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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 2: Spécification et définition des services de la couche physique

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 2: Physical layer specification and service definition

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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Attention is drawn to the fact that the 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 layer protocol type to be used with other layer protocols of the same type, or in other type combinations explicitly authorized by their respective intellectual property right holders.

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

IEC 61158-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This seventh edition cancels and replaces the sixth edition published in 2014. This edition constitutes a technical revision.

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

a) Type 12 added power option to 100BASE-TX in Clause 29;
b) enhanced Type 24 specification in Clause 33, Annex S and Annex U;
c) new Type 28 specification;
d) LVDS wire medium up to 100 Mbit/s of Type 12 is removed.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1200/FDIS	65C/1241/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

NOTE 2 Slight variances from the directives have been allowed by the IEC Central Office to provide continuity of subclause numbering with prior editions.

A list of all the parts of the IEC 61158 series, under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

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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. It is related to other standards in the set as defined by the "three-layer" fieldbus reference model described in IEC 61158-1.

0.2 Physical layer overview

The primary aim of this document 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.

0.3 Document overview

This document comprises physical layer specifications corresponding to many of the different DL-Layer protocol Types specified in IEC 61158 series.

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

NOTE 2 Specifications for Types 1, 2, 3, 4, 8, 12, 16, 18, 20, 24 and 28 are included. Type 7 uses Type 1 specifications. The other Types do not use any of the specifications given in this document.

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 document to select interoperating sets of provisions. Refer to the IEC 61784-1 series or the IEC 61784-2 series for standardized communication profiles based on the IEC 61158 series.

A general model of the physical layer is shown in Figure 1.

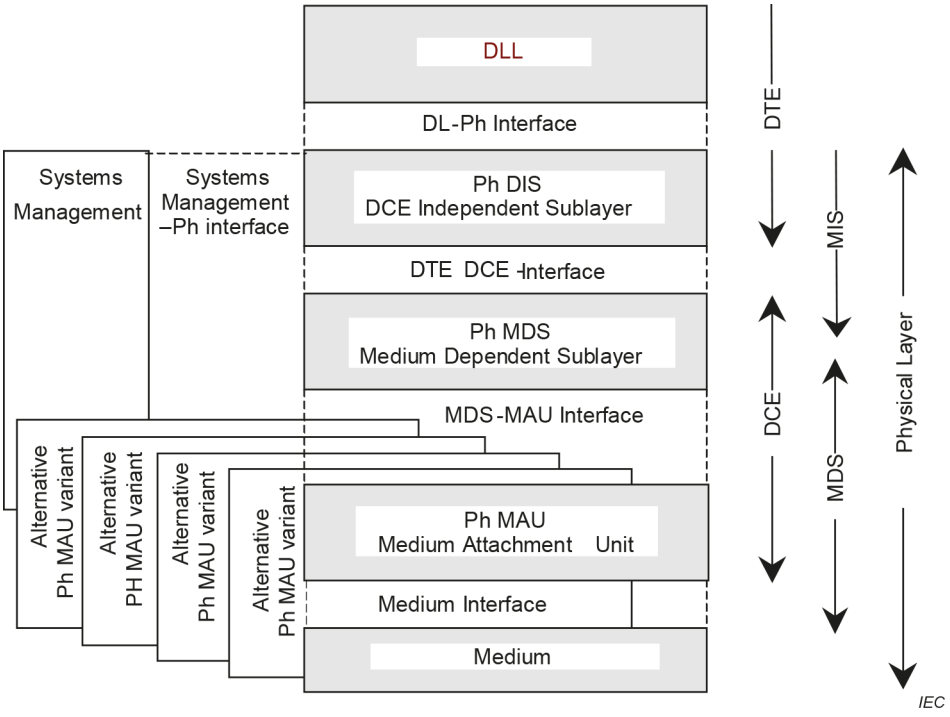


Figure 1 – General model of physical layer

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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.

0.4 Major physical layer variations specified in this document

0.4.1 Type 1 media

0.4.1.1 Type 1: Wire media

For twisted-pair wire media, Type 1 specifies two modes of coupling and different signaling 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 document 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.

0.4.1.2 Type 1: Optical media

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

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

0.4.2 Type 2: Coaxial wire and optical media

Type 2 specifies the following variants:

– coaxial copper wire medium, 5 Mbit/s;
– optical fiber 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.

