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# PESCA Instrument Digital Electronics and Control System

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**Abstract**

The PESCA Instrument has been designed and built with the purpose of studying the Solar Energetic Particles and the Anomalous Cosmic Rays from hydrogen to iron in the energy range 1.5-50 MeV/uma. The instrument will be part of the Russian PHOTON satellite payload. The instrument electronics system comprises two blocks: the analog block for the amplification process and the digital block for the data acquisition process. The hardware is based on MAS281 microprocessor and consists of two units, nominal and redundant, in order to prevent faults. The software and hardware control system are described.

## 1 Introduction:

The PESCA Instrument comprises a detector telescope, which consists of 4 ion implanted silicon detectors, an analog electronics for the pulses amplification, and a digital electronics for the instrument control. The instrument will be part of the Russian PHOTON satellite payload, which is to be launched in 2001. A detailed description of the telescope and of the analog electronics (AE) has been made by at Peral et al. (1995,1997). The present work describes digital electronics hardware and software, whose goals are the following: 1) To collect the experimental data coming from the analog electronics. 2) To pack and to prepare these data for their transmission to the satellite computer. 3) To temporarily store the experimental data in memory until the satellite computer demands them. 4) To send these data to the satellite computer. 5) To receive, to interpret and to execute the telecommands sent from ground through the satellite computer. 6) To detect every fault that may arise in the instrument, analizing the housekeeping data. 7) To switch the power lines of the whole instrument, including the high voltage lines for the detectors.

## 2 Hardware:

The digital electronics (DE) is based on MAS281 microprocessor, which is a MIL-STD-1750A microprocessor from Marconi Electronic Devices. This 16 bit microprocessor works with a two byte word width and is able to address an indivisible 64 kw memory map. The DE has been designed with a 8 kw PROM space and a 24 kw RAM space, divided into 16 kw for data storing and 8 kw for program storing. The control program is stored in the PROM chips, however, in order to increase execution speed and to reduce the system power consumption, during the initiation phase, a copy of this program is made in RAM, where the program is finally executed.

The DE consists of two circuit boards, one mainly containing the microprocessor and the memory chips mentioned above, called Data Procesing Unit (Fig. 1), and the other one containing the interfaces with the rest of the instrument units - analog electronics (AE) and low voltage power converter (LVPC) - and the on board satellite computer (OBDH) (Fig. 2). The comunication with the AE and the OBDH is a serial comunication, therefore the respective interfaces are mainly formed by serial to parallel and by parallel to serial converters. Once the DE is switched on by the satellite, the power of the rest of the instrument, both AE and the detectors, is controlled by the DE. Whereas the AE power control is based on a simple on-off circuit, the detector power suply or the detector power cut off is done in an exponential way that lasts 1 minute.The DE has been built with a cold redundancy and therefore is composed of two units, nominal and redundant, that may work independently but not simultaneously.

