# SMPTE STANDARD

# SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications



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## Foreword

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

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2059-2 was prepared by Technology Committee 32NF.

## Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

## Introduction

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

IEEE 1588 is a standard for a Precision Time Protocol (PTP) that enables precise synchronization of clocks in measurement and control systems implemented with technologies such as network communication, local computing, and distributed objects. The clocks communicate with each other over a communication network. The protocol generates a master-slave relationship among the clocks in the system. All clocks ultimately derive their time from a clock known as the grandmaster clock. In its basic form, this protocol is intended to be administration free.

IEEE Std 1588-2008 introduces the concept of a PTP profile. The purpose is to specify particular combinations of options and attribute values to support a given application. The purpose of the profile is described in Subclause 19.3.1.1 'General' of IEEE Std 1588-2008:

> *"The purpose of a PTP profile is to allow organizations to specify specific selections of attribute values and optional features of PTP that, when using the same transport protocol, inter-work and achieve a performance that meets the requirements of a particular application.*
>
> *A PTP profile is a set of required options, prohibited options, and the ranges and defaults of configurable attributes. Profiles specifications shall be consistent with the specifications in Subclauses 19.2.1 and 19.2.2."*

Subclause 19.3.1.2 ‘PTP profile recommendations’ of IEEE Std 1588-2008 specifies what a PTP Profile should contain. This includes:

- Which of the best master clock algorithm options is to be implemented.
- Which of the configuration management options is to be implemented.
- Which of the path delay mechanisms, delay request-response or peer delay is to be implemented.
- The range and default values of all PTP configurable attributes and data set members.
- The transport mechanisms required, permitted, or prohibited.
- The node types required, permitted, or prohibited.
- The options required, permitted, or prohibited.

This Standard defines the SMPTE PTP Profile for time and frequency synchronization in a professional broadcast environment. It is intended to be used with SMPTE ST 2059-1 which defines a point in time, the SMPTE Epoch, which is used for alignment of real-time signals; formulae which specify the ongoing alignment of signals to time since the SMPTE Epoch; and formulae which specify the calculation of SMPTE ST 12-1 time address values and SMPTE ST 309 date values. A basic understanding of these concepts that are described in SMPTE ST 2059-1 will be helpful to readers of ST 2059-2.

Synchronization is considered to have been achieved when network-based time accuracy between any two slave devices with respect to the master reference is within 1 microsecond. This standard is capable of providing a higher degree of accuracy depending on the network architecture.

This profile is designed with the following purposes in mind:

- To permit a slave to be synchronized within 5 seconds of its connection to the operational PTP network. While there are many factors that will in practice influence the synchronization time, the default values of configurable attributes have been chosen to help achieve this target.
- Having achieved initial synchronization, to maintain network-based time accuracy between any two slave devices with respect to the master reference within 1 microsecond.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.

## 1 Scope

This standard specifies a Precision Time Protocol profile specifically for the synchronization of audio/video equipment in a professional broadcast environment.

The profile is based on IEEE Std 1588-2008 and includes a self-contained description of parameters, their default values, and permitted ranges.

## 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 section explicitly labeled as "Informative" or individual paragraphs that start with "Note:”

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

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

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

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

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

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

## 3 Normative References

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

IEEE Std 1588-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems[1]

IETF RFC 2236, Internet Group Management Protocol , Version 2 (IGMPv2)

[1] IEEE-1588 is a registered trademark of the Institute of Electrical and Electronics Engineers, Inc.

IETF RFC 2710, Multicast Listener Discovery (MLD) for IPv6

IETF RFC 3376, Internet Group Management Protocol, Version 3 (IGMPv3)

IETF RFC 3810, Multicast Listener Discovery Version 2 (MLDv2) for IPv6

# 4 Definition of Terms and Acronyms

## 4.1 Big-endian

Also known as ‘network order’, a byte order where the bytes of a word are transmitted such that the most significant Byte is transmitted first.

## 4.2 Byte

An ordered sequence of 8-bits, also termed an octet.

## 4.3 Daily Jam

An optional daily procedure carried out within a facility that uses SMPTE ST 12-1 time code in which the time address value is adjusted to correspond to Local Time at the chosen time of the Daily Jam. It is usually carried out in the early hours of the morning at a non-sensitive time as determined by the operator of the facility.

