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Ersatz für
DIN EN 61784-2:2011-04
Siehe Anwendungsbeginn

**Industrielle Kommunikationsnetze –
Profile –****Teil 2: Zusätzliche Feldbusprofile für Echtzeitnetzwerke basierend auf
ISO/IEC 8802-3
(IEC 61784-2:2014);
Englische Fassung EN 61784-2:2014, nur auf CD-ROM**

Industrial communication networks –
Profiles –

Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3
(IEC 61784-2:2014);

English version EN 61784-2:2014, only on CD-ROM

Réseaux de communication industriels –
Profils –

Partie 2: Profils de bus de terrain supplémentaires pour les réseaux en temps réel basés
sur l'ISO/CEI 8802-3
(CEI 61784-2:2014);

Version anglaise EN 61784-2:2014, seulement en CD-ROM

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Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2014-08-21 angenommene Europäische Norm als DIN-Norm ist 2015-02-01.

Für DIN EN 61784-2:2011-04 besteht eine Übergangsfrist bis 2017-08-21.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN EN 61784-2:2013-01.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Feldbus“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 65C „Industrial networks“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „<http://webstore.iec.ch>“ zu dieser Publikation angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation

- bestätigt,
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Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm.

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN 61784-2 veröffentlicht. Zu deren Abschnitt 1, der den Anwendungsbereich festlegt, und Abschnitt 3, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als informativer Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Das Original-Dokument enthält Bilder in Farbe, die in der Papierversion in einer Graustufen-Darstellung wiedergegeben werden. Elektronische Versionen dieses Dokuments enthalten die Bilder in der originalen Farbdarstellung.

Änderungen

Gegenüber DIN EN 61784-2:2011-04 wurden folgende Änderungen vorgenommen:

- a) Aktualisierung der datierten Verweise zur IEC 61158-Reihe, IEC 61784-1, IEC 61784-3-Reihe, IEC 61784-5-Reihe und IEC 61918;
- b) Aktualisierung der Auswahltabellen für die Kommunikationsprofilfamilie 3 wie die folgenden: Aktualisierung der Anforderungen für alle konformen Klassen, zusätzliche genaue Zeitanforderungen für IP, Aktualisierung der Zeitanforderungen für I/O Geräte, zusätzliche genaue Zeitanforderungen für PTCP, Steigerung der Menge der synchronisierten Geräte in der Linienstruktur, zusätzlicher konsistenter Parametersatz, zusätzliche Anwendungsklassen, Einführung des schnellen Anlaufs als zusätzliche Eigenschaft;
- c) Aktualisierung der Auswahltabellen für die Kommunikationsprofilfamilien 11 und 14;
- d) in 12.4 neues Kommunikationsprofil 11/3 hinzugefügt;
- e) in 15.6 neues Kommunikationsprofil 14/4 hinzugefügt;
- f) in Abschnitt 20 neue Kommunikationsprotokollfamilie 8 hinzugefügt.

Frühere Ausgaben

DIN EN 61784-2: 2008-10, 2011-04

Nationaler Anhang NA (informativ)

1 Anwendungsbereich

Dieser Teil der IEC 61784 beschreibt

- Leistungsindikatoren zur Unterstützung von Klassifizierungsschemas für Echtzeit-Ethernet-Anforderungen (en: Real-Time Ethernet (RTE)),
- Profile und zugehörige Netzwerkkomponenten basierend auf ISO/IEC 8802-3 oder IEEE 802.3, IEC 61158-Reihe und IEC 61784-1,
- RTE-Lösungen, welche imstande sind, parallel mit ISO/IEC 8802-3 oder IEEE 802.3 basierte Anwendungen zu laufen.

Diese Kommunikationsprofile werden Real-Time Ethernet Kommunikationsprofile genannt.

ANMERKUNG Die RTE Kommunikationsprofile verwenden ISO/IEC 8802-3 oder IEEE 802.3 Kommunikationsnetzwerke und ihre zugehörigen Netzwerkkomponente oder IEC 61588 und können in einigen Fällen diese Standards ergänzen um RTE Eigenschaften zu erhalten.

3 Begriffe, Abkürzungen und Konventionen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die Begriffe nach ISO/IEC 8802-3, IEEE 802, IEEE 802.1AB, IEEE 802.1AS, IEEE 802.1D, IEEE 802.1Q und IEEE 802.3 und die folgenden Begriffe.

3.1.1

aktives Netz

(en: active network)

Netz, in dem die Datenübertragung zwischen nicht direkt verbundenen Geräten von aktiven Elementen in den Geräten abhängt, die die Verbindung herstellen

[QUELLE: IEC 61918:2012, 3.1.2]

3.1.2

Kommunikationszyklus

(en: communication cycle)

<CPF 16>

festgelegte Zeitdauer zwischen zwei Master-Synchronisationstelegrammen

3.1.3

zyklisch

(en: cyclic)

sich regelmäßig wiederholend

3.1.4

Domäne

(en: domain)

<CPF 10>

Teil des Netzwerks, der aus einem oder zwei Subnetzen besteht

Anmerkung 1 zum Begriff: Zwei Subnetze sind für ein zweifach redundantes Netzwerk erforderlich und jede Endstation in der Domäne ist mit beiden Subnetzen verbunden.

3.1.5

Endstation

(en: end-station)

ein an ein Netzwerk angeschlossenes System, das eine erste Quelle oder ein letztes Ziel von MAC-Rahmen, die über dieses Netzwerk übertragen werden, ist

Anmerkung 1 zum Begriff: Aus der Sicht des Netzwerks ist ein Router der Netzwerkschicht eine Endstation. Ein Switch stellt in seiner Funktion zur Weiterleitung von MAC-Rahmen von einem Verbindungszweig auf einen anderen Verbindungszweig keine Endstation dar.

3.1.6

Feldbereich

(en: field area)

Bereich am Ort der Produktion oder des Prozesses, in dem Feldgeräte angeordnet sind

3.1.7

Rahmen

(en: frame)

Datenübertragungseinheit auf der MAC-Unterschicht (en: Media Access Control) basierend auf ISO/IEC 8802-3, die eine Protokolldateneinheit (PDU) zwischen MAC-Dienstbenutzern übermittelt

[QUELLE: IEEE Std. 802.1Q-2011]

3.1.8

Identifikationsnummer

(en: identification number)

IDN

<CPF 16>

Kennzeichnung von Betriebsdaten, unter der ein Datenblock mit seinem Attribut, seinem Namen, seiner Einheit, seinen minimalen und maximalen Eingabewerten und den Daten aufbewahrt wird

3.1.9**IP-Kanal****(en: IP channel)**

<CPF 16>

festgelegtes Zeitfenster innerhalb des Kommunikationszyklus, in dem Ethernet-Protokollrahmen basierend auf ISO/IEC 8802-3 weitergegeben werden (Nicht-Echtzeit-Kommunikation)

3.1.10**Jitter****(en: jitter)**

zeitliche Veränderung des Taktsignals oder zeitliche Veränderung eines anderen regelmäßigen Ereignisses

3.1.11**lineare Topologie****(en: linear topology)**

Topologie, in der die Knoten hintereinander geschaltet sind, wobei zwei Knoten lediglich mit jeweils einem weiteren Knoten verbunden sind und alle anderen Knoten jeweils mit zwei weiteren Knoten verbunden sind (entspricht Verbindung in Form einer Linie)

[QUELLE: IEC 61918:2012, 3.1.40]

3.1.12**Verbindungszweig****(en: link)**

Übertragungspfad zwischen zwei benachbarten Knoten

[QUELLE: abgeleitet von ISO/IEC 11801]

3.1.13**logische Doppellinie****(en: logical double line)**

<CPF 18>

Reihung des Root-Gerätes und sämtlicher gewöhnlicher Geräte, die die DLPDU in Vorwärts- und Rückwärtsrichtung verarbeiten

3.1.14**Master****(en: master)**

<CPF 16>

Knoten, der den anderen Knoten das Recht zur Übertragung zuweist

3.1.15**Nachricht****(en: message)**

geordnete Folge von Oktetten für die Übermittlung von Informationen

[QUELLE: abgeleitet von ISO 2382-16.02.01]

Anmerkung 1 zum Begriff: Nachrichten werden normalerweise für die Übermittlung von Informationen zwischen Peers auf der Anwendungsschicht verwendet.

