SMPTE PUBLIC COMMITTEE DRAFT

UTC Aligned Timecode

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE"s Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE"s Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee 32NF.

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

At the time of publication, no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

1 Scope

This standard specifies a conformant and compliant application of SMPTE ST 12-1 Time and Control Code for applications that require or could benefit from a defined relationship to calendar date, Coordinated Universal Time (UTC), and local wall-clock time.

This standard supports integer or fractional base-rates of 24/1.001 Hz, 24 Hz, 25 Hz, 30/1.001 Hz, 30 Hz, and their integer multiples for UTC and calendar dates beginning at 1970.

A UTC-Aligned Count (UAC) specifies the precise timecode start-of-day offset relative to the calendar beginning-of-day and to seconds throughout the day.

This standard adjusts the drop frame count algorithm at the end-of-day adding additional counts according to a defined 1001-day sequence and also enables the introduction of leap second counts.

The standard specifies the optional coding of related metadata in the binary groups using the SMPTE ST 262 page-line multiplex to convey the rate, date, UTC offset, leap second offset (DTAI), user data, and other operational metadata or the date, time zone, and UTC offset, using the SMPTE ST 309 protocols.

2 Normative references

The following standard contains provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All standards are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

ST 12-1:2014 Time and Control Code

ST 262:1995 Binary Groups of Time and Control Codes - Storage and Transmission of Data

ST 309:2012 Transmission of Date and Time zone Information in Binary Groups of Time and Control Code

ST 2059-1:2021 Generation and Alignment of Interface Signals to the SMPTE Epoch

ST 2059-2:2021 SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

Audio Engineering Society (AES) AES67:2018, AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability

IEEE Std 1588-2019 IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

ITU-R Recommendation TF.460-6 (02/02), Standard-Frequency and Time-Signal Emissions http://www.itu.int/rec/R-REC-TF.460/en

Recommendation ITU-R TF.686-3 (12/2013), Glossary and definitions of time and frequency terms https://www.itu.int/dms_pubrec/itu-r/rec/tf/R-REC-TF.686-3-201312-I PDF-E.pdf.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1. time

one-dimensional subspace of space-time, which is locally orthogonal to space

[SOURCE: IEC 60050 113-01-03]

3.2. time point
instant

point on the time axis

NOTE An instantaneous event occurs at a specified instant.

3.3. timing reference datum

reference location in the signal used to specify the timing of the signal

NOTE SMPTE ST 12-1 uses the term timing reference datum to specify this location as the half-amplitude point of the first transition of bit 0 of the 80-bit LTC codeword.

3.4. Modified Julian Date
MJD

integer day count assigned to a whole lunar day starting from calendar beginning-of-day to end-of-day

NOTE The MJD value equals the JD less 2 400 000.5 and therefore has its origin, in the case of UT, at 0000 hours UT, 17 November 1858 and represent Gregorian calendar days.

3.5. International Atomic Time
TIA

timescale established by the International Bureau of Weights and Measures (BIPM) on the basis of data from atomic clocks operating in several establishments conforming to the definition of the second, the unit of time of the International System of Units (SI)

[SOURCE: ITU-R Rec. 686 MOD]

3.6. Coordinated Universal Time
UTC

timescale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals. It corresponds exactly in rate with international atomic time, but differs from it by an integral number of seconds

[SOURCE: ITU-R Rec. 686 MOD]

3.7. standard time-of-day
STD

quantitative expression marking a time point within a calendar day by the duration elapsed after the beginning of-day in the local standard time and commonly referred to as wall clock time

3.8. daylight saving time
DST

shift of the standard time in some regions of the world during the warmer months of the year to give more daylight hours in the evening

NOTE The local time zone offset is advanced by one hour or in some cases an offset in quarter hour increments. The dates for the onset and end of the daylight saving period are determined by the local legal authorities and this information should be supplied by the application.

3.9. beginning-of-day
end-of-day

time point denoting the beginning or end of a nominal 24-hour calendar day

NOTE 1. The term midnight is ambiguous representing a time point in two days.

NOTE 2. The beginning-of-day is assigned the value zero however a fixed value is not assigned to the end-of-day.

3.10. Precision Time Protocol
PTP

Precision Time Synchronization Protocol as specified by IEEE Std 1588

NOTE 1. PTP is used by SMPTE ST 2059-2 to synchronize a local clock to a PTP grandmaster clock.

NOTE 2. Although commonly used as such, PTP does not meet the strict criteria of a timescale.

3.11. timestamp PTP
timestamp ARB

elapsed time since the PTP epoch

NOTE The timestamp represents time as a 48-bit seconds field plus a 32-bit nanoseconds field.

3.12. epoch

origin of a timescale

[SOURCE: SMPTE ST 2059-1]

3.13. PTP epoch

1 January 1970 00:00:00 TAI, which is 31 December 1969 23:59:51.999918 UTC

[SOURCE: IEEE 1588-2008]

3.14. SMPTE Epoch

1970-01-01 00:00:00 (TAI)

The SMPTE Epoch is the same as the PTP Epoch as specified in IEEE STD 1588

The SMPTE Epoch is 63072010 seconds SI before 1972-01-01T00:00:00 (UTC).

NOTE 3. The alignment DTAI between TAI and UTC was set to the initial value of 10 seconds at 1972-01-01 00:00:10 (TAI) = 1972-01-01T00:00:00 (UTC).

[SOURCE: SMPTE ST 2059-1 modified by the addition of Note 3]

3.15. POSIX time
Portable Operating System Interface time

[as written in the official POSIX documentation]

number of seconds that have elapsed since 1970-01-01T00:00:00Z (UTC), not counting leap seconds

3.16. Global Navigation Satellite System
GNSS

general term describing any satellite constellation that provides positioning, navigation, and timing services on a global or regional basis.

3.17. UTC-aligned count
UAC

zero-based integer count of media-units with an origin related to UTC or UTC offset calendar beginning-of-day

3.18. leap second

one-second adjustment, occasionally applied to UTC, to accommodate the difference between precise TAI time and observed solar time

3.19. DTAI

value of the difference between the TAI and UTC timescales, as disseminated with time signals

NOTE 1. "DTAI = TAI – UTC" is a correction added to TAI to obtain UTC.

NOTE 2. IEEE Std 1588 specifies "The value <dLS> is the offset between TAI and UTC".

NOTE 3. The POSIX standard specifies a proleptic UTC 63072000 seconds before 1972-01-01 (UTC) at 1970-01-01 retaining the 10-second DTAI initial calibration offset.

[SOURCE: ITU-R TF.460-6]

3.20. rate

quotient of a quantity by a duration

[SOURCE: IEC 60050 112-03-18]

3.21. SMPTE timecode

ST 12 timecode

generic reference to Time and Control Codes as defined one or more of SMPTE ST 12-1, ST 12 2, ST 12-3, this standard ST 12-4 family of timecodes and other contributing engineering documents

3.22. media-unit

video frame

duration media-units for 24 Hz, 24/1.001 Hz, 25 Hz, 30 Hz or 30/1.001 Hz related video media with a defined color frame sequence

Note: This is not to be confused with the smallest accessible temporal increment. Editing constraints are outside the scope of this document.

3.23. media-unit block

even-odd numbered pair of media-units for 24, 24/1.001, 30, and 30/1.001 Hz related media or four media-unit for 25 Hz media representing the four media-unit, color frame sequence

NOTE 1:For. 25 Hz analog video the four-frame color sequence block rate is 6.25 Hz. With SMPTE Epoch alignment this only results in calendar beginning-of-day alignment every four days.

NOTE 2:A media-unit block does not necessarily serve the needs of ST12-3 higher frame rate super-blocks.

3.24. media-index

integer count of media-units from a defined origin

3.25. phase-index

measure of media phase alignment relative to a seconds time point

NOTE The phase-index for fractional-1001 media is in discrete integer steps with a nominal range from zero to 1000.

3.26. calendar day

day in the Gregorian calendar for the applicable local time zone

3.27. day-number

zero-based index of calendar days from 1970-01-01

NOTE The day-number is applied to both the TAI and UTC timescales. The day-number zero is 1970-01-01 on both the TAI and UTC timescales. At the second SI rate leap seconds maintaining the relationship between the TAI and UTC timescales.

3.28. time zone

geographical region of the earth that selects an offset from UTC as the basis for local time keeping

NOTE Some time zones might apply a DST offset to the Standard time (STD) UTC offset for part of the year.

3.29. Resolution,
precision,
accuracy

trio of terms that relate to how closely an objective can be met

NOTE 1: Resolution is the fineness or smallest unit of measure or change that can be displayed or recorded.

Resolution sometimes referred to as granularity. One way that the resolution and precision are always related is that resolution determines the upper limit of precision. The precision cannot exceed resolution.

NOTE 2: Precision is the fineness to which a measurement can be made repeatedly and reliably.

Precision is a measure of variability. Precision indicates how reproducible or close identical measurements will be reported as a percentage of full scale.

Note 3: Accuracy is a measure of “trueness”.

Accuracy is the ability to measure the designated parameter to the absolute true and correct value. Accuracy is analogous to the amount of uncertainty in a measurement.

3.30. timecode day
media-index day

period from the timecode start-of-day up until the end-of-day roll-over to the next day and having a length-of-day that can vary from day-to-day

NOTE For a calendar date and media at integer rates the timecode day can be associated with a calendar date and time-of-day. However, for media at fractional rates the timecode start-of-day and timecode end-of-day are expected to be shifted slightly and this adjustment will change from day-to-day and with the UTC offset.

3.31. timecode start-of-day

timecode with time address value 00:00:00:00

NOTE 1. The UTC-Aligned Timecode (UAT) algorithm assigns this timecode to a time point related to the UTC calendar beginning-of-day by a non-negative timecode start-of-day offset.

NOTE 2. The timecode end-of-day time point at which the timecode or media-index rolls over to the next start-of-day.

NOTE 3. The timecode start-of-day offset can vary from day-to-day.

3.32. length-of-day

duration from a timecode start-of-day to the next timecode end-of-day

NOTE For a calendar date and media at integer rates the timecode day can be associated with a calendar date and time-of-day. However, for media at fractional rates the timecode start-of-day and timecode end-of-day are expected to be shifted slightly and this adjustment will change from day-to-day and with the UTC offset.

4 (Informative) System and environment

4.1. Timecode label generation

The UTC-Aligned Timecode generation process:

- Specifies the alignment of media relative to the SMPTE Epoch and the timecode start-of-day offset from the UTC or UTC offset beginning-of-day.
- Facilitates the generation of timecodes that have a mathematically precise relationship to commonly accepted wall-clock time.
- Results in timecode that can be fully compatible and compliant with the SMPTE ST 12-1 standard.

For integer rate media aligned relative to the SMPTE Epoch there is a fixed relationship between media alignments and clock time. For fractional rate media there is regular day-to-day shift of the media start-of-day time and the clock time beginning-of-day. The math involves an integer calculation multiplied by a fixed phase-index fractional constant.

