IEC/PAS 62633

Edition 1.0 2009-08

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

Industrial communication networks – Profiles –
Additional Fieldbus profiles for real-time networks based on ISO/IEC 8802-3 – SNpTYPE

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The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
65C/530/PAS	65C/534/RVD

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INTRODUCTION

This PAS contains an additional profile – SNpTYPE – which may be integrated into a future new edition of IEC 61784-2.

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INDUSTRIAL COMMUNICATION NETWORKS – PROFILES – ADDITIONAL FIELDBUS PROFILES FOR REAL-TIME NETWORKS BASED ON ISO/IEC 8802-3 – SNpTYPE

1 Scope

This Clause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

2 Normative references

The following referenced documents are indispensable for the application 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.

This Clause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

IEC 61784-2:2007, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

3 Terms, definitions, abbreviated terms, acronyms, and conventions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply, in addition to those of IEC 61784-2:2007.

3.1.30

real time frame line (RTFL)
<CPF SNpFAMILY>
communication model for communication with high real time requirements

3.1.31
real time frame network (RTFN)
<CPF SNpFAMILY>
communication model for communication with low real time requirements

3.2 Abbreviated terms and acronyms

The following additional abbreviated terms and acronyms for CPF SNpFAMILY apply, in addition to those of IEC 61784-2:2007.

RTFL Real time frame line

RTFN Real time frame network

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3.3 Symbols

The following additional subclause for the symbols of the new CPF SNpFAMILY applies, in addition to those of IEC 61784-2:2007.

3.3.12 CPF SNpFAMILY symbols

Symbol	Definition	Unit
l_B	Distance along the cable in backward direction	m
l_C	Cable length	m
l_F	Distance along the cable in forward direction	m
NoDoB	Number of devices in backward direction	—
NoDoF	Number of devices in forward direction	—
NoS	Number of switching devices	—
t_{CD}	Cable delay	ns/m
t_{cyc}	Cycle time of communication system/relation	µs
t_D	Delivery time	µs
t_{data}	Transmit time of data frame(s)	µs
t_{pd}	Propagation delay	µs
t_{STsink}	Sink stack traversal time	µs
t_{STsrc}	Source stack traversal time	µs
t_{SW}	Delay time of a switch	µs

3.4 Conventions

This Subclause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

4 Conformance to communication profiles

This Clause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

5 RTE performance indicators

This Clause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

6 Conformance tests

This Clause is identical in form and content for all CPFs to that of IEC 61784-2:2007.

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7 Communication Profile Family SNpFAMILY (SafetyNET p[1]) - RTE communication profiles

7.1 General overview

Communication Profile Family SNpFAMILY defines profiles based on IEC/PAS 61158-3-22 through IEC/PAS 61158-6-22.

In this part of IEC 61784, the following communication profiles are specified for CPF SNpFAMILY.

- Profile SNpFAMILY/1

  This profile defines protocol and service selection for devices which utilize the communication model real time frame line (RTFL).

- Profile SNpFAMILY/2

  This profile defines protocol and service selection for devices which utilize the communication model real time frame network (RTFN).

7.2 Profile SNpFAMILY/1

7.2.1 Physical layer

The physical layer shall be based on standard Ethernet hardware according to ISO/IEC 8802-3.

CP SNpFAMILY/1 devices shall use a data rate of 100 Mbit/s and full-duplex transmission mode. A combination of full-duplex and 100Base-TX with auto crossover function (wire, 2 twisted pairs) should be used.

When using cables, they shall be rated Cat5e or better, and shielded in an appropriate way (FTP, STP or SFTP) depending upon EMC constraints.

7.2.2 Data link layer

Data link layer is described in IEC/PAS 61158-3-22 and IEC/PAS 61158-4-22. Table 1 specifies the use of the services included in this profile. Table 2 specifies the use of the protocol included in this profile.

Table 1 – CP SNpFAMILY/1: DLL service selection

Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4	Data-link layer services and concepts	—	—
4.1	Operating principle	YES	—
4.2	Communication models	—	—
4.2.1	Overview	YES	—
4.2.2	RTFL device reference model	YES	—
4.2.3	RTFN device reference model	NO	—
4.3	Topology	—	—

[1] SafetyNET p is a trade name of the Pilz GmbH & Co. KG. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trade name holder or any of its products. Compliance to this profile does not require use of the trade name SafetyNET p. Use of the trade name SafetyNET p requires permission of the trade name holder.

