IEC 61158-3-28

Edition 1.0 2023-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Industrial communication networks – Fieldbus specifications – Part 3-28: Data-link layer service definition – Type 28 elements

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 3 28: Définition des services de la couche liaison de données – Éléments de type 28



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Part 3-28: Data-link layer service definition – Type 28 elements

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

Draft	Report on voting
65C/1206/FDIS	65C/1235/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.

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INTRODUCTION

This document 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 3-28: Data-link layer service definition – Type 28 elements

1 Scope

1.1 General

This part of IEC 61158 describes basic packet communication services and models in an automation control industrial field environment. The Type 28 data-link layer provides time-critical and non-time-critical communication services. Time-critical refers to the requirement to complete specified functions between devices in a defined time window in an industrial field environment. Failure to complete specified functions within the time window can lead to failure or harm in industrial production.

This document defines in an abstract way the externally visible service provided by the Type 28 fieldbus data-link layer in terms of

a) function description;

b) primitive actions and events with primitive sequence diagram;

c) the form of externally service interface and related parameters.

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

- the Type 28 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 28 DL-service provides both a connected and a connectionless subset of those services provided by OSI data-link protocols as 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-sensitive communications. A secondary objective is to provide migration paths from previously-existing industrial communications protocols.

This specification 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:

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 fulfills the Type 28 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 61158-2:2023, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-4-28:2023, *Industrial communication networks – Fieldbus specifications – Part 4-28: Data-link layer protocol specification – Type 28 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: Naming and addressing*

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

ISO/IEC 8886*, Information technology – Open Systems Interconnection – Data link service definition*

ISO/IEC/IEEE 8802-3:2021, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

3 Terms, definitions, 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 **[ISO/IEC 7498-1]**
correspondent DL-entities (N=2)
correspondent Ph-entities (N=1)

3.1.12 DL-duplex-transmission **[ISO/IEC 7498-1]**

3.1.13 (N)-entity **[ISO/IEC 7498-1]**
DL-entity (N=2)
Ph-entity (N=1)

3.1.14 DL-facility **[ISO/IEC 7498-1]**

3.1.15 flow control **[ISO/IEC 7498-1]**

3.1.16 (N)-layer **[ISO/IEC 7498-1]**
DL-layer (N=2)
DL-layer (N=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 **[ISO/IEC 7498-1]**
DL-service (N=2)
Ph-service (N=1)

3.1.32 (N)-service-access-point **[ISO/IEC 7498-1]**
DL-service-access-point (N=2)
Ph-service-access-point (N=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

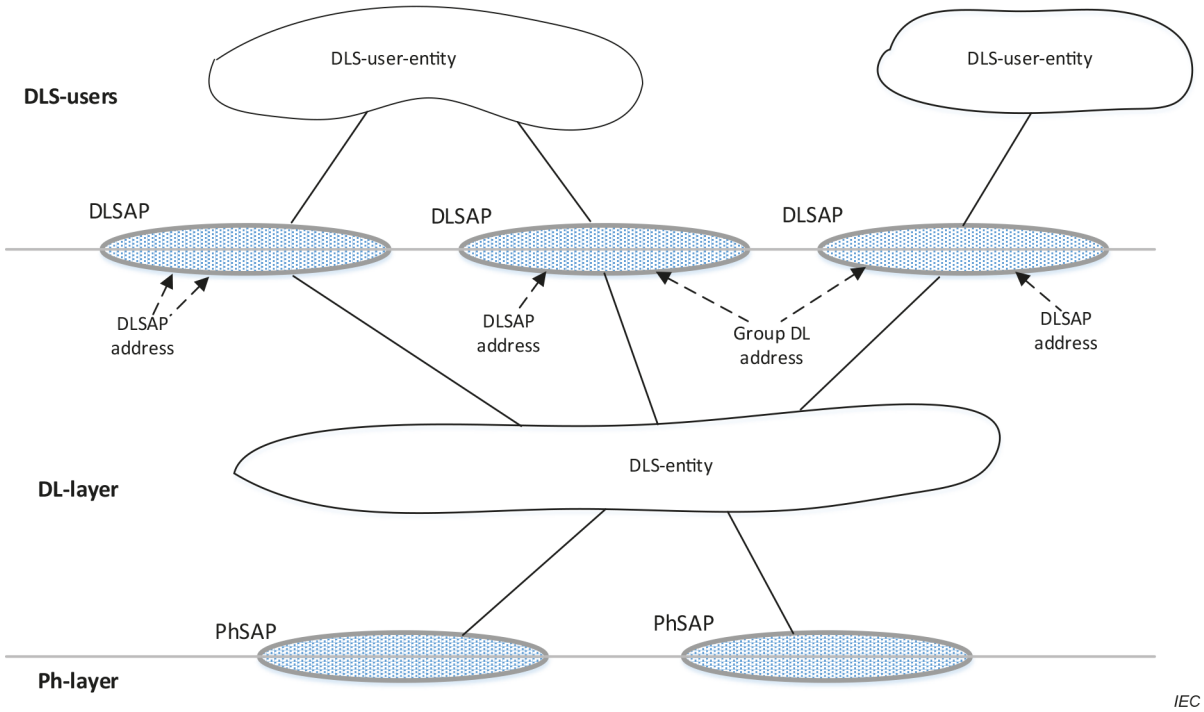
For the purposes of this document, the following terms and definitions apply.

