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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial networks – Profiles – Part 2-20: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 20

Réseaux industriels – Profils – Partie 2-20: Profils de bus de terrain supplémentaires pour les réseaux en temps réel fondés sur l'ISO/IEC/IEEE 8802-3 – CPF 20

IEC 61784-2-20:2023-05(en-fr)

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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 9
3.4 Conventions 9
4 CPF 20 (ADS-net) – RTE communication profiles 10
4.1 General overview 10
4.2 CP 20/1 10
4.2.1 Physical layer 10
4.2.2 Data link layer 10
4.2.3 Application layer 10
4.2.4 Performance indicator selection 12
4.3 CP 20/2 15
4.3.1 Physical layer 15
4.3.2 Data link layer 15
4.3.3 Application layer 15
4.3.4 Performance indicator selection 17
Annex A (informative) CPF 20 (ADS-net) – Performance Indicator calculation 21
A.1 Profile 20/1 21
A.1.1 Delivery time 21
A.1.2 RTE throughput 21
A.1.3 Non-RTE bandwidth 22
A.2 Profile 20/2 22
A.2.1 Delivery time 22
A.2.2 RTE throughput 23
A.2.3 Non-RTE bandwidth 23
Bibliography 24

Table 1 – CPF 20 symbols 9
Table 2 – CP 20/1: DLL service selection 10
Table 3 – CP 20/1: DLL protocol selection 10
Table 4 – CP 20/1: AL service selection 11
Table 5 – CP 20/1: AL protocol selection 11
Table 6 – CP 20/1: performance indicator overview 12
Table 7 – CP 20/1: Performance indicator dependency matrix 12
Table 8 – VLAN priority mapping of CP20/1 network 13
Table 9 – CP 20/1: Consistent set of performance indicators 15
Table 10 – CP 20/2: AL service selection 16

Documents
Document Sharing Hub
Full document details: IEC 61784-2-20-2023

Table 11 – CP 20/2: AL protocol selection 16
Table 12 – CP 20/2: Performance indicator overview 17
Table 13 – CP 20/2: Performance indicator dependency matrix 17
Table 14 – CP 20/2: Consistent set of performance indicators 20

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INDUSTRIAL NETWORKS – PROFILES –

Part 2-20: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 20

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

IEC 61784-2-20 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:

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.

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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 2-20: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 20

1 Scope

This part of IEC 61784-2 defines Communication Profile Family 20 (CPF 20). CPF 20 specifies a set of Real-Time Ethernet (RTE) communication profiles (CPs) and related network components based on the IEC 61158 series (Type 25), 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 61158-3-25:2019, *Industrial communication networks – Fieldbus specifications – Part 3-25: Data-link layer service definition – Type 25 elements*

IEC 61158-4-25:2019, *Industrial communication networks – Fieldbus specifications – Part 4-25: Data-link layer protocol specification – Type 25 elements*

IEC 61158-5-25:2019, *Industrial communication networks – Fieldbus specifications – Part 5-25: Application layer service definition – Type 25 elements*

IEC 61158-6-25:2019, *Industrial communication networks – Fieldbus specifications – Part 6-25: Application layer protocol specification – Type 25 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*

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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]

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]

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)

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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 20 symbols

