

CONTENTS

<u>FOREWORD</u>	5	Formatted: English (United States)
<u>INTRODUCTION</u>	2	Formatted: English (United States)
<u>1 Scope</u>	3	Formatted: English (United States)
<u>2 Normative references</u>	3	Formatted: English (United States)
<u>3 Terms, definitions, symbols and abbreviated terms</u>	4	Formatted: English (United States)
<u>3.1 TSN-IA defined Terms</u>	4	Formatted: English (United States)
<u>3.2 List of terms and definitions given in IEC 61784-2, IEEE 802, IEEE 802.3, IEEE 802.1Q and IEEE 802.1AS</u>	4	Formatted: English (United States)
<u>3.3 Abbreviated terms and acronyms</u>	5	Formatted: English (United States)
<u>3.4 Conventions</u>	5	Formatted: English (United States)
<u>3.4.1 Conventions for (sub)clause selections of referenced documents</u>	5	Formatted: English (United States)
<u>3.4.2 Convention for Capitalizations</u>	7	Formatted: English (United States)
<u>3.4.3 Unit conventions</u>	7	Formatted: English (United States)
<u>4 Conformance</u>	10	Formatted: English (United States)
<u>4.1 Requirements Terminology</u>	10	Formatted: English (United States)
<u>4.2 Profile Conformance Statement (PCS)</u>	10	Formatted: English (United States)
<u>4.3 Required Functions for an Industrial Network</u>	16	Formatted: English (United States)
<u>4.3.1 PHY and MAC selection</u>	16	Formatted: English (United States)
<u>4.3.2 IEEE 802.1 selection</u>	18	Formatted: English (United States)
<u>4.3.3 Security selection</u>	23	Formatted: English (United States)
<u>4.3.4 Other IEEE 802.1 standard selections</u>	24	Formatted: English (United States)
<u>4.3.5 Other profiles</u>	24	Formatted: English (United States)
<u>4.3.6 Management selection</u>	Error! Bookmark not defined.	Formatted: English (United States)
<u>5 Industrial Automation</u>	24	Formatted: English (United States)
<u>5.1 Overview</u>	24	Formatted: English (United States)
<u>5.1.1 Control Loop Basic Model</u>	25	Formatted: English (United States)
<u>5.1.2 Industrial Traffic Types</u>	26	Formatted: English (United States)
<u>5.2 Requirements</u>	27	Formatted: English (United States)
<u>5.2.1 Bridge delay requirements</u>	27	Formatted: English (United States)
<u>5.2.2 Network access</u>	27	Formatted: English (United States)
<u>5.2.3 Bridge FDB requirements</u>	29	Formatted: English (United States)
<u>5.2.4 Bridge resource requirements</u>	29	Formatted: English (United States)
<u>5.2.5 Quantities</u>	29	Formatted: English (United States)
<u>5.2.6 Synchronization requirements</u>	30	Formatted: English (United States)
<u>Annex A PCS proforma – Time-sensitive networking profile for industrial automation</u>	35	Formatted: English (United States)
<u>A.1 General</u>	35	Formatted: English (United States)
<u>A.2 Abbreviations and special symbols</u>	35	Formatted: English (United States)
<u>A.2.1 Status symbols</u>	35	Formatted: English (United States)
<u>A.2.2 General abbreviations</u>	35	Formatted: English (United States)
<u>A.3 Instructions for completing the PCS proforma</u>	36	Formatted: English (United States)
<u>A.3.1 General structure of the PCS proforma</u>	36	Formatted: English (United States)
<u>A.3.2 Additional information</u>	36	Formatted: English (United States)
<u>A.3.3 Exception Information</u>	36	Formatted: English (United States)
<u>A.3.4 Conditional status</u>	36	Formatted: English (United States)
<u>A.4 Common requirements</u>	37	Formatted: English (United States)

<u>A.4.1</u>	<u>Implementation identification</u>	<u>37</u>
<u>A.4.2</u>	<u>Profile summary, IEC/IEEE 60802</u>	<u>38</u>
<u>A.4.3</u>	<u>Implementation type</u>	<u>38</u>
<u>A.4.4</u>	<u>Common requirements— PHY and MAC</u>	<u>38</u>
<u>A.4.5</u>	<u>Common requirements— Bridges</u>	<u>39</u>
<u>A.4.6</u>	<u>Major capabilities—Bridges</u>	<u>39</u>
<u>A.4.7</u>	<u>IEEE Std 802.1Q requirements—Bridges</u>	<u>40</u>
<u>A.4.8</u>	<u>Time Synchronization Requirements</u>	<u>40</u>
<u>A.4.9</u>	<u>Security Requirements</u>	<u>41</u>
<u>Annex Z (informative/normative)</u>	<u>Gaps</u>	<u>43</u>
<u>Bibliography</u>		<u>44</u>
<u>FOREWORD</u>		<u>4</u>
<u>INTRODUCTION</u>		<u>2</u>
<u>1</u>	<u>Scope</u>	<u>3</u>
<u>2</u>	<u>Normative references</u>	<u>3</u>
<u>3</u>	<u>Terms, definitions, symbols and abbreviated terms</u>	<u>4</u>
<u>3.1</u>	<u>TSN-IA defined Terms</u>	<u>4</u>
<u>3.2</u>	<u>List of terms and definitions given in IEC 61784-2, IEEE 802, IEEE 802.3, IEEE 802.1Q and IEEE 802.1AS</u>	<u>4</u>
<u>3.3</u>	<u>Abbreviated terms and acronyms</u>	<u>5</u>
<u>3.4</u>	<u>Conventions</u>	<u>5</u>
<u>3.4.1</u>	<u>Conventions for (sub)clause selections of referenced documents</u>	<u>5</u>
<u>3.4.2</u>	<u>Convention for Capitalizations</u>	<u>7</u>
<u>3.4.3</u>	<u>Unit conventions</u>	<u>7</u>
<u>4</u>	<u>Overview of TSN in Industrial Automation</u>	<u>7</u>
<u>4.1</u>	<u>Control Loop Basic Model</u>	<u>7</u>
<u>4.2</u>	<u>Industrial Traffic Types</u>	<u>9</u>
<u>5</u>	<u>Conformance</u>	<u>10</u>
<u>5.1</u>	<u>Requirements Terminology</u>	<u>10</u>
<u>5.2</u>	<u>Profile Conformance Statement (PCS)</u>	<u>10</u>
<u>6</u>	<u>Required Functions for an Industrial Network</u>	<u>10</u>
<u>6.1</u>	<u>PHY and MAC selection</u>	<u>10</u>
<u>6.1.1</u>	<u>General</u>	<u>10</u>
<u>6.1.2</u>	<u>IEEE 802.3-2015 Selections</u>	<u>10</u>
<u>6.2</u>	<u>IEEE 802.1 selection</u>	<u>12</u>
<u>6.2.1</u>	<u>General</u>	<u>12</u>
<u>6.2.2</u>	<u>Bridge selections</u>	<u>12</u>
<u>6.2.3</u>	<u>Applicable amendments to IEEE 802.1Q™-2018</u>	<u>14</u>
<u>6.2.4</u>	<u>Clock synchronization selection</u>	<u>14</u>
<u>6.2.5</u>	<u>Security selection</u>	<u>17</u>
<u>6.2.6</u>	<u>Other IEEE 802.1 standard selections</u>	<u>18</u>
<u>6.3</u>	<u>Other profiles</u>	<u>18</u>
<u>6.4</u>	<u>Bridge delay requirements</u>	<u>18</u>
<u>6.5</u>	<u>Network access</u>	<u>19</u>
<u>6.6</u>	<u>Bridge FDB requirements</u>	<u>21</u>
<u>6.7</u>	<u>Bridge resource requirements</u>	<u>21</u>
<u>6.8</u>	<u>Quantities</u>	<u>21</u>

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Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

6.9	Management selection	22
6.9.1	General	22
6.9.2	Protocols	22
Annex A	PCS proforma – Time sensitive networking profile for industrial automation	23
A.1	General	23
A.2	Abbreviations and special symbols	23
A.2.1	Status symbols	23
A.2.2	General abbreviations	23
A.3	Instructions for completing the PCS proforma	24
A.3.1	General structure of the PCS proforma	24
A.3.2	Additional information	24
A.3.3	Exception Information	24
A.3.4	Conditional status	24
A.4	Common requirements	25
A.4.1	Implementation identification	25
A.4.2	Profile summary, IEC/IEEE 60802	26
A.4.3	Implementation type	26
A.4.4	Common requirements – PHY and MAC	26
A.4.5	Common requirements – Bridges	27
A.4.6	Major capabilities – Bridges	27
A.4.7	IEEE Std 802.1Q requirements – Bridges	28
A.4.8	Time Synchronization Requirements	28
A.4.9	Security Requirements	29
Annex Z (informative/normative)	Gaps	31
Bibliography		32
Figure 1	Principle data flow of control loop	8
Figure 2	Delay measurement reference points	27
Table 1	List of terms	4
Table 6	Application types	26
Table 7	Industrial automation traffic types summary	26
Table 8	Required Ethernet Bridge delays	27
Table 9	Values of the parameter NetworkCycle	28
Table 10	Synchronization Domains	30
Table 11	Synchronization Roles	31
Table 12	Maximum deviation to grandmaster time requirements	31
Table 13	Maximum number of hops between grandmaster and time aware end-point	31
Table 14	Maximum error contribution per network node	31
Table 15	Timestamp accuracy	32
Table 16	Synchronization Roles	33
Table 1	List of terms	5
Table 2	Layout of profile (sub)clause selection tables	5
Table 3	Contents of (sub)clause selection tables	6
Table 4	Example of a selection table that apply for multiple device types	7
Table 5	Application types	9

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supporting ballot comment on 60802/D1.0 – 5 –
Step 1 & 2

Table 6 – Industrial automation traffic types summary.....	9
Table 7 – PHY and MAC selection within IEEE 802.3-2015.....	10
Table 8 – CP 802PHY/2 PHY selection and the MAC speeds of Amendments.....	11
Table 10 – Bridge selections of current amendments to IEEE 802.1Q™-2018.....	14
Table 11 – Synchronization Domains.....	15
Table 12 – Synchronization Roles.....	15
Table 13 – Maximum deviation to grandmaster time requirements.....	16
Table 14 – Maximum number of hops between grandmaster and time aware end-point.....	16
Table 15 – Maximum error contribution per network node.....	16
Table 16 – Timestamp accuracy.....	16
Table 17 – Selection of IEEE 802.1AS-2019.....	17
Table 18 – MAC Security selection.....	17
Table 19 – Other IEEE 802.1 standard selections.....	18
Table 20 – Other IEEE 802.1 TSN profiles.....	18
Table 21 – Required Ethernet Bridge delays.....	19
Table 22 – Values of the parameter NetworkCycle.....	20

FOREWORD

<<Contributor's notes:

This document has been contributed to the IEC/IEEE 60802 Joint Project via the 1st Task Group ballot on D1.0.

The only intention with this document is to outline some potential slight restructuring of the Draft for consideration for the group.

The intention behind the proposal is to improve clarity and readability of the Draft (improve the "flow" of the Draft.)

No rewrite is suggested by this contribution.

The contributor has submitted separate ballot comments with respect to the content of the Draft.

This contribution only focuses on the structure. The content aimed to be kept the same as D1.0, with some illustrative suggested new text in some of the suggested new clauses. However, restructuring and reformatting may provide a different look. Furthermore, some introductory text is suggested at the beginning of some of the clauses to aid the flow of reading.

In order to make it clearer that this is just an individual contribution not an IEC/IEEE 60802 Draft, the FOREWORD has been replaced with this explanation and the INTRODUCTION has been removed.

Proper cross-references were used in the contribution; however, the final outcome is not under the control of the contributor.

This commenter suggests two restructuring steps. This version of the contribution includes both Step 1 and Step 2.

Step 1: Structure

Different kind of requirements could be distinguished clearer. There are conformance requirements. There are requirements coming from Industrial Automation being the target, e.g.,

from the characteristics of control loops etc. All kinds of requirements are in Clause 6 in D1.0. It would be good to have the conformance and other kind of requirements in separate Clauses.

The Conformance Clause will be not part of the “reading flow” of the document anyways, so it would be good to have it before or after the descriptive clauses. As the Conformance Clause can give orientation to the reader, this commenter suggests having the Conformance Clause right after the terms and definitions, i.e., as Clause 4.

The “Overview of TSN for Industrial Automation” Clause could be Clause 5, i.e., follow Clause 4 Conformance.

The requirements coming from the nature of Industrial Automation, could be part of Clause 5 Overview of TSN for Industrial Automation, because they are closely related to what is Industrial Automation. With that the title of Clause 5 could be “Industrial Automation” with subclauses 5.1 Overview and 5.2 Requirements and an introductory text before 5.1. Thus, Clause 5 would give input to the rest of the document, e.g., to verbal description of industrial profile(s).

If textual description will be provided for the Industrial Automation profile, then it is suggested to be Clause 6. This contribution assumes a single profile. Clause 6 should be sub-divided in case of multiple profiles.

Step 2: Conformance

Step 2 intends to improve conformance statements. Content of D1.0 was not intended to be changed. However, some additions have been made as part of the improvement attempt. Difference, mistakes in this contribution are because the difficulties this commenter had to figure out conformance statements from D1.0.

This contribution assumes a single profile. Additional conformance statements are needed in case of multiple profiles.

Conformance statements in Clause 6 of D1.0 are ambiguous, not precise. Conformance statements should be precise. There should be conformance statements relatively easy to read for a human being. This commenter considers D1.0 Annex A PCS machine-readable, or very close, from which it is an easy step to create further machine-readable formats at the end of the project. However, conformance statements in Clause 6 D1.0 are not friendly to a human reader because it is very difficult to figure out for a vendor what actually needs to be implemented.

It is not possible to refer to entries of tables in D1.0. For instance, in D1.0, the PCS can only refer to subclause or table number but not the specific entry that is meant. This proposal resolves the referencing issue.

For instance, if a vendor only implements end stations, then it is very difficult to figure out what must be implemented. The difficulty is the same for a bridge vendor. This reader ended up needing to open the referred standards to figure it out despite of trying various other method beforehand.

One of the methods this reader tied to figure out what needs to be implemented in case of being a bride vendor.

- 1) Check the mandatory features for bridges in Annex A PCS of D1.0
- 2) Follow the references provided by the PCS items

It is understood that it is an early draft, references are not filled. However, references are not helpful in most of the cases.

For instance, Annex A.4.6 Major capabilities—Bridges refers to subclause 6.2.1.1 General required Bridge features, which however, includes end station features as well. For example, B-Q-1 makes subclause 5.4 of IEEE Std 802.1Q mandatory; however, other conformance statements make some parts of subclause 5.4 of IEEE Std 802.1

optional. Furthermore, Annex A.4.6 just refers to Table 9 in 6.2.1.1 for all the mandatory and optional features. Nonetheless, Table 9 includes both mandatory and optional features, as well as features that are not relevant for IEC/IEEE 60802 at all. Thus, the reader is left out to figure it out from Table 9. Nevertheless, Table 9 is confusing. For instance, makes subclause 5.4 of IEEE Std 802.1Q mandatory in its second entry; but further entries claim some subclauses with 5.4.1 optional or even irrelevant.

