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TECHNICAL REPORT

Information technology – Generic cabling for customer premises – Part 9904: Assessment and mitigation of installed balanced cabling channels to support 2,5GBASE-T and 5GBASE-T

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Information technology – Generic cabling for customer premises – Part 9904: Assessment and mitigation of installed balanced cabling channels to support 2,5GBASE-T and 5GBASE-T

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INFORMATION TECHNOLOGY – GENERIC CABLING FOR CUSTOMER PREMISES –

Part 9904: Assessment and mitigation of installed balanced cabling channels to support 2,5GBASE-T and 5GBASE-T

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ISO/IEC TR 11801-9904, which is a Technical Report, has been prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

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 web site.

ISO/IEC TR 11801-9904 should be read in conjunction with IEEE Std. 802.3bz.

This document has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

INTRODUCTION

This document provides guidance on whether installed Class D and Class E channels specified in ISO/IEC 11801:2002 will support 2,5GBASE-T and 5GBASE-T. This document also provides mitigation procedures to improve the performance of Class D and Class E channels to the point where these applications are supported. Higher classes according to ISO/IEC 11801:2002 will support 2,5GBASE-T and 5GBASE-T without mitigation up to 100 m.

The support of 2,5GBASE-T and 5GBASE-T includes additional parameters and an extended frequency range for Class D. Conformance of installed cabling beyond the original cabling specifications should be determined on a case-by-case basis, and is primarily needed due to new application requirements. Whether these requirements are met by a specific channel is influenced by the components and installation practices used. As 2,5GBASE-T and 5GBASE-T use frequencies above those specified for Class D of ISO/IEC 11801:2002 as well as exogenous noise parameters, input from supplier and installer might be helpful to evaluate the performance of installed Class D and Class E channels.

This document takes into account the design goals for 2,5GBASE-T and 5GBASE-T equipment such as frequency signal range up to 100 MHz for 2,5GBASE-T and up to 250 MHz for 5GBASE-T.

INFORMATION TECHNOLOGY – GENERIC CABLING FOR CUSTOMER PREMISES –

Part 9904: Assessment and mitigation of installed balanced cabling channels to support 2,5GBASE-T and 5GBASE-T

1 Scope

This part of ISO/IEC 11801

a) specifies the transmission performance for balanced cabling channels to support 2,5GBASE-T and 5GBASE-T,

b) specifies the methods to assess whether installed Class D and Class E channels meet 2,5GBASE-T and 5GBASE-T requirements,

c) provides mitigation techniques to improve the performance of an existing installation to meet the 2,5GBASE-T and 5GBASE-T requirements,

d) provides cabling recommendations for new installations.

NOTE 1 The channel transmission performance specified in this document is derived from IEEE Std 802.3bz:2016.

NOTE 2 IEEE Std 802.3bz:2016 specifies requirements beyond the frequency range specified for Class D of ISO/IEC 11801:2002 and additional parameters to those specified for Class D and Class E cabling in ISO/IEC 11801:2002.

NOTE 3 This document does not re-specify Class D and Class E cabling of ISO/IEC 11801:2002.

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 11801:2002, *Information technology – Generic cabling systems*
ISO/IEC 11801:2002/AMD1:2008

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11801:2002 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 http://www.iso.org/obp

3.1.1
alien (exogenous) crosstalk
signal coupling from a disturbing pair of a channel to a disturbed pair of another channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.2]

3.1.2
alien (exogenous) far-end crosstalk loss
AFEXT
signal isolation between a disturbing pair of a channel and a disturbed pair of another channel, measured at the far-end

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.3]

3.1.3
alien (exogenous) near-end crosstalk loss
ANEXT
signal isolation between a disturbing pair of a channel and a disturbed pair of another channel, measured at the near-end

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.4]

3.1.4
attenuation to alien (exogenous) crosstalk ratio at the far-end
AACR-F
difference, in dB, between the alien far-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair in another channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.7]

3.1.5
attenuation to alien (exogenous) crosstalk ratio at the near-end
AACR-N
difference, in dB, between the alien near-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair in another channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.8]

3.1.6
attenuation to crosstalk ratio at the far-end
ACR-F
difference, in dB, between the far-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair of the same channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.9]

3.1.7
attenuation to crosstalk ratio at the near-end
ACR-N
difference, in dB, between the near-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair of the same channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.10]

3.1.8
equal level far-end crosstalk ratio
ELFEXT
difference, in dB, between the far-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbing pair of the same channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.35]

