16th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

Author: Mr. Marcus Gunnarsson
AAC Microtec, Sweden, marcus.gunnarsson@aacmicrotec.com

Mr. Henrik Loefgren
AAC Microtec, Sweden, henrik.lofgren@aacmicrotec.com
Mr. Johan Bjurstroem
AAC Microtec, Sweden, johan.bjurstrom@aacmicrotec.com
Mr. Luca Celotti
Sonaca Space GmbH, Germany, luca.celotti@sonaca-space.com
Mr. Sergio Rufini Mastropasqua
Sonaca Space GmbH, Germany, sergio.rufini@sonaca-space.com
Ms. Bianca Cefalo
Sonaca Space GmbH, Germany, bianca.cefalo@sonaca-space.com
Mr. Oliver Korashy
ESA - European Space Agency, The Netherlands, Oliver.Korashy@esa.int

LOW TEMPERATURE ELECTRONICS DESIGN FOR FUTURE EXPLORATION MISSIONS

Abstract

In missions involving extreme environmental conditions, such as the temperature variations on the Martian or Lunar surfaces, an exploration vehicle can be exposed to temperature ranges significantly outside the specification of the on-board electronics. A common mitigation method is to place the electronic parts in a warm compartment. This imposes requirements on the power budget, the system and thermal architecture and also the surface operations. The possibility of avoiding this commonly used solution is a clear incentive for identifying electronics surviving and operating at low temperatures. A distributed system would thereby be achievable, placing electronics close to sensors and actuators. The objective of this activity is to select and evaluate components and materials through analysis and testing in order to derive guidelines for circuit design and manufacturing of circuit boards robust to thermal cycling down to -120C and operation at -100C. The temperature range given in component data sheets does not normally reach this low, and the testing has been performed outside the manufacturer specifications. Also negative test results are of value, pointing out risks in certain component types when exposed to low temperature conditions. A number of selected discrete components and integrated circuits with basic functionality have been tested in two test stages. Both high reliability and commercial component grades were evaluated. The first test was done to characterize the components for operation in low temperatures. The results from the first test were used to set up simulation models in order to design circuit blocks, which were then manufactured and evaluated in the second test. Different circuit board and solder materials have been used to evaluate assembly robustness in 200 thermal cycles between 60C and -120C. The tests show that certain types of passive components and semiconductors can perform mostly unaffected down to -100C, while others exhibit reduced performance or failure. In particular, the use of capacitors and bipolar semiconductors require careful type selection and compensation for temperature effects. The second test has demonstrated that it is feasible to build circuits operating at low temperatures if the empirically derived component selection and guidelines are observed.