

# 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 Std 1588-2008 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 hierarchical 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 IEEE Std 1588-2008 subclause 19.3.1.1 'General':

*"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 algorithm to implement to compare clocks to determine the best clock to use as a source of time.
- 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.

This profile is designed with the following purposes in mind:

- To permit clocks to be synchronized quickly and accurately to enable professional media over IP applications.
- 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 SMPTE PTP profile is based on IEEE Std 1588-2008 and includes a 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<sup>1</sup>

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

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<sup>1</sup> IEEE Std 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

byte order where the bytes of a word are transmitted such that the most significant Byte is transmitted first

Note 1 to entry: This is commonly known as 'network byte order'.

### 4.2 Daily Jam

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

Note 1 to entry: 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 2 to entry: 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.

### 4.3 follower

clock in the context of a Precision Time Protocol (PTP) communication path that synchronizes to a source of time

Note 1 to entry: Referred to as 'slave' in IEEE Std 1588-2008.

### 4.4 FOLLOW state

state of a clock port that synchronizes to the device on the path with the port that is in the LEAD state

Note 1 to entry: Equivalent to SLAVE state as defined in IEEE Std 1588-2008 subclauses 6.6.2.2 and 9.2.5.

### 4.5 grandmaster clock

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

### 4.6 leader

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

Note 1 to entry: Referred to as 'master' in IEEE Std 1588-2008.

### 4.7 LEAD state

state of a clock port that is the source of time on the path served by the port

Note 1 to entry: Equivalent to MASTER state as defined in IEEE Std 1588-2008 subclauses 6.6.2.2 and 9.2.5.

#### **4.8 link**

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

#### **4.9 Local Time**

time (and date) as chosen by the facility's system administrator and implemented by the system

Note 1 to entry: This is typically the calendar date and time-of-day in common use in the locality. It usually includes an offset from UTC including 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.

#### **4.10 octet**

byte

ordered sequence of 8 bits

Note 1 to entry: usage of byte is retained in this document where applicable reference is made to IEEE Std 1588-2008 in which both usages occur.

#### **4.11 Precision Time Protocol**

##### **PTP**

time communication protocol as defined in IEEE Std 1588-2008

#### **4.12 PTP Domain**

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

Note 1 to entry: See IEEE Std 1588-2008, subclause 7.1.

#### **4.13 PTP epoch**

origin of the timescale of a domain as defined in IEEE Std 1588-2008 (subclause 7.2.2)

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

#### **4.14 PTP time**

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

Note 1 to entry: The PTP epoch as defined above is 63072010 seconds before 1972-01-01T00:00:00Z (UTC).

#### **4.15 Synchronization Metadata**

##### **SM**

metadata required for the synchronization of audio/video signals

#### **4.16 Synchronization signal**

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

Note 1 to entry: see SMPTE ST 2059-1.

#### **4.17 Time Jump**

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 Byte Order**

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

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

### **6 PTP Profile**

#### **6.1 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)

#### **6.2 BMCA**

The default algorithm defined in IEEE Std 1588-2008 subclauses 9.3.2, 9.3.3, and 9.3.4 (BMCA) shall be used.

#### **6.3 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.

#### **6.4 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 specified in IEEE Std 1588-2008, for each connection only a single mechanism is permitted.



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 clocks to synchronize quickly. In order to facilitate quick synchronization, 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 6.4 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: Quick synchronization might not be possible 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.

### 6.5.3 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 leader based on the ability of the leader 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 leader should not increase the value of portDS.logMinDelayReqInterval with respect to the initialized value (decrease the message rate) unless the number of followers exceeds the number that the leader is able to support at the initialized rate.

#### 6.5.4 Other attributes

$\tau$ : Default value: 1.0 s

This parameter  $\tau$  (Greek letter tau) 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.

#### clockClass

The characteristics applicable to this profile shall be those defined in Table 5 of IEEE Std 1588-2008.

#### timePropertiesDS.timeTraceable

The value of this flag shall be as specified in subclauses 8.2.4.6 and 9.4 of IEEE Std 1588-2008.

Note 1: This flag, in conjunction with other clock parameters, can be used to determine whether independent grandmasters are providing an equivalent time reference.

Note 2: The use of timePropertiesDS.timeTraceable in this profile is not intended to indicate legal traceability.

