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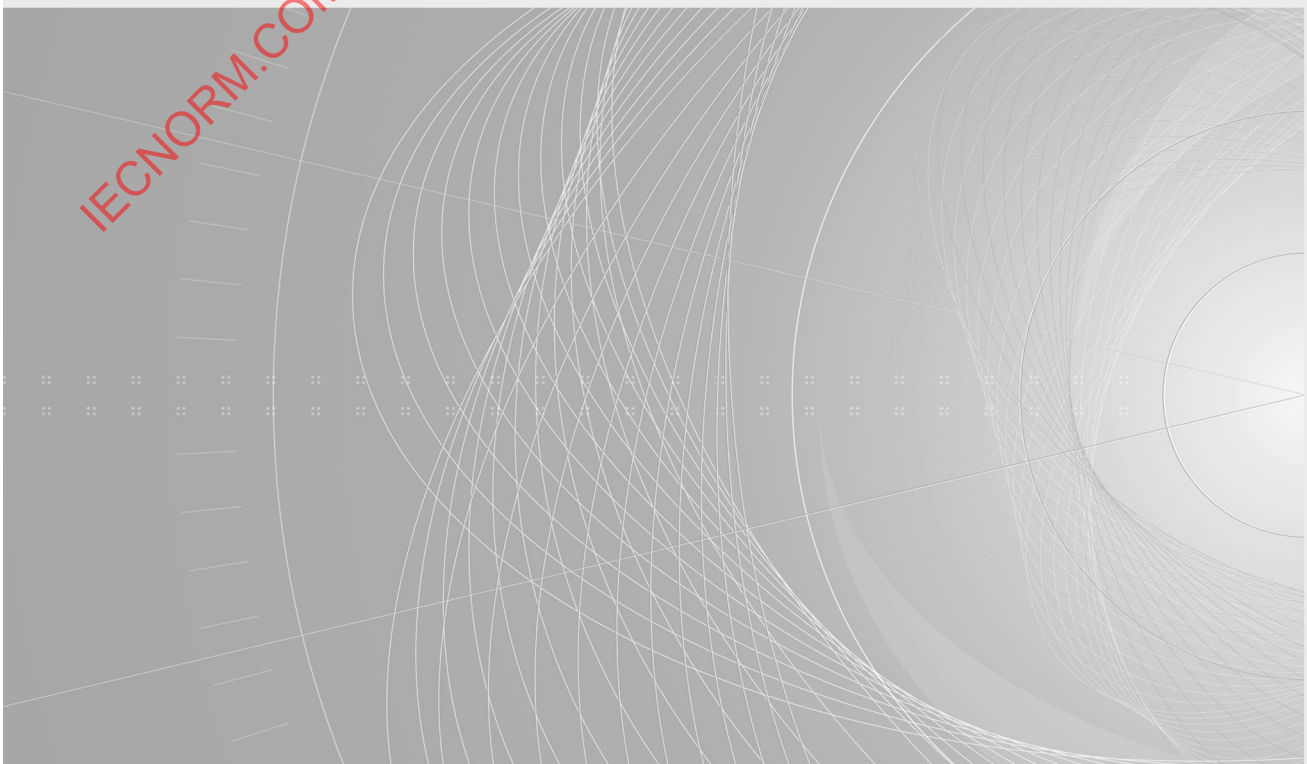
TECHNICAL REPORT

Information technology – Generic cabling for customer premises – Part 9906: Balanced single-pair cabling channels up to 600 MHz for single-pair Ethernet (SPE)



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Part 9906: Balanced single-pair cabling channels up to 600 MHz for single-pair Ethernet (SPE)

FOREWORD

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ISO/IEC TR 11801-9906 has been prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2020. This edition constitutes a technical revision.

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

a) the addition of ISO/IEC/IEEE 8802-3, 100BASE T1L, long reach;
b) complete rearrangement of the information contained in Clause 4, Clause 5, Annex A, Annex B, and Annex C.

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

Draft	Report on voting
JTC1-SC25/3279/DTR	JTC1-SC25/3293/RVDTR

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 Report is English.

The list of all currently available parts of the ISO/IEC 11801 series, under the general title *Information technology – Generic cabling for customer premises*, can be found on the IEC and ISO websites.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, and the ISO/IEC Directives, JTC 1 Supplement available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

INTRODUCTION

This document is a compendium of balanced single-pair cabling channel specifications, which support application-specific use in the link-segments specified in ISO/IEC/IEEE 8802-3 single-pair Ethernet (SPE) physical interface (PHY) standards.

The balanced single-pair cabling channels support SPE PHYs as specified in ISO/IEC/IEEE 8802-3, including 1000BASE-T1 Type B, 1000BASE-T1 Type A, 100BASE-T1L, 100BASE-T1, 10BASE-T1L, and 10BASE-T1S.

NOTE At the time of publication, 100BASE-T1L is unpublished.

