

Key comparisons in Time & Frequency: duration of the TAI scale interval

Key comparison of primary frequency standards

Elisa Felicitas Arias
(after discussions with the CCTF WG on the MRA)

Present situation

The accuracy of TAI is evaluated from the duration of its scale unit (u_{TAI}). It is expressed by the relative departure d of u_{TAI} from the SI second on the rotating geoid (u_0). The value of d corresponds (with the opposite sign) to the relative frequency of TAI with respect to an ideal time scale whose unit is the SI second, and can be calculated through the comparison of a primary frequency standard with a clock participating into TAI over a time interval.

The time laboratories that operate primary frequency standards report rather regularly to the BIPM Time, frequency and gravimetry section frequency measurements over a time interval. These measurements are relative to a clock participating into TAI (if the primary frequency standard is not a participating clock).

For a specific date and time interval, the comparison of a primary frequency standard to the clock in TAI has a complete characterization of its uncertainty, this according to the ISO Guide designations.

The reported measurements of primary frequency standards are used at the BIPM to evaluate the relative departure of the scale unit of TAI from the SI second on the rotating geoid.

The values of d resulting of the reported measurements of primary frequency standards for a period are published in monthly *Circular T*, as well as the BIPM evaluation of d based on the reported measurements.

The following table has been extracted from Section 4 of *Circular T 256* published on May 2009. u_A is the uncertainty originating in the instability of the primary frequency standard, u_B is the combined uncertainty from systematic effects, $\text{Ref}(u_B)$ is a reference giving information on the stated value of u_B or is the *Circular T* where this reference was first given, u_{lab} is the uncertainty in the link between the primary frequency standard and the clock participating to TAI, including the uncertainty due to the dead-time, u_{TAI} is the uncertainty in the link to TAI, u is the quadratic sum of all four uncertainty values. All values are expressed in 10^{-15} .

Standard	Period of Estimation	d	u_A	u_B	$\text{Ref}(u_B)$	u_{lab}	u_{TAI}	u	Note
PTB-CS1	54919 54949	6.9	5.0	8.0	T148	0.0	0.1	9.4	(1)
PTB-CS2	54919 54949	5.5	3.0	12.0	T148	0.0	0.1	12.4	(1)
NIST-F1	54924 54939	6.8	0.3	0.3	T214	0.4	0.6	0.9	(2)
NMIJ-F1	54919 54949	6.2	0.7	3.9	T213	0.3	0.5	4.0	(3)
SYRTE-JPO	54919 54949	4.3	0.7	6.3	T160	0.3	0.3	6.4	(4)
SYRTE-FO1	54919 54949	4.7	0.3	0.4	T227	0.1	0.3	0.6	(4)
SYRTE-FO2	54934 54949	5.1	0.5	0.5	T227	0.1	0.6	0.9	(4)
SYRTE-FOM	54919 54944	6.1	0.2	0.7	T184	2.0	0.4	2.2	(5)

In the Guidelines for CIPM key comparisons is stated that " A special case is the regular calculation of the time scales TAI and UTC at the BIPM. These are based on the results of a continuing series of clock comparisons carried out and interpreted following guidelines agreed by the CCTF. Equivalence of national time scales throughout the world is assured by the universal adoption of the UTC system. Nothing in these Guidelines alters those arrangements".

Proposal

The CCTF WG on the MRA has agreed on discussion on the possibility of publishing the contents of Section 4 of *Circular T* as a BIPM key comparison in frequency for primary frequency standards, considering that the procedures implemented and applied at the BIPM Time, frequency and gravimetry section should not be modified, as stated in the Guidelines for the regular calculation of TAI and UTC, in which the measurements of primary frequency standards serve to assure the accuracy of the time scales. The name of the key comparison should be CCTF-K003.PFS.

No measurement campaigns specially designed will be organized within this key comparison (unless requested by the CCTF WG on PFS). Laboratories having contributed with measurements of PFS to the accuracy of TAI in a month will decide on their participation to the key comparison.

If the proposal is retained, the BIPM TFG section should be charged of implementing its publication on the KCDB.