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Edition 1.0 2023-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial networks – Profiles –
Part 2-21: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 21

Réseaux industriels – Profils –
Partie 2-21: Profils de bus de terrain supplémentaires pour les réseaux en temps réel fondés sur l'ISO/IEC/IEEE 8802-3 – CPF 21

IEC 61784-2-21:2023-05(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 61784-2-21 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;
b) expand Common-memory-area as a new Common-memory-area-3 (CM3);
c) add new services and the protocols with expansion of Common-memory-area:
   – Extended-cyclic-data service and the protocol;
   – Extended-participation-req service and the protocol;
   – Extended-network-parameter-read service and the protocol;
   – Extended-network-parameter-write service and the protocol;
d) add new Table for CP 21/1: Consistent set of PIs with CM3.

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 2-21: Additional real-time fieldbus profiles based on ISO/IEC/IEEE 8802-3 – CPF 21

1 Scope

This part of IEC 61784-2 defines Communication Profile Family 21 (CPF 21). CPF 21 specifies a Real-Time Ethernet (RTE) communication profile (CP) and related network components based on the IEC 61158 series (Type 26), 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.

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 61158-5-26:2023, *Industrial communication networks – Fieldbus specifications – Part 5-26: Application layer service definition – Type 26 elements*

IEC 61158-6-26:2023, *Industrial communication networks – Fieldbus specifications – Part 6-26: Application layer protocol specification – Type 26 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*

IEC 61784-5-21, *Industrial communication networks – Profiles – Part 5-21: Installation of fieldbuses – Installation profiles for CPF 21*

IEC 61918, *Industrial communication networks – Installation of communication networks in industrial premises*

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 in Bridged Local Area Networks*

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 796, J. Postel, *Address mappings,* September 1981, available at https://www.rfc-editor.org/info/rfc796 [viewed 2022-02-18]

IETF RFC 826, D. Plummer, *An Ethernet Address Resolution Protocol: Or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware*, November 1982, available at https://www.rfc-editor.org/info/rfc826 [viewed 2022-02-18]

IETF RFC 894, C. Hornig, *A Standard for the Transmission of IP Datagrams over Ethernet*, April 1984, available at https://www.rfc-editor.org/info/rfc894 [viewed 2022-02-18]

IETF RFC 919, J.C. Mogul, *Broadcasting Internet Datagrams*, October 1984, available at https://www.rfc-editor.org/info/rfc919 [viewed 2022-02-18]

IETF RFC 922, J.C. Mogul, *Broadcasting Internet datagrams in the presence of subnets*, October 1984, available at https://www.rfc-editor.org/info/rfc922 [viewed 2022-02-18]

IETF RFC 950, J.C. Mogul and J. Postel, *Internet Standard Subnetting Procedure*, August 1985, available at https://www.rfc-editor.org/info/rfc950 [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.

ARP Address Resolution Protocol (see IETF RFC 826)
CP Communication Profile [according to IEC 61784-1-0]
CPF Communication Profile Family [according to IEC 61784-1-0]
FA Factory Automation
FCS Frame check sequence
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)
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 21 symbols

Symbol	Definition	Unit
BW	Total bandwidth in %, and the 100 % is Erate	%
BWnrt	Non-RTE bandwidth	%
BWrte	Bandwidth used for the RTE communications	%
Cd_i	Signal propagation delay on the cable segment #i	µs
$Clen_i$	Cable length of a cable segment #i	m
Cpd	Signal propagation delay on the cabling path between sending and receiving end-stations	µs
$C\varepsilon_i$	Cable prppagation delay constant per meter on the cable segment #i	µs/m
DT	Delivery time	µs
DVct	Total volume of the cyclic-data sent out by all end-stations	Octets
Erate	Ethernet data-transmission rate	Mbit/s
NoC	Number of cable segments between sending and receiving end-stations	
NoS	Number of switches (including Hub) between sending and receiving end-stations	
$STTsr_i$	Sender and Receiver stack traversal time including Phy, MAC, IP, UDP or TCP and FAL processing time of end-station #i	µs
Tct	Sum total of the transmission time of all Cyclic-data frames by all end-stations	µs
$Tctn_i$	Total number of Cyclic-data frames sent out by end-station #i	
Tcs	Sum total of the transmission time up to the permissible count of general Ethernet frame including the general-purpose-server-command transmission	µs
Tms	Sum total of the transmission time up to the permissible count of message-data frame sporadically requested during one Tttkr time period	µs
Tnn	The total number of nodes participating in the logical ring	
Trmt	Refresh-cycle-measurement time which is the elapsed time period from the time after obtaining the token by an end-station until the time the end-station obtains the token once again	µs
TRrte	Throughput RTE	Octets/s
Ttf	Packet frame transmission time	µs
Tsw_i	Latency of the switch (including Hub) #i	µs
Tsw	Sum total of the switch (including Hub) latencies on the connection path between sending and receiving end-stations	µs
Ttk	Transmission time of the token frames out of all end-stations including the inter-frame space time for sending out the token frame immediately after sending out the final-cyclic-data frame	µs
$Ttkif_i$	Inter-frame space time for sending out the token frame immediately after sending out the final-cyclic-data frame by end-station #i	µs
Tttkr	Target-token-rotation time	µs

