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WIDE BANDGAP MICROSYSTEM COMPONENTS FOR NANO, PICO & FEMTO-SATELLITE APPLICATIONS

Abstract

With the recent boom in small satellite missions and their numerous applications, there is a need to develop robust system components to improve mission lifetime. Environmental factors such as radiation and temperature play a role in limiting reliability of satellite components. In general, due to mass and size restrictions small satellites (nanosatellites and smaller) are not equipped with adequate level of protection against the space environment. With silicon-based components being used for most subsystems, the lifespans of small satellites are currently limited from few months up to 5 years. The objective of this paper is to present radiation-hardened, temperature-tolerant wide bandgap (eg. SiC/GaN) micro-system components as an alternative solution to overcome limitations in traditional silicon-based components for small satellite applications.

As a first step, the response results of commercial off the shelf (COTS) wide bandgap components to space environmental factors such as temperature and radiation are presented. A discrete wireless RF-transmitter module is used as a test subject. Parameters such as bias voltage and transmitter frequencies are used as parametric reference points. Reference standards such as European Space Agency's (ESA) European Cooperation for Space Standardization (ECSS), NASA's Standards And Technical Assistance Resource Tool (START) are discussed along with special case radiation profiles generated with software models using SPENVIS and Space Radiation. The tests and case studies include but not limited to total ionizing radiation dose (TID) and single event effects (SEEs). Target inspection radiation dose (10 Mrad @ 110Mev-cm2/mg) is achieved by a low energy X-ray source (LEXR) and Cobalt-60 (Co-60) gamma source. Additionally, components are subjected to Thermo-Vacuum Cycling (-130C to +150C) for evaluating behavior with variation in temperature. In both radiation and thermo-vacuum testing several satellite trajectories are analysed including orbits of neighbouring planets such as Venus\Mars.

Finally, as a case study a simple wide bandgap sensor (eg. photo detector) design is presented for test and evaluation. In conclusion, first of its kind design approach is taken to realise future small satellites based on wide bandgap microsystem components. A number of exciting applications can be realised by integrating presented RF-transmitter with a sensor using system-in-package technology. With the offered radiation and temperature qualification data it can be comprehended that, the natural tolerance of wide bandgap components to extreme environmental factors serve as an ideal solution to meet the

high reliability required for small satellite systems, thereby widening the scope of small satellites in future space technology.