Development of a 64 Channels DAQ System for X-ray Imaging

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1. Introduction

CdTe and CdZnTe (CZT) have the advantage of X-ray imaging systems because they have good energy resolution at room temperature. Also space resolution is superior then scintillating materials, such as NaI(Tl), CsI(Tl), and $Bi_4Ge_3O_{12}$ (BGO), because they don't need photomultiplier tubes (PMTs) of photodiode [1-2].

The dimension of multi channels DAQ system is need to be minimized for increasing portability and application area. In addition, development of low noise level electronic system is necessary for high detection efficiency with CdTe sensor.

For X-ray imaging, we develop a 64 channels CdTe array sensor and a FPGA based digital data acquisition (DAQ) system. The developed DAQ system consist of three parts such as FEE board, digital process board, and HV module, for small size and portability.

In this study, the energy resolution of a 64 channels CdTe array sensor and noise level of developed DAQ system are measured.

2. Methods and Results

2.1 CdTe array sensor

We develop a large area 64 channels array sensor with high efficiency. Figure 1 shows the CdTe array sensor bonded to PCB (Printed Circuit Board) by using Ag epoxy. The dimensions of 64 channels CdTe array sensor is 50 mm x 50 mm x 1 mm and one pixel size is 5 mm x 5 mm, respectively.

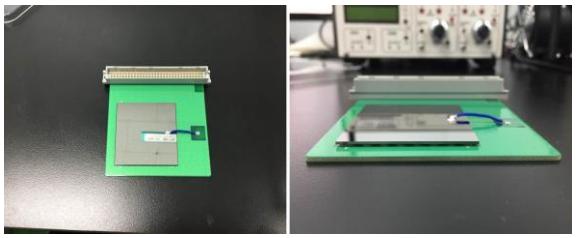

Fig. 1. The photographs of the CdTe array sensor bonded to PCB by using Ag epoxy.

The pulse height spectrum of a 64 channels CdTe array sensor under ^{133}Ba ɣ-ray excitation is shown in Fig.2. The energy resolution (FWHM) is measured to be 16.79 % at 81 keV.

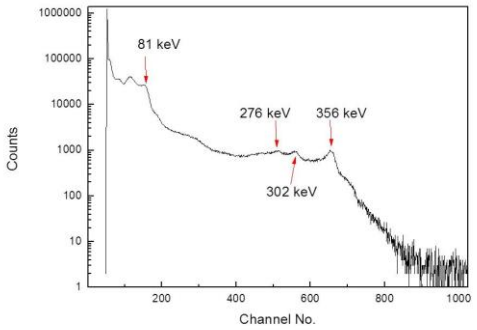

Fig. 2. The pulse height spectrum of a 64 channels CdTe array sensor at room temperature under ^{133}Ba ɣ-ray source.

2.2 DAQ system

We develop a low noise DAQ system, which consists of preamplifier, shaping amplifier, multi-channel analyzer (MCA). The DAQ system is composed of FEE board, digital board, and HV module.

The FEE board consist of preamplifier, shaping amplifier, voltage amplifier, and analog to digital converter (ADC) driver. The ADC data is processed at every 20 ns, and the FPGA (Field Programmable Gate Array, Xilinx, Spartan-6) [3] plays a role of controlling interface between ADC and FPGA. Also HV module can be controlled by using software for increasing convenience. For HV module, Ultravolt [4] chip is used.

Figure 3 shows the developed low noise and high efficiency DAQ system without HV module. The dimension of analog part is 120 mm x 120 mm x 120 mm. For electromagnetic (EM) shielding, the system is shielded by using Al case. For preventing thermal noise, the cooling fan is installed to Al case. The dimension of Al case is about 120 mm x 220 mm x 120 mm. The system consist of six boards which are preamplifier, shaper, amplifier, ADC, DAQ, power supplier in order.

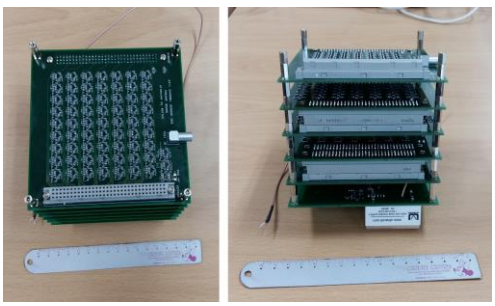

Fig. 3. The photographs of developed low noise DAQ system for X-ray imaging.

The noise level of DAQ system is measured after injecting 100 fC charge signal. As shown in Fig.4, The electronics noise level of the DAQ system is about 760 e-rms. After a 64 channels CdTe array sensor is attached to the DAQ system, the noise level is measured to be about 2,070 e-rms as shown in the Fig.5.

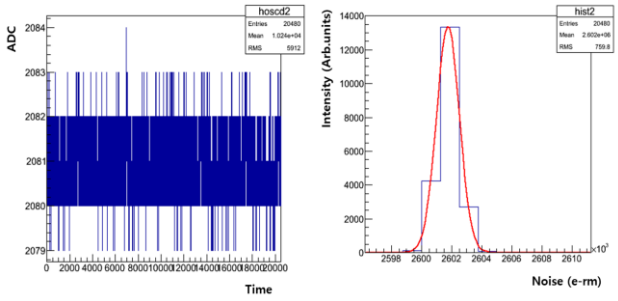

Fig. 4. The noise level of the developed DAQ system after injecting 100 fC signal

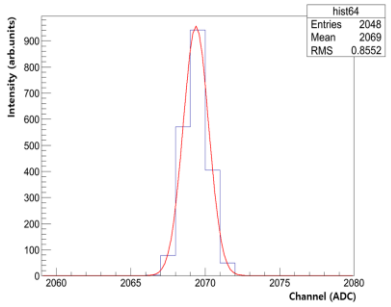

Fig. 5. The noise level of 64 channels CdTe array sensor with developed DAQ system

For understanding correlation between detector size and noise level, we measured noise level as changing the capacitance size instead of changing detector. The detector size is dependence on capacitance. As changing capacitance such as 0 pF, 10 pF, 100 pF, 330 pF, 1 nF, the noise level of DAQ system is measured. The noise level is increasing as capacitance size is increased as shown in Fig. 6.

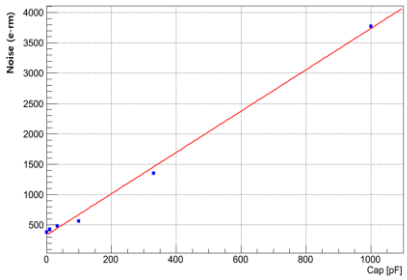

Fig. 6. The correlation between capacitance size and DAQ noise level

3. Conclusions

In this experiment, the low noise and high efficiency 64 channels DAQ system is developed for X-ray imaging. The large area 64 channels CdTe array sensor is used with developed DAQ system as radiation detector. The energy resolution of 64 channels CdTe array sensor is measured to be 16.79 % at 81 keV of ^{133}Ba ɣ-ray excitation. The noise level of developed DAQ system is about 760 e-rms. After connected a 64 channels CdTe array sensor, the noise level is measured to be about 2,070 e-rms. Therefore, the developed low noise and high efficiency 64 channels DAQ system can be applied to X-ray imaging.

ACKNOWLEDGEMENT

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