

**NIST TIME AND FREQUENCY BULLETIN**  
**NIST IR 6653-10**

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## 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                                |         |               |
| NIST  | - National Institute of Standards and Technology      |         |               |
| NOAA  | - National Oceanic and Atmospheric Administration     |         |               |
| NVLAP | - National Voluntary Laboratory Accreditation Program | ns      | - nanosecond  |
| SI    | - International System of Units                       | $\mu$ s | - 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 |       |                                |                                            |
|---------------------------------------|-------|--------------------------------|--------------------------------------------|
| SEP 2008                              | MJD   | UT1-UTC(NIST)<br>( $\pm 5$ ms) | UTC(USNO,MC) - UTC(NIST)<br>( $\pm 20$ ns) |
| 4                                     | 54713 | -468 ms                        | -5 ns                                      |
| 11                                    | 54720 | -470 ms                        | -8 ns                                      |
| 18                                    | 54727 | -479 ms                        | -10 ns                                     |
| 25                                    | 54734 | -484 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  $\pm 0.9$  s of the UT1 astronomical time scale, which changes slightly due to variations in the Earth's period of rotation.

**NOTE:** A positive leap second will be added at the end of December 2008.

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, 1992-1994, 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  $\pm 0.9$  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 = | -0.6 s beginning 0000 UTC 20 November 2008 |
|                    | -0.5 s beginning 0000 UTC 07 August 2008   |
|                    | -0.4 s beginning 0000 UTC 13 March 2008    |
|                    | -0.3 s beginning 0000 UTC 29 November 2007 |

The difference between UTC(NIST) and UTC has been within  $\pm 100$  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 |
| Aug. 31, 2008                         | 54709 | -1.4             |
| Aug. 21, 2008                         | 54699 | 0.9              |
| Aug. 11, 2008                         | 54689 | 1.3              |
| Aug. 01, 2008                         | 54679 | 3.0              |
| Jul. 22, 2008                         | 54669 | 3.5              |
| Jul. 12, 2008                         | 54659 | 4.1              |
| Jul. 02, 2008                         | 54649 | 3.9              |
| Jun. 22, 2008                         | 54639 | 1.1              |
| Jun. 12, 2008                         | 54629 | -2.0             |
| Jun. 02, 2008                         | 54619 | -4.6             |
| May 23, 2008                          | 54609 | -7.8             |
| May 13, 2008                          | 54599 | -8.4             |
| May 03, 2008                          | 54589 | -10.2            |
| Apr. 23, 2008                         | 54579 | -10.1            |
| Apr. 13, 2008                         | 54569 | -12.8            |
| Apr. 03, 2008                         | 54559 | -12.5            |
| Mar. 24, 2008                         | 54549 | -12.6            |
| Mar. 14, 2008                         | 54539 | -13.0            |
| Mar. 04, 2008                         | 54529 | -9.9             |
| Feb. 23, 2008                         | 54519 | -6.7             |
| Feb. 13, 2008                         | 54509 | -5.1             |
| Jan. 03, 2008                         | 54499 | -3.8             |
| Jan. 24, 2008                         | 54489 | -1.2             |
| Jan. 14, 2008                         | 54479 | -0.9             |
| Jan. 04, 2008                         | 54469 | 1.3              |
| Dec. 25, 2007                         | 54459 | 3.0              |
| Dec. 15, 2007                         | 54449 | 5.2              |
| Dec. 05, 2007                         | 54439 | 5.1              |

### 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  $\pm 0.5 \mu\text{s}$ . 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.**

