

NISTIR 8104-10

NIST Time and Frequency Bulletin

Karen Hansen Lichtfuss, Editor

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October 2016



U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie May, Under Secretary of Commerce for Standards and Technology and Director

**NIST TIME AND FREQUENCY BULLETIN
NIST IR 8104-10**

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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 | | |
| GPS | - Global Positioning System | | |
| IERS | - International Earth Rotation Service | | |
| MC | - Master Clock | | |
| MJD | - Modified Julian Date | | |
| NIST | - National Institute of Standards and Technology | 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 |
| UT1 | - Universal Time (Astronomical) | | |
| 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 | | | |
|---------------------------------------|-------|--------------------------|--------------------------------------|
| September 2016 | MJD | UT1-UTC(NIST) (±5 ms) | UTC(USNO,MC) - UTC(NIST) (±20 ns) |
| 1 | 57632 | - 246 ms | - 1.8 ns |
| 8 | 57639 | - 252 ms | 0.8 ns |
| 15 | 57646 | - 258 ms | 1.0 ns |
| 22 | 57653 | - 267 ms | 0.8 ns |
| 29 | 57660 | - 276 ms | 2.7 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 period of rotation.

NOTE: A positive leap second will be added at the end of December 2016.

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 time scale on 30 June 1972, 1981-1983, 1985, 1992-1994, 1997, 2012, 2015 and on 31 December 1972-1979, 1987, 1989, 1990, 1995, 1998, 2005, 2008.

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 the received UTC time signals in order to obtain UT1.

| | |
|--------------------|---|
| DUT1 = UT1 - UTC = | -0.3 s beginning 0000 UTC 01 September, 2016 -0.1 s beginning 0000 UTC 24 March 2016 +0.0 s beginning 0000 UTC 31 January 2016 +0.1 s beginning 0000 UTC 26 November 2015 +0.2 s beginning 0000 UTC 11 September 2015 +0.3 s beginning 0000 UTC 01 July 2015 -0.7 s beginning 0000 UTC 28 May 2015 -0.6 s beginning 0000 UTC 19 March 2015 -0.5 s beginning 0000 UTC 25 December 2014 -0.4 s beginning 0000 UTC 25 September 2014 -0.3 s beginning 0000 UTC 08 May 2014 |
|--------------------|---|

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 ten-day intervals. Five-day interval data are available in *Circular T*.

| 0000 Hours Coordinated Universal Time | | |
|---------------------------------------|-------|-------------------|
| DATE | MJD | UTC-UTC(NIST), ns |
| Sep. 28, 2016 | 57659 | 4.1 |
| Sep. 18, 2016 | 57649 | 1.3 |
| Sep. 8, 2016 | 57639 | 0.4 |
| Aug. 29, 2016 | 57629 | -1.6 |
| Aug. 19, 2016 | 57619 | -4.7 |
| Aug. 9, 2016 | 57609 | -4.2 |
| Jul. 30, 2016 | 57599 | -4.1 |
| Jul. 20, 2016 | 57589 | -2.0 |
| Jul. 10, 2016 | 57579 | -0.3 |
| Jun. 30, 2016 | 57569 | 0.7 |
| Jun. 20, 2016 | 57559 | 1.1 |
| Jun. 10, 2016 | 57549 | 0.9 |
| May 31, 2016 | 57539 | 0.4 |
| May 21, 2016 | 57529 | -0.3 |
| May 11, 2016 | 57519 | -0.6 |
| May 1, 2016 | 57509 | -2.0 |
| Apr. 21, 2016 | 57499 | -1.4 |
| Apr. 11, 2016 | 57489 | 3.4 |
| Apr. 1, 2016 | 57479 | 4.4 |
| Mar. 22, 2016 | 57469 | 2.8 |
| Mar. 12, 2016 | 57459 | 0.9 |
| Mar. 2, 2016 | 57449 | -0.4 |
| Feb. 11, 2016 | 57439 | -4.9 |
| Feb. 11, 2016 | 57429 | -7.6 |
| Feb. 01, 2016 | 57419 | -8.6 |
| Jan. 22, 2016 | 57409 | -7.4 |
| Jan. 12, 2016 | 57399 | -3.0 |
| Jan. 02, 2016 | 57389 | 1.7 |
| Dec. 23, 2015 | 57379 | 3.5 |
| Dec. 13, 2015 | 57369 | 4.3 |
| Dec. 03, 2015 | 57359 | 6.4 |
| Nov. 23, 2015 | 57349 | 5.8 |
| Nov. 13, 2015 | 57339 | 4.8 |
| Nov. 3, 2015 | 57329 | 5.3 |