3.4 Conventions

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

4 CPF 21 (FL-net[1]) – RTE communication profiles

4.1 General overview

Communication Profile Family 21 defines the communication profile based on IEC 61158-5-26 and IEC 61158-6-26 which corresponds to the communication systems commonly known as FL-net.

- Profile 21/1 (FL-net)

  This profile constitutes an FL-net communication system with star topology. It contains a selection of AL services and protocol definitions from IEC 61158-5-26 and IEC 61158-6-26.

Table 2 shows the overview of FL-net profile set.

Table 2 – CPF 21: Overview of profile sets

Layer	Profile 21/1
Application	IEC 61158-5-26, IEC 61158-6-26
Data-link	a set of the off-the-shelf protocol suite as follows: IETF RFC 768(UDP), IETF RFC 793(TCP) IETF RFC 791(IP) IETF RFC 919, IETF RFC 922 IETF RFC 792, IETF RFC 950 IETF RFC 894 / ISO/IEC/IEEE 8802-3 Ethernet MAC IETF RFC 826
Physical	ISO/IEC/IEEE 8802-3 Phy

4.2 CP 21/1

4.2.1 Physical layer

The physical layer of 100 Mbit/s and 1 000 Mbit/s shall be according to ISO/IEC/IEEE 8802-3.

Connectors, cables and the installation guideline are specified in IEC 61784-5-21 and IEC 61918.

4.2.2 Data-link layer

4.2.2.1 Overview

Functions of the intermediate OSI layers, layers 3 through 6, are consolidated into the IEC 61158 data-link layer of a Type 26 fieldbus.

Three kinds of Type 26 data transmission services are defined in IEC 61158-5-26 and IEC 61158-6-26, which are Cyclic-data transmission (CT), Message-data transmission (MT) and General-purpose-server-command transmission (CS).

The Cyclic-data transmission and the Message-data transmission are performed as message transfer services through UDP communication channels. The General-purpose-server-command transmission is performed as server-command transfer service through the communication channels of UDP or TCP.

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[1] FL-net is the trade name of the JEMA/FL-net: the Japan Electrical Manufacturers' Association / the Factory Automation Link network. 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 trade name. Use of the trade name requires permission of the trade name holder.

The service interface to the UDP and/or TCP channels of the DL-layer for Type 26 FAL services is by means of any off-the-shelf UDP and TCP protocol suite, and the requirement to the DL-layer service is not peculiar and is minimal and general.

Figure 1 shows the protocol stack for a Type 26 fieldbus, the OSI layers and the equivalent layers in the IEC 61158 basic fieldbus reference model.

OSI layer			IEC 61158 layer
7	Application		**Application (FAL)** IEC 61158-5-26 IEC 61158-6-26
6	Presentation	null	
5	Session	null	
4	Transport		**Data-link** IETF RFC 768, (IETF RFC 793)
3	Network		IETF RFC 791 IETF RFC 919, IETF RFC 922 (IETF RFC 792, IETF RFC 950)
2	Data-link		IETF RFC 894/ ISO/IEC/IEEE 8802-3 MAC (IETF RFC 826)
1	Physical		**Physical** ISO/IEC/IEEE 8802-3 Phy

Figure 1 – Protocol stack for Type 26 fieldbus

4.2.2.2 DL-layer service and protocol suite selection

Table 3 specifies the DL-layer protocol/service suite selection for the MT, the CT and the CS services of CPF 21.

