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The Housekeeping subsystem of the JEM-EUSO instrument

G. MEDINA-TANCO[1], J. C. D'OLIVO[1], A. ZAMORA[1], H. SILVA[1], L. SANTIAGO CRUZ[2], F. TRILLAUD[2], M. CASOLINO[3], K. TSUNO[4] FOR THE JEM-EUSO COLLABORATION

[1]*Instituto de Ciencias Nucleares, UNAM, Circuito Exteriror S/N, Ciudad Universitaria, México D. F. 04510, México.*

[2]*Instituto de Ingenieria, UNAM, Circuito Exteriror S/N, Ciudad Universitaria, México D. F. 04510, México.*

[3]

[4]*RIKEN Advanced Science Institute, Japan.*

gmtanco@nucleares.unam.mx

Abstract: The JEM-EUSO instrument is a refractive telescope being proposed for attachment to the Japanese Experiment Module, Kibo, onboard ISS. The instrument is substantially complex, including large Fresnel lenses, an focal surface covered by 4932 MAPMTs of 64 pixels, atmospheric monitoring subsystems (IR camer and LIDAR), low and high voltage power supply subsystems, tilting mechanism and a lid. All these subsystems must be turned on and off and monitored, and telemetry has to be conveyed between them and the principal CPU. The housekeeping subsystem (HKSS) is in charge of those tasks. In this contribution we describe the requirements and design of the JEM-EUSO HKSS.

Keywords: Cosmic Rays; High Energy Neutrinos; Space Observation.

1 Introduction

The JEM-EUSO instrument is a large refractive telescope to be installed at the Kibo module of the International Space Station (ISS) for the observation of extreme energy extensive air showers, using the fluorescence technique [1, 2]. The instrument as a whole is described in [3] and references there in.

The overall purpose of the Housekeeping Subsystem (HK) is to monitor and to relay control commands to the several subsystems that constitute the JEM-EUSO instrument. The HK sub-system is subservient to the CPU and all its activities are defined as slow control, i.e., with reaction time scales typically larger than a second. The HK subsystem architecture is conditioned by the wide variety of subsystems that constitute the JEM-EUSO instrument and with which it has to interact. The HK performs several tasks: (a) sensor monitoring of different subsystems in order to detect faults, (b) generation of alarms for the CPU, (c) distribution of telecommands to several subsystems, (d) telemetry acquisition from all subsystems, (e) monitoring of the status of the various electronic systems of the Focal Surface (FS), (f) switching between main and spares boards when appropriate, and (g) interaction with the power distribution system of the telescope, in order to turn ON and OFF the secondary power supplies, and therefore the FS, and verify adequate levels of power consumption. Fig. 1 shows schematically the architecture of the HK and its interaction with various elements of the telescope. The HK prefix denotes the main boards that constitute the HK subsystem. The core of the HK is the HK principal board (HK-PB), which centralizes most tele-command distribution and telemetry gathering. The HK-PB is the direct responsible for monitoring the FS and other subsystems, as well as providing on/off and status verification for every single component of the instrument.

The anchor points of the HK in the focal surface are the Power Supply Boards (PSB), as shown in Figure 1 and **??**. The later board contains the relays that turn on and off the Points of Load (POLs) that generate the lowest voltages (1.5V, 2.5V, 3.0V and 3.3V) required by the different components of the FS (e.g., ASIC, Photo-detector Module (PDM) and High-Voltage Power Supply (HV-PS)). The PSB also contains a footprint of the HK for telemetry: the ADC responsible for the digitalization of, mostly, the temperature sensors of the FS.

Due to its pervasive interaction with different subsystems, the HK is spatially distributed throughout the telescope. Thus, the HK sub-system also possesses a secondary stage directly installed inside the main computer, the System Control Unit (SCU). The latter is divided in two boards, one of which (HK1) centralizes communication to and from the HK-PB and Power Distribution System (PDS), turning on and off and monitoring status of all the DC/DC converters of the Secondary Power Supply. The second module (HK2) receives lenses temperature data and relays tele-commands to the lid-mechanism, the tilting mechanism, the deployment mechanism, and the IR camera and LIDAR of the Atmosferic Monitoring System (AMS).

