

DIN EN 61158-6-22

ICS 35.100.70; 35.160

**Industrielle Kommunikationsnetze –
Feldbusse –
Teil 6-22: Protokollspezifikation des Application Layer
(Anwendungsschicht) – Typ 22-Elemente
(IEC 61158-6-22:2010);
Englische Fassung EN 61158-6-22:2012, nur auf CD-ROM**

Industrial communication networks –
Fieldbus specifications –
Part 6-22: Application layer protocol specification – Type 22 elements
(IEC 61158-6-22:2010);
English version EN 61158-6-22:2012, only on CD-ROM

Réseaux de communication industriels –
Spécifications des bus de terrain –
Partie 6-22: Spécification des protocoles des couches d'application – Eléments de type 22
(CEI 61158-6-22:2010);
Version anglaise EN 61158-6-22:2012, seulement en CD-ROM

Gesamtumfang 92 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2012-03-28 angenommene Europäische Norm als DIN-Norm ist 2013-03-01.

Nationales Vorwort

Zu diesem Dokument wurde ein Manuskriptverfahren in den DIN-Mitteilungen veröffentlicht.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Feldbus“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 65C „Industrial networks“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „<http://webstore.iec.ch>“ zu dieser Publikation angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation

- bestätigt,
- zurückgezogen,
- durch eine Folgeausgabe ersetzt oder
- geändert.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm.

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die englische Fassung der EN 61158-6-22 veröffentlicht. Zu deren Abschnitt 3, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als informativer Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Einführung

Ein Feldbus ist ein digitaler serieller Datenbus für die Kommunikation zwischen Geräten der industriellen Automatisierungstechnik wie beispielsweise Messeinrichtungen, Stellgliedern, Reglern und speicherprogrammierbaren Steuerungen. Die Normen der Reihe DIN EN 61158 legen eine Anzahl von Feldbus-Protokolltypen fest. Die vorliegende Norm legt das Protokoll des Application Layer für Typ 22 fest.

Nationaler Anhang NA (informativ)

3.2 Spezielle Begriffe für die Feldbus-Anwendungsschicht

3.2.1

azyklische Daten

(en: **acyclic data**)

Daten, die von Zeit zu Zeit zu bestimmten Zwecken übertragen werden

3.2.2

Bit

(en: **bit**)

Informationseinheit, die aus einer 0 oder 1 besteht. Ein Bit ist die kleinste Dateneinheit, die übertragen werden kann

3.2.3

Zelle

(en: **cell**)

Synonym für ein einzelnes DL-Segment, welches das RTFL-Kommunikationsmodell einsetzt

3.2.4

Kanal

(en: **channel**)

Pfad, der für die Übertragung von Daten bereitgestellt wird

3.2.5

Client

(en: **client**)

Objekt, das die Dienste eines Servers nutzt, indem es eine Nachricht initiiert, um eine Aufgabe auszuführen

3.2.6

Kommunikationszyklus

(en: **communication cycle**)

festgelegte Zeitdauer, innerhalb derer das Root-Gerät leere Rahmen für die Initiierung der zyklischen Kommunikation ausgibt, bei der Daten über den CDC und den MSC übertragen werden

3.2.7

Verbindung

(en: **connection**)

logische Zuordnung zwischen zwei Anwendungsobjekten

3.2.8

Zykluszeit

(en: **cycle time**)

Dauer eines Kommunikationszyklus

3.2.9

zyklisch

(en: **cyclic**)

Ereignisse, die sich regelmäßig wiederholen

3.2.10

zyklische Kommunikation

(en: **cyclic communication**)

periodischer Austausch von Telegrammen

3.2.11

zyklische Daten

(en: **cyclic data**)

Daten, die regelmäßig und wiederholt zu bestimmten Zwecken übertragen werden

3.2.12

zyklischer Datenkanal (CDC)

(en: **cyclic data channel, CDC**)