#### parentDS.grandmasterClockQuality

The value of this attribute shall be as specified in subclauses 7.6.2.4, 7.6.2.5 and 7.6.3 of IEEE Std 1588-2008. The clockAccuracy member should not be set to "Unknown".

Note: This attribute, in conjunction with other clock parameters, can be used to determine whether independent grandmasters are providing an equivalent time reference.

#### 6.5.5 Additional Enumerated Values

##### timeSource

The value of timeSource provides information about the source of time used by the grandmaster 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 grandmaster 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 grandmaster is derived from the periodicity of a synchronization signal where the time value was initialized using the PTP timescale. Subsequent time accuracy in relation to real time will depend on the frequency accuracy of the synchronization signal.

#### 6.6 One-step and two-step Clocks

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

## 6.7 Clock Physical Requirements

### 6.7.1 Frequency accuracy

For application as the reference for a facility synchronization system, the PTP grandmaster clock shall maintain a frequency such that the value of the second as measured by the Grandmaster Clock deviates by no more than  $\pm 5$  parts per million (ppm) from the SI second.

This accuracy might not be appropriate for all applications; requirements for precision and stability of oscillators for both leaders and followers are application dependent, and appropriate choices should be made during system design.

### 6.7.2 Frequency adjustment range

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

## 6.8 Node Types Required, Permitted or Prohibited

Required node types:	Ordinary Clocks
Permitted node types:	Boundary Clocks, End-to-end Transparent Clocks, Management node
Prohibited node types:	Peer to peer Transparent Clocks

## 6.9 Transport Mechanisms Permitted

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

Annex D.5 of IEEE Std 1588-2008 states that for PTP event messages in the case of IPv4, the value of the differentiated service (DS) field in the Type of Service (ToS) field should be set to the highest traffic class selector code point available. The highest available codepoint typically corresponds to Expedited Forwarding (EF) as defined in RFC 3246. If the network supports Expedited Forwarding, PTP event messages should be marked with the corresponding codepoint. The recommended codepoint for EF is 46 decimal. If the forwarding behaviors and codepoints supported by the network are unknown, PTP event messages should be marked with the codepoint 46 decimal. PTP general messages should be marked with the same or lower DSCP value as event messages.

## 6.10 Communication Model

### 6.10.1 General

For IPv4 multicast messages, IGMPv2 shall be supported. For IPv6 multicast messages, MLDv2 shall be supported and MLDv1 may be supported.

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

If a Follow\_Up message is associated with an optional unicast Sync message then the Follow\_Up message shall also be transmitted as a unicast message to the same unicast address as the associated Sync message in accordance with IEEE Std 1588-2008 subclause 9.5.10.

For any Delay\_Req messages received in either multicast or unicast, the PTP leader shall respond with a Delay\_Resp message in the same mode in accordance with IEEE Std 1588-2008 subclause 9.5.12.

Management messages may be multicast or unicast.

Within a PTP Domain, SM TLV management messages shall use the same transport mode as the Announce, Sync and Follow\_Up messages.

Replies to SM TLV management messages shall be unicast. However, to avoid packet burst in large PTP networks a device should not reply to SM TLV management messages.

The only valid transport modes shall be multicast, mixed, and unicast as defined below. Multicast and mixed transport modes may coexist within a given PTP Domain while unicast transport mode shall not coexist with other transport modes.

Leaders shall support multicast transport mode and mixed transport mode simultaneously and may support unicast transport mode. Followers shall support multicast transport mode. Followers may support mixed transport mode and may support unicast transport mode.

### 6.10.2 Multicast transport mode

In this mode, leaders shall send Announce, Sync, SMPTE TLV management messages and, if applicable, Follow\_Up messages as multicast and followers shall send Delay\_Req messages as multicast. Delay\_Resp messages are sent as multicast.

### 6.10.3 Mixed transport mode

In this mode which is optional for followers to support, leaders shall send Announce, Sync, SMPTE TLV management messages and, if applicable, Follow\_Up messages as multicast and followers shall send Delay\_Req messages as unicast. Delay\_Resp messages are sent as unicast. Unicast negotiation shall not be used for Delay\_Resp messages.

In this mode, followers shall send unicast Delay\_Req messages to the IP source address in the Announce message from the leader. The IP source addresses of Sync and Follow\_Up messages cannot be relied upon because they might have been replaced by the source address of a Transparent Clock. The Sync and Follow\_Up messages can be correlated with the Announce message using the sourcePortIdentity field in the common message header, which is not altered by Transparent Clocks.

