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**Liaison report from ISO/IEC JTC 1/SC 25/WG 3 to IEEE 802.3 on
topics relating to the link segment specification in IEEE802.3an D3.1**

To: IEEE 802.3
From: ISO/IEC JTC 1/SC 25/WG 3 Customer premises cabling
Date: 2006-02-20
Venue: Buenos Aires, Argentine, 2006-02-10

ISO/IEC JTC 1/SC 25/WG 3 kindly asks IEEE 802.3 note the following including the attached annexes which together cover the following topics relating to the link segment specification in IEEE802.3an D3.1.

- 1) Adoption of terms to be used in cabling standards which are currently under development in ISO/IEC JTC 1/SC 25/WG 3, see Annex 1.

These terms have been implemented in ISO/IEC TR24750 and in the 1st amendment to the 2nd edition of ISO/IEC 11801.

Specifically, these terms include:

- a. ACR-N for ACR (the insertion loss of the disturbed link segment is used to compute ACR-N from NEXT and insertion loss)
- b. ACR-F for ELFEXT (the insertion loss of the disturbed link segment is used to compute ACR-F from FEXT and insertion loss)

In order to avoid confusion in the future, SC 25/WG 3 suggests that IEEE802.3an adopts these terms as well.

- 2) Computation of PS AACR-F (formerly PS AELFEXT) method from measured AFEXT values, see Annex 2.

This computation applies to the PS AACR-F specifications for Class E_A and F_A cabling in the 1st amendment to the 2nd edition of ISO/IEC 11801. It specifically applies to unequal length link segments and includes a "normalization" based on insertion losses of disturbed and disturbing link segments.

SC 25/WG 3 kindly asks that IEEE 802.3 provides SC 25/WG 3 with any comments and confirms that this method will provide IEEE 802.3 with sufficient information on alien FEXT performance. Please confirm that this formulation will assure IEEE802.3 10GBASE-T operation on Class E_A and F_A cabling.

- 3) Expression of IEEE802.3an alien crosstalk requirements for ISO/IEC TR 24750.

ISO/IEC TR 24750 draft Technical Report includes a specification of the IEEE 802.3an link segment alien crosstalk requirements. Annex 3 shows an excerpt from IEEE 802.3an amended using the terminology specified in Annex 2. Annex 4 provides the text of Annex 3 with the additional replacement of equations presently used in IEEE 802.3an with equations that SC 25/WG 3 intends to use in order to provide additional detail and clarification.

SC 25/WG 3 kindly asks that IEEE 802.3 evaluates Annex 3 and Annex 4 and provides SC 25/WG 3 with its observations. IEEE 802.3 may wish not only to use the terminology from Annex 1 but also the equations from Annex 4 in IEEE 802.3an for harmonization purposes.

SC 25/WG 3 is pleased to inform IEEE 802.3 that the secretary of ISO/IEC JTC 1/SC 25 will be forwarding to IEEE 802.3 the updated PDTR 24750 and FPDAM for the Amendment to ISO/IEC 11801, both of which will reflect the significant progress achieved during the recent meeting of SC 25/WG 3. IEEE 802.3 may expect these documents before the end of March 2006.

Please ask the Secretary of SC 25 to provide you with the current text and copying permission in case you need to archive drafts of these documents.

Annex 1 – Definitions per 1st Amendment to 2nd Edition of ISO/IEC 11801 and per ISO/IEC TR 24750

alien (exogenous) crosstalk

signal coupling from pairs of a disturbing channel or part thereof, to a disturbed pair of another channel.

alien (exogenous) near-end crosstalk (ANEXT)

signal coupling from pairs of a disturbing channel or part thereof, to a disturbed pair of another channel or part thereof, measured at the near-end.

power sum alien (exogenous) near-end crosstalk (PS ANEXT)

a computation of the signal coupling from a pair of a disturbing channel, to a disturbed pair of another channel, measured at the near-end.

attenuation to crosstalk ratio at the near end (ACR-N)

a computation of the signal coupling from a disturbing pair, to a disturbed pair of within the same channel, measured at the near-end, and relative to the received signal level in the disturbed pair at the near-end.

power sum attenuation to crosstalk ratio at the near end (PS ACR-N)

a computation of the signal coupling from multiple disturbing pairs, to a disturbed pair within a channel, measured at the near-end, and relative to the received signal level in the disturbed pair at the near-end.

