

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

Part 2: Physical layer specification and service definition

The European Standard EN 61158-2:2004 has the status of a
British Standard

ICS 25.040; 35.100; 35.240.50

National foreword

This British Standard is the official English language version of EN 61158-2:2004. It is identical with IEC 61158-2:2004. It supersedes BS EN 61158-2:1994, which is withdrawn. It, together with BS EN 61158-3:2004, BS EN 61158-4:2004, BS EN 61158-5:2004, BS EN 61158-6:2004 and BS EN 61784-1:2004 supersedes BS EN 50170:1997 and BS EN 50254:1999, which are withdrawn

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English version

**Digital data communications for measurement and control -
Fieldbus for use in industrial control systems
Part 2: Physical layer specification and service definition
(IEC 61158-2:2003 + corrigendum 2004)**

Communications numériques pour les
systèmes de mesure et de commande -
Bus de terrain utilisés dans les systèmes
de commande industriels
Partie 2: Spécification de la couche
physique
(CEI 61158-2:2003 + corrigendum 2004)

Digitale Datenkommunikation
in der Leittechnik -
Feldbus für industrielle Leitsysteme
Teil 2: Spezifikation der
Bitübertragungsschicht (Physical Layer)
(IEC 61158-2:2003 + Corrigendum 2004)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

The text of the International Standard IEC 61158-2:2003, prepared by SC 65C, Digital communications, of IEC TC 65, Industrial-process measurement and control, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 61158-2 on 2004-03-16 with inclusion of the accepted future IEC corrigendum.

This European Standard supersedes EN 61158-2:1994 + A1:1996 + A2:1996.

This European Standard, together with EN 61158-3:2004 to EN 61158-6:2004 and EN 61784-1:2004, supersedes EN 50170:1996 + A1:2002 (+ corr. Aug. 2002) + A2:1999 + A3:2002 (+ corr. Aug. 2002) and EN 50254:1998.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-04-01

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Type 2 (subclauses 5.3, 9.4, 10.4, Clauses 18 through 20, Annex F through Annex H):

5,396,197 [AB] Network Node TAP

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IEC 60793	NOTE Harmonized in 60793 series (partially modified).
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IEC 61596	NOTE Harmonized as EN 61596:1997 (not modified).
IEC 61784	NOTE Part 1 harmonized as EN 61784-1:2004 (not modified).

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61158-2:2003 and its corrigendum July 2004 was approved by CENELEC as a European Standard without any modification.

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0 Introduction

0.1 General

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components by fieldbus networks. It is related to other parts in the set as defined by the fieldbus Reference Model, which is based in principle on the Reference Model for Open Systems Interconnection. Both Reference Models subdivide the area of standardization for interconnection into a series of layers of specification, each of manageable size.

0.2 Fieldbus overview

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 local controllers. The Physical Layer specified in this International Standard provides for transparent transmission of data units between Data Link Layer entities across physical connections. The PhL provides services used by Data Link Protocol and Systems Management. The relationship between the fieldbus Data Link Layer standard, fieldbus Physical Service standard and Systems Management application is illustrated in Figure 1.

NOTE Systems Management, as used in this standard, is a local mechanism for managing the layer protocols.

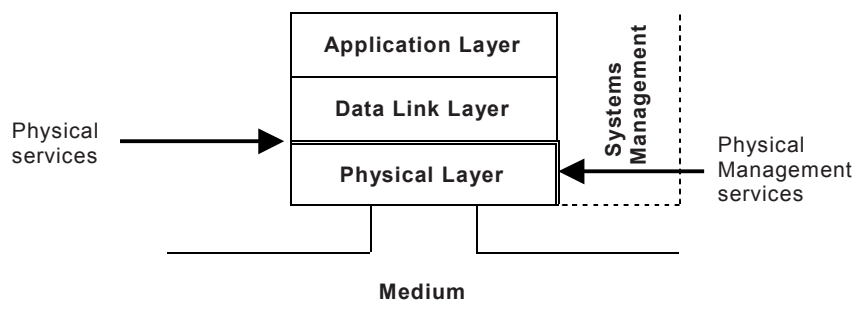


Figure 1 – Relationship of IEC 61158-2 to other fieldbus layers and to users of the fieldbus Physical layer service

0.3 Physical Layer overview

The primary aim of this International Standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer Ph-entities at the time of communication.

The Physical Layer receives data units from the Data Link Layer, encodes them, if necessary by adding communications framing information, and transmits the resulting physical signals to the transmission medium at one node. Signals are then received at one or more other node(s), decoded, if necessary by removing the communications framing information, before the data units are passed to the Data Link Layer of the receiving device.

0.4 Document overview

This International Standard comprises Physical Layer specifications corresponding to the different DL-Layer protocol types specified in IEC 61158-4.

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

NOTE 2 Specifications for Types 1, 2, 3, 4, 6 and 8 are included. Type 5 does not use any of the specifications given in this standard. Type 7 uses Type 1 specifications.

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 International Standard to select for interworking sets of provisions. Refer to IEC 61784 for standardized communication profiles based on IEC 61158.

A general model of the Physical Layer is shown in Figure 2.

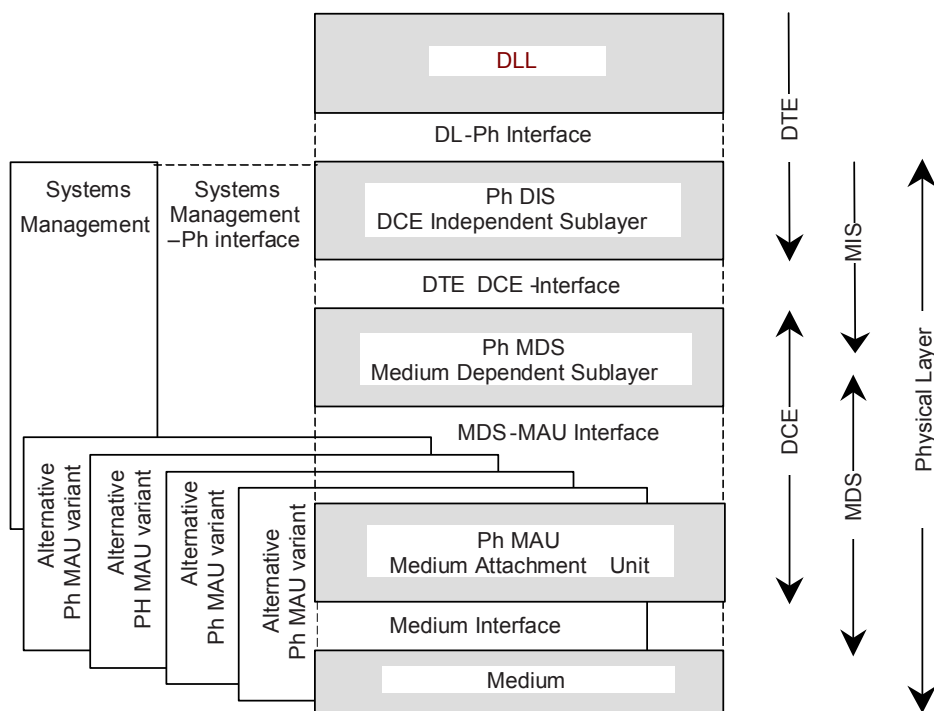


Figure 2 – General model of Physical Layer

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

0.5 Major Physical Layer variations specified in this part of IEC 61158

0.5.1 Type 1 media

0.5.1.1 Type 1: twisted-pair wire, optical and radio media

For twisted-pair wire media, Type 1 specifies two modes of coupling and different signalling speeds as follows:

- a) voltage mode (parallel coupling), 150 Ω , data rates from 31,25 kbit/s to 25 Mbit/s;
- b) voltage mode (parallel coupling), 100 Ω , 31,25 kbit/s;
- c) current mode (serial coupling), 1,0 Mbit/s including two current options.

The voltage mode variations may be implemented with inductive coupling using transformers. This is not mandatory if the isolation requirements of this part of IEC 61158 are met by other means.

The Type 1 twisted-pair (or untwisted-pair) wire medium Physical Layer provides the options:

- no power via the bus conductors; not intrinsically safe;
- power via the bus conductors; not intrinsically safe;
- no power via the bus conductors; intrinsically safe;
- power via the bus conductors; intrinsically safe.

0.5.1.2 Type 1: optical media

The major variations of the Type 1 optic fibre media are as follows:

- dual fibre mode, data rates from 31,25 kbit/s to 25 Mbit/s;
- single fibre mode, 31,25 kbit/s.

