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DATA ACQUISITION SYSTEM OF A FOUR SEGMENTED POSITION SENSITIVE DETECTOR FOR AN ADVANCED X-RAY IMAGING CRYSTAL SPECTROMETER

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1. INTRODUCTION

The data acquisition (DAQ) system of a four segmented detector for an advanced X-ray imaging crystal spectrometer (XICS) has been developed. The XICS system will measure the ion and electron temperature profiles in fusion plasmas and was discussed in Ref. 1. The DAQ system for the XICS consists of a position sensitive detector (PSD) based on delay-line readout method, and the readout electronics utilize a time-to-digital converter (TDC) with a F1 TDC. A photon count rate capability for our PSD showed as high as 2 MHz, but the measured maximum counting rate for the F1 TDC with random pulses was limited to 300 kHz due to the pileup rejection effect in our F1 chip TDC. Therefore, in order to improve the counting rate capability of the XICS DAQ system, the PSD has divided into 4 segments and then each segment has been connected to the individual TDC readout electronics system. The performance test results of the proof-of-principle experiment of the four segmented PSD DAQ system are described.

2. F1 TDC MODULE AND FUNCTIONS

The architecture of F1 TDC module was discussed in Ref. 2. The digitization of time intervals incoming from both ends of delay lines of the PSD is performed by using a TDC-F1[3] and the digital signal processing circuitry with TMS320C6713 from the

texas instruments(TI) with a 128 Mbytes SDRAM. Since the developed F1 chip TDC modules are equipped with an USB 2.0 communication port, it enables easily to be configured for the multi-segmented PSD at low cost. The count rates tested with a function generator reach up to 2 MHz at 110 ps resolution. Unfortunately, for random events, the rate drops to about 300K events/s. The TDC module has two modes : the static mode (time-integrated mode) and the dynamic mode(time-resolved mode). In the static mode, the image frame built during the acquisition can be displayed on the screen in intervals of a few seconds. This mode is useful to check and monitor the detector condition in the preparation stage before the main plasma experiment. In the dynamic mode, which is used in the real plasma experiment, the acquired raw data trigged from the experiments consist of 32 bits of position (X,Y) data and 32 bits of time-tag (T) data per photon event. The time-tag position data (X, Y, and T) stored in the individual TDC modules are transferred to and analyzed at the PC just after the discharge period in the plasma operations so that the time resolved images can be easily reconstructed. The time resolution for the dynamic mode is 1 μs.

3. ELECTRONICS SETUP FOR FOUR SEGMENTED PSD

The four segmented PSD have four sets of 5 input signals : ANODE – timing signal fed as COM to trigger into TDC; X1, X2, Y1, Y2 signals from X and Y delay lines of the PSD; The horizontal and vertical coordinates are given by $X= k_x(X2-X1)$ and $Y = k_y(Y2-Y1)$ with k_x and k_y being the corresponding time-to-position conversion factors. All detector signals are preamplified and then fed to constant fraction discriminators. The discriminated signals are inputs for the 4 TDC modules, as shown in Fig. 1. Also, the acquired raw data trigged by TRIG_SHOT from tokamak consist of 32 bits position

(X,Y) data with 32 bits time-tag T(time resolution = 1 μs) data per event so that a time-sliced images can be reconstructed easily. Each TDC modules can store up to 16M time- tag data to its SDRAM. A GUI program for XICS has been developed with the CIV/Lab windows.

