BSI Standards Publication

Industrial communication networks – Fieldbus specifications

Part 6-3: Application layer protocol specification – Type 3 elements (IEC 61158-6-3:2019)

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National foreword

This British Standard is the UK implementation of EN IEC 61158-6-3:2019. It is identical to IEC 61158-6-3:2019. It supersedes BS EN 61158-6-3:2014, which will be withdrawn on 25 July 2022.

The UK participation in its preparation was entrusted to Technical Committee GEL/65/3, 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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Industrielle Kommunikationsnetze - Feldbusse - Teil 6-3: Protokollspezifikation des Application Layer (Anwendungsschicht) - Typ 3-Elemente (IEC 61158-6-3:2019)

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European foreword

The text of document 65C/948/FDIS, future edition 4 of IEC 61158-6-3, 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 IEC 61158-6-3:2019.

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- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-04-25
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-07-25

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

IEC 61158-1:2019	NOTE Harmonized as EN IEC 61158-1:2019 (not modified)
IEC 61784-1	NOTE Harmonized as EN IEC 61784-1
IEC 61784-2	NOTE Harmonized as EN IEC 61784-2

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 61158-3-3	2014	Industrial communication networks - Fieldbus specifications - Part 3-3: Data-link layer service definition - Type 3 elements	EN 61158-3-3	2014
IEC 61158-4-3	2019	Industrial communication networks - Fieldbus specifications - Part 4-3: Data-link layer protocol specification - Type 3 elements	EN IEC 61158-4-3	2019
IEC 61158-5-3	2014	Industrial communication networks - Fieldbus specifications - Part 5-3: Application layer service definition - Type 3 elements	EN 61158-5-3	2014
IEC 61158-5-10	2019	Industrial communication networks - Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements	EN IEC 61158-5-10	2019
IEC 61158-6-10	2019	Industrial communication networks -- Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements		-
ISO/IEC 7498-1	-	Information technology - Open Systems-Interconnection - Basic reference model: The basic model		-
ISO/IEC 8822	-	Information technology - Open Systems-Interconnection - Presentation service definition		-
ISO/IEC 8824-1	-	Information technology - Abstract Syntax-Notation One (ASN.1): Specification of basic notation		-
ISO/IEC 9545	-	Information technology - Open Systems-Interconnection - Application layer structure		-
ISO/IEC 10731	-	Information technology - Open Systems-Interconnection - Basic Reference Model - Conventions for the definition of OSI services		-
IEEE 754	-	IEEE Standard for Binary Floating-Point-Arithmetic		-

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-3: Application layer protocol specification – Type 3 elements

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

International Standard IEC 61158-6-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

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This edition includes the following significant technical changes with respect to the previous edition:

- corrected substitutions in Table 4;
- corrections in 5.3.14;
- corrections in 5.5.6;
- corrections in 5.17.15;
- corrections in 5.17.16.2;
- spelling and grammar.

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

FDIS	Report on voting
65C/948/FDIS	65C/956/RVD

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

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

A list of all 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.

A bilingual version of this publication may be issued at a later date.

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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 61158-1.

The application protocol provides the application service by making use of the services available from the data-link or other immediately lower layer. The primary aim of this document is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer application entities (AEs) 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:

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

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

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-3: Application layer protocol specification – Type 3 elements

1 Scope

1.1 General

The Fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a “window between corresponding application programs.”

This part of IEC 61158 provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment and material specific to Type 3 fieldbus. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This International Standard defines in an abstract way the externally visible behavior provided by the Type 3 fieldbus application layer in terms of

a) the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
b) the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
c) the application context state machine defining the application service behavior visible between communicating application entities; and
d) the application relationship state machines defining the communication behavior visible between communicating application entities.

The purpose of this document is to define the protocol provided to

a) define the wire-representation of the service primitives specified in IEC 61158-5-3, and
b) define the externally visible behavior associated with their transfer.

This document specifies the protocol of the Type 3 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) and the OSI Application Layer Structure (ISO/IEC 9545).

FAL services and protocols are provided by FAL application-entities (AE) contained within the application processes. The FAL AE is composed of a set of object-oriented Application Service Elements (ASEs) and a Layer Management Entity (LME) that manages the AE. The ASEs provide communication services that operate on a set of related application process object (APO) classes. One of the FAL ASEs is a management ASE that provides a common set of services for the management of the instances of FAL classes.

Although these services specify, from the perspective of applications, how request and responses are issued and delivered, they do not include a specification of what the requesting and responding applications are to do with them. That is, the behavioral aspects of the applications are not specified; only a definition of what requests and responses they can

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send/receive is specified. This permits greater flexibility to the FAL users in standardizing such object behavior. In addition to these services, some supporting services are also defined in this document to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this document is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-3.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of protocols standardized in parts of the IEC 61158-6 subparts.

1.3 Conformance

This does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems.

There is no conformance of equipment to the application layer service definition standard. Instead, conformance is achieved through implementation of this application layer protocol specification.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61158-3-3:2014, *Industrial communication networks – Fieldbus specifications – Part 3-3: Data-link layer service definition – Type 3 elements*

IEC 61158-4-3:2019, *Industrial communication networks – Fieldbus specifications – Part 4-3: Data-link layer protocol specification – Type 3 elements*

IEC 61158-5-3:2014, *Industrial communication networks – Fieldbus specifications – Part 5-3: Application layer service definition – Type 3 elements*

IEC 61158-5-10:2019, *Industrial communication networks – Fieldbus specifications – Part 5-10: Application layer service definition – Type 10 elements*

IEC 61158-6-10:2019, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

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

ISO/IEC 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

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ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

IEEE 754, *IEEE Standard for Floating-Point Arithmetic,* available at <http://www.ieee.org> [viewed 2018-09-10]

3 Terms, definitions, abbreviations, symbols and conventions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Referenced terms and definitions

3.1.1 ISO/IEC 7498-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 7498-1 apply:

a) application entity
b) application process
c) application protocol data unit
d) application service element
e) application entity invocation
f) application process invocation
g) application transaction
h) real open system
i) transfer syntax

3.1.2 ISO/IEC 8822 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8822 apply:

a) abstract syntax
b) presentation context

3.1.3 ISO/IEC 9545 terms

For the purposes of this document, the following terms as defined in ISO/IEC 9545 apply:

a) application-association
b) application-context
c) application context name
d) application-entity-invocation
e) application-entity-type
f) application-process-invocation
g) application-process-type

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h) application-service-element

i) application control service element

3.1.4 ISO/IEC 8824-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8824-1 apply:

a) object identifier

b) type

3.1.5 Fieldbus Data Link Layer terms

For the purposes of this document, the following terms as defined in IEC 61158-3-3 and IEC 61158-4-3 apply.

a) DL-Time

b) DL-Scheduling-policy

c) DLCEP

d) DLC

e) DL-connection-oriented mode

f) DLPDU

g) DLSDU

h) DLSAP

i) link

j) network address

k) node address

l) node

m) scheduled

3.2 Additional definitions

3.2.1
access protection
limitation of the usage of an application object to one client

3.2.2
address-assignment-table
mapping of the client's internal I/O-Data object storage to the decentralized input and output data objects

3.2.3
channel
single physical or logical link of an input or output application object of a server to the process

3.2.4
channel related diagnosis
information concerning a specific element of an input or output application object, provided for maintenance purposes

EXAMPLE: validity of data.

