IEC 61784-2

Edition 3.0 2014-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

IEC 61784-2:2014-07(en-fr)

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colour inside

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INDUSTRIAL COMMUNICATION NETWORKS – PROFILES –

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

FOREWORD

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NOTE Combinations of protocol types are specified in IEC 61784-1 and IEC 61784-2.

International Standard IEC 61784-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- update of the dated references to the IEC 61158 series, to IEC 61784-1, to the IEC 61784-3 series, to the IEC 61784-5 series and to IEC 61918 throughout the document;
- update of selection tables for CPF 3
  - update of the requirements for all conformance classes;
  - added precise timing requirements for IP;
  - updated timing requirements for IO devices;
  - added precise timing requirements for PTCP;
  - increasing the amount of synchronized devices in line;
  - added consistent set of parameters;
  - added application classes;
  - integrating the fast startup as additional feature.
- update of selection tables for CPF 11 and CPF 14;
- addition of a new profile CP 11/3 in 12.4;
- addition of a new profile CP 14/4 in 15.6;
- addition of a new Communication Profile Family – CPF 8 in Clause 20.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/761FDIS	65C/771/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61784 series, published under the general title *Industrial communication networks – Profiles*, can be found on the IEC web site.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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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 specification*s

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*

IEC 61158-3-11:2007, *Industrial communication networks – Fieldbus specifications – Part 3-11: Data-link layer service definition – Type 11 elements*

IEC 61158-3-12:2014, *Industrial communication networks – Fieldbus specifications – Part 3-12: Data-link layer service definition – Type 12 elements*

IEC 61158-3-13:2014, *Industrial communication networks – Fieldbus specifications – Part 3-13: Data-link layer service definition – Type 13 elements*

IEC 61158-3-14:2014, *Industrial communication networks – Fieldbus specifications – Part 3-14: Data-link layer service definition – Type 14 elements*

IEC 61158-3-17:2007, *Industrial communication networks – Fieldbus specifications – Part 3-17: Data-link layer service definition – Type 17 elements*

IEC 61158-3-19:2014, *Industrial communication networks – Fieldbus specifications – Part 3-19: Data-link layer service definition – Type 19 elements*

IEC 61158-3-21:2010, *Industrial communication networks – Fieldbus specifications – Part 3-21: Data-link layer service definition – Type 21 elements*

IEC 61158-3-22:2014, *Industrial communication networks – Fieldbus specifications – Part 3-22: Data-link layer service definition – Type 22 elements*

IEC 61158-4-2:2014, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 elements*

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

IEC 61158-4-11:2014, *Industrial communication networks – Fieldbus specifications – Part 4-11: Data-link layer protocol specification – Type 11 elements*

IEC 61158-4-12:2014, *Industrial communication networks – Fieldbus specifications – Part 4-12: Data-link layer protocol specification – Type 12 elements*

IEC 61158-4-13:2014, *Industrial communication networks – Fieldbus specifications – Part 4-13: Data-link layer protocol specification – Type 13 elements*

IEC 61158-4-14:2014, *Industrial communication networks – Fieldbus specifications – Part 4-14: Data-link layer protocol specification – Type 14 elements*

IEC 61158-4-17:2007, *Industrial communication networks – Fieldbus specifications – Part 4-17: Data-link layer protocol specification – Type 17 elements*

IEC 61158-4-19:2014, *Industrial communication networks – Fieldbus specifications – Part 4-19: Data-link layer protocol specification – Type 19 elements*

IEC 61158-4-21:2010, *Industrial communication networks – Fieldbus specifications – Part 4-21: Data-link layer protocol specification – Type 21 elements*

IEC 61158-4-22:2014, *Industrial communication networks – Fieldbus specifications – Part 4-22: Data-link layer protocol specification – Type 22 elements*

IEC 61158-5-2:2014, *Industrial communication networks – Fieldbus specifications – Part 5-2: Application layer service definition – Type 2 elements*

IEC 61158-5-4:2014, *Industrial communication networks – Fieldbus specifications – Part 5-4: Application layer service definition – Type 4 elements*

IEC 61158-5-10:2014, *Industrial communication networks – Fieldbus specifications – Part 5-10: Application layer service definition – Type 10 elements*

IEC 61158-5-11:2007, *Industrial communication networks – Fieldbus specifications – Part 5-11: Application layer service definition – Type 11 elements*

