Open-Source Radiation Hardening Test Structure

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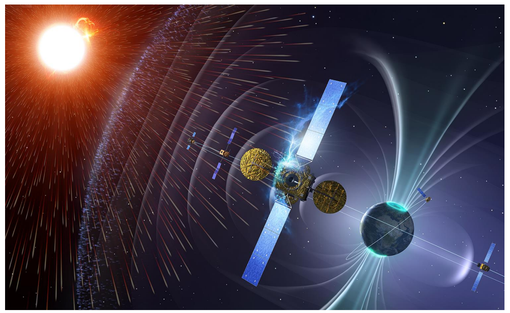
Research question: Is it possible to create a repeatable design process and test procedure for electronic radiation hardening?

Motivation

- More frequent spaceflight means higher risk of electronic radiation damage.
- Military, nuclear powerplants, and scientific research industries are at risk of radiation exposure.
- Standardized design procedures will open doors for companies to provide radiation robust products to support the space industry.



Radiation Hardening Background

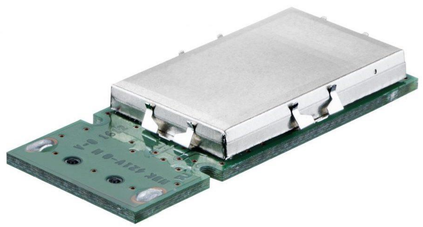
- Space radiation is composed of high energy protons, alpha particles, heavy ions, x- and gamma rays.
- Exposure to these radiation sources increases with altitude.
- High speed particles can knock electrons loose and ionize atoms which disrupts the crystal structure of a semiconductor.
- Resulting damage includes electronic noise, signal spikes, and inaccurate or incomprehensible results.
- Creating radiation hardened electronics involves circuit design, processing, and testing.

Currently Used Techniques

- **Materials**: Manufacturing on insulating substrates as opposed to typical semiconductor wafers.

Rad-hardened CMOS memory device for the Radiation Hardened Electronic Memory Experiment (RHEME).

- **Circuit type**: Bipolar integrated circuits generally have higher radiation tolerance than CMOS circuits.
- **Magneto-resistive RAM (MRAM)**: a potential candidate for rad-hardened, rewritable, non-volatile conductor memory. Memory is stored in magnetic domains.
- **Shielding**: wrapping hardware in a material that is resistant to interaction with harmful rays.



Example of circuit encased in a shielding cabinet.

Summary of Recent Experimental Radiation Test Methodologies.

- **Circuits**: most tested circuits were CMOS and diodes
- **Test methods**: several papers did not describe their specific test set up, only that an object was irradiated and the level to which it was. Others used computer simulation or mathematical analysis. We were hoping for examples done with a radiation chamber, since that is our planned test method.
- **Parameters**: most tested were threshold voltage (Vth), i-V (current-voltage) characteristics.

Conclusion

It is difficult to determine the most optimal radiation test method, as there was little to no overlap of the testing methods used. In the future, we may need to deepen our journal search or consider specific instrumentation used in space flight.

Future Research

- Choose 3-5 circuit subsystems and determine the most optimal rad-hardening techniques for them.
- Develop a test plan for the prototype structures
- Measure and plot chosen parameters of the prototypes under radiation.

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