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Metrics and Methods for TTC-PON System Characterization

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A new generation FPGA-based Timing-Trigger and Control (TTC) system based on emerging Passive Optical Network (PON) technology is being investigated to potentially replace the existing off-detector TTC system used by the LHC experiments. The new system must deliver trigger and data with low and deterministic latency as well as a recovered bunch clock with picosecond-level jitter. It also offers major improvements over its predecessor: bi-directionality as well as higher capacity. This article focuses on the figures of merit used to characterize the various flavours of TTC-PON system architectures, and on the techniques used to extract them.

Summary

The Timing-Trigger and Control (TTC) system is a crucial system dedicated to synchronization of experiment electronics to the LHC beam. Currently, it is a unidirectional network extensively deployed in all major detectors distributing the LHC bunch clock and the level-1 trigger accept decision (L1A) as well as individually addressed or broadcast commands to the various detector sub-partitions. To match the needs for increased payload capacity and to provide bi-directionality, a feature absent from the legacy TTC, a new generation TTC system is being investigated for off-detector use, based on Passive Optical Network technology (PON). A PON is a bidirectional (but single fibre) point-to-multipoint network architecture in which optical splitters are used to enable a master node or Optical Line Terminal (OLT) to communicate with typically 64 slave nodes or Optical Network Units (ONUs). It is based on mature devices, as the PON is nowadays the most successful solution worldwide for deploying FTTx networks.
A first TTC-PON demonstrator was built in 2010 during early investigations made at CERN, using commercial FPGAs and 1-Gigabit Ethernet PON transceivers. The first and very promising results motivated the work to explore the emerging XG-PON technology in order to better fit the user requirements in terms of latency and payload.
With the aim of proposing first prototypes for 2015, the present phase of the TTC-PON project consists of exploring several types of PON technologies and architectures being developed for commercial access networks. One or several potential solutions will be then identified and adjusted to experiment-specific TTC requirements in terms of bandwidth, clock recovery, upstream and downstream latency, as well as system feasibility, price, and compatibility with legacy TTC.
To fully evaluate and compare the performance of the existing and future TTC-PON system prototypes, a detailed set of characterization methods and criteria has been developed. The complete set consists of two groups: those that assess the functionality of the system; and those that relate to the various aspects of the enabling PON technology. The former cover: latency, payload size, recovered clock phase/jitter, and error detection/correction capability. Those related to the technology include: split ratio, dynamic range, upstream burst-mode sensitivity penalty, and CDR phase acquisition time. These parameters are evaluated by measuring Bit Error Rate (BER) and upstream Packet Loss Ratio (PLR) with changing network parameters such as split ratio, relative power ratio and phase of upstream consecutive packets, duration of the silence period between packets and training pattern duration. This article describes the metrics characterizing a TTC-PON network, the methods used to assess them and the results obtained so far.

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