3.1.9
power sum alien (exogenous) far-end crosstalk loss
PSAFEXT
power sum of the signal isolation between multiple disturbing pairs of one or more channels and a disturbed pair of another channel, measured at the far-end

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.64]

3.1.10
power sum alien (exogenous) near-end crosstalk loss
PSANEXT
power sum of the signal isolation between multiple disturbing pairs of one or more channels and a disturbed pair of another channel, measured at the near-end

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.65]

3.1.11
power sum attenuation to alien (exogenous) crosstalk ratio at the far-end
PSAACR-F
difference, in dB, between the power sum alien far-end crosstalk loss from multiple disturbing pairs of one or more channels and the insertion loss of a disturbed pair in another channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.66]

3.1.12
power sum attenuation to alien (exogenous) crosstalk ratio at the near-end
PSAACR-N
difference, in dB, between the power sum alien near-end crosstalk loss from multiple disturbing pairs of one or more channels and the insertion loss of a disturbed pair in another channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.67]

3.1.13
power sum attenuation to crosstalk ratio at the far-end
PSACR-F
difference, in dB, between the power sum far-end crosstalk loss from multiple disturbing pairs of a channel and the insertion loss of a disturbed pair in the same channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.68]

3.1.14
power sum attenuation to crosstalk ratio at the near-end
PSACR-N
difference, in dB, between the power sum near-end crosstalk loss from multiple disturbing pairs of a channel and the insertion loss of a disturbed pair in the same channel

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.69]

3.1.15
power sum equal level far-end crosstalk ratio
PSELFEXT
power sum of all disturbing pairs of a channel, of the difference, in dB, between the far-end crosstalk loss and the insertion loss of each disturbing pair

[SOURCE: ISO/IEC 11801:2002/AMD1:2008, 3.1.70]

3.2 Abbreviations

For the purposes of this document, the abbreviations given in ISO/IEC 11801:2002 and the following apply.

AACR-F	attenuation to exogenous crosstalk ratio at the far-end
AACR-N	attenuation to exogenous crosstalk ratio at the near-end
ACR-F	attenuation to crosstalk ratio at the far-end
ACR-N	attenuation to crosstalk ratio at the near-end
AFEXT	exogenous far-end crosstalk loss
ALSNR	alien (exogenous) limited signal to noise ratio
ANEXT	exogenous near-end crosstalk loss
ELFEXT	equal level far-end crosstalk ratio
PBO	power back off
PSAACR-F	power sum attenuation to exogenous crosstalk ratio at the far-end
PSAACR-N	power sum attenuation to exogenous crosstalk ratio at the near-end
PSACR-F	power sum attenuation to crosstalk ratio at the far-end
PSACR-N	power sum attenuation to crosstalk ratio at the near-end
PSAFEXT	power sum exogenous far-end crosstalk loss
PSANEXT	power sum exogenous near-end crosstalk loss
PSD	power spectral density
PSELFEXT	power sum equal level far-end crosstalk ratio
WAP	wireless access point

4 Channel transmission performance

4.1 General

Clause 4 specifies the transmission performance of cabling channels

– ≤ 100 MHz to support 2,5GBASE-T,

– ≤ 250 MHz to support 5GBASE-T.

The channel performance described in 4.2 to 4.9 for frequencies up to 100 MHz and 250 MHz are for re-assessment of internal parameters (IL, RL, NEXT, PSNEXT, ACR-F, PSACR-F, Delay, Delay Skew) of Class D channels.

Class E channel internal parameters do not need any changes to support these two applications.

Additionally, the alien limited signal-to-noise ratio (ALSNR) criterion in 4.12 has to be met by both Class D and Class E channels.

4.2 Insertion loss

Insertion loss should meet or be less than the values determined using the formulas shown in Table 1 for all specified frequencies.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 1 – Channel insertion loss

Frequency MHz	**Channel insertion loss** dB
$1 < f \leq 250$	$1{,}05 \times \left(1{,}910\,8\sqrt{f} + 0{,}022\,2 \times f + 0{,}2/\sqrt{f}\right) + 4 \times 0{,}04 \times \sqrt{f}$

The channel insertion loss values in Table 2 are provided for information only.

Table 2 – Maximum channel insertion loss

Frequency MHz	**Channel insertion loss** dB
1,00	2,4
4,00	4,5
8,00	6,4
10,00	7,2
16,00	9,1
20,00	10,2
25,00	11,5
31,25	12,9
62,50	18,7
100,00	24,1
200,00	35,4
250,00	40,2

4.3 Return loss

The channel return loss should meet or exceed the values determined using the formulas shown in Table 3 for all specified frequencies.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 3 – Channel return loss

Frequency MHz	**Return loss** dB
$1 \leq f < 20$	17
$20 \leq f \leq 250$	$30 - 10\log(f)$

The channel return loss values in Table 4 are provided for information only.

