



IEC 61158-5-15

Edition 2.0 2010-08

INTERNATIONAL STANDARD

**Industrial communication networks – Fieldbus specifications –
Part 5-15: Application layer service definition – Type 15 elements**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE

XF

ICS 25.04.40; 35.100.70; 35.110

ISBN 978-2-88912-110-6

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
1.1 Overview.....	8
1.2 Specifications.....	9
1.3 Conformance.....	9
1.4 Type overview.....	10
2 Normative references.....	10
3 Terms and definitions, abbreviations, symbols and conventions.....	11
3.1 Terms and definitions.....	11
3.2 Abbreviations and symbols.....	19
3.3 Conventions.....	20
4 Concepts.....	23
4.1 Common concepts.....	23
4.2 Client/server specific concepts.....	23
4.3 Publish/subscribe specific concepts.....	32
5 Data type ASE.....	41
5.1 General.....	41
5.2 Formal definition of data type objects.....	41
5.3 FAL defined data types.....	41
5.4 Data type ASE service specification.....	54
6 Client/server communication model specification.....	54
6.1 ASEs.....	54
6.2 ARs.....	113
6.3 Summary of FAL classes.....	116
6.4 Permitted FAL services by AREP role.....	116
7 Publish/subscribe communication model specification.....	118
7.1 ASEs.....	118
7.2 ARs.....	137
7.3 Summary of FAL classes.....	139
7.4 Permitted FAL services by AREP role and sub-role.....	139
Bibliography.....	140
Figure 1 – Client/server stacks.....	24
Figure 2 – Client/server communication on different buses or networks.....	24
Figure 3 – Client/server APOs services conveyed by the FAL.....	25
Figure 4 – Interpretation as distinct tables.....	26
Figure 5 – Interpretation as overlapping tables.....	27
Figure 6 – APO and real objects, non obvious possible interpretation.....	27
Figure 7 – ASE service conveyance.....	29
Figure 8 – Client/server confirmed interaction.....	30
Figure 9 – Client/server AR confirmed service primitives (positive case).....	31
Figure 10 – Client/server AR confirmed service primitives (negative case).....	31
Figure 11 – Client/server unconfirmed interaction.....	32

Figure 12 – Client/server AR unconfirmed service primitives	32
Figure 13 – Publish/subscribe communications stacks	33
Figure 14 – Publish/subscribe data-centric exchanges between decoupled network objects	34
Figure 15 – Publish/subscribe APOs services conveyed by the FAL.....	35
Figure 16 – Examples of publish/subscribe configurable behaviors via QoS.....	36
Figure 17 – Pull model interactions	38
Figure 18 – Push model interactions	39
Figure 19 – Publish/subscribe model interactions.....	40
Figure 20 – Status bit sequence numbering	44
Figure 21 – ObjectId	48
Figure 22 – Bitmap	52
Figure 23 – ParameterSequence.....	54
Figure 24 – FAL ASEs	55
Figure 25 – Client/server encapsulated interface mechanism.....	102
Figure 26 – Publish/subscribe class derivations and relationships.....	118
Figure 27 – FAL ASEs and classes	119
Figure 28 – Publish/subscribe service request composition.....	129
Table 1 – Common client/server APOs.....	25
Table 2 – Class identification	49
Table 3 – Assigned vendor IDs	50
Table 4 – Bitmap “1234/12:00110”	53
Table 5 – Filter service parameters.....	58
Table 6 – Read discretely service parameters.....	60
Table 7 – Read coils service parameters	63
Table 8 – Write single coil service parameters	65
Table 9 – Write multiple coils service parameters	66
Table 10 – Broadcast write single coil service parameters	68
Table 11 – Broadcast write multiple coils service parameters.....	69
Table 12 – Read input registers service parameters.....	71
Table 13 – Read holding registers service parameters	76
Table 14 – Write single holding register service parameters.....	78
Table 15 – Write multiple holding registers service parameters	79
Table 16 – Mask write holding register service parameters	81
Table 17 – Read/write holding registers service parameters	83
Table 18 – Read FIFO service parameters.....	85
Table 19 – Broadcast write single holding register service parameters.....	86
Table 20 – Broadcast write multiple holding registers service parameters	87
Table 21 – Read file service parameters	94
Table 22 – Write file service parameters	98
Table 23 – Device identification categories	104
Table 24 – Read device ID code	105

