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PRE-STANDARD

Industrial communication networks – Fieldbus specifications –
Part 6-22: Application layer protocol specification – Type SNpTYPE elements

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-22: Application layer protocol specification – Type SNpTYPE elements

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

INTRODUCTION

This PAS contains an additional profile – SNpTYPE – which may be integrated into a future new edition of the IEC 61158-6 series.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-22: Application layer protocol specification – Type SNpTYPE 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 61158-6 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 SNpTYPE 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 part of IEC 61158-6 defines in an abstract way the externally visible behavior provided by the different Types of the 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 part of IEC 61158-6 is to define the protocol provided to:

1) define the wire-representation of the service primitives defined in IEC/PAS 61158-5-22; and

2) define the externally visible behavior associated with their transfer.

This part of IEC 61158-6 specifies the protocol of the IEC fieldbus Application Layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) 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 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 part of IEC 61158-6 to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this part of IEC 61158-6 is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC/PAS 61158-5-22.

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 subparts of IEC 61158-6.

1.3 Conformance

This part of IEC 61158-6 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 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 60559, *Binary floating-point arithmetic for microprocessor systems*

IEC/PAS 61158-3-22, *Industrial communication networks – Fieldbus specifications – Part 3-SNpTYPE: Data-link layer service definition – Type SNpTYPE elements*

IEC/PAS 61158-4-22, *Industrial communication networks – Fieldbus specifications – Part 4-SNpTYPE: Data-link layer protocol specification – Type SNpTYPE elements*

IEC/PAS 61158-5-22, *Industrial communication networks – Fieldbus specifications – Part 5–SNpTYPE: Application layer service definition - Type SNpTYPE elements*

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

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/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*

3 Terms, definitions, abbreviations, symbols and conventions

For the purposes of this document, the following terms as defined in these publications apply:

3.1 Referenced terms and definitions

3.1.1 ISO/IEC 7498-1 terms

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
h) application-service-element
i) application control service element

3.1.4 ISO/IEC 8824 terms

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

a) object identifier
b) type

3.2 Fieldbus application-layer specific definitions

3.2.1
acyclic data
data which is transferred from time to time for dedicated purposes

3.2.2
bit
unit of information consisting of a 1 or a 0. This is the smallest data unit that can be transmitted

3.2.3
cell
synonym for a single DL-segment which uses RTFL communication model

3.2.4
channel
path provided for conveying data

3.2.5
client
object which uses the services of a server by initiating a message to perform a task

3.2.6
communication cycle
fixed time period between which the root device issues empty frames for cyclic communication initiation in which data is transmitted utilizing CDC and MSC

3.2.7
connection
logical binding between two application objects

3.2.8
cycle time
duration of a communication cycle

3.2.9
cyclic
events which repeat in a regular and repetitive manner

3.2.10
cyclic communication
periodic exchange of telegrams

3.2.11
cyclic data
data which is transferred in a regular and repetitive manner for dedicated purposes

3.2.12
cyclic data channel (CDC)
part of one or more frames, which is reserved for cyclic data

3.2.13
data
generic term used to refer to any information carried over a fieldbus

3.2.14
device
physical entity connected to the fieldbus

3.2.15
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.2.16
error code
identification number of a specific type of error

3.2.17
gateway
device acting as a linking element between different protocols

3.2.18
index
position of an object within the object dictionary

3.2.19
inter-cell communication
communication between a RTFL device and a RTFN device or communication between a RTFL device and another RTFL device in different cells linked by RTFN

3.2.20
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristic, or other characteristics as appropriate

3.2.21
intra-cell communication
communication between a RTFL device and another RTFL device in the same cell

3.2.22
mapping parameters
set of values defining the correspondence between application objects and process data objects

3.2.23
master clock
global time base for the PCS mechanism

3.2.24
message
ordered sequence of octets intended to convey data

3.2.25
message channel (MSC)
part of one or more frames, which is reserved for acyclic data

3.2.26
network
set of devices connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.2.27
ordinary device (OD)
slave in the communication system, which utilizes RTFL for cyclic and acyclic data interchange with other ODs in the same logical double line

3.2.28
precise clock synchronization (PCS)
mechanism to synchronize clocks of RTFL devices and maintain a global time base

3.2.29
process data
data designated to be transferred cyclically or acyclically for the purpose of processing

3.2.30
process data object
dedicated data object(s) designated to be transferred cyclically or acyclically for the purpose of processing

3.2.31
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.2.32
root device (RD)
master in the communication system, which organises, initiates and controls the RTFL cyclic and acyclic data interchange for one logical double line

3.2.33
real time frame line (RTFL)
communication model for communication with high real time requirements

3.2.34
real time frame network (RTFN)
communication model for communication with low real time requirements

3.2.35
round trip time
transmission time needed by a DLPDU from the RD to the last OD in forward and backward direction

3.2.36
sub-index
sub-position of an individual element of an object within the object dictionary

3.2.37
timing signal
time-based indication of the occurrence of an event, commonly as an interrupt signal, used for DL-user synchronization

3.2.38
topology
physical network architecture with respect to the connection between the stations of the communication system

3.3 Abbreviations and symbols

AE	Application entity
AL	Application layer
AP	Application process
APDU	Application layer protocol data unit
APO	Application process object

AR	Application relationship
AREP	Application relationship end point
ASE	Application service element
CDC	Cyclic data channel
CL	Communication layer
Cnf	Confirmation
DA	Device address or destination address
DHCP	Dynamic Host Configuration Protocol
DL-	Data-link layer (as a prefix)
DLL	DL-layer
DLPDU	DL-protocol data unit
EDS	Electronic data sheet
EMCY	Emergency
FAL	Fieldbus application layer
FCS	Frame check sequence
ID	Identification
Ind	Indication
IP	Internet protocol
IPv4	IP version 4
IPv6	IP version 6
IRQ	Interrupt request
LME	Layer management entity
MAC	Medium access control
MII	Media independent interface
MSC-MTP	Message channel message transfer protocol
MSC	Message channel

OD	Ordinary device
OS	Operating system
OSI	Open systems interconnection
PCS	Precise clock synchronization
PDO	Process data object
PID	Packet ID
PTPMSU	Point-to-multipoint network-scheduled unconfirmed
PTPNSC	Point-to-point network-scheduled confirmed
PTPNSU	Point-to-point network-scheduled unconfirmed
PTPUTC	Point-to-point user-triggered confirmed
RD	Root device
Req	Request
Rsp	Response
RTF	Real time frame
RTFL	Real time frame line
RTFN	Real time frame network
RO	Read only
RW	Read and write access
Rx	Receive direction
RxPDO	Receive PDO
SA	Source address
SDO	Service data object
SEF	Standard Ethernet frame
StdErr	Standard error output
StdIn	Standard input
StdOut	Standard output

SYNC	Synchronization
TCP	Transmission control protocol
TT	Transmission type
Tx	Transmit direction
TxPDO	Transmit PDO
UDP	User datagram protocol
WO	Write only

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 clause. Each ASE specification is composed of three parts: its class definitions, its services, and its protocol specification. The first two are contained in IEC/PAS 61158-5-22. The protocol specification for each of the ASEs is defined in this part of IEC 61158-6.

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/PAS 61158-5-22. The service specification defines the services that are provided by the ASE.

This part of IEC 61158-6 uses the descriptive conventions given in ISO/IEC 10731.

3.4.2 Abstract syntax conventions

The data type BYTE used within this part of IEC 61158-6 is of the type Unsigned8 as specified in 5.2.

The AL syntax elements related to PDU structure are described as shown in Table 1.

- Frame part denotes the element that will be replaced by this reproduction.
- Data field is the name of the elements.
- Data type denotes the type of the terminal symbol.
- Value/description contains the constant value or the meaning of the parameter.

Table 1 – PDU element definition

Frame part	Data field	Data type	Value/description

The attributes of an object of the object dictionary are described in a form as shown in Table 2.

- Index describes the position within the object dictionary of an object.
- Sub-index describes a single element of the object.

- Name denotes a name string for this attribute.
- Object type denotes the characterizing type for each object as specified in Table 7.
- Data type denotes the data type of this element.
- Category indicates whether the element is mandatory (M), optional (O) or depends upon setting of other attributes (C).
- Access attribute shows the access right to this element. RO means read access right, RW means read and write access right, while WO means write access right.
- PDO mapping denotes the possibility to map this attribute to TxPDO or RxPDO or to indicate that this parameter is not mappable.
- Value range contains the value range of a dedicated element or 'No' for no pre-defined value range.
- Value contains the constant value(s) and/or the meaning of the parameter or 'No' for no pre-defined value.

