NISTIR 8418-03

NIST Time and Frequency Bulletin

Kelsey Rodriguez, Editor

This publication is available free of charge from:
https://doi.org/10.6028/NIST.IR.8418-03

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

NISTIR 8418-03

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.8418-03

March 2022

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 8418-03

No. 771 March 2022

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			
February 2022	MJD	UT1-UTC(NIST) (±1 ms)	UTC(USNO,MC) - UTC(NIST) (±5 ns)
4	59614	-107.2 ms	-0.4 ns
9	59619	-107.2 ms	-0.8 ns
14	59624	-103.6 ms	-0.6 ns
19	59629	-102.4 ms	-1.0 ns
24	59634	-103.7 ms	-1.4 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.

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 =

-0.1 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 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*.

This publication is available free of charge from: https://doi.org/10.6028/NIST.IR.8418-03

0000 Hours Coordinated Universal Time		
DATE	**MJD**	**UTC-UTC(NIST), ns**
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**
Dec. 31, 2021	**59579**	**0.7**
Dec. 21, 2021	**59569**	**0.2**
Dec. 11, 2021	**59559**	**0**
Dec. 01, 2021	**59549**	**0.6**
Nov. 21, 2021	**59539**	**0**
Nov. 11, 2021	**59529**	**-0.8**
Nov. 01, 2021	**59519**	**-0.4**
Oct. 22, 2021	**59509**	**0.5**
Oct. 12, 2021	**59499**	**0.6**
Oct. 02, 2021	**59489**	**-1.4**
Sep. 22, 2021	**59479**	**-2.1**
Sep. 12, 2021	**59469**	**-1.2**
Sep. 02, 2021	**59459**	**-0.1**
Aug. 23, 2021	**59449**	**0.6**
Aug. 13, 2021	**59439**	**0.1**
Aug. 03, 2021	**59429**	**-0.8**
Jul. 24, 2021	**59419**	**-2**
Jul. 14, 2021	**59409**	**-1.7**
Jul. 4, 2021	**59399**	**-0.6**
Jun. 24, 2021	**59389**	**-0.5**
Jun. 14, 2021	**59379**	**-0.8**
Jun. 4, 2021	**59369**	**-1.5**
May 25, 2021	**59359**	**-0.6**
May 15, 2021	**59349**	**1.7**
May 5, 2021	**59339**	**2.2**
Apr. 25, 2021	**59329**	**1.1**
Apr. 15, 2021	**59319**	**0.2**

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Feb 2022	MJD	Began UTC	Ended UTC	Freq.	Feb 2022	MJD	Began UTC	End UTC
WWVB	10 14	59620 59629	0321 1006	0417 1024	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).

This publication is available free of charge from: https://doi.org/10.6028/NIST.IR.8418-03

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)
Feb 22	-37	-509443.64	-37.78†	59627	59639
Feb 22	-37	-509179.53	-37.73†	59620	59627
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
Sep 21	-37	-503087.22	-37.31	58458	59466
Aug 21	-37	-502602.19	-37.31†	59445	59458
Aug 21	-37	-502078.45	-37.41†	59431	59445
Aug 21	-37	-501928.21	-37.56	59427	59431
Jul 21	-37	-501552.61	-37.56†	59417	59427
Jul 21	-37	-500767	-37.41	59396	59417
Jun 21	-37	-499719.48	-37.41†	59368	59396
Jun 21	-37	-499644.96	-37.26	59366	59368
May 21	-37	-499458.66	-37.26†	59361	59366
May 21	-37	-498939.82	-37.06†	59347	59361
May 21	-37	-498493.9	-37.16	59335	59347
Apr 21	-37	-497897.74	-37.26†	59319	59335

† Rate change in mid-month

***Provisional value**