

NIST TIME AND FREQUENCY BULLETIN
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1. GENERAL BACKGROUND INFORMATION..... 2

2. TIME SCALE INFORMATION 2

3. PHASE DEVIATIONS FOR WWVB AND LORAN-C4

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB
PHASE PERTURBATIONS..... 5

5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS..... 5

6. BIBLIOGRAPHY5

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 80305-3328
(303) 497-3295
Email: pettye@boulder.nist.gov



U.S. DEPARTMENT OF COMMERCE, CARLOS GUTIERREZ, Secretary
TECHNOLOGY ADMINISTRATION, William A. Jeffrey, Act. Under Secretary of Commerce for Technology
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, William A. Jeffrey, 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 | 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 | | | |
|---------------------------------------|-------|--------------------------|--------------------------------------|
| JAN 2006 | MJD | UT1-UTC(NIST) (±5 ms) | UTC(USNO,MC) - UTC(NIST) (±20 ns) |
| 5 | 53740 | 337 ms | 5 ns |
| 12 | 53747 | 333 ms | 3 ns |
| 19 | 53754 | 333 ms | 0 ns |
| 26 | 53761 | 329 ms | 1 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: A positive leap second was added at the end of December 2005.

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, 1998 and 2005.

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 = | -0.3 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 -0.6 s beginning 0000 UTC 17 March 2005 +0.3 s beginning 0000 UTC 01 January 2006 |
|--------------------|---|

The difference between UTC(NIST) and 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 10 day intervals. Five day interval data are available in Circular T.

0000 Hours Coordinated Universal Time

| DATE | MJD | UTC-UTC(NIST) ns |
|---------------|------------|-------------------------|
| Dec. 25, 2005 | 53729 | 3.7 |
| Dec. 15, 2005 | 53719 | 2.6 |
| Dec. 05, 2005 | 53709 | 3.4 |
| Nov. 25, 2005 | 53699 | 0.1 |
| Nov. 15, 2005 | 53689 | -4.3 |
| Nov. 05, 2005 | 53679 | -7.2 |
| Oct. 26, 2005 | 53669 | -9.7 |
| Oct. 16, 2005 | 53659 | -11.5 |
| Oct. 06, 2005 | 53649 | -12.2 |
| Sep. 26, 2005 | 53639 | -12.7 |
| Sep. 16, 2005 | 53629 | -12.6 |
| Sep. 06, 2005 | 53619 | -11.8 |
| Aug. 27, 2005 | 53609 | -11.6 |
| Aug. 17, 2005 | 53599 | -10.3 |
| Aug. 07, 2005 | 53589 | -6.1 |
| Jul. 28, 2005 | 53579 | -1.9 |
| Jul. 18, 2005 | 53569 | 4.3 |
| Jul. 08, 2005 | 53559 | 8.4 |
| Jun. 28, 2005 | 53549 | 10.5 |
| Jun. 18, 2005 | 53539 | 15.6 |
| Jun. 08, 2005 | 53529 | 14 |
| May 29, 2005 | 53519 | 8.4 |
| May 19, 2005 | 53509 | 5.7 |
| May 09, 2005 | 53499 | 3.4 |
| Apr. 29, 2005 | 53489 | 1.4 |
| Apr. 19, 2005 | 53479 | 1.8 |
| Apr. 09, 2005 | 53469 | 0.6 |
| Mar. 30, 2005 | 53459 | -1.1 |
| Mar. 20, 2005 | 53449 | -2.2 |
| Mar. 10, 2005 | 53439 | -3.6 |

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 $\pm 0.5 \mu\text{s}$. The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift. 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, Minnesota (8970) and Boise City, Oklahoma (9610). The monitoring is done from the NIST laboratories in Boulder, Colorado.

Note: The values shown for Loran-C are in nanoseconds.

