Contribution ID: **167** Type: **Oral**

A Radiation-Tolerant Low-power 4x10 Gb/s VCSEL Driver Array IC with on-Chip Power-On Control Circuit

Wednesday, 19 September 2018 11:35 (25 minutes)

We report the design and irradiation results of a radiation-tolerant low-power 4x10 Gbps VCSEL Driver array IC in 65 nm CMOS. The driver IC consumes 130 mW at 4x10 Gbps and occupies 1.9 mm x 1.7 mm. The IC is capable of sustaining TID up to 300 Mrad and produces no errors after being irradiated with a total fluence of 2.8e15 20Mev neutrons over 36 hours. The IC is powered by 1.2 V for the core circuit and 2.5 V for the VCSELs. An on-chip power-on circuit is designed to ensure all transistors operate reliably during power-on and normal operation.

Summary

Low-power, high-speed and radiation-tolerant Gigabit data links are needed for data transmission in High-Energy Physics (HEP) applications. Previously, we demonstrated and reported a low-power 4x10 Gb/s four-channel laser driver IC (LDQ10) implemented in 65 nm standard CMOS technology as part of the Versatile link. In this paper, we present an updated design with improved radiation tolerance and an on-chip power-on circuit as well as the TID and Neutron irradiation results of this driver array IC. The on-chip power-on control circuit ensures the right turn-on sequence of the two supply voltages (1.2 V and 2.5 V) so that the IC can operate reliably during the power-on and normal operations,

For low-power operation, the driver array IC is powered by two supply voltages: a 1.2 V supply for the core circuit and a 2.5 V for the output stage to drive the VCSEL devices. Although 2.5 V is used as the supply voltage for the output stage to provide enough voltage headroom for the VCSELs, the transistors used in the output stage are still 65nm core devices with nominal supply voltage of 1.2 V to achieve the targeted 10 Gbps data rate and bandwidth. To ensure transistors in the output stage can operate reliably, the output stage employs multiple 1.2 V transistors stacked together in a totem-pole fashion to share the voltage drop of 2.5 V, so that at any time no transistors would experience signal swings that is higher than the nominal voltage of 1.2 V. To ensure the reliable operation of all the transistors, it is required that 1.2 V supply is turned on before 2.5 V on the chip. However, Both the 1.2 V and 2.5 V supply voltages are provided on the system level and they may be turned on in a random order. To solve this problem, we design an on-chip power-on control circuit which ensures that the 1.2 V supply on the IC is always turned on earlier than the 2.5 V. This way all transistors are turned on without being jeopardized with higher than 1.2 V. The power-on control circuit adds negligible silicon area overhead and does not introduce degradation on the supply voltage that power the core and output stage. In addition, the I2C control circuit is optimized to increase its radiation tolerance.

The driver IC was irradiated with both Total Ionization Dose (TID) and Neutron irradiation. Measurement results show that the IC is capable of sustaining TID up to 30 Mrad with negligible degradation on the speed and jitter performance of the driver. The driver IC was irradiated with a total fluence of 2.8e15 20Mev neutrons over 36 hours and no error was observed. The entire driver chip consumes 130 mW at 4x10Gbps operation and occupies a silicon area of 1.9 mm x 1.7 mm. The four-channel LDQ10v2 can be directly wire-bonded to a VCSEL array with 250 µm pitch for the Versatile Link.

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Session Classification: Optoelectronics and Links

Track Classification: Optoelectronics and Links