URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Optical Fibre Link for Traceability in EGNSS

D. Calonico(1), C. Clivati(1), A. Mura(1), I. Sesia, G. Signorile, A. Tuozzi (3) and F. Levi(1)
(1) Quantum Metrology and Nanotechnology Division, INRIM, Turin, Italy e-mail: d.calonico@inrim.it;
(2) Agenzia Spaziale Italiana, ASI, Rome, Italy

Coherent optical fiber links have been developed for frequency dissemination demonstrating the best achievable performances [1-3], with relevant applications also in other scientific and technological areas [4, 5]. Timing and time transfer over fibre is also very accurate, stable and resilient, and different techniques have been proved: among them, Precision Time Protocol (PTP) offers also a a standardization level [6]. An outstanding evolution of PTP is called White Rabbit (PTP-WR), a time transfer method invented at CERN [7], now close to standardization with the name PTP-High Accuracy Option. PTP-WR offers benefits in terms of stability and accuracy, cost effectiveness with respect to other techniques, and the inclusion within the standardization via the update of IEEE-1588 [6], most likely already in 2020. Also PTP-WR has been applied in different scientific areas where synchronization and timing is needed [8, 9].

INRIM developed a coherent fiber-optic link in Italy realizing a fiber backbone for T/F distribution and quantum applications [1, 10]. This backbone has been equipped with coherent frequency transfer over 1850 km, but also with time transfer using PTP-WR over about 1200 km. This latter link is now connecting different point of presence for industry and for GNSS applications. We are now able to disseminate UTC(IT) at the sub-nanosecond level with a time deviation of 10 ps over days of continuous operations. Expected performance in terms of reliability are even longer, and we are ready to implement continuous operations.
The Time and Frequency infrastructure is now ready to offer traceability to the International System of Units also for the EGNSS program, connecting INRIM (in Turin) with Rome and middle Italy, where ground operations for EGNSS are present. The optical fibre link can offer both frequency traceability through the primary realizations based on the atomic clocks at INRIM, and time traceability to UTC through the Italian Time scale UTC(IT).
The realization is partly within the DTF-Galileo project funded and deployed with the Italian Space Agency (ASI).

At the conference, we will describe the results on the optical fibre link for EGNSS: the general architecture, the innovative adopted solutions, the achievements in terms of accuracy, stability and reliability. Also, we will illustrate other recently achieved results obtained at INRIM for Time and Frequency transfer using optical fibres.

References

[1] K. Predehl et al. “A 920-Kilometer Optical Fiber Link for Frequency Metrology at the 19th Decimal Place”, vol. 336, p. 441-442, DOI: 10.1126/science.1218442, 2012
[2] D. Calonico, et al. “High-accuracy coherent optical frequency transfer over a doubled 642-km fibre link,” Appl.Phys.B 117, 979–986, (2014)
[3] C. Lisdat, et al. “A clock network for geodesy and fundamental science,” Nat. Commun. 7, 12443 (2016).
[4] G. Marra, et al., “Ultrastable laser interferometry for earthquake detection with terrestrial and submarine cables”, Science 10.1126/science.aat4458 (2018)
[5] C. Clivati et al., “A VLBI experiment using a remote atomic clock via a coherent fibre link,” Sci. Rep. 7, 40992-8, (2017)
[6] IEEE Instrumentation and Measurement Society, “IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE Std 1588-2002).”
[7] M. Rizzi, et al. "White Rabbit Clock Characteristics", ISPCS2016, Stockholm, Sweden, 2016
[8] M.Jimènez-Lopèz, et al. “A Fully Programmable White-Rabbit Node for the SKA Telescope PPS Distribution System”, IEEE Transa. Instrum. Meas., Early Access, p. 1-10, 2018. .
[9] A. Creusot (KM3NeT Collaboration), Calibration, performances and tests of the first detection unit of the KM3NeT neutrino telescope, in proceedings of 34th ICRC, The Hague, The Netherlands, PoS(ICRC2015)1154 (2015).
[10] D. Bacco, et al. “Field trial of a three-state quantum key distribution scheme in the Florence metropolitan area,” EPJ Quantum Technology 6, 5 (2019).