

## Attitude Control System for Kanazawa-SAT3 Microsatellite

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Kanazawa University has been developing a microsatellite. This satellite is equipped with a device to observe celestial bodies emitting gravitational waves with X rays, and aims to elucidate the mechanism of black hole formation by estimating the time of arrival and direction of arrival of gravitational waves. In this research, the attitude control system is being developed using GAS (Geomagnetic Aspect Sensor) and MTQ (Magnetic Torque). We have constructed the environment for the unit test of RW (Reaction Wheel) also used for attitude control of the satellite.

MTQ is a device that controls the attitude of the satellite by generating a magnetic torque against the geomagnetic field by applying a voltage (an electric current) to a magnetic coil. GAS is a device for detecting the direction of the geomagnetic vector. OBC (On Board Computer) which controls all devices mounted on the satellite receives the geomagnetic field data detected by GAS, and transmits commands to control MTQ. GAS and MTQ cannot be connected to OBC directly, because OBC has just a digital interface, but the output of GAS and the input to MTQ are analog voltages. Therefore, we have developed a control device for on-board equipment using a microcontroller. For the GAS, the voltages are A/D-converted by the microcontroller and transmitted to the OBC. For the MTQ, OBC transmits control commands to the microcontroller, which generates a PWM (Pulse Width Modulation) signal according to the received command that determines the effective voltage to be given to the MTQ. For the system development and operation tests, a PC is used instead of OBC and we carried out experiments of control equipment. For the GAS, we have confirmed the linearity between the analog magnetic field and the corresponding digital values transmitted to the PC. For the MTQ, we have confirmed that the voltage to be given to MTQ were precisely controlled by the duty ratio of the PWM signal output from the microcontroller.

RW is a device to generate a control torque around the rotation axis by accelerating a rotor by a motor and is controlled by transmitting a command from the OBC via an RS-422 serial communication line. The unit test has been carried out by using a PC as a substitute of OBC, but the cable had a influence on the rotation operation of RW. Therefore, we have constructed a system for wirelessly connecting the RW with the PC via a wireless RS-422 communication. Specifically, commands from the PC are wirelessly transmitted to an Arduino microprocessor by a low-power radio module XBee, and the RW is controlled via an RS-422 transceiver. With this system, we demonstrated the basic functions for command and data between the PC and the Arduino via the wireless RS-422 transceiver.

We plan to construct a system that applies appropriate PWM signals to MTQ according to the value detected by GAS. We will also evaluate RW performance by the unit test using the wireless RS-422 communication system.

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