Development and Characterization of a 64 Channel DAQ System for X-ray Imaging

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1. Introduction

X-ray imaging system is widely used in medical imaging equipment, nondestructive testing of industry, and homeland security. Among them, medical imaging system is 30% of total radiation imaging market [1].

In X-ray imaging systems, semiconductor detectors, such as CdTe and CdZnTe (CZT), are used for radiation detection because of their good energy resolution at room temperature. Spatial resolution is also better than scintillating materials, because can be made by using tens μm semiconductor process [2-3].

For X-ray imaging, we develop a 64 channels digital data acquisition (DAQ) system which is composed of CdTe array sensor and a FPGA based DAQ system. For increasing convenience of user, we developed software based of Windows OS. We also developed imaging formation algorithm for high resolution imaging results.

In this paper, the status and test results of 64 channels DAQ system for X-ray imaging are addressed.

2. Methods and Results

2.1 64 Channels DAQ system for X-ray Imaging

Figure 1. shows the developed low noise and high efficiency DAQ system. One box is HV module and the other is DAQ part as shown in Fig. 1 (bottom). System is consist of a preamplifier, shaper, amplifier, ADC, DAQ and power supplier. The dimension of each Al case is about 120 mm x 220 mm x 120 mm, and Al case is used for electromagnetic (EM) shieling. For preventing thermal noise, the cooling fan is installed to HV module part.

Figure 2 shows the developed imaging software. The X-ray imaging software is developed based on window OS for increasing user convenience. The system has not only the option for applying developed algorithm but also basic function, such as zoom in/out, rotation, capture, etc. By using this option, we can obtain higher resolution X-ray image.

Fig. 1. The photographs of developed low noise DAQ system without HV module (top) and with Al case and imaging software (bottom).

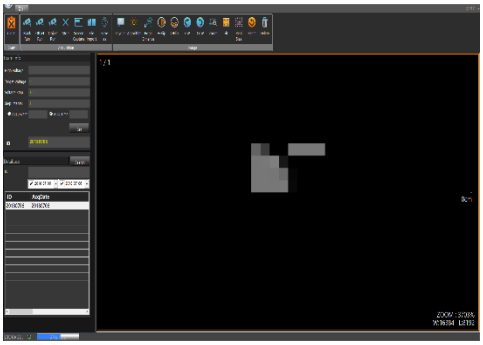

Fig. 2. The photograph of developed imaging software.

2.2 Test results with image formation algorithm

The developed 64 channels DAQ system is tested by using X-ray. A 10 mm thick rectangular lead is placed in front of detector with Z-shape pattern. The distance between detector and X-ray is 25 cm. The initial X-ray intensity is 50 kV and current is 40 μA.

For X-ray count image formation, first the energy of the incident x-ray photon into detector was determined with the measured peak signals of 64 DAQ channels as in (1).

$$E_{event} = \sum_i \sum_j Peak_{i,j;event} \quad (1)$$

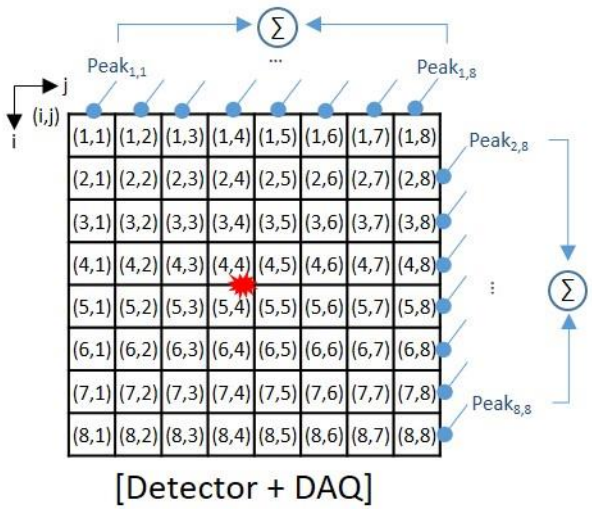

Fig. 3. X-ray image formation algorithm.

In order to determine the major interaction position (i_{max}, j_{max}) in the detector for count image formation, the measured 64-ch peak signals for each event were summed along row and column directions, respectively. And then the major interaction position, i_{max} and j_{max}, correspond to the indices of maximum summed peak values on row- and column-directions as in (2).

$$i_{max;event} = maxind\{\sum_j Peak_{i,j;event}\} \quad 2)$$

$$j_{max;event} = maxind\{\sum_i Peak_{i,j;event}\} \quad (2)$$

In (2), *maxind*{} is a function to find an index having maximum value. For all measured events, the x-ray count image was formed by counting event numbers corresponding to each (i_{max}, j_{max}). Finally, we divided the object image (center in Fig. 4) by the initial X-ray intensity image (left in Fig. 4) for normalization. Finally, we obtain more uniform object image (right in Fig. 4).

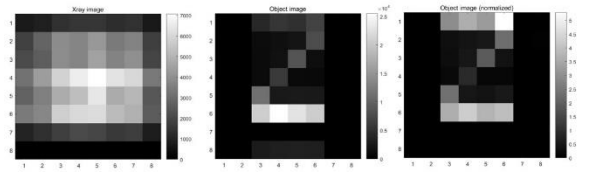

Fig. 4. Obtained X-ray (left) and z-shaped object images: without (center) and with (right) normalization by initial X-ray intensity image.

3. Conclusions

In this experiment, we test 64 channels DAQ system for X-ray imaging. Imaging software based on window OS and image formation algorithm are developed for obtaining high resolution X-ray image. The developed 64 channels DAQ systems and image formation algorithm are tested by using X-ray and Z-shape object. As according to this result, we can check the possibility to applying for X-ray imaging system.

ACKNOWLEDGEMENT

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REFERENCES

[1] Medical Imaging Equipment Market: Global Industry Analysis, Size, Volume, Share, Growth, Trends and Forecast, 2015-2023, Transparency Market Research, 2015..
[2] Csaba Szeles, Stephen A. Soldner, Member, IEEE, Steve Vydrin, Jesse Graves, and Derek S. Bale, CdZnTe Semiconductor Detectors for Spectroscopic X-ray Imaging, IEEE Transaction on Nuclear Science, Vol.55, p.572, 2008.
[3] Yossi Eisen, Asher Schor, and Israel Mardor, CdTe and CdZnTe X-Ray and Gamma-Ray Detectors for Imaging Systems, IEEE Transactions on Nuclear Science, Vol51, p.1191, 2004.