0.5.1.3 Type 1: radio media

The Type 1 radio medium specification provides a 4,8 kbit/s bit rate.

0.5.2 Type 2: coaxial wire and optical media

Type 2 specifies the following variants:

- coaxial copper wire medium, 5 Mbit/s
- optical fibre medium, 5 Mbit/s
- Network Access Port (NAP), a point-to-point temporary attachment mechanism that can be used for programming, configuration, diagnostics or other purposes
- Repeater machine sublayers (RM, RRM) and redundant Physical Layers.

0.5.3 Type 3: twisted-pair wire and optical media

Type 3 specifies the following synchronous transmission:

- a) twisted-pair wire medium, 31,25 kbit/s, voltage mode (parallel coupling) with the options:
 - power via the bus conductors: not intrinsically safe
 - power via the bus conductors: intrinsically safe

and the following asynchronous transmission variants:

- b) twisted-pair wire medium, up to 12 Mbit/s, ANSI TIA/EIA-485-A
- c) optical fibre medium, up to 12 Mbit/s

0.5.4 Type 4: wire medium

Type 4 specifies wire media with the following characteristics:

- RS-485 wire medium up to 76,8 kbit/s
- RS-232 wire medium up to 230,4 kbit/s

0.5.5 Type 6: wire medium

Type 6 specifies wire media with the following characteristics:

- RS 485 wire medium up to 5 Mbit/s

The characteristics for wire media are as follows:

- half-duplex communication (bi-directional but in only one direction at a time)
- Manchester coding

0.5.6 Type 8: twisted-pair wire and optical media

The Physical Layer also allows transmitting data units that have been received through a medium access by the transmission medium directly through another medium access and its transmission protocol to another device.

Type 8 specifies the following variants:

- twisted-pair wire medium, up to 16 Mbit/s;
- optical fibre medium, up to 16 Mbit/s;

The general characteristics of these transmission media are as follows:

- full-duplex transmission
- Non Return to Zero (NRZ) coding

The wire media type provides the following options:

- No power supply via the bus cable, not intrinsically safe
- Power supply via the bus cable and on additional conductors, not intrinsically safe

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

Part 2: Physical Layer specification and service definition

1 Scope

This part of IEC 61158 specifies the requirements for fieldbus component parts. It also specifies the media and network configuration requirements necessary to ensure agreed levels of

- a) data integrity before Data Link Layer error checking;
- b) interoperability between devices at the Physical Layer.

The fieldbus Physical Layer conforms to layer 1 of the OSI 7-layer model as defined by ISO 7498 with the exception that, for some types, frame delimiters are in the Physical Layer while for other types they are in the Data Link Layer.

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 60050(131):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 131: Electric and magnetic circuits*

IEC 60050-731:1991, *International Electrotechnical Vocabulary, Chapter 731: optical fibre communication*

IEC 60079, *Electrical apparatus for explosive gas atmospheres*

IEC 60079-11, *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety “i”*

IEC 60079-27, *Electrical apparatus for explosive gas atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO)*

IEC 60096-1, *Radio-frequency cables – Part 1: General requirements and measuring methods*

IEC 60169-8, *Radio-frequency connectors – Part 8: RF coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with bayonet lock – Characteristic impedance 50 ohms (Type BNC)*

IEC 60189-1:1986, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*

IEC 60255-22-1:1988, *Electrical relays – Part 22-1: Electrical disturbance tests for measuring relays and protection equipment – 1 MHz burst disturbance tests*

IEC 60364-4-41, *Electrical installations of buildings – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-5-54, *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60603-7, *Connectors for frequencies below 3 MHz for use with printed boards – Part 7: Detail specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality*

IEC 60760, *Flat, quick-connect terminations*

IEC 60793-2:2001, *Optical fibres – Part 2: Product specifications*

IEC 60807-3, *Rectangular connectors for frequencies below 3 MHz – Part 3: Detail specification for a range of connectors with trapezoidal shaped metal shells and round contacts – Removable crimp contact types with closed crimp barrels, rear insertion/rear extraction*

IEC 60874, *Connectors for optical fibres and cables*

IEC 60874-2, *Connectors for optical fibres and cables — Part 2: Sectional specification for fibre optic connector – Type F-SMA*

IEC 60874-7, *Connectors for optical fibres and cables — Part 7: Sectional specification for fibre optic connector - Type FC*

IEC 60874-10-1, *Connectors for optical fibres and cables — Part 10-1: Detail specification for fibre optic connector type BFOC/2,5 terminated to multimode fibre type A1*

IEC 60947-5-2, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 61000-4, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques — Part 4-2: Electrostatic discharge immunity test – Basic EMC Publication*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques — Part 4-3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques — Part 4-4: Electrical fast transient/burst immunity test – Basic EMC Publication*

IEC 61131-2:1992, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61156-1:1994, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61158, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems*

IEC 61158-3:2003, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems — Part 3: Data Link Service definition*

IEC 61158-4:2003, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems — Part 4: Data Link protocol specification*

IEC 61300-34:2001, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examinations and measurements – Attenuation*

IEC 61754-2, *Fibre optic connector interfaces – Part 2: Type BFOC/2,5 connector family*

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

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic reference model – Conventions for the definition of OSI services*

ANSI TIA/EIA-232-F, *Interface Between Data Terminal Equipment and Data Circuit – Terminating Equipment Employing Serial Binary Data Interchange*

ANSI TIA/EIA-422-B, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

ANSI TIA/EIA-485-A, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

IEEE Std 100:1996, *The IEEE Standard Dictionary of Electrical and Electronics Terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions of ISO/IEC 7498, and the following definitions apply.

3.1 Common terms and definitions

NOTE Many definitions are common to more than one protocol type; they are not necessarily used by all protocol types.

3.1.1 activity

presence of a signal or noise at the input terminals of a fieldbus device that is of a level that is above the receiver signal level threshold of that device

3.1.2 barrier

physical entity that limits current and voltage into a hazardous area in order to satisfy Intrinsic Safety requirements

3.1.3 bus

trunk and all devices connected to it

3.1.4 cable plant interface connector (CPIC)

point at which test and conformance measurements are made and that the interface between the network device and the cable plant

3.1.5 communication element

part of a fieldbus device that communicates with other elements via the bus

3.1.6 connector

coupling device employed to connect the medium of one circuit or communication element with that of another circuit or communication element
[IEEE Std 100-1996, modified]

3.1.7 coupler

physical interface between trunk and spur or trunk and device

3.1.8 Data Communications Equipment (DCE)

embodiment of the media, modulation and coding-dependent portion of a fieldbus-connected device, comprising the lower portions of the Physical Layer within the device

3.1.9 Data Terminal Equipment (DTE)

embodiment of the media, modulation and coding-independent portion of a fieldbus-connected device, comprising the uppermost portion of the Physical Layer and all higher layers within the device

3.1.10 decibel(milliwatt) [dB(mW)]

a logarithmic unit of power, referenced to 1 mW. Also written **dBm**.

$$P_{\text{dBm}} = 10 \log (P_{\text{mW}})$$

NOTE If P_{mW} is the measured power in mW, then P_{dBm} is the power expressed logarithmically in dB(mW), or equivalently, dBm.

3.1.11 delimiter

flag that separates and organizes items of data

3.1.12 device

physical entity connected to the fieldbus composed of at least one communication element (the network element) and which may have a control element and/or a final element (transducer, actuator, etc.)

NOTE A device may contain more than one node.

3.1.13 effective launch power

effective power coupled into the core of a fibre optic waveguide by the transmitter. This power is measured with a standard test fibre connected to the CPIC

3.1.14 effective power

the difference, expressed in DBm, between the absolute optical power measured in milliwatt at the midpoint in time of the Hi level to the absolute optical power measured in milliwatt at the midpoint of the Lo level

NOTE Effective power is believed to give a more accurate measurement of the conditions that affect the receivers than traditional measurements, such as peak and average power. methods for measuring effective power are for further study.

3.1.15 extinction ratio

ratio of the absolute optical power measured in milliwatt at the midpoint in time of the Hi level to the absolute optical power measured in milliwatt at the midpoint in time of the Lo level.

NOTE The following gives an example of the computation of effective power and extinction ratio. If the midpoint of Hi level is measured as 105 μW , and if the midpoint of Lo level is measured as 5 μW , then the difference is 100 μW . Therefore, the effective power is $10 \log ((100 \mu\text{W}) / 1 \text{ mW})$, which equals -10,0 dBm. The extinction ratio is (105/5), which equals 21:1.

