SMPTE REGISTERED DISCLOSURE DOCUMENT

SMPTE Timecode Extensions – Relationships to Higher Rates and Date-Time

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Introduction

This clause is entirely informative and does not form an integral part of this Registered Disclosure Document.

Legacy wired infrastructure transition to IP network

The transition from SDI to IP network-based ecosystems combined with integer, fractional and higher media-rates presents a requirement for media labeling with a precise, symetric mathematical relationship to clock time. The reference clock time is subject to local adjustments for time zones, seasonal daylight saving time shifts and leap second corrections.

Centralized master reference sync generators with a wired distribution tree are to be supplanted or replaced by a global clock time distribution and local reference signal generation. These master generators can synchronously generate signals for multiple audio and video media-rates. SMPTE timecodes have commonly been used as the clock time reference within a facility and they will need to interoperate with global clock time sources. Fractional media-rates present a particular problem since their representation of time shifts throughout a calendar day and the alignment to midnight or any other time point changes. Maintaining synchronization and timing precision across multiple references requires the ability to precisely and symetrically convert timecodes at different rates to and from clock time,

Synchronization in an IP network based on clock time

PTP is typically the most convenient and appropriate method for the transport of clock time within most production environments, however events that occur over dispersed and remote locations, (e.g. sporting events such as skiing, golf, car racing and sailing) might require other means of acquiring accurate date and clock time.

The typical workplace for both equipment and people operates with a perceived relationship to local calendar date and clock time.

With a 43 plus year history, SMPTE timecode equipment, applications, and peta bytes in media archives there is a requirement to maintain support for the standard. Established working practices and interoperability with media at different rates, in particular those involving fractional rates, requires the symetric conversion between media timecode labels at different rates.

The current SMPTE ST 12-1 is nominally constrained to the video frame rates of 24, 25, 30, 24/1.001 and 30/1.001 Hz. Video at twice these rates can be accommodated for progressive video formats. Higher media-rates such as 100, 120 and 120/1.001 Hz are already standardized and higher integer multiples are anticipated in the future. This RDD specifies an extension to the SMPTE timecode to accomodate integer multiples of the legacy rates in a manner similar to SMPTE ST 12-3 but without deprecating the flag bit functions.

The binary groups with a standard multiplex protocol as defined in SMPTE ST 262 enables the higher rate labeling and encoding of date, rate, leap second, time zone UTC offset and other metadata.

Integer and fractional rate media signals

With media signals aligned relative to the SMPTE epoch media signals that are at integer rates will be aligned at midnight of each day and furthermore to each integer second. As a result the length-of-day in media units will be an integer number of media units in a 24-hour day, whether this is or is not a leap second introduction day. It is noted that although 25 Hz PAL video signals are at an integer media-rate, when the color field sequence is taken into consideration the color frame block has a non-integer 6.25 Hz rate.

For media signals that are at fractional rates, such as 30/1.001 Hz, these signals will only rarely be aligned at midnight or even at integer seconds. These fractional rates result in a nominal 24-hour day where the alignment of the media units have a varying alignment to midnight on a day-to-day basis and the length-of-day in media units will be an alternating integer number of media units starting in successive day periods.

Integer count media label

This RDD sets out procedures to label media units with a zero-based integer media count that has a symmetric relationship to a calendar date and time. This process takes into consideration timescale shifts such as time zone UTC offsets, leap second introductions, and daylight saving time shifts.

For media that has been aligned relative to the SMPTE epoch as specified in SMPTE ST 2059-1 there is a defined mathematical relationship between the media timescales and the clock timescales. This is true for integer media-rates and although the relationship is slightly more complex this is also true for the fractional (n/1.001) media-rates. This alignment to the SMPTE epoch enables SMPTE timecodes to be generated with a symmetric, mathematically precise correspondence.

Since the precise time point of the first media unit is known the precise time of any media unit within the day can be calculated and the reverse calculation to date and clock time can also be precisely calculated from the date and media-index values.

Timecode extensions

Legacy systems define a correlation between the video signal's color sequence and time address values. Thus there is the concept of a two unit media block for analog NTSC video or a four unit media block for analog PAL video. For 30/1.001 Hz timecode with drop frame time address labelling the drop frame algorithm makes corrections to the time address in increments of two media unit counts. To minimize anomalies in converting between the new media-index label and legacy timecode time address values it is desirable to maintain blocks of two media unit counts when labeling video media in these systems. The legacy term "color frame" now more correctly relates to the concept of an alignment in "even/odd frame" media unit pairs.

Summary

1. There is no change to the standard SMPTE ST 12-1 time address other than allowing the last minute of the day to count beyond 59 seconds to 60 or 61 in order to accommodate the short-day and long-day UCC counts and the incorporation of a leap second. This change from conventional implementations is already envisaged in SMPTE ST 12-1 Annex A.2.
2. There are no changes to the functions of the six flag bits of the SMPTE ST 12-1 timecode.
3. Additional data and metadata can be coded in the binary groups using SMPTE ST 262 Page-Line protocol.
4. Optionally SMPTE ST 309 can be used to code the date, UTC offset and DST for compatibility with existing applications. This will code some of the additional data and metadata but will not provide all of the new features.
5. New extended features

- The existing 24, 24/1.001, 25, 30, and 30/1.001 count rates are extended to include integer multiples up to 32 times the existing rates. This is similar to SMPTE ST 12-3 but without deprecating the functions of the ST 12-1 flag bits.
- The binary groups can code the following:
  - The media unit (frame) count rate.
  - The UTC compensated count (UCC) mode status.
  - The local time UTC offset.
  - The heritage flag that can signal an original timecode label that should not be modified in the production process.
  - The local time DST shift.
  - The date is a day-number expressed as a zero based count from the calendar day 1972-01-01.
  - Three binary group multiplex structures can code the additional data and metadata.
  - Critical fast changing data is coded in each multiplex so that it is there on every frame.
  - Day-number, UTC offset and DST are generally static and share multiplex over sequential frames.
  - Seven bits in the second multiplex enable a user defined binding to an external device or process.
  - Sixteen bits in a third multiplex can be used for user defined metadata.

The end result is a compatible extension of SMPTE ST 12-1 LTC or VITC and ST 12-2 ATC that have a symmetric, mathematically precise relationship to a precision clock time source and that supports extended count rates up to 960 frames per second.

Legacy equipment, applications and standards can transport and store the enhanced timecode without the requirement for modifications. Naturally they will need updating to utilize new capabilities but this is only required at the end points.

1 Scope

This RDD is for media at the integer or fractional base-rates of 24, 24/1.001, 25, 30, 30/1.001 Hz and their integer multiples. This RDD describes a UTC Compensated Count (UCC) algorithm that defines the generation of media counts with a symmetric and mathematically precise relationship to the local calendar date and time. From the calendar date and UTC offset this UCC algorithm, determines the phase offset from midnight to the start of the first media block of the timecode day and the media counts throughout the day. The media count converted to a SMPTE ST 12-1 time address inherits the precision relationship to the local time-of-day and also to media at other rates. For rates at integer multiples of the base-rates the time address frame count extensions can be coded in the binary groups along with date, UTC offset, DTAI, user data and other operational metadata. The extra media counts for 30 Hz related fractional rates that exceed the normal 24 hour time address labels and labels for leap seconds can be coded in extended labels at the end-of-day. The RDD supports coding of data into the binary groups using the SMPTE ST 262 page-line multiplex or optionally the SMPTE ST 309 protocols.

2 Conformance Notation

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 clause 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 sui, 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; s shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this RDD. At the time-of-publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this RDD are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 12-1:2014, Time and Control Code

SMPTE ST 262:1995, Binary Groups of Time and Control Codes – Storage and Transmission of Data

SMPTE ST 309:2012, Transmission of Date and Time Zone Information in Binary Groups of Time and Control Code

SMPTE ST 318:2015, Synchronization of 59.94- or 50-Hz Related Video and Audio Systems in Analog and Digital Areas — Reference Signals

SMPTE ST 2059-1:2015, Generation and Alignment of Interface Signals to the SMPTE epoch

SMPTE ST 2059-2:2015, SMPTE Profile for Use of IE-1588-2008 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

Institute of Electrical and Electronics Engineers (IEEE) IEEE 1588-2008, Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

Internet Engineering Task Force (IETF) RFC 5905 Network Time Protocol Version 4: Protocol and Algorithms Specification, June 2010, Available: https://tools.ietf.org/html/rfc5905

4 Terms and Definitions

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

4.1 Acronyms and symbols

The following acronyms and their definitions apply.

4.1.1 § clause

4.1.2 BCD binary coded decimal

4.1.3 GNSS Global Navigation Satellite Systems

4.1.3.1 GPS Global Positioning System (US)

4.1.3.2 Galileo (European Union)

4.1.3.3 GLONASS (Russia)

4.1.3.4 BeiDou (China)

4.1.3.5 IRNSS (India)

4.1.4 LoD length-of-day

4.1.4.1 LoDmu length-of-day in media units

4.1.4.2 LoDss length-of-day in seconds

4.1.5 NTP Network time protocol

4.1.6 PTP Precision time protocol

4.1.7 SoD midnight start-of-day

4.1.7.1 SoDss timecode start-of-day offset in seconds

4.1.7.2 SoDmu timecode start-of-day offset in media units

4.1.8 TAI International Atomic Time

4.1.9 ToD time-of-day

4.1.9.1 ToDss time-of-day in seconds

4.1.10 UCC UTC compensated count

4.1.11 UTC Universal Coordinated Time

4.1.12 VANC vertical ancillary

4.2 Mathematical functions

The following mathematical functions and their definitions apply.

4.2.1
absolute value function;
ABS(x)

arithmetic operation that returns the absolute value of the parameter ‘x’

4.2.2
less than;
a < b

logical comparison operation that returns ‘True’ if the value of the parameter ‘a’ is less than the value of parameter ‘b’ and otherwise returns ‘False’

4.2.3
greater than;
a > b

logical comparison operation that returns ‘True’ if the value of the parameter ‘a’ is greater than the value of parameter ‘b’ and otherwise returns ‘False’

4.2.4
greater than or equal to;
a ≥ b

logical comparison operation that returns ‘True’ if the value of the parameter ‘a’ is greater than or equal to the value of parameter ‘b’ and otherwise returns ‘False

4.2.5
less than or equal to;
a ≤ b

logical comparison operation that returns ‘True’ if the value of the parameter ‘a’ is less than or equal to the value of parameter ‘b’ and otherwise returns ‘False’

4.2.6
assignment;
a = b

mathematical or logical operation that’s assigns the value of parameter ‘b’ to the parameter ‘a’

4.2.7
equal to (comparative);
a == b

logical comparison operation that returns ‘True’ if the value of the parameter ‘a’ is equal to the value of parameter ‘b’ and otherwise returns ‘False’

4.2.8
modulus operator;
a % b;
MOD(a, b)

mathematical operation that divides the operand ‘a’ by the operand ‘b’ and returns the remainder

The mathematical operation is equivalent to the following formulae:

$$MOD(a,b) = a \% b = a - b \times FLOOR(a / b)$$

4.2.9
ceiling function;
least integer function;
CEIL(x)

step function of ‘x’ which is the least integer greater than or equal to ‘x’

The mathematical operation that rounds the element ‘x’ to the nearest integer towards positive infinity

4.2.10
floor function;
greatest integer function;
FLOOR(x)

step function of ‘x’ which is the greatest integer less than or equal to ‘x’

The mathematical operation that rounds the element ‘x’ to the nearest integer towards negative infinity

4.2.11
round function;
ROUND(x)

step function of ‘x’ that rounds the element ‘x’ to the nearest integer

Since the definition is ambiguous for half-integers, the additional rule that half-integers are always rounded to even numbers is usually added in order to avoid statistical biasing.

Note to entry: The round function is also called NINT or the nearest integer function.

4.2.12 SIGN(x)

mathematical function that returns “one” when the element ‘x’ is zero or a positive number and returns “minus one”

Note to entry: Since some implementations of this function might return different results if the element ‘x’ is zero.

4.3 General terms and definitions

4.3.1
Boolean

binary variable, having two possible values called “True” and “False”

When converting other value types to Boolean; values that equate to zero, null, void or empty are considered to equate to ‘False’ and all other values are considered to equate to ‘True’.

4.3.1.1
False

Boolean truth value representing a negated or not valid condition

4.3.1.2
True

Boolean truth value representing a valid condition

4.3.2
calendar day

day in the Gregorian calendar for the applicable local time zone

4.3.3
DST
daylight saving time

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

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.

Note: The DST offset is typically one hour, however in a few regions of the world a different DST offset bias such as 15 or 30 minutes is employed. Historically other DST offsets have been used, for example a DST offset of two hours was used in the UK during WWII.

4.3.4
day-number

zero based count of calendar days from the day-zero

4.3.4.1
day-zero

calendar day 1972-01-01, local time UTC offset as adopted for use by the application

4.3.5 DTAI

value of the leap second offset as the difference between TAI and UTC

DTAI = TAI – UTC can be regarded as a correction to be added to UTC to obtain TAI.

SOURCE: *ITU-R TF.460-6*

4.3.6
Julian Day Number
JD

integer day count assigned to a whole solar day starting from noon Universal time (UT)

The JD zero is assigned to the day starting at noon on Monday, January 1, 4713 BC, proleptic Julian calendar (November 24, 4714 BC, in the proleptic Gregorian calendar). The Julian date (JD) of any instant is the Julian day number plus the fraction of a day since the preceding noon in Universal Time.

4.3.7
media unit

video frame

4.3.8
media block

even-odd numbered pair of media units for 24, 24/1.001, 30 and 30/1.001 Hz related media or four media units for 25 Hz analog media with a defined color frame sequence

4.3.9
media-index

zero based count of media units from a defined origin

4.3.10
midnight
end-of-day midnight
start-of-day midnight

transition time from one day to the next and the moment when the date changes.

4.3.11
Modified Julian Day
MJD

integer day count assigned to a whole lunar day starting from midnight to midnight

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.

4.3.12
phase-index

measure of media phase alignment relative to a seconds’ time point

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

4.3.13
resolution, precision and accuracy

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

4.3.13.1
resolution

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.

