Radiation Hardened Circuitry Using Mask-Programmable Analog Arrays

PI: Charles L. Britton, Jr- Oak Ridge National Laboratory
Program: NEET: Advanced Sensors and Instrumentation

Collaborators: Nance Ericson- Oak Ridge National Laboratory
Benjamin Blalock- University of Tennessee

ABSTRACT:

Since the end of the Cold War, the primary military need for radiation-hardened semiconductor processes has all but vanished. The driver up until the late 1980's was the expectation of nuclear exchanges that could instantaneously damage military components in exposed aircraft or ground-based systems. At the end of the Cold War, the need for radiation-resistant electronics transitioned to space-based applications such as satellite systems. The requirements for this environment are quite different as the total dose received by space-borne devices occurs over a much longer time period and therefore other types of radiation events such as single-event effects (SEE) become more important. The radiation damage issues to be considered in building electronic systems for robotics that will potentially be used for post-accident inspection and monitoring in nuclear power plants lie somewhere between the Cold War instantaneous dose effects and the present day satellite continuous dose combined with the SEE.

The reduced availability of truly radiation-hardened semiconductor processes has resulted in development of a variety of techniques to mitigate some of these effects while using standard, readily-available commercial processes. Collectively these techniques are referred to as radiation-hardened-by-design or RHBD. These techniques extend from actual transistor layout techniques to reduce device damage to the use of special circuit architecture designs ensuring that damaged devices will not be allowed to override the operation of good devices. Radiation tolerant electronics are therefore one of the major limiting technologies preventing effective telerobotic application to high radiation environments present under severe accident conditions or in support of fuel reprocessing. Moreover, the electronics, once developed, are low cost enabling frequent replacement when used under high dose-rate conditions.

This project will develop and demonstrate a general-purpose data acquisition system built from commercial or near-commercial radiation-hard analog arrays and digital arrays that will be the building blocks of a family of future fieldable radiation-hard systems.

The outcome will result in the prototype rad-hard data acquisition system that will be constructed and tested to demonstrate functionality and rad-hardness of the identified commercially available technology, as applied to a nuclear reactor environment. The system prototype will be delivered along with measured functional metrics for both pre- and post-radiation scenarios. Comparison of this data will be performed and will validate the radiation survivability of this technology path. In addition, the measured degradation observed in each of the circuit functions will also be summarized. Successful completion of this project will demonstrate the feasibility of using commercial or near-commercial radiation-hardened custom circuits for this application.