#### **6.10.4 Unicast transport mode**

In this optional mode, leaders shall send Announce, Sync, SMPTE TLV management messages and, if applicable, Follow\_Up messages as unicast and followers shall send Delay\_Req messages as unicast. Unicast negotiation shall be used.

All applicable follower ports are configured with a set of potential leaders. Each follower uses the unicast negotiation option to request that the potential leaders transmit unicast Announce, Sync, and Delay\_Resp messages to it. In this mode, leaders grant unicast transmission of Announce, Sync, and Delay\_Resp messages and followers send unicast Delay\_Req messages.

The unicast discovery option specified in IEEE Std 1588-2008 subclause 17.5 may be used to implement this set of leaders. If more than one leader grants unicast announce messages, the follower shall select the best leader according to the BMCA as specified in IEEE Std 1588-2008 subclause 9.3.

Note: The number of potential leaders configured in each follower port is implementation specific. In most cases all the followers in a system would be configured with the same set of potential leaders to facilitate all followers choosing the same best leader.

#### **6.11 PTP Options**

Required: none

Permitted: Path trace, unicast message negotiation, unicast discovery, alternate timescales, acceptable master table

Prohibited: alternate master, grandmaster clusters

## 6.12 Organization Extension TLV: Synchronization Metadata

Once every second and also when its locking status is changed, every port in LEAD state in a grandmaster clock shall issue a Management Message with Synchronization Metadata (SM) TLV appended. If followers have negotiated unicast Announce/Sync messages then SM TLV shall be sent as unicast to these destinations.

The Management Message (COMMAND) shall be as defined in Table 1 and the SM TLV shall be set as defined in Table 2.

Note 1: SM TLV is an organization-specific TLV. Its structure is not the same as that of the management TLV specified in subclause 15.5 of IEEE Std 1588-2008 for use with PTP management messages. Processing of PTP management messages according to IEEE Std 1588-2008 uses the value of the managementId present in the 5th and 6th octets of management TLVs. The SM TLV is of ORGANIZATION\_EXTENSION tlvType in which the 5th and 6th octets instead contain part of the organizationId, 0x6897. While not an issue with implementations that follow this standard, it is possible that devices that do not support the SMPTE Profile might respond with an error message, either because the tlvType is ORGANIZATION\_EXTENSION and not MANAGEMENT or because an expected managementId appears as 0x6897, which is in a reserved range.

Note 2: Messages related to synchronization, establishing the clock 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 1 – 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	See IEEE Std 1588-2008 subclause 15.4.1.4  Note: The value of startingBoundaryHops is chosen to take into account the maximum number of boundary clocks through which the message is expected to propagate.
boundaryHops								1	45	See IEEE Std 1588-2008 subclause 15.4.1.5
Reserved				actionField				1	46	actionField = COMMAND
Reserved								1	47	
SM TLV (see Table 2)								52	48	

Table 2 – Structure of SM TLV

Item	Octets (Bytes)	Offset	Description
tlvType	2	0	ORGANIZATION_EXTENSION, which has the value of 00 03.
lengthField	2 (uint16)	2	The length of the SM TLV data structure excluding tlvType and lengthField. This shall be an even number (see IEEE Std 1588-2008, subclause 14.3.2.2). For this version, the value of the lengthField shall be 48.
organizationId	3	4	68 97 E8 (SMPTE OUI)
organizationSubType	3	7	Used to indicate the SM TLV version for management of forward / backward compatibility. 00 00 01 for this version.
defaultSystemFrameRate	8	10	Default video frame rate of the 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 <sup>2</sup> .

<sup>2</sup> 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.