Note: The term "Daily Jam" is historical and used in that context. This standard does not constrain the jam to take place on a daily basis. In some systems it could occur only as required to accommodate discontinuities such as Leap Seconds or daylight saving time adjustment.

## 4.4 Grandmaster clock

Within a PTP domain, a clock that is the ultimate source of time for clock synchronization using the Precision Time Protocol as defined in IEEE Std 1588-2008.

## 4.5 Link

A network segment between two Precision Time Protocol (PTP) ports supporting the peer delay mechanism of the IEEE Std 1588-2008.

## 4.6 Local Time

The time (and date) as chosen by the facility's system administrator and implemented by the system. This is typically the calendar date and time-of-day in common use in the locality. It usually includes an offset from UTC indicating the time zone, accumulated Leap Seconds by the rules of UTC, and, where observed, daylight saving time (summer time) by the rules of the responsible authority.

## 4.7 Master clock

In the context of a single Precision Time Protocol (PTP) communication path, a clock that is the source of time to which all other clocks on that path synchronize.

## 4.8 Octet

A sequence of 8 bits, also known as a byte.

## 4.9 PTP

Precision Time Protocol as defined in IEEE Std 1588-2008.

### 4.10 PTP Domain

A logical grouping of clocks that synchronize to each other using the Precision Time Protocol, but that are not necessarily synchronized to clocks in another domain. See also IEEE Std 1588-2008, Subclause 7.1.

### 4.11 PTP epoch

The origin of the timescale of a domain as defined in IEEE Std 1588-2008 (see Subclause 7.2.2).

### 4.12 PTP time

The time elapsed since the PTP epoch as conveyed by the Precision Time Protocol as defined in IEEE Std 1588-2008 (see Subclause 7.2).

Note: The PTP epoch as defined above is 63072010 seconds before 1972-01-01T00:00:00Z (UTC).

Note: This PTP epoch is the same as the SMPTE epoch as defined in SMPTE ST 2059-1.

### 4.13 Slave clock

In the context of a single Precision Time Protocol (PTP) communication path, a clock that may synchronize to another clock.

### 4.14 SM: Synchronization Metadata

Metadata required for the synchronization of audio/video signals.

### 4.15 Synchronization signal

A reference signal used for the synchronization of audio/video equipment in a professional broadcast environment, for which a phase relationship with respect to the SMPTE Epoch has been defined (see SMPTE ST 2059-1).

### 4.16 Time Jump

A discontinuity in local time that is known in advance, caused typically by an adjustment to the number of accumulated leap seconds or a change in daylight saving time.

## 5 PTP Profile

### 5.1 Profile Identification

The PTP Profile shall be identified as follows:

PTP Profile:
SMPTE profile for synchronization in a professional broadcast environment
Version 1.0
Profile identifier: 68-97-E8-00-01-00
This profile is specified by Society of Motion Picture and Television Engineers (SMPTE)
A copy may be obtained from www.smpte.org

### 5.2 Best Master Clock Algorithm (BMCA)

The default best master clock algorithm (BMCA) defined in IEEE Std 1588-2008 (Subclauses 9.3.2, 9.3.3, 9.3.4) shall be used.

### 5.3 Management Mechanism

Management messages are used to access attributes and to generate certain events defined in this standard, and for sending the SM dataset.

The management mechanism specified in Subclause 15.2 ‘PTP management mechanism’ of IEEE Std 1588-2008 shall be used.

### 5.4 Path Delay Measurement Mechanism

The delay request-response mechanism shall be the default path delay measurement mechanism. The peer delay mechanism may also be implemented.

Note: A boundary clock with ports supporting each of the two mechanisms could be used to bridge between the different mechanisms. As per IEEE Std 1588-2008, for each master-slave connection only a single mechanism is permitted.