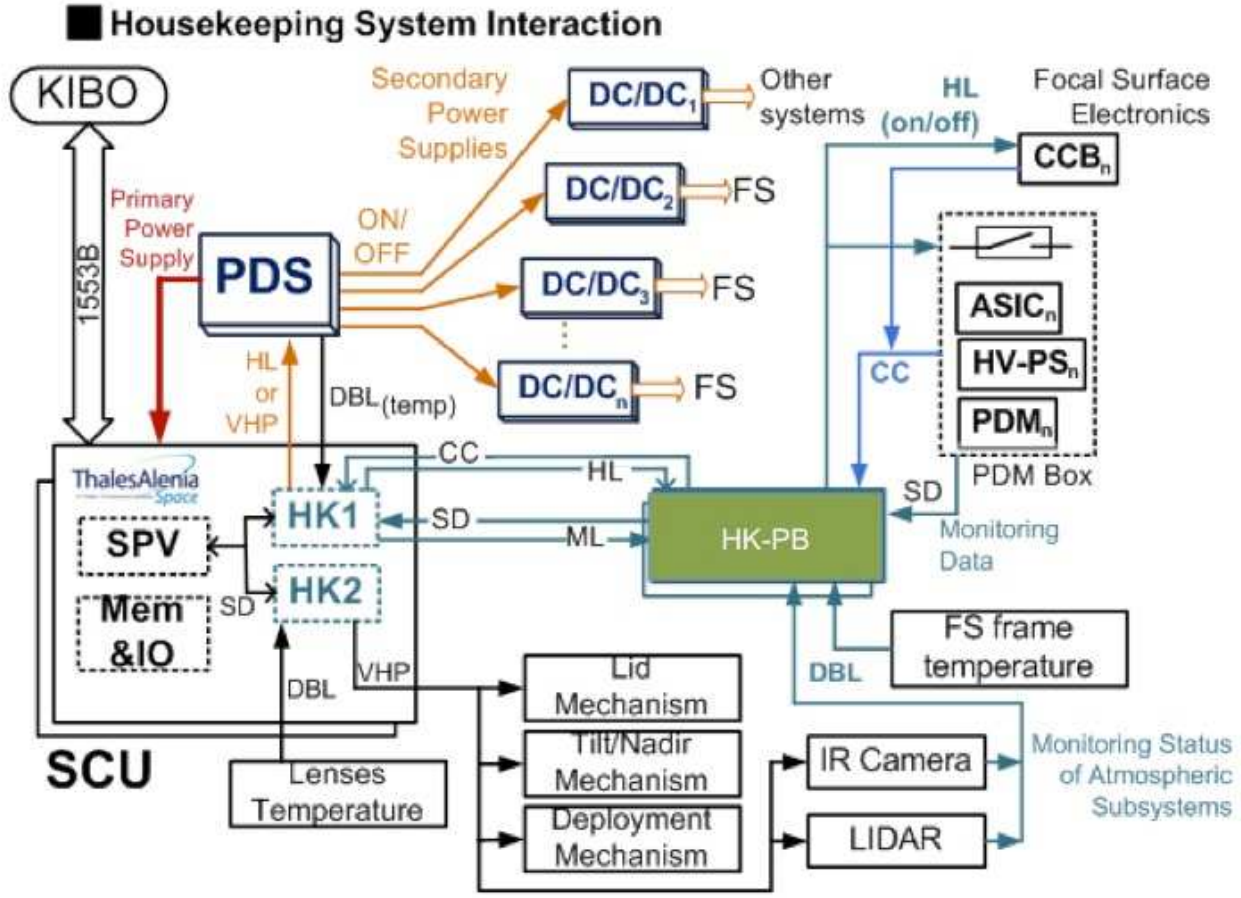

Figure 1: General architecture of the JEM-EUSO housekeeping system

The CPU and HK are turned on at the same time. HK has a direct interface with the CPU to distribute tele-commands sent from the ground by CPU users, it collects telemetry from different subsystems responsible for tasks such as atmosphere monitoring, telescope tilting, temperature measurement of lenses, and so on. Subsystem anomalies detected by the HK are reported as alarms to the CPU. In principle, HK does not take any action on these alarms, waiting for further commands from the CPU. At most, on critical instances, it can switch off a subsystem that triggered an alarm, in order to avoid possible further damage, while waiting for commands from the CPU for either restarting the reported system or its spare. The commands received and executed by the HK are either generated by the CPU itself or sent from the ground through the CPU. The HK is an auxiliary subsystem for tele-command distribution, monitoring status of the telescope's subsystems and alarms reporter.

