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Seibersdorf, Austria

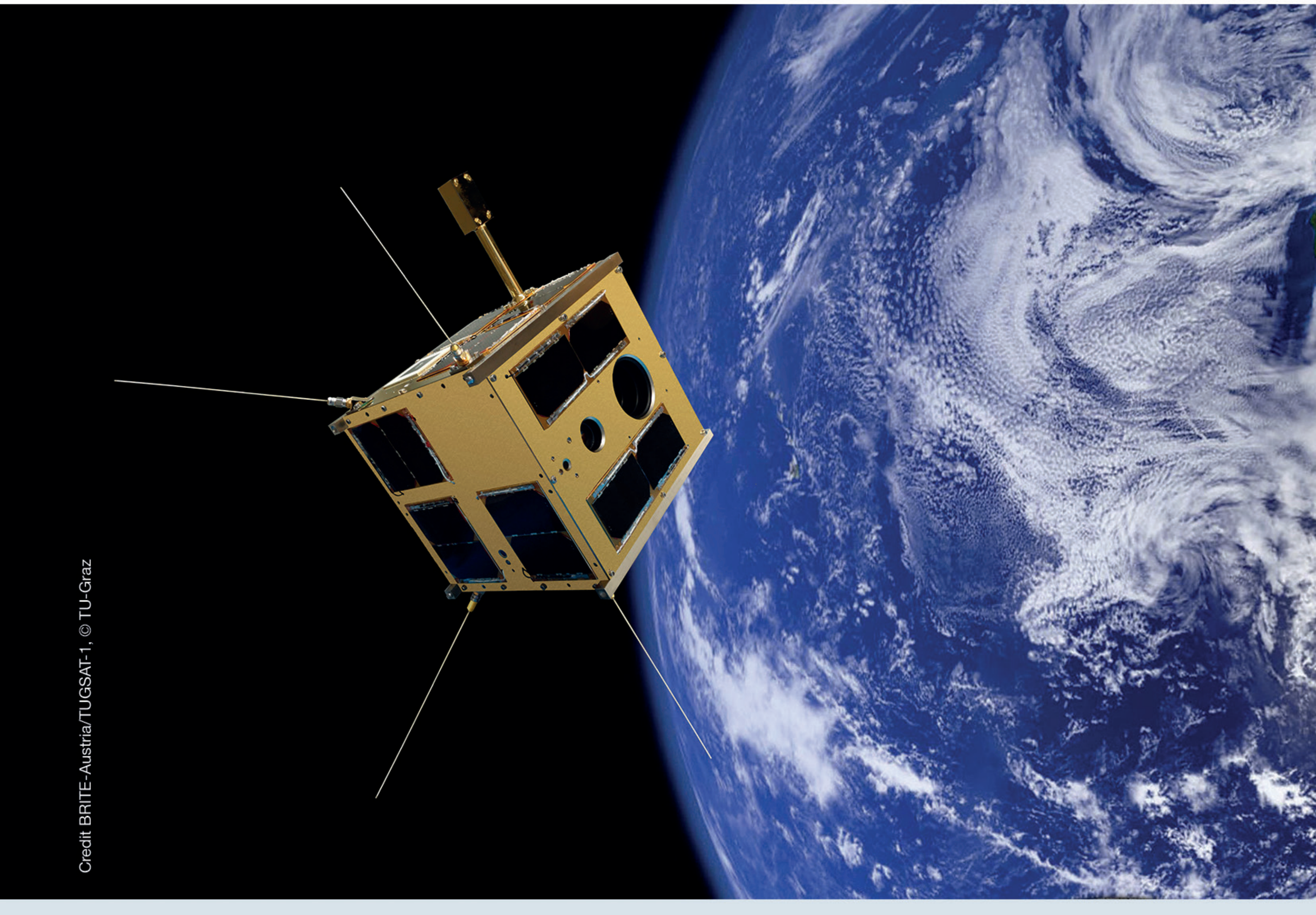

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Table of Contents

Programme Tuesday, May 16th, 2017

08:00 Registration

09:00 **Welcome Notes by the General Manager**
M. Schwaiger, Seibersdorf Labor GmbH, Austria

Welcome Notes by the Head of Austrian Aeronautics and Space Agency
A. Geisler, Austrian Aeronautics and Space Agency, Austria

Introduction and Scope of the Symposium
P. Beck, Seibersdorf Labor GmbH, Austria

Keynote
09:30 **Total Ionizing Dose (TID) and Total Non Ionizing Dose (TNID) Radiation Hardness Assurance (RHA) for Space Systems – from Big Systems to Smallsats**
Ch. Poivey, European Space Agency, ESTEC, The Netherlands

Session: Radiation Environment

10:00 **Radiation Environment and Exposure of CubeSat Missions**
G. Santin, European Space Agency, ESTEC, The Netherlands

10:30 **Coffee Break**

Session: CubeSat Space Missions - Radiation Hardness Assurance Experiences and Challenges

11:00 **Radiation Hardness Assurance and CubeSat: A new Approach for a „New Space“**
L. Dusseau, University Montpellier, France

11:15 **BRITE/TUGSat-1 Mission and Radiation Effects**
O. Koudelka, Graz University of Technology, Austria

11:30 **Austrian‘s CubeSat PEGASUS: Development and Testing**
C. Scharlemann, University of Applied Sciences Wiener Neustadt Ltd., Austria

11:45 **System Level Radiation Characterization of a 1U CubeSat at the CHARM facility at CERN**
R. Secondo, CERN, Switzerland

12:00 **Robust Miniaturized Onboard Computer with COTS Components using Advanced FDIR Methods**
Tzschichholz T., Zentrum f. Telematik, Germany

12:15 **Evaluation of Response and Radiation Damage to Protons in Timepix Detectors at Particle Accelerators and in LEO Orbit by the SATRAM Spacecraft Payload on Board ESA‘s Proba-V satellite**
C. Granja, Czech Space Research Center, Brno; Nuclear Physics Inst.,
Czech Acad. Sci., Prague, Czech Republic

Programme status at the editorial deadline.