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Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4.3.1	RTFL topology	YES	—
4.3.2	RTFN topology	NO	—
4.4	Addressing	—	—
4.4.1	Overview	YES	—
4.4.2	RTFL device addressing	YES	—
4.4.3	RTFN device addressing	NO	—
4.5	Gateway	YES	—
4.6	Interaction models	—	—
4.6.1	Overview	YES	—
4.6.2	Producer-consumer	YES	—
4.6.3	Publisher-subscriber	NO	—
4.7	Synchronization concept	YES	—
5	Communication services	—	—
5.1	Overview	Partial	Only services selected by this CP
5.2	Communication management services	—	—
5.2.1	Overview	YES	—
5.2.2	Network verification	—	—
5.2.2.1	DL-Network verification service (NV)	YES	—
5.2.2.2	DL-RTFN scan network read service (RTFNSNR)	NO	—
5.2.3	Communication management	—	—
5.2.3.1	DL-RTFN connection establishment service (RTFNCE)	NO	—
5.2.3.2	DL-RTFN connection release service (RTFNCR)	NO	—
5.2.3.3	DL-RTFL control service (RTFLCTL)	YES	—
5.2.3.4	DL-RTFL configuration service (RTFLCFG)	YES	—
5.2.3.5	DL-Read configuration data service (RDCD)	YES	—
5.3	CDC service	YES	—
5.4	MSC services	YES	—
5.5	Time synchronization	—	—
5.5.1	DL-DelayMeasurement start service (DMS)	YES	—
5.5.2	DL-DelayMeasurement read service (DMR)	YES	—
5.5.3	DL-PCS configuration service (PCSC)	YES	—
5.5.4	DL-Sync master configuration service (SYNC_MC)	YES	—
5.5.5	DL-Sync start service (SYNC_START)	YES	—
5.5.6	DL-Sync stop service (SYNC_STOP)	YES	—
5.6	Media independent interface (MII) management services	YES	—

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Table 2 – CP SNpFAMILY/1: DLL protocol selection

Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4	DL-protocol overview	—	—
4.1	Operating principle	YES	—
4.2	Communication model	—	—
4.2.1	Overview	YES	—
4.2.2	RTFL device reference model	YES	—
4.2.3	RTFN device reference model	NO	—
4.3	Topology	—	—
4.3.1	RTFL topology	YES	—
4.3.2	RTFN topology	NO	—
4.4	Frame processing	—	—
4.4.1	Communication model RTFL	YES	—
4.4.2	Communication model RTFN	NO	—
4.5	General communication mechanisms	YES	—
4.6	Gateway	YES	—
4.7	Interaction models	—	—
4.7.1	Overview	YES	—
4.7.2	Producer-consumer	YES	—
4.7.3	Publisher-subscriber	NO	—
5	DLPDU structure	—	—
5.1	Overview	YES	—
5.2	Data types and encoding rules	YES	—
5.3	DLPDU identification	YES	—
5.4	General DLPDU structure	—	—
5.4.1	Type SNpTYPE frame inside an Ethernet frame	YES	—
5.4.2	Type SNpTYPE frame inside a VLAN tagged Ethernet frame	NO	—
5.4.3	Type SNpTYPE frame inside an UDP datagram	NO	—
5.4.3	Type SNpTYPE frame structure	YES	—
5.5	Communication management DLPDUs	—	—
5.5.1	Network verification DLPDUs	YES	—
5.5.2	RTFN scan network read DLPDUs	NO	—
5.5.3	Identification data	YES	—
5.5.4	RTFN connection management DLPDU	NO	—
5.5.5	ID data	NO	—
5.5.6	RTFL control DLPDU	YES	—
5.5.7	RTFL configuration DLPDU	YES	—
5.6	Cyclic data channel (CDC) DLPDUs	—	—
5.6.1	Cyclic data channel line (CDCL) DLPDU	YES	—
5.6.2	Cyclic data channel network (CDCN) DLPDU	NO	—
5.7	Cyclic data channel (CDC) DLPDU data	YES	—
5.8	Message channel (MSC) DLPDUs	—	—