### 5.5 PTP Attribute Values

Attributes not specified by this profile shall use the default initialization values and ranges specified in IEEE Std 1588-2008. The following attributes are specified by this profile:

#### 5.5.1 Configurable data set members

| | | |
|---|---|---|
| **defaultDS.priority1** | Default value: | 128 |
| | Configurable range: | 0 to 255 |

| | | |
|---|---|---|
| **defaultDS.priority2** | Default value: | 128 |
| | Configurable range: | 0 to 255 |

defaultDS.priority1 specifies the priority to be used in the execution of the BMCA. defaultDS.priority2 specifies the secondary priority to be used in the execution of the BMCA.

The above default initialization values are the same as those specified in the Default PTP profiles in Annex J.3 and Annex J.4 of IEEE Std 1588-2008.

| | | |
|---|---|---|
| **defaultDS.domainNumber** | Default value: | 127 |
| | Configurable range: | 0 to 127 |

A domain consists of one or more PTP devices communicating with each other as defined by the protocol. The domain is identified by an integer, the domainNumber, in the configurable range of 0 to 127.

| | | |
|---|---|---|
| **defaultDS.slaveOnly** | Ordinary clocks not capable of or not intended to enter the master state: | TRUE |
| | Otherwise: | FALSE |

Note: Slave-only devices are expected to be common in typical system configurations using this profile.

| | | |
|---|---|---|
| **portDS.logAnnounceInterval**: | Default value: | -2 |
| | Configurable range: | -3 to +1 |

The portDS.logAnnounceInterval specifies the mean time interval between successive Announce messages, i.e., the announceInterval. This interval in concert with announceReceiptTimeout governs how quickly the BMCA re-configures the system in the event of a master failure.

The portDS.logAnnounceInterval shall be chosen to be uniform throughout a domain.

Note: The value of the parameter is the logarithm to base 2 of the time interval in seconds. (For example, an interval of 0.25 s gives a value of -2, and an interval of 2 s gives a value of +1.)

In order to facilitate the 5-second synchronization time requirement, the default value, or a shorter interval than the default, is recommended.

| | | |
|---|---|---|
| **portDS.announceReceiptTimeout**: | Default value: | 3 |
| | Configurable range: | 2 to 10 |

The value of portDS.announceReceiptTimeout specifies the number of announceIntervals that have to pass without receipt of an Announce message before the occurrence of the event ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES.

The above default initialization value and configurable range is as specified in the Delay Request-Response Default PTP profile in Annex J.3 of IEEE Std 1588-2008.

| | | |
|---|---|---|
| **portDS.logSyncInterval**: | Default value: | -3 |
| | Configurable range: | -7 to -1 |

The portDS.logSyncInterval specifies the mean time interval between successive Sync messages. The value of the parameter is the logarithm to base 2 of the time interval in seconds.

This interval is set to a low value (i.e. high message rate) to allow the slaves to synchronize quickly. In order to facilitate the 5-second synchronization time requirement, the default value, or a shorter interval than the default, is recommended.

| | | |
|---|---|---|
| **portDS.delayMechanism:** | Delay request-response: | 01h |
| | Peer delay: | 02h |

The portDS.delayMechanism specifies the propagation delay measuring option used by the port, as per Subclause 5.4 of this profile.

| | | |
|---|---|---|
| **portDS.logMinPDelayReqInterval** | Default value: | equal to portDS.logSyncInterval |
| | Configurable range: | portDS.logSyncInterval to portDS.logSyncInterval+5 |

The portDS.logMinPDelayReqInterval specifies the minimum permitted mean time interval between successive Pdelay_Req messages, i.e., the minPdelayReqInterval, sent over a link.

Note: Synchronization might not be possible within 5 seconds with portDS.logMinPDelayReqInterval values greater than 2.

| | | |
|---|---|---|
| **transparentClockDefaultDS.delayMechanism** | End-to-end transparent clock: | 01h |
| | Peer-to-peer transparent clock | 02h |

The transparentClockDefaultDS.delayMechanism specifies the delay measuring option used by the transparent clock.

**transparentClockDefaultDS.primaryDomain** Default value: same as defaultDS.domainNumber

The transparentClockDefaultDS.primaryDomain specifies the primary syntonization domain of the transparent clock.

