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Edition 1.0 2014-05

INTERNATIONAL STANDARD

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Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 1: Présentation et lignes directrices des séries CEI 61158 et CEI 61784

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Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series

FOREWORD

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NOTE Combinations of protocol types are specified in IEC 61784-1 and IEC 61784-2.

International Standard IEC 61158-1 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition cancels and replaces the third edition of IEC/TR 61158-1 published in 2010. This edition constitutes a technical revision.

This first edition includes the following significant changes with respect to the previous Technical Report:

- updates of the references to and information about the IEC 61158 series, IEC 61784-1, IEC 61784-3, IEC 61784-5 series and IEC 61918 throughout the document;
- new Type 23 for profile family 8;
- new Type 24 and the related profile family CPF 19;
- new Subclause 7.7 Communication profiles for wireless communication networks;
- new Clause 11 Fieldbus system requirements;
- new Annex B Media selection for fieldbus systems.

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

FDIS	Report on voting
65C/757/FDIS	65C/767/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 the ISO/IEC Directives, Part 2.

A list of all the 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- withdrawn,
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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series

1 Scope

This document specifies the generic concept of fieldbuses.

This document also presents an overview and guidance for the IEC 61158 series by:

- explaining the structure and content of the IEC 61158 series;
- relating the structure of the IEC 61158 series to the ISO/IEC 7498-1 OSI Basic Reference Model;
- showing the logical structure of the IEC 61784 series;
- showing how to use parts of the IEC 61158 series in combination with the IEC 61784 series;
- providing explanations of some aspects of the IEC 61158 series that are common to the type specific parts of the IEC 61158-5 including the application layer service description concepts and the generic fieldbus data types.

2 Normative references

None.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
communication system
arrangement of hardware, software and propagation media to allow the transfer of messages from one application to another

3.1.2
fieldbus
communication system based on serial data transfer as typically used in industrial automation and process control applications

3.1.3
fieldbus system
system using a fieldbus with connected devices

3.1.4
message
ordered series of octets intended to convey information

[SOURCE: ISO/IEC 2382-16:1996, 16.02.01, modified]

3.1.5
network
all of the media, connectors, repeaters, routers, gateways and associated node communication elements by which a given set of communicating devices are interconnected

3.2 Abbreviations

For the purposes of this document, the following abbreviations, based partially on the concepts developed in ISO/IEC 7498-1, apply:

AE	application entity
AL	application layer (N = 7)
APDU	application layer protocol data unit
APO	application process object
AR	application relationship
AREP	application relationship endpoint
ASE	application service element
CP	communication profile
CPF	communication profile family
DL-	data-link layer (as a prefix)
DLL	data-link layer (N = 2)
FAL	fieldbus application layer
FSCP	functional safety communication profile
IETF	Internet Engineering Task Force
IO	input output
IP	Internet protocol (see RFC 791)
kbit/s	thousand bit per second
Mbit/s	million bit per second
LME	layer management entity
(*n*)-layer	layer *n* of the OSI basic reference model
OSI	open systems interconnection
Ph-	physical layer (as a prefix)
PhL	physical layer (N = 1)
SIL	safety integrity level

4 Guidelines for implementers and users

4.1 Background and purpose

Communication in global markets requires a global understanding of a specification (standard or not). ISO/OSI related specifications provide a common basis for understanding and acceptance between international experts (manufacturers and end-users).

Examples are

- ISO/IEC 7498-1 for general layering and structuring;
- ISO/IEC 9545 for general application layer modeling;
- ISO/IEC 8886 for data-link layer modeling.

The IEC 61158 series specifies a number of different fieldbus types in each of its parts (IEC 61158-2 and the type specific parts of IEC 61158-3-***tt***, IEC 61158-4-***tt***, IEC 61158-5-***tt*** and IEC 61158-6-***tt***). As a result of the editorial harmonization work done by IEC, each PhL, DLL and AL specification within IEC 61158 is shown in a homogeneous way. The description of each layer offers, as far as possible, common views, concepts, definitions, and descriptive methods.

NOTE The list of IEC 61158 parts is abbreviated as IEC 61158-3-***tt***, IEC 61158-4-***tt***, IEC 61158-5-***tt***, or IEC 61158-6-***tt***, where ***tt*** represents one or more type numbers.

This common approach has been adopted to assist users and implementers in understanding the several specifications. It is also intended to assist in comparing available products and their communications-related features.

