IEC 61784-2-19

Edition 1.0 2023-03

INTERNATIONAL STANDARD

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Industrial networks – Profiles – Part 2-19: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 19

Réseaux industriels – Profils – Partie 2-19: Profils de bus de terrain supplémentaires pour les réseaux en temps réel fondés sur l'ISO/IEC/IEEE 8802-3 – CPF 19

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INDUSTRIAL NETWORKS – PROFILES –

Part 2-19: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 19

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

IEC 61784-2-19 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.

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

- 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;
- new Communication Profile (CPF 19/4).

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

Draft	Report on voting
65C/1210/FDIS	65C/1238/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

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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.

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INDUSTRIAL NETWORKS – PROFILES –

Part 2-19: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 19

1 Scope

This part of IEC 61784-2 defines extensions of Communication Profile Family 19 (CPF 19) for Real-Time Ethernet (RTE). CPF 19 specifies a Real-Time Ethernet (RTE) communication profile (CP) and related network components based on the IEC 61158 series (Type 27), 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 profile uses ISO/IEC/IEEE 8802-3 communication networks and its related network components and in some cases amend those standards to obtain RTE features.

NOTE 3 Some CPs of CPF 19 are specified in IEC 61784-1-19.

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

IEC 61158-3-24:2023, *Industrial communication networks – Fieldbus specifications – Part 3-24: Data-link layer service definition – Type 24 elements*

IEC 61158-4-24:2023, *Industrial communication networks – Fieldbus specifications – Part 4-24: Data-link layer protocol specification – Type 24 elements*

IEC 61158-5-24:2023, *Industrial communication networks – Fieldbus specifications – Part 5-24: Application layer service definition – Type 24 elements*

IEC 61158-5-27:2023, *Industrial communication networks – Fieldbus specifications – Part 5-27: Application layer service definition – Type 27 elements*

IEC 61158-6-24:2023, *Industrial communication networks – Fieldbus specifications – Part 6-24: Application layer protocol specification – Type 24 elements*

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IEC 61158-6-27:2023, *Industrial communication networks – Fieldbus specifications – Part 6-27: Application layer protocol specification – Type 27 elements*

IEC 61784-1-19:2023, *Industrial networks – Profiles – Part 1-19: Fieldbus profiles – Communication Profile Family 19*

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]

TIA-485-A:1998, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

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, IEEE Std 802.1Q-2018 and the following 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

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3.1.1
control domain
logical group which consists of a master and slaves to exchange control data and/or message data

Note 1 to entry: A slave shall belong to one or more control domains.

Note 2 to entry: Multiple control domains can exist in the network, and, in this case, they are indicated as control domain #*n* (*n* is an integer).

3.1.2
C1 master
AP type that has master facilities for the FDC service of the Type 27 FAL, or the device implementing that AP type

Note 1 to entry: Only one C1 master exists in a network of the Type 27 fieldbus.

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]
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)
PI Performance indicator
RSTP Rapid Spanning Tree Algorithm and Protocol (see IEEE Std 802.1Q-2018)
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 19 symbols

Symbol	Definition	Unit
DT	Delivery time	µs
L_{cable_len}	length of Ethernet cable between nodes	m
N_{c_domain}	number of the concurrent I/O data exchange domains	-
N_{hop}	number of hobs between master and slave	-
N_{retry}	number of retry	-
N_{retry_node}	number of node to retry	-
N_{s_domain}	number of the sequential I/O data exchange domains	-
N_{slaves}	number of slaves in domain	-
T_{c_domain}	the domain that concurrent I/O data exchange	µs
T_{cable_dly}	propagation delay(6 ns/m)	µs

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Symbol	Definition	Unit
T_{ctrl}	network control band (Option)	µs
T_{domain}	I/O data exchange band	µs
T_{guard}	guard time. It is 10 µs fixed	µs
T_{ifg}	inter fame gap	µs
T_{input}	time of input data transmission for all slaves	µs
T_{ip}	IP communication band for Internet Protocols (Option). It shall be set by application	µs
T_{msg}	time of asynchronous message communication	µs
T_{msg_req}	time of asynchronous message request	µs
T_{msg_res}	time of asynchronous message response	µs
T_{output}	time of output data transmission that master send	µs
T_{repeat_dly}	delay time of repeat(depend on implementation)	µs
T_{retry}	time of I/O data exchange retry (Option)	µs
T_{retry_req}	time of retry request	µs
T_{retry_res}	time of retry response	µs
T_{s_domain}	domain that sequential I/O data exchange	µs
T_{sync}	synchronization band	µs
T_{sync_dly}	delay time until synchronization packet reaches the farthest station	µs
T_{tr_dly}	delay time between master node and slave node	µs
T_{tr_input}	transmission time for input data packet, that all slaves send	µs
$T_{tr_msg_req}$	transmission time for asynchronous message packet	µs
$T_{tr_msg_res}$	transmission time for asynchronous message packet	µs
T_{tr_output}	transmission time for output data packet	µs
T_{tr_retry}	transmission time for retry request packet	µs
T_{tr_sync}	transmission time for synchronization packet	µs

