SIGNAL PROCESSING TECHNIQUES FOR SILICON DRIFT DETECTOR BASED X-RAY SPECTROMETER FOR PLANATARY INSTRUMENTS. A R Patel, M. Shanmugam, T. Ladiya, Physical Research Laboratory (Navarangpura, Ahmedabad-380009, Gujarat,India; arpitp@prl.res.in, shans@prl.res.in, tinkal@prl.res.in).

Introduction: Most radiation detectors require pulse (or signal) processing electronics so that energy or time information involved with radiation interactions can be properly extracted. The objective of this work is to develop and compare various pulse processing techniques for x-ray and Gamma ray spectrometers which can be used for future scientific missions. A preamplifier is the first component in a signal processing chain of a radiation detector which has a main function to extract the signal from the detector without significantly degrading the intrinsic signal-to-noise ratio. CSPA output signal is given to pulse height analyzer for energy spectroscopy.

To study we are developing SDD (silicon drift detector) based x-ray spectrometer using various pulse height analysis techniques. We are working on different techniques of pulse height analysis like Wilkinson ADC technique, Pulse width modulation technique, Digital pulse processing technique and pulse height measurement using peak detector & successive approximation ADC. This study will help to identify the proper processing technique based on planetary instrument specifications like number of detectors, total incoming photon count rate, spectral resolution, size, mass and power. The design details and evaluation results of techniques are presented in this paper.

SDD based Spectrometer with conventional peak detection technique: SDD based spectrometer is mainly divided in two parts. Sensor package and processing package. sensor package consists of SDD module coupled with Charge Sensitive Pre-Amplifier (CSPA), shaping amplifier, HV supply for SDD module, controller for and the Peltier cooler. The analog front end electronics include shaping amplifiers with peaking times of 1µs. The block schematic of spectrometer is shown in figure 1.

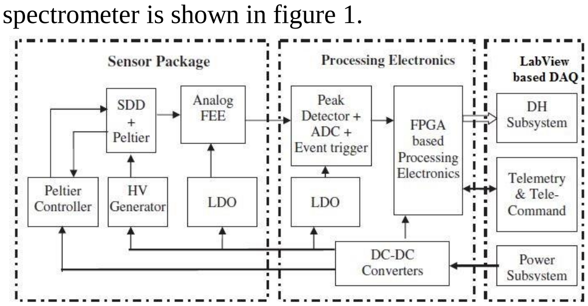

Figure 1. Block schematic of SDD based Spectrometer with conventional Peak detection method.

The hardware setup for SDD based spectrometer is shown in figure 2. With this setup we are getting ~200 ev resolution at 5.9 Kev by putting the Fe55 source in front of the detector.

Figure 2. Set up for SDD based X-ray spectrometer.

Digital Pulse Processing technique for real-time pulse shaping: Shaping amplifier and peak detector use in system limits the count rate and performance at higher count rate, to overcome to this problem digital pulse processing technique is developed which can be used for space instruments. In this system the digitizer replaces both the Shaping Amplifier and the Peak Sensing circuitry by direct digitizing pre-filter output as shown in figure-3.

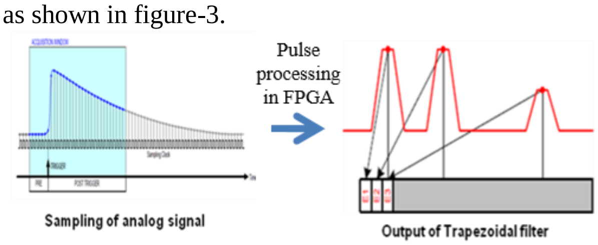

Figure 3. Pulse processing technique (sampling and Trapezoidal filtering)

The pulse shaping is done in digital by means of a trapezoidal filter implemented in FPGA running online on the digitizer data. Efficient recursive algorithm is developed for ACTEL A3P250 FPGA which allow real time implementation of a shaper that can produce either trapezoidal or triangular pulse shape. The setup for large area SDD detector is shown in figure 4 which has an interface with programmable FPGA board. With keeping the X-ray source Fe55 to front of detector we are getting 200 ev resolution at 5.9 Kev. The spectra is shown in figure 5.