Table 2 – Object definition

Attribute	Value
Index	
Sub-index	
Name	
Object type	
Data type	
Category	
Access attribute	
PDO mapping	
Value range	
Value	

4 Application layer protocol specification

4.1 Operating principle

Type SNpTYPE consists of two types of communication models: RTFL and RTFN. RTFL is used to ensure synchronized cyclic real-time communication. RTFN is used to network several RTFL cells to an overall system providing data interchange between several RTFL cells and between RTFL cells and RTFN devices.

In this context, a RTFL cell describes a cell which uses RTFL for communication. An RTFL cell consists of a root device (RD) and one or several ordinary devices (OD). The central RTFL cell element is the root device which organizes and controls RTFL cell sequences such as cyclic real-time frame sending. A RTFL RD has at least one connection to RTFL, and can include a gateway (GW) which additionally has connection to RTFN. As each OD in the RTFL cell can only have a RTFL connection, the RD incorporating a GW therefore operates as a link between RTFL and RTFN. RTFN communication is not coordinated like communication in RTFL, but utilized by a switched fully duplex standard Ethernet. Thus, no determinism can be guaranteed for RTFN data transfer.

Communication of process and service data is accommodated by Type SNpTYPE networks using different mechanisms (channels) in RTFL and RTFN. Cyclic data can be transferred over the cyclic data channel (CDC). The message channel (MSC) allows additional acyclic data communication and is used for service data exchange.

Service data is typically transferred acyclic and is used for transfer of parameters, control commands, status and diagnostic data as well as for generally larger data segments. Service data are transferred either event driven or user driven (acyclic character). Parameter data used in particular in device configuration do not require strict time conditions whereas diagnostic data may have much greater time requirements.

In contrast, process data is typically transferred cyclically with different cycle times and higher real-time requirements.

Type SNpTYPE AL supports a variety of services and protocols to meet these differing requirements. Both communication models support the same fieldbus application layer. The services and protocols are mapped to the corresponding DL-services.

4.2 Device reference models

4.2.1 RTFL device reference model

Type SNpTYPE services are described using the principles, methodology and model of ISO/IEC 7498-1 (OSI). The OSI model provides a layered approach to communications standards, whereby the layers can be developed and modified independently. The Type SNpTYPE specification defines functionality from top to bottom of a full OSI model. Functions of the intermediate OSI layers, layers 3 to 6, are consolidated into either the Type SNpTYPE data-link layer or the Type SNpTYPE application layer. The device reference model for a Type SNpTYPE RTFL device is shown in Figure 1.

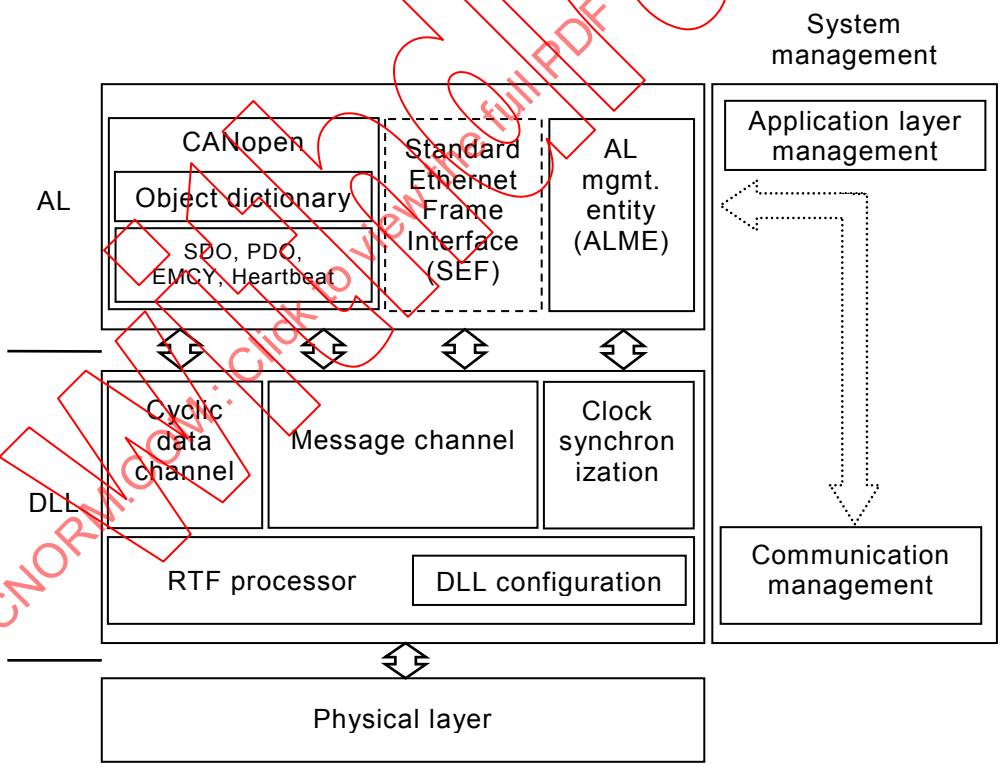

Figure 1 – RTFL device reference model

4.2.2 RTFN device reference model

Type SNpTYPE services are described using the principles, methodology and model of ISO/IEC 7498-1 (OSI). The OSI model provides a layered approach to communications standards, whereby the layers can be developed and modified independently. The Type SNpTYPE specification defines functionality from top to bottom of a full OSI model. Functions of the intermediate OSI layers, layers 3 to 6, are consolidated into either the Type SNpTYPE

data-link layer or the Type SNpTYPE application layer. The device reference model for a Type SNpType RTFN device is shown in Figure 2.

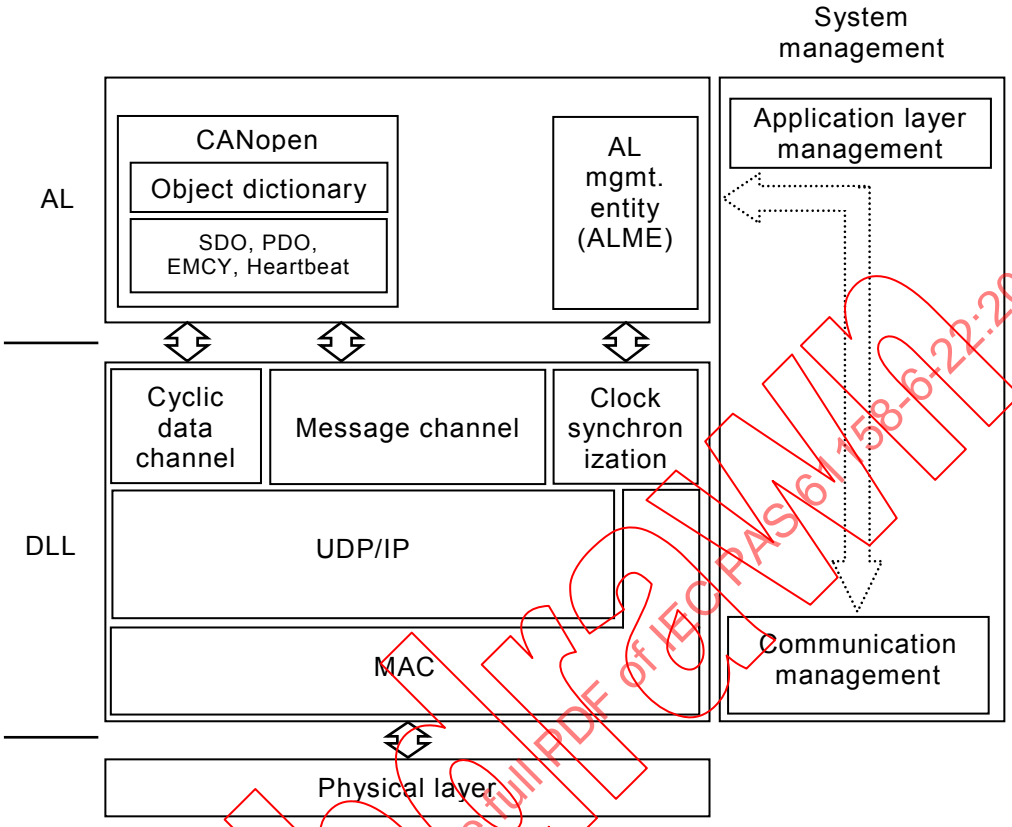

Figure 2 – RTFN device reference model

4.3 Application Layer structure

The Application Layer consists of the following elements.

- A mandatory unit for real time data processing (CeS).
- An optional entity to enable Standard Ethernet frame communication.
- A mandatory management entity for system management.

The Application Layer uses the services provided by the Type SNpTYPE DLL to convey the AL-service data.

5 FAL syntax description

5.1 Introduction and coding principles

The abstract syntax and the transfer syntax are merged into a fixed format that is defined in the following clauses.

5.2 Data type encoding

5.2.1 Overview

To be able to exchange meaningful data across a Type SNpTYPE network, the format of this data and its meaning have to be known by communicating entities. This specification models this by the concept of data types.