3.1.16 fibre optic cable

cable containing one or more fibre optic waveguides with jacketing material provided to facilitate handling and to protect the fibre

3.1.17 fibre optic receiver

combined optics and electronics in the communicating device that accept the optical signal received by the communicating device through the CPIC

3.1.18 fibre optic receiver operating range

range of optical power that must be present at the CPIC to ensure that the bit error rate specifications are met

3.1.19 fibre optic transmitter

device that emits optical signals for propagation into a fibre optic waveguide through the CPIC

3.1.20 fibre optic waveguide

flexible, optically transparent strand that is used to transport optical signals from one geographic point to another geographic point

3.1.21 frame

set of consecutive digit time slots in which the position of each digit time slot can be identified by reference to a framing signal
[IEEE Std 100-1996]

3.1.22 Intrinsic Safety

design methodology for a circuit or an assembly of circuits in which any spark or thermal effect produced under normal operating and specified fault conditions is not capable under prescribed test conditions of causing ignition of a given explosive atmosphere
[IEC 60079-11]

3.1.23 isolation

physical and electrical arrangement of the parts of a signal transmission system to prevent electrical interference currents within or between the parts
[IEEE Std 100-1996]

3.1.24 jabber

continuous transmission on the medium due to a faulty device

3.1.25 jitter

offset of the 50 % transition points of pulse edges from their ideal position as the result of all causes

3.1.26 Manchester encoding

means by which separate data and clock signals can be combined into a single, self-synchronizing data stream, suitable for transmission on a serial channel

3.1.27 medium

cable, optical fibre, or other means by which communication signals are transmitted between two or more points

NOTE In this part of IEC 61158 "media" is used only as the plural of medium.

3.1.28 network

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

3.1.29 node

end-point of a branch in a network or a point at which one or more branches meet
[IEV 131-02-04]

3.1.30 optical active star

active device in which a signal from an input fibre is received, amplified and retransmitted to a larger number of output optical fibres. Retiming of the received signal is optional.

3.1.31 optical fall time

time it takes for a pulse to go from 90 % effective power to 10 % effective power, specified as a per cent of the nominal bit time

3.1.32 optical passive star

passive device in which signals from input fibres are combined and then distributed among output optical fibres

3.1.33 optical rise time

time it takes for a pulse to go from 10 % effective power to 90 % effective power, specified as a per cent of the nominal bit time

3.1.34 peak emission wavelength (λ_p)

wavelength at which radiant intensity is maximized

3.1.35 receiver

receive circuitry of a communication element

3.1.36 repeater

Two-port active Physical Layer device that receives and retransmits all signals to increase the distance and number of devices for which signals can be correctly transferred for a given medium

3.1.37 segment

trunk-cable section of a fieldbus that is terminated in its characteristic impedance

NOTE Segments are linked by repeaters within a logical link and by bridges to form a fieldbus network

3.1.38 separately powered device

device that does not receive its operating power via the fieldbus signal conductors

3.1.39 shield

surrounding earthed metallic layer to confine the electric field within the cable and to protect the cable from external electrical influence

NOTE Metallic sheaths, armours and earthed concentric conductors may also serve as a shield.

3.1.40 spur

branch-line (i.e. a link connected to a larger one at a point on its route) that is a final circuit

NOTE The alternative term 'drop cable' is used in this part of IEC 61158.

3.1.41 terminator

resistor connecting conductor pairs at both ends of a wire medium segment to prevent reflections from occurring at the ends of cables

NOTE For Type 2 the terminator is mounted in a BNC plug.

3.1.42 transceiver

combination of receiving and transmitting equipment in a common housing employing common circuit components for both transmitting and receiving [IEEE Std 100-1996 modified for non-radio use]

NOTE A medium attachment unit can be the transceiver or can contain the transceiver, depending on Type and implementation.

3.1.43 transmitter

transmit circuitry of a communication element

3.1.44 trunk

main communication highway acting as a source of main supply to a number of other lines (spurs)

3.1.45 typical half-intensity wavelength ($\Delta\lambda$)

range of wavelength of spectral distribution in which the radiant intensity is no less than one-half of the maximum intensity

3.2 Type 1: Terms and definitions

3.2.1	activity	[see 3.1.1]
3.2.2	barrier	[see 3.1.2]
3.2.3	bus	[see 3.1.3]
3.2.4	cable plant interface connector (CPIC)	[see 3.1.4]
3.2.5	communication element	[see 3.1.5]
3.2.6	connector	[see 3.1.6]
3.2.7	coupler	[see 3.1.7]
3.2.8	Data Communications Equipment (DCE)	[see 3.1.8]
3.2.9	Data Terminal Equipment (DTE)	[see 3.1.9]
3.2.10	dBm	[see 3.1.10]
3.2.11	delimiter	[see 3.1.11]
3.2.12	device	[see 3.1.12]
3.2.13	effective launch power	[see 3.1.13]
3.2.14	effective power	[see 3.1.14]
3.2.15	fibre optic cable	[see 3.1.15]
3.2.16	fibre optic receiver	[see 3.1.17]
3.2.17	fibre optic receiver operating range	[see 3.1.18]
3.2.18	fibre optic transmitter	[see 3.1.19]
3.2.19	fibre optic waveguide	[see 3.1.20]
3.2.20	frame	[see 3.1.21]

3.2.21 Gaussian Minimum Shift Keying

form of frequency modulation where a 1 is represented by a frequency of F_c+f and a 0 is represented by F_c-f where f is equal to the bit rate divided by 4 and where the modulating frequency is first passed through a Gaussian filter before being imposed on the carrier

3.2.22 Intrinsic Safety [see 3.1.22]

3.2.23 isolation [see 3.1.23]

3.2.24 jabber [see 3.1.24]

3.2.25 low speed radio medium fieldbus

fieldbus physical layer covered by this standard operating at the lower of the standard bit rates as defined in 21.2

3.2.26 Manchester encoding [see 3.1.25]

3.2.27 medium [see 3.1.27]

3.2.28 network [see 3.1.28]

3.2.29 node [see 3.1.29]

3.2.30 optical fall time [see 3.1.30]

3.2.31 optical rise time [see 3.1.32]

3.2.32 peak emission wavelength (λ_p) [see 3.1.34]

3.2.33 repeater [see 3.1.36]

3.2.34 segment [see 3.1.37]

3.2.35 separately powered device [see 3.1.38]

3.2.36 shield [see 3.1.39]

3.2.37 spur [see 3.1.40]

3.2.38 terminator [see 3.1.41]

3.2.39 transceiver [see 3.1.41]

3.2.40 transmitter [see 3.1.43]

3.2.41 trunk [see 3.1.44]

3.3 Type 2: Terms and definitions

3.3.1 activity [see 3.1.1]

3.3.2 bit

unit of data consisting of a 1 or a 0

NOTE A bit is the smallest data unit that can be transmitted

3.3.3 blanking or blanking time

length of time required after transmitting before a node is allowed to receive

3.3.4 bus	[see 3.1.3]
3.3.5 communication element	[see 3.1.5]
3.3.6 connector	[see 3.1.6]
3.3.7 Data Communications Equipment (DCE)	[see 3.1.8]
3.3.8 dBm	[see 3.1.10]
3.3.9 delimiter	[see 3.1.11]
3.3.10 device	[see 3.1.12]

3.3.11 end delimiter

unique sequence of symbols that identifies the end of a frame

3.3.12 end node

producing or consuming node

3.3.13 error

discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.3.14 frame	[see 3.1.21]
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3.3.15 isolation	[see 3.1.23]
-------------------------	--------------

3.3.16 jabber	[see 3.1.24]
----------------------	--------------

3.3.17 Manchester encoding	[see 3.1.25]
-----------------------------------	--------------

3.3.18 medium	[see 3.1.27]
----------------------	--------------

3.3.19 M_symbol

representation of the MAC data bits to be encoded and transmitted by the Physical Layer

3.3.20 MAC frame

collection of M_symbols transmitted on the medium that contains a preamble, start delimiter, data, CRC and end delimiter

3.3.21 network	[see 3.1.28]
-----------------------	--------------

3.3.22 network access port

Physical Layer variant that allows a temporary node to be connected to the link by connection to the NAP of a permanent node

3.3.23 node	[see 3.1.29]
--------------------	--------------

NOTE A node is additionally a connection to a link that requires a single M_ID

3.3.24 non-data symbol

Physical Layer Manchester coded signal, used for delimiters, carrying no data

3.3.25 optical isolators, optos

components located within the Physical Layer transceiver of a node that converts current into light, and then back to an electrical signal

3.3.26 permanent node

node whose connection to the network does not utilize the network access port (NAP)
Physical Layer variant

NOTE This node may optionally support a NAP Physical Layer variant to allow temporary nodes to connect to the network.

