Characterization of COTS-based Ionizing Radiation Monitoring Systems for CubeSat Applications

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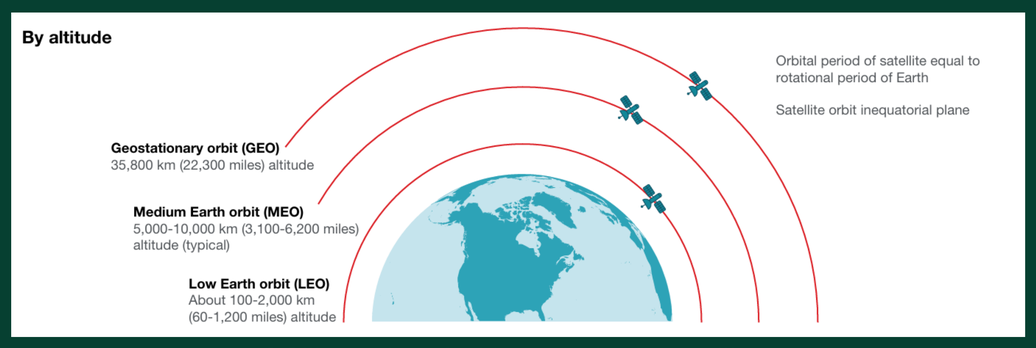
Introduction

When it comes to the implementation phase of an educational project, the factor of cost-effectiveness is always significant. This is especially true when the project in question is a CubeSat, where low costs must be in balance with the reliabilty of the instrument. However, the price of radhard components are quite expensive, our goal is to find an alternative solution with the application of COTS items.



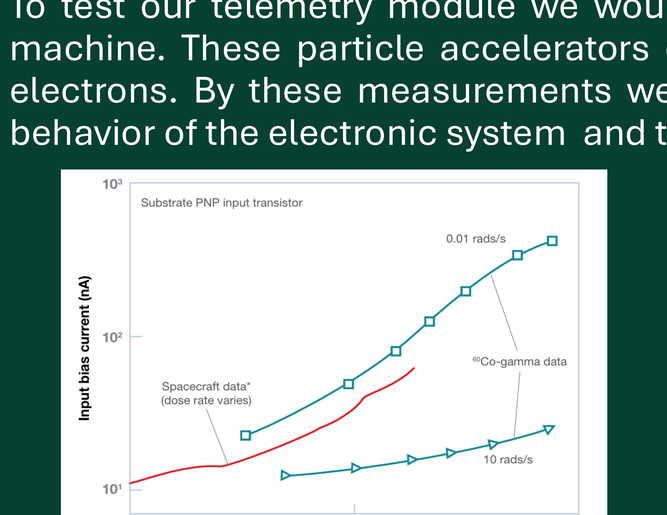
[1] Illustration of orbit properties for satellites

Methodology

By using COTS items we forgo the protection offered by more expensive ones. We must ensure that our equipment continues to produce reliable results even under these conditions, without causing system failures or providing inaccurate measurement data. In order to validate this, we need to test the operation of our device under similar conditions.

Operational and Testing Conditions

Our telemetry board is going to feature the capabilities for the measurement for four different environmental parameters that plays a key role in the deployment of the satellite on LEO and operating the system in such conditions. These are the following values: temperature, vibration, altitude and radiation. The last one of these is going to be the core of our project. Our intention contains the measurement of space radiation which consists of the absorbed TID (Total-Ionizing Dose) and the effect of high-energy particles that cause SEE (Single-Event Error).



[4] The map of high-energy particles in LEO

Total Ionizing Dose (TID) is the energy absorbed by a material over its entire mission life.

It leads to lasting parametric shifts, such as increased leakage current and threshold voltage changes.

Single Event Effects (SEE) occur when one energetic particle (like a heavy ion or proton) hits a sensitive circuit node.

Soft Errors
Temporary
Bit-Flips
(SEU)

Hard Errors
Permanent
Destruction
(SEL/SEB)

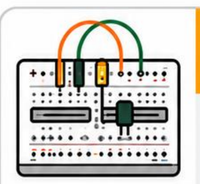
The 6-Step Development Roadmap

1. Define Measurement Parameters

Select the **specific metrics** and **parameters** required for the project.

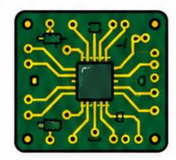
2. Select COTS Components

Choose the appropriate **Commercial Off-The-Shelf** hardware.



3. Assemble Breadboard Model

Build the initial prototype to test basic functionality.



4. Implement PCB Model

Transition the design from a breadboard to a **Printed Circuit Board.**

5. Conduct Laboratory Testing

Execute **rigorous testing** within a controlled lab environment.

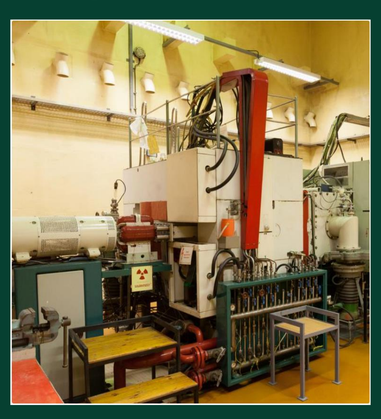
6. Evaluate Data & Experiences

Analyze the final **results** and document key **learnings** from the process.

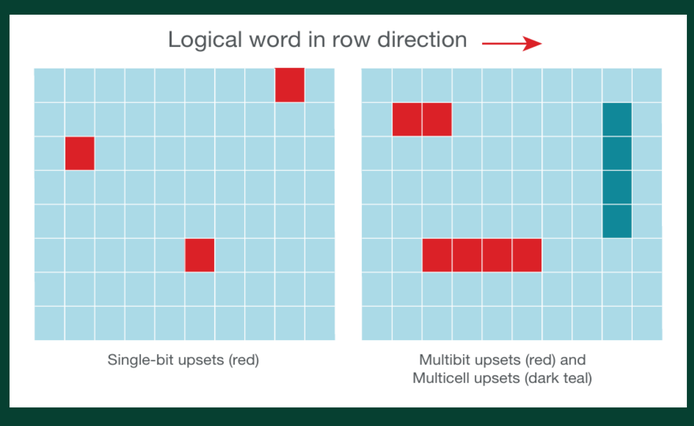
Data Evaluation and Expectations

To test our telemetry module we would like to subject it to a radiation test which would be realized by a tandetron and a cyclotron machine. These particle accelerators can radiate high-energy particles such as alpha-particles, H-ions (protons) and heavy ions and electrons. By these measurements we would like to create a model that can predict the life expectancy of our device, the changing behavior of the electronic system and the degradation of our sensors and memory units.

[1] The increasing input bias current as a function of TID



Cyclotron and Tandetron accelerators at the ATOMKI Institute in Debrecen



[1] The effects of SEE: Single and Multiplebit upsets in silicon (SBU &MBU)

References
[1] Texas Instruments – Radiation Handbook for Electronnics
[3] Edward P. Wilcox - A TID and SEE Characterization of Multi-Terabit COTS 3D NAND Flash
[4] Yifan Lu, Qi Shao, Honghao Yue, Fei Yang - A review of the space environment effects on spacecraft in different orbits
[5] R. L. Pease - Total Ionizing Dose Effects in Bipolar Devices and Circuits

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