**NIST TIME AND FREQUENCY BULLETIN**
**NISTIR 6630-10**

**NO. 562 OCTOBER 2004**



This bulletin is published monthly. Address correspondence to:


Eyvon M. Petty, Editor
Time and Frequency Division
National Institute of Standards and Technology
325 Broadway
Boulder, CO 8O3O5-3328
(3O3) 497-3295
Email: pettye@boulder.nist.gov



U.S. DEPARTMENT OF COMMERCE, DONALD L. EVANS, Secretary
TECHNOLOGY ADMINISTRATION, Phillip J. Bond, Under Secretary of Commerce for Technology
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, Arden L. Bement, Jr., Director

## 1. GENERAL BACKGROUND INFORMATION

### ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

| | |
|---|---|
| ACTS | - Automated Computer Time Service |
| BIPM | - Bureau International des Poids et Mesures |
| Cs | - Cesium standard |
| 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 | | | |
|---|---|---|---|
| SEP 2004 | MJD | UT1-UTC(NIST) (±5 ms) | UTC(USNO,MC) - UTC(NIST) (±20 ns) |
| 2 | 53250 | -454 ms | 7 ns |
| 9 | 53257 | -452 ms | 11 ns |
| 16 | 53264 | -452 ms | 13 ns |
| 23 | 53271 | -453 ms | 11 ns |
| 30 | 53278 | -456 ms | 11 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.

**NOTE: No leap second will be added at the end of December 2004.**

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.

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 = | +0.0 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 |
| | -0.5 s beginning 0000 UTC 29 April 2004 |

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 |
|---|---|---|
| Aug. 22, 2004 | 53239 | 0.9 |
| Aug. 12, 2004 | 53229 | -2.5 |
| Aug. 02, 2004 | 53219 | -2.5 |
| Jul. 23, 2004 | 53209 | -4.0 |
| Jul. 13, 2004 | 53199 | -6.0 |
| Jul. 03, 2004 | 53189 | -5.3 |
| Jun. 23, 2004 | 53179 | -6.4 |
| Jun. 13, 2004 | 53169 | -5.2 |
| Jun. 03, 2004 | 53159 | 0.2 |
| May 24, 2004 | 53149 | 5.4 |
| May 14, 2004 | 53139 | 9.9 |
| May 04, 2004 | 53129 | 10.5 |
| Apr. 24, 2004 | 53119 | 7.5 |
| Apr. 14, 2004 | 53109 | 6.9 |
| Apr. 04, 2004 | 53099 | 6.7 |
| Mar. 25, 2004 | 53089 | 6.3 |
| Mar. 15, 2004 | 53079 | 4.1 |
| Mar. 05, 2004 | 53069 | 3.2 |
| Feb. 24, 2004 | 53059 | 1.2 |
| Feb. 14, 2004 | 53049 | -2.0 |
| Feb. 4, 2004 | 53039 | -4.5 |
| Jan. 25, 2004 | 53029 | -4.6 |
| Jan. 15, 2004 | 53019 | -4.2 |
| Jan. 5, 2004 | 53009 | -3.1 |
| Dec. 26, 2003 | 52999 | -4.0 |
| Dec. 16, 2003 | 52989 | -2.8 |
| Dec. 6, 2003 | 52979 | -0.2 |
| Nov. 26, 2003 | 52969 | -1.1 |
| Nov. 16, 2003 | 52959 | 2.0 |
| Nov. 6, 2003 | 52949 | 2.1 |

## 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) |
| 09/01/04 | 53249 | 5. 78 | +170 | -66 |
| 09/02/04 | 53250 | 5. 77 | -101 | +40 |
| 09/03/04 | 53251 | 5. 78 | -34 | -263 |
| 09/04/04 | 53252 | 5. 78 | -61 | +271 |
| 09/05/04 | 53253 | 5. 77 | -104 | -65 |
| 09/06/04 | 53254 | 5. 77 | -30 | -35 |
| 09/07/04 | 53255 | 5. 76 | +85 | -143 |
| 09/08/04 | 53256 | 5. 76 | -59 | -428 |
| 09/09/04 | 53257 | 5. 78 | -149 | +7 |
| 09/10/04 | 53258 | 5. 77 | -37 | +107 |
| 09/11/04 | 53259 | 5. 76 | -190 | -294 |
| 09/12/04 | 53260 | 5. 78 | -1 | -215 |
| 09/13/04 | 53261 | 5. 79 | -24 | -73 |
| 09/14/04 | 53262 | 5. 78 | -106 | -38 |
| 09/15/04 | 53263 | 5. 77 | -205 | +427 |
| 09/16/04 | 53264 | 5. 78 | +52 | +34 |
| 09/17/04 | 53265 | 5. 79 | -19 | +242 |
| 09/18/04 | 53266 | 5. 78 | -32 | +0 |
| 09/19/04 | 53267 | 5. 78 | -20 | +139 |
| 09/20/04 | 53268 | 5. 78 | +45 | -18 |
| 09/21/04 | 53269 | 5. 80 | -55 | +123 |
| 09/22/04 | 53270 | 5. 83 | -16 | -58 |
| 09/23/04 | 53271 | 5. 83 | -17 | +178 |
| 09/24/04 | 53272 | 5. 82 | -24 | -291 |
| 09/25/04 | 53273 | 5. 82 | +41 | +196 |
| 09/26/04 | 53274 | 5. 82 | -- | -- |
| 09/27/04 | 53275 | 5. 83 | -35 | -187 |
| 09/28/04 | 53276 | 5. 82 | -131 | -87 |
| 09/29/04 | 53277 | 5. 84 | -3 | +10 |
| 09/30/04 | 53278 | 5. 85 | -88 | +276 |

## 4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

| OUTAGES OF 5 MINUTES OR MORE | | | | | | | PHASE PERTURBATIONS 2 ms | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Station | SEP 2004 | MJD | Began UTC | Ended UTC | Freq. | | SEP 2004 | MJD | Began UTC | End UTC |
| WWVB | 09-02-04 | 53250 | 0612 | 0736 | 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 about 1 part in $10^{15}$.

