IEC 61784-2-15

Edition 1.0 2023-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial networks – Profiles –
Part 2-15: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 15

Réseaux industriels – Profils –
Partie 2-15: Profils de bus de terrain supplémentaires pour les réseaux en temps réel fondés sur l'ISO/IEC/IEEE 8802-3 – CPF 15

IEC 61784-2-15:2023-05(en-fr)

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

IEC 61784-2-15 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- withdrawn,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 2-15: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 15

1 Scope

This part of IEC 61784-2 defines Communication Profile Family 15 (CPF 15). CPF 15 specifies a set of Real-Time Ethernet (RTE) communication profiles (CPs) and related network components based on the IEC 61158 series (Type 15), 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 61158-5-15:2010, *Industrial communication networks – Fieldbus specifications – Part 5-15: Application layer service definition – Type 15 elements*

IEC 61158-6-15:2010, *Industrial communication networks – Fieldbus specifications – Part 6-15: Application layer protocol specification – Type 15 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, *Telecommunications and exchange between information technology systems – Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*

IEEE Std 802-2014, *IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture*

IEEE Std 802.1AB-2016, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE Std 802.1AS-2020, *IEEE Standard for Local and Metropolitan Area Networks – Timing and Synchronization for Time-Sensitive Applications*

IEEE Std 802.1Q-2018, *IEEE Standard for Local and Metropolitan Area Networks – Bridges and Bridged Networks*

IETF RFC 768, J. Postel, *User Datagram Protocol*, August 1980, available at https://www.rfc-editor.org/info/rfc768 [viewed 2022-02-18]

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

IETF RFC 792, J. Postel, *Internet Control Message Protocol*, September 1981, available at https://www.rfc-editor.org/info/rfc792 [viewed 2022-02-18]

IETF RFC 793, J. Postel, *Transmission Control Protocol*, September 1981, available at https://www.rfc-editor.org/info/rfc793 [viewed 2022-02-18]

IETF RFC 1305, D. Mills, *Network Time Protocol (Version 3) Specification, Implementation and Analysis*, March 1992, available at https://www.rfc-editor.org/info/rfc1305 [viewed 2022-02-18]

IETF RFC 2988, V. Paxson, M. Allman, *Computing TCP's Retransmission Timer*, November 2000, available at https://www.rfc-editor.org/info/rfc2988 [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, ISO/IEC/IEEE 8802-3, IEEE Std 802-2014, IEEE Std 802.1AB-2016, IEEE Std 802.1AS-2020 and IEEE Std 802.1Q-2018 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]
IANA	Internet Assigned Numbers Authority
ICMP	Internet Control Message Protocol (see IETF RFC 792)
IETF	Internet Engineering Task Force
IP	Internet Protocol (see IETF RFC 791)
LLDP	Link Layer Discovery Protocol (see IEEE Std 802.1AB-2016)
NoS	Number of Switches
Phy	PHY Physical layer entity sublayer (see ISO/IEC/IEEE 8802-3)
PI	Performance indicator
RSTP	Rapid Spanning Tree Algorithm and Protocol (see IEEE Std 802.1Q-2018)

RTO Retransmission Time Out
[according to IETF RFC 2988 – Computing TCP's Retransmission Timer]

RTPS Real-Time Publish-Subscribe

TCP Transmission Control Protocol (see IETF RFC 793)

UDP User Datagram Protocol (see IETF RFC 768)

3.3 Symbols

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

NOTE Definitions of symbols in this Subclause 3.3 do not use the italic font, as they are already identified as symbols.

Table 1 – 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
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

3.4 Conventions

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

4 CPF 15 (MODBUS-RTPS) – RTE communication profiles

4.1 General overview

Communication Profile Family 15 defines profiles based on ISO/IEC/IEEE 8802-3, IETF RFC 791 (IP), IETF RFC 793 (TCP), IETF RFC 768 (UDP), IEC 61158-5-15 and IEC 61158-6-15, which specify the communication system protocols commonly known as Modbus®[1] and Modbus TCP, and RTPS (Real-Time Publish-Subscribe).

In this document, the following communication profiles are specified for CPF 15:

– Profile 15/1

  Is a profile using Modbus TCP

– Profile 15/2

  Is a profile using RTPS.

For both profiles the communication is assumed to be full-duplex, with network topologies built via switches.