The encoding rules define the representation of values of data types and the transfer syntax for the representation. Values are represented as bit sequences. Bit sequences are transferred in sequences of octets. For numerical data types the encoding is little endian style.

The data types and encoding rules shall be valid for the AL services and protocols. The encoding rules for the Ethernet frame are specified in ISO/IEC 8802-3. The DLSDU of Ethernet is an octet string. The transmission order within octets depends upon MAC and PhL encoding rules.

5.2.2 Transfer syntax for bit sequences

For transmission across Type SNpTYPE AL a bit sequence is reordered into a sequence of octets. Let b = b_{n-1} to b_0 be a bit sequence. Denote k a non-negative integer such that 8(k - 1) < n < 8k. Then b is transferred in k octets assembled as shown in Table 3. The bits b_i, i > n of the highest numbered octet are do not care bits.

Octet 1 is transmitted first and octet k is transmitted last. Hence the bit sequence is transferred as follows across the network:

b7, b6, ..., b0, b15, ..., b8, ...

Table 3 – Transfer syntax for bit sequences

Octet number	1.	2.	k.
—	b_7 ... b_0	b_{15} ... b_8	b_{8k-1} ... b_{8k-8}

5.2.3 Encoding of a Boolean value

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

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

5.2.4 TimeOfDay

a) The encoding of a TimeOfDay with and without date indication value shall be primitive.

b) The octets shall be equal in value to the octets in the data value, as shown in Figure 3.

Bits	7	6	5	4	3	2	1	0	Meaning
Octets									
1	0	0	0	0	2^{27}	2^{26}	2^{25}	2^{24}	Number of milliseconds since midnight
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	
4	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	Number of days since 01.01.84 only with date indication
6	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
	msb								

Figure 3 – Encoding of TimeOfDay value

5.2.5 TimeDifference

a) The encoding of a Time Difference with and without date indication value shall be primitive.

b) The content octets shall be equal in value to the octets in the data value, as shown in Figure 4.

Bits	7	6	5	4	3	2	1	0	Meaning
Octets									
1	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	milliseconds
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	days
6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	only with date indication
	msb								

Figure 4 – Encoding of TimeDifference value

5.2.6 Encoding of floating point values

These encoding rules are applied for data types float, Float32, double and Float64 as specified in IEC/PAS 61158-5-22.

a) The encoding of a fixed-length Floating-Point value of Floating32 and Floating64 types shall be primitive, and the content octets shall consist of exactly four or eight octets, respectively.

b) The content octets shall contain floating-point values defined in conformance with IEC 60559. 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 or Floating64.

5.2.7 Encoding of Integer values

Data of basic data type Integer has values in the integers. The value range is from -2^{n-1} to $2^{n-1}-1$. The data is represented as bit sequences of length n. The bit sequence

$b = b_0$ to b_{n-1}

is assigned the value

$\text{Integer}(b) = b_{n-2}\times 2_{n-2} + \ldots + b_1\times 2^1 + b_0\times 2^0$ if $b_{n-1} = 0$

and, performing two's complement arithmetic,

$\text{Integer}(b) = -\text{Integer}(\hat{}b) - 1$ if $b_{n-1} = 1$

Note that the bit sequence starts on the left with the least significant bit.

EXAMPLE The value –257 = 0xFEFF with data type Integer16 is transferred in two octets, first 0xFF and then 0xFE.

The Integer data types are transferred as specified in Table 4.

Table 4 – Transfer syntax for Integer data type

Octet number	1.	2.	3.	4.	5.	6.	7.	8.
Integer8	$b_7 - b_0$	—	—	—	—	—	—	—
Integer16	$b_7 - b_0$	$b_{15} - b_8$	—	—	—	—	—	—
Integer32	$b_7 - b_0$	$b_{15} - b_8$	$b_{23} - b_{16}$	$b_{31} - b_{24}$	—	—	—	—
Integer64	$b_7 - b_0$	$b_{15} - b_8$	$b_{23} - b_{16}$	$b_{31} - b_{24}$	$b_{39} - b_{32}$	$b_{47} - b_{40}$	$b_{55} - b_{48}$	$b_{63} - b_{56}$

NOTE 1 Data types SINT and char as defined in IEC/PAS 61158-5-22 corresponds to Integer8.

NOTE 2 Data types INT and short as defined in IEC/PAS 61158-5-22 corresponds to Integer16.

NOTE 3 Data types DINT and long as defined in IEC/PAS 61158-5-22 corresponds to Integer32.

NOTE 4 Data type LINT as defined in IEC/PAS 61158-5-22 corresponds to Integer64.

5.2.8 Encoding of Unsigned Integer values

Data of basic data type Unsigned Integer has values in the non-negative integers. The value range is 0 to 2^{n-1}. The data is represented as bit sequences of length n. The bit sequence

$b = b_0 \ldots b_{n-1}$

is assigned the value

$\text{Unsigned}(b) = b_{n-1} \times 2^{n-1} + \ldots + b_1 \times 2^1 + b_0 \times 2^0$

The bit sequence starts on the left with the least significant octet.

EXAMPLE The value 286 = 0x11E with data type Unsigned16 is transferred in two octets, first 0x1E and then 0x01.

The unsigned data types are transferred as specified in Table 5.

Table 5 – Transfer syntax for Unsigned data type

Octet number	1.	2.	…	4.	…	8.	…	16.	…	32.
Unsigned8	b_7–b_0	—	—	—	—	—	—	—	—	—
Unsigned 16	$b_7 - b_0$	$b_{15} - b_8$	—	—	—	—	—	—	—	—
Unsigned32	$b_7 - b_0$	$b_{15} - b_8$	—	$b_{31} - b_{24}$	—	—	—	—	—	—
Unsigned64	$b_7 - b_0$	$b_{15} - b_8$	—	$b_{31} - b_{24}$	—	$b_{63} - b_{56}$	—	—	—	—
Unsigned128	$b_7 - b_0$	$b_{15} - b_8$	—	$b_{31} - b_{24}$	—	$b_{63} - b_{56}$	—	$b_{127} - b_{120}$	—	—
Unsigned256	$b_7 - b_0$	$b_{15} - b_8$	—	$b_{31} - b_{24}$	—	$b_{63} - b_{56}$	—	$b_{127} - b_{120}$	—	$b_{255} - b_{248}$

NOTE 1 Data types USINT and unsigned char as defined in IEC/PAS 61158-5-22 corresponds to Unsigned8.

NOTE 2 Data types UINT and WORD as defined in IEC/PAS 61158-5-22 corresponds to Unsigned16.

NOTE 3 Data types UDINT and DWORD as defined in IEC/PAS 61158-5-22 corresponds to Unsigned32.

NOTE 4 Data type ULINT as defined in IEC/PAS 61158-5-22 corresponds to Unsigned64.

5.2.9 Encoding of an OctetString 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 content octets 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 content octets.

5.2.10 Encoding of a VisibleString value

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

b) There is no length field and no termination symbol; the length is encoded implicitly.

c) The content octets 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 content octets.

5.2.11 Encoding of an UnicodeString value

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

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

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

5.3 CeS encoding

5.3.1 Object dictionary

5.3.1.1 Object dictionary structure

The dictionary is structured in form of a table as indicated in Table 6.

Table 6 – Object dictionary structure

Index	Section	Sub-section	Content
0x0001 to 0x001F	Data type	Basic data types	Definition of basic data types
0x0020 to 0x003F	—	Complex data types	Definition of complex data types
0x0040 to 0x005F	—	Manufacturer specific data types	Definition of manufacturer specific data types
0x0060 to 0x007F	—	Device profile specific basic data types	Definition of device profile specific basic data types
0x0080 to 0x009F	—	Device profile specific complex data types	Definition of device profile specific complex data types
0x00A0 to 0x0FFF	Reserved	—	—
0x1000 to 0x1FFF	Communication profile	—	Definition of the parameters which are used for communication configuration and dedicated communication purposes
0x2000 to 0x5FFF	Manufacturer defined profile	—	Definition of manufacturer specific parameters
0x6000 to 0x9FFF	Standardized device profile	—	Definition of the parameters defined in a standardized device profile
0xA000 to 0xBFFF	Standardized interface profile	—	Definition of the parameters defined in standardized interface profile
0xC000 to 0xC8FF	Type SNpTYPE RTFN interface profile	—	Definition of the parameters defined in Type SNpTYPE RTFN interface profile
0xC900 to 0xFFFF	Reserved	—	—

A logical addressing scheme is used for object dictionary access. The index field describes the position within the object dictionary. Each index is further described by an 8 bit sub-index. In case of a complex entry consisting of several elements, the sub-index subdivides an entry in up to 255 elements. For complex entries, sub-index 0x00 shall indicate the number of entries. Sub-index 255 depicts a reference to the data structure of the object and is optional. For simple object dictionary entries consisting of one object the sub-index shall have the value 0x00. Figure 5 shows the addressing scheme.