The AT1 scale is run in real-time by use of 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 by use of 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 available data.

## 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 (1975).

Allan, D.W.; Davis, D.D.; Weiss, M.A.; Clements, A.; Guinot, B.; Granveaud, M.; Dorenwendt, K.; Fischer, B.; Hetzel, P.; Aoki, S.; Fujimoto, M.; Charron, L.; and Ashby, N., "Accuracy of International Time and Frequency Comparisons Via Global Positioning System Satellites in Common-view," IEEE Transactions on Instrumentation and Measurement, Vol. IM-34, pp.118-125, 1985.

Jefferts, S.R.; Shirley, J.; Parker, T.E.; Heavner, T.P.; Meekhof, D.M.; Nelson, C., Levi, F.; Costanza, G.; De Marchi, A.; Drullinger, R.; Hollberg, L.; Lee, W.D.; and Walls, F.L., "Accuracy evaluation of NIST-F1," Metrologia, Vol. 39, pp. 321-336, (2002).

Lewandowski, W. and Thomas, C.; "GPS Time transfer," Proceedings of the IEEE, Vol. 79, pp. 991-1000, 1991.

Shirley, J.H.; Lee, W.D.; Drullinger, R.E.; "Accuracy evaluation of the primary frequency standard NIST-7," Metrologia, Vol. 38, pp. 427-458, (2001).

Weiss, M.A.; Allan, D.W.; "An NBS Calibration Procedure for Providing Time and Frequency at a Remote Site by Weighting and Smoothing of GPS Common View Data," IEEE Transactions on Instrumentation and Measurement, Vol. IM-36, pp. 572-578, 1987.

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) |
|---|---|---|---|---|---|
| Nov 04 | -32 | -270718.05 | -39.1* | 53310 | 53340 |
| Oct 04 | -32 | -269505.95 | -39.1 | 53279 | 53310* |
| Sep 04 | -32 | -268723.95 | -39.1 | 53259 | 53279 |
| Sep 04 | -32 | -268330.95 | -39.3 | 53249 | 53259† |
| Aug 04 | -32 | -267898.65 | -39.3 | 53238 | 53249 |
| Aug 04 | -32 | -267110.65 | -39.4 | 53218 | 53238† |
| Jul 04 | -32 | -266716.65 | -39.4 | 53208 | 53218 |
| Jul 04 | -32 | -265892.4 | -39.25 | 53187 | 53208† |
| Jun 04 | -32 | -265342.9 | -39.25 | 53173 | 53187 |
| Jun 04 | -32 | -264722.9 | -38.75 | 53157 | 53173† |
| May 04 | -32 | -264064.15 | -38.75 | 53140 | 53157 |
| May 04 | -32 | -263514.65 | -39.25 | 53126 | 53140† |
| Apr 04 | -32 | -263004.4 | -39.25 | 53113 | 53126 |
| Apr 04 | -32 | -262334.6 | -39.4 | 53096 | 53113† |
| Mar 04 | -32 | -261783.0 | -39.4 | 53082 | 53096 |
| Mar 04 | -32 | -261110.65 | -39.55 | 53065 | 53082† |
| Feb 04 | -32 | -259963.7 | -39.55 | 53036 | 53065 |
| Jan 04 | -32 | -259410.0 | -39.55 | 53022 | 53036 |
| Jan 04 | -32 | -258738.5 | -39.5 | 53005 | 53022† |
| Dec 03 | -32 | -258343.5 | -39.5 | 52995 | 53005 |
| Dec 03 | -32 | -257516.1 | -39.4 | 52974 | 52995† |
| Nov 03 | -32 | -256925.1 | -39.4 | 52959 | 52974 |
| Nov 03 | -32 | -256334.85 | -39.35 | 52944 | 52959† |

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

## 7. SPECIAL ANNOUNCEMENTS

### NOTICE TO DISCONTINUE INVOLVEMENT WITH GOES TIME CODE SERVICE

NIST and NOAA (National Oceanic and Atmosphere Administration) have announced that the GOES Time Code Service will end on January 1, 2005. Existing GOES Time Code receivers will no longer be able to synchronize after that date, since the time code will then be removed from the broadcast. 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 have not existed for several years.

The GOES time broadcasts began in 1974 and have served many applications and thousands of users. The service works by providing a time code referenced to UTC(NIST) through two satellites (GOES EAST and GOES WEST) that are operated by NOAA. NIST will continue to control and monitor the time code through January 1, 2005 to allow existing GOES users sufficient time to replace their receivers.

For questions or more information contact Michael Lombardi at lombardi@boulder.nist.gov.