



Leapseconds and Spacecraft Clock Kernels

LSK and SCLK

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SPICE Time Conversion Kernels

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In most cases one or two kernel files are needed to perform conversions between supported time systems.

- **LSK** - The leapseconds kernel is used in conversions between ephemeris time (ET/TDB) and Coordinated Universal Time (UTC).
- **SCLK** - The spacecraft clock kernel is used in conversions between spacecraft clock time (SCLK) and ephemeris time (ET/TDB).
 - (It's possible there could be two or more clocks associated with a given spacecraft.)

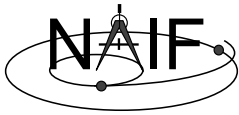


The Leapseconds Kernel (LSK)

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The leapseconds kernel contains a tabulation of all the leapseconds that have occurred, plus additional terms.

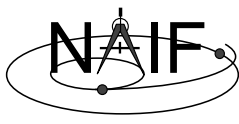
- Used in ET \leftrightarrow UTC and in ET \leftrightarrow SCLK conversions.
 - Utility programs: *spkmerge*, *chronos*, *spacit*, etc.
 - Subroutines: STR2ET, ET2UTC, TIMOUT, etc.
- As with all SPICE kernels, load it using FURNISH.
- NAIF updates the LSK when a new leapsecond is announced by the International Earth Rotation Service (IERS).
 - The latest LSK file is always available from the NAIF server.
 - » The latest is always the best one to use.
 - Announcement of each new LSK is made using the “spice_announce” system.
 - » http://naif.jpl.nasa.gov/mailman/listinfo/spice_announce



Out of Date LSKs

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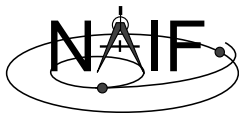
- An out-of-date leapseconds kernel can be used successfully for conversions that occur at epochs prior to the epoch of the first missing leapsecond.
 - But any conversions of epochs occurring after the epoch of a missing leapsecond will introduce inaccuracies in multiples of one second per missed leapsecond.
- Using the latest leapseconds kernel to perform conversions at epochs more than six months ahead of the last leapsecond listed may result in an error if, later on, a new leapsecond is declared for a time prior to the epochs you processed.



The Spacecraft Clock Kernel (SCLK)

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- The spacecraft clock kernel contains data to perform conversions from SCLK to other time systems.
- It is required by Toolkit utilities and routines that utilize SCLK time.
 - For example, the SPICE CK subsystem makes heavy use of spacecraft clock time.
- As with all SPICE kernels, use FURNSH to load it.
- Ensure you have the correct version of the SCLK file for your spacecraft since this kernel may be updated rather frequently.
 - SCLK files are usually maintained on a flight project's database.
 - » For JPL operated missions they can usually be found on the NAIF server as well.
 - When using a CK, “correct SCLK” means compatible with that CK.
 - » For reconstructed CKs, this is most likely the latest version of the SCLK.
 - » For “predict” CKs, this is probably the SCLK kernel used when the CK was produced.



