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
NVLAP	-	National Voluntary Laboratory Accreditation Program
NIST	-	National Institute of Standards and Technology
NOAA	-	National Oceanic and Atmospheric Administration
SI	-	International System of Units
TA	-	Atomic Time
TAI	-	International Atomic Time
USNO	-	United States Naval Observatory
UTC	-	Coordinated Universal Time

ns	-	nanosecond
µs	-	microsecond
ms	-	millisecond
s	-	second
min	-	minute

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			
APR 2004	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
1	53068	-434 ms	4 ns
8	53075	-443 ms	10 ns
15	53082	-447 ms	14 ns
22	53089	-453 ms	17 ns
29	53124	-452 ms	18 ns

CORRECTION: The data for UTC(USNO,MC) was incorrectly reported as negative in the bulletin posted 5/3/04.

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 rotation.

NOTE: No leap second will be added at the end of June 2004.

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, 1993, 1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990,1995, and 1998.

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.

DUT1 = UT1 - UTC =

+0.0 s beginning 0000 UTC 01 March 2001
-0.1 s beginning 0000 UTC 04 October 2001
-0.2 s beginning 0000 UTC 14 February 2002
-0.3 s beginning 0000 UTC 24 October 2002
-0.4 s beginning 0000 UTC 03 April 2003
-0.5 s beginning 0000 UTC 29 April 2004

The difference between UTC(NIST) from 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
Mar. 25, 2004	53089	6.3
Mar. 15, 2004	53079	4.1
Mar. 05, 2004	53069	3.2
Feb. 24, 2004	53059	1.2
Feb. 14, 2004	53049	-2.0
Feb. 4, 2004	53039	-4.5
Jan. 25, 2004	53029	-4.6
Jan. 15, 2004	53019	-4.2
Jan. 5, 2004	53009	-3.1
Dec. 26, 2003	52999	-4.0
Dec. 16, 2003	52989	-2.8
Dec. 6, 2003	52979	-0.2
Nov. 26, 2003	52969	-1.1
Nov. 16, 2003	52959	2.0
Nov. 6, 2003	52949	2.1
Oct. 27, 2003	52939	1.8
Oct. 17, 2003	52929	1.2
Oct. 7, 2003	52919	3.9
Sep. 27, 2003	52909	7.9
Sep. 17, 2003	52899	7.5
Sep. 7, 2003	52889	7.6
Aug. 28, 2003	52879	7.7
Aug. 18, 2003	52869	8.0
Aug. 8, 2003	52859	10.2
Jul. 29, 2003	52849	10.7
Jul. 19, 2003	52839	12.7
Jul. 9, 2003	52829	12.6
Jun. 29, 2003	52819	9.2
Jun. 19, 2003	52809	7.5
Jun. 9, 2003	52799	3.8

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 ±0.5 μs. The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift (in ns). 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, ND (8970-Y) and Fallon, NV (9940). The monitoring is done from the NIST laboratories in Boulder, Colorado.

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

		UTC(NIST)-WWVB (60 kHz)	UTC(NIST) - LORAN PHASE (ns)	
DATE	MJD	ANTENNA PHASE (μs)	LORAN-C (BAUDETTE) (8970)	LORAN-C (FALLON) (9940)
04/01/04	53096	5.67	-37	-160
04/02/04	53097	5.69	-9	+228
04/03/04	53098	5.70	+161	+437
04/04/04	53099	5.70	-41	+161
04/05/04	53100	5.70	-55	+366
04/06/04	53101	5.71	+2	-295
04/07/04	53102	5.71	-66	+406
04/08/04	53103	5.69	+54	-135
04/09/04	53104	5.70	+111	-256
04/10/04	53105	5.70	+26	-403
04/11/04	53106	5.69	+5	+393
04/04/04	53107	5.69	-71	+219
04/13/04	53108	5.70	-26	+83
04/14/04	53109	5.71	-55	+104
04/15/04	53110	5.71	-0	+110
04/16/04	53111	5.71	-32	+16
04/17/04	53112	5.71	+10	+150
04/18/04	53113	5.71	-18	+12
04/19/04	53114	5.71	+52	+274
04/20/04	53115	5.72	+17	+119
04/21/04	53116	5.71	+42	+18
04/22/04	53117	5.71	-78	+46
04/23/04	53118	5.71	+52	-55
04/24/04	53119	5.71	-33	-497
04/25/04	53120	5.72	+27	-235
04/26/04	53121	5.71	+16	-37
04/27/04	53122	5.71	+36	-161
04/28/04	53123	5.71	-10	+399
04/29/04	53124	5.72	-3	-458
04/30/04	53125	5.73	+4	-206

