CONCEPT OF IMPLEMENTATION THE DIGITAL SIGNAL PROCESSING OF THE MINIATURE PARTICLE DETECTOR MIRA_EP IN THE CUBESAT FORMAT

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Earthquakes are a very destructive natural phenomenon, leading to human tolls and great material damage. The energy of powerful seismic activity can be converted into several types of energy, such as acoustic, electromagnetic, light, and other ones. Thus, different physical phenomena can be served as precursors of the Earthquakes One of these phenomena of the seismic-ionospheric-magnetospheric activity is based on the local breakdown of the pitch-angular distribution of high energy particles fluxes in the Earth's radiation belts caused by the resonant interaction of the low-frequency electromagnetic emission of the seismic origin with the gyration periods of electron rotation around field lines of the Earth's geomagnetic field. Previous satellite experiments at the Low Earth Orbits (LEO) have revealed the presence of precipitating electron fluxes before powerful Earthquakes [1-3].

As far as the launch of a full-scale satellite is quite expensive, the CubeSat chassis format was developed in California state (USA) in the 1990s, to accommodate the payload of small dimensions and weight on the board. In this paper, we provide a brief description of the electronic modules for processing of signals that will come from the sensors of high energy charged particles. The microbursts of these particles will be targets for founding out prior the different manifestations of seismic and magnetospheric activity at the altitudes of low-orbiting satellites.

The format for the nanosatellite assembling was chosen by CubeSat 2U. The payload of a 1U format, which is the Miniature Recording Analyzer of electrons and protons, is advisable to be perform as an assembly from three modules - a detector head with sensitive sensors of charged particles, an analog processing module and a digital signal processing module. The analog processing module amplifies and shapes analog signals coming from scintillation detectors, generates signals to start the conversion into digital form. The Digital processing module sorts incoming signal packets by energy and types, with the subsequent accumulation of information received.

To solve the tasks of digital signal processing we propose: first – with using of the FPGA, the second is with a usage of the two thirty-two-bit general purpose microcontrollers STM32F407 (Fig. 1). The use of two microcontrollers improves the reliability of the module when one of them fails.

The latter is ensured by the fact that each channel allows us to check the efficiency of the previous one and to change its configuration directly during a communication session once a day while the satellite flying over the ground control station. The presence of digital-to-analog converters in the microcontrollers allows us to check outgoing testing signals for the verification of the analog module functionality. The second microcontroller "communicates" through the serial interface (UART), thus checks the functionality of the first one. At last, the efficiency of the second microcontroller is checked by the onboard computer. Thus, the reliability of the system increases.

The analog signal processing module comprises of three channels that are identical in structure to the number of installed detectors. Each channel consists of charge-sensitive preliminary amplifier, shaping amplifier, peak detector unit.

