

INTERNATIONAL STANDARD

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**Industrial networks – Profiles –
Part 2-12: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 –
CPF 12**

**Réseaux industriels – Profils –
Partie 2-12: Profils de bus de terrain supplémentaires pour les réseaux en temps
réel fondés sur l'ISO/IEC/IEEE 8802-3 – CPF 12**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms, definitions, abbreviated terms, acronyms, and conventions.....	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms and acronyms	8
3.3 Symbols.....	8
3.4 Conventions.....	8
4 CPF 12 (EtherCAT®) – RTE communication profiles	9
4.1 General overview	9
4.2 CP 12/1	9
4.2.1 Physical layer	9
4.2.2 Data-link layer	11
4.2.3 Application layer.....	14
4.2.4 Performance indicator selection.....	17
4.3 CP 12/2	20
4.3.1 Physical layer	20
4.3.2 Data-link layer	20
4.3.3 Application layer.....	24
4.3.4 Performance indicator selection.....	26
Bibliography.....	29
https://standards.iteh.ai/catalog/standards/sist/8189e1ca-86ac-4291-aa7c-9c6892c47eb9/iec-61784-2-12-2023	
Table 1 – CPF 12 symbols.....	8
Table 2 – CP 12/1: PhL selection of physical layer from ISO/IEC/IEEE 8802-3:2021.....	9
Table 3 – CP 12/1: PhL selection of a power integrated physical layer from IEC 61158-2	11
Table 4 – CP 12/1: DLL service selection.....	11
Table 5 – CP 12/1: DLL protocol selection	12
Table 6 – CP 12/1: DLL service selection.....	13
Table 7 – CP 12/1: DLL protocol selection	13
Table 8 – CP 12/1: AL service selection.....	15
Table 9 – CP 12/1: AL protocol selection	15
Table 10 – CP 12/1: AL service selection.....	16
Table 11 – CP 12/1: AL protocol selection	17
Table 12 – CP 12/1: PI overview	17
Table 13 – CP 12/1: PI dependency matrix	18
Table 14 – CP 12/1: PI ranges	18
Table 15 – CP 12/1: Consistent set of PIs for mid size automation systems	20
Table 16 – CP 12/2: DLL service selection.....	20
Table 17 – CP 12/2: DLL protocol selection	21
Table 18 – CP 12/2: DLL service selection.....	22
Table 19 – CP 12/2: DLL protocol selection	23
Table 20 – CP 12/2: AL service selection.....	24

Table 21 – CP 12/2: AL protocol selection 24

Table 22 – CP 12/2: AL service selection 25

Table 23 – CP 12/2: AL protocol selection 26

Table 24 – CP 12/2: PI overview 27

Table 25 – CP 12/2: PI dependency matrix 27

Table 26 – CP 12/2: Consistent set of PIs 28

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[IEC 61784-2-12:2023](https://standards.iteh.ai/catalog/standards/sist/8f89e1ca-86ac-4291-aa7c-9c6892c47eb9/iec-61784-2-12-2023)

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**INDUSTRIAL NETWORKS –
PROFILES –****Part 2-12: Additional real-time fieldbus profiles
based on ISO/IEC/IEEE 8802-3 –
CPF 12**

FOREWORD

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

IEC 61784-2-12 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This first edition, together with the other parts of the same series, cancels and replaces the fourth edition of IEC 61784-2 published in 2019. This first edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 61784-2:2019:

- a) split of the original IEC 61784-2 into several subparts, one subpart for the material of a generic nature, and one subpart for each Communication Profile Family specified in the original document.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1209/FDIS	65C/1237/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 61784-2 series, published under the general title *Industrial networks – Profiles – Part 2: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

INTRODUCTION

The IEC 61784-2 series provides additional Communication Profiles (CP) to the existing Communication Profile Families (CPF) of the IEC 61784-1 series 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/IEEE 8802-3 – commonly known as Ethernet. These RTE communication networks use provisions of ISO/IEC/IEEE 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/IEEE 8802-3, 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 the 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 can 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, whose values will be provided with RTE devices based on communication profiles specified in the IEC 61784-2 series, enable the user to match network devices with application-dependent performance requirements of an RTE network.

