

INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 3-12: Data-link layer service definition – Type 12 elements**





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INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 3-12: Data-link layer service definition – Type 12 elements**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 3-12: Data-link layer service definition –
Type 12 elements**

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

International Standard IEC 61158-3-12 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:

- technical corrections in the communication services;
- editorial improvements for clarification.

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

FDIS	Report on voting
65C/945/FDIS	65C/954/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 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- withdrawn,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.

Throughout the set of fieldbus standards, the term “service” refers to the abstract capability provided by one layer of the OSI Basic Reference Model to the layer immediately above. Thus, the data-link layer service defined in this standard is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-12: Data-link layer service definition – Type 12 elements

1 Scope

1.1 General

This part of IEC 61158 provides common elements for basic time-critical messaging communications between devices in an automation environment. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This International standard defines in an abstract way the externally visible service provided by the Type 12 fieldbus data-link layer in terms of

- a) the primitive actions and events of the service;
- b) the parameters associated with each primitive action and event, and the form which they take;
- c) the interrelationship between these actions and events, and their valid sequences.

The purpose of this document is to define the services provided to

- the Type 12 fieldbus application layer at the boundary between the application and data-link layers of the fieldbus reference model;
- systems management at the boundary between the data-link layer and systems management of the fieldbus reference model.

1.2 Specifications

The principal objective of this document is to specify the characteristics of conceptual data-link layer services suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of data-link protocols for time-critical communications. A secondary objective is to provide migration paths from previously-existing industrial communications protocols.

This specification may be used as the basis for formal DL-Programming-Interfaces. Nevertheless, it is not a formal programming interface, and any such interface will need to address implementation issues not covered by this specification, including

- a) the sizes and octet ordering of various multi-octet service parameters, and
- b) the correlation of paired request and confirm, or indication and response, primitives.

1.3 Conformance

This document does not specify individual implementations or products, nor does it constrain the implementations of data-link entities within industrial automation systems.

There is no conformance of equipment to this data-link layer service definition standard. Instead, conformance is achieved through implementation of the corresponding data-link protocol that fulfils the Type 12 data-link layer services defined in this document.

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.

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/IEEE 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

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

IEEE Std 802.1D, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*; available at <http://www.ieee.org> [viewed 2018-09-11]

3 Terms, definitions, symbols, abbreviations and conventions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Reference model terms and definitions

This document is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3 and makes use of the following terms defined therein.

3.1.1	DL-address	[7498-3]
3.1.2	DL-connectionless-mode transmission	[7498-1]
3.1.3	correspondent (N)-entities	[7498-1]
	correspondent DL-entities (N=2)	
	correspondent Ph-entities (N=1)	
3.1.4	DL-duplex-transmission	[7498-1]
3.1.5	(N)-entity	[7498-1]
	DL-entity (N=2)	
	Ph-entity (N=1)	
3.1.6	(N)-layer	[7498-1]
	DL-layer (N=2)	
	Ph-layer (N=1)	
3.1.7	layer-management	[7498-1]
3.1.8	peer-entities	[7498-1]
3.1.9	primitive name	[7498-3]
3.1.10	DL-protocol	[7498-1]
3.1.11	DL-protocol-data-unit	[7498-1]
3.1.12	DL-relay	[7498-1]
3.1.13	reset	[7498-1]
3.1.14	responding-DL-address	[7498-3]
3.1.15	routing	[7498-1]
3.1.16	segmenting	[7498-1]
3.1.17	(N)-service	[7498-1]
	DL-service (N=2)	
	Ph-service (N=1)	
3.1.18	(N)-service-access-point	[7498-1]
	DL-service-access-point (N=2)	
	Ph-service-access-point (N=1)	
3.1.19	DL-service-data-unit	[7498-1]
3.1.20	DL-simplex-transmission	[7498-1]
3.1.21	DL-subsystem	[7498-1]
3.1.22	systems-management	[7498-1]
3.1.23	DLS-user	[7498-1]
3.1.24	DLS-user-data	[7498-1]

3.2 Service convention terms and definitions

This document also makes use of the following terms defined in ISO/IEC 10731 as they apply to the data-link layer:

- 3.2.1 acceptor**
- 3.2.2 asymmetrical service**
- 3.2.3 confirm (primitive);
requestor.deliver (primitive)**
- 3.2.4 deliver (primitive)**
- 3.2.5 DL-service-primitive;
primitive**
- 3.2.6 DL-service-provider**
- 3.2.7 DL-service-user**
- 3.2.8 DL-user-optional-facility**
- 3.2.9 indication (primitive);
acceptor.deliver (primitive)**
- 3.2.10 request (primitive);
requestor.submit (primitive)**
- 3.2.11 requestor**
- 3.2.12 response (primitive);
acceptor.submit (primitive)**
- 3.2.13 submit (primitive)**
- 3.2.14 symmetrical service**

3.3 Data-link service terms and definitions

3.3.1 application

function or data structure for which data is consumed or produced

3.3.2 application objects

multiple object classes that manage and provide a run time exchange of messages across the network and within the network device

3.3.3 basic slave

slave device that supports only physical addressing of data

3.3.4 bit

unit of information consisting of a 1 or a 0

Note 1 to entry: This is the smallest data unit that can be transmitted.