3.2.5
configuration check
comparison of the expected I/O-Data object structuring of the client with the real I/O-Data object structuring to the server in the start-up phase

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3.2.6
configuration fault
an unacceptable difference between the expected I/O-Data object structuring and the real I/O-Data object structuring, as detected by the server

3.2.7
configuration identifier
representation of a portion of I/O Data of a single input- and/or output-module of a server.

3.2.8
configuration identifier related diagnosis
compromises all module specific data available at the server for maintenance purposes

3.2.9
control commands
action invocations transferred from client to server to clear outputs, freeze inputs and/or synchronize outputs

3.2.10
data consistency
means for coherent transmission and access of the input- or output-data object between and within client and server

3.2.11
Data-eXchange-Broadcast
DXB
service for conveyance of information between the DP-master (Class 1) and the assigned DP-slaves initiating the Publisher and Subscriber functionality in the DP-slaves

3.2.12
default DL-address
value 126 as an initial value for DL-address, which has to be changed (e.g. by assignment of an DL-address via the fieldbus) before operation with a DP-master (class 1)

3.2.13
device related diagnosis
compromises all data related to the whole DP-slave available at the server for maintenance purposes

3.2.14
diagnosis information
all data available at the server for maintenance purposes

3.2.15
diagnosis information collection
system diagnosis information that is assembled at the client side

3.2.16
DP-master (class 1)
a controlling device which controls several DP-slaves (field devices)

Note 1 to entry: This is usually a programmable controller or a distributed control system.

3.2.17
DP-master (class 2)
controlling device which manages configuration data (parameter sets) and diagnosis data of a DP-master (Class 1), and that additionally performs all communication capabilities of a DP-master (Class 1)

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3.2.18
DP-slave
field device that can be assigned to one DP-master (Class 1) as a provider for cyclic I/O data exchange, in addition acyclic functions and alarms could be provided

3.2.19
DXB request
cyclic data exchange service request with a specific DL service between the DP-master (Class 1) and the assigned DP-slaves initiating the Publisher functionality in the DP-slaves

3.2.20
DXB response
cyclic data exchange service response not to the individual address of the requester (DP-master (Class 1)) but to the broadcast address (=127)

3.2.21
freeze

function at the DP-slaves for simultaneous data transfer between the input data object and the process

3.2.22
group
set of DP-slaves which perform a Freeze or Sync function

3.2.23
I/O data
object designated to be transferred cyclically for the purpose of processing.

3.2.24
ident number
DP-master (Class 1) or DP-slave device type

3.2.25
index
address of an object within an application process

3.2.26
isochronous mode
special operation mode of a DP system that implies both a constant DP cycle with a fixed schedule of the cyclic and acyclic DP services, and the synchronisation of the application in the DP-master (Class 1) and the DP-slaves with this constant DP cycle

3.2.27
master parameter set
the configuration and parameterization data of all DP-slaves that are assigned to the corresponding DP-master and the bus parameters

3.2.28
module
addressable unit inside the DP-slave

3.2.29
process data
object(s) which are already pre-processed and transferred acyclically for the purpose of information or further processing

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3.2.30
publisher
role of a CR endpoint that transmits APDUs onto the Fieldbus for consumption by one or more subscribers

Note 1 to entry: A publisher may not be aware of the identity or the number of subscribers and it may publish its APDUs using a dedicated CR.

3.2.31
real configuration
input and output data structure of a DP-slave, including definition of data consistency

3.2.32
subscriber
role of a CREP in which it receives APDUs produced by a publisher

3.2.33
slot
address of a module within a DP-slave

3.2.34
sync
function at the DP-slaves for simultaneous data transfer between the output data object and the process

3.3 Abbreviations and symbols

Ack	Acknowledgement
Add	Address
AP	Application Process
APDU	Application Protocol Data Unit
API	Application Process Identifier
AR	Application Relationship
AREP	Application Relationship End Point
ARL	Application Relationship List
ASE	Application Service Element
Cfg	Configuration
cnf	confirmation primitive
CREP	Communication Relationship End Point
CRL	Communication Relationship List
D_	Destination
DLL	Data Link Layer
DLM	Data Link-management
DLSAP	Data Link Service Access Point
DLSDU	Data Link Service Data Unit
DMPM	Data Link Mapping Protocol Machine
DMPMM1	Data Link Mapping Protocol Machine DP-master (Class 1)
DMPMM2	Data Link Mapping Protocol Machine DP-master (Class 2)
DMPMS	Data Link Mapping Protocol Machine DP-slave

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DSAP	Destination Service Access Point
DXB	Data eXchange Broadcast
FAL	Fieldbus Application Layer
FIFO	First In First Out
FSPMM1	FAL Service Protocol Machine DP-master (Class 1)
FSPMM2	FAL Service Protocol Machine DP-master (Class 2)
FSPMS	FAL Service Protocol Machine DP-slave
HSA	Highest Station Address
I&M	Identification and Maintenance Profile
ID	Identifier
IEC	International Electrotechnical Commission
ind	indication primitive
Inp	Input
ISO	International Organization For Standardization
IsoM	Isochronous Mode
L_sdu	Link Service Data Unit
lsb	least significant bit
msb	most significant bit
OSI	Open Systems Interconnection
Outp	Output
Param	Parameter
PDU	Protocol Data Unit
RD_	Read
Rem	Remote
Req	Request (used to indicate an APDU type)
req	request primitive
REQ	Request to indicate a Request PDU
RES	Response to indicate a Response PDU
RM	Resource Manager
RPL_UPD	Reply Update
Rsp	Response (used to indicate an APDU type)
rsp	response primitive
S_	Source
SAP	Service Access Point
SCL	Security Level
SD	Start Delimiter
SDN	Send Data with no Acknowledge
SDR	Station Delay Responder
Seq	Sequence
Src	Source

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SRD	Send and Request Data with Reply
SSAP	Source Service Access Point
TR	Technical Report
USIF	User Interface
WD	Watchdog

3.4 Conventions

3.4.1 General concept

The FAL is defined as a set of object-oriented ASEs. Each ASE is specified in a separate subclause. Each ASE specification is composed of three parts: its class definitions, its services, and its protocol specification. The first two are contained in IEC 61158-5-3. The protocol specification for each of the ASEs is defined in this document.

The class definitions define the attributes of the classes supported by each ASE. The attributes are accessible from instances of the class using the Management ASE services specified in IEC 61158-5-3. The service specification defines the services that are provided by the ASE.

This document uses the descriptive conventions given in ISO/IEC 10731.

3.4.2 Abstract syntax conventions

PDUs are described as octets or groups of octets.

a) Groups of octets separated by a comma appear in the order they are transferred If optional octets are not present the following octets appear without a gap

b) If octets or groups of octets are grouped within "{ }" the order is arbitrary

c) If octets or groups of octets are marked with "*" they may appear more than once. If it is used within a "{ }" section they may appear mixed with other octets or group of octets of this section.

d) Octets can be grouped or values can be assigned within "( )"

e) If octets or groups of octets are grouped within "[ ]" the group can be omitted

f) Complex APDUs may be built by means of substitutions (sub-structures)

g) Exclusive selections of octets or groups of octets are separated by "^"

NOTE 1 The formal PDU example

AP_PDU=Octet1,OctetGroup1,[Octet2],[Octet3],{[OctGroup2*],OctetGroup3^Octet4}
According to this the following variants are valid on the wire (non exhaustive):

Variant 1: Octet1, OctetGroup1, Octet2, Octet3, OctetGroup2,OctetGroup3

Variant 2: Octet1, OctetGroup1, Octet2, Octet3, OctetGroup2, OctetGroup2, OctetGroup2,OctetGroup3

Variant 3: Octet1, OctetGroup1, OctetGroup2, OctetGroup2, OctetGroup2,OctetGroup3, OctetGroup2

Variant4: Octet1, OctetGroup1, OctetGroup2, OctetGroup3, OctetGroup2, OctetGroup2, OctetGroup2, OctetGroup2

Variant 5: Octet1, OctetGroup1, Octet3, Octet4

NOTE 2 The arbitrary order implies that groups of octets are characterized by a special header that is described within the coding rules.

