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INTERNATIONAL STANDARD

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Industrial communication networks – Fieldbus specifications – Part 3-24: Data-link layer service definition – Type 24 elements



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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-24: Data-link layer service definition – Type 24 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 61158-3-24 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 second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- addition of a new cyclic transmission mode which called "no time slot type" in Clause 4;
- addition of some parameters for Table 14 and Table 15 in Clause 5.3.2.2;
- in Subclause 5.3.5.2, addition of some parameters for Table 31 and addition of a new Table 32.

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- withdrawn,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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 3-24: Data-link layer service definition – Type 24 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 24 fieldbus data-link layer in terms of

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

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

- the Type 24 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 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, and
- 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 24 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.

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 10731:2005, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO/IEC 19501:2005, *Information technology – Open Distributed Processing – Unified Modeling Language (UML) Version 1.4.2*

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 acknowledgement [ISO/IEC 7498-1]

3.1.2 correspondent (N)-entities
correspondent DL-entities (N=2)
correspondent Ph-entities (N=1) [ISO/IEC 7498-1]

3.1.3 DL-address [ISO/IEC 7498-3]

3.1.4 DL-protocol [ISO/IEC 7498-1]

3.1.5 DL-protocol-data-unit [ISO/IEC 7498-1]

3.1.6 DL-service-data-unit [ISO/IEC 7498-1]

3.1.7 DLS-user [ISO/IEC 7498-1]

3.1.8 DLS-user-data [ISO/IEC 7498-1]

3.1.9 event [ISO/IEC 19501]

3.1.10 layer-management [ISO/IEC 7498-1]

3.1.11 primitive name [ISO/IEC 7498-1]

3.1.12 reset [ISO/IEC 7498-1]

3.1.13 segmenting [ISO/IEC 7498-1]

3.1.14 state [ISO/IEC 19501]

3.1.15 state machine [ISO/IEC 19501]

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

3.1.17 transition [ISO/IEC 19501]

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

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

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

3.1.21 (N)-service-access-point [ISO/IEC 7498-1]
DL-service-access-point (N=2)
Ph-service-access-point (N=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 confirm (primitive)

3.2.2 DL-service-primitive; primitive

3.2.3 DL-service-provider

3.2.4 DL-service-user

3.2.5 indication (primitive)

3.2.6 request (primitive)

3.2.7 requestor

3.2.8 response (primitive)

3.3 Additional Type 24 data-link specific definitions

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

3.3.1
acknowledge
acknowledgement

3.3.2
acyclic transmission
non-periodic exchange of telegrams

3.3.3
C1 master
one of the network device type that initiates and control cyclic transmission

3.3.4
C1 message
message communication that C1 master operates as initiator to exchange messages with slave or C2 master

3.3.5
C2 master
one of the network device types that has the function of monitoring all process data transmitted through the network and initiate message communication

3.3.6
C2 message
message communication that C2 master operates as initiator to exchange messages with slave or C1 master

3.3.7
cyclic transmission
periodic exchange of telegrams

3.3.8
data
generic term used to refer to any information carried over a fieldbus

3.3.9
device
physical entity connected to the fieldbus composed of at least one communication element (the network element) and which has a control element and/or a final element (transducer, actuator, etc.)

3.3.10
event driven mode
transmission mode for the application layer protocol of the communication type 24 in which a transaction of command-response-exchanging arises as user's demands

3.3.11
frame
synonym for DLPDU

3.3.12
initiator
network device that initiates the exchange of process data or message

3.3.13
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

3.3.14
input data
process data sent by the slave and received by the C1 master

3.3.15
message
ordered series of octets intended to convey information

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

3.3.16
monitor slave
slave that has the function of monitoring all process data transmitted through the network

3.3.17
network
set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.3.18
node
- single DL-entity as it appears on one local link
- end-point of a link in a network or a point at which two or more links meet

3.3.19
output data
process data sent by the C1 master and received by the slaves

3.3.20
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.3.21
real-time communication
transfer of data in real-time

3.3.22
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.

3.3.23
responder
network device that responds process data or message after it has been initiated by initiator

3.3.24
send data with acknowledge
data transfer service with acknowledge of reception from corresponding DLE

3.3.25
send data with no-acknowledge
data transfer service without acknowledgement of reception from corresponding DLE

3.3.26
slave
one of the network device types that accesses the medium only after it has been initiated by C1-Maser or C2 Master

3.3.27
sending DLS-user
DL-service user that acts as a source of DL-user-data

3.3.28
station
network device embodying one node

3.3.29
topology
physical network architecture with respect to the connection between the network devices of the communication system

3.3.30
transmission cycle
fixed time period of cyclic transmission

3.3.31
time slot
time period reserved so that initiator and responder can exchange one frame respectively

3.4 Common symbols and abbreviations

DA	Destination address
DL-	Data-link layer (as a prefix)
DLE	DL-entity (the local active instance of the data-link layer)
DLL	DL-layer
DLM	DL-management
DLMS	DL-management service
DLPDU	DL-protocol-data-unit
DLS	DL-service
DLSAP	DL-service-access-point
DLSDU	DL-service-data-unit
FIFO	First-in first-out (queuing method)
ID	Identifier
OSI	Open systems interconnection
PDU	Protocol data unit
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 8802-3)
QoS	Quality of service
RT	Real-time
SAP	Service access point
SDU	Service data unit

3.5 Additional type 24 symbols and abbreviations

ACK	Acknowledge
C1MSG	C1 message
C2MSG	C2 message
I/O	Input and/or output
MSG	Message
Rx	Receive
SDA	Send data with acknowledge
SDN	Send data with no-acknowledge
SM	State machine
T_{cycle}	Transmission cycle
T_{slot}	Time slot
Tx	Transmit

3.6 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 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 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 to 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.

3.7 Additional Type 24 conventions

The following notation, a shortened form of the primitive classes defined in 3.2, is used in the figures.

req request primitive

ind indication primitive

cnf confirm primitive (confirmation)

4 Data-link service and concepts

4.1 Overview

The services provided by this interface are used to utilize the following functions which are required in factory automation system, especially in motion control system.

- Exchange I/O data between the controller and the device.
- Transfer message between the controller and the device, or between the equipment for engineering and them.
- Exactly synchronize the controller with the device.

This interface provides the data exchange service for the above usage. For the data exchange, this service classifies the stations into three types of C1 master, C2 master and slave. The data exchange is executed between one master station (C1 master or C2 master) and N slave stations. There are two types of transmission modes, cyclic transmission and acyclic transmission.

In cyclic transmission mode, transmission is executed cyclically with an accurate period. The transmission cycle is set by the C1 master and slave and C2 master follow it. The transmission cycle has I/O data exchange band to transmit process data and message communication band to transmit message. In I/O data exchange band, C1 master transmits output data to all slaves and the slaves transmit input data to C1 master. This transmission is executed once to each slave, to provide real-time transmission service to DLS-user. In message communication band, transmission is executed only when DLS-user requests.

The DLE in C1 master controls transmission sequence in cyclic transmission mode. The time period for a master station to exchange with one slave station is called time slot. There are two types of communication sequence, one is "fixed-width time slot type" whose time slot width is same for all stations and the other is "configurable time slot type" whose time slot can be defined for each station. All stations shall use the same-data-length frame when the DLE adopts fixed-width time slot type. The width of the time slot is static in both types, and it is set by DL-management during initialization. Once cyclic communication starts, it shall not be changed.