3.4 Conventions

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

4 CPF 19 (MECHATROLINK[1]) – RTE communication profiles

4.1 General overview

Communication Profile Family 19 defines communication profiles(CPs) based on IEC 61158-2 type 24, IEC 61158-3-24, IEC 61158-4-24, IEC 61158-5-24 and IEC 61158-6-24, and on IEC 61158-2 type 27, IEC 61158-5-27, and IEC 61158-6-27, and on other standards (see Table 2 and Table 3).

[1] MECHATROLINK™ is a trade name of YASKAWA ELECTRIC CORPORATION. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trade names holder or any of its products. Compliance with this profile does not require use of the trade names. Use of the trade name MECHATROLINK requires permission of the trade name holder.

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The CPF 19 (MECHATROLINK) consists of four distinct protocol sets, known generically (for historical reasons) as MECHATROLINK-II (M-II) for CP 19/1, MECHATROLINK-III (M-III) for CP 19/2, ∑-LINK II for CP19/3, and MECHATROLINK-4 (M-4) for CP 19/4, which have major differences in their physical layers.

- MECHATROLINK-II (Profile 19/1, M-II): based on TIA-485-A PhL, which operates at 10 Mbit/s, and provides for additional features (IEC 61784-1-19, 4.2);
- MECHATROLINK-III (Profile 19/2, M-III): based on ISO/IEC/IEEE 8802-3 (Ethernet) PhL, which operates at 100 Mbit/s, and provides for additional features (IEC 61784-1-19, 4.3);.
- ∑-LINK II (Profile 19/3): based on TIA-485-A PhL, which operates at up to 32 Mbit/s, and provides for additional features (IEC 61784-1-19, 4.4);
- MECHATROLINK-4 (Profile 19/4, M-4): based on ISO/IEC/IEEE 8802-3 (Ethernet) PhL, which operates at 100 Mbit/s, and provides for additional features (see 4.2).

Each CPs is classified into more detailed profiles, based on another aspect of application process (AP) type or a sort of device type. Each AP type in a same CP plays different roles in a same network as C1 master, C2 master and slave. Such detailed profiles are described in each subclause if needed.

Table 2 – CPF 19: Overview of profile sets (CP19/1 and CP19/2)

Layer	Profile 19/1 (M-II)			Profile 19/2 (M-III)		
	C1 master	C2 master	Slave	C1 master	C2 master	Slave
Application	IEC 61158-5-24, IEC 61158-6-24			IEC 61158-5-24, IEC 61158-6-24		
Data link	IEC 61158-3-24, IEC 61158-4-24			IEC 61158-3-24, IEC 61158-4-24		
Physical	IEC 61158-2			IEC 61158-2 ISO/IEC/IEEE 8802-3		

Table 3 – CPF 19: Overview of profile sets (CP19/3 and CP19/4)

Layer	Profile 19/3(∑-LINK II)			Profile 19/4(M-4)-	
	C1 master	C2 master	Slave	C1 master	Slave
Application	IEC 61158-5-24, IEC 61158-6-24			IEC 61158-5-27, IEC 61158-6-27	
Data link	IEC 61158-3-24, IEC 61158-4-24			—	
Physical	IEC 61158-2			IEC 61158-2 ISO/IEC/IEEE 8802-3	

4.2 Profile 19/4 (MECHATROLINK-4)

4.2.1 Physical layer

The Physical Layer of the CP 19/4 shall be according to ISO/IEC/IEEE 8802-3.

The bit rate shall be 100 Mbit/s or 1 000 Mbit/s. But mixing both 100 Mbit/s and 1 000 Mbit/s is not allowed in same network.

4.2.2 Data link layer

The Data Link Layer shall be according to ISO/IEC/IEEE 8802-3.

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4.2.3 Application layer

4.2.3.1 General

The application layer specified in IEC 61158-5-27 and IEC 61158-6-27 shall be used.