Another example is that it is not clear in D1.0 whether or not time synchronization must be supported in all kinds of deployment, or is it optional as it only needs to be supported in some cases, therefore, it is overall optional; but certain aspects must be supported if conformance claim for synchronization support has been made. The difference between bridges and end stations is not clear in D1.0 with respect to what synchronization features must be supported and what are the optional features. Therefore, in this contribution, support for synchronization has been interpreted as an optional feature overall based on the rightmost column of Table 5 in D1.0. Thus, the conformance statements in this contribution try to capture based on D1.0 what is mandatory and what is optional if support for synchronization is claimed (which is optional overall). Note that if synchronization is mandatory overall, then the structure of synchronization conformance statements can be simplified.

The structure suggested in this contribution makes it very clear what a vendor needs to implement.

A bridge vendor claiming conformance to IEC/IEEE 60802:

- must implement subclauses 4.3.1, 4.3.2, 4.5.1, and 4.5.2 in all cases and must implement 4.3.3 and 4.5.3 if support for synchronization is claimed;
- may optionally implement subclauses 4.4 and 4.6.

An end station vendor claiming conformance to IEC/IEEE 60802:

- must implement subclauses 4.3.1, 4.3.2, and 4.7 in all cases and must implement 4.3.3 if support for synchronization is claimed;
- may optionally implement subclauses 4.4 and 4.8.

Furthermore, referencing from the PCS to the corresponding conformance is clear and unambiguous, see, e.g.,: BGE-1 to BGE-8, B-Q-1, or B-Q-2.

Note that the structure of Clause 4 may become simpler if different approach is taken for synchronization. This contribution is intended to illustrate the complex case. Note also that this contribution is just a first attempt, further improvements are expected if this approach gets applied in the Draft.

Note also that this commenter suggests distinguishing whether an optional feature in a standard (or a complete standard) is irrelevant or an optional feature needs to be excluded. If an optional feature needs to be excluded or options should be specified further, then IEC/IEEE 60802 should provide the reference and specify what to do with it. This commenter considers unnecessary to mention standards or options that are irrelevant for IEC/IEEE 60802. Thus, statements introduced like "implementation for which a claim of conformance to support ... is made does not need to support" and "implementation that conforms to the provisions of this standard does not need to" could be removed. (They are only there in this contributing to maintain the content of D1.0)

Step 3: Mandatory Time Sync

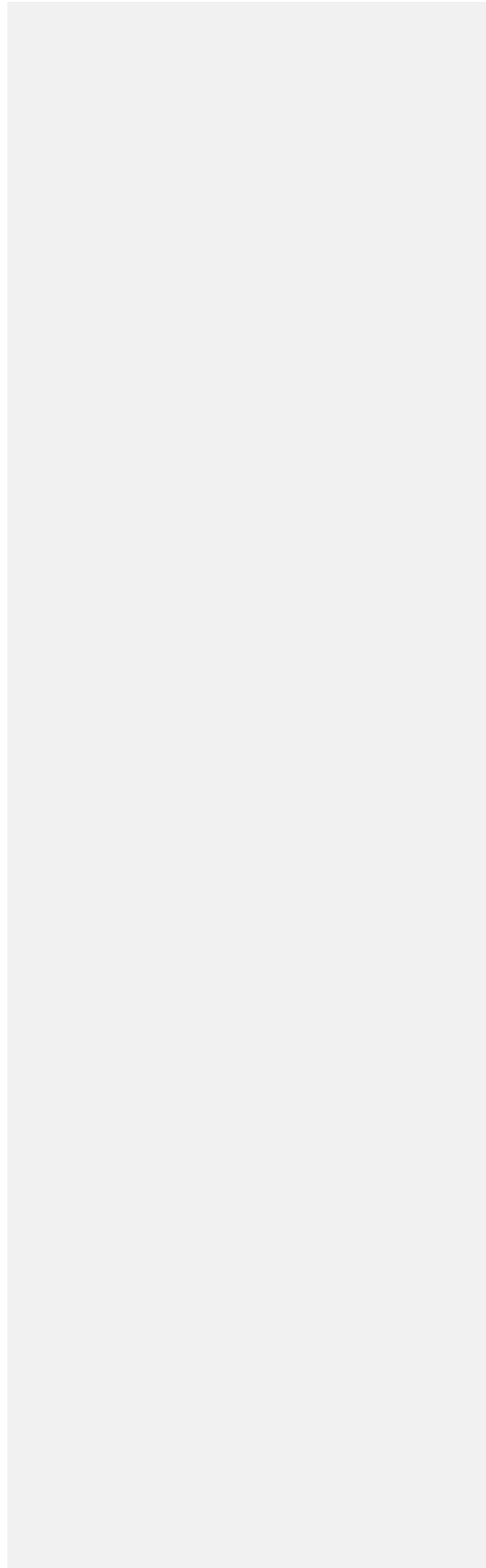
In Step 3, time synchronization has been made mandatory. It simplifies the structure of the conformance clause, i.e., in this contribution. (In step 2, time synchronization was optional because this contributor could not figure out from D1.0 whether time synchronization is mandatory or optional. Optional is more complicated for crafting conformance statements.)

Clarification text has been added that no need to support standards or parts of standards that are irrelevant, therefore, no need to be mentioned.

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INTRODUCTION



Time-sensitive networking profile for industrial automation

1 Scope

This standard defines time-sensitive networking profiles for industrial automation. The profiles select features, options, configurations, defaults, protocols, and procedures of bridges, end stations, and LANs to build industrial automation networks.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Editor Note: The list of normative references will be updated before CDV circulation.

IEEE P802.1AS-Rev/D7.4, June 12, 2017– *IEEE Draft standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications*

IEEE Std 802.1AE™-2006, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security*

IEEE Std 802.1AEbn™-2011, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security Amendment 1: Galois Counter Mode—Advanced Encryption Standard—256 (GCM-AES-256) Cipher Suite*

IEEE Std 802.1AEbw™-2013, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security Amendment 2: Extended Packet Numbering*

IEEE P802.1AEcg/D1.5, October 25, 2016, *IEEE Draft Standard for Local and metropolitan area networks—Media Access Control (MAC) Security Amendment 3: Ethernet Data Encryption devices*

IEEE Std 802.1AR™-2009, *IEEE Standard for Local and metropolitan area networks – Secure Device Identity*

IEEE Std 802.1Q™-2014, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks*, available at <http://www.ieee.org>

IEEE P802.1Qcc/ D1.1, September 1, 2016, *IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks Amendment: Stream Reservation Protocol (SRP) Enhancements and Performance Improvements*

IEEE 802.1Qch™-2017, *IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: Cyclic Queuing and Forwarding*

IEEE 802.1Qci™-2017, *IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: Per Stream Filtering and Policing*

IEEE 802.1CB™-2017, *IEEE Standard for Local and metropolitan area networks—Frame Replication and Elimination for Reliability*

IEEE P802.1CS/ D0.0, *IEEE Standard for Local and metropolitan area networks—LRP (Registration)*

IEEE P802.1Qcj/D0.1 March 7, 2016, *IEEE Standard for Local and Metropolitan Area Networks— Bridges and Bridged Networks—Automatic Attachment to Provider Backbone Bridging (PBB) services*

47 IEEE P802.1Qcp/ D0.7 December 12, 2016, *IEEE Standard for Local and Metropolitan Area*
48 *Networks—Bridges and Bridged Networks—Amendment: YANG Data Model*

49 IEEE P 802.1Qcr/D0.2, October 20, 2017, *IEEE Standard for Local and Metropolitan Area*
50 *Networks—Bridges and Bridged Networks—Amendment: Asynchronous Traffic Shaping*

51 IEEE Std 802.1X-2010, *IEEE Standard for Local and Metropolitan Area Networks—Port-based*
52 *Network Access Control*, available at <<http://www.ieee.org>>

53 IEEE 802.3-2015, *IEEE Standard for Ethernet*, available at <<http://www.ieee.org>>

54 IEEE Std 802.3bp™-2016, *IEEE Standard for Ethernet - Amendment 4: Physical Layer*
55 *Specifications and Management Parameters for 1 Gb/s Operation over a Single Twisted-Pair*
56 *Copper Cable*

57 IEEE Std 802.3br™-2016, *IEEE Standard for Ethernet - Amendment 5: Specification and*
58 *Management Parameters for Interspersing Express Traffic*

59 IEEE Std 802.3bu™-2016, *IEEE Standard for Ethernet – Amendment #: Physical Layer and*
60 *Management Parameters for Power over Data Lines (PoDL) of Single Balanced Twisted-Pair*
61 *Ethernet*

62 IEEE P802.3bv™/D3.3, 12th December 2016^{Error! Bookmark not defined.}, *IEEE Standard for Ethernet*
63 *– Amendment 9: Physical Layer Specifications and Management Parameters for 1000 Mb/s*
64 *Operation Over Plastic Optical Fiber*

65 IEEE P802.3cg, *IEEE Standard for Ethernet – Amendment: Physical Layer Specifications and*
66 *Management Parameters for 10 Mb/s Operation over Single Balanced Twisted-pair Cabling and*
67 *Associated Power Delivery*

68

69 **3 Terms, definitions, symbols and abbreviated terms**

70 For the purposes of this document, the terms and definitions given in IEC 61784-2, IEEE 802,
71 IEEE 802.3, IEEE 802.1Q and IEEE 802.1AS and the following apply.

- 72
- 73 • ISO Online browsing platform: available at <https://www.iso.org/obp>
 - 74 • IEC Electropedia: available at <http://www.electropedia.org/>

74 **3.1 TSN-IA defined Terms**

75

76 **3.1.1**

77 **TSN Domain**

78 quantity of commonly managed industrial automation devices

79 Note 1 to entry: It is an administrative decision to group these devices.

80

81

82 **3.2 List of terms and definitions given in IEC 61784-2, IEEE 802, IEEE 802.3,**

83 **IEEE 802.1Q and IEEE 802.1AS**

84 For ease of understanding the most important terms used within this profile document are listed
85 but not repeated in [Table 1](#)Table 4.

86

Table 1 – List of terms

Term	Source
Bridge	IEEE Std 802.1Q™-2018

Bridge Port	IEEE Std 802.1Q™-2018
Bridged Network	IEEE Std 802.1Q™-2018
end station	IEEE Std 802
Ethernet	IEEE Std 802.1Q™-2018
Frame	IEEE Std 802.1Q™-2018
Frame relay	IEEE Std 802.1Q™-2018
latency	IEEE Std 802.1Q™-2018
Listener	IEEE Std 802.1Q™-2018
Port	IEEE Std 802.1Q™-2018
preemption	IEEE Std 802.1Q™-2018
station	IEEE Std 802
Stream	IEEE Std 802.1Q™-2018
Talker	IEEE Std 802.1Q™-2018
time-sensitive stream	IEEE Std 802.1Q™-2018
traffic class	IEEE Std 802.1Q™-2018

87

88 **3.3 Abbreviated terms and acronyms**

89 Editor's Note: has to be updated before CDV stage!

IA Industrial automation
TSN-IA Time-Sensitive Networking for Industrial Automation

90 **3.4 Conventions**

91 ~~**3.4.1 Conventions for (sub)clause selections of referenced documents**~~

92 ~~(Sub)clause selections of referenced documents are done in tables, as shown in Table 2 and~~
 93 ~~Table 3. The selected base specifications are indicated just before the selection table(s) or in~~
 94 ~~the table title. Selections are done at the highest (sub)clause level possible to define the profile~~
 95 ~~selection unambiguously.~~

96 **Table 2 – Layout of profile (sub)clause selection tables**

Clause	Header	Presence	Constraints

97

98

Table 3 – Contents of (sub)clause selection tables

Column	Text	Meaning
Clause	<#>	(Sub)clause number of the base specifications
	Next clauses	any following clauses up to the last clause of the base specification
	Next Annexes	any following annexes up to the last annex of the base specification
Header	<text>	(Sub)clause title of the base specifications
Presence	NO	This (sub)clause is not included in the profile
	YES	This (sub)clause is fully (100 %) included in the profile in this case no further detail is given
	—	Presence is defined in the following (sub)clauses
	Partial	Parts of this (sub)clause are included in the profile
	Optional	This (sub)clause may be additionally included in the profile
Constraints	See <#>	Constraints/remarks are defined in the given (sub)clause, table or figure of this profile document
	—	No constraints other than given in the reference document (sub)clause, or not applicable
	<text>	The text defines the constraint directly; for longer text table footnotes or table notes may be used

99

If sequences of (sub)clauses match or do not match the profile, then the numbers are concatenated.

102 EXAMPLE Concatenated (sub)clauses

1-6	—	YES	—
7-11	—	NO	—

103

Conventions for different cases in selection tables, which apply for multiple or different device types (end-station, bridge):

1. Presence column value YES and NO Constraints given: This (sub)clause is fully (100 %) included in the profile for all device types
2. Presence column value YES and some Constraints given: the constraints can limit the applicability to a device type
3. Presence column value PARTIAL and general Constraints without device type constraints given: the constraints can limit the applicability to all device types
4. Presence column value PARTIAL and general Constraints with device type constraints given: the constraints limit the applicability to a device types
5. Presence column value NO and no Constraints given: This (sub)clause is not included in the profile for all device types
6. Subclauses, which are dedicated to a specific device type, do not need to repeat the device type applicability in the Constraints column.

Table 4 shows an example of a selection table that apply for multiple device types (end-station, bridge). The Clause numbers used in Table 4 corresponds to the list numbers above.

119

supporting ballot comment on 60802/D1.0 – 7 –
Step 1 & 2

120 **Table 4 – Example of a selection table that apply for multiple device types**

Clause	Header	Presence	Constraints
1	Xyz	YES	—
2	Xyz	YES	Applicable to device type end-station only
3	Media Access Control (MAC) frame and packet specifications	PARTIAL	The option xyz does not apply
4	Xyz	PARTIAL	The option xyz does not apply Applicable to device type end-station only
5	Xyz	NO	—
6	End-station behavior	YES	—

121
122 **3.4.23.4.1 Convention for Capitalizations**

123 Capitalized terms are either based on the rules given in the ISO/IEC Directives Part 2 or
124 emphasize that these terms have a specific meaning throughout this document.

125 The following capitalized terms are used:

- 126 – Bridge
- 127 – Ethernet
- 128 – Internet
- 129 – Universal Time
- 130 – Working Clock

131
132 Parameter names are capitalized for example

- 133 – MinimumFrameMemory
- 134 – NetworkCycleTime
- 135 – NetworkCycle
- 136 – Phase
- 137 – ReductionRatio
- 138 – Sequence.

139
140 **3.4.33.4.2 Unit conventions**

141 This document uses

- 142 – Tbps for Tbit/s
- 143 – Gbps for Gbit/s and
- 144 – Mbps for Mbit/s.

145 This form is used by IEEE 802.3 and as this document is a profile to IEEE 802, it is better
146 readable and consistent.

147 **41 Overview of TSN in Industrial Automation**

148 **4.11.1 Control Loop Basic Model**

149 Control loops are fundamental building blocks of industrial automation systems. Control loops
150 include process sensors, a controller function, and output signals. Control loops may require
151 guaranteed low latency or more relaxed bounded latency network transfer quality.

