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Design Automation of Radiation Hardened Mixed Single, Dual, and Triple Mode Redundant Digital Circuits

The fundamental building blocks of all computer electronics, integrated circuits (ICs) are the least expensive way to create the digital circuits needed for processing binary information. A soft error is when a binary switch within a digital circuit flips to its opposite state and causes an electronic device to malfunction. Modular redundancy is a method of radiation hardening by design (RHBD) that acts as a fail-safe for soft error in which multiple switches produce a single output based on their majority state. However, particles energized by radiation create "ionizing tracks" within a semiconductor that can cross several circuit nodes and trigger multiple soft-error malfunctions, effectively thwarting the redundant design. To ensure hardness, critical circuit nodes must be placed far enough apart so that one ionizing track does not affect multiple nodes, but this increases delay and power consumption. Current computer aided design (CAD) software is designed to minimize delay and power consumption by placing nodes of an IC as close together as possible, therefore, new CAD methodology is needed that implements state-of-the-art RHBD.

Researchers at ASU have developed a fully automated circuit design and CAD methodology to implement RHBD application specific ICs (ASICs) using mixed single, dual, and triple modular redundant synthesis and automated place and route. The computer drafted ASICs can be used to manufacture physical ASICs that have self-correcting modular redundancy and effective critical node spacing. This methodology invokes modular redundant design using standard, non-redundant CAD input, and completely automates placement and routing with essentially no timing penalty over conventional unhardened circuits. Since each modular redundant switch has independent clock and control signals, full clock and control gating for low power is also supported. This methodology is entirely compatible with existing commercial CAD software, and existing CAD tools can even be used without modification by enforcing the correct operations in the correct order.

Potential Applications

- Electronic Components for
  - Spacecraft
  - Satellites
  - Nuclear Reactors
- Electronic Design Automation
- Technology CAD Software

Benefits and Advantages

- Compatible – Can be used with any existing CAD IC development software.
- Faster – Produces radiation-hardened ASICs with no timing penalty over conventional unhardened circuits
- Reliable – Automation ensures self-correcting modular redundant design and effective critical node spacing needed for radiation hardening.

For more information about the inventor(s) and their research, please see

Dr. Lawrence Clark's directory webpage