



IEC 61158-6-15

Edition 1.0 2007-12

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XD**

ICS 35.100.70; 25.040.40

ISBN 2-8318-9493-X

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
1.1 General.....	9
1.2 Specifications.....	9
1.3 Conformance.....	9
2 Normative references	10
3 Terms and definitions, abbreviations, symbols and conventions	10
3.1 Terms and definitions.....	10
3.2 Abbreviations and symbols.....	17
3.3 Conventions	18
3.4 Conventions used in state machines	20
4 Abstract syntax for client/server	22
5 Transfer syntax for client/server	22
5.1 General.....	22
5.2 Common APDU structure	22
5.3 Service-specific APDU structures.....	26
5.4 Data representation ‘on the wire’.....	50
6 Abstract syntax for publish/subscribe	50
7 Transfer syntax for publish/subscribe	51
7.1 General.....	51
7.2 APDU structure	51
7.3 Sub-message structure	52
7.4 APDU interpretation	54
7.5 Service specific APDU structures.....	56
7.6 Common data representation for publish/subscribe	77
8 Structure of FAL protocol state machines	82
9 AP-context state machines for client/server.....	84
10 FAL service protocol machine (FSPM) for client/server.....	84
10.1 General.....	84
10.2 FSPM state tables.....	84
10.3 Functions used by FSPM.....	90
10.4 Parameters of FSPM/ARPM primitives	90
10.5 Client/server server transactions	90
11 Application relationship protocol machines (ARPMs) for client/server	91
11.1 Application relationship protocol machines (ARPMs).....	91
11.2 AREP state machine primitive definitions	93
11.3 AREP state machine functions	94
12 DLL mapping protocol machine (DMPM) for client/server.....	94
12.1 AREP mapping to data link layer	94
12.2 DMPM states.....	95
12.3 DMPM states.....	95
12.4 Primitives exchanged between data link layer and DMPM	95
12.5 Client/server on TCP/IP.....	96
13 AP-Context state machines for publish/subscribe	97

14 Protocol machines for publish/subscribe.....	97
14.1 General.....	97
14.2 Publish/subscribe on UDP.....	99
Bibliography.....	100
Figure 1 – APDU Format.....	22
Figure 2 – Client to server confirmed service request.....	24
Figure 3 – Normal response from server to client.....	24
Figure 4 – Exception response from server to client.....	24
Figure 5 – Client to server unconfirmed service request.....	25
Figure 6 – Publish/subscribe APDU.....	51
Figure 7 – Relationships among protocol machines and adjacent layers.....	83
Figure 8 – State transition diagram of FSPM.....	84
Figure 9 – Client/server server transactions.....	91
Figure 10 – State transition diagram of the client ARPM.....	92
Figure 11 – State transition diagram of the server ARPM.....	92
Figure 12 – State transition diagram of DMPM.....	95
Figure 13 – APDU format.....	96
Figure 14 – TCP/IP PDU format.....	97
Figure 15 – Publish/subscribe receiver.....	98
Table 1 – Conventions used for state machines.....	21
Table 2 – Exception code.....	25
Table 3 – Read discretely request.....	26
Table 4 – Read discretely response.....	26
Table 5 – Read coils request.....	27
Table 6 – Read coils response.....	27
Table 7 – Write single coil request.....	28
Table 8 – Write single coil response.....	28
Table 9 – Write multiple coils request.....	29
Table 10 – Write multiple coils response.....	29
Table 11 – Broadcast write single coil request.....	30
Table 12 – Broadcast write multiple coils request.....	31
Table 13 – Read input registers request.....	31
Table 14 – Read input registers response.....	32
Table 15 – Read holding registers request.....	32
Table 16 – Read holding registers response.....	33
Table 17 – Write single holding register request.....	33
Table 18 – Write single holding register response.....	34
Table 19 – Write multiple holding registers request.....	34
Table 20 – Write multiple holding registers response.....	35
Table 21 – Mask write holding register request.....	36
Table 22 – Mask write holding register request.....	36