3.1.16**MDT0-Telegramm****(en: MDT0 telegram)**

<CPF 16>

Telegramm, mit dem der Master seine Synchronisationsdaten sowie Teile seiner Echtzeit-Daten oder alle seine Echtzeit-Daten an die Slaves überträgt

3.1.17**Knoten****(en: node)**

Netzwerkeinheit, die mit einem oder mehreren Verbindungszweigen verbunden ist

Anmerkung 1 zum Begriff: Ein Knoten kann entweder ein Switch, eine Endstation oder eine RTE-Endstation sein.

3.1.18

Paket

(en: packet)

logische Gruppierung von Informationen, die zur Beschreibung einer Dateneinheit auf einer beliebigen Schicht verwendet wird, um die Benutzerdaten der höheren Schicht an die entsprechende Peer-Schicht zu übermitteln

Anmerkung 1 zum Begriff: Im Sinne des OSI-Referenzmodells entspricht ein Paket auf jeder Schicht der PDU. Ein Paket auf Sicherungsschicht ist ein Rahmen.

3.1.19

Echtzeit

(en: real-time)

Fähigkeit eines Systems, ein erforderliches Ergebnis in einer begrenzten Zeit bereitzustellen

3.1.20

Echtzeit-Kommunikation

(en: real-time communication)

Transfer von Daten in Echtzeit

3.1.21

Echtzeit-Ethernet

(en: Real-Time Ethernet)

RTE

Netzwerk, das auf ISO/IEC 8802--3 basiert und Echtzeit-Kommunikation unterstützt

Anmerkung 1 zum Begriff: Sofern die Echtzeit-Kommunikation nicht beeinträchtigt wird, können andere Kommunikationsarten unterstützt werden.

Anmerkung 2 zum Begriff: Diese Definition bezieht sich auf ISO/IEC 8802--3, ist aber nicht darauf beschränkt. Sie könnte auch auf andere IEEE-802-Spezifikationen, z. B. IEEE 802.11, anwendbar sein.

3.1.22

RTFL

(en: real time frame line (RTFL))

<CPF 18>

Kommunikationsmodell mit Geräten, die in einer logischen Doppellinie kommunizieren

3.1.23

RTFN

(en: real time frame network (RTFN))

<CPF 18>

Kommunikationsmodell mit Geräten, die in einem vermittelten Netzwerk kommunizieren

3.1.24

Ring

(en: ring)

aktives Netz, in dem jeder Knoten mit zwei weiteren Knoten in Reihe geschaltet ist

[QUELLE: IEC 61918:2012, 3.1.58]

Anmerkung 1 zum Begriff: Ein Ring kann auch als Schleife bezeichnet werden.

3.1.25

Router

(en: router)

<CPF 10>

Zwischeneinrichtung, die zwei oder mehr Subnetze mittels einer Netzwerkschicht-Relais-Funktion verbindet

3.1.26

RTE-Endgerät

(en: RTE end device)

Gerät mit mindestens einer RTE-Endstation

3.1.27

RTE-Endstation

(en: RTE end-station)

Endstation mit RTE-Funktion

3.1.28

Plan

(en: schedule)

zeitliche Einteilung einer Menge von in Beziehung stehenden Operationen

3.1.29

Stern

(en: star)

Netz aus drei oder mehr Geräten, bei dem alle Geräte an einem zentralen Punkt angeschlossen sind

[QUELLE: abgeleitet von IEC 61918:2012, 3.1.69]

3.1.30

Subnetz

(en: subnetwork)

<CPF 10>

Teil des Netz, der keine Router umfasst

Anmerkung 1 zum Begriff: Ein Subnetz besteht aus Endstationen, Bridges und Segmenten.

Anmerkung 2 zum Begriff: Jede in ein Subnetz eingeschlossene Endstation hat dieselbe IP-Netzwerkadresse.

3.1.31

Switch

(en: switch)

MAC-Bridge, wie in IEEE 802.1D definiert

3.1.32

Telegramm

(en: telegram)

<CPF 16>

Rahmen

– Leerseite –

English Version

**Industrial communication networks - Profiles - Part 2: Additional
fieldbus profiles for real-time networks based on ISO/IEC 8802-3
(IEC 61784-2:2014)**

Réseaux de communication industriels - Profils - Partie 2:
Profils de bus de terrain supplémentaires pour les réseaux
en temps réel basés sur l'ISO/CEI 8802-3
(CEI 61784-2:2014)

Industrielle Kommunikationsnetze - Profile - Teil 2:
Zusätzliche Feldbusprofile für Echtzeitnetzwerke basierend
auf ISO/IEC 8802-3
(IEC 61784-2:2014)

This European Standard was approved by CENELEC on 2014-08-21. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 65C/761/FDIS, future edition 3 of IEC 61784-2, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61784-2:2014.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-05-21
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-08-21

This document supersedes EN 61784-2:2010.

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Endorsement notice

The text of the International Standard IEC 61784-2:2014 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This part of IEC 61784 provides additional Communication Profiles (CP) to the existing Communication Profile Families (CPF) of IEC 61784-1 and additional CPFs with one or more CPs. These profiles meet the industrial automation market objective of identifying Real-Time Ethernet (RTE) communication networks coexisting with ISO/IEC 8802-3 or IEEE 802.3 – commonly known as Ethernet. These RTE communication networks use provision from ISO/IEC 8802-3 for the lower communication stack layers and additionally provide more predictable and reliable real-time data transfer and means for support of precise synchronization of automation equipment.

More specifically, these profiles help to correctly state the compliance of RTE communication networks with ISO/IEC 8802-3 or IEEE 802.3, and to avoid the spreading of divergent implementations.

Adoption of Ethernet technology for industrial communication between controllers and even for communication with field devices promotes use of Internet technologies in the field area. This availability would be unacceptable if it causes the loss of features required in the field area for industrial communication automation networks, such as:

- real-time,
- synchronized actions between field devices like drives,
- efficient, frequent exchange of very small data records.

These new RTE profiles may take advantage of the improvements of Ethernet networks in terms of transmission bandwidth and network span.

Another implicit but essential requirement is that the typical Ethernet communication capabilities, as used in the office world, are fully retained, so that the software involved remains applicable.

The market is in need of several network solutions, each with different performance characteristics and functional capabilities, matching the diverse application requirements. RTE performance indicators (see Clause 5), which values will be provided with RTE devices based on communication profiles specified in this part of IEC 61784, enable the user to match network devices with application dependant performance requirements of an RTE network.