3.3.27 redundant media

more than one medium to minimize communication failures

3.3.28 repeater

[see 3.1.36]

3.3.29 segment

[see 3.1.37]

3.3.30 shield

[see 3.1.39]

3.3.31 slot time

maximum time required for detecting an expected transmission

NOTE Each node waits a slot time for each missing node during the implied token pass.

3.3.32 spur

[see 3.1.40]

NOTE This is an integral part of network taps.

3.3.33 start delimiter

unique sequence of symbols that identifies the beginning of a frame

3.3.34 tap

point of attachment from a node or spur to the trunk cable

NOTE A tap provides easy removal of a node without disrupting the link.

3.3.35 terminator

[see 3.1.41]

3.3.36 tool

executable software program that interacts with the user to perform some function

3.3.37 transceiver

[see 3.1.41]

3.3.38 transient node

node that is only intended to be connected to the network on a temporary basis using the NAP
Physical Layer medium connected to the NAP of a permanent node

3.3.39 transmitter

[see 3.1.43]

3.3.40 trunk

[see 3.1.44]

3.3.41 trunk cable

bus or central part of a cable system

3.3.42 trunk-cable section

length of trunk cable between any two taps

3.4 Type 3: Terms and definitions

3.4.1 activity	[see 3.1.1]
3.4.2 barrier	[see 3.1.2]
3.4.3 bit time time to transmit one bit	
3.4.4 bus	[see 3.1.3]
3.4.5 communication element	[see 3.1.5]
3.4.6 confirmation (primitive)	[ISO/IEC 10731]
3.4.7 connector	[see 3.1.6]
3.4.8 coupler	[see 3.1.7]
3.4.9 Data Communications Equipment (DCE)	[see 3.1.8]
3.4.10 Data Terminal Equipment (DTE)	[see 3.1.9]
3.4.11 dBm	[see 3.1.10]
3.4.12 device	[see 3.1.12]
3.4.13 DL-entity	[ISO/IEC 7498-1]
3.4.14 fibre optic cable (FOC)	[see 3.1.15]
3.4.15 frame	[see 3.1.21]
3.4.16 indication (primitive)	[ISO/IEC 10731]
3.4.17 Intrinsic Safety	[see 3.1.22]
3.4.18 isolation	[see 3.1.23]
3.4.19 jabber	[see 3.1.24]
3.4.20 medium	[see 3.1.27]
3.4.21 (N)-entity	[ISO/IEC 7498-1]
3.4.22 (N)-service	[ISO/IEC 7498-1]
3.4.23 network	[see 3.1.28]
3.4.24 node	[see 3.1.29]
3.4.25 Ph-entity	[ISO/IEC 7498-1]
3.4.26 Ph-service	[ISO/IEC 7498-1]
3.4.27 repeater	[see 3.1.36]
3.4.28 request (primitive)	[ISO/IEC 10731]
3.4.29 reset	[ISO/IEC 7498-1]
3.4.30 segment	[see 3.1.37]
3.4.31 separately powered device	[see 3.1.38]

3.4.32 shield [see 3.1.39]

3.4.33 spur [see 3.1.40]

3.4.34 station

node

3.4.35 terminator [see 3.1.41]

3.4.36 transceiver [see 3.1.41]

3.4.37 transmitter [see 3.1.43]

3.4.38 trunk [see 3.1.44]

3.5 Type 4: Terms and definitions

3.5.1 activity [see 3.1.1]

3.5.2 bus [see 3.1.3]

3.5.3 connector [see 3.1.6]

3.5.4 Data Communications Equipment (DCE) [see 3.1.8]

3.5.5 Data Terminal Equipment (DTE) [see 3.1.9]

3.5.6 device [see 3.1.12]

3.5.7 idle counter

counter to measure the number of bit periods for which the signal level on the physical link has been high for normal class and simple class devices in half duplex mode

3.5.8 isolation [see 3.1.23]

3.5.9 medium [see 3.1.27]

3.5.10 network [see 3.1.28]

3.5.11 normal class device

a device that initiates transmission and replies to requests and that can act as a server (responder) and as a client (requestor) - this is also called a peer

3.5.12 shield [see 3.1.39]

3.5.13 simple class device

a device that replies to requests from Normal Class Devices and acts as a server or responder only

3.5.14 transmitter [see 3.1.43]

3.6 Type 6: Terms and definitions

3.6.1 activity [see 3.1.1]

3.6.2 bus

one or more connected (by repeaters) Ph-segments

3.6.3 communication element [see 3.1.5]

3.6.4 connector [see 3.1.6]

3.6.5 delimiter [see 3.1.11]

3.6.6 device

physical entity connected to the fieldbus composed of communication element and possibly other functional elements

3.6.7 frame [see 3.1.21]

3.6.8 isolation [see 3.1.23]

3.6.9 Manchester encoding [see 3.1.25]

3.6.10 medium [see 3.1.27]

3.6.11 Ph-segment

trunk-cable section of a fieldbus that is terminated in its characteristic impedance, together with all stubs and connected devices

NOTE Segments are linked by repeaters within a logical link and by bridges to form a fieldbus network

3.6.12 receiver [see 3.1.35]

3.6.13 repeater [see 3.1.36]

3.6.14 shield [see 3.1.39]

3.6.15 slot

a PhPDU and its associated Interframe Gap

3.6.16 stub

a short length of cable connecting a node to a segment

3.6.17 terminator [see 3.1.41]

3.6.18 transceiver [see 3.1.41]

3.6.19 transmitter [see 3.1.43]

3.6.20 trunk cable

cable used to connect devices on a Ph-segment of the fieldbus

3.7 Type 8: Terms and definitions

3.7.1 activity [see 3.1.1]

3.7.2 bus coupler

a device that divides the ring into segments by opening the ring and integrating another ring at this point

3.7.3 cable plant interface connector (CPIC) [see 3.1.4]

3.7.4 communication element [see 3.1.5]

3.7.5 connector [see 3.1.6]

3.7.6 dBm [see 3.1.10]

3.7.7 effective launch power [see 3.1.13]

3.7.8 effective power [see 3.1.14]

3.7.9 fibre optic cable [see 3.1.15]

3.7.10 fibre optic receiver [see 3.1.17]

3.7.11 fibre optic receiver operating range [see 3.1.18]

3.7.12 fibre optic transmitter [see 3.1.19]

3.7.13 fibre optic waveguide [see 3.1.20]

3.7.14 frame [see 3.1.21]

3.7.15 incoming interface

interface to receive data from the previous device and to send data, which are received via an outgoing interface, to the previous device

3.7.16 isolation [see 3.1.23]

3.7.17 local bus

a ring segment of a network with alternate media specifications, which is coupled to a remote bus via the bus coupler

3.7.18 local bus device

a device that operates as a slave on a local bus

3.7.19 master

a device that controls the data transfer on the network and initiates the media access of the slaves by sending messages and that constitutes the interface to the control system

3.7.20 medium [see 3.1.27]

3.7.21 minimum optical receiver sensitivity

minimum optical power at the optical receiver input required to achieve a bit error rate of less than 10^{-9} for the optical transmission system

3.7.22 network [see 3.1.28]

3.7.23 optical fall time [see 3.1.30]

3.7.24 optical rise time [see 3.1.32]

3.7.25 outgoing interface

interface to send data to the next slave in a way, that data that is received through this interface is sent via another outgoing interface to the next slave or via an incoming interface to the previous slave and back to the master

3.7.26 peak emission wavelength (λ_p) [see 3.1.34]

3.7.27 polymer optical fibre (POF)

plastic fibre optic waveguide whose nominal characteristics are compatible with IEC 60793-2 [fibre type: A4a (980/1000)]

3.7.28 plastic clad silica fibre (PCS)

fibre optic waveguide consisting of a glass core and a plastic cladding and whose nominal characteristics are compatible with IEC 60793-2 [fibre type: A3c (200/230)]

3.7.29 remote bus

a ring segment of a network

3.7.30 remote bus device

device operating as a slave on a remote bus

3.7.31 remote bus link

connection of two remote bus devices

3.7.32 ring segment

one section of a network

NOTE The master constitutes the first ring segment, further ring segments may be linked by bus couplers

3.7.33 shield

[see 3.1.39]

3.7.34 slave

a device that accesses the medium only after it has been initiated by the preceding slave or master

3.7.35 spectral full width half maximum ($\Delta\lambda$)

range of wavelength of spectral distribution in which the radiant intensity is no less than one-half of the maximum intensity

