

## APPLICATION NOTE

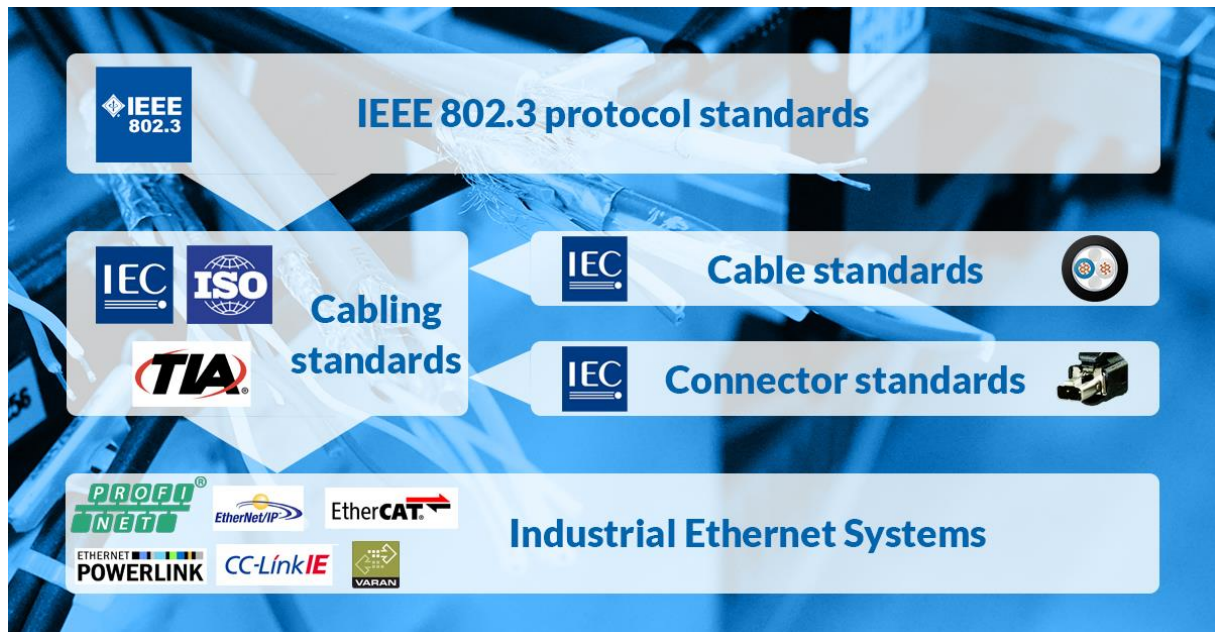
# SINGLE PAIR ETHERNET – STANDARDS LANDSCAPE

### SPE STANDARDS BASE

For communication systems in particular, international uniform standards are existentially important and necessary, because only in this way worldwide Ethernet networks can be planned, set up and operated. The following organisations and committees are relevant for the standardisation of SPE, and we are actively involved there:

- IEEE 802.3 – Ethernet protocols, MDI, Link segment
- IEC SC46C – Balanced copper cables (IEC 61156-x Series)
- IEC SC 48B – Connectivity (IEC 63171-x Series)
- ISO/IEC JTC 1/SC 25/WG3 – Generic cabling (ISO/IEC 11801 Series)
- IEC SC65C – Industrial networks, cabling (IEC 61918 and IEC 61784-5 Series)
- ANSI/TIA TR-42 – Cabling systems (valid for North America)

