IEC 61158-5-12

Edition 3.0 2014-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial communication networks – Fieldbus specifications – Part 5-12: Application layer service definition – Type 12 elements

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 5-12: Définition des services de la couche application – Éléments de type 12

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colour inside

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CONTENTS

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-12: Application 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 61158-5-12 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision. The main changes with respect to the previous edition are listed below:

- bug fixes;
- editorial improvements;
- support of Explicit Device Identification added in ESM (see 6.2.2)

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

FDIS	Report on voting
65C/763/FDIS	65C/773/RVD

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.

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- withdrawn;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.

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.

The application service is provided by the application protocol making use of the services available from the data-link or other immediately lower layer. This standard defines the application service characteristics that fieldbus applications and/or system management may exploit.

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 application layer service defined in this standard is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-12: Application layer service definition – Type 12 elements

1 Scope

1.1 General

The fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a "window between corresponding application programs."

This standard provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment and material specific to Type 12 fieldbus. 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 standard defines in an abstract way the externally visible service provided by the different Types of the fieldbus Application Layer in terms of

a) an abstract model for defining application resources (objects) capable of being manipulated by users via the use of the FAL service,
b) the primitive actions and events of the service;
c) the parameters associated with each primitive action and event, and the form which they take; and
d) the interrelationship between these actions and events, and their valid sequences.

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

a) the FAL user at the boundary between the user and the Application Layer of the Fieldbus Reference Model, and
b) Systems Management at the boundary between the Application Layer and Systems Management of the Fieldbus Reference Model.

This standard specifies the structure and services of the IEC fieldbus Application Layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) and the OSI Application Layer Structure (ISO/IEC 9545).

FAL services and protocols are provided by FAL application-entities (AE) contained within the application processes. The FAL AE is composed of a set of object-oriented Application Service Elements (ASEs) and a Layer Management Entity (LME) that manages the AE. The ASEs provide communication services that operate on a set of related application process object (APO) classes. One of the FAL ASEs is a management ASE that provides a common set of services for the management of the instances of FAL classes.

Although these services specify, from the perspective of applications, how request and responses are issued and delivered, they do not include a specification of what the requesting and responding applications are to do with them. That is, the behavioral aspects of the applications are not specified; only a definition of what requests and responses they can

send/receive is specified. This permits greater flexibility to the FAL users in standardizing such object behavior. In addition to these services, some supporting services are also defined in this standard to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this standard is to specify the characteristics of conceptual application layer services suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of application layer protocols for time-critical communications.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of services standardized as the various Types of IEC 61158, and the corresponding protocols standardized in subparts of IEC 61158-6.

This specification may be used as the basis for formal Application 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 standard does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems.

There is no conformance of equipment to this application layer service definition standard. Instead, conformance is achieved through implementation of conforming application layer protocols that fulfill any given Type of application layer services as defined in this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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.

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61158-1:2014, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-3-12, *Industrial communication networks – Fieldbus specifications – Part 3-12: Data-link layer service definition – Type 12 elements*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange*

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 8802-3, *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 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 10646, *Information technology – Universal Coded Character Set (UCS)*

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

ISO/IEC/IEEE 60559, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

IEEE 802.1D, *IEEE standard for local and metropolitan area networks – Media access control (MAC) Bridges;* available at <http://www.ieee.org>

IETF RFC 791, *Internet Protocol darpa internet program protocol specification;* available at <http://www.ietf.org>

3 Terms, definitions, symbols, abbreviations and conventions

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

3.1 Reference model terms and definitions

This standard 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 correspondent (N)-entities [ISO/IEC 7498-1]
correspondent AL-entities (N=7)

3.1.2 (N)-entity [ISO/IEC 7498-1]
AL-entity (N=7)

3.1.3 (N)-layer [ISO/IEC 7498-1]
AL-layer (N=7)

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

3.1.5 peer-entities [ISO/IEC 7498-1]

3.1.6 primitive name [ISO/IEC 7498-3]

3.1.7 AL-protocol [ISO/IEC 7498-1]

3.1.8 AL-protocol-data-unit [ISO/IEC 7498-1]

3.1.9 reset [ISO/IEC 7498-1]

3.1.10 routing [ISO/IEC 7498-1]

3.1.11 segmenting [ISO/IEC 7498-1]

3.1.12 (N)-service [ISO/IEC 7498-1]
AL-service (N=7)

3.1.13 AL-service-data-unit [ISO/IEC 7498-1]

3.1.14 AL-simplex-transmission [ISO/IEC 7498-1]

3.1.15 AL-subsystem [ISO/IEC 7498-1]

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

3.1.17 AL-user-data [ISO/IEC 7498-1]

3.2 Service convention terms and definitions

This standard 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 AL-service-primitive;
primitive

3.2.6 AL-service-provider

3.2.7 AL-service-user

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

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

3.2.10 requestor

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

3.2.12 submit (primitive)

3.2.13 symmetrical service

3.3 Application layer and data-link service terms and definitions

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

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

2) initiator of a message to which a server reacts

3.3.6
communication object
component that manage and provide a run time exchange of messages across the network

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

3.3.10
data consistency
means for coherent transmission and access of the input- or output-data object between and within client and server

3.3.11
data type
relation between values and encoding for data of that type

Note 1 to entry: The data type definitions of IEC 61131-3 apply.