152 To achieve the needed quality for Control loops the roundtrip delay of the exchanged data is
153 essential.

154 Figure 1 shows the whole transmission path from Controller application to Device application(s)
155 and back. The blue and red arrows show the contributions to the e2e (end-to-end) latency
156 respectively.

Field Code Changed

157 Figure 1 and Table 5 show three levels of a control loop:

Field Code Changed

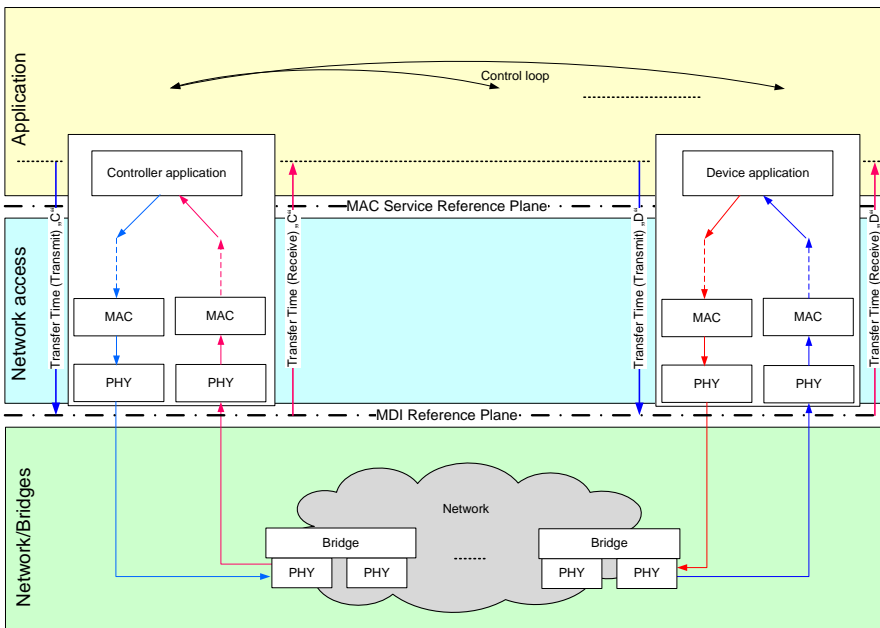
- 158 • Application within End Station,
- 159 • Network Access within End Station,
- 160 • Network / Bridges within Bridges.

Field Code Changed

161 Applications may or may not be synchronized to the Network Access depending on the
162 application requirements. Applications which are synchronized to Network Access are called
163 "isochronous applications". Applications which are not synchronized to Network Access are
164 called "non-isochronous applications".

165 Network Access shall be synchronized to a common working clock or to a local timescale.

166 Network / Bridges may or may not be synchronized to a common working clock depending on
167 whether the Enhancements for Scheduled Traffic (IEEE 802.1Q-2018) are applied.



168 **Figure 1 — Principle data flow of control loop**

170 Transfer Times contain PHY and MAC delays. Both delays are asymmetric and vendor specific.
171 Device vendors have to take into account these transfer times when their application cycle
172 models are designed (see Figure 1).

Field Code Changed

173

Table 5 – Application types

Level	Isochronous Application		Non-isochronous Application		
Application	Synchronized to network access		Synchronized to local timescale		
Network access	Synchronized to working clock, Stream-Class-based scheduling, Preemption				Synchronized to local timescale, Stream-Class based scheduling, Preemption
Network/Bridges	Synchronized to working clock	Free-running	Synchronized to working clock	Free-running	Free-running
	Scheduled traffic + Strict Priority + Preemption	Strict Priority or other Shaper + Preemption	Scheduled traffic + Strict Priority + Preemption	Strict Priority or other Shaper + Preemption	Strict Priority or other Shaper + Preemption

174

175 **4.21.1 Industrial Traffic Types**

176 Industrial automation applications concurrently make use of different traffic schemes/patterns
177 for different functionalities, e.g. parameterization, control, alarming. The various traffic patterns
178 have different characteristics and thus impose different requirements on a TSN network.

179 Table 3 subsumes the industrial automation relevant traffic patterns to traffic types with their
180 associated properties.

181

Table 6 – Industrial automation traffic types summary

Traffic type name	Periodic/ Sporadic	Guarantee	Data size	Redundancy
Isochronous cyclic real-time	P	Deadline/ bounded latency (e.g. 20% @ 1 Gbps / 50% @ 100 Mbit/s network cycle)/ bandwidth	Bounded	Up to seamless ^{††}
Cyclic real-time	P	Deadline/ bounded latency (e.g. n-times network cycle)/bandwidth	Bounded	Up to seamless ^{††}
Network control	S	Priority	—	Up to seamless ^{††} as required
Audio/video	P	Bounded latency/ bandwidth	Bounded	Up to seamless ^{††} as required
Brownfield	P	Bounded latency/ bandwidth	-	Up to regular ^{††}
Alarms/ events	S	Bounded latency/ bandwidth	-	Up to regular ^{††}
Configuration/ diagnostics	S	Bandwidth	-	Up to regular ^{††}
Internal / Pass- through	S	Bandwidth	-	Up to regular ^{††}
Best effort	S	-	-	Up to regular ^{††}

^{††}almost zero failover time;

2) larger failover time because of network re-convergence

182 **5.4 Conformance**

183 A claim of conformance to this standard is a claim that the behavior of an implementation of a
184 bridge (X.X, X.X) or of an end station (X.X, X.X) meets the mandatory requirements of this
185 standard and may support options identified in this standard.

186 Bridge and end station implementations for which a claim of conformance to this standard is
187 made do not need to support standards and the parts of standards that are not mentioned in
188 this standard. Bridge and end station implementations for which a claim of conformance to this
189 standard is made shall or may support only the standards referred from this Clause as specified
190 by this Clause.

191 **5.14.1 Requirements Terminology**

192 Conformance requirements placed upon conformant implementations of this standard are
193 expressed using the following terminology:

- 194 a) **Shall** is used for mandatory requirements;
195 b) **May** is used to describe implementation or administrative choices (“may” means “is
196 permitted to,” and hence, “may” and “may not” mean precisely the same thing);
197 c) **Should** is used for recommended choices (the behaviors described by “should” and
198 “should not” are both permissible but not equally desirable choices).

199
200 The Profile Conformance Statement (PCS) proformas (see Annex A) reflect the occurrences of
201 the words “shall,” “may,” and “should” within this document.

202 The standard avoids needless repetition and apparent duplication of its formal requirements by
203 using **is**, **is not**, **are**, and **are not** for definitions and the logical consequences of conformant
204 behavior. Behavior that is permitted but is neither always required nor directly controlled by an
205 implementer or administrator, or whose conformance requirement is detailed elsewhere, is
206 described by **can**. Behavior that never occurs in a conformant implementation or system of
207 conformant implementations is described by **cannot**. The word **allow** is used as a replacement
208 for the phrase “Support the ability for,” and the word **capability** means “can be configured to.”

210 **5.24.2 Profile Conformance Statement (PCS)**

211 The supplier of an implementation that is claimed to conform to this standard shall provide the
212 information necessary to identify both the supplier and the implementation, and shall complete
213 a copy of the PCS proforma provided in Annex A.

214 **4.3 Common requirements**

215 This subclause defines the common conformance requirements that are applicable for both
216 bridge and end station implementations claiming conformance to this standard.

217 **4.3.1 Common TSN-IA Profile requirements**

218 Bridge and end station implementations for which a claim of conformance to the TSN-IA Profile
219 (Clause 6) is made, shall support

- 220 a) The common PHY and MAC requirements (4.3.2);
221 b) The common synchronization requirements (4.3.3);
222 c) The common management requirements (4.3.4);
223 d) IEEE Std 802.1AB-2016;
224 e) IEEE Std 802.1AC-2016.

225

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226 **4.3.2 Common PHY and MAC requirements**

227 A bridge or end station implementation that conforms to the provisions of this standard shall
228 support the following features as specified in IEEE Std 802.3-2018 or in its amendment:

229 a) Implement at least one full duplex IEEE Std 802.3-2018 MAC with data rate of 10 Mbps or
230 greater together with the corresponding managed objects on each port, including 10 Mb/s
231 Single Twisted Pair Ethernet specified in IEEE Std 802.3cg-20XX as a possibility;

232 b) Media Access Control (MAC) service specification (Clause 2 of IEEE Std 802.3-2018);

233 c) Media Access Control (MAC) frame and packet specifications (Clause 3 of IEEE Std 802.3-
234 2018);

235 d) Each of the maximum MAC Client Data field sizes according (3.2.7 of IEEE 802.3-2018);

236 e) Media Access Control (Clause 4 of IEEE Std 802.3-2018);

237 f) Layer Management (Clause 5 of IEEE Std 802.3-2018);

238 g) Physical Signaling (PLS) service specifications (Clause 6 of IEEE Std 802.3-2018);

239 h) Physical Signaling (PLS) and Attachment Unit Interface (AUI) specifications (Clause 7 of
240 IEEE Std 802.3-2018);

241 i) The capability not to assert Low Power Idle (LPI) on each port that supports Energy Efficient
242 Ethernet (Clause 78 of IEEE Std 802.3-2018);

243 j) Ethernet support for time synchronization protocols (Clause 90 of IEEE Std 802.3-2018);

244 k) Interspersing Express Traffic (Clause 99 of IEEE Std 802.3-2018) for each MAC up to 1
245 Gbps;

246 l) The capability to disable MAC control PAUSE if it is implemented.

247

248

249 **4.3.3 Common requirements for synchronization**

250 A bridge or end station implementation that conforms to the provisions of this standard shall
251 support the following gPTP requirements (4.3.3.1) and meet the precision requirements
252 (4.3.3.2).

253 **4.3.3.1 gPTP requirements**

254 A bridge or end station implementation that conforms to the provisions of this standard shall
255 support the following features with the corresponding managed objects and PICS as specified
256 in IEEE Std 802.AS-2019:

257 a) Time-aware system requirements (5.3 of IEEE Std 802.1AS-2019);

258 b) PTP Instance requirements (5.4 of IEEE Std 802.1AS-2019);

259 c) PTP Relay Instance requirements (5.4.2 of IEEE Std 802.1AS-2019);

260 d) MAC-specific timing and synchronization methods for IEEE 802.3 full-duplex links (5.6 of
261 IEEE Std 802.1AS-2019).

262

263 **4.3.3.2 Synchronization precision requirements**

264 A bridge or end station implementation for which a claim of conformance to support
265 synchronization is made (see item **Error! Reference source not found.** in 4.4) shall meet the
266 following precision requirements:

267 The maximum link delay error shall be not greater than 10 ns;

268 Note – The maximum link delay error is externally measured from the MDI to MDI at the local
269 link, including the asymmetry error contribution.

270 a) The Minimal timestamp accuracy for any kind of timestamp shall be not greater than

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- 271 1) 8 ns for a Working Clock;
272 2) 8 ns for universal time.
273

274 **4.3.4 Common management requirements**

275 A bridge or end station implementation for which a claim of conformance to support SNMP MIBs
276 is made shall support SNMP as specified in RFC 4789.

277 A bridge or end station implementation for which a claim of conformance to support SNMP MIBs
278 is made shall support NETCONF as specified in RFC 6241.

279

280 **4.4 Common options**

281 This subclause defines options that are common for both bridge and end station
282 implementations claiming conformance to this standard. A bridge or end station implementation
283 that conforms to the provisions of this standard may support:

- 284 a) The common PHY and MAC options (4.4.1);
285 b) The common synchronization options (4.4.2);
286 c) The common management options (4.4.3);
287 d) The common security options (4.4.4);
288 e) IEEE Std 802.1CB-2017.
289

290 **4.4.1 Common PHY and MAC options**

291 A bridge or end station implementation that conforms to the provisions of this standard may
292 support the following features as specified in IEEE Std 802.3-2018:

- 293 a) Interspersing Express Traffic (Clause 99 of IEEE Std 802.3-2018) for MAC greater than 1
294 Gbps;
295

296 **4.4.2 Common synchronization options**

297 A bridge or end station implementation for which a claim of conformance to support
298 synchronization is made shall support the IEEE Std 802.1AS-2019 features listed in 4.3.3 and
299 may support the following IEEE Std 802.1AS-2019 features:

- 300 a) Time-aware system options (5.4.1 of IEEE Std 802.1AS-2019);
301 b) MAC-specific timing and synchronization methods for IEEE Std 802.11 (5.6 of IEEE Std
302 802.1AS-2019);
303

304 <<Editor's Note: The Time-aware system options of 5.4.1 should be examined carefully to
305 determine if any of those options should be mandatory for the purposes of this profile. A
306 contribution is welcome.>>
307

308 A bridge or end station implementation for which a claim of conformance to support
309 synchronization is made does not need to support the following IEEE Std 802.1AS-2019
310 features:

- 311 c) MAC-specific timing and synchronization methods for IEEE 802.3 EPON (5.7 of IEEE Std
312 802.1AS-2019);
313 d) MAC-specific timing and synchronization methods for coordinated shared network (CSN)
314 (5.8 of IEEE Std 802.1AS-2019).

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315
316 **4.4.3 Common management options**
317 A bridge or end station implementation that conforms to the provisions of this standard may
318 support:
319 a) SNMP MIBs;
320 b) YANG.
321
322
323 **4.4.4 Common security options**
324 A bridge or end station implementation that conforms to the provisions of this standard may
325 support the following standards for security:
326 a) MAC Security as specified by IEEE Std 802.1AE-2018 (6.7);
327 b) Port-Based Network Access Control, as specified by IEEE Std 802.1X-2019 (6.7).
328
329
330 **4.5 Bridge requirements**
331 This subclause defines the conformance requirements that are applicable for bridge
332 implementations claiming conformance to this standard.
333 **4.5.1 Bridge TSN-IA Profile requirements**
334 Bridge implementations for which a claim of conformance to the TSN-IA Profile (Clause 6) is
335 made, shall support the common requirements (4.3), the bridging requirements (4.5.2), and the
336 bridge requirements for synchronization (4.5.3).
337 **4.5.2 Bridging requirements**
338 A bridge implementation that conforms to the provisions of this standard shall:
339 a) Meet the VLAN Bridge requirements stated in items a) through r) in 5.4 of IEEE Std 802.1Q-
340 2018;
341 b) Support Multiple Spanning Tree (MST) operation as stated in item a) in 5.4.1 and in 5.4.1.1
342 of IEEE Std 802.1Q-2018;
343 c) Support frame preemption as stated in item ad) in 5.4.1.1 of IEEE Std 802.1Q-2018;
344 d) Meet the Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)
345 requirements as stated in 5.4.1.5 of IEEE Std 802.1Q-2018;
346 e) Meet the C-VLAN component requirements stated in items a) through e) in 5.5 of IEEE Std
347 802.1Q-2018;
348 f) Meet the C-VLAN Bridge requirements stated in the introductory text in 5.9 of IEEE Std
349 802.1Q-2018;
350 g) Meet the MAC Bridge component requirements stated in items a) through j) in 5.13 of IEEE
351 Std 802.1Q-2018;
352 h) Meet the MAC Bridge requirements stated in the introductory text in 5.14 of IEEE Std
353 802.1Q-2018;
354 i) Meet the MAC-specific bridging methods requirements stated in the introductory text in 5.22
355 of IEEE Std 802.1Q-2018;
356 j) Support the strict priority algorithm for transmission selection (8.6.8.1 in IEEE Std
357 802.1Q-2018) on each port for each traffic class;
358 k) Support at least eight traffic classes on each port;
359 l) Support at least five VLANs;

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- 360 m) Support flow metering as specified in 8.6.5 in IEEE Std 802.1Q-2018;
361 n) Support priority regeneration as specified 6.9.4 in IEEE Std 802.1Q-2018;
362 o) Support the capability to disable Priority-based flow control if it is implemented (Clause 36
363 of IEEE Std 802.1Q-2018).