Table 4 – Minimum channel return loss

Frequency MHz	**Channel return loss** dB
1,00	17,0
4,00	17,0
8,00	17,0
10,00	17,0
16,00	17,0
20,00	17,0
25,00	16,0
31,25	15,1
62,50	12,1
100,00	10,0
200,00	7,0
250,00	6,0

4.4 NEXT

The channel NEXT should meet or exceed the values determined using the formulas shown in Table 5 for all specified frequencies. Calculations that result in channel NEXT values greater than 60 dB should revert to a requirement of 60 dB minimum.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 5 – Channel NEXT

Frequency MHz	**NEXT** dB
$1 \leq f \leq 100$	$-20\log\left(10^{\frac{(65{,}3-15\log(f))}{-20}}+2\times 10^{\frac{(83-20\log(f))}{-20}}\right)$
$100 < f \leq 250$	$-20\log\left(10^{\frac{(65{,}3-15\log(f))}{20}}+2\times 10^{\frac{(83-40\log(f))}{20}}\right)$

The channel NEXT loss values in Table 6 are provided for information only.

Table 6 – Minimum channel NEXT

Frequency MHz	**Channel NEXT** dB
1,00	60,0
4,00	53,5
8,00	48,6
10,00	47,0
16,00	43,6
20,00	42,0
25,00	40,3
31,25	38,7
62,50	33,6
100,00	30,1
200,00	21,4
250,00	18,2

4.5 PSNEXT

The channel PSNEXT should meet or exceed the values determined using the formulas shown in Table 7 for all specified frequencies. Calculations that result in Class D channel PSNEXT values greater than 57 dB should revert to a requirement of 57 dB minimum.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 7 – Channel PSNEXT

Frequency MHz	**PSNEXT** dB
$1 \le f \le 100$	$-20\log\left(10^{\frac{(62,3-15\log(f))}{-20}} + 2\times 10^{\frac{(80-20\log(f))}{-20}}\right)$
$100 < f \le 250$	$-20\log\left(10^{\frac{(62,3-15\log(f))}{-20}} + 2\times 10^{\frac{(80-40\log(f))}{-20}}\right)$

The channel PSNEXT values in Table 8 are provided for information only.

Table 8 – Minimum channel PSNEXT

Frequency MHz	**Channel PSNEXT** dB
1,00	57,0
4,00	50,5
8,00	45,6
10,00	44,0
16,00	40,6
20,00	39,0
25,00	37,3
31,25	35,7
62,50	30,6
100,00	27,1
200,00	18,4
250,00	15,2

4.6 ACR-F

The channel ACR-F should meet or exceed the values determined using the formulas shown in Table 9 for all specified frequencies. Due to measurement considerations, channel ACR-F values that correspond to measured channel FEXT values of greater than 70 dB are for information only.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 9 – Channel ACR-F

Frequency MHz	**ACR-F** dB
$1 < f \leq 250$	$-20\log\left(10^{\frac{(63,8-20\log(f))}{-20}}+4\times 10^{\frac{(75,1-20\log(f))}{-20}}\right)$

The channel ACR-F values in Table 10 are provided for information only.

Table 10 – Minimum channel ACR-F

Frequency MHz	**Channel ACR-F** dB
1,00	57,4
4,00	45,4
8,00	39,3
10,00	37,4
16,00	33,3
20,00	31,4
25,00	29,4
31,25	27,5
62,50	21,5
100,00	17,4
200,00	11,4
250,00	9,4

4.7 PSACR-F

The channel PSACR-F should meet or exceed the values determined using the formulas shown in Table 11 for all specified frequencies.

NOTE For 2,5GBASE-T the formulas are applicable only to 100 MHz.

Table 11 – Channel PSACR-F

Frequency MHz	**Channel PSACR-F** dB
$1 < f \leq 250$	$-20\log\left(10^{\frac{(60{,}8-20\log(f))}{-20}} + 4\times 10^{\frac{(72{,}1-20\log(f))}{-20}}\right)$

The channel PSACR-F values in Table 12 are provided for information only.

