# Service data acquisition and onboard control for "GRIS-BD" unit in "GRIS" space experiment

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**Abstract.** Problems of onboard space scientific devices control, collecting auxiliary service information about working capacity, conditions of experiment carrying out and preliminary data processing for real time calibration and stabilizing of operational parameters are actual for any space devices. In this paper we describe and discuss service data acquisition and onboard control for "GRIS-BD" unit in "GRIS" space experiment onboard ISS. This system provides temperature measurements in different equipment parts (in power supplies, on scintillation crystals for energy ranges correction, etc.), precision thresholds measurements in discrimination circuits, status different switching on/off (in real time), precision control detector parameters by high-voltage regulation, fine thresholds changing (analog regulation), different switching on/off (in real time), statistical analysis of data flows and change of operation modes of the device.

## 1. Introduction

"GRIS" (Gamma and Roentgen Irradiation of the Sun) is a scientific instrument for a spectroscopy of hard X-ray and gamma-ray of solar flares with the energy from 50 keV to 200 MeV and for registration of solar neutrons with energy above 30 MeV on board the service module "Zvezda" ("Star") of the Russian segment of the International Space Station. The main information on this experiment is provided in [1]. Not only for this experiment, but also for any space experiment the tasks of control, additional service data acquisition and preliminary data handling are important and urgent.

## 2. GRIS experiment technical data

"GRIS" instrument consists of two units (see figure 1 and 2):

- an electronic unit, "GRIS-BE", placed in a pressurized compartment of the "Zvezda" module, realizing functions of data acquisition, control and synchronization of instrument operation, information exchange with the unit "GRIS-BD", preliminary processing, package, storage of scientific data and data transfer to the RS ISS service systems by means Ethernet channel;
- a detector unit ("GRIS-BD") which will be mounted outside the "Zvezda" service module of the ISS on two-axis orientable platform. GRIS detector unit includes two spectrometers (a low

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energy spectrometer, based on $CeBr_3$ scintillator, and a high energy spectrometer, based on CsI(Tl) scintillator) and electronic subsystems for data acquisition, preprocessing and information exchange with the unit "GRIS-BE".