12:30	Investigating the Use of Commercial FPGAs in Two Case Studies - Cubesats: NanoSatC-BR1 and NanoSatC-BR2 F. L. Kastensmidt, UFRGS University, Brazil
12:45	Lunch Buffet Photo and Visit of the TEC-Laboratory
Session:	Selected Topics - Components and System Testing
14:00	Compendium of Circuit Effects in COTS Op Amps L. Dusseau, University Montpellier, France
14:15	Combination of Heavy Ion, Laser and Proton Irradiation for SEE Qualification Test, Advantages and Limitations A. Koziukov E. - JSC URSC-ISDE, Russia
14:30	Experiences from Radiation Testing at RUAG Space M. Larsson, RUAG Space, Sweden
14:45	New Radiation Testing Aspects at Fraunhofer INT J. Kuhnhenn, Fraunhofer INT, Germany
15:00	Fast Real Time Assessment and Characterisation of Transients M. Wind, Seibersdorf Labor GmbH, Austria
15:15	Coffee Break
Session:	Selected Topics - Radiation Hardness Assurance
15:45	Radiation qualification of COTS Hardware for a specific LEO space application C. Tran Thi , OHB System AG, Germany
16:00	Variability in Floating Gate Errors in Flash Memories Exposed to Total Ionizing Dose S. Gerardin, University of Padova, Italy
16:15	Radiation Hardening of Integrated Circuits V. Bezhenova, Graz University of Technology, Austria
16:30	STREAM: Smart Sensor Solutions Design and Testing T. Vincenzi, ams AG, Graz University of Technology, Austria
16:45	Closing Visit of the Radiation Testing Laboratories at Seibersdorf

Programme status at the editorial deadline.

Total Ionizing Dose (TID) and Total Non Ionizing Dose(TNID) Radiation Hardness Assurance (RHA) for Space Systems – from Big Systems to Smallsats [Keynote]

Christian Poivey
European Space Agency, ESTEC, The Netherlands

Abstract

Basics of TID and TNID RHA for Space Systems, will be introduced including a discussion of Radiation Design Margin (RDM) requirements. Systematic errors and uncertainties on the different inputs used to define TID and TNID RDM will be reviewed: mission radiation environment models, radiation levels within the spacecraft, electrical, electronic, and electromechanical (EEE) parts radiation sensitivity, and circuit design. Finally, the challenges of adapting current TID and TNID RHA methodologies to small satellites will be presented, including the use of Commercial-Off-The-Shelf (COTS) parts and performing radiation testing at the board level. Application examples will be also presented.

Session:
Radiation Environment

Radiation Environment and Exposure of CubeSat Missions

Giovanni Santin[1], Hugh Evans[1]
[1] European Space Agency, ESTEC, The Netherlands & RHEA System

Abstract

Space missions are exposed to a range of hostile environments, which can limit part, unit or system reliability, and whose combined and often synergistic effects need to be addressed in hardness assurance processes. For the radiation element, environment specification and shielding analyses are a pre-requisite for detailed calculation of degradation and single event effects in electronic components, and in recent years significant effort has been put R&D aiming at understanding of the underlying physics phenomena, improving the prediction capability of our models and assessing their uncertainties.

In the lecture, an introduction to established and new models for the (external) space radiation environment experienced near Earth shall be followed by a discussion of the radiation environment encountered by satellites along orbits often used for CubeSats. A basic introduction will be provided to the mechanisms by which radiation interacts with satellite structures and components, inducing performance degradation and single events, and to tools made available to the community for simple and detailed radiation analyses. Typical exposure to total dose and single event effects for CubeSat scenarios will be compared to other Earth orbits and will put in context with the challenges brought by ambitious deep space exploration programmes, including Jupiter missions or planetary habitats.

Session:
CubeSat Space Missions - Radiation Hardness Assurance Experiences and Challenges

Radiation Hardness Assurance and CubeSat: A new Approach for a „New Space“

Laurent Dusseau
University Montpellier, France

Abstract

During the last few years, the number of launched cubesats has grown drastically. Recently more than one hundred cubesats were put in orbit on a single launch. The type of missions has also changed from education to science and then to commercial applications. In this context, there are two main reasons to increase the reliability of cubesats: First, it is necessary to avoid at all cost the production of debris-like cubesats which may result from series of failure in constellations. Second, the impact of radiation induced failures may have an unbearable impact on the project costs. However, considering the budget for a cubesat project, it is unacceptable to follow the usual RHA process, perform RLAT or even test at device level. A new approach is being investigated at the University of Montpellier, based on precise evaluation of the environment, mitigation and test at system / subsystem level. A series of 1U cubesat missions are currently at different stage of development to collect data and validate the models. Robusta-1B will be launched before the end will evaluate the impact of TID on operational amplifiers in bipolar technology. MTCUBE will measure the error rates on various types of memories. Finally, Celesta will compare the LEO environment and its effects with the environment simulated in the charm facility at CERN.

BRITE/TUGSat-1 Mission and Radiation Effects

Otto Koudelka[1], Rainer Kuschnig[1]
[1] Graz University of Technology, Austria

Abstract

TUGSAT-1 / BRITE-Austria, the first Austrian satellite was launched together with its sister satellite UniBRITE in February 2013. They are part of the world's first nanosatellite constellation to measure the brightness variations of massive luminous stars. Five nearly identical nanosatellites from Austria, Poland and Canada are in continuous operations since 2013. Each spacecraft carries a small telescope with CCD sensor as the scientific payload. Although designed for a lifetime of two years, the Austrian BRITEs are now in operations for four years and three months and exhibit an excellent health status. None of the components are space-qualified, although critical components were radiation-tested. The CCD naturally has accumulated radiation damage, resulting in hot pixels and warm columns. A method called "chopping" was introduced two years ago to overcome the radiation impairments by image processing. Thus, the mission can be extended for at least two more years. This impressively demonstrates that challenging scientific requirements can be fulfilled by a low-cost nanosatellite mission [1].

