



BSI Standards Publication

Industrial communication networks — Fieldbus specifications

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

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National foreword

This British Standard is the UK implementation of EN 61158-4-19:2012. It is identical to IEC 61158-4-19:2010. It supersedes BS EN 61158-4-19:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AMT/7, Industrial communications: process measurement and control, including fieldbus.

A list of organizations represented on this committee can be obtained on request to its secretary.

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**Industrial communication networks -
Fieldbus specifications -
Part 4-19: Data-link layer protocol specification -
Type 19 elements
(IEC 61158-4-19:2010)**

Réseaux de communication industriels -
Spécifications de bus de terrain -
Partie 4-19: Spécification du protocole de
couche de liaison de données -
Éléments de Type 19
(CEI 61158-4-19:2010)

Industrielle Kommunikationsnetze -
Feldbusse -
Teil 4-19: Protokollspezifikation des Data
Link Layer (Sicherungsschicht) -
Typ 19-Elemente
(IEC 61158-4-19:2010)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 65C/605/FDIS, future edition 2 of IEC 61158-4-19, prepared by SC 65C, "Industrial networks", of IEC/TC 65, "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61158-4-19:2012.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2012-12-28
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2015-03-28

This document supersedes EN 61158-4-19:2008.

EN 61158-4-19:2012 includes the following significant technical changes with respect to EN 61158-4-19:2008:

- 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61158-4-19:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61131 series	NOTE	Harmonized in EN 61131 series.
IEC/TR 61158-1:2010	NOTE	Harmonized as CLC/TR 61158-1:2010 (not modified).
IEC 61158-3-19:2010	NOTE	Harmonized as EN 61158-3-19:2012 (not modified).
IEC 61158-5-16:2007	NOTE	Harmonized as EN 61158-5-16:2008 (not modified).
IEC 61158-5-19:2010	NOTE	Harmonized as EN 61158-5-19:2012 (not modified).
IEC 61158-6-16:2007	NOTE	Harmonized as EN 61158-6-16:2008 (not modified).
IEC 61158-6-19:2010	NOTE	Harmonized as EN 61158-6-19:2012 (not modified).
IEC 61800-7-20x series	NOTE	Harmonized in EN 61800-7-20x series.

Annex ZA
(normative)**Normative references to international publications
with their corresponding European publications**

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61158-4-16	2007	Industrial communication networks - Fieldbus specifications - Part 4-16: Data-link layer protocol specification - Type 16 elements	EN 61158-4-16	2008
ISO/IEC 7498-1	-	Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model	-	-
ISO/IEC 7498-3	-	Information technology - Open Systems Interconnection - 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	-	-

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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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ISO (www.iso.org/patents) and IEC (http://www.iec.ch/tctools/patent_decl.htm) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

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 ($1 \leq \text{ADR} \leq 511$) 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

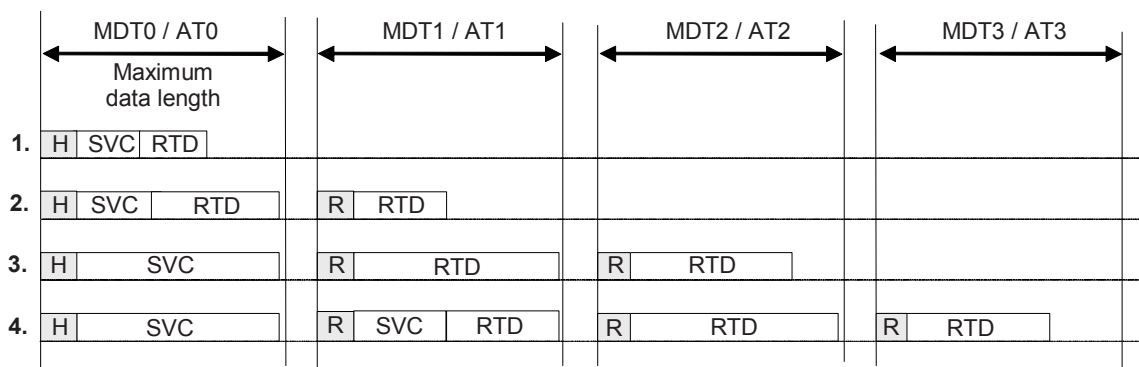
the slaves to the master as well as from one device to other devices through the real-time channel.

