

Data acquisition system for an advanced X-ray imaging crystal spectrometer using two segmented position sensitive detector

U. W. Nam¹, S. G. Lee², J. G. Bak², M. K. Moon³ and J. K. Cheon³

¹*Korea Astronomy & Space Science Institute, Taejeon, Korea*

²*National Fusion Research Center, Taejeon, Korea*

³*Korea Atomic Energy Research Institute, Taejeon, Korea*

1. INTRODUCTION

The data acquisition system for an advanced X-ray imaging crystal spectrometer (XICS)[1] using two dimensional(2D) segmented position sensitive detector(PSD) has been developed. The XICS system will measure the ion and electron temperature profiles in fusion plasmas. Each segmented position sensitive detector is connected to the individual time-to-digital converter(TDC) electronics which comprise a F1 TDC chip with about 110 ps time resolution. Since TDC modules are equipped with USB 2.0 communication port, this system enables easily to be configured for the multi-segmented position sensitive detector at low cost. The time-tag position data (X, Y and T) stored in the individual TDC modules are transferred to and analyzed at PC just after the discharge period in plasma operations. A description of the hardware and software of data acquisition system for XICS, their feature and result of some performance tests will be presented.

2. ARCHITECTURE OF TDC-BOARD

The architecture of the TDC-board is shown in Figure 1. The digitization of time intervals incoming from both ends of delay lines of the PSD is performed by using a TDC-F1[2]. All of functions including a pileup rejection, a data grabber, a preset control unit based on time and event counts, a time tagged position decoding, and

calculation units are implemented in FPGA. To handle more efficient data acquisition functions such as controlling the TDC-F1 and FPGA, acquiring event positions and time information, building image frame in the internal memory and communicating with PC, the digital signal processing circuitry with TMS320C6713[3] was adapted. The pileup rejection monitors the temporal spacing between adjacent event hits(ANODE pulses) as well as between each X and Y signals of the position sensitive detector. As a result, a stable and good spectrum shape can be obtained. The dynamic range of the digitization circuitry is 16 bits and the range of an user-programmable time resolution is from 110 ps to 150 ps. The measured count rates reached up to 1.4 MHz at 110 ps resolution and depended on the time resolution due to the dead-time effects.