While the original use case for SPE was automotive applications, this document describes balanced single-pair cabling channels intended for use in non-automotive, SPE applications, for example:

1) industrial automation applications, Industrial Internet of Things (IIoT), Industry 4.0;
2) enterprise building applications, Internet of Things (IoT), smart lighting, energy management, and access control;
3) other IoT applications, smart building, and home automation applications.

SPE cabling channels support bidirectional signal transmission, using one balanced pair, for 1 000 Mbit/s up to 40 m, 100 Mbit/s up to 500 m, or 10 Mbit/s up to 1 000 m, where reach is influenced by cabling channel capacity limitations from signal loss.

INFORMATION TECHNOLOGY – GENERIC CABLING FOR CUSTOMER PREMISES –

Part 9906: Balanced single-pair cabling channels up to 600 MHz for single-pair Ethernet (SPE)

1 Scope

This document covers cabling channel specifications, for cabling channels constructed from balanced single-pair cabling components, intended for use in:

1) industrial automation applications, Industrial Internet of Things (IIoT), Industry 4.0;
2) enterprise building applications, Internet of Things (IoT), smart lighting, energy management, and access control;
3) other IoT applications, smart building, and home automation applications.

The cabling channel specifications are intended to support ISO/IEC/IEEE 8802-3 single-pair Ethernet (SPE) link segment specifications in the following SPE physical layer specifications (PHYs):

a) 1000BASE-T1 Type B, with reach up to 40 m;
b) 1000BASE-T1 Type A, with reach up to 15 m;
c) 100BASE-T1L, with reach up to 500 m;
d) 100BASE-T1, with reach up to 15 m;
e) 10BASE-T1L, with reach up to 1000 m;
f) 10BASE-T1S, with reach up to 15 m.

NOTE At the time of publication, 100BASE-T1L is unpublished.

The channel component specifications are referenced according to corresponding IEC balanced single-pair cable and connector specifications.

Channel specifications include IL, RL, TCL, coupling attenuation, and alien crosstalk parameters specifications.

The channel EMC related specifications are referenced according to the MICE standard environmental characterization systems specified in ISO/IEC 11801-1.

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.

ISO/IEC 11801-1, *Information technology – Generic cabling for customer premises – Part 1: General requirements*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11801-1 and the following apply.

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

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

3.1.1
balanced single-pair cabling channel
cabling channel constructed from balanced single-pair cables, balanced single-pair connectors and balanced single-pair cords to form a cabling channel intended for use in differential-mode signal transmission and power delivery applications

3.1.2
balanced single-pair cable
cable consisting of a single pair of conductors, optional screen, and overall jacket, primarily intended for use in differential-mode signal transmission and power delivery applications

3.1.3
balanced single-pair connector
connector intended for use with balanced single-pair cable in differential-mode signal transmission and power delivery applications

3.1.4
balanced single-pair cord
cable assembly constructed from a single-pair cable and single-pair connectors

3.2 Symbols

V_{pp} peak-to-peak voltage

4 Single-pair Ethernet (SPE) link segment specifications

4.1 General

The cabling channel specifications are intended to support ISO/IEC/IEEE 8802-3 single-pair Ethernet (SPE) link segment specifications in the SPE physical layer specifications (PHYs) listed in Clause 1.

The information provided in this Clause 4 on single-pair cabling is from ISO/IEC/IEEE 8802-3, which gives additional information.

4.2 Link segment specifications

ISO/IEC/IEEE 8802-3 single-pair Ethernet (SPE) link segment characteristics are summarized in Table 1.

Table 1 – SPE link segment characteristics

SPE link segment	Data rate	Reach	Frequency range	Number of inline connectors	Screen Type
PHY	Mb/s	m	MHz		
1000BASE-T1 Type B	1 000	40	$1 \leq f \leq 600$		Screened and unscreened
1000BASE-T1 Type A	1 000	15	$1 \leq f \leq 600$		Screened and unscreened
100BASE-T1L	100	500	$0{,}1 \leq f \leq 60$	5	Screened and unscreened
100BASE-T1	100	15	$0{,}3 \leq f \leq 66$		Screened and unscreened
10BASE-T1L	10	1 000	$0{,}1 \leq f \leq 20$	10	Screened and unscreened
10BASE-T1S	10	15	$0{,}1 \leq f \leq 20$		Screened and unscreened

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.3 Environmental classifications

The balanced single-pair cabling specifications referenced in ISO/IEC/IEEE 8802-3 include channel EMC related specifications for electromagnetic isolation levels E_1, E_2 and E_3, which are defined according to the MICE standard environmental characterization system specified in ISO/IEC 11801-1.

4.4 SPE link segment signal transmission specifications

4.4.1 SPE link segment return loss (RL)

The SPE link segment return loss (RL) specifications are given in Table 2.