3.3.5 client

<object> object which uses the services of another (server) object to perform a task

3.3.6 client

<message> initiator of a message to which a server reacts

3.3.7**connection**

logical binding between two application objects within the same or different devices

3.3.8**cyclic**

events which repeat in a regular and repetitive manner

3.3.9**cyclic redundancy check****CRC**

residual value computed from an array of data and used as a representative signature for the array

3.3.10**data**

generic term used to refer to any information carried over a fieldbus

3.3.11**data consistency**

means for coherent transmission and access of the input- or output-data object between and within client and server

3.3.12**device**

physical entity connected to the fieldbus composed of at least one communication element (the network element) and which may have a control element and/or a final element (transducer, actuator, etc.)

3.3.13**distributed clocks**

method to synchronize slaves and maintain a global time base

3.3.14**DL-segment****link****local link**

single DL-subnetwork in which any of the connected DLEs may communicate directly, without any intervening DL-relaying, whenever all of those DLEs that are participating in an instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication

3.3.15**error**

discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.3.16**event**

instance of a change of conditions

3.3.17**fieldbus memory management unit**

function that establishes one or several correspondences between logical addresses and physical memory

3.3.18**fieldbus memory management unit entity**

single element of the fieldbus memory management unit: one correspondence between a coherent logical address space and a coherent physical memory location

3.3.19**frame**

denigrated synonym for DLPDU

3.3.20**full slave**

slave device that supports both physical and logical addressing of data

3.3.21**interface**

shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

3.3.22**master**

device that controls the data transfer on the network and initiates the media access of the slaves by sending messages and that constitutes the interface to the control system

3.3.23**mapping**

correspondence between two objects in the way that one object is part of the other object

3.3.24**medium**

cable, optical fibre, or other means by which communication signals are transmitted between two or more points

Note 1 to entry: "media" is used as the plural of medium.

3.3.25**message**

ordered series of octets intended to convey information

Note 1 to entry: Normally used to convey information between peers at the application layer.

3.3.26**network**

set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.3.27**node**

- a) single DL-entity as it appears on one local link
- b) end-point of a link in a network or a point at which two or more links meet

[SOURCE: IEC 61158-2, for option b), with some wording adjustment]

3.3.28**object**

abstract representation of a particular component within a device

Note 1 to entry: An object can be

- a) an abstract representation of the capabilities of a device, composed of any or all of the following components:
 - 1) data (information which changes with time);
 - 2) configuration (parameters for behavior);
 - 3) methods (things that can be done using data and configuration); or
- b) a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have a clearly defined interface and behavior.

3.3.29**process data**

data object containing application objects designated to be transferred cyclically or acyclically for the purpose of processing

3.3.30**receiving DLS-user**

DL-service user that acts as a recipient of DL-user-data

Note 1 to entry: A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.31**sending DLS-user**

DL-service user that acts as a source of DL-user-data

3.3.32**server**

object which provides services to another (client) object

3.3.33**service**

operation or function than an object and/or object class performs upon request from another object and/or object class

3.3.34**slave**

DL-entity accessing the medium only after being initiated by the preceding slave or the master

