

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8275.1/Y.1369.1

Amendment 2

(03/2018)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Synchronization, quality
and availability targets

SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS,
NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

Internet protocol aspects – Transport

Precision time protocol telecom profile for
phase/time synchronization with full timing support
from the network

Amendment 2

Recommendation ITU-T G.8275.1/Y.1369.1 (2016) –
Amendment 2



International
Telecommunication
Union

Document Sharing Hub

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	G.8000–G.8099
MPLS over Transport aspects	G.8100–G.8199
Synchronization, quality and availability targets	G.8200–G.8299
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.8275.1/Y.1369.1

Precision time protocol telecom profile for phase/time synchronization with full timing support from the network

Amendment 2

Summary

Recommendation ITU-T G.8275.1/Y.1369.1 contains the ITU-T precision time protocol (PTP) profile for phase and time distribution with full timing support from the network. It provides the necessary details to utilize IEEE 1588 in a manner consistent with the architecture described in Recommendation ITU-T G.8275/Y.1369.

Amendment 2 provides the following updates:

- Changes Annex C to reference Annex B of ITU-T G.8275
- Corrects some settings in Tables V.2 and V.3
- Clarifies the requirements on the T-TSC when it is embedded in the end application
- Adds an example to Appendix XII.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8275.1/Y.1369.1	2014-07-22	15	11.1002/1000/12197
1.1	ITU-T G.8275.1/Y.1369.1 (2014) Cor. 1	2015-01-13	15	11.1002/1000/12397
2.0	ITU-T G.8275.1/Y.1369.1	2016-06-22	15	11.1002/1000/12815
2.1	ITU-T G.8275.1/Y.1369.1 (2016) Amd. 1	2017-08-29	15	11.1002/1000/13329
2.2	ITU-T G.8275.1/Y.1369.1 (2016) Amd. 2	2018-03-16	15	11.1002/1000/13553

Keywords

Full timing support, IEEE 1588, phase and time synchronization, PTP, telecom profile.

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/1830-en>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2018

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	2
3.1 Terms defined elsewhere	2
3.2 Terms defined in this Recommendation.....	2
4 Abbreviations and acronyms	2
5 Conventions	3
6 Use of PTP for phase/time distribution	3
6.1 High-level design requirements.....	4
6.2 PTP modes and options	4
6.3 Protection aspects and Alternate BMCA.....	8
6.4 Phase/time traceability information.....	14
7 ITU-T PTP profile for phase/time distribution with full timing support from the network	16
8 Security aspects	17
Annex A – ITU-T PTP profile for phase/time distribution with full timing support from the network	18
A.1 Profile identification.....	18
A.2 PTP attribute values.....	18
A.3 PTP options	23
A.4 Best master clock algorithm options	24
A.5 Path delay measurement option (delay request/delay response)	24
A.6 Clock identity format.....	24
A.7 Configuration management options	24
A.8 Security aspects	24
A.9 Other optional features of IEEE 1588	24
A.10 PTP common header flags.....	24
Annex B – Options to establish the PTP topology with the Alternate BMCA.....	26
Annex C – Inclusion of an external phase/time input interface in a T-BC	27
Annex D – Path trace (optional)	28
Annex E – Synchronization uncertain indication (optional).....	29
Annex F – Use of stepsRemoved to limit reference chain (optional).....	30
Annex G – Monitoring a PTP MASTER port by a PTP PASSIVE port (optional)	31
Appendix I – Considerations on the use of transparent clock.....	32
Appendix II – Considerations on the transmission of Delay_Req messages.....	33
Appendix III – Considerations on the choice of the PTP Ethernet multicast destination address	35

	Page
Appendix IV – Considerations on the use of priority2	36
Appendix V – Description of PTP clock states and associated contents of Announce messages	37
V.1 Purpose of this appendix	37
V.2 Description of the states	37
V.3 Example of mapping between PTP port states and PTP clock states for a 3-port T-BC	39
V.4 T-GM Announce message contents based on the internal PTP clock states..	40
V.5 T-BC Announce message contents based on the internal PTP clock states...	41
Appendix VI – Operations over link aggregation.....	50
Appendix VII – Relationship between clockClass and holdover specification	51
Appendix VIII – Considerations on a T-TSC connected to an end application	53
Appendix IX – Calculation of offsetScaledLogVariance for T-GM timed by PRTC or ePRTC.....	54
IX.1 Observation interval and TDEV noise generation.....	54
IX.2 Computation of PTP variance from TDEV	54
IX.3 Computation of offsetScaledLogVariance from PTP variance	55
Appendix X – Description of a T-BC extended clockClass application.....	57
X.1 Purpose of T-BC extended clockClass application	57
X.2 DefaultDS data set member specifications under this extended application..	57
Appendix XI – Considerations on native access equipment.....	59
Appendix XII – Monitoring alternate master time information provided by a peer PTP port.....	60
Bibliography.....	61

Recommendation ITU-T G.8275.1/Y.1369.1

Precision time protocol telecom profile for phase/time synchronization with full timing support from the network

Amendment 2

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.8275.1/Y.1369.1 (2016) plus its Amendment 1 (2017).

1 Scope

This Recommendation specifies a profile for telecommunication applications based on IEEE 1588 precision time protocol (PTP). The profile specifies the IEEE 1588 functions that are necessary to ensure network element interoperability for the delivery of accurate phase/time synchronization. The profile is based on the full timing support from the network architecture as described in [ITU-T G.8275] and definitions described in [ITU-T G.8260].

This version of the profile specifies the high-level design requirements, modes of operation for the exchange of PTP messages, the PTP protocol mapping, the best master clock algorithm (BMCA) options, as well as the PTP protocol configuration parameters.

NOTE – The parameters defined in the first version of the profile have been chosen based on the case where physical layer frequency support is provided.