3.7.36 terminator

[see 3.1.41]

4 Symbols and abbreviations

4.1 Symbols

4.1.1 Type 1: Symbols

Symbol	Definition	Unit
$A_{\max}$	Maximum inter-device attenuation	dB
$AD_{\max}$	Maximum inter-device attenuation distortion	dB
BR	Nominal bit rate	Mbit/s
ΔBR	Maximum deviation from BR	–
$CS_{\max}$	Maximum coupler spacing to form a cluster	m
$D_{\min}$	Minimum device input impedance	$k\Omega$
dBm	logarithmic unit of power referenced to 1 mW	dB (mW)
F_c	Centre carrier frequency used in frequency shift keying	kHz
F_{c+f}	Frequency that corresponds to logical 1 in frequency shift keying	kHz
F_{c-f}	Frequency that corresponds to logical 0 in frequency shift keying	kHz
f_r	Frequency corresponding to the nominal bit rate	MHz
$f_{\min}$	Nominal minimum frequency for the nominal bit rate	MHz
$f_{\max}$	Nominal maximum frequency for the nominal bit rate	MHz
$f_{QTO_{\max}}$	Maximum frequency for $QTO_{\max}$ measurement	MHz
$L_{\max}$	Maximum inter-device distance	m
$MD_{\max}$	Maximum inter-device mismatching distortion	dB
N^+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters, carrying no data	–
N^-	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters, carrying no data	–
$N_{\max}$	Maximum number of devices	–
P	Nominal period of octet transmission	s
$PICS$	Protocol Implementation Conformance Statement	–
$QTO_{\max}$	Maximum quiescent transmitter output	mV
T_{bit}	Nominal bit duration	μs
ΔT_{bit}	Maximum deviation from T_{bit}	–
T_{rf}	Maximum signal rise or fall time	ns
V_{DD}	The most positive (or least negative) supply level	V
V_{IH}	Minimum high-level input voltage	V
V_{IL}	Maximum low-level input voltage	V
V_{OH}	Minimum high-level output voltage	V
V_{OL}	Maximum low-level output voltage	V
Z	Impedance; vector sum of resistance and reactance (inductive or capacitive)	Ω
Z_{f_r}	Characteristic impedance ; impedance of a cable, and of its terminators, at frequency f_r	Ω
Z_O	Characteristic impedance ; impedance of a cable, and of its terminators, over the defined frequency range	Ω

4.1.2 Type 2: Symbols

Symbol	Definition	Unit
dBm	logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz
GND	Ground supply level	V
H	Physical symbol – high level	–
L	Physical symbol – low level	–
M₀	Medium Access Control – data symbol – “zero”; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a high level for half a bit time, and a low level for half a bit time, carrying data “zero”	–
M₁	Medium Access Control – data symbol – “one”; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a low level for half a bit time, and a high level for half a bit time, carrying data “one”	–
M_{ND+}	Medium Access Control – non-data symbol – positive; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a high level for one complete bit time, used for delimiters, carrying no data	–
M_{ND–}	Medium Access Control – non-data symbol – negative; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a low level for one complete bit time, used for delimiters, carrying no data	–
Rx_H	Receive – high level (NAP interface)	V
Rx_L	Receive – low level (NAP interface)	V
Tx_H	Transmit – high level (NAP interface)	V
Tx_L	Transmit – low level (NAP interface)	V
V_{in}	Voltage on the coaxial cable centre conductor (V _{in+} or V _{in–}) as referenced to the coaxial shield	V
V_{sense+}	Positive data sensitivity limit	V
V_{sense–}	Negative data sensitivity limit	V
V_{senseH}	High carrier sensitivity limit	V
V_{senseL}	Low carrier sensitivity limit	V

4.1.3 Type 3: Symbols

Symbol	Definition	Unit
dBm	logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz
N–	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters, carrying no data	–
N+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters, carrying no data	–
P	Nominal period of octet transmission	s
R_d	pulldown resistor	Ω
R_t	Bus terminator	Ω
R_u	pullup resistor	Ω
SYN	Synchronizing bits of a frame (period of idle)	s
t_{BIT}	The bit time t _{BIT} is the time, which elapses during the transmission of one bit.	s
T_{SBIT}	extended tolerance (only for stop bit)	s
T_{SYN}	Synchronization time	s

Symbol	Definition	Unit
T_{SYNI}	Synchronization interval time	s
V_{DD}	The most positive (or least negative) supply level	V
V_{IH}	Minimum high-level input voltage	V
V_{IL}	Maximum low-level input voltage	V
V_{OH}	Minimum high-level output voltage	V
V_{OL}	Maximum low-level output voltage	V
V_P	Voltage-Plus	V
Z	Impedance; vector sum of resistance and reactance (inductive or capacitive)	Ω
Z_O	Characteristic impedance ; impedance of a cable, and of its terminators, over the defined frequency range	Ω

4.1.4 Type 4: Symbols

Symbol	Definition	Unit
V_{CC}	The most positive (or least negative) supply level	V
GND	Ground supply level	V

4.1.5 Type 6: Symbols

Symbol	Definition	Unit
0	Manchester coded signal with a LO-HI transition at the middle of the bit cell	–
1	Manchester coded signal with a HI-LO transition at the middle of the bit cell	–
HI	differential bus signal level with Rx/ TxData-P positive with respect to Rx/ TxData-N	V
LO	differential bus signal level with Rx/ TxData-P negative with respect to Rx/ TxData-N	V
N+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters	–
N–	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters	–
SILENCE	differential bus signal level with Rx/ TxData-P positive with respect to Rx/ TxData-N	V

4.1.6 Type 8: Symbols

Symbol	Definition	Unit
dBm	logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz
V_{DD}	The most positive (or least negative) supply level	V
GND	Ground supply level	V

4.2 Abbreviations

4.2.1 Type 1: Abbreviations

CTS	Clear To Send signal (from DCE)
DCE	Data Communication Equipment
DIS	DCE Independent Sublayer
DL	Data Link (as a prefix) – approximately Layer 2 of the OSI model [ISO/IEC 7498-1]
DLE	Data Link Entity

DLL	Data Link Layer	[ISO/IEC 7498-1]
DTE	Data Terminal Equipment	
EMI	Electro-Magnetic Interference	
ERP	Effective Radiated Power	
FEC	Forward Error Correction	
GMSK	Gaussian Minimum Shift Keying	
IDU	Interface Data Unit	[ISO/IEC 7498-1]
IS	Intrinsic Safety	
kbit/s	Thousand bits per second	
LbE	Loopback Enable signal (to MAU)	
MAU	Medium Attachment Unit – For wire media, MAU = transceiver	
Mbit/s	Million bits per second	
MDS	Medium Dependent Sublayer	
MIS	Media Independent Sublayer	
NRZ	Non-return-to-zero code – High level = logic 1, Low level = logic 0	
Ph	Physical (as a prefix) – Approximately Layer 1 of the OSI model	[ISO/IEC 7498-1]
PhE	Physical Layer Entity	[ISO/IEC 7498-1]
PhL	Physical Layer	[ISO/IEC 7498-1]
PhICI	Physical Layer Interface Control Information	[ISO/IEC 7498-1]
PhID	Physical Layer Interface Data	[ISO/IEC 7498-1]
PhIDU	Physical Layer Interface Data Unit	[ISO/IEC 7498-1]
PhPCI	Physical Layer Protocol Control Information	[ISO/IEC 7498-1]
PhPDU	Physical Layer Protocol Data Unit	[ISO/IEC 7498-1]
PhS	Physical Layer Service	[ISO/IEC 7498-1]
PhSAP	Physical Layer Service Access Point	[ISO/IEC 7498-1]
PhSDU	Physical Layer Service Data Unit	[ISO/IEC 7498-1]
pk	Peak	
pk-pk	Peak-to-peak	
RDF	Receive Data and Framing signal (from DCE)	
RFI	Radio Frequency Interference	
RMCF	Radio Medium dependent sublayer Code Frame	
RPhPDU	Radio Physical Layer Protocol Data Units	
RTS	Request To Send signal (to DCE)	
RxA	Receive Activity signal (from DCE)	
RxC	Receive Clock signal (from DCE)	
RxS	Receive Signal (from MAU)	
SDU	Service Data Unit	[ISO/IEC 7498-1]
TxC	Transmit Clock signal (from DCE)	
TxD	Transmit Data signal (to DCE)	
TxE	Transmit Enable signal (to MAU)	
TxS	Transmit Signal (to MAU)	