attenuation to alien (exogenous) crosstalk ratio at the near end (AACR-N)

a computation of the signal coupling of a pair of a disturbing channel, to a disturbed pair in another channel, measured at the near-end, and relative to the received signal level in the disturbed pair at the near-end.

power sum attenuation to alien (exogenous) crosstalk ratio at the near end (PS AACR-N)

a computation of the signal coupling from multiple pairs of disturbing channels, to a disturbed pair in another channel, measured at the near-end, and relative to the received signal level in the disturbed pair at the near-end.

alien (exogenous) far-end crosstalk (AFEXT)

signal coupling from a pair of a disturbing channel to a disturbed pair of another channel, measured at the far-end.

power sum alien (exogenous) far-end crosstalk (PS AFEXT)

a computation of signal coupling from pairs of multiple disturbing channels to a disturbed pair of another channel, measured at the far-end.

attenuation to crosstalk ratio at the far end (ACR-F)

a computation of the signal coupling from a disturbing pair, to a disturbed pair within the same channel, measured at the far-end, and relative to the received signal level in the disturbed pair at the far-end.

power sum attenuation to crosstalk ratio at the far end (PS ACR-F)

a computation of signal coupling from multiple disturbing pairs, to a disturbed pair within the same channel, measured at the far-end, and relative to the received signal level in the disturbed pair at the far-end.

attenuation to alien (exogenous) crosstalk ratio at the far end (AACR-F)

a computation of the signal coupling of a pair of disturbing channel, to a disturbed pair in another channel, measured at the far-end, and relative to the received signal level in the disturbed pair at the far-end

power sum attenuation to alien (exogenous) crosstalk ratio at the far end (PS AACR-F)

a computation of signal coupling from multiple pairs of disturbing channels, to a disturbed pair in another channel, measured at the far-end, and relative to the received signal level in the disturbed pair at the far-end.

equal level far-end crosstalk (*EL FEXT*)

a computation of the signal coupling from a disturbing pair, to a disturbed pair of within the same channel, measured at the far-end, and relative to the received signal level in the disturbing pair at the far-end (equivalent to the ratio of the signal level in the disturbing pair to the signal coupling in the disturbed pair, hence output-to-output FEXT which is on an equal level along the transmission lines).

power sum equal level far-end crosstalk (*PS ELFEXT*)

a computation of the signal coupling from multiple disturbing pairs, to a disturbed pair within the same channel, measured at the far-end, and relative to the received signal level in each disturbing pair at the far-end.

Normalized alien FEXT (*AFEXT_{norm}*)

Alien far end crosstalk adjusted so that the signal of the disturbing pair is attenuated to the same length as the disturbed pair.

Average PS ANEXT (*PS ANEXT_{avg}*)

The average *PS ANEXT* of all pairs in the same channel, expressed in dB.

Average PS AACR-F (*PS AACR-F_{avg}*)

The average *PS AACR-F* of all pairs in the same channel, expressed in dB.

Annex 2 - Computation of PS AACR-F from PS AFEXT and Insertion Loss measurements

These computations address evaluation of Class E_A and F_A cabling. They are intended to be application independent, and implicitly guarantee IEEE802.3an transmission requirements. Specifically, these computations address links which have unequal length/insertion loss properties. In cases where the lengths/insertion loss values are equal, there is no "normalization" as shown in the following, and computations of *PS AACR-F* from *PS AFEXT* and insertion loss values are straightforward. This annex specifies how SC 25/WG 3 calculates PS AACR-F.

Figure 1. shows a disturbing channel j with a pair i that is affecting pair k of a disturbed channel. The Alien FEXT coupling is shown as $AFEXT_{k,i,j}$.

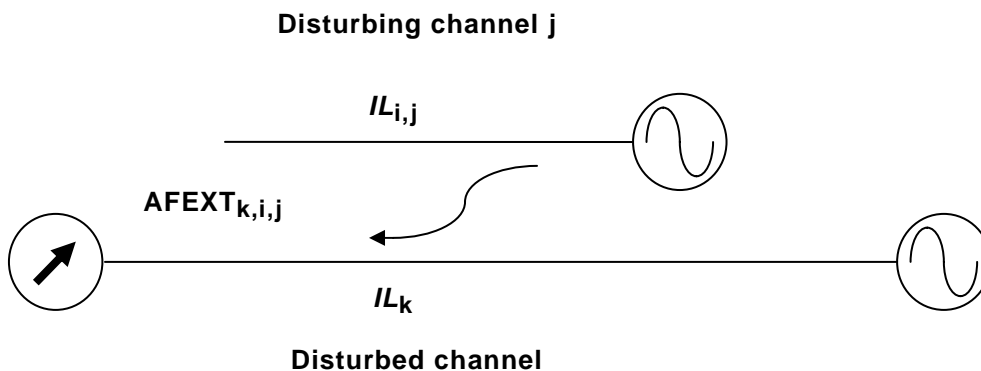


Figure 1: Schematic diagram of AFEXT coupling.