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE							PHASE PERTURBATIONS 2 ms			
Station	APR 2004	MJD	Began UTC	Ended UTC	Freq.		APR 2004	MJD	Began UTC	End UTC
WWVB					60 kHz					
WWVB										
WWV										

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-7 was the U.S. primary standard from 1994 to 1999, when it was replaced by NIST-F1, a cold-atom cesium fountain frequency standard. The uncertainty of NIST-F1 is currently about 1 part in 10^{15}.

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 $\pm$ 2 ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM using 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.

6. BIBLIOGRAPHY

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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 offset in time and in 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)
May 04	-32	-264731.4	-39.25*	53157*	53187
May 04	-32	-263514.65	-39.25	53126	53157*
Apr 04	-32	-263004.4	-39.25	53113	53126
Apr 04	-32	-262334.6	-39.4	53096	53113†
Mar 04	-32	-261783.0	-39.4	53082	53096
Mar 04	-32	-261110.65	-39.55	53065	53082†
Feb 04	-32	-259963.7	-39.55	53036	53065
Jan 04	-32	-259410.0	-39.55	53022	53036
Jan 04	-32	-258738.5	-39.5	53005	53022†
Dec 03	-32	-258343.5	-39.5	52995	53005
Dec 03	-32	-257516.1	-39.4	52974	52995†
Nov 03	-32	-256925.1	-39.4	52959	52974
Nov 03	-32	-256334.85	-39.35	52944	52959†
Oct 03	-32	-255783.95	-39.35	52930	52944
Oct 03	-32	-255112.45	-39.5	52913	52930†
Sep 03	-32	-253927.745	-39.5	52883	52913
Aug 03	-32	-252702.95	-39.5	52852	52883
Jul 03	-32	-252228.95	-39.5	52840	52852
Jul 03	-32	-251473.7	-39.75	52821	52840†
Jun 03	-32	-251076.2	-39.75	52811	52821
Jun 03	-32	-250276.2	-40.0	52791	52811†
May 03	-32	-249652.2	-39.0	52775	52791
May 03	-32	-249052.2	-40.0	52760	52775†
Apr 03	-32	-248495.7	-39.75	52746	52760
Apr 03	-32	-247855.7	-40.0	52730	52746†

† Rate change in mid-month
†† Rate change one day early
***Provisional value**

7. SPECIAL ANNOUNCEMENTS

NOTICE TO DISCONTINUE INVOLVEMENT WITH GOES TIME CODE SERVICE

NIST has announced that it will discontinue its involvement with the time code broadcast from the GOES WEST and GOES EAST satellites operated by the National Oceanic and Atmosphere Administration (NOAA) on January 1, 2005. This decision has been jointly made by NIST and NOAA in response to the fact that nearly all users requiring time more accurate than 1 ms now use the Global Positioning System (GPS), and as a result, commercial sources for GOES timing receivers no longer exist.

NOAA is expected to continue to provide a GOES time code indefinitely after January 1, 2005, and existing receivers should be able to continue to receive and decode the time signal. However, the time code will no longer be controlled and checked by NIST, and the received time is expected to be less accurate when NIST discontinues its involvement. The GOES satellites currently broadcast continuously updated position information in addition to the time, so that GOES receivers can automatically correct for path delay changes caused by satellite motion. This allows the current system to have a time uncertainty of less than 100 ms. NOAA is expected to continuously broadcast a fixed position from the satellites, which could increase the time uncertainty to 1 ms or more.

The GOES time broadcasts began in 1974 and have served many applications and thousands of users. NIST will continue to control and monitor the time code through January 1, 2005 to allow users who require a high accuracy signal sufficient time to replace their existing receivers. If you have additional questions, please contact Michael Lombardi, 303-497-3212, or email lombardi@boulder.nist.gov.