Design of a Data Acquisition Module Based on PXI for Waveform Digitization

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Outline

Waveform digitization in physics experiment

Description of the module

Performance of the system

Summary and Prospect
Waveform digitization

- **SCA**
  - Switch Capacitor Arrays
  - High resolution ADC

- **Experiments**
  - ANTARES
  - AMANDA
  - H.E.S.S-II
  - MAGIC-II
  - Etc.

- **ADC**
  - High speed & high resolution ADC

- **Experiments**
  - DANCE
  - TAC
  - GTAF
  - Darkside
  - LUX
  - XENON
  - PANDAX IV
  - Etc.
PandaX-4T

- Particle and Astrophysical Xenon Experiments
  - China Jinping underground laboratory
  - Dark matter direction detection
  - 4-ton Double phase Xenon TPC

- Principle verification
  - Waveform digitization
  - Trigger mode
  - Data buffer & storage

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ADC & EPLD

- **ADC12D1800**
  - TI co.
  - folding interpolating
  - 2 ch.
  - 12 bits
  - Up to 1.8 GSPS

- **Artix7**
  - Config, control & status
  - Buffer & storage
  - Find triggered data
    - -100us to +∞

- **MAX II**
  - PXI interface
  - Module reuse
  - DMA transfer
Clock & trigger

• **Clock**
  - Local or external
    \[ SNR = -20 \log(2\pi f_{in} t_{jitter}) \]
  - PLL
    - Low frequency to high frequency
    - RMS jitter = 139fs

• **Trigger**
  - External
    - Discriminator
  - Internal
    - Star trigger from slot2
  - Self
    - Software
Virtual instrumentation

- **Benefit of test, measurement, automation**
  - Powerful application software
  - Cost-effective hardware
- **LabVIEW**
  - Configuration: ADC, PLL, FPGA
  - Channel: up to 4 ch.
  - Trigger: external or channel, trigger level, trigger delay
  - Operation mode: run, single
  - Sample depth (horizontal): up to 50 us
  - Display (vertical): amplitude, offset
GUI

Horizontal set

Vertical set

Channel config

Trigger config

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System test

- **Performance test**
  - Frequency response
  - ENOB
- **Detector test**
  - BaF$_2$ with PMT
- **Test equipment**
  - PXI platform
    - Adlink PXIS-3320 with controller: 15-slot, 6U
  - Oscilloscope
    - Lecroy 715Zi: 20GSPS, 8bits, 1.5GHz
    - Lecroy HDO6104: 2.5GSPS, 12bits, 1GHz
  - Vector signal generator
    - R&S SMA100A: 9kHz~6GHz
  - Bandpass filter
    - A series of filter from 2.4MHz~798MHz
Balun module for test

- **Single end to differential**
  - From generator or detector to module

- **ADT2-1T**
  - Conventional
  - Insertion loss: 0.4~450MHz@3dB

- **ADTL-18**
  - Transmission line
  - Insertion loss: 30~1800MHz@3dB
Frequency response test

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Result@1.8GSPS

The frequency figure of the ADC ch. I

The frequency figure of the ADC ch. Q
ENOB test

\[ SINAD = 20 \log \left( \frac{RMS_{\text{signal}}}{RMS_{\text{(noise+distortion)}}} \right) \]

\[ ENOB = \frac{SINAD - 1.76 \, \text{dB}}{6.02} \]

- IEEE STD 1241-2000
Result@1.8GSPS

The ENOB figure of the ADC ch. I

The ENOB figure of the ADC ch. Q
BaF₂ with PMT
Result vs. oscilloscope

Acquired by the module

Acquired by oscilloscope
Next & Acknowledgment

- **Next**
  - Test with TPC
  - Extract T & Q
  - Improve data transmission bandwidth

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MAHALO!