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GBT20, a 20.48 Gbps PAM4 Optical Transmitter Module for Particle Physics Experiments

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We report a pluggable radiation-tolerant PAM4 optical transmitter module called GBT20 (Gigabit transmitter at 20 Gbps) for the high-energy physics experiments. The core of GBT20 is an ASIC GBS20. GBT20 uses an OSFP or firefly connector to input 16-bit data each at 1.28 Gbps. GBT20 drives a VCSEL die with an LC lens or a VCSEL TOSA and interfaces an optical fiber with a standard LC connector. A custom latch couples an optical fiber to the module. Preliminary test results indicate the module meets the design goal. Full test results will be presented in the workshop.

Summary (500 words)

High-speed optical links are commonly used in modern high-energy physics experiments to transmit large-volume data from detectors to counting rooms. Optical transmitter modules are essential components of optical links. Future high-energy physics experiments demand optical transmitter modules with even higher bandwidth than those currently available. Based on an ASIC GBS20 we recently developed, a pluggable radiation-tolerant PAM4 optical transmitter module GBT20 is designed.

The core of GBT20 is GBS20. GBS20 has 16 input data channels, each at 1.28 Gbps. The input data channels are split into the Least Significant Bit (LSB) or the Most Significant Bit (MSB) channels. Each input data is always sampled correctly by employing a phase aligner. The input data are scrambled with an internal 27-1 Pseudo-Random Binary Sequence (PRBS) to guarantee the DC balance of the output data stream before being fed to two 8:1 serializers. After five-stage Limiting Amplifiers (LAs), the output serial data from the LSB and MSB channels are encoded into a PAM4 signal. GBS20 drives directly a VCSEL diode and integrates a VCSEL bias generator. The ASIC operates at speeds up to 20.48 Gbps.

The GBT20 module consists of all the components of an optical transmitter module. GBT20 uses an OSFP connector or a firefly as the electrical interface. GBT20 has a VCSEL TOSA or a VCSEL die with an LC lens, both interfacing with a commercial LC connector. By employing different electrical interfaces and optical components, GBT20 has four variants (OSFP-TOSA, OSFP-lens, firefly-TOSA, and Firefly-lens). The minimum dimension of GBT20 is 40 mm (L) x 13 mm (W) x 5.75 mm(H), corresponding to the firefly-lens variant.

While the firefly variants are under production, we have conducted preliminary tests of the OSFP variants. The OSFP-TOSA module has a clear optical PAM4 eye diagram. The maximum OMA is around 1 mW. The power dissipation of GBT20 is 238 mW and 164 mW in the high or low power modes, respectively. The OSFP-lens module has higher optical noise than the OSFP-TOSA module. The difference in the noise performance may come from different VCSELs and light couplings. The irradiation tests find no single-event effect after a fluence of 8.6×10^{13} in a 400 MeV proton beam, and no obvious performance degradation after a total ionizing dose of 35 kGy. Full test results will be presented at the workshop.

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