Table 12 – Minimum channel PSACR-F

Frequency MHz	Channel PSACR-F dB
1,00	54,4
4,00	42,4
8,00	36,3
10,00	34,4
16,00	30,3
20,00	28,4
25,00	26,4
31,25	24,5
62,50	18,5
100,00	14,4
200,00	8,4
250,00	6,4

4.8 Propagation delay

The channel propagation delay should not exceed 570 ns at all frequencies between 1 MHz and 250 MHz. For field testing channels, it is sufficient to test at 10 MHz only and channel propagation delay at 10 MHz should not exceed 570 ns.

NOTE For 2,5GBASE-T the requirements are applicable only to 100 MHz.

4.9 Propagation delay skew

The channel propagation delay skew should be less than 50 ns for all frequencies from 1 MHz to 250 MHz. For field testing channels, it is sufficient to test at 10 MHz only and channel propagation delay skew at 10 MHz should not exceed 50 ns.

NOTE For 2,5GBASE-T the requirements are applicable only to 100 MHz.

4.10 PSANEXT

PSANEXT performance values are not specified for ISO/IEC 11801:2002 Class D and Class E channels. See 4.12 for ALSNR criterion.

4.11 PSAACR-F

PSAACR-F performance values are not specified for ISO/IEC 11801:2002, Class D and Class E channels. See 4.12 for ALSNR criterion.

4.12 Alien (exogenous) limited signal-to-noise ratio (ALSNR)

NOTE The ALSNR procedure requires measurements up to 200 MHz while the internal parameters defined in Clause 3 require measurements up to 250 MHz for 5GBASE-T.

The procedure and terminology in 4.12 is adopted from IEEE Std 802.3bz:2016[1] and contains additional measurement and computational details.

[1] IEEE has granted permission to use "Subclause 126.7.3.1 'Alien Crosstalk Limited Signal-to-Noise Ratio Criteria' from IEEE Std 802.3bz-2016 2.5G/5GBASE-T. Copyright IEEE 2016. All rights reserved" in 4.12.

The ALSNR is met by design if the coupling attenuation for all victims and disturbers to be assessed meets the requirements of ISO/IEC 11801:2002 and ISO/IEC 11801:2002/AMD1:2008, Class E_A.

ALSNR criterion is specified to ensure the total noise from exogenous crosstalk due to exogenous NEXT and exogenous FEXT is limited. The following procedure is prescribed for calculation of the ALSNR criterion.

In 4.12 the following indices are used:

i	1 to 4	pair of the disturbed channel
k	1 to 4	pair of the disturbing channel
m	1 to M	index of the disturbing channel
M		is the number of disturbing channels

Linear spacing with a minimum of 100 points should be used across the frequency range of measurement. The frequency points spacing according to IEC 61935-1 may also be used.

a) Step 1

Measure the insertion loss of all the pairs in the disturbed channel and the disturbing channels in the frequency range given by Table 13.

Table 13 – Frequency range of insertion loss measurements

Application running on the disturbed channel	Frequency range of measurement
2,5GBASE-T	$1 \leq f \leq 100$ MHz
5GBASE-T	$1 \leq f \leq 200^a$ MHz
[a] Aligns with the baud of 5GBASE-T	

Denote each pair of the disturbed channel insertion loss as $IL_{\text{disturbed}_i}$

Denote each pair of the disturbing channel insertion loss as $IL_{\text{disturbing}_{k,m}}$

While disturbing signals might contain higher frequencies, the received power, which determines the PBO, is dominated by the power below 100 MHz for 2,5GBASE-T and 5GBASE-T and when 10GBASE-T PBO is to be computed, frequencies up to 200 MHz should be used. Neglecting the higher frequencies has no appreciable effect in computing the 10GBASE-T or 5GBASE-T PBO.

b) Step 2

Determine the received signal transmit power including PBO, S_i, for each pair, i, of the disturbed channel, at each frequency point.

1) **Step 2a**

Determine the nominal (i.e. without PBO) received signal transmit power for each pair of the disturbed channel, $Rx\_TP\_\text{dBm}_{\text{disturbed}_i}$, at each frequency point by using Formula (1).

$$Rx_{TP_{\text{dBm}}}{}_{\text{disturbed}_i}(f) = TemplatePSD_{\text{disturbed}}(f) - IL_{\text{disturbed}_i}(f) \qquad (\text{dBm/Hz}) \qquad (1)$$

Determine the signal PSD. $TemplatePSD_{\text{disturbed}}$ is provided by Table 14, according to which application is running on the disturbed channel. Ensure that the same selection as the frequency range selected in Step 1 is made.

