NISTIR 8346-05

NIST Time and Frequency Bulletin

Kelsey Rodriguez, Editor

This publication is available free of charge from:
https://doi.org/10.6028/NIST.IR.8346-05

National Institute of
Standards and Technology
U.S. Department of Commerce

NISTIR 8346-05

NIST Time and Frequency Bulletin

Kelsey Rodriguez, Editor
Time and Frequency Division
Physical Measurement Laboratory

This publication is available free of charge from:
https://doi.org/10.6028/NIST.IR.8346-05

May 2021

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
James K. Olthoff, Performing the Non-Exclusive Functions and Duties of the Under Secretary of Commerce for Standards and Technology & Director, National Institute of Standards and Technology

NIST TIME AND FREQUENCY BULLETIN
NIST IR 8346-05

No. 761 May 2021

This bulletin is published monthly. Address correspondence to:

Kelsey Rodriguez, Editor
Time and Frequency Division
National Institute of Standards and Technology
325 Broadway MS847
Boulder, CO 80305
(303) 497-5398
Email: kelsey.rodriguez@nist.gov

U.S. DEPARTMENT OF COMMERCE, Gina M. Raimondo, Secretary
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, James K. Olthoff, Performing the Non-Exclusive Functions and Duties of the Under Secretary of Commerce for Standards and Technology & Director, National Institute of Standards and Technology

1. GENERAL BACKGROUND INFORMATION

ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

ACTS	- Automated Computer Time Service		
BIPM	- Bureau International des Poids et Mesures		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
MC	- Master Clock		
MJD	- Modified Julian Date		
NIST	- National Institute of Standards and Technology	ns	- nanosecond
SI	- International System of Units	µs	- microsecond
TA	- Atomic Time	ms	- millisecond
TAI	- International Atomic Time	s	- second
USNO	- United States Naval Observatory	min	- minute
UT1	- Universal Time (Astronomical)		
UTC	- Coordinated Universal Time		

2. TIME SCALE INFORMATION

The values listed 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.

0000 HOURS COORDINATED UNIVERSAL TIME			
April 2021	MJD	UT1-UTC(NIST) (±1 ms)	UTC(USNO,MC) - UTC(NIST) (±5 ns)
5	59309	-174.4 ms	-0.4 ns
10	59314	-175.7 ms	0.1 ns
15	59319	-177.8 ms	-0.7 ns
20	59324	-177.8 ms	-0.8 ns
25	59329	-179.9 ms	0.5 ns
30	59334	-183.3 ms	1.7 ns

The master 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.

NOTE: No leap second will be introduced at the end of June 2021.

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 use 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.

DUT1 = UT1 - UTC =	-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 the most recent 310-day period in which data are available. Data are given at ten-day intervals. Five-day interval data are available in *Circular T* .

	0000 Hours Coordinated Universal Time		
	DATE	**MJD**	**UTC-UTC(NIST), ns**
	Apr. 25, 2021	59329	1.1
	Apr. 15, 2021	59319	0.2
	Apr. 5. 2021	59309	0.7
	Mar. 26, 2021	59299	0
	Mar. 16, 2021	59289	-1.1
	Mar. 6, 2021	59279	-1
	Feb. 24, 2021	59269	-0.5
	Feb. 14, 2021	59259	-0.4
	Feb. 4, 2021	59249	0.6
	Jan. 25, 2021	59239	-0.5
	Jan. 15, 2021	59229	-1
	Jan. 5, 2021	59219	-1
	Dec. 26, 2020	59209	-0.7
	Dec. 16, 2020	59199	-0.7
	Dec. 6, 2020	59189	-0.9
	Nov. 26, 2020	59179	0
	Nov. 16, 2020	59169	1
	Nov. 6, 2020	59159	1.2
	Oct. 27, 2020	59149	1.3
	Oct. 17, 2020	59139	0.3
	Oct 7, 2020	59129	0.8
	Sep. 27, 2020	59119	1.4
	Sep. 17, 2020	59019	0.3
	Sep. 7, 2020	59099	-0.7
	Aug. 28, 2020	59089	-0.9
	Aug. 18, 2020	59079	-0.6
	Aug. 8, 2020	59069	-0.3
	Jul. 29, 2020	59059	0
	Jul. 19, 2020	59049	-0.4
	Jul. 9, 2020	59039	0.2
	Jun. 29, 2020	59029	0.5
	Jun. 19, 2020	59019	-0.5
	Jun. 9, 2020	59009	-2.3

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Apr 2021	MJD	Began UTC	Ended UTC	Freq.	Apr 2021	MJD	Began UTC	End UTC
WWVB	30 21 10	59334 59325 59314	1520 1459 2212	2256 1823 2241	60 kHz 60 kHz 60 kHz	None			
WWV	None					None			
WWVH	None					None			

4. 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. NIST-F1 and NIST-F2, cold-atom cesium fountain frequency standards, have served as the U.S. primary standards of time and frequency since 1999. The uncertainty of NIST-F2 is currently about 1 part 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.

