IEC/TR 61158-1

Edition 3.0 2010-08

TECHNICAL REPORT

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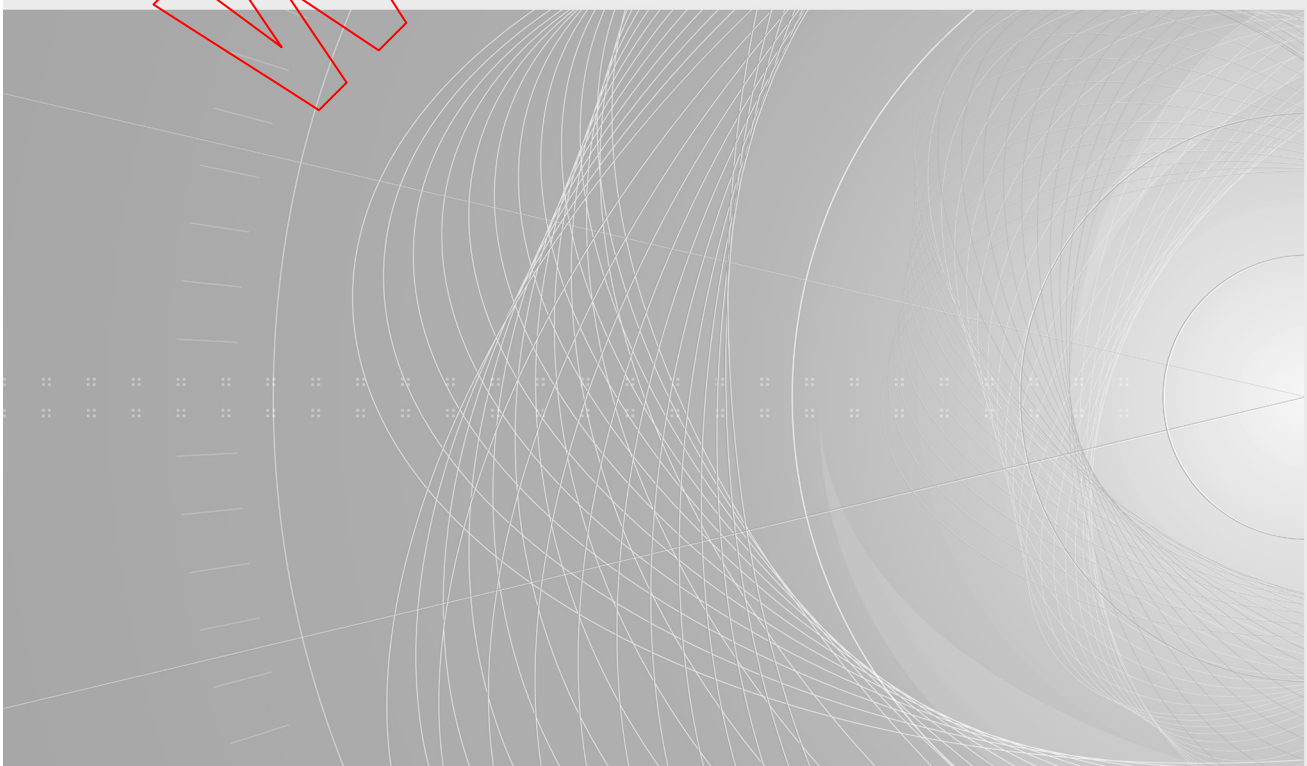
Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series



IEC/TR 61158-1:2010(E)

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XB

ICS 25.040; 35.100; 35.240.50

ISBN 978-2-88912-137-3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

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

FOREWORD

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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 its profile parts. Use of the various protocol types in other combinations may require permission of their respective intellectual-property-right holders.

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

This third edition cancels and replaces the second edition published in 2007. It constitutes a technical revision.

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

- Updates of the references to the IEC 61158 series, IEC 61784-1, IEC 61784-3, IEC 61784-5 series and IEC 61918 throughout the document;
- new Type 21 and the related profile family CPF 17;
- new Type 22 and the related profile family CPF 18.

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

Enquiry draft	Report on voting
65C/590A/DTR	65C/608/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.

A list of all the parts in 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;
- replaced by a revised edition, or
- amended.

NOTE The revision of this technical report will be synchronized with the other parts of the IEC 61158 series.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

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

1 Scope

This technical report 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 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 parts of the IEC 61158-5 series.

2 Normative references

None

3 Abbreviations

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

AL	**Application layer (N = 7)**
AR	**Application relationship**
AREP	**Application relationship endpoint**
DL-	**Data-link layer (as a prefix)**
DLL	**Data-link layer (N = 2)**
IETF	**Internet Engineering Task Force**
IP	**Internet Protocol (see RFC 791)**
(*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)**

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 8886 for data-link layer modeling.