Teil eines Rahmens oder mehrerer Rahmen, der für zyklische Daten reserviert ist

3.2.13

Daten

(en: **data**)

allgemeine Bezeichnung für jegliche über einen Feldbus übertragene Informationen

3.2.14

Gerät

(en: **device**)

mit dem Feldbus verbundene physikalische Einheit

3.2.15

Fehler

(en: **error**)

Nichtübereinstimmung zwischen einem berechneten, beobachteten oder gemessenen Wert oder Zustand und dem festgelegten oder theoretisch richtigen Wert oder Zustand

3.2.16

Fehlercode

(en: **error code**)

Identifikationsnummer eines bestimmten Fehlertyps

3.2.17

Gateway

(en: **gateway**)

Gerät, das als Verbindungselement zwischen verschiedenen Protokollen agiert

3.2.18

Index

(en: **index**)

Position eines Objektes innerhalb des Objektverzeichnisses

3.2.19

Kommunikation zwischen Zellen

(en: **inter-cell communication**)

Datenübermittlung zwischen einem RTFL-Gerät und einem RTFN-Gerät oder zwischen einem RTFL-Gerät und einem anderen RTFL-Gerät in verschiedenen Zellen, die über ein RTFN miteinander verbunden sind

3.2.20

Schnittstelle

(en: **interface**)

gemeinsam genutzte Grenze zwischen zwei funktionalen Einheiten, die durch funktionale Merkmale, Signalmerkmale oder entsprechend andere Merkmale festgelegt ist

3.2.21

Kommunikation innerhalb von Zellen

(en: **intra-cell communication**)

Datenübermittlung zwischen einem RTFL-Gerät und einem anderen RTFL-Gerät in der gleichen Zelle

3.2.22**logische Doppellinie****(en: logical double line)**

Reihung des Root-Gerätes und sämtlicher gewöhnlicher Geräte, die den Kommunikationsrahmen in Vorwärts- und Rückwärtsrichtung verarbeiten

3.2.23**Zuordnungsparameter****(en: mapping parameters)**

Satz von Werten, der die Verbindung zwischen Anwendungsobjekten und Prozessdatenobjekten festlegt

3.2.24**Master-Uhr****(en: master clock)**

globale Zeitbasis für den PCS-Mechanismus

3.2.25**Nachricht****(en: message)**

geordnete Folge von Oktetten für die Übermittlung von Daten

3.2.26**Nachrichtenkanal (MSC)****(en: message channel, MSC)**

Teil eines Rahmens oder mehrerer Rahmen, der für azyklische Daten reserviert ist

3.2.27**Netzwerk****(en: network)**

Menge von Geräten, die über ein bestimmtes Kommunikationsmedium miteinander verbunden sind, einschließlich zwischengeschalteter Repeater, Bridges, Router und Gateways unterer Schichten

3.2.28**gewöhnliches Gerät (OD)****(en: ordinary device, OD)**

Slave im Kommunikationssystem, der RTFL für den zyklischen und azyklischen Datenaustausch mit anderen ODs in derselben logischen Doppellinie einsetzt

3.2.29**präzise Uhrensynchronisation (PCS)****(en: precise clock synchronisation, PCS)**

Mechanismus zur Synchronisation von Uhren in RTFL-Geräten und zur Unterstützung einer globalen Zeitbasis

3.2.30**Prozessdaten****(en: process data)**

Daten, die zu Verarbeitungszwecken zyklisch oder azyklisch übertragen werden

3.2.31**Prozessdatenobjekt****(en: process data object)**

zweckbestimmte Datenobjekte, die zu Verarbeitungszwecken zyklisch oder azyklisch übertragen werden

3.2.32**Protokoll****(en: protocol)**

Vereinbarung über die Datenformate, Zeitabfolgen und die Fehlerkorrektur im Datenaustausch von Kommunikationssystemen

3.2.33

Root-Gerät (RD)

(en: root device, RD)

Master im Kommunikationssystem, der den zyklischen und azyklischen RTFL-Datenaustausch für eine logische Doppellinie organisiert, initiiert und steuert

3.2.34

RTFL

(en: real time frame line, RTFL)

