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MISSION FAILURE OF AN INTEGRATED PROCESSOR AND RADIATION HARDENING  
TECHNOLOGY RESEARCH

**Abstract**

A spacecraft often operates in a rough natural radiation environment, which is composed of galactic cosmic rays, solar cosmic rays, and radiation belts of the Earth. The environment, may cause spacecraft's electronic system failure, is a big threat to spacecraft's normal operation in orbit. As much as system designers are lack of understanding of space radiation environment effect, and depend largely on design experience of predecessors, in orbit spacecraft failures caused by radiation particles still happen from time to time.

The phenomena, reasons, and measures of mission failure of an integrated processor device were deeply analyzed in this paper. After opening the device, the data which are received from the ground encountered abnormal phenomenon many times. The image that was drawn from the data was ambiguous, or even unable to be recognized. After checking the reason by many methods, including experiment validation, the problem was that the Xilinx FPGA was lacking of space environment adaptability. The observed times of the FPGA's single event upsets (SEU) was conformed to the value of calculation. Since the FPGA's function was influenced by SEU, it can only be solved by closing and opening the device to reload program, which resulting in the loss of data many times.

Simulation result indicated that saturated cross section and upset threshold of FPGA (or other SEU sensitive electrical component) were two important influencing factors of SEU. Based on the mission failure lesson, this paper combined engineering experience with simulated analysis results, and proposed many ways which concerning radiation hardening technology in detail, including hardware radiation hardening ways and software radiation hardening ways.

The ways that proposed in this paper can mitigate the SEU and extend the reliability and lifespan of spacecrafts, and it was already used in many spacecrafts. The conclusions of this way can be used to guide spacecraft design.