Table 25 – Conformity level	106
Table 26 – Requested vs. returned known objects	107
Table 27 – Read device identification service parameters	109
Table 28 – FAL class summary	116
Table 29 – Services by AREP role	117
Table 30 – Issue service parameters	121
Table 31 – Heartbeat service parameters	122
Table 32 – VAR service parameters	124
Table 33 – VAR service parameters	126
Table 34 – ACK service parameters	128
Table 35 – Header service parameters	131
Table 36 – INFO_DST service parameters	132
Table 37 – INFO_REPLY service parameters	133
Table 38 – INFO_SRC service parameters	135
Table 39 – INFO_TS service parameters	136
Table 40 – PAD service parameters	137
Table 41 – FAL class summary	139
Table 42 – Services by AREP role and sub-role	139

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELD BUS SPECIFICATIONS –****Part 5-15: Application layer service definition –
Type 15 elements**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

NOTE 1 Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in type combinations as specified explicitly in the profile parts. Use of the various protocol types in other combinations may require permission of their respective intellectual-property-right holders.

International Standard IEC 61158-5-15 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

- Editorial corrections.

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

FDIS	Report on voting
65C/606/FDIS	65C/620/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.

NOTE 2 The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

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 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 5-15: Application layer service definition – Type 15 elements

1 Scope

1.1 Overview

In network communications, as in many fields of engineering, it is a fact that “one size does not fit all.” Engineering design is about making the right set of trade-offs, and these trade-offs must balance conflicting requirements such as simplicity, generality, ease of use, richness of features, performance, memory size and usage, scalability, determinism, and robustness. These trade-offs must be made in light of the types of information flow (e.g. periodic, one-to-many, request-reply, events), and the constraints imposed by the application and execution platforms.

The Type 15 fieldbus provides two major communication mechanisms that complement each others to satisfy communication requirements in the field of automation: the Client/Server and the Publish/Subscribe paradigms. They can be used concurrently on the same device.

Type 15 Client/Server operates in a Client/Server relationship. Its application layer service definitions and protocol specifications are independent of the underlying layers, and have been implemented on a variety of stacks and communication media, including EIA/TIA-232, EIA/TIA-422, EIA/TIA-425, HDLC (ISO 13239), fiber, TCP/IP, Wireless LANs and Radios.

Type 15 Publish/Subscribe operates in a Publish/Subscribe relationship. Its application layer service definitions and protocol specifications are independent of the underlying layers and can be configured to provide reliable behavior and support determinism. The most common stack is UDP/IP.

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 15 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 part of IEC 61158 defines in an abstract way the externally visible service provided by the Type 15 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 part of IEC 61158 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 part of IEC 61158 specifies the structure and services of the Type 15 IEC 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 standard to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this part of IEC 61158 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 part of IEC 61158 does not specify individual implementations or products, nor do they 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 15 application layer services as defined in this part of IEC 61158.

1.4 Type overview

In network communications, as in many fields of engineering, it is a fact that “one size does not fit all.” Engineering design is about making the right set of trade-offs, and these trade-offs must balance conflicting requirements such as simplicity, generality, ease of use, richness of features, performance, memory size and usage, scalability, determinism, and robustness. These trade-offs must be made in light of the types of information flow (e.g. periodic, one-to-many, request-reply, events), and the constraints imposed by the application and execution platforms.

The Type 15 fieldbus provides two major communication mechanisms that complement each others to satisfy communication requirements in the field of automation: the Client/Server and the Publish/Subscribe paradigms. They can be used concurrently on the same device.

Type 15 Client/Server operates in a Client/Server relationship. Its application layer service definitions and protocol specifications are independent of the underlying layers, and have been implemented on a variety of stacks and communication media, including EIA/TIA-232, EIA/TIA-422, EIA/TIA-425, HDLC (ISO 13239), fiber, TCP/IP, Wireless LANs and Radios.

Type 15 Publish/Subscribe operates in a Publish/Subscribe relationship. Its application layer service definitions and protocol specifications are independent of the underlying layers and can be configured to provide reliable behavior and support determinism. The most common stack is UDP/IP.

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/TR 61158-1:2010¹, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-6-15:2010¹, *Industrial communication networks – Fieldbus specifications - Part 6-15: Application layer protocol specification – Type 15 elements*

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

¹ To be published.