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Development of the data acquisition system for the X-ray CCD camera onboard the ASTRO-H satellite using SpaceWire

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X-ray observations are indispensable to study very hot plasmas in space. In fact, hot plasma ranging from a few to a few tens million K is found various places in space, such as in supernova remnants, compact X-ray binaries, galaxies and clusters of galaxies. X-ray observations enable us to measure its various parameters, e.g., temperature, density, elemental abundances, and ionization degree. In some cases, non-thermal X-ray emission is often observed from the hot plasma regions; this indicates high-energy particle acceleration in the plasma.

As X-rays from space are completely absorbed by the atmosphere, we need to employ satellites, sounding rockets or balloons to observe the cosmic X-rays. Japan has already launched five X-ray satellites including the currently working "Suzaku". The next Japanese X-ray astronomy satellite, ASTRO-H, is scheduled to be launched in 2014. ASTRO-H carries three X-ray telescopes and four detectors. Among them, SXI (Soft X-ray Imager) uses CCDs (Charge Coupled Devices) and is located at the focal plane of an SXT (Soft X-ray Telescope). SXI adopts 2x2 CCD array to cover the wide field of view, and works as an imager and a spectrometer in the 0.2-12 keV band. In addition to SXI, SXS (Soft X-ray Spectrometer), HXI (Hard X-ray Imager) and SGD (Soft Gamma -ray Detector) are also equipped and covers 0.1-600 keV band in total.

ASTRO-H is the first scientific satellite in Japan which adopts SpaceWire widely as the onboard network architecture. SpaceWire is a specification to become international standard for the satellite's network through the collaboration of ESA, JAXA and NASA, and expected to reduce the development cost and time. The ASTRO-H team developed a universal digital circuit board for the SpaceWire communication, which will be commonly used by the scientific instruments onboard ASTRO-H. For the communication, RMAP (Remote Memory Access Protocol) will be used at an upper layer of SpaceWire protocol. T. Yuasa implemented "SpaceWire/RMAP Library" for the communication using RMAP, and established a framework for instrument development with a SpaceCube computer.

With these technologies, we started to development of a prototype, or a bread board model (BBM), of the circuit boards required for SXI in 2007. The SXI BBM consists of (1) Sequencer to send timing clocks to other circuit boards, (2) Driver Board to provide analogue signal to CCD, (3) Video Board to convert the CCD output signal to digital signal, (4) DE I/F to process the CCD digital signal and to interface the SpaceWire network, (5) SpaceCube and (6) POSIX OS computer. CCD data are temporarily stored in SDRAM on DE I/F and are read by the POSIX computer.

As the data acquisition software for the BBM, we developed a software "sxiSpWdaq", which works on the POSIX computer. The software controls the CCD exposure and the acquisition of the

stored data in SDRAM by RMAP access, and repeat them arbitrary times. In the acquisition framework, SpaceCube works as a protocol converter, between SpaceWire and TCP/IP on Ethernet. A running test showed that the data acquisition was stable for more than 24 hours and the mean transfer speed was 4.4 Mbps. We also combined the system with the analogue part, and succeeded in acquiring the CCD data. This paper describes the details of the system and the results of the performance test.

Keywords: ASTRO-H satellite, X-ray CCD camera, SpaceWire