The core of the HK subsystem is the master board HK-PB, to which all other portions of the HK report. Only slow data transmission rate is allowed between the HK-PB and any of its other components. Thus, for example, if an element of the FS is monitored at a particular time by a HK-CB, that same element will not be subsequently monitored for at least one or more seconds after the HK has established its status. FS faults, or indeed any other subsystems critical faults which require immediate shutdown in order to avoid damage, are the responsibility of the corresponding subsystem, which shall not wait for a reaction from the HK. The philosophy of monitoring and troubleshooting established for monitoring the FS will be by polling, in order to minimize power consumption by turning on sensors only when required.

An exception to the previous rule is the interaction with the power distribution subsystem. In this case, due to the critical nature of the subsystem, fault detection will be implemented by logical interruptions, which will allow fast detection and addressing of DC/DC converter failures and the consequent off-lining of the power system component in trouble. Concomitantly, HK will generate an alarm to the CPU, who is responsible for reporting operating conditions to the ground and/or deciding on an appropriate action to deal with the condition that triggered the alarm.

In order to improve the offline reconstruction of the acquired scientific data, the HK will monitor the temperature of the lenses during observation. The HK will periodically activate and deactivate the conditioning and digiti-

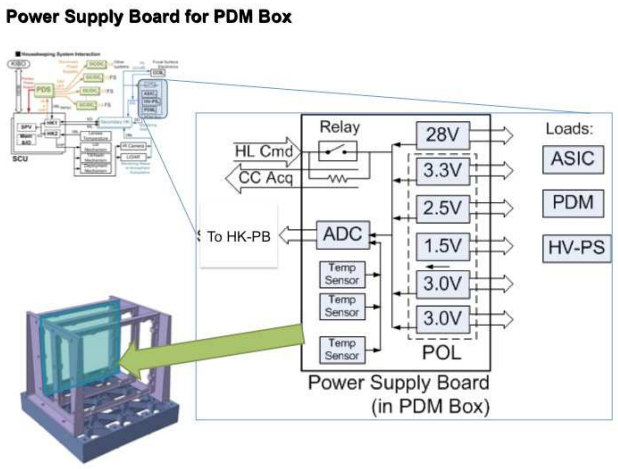

Figure 2: Focal surface monitoring scheme.

zation board that interfaces the HK with the output signals from 15 analog temperature sensors, which will be located at five different points on each of the three lenses of the optical system. It is estimated that cycles of measurements will take place around a dozen times per observation run.

HK also includes a General Subsystems I/F Board (HK-GSB) to interact with atmospheric monitoring subsystems, and mechanical subsystems of the telescope. The HK interaction will be limited to turn on and off subsystems, to monitor any physical parameters necessary to determine whether the subsystem is within an acceptable working range and to relay commands received from the CPU.

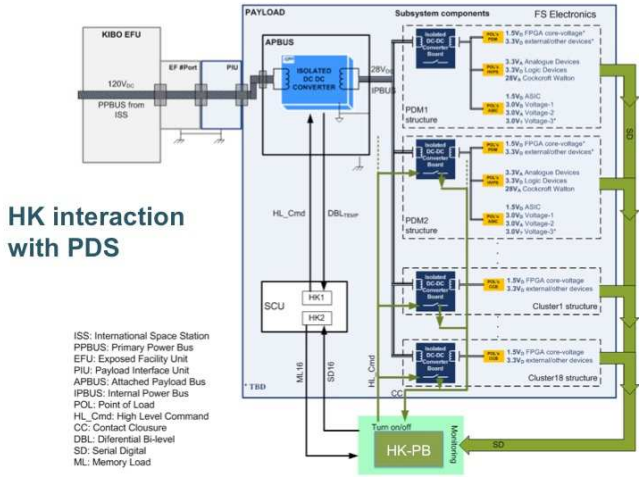

Figure 3: Interaction between the JEM-EUSO housekeeping system and the power distribution system (PDS).

References

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