Attitude Control System for Kanazawa-SAT3 Microsatellite

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Kanazawa University has been developing a micro satellite, Kanazawa- SAT3. The observation mission is estimation of the direction of gravitational wave arrival by X-rays. This mission aims to clarify the mechanism of black hole formation. The Kanazawa University satellite is equipped with RW(Reaction Wheel) and MTQ (Magnetic Torquer) as actuators, and STT (Star Tracker), GAS (Geomagnetic Aspect Sensor), GYR (Gyro Sensor), FSS (Fine Sun Sensor), CSS (Coarse Sun Sensor) and GPS (Global Positioning System) as sensors, and these devices are used to attitude control. In the Kanazawa University satellite, the SAPs(Solar Array Panels) are expanded after separation from the rocket, and stops the rotation of the satellite by detumbling control. After that, FSS and STT are used to determine whether day side or night side of the earth. If day side of the earth, sun supplement by using FSS. If night side of the earth, attitude determination by using STT. In stationary operation, the attitude control is conducted to keep the mission equipment facing the deep space direction. In this presentation, we report 1) A Study of Attitude Control System Using MTQ and GAS, 2) A Study on Attitude Control of RW and STT, and 3) Performance comparison and accuracy correction of angular velocity detection for GYR and STT.

MTQs are the device that generates a magnetic moment when current flows through its internal coil. The torque is generated by the interference between this magnetic moment and the earth's magnetic field, the satellite has 3 MTQs placed orthogonal tri-axially, and the direction of total magnetic moment is controlled by the balance of them. GAS is an instrument that detects geomagnetic vectors. MTQ and GAS are connected to a sub processing system named MC (Media Converter), and MC is connected to OBC (Onboard Computer) via UART communication. MC reads the strength of the geomagnetic filed from GAS and send it to OBC, and also controls the electric current of each MTQ by PWM control, according to the command which is sent from OBC. We designed the system that performs control in 2-second cycles. When MTQ is activated, GAS detect the magnetic field including the one generated by MTQ, so that the processing routine should be adjusted to prevent this.

RWs are the device that control the attitude of satellite by rotating the internal rotor to generate reaction torque. To study the attitude control method using the RW, we placed a RW on air bearing and rotated, and measured the rotational speed by RE (Rotary Encoder) attached to the air bearing. In this way, we performed angular velocity control by P-control and angular control by PID-control.

STT is the device that observes position of stars in its view and outputs its quaternion and Euler angle of the STT cameras direction. Calculating the declination from the quaternions, the stellar determination accuracy of the STT at stationary conditions is determined to be of the order of 10^-3. And also, the STT has a MEMS gyro, and calculating the accuracy, it is on the order of 10^-2. The Kanazawa University satellite also has a gyro sensor on MC, and its accuracy is on the order of 10^-1, so STT is better in accuracy. However, since the MC is equipped with a microcontroller board, it has advantages in terms of time resolution and the ability to perform signal processing such as digital filtering.

The devices described in this presentation are currently tested for communication with OBC without any problems. In the future, it is necessary to develop OBC software that follows the control laws of the

satellite.

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