This Recommendation also specifies some aspects necessary for use in a telecom environment that are outside the scope of, and complement the PTP profile.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.781] Recommendation ITU-T G.781 (2008), *Synchronization layer functions*.
- [ITU-T G.810] Recommendation ITU-T G.810 (1996), *Definitions and terminology for synchronization networks*.
- [ITU-T G.8260] Recommendation ITU-T G.8260 (2015), *Definitions and terminology for synchronization in packet networks*.
- [ITU-T G.8265.1] Recommendation ITU-T G.8265.1/Y.1365.1 (2014), *Precision time protocol telecom profile for frequency synchronization*.
- [ITU-T G.8271] Recommendation ITU-T G.8271/Y.1366 (2016), *Time and phase synchronization aspects of packet networks*.
- [ITU-T G.8271.1] Recommendation ITU-T G.8271.1/Y.1366.1 (2013), *Network limits for time synchronization in packet networks*.
- [ITU-T G.8272] Recommendation ITU-T G.8272/Y.1367 (2012), *Timing characteristics of primary reference time clocks*.

- [ITU-T G.8273] Recommendation ITU-T G.8273/Y.1368 (2013), *Framework of phase and time clocks*.
- [ITU-T G.8273.2] Recommendation ITU-T G.8273.2/Y.1368.2 (2014), *Timing characteristics of telecom boundary clocks and telecom time slave clocks*.
- [ITU-T G.8275] Recommendation ITU-T G.8275/Y.1369 (2013), *Architecture and requirements for packet-based time and phase distribution*.
- [IEEE 1588] IEEE 1588-2008, *IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

The terms and definitions used in this Recommendation are contained in [ITU-T G.810] and [ITU-T G.8260].

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 special port: A PTP special port is a PTP port that translates between the native timing mechanism of a medium and PTP.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AVAR	Allan Variance
BC	Boundary Clock
BMCA	Best Master Clock Algorithm
EEC	synchronous Ethernet Equipment Clock
ePRTC	Enhanced Primary Reference Time Clock
EUI	Extended Unique Identifier
FPM	Flicker Phase Modulation
GM	Grandmaster
GNSS	Global Navigation Satellite System
LAG	Link Aggregation
MVAR	Modified Allan Variance
OC	Ordinary Clock
PRC	Primary Reference Clock
PRS	Primary Reference Source
PRTC	Primary Reference Time Clock
PSD	Power Spectral Density
PTP	Precision Time Protocol
QL	Quality Level
SDH	Synchronous Digital Hierarchy

SSM	Synchronization Status Message
SSU	Synchronization Supply Unit
SSU-A	primary level SSU
SSU-B	secondary level SSU
ST2	Stratum 2
ST3E	Stratum 3 Enhanced
T-BC	Telecom Boundary Clock
TC	Transparent Clock
T-GM	Telecom Grandmaster
T-TC	Telecom Transparent Clock
T-TSC	Telecom Time Slave Clock
TLV	Type Length Value
TVAR	Time Variance
VLAN	Virtual Local Area Network
WPM	White Phase Modulation

5 Conventions

Within this Recommendation, the following conventions are used: the term PTP refers to the PTP version 2 protocol defined in [IEEE 1588]. PTP messages used within this Recommendation are defined in [IEEE 1588] and are identified using italicized text.

The term telecom boundary clock (T-BC) refers to a device consisting of a boundary clock (BC) as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics defined in [ITU-T G.8273.2].

The term telecom transparent clock (T-TC) refers to a device consisting of a transparent clock (TC) as defined in [IEEE 1588], with additional performance characteristics for further study.

The term telecom grandmaster (T-GM) refers to a device consisting of a grandmaster (GM) clock as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics for further study.

The term telecom time slave clock (T-TSC) refers to a device consisting of a slave-only ordinary clock (OC) as defined in [IEEE 1588] and this Recommendation, with additional performance characteristics defined in the Annex C of [ITU-T G.8273.2].

The term primary reference time clock (PRTC) refers to the clock defined in [ITU-T G.8272]. The term enhanced primary reference time clock (ePRTC) refers to an enhanced version of the PRTC, which is being studied.

6 Use of PTP for phase/time distribution

The 2002 version of the IEEE 1588 was developed by the IEEE initially to support the timing requirements of industrial automation, and defines the precision time protocol (PTP) designed to enable accurate time transfer in this context.

The 2008 version of IEEE 1588 (defined in [IEEE 1588]) contains features useful to the transport of the protocol over a wide area network, and introduces the concept of "profile", whereby aspects of the protocol may be selected and specified for a particular use other than the originally intended industrial automation.

A PTP profile has been defined in [ITU-T G.8265.1] to address applications requiring frequency synchronization only. This Recommendation defines another PTP profile, for telecom applications requiring accurate phase and time synchronization. It supports the specific architecture described in [ITU-T G.8275] in order to allow the distribution of phase/time with full timing support from the network, and is based on the 2008 version of PTP defined in [IEEE 1588].

In order to claim compliance with the telecom profile, the requirements of this Recommendation and the relevant requirements of [IEEE 1588], as referenced in Annex A, must be met.

The detailed aspects related to the telecom profile are described in the following clauses, while the profile itself is contained in Annex A. It follows the general rules for profile specification developed in [IEEE 1588].

This PTP telecom profile defines the parameters from [IEEE 1588] to be used in order to guarantee protocol interoperability between implementations and specifies the optional features, default values of configurable attributes and mechanisms that must be supported. However, it does not guarantee that the performance requirements of a given application will be met. These performance aspects are defined in other ITU-T Recommendations, and imply additional elements beyond the content of the PTP profile itself.

6.1 High-level design requirements

Clause 19.3.1.1 of [IEEE 1588] states:

"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."

For operation in a telecom network, some additional criteria are also required to be consistent with standard telecom synchronization practices. Therefore, the PTP profile for time and phase distribution must meet the following high-level requirements:

- 1) Mechanisms must be specified to allow interoperability between the various phase/time clocks belonging to the architecture defined in [ITU-T G.8275] and described in [ITU-T G.8273].
- 2) Mechanisms must permit consistent operation over managed wide area telecom networks.
- 3) Packet-based mechanisms must allow the synchronization network to be designed and configured in a fixed arrangement.
- 4) Protection schemes used by packet-based systems must be based on standard telecom operational practice and allow telecom time slave clocks the ability to take phase and time from multiple geographically separate telecom grandmaster clocks.
- 5) Phase/time reference source selection based on received phase/time traceability and local priority, as well as automatic establishment of the phase/time synchronization network topology, should be permitted.