4.2 Supported options

Most of the fieldbus types specified in the IEC 61158 series include a range of selectable and configurable options within their detailed specifications. In general, only certain restricted combinations of options will interwork or interoperate correctly.

The recommended combinations of options are collected in IEC 61784-1 and IEC 61784-2.

IEC 61784-1 and IEC 61784-2 provide users and implementers with details of supported fieldbus specifications based on selected options that are intended to work together consistently and correctly. In most cases, available product demonstrations and working plant experience support these profiles.

Annex A of IEC 61784-1 and Annex A of IEC 61784-2 help select the needed fieldbus by showing the key features of each of the profiled fieldbus protocol families.

As a result, the route map recommended to select a fieldbus is:

- Clause 5 to Clause 8 of this part of IEC 61158;
- IEC 61784-1, Annex A: Communication concepts;
- IEC 61784-2, Annex A: Performance indicator calculations;
- IEC 61784-1 and IEC 61784-2, Communication profile family;
- the parts of IEC 61158 as referenced in IEC 61784-1 and IEC 61784-2 for the selected communication profile of interest.

4.3 Benefits from using a common and formal style

The benefits gained from using a common and formal style to specify the communication system are:

- the common look and feel of a specification saves effort during evaluation;
- a common structure helps to identify and to specify common parts and contents;
- the common approach represents a first step to ensure long-term quality and stability;
- the missing parts and items of any specification are more readily identified by comparison with the other specifications, leading to a simplified review and evaluation procedure;
- a common basis facilitates the development of test and certification procedures;
- the modular concepts support future enhancements, extensions and adaptation of new technologies.

5 Concept of the IEC 61158 series

Conceptually, a fieldbus is an industrial digital communication network for integration of industrial control and instrumentation devices into a system. Examples of such devices are transducers, sensors, actuators and controllers.

The IEC 61158 series specifies a number of fieldbus protocol types. Each protocol type is designed to permit multiple measurement and control devices to communicate. Devices communicate directly only with other devices of the same protocol type. The basic requirements of industrial communication networks for measurement and control are given in Clause 11.

Devices which use the same lower-layer protocols in a compatible fashion but differ in their higher-layer protocols may be able to share a lower-layer medium.

In all cases, a particular data-link layer protocol type may be used without restriction when coupled with physical layer and application layer protocols of the same type or with other combinations as specified in IEC 61784-1 and IEC 61784-2. Use of the various protocol types in other combinations may require permission from their respective copyright holders.

The protocol types in IEC 61158 have been engineered to support information processing, monitoring and control systems for any industrial sector and related domains. An example application for high-integrity low-level communication between sensors, actuators and local controllers in a process plant, together with the interconnection of programmable controllers, is shown in Figure 1.

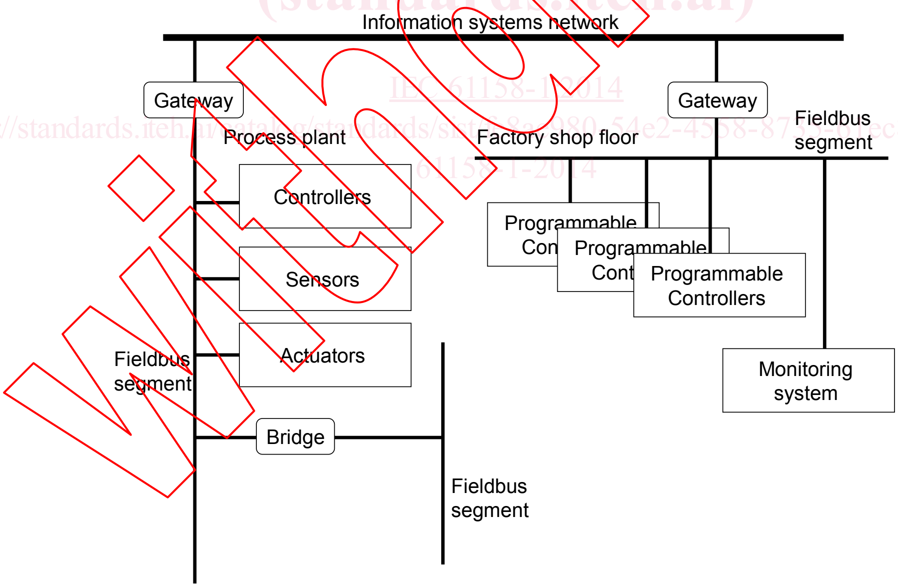

Figure 1 – Example of a fieldbus system

A number of fieldbus types are specified in the IEC 61158 series using the following concepts for decomposition.

a) **First concept:** The complex communication task is divided into different layers based on an adaptation of ISO/IEC 7498-1, the ISO/OSI Basic Reference Model, thereby facilitating well-structured functions and interfaces (see Clause 6). This has the following benefits:
   – decomposition of complex tasks;
   – modular structure to adapt different technologies.

b) **Second concept:** Each fieldbus type is composed of one or more layer specifications.