ISO/IEC 11801 uses the following computation for Class E_A and F_A cabling.

The *PS AACR-F* is computed as follows from the pair-to-pair *FEXT* measurements, and insertion losses of disturbing and disturbed channels.

The measured pair-to-pair alien *FEXT* values of a wire pair *k* in a disturbed channel from the disturbing channel *j* are normalized by the difference of the insertion losses of disturbing and disturbed channels as in equation (1).

If $IL_k - IL_{i,j} > 0$ then:

$$AFEXT_{norm_{k,i,j}} = AFEXT_{k,i,j} + IL_k - IL_{i,j} \quad (1)$$

Otherwise:

$$AFEXT_{norm_{k,i,j}} = AFEXT_{k,i,j} \quad (2)$$

where:

k is the number of the disturbed pair in a disturbed channel

i is the number of a disturbing pair in a disturbing channel

j is the number of a disturbing channel

$AFEXT_{k,i,j}$ is the measured pair-to-pair FEXT in dB to wire pair *k* of the disturbed channel from wire pair *i* in disturbing channel *j*.

IL_k is the measured insertion loss in dB of wire pair *k* of the disturbed channel.

$IL_{i,j}$ is the measured insertion loss in dB of wire pair *i* of disturbing channel *j*.

The power sum alien *FEXT* of pair *k* $PS AFEXT_k$ of a disturbed channel is computed per equation (2).

$$PS AFEXT_k = -10 \lg \sum_{j=1}^N \sum_{i=1}^n \frac{AFEXT_{norm_{k,i,j}}}{10} \quad (2)$$

where:

n is the number of wire pairs in disturbing channel *j*

N is the total number of disturbing channels.

The $PS AACR_F_k$ of pair *k* of a disturbed channel is computed per equation (3).

$$PS AACR_F_k = PS AFEXT_k - IL_k \quad (3)$$

1 **Annex 3 - IEEE 802.3an link segment specification with SC 25 terminology**

2 **5.1 Alien (Exogenous) crosstalk**

3 **5.1.1 General**

4 Power-Sum Alien NEXT (*PS ANEXT*) and Power-Sum Alien attenuation to crosstalk ratio far
5 end (*PS AACR-F*) are specified in the following clause, in accordance with 10GBASE-T.

6 NOTE Formulae used in 5.1.2 and 5.1.3 for alien crosstalk limits are numerically different to those currently used
7 by IEEE 802.3an; however they are technically equivalent, more concise and better suited for a cabling document.

8 For a detail description of how to proceed for compliance in case some limits of alien noise
9 are not met see clause 5.1.4.

10 **5.1.2 Power Sum alien NEXT (PSANEXT)**

11 The following limits shall be met (see also clause 4).

- 12 ▪ One limit to be met by all pairs
- 13 ▪ Another limit of +2,25 dB for the average of the four pairs in the channel. Average
14 *PS ANEXT* is calculated by averaging the individual *PS ANEXT* calculations in decibels at each
15 frequency point. The average applies to all pairs of the disturbed channel.

16 The allowable *PS ANEXT* is inter-related to the insertion loss of the channel and is based
17 upon the calculated or measured insertion loss at 250 MHz as detailed below.

18 To support 10GBASE-T the *PS ANEXT* for each pair in a channel shall meet the limits
19 computed, to one decimal place, using the formulae Table 1. The limits shown in Table 2 are
20 derived from the formulae at key frequencies.

21 The *PS ANEXT* requirements shall be met at both ends of the cabling.

22 *PS ANEXT_k* of pair *k* is computed as follows:

$$23 \quad PS ANEXT_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-ANEXT_{l,i,k}}{10}} \quad (1)$$

24 where

25 *k* is the number of the disturbed pair in the disturbed channel;

26 *i* is the counter of the disturbing pairs in the disturbing channel *l*;

27 *l* is the summing counter of the disturbing channels;

28 *N* is the number of disturbing channels

29 *n* is the number of disturbing pairs in each of the *N* channels;

30 *ANEXT_{l,i,k}* is the alien near end crosstalk loss coupled from pairs *i* of disturbing channel *l*
31 to the disturbed pair *k*.