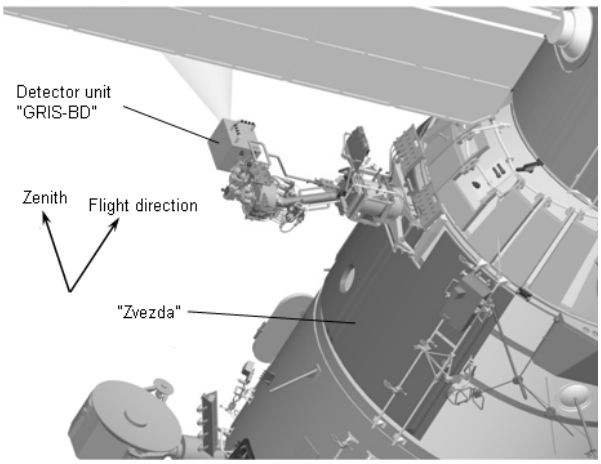


**Figure 1.** Placement of "GRIS-BD" unit.

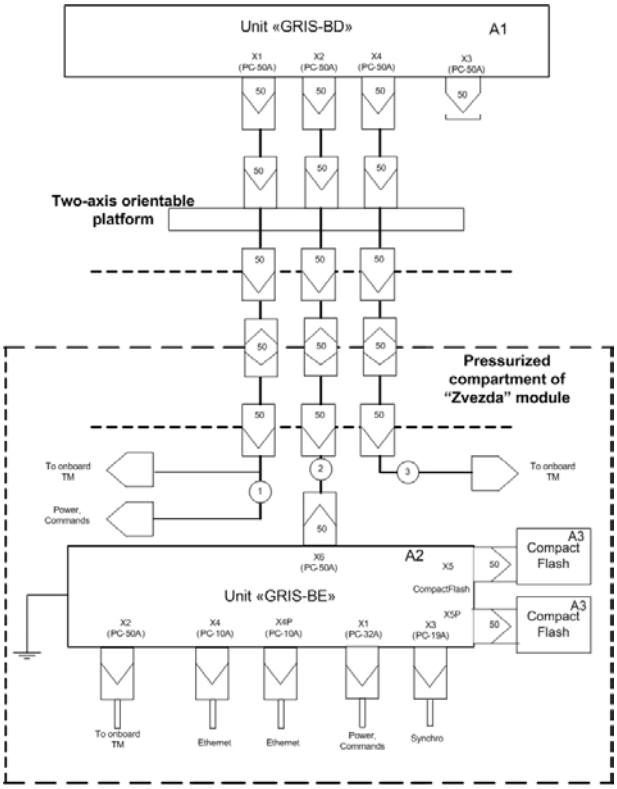


**Figure 2.** "GRIS" electrical connections.

The onboard ISS systems provide the following resources for operation of GRIS instrument: 5 impulse commands (including 3 for the unit "GRIS-BD": switching to the reserve set of "GRIS-BD", switching to the reserve set of internal thermo regulation subsystem of "GRIS-BD", switching to the main sets of "GRIS-BD" and internal thermo regulation subsystem of "GRIS-BD") and reception of a set of telemetric parameters, for "GRIS-BD": 3 parameters "dry contact" type (2 monitoring of cables connection and 1 – status of internal thermo regulation subsystem); 3 resistive thermo sensors (1 – temperature monitoring of internal thermo regulation subsystem, 2 – temperature of the detectors CsI(Tl) and $LaBr_3$) and 4 parameters of "electronic key" type for monitoring of switching on/off of power supplies on main and reserve sets of "GRIS-BD".

Communication "GRIS-BE" unit by Ethernet link provides transmission of a complete data stream from the GRIS instrument to the ISS onboard computer and reception of digital control instructions and auxiliary information.

## 3. "GRIS-BD" internal control, power supply and telemetric parameters acquisition

To improve the reliability of the equipment, taking into account available ISS resources, structure of electronic with duplication of all possible electronic schemes of unit "GRIS-BD" was chosen. Only the nodes directly connected to information processing from detectors aren't redundant. Switching between semi-sets of units it is carried out by switching of secondary power supplies. For non-redundant nodes is used so-called "non-switched" power, i.e., for this purpose is used connection to both, main and reserve power supplies.

The scheme of control, power supply and telemetric parameters acquisition for the unit "GRIS-BD" is given in a figure 3.