6.2 PTP modes and options

6.2.1 PTP domains

A domain consists of a logical grouping of clocks communicating with each other using the PTP protocol.

PTP domains are used to partition a network within an administrative entity. The PTP messages and data sets are associated with a domain and therefore, the PTP protocol is independent for different domains.

In this PTP telecom profile, the default PTP domain number is 24, and the range of applicable PTP domain numbers is {24 – 43}.

NOTE – This range has been selected from the user-defined PTP domain number range defined in [IEEE 1588]. Although non-overlapping ranges have been considered for the different PTP telecom profiles so that interactions between the profiles are prevented, nothing precludes another industry from using the same user-defined PTP domain number range when defining a non-telecom PTP profile. It is the responsibility of the network operator to identify if the risk of unintentional interactions between PTP profiles exists, and to take the necessary actions to prevent such behaviour.

6.2.2 PTP messages used in the profile

This PTP profile uses the messages: *Sync*, *Follow_Up*, *Announce*, *Delay_Req*, and *Delay_Resp*.

The use of *Signalling* and *Management* messages is for further study.

Pdelay_Req, *Pdelay_Resp*, and *Pdelay_Resp_Follow_Up* messages are not used.

6.2.3 Types of PTP clocks supported in the profile

The ordinary clock (OC), boundary clock (BC) and transparent clock (TC) according to [IEEE 1588] are used in this profile.

There are two types of OCs:

- 1) An OC that can only be a grandmaster (T-GM according to the architecture defined in [ITU-T G.8275], and as included in [ITU-T G.8272]).
- 2) An OC that can only be a slave, i.e., slave-only OC (T-TSC according to the architecture defined in [ITU-T G.8275], and compliant with Annex C of [ITU-T G.8273.2]).

There are two types of BCs:

- 1) A BC that can only be a grandmaster (T-GM according to the architecture defined in [ITU-T G.8275], and as included in [ITU-T G.8272]).
- 2) A BC that can become a grandmaster and can also be slaved to another PTP clock (T-BC according to architecture defined in [ITU-T G.8275] and compliant with [ITU-T G.8273.2]).

NOTE – T-GM and grandmaster (GM) are different concepts; GM is a status defined in [IEEE 1588] that a PTP clock may obtain if it wins the best master clock algorithm (BMCA), while T-GM is a type of clock defined in the [ITU-T G.8275] architecture.

The transparent clock used in this profile (T-TC according to the architecture defined in [ITU-T G.8275] and the framework of phase and time clocks [ITU-T G.8273]) is the end-to-end transparent clock defined in [IEEE 1588]. It is not permitted to use peer-to-peer transparent clocks in this profile.

The mapping between these PTP clock types and the phase/time clocks defined in the [ITU-T G.8275] architecture is described in Table 1.

Table 1 – Mapping between [ITU-T G.8275] and PTP clock types

Clock type from [ITU-T G.8275]	Description	Clock type from [IEEE 1588]
T-GM	Master-only ordinary clock (master with a single PTP port, always a GM, cannot be slaved to another PTP clock)	OC
	Master-only boundary clock (master with multiple PTP ports, always a GM, cannot be slaved to another PTP clock)	BC
T-BC	Boundary clock (may become a GM, or may be slaved to another PTP)	BC

Table 1 – Mapping between [ITU-T G.8275] and PTP clock types

Clock type from [ITU-T G.8275]	Description	Clock type from [IEEE 1588]
	clock)	
T-TSC	Slave-only ordinary clock (always a slave, cannot become a GM)	OC
T-TC	Transparent clock	End-to-end TC

6.2.4 One-way versus two-way operation

PTP operation must be two-way in this profile in order to transport phase/time synchronization, because propagation delay must be measured. Therefore, only two-way mode is allowed in this profile.

6.2.5 One-step versus two-step clock mode

Both one-step and two-step clocks are supported in the profile. A clock compliant with the profile may use either a one-step clock or a two-step clock.

To be compliant with [IEEE 1588], a slave port must be capable of receiving and processing messages from both one-step clocks and two-step clocks, without any particular configuration.

6.2.6 Ethernet multicast addressing for PTP messages

This PTP telecom profile uses Ethernet multicast addressing for the transmission of all PTP messages.

For the PTP profile specified in this Recommendation, when using the PTP mapping defined in [IEEE 1588] Annex F, both the non-forwardable multicast address 01-80-C2-00-00-0E and forwardable multicast address 01-1B-19-00-00-00 are supported.

A T-GM, T-BC, T-TSC or T-TC clock compliant with this profile must be capable of handling both the non-forwardable multicast address 01-80-C2-00-00-0E and the forwardable multicast address 01-1B-19-00-00-00 on all its PTP-capable ports.

For a T-GM, T-BC and T-TSC clock, the choice of the multicast address is made by configuration on a per-port basis; all the PTP messages of a port must use the configured address for transmitting PTP messages to the remote PTP port. In case the remote PTP port is configured with the other address, the local PTP port must accept and process the received messages.

The default address depends on the operator policy. See information in Appendix III.

On transmission, the default mode for a T-TC does not require any configuration: the PTP messages retransmitted by the T-TC must use the same multicast destination address as the received PTP message. It is mandatory to support this default mode in transmission.

NOTE – This profile uses [IEEE 1588] Annex F, *Transport of PTP over IEEE802.3/Ethernet*, for the transport layer. In particular, according to the relevant Ethernet bridge models, the appropriate MAC address of the transmit Ethernet port is placed into the sourceAddress field of the header of the Ethernet frame encapsulating the PTP packets sent by any of the PTP clocks defined in this profile (i.e., T-GM, T-BC, T-TC or T-TSC).

This profile processes PTP messages with Ethernet multicast encapsulation. PTP messages with other encapsulations should be forwarded based on the forwarding rules of the respective transport protocol.