Kommunikationsmodell in einer logischen Doppellinie

3.2.35

RTFN

(en: real time frame network, RTFN)

Kommunikationsmodell in einem vermittelten Netzwerk

3.2.36

Rundlaufzeit

(en: round trip time)

Übertragungszeit, die eine DLPDU vom RD zum letzten OD in Vorwärts- und Rückwärtsrichtung benötigt

3.2.37

Subindex

(en: sub-index)

untergeordnete Position eines einzelnen Elementes eines Objektes innerhalb des Objektverzeichnisses

3.2.38

Zeitsteuerungssignal

(en: timing signal)

zeitbasierte Meldung des Auftretens eines Ereignisses, üblicherweise als Unterbrechungssignal, eingesetzt für die DL-Benutzersynchronisation

3.2.39

Topologie

(en: topology)

physikalische Netzwerkarchitektur in Bezug auf die Verbindung zwischen den Stationen des Kommunikationssystems

**Industrial communication networks -
Fieldbus specifications -
Part 6-22: Application layer protocol specification -
Type 22 elements
(IEC 61158-6-22:2010)**

Réseaux de communication industriels -
Spécifications des bus de terrain -
Partie 6-22: Spécification des protocoles
des couches d'application -
Éléments de type 22
(CEI 61158-6-22:2010)

Industrielle Kommunikationsnetze -
Feldbusse -
Teil 6-22: Protokollspezifikation des
Application Layer (Anwendungsschicht) -
Typ 22-Elemente
(IEC 61158-6-22:2010)

This European Standard was approved by CENELEC on 2012-03-28. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 65C/607/FDIS, future edition 1 of IEC 61158-6-22, prepared by SC 65C, "Industrial networks", of IEC/TC 65, "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61158-6-22:2012.

The following dates are fixed:

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

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

Endorsement notice

The text of the International Standard IEC 61158-6-22:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC/TR 61158-1:2010 NOTE Harmonized as CLC/TR 61158-1:2010 (not modified).

CONTENTS

INTRODUCTION	7
1 Scope	8
1.1 General	8
1.2 Specifications	9
1.3 Conformance	9
2 Normative references	9
3 Terms, definitions, abbreviations, symbols and conventions	10
3.1 Terms and definitions from other ISO/IEC standards	10
3.2 Fieldbus application-layer specific definitions	10
3.3 Abbreviations and symbols	13
3.4 Conventions	15
4 Application layer protocol specification	16
4.1 Operating principle	16
4.2 Device reference models	17
4.3 Application layer structure	18
5 FAL syntax description	18
5.1 Introduction and coding principles	18
5.2 Data type encoding	19
5.3 CeS encoding	22
5.4 ISO/IEC 8802-3 DLPDU communication inside Type 22 RTFL	68
5.5 Management encoding	68
6 FAL protocol state machines	69
6.1 Overview	69
6.2 Fieldbus service protocol machine (FSPM)	71
6.3 Application relationship protocol machine (ARPM)	71
6.4 DLL mapping protocol machine	71
7 AP-context state machine	71
8 FAL service protocol machine (FSPM)	71
9 Application layer state machine (ALSM)	72
9.1 Description	72
9.2 States	74
9.3 Primitive definitions	74
9.4 State table	75
9.5 AL-service forwarding depending on AL-state	76
10 DLL mapping protocol machine (DMPM)	77
10.1 Overview	77
10.2 Primitives exchanged between ALSM and DMPM	77
10.3 Primitives exchanged between DLL and DMPM	81
10.4 ALSM to DLL mapping	83
Bibliography	85
Annex ZA (normative) Normative references to international publications with their corresponding European publications	86
Figure 1 – RTFL device reference model	17
Figure 2 – RTFN device reference model	18

