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NORME INTERNATIONALE

Industrial communication networks – Fieldbus specifications – Part 6-16: Application layer protocol specification – Type 16 elements

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 6-16: Spécification de protocole de la couche d'application – Eléments de Type 16

IEC 61158-6-16:2007

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-16: Application layer protocol specification – Type 16 elements

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International Standard IEC 61158-6-16 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition and its companion parts of the IEC 61158-6 subseries cancel and replace IEC 61158-6:2003. This edition of this part constitutes a technical addition.This publication, together with its companion parts for Type 16, also partially replaces IEC 61491:2002 which is at present being revised. IEC 61491 will be issued as a technical report.

This edition of IEC 61158-6 includes the following significant changes from the previous edition:

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a) deletion of the former Type 6 fieldbus for lack of market relevance;

b) addition of new types of fieldbuses;

c) partition of part 6 of the third edition into multiple parts numbered -6-2, -6-3, …

This bilingual version (2013-09) corresponds to the monolingual English version, published in 2007-12. The text of this standard is based on the following documents:

FDIS	Report on voting
65C/476/FDIS	65C/487/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.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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- withdrawn;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.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

The 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 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/TR 61158-1.

The application protocol provides the application service by making use of the services available from the data-link or other immediately lower layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer application entities (AEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

- as a guide for implementors and designers;
- for use in the testing and procurement of equipment;
- as part of an agreement for the admittance of systems into the open systems environment;
- as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-16: Application layer protocol specification – Type 16 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 16 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 define in an abstract way the externally visible service provided by the different Types of fieldbus Application Layer in terms of

- an abstract model for defining application resources (objects) capable of being manipulated by users via the use of the FAL service,
- 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 standard is to define the services provided to

- the FAL user at the boundary between the user and the Application Layer of the Fieldbus Reference Model, and
- 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

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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 syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-16.

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 protocols standardized in subparts of IEC 61158-6.

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 referenced documents are indispensable for the application 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.

IEC 61158-4-16, *Industrial communication networks – Fieldbus specifications – Part 4-16: Data-link layer protocol specification – Type 16 elements*

IEC 61158-5-16, *Industrial communication networks – Fieldbus specifications – Part 5-16: Application layer service definition – Type 16 elements*

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

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model – Part 1: The Basic Model*

ISO/IEC 8822:1994, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824, *Information technology – Open Systems Interconnection – Specification of Abstract Syntax Notation One (ASN.1)*

ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

3 Terms, definitions, abbreviations, symbols and conventions

3.1 Referenced terms and definitions

3.1.1 ISO/IEC 7498-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 7498-1 apply:

a) application entity

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b) application process
c) application protocol data unit
d) application service element
e) application entity invocation
f) application process invocation
g) application transaction
h) real open system
i) transfer syntax

3.1.2 ISO/IEC 8822 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8822 apply:

a) abstract syntax
b) presentation context

3.1.3 ISO/IEC 9545 terms

For the purposes of this document, the following terms as defined in ISO/IEC 9545 apply:

a) application-association
b) application-context
c) application context name
d) application-entity-invocation
e) application-entity-type
f) application-process-invocation
g) application-process-type
h) application-service-element
i) application control service element

3.1.4 ISO/IEC 8824 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8824 apply:

a) object identifier
b) type

3.1.5 Fieldbus Data Link Layer terms

For the purposes of this document, the following terms as defined in IEC 61158-3-3 and IEC 61158-4-3 apply.

a) DL-Time
b) DL-Scheduling-policy
c) DLCEP
d) DLC
e) DL-connection-oriented mode
f) DLPDU
g) DLSDU
h) DLSAP
i) fixed tag
j) generic tag

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k) link

l) MAC ID

m) network address

n) node address

o) node

p) tag

q) scheduled

r) unscheduled

3.2 Additional terms and definitions for Type 16

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

3.2.1
communication cycle
fixed time period between two master synchronization telegrams in which real-time telegrams are transmitted in the RT channel and non real-time telegrams are transmitted in the IP channel

3.2.2
control unit
control device (e.g., a PLC as specified in the IEC 61131 standard family)

3.2.3
control word
two adjacent octets inside the master data telegram containing commands for the addressed device

3.2.4
cycle time
duration of a communication cycle

3.2.5
device
a slave in the communication network, (e.g., a power drive system as defined in the IEC 61800 standard family, I/O stations as defined in the IEC 61131 standard family)

3.2.6
device status
four adjacent octets inside the acknowledge telegram containing status information for each device

3.2.7
identification number (IDN)
designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.2.8
little endian
describes a model of memory organisation which stores the least significant octet at the lowest address, or for transfer, which transfers the lowest order octet first

3.2.9
master data telegram (MDT)
telegram, in which the master inserts its data

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3.2.10
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.2.11
slave
node, which is assigned the right to transmit by the master

3.2.12
status word
two adjacent octets inside the acknowledge telegram containing status information of a device

3.2.13
S-0-nnnn
designation of IDNs

3.3 Additional abbreviations and symbols for Type 16

AT	acknowledge telegram
CC	procedure command control
CC-data	cross communication between participants
IDLE	inter packet gap (see IPG)
IDN	identification number
IPOSYNC	synchronization for PDS interpolator
MDT	master data telegram
RTC	real-time channel
SERCOS	serial real-time communication system interface

3.4 Conventions

3.4.1 General concept

The FAL is defined as a set of object-oriented ASEs. Each ASE is specified in a separate subclause. Each ASE specification is composed of three parts: its class definitions, its services, and its protocol specification. The first two are contained in IEC 61158-5-16. The protocol specification for each of the ASEs is defined in this standard.