NOTE 3 The APDU syntax implies that according to the maximum DLSDU a APDU shall not exceed 244 octets in total.

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3.4.3 Convention for the encoding of reserved bits and octets

The term "reserved" may be used to describe bits in octets or whole octets. All bits or octets that are reserved should be set to zero at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved bits or octets are checked by a state machine.

The term "reserved" may also be used to indicate that certain values within the range of a parameter are reserved for future extensions. In this case the reserved values should not be used at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved values are check by a state machine.

3.4.4 Conventions for the common coding s of specific field octets

APDUs may contain specific fields that carry information in a primitive and condensed way. These fields shall be coded in the order according to Figure 1.

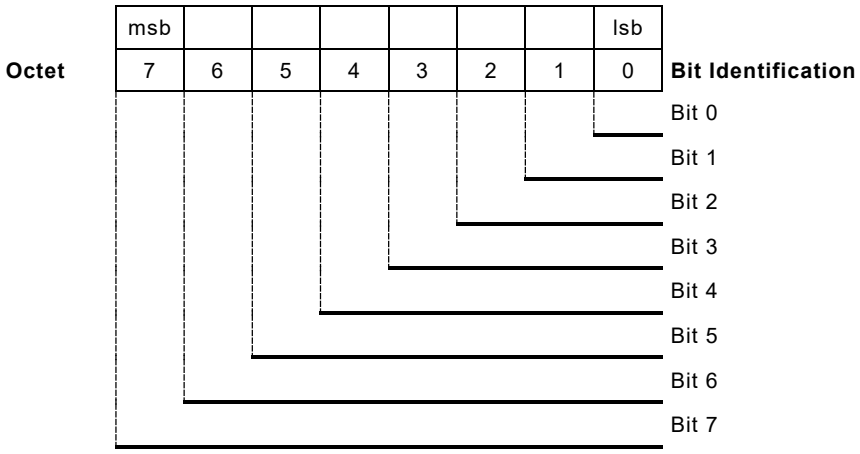

Figure 1 – Common structure of specific fields

– Bits may be grouped as group of bits. Each bit or group of bits shall be addressed by its Bit Identification (e.g. Bit 0, Bit 1 to 4). The position within the octet shall be according to the figure above. Alias names may be used for each bit or group of bits or they may be marked as reserved. The grouping of individual bits shall be in ascending order without gaps. The values for a group of bits may be represented as binary, decimal or hexadecimal values. This value shall only be valid for the grouped bits and can only represent the whole octet if all 8 bits are grouped. Decimal or hexadecimal values shall be transferred in binary values so that the bit with the highest number of the group represents the msb concerning the grouped bits.

EXAMPLE 1: Description and relation for the specific field octet

Bit 0: reserved.

Bit 1-3: Reason_Code The decimal value 2 for the Reason_Code means general error.

Bit 4-7: shall always set to one.

The octet that is constructed according to the description above looks as follows:

(msb) Bit 7 = 1,

Bit 6 = 1,

Bit 5 = 1,

Bit 4 = 1,

Bit 3 = 0,

Bit 2 = 1,

Bit 1 = 0,

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(lsb) Bit 0 = 0.

The bit combination "0-1-0" for Bit 1-3 equals the decimal value 2.

3.5 Conventions used in state machines

3.5.1 State machine conventions

The protocol sequences are described by means of State Machines.

In state diagrams states are represented as boxes state transitions are shown as arrows. Names of states and transitions of the state diagram correspond to the names in the textual listing of the state transitions.

The textual listing of the state transitions is structured as follows, see also Table 1.

a) The first row contains the name of the transition.

b) The second row in define the current state.

c) The third row contains an optional event followed by Conditions starting with a “/” as first line character and finally followed by the Actions starting with a “=>” as first line character.

d) The last row contains the next state.

e) If the event occurs and the conditions are fulfilled the transition fires, i.e. the actions are executed and the next state is entered.

The layout of a Machine description is shown in Table 1. The meaning of the elements of a State Machine Description are shown in Table 2.

Table 1 – State machine description elements

#	Current state	Event or condition => action	Next state

Table 2 – Description of state machine elements

Description element	Meaning
Current state Next state	Name of the given states.
#	Name or number of the state transition.
Event	Name or description of the event.
/Condition	Boolean expression. The preceding “\” is not part of the condition.
=> Action	List of assignments and service or function invocations. The preceding “=>” is not part of the action.

The conventions used in the state machines are shown in Table 3.

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Table 3 – Conventions used in state machines

Convention	Meaning
:=	Value of an item on the left is replaced by value of an item on the right. If an item on the right is a parameter, it comes from the primitive shown as an input event.
xxx	A parameter name. Example: Identifier:= reason means value of a 'reason' parameter is assigned to a parameter called 'Identifier.'
"xxx"	Indicates fixed value. Example: Identifier:= "abc" means value "abc" is assigned to a parameter named 'Identifier.'
=	A logical condition to indicate an item on the left is equal to an item on the right.
<	A logical condition to indicate an item on the left is less than the item on the right.
>	A logical condition to indicate an item on the left is greater than the item on the right.
<>	A logical condition to indicate an item on the left is not equal to an item on the right.
&&	Logical "AND"
||	Logical "OR"

for (Identifier:= start_value to end_value)
actions
endfor
	This construct allows the execution of a sequence of actions in a loop within one transition. The loop is executed for all values from start_value to end_value.

If (condition)
actions
else
actions
	This construct allows the execution of alternative actions depending on some condition (which might be the value of some identifier or the outcome of a previous action) within one transition. The parts beginning with “else” can be omitted if there is no action if the condition is not fulfilled.

Readers are strongly recommended to refer to the subclauses for the AREP and CREP attribute definitions, the local functions, and the FAL-PDU definitions to understand protocol machines. It is assumed that readers have sufficient knowledge of these definitions and they are used without further explanations.

In addition the following description elements are used:

Wildcard in names

name_XXX: “XXX” is used as wildcard string for all names beginning with “name”.

The typical use of a wildcard is an Event. In this context there are as many state transitions as possible events for this wildcard exists.

Conditional macro

<CONDITIONAL -MACRO-NAME>

<

CONDITION1: macrobody1

CONDITION2: macrobody2

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…

>

CONDITION1, CONDITION2, etc. define all possible cases for the conditional macro. The “CONDITIONAL-MACRO-NAME” acts as place holder for the “macrocode” depending on the result of the condition.

Replacement macro

<REPLACEMENT-MACRO-NAME>

<

XXX= Name1: macrobody1

XXX= Name2: macrobody2

…

>

Name1, Name2, etc. define all possible cases for the replacement macro. The “REPLACEMENT-MACRO-NAME” acts as place holder for the “macrocode” depending on the value of the current use of the wildcard XXX.

Example:
<SERVICE_REQ_PARA>
<
XXX=Read: Para1, Para2
XXX=Write: Para1, Para2, Para3
>
when called in
MSAB_XXX.req(<SERVICE_REQ_PARA>)
will result in
MSAB_Read.req(Para1, Para2) or MSAB_Write.req(Para1, Para2, Para3)

4 FAL syntax description

4.1 APDU abstract syntax

Table 4 defines the abstract syntax of the DP Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs.