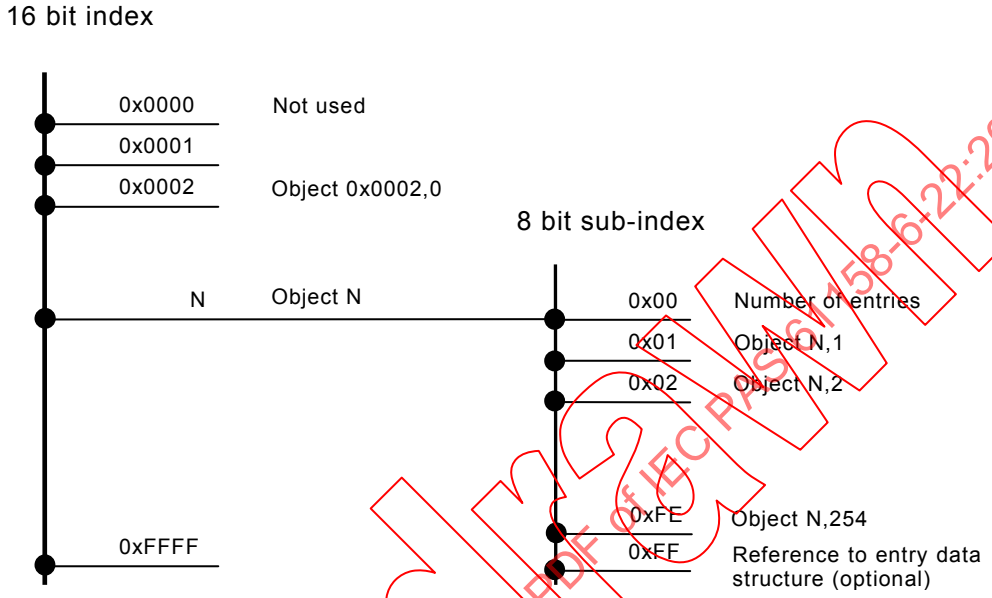

Figure 5 – Object dictionary addressing schema

5.3.1.2 Object type definitions

The index field describes the position in the object dictionary. Each single entry in the object dictionary is specified by a characterizing object type. The object type definitions are listed in Table 7.

Table 7 – Object dictionary object type definitions

Object name	Object code	Description
DOMAIN	0x0002	Indicates an entry with large variable amount of data
DEFTYPE	0x0005	Indicates a data type definition
DEFSTRUCTURE	0x0006	Indicates a record definition or definition of a structured data type
VAR	0x0007	Indicates a simple variable or a value of a simple data type
ARRAY	0x0008	Indicates a simple data type array variable
RECORD	0x0009	Indicates a record variable

5.3.1.3 Basic data type section

The basic data type section is specified in Table 8.

Table 8 – Basic data type definitions

Index	Object	Name
0x0001	DEFTYPE	BOOLEAN
0x0002	DEFTYPE	INTEGER8
0x0003	DEFTYPE	INTEGER16
0x0004	DEFTYPE	INTEGER32
0x0005	DEFTYPE	UNSIGNED8
0x0006	DEFTYPE	UNSIGNED16
0x0007	DEFTYPE	UNSIGNED32
0x0008	DEFTYPE	REAL32
0x0009	DEFTYPE	VISIBLE_STRING
0x000A	DEFTYPE	OCTET_STRING
0x000B	DEFTYPE	UNICODE_STRING
0x000C	DEFTYPE	TIME_OF_DAY
0x000D	DEFTYPE	TIME_DIFFERENCE
0x000E	Reserved	
0x000F	DEFTYPE	DOMAIN
0x0010	DEFTYPE	INTEGER24
0x0011	DEFTYPE	REAL64
0x0012	DEFTYPE	INTEGER40
0x0013	DEFTYPE	INTEGER48
0x0014	DEFTYPE	INTEGER56
0x0015	DEFTYPE	INTEGER64
0x0016	DEFTYPE	UNSIGNED24
0x0017	Reserved	
0x0018	DEFTYPE	UNSIGNED40
0x0019	DEFTYPE	UNSIGNED48
0x001A	DEFTYPE	UNSIGNED56
0x001B	DEFTYPE	UNSIGNED64
0x001C	DEFTYPE	UNSIGNED128
0x001D	DEFTYPE	UNSIGNED256
0x000E-0x000F	Reserved	

5.3.1.4 Complex data type section

The complex data type section is specified in Table 9.

Table 9 – Complex data type definition

Index	Object	Name
0x0020	DEFSTRUCT	PDO_COMMUNICATION_PARAMETER (PDO COM_PAR)
0x0021	DEFSTRUCT	PDO_MAPPING
0x0022	DEFSTRUCT	SDO_PARAMETER
0x0023	DEFSTRUCT	IDENTITY
0x0024	DEFSTRUCT	DEBUGGER_PARAMETER
0x0025	DEFSTRUCT	COMMAND_PARAMETER
0x0026 to 0x002F	Reserved	
0x0030	DEFSTRUCT	DIAGNOSIS_PAR
0x0031 to 0x003F	Reserved	
0x0040 to 0x005F	DEFSTRUCT	Manufacturer defined data types
0x0060 to 0x007F	DEFTYPE	Device profile 0 specific basic data types
0x0080 to 0x009F	DEFSTRUCT	Device profile 0 specific complex data types
0x00A0 to 0x00BF	DEFTYPE	Device profile 1 specific basic data types
0x00C0 to 0x00DF	DEFSTRUCT	Device profile 1 specific complex data types
0x00E0 to 0x00FF	DEFTYPE	Device profile 2 specific basic data types
0x0100 to 0x011F	DEFSTRUCT	Device profile 2 specific complex data types
0x0120 to 0x013F	DEFTYPE	Device profile 3 specific basic data types
0x0140 to 0x015F	DEFSTRUCT	Device profile 3 specific complex data types
0x0160 to 0x017F	DEFTYPE	Device profile 4 specific basic data types
0x0180 to 0x019F	DEFSTRUCT	Device profile 4 specific complex data types
0x01A0 to 0x01BF	DEFTYPE	Device profile 5 specific basic data types
0x01C0 to 0x01DF	DEFSTRUCT	Device profile 5 specific complex data types
0x01E0 to 0x01FF	DEFTYPE	Device profile 6 specific basic data types
0x0200 to 0x021F	DEFSTRUCT	Device profile 6 specific complex data types
0x0220 to 0x023F	DEFTYPE	Device profile 7 specific basic data types
0x0240 to 0x025F	DEFSTRUCT	Device profile 7 specific complex data types
0x0260 to 0x0FFF	Reserved	

5.3.1.5 Communication section

5.3.1.5.1 Overview

Communication object dictionary section consists of the elements described in Table 10.

Table 10 – Communication section

Index	Object	Name	Data type	Attr.	Cat.
0x1000	VAR	Device type	Unsigned32	RO	M
0x1001	VAR	Error register	Unsigned8	RO	M
0x1002	VAR	Manufacturer status register	Unsigned32	RO	O
0x1003	ARRAY	Pre-defined error field	OCTET_STRING	RO	O
0x1004 to 0x1007	Reserved				
0x1008	VAR	Manufacturer device name	VISIBLE_STRING	RO	O
0x1009	VAR	Manufacturer HW version	VISIBLE_STRING	RO	O
0x100A	VAR	Manufacturer SW version	VISIBLE_STRING	RO	O
0x100B	RECORD	CL configuration	CL configuration record	RW	O
0x100C	ARRAY	Time sync IRQ configuration	Unsigned128	RW	O
0x100D	ARRAY	Time sync IRQ state	Unsigned8	RO	O
0x100E 0x100F	Reserved				
0x1010	ARRAY	Store parameters	Unsigned32	RW	O
0x1011	ARRAY	Restore default parameters	Unsigned32	RW	O
0x1012	RECORD	Diagnostic information	Diagnosis_Par	RW	O
0x1013	RECORD	Diagnostic thresholds	Diagnosis_Par	RW	O
0x1014	VAR	MSCN-address EMCY	Unsigned48	RW	O
0x1015	VAR	Inhibit time EMCY	Unsigned16	RW	O
0x1016	ARRAY	Consumer heartbeat list	Unsigned256	RW	O
0x1017	RECORD	Producer heartbeat parameter	PDO COM_PAR	RW	O
0x1018	RECORD	Identity object	IDENTITY	RO	M
0x1019 0x101A	Reserved				
0x101B	VAR	SDO protocol timeout	Unsigned32	RW	O
0x101C	VAR	Enable client SDO parameter	Boolean	RW	M/O
0x101D	VAR	Enable EMCY	Boolean	RW	M/O
0x101E	VAR	PDO timeout tolerance	Unsigned8	RW	M/O
0x101F 0x1020					
0x1021	VAR	Store EDS	DOMAIN	RW	O
0x1022	VAR	Storage format	Unsigned8	RW	O
0x1023	RECORD	OS command	Command Par	RW	O
0x1024	VAR	OS command mode	Unsigned8	RW	O
0x1025	RECORD	OS debugger interface	Debugger Par	RW	O
0x1026	ARRAY	OS prompt	Unsigned8	WO	O