Most types include a number of services and protocol options that require an appropriate selection to support a working system. Compatible selections of options and services within one of the IEC 61158 fieldbus types are specified as standardized communication profiles in IEC 61784-1 and IEC 61784-2. Most of these profiles are supported by consortia or trade associations which are identified in the profile specification.

c) **Third concept:** The physical, data-link and application layers are described in complementary ways, in terms of the offered services and the protocol which provides those services.

Figure 2 illustrates the differences between service and protocol viewpoints of the data-link and application layers. The protocol parts show the layer implementer's oriented view and the service parts show the layer user's oriented view.

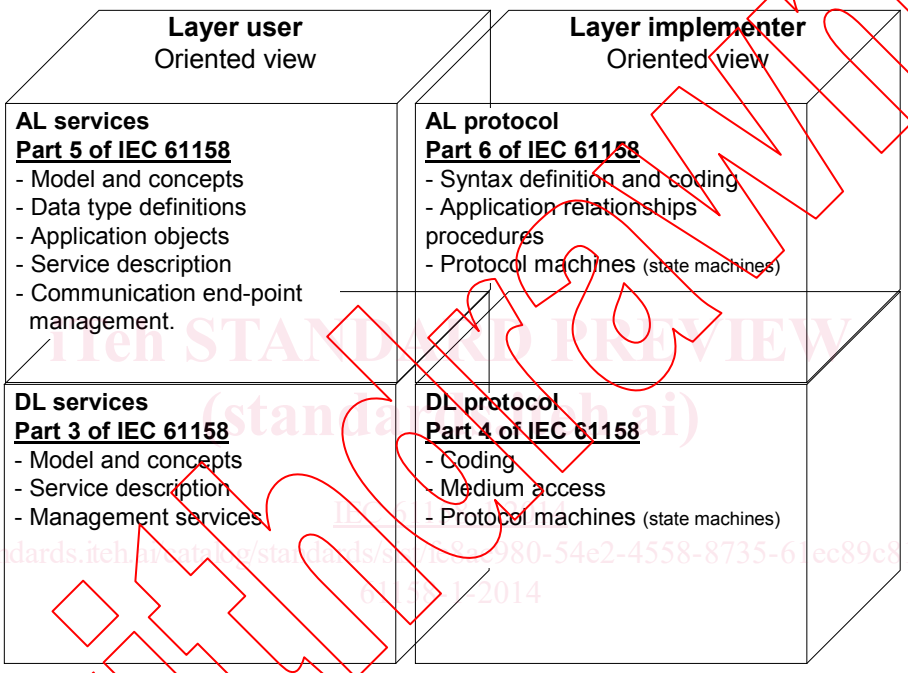

Figure 2 – Concept of DL/AL to separate service and protocol parts

The application layer structure is as follows:

– the "what" is described by application layer service elements (ASE) in the type specific parts of IEC 61158-5; and

– the "how" is described by application layer relationships (AR) in the type specific parts of IEC 61158-6.

The data-link layer structure is as follows:

– the "what" is described by data-link layer services and models in the type specific parts of IEC 61158-3; and

– the "how" is described by data-link layer protocol machines and medium access principles in the type specific parts of IEC 61158-4.

The physical layer is structured similarly, but, because its services are readily described, they are described in IEC 61158-2 together with the definitions of the physical protocols:

– the "what" is described by physical layer services and models, and

– the "how" is described by physical layer electrical and mechanical specifications.

6 Mapping onto the OSI Basic Reference Model

6.1 Overview

IEC 61158 protocol types are described using the principles, methodology and model of ISO/IEC 7498-1. The OSI model provides a layered approach to communications standards, whereby the layers can be developed and modified independently. IEC 61158 specifies functionality from top to bottom of a full OSI stack and, potentially, some functions for the users of the stack. Functions of the intermediate OSI layers, layers 3 through 6, may be consolidated into either the IEC 61158 data-link layer or the IEC 61158 application layer, or may be realized by a separate layer. Likewise, some features common to users of the fieldbus application layer may be provided by the IEC 61158 application layer to simplify user operation.