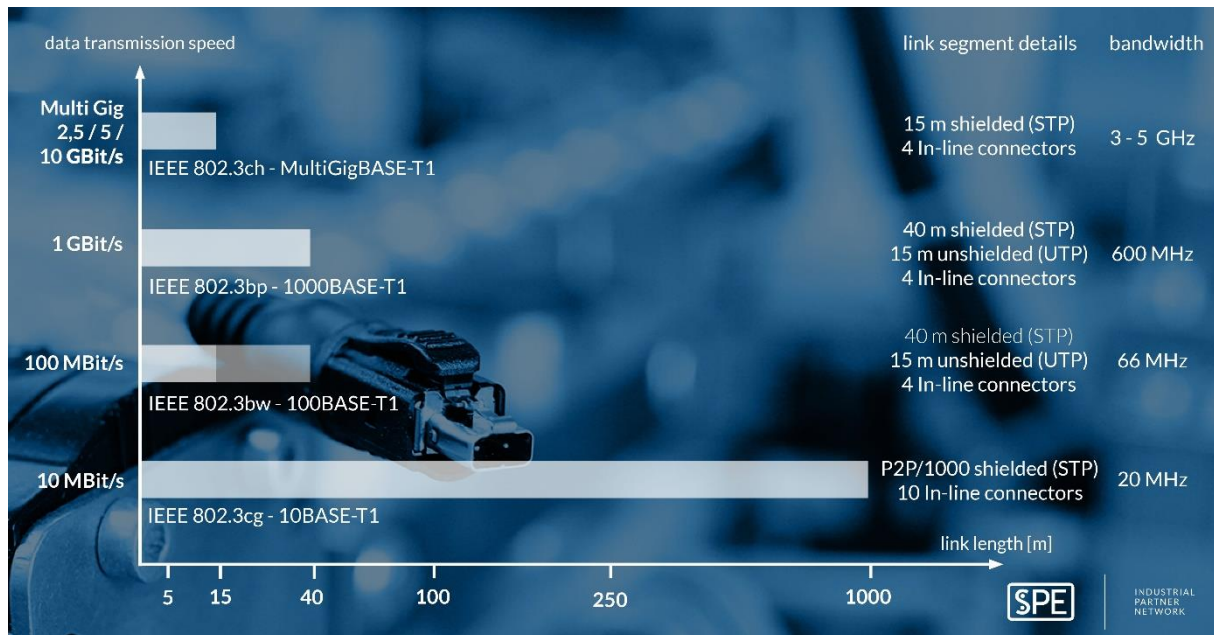
The following diagram shows the essential interaction of these standards organizations:



The IEEE 802.3 specifies the primary transmission method and must also specify the transmission channel, such as the transmission length and number of connectors. The cabling committees ISO/IEC and TIA consider the transmission channel and access the corresponding IEC groups for connectors and cables. There is close cooperation between IEEE802.3 and ISO/IEC and TIA.

## IEEE 802.3 ETHERNET PROTOCOLS

This diagram shows the published SPE protocols with their corresponding possible transmission lengths and essential details:



In addition to the "classic" point-to-point (P2P) SPE protocols shown above, a type of BUS standard 10BASE-T1S is also available. These are also compatible with the Power over DataLine (PoDL) remote power supply technology. The 10BASE-T1S standard is a point-to-multipoint (P2MP) or, as IEEE802.3 calls it, a multi-drop transmission system thus functions like an Ethernet bus via an unshielded cable at least 25 m long with a minimum of 8 devices. PoDL cannot be used here at present. The IEEE802.3da working group wants to change this and increase the number of bus nodes to at least 16 and the transmission length to at least 50 metres.

Due to the focus on automotive applications, no specific MDI connectors are specified for all SPE standards except IEEE 802.3cg. This enables users in the automotive industry in particular to use manufacturer-specific connectors.

The IEEE 802.3cg was approved in November 2019 and there the "LC Style" according to IEC 63171-1 and the T1 Industrial according to IEC 63171-6 are listed as optional MDI ("...may be used..."). This formulation was chosen in order to be able to use other connectors, in particular special types for



automotive applications or also PCB terminals, provided they meet the defined requirements. However, for cabling in buildings, data centers and industry, the LC style connectors selected in the ISO/IEC 11801 and TIA sets of standards according to IEC 63171-1 and the "T1 Industrial Style" according to IEC 63171-6 must be used.