4.2.2 Type 2: Abbreviations

BNC	Bayonet N-series Coaxial connector – connector for coaxial cable having a bayonet-type shell with two small knobs on the female connector, which lock into spiral slots in the male connector when it is twisted
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DCE	Data Communication Equipment
DL	Data Link (as a prefix) – approximately Layer 2 of the OSI model [ISO/IEC 7498-1]
DLL	Data Link Layer [ISO/IEC 7498-1]
MAC	Medium access control – lower section of the Data Link layer, interfacing with the Physical Layer
MAC ID	Medium access control identification - address of a node
MAU	Medium Attachment Unit – For wire media, MAU = transceiver
Mbit/s	Million bits per second
MDS	Medium Dependent Sublayer
MIS	Media Independent Sublayer
NAP	Network access port – local access to a device, i.e. not via the bus
NetEnable	Transmit Enable signal
NUT	Network update time [IEC 61158-3]
Ph	Physical (as a prefix) – Approximately Layer 1 of the OSI model [ISO/IEC 7498-1]
PhL	Physical Layer [ISO/IEC 7498-1]
pk	Peak
Rcv	Receive
Rx	Receive
RxCARRIER	Receive Carrier signal
RxDATA	Receive Data signal
RxPTC	Receive Data signal (NAP interface)
RM	Repeater machine – mechanism for extending bus length, providing multiple medium interfaces, and allowing medium redundancy
RRM	Ring repeater machine – mechanism for providing a ring topology on optical medium
SMAx	Scheduled maximum address [IEC 61158-3]
Tx	Transmit
TxDATABAR	Transmit Data signal (inverted)
TxDATAOUT	Transmit Data signal
TxPTC	Transmit Data signal (NAP interface)
Xmit	Transmit

4.2.3 Type 3: Abbreviations

ASC	Active Star Coupler
BER	Bit error rate
CO	Converter
CTS	Clear To Send signal (from DCE)
DCE	Data Communication Equipment
DGND	Data Ground
DIS	DCE Independent Sublayer
DL	Data Link (as a prefix)
DLE	Data Link Entity
DLL	Data Link Layer [ISO/IEC 7498-1]
DLPDU	Data Link Protocol Data Unit [ISO/IEC 7498-1]
DTE	Data Terminal Equipment
DUT	Device Under Test

EMC	Electro-Magnetic-Compatibility
EMI	Electro-Magnetic Interference
FEC	Forward Error Correction
FISCO	Fieldbus Intrinsically Safe COncept [7]
FO	Fibre optic
FOC	Fibre optic cable
IS	Intrinsic Safety
kbit/s	Thousand bits per second
LbE	Loopback Enable signal (to MAU)
LSS	Line Selector Switch
M/S	Master / Slave station
MAU	Medium Attachment Unit – For wire media, MAU = transceiver
Mbit/s	Million bits per second
MDS	Medium Dependent Sublayer
MIS	Media Independent Sublayer
n	Number of a station
NRZ	Non-return-to-zero code – High level = logic 1, Low level = logic 0
OST	Overshot of transition
PC	Physical Contact
Ph	Physical (as a prefix)
Ph-ASYN-DATA	data service for asynchronous transmission
PhE	Physical Layer Entity [ISO/IEC 7498-1]
PhICI	Physical Layer Interface Control Information [ISO/IEC 7498-1]
PhID	Physical Layer Interface Data [ISO/IEC 7498-1]
PhIDU	Physical Layer Interface Data Unit [ISO/IEC 7498-1]
PhL	Physical Layer [ISO/IEC 7498-1]
PhM	Ph-management
PhMS	Ph-management service
PhPCI	Physical Layer Protocol Control Information [ISO/IEC 7498-1]
PhPDU	Physical Layer Protocol Data Unit [ISO/IEC 7498-1]
PhS	Physical Layer Service [ISO/IEC 7498-1]
PhSAP	Physical Layer Service Access Point [ISO/IEC 7498-1]
PhSDU	Physical Layer Service Data Unit [ISO/IEC 7498-1]
pk-pk	Peak-to-peak
RDF	Receive Data and Framing signal (from DCE)
REP	Repeater
RFI	Radio Frequency Interference
RTS	Request To Send signal (to DCE)
RxA	Receive Activity signal (from DCE)
RxC	Receive Clock signal (from DCE)
RxS	Receive Signal (from MAU)
Stn	Stations like M/S
TPC	Twisted-pair Cable
TxC	Transmit Clock signal (from DCE)
TxD	Transmit Data signal (to DCE)

TxE	Transmit Enable signal (to MAU)
TxS	Transmit Signal (to MAU)
UART	Universal asynchronous receiver/transmitter

4.2.4 Type 4: Abbreviations

CTS	Clear To Send signal (from DCE)
DCE	Data Communication Equipment
DL	Data Link (as a prefix) – approximately Layer 2 of the OSI model [ISO/IEC 7498-1]
DLE	Data Link Entity
DLL	Data Link Layer [ISO/IEC 7498-1]
DTE	Data Terminal Equipment
kbit/s	Thousand bits per second
MAU	Medium Attachment Unit – For wire media, MAU = transceiver
MDS	Medium Dependent Sublayer
MIS	Media Independent Sublayer
NRZ	Non-return-to-zero code – High level = logic 1, Low level = logic 0
Ph	Physical (as a prefix) – Approximately Layer 1 of the OSI model [ISO/IEC 7498-1]
PhE	Physical Layer Entity [ISO/IEC 7498-1]
PhL	Physical Layer [ISO/IEC 7498-1]
PhID	Physical Layer Interface Data [ISO/IEC 7498-1]
PhPDU	Physical Layer Protocol Data Unit [ISO/IEC 7498-1]
RTS	Request To Send signal (to DCE)
RxS	Receive Signal (from MAU)
TxE	Transmit Enable signal (to MAU)
TxS	Transmit Signal (to MAU)

4.2.5 Type 6: Abbreviations

BSD	Bus-sync delimiter
Control-	Control negative - connector pin provided for repeater control
Control+	Control positive - connector pin provided for repeater control
DGND	Data ground - connector pin connected to ANSI TIA/EIA-485-A C/C'
DIS	Device independent sublayer
DLE	Data Link entity
DLL	Data Link layer
ED	End of data delimiter
ETF	End transfer frame delimiter
ExV	Excitation voltage - connector pin supplying terminator excitation voltage
MAC	Medium access control
MAU	Medium access unit
MDS	Medium dependent sublayer
MIS	Media Independent Sublayer
PAD	PAD idle sequence
PhE	Ph entity
PhICI	Ph interface control information
PhID	Ph interface data

PhIDU	Ph interface data unit
PhL	Physical layer
PhPDU	Ph protocol data unit
PhS	Ph service
PhSDU	Ph service data unit
PRE	Preamble
Pwr-	Power Negative - connector pin supplying 24 V power negative
Pwr+	Power Positive - connector pin supplying 24 V power positive
Rx/ TxData-N	Receive/ Transmit Data Negative - connector pin connected to ANSI TIA/EIA-485-A A/A'
Rx/ TxData-P	Receive/ Transmit Data Positive - connector pin connected to ANSI TIA/EIA-485-A B/B''
ST	Start delimiter
SYN	the Strobe signal for bus synchronization by each node's DLE
TR	the Strobe signal for Data-Strobe by each node's DLE

4.2.6 Type 8: Abbreviations

BC	Bus Connector
BLL	Basic Link Layer
BSY	Busy
CPIC	Cable Plant Interface Connector
CRC	Cyclic Redundancy Check
CTS	Clear to Send
DL	Data Link (as a prefix) – approximately Layer 2 of the OSI model [ISO/IEC 7498-1]
DLL	Data Link Layer [ISO/IEC 7498-1]
DI	Data In
DLPDU	Data Link Process Data Unit
DO	Data Out
DS	Data Select
GND	Ground
ICI	Interface Control Information
ID	Identifier
kbit/s	Thousand bits per second
LbE	Loopback Enable
LSB	Least Significant Byte
MA	Medium Activity
MAC	Medium Access Control
MAU	Medium Attachment Unit
MDS	Medium Dependent Sublayer
MIS	Media Independent Sublayer
MSB	Most Significant Bit
NRZ	Non Return to Zero
PCS	Plastic Clad Silica Fibre
Ph	Physical (as a prefix) – Approximately Layer 1 of the OSI model [ISO/IEC 7498-1]
PhE	Physical Layer Entity [ISO/IEC 7498-1]
PhICI	Physical Interface Control Information