Table 2 – SPE link segment return loss (RL)

SPE link segment	Reach	Frequency range	RL	Screen type
PHY	m	MHz	dB max.	
1000BASE-T1 Type B	40	$1 \le f \le 10$	19,0	Screened and unscreened
		$10 < f \le 40$	$24 - 5 \lg(f)$	
		$40 < f \le 130$	16	
		$130 < f \le 400$	$37 - 10 \lg(f)$	
		$400 < f \le 600$	11	
1000BASE-T1 Type A	15	$1 \le f \le 10$	19,0	Screened and unscreened
		$10 < f \le 40$	$24 - 5 \lg(f)$	
		$40 < f \le 130$	16	
		$130 < f \le 400$	$37 - 10 \lg(f)$	
		$400 < f \le 600$	11	
100BASE-T1L	500	$0,1 \le f \le 0,5$	$9,0 + 8f$	Screened and unscreened
		$0,5 < f \le 20$	13,0	
		$20 < f \le 60$	$13 - 10 \lg(f/20)$	
100BASE-T1	15	$0,3 \le f \le 20$	18,0	Screened and unscreened
		$20 < f \le 66$	$18 - 10 \lg(f/20)$	
10BASE-T1L	1 000	$0,1 \le f \le 0,5$	$9,0 + 8f$	Screened and unscreened
		$0,5 < f \le 20$	13,0	
10BASE-T1S	15	$0,3 \le f < 10$	14	Screened and unscreened
		$10 \le f \le 40$	$14 - 10 \lg(f/10)$	

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.4.2 SPE link segment insertion loss (IL)

The SPE link segment insertion loss (IL) specifications are given in Table 3.

Table 3 – SPE link segment IL

SPE link segment	Reach	Frequency range	SPE link segment IL	Screen type
PHY	m	MHz	dB max.	
1000BASE-T1 Type B	40	$1 \le f \le 600$	$0,7131\sqrt{f} + 0,004f + (\frac{0,11}{\sqrt{f}}) + 0,08\sqrt{f} + 0,018\sqrt{f}$	Screened
1000BASE-T1 Type A	15	$1 \le f \le 600$	$\left(0,5907\sqrt{f} + 0,0023f + \frac{0,0639}{\sqrt{f}}\right)$	Screened and unscreened
100BASE-T1L	500	$0,1 \le f \le 60$	$\left(5,42\sqrt{f} + 0,044f + \frac{1,76}{\sqrt{f}}\right) + 5 \times 0,02\sqrt{f}$	Screened and unscreened
100BASE-T1	15	$1 < f < 10$	$1,0 + 1,6 \times \frac{f-1}{9}$	Screened and unscreened
		$10 < f < 33$	$2,6 + 2,3 \times \frac{f-10}{23}$	
		$33 < f \le 66$	$4,9 + 2,3 \times \frac{f-33}{33}$	
10BASE-T1L	1 000	$0,1 \le f \le 20$	$10 \times \left(1,23\sqrt{f} + 0,01f + \frac{0,2}{\sqrt{f}}\right) + 10 \times 0,02\sqrt{f}$ For PHY in the 2,4 V_{pp} operation	Screened and unscreened
			$5,9 \times \left(1,23\sqrt{f} + 0,01f + \frac{0,2}{\sqrt{f}}\right) + 10 \times 0,02\sqrt{f}$ For PHY in the 1,0 V_{pp} operation	
10BASE-T1S	15	$1 < f \le 10$	$1,0 + 1,6 \times \frac{f-1}{9}$	Screened and unscreened
		$10 < f \le 33$	$2,6 + 2,3 \times \frac{f-10}{23}$	
		$33 < f \le 40$	$4,9 + 2,3 \times \frac{f-33}{33}$	

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.4.3 SPE link segment unbalance attenuation and coupling attenuation

4.4.3.1 General

SPE link segment unbalance attenuation parameters, transverse-conversion-loss (TCL) and equal-level-transverse-conversion-transfer-loss (ELTCTL) are used for differential-mode-to-common-mode conversion loss specifications, for unscreened cabling.

SPE link segment coupling attenuation is used for screened cabling.

SPE link segment differential-mode-to-common-mode conversion loss specifications correspond to balanced single-pair cabling channel EMC related specifications in accordance with E_1, E_2 and E_3 electromagnetic characterizations.

4.4.3.2 SPE link segment transverse-conversion-loss (TCL)

The SPE link segment transverse-conversion-loss (TCL) specifications are given in Table 4.

Table 4 – SPE link segment TCL

SPE link segment	Reach	Frequency range	TCL			Screen type
			E_1	E_2	E_3	
PHY	m	MHz	dB min.	dB min	dB min	
1000BASE-T1 Type B	40	$1 \le f \le 600$	Not specified	Not specified	Not specified	Screened
1000BASE-T1 Type A	15	$10 \le f \le 80$	50	50	50	Screened and unscreened
		$80 < f \le 600$	$72 - 11{,}51 \lg(f)$	$72 - 11{,}51 \lg(f)$	$72 - 11{,}51 \lg(f)$	
100BASE-T1L	500	$0{,}1 \le f \le 5$	≥ 30	Not specified	Not specified	Screened and unscreened
		$5 < f \le 60$	$\ge 30 - 10 \lg(f/5)$			
100BASE-T1	15	$1 \le f \le 33$	43	43	43	Screened and unscreened
		$33 < f \le 200$	$43 - 20 \lg(f/20)$	$43 - 20 \lg(f/20)$	$43 - 20 \lg(f/20)$	
10BASE-T1L	1 000	$0{,}1 \le f \le 10$	≥ 50	≥ 50	Not specified	Screened and unscreened
		$10 < f \le 20$	$\ge 50 - 20 \lg(f/10)$	$\ge 50 - 20 \lg(f/10)$	Not specified	
10BASE-T1S	15	$0{,}3 \le f \le 20$	43	43	43	Screened and unscreened
		$20 < f \le 200$	$43 - 20 \lg(f/20)$	$43 - 20 \lg(f/20)$	$43 - 20 \lg(f/20)$	