In March 2021, at the IEEE802 - Plenary Meeting, a task force was formed to extend point-to-point protocols to add TSN functionality for 10BASE-T1L and look at possible increases in transmission lengths. This 802.3de "Time Synchronization for Point-to-Point Single Pair Ethernet Task Force" is developing an extension to IEEE Std 802.3 to add 10 Mbit/s Single Pair Ethernet point to point PHYs to the PHYs supporting the MAC Merge function and the Time Synchronization Service Interface (TSSI). The 802.3dg working group will develop a new protocol for 100 Mbit/s over at least 500 m transmission length. Furthermore, the IEEE802.3cy working group is working on SPE speeds above 10 Gbit/s for automotive Ethernet applications. Results in the form of approved standards for all these working groups are expected from 2023 to 2025 (see also: [www.ieee802.org/3/index.html](http://www.ieee802.org/3/index.html)).

## IEC 61156-x – STANDARTISATION OF SPE CABLE

Within the IEC working group SC46C for the standardization of data cables as meter goods, the following standards projects are in progress:

- IEC 61156-11 – SPE - Data cable up to 600 MHz bandwidth for permanent installation (Edition 1 final published)
- IEC 61156-12 – SPE - Data cable up to 600 MHz bandwidth for flexible installation (Edition 1 final published)
- IEC 61156-13 – SPE - Data cable up to 20 MHz bandwidth for permanent installation (CD available)
- IEC 61156-14 – SPE - Data cable up to 20 MHz bandwidth for flexible installation (planned and publication of Edition 1 planned for 07/2022)

For IEC 61156-11 and -12, a 2nd edition is being prepared for a bandwidth of 1250 MHz to support the SPE transmission channel T1-C in ISO/IEC 11801-1. For IEC 61156-13 and -14, a 2nd edition is preparation for a bandwidth of 1250 MHz to support the SPE transmission channel T1-C in ISO/IEC 11801-1. Further standards projects, for example for higher bandwidths to support data rates above 1 Gbit/s, will also be processed in the future.



## IEC 63171 – STANDARDISATION OF SPE CONNECTION TECHNOLOGY

The first SPE connector standard draft was already submitted by HARTING to SC48B in 2016 and published as IEC 61076-3-125 until the CD document. In 2017, another SPE connector face was submitted for standardisation by CommScope and it was decided to create the common IEC 63171 series of standards for all SPE connectors. Accordingly, the PT63171 project team was set up at SC48B and commissioned with the creation of this new series of standards. The standards already in progress at that time were completed as self-contained documents and later integrated into this new series of standards within the framework of revisions. The following standards projects have already been published or are in progress:

- [IEC 63171](#) – Basic standard Basic standard with all specifications and test sequences (Edition 1 published)
- [IEC 63171-1](#) – SPE- plug of the company CommScope based on the LC interlock for M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub> Applications (Edition 1 published und Edition 2 started)
- [IEC 63171-2](#) – SPE-Steckverbinder der Firma Reichle & De-Massari für M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub> Anwendungen (Edition 1 published)
- IEC 63171-3 – SPE- plug of the company Siemon based on a pair of the well-known Tera connectors for M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub> Applications (withdrawn)
- IEC 63171-4 – SPE- plug of the company BKS for M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub> Applications (CD available)
- IEC 63171-5 – SPE- plug of the company Phoenix Contact based on IEC 63171-2 mating face for M<sub>2</sub>I<sub>2</sub>C<sub>2</sub>E<sub>2</sub> und M<sub>3</sub>I<sub>3</sub>C<sub>3</sub>E<sub>3</sub> Applications (Second CDV in preparation)
- [IEC 63171-6](#) (so far IEC 61076-3-125) – SPE plug of the companies HARTING and TE Connectivity for M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub>, M<sub>2</sub>I<sub>2</sub>C<sub>2</sub>E<sub>2</sub> and M<sub>3</sub>I<sub>3</sub>C<sub>3</sub>E<sub>3</sub> Applications (Published in January 2020 and Edition 2 published in March 2020)
- IEC 63171-7 – M12 Hybrid SPE plugs of the company TE for M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub>, M<sub>2</sub>I<sub>2</sub>C<sub>2</sub>E<sub>2</sub> and M<sub>3</sub>I<sub>3</sub>C<sub>3</sub>E<sub>3</sub> Applications with up to 5 additional contacts for power supply (CDV in circulation)

**Note:** IEC 63171-1 (LC Style) and IEC 63171-6 (Industrial Style) are complete standard documents with all necessary specifications and test sequences. All standards started later referring to the basic standard IEC 63171 and only include the different mechanical designs.