In another project called OPS-SAT [2], contracted by ESA, TU Graz has selected industry-grade electronics components, such as system-on-chip modules, mixed-signal chips and single-photon counter modules. They were radiation-tested at ESTEC in 2015 up to 20 krad and showed no degradation.

The presentation will discuss the radiation effects identified in the BRITE mission and the countermeasures taken. Also the results of the OPS-SAT radiation tests will be shown.

References

[1] Pablo, H.; Whittaker, G. N.; Popowicz, A.; Mochnacki, S. M.; Kuschnig, R.; Grant, C. C.; Moffat, A. F. J.; Rucinski, S. M.; Matthews, J. M.; Schwarzenberg-Czerny, A.; Handler, G.; Weiss, W. W.; Baade, D.; Wade, G. A.; Zocłońska, E.; Ramiaramanantsoa, T.; Unterberger, M.; Zwintz, K.; Pigulski, A.; Rowe, J.; Koudelka, O.; Orleański, P.; Pamyatnykh, A.; Neiner, C.; Wawrzaszek, R.; Marciniszyn, G.; Romano, P.; Woźniak, G.; Zawistowski, T.; Zee, R. E., **The BRITE Constellation Nanosatellite Mission: Testing, Commissioning, and Operations**, ,in Publ. Astron. Soc. Pac., 128, 970, 2016.

[2] Koudelka, O., D.Evans, **The OPS-SAT Nanosatellite Mission- A Flexible Platform for On-Board Experiments,** Proc. 11th IAA Small Satellite Symposium, Berlin, 2017

Acknowledgements

BRITE-Austria/TUGSAT-1 is funded by the Austrian Aeronautics and Space Agency within the ASAP program. OPS-SAT is funded by the ESA GSTP program.

Austrian‘s CubeSat PEGASUS: Development and Testing

Carsten Scharlemann[1], Georg Janisch[2], Michael Taraba[3]
[1] University of Applied Sciences Wiener Neustadt Ltd., Austria
[2] Spaceteam, TU Vienna
[3] Space Tech Group

Abstract

The PEGASUS CubeSat project is a cooperation between Austrian entities, mostly consisting of students and university staff. PEGASUS itself is part of the QB50 project which has the goal to launch up to 50 CubeSats. One of the goals of the PEGASUS project was to develop the majority of the satellite by the team itself rather than relying on procured parts. This allowed the team to implement and test new concepts instead of being forced to comply with standards which were conceived as ineffective or disadvantageous.

This objective and the very small budget of PEGASUS did not allow the use of space rated or radiation hardened electronic parts or subsystems. However, a review of the impact of space radiation on CubeSats or, similar the use of not-space rated parts, has shown only little impact for CubeSat in LEO. However, considering that most CubeSat teams have faced the same situation and that most (short term) failures are not directly related to this fact, the PEGASUS team felt significantly confident with their design.

In the following the design of PEGASUS will be provided and how space environmental effects have impacted its design.

System Level Radiation Characterization of a 1U CubeSat at the CHARM facility at CERN

Raffaello Secondo
CERN, Geneva, Switzerland

Abstract

Nanosatellites are increasingly attractive for space research and commercial applications. The success of a mission is highly dependent on the qualification process at system and component level, with requirements of reduced power, low cost, small dimensions and tolerance to radiation fields. As a result, the validation procedure is time consuming and involves tests at several ground facilities.

An alternative qualification methodology for high radiation environment applications has been studied at the CERN High energy AcceleRator Mixed field facility (CHARM) [1]. The test facility allows to reproduce environments representative of the Low Earth Orbit (LEO) space, atmospheric and high energy particle accelerators. The CERN Latchup Experiment and STudent sAtellite (CELESTA) project has been proposed as a 1U CubeSat mission based on the CERN Radiation Monitoring technology, to benchmark radiation fields measured in flight with experimental data collected at CHARM [2].

A Payload board has been developed as a stand-alone dosimetry module, based on the CERN Radiation Monitoring (RadMon) technology [3], and coupled with a latchup experiment. The CubeSat, featuring the Payload and the On-Board Data Handling modules, has recently been successfully tested at CHARM. Results provided a deep understanding of the impact of radiation failures on the system, thus giving insight on the qualification of the nanosatellite with respect to the mission constraints and ultimately highlighting the critical aspects of the design related to radiation.

References

[1] J. Mekki, M. Brugger, R. G. Alia, A. Thornton, N. C. D. S. Mota, and S. Danzeca, “CHARM: A Mixed Field Facility at CERN for Radiation Tests in Ground, Atmospheric, Space and Accelerator Representative Environments,” IEEE Transactions on Nuclear Science, vol. 63, no. 4, pp. 2106–2114, Aug. 2016.

[2] R. Secondo, P. Peronnard, M. Brugger, S. Danzeca, E. Chesta, A. Masi, R. Garcia Alia, A. Merlenghi, L. Dusseau, M. Bernard, J.R. Vaillé, “A Nanosatellite Radiation Qualification Procedure At The CHARM Facility Based On The CELESTA Payload Demonstrator,” in Proc. of ESA 4S Symposium 2016, Malta, 2016.

[3] G. Spiezia, P. Peronnard, A. Masi, M. Brugger, M. Brucoli, S. Danzeca, R.G. Alia, R. Losito, J. Mekki, P. Oser, R. Gaillard and L. Dusseau, “A New RadMon Version for the LHC and its Injection Lines,” IEEE Transactions on Nuclear Science, vol. 61, no. 6, pp. 3424–3431, Dec. 2014.