### 5.5.2 Dynamic data set members

**portDS.logMinDelayReqInterval**: Default initialization value: portDS.logSyncInterval

Permitted range:
portDS.logSyncInterval to portDS.logSyncInterval + 5

portDS.logMinDelayReqInterval is a dynamic attribute determined and advertised by a master clock based on the ability of the master clock to process the Delay_Req message traffic. (See Subclause 7.7.2.4 'Delay_Req message transmission interval' of IEEE Std 1588-2008).

The default initialization value should be as above. Optionally, a different initialization value may be configured within the permitted range. The master should not increase the value of portDS.logMinDelayReqInterval with respect to the initialized value (decrease the message rate) unless the number of slaves exceeds the number that the master is able to support at the initialized rate.

### 5.5.3 Other attributes

**τ**: Default value: 1.0 s

This is the sample period between measurements in the variance algorithm, as described in Subclause 7.6.3.2 'Variance algorithm' of IEEE Std 1588-2008.

The above default initialization value is as specified in the Delay Request-Response Default and the Peer-to-Peer Default PTP profiles in Annex J.3 and J.4 of IEEE Std 1588-2008.

### 5.5.4 Additional Enumerated Values

**timeSource**

The value of timeSource provides information about the source of time used by the master and shall be as enumerated in Subclause 7.6.2.6 of IEEE Std 1588-2008 or one of the following two additional enumerated values defined in this profile:

| | |
|---|---|
| timeSource = F0h | Time in the master is derived from the periodicity of a synchronization signal where the time value is undefined and is not related to real time and the timescale is ARB. |
| timeSource = F1h | Time in the master is derived from the periodicity of a synchronization signal and is initially referenced to a local time source. Subsequent time accuracy in relation to real time will depend on the frequency accuracy of the synchronization signal. |

**clockClass**

In addition to the characteristics defined in Table 5 of IEEE Std 1588-2008, a clock may be designated by the additional enumerated values of clockClass defined in this profile as shown in Table 1.

**Table 1 – Additional clockClass values**

| clockClass (decimal) | Specification |
|---|---|
| 150 | A clock whose frequency is synchronized to a reference with ± 1 ppm frequency accuracy (for example, a Grade-1 DARS according to AES11-2009), relative to the SI second, that has been previously synchronized to a primary reference time source. The timescale distributed shall be PTP. |
| 158 | A clock whose frequency is synchronized to a reference with ± 10 ppm frequency accuracy (for example, a Grade-2 DARS according to AES11-2009), relative to the SI second, that has been previously synchronized to a primary reference time source. The timescale distributed shall be PTP. |
| 220 | A clock whose frequency is synchronized to a reference with ± 1 ppm frequency accuracy (for example, a Grade-1 DARS according to AES11-2009), relative to the SI second, that has not been previously synchronized to a primary reference time source. The timescale distributed shall be ARB. |
| 228 | A clock whose frequency is synchronized to a reference with ± 10 ppm frequency accuracy (for example, a Grade-2 DARS according to AES11-2009), relative to the SI second, that has not been previously synchronized to a primary reference time source. The timescale distributed shall be ARB. |

## 5.6 Slave Clocks

Slaves shall support one-step and two-step clocks.

## 5.7 Clock Physical Requirements

### 5.7.1 Frequency accuracy

For application as the master reference for a plant synchronization system, the PTP grandmaster clock shall maintain a frequency deviating within 5 parts per million (ppm) from the SI second.

This accuracy may not be appropriate for all applications; requirements for precision and stability of oscillators for both Master and Slave devices are application dependent, and appropriate choices should be made during system design.

### 5.7.2 Frequency adjustment range

Any clock in the SLAVE state shall be able to correct its frequency to match any master clock meeting the requirement above.

## 5.8 Node Types Required, Permitted or Prohibited

| | |
|---|---|
| Required node types: | Ordinary Clocks |
| Permitted node types: | Boundary Clocks, End-to-end Transparent Clocks, Peer-to-peer Transparent Clocks, Management node |
| Prohibited node types: | None |

Note: It is intended that the SMPTE profile be flexible and allow any kind of node type to be used according to application requirements.

### 5.9 Transport Mechanisms Permitted

Permitted transport mechanisms: UDP over IPv4 as specified in in Annex D of IEEE Std 1588-2008
UDP over IPv6 as specified in in Annex E of IEEE Std 1588-2008

At least one of the two permitted transport mechanisms shall be supported.