The class definitions define the attributes of the classes supported by each ASE. The attributes are accessible from instances of the class using the Management ASE services specified in IEC 61158-5-16. The service specification defines the services that are provided by the ASE.

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

3.4.2 Conventions for Type 16

No specific Type 16 conventions

4 Abstract syntax

The abstract syntax and the transfer syntax are merged into a fixed format that is defined in the the next clause.

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5 Transfer syntax

5.1 Introduction

Type 16 transfer syntax shall be bit-coded, and therefore does not comply with usual data type specifications such as integer32 and alike.

The octet encoding shall use little endian.

5.2 RTC-MDT PDU merged abtract and transfer syntax

The merged abtract and transfer syntax for attributes belonging to this class is described in Table 1.

Table 1 – RTC-MDT PDU attribute format

Attribute	Format	Size (bits)
Control word	2 Octets, bit mapped	16
Reserved field (for future extension)	5 Bits	5
IPOSYNC: Control unit synchronization bit	1 Bit	1
Reserved field (for application profile)	2 Bits	2
Real-time control bit 2	1 Bit	1
Real-time control bit 1	1 Bit	1
Reserved field (for DLL)	6 Bits	6
Configurable part of data record	List of 2, 4 or 8 Octets	
Configured cyclic command value 1	2, 4 or 8 Octets	
Configured cyclic command value 2	2, 4 or 8 Octets	
…	…	
Configured cyclic command value n	2, 4 or 8 Octets	
NOTE n = number of configured cyclic command values. The structure and content of the configurable part of the data record is determined by the configuration list labeled IDN S-0-0024, as specified in IEC 61158-4-16, A.3.17.		

5.3 RTC-AT PDU merged abtract and transfer syntax

The merged abtract and transfer syntax for attributes belonging to this class is described in Table 2.

Table 2 – RTC-AT PDU attribute format

Attribute	Format	Size (bits)
Status word	2 Octets, bit mapped	16
Reserved field (for application profile)	8 Bits	8
Real-time status bit 2	1 Bit	1
Real-time status bit 1	1 Bit	1
Procedure command change bit	1Bit	1
Real-time valid bit	1 Bit	1
Command value processing	1 Bit	1
Reserved field (for DLL)	3 Bits	3
Configurable part of data record	List of 2, 4 or 8 Octets	

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Attribute	Format	Size (bits)
Configured cyclic feedback value 1	2, 4 or 8 Octets	
Configured cyclic feedback value 2	2, 4 or 8 Octets	
…	…	
Configured cyclic feedback value n	2, 4 or 8 Octets	
NOTE n = number of configured cyclic command values. The structure and content of the configurable part of the data record is determined by the configuration list labeled IDN S-0-0016, as specified in IEC 61158-4-16, A.3.12.		

5.4 RTC-MDT PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 3.

Table 3 – RTC-MDT PDU attribute encoding

Attribute	Encoding	
	Bits	Description
Reserved field	15-11	Reserved
IPOSYNC: Control unit synchronization bit	10	Toggle-Bit
Reserved field	9-8	Reserved
Real-time control bit 2	7	Signal indicating specific events
Real-time control bit 1	6	Signal indicating specific events
Reserved field (for DLL)	5-0	Reserved

5.5 RTC-AT PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 4.

Table 4 – RTC-AT PDU attribute encoding

Attribute	Encoding	
	Bits	Description
Reserved field	15-8	reserved
Real-time status bit 2	7	Signal indicating specific event
Real-time status bit 1	6	Signal indicating specific event
Procedure command change bit	5	See Table 2
Real-time valid bit	4	Data has been inserted by a slave device
Command value processing	3	Data are being processed by the slave device
Reserved field (for DLL)	2-0	Reserved

6 Structure of FAL protocol state machines

Interface to FAL services and protocol machines are specified in this subclause.

The behavior of the FAL is described by three integrated protocol machines. Specific sets of these protocol machines are defined for different AREP types. The three protocol machines are: FAL Service Protocol Machine (FSPM), the Application Relationship Protocol Machine (ARPM), and the Data Link Layer Mapping Protocol Machine (DMPM). The relationships

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among these protocol machines as well as primitives exchanged among them are depicted in Figure 1.