Robust Miniaturized Onboard Computer with COTS Components using Advanced FDIR Methods

Klaus Schilling, Tristan Tzschichholz
Zentrum für Telematik e.V., Würzburg, Germany
klaus.schilling@telematik-zentrum.de

Abstract

Use of miniaturized commercial-of-the-shelf technology (COTS) micro-electric components for satellites was so far limited, as space radiation noise affect severely the performance by frequent reboot activity or even loss of components. Here advanced redundancy concepts in combination with Fault Detection, Identification and Recovery (FDIR) methods are used to cure this deficit.

In the context of UWE-3 the OBDH core module used an energy-efficient onboard computer for the pico-satellite UWE-3 launched in 2013. The core module is built around two tightly coupled redundant ultra-low power microcontrollers. A dynamically decided master-slave configuration enables the instantaneous master module to maintain and re-program the (even unresponsive) slave via its embedded emulation module. Thus, the core module implements special support for mutual assistance such as mutual program memory protection and recovery up to complete mutual reconfiguration in the context of fail-save in-orbit software updates. With less than 10 mW nominal power consumption the design belongs to the most efficient redundant onboard computers available for pico-satellites. The two redundant micro-controllers are supervised by an "intelligent" watchdog, detecting deviations. It is then the task of this watchdog to decide with its FDIR software in almost real-time, which is the faulty device and to transfer responsibility to the correctly performing device. The core module has proved excellent performance for more than three years of operation without any interruption of service in orbit until today.

Evaluation of Response and Radiation Damage to Protons in Timepix Detectors at Particle Accelerators and in LEO Orbit by the SATRAM Spacecraft Payload on Board ESA's Proba-V satellite

Carlos Granja[1,2,*], Zdenek Dvorak[1]
[1] Czech Space Research Center (CSRC), Brno, Czech Republic
[2] Nuclear Physics Institute (NPI), Czech Acad. Sci. (CAS), Prague, Czech Republic

Abstract

The semiconductor pixel detector Timepix is been used for a broad range of applications from radiation imaging to particle tracking, radiation detection and spectrometry. The radiation environments include harsh conditions in terms of particle composition and fluxes such as beam and experimental targets at particle accelerators as well as LEO in space. In this contribution I review existing knowledge in registering and evaluating the exposure and response of Timepix detectors to prolonged or intense radiation fields in particular particle accelerator beams, namely the electron Microtron, the light ion Cyclotron and ion Tandetron accelerators (all at the NPI-CAS) and in open space – by preliminary evaluation of data acquired with the SATRAM/Timepix payload on board the Proba-V satellite of ESA, in LEO orbit since 2013. Mention is included of radiation exposure estimate for a new Timepix payload on board the VZLUSAT-1 cubesat (built by VZLU Prague).

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Investigating the Use of Commercial FPGAs in Two Case Studies - Cubesats: NanoSatC-BR1 and NanoSatC-BR2

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Abstract

The use of small satellites has increased substantially in the past years due to the reduced cost in development and launch and the flexibility offered by commercial components. NanoSatC-BR1 was the first Brazilian CubeSat project, developed at the Southern Regional Space Research Center (CRS/CCR/INPE-MCT) in collaboration with the Space Science Laboratory of the Federal University of Santa Maria (LACESM/CT - UFSM), Santa Maria, RS, Brazil. Part of the payload of the NanoSatC-BR1 was developed at Federal University of Rio Grande do Sul (UFRGS) with the objective to qualify the use of commercial FPGAs in space. The NanoSatC-BR1 was successfully launched on June 19st, 2014. Deployed into space in a rideshare mission by the Ukrainian DNEPR rocket, launched in the Yasni launch base, in south of Russia, the nanosatellite is fully operational since then. The main scientific goal is to monitor the Earth's magnetosphere by measuring the magnetic field, especially over the Brazilian territory, and to study the magnetic phenomena of the SAA (South Atlantic Anomaly).

The payload platform was developed to be adjusted to a wide array of and quantity of components and interfaces. The payload data is being downloaded through the communication base in INPE, Santa Maria, and it is being processed. The target component that is being analyzed is the Flash-based ProASIC3E FPGA from Microsemi composed of an embedded 32-bit processor MIPS-like. The software running in this processor has been modified to detect transient faults in the microprocessor. All the variables are duplicated and compared at software level and the program flow has some signatures that communicate with specific watchdog circuit to detect errors. Faults can be diagnosed and classified due to its effects: data and control flow effects. Fig. 1 illustrates the NanoSatC-BR1 and fig. 2 shows the payload board with the commercial Flash-based FPGA ProASIC3E.