Boundary clocks supporting both transports simultaneously shall be permitted.

Transparent Clocks shall forward IPv4 messages using IPv4 and shall forward IPv6 messages using IPv6.

### 5.10 Communication Model

Required message transport modes for Announce, Sync and Follow_Up messages: multicast

Permitted message transport modes for Announce, Sync and Follow_Up messages: unicast

Unicast negotiation is not mandatory for Announce and Sync messages.

Within a PTP Domain, Announce, Sync and Follow_Up messages shall use the same transport mode, and shall be either all multicast or all unicast.

Delay_Req messages may be multicast or unicast.

Unicast negotiation is not required for Del_Req messages. Every port in the MASTER state receiving the unicast Delay_Req message shall transmit a unicast Delay_Resp message (see IEEE Std 1588-2008, Subclause 9.5.12).

Note: If unicast is used for Sync and Announce messages, and unicast negotiation is not used, another mechanism is required to convey IP addresses of slaves to the master.

Pdelay_Req messages may be multicast or unicast.
Pdelay_Resp and Pdelay_Resp_Follow_Up messages shall be unicast.

Management messages may be multicast or unicast. Replies to management messages shall be unicast.

For IPv4 multicast messages, receivers shall support IGMPv2 and should support IGMPv3. For IPv6 multicast messages, receivers shall support MLDv2 and may support MLDv1.

### 5.11 PTP Options

Required: none

Permitted: Alternate master, Path trace, unicast message negotiation, Alternate timescales, Acceptable master table

Prohibited: Grandmaster clusters, Unicast discovery

### 5.12 Alternate Master

To allow seamless switch-over to a new master, one or more alternate master nodes may be supported.

A Master acting as an Alternate Master shall respond to a Delay_Req message.

The Alternate Master TLV (type, length, value) as described in Subclause 17.4 ‘Alternate master (optional)’ of IEEE Std 1588-2008 shall not be used. Instead both the sync and the announce message rate shall be communicated via the respective data fields in the common header section of the respective message.

For every Alternate Master Announce and Sync message, the rate should be set to the same values as used by the current master.

### 5.13 Organization Extension TLV: Synchronization Metadata

This document follows the byte and bit endianness presentation conventions used in IEEE Std 1588-2008 conventions.

Once every second and also when Master Locking Status is changed, every port in MASTER state in a grandmaster clock shall issue a Management Message with Synchronization Metadata (SM) TLV appended.

The Management Message (COMMAND) shall be as defined in Table 2 and the SM TLV shall be set as defined in Table 3. To avoid packet burst in large PTP networks a slave should not issue the Management Message (ACKNOWLEDGE) when the Management Message (COMMAND) with the SM TLV is received.

Note: Messages related to synchronization, establishing the master−slave hierarchy, and signaling terminate in the protocol engine of a boundary clock and are not forwarded. Management messages are forwarded by other ports on the boundary clock subject to restrictions to limit the propagation of these messages within the system.

**Table 2 – Structure of Management Message (COMMAND)**

| Bits | | | | | | | | Octets (Bytes) | Offset | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | | |
| Header | | | | | | | | 34 | 0 | See IEEE Std 1588-2008, Subclause 13.3 |
| targetPortIdentity | | | | | | | | 10 | 34 | All ones |
| startingBoundaryHops | | | | | | | | 1 | 44 | Maximum 32 |
| boundaryHops | | | | | | | | 1 | 45 | Updated by Boundary Clock |
| Reserved | | | | actionField | | | | 1 | 46 | actionField = COMMAND |
| Reserved | | | | | | | | 1 | 47 | |
| SM TLV (see Table 3) | | | | | | | | 52 | 48 | |

