Development of a Data Acquisition System for Real-time Beam Monitoring of Flash Ion Beam

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INTRODUCTION

Recently, our research team is developing and constructing a high-energy ion beam irradiation device capable of ultra-high dose rates for biomedical research in connection with the main accelerator of RAON (Rare isotope accelerator complex for ON-line experiments). In this ion beam irradiation line, an x, y scanner will be installed in the active scanning type research beam delivery line. In order to measure the beam current, profile, and position before and after scanning, it is necessary to develop a system that can monitor the ultra-high dose rate ion beam in real time.

The **objective of this study** is **to develop and verify a data acquisition system that can measure the position and intensity of a flash ion beam in real time**.

System configuration

Data Acquisition System (Ion chamber)

To measure the beam profile, output terminals of 128 channels each for X and Y are required, and the accumulated detector current must be read using a charge integrator. The amount of detector current of each 128 channels is measured in units of 100 us for a pre-programmed time, the accumulated value is obtained from the FPGA and stored in the data memory of 1 Gbyte (part of the 2 Gbyte memory), and I-V converter method is applied to output voltage. The raw data of each channel is stored in the memory, and center, sigma, and sum are calculated based on the voltage values of 128 channels for each x and y axis and then transferred to the PC. For beam intensity measurement, an input value is given by connecting two flux monitors, and the measured beam intensity is designed to store negative charge in the data memory inside the FPGA every 30 us.

Data processing

Ion Chamber DAQ is composed as shown in the figure, and the functions of each part for data processing are as follows. The current output from the 2-channel intensity detector is measured by the charge integration method. Charge integrator uses Texas Instrument's AFE0064 chip to integrate the input current for every 30 us, then converts the accumulated charge during that time into an analog to digital converter (ADC) and sends it to the digital signal processor (DSP) at the rear end. send. AFE0064 used as an integrator has 64 channels of input on one chip, charge integration of 15 us for 30 us and signal readout time for 15 us after that. Therefore, in order to integrate the input current through the entire 30 us section without loss, two AFE0064 chips were interleaved and each integration and signal readout were alternately performed to achieve lossless current integration for 30 us. The integrated current in the AFE0064 chip is output as a voltage signal proportional to the integral charge, which is converted into a 12-bit ADC and transmitted to the DSP.

