



**NIST Interagency Report  
NISTIR 8418-11-upd1**

# **NIST Time and Frequency Bulletin**

Kelsey Rodriguez, Editor

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*Time and Frequency Division  
Physical Measurement Laboratory*

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## **Abstract**

The Time and Frequency Bulletin provides information on performance of time scales and a variety of broadcasts (and related information) to users of the NIST services.

## **Keywords**

Clocks; dissemination; frequency; GPS; oscillators; time.

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## 1. Time Scale Information

The values listed in the table below are based on data from the IERS, the USNO, and NIST. The UTC(USNO, MC) – UTC(NIST) values are obtained from the BIPM. UTC – UTC(NIST) data are on page 3.

**Table 1.** Variation in UT1 – UTC(NIST) and UTC(USNO, MC) – UTC(NIST) Time Scales.

0000 HOURS COORDINATED UNIVERSAL TIME			
October 2022	MJD	UT1 – UTC(NIST) (±1 ms)	UTC(USNO, MC) – UTC(NIST) (±5 ns)
2	59854	-4.5 ms	-0.9 ns
7	59859	-3.2 ms	-0.3 ns
12	59864	-5.5 ms	-0.6 ns
17	59869	-4.7 ms	+0.4 ns
22	59874	-5.7 ms	+0.8 ns
27	59879	-9.9 ms	+1.6 ns

The 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.

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, 2016.

No leap second will be introduced at the end of December 2022.

The insertion 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.

**Table 2.** Corrections made to DUT1.

DUT1 = UT1 – UTC =	-0.1 s beginning 0000 UTC 17 July 2021
	-0.2 s beginning 0000 UTC 02 May 2019
	-0.1 s beginning 0000 UTC 17 January 2019
	+0.0 s beginning 0000 UTC 21 September 2018
	+0.1 s beginning 0000 UTC 15 March 2018
	+0.2 s beginning 0000 UTC 30 November 2017
	+0.3 s beginning 0000 UTC 29 June 2017
	+0.4 s beginning 0000 UTC 30 March 2017
	+0.5 s beginning 0000 UTC 26 January 2017
	+0.6 s beginning 0000 UTC 01 January 2017
-0.4 s beginning 0000 UTC 17 November 2016	

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 recent periods where data are available. Data are given at ten-day intervals. Five-day interval data are available in *Circular T*.

**Table 3. UTC – UTC(NIST).**

0000 Hours Coordinated Universal Time		
DATE	MJD	UTC-UTC(NIST), ns
Oct. 27, 2022	59879	0.8
Oct. 17, 2022	59869	-0.8
Oct. 7, 2022	59859	-1.3
Sep. 27, 2022	59849	-1.9
Sep. 17, 2022	59839	-2.6
Sep. 07, 2022	59829	-1.8
Aug. 28, 2022	59819	-1.1
Aug. 18, 2022	59809	-0.7
Aug. 8, 2022	59799	-0.8
Jul. 29, 2022	59789	-1.5
Jul. 19, 2022	59779	-2.4
Jul. 9, 2022	59769	-1.8
Jun. 29, 2022	59759	-0.4
Jun. 19, 2022	59749	0.2
Jun. 9, 2022	59739	0.3
May 30, 2022	59729	-0.2
May 20, 2022	59719	-1
May 10, 2022	59709	0
Apr. 30, 2022	59699	1.4
Apr. 20, 2022	59689	1.5
Apr. 10, 2022	59679	0.1
Mar. 31, 2022	59669	-1.4
Mar. 21, 2022	59659	0.3
Mar. 11, 2022	59649	0.2
Mar. 1, 2022	59639	-0.4
Feb. 19, 2022	59629	-0.9
Feb. 9, 2022	59619	-1.1

## 2. Broadcast Outages Over Five Minutes and WWVB Phase Perturbations

**Table 4.** Broadcast Outages and Phase Perturbations.

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	October 2022	MJD	Began UTC	Ended UTC	Freq.	October 2022	MJD	Began UTC	End UTC
WWVB	07	59859	0553	0619	60 kHz	None			
WWV	None					None			
WWVH	06	59858	2217	2256	10 MHz	None			

## 3. 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. Cold-atom cesium fountain frequency standards, currently NIST-F1 and NIST-F3, have served as the U.S. primary standards of time and frequency since 1999. The uncertainty of the primary standards is currently 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 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.