Figure 3 – Encoding of TimeOfDay value.....	19
Figure 4 – Encoding of TimeDifference value	20
Figure 5 – Object dictionary addressing schema	23
Figure 6 – Relationships among protocol machines and adjacent layers	70
Figure 7 – ALSM protocol machine	71
Figure 8 – ALSM diagram.....	73
Table 1 – PDU element definition	16
Table 2 – Object definition	16
Table 3 – Transfer syntax for bit sequences	19
Table 4 – Transfer syntax for Integer data type.....	21
Table 5 – Transfer syntax for Unsigned data type.....	21
Table 6 – Object dictionary structure	22
Table 7 – Object dictionary object type definitions	23
Table 8 – Basic data type definitions	23
Table 9 – Complex data type definition	24
Table 10 – Communication section	25
Table 11 – Device type	27
Table 12 – Error register encoding	27
Table 13 – Error register.....	28
Table 14 – Object definition template	28
Table 15 – Encoding of event log entries	28
Table 16 – Event log	29
Table 17 – Manufacturer device name	29
Table 18 – Manufacturer HW version	30
Table 19 – Manufacturer SW version	30
Table 20 – CL configuration.....	30
Table 21 – Time sync IRQ configuration encoding.....	32
Table 22 – Time sync IRQ configuration	33
Table 23 – Time sync IRQ state	33
Table 24 – Store parameters read information.....	34
Table 25 – Store parameters	34
Table 26 – Restore parameters read information.....	35
Table 27 – Restore default parameters	36
Table 28 – Diagnostic information	37
Table 29 – Diagnostic threshold	40
Table 30 – IP address EMCY	42
Table 31 – Inhibit time EMCY	42
Table 32 – Encoding of consumer heartbeat entries.....	42
Table 33 – Consumer heartbeat list.....	43
Table 34 – Producer heartbeat parameter	44
Table 35 – Identity object.....	46
Table 36 – SDO protocol timeout	47

Table 37 – Enable client SDO parameter.....	47
Table 38 – Enable EMCY	48
Table 39 – PDO timeout tolerance	48
Table 40 – Store EDS.....	49
Table 41 – Storage format.....	49
Table 42 – OS command.....	49
Table 43 – OS command mode	51
Table 44 – OS debugger interface	51
Table 45 – OS prompt	52
Table 46 – Module list	53
Table 47 – Emergency subscriber encoding	54
Table 48 – Emergency subscriber.....	54
Table 49 – Client SDO parameter encoding	55
Table 50 – Client SDO parameter	55
Table 51 – Receive PDO communication parameter.....	55
Table 52 – Transmit PDO communication parameter.....	58
Table 53 – Mapping format.....	60
Table 54 – Receive PDO mapping parameter	60
Table 55 – Transmit PDO mapping parameter	61
Table 56 – Initiate SDO expedited download request.....	61
Table 57 – Initiate SDO expedited download response	62
Table 58 – Initiate SDO normal download request	62
Table 59 – Initiate SDO normal download response.....	62
Table 60 – SDO download request	63
Table 61 – SDO download response	63
Table 62 – Initiate SDO expedited upload request	63
Table 63 – Initiate SDO expedited upload response.....	63
Table 64 – Initiate SDO normal upload response	64
Table 65 – SDO upload request.....	64
Table 66 – SDO upload response	64
Table 67 – SDO abort request	65
Table 68 – SDO abort codes	65
Table 69 – Process data write request via MSC	66
Table 70 – Process data write request via CDC	66
Table 71 – Emergency request	66
Table 72 – Emergency error codes	67
Table 73 – Heartbeat request via MSC	68
Table 74 – Heartbeat request via CDC	68
Table 75 – Send frame request.....	68
Table 76 – Application layer management request.....	69
Table 77 – State transitions and management services	73
Table 78 – Primitives issued by ALSM to DLL	75
Table 79 – Primitives issued by DLL to ALSM	75

Table 80 – Primitives issued by FSPM to ALSM 75

Table 81 – Primitives issued by ALSM to FSPM 75

Table 82 – ALSM state table 76

Table 83 – Application layer states and communication services 76

Table 84 – Primitives issued by ALSM to DMPM 77

Table 85 – Primitives issued by DMPM to ALSM 79

Table 86 – Primitives issued by DMPM to DLL 81

Table 87 – Primitives issued by DLL to DMPM 83

Table 88 – ALSM to DLL mapping..... 83

INTRODUCTION

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

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

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-22: Application layer protocol specification – Type 22 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 standard 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 22 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 standard 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 standard is to define the protocol provided to:

- a) define the wire-representation of the service primitives defined in IEC 61158-5-22:2010; and
- b) define the externally visible behavior associated with their transfer.