**Table 3 – Structure of SM TLV**

| Item | Octets (Bytes) | Offset | Description |
|---|---|---|---|
| tlvType | 2 | 0 | ORGANIZATION_EXTENSION, which has the value of 00 03. |
| lengthField | 2 | 2 | The length of the whole SM TLV data structure. This shall be an even number. |

| Item | Octets (Bytes) | Offset | Description |
|---|---|---|---|
| organizationId | 3 | 4 | 68 97 E8 (SMPTE OUI) |
| organizationSubType | 3 | 7 | Used to indicate the SM TLV version for management of forward / backward compatibility.<br>00 00 01 for this version. |
| defaultSystemFrameRate | 8 | 10 | Default video frame rate of the slave system as a lowest term rational. The data type shall be composed of a pair of unsigned Int32 values coded in big-endian form where the first shall be the numerator and the second shall be the denominator. The denominator shall be the smallest value that represents the frame rate denominator[2]. |
| masterLockingStatus | 1 | 18 | Complementary information to clockClass[3]<br>0: Not in use<br>1: Free Run<br>2: Cold Locking<br>In response to a disturbance, the grandmaster is re-locking quickly. In this situation, a rapid phase adjustment with a time discontinuity can be expected.<br>3: Warm Locking<br>In response to a disturbance, the grandmaster is re-locking slowly by means of a frequency adjustment, with no phase discontinuity. Time continuity is maintained.<br>4: Locked (i.e., in normal operation and stable) |
| timeAddressFlags | 1 | 19 | Indicates the intended SMPTE ST 12-1 flags.<br>Bit 0: Drop frame<br>0: Non-drop-frame<br>1: Drop-frame<br>Bit 1: Color Frame Identification<br>0: Not in use<br>1: In use<br>Bits 2-7: Reserved |

[2] For example, for a video frame rate of 30000/1001 Hz (i.e., 30/1.001 Hz or nominally “29.97” Hz), the number would appear as 00 00 75 30 00 00 03 e9 in hexadecimal format.

[3] The Announce Message has a parameter named clockClass which can convey similar information. Because the clockClass parameter indicates only whether the grandmaster is locked or unlocked, complementary information about the behavior of the grandmaster in the event of a disturbance can be set using this field.

| Item | Octets (Bytes) | Offset | Description |
|---|---|---|---|
| currentLocalOffset | 4 (int32) | 20 | Offset in seconds of Local Time from grandmaster PTP time[4]. See Section 5.14. |
| jumpSeconds | 4 (int32) | 24 | The size of the next discontinuity, in seconds, of Local Time. A value of zero indicates that no discontinuity is expected. A positive value indicates that the discontinuity will cause the currentLocalOffset to increase. |
| timeOfNextJump | 6 (uint48) | 28 | The value of the seconds portion of the grandmaster PTP time at the time that the next discontinuity of the currentLocalOffset will occur. The discontinuity occurs at the start of the second indicated. See Section 5.14. |
| timeOfNextJam | 6 (uint48) | 34 | The value of the seconds portion of the PTP time corresponding to the next scheduled occurrence of the Daily Jam.<br>If no Daily Jam is scheduled, the value of timeOfNextJam shall be zero. See Section 5.14. |
| timeOfPreviousJam | 6 (uint48) | 40 | The value of the seconds portion of the PTP time corresponding to the previous occurrence of the Daily Jam.<br>See Section 5.14. |
| previousJamLocalOffset | 4 (int32) | 46 | The value of currentLocalOffset at the time of the previous Daily Jam event.<br>If a discontinuity of Local Time occurs at the jam time, this parameter reflects the offset after the discontinuity. The default value shall be the current value of currentLocalOffset<br>See Section 5.14. |
| daylightSaving | 1 | 50 | Bit 0: Current Daylight Saving<br>0: Not in effect<br>1: In effect<br>Bit 1: Daylight Saving at next discontinuity<br>0: Not in effect<br>1: In effect<br>Bit 2: Daylight Saving at previous Daily Jam event<br>0: Not in effect<br>1: In effect<br>Bits 3-7: Reserved<br>See Section 5.14. |

[4] For example, if Local Time is Eastern Standard Time (North America) UTC−5, the date is 2014-01-01, and the time difference between TAI and UTC taking into account the number of leap seconds is -35, the value will be -18035 (decimal). If Daylight Saving is in effect (Eastern Daylight Time) UTC−4, the date is 2014-07-01, and the time difference between TAI and UTC taking into account the number of leap seconds is -35, the value will be -14435 (decimal).

| Item | Octets (Bytes) | Offset | Description |
|---|---|---|---|
| leapSecondJump | 1 | 51 | The reason for the forthcoming discontinuity of currentLocalOffset indicated by timeOfNextJump<br>Bit 0:<br>0: Other than a change in the number of leap seconds (default)<br>1: A change in number of leap seconds<br>Bits 1-7: Reserved<br>See Section 5.14.1 |

Note: In the event that Local Time has a discontinuity arising from the application of jumpSeconds, precautions need to be taken to ensure that multiple Daily Jam events do not occur as a consequence or are not missed.

