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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 up to 10 GPS satellites (see bibliography on page 5). **UTC - UTC(NIST) data are on page 3.**

0000 HOURS COORDINATED UNIVERSAL TIME			
FEB 2000	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
3	51577	+327 ms	18 ns
10	51584	+321 ms	23 ns
17	51591	+315 ms	24 ns
24	51598	+308 ms	24 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

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
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 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

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 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.

		UTC(NIST)-WWVB (60 kHz)	UTC(NIST) - LORAN PHASE (ns)	
DATE	MJD	ANTENNA PHASE (µs)	LORAN-C (DANA) (8970)	LORAN-C (FALLON) (9940)
02/01/00	51575	5.78	+678	+298
02/02/00	51576	5.71	-192	-627
02/03/00	51577	5.71	-100	+369
02/04/00	51578	5.71	+569	-489
02/05/00	51579	5.69	+62	+538
02/06/00	51580	5.70	-427	-533
02/07/00	51581	5.70	-136	+22
02/08/00	51582	5.71	+624	-567
02/09/00	51583	5.72	-44	+548
02/10/00	51584	5.71	+550	-414
02/11/00	51585	5.71	+273	-716
02/12/00	51586	5.71	-323	+210
02/13/00	51587	5.71	-164	+294
02/14/00	51588	5.72	-796	-16
02/15/00	51589	5.71	+365	+252
02/16/00	51590	5.71	+622	-88
02/17/00	51591	5.71	-541	+328
02/18/00	51592	5.71	-240	-191
02/19/00	51593	5.71	-166	+250
02/20/00	51594	5.71	+243	-327
02/21/00	51595	5.73	-595	-237
02/22/00	51596	5.72	-170	-58
02/23/00	51597	5.72	-238	+106
02/24/00	51598	5.72	-204	-227
02/25/00	51599	5.71	-150	-354
02/26/00	51600	5.72	+119	-394
02/27/00	51601	5.71	+632	+346
02/28/00	51602	5.72	-690	+220
02/29/00	51603	5.74	+42	-33

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

WWVB 60 kHz	OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS			
Station	FEB 2000	MJD	Began UTC	Ended UTC	Freq.		FEB 2000	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. 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 10^{15}.

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

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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 98	-32	-175340.5	-42.0	50934	50965
Jun 98	-32	-176642.5	-41.5	50965	50995
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

† 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!

The Time and Frequency Bulletin data are now online at

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