IEC 61158-6-8

Edition 1.0 2007-12

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications – Part 6-8: Application layer protocol specification – Type 8 elements

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XD

ICS 35.100.70; 25.040.40

ISBN 2-8318-9478-6

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 10
3.1 ISO/IEC 7498-1 terms 10
3.9 ISO/IEC 8822 terms 11
3.11 ISO/IEC 9545 terms 11
3.16 ISO/IEC 8824 terms 11
3.37 ISO/IEC 8825 terms 12
3.40 Terms and definitions from IEC 61158-5-8 12
3.47 Other terms and definitions 12
4 FAL syntax description 13
4.1 FAL-AR PDU abstract syntax 13
4.2 Abstract syntax of PDUBody 16
4.3 Type definitions for ASEs 20
4.4 Object definitions 23
4.5 Abstract syntax of Data types 25
5 Transfer syntax 26
5.1 Peripherals encoding rules (PER) 26
5.2 Encoding of APDU types 26
5.3 Encoding of tagged type values 28
5.4 Encoding of simple values 29
6 Protocol machine overview 35
7 AP-context state machine 35
7.1 Primitive definitions 35
7.2 State machine description 36
7.3 AP to AP-context initiation state transitions 37
7.4 Functions 48
8 FAL service protocol machine (FSPM) 51
8.1 Summary 51
8.2 Primitive definitions 51
8.3 FSPM state tables 53
9 Application relationship protocol machines (ARPMs) 56
9.1 Queued user-triggered bidirectional-flow control (QUB-FC) ARPM 56
9.2 Buffered network-scheduled unidirectional (BNU) ARPM 78
9.3 Queued user-triggered bidirectional – transparent mode (QUB-TM) ARPM 86
10 DLL mapping protocol machine 90
10.1 Overview 90
10.2 Primitive definitions 91
10.3 DMPM state machine 94
Bibliography 101

Figure 1 – APDU overview 26
Figure 2 – APDU header 26
Figure 3 – PDU with type extension 26
Figure 4 – PDU with address extension 27
Figure 5 – PDU with type and length extension 27
Figure 6 – Example of an Establish-Request PDU 27
Figure 7 – Encoding of a PRIVATE tagged value 28
Figure 8 – Encoding of a context specific tagged value 28
Figure 9 – Identification information fields 28
Figure 10 – ID-info for tag 0 .. 14 , length entry 0 .. 6 29
Figure 11 – ID-info for tag 15 .. 255 , length entry 0 .. 6 29
Figure 12 – ID-info for tag 0 .. 14 , length entry 7 .. 255 29
Figure 13 – ID-info for tag 15 .. 255 , length entry 7 .. 255 29
Figure 14 – Encoding of Boolean value TRUE 29
Figure 15 – Encoding of Boolean value FALSE 29
Figure 16 – Encoding of Strings 30
Figure 17 – Encoding of BinaryDate value 31
Figure 18 – Encoding of BinaryDate2000 value 31
Figure 19 – Encoding of Time-of-day value 32
Figure 20 – Encoding of Time-difference value 32
Figure 21 – Encoding of Time value 33
Figure 22 – Example for an Object definition 34
Figure 23 – Primitives exchanged between protocol machines 35
Figure 24 – AP to AP-context initiation state machine 37
Figure 25 – State transition diagram of FSPM 53
Figure 26 – State transition diagram of QUB-FC ARPM 59
Figure 27 – State transition diagram of the BNU ARPM 81
Figure 28 – State transition diagram of QUB-TM AREP 88
Figure 29 – State transition diagram of DMPM 94

Table 1 – Primitives issued by FAL-user to AP-context 35
Table 2 – Primitives issued by AP-context to FAL-user 36
Table 3 – AP-context state machine sender transactions 37
Table 4 – AP-context state machine receiver transactions 41
Table 5 – Function ResetArep 49
Table 6 – Function ApContextTest 49
Table 7 – Function ServicesSupportedTest 49
Table 8 – Function ApExplicitConnection 49
Table 9 – Function ImmediateAcknowledge 49
Table 10 – Function ConfirmedServiceCheck 49
Table 11 – Function UnconfirmedServiceCheck 49
Table 12 – Function ArServiceCheck 50