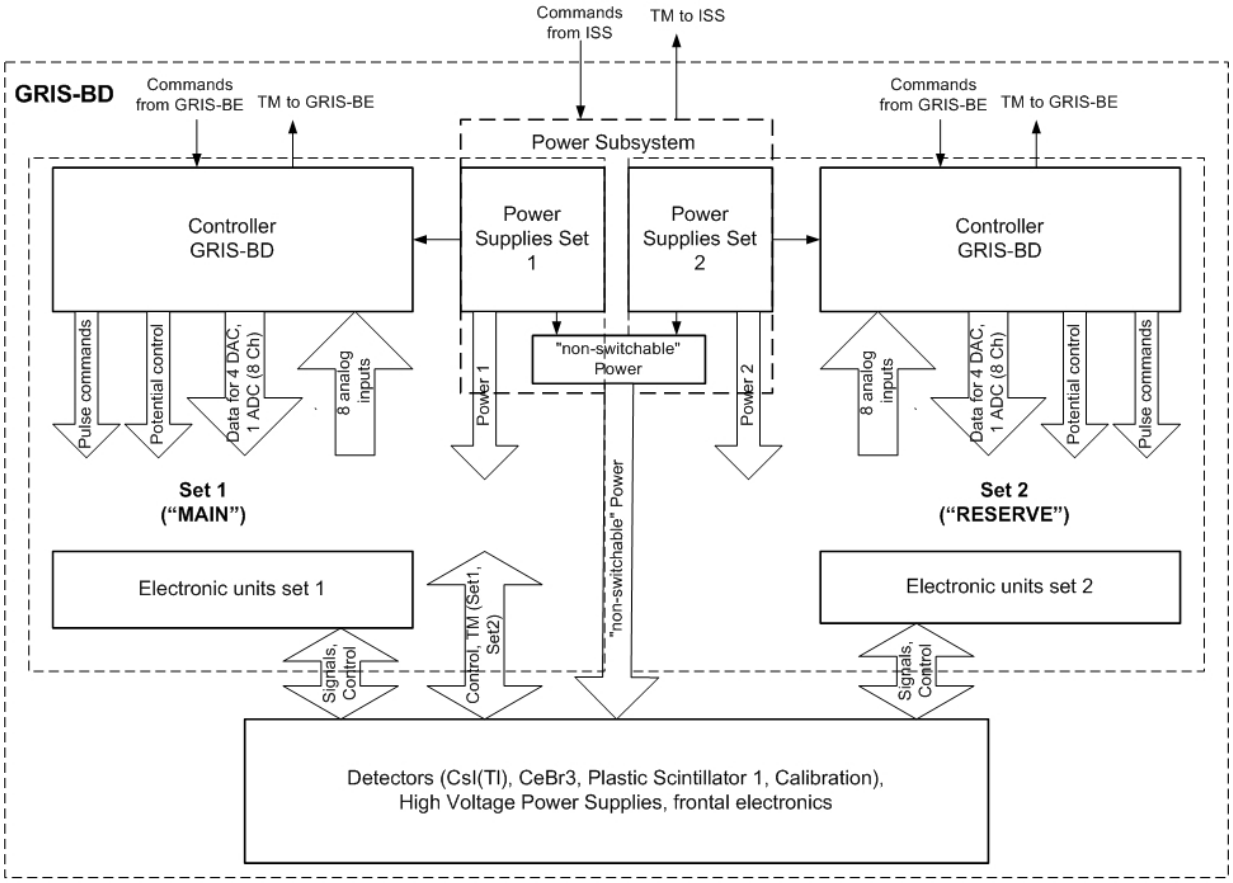


**Figure 3.** Control, power supply and telemetric parameters acquisition for "GRIS-BD" unit.

Acquisition of the service (status) data and control of internal electronic subsystems in "GRIS-BD" unit is realized by the controller of "GRIS-BD" [2]. Set of the sensors and executive elements (polarized relays and so on), are distributed on the unit. Remote DACs and ADCs are intended for precision generation of analog control signals and for conversion of analog parameters to digital form. Controller of "GRIS-BD" generate final internal service TM frames and transfers data to "GRIS-BE". Controller of "GRIS-BD" receives control data frames from "GRIS-BE", decodes it and realizes the sequence of the controlling operations. All information interchange with "GRIS-BE" realizes by SPI interface, a master device is "GRIS-BE".

Controller of "GRIS-BD" provides:

- generation of eight impulse commands for control of operation of nodes of the unit "GRIS-BD";
- eight potential commands (LVTTL) for control of nodes operation in the "GRIS-BD" unit;
- processing and conversion of eight analog parameters directly on board and eight analog parameters by means of remote ADC;
- operation control for four remote DACs (8 channels);
- reception of 8 "digital" (LVTTL) parameters.

As thermal sensors we plan to use the electronic sensors AD590 (Analog Devices, USA). As ADC in the developed system, we use 12-bit eight-channels ADC ADC128S102, (Texas Instruments, USA) providing measuring accuracy less than 1 mV. Analog control realized by the dual-channel DACs TLV5638M (Texas Instruments, USA) providing output voltage accuracy less than 1 mV. For relay control we used electronic keys 249KP5R providing current switching up to 1 A at a voltage ± 60V and isolation voltage 500 V not worse.