PhIDU	Physical Interface Data Unit
PhL	Physical Layer [ISO/IEC 7498-1]
PhPDU	Physical Protocol Data Unit
PhSDU	Physical Service Data Unit
PNM1	Peripherals Network Management of Layer 1
POF	Polymer Optical Fibre
RI	Reset In
RO	Reset Out
RqDly1	Request Delay 1
RqDly2	Request Delay 2
RTS	Request to Send
RxA	Receive Activity
RxC	Receive Clock
RxCR	Receive Control Line
RxD	Receive Data
RxS	Receive Sequence
RxSL	Receive Select Line
SL	Select Line
T_{Rst}	Coding and Decoding (of the Reset PhPDU)
TxC	Transmit Clock
TxCR	Transmit Control Line
TxD	Transmit Data
TxS	Transmit Sequence
TxSL	Transmit Select Line

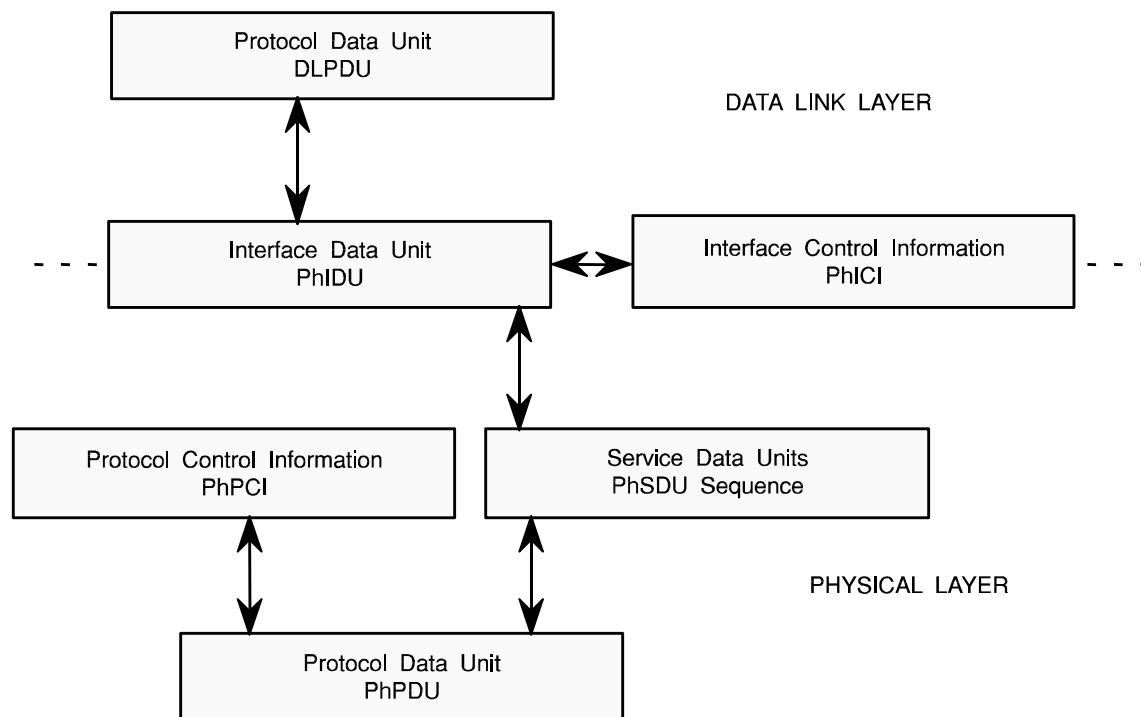
5 DLL – PhL interface

5.1 General

Clause 5 defines the required Physical Service (PhS) primitives and constraints on their use.

NOTE 1 The Data Link – Physical interface is a virtual service interface between virtual machines; there are no requirements for physical signal lines as the standard does not require this interface to be exposed.

PhIDUs shall be transferred between the DLL and the PhL in accordance with the requirements of ISO/IEC 7498 as shown in Figure 3.



NOTE PhPCI and PhICI support are type specific.

Figure 3 – Mapping between data units across the DLL – PhL interface

NOTE 2 These services provide for the interchange of PhIDUs between a DLL entity and its associated PhL entity. Such a transfer is part of a transaction between cooperating DLL entities. The services listed in this section are the minimum that can jointly provide the means by which cooperating DLL entities can coordinate their transmission and their exchange of data on the shared communication medium. Synchronization of data exchange and related actions is also provided if needed.

NOTE 3 Proper layering requires that an (N+1)-layer entity be not concerned with, and that an (N)-service interface not overly constrain, the means by which an (N)-layer provides its (N)-services. Thus, the Ph-service interface does not require DLEs to be aware of internal details of the PhE (e.g. preamble, postamble and frame delimiter signal patterns, number of bits per baud), and should not prevent the PhE from using appropriate evolving technologies.

NOTE 4 A number of different DLL – PhL interfaces are specified, based on industry practice.

5.2 Type 1: Required services

5.2.1 Primitives of the PhS

5.2.1.1 General

The granularity of PhS-user data exchanged at the PhL – DLL interface is one octet.

5.2.1.2 Ph-CHARACTERISTICS Indication

The PhS shall provide the following service primitive to report essential PhS characteristics (which may be used in DLL transmission, reception, and scheduling activities):

Ph-CHARACTERISTICS indication (minimum-data-rate, framing-overhead)

where

minimum-data-rate – shall specify the effective minimum rate of data conveyance in bits/second, including any timing tolerances

NOTE 1 A PhE with a nominal data rate of 1 Mbit/s $\pm$ 0,01 % would specify a minimum data rate of 0,9999 Mbit/s.

framing overhead – shall specify the maximum number of bit periods (where the period is the inverse of the data rate) used in any transmission for PhPDUs that do not directly convey data (e.g. PhPDUs conveying preamble, frame delimiters, postamble, inter-frame "silence", etc.).

NOTE 2 If the framing overhead is F and two DL message lengths are L_1 and L_2 , then the time to send one message of length $L_1 + F + L_2$ will be at least as great as the time required to send two immediately consecutive messages of lengths L_1 and L_2 .

5.2.1.3 PhS transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

PH-DATA request (class, data)

PH-DATA indication (class, data)

PH-DATA confirm (status)

where

class – shall specify the PhICI component of the PhIDU.

For a PH-DATA request, its possible values shall be:

START-OF-ACTIVITY – transmission of the PhPDUs which precede Ph-user data shall commence;

DATA – the single-octet value of the associated data parameter shall be transmitted as part of a continuous correctly formed transmission; and

END-OF-DATA-AND-ACTIVITY – the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding octet of Ph-user data, culminating in the cessation of active transmission.

For a PH-DATA indication, its possible values shall be:

START-OF-ACTIVITY – reception of an apparent transmission from one or more PhEs has commenced;

DATA – the associated data parameter was received as part of a continuous correctly formed reception;

END-OF-DATA – the ongoing continuous correctly formed reception of Ph-user data has concluded with correct reception of PhPDUs implying END-OF-DATA;

END-OF-ACTIVITY – the ongoing reception (of an apparent transmission from one or more PhEs) has concluded, with no further evidence of PhE transmission; and

END-OF-DATA-AND-ACTIVITY – simultaneous occurrence of END-OF-DATA and END-OF-ACTIVITY.

data – shall specify the PhID component of the PhIDU. It consists of one octet of Ph-user-data to be transmitted (PH-DATA request) or which was received successfully (PH-DATA indication).

status – shall specify either success or the locally detected reason for inferring failure.

The PH-DATA confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DLE from starting a second transmission before the first is complete. The final PH-DATA confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.2.2 Notification of PhS characteristics

The PhE has the responsibility for notifying the DLE of those characteristics of the PhS that may be relevant to DLE operation. The PhE shall do this by issuing a single PH-CHARACTERISTICS indication primitive at each of the PhEs PhSAPs at PhE start-up.

5.2.3 Transmission of Ph-user-data

The PhE shall determine the timing of all transmissions. When a DLE transmits a sequence of PhSDUs, the DLE shall send the sequence of PhSDUs by making a well-formed sequence of PH-DATA requests, consisting of a single request specifying START-OF-ACTIVITY, followed by 3 to 300 consecutive requests, inclusive, specifying DATA, each conveying a PhSDU, and concluded by a single request specifying END-OF-DATA-AND-ACTIVITY.

The PhE shall signal its completion of each PH-DATA request, and its readiness to accept a new PH-DATA request, by issuing a PH-DATA confirm primitive; the status parameter of the PH-DATA confirm primitive shall convey the success or failure of the associated PH-DATA request. A second PH-DATA request shall not be issued by the DLE until after the PH-DATA confirm corresponding to the first request has been issued by the PhE.