Table 1 shows the OSI layers, their functions, and the equivalent layers in the IEC 61158 basic fieldbus reference model (see Figure 3).

Table 1 – OSI and IEC 61158 layers

OSI layer	Function	IEC 61158 layer
7 Application	Translates demands placed on the communications stack into a form understood by the lower layers and vice versa	Application (IEC 61158-5-*tt*, IEC 61158-6-*tt*)
6 Presentation	Converts data to/from standardized network formats	↑
5 Session	Creates and manages dialogue among lower layers	↑
4 Transport	Provides transparent reliable data transfer (end-to-end transfer across a network which may include multiple links)	↓ or ↑
3 Network	Performs message routing	↓ or ↑
2 Data-link	Controls access to the communication medium. Performs error detection. (point-to-point transfer on a link)	Data-link (IEC 61158-3-*tt*, IEC 61158-4-*tt*)
1 Physical	Encodes/decodes signals for transmission/reception in a form appropriate to the communications medium. Specifies communication media characteristics	Physical (IEC 61158-2)

NOTE -***tt*** is a placeholder for the part numbers representing types.

NOTE ↓ and ↑ indicate that the functionality of this layer, when present, is included in the fieldbus layer that is nearest in the direction of the arrow. Thus it is possible that the network and transport functionality are included in either the data-link or application layers, and it is possible that the session and presentation functionality are included in the application layer but not in the data-link layer.

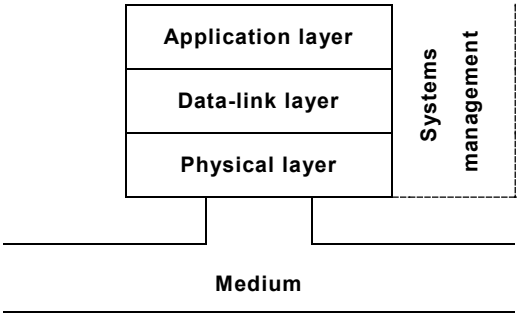

Figure 3 – Basic fieldbus reference model

6.2 Physical layer service and protocol

IEC 61158-2 comprises physical layer specifications corresponding to many of the different DL-Layer protocol types specified in the type specific parts of IEC 61158-4.

NOTE 1 The type numbers used are consistent throughout the IEC 61158 series.

NOTE 2 Not all types have a physical layer specification in IEC 61158-2. In that case the communication profile in IEC 61784-1 or IEC 61784-2 provides appropriate references to other standards.

NOTE 3 For ease of reference, type numbers are given in clause names. This means that the specification given therein applies to this type but does not exclude its use for other types.

NOTE 4 It is up to the user of IEC 61158 to select interoperating sets of provisions. Refer to the IEC 61784-1 and IEC 61784-2 for standardized communication profiles based on IEC 61158 .

A general model of the physical layer is shown in Figure 4.

