



IEC 61158-4-16

Edition 1.0 2007-12

# INTERNATIONAL STANDARD

---

**Industrial communication networks – Fieldbus specifications –  
Part 4-16: Data-link layer protocol specification – Type 16 elements**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE **XE**

---

ICS 35.100.20; 25.040.40

ISBN 2-8318-9441-7

## 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.....	10
2 Normative references .....	11
3 Terms, definitions, symbols, abbreviations and conventions .....	11
3.1 Reference model terms and definitions.....	11
3.2 Service convention terms and definitions.....	13
3.3 Other terms and definitions .....	14
3.4 Abbreviations .....	18
3.5 Symbols .....	20
3.6 DLPDU IDN concept.....	21
4 DL-protocol overview.....	21
5 Basic DLPDU structure.....	22
5.1 Overview .....	22
5.2 MST DLPDU.....	23
5.3 MDT DLPDU .....	24
5.4 AT DLPDU .....	31
6 Network management methods.....	38
6.1 Overview .....	38
6.2 Enable and disable cyclic communication.....	38
6.3 File transfer.....	43
6.4 Status procedures .....	44
7 Data transmission methods .....	44
7.1 Overview .....	44
7.2 SVC .....	44
7.3 RTC .....	56
8 DL management .....	57
8.1 Overview .....	57
8.2 Access to PhL .....	57
9 Error handling and monitoring .....	62
9.1 Invalid telegrams.....	62
9.2 Response to MDT and AT telegram failure .....	63
9.3 Reaction to handshake timeout .....	64
9.4 Service channel error messages.....	65
9.5 Reaction to error messages in the service channel.....	67
9.6 Error counters in the master and the slave .....	67
9.7 Error effects on communication phases .....	69
9.8 Monitoring in the master .....	69
9.9 Monitoring in the slave .....	70
Annex A (normative) – IDN – Identification numbers .....	72
A.1 IDN specification .....	72

A.2 Identification numbers in numerical orders .....	79
A.3 Detailed specification of communication-related IDNs .....	80
Bibliography.....	108
Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses .....	16
Figure 2 – Master service INFO field k .....	26
Figure 3 – Structure of the master data telegram .....	27
Figure 4 – Device service INFO field m .....	32
Figure 5 – Timing of U/D bits in CP5 .....	36
Figure 6 – Timing of U/D bits in CP6 .....	38
Figure 7 – Switching to CP0.....	43
Figure 8 – Phase transitions .....	43
Figure 9 – Service channel handling diagram.....	46
Figure 10 – Communication step proceeding diagram .....	48
Figure 11 – State machine for procedure command execution .....	53
Figure 12 – Interaction of procedure command control and acknowledgement .....	54
Figure 13 – Procedure command execution without interrupt .....	55
Figure 14 – Procedure command execution with interrupt .....	55
Figure 15 – Procedure command execution with error message .....	56
Figure 16 – Access to the transfer medium .....	58
Figure 17 – Timing diagram for CP0 .....	59
Figure 18 – Telegram transmission starting times of CP1 and CP2 .....	59
Figure 19 – Timing diagram for cyclic operation .....	60
Figure 20 – Telegram transmission times in CP5 .....	61
Figure 21 – Telegram transmission times in CP6 .....	61
Figure 22 – Required time intervals between telegrams .....	62
Figure A.1 – General IDN structure .....	73
Figure A.2 – IDN name structure.....	73
Figure A.3 – IDN data unit structure.....	76
Figure A.4 – Structure of IDN operation data with variable length .....	77
Figure A.5 – Example of the structure of an IDN-list.....	78
Figure A.6 – SLKN example .....	95
Table 1 – General telegram structure.....	22
Table 2 – BOF field.....	22
Table 3 – Device address field.....	23
Table 4 – FCS field .....	23
Table 5 – Master synchronization telegram structure .....	23
Table 6 – MST INFO field .....	24
Table 7 – Data fields of the master data telegram .....	24
Table 8 – Master real-time data (for each device) .....	25
Table 9 – Control word description (DLL).....	25
Table 10 – Structure of the ID request telegram in CP1 .....	26

Table 11 – Structure of MDT in CP5 .....	27
Table 12 – Structure of Data Record in MDT in CP5 .....	28
Table 13 – File block size in CP5 .....	28
Table 14 – U/D control word in CP5 .....	28
Table 15 – Structure of MDT in CP6 .....	29
Table 16 – Structure of data record field in MDT in CP6 .....	30
Table 17 – U/D control word in CP6 .....	30
Table 18 – Data field of the acknowledge telegram .....	31
Table 19– AT real-time data (for each device).....	31
Table 20 – Status word description (DLL) .....	32
Table 21 – Structure of the ID acknowledge telegram in CP1 .....	33
Table 22 – Structure of the operation data of device m in acknowledge telegram.....	33
Table 23 – Structure of AT in CP5 .....	34
Table 24 – Structure of data record in AT in CP5 .....	34
Table 25 – U/D status word in CP5 .....	34
Table 26 – File block index in CP5.....	35
Table 27 – Structure of AT in CP6 .....	36
Table 28 – Structure of data record in AT in CP6 .....	36
Table 29 – File block size in CP6 .....	36
Table 30 – U/D status word in CP6 .....	37
Table 31 – File block index in CP6.....	38
Table 32 – List of IDNs element and step numbers .....	47
Table 33 – Condition for modifying data block elements.....	47
Table 34 – SVC channel evaluation .....	49
Table 35 – IDN for list transfer .....	50
Table 36 – Procedure command control.....	50
Table 37 – Procedure command acknowledgment (data status).....	51
Table 38 – Allowed jitter .....	58
Table 39 – Jitter in $t_2$ .....	60
Table 40 – Jitter in $t_1$ .....	61
Table 41 – Loss or failure of master synchronization telegram (MST) .....	63
Table 42 – Failure of master data telegrams (MDT) .....	64
Table 43 – Failure of acknowledge telegrams (AT).....	64
Table 44 – Reaction to handshake timeout .....	64
Table 45 – Error messages.....	65
Table 46 – Reaction to error message .....	67
Table 47 – States of error counters 1 in the master for MST and AT failures.....	67
Table 48 – States of error counter 1 in the devices for MST-failures in CP3 and CP4 .....	67
Table 49 – States of error counter 1 in the devices for MDT-failures in CP4.....	67
Table 50 – States of error counters 2 in the master for AT-failures.....	68
Table 51 – States of error counter 2 in the devices for MST-failures .....	68
Table 52 – States of error counter 2 in the devices for MDT-failures .....	69
Table 53 – Master monitoring.....	70

