TECHNICAL REPORT

IEC TR 61158-1

First edition
2003-04

Digital data communications for measurement and control – Fieldbus for use in industrial control systems –

Part 1: Overview and guidance for the IEC 61158 series

Reference number
IEC/TR 61158-1:2003(E)

Publication numbering

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE L

For price, see current catalogue

INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIGITAL DATA COMMUNICATIONS FOR MEASUREMENT AND CONTROL – FIELDBUS FOR USE IN INDUSTRIAL CONTROL SYSTEMS –

Part 1: Overview and guidance for the IEC 61158 series

FOREWORD

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Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 61158-1, which is a Technical Report, has been prepared by subcommittee 65C: Digital communications, of IEC technical committee 65: Industrial-process measurement and control.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
65C/267/DTR	65C/277/RVC

Full information on the voting for the approval of this Technical Report 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.

IEC 61158 consists of the following parts, under the general title *Digital data communications for measurement and control – Fieldbus for use in industrial control systems*:

Part 1: Overview and guidance for the IEC 61158 series

Part 2: Physical Layer specification and service definition

Part 3: Data Link Service definition

Part 4: Data Link protocol specification

Part 5: Application Layer Service definition

Part 6: Application Layer protocol specification

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

NOTE When revised, this report will be synchronized with the other parts of the IEC 61158 series.

DIGITAL DATA COMMUNICATIONS FOR MEASUREMENT AND CONTROL – FIELDBUS FOR USE IN INDUSTRIAL CONTROL SYSTEMS –

Part 1: Overview and guidance for the IEC 61158 series

1 Scope

This Technical Report presents an overview and guidance for the IEC 61158 series. It explains the structure and content of IEC 61158, shows how to use it in combination with IEC 61784, and relates the structure to the ISO/IEC 7498 OSI Basic Reference Model.

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 61158-2, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Part 2: Physical Layer specification and service definition*

IEC 61158-3, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Part 3: Data Link Service definition*

IEC 61158-4, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Part 4: Data Link protocol specification*

IEC 61158-5, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Part 5: Application Layer service definition*

IEC 61158-6, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Part 6: Application Layer protocol specification*

IEC 61784, *Digital data communications for measurement and control — Fieldbus for use in industrial control systems – Profile sets for continuous and discrete manufacturing*

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

3 Definitions and abbreviations

This part of IEC 61158 is based partially on the concepts developed in ISO/IEC 7498-1 and makes use of the following definitions and abbreviations derived from that standard:

Term or abbreviation	Definition or meaning
3.1 OSI	Open Systems Interconnection
3.2 N-layer	Layer N of the OSI Basic Reference Model
3.3 AL	Application layer (N = 7)
3.4 DL-	Data link layer (as a prefix)
3.5 DLL	Data link layer (N = 2)
3.6 Ph-	Physical layer (as a prefix)
3.7 PhL	Physical layer layer (N = 1)

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 series for general layering and structuring;
- ISO/IEC 9545 for general application layer modeling;
- ISO/IEC 8824 for data link layer modeling.

The IEC 61158 series specifies a number of different fieldbus types in each of the parts of the series (Parts 2 to 6). 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 method.

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 correctly.

The recommended combinations of options are collected in another standard, IEC 61784.

IEC 61784 provides 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 helps select the needed fieldbus by showing the key concepts of each of the profiled fieldbus protocol families.

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

– IEC 61784, Annex A: Common concepts
– IEC 61784, communication profile family
– IEC 61158, Parts 2 to 6, for the particular fieldbus type 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;
– 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;
– modular concepts support future enhancements, extensions and adaptation of new technologies.

5 Structure of IEC 61158 series

Conceptually, a fieldbus is a digital, serial, multidrop, data bus for communication with industrial control and instrumentation devices such as — but not limited to — transducers, 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 on a shared medium. Devices communicate directly only with other devices of the same protocol type.