32 NOTE Pairs external to the channel are all those pairs surrounding the channel that belong to other channels and that could
33 disturb each pair in the channel (ffs)

34 The average *PS ANEXT* of all wire pairs is computed by averaging the values of each wire
 35 pair expressed in dB as in equation (2).

$$36 \quad PS ANEXT_{avg} = \frac{1}{4} \sum_{k=1}^4 PS ANEXT_k \quad (2)$$

37 **Table 1- Formulae for PS ANEXT limits for a channel**

Frequency MHz	Minimum PS ANEXT dB	
$1 \leq f \leq 100$	$27,48 + IL(250)/1,04 - 10\lg(f/100)$	For every pair
$100 < f \leq 500$	$27,48 + IL(250)/1,04 - 15\lg(f/100)$	
$1 \leq f \leq 100$	$29,73 + IL(250)/1,04 - 10\lg(f/100)$	For the average of the 4 pairs per disturbed channel
$100 < f \leq 500$	$29,73 + IL(250)/1,04 - 15\lg(f/100)$	

Where *IL*(250) is channel insertion loss at 250 MHz in dB rounded to one decimal place
IL(250) values less than 6,3 dB revert to a value of 6,3 dB
 For pass/fail evaluation of measured *PS ANEXT* performance, calculated values greater than 67 dB shall revert to a minimum requirement of 67,0 dB.

38 **Table 2 – PS ANEXT limits for a channel at key frequencies**

Frequency (MHz)	Minimum PS ANEXT dB					
	1,0	16,0	100,0	250,0	500,0	
<i>IL</i> (250) = 20,3 dB	67,0	55,0	47,0	41,0	36,5	For every pair
<i>IL</i> (250) = 33,8 dB	67,0	67,9	60,0	54,0	49,5	
<i>IL</i> (250) = 35,9 dB	67,0	70,0	62,0	56,0	51,5	
<i>IL</i> (250) = 20,3 dB	67,0	57,25	49,25	43,25	38,75	For the average of the 4 pairs per disturbed channel
<i>IL</i> (250) = 33,8 dB	67,0	67,0	62,25	55,25	51,75	
<i>IL</i> (250) = 35,9 dB	67,0	67,0	64,25	58,25	53,75	

NOTE The IEEE 802.3an *PSNEXT* constants are shown in bold

39
 40 Values of *PS ANEXT* at frequencies for which the measured channel insertion loss is below
 41 4,0 dB are for information only.

42 **5.1.3 Power sum alien attenuation to crosstalk ratio far end (PS AACR-F)**

43 To support 10GBASE-T the following limits shall be met (see also clause 4).

- 44 • One limit to be met by all pairs
- 45 ▪ Another limit of +4 dB for the average of the four pairs in the channel. Average *PS AACR-F*
 46 *F* is calculated by averaging the individual *PS AACR-F* calculations in decibels at each
 47 frequency point. The average applies to all pairs of the disturbed channel.

48 The *PS AACR-F* for each pair combination of a channel shall meet the limits computed, to
 49 one decimal place, using the formulae of Table 3. The limits shown in Table 4 are derived
 50 from the formulae at key frequencies.

51 $PS AFEXT_k$ of pair k is computed as follows:

$$52 \quad PS AFEXT_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-AFEXT_{l,i,k}}{10}} \quad (3)$$

53 where

54 k is the number of the disturbed pair in the disturbed channel;

55 i is the counter of the disturbing pairs in the disturbing channel l ;

56 l is the summing counter of the disturbing channels;

57 N is the number of disturbing channels

58 n is the number of disturbing pairs in each of the N channels;

59 $AFEXT_{l,i,k}$ is the alien far end crosstalk loss coupled from pairs i of channel l to the pair k .

