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Radiation-Tolerant, High-speed Serial Link Design with SRAM-based FPGAs

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In the field of High Energy Physics experiments, high-speed serial links implemented on SRAM-based FPGAs have been extensively used in the trigger and data acquisition systems. Their application has been usually limited to the off-detector electronics, due to SRAM-based FPGA susceptibility to ionizing radiation effects. However, in order to use these devices in radiation environments, dedicated mitigation techniques can be adopted: information redundancy (typical of error correcting codes), hardware redundancy - such as triple modular redundancy (TMR) - and configuration scrubbing.
In this paper, we present a serial link running at 6.25 Gbps implemented in a Xilinx Kintex-7 FPGA which is protected against radiation effects by means of all the above-mentioned methods.
The link uses a self-synchronizing scrambler for data randomization and a Reed-Solomon encoder/decoder, whose error correction capability is increased by adopting the interleaving technique. The link can vary the protection level of the Reed-Solomon code to cope with different rates of radiation induced faults, trading the available bandwidth off for data redundancy. The reliability of the link is also improved by means different TMR strategies. Moreover, on the same FPGA, a scrubber repairs corrupted configuration frames in real-time.
We present the test results carried out using the fault injection method. We show the performance of the link in terms of mean time between failures (MTBF) of its subcomponents. We also present measurements of mean time between losses of lock of the link. Furthermore, we show the effective bit error ratio (BER) and FPGA current trends versus injected upsets.

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Description

SRAM

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