

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

Industriell processtyrning – Fältbuss – Del 4-12: Specifikation av protokoll i datalänksskiktet – Delar i fältbuss, Typ 12

*Industrial communication networks –
Fieldbus specifications –
Part 4-12: Data-link layer protocol specification –
Type 12 elements*

Som svensk standard gäller europastandarden EN 61158-4-12:2008. Den svenska standarden innehåller den officiella engelska språkversionen av EN 61158-4-12:2008.

Nationellt förord

Europastandarden EN 61158-4-12:2008

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 61158-4-12, First edition, 2007 - Industrial communication networks - Fieldbus specifications - Part 4-12: Data-link layer protocol specification - Type 12 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 4-12: Data-link layer protocol specification -
Type 12 elements
(IEC 61158-4-12:2007)**

Réseaux de communication industriels -
Spécifications des bus de terrain -
Partie 4-12: Spécification des protocoles
des couches de liaison de données -
Éléments de type 12
(CEI 61158-4-12:2007)

Industrielle Kommunikationsnetze -
Feldbusse -
Teil 4-12: Protokollspezifikation
des Data Link Layer (Sicherheitsschicht) -
Typ 12-Elemente
(IEC 61158-4-12:2007)

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 61158-4-12, 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 61158-4-12 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.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61158-4-12:2007 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 61131-2	NOTE Harmonized as EN 61131-2:2007 (not modified).
IEC 61131-3	NOTE Harmonized as EN 61131-6:2007 (not modified).
IEC 61158-5-12	NOTE Harmonized as EN 61158-5-12:2008 (not modified).
IEC 61158-6-12	NOTE Harmonized as EN 61158-6-12:2008 (not modified).
IEC 61784-2	NOTE Harmonized as EN 61784-2:2008 (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 61158-3-12	- ¹⁾	Industrial communication networks - Fieldbus specifications - Part 3-12: Data-link layer service definition - Type 12 elements	EN 61158-3-12	2008 ²⁾
IEC 61588	- ¹⁾	Precision clock synchronization protocol for networked measurement and control systems	-	-
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 8802-1	- ¹⁾	Information technology - Telecommunications - and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 1: Overview of Local Area Network Standards	-	-
ISO/IEC 8802-3	- ¹⁾	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	-	-

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
ISO/IEC 10731	- ¹⁾	Information technology - Open Systems Interconnection - Basic reference model - Conventions for the definition of OSI services	-	-
IEEE 802.1Q	- ¹⁾	IEEE Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks	-	-
IETF RFC 768	- ¹⁾	User Datagram Protocol	-	-
IETF RFC 791	- ¹⁾	Internet Protocol	-	-

CONTENTS

INTRODUCTION.....	9
1 Scope.....	10
1.1 General.....	10
1.2 Specifications.....	10
1.3 Procedures.....	10
1.4 Applicability.....	10
1.5 Conformance.....	10
2 Normative references	11
3 Terms, definitions, symbols and abbreviations.....	11
3.1 Reference model terms and definitions.....	11
3.2 Service convention terms and definitions.....	12
3.3 Common terms and definitions	13
3.4 Additional Type 12 definitions.....	13
3.5 Common symbols and abbreviations	16
3.6 Additional Type 12 symbols and abbreviations	17
3.7 Conventions	19
4 Overview of the DL-protocol	24
4.1 Operating principle	24
4.2 Topology	24
4.3 Frame processing principles.....	24
4.4 Data-link layer overview	25
4.5 Error detection overview.....	26
4.6 Node reference model	26
4.7 Operation overview	27
5 Frame structure	28
5.1 Frame coding principles	28
5.2 Data types and encoding rules	28
5.3 DLPDU structure	31
5.4 Type 12 DLPDU structure.....	33
5.5 Network variable structure.....	48
5.6 Type 12 mailbox structure	48
6 Attributes.....	49
6.1 Management	49
6.2 Statistics	66
6.3 Watchdogs	69
6.4 Slave information interface.....	72
6.5 Media independent interface (MII).....	77
6.6 Fieldbus memory management unit (FMMU).....	80
6.7 Sync manager	83
6.8 Distributed clock.....	90
7 DL-user memory.....	94
7.1 Overview	94
7.2 Mailbox access type	95
7.3 Buffered access type.....	98
8 Type 12: FDL protocol state machines.....	100