This standard 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 standard to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this standard is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-22:2010.

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 standard 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 61158-3-22:2010¹, *Industrial communication networks – Fieldbus specifications – Part 3-22: Data-link layer service definition – Type 22 elements*

IEC 61158-4-22:2010¹, *Industrial communication networks – Fieldbus specifications – Part 4-22: Data-link layer protocol specification – Type 22 elements*

IEC 61158-5-22:2010¹, *Industrial communication networks – Fieldbus specifications – Part 5-22: Application layer service definition – Type 22 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*

¹ To be published.

3 Terms, definitions, abbreviations, symbols and conventions

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

3.1 Terms and definitions from other ISO/IEC standards

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

- a) abstract syntax
- b) presentation context

3.1.3 ISO/IEC 9545 terms

- 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 8824-1 terms

- 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

logical double line

sequence of root device and all ordinary devices processing the communication frame in forward and backward direction

3.2.23

mapping parameters

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

3.2.24

master clock

global time base for the PCS mechanism

3.2.25

message

ordered sequence of octets intended to convey data

3.2.26

message channel

MSC

part of one or more frames, which is reserved for acyclic data

3.2.27

network

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

3.2.28

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

3.2.29

precise clock synchronization

PCS

mechanism to synchronize clocks of RTFL devices and maintain a global time base

3.2.30

process data

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

3.2.31

process data object

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

3.2.32

protocol

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

3.2.33

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

3.2.34

real time frame line

RTFL

communication model communicating in a logical double line

3.2.35

real time frame network

RTFN

communication model communicating in a switched network

3.2.36

round trip time

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

3.2.37

sub-index

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

3.2.38

timing signal

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

3.2.39

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 ISO/IEC 8802-3 Ethernet DLPDU
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 61158-5-22:2010. The protocol specification for each of the ASEs is defined in this standard.

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 61158-5-22:2010. The service specification defines the services that are provided by the ASE.

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

3.4.2 Abstract syntax conventions

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 22 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 ISO/IEC 8802-3 network. Thus, no determinism can be guaranteed for RTFN data transfer.

Communication of process and service data is accommodated by Type 22 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 22 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 22 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 22 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 22 data-link layer or the Type 22 application layer. The device reference model for a Type 22 RTFL device is shown in Figure 1.

