



IEC 61158-4-7

Edition 1.0 2007-12

# INTERNATIONAL STANDARD

---

**Industrial communication networks – Fieldbus specifications –  
Part 4-7: Data-link layer protocol specification – Type 7 elements**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE **XE**

---

ICS 35.100.20; 25.040.40

ISBN 2-8318-9434-4

## CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
1.1 General.....	9
1.2 Specifications.....	9
1.3 Procedures.....	9
1.4 Applicability.....	9
1.5 Conformance.....	9
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.....	11
3.3 Other terms and definitions .....	12
3.4 Symbols and abbreviations.....	16
4 Overview of the DL-protocol .....	18
4.1 Overall description of medium allocation .....	18
4.2 Types of entities .....	20
4.3 Addressing .....	23
4.4 Flow control.....	29
4.5 Graphical representation .....	31
5 General structure and encoding of PhIDUs and DLPDUs and related elements of procedure.....	32
5.1 DLPDU formats and components.....	32
5.2 Description of each DLPDU component.....	32
5.3 PhIDU structure and encoding.....	36
5.4 Common DLPDU structure, encoding and elements of procedure .....	37
5.5 Valid DLPDU types.....	37
5.6 DLL timers.....	39
6 DLPDU-specific structure, encoding and element of procedure.....	43
6.1 General.....	43
6.2 Buffer read .....	43
6.3 Buffer write.....	44
6.4 Buffer transfer .....	44
6.5 Specified explicit request.....	45
6.6 Free explicit request.....	50
6.7 Messaging.....	53
6.8 Acknowledged messaging .....	58
6.9 Numbering of acknowledged messages .....	62
6.10 Behavior with mismatched parameters .....	64
7 DL-service elements of procedure, interfaces and conformance .....	66
7.1 General.....	66
7.2 Producer/consumer entity.....	67
7.3 Protocol elements by service.....	70
7.4 Bus arbitrator operation.....	77
7.5 Bridges.....	85
7.6 Interfaces .....	92

7.7 Conformance.....	94
Annex A (informative) Exemplary FCS implementation.....	97
Annex B (informative) Object modeling .....	99
B.1 Modeling of the IDENTIFIER object .....	99
B.2 Description of the IDENTIFIER object attributes .....	99
B.3 Modeling of the QUEUE object.....	103
B.4 Description of the QUEUE object attributes .....	103
B.5 Modeling of the BUFFER object.....	104
B.6 Description of the BUFFER object attributes.....	104
Annex C (informative) Topology of multi-segment DL-subnetwork.....	106
C.1 Introduction .....	106
C.2 Global specification .....	106
C.3 Local specification.....	107
C.4 Properties .....	107
C.5 Methods .....	107
Annex D (informative) Management of transmission errors .....	111
D.1 Transmission of RP_DAT_XX.....	111
D.2 Transmission of a free RP_RQ(1/2).....	111
D.3 Transmission of the specified RP_RQ1 .....	112
D.4 Transmission of RP_MSG_NOACK.....	113
D.5 Transmission of RP_MSG_ACK.....	115
Bibliography.....	118
Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses .....	13
Figure 2 – General description of medium allocation .....	19
Figure 3 – Internal structure of a producer/consumer entity.....	20
Figure 4 – Associated buffers and queues .....	22
Figure 5 – Internal structure of a bus arbitrator .....	23
Figure 6 – Polling BA Table .....	23
Figure 7 – Addressing scheme.....	24
Figure 8 – Address partitioning .....	26
Figure 9 – Structure of an individual physical address .....	27
Figure 10 – Structure of an individual logical address .....	27
Figure 11 – Structure of restricted physical group address.....	27
Figure 12 – Structure of a restricted logical group address .....	28
Figure 13 – Structure of a generalized group address.....	28
Figure 14 – Summary of address structure.....	29
Figure 15 – Example of an evaluation net .....	31
Figure 16 – Basic DLPDU structure.....	32
Figure 17 – DLPDU transmission / reception order.....	32
Figure 18 – Identifier DLPDU .....	38
Figure 19 – Variable response DLPDU.....	38
Figure 20 – Request response DLPDU.....	38
Figure 21 – Message response DLPDU.....	39
Figure 22 – Acknowledgement response DLPDU .....	39