Index	Object	Name	Data type	Attr.	Cat.
0x1027	ARRAY	Module list	Unsigned16	RO	O
0x1028	ARRAY	Emergency subscriber	Unsigned64	RW	O
0x1029 to 0x11FF	Reserved				
0x1200 to 0x127F	Reserved for safety extensions				
0x1280 to 0x12FF	ARRAY	Client SDO parameter	Unsigned256	RW	M/O
0x1300 to 0x13FF	Reserved				
0x1400 to 0x15FF	RECORD	Rx PDO parameter	PDO COM_PAR	RW	M/O
0x1600 to 0x17FF	RECORD	Rx PDO mapping	PDO MAPPING	RW	M/O
0x1800 to 0x19FF	RECORD	Tx PDO parameter	PDO COM_PAR	RW	M/O
0x1A00 to 0x1BFF	RECORD	TX PDO mapping	PDO MAPPING	RW	M/O
0x1C00 to 0x1FFF	Reserved for safety extensions				

5.3.1.5.2 Device type

The device type object indicates the implemented device profile and its function and is specified in Table 11. It comprises of two 16 bit fields. The first field depicts the device profile number and describes the used device profile. The second 16 bit field supplies additional information on optional device functions and is part of the device profile or product specification. The value 0x0000 indicates a device that does not follow a standardized device profile. For multiple device modules the additional information parameter contains 0xFFFF and the device profile number referenced by object 0x1000 is the device profile of the first device in the object dictionary. All other devices of a multiple device module identify their profiles at objects 0x67FF + X * 0x800 with X = internal number of the device (0 to 7). These entries describe the device type of the preceding device. Devices use device profile numbers from four to seven for failsafe functions, so that the first failsafe application objects start at 0x8000.

Table 11 – Device type

Attribute	Value
Index	0x1000
Name	Device type
Object type	VAR
Data type	Unsigned32
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	No
Value	Bit 0 to 15: Device profile number Bit 16 to 31: Additional information depending on the used device profile

5.3.1.5.3 Error register

The error register object as specified in Table 13 assigns categories to the different error groups allowing to indicate the presence of a device error in a certain category. The structure and encoding of the error register is specified in Table 12.

Table 12 – Error register encoding

Bit number	Category	Definition
0	M	Generic error
1	O	Current
2	O	Voltage
3	O	Temperature
4	O	Communication error
5	O	Device profile specific
6	O	Reserved (always 0)
7	O	Manufacturer defined

Table 13 – Error register

Attribute	Value
Index	0x1001
Name	Error register
Object type	VAR
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	Yes
Value range	No
Value	No

5.3.1.5.4 Manufacturer status register

The manufacturer status register as specified in Table 14 specifies a general status register for manufacturer specific usage.

Table 14 – Object definition template

Attribute	Value
Index	0x1002
Name	Manufacturer status register
Object type	VAR
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	Optional
Value range	No
Value	No

5.3.1.5.5 Event log

The event log object as specified in Table 16 stores the errors/warnings and events which occurred in a device and were optionally signaled using an EMCY message in a list. This list represents an error history. Two modes of error information are available, the mandatory normal format or an optional extended format. Table 15 specifies the normal format and the optional extensions for the extended format.

Table 15 – Encoding of event log entries

Octet	Name	Category	Meaning
0 to 1	Emergency error code	Mandatory	As specified in Table 72
2	Reserved	Mandatory	—
3 to 7	Manufacturer specific error field	Mandatory	Indicates a manufacturer specific error code
8 to 11	Time stamp part 1	Optional	Indicates the number of seconds passed since a relative time/absolute time. The absolute time defaults to 01.01.1970 – 0 GMT
12 to 13	Time stamp part 2	Optional	Indicates the time additionally in 65.536 increments per second
14	Length	Optional	Length of extended manufacturer information field
15 to 269	Extended manufacturer information	Optional	Indicates extended manufacturer information

Table 16 – Event log

Attribute	Value
Index	0x1003
Name	Event log
Object type	ARRAY
Data type	OCTET_STRING
Category	Mandatory
Sub-index	0x00
Name	Number of events
Data type	Unsigned8
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Event log entry
Data type	OCTET_STRING
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	0x00 to 0xFE
Value	No

5.3.1.5.6 Manufacturer device name

The manufacturer device name object is specified in Table 17.

Table 17 – Manufacturer device name

Attribute	Value
Index	0x1008
Name	Manufacturer device name
Object type	VAR
Data type	VISIBLE_STRING
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.7 Manufacturer HW version

The manufacturer HW version is specified in Table 18.

Table 18 – Manufacturer HW version

Attribute	Value
Index	0x1009
Name	Manufacturer HW version
Object type	VAR
Data type	VISIBLE_STRING
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.8 Manufacturer SW version

The manufacturer SW version is specified in Table 19.

Table 19 – Manufacturer SW version

Attribute	Value
Index	0x100A
Name	Manufacturer SW version
Object type	VAR
Data type	VISIBLE_STRING
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.9 CL configuration

This object contains configuration data as specified in Table 20.

Table 20 – CL configuration

Attribute	Value
Index	0x100B
Name	CL configuration
Object type	RECORD
Data type	CL_Config_Par
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x00 to 0x08
Value	No
Sub-index	0x01
Name	Symbolic device name
Data type	Domain
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Device role
Data type	Unsigned8
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x03
Name	RTFN Base cycle time
Data type	Unsigned32
Category	Conditional: if RTFN is supported
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x04
Name	IP address (IPv4)
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No

Attribute	Value
Value range	No
Value	No
Sub-index	0x05
Name	Subnet mask (IPv4)
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x06
Name	Default Gateway (IPv4)
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x07
Name	DHCP enabled (IPv4)
Data type	Unsigned8
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x08
Name	Activate current IP configuration
Data type	Unsigned8
Category	Optional
Access attribute	WO
PDO mapping	No
Value range	No
Value	By writing any value to this sub-index, the configuration is actuated.

5.3.1.5.10 Time sync IRQ configuration

This object contains configuration data for time sync IRQs and is specified in Table 22. The encoding of time sync IRQ configuration entries as a 32 octet long OCTET_STRING is specified in Table 21.

Table 21 – Time sync IRQ configuration encoding

Octet	Name	Meaning
0 to 1	Time sync ID	Unique identifier
2 to 5	Cycle time	Cycle time of the timer IRQ
6 to 9	Time offset	Offset to the sync master's timer IRQ
10	Is master	Denotes the device as sync master for a dedicated timer IRQ
11	Reserved	—
12 to 15	IPv4 sync master address	IPv4 address of the sync master
16 to 31	IPv6 sync master address	IPv6 address of the sync master

Table 22 – Time sync IRQ configuration

Attribute	Value
Index	0x100C
Name	Time sync IRQ configuration
Object type	ARRAY
Data type	OCTET_STRING
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x00 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Time sync IRQ configuration
Data type	OCTET_STRING
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.11 Time sync IRQ state

This object contains state information of time sync IRQs and is specified in Table 23.

Table 23 – Time sync IRQ state

Attribute	Value
Index	0x100D
Name	Time sync IRQ state
Object type	ARRAY
Data type	Unsigned8
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x00 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Time sync IRQ state
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	0x00: IRQ is not synchronized 0x01: IRQ is synchronized

5.3.1.5.12 Store parameters

This object allows storing of parameters in a non-volatile device specific memory. To initiate a storage procedure, the save signature 0x65766173 shall be written to the appropriate sub-indexes as indicated in Table 25. Reading the appropriate sub-indexes provide information on memory functions as specified in Table 24.

Table 24 – Store parameters read information

Bit number	Value	Definition
31 to 2	0	Reserved
1	0	Device can not save parameters autonomously
	1	Device saves parameters autonomously
0	0	Device does not save parameters on request
	1	Device saves parameters on request

Table 25 – Store parameters

Attribute	Value
Index	0x1010
Name	Store parameters
Object type	ARRAY
Data type	Unsigned32
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x7F
Value	No
Sub-index	0x01
Name	Save all parameters
Data type	Unsigned32
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Save communication parameters
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x03
Name	Save application parameters
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x04 to 0x7F
Name	Save manufacturer defined parameters
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No

Attribute	Value
Value range	No
Value	No

5.3.1.5.13 Restore default parameters

This object allows restoring of default parameters. The load signature 0x64616F6C shall be written to the appropriate sub-index as specified in Table 27. Writing the correct signature in the appropriate sub-index causes a device to restore the default parameters on the device. The default values are only enabled following a reset or power on of the device.