4.3.13.2
precision

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.

4.3.13.3
accuracy

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.

4.3.14
SMPTE timecode

generic reference to SMPTE Time and Control Codes as defined in SMPTE ST 12-1, ST 12-2 or ST 12-3

4.3.15
time zone

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

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

4.3.16
time point

mark attributed to an instant by means of a specified timescale

4.3.17
time instant;
instant

time point on the time axis.

4.3.18
timecode day

timecode associated with the values from 00:00:00:00 up until the roll-over to 00:00:00:00 of the next day

For a calendar day and media at integer rates the timecode day can be associated with a calendar however for media at fractional rates the start and end of the timecode dayare is expected to be shifted slightly and this shift will change from day-to-day and with the UTC offset.

4.3.19
timing reference point;
timing reference datum

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

Note to entry: 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.

5 Executive summary (informative)

5.1 General

For media that has been aligned relative to the SMPTE epoch as specified in SMPTE ST 2059-1 there is a precise mathematical relationship between the media timescales and the TAI or UTC timescales. This enables SMPTE timecodes to be generated with a symmetric, mathematically precise correspondence to clock time.

This RDD uses date, time and related metadata from a clock time source or the user application to manage the creation of a SMPTE timecode and the coding of sufficient metadata to recover the date and time. The process of creating the timecode involves four basic steps:

1. Conversion of the reference date, time and related metadata to the form of a day-number and count of seconds from midnight is specified in Annex A through Annex E. The timestamp reference might be in the form of a calendar date and time-of-day or in the form of a seconds count such as a PTP timestamp.
2. Generation of a media-index as an integer count of media units from the day-number, time-of-day and related metadata is specified in § 6.
3. Formatting the media-index, day-number and metadata to data elements suitable for mapping into a timecode time address and binary groups is specified in § 6.
4. Mapping the time data elements into a SMPTE ST 12-1 timecode time address is specified in § 7 through § 9. Mapping of other data and metadata elements into the SMPTE ST 12-1 timecode binary groups is specified in § 8 and § 9.

Additional topics related to handling SMPTE timecodes and applications are covered in § 10 and § 11.

5.2 Date and time sources

The source of accurate date, time and related metadata can be PTP, GPS, NTP or the application itself. A LTC, VITC or ATC source that was generated according to this RDD could also be used. The generation of a precise timecode from date and clock time depends on the application in consort with date, time and related metadata sources to derive the following data elements:

- Day-number as a zero based integer count od days from the local calendar day 1972-01-01.
- Local time-of-day, formatted as a zero based count of seconds from the local time midnight.
- Local time offset from UTC, as a signed value in hours and minutes in 15-minute increments.
- Time-of-day count origin, as the timecode start-of-day, or optionally as user defined.
- Media-rate, formatted as a base-rate (24, 25, or 30 Hz), a scale factor (1/1 or 1/1.001), and an integer rate-multiplier (selected multipliers in the range from: one to 32).
- DTAI, as an integer value of the leap second offset for the calendar day.
- Media format, as progressive video, interlaced video first field, interlaced video second field, or undefined.
- Status flags: (True/False)
  - Date and clock time is derived from an accurate source.
  - Media is time aligned relative to the SMPTE epoch.

- Local daylight saving time (DST) is in effect.
- A leap second incorporation is scheduled for the current calendar day.
- The current second is a leap second.
- Timecode is an original or heritage timecode intended to be preserved through the production process.

The generation of precise timecodes is based on the presumption that the media is generated in alignment relative to the SMPTE epoch as defined by SMPTE ST 2059-1 and the accurate time clock reference is consistent with this alignment. The process uses the calendar day 1972-01-01 as an origin for a day-number count.

The process of media count generation can be referenced to different sources of calendar date and clock time as specified in § 6 and Annex A through Annex E.

5.3 Media-index and metadata generation

Media essences at integer media-rates have integer numbers of media units in a 24-hour calendar day. For media aligned to the SMPTE epoch time point according to SMPTE ST 2059-1, the first media block of the day will be aligned at midnight and also a media unit will be aligned to each second throughout the day.

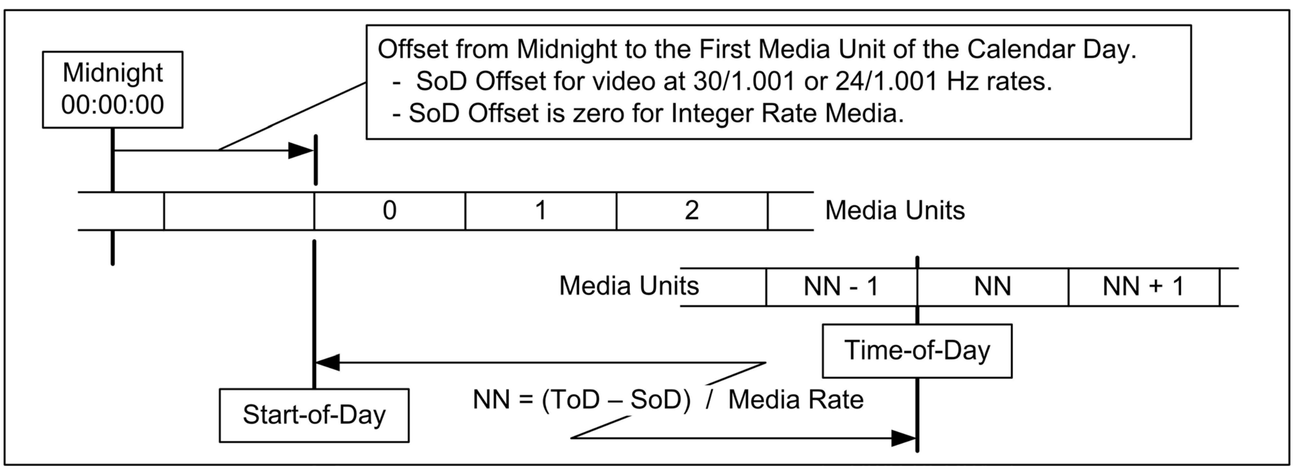

Figure 1 – Alignment offset from midnight to first media block

Media essence at fractional media-rates does not have an integer number of media units in a 24-hour day. For media aligned to the SMPTE epoch time point according to SMPTE ST 2059-1, the phase alignment of the calendar day midnight to the first media block has an offset at the start of each calendar day. This phase alignment offset varies from day-to-day and also with the local time UTC offset. The midnight to first media block phase alignment offset is shown in Figure 1 above. The phase alignments are in discrete steps labeled with integer phase-index numbers,which have a nominal range from zero to 1000.

The resulting media-index can have a symmetric, mathematically precise relationship to date and clock time.

Note: The media-index is formally defined as a zero-based count of media units in § 6.4.

5.4 Date, time and metadata formatting

The integer day-number and media-index counts are formatted as discrete YYYY. MM, DD, hh, mm, ss, ff, ee date-time elements plus related metadata and flags as specified in § 7.2.

The discrete date-time elements as a compound element representation of the integer media-index maintains the precise mathematical relationship to clock time.

5.5 Mapping into SMPTE timecodes

The date and time elements and related metadata are mapped into the time address of SMPTE timecodes is specified in § 7. The date, extended frame counts, media-rate, time zone UTC offsets plus flags for DST, SMPTE epoch alignment, UCC count, accurate date-time clock reference and heritage status can be multiplexed into the binary groups according to SMPTE ST 262 as detailed in § 8.

The resulting SMPTE timecodes have a symmetric, mathematically precise relationship to clock time and the binary groups include sufficient data to support a precise conversion to local calendar date and clock time.

Alternately the date, time zone UTC offsets and DST flag can be mapped into the binary groups according to SMPTE ST 309 as detailed in § 9.

6 Generation of a media-index related to a calendar day

6.1 Date and time data sources

The principal data source is the clock timestamp, which is used to align and set the media-index counter. The clock timestamp represents a time point that can be presented in different measures of date and clock time.

There are many methods of acquiring a clock timestamp including a wired network such as the Ethernet, a GNSS receiver, a timecode, or a radio broadcast. Some of these methods are:

- IEEE 1588-2008 Precision time protocol (PTP) as specified in Annex A.
- Global navigation satellite systems (GNSS) as specified in Annex B.
- NTPv4 Network Time Protocol as specified in § Annex C.
- SMPTE ST 12-x suite of timecodes as specified in Annex D.
- Generic date and time-of-day as specified in Annex E.

The timestamp is expressed as a day-number, a UTC offset and a time-of-day according to the time source used and as detailed in Annex A through Annex E and detailed in Table 1. The application that uses this RDD shall be responsible for providing any data or metadata that is not available from the clock timestamp sources.

Table 1 – Data parameters from date-time and metadata sources

Parameter	Remarks	Date and time sources				
		PTP Annex A	**GPS Annex B**	**NTP Annex C**	**Timecode Annex D**	**YMDhms Annex E**
Day-number**	Count of days	§ A.5	§ B.3	§ C.3	§ D.4	§ E.4, § E.5
Time-of-day **	Count of seconds (ToDss)	§ A.4	§ B.4	§ C.4	§ D.5	§ E.6
Time metadata	UTC offset (±hh:mm)	§ A.2			§ D.3	§ E.3
	Daylight saving flag (DST)	§ A.2			§ D.1	§ E.1
	DTAI	§ A.2	§ B.1.1		§ D.1	§ E.1
** Note: The timestamp data source might report the day-number and time-of-day related to UTC or an UTC offset local date and time.						

6.2 Day-number, time-of-day and related metadata timestamp parameters

To calculate a media-index related to local time this RDD uses the date-time data as a day-number and the local time-of-day, *local time* UTC offset, DTAI and media-rate.

The date, time, related metadata and other data gathered from the various date and time sources is summarized in the following clauses. The data and metadata not provided by these sources needs to be provided by the application. The count origin is specified in § 6.6 and the count rate is specified in § 6.7.

Based on the date and clock time source as specified in § 6.1, the media-index is determined as specified in § 6.8 through § 6.11.

Note: When the time-of-day (ToDss) is a value before the start-of-day in seconds (SoDss) as determined in § 6.11 this indicates that this is a time in the prior day-number, The day-number might need decrementing and the calculations repeated.

Calendar dates shall be based on the Gregorian calendar. The day-number shall be the zero-based number of days since the day-zero time point, 1972-01-01T00:00:00±hh:mm (UTC) on the local UTC offset timescale. The day-number is used to calculate the number of media unit counts in the day, LoDmu, as detailed in § 6.8.1 or § 6.10.1 and the timecode start-of-day alignment phase-index offset for a UTC time midnight as detailed in. § 6.10.2.

The clock time-of-day, which can be input in any combination of hours, minutes, seconds and sub-seconds . The *local time,* UTC offset is a value in signed hours and minutes.

Since leap second introductions do not follow a regular pattern the DTAI value could be input from the date and clock time source or determined based on the date in conjunction with a look-up such as Table 12 in Annex F, § F.2.

6.3 Calendar day length

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,

For each leap second, the Annex F, Table 12 “DTAI history” lists the day-numbers of the days that begin a period with a changed DTAI value. These are the days that begin just after the incorporation of a leap second. The day-number should be tested with the procedure IsLeapSecondDay(day-number) as specified in Annex H, § H.1.5 to determine if a leap second is incorporated at the end of a day-number and thus determine the length in seconds for the calendar day.

6.4 Media-index count

The media-index shall be a zero-based count of media units (for example video frames). For media at integer rates the timecode start-of-day origin can be at midnight, however for media at fractional rates the timecode start-of-day origin will vary from day-to-day and although close to midnight will rarely be precisely at midnight. User applications that simply need a label to facilitate referencing media positions without a symmetric, mathematically precise relationship to precision clock time may choose a user designated count origin.

6.5 UTC compensated count (UCC)

This RDD defines a UCC media-index that has a symmetric, mathematically precise relationship to clock time.

For a UCC the media shall have been generated with an alignment relative to the SMPTE epoch. For media at integer rates the media will be aligned to each second time point. For media at the fractional rates the media aligned at the SMPTE epoch time point is aligned every 1001 seconds after that. The alignment relative to the other 1000 seconds follows a defined sequence of offsets returning to in alignment on second 1001.

For media at integer rates there is a constant media-index count range for each calendar day UTC offset. For media at fractional rates the count range follows a defined sequence of short-days and long-days over a nominal period of 1001 days. On days when a leap second is incorporated the count range sequence is adjusted accordingly.

The UCC algorithms determine the media alignment relative to midnight based on the day-number, UTC offset, DTAI, and the media-rate. The media-index can be calculated for any time point within the day.

6.6 Media-index count origin

The media-index count origin should be related to the calendar day midnight origin, however a different user designated origin may be defined. For a user designated origin the procedures may be used but the results might not have a defined relationship to clock time.

6.7 Media-rates

The media-index typically has a one-to-one relationship to the media units however the application may generate media-index and timecodes at other rates. This RDD supports rates based on the SMPTE ST 12-1 count rates of 24, 25, and 30 frames per second. The media-rate is expressed by the base-rate as defined in § 8.4, the rate-scale-factor as defined in § 8.5 and the rate-multiplier as defined in § 8.6.

While the media-index is an integer count the media may be at an integer rate or a fractional rate The media count should reflect the actual rate of the media.

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.

6.8 Integer rate video media-index

Media at integer media-rates have an integer number of media units in a 24-hour calendar day and for media aligned to the SMPTE epoch according to SMPTE ST 2059-1 the first media block of the day will be aligned relative to midnight and also video frames will be aligned to each second throughout the day. Thus the alignment phase-index shall be equal to zero for integer rate video.

Note: For color framed 25 Hz analog video the media block rate is 6.25 Hz and thus the media blocks will only be aligned every four seconds and aligned to a midnight every four days.

6.8.1 Length-of-day in media units (LoDmu)

The media-index length-of-day in media units for integer media-rates shall be a constant value for common days and changes for days with the incorporation of a leap second.

LoDmu = day-length x media-rate
Where: day-length is the length-of-day in seconds as specified in § 6.8.1.
media-rate is the value in Hz (integer values), as specified in § 6.7.