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.4.3.3 SPE link segment equal-level-transverse-conversion-transfer-loss (ELTCTL)

The SPE link segment equal-level-transverse-conversion-transfer-loss (ELTCTL) specifications are given in Table 5.

Table 5 – SPE link segment ELTCTL

SPE link segment	Reach	Frequency range	ELTCTL			Screen type
			E_1	E_2	E_3	
PHY	m	MHz	dB	dB	dB	
1000BASE-T1 Type B	40	$1 \le f \le 600$	Not specified	Not specified	Not specified	Screened
1000BASE-T1 Type A	15	$1 \le f \le 600$	Not specified	Not specified	Not specified	Screened and unscreened
100BASE-T1L	500	Not specified	Not specified	Not specified	Not specified	Screened and unscreened
100BASE-T1	15	$0{,}1 \le f \le 40$	Not specified	Not specified	Not specified	Screened and unscreened
10BASE-T1L	1 000	$0{,}1 \le f \le 10$	Not specified	Not specified	Not specified	Screened and unscreened
		$10 < f \le 20$	Not specified	Not specified	Not specified	
10BASE-T1S	15	$0{,}1 \le f \le 20$	Not specified	Not specified	Not specified	Screened and unscreened

NOTE 1 While none of the SPE link segment specifications have ELTCTL requirements, both 1000BASE-T1 and 100BASE-T1 have TCTL requirements, and 10BASE-T1S has a "mode conversion" requirement, which are not given in this document.

NOTE 2 While no ELTCTL link segment specifications are given by ISO/IEC/IEEE 8802-3 for these applications, it is important to consider them for long lengths; these values are implicit from the TCL values and correspond to ISO/IEC 11801-1 values.

NOTE 3 At the time of publication, 100BASE-T1L is unpublished.

4.4.3.4 SPE link segment coupling attenuation

The SPE link segment coupling attenuation specifications are given in Table 6.

Table 6 – SPE link segment coupling attenuation

SPE link segment	Reach	Frequency range	Coupling attenuation			Screen type
			E_1	E_2	E_3	
PHY	m	MHz	dB max.	dB max.	dB max.	
1000BASE-T1 Type B	40	$30 \le f \le 600$	$80 - 20 \lg(f)$ 40 max.	$90 - 20 \lg(f)$ 50 max.	$100 - 20 \lg(f)$ 60 max.	Screened
1000BASE-T1 Type A	15	$10 \le f \le 600$	Not specified	Not specified	Not specified	Screened and unscreened
100BASE-T1L	500	Not specified	Not specified	Not specified	Not specified	Screened and unscreened
100BASE-T1	15	Not specified	Not specified	Not specified	Not specified	Screened and unscreened
10BASE-T1L	1 000	$0{,}1 \le f \le 20$	≥ 50	≥ 50	≥ 60	Screened and unscreened
10BASE-T1S	15	$0{,}1 \le f \le 20$	$43 - 20 \lg(f/33)$	Not specified	Not specified	Screened and unscreened

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.4.4 SPE link segment alien (exogenous) crosstalk

4.4.4.1 General

For unscreened SPE link segments, alien (exogenous) crosstalk parameters, power-sum alien near-end crosstalk (PS ANEXT) and power-sum alien attenuation to crosstalk ratio far-end (PS AACR-F) are used for differential-mode-to-differential-mode alien noise loss specifications.

For screened SPE link segments, E_1 coupling attenuation specifications, given in 4.4.3.4, can be substituted for alien noise loss specifications, see ISO/IEC 11801-1.

These alien noise loss specifications are based on the 6-around-1 measurement setup according to IEC 61156-1.

4.4.4.2 SPE link segment PS ANEXT

The SPE link segment PS ANEXT specifications are given in Table 7.