Subclause 5.1 specifies basic principles of performance indicators required to express RTE performance of a CP. Subclause 5.2 describes the view of application requirements. An application-dependant class could be used to find out a suitable CP. Clause 4 specifies how conformance of a device to the CPF or CP should be stated.

INDUSTRIAL COMMUNICATION NETWORKS – PROFILES –

Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3

1 Scope

This part of IEC 61784 specifies

- performance indicators supporting classification schemes for Real-Time Ethernet (RTE) requirements;
- profiles and related network components based on ISO/IEC 8802-3 or IEEE 802.3, IEC 61158 series, and IEC 61784-1;
- RTE solutions that are able to run in parallel with ISO/IEC 8802-3 or IEEE 802.3 based applications.

These communication profiles are called Real-Time Ethernet communication profiles.

NOTE The RTE communication profiles use ISO/IEC 8802-3 or IEEE 802.3 communication networks and its related network components or IEC 61588 and may in some cases amend those standards to obtain RTE features.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use*

IEC 61131-2, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61158-1:2014, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-2:2014, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-2:2014, *Industrial communication networks – Fieldbus specifications – Part 3-2: Data-link layer service definition – Type 2 elements*

IEC 61158-3-4:2014, *Industrial communication networks – Fieldbus specifications – Part 3-4: Data-link layer service definition – Type 4 elements*

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- IEC 61158-3-21:2010, *Industrial communication networks – Fieldbus specifications – Part 3-21: Data-link layer service definition – Type 21 elements*
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- IEC 61158-4-2:2014, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 elements*
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- IEC 61158-5-2:2014, *Industrial communication networks – Fieldbus specifications – Part 5-2: Application layer service definition – Type 2 elements*
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- IEC 61158-5-10:2014, *Industrial communication networks – Fieldbus specifications – Part 5-10: Application layer service definition – Type 10 elements*
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IEC 61158-6-23:2014, *Industrial communication networks – Fieldbus specifications – Part 6-23: Application layer protocol specification – Type 23 elements*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 61784-1:2014, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61784-5-2:2013, *Industrial communication networks – Profiles – Part 5-2: Installation of fieldbuses – Installation profiles for CPF 2*

IEC 61784-5-3:2013, *Industrial communication networks – Profiles – Part 5-3: Installation of fieldbuses – Installation profiles for CPF 3*

IEC 61784-5-6:2013, *Industrial communication networks – Profiles – Part 5-6: Installation of fieldbuses – Installation profiles for CPF 6*

IEC 61784-5-8:2013, *Industrial communication networks – Profiles – Part 5-8: Installation of fieldbuses – Installation profiles for CPF 8*

IEC 61784-5-11:2013, *Industrial communication networks – Profiles – Part 5-11: Installation of fieldbuses – Installation profiles for CPF 11*

IEC 61918:2013, *Industrial communication networks – Installation of communication networks in industrial premises*

IEC 61800 (all parts), *Adjustable speed electrical power drive systems*

ISO/IEC 2382-16:1996, *Information technology – Vocabulary – Part 16: Information theory*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

Corrigendum 1

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 8802-11, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*¹
Amendment 1: 2008
Amendment 2:2010

ISO 15745-3, *Industrial automation systems and integration – Open systems application integration framework – Part 3: Reference description for IEC 61158-based control systems*

ISO 15745-4:2003, *Industrial automation systems and integration – Open systems application integration framework – Part 4: Reference description for Ethernet-based control systems*
Amendment 1:2006, *PROFINET profiles*

IEEE 802-2001, *IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture*

IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks Station and Media Access Control Connectivity Discovery*

IEEE 802.1AS-2011, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*

IEEE 802.1D-2004, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for local and metropolitan area networks – Common specifications – Media access control (MAC) Bridges*

IEEE 802.1Q-2011 *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for Local and metropolitan area networks – Virtual bridged local area networks*

IEEE 802.3-2008, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*

NOTE Compliance with future editions of this standard will need checking.

IEEE Std 802.11-2007, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks– Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications*

IEEE Std 802.15.1, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs)*

IETF RFC 768, *User Datagram Protocol*, available at <<http://www.ietf.org>>

IETF RFC 791, *Internet Protocol*, available at <<http://www.ietf.org>>

¹ There exists a consolidated edition 2.2:2011 that comprises ISO/IEC 11801:2002, its Amendment 1:2008 and its Amendment 2:2010.

- IETF RFC 792, *Internet Control Message Protocol*, available at <<http://www.ietf.org>>
- IETF RFC 793, *Transmission Control Protocol*, available at <<http://www.ietf.org>>
- IETF RFC 826, *Ethernet Address Resolution Protocol*, available at <<http://www.ietf.org>>
- IETF RFC 894, *A standard for the Transmission of IP Datagrams over Ethernet Networks*, available at <<http://www.ietf.org>>
- IETF RFC 1034, *Domain names – concepts and facilities*, available at <<http://www.ietf.org>>
- IETF RFC 1112, *Host Extensions for IP Multicasting*, available at <<http://www.ietf.org>>
- IETF RFC 1122, *Requirements for Internet Hosts – Communication Layers*, available at <<http://www.ietf.org>>
- IETF RFC 1123, *Requirements for Internet Hosts – Application and Support*, available at <<http://www.ietf.org>>
- IETF RFC 1127, *A Perspective on the Host Requirements RFCs*, available at <<http://www.ietf.org>>
- IETF RFC 1157, *Simple Network Management Protocol (SNMP)*, available at <<http://www.ietf.org>>
- IETF RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*, available at <<http://www.ietf.org>>
- IETF RFC 1305, *Network Time Protocol (Version 3)*, available at <<http://www.ietf.org>>
- IETF RFC 2131, *Dynamic Host Configuration Protocol*, available at <<http://www.ietf.org>>
- IETF RFC 2236, *Internet Group Management Protocol, Version 2*, available at <<http://www.ietf.org>>
- IETF RFC 2544, *Benchmarking Methodology for Network Interconnect Devices*, available at <<http://www.ietf.org>>
- IETF RFC 2988, *Computing TCP's Retransmission Timer*, available at <<http://www.ietf.org>>
- IETF RFC 4836, *Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)*, available at <<http://www.ietf.org>>
- Open Software Foundation (OSF): C706, *CAE Specification DCE1.1: Remote Procedure Call*, available at <<http://www.opengroup.org/onlinepubs/9629399/toc.htm>>

3 Terms, definitions, abbreviated terms, acronyms, and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 8802-3, IEEE 802, IEEE 802.1AB, IEEE 802.1AS, IEEE 802.1D, IEEE 802.1Q and IEEE 802.3, as well as the following, apply.

3.1.1

active network

network in which data transmission between non-immediately-connected devices is dependent on active elements within those intervening devices that form the connection path

[SOURCE: IEC 61918:2013, 3.1.3]

3.1.2

communication cycle

<CPF 16>

fixed time period between two master synchronization telegrams

3.1.3

cyclic

repetitive in a regular manner

3.1.4

domain

<CPF 10>

part of the network consisting of one or two subnetwork(s)

Note 1 to entry: Two subnetworks are required to compose a dual-redundant network, and each end-station in the domain is connected to both of the subnetworks.

3.1.5

end-station

a system attached to a network that is an initial source or a final destination of MAC frames transmitted across that network

Note 1 to entry: A network layer router is, from the perspective of the network, an end-station. A switch, in its role of forwarding MAC frames from one link to another, is not an end-station.