The generation of a UTC-Aligned Timecode label follows a sequence of steps:

1. Local UTC time source
   Facilities typically operate with a local UTC offset as their "wall clock time". The timecode zero start-of-day alignment is specified relative to the UTC beginning-of-day. Clause 5 determines the local UTC calendar day-number, time-of-day and other time parameters are determined with the process described the IEEE STD 1588 Precision Time Synchronization Protocol or with the processes for other clock time sources.
2. Media-index
   For a calendar day-number the media-index as a zero-based integer count of video frames is specified in Clause 6. At the base 24, 25, and 30 integer and fractional (n/1.001) rates and their integer multiples. Similar to the SMPTE Epoch media alignment, a UTC-aligned count (UAC), defines the UTC-Z calendar beginning-of-day as the media-index timing reference point. At integer rates the media-index start-of-day has zero-offset to the UTC calendar beginning-of-day. For the fractional rates the media-index start-of-day is rarely aligned at a calendar beginning-of-day. On the UTC-Z timescale the media-index start-of-day points forms a date defined array of 1001 points. Independently for each UTC offset timescales the media-index start-of-day is shifted earlier or later according to the UTC offset. Thus, these media-index counts have a defined alignment to wall-clock time. Leap seconds are inserted as necessary.
3. Time address from media-index
   The media-index is converted to a time address value in hours, minutes, seconds and frames with the process of Clause 7.
4. Calendar day-number to MJD or year, month, day
   As described in Clause 8 the calendar day-number is converted to either a Modified Julian Day (MJD) or a calendar year, month, day format suitable for encoding in the timecode binary groups.
5. Binary groups
   The setting of the timecode binary group flag bits is detailed in Clause 9. This includes the facility to signal the format of the coding of the binary groups. There are two options for the transport of date time and other metadata in the timecode binary groups using either the ST 262 page-line multiplex or the ST 309 process as currently detailed in ST 12-1.

6. Page-line ST 262 binary group encoding
   As described in Clause 10 the use of the ST 262 page-line protocol facilitates the transport of the date, rate, rate multiplier, UTC offset, time zone, and user defined data.
7. Legacy ST 309 binary group encoding
   Alternately described in ST 12-1 the ST 309 standard Clause 11 details the coding the date, UTC offset, time zone, DST flag and MJD flag in the binary groups for legacy application compatibility.

4.2. Timecode reception and processing

When the timecode binary bits are generated using the ST 262 page-line protocol a flag bit signals that the timecode was generated in conformance with this standard.

The decoder also receives additional date, rate and offset information as described in the Clause 12, and applies this information to the received time bits to derive a precise UTC time of the associated media unit.

For streams containing page-line encoding of the offset information, which might be repeated and change between repetitions, the applicable offset is the one most recently received.

Applications include live real time media streams, recorded live streams, and file-based playout and other processing systems. In the live cases the instant at which the time bits are decoded is close to the presentation time of the associated media unit (earlier or slightly later); in file-based systems there is no such relationship, and indeed the offset information might be stored completely separately from the time bits."

In general, the usage of ST12-4 is that a decoder receives the time bits of a timecode word that gives the intended timestamp of an associated media unit. The time bits are encoded using the formats and methodology described in this standard.

The timecode reception and recovery of an accurate date-timestamp and related metadata follows a sequence of conventional timecode processing steps:

1. Accurate date, time and metadata recovery from the timecode receivers
2. Comparison with local date-time and from other timecode sources.

4.3. Local date, time, and timecode

There is an installed base of millions of devices capable of both generating and receiving ST 12 timecodes. In archives and storage there are Peta-bytes of timecoded media.

UTC local wall-clock time is a dominant operational time in most facilities. For media that has been aligned relative to the SMPTE Epoch as specified in SMPTE ST 2059-1 there is a relationship between the media alignment point and clock time. This facilities SMPTE timecodes that have a correspondence with wall-clock time.

The IEEE STD 1588 Precision Time Synchronization Protocol and IP Networks facilitated the establishment of date and clock time throughout the facility and the creation of a SMPTE timecodes that include sufficient metadata to recover the date, time, and related metadata from recorded media.

The PTP Epoch ant the SMPTE Epoch are each defined as the common time point 1970-01-01 00:00:00 (TAI).
From this point days on the TAI timescale are designated with a zero-based count of 86400 seconds SI.

Dates based on the Gregorian calendar have 365-day normal years and 366-day leap years. On the TAI timescale the day-number is a zero-based index of 86400 second days from 1970-01-01 however, the introduction of leap seconds shifts the UTC length-of-day and thus shifts the UTC end-of-day. The day-numbers facilitate the calculation of media start-of-day alignments and time labels relative to the calendar beginning-of-day.

The day-numbers facilitate the calculation of media start-of-day alignments and time labels relative to the calendar beginning-of-day. Common days have a duration of 86400 seconds and 86401 seconds for a positive lea-second days or 86399 seconds for a negative lea-second day. Time-of-day can be expressed as a zero-based integer count of seconds from the UTC calendar beginning-of-day.

4.4. Timescales

There are several methods available for the distributing of clock date and tine including TAI, UTC, and PTP.

The SMPTE Epoch and PTP Epoch are each located at 1970-01-01 00:00:00 (TAI).

The TAI and UTC timescales share a common origin at the 1958-01-01 0h, beginning-of-day.

The TAI timescale represents time as a linear count of years, months, days, hours, minutes, and seconds, progressing at the constant second SI rate and days have a constant duration of 86400 seconds.

The UTC timescale, as specified by the BIPM, adopted the second SI rate and a 10-second offset from TAI beginning at 1972-01-01 00:00:00 (TAI).

The POSIX standard specifies timescales that progress at the second SI rate and a proleptic UTC shift back to 1970-01-01 for the 10-second DTAI offset and the second SI rate. When there is a leap second there are no 60 second labels inserted the 59 second label is repeated.

UTC common days have a duration of 86400 seconds. To maintain a close relationship between the UTC and UT1 timescales, leap seconds are periodically incorporated into the UTC timescale on dates as designated by the IERS. A positive leap second day has 86401 seconds and a negative leap second day has 86399 seconds. As of 2017 no negative leap second days have been declared.

The IEEE STD 1588 Precision Time Synchronization Protocol (PTP) is an IP Network protocol that facilitates the synchronization of a local clock to the reference in the grandmaster.

The GNSS, Global Network Satellite System includes GPS and other Nationally administrated satellite systems including GPS that uses a time origin 1980-01-06 (UTC).

Network Time Protocol (NTP) is an Internet protocol. NTP has an origin at 1900-01-01 (proleptic UTC without leap-seconds)

Windows has an origin at 1601-01-01 (proleptic UTC without leap-seconds)

A calendar day-number that can be applied to days on both the TAI and UTC timescales is a zero-based integer count of days from 1970-01-01 on both the TAI and UTC timescales.

The relationships among TAI, UTC, POSIX timescales, and PTP defined by IEEE STD 1588 PTP are detailed in Figure 1.

The timecode generation process is outlined in Clause 4.1.

When the timecode binary bits are generated using the ST 262 page-line protocol a UAC flag bit as specified in Clause 7.4 signals that the timecode was generated in conformance with this standard.

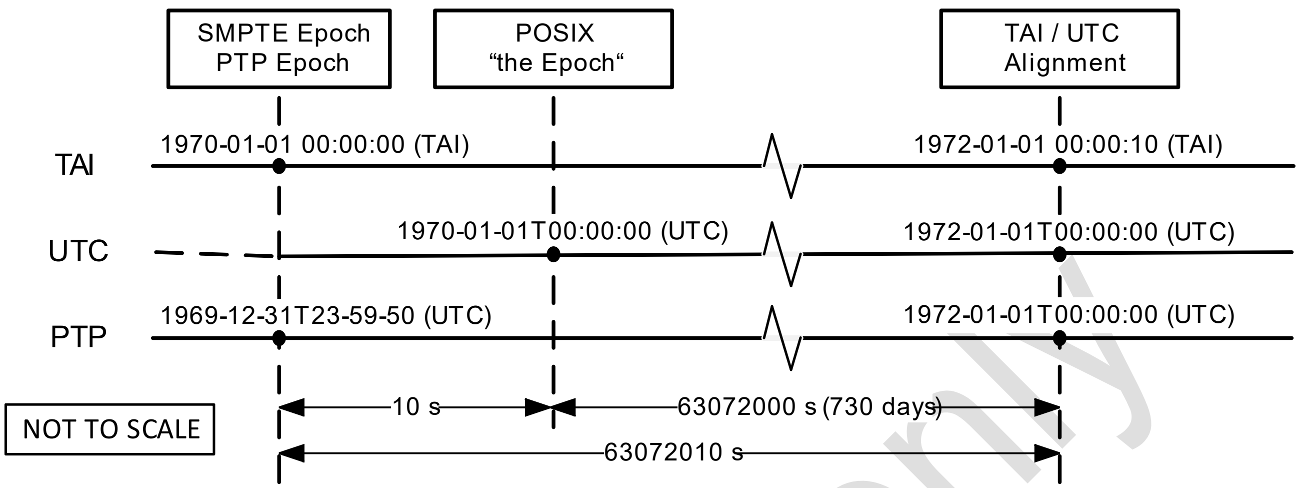

Figure 1 – Timescales

4.5. Local timescales

In some locations there is a regularly scheduled seasonal DST time shift where, the local time is advanced or retarded by one-hour. This effectively shifts the displayed local time from one UTC offset timescale to another.

Similarly in some locations the local authorities choose to modify the selection of UTC offset to meet local needs by changing the selection of UTC offset timescale.

4.6. Leap seconds

Leap seconds are incorporated into the UTC timescale to maintain a close relationship between the UTC and UT1 timescales. Annex A details leap second history and other details.

From an initial start-of-day zero-count the timecode follows a regular ascending count throughout the day with any required leap seconds incorporate at the end-of-day.

At the integer related rates a full count progression from zero to 23:59:59:ff and for the introduction of a positive leap second is followed by the one-second 23:59:60:ff counts. For the case of a negative leap second the regular counts 23:59:59:ff are omitted at the end-of-day.

For the non-drop frame fractional rates, the calendar end-of-day is reached before the regular timecode end-of-day is reached and the timecode rolls over to zero.

For the fractional 30/1.001 Hz, drop frame rate the number of counts in a normal day exceeds the normal count of the conventional timecode thus requiring the daily addition of labels 23:59:60;00 to 23:59:60;01 or 23:59:60;03 according to the date. Although both positive and negative leap seconds are defined, as of 2017 only positive leap seconds have been declared however, there are indications of a requirement for a negative leap second in the next few years.

5 Date and time references

5.1. PTP reference

The IEEE Std 1588 standard provides the facility for date and time labeling of media at both integer and fractional rates.

The PTP ALTERNATE_TIME_OFFSET_INDICATOR TLV message conveys the leap second offsets (DTAI), the local wall-clock UTC offset, and other parameters.

The IEEE STD 1588-2019 time is a count of seconds (48-bit secondsField) and nanoseconds (32-bit nanosecondsField) relative to the PTP Epoch.