3.3.12
data type object
entry in the object dictionary indicating a data type

3.3.13
default gateway
device with at least two interfaces in two different IP subnets acting as router for a subnet.

3.3.14
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.)

3.3.15
device profile
collection of device dependent information and functionality providing consistency between similar devices of the same device

3.3.16
diagnosis information
all data available at the server for maintenance purposes

3.3.17
distributed clocks
method to synchronize slaves and maintain a global time base

3.3.18
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.3.19
error class
general grouping for related error definitions and corresponding error codes

3.3.20
error code
identification of a specific type of error within an error class

3.3.21
event
instance of a change of conditions

3.3.22
fieldbus memory management unit
function that establishes one or several correspondences between logical addresses and physical memory

3.3.23
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

3.3.24
frame
denigrated synonym for DLPDU

3.3.25
full slave
slave device that supports both physical and logical addressing of data

3.3.26
index
address of an object within an application process

3.3.27
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

3.3.28
little endian
method for data representation of numbers greater 8 bit where the least significant octet is transmitted first

3.3.29
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

3.3.30
mapping
correspondence between two objects in that way that one object is part of the other object

3.3.31
mapping parameters
set of values defining the correspondence between application objects and process data objects

3.3.32
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.

3.3.33
message
ordered series of octets intended to convey information

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

3.3.34
network
set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.3.35
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

[Derived from IEC 61158-2]

3.3.36
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. Objects can be 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).

b) a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have clearly defined interface and behavior.

3.3.37
object dictionary
data structure addressed by Index and Sub-index that contains descriptions of data type objects, communication objects and application objects

3.3.38
process data
collection of application objects designated to be transferred cyclically or acyclically for the purpose of measurement and control

3.3.39
process data object
structure described by mapping parameters containing one or several process data entities

3.3.40
segment
collection of one real master with one or more slaves

3.3.41
server
object which provides services to another (client) object

3.3.42
service
operation or function that an object and/or object class performs upon request from another object and/or object class

3.3.43
slave
DL-entity accessing the medium only after being initiated by the preceding slave or the master

3.3.44
sub-index
subaddress of an object within the object dictionary

3.3.45
Sync Manager
collection of control elements to coordinate access to concurrently used objects.

3.3.46
Sync Manager channel
single control elements to coordinate access to concurrently used objects.

3.3.47
switch
MAC bridge as defined in IEEE 802.1D

3.4 Common symbols and abbreviations

AL-	Application layer (as a prefix)
ALE	AL-entity (the local active instance of the application layer)
AL	AL-layer
APDU	AL-protocol-data-unit
ALM	AL-management
ALME	AL-management Entity (the local active instance of AL-management)
ALMS	AL-management service
ALS	AL-service
AR	Application relationship
ASE	Application service element
CAN	Controller Area Network

CiA	CAN in Automation
CoE	CAN appliclication protocol over Type 12 services
CSMA/CD	Carrier sense multiple access with collision detection
DC	Distributed clocks
DL	Data-link-layer
DNS	Domain name system (server for name resolution in IP networks)
E²PROM	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
HDR	Header
ID	Identifier
IETF	Internet engineering task force
IP	Internet protocol
LAN	Local area network
MAC	Medium access control
OD	Object dictionary
OSI	Open systems interconnection
PDI	Physical device internal interface (a set of elements that allows access to DL-services from the AL)
PDO	Process data object
PhL	Ph-layer
QoS	Quality of service
RAM	Random access memory
Rx	Receive
SDO	Service data object
SII	slave information interface
SM	Synchronization manager
SyncM	Synchronization manager
TCP	Transmission control protocol
Tx	Transmit
UDP	User datagram protocol
WKC	Working counter

3.5 Conventions

This standard 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 standard uses a tabular format to describe the component parameters of the service primitives. The parameters that apply to each group of service primitives are set out in tables

throughout the remainder of this standard. Each table consists of up to five columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the service:

– 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 service-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 service-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 Concepts

4.1 Common concepts

All of IEC 61158-1, Clause 9 is incorporated by reference, except as specifically overwritten in 4.2.

4.2 Type specific concepts

4.2.1 Operating principle

This standard and its companion Type 12 standards describe 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 standard ISO/IEC 8802-3 Ethernet frames. However, this Ethernet device