Table 7 – SPE link segment PS ANEXT

SPE link segment	Reach	Frequency range	PS ANEXT	Screen type
PHY	m	MHz	dB max.	
1000BASE-T1 Type B	40	$1 \le f \le 600$	65	Screened
1000BASE-T1 Type A	15	$1 \le f \le 100$	$54 - 10 \lg(f/100)$	Screened and unscreened
		$100 < f \le 600$	$54 - 15 \lg(f/100) - 6\,(f - 100)/400$	
100BASE-T1L[a]	500	$0{,}1 \le f < 10$	$50 + 5 \times N$	Screened and unscreened
		$100 < f \le 60$	$50 + 5 \times N - 15 \lg(f/10)$	
100BASE-T1	15	$0{,}1 \le f \le 100$	$31{,}5 - 10 \lg(f/100)$	Screened and unscreened
10BASE-T1L	1 000	$0{,}1 \le f \le 20$	$37{,}5 - 17 \lg(f/20)$	Screened and unscreened
10BASE-T1S	15	$0{,}1 \le f \le 40$	$31{,}5 - 10 \lg(f/100)$	Screened and unscreened

[a] For 100BASE-T1L:

$N = 0$	for IL(20) < 16 dB
$N = 0{,}5 \times (\text{IL}(20) - 16)$	for 16 ≤ IL(20) < 18 dB
$N = 1$	for 18 ≤ IL(20) < 21 dB
$N = 1 + 0{,}5 \times (\text{IL}(20) - 21)$	for 21 ≤ IL(20) < 23 dB
$N = 2$	for 23 ≤ IL(20) dB

NOTE At the time of publication, 100BASE-T1L is unpublished.

4.4.4.3 SPE link segment PS AACR-F

The SPE link segment PS AACR-F specifications are given in Table 8.

Table 8 – SPE link segment PS AACR-F

SPE link segment	Reach	Frequency range	PS AACR-F	Screen type
PHY	m	MHz	dB max.	
1000BASE-T1 Type B	40	$1 \le f \le 600$	$61 - 20 \lg(f/100)$ 70 dB max.	Screened
1000BASE-T1 Type A	15	$1 \le f \le 600$	[a]	Screened and unscreened
100BASE-T1L	500	Not specified	Not specified	Screened and unscreened
100BASE-T1	15	$0{,}1 \le f \le 100$	$16{,}5 - 20 \lg(f/100)$	Screened and unscreened
10BASE-T1L	1 000	$0{,}1 \le f \le 20$	$38 - 18 \lg(f/20)$	Screened and unscreened
10BASE-T1S	15	$0{,}1 \le f \le 40$	$16{,}5 - 20 \lg(f/100)$	Screened and unscreened

[a] 1000BASE-T1 Type A: $-20\lg\left(10\left(\left(-10\lg(0{,}15) + 38{,}2 - 20\lg\left(f/100\right)\right)/-20\right) + 4 \times 10\left(\left(67 - 20\lg\left(f/100\right)\right)/-20\right)\right)$

NOTE 1 ISO/IEC/IEEE 8802-3, 10BASE-T1L and 10BASE-T1S, changed the limit line from PS AACRF to PS AFEXT and is valid under all circumstances, for example, a short disturber disturbing a long cable.

NOTE 2 At the time of publication, 100BASE-T1L is unpublished.

4.4.5 SPE link segment DC loop resistance

The SPE link segment DC loop resistance specifications are given in Table 9.

Table 9 – SPE link segment DC loop resistance

Upper frequency	Reach	Frequency range	DC loop resistance	Screen type
MHz	m	MHz	Ω	
600	15	$1 \le f \le 600$	Not specified	Screened and unscreened
600	40	$1 \le f \le 600$	Not specified	Screened
66	15	$0{,}3 \le f \le 66$	Not specified	Screened and unscreened
20	15	$0{,}1 \le f \le 20$	Not specified	Screened and unscreened
20	1 000	$0{,}1 \le f \le 20$	Not specified	Screened and unscreened

4.4.6 SPE link segment propagation delay

The SPE link segment propagation delay specifications are given in Table 10.

Table 10 – SPE link segment propagation delay

SPE link segment	Reach	Frequency range	Delay	Screen type
PHY	m	MHz	ns max.	
1000BASE-T1 Type B	40	$1 \le f \le 600$	234	Screened
1000BASE-T1 Type A	15	$1 \le f \le 600$	94	Screened and unscreened
100BASE-T1L	500	$0{,}1 \le f \le 60$	3 500[a]	Screened and unscreened
100BASE-T1	15	$0{,}1 \le f \le 100$	Not specified	Screened and unscreened
10BASE-T1L	1 000	$0{,}1 \le f \le 20$	8 834[b]	Screened and unscreened
10BASE-T1S	15	$0{,}1 \le f \le 100$	Not specified	Screened and unscreened

[a] For 100BASE-T1L, 3 500 ns corresponds to 630 m of cable, which is the maximum length possible, using 1,6 mm (AWG 14) or larger conductor, while conforming to attenuation requirements.

[b] For 10BASE-T1L, 8 834 ns corresponds to 1 485 m of cable, which is the maximum length possible, using 1,6 mm (AWG 14) or larger conductor, while conforming to attenuation requirements.

NOTE At the time of publication, 100BASE-T1L is unpublished.

5 Balanced single-pair cabling channels

5.1 General

Cabling channel signal transmission specifications for balanced single-pair cabling are intended to support SPE physical layer PHY standards link segment specifications which are covered in Clause 4.

The channel specifications are provided by Table 11.