3.1.6

field area

place in a manufacturing or process site where field devices are located

3.1.7

frame

a unit of data transmission on an ISO/IEC 8802-3 MAC (Media Access Control) that conveys a protocol data unit (PDU) between MAC service users

[SOURCE: IEEE 802.1Q-2011]

3.1.8

identification number

IDN

<CPF 16>

designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.1.9

IP channel

<CPF 16>

defined time slot within the communication cycle, which passes ISO/IEC 8802-3 Ethernet protocol frames (non-real-time communication)

3.1.10

jitter

temporal change in clock signal or temporal change in otherwise regular event

3.1.11

linear topology

topology where the nodes are connected in series, with two nodes each connected to only one other node and all others each connected to two other nodes (that is, connected in the shape of a line)

[SOURCE: IEC 61918:2013, 3.1.44]

3.1.12

link

transmission path between two adjacent nodes

[SOURCE: derived from ISO/IEC 11801]

3.1.13

logical double line

<CPF 18>

sequence of root device and all ordinary devices processing the DLPDU in forward and backward direction

3.1.14

master

<CPF 16>

node which assigns the other nodes the right to transmit

3.1.15

message

ordered series of octets intended to convey information

[SOURCE: derived from ISO/IEC 2382-16:1996,16.02.01]

Note 1 to entry: Normally used to convey information between peers at the application layer.

3.1.16

MDT0 telegram

<CPF 16>

telegram, in which the master transmits its synchronization data, as well as parts or all of its real-time data, to the slaves

3.1.17

node

network entity connected to one or more links

Note 1 to entry: A node may be either a switch, an end-station or an RTE end-station.

3.1.18

packet

logical grouping of information used to describe a unit of data at any layer to convey the upper layer user data to its peer layer

Note 1 to entry: A packet is identical to the PDU at each layer in terms of the OSI reference model. A data-link layer packet is a frame.

3.1.19

real-time

the ability of a system to provide a required result in a bounded time

3.1.20

real-time communication

transfer of data in real time

3.1.21

Real-Time Ethernet

RTE

ISO/IEC 8802-3 or IEEE 802.3 based network that includes real-time communication

Note 1 to entry: Other communication can be supported, providing the real-time communication is not compromised.

Note 2 to entry: This definition is dedicated but not limited to ISO/IEC 8802-3. It could be applicable to other IEEE 802 specifications, for example IEEE 802.11.

3.1.22

real time frame line

RTFL

<CPF 18>

communication model with devices communicating in a logical double line

3.1.23

real time frame network

RTFN

<CPF 18>

communication model with devices communicating in a switched network

3.1.24

ring

active network where each node is connected in series to two other nodes

Note 1 to entry: Ring may also be referred to as loop.

[SOURCE: IEC 61918:2013, 3.1.63]

3.1.25

router

<CPF 10>

intermediate equipment that connects two or more subnetworks using a network layer relay function

3.1.26

RTE end device

device with at least one RTE end-station

3.1.27

RTE end-station

end-station with RTE capability

3.1.28

schedule

temporal arrangement of a number of related operations

3.1.29

star

network of three or more devices where all devices are connected to a central point

[SOURCE: IEC 61918:2013, 3.1.69, modified – "which may be active or passive" has been suppressed]

3.1.30

subnetwork

<CPF 10>

part of a network that does not contain any routers

Note 1 to entry: A subnetwork consists of end-stations, bridges and segments.

Note 2 to entry: Every end-station included in a subnetwork has the same IP network address.

3.1.31 switch

MAC bridge as defined in IEEE 802.1D

3.1.32 telegram <CPF 16> frame

3.2 Abbreviated terms and acronyms

AL	Application Layer
APDU	Application Protocol Data Unit
API	Application Process Identifier
AR	Application Relationship
ARP	Address Resolution Protocol
ASE	Application Service Elements
CP	Communication Profile [according to IEC 61784-1]
CPF	Communication Profile Family [according to IEC 61784-1]
CRC	Cyclic Redundancy Check
CSMA-CD	Carrier Sense Multiple Access with Collision Detection
DA	Destination MAC Address
DHCP	Dynamic Host Configuration Protocol (see RFC 2131)
DL	Data-Link layer (as a prefix)
DLL	DL-Layer
DNS	Domain Name Service
DUT	Device under test
ECSME	EPA Communication Scheduling Management Entity
FA	Factory Automation
FCS	Frame check sequence
FrameID	Frame Identifier (see IEC 61158-6-10)
GSD	General station description
HW	Hardware
IANA	Internet Assigned Numbers Authority
ICMP	Internet Control Message Protocol (see RFC 792)
ID	Identifier
IDN	IDentification Number
IETF	Internet Engineering Task Force
IO	Input Output
IP	Internet Protocol (see RFC 791)
IPv4	Internet Protocol version 4 (see RFC 791)
IRT	Isochronous RT
LAN	Local Area Network
LLC	Logical Link Control
LLDP	Link Layer Discovery Protocol (see IEEE 802.1AB)
MAC	Media Access Control

MAC	Media Access Control (see ISO/IEC 8802.3 or IEEE 802.3)
Mbit/s	Million bits per second
Moctets/s	Million octets per second
MCR	Multicast communication relation
MIB	Management Information base
MRP	Medium redundancy protocol
MRPD	Media redundancy for planned duplication
ms	milli seconds
n.a.	Not applicable
NoS	Number of Switches
NRT	Non-real-time
PDU	Protocol Data Unit
PI	Performance indicator
ns	nano seconds
OID	Object Identifier (see IETF RFC 1157)
PDU	Protocol Data Unit
PhL	Physical Layer
Phy	PHY Physical layer entity sublayer (see ISO/IEC 8802.3 or IEEE 802.3)
PI	Performance indicator
pps	Packets per second
PTCP	Precision Transparent Clock Protocol
PTP	Precision Time Protocol [IEC 61588]
RPC	Remote Procedure Call
RSTP	Rapid Spanning Tree Algorithm and protocol (see IEEE 802.1D)
RT	Real-time
RTA	Real-time protocol acyclic
RTE	Real-time Ethernet
RT-Ethernet	Real-time Ethernet
RTFL	Real time frame line
RTFN	Real time frame network
RTO	Retransmission Time Out [according to RFC 2988 – Computing TCP's Retransmission Timer]
RTPS	Real-Time Publish-Subscribe
SERCOS	SERial Real time COmmunication System
SNMP	Simple Network Management Protocol (see IETF RFC 1213)
TCC	Time-Critical Cyclic
TCP	Transmission Control Protocol (see IETF RFC 793)
TOS	Type of Service
UDP	User Datagram Protocol (see IETF RFC 768)
VLAN	Virtual LAN

