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Industriell processtyrning – Fältbuss – Del 5-10: Definition av tjänster i applikationsskiktet – Delar i fältbuss, Typ 10

*Industrial communication networks –
Fieldbus specifications –
Part 5-10: Application layer service definition –
Type 10 elements*

Som svensk standard gäller europastandarden EN IEC 61158-5-10:2019. Den svenska standarden innehåller den officiella engelska språkversionen av EN IEC 61158-5-10:2019.

Nationellt förord

Europastandarden EN IEC 61158-5-10:2019

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- **IEC 61158-5-10, Fourth edition, 2019 - Industrial communication networks - Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 61158-5-10, utgåva 3, 2015, gäller ej fr o m 2022-05-15.

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English Version

**Industrial communication networks - Fieldbus specifications -
Part 5-10: Application layer service definition - Type 10 elements
(IEC 61158-5-10:2019)**

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 5-10 : Définition des services de la
couche application - Éléments de type 10
(IEC 61158-5-10:2019)

Industrielle Kommunikationsnetze - Feldbusse - Teil 5-10:
Dienstfestlegungen des Application Layer
(Anwendungsschicht) - Typ 10-Elemente
(IEC 61158-5-10:2019)

This European Standard was approved by CENELEC on 2019-05-15. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 65C/947/FDIS, future edition 4 of IEC 61158-5-10, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61158-5-10:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-02-15
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-05-15

This document supersedes EN 61158-5-10:2014.

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Endorsement notice

The text of the International Standard IEC 61158-5-10:2019 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60870-5-4	NOTE	Harmonized as EN 60870-5-4
IEC 61131-1	NOTE	Harmonized as EN 61131-1
IEC 61131-3	NOTE	Harmonized as EN 61131-3
IEC 61375-2-1	NOTE	Harmonized as EN 61375-2-1
IEC 61784-1	NOTE	Harmonized as EN 61784-1
IEC 61784-2	NOTE	Harmonized as EN 61784-2

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61158-1	2019	Industrial communication networks - Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series	EN IEC 61158-1	2019
IEC 61158-5-3	-	Industrial communication networks - Fieldbus specifications - Part 5-3: Application layer service definition - Type 3 elements	EN 61158-5-3	-
IEC 61158-6-3	-	Industrial communication networks - Fieldbus specifications - Part 6-3: Application layer protocol specification - Type 3 elements	EN 61158-6-3	-
IEC 61158-6-10	2019	Industrial communication networks - Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements	EN 61158-6-10	2019
IEC 61800-7-203	2015	Adjustable speed electrical power drive systems - Part 7-203: Generic interface and use of profiles for power drive systems - Profile type 3 specification	EN 61800-7-203	2016
IEC 62439-2	-	Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)	EN 62439-2	-
ISO/IEC 646	-	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 8822	-	Information technology - Open Systems - Interconnection - Presentation service definition		-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
ISO/IEC 8824-1	-	Information technology - Abstract Syntax - Notation One (ASN.1): Specification of basic notation	-	-
ISO/IEC 9545	-	Information technology - Open Systems - Interconnection - Application layer structure	-	-
ISO/IEC 9834-8	-	Information technology - Procedures for the operation of object identifier registration authorities - Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers	-	-
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 15802-1	-	Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Common specifications - Part 1: Medium Access Control (MAC) service definition	-	-
ISO/IEC/IEEE 60559	2011	Information technology - Microprocessor - Systems - Floating-Point arithmetic	-	-
ISO 8601	-	Data elements and interchange formats - Information interchange - Representation of dates and times	-	-
IEEE Std 802	-	IEEE Standard for Local and metropolitan area networks: Overview and Architecture	-	-
IEEE Std 802.1	-	IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery	-	-
IEEE Std 802.1AB	-	IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery	-	-
IEEE Std 802.1AS	-	IEEE Standard for Information technology - Telecommunications and information exchange between systems - IEEE standard for Local and metropolitan area networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks	-	-
IEEE Std 802.1Q	-	IEEE Standard for Local and metropolitan area networks - Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks	-	-
IEEE Std 802.3	-	IEEE Standard for Ethernet	-	-
IETF RFC 768	-	User Datagram Protocol	-	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IETF RFC 791	-	Internet Protocol	-	-
IETF RFC 792	-	Internet Control Message Protocol	-	-
IETF RFC 826	-	Ethernet Address Resolution Protocol: Or - Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware	-	-
IETF RFC 894	-	Standard for the Transmission of IP - Datagrams over Ethernet Networks	-	-
IETF RFC 1034	-	Domain names - concepts and facilities	-	-
IETF RFC 1112	-	Host Extensions for IP Multicasting	-	-
IETF RFC 1157	-	Simple Network Management Protocol - (SNMP)	-	-
IETF RFC 1213	-	Management Information Base for Network - Management of TCP/IP-based Internets: MIB-II	-	-
IETF RFC 2131	-	Dynamic Host Configuration Protocol	-	-
IETF RFC 2132	-	DHCP Options and BOOTP Vendor - Extensions	-	-
IETF RFC 2365	-	Administratively Scoped IP Multicast	-	-
IETF RFC 2674	-	Definitions of Managed Objects for Bridges - with Traffic Classes, Multicast Filtering and Virtual LAN Extensions	-	-
IETF RFC 2737	-	Entity MIB (Version 2)	-	-
IETF RFC 2863	-	The Interfaces Group MIB	-	-
IETF RFC 3418	-	Management Information Base (MIB) for - the Simple Network Management Protocol (SNMP)	-	-
IETF RFC 3490	-	Internationalizing Domain Names in - Applications (IDNA)	-	-
IETF RFC 3621	-	Power Ethernet MIB	-	-
IETF RFC 4836	-	Definitions of Managed Objects for IEEE - 802.3 Medium Attachment Units (MAUs)	-	-
IETF RFC 5905	-	Network Time Protocol Version 4: Protocol - and Algorithms Specification	-	-
IETF RFC 6890	-	Special-Purpose IP Address Registries	-	-
The Open Group -- Publication C706	-	Technical standard DCE1.1: Remote - Procedure Call	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 5-10: Application layer service definition –
Type 10 elements****FOREWORD**

