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Abstract

This document presents the conclusions taken during ESA's CTTB Data Analysis project.

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1 GENERAL

1.1 Relevant Documentation

1.1.1 Applicable Documents

This document incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these apply to this document only when incorporated in the amendment or revision.

For undated references, the latest edition of the publication referred to applies.

AD#	Reference	Title
AD 1		

Table 1-1 – Applicable Documents

1.1.2 Reference Documents

The following documents, although not a part of this document, amplify or clarify its contents:

RD#	Reference	Title
RD 1	CTTB_DA-EFA-FR-001 1.0	CTTB Data Analysis Final Report

Table 1-2 – Reference Documents

1.2 Acronym List

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2 TDP8 INFORMATION

The Alphasat TDP8, also known as the AEEF, contains a CTTB and a MFS. The CTTB in the AEEF configuration includes three EBs that were designed, developed, and manufactured under previous ESA activities. The goals of these EBs was to test the ability of different industrial components technology to withstand space conditions. The three EBs are:

EB1: Intra satellite optical technology demonstration board (SIOS) ;

EB2: GAN technology experiment to assess potential radiation issues (cumulative or single event) on GAN MESFETs;

EB3: MTB including SEU and SEL experiments in SRAMs and a 8 Gbit NAND flash memory technology demonstration.

All these experiment boards have embedded a RADFET 02-400 nm IMPL, manufactured by Tyndall National Institute (Ireland), to monitor the radiation levels at that orbit. The EBs register data in 64 seconds steps and transmits the raw information back to Earth. Under the present contract it was also requested to determine the Radfets transfer function and apply it to the collected data.

2.1 TDP8 IFDA Status

IFDA is the software developed by the consortium that collects, processes and stores all the data originated by TDP8. The data is accessible on the website http://ifdatdp8.efacec.com/.

During CTTB Data Analysis project EFACEC and EVOLEO validated functions from IFDA software that generates the Level 2 data (processed data) based on TDP8 raw data.

The processed data is available on the mentioned website, and the results have been analysed with all the CTTB experiments experts and ESA to understand if the data generated is according to the initially expected.

3 CONCLUSIONS

CTTB first level data was processed into second level data during the execution of this project, it is now available for the scientific community so that more investigation can be done and more information collected from the experiments.

Valid information was taken, and some special events like solar flares have occurred during the analysis.

The analysis performed during this contract are summarized on the following chapters.

3.1 RADFET Conclusions

All the results are described in RD 1.

The accumulated doses measured by the RADFETs on board the Alphasat have been estimated from a calibration model derived under previous ESA activities. Since the average dose rate on board the Alphasat are well below 5 krad/h, the dose values were determined in the LDR regime.

It should be noted that the largest uncertainties in the dose values come from the calibration model. Thus, the error in the fitting procedure is predicted to be small when compared with the uncertainties from the calibration parameters.

The RADFET threshold voltages in the SIOS EB are roughly ten times smaller than the threshold voltages in the MTB and EBs for the whole-time period of measurements on-board the Alphasat, including the qualification tests period. From the pre-irradiation values of the unbiased RADFET samples used in calibration campaign, we expect the pre-irradiation threshold voltages to be $V_{th}(0)$≈2.2 V, which is compatible with the values measured in the MTB and GAN EBs, but not with the values from the SIOS EB. It was confirmed that the circuits in the three boards are the same.

The accumulated doses in the EBs on June 16th, 2018 are ≈1.93 (MTB), ≈2.62 krad (SIOS), and ≈3.15 krad (GAN). Simulated doses in the CTTB RADFETS are larger (factor of ≈3) than the measured values, predicting, however, the correct dose ratios between the three boards.

By the end of 2017 and beginning of 2018 the rate of increase in threshold voltage shift and accumulated dose seems to be decreasing. It is not clear from the analysis of the graphs that there is a correlation between this behaviour and the MFS counting.

3.2 GAN Conclusions

The following conclusions were taken when observing GaN collected data (all results in RD 1):

- GaN global power has increased, that caused overcurrent FDIR action by TDP8 SW. this increase could have been caused by components aging or loosing circuit efficiency.