Reading the appropriate sub-index causes the device to provide information on its restore functions. This information is coded as specified in Table 26.

Table 26 – Restore parameters read information

Bit number	Value	Definition
31 to 1	0	Reserved
0	0	Device can not restore parameters on request
	1	Device can restore parameters on request

Table 27 – Restore default parameters

Attribute	Value
Index	0x1011
Name	Restore default parameters
Object type	ARRAY
Data type	Unsigned32
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x7F
Value	No
Sub-index	0x01
Name	Restore all default parameters
Data type	Unsigned32
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Restore default communication parameters
Data type	Unsigned32

Attribute	Value
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x03
Name	Restore default application parameters
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x04 to 0x7F
Name	Restore default manufacturer defined parameters
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.14 Diagnostic information

Diagnostic information values are stored in this object as specified in Table 28.

Table 28 – Diagnostic information

Attribute	Value
Index	0x1012
Name	Diagnostic information
Object type	RECORD
Data type	Diagnosis_Par
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x12
Value	No
Sub-index	0x01
Name	Application layer state
Data type	Unsigned8

Attribute	Value
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x03
Name	Application state
Data type	DOMAIN
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x05
Name	CL state RTFL
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x06
Name	CL state RTFN
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x07
Name	Number of delayed RTFL frames
Data type	Unsigned16
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x09
Name	Number of corrupt frames
Data type	Unsigned16
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No

Attribute	Value
Value	No
Sub-index	0x0A
Name	Number of received frames since startup
Data type	Unsigned64
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0B
Name	Number of MSC buffer overflows
Data type	Unsigned16
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0C
Name	Number of received MSC messages since startup
Data type	Unsigned64
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0D
Name	Cable attenuation port 1
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0E
Name	Cable attenuation port 2
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0F
Name	Cable length port 1
Data type	Unsigned8

Attribute	Value
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x10
Name	Cable length port 2
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x011
Name	Distance to fault port 1
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x12
Name	Distance to fault port 2
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.15 Diagnostic thresholds

Some diagnostic information values concerning the communication are stored in this object as specified in Table 29.

Table 29 – Diagnostic threshold

Attribute	Value
Index	0x1013
Name	Diagnostic thresholds
Object type	RECORD
Data type	Diagnosis_Par
Category	Optional
Sub-index	0x00
Name	Number of supported entries

Attribute	Value
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x0E
Value	No
Sub-index	0x07
Name	Expected RTFL roundtrip time
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x08
Name	Delayed RTFL rate threshold
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x09
Name	Corrupt frame rate threshold
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0B
Name	MSC buffer overflows rate threshold
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0D
Name	Cable attenuation port 1 threshold
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No

Attribute	Value
Value range	No
Value	No
Sub-index	0x0E
Name	Cable attenuation port 2 threshold
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.16 IP address EMCY

The IP address EMCY object is specified in Table 30. This object depicts a RTFN destination device for EMCY messages which is directly addressed by its IP address.

Table 30 – IP address EMCY

Attribute	Value
Index	0x1014
Name	IP address EMCY
Object type	VAR
Data type	Unsigned128
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.17 Inhibit time EMCY

The inhibit time EMCY object is specified in Table 31.

Table 31 – Inhibit time EMCY

Attribute	Value
Index	0x1015
Name	Inhibit time EMCY
Object type	VAR
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.18 Consumer heartbeat list

The consumer heartbeat list object is specified in Table 33. The encoding of consumer heartbeat list entries as a 40 octet long OCTET_STRING is specified in Table 32.

Table 32 – Encoding of consumer heartbeat entries

Octet	Name	Meaning
0 to 2	RTFL-PID	RTFL packet ID of monitored heartbeat
3	Reserved	—
4 to 6	RTFN-PID	RTFN packet ID of monitored heartbeat
7	Reserved	—
8	Transmission type	Transmission type of the heartbeat
9	Reserved	—
10 to 11	Heartbeat-time	Heartbeat time as a multiple of the base cycle time
12 to 13	Cycle multiplier	Expected transmission cycle
14 to 15	Cycle offset	Offset in relation to a communication cycle
16 to 17	Device address	Device address of heartbeat producer
18 to 21	IPv4 address	IPv4 address of heartbeat producer
22 to 37	IPv6 address	IPv6 address of heartbeat producer
38 to 39	Reserved	—

Table 33 – Consumer heartbeat list

Attribute	Value
Index	0x1016
Name	Consumer heartbeat list
Object type	ARRAY
Data type	OCTET_STRING
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01
Name	Consumer heartbeat
Data type	OCTET_STRING
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02 to 0xFE
Name	Consumer heartbeat
Data type	OCTET_STRING
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.19 Producer heartbeat parameter

The producer heartbeat parameter object is specified in Table 34.

Table 34 – Producer heartbeat parameter

Attribute	Value
Index	0x1017
Name	Producer heartbeat parameter
Object type	RECORD
Data type	PDO COMMUNICATION PARAMETER
Category	Mandatory
Sub-index	0x00
Name	Number of entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x0C
Value	No
Sub-index	0x01
Name	RTFL PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x02
Name	RTFN PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x04
Name	Transmission type
Data type	Unsigned8
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x05
Name	Time sync ID

Attribute	Value
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0xFF
Value	No
Sub-index	0x07
Name	Cycle multiplier
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0xFFFF
Value	No
Sub-index	0x08
Name	Cycle offset
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0A
Name	Device address
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0x200
Value	No
Sub-index	0x0B
Name	IPv4 address
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0C
Name	IPv6 address
Data type	Unsigned128
Category	Conditional
Access attribute	RW
PDO mapping	No

Attribute	Value
Value range	No
Value	No

5.3.1.5.20 Identity object

The identity object is specified in Table 35.

Table 35 – Identity object

Attribute	Value
Index	0x1018
Name	Identity object
Object type	RECORD
Data type	IDENTITY
Category	Mandatory
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x08
Value	No
Sub-index	0x01
Name	Vendor ID
Data type	Unsigned32
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Product code
Data type	Unsigned32
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x03
Name	Revision number
Data type	Unsigned32
Category	Optional
Access attribute	RO
PDO mapping	No

Attribute	Value
Value range	No
Value	No
Sub-index	0x04
Name	Serial number
Data type	Unsigned32
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No
Sub-index	0x05
Name	Type SNpTYPE version
Data type	Unsigned16
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.21 SDO protocol timeout

The SDO protocol timeout object is specified in Table 36.

Table 36 – SDO protocol timeout

Attribute	Value
Index	0x101B
Name	SDO protocol timeout
Object type	VAR
Data type	Unsigned32
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	Unsigned32
Value	No

5.3.1.5.22 Enable client SDO parameter

The enable client SDO parameter object is specified in Table 37.

Table 37 – Enable client SDO parameter

Attribute	Value
Index	0x101C
Name	Enable client SDO parameter
Object type	VAR
Data type	Boolean
Category	Conditional; Mandatory for supported client SDO parameters
Access attribute	RW
PDO mapping	No
Value range	TRUE | FALSE
Value	TRUE

5.3.1.5.23 Enable EMCY

The enable EMCY object is specified in Table 38.

Table 38 – Enable EMCY

Attribute	Value
Index	0x101D
Name	Enable EMCY
Object type	VAR
Data type	Boolean
Category	Conditional; Mandatory for supported client SDO parameters
Access attribute	RW
PDO mapping	No
Value range	TRUE | FALSE
Value	TRUE

5.3.1.5.24 PDO timeout tolerance

The PDO timeout tolerance object is specified in Table 39.

Table 39 – PDO timeout tolerance

Attribute	Value
Index	0x101E
Name	PDO timeout tolerance
Object type	VAR
Data type	Unsigned8
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	Unsigned8
Value	No

5.3.1.5.25 Store EDS

The store EDS object is specified in Table 40.

Table 40 – Store EDS

Attribute	Value
Index	0x1021
Name	Store EDS
Object type	VAR
Data type	DOMAIN
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.26 Storage format

The storage format object is specified in Table 41.

Table 41 – Storage format

Attribute	Value
Index	0x1022
Name	Storage format
Object type	VAR
Data type	Unsigned8
Category	Conditional; Mandatory if store EDS is implemented
Access attribute	RW
PDO mapping	No
Value range	No
Value	0x00: ASCII, not compressed 0x1 to 0xFF: reserved

5.3.1.5.27 OS command

The OS command object is specified in Table 42.

Table 42 – OS command

Attribute	Value
Index	0x1023
Name	OS command
Object type	RECORD
Data type	Command Par
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x03
Value	0x03
Sub-index	0x01
Name	Command
Data type	OCTET_STRING
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Status
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	0x00: Last command completed, no errors, no reply 0x01: Last command completed, no errors, reply available 0x02: Last command completed, error, no reply 0x03: Last command completed, error, reply available 0x04 to 0xFE: reserved 0xFF: Command is executing
Sub-index	0x03
Name	Reply
Data type	OCTET_STRING
Category	Mandatory
Access attribute	RO
PDO mapping	No

Attribute	Value
Value range	No
Value	No

5.3.1.5.28 OS command mode

The OS command mode object is specified in Table 43.

