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Industrial networks — Ethernet-APL port profile specification

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The text of this Technical Specification is based on the following documents:

Draft	Report on voting
65C/1250/DTS	65C/1275/RVDTS

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 Technical Specification is English.

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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.

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- withdrawn,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

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INTRODUCTION

IEEE Std 802.3™-2022, Clause 146 specifies the Ethernet Physical Layer 10BASE-T1L, suitable to be used for full-duplex communication over a single balanced pair of conductors.

This physical layer is specifically designed for industrial applications, supporting the main requirements for advanced, robust process control and monitoring in safe or hazardous areas.

The primary physical layer solution focuses on four requirements:

- support of single pair cables providing both communication and optional power;
- increased data bandwidth, 10 Mbit/s;
- support of extended Ethernet cable length of up to 1 km;
- support of intrinsically safe protection for use in hazardous areas.

IEEE Std 802.3-2022, Clause 146 only specifies the digital communication method and its electrical characteristics. To assure interoperability between the various interconnected components at different parts of the network, applying this new physical layer for industrial applications requires a further set of specifications and classifications. The "Ethernet Advanced Physical Layer" (Ethernet-APL or APL) references and standardizes industrial automation extensions.

This document specifies port profiles for use in non-hazardous and hazardous areas, with and without power. Ethernet-APL intrinsically safe profiles facilitate the examination of the interconnection of different Ethernet-APL ports. Most common industrial rated connectors for use in process industries are part of this document. A multi-length cable category system maintains communication integrity, while permitting cable constructions optimized for specific applications or environmental ratings.

Ethernet-APL impacts the various physical layers in IEC 61158-2 and its associated Types. This document provides a neutral approach for the new advanced physical layer which can be then transferred to the next editions of different IEC intrinsically safe fieldbus documents. The following documents are representative of potentially affected next editions: IEC 61158-2, IEC 61784-1 series, IEC 61784-2 series, IEC 61918, IEC 61784-5 series.

This document is not intended to assure interoperability at the product level but only at the port level. No reference is made to any Ethernet-based communication protocol above the physical layer.

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Ethernet-APL port profile specification

1 Scope

This document is applicable to process automation equipment using a 10BASE-T1L compliant (see IEEE Std 802.3-2022, Clause 146) Physical Layer (PHY). Ethernet-APL intrinsically safe profiles with different predefined entity or limitation parameters (for example voltage, current, power, capacitance, inductance, cable length) simplify the examination of the interconnection of different Ethernet-APL ports.

The following technical features are part of this document:

- topology with trunk/spur installation capability;
- 2-wire technology (full-duplex communication data rate of 10 Mbit/s);
- long distance (refers to cable lengths of several hundred meters, with spans up to 1 000 m);
- intrinsic safety (installation of Ethernet-capable field devices in hazardous areas);
- power supply to field devices over the same 2-wire cable used for data communication.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

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

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

IEC TS 60079-47:2021, *Explosive atmospheres – Part 47: Equipment protection by 2-wire intrinsically safe ethernet concept (2-WISE)*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61076-2-101, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for circular connectors for M12 connectors with screw-locking*

IEC 61076-2-104, *Connectors for electronic equipment – Product requirements – Part 2-104: Circular connectors – Detail specification for circular connectors with M8 screw-locking or snap-locking*

IEC 61158-2:2023, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61643-21, *Low voltage surge protective devices − Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

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IEEE Std 802.3-2022, *IEEE Standard for Ethernet*

ASTM D4566-05, *Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable*; available at < ASTM D4566-05 - Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable (ansi.org)> [viewed 2023-10-13]

3 Terms, definitions, abbreviated terms and acronyms

3.1 Terms and definitions

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

ISO and IEC maintain terminology 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

3.1.1
Advanced Physical Layer
APL
physical layer based on 10BASE-T1L according to IEEE Std 802.3-2022 with additional optional features like intrinsic safety, power over 2 wires

Note 1 to entry: Additional requirements for use in process industries are specified in this document.

3.1.2
APL segment
segment that consists of two APL ports, each containing a 10BASE-T1L compatible PHY, connected at each end of a two-wire, shielded cable

Note 1 to entry: An APL segment can optionally be equipped with a maximum of two auxiliary devices and can contain up to 10 inline terminal connections. An auxiliary device corresponds to one inline connection; for example, having two auxiliary device connected to one APL segment will reduce the number of inline connections by two.