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Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
5.8.1	Message channel line (MSCL) DLPDU	YES	—
5.8.2	Message channel network (MSCN) DLPDU	NO	—
5.9	Message channel DLPDU data - MSC message transfer protocol (MSC-MTP)	YES	—
5.10	Time synchronization	YES	—
6	Telegram timing and DLPDU handling	—	—
6.1	Communication mechanism	—	—
6.1.1	Communication model RTFL	YES	—
6.1.2	Communication model RTFN	NO	—
6.2	Device synchronization	—	—
6.2.1	Communication model RTFL - precise clock synchronization	YES	—
6.2.2	Communication model RTFN	NO	—
7	Type SNpTYPE protocol machines	—	—
7.1	RTFL device protocol machines	YES	—
7.2	RTFN device protocol machines	NO	—
7.3	Message channel - message transfer protocol (MSC-MTP)	YES	—

7.2.3 Application layer

Application layer is described in IEC/PAS 61158-5-22 and IEC/PAS 61158-6-22. Table 3 specifies the use of the services included in this profile. Table 4 specifies the use of the protocol included in this profile.

Table 3 – CP SNpFAMILY/1: AL service selection

Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4	Concepts	—	—
4.1	Common concepts	YES	—
4.2	Type specific concepts	—	—
4.2.1	Operating principle	YES	—
4.2.2	Communication model overview	—	—
4.2.2.1	Overview	YES	—
4.2.2.2	Communication model RTFL	YES	—
4.2.2.3	Communication model RTFN	NO	—
4.2.3	Application layer element description	YES	—
4.2.4	Producer-consumer interaction	YES	—
4.2.5	Device reference models	—	—
4.2.5.1	RTFL device reference model	YES	—
4.2.5.2	RTFN device reference model	NO	—
5	Data type ASE	YES	—

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Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
6	Communication model specification	—	—
6.1	ASEs	—	—
6.1.1	CeS ASE	YES	—
6.1.2	Standard Ethernet frame (SEF) communication ASE	YES	—
6.1.3	Management ASE	YES	—
6.2	ARs	—	—
6.2.1	Overview	YES	—
6.2.2	Point-to-point network-scheduled unconfirmed producer-consumer AREP	YES	—
6.2.3	Point-to-multipoint network-scheduled unconfirmed producer-consumer AREP	YES	—
6.2.4	Point-to-point network-scheduled confirmed client/server AREP	YES	—
6.2.5	Point-to-point user-triggered confirmed client/server AREP	NO	—
6.2.6	AR classes	Partial	According to the present ARs
6.2.7	FAL services by AREP class	Partial	According to the present ARs
6.2.8	Permitted FAL services by AREP role	Partial	According to the present ARs

Table 4 – CP SNpFAMILY/1: AL protocol selection

Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4	Application layer protocol specification	—	—
4.1	Operating principle	YES	—
4.2	Device reference models	—	—
4.2.1	RTFL device reference model	YES	—
4.2.2	RTFN device reference model	NO	—
4.3	Application layer structure	YES	—
5	FAL syntax description	YES	—
6	FAL protocol state machines	YES	—
7	AP-context state machine	YES	—
8	FAL service protocol machine (FSPM)	YES	—
9	Application layer state machine (ALSM)	YES	—
10	DLL mapping protocol machine (DMPM)	YES	—

7.2.4 Performance indicator selection

7.2.4.1 Performance indicator overview

Table 5 gives an overview of the performance indicator usage.

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Table 5 – CP SNpFAMILY/1: Performance indicator overview

Performance indicator	Applicable	Constraints
Delivery time	YES	None
Number of RTE end-stations	YES	None
Basic network topology	YES	Hierarchical star and linear topology
Number of switches between RTE end-stations	YES	For highest performance usage of switches shall be omitted
Throughput RTE	YES	None
Non-RTE bandwidth	YES	None
Time synchronization accuracy	YES	None
Non-time-based synchronization accuracy	NO	—
Redundancy recovery time	NO	—

7.2.4.2 Performance indicator dependencies

Table 6 specifies the dependencies of the performance indicators (row) from the performance indicators (column).