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Table 4 – APDU syntax

APDU name	APDU structure
DataExchange-REQ-PDU	[Outp_Data*]
DataExchange-RES-PDU	[Inp_Data*]
RD_Input-RES-PDU	[Inp_Data*]
RD_Output-RES-PDU	[Outp_Data*]
Chk_Cfg-REQ-PDU	{ [Identifier_Format*], [Special_Identifier_Format*] ^ [Extended_Special_Identifier_Format*] } The field SI_Flag.DPV1_Data_Types defines whether Special_Identifier_Format or Extended_Special_Identifier_Format applies. The sequence of identifiers shall follow the ascending number of slots/moduls.
Get_Cfg-RES-PDU	{ [Identifier_Format*], [Special_Identifier_Format*] ^ [Extended_Special_Identifier_Format*] }
Set_Prm-REQ-PDU	Station_status, WD_Fact_1, WD_Fact_2, min_TSDR, Ident_Number, Group_Ident, User_Prm_Data
Set_Ext_Prm-REQ-PDU	Structured_Prm_Data*
Diagnosis-RES-PDU	Station_status_1, Station_status_2, Station_status_3, Diag_Master_Add, Ident_Number, { [Device_Related_Diagnosis*] ^ ([Alarm], [Status*], [Modul_Status], [DXB_Link_Status], { [Red_Status] ^[PrmCmdAck] }), [Identifier_Related_Diagnosis], [Channel_Related_Diagnosis*], [Revision_Number] } The field Device_Related_Diagnosis may be present if DPV1=FALSE, otherwise if DPV1=TRUE it shall not be present. In this case the fields Alarm, Status, Modul_Status may be present.
Set_Slave_Add-REQ-PDU	New_Slave_Add, Ident_Number, No_Add_Chg, [Rem_Slave_Data*]
Global_Control-REQ-PDU	Control_Command, Group_Select
Clock-Value-PDU	Clock_value_time_event, Clock_value_previous_TE, Clock_value_status1, Clock_value_status2
Initiate-REQ-PDU	Function_Num(0x57), reserved (3 Octets), Send_Timeout, Features_Supported, Profile_Features_Supported, Profile_Ident_Number, Add_Addr_Param
Initiate-RES-PDU	Function_Num(0x57), Max_Len_Data_Unit, Features_Supported, Profile_Features_Supported, Profile_Ident_Number, Add_Addr_Param
Initiate-NRS-PDU	Function_Num(0xD7), Error_Decode, Error_Code_1, Error_Code_2
Abort-REQ-PDU	Function_Num(0x58), Subnet, Instance_Reason_Code
Read-REQ-PDU	Function_Num(0x5E), Slot_Number, Index (0 .. 254), Length
Read-RES-PDU	Function_Num(0x5E), Slot_Number, Index (0 .. 254), Length, [Data*]
Read-NRS-PDU Pull-NRS-PDU	Function_Num(0xDE), Error_Decode, Error_Code_1, Error_Code_2
Write-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (0 .. 254), Length, [Data*]
Write-RES-PDU	Function_Num(0x5F), Slot_Number, Index (0 .. 254), Length
Write-NRS-PDU Initiate_Load_NRS-PDU Push-NRS-PDU Terminate_Load-NRS-PDU Start-NRS-PDU Stop-NRS-PDU Resume-NRS-PDU Reset-NRS-PDU Call-NRS-PDU Get_FI_State-NRS-PDU	Function_Num(0xDF), Error_Decode, Error_Code_1, Error_Code_2
Alarm_Ack-REQ-PDU	Function_Num(0x5C), Slot_Number, Alarm_Type, Alarm_Specifier
Alarm_Ack-RES-PDU	Function_Num(0x5C), Slot_Number, Alarm_Type, Alarm_Specifier
Alarm_Ack-NRS-PDU	Function_Num(0xDC), Error_Decode, Error_Code_1, Error_Code_2
Idle-REQ-PDU	Function_Num(0x48)

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APDU name	APDU structure
Idle-RES-PDU	Function_Num(0x48)
Data_Transport-REQ-PDU	Function_Num(0x51), Slot_Number, Index, Length, [Data*]
Data_Transport-RES-PDU	Function_Num(0x51), Slot_Number, Index, Length, [Data*]
Data_Transport-NRS-PDU	Function_Num(0xD1), Error_Decode, Error_Code_1, Error_Code_2
Initiate_Load-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x00), Options, LR_Index, LR_Length, Intersegment_Request_Timeout, [User_Specific]
Initiate_Load-RES-PDU	Function_Num(0x5E), Slot_Number, Index (255), Length, Extended_Function_Num (0x00), Max_Segment_Length, LR_Index, LR_Length, Max_Response_Delay
Push-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x01), Options, Sequence_Number, LR_Data
Pull-REQ-PDU	Function_Num(0x5E), Slot_Number, Index (255), Length
Pull-RES-PDU	Function_Num(0x5E), Slot_Number, Index (255), Length, Extended_Function_Num (0x02), Options, Sequence_Number, LR_Data
Terminate_Load-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x03), reserved (1 octet), reserved (2 Octets),
Start-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x04), reserved (1 octet), FI_Index, [Execution_Argument]
Stop-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x05), reserved (1 octet), FI_Index
Resume-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x06), reserved (1 octet), FI_Index, [Execution_Argument]
Reset-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x07), reserved (1 octet), FI_Index
Call-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x08), Entity Number, FI_Index (=0…64999), [Execution_Argument] Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x08), Entity Number, FI_Index (=65000..65199), [IMData_Execution_Argument]
Call-RES-PDU	Function_Num(0x5E), Slot_Number, Index (255), Length, Extended_Function_Num (0x08), Entity Number, FI_Index (=0…64999), [Result_Argument] Function_Num(0x5E), Slot_Number, Index (255), Length, Extended_Function_Num (0x08), Entity Number, FI_Index (=65000…65199), [IMData_Result_Argument]
Get_FI_State-REQ-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length, Extended_Function_Num (0x09), reserved (1 octet), FI_Index
Get_FI_State-RES-PDU	Function_Num(0x5E), Slot_Number, Index (255), Length, Extended_Function_Num (0x09), reserved (1 octet), FI_Index, FI_State
Push-RES-PDU Terminate_Load-RES-PDU Start-RES-PDU Stop-RES-PDU Resume-RES-PDU Reset-RES-PDU	Function_Num(0x5F), Slot_Number, Index (255), Length
RM-REQ-PDU	Function_Num(0x56), Server_SAP, Send_Timeout
Get_Master_Diag-REQ-PDU	Function_Num(0x41), MDiag_Identifier
Get_Master_Diag-RES-PDU	Function_Num(0x41), MDiag_Identifier(=0..125), Diagnosis-RES-PDU Function_Num(0x41), MDiag_Identifier(=126), System_Diagnosis Function_Num(0x41), MDiag_Identifier(=127), Master_Status Function_Num(0x41), MDiag_Identifier(=128), Data_Transfer_List
Start_Seq-REQ-PDU	Function_Num(0x42), Area_CodeUpDownload, Timeout
Start_Seq-RES-PDU	Function_Num(0x42), Area_CodeUpDownload, Timeout, Max_Len_Data_Unit