6.9 Fractional rate video media-index

Video media at fractional media-rates does not have an integer number of media units in a 24-hour day. The phase alignment of the first media block to the calendar day midnight varies from day-to-day, the local time UTC offset and DTAI. These phase offsets are in quantum steps designated by a phase-index number.

The media-index value is calculated based on the day-number, the local time UTC offset, the time-of-day and the media-rate. The method accommodates leap second incorporations to the clock timescale.

6.10 Daylight saving time offset

In this RDD the daylight saving 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”.

UTC offset(DST) = UTC offset (STD) + 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.

6.10.1 Length-of-day in media units (LoDmu)

For media at the fractional rates, the day shall be designated as a short-day or a long-day and a corresponding number of media unit counts in the day.

The procedure in § 6.10.1.1 calculates the length-of-day in media units (LoDmu), and the long-day / short-day designation. These calculations shall determine the LoDmu for media at the base-rate and for rates that are an integer multiple of the base-rate the LoDmu values shall be multiplied by that multiple.

Note: It is important that these calculations use the base-rate so that at the higher media-rates, the media-index zero start is at the same time instant for all rate family members.

6.10.1.1 Calculation of LoDmu and Short-day / Long-day designation

```
Procedure()
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 or long-day = True                 ;// Length-of-day designation
```

Note 1: Parameter constants “PhIdxLD(Leap second day)”, “PhIdxLD(Common day}”, LoDmu(long-day) and LoDmu(short-day) are defined in Table 2.

Note 2: Parameter “LeapSecondDay” is calculated with the procedure IsLeapSecondDay() as detailed in § F.1.5, and parameters “PositiveLeapSecond” and “NegativeLeapSecond” are calculated in procedure IsLeapSecond() as detailed in § F.1.4.

6.10.2 Media-index zero, Offset from midnight

For fractional media-rates the designated first media unit (media-index “zero”) has a phase offset from the calendar day midnight. This phase offset expressed as a phase-index number varies from day-to-day and with the local time UTC offset. These phase-index numbers can be converted into absolute measures of media units or time units.

6.10.2.1 Timecode start-of-day phase-index offset from UTC midnight

For fractional rate media aligned relative to the SMPTE epoch, the media unit "zero" alignment SoDPhIdx{} relative to the midnight UTC shall be as determined by the following formula. The phase-index *SoDPhIdx*(UTC) is a constant value for a day-number, DTAI and media base-rate.

SoDPhIdx(UTC) = (PhIdxO72 + ((DTAI – 10) x PhFss) + (day-number x PhFDD)) % 1001
Where: PhIdxO72 is the phase-index at 1972-01-01T00:00:00Z (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 2.

Table 2 – Constants for video at 30/1.001 and 24/1.001 Hz rates

	Video system		Units
Fractional rate	**30/1.001**	**24/1.001**	**Hz**
Base-rate (integer)	30	24	Hz
Timecode day – NDF (base-rate)	2592000	2073600	Media unit
Timecode day – DF (fractional rate)	2589408	2071536	Media unit
UCC Correction – short-day	-2	-8	Media unit
UCC Correction – long-day	-4	-6	Media unit
UCC LoD: short-day	2589410	2071530	Media unit
UCC LoD: long-day	2589412	2071528	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 1972-01-01T00:00:00Z (UTC)	15	12	Phase-Index

6.10.2.2 Timecode start-of-day phase-index offset shift for UTC offset midnight

Media-index zero alignment relative to midnight local time shall be determined by the following formulae. 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.

SoDPhIdx_LocalOffset = TzSign
x ((ABS(Tzhh) x (1001 – PhFhh)) % 1001)
+ ABS(Tzmm) x (1001 – PhFmm)) % 1001))
SoDPhIdx(UTC-Offset) = SoDPhIdx(UTC) + SoDPhIdx_LocalOffset
Where: SoDPhIdx(UTC) is the timecode start-of-day phase-index on the UTC 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
SoDPhIdx(UTC-Offset) is the timecode start-of-day phase-index on the UTC offset timescale

The media SoD phase alignment expressed in media units (SoDmu) shall be as determined by the following formula.

SoDmu = SoDPhIdx() x media-block-size / 1001
Where: SoDPhIdx() is the timecode start-of-day phase-index
media-block-size is the number of media units in an alignment block.

The media SoD phase alignment expressed in seconds (SoDss) is determined by the following formula.:

SoDss = SoDPhIdx() x media-block-size / (base-rate x 1000)
Where: base-rate is the integer count-modulus.

6.11 Media-index value at a ToD

For fractional rate media the start or the end of the timecode day are not expected to precisely match the local day midnights.

Calculate the time points for the first and last media units of the timecode day. The timecode day starts at the time point SoDss for the day-number to the timecode end-of- day time point LoDss plus SoDss which is also the SoDss for the next day. The LoDss is calculated as part of the procedure “IsLeapSecondDay()” as specified in Annex H, § H.1.5.

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 the revised day-number.

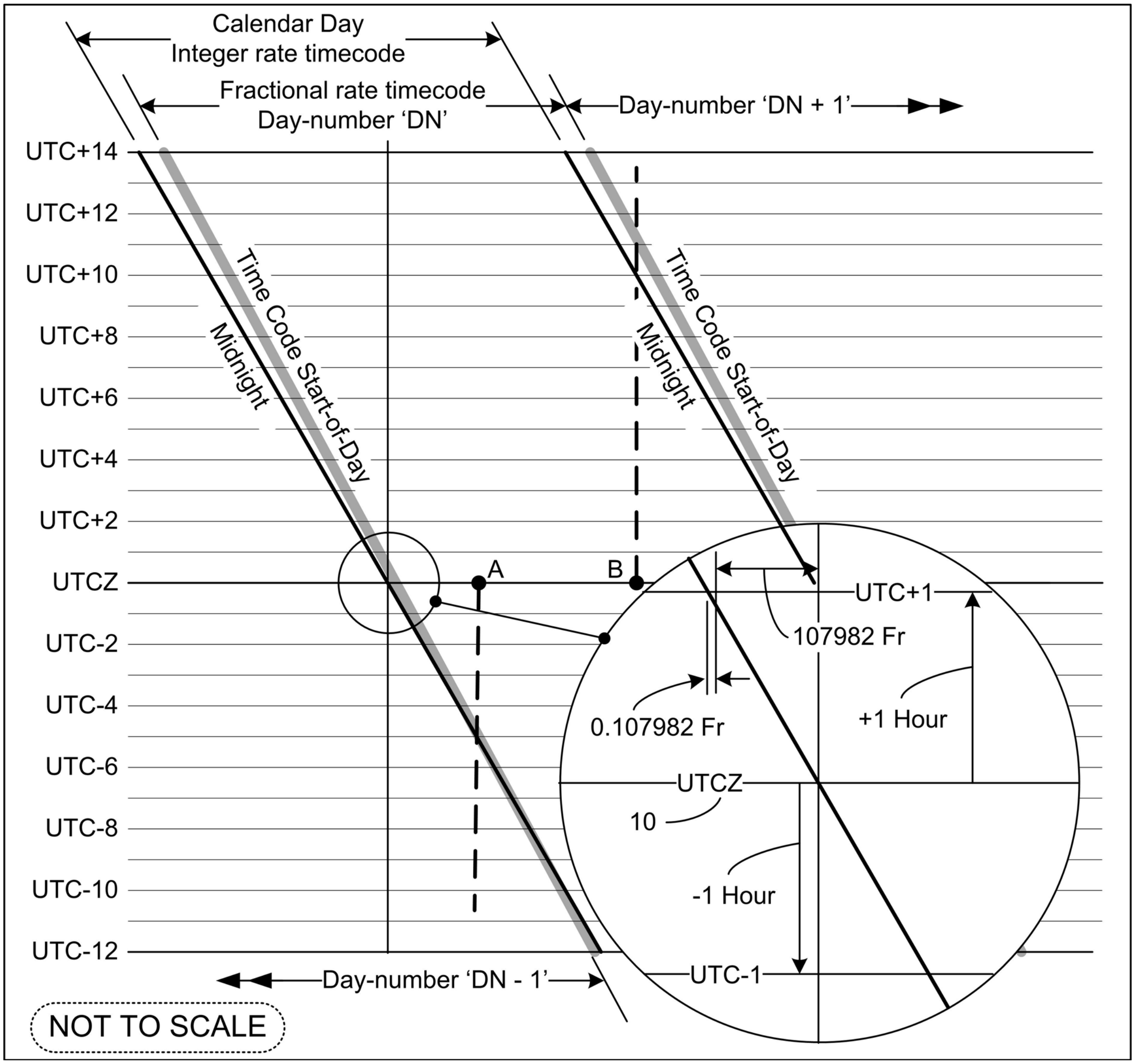

Figure 2 – Range of timecode day shifts for local times and UTC offsets

The local time clock value might be either very close to a media timing reference datum (media unit boundary) or else it is within the "main" time period of the media unit. The following procedure, which allows for normal timing tolerances, shall 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.

6.12 Media-index related metadata

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.

6.12.1 Designation of the count origin and range

The count origin might have been related to the local time midnight or a user designated time point.

For media at fractional rates the count range for a day depends on whether the day is designated as a short-day or a long-day. For integer rates the normal count range for a day is constant and is designated as a short-day. In addition a leap second introduction also affects the count range. The count range is determined in § 6.8.1 for integer rates or § 6.10.1 for fractional rates.

6.12.2 SMPTE ST 2059-1 conformance flag

Fixed rate media, including media at integer multiples of a base-rate, that has been generated with an alignment relative to the SMPTE epoch as specified in SMPTE ST 2059-1 shall be designated as ST 2059-1 conformant.

6.12.3 Reference timebase accuracy flag

The clock time accuracy designation should be as provided by the timestamp source or the application.

6.12.4 Date format

The date may be expressed as a day-number, a Gregorian calendar date, or a Modified Julian date depending on the binary group formatting method.

6.12.5 Local time UTC offset

The local time UTC offset can be a signed value in hours and minutes or as a signed integer multiple of 15-minutes and should include a flag to indicate whether DST is in effect. The integer DTAI had an initial value of 10 seconds on 1972-01-01 (UTC).

6.12.6 Drop frame count mode flag

In particular when the clock time source is from a SMPTE ST 12-x timecode source the time address might be using the drop frame counting mode. The application should determine whether the generated timecode follows or uses a specified counting mode.

6.13 Ten frame cadence for 30/1.001 Hz related media

A ten-frame cadence that is a zero-based cadence number (0 to 9) may be derived from the phase-index at midnight and the media-index within the day. Table 3 shows the relationship between this ten-frame cadence and a ten-field (five-frame) sequence described in SMPTE ST 318. SMPTE ST 12 1 defines a two-frame color frame sequence that has a relationship to odd and even time address numbers. A five frame cadence combines with the color frame (even, odd) cadence resulting in a combined ten frame cadence. Table 3 shows the relationship of the cinema four-frame cadence relationship for 30/1.001 frame video with 24/1.001 frame film.

Table 3 – Ten-frame cadence relation to ST 318 sequence coding

<table>
<tr><th rowspan="2">Ten-frame cadence</th><th colspan="3">ST 318 sequences</th><th>Film</th></tr>
<tr><th>Ten-field</th><th>Five-frame</th><th>Field</th><th>Four-frame</th></tr>
<tr><td rowspan="2">0, 5</td><td>1</td><td rowspan="2">1</td><td>0</td><td rowspan="2">A</td></tr>
<tr><td>2</td><td>1</td></tr>
<tr><td rowspan="2">1, 6</td><td>3</td><td rowspan="2">2</td><td>0</td><td rowspan="3">B</td></tr>
<tr><td>4</td><td>1</td></tr>
<tr><td rowspan="2">2, 7</td><td>5</td><td rowspan="2">3</td><td>0</td></tr>
<tr><td>6</td><td>1</td><td rowspan="2">C</td></tr>
<tr><td rowspan="2">3, 8</td><td>7</td><td rowspan="2">4</td><td>0</td></tr>
<tr><td>8</td><td>1</td><td rowspan="3">D</td></tr>
<tr><td rowspan="2">4, 9</td><td>9</td><td rowspan="2">5</td><td>0</td></tr>
<tr><td>10</td><td>1</td></tr>
</table>

The following formulae define a ten frame, zero-based cadence number (0 to 9) that is derived from the phase-index at the timecode start-of-day. The cadence at any instant during the day may then be derived from media-index.

ten-frame = ((SoDPhId(UTC-Offset) x 4) + media-index) % 10
Where: SoDPhIdx(UTC-Offset) is the media-index "zero" alignment relative to the midnight start-of-day (SoD) as defined in § 6.10.2;
media-index is the value of the media-index;
ten-frame is the zero-based ten frame cadence number.

Note 1: For 48 kHz digital audio embedding into a 30/1.001 Hz SDI video signal there is a five frame cadence for the embedding of 8008 audio samples into five video frames. One possible sequence embeds 1602, 1601, 1602, 1601, and 1602 into five video frames. This is only one of many possible embedding pattern that are used in legacy equipment.

Note 2: The cadence between media at 24/1.001 Hz and 30/1.001 Hz media is an example of a five-frame sequence that results from a 3;2 conversion process.

7 Mapping into a SMPTE timecode

7.1 Timecode parameters

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

7.2 Time address

The time address hours, minutes seconds and frames components shall be derived from the media-index. Annex J defines methods and formulae to convert the media-index into “hh”, “mm”, “ss”, “ff” and “ee” elements suitable for mapping into SMPTE timecodes. The elements “ff” and “ee” present the frames value as a base-rate frame count value “ff” that can be coded in the time address frames and a frame count extension “ee” that can be coded into the binary groups as specified in § 8.3.

At integer media-rates the conversion of an integer media-index to hours, minutes, seconds and frames format as specified in Annex J is a straight forward conversion.

At fractional media-rates the number of media unit counts in a nominal 24-hour period varies from day-to-day. The short-day and long-day counts, which are determined by the date, permits a long term symmetric, mathematically precise correspondence with clock time. The drop frame count and UTC compensated count (UCC) algorithms are detailed in Annex I.

7.3 Binary group data

Binary group coding using SMPTE ST 262 as specified in § 8 provides a comprehensive set of data and metadata.. Alternately specific data and metadata elements can be coded using SMPTE ST 309 as specified in § 9.