6.2.7 PTP mapping

This PTP telecom profile is based on the PTP mapping defined in [IEEE 1588] Annex F, *Transport of PTP over IEEE 802.3/Ethernet*.

Therefore, a PTP clock compliant with the profile described in this Recommendation must be compliant with [IEEE 1588] Annex F.

The transportSpecific field is used in this profile and must be set to "0".

In the scenarios currently considered, e.g., based on full timing support with T-BC and T-TC, the insertion of a virtual local area network (VLAN) tag in the frames carrying PTP messages is not allowed for T-GMs, T-BCs and T-TSC,. In this case, when receiving a PTP message within a frame containing a VLAN tag, this frame must be discarded by the T-GM, T-BC, and T-TSC.

Some specific T-TC based configurations are discussed in Appendix I.

Using VLAN tags in other scenarios is for further study.

6.2.8 Message rates

Within the scope of the profile, the following messages can be used and the corresponding indicated nominal rates must be respected:

- Sync messages (if used, Follow_up messages will have the same rate) – nominal rate: 16 packets-per-second.
- Delay_Req/Delay_Resp messages – nominal rate: 16 packets-per-second.
- Announce messages – nominal rate: 8 packets-per-second.

The requirements of section 7.7.2.1 of [IEEE 1588] must also be respected for the transmission of Sync and Announce messages. In addition, the time between successive Sync messages must not exceed twice the mean Sync interval specified above, and the time between successive Announce messages must not exceed twice the mean Announce interval specified above.

The transmission of Delay_Req messages is specified in section 9.5.11.2 of [IEEE 1588].

In addition to bullet 1 and bullet 2 of section 9.5.11.2 of [IEEE 1588], a clock compliant to this profile must follow one of the following options:

- Transmission time requirements according to bullet 3 of section 9.5.11.2 of [IEEE 1588], using an implementation-specific distribution. In this case, the PTP node must, with 90% confidence, issue Delay_Req messages with inter-message intervals within $\pm 30\%$ of $2^{\log \text{MinDelayReqInterval}}$ seconds.
- Transmission time requirements specified in bullet 4 of clause 9.5.11.2 of [IEEE 1588].

In addition, the time between successive Delay_Req messages must not exceed $2^{\log \text{MinDelayReqInterval}+1}$ seconds.

As per section 9.5.12 of [IEEE 1588], the Master sets the logMessageInterval in the header of Delay_Resp messages to a value accepted by the Master. In this profile that value is -4 (16 pps).

Additional background information concerning the Delay_Req message transmission specified in section 9.5.11.2 of [IEEE 1588] is included in Appendix II.

The use of signalling and management messages is for further study.

6.3 Protection aspects and Alternate BMCA

6.3.1 Alternate BMCA

The PTP profile specified in this Recommendation uses an Alternate BMCA, as described in clause 9.3.1 of [IEEE 1588]. This Alternate BMCA differs from the default BMCA of [IEEE 1588] as follows:

- a) The Alternate BMCA considers the per-port Boolean attribute `masterOnly`. If `masterOnly` is TRUE, the port is never placed in the SLAVE state, and will always go to the MASTER state. If `masterOnly` is FALSE, the port can be placed in the SLAVE state. The `masterOnly` attribute is set via the configurable port data set member `portDS.masterOnly`.

The default value and range of values for this attribute, for the ports of a BC or OC that can only be a GM (i.e., T-GM), are TRUE and {TRUE}.

The default value and range of values for this attribute, for the port of a slave-only OC (i.e., T-TSC) are FALSE and {FALSE}.

The default value and range of values for this attribute, for the ports of a BC that may or may not be a GM (i.e., T-BC) are TRUE and {TRUE, FALSE}.

Note that for a T-BC, the `masterOnly` attribute must be set to FALSE on at least one port in order for the T-BC to be able to synchronize to another clock.

- b) The computation of $E_{r_{best}}$ is according to the description provided in clause 9.3.2.3 of [IEEE 1588], with the exception that the $E_{r_{best}}$ of a port r must be set to the empty set when the `masterOnly` attribute of this port r is set to TRUE, irrespective of any other consideration. This is so that the computation of E_{best} will not use the information contained in any *Announce* messages received on a port r where the `masterOnly` attribute is set to TRUE.
- c) The Alternate BMCA allows for multiple clocks to be active GMs simultaneously (clocks with `clockClass` less than 128 cannot be a slave). If there are multiple active GMs, every clock that is not a GM is synchronized by a single GM in the PTP domain.
- d) The per-port attribute `localPriority` is assigned to each port r of a clock and is used in the determination of $E_{r_{best}}$ and E_{best} . Each parent clock or foreign master clock data set, whose *Announce* information was received on the port r , is appended with the `localPriority` attribute of the local port r before the data set comparison defined in Figure 2 and Figure 3 below is invoked. The `localPriority` attribute is not transmitted in *Announce* messages. This attribute is used as a tie-breaker in the data set comparison algorithm, in the event that all other previous attributes of the data sets being compared are equal. The `localPriority` attribute is set via the configurable, unsigned integer, port data set member `portDS.localPriority`. The data type for this attribute is `UInteger8`. The range of values for this attribute is {1-255}. The default value for this attribute is 128. A clock compliant with this PTP profile is allowed to support a subset of the values defined in the range.
- e) The attribute `localPriority` is assigned to the local clock, to be used if needed when the data associated with the local clock, D_0 , is compared with data on another potential GM received via an *Announce* message. The local clock `localPriority` attribute is set via the configurable, unsigned integer, default data set member `defaultDS.localPriority`. The data type for this attribute is `UInteger8`. The range of values for this attribute is {1-255}. The default value for this attribute is 128. A clock compliant with this PTP profile is allowed to support a subset of the values defined in the range.
- f) The data set comparison algorithm is modified according to Figures 2 and 3 in clause 6.3.7.
- NOTE 1 – Because the value of the `masterOnly` attribute is, per definition, always TRUE on all PTP ports of a T-GM, the `localPriority` attribute is, in practice, not used for a T-GM.