Table 23 – Read/Write multiple holding registers request.....	37
Table 24 – Read/Write multiple holding registers response	37
Table 25 – Read FIFO request.....	38
Table 26 – Read FIFO response	38
Table 27 – Broadcast write single holding register request.....	39
Table 28 – Broadcast write multiple holding registers request	40
Table 29 – Read file record request	41
Table 30 – Read file record response	42
Table 31 – Write file record request	43
Table 32 – Write file record response	45
Table 33 – Read device identification request	46
Table 34 – Device identification categories	47
Table 35 – Read device ID code	47
Table 36 – Read device identification response	48
Table 37 – Conformity level	49
Table 38 – Requested vs. returned known objects	50
Table 39 – APDU structure	52
Table 40 – Sub-message structure	53
Table 41 – Publish/subscribe service identifier encoding	53
Table 42 – Attributes changed modally and affecting APDUs interpretations	55
Table 43 – Issue request	56
Table 44 – Flags of issue request	57
Table 45 – Meaning of issue request flags	57
Table 46 – Interpretation of issue.....	58
Table 47 – Heartbeat request	59
Table 48 – Flags of heartbeat request.....	59
Table 49 – Meaning of heartbeat request flags	60
Table 50 – Interpretation of heartbeat	61
Table 51 – VAR request.....	62
Table 52 – Flags of VAR request	63
Table 53 – Meaning of VAR request flags	63
Table 54 – Interpretation of VAR.....	64
Table 55 – GAP request.....	65
Table 56 – Flags of GAP request	65
Table 57 – Meaning of GAP request flags	66
Table 58 – Interpretation of GAP.....	66
Table 59 – ACK request.....	67
Table 60 – Flags of ACK request	67
Table 61 – Meaning of ACK request flags	68
Table 62 – Interpretation of ACK.....	68
Table 63 – Header request	69
Table 64 – Change in state of the receiver.....	70
Table 65 – INFO_DST request.....	70

Table 66 – Flags of INFO_DST request	71
Table 67 – Meaning of INFO_DST request flags	71
Table 68 – INFO_REPLY request	72
Table 69 – Flags of INFO_REPLY request	72
Table 70 – Meaning of INFO_REPLY request flags	72
Table 71 – INFO_SRC request	74
Table 72 – Flags of INFO_SRC request	74
Table 73 – Meaning of INFO_SRC request flags	74
Table 74 – INFO_TS request	75
Table 75 – Flags of INFO_TS request	76
Table 76 – Meaning of INFO_TS request flags	76
Table 77 – PAD request	77
Table 78 – Flags of PAD request	77
Table 79 – Meaning of PAD request flags	77
Table 80 – Semantics	78
Table 81 – FSPM state table – client transactions	85
Table 82 – FSPM state table – server transactions	90
Table 83 – Function MatchInvokeID()	90
Table 84 – Function HighBit()	90
Table 85 – Parameters used with primitives exchanged between FSPM and ARPM	90
Table 86 – Client ARPM states	92
Table 87 – Client ARPM state table	92
Table 88 – Server ARPM states	92
Table 89 – Server ARPM state table	93
Table 90 – Primitives issued from ARPM to DMPM	93
Table 91 – Primitives issued by DMPM to ARPM	93
Table 92 – Parameters used with primitives exchanged between ARPM and DMPM	93
Table 93 – DMPM state descriptions	95
Table 94 – DMPM state table – client transactions	95
Table 95 – DMPM state table – server transactions	95
Table 96 – Primitives exchanged between data-link layer and DMPM	96
Table 97 – Encapsulation parameters for client/server on TCP/IP	96

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-15: Application layer protocol specification – 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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 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 IEC 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

International Standard IEC 61158-6-15 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 part and its Type 15 companion parts also cancel and replace IEC/PAS 62030, published in 2005.

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

- 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, ...

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.

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.

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.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-15: Application layer protocol specification – Type 15 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 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 standard defines in an abstract way the externally visible behavior provided by the Type 15 fieldbus Application Layer in terms of

- a) the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
- b) the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
- c) the application context state machine defining the application service behavior visible between communicating application entities; and
- d) the application relationship state machines defining the communication behavior visible between communicating application entities; and.

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

- 1) define the wire-representation of the service primitives defined in IEC 61158-5-15, and
- 2) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the Type 15 IEC fieldbus Application Layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) and the OSI Application Layer Structure (ISO/IEC 9545).

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 61158-5-15.

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 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.

Conformance is achieved through implementation of this application layer protocol specification.

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 61158-5-15, *Industrial communication networks – Fieldbus specifications – Part 5-15: Application layer service definition – Type 15 elements*

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

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

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

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