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Structures and Methods for Design Automation of Radiation Hardened Triple Mode Redundant Digital Circuits

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Protecting high performance integrated circuits (ICs) from ionizing radiation induced upset is a key issue in the design of microcircuits for applications such as spacecraft, high altitude aircraft, and around nuclear accidents or nuclear warfare. A radiation induced soft error occurs in a semiconductor device when a high-energy particle travels through the semiconductor, leaving an ionized track behind. The resultant charge can cause a transient voltage glitch called a single event transient (SET) or flip a bistable storage cell to its opposite state, called a single event upset (SEU). The charge collection can affect multiple nodes. To ensure hardness, this requires that the critical nodes be placed far enough apart so that one ionizing track does not affect the other nodes. Radiation hardening by design (RHBD) is a new method that promises to allow commercial circuit speeds by using state-of-the-art foundries. However, many current RHBD techniques significantly affect circuit speed.

Researchers at Arizona State University have developed a fully automated circuit design and CAD methodology to implement single event effect (SEE) hardened application specific integrated circuits (ASIC) using triple mode redundancy (TMR) synthesis and automated place and route that is fully self-correcting and guarantees effective critical node spacing. The TMR circuits have been experimentally proven in both heavy ion and proton testing on both the low standby power and standard versions of trusted foundry CMOS technology. This technology allows standard non-redundant register transfer language input to synthesize and fully automate placement and routing of circuits, with virtually no timing penalty when compared to unhardened circuitry. The layout of the circuits ensures that critical nodes are suitably placed so as to make the nodes radiation hardened by design.

Potential Applications

- Space Vehicles
- Satellites
- High Altitude Flight
- Devices Used Near Nuclear Accidents or Nuclear Warfare

Benefits and Advantages

- Dependable - Produces circuits that are radiation hardened
- Easy Application - Simple to use automated place and route of circuitry
- High Speed - Virtually no timing penalty over unhardened circuits