8.1 Overview of slave DL state machines	100
8.2 State machine description	100
Annex A (informative) – Type 12: Additional specifications on DL-Protocol state machines	108
A.1 DHSM	108
A.2 SYSM	127
A.3 RMSM	140
Bibliography	144
Figure 1 – Type description example	20
Figure 2 – Common structure of specific fields	21
Figure 3 – Frame structure	25
Figure 4 – Mapping of data in a frame	26
Figure 5 – Slave node reference model	27
Figure 6 – Type 12 PDUs embedded in Ethernet frame	28
Figure 7 – Type 12 PDUs embedded in UDP/IP	28
Figure 8 – DL information type description	51
Figure 9 – Address type description	53
Figure 10 – DL control type description	55
Figure 11 – DL status type description	57
Figure 12 – Successful write sequence to DL-user control register	59
Figure 13 – Successful read sequence to the DL-user status register	60
Figure 14 – RX error counter type description	67
Figure 15 – Lost link counter type description	68
Figure 16 – Additional counter type description	69
Figure 17 – Sync configuration type description	70
Figure 18 – Watchdog divider type description	70
Figure 19 – Sync manager watchdog type description	71
Figure 20 – Sync manager watchdog status type description	71
Figure 21 – Watchdog counter type description	72
Figure 22 – Slave information interface access type description	72
Figure 23 – Slave information interface control/status type description	74
Figure 24 – Slave information interface address type description	76
Figure 25 – Slave information interface data type description	77
Figure 26 – MII control/status type description	78
Figure 27 – MII address type description	79
Figure 28 – MII data type description	80
Figure 29 – FMMU mapping example	80
Figure 30 – FMMU entity type description	81
Figure 31 – SyncM mailbox interaction	84
Figure 32 – SyncM buffer allocation	84
Figure 33 – SyncM buffer interaction	85
Figure 34 – Handling of write/read toggle with read mailbox	86
Figure 35 – Sync manager channel type description	88

Figure 36 – Distributed clock local time parameter type description	92
Figure 37 – Successful write sequence to mailbox	95
Figure 38 – Bad write sequence to mailbox	96
Figure 39 – Successful read sequence to mailbox	96
Figure 40 – Bad read sequence to mailbox	97
Figure 41 – Successful write sequence to buffer	98
Figure 42 – Successful read sequence to buffer	99
Figure 43 – Structuring of the protocol machines of an slave	100
Figure 44 – Slave information interface read operation	102
Figure 45 – Slave information interface write operation	103
Figure 46 – Slave information interface reload operation	104
Figure 47 – Distributed clock	106
Figure 48 – Delay measurement sequence	107
Table 1 – PDU element description example	20
Table 2 – Example attribute description	21
Table 3 – State machine description elements	22
Table 4 – Description of state machine elements	23
Table 5 – Conventions used in state machines	23
Table 6 – Transfer Syntax for bit sequences	29
Table 7 – Transfer syntax for data type Unsignedn	29
Table 8 – Transfer syntax for data type Integern	30
Table 9 – Type 12 frame inside an Ethernet frame	31
Table 10 – Type 12 frame inside an UDP PDU	32
Table 11 – Type 12 frame structure containing Type 12 PDUs	33
Table 12 – Type 12 frame structure containing network variables	33
Table 13 – Type 12 frame structure containing mailbox	33
Table 14 – Auto Increment Physical Read (APRD)	34
Table 15 – Configured Address Physical Read (FPRD)	35
Table 16 – Broadcast Read (BRD)	36
Table 17 – Logical Read (LRD)	37
Table 18 – Auto Increment Physical Write (APWR)	38
Table 19 – Configured Address Physical Write (FPWR)	39
Table 20 – Broadcast Write (BWR)	40
Table 21 – Logical Write (LWR)	41
Table 22 – Auto Increment Physical ReadWrite (APRW)	42
Table 23 – Configured Address Physical ReadWrite (FPRW)	43
Table 24 – Broadcast ReadWrite (BRW)	44
Table 25 – Logical ReadWrite (LRW)	45
Table 26 – Auto Increment Physical Read Multiple Write (ARMW)	46
Table 27 – Configured Address Physical Read Multiple Write (FRMW)	47
Table 28 – Network variable	48
Table 29 – Mailbox	48