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 2 to entry: DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

Note 3 to entry: DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

Note 4 to entry: A single DL-entity may 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 where each DLSAP is from 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 may also 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 28 data-link specific definitions

3.4.1
control device
device that controls all field devices for logical operations, timing, calculations, etc.

3.4.2
management node
device for allocating and managing Type 28 network physical communication resources

3.4.3
terminal node
device in Type 28 network that communicates based on allocated physical communication resources

3.4.4
clock synchronization
clock calibration of the terminal node device

3.4.5
cyclic time
time of cyclic processing of a device or module

3.4.6
RT data
data sensitive to time deterministic requirements

3.4.7
non-RT data
data insensitive to time deterministic requirements

3.4.8
orthogonal frequency division multiplexing (OFDM) symbol
minimum data transmission unit in time domain that includes all subcarriers in frequency based on OFDM technology

3.4.9
upper sideband
subcarriers with a frequency range from 16,896 MHz to 32,256 MHz on an OFDM symbol

3.4.10
lower sideband
subcarriers with a frequency range from 1,536 MHz to 16,896 MHz on an OFDM symbol

3.4.11
carrier mode
data transfer mode over available resources made up of OFDM symbols

3.4.12
working mode
OFDM operation in a specific transmission mode, RS coding, convolutional coding, and modulation mode

3.4.13
cyclic frame
signal frames which are processed in a regular and repetitive manner

3.4.14
cyclic symbol
OFDM symbols in signal frames which are processed in a regular and repetitive manner

3.4.15
code block
octet sequence of data interaction between the Type 28 physical layer entity and the Type 28 data-link layer entity

3.4.16
data transmission channel
logical channel of the Type 28 data-link layer mapped by the determined physical communication resource for transmitting data-link layer data frames

3.4.17
BITMAP
bitmap format type including Width and Mask_Info information and the length range from 2 octets to 256 octets

Note 1 to entry: See Figure 2.

Note 2 to entry: Width has 1 octet and its value indicates the number of the octets of Mask_Info.

Note 3 to entry: Mask_Info represented by bit. The octet length is Width value and the bit length is Width $\times$ 8.

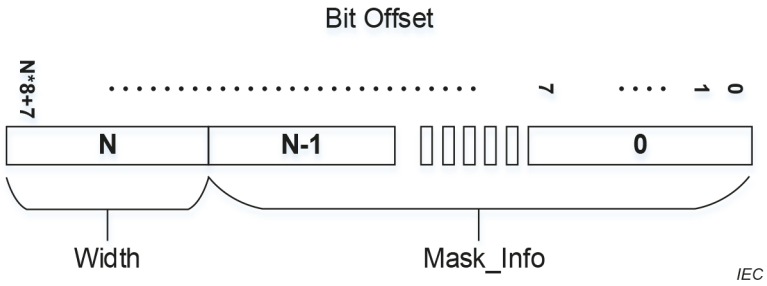


Figure 2 – Bitmap Data type diagram

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 28 symbols and abbreviations

For the purposes of this document, the following abbreviations apply.

AL Application layer
C/S Client/Server
CLMDTA Connection-less Mode Data Transmission with Acknowledge
CLMDTNA Connection-less Mode Data Transmission with No Acknowledge
CLMDTRA Connection-less Mode Data Transmission with Request and Acknowledge
CLMDTRRNA Connection-less Mode Data Transmission with Request and Response but No Acknowledge
CMDTA Connection Mode Data Transmission with Acknowledge
CMDTNA Connection Mode Data Transmission with No Acknowledge

DLCSS Data-link clock synchronization service
DLDE Data-link data entity
DLE Data-link entity
DLMS-user Data-link management service user
DLP Data-link protocol
DLS-user Data-link service user
DTC Data transmission channel
DTS Data transmission service
DLPDU Data-link protocol data unit
MAC Medium access control
MN Management node
NodeID Node identifier
nRT non-Real-Time
OFDM Orthogonal Frequency Division Multiplexing
RT Real-Time
RTA Real-Time acyclic
RTC Real-Time cyclic
TM Transmit mode
TN Terminal node

4 Type 28 Data-link service

4.1 Overview

This document specifies the Type 28 data-link services (DLS) based on the Type 28 physical layer. The Type 28 DLL provides two services between management nodes and terminal nodes:

a) Data transmission service (DTS) based on connection-less mode or connection mode,
b) Data-link Clock synchronization service (DLCSS) with delay measurement and clock interruption.

These services are the typical services required for industrial automation applications.

Table 1 indicates the description of DTS status output value.

Table 1 – DTS status output value

Status name	Status coding	Status description
DTS_SUCCESS	0x00000100	DTS success
DTS_FAILED	0x00000101	DTS failure
DTS_ERR_CONNECT	0x00000102	DTS connection error
DTS_ERR_PARA	0x00000103	DTS parameter error
DTS_ERR_DATA	0x00000104	DTS data error
DTS_ERR_CRC	0x00000105	Transmitted data CRC error
DTS_DLDE_NO_EXIST	0x00000106	DLDE does not exist
DTS_ERR_UNKNOW	0x0000010F	Unknown DTS error

Table 2 indicates the description of DLCSS status return value.