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This International Standard IEC 61158-5-10 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

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

- integration of system redundancy basic functionality;
- integration of dynamic reconfiguration basic functionality;
- integration of reporting system basic functionality;

- integration of asset management basic functionality;
- integration of media redundancy ring interconnection basic functionality.

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

FDIS	Report on voting
65C/947/FDIS	65C/950/RVD

Full information on the voting for the approval of this International 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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

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

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-10: Application layer service definition – Type 10 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 part of IEC 61158 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 10 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 International Standard defines in an abstract way the externally visible service provided by the Type 10 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 document 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 document specifies the structure and services of the Type 10 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) 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 document to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this document 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 document 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 the Type 10 application layer services as 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 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 61158-1:2019, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-5-3, *Industrial communication networks – Fieldbus specifications – Part 5-3: Application layer service definition – Type 3 elements*

IEC 61158-6-3, *Industrial communication networks – Fieldbus specifications – Part 6-3: Application layer protocol specification – Type 3 elements*

IEC 61158-6-10:2019, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 61800-7-203:2015, *Adjustable speed electrical power drive systems – Part 7-203: Generic interface and use of profiles for power drive systems – Profile type 3 specification*

IEC 62439-2, *Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*

ISO/IEC 646, *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 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

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

ISO/IEC 9834-8, *Information technology – Procedures for the operation of object identifier registration authorities – Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*

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 15802-1, *Information technology -- Telecommunications and information exchange between systems – Local and metropolitan area networks – Common specifications – Part 1: Medium Access Control (MAC) service definition*

ISO/IEC/IEEE 60559:2011, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

IEEE Std 802, *IEEE Standard for Local and metropolitan area networks: Overview and Architecture*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IEEE Std 802.1, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IEEE Std 802.1AB, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IEEE Std 802.1AS, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IEEE Std 802.1Q, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IEEE Std 802.3, *IEEE Standard for Ethernet*, available at <<http://www.ieee.org>>[viewed 2018-09-21]

IETF RFC 768, *User Datagram Protocol*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 791, *Internet Protocol*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 792, *Internet Control Message Protocol*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 826, *An Ethernet Address Resolution Protocol or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 894, *A Standard for the Transmission of IP Datagrams over Ethernet Networks*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 1034, *Domain names – concepts and facilities*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 1112, *Host Extensions for IP Multicasting*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 1157, *A Simple Network Management Protocol (SNMP)*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2131, *Dynamic Host Configuration Protocol*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2132, *DHCP Options and BOOTP Vendor Extensions*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2365, *Administratively Scoped IP Multicast*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2674, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2737, *Entity MIB (Version 2)*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 2863, *The Interfaces Group MIB*; available at <<http://www.ietf.org>>[2018-09-21]

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 3490, *Internationalizing Domain Names in Applications (IDNA)*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 3621, *Power Ethernet MIB*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 4836, *Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)*, available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 5905, *Network Time Protocol Version 4: Protocol and Algorithms Specification*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

IETF RFC 6890, *Special-Purpose IP Address Registries*; available at <<http://www.ietf.org>>[viewed 2018-09-21]

The Open Group — Publication C706, *Technical standard DCE1.1: Remote Procedure Call*, available at <<http://www.opengroup.org/onlinepubs/9629399/toc.htm>>[viewed 2018-09-21]