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Industrial communication networks – Fieldbus specifications – Part 4-19: Data-link layer protocol specification – Type 19 elements

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-19: Data-link layer protocol specification – Type 19 elements

FOREWORD

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International Standard IEC 61158-4-19 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- increasing the number of supported devices (511 instead of 254);
- introducing a communication version identification;
- adding a mechanism for remote address allocation;
- introducing enhanced parameter addressing (32 bit instead of 16 bit);
- restructuring control and status word;
- improving the redundancy and hotplug features;

- improving the error handling;
- adding a multiplexing protocol (SMP: Type 19 Messaging Protocol).

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/605/FDIS	65C/619/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

A list of all the parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the "three-layer" fieldbus reference model described in IEC/TR 61158-1.

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer data-link entities (DLEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

a) as a guide for implementors and designers;
b) for use in the testing and procurement of equipment;
c) as part of an agreement for the admittance of systems into the open systems environment;
d) as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in the profile parts. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning Type 19 elements and possibly other types given in this document as follows:

DE 102 37 097	[RI]	Korrektur von Signallaufzeiten in verteilten Kommunikationssystemen
DE 102 00 405 0416.4-42	[RI]	Verfahren zur Synchronisation in einem redundanten Kommunikationssystem
DE 102 00 502 4759.8-32	[RI]	Verfahren zur Laufzeitkorrektur in einer Kommunikationsstruktur
DE 102 00 4056364.0-31	[RI]	Verfahren zum Betreiben eines Netzwerks mit Ringtopologie
DE 103 12 907.3-31	[RI]	Kommunikationssystem mit redundanter Kommunikation

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-19: Data-link layer protocol specification – Type 19 elements

1 Scope

1.1 General

The data-link layer provides basic time-critical messaging communications between devices in an automation environment.

This protocol provides communication opportunities to all participating data-link entities

a) in a synchronously-starting cyclic manner, according to a pre-established schedule, and
b) in a cyclic or acyclic asynchronous manner, as requested each cycle by each of those data-link entities.

Thus this protocol can be characterized as one which provides cyclic and acyclic access asynchronously but with a synchronous restart of each cycle.

1.2 Specifications

This standard specifies

a) procedures for the timely transfer of data and control information from one data-link user entity to a peer user entity, and among the data-link entities forming the distributed data-link service provider;
b) the structure of the fieldbus DLPDUs used for the transfer of data and control information by the protocol of this standard, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of

a) the interactions between peer DL-entities (DLEs) through the exchange of fieldbus DLPDUs;
b) the interactions between a DL-service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;
c) the interactions between a DLS-provider and a Ph-service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems which support time-critical communications services within the data-link layer of the OSI or fieldbus reference models, and which require the ability to interconnect in an open systems interconnection environment.

Profiles provide a simple multi-attribute means of summarizing an implementation's capabilities, and thus its applicability to various time-critical communications needs.

1.5 Conformance

This standard also specifies conformance requirements for systems implementing these procedures. This part of this standard does not contain tests to demonstrate compliance with such requirements.

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.

IEC 61158-4-16:2007, *Industrial communication networks – Fieldbus specifications – Part 4-16: Data-link layer protocol specification – Type 16 elements*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Part 1: Basic Reference Model: The Basic Model*

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Part 3: Basic Reference Model: Naming and addressing*

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO 8601:2004, *Data elements and interchange formats — Information interchange — Representation of dates and times*

3 Terms, definitions, symbols, acronyms, abbreviations and conventions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions apply.

3.1 Reference model terms and definitions

This standard is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3, and makes use of the following terms defined therein.

3.2 Additional Type 19 terms and definitions

3.2.1
broadcast
transmission to all devices in a network without any acknowledgment by the receivers

3.2.2
communication cycle
fixed time period between two master synchronization telegrams in which real-time telegrams are transmitted in the RT channel and non real-time telegrams are transmitted in the IP channel

3.2.3
control unit
control device (for example, a PLC as specified in the IEC 61131 standard family)

3.2.4
control word
two adjacent octets inside the master data telegram containing commands for the addressed device

3.2.5
cross communication
direct multicast data transfer between devices

3.2.6
cycle time
duration of a communication cycle

3.2.7
cyclic communication
periodic exchange of telegrams

3.2.8
cyclic data
part of a telegram, which does not change its meaning during cyclic operation of the network

3.2.9
cyclic operation
operation in which devices in the communication network are addressed and queried one after the other at fixed, constant time intervals

3.2.10
device
a slave in the communication network, (for example, a power drive system as defined in the IEC 61800 standard family, I/O stations as defined in the IEC 61131 standard family)

3.2.11
device address field
address field (eight bits) containing the address of the device

3.2.12
device control
four adjacent octets inside the master data telegram containing commands for each device

3.2.13
device status
four adjacent octets inside the acknowledge telegram containing status information for each device

3.2.14
DLE station identifier
network address assigned to a DLE

3.2.15
DLE station slot
unit (granularity of one) of position dependent mapping (for cyclic data field) of which a DLE may occupy one or more, delineated by the range beginning at the DLE station identifier with a length equal to the configured number of occupied slots

3.2.16
element
part of IDNs – each IDN has 7 elements, whereas each one has a specific meaning (for example: number, name, data)

3.2.17
EtherType
part of the Type 19 specific telegram header

3.2.18
forwarding
mode by which a device passes on a received telegram to the other port, either changed or unchanged

3.2.19
identification number
IDN
designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.2.20
line, line structure
network topology, in which the transmission medium is routed from station to station in the form of a line; the information is transmitted in one direction from the master down to the last slave in the line, and then flows back to the master via all the slaves in the reverse order (CP16/3)

3.2.21
loopback
mode by which a device passes on a received telegram to the same port and to the other port, either changed or unchanged

3.2.22
master
node, which assigns the other nodes (i.e., slaves) the right to transmit

3.2.23
master data telegram
MDT
telegram, in which the master inserts its data

3.2.24
master DLE
DLE that performs the functions of network master

3.2.25
master synchronization telegram
MST
telegram, or part of a telegram, in which the master inserts a time synchronization signal

3.2.26
MDT0 telegram
telegram, in which the master transmits its synchronization data, as well as parts or all of its real-time data, to the slaves

3.2.27
participant
node

3.2.28
physical layer
first layer of the ISO-OSI reference model

3.2.29
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.2.30
real-time data
part of the telegram that does not change its meaning during cyclic operation of the interface

3.2.31
RT channel
defined time slot within the communication cycle, which passes the CPF16 real-time telegrams

3.2.32
service channel
SVC
non real-time transmission of information upon master request during RT channel

3.2.33
slave
node, which is assigned the right to transmit by the master

3.2.34
slave DLE
DLE that performs the functions of network slave

3.2.35
station
node

3.2.36
status word
two adjacent octets inside the acknowledge telegram containing status information of a device

3.2.37
S-0-nnnn
designation of IDNs

3.2.38
telegram
DLPDU

3.2.39
topology
physical network architecture with respect to the connection between the stations of the communication system

3.3 Symbols

ADR	device address (1 ≤ ADR ≤ 511) adjusted directly on the device, for example using a selector switch
AT MST	header in AT
AT0...3	acknowledge telegrams
INFO	service channel information

J_{tscyc}	jitter in t_{Scyc}
MDT0	master data telegram with synchronization data that the slaves evaluates
MDT1...3	master data telegrams without synchronization data
P1	port 1
P2	port 2
RxD	received data
SLKN	slave identification parameter, slave arrangement
SVC	service channel
t_1	AT transmission starting time
t_{1min}	shortest AT transmission starting time
t_3	command value valid time
t_4	feedback acquisition capture point
t_5	minimum feedback processing time
t_{ATAT}	transmit to transmit recovery time in a slave with several slaves
t_{cable}	time, by which the transmitted signal is delayed by the cable, for each unit of length (approx., 5 ns/m)
t_{Ncyc}	control unit cycle time
t_{rep}	time, by which the received signal is delayed by a forwarding slave (input-output)
t_{ring}	time, which a master telegram needs, until it has passed through the network and reached the master again
t_{Scyc}	communication cycle time
TxD	transmitted data

3.4 Acronyms and abbreviations

AHS	service transport handshake of the device (acknowledge HS)
AT	acknowledge telegram
C1D	class 1 diagnostic
CP	communication phase

CPS	communication phase switching
CRC	cyclic redundancy check
FCS	DLPDU check sequence
GDP	Generic Device Profile
HS	service channel handshake (see AHS and MHS)
IDN	identification number
MDT	master data telegram
MDT MST	header in MDT
MHS	service transport handshake of the master
MS	communication from slave to master
MST	master synchronization telegram
NRT	non real-time mode
RT	real-time
RTC	real-time channel
RTD	real-time data in MDT or AT
SCH	session control header
SCP	Type 19 Communication Profile
SERCOS	serial real-time communication system interface
SFD	start DLPDU delimiter
SMP	Type 19 Messaging Protocol
SVC	service channel

3.5 Additional conventions

All data types are assigned identification numbers (IDNs). They include real-time data (commands and feedback values), parameters, and procedures. Most IDNs are similar to those for Type 16 (see IEC 61158-4-16, 3.6). Several IDNs relate to the application and are defined in their relevant standards (for example, IEC 61800-7-20x for Power Drive Systems).

Refer to Annex A for additional information, as well as to IEC 61158-4-16, A.1 for detailed IDN specification.

4 DL-protocol overview

This protocol type provides a highly optimized means of interchanging fixed-length real-time data and variable-length segmented messages between a single master device and a set of slave devices, interconnected in a ring or a line topology. The ring topology provides for redundant communication paths, and in case of a fault it automatically switches to a set of two lines without disturbing the communication.

This protocol type also provides for direct real-time data transmission between slaves, inside the real-time channel (RTC), within each cycle.

The exchange of real-time data is totally synchronous by configuration and is unaffected by the messaging traffic.

The device addresses are set by the user, for example, using a selector. Additional devices may be added whenever required, even during operation, without affecting the address selections, which already exist. The determination of the number, identity and characteristics of each device may be configured or may be detected automatically at start-up.

Slave interfaces shall be used to connect the slave devices to the network. At the physical layer, a slave represents the connection of one or more devices to the network. Logically, one slave with several devices shall act the same as several slaves with one device each.

This protocol type also provides a non real-time channel (NRT channel), in which any Standard Ethernet DLPDUs can be exchanged between Type 19 devices and any other connected Ethernet network nodes.

There are two classes of Type 19 DLE:

a) master DLE;
b) slave DLE.

Only the master DLE is able to initiate cyclic and acyclic transmission.

Type 19 telegrams are Ethernet DLPDUs according to ISO/IEC 8802-3. Type 19 real-time telegrams shall be transmitted in the real-time part of the communication cycle time. They transport mainly command values and actual values. Type 19 header specifies two sub types of type 19 telegrams:

a) Master data telegram (MDT), in which the master transmits real-time data to the slaves;
b) Acknowledge telegram (AT), in which the slaves and the master transmit real-time data to other devices.

Other Ethernet DLPDUs can be transmitted in the NRT channel.

Type 19 specifies 4 MDTs (MDT0 to MDT3). The MDTs shall be transmitted by the master and received by each slave. The MDTs shall contain all information (for example: synchronization, command values, digital outputs) which is sent from the master to the slaves through the real-time channel.

MDT0 shall always be transmitted. MDT1 through 3 shall be transmitted only if required depending on the total amount of data to be transmitted to the slaves. The master shall always send the same number of MDTs during each communication cycle.

Type 19 specifies 4 ATs (AT0 to AT3). The ATs shall be transmitted by the master with empty data fields. Each slave shall insert its data into its allocated data field within the AT. The ATs shall contain all information (for example: feedback values, digital inputs) which is sent from the slaves to the master as well as from one device to other devices through the real-time channel.

AT0 shall always be transmitted. AT1 through 3 shall be transmitted only if required depending on the total amount of data to be transmitted to the master. The master shall always send the same number of ATs during each communication cycle.

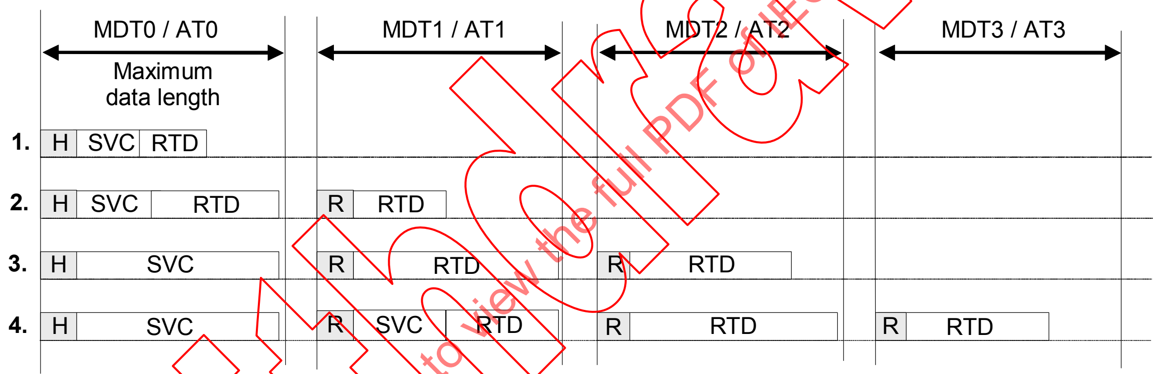
The allocations of the service channels (SVC) and the real-time data fields (RTD) in the MDT as well as in the AT shall be configured with parameters. The RTD lengths in the MDTs and the ATs shall depend on the configuration and may be different for each slave depending upon configuration. The number of MDTs and ATs may also be different. This configuration shall meet the following requirements.

a) All service channels shall be configured directly after the hot-plug field.

b) All real-time data fields shall be configured directly after the last service channel.

c) All SVCs of a device shall be transmitted within one MDT and one AT. The telegrams shall be filled up with SVCs as much as possible before using the next MDT and AT.

Telegram combinations of MDTs and ATs shall fit to any one of the four possibilities shown in Figure 1, exclusively.



NOTE In this figure, H = hot-plug field, R = reserved.

Figure 1 – Valid MDT and AT telegram combinations

5 DLPDU structure

5.1 Overview

Networks of this protocol type use standard ISO/IEC 8802-3 Ethernet DLPDUs for transporting Type 19 DLPDUs.

5.2 General DLPDU identification

5.2.1 Introduction

DLPDUs shall be identified as specified in Table 1.

Table 1 – Ethernet DLPDU identification

DLPDU field	Data type	Value/description
Dest MAC	octet[6]	Destination MAC address
Src MAC	octet[6]	Source MAC address
EtherType	WORD	0x88CD (Type 19)

5.2.2 Destination address (Dest MAC)

The master shall transmit DLPDUs to all slaves using the broadcast address 0xFFFF FFFF FFFF as the destination address.

5.2.3 Source address (Src MAC)

The source address shall always be the MAC address of the master.

5.2.4 EtherType

The EtherType for real-time DLPDUs shall contain the value 0x88CD, which is the unique type field number that has been allocated by the IEEE EtherType Field Registration Authority for Type 19 telegrams.

NOTE This field number refers to Type 19 communication.

5.3 General DLPDU structure

5.3.1 Introduction

The data structure in a DLPDU shall consist of the following data entries as specified in Table 2.

Table 2 – Data structure in a DLPDU

Data field	Data type	Value/description
Header	octet[6]	Defines the DLPDU type
Payload	octet[40-1494]	Data fields are padded

5.3.2 DLPDU header

The DLPDU header shall specify two types of telegrams, as specified in 5.4:

- **Master data telegram (MDT):** MDTs shall transmit data from the master to the slaves;
- **Acknowledge telegram (AT):** ATs shall transmit data from the slaves back to the master, as well as from one device to one or several devices within the Type 19 network.

5.3.3 DLPDU payload

All transmitted data are permitted to have arbitrary bit sequences.

Padding octets shall be added if the Type 19 data is less than 40 octets, in order to reach a total data field length of at least 46 octets.

The DLPDU payload shall be as described in 5.5 and 5.6.

5.4 DLPDU header

5.4.1 Introduction

The DLPDU header shall distinguish the various DLPDUs. It shall be coded in the telegram whether it is in the primary or secondary channel, whether it is an MDT or an AT, and which one (MDT0 to MDT3, respectively AT0 to AT3).

In a line topology, the master shall decide whether the telegrams are marked as primary or secondary telegrams, depending upon configuration.

The DLPDU header structure is shown in Table 3:

Table 3 – DLPDU payload header

Data field	Data type	Value/description
DLPDU type	octet[1]	See 5.4.2
Reserved	octet[1]	—
Reserved	octet[4]	—

5.4.2 DLPDU type

The DLPDU type shall be generated by the master and transmitted in every MDT. Its content shall be as shown in Table 4.

Table 4 – DLPDU type

Bit number	Bit value	Description
7	—	Primary or secondary telegram
	0	Telegram on the primary channel (P-Telegram)
	1	Telegram on the secondary channel (S-Telegram)
6	—	MDT or AT
	0	MDT
	1	AT
5	—	Cycle CNT
	0	Cycle CNT not valid
	1	Cycle CNT valid
4-2	—	Reserved
1-0	—	Telegram number
	00	Telegram number 0
	01	Telegram number 1
	10	Telegram number 2
	11	Telegram number 3

5.5 MDT DLPDU

5.5.1 MDT MST field summary

The MDT is a Type 19 telegram and shall be as specified in Table 5, whereas the Type 19 header is called MDT MST.

Table 5 – MDT MST header

DLPDU part	Data field	Data type	Value/Description
MDT MST header	MDT type	octet[1]	See 5.5.3
	MDT phase	octet[1]	See 5.5.4
	MDT CRC	octet[4]	See 5.5.5

5.5.2 Evaluation of MDT MST in the slaves

The MDT MST shall be generated by the master and evaluated by the slaves. Each slave shall evaluate the MDT MST according to Table 6.

Table 6 – MDT MST fields to be considered by the slave

	MDT type	MDT phase	MDT CRC
MDT0	Yes	Yes	Yes
MDT1	Yes	No	Yes
MDT2	Yes	No	Yes
MDT3	Yes	No	Yes

5.5.3 MDT type

Refer to 5.4.2, whereas bit #6 shall be 0.

5.5.4 MDT phase

The MDT phase shall contain the status of the Type 19 communication. The phase shall be generated by the master and transmitted in every MDT. The structure is shown in Table 7.

Table 7 – MDT phase

Bit number	Bit value	Description
7	—	Communication phase switching (CPS)
	0	Current CP
	1	New CP
6-4	—	Cycle CNT
	0-7	Value of Cycle CNT
3-0	—	Communication phase (CP)
	0000	CP0
	0001	CP1
	0010	CP2
	0011	CP3
	0100	CP4
	0101 to 1111	Reserved

5.5.5 MDT CRC

The cyclic redundancy check (CRC) shall be used by the transmit and receive algorithms to generate a CRC value for the MDT CRC field. The MDT CRC field shall contain a 4-octet (32-bit) cyclic redundancy check (CRC) value. This value shall be computed as a function of the contents of the destination address (see 5.2.2), source address (see 5.2.3), EtherType (see 5.2.4), Type 19 type (see 5.4.2) and phase (see 5.5.4). The encoding shall be as defined by the Standard Ethernet CRC generating polynomial (see ISO/IEC 8802-3).

The MDT CRC shall be generated by the master and transmitted in every MDT (MDT0 to MDT3). This CRC shall be monitored in MDT0 only, for synchronization purposes.

5.5.6 MDT payload during initialization

5.5.6.1 General

The content of the MDT data field depends on the communication phase (CP) and is described in the following subclauses.

5.5.6.2 CP0

The master shall always transmit MDT0 telegrams, and no MDT1, MDT2, nor MDT3 telegrams. MDT0 shall be structured as stated in Table 8.

Table 8 – MDT0 structure in CP0

DLPDU part	Data field	Data type	Value/Description
MDT	MDT type	octet[1]	MDT0, see 5.5.3
	MDT phase	octet[1]	CP0, see 5.5.4
	MDT CRC	octet[4]	See 5.5.5
MDT payload	Communication version	octet[4]	See Table 9
	MDT Data Field	octet[36]	Shall be padded and not used

Table 9 – Communication version

Bit number	Bit value	Description
31-18	—	Reserved
17-16	—	Number of MDTs and ATs in CP1 and CP2
	00	2 MDTs and 2 ATs in CP1 and CP2
	01	4 MDTs and 4 ATs in CP1 and CP2
	10	Reserved
	11	Reserved
15-8	—	Revision number
	0	Initial revision
	1-255	Reserved
7-0	—	Initialization procedure version number
	0	Void
	1	Remote address allocation
	2-255	Reserved

5.5.6.3 CP1 and CP2

The master shall choose between two communication sequences used in CP1 and CP2:

a) If the master expects 255 slaves or less, it may transmit either MDT0 to MDT3 or MDT0 and MDT1 only, for example to save initialization time. The slaves shall support both sequence options by evaluating the Communication version.

b) If the master expects 256 slaves or more (up to 511 slaves) it shall transmit MDT0 to MDT3.

The MDT data fields shall contain the service channel (see 7.2) and the device control (see 5.5.7.4.2) of topology addresses as shown in Table 10, Table 11, Table 12 and Table 13 respectively.

In CP1 a slave shall behave as requested if the handshake bit (MHS) is set to 1 in the corresponding SVC control. The MDT SVC INFO and the device control are "don't care". The content of device control shall be valid.

Telegrams in CP2 shall have the same structure as in CP1, but the contents of SVC INFO shall be valid only in CP2.

Table 10 – MDT0 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
MDT MST	MDT type	octet[1]	MDT0, see 5.5.3
	MDT phase	octet[1]	CP1 or CP2, see 5.5.4
	MDT CRC	octet[4]	See 5.5.5
MDT data field	SVC of device 0	octet[6]	—
	…	…	(And so on for device 1 to device 126)
	SVC of device 127	octet[6]	—
	Device control of device 0	octet[2]	—
	Reserved for device 0	octet[2]	—
	…	…	(And so on for device 1 to device 126)
	Device control of device 127	octet[2]	—
	Reserved for device 127	octet[2]	—

Table 11 – MDT1 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
MDT MST	MDT type	octet[1]	MDT1, see 5.5.3
	MDT phase	octet[1]	CP1 or CP2, see 5.5.4
	MDT CRC	octet[4]	See 5.5.5
MDT data field	SVC of device 128	octet[6]	—
	…	…	(And so on for device 129 to device 254)
	SVC of device 255	octet[6]	—
	Device control of device 128	octet[2]	—
	Reserved for device 128	octet[2]	—
	…	…	(And so on for device 129 to device 254)
	Device control of device 255	octet[2]	—
	Reserved for device 255	octet[2]	—

Table 12 – MDT2 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
MDT MST	MDT type	octet[1]	MDT2, see 5.5.3
	MDT phase	octet[1]	CP1 or CP2, see 5.5.4
	MDT CRC	octet[4]	See 5.5.5
MDT data field	SVC of device 256	octet[6]	—
	…	…	(And so on for device 257 to device 382)
	SVC of device 383	octet[6]	—
	Device control of device 256	octet[2]	—
	Reserved for device 0256	octet[2]	—
	…	…	(And so on for device 257 to device 382)
	Device control of device 383	octet[2]	—
	Reserved for device 383	octet[2]	—

Table 13 – MDT3 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
MDT MST	MDT type	octet[1]	MDT3, see 5.5.3
	MDT phase	octet[1]	CP1 or CP2, see 5.5.4
	MDT CRC	octet[4]	See 5.5.5
MDT data field	SVC of device 384	octet[6]	—
	…	…	(And so on for device 385 to device 510)
	SVC of device 511	octet[6]	—
	Device control of device 384	octet[2]	—
	Reserved for device 384	octet[2]	—
	…	…	(And so on for device 385 to device 510)
	Device control of device 511	octet[2]	—
	Reserved for device 511	octet[2]	—

5.5.6.4 CP3 and CP4

In CP3 and CP4, the master shall transmit MDTs as in normal operation (see 5.5.7).

