

ISSRAD Fast Neutron Detector Pulse Processing

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WRMISS 2015 FND Pulse Processing



Agenda

- FND Overview
- Analog Processing
- Moving Integration and Peak Detection
- Baseline Estimation
- Pulse Pair Detection
 - Interesting High Rate Issues
- Conclusions



Meet the FND





- PMT outputs a current impulse
- Analog front end shapes pulse with three-stage Gaussian shaper
- PMT current proportional to area in the peak
- Flight qualified low noise, low power ADC had AC Coupled input
- Digitized to FPGA (12-bit, 33MHz)



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Digital Pulse Processing

Rad Detector – The Radiation Assessment Detector for ISS

Provides accurate pulse height

- Area in the peak
- DC Baseline Estimation
- Remove AC Coupling artifacts

Detect neutron pairs

• Identify pulse pairs given

Computationally efficient



Digital Pulse Processor





Moving Integral with 2 adders

Rad Detector – The Radiation Assessment Detector for ISS



Jordanov & Gnoll, IEEE Nuclear Science, Aug 1993



Peak Detection







DC Estimation

- Gated baseline
 - Don't want to include pulses
- Simple error feedback with increment/decrement





AC Estimation

Rad Detector – The Radiation Assessment Detector for ISS

- Gate out detected peaks to not influence baseline estimate
- Remember: AC coupled ADC Input



Looks like a good approximation would be $A(1 - e^{\frac{t}{\tau}})$



AC Estimation, 2 mult and sub

- k1 tunes the gain
- k2 tunes the time constant





- k1 tunes
- k2 tunes

Peak



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Baseline Restored, Pulse Integrated, Peaks Detected





Pulse Pair Identification

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 Buffer Two Peaks with Programmable capture window

Examine:

- Minimum height
- Maximum height
- Maximum time delta





TSL Data (2012)

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Issue

- ISSRAD run parasitically during MSL RAD testing
- Strange effects in recoil histogram at very high pulse rates
- Deficit corresponding to Amin, Amax capture pulse window





High Rate Pulse

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Cause

- In high rate environment, there will be event pulses that meet capture criteria, but are not captures
- Non-neutron signal followed by recoil with amplitude in the capture window will incorrectly register as pulse pair
- Gets processor "out of sync"





Solution: Examine Triples

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- Exponential Distribution: Most likely outcome is t=0
- Buffer three peaks Examine pairs:
 - Minimum height
 - Maximum height
 - Maximum time delta between peaks
- If both pairs meet discrimination criteria
 - Select peak pair with lower time delta between peaks

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Registered Pulse Pair

Registered pulse pair

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"Most Likely" Discrimination

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Before

After



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Digital Pulse Processor





- We were able to make a highly computationally efficient real-time pulse processor
 - Two Multiplications the most complicated elements, and even those were implemented as shift/adders
- Practice, practice, practice
 - Interesting issues were discovered and resolved during beam runs not even intended for the FND





Rad Detector – The Radiation Assessment Detector for ISS

Thank you for your attention.

Special thanks to NASA Space Radiation Analysis Group