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DTCC, a Point-to-Point Link for Data, Trigger, Clock and Control over Copper or Fiber

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Upgrades of the LHC detectors target significantly higher event rates and higher bandwidth over custom links which transmit data, trigger, clock and control (DTCC) between the front-end and the readout units. We report on a DTCC point-to-point link protocol designed to work over 8B/10B encoding with 2 or 4 pair copper implementation or over optical fiber. A version of the DTCC protocol over standard CAT6 cables is already used by the Scalable Readout System (SRS) [1] as data/trigger uplink and clock/trigger/controls downlink. DTCC features an automatic low-skew phase adjustment inside a crate down to 500 ps.

Summary

Developed within the RD51 Collaboration, more than 80 institutions world-wide, the Scalable Readout System (SRS) is intended as a general purpose multi-channel readout solution for a wide range of detector types and detector complexities. The scalable architecture is based on high-speed point-to-point links - with no buses involved, facilitating scalability without any loss of performance –in which the DTCC (Data, Trigger, Clock and Control) link is a key component.

The DTCC link hosts all digital communications between the Front-End Cards (FEC) and the Scalable Readout Unit (SRU) for large SRS system (up to 82 kchannels). With digital front-ends, the DTCC link can be also used as interface between the FEC cards and the front-end electronics. Therefore, the DTCC link allows to establish a connection between all the elements of an SRS system. In this way, the user can manage each element of the chain from an online PC or farm, via 1, 10 GbE network ports or another application specific protocol, or even from a Passive Optical Network (PON) planned to handle trigger commands.

The DTCC link is a generic protocol that can be used in any system because of its high versatility. It offers different manners of use, over standard SFTP (Shielded Foiled Twisted Pair) Category 6/7 cables, HDMI cables (in both cases with LVDS signalling) and also by means of optical fiber (using FPGA transceivers) if higher date rates and/or a longer cables are required.

An outstanding characteristic of the DTCC link is its low-skew clock distribution based on the Digital Dual-Mixer Time Difference (DDMTD) method. Thus, all the FEC cards achieve a perfect synchronization, getting a low-skew between all of them, under 500 ps. This synchronization is reached dynamically and is independent of the length of the DTCC links. On the other hand, the link offers two data channels, with low and high priority. Both channels are time multiplexed using the out-of-band signalling provided by the 8B/10B encoding, with the exception that the high-priority channel can interrupt any ongoing data transmission, which is later resumed after completion of the high-priority transmission. In this way, the high-priority channel provided fixed latency necessary for the timing information (like trigger and flow control). The low-priority channel is sub-partitioned between DAQ data frames and Ethernet transmission for slow-control.

As described above, the DTCC link is a very important part of the SRS system since it makes possible for different experiments and applications within the collaboration to synchronize and configure the readout nodes, while gathering DAQ data from the detectors over the same link.

The architecture, implementations and outcome of the DTCC link will be presented.

[1] "Front-End Electronics for the Scalable Readout System of RD51"
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