NOTE POSIX "The Epoch" proleptically shifts the initial 10-secons leap second offset earlier by two years to 1970. This might affect some calculations in this period.

5.1.1. ST 2059-2 PTP media profile

The SMPTE ST 2059-1 defines the SMPTE Epoch as being identical to the PTP Epoch and uses the PTP SM TLV message to signal the leap second offset (DTAI) and local wall-clock UTC offset. The SM TLV message signals upcoming changes that for UTC offset shifts can be implemented at a "daily jam" time point as specified by the timeOfNextJam field however, this standard incorporates leap second changes at the end-of-day.

The SM TLV message indicates the default system frame rate coded as a numerator and denominator, in the defaultSystemFrameRate field. This standard supports the media rates as specified in Clause 5.2.

5.1.2. AES67 PTP media profile

The AES67 PTP Media Profile does not specifically mandate the transport of time related data parameters such as the UTC offset to local time or the application of a daylight saving time offset. This ALTERNATE_TIME_OFFSET_INDICATOR TLV message is optional in AES67.

5.2. Media rate

This standard supports media at the base-rates 24/1.001 Hz, 24 Hz, 25 Hz, 30/1.001 Hz, and 30 Hz, plus their integer multiples. These media-rates are expressed as a base-rate, a rate-multiplier and rate-scale-factor as specified in Clause 7.2.

NOTE As signaled by ST 2059-2 the default video system frame rate is expressed as rational numerator and denominator values. For the integer rates the denominator should be "0x0001" and for the fractional rates supported by this standard, should be "0x03E9".

5.3. Calendar day length

The calendar day length for common days is 86400 seconds, for a positive leap second day is 86401 seconds, and for a negative leap second day is 86399 seconds.

5.3.1. UTC offset and wall-clock time

The workplace generally functions based on calendar days and local wall-clock time.

From the SMPTE ST 2059-2 PTP Profile the local time, UTC offset can be determined from the SM TLV message, currentLocalOffset field.

The local time UTC offset expressed as sign, hour and minute values can be calculated with the procedure and formulae.

```
TzSign: IF currentLocalOffset = 0;                              ;// Sign of UTC offset
                TzSign = 1                                      ;//
        Else    TzSign = 0                                      ;// SIGN(currentLocalOffset)
Tzhh    = FLOOR(ABS(currentLocalOffset - DTAI) / 3600)          ;// UTC offset hours
Tzmm    = ABS((currentLocalOffset - DTAI) - TzSign x Tzhh x 3600) / 60   ;// UTC offset minutes
```

Where: currentLocalOffset field specifies DTAI, the difference between TAI and UTC. *See Clause 5.3.2.*

The UTC local wall-clock time-of-day in seconds (ToDss) is a zero-based count of seconds from local calendar beginning-of-day.

```
ToDss = (seco0ndsField                          ;// PTP secondsField
        – 10                                    ;// offset from SMPTE Epoch to day-number zero
        – (DTAI – 10)                           ;// leap second introductions since day-number zero
        – (day-number x 86400))                 ;// days offset to UTC calendar beginning-of-day
        – (TzSign x ((Tzhh x 3600) + (Tzmm x 60)))   ;// offset to local calendar beginning-of-day
```

Where: secondsField *is the value of the PTP timestamp secondsField,*
DTAI is the difference between TAI and UTC
day-number *is the offset from 1970-01-01 (UTC) as calculated above in Clause 5.3.3 .*
TzSign, Tzhh, TZmm are components of local time UTC timescale offset

For negative UTC offset time zones and if the ToDss is a negative value then this time point on the local timescale is in the prior day. The DTAI value should be shifted to the prior day-number before recalculating ToDss for this prior day-number.

The status of local time daylight saving time is signaled by the daylightSaving flag in the PTP SM TLV message.

NOTE 4. As cautioned in SMPTE ST 2059-2 care needs to be taken on days when daylight saving time starts or ends to ensure that time-related SM TLV items signaled using PTP time achieve the required results at the intended local times. The information in the SMPTE ST 2059-2 PTP Profile SM TLV message can change at a different time point than that which would be signaled by an ALTERNATE_TIME_OFFSET_INDICATOR TLV message or the timePropertiesDS message fields.

NOTE 5. In conformance with common practice, local time UTC offsets in this standard are generally constrained to signed hour values from -12 to +14 and minute values of 00, 15, 30 or 45.

5.3.2. Leap second offset

The current value in seconds of DTAI, the leap second offset is signaled by the timePropertiesDS.currentUtcOffset field. Upcoming changes are signaled with the timePropertiesDS.leap59 or the timePropertiesDS.leap61 fields.

NOTE 6. The currentUtcOffset field is set in advance of a scheduled leap second change and cleared after the change. The time point at which the change becomes effective is signaled by the timeofnextjump field.

NOTE 7. While standards provide for the possibility of a negative leap second correction where the last second of the day is omitted, there have been no negative leap second corrections as of the publication data of this standard.

5.3.3. Calendar day number

The calendar date and wall-clock time can be derived from the SM TLV message as specified in SMPTE ST 2059-2. The date is represented by a day-number that shall be a zero-based number of days from 1970+01+01.
The timestamp for the last second of the day might represent a positive leap second that has not yet been accounted for in the value of DTAI. The day-number for a time point on the UTC timescale can be calculated from a PTP timestamp with the formula

$$\text{day-number} = \text{FLOOR}(\ (\text{FLOOR}(\text{ts}) - 10 - \text{PLS})\ /\ 86400)$$

Where: ts is the value of the PTP timestamp in seconds,
SMPTE Epoch to day-number zero is 10 seconds,
DTAI is the difference between TAI and UTC,
PLS = 1 if this timestamp represents a positive leap second, else PLS = 0.

While the day-number is calculated on the UTC-Z timescale it is also applicable to the UTC offsets for this calendar day. As illustrated in Figure 2 for UTC offset timescales the UTC offset might shift the time point to the prior or next calendar day and thus the day-number shall be shifted accordingly.

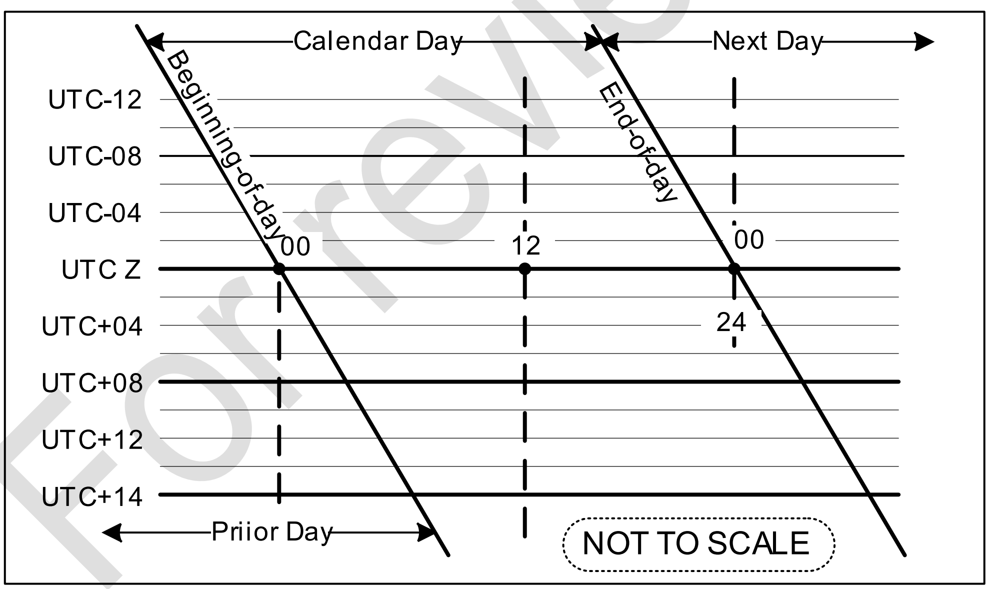

Figure 2 – Calendar Day

5.3.4. Daylight saving and other UTC offset shifts

The daylight saving time shift applies a different UTC offset timescale to the calculation of the media-index. For example, in an Eastern US time zone the standard time UTC offset is “-05:00”, however when daylight saving (DST) is in effect the UTC offset is “-04:00”.

$$\text{UTC offset (DST)} = \text{UTC offset (STD)} + \text{DST offset}$$

The result is that media labels expressed in a clock time format shall shift by exactly the magnitude of the DST offset shift that corresponds to the UTC offset. All media-units are uniquely labeled.

Similar to daylight saving time shifts the time label shift corresponds to the UTC offset shift. All media-units are uniquely labeled.

5.4. Alternate date and time sources

This standard specifies the determination of date, time and related metadata parameters from PTP. Other sources that can yield similar information may also be used.

6 Media-index

6.1. Media-index count

The media-index shall be a zero-based integer count of media-units (video frames) from the timecode start-of-day.

For media that has been aligned relative to the SMPTE Epoch the date, UTC offset, time, and related metadata can be used to calculate a media-index.

The date as specified in Clause 5.3.3 is a zero-based count of days from 1970-01-01T00:00:00Z (UTC). The local wall-clock time is a zero-based count of seconds from the calendar beginning-of-day.

6.2. Media-rates

For media at the 24/1.001 Hz, 24 Hz, 30/1.001 Hz, and 30 Hz related rates the media-unit blocks maintain an even-odd cadence to support processes such as color frames and two-frame markers each day maintains an even number of media-units even with the end-of-day rollover and the introduction of leap seconds.

For media at integer rates the media-index start-of-day can be at the calendar beginning-of-day. However, for media at fractional rates the media-index start-of-day will vary from day-to-day and although close will rarely be precisely at a calendar beginning-of-day.

NOTE User applications that simply need a label to facilitate referencing media positions without a precise wall-clock time reference might choose another user designated media-index count origin.

The supported rates are based on the SMPTE ST 12-1 time address frame counts of 24, 25, and 30 frames per timecode second. The base-rates include both the integer and fractional (n/1.001) rates. The rate families consist of a base-rate and integer multiples of the base-rate. A media-rate is expressed by a combination of:

- a base-rate code as specified in Clause 7.2.1,
- a rate-scale-factor as specified in Clause 7.2.2, and
- a rate-multiplier as specified in Clause 7.2.3.

NOTE In a family of media-rates where members in the family are at integer multiples of the base-rate, some higher rates can also be a member of more than one family, each with a different base-rate and rate-multiplier. For example media at a 120/1.001 Hz rate can be a four times multiple of 30/1.001 Hz or a five times multiple of 24/1.001 Hz.

6.3. Start-of-day

For media that has been aligned relative to the SMPTE Epoch the UTC calendar beginning-of-day is a timing reference point for media-index counts.

For media at the integer rates the media-index start-of-day has a zero-offset to the UTC calendar beginning-of-day.

For media at the fractional rates the media-index start-of-day is rarely aligned at a calendar beginning-of-day. On the UTC-Z timescale the media-index start-of-day points forms a date defined array of 1001 points. Independently for each UTC offset timescales the media-index start-of-day is shifted earlier or later according to the UTC offset value. Thus, these media-index counts have a defined alignment to the local UTC offset clock time.