Table 14 – Template PSD for disturbed channel

Application running on the disturbed channel	**Template PSD** (dBm/Hz)
2,5GBASE-T	$-77{,}9 + 20\log_{10}\left(\frac{\left\lvert\sin\left(\frac{\pi f}{200}\right)\right\rvert}{\left(\frac{\pi f}{200}\right)}\right) - 10\log_{10}\left(1 + \left(\frac{f}{490}\right)^{4}\right)$
5GBASE-T	$-80{,}7 + 20\log_{10}\left(\frac{\left\lvert\sin\left(\frac{\pi f}{400}\right)\right\rvert}{\left(\frac{\pi f}{400}\right)}\right) - 10\log_{10}\left(1 + \left(\frac{f}{490}\right)^{4}\right)$

2) Step 2b

Calculate the received signal transmit power, for each pair of the disturbed channel, i, at each frequency point, to a linear magnitude and multiply by the frequency step size according to Formula (2).

$$Rx\_TP_{\text{mW}_{\text{disturbed}_i}}(f) = \Delta f\left(10^{\left(\frac{Rx\_TP\_\text{dBm}_{\text{disturbed}_i}(f)}{10}\right)}\right)(\text{mW}) \qquad (2)$$

where Δf is the step size between frequency points at that data point in Hz (not MHz).

3) Step 2c

Calculate the total received power in dBm, $Total\_Rx\_TP_{\text{dBm}_{disturbed_i}}$, for each pair, i, of the disturbed cable according to Formula (3).

$$Total\_Rx\_TP_{\text{dBm}_{\text{disturbed}_i}} = 10\log_{10}\left(\sum_{f=f_{\min}}^{f_{\max}} Rx\_TP_{\text{mW}_{\text{disturbed}_i}}(f)\right) \qquad (3)$$

where $f_{\min}$ and $f_{\max}$ are provided by Table 13.

4) Step 2d

Determine the PBO for the disturbed cable, $PBO_{\text{disturbed}}$, by calculating the mean value of $Total\_Rx\_TP_{\text{dBm}_{\text{disturbed}_i}}$ across the pairs, and determining $PBO_{\text{disturbed}}$ from Table 15, for 2,5GBASE-T, or Table 16 for 5GBASE-T running on the disturbed channel.

For each value of m:

$$\overline{Rx\_TP_{\text{disturbed}}} = \frac{\left(\sum_{i=1}^{i=4} Total\_Rx\_TP_{\text{dBm}_{\text{disturbed}_i}}\right)}{4} \qquad (4)$$

Table 15 – PBO for 2,5GBASE-T

Total Received Power dBm	**2,5GBASE-T PBO** dB
-4,3 < $\overline{Rx\_TP_{\text{disturbed}}}$	2
$\overline{Rx\_TP_{\text{disturbed}}}$ ≤ -4,3	0

Table 16 – PBO for 5GBASE-T

Total Received Power dBm	**5GBASE-T PBO** dB
-5,8 < $\overline{Rx\_TP_{\text{disturbed}}}$	8
-7,0 < $\overline{Rx\_TP_{\text{disturbed}}}$ ≤ -5,8	6
-9,2 < $\overline{Rx\_TP_{\text{disturbed}}}$ ≤ -7,0	4
-11 < $\overline{Rx\_TP_{\text{disturbed}}}$ ≤ -9,2	2
$\overline{Rx\_TP_{\text{disturbed}}}$ ≤ -11	0

5) **Step 2e**

Calculate the received signal transmit PSD including PBO, S_i, for each pair of the disturbed channel at each frequency point by using Formula (5).

For i = 1 to 4:

$$S_i(f) = Rx\_TP\_\text{dBm}_{\text{disturbed}_i}(f) - PBO_{\text{disturbed}} \quad (5)$$

c) **Step 3**

Determine the PBO for applications running on each disturbing channel PBO_m. This step involves selecting which application is running on each disturbing channel (see Step 8 for further details of calculations for all possible permutations).

NOTE 1 The PBO for 1000BASE-T is always 0 dB.

NOTE 2 When 2,5GBASE-T is running on the disturbed channel, then the calculations only need to consider 2,5GBASE-T and 1000BASE-T running on the disturbing channels.

1) **Step 3a**

Determine the nominal (i.e. without PBO applied) received signal transmit power, $Rx\_TP\_\text{dBm}_{\text{disturbing}_{k,m}}(f)$, for each pair, k, of the disturbing channel, m, at each frequency point by using Formula (6).

$$Rx\_TP\_\text{dBm}_{\text{disturbing}_{k,m}}(f) = TemplatePSD_m(f) - IL_{\text{disturbing}_{k,m}}(f) \quad \text{(dBm/Hz)} \quad (6)$$

where $TemplatePSD_m$ is provided by Table 17.

