Development of the ARICA-2 Satellite using Spresense as an Onboard Computer

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Abstract

Gamma-ray bursts (GRBs) are transient astronomical phenomena that emit enormous amounts of energy in electromagnetic waves, mainly in the gamma-ray range, for several seconds to tens of seconds. GRB observations are challenging because of the difficulty in predicting the location and time of occurrence and its extremely short duration. Therefore, it is necessary to notify about the discovery in space and to conduct follow-up observations by researchers. The AGU Remote Innovative CubeSat Alert system-2 (ARICA-2) has been developed to demonstrate a new alert system using commercial satellite network services. ARICA-2 uses SONY's Spresense as its onboard computer (OBC). We manufactured the special board to attach two Spresenses as a redundancy of the OBC system. We will present the system development of ARICA-2 using Spresense.

ARICA-2

AGU Remote Innovative CubeSat Alert system-2

- Alert GRBs detection information to the ground using commercial satellite networks
- Size：2U（ 10cm× 10cm × 20cm ）
- Orbit altitude：540km
- Development is underway with the goal of launching in Japanese fiscal year 2024 as a part of the JAXA's Innovative Satellite Technology Demonstration-4

Background

Gamma-ray-Burst (GRB)

- Duration of the phenomenon：a few milliseconds to several minutes
- Impossible to predict where and when GRBs occur

These features **requires a quick alert to the ground for the follow-up observations by various telescopes** and understand the nature of GRBs.

Mission Goals

Alert a detection of a GRB to the ground using Iridium and Globalstar satellite networks

System

Electrical Power

Manage the power supply of all the devices by

- EPS + 20Whr battery （AAC-Clyde Space Inc.）
- 6 SAPs

Communication

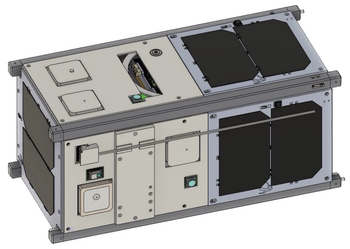
Three types of a communication system

Two commercial satellite network devices

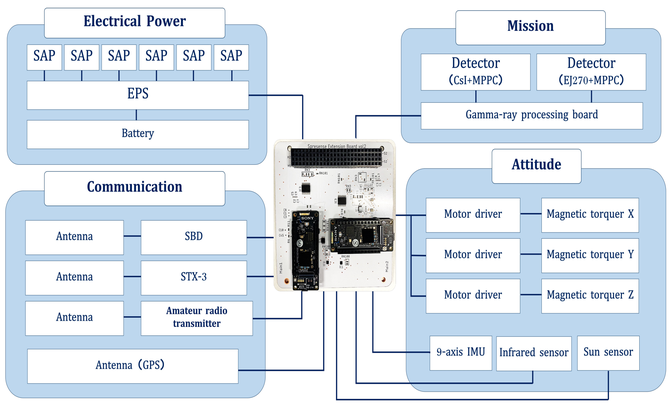
- SBD （Short Burst Data）using Iridium satellite
- STX-3 using Globalstar satellite

Amateur radio transmitter （430MHz）

Two types of commercial satellite communications and an amateur radio transmitter are used to immediately alert GRBs information. SBD and an amateur radio transmitter can communicate two-way, and can perform uplink as needed.



CAD image of ARICA-2



System diagram of ARICA-2

Mission （Gamma-ray detector）

Two types of crystals：CsI & EJ-270 （7cm× 7cm × 1cm ）

- Generate triggers if the count rate of gamma-ray photons rises rapidly
- Expect to detect GRBs about once a month

Attitude system

Attitude Determination and Control System

- 9-axis IMU, Infrared sensor as a Sun and an Earth identification
- Magnetic torque x 3

Attitude determination is based on information from gyro, magnetic and infrared sensors. The magnetic torquer is used to control the attitude of the satellite as needed.

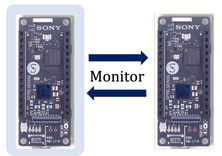
OBC

SONY Spresense

ARICA-2 uses SONY's Spresense as an onboard computer, which is a multi-core processors with a low power consumption. Spresense has been used in space about a year without any issue. Spresense controls all the system of ARICA-2. Two Spresense boards are installed on our designed interface board to provide a redundancy in the satellite OBC system.

Point

- ✓ Low power board
- ✓ Multi-core processors
- ✓ Used in space environment



Model name	CXD5602PWBMAIN1
Size	50.0 mm x 20.6 mm
CPU	ARM® Cortex®-M4F x 6 cores
Digital input/output	GPIO, I2C, UART
SRAM	1.5MB
Flash memory	8MB

Interface board to attach Spresence main boards

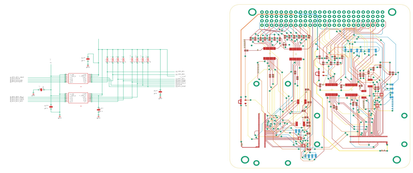
Need

- A board that can accommodate two Spresense main boards
- Extend the interfaces to control all devices The interface voltage to send and receive signals to all devices

Spresense main board.	：	1.8 V
Our interface board	：	3.3 V

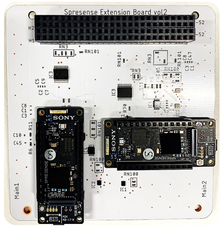
Create an interface board that accommodate two mainboards and extend interfaces

I designed the schematic and board drawings by using software called Eagle, and ordered them to a company that produces boards.



The schematic and board drawings

The circuits were added to monitor the Spresense to ensure that they are working properly with each other. The interface voltage was level shifted from 1.8 V to 3.3 V.



New board functions

1. Two Spresense main boards can be mounted
2. Designing a circuit that can monitor two Spresense each other
3. Interface voltage changed from 1.8 V to 3.3 V

Development of an interface for using Spresense as the OBC has been completed. No issue was found in our designed board. The board will control the entire satellite system.

Contact Information

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