IEC 61158-6-11

Edition 1.0   2007-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial communication networks – Fieldbus specifications –
Part 6-11: Application layer protocol specification – Type 11 elements

Réseaux de communication industriels – Spécifications des bus de terrain –
Partie 6-11: Spécification du protocole de la couche d'application – Éléments de Type 11

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**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –**

Part 6-11: Application layer protocol specification – Type 11 elements

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International standard IEC 61158-6-11 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 11 companion parts also cancel and replace IEC/PAS 62406, published in 2005.

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.

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 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• withdrawn;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.

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 6-11: Application layer protocol specification – Type 11 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 11 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 different Types of the 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 61158-5-11, and

2) define the externally visible behavior associated with their transfer.

This standard specify the protocol 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

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 61158-5-11.

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 parts of 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.

There is no conformance of equipment to the application layer service definition standard. Instead, 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 61158-3-11, *Industrial communication networks – Fieldbus specifications – Part 3-11: Data-link layer service definition – Type 11 elements*

IEC 61158-5-11, *Industrial communication networks – Fieldbus specifications – Part 5-11: Application layer service definition – Type 11 elements*

IEC 61784-2, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

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

3   Terms, definitions, symbols, abbreviations and conventions

3.1   Introduction

For the purposes of this documents, the followings apply.

3.2   Terms and definitions from other ISO/IEC standards

3.2.1   Terms and definitions from ISO/IEC 7498-1

   a)   application entity
   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

3.2.2   Terms and definitions from ISO/IEC 8822

   a)   abstract syntax
   b)   presentation context

3.2.3   Terms and definitions from ISO/IEC 9545

   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

3.2.4   Terms and definitions from ISO/IEC 8824

   a)   object identifier
   b)   type
   c)   value
   d)   simple type
   e)   structured type
   f)   component type
   g)   tag
   h)   Boolean type
   i)   true
   j)   false
   k)   integer type
   l)   bitstring type
   m)   octetstring type
   n)   null type
   o)   sequence type
   p)   sequence of type
   q)   choice type
   r)   tagged type
   s)   any type
   t)   module
   u)   production

3.2.5   Terms and definitions from ISO/IEC 8825

a) encoding (of a data value)
b) data value
c) identifier octets (the singular form is used in this standard)
d) length octet(s) (both singular and plural forms are used in this standard)
e) contents octets

3.3   Terms and definitions from IEC/TR 61158-1

a) application relationship
b) conveyance path
c) client
d) dedicated AR
e) dynamic AR
f) error class
g) error code
h) name
i) numeric identifier
j) peer
k) pre-defined AR endpoint
l) pre-established AR endpoint
m) publisher
n) subscriber
o) server

3.4   Other terms and definitions

NOTE The following definitions may apply to all the types except if the same item is used with different definitions in a specific type. In this case the latter has precedence.

The following terms and definitions are used in this series of standards.

3.4.1
called
service user or a service provider that receives an indication primitive or a request APDU

3.4.2
calling
service user or a service provider that initiates a request primitive or a request APDU

3.4.3
common memory
virtual common memory over the Type 11 fieldbus, which is shared with the nodes participating in the Type 11 fieldbus and is primarily used for the real-time communications by the TCC data service

3.4.4
interoperability
capability of User Layer entities to perform coordinated and cooperative operations using the services of the FAL

3.4.5
management information
network accessible information that supports the management of the Fieldbus environment

3.4.6
receiving
service user that receives a confirmed primitive or an unconfirmed primitive, or a service provider that receives a confirmed APDU or an unconfirmed APDU

3.4.7
resource
resource is a processing or information capability of a subsystem

3.4.8
sending

service user that sends a confirmed primitive or an unconfirmed primitive, or a service provider that sends a confirmed APDU or an unconfirmed APDU