IEC 61158-5-12:2014, *Industrial communication networks – Fieldbus specifications – Part 5-12: Application layer service definition – Type 12 elements*

IEC 61158-5-13:2014, *Industrial communication networks – Fieldbus specifications – Part 5-13: Application layer service definition – Type 13 elements*

IEC 61158-5-14:2014, *Industrial communication networks – Fieldbus specifications – Part 5-14: Application layer service definition – Type 14 elements*

IEC 61158-5-15:2010, *Industrial communication networks – Fieldbus specifications – Part 5-15: Application layer service definition – Type 15 elements*

IEC 61158-5-17:2007, *Industrial communication networks – Fieldbus specifications – Part 5-17: Application layer service definition – Type 17 elements*

IEC 61158-5-19:2014, *Industrial communication networks – Fieldbus specifications – Part 5-19: Application layer service definition – Type 19 elements*

IEC 61158-5-21:2010, *Industrial communication networks – Fieldbus specifications – Part 5-21: Application layer service definition – Type 21 elements*

IEC 61158-5-22:2014, *Industrial communication networks – Fieldbus specifications – Part 5-22: Application layer service definition – Type 22 elements*

IEC 61158-5-23:2014, *Industrial communication networks – Fieldbus specifications – Part 5-23: Application layer service definition – Type 23 elements*

IEC 61158-6-2:2014, *Industrial communication networks – Fieldbus specifications – Part 6-2: Application layer protocol specification – Type 2 elements*

IEC 61158-6-4:2014, *Industrial communication networks – Fieldbus specifications – Part 6-4: Application layer protocol specification – Type 4 elements*

IEC 61158-6-10:2014, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 61158-6-11:2007, *Industrial communication networks – Fieldbus specifications – Part 6-11: Application layer protocol specification – Type 11 elements*

IEC 61158-6-12:2014, *Industrial communication networks – Fieldbus specifications – Part 6-12: Application layer protocol specification – Type 12 elements*

IEC 61158-6-13:2014, *Industrial communication networks – Fieldbus specifications – Part 6-13: Application layer protocol specification – Type 13 elements*

IEC 61158-6-14:2014, *Industrial communication networks – Fieldbus specifications – Part 6-14: Application layer protocol specification – Type 14 elements*

IEC 61158-6-15:2010, *Industrial communication networks – Fieldbus specifications – Part 6-15: Application layer protocol specification – Type 15 elements*

IEC 61158-6-17:2007, *Industrial communication networks – Fieldbus specifications – Part 6-17: Application layer protocol specification – Type 17 elements*

IEC 61158-6-19:2014, *Industrial communication networks – Fieldbus specifications – Part 6-19: Application layer protocol specification – Type 19 elements*

IEC 61158-6-21:2010, *Industrial communication networks – Fieldbus specifications – Part 6-21: Application layer protocol specification – Type 21 elements*

IEC 61158-6-22:2014, *Industrial communication networks – Fieldbus specifications – Part 6-22: Application layer protocol specification – Type 22 elements*

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>

[1] There exisits a consolidated edition 2.2:2011 that compreises ISO/IEC 11801:2002, its Amendment 1:2008 and its Amendment 2:2010.

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

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 Identificator (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
Clt	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 *Reduction Ratio* (see IEC 61158–5–10)	–
SCF	Attribute *Send Clock Factor* (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	µs
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	µs
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	µs
T_{MS}	Total sum of the frame transmit time, in which the TCC data frame conveys the medium-speed cyclic data	µs
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	µs
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	µs
T_{SCH}	Total sum of the frame transmit time for the transmission scheduling	µs
tt	Transfer time	µs

3.3.7 CPF 12 symbols

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

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	µs
T_C	Communication cycle time	µs
T_D	Delivery time	µs

Symbol	Definition	Unit
$T_{FT,i}$	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
RMData	Redundancy management data	octets
RTEData	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
TSData	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_lf	Delivery time when a frame is lost	µs
DT_lfh	Delivery time when a frame is lost and the configuration is reliable with heartbeat	µs
DT_lfp	Delivery time when a frame is lost and the configuration is reliable periodic	µs
DT_n	Delivery time for the NACK message	µs

Symbol	Definition	Unit
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	–
NF_{E/S_MAX}	Maximum number of frames allowed to be sent per second for one end station	pps

Symbol	Definition	Unit
$NF_{RTE/S}$	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
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	–

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

2 In accordance with ISO/IEC Directives