Instruments that Advance the Art

Pixie-500

4-Channel 500 MHz PXI Digital Spectrometer

GENERAL DESCRIPTION

The DGF Pixie-500 is a 4-channel all digital spectrometer on a single 3U CompactPCI/PXI card. Designed for fast detectors such as $LaBr_3$, fast silicon strip detectors, or plastic scintillators, the Pixie-500 not only offers very high speed waveform acquisition but also pulse height measurements with good precision and time stamping for event reconstruction.

Incoming signals are digitized at a rate of 500 MSPS with a 12-bit ADC. The digital data stream is used for triggering, pile-up inspection and filtering in real time. Waveforms with 2 ns sampling intervals, up to 16 µs in length, can be stored in an on-board FIFO. Pulse height reconstruction, accumulation of a 32K MCA spectrum for each channel, and optional pulse shape analysis are performed on an event-by event basis by a digital signal processor and a Virtex-4 FPGA. Waveforms and spectra can be read out through the PCI data interface at rates of ~100 MByte/s.

Multiple Pixie-500 modules can share clocks and triggers through the PXI chassis backplane, which implements bussed and nearest neighbor lines between slots. With some limitations, the Pixie-500 can be operated together with the 75 MSPS, 14-bit DGF Pixie-4, combining high speed acquisition channels with slower high precision channels.

An improved version of this module, the DGF Pixie-500 Express, is using the PXI Express platform which allows much higher data transfer rates to the host PC and a 14-bit ADC.

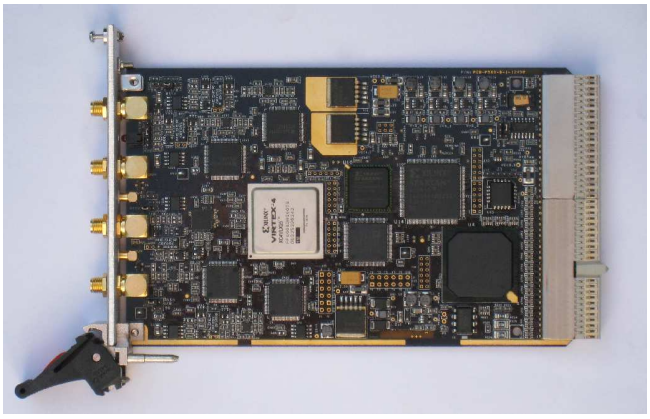

Figure 1: *Pixie-500 spectrometer*

SPECIFICATIONS

Front Panel I/O

4 analog signal inputs, input impedance 50 Ω or 8.5k Ω.
2 digital inputs/outputs for triggers or veto signals.

Backplane I/O

Low skew system clock distributed to all modules.
Configurable LVTTL lines in PXI backplane are used for veto, run synchronization, multiplicity information, and trigger distribution.

PXI Platform

3U CompactPCI form factor with PCI data interface
Data rates of ~100 MByte/s from single module to host PC.

Pulse Processing

Signal digitized at 500 MSPS, 12 bit
Waveform capture at full ADC rate (2ns sampling)
Energy filter operating on averaged samples at ¼ ADC rate
16 bit DSP operating at 75 MHz, processing limit 200,000-400,000 pulses/s combined for 4 channels.

Digital Controls

Input: High/low gain selection
Offset: -2.5V to 2.5V in 65536 steps.
Energy filter: Rise time and flat top: 0.02 - 80µs in small steps.
Acquisition: Coincidence pattern and window
Digital oscilloscope and FFT for health-of-system analysis

Data Reported

List mode data (hit patterns, energies, timestamps and waveforms)
Energy spectra
Run statistics

Customization

Users can add code to DSP processing.
General purpose pulse shape analysis firmware
Phase controlled ADC clocking allows combination of 2 or 4 channels for 2x or 4x overall digitization rate

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SAMPLE PERFORMANCE (USING P500 PROTOTYPE)

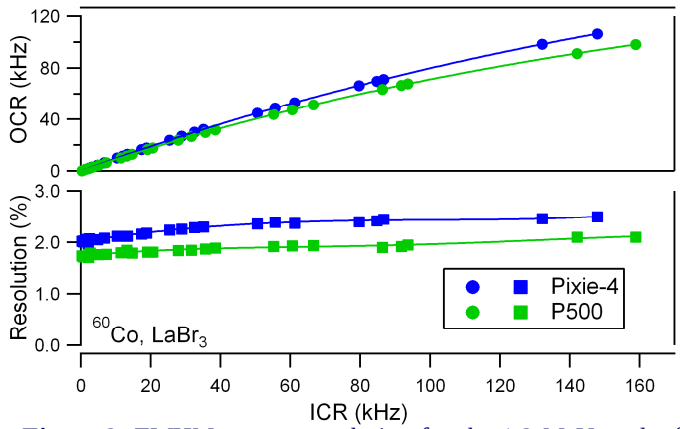

Figure 2: *FWHM energy resolution for the 1.3 MeV peak of ^{60}Co and output count rate as a function of input count rate for Pixie-4 and P500 with a LaBr$_3$ crystal.*