NOTE 2 – For a T-GM, the Alternate BMCA output is in practice static and provides a recommended state = BMC_MASTER, because the masterOnly attribute = TRUE for all the PTP ports of a T-GM. The resulting decision code can be M1 or M2, depending on the status of the T-GM (i.e., clockClass value of the T-GM).

NOTE 3 – For a T-BC, the ports for which the masterOnly attribute is FALSE should be selected according to the network synchronization plan. One typical use case where this parameter should remain TRUE is to prevent timing from propagating from the access portion of the network to the core portion of the network.

NOTE 4 – The use of masterOnly is intended primarily to be used in two scenarios

1. A PTP port of a T-GM;
2. A PTP port of a T-BC that is facing the ‘downstream’ direction towards the access portion of a tree topology.

The use of the masterOnly parameter in other scenarios, such as on PTP ports participating in a ring architecture, may result in unintended operation, especially during re-configuration or topology changes.

6.3.2 Considerations on the use of the localPriority attributes

The localPriority attributes provide a powerful tool in defining the synchronization network architecture.

The use of the default values for these attributes as defined by the Alternate BMCA results in a timing-loop free synchronization network.

Proper planning will be mandatory to avoid timing-loops when configuring values different from the default ones.

6.3.3 Static clock attribute priority1

In this PTP profile, the clock attribute priority1 is static. It is initialized to a default value equal to the midpoint value, 128, of its range, and this value must not be changed.

The priority1 parameter is not used in this version of the PTP telecom profile. Future versions may consider using this attribute, this is for further study.

6.3.4 Clock attribute priority2

In this PTP profile, the clock attribute priority2 is configurable.

It is initialized to a default value, equal for T-GM and T-BC clocks to the midpoint value, 128, of its range {0-255}. The default value for T-TSC clocks is 255, and the range is {255}.

A T-GM or T-BC compliant with this PTP profile must support all the values of priority2 defined in the range. A T-TSC compliant with this profile must support, on reception, all the values of priority2 defined in the full IEEE 1588 range (i.e., {0-255}).

Appendix IV describes possible use cases for the priority2 attribute; Appendix X describes possible use cases for the priority2 attribute under Note 3 of Table 2; other cases are for further study.

6.3.5 Other clock attributes

A PTP clock compliant with this PTP profile must support all the values of clockClass, clockAccuracy, and offsetScaledLogVariance upon reception [shall not discard] defined in the full [IEEE1588] range.

The applicable values of the clock attribute clockClass are specified in 6.4.

NOTE – The behaviour on reception of a clockClass value not specified in Table 2 is for further study.

The following values of the clock attribute clockAccuracy apply for the following situations:

- 0x20 for a T-GM connected to an Enhanced Primary Reference Time Clock (ePRTC) in locked-mode (i.e., ePRTC traceable to global navigation satellite system (GNSS));
- 0x21 for a T-GM connected to a PRTC in locked-mode (i.e., PRTC traceable to GNSS);
- 0xFE for a T-GM not connected to an ePRTC in locked-mode nor to a PRTC in locked-mode;
- 0xFE for a T-BC, all the time.

The following values of the clock attribute `offsetScaledLogVariance` apply for the following situations:

- 0x4B32 for a T-GM connected to an ePRTC in locked-mode (i.e., ePRTC traceable to GNSS). This corresponds to TDEV of 10 ns, at observation interval of 10000 s. The corresponding value of PTP Variance (PTPVAR) is $1.271 \times 10^{-16} \text{ s}^2$ (see Appendix IX);
- 0x4E5D for a T-GM connected to a PRTC in locked-mode (i.e., PRTC traceable to GNSS). This corresponds to TDEV of 30 ns, at observation interval of 10000 s. The corresponding value of PTP Variance (PTPVAR) is $1.144 \times 10^{-15} \text{ s}^2$ (see Appendix IX);
- 0xFFFF for a T-GM not connected to an ePRTC in locked-mode nor to a PRTC in locked-mode;
- 0xFFFF for a T-BC, all the time.

6.3.6 State decision algorithm

The state decision algorithm applicable to the Alternate BMCA of the PTP profile specified in this Recommendation is given in Figure 1. After a decision is reached by use of this algorithm, the data sets of the local clock are updated as specified in clause 9.3.5 of [IEEE 1588]. Details on the use of the algorithm are given in clause 9.3.3 of [IEEE 1588].

6.3.7 Data set comparison algorithm

The data set comparison algorithm for the Alternate BMCA of the PTP profile specified in this Recommendation is given in Figures 2 and 3 below. With this algorithm, one clock is compared with another using the data sets representing those clocks, appended with the `localPriority` attribute. Details on the use of the algorithm are given in clause 9.3.4 of [IEEE 1588].

If either of the data sets, A or B, in Figures 2 and 3 contain the data of the parent clock or a foreign master clock, the corresponding `localPriority` for its data set is the `localPriority` of the local port `r` on which the information from that parent clock or foreign master clock has been received (see item (d) of clause 6.3.1).

If either of the data sets, A or B, in Figures 2 and 3 contain the data of the local clock, `D0`, the corresponding `localPriority` for that data set is the `localPriority` of the local clock (see item (e) of clause 6.3.1).

NOTE 1 – It is recommended that the entire data set comparison algorithm described in Figures 2 and 3 be implemented even if some parameters are currently static, because they may be used in future versions of this Recommendation.

NOTE 2 – The block in Figure 2 "GM clockClass of A is 127 or less" enables different T-BCs in the network to be synchronized by different T-GMs when multiple T-GMs are deployed.