In CP3 only the service channel and the device control shall be used. The configurable real-time data of the MDT do not matter, but they shall have the number of octets required for CP4 and normal operation. The positions of the service channels and the real-time data fields in the MDT relevant to the individual slaves shall be as transmitted by the master to the slaves during CP2 with the corresponding communication parameters.

Depending on the application profile some bits in the device control may be valid starting at CP3 and up to CP4.

In CP4, the configurable real-time data shall be valid and filled with command values as determined by the parameters that the master transmitted to the slaves during CP2. The connection control and the resource control which depend on the application profile shall be valid.

5.5.7 MDT payload in normal operation

5.5.7.1 Introduction

The MDT payload (see Table 14) shall always contain an MDT hot-plug field (see 5.5.7.2), and either one or both of the following fields:

a) MDT service channel field (see 5.5.7.2.4);

b) MDT real-time data field (see 5.5.7.4).

Table 14 – MDT data field

DLPDU part	Data field	Data type	Value/Description
MDT data field	MDT hot-plug field	octet[8]	See 5.5.7.2
	MDT service channel field	octet[See 5.5.7.3]	Optional. See Figure 1
	MDT real-time data field	octet[See 5.5.7.4]	Optional. See Figure 1

For each slave, IDN S-0-1013 shall set the offset for its service channel. IDN S-0-1009 shall set the offset for the device control, the IDN S-0-1050.x.3 Telegram assignment shall set the offset for the connection data, the IDN S-0-1050.x.5 Current length of connection shall contain the length of the connection data, IDN S-0-1010 shall set the length of the MDTs (see Figure 2). These parameters shall be transmitted by the master to the slaves in CP2 during initialization.

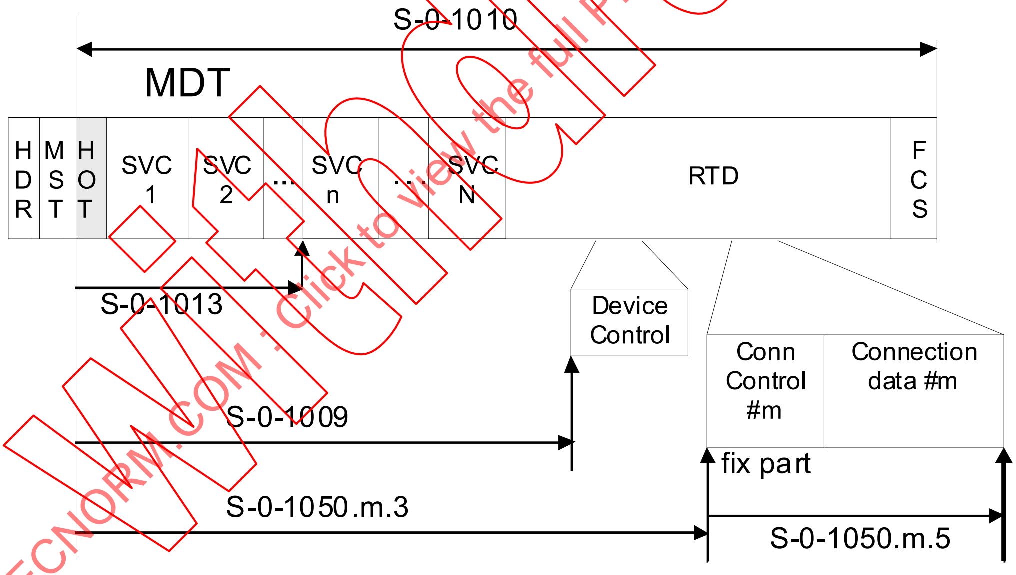


Figure 2 – Offsets within MDT payload

5.5.7.2 MDT hot-plug field

5.5.7.2.1 MDT hot-plug field summary

The structure of the MDT hot-plug field shall be as specified in Table 15 (see 6.3).

Table 15 – MDT hot-plug field in HP0 and HP1

DLPDU part	Data field	Data type	Value/Description
MDT hot-plug field	Device address	octet[2]	See 5.5.7.2.2
	HP control	octet[2]	See 5.5.7.2.3
	HP INFO	octet[4]	See 5.5.7.2.4

5.5.7.2.2 Device address field

The content of device address field shall be as specified in Table 16:

Table 16 – Device address field

Bit number	Value	Description
15-12	—	Slave indices within one device
11-0	—	Device addresses
	0	Default device address
	1-511	Device addresses for operation
	512-4092	Reserved
	4093	End of scanning of slave indices
	4094	Invalid address during scanning of slave indices
	4095	Broadcast address

5.5.7.2.3 HP control field (in HP0 and HP1)

The content of HP control field shall be as specified in Table 17.

Table 17 – HP control field (in HP0 and HP1)

Bit number	Value	Description
15	—	Hot-Plug support
	0	Hot-Plug not supported by master
	1	Hot-Plug supported by master
14-10	—	Reserved
9	—	Enable / disable Hot-plug
	0	Hot-Plug disabled
	1	Hot-Plug enabled
8	—	HP field vs. SVC communication
	0	Transmission via HP field
	1	Transmission via HP field and SVC
7-0	—	HP function codes
	0	No data
	1	Communication cycle time (tScyc)
	2	Begin of NRT channel (t6)
	3	End of NRT channel (t7)
	4	Requested MTU
	5	Communication version
	6-15	Reserved
	16	MDT0 length
	17	MDT1 length
	18	MDT2 length
	19	MDT3 length
	20-31	reserved
	32	AT0 length
	33	AT1 length
	34	AT2 length
	35	AT3 length
	36-47	reserved
	48-127	reserved
	128	MDT-SVC offset
	129	AT-SVC offset
	130-255	reserved

5.5.7.2.4 HP INFO fields (in HP0 and HP1)

Refer to the MDT service channel INFO field as described in 5.5.7.3.3.

5.5.7.3 MDT service channel (SVC) field

5.5.7.3.1 MDT service channel field summary

The MDT service channel field (see Table 18) shall contain all service channels (SVC) of the configured devices within a Type 19 network. Only configured slave devices shall have their own dedicated service channel, depending upon the application, whereas there shall be no restriction regarding device address order.

The service channel for each device shall be as specified in Table 19.

Table 18 – MDT service channel field

DLPDU part	Data field	Data type	Value/Description
MDT service channel field	MDT SVC for slave device 1	octet[6]	—
	MDT SVC for slave device 2	octet[6]	—
	…	…	(And so on for slave device 3 to slave device (N-1))
	MDT SVC for slave device N	octet[6]	—

Table 19 – MDT SVC (for each slave)

DLPDU part	Data field	Data type	Value/Description
MDT SVC of slave device k	SVC control	octet[2]	—
	SVC INFO	octet[4]	—

5.5.7.3.2 SVC control

The content of service channel (SVC) control word shall be as specified in Table 20.

Table 20 – SVC control word (DLL)

Bit number	Bit value	Control word description
15-6	—	Reserved
5-3	—	Data block element
	000	Service channel not active, close service channel or break a transmission in progress
	001	IDN of the operation data. The service channel is closed for the previous IDN and opened for a new IDN
	010	Name of operation data
	011	Attribute of operation data
	100	Unit of the operation data
	101	Minimum input value
	110	Maximum input value
	111	Operation data
2	—	Bit last transmission
	0	Transmission in progress
	1	Last transmission
1	—	R/W (read/write)
	0	Read service INFO
	1	Write service INFO
0	—	MHS (master handshake bit)
	toggle	Service transport handshake of the master

5.5.7.3.3 SVC INFO

The structure of SVC INFO shall be as specified for Type 16 control word (see IEC 61158-4-16, 5.3.1.3).

Exception: As compared to Type 16, SVC INFO shall always be 4 octet long. If only 2 octets are transmitted in a step, then the value shall be in the low word, and the high word value shall be "don't care".

5.5.7.4 MDT real-time data field

5.5.7.4.1 General

The MDT real-time data field (see Table 21) shall contain all real-time data of the configured devices. Each device shall have its own real-time data field as specified in Table 22.The master real-time data (see Table 23) to any one device shall not be spread into two different master data telegrams. There shall be no restriction regarding device address order.

The master shall at least process the real time data in the corresponding producer cycle time.

Table 21 – MDT real-time data field

DLPDU part	Data field	Data type	Value/Description
MDT real-time data field	Real-time data for slave device 1	octet [See Table 22 or Table 23]	—
	Real-time data for slave device 2	octet [See Table 22 or Table 23]	—
	…	…	(And so on for slave device 3 to slave device (N-1))
	Real-time data for slave device N	octet [See Table 22 or Table 23]	—

Table 22 – MDT real-time data (device control)

DLPDU part	Data field	Data type	Value/Description
Real-time data for device k	Device control	octet[2]	See 5.5.7.4.2

NOTE The device control is present for each slave exactly once.

Table 23 – MDT real-time data (connection data)

DLPDU part	Data field	Data type	Value/Description
Real-time data of slave device k	Connection data	Container	See 5.5.7.4.4

NOTE The connection data may be present for each slave 0..255 times.

5.5.7.4.2 Device control

The content of device control field shall be as specified in Table 24.

Table 24 – Device control field

Bit number	Bit value	Description
15	—	Identification
	0	No Identification request
	1	Identification request
14	—	Topology HS
	toggle	—
13-12	—	Topology control
	00	Fast-Forward on both ports
	01	Loopback with Forward of P-Telegrams
	10	Loopback with Forward of S-Telegrams
	11	Reserved
11	—	Status physical topology
	0	physical ring is broken
	1	physical ring is closed
10-0	—	Reserved

5.5.7.4.3 Connection control

The content of connection control field shall be as specified in Table 25.

Table 25 – Connection control

Bit number	Bit value	Description
15-8	—	Reserved
7	0 or 1	Real-time bit 2
6	0 or 1	Real-time bit 1
5-4	—	Reserved
3	—	Producer synchronization
	0	Not synchronized
	1	Synchronized
2	—	Data field delay
	0	No delay
	1	Delay
1	—	New data
	toggle	—
0	—	Producer ready
	0	Not valid
	1	Valid

5.5.7.4.4 Configuration of connection data

The configuration of the connection data is done using IDN S-0-1050. It shall be assigned to a slave with device address XX during initialization (CP2). All configured data in a connection shall be write-protected in CP3 and CP4.

Only operation data shall be used. For lists, only actual data length with even number of octets shall be used. The structure of the application telegram shall be determined by the configuration list labelled IDN S-0-1050.x.6. The value for "x" shall be the connection number (see Table 26).

The connection shall be defined as configured in IDN S-0-1050.x.1. This connection shall be either consumer or producer. Depending upon configuration, it shall be either:

a) configurable by the master during initialization (see IDN S-0-1050.x.6);

b) configurable by the slave during initialization (see IDN S-0-1500.x.5);

c) as specified in the telegram type parameter IDN S-0-0015.

The assignment of the connection offset shall be as configured in IDN S-0-1050.x.3.

The resource control has to be configured exactly once per resource in one of the consuming connections. Otherwise the sub-device generates the error code in IDN S-0-0390.

If needed, the resource status may to be configured in one or more producing connections.

Table 26 – Structure of a configured connection

DLPDU part	Data field	Data type	Value/Description
Configurable connection data of slave k	Connection control	octet[2]	See 5.5.7.4.3
	Operation data IDN …	octet[depending upon IDN]	Number and length of operation data k shall be as configured in IDN S-0-1050.x.6, defined by the slave or by the selected standard telegram IDN S-0-0015.
	Operation data IDN …	octet[depending upon IDN]	
	…	…	
	Operation data IDN …	octet[depending upon IDN]	

5.6 AT DLPDU

5.6.1 AT MST field summary

The AT is a Type 19 telegram and shall be as specified in Table 27, whereas the Type 19 header is called AT MST header.

Table 27 – AT MST header

DLPDU part	Data field	Data type	Value/Description
AT MST header	AT type	octet[1]	See 5.6.3
	AT phase	octet[1]	See 5.6.4
	AT CRC	octet[4]	See 5.6.5

5.6.2 Evaluation of AT MST in the slaves

The AT MST shall be generated by the master and evaluated by the slaves. Each slave shall evaluate the AT MST according to Table 28.

Table 28 – AT MST fields to be considered by the slave

	AT type	AT Phase	AT CRC
AT0	Yes	No	Yes
AT1	Yes	No	Yes
AT2	Yes	No	Yes
AT3	Yes	No	Yes

5.6.3 AT type

Refer to 5.4.2, whereas bit #6 shall be 1.

5.6.4 AT Phase

The AT phase shall contain the status of the Type 19 communication during initialization and during normal operation. The phase shall be generated by the master and transmitted in every AT. The structure is the same as for MDT phase (see 5.5.4).

The phase of an AT shall not be evaluated by the slave (see Table 28).

5.6.5 AT CRC

The AT CRC shall be generated by the master as the MDT CRC (see 5.5.5).

The AT CRC shall be evaluated by the slave (see Table 28).

5.6.6 AT Payload during initialization

5.6.6.1 General

The content of the AT payload depends on the communication phase (CP) as described in the following subclauses.

5.6.6.2 CP0

The master shall always transmit AT0 telegrams, and no AT1, AT2, nor AT3 telegrams. AT0 shall be structured as stated in Table 29.

Table 29 – AT0 structure in CP0

DLPDU part	Data field	Data type	Value/Description
AT MST	AT type	octet[1]	AT0, see 5.6.3
	AT phase	octet[1]	CP0, see 5.6.4
	AT CRC	octet[4]	See 5.6.5
AT payload	Sequence counter	octet[2] octet	0x0001 in case of a P-telegram, 0x8001 in case of a S-telegram,
	Topology address 1	octet[2]	0xFFFF
	……	…octet	0xFFFF
	Topology address 511	octet[2]	0xFFFF

5.6.6.3 CP1 and CP2

The master shall choose between two communication sequences in CP1 and CP2:

a) If the master expects 255 slaves or less, it may transmit either AT0 to AT3 telegrams, or AT0 and AT1 telegrams only, for example to save initialization time. The slaves shall support both sequence options by evaluating the Communication (see Table 30).

b) If the master expects 256 slaves or more (up to 511 slaves) it shall transmit AT0 to AT3 telegrams.

The AT data field shall contain the service channel (see 5.6.7.3) and the device status (see 5.6.7.4.2) of topology addresses as shown in Table 30, Table 31, Table 32 and Table 33 respectively.

In CP1 the requested slave shall respond by setting the handshake bit (AHS) and valid bit (SVC valid) to 1 in the corresponding SVC status. The AT SVC INFO shall be “don’t care”.

In the device status the slave shall process the following bits:

a) slave valid bit is set to 1;

b) topology bits are updated;

c) parameterization level and communication error interface are valid.

In CP2 the telegrams shall have the same structure as in CP1, but the contents of AT SVC INFO shall be valid in CP2.

Table 30 – AT0 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
AT MST	AT type	octet[1]	AT0, see 5.6.3
	AT phase	octet[1]	CP1 or CP2, see 5.6.4
	AT CRC	octet[4]	See 5.6.5
AT data field	SVC of device 0	octet[6]	—
	…	…	(And so on for devices 1 to 126)
	SVC of device 127	octet[6]	—
	Device status of device 0	octet[2]	—
	Reserved for device 0	octet[2]	—
	…	…	(And so on for devices 1 to 126)
	Device status of device 127	octet[2]	—
	Reserved for device 127	octet[2]	—

Table 31 – AT1 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
AT MST	AT type	octet[1]	AT1, see 5.6.3
	AT phase	octet[1]	CP1 or CP2, 5.6.4
	AT CRC	octet[4]	See 5.6.5
AT data field	SVC of device 128	octet[6]	—
	…	…	(And so on for devices 128 to 255)
	SVC of device 255	octet[6]	—
	Device status of device 128	octet[2]	—
	Reserved for device 128	octet[2]	—
	…	…	(And so on for devices 128 to 255)
	Device status of device 255	octet[2]	—
	Reserved for device 255	octet[2]	—

Table 32 – AT2 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
AT MST	AT type	octet[1]	AT3, see 5.6.3
	AT phase	octet[1]	CP1 or CP2, 5.6.4
	AT CRC	octet[4]	See 5.6.5
AT data field	SVC of device 256	octet[6]	—
	…	…	(And so on for devices 257 to 382)
	SVC of device 383	octet[6]	—
	Device status of device 256	octet[2]	—
	Reserved for device 256	octet[2]	—
	…	…	(And so on for devices 257 to 382)
	Device status of device 383	octet[2]	—
	Reserved for device 383	octet[2]	—

Table 33 – AT3 in CP1 and CP2

DLPDU part	Data field	Data type	Value/Description
AT MST	AT type	octet[1]	AT3, see 5.6.3
	AT phase	octet[1]	CP1 or CP2, 5.6.4
	AT CRC	octet[4]	See 5.6.5
AT data field	SVC of device 0	octet[6]	—
	…	…	(And so on for devices 1 to 126)
	SVC of device 127	octet[6]	—
	Device status of device 0	octet[2]	—
	Reserved for device 0	octet[2]	—
	…	…	(And so on for devices 1 to 126)
	Device status of device 127	octet[2]	—
	Reserved for device 127	octet[2]	—

5.6.6.4 CP3 and CP4

In CP3 and CP4, the master shall transmit ATs with the same structure. The slaves insert their data in the corresponding data fields.

In CP3 only the service channel and the device status are vaild. The configurable real-time data of the AT do not matter, but they shall have the number of octets required for CP4 and normal operation. The positions of the service channels and the real-time data fields in the AT relevant to the individual slaves shall be as transmitted by the master to the slaves during CP2 with the corresponding communication parameters. Depending on the application profile, some bits in the connection control may be valid starting at CP3 and up to CP4.

In CP4 the configurable real-time data shall be valid and filled with actual values as determined by the parameters that the master transmitted to the slaves during CP2. The connection control and the resource status which depend on the application profile shall be valid.

5.6.7 AT payload in normal operation

5.6.7.1 Introduction

The AT payload structure shall be as specified in Table 34.

Table 34 – AT data field

DLPDU part	Data Field	Data Type	Value/Description
AT data field	AT hot-plug field	octet[8]	See 5.5.7.2
	AT service channel field	octet[See 5.6.7.3]	Optional. See Figure 1
	AT real-time data field	octet[See 5.6.7.4]	Optional. See Figure 1

For each slave, IDN S-0-1014 shall set the offset for its service channel. IDN S-0-1011 shall set the offset for the device status, the IDN S-0-1050.x.3 Telegram assignment shall set the offset for the connection data, the IDN S-0-1050.x.5 Current length of connection shall contain the length of the connection data,. IDN S-0-1012 shall set the length of the AT (see Figure 3). These parameters shall be transmitted from the master to the slaves in CP2 during initialization.

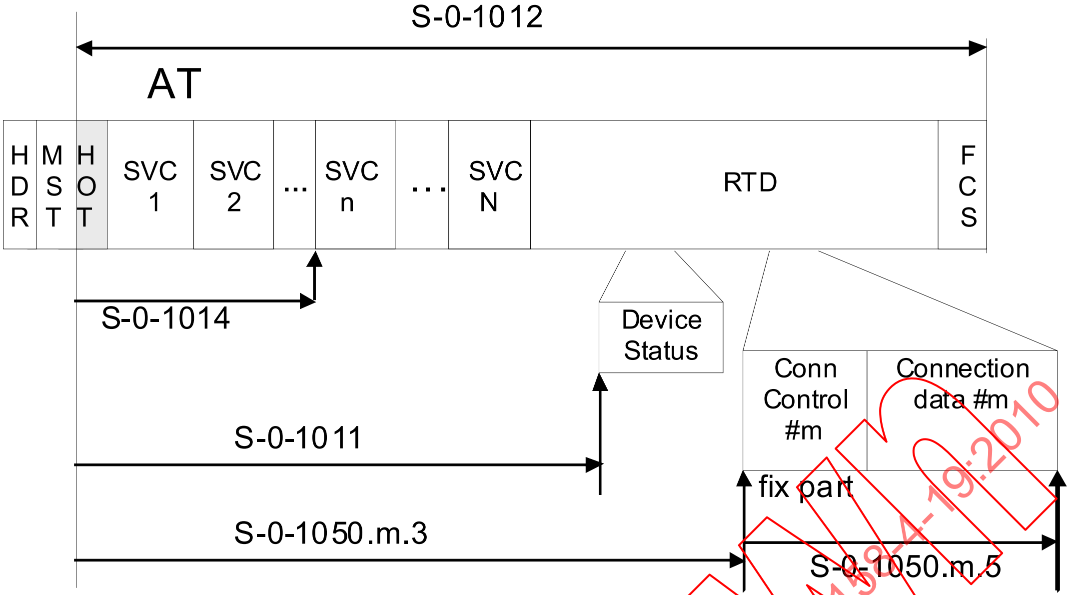


Figure 3 – Offsets within AT payload

5.6.7.2 AT hot-plug field

5.6.7.2.1 AT hot-plug field summary

The structure of the AT hot-plug field shall be as specified in Table 35, depending upon hot-plug phase (HP0, HP1, see 6.3).

Table 35 – AT hot-plug field in HP0 and HP1

DLPDU part	Data field	Data type	Value/Description
AT hot-plug field	Device address	octet[2]	See 5.6.7.2.2
	HP status	octet[2]	See 5.6.7.2.3
	HP INFO	octet[4]	See 5.6.7.2.4

5.6.7.2.2 Device address field

See 5.5.7.2.2.

5.6.7.2.3 HP status field (in HP0 and HP1)

The content of HP control field shall be as specified in Table 36.