Table 6 – CP SNpFAMILY/1: Performance indicator dependency matrix

Dependent PI	Influencing PI						
	Delivery time	Number of end-stations	Basic network topology	Number of switches between RTE end-stations	Throughput RTE	Non-RTE bandwidth	Time synchronization accuracy
Delivery time		YES 7.2.4.5	YES 7.2.4.6	YES 7.2.4.7	YES 7.2.4.8	NO	NO
Number of end-stations	NO		NO	NO	NO	NO	YES 7.2.4.9
Basic network topology	NO	NO		YES 7.2.4.10	NO	NO	YES 7.2.4.11
Number of switches between RTE end-stations	NO	NO	YES 7.2.4.10		NO	NO	YES 7.2.4.13
Throughput RTE	NO	NO	NO	NO		YES 7.2.4.14	NO
Non-RTE bandwidth	NO	NO	NO	NO	YES 7.2.4.14		NO
Time synchronization accuracy	NO	YES 7.2.4.9	YES 7.2.4.11	YES 7.2.4.13	NO	NO	

7.2.4.3 Delivery time calculation

The performance indicator delivery time for a linear topology and a star topology can be calculated by formula (1).

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$$t_D = t_{cyc} + t_{STsrc} + t_{data} + t_{CD} * (l_F + l_B) + \sum_{i=1}^{NoDoF} (t_{pd}(i) + t_{SW}(i)) + \sum_{i=1}^{NoDoB} (t_{pd}(i) + t_{SW}(i)) + t_{ST\sin k} \quad (1)$$

where

t_D is the delivery time;

t_{cyc} is the cycle time of the communication system ($t_{cycle} \geq t_{data}$);

t_{STsrc} is the stack traversal time including data-link layer and physical layer of the source;

t_{data} is the time to transmit all Real-time Ethernet frames for one cycle;

t_{CD} is the cable delay (4,5 to 5 ns/m);

l_F is the distance along the cable in meters which is passed by the packed from source to last device of the logical line;

l_B is the distance along the cable in meters which is passed by the packed from last device of the logical line to sink;

t_{pd} is the propagation delay of a device in forward or backward direction;

t_{SW} is the delay caused by switching procedure;

NoDoF is the number of succeeding devices on forward direction from the source to the last device of the logical line;

NoDoB is the number of succeeding devices on backward direction from the last device of the logical line to the sink;

t_{STsink} is the stack traversal time including data-link layer and physical layer of the sink.

NOTE 1 In the case of a linear topology the time factor t_{SW} has the value 0.

NOTE 2 The distance in each direction is affected by the number of switching devices within the network topology.

7.2.4.4 Basic network topology

The basic network topologies supported by this profile are hierarchical star or linear topology. It is highly recommended to use linear topology to reach highest performance. For both basic network topologies this profile establishes a logical line topology by appropriate addressing within devices. For detailed information refer to IEC/PAS 61158-4-22.

7.2.4.5 Delivery time dependency on number of end-stations

The number of end-stations typically influences the amount of data, thus the time to transmit the data frame as well as the sum of propagation delays. Furthermore the number of devices on forward and backward direction is influenced and hence the delivery time as described in (1).

7.2.4.6 Delivery time dependency on basic network topology

The delivery time depends on the amount of signal propagation delays within a network which are introduced by a given network topology. The network topology dependent parameters in terms of additional delay times are considered in formula (1).

7.2.4.7 Delivery time dependency on number of switches between RTE end-stations

The delivery time depends on the amount of signal propagation delays within a network which are introduced by switches between RTE end-stations. The switch dependent parameters in terms of additional delay times are considered in formula (1).

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7.2.4.8 Delivery time dependency on throughput RTE

The delivery time depends on throughput RTE via data amount and cycle time. Throughput RTE can be adapted by changing the parameters data amount and cycle time, whereas the minimal reachable cycle time depends highly on the amount of data to be transferred. If throughput RTE is increased by increasing the amount of data transferred within one cycle, the delivery time is increased. An increase of throughput RTE by reducing the cycle time decreases the delivery time. Throughput RTE can be increased by an adequate adjustment of both parameters without influencing the delivery time as described in (1).

7.2.4.9 Relation between number of end-stations and time synchronization accuracy

The number of end-stations influences the accuracy of time synchronization and vice versa.

7.2.4.10 Relation between basic network topology and number of switches between RTE end-stations

The usage of switches is restricted to hierarchical star topology.