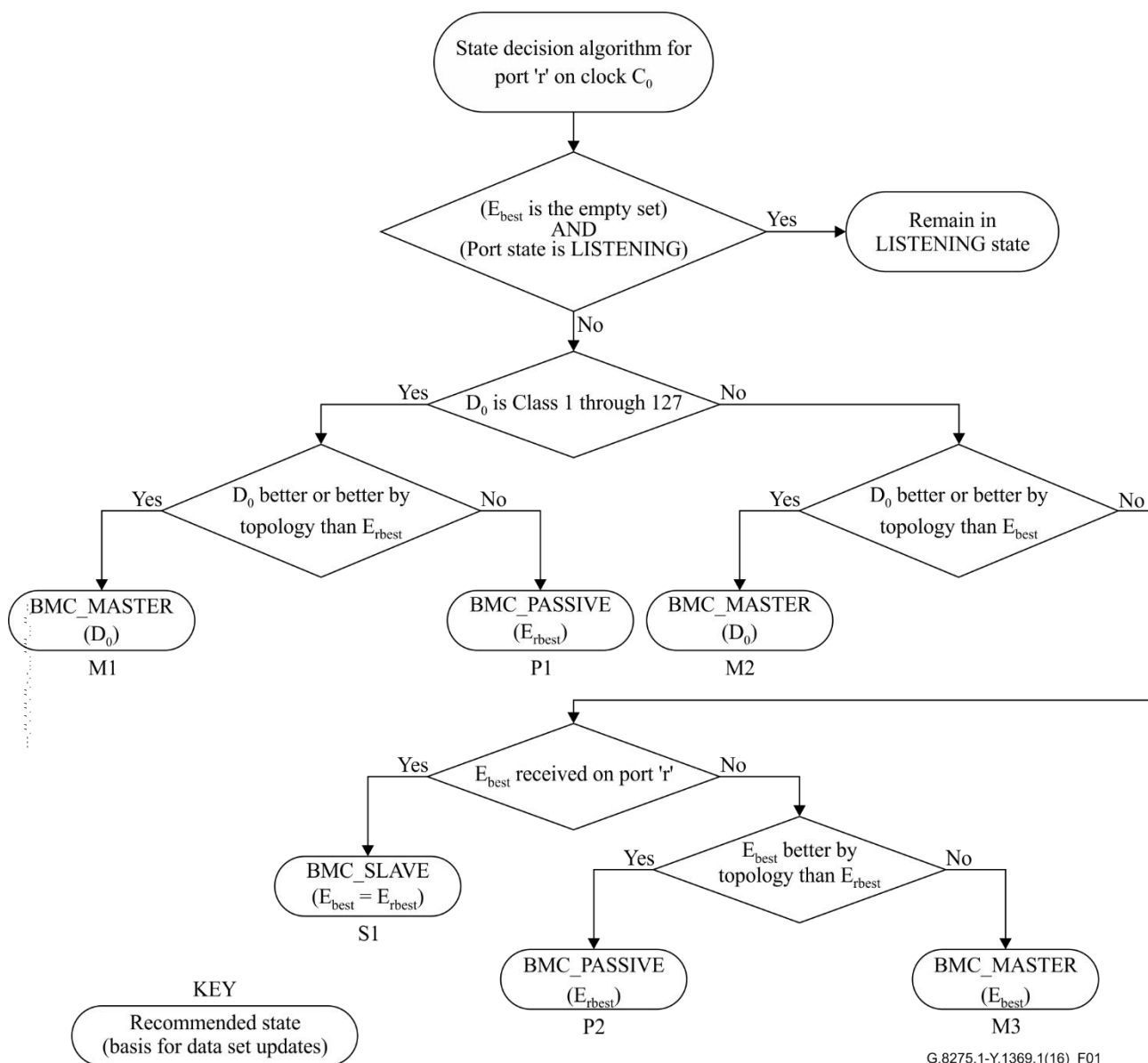


Figure 1 – State decision algorithm for Alternate BMCA

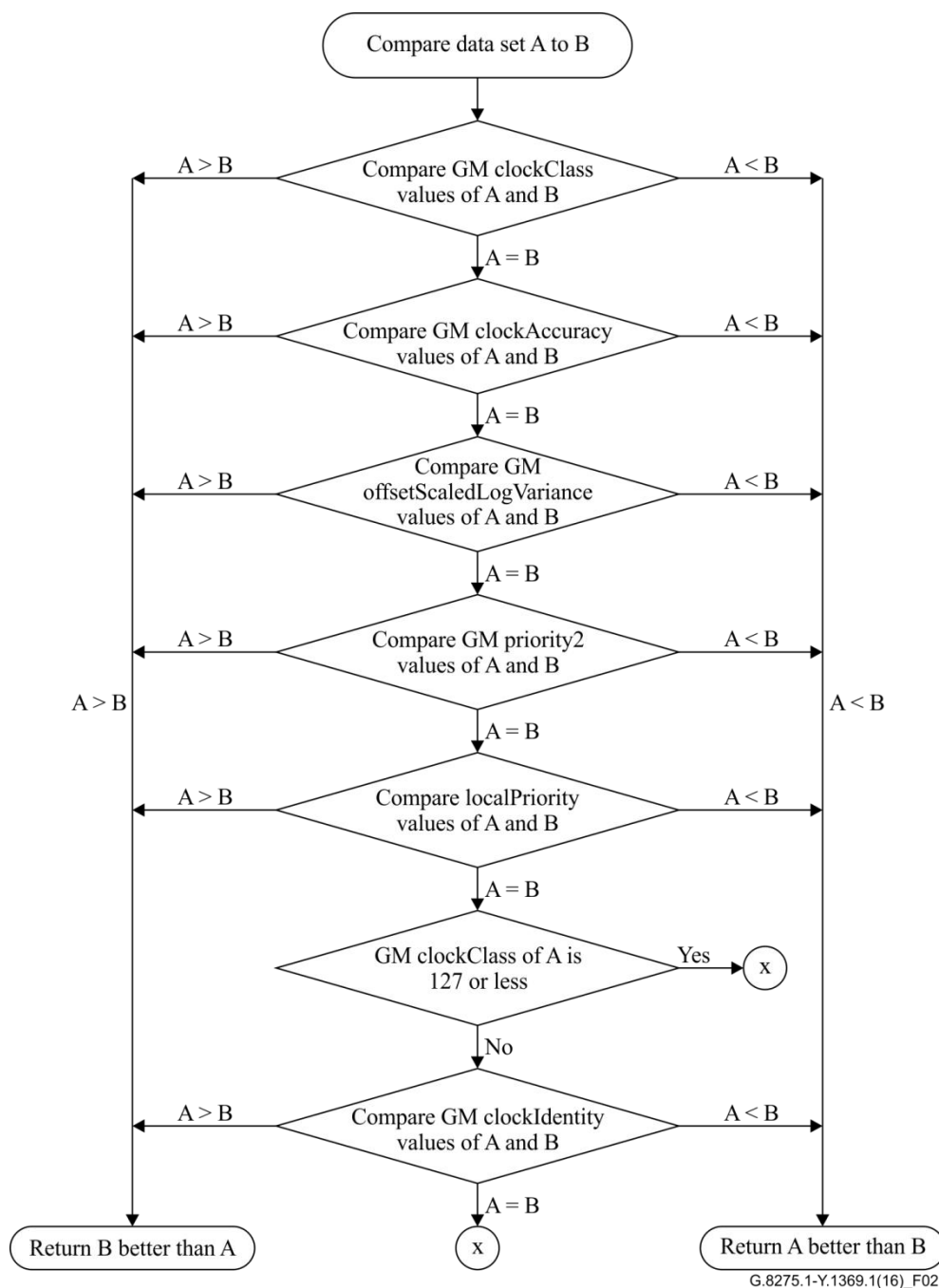


Figure 2 – Data set comparison algorithm, part 1, for Alternate BMCA

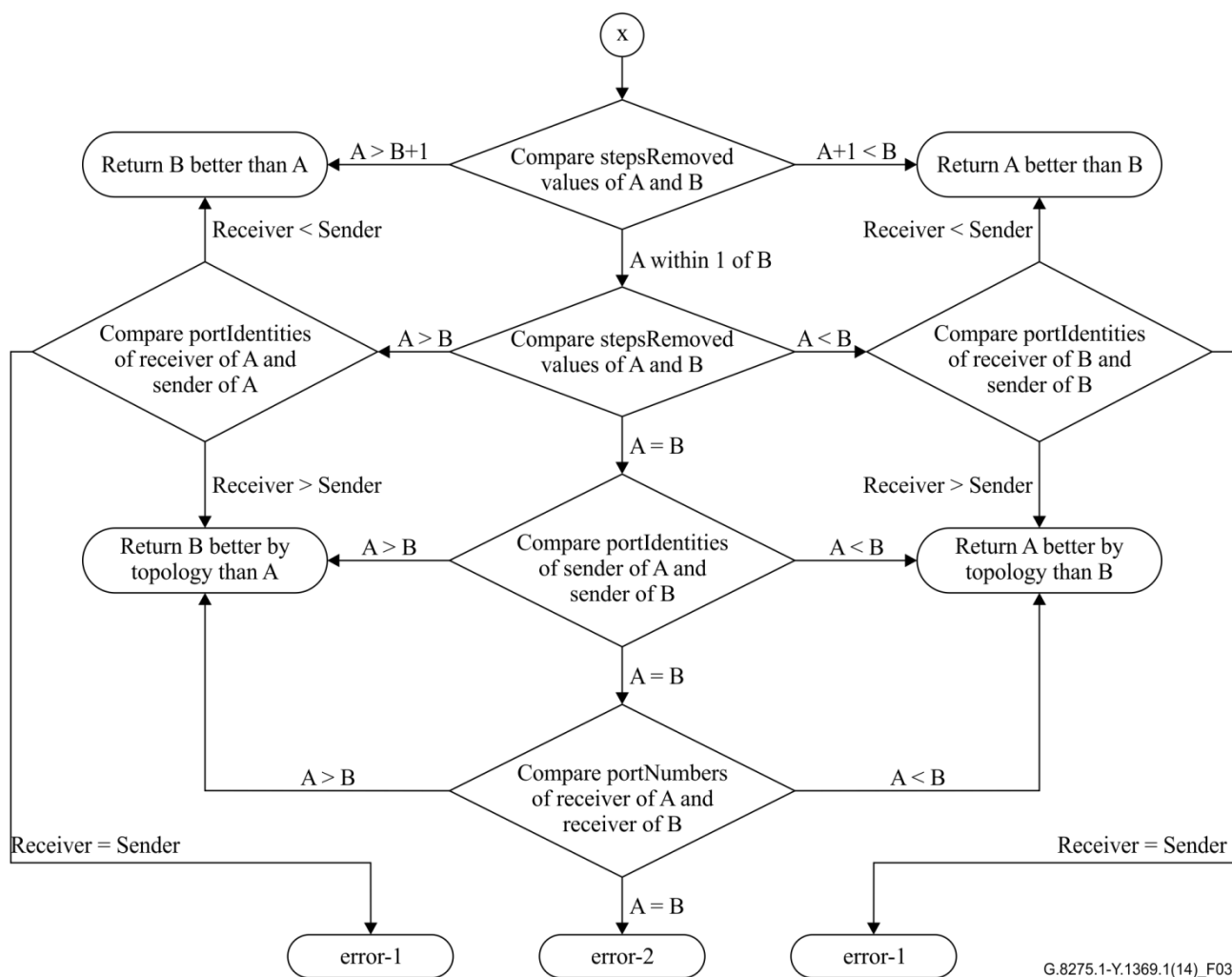


Figure 3 – Data set comparison algorithm, part 2, for Alternate BMCA

6.3.8 Unused PTP fields

Some PTP fields are not used in this PTP profile. This clause defines the actions applicable to these unused PTP fields.

Table A.8 in clause A.10 of this Recommendation defines the PTP common header flag values, and whether or not each flag is used in this profile.

In addition, the following fields are not used in this profile:

- The "controlField" in the common header of PTP messages is not used in this profile. This field must be ignored by the receiver for all types of PTP messages;
- The "priority1" field in the *Announce* message is not used, and must be set to a fixed value specified in clause 6.3.3.

When a PTP clock receives a PTP message with a field, whose use is not specified in this PTP profile, containing a value outside the allowed range, then this field of the PTP message must be ignored, without discarding the PTP message.

As an example, a PTP clock compliant with this PTP profile must ignore on reception the field value for the following fields. A clock compliant with this PTP profile must not update its local data sets with the ingress value for these fields:

- flagField – alternateMasterFlag;
- flagField – unicastFlag;
- flagField – PTP profile Specific 1;

- flagField – PTP profile Specific 2.