Table 36 – HP status field (in HP0 and HP1)

Bit number	Value	Description
15-9	—	Reserved
8	—	HP Condition
	0	Acknowledgment in HP1
	1	Error in HP1
7-0	—	HP1 acknowledgment or error codes
	0	Reserved
	1	No data
	2	Error: SVC activation
	3	reserved
	4	Error: Device address
	5	Error: Slave scan
	6 to 127	Reserved
	128	MDT-SVC pointer
	129	AT-SVC pointer
	130 to 254	Reserved
	255	Error: Next HP slave has same device address

5.6.7.2.4 HP INFO fields (in HP0 and HP1)

Refer to the AT service channel field as described in 5.6.7.3.3.

5.6.7.3 AT service channel SVC field

5.6.7.3.1 AT service channel fields summary

The AT service channel field (see Table 37) shall contain all service channels (SVC) of the configured devices within a Type 19 network. Only configured slave devices shall have their own dedicated service channel, depending upon the application, whereas there shall be no restriction regarding device address order.

The service channel for each device shall be as specified in Table 38.

Table 37 – AT service channel field

DLPDU part	Data field	Data type	Value/Description
AT service channel field	AT SVC for slave device 1	octet[6]	See Table 38
	AT SVC for slave device 2	octet[6]	See Table 38
	…	…	(And so on for slave device 3 to slave device (N-1))
	AT SVC for slave device N	octet[6]	See Table 38

Table 38 – AT SVC (for each slave)

DLPDU part	Data field	Data type	Value/Description
AT SVC of slave device k	SVC status	octet[2]	—
	SVC INFO	octet[4]	—

5.6.7.3.2 SVC status

The structure of SVC status shall be as specified in Table 39.

Table 39 – AT SVC status description (DLL)

Bit number	Bit value	Description
15-4	—	Reserved
3	—	SVC processing
	0	SVC invalid
	1	SVC valid
2	—	SVC error
	0	No error
	1	Error in SVC, error message in SVC INFO
1	—	Busy
	0	Step finished, slave ready for new step
	1	Step in process, new step not allowed
0	—	AHS
	toggle	SVC transport handshake of the slave (toggle bit)

5.6.7.3.3 SVC INFO

The structure of service channel (SVC) INFO shall be as specified for Type 16 control word (see IEC 61158-4-16, Table 7).

Exception: As compared to Type 16, SVC INFO shall always be 4 octet long. If only 2 octets are transmitted in a step, then the value shall be in the low word, and the high word value shall be "don't care".

5.6.7.4 AT real-time data field

5.6.7.4.1 General

The AT real-time data field (see Table 40) shall contain real-time data of the configured devices. Each device shall have its one device status (see Table 41) and may have connection data (see Table 42).

The slave shall at least process the real time data in the corresponding producer cycle time.

Table 40 – AT real-time data field

DLPDU part	Data field	Data type	Value/Description
AT real-time data field	Real-time data for slave device 1	octet[see Table 41 or Table 42]	—
	Real-time data for slave device 2	octet[see Table 41 or Table 42]	—
	…	…	(And so on for slave device 3 to slave device (N-1).)
	Real-time data for slave device N	octet[see Table 41 or Table 42]	—

Table 41 – AT real-time data (device status)

DLPDU part	Data field	Data type	Value/Description
Real-time data of slave device k	Device status	octet[2]	—

NOTE The device status is present for each slave exactly once.

Table 42 – AT real-time data (connection data)

DLPDU part	Data field	Data type	Value/Description
Real-time data of slave device k	Connection data	Container	—

NOTE The connection data may be present for each slave 0..255 times.

5.6.7.4.2 Device status

The content of device status field shall be as specified in Table 43

Table 43 – Device status field

Bit number	Bit value	Description
15	—	Communication warning interface
	0	No warning
	1	Communication warning occurred
14	—	Topology HS
	toggle	
13-12	—	Topology status
	00	Fast-Forward on both ports
	01	Loopback with Forward of P-Telegrams
	10	Loopback with Forward of S-Telegrams
	11	NRT mode (store and forward)
11-10	—	Status of inactive port
	00	No link on inactive port
	01	Link on inactive port
	10	P-Telegram on inactive port
	11	S-Telegram on inactive port
9	—	Error connection
	0	Error-free connection
	1	Error in the connection occurred
8	—	Slave valid
	0	Slave not valid
	1	Slave valid
7	—	Error (C1D)
	0	No error
	1	Error
6	—	Warning (C2D)
	0	No Warning
	1	Warning
5	—	Procedure command change bit
	0	No change in procedure command acknowledgement
	1	Changing procedure command acknowledgment
4	—	Parameterization level
	0	PL is not active
	1	PL is active
3	—	Reserved
2	—	Reserved
1-0	—	Reserved

5.6.7.4.3 Connection control

The content of connection control field shall be as specified in 5.5.7.4.3

5.6.7.4.4 Configuration of connection data

The content of connection data field shall be as specified in 5.5.7.4.4

6 DL management

6.1 Overview

DL-management procedures are functionally processed in response to DL-management service requests submitted by the DL-user and events caused by the network.

6.2 Enable and disable cyclic communication

6.2.1 Introduction

Upon an Initiate_cyclic_communication (ICC) request by the DL user in the master device the so-called phase upshift is initiated.

A Notify_cyclic_communication (NCC) indication is generated for the DL user in the slave device if the phase upshift has been successfully completed.

Upon a Disable_cyclic_communication (DCC) request by the DL user in the master device the so-called phase downshift is initiated.

A Notify_cyclic_communication_disabled (NCCD) indication is generated for the DL user in the slave device if the cyclic communication has been disabled.

A Notify_error (NER) indication is generated for the DL user in a master and a slave device if an error has occurred in the cyclic communication.

6.2.2 Communication phases (CP)

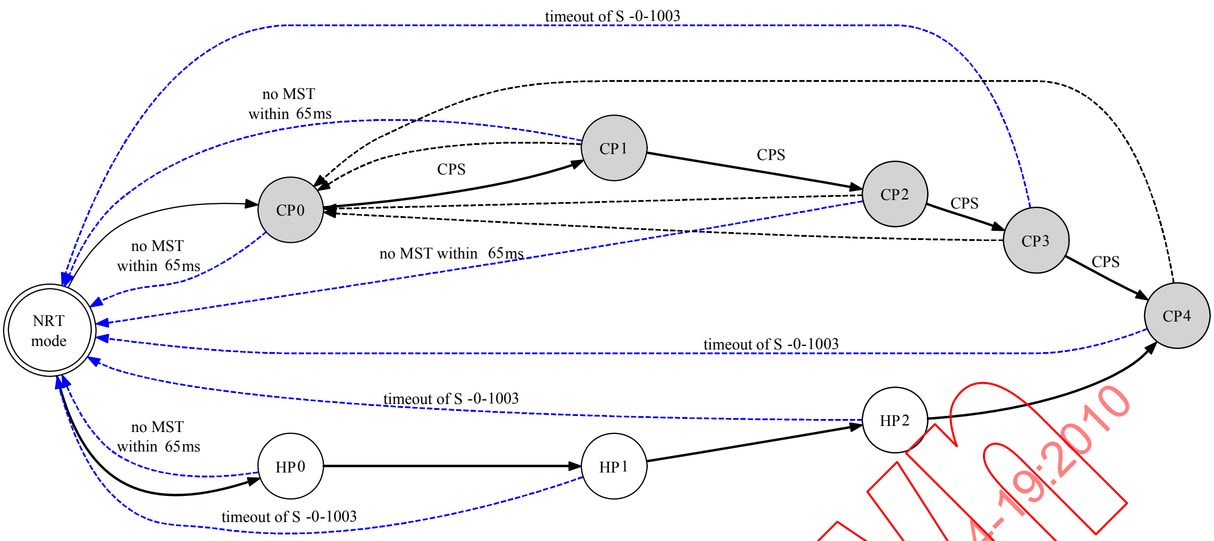
Initialization shall be divided into six communication phases (NRT and 5 CPs):

a) After a station has been powered up, and internal checks are completed and error-free, it shall operate in non real-time (NRT) mode (see 6.2.2.1).
b) initialization of a Type 19 network shall always begin with CP0;
c) CP0 shall be used for recognizing the participating devices;
d) CP1 shall be used to configure the slave devices for acyclic communication;
e) CP2 shall be used to configure the slave devices for cyclic communication and for parameter setting in the device via acyclic communication;
f) CP3 shall be used to further configure the slave devices, the cyclic communication shall already be running but shall not be used;
g) in CP4 the initialization process is complete and the Type 19 network shall be in normal operation.

It shall also be possible to enter CP0 from any higher phase. It shall not be possible to enter other phases except when leaving the previous one in ascending order.

The master shall initiate a specific CP by setting the MDT phase octet in the Type 19 DLPDUs (see 5.5.4). The slaves shall follow accordingly. Only in the case of a communication error shall the slaves switch to NRT mode.

The communication phase state machine is shown in Figure 4.



NOTE Dotted blue transitions: timeouts, see labels

Figure 4 – Communication phase transitions

If a slave is connected to an already operational network and thus receive an MDT0 that indicates CP4, it shall enter the hot-plug procedure (see 6.3).

6.2.2.1 Non-real-time mode (NRT)

Upon their powering on, the master and each slave shall activate NRT mode independently. In this mode they shall behave as store-and-forward switches. Standard Ethernet communication shall be active, if supported.

The master shall leave NRT mode to CP0 upon request by its DL user.

If the slave receives an MDT0 with CP0 while it is in NRT mode the sending of a Standard Ethernet telegram shall be cancelled immediately and the MDT0 shall be sent instead. After this, the slave shall activate CP0 as well as the loopback at the port at which the slave has received the MDT0.

6.2.2.2 Communication phase 0 (CP0)

6.2.2.2.1 General

During CP0, the master shall send MDT0 and AT0 as specified in Clause 5 on one or both of its ports, depending on the given topology, in order to

a) check the wiring (for example check if the network is closed);

b) check all present slaves in the received AT0;

The master shall transmit the AT0 and set the content to 0.

The slave shall read and increment the content of sequence counter field in the AT. The slave shall also write its device address into the topology address field which corresponds to its topology address. Slaves with device address ADR = 0 shall act in CP0 in the same way as slaves with ADR > 0. This shall be done on every AT0 passing the slave. Devices with multiple slaves increment the sequence count by one for each slave.

a) Each slave determines two sequence counters, the higher sequence counter is discarded.

b) The slave will always mask the bit 15 in the valid sequence counter when determining his own topology address.

The slave shall behave as follows:

a) During CP0, a slave in store+forward mode shall activate the loopback with forward mode on the port it receives the first MDT0.
b) During CP0, a slave in loopback with forward mode shall disable loopback and enable fast-forward as soon as it receives MDT0 on both ports.
c) During CP0, a slave in fast-forward mode shall activate loopback on one port as soon as it does not receive MDT0 on the other port for over 65 ms.
d) If the slave recognizes the phase switching (CPS=1, CP=1) it shall stop the automatic changing of the topology.

6.2.2.2.2 Leaving CP0

The master shall wait for its MDT0 and AT0 to be received. Depending on its configuration, the master may compare the detected device addresses with the device addresses that it is expecting to find, and then evaluate deviations (and for example generate an error message). As soon as the master has received 100 AT0 with the same content, the master shall initiate to switch to CP1 (see 6.2.2.7).

If this procedure cannot be achieved within the time set by the master, the master shall remain in CP0 and generate a message. The scope of the message and at what point it has to be activated is a function of the master.

If CP0 is initiated as a response to a previous communication error, a routine in the master may be used to cause an automatic advance routine to CP2 with the possibility of error diagnostics, as specified by its manufacturer or depending upon configuration.

If a slave does not receive any MDT0 while it is in CP0 within the time window of 65 ms, it shall switch to the NRT mode.

6.2.2.3 Communication phase 1 (CP1)

6.2.2.3.1 General

The topology addresses which are determined in CP0 are used for the addressing of the service channels in CP1.

In CP1, the master shall initialize the service channels of all used slaves. Per device (interface) at least one slave has to be used.

The master shall send MDT0 and MDT1 (additional MDT2 and MDT3, if more than 255 slaves are expected) and set MHS=1 in the SVC control to request each used slave to insert data into the corresponding AT. AT0 and AT1 (additional AT2 and AT3, if more than 255 slaves are expected) shall be transmitted by the master with an allocated AT data field (content is set to 0). In the device control, the master shall adjust the following bits and all used slaves shall evaluate them:

a) Identification;
b) Topology;
c) Status physical topology, only if NRT channel is supported.

All used slaves shall set AHS=1 and SVC valid=1 into their corresponding SVC status. If a slave does not respond, the master may address it again depending upon the configuration. This request procedure shall be repeated until the identification time has elapsed. The identification time is defined by the master.

In the device status, the slave shall adjust the following bits and the master shall evaluate them:

a) Slave valid=1;
b) Topology;
c) Parameterization level;
d) Communication warning interface;
e) Error.

NOTE All used slaves behave as described here, even those with device address = 0.

6.2.2.3.2 Leaving CP1

After the master has identified the slaves on the network, the master shall initiate to switch to CP2 (see 6.2.2.7).

If the identification time is exceeded or deviations to the needed and expected device addresses are detected, the initialization shall not be continued. The master may respond with an error message depending upon configuration.

If a slave does not receive any MDT0 in CP1 within 65 ms it shall switch to NRT mode.

6.2.2.4 Communication phase 2 (CP2)

6.2.2.4.1 General

During CP2, the slaves shall be addressed specifically using their corresponding service channel. For CP2 and higher phases, they shall support complete service channel functionality.

As a minimum, the master shall transmit to all present slaves:

a) the communication parameters required for CP3 and CP4;
b) the length of all MDTs and ATs;
c) the offsets of their service channels and real-time data.

The master shall transmit the ring delays to all slaves, which shall be synchronized. The slaves shall adjust the synchronization time depending on the ring delays.

In the device control, the master shall adjust the following bits and all present slaves shall evaluate them:

a) Identification;
b) Topology;
c) Status of physical topology, only if NRT channel is supported.

In the device status, the slave shall adjust the following bits and the master shall evaluate them:

a) Slave valid=1;
b) Topology;
c) Parameterization level;
d) Communication warning interface;
e) Error;
f) Procedure command change bit.

The entire information exchange takes place via the mechanisms of the service channel (see 7.2). The reliability of transmission shall be guaranteed by the MHS and AHS bits as well as the HS timeout. Further parameter exchanges can take place in CP2 or CP3.

NOTE If the master sets t6 = 0, the NRT channel is deactivated in CP3 and CP4.

6.2.2.4.2 Leaving CP2

The transition from CP2 to CP3 shall be performed according to the following procedure:

a) The master shall activate the procedure command "CP3 transition check" as defined in IDN S-0-0127.
b) The slave shall then determine the validity of the parameters for CP3.
c) The slave shall acknowledge the procedure command positively (i.e., "Procedure command executed correctly").
d) After the positive procedure command acknowledgment, the master shall delete the procedure command in the slave.
e) The master shall then initiate a switch to CP3.

If there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment: "Error, procedure command execution impossible". In this case, the master shall remain in CP2 and, depending on its capabilities, try again to set the parameters identified as invalid or send an error message to allow further initialization by means of an operator intervention. If a fault occurs, the slave shall save the IDNs of the invalid data into the "IDN-list of invalid operation data for CP2" (IDN S-0-0021).

After the master has transmitted further parameters (depending on IDN S-0-0021) to the slave in CP2, the procedure command "CP3 transition check" shall be activated once more.

The validity check of the parameters by the slave shall refer only to general criteria (for example: minimum, maximum). It shall not recognize if all parameters that have been transmitted by the master are correct with respect to the master data and the total installation. This means that even if a slave acknowledges the "CP3 transition check" positively, there can be incorrect communication parameters with respect to the total installation which can lead to a disruption of the communication.

Depending upon configuration, the master may also switch to CP0 in case of communication error or human intervention.

If a slave does not receive any MDT0 in CP2 within 65 ms, it shall switch to NRT mode.

6.2.2.5 Communication phase 3 (CP3)

6.2.2.5.1 General

Starting with CP3, the exchange of data shall be done via the telegrams defined for CP3 and CP4. The master shall send the configured MDTs and ATs to all slaves.

Supporting NRT-Plug the master shall transmit the time slot of the NRT channel in the MDT HP field using the broadcast address. Directly after the start of CP3 and immediately after ring recovery the master shall transmit t6 at least 10 times successively and then t7 at least 10 times successively. The master may repeat it or not. The contents of the MDT HP field are shown in Table 44.

Table 44 – MDT hot-plug field in CP3 and after ring recovery

DLPDU part	Data Field	Data Type	Value/Description
AT MST	Device address	octet[1]	4095 (broadcast)
	HP control	octet[1]	least 10 times successively: - 0x02, value of t6 in HP INFO - 0x03, value of t7 in HP INFO
	HP INFO	octet[4]	—

During CP3, the parameters for the slaves shall be set by means of the service channel. Transmission reliability for the service channel shall be guaranteed by the MHS and AHS-bits as well as the HS timeout.

In CP3, the function specific profile shall be activated.

6.2.2.5.2 Leaving CP3

The transition from CP3 to CP4 shall be performed according to the following procedure:

a) The master shall activate the procedure command “CP4 transition check” as defined in IDN S-0-0128.

b) The slave shall then determine the validity of the parameters for CP4.

c) Afterwards, the slave shall complete the processing of the parameters that are required for operating the slave.

d) The slave shall then activate the synchronization.

e) And finally, the slave shall acknowledge the procedure command positively (for example: “procedure command executed correctly”).

f) After receiving the positive procedure command acknowledgment, the master shall delete the procedure command in the slave.

g) The master shall then initiate a switch to CP4.

If there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment: “Error, procedure command execution impossible”. In this case, the master shall remain in CP3 and, depending on the capabilities of the master, try to re-establish the parameters identified as invalid or send an error message indicating that human intervention is required. In a faulty case, the slave shall save the IDNs of the invalid data into the “IDN-list of invalid operation data for CP3” (IDN S-0-0022).

After the master has transmitted further parameters (depending on IDN S-0-0022) to the slave in CP3, the procedure command “CP4 transition check” shall be activated once more.

Depending upon configuration, the master can also switch to CP0 in case of communication errors or human intervention.

If one of the telegram error counters exceeds the maximum number of telegram losses (communication error), then the slave switches to NRT mode.

6.2.2.6 Communication phase 4 (CP4) – end of initialization

6.2.2.6.1 General

Upon switching to CP4 the initialization is complete.

6.2.2.6.2 Leaving communication phase 4 (CP4)

The only possibility of leaving CP4 shall be a return to CP0. The reason for this can be communication faults or operator intervention. Any slave which recognizes CP0 shall shut itself down in the best possible manner. The method of shutting down the slaves is part of the function specific profiles.

If one of the telegram error counters exceeds the maximum number of telegram losses (communication error), then the slave switches to NRT mode.

6.2.2.7 Switching of communication phases (CPS)

6.2.2.7.1 Sequence of CP switching in the master

Figure 5 shows the master state machine for communication phase switching.

State 1: In order to switch the communication phase, the master shall set the condition in the MST (CPS = 1 and new CP). The master shall determine the next CP, which shall be the current CP + 1 or CP0.

State 2: The master shall determine a time-out of 200 ms and wait until the slaves no longer write data to the ATs. For this purpose, the master shall check in CP0 if the sequence counter in the AT0-P/S has been changed by any slave. In CP1 to CP4 the master shall check the slave valid bit to see if it is 0. Now the following transitions (1 to 3) may happen:

a) Transition 1: If the sequence counter is not changed by any slave in CP0 or slave valid = 0 of all slaves in CP1 to CP4, the master shall prepare the new CP. The master shall stop the transmission of MDTs and ATs during 120 ms (>65 ms <130 ms). Only when switching from CP3 to CP4 the master shall continue transmitting MDTs and ATs to keep the slaves synchronized.

b) Transition 2: If the master receives a communication error in one slave's C1D (only possible in CP1 to CP4) during the time-out, it shall display an error message, deactivate the time-out, and stay in the current CP in order to fix the error. If the cause of the error can be fixed, the phase switching shall continue, if it cannot be fixed, the master shall switch to CP0.

c) Transition 3: If the master still receives data from the slaves after the time-out is exceeded (in CP0: sequence counter changed by any slave, in CP1 to CP4: Slave valid = 1), it shall produce an error message showing the respective device addresses and topology addresses. After deleting the error by the user, the master shall switch to CP0.

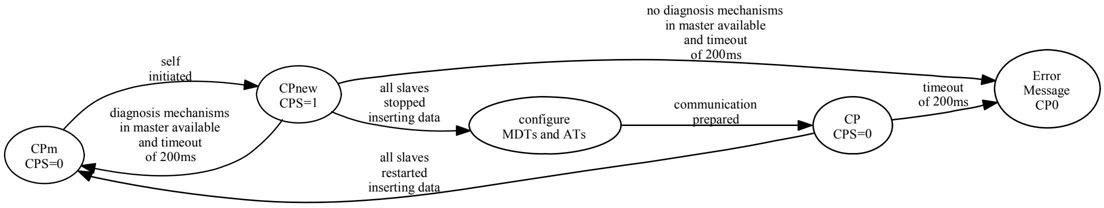
State 3: Once all internal preparations are done, the master shall start sending MDTs and ATs again.

Transition 4: The master shall set either the condition “phase switching completed with new CP” (CPS = 0 and new CP).

State 4: The master again shall set a time-out of 200 ms and wait until all slaves restart writing data to the ATs. The master shall therefore check in CP0 the sequence counter to see if it is valid; and in CP1 to CP4 the slave valid bit to see if it is 1. Now the following transitions (5 and 6) may happen:

a) Transition 5: If the master does not receive any more data from the slaves after the time-out is exceeded (in CP0: sequence counter is invalid, in CP1 to CP4: slave valid = 0), it shall display an error message showing the respective device addresses and topology addresses. After deleting the error by the user, the master shall switch to CP0.

b) Transition 6: If the condition (sequence counter is valid or Slave valid = 1) is true, the new CP shall be active and the switching is complete.



NOTE CPm: communication phase m; CPS:CPS bit in MST; this indicates an imminent switch of the communication phase; CPnew: target communication phase.

Figure 5 – CPS state machine master

6.2.2.7.2 Sequence of CP switching in the slave

Figure 6 shows the slave state machine for communication phase switching.