NOTE 1 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.

NOTE 2 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. Use of the various protocol types in other combinations may require permission from their respective copyright holders.

These protocol types 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.

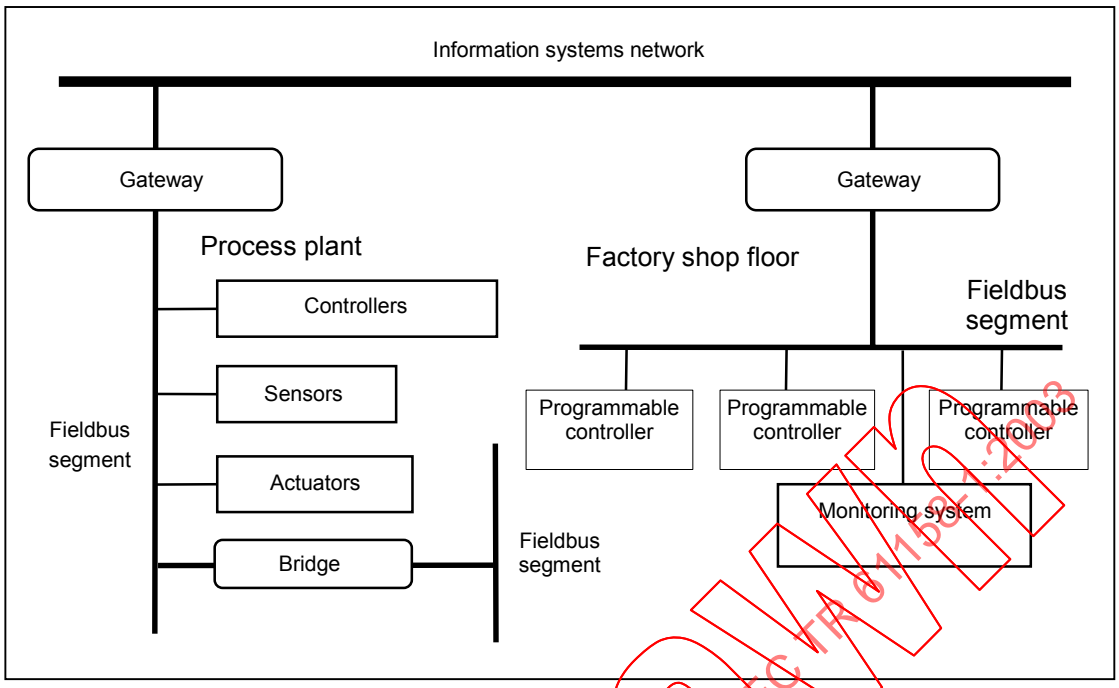

Figure 1 – Generic fieldbus network

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, 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. 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 view and the Service parts show the Layer user's view.