7.4 Timecode 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 defined in the following clauses.

7.4.1 Drop frame flag

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 clock time. The drop frame flag should only be set for fractional rates.

7.4.2 Color frame flag

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.

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 RDD will also have a matching even/odd time address cadence.

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 RDD does not maintain the modulo 4 time address cadence. Thus the color frame to time address will only be correct every fourth day.

Note: 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.

7.4.3 Phase bit / Field flag

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.

7.4.4 Binary group flags

If the date, time zone, and frame number extensions are coded in the binary groups according to SMPTE ST 262 as described in § 8 then the binary group flags shall be set as follows: (BGF2 = 1, BGF1 = 1, BGF0 = 1).

If the date and time zone information are coded in the binary groups according to SMPTE ST 309 as described in § 9 and the time address has been derived from a media count that is referenced to a time-of-day clock reference then the binary group flags shall be set as follows: (BGF2 = 1, BGF1 = 1, BGF0 = 0). Alternately if the media count was not derived from a time-of-day clock reference then the flags shall be set as follows: (BGF2 = 1, BGF1 = 0, BGF0 = 0).

Otherwise the binary group flags should be set in accordance with the data that is coded in the binary groups of the timecode.

7.5 Media count rate

The timecode can present the media-rate as an enumerated rate that directly identifies the base-rate, a fractional-scaling-factor and a rate-multiplier as specified in § 6.7.

7.5.1 Base-rate

The base-rate values are the nominal rates defined for SMPTE ST 12-1 LTC, that is the frames count-modulus: 24, 25, and 30 fps. For the 30 fps rate SMPTE ST 12-1 also defines a drop frame counting mode that periodically drops two counts to minimize the drift of fractional rate media relative to clock time.

7.5.2 Higher frame rate (HFR) frame-block and extended frames

A HFR frame-block is a group of ‘N’ frames such that the frame-block rate is a nominal 24, 25 or 30 fps (as specified in Table 6) for compatibility with SMPTE ST 12-1 time address rates. The supported HFR multiples of the base-rates are listed in Table 7. The nominal HFR is an integer multiple of the base-rate.

7.5.3 Extended frame identifier

The extended frame identifier bits shall be Ext-frame-1, Ext-frame-2, Ext-frame-3, Ext-frame-4 and Ext-frame-5 as defined in Table 5. The combination of the base-rate frame number and the extended frame identifier shall represent the full frame number.

Each frame shall be identified by a complete address consisting of an hour, minute, second and the full frame number. The hours, minutes, and seconds follow the ascending progression of a 24-hour clock beginning with 00 hours, 00 minutes, and 00 seconds to 23 hours, 59 minutes, and 59 seconds. For cases where there are additional 30DF fractional rate counts and the exceptional leap second introductions the seconds value may extend beyond 59. The frames shall be labeled successively according to the counting mode (drop frame or non-drop frame) as defined in SMPTE ST 12-1 plus the extended frame identifier.

Note: The drop frame mode that is only defined for a multiple of 30-frame counting is not applicable to a multiple of 24-frame counting.

7.6 Calendar date

This day-number is used for binary group coding using SMPTE ST 262 as specified in § 8.9. Otherwise the day-number value can be converted into a “YY-MM-DD” format or a Modified Julian date (MJD) value for binary group coding using SMPTE ST 309 as specified in § 9.1. The day-number can be converted to the year, month and day elements using the procedure in Annex H, § H.4.1, which returns the numeric values for the calendar year, month and day elements.

7.7 UTC compensated count (UCC)

The UCC flag can be coded in the binary groups using SMPTE ST 262 as specified in § 8. However SMPTE ST 309 does not provide for coding of this flag.

The UCC flag with a True value indicates the following:

1. The media signal is aligned relative to the SMPTE epoch as defined in SMPTE ST 2059-1 and the timecode was also generated relative to the calendar date and UTC or local time UTC offset timestamp.
2. For fractional rate media the conversion of the media-index to a drop frame time address includes extensions to label the additional frame counts associated with media at 30/1.001 Hz rates to ensure a symmetric, mathematically precise, long term correspondence between time address values and clock time.
3. For days when there is a leap second introduction that this correction is applied to the time address as the last second of the time address day. For a positive leap second introduction the seconds shall count beyond 59 for the last minute of the day. For a negative leap second introduction the seconds might only count to 58 for the last minute of the day,.
4. For days when there is a leap second introduction and for media at 30/1.001 Hz related rates, additional labels at the very end of the day might have the count of seconds extend beyond 59 to 60 or 61. This maps each media-index label value to a unique time address value and there is a mathematically precise relationship among the media-index, the time address and clock time values. This deviation from the normal time address count is foreseen as described in SMPTE ST 12-1 Annex A.2. Due to their design some SMPTE timecode devices might not be able to process or display a time address label with a value of 60 or 61 seconds. For these implementations of RDD46 the formulas elsewhere in the document may be overridden and seconds (ss) greater than 59 may be replaced by seconds (ss) equal to 59.

Note: In many geographic locations it is a practice to incorporate the leap second at the same time instant as it is incorporated into the UTC timescale. Notwithstanding the local practice individual applications might deviate from this practice when this creates a timescale disturbance for time critical operations.

8 Generation of ST 262 binary group multiplexed data

8.1 Page-line directory system

The SMPTE ST 262 page-line system of coding data in the binary groups is a directory system that permits the self-identification of data blocks in the binary groups of a SMPTE ST 12-1 timecode. This system uses a page-line identifier in binary groups 7 and 8 to identify the data in the eight binary groups.

The use of the page-line multiplexing shall be signaled by the binary group flag combination: BGF2 = ‘1’, BGF1 = ‘1’ and BGF0 = ‘1’ as specified in § 8.14 and Table 8.

This RDD uses several page-line combinations as indicated in Table 4 and detailed in Table 5. The selection and distribution of multiplex-1, multiplex-2, or multiplex-3 over successive timecodes should be such that the spacing of the data is uniformly accessible over time even when, as might be the case for LTC, only the base-rate timecodes are presented. For example multiplex-1 could be used for even values of time address frames and multiplex-2 is used for odd values of time address frames.

Table 4 – Page-line combinations for this application

Page	Line	Application	Description
0h, 1h, 2h	Not used for this application. Usage 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 application.		
Fh	Not used for this application. Reserved by SMPTE ST 262.		

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

8.2 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 multiplexed into the remaining binary group bits. Three data sub-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.

8.2.1 Binary group bit assignment

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 UCC 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 5 – 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 § 8.3 (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 § 8.6 (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 § 8.4 (2 bits)</td></tr>
<tr><td>37</td><td>47</td><td colspan="3">Fractional rate-scale-factor flag as specified in § 8.5 (1 bit)</td></tr>
<tr><td>36</td><td>46</td><td colspan="3">UCC flag as specified in § 8.7 (1 bit)</td></tr>
<tr><td rowspan="2">4</td><td>31</td><td>39</td><td rowspan="6">Day-number
as specified in § 8.9</td><td>Heritage flag
as specified in § 8.8</td><td rowspan="6">User defined
as specified in
§ 8.13</td></tr>
<tr><td>30 – 28</td><td>38 – 36</td><td rowspan="2">UTC offset code
as specified in § 8.10</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 § 8.11</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 § 8.12</td></tr>
</table>

8.3 Extended frame count

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). 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.

8.4 Base-rate code

The base-rate shall be indicated in each multiplex structure by an enumerated code as defined in Table 6.

Table 6 – Base-rate codes

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

8.5 Integer or fractional rate-scale-factor

This RDD supports media at both Integer rates and fractional rates The rate-scale-factor shall be indicated by the fractional flag bit in each page-line multiplex structure. A False value shall indicate an integer rate (rate-scale-factor: 1/1) and a True value shall indicate a fractional rate (rate-scale-factor: 1/1.1001).

8.6 Rate-multiplier code

The base-rate, rate-multiplier codes and the nominal media-rates for each base-rate supported by this RDD shall be as defined in Table 7.

Table 7 – Base-rate, rate-multiplier codes and supported media count-modulus

	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			
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			

8.7 UTC compensated count (UCC) identification

A UTC compensated count is a media-index generated as specified by § 7.7 and this flag when set to True indicates that the media label has a mathematically precise relationship to 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.

8.8 Heritage flag

The heritage flag in page-line multiplex-2 can indicate that the timecode represents an original timecode as defined in § E.7.4.

8.9 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 Annex H, § H.3.1.

8.10 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 Annex H, § H.1.6 :

8.11 Binding code

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

8.12 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.

8.13 User defined data

The user defined data may be coded in page-line multiplex-3 as a 16-bit binary data word.

8.14 Binary group timecode flag bits

For the page-line multiplex system and clock time conforming to the format in this § 8 the binary group flag bits shall be set in accordance with SMPTE 12-1 as shown in Table 8. For vertical interval applications, this flag designation shall be repeated in both fields for interlaced or progressive segmented frame video.

Table 8 – Binary group flag values for page-line coding with ToD

		24- and 30-fps systems		25-fps systems	
Binary group flag	**Bit value**	**LTC bit**	**VITC bit**	**LTC bit**	**VITC bit**
BGF2	1	59	75	43	55
BGF1	1	58	74	58	74
BGF0	1	43	55	27	35

9 Generation of ST 309 binary group data

9.1 Date

SMPTE ST 309 can code the date either as a "YY-MM-DD" format calendar date or as a MJD format day,

Conversion of the to "YY-MM-DD" format is specified in Annex H, § H.3.1. Conversion of the day-number to MJD is specified in Annex H, § H.3.2:

9.2 Time zone

Time zones are signaled by a code from SMPTE ST 309 that identifies the current UTC offset and DST status.

Note: Some applications use the standard UTC offset as a label to identify a time zone whether DST is in effect or not however ST 309 codes the actual time zone UTC offset for both with and without DST..

9.3 Binary group flag bits

When the data structure conforms to this format, the binary group flag bits are set in accordance with SMPTE 12-1 as shown in Table 9. For vertical interval applications with interlaced video or progressive segmented frame video this flag designation is repeated in both fields.

Table 9 – Binary group flag values for SMPTE ST 309 coding

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

10 Timecode outputs

The timecode can be output in several standard timecode signal formats as described in the following sub clauses.

10.1 LTC alignment

For media that is aligned in accordance with SMPTE ST 2059-1 the LTC shall also be similarly aligned. Thus for media that is at a rate that is supported by SMPTE ST 12-1 (that is at a base-rate) the LTC will be aligned with the media signal in accordance with the SMPTE ST 12-1. For media that is a multiple of the base-rate the LTC should be aligned relative to the first frame of the multi frame block. The first frame of the block shall be designated by the extended frame count value of zero.

For media that is a multiple of the base-rate the LTC should be generated at the base-rate and the timecode data should be a sample of the higher rate timecode data sampled at the first media unit of the extended frame of the sequence.

10.2 VITC embedding

For analog video media that is at a rate that is supported by SMPTE ST12-1 the VITC should be embedded in the video signal in accordance with the SMPTE ST 12-1.

For media that is at higher rates and for media that does not support VITC embedding the reference to VITC generation shall relate only to the generation of the VITC data that may be used for embedding in accordance with SMPTE ST 12-2. This shall also apply to other applications that specify VITC as a media label.

The VITC process shall generate the time address data at the base-rate. For rates that are a multiple of the base-rate the data for the extended rate frames should be multiplexed into the binary groups in accordance with § 8 above.

10.3 ATC embedding

The LTC or VITC data should be formatted and embedded in the ancillary data space of the video signal in accordance with the SMPTE ST 12-2.

10.4 Higher frame rate timecode embedding

For media at rates that exceed the supported rates of either LTC or VITC, the VITC time address and binary groups should be coded using process described in § 8 and the VITC data coded in ANC according to SMPTE ST 12-2.

11 Applications (informative)

11.1 Timing of daily corrections and adjustments

Corrections to the timescale at the midnight rollover might be undesirable for some applications. This might include legacy installations that currently make the corrections at the daily jam time point and would be disrupted by the corrections at the midnight rollover.

11.1.1 Leap second incorporation at the same time point as it is incorporated in UTC.

The local time-of-day at which leap seconds are incorporated is subject to local practice and in some applications is applied at the UTC zero offset time point. This can occur at a time that is disruptive to critical operations and will result in a one second step in the time address sequence.

Note: This practice is not normally used for television production since for many geographic locations this would occur at time critical times of the day. Legacy applications have used the daily jam process to avoid this inconvenience.

11.1.2 Leap second and fractional rate drift corrections applied at the daily jam time point.

At the daily jam time point the master reference generator could be slaved to a timecode conforming to this RDD. This can be achieved by calculating the clock time using the procedures in § 6 to calculate the exact clock time for the media daily jam time value and setting the timecode to the daily jam time at that time point. This method would result in a deviation of the time address by the magnitude of the correction prior to the daily jam point but the time address would have a symmetric, mathematically precise relationship to clock time for the balance of the day after the daily jam time point.

11.2 UCC calculation of time points to align media signals relative to the SMPTE epoch

The procedures in § 6 calculate timing reference datum from the day-number, time-of-day, UTC offset, DTAI and the media-rate. These same time points can be used to align the media timing reference datum in a similar manner to that specified in SMPTE ST 2059-1.

11.3 Verification of SMPTE epoch alignment.

For a media-index or timecode value the expected clock time can be calculated and compared with the clock time sampled at the timecode timing reference datum. If the difference is within the desired tolerance then the media can be considered to be SMPTE epoch aligned.

Note: While media can be generated in alignment with the SMPTE epoch any processing or transport delays will likely modify that alignment.

Annex A Precision time protocol (PTP) (normative)

A.1 General

The IEEE 1588-2008 PTP can use an Ethernet IP network to deliver a timestamp in the form of a count of seconds (48-bit secondsField) and nanoseconds (32-bit nanosecondsField) relative to the PTP epoch, 1970-01-01_00:00:00 (TAI). The PTP epoch is 63072010 seconds before the leap second epoch 1972-01-01T00:00:00Z (UTC) at which time the DTAI was 10 seconds. The PTP can signal the current DTAI value in the PTP message field timePropertiesDS.currentUtcOffset and upcoming changes in the timePropertiesDS.leap59 or the timePropertiesDS.leap61 message fields.