3.3 Symbols

3.3.1 CPF 2 symbols

Symbol	Definition	Unit
APDUsize	Size of the application protocol data unit per CP 2/2 connection	octets
CD	Cable segment delay	μs
CL	Cable segment length	m
DT	Delivery time	μs
EN_NRTE_PR	End-station non-RTE packet rate per CP 2/2 connection	pps
EN_RTE_PR	End-station RTE packet rate per CP 2/2 connection	pps
EN_PR	End-station packet rate	pps
EN_PR_MAX	End-station maximum packet rate	pps
EN_TNRTE_PR	End-station total non-RTE packet rate in pps	pps
EN_TRTE_PR	End-station total RTE packet rate	pps
k	Number of CP 2/2 connections supported by the end-station	—
m	Number of CR 2/2 non-RTE connections	—
n	Number of switches between sending and receiving end-stations	—
p	Number of CR 2/2 RTE connections	—
NRTE_BW	Non-RTE bandwidth	%
PD	Cable propagation delay	n/m
SD _r	Receiver stack delay	μs
SD _s	Sender stack delay	μs
SL	Switch latency	μs
SPD	Switch processing delay	μs
T _{x_packet}	Packet transmit time	μs

3.3.2 CPF 3 symbols

Symbol	Definition	Unit
Cd	Cable delay (see attribute cable_delay in IEC 61158–5–10)	s
Cl _t	Total cable length	m
cta _R	Application cycle time of the Receiver	s
cta _S	Application cycle time of the Sender	s
Ctc	Communication cycle time	s
Ctc	Communication cycle time	s
Data	Complete Ethernet frame	octets
data_request	Requested RTE throughput	octets/s
data_RTE	Actual RTE throughput	octets/s
DT	Delivery time	s
endStations	Number of end-stations	–
EthernetDataRate	Ethernet data rate of the network	Mbit/s
MAC_delay	Delay on MAC layer	s
NonRTE	Percentage of non-RTE bandwidth	%
NoS	Number of switches	–
Od	Other delays, e. g. signal forwarding in a ring	s
Pd	Propagation delay	s
Phy_R_delay	Phy delay on receiver side	s
Phy_S_delay	Phy delay on sender side	s
protocolRTE	Percentage of protocol time	s
Queue_delay	Queue delay in a switch	s
RM	Time needed for management functions to support redundancy	s
RR	Attribute <i>Reduction Ratio</i> (see IEC 61158–5–10)	–
SCF	Attribute <i>Send Clock Factor</i> (see IEC 61158–5–10)	–
STTr	Receiver stack traversal time including Phy and MAC	s
STTs	Sender stack traversal time including Phy and MAC	s
Throughput_RTE	Throughput RTE	octets/s
Time_synchron_accuracy	Time synchronization accuracy	s
Tt	Transfer time	s

3.3.3 CPF 4 symbols

Symbol	Definition	Unit
cd	Cable delay (Maximum on 100m)	μs
DT	Delivery time	μs
DTb	Delivery time, calculated by best-case values	μs
DTw	Delivery time, calculated by worst-case values	μs
FS	Number of frames allowed to be sent per second for one RTE end-station	—
NoAS	Number of accesses allowed per device per second	—
NoCEN	Number of RTE end-stations which can produce frames on the critical switch-to-switch link	—
NoNs[x]	Number of RTE end-stations connected to switch number x	—
NoNt	Number of RTE end-stations, in total	—
NoS	Number of switches in path from sender to receiver	—
pd	Propagation delay within a switch. Required minimum value	μs
QTES	Ethernet enforced quiet time on end-station to switch link	μs
QTSS	Ethernet enforced quiet time on switch-to-switch link	μs
STTr	Receiver stack transversal time including Phy and MAC	μs
STTs	Sender stack transversal time including Phy and MAC	μs
ttES	P-NET transfer time RTE end-station to switch (at maximum APDU size)	μs
ttESmin	P-NET transfer time RTE end-station to switch (at min APDU size)	μs
ttSS	P-NET transfer time switch-to-switch (at maximum APDU size)	μs

3.3.4 CPF 6 symbols

Symbol	Definition	Unit
DTLD	Total delivery time between a Type 8 slave and a Type 10 entity	μs
DT10	Delivery time of the Type 10 network	μs
Cta_M	Application cycle time of the mapping application in the linking-device	
M	Type 8 Master implementation factor	—
n	Number of data octets (user data; payload)	octets
sl8	Number of Type 8 slaves connected to the linking-device	—
T _{bit}	Nominal bit duration (see 27.2 in IEC 61158-2)	μs
t _s	Software processing time of the Type 8 master (application specific)	μs

3.3.5 CPF 10 symbols

Symbol	Definition	Unit
Cdly	Cable delay	μs
Clen	Cable length	m
Dlen	Length of the complete Ethernet frame	bit
DT	Delivery time	μs
DTlost1	maximum delivery time with one lost frame for communication between two end-stations belonging to the same domain	μs
DTlost2	maximum delivery time with one lost frame for communication between two end-stations belonging to different domains	μs
DTmax1	maximum delivery time for communication between two end-stations belonging to the same domain	μs
DTmax2	maximum delivery time for communication between two end-stations belonging to different domains	μs
NoS	Number of switches in path from sender to receiver	—
Spd	Switch delay under not congested condition	μs
STTr	Receiver stack transversal time including PhL, DLL and AP	μs
STTs	Sender stack transversal time including PhL, DLL and AP	μs
Trate	Transfer bit rate	Mbit/s

3.3.6 CPF 11 symbols

Symbol	Definition	Unit
BW _{CNT}	Bandwidth used both for the communication scheduling and the protocol overhead	%
BW _{NRT}	Bandwidth used for the non-RTE communications	%
BW _{RTE}	Bandwidth used for the RTE communications	%
cd	Cable delay	μs
cdl	Cable length total	km
ct	Cycle time	ms
data	Complete Ethernet frame	—
DT _H	Delivery time of the high-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DT _L	Delivery time of the low-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DT _M	Delivery time of the medium-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DV _{HS}	Total volume of the high-speed cyclic data	octets
DV _{LS}	Total volume of the low-speed cyclic data	octets
DV _{MS}	Total volume of the medium-speed cyclic data	octets
NoS	Number of switches	—
od	Other delays	μs
pd	Propagation delay	μs
STTs	Sender stack traversal time including Phy and MAC	μs
STTr	Receiver stack traversal time including Phy and MAC	μs

Symbol	Definition	Unit
T_h	The high-speed transmission time period – the basic cycle_time (ct) of the TCC data service	ms
T_{HS}	Total sum of the frame transmit time, in which the TCC data frame conveys the high-speed cyclic data	μ s
T_l	The Low-speed transmission time period	ms
T_{LS}	Total sum of the frame transmit time, in which the TCC data frame conveys the Low-speed Cyclic data	μ s
T_m	The Medium-speed transmission time period	ms
T_{MAC}	Time for the maintenance and control, in which a new end-station is solicited to join and the periodic time operation is controlled	μ s
T_{MS}	Total sum of the frame transmit time, in which the TCC data frame conveys the medium-speed cyclic data	μ s
T_{NRT}	Total sum of the frame transmit time, in which the frame, with the non-RTE data as a payload, is sent out of the end-station within the time period of T_h and is used for the standard Ethernet application on sporadic basis	μ s
TR_{HS}	Throughput RTE of the high-speed cyclic data	Moctets/s
TR_{LS}	Throughput RTE of the low-speed cyclic data	Moctets/s
TR_{MS}	Throughput RTE of the medium-speed cyclic data	Moctets/s
TR_{RTE}	Throughput RTE, and the sum of TR_{HS} , TR_{LS} and TR_{MS}	Moctets/s
T_{RTE}	Total sum of the frame transmit time, in which the frame, with the RTE data as a payload of a fixed length, is sent out of the end-station within the time period of T_h	μ s
T_{SCH}	Total sum of the frame transmit time for the transmission scheduling	μ s
tt	Transfer time	μ s