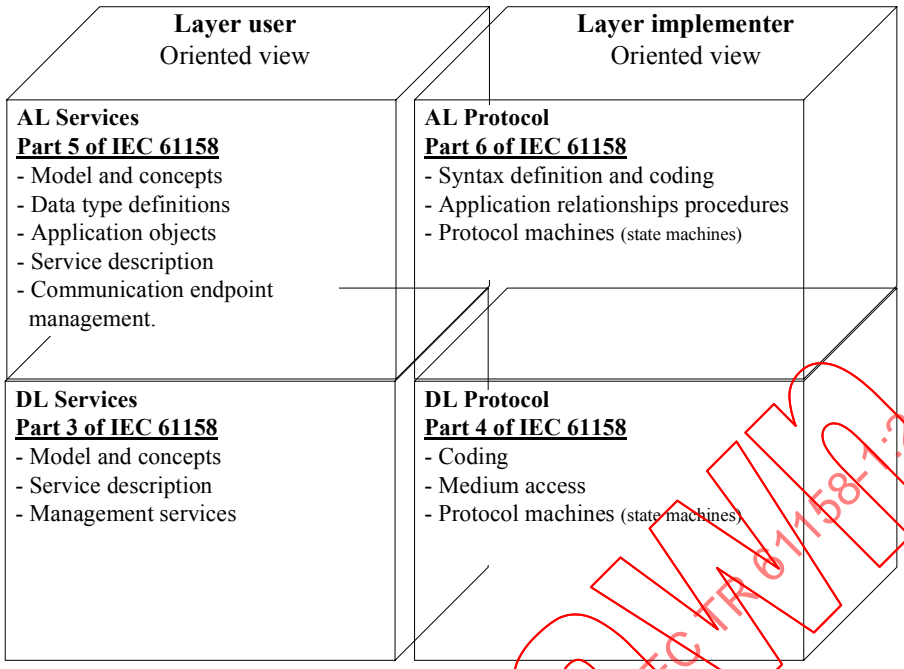

Figure 2 – Concept of DL/AL to separate service and protocol parts

The Application Layer structure is as follows:

– the "What" is described by Application Service Elements (ASE); and

– the "How" is described by Application Relationships (AR).

The Data Link Layer structure is as follows:

– the "What" is described by Data Link services and models; and

– the "How" is described by Data Link protocol machines and medium access principles.

The Physical Layer is structured similarly, but, because its services are readily described, they occur in the same specification (IEC 61158-2) as the definitions of the physical protocols.

– The "What" is described by PhL services and models, and

– The "How" is described by PhL electromagnetic and mechanical specifications.

6 Mapping onto the OSI basic reference model

IEC 61158 protocol types are described using the principles, methodology and model of ISO/IEC 7498. 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 – 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, -6)
6 Presentation	Converts data to/from standardized network formats	↑
5 Session	Synchronizes and manages data	↑
4 Transport	Provides transparent reliable data transfer	↓ or ↑
3 Network	Performs message routing	↓ or ↑
2 Data link	Controls access to the communication medium. Performs error detection	Data link (IEC 61158-3, -4)
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 ↓ and ↑ indicate that the functionality of this layer, when present, may be included in the fieldbus layer that is nearest in the direction of the arrow. Thus network and transport functionality may be included in either the Data Link or Application Layers, while session and presentation functionality may be included in the Application Layer, but not in the Data Link Layer.		

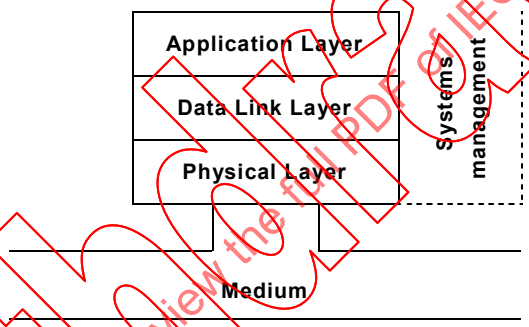

Figure 3 – Basic fieldbus reference model

7 Structure of IEC 61158

7.1 The IEC 61158 Physical Layer

The IEC 61158 Physical Layer receives data units from the Data Link Layer, encapsulates them if necessary by adding communications framing information, encodes the bits and framing information into signals, and transmits the resulting physical signals to the transmission medium connected to the transmitting node.

Signals are then received at one or more other node(s) and decoded, and any communications framing information is checked and removed, before the data units are passed to the Data Link Layer of the receiving device.

IEC 61158-2 comprises Physical Layer specifications to support the DL-protocol types specified in the IEC 61158 Data Link Layer. It defines the services provided

a) to the various types of fieldbus Data Link Layer at the boundary between the Data Link and Physical Layers of the fieldbus Reference Model, and

b) to Systems Management at the boundary between the Physical Layer and Systems Management of the fieldbus Reference Model.

NOTE This combination of Physical Service definition and Physical protocol specification into a single document is a historic anomaly; it is not common standards practice.