

© Copyright SEK. Reproduction in any form without permission is prohibited.

Industriell processtyrning – Fältbuss – Del 4-3: Specifikation av protokoll i datalänksskiktet – Delar i fältbuss, Typ 3

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

Som svensk standard gäller europastandarden EN 61158-4-3:2008. Den svenska standarden innehåller den officiella engelska språkversionen av EN 61158-4-3:2008.

Nationellt förord

Europastandarden EN 61158-4-3:2008

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 61158-4-3, First edition, 2007 - Industrial communication networks - Fieldbus specifications - Part 4-3: Data-link layer protocol specification - Type 3 elements**

utarbetad inom International Electrotechnical Commission, IEC.

Denna standard, och de andra delarna i serien SS-EN 61158-4, ersätter SS-EN 61158-4, utgåva 1, 2004.

Tidigare fastställd svensk standard SS-EN 61158-4, utgåva 1, 2004, gäller ej fr o m 2011-02-01.

Standarder underlättar utvecklingen och höjer elsäkerheten

Det finns många fördelar med att ha gemensamma tekniska regler för bl a säkerhet, prestanda, dokumentation, utförande och skötsel av elprodukter, elanläggningar och metoder. Genom att utforma sådana standarder blir säkerhetskraven tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

SEK är Sveriges röst i standardiseringsarbetet inom elområdet

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

Stora delar av arbetet sker internationellt

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

Var med och påverka!

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

SEK Svensk Elstandard

Box 1284
164 29 Kista
Tel 08-444 14 00
www.elstandard.se

English version

**Industrial communication networks -
Fieldbus specifications -
Part 4-3: Data-link layer protocol specification -
Type 3 elements
(IEC 61158-4-3:2007)**

Réseaux de communication industriels -
Spécifications des bus de terrain -
Partie 4-3: Spécification des protocoles
des couches de liaison de données -
Éléments de type 3
(CEI 61158-4-3:2007)

Industrielle Kommunikationsnetze -
Feldbusse -
Teil 4-3: Protokollspezifikation des
Data Link Layer (Sicherheitsschicht) -
Typ 3-Elemente
(IEC 61158-4-3:2007)

This European Standard was approved by CENELEC on 2008-02-01. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, 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 and the United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 65C/474/FDIS, future edition 1 of IEC 61158-4-3, prepared by SC 65C, Industrial networks, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61158-4-3 on 2008-02-01.

This and the other parts of the EN 61158-4 series supersede EN 61158-4:2004.

With respect to EN 61158-4:2004 the following changes were made:

- deletion of Type 6 fieldbus, and the placeholder for a Type 5 fieldbus data-link layer, for lack of market relevance;
- addition of new fieldbus types;
- partition into multiple parts numbered 4-1, 4-2, ..., 4-19.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2008-11-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2011-02-01

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in type combinations as specified explicitly in the EN 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

IEC and CENELEC draw attention to the fact that it is claimed that compliance with this standard may involve the use of patents as follows, where the [xx] notation indicates the holder of the patent right:

Type 3 and possibly other types:

DE 36 43 979 C2	[SI]	Deterministisches Zugriffsverfahren nach dem Tokenprinzip für eine Datenübertragung
DE 36 43 979 A1	[SI]	Deterministisches Zugriffsverfahren nach dem Tokenprinzip für eine Datenübertragung

IEC and CENELEC take no position concerning the evidence, validity and scope of these patent rights.

The holders of these patent rights have assured IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holders of these patent rights are registered with IEC. Information may be obtained from:

[SI]: SIEMENS AG
Ludwig Winkel
Siemensallee 84
D-76181 Karlsruhe
Germany

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights other than those identified above. IEC and CENELEC shall not be held responsible for identifying any or all such patent rights.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61158-4-3:2007 was approved by CENELEC as a European Standard without any modification.

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

IEC 60870-5-1	NOTE Harmonized as EN 60870-5-1:1993 (not modified).
IEC 61158-5-3	NOTE Harmonized as EN 61158-5-3:2008 (not modified).
IEC 61158-6-3	NOTE Harmonized as EN 61158-6-3:2008 (not modified).
IEC 61784-1	NOTE Harmonized as EN 61784-1:2008 (not modified).
IEC 61784-2	NOTE Harmonized as EN 61784-2:2008 (not modified).
ISO 9314-2	NOTE Harmonized as EN 29314-2:1993 (not modified).

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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.