Table 11 – Balanced single-pair cabling channels

Cabling type	Frequency range
Type name	MHz
T1-C	$0,1 \leq f \leq 1\,250$
T1-B	$0,1 \leq f \leq 600$
T1-A	$0,1 \leq f \leq 20$

NOTE For limits involving more than one pair within a channel, the following parameters are not applicable to balanced single-pair cabling channels: NEXT, PS NEXT, ACR-F, PS ACR-F, ACR-N, PS ACR-N, delay skew and pair-to-pair resistance unbalance.

5.2 Component specifications

Balanced single-pair cabling channel characteristics are specified using balanced single-pair cabling component specifications. Balanced single-pair cable and connector component specification references are given in Annex A and Annex B, respectively.

The characteristics of a channel are specified between connections to active equipment. The channel comprises only passive sections of cable, connecting hardware and cords. The connections at the hardware interface to active equipment are not taken into account.

Application support depends on channel performance, which in turn depends on cable length, number of connections, connector termination practices, workmanship and performance. It is possible to achieve equivalent channel performance over greater lengths using fewer connections or by using components with higher performance.

5.3 Environmental classifications

ISO/IEC 11801-1 classifies the environments for generic cabling according to three "MICE" environmental classifications.

The balanced single-pair cabling specifications referenced in ISO/IEC/IEEE 8802-3 include channel EMC related specifications for electromagnetic isolation levels E_1, E_2 and E_3, which are defined according to the MICE standard environmental characterization system specified in ISO/IEC 11801-1.

The channel EMC related specifications are unbalance attenuation, coupling attenuation, and alien (exogenous) crosstalk, which are specified for channels and components in accordance with E_1, E_2 and E_3.

5.4 Channel reference implementations

The 15 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 11 m length and four connectors, based on components referenced in Annex A and Annex B.

The 40 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 36 m length and four connectors, based on components referenced in Annex A and Annex B.

The 1 000 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 996 m length and 10 connectors, based on components referenced in Annex A and Annex B.

Annex A
(informative)

Balanced single-pair cable specifications

A.1 General

For information regarding balanced single-pair cables, see the IEC balanced single-pair cable general standard, IEC 61156-1, and the specific cable standards intended for balanced single-pair cabling applications, which are listed in Table A.1.

Balanced single-pair cables are specified in IEC 61156-11 and IEC 61156-12:–[1] for the 1 250 MHz and 600 MHz channel and single-pair cables are specified in IEC 61156-13 and IEC 61156-14 for the 20 MHz channel.

Table A.1 – Balanced single-pair cable standards

Cable type	Frequency range	Conductor type	Screen type	Balanced single-pair cable standard	Cable use case
Type name	MHz				
T1-C	0,1 ≤ f ≤ 1 250	Solid	Screened or unscreened	IEC 61156-11	Horizontal
T1-C	0.1 ≤ f ≤ 1 250	Stranded or solid	Screened or unscreened	IEC 61156-12:–	Work area
T1-B	0,1 ≤ f ≤ 600	Solid	Screened or unscreened	IEC 61156-11	Horizontal
T1-B	0,1 ≤ f ≤ 600	Stranded or solid	Screened or unscreened	IEC 61156-12:–	Work area
T1-A-1000	0,1 ≤ f ≤ 20	Solid	Screened or unscreened	IEC 61156-13	Horizontal
T1-A-1000	0,1 ≤ f ≤ 20	Stranded or solid	Screened or unscreened	IEC 61156-14	Work area
T1-A-400	0,1 ≤ f ≤ 20	Solid	Screened or unscreened	IEC 61156-13	Horizontal
T1-A-400	0,1 ≤ f ≤ 20	Stranded or solid	Screened or unscreened	IEC 61156-14	Work area

A.2 Cables using alternative conductor sizes

Cabling channel insertion loss can be reduced for extended reach by reducing cable IL with larger conductor size, see Annex C; it is important to consider maximum link delay specifications.

[1] Under preparation. Stage at the time of publication: IEC CDV 61156-12:2024.

A.3 Balanced single-pair cable specifications

A.3.1 Return loss (RL)

The balanced single-pair cable return loss (RL) specifications are given in Table A.2.

Table A.2 – Balanced single-pair cable RL

Cable type Upper frequency	Frequency range	RL	Conductor type	Screen type
MHz	MHz	dB (f in MHz)		
1 250	$0,1 \le f \le 1$	$20 + 10 \lg(f)$	Stranded or solid	Screened or unscreened
	$1 < f \le 10$	$20 + 5 \lg(f)$		
	$10 < f \le 20$	25		
	$20 < f \le 600$	$25 - 7 \lg(f/20)$ 17,3 min.		
	$600 < f \le 1\,250$	$17,3 - 10 \lg(f/600)$		
600	$0,1 \le f \le 1$	$20 + 10 \lg(f)$	Stranded or solid	Screened or unscreened
	$1 < f \le 10$	$20 + 5 \lg(f)$		
	$10 < f \le 20$	25		
	$20 < f \le 600$	$25 - 7 \lg(f/20)$ 17,3 min.		
20	$0,1 \le f \le 10$	$20 + 5 \lg(f)$	Solid	Screened
	$10 < f \le 20$	25		
20	$0,1 \le f \le 10$	$20 + 5 \lg(f)$	Stranded or solid	Screened or unscreened
	$10 < f \le 20$	25		

A.3.2 Insertion loss (IL)

The balanced single-pair cable insertion loss (IL) specifications are given in Table A.3.