Table 17 – Template PSD for disturbing channel

Application running on the disturbing channel	Template PSD (dBm/Hz)
1000BASE-T	$-72{,}4 + 20\log_{10}\left(\frac{\left\|\sin\left(\frac{\pi f}{125}\right)\right\|}{\left(\frac{\pi f}{125}\right)}\right) - 10\log_{10}\left(1+\left(\frac{f}{100}\right)^2\right) + 10\log_{10}\left(0{,}625 + 0{,}375\cos\left(\frac{2\pi f}{125}\right)\right)$
2,5GBASE-T	$-77{,}9 + 20\log_{10}\left(\frac{\left\|\sin\left(\frac{\pi f}{200}\right)\right\|}{\left(\frac{\pi f}{200}\right)}\right) - 10\log_{10}\left(1+\left(\frac{f}{490}\right)^4\right)$
5GBASE-T	$-80{,}7 + 20\log_{10}\left(\frac{\left\|\sin\left(\frac{\pi f}{400}\right)\right\|}{\left(\frac{\pi f}{400}\right)}\right) - 10\log_{10}\left(1+\left(\frac{f}{490}\right)^4\right)$
10GBASE-T	$-80{,}89 + 20\log_{10}\left(\frac{\left\|\sin\left(\frac{\pi f}{800}\right)\right\|}{\left(\frac{\pi f}{800}\right)}\right) - 10\log_{10}\left(1+\left(\frac{f}{490}\right)^4\right)$

2) **Step 3b**

Convert the received signal transmit power for each pair, k, of each disturbing channel, m, at each frequency point to a linear magnitude and multiply by the frequency step size.

$$Rx\_TP\_\mathrm{mW}_{\mathrm{disturbing}_{k,m}}(f) = \Delta f \left(10^{\left(\frac{Rx\_TP\_\mathrm{dBm}_{\mathrm{disturbing}_{k,m}}(f)}{10}\right)}\right) \quad \text{(mW)} \qquad (7)$$

where Δf is the step size between frequency points at that data point in Hz (not MHz).

3) **Step 3c**

Calculate the total received power in dBm, for each pair, k, of each disturbing channel, m, by adding the values at each frequency point and converting to dBm using Formula (8).

$$Total\_Rx\_TP\_\mathrm{dBm}_{\mathrm{disturbing}_{k,m}} = 10\log_{10}\left(\sum_{f=f_{\min}}^{f_{\max}} Rx\_TP\_\mathrm{mW}_{\mathrm{disturbing}_{k,m}}(f)\right) \quad \text{(dBm)} \qquad (8)$$

where $f_{\min}$ and $f_{\max}$ are provided by Table 13.

4) **Step 3d**

Determine the PBO, PBO_m, for each disturbing channel, m, by calculating the mean value of $Total\_Rx\_TP\_\mathrm{dBm}_{\mathrm{disturbing}_{k,m}}$ across the pairs, for each channel, and determining PBO_m from Table 18 for 2,5GBASE-T, Table 19 for 5GBASE-T or Table 20 for 10GBASE-T running on the disturbing channel. The PBO for 1000BASE-T is always 0 dB.

For each value of m:

$$\overline{Rx\_TP_{\mathrm{disturbing}_m}} = \frac{\sum_{k=1}^{k=4} Total\_Rx\_TP\_\mathrm{dBm}_{\mathrm{disturbing}_{k,m}}}{4} \qquad (9)$$

Table 18 – PBO for 2,5GBASE-T

Total Received Power dBm	**2,5GBASE-T PBO** dB
-4,3 < $\overline{Rx\_TP_{\text{disturbing}_m}}$	2
$\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -4,3	0

Table 19 – PBO for 5GBASE-T

Total Received Power dBm	**5GBASE-T PBO** dB
-5,8 < $\overline{Rx\_TP_{\text{disturbing}_m}}$	8
-7,0 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -5,8	6
-9,2 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -7,0	4
-11 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -9,2	2
$\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -11	0

Table 20 – PBO for 10GBASE-T

Total Received Power dBm	**10GBASE-T PBO** dB
-1,1 < $\overline{Rx\_TP_{\text{disturbing}_m}}$	10
-2,3 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -1,1	8
-3,3 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -2,3	6
-4,2 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -3,3	4
-5,0 < $\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -4,2	2
$\overline{Rx\_TP_{\text{disturbing}_m}}$ ≤ -5,0	0

d) Step 4

Measure the ANEXT and AFEXT combinations for each disturbing channel, m.