These communication profiles can be active at the same time on the same device and network, and as such they do not constitute alternative profiles, but can provide complementary and concurrent functionality.

4.2 CP 15/1

4.2.1 Physical layer

The physical layer of CP 15/1 is as specified in ISO/IEC/IEEE 8802-3.

4.2.2 Data-link layer

The data-link layer of CP 15/1 is as specified in ISO/IEC/IEEE 8802-3.

4.2.3 Application layer

4.2.3.1 General

The application layer of CP 15/1 is mapped on TCP (IETF RFC 793), using TCP Port Number 502, registered with IANA, over IP (IETF RFC 791), as described in IEC 61158-5-15 and IEC 61158-6-15.

4.2.3.2 AL service selection

The application layer services are defined in IEC 61158-5-15. Table 2 shows the subclauses included in this profile.

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1 Modbus is a trademark of Schneider Automation Inc registered in the United States of America and other countries. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trademark holder or any of its products. Compliance with this profile does not require use of the trademark Modbus. Use of the trademark Modbus requires permission from Schneider Automation Inc.

Table 2 – CP 15/1: AL service selection

Clause	Header	Presence	Constraints
Whole document	Application layer services definition (Type 15)	Partial	Subclauses qualified as Common or Client/Server

4.2.3.3 AL protocol selection

The application layer protocols are defined in IEC 61158-6-15. Table 3 shows the subclauses included in this profile.

Table 3 – CP 15/1: AL protocol selection

Clause	Header	Presence	Constraints
Whole document	Application layer protocol specification (Type 15)	Partial	Subclauses qualified as Common or Client/Server

4.2.4 Performance indicator selection

4.2.4.1 Performance indicator overview

Table 4 provides an overview of the CP 15/1 performance indicators.

Table 4 – CP 15/1: PI overview

Performance indicator	Applicable	Constraints
Delivery time	YES	—
Number of end-stations	YES	—
Basic network topology	YES	—
Number of switches between end-stations	YES	—
Throughput RTE	YES	—
Non-RTE bandwidth	YES	—
Time synchronization accuracy	YES	Provided with NTP (IETF RFC 1305)
Non-time-based synchronization accuracy	YES	—
Redundancy recovery time	YES	—

4.2.4.2 Performance indicator dependencies

4.2.4.2.1 Dependency matrix

Table 5 provides the CP 15/1 performance indicator dependency matrix.

Table 5 – CP 15/1: PI dependency matrix

Dependent PI	Influencing PI								
	Delivery time	Number of end-stations	Basic network topology	Number of switches between end-stations	Throughput RTE	Non-RTE bandwidth	Time synchronization accuracy	Non-time-based synchronization accuracy	Redundancy recovery time
Delivery time		NO	YES 4.2.4.2.2 4.2.4.2.24	YES 4.2.4.2.24	NO	NO	NO	NO 4.2.4.2.3	YES 4.2.4.2.4
Number of end-stations	NO		NO 4.2.4.2.5	YES 4.2.4.2.6	NO	NO	NO	NO	NO
Basic network topology	NO	YES 4.2.4.2.7		YES 4.2.4.2.8	NO	NO	NO	NO	NO
Number of switches between end-stations	NO	YES 4.2.4.2.9	YES 4.2.4.2.10		NO	NO	NO	NO	NO
Throughput RTE	NO	NO	NO	NO		YES 4.2.4.2.11	NO	NO 4.2.4.2.12	YES 4.2.4.2.13
Non-RTE bandwidth	NO	NO	NO	NO	YES 4.2.4.2.14		NO	NO	YES 4.2.4.2.15
Time synchronization accuracy	NO	NO	YES 4.2.4.2.16	YES 4.2.4.2.17	NO	NO		NO	YES 4.2.4.2.18
Non-time-based synchronization accuracy	NO	NO	YES 4.2.4.2.19	YES 4.2.4.2.20	NO	NO	NO		YES 4.2.4.2.21
Redundancy recovery time	NO	NO	YES 4.2.4.2.22	YES 4.2.4.2.23	NO	NO	NO	NO	

4.2.4.2.2 Delivery time and basic network topology

The following network topologies are supported:

- Star,
- Linear (embedded or bus),
- Ring,
- Redundant ring,
- Mesh.

The network topology influences the delivery time indirectly by influencing the number of switches to be traversed and the queuing and directly when supporting redundancy, by reacting differently in case of failures.

CP 15/1 has no switch technology dependencies.