Period	HK Data		
	+15V Input	-10V Input	Total
Sep 2013	108,35	10,40	1,73
Jan-14	110,57	10,79	1,77
July 2014	112,63	10,71	1,80
Jan-15	114,35	10,95	1,82
July 2015	117,76	11,29	1,88
Sep-2015	118,63	11,09	1,89

On October 2017 average power consumption was 1,92W. Since beginning of operations, power drifted approx. 200mW. It is not possible to conclude who is causing the power increase, if the oscillators or auxiliary circuits.

- Oscillator#4 output power is higher than the others since the beginning. Its tuning point is different from the others;
- The dependence of the oscillators output power and the board temperature is visible on the plots: Oscillator Power is inverse proportional to the temperature;
- The radiation dose has little impact on the oscillators power. GaN Radfet has measured a dose ~5krad since beginning of operations (On the plots radiation data is cumulative).

3.3 SIOS Conclusions

The following conclusions were taken from SIOS collected data (all results in RD 1):

- IFDA software is not correctly processing SIOS data. DAS Photonics has never confirmed has the data shall be decoded, during the conversations with DAS it was discussed the following algorithm to be implemented:
    - For each request from S/C or TDP8 the maximum number of errors is 511. Values greater than 511 implies that the parity bit is activated (bit number 10), so we need deep analysis of each received value to check if parity is ON or not. Pseudo code for this check will be “if (value > 511), value = value-512”. 512 (10’b1000000000 means that the link is not synchronized, and the value shall not be taken into account).
- SIOS chanel1, for limited time periods has reported burst of errors, this behavior has never been correctly understood. These events have occurred Jan 2016, Jan 2018 June 2018 and October 2018. Outside these periods this channel had the same behaviour as the other channels. Channel 1 is the one with least security margin.
- All the other channels have reported few errors during the mission.

3.4 MTB Conclusions

The following conclusions were taken from MTB collected data (all results in RD 1):

3.4.1 SRAM Memories

- Memory Burst were considered only one memory error;
- SEL and SEU Events over time seem to happen at a constant rate, the differences between the memories rate can be justified by the component placement on the board;

- A higher occurrence of SEL and SEU events happens at higher board temperature;
- SEL Events rate on SRAM is not affected by the received dose
- Some memory PN showed to be more sensible to SEU

3.4.2 Flash Memories

Due to the fact of IFDA doesn't report any latch-up errors related to Flash memories, except for some invalid blocks, it was created an independent tool that ingests all the raw data looking for latch-up events on flash memories. It is expected these events to occur on these memories.

The new tool (named as SEU Flash Finder tool) reported some errors found and listed below:

time	seu.memid	seu.data	seu.addr
2013-12-30T03:32:45.824Z	20	0	503353072
2014-03-23T18:13:01.696Z	20	0	805340900
2014-10-03T02:51:39.368Z	19	44	160827830
2014-10-15T06:10:03.368Z	22	236	193334166
2014-10-20T11:58:02.496Z	19	156	166595054
2015-09-27T13:51:36.960Z	20	0	755009236
2015-10-01T15:22:24.960Z	20	0	1711276032
2016-02-22T09:57:52.704Z	20	0	1400938208
2016-10-11T11:45:44.448Z	20	0	943833728
2017-04-05T06:34:46.912Z	20	0	1978904448
2017-12-13T09:24:46.400Z	20	0	2139139200
2018-01-19T05:51:26.144Z	20	0	1006755840
2018-01-21T04:05:50.144Z	20	0	360710145
2018-07-05T16:36:29.632Z	20	0	1976807040
2018-08-02T19:28:23.552Z	20	0	1862315520

Inconsistent errors due to the fact in even addresses the expected SEU data should be 0.

Table 1 – Flash memories errors

Analysing the errors data, only three errors are consistent since some errors reported are even addresses with data with value zero, which in fact is the expected data.

Two new inconsistent errors were found between 01/06/2018 and 31/10/2018.

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