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Industrial networks - Ethernet-APL port profile / Ethernet-SPE profile specification

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FOREWORD

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IEC TS 63444 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2023. This edition constitutes a technical revision.

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

a) new power class for Ethernet-APL;
b) addition of Ethernet-SPE;
c) clarification of usability of Ethernet-APL in non-hazardous locations.

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

Draft	Report on voting
65C/1386/DTS	65C/1411/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.

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.

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– withdrawn, or
– revised.

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 achieve interoperability between the various interconnected components at different parts of the network, a further set of specifications and classifications are supportive when applying this new physical layer for industrial applications.

In addition, IEEE Std 802.3™-2022, Clause 104, as corrected and amended by IEEE Std 802.3dd-2022 specifies the Power over Data Lines (PoDL) of Single-Pair Ethernet. This clause specifies two optional power entities. These entities allow devices to supply or draw power using the cabling that may be used for data transmission. PoDL does not support intrinsic safety and is optimized for applications that do not require intrinsic safety.

The "Ethernet Advanced Physical Layer" (Ethernet-APL or APL) standardizes 2-wire (single-pair) industrial Ethernet supporting the "2-WISE" (IEC TS 60079-47) intrinsically safe concept. Clause 146 is referenced and extended, and Clause 104 is replaced with an alternate power method. Ethernet-SPE standardizes non-intrinsically safe single-pair industrial Ethernet for process automation, factory automation and building automation. Clause 146 and Clause 104 (PoDL) are referenced and extended. Ethernet-SPE can be used in combination with Ethernet-APL.

The first part of this document specifies 2-WISE compliant Ethernet-APL port profiles for use in hazardous and non-hazardous 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. The second part of this document specifies Ethernet-SPE profiles without intrinsic safety for use in non-hazardous locations, with and without power. This also includes hazardous locations not requiring intrinsic safety.

Ethernet-APL and Ethernet-SPE impact 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, the IEC 61784-1 series, the IEC 61784-2 series, IEC 61918 and the 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.

NOTE 1 As a simplification, this document describes some applications as 'requiring 2-WISE'. Ethernet-APL supports intrinsic safety with 2-WISE can suit these applications. This document describes other applications as 'not requiring 2-WISE'. Ethernet-SPE does not support intrinsic safety (and therefore not 2-WISE) and suits these applications (Ethernet-APL can also be used).

NOTE 2 Heating of cable due to remote powering is not considered in this document. Information is supplied by ISO/IEC TS 29125.

1 Scope

This document is applicable to process automation equipment using a 10BASE-T1L compliant 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. Furthermore, this document is also applicable to factory and building automation and control equipment using a 10BASE-T1L compliant, and Power over Data Lines (PoDL) compliant Physical Layer (PHY) for non-intrinsically safe Ethernet installations.

NOTE In this document the term Ethernet-SPE is used for PoDL compliant PHY.

The following technical features are part of this document:

– topology with trunk and 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;
– non-intrinsically safe Ethernet installation in factory and building automation.

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 installation of equipment, including initial inspection*

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 61156-13, *Multicore and symmetrical pair/quad cables for digital communications - Part 13: Symmetrical single pair cables with transmission characteristics up to 20 MHz - Horizontal floor wiring - Sectional specification*

IEC 61156-14, *Multicore and symmetrical pair/quad cables for digital communications - Part 14: Symmetrical single pair cables with transmission characteristics up to 20 MHz - Work area wiring - Sectional specification*

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 - Part 21: Surge protective devices connected to telecommunications and signalling networks - Requirements and test methods*

IEC 63171:2025, *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 11801-1:2017, *Information technology - Generic cabling for customer premises - Part 1: General requirements*
ISO/IEC 11801-1:2017/AMD1:2025

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

IEEE Std 802.3dd-2022, *IEEE Standard for Ethernet, Amendment 1: Power over Data Lines of Single Pair Ethernet*

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 devices 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 specified 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

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 can 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
power interface
PI
mechanical and electrical interface between the PoDL power sourcing equipment (PSE) or PoDL powered device (PD) and the transmission medium

3.1.15
physical layer
PHY
lowest layer of a communication system model, primarily concerned with the transmission of raw bit streams over a physical medium, which encompasses the hardware technologies that interface with the medium, such as cables, switches, and network interface cards

Note 1 to entry: The physical layer defines the electrical, optical, and mechanical characteristics that enable the data to travel across the network.

3.1.16
data only port
Ethernet-SPE port implementing the 10BASE-T1L PHY (IEEE Std 802.3-2022, Clause 146) without PoDL

3.1.17
power source equipment port
segment of an equipment using power over data line technology

3.1.18
powered device port
segment of a device using power over data line technology

3.1.19
overcurrent condition
condition when a power load port draws more than the minimum continuously provided current $I_{PS(min)}$ of the power source port

3.1.20
Ethernet-SPE device
device with one of two optional PHY interfaces, a PoDL interface or a data only interface

3.1.21
Ethernet-SPE port
either PoDL interface of a device with one of two optional power entities, a PSE or PD for use with supported single balanced twisted-pair Ethernet Physical Layers (see IEEE Std 802.3™-2022, Clause 104.1 as corrected and amended by IEEE Std 802.3dd-2022) or interface for data only communication

3.1.22
Ethernet-SPE transmission channel
segment that consists of two Ethernet-SPE ports, connected at each end of a single pair, shielded cable

3.1.23
spur
<APL> segment which connects a field device to a field switch

3.1.24
segment
point-to-point connection between two APL ports

3.1.25
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.

3.1.26
trunk
<APL> segment which connects a power switch to a field switch or a field switch to a field switch

3.1.27
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.]

3.1.28
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.

3.1.29
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