Symbol	Description	Unit
BW	Total bandwidth	%
BW_{NRTE}	Non-RTE bandwidth	%
BW_{RTE}	RTE bandwidth	%
CD	Cable segment delay	µs
CL	Cable length	km
DL_{CY}	Delay of RTE frame on sender node	µs
DL_{NCY}	Delay of Non-RTE frame on sender node	µs
DL_{R}	Delay of receiver node	µs
DL_{S}	Delay of sender node	µs
DT	Delivery time of RTE	µs
F_{N}	The number of frames in the RTE	-
M	The number of nodes sending RTE frame	-
MC_{RTE}	Common memory capacity	octet
N	The number of nodes between sending and receiving end-stations	-
PD	Cable propagation delay	µs
P_{OH}	Protocol overhead	µs
q	The number packets in the port transmit queue	µs
RD_{HD}	Delay of hardware receiving process	µs
SD_{FM}	Delay of sending process by firmware	µs
SD_{HD}	Delay of sending process by hardware	µs
SD_{s}	Sender stack delay	µs
SD_{r}	Receiver stack delay	µs
SL	Switch latency	µs
SPD	Switch processing delay	µs
ST_{RTE}	Communication cycle time	ms
T_{CI}	Transmit time of control and information communication packet	µs
T_{CN}	Transmit time of ring control communication packet	µs
T_{CY}	Transmit time of cyclic communication packet	µs
TR_{RTE}	Throughput RTE	µs
T_{X}	Transmit time of target packet	µs
T_{X_j}	Transmit time of packet j	µs

3.4 Conventions

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

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4 CPF 20 (ADS-net[1]) – RTE communication profiles

4.1 General overview

Communication Profile Family 20 defines profiles based on ISO/IEC/IEEE 8802-3, IEC 61158-3-25, IEC 61158-4-25, IEC 61158-5-25, and IEC 61158-6-25 which specify the communication system protocols commonly known as ADS-net.

In this document, the following communication profiles are specified for CPF 20:

– Profile 20/1

  A profile using ADS-net technology in a ring topology (ADS-net/μΣNETWORK-1000[1]),

– Profile 20/2

  A profile using ADS-net technology in a star / linear topology (ADS-net/NX[1]).

4.2 CP 20/1

4.2.1 Physical layer

The physical layer of CP 20/1 is as specified in ISO/IEC/IEEE 8802-3.

4.2.2 Data link layer

4.2.2.1 DLL service selection

DLL services are defined in IEC 61158-3-25. Table 2 shows the subclauses included in this profile.

Table 2 – CP 20/1: DLL service selection

Clause	Header	Presence	Constraints
Whole document	Data link service definition (Type 25)	YES	–

4.2.2.2 DLL protocol selection

DLL protocols are defined in IEC 61158-4-25. Table 3 shows the subclauses included in this profile.

Table 3 – CP 20/1: DLL protocol selection

Clause	Header	Presence	Constraints
Whole document	Data link protocol specification (Type 25)	YES	–

4.2.3 Application layer

4.2.3.1 AL service selection

Application Layer services are defined in IEC 61158-5-25. Table 4 shows the subclauses included in this profile.

[1] In Japan, μΣNETWORK-1000 is the trade name of Hitachi. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trade name holder or any of its products. Compliance with this profile does not require use of the trade name μΣNETWORK-1000. Use of the trade name μΣNETWORK-1000 requires permission of the trade name holder. ADS-net, ADS-net/μΣNETWORK-1000 and ADS-net/NX are used to describe the communication concept specified in Type 25 and the profiles in CPF 20.

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Table 4 – CP 20/1: AL service selection

Clause	Header	Presence	Constraints
1	Scope	YES	—
2	Normative references	YES	—
3	Terms, definitions, symbols and abbreviations	Partial	Used if needed
4	Concept	YES	—
5	Data type ASE	Partial	Used if needed
6	Communication model specification	—	—
6.1	Communication model	YES	—
6.2	ASE type S	YES	—
6.3	ASE type N	NO	—
6.4	AR type S	YES	—
6.5	AR type N	NO	—

4.2.3.2 AL protocol selection

Application Layer protocols are defined in IEC 61158-6-25. Table 5 shows the subclauses included in this profile.