6.4. Integer rate media

Media at integer media-rates has a constant integer number of media-units in a calendar day unless this is a leap second day. For SMPTE Epoch aligned media the first media-block of the day is aligned relative to the calendar beginning-of-day and also to each second throughout the day. Thus, the alignment phase-index shall be zero.

NOTE For 25 Hz analog, color framed video the 4-frame media-block rate is 6.25 Hz and thus the media-blocks will only be aligned every four seconds and aligned to a calendar beginning-of-day every four days.

6.4.1. Length-of-day in media-units (LoDmu)

The length-of-day in media-units for integer media-rates is constant for common days and changes for leap second days.

The length-of-day can be calculated with the formulae.

$$\text{LoDmu} = \text{day-length x media-rate}$$

Where: Day-length is the length-of-day in seconds as specified in Clause 5.3.

Media-rate is the value in Hz (integer values), as specified in Clause 6.2..

6.5. Fractional rate media

At fractional rates the media alignment shifts for each second with alignment only expected every 1001 seconds or days. There is a regular sequence of phase alignments for the other seconds and days. The pattern of day lengths follows a sequence of short-days and long-days over a period of 1001 days and is adjusted accordingly with a leap second introduction.

Based on the day-number, UTC offset, DTAI, and media-rate can be used to determine the calendar beginning-of-day to media and media-index start-of-day alignments. The media-index and alignment to a second can be calculated for each second of the day. The resulting media-index facilitates a symmetric, mathematically precise relationship to date and wall-clock time. The calendar beginning-of-day to first media-unit block phase alignment offset is shown in Figure 3. The phase alignments are in discrete steps labeled with integer phase-index numbers from zero to 1000.

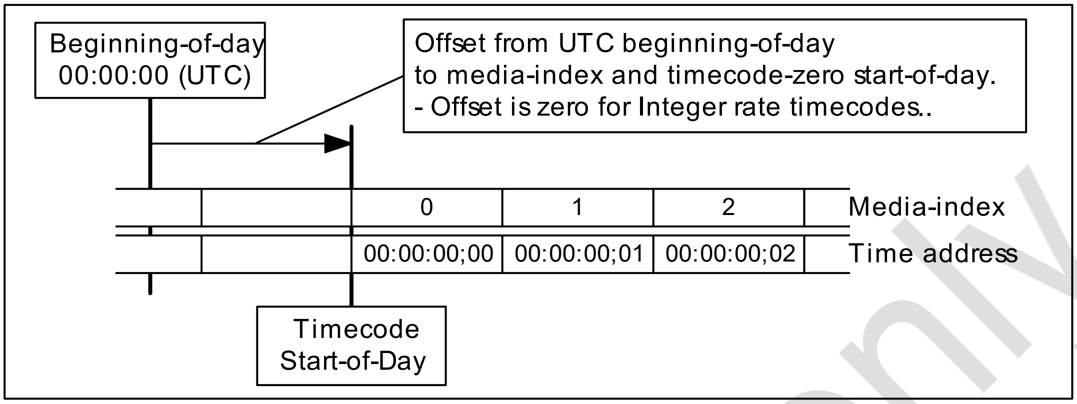

Figure 3 – Start-of-Day Alignment

6.5.1. Media-index start of day

Video media at fractional media-rates has a shifting number of media-units related to each 24-hour day. Phase-index numbers represent the start-of-day media alignments. Throughout the day media-index and phase-index are calculated based on the media-rate, day-number, leap second offset, local UTC offset, and the time-of-day.

For media aligned relative to the SMPTE Epoch, the media-index start-of-day offset from the calendar beginning-of-day is the sum of two independent phase-offsets. The UTC-Z phase-index is a function of the day-number. The UTC offset phase-index is a function of the UTC offset hours (-12 to +14) and minutes (00, 15, 30, or 45). The combined start of-day phase-offset is calculated with the following formula.

$$\mathrm{SoDPhIdx}() = \mathrm{SoDPhIdx}(\text{UTC-Z}) + \mathrm{SoDPhIdx}(\text{UTC offset})$$

Where: SoDPhIdx() is the combined offset for the day.

SoDPhIdx(UTC-Z) is offset related to the day-number as specified in Clause 6.5.1.1.

SoDPhIdx(UTC offset) is offset related to the UTC offset as specified in Clause 6.5.1.2.

These phase-index numbers can be converted into a measure of media-units or of time in seconds.

The media-index start-of-day phase alignment expressed in media-units (SoDmu) can be as determined by the formula.

$$\mathrm{SoDmu} = \mathrm{SoDPhIdx}() \text{ x media-block-size } / \ 1001$$

The media-index start-of-day phase alignment expressed in seconds (SoDss) is determined by the formula.

$$\mathrm{SoDss} = \mathrm{SoDPhIdx}() \text{ x media-block-size } / \ (\text{base-rate x } 1000)$$

Where: SoDPhIdx() is the media-index start-of-day phase-index

base-rate is the integer rate count-modulus.

media-block-size is the number of media-units in an alignment block.

NOTE The formulae are based on time relative to the SMPTE Epoch and a constant UTC seconds SI rate the results are only validbeginning at 1972.

6.5.1.1. Media-index start-of-day phase-index – UTC-Z

The media-unit alignment zero related to UTC-Z as a function of the day-number can be determined by the formula.

$$\mathrm{SoDPhIdx(UTC\text{-}Z)} = (\mathrm{PhIdxO70} + ((\mathrm{DTAI} - 10) \times \mathrm{PhFss}) + (\text{day-number} \times \mathrm{PhFDD}))\ \%\ 1001$$

Where: SoDPhIdx(UTC-Z) is the media-index start-of-day phase-index on the UTC-Z timescale

PhIdxO70 is the phase-index at 1970-01-01T00:00:00Z (UTC).

DTAI is the leap second difference (TAI – UTC).

PhFss is the phase-factor for seconds.

PhFDD is the phase-factor for days.

Phase-factors and other constants are listed in Table 1.

NOTE The phase-index SoDPhIdx(UTC) is a constant value for a combination of a day-number, a DTAI, and a media base-rate.

Table 1 – Constants for video at 30/1.001 Hz and 24/1.001 Hz rates

	Video system		Units
Fractional rate	**30/1.001**	**24/1.001**	**Hz**
Base-rate (integer)	**30**	**24**	**Hz**
86400 second LoD	2589410.(589410)	2071528.(471528)	Media-unit
UAC LoD: short-day	2589410	2071528	Media-unit
UAC LoD: long-day	2589412	2071530	Media-unit
Leap second LoD	+30	+24	Media-unit
PhIdxCD (Common day) long-day if PhIdx less than	295	236	Phase-Index
PhIdxLD (Leap second day) long-day if PhIdx less than	280	224	Phase-Index
PhFDD Phase-index factor- Days	706	765	Phase-Index
PhFhh Phase-index factor- Hours	947	157	Phase-Index
PhFmm Phase-index factor- Minutes	900	720	Phase-Index
PhFss Phase-index factor- Seconds	15	12	Phase-Index
PhIdx at 1970-01-01T00:00:00Z (UTC)	150	120	Phase-Index

6.5.1.2. Media-index start-of-day phase-index–UTC offset shifts

The media-unit zero alignment related to the UTC offset shall be as determined by the following formula.

NOTE The phase-index local offset (SoDPhIdx_LocalOffset) is a constant value for each UTC offset as determined by the media base-rate and the local time UTC offset.

$$\begin{aligned}\mathrm{SoDPhIdx(Shift)} = {} & \mathrm{TzSign} \\ & \times ((\mathrm{ABS(Tzhh)} \times (1001 - \mathrm{PhFhh}))\ \%\ 1001) \\ & + \mathrm{ABS(Tzmm)} \times (1001 - \mathrm{PhFmm}))\ \%\ 1001))\end{aligned}$$

$$\mathrm{SoDPhIdx(UTC\ offset)} = \mathrm{SoDPhIdx(UTC\text{-}Z)} + \mathrm{SoDPhIdx(Shift}$$

Where: SoDPhIdx(UTC-Z) is the media-index start-of-day phase-index on the UTC-Z timescale

TzSign is the sign of the local time UTC offset

Tzhh is the hours component of the local time UTC offset

Tzmm is the minutes component of the local time UTC offset

PhFhh is the phase-index phase-factor for hours

PhFmm is the phase-index phase-factor for minutes

6.5.2. Length-of-day in media-units (LoDmu)

For media at the fractional rates, the day is designated either as a short-day or a long-day with a corresponding number of media-unit in the day.

The procedure in Clause 6.5.2.1 determines the long-day / short-day designation and calculates the length-of-day in media-units (LoDmu). These calculations determine the LoDmu for the base-rate and for integer multiple the LoDmu values is multiplied by that multiple.

NOTE The base-rate is use for these media-index start-of-day and length-of-day calculations so that at the higher media-rates multiples the media-index zero start is at the same time point for all members of the rate family.

6.5.2.1. Short-days and long-days

Based on the day-number the procedure determines the short-day or a long-day designation and calculates the media-index length-of-day.

Procedure(Long-day, Short-day)

```
If LeapSecondDay = True                          ;// This is a leap second day
    LsShift = PositiveLeapSecond − NegativeLeapSecond
    If SoDPhIdx(UTC) < PhIdxLD                   ;// Is long-day as specified in Table 2
        LoDmu = LoD-long-day + (LsShift x base-rate)
        long-day = True
        short-day = False
    Else                                         ;// This is a short-day
        LoDmu = LoD-short-day + (LsShift x base-rate)
        long-day = False
        short-day = True
    EndIf
Else                        ;// This is not a leap second day
    If SoDPhIdx(UTC) < PhIdxCD                   ;// Is long-day as specified in Table 2
        LoDmu = LoD-long-day                     ;// as specified in Table 2
        long-day = True
        short-day = False
    Else                                         ;// This is a short-day
        LoDmu = LoD-short-day                    ;// as specified in Table 2
        long-day = False
        short-day = True
    EndIf
EndIf
```


Return LoDmu ;// LoDmu in Media-units
short-day = True or long-day = True ;// Length-of-day designation

NOTE 8. Parameter constants “PhIdxLD(Leap second day)”, “PhIdxLD(Common day}”, LoDmu(long-day) and LoDmu(short-day) are defined in Table 2.

6.6. Start-of-day, end-of-day

For fractional rate media both the media-index start-or-day and the media-index end-of-day are not expected to precisely align with the local calendar day boundaries. These variations are illustrated in Figure 4.

Calculate the time points for the first and last media-units of the media-index day.

The media-index day starts at the start-of-day (SoDss) for the day-number until the media-index end-of-day time point SoDss plus LoDss which is also the SoDss for the next day. The LoDss is calculated as part of the procedure “IsLeapSecondDay()” as specified in Clause 6.7.2.

