Time-Transfer over Optical Fibre Using Pseudo-random Noise Ranging

Michael J. Wouters

National Measurement Institute, Sydney, Australia

Email: Michael.Wouters@measurement.gov.au

NMIA has been developing methods for time and frequency transfer over optical fibre, initially with an eye towards radio-astronomy applications.[1,2] More recently, we have been working on time-transfer, since this has potentially wider applications than precise frequency transfer.

We have chosen to make the delay measurements required for a time-transfer system via pseudo-random noise (PRN) ranging, similar to the technique used in modems designed for two-way time-transfer via satellite. The reasons for this choice are that: the technique can be implemented with relatively simple, FPGA-based signal processing electronics; there is potential for multipoint distribution via the orthogonality of properly chosen PRN sequences; and such a system would integrate well with our already-reported digital radio-frequency distribution technique.

The electronics have been prototyped using a National Instruments FPGA development platform. FPGA programming is done in LabVIEW, whose parallelism is particularly suited to the FPGA programming model.

The prototype system comprises two identical stations, each with a 1530-nm DFB laser transmitting to the other station. PRN codes are modulated onto the laser beam using a Mach-Zehnder intensity modulator, with timing for the codes defined by the local RF reference and a phase-coherent one pps trigger. Each station has an FPGA device for signal generation and processing. The performance of this system, operating on a 100-km link simulated by a fibre spool in the laboratory, is shown in Fig. 1. The time deviation is less than 1 ps.

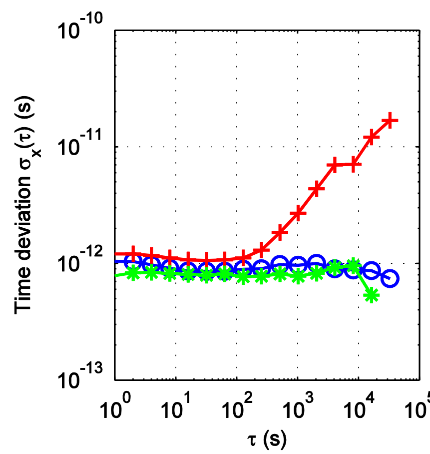

Fig. 1: Time deviation of the delay measured on a 100-km link. Key: (+) one-way delay; (o) two-way delay; (*) noise floor.

Recent work has focused on improving some aspects of the electronics to allow operation over longer distances; understanding and mitigating the causes of some periodic systematic errors which otherwise limit the accuracy of the time-transfer; multipoint transfer; and the use of longer PRN codes.

---

[1] M. T. L. Hsu et al "All-digital radio-frequency signal distribution via optical fibers", IEEE Phot. Tech. Lett., vol. 24, p. 1015–1017, 2012.

[2] Y. B. He et al "Stable radio-frequency transfer over optical fiber by phase conjugate frequency mixing", Optics Expr., vol. 21, p. 18754–18764, 2013.