

**NIST TIME AND FREQUENCY BULLETIN
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1. GENERAL BACKGROUND INFORMATION

ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

BIPM	- Bureau International des Poids et Mesures		
CCIR	- International Radio Consultative Committee		
Cs	- Cesium standard		
GOES	- Geostationary Operational Environmental Satellite		
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	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 up to 10 GPS satellites (see bibliography on page 5). **UTC - UTC(NIST) data are on page 3.**

0000 HOURS COORDINATED UNIVERSAL TIME			
MAY 2000	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
4	51668	+240 ms	7 ns
11	51675	+233 ms	10 ns
18	51682	+225 ms	9 ns
25	51689	+221 ms	9 ns

NOTE: It has been announced that there will be no leap second introduced at the end of June 2000.

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 rate of rotation of the Earth.

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. There have been 22 leap seconds inserted in total.

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 GOES are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

DUT1 = UT1 - UTC =	+0.4 s beginning 0000 UTC 14 October 1999 +0.3 s beginning 0000 UTC 06 January 2000 +0.2 s beginning 0000 UTC 13 April 2000
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The deviation of 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
Jun 30, 1999	51359	-12
Jul 10, 1999	51369	-6
Jul 20, 1999	51379	-3
Jul 30, 1999	51389	-1
Aug 9, 1999	51399	-2
Aug 19, 1999	51409	4
Aug 29, 1999	51419	12
Sep 8, 1999	51429	15
Sep 18, 1999	51439	13
Sep 28, 1999	51449	15
Oct 8, 1999	51459	9
Oct 18, 1999	51469	9
Oct 29, 1999	51479	10
Nov 7, 1999	51489	7
Nov 17, 1999	51499	6
Nov 27, 1999	51509	-1
Dec 7, 1999	51519	-1
Dec 17, 1999	51529	-5
Dec 27, 1999	51539	-3
Jan 6, 2000	51549	0
Jan 16, 2000	51559	2
Jan 26, 2000	51569	0
Feb 5, 2000	51579	6
Feb 15, 2000	51589	5
Feb 25, 2000	51599	7
Mar 6, 2000	51609	8
Mar 16, 2000	51619	15
Mar 26, 2000	51629	15
Apr 5, 2000	51639	20
Apr 15, 2000	51649	20
Apr 25, 2000	51659	17

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 (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 master stations monitored are Dana, IN (8970) 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.

DATE	MJD	UTC(NIST)-WWVB (60 kHz)		UTC(NIST) - LORAN PHASE (ns)	
		ANTENNA PHASE (μs)	LORAN-C (DANA) (8970)	LORAN-C (FALLON) (9940)	
05/01/00	51665	5.66	-33	-266	
05/02/00	51666	5.67	-97	-449	
05/03/00	51667	5.68	+78	+168	
05/04/00	51668	5.69	-432	-338	
05/05/00	51669	5.63	-365	+318	
05/06/00	51670	5.64	+80	+500	
05/07/00	51671	5.64	+303	-117	
05/08/00	51672	5.64	+336	-257	
05/09/00	51673	5.62	-253	+182	
05/10/00	51674	5.64	-205	+40	
05/11/00	51675	5.66	+399	+779	
05/12/00	51676	5.64	+470	-609	
05/13/00	51677	5.62	-180	-626	
05/14/00	51678	5.61	+367	+436	
05/15/00	51679	5.60	-437	-328	
05/16/00	51680	5.77	+348	-673	
05/17/00	51681	5.76	+493	+17	
05/18/00	51682	5.76	-468	+468	
05/19/00	51683	5.76	+554	+3	
05/20/00	51684	5.76	+726	-200	
05/21/00	51685	5.76	-318	+110	
05/22/00	51686	5.77	-105	-404	
05/23/00	51687	5.82	-550	+410	
05/24/00	51688	5.65	+368	+171	
05/25/00	51689	5.66	+281	+427	
05/26/00	51690	5.66	+38	+312	
05/27/00	51691	5.65	+262	-481	
05/28/00	51692	5.66	-605	+472	
05/29/00	51693	5.66	-259	-351	
05/30/00	51694	5.69	-490	+467	
05/31/00	51695	5.62	-357	-353	

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE WWVB 60 kHz						PHASE PERTURBATIONS			
Station	MAY 2000	MJD	Began UTC	Ended UTC	Freq.	MAY 2000	MJD	Began UTC	End UTC
WWVB	5/29	51693	0145	0250	60 kHz				
WWV									
WWVH									

5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and maintained by NIST are used to provide accuracy (rate) input to the BIPM. NIST-7, which had served as the U.S. primary standard since 1994, has been replaced by NIST-F1, a cesium fountain frequency standard. The uncertainty of the new standard is currently 1.7 parts in 10¹⁵.

The AT1 scale is run in real-time using 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 using 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 very 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 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 data available.

6. BIBLIOGRAPHY

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 (September 1975).