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61158-2	2007	Industrial communication networks - Fieldbus specifications - Part 2: Physical layer specification and service definition	EN 61158-2	2008
IEC 61158-3-3	- ¹⁾	Industrial communication networks - Fieldbus specifications - Part 3-3: Data-link layer service definition - Type 3 elements	EN 61158-3-3	2008 ²⁾
ISO/IEC 2022	- ¹⁾	Information technology - Character code structure and extension techniques	-	-
ISO/IEC 7498-1	- ¹⁾	Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model	EN ISO/IEC 7498-1	1995 ²⁾
ISO/IEC 7498-3	- ¹⁾	Information technology - Open Systems Interconnection - Basic Reference Model: Naming and addressing	-	-
ISO/IEC 10731	- ¹⁾	Information technology - Open Systems Interconnection - Basic reference model - Conventions for the definition of OSI services	-	-
ISO 1177	- ¹⁾	Information processing - Character structure for start/stop and synchronous character- oriented transmission	-	-

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

CONTENTS

INTRODUCTION.....	8
1 Scope.....	9
1.1 General.....	9
1.2 Specifications.....	9
1.3 Procedures.....	9
1.4 Applicability.....	9
1.5 Conformance.....	10
2 Normative references	10
3 Terms, definitions, symbols and abbreviations.....	10
3.1 Reference model terms and definitions.....	10
3.2 Service convention terms and definitions.....	12
3.3 Common terms and definitions	13
3.4 Additional Type 3 definitions.....	15
3.5 Common symbols and abbreviations	17
3.6 Type 3 symbols and abbreviations.....	18
4 Common DL-protocol elements.....	22
4.1 Frame check sequence	22
5 Overview of the DL-protocol	24
5.1 General.....	24
5.2 Overview of the medium access control and transmission protocol.....	25
5.3 Transmission modes and DL-entity.....	26
5.4 Service assumed from the PhL.....	31
5.5 Operational elements	34
5.6 Cycle and system reaction times	50
6 General structure and encoding of DLPDUs, and related elements of procedure	53
6.1 DLPDU granularity	53
6.2 Length octet (LE, LEr)	54
6.3 Address octet.....	55
6.4 Control octet (FC).....	57
6.5 DLPDU content error detection.....	61
6.6 DATA_UNIT	62
6.7 Error control procedures.....	62
7 DLPDU-specific structure, encoding and elements of procedure	64
7.1 DLPDUs of fixed length with no data field.....	64
7.2 DLPDUs of fixed length with data field.....	65
7.3 DLPDUs with variable data field length.....	67
7.4 Token DLPDU	68
7.5 ASP DLPDU	69
7.6 SYNCH DLPDU	69
7.7 Time Event (TE) DLPDU.....	69
7.8 Clock Value (CV) DLPDU	69
7.9 Transmission procedures	70
8 Other DLE elements of procedure.....	73
8.1 DL-entity initialization	73
8.2 States of the media access control of the DL-entity	73

8.3 Clock synchronization protocol	79
Annex A (normative) – DL-Protocol state machines	84
A.1 Overall structure	84
A.2 Variation of state machines in different devices	85
A.3 DL Data Resource	86
A.4 FLC / DLM	91
A.5 MAC	115
A.6 SRU	143
Annex B (informative) – Type 3 (synchronous): exemplary FCS implementations	161
Annex C (informative) – Type 3: Exemplary token procedure and message transfer periods	163
C.1 Procedure of token passing	163
C.2 Examples for token passing procedure	164
C.3 Examples for message transfer periods – asynchronous transmission	169
C.4 Examples for message transfer periods – synchronous transmission	170
Bibliography	171
Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses	14
Figure 2 – Logical token-passing ring	27
Figure 3 – PhL data service for asynchronous transmission	31
Figure 4 – Idle time T_{ID1}	37
Figure 5 – Idle time T_{ID2} (SDN, CS)	37
Figure 6 – Idle time T_{ID2} (MSRD)	38
Figure 7 – Slot time T_{SL1}	38
Figure 8 – Slot time T_{SL2}	39
Figure 9 – Slot time T_{SL1}	44
Figure 10 – Slot time T_{SL2}	44
Figure 11 – Token transfer period	50
Figure 12 – Message transfer period	51
Figure 13 – UART character	53
Figure 14 – Octet structure	54
Figure 15 – Length octet coding	54
Figure 16 – Address octet coding	55
Figure 17 – DAE/SAE octet in the DLPDU	56
Figure 18 – Address extension octet	56
Figure 19 – FC octet coding for send/request DLPDUs	57
Figure 20 – FC octet coding for acknowledgement or response DLPDUs	58
Figure 21 – FCS octet coding	61
Figure 22 – Data field	62
Figure 23 – Ident user data	62
Figure 24 – DLPDUs of fixed length with no data field	64
Figure 25 – DLPDUs of fixed length with no data field	65
Figure 26 – DLPDUs of fixed length with data field	66
Figure 27 – DLPDUs of fixed length with data field	66