If the ToDss is before the SoDss time point then the media-unit is part of the prior day-number and if the ToD is after the end-of-day time point then then the media-unit is part of the next day-number. In either case the calculations need to be recalculated with a revised day-number.

The local time clock value might be either very close to a media time reference datum (media-unit boundary) or else it is within the body of the media-unit. The procedure, which allows for normal timing tolerances, should be used to determine the media-index value for the media-unit at the time point ToDss

If ABS((ToDss – SoDss) / media-rate) < (1 / (media-rate x 2000)) ;// test position
media-index = ROUND((ToDss – SoDss) / media-rate) ;// near boundary
Else media-index = FLOOR((ToDss – SoDss) / media-rate) ;// within media-unit

Where: ToDss is the time-of-day in seconds.

SoDss is the offset in seconds from midnight to the media-index SoD.

media-rate is the rate of the media in Hz.

The correct interpretation of the media-index by receiving applications depends on several metadata items, which might have been created as part of the count generation or input from the supporting application.

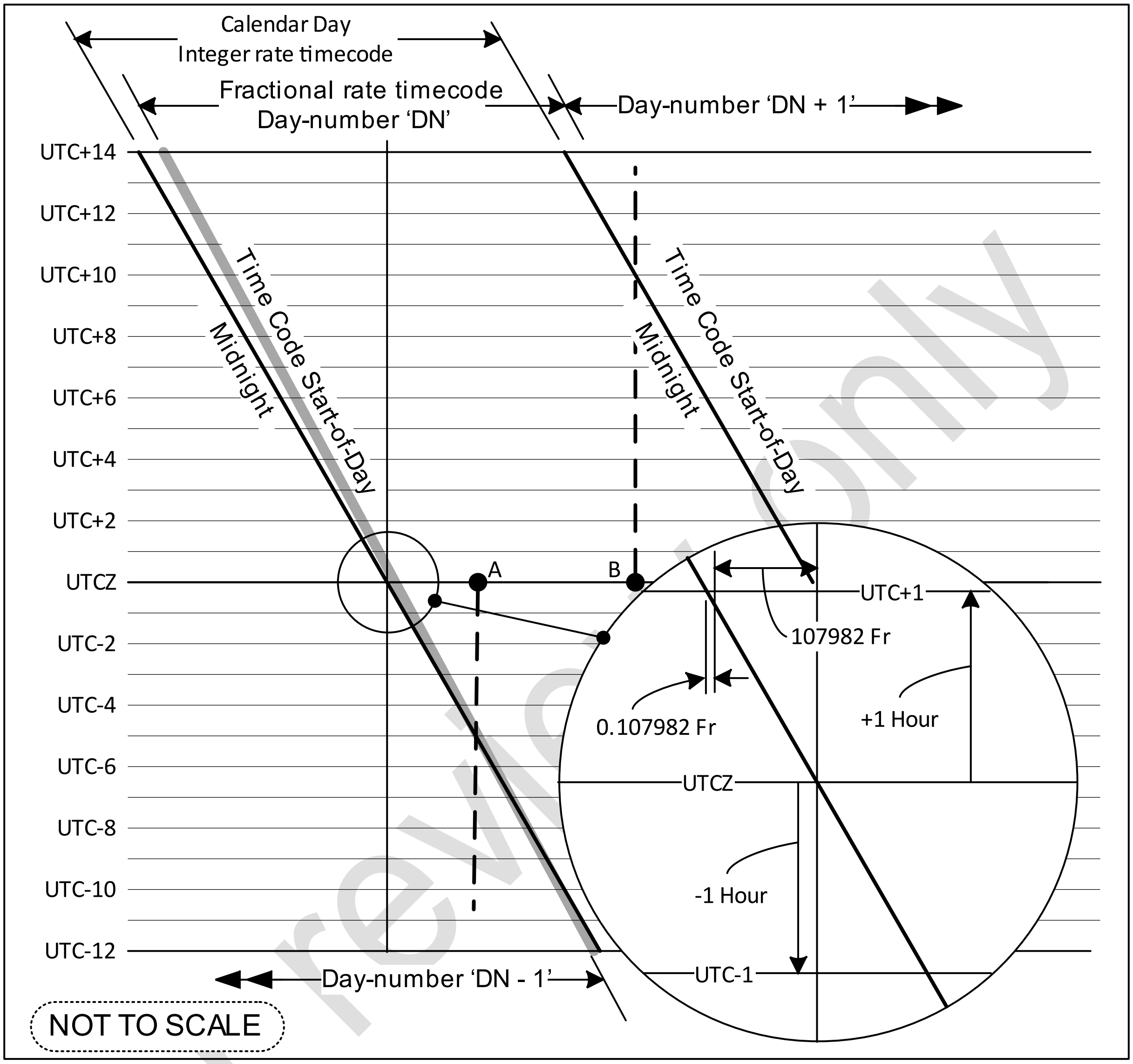

Figure 4 – Range of timecode day shifts for local times and UTC offsets (30/1.001 Hz DF)

6.7. Leap second procedures (informative)

Parameter "LeapSecondDay" is calculated with the procedure IsLeapSecondDay() as detailed in Clause 6.6.2 and parameters "PositiveLeapSecond" and "NegativeLeapSecond" are calculated in procedure IsLeapSecond() as detailed in Clause 6.7.1.

6.7.1. IsLeapsecond – procedure

The Annex A, Table 9 "DTAI history" lists the time points for the start of each DTAI interval. This procedure identifies leap seconds based on time points on the TAI seconds timescale or a scale of seconds since 1970-01-01T00:00:00Z (UTC). Since the leap second is incorporated as the last second of the month the leap second is only incorporated into the value of DTAI on the next second. A time point could represent a positive leap second that is not already included in the current value of DTAI.

```
Procedure: IsLeapSecond(ss)                           ;//
          mightBeLeapSecond = ss + 1                  ;// check next second
     Scan the "SMPTE Epoch" column of Table 9 for the value mightBeLeapSecond,
          If found mightBeLeapSecond
                    If (DTAI(this row) = DTAI(prior row) + 1)
                    PositiveLeapSecond = 1            ;// True, positive leap second
                    Else NegativeLeapSecond = 1       ;// True, negative leap second
                    endIf
          Else PositiveLeapSecond = NegativeLeapSecond = 0 ;// False (not a leap second)
          endIf
```

6.7.2. IsLeapSecondDay – procedure

For each leap second, the DTAI history Annex A, Table 9 lists the day-numbers of the days that begin a period with a changed DTAI value that indicates that a leap second was incorporated just prior to this day-number. This table can be used to determine the length of the calendar day in seconds.

The calendar day length for a common day is 86400 seconds, for a positive leap second day is 86401 seconds, and for a negative leap second day is 86399 seconds,

Test the day-number to determine if a leap second is incorporated at the end of the day and to determine the *length of calendar day (LoDss)*.

```
Procedure: IsLeapSecondDay(day-number)                          .// Procedure to test for day
     type.
     mightBeDayAfterLS = day-number + 1                         ;// check next `DTAI ofset
     Scan the "day-number" column of the "DTAI table" for "mightBeDayAfterLS",
          If found
                    LeapSecondDay = True                        ;// leap second day
                    If (DTAI(this row) = DTAI(prior row) + 1)          ;//
                    LoDss = 86401 seconds                       ;// positive leap second day
                    Else LoDss = 86399 seconds                  ,// negative leap second day
          Else      leapSecondDay = False                       ;// common day;
                    LoDss = 86400 seconds.                      ;//
```

7 Date, UTC offset, and related metadata

7.1. Calendar date

The day-number as calculated in Clause 5.3.3 can be converted to a decimal MJD value or as year, month, day BCD elements.

Binary group coding using either SMPTE ST 262 as specified in Clause 10, or SMPTE ST 309 as specified in Clause 11 can present the date in a "YY-MM-DD" format or as a MJD decimal value.

7.1.1. Modified Julian Day (MJD)

The MJD can be calculated from a day-number with the formulae:

$$\mathrm{MJD} = \text{day-number} + 40587$$

Where: MJD is the Modified Julian Day.

Day-number is as specified above.

40587 is the MJD for Gregorian calendar day 1970-01-01.

7.1.2. Calendar year, month, day

The day-number as specified above can be converted to the numeric year, month, and day elements with the procedure “Year and day-of-year” that intern uses the following two functions.

1. The function “LeapsThroughEndOf()”determines the number of leap years up to and including the specified year number “YYYY”.

   Function: LeapsThroughEndOf(YYYY)

   $$\mathrm{LeapYears} = \mathrm{FLOOR}(\mathrm{YYYY}\ /\ 4) - \mathrm{FLOOR}(\mathrm{YYYY}\ /\ 100) + \mathrm{FLOOR}(\mathrm{YYYY}\ /\ 400)$$

2. The function “IsLeapYear(YYYY)” determines if the year number “YYYY” returns the Boolean value “True” for a leap year or else “False” for a common year.

   Function: IsLeapYear(YYYY)

   $$\mathrm{IsLeapYear(YYYY)} = ((\mathrm{YYYY}\ \%\ 4) == 0)\ \mathrm{AND}\ (\ \mathrm{NOT}((\mathrm{YYYY}\ \%\ 100) == 0)\ \mathrm{OR}\ ((\mathrm{YYYY}\ \%\ 400) == 0)\ )$$

The year “YYYY” and the ordinal day number “DDD” can be calculated from the day-number using the procedure.

Procedure(Year and day-of-year)

```
        Y = 1970                        ;// Initialize year to 1970
        D = day-number                  ;// Initialize to days since start of that year 1970
While D < 0 or D ≥ DaysInYear(Y) :      ;// While loop
        Ye = Y + FLOOR(D / 365)         ;// Make an estimate of the year
                ;// Adjust days to be days from the start of the estimated year
        D = D – (Ye – Y) × 365 – LeapsThroughEndOf(Ye – 1) + LeapsThroughEndOf(Y – 1)
                ;// For procedure LeapsThroughEndOf() as defined in Clause 7.1.2.
        Y = Ye                          ;// Update year.
End_While                               ;// End of loop
Returns:        Year YYYY = Y           ;// Year number,
                DDD = D + 1             ;// Ordinal day number (1 to 366)
```

The day-number can be converted to the numeric year, month, and day elements as follow.

With refer to Table 2 convert the ordinal day number (days from start-of-year) to month and day. Use the function IsLeapYear(YYYY) as defined above selecting the “Start day” column for a “Common year” or the “Leap year”. The month is determined from the table as follows:

Select MM as the greatest value of MM for which the start day of the month is less than or equal to “DDD.

The day of the month DD is given by:

DD = DDD – [start day of month MM] + 1

Table 2 – Months and ordinal day numbers

Month		Days in month and days to start or end of month					
Name	Number	Common year			Leap year		
		Days in month	Start day	End day	Days in month	Start day	End day
January	01	31	000	030	31	000	030
February	02	28	031	058	29	031	059
March	03	31	059	089	31	060	090
April	04	30	090	109	30	091	120
May	05	31	120	150	31	121	151
June	06	30	151	180	30	152	181
July	07	31	181	211	31	182	212
August	08	31	212	242	31	213	243
September	09	30	243	272	30	244	273
October	10	31	273	303	31	274	304
November	11	30	304	333	30	305	334
December	12	31	334	364	31	335	365

7.2. Rate

The rate can be expressed as a combination of three factors: a base-rate code, a rate-scale-factor and an integer rate-multiplier.