Allan, D.W. and Weiss, M.A., "Accurate time and frequency transfer during common view of a GPS satellite," Proc. 34th Annual Symposium on Frequency Control, p.334 (1980).

Allan, D.W. and Barnes, J.A., "Optimal time and frequency using GPS signals," Proc. 36th Annual Symposium on Frequency Control, p.378 (1982).

Drullinger, R.E.; Glaze, D.J.; Lowe, J.P.; and Shirley, J.H., "The NIST optically pumped cesium frequency standard," IEEE Trans. Instrum. Meas., IM-40, 162-164 (1991).

Glaze, D.J.; Hellwig, H.; Allan, D.W.; and Jarvis, S., "NBS-4 and NBS-6: The NIST primary frequency standards," Metrologia, Vol.13, pp.17-28 (1977).

Wineland, D.J.; Allan, D.W.; Glaze, D.J.; Hellwig, H.; and Jarvis, S., "Results on limitations in primary cesium standard operation," IEEE Trans. Instrum. Meas., IM-25, pp.453-458 (December 1976).

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 T₀ 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)
Jul 98	-32	-177887.5	-41.5	50995	51025
Aug 98	-32	-179174.0	-41.0	51025	51057
Sep 98	-32	-180445.0	-41.0	51057	51087
Oct 98	-32	-181675.0	-41.5	51087	51118
Nov 98	-32	-182961.5	-41.5	51118	51148
Dec 98	-32	-184206.5	-41.5	51148	51179
Jan 99	-32	-185493.0	-41.5	51179	51210
Feb 99	-32	-186779.5	-41.0	51210	51238
Mar 99	-32	-187927.5	-40.5	51238	51269
Apr 99	-32	-189183.0	-40.0	51269	51299
May 99	-32	-190383.0	-41.0	51299	51330
Jun 99	-32	-191654.0	-41.0	51330	51360
Jul 99	-32	-192884.0	-41.0	51360	51391
Aug 99	-32	-194155.0	-41.0	51391	51422
Sep 99	-32	-195426.0	-40.5	51422	51452
Oct 99	-32	-196641.0	-40.5	51452	51483
Nov 99	-32	-197896.5	-40.0	51853	51513
Dec 99	-32	-199096.5	-40.0	51513	51533†
Dec 99	-32	-199896.5	-41.0	51533	51544
Jan 00	-32	-200347.5	-40.5	51544	51575
Feb 00	-32	-201603.0	-40.5	51575	51604
Mar 00	-32	-202777.5	-40.5	51604	51635
Apr 00	-32	-204033.0	-40.5	51635	51665
May 00	-32	-205248.0	-40.5	51665	51696
Jun 00	-32	-206495.75	-40.25	51696	51726
Jul 00	-32	-207703.25	-40.25*	51726	51757*

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

7. SPECIAL ANNOUNCEMENTS

TRACEABLE FREQUENCY CALIBRATIONS (Now NVLAP Certified)

Laboratories can get any needed traceable frequency calibrations by subscribing to the NIST Frequency Measurement and Analysis Service. This service is offered on a lease basis by NIST to provide an easy and inexpensive means to obtain traceability of a laboratory frequency standard and, in addition, to calibrate other devices in the lab. This service has been designed for ease of operation and as a practical calibration tool.

All necessary hardware and software is provided by NIST. Users must provide their own oscillator(s) and an ordinary telephone line so that NIST can access the system by modem. A maximum total of five oscillators can be calibrated at the same time. Radio signals from GPS satellites are used and the measurement uncertainty is $\pm 2 \times 10^{-13}$ per day. Any frequency from 1 Hz to 120 MHz (in 1 Hz increments) can be measured.

The calibration data are displayed in color, and a graph is plotted daily for each oscillator. Data are also stored on disk. The user can call up any of the data and view them onscreen or in the form of plots. Up to 5 months of data can be plotted on one graph.

The system plots are easy to read and understand. The system manual is written clearly and the NIST staff are available by telephone to assist. The modem connection allows NIST to access the data and to prepare a monthly traceability report, which is mailed to the user.

Frequency sources of any accuracy can be calibrated. The FMAS is particularly useful at the highest levels of performance. This is because each user of the system contributes information and calibration data for the others. If an uncertainty arises, it is possible for NIST to call by modem to another user nearby. In this way problems in data interpretation can be resolved.

NVLAP certification requirements for frequency measurement are met by following the NIST-FMAS operating manual. This service does not eliminate the NVLAP audits but, when installed and operated per the NIST guidelines, audit requirements are easily met.

NIST retains title to the equipment and supplies. All necessary replacement parts are replaced by overnight shipment. Training for use of the system is available if requested by the user.

The NIST Frequency Measurement and Analysis Service provides a complete solution to nearly all frequency measurement and calibration problems. For a free information package, please phone Michael Lombardi at (303) 497-3212, or E-mail him at lombardi@boulder.nist.gov, or write to Michael Lombardi, NIST, Division 847, 325 Broadway, Boulder, CO 80305.

IMPORTANT NOTICE!

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