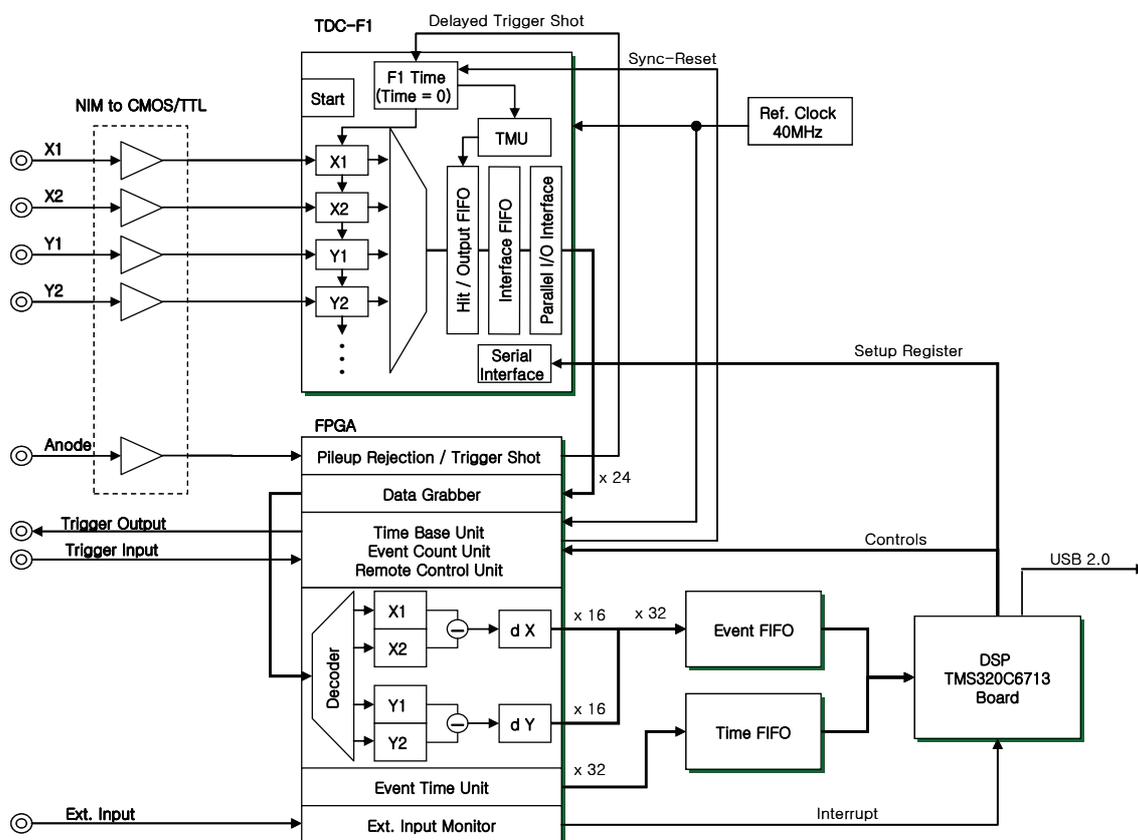


Fig. 1. The architecture of DAQ-board.

3. ELECTRONICS SETUP FOR TWO SEGMENTED PSD

The two segmented PSD have two sets of 5 input signals : ANODE – timing signal fed as COM to trigger into the TDC; X1, X2, Y1, Y2 signals from X and Y delay lines of the PSD. The horizontal and vertical coordinates are given by $X = k_x \Delta t (X_2 - X_1)$ and $Y = k_y \Delta t (Y_2 - Y_1)$ with k_x and k_y being the corresponding time-to-position conversion factors. To minimize a timing jitter caused by varying pulse height all detector signals are subjected to a constant fraction discriminator (CFD) which is located between the fast preamplifiers and TDC inputs. Two TDC modules have USB interface so that the DAQ system having 2 or more TDC modules can be controlled and acquired data with one desktop or laptop computer. Also, the acquired raw data triggered by TRIG_SHOT from tokamak consist of 32 bits position (X,Y) data with 32 bits time-tag T (time resolution = 1 us) data per event so that a time resolved images can be reconstructed easily.

