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Edition 3.0 2023-03

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications – Part 3-2: Data-link layer service definition – Type 2 elements



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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-2: Data-link layer service definition – Type 2 elements

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

IEC 61158-3-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2014 and Amendment 1:2019. This edition constitutes a technical revision.

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

a) update of normative and bibliographic references;
b) use of more inclusive terminology ("master" replaced by "active" or "supervisor");
c) miscellaneous editorial corrections.

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

Draft	Report on voting
65C/1201/FDIS	65C/1242/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A 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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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 document is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-2: Data-link layer service definition – Type 2 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 document defines in an abstract way the externally visible service provided by the Type 2 fieldbus data-link layer in terms of:

- the primitive actions and events of the service;
- the parameters associated with each primitive action and event, and the form which they take; and
- 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 2 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.

Type 2 DL-service provides both a connected and a connectionless subset of those services specified in ISO/IEC 8886.

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 document can 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:

- the sizes and octet ordering of various multi-octet service parameters;
- 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 fulfills the Type 2 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 the IEC 61784-1 series and the IEC 61784-2 series 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 61158-4-2:2023, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 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 8886, *Information technology – Open Systems Interconnection – Data link service definition*

ISO/IEC 10731:1994, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

3 Terms, definitions, symbols, abbreviated terms and conventions

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

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://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**	[ISO/IEC 7498-3]
3.1.2	**DL-address-mapping**	[ISO/IEC 7498-1]
3.1.3	**called-DL-address**	[ISO/IEC 7498-3]
3.1.4	**calling-DL-address**	[ISO/IEC 7498-3]
3.1.5	**centralized multi-end-point-connection**	[ISO/IEC 7498-1]
3.1.6	**DL-connection**	[ISO/IEC 7498-1]
3.1.7	**DL-connection-end-point**	[ISO/IEC 7498-1]
3.1.8	**DL-connection-end-point-identifier**	[ISO/IEC 7498-1]
3.1.9	**DL-connection-mode transmission**	[ISO/IEC 7498-1]
3.1.10	**DL-connectionless-mode transmission**	[ISO/IEC 7498-1]
3.1.11	**correspondent (N)-entities** **correspondent DL-entities (N=2)** **correspondent Ph-entities (N=1)**	[ISO/IEC 7498-1]
3.1.12	**DL-duplex-transmission**	[ISO/IEC 7498-1]
3.1.13	**(N)-entity** **DL-entity (N=2)** **Ph-entity (N=1)**	[ISO/IEC 7498-1]
3.1.14	**DL-facility**	[ISO/IEC 7498-1]
3.1.15	**flow control**	[ISO/IEC 7498-1]
3.1.16	**(N)-layer** **DL-layer (N=2)** **Ph-layer (N=1)**	[ISO/IEC 7498-1]
3.1.17	**layer-management**	[ISO/IEC 7498-1]
3.1.18	**DL-local-view**	[ISO/IEC 7498-3]
3.1.19	**DL-name**	[ISO/IEC 7498-3]
3.1.20	**naming-(addressing)-domain**	[ISO/IEC 7498-3]
3.1.21	**peer-entities**	[ISO/IEC 7498-1]
3.1.22	**primitive name**	[ISO/IEC 7498-3]
3.1.23	**DL-protocol**	[ISO/IEC 7498-1]
3.1.24	**DL-protocol-connection-identifier**	[ISO/IEC 7498-1]
3.1.25	**DL-protocol-data-unit**	[ISO/IEC 7498-1]
3.1.26	**DL-relay**	[ISO/IEC 7498-1]
3.1.27	**reset**	[ISO/IEC 7498-1]
3.1.28	**responding-DL-address**	[ISO/IEC 7498-3]
3.1.29	**routing**	[ISO/IEC 7498-1]
3.1.30	**segmenting**	[ISO/IEC 7498-1]
3.1.31	**(N)-service** **DL-service (N=2)** **Ph-service (N=1)**	[ISO/IEC 7498-1]
3.1.32	**(N)-service-access-point** **DL-service-access-point (N=2)** **Ph-service-access-point (N=1)**	[ISO/IEC 7498-1]
3.1.33	**DL-service-access-point-address**	[ISO/IEC 7498-3]
3.1.34	**DL-service-connection-identifier**	[ISO/IEC 7498-1]
3.1.35	**DL-service-data-unit**	[ISO/IEC 7498-1]
3.1.36	**DL-simplex-transmission**	[ISO/IEC 7498-1]

3.1.37 DL-subsystem [ISO/IEC 7498-1]

3.1.38 systems-management [ISO/IEC 7498-1]

3.1.39 DLS-user-data [ISO/IEC 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-confirmed-facility

3.2.6 DL-facility

3.2.7 DL-local-view

3.2.8 DL-mandatory-facility

3.2.9 DL-non-confirmed-facility

3.2.10 DL-provider-initiated-facility

3.2.11 DL-provider-optional-facility

3.2.12 DL-service-primitive; primitive

3.2.13 DL-service-provider

3.2.14 DL-service-user

3.2.15 DLS-user-optional-facility

3.2.16 indication (primitive); acceptor.deliver (primitive)

