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Downlink Equalization and Eye Opening Monitor in the lpGBT

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The architecture and experimental results for the downlink Equalizer (Eq) and Eye Opening Monitor (EOM) circuits in the lpGBT ASIC are presented. The 2.56 Gbps downlink NRZ data is received by a line receiver that is followed by a Continuous Time Linear Equalizer (CTLE) with programmable transfer function. The EOM circuit scans the output of the Eq with a time resolution of 6.1 ps and a voltage resolution of 40 mV allowing to monitor the quality of the data transmission over the channel. Both circuits have been evaluated and detailed test results will be presented at the conference.

Summary

The lpGBT ASIC is a radiation hardened gigabit transceiver. It is used to transmit data, timing and control to the detectors in the LHC experiment. The lpGBT downlink (counting room to the detectors) is typically comprised of a short optical fiber (up to 300 m) transmitting NRZ data at 2.56 Gbps. The light is converted to an electrical signal by a PIN-diode and then amplified by Transimpedance Amplifier (TIA). The length of the electrical link between the TIA and the lpGBT can be from a few centimeters to a few tens of centimeters. To be able to compensate for the bandwidth of the transmission line between the TIA and the lpGBT, a line receiver with programmable equalization (EQ) is used. The Eye Opening Monitor circuit (EOM), that follows the EQ, allows to control the quality of the signal at the output equalizer and to adjust its transfer function for optimum performance. Both circuits are fabricated as part of lpGBT in a 65 nm CMOS process.

The line receiver consists of a programmable attenuator, four equalizing stages and a buffer. As the amplitude of the input signal might be ranging from a few tens of millivolt to 1 V, the programmable attenuator which acts as the first stage of the line receiver allows for the following stages to operate linearly under all conditions. The attenuator is implemented with a passive network, providing three attenuation setting, 0 dB, 3.5 dB and 9.5 dB. A 100 Ohm termination resistor is integrated in the attenuation network. To compensate for the channel loss, each of the equalizer stages is a continuous time linear equalization (CTLE) structure in which the position of the zero is programmable by adjusting the value of resistance and capacitance. The equalizing stages are sized for low power consumption. Enclosed layout transistors (ELT) are used to minimize performance degradation under radiation. The size of the line receiver is 300 X 180 µm2, including the line receiver core circuits, ESD circuits for input and power supply, and decoupling capacitance. The simulated power consumption is below 1.8 mW in nominal condition.

The EOM follows the equalizer and allows to monitor the NRZ signal quality after equalization. It scans the equalizer output signal both in amplitude and time. A reference voltage is used to measure the signal amplitude using a differential comparator with 40 mV resolution. The time sampling resolution is of 6.1 ps and is achieved by interpolation between in-phase and quadrature clocks at 2.56 GHz. The integration of EOM allows to probe the equalizer output and serves three purposes. First, the channel losses vary from case to case making the choice of a fixed equalization

non-optimal. Second, since the line receiver is integrated in lpGBT the direct monitoring of the eye diagram is not feasible. Third, the EOM can work together with the line receiver to act as an offline adaptive decision-feedback equalization. Both circuits will be detailed and experimental results presented at the conference.

Primary authors: Dr SUN, Quan (Southern Methodist University); VICENTE LEITAO, Pedro (CERN); GONG, Datao (Southern Methodist Univeristy); GUO, Di (Southern Methodist University); KULIS, Szymon (CERN); YE, Jingbo (Southern Methodist University, Department of Physics); RODRIGUES SIMOES MOREIRA, Paulo (CERN)

Presenter: Dr SUN, Quan (Southern Methodist University)

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