

TECHNICAL SPECIFICATION

REDLINE VERSION

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

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	1
1 Scope.....	9
2 Normative references	9
3 Terms, definitions, abbreviated terms and acronyms	10
3.1 Terms and definitions.....	10
3.2 Abbreviated terms, symbols and acronyms	13
4 Ethernet-APL and Ethernet-SPE general overview.....	14
5 APL.....	14
5.1 APL overview.....	14
5.1.1 General	14
5.1.2 APL relationship to IEEE Std 802.3-2022 and 10BASE-T1L	17
5.1.3 Conformance test requirements	18
5.2 Port classification	18
5.2.1 Overview	18
5.2.2 Segment class	19
5.2.3 Port class	20
5.2.4 Power class.....	20
5.2.5 Intrinsically safe protection class	26
5.3 General port requirements	28
5.3.1 Terminals and connectors.....	28
5.3.2 Cable shield termination	28
5.3.3 Polarity sensitivity.....	29
5.3.4 Electrical isolation	30
5.4 Short circuit behavior.....	30
5.5 Network configuration rules.....	30
5.5.1 Segment components	30
5.5.2 Topology	30
5.5.3 Cables	31
5.5.4 Wiring rules	32
5.5.5 APL segment definition.....	33
5.6 Electromagnetic compatibility.....	33
6 Ethernet-SPE	33
6.1 Overview	33
6.1.1 General	33
6.1.2 Ethernet-SPE relationship to IEEE 802.3-2022 and 10BASE-T1L	35
6.1.3 Conformance test requirements	36
6.2 Device classification	37
6.2.1 Overview	37
6.2.2 Device port class	37
6.2.3 Power class.....	37
6.3 General device requirements	38
6.3.1 Terminals and connectors.....	38
6.3.2 Cable shield termination	38
6.3.3 Polarity sensitivity.....	39
6.3.4 Electrical isolation	40

6.3.5	Short circuit behavior	40
6.4	Network configuration rules.....	40
6.4.1	Segment components	40
6.4.2	Ethernet-SPE transmission channel definition.....	40
6.4.3	Topology	41
6.4.4	Cables	43
6.4.5	Wiring rules	43
6.5	Electromagnetic compatibility.....	43
Annex A (normative)	APL connectors.....	44
A.1	General.....	44
A.2	M8 and M12 connectors	45
A.2.1	General	45
A.2.2	Requirements	45
A.2.3	Pin assignment.....	45
A.3	Printed circuit board and modular terminal blocks	46
A.3.1	General	46
A.3.2	Requirements	46
A.3.3	Pin assignment.....	47
A.4	Junction terminal blocks.....	48
A.4.1	General	48
A.4.2	Requirements	48
A.4.3	Pin assignment.....	48
Annex B (normative)	Auxiliary devices	49
B.1	General requirements	49
B.2	Surge protection	49
Annex C (normative)	Ethernet-SPE connectors.....	51
C.1	General.....	51
C.2	Pin assignment	52
Annex D (informative)	Ethernet-SPE power cable length calculation	55
Annex E (informative)	Ethernet-SPE interconnection module	57
Annex F (informative)	Connecting Ethernet-APL devices to Ethernet-SPE switch.....	58
Bibliography.....		59
Figure 1 – APL topology example		15
Figure 2 – Example APL segment including auxiliary devices and inline terminals		16
Figure 3 – Port classes and related options		19
Figure 4 – Powered trunk segments with cascade ports		20
Figure 5 – Example of port class matching between source and load		22
Figure 6 – Illustrative current step characteristics during start-up of a load port		26
Figure 7 – Example of intrinsically safe protection class matching to port class and power class		27
Figure 8 – Cable shield grounding options		29
Figure 9 – Ethernet-SPE topology example.....		34
Figure 10 – Example Ethernet-SPE transmission channel including auxiliary devices and inline terminals.....		35
Figure 11 – Cable shield grounding options		39

Figure A.1 – Port class to connector type matching.....	45
Figure A.2 – Pin assignment of the plug and socket M8 A-coding connectors	46
Figure A.3 – Pin assignment of the plug and socket M12 A-coding connectors.....	46
Figure A.4 – Examples of modular pluggable terminal blocks	48
Figure A.5 – Representative junction terminal block.....	48
Figure B.1 – Basic circuit diagram of coordination between surge protector and powered APL port	49
Figure B.2 – Parallel connection of an SPD to an APL segment	50
Figure C.1 – Port class to connector type matching	52
Figure C.2 – Pin assignment of the plug and socket M8 connectors ("Type I")	53
Figure C.3 – Pin assignment of the plug M12 hybrid connector ("Type I")	53
Figure C.4 – Pin assignment of the plug and socket M12 connectors ("Type I")	53
Figure C.5 – Pin assignment of the plug and socket IP20 connectors ("Type I")	54
Figure E.1 – Coupler from AWG18 cable to AWG22 connector interface (IEC 63171)	57
Figure F.1 – Ethernet-SPE to Ethernet-APL adapter example	58
Table 1 – IEEE Std 802.3-2022 PHY, management and power options	17
Table 2 – Segment class.....	19
Table 3 – Port classes	20
Table 4 – Power classes.....	21
Table 5 – Electrical characteristics of power classes.....	22
Table 6 – Electrical characteristics for trunk ports.....	23
Table 7 – Electrical characteristics for spur ports.....	25
Table 8 – Intrinsically safe protection class.....	27
Table 9 – Minimum required shielding options of a port.....	28
Table 10 – Polarity sensitivity	29
Table 11 – Cable category system	32
Table 12 – IEEE Std 802.3-2022 PHY, management and power options	36
Table 13 – Class power requirements matrix for PSE, power interface (PI), and PD for classes 10 to 15.....	38
Table 14 – PSE power availability matrix for PSE and PD for class 10 through 15	38
Table 15 – Minimum required shielding options.....	39
Table 16 – Basic Ethernet-SPE transmission channel characteristics (data only)	41
Table 17 – Basic Ethernet-SPE transmission channel characteristics (Data and Power)	42
Table A.1 – Supported terminal block/connector types.....	44
Table A.2 – Electrical requirements terminal block/connector.....	44
Table A.3 – Pin assignments for plug and socket M8 and M12 A-coding connectors	46
Table A.4 – Pin assignments for 3 position terminal blocks	47
Table A.5 – Pin assignments for 4 position terminal blocks	47
Table A.6 – Pin assignments for 6 position terminal blocks	47
Table C.1 – Supported terminal block/connector types.....	51
Table C.2 – Electrical requirements Ethernet-SPE connectors (Type I).....	51
Table C.3 – Standard requirements of M12 hybrid Ethernet-SPE connector ("Type I")	52

Table C.4 – Pin assignments for Ethernet-SPE connectors (2 pins)	53
Table C.5 – Pin assignment for Ethernet-SPE M12 hybrid connectors.....	53
Table D.1 – DC loop resistance calculation for power class 10 to 15.....	55
Table D.2 – DC loop resistance for cable sizes AWG13 to AWG24	55
Table D.3 – Additional DC loop resistance	56
Table D.4 – Calculated cable length on power class and wire size	56

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

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 63444:2023. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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 ~~assure~~ 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 ~~requires a further set of specifications and classifications. The "Ethernet Advanced Physical Layer" (Ethernet-APL or APL) references and standardizes industrial automation extensions.~~

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 ~~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. 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.

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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. 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~~l~~ 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 ~~erection~~ 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 - ~~Performance~~ Requirements and ~~testing~~ 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*

~~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]~~

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 ~~could~~ 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

~~physical layer circuitry required to implement physical layer functions~~

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