7.2.4.11 Relation between basic network topology and time synchronization accuracy

The usage of switches (for example to build up a hierarchical star topology) reduces the reachable accuracy of time synchronization of devices.

7.2.4.12 Relation between number of end-stations and time synchronization accuracy

The number of end-stations influences the accuracy of time synchronization and vice versa.

7.2.4.13 Relation between number of switches between RTE end-stations and time synchronization accuracy

Accuracy of time synchronization is the maximum jitter between device clocks. The usage of switches reduces the reachable accuracy of time synchronization of devices.

7.2.4.14 Relation between throughput RTE and non-RTE bandwidth

The non-RTE bandwidth is the difference between overall bandwidth and the RTE throughput (RTE overhead included) hence both values influence each other.

7.3 Profile SNpFAMILY/2

7.3.1 Physical layer

The physical layer shall be based on standard Ethernet hardware according to ISO/IEC 8802-3.

7.3.2 Data link layer

Data link layer is described in IEC/PAS 61158-3-22 and IEC/PAS 61158-4-22. Table 7 specifies the use of the services included in this profile. Table 8 specifies the use of the protocol included in this profile.

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Table 7 – CP SNpFAMILY/2: DLL service selection

Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
4	Data-link layer services and concepts	—	—
4.1	Operating principle	YES	—
4.2	Communication models	—	—
4.2.1	Overview	YES	—
4.2.2	RTFL device reference model	NO	—
4.2.3	RTFN device reference model	YES	—
4.3	Topology	—	—
4.3.1	RTFL topology	NO	—
4.3.2	RTFN topology	YES	—
4.4	Addressing	—	—
4.4.1	Overview	YES	—
4.4.2	RTFL device addressing	NO	—
4.4.3	RTFN device addressing	YES	—
4.5	Gateway	YES	—
4.6	Interaction models	—	—
4.6.1	Overview	YES	—
4.6.2	Producer-consumer	NO	—
4.6.3	Publisher-subscriber	YES	—
4.7	Synchronization concept	YES	—
5	Communication services	—	—
5.1	Overview	Partial	Only services selected by this CP
5.2	Communication management services	—	—
5.2.1	Overview	YES	—
5.2.2	Network verification	—	—
5.2.2.1	DL-Network verification service (NV)	NO	—
5.2.2.2	DL-RTFN scan network read service (RTFNSNR)	YES	—
5.2.3	Communication management	—	—
5.2.3.1	DL-RTFN connection establishment service (RTFNCE)	YES	—
5.2.3.2	DL-RTFN connection release service (RTFNCR)	YES	—
5.2.3.3	DL-RTFL control service (RTFLCTL)	NO	—
5.2.3.4	DL-RTFL configuration service (RTFLCFG)	NO	—
5.2.3.5	DL-Read configuration data service (RDCD)	YES	—
5.3	CDC service	YES	—
5.4	MSC services	YES	—
5.5	Time synchronization	—	—
5.5.1	DL-DelayMeasurement start service (DMS)	NO	—
5.5.2	DL-DelayMeasurement read service (DMR)	NO	—
5.5.3	DL-PCS configuration service (PCSC)	NO	—

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Clause or subclause of IEC/PAS 62633	Header	Presence	Constraints
5.5.4	DL-Sync master configuration service (SYNC_MC)	YES	—
5.5.5	DL-Sync start service (SYNC_START)	YES	—
5.5.6	DL-Sync stop service (SYNC_STOP)	YES	—
5.6	Media independent interface (MII) management services	NO	—