State 1: The slave shall recognize the phase switching in the MST (CPS = 1 and new CP value in phase field) and check if the new CP is valid. Now the following transitions (1 and 2) may happen:

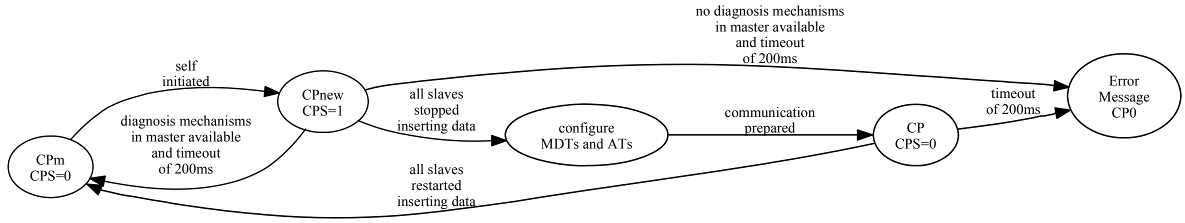
- Transition 1: If the slave is ready for the requested CP, the slave shall only evaluate data of the MST and not write data to the ATs any more. The slave prepares the new CP internally and activates the watchdog with a time-out of 500 ms. This watchdog is triggered with every received MST. The slave waits for CPS = 0 with CPnew. All other conditions are ignored.
- Transition 2: If the slave is not ready for the requested CP, the slave continues to process MDT and AT data (CP related). The slave reacts on CPS=0 with current CP. All other conditions are ignored by the slave and the slave stops processing MDT and AT data.

State 2: After the slave is internally configured for the new CP (transition 1) the following transitions (3-5) may happen:

a) Transition 3: If the slave receives the MST with the valid condition (CPS = 0 and CP = new), then the new CP shall be active and the switching is complete. The slave shall restart evaluating the data in the MDT and write data to the AT. The watchdog is cancelled.

b) Transition 4: If the slave receives a MST with invalid condition (CP has changed), it shall store the error and may display it (for example by means of type 19 network device LED). The slave shall then switch to CP0.

c) Transition 5: If the slave does not receive MST from the master and the time-out is exceeded it shall store this error and may display it (for example by means of type 19 network device LED). The slave shall switch to CP0.



NOTE CPS: CPS bit in MST; this indicates an imminent switch of the communication phase; CPnew: target communication phase in MST.

Figure 6: CPS state machine slave

6.3 Hot-plug procedure

6.3.1 Introduction

Upon an Enable_Hotplug (EHP) request by the DL user in the master device a list of expected devices that may be hot-plugged (depending on the application) is passed to the DL.

Hot-plugging is only possible in communication phase CP4 (normal operation).

The DL user is informed by a Notify_Device_Status_Change (NDSC) if a new device has been hot-plugged.

The last slave in a line configuration shall monitor continuously its unused port and, if an additional device gets connected, it shall forward all received telegrams to this new device.

The additional device shall start in the NRT mode (“store and forward”) as described in 6.2.2.1. If the additional device supports the Type 19 protocol, it shall send the real-time telegrams (MDTs and ATs) back. Using the hot-plug fields in MDT0 and AT0, the master and the additional device shall be able to communicate. After processing through the hot-plug procedure, the additional device shall become the last slave within the line configuration.

Running up a slave device into CP4 shall be achieved using a specific procedure, which is divided in 3 phases (HP0, HP1, HP2).

6.3.2 Hot-plug phase HP0

In HP0, the hot-plugging slave activates the parameterization level. In HP0 the master shall transmit the following basic parameters that are common to all devices, without acknowledgment (MHP-ADR = 0xFF):

a) communication cycle time (t_{Scyc}) (IDN S-0-1002);
b) NRT channel transmission time (t_6 and t_7)(IDN S-0-1017);
c) requested MTU (S-0-1027.0.1)
d) communication Version (MDT0 of CP0)
e) lengths of MDTs (IDN S-0-1010);
f) lengths of ATs (IDN S-0-1012).

As soon as the hot-plugging device has received these parameters, it shall switch to loopback at the port at which it has received the MDT0s.

If loopback with forward is activated,

a) the slave transmits the device address of the sub-device which corresponds to the transmitted slave index in the HP control.
b) the master stops the transmission of the parameters in HP0.

6.3.3 Hot-plug phase HP1

In HP1 the master shall scan all slaves of the hot-plug device. The master shall start the slave scan with slave index 0. The device shall match the slave index in the hot-plug field within the AT when it inserts the corresponding slave address. The slave shall react to a changing slave index in the MDT0 hot-plug field within the given amount of cycles:

a) tscyc <= 2 ms: max. cycles = (2 ms / tscyc) × 10 cycles;

b) tscyc > 2 ms: max. cycles = 10 cycles.

Otherwise the master will stop the hot-plug procedure with an error message. If a slave is addressed by the master that is not existent in the device, the device shall add the device address 0xFFD and match the slave index. The Master shall end the scanning of slaves if it receives 0xFFD as device address in the AT0 hot-plug field. If the master has scanned all slaves, the master shall transmit the following device-specific parameters, with acknowledgment (MHP-ADR = device address), using the hot-plug fields in MDTs and ATs:

a) SVC offset in MDT (IDN S-0-1013);

b) SVC offset in AT (IDN S-0-1014).

If the transfer of all HP1 parameters from all slaves of one device are acknowledged without error, the master shall then activate the SVC (service channel) for each slave of one device by addressing each slave with its device address, setting the MHS = 1 in the SVC control and bit 8 in the HP control within the MDT hot-plug field. The hot-plugging device acknowledges by setting AHS=1 and SVC valid=1 in the SVC status within the AT SVC field.

6.3.4 Hot-plug phase HP2

In HP2 the master shall fully configure the hot-plugging device using SVC (service channel) as in CP2 (see 6.2.2.4).

The master shall then initiate hot-plugging device to leave HP2 using IDN S-0-0127 and IDN S-0-0128, switching to CP4. The hot-plugging device shall perform the check procedures as described in 6.2.2.4.2 and 6.2.2.5.2.

At the end of this procedure, the hot-plugging device shall be in CP4.

6.4 Status procedures

Upon a Get_Device_Status (GDS) request by the DL user in the master device, the status word of the specified device is returned to the DL user.

Upon a Set_Device_Status (GDS) request by the DL user in the master device, the control word of the specified device is set.

Upon a Get_Network_Status (GNS) request by the DL user in the master device, the status of the network is returned to the DL user.

7 Data transmission methods

7.1 Overview

Data transmission methods are the means by which a DLE performs its functions and affects the behavior of the DL-protocol. Methods are initiated, executed and terminated under the control of invoked services, as specified in the Type 19 DL-service.

7.2 SVC

Acyclic data is exchanged between a master and a slave device upon a Read (RD) or Write (WR) request initiated by the DL user in a master device.

Type 19 service channel (SVC) shall be as specified for Type 16 (see IEC 61158-4-16, 6.2), with the following exceptions:

a) the service channel shall be initialized during CP2 (and not in CP1 as in Type 16);

b) the number of data octets is fixes as always being 4 octets.

7.3 RTC

7.3.1 Introduction

Cyclic data is exchanged between all devices in a Type 19 network in communication phase CP4 according to the configuration given by the Initiate_cyclic_communication request (see 6.2).

7.3.2 Read_Cyclic (RDC)

Cyclic data is read by a DL user using the Read_Cyclic (RDC) request.

7.3.3 Write (WRC)

Cyclic data is written by a DL user using the Write_Cyclic (WRC) request. The cyclic data is transmitted in the next communication cycle of the Type 19 network.

7.3.4 Notify_Cyclic_Data (NCD)

Upon reception of a DLPDU of Type MDT0-MST the DL generates a Notify_Cyclic_Data (NCD) indication for the DL user.

7.4 Multiplexing of real-time data with data containers

7.4.1 General

The multiplexing of parameters offers additional functions in the communication.

This means:

a) In the same place of the real-time data field different parameters may be transferred;

b) It is not necessary to change the telegram configuration by a new phase initialization;

c) The access of discrete list elements works by this procedure.

Multiplexing uses:

a) Parameters in form of containers, for transmitting different parameters;

b) Parameters in form of lists, for listing all parameters to be transmitted;

c) Parameters in form of pointers, to address the parameter which will be transmitted;

d) Parameters in form of indices, to address the list element which will be transmitted in case a list parameter is addressed.

For multiplexing two methods are available:

a) Standard data container

b) Extended data container

7.4.2 Standard Data container

7.4.2.1 General

The standard data container offers multiplexed switching between different real-time data in MDT and AT with a separate addressing mechanism.

In order to use this mechanism the standard data containers shall be configured in MDT and AT.

Via standard data containers it is possible to

a) exchange more data in MDT and AT in spite of limited length of connection data;
b) access discrete list elements by means of the list index parameters of MDT and AT;
c) transfer multiplexed data in every communication cycle with a cycle time of tscyc * number of multiplex parameters by incrementing the addressing.

There are 2 data containers with 4 octets and 2 data containers with 8 octets length defined for MDT and AT.

7.4.2.2 Data containers (standard)

Several standard data container are defined for the MDT and AT, serving as placeholders. The contents of the data containers can be dynamically changed by the master if necessary.

The master writes parameters in the slave by using "MDT data containers". The master reads parameters from the slave by using "AT data containers".

For both the „MDT data containers" and the „AT data containers" the following combinations are allowed:

a) Maximum one "data container A" (A1 or A9) is allowed;
b) Maximum one "data container B" (B1 or B2) is allowed but only in addition to a "data container A".

The "MDT data container" combination is independent of the "AT data container" combination. Data containers shall be configured in CP2 only.

If a transmitted parameter is shorter than its data container, the parameter shall placed to the lower part of the data container. In this case the higher part remains free respectively not valid.

7.4.2.3 Configuration of standard data container

a) Configuration lists
    1) There is only one configuration list (IDN S-0-0370) of the configured parameter in the MDT data containers.
    2) There is only one configuration list (IDN S-0-0371) of the configured parameter in the AT data containers.
    3) These two configuration lists are writable in CP2 only.
b) Configurable parameters
    1) All configurable parameters for the MDT data container are optionally stored in the IDN lists of configurable data (IDN S-0-0445).
    2) All configurable parameters for the AT data container are optionally stored in the IDN lists of configurable data (IDN S-0-0444).

7.4.2.4 Addressing of standard data container

The data container pointer is the offset within the data container configuration list (IDN S-0-0370/IDN S-0-0371) from the start of the configuration list to the desired IDN. The master places the desired parameter in the MDT data container, while the slave places the desired parameter in the AT data container.

a) Data container A pointer (IDN S-0-0368) and
b) Data container B pointer (IDN S-0-0369) are specified.

Each data container pointer contains two 8-bit pointers.

a) One 8-bit pointer addresses the IDNs in the MDT data container A/B configuration list (IDN S-0-0370). The parameter of the selected IDN shall be placed in the MDT data container.
b) The other 8-bit pointer addresses the IDNs in the AT data container A/B configuration list (IDN S-0-0371). The parameter of the selected IDN shall be placed in the AT data container.

The data container pointers (IDN S-0-0368/ IDN S-0-0369) shall be configured in the MDT since the master commands the interpretation of the data containers to the slave. Thereby, a switching of the parameters in the data container during a communication cycle is possible.

If the master requires an acknowledgment of the data container transmission, then two possibilities exist:

a) To configure the identical data container pointer as well in the AT.
b) To read the identical data container pointer via the SVC.

The slave shall generate the acknowledgment by copying the data container pointer of MDT to the AT.

The slave shall acknowledge the 8-bit pointer in the AT with the value 255 (not valid) if

a) the pointer is situated outside of the configuration lists for the MDT or AT data container or
b) the parameter is larger than the data container.

In this case the master and the slave shall ignore the corresponding data container.

The master shall compare the data container pointer (IDN S-0-0368/ IDN S-0-0369) of MDT and AT. If the result is equal, then the slave accepted the data in the MDT data container or wrote the requested data into the AT data container.

7.4.2.5 Addressing with list index (parameter lists)

If at least one parameter with „variable length“ (i.e. list parameter) has been programmed inside the “data container A/B configuration list“, this data would be too long for a data container. In this case

a) the corresponding list element will be addressed via the list index, therefore
b) the length of the list parameter shall not be changed.

There are 4 data container list indices specified, one for each data container:

a) IDN S-0-0362 MDT data container A list index;
b) IDN S-0-0363 MDT data container B list index;
c) IDN S-0-0366 AT data container A list index;
d) IDN S-0-0367 AT data container B list index.

Every data container list index consists of a 16 bit address.

Data container list indices shall be configured in the MDT since the master commands the slave the interpretation of the data containers. Thereby, a switching of the list elements in the data container during a communication cycle is possible.

Every data container list index consists of a 16 bit address.

Data container list indices shall be configured in the MDT since the master commands the slave the interpretation of the data containers. Thereby, a switching of the list elements in the data container during a communication cycle is possible.

If the master requires an acknowledgment of the data container transmission, then it has 2 possibilities.

a) To configure the identical data container list index as well in the AT;
b) To read the identical data container list index via the SVC.

The slave shall generate the acknowledgment by copying the data container list index of MDT to the AT.

The slave shall acknowledge the data container list index in the AT with the value 65 535 (not valid) if the data container list index is situated outside of the length of the list parameter. In this case the master and slave shall ignore the corresponding data container. Optionally the slave may acknowledge the corresponding data container pointer in the AT with the value 255 (not valid).

The master shall compare the data container list index of MDT and AT. If the result is equal, then the slave accepted the data in the MDT data container or wrote the requested data into the AT data container.

7.4.3 Extended data container (preferred function)

7.4.3.1 General

The extended data container offers multiplexed switching between different real-time data in MDT and AT with a common addressing mechanism.

In order to use this mechanism the data containers should be configured in MDT and AT.

Via extended data containers it is possible to

a) exchange more data in MDT and AT in spite of limited length of connection data;
b) access discrete list elements by means of list index parameters of MDT and AT;
c) transfer multiplexed data in every communication cycle with a cycle time of tscyc * number of multiplex levels by incrementing the addressing.

There are 8 data containers with 4 octets and 2 data containers with 8 octets length defined for MDT and AT.

7.4.3.2 Data containers (extended)

There are 10 data containers defined for the MDT and another 10 for the AT, serving as placeholders. The contents of the data containers can be dynamically changed by the master as necessary.

The master writes parameters in the slave by using "MDT data containers".

The master reads parameters from the slave by using “AT data containers”.

a) MDT data container
   1) IDN S-0-0360 MDT data container A1
   2) IDN S-0-0450 MDT data container A2
   3) IDN S-0-0451 MDT data container A3
   4) IDN S-0-0452 MDT data container A4
   5) IDN S-0-0453 MDT data container A5
   6) IDN S-0-0454 MDT data container A6
   7) IDN S-0-0455 MDT data container A7
   8) IDN S-0-0456 MDT data container A8
   9) IDN S-0-0457 MDT data container A9
   10) IDN S-0-0458 MDT data container A10
b) AT data container
   1) IDN S-0-0364 AT data container A1
   2) IDN S-0-0480 AT data container A2
   3) IDN S-0-0481 AT data container A3
   4) IDN S-0-0482 AT data container A4
   5) IDN S-0-0483 AT data container A5
   6) IDN S-0-0484 AT data container A6
   7) IDN S-0-0485 AT data container A7
   8) IDN S-0-0486 AT data container A8
   9) IDN S-0-0487 AT data container A9
   10) IDN S-0-0488 AT data container A10

Any combination of "MDT data container" may be selected for the MDT. Any combination of "AT data container" may be selected for the AT.

Data containers shall be configured in CP2 only.

If a transmitted parameter is shorter then its data container, the parameter shall placed to the lower part of the data container. In this case the higher part remains free respectively not valid.

7.4.3.3 Configuration of extended data container

a) Configuration lists (general)
   1) Each MDT data container and AT data container corresponds exclusively with its data container configuration list.
   2) The configuration lists can be written in CP2 only.
b) Configuration lists (MDT)
   1) All used MDT data container configuration lists shall have the same length.
   2) Unused list elements shall be programmed with IDN S-0-0000.
   3) If parameters of "variable length" (i.e. list parameter) are programmed in a MDT data container configuration list, then these list parameters shall have the same length.
c) Configuration lists (AT)
   1) All used AT data container configuration lists shall have the same length.
   2) Unused list elements shall be programmed with IDN S-0-0000.

3) If parameters of "variable length" (i.e. list parameter) are programmed in a AT data container configuration list, then these list parameters shall have the same length.

d) Configurable parameters

1) All configurable parameters for the MDT data container are optionally stored in the IDN lists of configurable data (IDN IDN S-0-0445).

2) All configurable parameters for the AT data container are optionally stored in the IDN lists of configurable data (IDN IDN S-0-0444).

During procedure command "CP3 transition check" (IDN S-0-0127) the slave may check the mentioned restrictions about same length of list parameters. In case of a negative result the procedure command generates the error code in the diagnostic number (IDN S-0-0390).

a) MDT data container configuration lists

1) IDN S-0-0370 MDT data container A/B configuration list
2) IDN S-0-0490 MDT data container A2 configuration list
3) IDN S-0-0491 MDT data container A3 configuration list
4) IDN S-0-0492 MDT data container A4 configuration list
5) IDN S-0-0493 MDT data container A5 configuration list
6) IDN S-0-0494 MDT data container A6 configuration list
7) IDN S-0-0495 MDT data container A7 configuration list
8) IDN S-0-0496 MDT data container A8 configuration list
9) IDN S-0-0497 MDT data container A9 configuration list
10) IDN S-0-0498 MDT data container A10 configuration list

b) AT data container configuration lists

1) IDN S-0-0371 AT data container A/B configuration list
2) IDN S-0-0500 AT data container A2 configuration list
3) IDN S-0-0501 AT data container A3 configuration list
4) IDN S-0-0502 AT data container A4 configuration list
5) IDN S-0-0503 AT data container A5 configuration list
6) IDN S-0-0504 AT data container A6 configuration list
7) IDN S-0-0505 AT data container A7 configuration list
8) IDN S-0-0506 AT data container A8 configuration list
9) IDN S-0-0507 AT data container A9 configuration list
10) IDN S-0-0508 AT data container A10 configuration list

c) IDN lists of configurable data

1) IDN S-0-0445 IDN list of configurable data in the MDT data container
2) IDN S-0-0444 IDN list of configurable data in the AT data container

7.4.3.4 Addressing of extended data container

The data container pointer is the offset, within all used data container configuration lists from the start of the configuration list to the desired IDN. The master places the desired parameter in the MDT data container, while the slave places the desired parameter in the AT data container.

Only the Data container A pointer (IDN S-0-0368) is required and it applies to any data container.

The data container A pointer contain two 8-bit pointers.

a) One 8-bit pointer addresses the IDNs in the MDT data container configuration lists (IDN S-0-0370, IDN S-0-0490 to IDN S-0-0498). The parameter of the selected IDN shall be placed in the MDT data container.

b) The other 8-bit pointer addresses the IDNs in the AT data container configuration lists (IDN S-0-0371, IDN S-0-0500 to IDN S-0-0508). The parameter of the selected IDN shall be placed in the AT data container.

The data container A pointer (IDN S-0-0368) shall be configured in the MDT since the master commands the slave the interpretation of the data containers.

If the master requires an acknowledgment of the data container transmission, then it has 2 possibilities.

a) To configure the data container A pointer as well in the AT;

b) To read the data container A pointer via the SVC.

The slave shall generate the acknowledgment by copying the data container A pointer of MDT to the AT.

The slave shall acknowledge the 8-bit pointer in the AT with the value 255 (not valid) if

a) the pointer is situated outside of the configuration lists for the MDT or AT data container or

b) the parameter is greater than the data container.

In this case the master and the slave shall ignore all data containers for which the 8-bit pointer is responsible.

The master shall compare the data container A pointer (IDN S-0-0368) of MDT and AT. If the result is equal, then the slave accepted the data in the MDT data container or wrote the requested data into the AT data container.

7.4.3.5 Addressing with list index

If at least one parameter with „variable length“ (i.e. list parameter) has been programmed inside the “data container configuration list“, this data would be too long for a data container. In this case

a) the corresponding list element will be addressed via the list index, therefore

b) the length of the list parameter shall not be changed and

c) the length of all selected list parameter shall have the same length.

There are 2 data container list indices specified:

a) the MDT data container A list index (IDN S-0-0362) for all MDT data containers

b) the AT data container A list index (IDN S-0-0366) for all AT data containers

Every data container list index consists of a 16 bit address.

The data container A list index shall be configured in the MDT since the master commands the slave the interpretation of the data containers. Thereby, a switching of the list elements in the data container during a communication cycle is possible.

If the master requires an acknowledgment of the data container transmission, then it has 2 possibilities.

a) To configure the identical data container list index as well in the AT.

b) To read the identical data container list index via the SVC.

The slave shall generate the acknowledgment by copying the data container list index of MDT to the AT.

The slave shall acknowledge the data container list index in the AT with the value 65535 (not valid) if the data container list index is situated outside of the length of one of the selected list parameters. In this case the master and slave shall ignore all corresponding data containers. Optionally the slave may acknowledge the corresponding data container pointer in the AT with the value 255 (not valid).

The master shall compare the data container list index of MDT and AT. If the result is equal, then the slave accepted the data in the MDT data container or wrote the requested data into the AT data container.

7.4.4 Data container diagnostic

The parameters in the data containers are checked during initialization as well as during operation in CP4. If a slave detects an error in the data container it generates the corresponding diagnostic message.

IDN can not be configured in MDT or AT data container. It has to make sure that the IDNs in the configuration lists can be transmitted as cyclic data. The slave checks it with procedure command IDN S-0-0127.

In CP4 the slave checks whether the addressing is outside of the configuration lists. In the case of error the appropriate addressing in AT is set to 255. The contents of the data containers are invalid. Therefore all configuration lists shall be programmed with the same length. Unused list elements have to be programmed with IDN S-0-0000.

In CP4 the slave checks whether the list index is outside of the list parameter. In in the case of error the appropriate list index is set to 65535. Optionally the appropriate addressing in AT is set to 255. Therefore all list parameters shall be programmed with the same length. Unused list elements have to be set to 0x0. The slave generates an error code in IDN S-0-0390.

7.5 Multiplexing of real-time data using SMP

7.5.1 Definitions

The Type 19 Messaging Protocol uses transport containers to transmit messages which may be configured in the cyclical real-time channels. The size of the containers may be between 4 and 258 octets without any restriction; thus, 0...256 octets of user data can be transmitted in each communication cycle.

In the first 2 octets of the transport container, a control word (Session Control Header, SCH) is stored in Little-Endian octet order. The remainder of the transport container is filled with user data. As an alternative, only a part of the container is filled with user data, and the number of user data octets is stored in the last octet of the container. It is indicated by means of the EXTF bit in the Session Control Header.

Thus, the start of the user data is always 16-bit-aligned with both formats.

7.5.2 Structure of the Session Control Header (SCH)

The Session Control Header controls

a) the fragmentation of data packages that are larger than the transport containers used,
b) the prioritization of messages, and
c) multiplexing several logic data transmission channels through a single transport container.

Its structure is as shown in Table 45.

