



IEC 61158-4-11

Edition 1.0 2007-12

INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 4-11: Data-link layer protocol specification – Type 11 elements**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XC**

ICS 35.100.20; 25.040.40

ISBN 2-8318-9436-0

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
1.1 General.....	8
1.2 Specifications.....	8
1.3 Procedures.....	8
1.4 Applicability.....	9
1.5 Conformance.....	9
2 Normative references.....	9
3 Terms, definitions, symbols and abbreviations.....	9
3.1 Reference model terms and definitions.....	9
3.2 Service convention terms and definitions.....	11
3.3 Terms and definitions.....	12
3.4 Symbols and abbreviations.....	16
4 Overview of the DL-protocol.....	17
4.1 General.....	17
4.2 Overview of the medium access control.....	17
4.3 Service assumed from the PhL.....	18
4.4 DLL architecture.....	19
4.5 Access control machine and schedule support functions.....	21
4.6 Local parameters, variable, counters, timers.....	22
5 General structure and encoding of PhIDUs and DLPDU and related elements of procedure.....	32
5.1 Overview.....	32
5.2 PhIDU structure and encoding.....	32
5.3 Common MAC frame structure, encoding and elements of procedure.....	33
5.4 Elements of the MAC frame.....	34
5.5 Order of bit transmission.....	38
5.6 Invalid DLPDU.....	38
6 DLPDU-specific structure, encoding and elements of procedure.....	39
6.1 General.....	39
6.2 Synchronization DLPDU (SYN).....	39
6.3 Transmission complete DLPDU (CMP).....	44
6.4 Transmission request DLPDU (REQ).....	45
6.5 Claim DLPDU (CLM).....	46
6.6 Command (COM) DLPDU.....	47
6.7 Cyclic data and cyclic data with transmission complete DLPDU (DT) and (DT-CMP).....	48
6.8 RAS DLPDU (RAS).....	49
7 DLE elements of procedure.....	50
7.1 Overall structure.....	50
7.2 Initialization.....	51
7.3 Cyclic transmission TX/RX control (CTRC).....	52
7.4 Sporadic TX/RX control (STRC).....	56
7.5 Access control machine (ACM).....	59
7.6 Redundancy medium control (RMC).....	67
7.7 Serializer and deserializer.....	74

7.8 DLL management protocol.....	74
Bibliography.....	80
Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses	13
Figure 2 – Basic principle of medium access control	18
Figure 3 – Interaction of PhS primitives to DLE	19
Figure 4 – Data-link layer internal architecture	21
Figure 5 – Common MAC frame format for DLPDUs.....	33
Figure 6 – Sporadic DLPDU format.....	34
Figure 7 – Structure of FC field.....	5
Figure 8 – Structure of SYN DLPDU.....	39
Figure 9 – Structure of CMP DLPDU	44
Figure 10 – Structure of the REQ DLPDU	45
Figure 11 – Structure of CLM DLPDU	46
Figure 12 – Structure of COM DLPDU.....	47
Figure 13 – Structure of DT DLPDU	48
Figure 14 – Structure of RAS DLPDU.....	49
Table 18 – RAS parameter : 3rd and 4th octets.....	49
Figure 15 – Overall structure of DLL	51
Figure 16 – DLE state transition.....	52
Figure 17 – State transition diagram of CTRC.....	54
Figure 18 – State transition diagram of STRC.....	57
Table 29 – Primitives exchanged between ACM and RMC	60
Figure 19 – State transition diagram of ACM.....	62
Figure 20 – State transition diagram of RMC sending and send arbitration	69
Figure 21 – State transition diagram of RMC receiving.....	72
Figure 22 – State transition diagram of DLM.....	77
Table 1 – Data-link layer components.....	20
Table 2 – Mandatory DLE-variables and permissible values.....	22
Table 3 – Observable variables and their value ranges.....	23
Table 4 – F-type: DLPDU type.....	35
Table 5 – FC3 length, polynomials and constants	36
Table 6 – PN -parameter: 3rd octet	40
Table 7 – CW -parameters: 4th octet.....	40
Table 8 – PM parameter.....	40
Table 9 – RMSEL parameter	41
Table 10 – ST-parameter: 5th octet.....	41
Table 11 – Th-parameter: 6th, 7th and 8th octets.....	41
Table 12 – Tm-parameter: 9th and 10th octets	42
Table 13 – Ts-parameter: 11th and 12th octets.....	42
Table 14 – TI-parameter: 13th and 14th octets	42
Table 15 – LL parameters: 15th to 46th octets	43