In the figure 4 you can see the example of thermal sensors placement for temperature measurement of LEDs in Current Pulse Generator.

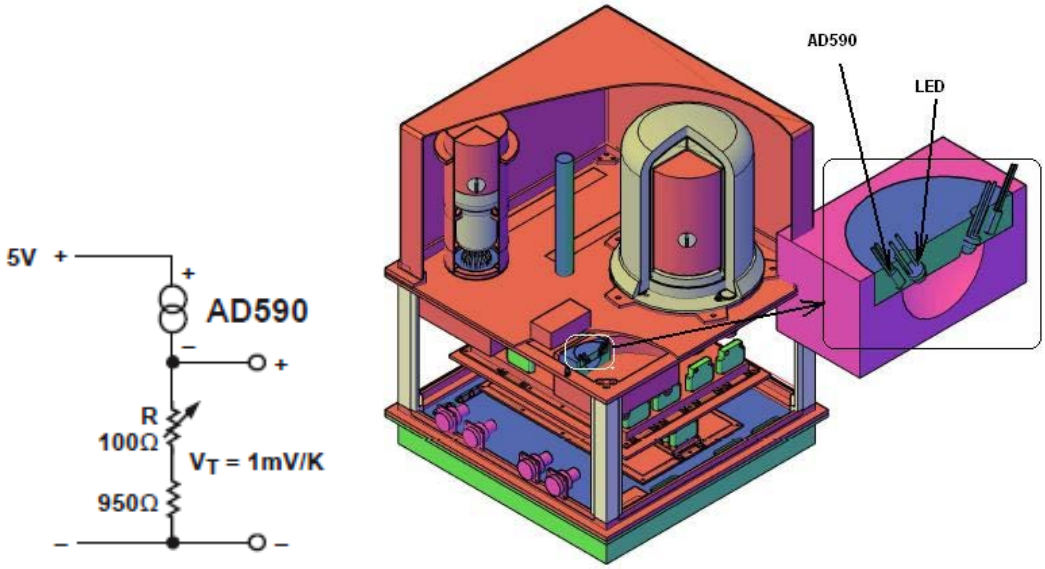


**Figure 4.** Example of the thermal sensors placement in Current Pulse Generator.

The examples of control and telemetry for thresholds in detectors (by changing voltage in comparator AD8561 input) and for high voltage power supplies are given in figures 5 and 6.

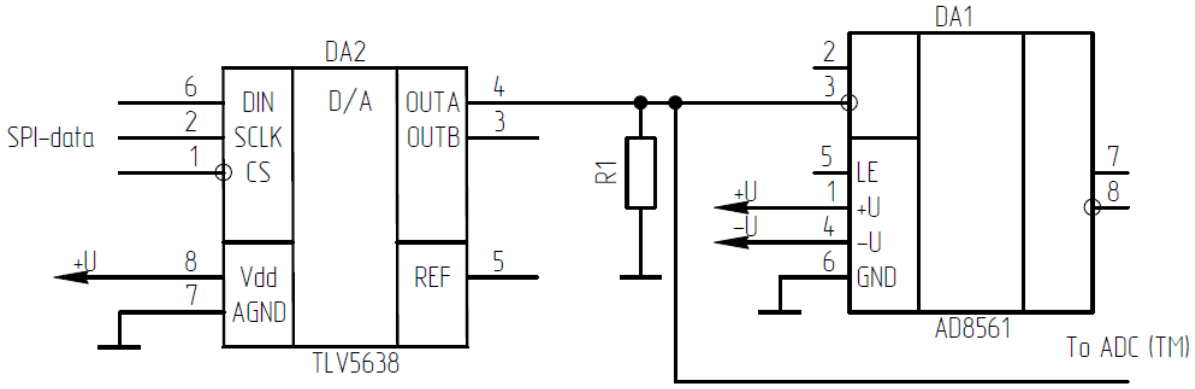


**Figure 5.** Control and telemetry for thresholds in detectors.

For high voltage power supplies (HVPS) control we use 2 impulse commands (CON1 and CON2) for switching on/off of this HVPS by K1 polarized relay and 1 analog control channel from TLV5638M DAC for precision high voltage setup. For telemetry by ADC128S102 the special analog low voltage output of 1M12-N05 chip is used.

