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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

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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			
FEB 1999	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
4	51213	+682 ms	22 ns
11	51220	+674 ms	21 ns
18	51227	+666 ms	17 ns
25	51234	+656 ms	18 ns

The master clock pulses used by the WWV, WWVH, WWVB and GOES 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 =
-0.3 s beginning 0000 UTC 26 November 1998
+0.7 s beginning 0000 UTC 01 January 1999
+0.6 s beginning 0000 UTC 04 March 1999

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
Mar. 7, 1998	50879	18
Mar. 17, 1998	50889	22
Mar. 27, 1998	50899	25
Apr. 6, 1998	50909	25
Apr. 16, 1998	50919	26
Apr. 26, 1998	50929	26
May 6, 1998	50939	26
May 16, 1998	50949	28
May 26, 1998	50959	26
June 5, 1998	50969	30
June 15, 1998	50979	27
June 25, 1998	50989	26
July 5, 1998	50999	24
July 15, 1998	51009	23
July 25, 1998	51019	22
Aug. 4, 1998	51029	15
Aug. 14, 1998	51039	16
Aug. 24, 1998	51049	11
Sep. 3, 1998	51059	6
Sep. 13, 1998	51069	1
Sep. 23, 1998	51079	-4
Oct. 3, 1998	51089	-7
Oct. 13, 1998	51099	5
Oct. 23, 1998	51109	-3
Nov. 2, 1998	51119	-3
Nov. 12, 1998	51129	-1
Nov. 22, 1998	51139	0
Dec. 2, 1998	51149	4
Dec. 12, 1998	51159	3
Dec. 22, 1998	51169	10
Jan. 1, 1999	51179	10
Jan. 11, 1999	51189	19
Jan. 21, 1999	51199	22
Jan. 31, 1999	51209	25

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 Dana, IN (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 (DANA) (8970)	LORAN-C (FALLON) (9940)
02/02/99	51210	5.62	-440	-244
02/02/99	51211	5.70	+533	-605
02/03/99	51212	5.64	-371	+807
02/04/99	51213	5.71	+0	+417
02/05/99	51214	5.66	-2	-477
02/06/99	51215	5.64	+559	+484
02/07/99	51216	5.64	-529	-426
02/08/99	51217	5.61	+287	-285
02/09/99	51218	5.63	+500	+296
02/10/99	51219	5.63	-180	+614
02/11/99	51220	5.64	-314	-412
02/12/99	51221	5.64	+473	-234
02/13/99	51222	5.64	-266	+258
02/14/99	51223	5.64	+360	-459
02/15/99	51224	5.65	-293	+385
02/16/99	51225	5.64	+339	-677
02/17/99	51226	5.63	+290	-132
02/18/99	51227	5.65	-464	+639
02/19/99	51228	5.65	+614	-579
02/20/99	51229	5.65	-177	+484
02/21/99	51230	5.65	-50	-117
02/22/99	51231	5.63	+333	+298
02/23/99	51232	5.59	-219	-642
02/24/99	51233	5.58	-414	-339
02/25/99	51234	5.72	-157	+193
02/26/99	51235	5.68	+180	-302
02/27/99	51236	5.69	-819	+322
02/28/99	51237	5.70	+196	-48

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE							PHASE PERTURBATIONS			
Station	FEB 1999	MJD	Began UTC	Ended UTC	Freq.		FEB 1999	MJD	Began UTC	End UTC
WWVB	03	51212	0700	0800	60 kHz					
WWVB	09	51218	1700	2000	60 kHz					
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-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 1 part 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 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 97	-30	-159812.0	-43.0	50569	50600
Jun 97	-30	-161145.0	-43.0	50600	50630
Jul 97	-31	-162435.0	-43.0	50630	50661
Aug 97	-31	-163768.0	-43.0	50661	50692
Sep 97	-31	-165101.0	-42.5	50692	50722
Oct 97	-31	-166376.0	-42.0	50722	50753
Nov 97	-31	-167678.0	-42.0	50753	50783
Dec 97	-31	-168938.0	-42.5	50783	50814
Jan 98	-31	-170255.0	-42.5	50814	50845
Feb 98	-31	-171573.0	-42.5	50845	50873
Mar 98	-31	-172763.0	-42.5	50873	50904
Apr 98	-31	-174080.5	-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	-179174.0	-41.0	51025	51057
Sep 98	-31	-180445.0	-41.0	51057	51087
Oct 98	-31	-181675.0	-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	-185493.0	-41.5	51179	51210
Feb 99	-32	-186779.5	-41.5	51210	51238
Mar 99	-32	-187927.5	-41.0	51238	51269
Apr 99	-32	-189183.0	-40.5*	51269	51299

***Provisional value**

7. SPECIAL ANNOUNCEMENTS

TRACEABLE FREQUENCY CALIBRATIONS
(Now NVLAP Certified)

Anyone 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 to 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 four oscillators can be calibrated at the same time. Radio signals form either Loran-C or GPS satellite are used. Results for either are at about the same accuracy.

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 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 any needed system spares. Equipment that fails is 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 contact Michael Lombardi at (30) 497-3212, email at lombardi@boulder.nist.gov, or write to: Michael Lombardi, NIST, Division 847, 325 Broadway, Boulder, CO 80303.