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.

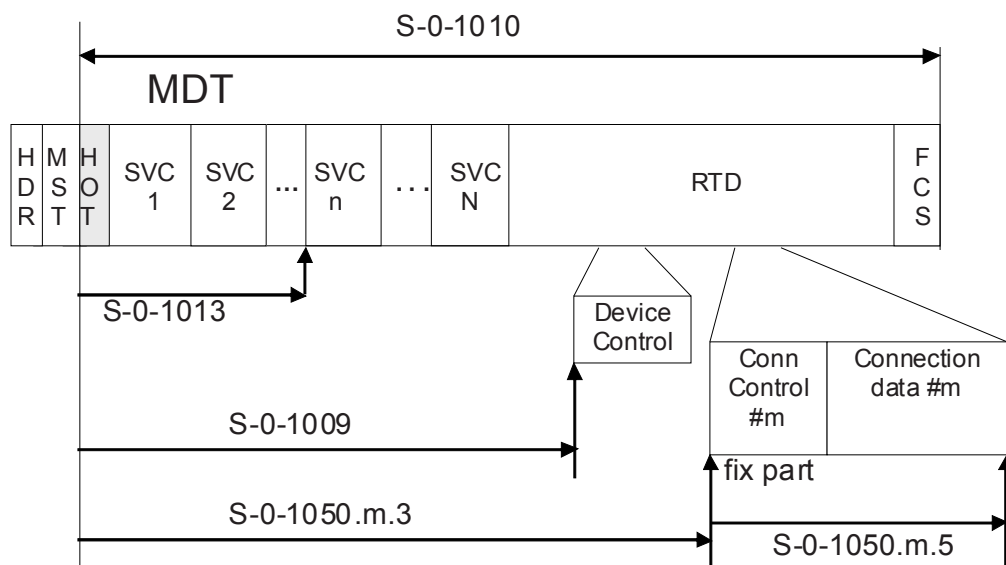


Figure 2 – Offsets within MDT payload

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

DLDPDU 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)

DLDPDU 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)

DLDPDU 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 valid. 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.

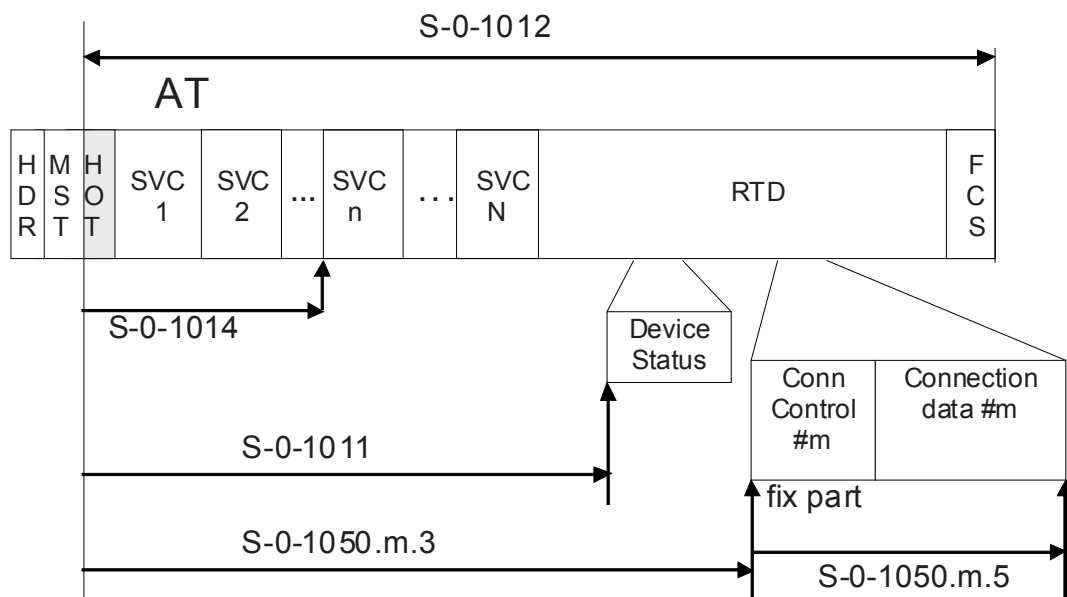


Figure 3 – Offsets within AT payload

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.