Figure 28 – DLPDUs with variable data field length.....	67
Figure 29 – DLPDUs with variable data field length.....	68
Figure 30 – Token DLPDU	68
Figure 31 – Token DLPDU	69
Figure 32 – Send/request DLPDU of fixed length with no data	70
Figure 33 – Token DLPDU and send/request DLPDU of fixed length with data.....	70
Figure 34 – Send/request DLPDU with variable data field length.....	71
Figure 35 – Send/request DLPDU of fixed length with no data	71
Figure 36 – Token DLPDU and send/request DLPDU of fixed length with data.....	72
Figure 37 – Send/request DLPDU with variable data field length.....	72
Figure 38 – DL-state-diagram	74
Figure 39 – Overview of clock synchronization.....	80
Figure 40 – Time master state machine	81
Figure 41 – Time receiver state machine	82
Figure 42 – Clock synchronization	83
Figure A.1 – Structuring of the protocol machines.....	85
Figure A.2 – Structure of the SRU Machine.....	144
Figure B.1 – Example of FCS generation for Type 3 (synchronous)	161
Figure B.2 – Example of FCS syndrome checking on reception for Type 3 (synchronous)	161
Figure C.1 – Derivation of the token holding time (T_{TH}).....	164
Figure C.2 – No usage of token holding time (T_{TH}).....	165
Figure C.3 – Usage of token holding time (T_{TH}) for message transfer (equivalence between T_{TH} of each Master station).....	166
Figure C.4 – Usage of token holding time (T_{TH}) in different working load situations	168
Table 1 – FCS length, polynomials and constants by Type 3 synchronous	23
Table 2 – Characteristic features of the fieldbus data-link protocol.....	25
Table 3 – Transmission function code	59
Table 4 – FCB, FCV in responder	61
Table 5 – Operating parameters	73
Table A.1 – Assignment of state machines.....	86
Table A.2 – Data resource	87
Table A.3 – Primitives issued by DL-User to FLC	91
Table A.4 – Primitives issued by FLC to DL-User	91
Table A.5 – Primitives issued by DL-User to DLM	93
Table A.6 – Primitives issued by DLM to DL-User	94
Table A.7 – Parameters used with primitives exchanged between DL-User and FLC.....	94
Table A.8 – Parameters used with primitives exchanged between DL-User and DLM.....	95
Table A.9 – FLC/DLM state table	96
Table A.10 – FLC / DLM function table.....	109
Table A.11 – Primitives issued by DLM to MAC.....	116
Table A.12 – Primitives issued by MAC to DLM.....	116

Table A.13 – Parameters used with primitives exchanged between DLM and MAC	116
Table A.14 – Local MAC variables	117
Table A.15 – MAC state table	117
Table A.16 – MAC function table.....	139
Table A.17 – Primitives issued by DLM to SRC	145
Table A.18 – Primitives issued by SRC to DLM.....	146
Table A.19 – Primitives issued by MAC to SRC.....	146
Table A.20 – Primitives issued by SRC to MAC.....	146
Table A.21 – Parameters used with primitives exchanged between MAC and SRC	147
Table A.22 – FC structure	147
Table A.23 – Local variables of SRC.....	147
Table A.24 – SRC state table.....	148
Table A.25 – SRC functions	160

INTRODUCTION

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

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

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

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

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-3: Data-link layer protocol specification – Type 3 elements

1 Scope

1.1 General

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

This protocol provides communication opportunities to a pre-selected “master” subset of data-link entities in a cyclic asynchronous manner, sequentially to each of those data-link entities. Other data-link entities communicate only as permitted and delegated by those master data-link entities.

For a given master, its communications with other data-link entities can be cyclic, or acyclic with prioritized access, or a combination of the two.

This protocol provides a means of sharing the available communication resources in a fair manner. There are provisions for time synchronization and for isochronous operation.

1.2 Specifications

This standard specifies

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

1.3 Procedures

The procedures are defined in terms of

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

1.4 Applicability

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

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

1.5 Conformance

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

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61158-2 (Ed.4.0), *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 2: Physical layer specification and service definition*

IEC 61158-3-3, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 3-3: Data link service definition – Type 3 elements*

ISO/IEC 2022, *Information technology – Character code structure and extension techniques*

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

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

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

ISO 1177, *Information processing – Character structure for start/stop and synchronous character oriented transmission*

1	