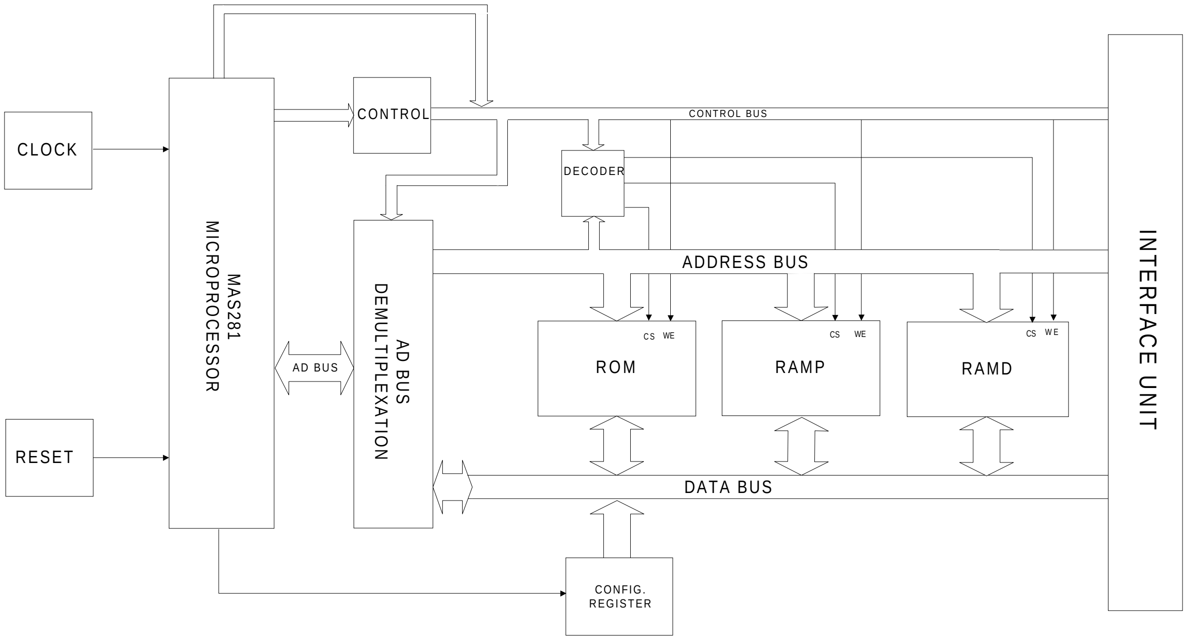


**Figure 1:** Data processing unit scheme

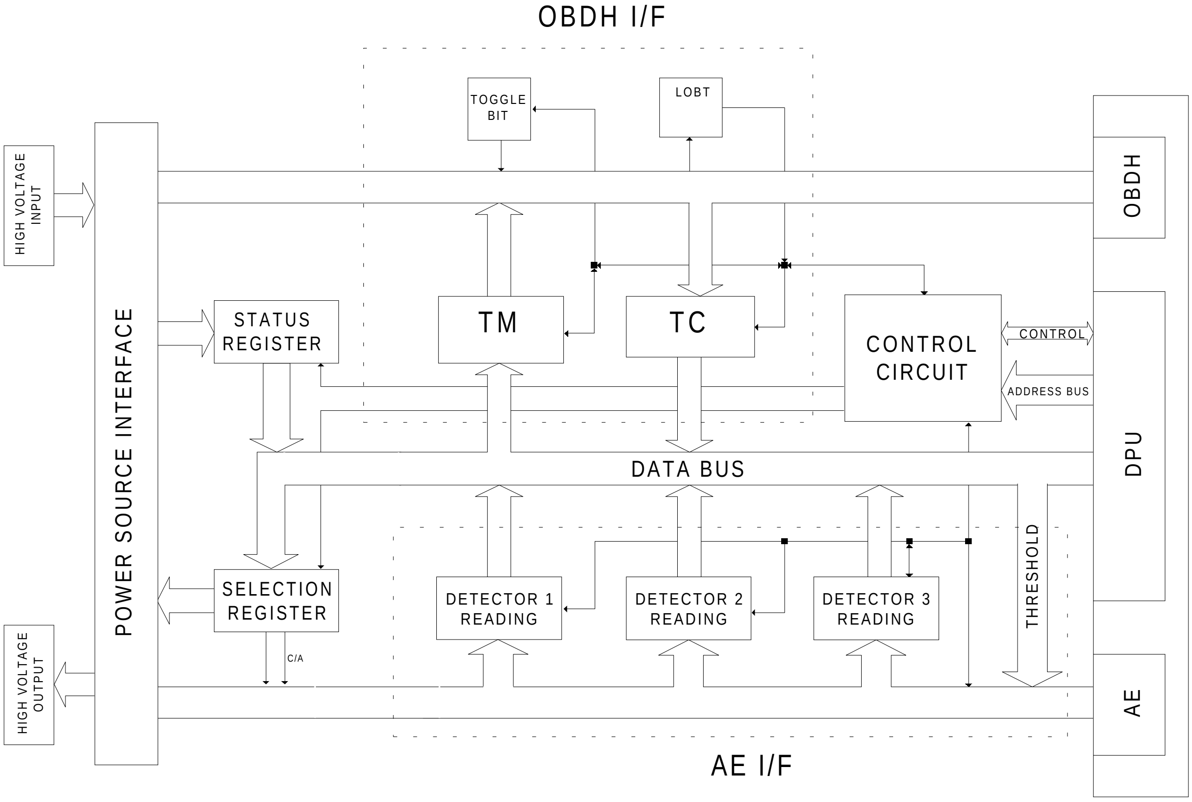


**Figure 2:** Interfaces board scheme.

## 3 Software:

The main characteristics of the control program are the following: 1) It is entirely programmed in assembly language with the purpose of reducing the code length. 2) Interrupt based program, that is, a microprocessor interrupt has been assigned to every event that can take place during the flight. 3) It performs the experimental data acquisition and transmission process control. 4) It mantains information about the general status of the instrument and about the program execution process by means of the housekeeping words. Any fault that may take place during the program execution (a wrong telecommand reception for instance) is recorded in certain of these status words. 5) It manages the telemetry sending to the on board satellite computer. This telemetry consists of the experimental data and of the housekeeping data. 6) It makes possible the reception and execution of the telecommands that are sent from the ground station to control the instrument.

The program presents two different phases: an initiation phase and an interrupt servicing phase. The initiation phase starts whenever the microprocessor is switched on (i.e. whenever the DE is switched on) or whenever the microprocessor is reset. During this phase interrupts are not enabled and, among others, the performed tasks are: the program variables initiation, memory integrity check and the ROM to RAM program transfer. When the last point of the initiation phase is reached, interrupts are enabled and the program enters in an indefinite loop in which it awaits an interrupt request. Any fault produced during the initiation phase is recorded in the housekeeping words that are sent as part of the telemetry.

