

This is a preview - click here to buy the full publication



IEC 61158-4-3

Edition 4.0 2019-04

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 25.040.40; 35.100.20; 35.110

ISBN 978-2-8322-6773-8

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
1.1 General.....	10
1.2 Specifications	10
1.3 Procedures	10
1.4 Applicability	10
1.5 Conformance	11
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	13
3.3 Common terms and definitions.....	14
3.4 Additional Type 3 definitions	16
3.5 Common symbols and abbreviations	18
3.5.1 Data units.....	18
3.5.2 Miscellaneous.....	18
3.6 Type 3 symbols and abbreviations	19
4 Common DL-protocol elements.....	23
4.1 Frame check sequence	23
4.1.1 General	23
4.1.2 At the sending DLE.....	24
4.1.3 At the receiving DLE.....	25
5 Overview of the DL-protocol	26
5.1 General.....	26
5.2 Overview of the medium access control and transmission protocol	26
5.3 Transmission modes and DL-entity	27
5.3.1 Overview	27
5.3.2 Token procedures.....	28
5.3.3 Send or send/request mode.....	32
5.4 Service assumed from the PhL	32
5.4.1 Asynchronous transmission	32
5.4.2 Synchronous transmission	33
5.5 Operational elements.....	36
5.5.1 Overview	36
5.5.2 Bit time t_{BIT}	36
5.5.3 Asynchronous transmission	36
5.5.4 Synchronous transmission	42
5.5.5 Timers and counters	47
5.6 Cycle and system reaction times.....	51
5.6.1 Asynchronous transmission	51
5.6.2 Synchronous transmission	53
6 General structure and encoding of DLPDUs, and related elements of procedure	54
6.1 DLPDU granularity.....	54
6.1.1 Asynchronous transmission – UART character	54
6.1.2 Synchronous transmission	55

6.2	Length octet (LE, LEr).....	55
6.3	Address octet.....	56
6.3.1	Destination and source station address (DA and SA).....	56
6.3.2	Address extension (EXT).....	56
6.3.3	Address check.....	57
6.3.4	DL-service-access-point (DLSAP).....	58
6.4	Control octet (FC).....	58
6.4.1	General.....	58
6.4.2	Frame count bit.....	60
6.5	DLPDU content error detection.....	62
6.5.1	Asynchronous transmission – frame checksum (FCS).....	62
6.5.2	Synchronous transmission – frame check sequence (FCS).....	62
6.6	DATA_UNIT.....	63
6.6.1	General.....	63
6.6.2	Ident user data.....	63
6.7	Error control procedures.....	64
6.7.1	Asynchronous transmission.....	64
6.7.2	Synchronous transmission.....	64
7	DLPDU-specific structure, encoding and elements of procedure.....	64
7.1	DLPDUs of fixed length with no data field.....	64
7.1.1	Asynchronous transmission.....	64
7.1.2	Synchronous transmission.....	66
7.2	DLPDUs of fixed length with data field.....	66
7.2.1	Asynchronous transmission.....	66
7.2.2	Synchronous transmission.....	67
7.3	DLPDUs with variable data field length.....	68
7.3.1	Asynchronous transmission.....	68
7.3.2	Synchronous transmission.....	68
7.4	Token DLPDU.....	69
7.4.1	Asynchronous transmission.....	69
7.4.2	Synchronous transmission.....	70
7.5	ASP DLPDU.....	70
7.6	SYNCH DLPDU.....	70
7.7	Time Event (TE) DLPDU.....	70
7.8	Clock Value (CV) DLPDU.....	70
7.9	Transmission procedures.....	71
7.9.1	Asynchronous transmission.....	71
7.9.2	Synchronous transmission.....	72
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.....	74
8.2.1	General.....	74
8.2.2	Offline.....	75
8.2.3	Passive_Idle.....	76
8.2.4	Listen_Token.....	76
8.2.5	Active_Idle.....	76
8.2.6	Claim_Token.....	77
8.2.7	Wait_TCT.....	77

8.2.8	Use_Token	78
8.2.9	Await_Data_Response.....	78
8.2.10	Check_Access_Time	78
8.2.11	Pass_Token	79
8.2.12	Check_Token_Pass.....	79
8.2.13	Await_Status_Response.....	80
8.3	Clock synchronization protocol.....	80
8.3.1	Overview	80
8.3.2	State machine time master	80
8.3.3	State machine time receiver	82
Annex A	(normative) DL-Protocol state machines	85
A.1	Overall structure	85
A.2	Variation of state machines in different devices	86
A.3	DL Data Resource	87
A.4	FLC / DLM	91
A.4.1	Primitive definitions	91
A.4.2	State machine description	96
A.5	MAC	115
A.5.1	Primitive definitions	115
A.5.2	State machine description	116
A.6	SRU.....	142
A.6.1	Overview	142
A.6.2	Character send SM(CTX).....	143
A.6.3	Character receive SM (CRX)	143
A.6.4	Timer-SM (TIM)	144
A.6.5	Primitive definition of SRC.....	144
A.6.6	State machine description	146
Annex B	(informative) Type 3 (synchronous): exemplary FCS implementations.....	160
Annex C	(informative) Type 3: Exemplary token procedure and message transfer periods	162
C.1	Procedure of token passing.....	162
C.2	Examples for token passing procedure.....	163
C.3	Examples for message transfer periods – asynchronous transmission	168
Bibliography	170
Figure 1	– Relationships of DLSAPs, DLSAP-addresses and group DL-addresses	15
Figure 2	– Logical token-passing ring	29
Figure 3	– PhL data service for asynchronous transmission	33
Figure 4	– Idle time T_{ID1}	38
Figure 5	– Idle time T_{ID2} (SDN, CS).....	39
Figure 6	– Idle time T_{ID2} (MSRD).....	39
Figure 7	– Slot time T_{SL1}	40
Figure 8	– Slot time T_{SL2}	40
Figure 9	– Slot time T_{SL1}	45
Figure 10	– Slot time T_{SL2}	45
Figure 11	– Token transfer period	51
Figure 12	– Message transfer period.....	52