7.2.1. Base rate code

The base-rate shall be indicated by an enumerated code as defined in Table 3.

Table 3 – Base-rate codes

	Codes and rates			
Code	0	1	2	3
Base-rate	Undefined	24 fps	25 fps	30 fps

7.2.2. Rate scale-factors for integer or fractional rates

This standard supports media at both integer and fractional rates. The rate-scale-factor shall be indicated by a binary flag with a False value indicating an integer rate (rate-scale-factor: 1/1) and a True value indicating a fractional rate (rate-scale-factor: 1/1.1001).

7.2.3. Rate multiplier

The base-rate, rate-multiplier codes and the nominal media-rates for each base-rate supported by this standard shall be as defined in Table 4.

Table 4 – Rates and multiplier codes

	Codes and count-modulus															
Code	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	Ah	Bh	Ch	Dh	Eh	Fh
Multiplier	1	2	3	4	5	6	8	10	12	16	20	24	32	Reserved		
x 24 Counts	24	48	72	96	120	144	192	240	288	384	480	576	768	Reserved		
x 25 Counts	25	50	75	100	125	150	200	250	300	400	500	600	800			
x 30 Counts	30	60	90	120	150	180	240	300	360	480	600	720	960			

7.3. UTC offset

As specified in Clause 5.3.1 UTC offset expressed as sign, hour, and minute values can be derived from the IEEE STD 1588 PTP and SMPTE ST 2059-2 PTP Profile.

7.4. UAC compliance flag

This standard specifies a UTC-Aligned Count algorithm that specifies the precise timecode start-of-day offset to the calendar beginning-of-day and to seconds throughout the day. A UAC compliance flag can be used to signal to receiving processes that this algorithm is being followed.

8 SMPTE Timecode –Time address

8.1. Data mapping

Several parameters are required for mapping into a SMPTE timecode. The time address is expressed in the format of hours, minutes, seconds, and frames, complemented by a date in the format of a Modified Julian Day (MJD), or as year, month, day elements, and supporting metadata.

8.2. Time address

The time address shall be derived from the media-index specified in Clause 6. The methods and formulae convert the media-index into the time address “hh”, “mm”, “ss”, “ff” elements. If the SMPTE ST 262 page-line multiplex is used as defined in Clause 10.1 the frames value can be represented as a base-rate frame count value “ff” the time address frames and sub-frame count extension “ee” into the binary groups.

The time address start-of-day with a value 00:00:00:00 shall be at the media-index start-of-day as specified in Clause 6.1.

Depending on the media-rate the range of counts will vary:

- At integer media-rates the time address follows the regular count progression from zero at the timecode start-of-day to the normal full count at the end-of day. As described in ST 12-1 Annex A.2, for the optional introduction of a positive leap second the additional labels are coded in the second 23:59:60 and for a negative leap second the second 23:59:59 is omitted.
- At the fractional media-rates with the non-drop frame counting mode the count progresses from zero at the timecode start-of-day however, the end-of-day occurs before reaching a full count even with the incorporation of a positive leap second.
- For the 30/1.001 Hz, drop-frame counting mode there are short-day and long-day counts that facilitate a long-term correspondence with clock time. This involves two or four counts beyond the traditional end-of-day count. These counts plus the counts for an optional positive leap second are coded in the end-of-day labels that extend beyond 59 to 60 or 61 seconds. If a negative leap second is incorporated the last label of the day will occur before completing second 59.

For media-rates that are at integer multiples of the base-rates the count of frames shall extend to higher values where, in order to label the higher rate media, the frames are represented by a count to a limit (ffff) according to the frame rate and the representation "ff.ee" where "ee" is a sub division of the count. The SMPTE ST 12-1 defines two time address count modes drop frame and non-drop frame.

The format conversion equates a media-unit zero count label with a time address label of 00:00:00:00 for all media-rates. Both the media-index and the time address count step forward in sync at the same rate.

Table 5 – Source constants and variables

Name	Type	Description	Remarks
Hh	Uint	Hour	00 to 23
Mm	Uint	Minute	00 to 59
Ss	Uint	Second	00 to 59 (60 or 61 for last minute of day)
Ff	Uint	Frame	00 to 23, 24, or 29
Ffff	Uint	Frame (extended rate)	0000 to media-rate –1
Ee	Uint	Frame extension	0 to limit
rate-multiplier	Uint	Rate-multiplier	Integer 1 to 32 as specified in 7.2.3
UACmode	Boolean	UTC-aligned count mode flag	'0' = False '1' = True
LSday	Boolean	Leap second introduction Day flag	
long-day	Boolean	Long-day flag	
base-rate	Fps	Frames per time address second.	24, 25, or 30
media-index	Uint	Media-unit count	Zero-based count

8.2.1. Non-drop frame time address components

For integer media-rates media-index conversion to a time address format with a non-drop frame counting mode will maintain a correspondence with clock time however, for fractional media-rates the resulting time address will drift relative to clock time.

8.2.1.1. Time address components for integer rates

For integer rate media-index conversion to a time address format counting mode can maintain a correspondence with clock time.

8.2.1.2. Time address components for 24/1.001 Hz

For the 24/1.001 Hz related media-rates and media-index conversion to a time address format with a non-drop frame counting mode the resulting time address will drift relative to clock time.

The calculation of the non-drop frame time address component values for all integer and fractional frame rates shall be calculated with the hours, minutes, seconds, and frames (hh, mm, ss, ff) time address component calculated as follows:

$$hh = FLOOR(Media\text{-}Index \,/\, (rate\text{-}multiplier \times base\text{-}rate \times 3600))\ \%\ 24$$

$$\mathrm{mm} = \mathrm{FLOOR}(\text{Media-Index} \,/\, (\text{rate-multiplier} \times \text{base-rate} \times 60))\ \%\ 60$$

$$\mathrm{ss} = \mathrm{FLOOR}(\text{Media-Index} \,/\, (\text{rate-multiplier} \times \text{base-rate}))\ \%\ 60$$

$$\mathrm{ff} = \mathrm{FLOOR}(\text{Media-Index} \,/\, \text{rate-multiplier})\ \%\ \text{base-rate}$$

For higher media-rates the extended media-unit offset (ee) can be the result of the modulo division of the media count by the media-rate-multiplier and for media at the base-rate the value of “ee” is zero.

$$\mathrm{ee} = \mathrm{FLOOR}(\text{Media-Index}\ \%\ \text{rate-multiplier})$$

The higher frame rate count can be the calculated value of the frames (ffff) component of the time address at the media-rate.

$$\mathrm{ffff} = \mathrm{ff}\ \mathrm{x}\ \text{rate-multiplier} + \mathrm{ee}$$

The resulting time address may be presented in the form “hh:mm:ss:ff.ee” with the frames component expressed as the frames at the base-rate plus a fraction or in the non-standard form “hh:mm:ss:ffff” with the frames expressed as frames at the full media count-modulus.

8.2.2. Drop frame UTC-aligned time address for fractional rates

For fractional media-rates the drop frame algorithm can provide a close but not precise relationship with clock time. There will be a linear and constant drift.

For fractional media-rates the UAC drop frame algorithms defines a precise relationship with clock time. There will be a small day-to-day variation that will repeat on a 1001-day cycle unless there is a leap second introduction. The daily variation is deterministic, based on the date and the precise timestamp can be calculated.

8.2.2.1. Fractional rates related to 30/1.001 Hz

This clause is only applicable to fractional media-rates related to the base-rate 30/1.001 Hz and its integer multiples.

The calculation of the time address component values for 30/1.001 Hz related fractional rates and their integer multiples can be calculated using the following formulae. When the variable “UACmode” is True the

UAC drop frame calculations are enabled, and when False the conventional drop frame calculations as defined by SMPTE ST 12-1 are enabled.

The length in media-units (frames) of one hour (LoH) is a constant value that can be calculated with the formulae:

$$\mathrm{LoH} = (60 \times 60 \times 30) - (6 \times 9 \times 2) = 108000 - 108 = 107892$$

The length in frames of a 24-hour day without a leap second introduction (LoCD) can be calculated with the formula:

$$\mathrm{LoCD} = (24 \times \mathrm{LoH}) + \mathrm{UACmode} \times (2 + 2 \times \text{Long-day})$$

The length in media-units (frames) of a day with a positive leap second introduction (LoDmu) shall be calculated with the formula:

$$\mathrm{LoDmu} = \mathrm{LoCD} + \mathrm{LSday} \times 30$$

The input media-index shall be converted to a base-rate count (FrCount) that is used for the calculation of the time address components (that is hh, mm, ss, and ff).

$$\mathrm{FrCount} = (\mathrm{FLOOR}(\textit{Media-Index} \,/\, \text{rate-multiplier}))\ \%\ \mathrm{LoDmu}$$

The temporary variable (fUac) is the number of UAC frames that have been added to a normal drop frame count and it shall be calculated with the formula:

$$\mathrm{fUac} = \mathrm{UACmode} \times (2 + 2 \times \text{Long-day}) \times \mathrm{FLOOR}(\mathrm{FrCount} \,/\, 2589408))$$

The temporary variable (fLs) is the number of leap second frames that have been added to a normal drop frame count and it shall be calculated with the formula:

$$\mathrm{fLs} = \mathrm{LSday} \times \mathrm{FLOOR}(\mathrm{FrCount} \,/\, \mathrm{LoCD}) \times 30$$

The hours (hh) component of the time address shall be calculated with the formula:

$$\mathrm{hh} = \mathrm{FLOOR}((\mathrm{FrCount} - \mathrm{fUac} - \mathrm{fLS}) \,/\, \mathrm{LoH})\ \%\ 24$$

The temporary variable (FoH) is the count of frames within the current hour and it shall be calculated with the formula:

$$\mathrm{FoH} = \mathrm{FrCount} - \mathrm{hh} \times \mathrm{LoH}$$

The temporary variable (FoTH) is the count of frames for the current hour discounting the UAC and leap second counts and it shall be calculated with the formula:

$$\mathrm{FoTH} = \mathrm{FoH} - \mathrm{fUac} - \mathrm{fLS}$$

The minutes (mm) component of the time address shall be calculated with the formula:

$$\mathrm{mm} = \mathrm{FLOOR}((\mathrm{FoTH} + 2 \times \mathrm{FLOOR}(\mathrm{FoTH} \,/\, 1800) - 2 \times \mathrm{FLOOR}(\mathrm{FoTH} \,/\, 18000)) \,/\, 1800)$$

The temporary variable (FoM) is the count of the frame offset in the current minute and it shall be calculated with the formula:

$$\mathrm{FoM} = \mathrm{FoH} - \mathrm{mm} \times 1798 - 2 \times \mathrm{FLOOR}(\mathrm{mm} \,/\, 10)$$

The seconds (ss) component of the time address shall be calculated with the formula:

$$\mathrm{ss} = \mathrm{FLOOR}(\mathrm{FoM} \,/\, 30)$$

The frames (ff) component of the time address at the base-rate shall be calculated with the formula:

$$\mathrm{ff} = \mathrm{FoM}\ \%\ 30$$

The extended-media-index (ee) is the offset from the base-rate media-index value and shall be calculated with the formula:

$$\mathrm{ee} = \mathrm{FrCount}\ \%\ \text{rate-multiplier}$$

The frames (ffff) component of the time address at the media-rate shall be calculated with the formula:

$$\mathrm{ffff} = \mathrm{ff}\ \mathrm{x}\ \text{rate-multiplier} + \mathrm{ee}$$

The resulting time address may be presented in the form "hh:mm:ss:ff.ee" with the frames component expressed as the frames at the base-rate plus a fraction or in the form "hh:mm:ss:ffff" with the frames expressed as frames at the full media-rate.

