Docket #: S09-055

High Fidelity, Radiation Tolerant Analog-to-Digital Converter

Stanford researchers have patented a radiation-tolerant, pipeline analog-to-digital converter (ADC) in a fully commercial CMOS technology. A novel digital self-calibration algorithm is used to achieve wideband high fidelity (90-dB SFDR) at low power (60 mW) and megahertz sampling rates (5 MS/s), and radiation-hardness-by-design techniques are used to overcome radiation damage effects such as transistor parameter shifts, increased transistor leakage current, and single event effects (e.g., charge accumulation, latchup). The stated performance is sustained through a total dose of 1 Mrad(Si) and the converter displays no latchup up to an LET of at least 63 MeV-cm2/mg (highest tested LET) at elevated temperature (130 degrees C) and supply. While demonstrated in a 0.25-um bulk CMOS process (single-well, STI interdevice isolation, non-epitaxial substrate), both the self-calibration algorithm and the radiation-hardness by design techniques can be readily applied to other manufacturing processes to achieve robust, high-fidelity, wideband analog-to-digital conversion.

Applications

- **Wideband systems** where high-fidelity digitization is needed, including broadband communication systems (e.g., digital radio, OFDM) and observational applications (e.g., remote sensing, spectrographic studies).
- **Satellite systems** where low power and radiation tolerance are key. The high radiation tolerance enables orbits even directly through the Earth's radiation belts, as well as orbits around other radiation-intensive planets (e.g., Jupiter). Applications range from communication links to housekeeping/monitoring system to instrument payloads.
- **Terrestrial radiation environments** where electronic monitoring and measurement equipment is exposed to radiation, including:
    - Nuclear power plants

    - Particle accelerators
    - Radiation processing, where products are exposed to radiation for cleansing (e.g., foodstuffs, waste treatment), sterilization (e.g., medical supplies), or materials modification (e.g., polymers, silicon processing)
    - Nuclear medicine, especially patient monitoring and data collection equipment

Advantages

- No other radiation-hard ADC currently available with comparable specifications.
- Self-calibration algorithm requires very little additional digital signal processing hardware.
- High level of radiation tolerance achieved in low-cost, easily accessible, fully commercial CMOS manufacturing process.
- 5 MS/s sampling rate captures full 1-MHz bandwidth with sufficient bandwidth for proper, high-fidelity anti-aliasing filtering.
- Techniques readily applicable to other manufacturing processes and circuits to produce high-performance, low-power, radiation-hard electronics.

Publications

- US Patent Issued 8,184,033: High fidelity, radiation tolerant analog-to-digital converters

Patents

- Published Application: 20110169678
- Issued: 8,184,033 (USA)

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