Table 16 – CLM parameter: 4th octet	46
Table 17 – DT parameter: 3rd and 4th octets	48
Table 18 – RAS parameter : 3rd and 4th octets.....	49
Table 19 – Primitives exchanged between DLS-user and CTRC.....	53
Table 20 – Primitives exchanged between CTRC and ACM.....	53
Table 21 – Parameters used with primitives exchanged between DLS-user and CTRC	54
Table 22 – CTRC state table.....	55
Table 23 – CTRC functions table	56
Table 24 – Primitives exchanged between DLS-user and STRC.....	56
Table 25 – Primitives exchanged between STRC and ACM.....	57
Table 26 – Parameters used with primitives exchanged between DLS-user and STRC	57
Table 27 – STRC state table.....	58
Table 28 – STRC functions table	59
Table 29 – Primitives exchanged between ACM and RMC	60
Table 30 – Parameters used with primitives exchanged between ACM and RMC	60
Table 31 – Primitives exchanged between ACM and CTRC.....	60
Table 32 – Parameters used with primitives exchanged between ACM and CTRC	60
Table 33 – Primitives exchanged between ACM and STRC.....	61
Table 34 – Parameters used with primitives exchanged between ACM and STRC.....	61
Table 35 – ACM state table.....	63
Table 36 – ACM function table.....	67
Table 37 – Primitives exchanged between ACM and RMC	68
Table 38 – Primitives exchanged between RMC and derializer / deserializer.....	68
Table 39 – Primitives exchanged between RMC and Ph-layer.....	68
Table 40 – Parameters between RMC and ACM	69
Table 41 – Parameters between RMC and Ph-layer.....	69
Table 42 – State table of RMC sending.....	70
Table 43 – State table of RMC send arbitration.....	71
Table 44 – State table for RMC receiving.....	72
Table 45 – RMC function table.....	74
Table 46 – Primitives exchanged between DLMS-user and DLM	75
Table 47 – Parameters used with primitives exchanged between DL-user and DLM.....	75
Table 48 – Event-related state change variables.....	76
Table 49 – DLM state table.....	77
Table 50 – DLM function table	79

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
 FIELDBUS SPECIFICATIONS –**
Part 4-11: Data-link layer protocol specification – Type 11 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 far 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.

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.

IEC draws 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 11 and possibly other Types:

US 5,930,121	[To]	Network system using token-passing bus with multiple priority levels
US 5,414,813	[To]	Direct transfer from a receive buffer to a host in a token-passing type network data transmission system
US 6,711,131	[To]	Data transmitting apparatus, network interface apparatus, and data transmitting system

IEC takes 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:

[To] Toshiba Corporation
 1-1, Shibaura 1-Chome
 Minato-ku Tokyo 105-8001, Japan
 Attention: Intellectual Property Rights Section.

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 shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61158-4-11 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 part and its Type 11 companion parts also cancel and replace IEC/PAS 62406, published in 2005.

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/475/R/D

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 for 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 4-11: Data-link layer protocol specification – Type 11 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) procedures for giving communication opportunities to all participating DL-entities, sequentially and in a cyclic manner for deterministic and synchronized transfer at cyclic intervals up to one millisecond;
- c) procedures for giving communication opportunities available for time-critical data transmission together with non-time-critical data transmission without prejudice to the time-critical data transmission;
- d) procedures for giving cyclic and acyclic communication opportunities for time-critical data transmission with prioritized access;
- e) procedures for giving communication opportunities based on standard ISO/ IEC 8802-3 medium access control, with provisions for nodes to be added or removed during normal operation;
- f) 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 61158-3-11, *Industrial communication networks – Fieldbus specifications – Part 3-11: Data-link layer service definition – Type 11 elements*

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

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

ISO/IEC 8802-3:2000, *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*

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