3.3.7 CPF 12 symbols

Symbol	Definition	Unit
l_{tc}	Total cable length	m
NoS	Number of slaves	
Pd	Propagation delay	μ s
t_{cd}	Cable delay	μ s/m
t_{cpdl}	Data copy delay within a slave	μ s
t_{cycle}	Cycle time	μ s
t_D	Delivery time	μ s
t_{data}	Time to transmit the longest real-time Ethernet frame	μ s

3.3.8 CPF 13 symbols

Symbol	Definition	Unit
B_{NRTE}	Non-RTE bandwidth	%
M	Network MTU (maximum transmission unit)	octets
N	Number of RTE end-stations processed in one communication cycle	–
T_A	Time reserved for non-RTE data within one communication cycle	μ s
T_C	Communication cycle time	μ s

Symbol	Definition	Unit
T_D	Delivery time	μs
$T_{FT,i}$	RTE frames transmission time for RTE end-station i	μs
T_{PR}	Processing time in the receiving end-station	μs
T_{PS}	Processing time in the sending end-station	μs
$T_{RD,i}$	Response delay of the RTE end-station i	μs
T_S	Communication cycle start delay	μs
$T_{SD,i}$	Sum of all delays of infrastructure components (switches, hubs, cabling) for the RTE end-station i	μs

3.3.9 CPF 14 symbols

Symbol	Definition	Unit
DT	Delivery time	μs
D_size	Data size	octets
LCable	Cable length	m
Ndata	Length of complete Ethernet frame	octets
NRTE_BW	Non-RTE bandwidth	%
NSwitch	Number of switches between end-stations	
RateofEthernet	Ethernet data rate	Mbit/s
RMDData	Redundancy management data	octets
RTEDData	Real-time data	octets
TApp_R	Receiver stack processing time including Phy and MAC	μs
TCable	Cable delay	μs
TD_Sw	Time delay in switch	μs
TEthernet_S	Sender traversal time through MAC and Phy based on ISO/IEC 8802-3	μs
ThroughputRTE	RTE throughput	octets/s
TQueue_S	Sender queuing delay	μs
TSDData	Time synchronization data	octets
TStack_S	Sender stack processing time	μs
TSwitch	Switch delay	μs
TTrf_S	Transfer time for one octet	μs
T_wire	Time per octet on a wire segment	μs
STT_s	Stack traversal time of the sender	μs
STT_r	Stack traversal time of the receiver	μs

3.3.10 CPF 15 symbols

Symbol	Definition	Unit
D_size	Data size	octets
DT	Delivery time	μs
DT_If	Delivery time when a frame is lost	μs
DT_Ifh	Delivery time when a frame is lost and the configuration is reliable with heartbeat	μs
DT_Ifp	Delivery time when a frame is lost and the configuration is reliable periodic	μs

Symbol	Definition	Unit
DT _n	Delivery time for the NACK message	μs
H	Period of the heartbeat, which is a configured parameter	μs
N _{Sw}	Number of switches between end-stations	—
RTO	TCP retransmission time out parameter	μs
STT _r	Stack traversal time of the receiver	μs
STT _{r1}	Part of the stack traversal time of the receiver that is independent of D-size	μs
STT _{r2}	Part of the stack traversal time of the receiver that depends linearly on D _{size}	μs
STT _s	Stack traversal time of the sender	μs
STT _{s1}	Part of the stack traversal time of the sender that is independent of D _{size}	μs
STT _{s2}	Part of the stack traversal time of the sender that depends linearly on D _{size}	μs
T	Period, which is a configured parameter	μs
T _{wire}	Time per octet on a wire segment	μs
TD _{Sw}	Time delay in switch	μs

3.3.11 CPF 16 symbols

Symbol	Definition	Unit
ac	Non-time based synchronization accuracy	ns
cd	Cable delay	μs/m
clt	Total cable length	m
ct	Cycle _{time} configured for the network segment	μs
data	Data to be transmitted in one cycle (including the complete Ethernet frame)	bit
DT	Delivery time	μs
fr	Frame runtime	μs
ma	Synchronization accuracy of the master device	μs
mct	Minimum cycle time	ms
N	Integer value	—
nf	Number of frames	—
nn	Number of nodes	—
pd	Propagation delay (signal delay) of a forwarding node	μs
sa	Synchronization accuracy of one slave device	μs
st	Separation time per frame	μs
tt	Transfer time	μs

3.3.12 CPF 17 symbols

Symbol	Definition	Unit
APDUsize	Size of the application protocol data unit in octets	octets
BW _{NRTE}	Non-RTE bandwidth, in %	%
LDR	Link data rate in bit per seconds	bps
LTC	Total cable length in meter	m
M	Number packets in the port transmit queue of node i in front on of this packet	—
N	Number of nodes between sending and receiving end-stations	—

Symbol	Definition	Unit
NF_{E/S_MAX}	Maximum number of frames allowed to be sent per second for one end station	pps
$NF_{RTE/S}$	Number of frames allowed to be sent per second for one RTE end station	pps
Posize	Size of the protocol overhead in octets	octets
T_{CPD}	Cable propagation delay time in microseconds	μs
$T_{CPD/M}$	cable propagation delay in nanoseconds per meter (depending on the characteristics of the selected cable)	ns/m
T_{DELAY}	Delivery time in microseconds	μs
T_{DELAY_MAX}	Maximum delivery time in microseconds	μs
T_{DELAY_MIN}	Minimum delivery time in microseconds	μs
Throughput_RTE	Throughput RTE	octets/s
Throughput_RTE_MAX	Maximum throughput RTE	octets/s
T_{NLD}	Node latency delay time in microseconds	μs
T_{NLD_i}	Node latency delay time of node i in microseconds	μs
T_{NPD}	Node propagation delay time in microseconds	μs
T_{NPD_i}	Node propagation delay time of node i in microseconds	μs
T_{PKT}	Packet transmit time in microseconds	μs
T_{PKT_i}	Packet transmit time of node i in microseconds	μs
T_{RCV}	Receiver stack traversal time including Phy and MAC in microseconds	μs
T_{SND}	Sender stack traversal time including Phy and MAC in microseconds	μs
$T_{TX_PKT_ij}$	packet transmit time of packet j in microseconds in the port transmit queue of node i in front on of this packet (depending on APDU size of node i)	μs
$T_{TX_PKT_j}$	packet transmit time of packet j in microseconds in the port transmit queue in front on of this packet (depending on APDU size of node i)	μs

3.3.13 CPF 18 symbols

Symbol	Definition	Unit
l_B	Distance along the cable in backward direction	m
l_C	Cable length	m
l_F	Distance along the cable in forward direction	m
NoDoB	Number of devices in backward direction	–
NoDoF	Number of devices in forward direction	–
NoS	Number of switching devices	–
t_{CD}	Cable delay	ns/m
t_{cyc}	Cycle time of communication system/relation	μs
t_D	Delivery time	μs
t_{data}	Transmit time of DLPDUs	μs
t_{pd}	Propagation delay	μs
t_{STsink}	Sink stack traversal time	μs
t_{STsrc}	Source stack traversal time	μs

Symbol	Definition	Unit
t_{SW}	Delay time of a switch	μs

3.4 Conventions

3.4.1 Conventions common to all layers

3.4.1.1 (Sub)clause selection tables

(Sub)clause selection for all layers is defined in tables, as shown in Table 1 and Table 2. The selected base specifications are indicated just before the selection table(s). Selection is done at the highest (sub)clause level possible to define the profile selection unambiguously.

