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NEW WAYS FOR HIGH-LEVEL DESIGN SOC FOR PROSPECTIVE SPACECRAFTS

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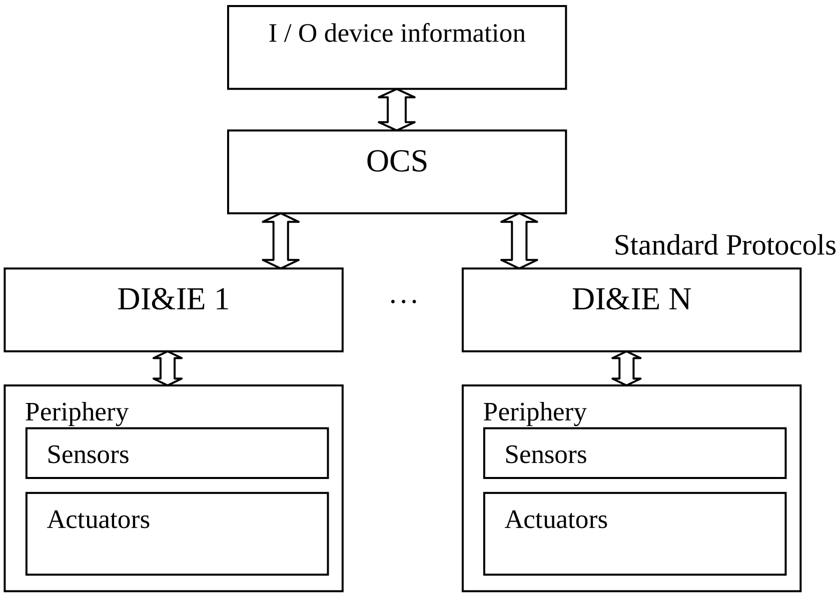
Onboard computer system (OCS) is the integral part of modern on-board control (OBC) of the spacecraft. OBC design is reduced to conduct a difficult task in modular distribution subsystems between the performers that make it impossible to test the fully assembled system and imposes a number of restrictions on the development of these modules, such as the standardization of data transfer protocols, the overall performance of the budget executed subsystem. Besides the restrictions imposed, based on the medium in which to operate the device for space equipment critical parameter in this case is resistant to radiation. Also an important requirement is the life of the unit.



The stages of the OBC in accordance with the stages of development of electronic components are the following:

1. Fully custom development based on analog component system of the first generation (Argon);
2. Custom computing systems based on the hierarchical bus-modular, second generation systems (Argon-16, Salyut-5B);
3. Computer systems based on pre-built components based on the network structure multimachine: three-level organization of data processing and computing systems of the third generation (composition of modern ISS);
4. Computer systems based semicustom processing elements (radiation-resistant FPGAs).

At each stage, the attention is paid to various constraints imposed on the design of subsystems. In the early development of space technology budget is allocated indefinitely by the prospects and less scrutiny of the art in low requirements for the functioning period of the device, so a fully custom analog and digital solutions is quite consistent with costs. At the moment, there is a tendency to reduce the budget by increasing the service life, resulting in a more cost effective solutions are required in this area on the basis of ready-made components.

The use of prefabricated commercial integrated circuits leads to some risk due to the fact that most of them are not applicable in space at a rate of about 10 krad failures by the total cumulative dose. Therefore, in the field of commercial integrated circuits (ICs) are isolated area of radiation-resistant IC.

One way to reduce the budget for the design of computing subsystems of an advanced spacecraft is to use custom and semicustom elements, namely radiation-resistant programmable logic integrated circuits (FPGAs). Sustainability of such IP reaches 1 Mrad on total accumulated dose.

OBC main site is a digital computing node (CCD), which is most often performed on the basis of custom integrated circuits ASIC due to the uniqueness of the various spacecraft. In today's advanced spacecraft being developed in Russia, as the CWU used three-channel PC-101 digital computer, the main feature of which is the fault-tolerance. Attached subsystems use standard protocols, consists of a device to collect and process information, and peripherals - sensors and actuators. Device for collecting and processing information, in turn, is a specialized computing device adapted to the tasks performed by the subsystem. Ideal basis of such a device can be a FPGA.

The main producers of radiation-resistant FPGA, supplying its products to Russia, are Xilinx iActel. There are a lot of radiation-resistant of Xilinx FPGAs include Virtex-4QV, Virtex-IIXQR, VirtexXQRiVirtex-5QV, the most modern of them is the Virtex-5QV. FPGA in this series are the most efficient and designed to withstand the hard radiation exposure - the total cumulative dose of radiation for these FPGAs is 1Mrad that with better performance than the last in a series of 3 to 10 times. Besides data FPGAs have a high level of integration, which allows their use for the design of high-performance aerospace system. One of the features of the IP is triple modular redundancy (Triple Modular Redundancy – TMR), equipment to protect memory from single failures. The basis of this method is three-fold increase in the number of memory cells, and selecting the correct stored value based on majority logic. However, this does not guarantee the absence of failures, so the manufacturer recommends to recover the correct value of a mechanism. The disadvantage of triple redundancy is a significant increase in the area. To restore the correct value schemes with feedback are used.

Actel company produces radiation-resistant single and multiple programmable FPGA. The family of one-time programmable FPGAs is RTAX-S/SL, RTAX-DSP (300 krad), RTSX-SU (100 krad). By repeatedly programmable chips are RTProASIC3, which retain the ability to reprogram the system when the absorbed radiation dose to 15kRad and keep working at the absorbed dose 25kRad.

RTAX-DSP feature is the large number of built-in hardware multiplier with accumulation, resulting in better performance when implementing arithmetic functions needed in DSPIP-blocks. Family RTSX-SU is an improved version of a series of commercial SX-A. To improve the radiation resistance of all registers RTSX-SU specialists use triple redundancy (TMR).

To sum it up we would like to say that we prototype of the board computing system which is designed to control the impulse voltage stabilization based on the evaluation board AlteraDE1 CycloneIIEP2C20. Major computing node in the system is a microcontroller core Leon3 firm Aeroflex Gaisler, based on the architecture SPARCV8. Also, there is a stable version of the kernel to crash Leon3ft. Since unification HDL languages on different platforms, the system with minor changes can be transferred to the FPGA Actel or Xilinx. Taking into consideration the results of research described in our article, we can say about possibility to build a specialized radiation-resistant onboard computer for a prospective spacecraft in near future.