4.2.3.2 M-4 Master

The application layer is described in IEC 61158-5-27 and IEC 61158-6-27. Table 4 specifies the use of the services specified in IEC 61158-5-27, included in this profile.

Table 5 specifies the use of the protocol specified in IEC 61158-6-27, included in this profile.

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Table 4 – CP 19/4: AL service selection

Clause	Header	Presence	Constraints
1	Scope	YES	—
2	Normative references	YES	—
3	Terms, definitions, symbols, abbreviated terms, and conventions	Partial	If applicable
4	Concepts	YES	—
5	Data type ASE	YES	—
6	Communication model specification	—	—
6.1	Type specific concepts	YES	—
6.2	Overview	YES	—
6.3	FAL ASEs	—	—
6.3.1	FSM ASE	—	—
6.3.1.1	Concepts	YES	—
6.3.1.2	FieldbusSystemManager class specifications	YES	Maximum number of instances: 1 object
6.3.1.3	FieldBusSysmteManagerUnderLayer class specification	YES	—
6.3.2	Field Device Control ASE	—	—
6.3.2.1	Service overview	YES	—
6.3.2.2	Master Class specification	YES	Maximum number of instances:128 objects
6.3.2.3	Slave Class specification	NO	—
6.3.3	Message ASE	—	—
6.3.3.1	Service overview	YES	—
6.3.3.2	Requester class specifications	YES	Optional Maximum number of instances: 1 object
6.3.3.3	Responder class specifications	YES	Optional Maximum number of instances: 1 object
6.3.4	Event Management ASE	YES	Maximum number of instances: 1 object
6.4	FAL Ars	—	—
6.4.1	AR model	YES	—
6.4.2	FSM AREP	YES	—
6.4.3	FDC AREP	—	—
6.4.3.1	FDC Master AR class	YES	—
6.4.3.2	FDC Slave AR class	NO	—
6.4.4	MSG AREP	YES	Optional Maximum number of instances: 2 objects

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Table 5 – CP 19/4: AL protocol selection

Clause	Header	Presence	Constraints
1	Scope	YES	—
2	Normative references	YES	—
3	Terms, definitions, symbols, abbreviated terms, and conventions	Partial	If applicable
4	Abstract syntax	YES	—
5	Transfer syntax	YES	—
6	Structure of FAL protocol state machine	YES	—
7	AP-context state machine (APC SM)	YES	—
8	FAL service protocol machines (FSPM)	—	—
8.1	Overview	YES	—
8.2	RT Protocol Machine (RT PM)	YES	—
8.3	Field System Management Protocol Machine (FSM PM)	—	—
8.3.1	Overview	YES	—
8.3.2	Discovery and basic configuration	YES	—
8.3.3	Starting up of system	—	—
8.3.3.1	Master Protocol Machine	YES	—
8.3.3.2	Slave Protocol Machine	NO	—
8.3.3.3	List of FSMUL macros	YES	—
8.3.4	Sync methods	YES	—
8.3.5	Plug-and-play entry	YES	—
8.4	Field Deice Control Protocol Machine (FDC PM)	—	—
8.4.1	Protocol overview	YES	—
8.4.2	Cyclic communication mode	YES	—
8.4.3	Event driven communication mode	YES	—
8.4.4	Master Protocol Machine (FDCPM-M)	YES	—
8.4.5	Slave Protocol Machine (FDCPM-S)	NO	—
8.4.6	Error procedure summary	YES	—
8.5	Message Protocol Machine (MSG PM)	—	—
8.5.1	Protocol overview	YES	—
8.5.2	Requester Protocol Machine (MSGPM-RQ)	YES	—
8.5.3	Responder Protocol Machine (MSGPM-RS)	YES	—
9	Application relationship protocol machine (ARPM)	—	—
9.1	General	YES	—
9.2	ARPM for FDC ASE	—	—
9.2.1	Overview	YES	—
9.2.2	ARPM for FDC Master (ARPM-FDCM)	YES	—
9.2.3	ARPM for FDC Slave (ARPM-FDCS)	NO	—
9.3	ARPM for MSG ASE (ARPM-MSG)	YES	—
10	DLL mapping protocol machines (DMPMs)	YES	—

4.2.3.3 M-4 Slave

The application layer is described in IEC 61158-5-27 and IEC 61158-6-27. Table 6 specifies the use of the services specified in IEC 61158-5-27, included in this profile.

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