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NIST Time and Frequency Bulletin

Kathryn Stephenson, Editor

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September 2019

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Under Secretary of Commerce for Standards and Technology

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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 averaged measurements from all available common-view GPS satellites (see bibliography on page 5). UTC - UTC(NIST) data are on page 3.

0000 HOURS COORDINATED UNIVERSAL TIME			
August 2019	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
1	58696	-160.22 ms	-4 ns
8	58703	-160.69 ms	-5.7 ns
15	58710	-156.73 ms	-4.3 ns
22	58717	-154.66 ms	-5.5 ns
29	58724	-152.80 ms	-4.7 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 added at the end of December 2019.

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**
Aug. 24, 2019	**58719**	**0.3**
Aug. 14, 2019	**58709**	**-0.1**
Aug. 4, 2019	**58699**	**-0.1**
July 25, 2019	**58689**	**1.2**
July 15, 2019	**58679**	**1.2**
July 5, 2019	**58669**	**0.7**
June 29, 2019	**58659**	**-1.9**
June 15, 2019	**58649**	**-3.6**
June 5, 2019	**58639**	**-2.6**
May 26, 2019	**58629**	**-2.3**
May 16, 2019	**58619**	**-2.8**
May 6, 2019	**58609**	**-0.8**
Apr. 26, 2019	**58599**	**0.4**
Apr. 16, 2019	**58589**	**0.6**
Apr. 6, 2019	**58579**	**-0.3**
Mar. 27, 2019	**58569**	**-1.9**
Mar. 17, 2019	**58559**	**-1.0**
Mar. 7, 2019	**58549**	**0.7**
Feb. 25, 2019	**58539**	**-2.4**
Feb. 15, 2019	**58529**	**-5.3**
Feb. 5, 2019	**58519**	**-3.3**
Jan. 26, 2019	**58509**	**-2.1**
Jan. 16, 2019	**58499**	**-2.4**
Jan. 6, 2019	**58489**	**-2.1**
Dec. 27, 2018	**58479**	**0.3**
Dec. 17, 2018	**58469**	**3.0**
Dec. 7, 2018	**58459**	**3.7**
Nov. 27, 2018	**58449**	**2.0**
Nov. 17, 2018	**58439**	**1.1**
Nov. 7, 2018	**58429**	**0.7**
Oct 28, 2018	**58419**	**0.1**
Oct. 18, 2018	**58409**	**-0.6**
Oct. 8, 2018	**58399**	**-1.3**

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Aug 2019	MJD	Began UTC	Ended UTC	Freq.	Aug 2019	MJD	Began UTC	End UTC
WWVB	08-29-19	58724	0826	0927	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.

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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)
Sep 19	-37	-475891.45	-37.35*	58727	58757
Aug 19	-37	-474995.05	-37.35	58703	58727*
Aug 19	-37	-474735.35	-37.10	58696	58703†
Jul 19	-37	-473696.55	-37.10	58668	58696
Jul 19	-37	-473584.35	-37.40	58665	58668†
Jun 19	-37	-473172.95	-37.40	58654	58665
Jun 19	-37	-472949.75	-37.20	58648	58654†
Jun 19	-37	-472469.4	-36.95	58635	58648†
May 19	-37	-471878.2	-36.95	58619	58635
May 19	-37	-471327.7	-36.70	58604	58619†
Apr 19	-37	-471107.5	-36.70	58598	58604
Apr 19	-37	-470592.3	-36.80	58584	58598†
Apr 19	-37	-470222.3	-37.00	58574	58584†
Mar 19	-37	-470074.3	-37.00	58570	58574
Mar 19	-37	-469817.05	-36.75	58563	58570†
Mar 19	-37	-469560.5	-36.65	58556	58563†
Mar 19	-37	-469304.65	-36.55	58549	58556†
Mar 19	-37	-469083.25	-36.90	58543	58549†
Feb 19	-37	-468788.05	-36.90	58535	58543
Feb 19	-37	-468528.35	-37.10	58528	58535†
Feb 19	-37	-468053.85	-36.50	58515	58528†
Jan 19	-37	-468017.35	-36.50	58514	58515
Jan 19	-37	-467244.55	-36.80	58493	58514†
Jan 19	-37	-466915.15	-36.60	58484	58493†
Dec 18	-37	-466219.75	-36.60	58465	58484
Dec 18	-37	-465962.15	-36.80	58458	58465†
Dec 18	-37	-465962.15	37.00	58453	58458†
Nov 18	-37	-464667.15	-37.00	58423	58453
Oct 18	-37	-463888.05	-37.10	58402	58423
Oct 18	-37	-463520.05	-36.80	58392	58402†
Sep 18	-37	-462857.65	-36.80	58374	58392

† Rate change in mid-month

***Provisional value**