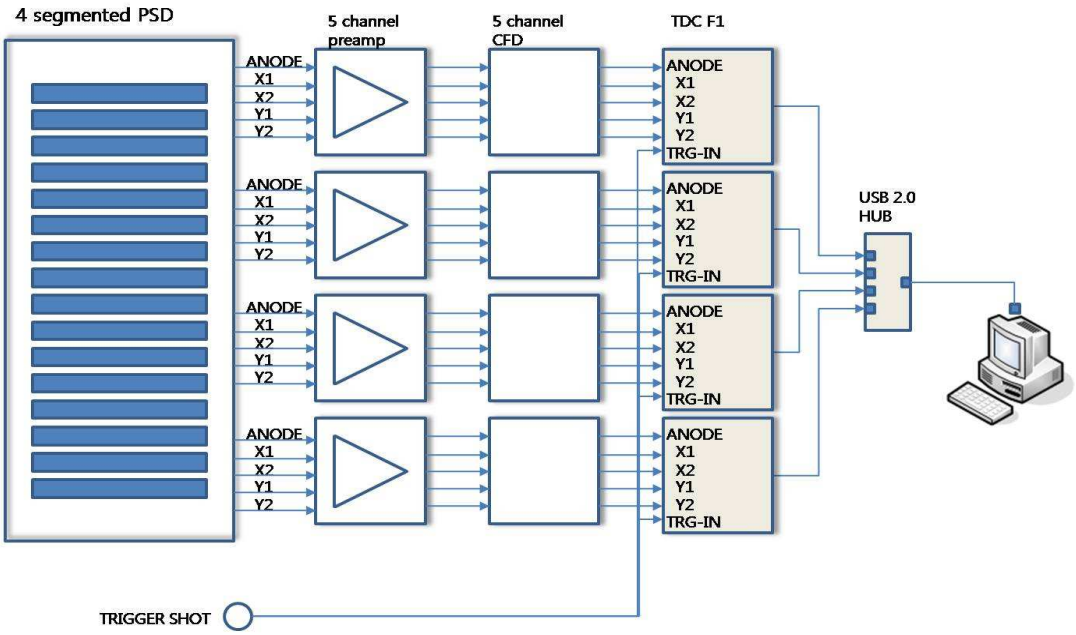

Fig. 1. Electronics setup for four segmented position sensitive detector.

4. TEST RESULTS

The performance test results of the proof-of-principle experiment of the four segmented PSD DAQ system is shown in Fig. 2. Figure 2 (a) shows the four segmented detector on which a plier is attached to verify an image measurement. Figure 2 (b) shows the measured plier image with GUI program obtained by illuminating the whole detector with ^{55}Fe x-ray source.

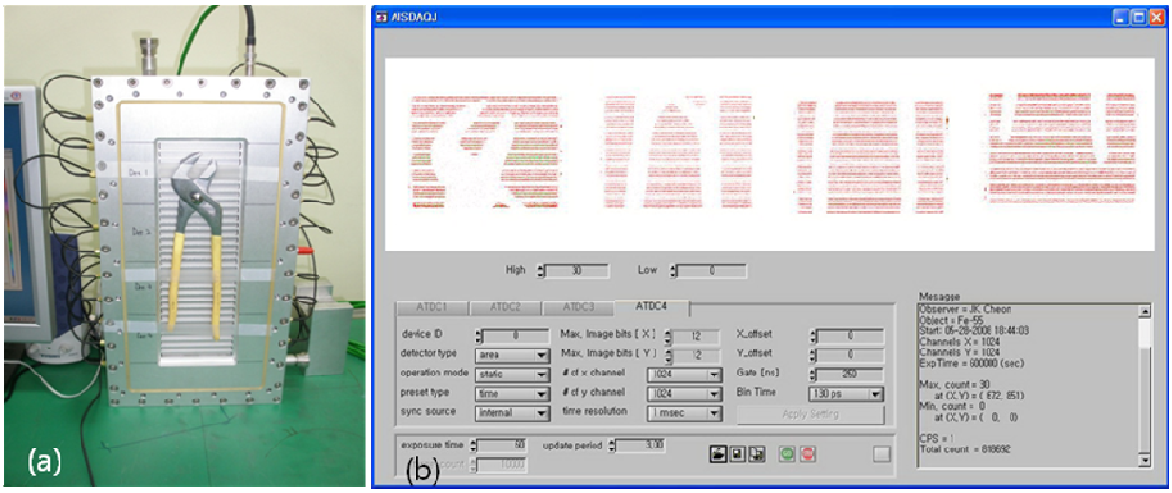

Fig. 2. (a) A plier image test setup. (b) The measured image with GUI program for 4 segmented PSD.

5. SUMMARY

The developed DAS provide a cost effective and optimized solution and have been successfully applied to a four-segment PSD. The DAS will be developed further to support eight-segments in order to improve the photon count rate capability of the advanced XICS system.

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