SCLK File Example

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```

\begindata
SCLK_KERNEL_ID      = ( @1999-08-02/10:53:19.72 )
SCLK_DATA_TYPE_82   = ( 1 ) ← Clock Type
SCLK01_TIME_SYSTEM_82 = ( 2 ) ← Time system ID:
                             1 --> TDB, Barycentric Dynamical Time
                             2 --> TDT, Terrestrial Dynamic Time
SCLK01_N_FIELDS_82   = ( 2 )
SCLK01_MODULI_82     = ( 4294967296 256 )
SCLK01_OFFSETS_82    = ( 0 0 )
SCLK01_OUTPUT_DELIM_82 = ( 1 )
SCLK_PARTITION_START_82 = ( 1.7772134886400E+11 ) ← Encoded clock readings at
SCLK_PARTITION_END_82  = ( 1.0995116277750E+12 ) ← partition start and stop.
SCLK01_COEFFICIENTS_82 = (
    0.00000000000000E+00  -6.3119514881600E+08  1.0001400000000E+00
    1.2098765056000E+10  -5.8393434781600E+08  1.0000900000000E+00
    2.0171981312000E+10  -5.5239834681600E+08  1.0001200000000E+00
    2.8245197568000E+10  -5.2086234581600E+08  1.0001100000000E+00
    4.4413748224000E+10  -4.5770394481600E+08  1.0000800000000E+00
    .
    .
    .
)
\begincomment
    SCLK value
    TDT or TDB value
    corresponding to
    SCLK value
    Clock Rate
    (seconds per most
    significant component)

```



Forms of SCLK Time Within SPICE

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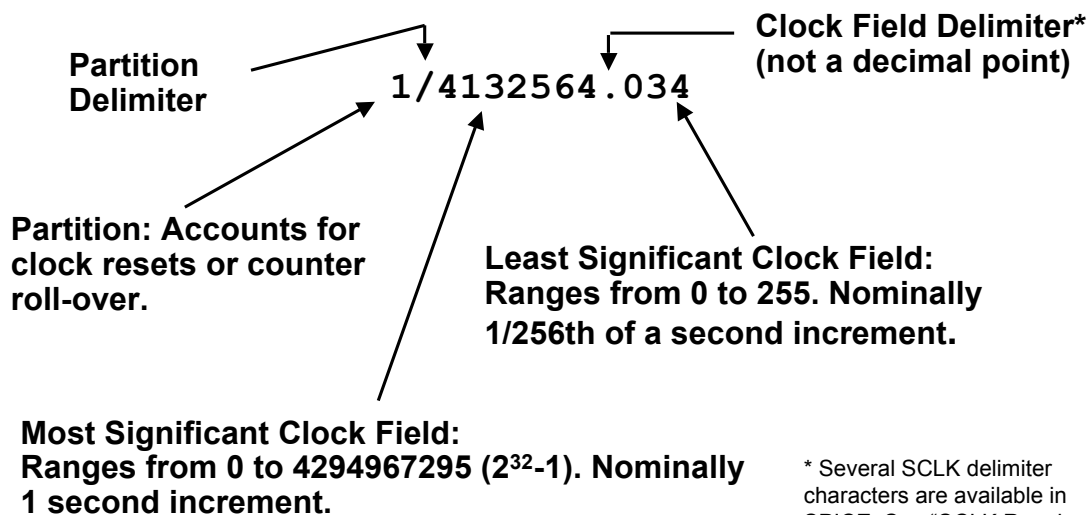
- **SCLK time in SPICE is represented in two different ways:**
 - a character string
 - a double precision (DP) number called “ticks”
- **A SCLK character string is composed of one or more cascading integer numbers – similar to a digital clock.**
 - This form is what is generally found in downlinked telemetry, whether for science or engineering/housekeeping data.
- **A SCLK value encoded as a double precision (DP) number (called “ticks”) is used internal to SPICE because it’s easy to convert this to other time systems, such as ephemeris time (ET).**



Sample SCLK String - 1

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The Cassini orbiter SCLK time string consists of three fields separated by delimiters.



* Several SCLK delimiter characters are available in SPICE. See "SCLK Required Reading" for details.



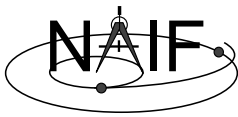
What is a Partition?

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1/4132564.034

The portion of the SCLK string circled above indicates the partition to which the remaining portion of the string is related.

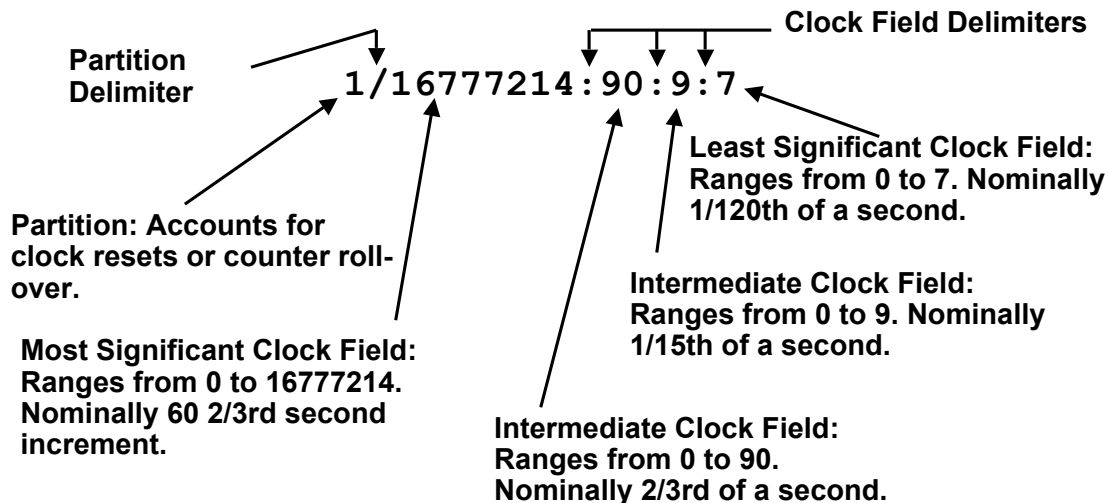
