Design of Front End Electronics for Direct Dark Matter Detection based on LAr

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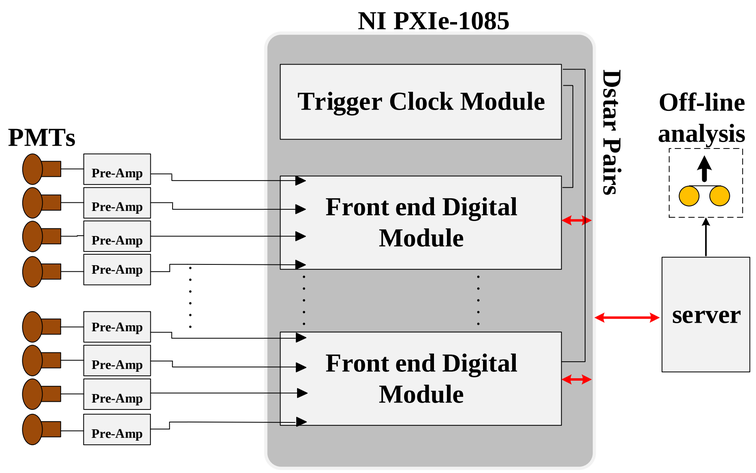
1. Introduction

Weakly interacting massive particle (WIMP) is a well-motivated galactic dark matter candidate. Numerous direct detection experiments are being developed to detect WIMPs. Liquid argon (LAr) detectors, with a high light yield of approximately 40 photons per keV, are attractive detectors for the direct detection of WIMPs.

The Front End Electronics is designed to simultaneously read out approximately 60 PMTs which combined with about 1-ton LAr. And these Front End Electronics has an input dynamic range from 5pC to 1nC, while also have high resolution that single photoelectron can be distinguished.

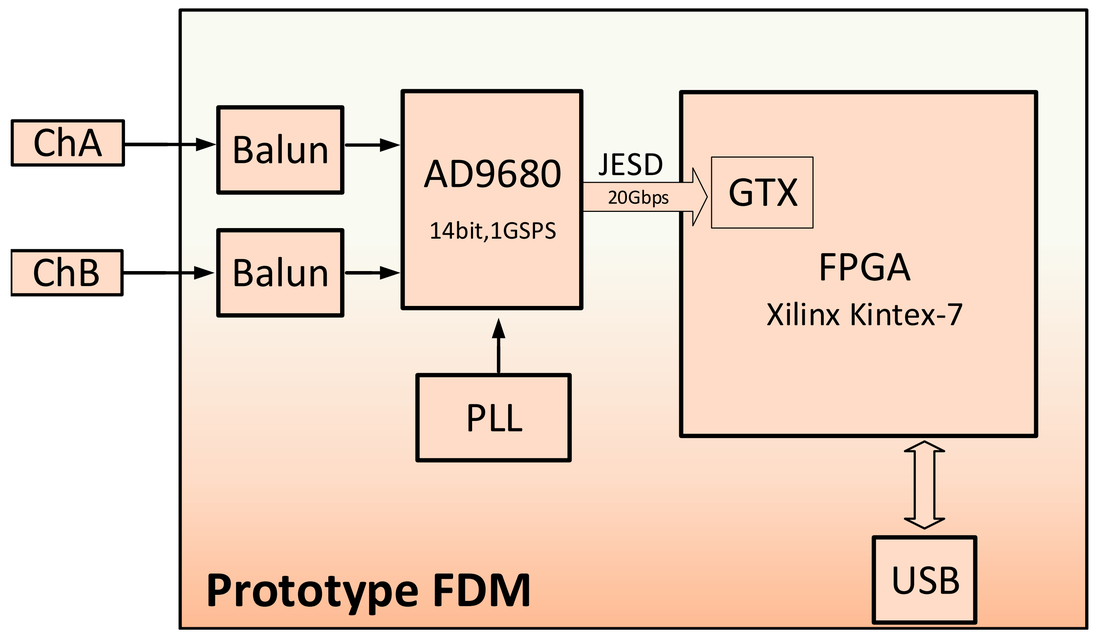
2. Basic structure

Fig. 1 shows the basic structure of the Front End Electronics. Signals from the PMTs are processed by preamplifier cards then sent to Front end Digital Module (FDM). Trigger Clock Module (TCM) processes the information from each FDM to obtain trigger information.