INDUSTRIAL NETWORKS – PROFILES –

Part 2-12: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 12

1 Scope

This part of IEC 61784-2 defines Communication Profile Family 12 (CPF 12). CPF 12 specifies a set of Real-Time Ethernet (RTE) communication profiles (CPs) and related network components based on the IEC 61158 series (Type 12), ISO/IEC/IEEE 8802-3 and other standards.

For each RTE communication profile, this document also specifies the relevant RTE performance indicators and the dependencies between these RTE performance indicators.

NOTE 1 All CPs are based on standards or draft standards or International Standards published by the IEC or on standards or International Standards established by other standards bodies or open standards processes.

NOTE 2 The RTE communication profiles use ISO/IEC/IEEE 8802-3 communication networks and its related network components and in some cases amend those standards to obtain RTE features.

2 Normative references

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

NOTE All parts of the IEC 61158 series, as well as the IEC 61784-1 series and the IEC 61784-2 series, 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 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61158-2:2023, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-12:2019, *Industrial communication networks – Fieldbus specifications – Part 3-12: Data-link layer service definition – Type 12 elements*

IEC 61158-4-12:2019, *Industrial communication networks – Fieldbus specifications – Part 4-12: Data-link layer protocol specification – Type 12 elements*

IEC 61158-5-12:2019, *Industrial communication networks – Fieldbus specifications – Part 5-12: Application layer service definition – Type 12 elements*

IEC 61158-6-12:2019, *Industrial communication networks – Fieldbus specifications – Part 6-12: Application layer protocol specification – Type 12 elements*

IEC 61784-2-0:2023, *Industrial networks – Profiles – Part 2-0: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – General concepts and terminology*

ISO/IEC/IEEE 8802-3:2021, *Telecommunications and exchange between information technology systems – Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*

IETF RFC 791, J. Postel, *Internet Protocol*, September 1981, available at <https://www.rfc-editor.org/info/rfc791> [viewed 2022-02-18]

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 IEC 61784-2-0 and ISO/IEC/IEEE 8802-3 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

3.2 Abbreviated terms and acronyms

For the purposes of this document, abbreviated terms and acronyms defined in IEC 61784-2-0 and the following apply.

CP	Communication Profile [according to IEC 61784-1-0]
CPF	Communication Profile Family [according to IEC 61784-1-0]
IETF	Internet Engineering Task Force
IP	Internet Protocol (see IETF RFC 791)
NoS	Number of Switches
PI	Performance indicator

3.3 Symbols

For the purposes of this document, symbols defined in IEC 61784-2-0 and Table 1 apply.

Table 1 – 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

3.4 Conventions

For the purposes of this document, the conventions defined in IEC 61784-2-0 apply.

4 CPF 12 (EtherCAT®) – RTE communication profiles

4.1 General overview

EtherCAT®¹ is a Real-Time Ethernet technology based on ISO/IEC/IEEE 8802-3, IEC 61158-2, IEC 61158-3-12, IEC 61158-4-12, IEC 61158-5-12 and IEC 61158-6-12 especially suitable for communication between control systems and peripheral devices like I/O systems, drives, sensors and actuators.

In this document, the following communication profiles are specified for CPF 12:

– Profile 12/1

This profile defines protocol and service selections for simple I/O devices which can communicate process data cyclically.

– Profile 12/2

This profile defines protocol and service selections for two types of devices:

- smart or modular devices with mailbox communication capabilities;
- such devices that additionally support time based synchronization for performing tightly coordinated actions.

All three types of devices can be mixed arbitrarily.

4.2 CP 12/1

4.2.1 Physical layer

The physical layer is described in IEC 61158-2 and ISO/IEC/IEEE 8802-3:2021. Table 2 specifies the use of the physical layer, specified in ISO/IEC/IEEE 8802-3:2021, included in this profile.

Table 3 specifies the use of a power integrated physical layer, specified in IEC 61158-2, included in this profile.