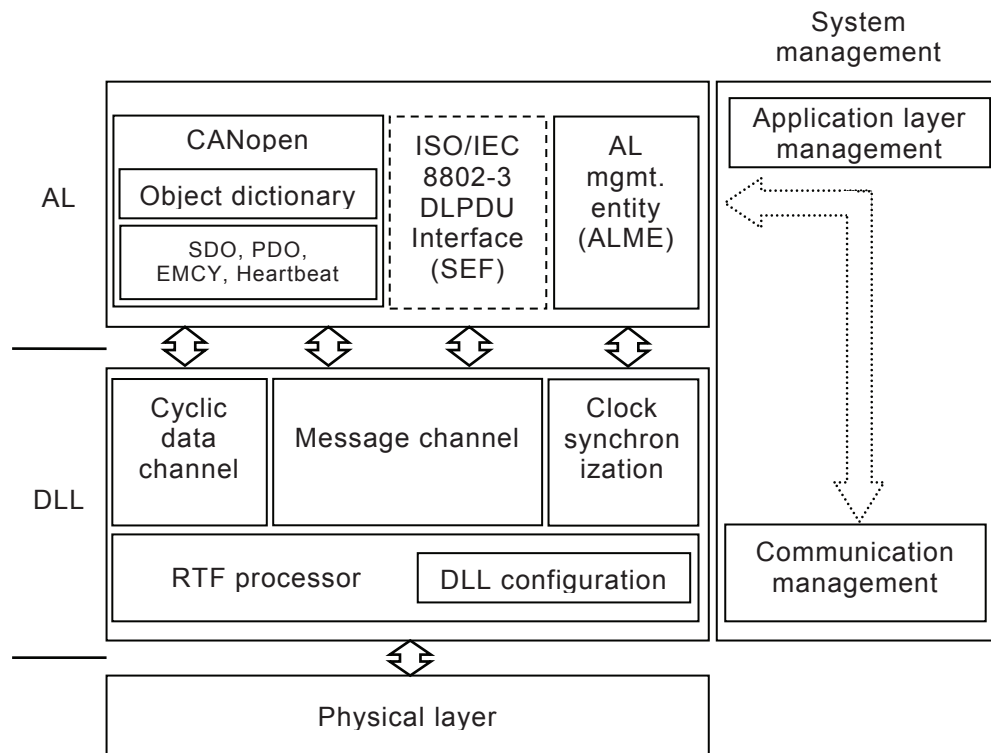


Figure 1 – RTFL device reference model

4.2.2 RTFN device reference model

Type 22 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 22 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 22 data-link layer or the Type 22 application layer. The device reference model for a Type 22 RTFN device is shown in Figure 2.

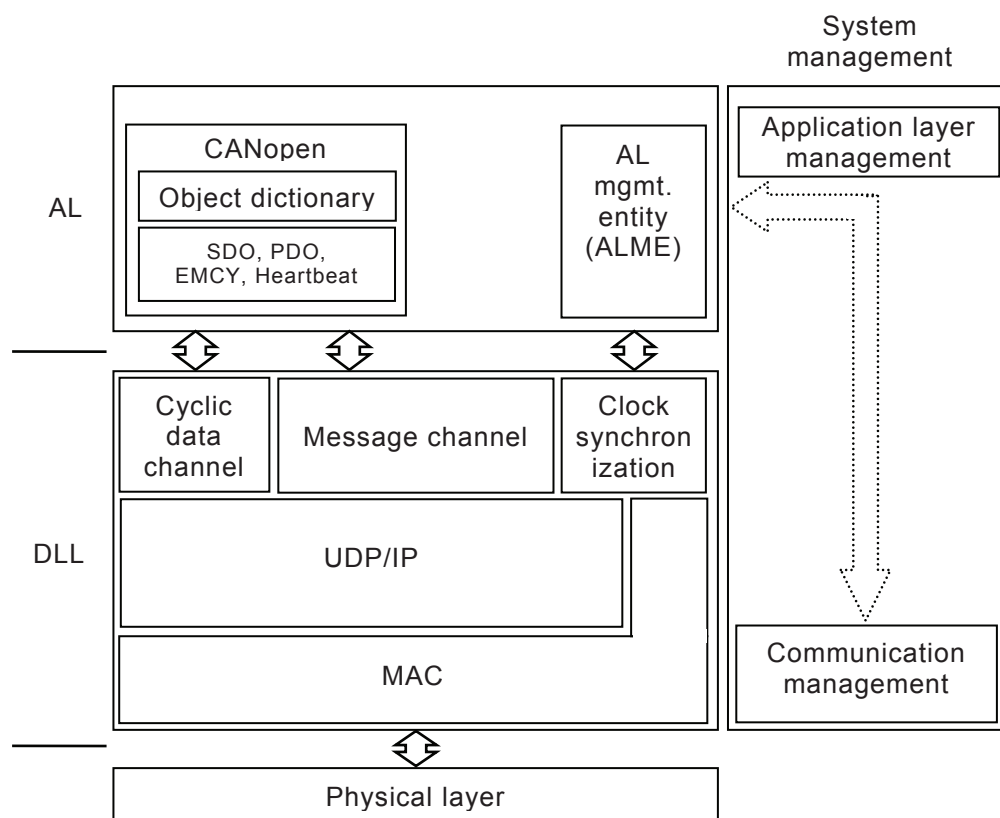


Figure 2 – RTFN device reference model

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 ISO/IEC 8802-3 Ethernet DLPDU communication.
- A mandatory management entity for system management.