364
365 <<Editor's note: insert reference to appropriate section once "FDB and resource requirements"
366 discussion is concluded.>>

368 **4.5.3 Bridge requirements for synchronization**

369 A bridge implementation that conforms to the provisions of this standard shall support the
370 common qPTP requirements (4.3.3.1) and meet the common precision requirements (4.3.3.2),
371 and support the following precision requirement:

- 372 a) The maximum residence time error contribution of a bridge shall be not greater than 10 ns.

373 Note – The maximum link delay error is externally measured from the MDI to MDI at the bridge.

374

375 **4.6 Bridge options**

376 A bridge implementation that conforms to the provisions of this standard may:

- 377 a) Meet the VLAN Bridge options stated in items b) through ac) in 5.4.1 of IEEE Std 802.1Q-
378 2018;

- 379 b) Support Multiple MAC Registration Protocol (MMRP) operation as stated in 5.4.1.3 of IEEE
380 Std 802.1Q-2018;

- 381 c) Meet the Per-stream filtering and policing (PSFP) requirements as stated in 5.4.1.8 of IEEE
382 Std 802.1Q-2018;

- 383 d) Meet the Cyclic queuing and forwarding (CQF) requirements as stated in 5.4.1.9 of IEEE
384 Std 802.1Q-2018;

- 385 e) Meet the Multiple VLAN Registration Protocol (MVRP) requirements as stated in 5.4.2 of
386 IEEE Std 802.1Q-2018;

- 387 f) Meet the Multiple Stream Registration Protocol (MSRP) requirements stated in 5.4.4 of IEEE
388 Std 802.1Q-2018;

- 389 g) Meet the C-VLAN component options stated in 5.5.1 of IEEE Std 802.1Q-2018;

- 390 h) Meet the C-VLAN Bridge options stated in 5.9.1 of IEEE Std 802.1Q-2018;

- 391 i) Meet the MAC Bridge component options stated in 5.13.1 of IEEE Std 802.1Q-2018;

- 392 j) Meet the MAC Bridge options stated in 5.14.1 of IEEE Std 802.1Q-2018;

- 393 k) Meet the bridge requirements specified by IEEE Std 802.1Qcc-2018;

- 394 l) Meet the bridge requirements specified by IEEE Std 802.1Qcp-2018.

395

396 A bridge implementation that conforms to the provisions of this standard does not need to:

- 397 m) Support Port-and-Protocol-based VLAN classification stated in 5.4.1.2 of IEEE Std 802.1Q-
398 2018;

- 399 n) Support Connectivity Fault Management (CFM) stated in 5.4.1.4 of IEEE Std 802.1Q-2018;

- 400 o) Meet the ETS Bridge requirements stated in 5.4.1.6 of IEEE Std 802.1Q-2018;

- 401 p) Meet the DCBX Bridge requirements stated in 5.4.1.7 of IEEE Std 802.1Q-2018;

- 402 q) Meet the VLAN Bridge requirements for congestion notification stated in 5.4.3 of IEEE Std
403 802.1Q-2018;

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- 404 r) Support Shortest Path Bridging (SPB) operation stated in 5.4.5 of IEEE Std 802.1Q-2018;
405 s) Support Path Control and Reservation (PCR) operation stated in 5.4.5 of IEEE Std 802.1Q-
406 2018;
407 t) Meet the S-VLAN component requirements stated in 5.6 of IEEE Std 802.1Q-2018;
408 u) Meet the I-component requirements stated in 5.7 of IEEE Std 802.1Q-2018;
409 v) Meet the B-component requirements stated in 5.8 of IEEE Std 802.1Q-2018;
410 w) Meet the Provider Bridge requirements stated in 5.10 of IEEE Std 802.1Q-2018;
411 x) Meet the System requirements for Priority-based Flow Control (PFC) requirements stated
412 in 5.11 of IEEE Std 802.1Q-2018;
413 y) Meet the Backbone Edge Bridge (BEB) requirements stated in 5.12 of IEEE Std 802.1Q-
414 2018;
415 z) Meet the TPMR component requirements stated in 5.15 of IEEE Std 802.1Q-2018;
416 aa) Meet the TPMR requirements stated in 5.16 of IEEE Std 802.1Q-2018;
417 bb) Meet the T-component requirements stated in 5.17 of IEEE Std 802.1Q-2018;
418 cc) Meet the EVB Bridge requirements stated in 5.23 of IEEE Std 802.1Q-2018.
419

420 **4.7 End station requirements**

421 This subclause defines the conformance requirements that are applicable for end station
422 implementations claiming conformance to this standard.

423 **4.7.1 End station TSN-IA Profile requirements**

424 End station implementations for which a claim of conformance to the TSN-IA Profile (Clause 6)
425 is made, shall support the common requirements (4.3).

426

427 **4.8 End station options**

428 An end station implementation that conforms to the provisions of this standard may:

- 429 a) Meet the end station requirements and options for MMRP, MVRP, and MSRP stated in 5.18
430 of IEEE Std 802.1Q-2018;
431 b) Meet the end station requirements for FQTSS as stated in 5.20 of IEEE Std 802.1Q-2018;
432 c) Meet the end station requirements for enhancements for scheduled traffic as stated in 5.25
433 of IEEE Std 802.1Q-2018;
434 d) Meet the end station requirements for enhancements for frame preemption as stated in 5.26
435 of IEEE Std 802.1Q-2018;
436 e) Meet the end station requirements for PSFP as stated in 5.27 of IEEE Std 802.1Q-2018;
437 f) Meet the end station requirements for cyclic queuing and forwarding as stated in 5.28 of
438 IEEE Std 802.1Q-2018;
439 g) Meet the end station requirements specified by IEEE Std 802.1Qcc-2018.

440

441

442 An end station implementation that conforms to the provisions of this standard does not need
443 to:

- 444 h) Support Port-and-Protocol-based VLAN classification stated in 5.4.1.2 of IEEE Std 802.1Q-
445 2018;
446 i) Meet the End station requirements for congestion notification stated in 5.21 of IEEE Std
447 802.1Q-2018;

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448 j) Meet the EVB station requirements stated in 5.24 of IEEE Std 802.1Q-2018.

451 ~~5.3 Required Functions for an Industrial Network~~

452 ~~5.3.1 PHY and MAC selection~~

453 ~~5.3.1.1 General~~

454 ~~The following requirements and features according to IEEE 802.3 shall be supported:~~

455 ~~a) Select one of the PHY with data rates from 10 Mbps to 1 Tbps with~~

456 ~~e) Full duplex, and~~

457 ~~e) Synchronization according IEEE 802.1AS supported.~~

458 ~~Table 7 specifies the elements of IEEE 802.3-2018 applicable to this profile. At least one~~
459 ~~PHY shall be selected out of the list of possible PHYs.~~

460 ~~b) The maximum frame size according IEEE 802.3-2015, 3.2.7, including envelope frame, shall~~
461 ~~be supported.~~

462 ~~Editor's Note: TBD: check max frame size in 802.1Q~~

463 ~~c) IEEE 802.3br™-2016 (preemption) up to 1 Gb/s; beyond optional.~~

464 ~~NOTE May be indicated by Annex A parameter.~~

465 ~~d) The selected medium shall be described in the IEEE 802.3 defined managed object.~~

466 ~~5.3.1.2 IEEE 802.3-2015 Selections~~

467 ~~Table 7 specifies the (sub)-clause selection of IEEE 802.3-2015.~~

~~Table 7 – PHY and MAC selection within IEEE 802.3-2015~~

Clause	Header	Presence	Constraints
2	Media Access Control (MAC) service specification	YES	–
3	Media Access Control (MAC) frame and packet specifications	YES	–
4	Media Access Control	YES	–
5	Layer Management	YES	–
6	Physical Signaling (PLS) service specifications	YES	–
7	Physical Signaling (PLS) and Attachment Unit Interface (AUI) specifications	YES	–
8–77	–	Partial	Applies only if 6.1.1 fulfilled.
Annex 57A–76A	–	Partial	Applies only if 6.1.16.1.1 fulfilled.
78	Energy Efficient Ethernet (EEE)	NO	
79	IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and value (TLV) information elements	YES	Relevant for IEEE 802.3br
80–89	–	Partial	Applies only if 6.1.1 fulfilled.
90	Ethernet support for time synchronization protocols	YES	Relevant for IEEE 802.3br
91–95	–	Partial	Applies only if 6.1.1 fulfilled.
Annex 83A–93G	–	Partial	Applies only if 6.1.1 fulfilled.

Table 8 – CP 802PHY/2-PHY selection and the MAC speeds of Amendments

Amendment	Title	Presence	Constraints
IEEE 802.3bw™-2015	IEEE Standard for Ethernet – Amendment 1: Physical Layer Specifications and Management Parameters for 100-Mb/s Operation over a Single Balanced Twisted-Pair Cable (100BASE-T1)	Partial	Applies only if 6.1.1 fulfilled.
IEEE 802.3by™-2016	IEEE Standard for Ethernet – Amendment 2: Media Access Control Parameters, Physical Layers, and Management Parameters for 25-Gb/s Operation	Partial	Applies only if 6.1.1 fulfilled.
IEEE 802.3bq™-2016	IEEE Standard for Ethernet – Amendment 3: Physical Layers and Management Parameters for 25-Gb/s and 40-Gb/s Operation, Types 25GBASE-T and 40GBASE-T	Partial	Applies only if 6.1.1 fulfilled.
IEEE 802.3bp™-2016	IEEE Standard for Ethernet – Amendment 4: Physical Layer Specifications and Management Parameters for 1-Gb/s Operation over a Single Twisted-Pair Copper Cable	Partial	Applies only if 6.1.1 fulfilled.
IEEE 802.3br™-2016	IEEE Standard for Ethernet – Amendment 5: Specification and Management Parameters for Interspersing Express Traffic	YES	Yes to all Options in 79.5 up to 1-Gb/s; beyond optional.
IEEE 802.3bz™-2016	IEEE Standard for Ethernet – Amendment 7: Media Access Control Parameters, Physical Layers, and Management Parameters for 2.5-Gb/s and 5-Gb/s Operation, Types 2.5GBASE-T and 5GBASE-T	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3bs™ /D2.2, 28th November 2016	IEEE Standard for Ethernet – Amendment #: Media Access Control Parameters, Physical Layers and Management Parameters for 200-Gb/s and 400-Gb/s Operation	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3bt™/D 2.2, 28 November 2016	IEEE Standard for Ethernet – Amendment #: Physical Layer and Management Parameters for DTE Power via MDI over 4-Pair	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3bu™/D3.3, 11 October 2016	IEEE Standard for Ethernet – Amendment #: Physical Layer and Management Parameters for Power over Data Lines (PoDL) of Single-Balanced Twisted-Pair Ethernet	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3bv™/D3.3, 12th December 2016	IEEE Standard for Ethernet – Amendment 9: Physical Layer Specifications and Management Parameters for 1000-Mb/s Operation Over Plastic Optical Fiber	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3ca™/D0.0, No Draft	IEEE Standard for Ethernet – Amendment #: Physical Layer Specifications and Management Parameters for 25-Gb/s, 50-Gb/s, and 100-Gb/s Passive Optical Networks	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3cb-20xx™/D2.1, 15th December 2016	IEEE Standard for Ethernet – Amendment #: Physical Layer Specifications and Management Parameters for 2.5-Gb/s and 5-Gb/s Operation over Backplane	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3cc™/D2.0, 27th November 2016	IEEE Standard for Ethernet – Amendment #: Physical Layer and Management Parameters for Serial 25-Gb/s Ethernet Operation Over Single-Mode Fiber	Partial	Applies only if 6.1.1 fulfilled.
IEEE P802.3cd™/D1.1, 2nd December 2016	IEEE Standard for Ethernet – Amendment #: Media Access Control Parameters for 50-Gb/s and Physical Layers and Management Parameters for 50-Gb/s, 100-Gb/s, and 200-Gb/s Operation	Partial	Applies only if 6.1.1 fulfilled.

Amendment	Title	Presence	Constraints
IEEE P802.3cg™/ Draft	IEEE Standard for Ethernet—Amendment #: 10 Mb/s Single Twisted Pair Ethernet	Partial	Applies only if 6.1.1 fulfilled.

471

472 **5.4 — IEEE 802.1 selection**

473 **5.4.1 — General**

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474 **5.4.1.1 — General required Bridge features**

475 The following requirements and features according to IEEE 802.1 shall be supported:

- 476 a) ~~Support the capability of 2 000 octets maximum size MAC Protocol Data Unit (PDU) on each~~
- 477 ~~port.~~
- 478 b) ~~Support the capability to disable MAC control PAUSE if it is implemented and support the~~
- 479 ~~capability to disable Priority-based flow control if it is implemented.~~
- 480 c) ~~Support the capability to disable support of Energy Efficient Ethernet.~~
- 481 d) ~~Support the strict priority algorithm for transmission selection (8.6.8.1 in IEEE Std 802.1Q-~~
- 482 ~~2014) on each port for each traffic class.~~
- 483 e) ~~Support a minimum of 8 Traffic Classes/Queues on every port.~~
- 484 f) ~~Support flow metering according to IEEE 802.1Q, 8.6.5.~~
- 485 g) ~~Support priority regeneration according to IEEE 802.1Q, 6.9.4.~~
- 486 h) ~~Support of preemption according to IEEE 802.1Q-2018, 5.26, 6.7.2, 12.30, 17.2.23, 17.3.24,~~
- 487 ~~17.4.24, 17.7.23, and Annex R.~~
- 488 i) ~~Time limits for bridge delay and delay variation according to 6.2.5.~~
- 489 j) ~~Required number of DA-MAC address entries used together with five VLANs (Default, High,~~
- 490 ~~High-Redundant, Low and Low-Redundant) according to---~~

491 **Editor's note: insert reference to appropriate section once "FDB and resource**

492 **requirements" discussion is concluded.**

493 **5.4.2 — Bridge selections**

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494 **5.4.2.1.1 — Selection of IEEE 802.1Q-2018 and the related Amendments**

495 Selections of IEEE 802.1Q™-2018 are specified in Table 9. The current amendments to IEEE

496 802.1Q are selected in Table 10.

