Measurement of Space Radiation Environment for Small Deep Space Probe - SHINEN-2

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Abstract

It is a grand opportunity to recover new small space probe Shinen2, developed by Kyushu Institute of Technology KIT, in partnership with the different companies and institutions of Engineering in Kagoshima University (Japan), NASA Johnson Space Center, and was launched by the rocket H-IIA of Japan Aerospace Exploration Agency (JAXA), in the December 3, 2014 in Tanegashima. The requested task of this small probe is to reach or demonstrate a communication system based on different methods using Weak Signal & Joe Taylor (WSJT) technique in deep space between the ground station and the space vehicle. The most important is to use small payload as sensor PPD Radiation Particles Pixels Detectors explored for our project in KIT, developed by NASA and Prairie View A&M University. Planned for the future to deep-space rights investigations, in excess of the protection of the magnetic field lines of the earth, we need to measure and evaluate the radiation particles flow changes. The aim is to evaluate or demonstrate different techniques as used a CMOS device as small payload for the Shinen2 mission. This device CMOS (Complementary Metal Oxide Semiconductor) with different electronics part inside. In fact, to do some simulations or tests of the sensor that used some radiation sources for testing and showing prototype of PPD radiation particles pixels detector, such as average or histogram distribution determined using Software Radio SDR and Matlab.

1. Introduction

Besides conventional passive detectors, the deployment of active real-time data acquisition and position-sensitive radiation detectors on board spacecraft would be highly advantageous for space radiation detection and spacecraft radiation monitoring.

In order to provide a precise detection of the varied radiation field in space with track visualization, we have constructed packed sensor and each pixel integrates electronics which enables counting of the number of particles generate the number of hits using the radiation level measurement instrument developed by NASA Johnson Space Center and Prairie View A&M University's Research. The Radiation Particle Pixel Detector for deep space exploration (PPD) system recently launched aboard the Shinen2 spacecraft as part of the Hayabusa2 Asteroid Explorer mission spearheaded by the Japan Aerospace Exploration Agency (JAXA). The results of the PPD mission could have lasting implications for the future of space exploration that use an expanded CMOS detector to measure to measure the energy generated by radiation particles pixel with particles capability based on the hybrid semiconductor particles pixel detector inside the instrument.

The reminder of this paper is organized as follows, section 2 is overview of the satellite Shinen2 and their missions. Other section, including description of (EM) for the adapted payload sensor for the small probe deep space Shinen2, summarizes payload orientation with different shapes and simulations. Finally, conclude the results obtained by achievement data of the sensor after launching.

2. Shinen2 Probe & main missions

Shinen2 is a first small probe deep space that was developed by the Kyushu Institute of Technology and

Kagoshima University. Our small probe was launched on December 3, 2014 together with JAXA`s Hayabusa2 by an H-IIA rocket in Tanegashima. It designed as structure 17,8 kg satellite with dimension 490×490×475 mm assembled by students of KIT Kyushu Institute of Technology 50cm class of small spacecraft for the purpose to demonstrate a deep space communication technology and establishment of ultra-lightweight satellite structure showing in Fig 1.

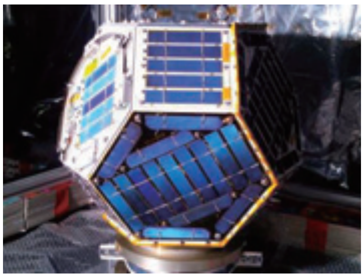

Fig 1 Shinen2 space probe

This probe's main missions are:

One of the missions of Shinen2 is to establish a mutual communication technology between the earth and a space probe in the lunar orbit (approximately 380,000km). This will be used for a realization of a technique to send a lunar exploration on moon orbit[4]. Also, it will be used for a moon mission realization such as moon sample return technologies.

To set a communication technology between the earth and a space probe in the deep space approximately 3,000,000km, the communication system has been using by many amateur radio stations was equipped in Shinen2 and may try mutual communications[5]. Amateur radio stations of the world can perform a detection experiment of a telemetry data and a morse code from Shinen2 which is flying the deep space [8].

To establish a development technology of the probe structure using a carbon-fiber reinforced thermoplastics (CFRTP). Once we use this technique CFRTP, can join composite materials like the welding of metal materials to reduce number of metal fasteners use such as bolts and rivets dramatically by using this CFRTP and able to realize a light weighting of a space vehicle and a large improvement of the structure reliability. Shinen2 projects adopted CFRTP in space vehicle structure for the first time in the world by using the PEEK resin.

3. Sensor Testing Procedure

This section present the CMOS detector contains two sensors (S1,S2) for the measurement of cosmic type radiation of deep space. Several prototype instruments were designed and was invented at NASA-JSC respecting some requirement, to verify the operational capability of the developed units, we use some radiations source such Co-60 for testing the payload with low energy radiation. Hence, we describe the connecting equipment's for the sensor and plot the histogram distribution of number of hits generate by sensors as shown in Fig 2.