The IEC 63171-6 for T1 Industrial is the world's first available standard for SPE connectors and covers all versions from IP20 to IP 65/67.

## SPE CABLING STANDARDS

SPE and the connectors standardised for it flow into the current cabling standards. Internationally, this primarily concerns the series of standards for structured cabling according to ISO/IEC 11801: 2017 (Edition 3) and, in a similar way, the European series of standards in CENELEC according to EN 50173.



Here, SPE is first incorporated into Part 3 *Industrial Cabling* via annexes (Amendments). The central document for these annexes is ISO/IEC 11801 TR9906 “TECHNICAL REPORT: Balanced 1-pair cabling channels up to 600 MHz”. The implementation of SPE in the ISO/IEC 11801 documents is important because only this standard describes the cabling channels with all the necessary parameters (length, number of connections, bandwidth and the complete set of transmission parameters including NEXT, FEXT, shielding characteristics, etc.) in relation to the environment - MICE - and can therefore also be metrologically verified after installation. [ISO/IEC 11801-3 AMD1](#) was published in April 2021. This new annex contains the SPE cabling channels:

- for industrial applications including the 10 Mbit/s 1000 m channel and the 1 Gbit/s 40 m channel in Annex E (normative) „Requirements for 1-pair cabling channels up to 600 MHz“
- and Specifications for the End-to-End Link (E2EL) up to 500 MHz / Cat.6<sub>A</sub> in Annex D (normative) “Requirements for End-to-End Link configurations”

In parallel, the installation standard IEC 61918 (IEC SC65C) for industry as a basis for the cabling of automation solutions was also adapted and supplemented by SPE. The new amendment to IEC 61918 addresses the new 1-pair cabling structures for Single Pair Ethernet (SPE) and the associated remote power supply PoDL (Power over Data Line). This closes the gap between classic IT infrastructure and industry, IoT/IIoT. SPE has a special significance for industry and the automation island. For the first time, it enables the universal application of TCP/IP-based automation protocols even for long distances, as in process automation or for the simple connection of sensors and actuators up to the industrial field level.

To what extent this will then also influence the automation profiles themselves remains to be seen. What is certain is that PI (with PROFINET according to IEC 61784-5-3) and ODVA (with EtherNet/IP™ according to IEC 61784-5-2) are actively involved in the further development and implementation of standards for SPE and are working on corresponding profile-specific standard documents. A similar approach will certainly be taken with Advance Physical Layer (APL), based on 10BASE-T1L, for the process industry and a new profile will also be developed for this in IEC 61784-5-x.

In conjunction with the component standards for connectors and cables, all users of SPE receive clear guidelines for the construction and testing of corresponding transmission links. For 1 Gbit/s SPE, these cabling are initially limited to a range of 40 metres. For the 10 MBit/s variant, ranges of 1,000 m and beyond are realised.



Other papers on SPE cabling relevant to the USA including Canada and Mexico, such as ANSI/TIA-568.5, are being prepared at TIA TR 42.9. In the TIA 42.9 papers, this is realised via a revision: ANSI/TIA-1005-B (industrial cabling without SPE). In terms of content, all these additions are largely congruent.

These cabling standards provide the user with information on the structure of the cabling, the cabling components to be used to achieve the performance specifications and the limit values for checking the cabling. Thus, they are the most important instrument for the construction and commissioning of SPE cabling. At the same time, they ensure compatibility between devices and cabling via the references to the component standards (e.g. connectors according to IEC 63171-6). This compatibility is a basic prerequisite for the function of networks and connections based on SPE and thus the basis for IoT/IIoT. The use of other cabling components is possible in principle, but then no longer complies with the standard and carries the risk of incompatibilities and functional losses.