Table 2 – CP 12/1: PhL selection of physical layer from ISO/IEC/IEEE 8802-3:2021

Clause	Header	Presence	Constraints
1	Introduction	YES	—
2	Media Access Control (MAC) service specification	YES	—
3	Media Access Control (MAC) frame and packet specifications	YES	—
4	Media Access Control	NO	—
5	Layer Management	Optional	—
6...20	--	NO	—
Annex 4A	Simplified full duplex media access control	YES	—
21	Introduction to 100 Mb/s baseband networks, type 100BASE-T	YES	—

¹ EtherCAT® is a registered trade name of Beckhoff, Verl. This information is given for the convenience of users of this document and does not constitute an endorsement by the IEC of the trademark holder or any of its products. Compliance with this profile does not require use of the trade name EtherCAT. Use of the trade name EtherCAT requires permission from the trade name holder.

Clause	Header	Presence	Constraints
22	Reconciliation Sublayer (RS) and Media Independent Interface (MII)	YES	—
23	Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 100BASE-T4	NO	—
24	Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 100BASE-X	YES	—
25	Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-TX	Optional	Preferred technology
26	Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-FX	Optional	Use for specific environmental conditions
27	Repeater for 100 Mb/s baseband networks	NO	
28	Physical Layer link signaling for Auto-Negotiation on twisted pair	Optional	Auto-negotiation and auto-crossover are highly recommended
29	System considerations for multisegment 100BASE-T networks	NO	—
30 ... 32	--	NO	—
33	Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI)	Optional	—
Annex 22A...D	MII	YES	—
Annex 23A...C	6T codewords	NO	—
Annex 27A	Repeater delay consistency requirements	NO	—
Annex 28A...D	Selector Field definitions	YES	
Annex 29A...B	DTE and repeater delay components	Optional	—
Annex 30A...C	GDMO specification for IEEE 802.3 managed object classes	NO	—
Annex 31A...D	MAC Control opcode assignments	NO	—
Annex 32A	Use of cabling systems with nominal differential characteristic impedance of 120 Ω or 150 Ω	NO	—
Annex 33A	PSE-PD stability	NO	—
34 ff	Introduction to 1 000 Mb/s baseband network	Optional	For future use

Table 3 – CP 12/1: PhL selection of a power integrated physical layer from IEC 61158-2

Clause	Header	Presence	Constraints
5	DLL – PhL interface	—	—
5.8	Type 12: Required services	YES	—
6	Systems management – PhL interface	—	—
6.7	Type 12: Systems management – PhL interface	YES	—
7	DCE independent sublayer (DIS)	—	—
7.6	Type 12: DIS	YES	—
8	DTE – DCE interface and MIS-specific functions	—	—
8.5	Type 12: DTE – DCE interface	YES	Interface not exposed
9	Medium dependent sublayer (MDS)	—	—
9.9	Type 12: MDS: Wire media	YES	—
10	MDS – MAU interface	—	—
29	Type 12: Medium attachment unit Power combined with Ethernet Physical Layer Device (PHY)	YES	—

4.2.2 Data-link layer

4.2.2.1 EtherCAT Slave

Data-link layer is described in IEC 61158-3-12 and IEC 61158-4-12. Table 4 specifies the use of the services, specified in IEC 61158-3-12, included in this profile. Table 5 specifies the use of the protocol, specified in IEC 61158-4-12, included in this profile.

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<https://standards.iech.ai/catalog/standards/si/61784-2-12-2023/7c-9c6892c47eb9/iec-61784-2-12-2023>
Table 4 – CP 12/1: DLL service selection

Clause	Header	Presence	Constraints
4	Data-link layer services and concepts	—	—
4.1	Operating principle	YES	—
4.2	Topology	YES	—
4.3	Data-link layer overview	YES	—
4.4	Error detection overview	YES	—
4.5	Parameter and process data handling introduction	Partial	Some examples are not describing mandatory functions
4.6	Node reference model	YES	—
4.7	Operation overview	Partial	Direct mode mandatory
4.8	Addressing	YES	—
4.9	Slave classification	Partial	Basic slave mandatory
4.10	Structure of the communication layer in the slave	Partial	—
5	Communication services	—	—
5.1	Overview	YES	—
5.2	Read services	Partial	Responder Services (.ind/.rsp)
5.3	Write services	Partial	Responder Services (.ind/.rsp)
5.4	Combined read/write services	Partial	Responder Services (.ind/.rsp)
5.5	Network services	NO	—
5.6	Mailbox	NO	—
6	Local interactions	—	—