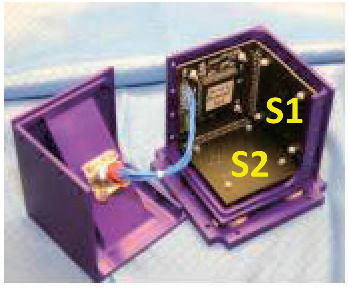

Fig 2 Position of S1 and S2 in PPD detector

Before connecting the cable to power supply, we should make sure that the Voltage is 5V and max current is set to 500mA, connect cables to RS422 USB converter, and to the power supply. Next step is turn on power supply. Voltmeter should read 5V and current meter would read about 0.279 A without RS422 converter, the value of current should be about 0.240 Amp (240mA) shows in Fig 3.

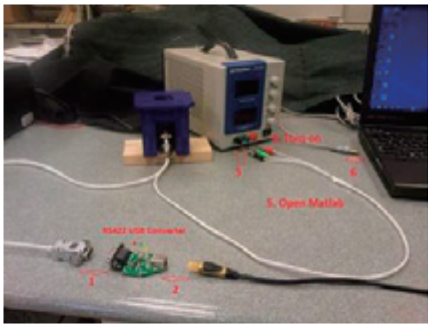

Fig 3 Connecting the Sensor to power supply and RS422 converter

We use the software Matlab to call our function (sensor1-lowflux-energy1) that contains the code for plotting the radiation hits of each sensor by using the sources radiation that identified before. When we connect the USB cable to the laptop. Yellow LED will be lit on the RS422 converter indicating is connected and ready to use for communication. After running the program we should enter the number of frame generated (example: 90000).

Now program will start collecting date and a window will display number of frame and number of counts that means the green LED blinking very fast indicating data exchange. We do the same procedure for the second sensor by calling the second function in Matlab (sensor2-lowflux-energy2). Finally, the windows displays the number of hits of each sensor means that our sensor worked well, ready for orientation and implanting in EM model of Shinen2.

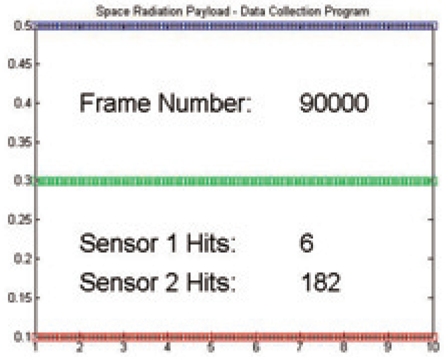

Fig 4 Co-60 frame data of space radiation payload

The preliminary result can display the histogram distribution of each sensor showing in Fig 5 and Fig 6.

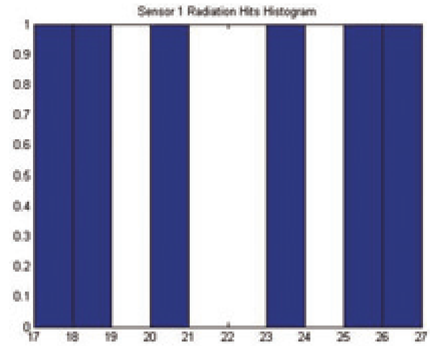

Fig 5 S1 radiation hits histogram

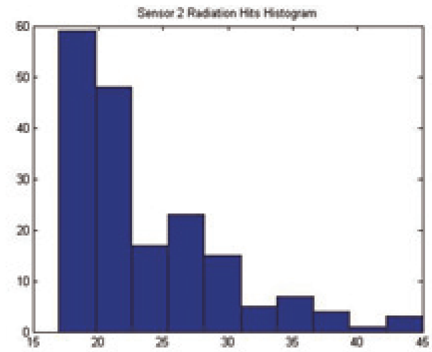

Fig 6 S2 radiation hits histogram

4. Payload Orientation in Shinen2

Based on such requirements, a radiation particle pixel detector PPD was designed and developed during past few months by NASA Johnson Center for the probe Shinen2 with low weight about 800 grams, operating capability for low power near to 1 Watt suitable for a period 2 to 5 years, tolerance in deep space environment and ability to generate data for low bit rate transmission in kilobyte[1,3].

Fig 7 Particle pixel detector for Shinen2

In this section, our team in Kyushu Institute of Technology and Prem-Saganti and Doug Holland from Prairie View and A&M University with NASA-JSC, we try to find a good way for implementing the payload orientation before launching that means to fix the position of the two sensors S1 and S2 of the PPD sensor and witch direction in the internal structure of Shinen2. Therefore,[2] to recommend two cases, suggestion orientation and current orientation. Once the different iterations tested, the results obtained in previous section shows some shapes how to familiarize the payload Shinen2 that provide a pre-eminent way for detecting the radiation level measurements in deep space showing in Fig 8 and Fig 9.