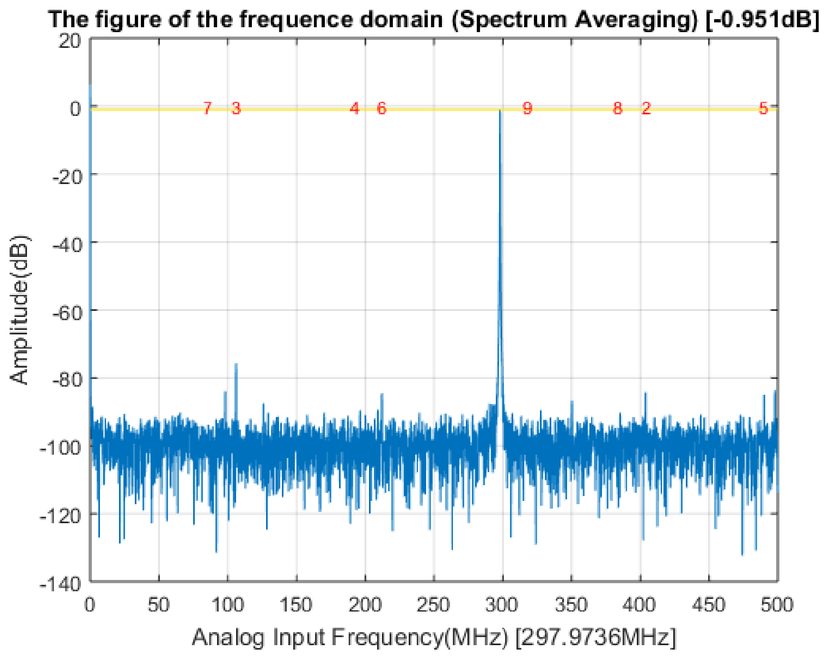
3. Prototype FDM

The analog signal from the PMT is received with SMA connector and converted from single-ended to differential by a transformer (TC1-1-13MA+), and then digitized by a 14-bit 1-GSPS ADC (AD9680). The ADC outputs were sent to an FPGA chip (XC7K410T) via high speed link (JESD204B). The block diagram is shown in fig. 2.



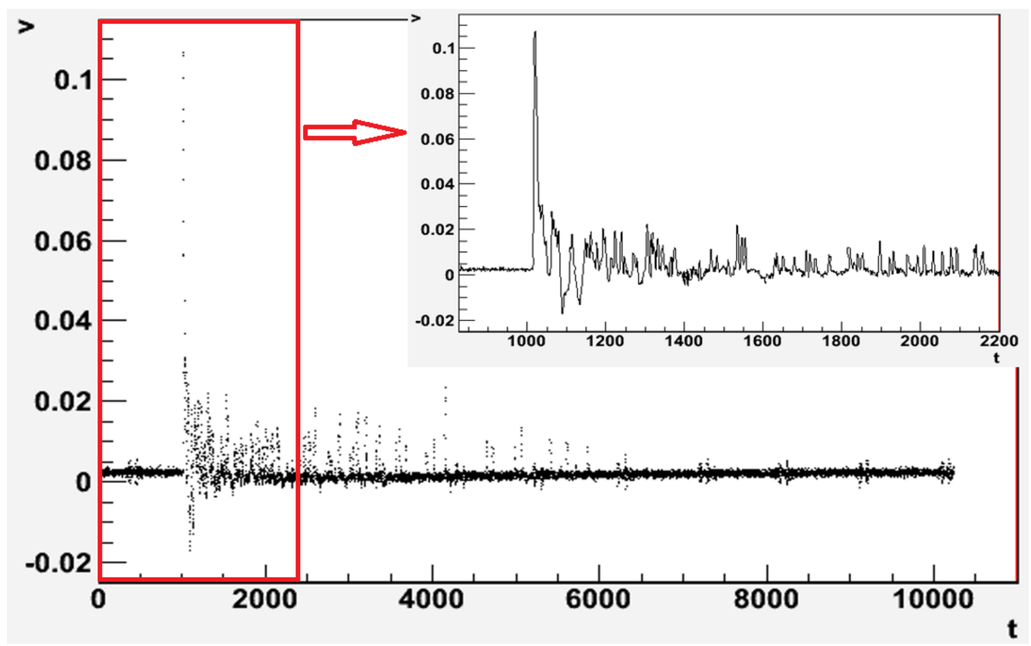
4. Performance

An Agilent E4438C Vector Signal Generator, with a series of narrow-band filters, were used as a sine wave signal source, to perform the evaluation test of the FDM. We acquired the data through USB2.0 data interface, then calculated the Effective number of bits (ENOB). Fig. 3 is the spectrum of sine wave. The Enob is 10.40 bits @ Fin = 298MHz.

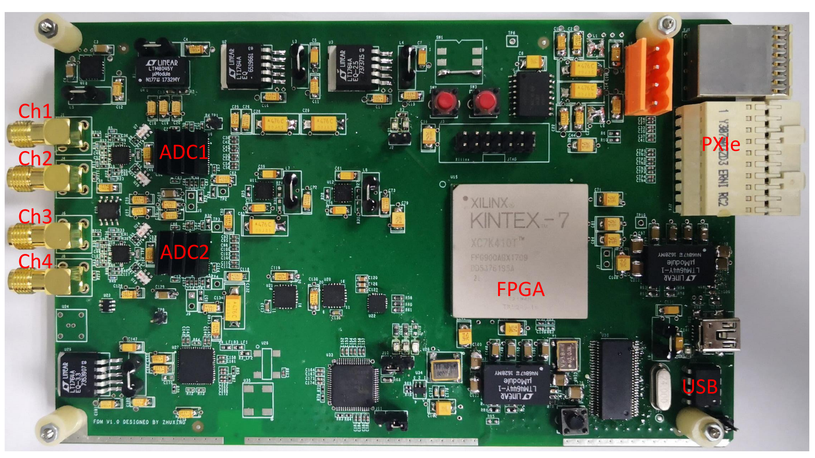


5. Waveform of LAr detector

We did some tests of LAr detector in Institute of High Energy Physics. The LAr detector was exposed to a 22Na gamma source. And the waveform of LAr detector acquired by prototype FDM is shown in Fig.4.



6. Next step



According to the test of prototype FDM, we had optimized the FDM shown in Fig. 5.

- Increase the number of channels from 2 to 4
- Replace the balun by amplifier
- Transmit the data by PXIe interface

We plan to use the PXI chassis (NI PXIe-1085) to receive data in the next step.

7. Conclusions

A prototype FDM are designed, and detailed tests of FDM have been done. This Front End Electronics can bring better performance in PSD to detect rare nuclear recoil events.