Figure 1. Manufactured IC chamber DAQ board box

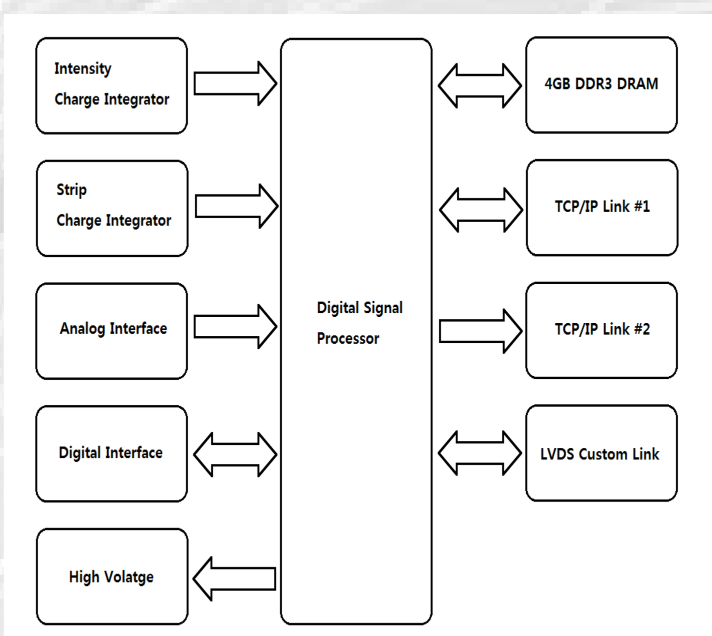

Figure 2. DAQ board configuration

Performance

Response to input current according to gain setting

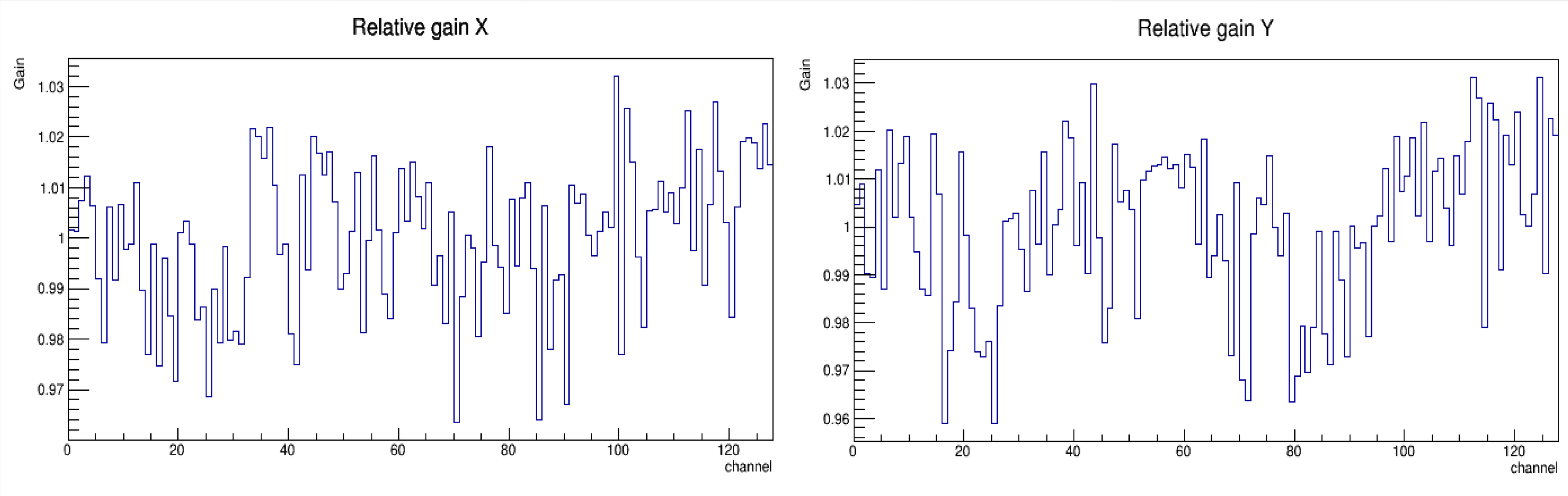

Figure 3. Measure the integrator output of each strip channel after applying the same DC current

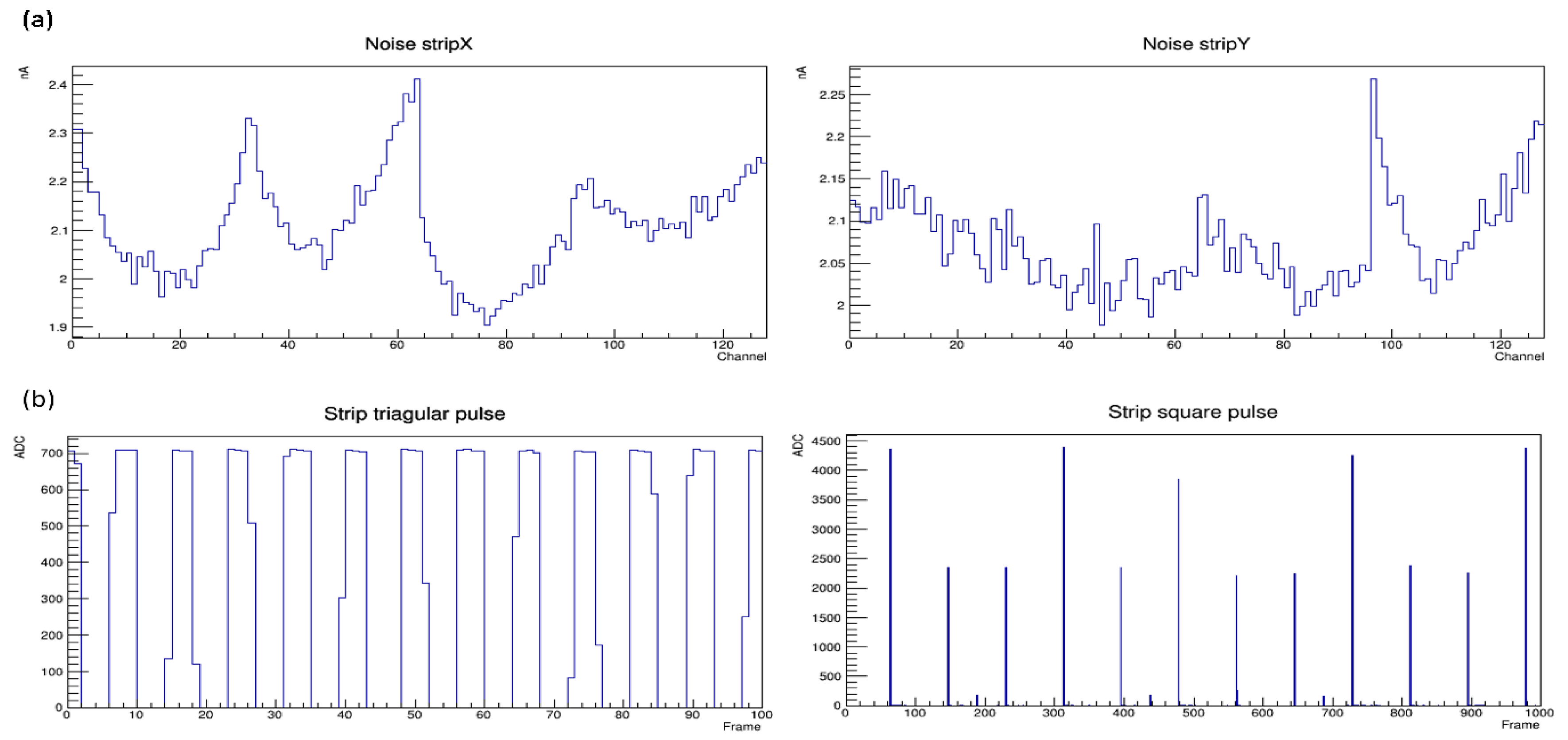

Figure 4. (a) Noise for each strip channel in gain setting 7 (b) Integrator response to triangle wave and square wave test input of strip channel