Table 45 – Structure of the Session Control Header

Bit number	Value	Description
15-8	—	Session identifier (SID) Up to 255 logic transmission channels (sessions) can be transmitted via a transport container. The Session Identifier indicates the session for which the data comprised in a data package is intended.
	0-254	Valid values for the SID (0x00–0xFE)
	255	The value 255 (0xFF) is reserved for services of the transport layer
7-6	—	Bit7: Last of Sequence (LOS). If this bit is set, the telegram in question is the last package of a transmission sequence. Bit6: First of Sequence (FOS). If this bit is set, the telegram in question is the first package of a transmission sequence. All fragments so far received on this priority level and not yet completed by a Last-of-Sequence are discarded. These bits control the fragmentation of messages that exceed the size of the transport container
	00	Ongoing fragmented transmission
	01	First telegram of a fragmented transmission
	10	Last telegram of a fragmented transmission
	11	Unfragmented transmission
5-4	—	Sequence Counter (SC) This counter, which is two bits wide, is managed separately for each session. It is incremented for every telegram transmitted within a session. The SC uncovers telegram failures that occurred within a fragmented message.
	0-3	Sequence Counter value

Bit number	Value	Description
3-2	—	Priority (PRI) Corresponds to the priority of the session through which this message is sent. In accordance with this bit field, the transport layer can give high-priority messages (for example: cyclical data) preferential treatment in contrast to less time-critical messages (for example: non-cyclical configuration services).
	00	Priority 0 (highest level)
	01	Priority 1
	10	Priority 2
	11	Priority 3 (lowest level)
1	—	Extended format (EXTF) This bit indicates that the transport container pertaining to the header has not been filled completely. In this case, the number of actually contained user data octets is entered in the last octet of the container
	0	Standard format
	1	Extended format
0	Toggle	New Data Toggle (NDT) This bit indicates that the contents of the transport container (i.e. the Session Control Header or the data field) have changed. The user only needs to edit the telegram contents if the status of this bit has changed.

7.5.3 Diagnosis of SMP

Diagnosis information is collected centrally in parameter IDN S-0-1100 SMP Diagnosis.

a) IDN S-0-1100.0.1 Diagnostic counter sent SMP fragments

b) IDN S-0-1100.0.2 Diagnostic counter received SMP fragments

c) IDN S-0-1100.0.3 Diagnostic counter discarded SMP fragments

7.5.4 Definition of the parameter structure of the SMP containers

Parameter IDN S-0-1101 SMP Transport container is defined for the transport of SMP fragments through the real-time channel:

a) SMP container data

b) List of the session identifiers

c) List of the session priorities

The structure element IDN S-0-1101.x.1 is configured in a cyclical telegram; thus, it comprises the data transmitted in this container. The other structure elements describe the sessions currently active for this container.

The lists in IDN S-0-1101.x.2 and IDN S-0-1101.x.3 shall have the same actual length. List elements with identical index describe one session.

8 Telegram timing and DLPDU handling

8.1 Usage of real-time channel with different network topologies

8.1.1 Introduction

The topology consists of full-duplex, point-to-point transmission lines and participants. The master and the slaves are parts of the network and are its participants.

Each participant has two communication ports (port 1 and port 2). Port 1 (P1) and port 2 (P2) shall be interchangeable.

The topology shall be either a ring structure or a line structure. A ring shall have two logical channels and a line shall have only one logical channel.

The difference between ring and line structure is that the ring has a built-in redundancy against transmission media faults (for example cable break) and should be therefore preferred.

Each master handles only one network.

NOTE A control unit may have one or more master interfaces depending on the configuration.

Slave interfaces shall be used to connect the devices to the network. At the physical layer, a slave represents the connection of one or more devices to the network. Logically, one slave with several devices shall act the same as several slaves with one device each. The slaves are physically connected to each other participants through the network. Communication takes place between the master and the slaves; direct cross communication between the slaves is also supported.

The physical arrangement of slaves in the network shall be independent from the predefined device addresses ADR for the slaves, as well as from the sequence of the real-time data fields in the MDT and AT (see 5.5.7.4 and 5.6.7.4).

Any slave shall be able to recognize the topology at any time, using the difference between primary and secondary telegrams. This is important when a slave is added to the communication at a later point in time (for example when adding new machine parts, hot-plug). If a slave receives telegrams with the same Type 19 type on both ports (MDT0-P or MDT0-S) it shall recognize a line. If it receives an MDT0-P on one port and an MDT0-S on the other port, it shall recognize a ring.

8.1.2 Ring structure

The ring structure shall consist of a primary and a secondary channel. All slaves shall work in forwarding mode. Redundancy to protect against cable fault (for example disconnection or undesired cable break) is achieved through this ring. It shall also be possible to open the ring and insert/remove slaves during operation (hot-plug).

8.1.3 Line structure

The line structure shall consist of either a primary or a secondary channel, depending upon configuration. The last physical slave shall perform the loopback function. All other slaves shall work in forwarding mode. It shall also be possible to add and remove slaves at the end of the line during operation (hot-plug). The ports which are not used for Type 19 communication shall support any Ethernet-based communication. The master may communicate with 2 sets of Type 19 slaves using two lines.

8.2 Communication mechanisms

8.2.1 General

Each port shall be assigned to a processing unit and a multiplexer (see Figure 6). The functions in the master and the slave shall depend on the topology and on the time slot within the communication cycle (RT channel or NRT channel, see Figure 7).

The master has only a processing unit for each port (no multiplexing nor loopback).

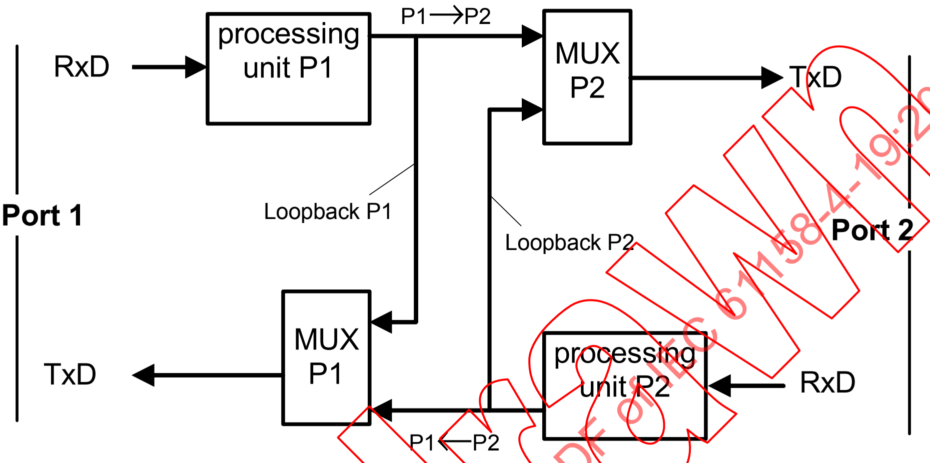


Figure 6 – Block diagram of master and slave

8.2.2 Fast-Forward

In the slave, the data from RxD (P1) shall be passed on with or without change to TxD (P2). The data from RxD (P2) shall be passed on with or without change to TxD (P1). While the RT channel is active, the data shall be passed on, delayed by t_{REP}. While the NRT channel is active, at least store and forward shall always be active and data shall be passed on, either at once or later, depending upon the communication load.

a) During CP0, a slave in loopback+forward mode shall disable loopback and enable fast+forward as soon as it receives MDT0 on both ports.

b) During CP0, a slave in fast forward mode shall activate loopback on one port as soon as it does not receive MDT0 on the other port for over 65ms.

8.2.3 Loopback with Forward

In the slave, the data shall be passed on with or without change. Loopback may be activated either at P1 or P2 depending on the topology, but not at both ports simultaneously. While the NRT channel is active, loopback shall never be active. While the RT channel is active, the slave shall activate loopback with forward in the following cases:

a) during CP0, as soon as an MDT0 has been received at a port (P1 or P2), but only as long as no MDT0 has been received at the other port;

b) if the slave is the last physical one in the line topology it shall thus activate loopback with forward only on the port from which it receives MDT0s;

c) if a cable fault (for example: disconnection, undesired cable break) is detected.

The master shall have no loopback functionality.

8.2.4 Redundancy of RT-communication with ring topology

The master shall send all telegrams with the same content on the P channel and on the S channel. Each slave shall receive both telegrams, work on the assigned data fields in P and S channel, and pass them on in their respective channels. Likewise, the master shall receive the telegrams from the slaves twice and process the data from the slave only once (either P or S channel).

8.2.5 Telegram sequence in communication cycles

The sequence of transmitted RT-data DLPDUs and Ethernet DLPDUs shall be repeated every communication cycle. The time slots for the RT channel and the NRT channel and the transmission time of the AT shall be transmitted during initialization and are therefore known by each slave. Figure 7 shows the two possible arrangements of the RT channel and the NRT channel. The master shall always use one method out of these two, the choice of which depends on configuration.

NOTE Some control units calculate the new command values only after having received all actual values. In method 1 there is more time available for the calculation of the command values. Method 2 is more appropriate for position control since the control unit can calculate the new command values while still receiving the actual values.

A synchronous collision-free media access control shall be used in the RT channel. Telegrams shall be exchanged in fixed communication cycles. The master shall start the communication cycle strictly equidistant with the communication cycle time t_{Scyc}, by transmitting the MDT0. The next communication cycle shall start with the transmitting of the next MDT0.

The MDTs (MDT0 through MDT3) shall be transmitted as broadcast telegrams to all slaves. The MDT0 shall contain the synchronization information and the status of the communication in the MDT MST field.

The ATs (AT0 through AT3) shall be transmitted by the master with the configured telegram length but the data field is prefilled with zeros . Each slave shall insert its data into its allocated data fields within the ATs. The sequence of the device data fields within the ATs shall be independent of the physical order of the topology as well as the predefined device address. The master shall be the final recipient of the ATs.

The data field length and content meaning of the MDT and AT MST fields shall remain constant and thus have the same length at each communication cycle.

Within the NRT channel there shall be no special time slots. Every participant may send its Ethernet DLPDUs during this time slot depending upon configuration.

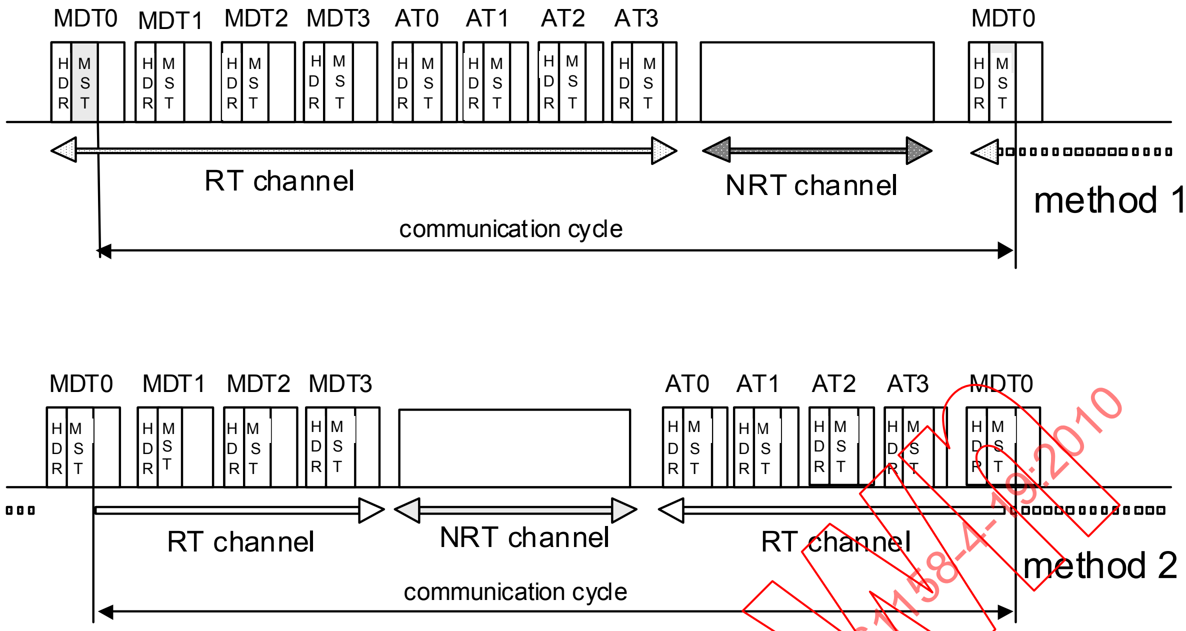


Figure 7 – Telegram sequence

8.2.6 Cycle time

The communication cycle time, t_{Scyc}, shall be as for Type 16 (see IEC 61158-4-16, 7.2.2), whereas the value t_{Scyc} = 31,25 µs shall also be possible in addition.

This cycle time may have some jitter. The jitter describes the deviations from the t_{Scyc} value in the distance between two MDT0.

Therefore, the actual time interval between the end of a MST and the end of the following MST shall have a minimum value of:

j x tScyc × 0,999 9 × JtScyc (j = 1, 2, 3, ...)

and a maximum value of:

j x tScyc × 1,000 1 + JtScyc (j = 1, 2, 3, ...)

NOTE j is an ordinary integer and not related to the abbreviations.

The factors 0,999 9 and 1,000 1 take into account the deviation of the communication cycle time tScyc, compared to the accuracy of the usual crystal oscillators (±100 ppm). Note that the jitter shall not accumulate over several periods (i.e., the average value shall be zero).

8.2.7 Timing parameters

The following timing parameters shall be characteristics of the network:

a) t_{rep} – time by which the received signal shall be delayed by a forwarding slave (input to output). This parameter shall be saved as an IDN in the slave;

b) t_{cable} – time by which the transmitted signal is actually delayed by the cable;

c) t_{ring} – time between the transmitted and received signal at the master. The master shall measure the network delay in CP0. The network delay shall contain all forwarding and cable delays in the network and shall be used for synchronization purposes.

8.2.8 Medium access

In the following text all timings refer to the "beginning of telegram" (see Figure 8). It is defined as the last edge time of the Start DLPDU Delimiter (SFD).

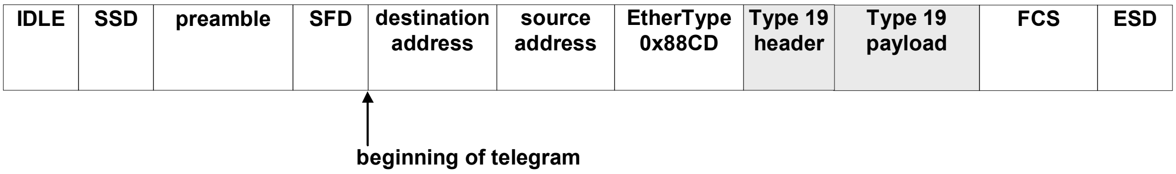


Figure 8 – Beginning of telegram

Figure 9 shows the medium access which is used at all time, except during initialization.

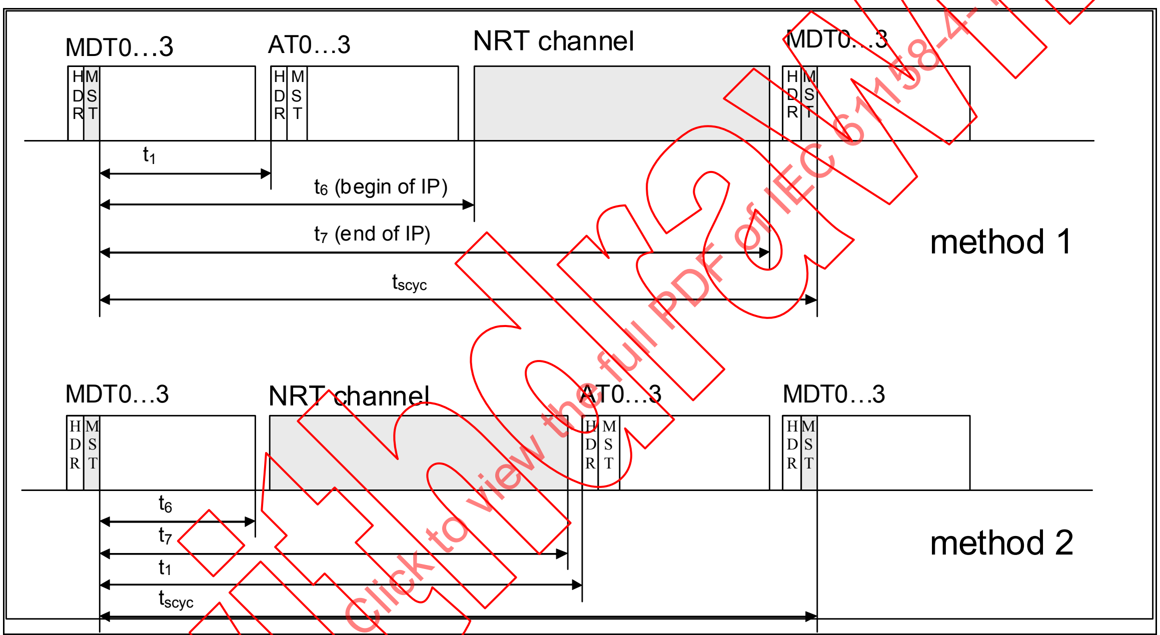


Figure 9 – Access to the medium

During the initialization phase, the master shall inquire for time parameters from the slaves (see 6.2.2.4). With this information, the master shall calculate collision-free transmission time-slots of the telegrams within the RT channel.

The master shall transmit to each slave the AT transmission starting time, t_1, as well as the beginning and ending times of the NRT channel, t_6 and t_7 respectively. These starting times for the transmitting time-slots for the telegrams are defined below, whereas the jitter has been incorporated in t_1:

a) t_1 – AT transmission starting time: this is the nominal time interval between the beginning of MDT0 and the beginning of AT0. This parameter shall be determined by the master and stored in the associated devices as an IDN;

b) J_{t1} – Jitter in t_1: this is the maximum deviation of the beginning of the AT0. It is the allowed deviation of the time interval t_1. The actual time interval between the beginning of MDT0 and the beginning of AT0 shall lie between t_1 - J_{t1} and t_1 + $J_{t1.}$ J_{t1} shall have the same value as the jitter of MDT0, J_{tscyc}. See Table 1;

c) t_6, t_7 – Time-slot of NRT channel (t_6 begin of NRT channel, t_7 end of NRT channel). Within the NRT channel there shall not be any special time-slots. Every participant shall be able to send its Ethernet DLPDUs during this time-slot. The time parameters (t_6 and t_7) shall be set by the master in communication phase 2 (CP2).

8.2.9 NRT communication mechanisms

8.2.9.1 Introduction

Before the Type 19 real-time communication is initialized, communication with the slaves shall use standard Ethernet mechanisms if it supports this function. As soon as initialization has started or is done, standard Ethernet communication shall be possible only in the NRT channel.

During the NRT channel (time slot between t_6 and t_7) the participants shall send their Ethernet DLPDUs on one port depending on the frames destination MAC address. If the Type 19 network devices have not yet learned the right port, the frame shall be sent on both ports. Ethernet DLPDUs may be forwarded either immediately or later depending on communication load (see 8.2.5).

Loopback with forward shall never be active while the NRT channel is on, even if a participant detects a communication interruption and becomes the last one in a line configuration (see 8.1.3).

8.2.9.2 Slaves within a line or a ring

If a slave receives a telegram of any other kind while the NRT channel is active and while it is transmitting an Ethernet DLPDU, the currently transmitted Ethernet DLPDU shall not be interrupted and the incoming telegram shall be stored.

Slaves shall always send their own Ethernet DLPDUs on one port (P1 and P2 depending on the destination MAC address, provided that all following conditions are met before doing so:

a) it is not already forwarding another telegram; otherwise the slave shall wait until this telegram has been fully forwarded;
b) the remaining NRT channel duration is long enough to fully transmit its own Ethernet DLPDU;
c) its memory has enough free capacity for storing at least one new incoming Ethernet DLPDU with maximum length.

If the slaves have not yet learned the right port, they shall send the frame on both ports.

8.2.9.3 Slave in the last position within a line

Although the last slave in a line (see 8.1.3) has its loopback active, it shall check for any incoming Ethernet DLPDU on its other port. It shall forward Ethernet DLPDUs if its NRT channel is active, provided that the remaining duration of this NRT channel is long enough to fully transmit this Ethernet DLPDU. Otherwise, or if the NRT channel is not active, the last slave shall store all incoming Ethernet DLPDUs. It shall forward one or several of them as soon as the NRT channel is active again, provided that the remaining duration of this new NRT channel is long enough.

8.2.10 Telegram timing in CP0

The communication cycle time shall be preset by the master with 1 ms ≤ t_{Scyc} ≤ 65 ms. The telegram timing of CP0 is shown in Figure 10. No transmission time is specified for AT0, but it shall be transferred after MDT0 and before time t_{6init} is started.

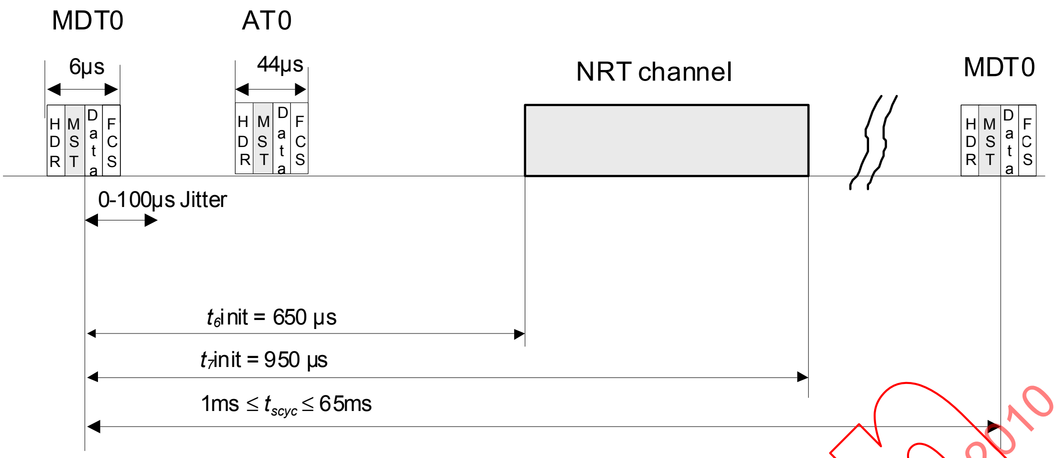


Figure 10 – Timing diagram of CP0

8.2.11 Telegram timing in CP1 and CP2

Two telegram set-ups are possible in CP1 and CP2. One has a minimum communication cycle time of 1 ms and can address up to 255 slaves; the other has a minimum communication cycle time of 2 ms and can address up to 511 slaves.

a) The communication cycle time shall be preset by the master with 1 ms ≤ t_{Scyc} ≤ 65 ms. The telegram transmission starting times during CP1 and CP2 are shown in Figure 11. No transmission times are defined by MDT1, AT0 and AT1; but they shall all be transferred in that order before the time t_{6init} is started. The master shall not send MDT1 nor AT1 if the time t_{6init} (begin of NRT channel) is exceeded by the AT1 (for example if jitter too large).

b) The communication cycle time shall be preset by the master with 2 ms <= tScyc <= 65 ms. The telegram transmission starting times during CP1 and CP2 are shown in Figure 12. No transmission times are defined for MDT1, MDT2, MDT3 , AT0, AT1, AT2 and AT3; but they shall all be transferred in that order before the time t6init is started. This set-up can address up to 511 slaves. t6init = 1050 µs and t7init = 1950 µs.

