Contribution ID: **124** Type: **Oral**

The lpGBTIA, a 2.5 Gbps Radiation-Tolerant Optical Receiver for InGaAs photodiodes

Friday, September 6, 2019 9:25 AM (25 minutes)

The Low Power GigaBit Transimpedance Amplifier (lpGBTIA) is the optical receiver amplifier in the lpGBT chipset. It is a highly sensitive transimpedance amplifier designed to operate at 2.56 Gbps. It is implemented in a commercial 65 nm CMOS process.
The device has been designed for radiation tolerance and, in particular, to accommodate the radiation effects in photodiodes that manifest themselves as an increase of both their dark current and junction capacitance. The operation of the lpGBTIA was successfully tested and this paper describes its architecture, the experimental and irradiation results.

Summary

High-energy physics experiments in the LHC require high-speed optical links for transmission of large amounts of data between the experiments and the counting room. In certain detectors or sub-detectors, the radiation levels reach 2 MGy and 1E15 particles/cm2. High-speed optical links and their constituent electronic and optoelectronic devices need thus to sustain such high radiation levels. In this paper, we report on the design of the radiation-tolerant lpGBTIA that is a highly sensitive optical receiver amplifier operating at 2.56 Gbps.
The first element of an optical receiver is the photodetector to convert the input optical signal into an electrical current. Given the relatively low radiation-induced degradation of the responsivity of InGaAs photodiodes, they are good candidates to implement optical transmission systems in HEP experiments. However, for these devices, radiation also results in a strong increase of the leakage current (up to 1 mA) and in a large increase of the junction capacitance especially at low reverse bias voltages that are typically encountered in detector systems due to power supply voltage limitations.
The lpGBTIA is designed to accommodate radiation-induced changes in InGaAs photodiodes. It is based on a differential structure to suppress power supply and substrate noise. It consists of a transimpedance amplifier, a limiting amplifier and a 100 Ohm output stage. The design is implemented in a commercial 65 nm CMOS process and radiation tolerant design principles have been followed in the design to ensure a high tolerance to the total ionizing dose.

Due to the relatively large impedance of the photodiode bias circuit, large dark currents can reduce the voltage across the photodiode and thus prevent the optical receiver from operating properly. To avoid this, a novel bias circuit for the photodetector has been designed and implemented in the chip to maintain sufficient voltage across the photodiode in the presence of the high DC leakage currents induced by irradiation. Moreover, this helps to maintain the capacitance of the photodiode within the low values needed for operation at 2.56 Gbps.
The bandwidth and the input-referred noise current of the lpGBTIA depend significantly on the photodetector capacitance. The pre-irradiation capacitance photodiode used in this optical receiver is typically less than 500 fF. The transimpedance input stage of the lpGBTIA is however optimized for 2 pF to accommodate the expected increase due to radiation.
The lpGBTIA chip size is 1750 µm × 461 µm. It has been fabricated and it is currently under characterisation. First measurements at 2.56 Gbps display a sensitivity better than -19 dBm for a BER of 1E-12. The differential output across an external 100 Ohm load remains constant at 400 mVpp even for signals near the sensitivity limit. The total power consumption is less than 67 mW. Radiation tolerance tests are being prepared and the results will be presented at the conference.

Authors: MENOUNI, Mohsine (Centre National de la Recherche Scientifique (FR)); DE OLIVEIRA FRANCISCO, Rui (CERN); OLANTERA, Lauri (CERN); TROSKA, Jan (CERN); SIGAUD, Christophe (CERN); SOOS, Csaba (CERN); VASEY, Francois (CERN); RODRIGUES SIMOES MOREIRA, Paulo (CERN)

Presenters: MENOUNI, Mohsine (Centre National de la Recherche Scientifique (FR)); DE OLIVEIRA FRANCISCO, Rui (CERN); TROSKA, Jan (CERN); RODRIGUES SIMOES MOREIRA, Paulo (CERN)

Session Classification: ASIC

Track Classification: ASIC