

Leap second

Leap second is closely related to the two following time scales:

- 1) *UTI* – kind of Universal time scale *UT* which related to Earth's rotation angle (*ERA*);
- 2) international atomic time scale (*TAI*) implemented on the basis of quantum transitions in the cesium atom, established and maintained by the International Bureau of Weights and Measures ([BIPM](#));

and one Universal coordinated time scale – the *UTC* (see below for more information).

Atomic time is closest to the concept of time in physics and is its practical implementation. It is time that is included in the formulas expressing the laws of mechanics. It has the highest accuracy and stability.

The Universal time scale *UTI* is used in practice formulas for Earth rotation evaluation¹ and *UTI* is expressed as linear function of *ERA*. It is used for calculation of Earth orientation in many fields of human activity, including navigation on the Earth and in Space. Astronomical phenomena, including sunrise and sunset, midnight and noon, also related with *UTI*.

The task to build a new time scale based on atomic standards of time and frequency was set in the 70-s of the last century. The new scale has to be as stable and accurate as atomic time, but at the same time not too far from time scale *UTI* (so that the moment 00:00:00 in this scale does not differ too much from the moment of the lower culmination of the average Sun on the Greenwich meridian).

The main idea of constructing such a scale was to create some coordinated time scale, which transforms (coordinates) *TAI* values according to a well-known algorithm. As results, the numerical expressions of the moments of occurrence of any event in a new coordinated time scale would not differ from the corresponding *UTI* moments by more than the value of the specified tolerance.

The current coordinate algorithm² based on additional second as such as Universal coordinate scale based on leap seconds were introduced according Recommendation № 374 of 12-th conference of International Radio Consultative Committee from 1 January 1972.

1 – In the Past, *UTI* was used to construct another kind of universal time scale – *UT2*, as the closest realization of physical time that can be built from observations of the Earth's rotation. However, with the advent of atomic frequency standards, *UTI* is not used for this purpose, since it loses more than three orders of magnitude to atomic time.

2 – The leap second addition is not only way of correction algorithm. Until 1 January 1972, another coordination algorithm was used, in which a continuously changing amendment was added. However, this was considered inconvenient and on 1 January 1972 the difference between International Atomic Time (*TAI*) and *UTC* was set to 10 seconds exactly, after which only an integer number of seconds was added.

(It was transformed into [Recommendation TF.460-6](#) of Radiocommunication Sector of International Telecommunication Union (ITU) later).

The *UTC* is time scale which realized and maintaining by *BIPM* and International Earth Rotation and reference systems Service ([IERS](#)) in such way that difference ($UTC - TAI$) is an integer number of seconds and value $|UTC - UTI|$ does not exceed 0,9 seconds. The unit of time of *UTC* scale is second of International System of units ([SI](#)).

The difference between *TAI* and *UTC* was adjusted to 10 seconds at start of introducing of the new algorithm (midnight on 1 January 1972). The first leap second was added on the night from June 30 to July 1, 1972.

The second of the correction was named as “*leap second*” because it is added irregular. The time of leap second adding depends from dynamic of Earth’s rotation and *IERS* decision.

The 27 leap seconds were added from 1 January 1972 to 2 November 2024 (the moment of translation the [original text](#) on English). So, difference $TAI - UTC$ is 37 seconds.

The complete list of $TAI - UTC$ differences (including first *UTC* realization with sliding difference $TAI - UTC$) is presented in [Table 1](#). It was full filled according with data of *IERS* table located on address: https://hpiers.obspm.fr/eop-pc/index.php?index=TAI-UTC_tab&lang=en.

Leap second is added at night from 31 December to 1 January or at night from 30 June to 1 July. The *IERS* makes a decision about leap second addition according to results of evaluation and prediction of Universal time scale *UTI*. This decision is published in [Bulletin C of IERS](#).

The decision about leap second addition in Nation universal time scale of Russian Federation *UTC(SU)* is made by Main metrological center of State service of time, frequency and determination of the Earth rotation parameters ([MMC SSTF](#)). This decision is published in [Bulletin G MMC SSTF](#).

It is useful to note that *IERS* releases *Bulletin C* twice on year regardless of whether it will be or not to add leap second in *UTC* time scale. It contains message that leap seconds will be or not added at the end of next half of year. *MMC SSTF* releases *Bulletin G SSTF* if leap second has to be added at the end of next half of year only.

Now days, for a number of reasons, international services are considering of the *UTC* time scale redefinition. The last news about this one can be find in [provisional final acts](#) of World Radiocommunication Conference 2023 (WRC-23).