| DATE | MJD | <u>UTC(NIST)-WWVB</u> | <u>UTC(NIST) - LORAN PHASE (ns)</u> | |
|----------|-------|-----------------------|-------------------------------------|----------------------|
| | | (60 kHz) | LORAN-C (BAUDETTE) | LORAN-C (BOISE CITY) |
| | | ANTENNA PHASE | (8970) | (9610) |
| | | (μs) | | |
| 01/01/06 | 53736 | 5.73 | -109 | +12 |
| 01/02/06 | 53737 | 5.72 | -67 | -12 |
| 01/03/06 | 53738 | 5.70 | +99 | +14 |
| 01/04/06 | 53739 | 5.69 | -19 | +4 |
| 01/05/06 | 53740 | 5.66 | +74 | -17 |
| 01/06/06 | 53741 | 5.69 | +212 | -12 |
| 01/07/06 | 53742 | 5.68 | -128 | +10 |
| 01/08/06 | 53743 | 5.67 | -84 | +35 |
| 01/09/06 | 53744 | 5.65 | -8 | -3 |
| 01/10/06 | 53745 | 5.65 | -26 | +12 |
| 01/11/06 | 53746 | 5.63 | +76 | -1 |
| 01/12/06 | 53747 | 5.62 | -15 | +14 |
| 01/13/06 | 53748 | 5.61 | -116 | +3 |
| 01/14/06 | 53749 | 5.62 | +106 | -14 |
| 01/15/06 | 53750 | 5.62 | +202 | +14 |
| 01/16/06 | 53751 | 5.62 | +28 | +15 |
| 01/17/06 | 53752 | 5.62 | +116 | -15 |
| 01/18/06 | 53753 | 5.62 | +113 | +3 |
| 01/19/06 | 53754 | 5.62 | -106 | +14 |
| 01/20/06 | 53755 | 5.62 | -94 | -10 |
| 01/21/06 | 53756 | 5.62 | +44 | -10 |
| 01/22/06 | 53757 | 5.62 | -11 | +12 |
| 01/23/06 | 53758 | 5.62 | +6 | -17 |
| 01/24/06 | 53759 | 5.62 | -52 | -17 |
| 01/25/06 | 53760 | 5.62 | +161 | +6 |
| 01/26/06 | 53761 | 5.62 | -17 | +12 |
| 01/27/06 | 53762 | 5.62 | -100 | +1 |
| 01/28/06 | 53763 | 5.62 | -45 | +17 |
| 01/29/06 | 53764 | 5.62 | -30 | -13 |
| 01/30/06 | 53765 | 5.62 | -23 | -36 |
| 01/31/06 | 53766 | 5.62 | +50 | +13 |

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

| OUTAGES OF 5 MINUTES OR MORE | | | | | | PHASE PERTURBATIONS 2 ms | | | |
|------------------------------|----------|-----|-----------|-----------|-------|-----------------------------|-----|-----------|---------|
| Station | JAN 2006 | MJD | Began UTC | Ended UTC | Freq. | JAN 2006 | MJD | Began UTC | End UTC |
| WWVB | | | | | | | | | |
| 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-F1, a cold-atom cesium fountain frequency standard, has served as the U.S. primary time and frequency standard since 1999. The uncertainty of NIST-F1 is currently about 5 parts in 10^{16} .

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.

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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) |
| Mar 06 | -33 | -289630.45 | -38.95* | 53795 | 53826 |
| Feb 06 | -33 | -288539.85 | -38.95* | 53767 | 53795 |
| Jan 06 | -33 | -287838.75 | -38.95 | 53749 | 53767 |
| Jan 06 | -33 | -287330.45 | -38.95 | 53736 | 53749 |
| Dec 05 | -32 | -286118.35 | -39.1 | 53705 | 53736 |
| Nov 05 | -32 | -284937.85 | -39.35 | 53675 | 53705 |
| Oct 05 | -32 | -284308.25 | -39.35 | 53659 | 53675 |
| Oct 05 | -32 | -283721.75 | -39.1 | 53644 | 53659† |
| Sep 05 | -32 | -283017.95 | -39.1 | 53626 | 53644 |
| Sep 05 | -32 | -282549.95 | -39 | 53614 | 53626† |
| Aug 05 | -32 | -282081.95 | -39 | 53602 | 53614 |
| Aug 05 | -32 | -281350.45 | -38.5 | 53583 | 53602† |
| Jul 05 | -32 | -280156.95 | -38.5 | 53552 | 53583 |
| Jun 05 | -32 | -279617.95 | -38.5 | 53538 | 53552 |
| Jun 05 | -32 | -278993.95 | -39.0 | 53522 | 53538† |
| May 05 | -32 | -277784.95 | -39.0 | 53491 | 53522 |
| Apr 05 | -32 | -277160.95 | -39.0 | 53475 | 53491 |
| Apr 05 | -32 | -276613.55 | -39.1 | 53461 | 53475† |
| Mar 05 | -32 | -276066.15 | -39.1 | 53447 | 53461 |
| Mar 05 | -32 | -275403.5 | -39.0 | 53430 | 53447† |
| Feb 05 | -32 | -274311.15 | -39.0 | 53402 | 53430 |
| Jan 05 | -32 | -273102.15 | -39.0 | 53371 | 53402 |

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