Contribution ID: **137** Type: **Poster**

Development of a 20 Gbps PAM4 Data Transmitter ASIC for Particle Physics Experiments

Tuesday, 21 September 2021 17:50 (3 minutes)

Abstract: GBS20 is a transmitter ASIC for particle physics experiments. Two serializers each at 5.12 or 10.24 Gbps share a 5.12 GHz PLL clock. The serializers' output is combined to a PAM4 signal that drives a VCSEL. The input data channels, each at 1.28 Gbps, is scrambled by a PRBS7 that is also the internal test pattern generator. Preliminary tests indicate that the prototype works at 10.24 and 20.48 Gbps PAM4 with a TOSA. More tests, including irradiation, will be carried out. The next step is to develop a pluggable transmitter module GBT20 base on this ASIC.

Summary (500 words)

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High-speed serial data transmission is widely used to send data from on-detector readout electronics to off-detector electronics in high-energy physics (HEP) experiments, demonstrated by experiments on the Large Hardon Collider (LHC). Physics and detector developments call for high data bandwidth yet the opto-electronics components of the optical link on the detector side face challenges such as radiation, low power dissipation and low mass plus small foot print. The lpGBT ASIC developed for the high-luminosity LHC (HL-LHC) upgrades reaches 10.24 Gbps NRZ (non-return-to-zero) data rate. Re-using many of the design blocks of lpGBT and adding the PAM4 (Pulse Amplitude Modulation 4-level) combiner, GBS20 doubles the transmission data rate in the same fiber.

GBS20 has 16 input data channels (each at 1.28 Gbps) that feed the two serializers. The input data is scrambled by a PRBS7 that doubles as an internal test pattern generator. The two serializers, adapted from that in lpGBT, share the 5.12 GHz PLL also from lpGBT. The output from the serializers is combined into a PAM4 signal after through a five stages limiting amplifier. The amplitudes of the MSB and LSB can be independently adjusted to cope with possible nonlinearity in the system. The LSB or MSB driver can also be turned off, providing a way to check the serializer's NRZ output. The PAM4 output driver uses a shared inductor and a CTLE structure to adjust its bandwidth. A programmable capacitive load is added to damp overshooting as in the PAM4 signal case that is more of a problem than in the case of NRZ.

The GBS20 prototype is 2 mm × 2 mm. Test boards are assembled with electrical output through SMA connectors, a TOSA or a VCSEL die under an LC lens. Preliminary tests with the TOSA display good performances. In the single channel output mode, the OMA is 650 μW, the peak-peak jitter is 20 ps. In the PAM4 mode, the maximal OMA is 1 mW and total jitter is around 50 ps. The power dissipation is less than 250 mW when PAM4 work in 2.5 V power supply during VCSEL with maximal bias and modulation current. In some low power dissipation application filed, this ASIC dissipation can reduce to 164 mW with switching power supply to 1.2 V. A full set of optical and irradiation tests will be carried out in the coming months. We will present the results we have by the time of the conference.

Primary authors: Ms ZHANG, Li (Southern Methodist University and Central China Normal University); Dr BINWEI, Deng (Hubei Polytechnic University); Mr C.-P., Chao (APAC Opto Electronics Inc.,); Ms CHEN, s.-w. (APAC Opto Electronics Inc.); FRANCISCO, Rui (CERN); Dr GONG, Datao (Southern Methodist University); GUO, DI (Southern Methodist University); YANG, Dongxu (Southern Methodist University); HOU, Suen (Academia Sinica); Prof. HUANG, Guangming (Central China Normal University); Mr LI, C.-Y. (APAC Opto Electronics Inc.); Mr LIU, Chonghan (Southern Methodist University); Dr LIU, Tiankuan (Southern Methodist University); MOREIRA, Paulo (CERN); PRINZIE, Jeffrey (KU Leuven); Prof. SUN, Xiangming (Central China Normal University); Ms SUN, Hanhan (Southern Methodist University and Central China Normal University); Dr SUN, Quan (FNAL); KULIS, Szymon (CERN); Prof. YE, Jingbo (Southern Methodist University); Mr ZHANG, Wei (Southern Methodist University and Central China Normal University); ZHOU, Wei (Southern Methodist University)

Presenter: Ms ZHANG, Li (Southern Methodist University and Central China Normal University)

Session Classification: Posters ASIC

Track Classification: ASIC