Table 1 – Relationship between *TAI* and *UTC*

Scale	Start – end of period of validity (in <i>UTC</i> time scale)	<i>TAI-UTC</i> , s
Time scale <i>UTC</i> with sliding <i>TAI-UTC</i> difference	01.01.1961 00:00:00 – 01.08.1961 00:00:00	$1,4228180 + 0,0012960 \cdot (MJD - 37300)$
	01.08.1961 00:00:00 – 01.01.1962 00:00:00	$1,3728180 + 0,0012960 \cdot (MJD - 37300)$
	01.01.1962 00:00:00 – 01.11.1963 00:00:00	$1,8458580 + 0,0011232 \cdot (MJD - 37665)$
	01.11.1963 00:00:00 – 01.01.1964 00:00:00	$1,9458580 + 0,0011232 \cdot (MJD - 37665)$
	01.01.1964 00:00:00 – 01.04.1964 00:00:00	$3,2401300 + 0,0012960 \cdot (MJD - 38761)$
	01.04.1964 00:00:00 – 01.09.1964 00:00:00	$3,3401300 + 0,0012960 \cdot (MJD - 38761)$
	01.09.1964 00:00:00 – 01.01.1965 00:00:00	$3,4401300 + 0,0012960 \cdot (MJD - 38761)$
	01.01.1965 00:00:00 – 01.03.1965 00:00:00	$3,5401300 + 0,0012960 \cdot (MJD - 38761)$
	01.03.1965 00:00:00 – 01.07.1965 00:00:00	$3,6401300 + 0,0012960 \cdot (MJD - 38761)$
	01.07.1965 00:00:00 – 01.09.1965 00:00:00	$3,7401300 + 0,0012960 \cdot (MJD - 38761)$
	01.09.1965 00:00:00 – 01.01.1966 00:00:00	$3,8401300 + 0,0012960 \cdot (MJD - 38761)$
	01.01.1966 00:00:00 – 01.02.1968 00:00:00	$4,3131700 + 0,0025920 \cdot (MJD - 39126)$
	01.02.1968 00:00:00 – 01.01.1972 00:00:00	$4,2131700 + 0,0025920 \cdot (MJD - 39126)$
Time scale <i>UTC</i> with the leap seconds	01.01.1972 00:00:00 – 01.07.1972 00:00:00	10
	01.07.1972 00:00:00 – 01.01.1973 00:00:00	11
	01.01.1973 00:00:00 – 01.01.1974 00:00:00	12
	01.01.1974 00:00:00 – 01.01.1975 00:00:00	13
	01.01.1975 00:00:00 – 01.01.1976 00:00:00	14
	01.01.1976 00:00:00 – 01.01.1977 00:00:00	15
	01.01.1977 00:00:00 – 01.01.1978 00:00:00	16
	01.01.1978 00:00:00 – 01.01.1979 00:00:00	17
	01.01.1979 00:00:00 – 01.01.1980 00:00:00	18
	01.01.1980 00:00:00 – 01.07.1981 00:00:00	19
	01.07.1981 00:00:00 – 01.07.1982 00:00:00	20
	01.07.1982 00:00:00 – 01.07.1983 00:00:00	21
	01.07.1983 00:00:00 – 01.07.1985 00:00:00	22
	01.07.1985 00:00:00 – 01.01.1988 00:00:00	23
	01.01.1988 00:00:00 – 01.01.1990 00:00:00	24
	01.01.1990 00:00:00 – 01.01.1991 00:00:00	25
	01.01.1991 00:00:00 – 01.07.1992 00:00:00	26
	01.07.1992 00:00:00 – 01.07.1993 00:00:00	27
	01.07.1993 00:00:00 – 01.07.1994 00:00:00	28
	01.07.1994 00:00:00 – 01.01.1996 00:00:00	29
	01.01.1996 00:00:00 – 01.07.1997 00:00:00	30
	01.07.1997 00:00:00 – 01.01.1999 00:00:00	31
	01.01.1999 00:00:00 – 01.01.2006 00:00:00	32
01.01.2006 00:00:00 – 01.01.2009 00:00:00	33	
01.01.2009 00:00:00 – 01.07.2012 00:00:00	34	
01.07.2012 00:00:00 – 01.07.2015 00:00:00	35	
01.07.2015 00:00:00 – 01.01.2017 00:00:00	36	
01.01.2017 00:00:00 и по настоящее время	37	

MJD – Modified Julian Data, days.