3.5 Abbreviations and symbols

AE	Application Entity
AE-I	Application Entity Invocation
AL	Application Layer
AP	Application Process
Ap_	Prefix for Data types defined for AP ASE
Ar_	Prefix for Data types defined for AR ASE
APDU	Application Protocol Data Unit
AR	Application Relationship
AREP	Application Relationship End Point
ASE	Application Service Element
ASN.1	Abstract Syntax Notation One
BCD	Binary Coded Decimal
BER	Basic Encoding Rule
BNU-PEC	Buffered Network-Scheduled Uni-directional Pre-Established Connection
CM	Common Memory
cnf	confirmation primitive
DI_	Prefix for Data types defined for data-link layer types
DL	Data-link
DLC	Data-link Connection
DLCEP	Data-link Connection End Point
DLPDU	Data-link Protocol Data Unit
DLSAP	Data-link Service Access Point
DLSDU	Data-link Service Data Unit
Dt_	Prefix for Data types defined for Data type ASE
Err	Error (used to indicate an APDU type)
Er_	Prefix for Error types defined
Ev_	Prefix for Data types defined for Event ASE
FAL	Fieldbus Application Layer
Fi_	Prefix for Data types defined for Function Invocation ASE
FIFO	First In First Out
Gn_	Prefix for Data types defined for general use
ID	Identifier
IEC	International Electrotechnical Commission
in	input primitive
ind	indication primitive
ISO	International Organization for Standardization
LAS	Link Active Scheduler
Lr_	Prefix for Data types defined for Load Region ASE
lsb	least significant bit
Mn_	Prefix for Data types defined for Management ASE
msb	most significant bit
out	output primitive
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PICS	Protocol Implementation Conformance Statement
QoS	Quality Of Service
Req	Request (used to indicate an APDU type)
req	request primitive
Rsp	Response (used to indicate an APDU type)
rsp	response primitive

SAP   Service Access Point
SDU   Service Data Unit
TCC   Time-critical cyclic
ToS   Type Of Service
Vr_   Prefix for Data types defined for Variable ASE

3.6   Conventions

3.6.1   Conventions for class definitions

The data-link layer mapping definitions are described using templates. Each template consists of a list of attributes for the class. The general form of the template is defined in IEC 61158-5.

3.6.2   Abstract syntax conventions

When the "optionalParametersMap" parameter is used, a bit number which corresponds to each OPTIONAL or DEFAULT production is given as a comment.

3.6.3   Conventions used in state machines

The state machines are described in Table 1.

Table 1 – Conventions used for state machines

#	Current state	Event / condition => action	Next state
Name of this transition	The current state to which this state transition applies	Events or conditions that trigger this state transaction. => The actions that are taken when the above events or conditions are met. The actions are always indented below events or conditions	The next state after the actions in this transition is taken

The conventions used in the state machines are as follows:

:=   Value of an item on the left is replaced by value of an item on the right. If an item on the right is a parameter, it comes from the primitive shown as an input event.

xxx   A parameter name.

    Example:
      Identifier := reason
        means value of a 'reason' parameter is assigned to a parameter called 'Identifier.'

"xxx"   Indicates fixed value.

Example:
  Identifier := "abc"
    means value "abc" is assigned to a parameter named 'Identifier.'

  =   A logical condition to indicate an item on the left is equal to an item on the right.

  <   A logical condition to indicate an item on the left is less than the item on the right.

  >   A logical condition to indicate an item on the left is greater than the item on the right.

  <> A logical condition to indicate an item on the left is not equal to an item on the right.

  && Logical "AND"

  || Logical "OR"

This construct allows the execution of a sequence of actions in a loop within one transition. The loop is executed for all values from start_value to end_value.

```
Example:
  for (Identifier := start_value to end_value)
      actions
  endfor
```

This construct allows the execution of alternative actions depending on some condition (which might be the value of some identifier or the outcome of a previous action) within one transition.

```
Example:
  If (condition)
      actions
  else
      actions
  endif
```

Readers are strongly recommended to refer to the subclauses for the AREP attribute definitions, the local functions, and the FAL-PDU definitions to understand protocol machines. It is assumed that readers have sufficient knowledge of these definitions, and they are used without further explanations.

4   FAL syntax description

4.1   Concept

This standard specifies the Application layer protocol of the Type 11 essential for the ISO/IEC 8802-3-based Time-critical control network (TCnet), which is one of the communication networks for the Real-Time Ethernet(RTE) defined in IEC 61784-2 and is referred to as RTE-TCnet hereafter.

This standard meets the industrial automation market objective of providing predictable time deterministic and reliable time-critical data transfer and means, which allow co-existence with non-time-critical data transfer over the ISO/IEC 8802-3 series communications medium, for support of cooperation and synchronization between automation processes on field devices in a real-time application system. 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.

This standard specifies the part of the protocol set of the RTE-TCnet communication profile and/or of one or more communication profiles related to a common family of the RTE-TCnet. The RTE-TCnet communication profile, shown in Figure 1 as one of the profile sets, is based on the 7 layer OSI Basic Reference model. For regular ISO/IEC 8802-3 based applications the upper layers mapped over the data-link layer is in the ordinary way; on the other hand, for time-critical applications with Common Memory running in parallel, the specific application layer for RTE-TCnet is specified. The data-link layer for RTE-TCnet has the extension, but is compliant to the ISO/IEC 8802-3 MAC protocol in order to provide both services for time-critical communications and common memory applications respectively.