Fig. 1 – NanoSatC-BR1

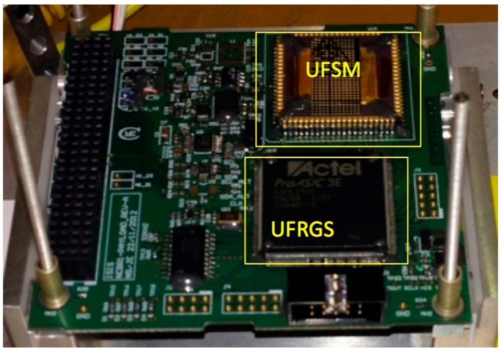

Fig. 2. Payload board of NanoSatC-BR1

The payload system of the NanoSatC-BR1 proposes a design and implementation of a test bed suitable for test and evaluation of commercial circuits within nanosatellites. The development of such platform allows developers to reduce the efforts in the integration of components and therefore speed up the overall system development time. The proposed test bed is a configurable platform implemented over a Field Programmable Gate Array (FPGA) that controls the communications protocols and connections to the devices under test. The Flash-based ProASIC3E FPGA from Microsemi is used as a control system. This adaptive system enables the control of new payloads and softcores for test and validation in space, so the integration can be easily performed, through configuration parameters. It is intended for modularity. Each component connected to the test bed can have a specific interface programmed using a hardware description language (HDL). The data of each component is stored in embedded memories. Each component has its own memory space reserved. The size of the allocated memory can be also configured. The data transfer priority can be set and packaging can be added to the logic, when needed. Communication with peripheral devices and the on-board computer is done through the pre-implemented protocols, such as I2C, SPI and external memory control. In loco primary tests demonstrated the control system functionality. The commercial ProASIC3E FPGA family is not space-flight qualified, but tests have been made under total ionizing dose (TID) showing it robustness up to 25 krads(Si). When considering proton and heavy ions, flash-based FPGAs provide immunity to configuration loss and low bit-flips susceptibility in flash memory. In this first version of the test bed two components are connected to the controller FPGA: a commercial magnetometer and a hardened test chip. The embedded FPGA implements a SEE hardened microprocessor and a few other soft-cores to be used in space.

NanoSatC-BR2 is the second Cubesat 3U that is being developed by Instituto Nacional de Pesquisas Espaciais (INPE) and its partners composed of 6 different payloads from many different Brazilian Universities and Institutions and it is planned to be launched on 2017. For NanoSatC-BR2, we are working in a new test bed platform composed by two commercial FPGAs, one Flash-based Smartfusion (130nm) from Microsemi and the other SRAM-based Artix from Xilinx (28nm). The embedded processor ARM in the Smartfusion is responsible for the main control of the payload board. The SRAM-based FPGA Artix will work as a sensor to detect single and multiple bit upsets in the configuration memory bits under the SAA.

The novelties of this test bed are:

- Qualifying commercial FPGAs in space in nanometer technologies such as 28nm
- Performing detailed analysis of SBU vs. MBU in the Artix FPGAs during the SAA and outside SAA.
- Testing a set of fault tolerant technique test in the Artix and in the Smartfusion specially the embedded memories.
- Using the embedded ARM in the Smartfusion as the main controller with all the peripherals of the FPGA

Fig. 3 presents the schematic of the payload of NanoSatC-BR2. Figure 4 illustrates the setup from the laboratory when the Smartfusion FPGA is controlling the Artix FPGA by loading its bitstream in a certain rate and comparing with the gold bitstream. The information about single and multiple SEUs are stored as well the location in order to diagnose the errors. The readback is done by JTAG and the rate can be configured from 90 seconds to a lower rate as needed.

In the presentation, we will present the main data from NanoSatC-BR1 and the detailed information of the NanoSatC-BR2.

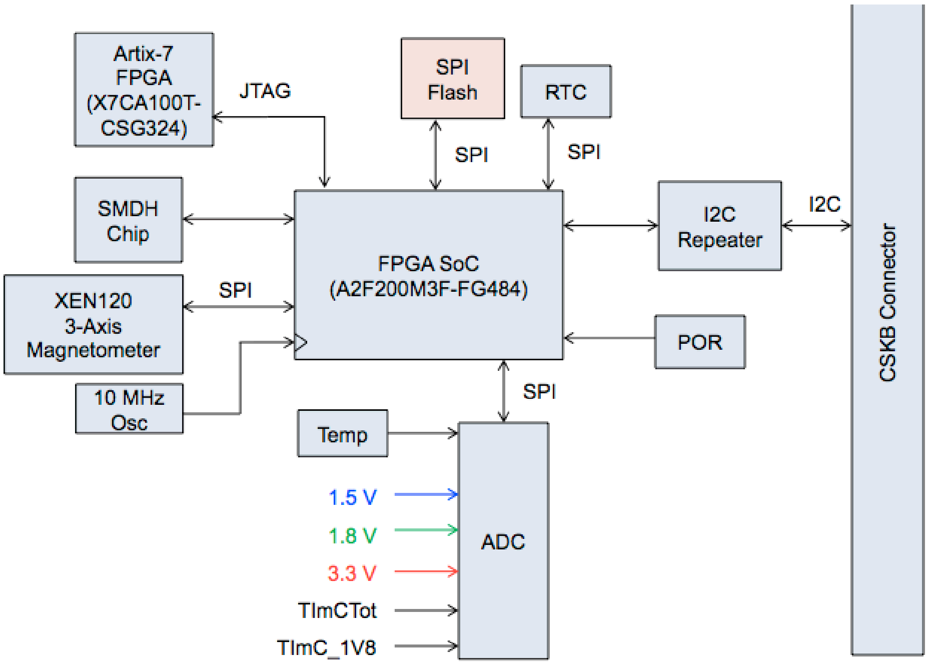

Fig. 3 – Payload schematic with both commercial Smartfusion and Artix FPGAs and the suronding components