Table 1 – Layout of profile (sub)clause selection tables

Clause	Header	Presence	Constraints

Table 2 – 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 subclauses
	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 subclause, 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

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

EXAMPLE concatenated subclauses

3.4 – 3.7	–	NO	–
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3.4.1.2 Service selection tables

If the selection of services is defined in a table, the format of Table 3 is used. The table identifies the selected services and includes service constraints, as explained in Table 4.

Table 3 – Layout of service selection tables

Service ref.	Service name	Usage	Constraint

Table 4 – Contents of service selection tables

Column	Text	Meaning
Service ref.	<#>	(Sub)clause number of the base specifications where the service is defined
	–	Not applicable
Service name	<text>	The name of the service
Usage	M	Mandatory
	O	Optional
	–	Service is never used
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	–	No constraints other than those 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

If selection of service parameters is defined in a table the format of Table 5 is used. Each table identifies the selected parameters and includes parameter constraints, as explained in Table 6.

Table 5 – Layout of parameter selection tables

Parameter ref.	Parameter name	Usage	Constraint

Table 6 – Contents of parameter selection tables

Column	Text	Meaning
Parameter ref.	<#>	(sub)clause number of the base specifications where the service is defined
	–	Not applicable
Parameter name	<text>	The name of the service parameter
Usage	M	Mandatory
	O	Optional
	–	Attribute is never present
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	–	No constraints other than those 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

3.4.2 Physical layer

No additional conventions are defined.

3.4.3 Data-link layer

3.4.3.1 Service profile conventions

No additional conventions are defined.

3.4.3.2 Service and parameter selections

These are described using the common conventions, see 3.4.1.2.

3.4.4 Application layer

3.4.4.1 Service profile conventions

ASE and class selection is described using (sub)clause selection tables, see 3.4.1.1. If the use of selected ASE and classes is further constrained this is specified in the profile (e.g. an optional item of the base standard is mandatory in the profile).

If the selection of class attributes is defined in a table the format of Table 7 is used. The table identifies the selected class attributes and includes their constraints, as explained in Table 8.

Table 7 – Layout of class attribute selection tables

Attribute	Attribute Name	Usage	Constraint

Table 8 – Contents of class attribute selection tables

Column	Text	Meaning
Attribute	<#>	Attribute number of the base specification class
	–	Not applicable
Attribute Name	<text>	The name of the attribute
Usage	M	Mandatory
	O	Optional
	–	Attribute is never present
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	–	No constraints other than those 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

3.4.4.2 Service and parameter selections

These are described using the common conventions, see 3.4.1.2.

4 Conformance to communication profiles

A statement of compliance with an RTE Communication Profile Family (CPF) Profile of this part of IEC 61784 shall be stated² as either

- Compliance to IEC 61784-2:2014 CPF n <Type>, or
- Compliance to IEC 61784-2 (Ed.3.0) CPF n <Type>

and a statement of compliance with a communication profile (CP) of this part of IEC 61784 shall be stated as either

- Compliance to IEC 61784-2:2014 CP n/n <Type>, or
- Compliance to IEC 61784-2 (Ed.3.0) CP n/n <Type>

where the Type within the angle brackets < > is optional and the angle brackets are not to be included. Type could be any character string.

A conformance statement should be supported with appropriate documentation as defined in Clause 6.

5 RTE performance indicators

5.1 Basic principles of performance indicators

A network that includes real-time communication and is based on the ISO/IEC 8802-3 standard is called a Real-time Ethernet (RTE) network. Users of RTE networks have different requirements for different applications. In order to satisfy these requirements in an optimal way RTE communication networks complying with CPs described in this standard will exhibit different performance.

Performance indicators (specified in 5.3) shall be used to specify capabilities of an RTE end device and an RTE communication network as well as to specify requirements of an application. Performance indicators will be used as a set of interaction means between the user of the RTE CP and the manufacturer of RTE CP compliant RTE end devices and network components. Subclause 5.2 specifies the application requirements view.

Performance indicators represent

- a) capabilities of an RTE end device,
- b) capabilities of an RTE communication network,
- c) as well as requirements of an application.

A consistent set of performance indicators (specified in 5.3) is used to represent the RTE capabilities. Some of the performance indicators are interdependent; in this case some indicator values depend on the value of others to provide a consistent set.

NOTE The interdependence is due to physical or logical constraints, which are not changeable. For example it is not possible to have the indicators "Throughput RTE (which would use 90 % of the total bandwidth)" and "Throughput non-RTE (90 %)" at the same time because that would describe a transmission load of 180 %.

No general boundary values to specify RTE performance are specified for the indicators in this standard, but device suppliers need to specify boundary values for a CP-based product if they claim to be compliant to this standard.

Technology specific CPF subclauses specify

² In accordance with ISO/IEC Directives

- a) selection of performance indicators out of possible performance indicators defined in 5.3 relevant to a given CP, optionally with their individual limits or ranges,
- b) interdependence between performance indicators,
- c) optionally, lists with consistent performance indicators values.
Each of the lists has one or more leading performance indicators. The leading performance indicators are preset to a fixed value (typically optimized to have the best overall performance). The other performance indicators in the list are shown with their related consistency limits,
- d) optionally, a more comprehensive representation of the relation between performance indicators (Figure 1 shows an example of a graphical representation).

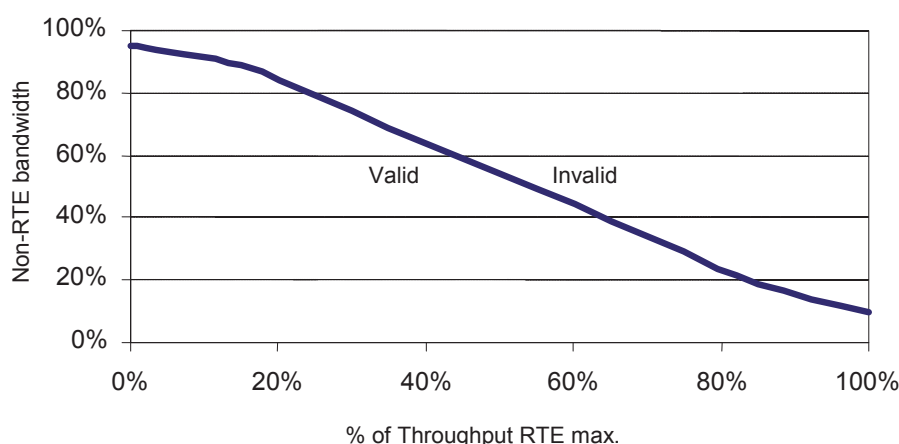


Figure 1 – Example of graphical representation of consistent indicators

The supplier of RTE end devices and RTE communication networks shall provide at least one consistent set of performance indicators. The boundary values given by the supplier should be based on conformance test principles specified in Clause 6.

NOTE 1 A set of lists with consistent performance indicators is only given when interdependence between performance indicators exists.

NOTE 2 It is possible that applications have requirements where one particular indicator has higher importance than all the others. Such applications will find useful the opportunity to select the consistent indicator list with the relevant leading indicator. Other applications may have requirements where several indicators are of equally high importance. For such applications, a graphical or otherwise more comprehensive representation of the relation between consistent indicators is more appropriate. Figure 1 is an example of a graphical representation of consistent indicators given by a CP.

