

On-Line Tests of Real-Time Time Scale Generation Algorithms Based on a Primary Frequency Standard and a Clock Ensemble

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Abstract— Recently, the official Italian time scale UTC(IT) has been successfully automatically generated in real-time, with a steering algorithm using Rapid UTC (UTCr) as steering reference [1]. This work aims to present the results of an on-line test of other two steering algorithms: one using the INRIM cesium fountain (ITCsF2) [2], and another one using an ensemble of various commercial clocks, as steering references alternative to UTCr [3].

Keywords—time scale; steering; atomic clocks; cesium fountain; clock ensemble;

I. MOTIVATION

Since January 2020, the UTC(IT) time scale has been generated by steering active hydrogen masers towards UTCr and has achieved a 95th percentile of 4.5 ns over one year, demonstrating that UTC(IT) is a stable and accurate local realization of UTC. Recent substantial works in operating INRIM cesium fountain ITCsF2 improved the reliability and availability of the INRIM primary frequency standard, allowing to measure almost continuously UTC(IT) master hydrogen maser frequency, providing daily frequency data for the steering algorithm. This improvement allows to generate a time scale using more updated steering reference information than using UTCr, which is available on the BIPM website (<https://www.bipm.org/en/bipm-services/timescales/time-ftp/Rapid-UTC.html>) with up to 10 days of delay. A steering algorithm using the laboratory primary frequency standard as steering reference is then being tested in real-time, with a dedicated test set-up, starting from the middle of February 2021.

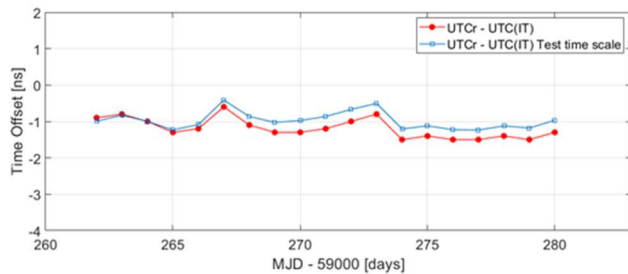


Fig. 1. Test time scale generated by steering with ITCsF2 vs the official UTC(IT) time scale steered towards UTCr

Apart from the active hydrogen masers, the laboratory also hosts several commercial Microsemi 5071A cesium clocks. The available clocks can be used to generate an ensemble time scale to be used as an additional steering reference. In the past, we performed an offline simulation of an ensemble-based steering algorithm with historical clock data [3], where only Cs clocks entered the ensemble, which showed promising results. Here, we present our effort to include the hydrogen masers in the ensemble, in order to improve the short-term stability of the resulting time scale. An online test is foreseen starting in April 2021 by implementing the algorithm in a MATLAB[®] program and integrating it in a general modular software architecture [4].

II. RESULTS

The time scale generated using near real-time frequency measurements from the cesium fountain ITCsF2 shows great stability over the first month of operation. Fig.1 shows the comparison of the real-time test time scale and the official UTC(IT) with respect to UTCr; the steering corrections of the two scales, realized with the same hydrogen maser, agree at 1e-15 relative units (Fig. 2). More updated results will be presented at the conference, along with those of the clock ensemble test, once validated.

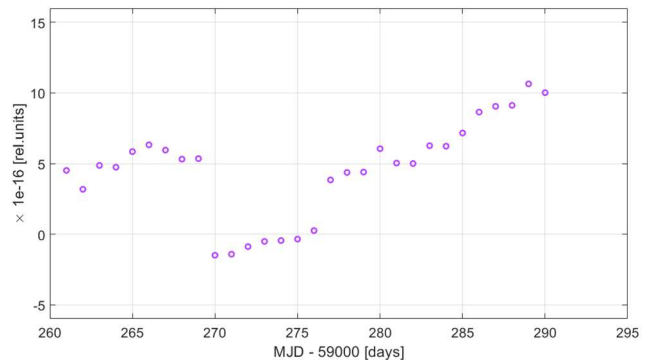


Fig. 2. Difference between steering corrections estimated based on ITCsF2 for the test time scale and UTCr for the official UTC(IT), for the same master hydrogen maser

REFERENCES

- [1] V. Formichella, G. Signorile, T. T. Thai, A. Perucca, E. Cantoni, M. Sellone, A Mura, I. Sesia and F. Levi, "Reliable and Robust Real-Time Time Scale Generation: Developments and Experimental Results at INRiM," Proceedings of the 51st Annual Precise Time and Time Interval Systems and Applications Meeting, San Diego, California, January 2020, pp. 340-346, <https://doi.org/10.33012/2020.17309>.
- [2] Filippo Levi et al 2014 Metrologia 51 270
- [3] L Galleani et al 2020 Metrologia 57 065015.
- [4] A. Perucca, T. T. Thai, F. Fiasca, G. Signorile, V. Formichella, I. Sesia and F. Levi, "Network and Software Architecture Improvements, for a Highly Automated, Robust and Efficient Realization of the Italian National Time Scale", accepted for publication in Proceedings of EFTF-IFCS 2021.