To communicate the UTC offset of local time from UTC the IEEE 1588-2008 PTP provides an option to signal the offset of an alternate timescale using the ALTERNATE_TIME_OFFSET_INDICATOR TLV message. The currentOffset field value is the time offset, in seconds, from the PTP node's time and, when used for local time, is the combination of UTC offset and DTAI. This message also signals the size of an upcoming discontinuity in the jumpSeconds field and the time of this discontinuity in the timeOfNextJump field. The timeOfNextJump could be the time of a DST change or a leap second incorporation.

The IEEE 1588-2008 PTP provides for customized profiles to accommodate specific application requirements. The following clauses provide details for some of these profiles that might be used in an audio or television facility.

A.1.1 SMPTE ST 2059-2 PTP SMPTE profile and SMPTE ST 2059-1 generation and alignment of media signals to the SMPTE epoch

The SMPTE ST 2059-1 defines the SMPTE epoch as being identical to the PTP epoch and uses the SM TLV message to signal the DTAI and *local time* UTC offset. The SM TLV message can signal that changes might be held off until a "daily jam" time point as specified by the timeOfNextJam field however this RDD does not implement changes at this time point.

The SM TLV message indicates the system frame rate, coded as a numerator and denominator, in the defaultSystemFrameRate field. For integer rates the denominator is expected to have the value one and for fractional (n/1.001) rates the denominator is expected to have the hexadecimal value 1001 (0x03E9}. Other rates are out of scope of this RDD.

A.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. The ALTERNATE_TIME_OFFSET_INDICATOR TLV message is optional.

A.2 Leap second data

From IEEE 1588-2008 PTP the DTAI value is signaled by the timePropertiesDS.currentUtcOffset field and the incorporation of a leap second is signaled in advance by the timePropertiesDS.leap59 or the timePropertiesDS.leap61 message fields. The DTAI value can be determined as follows.

DTAI = TAI – UTC = timePropertiesDS.currentUtcOffset

The value of DTAI might need verification if the day-number changes as is described in § A.5.

A.3 Local time UTC offset

From IEEE 1588-2008 PTP conforming to the SMPTE ST 2059-2 PTP Profile the local time UTC offset can be determined from the SM TLV message currentLocalOffset field. The sign (TzSign), hour (Tzhh) and minute (Tzmm) components of the local time UTC offset can be calculated with following formulae.

TzSign: IF currentLocalOffset = 0; ;// Sign of UTC offset
TzSign = 1;
Else TzSign = SIGN(currentLocalOffset)
endIF
Tzhh = FLOOR(ABS(currentLocalOffset - DTAI) / 3600) ;// UTC offset hours
Tzmm = ABS((currentLocalOffset - DTAI) - TzSign x Tzhh x 3600) / 60
;// UTC offset minutes
Where: currentLocalOffset is the ST 2059-2 currentLocalOffset field
DTAI is the difference between TAI and UTC

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

Note: 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.

A.4 Time-of-day in seconds since midnight:

The local clock time-of-day in seconds (ToDss) can calculated with the formulae in Annex H, § H.2.1.

A.5 Day-number:

The day-number for the time point on the UTC timescale can be calculated from a PTP timestamp with the formulae in Annex H, § H.3.3.

As illustrated in Figure 2 (§ 6.11) 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 adjusted accordingly. Also for fractional rate media the timecode day is not perfectly aligned with the calendar day and thus the day-number boundaries shall be verified as described in § 6.11.

Since leap seconds are incorporated at the end of the last day of a month the change of calendar day might affect the value of DTAI as calculated in § A.2. PTP does not provide prior or future DTAI values, thus procedures such as described in § H.1.5 can be used to validate the DTAI value.

Annex B Global Navigation Satellite Systems (GNSS) normative)

B.1 General

There are several Global Navigation Satellite Systems (GNSS) in operation, including GPS (USA), Galileo (EU), GLONASS (Russia), BeiDou (China), and IRNSS (India). A day-number and time-of-day along with other time and date metadata can be derived from these GNSS systems, however these derivations are not currently defined in this RDD..

B.1.1 Global Positioning Satellite (GPS)

GPS time is a continuous timescale (no leap seconds) defined by the GPS control segment on the basis of a set of atomic clocks at the GPS monitor stations and onboard the satellites. The GPS epoch is 1980-01-06T00:00:00Z (UTC). At the GPS epoch, the DTAI was 19 seconds.

GPS time is available from a GPS system, maintained by the U.S. Department of Defense. The accuracy of GPS receivers is typically in the 10 ns to 100 ns range. GPS system transmissions represent the time as (weeks, secondsInWeek}, the number of weeks since the GPS epoch and the number of seconds since the beginning of the current week. The weeks are coded as a ten-bit value, which rolls over every 1024 weeks.

GPS also provides the current “leapSeconds” value, and warning flags marking the introduction of a leap second. UTC and TAI times may be computed solely based on the information contained in the GPS transmissions.

GPS timing receivers generally manage the GPS epoch transitions (1024-week rollovers), providing the current time (YYYY-MM-DD hh:mm:ss) as TAI and/or UTC timescales, and often also local time; in addition to providing the raw GPS week, second-of-week, and leap second information. GPS receivers typically communicate using the protocols defined in NEMA 0183 or NEMA 2000 to label the time of a one Hertz clock pulse.

B.1.2 Other GNSS sources

The application or other GNSS sources should provide the conversion of satellite receiver data from other navigation satellite systems.

B.2 Local time UTC offset and leap second data

UTC offset values for local time and DTAI data is not part of the GPS data. Some GPS receivers might provide this information based on user application inputs.

B.3 Day-number from timestamp:

For GPS receivers that provide the local date as a character formatted “YYYY-MM-DD” value the day-number can be calculated as the number of calendar days since 1972-01-01 with the formulae in Annex H, § H.3.1.

B.4 Time-of-day in seconds since midnight:

For GPS receivers that provide the local time-of-day data in the form: “hh:mm:ss” the time-of-day in seconds (ToDss) since midnight can be determined with the formula in Annex H, § H.2.3.

Annex C Network Time Protocol. (NTPv4) (normative)

C.1 General

The RFC 5905 Network Time Protocol (NTP) is widely used to synchronize computer clocks in the Internet. NTPv4 includes fundamental improvements in the algorithms that extend the potential accuracy to tens of microseconds with modern workstations and fast LANs.

The 64-bit timestamp format includes a 32-bit unsigned seconds field spanning 136 years and a 32-bit fraction field resolving 232 picoseconds. Era 0 includes dates from the prime epoch to sometime in 2036, when the timestamp field wraps around.

Note: Strictly speaking, UTC did not exist prior to 1972-01-01, but it is convenient to assume it has existed for all eternity, even if all knowledge of historic leap seconds has been lost.

C.2 Local time UTC offset and leap second data

The NTP does not convey local UTC offset data. It is the responsibility of the application to convey this information separately.

As specified in NTPv4 the LI field Leap Indicator (leap) is a 2-bit integer warning of an impending leap second to be inserted or deleted in the last minute of the current month with values defined in Table 10.

Table 10 – Leap indicator

Value	Meaning
0	no warning
1	last minute of the day has 61 seconds
2	last minute of the day has 59 seconds
3	unknown (clock unsynchronized)

C.3 Day-number from NTP timestamp:

The day-number for this time point on the UTC timescale can be calculated from a NTP timestamp with the formulae in Annex H, § H.3.4.

C.4 Time-of-day in seconds since midnight:

UTC offset values for local time and DTAI data are not part of the NTP data and thus these should be supplied by the application.

Annex D SMPTE timecode sources (normative)

D.1 General

The SMPTE ST 12-1 timecode signal codes the 24-hour time address as binary coded decimal (BCD) values of hours, minutes, seconds and frames (media units). The clock time accuracy of the time address, in particular for fractional rates, is dependent on the source timecode generation process. The count-modulus and rate of the timecode are not normally coded in the timecode and other means should be used by the application to determine the rate. The SMPTE ST 12-1 defines the LTC and VITC signal forms and SMPTE ST 12-2 defines the mapping of LTC or VITC data as ancillary (ANC) data packets for a SDI video signal.

The binary groups formatted according to SMPTE ST 309 can code the date either as a “YY-MM-DD” character format date with only a two digit year value or a MJD date. These binary groups can also code the time zone, *local time* UTC offset and a DST flag.

The binary groups coded utilizing the SMPTE ST 262 Page-line directory multiplex according to § 8, includes the date as a day-number, the frame count extension bits for higher media frame rates, the media base-rate and rate-multiplier codes, a *local time* UTC offset code, DTAI, a user defined code, and flags to signal fractional rate-scale-factor, DST, UTC compensated count (UCC), and SMPTE epoch alignment.

The SMPTE ST 12-1 time address and binary group data can be converted to a media-index and day-number with the procedures of Annex G. Other related metadata are also determined.

A SMPTE ST 12-3 ancillary timecode for higher frame rates provides a media count in the form of the conventional time address bits plus the super frame bits that extend the count-modulus of the frame count. These super frame bits replace traditional flag bits within the time address space. Since the flag bit functions, with the exception of the drop frame flag, are preempted for the super frame bit extensions there is presently no defined standard facility for coding of the date or any other information in the binary groups.

D.2 Time-of-day timestamp

The SMPTE ST 12-x family time address hour, minute, second and frame values are BCD coded in ten’s and unit’s nibbles. These nibble pairs of BCD coded values can be converted to decimal values with the formulae:

DigitDecimalValue = TensDigit x 10 + UnitsDigit
Where: Digit is hour, minute, second or frame.

The flag bits can be extracted for use by the application and by other engineering documents. These flag bits are listed in Table 11, SMPTE ST 12-1 Timecode flag bits. Refer to SMPTE ST 12-1 for the timecode bit positions.

Table 11 – SMPTE ST 12-1 Timecode flag bits

Flag bit	Remarks
Drop frame flag	
Color frame flag	
Phase bit	LTC only
Field flag	VITC only
Binary group BGF0	
Binary group BGF1	
Binary group BGF2	

D.3 Local time UTC offset and leap second data

The local time UTC offset might be provided by the application or from SMPTE ST 12-1 binary groups. For binary groups formatted according to SMPTE ST 309 the date and local time UTC offset can be determined as detailed in Annex K. For binary groups formatted according to § 8 using SMPTE ST 262 the media-rate, date, *local time* UTC offset and other metadata parameters can be determined as detailed in Annex G.

D.4 Day-number from timestamp:

If the date is coded in the binary groups per SMPTE ST 309 formatted as a character string “YY-MM-DD” then the day-number can be calculated as described in Annex G, § G.3 and Annex H, § H.3.1. For MJD coded dates the formula of Annex H, § H.3.2 can be used.

The binary groups mapped according to § 8.9 maps the date directly as a day-number.

D.5 Time-of-day in seconds since midnight:

For a time address that is flagged as being UCC conformant as indicated by the UCC flag coded in the binary groups as defined in § 8.7 using SMPTE ST 262 the day-number and the clock time-of-day can be calculated. The timecode start-of-day offset from midnight can be calculated from the day-number according to Annex H, § H.4.3. The time address can be converted to a time in seconds according to Annex H, § H.2.4. The clock time-of-day in seconds can be calculated by adding the timecode start-of-day offset to the time address in seconds

Annex E Generic date and time-of-day sources (normative)

E.1 General

Not all of the necessary data or metadata to complete the media unit will be available from the date and clock time sources.

The date and timestamp might be sourced from other sources in a format such as "YYYY-MM-DDThh:mm:ss.ff±hh:mm" as detailed by ISO 8601 or as the individual elements of a Gregorian date in the form: "YYYY-MM-DD", clock time in the form: "hh:mm:ss.s", and the local time UTC offset in the form "±hh:mm". Extended versions of this format might include the DTAI value and a DST flag.

E.2 Count rate

The count rate is typically the same as the media-rate and unless otherwise specified needs to be defined by the application. While the PTP source in Annex A might signal an application defined default system rate, the application might require the generation of timecodes at one or more other rates.

E.3 Local time UTC offset

The local time UTC offset might be provided in the YMDhms format, otherwise it could be provided by the application. The UTC offset can be converted to a signed count of 15-minute increments as specified in § 6.2.

E.4 Day-number from a Gregorian calendar date

The day-number can be calculated as the number of calendar days since 1972-01-01 with the formulae in Annex H, § H.3.1.

E.5 Day-number from a Modified Julian date

The day-number can be calculated from a Modified Julian date with the formulae in Annex H, § H.3.2:

Note: MJD is officially defined to represent days on the UTC timescale.

E.6 Time-of-day in seconds

For time-of-day data in the form: "hh:mm:ss" the time-of-day in seconds (ToDss) since midnight can be determined with the formula in Annex H, § H.2.3.

E.7 Status flags

E.7.1 UTC compensated count (UCC) flag

A True value of this flag signals that the media has been aligned to the SMPTE epoch and that the media has been referenced to an accurate clock such as specified in SMPTE ST 2059-1, and that the media count has been generated as defined consistent with this RDD.

E.7.2 SMPTE epoch alignment flag

A True value of this flag signals that the media has been aligned to the SMPTE epoch and that the media has been referenced to an accurate clock such as specified in SMPTE ST 2059-1.

A method for verification of the SMPTE epoch alignment is described in § 11.3.

E.7.3 Daylight saving time (DST) flag

A True value of this flag signals that daylight saving is effect for the local time.

E.7.4 Heritage flag

The heritage flag set to True indicates that this timecode represents an original timecode related to the media that should be preserved and should not be modified by subsequent processes. This flag set to False represents a timecode that may have been derived from an original timecode or otherwise created in the production process

Annex F Calendar days and leap seconds (normative)

F.1 Leap second introductions

Leap seconds are introduced 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 at the end of the day just before the UTC midnight. UTC clocks introduce a 60th second at the end of the day when a positive leap second introduction is scheduled. The leap second is designated "23:59:60".

Note 1: 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”, which are negative integer values.

Note 2: The standards also 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 document.

