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NIST Time and Frequency Bulletin

Kelsey Rodriguez, Editor

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Abstract

The Time and Frequency Bulletin provides information on performance of time scales and a variety of broadcasts (and related information) to users of the NIST services.

Keywords

Clocks; dissemination; frequency; GPS; oscillators; time.

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1. Time Scale Information

The values listed in the table below are based on data from the IERS, the USNO, and NIST. The UTC(USNO, MC) – UTC(NIST) values are obtained from the BIPM. UTC – UTC(NIST) data are on page 3.

Table 1. Variation in UT1 – UTC(NIST) and UTC(USNO, MC) – UTC(NIST) Time Scales.

0000 HOURS COORDINATED UNIVERSAL TIME			
September 2022	MJD	UT1 – UTC(NIST) (±1 ms)	UTC(USNO, MC) – UTC(NIST) (±5 ns)
2	59824	-13.3 ms	-1.2 ns
7	59829	-10.4 ms	-1.5 ns
12	59834	-10.6 ms	-2.5 ns
17	59839	-10.0 ms	-1.9 ns
22	59844	-6.0 ms	-1.6 ns
27	59849	-5.1 ms	-1.3 ns

The clock pulses used by the WWV, WWVH, and WWVB time-code transmissions are referenced to the UTC (NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the Earth's period of rotation.

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC time scale on 30 June 1972, 1981, 1983, 1985, 1992-1994, 1997, 2012, 2015 and on 31 December 1972-1979, 1987, 1989, 1990, 1995, 1998, 2005, 2008, 2016.

No leap second will be introduced at the end of December 2022.

The insertion of leap seconds ensures that UT1 - UTC will always be held within ±0.9 s. The current value of UT1 – UTC is called the DUT1 correction. DUT1 corrections are broadcast by WWV, WWVH, WWVB, and ACTS and are printed below. These corrections may be added to the received UTC time signals in order to obtain UT1.

Table 2. Corrections made to DUT1.

DUT1 = UT1 – UTC =	-0.1 s beginning 0000 UTC 17 July 2021 -0.2 s beginning 0000 UTC 02 May 2019 -0.1 s beginning 0000 UTC 17 January 2019 +0.0 s beginning 0000 UTC 21 September 2018 +0.1 s beginning 0000 UTC 15 March 2018 +0.2 s beginning 0000 UTC 30 November 2017 +0.3 s beginning 0000 UTC 29 June 2017 +0.4 s beginning 0000 UTC 30 March 2017 +0.5 s beginning 0000 UTC 26 January 2017 +0.6 s beginning 0000 UTC 01 January 2017 -0.4 s beginning 0000 UTC 17 November 2016

The difference between UTC(NIST) and UTC has been within ±100 ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in their *Circular T* publication for recent periods where data are available. Data are given at ten-day intervals. Five-day interval data are available in *Circular T*.

Table 3. UTC – UTC(NIST).

0000 Hours Coordinated Universal Time		
DATE	**MJD**	**UTC-UTC(NIST), ns**
Sep. 27, 2022	59849	-1.9
Sep. 17, 2022	59839	-2.6
Sep. 07, 2022	59829	-1.8
Aug. 28, 2022	59819	-1.1
Aug. 18, 2022	59809	-0.7
Aug. 8, 2022	59799	-0.8
Jul. 29, 2022	59789	-1.5
Jul. 19, 2022	59779	-2.4
Jul. 9, 2022	59769	-1.8
Jun. 29, 2022	59759	-0.4
Jun. 19, 2022	59749	0.2
Jun. 9, 2022	59739	0.3
May 30, 2022	59729	-0.2
May 20, 2022	59719	-1
May 10, 2022	59709	0
Apr. 30, 2022	59699	1.4
Apr. 20, 2022	59689	1.5
Apr. 10, 2022	59679	0.1
Mar. 31, 2022	59669	-1.4
Mar. 21, 2022	59659	0.3
Mar. 11, 2022	59649	0.2
Mar. 1, 2022	59639	-0.4
Feb. 19, 2022	59629	-0.9
Feb. 9, 2022	59619	-1.1
Jan. 30, 2022	59609	-0.6
Jan. 20, 2022	59599	0.5
Jan. 10, 2022	59589	1.1

2. Broadcast Outages Over Five Minutes and WWVB Phase Perturbations

Table 4. Broadcast Outages and Phase Perturbations.