The IEC 61158 series specifies a number of different fieldbus types in each of the parts of the series (part 2 and the parts of part 3 through part 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 methods.

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 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 Technical Report
- 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
- IEC 61158 series as appropriate 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;
- 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 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 61784-1 and IEC 61784-2. 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.

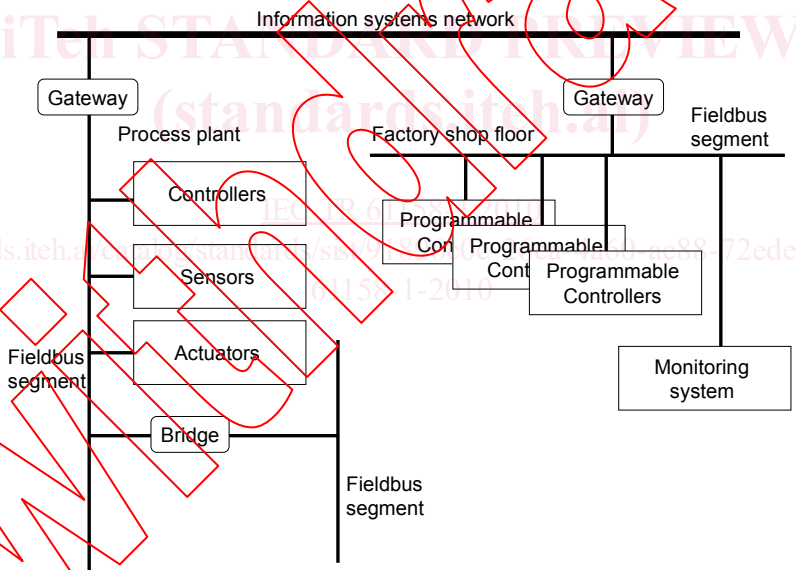

Figure 1 – Generic fieldbus network

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 61784-1 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 view and the service parts show the layer user's view.

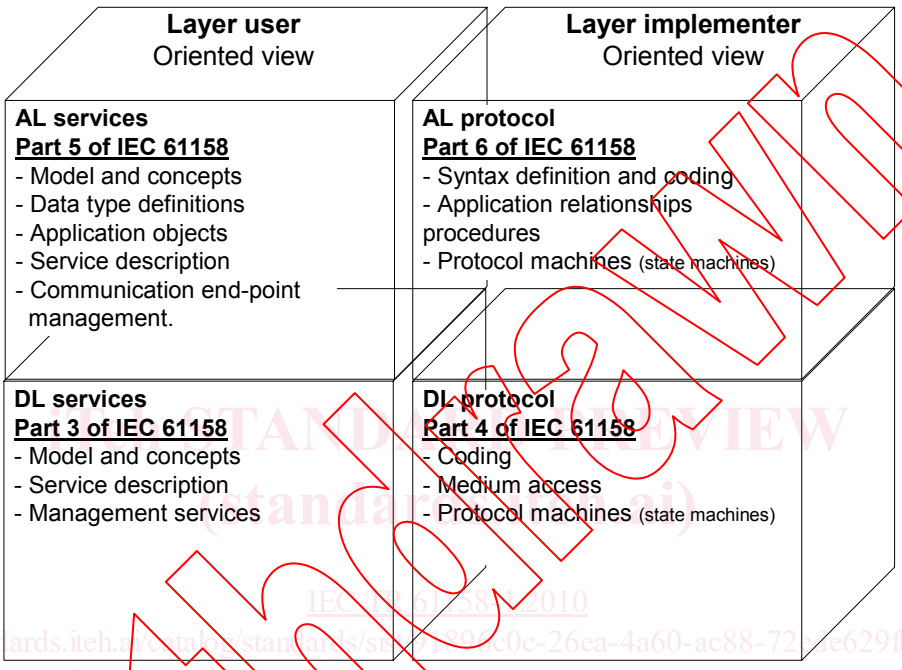

Figure 2 – Concept of DL/AL to separate service and protocol parts

The application layer structure is as follows:

– the "what" is described by application layer service elements (ASE); and

– the "how" is described by application layer relationships (AR).

The data-link layer structure is as follows:

– the "what" is described by data-link layer services and models; and

– the "how" is described by data-link layer 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 physical layer services and models, and

– the "how" is described by physical layer electromagnetic 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. 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)

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

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.