8.2.2.2. Fractional rates related to 24/1.001 Hz

There is no drop frame mode that is defined by SMPTE ST 12-1 for these rates.

9 SMPTE Timecode – Flag bits

9.1. Flag bits

SMPTE timecode LTC, VITC, and ATC formats include six flag bits to signal operational modes of the timecodes. These flag bits shall be set in accordance with SMPTE ST 12-1 as described in the following clauses.

9.1.1. Drop frame

When generating timecodes at nominal 30 fps rates there is the choice of using either the drop frame or the non-drop frame count modes. For media at fractional rates that are an integer multiple of 30/1.001 Hz the drop frame count mode should be used to minimize drift relative to wall-clock time. The drop frame flag should only be set for fractional rates.

9.1.2. Color frame

If the conversion of the media-index to the time address is in accord with the specifications of SMPTE ST 12-1 then the color frame flag should be set to a True value, otherwise this flag should be set to a False value.

NOTE 9. For analog composite video at the 30/1.001 Hz rate, aligned relative to the SMPTE Epoch as specified by SMPTE ST 2059-1, the color frame sequence will be correct and the time address generated by this standard I also have a matching even/odd time address cadence.

NOTE 10. For analog composite video at the 25 Hz rate, aligned relative to the SMPTE Epoch as specified by SMPTE ST 2059-1, the color frame sequence will be correct. However, the time address generated by this standard does not maintain the modulo-4 time address cadence. Thus, the color frame to time address will only be correct every fourth day.

NOTE 11. Color frame identification defines a relationship of the time address values to the color encoding of an analog composite video signal. This has implications beyond analog video in that for 30/1.001 Hz related media a timecode that is aligned to the even/odd media-index count will maintain that relationship even with drop-frame count and short-day, long-day corrections.

9.1.3. Phase / Field

For LTC the phase bit is recalculated as required. Historically this bit has created compatibility problems and unless specifically required, should be set to logic ‘0’.

For VITC the field flag will be determined based on the rates of the source video and the generated VITC rate. At media base-rates the field flag should be set to logic ‘0’ unless it is being used to signal the field for interlaced video formats or segments of a progressive segmented frame video format. At media-rates that are twice the base-rate the field flag should be set in accordance with SMPTE ST 12-1 to identify the frame pairs.

9.1.4. Binary group flags – 3 bits

Three flag bits signal the content and coding of binary group data. This standard uses some of these combinations for the coding of either ST 309 or ST 262 coded data.

The following Table 6 details the assignment of the flag bits that signal the Binary Group coding method in used.

Table 6 – Binary group flags for SMPTE ST 309 and ST 262 binary group coding

ST 262	ST 309		Binary group flag	24 and 30-fps systems		25-fps systems	
ToD clock		No clock		LTC bit	VITC bit	LTC bit	VITC bit
1	1	1	BGF2	59	75	43	55
1	1	0	BGF1	58	74	58	74
1	0	0	BGF0	43	55	27	35

The ST 262 page-line multiplex extended coding of date, rate, and additional metadata as specified in Clause 10.

The ST 309 coding of date, UTC offset, and time zone can be used for backward compatibility with legacy applications as specified in Clause 11

10 ST 262 Page-line multiplex binary group codingxxxx

10.1. ST 262 Binary group page-line multiplex

The SMPTE ST 262 page-line standard is a directory system that facilitates the self-identification of data blocks in the binary groups. This system uses a page-line identifier in binary groups 7 and 8 to identify the data in the eight binary groups.

This standard uses several page-line combinations as detailed in Table 7. The use and distribution of multiplex-1, multiplex-2, or multiplex-3 over successive timecodes should ensure a uniformly accessible of the data over time. Several timing sensitive data elements appear in each multiplex.

NOTE Odd time address values could be used with multiplex-4 and even values with multiplex-2.

Table 7 – Page-line combinations

Page	Line	Application	Description
0h, 1h, 2h	Not used for this application. Usage is defined by SMPTE RP 169 and RP 179.		
3h	Not used for this application.		
4h, 5h,	All	multiplex-1	Rate and rate-multiplier plus date
6h, 7h,	All	multiplex-2	Rate and rate-multiplier plus time zone UTC offset
8h, 9h	All	multiplex-3	Rate and rate-multiplier plus a user defined code
Ah – Eh	Not used for this standard.		
Fh	Not used for this standard. Reserved by SMPTE ST 262.		

NOTE SMPTE ST 262 does not designate any specific application for the use of pages 03h through 0Eh.

10.1.1. Page-line data structure

Conforming to the page-line directory index this application uses the three most significant bits of the "page" binary group to identify the timecode data that is multiplexed into the remaining binary group bits. Three data structures are identified as multiplex-1, multiplex-2, and multiplex-3. The assignment of the data for the three structures of multiplexed data shall be as shown in Table 5.

The mapping of data into the binary group bits is defined in Table 8. The frame count, extended frame count bits shall be coded into the least significant bit of the "page" index, binary group 8, and the full four bits of the "line" index, binary group 7. The rate-multiplier, the enumeration of the base-rate, the fractional rate-scale-factor flag and the UAC flag shall be present in binary group 5 and binary group 6 of each multiplex structure. The four remaining binary groups shall code the date in the multiplex-1 structure, time zone data in the multiplex-2 structure, and user defined data in the multiplex-3 structure. Numeric values shall be mapped with the most significant data bits towards the highest numbered binary group bits.

Table 8 – Assignment of binary group bits

<table>
<tr><th>Binary group</th><th>LTC bits</th><th>VITC bits</th><th>Multiplex-1
Pages 4 and 5</th><th>Multiplex-2
Pages 6 and 7</th><th>Multiplex-3
Pages 8 and 9</th></tr>
<tr><td rowspan="2">8
(Page)</td><td>63 – 61</td><td>79 – 77</td><td>Set = 010b</td><td>Set = 011b</td><td>Set = 100b</td></tr>
<tr><td>60</td><td>76</td><td colspan="3" rowspan="2">Ext-frame-5 to Ext-frame-1
as specified in Clause 10.1.2. (5 bits)</td></tr>
<tr><td>7
(Line)</td><td>55 – 52</td><td>69 – 66</td></tr>
<tr><td>6</td><td>47 – 44</td><td>59 – 56</td><td colspan="3">Rate-multiplier code as specified in Clause 7.2.3 (4 bits)</td></tr>
<tr><td rowspan="3">5</td><td>39 – 38</td><td>49 – 48</td><td colspan="3">Base-rate code as specified in Clause 7.2.1 (2 bits)</td></tr>
<tr><td>37</td><td>47</td><td colspan="3">Fractional rate-scale-factor flag as specified in Clause 7.2.2 (1 bit)</td></tr>
<tr><td>36</td><td>46</td><td colspan="3">UAC flag as specified in Clause 7.4 (1 bit).</td></tr>
<tr><td rowspan="2">4</td><td>31</td><td>39</td><td rowspan="6">Day-number
as specified in
Clause 10.1.6.</td><td>Reserved for future definition.</td><td rowspan="6">Application defined
as specified in
Annex B1.</td></tr>
<tr><td>30 – 28</td><td>38 – 36</td><td rowspan="2">UTC offset code
as specified in
Clause 7.3.</td></tr>
<tr><td>3</td><td>23 – 20</td><td>29 – 26</td></tr>
<tr><td>2</td><td>15 – 12</td><td>19 – 16</td><td rowspan="2">Binding code
as specified in
Clause 10.1.9</td></tr>
<tr><td rowspan="2">1</td><td>7 – 5</td><td>9 – 7</td></tr>
<tr><td>4</td><td>6</td><td>DST flag
as specified in
Clause 10.1.9.</td></tr>
</table>

10.1.2. Extended frame count

The extended frame count facilitates the coding of higher frame rate counts for multiples of the base-rate. The extended frame count is a zero-based binary count comprising five bits: Ext-frame-5 (the most significant bit) through Ext-frame-1 (the least significant bit). The assignment of these five bits is detailed in Table 8 – Assignment of binary group bits. Ext-frame-5 is coded as the least significant bit of the page index (binary group 8) and Ext-frame-4 through Ext-frame-1 are coded as the four bits of the line index (binary group 7). The extended frame identifier counts from zero to the base-rate-multiplier minus one. The count of zero shall be aligned with the rollover of the base-rate frame number.

The extended frame count shall be indicated in each multiplex structure as a part of the page-line identifier value. The extended count provides for extended resolution, precision, and accuracy.

10.1.3. Rate coding

This standard supports media at a range of both integer fractional rates as specified in Clause 7.2 as specified by a base-rate in Clause 7.2.1, a rate-scale-factor as specified in Clause 7.2.2, and a rate-multiplier as specified in Clause 7.2.3.

10.1.4. UTC-aligned count (UAC) identification page-line data structure

A UTC-aligned count is a media-index generated as specified by Clause 7.7 and this flag when set to True indicates that the media label has a mathematically precise relationship to wall-clock time and is aligned relative to the SMPTE Epoch as specified in SMPTE ST 2059-1. This flag bit shall be indicated in each page-line multiplex structure.

NOTE Data items that are expected to change from frame-to-frame are included in each multiplex. However data items such as the date that are not expected to change for long periods of time are distributed over different multiplexes. Thus it necessary to confirm the current validity by comparing prior and next timecode words.

10.1.5. Reserved flag bit

A bit in page-line multiplex-2 is reserved for future definition.

10.1.6. Date code

The date as a day-number shall be coded in page-line multiplex-1 as a 16-bit unsigned binary value. The day-number can be calculated from the Gregorian calendar date using the formulae defined in Clause 5.3.3.

10.1.7. Time zone UTC offset

A time zone is a geographical territory with an associated UTC offset that possibly includes a daylight saving offset. The UTC offset shall be indicated in page-line multiplex-2 as a 7-bit signed integer coding of the UTC offset in 15-minute increments. The UTC offset code can be calculated from the UTC offset value in signed hours and minutes or from an offset in signed integer seconds as specified in Clause 5.3.1.