Table 30 – Error Reply Service Data	49
Table 31 – DL information	52
Table 32 – Configured station address	54
Table 33 – DL control	55
Table 34 – DL status	58
Table 35 – DLS-user specific registers	61
Table 36 – DLS-user event	63
Table 37 – DLS-user event mask	64
Table 38 – External event	65
Table 39 – External event mask	66
Table 40 – RX error counter	67
Table 41 – Lost link counter	68
Table 42 – Watchdog divider	70
Table 43 – PDI watchdog	70
Table 44 – Sync manager channel watchdog	71
Table 45 – Sync manager watchdog Status	71
Table 46 – Watchdog counter	72
Table 47 – Slave information interface size	73
Table 48 – Slave information interface control/status	75
Table 49 – Actual slave information interface address	76
Table 50 – Actual slave information interface data	77
Table 51 – MII control/status	78
Table 52 – Actual MII address	79
Table 53 – Actual MII data	80
Table 54 – Fieldbus memory management unit (FMMU) entity	82
Table 55 – Fieldbus memory management unit (FMMU)	83
Table 56 – Sync manager channel	88
Table 57 – Sync manager Structure	90
Table 58 – Distributed clock local time parameter	93
Table 59 – Distributed clock DLS-user parameter	94
Table A.1 – Primitives issued by DHSM to PSM	108
Table A.2 – Primitives issued by PSM to DHSM	108
Table A.3 – Parameters used with primitives exchanged between DHSM and PSM	108
Table A.4 – Identifier for the octets of a Ethernet frame	109
Table A.5 – DHSM state table	111
Table A.6 – DHSM function table	127
Table A.7 – Primitives issued by SYSM to DHSM	127
Table A.8 – Primitives issued by DHSM to SYSM	128
Table A.9 – Primitives issued by DL-User to SYSM	128
Table A.10 – Primitives issued by SYSM to DL-User	128
Table A.11 – Parameters used with primitives exchanged between SYSM and DHSM	128
Table A.12 – SYSM state table	130
Table A.13 – SYSM function table	140

Table A.14 – Primitives issued by RMSM to SYSM	140
Table A.15 – Primitives issued by SYSM to RMSM	140
Table A.16 – Parameters used with primitives exchanged between RMSM and SYSM	140
Table A.17 – RMSM state table.....	142
Table A.18 – RMSM function table	143

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 4-12: Data-link layer protocol specification – Type 12 elements

1 Scope

1.1 General

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

This protocol provides communication opportunities to all participating data-link entities

- a) in a synchronously-starting cyclic manner, and
- b) in a cyclic or acyclic asynchronous manner, as requested each cycle by each of those data-link entities.

Thus this protocol can be characterized as one which provides cyclic and acyclic access asynchronously but with a synchronous restart of each cycle.

1.2 Specifications

This standard specifies

- a) procedures for the transfer of data and control information from one data-link user entity to one or more user entity;
- b) the structure of the 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 DL-entities (DLEs) through the exchange of 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 the MAC services of ISO/IEC 8802-3.

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 reference model, and which require the ability to interconnect in an open systems interconnection environment.

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

1.5 Conformance

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