There are 5 possible interrupt requests: 1) OBDH demand of housekeeping data; 2) OBDH demand of experimental data; 3) Data reception from the AE; 4) Telecommand Reception from OBDH; 5) Local on board time (LOBT). Interrupts can be interpreted as the means of starting a specific process in the program. Although there are 5 interrupts, the processes can be classified into 3: 1) Telecommand reception and execution process. 2) Telemetry processing and transmission process. 3) LOBT increment process. In the present work we will deal with the two first processes because of their importance in the program.

## 4 Telecommand reception and execution:

The PESCA instrument can be controlled from the ground station by means of telecommands, which reach the DE through the OBDH. These telecommands consist of a group of words that are received and interpreted by the DE. Finally, if everything is correct, the telecommand is executed. These words must follow a specific structure so that the DE could recognize which telecommands are valid, the task to perform and if any faults have taken place during their reception. A communication protocol based in messages is established between the OBDH and the DE. This protocol, in addition to make the communication very reliable, allows more than a telecommand (task to perform) inside a message. Therefore, we can summarize the process tasks in the following: 1) Reception of all the words that the message comprises. 2) To check the protocol defined for the communication with the OBDH. 3) To check the telecommand structure. 4) To execute the telecommands received if any faults have not been found.

Should the message contain more than a telecommand, these are executed sequentially in the order that are inside the message. If any faults are detected, the process is aborted, recording the type of fault in a specific housekeeping word. Some of the telecommands admitted by the DE are the following:

1) AE and detectors switching on/off. By means of this telecommand, the power of the AE and of the four detectors that the telescope comprises, is controlled.

2) Set of the register threshold value of the detectors and the coincidence mode for the AE. This telecommand permits the configuration of the particle detection mode.

3) The DE reset.

4) Storing and execution of a program sent from ground. If it were necessary, it would be possible to send new routines from the ground station, because the program allows an uploading through this telecommand.

5) LOBT value setting. Time reference may be adjusted with this telecommand.

## 5 Telemetry processing and transmission:

Telemetry received at ground is composed of the experimental data registered by the AE and of the housekeeping data. Any experimental data consist of a datum label (that it is only a time reference) and of the 3 detector data. Six housekeeping words have been defined and they are kept in a small memory buffer of data RAM. These words are updated for every telemetry frame that is sent to the ground station and their principal function is to provide a way of knowing the instrument status and the program progress from ground. The housekeeping words provide every kind of information such as the possible faults detected during the telecommand reception or during the telemetry sending, status information about the AE or the detectors (on/off), LOBT, etc.

The housekeeping words are fixed words that are always ready to be sent to ground. However, we cannot say the same of the experimental data. The data acquisition rate from the AE and the transmission rate to the OBDH may differ in speed. If the acquisition rate is faster than the transmission rate, the result will be a saturation in the storage buffer. In the other hand, if the acquisistion rate is slower than the transmission one, the process will reach a point in which there are no valid data to be sent. The telemetry demand of the OBDH is of about 100 bytes per second. An algorithm has been developed that establishes a relationship between both processes and that is independent of the buffer size and of the data acquisition and transmission rate. It is summarized in the following way: a) Experimental data will not be acquired while there are not free memory positions where they could be stored, and it is the telemetry transmission process the one which frees memory positions. b) A key word will be sent to ground while there are not new data to be sent, being the acquisition process the one which stores new data in memory.

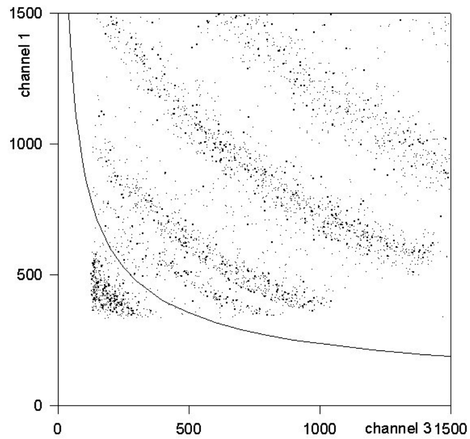


**Figure 1:** Proton algorithm

Therefore, the data acquisition and their later transmission to ground are complementary. The slowest process will be the one which will mark the effective speed of the other. The aim of our instrument is to measure ions from He to Fe , for that reason, protons are less interesting for our work. An algorithm has been developed that will only act in the case that the data buffer is full. It consists of delimiting a specific zone with a line, beneath which protons are expected to be found (Fig. 3). If the data buffer full condition is fulfilled, events that may be interpreted as protons - with energy losses beneath the delimitation line - are not acquired but a software counter is increased depending on the energy levels. In such a way, in great particle flow seasons, our instrument is able to count protons and to measure all the ions that reach the telescope.

# References


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