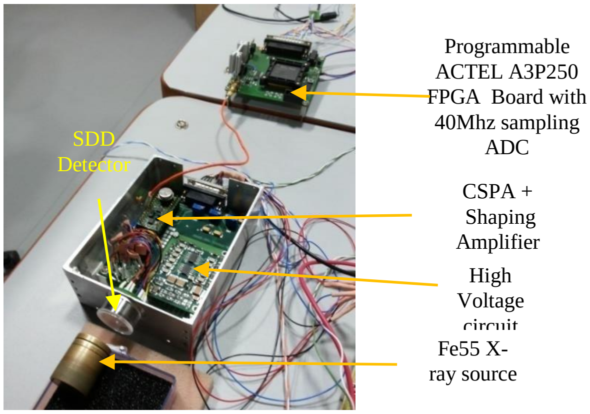

Figure 4. **S**DD detector setup for digital pulse processing including sampling ADC and on-board programmable FPGA.

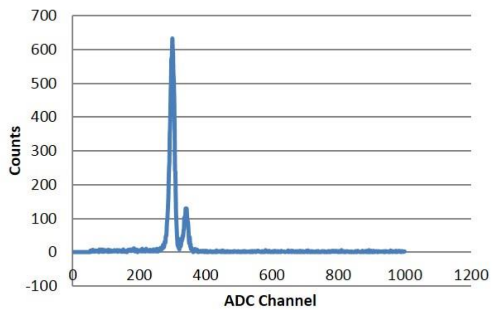

Figure 5. Initial results - Spectra obtained with Fe55 source using digital pulse processing technique.

Designed scheme for Wilkinson ADC technique (linear discharge): This work has been in inspired from the Wilkinson ADC. The detail schematic block diagram is shown figure 6. The comparator compares the shaping amplifier output with discharge output which is delayed by few ns. This delay can help us to identify the peak of shaped pulse. The comparator output pulse is given to a switch to initiate the discharge process. The higher discharge time can help to cover a wide energy.

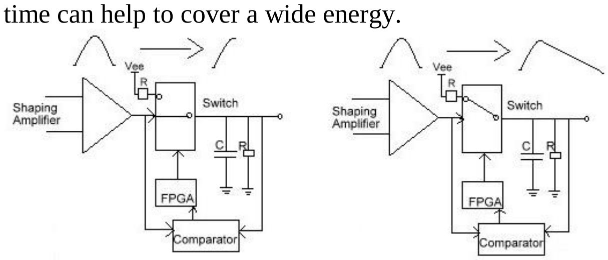

Figure 6. Conceptual method for the linear discharge of the signal.

Figure- 7 shows the shaping amplifier last stage output and the discharge pulse output. The discharge pulse is compared with small reference voltage using fast comparator. The width of the pulse output of comparator has the information about peak height. This pulse is given as an input signal to the FPGA where the logic is implemented to count the number of clocks within the entire width. The Counter clock is at 320 MHz which is generated using FPGA internal PLL block which gives the pulse width resolution of 3.125ns.

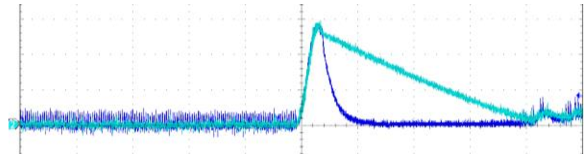

Figure 7. CRO screen showing Shaping amplifier output (Dark Blue) and Linear discharge pulse Output (light Blue).

With this technique we obtain the resolution ~300 ev at 5.9 Kev. We are targeting the 200 ev resolution with this system by making printed boards. Results for this technique will be discussed more at workshop.

PWM technique to measure pulse height: People are mostly use it in the DC signal only, here we are trying to measure the pulse height with use of PWM. We have generated a triangular waveform of frequency ~500Khz with use of integrator circuit. The fast comparator AD8561 is used to compare the triangle wave with Gaussian pulse which is coming from Shaping amplifier output. The output of PWM is shown in figure 8.

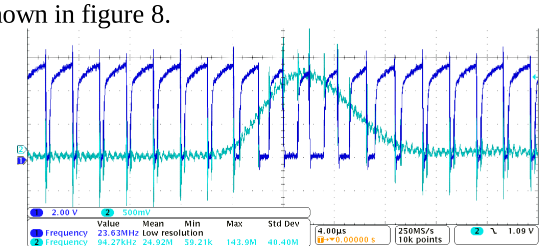

Figure 8. PWM output with Gaussian input pulse.

The PWM output will be given to FPGA to measure the pulse width. The width is proportional to the height of analog pulse. We have made 320Mhz PLL internal to FPGA to measure the pulse width with resolution of 3.125 ns. System with PWM circuit and FPGA is connected with SDD detector and initial results are obtains which shows 300ev resolution at 5.9Kev. Further we like to improve the results by increasing the PLL frequency or by using the Vernier method to measure the pulse width with resolution of <1 ns.We are optimizing all designs for better performance and count rate achievement so the comparative study will be more discussed during workshop.