Table 8 – CP SNpFAMILY/2: DLL protocol selection

Clause	Header	Presence	Constraints
4	DL-protocol overview	—	—
4.1	Operating principle	YES	—
4.2	Communication model	—	—
4.2.1	Overview	YES	—
4.2.2	RTFL device reference model	NO	—
4.2.3	RTFN device reference model	YES	—
4.3	Topology	—	—
4.3.1	RTFL topology	NO	—
4.3.2	RTFN topology	YES	—
4.4	Frame processing	—	—
4.4.1	Communication model RTFL	NO	—
4.4.2	Communication model RTFN	YES	—
4.5	General communication mechanisms	YES	—
4.6	Gateway	YES	—
4.7	Interaction models	—	—
4.7.1	Overview	YES	—
4.7.2	Producer-consumer	NO	—
4.7.3	Publisher-subscriber	YES	—
5	DLPDU structure	—	—
5.1	Overview	YES	—
5.2	Data types and encoding rules	YES	—
5.3	DLPDU identification	YES	—
5.4	General DLPDU structure	YES	—
5.5	Communication management DLPDUs	—	—
5.5.1	Network verification DLPDUs	NO	—
5.5.2	RTFN scan network read DLPDUs	YES	—
5.5.3	Identification data	YES	—
5.5.4	RTFN connection management DLPDU	YES	—
5.5.5	ID data	YES	—
5.5.6	RTFL control DLPDU	NO	—
5.5.7	RTFL configuration DLPDU	NO	—
5.6	Cyclic data channel (CDC) DLPDUs	—	—
5.6.1	Cyclic data channel line (CDCL) DLPDU	NO	—

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Clause	Header	Presence	Constraints
5.6.2	Cyclic data channel network (CDCN) DLPDU	YES	—
5.7	Cyclic data channel (CDC) DLPDU data	YES	—
5.8	Message channel (MSC) DLPDUs	—	—
5.8.1	Message channel line (MSCL) DLPDU	NO	—
5.8.2	Message channel network (MSCN) DLPDU	YES	—
5.9	Message channel DLPDU data - MSC message transfer protocol (MSC-MTP)	YES	—
5.10	Time synchronization	—	—
5.10.1	DelayMeasurement start	NO	—
5.10.2	DelayMeasurement stop	NO	—
5.10.3	PCS configuration	NO	—
5.10.4	Time synchronization service	YES	—
6	Telegram timing and DLPDU handling	—	—
6.1	Communication mechanism	—	—
6.1.1	Communication model RTFL	NO	—
6.1.2	Communication model RTFN	YES	—
6.2	Device synchronization	—	—
6.2.1	Communication model RTFL - precise clock synchronization	NO	—
6.2.2	Communication model RTFN	YES	—
7	Type SNpTYPE protocol machines	—	—
7.1	RTFL device protocol machines	NO	—
7.2	RTFN device protocol machines	YES	—
7.3	Message channel - message transfer protocol (MSC-MTP)	YES	—

7.3.3 Application layer

Application layer is described in IEC/PAS 61158-5-22 and IEC/PAS 61158-6-22. Table 9 specifies the use of the services included in this profile. Table 10 specifies the use of the protocol included in this profile.

Table 9 – CP SNpFAMILY/2: AL service selection

Clause	Header	Presence	Constraints
4	Concepts	—	—
4.1	Common concepts	YES	—
4.2	Type specific concepts	—	—
4.2.1	Operating principle	YES	—
4.2.2	Communication model overview	—	—
4.2.2.1	Overview	YES	—
4.2.2.2	Communication model RTFL	NO	—
4.2.2.3	Communication model RTFN	YES	—
4.2.3	Application layer element description	YES	—
4.2.4	Producer-consumer interaction	YES	—
4.2.5	Device reference models	—	—
4.2.5.1	RTFL device reference model	NO	—

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Clause	Header	Presence	Constraints
4.2.5.2	RTFN device reference model	YES	—
5	Data type ASE	YES	—
6	Communication model specification	—	—
6.1	ASEs	—	—
6.1.1	CeS ASE	YES	—
6.1.2	Standard Ethernet frame (SEF) communication ASE	NO	—
6.1.3	Management ASE	YES	—
6.2	ARs	—	—
6.2.1	Overview	YES	—
6.2.2	Point-to-point network-scheduled unconfirmed producer-consumer AREP	YES	—
6.2.3	Point-to-multipoint network-scheduled unconfirmed producer-consumer AREP	YES	—
6.2.4	Point-to-point network-scheduled confirmed client/server AREP	NO	—
6.2.5	Point-to-point user-triggered confirmed client/server AREP	YES	—
6.2.6	AR classes	Partial	According to the present ARs
6.2.7	FAL services by AREP class	Partial	According to the present ARs
6.2.8	Permitted FAL services by AREP role	Partial	According to the present ARs

