Improving the Uncertainty of NIST Remote Time and Frequency Calibration Services

Andrew N. Novick[1], Aidan A. Montare[1]

[1]National Institute of Standards and Technology, Boulder, CO, USA

Email: novick@nist.gov

The National Institute of Standards and Technology (NIST) has offered remote time and frequency calibration services since the late 1980s. At that time, the Services Group was calibrating frequency references at a customer's site using terrestrial radio signals, and the service was later upgraded to using signals from the global positioning system (GPS) satellites. The original Time Measurement and Analysis Service (TMAS) was introduced in 2006, which used the GPS common-view method to make ongoing time comparisons between UTC(NIST) and a remote clock or oscillator, and the results were available in near real-time online. A major benefit of a remote calibration service is that the device under test (DUT) can be measured continually, while it is in operation, instead being sent to a laboratory periodically. Constant legal traceability to the International System of Units (SI) warrants several advantages, including more robust traceability when using the calibrated device as a reference for local measurements and very early indication if the DUT is not working correctly.

Several improvements have been implemented since the service began. Originally, the system utilized a single-frequency eight-channel GPS timing receiver for the common-view measurements and relied on the self-survey for the position determination, which could be several meters off in height. The current TMAS uses single-frequency 12-channel GPS timing receiver and the option to use an external geodetic receiver to augment the position accuracy. The combined measurement uncertainties are 11.8 ns for time measurements and 1×10^{-14} after one day of averaging for frequency measurements.

In this paper, we introduce our substantial improvements to the service. The upgraded TMAS implements a dual-frequency GNSS receiver capable of using satellite data from multiple constellations. The use of two frequencies broadcast from each of the GNSS satellites (designated as L1 and L2) affords improvements by minimizing ionospheric effects on the signals by applying measured differential corrections instead of using modeled corrections. The timing diurnals seen in the prior single-frequency GPS data due to propagation through the ionosphere are greatly reduced, resulting in better position determination and lower noise common-view comparisons. With significant reduction of Type A and Type B uncertainties, we expect the combined time uncertainty of the new service to be around 5 ns and a frequency uncertainty towards 5×10^{-15} after one day of averaging.

Improvements to the TMAS are beneficial to current users of the calibration service, in addition to having the ability to measure better clocks and reporting data even closer to real-time. Also, there will be increased stability for the NIST disciplined clock (NISTDC) option of the service, where the common-view results are used to steer a rubidium oscillator contained within the measurement system. A highly portable version of the refined TMAS will sharpen calibrations of other NIST time and frequency services, such as Time over Fiber and Time over Satellite and support the re-calibration of existing systems.