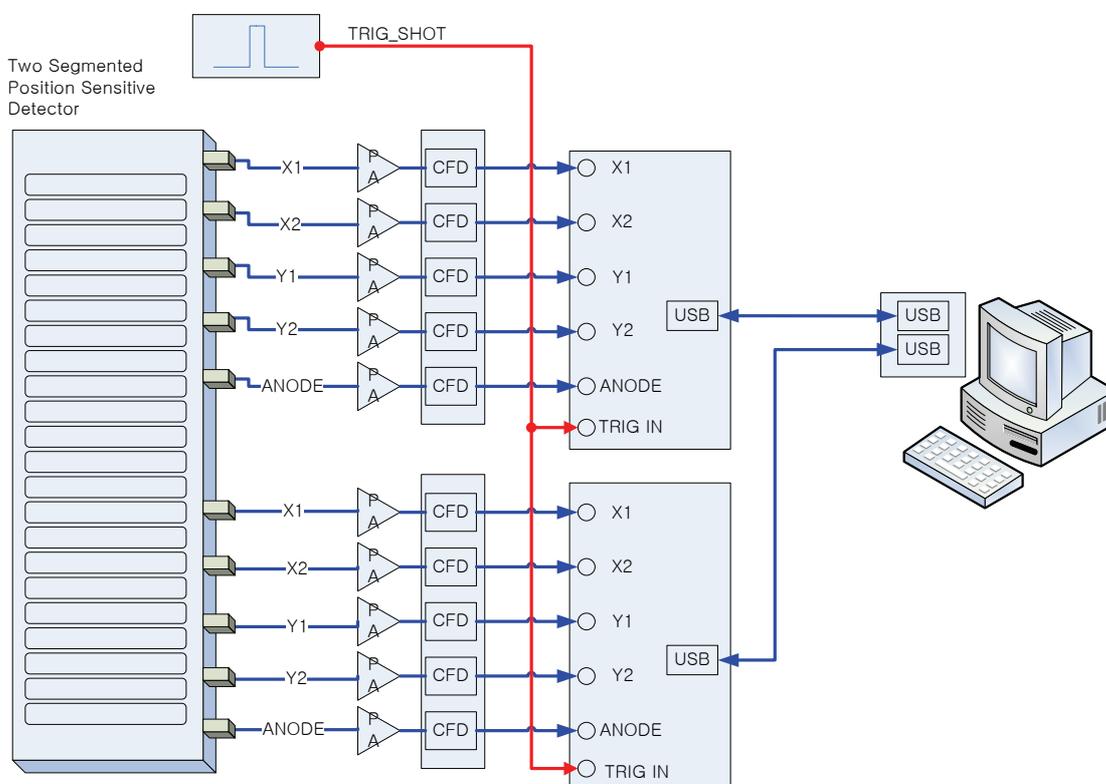


Fig. 2. Electronics setup for two segmented position sensitive detector.

4. SUMMARY

A hardware and software of DAQ for two segmented PSD have been developed. Figure 3(a) shows the two segmented detector on which nipper is attached to verify an image measurement. Figure 3(b) shows the measured nipper image with GUI program obtained by illuminating the whole detector with ^{55}Fe x-ray source. DAQ system is being applied to acquire real plasma data with XICS.

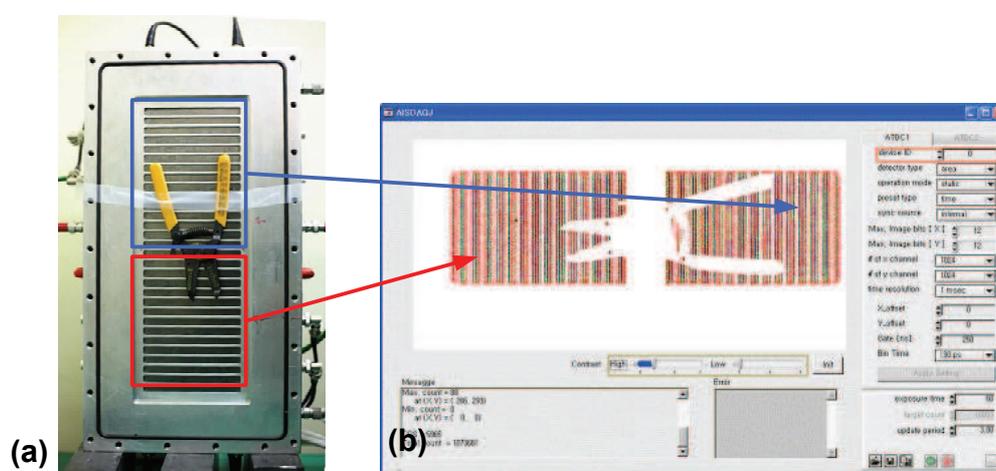


Fig. 3. (a) A nipper image test setup. (b) The measured image with GUI program for 2 segmented PSD.

ACKNOWLEDGMENTS

This work was supported by the Korea Research Council of Fundamental Science and Technology.

REFERENCES

- [1] S.G. Lee et al., to be published in Rev. Sci. Instrum. (2007)
- [2] acam-messeletronic GmbH, 76131 Karlsruhe, Germany; <http://www.acam.de>
- [3] Texas Instrument, <http://www.ti.com>