Table 5 – CP 20/1: AL protocol selection

Clause	Header	Presence	Constraints
1	Scope	YES	—
2	Normative references	YES	—
3	Terms, definitions, symbols and abbreviations	Partial	Used if needed
4	FAL syntax description	—	—
4.1	FALPDU type S abstract syntax	YES	—
4.2	FALPDU type N abstract syntax	NO	—
4.3	Data type assignments for type S	YES	—
4.4	Data type assignments for type N	NO	—
5	FAL transfer syntax	—	—
5.1	Encoding rules	YES	—
5.2	FALPDU type S elements encoding	YES	—
5.3	FALPDU type N elements encoding	NO	—
6	Structure of the FAL protocol state machine	YES	—
7	FAL service protocol machine (FSPM)	—	—
7.1	Overview	YES	—
7.2	FSPM type S	YES	—
7.3	FSPM type N	NO	—
8	Application relationship protocol machine (ARPM)	—	—
8.1	ARPM type S	YES	—
8.2	ARPM type N	NO	—
9	DLL mapping protocol machine (DMPM)	—	—
9.1	DMPM type S	YES	—
9.2	DMPM type N	NO	—

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4.2.4 Performance indicator selection

4.2.4.1 Performance indicator overview

Table 6 provides an overview of CP 20/1 performance indicators.

Table 6 – CP 20/1: performance indicator overview

Performance indicator	Applicable	Constraints
Delivery time	YES	None
Number of end-stations	YES	None
Basic network topology	YES	Only ring topology is supported
Number of switches between end-stations	NO	—
Throughput RTE	YES	None
Non-RTE bandwidth	YES	—
Time synchronization accuracy	NO	—
Non-time-based synchronization accuracy	NO	—
Redundancy recovery time	YES	None

4.2.4.2 Performance indicator dependencies

4.2.4.2.1 Dependency matrix

Table 7 shows the dependencies between performance indicators for CP 20/1.

Table 7 – CP 20/1: Performance indicator dependency matrix

Dependent PI	Influencing PI					
	Delivery time	Number of end-stations	Basic network topology	Throughput RTE	Non-RTE bandwidth	Redundancy recover time
Delivery time		YES	NO	YES	YES	NO
Number of end-stations	YES		NO	YES	YES	NO
Basic network topology	NO	NO		NO	NO	NO
Throughput RTE	YES	YES	NO		NO	NO
Non-RTE bandwidth	NO	YES	NO	YES		NO
Redundancy recover time	NO	NO	NO	NO	NO	

4.2.4.2.2 Delivery time

Table 8 shows VLAN priority mapping of the CP20/1 network. CP 20/1 network maps VLAN priority to four types of communication, Ring control, Cyclic, Control, and Information communication. Ring control communication, CP20/1 ring network reconfiguration frame is the highest priority. Cyclic communication, real-time communication frame is the second highest priority. Control communication is the third priority and Information is the lowest priority.

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Table 8 – VLAN priority mapping of CP20/1 network

VLAN	Usage	VLAN priority
VLAN-1	Ring control communication	7 (Highest)
VLAN-2	Cyclic communication	5 (High)
VLAN-3	Control communication	3 (Low)
VLAN-4	Information communication	1 (Lowest)

The performance indicator “Delivery time” is related to the VLAN priority classes as shown above. The frame delivery time of each communication between any two end-nodes depends on multiple factors (e.g. frame buffering delay).

Cyclic communication time is calculated using Formulae (1), (2), (3), (4), (5) and (6).

$$DT = DL_S + \sum_{i=1}^{M-2} DL_{CY} + \sum_{i=1}^{N-M} DL_{NCY} + DL_R + CD \tag{1}$$

$$DL_S = SD_{FM} + SD_{HD} + T_{CN} + T_{CI} + SPD + T_X \tag{2}$$

$$DL_{CY} = T_{CN} + T_{CY} + T_{CI} + SPD + T_X \tag{3}$$

$$DL_{NCY} = T_{CN} + T_{CI} + SPD + T_X \tag{4}$$

$$DL_R = T_{CN} + T_{CI} + SPD + T_X + RD_{HD} \tag{5}$$

$$CD = PD \times CL \tag{6}$$

where

DT is the delivery time of cyclic communication in microseconds (one frame/nodes sending);

DL_S is the delay of sender node (sending the cyclic communication packet);