Table 10 – CP SNpFAMILY/2: AL protocol selection

Clause	Header	Presence	Constraints
4	Application layer protocol specification	—	—
4.1	Operating principle	YES	—
4.2	Device reference models	—	—
4.2.1	RTFL device reference model	NO	—
4.2.2	RTFN device reference model	YES	—
4.3	Application layer structure	YES	—
5	FAL syntax description	—	—
5.1	Introduction and coding principles	YES	—
5.2	Data type encoding	YES	—
5.3	CeS encoding	YES	—
5.4	Standard Ethernet frame communication	NO	—
5.5	Management encoding	YES	—
6	FAL protocol state machines	YES	—
7	AP-context state machine	YES	—
8	FAL service protocol machine (FSPM)	YES	—
9	Application layer state machine (ALSM)	YES	—
10	DLL mapping protocol machine (DMPM)	YES	—

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7.3.4 Performance indicator selection

7.3.4.1 Performance indicator overview

Table 11 gives an overview of the performance indicator usage.

Table 11 – CP SNpFAMILY/2: Performance indicator overview

Performance indicator	Applicable	Constraints
Delivery time	YES	None
Number of RTE end-stations	YES	None
Basic network topology	YES	Hierarchical star topology
Number of switches between RTE end-stations	YES	None
Throughput RTE	YES	None
Non-RTE bandwidth	YES	None
Time synchronization accuracy	YES	Requires switches capable to function as IEC 61588:2004 boundary clocks
Non-time-based synchronization accuracy	NO	—
Redundancy recovery time	NO	—

7.3.4.2 Performance indicator dependencies

Table 12 specifies the dependencies of the performance indicators (row) from the performance indicators (column).

Table 12 – CP SNpFAMILY/2: Performance indicator dependency matrix

Dependent PI	Influencing PI						
	Delivery time	Number of end-stations	Basic network topology	Number of switches between RTE end-stations	Throughput RTE	Non-RTE bandwidth	Time synchronization accuracy
Delivery time		NO	NO	YES 7.3.4.4	NO	NO	NO
Number of end-stations	NO		NO	YES 7.3.4.5	NO	NO	NO
Basic network topology	NO	NO		NO	NO	NO	NO
Number of switches between RTE end-stations	NO	NO	NO		NO	NO	YES 7.3.4.6
Throughput RTE	NO	NO	NO	NO		YES 7.3.4.7	NO
Non-RTE bandwidth	NO	NO	NO	NO	YES 7.3.4.7		NO
Time synchronization accuracy	NO	NO	NO	YES 7.3.4.6	NO	NO	

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7.3.4.3 Delivery time calculation

The performance indicator delivery time for a linear topology (physical line) can be calculated by formula (2).

$$t_D = t_{cyc} + t_{STsrc} + t_{data} + t_{CD} * l_C + \sum_{i=1}^{NoS} t_{SW}(i) + t_{ST\,\sin k} \qquad (2)$$

where

t_D is the delivery time;

t_{cyc} is the cycle time of the communication relation ($t_{cycle} \geq t_{data}$);

t_{STsrc} is the stack traversal time of the source;

t_{data} is the time to transmit the packet containing the APDU;

t_{CD} is the cable delay (4,5 to 5 ns/m);

l_C is the cable length in m from source to sink;

t_{SW} is the delay time of the switch;

NoS is the number of switches between source and sink;

t_{STsink} is the stack traversal time of the sink.

NOTE 1 In the case of event-driven communication the time factor t_{cyc} has the value 0.

NOTE 2 The time behavior of switching devices is device-dependent.

7.3.4.4 Delivery time dependence on number of switches between RTE end-stations

The delivery time depends on the amount of signal propagation delays within a network which are introduced by switches between RTE end-stations. The switch dependent parameters in terms of additional delay times are considered in formula (2).

7.3.4.5 Number of end-stations dependence on number of switches between RTE end-stations

A hierarchical star topology can be extended by additional switches, thus the number of RTE end-stations can be increased.

7.3.4.6 Relation between number of switches between RTE end-stations and time synchronization accuracy

Accuracy of time synchronization is the maximum jitter between device clocks. In order to achieve accuracy in a star network, it is necessary to use switches containing IEC 61588:2004 boundary clocks.

7.3.4.7 Relation between throughput RTE and non-RTE bandwidth

The non-RTE bandwidth is the difference between overall bandwidth and the RTE throughput (RTE overhead included) hence both values influence each other.

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