Note 3: International standards specify that the leap second is introduced into the UTC timescale just before midnight 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 instant 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 application specifies the leap second introduction on each individual timescale should occur just before midnight local time at the end of the last day of the designated month. With the leap second correction applied at the end of the 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 instant. 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 midnight is that media labels expressed in a clock time format each have the same count sequence, independent of the UTC offset.

Note 4: 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 RDD.

F.2 Leap second offsets – DTAI

The following Table 12 details the historical data relating to the UTC timescale and leap second introductions.

Table 12 – DTAI history

DTAI	MJD	Day-number	Gregorian Calendar date	Seconds-since-origin	
				UTC 1972	TAI 1958
10	41317	0	1972-01-01	0	441763210
11	41499	182	1972-07-01	15724801	457488011
12	41683	366	1973-01-01	31622402	473385612
13	42048	731	1974-01-01	63158403	504921613
14	42413	1096	1975-01-01	94694404	536457614
15	42778	1461	1976-01-01	126230405	567993615
16	43144	1827	1977-01-01	157852806	599616016
17	43509	2192	1978-01-01	189388807	631152017
18	43874	2557	1979-01-01	220924808	662688018
19	44239	2922	1980-01-01	252460809	694224019
20	44786	3469	1981-07-01	299721610	741484820
21	45151	3834	1982-07-01	331257611	773020821
22	45516	4199	1983-07-01	362793612	804556822
23	46247	4930	1985-07-01	425952013	867715223
24	47161	5844	1988-01-01	504921614	946684824
25	47892	6575	1990-01-01	568080015	1009843225
26	48257	6940	1991-01-01	599616016	1041379226
27	48804	7487	1992-07-01	646876817	1088640027
28	49169	7852	1993-07-01	678412818	1120176028
29	49534	8217	1994-07-01	709948819	1151712029
30	50083	8766	1996-01-01	757382420	1199145630
31	50630	9313	1997-07-01	804643221	1246406431
32	51179	9862	1999-01-01	852076822	1293840032
33	53736	12419	2006-01-01	1073001623	1514764833
34	54832	13515	2009-01-01	1167696024	1609459234
35	56109	14792	2012-07-01	1278028825	1719792035
36	57204	15887	2015-07-01	1372636826	1814400036
37	57754	16427	2017-01-01	1420156827	1861920037
37	58845	17528	Expiry date : 2019-12-28		

F.2.1 DTAI table maintenance

The DTAI Table 12 is valid until the expiry date shown in the last row. This table should 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.

F.3 Start-of-month, Ordinal days

The following Table 13 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 13 – 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 G Media-index and day-number from SMPTE timecodes (normative)

G.1 Background

SMPTE ST 12-1 defines a time address in the form of “hh:mm:ss:ff” for base-rates of 24, 25 or 30 fps. For progressive video at twice these rates the time address count identifies media unit pairs and the field mark flag can be used to identify each media unit of the pair. The preferred implementation is to set the field mark flag of the VITC data to logic zero for the first media unit of a pair and to logic one for the second media unit of the pair. § 7 defines the mapping into SMPTE ST 12-1 of the base-rate count in the time address and § 8 defines the mapping of the count extension, date, UTC offset, rate and other related metadata in the binary groups.

SMPTE ST 12-3 defines the labeling of media units at multiples of the base-rates with a zero-based sub-unit count that identifies the individual media units in the media block associated with each base-rate media unit label. However ST 12-3 does not provide for the coding of the date or other metadata in the binary groups.

For progressive video media at multiples of the base-rates the media-index identifies a block of extended media units. A zero-based integer count can be used to identify each media unit of the extended media block. The extended media unit identifier is zero for the first media unit of the block.

SMPTE ST 309 defines the coding of local time UTC offsets that can be mapped into the binary groups of the timecode. The offsets are enumerated and defined in the form of signed values of hours and minutes.

This RDD using SMPTE ST 262 defines the multiplexed mapping into the binary groups of the extended media unit bits, the time local UTC offset, the date, the rate and other related metadata.,

G.2 Media-index from time address

The SMPTE ST 12-1 and similarly ST 12-3 can label video at integer and fractional rates that are related to a rate-multiplier of the 24, 25 or 30 base-rate. Also the time address can count in either the drop frame or non-drop frame counting mode as signaled by the drop frame flag bit in the timecode.

The video media-index may be represented by the label “hh:mm:ss:ff.ee”

rate-multiplier = CEIL(media-rate / base-rate)
Where input variables are:

media-rate is the video media-rate,
base-rate is the related system count-modulus (24, 25 or 30),
hh is the time address hours value
mm is the time address minutes value
ss is the time address seconds value
ff is the time address frames value
ee is zero for rates that are a rate-multiplier of one, or
ee is the field mark flag value for rates with a rate-multiplier of two, or
ee is the extended-media-index value for the higher rates.

G.2.1 Non-drop frame time address count mode

The non-drop frame counting mode can be applicable for all supported timecode count rates. The timecode may be converted to a count of media units with the following formula.

media-index = rate-multiplier × ((base-rate × (3600 × hh + 60 × mm + ss) + ff) + ee

G.2.2 Drop frame time address count mode at 30 fps related rates

The drop frame counting mode is only applicable for media-rates that are a multiple of 30 or 30/1.001 Hz although it is normally not used with 30 Hz related media-rates .

The UCC counting mode is an extension of the traditional drop frame counting mode that provides tor additional count values at the end of the day.

The timecode may be converted to a count of media units with the following formula.

media-index = rate-multiplier × ((107892 × hh) + (1798 × mm) + (2 × FLOOR(mm / 10)) + (30 × ss) + ff) + ee
Where: hh, mm, ss, ff are the components of the time address label
ee is the frame extension for rates that are a multiple of the base-rate
rate-multiplier is the multiplier of the base-rate.

G.3 Day-number from binary groups date coded per SMPTE ST 309

The date as coded by ST 309 can be coded either as a Modified Julian day (MJD) or as a character string in the form of “YY-MM-DD”. The year is only coded as a two digit value, thus the user application will need to complete the century digits of the year.

The day-number can be calculated with the formulae in Annex H, § H.3.1.

G.4 Day-number from binary groups multiplexed per SMPTE ST 262

Since the date is mapped in page-line “multiplex-1” as a day-number (as specified in § 8.9) no conversion is required.

Annex H Date, time and media count format conversions (normative)

Dates in a day-number or “YMD” format, time in “hms” or all seconds format, and a count of media units represent a variety of representations that are used interactively. The object of this clause is to present the conversions among many of these formats.

H.1 Utility functions

These utility functions and procedures determine parameters of the common or leap year properties of a specified Gregorian calendar year number or of a calendar day.

H.1.1 Function: LeapsThroughEndOf()

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

Function: LeapsThroughEndOf(YYYY)
LeapYears = FLOOR(YYYY / 4) – FLOOR(YYYY / 100) + FLOOR(YYYY / 400)
Returns: LeapYears ;// number of leap years

H.1.2 Function: IsLeapYear()

The function “IsLeapYear(YYYY)” shall determine if the year number “YYYY” represents a common year or a leap year. The formula returns the Boolean value “True” if the year “YYYY” is a leap year else this is a common year and “False” is returned.

Function: IsLeapYear(YYYY)
IsLeapYear(YYYY) = ((YYYY % 4) == 0) AND (NOT((YYYY % 100) == 0) OR ((YYYY % 400) == 0))

H.1.3 Function: DaysInYear()

The function “DaysInYear(YYYY)” shall determine and return the number of days, either 365 or 366, in the specified year number “YYYY”.

Function: DaysInYear(YYYY)
If IsLeapYear(YYYY) == “True”; DaysInYear() = 366 Else DaysInYear() = 365
Returns: DaysInYear() ;// number of days in year

H.1.4 Procedure: IsLeapSeconf()

The Annex F, Table 12 “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 1972-01-01T00:00:00Z (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 12 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
```

H.1.5 Procedure: IsLeapSecondDay()

For each leap second, the DTAI history Annex F, Table 12 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 should 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.               ;//
```

H.1.6 Functions: UTCoffset()

Local time UTC offset is a UTC offset that might be presented as a signed hours value and an unsigned minutes value in the form "±hh:mm" or as a signed integer count of seconds.

The UTC offset presented as signed hours and minutes can be converted to a *local time* offset (UTCoffset) value in seconds with the following formula.

```
Function: UTCoffset(TzSign, Tzhh, Tzmm)
UTCoffset() = Tzss = TzSign x (ABS(Tzhh x 3600) + (Tzmm x 60))
Where: TzSign is the sign of the UTC offset hours       ;// 1 = positive; –1 = negative,
    Tzhh is the UTC offset hours                        ;// signed integer +14 to -12,
    Tzmm is the UTC offset minutes                      ;// unsigned integer (00. 15, 30, or 45).
```

The UTC offset value in seconds can be converted to a binary code that represents the UTC offset as a signed integer count of 15 minute increments with the following formula.

```
Function, UTC offset code(TzSign, Tzss)
UTC offset code = TzSign x FLOOR(Tzss / 900)          ;// in 15 minute increments
Where: TzSign is the sign of the UTC offset seconds   ;// 1 = positive; –1 = negative,
       Tzss is the UTC offset in signed integer seconds
```

H.2 Seconds since origin calculations

A seconds count can be calculated from various time sources and with different origins.

H.2.1 Time-of-day in seconds from a PTP timestamp:

The time-of-day in seconds shall be a zero-based count of seconds from local clock time midnight.

```
ToDss = (secondsField                         ;// PTP secondsField
       – 63072010                             ;// offset from SMPTE epoch to day-zero
       – (DTAI – 10)                          ;// leap second introductions since day-zero
       – (day-number x 86400))                ;// days offset to UTC midnight
       – (TzSign x ((Tzhh x 3600) + (Tzmm x 60)))   ;// offset to local midnight
Where: secondsField is the value of the PTP timestamp secondsField,
       DTAI is the difference between TAI and UTC
       day-number is the offset from 1972-01-01(UTC) as calculated in § H.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 recalculated for the prior day-number before recalculating ToDss for this prior day-number.

For positive UTC offset time zones and if the ToDss is greater than the LoD then then this time point on the local timescale is in the next day. The DTAI, value should be recalculated for the next day-number before recalculating ToDss for this next day-number.

H.2.2 Seconds since SMPTE epoch

The elapsed time in seconds since the SMPTE epoch (1970-01-01 00:00:00 (TAI)) to the local time-of-day time point may be calculated with the following formula.

```
Seconds-Since-SMPTE- epoch =
       63072010                               ;// offset from SMPTE epoch to day-zero
       + (day-number x 86400)                 ;// days since day-zero
       + (DTAI – 10)                          ;// leap second introductions since day-zero
       + ToDss                                ;// seconds from midnight
       + TzSign x ((Tzhh x 3600) + (Tzmm x 60))     ;// local time UTC offset
```

H.2.3 Seconds from time-of-day hours, minutes and seconds

The time-of-day consists of the hour (0 to 24), minute (00 to 59) and second (00 to 60) elements. The hour and minutes shall be presented as integer values. The seconds may be presented as an integer (ss) or as an integer with a fractional value in the form(ss.ss). The time-of-day in seconds (ToDss) shall be determined from the time-of-day hours, minutes and seconds with the following formula.

ToDss = (hh x 3600) + (60 x mm) + (ss.ss)

H.2.4 Seconds from SMPTE ST 12-1 time address

The timecode consists of the time address hour (0 to 24), minute (00 to 59), second (00 to 61) and frames plus extended frames elements. The hours, minutes, seconds and frames (00 to frame limit) plus an optional extended frames element (0 to 31).shall be presented as integer values. The time-of-day in seconds (ToDss) shall be determined from the time-of-day hours, minutes and seconds with the following formula.

ToDss = (hh x 3600) + (60 x mm) + (ss) + (ff x rate-multiplier + ee) / media-rate

H.3 Day-number calculations

The day-number is a zero-based count of calendar days from the day-zero.

H.3.1 Day-number from a Gregorian calendar date

The Gregorian calendar date shall represent the date on the local timescale and might be presented in the form of year, month and day elements. The values YYYY, MM, and DD shall follow conventional rules of Gregorian Calendar date and time. The day-number can be calculated from these elements with the following formulae:

```
tm_year = YYYY – 1900                       ;// Years since 1900
day-number = ((tm_year – 72) * 365)         ;// Count of common days
        + FLOOR((tm_year – 69) / 4)         ;// Correction for 4 year leap year cycle.
        – FLOOR((tm_year – 1) / 100)        ;// Correction for 100 year leap year cycle.
        + FLOOR((tm_year + 299) / 400)      ;// Correction for 400 year leap year cycle.
        + (MonthTable(MM, IsLeapYear()) )   ;// Days to start-of-month,
        + (DD – 1)                          ;// Days from start-of-month.
Where: YYYY is the 4-digit year (1972 to 9999),
        MM is the month number (1 to 12),
        DD is the day number of the month (1 to 31),
        IsLeapYear() is the determination of whether YYYY is a leap year as defined in § H.1.2,
        MonthTable() look up of the start day of the month as defined in Annex F, Table 13.
```

Note: These formulae are similar to conversions specified in POSIX.1-2008 and provided in certain computer operating system environments by functions such as gmtime. A significant difference is that the day-zero is 1972-01-01, whereas the Posix conversions are based on an origin at calendar date 1970-01-01.

H.3.2 Day-number from a Modified Julian date

The day-number can be calculated from a Modified Julian date with the following formulae:

day-number = FLOOR(MJD – 41317)
Where: MJD is the Modified Julian date that can include a fraction to denote an offset from midnight,
41317 is the MJD for Gregorian calendar day 1972-01-01.

Note: Modified Julian Dates typically represents days on the UTC timescale. Appropriate adjustments are required if the MJD represents dates on a local UTC offset timescale.

H.3.3 Day-number from the elapsed time in seconds since the SMPTE epoch

The calendar day typically has a constant duration of 86400 seconds except when a leap second is incorporated at the end of the day. The timestamp for the last second of the day could possibly represent a leap second that would not yet be included in the value of DTAI. For each incorporated leap second, the Annex F, Table 12 "DTAI history" lists the time points on various timescales. The procedure "IsLeapSecond ()" uses this table to determine if the timestamp is a positive leap second time point.

The offset from the SMPTE epoch to the day-zero and all leap seconds shall be deducted from the timestamp for the calculation of the day-number with the following formula:

Procedure: day-number from seconds since SMPTE epoch ()
day-number = FLOOR((FLOOR(ts) – 63072000 – DTAI – PositiveLeapSecond) / 86400)
Where: ts is the value of the timestamp in seconds,
SMPTE epoch to day-zero is 63072000 +10 seconds,
DTAI is the difference between TAI and UTC,
PositiveLeapSecond has the value '1' if this second is a positive leap second.
This day-number is on the UTC timescale.

H.3.4 Day-number from the elapsed time in seconds since the NTP Era 0 epoch

For NTP timestamps the count is held for the leap second and thus the calendar day has a constant duration of 86400 seconds.

The offset from the NTP Era 0 epoch to the day-zero shall be deducted from the timestamp for the calculation of the day-number with the following formula:

Procedure: day-number from seconds since NTP Era 0 epoch ()
day-number = FLOOR(ts – 2272147200) / 86400)
Where: ts is the value of the NTP timestamp in integer seconds,
NTP Era 0 epoch to day-zero is 2,272,147,200 seconds.
This day-number is on the UTC timescale.

H.4 Calendar date and time calculation and formatting

H.4.1 Calendar date from the day-number

The calendar day typically has a constant duration of 86400 seconds except when a leap second is incorporated at the end of the last day of the designated month.

The year number "YYYY" and the ordinal day number "DDD" shall be calculated from the day-number using the following formulae and procedure.

