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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 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 2002	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
4	52368	-191 ms	-15 ns
11	52375	-196 ms	-17 ns
18	52382	-200ms	-14 ns
25	52389	-205 ms	-12 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 rate of rotation of the Earth.

NOTE: There will be NO leap second inserted at the end of June 2002.

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, and WWVB 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 0000UTC 14 February 2002

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. 26, 2002	52359	-15
Mar. 16, 2002	52349	-13
Mar. 6, 2002	52339	-9
Feb. 24, 2002	52329	-12
Feb. 14, 2002	52319	-19
Feb. 4, 2002	52309	-19
Jan. 25, 2002	52299	-20
Jan. 15, 2002	52289	-19
Jan. 5, 2002	52279	-11
Dec. 26, 2001	52269	-1
Dec. 16, 2001	52259	9
Dec. 6, 2001	52249	17
Nov. 26, 2001	52239	27
Nov. 16, 2001	52229	31
Nov. 6, 2001	52219	34
Oct. 27, 2001	52209	39
Oct. 17, 2001	52199	42
Oct. 7, 2001	52189	46
Sep. 27, 2001	52179	40
Sep. 17, 2001	52169	32
Sep. 7, 2001	52159	26
Aug. 28, 2001	52149	17
Aug. 18, 2001	52139	2
Aug. 8, 2001	52129	-11
July 29, 2001	52119	-18
July 19, 2001	52109	-20
July 9, 2001	52099	-23
June 29, 2001	52089	-26
June 19, 2001	52079	-23
June 9, 2001	52069	-21

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 unce rtainty 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) 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)
04/01/02	52365	5.69	-180	-34
04/02/02	52366	5.66	+72	-232
04/03/02	52367	5.65	-18	-169
04/04/02	52368	5.67	+21	+498
04/05/02	52369	5.68	-65	+241
04/06/02	52370	5.68	+11	-76
04/07/02	52371	5.69	+230	-323
04/08/02	52372	5.68	+440	+34
04/09/02	52373	5.70	-220	-304
04/10/02	52374	5.66	+243	+162
04/11/02	52375	5.67	-8	-5
04/12/02	52376	5.66	-340	+200
04/13/02	52377	5.65	+108	-419
04/14/02	52378	5.65	-259	-97
04/15/02	52379	5.65	+60	+94
04/16/02	52380	5.65	+131	+93
04/17/02	52381	5.63	-186	-22
04/18/02	52382	5.67	+4	+335
04/19/02	52383	5.64	+295	+70
04/20/02	52384	5.65	-82	-19
04/21/02	52385	5.65	+299	-189
04/22/02	52386	5.66	-113	-231
04/23/02	52387	5.64	-502	+37
04/24/02	52388	5.64	+220	-252
04/25/02	52389	5.64	+299	+158
04/26/02	52390	5.62	+161	+113
04/27/02	52391	5.62	+197	+186
04/28/02	52392	5.62	+53	+74
04/29/02	52393	5.61	+34	+122
04/30/02	52394	5.60	-50	-228

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

WWVB 60 kHz	OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS			
Station	APR 2002	MJD	Began UTC	Ended UTC	Freq.		APR 2002	MJD	Began UTC	End UTC
WWVB	4/22/02	52386	2230	2300	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 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 $\pm$ 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 data available.

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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 02	-32	-231829.5	-41.5*	52395	52426*
Apr 02	-32	-233558.5	-41.0	52377	52395
Apr 02	-32	-231829.5	-40.5	52365	52377†
Mar 02	-32	-232829.5	-40.0	52359	52365
Mar 02	-32	-231829.5	-40.0	52334	52359†
Feb 02	-32	-231255.5	-41.0	52320	52334
Feb 02	-32	-230695.5	-40.0	52306	52320†
Jan 02	-32	-230169.0	-40.5	52293	52306
Jan 02	-32	-229467.0	-39.0	52275	52293†
Dec 01	-32	-228258.0	-39.0	52244	52275
Nov 01	-32	-227073.0	-39.5	52214	52244
Oct 01	-32	-225848.5	-39.5	52183	52214
Sep 01	-32	-224633.5	-40.5	52153	52183
Aug 01	-32	-223362.5	-41.0	52122	52153
Jul 01	-32	-222122.5	-40.0	52091	52122
Jun 01	-32	-220937.5	-39.5	52061	52091
Apr 01	-32	-218543.0	-39.0	52000	52030
Dec 00	-32	-213746.5	-40.0	51879	51910
Nov 00	-32	-212546.5	-40.0	51849	51879
Oct 00	-32	-211337.5	-39.0	51818	51849
Sep 00	-32	-210167.5	-39.0	51788	51818

† 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.

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 millisecond 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 microseconds. NOAA is expected to continuously broadcast a fixed position from the satellites, which could increase the time uncertainty to 1 millisecond 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.

IMPORTANT NOTICE!

The Time and Frequency Bulletin data are now online at

http://tf.nist.gov