Clause	Header	Presence	Constraints
6.1	Read Local	YES	—
6.2	Write Local	YES	—

Table 5 – CP 12/1: DLL protocol selection

Clause	Header	Presence	Constraints
4	Overview of the DL-protocol	—	—
4.1	Operating principle	YES	—
4.2	Topology	YES	—
4.3	Frame processing principles	YES	—
4.4	Data-link layer overview	YES	—
4.5	Error detection overview	YES	—
4.6	Node reference model	YES	—
4.7	Operation overview	Partial	Direct mode mandatory
5	Frame Structure	—	—
5.1	Frame coding principles	YES	—
5.2	Data types and encoding rules	Partial	Types needed for application and unsigned integer types
5.3	DL PDU structure	YES	—
5.4	Type 12 DLPDU structure	YES	—
5.5	Network variable structure	NO	—
5.6	Type 12 mailbox structure	NO	—
6	Attributes	—	—
6.1	Management	YES	—
6.2	Statistics	YES	—
6.3	Watchdogs	YES	—
6.4	Slave information interface	YES	—
6.5	Media independent interface (MII)	YES	—
6.6	Fieldbus memory management unit (FMMU)	YES	—
6.7	Sync manager	NO	—
6.8	Distributed Clock	Partial	Timestamping of messages if more than 2 ports
7	DL-user memory	—	—
7.1	Overview	Optional	If mailbox supported
7.2	Mailbox access type	Optional	If mailbox supported
7.3	Buffered access type	Optional	—
8	Type 12:FDL Protocol state machines	—	—
8.1	Overview of slave DL state machines	Partial	Machines mandatory
8.2	State machine description	—	—
8.2.1	Port state machine (PSM)	YES	—
8.2.2	PDU handler state machine (DHSM)	YES	—
8.2.3	Synch manager state machine (SYMSM)	YES	—
8.2.4	Resilient Mailbox State Machine (RMSM)	Optional	If mailbox supported
8.2.5	SII State Machine (SIISM)	YES	—
8.2.6	MII State Machine (MIISM)	YES	—

Clause	Header	Presence	Constraints
8.2.7	DC State Machine (DCSM)	Partial	Timestamping of messages if more than 2 ports

4.2.2.2 EtherCAT Master

The data-link layer is described in IEC 61158-3-12 and IEC 61158-4-12. Table 6 specifies the use of the services, specified in IEC 61158-3-12, included in this profile. Table 7 specifies the use of the protocol, specified in IEC 61158-4-12, included in this profile. The selection of services used is up to the master. The Auto Increment Read and Write services are mandatory.

Table 6 – CP 12/1: DLL service selection

Clause	Header	Presence	Constraints
4	Data-link layer services and concepts	—	—
4.1	Operating principle	YES	—
4.2	Topology	YES	—
4.3	Data-link layer overview	YES	—
4.4	Error detection overview	YES	—
4.5	Parameter and process data handling introduction	Partial	Some examples are not describing mandatory functions
4.6	Node reference model	YES	—
4.7	Operation overview	Partial	Direct mode mandatory
4.8	Addressing	YES	—
4.9	Slave classification	NO	—
4.10	Structure of the communication layer in the slave	Partial	—
5	Communication services	—	—
5.1	Overview	YES	—
5.2	Read services	Partial	Requestor Services (.req/.cnf)
5.3	Write services	Partial	Requestor Services (.req/.cnf)
5.4	Combined read/write services	Partial	Requestor Services (.req/.cnf)
5.5	Network services	NO	—
5.6	Mailbox	NO	—
6	Local interactions	—	—
6.1	Read local	YES	—
6.2	Write local	YES	—

Table 7 – CP 12/1: DLL protocol selection

Clause	Header	Presence	Constraints
4	Overview of the DL-protocol	—	—
4.1	Operating principle	YES	—
4.2	Topology	YES	—
4.3	Frame processing principles	YES	—
4.4	Data-link layer overview	YES	—
4.5	Error detection overview	YES	—
4.6	Node reference model	YES	—
4.7	Operation overview	Partial	Direct mode mandatory