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APDU name	APDU structure
Download-REQ-PDU	Function_Num(0x43), Area_CodeUpDownload(=0..125), Add_Offset, DP_Slave_Parameter_Set Function_Num(0x43), Area_CodeUpDownload(=127), Add_Offset, Bus_Parameter_Set Function_Num(0x43), Area_CodeUpDownload(=129), Add_Offset, Statistic_Counters Function_Num(0x43), Area_CodeUpDownload(=136 to 139), Add_Offset, Master_Parameter_Set
Download-RES-PDU	Function_Num(0x43), Area_CodeUpDownload, Add_Offset
Upload-REQ-PDU	Function_Num(0x44), Area_CodeUpDownload, Add_Offset, Data_Len
Upload-RES-PDU	Function_Num(0x44), Area_CodeUpDownload(=0..125), Add_Offset, DP_Slave_Parameter_Set Function_Num(0x44), Area_CodeUpDownload(=127), Add_Offset, Bus_Parameter_Set Function_Num(0x44), Area_CodeUpDownload(=129), Add_Offset, Statistic_Counters Function_Num(0x43), Area_CodeUpDownload(=136 to 139), Add_Offset, Master_Parameter_Set
End_Seq-REQ-PDU	Function_Num(0x45)
End_Seq-RES-PDU	Function_Num(0x45)
Act_Para_Brct-REQ-PDU	Function_Num(0x46), Area_CodeActBrct
Act_Param-REQ-PDU	Function_Num(0x47), Area_CodeAct, Activate
Act_Param-RES-PDU	Function_Num(0x47), Area_CodeAct, Activate
ZERO-PDU	Octet1(0)
NULL-PDU	

NOTE 1 If a APDU consists only of user data octets the distinction is made by use of different Data Link Layer service access points (see Protocol Machines).

NOTE 2 A ZERO-PDU contains one octet with all bits set to zero. This APDU is used to indicate diagnosis from a device without inputs.

NOTE 3 A NULL-PDU contains no octets. It is used to submit no DLSDU to data link layer.

Table 5 defines structures for substitutions of elements of the APDU structures shown in Table 4.

Table 5 – Substitutions

Substitution name	Structure
Identifier_Format	Cfg_Identifier
Special_Identifier_Format	Special_Cfg_Identifier, [Length_Octet] , [Length_Octet], [Manufacturer_Specific_Data*] Length_Octet fields shall always start with fields that indicate output data if present.
Extended_Special_Identifier_Format	Special_Cfg_Identifier, [Extended_Length_Octet], [Extended_Length_Octet], [Data_Type*], [Manufacturer_Specific_Data*] Extended_Length_Octet fields shall always start with fields that indicate output data if present. The field Data_Type shall only be omitted in case of an empty slot. Otherwise it shall be present in relation to the length fields.
Device_Related_Diagnosis	Header_Octet, Diagnosis_User_Data*
Identifier_Related_Diagnosis	Header_Octet, Identifier_Diagnosis_Data_Array
Channel_Related_Diagnosis	Identifier_Number, Channel_Number, Type_of_Diagnosis
Alarm	Header_Octet, Alarm_Type, Slot_Number, Alarm_Specifier, [Diagnosis_User_Data*]

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Substitution name	Structure
Status	Header_Octet, Status_Type, Slot_Number, Status_Specifier, [Diagnosis_User_Data*]
Modul_Status	Header_Octet, Status_Type(=Modul_Status), Slot_Number(=0), Status_Specifier, Modul_Status_Array
DXB_Link_Status	Header_Octet, Status_Type(=DXB_Link_Status), Slot_Number(=0), Status_Specifier, (Publisher_Address, Publisher_Status)*
PrmCmdAck	Header_Octet, Status_Type(=PrmCmdAck), Slot_Number(=0), Status_Specifier, Function, Red_Status1, Red_Status2, Red_Status3
Red_Status	Header_Octet, Status_Type(=Red_Status), Slot_Number(=0), Status_Specifier, Function, Red_Status1, Red_Status2, Red_Status3
User_Prm_Data	[DPV1_Status_1, DPV1_Status_2, DPV1_Status_3], [Structured_Prm_Data*] ^ [User_Prm_Data_Element*] Special case DPV1=FALSE: [User_Prm_Data_Element*] Special case DPV1=TRUE and DPV1_Status_3.Prm_Structure=FALSE: DPV1_Status_1, DPV1_Status_2, DPV1_Status_3, [User_Prm_Data_Element*] Special case DPV1=TRUE and DPV1_Status_3.Prm_Structure=TRUE: DPV1_Status_1, DPV1_Status_2, DPV1_Status_3, Structured_Prm_Data* The fields DPV1_Status_1, DPV1_Status_2 and DPV1_Status_3 shall be present if DPV1=TRUE. Structured_Prm_Data shall be present if the DPV1_Status_3.Prm_Structure is TRUE, otherwise it shall not be used.
Structured_Prm_Data	Structure_Length, Structure_Type, Slot_Number, reserved (1 octet), User_Prm_Data_Element* Special Case PrmCmd: Structure_Length, Structure_Type(=2), Slot_Number(=0), Specifier, Function, Properties, Output_Hold_Time Special Case DXB LinkTable: Structure_Length, Structure_Type(=3), Slot_Number(=0), reserved (1 octet), Version(=1), (Publisher_Addr, Publisher_Length, Sample_Offset, Sample_Length)* Special Case IsoM Parameter: Structure_Length, Structure_Type(=4), Slot_Number(=0), reserved (1 octet), Version(=1), TBASE_DP, TDP, TMAPC, TBASE_IO, TI, TO, TDX, TPLL_W, TPLL_D Special Case F-Parameter: Structure_Length, Structure_Type(=5), Slot_Number, reserved (1 octet), User_Prm_Data* Special Case DXB-Subscribertable: Structure_Length, Structure_Type(=7), Slot_Number(=0), reserved (1 octet), Version(=1), (Publisher_Addr, Publisher_Length, Sample_Offset, Dest_Slot_Number, Offset_Data_Area, Sample_Length)* Special Case Time AR Parameter: Structure_Length, Structure_Type(=8), Slot_Number(=0), reserved (1 octet), Clock Sync Interval, [CS Delay Time]
Features_Supported	Features_Supported_1, Features_Supported_2
Profile_Features_Supported	Profile_Features_Supported_1, Profile_Features_Supported_2
Add_Addr_Param	S_Type, S_Len, D_Type, D_Len, S_API, S_SCL, [S_Network_Address], [S_MAC_Address], D_API, D_SCL, [D_Network_Address], [D_MAC_Address]
Master_Status	USIF_State, Ident_Number, Hardware_Release_DP, Firmware_Release_DP, Hardware_Release_User, Firmware_Release_User, reserved (9 Octets)
DP_Slave_Parameter_Set	Slave_Para_Len, Sl_Flag, Slave_Type, Max_Diag_Data_Len, Max_Alarm_Len, Max_Channel_Data_Length, Diag_Upd_Delay, Alarm_Mode, Add_Sl_Flag, MS1_Timeout, reserved (4 Octets), Prm_Data_Len, Prm_Data, Cfg_Data_Len, Cfg_Data, Add_Tab_Len, Add_Tab, Slave_User_Data_Len, Slave_User_Data, Ext_Prm_Data_Len, [Ext_Prm_Data]
Bus_Parameter_Set	Bus_Para_Len, DL_Add, Data_rate, T_{SL}, min T_{SDR}, max T_{SDR}, T_{QUI}, T_{SET}, T_{TR}, G, HSA, max_retry_limit, Bp_Flag, Min_Slave_Interval, Poll_Timeout, Data_Control_Time, Alarm_Max, Max_User_Global_Control, reserved (4 Octets), Master_User_Data_Len, Master_Class2_Name, Master_User_Data*, T_{CL}, maxT_{SET}

