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IMPACT: Power Control

Effects of Radiation on ICs and BJTs

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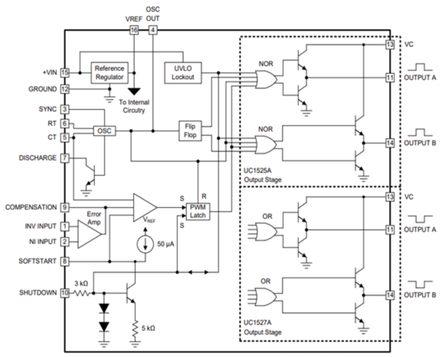
Introduction:

Radiation causes adverse effects in many things in the world. One of these affected is integrated circuits (ICs). ICs have small switches called transistors that are used to control electrical signals and allow chips to perform their tasks. When exposed to radiation these switches will begin to falter and have errors. Radiation is a major issue when leaving the Earth's atmosphere and spaceships are naturally packed with electronics. There are many ways to build circuits in simulation, however, as of right now, there is no modern way of simulating the effects of radiation. Our work focuses on simulating radiation-induced changes in BJTs and comparing these results with experimental data to develop an accurate, new, and modern modeling tool for radioactive environments.

Project Objective:

Our objective can be broken down into a few major parts:

- Build a test board and get base specifications pre-rad
- Irradiate the part at 4 levels to get data after radiation
- Use a circuit simulator to create each block of the part
- Get data from simulation to compare to non-ideal parts
- Export the simulated parts to the IMPACT code base
- Use IMPACT to get the simulated post-rad data
- Compare results to prove accuracy of simulation
- Adjust simulator as needed to match real-world results

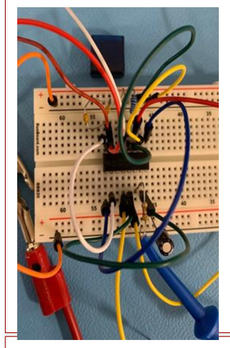


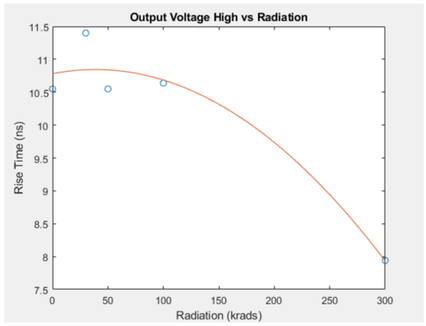
Testing Results:

Nine specs were tested and can be broken into 3 subcategories:

- Output Stage: Rise and Fall time of the Output Voltage.
- Oscillator: Max Frequency, Min Frequency, and Oscillator Capacitor Charge Time.
- Error Amplifier: Open Loop Gain, Input Offset Voltage, Input Bias Current, and CMRR

The part was irradiated using Cobalt-60 in four incremental doses of radiation: 30k rads, 50k rads, 100k rads, and 300k rads. Each pin was soldered onto a perf board and grounded before irradiation.

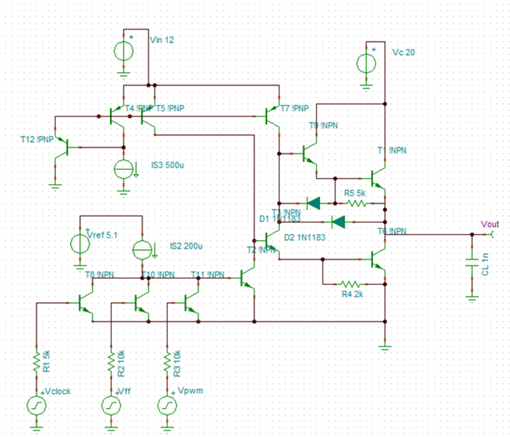




Simulation Results:

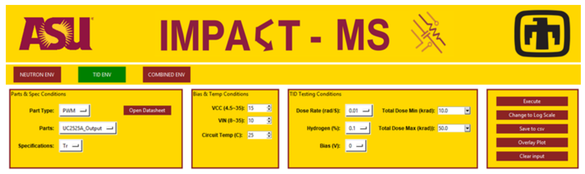
The part was broken into functional blocks, each simulated individually: the error amplifier, oscillator, output stage

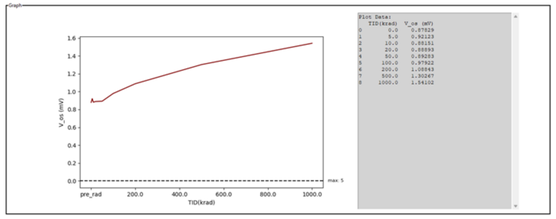
- Developed and simulated transistor-level schematics in TINA-TI simulation tool.
- Transistor sizing to match the operation to datasheet specifications and physical test data.
- Finalized layouts of the functional blocks were exported to the final code to model radiation and dosage effects.



Final Code:

- Concentrate on base current for modeling deposited positive charge.
- A diode is connected along the direction of base current flow.
- Diode parameters are modulated as the total dose increases
- This is all handled in our software IMPACT, a Python program with a GUI.
- Settings are then passed on to Xyce, a SPICE program where simulations occur.
- The results are a list of output data along with a graph





Conclusion:

- Team was able to accomplish the goal and show how radiation affected the part
- Physical test data shows a change in how the IC operates, specifically that the output voltage tends to decrease while the fall and rise times increase
- Successfully able to replicate radiation changes in IMPACT tool and plot them