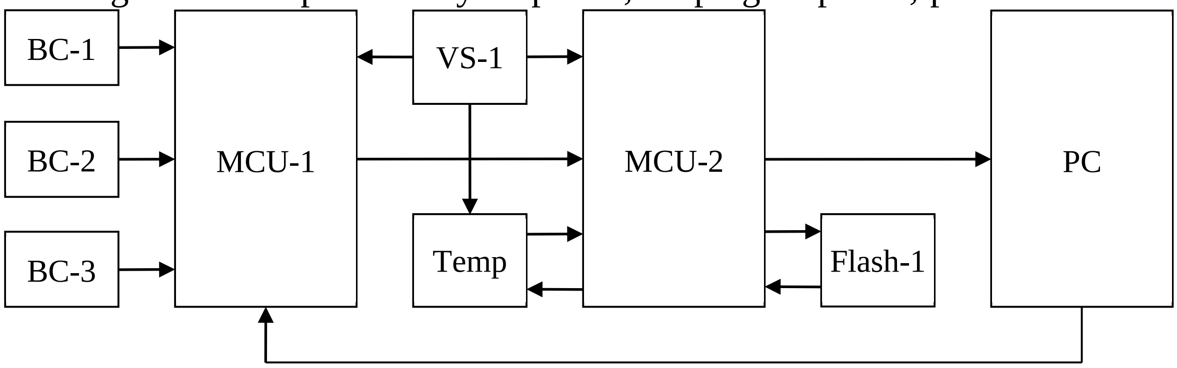

Figure 1. Simplified block diagram of the DSP module

The digital signal processing module comprises an analog converter of the incoming signals from differential (bipolar) to asymmetric (unipolar) ones. After that the signal goes to the analog-to-digital converter (ADC) of the first microcontroller (MCU-1). The first microcontroller sorts particles by ADC code levels. The second microcontroller (MCU-2) stores in flash memory (Flash-1) the values of the particle arrays and sends the data to the onboard computer (PC). The second microcontroller has also the property of measuring the temperature of the block (Temp) and the battery voltage of the nanosatellite. A simplified block-scheme for digital signal processing module is shown in Fig. 1.

The particle sorts and energies are determined according to predetermined ranges of probable values of proton and electron energies (Fig. 2). These values are recorded in the memory of the microcontroller and compared to the values received from the detectors in the ADC codes.

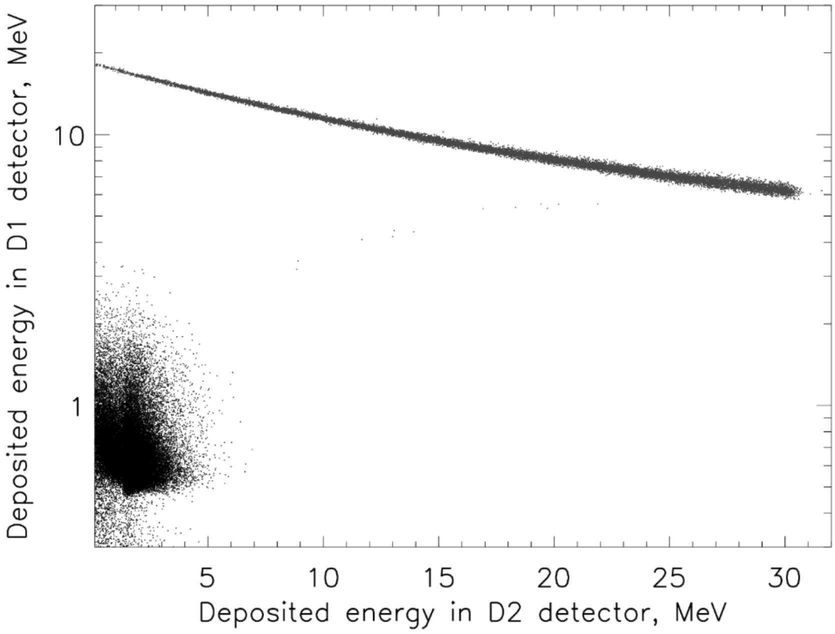

Figure 2. Deposited energy in D1 detector vs deposited energy in D2 detector. Black dots presented the electrons, blue dots protons.

Перелік посилань

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Анотація

Представлено принципи вирішення задачі збирання, сортування, формування та відправлення до бортового комп’ютеру вихідних інформаційних масивів мініатюрного реєстратору-аналізатору електронів і протонів МіРА_ер у форматі CubeSat.

Ключові слова: CubeSat, радіаційні пояси Ван-Алена, цифрова обробка сигналів.

Аннотация

Представлены принципы решения задачи сбора, сортировки формирования и отправки в бортовой компьютер выходных информационных массивов миниатюрного регистратора-анализатора электронов и протонов МиРА-ер в формате CubeSat

Ключевые слова: CubeSat, радиационные пояса Ван Алена, цифровая обработка сигналов.

Abstract

The concept of an implementation of tasks on the collecting, sorting, the formation and sending to the on-board computer of the output information frames of the miniature electron and proton recording analyzer MiRA-er in CubeSat format is presented.

Keywords: CubeSat, Van Allen radiation belts, digital signal processing.