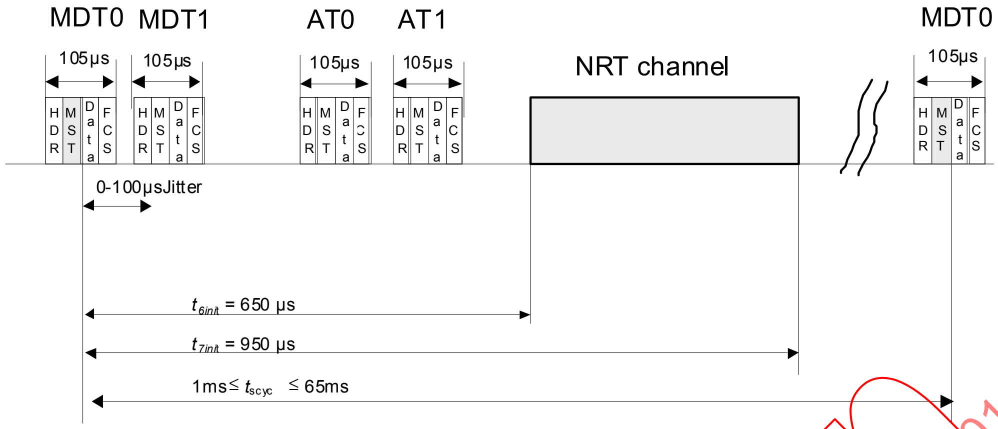


Figure 11 – Timing diagram of CP1 and CP2 with 2 MDT/AT

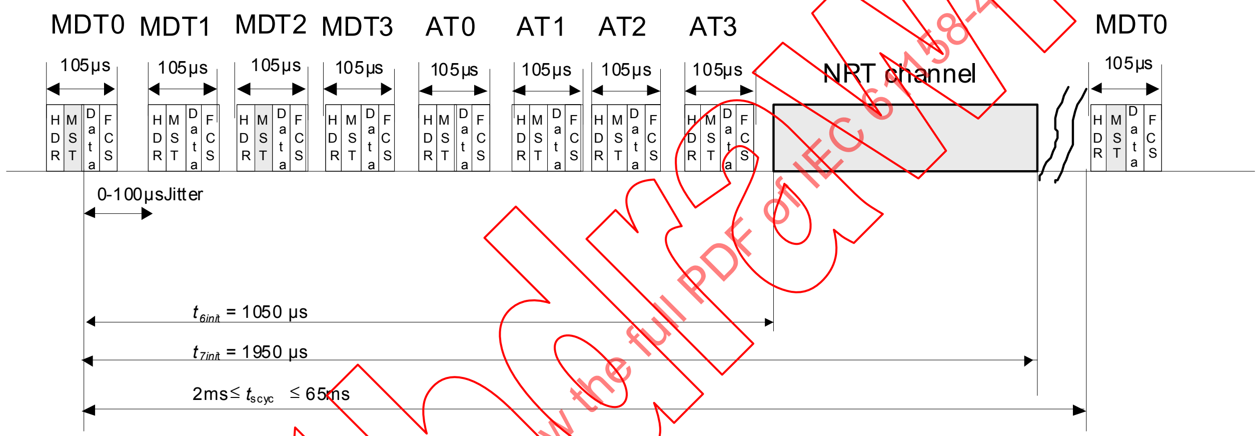


Figure 12 – Timing diagram of CP1 and CP2 with 2 MDT/AT

8.2.12 Telegram timing in CP3 and CP4

Telegram transmission starting times shall be specified by the parameters which shall have been transmitted by the master to the slaves during CP2 and correspond to the time-slots for CP3 and CP4 (see Figure 9).

8.3 Device synchronization

The synchronization shall be used for synchronizable slaves which supports SCP_Sync only and consists of several functions.

a) Compensation of the physical delay times (tring);

b) Determination of the synchronization reference time (TSref) related to ring delay;

c) Trigger of synchronization with end of MST (TTref);

d) Determination of the optimal synchronization time (TSync) related to the processing times in the slaves.

The master shall measure the network delays in CP0, CP1 or CP2 as specified in this clause. The master shall transmit the ring delay (S-0-1015) to all synchronizable slaves. The master may measure also the physical delay times in CP4 for monitoring and diagnosis purposes.

Then the slaves shall calculate its internal synchronization timing (IDN S-0-1016). This synchronization time and all times derived from it in the slave shall be activated with a procedure command (IDN S-0-1024). The status of synchronization shall be shown in the connection control produced by the corresponding slave.

Synchronization shall be generated once per communication cycle by the MDT-MST of MDT0 only (see Figure 13). The MDT MST shall be protected via CRC by the master. The end of the MDT MST shall be a constant in every communication cycle and shall yield a stable synchronization signal. The slaves shall check the MDT MST data via CRC and evaluate the data of MDT MST.

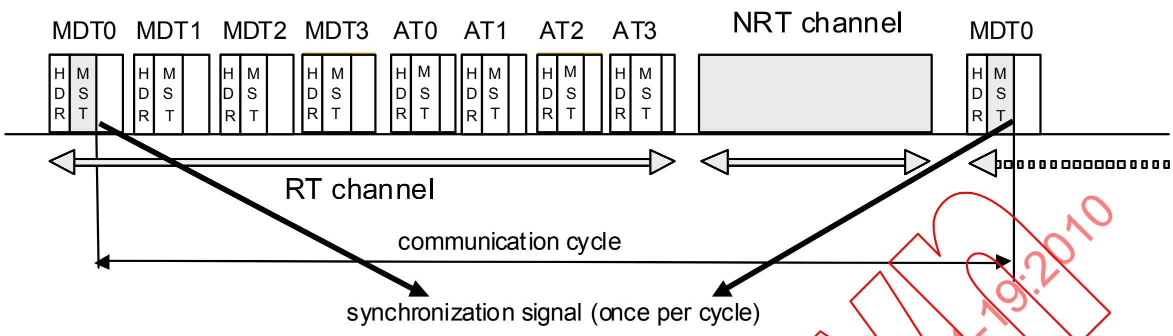


Figure 13 – Synchronization timing

In line or ring topology each slave shall receive two MDT MSTs. This provides for two synchronization signals with a constant delay (see Figure 14). These two signals shall be combined to one synchronization trigger.

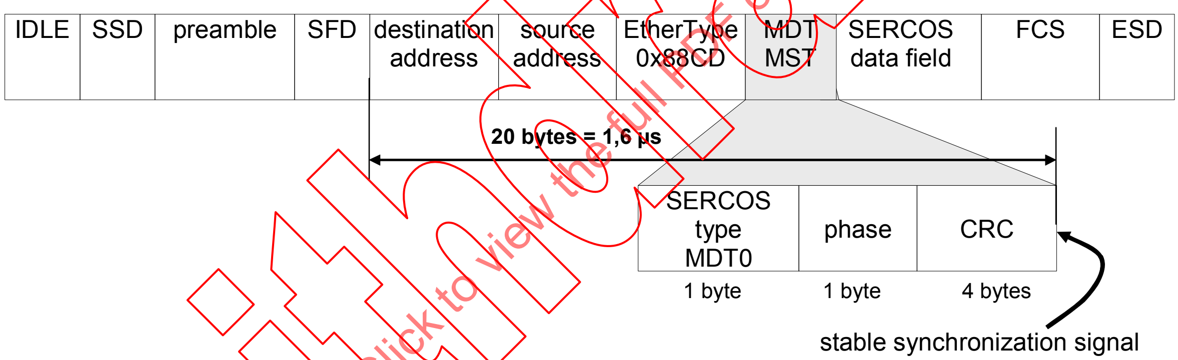


Figure 14 – Synchronization signal generation

9 Error handling and monitoring

9.1 Failure of telegrams

A telegram shall be invalid if any of the following faults occur or any combination hereof:

a) any of the Ethernet relevant DLPDU controls as per ISO/IEC 8802-3 is not correct;

b) the length of the Type 19 telegram does not correspond to the length defined during initialization;

c) the telegram does not arrive within the defined time tolerance limits;

d) the CRC check in Type 19 telegram header is not correct.

9.2 Response to MDT and AT telegram failure

9.2.1 General

If a telegram failure occurs, the master and the slave shall respond as follows:

a) the synchronization of the interface shall be maintained;

b) internal counters shall be incremented for missing telegrams;

The application profile may specify additional response (for example: on the basis of the last correct command values, a power drive system shall calculate internal command values to replace the data of the missing telegram, as specified in FSP_Drive).

The parameter IDN S-0-1003 defines the maximum number of communication cycles in which a slave may not receive its relevant telegrams in CP3 and CP4. The slave shall switch from CP3 and CP4 back to NRT mode if it did not receive its relevant telegrams within more than the user-defined quantity in IDN S-0-1003. After half the amount of cycles specified in this parameter, the slave shall set the communication warning bit in its device status (bit 15).

9.2.2 Error counters in the master and the slave

In order to make available the amount of errors recognized in the slaves two IDN are defined and shall be implemented in the slaves:

a) IDN S-0-1028: This IDN shall be used to show the maximum amount of consecutive telegram loss occurred;
b) IDN S-0-1035: This IDN shall be used to show the total amount of telegram losses occurred.

9.2.3 Error effects on communication phases

9.2.3.1 Ascending communication phases

The sequence of communication phases shall be maintained in ascending order (0, 1, 2, 3, 4). If this sequence is not maintained, the slave shall return to CP0. The communication error bit shall be set in C1D.

9.2.3.2 Descending communication phases

A change of the CPs in descending order shall only be accomplished through CP0.

If the master switches from a higher CP to a lower CP other than CP0, the slave shall then immediately return to CP0 and wait for the MDT0 of CP0 from the master. The communication error bit shall then be set in C1D.

9.3 Service channel error messages

Type 19 SVC error messages specifications shall be as for Type 16 (see IEC 61158-4-16, 7.3), with the following exceptions:

a) the error bit (bit) is defined in the SVC status;
b) if the slave recognizes an error, it shall acknowledge in addition by sending the error codes in the SVC INFO field (see 5.5.7.3.3);

Annex A
(normative)

IDN – Identification numbers

A.1 IDN specification

See IEC 61158-4-16, A.1.

Exception: As compared to Type 16, the numbering is extended to 32 bit. The upper 16 bits are set to zero if not used.

A.2 Identification numbers in numerical orders

Table A.1 lists the IDNs which are related to communication, and that devices of this type shall support. Their detailed description appears in A.3.

Application-specific data content is specified in other relevant standards, for example IEC 61800-7-20x.

Table A.1 – List of relevant communication-related IDNs

IDN number	IDN name
S-0-0014	Interface status
S-0-0015	Telegram type
S-0-0021	IDN-list of invalid operation data for CP2
S-0-0022	IDN-list of invalid operation data for CP3
S-0-0026	Configuration list for signal status word
S-0-0127	CP3 transition check
S-0-0128	CP4 transition check
S-0-0144	Signal status word
S-0-0145	Signal control word
S-0-0187	IDN-list of configurable data in the AT
S-0-0188	IDN-list of configurable data in the MDT
S-0-0328	IDN-list of configurable data as consumer
S-0-0329	Bit number allocation list for signal control word
S-0-0360	MDT data container A1
S-0-0361	MDT data container B1
S-0-0362	MDT data container A list index
S-0-0363	MDT data container B list index
S-0-0364	AT data container A1
S-0-0365	AT data container B1
S-0-0366	AT data container A list index
S-0-0367	AT data container B list index
S-0-0368	Data container A pointer
S-0-0369	Data container B pointer
S-0-0370	MDT data container A/B configuration list

IDN number	IDN name
S-0-0371	AT data container A/B configuration list
S-0-0398	IDN list of configurable real-time/status bits
S-0-0399	IDN list of configurable real-time/control bits
S-0-0444	IDN-list of configurable data in the AT data container
S-0-0445	IDN-list of configurable data in the MDT data container
S-0-0450	MDT data container A2
S-0-0451	MDT data container A3
S-0-0452	MDT data container A4
S-0-0453	MDT data container A5
S-0-0454	MDT data container A6
S-0-0455	MDT data container A7
S-0-0456	MDT data container A8
S-0-0457	MDT data container A9
S-0-0458	MDT data container A10
S-0-0459	MDT data container B2
S-0-0480	AT data container A2
S-0-0481	AT data container A3
S-0-0482	AT data container A4
S-0-0483	AT data container A5
S-0-0484	AT data container A6
S-0-0485	AT data container A7
S-0-0486	AT data container A8
S-0-0487	AT data container A9
S-0-0488	AT data container A10
S-0-0490	MDT data container A2 configuration list
S-0-0491	MDT data container A3 configuration list
S-0-0492	MDT data container A4 configuration list
S-0-0493	MDT data container A5 configuration list
S-0-0494	MDT data container A6 configuration list
S-0-0495	MDT data container A7 configuration list
S-0-0496	MDT data container A8 configuration list
S-0-0497	MDT data container A9 configuration list
S-0-0498	MDT data container A10 configuration list
S-0-0500	AT data container A2 configuration list
S-0-0501	AT data container A3 configuration list
S-0-0502	AT data container A4 configuration list
S-0-0503	AT data container A5 configuration list
S-0-0504	AT data container A6 configuration list
S-0-0505	AT data container A7 configuration list
S-0-0506	AT data container A8 configuration list
S-0-0507	AT data container A9 configuration list
S-0-0508	AT data container A10 configuration list
S-0-1000	SCP Type & Version

IDN number	IDN name
S-0-1002	Communication cycle time (t_{Scyc})
S-0-1003	Allowed MST losses in CP3/CP4
S-0-1005	Minimum feedback processing time (t_5)
S-0-1006	AT transmission starting time (t_1)
S-0-1007	Feedback acquisition capture point (t_4)
S-0-1008	Command value valid time (t_3)
S-0-1009	Device Control (C-Dev) offset in MDT
S-0-1010	Lengths of MDTs
S-0-1011	Device Status (S-Dev) offset in AT
S-0-1012	Lengths of ATs
S-0-1013	SVC offset in MDT
S-0-1014	SVC offset in AT
S-0-1015	Ring delay
S-0-1016	Slave delay
S-0-1017	NRT channel transmission time (t_6 and t_7)
S-0-1019	MAC address
S-0-1020	IP address
S-0-1021	Subnet mask
S-0-1022	Gateway address
S-0-1023	SYNC jitter
S-0-1024	SYNC delay measuring procedure command
S-0-1026	Version of communication hardware
S-0-1027.0.1	Requested MTU
S-0-1027.0.2	Effective MTU
S-0-1028	Error counter MST-P/S
S-0-1035	Error counter Port 1 & Port 2
S-0-1040	Device address
S-0-1041	AT Command value valid time (t9)
S-0-1044	Device control
S-0-1045	Device status
S-0-1046	List of device addresses in device
S-0-1050.x.1	Connection setup
S-0-1050.x.2	Connection Number
S-0-1050.x.3	Telegram assignment
S-0-1050.x.4	Max. Length of Connection
S-0-1050.x.5	Current length of Connection
S-0-1050.x.6	Configuration List
S-0-1050.x.8	Connection control
S-0-1050.x.10	Producer cycle time
S-0-1050.x.11	Allowed Data Losses
S-0-1050.x.12	Error Counter Data Losses
S-0-1050.x.20	IDN Allocation of real-time bit

IDN number	IDN name
S-0-1051	Image of connection setups
S-0-1100.0.1	Diagnostic counter sent SMP fragments
S-0-1100.0.2	Diagnostic counter received SMP fragments
S-0-1100.0.3	Diagnostic counter dropped SMP fragments
S-0-1101.x.1	SMP Container Data
S-0-1101.x.2	List of session identifiers
S-0-1101.x.3	List of session priorities

NOTE All other IDN numbers are reserved.

A.3 Detailed specification of communication-related IDNs

A.3.1 Type 16 IDNs that are relevant for Type 19

IDNs S-0-0001 to S-0-0999 are specified in IEC 61158-4-16, A.3.

Exception: All IDN-related IDNs use 4 octets instead of 2 octets.

A.3.2 IDN S-0-1000 SCP Type & Version

A.3.2.1 Attributes

Table A.2 shows the possible attributes for this IDN.

Table A.2 – Attributes of IDN S-0-1000

Attribute	Value
Name	SCP Type & Version
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	—
Unit	—

A.3.2.2 Description

The SCP Type & Version contains a list of the communication capabilities of this slave device and the dedicated version.

The bits 15 … 8 indicate the function group which is available in the slave device, bits 7 … 0 indicates the version of the function group.

A.3.3 IDN S-0-1002 Communication cycle time

A.3.3.1 Attributes

Table A.3 shows the possible attributes for this IDN.

Table A.3 – Attributes of IDN S-0-1002

Attribute	Value
Name	Communication cycle time (t_{Scyc})
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	31,250
Max. input value	65 000,000
Scaling/resolution	1
Unit	µs

A.3.3.2 Description

The communication cycle time of the interface defines the intervals during which the cyclic data are transferred. The communication cycle time shall be defined as 31,25 µs, 62,5 µs, 125 µs, 250 µs, ..., up to 65 000 µs in steps of 250 µs. The communication cycle time shall be transferred from the master to the slave during CP2 and becomes active in the master and all slaves during CP3.

Min/max input values are mandatory.

A.3.4 IDN S-0-1003 Allowed MST losses in CP3/CP4

A.3.4.1 Attributes

Table A.4 shows the possible attributes for this IDN.

Table A.4 – Attributes of IDN S-0-1003

Attribute	Value
Name	Allowed MST losses in CP3/CP4
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	—
Unit	—

A.3.4.2 Description

This parameter defines the maximum number of communication cycles in which a slave may not receive the MST in CP3 and CP4. The slave shall switch from CP3 or CP4 back to NRT mode if it did not receive its MST within more than this user-defined quantity. After half the amount of cycles specified in this parameter, the slave shall set the communication warning bit (bit 15) in its device status.

Whereas this parameter shall be set to a value that is large enough (compare to S-0-1050.x.11), so that the master can keep communicating with undisturbed sub-devices for safely stopping the other parts of the machine.

A.3.5 IDN S-0-1005 Minimum feedback processing time (t_5)

A.3.5.1 Attributes

Table A.5 shows the possible attributes for this IDN.

Table A.5 – Attributes of IDN S-0-1005

Attribute	Value
Name	Minimum feedback processing time (t_5)
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	0,001 µs

A.3.5.2 Description

The time t_5 determines the minimum time duration that is required by a drive between the start of feedback acquisition and the next AT transmission starting time (t_1). This value shall be declared by the drive in such a way that feedback values are transferred to the control unit during the next drive telegram. The master reads this value during CP2 in order to synchronize the measurement times of the feedback acquisition capture point, t_4 (S-0-1007) appropriately for all drives.

A.3.6 IDN S-0-1006 AT transmission starting time (t_1)

A.3.6.1 Attributes

Table A.6 shows the possible attributes for this IDN.

Table A.6 – Attributes of IDN S-0-1006

Attribute	Value
Name	AT transmission starting time (t_1)
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	T_{1min}
Max. input value	t_{Scyc}
Scaling/resolution	1
Unit	0,001 µs

A.3.6.2 Description

The AT transmission starting time determines when the master sends the AT0 during CP3 and CP4, following the MST. This parameter shall be transferred by the master to the slave during CP2.

A.3.7 IDN S-0-1007 Feedback acquisition capture point (t_4)

A.3.7.1 Attributes

Table A.7 shows the possible attributes for this IDN.

Table A.7 – Attributes for IDN S-0-1007

Attribute	Value
Name	Feedback acquisition capture point (t_4)
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	0
Max. input value	—
Scaling/resolution	1
Unit	0,001 µs

A.3.7.2 Description

The time t_4 determines the time duration between the end of the MST and the feedback acquisition capture point. In this way the master shall declare a default acquisition capture point for the feedback for all drives that work in coordination with each other. This ensures synchronized data acquisition of the feedback for the appropriate drives. The master shall set the acquisition capture point of the feedback related to the AT transmission starting time (S-0-1006), the requested minimum feedback processing time (S-0-1005) and the communication cycle time (S-0-1002) in either one of the following ways:

$t_4 \leq t_1 - t_5$ (feedback values transmitted in same communication cycle);

$t_{Scyc} \geq t_4 \geq t1$ (feedback values transmitted in next communication cycle).

The drive shall enable the acquisition capture point of the feedback during CP3.

A.3.8 IDN S-0-1008 Command value valid time (t_3)

A.3.8.1 Attributes

Table A.8 shows the possible attributes for this IDN.

Table A.8 – Attributes for IDN S-0-1008

Attribute	Value
Name	Command value valid time (t_3)
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	0
Max. input value	t_{Scyc}
Scaling/resolution	1
Unit	0,001 µs

A.3.8.2 Description

The time t_3 determines the time at which the drive is allowed to access the new command values after the completion of a MST. In this way the master provides the command value valid time for command values among all coordinated drives. The drive activates the command value valid time during CP3.

A.3.9 IDN S-0-1009 Device Control (C-Dev) offset in MDT

A.3.9.1 Attributes

Table A.9 shows the possible attributes for this IDN.

Table A.9 – Attributes of IDN S-0-1009

Attribute	Value
Name	Device Control (C-Dev) offset in MDT
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	14 (one slave)
Max. input value	1 492
Scaling/resolution	1
Unit	—

A.3.9.2 Description

The Device Control offset in MDT defines the position of a real-time data field of the slave in one of the four MDTs, expressed as an octet position. The offset shall start with 0xE for the initial data octet after the Type 19 header within the MDT. This parameter shall be transferred by the master to each slave during CP2. It shall become active during CP3 in the master and slave.

Table A.10 shows the structure of this IDN.

Table A.10 – C-Dev Offset in MDT

Bit number	Bit value	Description
15-14	00	No others values allowed
13-12	—	MDT-number
	00	MDT0
	01	MDT1
	10	MDT2
	11	MDT3
11-0	—	MDT RTC Offset in octet

A.3.10 IDN S-0-1010 Lengths of MDTs

A.3.10.1 Attributes

Table A.11 shows the possible attributes for this IDN.

Table A.11 – Attributes of IDN S-0-1010

Attribute	Value
Name	Lengths of MDTs
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min. input value	0
Max. input value	1 494 octet
Scaling/resolution	1
Unit	—

A.3.10.2 Description

The lengths of the MDTs shall be expressed in octets. The parameter shall contain the lengths of the four possible master data telegrams. All four lengths shall always be programmed. The lengths of the not configured MDTs shall be marked with 0. Each slave shall be informed by the master during CP2 of the lengths of all configured MDTs. It shall become active in the master and slave during CP3.