Figure 23 – End of message transaction response DLPDU .....	39
Figure 24 – Buffer reading service interactions .....	44
Figure 25 – Buffer writing service interactions.....	44
Figure 26 – Buffer transfer service interactions .....	44
Figure 27 – Buffer transfer DLPDU sequence .....	45
Figure 28 – Interactions within the specified explicit request for buffer transfer service in the aperiodic window .....	46
Figure 29 – Interactions within the specified explicit request for buffer transfer service in the periodic window.....	47
Figure 30 – DLPDU sequence for an explicit request for a transfer .....	48
Figure 31 – Evaluation network for a buffer transfer specified explicit request with (RQ_INHIBITED = False) .....	49
Figure 32 – Evaluation network for a buffer transfer specified explicit request with (RQ_INHIBITED = True).....	49
Figure 33 – Diagram of interactions within the free explicit request for buffer transfer service .....	51
Figure 34 – Evaluation network for a free explicit request .....	52
Figure 35 – Diagram of interactions within the unacknowledged message transfer request service for an aperiodic transfer .....	55
Figure 36 – Diagram of interactions within the unacknowledged message transfer request service for a cyclical transfer .....	56
Figure 37 – DLPDU sequence for an aperiodic message transfer.....	57
Figure 38 – DLPDU sequence for a cyclical message transfer .....	58
Figure 39 – Diagram of interactions within the acknowledged message transfer request service for an aperiodic transfer .....	59
Figure 40 – Diagram of interactions within the acknowledged message transfer request service for a cyclical transfer.....	60
Figure 41 – DLPDU sequence for an aperiodic message transfer.....	61
Figure 42 – DLPDU sequence for a cyclical message transfer .....	62
Figure 43 – Evaluation network for message aperiodic transfer.....	65
Figure 44 – Evaluation network for message cyclic transfer .....	66
Figure 45 – Simplified states machine for a producer/consumer entity .....	67
Figure 46 – Active bus arbitrator's simplified state machine .....	83
Figure 47 – Typical bridge usage .....	85
Figure 48 – Architectural placement of bridges in OSI Basic Reference Model (ISO/IEC 7498) .....	85
Figure 49 – Representation of an extended link communication .....	86
Figure 50 – Evaluation network for reception of an RP_MSG_ACK DLPDU.....	91
Figure 51 – Evaluation network for reception of an RP_MSG_NOACK DLPDU.....	92
Figure A.1 – Example of FCS generation .....	97
Figure A.2 – Example of FCS syndrome checking on reception.....	97
Figure D.1 – Evaluation DL-subnetwork for transmission of RP_DAT_XX.....	111
Figure D.2 – Evaluation DL-subnetwork for transmission of a free RP_RQ(1/2).....	112
Figure D.3 – Evaluation DL-subnetwork for transmission of the specified RP_RQ1 .....	113
Figure D.4 – Evaluation DL-subnetwork for transmission of RP_MSG_NOACK, first behavior.....	114

Figure D.5 – Evaluation DL-subnetwork for transmission of RP_MSG_NOACK, second behavior .....	115
Figure D.6 – Evaluation DL-subnetwork for transmission of RP_MSG_ACK, first behavior .....	116
Figure D.7 – Evaluation DL-subnetwork for transmission of RP_MSG_ACK, second behavior .....	117
Table 1 – Individual and group address encoding .....	26
Table 2 – DLPDU control-field coding .....	33
Table 3 – Correspondence between name and coding of 8 bits in the control field .....	34
Table 4 – FCS length, polynomial and expected residual .....	35
Table 5 – DL-Timers .....	41
Table 6 – Bus arbitrator state transition table .....	84
Table 7 – Bridge object description .....	87
Table 8 – Channel object description .....	88
Table 9 – Segment directory object description .....	89
Table 10 – Network directory object description .....	89
Table 11 – Service primitives by type .....	93
Table 12 – Conformance classes .....	96

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**INDUSTRIAL COMMUNICATION NETWORKS –  
FIELDBUS SPECIFICATIONS –****Part 4-7: Data-link layer protocol specification – Type 7 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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.

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 IEC 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

International Standard IEC 61158-4-7 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition and its companion parts of the IEC 61158-4 subseries cancel and replace IEC 61158-4:2003. This edition of this part constitutes an editorial revision.

This edition of IEC 61158-4 includes the following significant changes from the previous edition:

- a) deletion of the former Type 6 fieldbus, and the placeholder for a Type 5 fieldbus data link layer, for lack of market relevance;
- b) addition of new types of fieldbuses;

c) division of this part into multiple parts numbered -4-1, -4-2, ..., -4-19.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/474/FDIS	65C/485/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

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

## INTRODUCTION

This 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 4-7: Data-link layer protocol specification – Type 7 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, according to a pre-established schedule, 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 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 part of 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 document. 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), *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-7, *Industrial communication networks – Fieldbus specifications – Part 3-7: Data link service definition – Type 7 elements*

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*