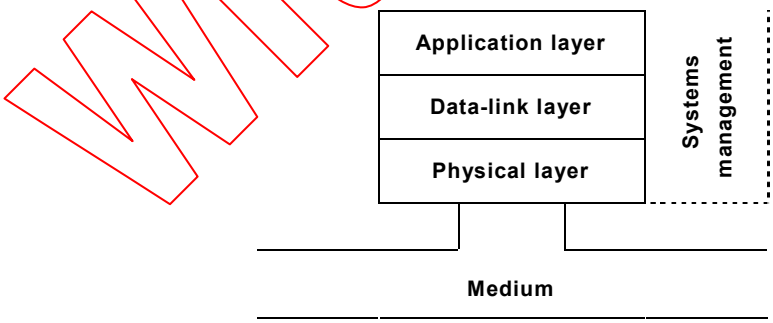

Figure 3 – Basic fieldbus reference model

6.2 Physical layer service and protocol

This technical report comprises physical layer specifications corresponding to many of the different DL-Layer protocol types specified in IEC 61158-4-1 to IEC 61158-4-19.

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

NOTE 2 Some specifications for types 1, 2, 3, 4, 8, 12, 16 and 18 are included. Some of these types also use ISO/IEC 8802-3. Type 7 uses Type 1 specifications. The other types do not use any of the specifications given in this report.

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 this report to select interoperating sets of provisions. Refer to the IEC 61784 series for standardized communication profiles based on the IEC 61158 series.

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

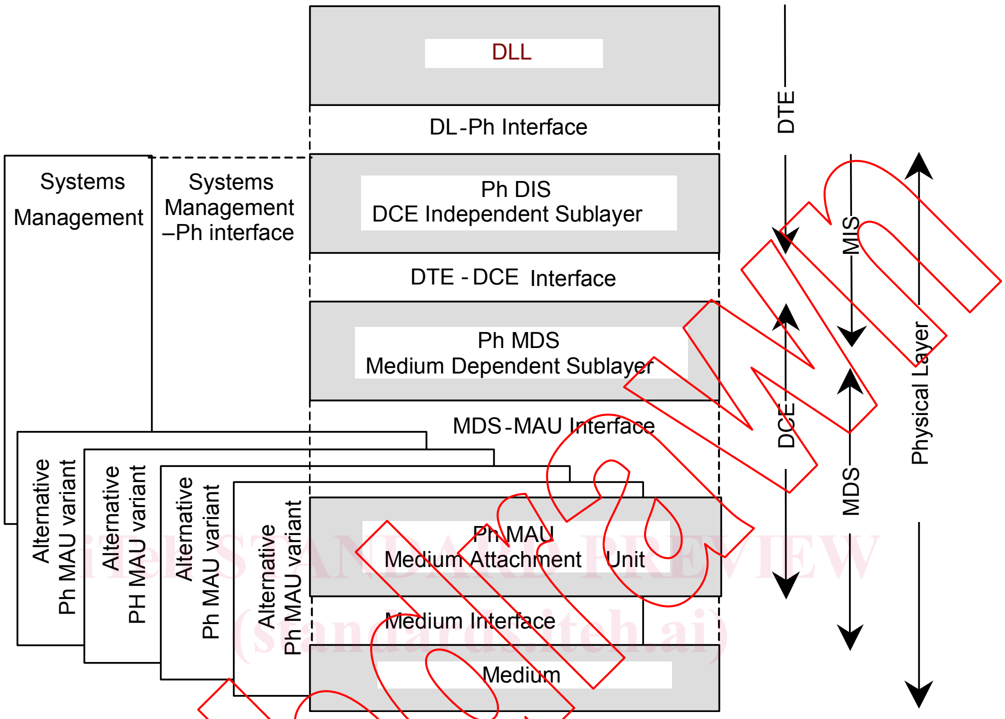

Figure 4 – General model of physical layer

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;
– no separate clock transmission;
– 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.

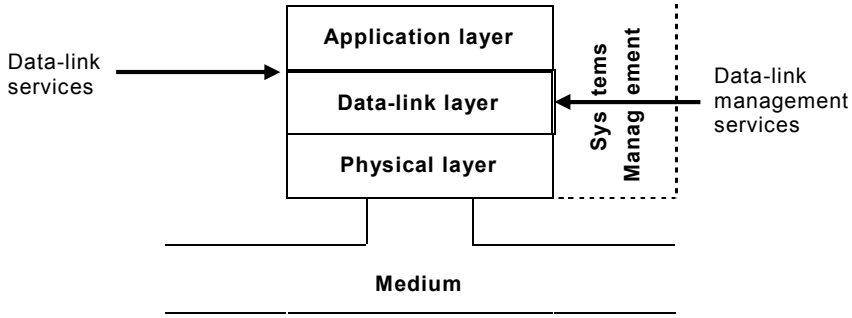

Figure 5 – Relationship of the IEC 61158-3 and IEC 61158-4 series to other fieldbus layers and to users of the fieldbus data-link service

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, the data-link service defined in this report 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 Systems management, as used in the IEC 61158 series, is a local mechanism for managing the layer protocols.

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 of standards, is a local mechanism for managing the layer protocols.