497 **Table 9 — Selection of IEEE 802.1Q-2018**

Clause	Header	Presence	Constraints
5.3	Protocol Implementation Conformance Statement (PICS)	YES	—
5.4	VLAN Bridge component requirements	YES	—
5.4.1	VLAN Bridge component options	YES	Optional
5.4.1.1	Multiple Spanning Tree (MST) operation	YES	—
5.4.1.2	Port and Protocol-based VLAN classification	NO	—
5.4.1.3	Multiple MAC Registration Protocol (MMRP) operation	YES	Optional
5.4.1.4	Connectivity Fault Management (CFM)	NO	—
5.4.1.5	Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS) requirements	YES	Optional
5.4.1.6	ETS Bridge requirements	NO	—
5.4.1.7	DCBX Bridge requirements	NO	—

supporting ballot comment on 60802/D1.0 – 19 –
Step 1 & 2

Clause	Header	Presence	Constraints
5.4.1.8	Per-stream filtering and policing (PSFP) requirements	YES	Optional
5.4.1.9	Cyclic queuing and forwarding (CQF) requirements	YES	Optional
5.4.2	Multiple VLAN Registration Protocol (MVRP) requirements	YES	Optional
5.4.3	VLAN Bridge requirements for congestion notification	NO	–
5.4.4	Multiple Stream Registration Protocol (MSRP) requirements	YES	Optional
5.4.5	Shortest Path Bridging (SPB) operation	NO	–
5.4.6	Path Control and Reservation (PCR)	NO	–
5.5	C-VLAN component conformance	YES	–
5.5.1	C-VLAN component options	YES	Optional
5.6	S-VLAN component conformance	NO	–
5.7	I-component conformance	NO	–
5.8	B-component conformance	NO	–
5.9	C-VLAN Bridge conformance	YES	–
5.10	Provider Bridge conformance	NO	–
5.11	System requirements for Priority-based Flow Control (PFC)	NO	–
5.12	Backbone Edge Bridge (BEB) conformance	NO	–
5.13	MAC Bridge component requirements	YES	–
5.13.1	MAC Bridge component options	YES	Optional
5.14	MAC Bridge conformance	YES	–
5.14.1	MAC Bridge options	YES	Optional
5.15	TPMR component conformance	NO	–
5.16	TPMR conformance	NO	–
5.17	T-component conformance	NO	–
5.18	End station requirements for MMRP, MVRP, and MSRP	YES	Optional
5.19	VLAN-aware end station requirements for CFM	NO	–
5.20	End station requirements—FQTSS	YES	Optional
5.21	End station requirements for congestion notification	NO	–
5.22	MAC-specific bridging methods	YES	–
5.23	EVB Bridge requirements	NO	–
5.24	EVB station requirements	NO	–
5.25	End station requirements—enhancements for scheduled traffic	YES	Optional
5.26	End station requirements—enhancements for frame preemption	YES	Optional
5.27	End station requirements—PSFP	YES	Optional
5.28	End station requirements—Cyclic queuing and forwarding	YES	Optional

5.4.3 Applicable amendments to IEEE 802.1Q™-2018

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Table 10 – Bridge selections of current amendments to IEEE 802.1Q™-2018

Amendment	Title	Presence	Constraints
IEEE P802.1Qcc™-2018	IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: Stream Reservation Protocol (SRP) Enhancements and Performance Improvements	YES	Optional
IEEE P802.1Qc/D 0.1-March 7, 2016	IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Automatic Attachment to Provider Backbone Bridging (PBB) services	NO	-
IEEE P802.1Qcp/D0.7-December 12, 2016	IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: YANG Data Model	YES	Optional if SNMP and MIBs are implemented.
IEEE P 802.1Qer/D0.0	IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: Asynchronous Traffic Shaping	YES	Optional
IEEE P 802.1Qdd/D0.0	IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment: RAP	YES	Optional

5.4.4 Clock synchronization selection

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5.4.4.1 General

~~The IEEE 802.1AS™-2019 shall apply according to Table 17.~~

~~Synchronization covering both universal time and working clock timescales is needed for industrial automation systems.~~

~~Redundancy for synchronization of universal time may be solved with “cold standby”. Support of “hot standby” for universal time synchronization is not current practice but is an option in this document and can be used depending on the application requirements.~~

~~Redundancy for Working Clock synchronization can be solved with “cold standby” or “hot standby” depending on the application requirements. Support of “hot standby” for working clock synchronization is required.~~

~~NOTE Global Time is often used as synonym term for “Universal Time”. Wall Clock is based on Universal Time and considers time zones, daylight saving time and leap seconds.~~

~~5.4.4.21.1.1.1 Universal Time synchronization~~

~~Universal time is used to plant wide align events and actions (e.g. for “sequence of events”). The assigned timescale is TAI, which can be converted into local date and time if necessary. The goal of Universal Time synchronization is to establish a worldwide aligned timescale for time. Thus, often satellites are used as source of the time.~~

~~5.4.4.31.1.1.1 Working Clock synchronization~~

~~Working Clock is used to align actions line, cell or machine wide. The assigned timescale is ARB. Robots, motion control, numeric control and any kind of clocked / isochronous application rely on this timescale to ensure that actions are precisely interwoven as needed. Often PLCs, Motion Controller or Numeric Controller are used as Working Clock source.~~

~~Working Clock domains may be doubled to support zero failover time for synchronization by aligning the both timescales at the Grandmaster.~~

~~TBD: two WC domains needs more definitions hot standby/cold standby need definitions~~

~~High precision Working Clock synchronization is a prerequisite for control loop implementations.~~

supporting ballot comment on 60802/D1.0 – 21 –
Step 1 & 2

530 **5.4.41.1.1.1 General Requirements for Synchronization**

531 Synchronization domain settings shall be according to ~~Table 11 and Table 12.~~

Field Code Changed

532 **Table 11 – Synchronization Domains**

Field Code Changed

Domain	ID	Timescales	Presence	Constraints
Working Clock	20	ARB	YES	Used for network access and application synchronization. If scheduled traffic is used then also used for Bridge synchronization.
Universal Time	0	TAI	YES	Used for Universal Time.
Redundant Working Clock	24	ARB	YES	Used for hot standby of Working Clock. Timescale shall be identical to Working Clock.
Redundant Universal Time	4	TAI	YES	Optional. Used for hot standby of Universal Time. Timescale shall be identical to Universal Time.

533 ~~TBD: ID is Domain number – all Timescales coded as PTP~~

534 ~~In the working clock domain bridges shall take the roles of time aware relay and time aware endpoint, because they shall be in sync for scheduled traffic transmission.~~

536 ~~In the Universal Time domain the role of a time aware relay is mandatory and the role of a time aware endpoint is optional for Bridges.~~

538 ~~At least one grandmaster shall be present in every synchronization domain.~~

539 ~~All members of a synchronization domain may take at least one of the roles specified in Table 12.~~

Field Code Changed

541 **Table 12 – Synchronization Roles**

Role	Working Clock		Universal Time	
	Bridge or Router	End Station	Bridge or Router	End Station
Time aware relay	mandatory	–	mandatory	–
Time aware endpoint	mandatory	mandatory	optional	mandatory
Grandmaster capable	Optional	optional	optional	optional

542 ~~Editor Note: is support of UniversalTime/Time aware endpoint mandatory or optional for end stations? Contributions are welcome.~~

544 ~~The requirements concerning the overall maximum deviation to the grandmaster time in the synchronization domains in Table 13 shall be fulfilled.~~

Field Code Changed

546 **Table 13 – Maximum deviation to grandmaster time requirements**

Domain	Maximum absolute value of deviation from grandmaster time	Comments
Working Clock	< 1 μs	Maximum deviation +/- 1 μs
Universal Time	< 100 μs	Maximum deviation +/- 100 μs

547 ~~Editor's Note: reference number of hops (100) – "grandmaster time" must be defined from TAI in case of universal time~~

549 ~~Table 14 shows the number of hops which shall be supported.~~

Field Code Changed

550 **Table 14 — Maximum number of hops between grandmaster and time aware end-point**

Domain	Number of hops	Comments
Working Clock	400	Grandmaster to time aware end-point. May be 200 between two time aware end-points.
Universal Time	400	From Grandmaster connected to the satellite receiver to each time aware endpoint.

551
552 The maximum working clock deviation between two devices, which are synchronized to the
553 same grandmaster, shall be $< 2 \mu\text{s}$ when the working clock requirement of Table 13 is observed.

Field Code Changed

554 The maximum error contribution of every single network node of the domains shall be according
555 to Table 15.

Field Code Changed

556 **Table 15 — Maximum error contribution per network node**

Error contribution	Max. error	Comments
Maximum residence time error	$< 40 \text{ ns}$	Externally measured from the MDI to MDI at the local Bridge.
Maximum link delay error	$< 40 \text{ ns}$	Externally measured from the MDI to MDI at the local link including the asymmetry error contribution.

557 Minimal timestamp accuracy for any kind of timestamp shall be according to Table 16.

Field Code Changed

558 **Table 16 — Timestamp accuracy**

Timestamp	Accuracy	Comments
Working Clock	$\leq 8 \text{ ns}$	—
Universal time	$\leq 8 \text{ ns}$	—

559 Table 17 specifies the clock synchronization profile contribution. The selection of the different
560 clock types per device shall be provided using PICS.

Field Code Changed

561 **Editor's Note: add requirement about asymmetry compensation**

562 **5.4.4.5 — IEEE 802.1AS-2019 Selections**

563

supporting ballot comment on 60802/D1.0 – 23 –
Step 1 & 2

564

Table 5 – Selection of IEEE 802.1AS-2019

Clause	Header	Presence	Constraints
5.2	Protocol Implementation Conformance Statement (PICS)	YES	–
5.3	Time-aware system requirements	YES	–
5.4	PTP Instance requirements	YES	–
5.4.1	Time-aware system options	YES	Optional
5.4.2	PTP Relay Instance requirements	YES	–
5.5	MAC-specific timing and synchronization methods for IEEE 802.3 full-duplex links	YES	–
5.6	MAC-specific timing and synchronization methods for IEEE Std 802.11	YES	Optional
5.7	MAC-specific timing and synchronization methods for IEEE 802.3-EPON	NO	–
5.8	MAC-specific timing and synchronization methods for coordinated shared network (CSN)	NO	–

565 ~~Editor's Note: The Time-aware system options of 5.4.1 should be examined carefully to~~
566 ~~determine if any of those options should be mandatory for the purposes of this profile.~~
567 ~~A contribution is welcome.~~

568 **5.4.5 – Security selection**

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569 ~~Media Access Control (MAC) Security according to IEEE 802.1AE can be used as an option.~~

570 ~~Table 18 specifies the optional MAC-Security selection.~~

571

Table 18 – MAC-Security selection

Amendment	Title	Presence	Constraints
IEEE 802.1AE™-2006	IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security	YES	Optional
IEEE 802.1AEbn™-2014	IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security Amendment 1: Galois Counter Mode – Advanced Encryption Standard – 256 (GCM-AES-256) Cipher Suite	YES	If IEEE 802.1AE™-2006 is used then this is mandatory.
IEEE 802.1AEbw™-M-2013	IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Security Amendment 2: Extended Packet Numbering	YES	If IEEE 802.1AE™-2006 is used then this is mandatory.
IEEE P802.1AEcg/D1.5, October 25, 2016	IEEE Draft Standard for Local and metropolitan area networks – Media Access Control (MAC) Security Amendment 3: Ethernet Data Encryption devices	YES	If IEEE 802.1AE™-2006 is used then this is mandatory.
IEEE 802.1AR™-2009	IEEE Standard for Local and metropolitan area networks – Secure Device Identity	YES	If IEEE 802.1AE™-2006 is used then this is mandatory.
IEEE 802.1X™-2010	IEEE Standard for Local and metropolitan area networks – Port Based Network Access Control	YES	Optional
IEEE 802.1Xbx-2014	IEEE Standard for Local and metropolitan area networks – Port Based Network Access Control Amendment 1: MAC Security Key Agreement Protocol (MKA) Extensions	YES	Optional

572

573 ~~The IEEE P802.1AEcg enables multiple, per traffic class, transmit secure channels for MAC~~
574 ~~and thus will also meet strict ordering requirements (within traffic class, with express of~~

~~preemptible transmission being selected for all the priorities allocated to a traffic class) for
preemption.~~

~~Secure Device Identifiers (DevIDs) are designed to be used as interoperable secure device
authentication credentials with Extensible Authentication Protocol (EAP) and other industry
standard authentication and provisioning protocols.~~

~~5.4.6~~ Other IEEE 802.1 standard selections

~~Table 19 specifies the other IEEE 802.1 standard selections.~~

Table 19 – Other IEEE 802.1 standard selections

Amendment	Title	Presence	Constraints
IEEE 802.1AB™- 2016	IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery	YES	–
IEEE 802.1AC™- 2016	IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition	YES	–
IEEE 802.1AX™- 2008	IEEE Standard for Local and metropolitan area networks—Link Aggregation	NO	–
IEEE 802.1BR™- 2012	IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks— Bridge Port Extension	NO	–
IEEE 802.1CB™- 2017	IEEE Standard for Local and Metropolitan Area Networks—Frame Replication and Elimination for Reliability	YES	Optional
IEEE P802.1CS/ D1.5	IEEE Standard for Local and metropolitan area networks—LRP (Registration)	YES	–

~~5.5~~ Other profiles

~~A vendor can decide to implement more than one profile per device. In this case the
implemented profiles shall be coexistent. Table 20 shows other profiles.~~

Table 20 – Other IEEE 802.1 TSN profiles

Amendment	Title	Presence	Constraints
IEEE 802.1BA™- 2014	IEEE Standard for Local and metropolitan area networks—Audio Video Bridging (AVB) Systems	YES	Optional; Coexistent with this profile contribution.
IEEE 802.1CM, 2018	IEEE Standard for Local and metropolitan area networks—Time Sensitive Networks for Fronthaul	YES	Optional; Coexistent with this profile contribution.

5 Overview of TSN in Industrial Automation

This standard is concerned with the requirements of Industrial Automation and meeting these
requirements with a bridged network. This clause gives an overview on Industrial Automation
and describes Industrial Automation requirements.

5.1 Overview

This subclause provides an introductory overview for the description of Industrial Automation
requirements to bridged networks provided in 6.2.

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supporting ballot comment on 60802/D1.0 – 25 –
Step 1 & 2

596 **5.1.1 Control Loop Basic Model**

597 Control loops are fundamental building blocks of industrial automation systems. Control loops
598 include: process sensors, a controller function, and output signals. Control loops may require
599 guaranteed low latency or more relaxed bounded latency network transfer quality.

600 To achieve the needed quality for Control loops the roundtrip delay of the exchanged data is
601 essential.

602 shows the whole transmission path from Controller application to Device application(s) and
603 back. The blue and red arrows show the contributions to the e2e (end-to-end) latency
604 respectively.

