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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
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			
NOV 1999	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
4	51486	+428 ms	13 ns
11	51493	+418 ms	14 ns
28	51500	+409 ms	14 ns
25	51507	+398 ms	16 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 rotation.

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.

NOTE: There will NOT be a leap second on December 31, 1999

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 =

+0.1 s beginning 0000 UTC 19 October 2000
+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

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
Feb. 10, 1999	51219	25
Feb. 20, 1999	51229	26
Mar. 2, 1999	51239	24
Mar. 12, 1999	51249	21
Mar. 22, 1999	51259	15
Apr. 1, 1999	51269	10
Apr. 11, 1999	51279	2
Apr. 21, 1999	51289	-9
May 1, 1999	51299	-18
May 11, 1999	51309	-18
May 21, 1999	51319	-18
May 31, 1999	51329	-16
Jun. 10, 1999	51339	-16
Jun. 20 1999	51349	-14
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. 28, 1999	51479	10
Nov. 7, 1999	51489	7
Nov. 17, 1999	51499	6
Nov. 27, 1999	51509	-1

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)
11/01/99	51483	5.74	-266	+126
11/02/99	51484	5.73	+247	+411
11/03/99	51485	5.75	+131	-223
11/04/99	51486	5.75	+112	+4
11/05/99	51487	5.75	-17	+149
11/06/99	51488	5.75	-	-279
11/07/99	51489	5.76	+158	+537
11/08/99	51490	5.75	-302	+183
11/09/99	51491	5.76	+157	+405
11/10/99	51492	5.76	+191	-338
11/11/99	51493	5.75	-283	+433
11/12/99	51494	5.74	-366	+58
11/13/99	51495	5.74	-69	+304
11/14/99	51496	5.75	+252	-408
11/15/99	51497	5.71	-465	+229
11/16/99	51498	5.76	+234	-67
11/17/99	51499	5.72	+48	+37
11/18/99	51500	5.73	+461	-508
11/19/99	51501	5.73	-69	+344
11/20/99	51502	5.76	-332	-125
11/21/99	51503	5.78	-7	+227
11/22/99	51504	5.76	-384	-648
11/23/99	51505	5.78	-540	+660
11/24/99	51506	5.75	+246	+304
11/25/99	51507	5.74	-427	-217
11/26/99	51508	5.74	+285	-173
11/27/99	51509	5.74	-65	+158
11/28/99	51510	5.75	+77	+211
11/29/99	51511	5.74	-205	+381
11/30/99	51512	5.75	+341	+279

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE							PHASE PERTURBATIONS 2 ms			
Station	NOV 1999	MJD	Began UTC	Ended UTC	Freq.		NOV 1999	MJD	Began UTC	End UTC
WWVB										
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. NBS-6, which served as the US. primary standard from 1975 through 1992, has been replaced by NIST-7, an optically pumped cesium-beam standard. The uncertainty of the new standard is currently 1 part in 10^{-14}.

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 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 ATI. 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 only at 0000 UTC on the first day of any month, and the change in frequency in any month is limited to ±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

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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)
Feb 98	-31	-171573	-42.5	50845	50873
Mar 98	-31	-172763	-42.5	50873	50904
Apr 98	-31	-147080.5	-42.0	50904	50934
May 98	-31	-175340.5	-42.0	50934	50965
Jun 98	-31	-176642.5	-41.5	50965	50995
Jul 98	-31	-177887.5	-41.5	50995	51025
Aug 98	-31	-179174	-41.0	51025	51057
Sep 98	-31	-180445	-41.0	51057	51087
Oct 98	-31	-181675	-41.5	51087	51118
Nov 98	-31	-182961.5	-41.5	51118	51148
Dec 98	-31	-184206.5	-41.5	51148	51179
Jan 99	-32	-185493	-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	-40.0	51269	51299
May 99	-32	-190383	-41.0	51299	51330
Jun 99	-32	-191654	-41.0	51330	51360
Jul 99	-32	-192884	-41.0	51360	51391
Aug 99	-32	-194155	-41.0	51391	51422
Sep 99	-32	-195426	-40.5	51422	51452
Oct 99	-32	-196641	-40.5	51452	51483
Nov 99	-32	-197896.5	-40.0	51483	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*

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

8. SPECIAL ANNOUNCEMENTS
TRACEABLE FREQUENCY CALIBRATIONS
(Now NVLAP Certified)

Laboratories needing traceable frequency calibrations can get them 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 t o obtain traceability of a laboratory main oscillator and, in addition, to calibrate other devices in the lab. This service has been designed for ease of operation and as a practical lab calibration tool.

All the equipment and software needed are 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 total of five oscillators can be calibrated at the same time. Radio signals from GPS satellites are used and the measurement uncertainty is $\pm 5 \times 10^{-13}$ per day.

The calibration data are displayed in color and a graph is plotted daily for each oscillator connected. 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. Many months of data can be plotted.

The system plots are easy to read and understand. The system manual is written for easy understanding and the NIST staff is 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 NET-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 t o nearly all Frequency measurement and calibration problems. For a free information package, please contact Michael Lombardi at (303) 497-3212, E-mail at lombardi@boulder.nist.gov, or write to: Michael Lombardi, NIST, Division 847, 325 Broadway, Boulder, CO 80303.

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