

**NIST TIME AND FREQUENCY BULLETIN
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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		
CS	- Cesium Standard		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
LORAN	- Long Range Navigation		
MC	- Master Clock		
MJD	- Modified Julian Date		
NIST	- National Institute of Standards and Technology		
NOAA	- National Oceanic and Atmospheric Administration		
NVLAP	- National Voluntary Laboratory Accreditation Program	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
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			
Sep 2009	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
3	55077	220 ms	-13 ns
10	55084	215 ms	-12 ns
17	55091	211 ms	-11 ns
24	55098	204 ms	-8 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 was added at the end of June 2009.

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 timescale on 30 June 1972, 1981-1983, 1985, 1992-1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990, 1995, 1998, 2005, and 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 received UTC time signals in order to obtain UT1.

	+0.2 s beginning 0000 UTC 11 June 2009
	+0.3 s beginning 0000 UTC 12 March 2009
	-0.6 s beginning 0000 UTC 20 November 2008
DUT1 = UT1 - UTC =	-0.5 s beginning 0000 UTC 07 August 2008
	-0.4 s beginning 0000 UTC 13 March 2008

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 10-day intervals. Five-day interval data are available in *Circular T*.

0000 Hours Coordinated Universal Time		
DATE	MJD	UTC-UTC(NIST) ns
Aug. 26, 2009	55069	-15.8
Aug. 16, 2009	55059	-16.4
Aug. 06, 2009	55049	-14.7
Jul. 27, 2009	55039	-12.3
Jul. 17, 2009	55029	-9.6
Jul. 07, 2009	55019	-4.9
Jun. 27, 2009	55009	0
Jun. 17, 2009	54999	4.7
Jun. 07, 2009	54989	5.7
May 28, 2009	54979	10.3
May 18, 2009	54969	11.2
May 08, 2009	54959	10.8
Apr. 28, 2009	54949	9.7
Apr. 18, 2009	54939	7.0
Apr. 08, 2009	54929	10.0
Mar. 28, 2009	54919	7.5
Mar. 18, 2009	54909	7.1
Mar. 08, 2009	54899	4.9
Feb. 27, 2009	54889	4.3
Feb. 17, 2009	54879	2.0
Feb. 07, 2009	54869	1.7
Jan. 28, 2009	54859	3.9
Jan. 18, 2009	54849	3.9
Jan. 08, 2009	54839	4.0
Dec. 29, 2008	54829	4.1
Dec. 19, 2008	54819	2.5
Dec. 09, 2008	54809	0.7

3. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time differences between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is $\pm 0.5 \mu\text{s}$. The values listed are for 1300 UTC.

LORAN-C - The values shown for LORAN-C represent the daily accumulated phase shift. The phase shift is measured by comparing the output of a LORAN receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the symbol (-) is printed. The stations monitored are Baudette, Minnesota (8970) and Boise City, Oklahoma (9610). The monitoring is done from the NIST laboratories in Boulder, Colorado.

Note: The values shown for LORAN-C are in nanoseconds.

DATE	MJD	UTC(NIST)-WWVB (60 kHz)		
		ANTENNA PHASE (μs)	UTC(NIST) - LORAN PHASE (ns)	
			LORAN-C (BAUDETTE) (8970)	LORAN-C (BOISE CITY) (9610)
09/01/2009	55075	5.65	+83	-4
09/02/2009	55076	5.65	-12	+17
09/03/2009	55077	5.65	-64	-10
09/04/2009	55078	5.65	+14	-5
09/05/2009	55079	5.65	+24	+17
09/06/2009	55080	5.65	+57	-5
09/07/2009	55081	5.65	+10	-10
09/08/2009	55082	5.65	-63	+4
09/09/2009	55083	5.65	+83	-22
09/10/2009	55084	5.65	-2	+25
09/11/2009	55085	5.65	-16	-10
09/12/2009	55086	5.65	-45	-32
09/13/2009	55087	5.65	+41	+34
09/14/2009	55088	5.65	+24	+46
09/15/2009	55089	5.65	-7	-2
09/16/2009	55090	5.65	+27	+2
09/17/2009	55091	5.65	-3	+10
09/18/2009	55092	5.65	-6	+6
09/19/2009	55093	5.65	+14	+3
09/20/2009	55094	5.65	-37	-38
09/21/2009	55095	5.65	+31	+13
09/22/2009	55096	5.65	-22	-1
09/23/2009	55097	5.65	-11	+3
09/24/2009	55098	5.65	+13	-16
09/25/2009	55099	5.65	-14	+10
09/26/2009	55100	5.65	+65	+27
09/27/2009	55101	5.65	+27	-10
09/28/2009	55102	5.65	-28	-16
09/29/2009	55103	5.65	+4	-5
09/30/2009	55104	5.65	-28	-12

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Sep 2009	MJD	Began UTC	Ended UTC	Freq.	Sep 2009	MJD	Began UTC	End UTC
WWVB									
WWV									
WWVH									

5. 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. NIST-F1, a cold-atom cesium fountain frequency standard, has served as the U.S. primary time and frequency standard since 1999. The uncertainty of NIST-F1 is currently about 5 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(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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Table 7.1 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 Day, 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 7.1 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)
Nov 09	-34	-341104.9	-39.0*	55136	55166
Oct 09	-34	-339895.9	-39.0	55105	55136*
Sep 09	-34	-339271.9	-39.0*	55089	55105
Sep 09	-34	-338730.1	-38.7	55075	55089†
Aug 09	-34	-337917.4	-38.7	55054	55075
Aug 09	-34	-337534.4	-38.3	55044	55054†
Jul 09	-34	-336691.8	-38.3	55022	55044
Jul 09	-34	-336349.8	-38.0	55013	55022†
Jun 09	-34	-335209.8	-38.0	54983	55013
May 09	-34	-334791.8	-38.0	54972	54983
May 09	-34	-334027.8	-38.2	54952	54972†
Apr 09	-34	-333225.6	-38.2	54931	54952
Apr 09	-34	-332880.9	-38.3	54922	54931†
Mar 09	-34	-331693.6	-38.3	54891	54922
Feb 09	-34	-330621.2	-38.3	54863	54891
Jan 09	-34	-329931.8	-38.3	54845	54863
Jan 09	-34	-329432.6	-38.4	54832	54845†
Dec 08	-33	-328895.0	-38.4	54818	54832
Dec 08	-33	-328240.5	-38.5	54801	54818†
Nov 08	-33	-327085.5	-38.5	54771	54801

† Rate change in mid-month

*Provisional value