Table 54 – Slave monitoring .....	71
Table A.1 – Data block structure .....	72
Table A.2 – IDN structure .....	73
Table A.3 – Element 3 of IDNs .....	74
Table A.4 – Valid combinations of the display formats .....	75
Table A.5 – Data status structure .....	79
Table A.6 – Communication related IDN list that are relevant for Type 16 .....	79
Table A.7 – Attributes for IDN S-0-0001 .....	81
Table A.8 – Attributes for IDN S-0-0002 .....	81
Table A.9 – Attributes for IDN S-0-0003 .....	82
Table A.10 – Attributes for IDN S-0-0004 .....	82
Table A.11 – Attributes for IDN S-0-0006 .....	83
Table A.12 – Attributes for IDN S-0-0008 .....	83
Table A.13 – Attributes for IDN S-0-0009 .....	84
Table A.14 – Attributes for IDN S-0-0010 .....	84
Table A.15 – Attributes for IDN S-0-0011 .....	85
Table A.16 – Structure of C1D .....	85
Table A.17 – Attributes for IDN S-0-0014 .....	86
Table A.18 – Structure of interface status .....	86
Table A.19 – Attributes for IDN S-0-0015 .....	87
Table A.20 – Structure of telegram type parameter .....	88
Table A.21 – Attributes for IDN S-0-0016 .....	88
Table A.22 – Attributes for IDN S-0-0018 .....	89
Table A.23 – Attributes for IDN S-0-0019 .....	89
Table A.24 – Attributes for IDN S-0-0021 .....	90
Table A.25 – Attributes for IDN S-0-0022 .....	90
Table A.26 – Attributes for IDN S-0-0024 .....	91
Table A.27 – Attributes for IDN S-0-0028 .....	91
Table A.28 – Attributes for IDN S-0-0029 .....	92
Table A.29 – Attributes for IDN S-0-0087 .....	92
Table A.30 – Attributes for IDN S-0-0088 .....	93
Table A.31 – Attributes for IDN S-0-0089 .....	93
Table A.32 – Attributes for IDN S-0-0090 .....	94
Table A.33 – Attributes for IDN S-0-0096 .....	94
Table A.34 – Structure of SLKN .....	95
Table A.35 – Attributes for IDN S-0-0097 .....	95
Table A.36 – Structure of Mask C2D .....	96
Table A.37 – Attributes for IDN S-0-0098 .....	96
Table A.38 – Structure of Mask C3D .....	96
Table A.39 – Attributes for IDN S-0-0127 .....	97
Table A.40 – Attributes for IDN S-0-0128 .....	97
Table A.41 – Attributes for IDN S-0-0134 .....	98
Table A.42 – Attributes for IDN S-0-0135 .....	98

Table A.43 – Attributes for IDN S-0-0143 .....	99
Table A.44 – Structure of Type 16 version .....	99
Table A.45 – Attributes for IDN S-0-0185 .....	100
Table A.46 – Attributes for IDN S-0-0186 .....	100
Table A.47 – Attributes for IDN S-0-0187 .....	101
Table A.48 – Attributes for IDN S-0-0188 .....	101
Table A.49 – Attributes for IDN S-0-0301 .....	102
Table A.50 – Attributes for IDN S-0-0303 .....	102
Table A.51 – Attributes for IDN S-0-0305 .....	103
Table A.52 – Attributes for IDN S-0-0307 .....	103
Table A.53 – Attributes for IDN S-0-0394 .....	104
Table A.54 – Attributes for IDN S-0-0395 .....	104
Table A.55 – Attributes for IDN S-0-0396 .....	105
Table A.56 – Attributes for IDN S-0-0397 .....	105
Table A.57 – Attributes for IDN S-0-0413 .....	106
Table A.58 – Attributes for IDN S-0-0414 .....	106
Table A.59 – Attributes for IDN S-0-0415 .....	107
Table A.60 – Attributes for IDN S-0-0416 .....	107

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**INDUSTRIAL COMMUNICATION NETWORKS –  
FIELDBUS SPECIFICATIONS –****Part 4-16: Data-link layer protocol specification – Type 16 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 61158-4-16 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 a technical addition. This publication, together with its companion parts for Type 16, also partially replaces IEC 61491:2002 which is at present being revised. IEC 61491 will be issued as a technical report.

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 4-16: Data-link layer protocol specification – Type 16 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 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), *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-16, *Industrial communication networks – Fieldbus specifications - Part 3-16: Data-link layer service definition – Type 16 elements*

IEC 61800-7-20x (all subparts), *Adjustable speed electrical power drive systems – Part 7-20x: Generic interface and use of profiles for power drive systems – Profile type x specification<sup>1</sup>*

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

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Part 3: 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/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

ITU X.25, *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*

---

<sup>1</sup> At present, these subparts are IEC 61800-7-201, 7-202, 7-203 and 7-204.