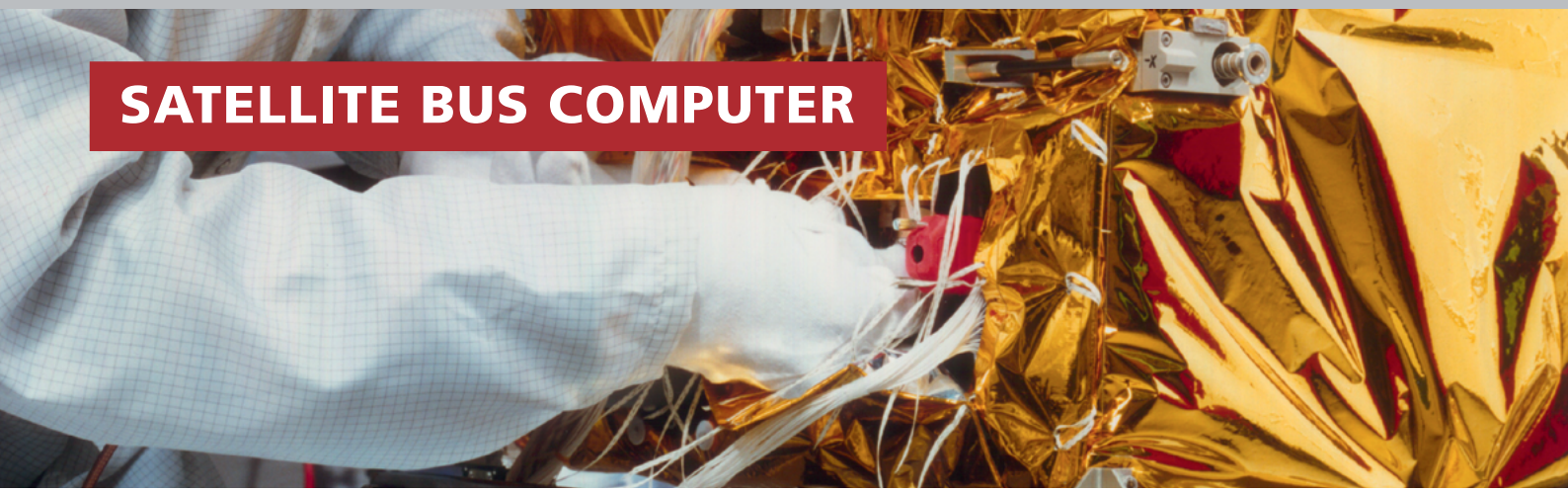
Fraunhofer FOKUS

FRAUNHOFER INSTITUTE FOR OPEN COMMUNICATION SYSTEMS FOKUS

# SATELLITE BUS COMPUTER




**Contact**
Samuel Pletner
Head of System Architectures
System Quality Center – SQC
Phone +49 30 3463-7450
samuel.pletner@fokus.fraunhofer.de

Fraunhofer FOKUS
Kaiserin-Augusta-Allee 31
10589 Berlin
Germany

www.fokus.fraunhofer.de/go/sqc

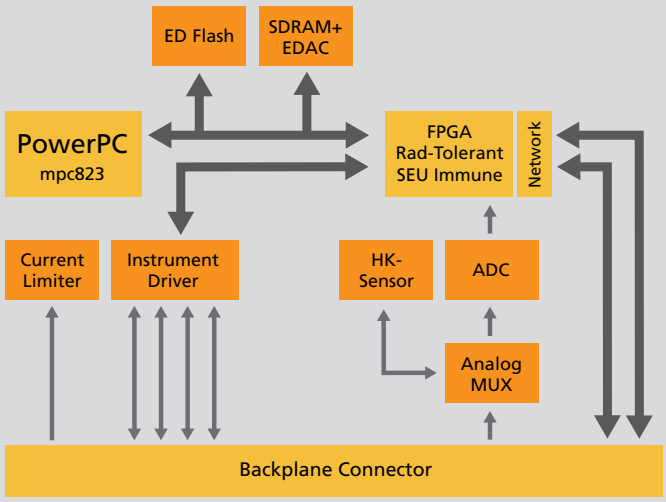

Radiation and great fluctuations of temperature pose tremendous challenges to computer systems in the aerospace industry. System reliability even under the extreme conditions in orbit has to be guaranteed for safety critical systems such as satellite control. Malfunctions or even system failures entail serious financial risks and can lead to a complete mission failure.

## Satellite Bus Computer (SBC)

Fraunhofer FOKUS has developed a control computer for the satellite project TET-1 that assumes the transmission, processing, and memory of all data on board the satellite. In addition to data acquisition from individual subsystems, such as the experiments conducted on board or the power supply, it also takes over communications with ground control. With its multitude of interfaces to subsystems, components, and application software, the on-board computer constitutes a highly complex system. FOKUS has developed the computer's operating system (BOSS), which meets the requirements of satellite construction through its high speed and stability.

## Redundancy

In spite of the system's complexity, the failsafe performance of the control computer in orbit has to be guaranteed. FOKUS is using a highly redundant architecture with a quadruple computer node, with each computer node offering redundant processing and memory structures. To prevent data loss in case of memory errors, each computer node is equipped with a shadow storage. The content of the shadow storage will replace the memory content in case an error is detected in a node. The control and communication unit is located in an FPGA (Field-Programmable Gate Array).




*Functional Block Diagram of the TET-Control Computer*

FOKUS is employing an FPGA because it is freely programmable and can thus be adapted to the various interfaces. The FPGA in turn is built with a triple redundancy (TMR-Triple Module Redundancy).

## Latch-Up Protection

Radiation in particular presents a major challenge to computer systems on board satellites. High-energy particles are constantly impinging on the satellite computer's components which can lead to a Single Event Upset (SEU). In a SEU, a so-called bit flip, in which the state of a bit is altered, can cause a malfunction of the affected component. In order to avoid this, Fraunhofer FOKUS is employing radiation-tolerant components as well as a latch-up protection: through continuous voltage metering in various modules of the computer, a short-term shutoff of the affected component is carried out in case of disproportionately high voltage rises, thus preventing destruction.

## Error Detection and Correction System

The control computer's error detection and correction system works according to the monitor-worker principle: two active computer nodes work together and monitor each other. A malfunction is for instance detected by one computer node not sending data at all, or sending obviously false data, that do not match the other computer node's results. The computer node receiving such false data or none at all, detects this and prompts a reset of the respective other computer node. Furthermore, each computer node can opt for a reset itself when it detects contradictory data. In the extreme case of one or both computer nodes delivering differing results even after a reset, the remaining computer nodes take over control. As long as they are not needed, they form the so-called emergency reserve: during this time, they are inactive and thus not subject to radiation-induced aging.

## Expertise

Fraunhofer FOKUS is an established expert in building qualified control computers for satellites which the institute has proven in several projects, such as the development of the on-board computer for the German micro satellite BIRD, for which cost-efficient commercial off-the-shelf components were used.

## Specifications

- Board Dimensions:
  - Width: 100 x 170 mm (connectors included)
  - Height: 20 mm (components on both sides)
- Weight: 0.166 kg
- Radiation Hardness > 13 Krad (tested)
- Power Supply: +3.3V, +5V, +15V, -15V
- Power Dissipation max. 4W
- Temperature Range: -40°C / +80°C

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