Note: SM TLV messages could experience slight delays from network transit times and internal processing in the slave before being ready for use. jumpSeconds and timeOfNextJump are designed to compensate for these delays by informing the slave in advance when changes signaled by the synchronization metadata are to be applied to time address calculations. Use of this mechanism in the slave is detailed in SMPTE ST 2059-1.

All SM TLV data types shall be encoded in big-endian format and the LSB shall be bit 0. Other data types are as described in IEEE Std 1588-2008.

To determine Local Time, the slave clock shall add the signed 32-bit seconds field currentLocalOffset to the PTP time reconstructed in the slave.

### 5.14 Setting dynamic SM TLV Values

A Time Jump event is signaled in advance to indicate the future occurrence of a discontinuity in local time. This may be caused by an adjustment to the number of accumulated leap seconds or daylight saving time.

The occurrence of the Daily Jam event, used to adjust the SMPTE ST 12-1 time address value generated in slaves to local time, is also signaled in advance. This is signaled separately to a Time Jump event.

The SMPTE ST 12-1 time address discontinuity arising from the Time Jump event might not be immediately reflected in the time address value generated in slaves. Rather, the adjustment to the SMPTE ST 12-1 time address value is made at the next Daily Jam event (see SMPTE ST 2059-1).

The values of several of the SM TLV items listed in Table 3 are dynamic in nature: currentLocalOffset, jumpSeconds, timeOfNextJump, timeOfNextJam, timeOfPreviousJam, previousJamLocalOffset, leapSecondJump and daylightSaving.

The values of some of these items are influenced by local operational policies and requirements. These include the local time zone, the time of the daily jam (if applicable), the dates and times when daylight saving time will take effect or end, and when leap-second changes occur.

Conversion of time in seconds from the SMPTE epoch on the local time scale into one of the date formats of SMPTE ST 309 is defined in ‘Generation of the SMPTE ST 309 Date’ in SMPTE ST 2059-1.

Care must 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.

Section 5.14.1 specifies how SM TLV items are set in order to signal a Time Jump event.

Section 5.14.2 specifies how SM TLV items are set in order to signal the Daily Jam event.

### 5.14.1 Signaling a Time Jump event

If the time of the next Time Jump event is not yet known, jumpSeconds and timeOfNextJump shall be set to 0.

To signal a Time Jump event, timeOfNextJump should be changed to the required value at least one day in advance of the event. In the same Management Message as the aforementioned change in value of timeOfNextJump and in subsequent Management messages, jumpSeconds shall be set to the value of the required time discontinuity of the Time Jump event and leapSecondJump shall be set to the appropriate value for the forthcoming discontinuity.

If the reason for the Time Jump event is the insertion or deletion of a leap second, Bit 0 of leapSecondJump shall be set to 1. In the case of an inserted (positive) leap second, jumpSeconds shall be set to −1 and timeOfNextJump shall be set to the PTP time of the second following the inserted second. In the case of a deleted (negative) leap second, jumpSeconds shall be set to +1 and timeOfNextJump shall be set to the PTP time of the second following the deleted second.

When the grandmaster PTP time seconds becomes greater than the unsigned 48-bit timeOfNextJump field (i.e., when the time of the event has been passed), the values of the following SM TLV items shall be changed as indicated:

- currentLocalOffset shall be adjusted to take into account the time discontinuity occurring at the Time Jump event.
- jumpSeconds and timeOfNextJump shall be set to 0 if no further Time Jump event is to be signaled and these values shall be maintained in subsequent Management Messages until the next Time Jump event is known.
- daylightSaving shall be set to an updated value in accordance with its usage as described in Table 3 and this value shall be maintained in subsequent Management Messages until the next Time Jump event related to a daylight saving change has taken place.
- if the value of Bit 0 of leapSecondJump had been set to 1, it shall be restored to its default value of 0.