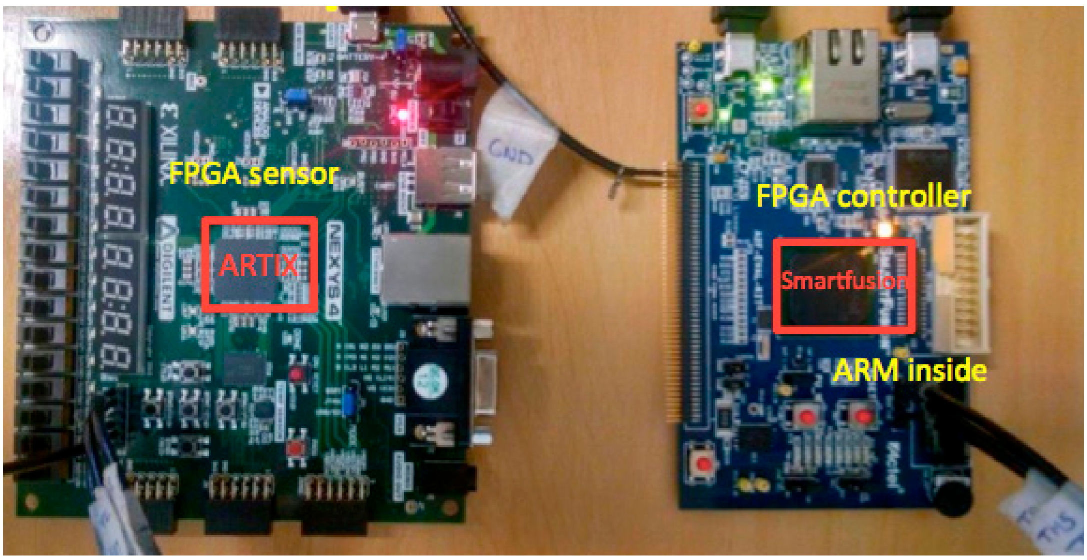

Fig. 4 – Payload board prototype scheme with both commercial Smartfusion and Artix FPGAs.

Session:
Selected Topics -
Components and System Testing

Compendium of Circuit Effects in COTS Op Amps

Thomas Borel[1,2], Laurent Dusseau[2]
[1] University Montpellier, France
[2] CERN, Switzerland

Abstract

Operational amplifiers and voltage comparators are still widely used in space electronics. Often tested in standard conditions, they exhibit large degradation in the electrical and functional parameters. The degradation curves may exhibit unexpected shapes that are difficult to explain a with a black box approach. A good example is the degradation of the input bias current, which sometimes exhibits a bell shape or a peak. Those atypical behaviours may not be explained by physical mechanisms. They derive from compensation mechanisms at circuit level referred to as circuit effects. The compensation may be enhanced of attenuated depending on the type of architecture, the value of the currents in the current sources or the bias conditions during irradiation. A few examples of circuit effects observed on LM139, LM124 and OP400 will be presented and their impact discussed on the bias conditions to apply during TID testing.

Combination of Heavy Ion, Laser and Proton Irradiation for SEE Qualification Test, Advantages and Limitations

Vasily S. Anashin, Aleksandr E. Koziukov
Branch of JSC URSC-ISDE, Moscow, Russia

Abstract

One of the most actual goal during radiation experiments is getting full information (more data) from tests with beam time and cost reducing. Sometimes one or another testing method is limited by impossibility of DUT de-encapsulation, impact penetration requirement, heavy ion LET discrete values [1] and small equivalent LET values of secondary particles from proton. The most effective approach for wide device parameterization is combination of different facility using (laser, heavy ion and proton beams). Each of them has a lot of advantages and limitations such as similar physical nature for ions and protons, high penetration ability and small size of a beam for protons, milli- and micro- size of laser spot, precise and monotonous adjusting of laser energy (having more equivalent LET values) and possibility of scanning for laser.

The consequence of test facilities choice is depended on type of the test (evaluation or validation). During validation test more rational is staring from proton facility for potentially susceptible devices rejection (without solving the problems with possibility de-encapsulation). Next heavy ion test is carried out (characterization of hardened DUT is performed) and in case of bad results an additional investigation on laser facility is carried out and allowed to clarify LET threshold values and localized sensitive to SEL regions [2], performing SEL stress test in every founded region. During evaluation test the main facility is based on heavy ion accelerator [3] while laser facility and proton cyclotron play a role of supporting tools.

References

[1] Vasily S. Anashin; Aleksandr E. Koziukov; Anatoly A. Kazyakin et al, “SEE Test Results of Electronic Components Performed on Roscosmos Test Facilities”

[2] N. A. Dodds, N. C. Hooten, R. A. Reed et al, “SEL-Sensitive Area Mapping and the Effects of Reflection and Diffraction From Metal Lines on Laser SEE Testing”

[3] Skuratov V.A., Anashin V.S., Chlenov A.M, Emeliyanov V.V., Gikal B.N., Gulbekyan G.G., Kalagin I.V., Milovanov Yu.A., Teterev Yu.G. “Roscosmos Ion Beam Line for SEE Testing at U400M FLNR JINR Cyclotron”// Reported on Single Event Effects (SEE) Symposium - SEES, 2011

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We would like to express our deep appreciation to our colleagues from the Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research (Dubna, Russia) for their help and participation in testing, as well as highlight their qualification and excellent personal qualities.

Experiences from Radiation Testing at RUAG Space

Marcus Larsson
RUAG Space, Sweden

Abstract

RUAG Space is a leading supplier of products for the space industry in Europe with production in six different countries. Capabilities include structures and separation systems for launch vehicles, structures and mechanisms for satellites, digital electronics for satellites and launch vehicles, and satellite communications equipment. Many of these products include EEE components sensitive to radiation effects, both long term effects, i.e. total non-ionizing dose (TID) and displacement damage (DD) as well as transient effects, i.e. single event effects (SEE). Ground testing of such sensitive components is necessary to predict their behavior in space.

The aim of this presentation is to describe the experiences of single event effect (SEE) and total ionizing dose (TID) testing of EEE components performed by RUAG Space. Examples of test results that will be presented include lot-to-lot variation in TID tests of commonly used voltage references and PWM controllers as well as SEE tests of radiation hardened versus non-hardened power drivers.

New Radiation Testing Aspects at Fraunhofer INT

Jochen Kuhnhenn
Fraunhofer INT, Euskirchen, Germany

Abstract

The presentation will give an overview about recent radiation test method advancements and their use in selected projects. This will include the presentation of radiation testing at extreme low temperatures and some connected practical operation details. It will also discuss an implementation of a fully digital radiation monitor concept to be used on-board the Heinrich-Hertz-Satellite within the Fraunhofer payload.