Table 3 – DL-layer protocol / service suite selection

OSI equivalent layer service	Corresponding DL protocol /Service	Usage	Constraint
Transport layer	UDP: IETF RFC 768	M	Used for MT and CT services
	UDP: IETF RFC 768	O	Used for CS service. The value of "Check-sum" is set to zero (0) at sender node, and the check-sum verification is not performed at receiver nodes.
	TCP: IETF RFC 793	O	Used for CS service
Network layer	IP: IETF RFC 791	M	Used for CT, MT and CS services. A broadcast communication function is mandatory fundamental function.
	ICMP: IETF RFC 792	O	Used for CT, MT and CS services
	Broadcast related: IETF RFC 919	M	Used for CT, MT and CS services. A broadcast communication function is mandatory fundamental function.
	Broadcast related: IETF RFC 922	M	Used for CT, MT and CS services. A broadcast communication function is mandatory fundamental function.
	Subnet related: IETF RFC 950	O	Used for CT, MT and CS services
Data-link layer	Ethernet: IETF RFC 894	M	Used for CT, MT and CS services
	ARP: IETF RFC 826	O	Used for CT, MT and CS services
Physical layer	ISO/IEC/IEEE 8802-3	M	Used for CT, MT and CS services

The DL-layer service shall specify a broadcast communication function as the mandatory fundamental function as CPF 21 lower layer, and any other special main functions are not specified or required as of mandatory for the DL-layer service except for the constraints shown in Table 4.

Table 4 specifies the data transmission service selection.

Table 4 – Data transmission service selection

Data transmission service	Usage	Constraint
CT and MT service	M	DL-SAP assignment: See Table 5. Network address and Node number: See Table 6.
CS service through UDP	M	Default selection for CS service. DL-SAP assignment: See Table 5. Network address and Node number: See Table 6.
CS service through TCP	O	Alternative selection for CS service DL-SAP assignment: See Table 5. Network address and Node number: See Table 6.

Table 5 – Port number selection

Data transmission Service	Channel type	Usage	Port number assigned / Constraint
Reception for CT including AR-control, Token frame excluding Extended-cyclic-data frame	UDP	M	55 000
Reception for MT including AR-control reception	UDP	M	55 001
Reception for AR-control: AR-Control.Participation-req frame, AR-Control.Trigger frame	UDP	M	55 002
Transmission for MT and CT including AR-control transmission	UDP	M	55 003
Reception for CS	UDP	M	55 004
Reception for CS	TCP	O	55 004
Transmission for CS	UDP	M	55 004
Transmission for CS	TCP	O	55 004
Reception for: Extended-cyclic-data frame, AR-Control.Extended-participation-req frame.	UDP	M	55 005
NOTE AR-control performs the FAL services coordination, the token passing control to establish and maintain a logical ring for right to send out data among nodes, the control for new node addition and member node drop-out, the logical-ring recovery, and the error handling with delivery confirmation and retransmission.			

Table 6 – IP address selection

IP address	Usage	Constraint
192.168.250.N Subnet mask = 255.255.255.0	M	Default selection. "N" is identical to the node number of 1 to 254. Destination node number "N = 255" is for broadcasting.
192.168.200.N Subnet mask = 255.255.255.0	O	Alternative selection. N" is identical to the node number of 1 to 254. Destination node number "N = 255" is for broadcasting.
NOTE IP address is picked and assigned out of the Class C IP address defined in IETF RFC 796, and each node number of 1 to 254 is identical to the host address in Class C IP address with subnet mask of 255.255.255.0.		

4.2.3 Application layer

4.2.3.1 AL service selection

Table 7 specifies the AL service selection within IEC 61158-5-26.

In addition, AL services are mapped onto the UDP/TCP/IP protocol suite, and corresponding minimum requirements shall be supported and implemented in accordance with IETF RFC 768, IETF RFC 791, IETF RFC 793, IETF RFC 894, IETF RFC 919, IETF RFC 922 and these subsequent documents which supersede them.