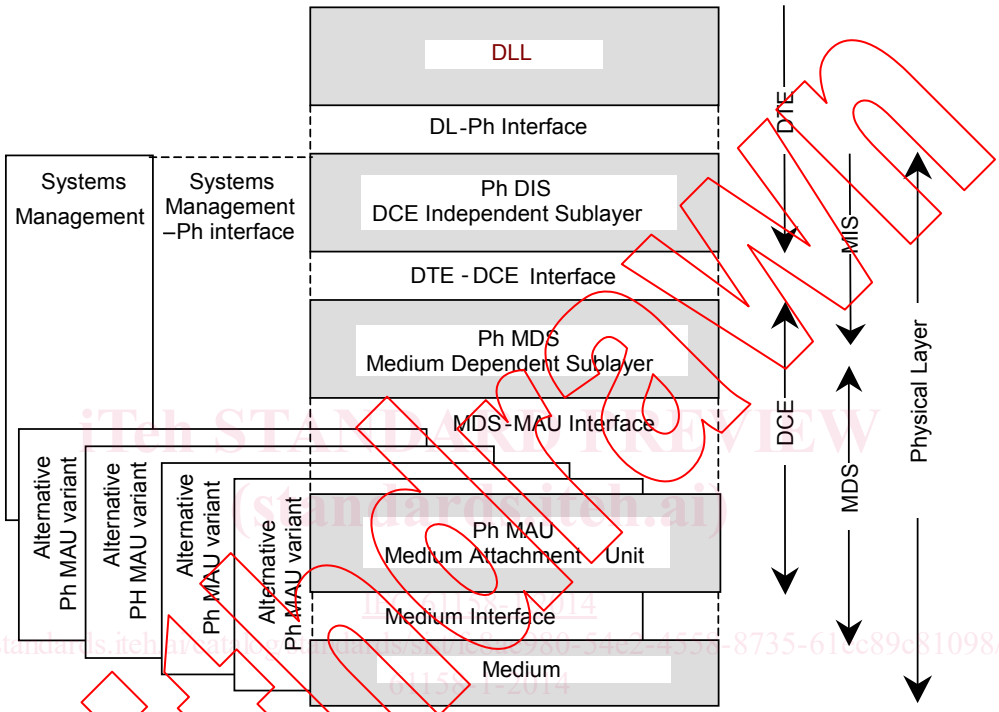

Figure 4 – General model of physical layer

NOTE 5 The protocol types use a subset of the structure elements.

NOTE 6 Since Type 8 uses a more complex DIS than the other types, it uses the term MIS to differentiate.

The common characteristics for all variants and types are as follows:

– digital data transmission; and

– either half-duplex communication (bi-directional but in only one direction at a time) or full-duplex communication.

6.3 Data-link layer service

The data-link service is provided by the data-link protocol making use of the services available from the physical layer. This and related parts of the IEC 61158 series defines the data-link service characteristics that the immediately higher-level protocol may exploit. The relationship between the international standards for fieldbus data-link service, fieldbus data-link protocol, fieldbus application protocol and systems management is illustrated in Figure 5.

NOTE Systems management, as used in the IEC 61158 series, is a local mechanism for managing the layer protocols.

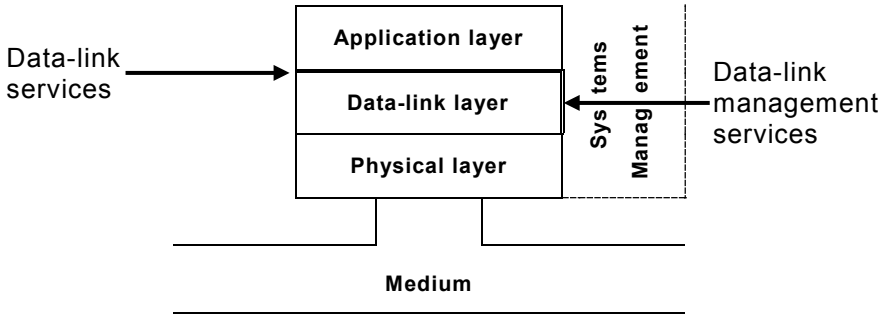

Figure 5 – Relationship of the Data-link layer to other fieldbus layers and to users of the fieldbus data-link service

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, a data-link service defined in IEC 61158 is a conceptual architectural service, independent of administrative and implementation divisions.

6.4 Data-link layer protocol

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The relationship between the International Standards for fieldbus data-link service, fieldbus data-link protocol, fieldbus physical service and systems management is illustrated in Figure 5.

NOTE 1 Systems management, as used in the IEC 61158 series, is a local mechanism for managing the layer protocols.

NOTE 2 Not all types have a data-link layer specification. In that case the communication profile in IEC 61784-1 or IEC 61784-2 provides appropriate references to other standards.

The primary aim of the data-link protocol standards is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer data-link entities (DLEs) 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:

a) as a guide for implementers and designers;

b) for use in the testing and procurement of equipment;

c) as part of an agreement for the admittance of systems into the open systems environment;

d) as a refinement to the understanding of time-critical communications within OSI.

These data-link protocol standards are concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices, using these standards, together with other standards positioned within the OSI or fieldbus reference models; otherwise, incompatible systems may work together in any combination.

6.5 Application layer service

The application service is provided by the application protocol making use of the services available from the data-link or other immediately lower layer. Each part of the IEC 61158-5 series defines the application service characteristics that any immediately higher-level protocols may exploit. The relationship between the international standards for fieldbus application service, fieldbus application protocol and systems management is illustrated in Figure 6.

NOTE Systems management, as used in the IEC 61158 series, is a local mechanism for managing the layer protocols.