References:

Allan, D.W.; Hellwig, H.; and Glaze, D.J., "An accuracy algorithm for an atomic time scale," Metrologia, Vol.11, No.3, pp. 133-138 (1975).

Allan, D.W.; Davis, D.D.; Weiss, M.A.; Clements, A.; Guinot, B.; Granveaud, M.; Dorenwendt, K.; Fischer, B.; Hetzel, P.; Aoki, S.; Fujimoto, M.; Charron, L.; and Ashby, N., “Accuracy of international time and frequency comparisons via global positioning system satellites in common-view,” IEEE Transactions on Instrumentation and Measurement, Vol. IM-34, pp.118-125 (1985).

Heavner, T.P.; Jefferts, S.R.; Donley; E.A.; Shirley, J.H. and Parker, T.E., “NIST F1; recent improvements and accuracy evaluations,” Metrologia, Vol. 42, pp. 411-422 (2005).

Jefferts, S.R.; Shirley, J.; Parker, T.E.; Heavner, T.P.; Meekhof, D.M.; Nelson, C., Levi, F.; Costanza, G.; De Marchi, A.; Drullinger, R.; Hollberg, L.; Lee, W.D.; and Walls, F.L., “Accuracy evaluation of NIST-F1,” Metrologia, Vol. 39, pp. 321-336 (2002).

Lewandowski, W. and Thomas, C., “GPS Time transfer,” Proceedings of the IEEE, Vol. 79, pp. 991-1000 (1991).

Parker, T.E.; Jefferts, S.R.; Heavner, T.P.; and Donley, E.A., “Operation of the NIST-F1 caesium fountain primary frequency standard with a maser ensemble, including the impact of frequency transfer noise,” Metrologia, Vol. 42, pp. 423-430 (2005).

Weiss, M.A.; Allan, D.W., “An NBS Calibration Procedure for Providing Time and Frequency at a Remote Site by Weighting and Smoothing of GPS Common View Data,” IEEE Transactions on Instrumentation and Measurement, Vol. IM-36, pp. 572-578 (1987).

5. UTC(NIST) – AT1 PARAMETERS

The table below 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.

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)
21-Apr	-37	-497897.74	-37.26†	59319	59335
21-Apr	-37	-497377.5	-37.16	59305	59319
21-Mar	-37	-496855.16	-37.31†	59291	59035
21-Mar	-37	-496334.22	-37.21†	59277	59291
21-Mar	-37	-496222.74	-37.16	59274	59277
21-Feb	-37	-495293.74	-37.16†	59249	59274
21-Feb	-37	-495181.81	-37.31	59246	59249
Jan 21	-37	-494771.4	-37.31	59235	59246
Jan 21	-37	-494026.4	-37.25	59215	59235
Dec 20	-37	-492946.15	-37.25†	59186	59215*
Dec 20	-37	-492872.05	-37.05	59184	59186
Nov 20	-37	-492427.45	-37.05†	59172	59184
Nov 20	-37	-491758.75	-37.15	59154	59172
Oct 20	-37	-491647.3	-37.15†	59151	59154
Oct 20	-37	-491125.8	-37.25†	59137	59151
Oct 20	-37	-490607.1	-37.05	59123	59137
Sep 20	-37	-490346.35	-37.25†	59116	59123
Sep 20	-37	-489898.15	-37.35†	59104	59116
Sep 20	-37	-489487.85	-37.3	59063	59104
Aug 20	-37	-488331.55	-37.30	59062	59093
Jul 20	-37	-487834.75	-37.30†	59046	59062
Jul 20	-37	-487213.95	-37.20†	59032	59046
Jul 20	-37	-487176.60	-37.35	59031	59032
Jun 20	-37	-486691.05	-37.35†	59018	59031
Jun 20	-37	486166.05	-37.50†	59004	59018
Jun 20	-37	-486054.45	-37.20	59001	59004
May 20	-37	-485384.85	-37.2	58983	59001
May 20	-37	-484903.85	-37	58970	58983
Apr 20	-37	-483793.85	-37	58940	58970

† Rate change in mid-month

***Provisional value**