

## Large systems with high resolution timing

Current technology permits to build large systems. For several projects (LHC at CERN, FAIR at GSI and KM3NeT at NIKHEF) an active compensated, high resolution timing system is required.

A high resolution PTP system would meet our requirement but is not available. Therefore an open collaboration, called “White Rabbit” [1], [2], was started. White Rabbit is a fully deterministic Ethernet-based field bus for general purpose data transfer and synchronization. The aim is to be able to synchronize more than 1000 nodes with sub-ns resolution. The key technologies used are Synchronous Ethernet and PTP (IEEE 1588).

A primary reference clock is distributed via the network as part of the network protocol [3]. The clocks of the receivers are carrier synchronized to the primary reference clock. All connections on the network are therefore synchronous to the primary reference clock.

For every point to point connection a timing marker signal is sent forth and back to measure the total propagation delay in bit clocks (see Figure 1). This results in a sub nanosecond timing resolution (for a Gigabit Ethernet 1000BASE-X connection one bit clock equals 800 ps).

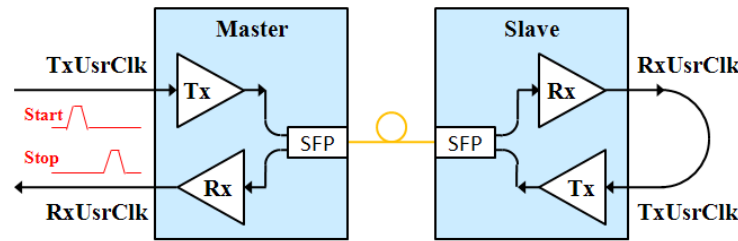


Figure 1: Clocks and timing marker on a point to point connection

To acquire a higher and continuous timing resolution, the phase relation between the transmitted and received clock is measured continuously at the master, which enables tracking of changes in propagation delay due to for example temperature or pressure.

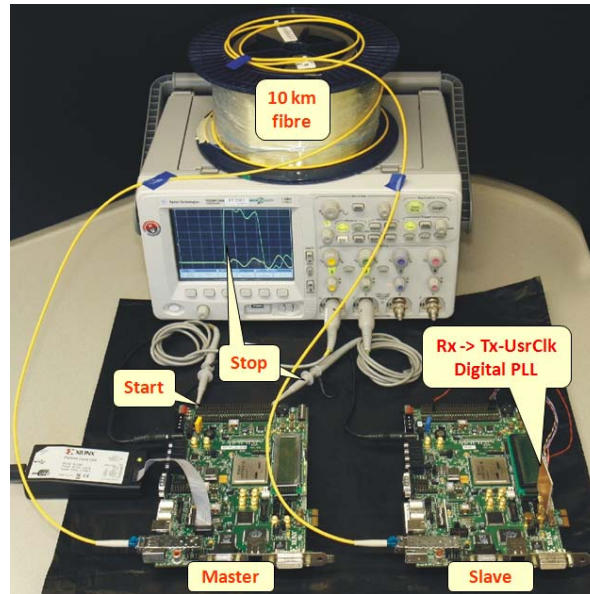


Figure 2: Test setup

A test setup (Figure 2) was built to verify the feasibility of measuring propagation delay over a bidirectional data link. Results are described in [4].

## References

- [1] <http://www.ohwr.org/projects/show/white-rabbit>
- [2] <http://www.ohwr.org/documents/21>
- [3] P.P.M. Jansweijer, H.Z. Peek, *Measuring propagation delay over a coded serial communication channel using FPGAs*, Nucl. Instr. and Meth. A (2010), <http://dx.doi.org/10.1016/j.nima.2010.04.126>
- [4] <http://www.nikhef.nl/pub/services/biblio/technicalreports/ETR2010-01.pdf>