3.2.17 multi-peer

3.2.18 request (primitive); requestor.submit (primitive)

3.2.19 requestor

3.2.20 response (primitive); acceptor.submit (primitive)

3.2.21 submit (primitive)

3.2.22 symmetrical service

3.3 Common data-link service terms and definitions

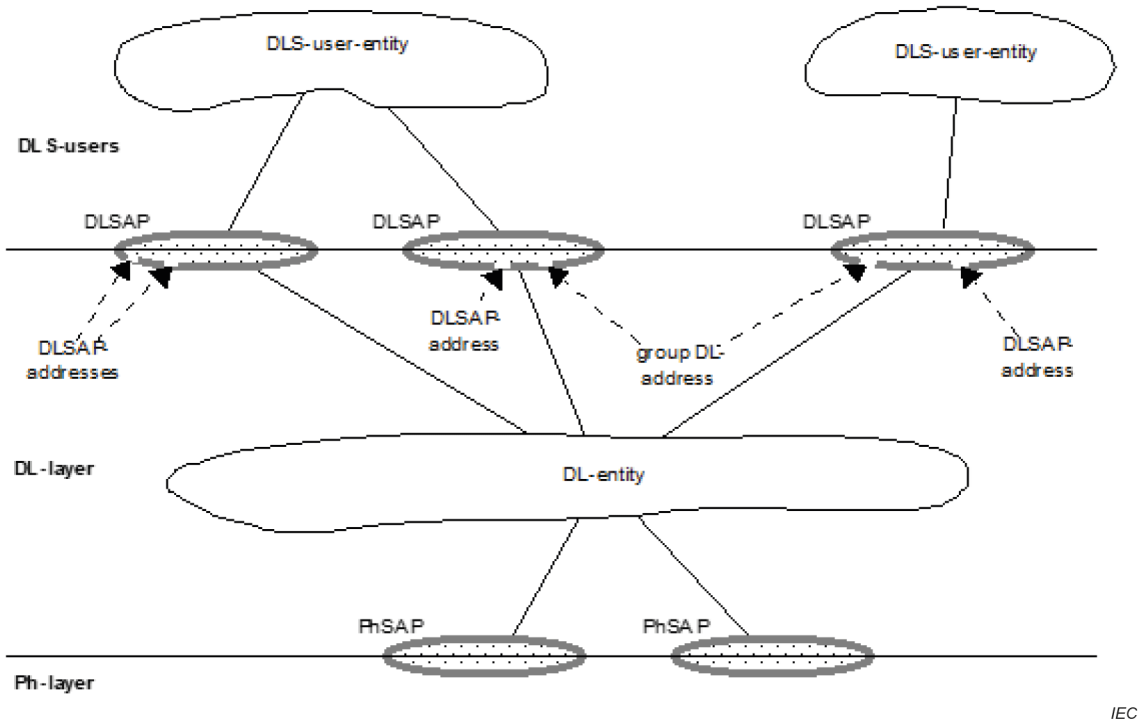
For the purposes of this document, the following terms and definitions apply.

NOTE Many definitions are common to more than one protocol Type; they are not necessarily used by all protocol Types.

3.3.1
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

3.3.2
DLSAP
distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity

Note 1 to entry: This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses (see Figure 1).



NOTE 1 DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

NOTE 2 DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

NOTE 3 A single DL-entity can have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses

3.3.3
DL(SAP)-address
either an individual DLSAP-address, designating a single DLSAP of a single DLS-user, or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user

Note 1 to entry: This terminology is chosen because ISO/IEC 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.4
(individual) DLSAP-address
DL-address that designates only one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

3.3.5
extended link
DL-subnetwork, consisting of the maximal set of links interconnected by DL-relays, sharing a single DL-name (DL-address) space, in which any of the connected DL-entities may communicate, one with another, either directly or with the assistance of one or more of those intervening DL-relay entities

Note 1 to entry: An extended link may be composed of just a single link.

3.3.6
frame
denigrated synonym for DLPDU

3.3.7
group DL-address
DL-address that potentially designates more than one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple group DL-addresses associated with a single DLSAP. A single DL-entity also may have a single group DL-address associated with more than one DLSAP.

3.3.8
node
single DL-entity as it appears on one local link

3.3.9
receiving DLS-user
DL-service user that acts as a recipient of DLS-user-data

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

3.3.10
sending DLS-user
DL-service user that acts as a source of DLS-user-data

3.4 Additional Type 2 data-link specific definitions

3.4.1
application
function or data structure for which data is subscribed or published

3.4.2
behavior
indication of how the object responds to particular events

Note 1 to entry: Its description includes the relationship between attribute values and services.

3.4.3
bridge, DL-router
DL-relay entity which performs selective store-and-forward and routing functions to connect two or more separate DL-subnetworks (links) to form a unified DL-subnetwork (the extended link)

3.4.4
cyclic
term used to describe events which repeat in a regular and repetitive manner

3.4.5
device
physical hardware connection to the link

Note 1 to entry: A device may contain more than one node.

