School of Electrical, Computer and Energy Engineering

**PhD Final Oral Defense**
Fully Automated Radiation Hardened by Design Circuit Construction

by
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**Abstract**
A fully automated logic design methodology for radiation hardened by design (RHBD) high speed logic using fine grained triple modular redundancy (TMR) is presented. The hardening techniques used in the cell library are described and evaluated, with a focus on both layout techniques that mitigate total ionizing dose (TID) and latchup issues and flip-flop designs that mitigate single event transient (SET) and single event upset (SEU) issues. The base TMR self-correcting master-slave flip-flop is described and compared to more traditional hardening techniques. The circuit approach is validated for hardness using both heavy ion and proton broad beam testing. For synthesis and auto place and route, the methodology and circuits leverage commercial logic design automation tools. These tools are interfaced with custom CAD tools designed to enable easy conversion of standard single redundant hardware description language (HDL) files into hardened TMR circuitry. The flow allows hardening of any synthesizable logic at clock frequencies comparable to unhardened designs and supports standard low-power techniques, e.g. clock gating and supply voltage scaling.