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Development of Data Acquisition System for 64-channel X-ray detectors

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1. Introduction

X-rays are widely used in the medical and industrial fields. In particular, they have been recently used in homeland security field recently. To overcome the disadvantages of existing security inspection systems, which use only X-rays, multi-radiation such as dual energy X-rays and fast neutron inspection systems have been studied as next-generation security inspection technologies [1, 2].

Conventional security inspection systems used in aviation or ports can identify only the cargo shape, while internal images and material information can be acquired simultaneously by a multi-radiation inspection system. Therefore, the ability to identify contraband such as nuclear materials, explosives, or drugs can be improved by using this technique [3, 4].

We have been developing a multi-radiation inspection system that includes X-ray generators, a neutron generator, cargo transporting equipment, an integrated control system and an image processing system. In this study, a 64-channel data acquisition system (DAS) for X-ray detection, to be applied in a multi-radiation inspection system, is described.

2. Data acquisition system

2.1. Design of the data acquisition system

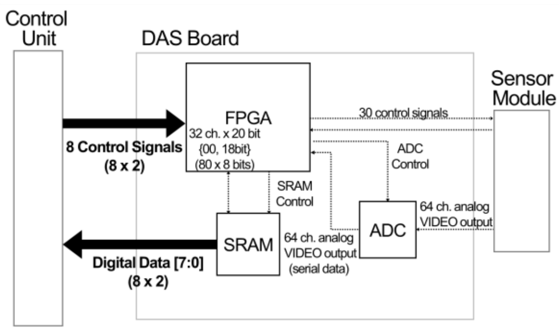

Fig. 1. Block diagram of the designed DAS board.

As shown in Fig. 1, the DAS board is connected with a control unit and sensor module. The DAS board receives control signals from the control unit. An field programmable gate array (FPGA) based DAS board produces local timing signals to control the sensor module which consists of scintillators, photodiodes, preamplifiers, samples and holds, and shift registers circuits. The operational principle of the sensor module connected with the DAS is as follows: First, the X-ray flux is converted into visible light by the scintillator, and is then converted into electrical current by the photodiode. The generated current is integrated by the preamplifier, and then output as a voltage signal at the preamplifier output terminal. The voltage signal is sampled and held for digital processing by the DAS. Finally, these voltage output signals from each detector channel are sequentially transferred into the analog-to-digital converter by the shift register.

2.2. Fabrication of the DAS board

For the precise digital processing of the analog signal, and the data transfer of the entire channel to the control unit without loss, the 18-bit high speed ADC and 256k SRAM were used. Differential line drivers, receivers, and buffers were used to reduce the loss and noise during data transmission through the connectors. In addition to supplying power to each component, some regulators were used.

The arrangement of the electronic components is optimized to minimize the loss and noise of the analog signal generated by the X-ray energies. The size of the DAS board is 184 (W) × 147 (D) mm^2, and the width of the DAS board is the same as the total width of the 64-channels X-ray sensors. The manufactured PCB board is shown in Fig. 2.

Fig. 2. Manufactured DAS PCB board.

3. Experimental results and discussion

3.1. Experimental setup

Fig. 3 shows the experimental setup. The system consists of a sensor module (pixelated $CdWO_4$ scintillator coupled to silicon photodiode, 32-channels KAERI XCIS readout board), DAS board, Tektronix's DPO 3034 oscilloscope, and Tektronix's TLA6403 logic analyzer.

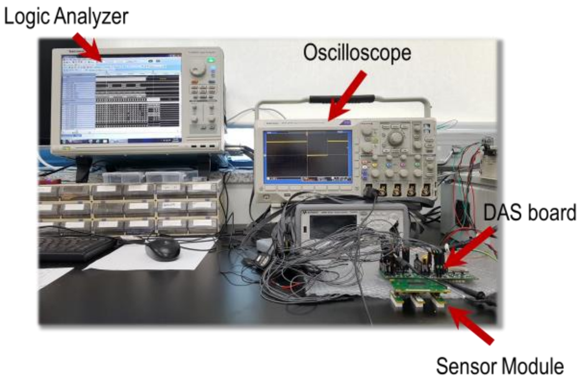

Fig. 3. Experimental setup.

3.2. Results of experiment

Each local timing and control signal produced by the FPGA programmed with Verilog in the DAS board was analyzed using an oscilloscope and logic analyzer. Some major timing signals measured by the logic analyzer to control the sensor module are shown in Fig. 4. In this experiment, a period to process the 64-channels analog signals and transfer the data to the control unit was 5 milliseconds.

Finally, we equipped only three sensors in the sensor module and acquired the image using a computer. Three vertical lines appeared at the location where the sensors were equipped. Fig. 5 shows the sensor module equipped with three sensors and the acquired image by using visible light source is shown in Fig. 6.

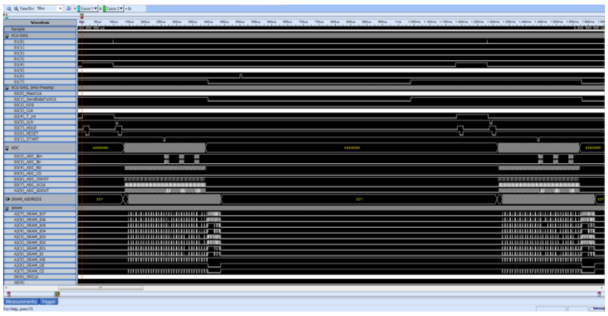

Fig. 4. Some timing signals measured by logic analyzer.

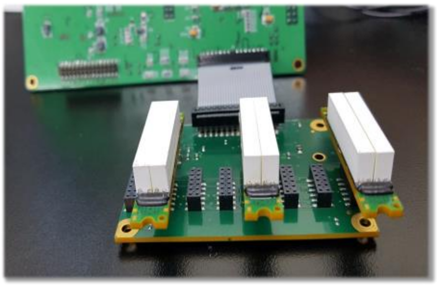

Fig. 5. Sensor module with three sensors (left) and the acquired images (right).

Fig. 6. An acquired image using three sensors by visible light source.

4. Conclusions

We developed a DAS board so that data from 64-channel X-ray detectors can be precisely acquired. A DAS board can be used as a single board, and can be connected with other DAS boards to increase the number of detectable channels.

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ACKNOWLEDGEMENT

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