Note 2 to entry: An APL segment is either a trunk or a spur.

3.1.3
APL switch
Ethernet switch including at least one APL compliant port

3.1.4
APL port
electrical and mechanical interface of a device to an APL segment

3.1.5
auxiliary device
device, which is connected within an APL segment and does not include a 10BASE-T1L PHY

Note 1 to entry: Auxiliary devices are defined in Annex B.

Note 2 to entry: An auxiliary device can comprise a power load or introduce communication signal insertion losses.

EXAMPLE A surge protector is an example of an auxiliary device.

3.1.6
cable stub
unterminated branch of the segment cable

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3.1.7
cascade port
APL port used in powered daisy chain networks

Note 1 to entry: If the cascade port is used in a powered ring network it shall be either a power source port or a power load port depending on the status of the ring.

3.1.8
inline connection
mated device or combination of devices, including terminations used to connect cables or cable elements to other cables or application specific equipment

3.1.9
current event
change of load current during power-up sequence with a specific characteristic

Note 1 to entry: A current event could be either a current step or a current spike.

3.1.10
field switch
APL switch having at least one port to which a spur can be connected

3.1.11
port
interface between a device and an APL segment

3.1.12
port class
port powering characteristics

3.1.13
power switch
APL switch including at least one port feeding power into a trunk

3.1.14
PHY
physical layer circuitry required to implement physical layer functions

3.1.15
overcurrent condition
condition when a power load port draws more than the minimum continuously provided current $I_{PS(min)}$ of the power source port

3.1.16
spur
<APL> segment which connects a field device to a field switch

3.1.17
segment
point-to-point connection between two APL ports

3.1.18
surge protective device
SPD
electrical device that is used to protect electronic equipment against electrical surges and voltage spikes

Note 1 to entry: A SPD is an auxiliary device.

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3.1.19
trunk
<APL> segment which connects a power switch to a field switch or a field switch to a field switch

3.1.20
2-WISE
2-Wire intrinsically safe Ethernet concept based on APL with standardized limits for intrinsic safety parameters, designed to simplify the examination process for components and cable parameters within APL segments

[SOURCE: IEC TS 60079-47:2021, 3.3, modified − a new term has been assigned.]

3.1.21
2.4 V_{pp} operating mode
10BASE-T1L compliant operating mode with a signal amplitude of 2,4 V_{pp}

Note 1 to entry: This mode is used on APL trunk segments.

3.1.22
1.0 V_{pp} operating mode
10BASE-T1L operating mode with a signal amplitude of 1,0 V_{pp}

Note 1 to entry: This mode is used on APL spur segments.

3.2 Abbreviated terms, symbols and acronyms

C_{in}	unlimited input capacitance of a load port
E_{in}	initial inrush energy of a load port or cascade port during power-up, caused by charging-up its input capacitance
EMC	electromagnetic compatibility
Ex	indicates that the electrical equipment corresponds to one or more of the types of protection which are subject of the standards IEC 60079-0 or IEC 60079-11
$I_{CSp(max)}$	maximum current during a current spike event of a load port during start-up
$I_{PS(min)}$	minimum continuously provided current at the power source terminals except during inrush or an overcurrent condition
$I_{PL(min)}$	minimum consumed current at the power load terminals except during inrush or an overcurrent condition
$I_{PL(max)}$	maximum consumed current at the power load terminals during an under voltage condition
$I_{PL(reverse)}$	reverse current for polarity sensitive power load ports
$P_{PL(min)}$	minimum available power at the power load terminals
$P_{PS(min)}$	minimum available output power at the power source terminals
PSANEXT	power sum alien near end crosstalk loss
PSAFEXT	power sum alien far end crosstalk loss
Q_{CSp}	electric charge during a current spike event for a load port during power-up
R_{out}	internal resistance of a power source port
$U_{PS(max)}$	maximum allowed voltage at the power source terminals over the full range of operating conditions
$U_{PS(min)}$	minimum available output voltage at the power source terminals over the full range of operation conditions

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