Table 13 – Function ArFspmService 50
Table 14 – Function ArAcceeSupported 50
Table 15 – Function MaxFalPduLengthTest 50
Table 16 – Function NegotiateOutstandingServices 50
Table 17 – Function RequestedServicesSupportedTest 51
Table 18 – Function IndicatedServicesSupportedTest 51
Table 19 – Function InvokeIdExistent 51
Table 20 – Function SameService 51
Table 21 – Primitives issued by AP-context to FSPM 52
Table 22 – Primitives issued by FSPM to AP-context 52
Table 23 – FSPM state table – sender transactions 53
Table 24 – FSPM state table – receiver transactions 55
Table 25 – Function SelectArep 55
Table 26 – Primitives issued by FSPM to ARPM 56
Table 27 – Primitives issued by ARPM to FSPM 56
Table 28 – Parameters used with primitives exchanged between FSPM and ARPM 57
Table 29 – QUB-FC ARPM states 59
Table 30 – QUB-FC ARPM state table – sender transactions 60
Table 31 – QUB-FC ARPM state table – receiver transactions 65
Table 32 – Function GetArepId () 76
Table 33 – Function BuildFAL-PDU 76
Table 34 – Function FAL_Pdu_Type 77
Table 35 – Function AREPContextCheck() 77
Table 36 – Function AbortIdentifier 77
Table 37 – Function AbortReason 77
Table 38 – Function AbortDetail 77
Table 39 – Function StartTimer 78
Table 40 – Function StopTimer 78
Table 41 – Function ResetCounters 78
Table 42 – Function IncrementCounter 78
Table 43 – Function DecrementCounter 78
Table 44 – Function GetCounterValue 78
Table 45 – Primitives issued by FSPM to ARPM 79
Table 46 – Primitives issued by ARPM to FSPM 79
Table 47 – Parameters used with primitives exchanged between FSPM and ARPM 79
Table 48 – BNU ARPM states 81
Table 49 – BNU ARPM state table – sender transactions 81
Table 50 – BNU ARPM state table – receiver transactions 82
Table 51 – Function GetArepId () 85
Table 52 – Function BuildFAL-PDU 85
Table 53 – Function FAL_Pdu_Type 85
Table 54 – Function AbortIdentifier 85
Table 55 – Function AbortReason 85

Table 56 – Function AbortDetail 85
Table 57 – Primitives issued by FAL to ARPM 86
Table 58 – Primitives issued by ARPM to FAL 86
Table 59 – Parameters used with primitives exchanged between FAL and ARPM 86
Table 60 – QUB-TM ARPM states 88
Table 61 – QUB-TM state table - sender transactions 88
Table 62 – QUB-TM state table - receiver transactions 89
Table 63 – Function GetArepId () 89
Table 64 – Function BuildFAL-PDU 89
Table 65 – Function FAL_Pdu_Type 89
Table 66 – Function ResetCounters 90
Table 67 – Function IncrementCounter 90
Table 68 – Function DecrementCounter 90
Table 69 – Function GetCounterValue 90
Table 70 – Primitives issued by ARPM to DMPM 91
Table 71 – Primitives issued by DMPM to ARPM 92
Table 72 – Parameters used with primitives exchanged between ARPM and DMPM 93
Table 73 – Primitives exchanged between data-link layer and DMPM 93
Table 74 – DMPM state descriptions 94
Table 75 – DMPM state table – sender transactions 94
Table 76 – DMPM state table – receiver transactions 98
Table 77 – Function PickArep 99
Table 78 – Function FindAREP 99
Table 79 – Function SelectNextArep 99
Table 80 – Function ArepRole 100
Table 81 – Function FalArHeader 100
Table 82 – Function AddUcsPduHeader 100
Table 83 – Function RemoveUcsPduHeader 100
Table 84 – Function DlLinkStatus 100

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-8: Application layer protocol specification – Type 8 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.

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.

IEC draws attention to the fact that it is claimed that compliance with this standard may involve the use of patents as follows, where the [xx] notation indicates the holder of the patent right:

Type 8:

DE 197 39 297 C2 [PxC] "Automatisierungssystem und Steuervorrichtung zur transparenten Kommunikation zwischen verschiedenen Netzwerken."

US 2002/0042845 A1 [PxC] "Automation System and connecting Apparatus for the Transparent Communication between two Networks."

The IEC takes no position concerning the evidence, validity and scope of these patent rights.:

The holders of these patent rights have assured the IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holders of these patent rights are registered with the IEC. Information may be obtained from:

[PxC]: Phoenix Contact GmbH & Co. KG
Intellectual Property Licenses & Standards
Flachsmarktstr. 8
D-32825 Blomberg,
Germany

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61158-6-8 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 revision.

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 6-8: Application layer protocol specification – Type 8 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 8 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 specifies interactions between remote applications and defines the externally visible behavior provided by the Type 8 fieldbus application layer in terms of

a) the formal abstract syntax defining the application layer protocol data units conveyed between communicating application entities;
b) the transfer syntax defining encoding rules that are applied to the application layer protocol data units;
c) the application context state machine defining the application service behavior visible between communicating application entities;
d) the application relationship state machines defining the communication behavior visible between communicating application entities.

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

1) define the wire-representation of the service primitives defined in IEC 61158-5-8, and
2) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the Type 8 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 61158-5-8.

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 the IEC 61158-6 series.

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 60559, *Binary floating-point arithmetic for microprocessor systems*

IEC 61158-3-8, *Industrial communication networks – Fieldbus specifications – Part 3-8: Data-link layer service definition – Type 8 elements*

IEC 61158-4-8, *Industrial communication networks – Fieldbus specifications – Part 4-8: Data-link layer protocol specification – Type 8 elements*

IEC 61158-5-8, *Industrial communication networks – Fieldbus specifications – Part 5-8: Application layer service definition – Type 8 elements*

ISO/IEC 7498 (all parts), *Information technology – Open Systems Interconnection – Basic Reference Model*

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)*

ISO/IEC 8825, *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*

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