3.3.35**Sync manager**

collection of control elements to coordinate access to concurrently used objects

3.3.36**Sync manager channel**

single control elements to coordinate access to concurrently used objects

3.3.37**switch**

MAC bridge as defined in IEEE 802.1D

3.4 Symbols and abbreviations

APRD	Auto-increment physical read
APRW	Auto-increment physical read/write

APWR	Auto-increment physical write
ARMW	Auto-increment physical read / multiple write
BRD	Broadcast read
BRW	Broadcast read/write
BWR	Broadcast write
CAN	Controller area network
CoE	CAN application protocol over Type 12 services
CSMA/CD	Carrier sense multiple access with collision detection
DC	Distributed clocks
DL-	Data-link layer (as a prefix)
DLC	DL-connection
DLCEP	DL-connection-end-point
DLE	DL-entity (the local active instance of the data-link layer)
DLL	DL-layer
DLPCI	DL-protocol-control-information
DLPDU	DL-protocol-data-unit
DLM	DL-management
DLME	DL-management entity (the local active instance of DL-management)
DLMS	DL-management service
DLS	DL-service
DLSAP	DL-service-access-point
DLSDU	DL-service-data-unit
E ² PROM	Electrically erasable programmable read only memory
EoE	Ethernet tunneled over Type 12 services
ESC	Type 12 slave controller
FCS	Frame check sequence
FIFO	First-in first-out (queuing method)
FMMU	Fieldbus memory management unit
FoE	File access with Type 12 services
FPRD	Configured address physical read
FPRW	Configured address physical read/write
FPWR	Configured address physical write
FRMW	Configured address physical read/multiple write
HDR	Header
ID	Identifier
IP	Internet protocol
LAN	Local area network
LRD	Logical memory read
LRW	Logical memory read/write
LWR	Logical memory write
MAC	Medium access control
MDI	Media-dependent interface (specified in ISO/IEC/IEEE 8802-3)
MDX	Mailbox data exchange
MII	Media-independent interface (specified in ISO/IEC/IEEE 8802-3)
PDI	Physical device interface (a set of elements that allows access to DL-services from the
PDO	Process data object

Ph-	Physical layer (as a prefix)
PhE	Ph-entity (the local active instance of the physical layer)
PhL	Ph-layer
PHY	Physical layer device (specified in ISO/IEC/IEEE 8802-3)
PNV	Publish network variable
OSI	Open systems interconnection
QoS	Quality of service
RAM	Random access memory
Rx	Receive
SDO	Service data object
SII	Slave information interface
SyncM	Synchronization manager
TCP	Transmission control protocol
Tx	Transmit
UDP	User datagram protocol
WKC	Working counter

3.5 Common conventions

This document uses the descriptive conventions given in ISO/IEC 10731.

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

Service primitives, used to represent service user/service provider interactions (see ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction.

This document uses a tabular format to describe the component parameters of the DLS primitives. The parameters that apply to each group of DLS primitives are set out in tables throughout the remainder of this document. Each table consists of up to six columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the DLS:

- the request primitive's input parameters;
- the indication primitive's output parameters;
- the response primitive's input parameters; and
- the confirm primitive's output parameters.

NOTE The request, indication, response and confirm primitives are also known as requestor.submit, acceptor.deliver, acceptor.submit, and requestor.deliver primitives, respectively (see ISO/IEC 10731).

One parameter (or part of it) is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive and parameter direction specified in the column:

- M** parameter is mandatory for the primitive.
- U** parameter is a User option, and may or may not be provided depending on the dynamic usage of the DLS-user. When not provided, a default value for the parameter is assumed.
- C** parameter is conditional upon other parameters or upon the environment of the DLS-user.
- (blank) parameter is never present.

Some entries are further qualified by items in brackets. These may be a parameter-specific constraint:

- (=) indicates that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table.

In any particular interface, not all parameters need be explicitly stated. Some may be implicitly associated with the primitive.

In the diagrams which illustrate these interfaces, dashed lines indicate cause-and-effect or time-sequence relationships, and wavy lines indicate that events are roughly contemporaneous.

4 Data-link layer services and concepts

4.1 Operating principle

This document describes a real-time Ethernet technology that aims to maximize the utilization of the full duplex Ethernet bandwidth. Medium access control employs the master/slave principle, where the master node (typically the control system) sends the Ethernet frames to the slave nodes, which extract data from and insert data into these frames.

From an Ethernet point of view, a Type 12 segment is a single Ethernet device which receives and sends ISO/IEC/IEEE 8802-3 Ethernet frames. However, this Ethernet device is not limited to a single Ethernet controller with downstream microprocessor, but may consist of a large number of Type 12 slave devices. These process the incoming Ethernet frames while they are in transit within the device, reading data from the Ethernet frame and/or inserting their own data into the frame before transferring the frame to the next slave device. The last slave device within the segment sends the fully processed Ethernet frame back in the reverse direction through the chain of devices, returning the collected information through the first slave device to the master, which receives it as an Ethernet response frame.

This procedure utilizes the full duplex capability of Ethernet: both communication directions are operated independently with reading and writing by the slaves on the outbound path and only transmission-to-reception timing measurements on the inbound path as the Ethernet frame retraverses each intermediate slave device.

Full-duplex communication between a master device and a Type 12 segment consisting of one or several slave devices may be established without using a switch.

4.2 Topology

The topology of a communication system is one of the crucial factors for the successful application in automation. The topology has significant influence on the cabling effort, diagnostic features, redundancy options and hot-plug-and-play features.