|            |       | <u>UTC(NIST)-WWVB</u><br>(60 kHz) | <u>UTC(NIST) - LORAN PHASE (ns)</u> |                         |
|------------|-------|-----------------------------------|-------------------------------------|-------------------------|
|            |       | ANTENNA PHASE                     | LORAN-C<br>(BAUDETTE)               | LORAN-C<br>(BOISE CITY) |
| DATE       | MJD   | ( $\mu\text{s}$ )                 | (8970)                              | (9610)                  |
| 09/01/2008 | 54710 | 5.65                              | -49                                 | +37                     |
| 09/02/2008 | 54711 | 5.65                              | +122                                | -46                     |
| 09/03/2008 | 54712 | 5.65                              | -67                                 | +15                     |
| 09/04/2008 | 54713 | 5.65                              | -43                                 | -17                     |
| 09/05/2008 | 54714 | 5.65                              | +11                                 | -15                     |
| 09/06/2008 | 54715 | 5.65                              | +117                                | +4                      |
| 09/07/2008 | 54716 | 5.65                              | +130                                | +15                     |
| 09/08/2008 | 54717 | 5.65                              | -30                                 | -10                     |
| 09/09/2008 | 54718 | 5.65                              | -2                                  | +13                     |
| 09/10/2008 | 54719 | 5.65                              | +21                                 | +2                      |
| 09/11/2008 | 54720 | 5.65                              | -20                                 | -27                     |
| 09/12/2008 | 54721 | 5.65                              | +55                                 | +14                     |
| 09/13/2008 | 54722 | 5.65                              | +75                                 | +17                     |
| 09/14/2008 | 54723 | 5.65                              | +3                                  | -25                     |
| 09/15/2008 | 54724 | 5.65                              | +45                                 | +18                     |
| 09/16/2008 | 54725 | 5.65                              | -28                                 | +13                     |
| 09/17/2008 | 54726 | 5.65                              | -214                                | -26                     |
| 09/18/2008 | 54727 | 5.65                              | +19                                 | -17                     |
| 09/19/2008 | 54728 | 5.65                              | +24                                 | +22                     |
| 09/20/2008 | 54729 | 5.65                              | -117                                | -37                     |
| 09/21/2008 | 54730 | 5.65                              | +6                                  | +21                     |
| 09/22/2008 | 54731 | 5.65                              | +16                                 | +1                      |
| 09/23/2008 | 54732 | 5.65                              | +1                                  | -16                     |
| 09/24/2008 | 54733 | 5.65                              | -7                                  | -13                     |
| 09/25/2008 | 54734 | 5.65                              | -4                                  | -18                     |
| 09/26/2008 | 54735 | 5.65                              | -19                                 | +35                     |
| 09/27/2008 | 54736 | 5.65                              | +4                                  | +2                      |
| 09/28/2008 | 54737 | 5.65                              | -6                                  | -2                      |
| 09/29/2008 | 54738 | 5.65                              | +22                                 | +15                     |
| 09/30/2008 | 54739 | 5.65                              | +14                                 | +10                     |

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

| OUTAGES OF 5 MINUTES OR MORE |          |       |           |           |        | PHASE PERTURBATIONS<br>2 ms |     |           |         |
|------------------------------|----------|-------|-----------|-----------|--------|-----------------------------|-----|-----------|---------|
| Station                      | Sep 2008 | MJD   | Began UTC | Ended UTC | Freq.  | Sep 2008                    | MJD | Began UTC | End UTC |
| WWVB                         | 09-10-08 | 54719 | 0100      | 0145      | 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-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  $\pm 2$  ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM by use of 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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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 offsets in time and 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<br>$UTC(NIST) - AT1 = x_{ls} + x + y*(T - T_0)$ |                 |             |               |                |                               |
|-----------------------------------------------------------|-----------------|-------------|---------------|----------------|-------------------------------|
| Month                                                     | $x_{ls}$<br>(s) | $x$<br>(ns) | $y$<br>(ns/d) | $T_0$<br>(MJD) | Valid until 0000 on:<br>(MJD) |
| Nov 08                                                    | -33             | -327085.5   | -38.3*        | 54771          | 54801                         |
| Oct 08                                                    | -33             | -325894.6   | -38.3         | 54740          | 54771*                        |
| Sep 08                                                    | -33             | -324745.6   | -38.3         | 54710          | 54740                         |
| Aug 08                                                    | -33             | -323558.3   | -38.3         | 54679          | 54710                         |
| Jul 08                                                    | -33             | -322792.3   | -38.3         | 54659          | 54679                         |
| Jul 08                                                    | -33             | -322369.9   | -38.4         | 54648          | 54659†                        |
| Jun 08                                                    | -33             | -321211.9   | -38.6         | 54618          | 54648                         |
| May 08                                                    | -33             | -320594.3   | -38.6         | 54602          | 54618                         |
| May 08                                                    | -33             | -320018.3   | -38.4         | 54587          | 54602†                        |
| Apr 08                                                    | -33             | -319288.7   | -38.4         | 54568          | 54587                         |
| Apr 08                                                    | -33             | -318867.4   | -38.3         | 54557          | 54568†                        |
| Mar 08                                                    | -33             | -318178.0   | -38.3         | 54539          | 54557                         |
| Mar 08                                                    | -33             | -317684.0   | -38.0         | 54526          | 54539†                        |
| Feb 08                                                    | -33             | -316582.0   | -38.0         | 54497          | 54526                         |
| Jan 08                                                    | -33             | -315974.0   | -38.0         | 54481          | 54497                         |
| Jan 08                                                    | -33             | -315405.5   | -37.9         | 54466          | 54481†                        |
| Dec 07                                                    | -33             | -314230.6   | -37.9         | 54424          | 54466                         |
| Nov 07                                                    | -33             | -313813.7   | -37.9         | 54435          | 54424                         |
| Nov 07                                                    | -33             | -313091.7   | -38.0         | 54405          | 54435†                        |
| Oct 07                                                    | -33             | -312635.7   | -38.0         | 54393          | 54405                         |
| Oct 07                                                    | -33             | -311911.8   | -38.1         | 54374          | 54393†                        |
| Sep 07                                                    | -33             | -310768.8   | -38.1         | 54344          | 54374                         |
| Aug 07                                                    | -33             | -309587.7   | -38.1         | 54313          | 54344                         |

† Rate change in mid-month

\*Provisional value