0.4.3 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;

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and the following asynchronous transmission variants:

b) twisted-pair wire medium, up to 12 Mbit/s, TIA-485-A;

c) optical fiber medium, up to 12 Mbit/s, with fiber type A4a of IEC 60793-2-40 and fiber type A3c of IEC 60793-2-30.

0.4.4 Type 4: Wire medium

Type 4 specifies wire media with the following characteristics:

– RS-485 wire medium up to 76,8 kbit/s;

0.4.5 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 fiber 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.

0.4.6 Type 12: Wire medium

Type 12 specifies wire media with the following characteristics:

– two pair of wires carrying two separate power supply channels combined with signal transmission.

0.4.7 Type 16: optical media

Type 16 specifies a synchronous transmission using optical fiber medium, at 2 Mbit/s, 4 Mbit/s, 8 Mbit/s and 16 Mbit/s.

0.4.8 Type 18: Media

0.4.8.1 Type 18: Basic media

The Type 18-PhL-B specifies a balanced transmission signal over a shielded 3-core twisted cable. Communication data rates as high as 10 Mbit/s and transmission distances as great as 1,2 km are specified.

0.4.8.2 Type 18: Powered media

The Type 18-PhL-P specifies a balanced transmission signal over a 4-core unshielded cable in both flat and round configurations with conductors specified for communications signal and network-embedded power distribution. Communication data rates as high as 2,5 Mbit/s and transmission distances as great as 500 m are specified.

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0.4.9 Type 20: Media

Type 20 uses binary phase continuous Frequency Shift Keying (FSK). A relatively high frequency current is superimposed on a low-frequency analog current, which is usually in 4 mA to 20 mA range. The digital signal and analog signal share the same medium, but differ in frequency contents. The communicating devices signal with either current or voltage, and all signaling appear as voltage when sensed across low impedance. Thus, digital signaling is an extension of conventional analog signaling.

The physical layer commonly uses twisted pair copper cable as its medium and provides solely digital or simultaneous digital and analog communication to distances of at least 1 500 m (ca. 5 000 feet). Maximum communication distances vary depending on network construction and environmental conditions.

0.4.10 Type 24: Media

0.4.10.1 Type 24: Basic media

Type 24 specifies twisted-pair wire medium. The general characteristics of this transmission medium are as follows:

– TIA-485-A bus interface with galvanic isolation using transformer;
– up to 10 Mbit/s;
– half-duplex transmission;
– Manchester coding.

0.4.10.2 Type 24: Powered media

The powered media type provides the following options:

– TIA-485-A bus interface without galvanic isolation using transformer;
– up to 32 Mbit/s;
– half-duplex transmission;
– Manchester coding or NRZI coding;
– power via the bus conductors.

0.4.11 Type 28: Media

Type 28 uses Orthogonal Frequency Division Multiplexing (OFDM) technology. The frequency subcarrier ranges from 1,536 MHz to 32,256 MHz. The transmission distances are up to 500 m on a single bus. The analog signal shall be delivered on the medium that connected to each device in network.

Type 28 specifies the following synchronous transmission:

a) twisted-pair wire medium, up to 100 Mbit/s;
b) coaxial wire medium, up to 100 Mbit/s.

The general characteristics of these transmission media are as follows:

a) full-duplex transmission;
b) OFDM coding.

0.5

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Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent. IEC takes no position concerning the evidence, validity, and scope of this patent right.

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

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/IEC 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE All parts of the IEC 61158 series, as well as the IEC 61784-1 series and the IEC 61784-2 series are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-14:2007[1], *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

IEC 60079-25, *Explosive atmospheres – Part 25: Intrinsically safe electrical systems*

IEC 60169-17, *Radio-frequency connectors – Part 17: R.F. coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with screw coupling – Characteristic impedance 50 ohms (Type TNC)*

IEC 60189-1:2018, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*

IEC 60255-22-1:1988[2], *Electrical relays – Part 22-1: Electrical disturbance tests for measuring relays and protection equipment – Section 1: 1 MHz burst disturbance tests*

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1 A 2013 edition exists but the listed edition applies.