```
Year-Day(day-number)                          ;// Procedure()
        Y = 1972                              ;// Initialize year to 1972
        ;// Initialize the day count (D) to the number of days since start of that year,(1972-01-01)
        D = day-number                        ;// Initialize variable "D"
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 Annex H, § H.1.1
        Y = Ye                                ;// Update year.
End_While                                     ;// End of loop
Returns:        Year YYYY = Y                 ;// Year number,
                DDD = D + 1                   ;// Ordinal day number (1 to 366)
```

Refer to Annex F, Table 13 "Months and ordinal day number" to convert the ordinal day number (days from start-of-year) to month and day. Use the function IsLeapYear(YYYY) as defined in Annex H, § H.1.2 to select a "Start day" column for a "Common year" or a "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

H.4.2 Time-of-day formatting as hours, minutes and seconds

The time-of-day in seconds (ToDss) is the elapsed time within the nominal 24-hour day.

```
hh = FLOOR( (ToDss % 86400) / 3600)           ;// hours
mm =FLOOR( (ToDss % 3600) / 60)               ;// minutes,
ss = (ToDss % 60)                             ;// seconds
tt = ToDss % 1                                ;// fraction of a second
```

H.4.3 Timecode start-of-day calculations

For SMPTE epoch aligned, integer rate media the timecode start-of-day shall be at the calendar day midnight and the timecode start-of-day offset in seconds (SoDss) shall be zero.

SoD = SoDss = 0

For SMPTE epoch aligned, fractional rate media the timecode start-of-day shall be at or near the calendar day midnight. The day-number, the local time UTC offset and the media-rate determines the timecode start-of-day offset from the local clock time midnight.

For fractional rate media the day will start near midnight of each day. The offset from midnight shall be determined by the day-number and the UTC offset.

SoDdn = ((day-number x PhFDD) % 1001)
+ TzSign x ((ABS(Tzhh) x PhIhh) % 1001) +(ABS(Tzmm) x PhImm) % 1001))
SoDss = SoDdn x (media-block-size / (base-rate x 1000))
Where: SoDdn is the fractional rate timecode start-of-day offset as a phase-index number;
SoDss is the fractional rate timecode start-of-day offset in seconds,
PhFDD is the phase alignment factor for days ;// as specified in Table 2
PhFhh is the phase alignment factor for hours ;// “.
PhFmm is the phase alignment factor for minutes ;//. “
Tzhh is the hours component of the local time UTC offset;
Tzmm is the minutes component of the local time UTC offset.

Annex I Drop frame and UCC compensation (normative)

I.1 Background

The media-index is a zero-based integer count with an upper day limit. On days when there is a leap second introduction the media-index upper limit is extended by the value of the media count-modulus. These values of short-day or long-day upper limits and extension for leap second introduction are shown in Table 2 for 30 Hz or for 24 Hz related rates.

I.1.1 Video media at integer rates

For media at integer rates, the number of media units in a 24-hour day is an integer value and thus each day will have the same upper limit, The representation of the media-index in a clock time "hh:mm:ss:ff" format follows a regular pattern each day with the exception of days when a leap second is incorporated.

I.1.2 Video media at fractional rates

Since, for media at fractional rates, the number of media units in a 24-hour day is not an integer value, media units that straddle the midnight boundary may be shifted into the next day. and thus some days will have different short-day and long-day upper limits. To facilitate compatibility with 30/1.001 Hz related legacy timecodes that employ color frame identification these day count limits have the daily count limit as an even number. The even daily count limit also simplifies the cadence when inter-working with both 24 and 30 related media-rates.

For fractional rates the number of media units in a 24-hour day is less than for the corresponding integer rate. To compensate for this drift when representing the media-index in a clock time "hh:mm:ss:ff" format a drop frame count compensation mode can be used to achieve a close approximation to clock time.

I.1.3 Representation in a clock time format

For integer rate media on common days the number of media units in a 24-hour period matches the number of "hh:mm:ss:ff" format labels.

For fractional 30/1.001 rate media with the drop frame count mode the number of media units in a 24-hour period exceeds the number of "hh:mm:ss:ff" format labels by either 2 or 4 counts for common days. For fractional 24/1.001 rate media with the drop frame count mode described in § I.3 the number of media units in a 24-hour period is fewer than the number of "hh:mm:ss:ff" format labels for common days.

To achieve a long term correlation of the media-index with clock time the media-index limits are designated by short-days and long-days that are determined by a calendar date-based algorithm.

For leap second days when a positive leap second is incorporated and for 30/1.001 Hz fractional rate media there will be more media unit counts than the normal number of "hh:mm:ss:ff" format labels. This creates a difficulty in representing each media unit value with a unique "hh:mm:ss:ff" format label. The media-index representation can be accommodated by a modification of the "hh:mm:ss:ff" count sequence.

Create the additional labels at the very end of the day by allowing the count of seconds to extend beyond '59' to '60' or '61'. This will map each media-index label value to a unique time address value and there is a precise, symmetric mathematical relationship among the media-index, the time address and clock time values. This technique is foreseen as described in SMPTE ST 12-1 Annex A.2.

I.2 Video media at rates related to 30/1.001 Hz

I.2.1 Video frame rate 30/1.001 Hz drop frame algorithm – DF30

For television signals with a frame rate of 30/1.001 Hz, monotonically counting at 30 frames per second yields a deviation of approximately plus 108 frames (+3.6 seconds) in one hour of elapsed time.

SMPTE ST 12-1 defines a drop frame counting mode to minimize the time deviation from clock time. With this count mode the first two frame numbers (00 and 01) are omitted from the count at the start of each minute except minutes 00, 10, 20, 30, 40, and 50.

For television systems operating at twice this rate (that is 60/1.001 Hz) and higher multiples similar drop frame counting modes are described in § I.2.2 below.

Note: When drop-frame compensation is applied to a fractional rate television timecode, the total deviation accumulated after one hour is reduced to approximately minus 3.6 milliseconds. The total deviation accumulated over a 24-hour period is approximately minus 2.59 frames (–86 milliseconds).

The drop frame application applied to a media signal at a 30/1.001 Hz rate will create 2589408 labels in a 24-hour SMPTE ST 12-1 time address day. The LoD for a short-day will have 2589410 media counts and 2589412 counts for a long-day. The UCC drop frame algorithm as specified in § I.2.3 modifies the DF30 count sequence and provides time address labels for the additional 2 or 4 media unit counts and also the additional leap second counts. With this algorithm applied there is zero long term (1001 day) drift between the time address label values and clock time.

I.2.2 Drop frame modes for media-rates at multiples of 30/1.001 Hz

For Media-rates at multiples “n” of 30/1.001 Hz, similar drop frame count modes may be used. These modes are the same as the DF30 drop frame mode for the 30/1.001 Hz video rate described in § I.2.1 above with the exception that the media count-modulus is 30n (counts zero to 30n-1) and the first 2n frame numbers (00, 01, 02, to 2n-1) shall be omitted from the count at the start of each minute except minutes 00, 10, 20, 30, 40, and 50. These drop frame modes are designated DF60, DF120, etc.

I.2.3 UTC compensated count (UCC) drop frame algorithms

To meet the requirement to uniquely label each media unit and provide a count that has a symmetric relationship with respect to clock time a modification of the time address counts for a 24-hour period is required.

The UCC drop frame algorithms are similar to the drop frame algorithm in § I.2.1 or § I.2.2 and is a modification to the count providing time address labels for short-days or for long-days that might also include a leap second. The last minute of the day (minute 23:59) the time address second's count extends beyond 59 to provide the additional labels. These UCC drop frame modes are designated DF30UCC,DF60UCC, DF120UCC, etc.

I.3 Video media at rates related to 24/1.001 Hz (informative)

I.3.1 Video frame rate 24/1.001 Hz – DF24

For fractional rate related television signals with a rate of 24/1.001 Hz, monotonically counting at 24 frames per second will yield a deviation of approximately plus 86 frames (+3.6 seconds) in one hour of elapsed time.

NOTICE: The DF24 drop frame counting mode is non-standard and might not be correctly recognized or processed by some SMPTE ST 12-1 conformant devices.

The DF24 drop frame counting mode can minimize the time deviation from real time. With this count mode the first two frame numbers (00 and 01) shall be omitted from the count at the start of each minute except minutes ‘x0’, ‘x4’, and ‘x8’, but the two frame numbers shall be omitted for minute ‘58’ as shown in Table 14.

Table 14 – Omitted counts for drop frame compensation DF24

		Minute units									
		x0	**x1**	**x2**	**x3**	**x4**	**x5**	**x6**	**x7**	**x8**	**x9**
Minute tens	0x		2	2	2		2	2	2		2
	1x		2	2	2		2	2	2		2
	2x		2	2	2		2	2	2		2
	3x		2	2	2		2	2	2		2
	4x		2	2	2		2	2	2		2
	5x		2	2	2		2	2	2	2	2

For television systems operating at multiples of this rate (such as 48/1.001 Hz or 96/1.001 Hz) similar DF48 and DF96 drop frame counting modes are described in § I.3.2 below.

Note: When drop-frame compensation is applied to a fractional rate television time address count, the total deviation accumulated after one hour is reduced to approximately minus 3.6 milliseconds. The total deviation accumulated over a 24-hour period is approximately minus 7.53 frames (–40.7 milliseconds).

I.3.2 Drop frame modes for media-rates at multiples of 24/1.001 Hz

For media-rates at multiples “n” of 24/1.001 Hz similar drop frame count modes should be used These modes are the same as the DF24 drop frame mode for the 24/1.001 Hz video rate described in § I.3.1 above with the exception that the frames count-modulus is ‘24n’ (zero to ‘24n-1’) and the first ‘2n’ frame numbers (00, 01, 02, to 2n-1’) shall be omitted from the count at the start of each minute except minutes ‘x0’, ‘x4’, and ‘x8’, but the ‘2n’ frame numbers shall be omitted for minute ‘58’. These drop frame modes are designated DF48, DF96, etc.

I.3.3 UTC compensated count (UCC) drop frame algorithms

The drop frame application applied to a media signal at a 24/1.001 Hz rate will create 2071536 labels in a 24-hour DF24 time address day. The LoD for a short-day will have 2071528 media counts and 2071530 counts for a long-day. Since for common days there are fewer counts in both a short-day and a long-day it is not necessary to incorporate additional labels at the end of the day. The count will rollover to “00:00:00;00” after the time address “23:59:59;15” for a short-day and after “23:59:59;17” for a long-day. For days when a leap second is incorporated the last minute of the day (minute 23:59) the time address second's count may extend beyond 59 to provide the additional labels. The process is similar for multiples of this rate. With this algorithm applied there is zero long term drift between the time address label values and clock time. These UCC drop frame modes are designated DF24UCC, DF48UCC, DF96UCC, etc.

Annex J Media-index to time address format conversions (normative)

The media-index is be a zero-based count of media units from a defined origin. The media-index extends up to a day limit that is a constant value for integer rate media and will be either a short-day limit or a long-day limit for fractional rate media. For the purpose of a conversion to a time address label the origin is related to a 24-hour period such as a calendar day with a local timescale origin at midnight.

The time address shall be based on the form of media labeling as defined by SMPTE ST 12-1. The time address shall be presented in the form “hh:mm:ss:ff” and composed of the elements hh (hours), mm (minutes), ss (seconds) and ff (frames). In accordance with SMPTE ST 12-1 the hours shall be a count from 00 to 23 and the minutes shall be a count from 00 to 59. The count of seconds will be a count from 00 to 59 except for the last minute of the day to accommodate additional counts for fractional rates and leap second introductions where the count can extend to 60 or 61. The count of frames is defined in SMPTE ST 12-1 as a count from 00 to one of 23, 24, or 29. For media-rates that are at integer multiples of the base-rates the count of frames shall extend to higher values in order to label the higher rate media. The frames are represented by a count from zero to a limit (ffff) according to the frame rate and by the representation “ff.ee” where a count-modulus (ff) conforms to the count range defined by SMPTE ST 12-1 and “ee” is a sub division (extension) of the count. The SMPTE ST 12-1 defines two time address count modes drop frame and non-drop frame. This RDD defines extended drop frame algorithms that accommodate the extended media-rates and changes to the process at the end of the day to enable a symmetric, mathematically precise relationship with precision clock time.

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 15 – 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 (61 for last minute of the 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 § 6.7
UCCmode	Boolean	UTC compensated count mode flag	‘0’ = False ‘1’ = True
LSday	Boolean	Leap second introduction Day flag	
long-day	Boolean	Long-day flag	
base-rate	Fps	Number of time address frames in one time address second.	24, 25, or 30
media-index	Uint	Media unit count	Zero-based count

J.1 Non-drop frame time address components for integer and fractional rates

For integer media-rates an integer media-index conversion to a time address format with a non-drop frame counting mode will maintain a correspondence with precision clock time. However for fractional media-rates 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 using the following formulae.

The hours, minutes, seconds and frames (hh, mm, ss, ff) component values of the time address shall be calculated as follows.

hh = FLOOR(Media-Index / (rate-multiplier × base-rate × 3600)) % 24

mm = FLOOR(Media-Index / (rate-multiplier × base-rate × 60)) % 60

ss = FLOOR(Media-Index / (rate-multiplier × base-rate)) % 60