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Substitution name	Structure
Master_Parameter_Set	Bus_Parameter_Set, DP_Slave_Parameter_Set*
Statistic_Counters	Counter_Group*
Counter_Group	if Add_Offset 0..126: DLPDU_sent_count(Add_Offset), Error_count(Add_Offset) if Add_Offset 127: SD_sent_count, SD_error_count
Add_Tab	[Number_of_Entries], [Add_Tab_Entry_Header, I/O_Data_Length, IO_Config_Address, Host_Address]*
IMData_Execution_Argument	[I&M1] ^ [I&M2] ^ [I&M3] ^ [I&M4] ^ [I&M_Profile_Specific_x] ^ [I&M_Manufacturer_Specific_x]
IMData_Result_Argument	I&M0 ^ [I&M1] ^ [I&M2] ^ [I&M3] ^ [I&M4] ^ [I&M_Profile_Specific_x] ^ [I&M_Manufacturer_Specific_x]
I&M0	IM_Header, IM_Manufacturer_ID, OrderID, IM_Serial_Number, IM_Hardware_Revision, IM_Software_Revision, IM_Revision_Counter, IM_Profile_ID, IM_Profile_Specific_Type, IM_Version, IM_Supported
I&M1	IM_Header, IM_Tag_Function, IM_Tag_Location
I&M2	IM_Header, IM_Date
I&M3	IM_Header, IM_Descriptor
I&M4	IM_Header, IM_Signature
I&M_Profile_Specific_x	IM_Header, IM_Profile_Specific_Data
IM_Version	IM_Version_Major, IM_Version_Minor
IM_Software_Revision	SWRevisionPrefix, IM_SWRevision_Functional_Enhancement, IM_SWRevision_Bug_Fix, IM_SWRevision_Internal_Change
NOTE The DP_Slave_Parameter_Set and the Bus_Parameter_Set may exceed the maximum APDU size to a size up to 64 Koctets. The conveyance of the data is therefore segmented by means of a window addressed with the parameter Add_Offset.	

4.2 Data types

4.2.1 Notation for the Boolean type

Boolean::= BOOLEAN -- TRUE if the value is non-zero.

-- FALSE if the value is zero.

4.2.2 Notation for the Integer type

Integer8::= INTEGER (-128..+127) -- range $-2^7 <= I <= 2^7-1$

Integer16::= INTEGER (-32768..+32767) -- range $-2^{15} <= I <= 2^{15}-1$

Integer32::= INTEGER -- range $-2^{31} <= I <= 2^{31}-1$

Integer64::= INTEGER -- range $-2^{63} <= I <= 2^{63}-1$

4.2.3 Notation for the Unsigned type

Unsigned8::= INTEGER (0..255) -- range $0 <= I <= 2^8-1$

Unsigned16::= INTEGER (0..65535) -- range $0 <= I <= 2^{16}-1$

Unsigned32::= INTEGER -- range $0 <= I <= 2^{32}-1$

Unsigned64::= INTEGER -- range $0 <= I <= 2^{64}-1$

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4.2.4 Notation for the Floating Point type

Floating32::= BIT STRING SIZE (4) -- IEEE 754 Single precision

Floating64::= BIT STRING SIZE (8) -- IEEE 754 Double precision

4.2.5 Notation for the OctetString type

OctetString::= OCTET STRING -- For generic use

4.2.6 Notation for VisibleString type

VisibleString2::= VISIBLE STRING -- For generic use

4.2.7 Notation for BinaryDate type

BinaryDate::= OctetString7

4.2.8 Notation for TimeOfDay type

TimeOfDay with date indication::= OctetString6

TimeOfDay without date indication::= OctetString4

4.2.9 Notation for TimeDifference type

TimeDifference with date indication::= OctetString6

TimeDifference without date indication::= OctetString4

4.2.10 Notation for Network Time type

Network Time::= OctetString8

4.2.11 Notation for Network Time Difference type

Network Time Difference::= OctetString8

5 Transfer syntax

5.1 Coding of basic data types

5.1.1 Encoding of a Boolean value

a) The encoding of a Boolean value shall be primitive. The ContentsOctets shall consist of a single octet.

b) If the Boolean value is FALSE, the ContentsOctets shall be 0 (zero). If the Boolean value is TRUE, the ContentsOctets shall be 0xff.

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5.1.2 Encoding of an Integer value

a) The encoding of a fixed-length Integer value of Integer8, Integer16, and Integer32 types shall be primitive, and the ContentsOctets shall consist of exactly one, two, or four octets, respectively.

b) The ContentsOctets shall be a two's complement binary number equal to the integer value, and consist of bits 7 to 0 of the first octet, followed by bits 7 to 0 of the second octet, followed by bits 7 to 0 of each octet in turn up to and including the last octet of the ContentsOctets.

NOTE The value of a two's complement binary number is derived by numbering the bits in the ContentsOctets, starting with bit 0 of the last octet as bit zero and ending the numbering with bit 7 of the first octet. Each bit is assigned a numerical value of 2^N, where N is its position in the above numbering sequence. The value of the two's complement binary number is obtained by adding the numerical values assigned to each bit for those bits which are set to one, excluding bit 7 of the first octet, and then reducing this value by the numerical value assigned to bit 7 of the first octet if that bit is set to one.

5.1.3 Encoding of an Unsigned value

a) The encoding of a fixed-length Unsigned value of Unsigned8, Unsigned16, and Unsigned32 types shall be primitive, and the ContentsOctets shall consist of exactly one, two, or four octets, respectively.

b) The ContentsOctets shall be a binary number equal to the Unsigned value, and consist of bits 7 to 0 of the first octet, followed by bits 7 to 0 of the second octet, followed by bits 7 to 0 of each octet in turn up to and including the last octet of the ContentsOctets.

NOTE The value of a binary number is derived by numbering the bits in the ContentsOctets, starting with bit 0 of the last octet as bit zero and ending the numbering with bit 7 of the first octet. Each bit is assigned a numerical value of 2^N, where N is its position in the above numbering sequence. The value of the binary number is obtained by adding the numerical values assigned to each bit for those bits which are set to one.

5.1.4 Encoding of a Floating-Point value

a) The encoding of a Floating32 value shall be primitive, and the ContentsOctets shall consist of exactly four octets.

b) The ContentsOctets shall contain floating-point values defined in conformance with IEEE 754. The sign is encoded in bit 7 of the first octet. It is followed by the exponent starting from bit 6 of the first octet, and then the mantissa starting from bit 6 of the second octet for Floating32.

5.1.5 Encoding of a Visible String value

a) The encoding of a variable length VisibleString value shall be primitive.

b) There is no Length field; the length is encoded implicitly.

c) The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by the second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

5.1.6 Encoding of an Octet String value

a) The encoding of a variable length OctetString value shall be primitive.

b) There is no Length field; the length is encoded implicitly.

c) The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

5.1.7 Encoding of a BinaryDate value

Coding of BinaryDate within IEC 61158-6-10 applies.

5.1.8 Encoding of a TimeOfDay with and without date indication value

Coding of TimeOfDay with and without date indication within IEC 61158-6-10 applies.

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5.1.9 Encoding of a Time Difference with and without date indication value

Coding of Time Difference with and without date indication within IEC 61158-6-10 applies.