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	September 2022	MJD	Began UTC	Ended UTC	Freq.	September 2022	MJD	Began UTC	End UTC
WWVB	None					None			
WWV	None					None			
WWVH	None					None			

3. Notes on NIST Time Scales and Primary Standards

Primary frequency standards developed and operated by NIST are used to provide accuracy (rate) input to the BIPM and to provide the best possible realization of the SI second. Cold-atom cesium fountain frequency standards, currently NIST-F1 and NIST-F3, have served as the U.S. primary standards of time and frequency since 1999. The uncertainty of the primary standards is currently parts in 10^{16}.

The AT1 scale is run in real-time by use of data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as nearly constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC is generated at the BIPM by use of a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent available data.

UTC(NIST) is generated as an offset from our real-time scale AT1. Time steps are never used. Instead, the frequency is steered so that the time output remains close to UTC. This is accomplished by using data published by the BIPM in its *Circular T* and by weekly estimates of UTC, which are published by the BIPM as rapid UTC or UTCr. Changes in the frequency may be made as often as once per week and are limited to $\pm 2.3 \times 10^{-14}$. The frequency of UTC(NIST) is kept as stable as possible at other times.

4. UTC NIST – AT1 Parameters

Table 5 lists parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. To find the value of UTC(NIST) – AT1 at any time T (expressed as a Modified Julian Date, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the T_0 column and less than the entry in the last column.

The values of x_{ls}, x, and y for that month are then used in the equation below to find the desired value. The parameters x and y represent the offsets in time and frequency, respectively, between UTC(NIST) and AT1; the parameter x_{ls} is the number of leap seconds applied to both UTC(NIST) and UTC, as specified by the IERS. Leap seconds are not applied to AT1.

Table 5. UTC(NIST) - AT1.

UTC(NIST) - AT1 = $x_{ls} + x + y(T - T_0)$					
Month	x_{ls} (s)	x (ns)	y (ns/d)	T_0 (MJD)	Valid until 0000 on: (MJD)
Sep 22	-37	-517346.79	-38.08†	59837	59853*
Sep 22	-37	-517157.14	-37.93†	59832	59837
Sep 22	-37	-516816.22	-37.88	59823	59832
Aug 22	-37	-515641.94	-37.88	59792	59823
Jul 22	-37	-515225.26	-37.88†	59781	59792
Jul 22	-37	-514961.15	-37.73†	59774	59781
Jul 22	-37	-514698.44	-37.53†	59767	59774
Jul 22	-37	-514473.86	-37.43	59761	59767
Jun 22	-37	-513912.41	-37.43†	59746	59761
Jun 22	-37	-513389.79	-37.33†	59732	59746
Jun 22	-37	-513352.36	-37.43	59731	59732
May 22	-37	-512603.76	-37.43†	59711	59731
May 22	-37	-512193.13	-37.33	59700	59711
Apr 22	-37	-512081.14	-37.33†	59697	59700
Apr 22	-37	-511818.78	-37.48†	59690	59697
Apr 22	-37	-511065.18	-37.68	59670	59690
Mar 22	-37	-510501.48	-37.58†	59655	59670
Mar 22	-37	-509897	-37.78	59639	59655
Feb 22	-37	-508916.12	-37.63†	59613	59620
Feb 22	-37	-508841	-37.56	59611	59613
Jan 22	-37	-508127.36	-37.56†	59592	59611
Jan 22	-37	-507675.44	-37.66	59580	59592
Dec 21	-37	-506507.98	37.66	59549	59580
Nov 21	-37	-506018.4	-37.66†	59536	59549
Nov 21	-37	-505754.08	-37.76†	59529	59536
Nov 21	-37	-505490.46	-37.66†	59522	59529
Nov 21	-37	-505377.93	-37.51	59519	59522
Oct 21	-37	-504702.75	-37.51†	59501	59519
Oct 21	-37	-504211.12	-37.81	59488	59501
Sep 21	-37	-504173.41	-37.81†	59487	59488
Sep 21	-37	-503910.14	-37.61†	59480	59487
Sep 21	-37	-503647.57	-37.51†	59473	59480
Sep 21	-37	-503385.7	-37.41†	59466	59473

† Rate change in mid-month

*Provisional value

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Appendix A. List of Symbols, Abbreviations, and Acronyms

ACTS
Automated Computer Time Service

BIPM
Bureau International des Poids et Mesures

GPS
Global Positioning System

IERS
International Earth Rotation Service

MC
Master Clock

min
minute

MJD
Modified Julian Date

ms
Millisecond

NIST
National Institute of Standards and Technology

ns
Nanosecond

SI
International System of Units

TA
Atomic Time

TAI
International Atomic Time

s
Second

USNO
United States Naval Observatory

UT1
Universal Time (Astronomical)

UTC
Coordinated Universal Time

µs
Microsecond