### 5.14.2 Signaling the Daily Jam event

If Daily Jam is not in use, timeOfNextJam shall be set to zero, and timeOfPreviousJam and previousJamLocalOffset shall be set to achieve the required initialization of slave devices.

Note: In integer frame rate environments, setting timeOfPreviousJam to any time in the past, such as zero, and previousJamLocalOffset to currentLocalOffset will result in generated time addresses being aligned with Local Time.

If Daily Jam is in use, timeOfNextJam shall be initialized to the value corresponding to the next scheduled occurrence of the Daily Jam event in accordance with the steps described in Annex A. timeOfPreviousJam shall be initialised to the value corresponding to when the previous Daily Jam event would have been and previousJamLocalOffset shall be initialised to the value of currentLocalOffset that would have been applicable at the time of the previous jam.

The values shall be such that:
timeOfNextJam + currentLocalOffset = timeOfPreviousJam + previousJamLocalOffset + (24 x 60 x 60)

Note: After initailization in the way described above, the above equation takes into account any adjustments to local time caused by changes in daylight saving or the number of leap second.

Following initialization of timeOfPreviousJam and previousJamLocalOffset, their values should not be changed until after a jam has taken place.

The following procedure shall then be followed.

When the grandmaster PTP time seconds becomes greater than the value of timeOfNextJam (i.e., when the time of the Daily Jam has been passed, the values of the following SM TLV items shall be changed as indicated:

- previousJamLocalOffset shall be set to the value of currentLocalOffset at the time of the Daily Jam event that has just passed and this value of previousJamLocalOffset shall be maintained in subsequent Management Messages until the next Daily Jam event.

- timeOfPreviousJam shall be set to the value of timeOfNextJam and this value of timeOfPreviousJam shall be maintained in subsequent Management Messages until the next Daily Jam event.

- timeOfNextJam shall be set to the value corresponding to the next scheduled Daily Jam event or zero if no forthcoming jam event is scheduled.

# Annex A Calculation of timeOfNextJam (Normative)

timeOfNextJam shall correspond to the Local Time of the Daily Jam that is an integer multiple of 600 seconds (i.e., in units of 10 minutes) after the hour of the next scheduled occurrence.

The following steps shall be used to calculate timeOfNextJam:

Where the jam is required to take place on a daily basis at a user-selected time of day on the Local Time scale and where the hours and minutes are userDailyJamTimeHH and userDailyJamTimeMM respectively:

t is the is the elapsed time from the PTP Epoch in seconds

int(x) rounds the element ‘x’ to the nearest integer towards zero

t_mlocal and t_pdjamLocal are local scope temporary variables

1. Calculate time of midnight on Local Time scale (t_mlocal)
   t_mlocal = int ((t + currentLocalOffset)/(24×60×60))×24×60×60
2. Calculate next Time of Daily Jam on local time scale (t_pdjamLocal)
   t_pdjamLocal = t_mlocal + (userDailyJamTimeHH×60×60) + (userDailyJamTimeMM×60)
3. Calculate time of next Daily Jam on the PTP scale
   timeOfNextJam = t_pdjamLocal - currentLocalOffset
4. Ensure timeOfNextJam is in the future
   If t is greater than or equal to timeOfNextJam then
   timeOfNextJam = timeOfNextJam + (24×60×60)
   endif

If currentLocalOffset is scheduled to change (as signaled by timeOfNextJump) in advance of the next planned occurrence of the Daily Jam, the value of timeOfNextJam shall be adjusted by the same amount to ensure that timeOfNextJam corresponds to the correct local time of the intended jam.

When the jam is required to take place at the time of the next discontinuity in Local Time (for example, to coincide with a change in daylight saving time), the following equation shall be used to generate timeOfNextJam.

timeOfNextJam = timeOfNextJump

Note: The above provision is also needed when implementing a single jam event in plants that do not use Daily Jam.

## Annex B Bibliography (Informative)

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