Figure A.1 shows the structure of this IDN as an example.

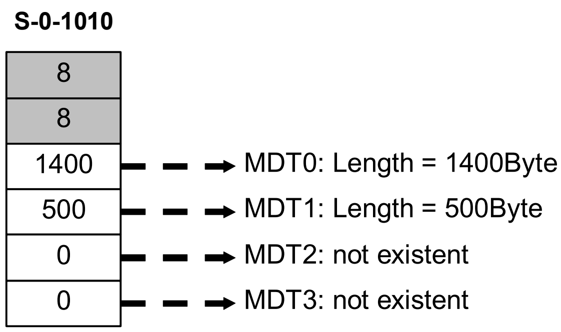


Figure A.1 – Lengths of MDTs (example)

A.3.11 IDN S-0-1011 Device Status (S-Dev) offset in AT

A.3.11.1 Attributes

Table A.12 shows the possible attributes for this IDN.

Table A.12 – Attributes of IDN S-0-1011

Attribute	Value
Name	Device Status (S-Dev) offset in AT
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	14 (one slave)
Max. input value	1 492
Scaling/resolution	1
Unit	—

A.3.11.2 Description

The Device Status offset in AT defines the position of a real-time data field of the slave in one of the four ATs, expressed as a octet position. The offset shall start with 0xE for the initial data octet after the Type 19 header within the AT. This parameter shall be transferred by the master to each slave during CP2. It shall become active during CP3 in the master and slave.

Table A.13 shows the structure of this IDN.

Table A.13 – S-Dev Offset in AT

Bit number	Bit value	Description
15-14	00	No others values allowed
13-12	—	AT-number
	00	AT0
	01	AT1
	10	AT2
	11	AT3
11-0	—	AT RTC Offset in octets

A.3.12 IDN S-0-1012 Lengths of ATs

A.3.12.1 Attributes

Table A.14 shows the possible attributes for this IDN.

Table A.14 – Attributes of IDN S-0-1012

Attribute	Value
Name	Lengths of ATs
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min input value	0
Max. input value	1 494 octet
Scaling/resolution	1
Unit	—

A.3.12.2 Description

The lengths of the ATs shall be expressed in octets. The parameter shall contain the lengths of the four possible ATs. All four lengths shall always be programmed. The lengths of the not configured ATs shall be marked with 0. Each slave shall be informed by the master during CP2 of the lengths of all configured ATs. It shall become active in the master and slave during CP3.

Figure A.2 shows the structure of this IDN, as an example.

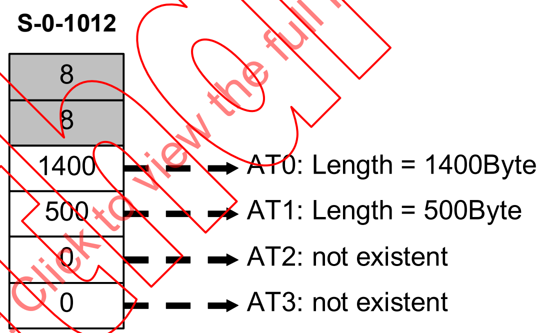


Figure A.2 – Lengths of ATs (example)

A.3.13 IDN S-0-1013 SVC offset in MDT

A.3.13.1 Attributes

Table A.15 shows the possible attributes for this IDN.

Table A.15 – Attributes of IDN S-0-1013

Attribute	Value
Name	SVC offset in MDT
Version	—
Length	2
Display Format	unsigned decimal
Min. input value	8
Max. input value	1 484
Scaling/resolution	1
Unit	—

A.3.13.2 Description

The SVC offset in MDT defines the position of a service channel for a slave in MDT0 or MDT1, expressed as a octet position. The offset shall start with 0x8 for the initial data octet after the Type 19 header within the MDT. Every slave shall be informed by the master during CP2 of the offset of the service channel in the MDT. This parameter shall become active during CP3 in the master and slave.

Table A.16 shows the structure of this IDN.

Table A.16 – SVC Offset in MDT

Bit number	Bit value	Description
15-14	0	No others values allowed
13-12	—	MDT-number
	00	MDT0
	01	MDT1
	10	MDT2
	11	Reserved
11-0	—	MDT SVC-Offset in octets

A.3.14 IDN S-0-1014 SVC offset in AT

A.3.14.1 Attributes

Table A.17 shows the possible attributes for this IDN.

Table A.17 – Attributes of IDN S-0-1014

Attribute	Value
Name	SVC offset in AT
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	8
Max. input value	1 484
Scaling/resolution	1
Unit	—

A.3.14.2 Description

The SVC offset in AT defines the position of a service channel of the slave in AT0 or AT1, expressed as a octet position. The offset shall start with 0x8 for the initial data octet after the Type 19 header within the AT. Every slave shall be informed by the master during CP2 of the offset of the service channel in the AT. This parameter shall become active during CP3 in the master and slave.

Table A.18 shows the structure of this IDN.

Table A.18 – SVC Offset in AT

Bit number	Bit value	Description
15-14	00	No others values allowed
13-12	—	AT-number
	00	AT0
	01	AT1
	10	AT2
	11	Reserved
11-0	—	AT SVC-Offset in octets

A.3.15 IDN S-0-1015 Ring delay

A.3.15.1 Attributes

Table A.19 shows the possible attributes for this IDN.

Table A.19 – Attributes of IDN S-0-1015

Attribute	Value
Name	Ring delay
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	0
Max. input value	—
Scaling/resolution	1
Unit	0,001 µs

A.3.15.2 Description

The master determines the ring delay and transfers it in CP2 to the slaves. Each slave shall use the ring delay for adjusting its synchronization time. With the synchronization adjustment the slave shall determine the synchronization counter (SYNCCNT-P/S) for the P and S channel.

A.3.16 IDN S-0-1016 Slave delay (P/S)

A.3.16.1 Attributes

Table A.20 shows the possible attributes for this IDN.

Table A.20 – Attributes of IDN S-0-1016

Attribute	Value
Name	Slave delay
Version	—
Length	4, variable
Display Format	Unsigned decimal
Min. input value	0
Max. input value	—
Scaling/resolution	1
Unit	0,001 µs

A.3.16.2 Description

The slave delay shall include two 4 octet elements. The first element shall be the SYNCCNT-P, the second element shall be the SYNCCNT-S. SYNCCNT-P shall be the delay from the MST-P to the synchronization time and SYNCCNT-S shall be the delay from the MST-S to the synchronization time. With SYNCCNT P/S the master shall determine the physical order of the slave in the topology.

A.3.17 IDN S-0-1017 NRT channel transmission time

A.3.17.1 Attributes

Table A.21 shows the possible attributes for this IDN.

Table A.21 – Attributes of IDN S-0-1017

Attribute	Value
Name	NRT channel transmission time
Version	—
Length	4, variable
Display Format	Unsigned decimal
Min. input value	0
Max. input value	$< t_{Scyc}$
Scaling/resolution	1
Unit	0,001 µs

A.3.17.2 Description

The transmission time of the non-real-time channel (NRT channel) shall include in the first element the time t_6 (begin of NRT channel) and in the second element the time t_7 (end of NRT channel). If t_6 is set to 0, the NRT channel shall not be used.

A.3.18 IDN S-0-1019 MAC address

A.3.18.1 Attributes

Table A.22 shows the possible attributes for this IDN.

Table A.22 – Attributes of IDN S-0-1019

Attribute	Value
Name	MAC address
Version	—
Length	1, variable
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.18.2 Description

The slave inserts his MAC address in this parameter.

Figure A.3 shows the structure of this IDN.

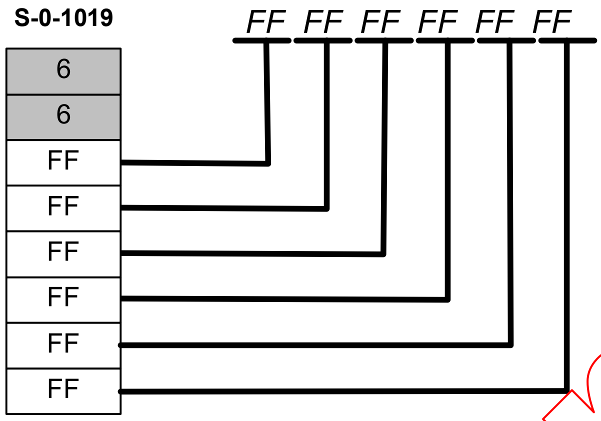


Figure A.3 – Structure of MAC address

A.3.19 IDN S-0-1020 IP address

A.3.19.1 Attributes

Table A.23 shows the possible attributes for this IDN.

Table A.23 – Attributes of IDN S-0-1020

Attribute	Value
Name	IP address
Version	—
Length	4, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.19.2 Description

This IDN contains the IP address. The master may change the IP address for NRT channel communication.

Figure A.4 shows the structure of this IDN.

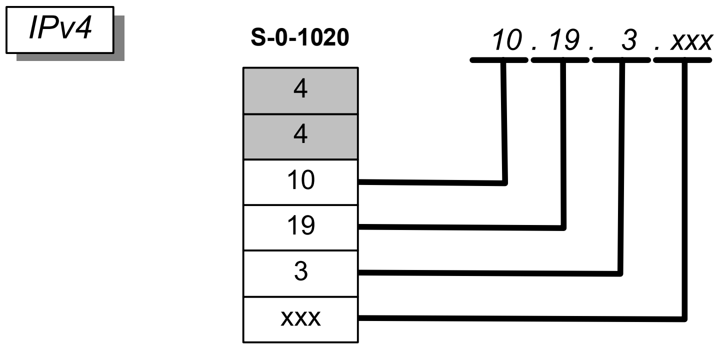


Figure A.4 – Structure of IP address

A.3.20 IDN S-0-1021 Subnet mask

A.3.20.1 Attributes

Table A.24 shows the possible attributes for this IDN.

Table A.24 – Attributes of IDN S-0-1021

Attribute	Value
Name	Subnet mask
Version	—
Length	1, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.20.2 Description

This IDN contains the subnet mask. The master may change the subnet mask for NRT channel communication.

Figure A.5 shows the structure of this IDN.

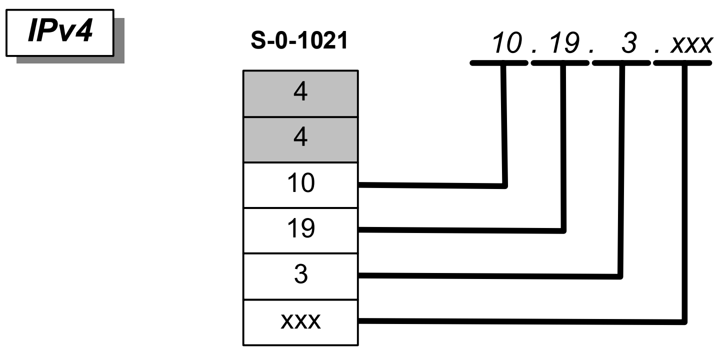


Figure A.5 – Structure of subnet mask

A.3.21 IDN S-0-1022 Gateway address

A.3.21.1 Attributes

Table A.25 shows the possible attributes for this IDN.

Table A.25 – Attributes of IDN S-0-1022

Attribute	Value
Name	Gateway address
Version	—
Length	1, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.21.2 Description

This IDN contains the gateway address. The master may change the gateway address for NRT channel communication.

Figure A.6 shows the structure of this IDN.

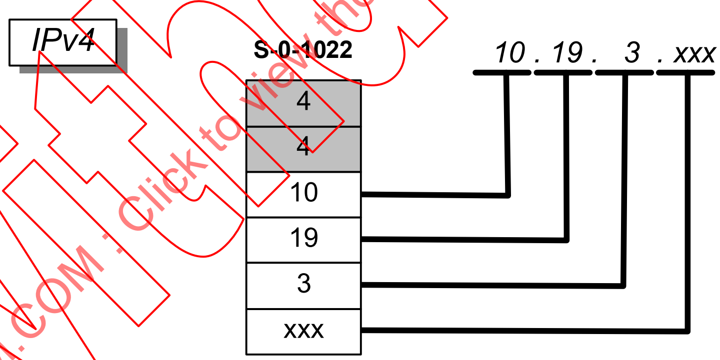


Figure A.6 – Structure of gateway address

A.3.22 IDN S-0-1023 SYNC jitter

A.3.22.1 Attributes

Table A.26 shows the possible attributes for this IDN.

Table A.26 – Attributes of IDN S-0-1023

Attribute	Value
Name	SYNC jitter
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.22.2 Description

The master shall program the maximum synchronization jitter. The jitter is used in the slave to determine the width of the MST receive window. The MST receive window is 2x synchronization jitter.

A.3.23 IDN S-0-1024 SYNC delay measuring procedure command

A.3.23.1 Attributes

Table A.27 shows the possible attributes for this IDN.

Table A.27 – Attributes of IDN S-0-1024

Attribute	Value
Name	SYNC delay measuring procedure command
Version	—
Length	2
Display Format	Binary
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.23.2 Description

After activation of this procedure command the slave shall determine the slave delay (P/S) (S-0-1016) depending on the ring delay (S-0-1015).

a) In CP2 the positive acknowledgment is generated if the slave was able to determine valid slave delay (P/S). In this case the slave synchronizes in CP3 automatically.
b) In CP3/4 the positive acknowledgment is generated if the slave was able to determine valid slave delay (P/S) and the slave has synchronized again.

Otherwise the slave will generate a negative acknowledgment and diagnostic codes in the diagnostic number (S-0-0390).

The master has to activate this procedure command

a) and wait until it is finished in CP2 before activation of S-0-0127;
b) in CP3 and CP4 after the ring recovery

in every slave which has to be synchronized.

A.3.24 IDN S-0-1026 Version of communication hardware

A.3.24.1 Attributes

Table A.28 shows the possible attributes for this IDN.

Table A.28 – Attributes of IDN S-0-1026

Attribute	Value
Name	Version of communication hardware
Version	—
Length	1, variable
Display Format	Text
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.24.2 Description

This parameter contains the version of the specific communication hardware.

A.3.25 IDN S-0-1027.0.1 Requested MTU

A.3.25.1 Attributes

Table A.29 shows the possible attributes for this IDN.

Table A.29 – Attributes of IDN S-0-1027.0.1

Attribute	Value
Name	Requested MTU
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.25.2 Description

The requested MTU defines the maximum number of octets, that may be sent within the NRT channel by higher layers. This IDN only defines the target value for the MTU and is used to calculate the effective MTU which can be read from S-0-1027.0.2. The effective value may be different from the target value, if the target value does not lie in between the limits of the current phase.

A.3.26 IDN S-0-1027.0.2 Effective MTU

A.3.26.1 Attributes

Table A.30 shows the possible attributes for this IDN.

Table A.30 – Attributes of IDN S-0-1027.0.2

Attribute	Value
Name	Effective MTU
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.26.2 Description

This IDN is the current MTU. The current MTU is calculated using S-0-1017 and S-0-1027.0.1.

A.3.27 IDN S-0-1028 Error counter MST-P/S

A.3.27.1 Attributes

Table A.31 shows the possible attributes for this IDN.

Table A.31 – Attributes of IDN S-0-1028

Attribute	Value
Name	Error counter MST-P/S
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.27.2 Description

The MST error counter is incremented if a valid MST is neither received on port 1 nor on port 2 in communication phases 3 and 4.

The MST error counter shall stop counting as soon as it reaches 65 535. It means that if the counter has a value of 65 535, there may have been more than 65 535 invalid MST's (for example: noisy transmission over a long period of time).

The error counter MST-P/S is reseted with S-0-0127.

A.3.28 IDN S-0-1035 Error counter Port 1 & Port 2

A.3.28.1 Attributes

Table A.32 shows the possible attributes for this IDN.

Table A.32 – Attributes of IDN S-0-1035

Attribute	Value
Name	Error counter Port 1 & Port 2
Version	—
Length	4
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.28.2 Description

This counter counts all Ethernet errors such as

a) received Ethernet frames with defective frame check sequence or RxER indications;

b) received Ethernet frames with a defective frame. Defective frames are wrong aligned frames.

The low word represents port 1, the high word represents port 2.

The counter shall start in CP0 and will be incremented maximal one time per communication cycle. The counter is writable, so a human machine interface may reset this counter. The maximum value is 0xFFFF. The counters are not buffered, so they are 0x0000 on power-on.

A.3.29 IDN S-0-1040 Device address

A.3.29.1 Attributes

Table A.33 shows the possible attributes for this IDN.

Table A.33 – Attributes of IDN S-0-1040

Attribute	Value
Name	Device address
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	0
Max. input value	511
Scaling/resolution	1
Unit	—

A.3.29.2 Description

This parameter contains the device address which is assigned to the sub-device.

a) If the sub-device has no address switch the sub-device shall store the known address in this parameter;

b) If the sub-device contains an address switch so this operational data is not changeable.

The default value shall be 0.

A.3.30 IDN S-0-1041 AT Command value valid time (t9)

A.3.30.1 Attributes

Table A.34 shows the possible attributes for this IDN.

Table A.34 – Attributes of IDN S-0-1041

Attribute	Value
Name	AT Command value valid time (t9)
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	µs

A.3.30.2 Description

Void.

A.3.31 IDN S-0-1044 Device Control

A.3.31.1 Attributes

Table A.35 shows the possible attributes for this IDN.

Table A.35 – Attributes of IDN S-0-1044

Attribute	Value
Name	Device Control
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.31.2 Description

Void.

A.3.32 IDN S-0-1045 Device Status

A.3.32.1 Attributes

Table A.36 shows the possible attributes for this IDN.

Table A.36 – Attributes of IDN S-0-1045

Attribute	Value
Name	Device Status
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.32.2 Description

Void.

A.3.33 IDN S-0-1046 List of device addresses in device

A.3.33.1 Attributes

Table A.37 shows the possible attributes for this IDN.

Table A.37 – Attributes of IDN S-0-1046

Attribute	Value
Name	List of device addresses in device
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.33.2 Description

The device stores the device addresses of the slaves that participate in the communication. If only one slave exists in the device, this IDN may be absent.

A.3.34 IDN S-0-1050.x.1 Connection setup

A.3.34.1 Attributes

Table A.38 shows the possible attributes for this IDN.

Table A.38 – Attributes of IDN S-0-1050.x.1

Attribute	Value
Name	Connection setup
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.34.2 Description

This parameter configures connections.

A.3.35 IDN S-0-1050.x.2 Connection Number

A.3.35.1 Attributes

Table A.39 shows the possible attributes for this IDN.

Table A.39 – Attributes of IDN S-0-1050.x.2

Attribute	Value
Name	Connection Number
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.35.2 Description

The connection number is used to identify a connection.

a) Producer and consumer of the same connection have the same connection number.

b) The master slave relation consists of two connections one in MDT and one in the AT.

A.3.36 IDN S-0-1050.x.3 Telegram assignment

A.3.36.1 Attributes

Table A.40 shows the possible attributes for this IDN.

Table A.40 – Attributes of IDN S-0-1050.x.3

Attribute	Value
Name	Telegram assignment
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.36.2 Description

The telegram assignment defines

a) the telegram type (MDT or AT);

b) the telegram number, and

c) the position (offset in the telegram)

for this connection. The telegram offset points to the Connection control (C-Con) of this connection. This offset shall start with 0xE octets for the initial data after the Type 19 telegram header within the MDT or AT.

A.3.37 IDN S-0-1050.x.4 Max. Length of Connection

A.3.37.1 Attributes

Table A.41 shows the possible attributes for this IDN.

Table A.41 – Attributes of IDN S-0-1050.x.4

Attribute	Value
Name	Max. Length of Connection
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.37.2 Description

This parameter defines the maximum length of this connection. The 2 octets for the connection control (C-Con) are part of this length. If the slave shows a length of n octets this length contains 2 octets C-Con and n-2 octets data.

A.3.38 IDN S-0-1050.x.5 Current length of connection

A.3.38.1 Attributes

Table A.42 shows the possible attributes for this IDN.

Table A.42 – Attributes of IDN S-0-1050.x.5

Attribute	Value
Name	Current length of connection
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.38.2 Description

This parameter defines the current length of this connection. The 2 octets for the connection control (C-Con) are part of this length. If the slave shows a length of n octets this length contains 2 octets C-Con and n-2 octets data. This parameter shall be updated by the slave if configuration parameter are changed.

A.3.39 IDN S-0-1050.x.6 Configuration List

A.3.39.1 Attributes

Table A.43 shows the possible attributes for this IDN.

Table A.43 – Attributes of IDN S-0-1050.x.6

Attribute	Value
Name	Configuration List
Version	—
Length	4, variable
Display Format	IDN
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.39.2 Description

If the connection data is configured with IDNs (type of connection, bit 5-4 = 00, in S-0-1050.x.1) this parameter contains the list of ident numbers (4 octets) within this connection.

A.3.40 IDN S-0-1050.x.8 Connection Control

A.3.40.1 Attributes

Table A.44 shows the possible attributes for this IDN.

Table A.44 – Attributes of IDN S-0-1050.x.8

Attribute	Value
Name	Connection Control
Version	—
Length	2
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.40.2 Description

This parameter contains the image of the control word C-Con of this connection.

A.3.41 IDN S-0-1050.x.10 Producer cycle time

A.3.41.1 Attributes

Table A.45 shows the possible attributes for this IDN.

Table A.45 – Attributes of IDN S-0-1050.x.10

Attribute	Value
Name	Producer cycle time
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	µs

A.3.41.2 Description

This parameter describes the cycle time of a connection.

A.3.42 IDN S-0-1050.x.11 Allowed Data Losses

A.3.42.1 Attributes

Table A.46 shows the possible attributes for this IDN.

Table A.46 – Attributes of IDN S-0-1050.x.11

Attribute	Value
Name	Allowed Data Losses
Version	
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.42.2 Description

This parameter indicates the maximum amount of consecutive lost producer data, before a connection is broken. If this connection is broken the consumer shall not process data anymore and sets the connection error in the device status. The default value = 1.

A.3.43 IDN S-0-1050.x.12 Error Counter Data Losses

A.3.43.1 Attributes

Table A.47 shows the possible attributes for this IDN.

Table A.47 – Attributes of IDN S-0-1050.x.12

Attribute	Value
Name	Error Counter Data Losses
Version	—
Length	2
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.43.2 Description

This parameter counts the amount of lost producer data. This counter will be reset with the positive edge of the designated Producer ready in the Connection control. This counter is without overrun and ends with 65 535.

A.3.44 IDN S-0-1050.x.20 IDN Allocation of real-time bit

A.3.44.1 Attributes

Table A.48 shows the possible attributes for this IDN.