NOTE 3 RTE end devices are designed under the discretion of manufactures of such a device. Therefore no assumption could be made how many RTE end-stations (network interfaces) are build in one device. In order to achieve comparable performance indicators from the application perspective the performance indicators are build on RTE end-stations not on RTE devices.

5.2 Application requirements

The capabilities of an RTE communication network are specified in 5.3 as indicators. The indicators are used to match application requirements to the capabilities of components compliant to one or more CP(s) of this part of IEC 61784.

A profile is suitable if its indicator values at least meet the required indicator values.

NOTE 1 Sophisticated requirements are likely to find a smaller number of matching profiles.

NOTE 2 A principle for selecting the matching CP is described in ISO 15745-1.

The application-dependent class should be a subset of a CP x/y to be suitable for this application.

5.3 Performance indicators

5.3.1 Delivery time

Delivery time shall indicate the time needed to convey an APDU containing data (message payload) that has to be delivered in real-time from one node (source) to another node (destination). The delivery time is measured at the interface between the application process and the (Fieldbus) application entity.

NOTE 1 A description of the Application Layer concept with a description of the Application Process and the Application Entity is given in the respective type-specific part of IEC 61158-5.

The maximum delivery time shall be stated for the following two cases:

- no transmission errors, and
- one lost frame with recovery.

NOTE 2 The permanent failure condition is described in 5.3.9.

Calculation of the maximum delivery time shall include the transmission time as well as any waiting time.

NOTE 3 Waiting time depends on the RTE network concept, the RTE network topology and the application load which is generated by the other nodes in the RTE network and the non-RTE traffic at that time.

5.3.2 Number of RTE end-stations

The number of RTE end-stations shall state the maximum number of RTE end-stations supported by a CP.

NOTE The network devices like a switch are not counted in the number of RTE end-stations.

5.3.3 Basic network topology

The basic network topology supported by a CP shall be stated out of the topologies listed in Table 9 or as a combination.

Table 9 – Basic network topology types

Basic network topology	CP
Hierarchical star	CP m/1
Ring (loop)	CP m/2
Linear topology	CP m/3
NOTE A real topology could be any combination of the three basic topologies.	

5.3.4 Number of switches between RTE end-stations

Number of switches between any two RTE end-stations that have an application relation.

5.3.5 Throughput RTE

Throughput RTE shall indicate the total amount of APDU data (by octet length) on one link per second.

5.3.6 Non-RTE bandwidth

The non-RTE bandwidth shall indicate the percentage of bandwidth, which can be used for non-RTE communication on one link. Additionally the total link bandwidth shall be specified.

NOTE The indicators throughput RTE and non-RTE bandwidth are related to each other.

5.3.7 Time synchronization accuracy

Time synchronization accuracy shall indicate the maximum deviation between any two node clocks.

5.3.8 Non-time-based synchronization accuracy

The non-time-based synchronization accuracy shall indicate the maximum jitter of the cyclic behavior of any two nodes, using triggering by periodical events over the network for establishing cyclic behavior.

NOTE 1 This factor accounts for coherency of data or actions triggered by the event, and it is a measure of the coherency spread.

NOTE 2 The event can be unicast, multicast or broadcast, or made of a set of simpler events.

5.3.9 Redundancy recovery time

Redundancy recovery time shall indicate the maximum time from failure to become fully operational again in case of a single permanent failure.

NOTE If a permanent failure occurs, the delivery time of a message is the redundancy recovery time.

6 Conformance tests

6.1 Concept

This part of IEC 61784 specifies the methodology of a conformance test for an RTE end device for one or more CPs. The concept of this conformance test is to verify the capabilities of a device under test (DUT) against a consistent set of indicators of a CP. The conformance test shall assure the interoperability of devices which claim compliance with the same CP. Figure 2 gives an overview of the conformance test related to this part of IEC 61784.

NOTE Conformance test implementation and conformance test execution are not defined in this standard.

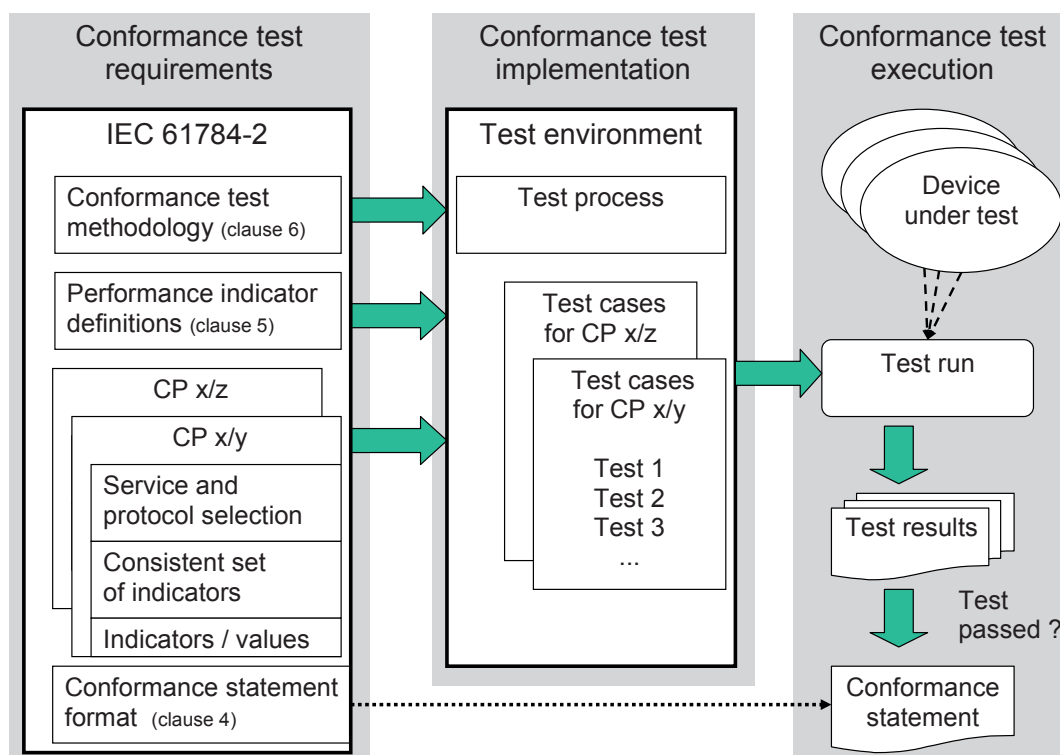


Figure 2 – Conformance test overview

6.2 Methodology

Test cases shall be developed in a way that tests are repeatable and the results can be verified. Test results shall be documented and shall be used as the basis for the conformance statement.

Conformance tests of a device shall include, as appropriate, the verification of

- the availability and correctness of the specified CP functionality,
- network related indicator values,
- device related indicator values.

The performance indicator values of the CP and of the device under test shall be used.

NOTE 1 It is assumed that the quality of the test cases guarantees the interoperability of a tested device. If any irregularities are reported the test cases will be adapted accordingly.

NOTE 2 A description of a conformance testing process is given in ISO/IEC 9646 series.

6.3 Test conditions and test cases

Test conditions and test cases shall be defined and documented based on a specific CP. This shall include the following indicators, when applicable:

- number of nodes;
- network topology;
- number of switches between nodes;
- RTE throughput,
- non-RTE bandwidth.