3.4.6
DL-subnetwork
series of nodes connected by PhEs and, where appropriate, DL-routers

3.4.7
DLPDU
Data-link Protocol Data unit

Note 1 to entry: A DLPDU consists of a source MAC ID, zero or more Lpackets, and an FCS, as transmitted or received by an associated PhE.

3.4.8
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.4.9
fixed tag
two octet identifier (tag) which identifies a specific service to be performed by either

a) that receiving node on the local link which has a specified MAC ID, or

b) all receiving nodes on the local link

Note 1 to entry: Identification of the target node(s) is included in the two octet tag.

3.4.10
generic tag
three octet identifier (tag) which identifies a specific piece of application information

3.4.11
guardband
time slot allocated for the transmission of the moderator DLPDU

3.4.12
link
collection of nodes with unique MAC IDs

Note 1 to entry: Ph-segments connected by Ph-repeaters make up a link; links connected by DL-routers make up an extended link (sometimes called a local area network).

3.4.13
Lpacket
well-defined sub-portion of a DLPDU containing (among other things)

c) a fixed tag or a generic tag, and

d) DLS-user data or, when the tag has DL-significance, DL-data

3.4.14
moderator
node with the lowest MAC ID that is responsible for transmitting the moderator DLPDU

3.4.15
moderator DLPDU
DLPDU transmitted by the node with the lowest MAC ID for the purpose of synchronizing the nodes and distributing the link configuration parameters

3.4.16
multipoint DLC
centralized multi-end-point DL-connection offering DL-simplex-transmission between a single distinguished DLS-user, known as the publisher or publishing DLS-user, and a set of peer but undistinguished DLS-users, known collectively as the subscribers or subscribing DLS-users, where the publishing DLS-user can send to the subscribing DLS-users as a group (but not individually)

Note 1 to entry: A multipoint DLC always provides asymmetrical service.

3.4.17
node
logical connection to a local link, requiring a single MAC ID

Note 1 to entry: A single physical device can appear as many nodes on the same local link. For the purposes of this protocol, each node is considered to be a separate DLE.

3.4.18
peer-to-peer DLC
point-to-point DL-connection offering DL-simplex-transmission between a single distinguished sending DLS-user and a single distinguished receiving DLS-user

Note 1 to entry: A peer-to-peer DLC always provides asymmetrical service.

3.4.19
rogue
node that has received a moderator DLPDU that disagrees with the link configuration currently used by this node

3.4.20
scheduled
data transfers that occur in a deterministic and repeatable manner on predefined NUTs.

3.4.21
tMinus
number of NUTs before a new set of link configuration parameters are to be used

3.4.22
tone
instant of time which marks the boundary between two NUTs

3.4.23
unscheduled
data transfers that use the remaining allocated time in the NUT after the scheduled transfers have been completed

3.5 Common symbols and abbreviations

NOTE Many symbols and abbreviations are common to more than one protocol Type; they are not necessarily used by all protocol Types.

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
FIFO	First-in first-out (queuing method)
OSI	Open systems interconnection
Ph-	Physical layer (as a prefix)
PhE	Ph-entity (the local active instance of the physical layer)
PhL	Ph-layer
QoS	Quality of service

3.6 Additional Type 2 symbols and abbreviations

MAC ID	DL-address of a node
MDS	Medium dependent sublayer
NUT	Network (actually, local link) update time

NOTE The use of the term "network" in the preceding definition is maintained for historic reasons, even though the scope involved is only a portion of a single DL-subnetwork.

RMS	root mean square
SMAX	MAC ID of the maximum scheduled node
Tx	Transmit
TUI	Table unique identifier
UCMM	Unconnected message manager
UMAX	MAC ID of maximum unscheduled node
USR	Unscheduled start register

3.7 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 request primitive’s output 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 can be provided or not 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) 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.

b) an indication that some note applies to the entry

(**n**) indicates that the following note n contains additional information pertaining to the parameter and its use.

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

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 Connection-mode and connectionless-mode data-link service

4.1 Overview

4.1.1 Data transfer services

The primary task of a DLE is to determine, in co-operation with other DLEs on the same local link, the granting of permission to transmit on the medium. At its upper interface, the DLL provides services to receive and deliver service data units (DLSDUs) for higher level entities.

NOTE 1 The following access mechanisms are not visible to the higher level entities. They are described here as an aid to understanding the purpose and use of DLS parameters and services that are visible to higher layer entities.

This DLL protocol is based on a fixed repetitive time cycle, called the network update time (NUT). The NUT is maintained in close synchronism among all nodes on the local link. A node is not permitted access to transmit if its configured NUT does not agree with the NUT currently being used on the local link. Different local links within the extended link may have different NUT durations.

Each node contains its own timer synchronized to the local link's NUT. Medium access is determined by local sub-division of the NUT into variable-duration access slots. Access to the medium is in sequential order based on the MAC ID of the node. Specific behaviors have been incorporated into the access protocol allowing a node which temporarily assumes a MAC ID of zero to perform link maintenance. The MAC ID numbers of all nodes on a link are unique. Any