Each disturbing channel will provide 16 ANEXT combinations and 16 AFEXT combinations selecting the disturbing channels in accordance with ISO/IEC 11801:2002 and ISO/IEC 11801:2002/AMD1:2008.

Denote the measurements as $ANEXT_{\text{measurement}_{i,k,m}}$, and $AFEXT_{\text{measurement}_{i,k,m}}$.

where:

i	1 to 4	is the pair of the disturbed channel
k	1 to 4	is the pair of the disturbing channel
m		is the index of the disturbing channel
1-M		is the number of disturbing channels

e) **Step 5**

Calculate the AXT components including PBO for each alien (exogenous) crosstalk measurement for each disturbing channel at each frequency point using Formula (10) and Formula (11). Ensure that the frequency points are measured or interpolated to the same frequencies used for the insertion loss measurements.

$$ANEXT_{\text{component}_{i,k,m}}(f) = TemplatePSD_m(f) - ANEXT_{\text{measurement}_{i,k,m}}(f) - PBO_m(f) \quad (10)$$

$$AFEXT_{\text{component}_{i,k,m}}(f) = TemplatePSD_m(f) - AFEXT_{\text{measurement}_{i,k,m}}(f) - PBO_m(f) \quad (11)$$

where $TemplatePSD_m(f)$ and $PBO_m(f)$ are from Steps 3a and 3d, respectively.

f) **Step 6**

Calculate the total noise received by each pair, i, of the disturbed channel by calculating the power sum of the ANEXT and AFEXT components together at each frequency point.

For i = 1 to 4:

$$N_i(f) = 10log_{10}\left(\sum_{m=1}^{M}\sum_{k=1}^{4}\left(\left(10^{\left(\frac{ANEXT_{\text{component}_{i,k,m}}(f)}{10}\right)}\right) + \left(10^{\left(\frac{AFEXT_{\text{component}_{i,k,m}}(f)}{10}\right)}\right)\right) + \left(10^{\left(\frac{\text{add\_noise}}{10}\right)}\right)\right) \quad (12)$$

where M is the number of disturbing channels and add_noise is in Table 21.

Table 21 – Values of add_noise noise term

Application running on the disturbed link segment	Value of impl_comp
2,5GBASE-T	-129 dBm/Hz
5GBASE-T	-135 dBm/Hz

g) **Step 7**

Calculate the ALSNR for each pair, i, of the disturbed channel by using Formula (13).

$$\text{ALSNR}_i = \left(\frac{1}{f_{\max}}\right)\sum_{f=f_{\min}}^{f_{\max}}(S_i(f) - N_i(f))\Delta f \quad (13)$$

where Δf is the step size between frequency points at that data point in MHz.

Determine the minimum of ALSNR_i, across all pairs, providing $\text{ALSNR}_{\min}$.

h) **Step 8**

Calculate $\text{ALSNR}_{\text{Criteria}}$ using Formula (14).

$$\text{ALSNR}_{\text{Criteria}} = \text{ALSNR}_{\min} - 28 \text{ dB} \quad (14)$$

The ALSNR criterion is met if $\text{ALSNR}_{\text{Criteria}} \geq 0$.

Note that 28 dB indicates a budgeted SNR component due to alien (exogenous) crosstalk that includes extra margin to account for PBO uncertainties and the differences between what is theoretically possible and what is feasible in the implementation of receivers. This is referred to as $SNR_{linkreq}$ in IEEE Std 802.3bz:2016.

In addition, the $ALSNR_{criteria}$ should be ≥ 0 for every possible permutation of application running on the disturbing channels. See step 9 for further details.

i) **Step 9 – Multiplicity**

Steps 1 to 8 determine the $ALSNR_{min}$ for a given application running on the disturbed channel, and a given permutation of applications running on the disturbing channels.

To calculate the worst case permutation of applications running on the disturbing channel, repeat steps 3 to 8 using every possible permutation of applications running on the disturbing channels, and determine $ALSNR_{criteria}$ for each permutation of disturbing applications.

For a given application on the disturbed channel (2,5GBASE-T or 5GBASE-T), the number of times this process needs to be repeated is determined by the number of disturbing channels according to Table 22. Select the disturbed channels in accordance with ISO/IEC 11801:2002 and ISO/IEC 11801:2002/AMD1:2008.