For this reason, ISO/IEC JTC 1/SC 25/WG 3 and TIA 42 launched international selection processes at the beginning of 2018 to define uniform interfaces. These two selection processes were co-initiated by IEEE 802.3, which requested a recommendation for an SPE MDI (= Media Depended Interface, the SPE device interface) from ISO/IEC and TIA.

More than 20 national expert panels participated in this selection process. As a result of this selection, two mating faces have prevailed:

- for the Enterprise cabling ( $M_{11}C_1E_1$ ) the mating face according to IEC 63171-1: this mating face is based on the proposal of the company CommScope;
- for the industry and industry-related applications ( $M_{21}C_2E_2$  and  $M_{31}C_3E_3$ ) the mating face according to IEC 63171-6 (so far IEC 61076-3-125): This mating face is based on the proposal of the company HARTING with the „T1 Industrial“.

The selection process at TIA 42 has confirmed the results of ISO/IEC and thus there is clear global agreement on the SPE interfaces. These selected mating faces are now being incorporated into the respective international cabling standards. IEEE 802.3 has also specified these SPE interfaces in IEEE 802.3cg as the recommended Media Depended Interface (MDI).

This is the prerequisite for the widespread use and thus for the successful marketing of SPE technology with the universal compatibility of devices, cables and connectors in different fields of application and provides planning security for all market participants.



**Glossary – MICE** describe ambient conditions for installations and provides planners and users with valuable information on the specification of technical equipment and cabling. Requirements for mechanical robustness (M), IPxx degree (I), chemical and climatic resistance (C) and electromagnetic safety (E) are described. In the broadest sense, M<sub>1</sub>I<sub>1</sub>C<sub>1</sub>E<sub>1</sub> describes an environment such as that found in an office building, for example, and M<sub>3</sub>I<sub>3</sub>C<sub>3</sub>E<sub>3</sub> describes an extreme environment such as that found in industry or outdoors.

## OUTLOOK – INDUSTRIAL ETHERNET USER GROUPS

Besides the completion of the cabling standards at ISO/IEC and TIA, the focus of SPE standardization will now be on the integration of SPE into the Industrial Ethernet standardization groups such as PI (PROFINET International), ETG (EtherCAT), IDA (Modbus), CLPA (CC-Link IE), ODVA (EtherNet/IP™) and other user groups.

Depending on the strategic orientation and skills of these user groups, however, the implementation of SPE in the individual automation profiles will probably be carried out from the device side (sensor/actuator networks) and will not automatically affect communication in the higher-level automation network. For the time being, Fast Ethernet (e.g. PROFINET) and Gigabit Ethernet (e.g. EtherNet/IP™) will continue to predominate.

## SUMMARY

**The T1 Industrial according to IEC 63171-6 is set in IEEE 802.3 as MDI as well as in the cabling standards of ISO/IEC and TIA. This makes the T1 Industrial the world's first and only standardised connector for SPE, giving users the certainty of using the right interface for all industrial applications. This comprehensive standardisation and referencing of the T1 Industrial makes it the only consistently standardised SPE interface on the market worldwide.**



## DOCUMENT INFORMATION



**Document:** 2022-04\_SPE-STANDARDS\_V12EN.DOCX

**Date:** 2022-04-04                      **Version:** 1.2

**Authors:** Rainer Schmidt & Matthias Fritsche

## COPYRIGHT NOTICE

This document is the intellectual property of the SPE Industrial Partner Network e.V., which also holds the exclusive copyright. No part of this document may be modified, reproduced or reprinted without the express permission of the SPE Industrial Partner Network e.V.

The SPE Industrial Partner Network e.V. reserves the right to change this document in whole or in part. All brand and product names are trademarks or registered trademarks of their respective owners.

## CONTACT

SPE Industrial Partner Network e.V.  
Weher Straße 151  
D-32369 Rahden  
Germany

[info@single-pair-ethernet.com](mailto:info@single-pair-ethernet.com)  
[www.single-pair-ethernet.com](http://www.single-pair-ethernet.com)