UTC(NIST) is generated as an offset from our real-time scale AT1. Time steps are never used. Instead, the frequency is steered so that the time output remains close to UTC. This is accomplished by using data published by the BIPM in its *Circular T* and by weekly estimates of UTC, which are published by the BIPM as rapid UTC or UTCr. Changes in the frequency may be made as often as once per week and are limited to  $\pm 2.3 \times 10^{-14}$ . The frequency of UTC(NIST) is kept as stable as possible at other times.

## 4. UTC NIST – AT1 Parameters

Table 5 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.

**Table 5. UTC(NIST) - AT1.**

UTC(NIST) - AT1 = $x_{1s} + x + y(T - T_0)$					
Month	$x_{1s}$ (s)	$x$ (ns)	$y$ (ns/d)	$T_0$ (MJD)	Valid until 0000 on: (MJD)
Oct 22	-37	-518411.98	-38.03†	59865	59884
Oct 22	-37	-518146.47	-37.93†	59858	59865
Oct 22	-37	-517956.07	-38.08	59853	59858
Sep 22	-37	-517346.79	-38.08†	59837	59853*
Sep 22	-37	-517157.14	-37.93†	59832	59837
Sep 22	-37	-516816.22	-37.88	59823	59832
Aug 22	-37	-515641.94	-37.88	59792	59823
Jul 22	-37	-515225.26	-37.88†	59781	59792
Jul 22	-37	-514961.15	-37.73†	59774	59781
Jul 22	-37	-514698.44	-37.53†	59767	59774
Jul 22	-37	-514473.86	-37.43	59761	59767
Jun 22	-37	-513912.41	-37.43†	59746	59761
Jun 22	-37	-513389.79	-37.33†	59732	59746
Jun 22	-37	-513352.36	-37.43	59731	59732
May 22	-37	-512603.76	-37.43†	59711	59731
May 22	-37	-512193.13	-37.33	59700	59711
Apr 22	-37	-512081.14	-37.33†	59697	59700
Apr 22	-37	-511818.78	-37.48†	59690	59697
Apr 22	-37	-511065.18	-37.68	59670	59690
Mar 22	-37	-510501.48	-37.58†	59655	59670
Mar 22	-37	-509897	-37.78	59639	59655
Feb 22	-37	-508916.12	-37.63†	59613	59620
Feb 22	-37	-508841	-37.56	59611	59613
Jan 22	-37	-508127.36	-37.56†	59592	59611
Jan 22	-37	-507675.44	-37.66	59580	59592
Dec 21	-37	-506507.98	37.66	59549	59580
Nov 21	-37	-506018.4	-37.66†	59536	59549
Nov 21	-37	-505754.08	-37.76†	59529	59536
Nov 21	-37	-505490.46	-37.66†	59522	59529
Nov 21	-37	-505377.93	-37.51	59519	59522
Oct 21	-37	-504702.75	-37.51†	59501	59519
Oct 21	-37	-504211.12	-37.81	59488	59501
Sep 21	-37	-504173.41	-37.81†	59487	59488

† Rate change in mid-month

\*Provisional value

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## **Appendix A. List of Symbols, Abbreviations, and Acronyms**

### **ACTS**

Automated Computer Time Service

### **BIPM**

Bureau International des Poids et Mesures

### **GPS**

Global Positioning System

### **IERS**

International Earth Rotation Service

### **MC**

Master Clock

### **min**

minute

### **MJD**

Modified Julian Date

### **ms**

Millisecond

### **NIST**

National Institute of Standards and Technology

### **ns**

Nanosecond

### **SI**

International System of Units

### **TA**

Atomic Time

### **TAI**

International Atomic Time

### **s**

Second

### **USNO**

United States Naval Observatory

### **UT1**

Universal Time (Astronomical)

### **UTC**

Coordinated Universal Time

### **μs**

Microsecond