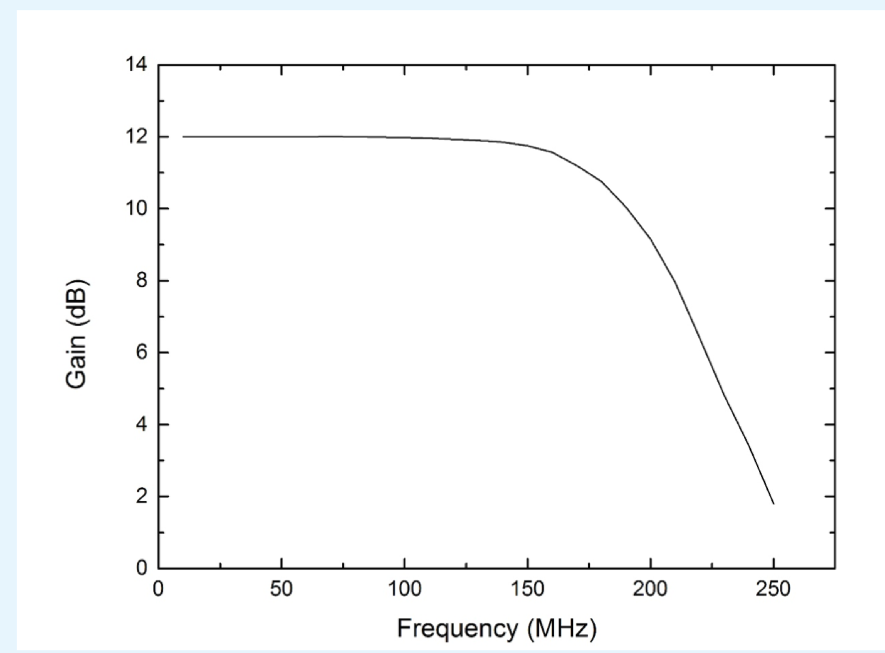

Fig.6: The typical Gain vs f plot of a single channel

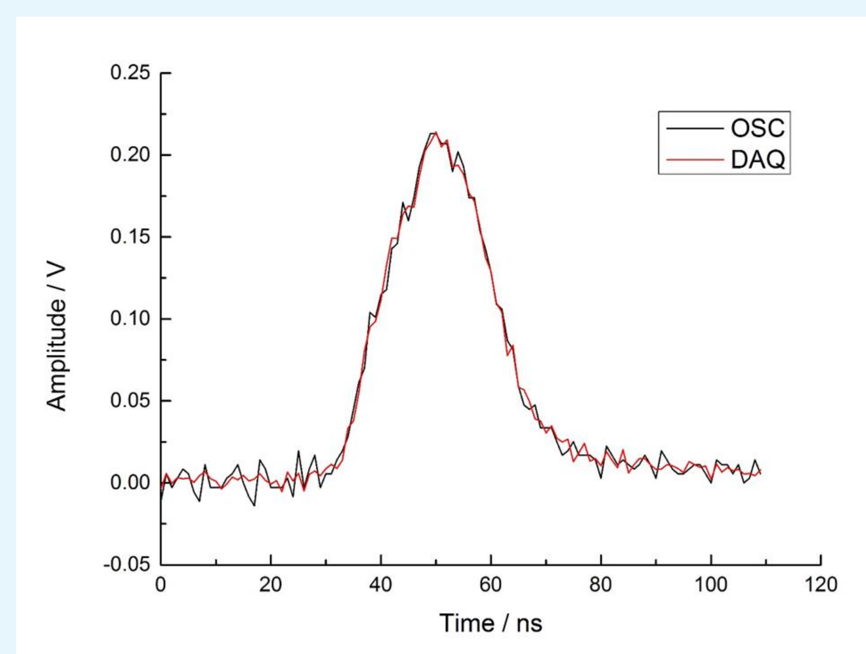

Fig.7: Typical comparison between our DAQ channel and a 12-bit 1Gsps oscilloscope channel when recording a typical transient pulsed signal .

3. Summary

❑ The DAS can integrate 16 DAQ boards in one chassis. With great scalability, the system can be used for modern big physics experiments.

❑ Primary measurements show that the each single card in our DAS achieves an analog bandwidth of higher than 200MHz and an ENOB of more than 9 bit at 1Gsps sampling rate.

❑ Each channel has a memory depth of 65kS and the trigger position can be programmable through software interface.

❑ The digitized data can be either transferred through PXI 32bit/33MHz bus to the disk of the local controller or through SFP interface to the remote receiver within 1ms.

❑ Qualitatively speaking, more research work should be done with record and test of single transient pulsed signals.

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