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DISCRETE CIRCUITS FOR LOW-BUDGET RADIATION TOLERANT SYSTEMS

Abstract

The space sector is constantly moving towards cheaper, faster turnaround missions. The proliferation of CubeSats and other programs targeting smaller payloads such as NASA's Commercial Lunar Payload Services (CLPS) program has created a new type of low-budget mission to space. These Commercial Autonomous Science (CAS) missions are often performed by groups such as universities and smaller contractors rather than government agencies. These organizations have smaller budgets and less time from conceptualization to launch. This paper discusses MoonRanger, a rover launching in 2023 on a CLPS mission to the lunar south pole to explore autonomously and measure ice content of regolith. Given the low budget and tight schedule, the rover's design uses a novel approach to building radiation tolerant circuitry.

In the space environment, all electronics are faced with radiation doses far exceeding those experienced by terrestrial systems. This radiation can cause many different types of faults, including Single Event Effects (SEE) and Total Ionizing Dose (TID) induced failures. TID leads to component failure over time, but is less of a risk for short, low-budget missions such as MoonRanger. However, single event faults can happen at any moment. They occur when a single high energy ionizing particle collides with a semiconductor, potentially causing both soft and hard faults within electronics. This means that in a harsh radiation environment, systems such as MoonRanger cannot use standard components. However, radiation-hardened components are often beyond the budget of Moonranger and similar missions. This has led to a surge in use of radiation tested Commercial Off-The-Shelf (COTS) components. However, this is a time consuming and resource intensive process requiring one to still spend substantial capital on components.

This paper proposes a new method for creating radiation-tolerant electronics with both a constrained budget and schedule. This is done by building discrete circuits out of inherently radiation-tolerant components rather than buying expensive parts or spending time and resources testing them. This approach costs physical space on a PCB rather than time or money, which can often be a more expendable resource for a mission. The paper discusses how this approach can be beneficial to a development team and the rationale behind it. It then explains how to go through the process from beginning to end. It also discusses use cases onboard the MoonRanger rover where this has been used to great effect.