When a PTP clock receives a PTP message with a field, whose use is specified in this PTP profile, containing a value outside the allowed range for reception, then this entire PTP message must be discarded. Except for the attributes clockClass, clockAccuracy, offsetScaledLogVariance, and priority2 (see clauses 6.3.4 and 6.3.5), the ranges for reception and for defaultDS members are the same.

As an example, a compliant clock must discard on reception the ingress packet (General and Event messages) when any of the following fields are outside of the allowed range for the profile:

- domainNumber;
- versionPTP.

The clock's local data set must not be updated with the ingress value.

NOTE 1 – If a clock receives an *Announce* message with the "priority1" field set to a value other than 128, and if the clock advertising this value is selected as the GM, then 128 must be re-advertised by the receiving clock. The unused attribute priority1 is ignored by the receiving clock for the purpose of the Alternate BMCA.

NOTE 2 – The allowed ranges for reception for the clock attributes priority2, clockClass, clockAccuracy, and offsetScaledLogVariance are the respective full [IEEE1588] ranges, see clauses 6.3.4 and 6.3.5.

6.4 Phase/time traceability information

To deliver phase/time traceability information, the clockClass values described in Table 2 below must be used in this PTP telecom profile. Additional information for interworking purposes is provided in Table 4.

The frequencyTraceable flag present in the header of the PTP messages is defined in this profile as follows: if the PTP clock is traceable to a PRTC in locked mode or to a primary reference clock (PRC), e.g., using a PRC-traceable physical layer frequency input, then this parameter must be set to TRUE, otherwise it must be FALSE. This flag is not used in the Alternate BMCA defined in clause 6.3; the values provided for this flag in Table 2 can be used by a network operator for monitoring purposes or by end applications to take definitive action as described in Appendix VIII.

When a T-GM first enters holdover, it downgrades the clockClass value that it uses to 7. It then calculates if the time error at its output is still within the holdover specification. When the T-GM determines that the time error at its output has exceeded the holdover specification, it downgrades the clockClass value that it uses to 140, 150 or 160 depending on the quality of its frequency reference (internal oscillator or received physical layer frequency signal on an external interface).

When a T-BC first enters holdover, it downgrades the clockClass value that it uses to 135. It then calculates if the time error at its output is still within the holdover specification. When the T-BC determines that the time error at its output has exceeded the holdover specification, it downgrades the clockClass value that it uses to 165 (internal oscillator or received physical layer frequency signal on an external interface).

NOTE 1 – The applicable holdover specification depends on the design and budgeting of the synchronization network. See Appendix V of [ITU-T G.8271.1] for examples of network budgeting. A typical value for the holdover budget, described in the failure scenario (b) depicted in [ITU-T G.8271.1] Table V.1, when using the T-GM or T-BC for holdover while still meeting a total time error of 1.5 µs, is 400 ns.

NOTE 2 – When the term clockClass is used with respect to the property of the individual PTP clock (T-GM, T-BC, T-TSC) it is referring to data set member defaultDS.clockQuality.clockClass.

NOTE 3 – For the T-BC, the traceability information of the currently selected best master clock will be passed to the downstream nodes, as per PTP. This means that the attributes and flags in the PTP header will always reflect the phase/time traceability information from the current parent clock, regardless of the frequency traceability of the T-BC's physical layer clock. Failure scenarios including holdover are for further study.

Table 2 – Applicable clockClass values

Phase/time traceability description	defaultDS. clockQuality. clockClass	frequencyTraceable flag	timeTraceable flag
T-GM connected to a PRTC in locked mode (e.g., PRTC traceable to GNSS)	6	TRUE	TRUE
T-GM in holdover, within holdover specification, traceable to Category 1 frequency source (Note 1)	7	TRUE	TRUE
T-GM in holdover, within holdover specification, non-traceable to Category 1 frequency source (Note 1)	7	FALSE	TRUE
T-BC in holdover, within holdover specification, traceable to Category 1 frequency source (Note 1)	135	TRUE	TRUE
T-BC in holdover, within holdover specification, non-traceable to Category 1 frequency source (Note 1)	135	FALSE	TRUE
T-GM in holdover, out of holdover specification, traceable to Category 1 frequency source (Note 1)	140	TRUE	FALSE
T-GM in holdover, out of holdover specification, traceable to Category 2 frequency source (Note 1)	150	FALSE	FALSE
T-GM in holdover, out of holdover specification, traceable to Category 3 frequency source (Note 1)	160	FALSE	FALSE
T-BC in holdover, out of holdover specification (Note 1)	165	(Note 2)	FALSE
T-GM or T-BC without time reference since start-up	248	(Note 2)	FALSE
Slave only OC (does not send <i>Announce</i> messages)	255	(Note 2)	As per PTP

NOTE 1 – The holdover specification threshold controlling the time spent advertising clockClass values 7 or 135 could be set to zero so that the T-GM or T-BC would advertise a degraded clockClass value directly after losing traceability to a PRTC. In this case, initially after advertising clockClass values 140, 150, 160, or 165, a clock may still be within the holdover specification.

NOTE 2 – The frequencyTraceable flag may be TRUE or FALSE, depending on the availability of a PRC-traceable physical layer frequency input signal.

NOTE 3 – As an option, the clockClass range of a T-BC can be extended from (135, 165, 248) to (135, 140, 150, 160, 165, 248) for some cases, where (a) 140, 150, 160, and 165 are related to the quality of the frequency reference, (b) the applicable circumstances of 140, 150, and 160 are the same as for the T-GM, and (c) 165 corresponds to synchronous Ethernet equipment clock (EEC). Details are in Appendix X. If this option is used, then in a single PTP domain, all PTP clocks should implement this option (and should not be intermixed with clocks that do not implement this option). Details are for further study.

NOTE 4 – The term "holdover" in this table refers to "time holdover".

NOTE 5 – Refer to Appendix VII for more information about the behaviour of a T-BC that was previously synchronizing to a T-GM or a T-BC that is advertising 'within holdover specification' or 'out of holdover specification'.