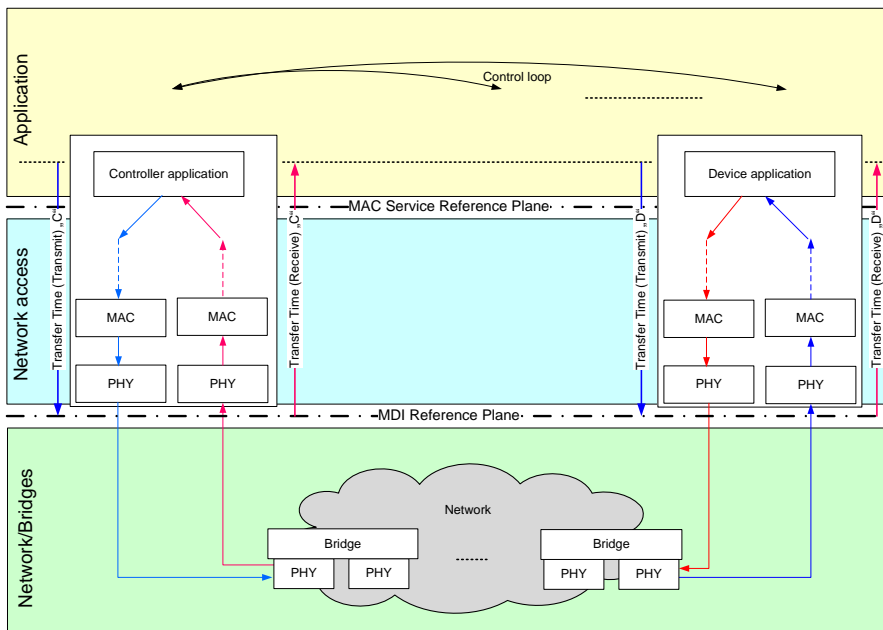
605 and show three levels of a control loop:

- 606 • Application - within End Station,
- 607 • Network Access - within End Station,
- 608 • Network / Bridges - within Bridges.

609 Applications may or may not be synchronized to the Network Access depending on the
610 application requirements. Applications which are synchronized to Network Access are called
611 "isochronous applications". Applications which are not synchronized to Network Access are
612 called "non-isochronous applications".

613 Network Access shall be synchronized to a common working clock or to a local timescale.

614 Network / Bridges may or may not be synchronized to a common working clock depending on
615 whether the Enhancements for Scheduled Traffic (IEEE 802.1Q-2018) are applied.



616

617

Figure 1 – Principle data flow of control loop

618 Transfer Times contain PHY and MAC delays. Both delays are asymmetric and vendor specific.
619 Device vendors have to take into account these transfer times when their application cycle
620 models are designed (see).

621

Table 2 – Application types

<u>Level</u>	<u>Isochronous Application</u>		<u>Non-isochronous Application</u>		
<u>Application</u>	<u>Synchronized to network access</u>		<u>Synchronized to local timescale</u>		
<u>Network access</u>	<u>Synchronized to working clock, Stream Class based scheduling, Preemption</u>				<u>Synchronized to local timescale, Stream Class based scheduling, Preemption</u>
<u>Network/Bridges</u>	<u>Synchronized to working clock</u>	<u>Free running</u>	<u>Synchronized to working clock</u>	<u>Free running</u>	<u>Free running</u>
	<u>Scheduled traffic + Strict Priority + Preemption</u>	<u>Strict Priority or other Shaper + Preemption</u>	<u>Scheduled traffic + Strict Priority + Preemption</u>	<u>Strict Priority or other Shaper + Preemption</u>	<u>Strict Priority or other Shaper + Preemption</u>

622

623 **5.1.2 Industrial Traffic Types**

624 Industrial automation applications concurrently make use of different traffic schemes/patterns for different functionalities, e.g. parameterization, control, alarming. The various traffic patterns
625 have different characteristics and thus impose different requirements on a TSN network.

627 Table 3 subsumes the industrial automation relevant traffic patterns to traffic types with their
628 associated properties.

629

Table 3 – Industrial automation traffic types summary

<u>Traffic type name</u>	<u>Periodic/ Sporadic</u>	<u>Guarantee</u>	<u>Data size</u>	<u>Redundancy</u>
<u>Isochronous cyclic real-time</u>	<u>P</u>	<u>Deadline/ bounded latency (e.g. 20%@1 Gbps / 50%@100 Mbit/s network cycle)/ bandwidth</u>	<u>Bounded</u>	<u>Up to seamless¹⁾</u>
<u>Cyclic real-time</u>	<u>P</u>	<u>Deadline/ bounded latency (e.g. n-times network cycle)/ bandwidth</u>	<u>Bounded</u>	<u>Up to seamless¹⁾</u>
<u>Network control</u>	<u>S</u>	<u>Priority</u>	<u>=</u>	<u>Up to seamless¹⁾ as required</u>
<u>Audio/video</u>	<u>P</u>	<u>Bounded latency/ bandwidth</u>	<u>Bounded</u>	<u>Up to seamless¹⁾ as required</u>
<u>Brownfield</u>	<u>P</u>	<u>Bounded latency/ bandwidth</u>	<u>=</u>	<u>Up to regular²⁾</u>
<u>Alarms/ events</u>	<u>S</u>	<u>Bounded latency/ bandwidth</u>	<u>=</u>	<u>Up to regular²⁾</u>
<u>Configuration/ diagnostics</u>	<u>S</u>	<u>Bandwidth</u>	<u>=</u>	<u>Up to regular²⁾</u>
<u>Internal / Pass-through</u>	<u>S</u>	<u>Bandwidth</u>	<u>=</u>	<u>Up to regular²⁾</u>
<u>Best effort</u>	<u>S</u>	<u>=</u>	<u>=</u>	<u>Up to regular²⁾</u>

¹⁾ almost zero failover time;

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supporting ballot comment on 60802/D1.0 – 27 –
Step 1 & 2

²⁾ larger failover time because of network re-convergence

630

631 **5.2 Requirements**

632 This subclause summarizes Industrial Automation requirements to bridged networks.

633 **5.65.2.1 Bridge delay requirements**

634 Figure 2 shows the definition the Bridge delay reference points. To make short control
635 loop times feasible Bridge-delays shall be independent from the frame size and meet the upper
636 limits of Table 4.

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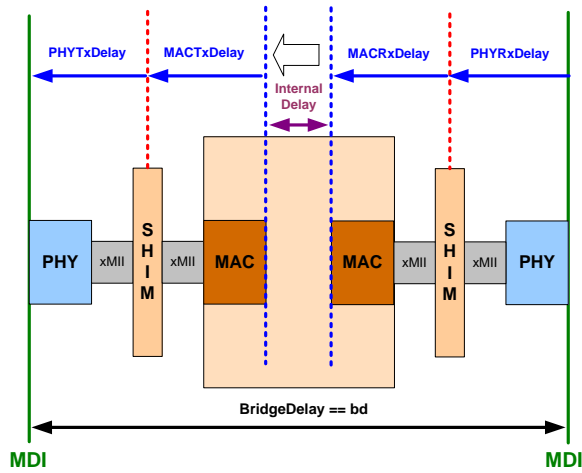


Figure 2 – Delay measurement reference points

637

638

639

640

Table 4 – Required Ethernet Bridge delays

Data rate	Value	Comment
10 Mbps	< 30 μs	Bridge delay measure from MII to MII ¹⁾
100 Mbps	< 3 μs	Bridge delay measure from MII to MII ¹⁾
1 Gbps	< 1 μs	Bridge delay measure from RGMII to RGMII ¹⁾
2,5 Gbps	< 1 μs	Bridge delay measure from XGMII to XGMII ¹⁾
5 Gbps	< 1 μs	Bridge delay measure from XGMII to XGMII ¹⁾
10 Gbps	< 1 μs	Bridge delay measure from XGMII to XGMII ¹⁾
25 Gbps – 1 Tbps:	< 1 μs	Bridge delay measure from XGMII to XGMII ¹⁾

¹⁾ first bit in, first bit out

641

642 **5.75.2.2 Network access**

643 The following network access features for end stations according to IEEE 802.1 shall be
644 supported:

- 645 a) Synchronization to working clock;
- 646 b) Stream class based scheduling with:

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- 647 o Network cycle,
- 648 - < 50 % bandwidth per link for < 1 Gbps for streams;
- 649 - < 20 % bandwidth per link for >= 1 Gbps for streams;
- 650 - < 25 % bandwidth per link for non-streams;
- 651 o Reduction ratio;
- 652 o Phase;
- 653 o Sequence;
- 654 o Transmit of frames as a convoy starts at network cycle start with minimum interpacket
- 655 gap (IPG); first isochronous cyclic real-time frames, second cyclic real-time frames, third
- 656 non-stream frames;
- 657 o Reception of frames before assigned network cycle based deadline;
- 658 c) Time limits for transfer time (receive), see , shall be <= 3 μs in addition to PHY-delay and
- 659 MAC-delay;
- 660 d) Time limits for transfer time (transmit), see , shall be <= 3 μs in addition to PHY-delay and
- 661 MAC-delay;
- 662 e) Network access parameters:
- 663 o NetworkCycle according to [Table 5](#)~~Table 9~~,
- 664 o ReductionRatio according to Formula [\(1\)](#)~~(4)~~,
- 665 o Phase according to Formula [\(2\)](#)~~(2)~~,
- 666 o Sequence according to Formula [\(3\)](#)~~(3)~~.
- 667

668 **Table 5 – Values of the parameter NetworkCycle**

NetworkCycle [time]	10 Mb/s [Data rate]	100 Mb/s [Data rate]	≥ 1 Gb/s [Data rate]
31,25 μs	n.a.	n.a.	Together with all ReductionRatios
62,5 μs	n.a.	n.a.	Together with all ReductionRatios
125 μs	n.a.	n.a.	Together with all ReductionRatios
250 μs	n.a.	Together with all ReductionRatios	Together with all ReductionRatios
500 μs	n.a.	Together with all ReductionRatios	Together with all ReductionRatios
1 ms	Together with ReductionRatio ≥ 8	Together with all ReductionRatios	Together with all ReductionRatios
2 ms	n.a.	Together with all ReductionRatios	n.a.
4 ms	n.a.	Together with all ReductionRatios	n.a.

669
670 The ReductionRatio shall be created according to Formula [\(1\)](#)~~(4)~~.

$$\text{ReductionRatio} = 2^n \mid n \in \mathbb{N}_0 \mid n \leq 10(1)$$

Where

ReductionRatio is the result of the operation

supporting ballot comment on 60802/D1.0 – 29 –
Step 1 & 2

n is actual factor for the operation
 \mathbb{N}_0 are the natural numbers including zero

671

672 The Phase shall be created according to Formula ~~(2)~~(2).

PhaseNumber = 1 to ReductionRatio (2)

Where

PhaseNumber is the chosen one out the list
ReductionRatio is the applied ReductionRatio

673

674 The Sequence shall be created according to Formula ~~(3)~~(3).

SequenceNumber = 1 to MaxListLength

(3)

Where

SequenceNumber is the chosen one out the list
MaxListLength is the maximum possible entries per Phase

675 **5-95.2.3 Bridge FDB requirements**

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676 **Editor's note: Contribution requested.**

677 **5-95.2.4 Bridge resource requirements**

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678 **Editor's note: Contribution requested.**

679 **5-105.2.5 Quantities**

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680 The following quantities shall be supported in a single TSN domain:

681 a)k) Stations: $\geq 1\ 024$

682 b)l) Network diameter: ≥ 64

683 c)m) Streams per PLC for Controller-to-Device (C2D) communication:

684 – ≥ 512 talker and ≥ 512 listener streams;

685 – $\geq 1\ 024$ talker and $\geq 1\ 024$ listener streams in case of seamless redundancy;

686 d)n) Streams per PLC for Controller-to-Controller (C2C) communication:

687 – ≥ 64 talker and ≥ 64 listener streams;

688 – ≥ 128 talker and ≥ 128 listener streams in case of seamless redundancy.

689 e)o) Streams per Device for Device-to-Device (D2D) communication:

690 – ≥ 2 talker and ≥ 2 listener streams;

691 – ≥ 4 talker and ≥ 4 listener streams in case of seamless redundancy.

692 Example calculation of data flow quantities for eight PLCs – without seamless redundancy:

693 ○ $8 \times 512 \times 2 = 8\ 192$ streams for C2D communication, plus

694 ○ $8 \times 64 \times 2 = 1\ 024$ streams for C2C communication

695 $0_{-}(8\ 192 + 1\ 024) * 2\ 000 = 18\ 432\ 000$ Bytes data of all streams

696 **5.2.6 Synchronization requirements**

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697 Synchronization covering both universal time and working clock timescales is needed for
698 industrial automation systems.

699 Redundancy for synchronization of universal time may be solved with "cold standby". Support
700 of "Hot standby" for universal time synchronization is not current practice - but is an option in
701 this document and can be used depending on the application requirements.

702 Redundancy for Working Clock synchronization can be solved with "cold standby" or "hot
703 standby" depending on the application requirements. Support of "hot standby" for working clock
704 synchronization is required.

705 NOTE Global Time is often used as synonym term for "Universal Time". Wall Clock is based on Universal Time and
706 considers time zones, daylight saving time and leap seconds.

707 **5.2.6.1 Universal Time synchronization**

708 Universal time is used to plant wide align events and actions (e.g. for "sequence of events").
709 The assigned timescale is TAI, which can be converted into local date and time if necessary.
710 The goal of Universal Time synchronization is to establish a worldwide aligned timescale for
711 time. Thus, often satellites are used as source of the time.

712 **5.2.6.2 Working Clock synchronization**

713 Working Clock is used to align actions line, cell or machine wide. The assigned timescale is
714 ARB. Robots, motion control, numeric control and any kind of clocked / isochronous application
715 rely on this timescale to ensure that actions are precisely interwoven as needed. Often PLCs,
716 Motion Controller or Numeric Controller are used as Working Clock source.

717 Working Clock domains may be doubled to support zero failover time for synchronization by
718 aligning the both timescales at the Grandmaster.

719 TBD: two WC domains – needs more definitions – hot standby/cold standby need
720 definitions

721 High precision Working Clock synchronization is a prerequisite for control loop implementations.

722 **5.2.6.3 General Requirements for Synchronization**

723 Synchronization domain settings shall be according to and.

724 **Table 6 – Synchronization Domains**

Domain	ID	Timescales	Presence	Constraints
Working Clock	20	ARB	YES	Used for network access and application synchronization. If scheduled traffic is used then also used for Bridge synchronization.
Universal Time	0	TAI	YES	Used for Universal Time.
Redundant Working Clock	21	ARB	YES	Used for hot standby of Working Clock. Timescale shall be identical to Working Clock.
Redundant Universal Time	1	TAI	YES	Optional. Used for hot standby of Universal Time. Timescale shall be identical to Universal Time.

725 TBD: ID is Domain number – all Timescales coded as PTP

726 In the working clock domain bridges shall take the roles of time aware relay and time aware
727 endpoint, because they shall be in sync for scheduled traffic transmission.

728 In the Universal Time domain the role of a time aware relay is mandatory and the role of a time
729 aware endpoint is optional for Bridges.

730 At least one grandmaster shall be present in every synchronization domain.

731 All members of a synchronization domain may take at least one of the roles specified in .

732 **Table 7 – Synchronization Roles**

<u>Role</u>	<u>Working Clock</u>		<u>Universal Time</u>	
	<u>Bridge or Router</u>	<u>End Station</u>	<u>Bridge or Router</u>	<u>End Station</u>
<u>Time aware relay</u>	<u>mandatory</u>	<u>=</u>	<u>mandatory</u>	<u>=</u>
<u>Time aware endpoint</u>	<u>mandatory</u>	<u>mandatory</u>	<u>optional</u>	<u>mandatory</u>
<u>Grandmaster capable</u>	<u>Optional</u>	<u>optional</u>	<u>optional</u>	<u>optional</u>

733 Editor Note: is support of UniversalTime/Time aware endpoint mandatory or optional for end
734 stations? Contributions are welcome.

