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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			
October 2024	MJD	UT1 – UTC(NIST) (±1 ms)	UTC(USNO, MC) – UTC(NIST) (±5 ns)
1	60584	59.0 ms	+0.4 ns
6	60589	58.7 ms	+0.1 ns
11	60594	58.3 ms	+0.2 ns
16	60599	57.8 ms	+0.6 ns
21	60604	54.7 ms	+2.8 ns
26	60609	55.8 ms	+2.9 ns
31	60614	53.8 ms	+4.5 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 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.

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.

	+0.1 s beginning 0000 UTC 05 September 2024
	+0.0 s beginning 0000 UTC 28 July 2022
	-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
DUT1 = UT1 – UTC =	+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**
Oct. 26, 2024	60609	0.0
Oct. 16, 2024	60599	-2.2
Oct. 6, 2024	60589	-2.0
Sep. 26, 2024	60579	-0.2
Sep. 16, 2024	60569	-0.8
Sep. 6, 2024	60559	-1.5
Aug. 27, 2024	60549	-1.1
Aug. 17, 2024	60539	-0.1
Aug. 7, 2024	60529	0.6
Jul. 28, 2024	60519	0.2
Jul. 18, 2024	60509	-0.1
Jul. 8, 2024	60499	0.2
Jun. 28, 2024	60489	0.1
Jun. 18, 2024	60479	-0.0
Jun. 8, 2024	60469	-0.2
May 29, 2024	60459	-0.0
May 19, 2024	60449	0.5
May 9, 2024	60439	0.3
Apr. 29, 2024	60429	-0.2
Apr. 19, 2024	60419	-0.1
Apr. 9, 2024	60409	2.0
Mar. 30, 2024	60399	0.0
Mar. 20, 2024	60389	-1.6
Mar. 10, 2024	60379	-0.5
Feb. 29, 2024	60369	-0.7
Feb. 19, 2024	60359	-0.4
Feb. 09, 2024	60349	-1.5

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	October 2024	MJD	Began UTC	Ended UTC	Freq.	October 2024	MJD	Began UTC	End UTC
WWVB	8	60591	1217	1239	60 kHz	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-F3 and NIST-F4, 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)
Oct 24	-37	-547131.57	-38.63†	60614	60615
Oct 24	-37	-546587.25	-38.88†	60600	60614
Oct 24	-37	-546316.49	-38.68†	60592	60600
Oct 24	-37	-545969.72	-38.53	60584	60592
Sep 24	-37	-545507.36	-38.53†	60572	60584
Sep 24	-37	-544811.12	-38.68	60554	60572
Sep 24	-37	-544695.08	-38.68	60551	60554
Aug 24	-37	-544425.02	-38.58†	60544	60551
Aug 24	-37	-543887.00	-38.43†	60530	60544
Aug 24	-37	-543617.29	-38.53	60523	60530
Jul 24	-37	-542419.76	-38.63	60491	60523
Jun 24	-37	-541260.86	-38.63	60462	60491
May 24	-37	-540642.78	-38.63†	60446	60462
May 24	-37	-540062.58	-38.68	60431	60446
Apr 24	-37	-539559.74	-38.68†	60418	60431
Apr 24	-37	-539021.72	-38.43†	60404	60418
Apr 24	-37	-538904.93	-38.98	60401	60404
Mar 24	-37	-538749.21	-38.93†	60397	60401
Mar 24	-37	-538477.40	-38.83†	60390	60397
Mar 24	-37	-537936.58	-38.63†	60376	60390
Mar 24	-37	-537703.90	-38.78	60370	60376
Feb 24	-37	-537122.20	-38.78†	60355	60370
Feb 24	-37	-536849.69	-38.93†	60348	60355
Feb 24	-37	-536578.58	-38.73	60341	60348
Jan 24	-37	-536307.47	-38.73†	60334	60341
Jan 24	-37	-535768.07	-38.53†	60320	60334
Jan 24	-37	-535384.27	-38.38	60310	60320
Dec 23	-37	-534962.09	-38.38†	60299	60310*
Dec 23	-37	-534428.27	-38.13†	60285	60299
Dec 23	-37	-534197.69	-38.43	60279	60285
Nov 23	-37	-533890.25	-38.43†	60271	60279

† 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