Timing waveform

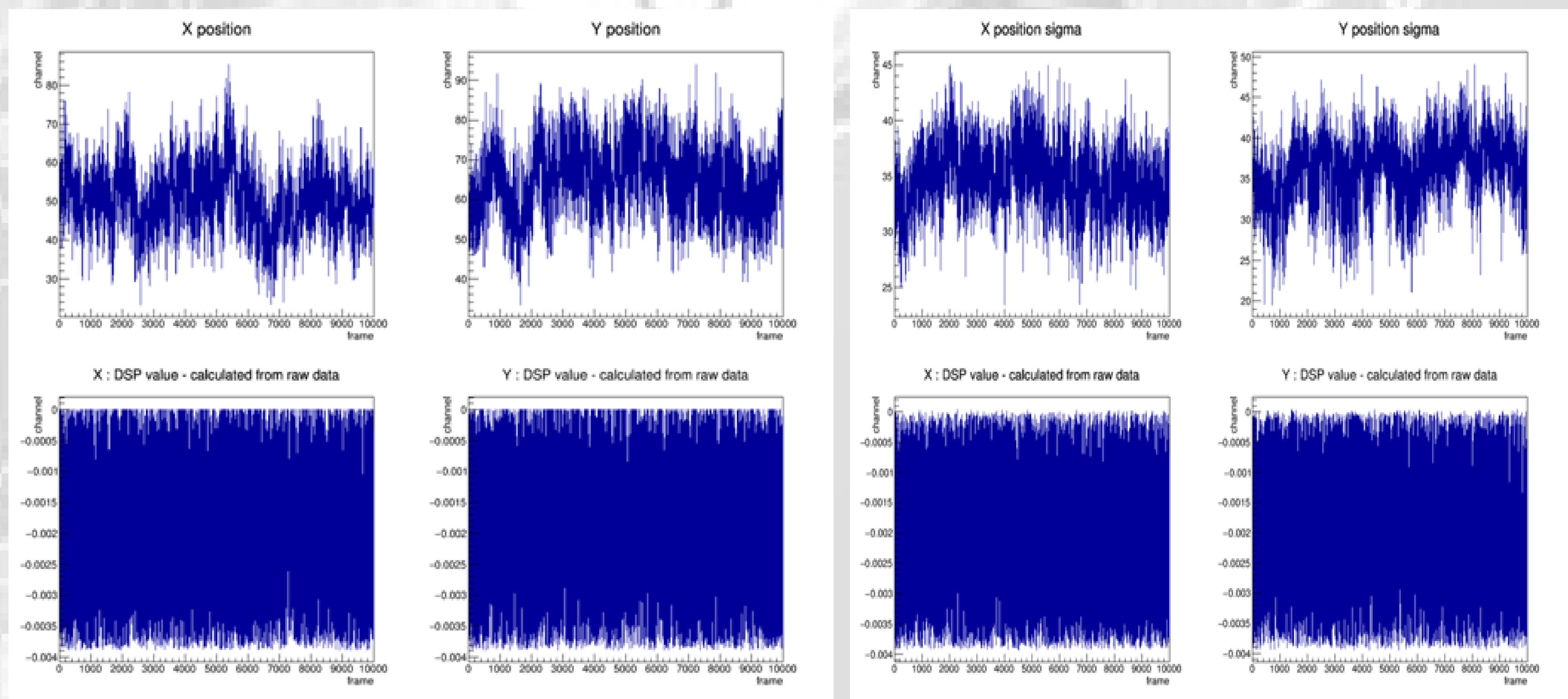

Figure 5. Difference between the average value of X and Y obtained in real time from DSP and the average value of X and Y obtained off-line using raw data of each strip channel current at the same instant as this value (left) Difference calculated from DSP and raw data of RMS values of X and Y measurement positions (right)

CONCLUSION

In this study, in order to evaluate the usefulness of the manufactured DAQ, the measurement response of the intensity charge integrator, noise according to the gain setting, response, and the measured value of the strip charge integrator according to the gain setting were tested, and it was confirmed that it is suitable for monitoring the ultra-high dose rate ion beam. It is expected that the DAQ system manufactured in this study can be used not only for the RAON ion beam currently under construction, but also for the flash electron beam accelerator. In the future, it will be conduct the test verification with a two-dimensional array type ion chamber in flash radiation.

Acknowledgment

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