The Application Layer uses the services provided by the Type 22 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 22 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 ISO/IEC 8802-3. DLPDUs are specified in ISO/IEC 8802-3. The DLSDU of ISO/IEC 8802-3 DLPDUs 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 22 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 $8(k - 1) < n \leq 8k$. 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:

$b_7, b_6, \dots, b_0, b_{15}, \dots, b_8, \dots$

Table 3 – Transfer syntax for bit sequences

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

5.2.3 Encoding of a Boolean value

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

- The encoding of a TimeOfDay with and without date indication value shall be primitive.
- 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									Number of milliseconds since midnight
1	0	0	0	0	227	226	225	224	
2	223	222	221	220	219	218	217	216	
3	215	214	213	212	211	210	209	208	
4	207	206	205	204	203	202	201	200	Number of days since 01.01.84 only with date indication
5	199	198	197	196	195	194	193	192	
6	191	190	189	188	187	186	185	184	
msb	183	182	181	180	179	178	177	176	

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.
c)

Bits	7	6	5	4	3	2	1	0	Meaning
Octets									milliseconds
1	231	230	229	228	227	226	225	224	
2	223	222	221	220	219	218	217	216	
3	215	214	213	212	211	210	29	28	
4	27	26	25	24	23	22	21	20	
5	215	214	213	212	211	210	29	28	days only with date indication
6	27	26	25	24	23	22	21	20	
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 61158-5-22:2010.

- 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

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

and, performing two's complement arithmetic,

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

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

EXAMPLE The value $-257 = 0xFFE7$ with data type Integer16 is transferred in two octets, first 0xFF and then 0xE7.

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	b7 – b0	—	—	—	—	—	—	—
Integer16	b7 – b0	b15 – b8	—	—	—	—	—	—
Integer32	b7 – b0	b15 – b8	b23 – b16	b31 – b24	—	—	—	—
Integer64	b7 – b0	b15 – b8	b23 – b16	b31 – b24	b39 – b32	b47 – b40	b55 – b48	b63 – b56

NOTE 1 Data types SINT and char as defined in IEC 61158-5-22:2010 corresponds to Integer8.

NOTE 2 Data types INT and short as defined in IEC 61158-5-22:2010 corresponds to Integer16.

NOTE 3 Data types DINT and long as defined in IEC 61158-5-22:2010 corresponds to Integer32.

NOTE 4 Data type LINT as defined in IEC 61158-5-22:2010 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

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

is assigned the value

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

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	b7–b0	—	—	—	—	—	—	—	—	—
Unsigned 16	b7 – b0	b15 – b8	—	—	—	—	—	—	—	—
Unsigned32	b7 – b0	b15 – b8	—	b31 – b24	—	—	—	—	—	—
Unsigned64	b7 – b0	b15 – b8	—	b31 – b24	—	b63 – b56	—	—	—	—
Unsigned128	b7 – b0	b15 – b8	—	b31 – b24	—	b63 – b56	—	b127 – b120	—	—
Unsigned256	b7 – b0	b15 – b8	—	b31 – b24	—	b63 – b56	—	b127 – b120	—	b255 – b248

NOTE 1 Data types USINT and unsigned char as defined in IEC 61158-5-22:2010 corresponds to Unsigned8.

NOTE 2 Data types UINT and WORD as defined in IEC 61158-5-22:2010 corresponds to Unsigned16.

NOTE 3 Data types UDINT and DWORD as defined in IEC 61158-5-22:2010 corresponds to Unsigned32.

NOTE 4 Data type ULINT as defined in IEC 61158-5-22:2010 corresponds to Unsigned64.

5.2.9 Encoding of an OctetString value

- The encoding of a variable length OctetString value shall be primitive.
- 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 22 RTFN interface profile	—	Definition of the parameters defined in Type 22 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