Finally some remarks will address potential pitfalls in radiation testing, exemplary shown in results obtained with optical fibers emphasizing the importance of experience and standardization.

Fast Real Time Assessment and Characterisation of Transients

Michael Wind, Peter Beck, Marcin Latocha, Christoph Tscherne
Seibersdorf Labor GmbH, Austria

Abstract

The characterisation of short transients requires a markedly fast test system being capable of monitoring the device output lines with a time resolution of less than a nano second. The occurrence of the transient is recorded and the transient is analysed in real-time with respect to several properties such as the time of the transient occurrence, the duration of the transient, the transient amplitude, etc. Additionally the shape of the transient is recorded by logging the time evolution of the DUT output signal with a time resolution of less than a nano second. All data are evaluated and stored in real time assuring that no transient event is missed.

The SET detection system used for this purpose is based on the National Instruments PXI (PCI extensions for Instrumentation) standard that offers a measurement infrastructure being quick enough for this challenging task. The systems consists of a PXIe-1085 express chassis having 18 slots that is adopting a PXIe-8135 controller. The system is capable of performing high speed data transfer at a rate of 3.2 GB/s within the PXI system. One of the system slots is equipped with a NI 5771 that is an 8-bit Oscilloscope Digitizer adapter for NI FlexRIO. This digitizer has a bandwidth of 3 G samples/s and thus is consequently quick enough to capture, analyse and store transients during a time span within the nanosecond regime.

Session:
Selected Topics -
Radiation Hardness Assurance

Radiation Testing of Satellite Systems

Chiara Tran Thi[1], Torsten Kohne[1], Antonella Sgambati[1], Marco Berg[1]
[1] OHB System AG, Bremen, Germany

Abstract

The space environment is a very harsh environment and the electronic devices that shall operate in this environment must perform their functions reliably. The radiation in space can directly affect the operation of electronic devices causing effects such as performance degradation, functional interrupts, transient effects, loss of data or memory integrity and even permanent loss of function as far as permanent damage. Furthermore, the equipment will be stressed mechanically during the launch event, mainly in terms of vibration, shock and extreme thermal cycling.

Therefore, it is imperative that agencies and the industry properly characterize electronic devices before these devices are flown in space.

The use of commercial electronic components and also fully commercial-of-the-shelf (COTS) equipment is increasingly attractive for the space domain. Performance – in the full meaning of the term – of COTS electronic components and devices is highly attractive compared to their Hil-Rel (High Reliability) / Rad-Hard (Radiation-Hardened) equivalents. Sometimes, especially for long term operational equipment like infrastructure facilities on the International Space Station, COTS equipment is mandatory in terms of availability, performance and nevertheless costs.

To qualify COTS equipment for space applications is usually very complex, time-consuming and therefore also very expensive process. But especially for Low-Earth-Orbit applications like the International Space Station (ISS), such a qualification process can be reduced and optimized if some key points are carefully attended.

This presentation describes the process of qualifying a COTS equipment for the utilization onboard the ISS. It focuses on the activities performed for the radiation qualification of a commercial hard disk storage system required as replacement and upgrade of obsolete equipment of a scientific facility of the ISS Columbus Module.

These activities had been conducted as part of a general cost effective approach for qualifying commercial hardware for low-earth-orbit applications.

References

[01] GPQ-MAN-02-Issue1 Commercial, Aviation and Military (CAM) Equipment Evaluation Guidelines for ISS Payloads Use
[02] GPQ-010_02 Product assurance requirements for payload projects
[03] SSP30512-C Space Station Ionizing Radiation Design Environment, International Space Station Alpha
[04] SSP30423RH Space Station Approved Electrical, Electronic, and Electromechanical Parts List - International Space Station
[05] SSP 30233 rev.F Space Station Requirements for Materials and Processes - International Space Station
[06] SSP 57000, Revision E Pressurized Payloads Interface Requirements Document - International Space Station Program

[07] COL-RIBRE-SPE-0164_01-A Columbus Pressurized Payloads Interface Requirements Document

[08] „Radiation Test Results on COTS & non-COTS Electronic Devices for NASA-JSC Spaceflight Projects“ Kimberly K. Allums PhD, Patrick M. O'Neill PhD, Brandon D. Reddell PhD, Charles R. Bailey, Kyson V. Nguyen - NASA Johnson Space Center, Avionics Systems Division, Radiation Effects Group

[09] JSC-64376 ESCG-6230-08-EPGG-DOC-0038_rev.A NASA ESC Radiation Test Report T61P Lenovo Thinkpad Laptop: Final Configuration

[10] PSTAR physics.nist.gov/PhysRefData/Star/Text/PSTAR.html

[11] ESCC Basic Specification No. 22900 TOTAL DOSE STEADY-STATE IRRADIATION TEST METHOD

[12] ESCC Basic Specification No. 25100 SINGLE EVENT EFFECTS TEST METHOD AND GUIDELINES

[13] ECSS E-ST-10-12C, "Methods for the calculation of radiation received and its effects, and a policy for design margins"

[14] ECSS-E-HB-10-12A "Calculation Of Radiation And Its Effects And Margin Policy Handbook"

[15] „High Energy Neutron and Proton Irradiation Facilities at TSL“ Alexander Prokofiev, 2007-11-30, 6th LHC Radiation Workshop

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Variability in Floating Gate Errors in Flash Memories Exposed to Total Ionizing Dose

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Abstract

The impact of sample-to-sample variability on the number of bit errors induced by total ionizing dose in 25-nm Single Level Cell (SLC) NAND Flash memories was experimentally studied using gamma rays from a Co60 source. Low total ionizing doses were considered, in such a way that degradation of the peripheral circuity was negligible and the errors were mainly due to charge loss from the floating gate cells, and to a much smaller extent to charge trapping in the oxides surrounding the storage element. Two production lots, for a total of more than 1 TBit of cells, were analyzed from a statistical point of view and the results were fitted with different distributions, in order to find the best match. The lognormal and Birnbaum-Saunders functions appeared to offer the best fit. However, physical modeling shows that neither of them is strictly justifiable and that a more complex form is needed to correctly capture the initial Gaussian distribution of cell threshold voltage and the shift induced by total dose. Implications of the choice of the statistical distribution on the number of samples needed to correctly estimate the number of floating gate errors as a function of dose are discussed.