10.1.8. Binding code

The user defined binding code is coded as a seven-bit binary word and provides a means of associating a timecode with another media source. This binding code might provide a link to the media source device.

NOTE A commonly requested use is to indicate which camera is the source with which the timecode is associated.

10.1.9. Standard time or daylight saving time

A DST flag bit in page-line multiplex-2 structures shall indicate whether standard time with or without a daylight saving time offset is in effect. A True value shall indicate that daylight saving time is in effect.

11 SMPTE Timecode – ST 309 Binary groups coding

11.1. ST 309 Binary group –Date and Time zone

ST 309 specifies a timecode binary groups coding for date and time zone information. A pair of binary group specifies the time zone information and the date encoding format for the remaining six binary groups.

11.1.1. Date

The date coded as six decimal digits "YY-MM-DD" format is specified in Clause 7.1.2, or as a MJD day-number as specified in Clause 7.1.1.

11.1.2. Time zone

As specified in SMPTE ST 309 the time zone is coded as the current UTC offset and DST status.

NOTE Some applications use the standard time UTC offset as a fixed label to identify a time zone whether DST is in effect or not however, ST 309 codes the actual time zone UTC offset..

12 (informative) Export of date, time and metadata for user applications

Timecodes that have been generated according to this and other standards can be a source of media date, time, and other related metadata. Otherwise, the missing data needs to be provided by the user application.

The recovery and interpretation can follow a process hierarchy with the interpretation of time being dependent on the date and the rate.

The data encoded in the binary groups might have been coded as either ST 262 page-line or the legacy ST 309 standard. As specified in Clause 9.1.4 the format of the data in the binary groups can be signaled with the binary group flags

12.1. Binary group page-line multiplex ST 262 coding

The ST 262 standard as described in Clause 10 supports a multiplex of several data items coded in the binary groups of a wide range of metadata items including:

To minimize the data recovery latency, some of the supporting metadata is coded in all three page-line multiplexes.

- Timestamps for higher rates can be a combination of time address plus a sub frame extension.
  - Can be supplemented by local time-of-day with a Standard or DST UTC offset
  - Time zone UTC offset set.
- Rate as specified in Clause 10.1.3
- Frame count extended resolution for higher rates as specified in Cause 10.1.2.
- UAC coding flag to confirm the use of this implementation.

Some metadata is not expected to change frame to frame and is included in only one of the three multiplexes.

- Date is coded as a day-number and can be converted to either a MJD day or to a calendar year, month, and day formats.
- User defined data.

- A UAC compliance flag as specified in Clause 7.4, that this standard is in effect.

The beginning-of-day to start-of-day offset can be calculated based on the rate, date, UTC offset, and DTAI.

12.2. Binary group legacy ST 309 coding

The coding of the binary groups using the ST 309 standard as described in Clause 11 supports a constrained set of metadata that can include:

- A code to signal a selection for most time zone UTC offsets.
- A flag indicates STD or DST time offsets.
- A flag to signal the date coding either as a MJD day number or as 2-digit year, month, and day values.

12.3. Timecode start-of-day

At the integer rates the timecode start-of-day can be aligned with the clock time beginning-of-day.

At the fractional rates the timecode start-of-day can be shifted from the calendar beginning-of-day. This offset can be calculated based on the rate, date, UTC offset, and DTAI with a process as described for the time address generation process as described in Clause 6.5.and Clause 6.6.

12.4. Media rate

Rate has been a long request by users. For ST 12-2 VITC the field flag can signal one or two times the base ST 12-1 rates. With ST 309 binary group coding rate is not coded and needs to be deduced from time address rollover.

To minimize latency with ST 262 the rate is coded in each multiplex. As specified in Clause 7.2 the rate can be expressed as a combination of three factors: an integer base-rate code, a fractional rate scale-factor,, and an integer rate-multiplier up to 32-times.

Annex A (Informative) Calendar days and leap seconds

A.1 Leap second introductions

Leap seconds are incorporated into the UTC timescale to maintain an approximate alignment with universal time (UT1}, which is a measure of the world's rotation. These leap second introductions are specified to occur just before the UTC end-day. For a positive leap second, UTC clocks introduce a 60th second at the end-of-day with a leap second designated "23:59:60". For a negative leap second, UTC clocks omit the second "23:59:59" at the end-of-day. .

NOTE 12. In other documents terminology for the leap second offset DTAI is denoted as and is equivalent to "TAI - UTC" or minus "UTC - TAI". The official values as published by the IERS are expressed as "UTC - TAI", w0hich are negative integer values.

NOTE 13. This standard also provides for the possibility of a negative leap second correction where the last second of the day is omitted. There have been no negative leap second corrections as of the publication data of this standard.

NOTE 14. International standards specify that the leap second is incorporated into the UTC timescale just before the end-of-day at the end of the last day of the designated month. While there is an international standard for the introduction of the leap second into the UTC timescale, there is no such international standard for the introduction into local timescales. This is the jurisdiction of the local authorities. In many locations the introduction is mandated to be at the same time point as it occurs on the UTC timescale. However, in many applications, including broadcast, private administrations shift the time of introduction to avoid the complications that might occur from a timescale shift at a critical point of daily operations. This standard specifies the leap second introduction for each individual timescale to occur just before the end-of-day local time at the end of the last day of the designated month. With the leap second correction applied at the end-of-day the time address is completely regular for the normal 24-hour period. The local UTC offset timescales are identical to the UTC timescale, just shifted earlier or later by the time offset thus treating the leap second just the same as the other 86400 seconds of the day. For time zones that have a negative offset from UTC this is a procedure that delays the leap second introduction time point.
However, for time zones with a positive offset from UTC this requires the local introduction to occur at a time point before it occurs on the UTC timescale, thus requiring sufficient advance knowledge of the upcoming change. The consequence of always effecting the leap second introduction just before the end-of-day is that media labels expressed in a clock time format each have the same count sequence, independent of the UTC offset.

NOTE 15. Some NTP time servers resolve the problem of incorporating leap seconds by slewing the frequency of the clocks over a significant period such as 20 hours. The duration of this slew period, its alignment to midnight, and its linearity is not consistent among different time servers. This practice of slewing the clock frequency is not appropriate for media applications that depend on stable and accurate timebase rates. One supplier of NTP time servers employs the technique of maintaining a linear time and incorporates the leap second just before midnight on each local timescale in a manner similar to that employed in this standard.

A.2 Leap second offset0s history

Table 9 details the historical data relating to the UTC timescale and leap second introductions.

Table 9 – DTAI history

DTAI	MJD	Day-number	UTC Calendar date	Seconds-since-UTC 1970 origin
10	40587	0	1970-01-01	0
10	41317	730	1972-01-01	63072000
11	41499	913	1972-07-01	78883200
12	41683	1098	1973-01-01	94867200
13	42048	1464	1974-01-01	126489600
14	42413	1830	1975-01-01	158112000
15	42778	2196	1976-01-01	189734400
16	43144	2563	1977-01-01	221443200
17	43509	2929	1978-01-01	253065600
18	43874	3295	1979-01-01	284688000
19	44239	3661	1980-01-01	316310400
20	44786	4209	1981-07-01	363657600
21	45151	4575	1982-07-01	395280000
22	45516	4941	1983-07-01	426902400
23	46247	5673	1985-07-01	490147200
24	47161	6588	1988-01-01	569203200
25	47892	7320	1990-01-01	632448000
26	48257	7686	1991-01-01	664070400
27	48804	8234	1992-07-01	711417600
28	49169	8600	1993-07-01	743040000
29	49534	8966	1994-07-01	774662400
30	50083	9516	1996-01-01	822182400
31	50630	10064	1997-07-01	869529600
32	51179	10614	1999-01-01	917049600
33	53736	13172	2006-01-01	1138060800
34	54832	14269	2009-01-01	1232841600
35	56109	15547	2012-07-01	1343260800
36	57204	16643	2015-07-01	1437955200
37	57754	17194	2017-01-01	1485561600

A.2.1 DTAI table maintenance

The DTAI Table 9 is valid until the expiry date shown in the last row. This table can be updated when and as announced by the IERS. Updated data in “Bulletin C” can be downloaded from the IERS Web site: https://www.iers.org/IERS/EN/Publications/Bulletins/bulletins.html.

1. Calculate new “day-number” value taking the prior value adding the number of days since prior leap second introduction.

2. Calculate new “Seconds since origin” values taking the prior value plus number of days times 86400 plus one second for a positive leap second or minus one for a negative leap second.
3. The next-to-last row holds most recent Leap second entry and the DTAI value at the expiry date is the same as the DTAI value in that next to last row
4. Bulletin C is mailed every six months, either to announce a time step in UTC, or to confirm that there will be no time step at the next possible date.

A.2.2 Month and day numbering

Table 10 lists the months as a text name and as a month number. For both common years and leap years the table lists the days to the first and last day of each month.

Table 10 – Months and days

Month		Days in month and days to start or end of month					
Name	Number [MM]	Common year			Leap year		
		Days in month	Start day	End day	Days in month	Start day	End day
January	01	31	000	030	31	000	030
February	02	28	031	058	29	031	059
March	03	31	059	089	31	060	090
April	04	30	090	109	30	091	120
May	05	31	120	150	31	121	151
June	06	30	151	180	30	152	181
July	07	31	181	211	31	182	212
August	08	31	212	242	31	213	243
September	09	30	243	272	30	244	273
October	10	31	273	303	31	274	304
November	11	30	304	333	30	305	334
December	12	31	334	364	31	335	365

NOTE Days of the year in this table are numbered from zero to 364 for common years or to 365 for leap years to simplify software calculations. Calendar, ordinal day numbers are one-based from one to 365 or 366.

Annex B (informative) User applications

B.1 Application defined data

Some application defined data might be coded in page-line multiplex-3 as 16-bit binary data words consisting of a 4-bit identifier and a 12-bit data word. The application and specification are user defined and out-of-scope for this standard.

The identifier code (0h) indicates that there is no intended meaning of the related data.

NOTE This can be used to signal that the user defined data mignt no longer valid with out the requirement to actually delete the date entriy.

B.2 Time zone identification (01h)

The time zone is indicated by a 12-bit code.

Customary practices for fixing this value will evolve over time; these implementation practices are outside the scope of this document. Please see informative annex ….

A list of timezone Index and Identifiers is listed in the file “WD-ST12-4-Aux-Timezone-Identifiers-2023-10-04.xlsx”.

B.3 Reference clock time source (02h)

The source of the clock time reference is SMPTE profile SM TLV as defined in ST 2059-2.

GNSS Global Navigation Satellite Systems such as: GPS, Galileo, and GLONASS.

B.4 Reference clock time accuracy (03h)

The accuracy of the PTP reference clock time is optional information.

A list of the IEEE 1588 PTP reference clock time accuracy is listed in the file “WD-ST12-4-Aux-IEEE 1588 Table 5.docx”.

B.5 Other application (for future definition)

Other codes from (04h) to (FFh) are undefined and are reserved for future specification.

Bibliography (Informative)

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