Table A.3 – Balanced single-pair cable IL

Cable type Upper frequency	Frequency range	Cable IL	Conductor type	Screen type
MHz	MHz	dB/100 m		
1 250	$0,1 \le f \le 1\,250$	$1,8\sqrt{f} + 0,005\,0f + 0,25/\sqrt{f}$	Solid	Screened
1 250	$0,1 \le f \le 1\,250$	$2,7\sqrt{f} + 0,007\,5f + 0,36/\sqrt{f}$	Stranded or solid	Screened or unscreened
600	$0,1 \le f \le 600$	$1,8\sqrt{f} + 0,005\,0f + 0,25/\sqrt{f}$	Solid	Screened
600	$0,1 \le f \le 600$	$2,7\sqrt{f} + 0,007\,5f + 0,36/\sqrt{f}$	Stranded or solid	Screened or unscreened
20	$0,1 \le f \le 20$	$1,23\sqrt{f} + 0,01f + 0,2/\sqrt{f}$	Solid	Screened
20	$0,1 \le f \le 20$	$1,84\sqrt{f} + 0,01f + 0,2/\sqrt{f}$	Stranded or solid	Screened or unscreened

A.3.3 Unbalance attenuation and coupling attenuation

A.3.3.1 General

Unbalance attenuation parameters, transverse-conversion-loss (TCL) and equal-level-transverse-conversion-transfer-loss (ELTCTL) are used for differential-mode-to-common-mode conversion loss specifications, for unscreened cabling.

Coupling attenuation is used for differential-mode-to-common-mode conversion loss specifications, for screened cabling.

A.3.3.2 Transverse-conversion-loss (TCL)

The balanced single-pair cable transverse-conversion-loss (TCL) specifications are given in Table A.4.

Table A.4 – Balanced single-pair cable TCL

Cable type upper frequency	Frequency range	TCL Level 1	TCL Level 2	TCL Level 3	TCL Level 4	Conductor type	Screen type
MHz	MHz	dB	dB	dB	dB		
1 250	$0{,}1 \le f \le 1\,250$	40 max. 7 min.	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	Stranded or solid	Screened
	$0{,}1 < f \le 1\,250$	40 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)		
600	$0{,}1 \le f \le 600$	40 max. 7 min.	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	Stranded or solid	Screened
	$0{,}1 < f \le 600$	40 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)		
600	$0{,}1 \le f \le 600$	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	Stranded or solid	Unscreened
	$0{,}1 < f \le 600$	68 − 15 lg(f)	68 − 15 lg(f)	76 − 15 lg(f)	84 − 15 lg(f)		
20	$0{,}1 \le f \le 20$	40 max. 7 min.	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	Stranded or solid	Screened
	$0{,}1 < f \le 20$	40 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)	68 − 15 lg(f)		
20	$0{,}1 \le f \le 20$	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	53 max. 7 min.	Stranded or solid	Unscreened
	$0{,}1 < f \le 20$	68 − 15 lg(f)	68 − 15 lg(f)	76 − 15 lg(f)	84 − 15 lg(f)		

A.3.3.3 Equal-level-transverse-conversion-transfer-loss (ELTCTL)

The balanced single-pair cable equal-level-transverse-conversion-transfer-loss (ELTCTL) specifications are given in Table A.5.

Table A.5 – Balanced single-pair cable ELTCTL

Cable type upper frequency	Frequency range	ELTCTL Level 1	ELTCTL Level 2	ELTCTL Level 3	Conductor type	Screen type
MHz	MHz	dB	dB	dB		
1 250	$0,1 \le f \le 1\,250$	53 max. 6 min.	53 max. 6 min.	53 max. 6 min.	Solid	Screened
	$0,1 < f \le 1\,250$	40 – 20 lg(f)	50 – 20 lg(f)	60 – 20 lg(f)		
600	$0,1 \le f \le 600$	53 max. 6 min.	53 max. 6 min.	53 max. 6 min.	Solid	Screened
	$0,1 < f \le 600$	40 – 20 lg(f)	50 – 20 lg(f)	60 – 20 lg(f)		
600	$0,1 \le f \le 600$	53 max. 6 min.	53 max. 6 min.	53 max. 6 min.	Stranded or solid	Unscreened
	$0,1 < f \le 600$	40 – 20 lg(f)	50 – 20 lg(f)	60 – 20 lg(f)		
20	$0,1 \le f \le 20$	53 max. 6 min.	53 max. 6 min.	53 max. 6 min.	Solid	Screened
	$0,1 < f \le 20$	40 – 20 lg(f)	50 – 20 lg(f)	60 – 20 lg(f)		
20	$0,1 \le f \le 20$	53 max. 6 min.	53 max. 6 min.	53 max. 6 min.	Stranded or solid	Unscreened
	$0,1 < f \le 20$	40 – 20 lg(f)	50 – 20 lg(f)	60 – 20 lg(f)		

A.3.3.4 Coupling attenuation and low-frequency coupling attenuation

The screened balanced single-pair cable coupling attenuation and low-frequency coupling attenuation specifications are given in Table A.6.