5.1.10 Encoding of a Network Time value

Coding of Network Time within IEC 61158-6-10 applies.

5.1.11 Encoding of a Network Time Difference value

Coding of Network Time Difference within IEC 61158-6-10 applies.

5.1.12 Encoding of a Null value

a) The encoding of a NULL value shall be primitive.

b) The ContentsOctet shall be omitted.

5.2 Coding section related to data exchange PDUs

5.2.1 General

IEC 61158-5-10, Clause 5 applies.

NOTE Data types with variable length (Visible String, Octet String, TimeOfDay, Time Difference) for Inp_Data or Outp_Data are only once present in the DataExchange-RES-PDU or DataExchange-REQ-PDU. The user data correspond to the contents of the Configuration-PDU.

5.2.2 Coding of the field Outp_Data

E.g. one of the following data types shall be used for each Outp_Data field:

Boolean, Integer, Unsigned, Floating Point, Visible String, Octet String, Date, TimeOfDay, Time-Difference.

5.2.3 Coding of the field Inp_Data

E.g. one of the following data types shall be used for each Inp_Data field:

Boolean, Integer, Unsigned, Floating Point, Visible String, Octet String, Date, TimeOfDay, Time-Difference.

5.3 Coding section related to slave diagnosis PDUs

5.3.1 Coding of the field Station_status_1

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0: Diag.Station_Non_Existent
Shall be set to zero in case of Diagnosis-RES-PDU

Value (0): means FALSE if Get_Master_Diag-RES-PDU

Value (1): means TRUE if Get_Master_Diag-RES-PDU

Bit 1: Diag.Station_Not_Ready
FALSE (0)

TRUE (1)

Bit 2: Diag.Cfg_Fault (Configuration Fault)
FALSE (0)

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TRUE (1)

Bit 3: Diag.Ext_Diag (Extended Diagnosis)
FALSE (0): means that the device is NOT in state diagnosis

TRUE (1): means that the device is in state diagnosis

Flag should be set to FALSE if no faulty conditions exist. If set to TRUE, the reason should be reported as Device Related Diagnosis, Identifier Related Diagnosis, or Channel Related Diagnosis.

Bit 4: Diag.Not_Supported
FALSE (0)

TRUE (1)

Bit 5: Diag.Invalid_Slave_Response
Shall be set to zero if Diagnosis-RES-PDU

Value (0): means FALSE if Get_Master_Diag-RES-PDU

Value (1): means TRUE if Get_Master_Diag-RES-PDU

Bit 6: Diag.Prm_Fault (Parameter Fault)
FALSE (0), TRUE (1)

Bit 7: Diag.Master_Lock
Shall be set to zero if Diagnosis-RES-PDU

Value (0): means FALSE if Get_Master_Diag-RES-PDU

Value (1): means TRUE if Get_Master_Diag-RES-PDU

5.3.2 Coding of the field Station_status_2

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0: Diag.Prm_Req (Parameterization Requested)
FALSE (0)

TRUE (1)

Bit 1: Diag.Stat_Diag (Static Diagnosis)
FALSE (0)

TRUE (1)

Bit 2: DP (DP Protocol)
Shall always set to ones

Bit 3: Diag.WD_On (Watchdog on)
FALSE (0)

TRUE (1)

Bit 4: Diag.Freeze_Mode
FALSE (0)

TRUE (1)

Bit 5: Diag.Sync_Mode (Synchronisation Mode)
FALSE (0)

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TRUE (1)

Bit 6: reserved

Bit 7: Diag.Deactivated
Shall be set to zero if Diagnosis-RES-PDU

Value (0): means FALSE if Get_Master_Diag-RES-PDU

Value (1): means TRUE if Get_Master_Diag-RES-PDU

5.3.3 Coding of the field Station_status_3

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 6: reserved

Bit 7: Diag.Ext_Diag_Overflow (Overflow of extended Diagnosis)
FALSE (0)

TRUE (1)

5.3.4 Coding of the field Diag_Master_Add

This field shall be coded as data type Unsigned8 with the following values:

Decimal (0-125)
means the address of the DP-master (Class 1) which has parameterized this DP-slave

Decimal (255)
means DP-slave has not been parameterized or has got invalid parameterisation.

Decimal (126-254)
not allowed

5.3.5 Coding of the field Ident_Number

This field shall be coded as data type Unsigned16.

5.3.6 Coding of the field Header_Octet

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 5: Block_Length
It shall contain the length of the diagnosis block according to the values of Table 6, Table 7, Table 8, and Table 9. The Header_Octet itself shall always be counted.

Table 6 – Block_Length for Selection:= 0

Value (decimal)	Meaning
2 to 63	Device Related Diagnosis in base diagnosis format
4 to 63	Device Related Diagnosis in DPV1 diagnosis format

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Table 7 – Block_Length for Selection:= 1

Value (decimal)	Meaning
2 to 32	Identifier Related Diagnosis

NOTE The Identifier Related Diagnosis is limited to 32 because the identifiers itself are limited to 244.

Table 8 – Block_Length for Selection:= 2

Value (decimal)	Meaning
0 to 63	Content of the field Header_Octet.Block_Length shall be used as Identifier_Number See 5.3.15

NOTE One Channel Related Diagnosis entry contains three octets.

Table 9 – Block_Length for Selection:= 3

Value (decimal)	Meaning
1 to 63	Content of the field Header_Octet.Block_Length shall be used as Revision_Number See 5.3.18

NOTE One Revision_Number entry contains one octet.

Bit 6 to 7: Selection
The Selection shall contain the values according to Table 10.

Table 10 – Selection range

Value (decimal)	Meaning
0	Device Related Diagnosis
1	Identifier Related Diagnosis
2	Channel Related Diagnosis
3	Revision_Number

5.3.7 Coding of the field Alarm_Type

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 6: Alarm_Type
The Alarm_Type shall contain the values according to Table 11.

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Table 11 – Alarm_Type range

Value (decimal)	Meaning
0	reserved
1	Diagnostic_Alarm
2	Process_Alarm
3	Pull_Alarm
4	Plug_Alarm
5	Status_Alarm
6	Update_Alarm
7 – 31	reserved
32 – 126	manufacturer-specific
127	reserved

Bit 7: shall be zero (identifying Alarm)
Decimal (0): means Alarm

5.3.8 Coding of the field Status_Type

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 6: Status_Type
The Status_Type shall contain values according to Table 12.

Table 12 – Status_Type value range

Value (decimal)	Meaning
0	reserved
1	Status_Message
2	Modul_Status
3	DXB_Link_Status
4 to 29	reserved
30	PrmCmdAck
31	Red_Status
32 to 126	Manufacturer-specific
127	reserved

Bit 7: shall be one (identifying Status)
Decimal (1): means Status

5.3.9 Coding of the field Slot_Number

This field shall be coded as data type Unsigned8. The value shall be taken from the range 0 to 254. The value 255 is reserved.

5.3.10 Coding of the field Alarm_Specifier

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

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Bit 0 to 1: Alarm_Specifier
This bit group shall contain the alarm specifier with the values according to Table 13.

Table 13 – Alarm_Specifier

Value (decimal)	Meaning	Comment
0	No further differentiation	—
1	Error appears and Slot disturbed	the slot generates an alarm due to an error
2	Error disappears and Slot is okay	the slot generates an alarm and indicates that the slot has no further errors
3	Error disappears and Slot is still disturbed	the slot generates an alarm and indicates that the slot has still further errors

Bit 2: Additional_Acknowledge
This bit group shall contain the Additional_Acknowledge with the values according to Table 14.