Table A.48 – Attributes of IDN S-0-1050.x.20

Attribute	Value
Name	IDN Allocation of real-time bit
Version	—
Length	4, variable
Display Format	IDN
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.44.2 Description

In order to assign signals to the real-time bits, the IDN of the signal is written to this parameter. After the allocation of the bit number in S-0-1050.x.21, the assigned signal is copied in the corresponding real-time bit. If the S-0-1050.x.21 isn't supported by the slave, the bit 0 of the IDN is configured automatically. This list contains a maximum of 2 entries.

a) List element 0 corresponds to real-time bit 1

b) List element 1 corresponds to real-time bit 2

A.3.45 IDN S-0-1050.x.21 IDN Allocation of real-time bit

A.3.45.1 Attributes

Table A.49 shows the possible attributes for this IDN.

Table A.49 – Attributes of IDN S-0-1050.x.21

Attribute	Value
Name	Bit allocation of real-time bit
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.45.2 Description

This parameter contains the bit number of the operation data assigned in the S-0-1050.x.20. The signal assigned by an IDN (S-0-1050.x.20) and a bit number (S-0-1050.x.21) is copied into the corresponding real-time bit. This list contains a maximum of 2 entries.

a) List element 0 corresponds to real-time bit 1

b) List element 1 corresponds to real-time bit 2

A.3.46 IDN S-0-1051 Image of connection setups

A.3.46.1 Attributes

Table A.50 shows the possible attributes for this IDN.

Table A.50 – Attributes of IDN S-0-1051

Attribute	Value
Name	Image of connection setups
Version	—
Length	2, variable
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.46.2 Description

This IDN shows the actual state of all the connections of the slave, corresponding to S-0-1050.x.1.

The quantity of list elements shows the maximum number of connections of this slave.

A.3.47 IDN S-0-1100.0.1 Diagnostic counter sent SMP fragments

A.3.47.1 Attributes

Table A.51 shows the possible attributes for this IDN.

Table A.51 – Attributes of IDN S-0-1100.0.1

Attribute	Value
Name	Diagnostic counter sent SMP fragments
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.47.2 Description

This parameter displays the number of SMP fragments transmitted via the SMP stack since system startup. The counter will auto-rollover to zero at 2^32-1.

A.3.48 IDN S-0-1100.0.2 Diagnostic counter received SMP fragments

A.3.48.1 Attributes

Table A.52 shows the possible attributes for this IDN.

Table A.52 – Attributes of IDN S-0-1100.0.2

Attribute	Value
Name	Diagnostic counter received SMP fragments
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.48.2 Description

This parameter displays the number of SMP fragments received by the SMP stack since system startup. The counter will auto-rollover to zero at 2^32-1.

A.3.49 IDN S-0-1100.0.3 Diagnostic counter dropped SMP fragments

A.3.49.1 Attributes

Table A.53 shows the possible attributes for this IDN.

Table A.53 – Attributes of IDN S-0-1100.0.3

Attribute	Value
Name	Diagnostic counter dropped SMP fragments
Version	—
Length	4
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.49.2 Description

This parameter displays the number of SMP fragments received by SMP stack that were dropped because its header did not match the receiver's expectations.

Reasons for this include:

a) invalid session ID,

b) wrong sequence count,

c) incorrect sequence of the FOS/LOS bits.

The counter shows the number of dropped fragments since system startup and will auto-rollover to zero at 2^32-1.

A.3.50 IDN S-0-1101.x.1 SMP Container Data

A.3.50.1 Attributes

Table A.54 shows the possible attributes for this IDN.

Table A.54 – Attributes of IDN S-0-1101.x.1

Attribute	Value
Name	SMP Container Data
Version	—
Length	2, variable
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.50.2 Description

This parameter contains the actual data transmitted via a SMP container.

A.3.51 IDN S-0-1101.x.2 List of session identifiers

A.3.51.1 Attributes

Table A.55 shows the possible attributes for this IDN.

Table A.55 – Attributes of IDN S-0-1101.x.2

Attribute	Value
Name	List of session identifiers
Version	—
Length	2, variable
Display Format	Hexadecimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.51.2 Description

This parameter contains the list of all session identifiers currently set up for a SMP container. Each list entry corresponds to the list entry with the same index in S-0-1101.x.3 and defines the identifier for this session.

The lists in S-0-1101.x.2 and S-0-1101.x.3 shall have the same actual length.

A.3.52 IDN S-0-1101.x.3 List of session priorities

A.3.52.1 Attributes

Table A.56 shows the possible attributes for this IDN.

Table A.56 – Attributes of IDN S-0-1101.x.3

Attribute	Value
Name	List of session priorities
Version	—
Length	2, variable
Display Format	Unsigned decimal
Min. input value	—
Max. input value	—
Scaling/resolution	1
Unit	—

A.3.52.2 Description

This parameter contains a list of priority values for the sessions in this SMP container. Each list entry corresponds to the list entry with the same index in S-0-1101.x.2 and defines the priority for this session. The highest priority is 0, the lowest priority is 3.

The lists in S-0-1101.x.2 and S-0-1101.x.3 shall have the same actual length.

Annex B
(normative)

SCP– Classification

B.1 General concept of profiling

Type 19 offers two different views upon the grouping of IDNs. One view is the view of the specification the other one is the point of view of an application.

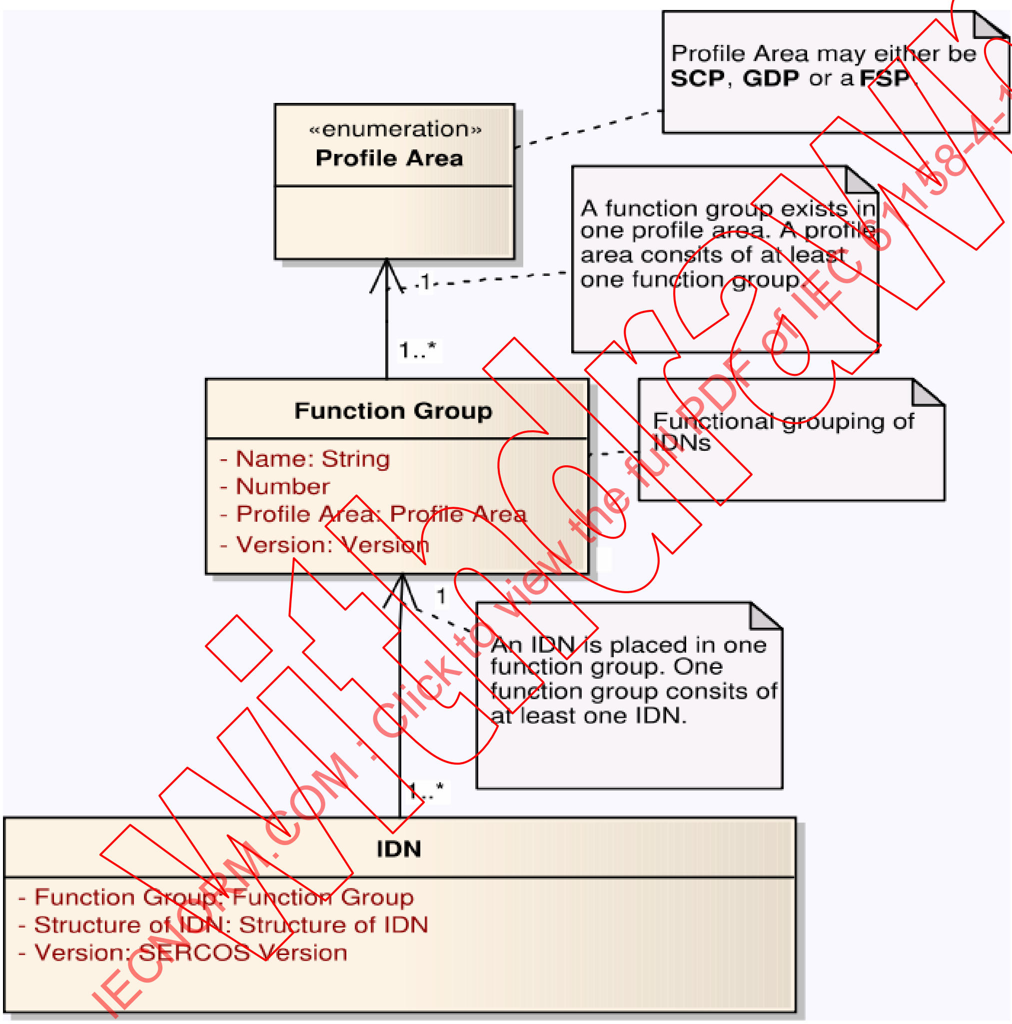


Figure B.1 – Technical Profiling in Type 19

Figure B.1 shows the technical view. Each IDNs is existent in a function group. A function group is a functional grouping of IDNs. Each function group is existent in a so called profile area. This profile area may either be SCP, GDP or a FSP (for example: FSP_Drive, FSP_IO).

An application expects certain functionalities in a device. So another view upon the profiling is introduced. This is called application profiling. Application profiling uses classes to group functionality described in the technical specification to groups that can be implemented in devices. This is to help device manufactures of slave devices to decide which functionality may be grouped to make sense. On the other hand this view also helps master manufactures, since this classing provides an easy view upon the slave device.

For the profile areas SCP and GDP an IDN exists, which shows the classes implemented in a device:

a) SCP: IDN S-0-1000 once per slave
b) GDP: IDN S-0-1301 once per sub-device

For modular structured devices, the following IDN for the FSP profile area exists:

a) FSP: IDN S-0-1302.x.2 one for each resource in the sub-device

B.2 Function Groups related to the SCP

B.2.1 FG SCP Identification

The function group FG SCP Classification groups all IDNs, that are related to the classification of a slave on SCP level. This function group includes the following IDNs:

a) IDN S-0-1000 SCP Type & Version

B.2.2 FG Timing

The function group FG Timing groups all IDNs that are related to the timing. This function group includes the following IDNs:

a) IDN S-0-1002 Communication Cycle time (tScyc)
b) IDN S-0-1005 Minimum feedback processing time (t5)
c) IDN S-0-1006 AT0 transmission starting time (t1)
d) S-0-1007 Feedback acquisition capture point (t4)
e) IDN S-0-1008 Command value valid time (t3)
f) IDN S-0-1015 Ring delay
g) IDN S-0-1016 Slave delay (P/S)
h) IDN S-0-1023 SYNC jitter
i) IDN S-0-1024 SYNC delay measuring procedure command
j) IDN S-0-1041 AT Command value valid time (t9)

B.2.3 FG Telegramm Setup

The function group FG Telegram Setup groups all IDNs, that are related to the configuration of the telegrams. This function group includes the following IDNs:

a) IDN S-0-1009 Device Control (C-Dev) offset in MDT
b) IDN S-0-1010 Lengths of MDTs
c) IDN S-0-1011 Device Status (S-Dev) offset in AT
d) IDN S-0-1012 Length of ATs
e) IDN S-0-1013 SVC offset in MDT
f) IDN S-0-1014 SVC offset in AT

B.2.4 FG Control

The function group FG Control groups all IDNs, which are related to the control of the communication state machine of the slave. This function group includes the following IDNs:

a) IDN S-0-0021 IDN-list of invalid operation data for CP2
b) IDN S-0-0022 IDN-list of invalid operation data for CP3
c) IDN S-0-0127 CP3 transition check

d) IDN S-0-0128 CP4 transition check

B.2.5 FG Bus-Diagnosis

The function group FG Bus-Diagnosis groups all IDNs, which are related to bus diagnosis. This function group includes the following IDNs:

a) IDN S-0-0014 Interface Status
b) IDN S-0-1003 Allowed MST losses in CP3/CP4
c) IDN S-0-1026 Version of communication hardware
d) IDN S-0-1028 Error counter MST-P/S
e) IDN S-0-1031 Test pin assignment Port 1 & Port 2
f) IDN S-0-1035 Error counter Port1 and Port2
g) IDN S-0-1040 Type 19 address
h) IDN S-0-1044 Device Control (C-Dev)
i) IDN S-0-1045 Device Status (S-Dev)
j) IDN S-0-1046 List of Type 19 addresses in device

B.2.6 FG Connection

The function group FG Connection groups all IDNs, that are related the configuration of connections. This function group includes the following IDNs:

a) IDN S-0-0187 IDN-list of configurable data as producer
b) IDN S-0-0188 IDN-list of configurable data as consumer
c) IDN S-0-1050 Connections
d) IDN S-0-1050.x.1 Connection setup
e) IDN S-0-1050.x.10 Producer Cycle Time
f) IDN S-0-1050.x.11 Allowed Data Losses
g) IDN S-0-1050.x.12 Error Counter Data Losses
h) IDN S-0-1050.x.2 Connection Number
i) IDN S-0-1050.x.20 IDN Allocation of real-time bit
j) IDN S-0-1050.x.3 Telegram Assignment
k) IDN S-0-1050.x.4 Max. Length Of Connection
l) IDN S-0-1050.x.5 Current length of connection
m) IDN S-0-1050.x.6 Configuration List
n) IDN S-0-1050.x.8 Connection Control (C-Con)
o) IDN S-0-1051 Image of connection setups

B.2.7 FG NRT

The function group FG Connection groups all IDNs, which are related to the communication in the NRT channel. This function group includes the following IDNs:

a) IDN S-0-1017 NRT transmission time
b) IDN S-0-1019 MAC Address
c) IDN S-0-1020 IP address
d) IDN S-0-1021 Subnet Mask
e) IDN S-0-1022 Gateway address
f) IDN S-0-1027.0.1 Requested MTU

g) IDN S-0-1027.0.2 Effective MTU

And the following Control and Status Bits

a) Status physical topology in the device control

B.2.8 FG MUX

The function group FG Mux groups all IDNs, that are related the usage of the multiplex channel within a connection. This function group includes the following IDNs:

a) IDN S-0-0360 MDT data container A1
b) IDN S-0-0361 MDT data container B1
c) IDN S-0-0362 MDT data container A list index
d) IDN S-0-0363 MDT data container B list index
e) IDN S-0-0364 AT data container A1
f) IDN S-0-0365 AT data container B1
g) IDN S-0-0366 AT data container A list index
h) IDN S-0-0367 AT data container B list index
i) IDN S-0-0368 Data container A pointer
j) IDN S-0-0369 Data container B pointer
k) IDN S-0-0370 MDT data container A/B configuration list
l) IDN S-0-0371 AT data container A/B configuration list
m) IDN S-0-0444 IDN-list of configurable data in the AT data container
n) IDN S-0-0445 IDN-list of configurable data in the MDT data container
o) IDN S-0-0450 MDT data container A2
p) IDN S-0-0451 MDT data container A3
q) IDN S-0-0452 MDT data container A4
r) IDN S-0-0453 MDT data container A5
s) IDN S-0-0454 MDT data container A6
t) IDN S-0-0455 MDT data container A7
u) IDN S-0-0456 MDT data container A8
v) IDN S-0-0457 MDT data container A9
w) IDN S-0-0458 MDT data container A10
x) IDN S-0-0459 MDT data container B2
y) IDN S-0-0480 AT data container A2
z) IDN S-0-0481 AT data container A3
aa) IDN S-0-0482 AT data container A4
bb) IDN S-0-0483 AT data container A5
cc) IDN S-0-0484 AT data container A6
dd) IDN S-0-0485 AT data container A7
ee) IDN S-0-0486 AT data container A8
ff) IDN S-0-0487 AT data container A9
gg) IDN S-0-0488 AT data container A10
hh) IDN S-0-0489 AT data container B2
ii) IDN S-0-0490 MDT data container A2 configuration list
jj) IDN S-0-0491 MDT data container A3 configuration list

kk) IDN S-0-0492 MDT data container A4 configuration list
ll) IDN S-0-0493 MDT data container A5 configuration list
mm) IDN S-0-0494 MDT data container A6 configuration list
nn) IDN S-0-0495 MDT data container A7 configuration list
oo) IDN S-0-0496 MDT data container A8 configuration list
pp) IDN S-0-0497 MDT data container A9 configuration list
qq) IDN S-0-0498 MDT data container A10 configuration list
rr) IDN S-0-0500 AT data container A2 configuration list
ss) IDN S-0-0501 AT data container A3 configuration list
tt) IDN S-0-0502 AT data container A4 configuration list
uu) IDN S-0-0503 AT data container A5 configuration list
vv) IDN S-0-0504 AT data container A6 configuration list
ww) IDN S-0-0505 AT data container A7 configuration list
xx) IDN S-0-0506 AT data container A8 configuration list
yy) IDN S-0-0507 AT data container A9 configuration list
zz) IDN S-0-0508 AT data container A10 configuration list

B.2.9 FG SMP

The function group FG SMP groups all IDNs, which are related to the usage of the Type 19 Messaging Protocol (SMP). This function group includes the following IDNs:

a) IDN S-0-1100.0.1 Diagnostic counter sent SMP fragments
b) IDN S-0-1100.0.2 Diagnostic counter received SMP fragments
c) IDN S-0-1100.0.3 Diagnostic counter dropped SMP fragments
d) IDN S-0-1101.x.1 SMP Container Data
e) IDN S-0-1101.x.2 List of session identifiers
f) IDN S-0-1101.x.3 List of session priorities

B.3 Type 19 communication classes

B.3.1 General

Type 19 defines several communication classes that may be implemented by slaves. Two of these define the basic communication and are mutually exclusive:

a) SCP_FixCFG
b) SCP_VarCFG

The other communication classes may be implemented on top of them.

B.3.2 SCP_FixCFG

SCP_FixCfg is a basic class in the SCP. A slave, which implements SCP_FixCfg provides the following features on the communication level:

a) A full-featured service channel.
b) Cyclic device control and status words.
c) Exact two connections are supported, one as consumer and one as producer:
   1) The connection which is consumed may either be placed in any MDT or AT. The position of this connection is not dependent on the place where device control is placed.

2) The connection which is produced may be placed in any AT. The position of this connection is not dependent on the place where device status is placed.

d) The content of the connections is defined by the slave and cannot be changed by the master

FG SCP Classification

IDN S-0-1000 SCP Type & Version

FG Timing

IDN S-0-1002 Communication Cycle time (tScyc)

FG Telegram Setup

a) IDN S-0-1009 Device Control (C-Dev) offset in MDT
b) IDN S-0-1010 Lengths of MDTs
c) IDN S-0-1011 Device Status (S-Dev) offset in AT
d) IDN S-0-1012 Length of ATs
e) IDN S-0-1013 SVC offset in MDT
f) IDN S-0-1014 SVC offset in AT

FG Control

a) IDN S-0-0021 IDN-list of invalid operation data for CP2
b) IDN S-0-0022 IDN-list of invalid operation data for CP3
c) IDN S-0-0127 CP3 transition check
d) IDN S-0-0128 CP4 transition check

FG Bus-Diagnosis

a) IDN S-0-1003 Allowed MST losses in CP3/CP4
b) IDN S-0-1026 Version of communication hardware
c) IDN S-0-1035 Error counter Port1 and Port2
d) IDN S-0-1040 Type 19 address
e) IDN S-0-1046 List of Type 19 addresses in device

FG Connection

a) IDN S-0-1050.x.3 Telegram Assignment
b) IDN S-0-1050.x.5 Current length of connection

Bits related to the Profile

a) New data (new producer data) in the connection control
b) Producer ready in the connection control
c) Identification in the connection control
d) Topology HS in the connection control
e) Topology control in the device control
f) Communication warning interface in the device status
g) Error connection in the device status
h) Parameterization levels in the device status
i) Procedure command change bit in the device status
j) Slave valid in the device status
k) Status of inactive port in the device status

l) Topology HS in the device status

m) Topology status in the device status

FG NRT

- IDN S-0-1017 NRT transmission time

Bits related to the Profile

- Status physical topology in the connection control

B.3.3 SCP_VarCFG

SCP_VarCfg is a basic class in the SCP. A slave, which implements SCP_VarCfg provides the following features on the communication level:

a) A full-featured service channel.

b) Cyclic device control and status words.

c) A certain number of connections is supported. The slave defines this number and provides it to the master.

   1) The connections which are consumed may either be placed in any MDT or AT. The position of this connection is not dependent on the place where device control is placed.

   2) The connections which are produced may be placed in any AT. The position of this connection is not dependent on the place where device status is placed.

d) The content of all connections have to be configured (for example by the master). The slave provides lists of IDNs, which can be cyclically produced and consumed, so the master can find it out.

FG SCP Classification

IDN S-0-1000 SCP Type & Version

FG Timing

IDN S-0-1002 Communication Cycle time (tScyc)

FG Telegram Setup

a) IDN S-0-1009 Device Control (C-Dev) offset in MDT

b) IDN S-0-1010 Lengths of MDTs

c) IDN S-0-1011 Device Status (S-Dev) offset in AT

d) IDN S-0-1012 Length of ATs

e) IDN S-0-1013 SVC offset in MDT

f) IDN S-0-1014 SVC offset in AT

FG Control

a) IDN S-0-0021 IDN-list of invalid operation data for CP2

b) IDN S-0-0022 IDN-list of invalid operation data for CP3

c) IDN S-0-0127 CP3 transition check

d) IDN S-0-0128 CP4 transition check

FG Bus-Diagnosis

a) IDN S-0-0014 Interface Status

b) IDN S-0-1003 Allowed MST losses in CP3/CP4

c) IDN S-0-1026 Version of communication hardware

d) IDN S-0-1035 Error counter Port1 and Port2

e) IDN S-0-1040 Type 19 address

f) IDN S-0-1046 List of Type 19 addresses in device

FG Connection

a) IDN S-0-0187 IDN-list of configurable data as producer

b) IDN S-0-0188 IDN-list of configurable data as consumer

c) IDN S-0-1050.x.07 Assigned connection capability

d) IDN S-0-1050.x.1 Connection setup

e) IDN S-0-1050.x.2 Connection Number

f) IDN S-0-1050.x.3 Telegram Assignment

g) IDN S-0-1050.x.4 Max. Length Of Connection

h) IDN S-0-1050.x.5 Current length of connection

i) IDN S-0-1050.x.6 Configuration List

j) IDN S-0-1051 Image of connection setups

Bits related to the Profile

a) New data (new producer data) in the connection control

b) Producer ready in the connection control

c) Identification in the device control

d) Topology HS in the device control

e) Topology control in the device control

f) Communication warning interface in the device status

g) Error connection in the device status

h) Parameterization levels in the device status

i) Procedure command change bit in the device status

j) Slave valid in the device status

k) Status of inactive port in the device status

l) Topology HS in the device status

m) Topology status in the device status

FG NRT

a) IDN S-0-1017 NRT transmission time

Bits related to the Profile

a) Status physical topology in the device control

B.3.4 SCP_Sync

SCP_Sync is a class in the SCP. A slave, which implements SCP_Sync provides the ability to isochronously produce and consume cyclic data.

The following bits have to be supported by a slave, which implements SCP_Sync:

a) Data field delay in the connection control

b) Producer synchronization in the connection control

The following IDNs have to be supported by a salve, which implements SCP_Sync:

a) IDN S-0-1005 Minimum feedback processing time (t5)