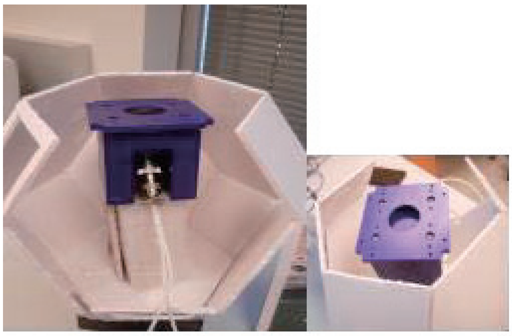

Fig 8 Suggestion orientation of sensor

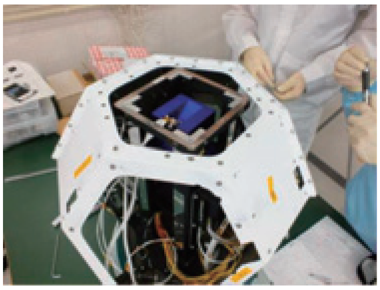

Fig 9 Current orientation of sensor

5. Data frame & Results

In this section, we define the type of frame data Shinen2 from SCU (System Control Unit) to CCU

(Communication Control Unit) data format that contains some packet with different bits or bytes in total 16 bytes.

- Control code 6Bytes with variable length
- Data (CCU command)
- Data length (the length of the data source)
- Data 8Bytes
- Exit code 2Bytes

From these frame, we can define the telemetry frame data of our sensor PPD, to know each sensor how much has number of byte before collecting all data from the signal wave saved in the software HDSDR, we can define this frame as shown in Fig 10.

Fig 10 Telemetry frame form

- 24 Bit Frame including 8 Bit Frame Sync
- Data sent LSB first
- 00000000 Sensor data for fill frames
- Byte 2: Frame Sync – 10101100 (0xAC)
- Byte 1: Sensor 1 pixel value (0x00 to 0xFF)
- Byte 0: Sensor 2 pixel value (0x00 to 0xFF)

After launching our probe Shinen2, we intend to work in the ground station to receive all data and save the sound signals in the HDSDR software as text files, that several data from the sensor should decrypted (acquisition data) after design all frame data of the system communication design and analyzing. Hence, we can plot the histogram distribution of space radiation payload in actual context means with real data received from the probe after one week of launching, define the measurement level radiation from Shinen2 probe shows in Fig 11 and Fig 12.

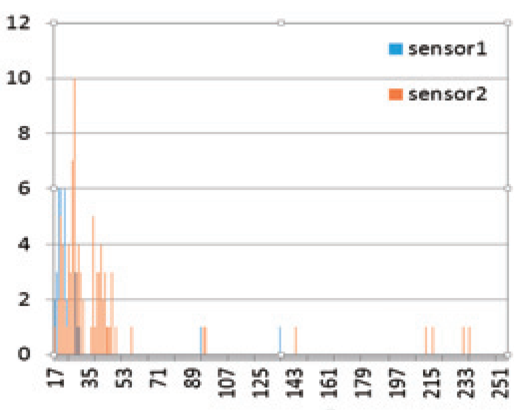

Fig 11 Histogram radiation

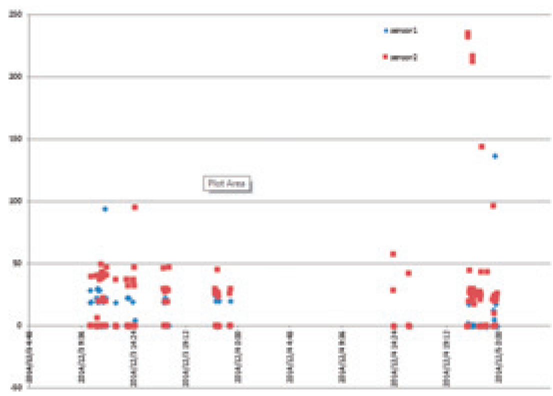

Fig 12 Radiation Intensity

6. Conclusion

This report presented a model of payload sensor for first small deep space probe in Kyushu Institute of Technology developed by the NASA-JSC with high performance to detect the measurement of cosmic radiation of deep space and demonstration of new deep space communication system using the amateur radio band. Future work will include new devices or units such the PPD detector used before but with high performance, different requirements and it can be used for long life cycle and with new design communication system using different transceiver (TX, RX) and transponder with wide band width for the new project including the attitude orbit determination system and receiving data from payload sensor that connect with relay satellite for long period of communication.

References

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