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NIST Time and Frequency Bulletin

Karen Hansen Lichtfuss, Editor

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U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie May, Under Secretary of Commerce for Standards and Technology and Director

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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			
July 2016	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
7	57576	- 216 ms	- 1.2 ns
14	57583	- 219 ms	- 2.2 ns
21	57590	- 220 ms	- 5.1 ns
28	57597	- 223 ms	- 5.2 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: A positive leap second will be added at the end of December 2016.

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.

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 =

-0.3 s beginning 0000 UTC 01 September, 2016
-0.1 s beginning 0000 UTC 24 March 2016
+0.0 s beginning 0000 UTC 31 January 2016
+0.1 s beginning 0000 UTC 26 November 2015
+0.2 s beginning 0000 UTC 11 September 2015
+0.3 s beginning 0000 UTC 01 July 2015
-0.7 s beginning 0000 UTC 28 May 2015
-0.6 s beginning 0000 UTC 19 March 2015
-0.5 s beginning 0000 UTC 25 December 2014
-0.4 s beginning 0000 UTC 25 September 2014
-0.3 s beginning 0000 UTC 08 May 2014

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**
Jul. 30, 2016	**57599**	**-4.1**
Jul. 20, 2016	**57589**	**-2.0**
Jul. 10, 2016	**57579**	**-0.3**
Jun. 30, 2016	**57569**	**0.7**
Jun. 20, 2016	**57559**	**1.1**
Jun. 10, 2016	**57549**	**0.9**
May 31, 2016	**57539**	**0.4**
May 21, 2016	**57529**	**-0.3**
May 11, 2016	**57519**	**-0.6**
May 1, 2016	**57509**	**-2.0**
Apr. 21, 2016	**57499**	**-1.4**
Apr. 11, 2016	**57489**	**3.4**
Apr. 1, 2016	**57479**	**4.4**
Mar. 22, 2016	**57469**	**2.8**
Mar. 12, 2016	**57459**	**0.9**
Mar. 2, 2016	**57449**	**-0.4**
Feb. 11, 2016	**57439**	**-4.9**
Feb. 11, 2016	**57429**	**-7.6**
Feb. 01, 2016	**57419**	**-8.6**
Jan. 22, 2016	**57409**	**-7.4**
Jan. 12, 2016	**57399**	**-3.0**
Jan. 02, 2016	**57389**	**1.7**
Dec. 23, 2015	**57379**	**3.5**
Dec. 13, 2015	**57369**	**4.3**
Dec. 03, 2015	**57359**	**6.4**
Nov. 23, 2015	**57349**	**5.8**
Nov. 13, 2015	**57339**	**4.8**
Nov. 3, 2015	**57329**	**5.3**
Oct. 24, 2015	**57319**	**9.6**
Oct. 14, 2015	**57309**	**13.9**
Oct. 4, 2015	**57299**	**16.1**
Sep. 24, 2015	**57289**	**15.8**
Sep. 14, 2015	**57279**	**14.3**
Sep. 4, 2015	**57269**	**13.6**

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Jul 2016	MJD	Began UTC	Ended UTC	Freq.	Jul 2016	MJD	Began UTC	End UTC
WWVB	None					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 F-2, 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(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC by use of data published by the BIPM in its *Circular T*. Changes in the steering frequency will be made, if necessary, at 0000 UTC on the first day of the month, and occasionally at mid-month. A change in frequency is limited to no more than ±2 ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

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.

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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	xls (s)	x (ns)	y (ns/d)	T0 (MJD)	Valid until 0000 on: (MJD)
Sep 16	-36	-435350.9	-37.3*	57632	57662
Aug 16	-36	-434936.7	-37.65	57621	57632*
Aug 16	-36	-434191.7	-37.25	57601	57621†
Jul 16	-36	-434079.95	-37.25	57598	57601
Jul 16	-36	-433041.2	-37.1	57570	57598†
Jun 16	-36	-431923.7	-37.25	57540	57570
May 16	-36	-431476.7	-37.25	57528	57540
May 16	-36	-430771.8	-37.1	57509	57528†
Apr 16	-36	-430697.6	-37.1	57507	57509
Apr 16	-36	-429672.75	-36.5	57479	57507†
Apr 16	-36	-429672.75	-36.9	57479	57486†
Mar 16	-36	-428636.75	-37.0	57451	57479
Mar 16	-36	-428521.05	-37.3	57448	57451†
Feb 16	-36	-427816.15	-37.3	57429	57448
Feb 16	-36	-427556.45	-37.1	57422	57429†
Feb 16	-36	-427446.05	-36.8	57419	57422†
Jan 16	-36	-427014.25	-36.8	57408	57419
Jan 16	-36	-426313.25	-36.4	57388	57408†
Dec 15	-36	-426056.65	-36.7	57381	57388
Dec 15	-36	-425761.45	-36.9	57373	57381†
Dec 15	-36	-425285.65	-36.6	57360	57373†
Dec 15	-36	-425162.45	-36.9	57357	57360†

† Rate change in mid-month

***Provisional value**