735 The requirements concerning the overall maximum deviation to the grandmaster time in the
736 synchronization domains in shall be fulfilled.

737 **Table 8 – Maximum deviation to grandmaster time requirements**

<u>Domain</u>	<u>Maximum absolute value of deviation from grandmaster time</u>	<u>Comments</u>
<u>Working Clock</u>	<u>< 1 μs</u>	<u>Maximum deviation +/- 1 μs</u>
<u>Universal Time</u>	<u>< 100 μs</u>	<u>Maximum deviation +/- 100 μs</u>

738 Editor's Note: reference number of hops (100) – “grandmaster time” must be defined
739 from TAI in case of universal time

740 shows the number of hops which shall be supported.

741 **Table 9 – Maximum number of hops between grandmaster and time aware end-point**

<u>Domain</u>	<u>Number of hops</u>	<u>Comments</u>
<u>Working Clock</u>	<u>100</u>	<u>Grandmaster to time aware end-point.</u> <u>May be 200 between two time aware end-points.</u>
<u>Universal Time</u>	<u>100</u>	<u>From Grandmaster connected to the satellite receiver</u> <u>to each time aware endpoint.</u>

742
743 The maximum working clock deviation between two devices, which are synchronized to the
744 same grandmaster, shall be < 2 μs when the working clock requirement of is observed.

745 <<Contributor's note:

746 Not sure about good location. Table 15 and Table 16 are device requirements. Sections 4.3.3.2
747 and 4.5.3 of this contribution show an attempt how Table 15 and Table 16 may look like if
748 converted to conformance requirement, i.e., if a device claiming conformance to this standard
749 must meet the requirement. Note that, in this contribution, support for synchronization has been
750 interpreted as an optional feature based on the rightmost column of Table 5 in D1.0.>>

751 The maximum error contribution of every single network node of the domains shall be according
752 to.

753 **Table 10 – Maximum error contribution per network node**

<u>Error contribution</u>	<u>Max. error</u>	<u>Comments</u>
<u>Maximum residence time error</u>	<u>< 10 ns</u>	<u>Externally measured from the MDI to MDI at the local</u> <u>Bridge.</u>
<u>Maximum link delay error</u>	<u>< 10 ns</u>	<u>Externally measured from the MDI to MDI at the local</u> <u>link – including the asymmetry error contribution.</u>

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754 Minimal timestamp accuracy for any kind of timestamp shall be according to.

755 **Table 11 – Timestamp accuracy**

<u>Timestamp</u>	<u>Accuracy</u>	<u>Comments</u>
<u>Working Clock</u>	<u>≤ 8 ns</u>	≡
<u>Universal time</u>	<u>≤ 8 ns</u>	≡

756 Table 5 specifies the clock synchronization profile contribution. The selection of the different
757 clock types per device shall be provided using PICS.

Field Code Changed

758 Editor's Note: add requirement about asymmetry compensation

759 ○

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760 **5.11 – Management selection**

761 **5.11.1 – General**

762 ~~End stations and bridges shall provide at least the managed objects, which are required by this~~
763 ~~profile contribution, from~~

764 ~~IEEE 802.3~~

765 ~~IEEE 802.3br~~

766 ~~IEEE 802.1Q~~

767 ~~IEEE 802.1Qca~~

768 ~~IEEE 802.1Qcc~~

769 ~~IEEE 802.1CBcv~~

770 ~~IEEE 802.1AS~~

771 ~~IEEE 802.1AB~~

772 ~~IETF RFC 1213~~

773 ~~etc.~~

774 ~~These managed objects shall be represented preferred in the YANG format; if the YANG (RFC~~
775 ~~6020) format is not available then MIB format (RFC 2358) shall be provided.~~

776 **5.11.2 – Protocols**

777 ~~Required access protocols are SNMP (RFC 4789) for a MIB representation and NETCONF~~
778 ~~(RFC 6241) for YANG representation of the device local data base.~~

779

780 **6 Industrial Automation profile**

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781 The objective of the Industrial Automation profile specified in this standard is to allow the
782 construction of bridged networks that meet the industrial automation requirements described in
783 Clause 5.

784 The bridges of an industrial automation bridged network shall meet the bridge requirements
785 specified in Clause 4 and each link of an industrial automation bridged network is a full duplex
786 point-to-point link. Furthermore, the industrial automation bridged network is designed,
787 configured, and operated as described in this clause in order to meet the industrial automation
788 requirements described in Clause 5. The end stations of an industrial automation deployment
789 shall meet the end station requirements specified in Clause 4 in order to meet the industrial
790 automation requirements described in Clause 5.

791

792 **6.1 Frame size**

793 The size of the Ethernet frames can influence whether or not the industrial automation
794 requirements are met.

795 The maximum frame size is configured at each port of the industrial automation bridged network
796 according to the maximum frame size rules that apply to IEEE 802.3 frames. That is, the
797 maximum possible frame size from the destination MAC address through the end of the CRC is
798 2000 octets. For example, if nothing but the basic IEEE 802.3 headers are being used with an
799 IEEE 802.1Q C-VLAN tag, then the maximum frame size is 1522 octets. The maximum frame
800 size applied in a network can be smaller than the maximum frame size allowed by IEEE Std
801 802.3. Furthermore, the maximum frame size applied for different traffic classes can be
802 different. The maximum frame size actually applied for the different traffic classes is used in
803 worst-case latency calculations.

804 **6.2 Traffic classes**

806 **6.3 Latency**

808 **6.4 Frame loss**

810 **6.5 VLANs**

812 **6.6 Synchronization**

814 Redundancy for synchronization of universal time may be solved with “cold standby”. Support
815 of “Hot standby” for universal time synchronization is not current practice - but is an option in
816 this document and can be used depending on the application requirements.

817 Redundancy for Working Clock synchronization can be solved with “cold standby” or “hot
818 standby” depending on the application requirements. Support of “hot standby” for working clock
819 synchronization is required.

820 Working Clock domains may be doubled to support zero failover time for synchronization by
821 aligning the both timescales at the Grandmaster.

823 All members of a synchronization domain may take at least one of the roles specified in .

824 **Table 12 – Synchronization Roles**

<u>Role</u>	<u>Working Clock</u>		<u>Universal Time</u>	
	<u>Bridge or Router</u>	<u>End Station</u>	<u>Bridge or Router</u>	<u>End Station</u>
<u>Time aware relay</u>	<u>mandatory</u>	<u>=</u>	<u>mandatory</u>	<u>=</u>
<u>Time aware endpoint</u>	<u>mandatory</u>	<u>mandatory</u>	<u>optional</u>	<u>mandatory</u>
<u>Grandmaster capable</u>	<u>Optional</u>	<u>optional</u>	<u>optional</u>	<u>optional</u>

825 Editor Note: is support of UniversalTime/Time aware endpoint mandatory or optional for end
826 stations? Contributions are welcome.

827

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828 **6.7 Security**

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829 IEEE Std 802.1AE enables multiple, per traffic class, transmit secure channels for MAC and
830 thus will also meet strict ordering requirements (within traffic class, with express or preemptible
831 transmission being selected for all the priorities allocated to a traffic class) for preemption.

832 Secure Device Identifiers (DevIDs) are designed to be used as interoperable secure device
833 authentication credentials with Extensible Authentication Protocol (EAP) and other industry
834 standard authentication and provisioning protocols.

835

836 **6.8 Further considerations**

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837 <<**Contributor's note:**

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838 Further considerations can be added here. A couple of examples provided in this contribution.

839 >>

840 **6.8.1 Frame preemption**

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841

842 **6.8.2 Flow control**

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843 The operation of flow control protocols, for example MAC control PAUSE (IEEE Std 802.3), or
844 Priority-based flow control (IEEE Std 802.1Q) operating on the priorities that are used to support
845 industrial automation traffic, can invalidate latency guarantees for industrial automation traffic.
846 Therefore, a bridge of an industrial automation bridged network shall be configurable to disable
847 MAC control PAUSE. MAC control PAUSE is disabled on any ports that support industrial
848 automation traffic. A bridge of an industrial automation bridged network shall be configurable
849 to disable Priority-based flow control. Priority-based flow control is disabled for the priorities
850 associated with industrial automation traffic on any ports that support industrial automation
851 traffic.

852 Given the bridge architectural model for points of attachment for higher layer entities, as
853 illustrated in Figure 8-18 of IEEE Std 802.1Q-2018, no higher layer entities within a bridge are
854 subject to these restrictions on the use of flow control protocols. However, where the
855 implementation makes use of the same MAC interface to support relayed frames and also higher
856 layer protocol operation, and where the implementation supports other MAC control protocols
857 that are not subject to relay by the bridge, all transmitted frames that are not relayed by the
858 bridge are subject to the same transmission selection algorithms as relayed frames, in order to
859 ensure that latency is not adversely affected.

860 **6.8.3 Energy Efficient Ethernet**

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861 Energy Efficient Ethernet (EEE, specified in IEEE Std 802.3) specifies a Low Power Idle (LPI)
862 mode of operation for Ethernet LANs that allows the LAN to transition to a low power state when
863 there is no activity. Control of the LPI state is performed by the LPI client, which determines,
864 on the transmission side, when LPI is asserted and when it is de-asserted. When LPI is de-
865 asserted, there is a delay (wake time) before the link is ready to operate; the longer the wake
866 time, the longer the additional latency due to the operation of EEE. Therefore, in an industrial
867 automation bridged network, bridges do not assert LPI on a port that supports EEE and
868 industrial automation traffic.

869

Annex A

PCS proforma – Time-sensitive networking profile for industrial automation

A.1 General

The supplier of an implementation that is claimed to conform to a particular profile defined in this standard shall complete the corresponding Profile Conformance Statement (PCS) proforma, which is presented in a tabular format based on the format used for Protocol Implementation Conformance Statement (PICS) proformas.

The tables do not contain an exhaustive list of all requirements that are stated in the referenced standards; for example, if a row in a table asks whether the implementation is conformant to Standard X, and the answer “Yes” is chosen, then it is assumed that it is possible, for that implementation, to fill out the PCS proforma defined in Standard X to show that the implementation is conformant; however, the tables in this standard will only further refine those elements of conformance to Standard X where particular answers are required for the profiles defined here.

The profiles are not intended to be mutually exclusive; it is possible that a given implementation can support more than one of the profiles defined in this standard. If that is the case, then either the PCS for the implementation should be filled out in order to reflect the support of multiple profiles, or a separate PCS should be filled out to reflect each profile supported.

A completed PCS proforma is the PCS for the implementation in question. The PCS is a statement of which capabilities and options of the protocol have been implemented. The PCS can have a number of uses, including use by the following:

- a) Protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight;
- b) Supplier and acquirer—or potential acquirer—of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PCS proforma;
- c) User—or potential user—of the implementation, as a basis for initially checking the possibility of interworking with another implementation (note that, while interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PCSs);
- d) Protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

A.2 Abbreviations and special symbols

A.2.1 Status symbols

M: mandatory

O: optional

O.n: optional, but support of at least one of the group of options labeled by the same numeral n is required

X: prohibited

pred: conditional-item symbol, including predicate identification: see A.3.4

¬ logical negation, applied to a conditional item’s predicate

A.2.2 General abbreviations

N/A: not applicable

PCS: Profile Conformance Statement

915 **A.3 Instructions for completing the PCS proforma**

916 **A.3.1 General structure of the PCS proforma**

917 The first part of the PCS proforma, implementation identification and protocol summary, is to
918 be completed as indicated with the information necessary to identify fully both the supplier and
919 the implementation.

920 The main part of the PCS proforma is a fixed-format questionnaire, divided into several
921 subclauses, each containing a number of individual items. Answers to the questionnaire items
922 are to be provided in the rightmost column, either by simply marking an answer to indicate a
923 restricted choice (usually Yes or No) or by entering a value or a set or range of values. (Note
924 that there are some items where two or more choices from a set of possible answers can apply;
925 all relevant choices are to be marked.) Each item is identified by an item reference in the first
926 column. The second column contains the question to be answered; the third column records the
927 status of the item—whether support is mandatory, optional, or conditional; see also A.3.4. The
928 fourth column contains the reference or references to the material that specifies the item in the
929 main body of this standard, and the fifth column provides the space for the answers.

930 A supplier may also provide (or be required to provide) further information, categorized as either
931 Additional Information or Exception Information. When present, each kind of further information
932 is to be provided in a further subclause of items labeled Ai or Xi, respectively, for cross-
933 referencing purposes, where i is any unambiguous identification for the item (e.g., simply a
934 numeral). There are no other restrictions on its format and presentation.

935 A completed PCS proforma, including any Additional Information and Exception Information, is
936 the Protocol Implementation Conformation Statement for the implementation in question.

937 NOTE Where an implementation is capable of being configured in more than one way, a single PCS may be able
938 to describe all such configurations. However, the supplier has the choice of providing more than one PCS, each
939 covering some subset of the implementation's configuration capabilities, in case that makes for easier and clearer
940 presentation of the information.

941 **A.3.2 Additional information**

942 Items of Additional Information allow a supplier to provide further information intended to assist
943 the interpretation of the PCS. It is not intended or expected that a large quantity will be supplied,
944 and a PCS can be considered complete without any such information. Examples might be an
945 outline of the ways in which a (single) implementation can be set up to operate in a variety of
946 environments and configurations, or information about aspects of the implementation that are
947 outside the scope of this standard but that have a bearing on the answers to some items.

948 References to items of Additional Information may be entered next to any answer in the
949 questionnaire and may be included in items of Exception Information.

950 **A.3.3 Exception Information**

951 It may occasionally happen that a supplier will wish to answer an item with mandatory status
952 (after any conditions have been applied) in a way that conflicts with the indicated requirement.
953 No preprinted answer will be found in the Support column for this item. Instead, the supplier
954 shall write the missing answer into the Support column, together with an Xi reference to an item
955 of Exception Information, and shall provide the appropriate rationale in the Exception item itself.

956 An implementation for which an Exception item is required in this way does not conform to this
957 standard.

958 NOTE A possible reason for the situation described previously is that a defect in this standard has been reported,
959 a correction for which is expected to change the requirement not met by the implementation.

960 **A.3.4 Conditional status**

961 **A.3.4.1 Conditional items**

962 The PCS proforma contains a number of conditional items. These are items for which both the
963 applicability of the item itself, and its status if it does apply—mandatory or optional—are
964 dependent on whether certain other items are supported.

965 Where a group of items is subject to the same condition for applicability, a separate preliminary
966 question about the condition appears at the head of the group, with an instruction to skip to a
967 later point in the questionnaire if the “Not Applicable” (N/A) answer is selected. Otherwise,
968 individual conditional items are indicated by a conditional symbol in the Status column.

969 A conditional symbol is of the form “pred: S” where pred is a predicate as described in A.3.4.2,
970 and S is a status symbol, M or O.

971 If the value of the predicate is true (see A.3.4.2), the conditional item is applicable, and its
972 status is indicated by the status symbol following the predicate: The answer column is to be
973 marked in the usual way. If the value of the predicate is false, the “Not Applicable” (N/A) answer
974 is to be marked.