5.2.4 Reception of Ph-user-data

The PhE shall report a received transmission with a well-formed sequence of PH-DATA indications, which shall consist of

- a) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA; and concluded by a single indication specifying END-OF-ACTIVITY; or
- b) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA-AND-ACTIVITY; or
- c) a single indication specifying START-OF-ACTIVITY; optionally followed by one or more consecutive indications specifying DATA, each conveying a PhSDU; and concluded by a single indication specifying END-OF-ACTIVITY.

This last sequence is indicative of an incomplete or incorrect reception. Detection of an error in the sequence of received PhPDUs, or in the PhEs reception process, shall disable further PH-DATA indications with a class parameter specifying DATA, END-OF-DATA, or END-OF-DATA-AND-ACTIVITY until after both the end of the current period of activity and the start of a subsequent period of activity have been reported by PH-DATA indications specifying END-OF-ACTIVITY and START-OF-ACTIVITY, respectively.

5.3 Type 2: Required services

5.3.1 General

Subclause 5.3 defines the required Physical Service (PhS) primitives and constraints on their use.

The DLL-PhL interface need not be exposed in the implementation of any PhL variant. This interface may be internal to the node and may be implemented as internal to a semiconductor device. If, however, conformance to the DLL-PhL interface is claimed, it shall conform to the requirements of 5.3.

5.3.2 M_symbols

The PhL Interface Data Units present at the DLL-PhL interface shall be M_symbols, as shown in Table 1. The M_ND symbols shall be used to create unique data patterns used for start and end delimiters.

Table 1 – Data encoding rules

Data bits (common name)	M_symbol representation
data “zero”	M_0 or {0}
data “one”	M_1 or {1}
“non_data+”	M_ND+ or {+}
“non_data–”	M_ND– or {–}

5.3.3 PH-LOCK indication

PH-LOCK indication shall provide an indication of either data lock or Ph-symbol synchronization by the MDS. Valid states for PH-LOCK indication shall be true and false. PH-LOCK indication shall be true whenever valid Ph-symbols are present at the MDS-MAU interface and the DLL-PhL interface timing of M_symbols conform to the requirements for clock accuracy. It shall be false between frames (when no Ph-symbols are present on the medium) or whenever data synchronization is lost or the timing fails to conform to the requirements for clock accuracy. PH-LOCK indication shall be true prior to the beginning of the start delimiter.

5.3.4 PH-FRAME indication

PH-FRAME indication shall provide an indication of a valid data frame from the MAU. Valid states for PH-FRAME indication shall be true and false. PH-FRAME indication shall be true upon PH-LOCK indication = true and reception of the first valid start delimiter. PH-FRAME indication shall be false at reception of next M_ND symbol (following the start delimiter) or PH-LOCK indication = false.

NOTE This signal provides octet synchronization to the DLL.

5.3.5 PH-CARRIER indication

PH-CARRIER indication shall represent the presence of a signal carrier on the medium. PH-CARRIER indication shall be true if RxCARRIER at the MDS-MAU interface has been true during any of the last 4 M_symbol times and it shall be false otherwise.

5.3.6 PH-DATA indication

PH-DATA indication shall represent the M_symbols shown in Table 1. Valid symbols shall be M_0, M_1, M_ND+ or M_ND– (or M_symbols). The PH-DATA indication shall represent the M_Symbols as decoded from the MAU whenever PH-LOCK indication is true.

5.3.7 PH-STATUS indication

PH-STATUS indication shall represent the status of the frame that was received from the MAU as shown in Table 2. Valid symbols shall be Normal, Abort, and Invalid. PH-STATUS indication shall indicate Normal after reception of a frame (PH-FRAME indication = true) composed of a start delimiter, valid Manchester encoded data (no M_ND symbols) and an end delimiter. PH-STATUS indication shall indicate Abort after reception of a frame (PH-FRAME indication = true) composed of a start delimiter, valid Manchester encoded data, and a second start delimiter. PH-STATUS indication shall indicate Invalid after reception of a frame (PH-FRAME indication = true) composed of a start delimiter and the detection of any M_ND symbol that was not part of a start or end delimiter.

Table 2 – Ph-STATUS indication truth table

Ph-STATUS indication	Ph-FRAME indication	Start delimiters in a single frame	End delimiter detection	Any non-delimiter Manchester violations
Normal	true	1	true	false
Abort	true	2	don't care	false
Invalid	true	1	don't care	true

5.3.8 PH-DATA request

PH-DATA request shall represent the M_symbols to be transmitted. Valid symbols shall be M_0, M_1, M_ND+ or M_ND– as shown in Table 1. PH-DATA request shall indicate M_0 when no data is to be transmitted (and PH-FRAME request = false).

5.3.9 PH-FRAME request

PH-FRAME request shall be true when PH-DATA request represents M_symbols to be encoded to the appropriate Ph-symbols and transferred to the MAU, and shall be false when no valid M_symbols are to be transferred to the MAU.

5.3.10 PH-JABBER indication

PH-JABBER indication shall be true if the MDS-MAU interface detects a single frame (PH-FRAME indication = true) that equals or exceeds 1024 bytes (8192 M_symbols) and PH-JABBER-TYPE request is true. PH-JABBER indication shall be true if the MDS-MAU interface detects a single frame (PH-FRAME indication = true) that equals or exceeds 2048 bytes (16384 M_symbols) and PH-JABBER-TYPE request is false. PH-JABBER indication shall be false otherwise. If PH-JABBER indication goes true, it shall be latched in this state by the MDS until the Ph-JABBER-CLEAR request is true or power to the node is removed and restored or the node is initialised.

5.3.11 Ph-JABBER-CLEAR request

Ph-JABBER-CLEAR request (optional) shall be false under normal operating conditions and shall be true to reset a PH-JABBER indication that has been latched in a true state.

5.3.12 Ph-JABBER-TYPE request

PH-JABBER-TYPE request shall be true if the node is the source of transmit data ("NODE") and shall be false if the node is retransmitting data received from another node (e.g. acting as a "REPEATER" of data from another node).

The combinations for PH-JABBER indication and PH-JABBER-TYPE request shall be as shown in Table 3.

Table 3 – Jabber indications

Ph-JABBER indication	Ph-JABBER-TYPE request	Frame length
true	true = "NODE"	≥ 1024 bytes
true	false = "REPEATER"	≥ 2048 bytes
false	true = "NODE"	< 1024 bytes
false	false = "REPEATER"	< 2048 bytes

5.4 Type 3: Required services

5.4.1 Synchronous Transmission

The services specified for Type 1 shall be used (see 5.2).

5.4.2 Asynchronous Transmission

5.4.2.1 PhS transmission and reception services

The data service for asynchronous transmission (Ph-ASYN-DATA) includes two service primitives. A request primitive is used to request a service by the DLE; an indication primitive is used to indicate a reception to the DLE. The names of the respective primitives are as follows:

Ph-ASYN-DATA request

Ph-ASYN-DATA indication

The temporal relationship of the primitives is shown in Figure 4.

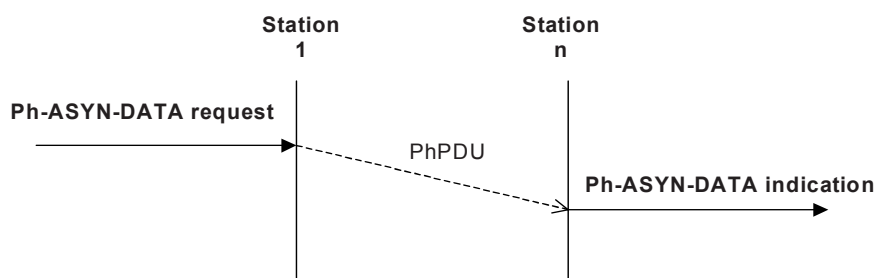


Figure 4 –Data service for asynchronous transmission

5.4.2.2 Detailed specification of the service and interaction

This subclause describes in detail the service primitives and the related parameter in an abstract way. The parameter contains the PhS-user data exchanged at the PhL – DLL interface with the granularity of one bit.

Parameters of the primitives:

Ph-ASYN-DATA request (DL_symbol)

The parameter DL_symbol shall have one of the following values specifying the PhID component of the PhIDU. Its possible values shall be:

- a) ZERO corresponds to a binary "0"
- b) ONE corresponds to a binary "1"
- c) SILENCE disables the transmitter when no DL_symbol is to be transmitted

The Ph-ASYN-DATA request primitive is passed from the DLE to the PhE to request that the given symbol shall be sent to the fieldbus medium.

The reception of this primitive shall cause the PhE to attempt encoding and transmission of the DL-symbol.