ff = FLOOR(Media-Index / rate-multiplier) % base-rate

For higher media-rates the extended media unit offset (ee) shall 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” shall be zero.

ee = FLOOR(Media-Index % rate-multiplier)

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

ffff = ff x rate-multiplier + 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 count-modulus.

J.2 Drop frame UTC compensated time address components for fractional rates

For fractional media-rates the drop frame algorithm may provide a close but not precise relationship with clock time. There will be a linear and constant drift. The UTC compensated count (UCC) drop frame algorithms described in Annex I define small extensions to the drop frame algorithms for short-day or long-day counts.

For fractional media-rates the UCC drop frame algorithms provide 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 incorporation. The daily variation is deterministic and, based on the date and the precise timestamp can be calculated.

J.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 shall be calculated using the following formulae. When the variable “UCCmode” is True the UCC 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 shall be calculated with the following formulae:

LoH = (60 x 60 x 30) – (6 x 9 x 2) = 108000 – 108 = 107892

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

LoCD = (24 x LoH) + UCCmode x (2 + 2 x Long-day)

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

LoDmu = LoCD + LSday x 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).

FrCount = (FLOOR(Media-Index / rate-multiplier)) % LoDmu

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

fUcc = UCCmode x (2 + 2 x Long-day) x FLOOR(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:

fLs = LSday x FLOOR(FrCount / LoCD) x 30

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

hh = FLOOR((FrCount – fUcc – fLS) / LoH) % 24

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

$$FoH = FrCount - hh \times LoH$$

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

$$FoTH = FoH - fUcc - fLS$$

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

$$mm = FLOOR((FoTH + 2 \times FLOOR(FoTH / 1800) - 2 \times FLOOR(FoTH / 18000)) / 1800)$$

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

$$FoM = FoH - mm \times 1798 - 2 \times FLOOR(mm / 10)$$

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

$$ss = FLOOR(FoM / 30)$$

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

$$ff = FoM \% 30$$

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

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

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

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

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.

J.2.2 Fractional rates related to 24/1.001 Hz

This clause is only applicable to fractional media-rates related to the base-rate 24/1.002 Hz and its integer multiples. There is no drop frame mode that is defined by SMPTE ST 12-1 for these rates.

The calculation of the time address component values for 24/1.001 Hz related fractional rates and their integer multiples shall be calculated using the following formulae. When the variable UCCmode is True the UCC drop frame calculations are enabled, and when False the normal drop frame calculations as defined by Annex I.3 are enabled.

The length in frames of one hour (LoH) is a constant value that shall be calculated with the following formula:

$$LoH = (60 \times 60 \times 24) - (6 \times 14 \times 2 + 2) = 86400 - 86 = 86314$$

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

$$LoCD = (24 \times LoH) + UCCmode \times (-8 + 2 \times Long\text{-}day)$$

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

$$LoDmu = LoCD + LSday \times 24$$

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).

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

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

$$fUcc = UCCmode \times (-8 + 2 \times Long\text{-}day) \times FLOOR(FrCount / LoCD))$$

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:

$$fLs = LSday \times FLOOR(FrCount / LoCD) \times 24$$

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

$$hh = FLOOR((FrCount - fUcc - fLS) / LoH) \% 24$$

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

$$FoH = FrCount - fUcc - fLS - hh \times LoH$$

The temporary variable (FoTM) is the count of frames for the current ten minute portion of the hour and it shall be calculated with the formula:

$$FoTM = FoH \% 14386$$

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

$$mm = FLOOR((FoTM + 2 \times FLOOR(FoTM / 1440) - 2 \times FLOOR(FoTM / 5760) + 2 \times FLOOR(FoTM / 84876)) / 1440) + 10 \times FLOOR(FoTM / 14386)$$

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

$$FoM = FoH - mm \times 1438 - 6 \times FLOOR(mm / 10) - 2 \times FLOOR((mm \% 10) / 4) + 2 \times FLOOR(FoH / 83438)$$

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

$$ss = FLOOR(FoM / 24)$$

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

$$ff = FoM \% 24$$

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

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

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

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

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.

Annex K SMPTE ST 309 date and time zone (informative)

The following Table 16, Table 17 and Table 18 replicate data from SMPTE ST 309 here for convenience. These define the optional coding of date and *local time* UTC offset in the binary groups of a SMPTE ST 12-1 timecode. The date is coded either as a 6-digit MJD or as a character format “YYMMDD” date as detailed in Table 16.

For MJD the date is coded as six BCD digits in binary groups 1 through 6. The units digit is in binary group 1.

For a “YYMMDD” character formatted date the century is not coded. The year should be presumed to be from 1970 to 2069, unless otherwise defined by the application. The date is coded as six BCD digits in binary groups 1 through 6. The day units digit is in binary group 1 and the year tens digit is in binary group 6.

Additional details are specified in SMPTE ST 309.

Table 16 – Date data in binary groups

Binary group	YYMMDD		MJD	
	Assignation	Value	Assignation	Value
1	‘D’ Day units	0 – 9	MJD units	0 – 9
2	‘D’ Day tens	0 – 3	MJD tens	0 – 9
3	‘M’ Month units	0 – 9	MJD hundreds	0 – 9
4	‘M’ Month tens	0 – 1	MJD thousands	0 – 9
5	‘Y’ Year units	0 – 9	MJD ten thousands	0 – 9
6	‘Y’ Year tens	0 – 9	n/a	0

Table 17 – ST 309 date format and time zone timescale offset in binary groups

Binary group	Assignation	Description	
7.0	TZ-0	1’s bit	Time zone code 0-63 (00-3FHEX) as specified in Table 18
7.1	TZ-1	2’s bit	
7.2	TZ-2	4’s bit	
7.3	TZ-3	8’s bit	
8.0	TZ-4	16’s bit	
8.1	TZ-5	32’s bit	
8.2	DST flag	‘0’ = DST not in effect ‘1’ = DST in effect.	
8.3	MJD flag	‘0’ = YYMMDD format ‘1’ = MJD format	

Table 18 – ST 309 time zone codes and UTC offsets

Code	Hours	Standard time (see Note 2)	Daylight saving time	Code	Hours	Standard time (see Note 2)	Daylight saving time
0	UTC	Greenwich		0A	UTC-00:30		
1	UTC-01:00	Azores		0B	UTC-01:30		
2	UTC-02:00	Mid-Atlantic		0C	UTC-02:30		Newfoundland
3	UTC-03:00	Buenos Aires	Halifax	0D	UTC-03:30	Newfoundland	
4	UTC-04:00	Halifax	New York	0E	UTC-04:30		
5	UTC-05:00	New York	Chicago	0F	UTC-05:30	Sri Lanka **	
6	UTC-06:00	Chicago	Denver	1A	UTC-06:30	Cocos Is. **	
7	UTC-07:00	Denver	Los Angeles	1B	UTC-07:30		
8	UTC-08:00	Los Angeles		1C	UTC-08:30	Venezuela **	
9	UTC-09:00	Alaska		1D	UTC-09:30	Marquesas Islands	
10	UTC-10:00	Hawaii		1E	UTC-10:30		
11	UTC-11:00	Midway Island	Lord Howe Is**	1F	UTC-11:30		
12	UTC-12:00	Kwajalein		2A	UTC+11:30		
13	UTC+13:00		New Zealand	2B	UTC+10:30	Lord Howe Is. **	Australia SA **
14	UTC+12:00	New Zealand		2C	UTC+09:30	Australia NT **	
15	UTC+11:00	Solomon Islands		2D	UTC+08:30		
16	UTC+10:00	Guam		2E	UTC+07:30		
17	UTC+09:00	Tokyo		2F	UTC+06:30		
18	UTC+08:00	Beijing		3A	UTC+05:30	India **	
19	UTC+07:00	Bangkok		3B	UTC+04:30	Afghanistan **	Iran **
20	UTC+06:00	Dhaka		3C	UTC+03:30	Iran **	
21	UTC+05:00	Islamabad		3D	UTC+02:30		
22	UTC+04:00	Abu Dhabi		3E	UTC+01:30		
23	UTC+03:00	Moscow		3F	UTC+00:30		
24	UTC+02:00	Eastern Europe	Central Europe	32	UTC+12:45	Chatham Island	
25	UTC+01:00	Central Europe	United Kingdom	33	Undefined		
26	Undefined	Reserved; do not use		34	Undefined		
27	Undefined	Reserved; do not use		35	Undefined		
28	Undefined	Deprecated		36	Undefined		
29	Undefined	Deprecated		37	Undefined		
30	Undefined	Deprecated		38	User defined time offset		
31	Undefined	Deprecated		39	Undefined		

Note 1: Locations marked with ** are updates to the table in the published SMPTE ST 309-2012.

Note 2: Time zones are under the jurisdiction of the local authorities and can change at any time.

Note 3: Not all time zones in effect are covered by this table. There are some 45 minute offsets missing.

Annex L Unresolved Comments received during Technology Committee Ballot

During the Ballot process, there were several comments received that were unable to be resolved to the satisfaction of the commenter. According to the provisions of the Standards Operations Manual, there was the recommendation from the Standards Vice President to append these comments.

L.1 Comments from various commenters

The comments expressed by the commenters submitted the comments primarily relate to modification of the standard and the effect on receiving devices..

Comment: “My concern is technical adequacy and this language from page 31:"Legacy equipment, applications and standards can transport and store the enhanced timecode without the requirement for modifications. "”

Comment: “I cannot accept that summary conclusion at face value. I believe that, were a device sending RDD-46 compliant time label streams to a receiving device that only knew ST 12, that receiving device is highly likely to be confused -- possibly terminally so -- were the device or its displays to encounter second values that run from 0 to 58, 0 to 59 or 0 to 60 (as one example). Many of the embedded universe of devices also have code committed to silicon that cannot be updated.”

Comment: “I will have to abstain from voting for RDD-46 until I am assured that one or changes are made to the document to prevent a ST 12 receiving/processing system to unknowingly be exposed to RDD-46-compliant streams.”

Comment: “Title is misleading. To me, "SMPTE Timecode Extensions – Relationships to Higher Rates and Date-Time" suggests that the extensions are part of SMPTE Timecode. Also, the word Extensions implies compatibility with SMPTE ST 12 .”

Proposed Solution by the Commenter: “I suggest "Modification to SMPTE Timecode – Relationships to Higher Rates and Date-Time"”

Comment: I don't think this is a bad idea, but it still concerns me that the RDD defines a stream that appears to conform to an approved standard, but does not. I am advised that an ST 12 receiver will decode the RDD 46 stream syntax, but I assume it will pass to the next level a series of values that contains (according to ST 12) illegal values and sequences.”

L.2 Aggregated Response containing elements discussed with the Commenters

An RDD by definition is a manufacturer's implementation that may deviate from the normative provisions of a standard. The title of this RDD is "SMPTE Timecode Extensions – Relationships to Higher Rates and Date-Time" Considering “Modifications” vs “Extensions” in the title, extensions are appropriately better classified as additions that are a subset of modifications. Using the word modifications would also imply more extensive and substantive changes.

There seems to be a common perception from the comments that the SMPTE Timecode is being extended in a manner that is not in conformance with SMPTE ST 12-1 and that this will break receiving devices. One comment expresses this concern with the use of the term extension rather than modification. The following highlights how RDD 46 and the extensions are conformant with the normative and informative provisions of SMPTE ST 12-1.

Media alignment relative to the SMPTE epoch as specified in SMPTE ST 2059-1 results in integer rate media being aligned to each second. However, at fractional rates the media is only aligned every 1001 seconds and there is a non-integer number of media units in a 24-hour time period. The SMPTE standard ST 12-1 clauses “Time Address of a Frame” normatively require “Each frame shall be identified by a unique and complete address” however it does not specify how the additional frames required for two cases shall be labeled.

1. The incorporation of a positive leap second that is referred to in defining standards as second “23:59:60” extends the calendar day to 85401 seconds and thus requires additional time address labels.
2. For the 30/1001 Hz rate there are 2589410.(589410) frames in a 24-hour (86400 second) day but there are only 2589408 time address labels from 00:00:00;00 to 23:59:59;29. An additional 2 or 4 labels (in pairs to preserve a two frame cadence) are required to maintain a long-term correspondence with clock time.

The time address ranges from 00:00:00:00 to 23:59:59:23/24/29 are not modified and are fully compliant with ST 12-1. Extending the counts at the end-of-day with a seconds’ count beyond ‘59’ is implicit with the provisions of Annex A.2 and also the time-of-day associated with the leap second. RDD 46 extends the time address beginning with 23:59:60;00, successively numbering the frames until the end-of-day in conformance with the ST 12-1 requirement for “unique and complete address” and “frames shall be successively numbered” for each time address of the timecode day.

There are no changes to the defined specifications for the flag bits. The binary groups flags can signal the SMPTE ST 262 page-line protocol used to extend the labels for integer multiples of the base rates and also to code the frame rate, the date, the UTC offset, the leap second offset, and operational status flags that facilitate the mathematically precise conversion back to clock timestamp..

In conclusion, these changes are better characterized as extensions rather that the broader term of modifications. These extensions are implemented in conformance with normative provisions of ST 12 1. While receiving devices are out-of-scope the extensions should not affect the normal operation of receivers with the possible exception of the midnight rollover. Guidance is provided for minimizing the effects of the changes around the midnight rollover. The determination of the precise time point for the first time address of the day facilitates a symmetric, mathematically precise relationship between the time address and clock time.

Bibliography (informative)

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SMPTE ST 12-3:2016, Time Code for High Rate Signals and Formatting in the Ancillary Data Space

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