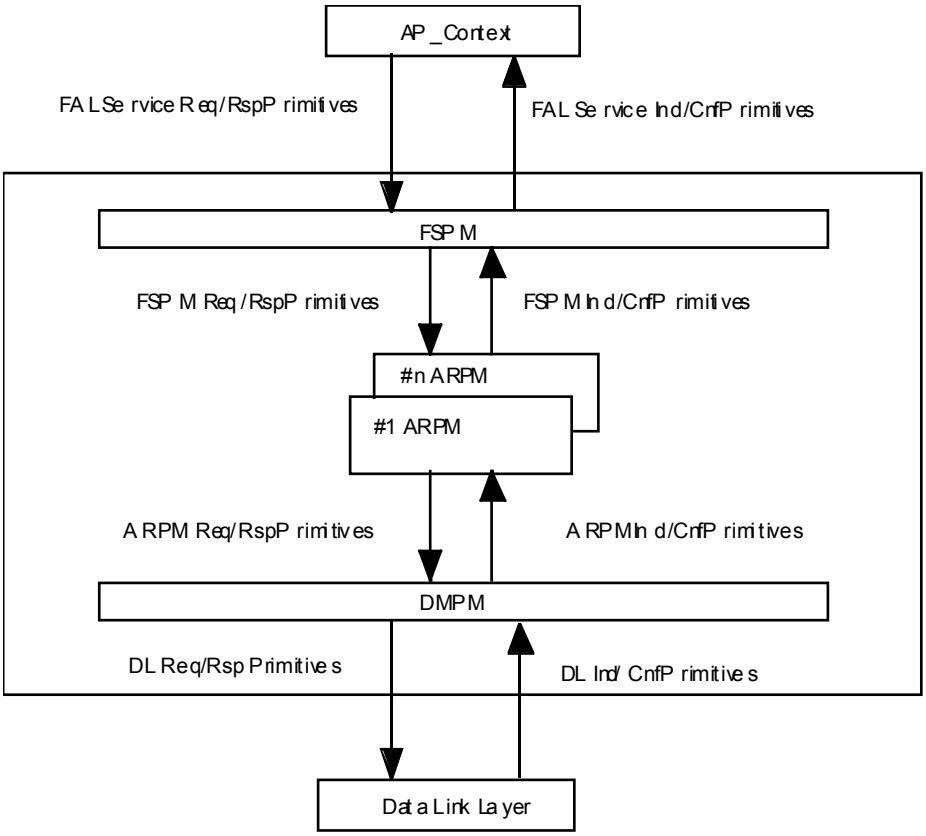

Figure 1 – Relationships among protocol machines and adjacent layers

The FSPM describes the service interface between the AP-Context and a particular AREP. The FSPM is common to all the AREP classes and does not have any state changes. The FSPM is responsible for the following activities:

a) to accept service primitives from the FAL service user and convert them into FAL internal primitives;

b) to select an appropriate ARPM state machine based on the AREP Identifier parameter supplied by the AP-Context and send FAL internal primitives to the selected ARPM;

c) to accept FAL internal primitives from the ARPM and convert them into service primitives for the AP-Context;

d) to deliver the FAL service primitives to the AP-Context based on the AREP Identifier parameter associated with the primitives.

The ARPM describes the establishment and release of an AR and exchange of FAL-PDUs with a remote ARPM(s). The ARPM is responsible for the following activities:

a) to accept FAL internal primitives from the FSPM and create and send other FAL internal primitives to either the FSPM or the DMPM, based on the AREP and primitive types;

b) to accept FAL internal primitives from the DMPM and send them to the FSPM as a form of FAL internal primitives;

c) if the primitives are for the Establish or Abort service, it shall try to establish or release the specified AR.

The DMPM describes the mapping between the FAL and the DLL. It is common to all the AREP types and does not have any state changes. The DMPM is responsible for the following activities:

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a) to accept FAL internal primitives from the ARPM, prepare DLL service primitives, and send them to the DLL;

b) to receive DLL indication or confirmation primitives from the DLL and send them to the ARPM in a form of FAL internal primitives.

7 AP-Context state machine

7.1 Overview

The AP-Context State Machine (APCSM) manages the behavioral states, transitions and interactions of all the objects contained in an implementation of the Type 16 FAL. As shown in Figure 2, there are three states. Event notifications are delivered to the APCSM from the FAL Services Protocol Machine (FSPM) or the AR Protocol Machine (ARPM) as specified. These event notifications, identified in Figure 2, result in state transitions.

The APCSM is initiated in the Idle state.

Figure 2 – APCSM state diagram

7.2 States

7.2.1 Idle

7.2.1.1 Behavior

The FAL is not connected to the network. The only behavior associated with the Idle state is a determination of errors or other fault conditions that are specified as preventing the transition to the Running state. If there are no such preventative conditions, an automatic invocation of the Establish primitive is self generated by the APCSM.

7.2.1.2 Events

- **Establish** – Connects the FAL to the network. Upon successful completion, the APCSM transitions to the Running state.

7.2.2 Running

7.2.2.1 Behavior

The FAL is connected to the network. The Master type device is able to perform the behavior associated with communicating to the Slaves to which it is connected. Slave type devices are able to perform the behavior associated responding to the Master to which it is connected.

7.2.2.2 Events

- **Release** – Disconnects the FAL from the network. Upon successful completion, the APCSM transitions to the Idle state.

7.3 States, events and transitions

The combination of all states events and possible transitions are shown in Table 5.

Documents
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