

Parallel Transfer of Time and Frequency Signals Over Single Optical Carrier via Fiber Link

Hanxu Wu¹, Xiaoming Zhang², Haifeng Wang¹, Xinyi Chen¹, Yang Fu¹, Weinan Zhao¹,
Honglei Yang^{1,*}, Shengkang Zhang^{1,*}, and Jun Ge¹

¹ Science and Technology on Metrology and Calibration Laboratory, Beijing Institute of Radio Metrology and Measurement, Beijing, China 100854

² Department of Electronic Engineering, Tsinghua University, Beijing, China 100084

* yhlpc@163.com, zhangsk@126.com

Abstract: With the rapid development of quantum frequency standards, remote precise time and frequency transfer is becoming increasingly important for diverse scientific research applications, such as large-scale optical clock networks, global positioning and timing, very-long baseline interferometry, and high-sensitivity tests of fundamental physics.

In this paper, we present simultaneous transfer of optical carrier frequency, microwave frequency, and time over single optical channel in fiber. The prototype makes full use of both coherent optical detection and pseudo-coded spread spectrum modulation, which benefits with parallel detection of the multiple time and frequency with a single detector, effectively reducing the dispersion and non-reciprocal effect, and increasing utilization rate of fiber link.

Preliminary experiments indicate that the additional fractional frequency stability of optical carrier reaches 1.69×10^{-16} at 1-s averaging time over a 100 km fiber link in the laboratory. Meanwhile, the time deviation and additional fractional frequency stability of microwave frequency reaches 90 fs and 1.56×10^{-13} at 1-s averaging time, respectively. This approach has a potential in extending to free-space parallel transfer of time and frequency signals to support satellite-to-ground/inter-satellite precise time-frequency comparisons and high-speed laser communications.

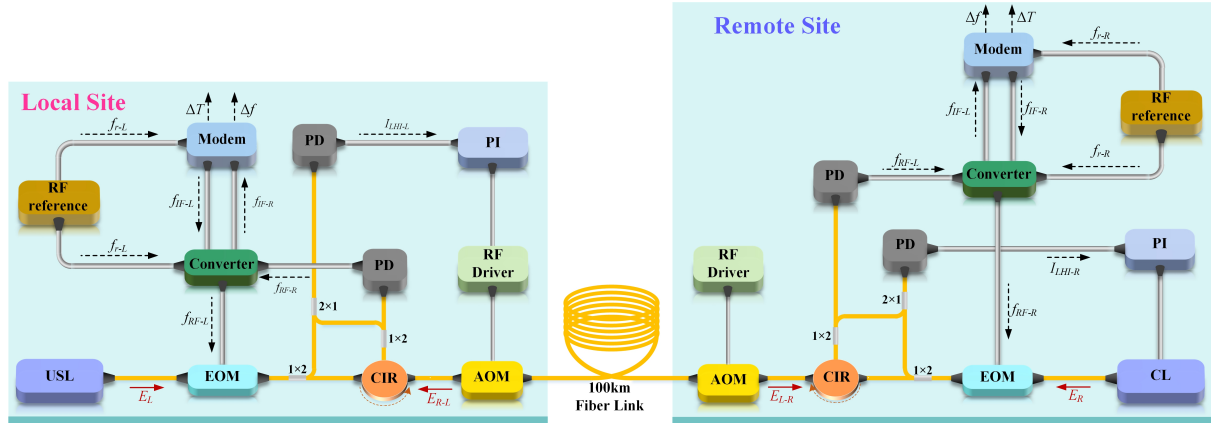


Fig. 1 Principle of parallel transfer of time, microwave frequency and optical frequency over fiber link. USL: ultra-stable laser, EOM: electro-optic modulator, PD: photodetector, CIR: circulator, AOM: Acousto-optic modulator, PI: proportional integral controller, CL: coherent laser.

References

- ¹ S. Droste, F. Ozimek, Th. Udem, K. Predehl, T. W. Hänsch, H. Schnatz, G. Grosche, and R. Holzwarth, "Optical-frequency transfer over a single-span 1840 km fiber link", Phys. Rev. Lett. vol. 111, p. 110801, 2013.
- ² N. R. Newbury, P. A. Williams, and W. C. Swann, "Coherent transfer of an optical carrier over 251 km", Opt. Lett., vol. 32, p. 3056-3058, 2007.
- ³ O. Lopez et al., "Simultaneous remote transfer of accurate timing and optical frequency over a public fiber network" Appl. Phys. B, vol.110, p. 3-6, 2013.