Radiation Hardening of Integrated Circuits

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Abstract

An approach to radiation hardening of MOS transistors for use in analog integrated circuits will be presented. In this procedure the integrated MOS devices and circuits are designed for increased robustness and then fabricated on a prototype IC. The electrical tests need to be run to check the conformity to simulation results before stress with the ionizing radiation. The prospects for radiation hardness assurance testing against the effects of the total ionizing dose will be also discussed. In particular for a large number of devices and analog blocks integrated on a single circuit the measurement optimization in terms of time, complexity and parasitics is a big issue for radiation hardness assurance testing.

References

V. Bezhenova, A. Michalowska-Forsyth „Effects of ionizing radiation on integrated circuits“, e&I, Elektrotechnik und Informationstechnik, vol. 133, No. 1, February 2016, pp 39-42.

V. Bezhenova, A. Michalowska-Forsyth „Total ionizing dose effects on MOS transistors fabricated in 0.18um CMOS technology“, 2016 Asia-Pacific International Symposium on Electromagnetic Compatibility, (APEMC), Shenzhen 2016, pp. 366-369.

J. Benfica et al., „Analysis of SRAM-based FPGA sensitivity to combined EMI and TID-imprinted effects“, IEEE Transactions on Nuclear Science, vol. 63, no. 2, pp. 1294-1300., April 2016.

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STREAM: Smart Sensor Solutions Design and Testing

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Abstract

In the scope of Horizon 2020 in Innovation and Research, this work is part of the ITN Project “Smart Sensor Technologies and Training for Radiation Enhanced Applications and Measurements” (STREAM). STREAM aims at the design, construction and manufacturing of smart-sensor solutions. In particular, the detectors for X-ray and CT imaging comprise a conversion stage for converting the X-ray quanta ultimately into electrical signals. In the majority of today’s detectors for dynamic X-ray imaging and CT imaging, the conversion is indirect. There are many parameters that affect the performance of imaging detectors: detection efficiency, spectral responsivity, signal-to-noise ratio and cross-talk are some of the most important.

Moreover, for the development of full sensor solutions, radiation hard digital and analog IPs have to be investigated. In particular, Non-Volatile Memories (NVM) are a key component. The Sidewall Spacer Memory Bit Cell [1] is a promising element compared to state-of-the-art, as it allows no mask addition in the process and has a promising endurance performance.

References

[1] Breitwisch, Matthew J., inventor; Chen, Bomy A., inventor; Lam, Chung H., inventor; International Business Machines Corp, assignee. Embedded one-time programmable non-volatile memory using prompt shift device. U.S. Patent 6518614B1. February 11, 2003.

List of Lecturers

Bezhenova V. - Graz University of Technology, Austria
Radiation Hardening of Integrated Circuits

Dusseau L. - University Montepellier, France
Radiation Hardness Assurance and CubeSat: A new Approach for a „New Space“
Compendium of Circuit Effects in COTS Op Amps

Gerardin S. - University of Padova, Italy
Variability in Floating Gate Errors in Flash Memories Exposed to Total Ionizing Dose

Granja C. - Czech Space Research Center, Brno; Nuclear Physics Institute, Acad. Sci, Prague, Czech Republic
Evaluation of Response and Radiation Damage of Timepix Detectors at Particle Accelerators and in LEO Orbit by the SATRAM Spacecraft Payload on Board ESA‘s Proba-V satellite

Kastensmidt F. L. - UFRGS University, Porto Alegre, Brazil
Investigating the Use of Commercial FPGAs in Two Case Studies - Cubesats: NanoSatC-BR1 and NanoSatC-BR2

Koudelka O. - Graz University of Technology, Austria
BRITE/TUGSat-1 Mission and Radiation Effects

Koziukov A., E. - JSC URSC-ISDE, Moscow, Russia
Combination of Heavy Ion, Laser and Proton Irradiation for SEE Qualification Test, Advantages and Limitations

Kuhnhenn J. - Fraunhofer INT, Germany
New Radiation Testing Aspects at Fraunhofer INT

Larsson M. - RUAG Space, Sweden
Experiences from Radiation Testing at RUAG Space

Poivey C. - European Space Agency, ESTEC, The Netherlands
Total Ionizing Dose (TID) and Total Non Ionizing Dose(TNID) Radiation Hardness Assurance (RHA)for Space Systems – from Big Systems to Smallsats [Keynote]

Santin G. - European Space Agency, ESTEC, The Netherlands
Typical Radiation Envornment and Exposure of CubeSat Missions

Scharlemann C. - University of Applied Sciences Wiener Neustadt Ltd., Austria
Austrian‘s CubeSat PEGASUS: Development and Testing

Secondo R. - CERN, Switzerland
System Level Radiation Characterization of a 1U CubeSat ant the CHARM facility at CERN

Tran Thi C. - OHB System AG, Bremen, Germany
Radiation qualification of COTS Hardware for a specific LEO space application

Tzschichholz T. - Zentrum f. Telematik, Würzburg, Germany
Robust Miniaturized Onboard Computer with COTS Components using Advanced FDIR Methods

Vincenzi T., ams AG; Graz University of Technology, Austria
STREAM: Smart Sensor Solutions Design and Testing

Wind M., Seibersdorf Labor GmbH, Austria
Fast Real Time Assessment and Characterisation of Transients

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