Table 14 – Additional_Acknowledge

Value (decimal)	Meaning	Comment
0	No additional acknowledge used	—
1	Additional acknowledge is used	—

Bit 3 to 7: Sequence_Number
The value range shall be from 0 to 31 (decimal).

5.3.11 Coding of the field Status_Specifier

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 1: Status_Specifier
This bit group shall contain the status specifier with the values according to Table 15.

Table 15 – Status_Specifier

Value (decimal)	Meaning	Comment
0	No further differentiation	—
1	Status appears	—
2	Status disappears	—
3	Reserved	—

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Bit 2 to 7: reserved

5.3.12 Coding of the field Diagnosis_User_Data

One of the following data types shall be used for each Diagnosis_User_Data field:

Boolean, Integer, Unsigned, Floating Point, Visible String, Octet String, Date, TimeOfDay, Time-Difference.

5.3.13 Coding of the field Modul_Status_Array

The field Modul_Status_Array is an array of octets that shall contain at least one and at most 61 octets referred to as Modul_Status_Octet. A Modul_Status_Octet shall consist of at least one and at most 4 module stati referred to as Modul_Status_Entry_1 to Modul_Status_Entry_4 coded in two bits each. Therefore, the number of Modul_Status_Octet corresponds to the number of configured modules within a device and shall be calculated as follows

a) $N = 1$ if $M_{highest} \leq 4$
b) $N = M_{highest}$ DIV 4 +1 if $M_{highest}$ MOD 4 $\neq 0$
c) $N = M_{highest}$ DIV 4 if $M_{highest}$ MOD 4 = 0

where

N is the number of octets Modul_Status_Octet or the number of array elements,

$M_{highest}$ is the highest number of configured modules within a device (maximum 244).

The last Modul_Status_Octet (octet N) may not contain all 4 module status entries. If $M_{highest}$ MOD 4 $\neq 0$ the octet N is not fully filled and the remaining bits shall be set to zero referred to as Padding Bits.

The status of the device's modules shall be structured in ascending order without gaps. The status of module number one is always placed in Modul_Status_Entry_1 of the Modul_Status_Octet number one. The coding of a Modul_Status_Octet shall be according to 3.4 and the individual bits shall have the following meaning:

NOTE The term "configured modules" addresses physical or virtual modules of a device that have had a related format field in the Chk_Cfg-REQ-PDU. Modules that are not part of the configuration are purely local and therefore not related to the Modul_Status_Array field.

Bit 0 to 1: Modul_Status_Entry_1
It shall contain the module status of a configured module with the number that meets m MOD 4 = 1. Padding bits shall not be used here.

Bit 2 to 3: Modul_Status_Entry_2
It shall contain the module status of a configured module with the number that meets m MOD 4 = 2. Otherwise padding bits (00 binary) shall be used.

Bit 4 to 5: Modul_Status_Entry_3
It shall contain the module status of a configured module with the number that meets m MOD 4 = 3. Otherwise padding bits (00 binary) shall be used.

Bit 6 to 7: Modul_Status_Entry_4
These 2 bits shall contain the module status of a configured module with the number that meets m MOD 4 = 0. Otherwise padding bits (00 binary) shall be used.

where

m is the number of the current module with $1 \leq m \leq N$.

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Figure 2 illustrates the arrangement of Modul_Status_Entry_(1 to 4) fields as an example for a device with 6 configured modules.

	Bit Number							
	7	6	5	4	3	2	1	0
Modul_ Status_ Octet 1	status module number 4		status module number 3		status module number 2		status module number 1	
Modul_ Status_ Octet 2	Padding Bits		Padding Bits		status module number 6		status module number 5	
	Modul_Status_Entry_4		Modul_Status_Entry_3		Modul_Status_Entry_2		Modul_Status_Entry_1	

Figure 2 – Example Modul_Status_Array

Each entry Modul_Status_Entry_1 to Modul_Status_Entry_4 shall contain the module status according to Table 16.

Table 16 – Range of Modul_Status_Entry (1-4)

Value (decimal)	Meaning
0	data valid
1	data invalid: the data of the corresponding module are not valid due to an error (e.g. short circuit)
2	data invalid/wrong module: the data of the corresponding module are not valid, due to a wrong module in place
3	data invalid/no module: the data of the corresponding module are not valid, because there is no module in place

5.3.14 Coding of the field Identifier_Diagnosis_Data_Array

The field Identifier_Diagnosis_Data_Array is an array of octets that shall contain at least one and at most 31 octets referred to as Identifier_Diagnosis_Data_Octet. A Identifier_Diagnosis_Data_Octet shall consist of at least one and at most 8 diagnosis entries referred to as Identifier_Diagnosis_Entry_1 to Identifier_Diagnosis_Entry_8. Therefore, the number of Identifier_Diagnosis_Data_Octet corresponds to the number of configured modules within a device and shall be calculated as follows:

a) $N = 1$ if $M_{highest} \leq 8$

b) $N = M_{highest}$ DIV 8 +1 if $M_{highest}$ MOD 8 $\neq 0$

c) $N = M_{highest}$ DIV 8 if $M_{highest}$ MOD 8 = 0

where

N is the number of octets Identifier_Diagnosis_Data_Octet or the number of array elements,

$M_{highest}$ is the highest number of configured modules within a device (maximum 244).

The last Identifier_Diagnosis_Data_Octet (octet N) may not contain all 8 diagnosis entries. If $M_{highest}$ MOD 8 $\neq 0$ the octet N is not fully filled and the remaining bits shall be set to zero referred to as Padding Bits.

NOTE The term DIV stands for division without rest. The term MOD stands for the rest of the division.

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The identifier diagnosis of the device's modules shall be structured in ascending order without gaps. The identifier diagnosis of module number one is always placed in Identifier_Diagnosis_Entry_1 of the Identifier_Diagnosis_Data_Octet number one. The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0: Identifier_Diagnosis_Entry_1
This bit shall be set to one if the module with the number that meets m MOD 8 = 1 indicates diagnosis otherwise it shall be set to zero. A padding bit shall not be used here.

Bit 1: Identifier_Diagnosis_Entry_2
This bit shall be set to one if the module with the number that meets m MOD 8 = 2 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 2: Identifier_Diagnosis_Entry_3
This bit shall be set to one if the module with the number that meets m MOD 8 = 3 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 3: Identifier_Diagnosis_Entry_4
This bit shall be set to one if the module with the number that meets m MOD 8 = 4 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 4: Identifier_Diagnosis_Entry _5
This bit shall be set to one if the module with the number that meets m MOD 8 = 5 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 5: Identifier_Diagnosis_Entry _6
This bit shall be set to one if the module with the number that meets m MOD 8 = 6 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 6: Identifier_Diagnosis_Entry _7
This bit shall be set to one if the module with the number that meets m MOD 8 = 7 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

Bit 7: Identifier_Diagnosis_Entry_8
This bit shall be set to one if the module with the number that meets m MOD 8 = 0 indicates diagnosis otherwise it shall be set to zero. A padding bit shall be used if there is no module configured.

where m is the number of the current module with $1 \leq m \leq N$.

5.3.15 Coding of the field Identifier_Number

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

Bit 0 to 5: Identifier_Number
The values 0 to 63 (decimal) are valid.

Bit 6 to 7: Selection
The Selection shall contain the value Channel Related Diagnosis according to Table 10.

5.3.16 Coding of the field Channel_Number

The coding of this field shall be according to 3.4 and the individual bits shall have the following meaning:

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