Figure 13 – UART character	54
Figure 14 – Octet structure	55
Figure 15 – Length octet coding.....	55
Figure 16 – Address octet coding.....	56
Figure 17 – DAE/SAE octet in the DLPDU.....	57
Figure 18 – Address extension octet.....	57
Figure 19 – FC octet coding for send/request DLPDUs	58
Figure 20 – FC octet coding for acknowledgement or response DLPDUs	59
Figure 21 – FCS octet coding.....	62
Figure 22 – Data field	63
Figure 23 – Ident user data.....	63
Figure 24 – DLPDUs of fixed length with no data field.....	65
Figure 25 – DLPDUs of fixed length with no data field.....	66
Figure 26 – DLPDUs of fixed length with data field	67
Figure 27 – DLPDUs of fixed length with data field	67
Figure 28 – DLPDUs with variable data field length.....	68
Figure 29 – DLPDUs with variable data field length.....	69
Figure 30 – Token DLPDU	69
Figure 31 – Token DLPDU	70
Figure 32 – Send/request DLPDU of fixed length with no data	71
Figure 33 – Token DLPDU and send/request DLPDU of fixed length with data.....	71
Figure 34 – Send/request DLPDU with variable data field length.....	72
Figure 35 – Send/request DLPDU of fixed length with no data	72
Figure 36 – Token DLPDU and send/request DLPDU of fixed length with data.....	73
Figure 37 – Send/request DLPDU with variable data field length.....	73
Figure 38 – DL-state-diagram	75
Figure 39 – Overview of clock synchronization.....	81
Figure 40 – Time master state machine	82
Figure 41 – Time receiver state machine	83
Figure 42 – Clock synchronization	84
Figure A.1 – Structuring of the protocol machines.....	86
Figure A.2 – Structure of the SRU Machine.....	143
Figure B.1 – Example of FCS generation for Type 3 (synchronous)	160
Figure B.2 – Example of FCS syndrome checking on reception for Type 3 (synchronous).....	160
Figure C.1 – Derivation of the token holding time (T_{TH}).....	163
Figure C.2 – No usage of token holding time (T_{TH}).....	164
Figure C.3 – Usage of token holding time (T_{TH}) for message transfer (equivalence between T_{TH} of each Master station).....	165
Figure C.4 – Usage of token holding time (T_{TH}) in different working load situations	167
Table 1 – FCS length, polynomials and constants by Type 3 synchronous	24
Table 2 – Characteristic features of the fieldbus data-link protocol.....	26

Table 3 – Transmission function code	60
Table 4 – FCB, FCV in responder	62
Table 5 – Operating parameters	74
Table A.1 – Assignment of state machines.....	87
Table A.2 – Data resource	88
Table A.3 – Primitives issued by DL-User to FLC.....	92
Table A.4 – Primitives issued by FLC to DL-User.....	92
Table A.5 – Primitives issued by DL-User to DLM.....	94
Table A.6 – Primitives issued by DLM to DL-User.....	94
Table A.7 – Parameters used with primitives exchanged between DL-User and FLC.....	95
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.....	108
Table A.11 – Primitives issued by DLM to MAC.....	115
Table A.12 – Primitives issued by MAC to DLM.....	115
Table A.13 – Parameters used with primitives exchanged between DLM and MAC	115
Table A.14 – Local MAC variables	116
Table A.15 – MAC state table	117
Table A.16 – MAC function table.....	138
Table A.17 – Primitives issued by DLM to SRC	144
Table A.18 – Primitives issued by SRC to DLM.....	145
Table A.19 – Primitives issued by MAC to SRC.....	145
Table A.20 – Primitives issued by SRC to MAC.....	145
Table A.21 – Parameters used with primitives exchanged between MAC and SRC	146
Table A.22 – FC structure	146
Table A.23 – Local variables of SRC.....	146
Table A.24 – SRC state table.....	147
Table A.25 – SRC functions	159

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

Attention is drawn to the fact that the use of the associated protocol type is restricted by its 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 layer protocol type to be used with other layer protocols of the same type, or in other type combinations explicitly authorized by its intellectual-property-right holders.

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

International Standard IEC 61158-4-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

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

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

- corrections in Table 3;
- corrections in Table A.15;
- spelling and grammar.

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

FDIS	Report on voting
65C/946/FDIS	65C/955/RVD

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

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under <<http://webstore.iec.ch>> in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

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

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this document is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer 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 document is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this document together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

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 its profile parts. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

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

2 Normative references

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

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

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61158-2:2014, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

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

ISO/IEC 646, *Information technology – ISO 7-bit coded character set for information interchange*

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*