Table 43 – OS command mode

Attribute	Value
Index	0x1024
Name	OS command mode
Object type	VAR
Data type	Unsigned8
Category	Optional
Access attribute	WO
PDO mapping	No
Value range	No
Value	0x00: Execute the next command immediately 0x01: Buffer the next command 0x02: Execute the commands in the buffer 0x03: Abort the current command and all commands in the buffer 0x04-0xFF: Manufacturer specific

5.3.1.5.29 OS debugger interface

The OS debugger interface object is specified in Table 44.

Table 44 – OS debugger interface

Attribute	Value
Index	0x1025
Name	OS debugger interface
Object type	RECORD
Data type	Debugger Par
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x03
Value	0x03
Sub-index	0x01
Name	Command
Data type	OCTET_STRING
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x02
Name	Status
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	0x00: Last command completed, no errors 0x01: Last command completed, error 0xFF: Command is still executing
Sub-index	0x03
Name	Reply
Data type	OCTET_STRING
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	No
Value	No

5.3.1.5.30 OS prompt

The OS prompt object is specified in Table 45.

Table 45 – OS prompt

Attribute	Value
Index	0x1026
Name	OS prompt
Object type	ARRAY
Data type	Unsigned8
Category	Optional
Sub-index	0x00
Name	Number of supported entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x02 to 0x03
Value	0x03
Sub-index	0x01
Name	StdIn
Data type	Unsigned8
Category	Mandatory
Access attribute	WO
PDO mapping	Optional
Value range	No
Value	No
Sub-index	0x02
Name	StdOut
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	Optional
Value range	No
Value	No
Sub-index	0x03
Name	StdErr
Data type	Unsigned8
Category	Optional
Access attribute	RO
PDO mapping	Optional
Value range	No
Value	No

5.3.1.5.31 Module list

The module list object is specified in Table 46.

Table 46 – Module list

Attribute	Value
Index	0x1027
Name	Module list
Object type	ARRAY
Data type	Unsigned16
Category	Optional
Sub-index	0x00
Name	Number of connected modules
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Module 1 to 254
Data type	Unsigned16
Category	Optional
Access attribute	RO
PDO mapping	No
Value range	No
Value	Manufacturer specific identification number

5.3.1.5.32 Emergency subscriber

The emergency subscriber object is specified in Table 48. The encoding of emergency subscriber as an Unsigned256 value is specified in Table 47.

Table 47 – Emergency subscriber encoding

Octet	Name	Meaning
0 to 1	Device address	Device address of EMCY producer
2 to 17	IP address	IP address of the EMCY producer (IPv4 or IPv6)
18 to 29	Reserved	—
30 to 31	Additional information	Additional information for a producer

Table 48 – Emergency subscriber

Attribute	Value
Index	0x1028
Name	Emergency subscriber
Object type	ARRAY
Data type	Unsigned256
Category	Optional
Sub-index	0x00
Name	Number of entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Emergency subscriber 1 to 254
Data type	Unsigned256
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.33 Client SDO parameter

The client SDO parameter object is specified in Table 50. The encoding of client SDO parameters as an Unsigned256 value is specified in Table 49.

Table 49 – Client SDO parameter encoding

Octet	Name	Meaning
0 to 1	Device address	Device address of server
2 to 17	IP address	IP address of the server (IPv4 or IPv6)
18 to 31	Reserved	—

Table 50 – Client SDO parameter

Attribute	Value
Index	0x1280 to 0x12FF
Name	Client SDO parameter
Object type	ARRAY
Data type	Unsigned256
Category	Conditional; Mandatory for each supported SDO client communication channel
Sub-index	0x00
Name	Number of entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	Server address
Data type	Unsigned256
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.34 Receive PDO communication parameter

The receive PDO communication parameters object is specified in Table 51.

Table 51 – Receive PDO communication parameter

Attribute	Value
Index	0x1400 to 0x15FF
Name	Receive PDO communication parameter
Object type	RECORD
Data type	PDO COMMUNICATION PARAMETER
Category	Conditional; Mandatory for each supported RxPDO
Sub-index	0x00
Name	Number of entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x0C
Value	No
Sub-index	0x01
Name	RTFL PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x02
Name	RTFN PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x04
Name	Transmission type
Data type	Unsigned8
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x05
Name	Time sync ID

Attribute	Value
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0xFF
Value	No
Sub-index	0x06
Name	Timeout
Data type	Unsigned16
Category	Optional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x07
Name	Cycle multiplier
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0xFFFF
Value	No
Sub-index	0x08
Name	Cycle offset
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0xFFFE
Value	No
Sub-index	0x0A
Name	Device address
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0x200
Value	No
Sub-index	0x0B
Name	IPv4 address
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No

Attribute	Value
Value range	No
Value	No
Sub-index	0x0C
Name	IPv6 address
Data type	Unsigned128
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.35 Transmit PDO communication parameter

The transmit PDO communication parameter object is specified in Table 52.

Table 52 – Transmit PDO communication parameter

Attribute	Value
Index	0x1800 to 0x19FF
Name	Transmit PDO communication parameter
Object type	RECORD
Data type	PDO COMMUNICATION PARAMETER
Category	Conditional; Mandatory for each supported TxPDO
Sub-index	0x00
Name	Number of entries
Data type	Unsigned8
Category	Mandatory
Access attribute	RO
PDO mapping	No
Value range	0x01 to 0x0C
Value	No
Sub-index	0x01
Name	RTFL PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x02
Name	RTFN PID
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No

Attribute	Value
Value range	0x01 to 0x00FFFFFF
Value	No
Sub-index	0x04
Name	Transmission type
Data type	Unsigned8
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x05
Name	Time sync ID
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0xFF
Value	No
Sub-index	0x07
Name	Cycle multiplier
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0xFFFF
Value	No
Sub-index	0x08
Name	Cycle offset
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0A
Name	Device address
Data type	Unsigned16
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	0x00 to 0x200
Value	No
Sub-index	0x0B
Name	IPv4 address

Attribute	Value
Data type	Unsigned32
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No
Sub-index	0x0C
Name	IPv6 address
Data type	Unsigned128
Category	Conditional
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.36 PDO mapping

5.3.1.5.36.1 PDO mapping principle

The PDO mapping parameters define the contents of a PDO. A valid PDO contains at least one and at most 254 application objects. The encoding of a format mapping entry is specified in Table 53.

Table 53 – Mapping format

Bit	Name	Meaning
0 to 7	Length	Length of application object in bits
8 to 15	Sub-index	Sub-index of the application object to be mapped
16 to 31	Index	Index of the application object to be mapped

5.3.1.5.36.2 Receive PDO mapping parameter

The receive PDO mapping parameter object is specified in Table 54.

Table 54 – Receive PDO mapping parameter

Attribute	Value
Index	0x1600 to 0x17FF
Name	Receive PDO mapping parameter
Object type	RECORD
Data type	PDO_MAPPING
Category	Conditional; Mandatory for each supported RxPDO
Sub-index	0x00
Name	Number of mapped application objects
Data type	Unsigned8
Category	Mandatory
Access attribute	RW

Attribute	Value
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	PDO mapping for the nth application object to be mapped
Data type	Unsigned32
Category	Conditional depending on the number and size of objects to be mapped
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.1.5.36.3 Transmit PDO mapping parameter

The transmit PDO mapping parameter object is specified in Table 55.

Table 55 – Transmit PDO mapping parameter

Attribute	Value
Index	0x1600 to 0x17FF
Name	Transmit PDO mapping parameter
Object type	RECORD
Data type	PDO_MAPPING
Category	Conditional: Mandatory for each supported TxPDO
Sub-index	0x00
Name	Number of mapped application objects
Data type	Unsigned8
Category	Mandatory
Access attribute	RW
PDO mapping	No
Value range	0x01 to 0xFE
Value	No
Sub-index	0x01 to 0xFE
Name	PDO mapping for the nth application object to be mapped
Data type	Unsigned32
Category	Conditional depending on the number and size of objects to be mapped
Access attribute	RW
PDO mapping	No
Value range	No
Value	No

5.3.2 SDO

5.3.2.1 Initiate SDO expedited download request

The initiate SDO expedited download request encoding is specified in Table 56.

Table 56 – Initiate SDO expedited download request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x01: Indicates SDO expedited download request
	JobID	BYTE	ID of this download job
	Index	WORD	Indicates the index of the object within server's object dictionary
	Sub-index	WORD	Indicates the sub-index of the object within server's object dictionary
	Data	BYTE[N]	Contains data to be downloaded

5.3.2.2 Initiate SDO expedited download response

The initiate SDO expedited download response encoding is specified in Table 57.