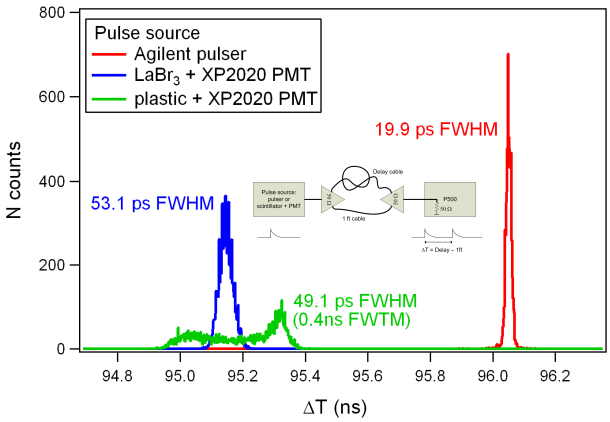

Figure 3: *Histograms of measured time difference ΔT between the two rising edges of a double pulse (created with 50 Ω splitters). The pulse shape variations in the different sources lead to different ΔT distributions, sometimes non-Gaussian.*

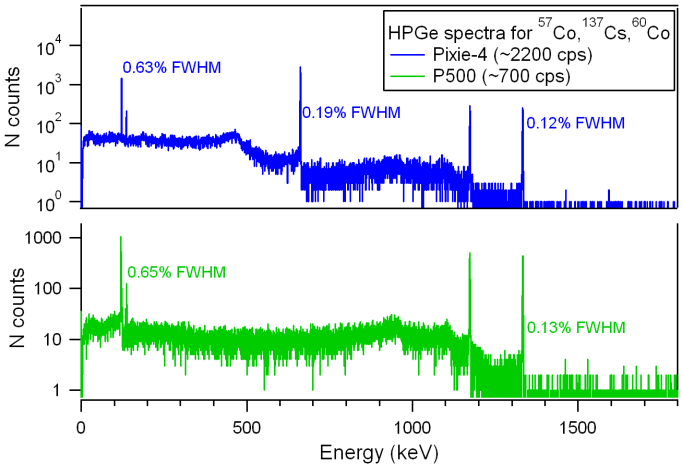

Figure 4: *HPGe energy spectra for Pixie-4 and P500. Even though the Pixie-500 is not directly intended for high precision applications like HPGe detectors, it can reach better than 2 keV resolution at 1.3 MeV at low count rates. (Nonlinearities in the ADC result in worse resolution at higher rates; e.g. ~0.2% at ICR = 40 kcps)*

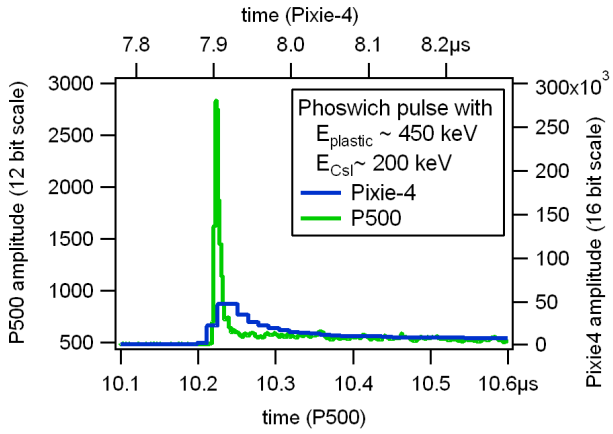

Figure 5: *Waveforms from CsI/plastic phoswich detector (same energy in fast and slow component for each waveform). The fast component is resolved much better with the higher digitization rate and bandwidth.*

SOFTWARE

The DGF Pixie-500 is operated through a graphical user interface based on Wavemetrics' Igor Pro. ROOT or LabVIEW demo interfaces are also available. All interfaces call functions from the same C driver library, which handles conversion of physical parameters (e.g. filter times) into numbers used by the firmware. All parameters can be saved to disk for easy switching between applications.

The C library is largely compatible with Linux and source code is available to users who plan to integrate Pixie modules into a custom data acquisition system. All host software is provided as open source. Users can also add their own functions to the DSP event processing code.

A firmware variant for general purpose pulse shape analysis (computing rise time, sums over specific pulse regions, etc) is available for use with phoswich, gamma/neutron discrimination in liquid scintillator, and similar applications.

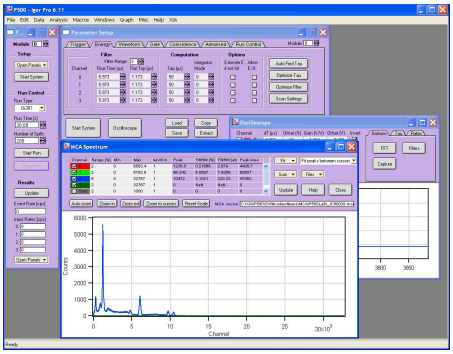

Figure 6: *Pixie-500 User Interface*