975 **A.3.4.2 Predicates**

976 A predicate is one of the following:

- 977 a) An item-reference for an item in the PCS proforma: The value of the predicate is true if the
978 item is marked as supported and is false otherwise.
- 979 b) A predicate-name, for a predicate defined as a Boolean expression constructed by
980 combining item-references using the Boolean operator OR: The value of the predicate is
981 true if one or more of the items is marked as supported.
- 982 c) The logical negation symbol “¬” prefixed to an item-reference or predicate-name: The value
983 of the predicate is true if the value of the predicate formed by omitting the “¬” symbol is
984 false, and vice versa.

985 Each item whose reference is used in a predicate or predicate definition, or in a preliminary
986 question for grouped conditional items, is indicated by an asterisk in the Item column.

987 **A.3.4.3 References to other standards**

988 The following shorthand notation is used in the References columns of the profile tables:

989 <standard abbreviation>:<clause-number>

990 where standard abbreviation is one of the following:

991 Q: IEEE Std 802.1Q

992 AS: P802.1AS-REV

993 Dot3: IEEE Std 802.3

994 Hence, a reference to “IEEE Std 802.1Q-2018, 5.4.2” would be abbreviated to “Q:5.4.2”

995 **A.4 Common requirements**

996 **A.4.1 Implementation identification**

997 The entire PCS pro forma is a form that shall be filled out by a supplier.

998

Supplier	
Contact point for queries about the PCS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification, e.g., name(s) and version(s) of machines and/or operating system names	

999

1000 Only the first three items are required for all implementations; other information may be
1001 completed as appropriate in meeting the requirement for full identification.

1002 NOTE The terms "Name" and "Version" should be interpreted appropriately to correspond with a supplier's
1003 terminology (e.g., Type, Series, Model).

1004 **A.4.2 Profile summary, IEC/IEEE 60802**

Identification of profile specification	IEC/IEEE 60802 - Time-Sensitive Networking Profile for Industrial Automation			
Identification of amendments and corrigenda to the PCS proforma that have been completed as part of the PCS	Amd.	:	Corr.	:
	Amd.	:	Corr.	:
Have any Exception items been required? (See A.3.3: the answer "Yes" means that the implementation does not conform to IEC/IEEE 60802)	No	[]	Yes	[]
Date of Statement				

1005

1006 **A.4.3 Implementation type**

1007 This form is used to indicate the type of system that the PCS describes.

1008

Item	Feature	Status	References	Support	
BGE	Is the implementation a Bridge?	O.1		Yes []	No []
TLK	Is the implementation a Talker end station?	O.1		Yes []	No []
LSN	Is the implementation a Listener end station?	O.1		Yes []	No []

1009 NOTE a single device can incorporate the functionality of one or more of the functions listed in this table. For
1010 example, a device could have both Talker end station and Listener end station capability.

1011 **A.4.4 Common requirements— PHY and MAC**

Item	Feature	Status	References	Support	
Dot3	Does one or more Port of the device support an IEEE 802.3 MAC?	M	Dot3_a)	Yes []	No []
Dot3-1	State the number of IEEE802.3cg Ports.	O.2		Number_____	
Dot3-2	State the number of 100 Mb/s Ports.	O.2		Number_____	
Dot3-3	State the number of 1 Gb/s Ports.	O.2		Number_____	
Dot3-4	State the number of 2,5 Gb/s Ports.	O.2		Number_____	
Dot3-5	State the number of 5 Gb/s Ports.	O.2		Number_____	
Dot3-6	State the number of 10 Gb/s or greater Ports.	O.2		Number_____	
Dot3-7	State the number of Ports supporting IEEE802.3bw-2015	O.2		Number_____	
Dot3-8	State the number of Ports supporting IEEE802.3by-2016	O.2		Number_____	
Dot3-9	State the number of Ports supporting IEEE802.3bq-2016	O.2		Number_____	
Dot3-10	State the number of Ports supporting IEEE802.3bp-2016	O.2		Number_____	

supporting ballot comment on 60802/D1.0 – 39 –
Step 1 & 2

Dot3-11	State the number of Ports supporting IEEE802.3br-2016	M		Number_____	
Dot3-12	State the number of Ports supporting IEEE802.3bz-2016	O.2		Number_____	
Dot3-10	State the number of Ports supporting IEEE802.3bs /D2.2	O.2		Number_____	
Dot3-11	State the number of Ports supporting IEEE802.3bt /D2.2	O		Number_____	
Dot3-12	State the number of Ports supporting IEEE802.3bu /D3.3	O		Number_____	
Dot3-13	State the number of Ports supporting IEEE802.3bv /D3.3	O.2		Number_____	
Dot3-14	State the number of Ports supporting IEEE802.3ca /D0.0	O.2		Number_____	
Dot3-15	State the number of Ports supporting IEEE802.3cb /D2.1	O.2		Number_____	
Dot3-16	State the number of Ports supporting IEEE802.3cc /D2.0	O.2		Number_____	
Dot3-17	State the number of Ports supporting IEEE802.3cd /D1.1	O.2		Number_____	
Dot3-19	Do all the IEEE 802.3 Ports support full duplex operation?	M		Yes []	No []
Dot3-20	Do all ports support a maximum frame size of 2000 octets?	M		Yes []	No []

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A.4.5 Common requirements— Bridges

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1014 If item BGE in A.4.3 is supported, then the Support column in ZZZZ through ZZZZ shall be
1015 completed; otherwise the support column items in these tables shall be left blank.

1016 The major capabilities to be supported in all Bridges are identified in ZZZZ. An Bridge shall
1017 support all mandatory requirements that apply to a VLAN-aware Bridge component, and to
1018 support IEEE Std 802.1AS.

1019 Additional requirements for IEEE 802.1Q implementation that apply to all Bridges are identified
1020 in ZZZZ. These cover detailed requirements for tagging, VID, FID, MSRP, and forwarding
1021 support.

1022 Additional requirements for IEEE 802.1AS implementation that apply to all AV Bridges are
1023 identified in ZZZZ.

A.4.6 Major capabilities—Bridges

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Item	Feature	Status	References	Support	
BGE-1	Do all ports support a maximum frame size of 2000 octets?	M	4.1.1.1.4.Dot3.4.3.2: d)	Yes []	No []
BGE-2	Does the Bridge support disabling of priority-based flow control?	M	4.1.1.1.4.5.2: o)	Yes []	No []
BGE-3	Does the Bridge support disabling MAC control PAUSE if implemented?	M	4.1.1.1.4.3.2: l)	Yes []	No []
BGE-4	Does the Bridge support disabling of Energy Efficient Ethernet?	M	4.1.1.1.4.3.2: i)	Yes []	No []

BGE-5	Does the Bridge support the strict priority algorithm on each port?	M	1.1.1.1.4.5.2: j)	Yes []	No []
BGE-6	Does the Bridge support 8 queues on each port?	M	1.1.1.1.4.5.2: k)	Yes []	No []
BGE-7	Does the Bridge support priority regeneration?	M	1.1.1.1.4.5.2: n)	Yes []	No []
BGE-8	Does the Bridge support preemption?	M	1.1.1.1.4.3.2: k)	Yes []	No []
BGE-9	Does the Bridge meet the bridge delays specified in 5.2.1?	M	Table 4Table 8	Yes []	No []

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A.4.7 IEEE Std 802.1Q requirements—Bridges

Item	Feature	Status	References	Support	
B-Q-1	Does the B bridge support requirements for-VLAN Bridge Ccomponents requirements a) through r) per IEEE802.1Q 5.4 and-?	M	1.1.1.1.4Q:5.4, 4.5.2: a)	Yes []	No []
B-Q-2	Does the B bridge support requirements for VLAN Bridge per IEEE802.1Q 5.4.1 and ?	MO	1.1.1.1.4.6: a)	Yes []	No []
B-Q-3	Does the Bridge support MSTP operation per IEEE802.1Q 5.4.1.1 and-?	M	Q:5.4.1 a), Q:5.4.1.1, 4.5.2: b)	Yes []	No []
B-Q-4	Does the B bridge support MMRP operation per IEEE802.1Q 5.4.1.3 and-?	O	1.1.1.1.4Q:5.4.1.3, 4.6: b)	Yes []	No []
B-Q-5	State the number of Ports supporting Enhancements for scheduled traffic per IEEE802.1Q 5.4.1 and	O		Number_____	
B-Q-6	State the number of Ports supporting FQTS per IEEE802.1Q 5.4.1.5 and	O		Number_____	
B-Q-7	State the number of Ports supporting PSFP per IEEE802.1Q 5.4.1.8 and	O		Number_____	
B-Q-8	State the number of Ports supporting CQF per IEEE802.1Q 5.4.1.9 and	O		Number_____	
B-Q-9	Does the Bridge support MVRP per IEEE802.1Q 5.4.2 and Table 10?	O		Yes []	No []
B-Q-10	Does the Bridge support MSRP per IEEE802.1Q 5.4.4 and ?	O	1.1.1.1.1	Yes []	No []
B-Q-11	Does the Bridge support C-VLAN requirements per IEEE802.1Q 5.5, 5.9 and ?	O	1.1.1.1.1	Yes []	No []
B-Q-12	Does the Bridge support MAC Bridge component requirements per IEEE802.1Q 5.13, 5.14 and ?	O	1.1.1.1.1	Yes []	No []
B-Q-13	State the number of Asynchronous Traffic Shaping per IEEE P802.1Qcr D0.0 and	O		Number_____	
B-Q-14	Does the Bridge support IEEE802.1Qcc-2018 per ?	O		Yes []	No []
B-Q-15	Does the Bridge support IEEE P802.1Qdd per Table 10?	O		Yes []	No []

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A.4.8 Time Synchronization Requirements

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Item	Feature	Status	References	Support	
TS-1	Does the implementation support four domains as specified in ?	M		Yes []	No []
TS-2	Does the implementation comply with the maximum error contribution per network node specified in ?	M		Yes []	No []
TS-3	Does the implementation comply with the timestamp accuracy specified in ?	M		Yes []	No []
TS-4	Does the implementation comply with Time aware system requirements specified in AS: 5.3 and Table 5 ?	M	AS:5.3, Table 5	Yes []	No []
TS-5	Does the implementation comply with PTP instance requirements specified in AS: 5.4 and Table 5 ?	M	AS:5.4, Table 5	Yes []	No []
TS-5	Does the implementation comply with PTP instance requirements specified in AS: 5.4 and Table 5 ?	M	AS:5.4, Table 5	Yes []	No []
TS-6	List the number of ports supporting the media-independent master capability	O	AS:5.4.1, Table 5	Number_____	
TS-7	Is the implementation Grand Master capable as specified in AS: 5.4.1 and Table 5 ?	O	AS:5.4.1, Table 5	Yes []	No []
TS-8	List the number of ports supporting PTP Relay Instance capability	O	AS:5.4.2, Table 5	Number_____	
TS-9	Does the implementation support media-independent attributes of the Announce message and the Signaling message	O	AS:5.4.1, Table 5	Yes []	No []
TS-10	Does the implementation support the SyncIntervalSetting state machine	O	AS:5.4.1, Table 5	Yes []	No []
TS-11	Does the implementation support timing and synchronization management	M	AS:5.4.1, Table 5	Yes []	No []
TS-12	List the number of ports supporting MAC-specific timing and synchronization methods for IEEE 802.3 full-duplex links	M	AS:5.5, Table 5	Number_____	
TS-13	List the number of ports supporting MAC-specific timing and synchronization methods for IEEE 802.11	O	AS:5.6, Table 5	Number_____	

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A.4.9 Security Requirements

Item	Feature	Status	References	Support	
SEC-1	Does the implementation support IEEE 802.1AE™- 2006?	O		Yes []	No []
SEC-2	Does the implementation support IEEE 802.1AEbn™- 2011?	Dot1AE:M		Yes []	No []
SEC-3	Does the implementation support IEEE 802.1AEbw™- 2013?	Dot1AE:M		Yes []	No []
SEC-4	Does the implementation support IEEE 802.1AEcg?	Dot1AE:M		Yes []	No []

– 42 – supporting ballot comment on 60802/D1.0
Step 1 & 2 & 3

SEC-5	Does the implementation support IEEE 802.1AR™- 2009?	Dot1AE:M		Yes []	No []
SEC-6	Does the implementation support IEEE 802.1X™- 2009?	O		Yes []	No []
SEC-6	Does the implementation support IEEE 802.1Xbx™- 2014?	O		Yes []	No []

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Annex Z
(informative/normative)

Gaps

- 1037
- 1038
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- 1040
- 1041 1. Regular synchronization of .1Qbv “tick” event to the 802.1AS-Rev clock
- 1042 2. Distributed and Centralized model “UNI” may need to be expanded.
- 1043 3. Need mechanism for identifying “In-sync” and “out of Sync” for all time-aware systems
- 1044 in the network.
- 1045 4. Network diagnostic – base on Gunter’s contribution.
- 1046 5. Synchronization – base on Gunter’s contribution.
- 1047 6. Defined range of destination MAC address, do we get our own OUI
- 1048 7. Do we need a standardized TLV for LLDP to identify the TSN domain
- 1049 8. Do we need a section to distinguish between constrained devices vs other devices?
- 1050 9. Management Reconciliation
- 1051 • [http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-Configuration-](http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-Configuration-0718-v02.pdf)
- 1052 [0718-v02.pdf](http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-Configuration-0718-v02.pdf)
- 1053 10. Need to identify network management access protocols and select data models for
- 1054 management.
- 1055 11. Bridge FDB and resource requirements
- 1056 12. Define procedures to implement hot-stand-by masters.
- 1057 13. Do we need an IEC/IEEE translation dictionary?
- 1058 14. Reference style IEC guides in the profile.
- 1059 **Editor’s note: Do we need a different class of device for constrained devices (two-port**
- 1060 **mac relays for instance) or a separate profile? (Table 12-24 in 802.1Q-2018 has an**
- 1061 **example of how this might be done)?**
- 1062 15. Do we need to specify link aggregation in support of event-based control?
- 1063 • [http://www.ieee802.org/1/files/public/docs2018/60802-stanica-event-based-](http://www.ieee802.org/1/files/public/docs2018/60802-stanica-event-based-control-1118-v02.pdf)
- 1064 [control-1118-v02.pdf](http://www.ieee802.org/1/files/public/docs2018/60802-stanica-event-based-control-1118-v02.pdf)
- 1065 • [http://www.ieee802.org/1/files/public/docs2018/60802-stanica-link-aggregation-](http://www.ieee802.org/1/files/public/docs2018/60802-stanica-link-aggregation-1118-v02.pdf)
- 1066 [1118-v02.pdf](http://www.ieee802.org/1/files/public/docs2018/60802-stanica-link-aggregation-1118-v02.pdf)
- 1067 16. How do we deal with destination MAC address constraints
- 1068 • [http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-](http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-DaMacConstraints-0718-v02.pdf)
- 1069 [DaMacConstraints-0718-v02.pdf](http://www.ieee802.org/1/files/public/docs2018/60802-Steindl-DaMacConstraints-0718-v02.pdf)
- 1070

Bibliography

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1073 IEEE Std 1588™-2008, *IEEE Standard for a Precision Clock Synchronization Protocol for*
1074 *Networked Measurement and Control Systems*

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