DL_{CY} is the delay of cyclic frame sender node;

DL_{NCY} is the delay of non-cyclic frame sender node;

DL_R is the delay of receiver node (receiving the cyclic communication packet);

CD is the cable delay in microseconds;

SD_{FM} is the delay of sending process by firmware (firmware waiting time, depending on the selected hardware platform and the embedded software implementation);

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SD_{HD} is the delay of sending process by hardware (depending on the selected hardware platform);

T_{CN} is the transmit time of ring control communication packet in microseconds;

T_{CI} is the transmit time of control and information communication packet in microseconds;

SPD is the switch processing delay in microseconds;

T_X is the transmit time of target packet in microseconds;

T_{CY} is the transmit time of cyclic communication packet in microseconds;

RD_{HD} is the delay of hardware receiving process (depending on the selected hardware platform);

PD is the cable propagation delay;

CL is the cable length in kilometers;

N is the number of nodes between sending and receiving end-nodes;

M is the number of nodes sending cyclic frame between sending and receiving end nodes.

4.2.4.2.3 Number of end-stations

The maximum number of end stations shall be up to 128.

4.2.4.2.4 Basic network topology

The network topology supported by this profile is of a loop (ring).

4.2.4.2.5 Throughput RTE

The throughput RTE is calculated according to Formula (7).

$$TR_{RTE} = \frac{MC_{RTE}}{ST_{RTE}} \tag{7}$$

where

TR_{RTE} is the throughput RTE;

MC_{RTE} is the common memory capacity for RTE (cyclic communication);

ST_{RTE} is the communication cycle time by RTE packets.

4.2.4.2.6 Non-RTE bandwidth

The non-RTE bandwidth is calculated using the Formulae (8) and (9).

$$BW_{NRTE} = BW - BW_{RTE} \tag{8}$$

$$BW_{RTE} = \frac{(MC_{RTE} + F_N \times P_{OH}) \times 8}{ST_{RTE} \times 10^9} \tag{9}$$

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where

BW_{NRTE} is the bandwidth used for non-RTE (control and information) communication in %;

BW is the total bandwidth in %, and the 100 % is 1 Gbps;

BW_{RTE} is the bandwidth used for the RTE communication in %;

F_N is the number of frames in the RTE communication;

P_{OH} is the protocol overhead.

4.2.4.2.7 Redundancy recovery time

CP 20/1 network (master less) is autonomously reconfigured with each node. Therefore, CP 20/1 network configuration is simple and fast. The maximum time to become fully operational again from a failure, in case of a single permanent failure, is 250 ms.

4.2.4.3 Consistent set of performance indicators

Table 9 shows the consistent set of the performance indicators for CP 20/1. The values in this table are maximum values of delivery time calculated in 4.2.4.2.2.

Details for calculating the performance indicators are given in Annex A.

Table 9 – CP 20/1: Consistent set of performance indicators

Performance indicator	Value	Constraints
Delivery time	1,7 ms	No failure, Total length = 10 km, 32 nodes
	9,1 ms	No failure, Total length = 500 km, 128 nodes
Number of end stations	32	Typical, Communication cycle time = 2 ms
	128	Max, Communication cycle time = 10 ms
Throughput RTE	16,4 M octets/s	Data=32 KB, 32 nodes
	26,1 M octets/s	Data=256 KB, 128 nodes
Non-RTE bandwidth	85,8 %	32 nodes
	77,2 %	128 nodes
Redundancy recovery time	250 ms	—

4.3 CP 20/2

4.3.1 Physical layer

The physical layer of CP 20/2 is as specified in ISO/IEC/IEEE 8802-3.

4.3.2 Data link layer

The data link layer of CP 20/2 is as specified in ISO/IEC/IEEE 8802-3.

4.3.3 Application layer

4.3.3.1 AL service selection

Application Layer services are defined in IEC 61158-5-25. Table 10 shows the subclauses included in this profile.

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