Table 57 – Initiate SDO expedited download response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x02: Indicates initiate SDO expedited download response
	JobID	BYTE	ID of this download job

5.3.2.3 Initiate SDO normal download request

The initiate SDO normal download request encoding is specified in Table 58.

Table 58 – Initiate SDO normal download request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x03: Indicates initiate SDO normal download request
	JobID	BYTE	ID of this download job
	Index	WORD	Indicates the index of the object within server's object dictionary
	Sub-index	WORD	Indicates the sub-index of the object within server's object dictionary
	Size	WORD	Contains size in octets of data to be downloaded

5.3.2.4 Initiate SDO normal download response

The initiate SDO normal download response encoding is specified in Table 59.

Table 59 – Initiate SDO normal download response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x04: Indicates initiate SDO normal download response
	JobID	BYTE	ID of this download job

5.3.2.5 SDO download request

The SDO download request encoding is specified in Table 60.

Table 60 – SDO download request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x05: Indicates SDO download request
	JobID	BYTE	ID of this download job
	Data	BYTE[N]	Contains data to be downloaded

5.3.2.6 SDO download response

The SDO download response encoding is specified in Table 61.

Table 61 – SDO download response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x06: Indicates SDO download response
	JobID	BYTE	ID of this download job

5.3.2.7 Initiate SDO expedited upload request

The initiate SDO expedited upload request encoding is specified in Table 62.

Table 62 – Initiate SDO expedited upload request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x07: Indicates initiate SDO upload request
	JobID	BYTE	ID of this upload job
	Index	WORD	Indicates the index of the object within server's object dictionary
	Sub-index	WORD	Indicates the sub-index of the object within server's object dictionary

5.3.2.8 Initiate SDO expedited upload response

The initiate SDO expedited upload response encoding is specified in Table 63.

Table 63 – Initiate SDO expedited upload response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x08: Indicates initiate SDO expedited upload response
	JobID	BYTE	ID of this upload job
	Data	BYTE[N]	Contains data to be uploaded

5.3.2.9 Initiate SDO normal upload request

The coding of initiate SDO normal upload request is the same as of initiate SDO expedited upload request (see 5.3.2.7).

5.3.2.10 Initiate SDO normal upload response

The initiate SDO normal upload response encoding is specified in Table 64.

Table 64 – Initiate SDO normal upload response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x0A: Indicates initiate SDO normal upload response
	JobID	BYTE	ID of this upload job
	Size	Word	Contains size in octets of data to be uploaded

5.3.2.11 SDO upload request

The SDO upload request encoding is specified in Table 65.

Table 65 – SDO upload request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x0B: Indicates SDO upload request
	JobID	BYTE	ID of this upload job

5.3.2.12 SDO upload response

The SDO upload response encoding is specified in Table 66.

Table 66 – SDO upload response

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0x0C: Indicates SDO upload response
	JobID	BYTE	ID of this upload job
	Data	BYTE[N]	Contains data to be uploaded

5.3.2.13 SDO abort

5.3.2.13.1 SDO abort request

The SDO abort request encoding is specified in Table 67.

Table 67 – SDO abort request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x03: Indicates SDO service
SDO	Command	BYTE	0xFE: Indicates SDO abort by the client 0xFF: Indicates SDO abort by the server
	JobID	BYTE	ID of this upload job
	Abort code	DWORD	Contains the SDO abort code as specified in Table 68

5.3.2.13.2 SDO abort codes

The SDO abort codes are specified in Table 68.

Table 68 – SDO abort codes

Abort code	Description
0x0504 0000	SDO protocol timed out
0x0504 0001	Client/server command ID not valid or unknown
0x0504 0005	Out of memory
0x0601 0001	Attempt to read a write only object
0x0601 0002	Attempt to write a read only object
0x0602 0000	Object does not exist in the object dictionary
0x0604 0041	Object can not be mapped to the PDO
0x0609 0011	Sub-index does not exist
0x0609 0030	Value range of parameter exceeded (only for write access)
0x0800 0000	General error
0x0800 0001	General protocol error
0x0800 0002	General access error
0x0A00 0000	Data type not supported
0x0A01 0000	Length does not match type
0x0A01 0001	Max length exceeded
0x0A01 0003	Access denied by application
0x0A01 0004	Changing communication parameter not allowed
0x0A01 0005	Read or write error
0x0A01 0006	Time sync id not unambiguous
0x0A01 0007	Time sync id in use
0x0A01 0008	Time sync id unknown
0x0A01 0009	Object inconsistent
0x0A01 000A	Transmission type active
0x0A01 000B	Changing transmission time not allowed in this state
0x0A01 000C	PDO mapping active
0x0A01 000D	No objects mapped for this PDO
0x0A01 000E	PDO over MSC not supported
0x0A01 000F	PDO communication parameter inconsistent
0x0A01 0010	Extended PDO mapping not supported
0x0A01 0011	PDO length exceeded
0x0A01 0012	Write to object to map as RX not allowed
0x0A01 0013	Read of object to map as TX not allowed
0x0A01 0014	Mapping length does not match
0x0A01 0015	Activation failed
0x0A01 0016	Internal error
0x0A01 0017	Read buffer to small
0x0A01 0018	Aborted due to change of state
0x0A01 0019	SDO queue full

5.3.3 Process data write

The process data write request encoding is specified in Table 69 and in Table 70.

Table 69 – Process data write request via MSC

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x02: Indicates PDO communication
PDO	PID	UINT24	Indicates the ID of the PDO packet
	Len	BYTE	Length of the CDC DLPDU data packet including PID and Len field in octets
	Data	BYTE[N]	Contains mapped application objects

Table 70 – Process data write request via CDC

Frame part	Data field	Data type	Value/description
CDC-packet	PID	UINT24	Indicates the ID of the PDO packet
PDO	Len	UINT8	Length of the CDC DLPDU data packet including PID and Len field in octets
	Data	BYTE	Contains mapped application objects

5.3.4 Emergency

5.3.4.1 Emergency request

The emergency request encoding is specified in Table 71.

Table 71 – Emergency request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x04: Indicates EMCY service
EMCY	Emergency error code	WORD	Standardized emergency error code
	Error register	BYTE	Error register object
	Manufacturer specific error field	BYTE[5]	Indicates manufacturer specific error information
	Time stamp	BYTE[6]	Occurrence time stamp (optional)
	Length	BYTE	Indicates the length of the MEF field (optional)
	MEF	BYTE[N]	Manufacturer specific field for further information (optional)

5.3.4.2 Emergency error codes

The emergency error codes are specified in Table 72.

Table 72 – Emergency error codes

Error code (hex)	Description
00xx	Error Reset or No Error
10xx	Generic Error
20xx	Current
21xx	Current, device input side
22xx	Current, inside the device
23xx	Current, device output side
30xx	Voltage
31xx	Main voltage
32xx	Voltage inside the device
40xx	Temperature
41xx	Ambient temperature
42xx	Device temperature
50xx	Device hardware
60xx	Device software
61xx	Internal software
62xx	User software
63xx	Data set
70xx	Additional modules
80xx	Monitoring
81xx	Communication
8110	Reserved
8120	Reserved
8130	Reserved
8140	Reserved
8150	Reserved
82xx	Protocol error
8210	PDO not processed due to length error
8220	PDO length exceeded
90xx	External error
F0xx	Additional functions
FFxx	Device specific

5.3.5 Heartbeat

The heartbeat request encoding is specified in Table 73 and in Table 74.

Table 73 – Heartbeat request via MSC

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	BYTE	0x02: Indicates PDO communication
Heartbeat	PID	UINT24	Indicates the ID of the heartbeat packet
	State	BYTE	0x00: Boot-up 0x04: Stopped 0x05: Operational 0x7F: PreOperational 0xFA: System-error

Table 74 – Heartbeat request via CDC

Frame part	Data field	Data type	Value/description
CDC-packet	PID	UINT24	Indicates the ID of the heartbeat packet
Heartbeat	Len	UINT8	Length of the CDC DLPDU data packet including PID and Len field in octets
	State	BYTE	0x00: Boot-up 0x04: Stopped 0x05: Operational 0x7F: PreOperational 0xFA: System-error

5.4 Standard Ethernet frame communication

5.4.1 Overview

Communication of devices with engineering tools and the possibility of integrated web servers in some devices require TCP/IP communication in addition to Type SNpTYPE RTFL communication on the same interface. For this purposes it is possible to transfer all types of Ethernet frames over Type SNpTYPE.

5.4.2 Send frame request

The send frame request encoding is specified in Table 75.

Table 75 – Send frame request

Frame part	Data field	Data type	Value/description
MSC-MTP message data	MSC service type	UINT8	0x20: Indicates SEF service
MSC service data	SEF Frame	BYTE[N]	Contains the complete SEF frame starting with field Dest MAC and ending with Ethernet FCS