- A partition is a NAIF-created construct to handle spacecraft clock rollovers or resets.
- When referring to epochs in the first partition, the leading '1/' may be omitted.
- Modern spacecraft rarely use a partition other than 1/.



Sample SCLK String - 2

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The Galileo spacecraft SCLK time string consists of five fields separated by delimiters.





Sample SCLK Strings - 3

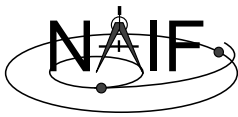
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The following are examples of SCLK strings* from missions using SPICE.

- | | | |
|---------------------------------------|--|--|
| • Cassini
1/1334314108.134 | • MPF
1/559627908.058 | • Viking 1&2
1/32233616 |
| • DS1
1/67532406.010 | • Mariner 9
1/11542909 | • Voyager 1&2
1/05812:00:001 |
| • Galileo
1/16777214:90:9:7 | • Mars Odyssey
1/687231994.091 | • Mars Express
1/0090979196.29713 |
| • Genesis
1/666230496.204 | • NEAR
1/40409721942 | • Venus Express
1/0033264000.50826 |
| • MGS
1/655931592.103 | • Stardust
1/697451990.042 | • Rosetta
1/0101519975.65186 |

* When clock strings are used as arguments in modules they must be contained in quotes:

- Single quotes for Fortran
- Double quotes for C
- Single quotes for IDL and MATLAB



Encoded SCLK (Ticks)

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The representation of SCLK time in the SPICE system is a double precision encoding of a SCLK string.

- **Encoded spacecraft clock values represent “ticks since spacecraft clock start.”**
 - The time corresponding to tick “0” is mission dependent and does not necessarily relate to launch time. In fact it is often an arbitrary epoch occurring before launch.
- **A tick is the smallest increment of time that a spacecraft clock measures. For example, in the case of the Cassini orbiter this is nominally 1/256th of a second.**
- **Encoded SCLK increases continuously independent of leapseconds, clock resets, and counter rollovers.**



SCLK Interface Routines

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Convert SCLK times using the following routines

SCS2E (SC, SCLKCH, ET)	(SCLK String\RightarrowET)
SCE2S (SC, ET, SCLKCH)	(ET\RightarrowSCLK String)
SCT2E (SC, SCLKDP, ET)	(Encoded SCLK\RightarrowET)
SCE2C ¹ (SC, ET, SCLKDP)	(ET\RightarrowContinuous Encoded SCLK)
SCE2T (SC, ET, SCLKDP)	(ET\RightarrowDiscrete Encoded SCLK)
SCENCD (SC, SCLKCH, SCLKDP)	(Encode SCLK)
SCDECD (SC, SCLKDP, SCLKCH)	(Decode SCLK)

¹ Use SCE2C (not SCE2T) for C-kernel data access.