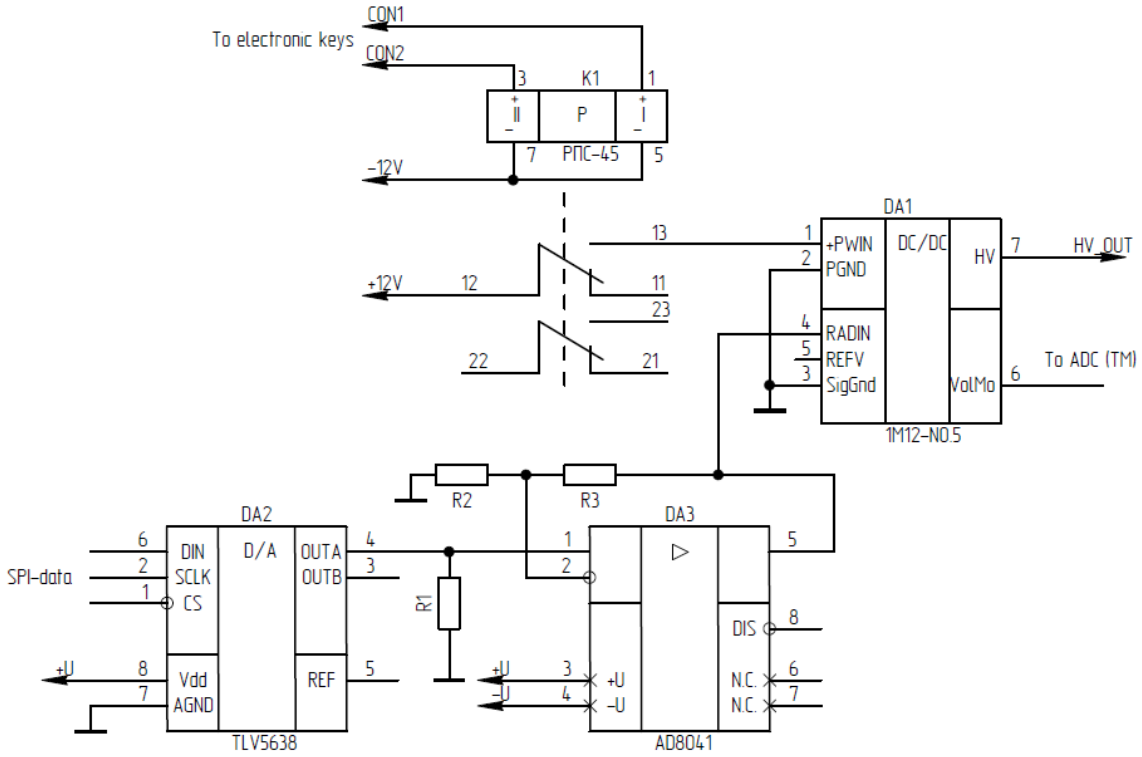


**Figure 6.** High voltage power supplies control and telemetry.

## 4. Conclusion

It was developed the internal service data acquisition and control subsystem for "GRIS-BD" unit. This system allows, in addition to opportunities of the ISS onboard service system, to measure 16 additional analog parameters 8 digital (LVTTL) parameters and use 8 impuls and 8 potential (LVTTL) commands for internal control, and 8 analog signal for precision setup of device characteristics.

## Acknowledgements

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## References

[1] Kotov Yu D *et al.* 2015 *Advances in Space Research* **56** 1797–804
[2] Glyanenko A S 2016 *Journal of Physics: Conference Series* **675** 042041