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

| OUTAGES OF 5 MINUTES OR MORE | | | | | | PHASE PERTURBATIONS 2 ms | | | |
|------------------------------|----------|-------|-----------|-----------|-------|-----------------------------|-----|-----------|---------|
| Station | Sep 2016 | MJD | Began UTC | Ended UTC | Freq. | Sep 2016 | MJD | Began UTC | End UTC |
| WWVB | 09/17/16 | 57648 | 0626 | 0645 | 60kHz | None | | | |
| | 09/15/16 | 57646 | 0147 | 0233 | 60kHz | | | | |
| | 09/13/16 | 57644 | 0643 | 0732 | 60kHz | | | | |
| | 09/13/16 | 57644 | 0340 | 0454 | 60kHz | | | | |
| WWV | None | | | | | None | | | |
| WWVH | None | | | | | None | | | |

4. 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 and to provide the best possible realization of the SI second. NIST-F1 and NIST F-2, cold-atom cesium fountain frequency standards, have served as the U.S. primary standards of time and frequency since 1999. The uncertainty of NIST-F2 is currently about 1 part 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 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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5. UTC(NIST) – AT1 PARAMETERS

The table below 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 Date, 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.

| 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) |
| Sep 16 | -36 | -435350.9 | -37.3* | 57632 | 57662 |
| Aug 16 | -36 | -434936.7 | -37.65 | 57621 | 57632* |
| Aug 16 | -36 | -434191.7 | -37.25 | 57601 | 57632† |
| Jul 16 | -36 | -434079.95 | -37.25 | 57598 | 57601 |
| Jul 16 | -36 | -433041.2 | -37.1 | 57570 | 57598† |
| Jun 16 | -36 | -431923.7 | -37.25 | 57540 | 57570 |
| May 16 | -36 | -431476.7 | -37.25 | 57528 | 57540 |
| May 16 | -36 | -430771.8 | -37.1 | 57509 | 57528† |
| Apr 16 | -36 | -430697.6 | -37.1 | 57507 | 57509 |
| Apr 16 | -36 | -429672.75 | -36.5 | 57479 | 57507† |
| Apr 16 | -36 | -429672.75 | -36.9 | 57479 | 57486† |
| Mar 16 | -36 | -428636.75 | -37.0 | 57451 | 57479 |
| Mar 16 | -36 | -428521.05 | -37.3 | 57448 | 57451† |
| Feb 16 | -36 | -427816.15 | -37.3 | 57429 | 57448 |
| Feb 16 | -36 | -427556.45 | -37.1 | 57422 | 57429† |
| Feb 16 | -36 | -427446.05 | -36.8 | 57419 | 57422† |
| Jan 16 | -36 | -427014.25 | -36.8 | 57408 | 57419 |
| Jan 16 | -36 | -426313.25 | -36.4 | 57388 | 57408† |
| Dec 15 | -36 | -426056.65 | -36.7 | 57381 | 57388 |
| Dec 15 | -36 | -425761.45 | -36.9 | 57373 | 57381† |
| Dec 15 | -36 | -425285.65 | -36.6 | 57360 | 57373† |
| Dec 15 | -36 | -425162.45 | -36.9 | 57357 | 57360† |

† Rate change in mid-month

*Provisional value