Simultaneous Accurate Timing & Frequency Transfer Over 540-km Through A Public Fiber Network

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Motivations

Frequency transfer over fiber has been demonstrated with uncertainties < 10−12 on distances of several hundred of km, with dark fiber and dark channel approaches [1-3]. The results are much better than those of satellite-based frequency comparisons, and open the way to accurate remote clocks comparison [4-8] and advanced tests of fundamental physics [9,10].

Accurate frequency transfer has also a key role for geodesy, high resolution radio-astronomy, modern particle physics, and for the underpinning of the accuracy of almost every type of precision measurement. For all these applications, accurate timing is also essential and gives the opportunity to precisely synchronise distant experiments.

Fiber-optic two-way time transfer methods have been demonstrated on dedicated links with an accuracy of the order of a few tens ps to a fraction of a ns [11,12]. Long distance accurate time dissemination is usually based on the signals of the Global Navigation Satellite System (GNSS), or dedicated geostationary satellites, with timing accuracy of the order of 1 μs in the best case [13,14].

In this work we present a novel method to simultaneously disseminate an ultra-stable optical frequency and accurate timing over a public telecommunication network on a 546 km optical link simultaneously carrying Internet data traffic, using a dedicated “dark” channel.

Experimental set-up

Time & Frequency Transfer

Time Delay Measurement

1. Delay calibration: Link’s length was varied from 10 m to 94 km, 400 km and 546 km along the public telecommunication link with fixed overall attenuation (attenuators). The procedure was repeated with 25km, 50km, 75km, 100 km fiber spools.
2. Differential delay variation < 50 ps
3. Power sensitivity < 15 ps/dB
4. Fiber chromatic dispersion < 25 ps
5. Polarisation mode dispersion (PMD) < 20 ps (network characteristics) < 50 ps (measurement)
6. Sagnac = 0

Link architecture

Experimental results

References