Table 22 – Calculated permutations

Application	Required permutations
2,5GBASE-T	2^M
5GBASE-T	4^M

5 Use cases

5.1 General

Support of 2,5GBASE-T and 5GBASE-T protocols on installed cabling will be largely determined by the alien (exogenous) crosstalk coupling between cables and the insertion loss of the cabling. These factors can be measured and the results calculated using the methods of 4.12. Performance testing of cabling for ALSNR (see 4.12) can be minimized through a combination of physical inspection together with the use of tables in Clause 5, and mitigation. This initial assessment will help to determine channels that merit further testing based upon overall lengths and bundled lengths of cabling. The methodology in Clause 5 is an example of a reasoned assessment of cabling infrastructure that will guide the user to understand which cabling links are likely to support 2,5GBASE-T and 5GBASE-T and those that require further evaluation to support these protocols.

5.2 Assessment procedure

a) A cabling expert should inspect the facility to determine capability of existing installation to support 2,5GBASE-T or 5GBASE-T.

b) Visually inspect the facility and examine the cabling layout using blueprints, administration system, and selective site measurements.

c) If the inspection finds bundled Category 5 or Category 6 equipment cords to the intended location of the 2,5GBASE-T or 5GBASE-T equipment, then it is recommended to unbundle the equipment cords. The risk matrices in Table 23 through Table 25 are based on such unbundling.

d) Identify and list cabling performance Classes, distances and bundling lengths in different areas of the building.

e) Compare these use cases against the risk matrices for bundled lengths and cabling types as shown in Table 23 through Table 25 to assess the risk of supporting 2,5GBASE-T or 5GBASE-T ALSNR criterion.

f) The system administrator should mark the channels that are identified as capable on blueprints or administration system.

g) The test technician should test the remaining channels using statistical sampling methods to determine capability of supporting 2,5GBASE-T or 5GBASE-T.

h) Products that compress cables together should not be used.

5.3 Risk assessment tables

Tables 23, 24, 25 indicate the risk of not meeting the ALSNR criterion with installed cabling based on bundling lengths and victim channel lengths.

NOTE See 4.12 for ALSNR specifications including alternative qualification of screened cabling using coupling attenuation.

Table 23 – ALSNR risk matrix for Class D

Class D	Speed	Victim length		
		1 m to 20 m	20 m to 75 m	75 m to 100 m
bundled distance up to 20 m	2,5 Gbit/s	Low	Low	Low
	5 Gbit/s	Low	Low	Medium
bundled distance 20 m to 75 m	2,5 Gbit/s	N/A	low	Medium
	5 Gbit/s	N/A	Medium	High
bundled distance 75 m to 100 m	2,5 Gbit/s	N/A	N/A	Medium
	5 Gbit/s	N/A	N/A	High
NOTE Risk refers to risk of bundled cable configurations not supporting an $ALSNR_{min}$ greater than or equal to 28 dB.				

Table 24 – ALSNR risk matrix for Class E

Class E	Speed	Victim length		
		1 m to 20 m	20 m to 75 m	75 m to 100 m
bundled distance up to 20 m	2,5 Gbit/s	Negligible	Low	Low
	5 Gbit/s	Negligible	Low	Low
bundled distance 20 m to 75 m	2,5 Gbit/s	N/A	Low	Low
	5 Gbit/s	N/A	Medium	Medium
bundled distance 75 m to 100 m	2,5 Gbit/s	N/A	N/A	Medium
	5 Gbit/s	N/A	N/A	High
NOTE Risk refers to risk of bundled cable configurations not supporting an $ALSNR_{min}$ greater than or equal to 28 dB.				

Table 25 – ALSNR risk matrix for Class E_A

Class E_A	Speed	Victim length		
		1 m to 20 m	20 m to 75 m	75 m to 100 m
bundled distance up to 20 m	2,5 Gbit/s	None	None	None
	5 Gbit/s	None	None	None
bundled distance 20 m to 75 m	2,5 Gbit/s	N/A	None	None
	5 Gbit/s	N/A	None	None
bundled distance 75 m to 100 m	2,5 Gbit/s	N/A	N/A	None
	5 Gbit/s	N/A	N/A	None

NOTE Risk refers to risk of bundled cable configurations not supporting an $ALSNR_{min}$ greater than or equal to 28 dB.

6 Guidance for existing installations and cabling for new installations

6.1 Certification, measurement and documentation

The test procedures for balanced cabling installations are specified in IEC 61935-1 in accordance with ISO/IEC 11801:2002 and ISO/IEC 14763-2.

Additional care should be taken for the documentation of channels intended to be used for 2,5GBASE-T and 5GBASE-T since these are evaluated beyond the original specifications.

Recommendations for new installations are described in Annex A.

6.2 Mitigation procedures for existing installations

Mitigation procedures for internal channel parameters are described in Annex B and mitigation procedures for exogenous channel parameters are described in Annex C.