2 This publication was withdrawn.

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IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

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

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

IEC 60603-7-4, *Connectors for electronic equipment – Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

IEC 60793 (all parts), *Optical fibres*

IEC 60793-2:2019, *Optical fibres – Part 2: Product specifications – General*

IEC 60793-2-30:2015, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40:2021, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

IEC 60794-1-2:2003[3], *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*

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 60811-403, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds*

IEC 60811-404:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

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

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

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 44: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61076-2-114:2020, *Connectors for electrical and electronic equipment – Product requirements – Part 2-114: Circular connectors – Detail specification for connectors with M8 screw- locking with power contacts and signal contacts for data transmission up to 100 MHz*

IEC 61131-2:2017, *Industrial-process measurement and control − Programmable controllers – Part 2: Equipment requirements and tests*

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[3] There exists a new edition of IEC 60794-1-2 (2021). Cross-references to 2003 version is described in informative Annex A.

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IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61158-3-20:2023, *Industrial communication networks – Fieldbus specifications – Part 3-20: Data-link layer service definition – Type 20 elements*

IEC 61158-4-2:2023, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link protocol specification – Type 2 elements*

IEC 61158-4-3:2019, *Industrial communication networks – Fieldbus specifications – Part 4-3: Data-link protocol specification – Type 3 elements*

IEC 61169-8:2007, *Radio-frequency connectors – Part 8: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with bayonet lock – Characteristic impedance 50 Ω (type BNC)*

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

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

IEC 61754-13, *Fibre optic connector interfaces – Part 13: Type FC-PC connector*

IEC 61754-22, *Fibre optic connector interfaces – Part 22: Type F-SMA connector family*

IEC 63171, *Connectors for electrical and electronic equipment − Shielded or unshielded free and fixed connectors for balanced single-pair data transmission with current carrying capacity – General requirements and tests*

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

ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 8482, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections*

ISO/IEC/IEEE 8802-3:2021, *Telecommunications and information exchange between systems – Requirements for local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

ISO 9314-1, *Information processing systems – Fibre Distributed Data Interface (FDDI) Part 1: Token Ring Physical Layer Protocol (PHY)*

ISO/IEC 10731:1994, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

TIA-422-B:1994, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

TIA-485-A:1998, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

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3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

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
bit
unit of data consisting of a 1 or a 0

Note 1 to entry: A bit is the smallest data unit that can be transmitted.

3.1.4
bus
trunk and all devices connected to it

3.1.5
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

3.1.6
communication element
part of a fieldbus device that communicates with other elements via the bus

3.1.7
connector
coupling device employed to connect the medium of one circuit or communication element with that of another circuit or communication element

3.1.8
coupler
physical interface between trunk and spur or trunk and device

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3.1.9
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

3.1.10
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

3.1.11
decibel(milliwatt)
dB(mW)
logarithmic unit of power, referenced to 1 mW

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

Note 1 to entry: db(mW) is also written dBm.

Note 2 to entry: If P_{mW} is the measured power in mW, then P_{dBm} is the power expressed logarithmically in dB(mW), or equivalently, dBm.

3.1.12
delimiter
flag that separates and organizes items of data

3.1.13
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 1 to entry: A device may contain more than one node.

3.1.14
effective launch power
effective power coupled into the core of a fiber optic waveguide by the transmitter

Note 1 to entry: Effective launch power is measured with a standard test fiber connected to the CPIC.

3.1.15
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 1 to entry: 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.

3.1.16
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

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3.1.17
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 1 to entry: 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 µW) / 1 mW)), which equals −10,0 dBm. The extinction ratio is (105/5), which equals 21:1.

3.1.18
fiber optic cable
cable containing one or more fiber optic waveguides with jacketing material provided to facilitate handling and to protect the fiber

3.1.19
fiber optic receiver
combined optics and electronics in the communicating device that accept the optical signal received by the communicating device through the CPIC

3.1.20
fiber optic receiver operating range
range of optical power that has to be present at the CPIC to ensure that the bit error rate specifications are met

3.1.21
fiber optic transmitter
device that emits optical signals for propagation into a fiber optic waveguide through the CPIC

3.1.22
fiber optic waveguide
flexible, optically transparent strand that is used to transport optical signals from one geographic point to another geographic point

3.1.23
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

3.1.24
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

3.1.25
isolation
physical and electrical arrangement of the parts of a signal transmission system to prevent electrical interference currents within or between the parts

3.1.26
jabber
continuous transmission on the medium due to a faulty device

3.1.27
jitter
offset of the 50 % transition points of pulse edges from their ideal position as the result of all causes

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