Coupling attenuation is specified for frequencies of 30 MHz and above, whereas low-frequency coupling attenuation is specified for frequencies of 30 MHz and below.

Table A.6 – Balanced single-pair cable coupling attenuation and low-frequency coupling attenuation

Cable type upper frequency	Coupling attenuation frequency range	Coupling attenuation Type III	Coupling attenuation Type II	Coupling attenuation Type Ib	Coupling attenuation Type I	Conductor type	Screen type
MHz	MHz	dB	dB	dB	dB		
1 250	30 ≤ f ≤ 100	Not specified	55 max.	70 max.	85 max.	Stranded or solid	Screened
	100 < f ≤ 1 250	Not specified	55 − 20 lg(f/100)	70 − 20lg(f/100)	85 − 20 lg(f/100)		
1 250	0,1 ≤ f ≤ 30	Not specified	55 max.	70 max.	85 max.	Stranded or solid	Screened or unscreened
	0,1 < f ≤ 30	Not specified	55 − 10 lg(f/100)	70 − 10lg(f/100)	85 − 10 lg(f/100)		
600	30 ≤ f ≤ 100	Not specified	55 max.	70 max.	85 max.	Stranded or solid	Screened
	100 < f ≤ 1 000	Not specified	55 − 20 lg(f/100)	70 − 20lg(f/100)	85 − 20 lg(f/100)		
600	0,1 ≤ f ≤ 30	Not specified	55 max.	70 max.	85 max.	Stranded or solid	Screened or unscreened
	0,1 < f ≤ 30	Not specified	55 − 10 lg(f/100)	70 − 10lg(f/100)	85 − 10 lg(f/100)		
20	0,1 ≤ f ≤ 20	40 max.	55 max.	70 max.	85 max.	Stranded or solid	Screened
	0,1 < f ≤ 20	40 − 10 lg(f/100)	55 − 10 lg(f/100)	70 − 10lg(f/100)	85 − 10 lg(f/100)		

A.3.4 Alien (exogenous) crosstalk

A.3.4.1 General

For unscreened cabling alien (exogenous) crosstalk parameters, power-sum alien near-end crosstalk (PS ANEXT) and power-sum alien attenuation to crosstalk ratio far-end (PS AACR-F) are used for differential-mode-to-differential-mode alien noise loss specifications.

For screened cabling, E_1 coupling attenuation specifications, given in A.3.3.4, can be substituted for alien noise loss specifications, see ISO/IEC 11801-1.

These alien noise loss specifications are based on the 6-around-1 measurement setup according to IEC 61156-1.

A.3.4.2 PS ANEXT

The balanced single-pair cable PS ANEXT specifications are given in Table A.7.

Table A.7 – Balanced single-pair cable PS ANEXT

Cable type Upper frequency	Frequency range	PS ANEXT	Conductor type	Screen type
MHz	MHz	dB		
1 250	0,1 ≤ f ≤ 1 250	75 − 10 lg(f/100) 75 max.	Solid	Screened
1 250	0,1 ≤ f ≤ 1 250	75 − 10 lg(f/100) 75 max.	Stranded or solid	Screened or unscreened
600	0,1 ≤ f ≤ 600	70 − 10 lg(f/100) 70 max.	Solid	Screened
600	0,1 ≤ f ≤ 600	70 − 10 lg(f/100) 70 max.	Stranded or solid	Screened or unscreened
20	0,1 ≤ f ≤ 20	40 − 17 lg(f/20) 67 max.	Solid	Screened
20	0,1 ≤ f ≤ 20	40 − 17 lg(f/20) 67 max.	Stranded or solid	Screened or unscreened

A.3.4.3 PS AACR-F

The balanced single-pair cable PS AACR-F specifications are given in Table A.8.

Table A.8 – Balanced single-pair cable PS AACR-F

Cable type Upper frequency	Frequency range	PS AACR-F	Conductor type	Screen type
MHz	MHz	dB		
1 250	0,1 ≤ f ≤ 1 250	103 − 20 lg(f)	Solid	Screened
1 250	0,1 ≤ f ≤ 1 250	103 − 20 lg(f)	Stranded or solid	Screened or unscreened
600	0,1 ≤ f ≤ 600	98 − 20 lg(f)	Solid	Screened
600	0,1 ≤ f ≤ 600	98 − 20 lg(f)	Stranded or solid	Screened or unscreened
20	0,1 ≤ f ≤ 20	40 − 17 lg(f/20) 67 max.	Solid	Screened
20	0,1 ≤ f ≤ 20	40 − 17 lg(f/20) 67 max.	Stranded or solid	Screened or unscreened