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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
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			
DEC 2010	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
2	55532	-123 ms	+ 9 ns
9	55539	-127 ms	+11 ns
16	55546	-132 ms	+12 ns
23	55553	-134 ms	+13 ns
30	55560	-140 ms	+ 14 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.

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, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990,1995, 1998, 2005, and 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 received UTC time signals in order to obtain UT1.

DUT1 = UT1 - UTC =
- 0.2 s beginning 0000 UTC 06 January 2011
- 0.1 s beginning 0000 UTC 03 June 2010
+0.0 s beginning 0000 UTC 11 March 2010
+0.1 s beginning 0000 UTC 12 November 2009
+0.2 s beginning 0000 UTC 11 June 2009
+0.3 s beginning 0000 UTC 12 March 2009

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**
Nov. 29, 2010	**55529**	**0.9**
Nov. 19, 2010	**55519**	**1.1**
Nov. 9, 2010	**55509**	**-0.6**
Oct. 30, 2010	**55499**	**-1.6**
Oct. 20, 2010	**55489**	**-3.7**
Oct. 10, 2010	**55479**	**-4.6**
Sep. 30, 2010	**55469**	**-3.3**
Sep. 20, 2010	**55459**	**-0.5**
Sep. 10, 2010	**55449**	**-0.1**
Aug. 31, 2010	**55439**	**-2.2**
Aug. 21, 2010	**55429**	**-3.6**
Aug. 11, 2010	**55419**	**-5.1**
Aug. 01, 2010	**55409**	**-7.4**
Jul. 22, 2010	**55399**	**-9.4**
Jul. 12, 2010	**55389**	**-9.5**
Jul. 02, 2010	**55379**	**-10.6**
Jun. 22, 2010	**55369**	**-11.8**
Jun. 12, 2010	**55359**	**-10.7**
Jun. 02, 2010	**55349**	**-9.3**
May 23, 2010	**55339**	**-8.1**
May 13, 2010	**55329**	**-6.8**
May 3, 2010	**55319**	**-5.6**
Apr. 23, 2010	**55309**	**-4.6**
Apr. 13, 2010	**55299**	**-3.9**
Apr. 03, 2010	**55289**	**-4.0**
Mar. 24, 2010	**55279**	**-3.4**
Mar. 14, 2010	**55269**	**-2.5**
Mar. 04, 2010	**55259**	**-3.4**

3. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	Dec 2010	MJD	Began UTC	Ended UTC	Freq.	Dec 2010	MJD	Began UTC	End UTC
WWVB	12-10-10	55540	1726	1759	60 kHz				
	12-13-10	55543	1731	1739	60 kHz				
WWV	12-01-10	55531	1606	1657	2.5, 5, 10, 15, 20 MHz				
	12-10-10	55540	1726	1759	2.5,5,10, 15,20 MHz				
WWVH									

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. NIST-F1, a cold-atom cesium fountain frequency standard, has served as the U.S. primary standard of time and frequency since 1999. The uncertainty of NIST-F1 is currently about 3 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 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.

References:

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).

Heavner, T.P.; Jefferts, S.R.; Donley; E.A.; Shirley, J.H. and Parker, T.E., "NIST F1; recent improvements and accuracy evaluations," Metrologia, Vol. 42, pp. 411-422 (2005).

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).

Parker, T.E.; Jefferts, S.R.; Heavner, T.P.; and Donley, E.A., "Operation of the NIST-F1 caesium fountain primary frequency standard with a maser ensemble, including the impact of frequency transfer noise," Metrologia, Vol. 42, pp. 423-430 (2005).

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).

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 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.

UTC(NIST) - AT1 = x_{ls} + x + y*(T -T_0)					
Month	xls (s)	x (ns)	y (ns/d)	T0 (MJD)	Valid until 0000 on: (MJD)
Feb 11	-34	-358711.5	-38.8*	55593	55621
Jan 11	-34	-357508.7	-38.8	55562	55593*
Dec 10	-34	-356305.9	-38.8	55531	55562
Nov 10	-34	-355141.9	-38.8	55501	55531
Oct 10	-34	-354365.9	-38.8	55481	55401†
Oct 10	-34	-353941.3	-38.6	55470	55481
Sep 10	-34	-353285.1	-38.6	55453	55470
Sep 10	-34	-352780.7	-38.8	55440	55470†
Aug 10	-34	-351577.9	-38.8	55409	55440
Jul 10	-34	-350957.1	-38.8	55393	55409
Jul 10	-34	-350378.1	-38.6	55378	55393†
Jun 10	-34	-349760.5	-38.6	55362	55378
Jun 10	-34	-349222.9	-38.4	55348	55362†
May 10	-34	-348032.5	-38.4	55317	55348
Apr 10	-34	-346880.5	-38.4	55287	55317
Mar 10	-34	-346150.9	-38.4	55268	55287
Mar 10	-34	-345688.3	-38.0	55256	55268†
Feb 10	-34	-344624.3	-38.0	55228	55256
Jan 10	-34	-343446.3	-38.0	55197	55228
Dec. 09	-34	-342952.3	-38.0	55184	55197
Dec. 09	-34	-342261.1	-38.4	55166	55184†
Nov 09	-34	-341838.7	-38.4	55155	55166
Nov 09	-34	-341101.5	-38.8	55136	55155†
Oct 09	-34	-340441.9	-38.8	55119	55136
Oct 09	-34	-339895.9	-39.0	55105	55119†

† **Rate change in mid-month**

***Provisional value**