Item	Octets (Bytes)	Offset	Description
gmLockingStatus	1	18	<p>Complementary information to clockClass<sup>3</sup></p> <p>0: Unavailable All information about the grandmaster clock is conveyed in the Announce Message.</p> <p>1: Internal Grandmaster is using a stable internal reference clock but is not synchronized to an external reference time source. Applies if time was set manually or if was previously locked to an external source. Followers would be expected to initiate (or maintain) synchronization with the grandmaster.</p> <p>2: Cold Locking 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.</p> <p>3: Warm Locking 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.</p> <p>4: Externally locked (i.e., in normal operation and stable) The grandmaster is locked to an external reference. Frequency stability and phase are determined by the external reference. Followers would be expected to initiate (or maintain) synchronization with the grandmaster.</p>
timeAddressFlags	1	19	<p>Indicates the intended SMPTE ST 12-1 flags.</p> <p>Bit 0: Drop frame 0: Non-drop-frame 1: Drop-frame</p> <p>Bit 1: Color Frame Identification 0: Not in use 1: In use</p> <p>Bits 2-7: Reserved</p>

<sup>3</sup> 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 <sup>4</sup> . See Section 6.13.
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 6.13.
timeOfNextJam	6 (uint48)	34	The value of the seconds portion of the PTP time corresponding to the next scheduled occurrence of the Daily Jam. If no Daily Jam is scheduled, the value of timeOfNextJam shall be zero. See Section 6.13.
timeOfPreviousJam	6 (uint48)	40	The value of the seconds portion of the PTP time corresponding to the previous occurrence of the Daily Jam. See Section 6.13.
previousJamLocalOffset	4 (int32)	46	The value of currentLocalOffset at the time of the previous Daily Jam event. 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 See Section 6.13.
daylightSaving	1	50	Bit 0: Current Daylight Saving 0: Not in effect 1: In effect Bit 1: Daylight Saving at next discontinuity 0: Not in effect 1: In effect Bit 2: Daylight Saving at previous Daily Jam event 0: Not in effect 1: In effect Bits 3-7: Reserved See Section 6.13.

<sup>4</sup> 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 Bit 0: 0: Other than a change in the number of leap seconds (default) 1: A change in number of leap seconds Bits 1-7: Reserved See Section 6.13.2.

Note 3: SM TLV messages can experience slight delays from network transit times and internal processing in the follower before being ready for use. jumpSeconds and timeOfNextJump are designed to compensate for these delays by informing the follower in advance when changes signaled by the Synchronization Metadata are to be applied to time address calculations. Use of this mechanism in the follower is detailed in SMPTE ST 2059-1.

Note 4: In Table 2, each reference to ‘Section’ is to a section within this document.

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

## 6.13 Setting dynamic SM TLV Values

### 6.13.1 General

A Time Jump event is signaled in advance to indicate the future occurrence of a discontinuity in Local Time. This might arise from 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 followers 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 followers. 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 2 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.

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 Time.

Section 6.13.2 in this document specifies how SM TLV items are set in order to signal a Time Jump event.

Section 6.13.3 in this document specifies how SM TLV items are set in order to signal the Daily Jam event.

### 6.13.2 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 2 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.

### 6.13.3 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 followers.

Note 1: 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 initialized to the value corresponding to when the previous Daily Jam event would have been and `previousJamLocalOffset` shall be initialized to the value of `currentLocalOffset` that would have been applicable at the time of the previous jam.

Note 2: After initialization 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 (Normative) Calculation of timeOfNextJam

timeOfNextJam shall correspond to a Local Time that is an integer multiple of 600 seconds (i.e., in units of 10 minutes).

There should not be more than one Daily Jam event between two successive midnights (Local Time).

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 elapsed time from the PTP Epoch in seconds

$\text{floor}(a)$  is the greatest integer less than or equal to the real number  $a$

$t\_mlocal$  and  $t\_pdjamLocal$  are local scope temporary variables

1. Calculate time of midnight on Local Time scale ( $t\_mlocal$ )  

$$t\_mlocal = \text{floor}((t + \text{currentLocalOffset}) / (24 \times 60 \times 60)) \times 24 \times 60 \times 60$$
2. Calculate next Time of Daily Jam on Local Time scale ( $t\_pdjamLocal$ )  

$$t\_pdjamLocal = t\_mlocal + (\text{userDailyJamTimeHH} \times 60 \times 60) + (\text{userDailyJamTimeMM} \times 60)$$
3. Calculate time of next Daily Jam on the PTP scale  

$$\text{timeOfNextJam} = t\_pdjamLocal - \text{currentLocalOffset}$$
4. Ensure timeOfNextJam is in the future  
 If  $t$  is greater than or equal to timeOfNextJam then  

$$\text{timeOfNextJam} = \text{timeOfNextJam} + (24 \times 60 \times 60)$$
 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.

$$\text{timeOfNextJam} = \text{timeOfNextJump}$$

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

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