60 $PS AACR-F_k$ of pair k is computed as follows:

$$61 \quad PS AACR - F_k = PS AFEXT_k - IL_{avg} \quad (4)$$

62 where

63 i is the counter of the disturbing pair;

64 k is the counter of the disturbed pair;

65 IL_{avg} is the average insertion loss of all 4 pairs of the disturbed channel in dB. When
66 required, it shall be measured according to IEC 61935-1 and calculated per
67 equation (11).

$$68 \quad IL_{avg} = \frac{1}{4} \sum_{k=1}^4 IL_k \quad (5)$$

69

70 NOTE Pairs external to the channel are all those pairs surrounding the channel that belong to other channels and that could
71 disturb each pair in the channel (ffs).

72 The average $PS AFEXT$ of all wire pairs is computed by averaging the values of each wire
73 pair expressed in dB as in equation (6).

$$74 \quad PS AFEXT_{avg} = \frac{1}{4} \sum_{k=1}^4 PS AFEXT_k \quad (6)$$

75 The $PS AACR-F_{avg}$ is computed per equation (7).

$$77 \quad PS AACR-F_{avg} = PS AFEXT_{avg} - IL_{avg} \quad (7)$$

78

Table 3- Formulae for PS AACR-F limits for a channel

Frequency MHz	Minimum PS AACR-F dB	
$1 \leq f \leq 500$	$22,22 + IL(250)/2,29 - 20\lg(f/100) - 10\lg(L/100)$	For every pair
$1 \leq f \leq 500$	$26,22 + IL(250)/2,29 - 20\lg(f/100) - 10\lg(L/100)$	For the average of the 4 pairs per disturbed channel

Where $IL(250)$ is channel insertion loss at 250 MHz in dB to one decimal place, L is physical channel length in m
 $IL(250)$ values less than 10,0 dB shall revert to a value of 10,0 dB; L reverts to 2,77 m

For the purpose of field measurements $L = 2,77 \cdot \sqrt{f}$, where f is the frequency in MHz.

The average measured $IL(250)$ of all wire pairs of the disturbed channel is used in limit calculations applicable to all wire pairs.

For pass/fail evaluation of measured $PS AACR-F$ performance, when the $PS AFEXT$ exceeds $72-15\lg(f/100)$ or 67,0 dB, the calculated $PS AACR-F$ result shall be for information only.

Table 4 - PS AACR-F limits for a channel at key frequencies and lengths

Frequency MHz	Minimum PS AACR-F dB					
	1,0	16,0	100,0	250,0	500,0	
$IL(250) = 20,3$ dB; $L=55$ m	67,0	49,6	33,7	25,7	19,7	For every pair
$IL(250) = 33,8$ dB; $L=100$ m	67,0	52,9	37,0	29,0	23,0	
$IL(250) = 35,9$ dB; $L=100$ m	67,0	53,8	37,9	29,9	23,9	
$IL(250) = 20,3$ dB; $L=55$ m	67,0	53,6	37,7	29,7	23,7	For the average of the 4 pairs per disturbed channel
$IL(250) = 33,8$ dB; $L=100$ m	67,0	56,9	41,0	33,0	27,0	
$IL(250) = 35,9$ dB; $L=100$ m	67,0	57,6	41,9	33,7	27,7	

Note: The IEEE 802.3an constants are shown in bold

82 5.1.4 Alien crosstalk margin computation**83 5.1.4.1 General**

84 Editors note: This clause is a one to one transcription from IEEE 802.3 an Draft 3.0 chapter 55.7.3.3. Only the
85 references and the equation numbers were adapted fit to ISO/IEC 24750, and the necessary backoff Table 19
86 copied.

87 The objective of alien crosstalk margin computation is to further characterise the alien
88 crosstalk coupling . The alien crosstalk margin computation ensures the total combined
89 $PS AFEXT$ and $PS ANEXT$ coupled into a duplex channel is limited in order to maintain the
90 minimum signal to noise ratio. The alien crosstalk margin computation can be applied in the
91 event that the $PS ANEXT$ limits specified in clause (5.1.2) or the $PS ACR-F$ limits specified in
92 clause (5.1.3) are not met. The alien crosstalk margin is specified for each of the individual 4-
93 pairs as well as the average "across the 4-pairs".

94 5.1.4.2 The alien crosstalk margin is determined by the following algorithm:

95 **Step 1:** Determine the length of the disturbed link segment and the disturbing link segments
96 using equation (8)

$$L = 2,77 IL_{avg} \quad (8)$$

100 Where:

101 IL_{avg} is the average measured insertion loss at 250 MHz "across the 4-pairs" of each
102 disturbed and disturbing link segment.

103 L is the length in meters for each disturbed and disturbing link segment derived
104 from the measured insertion loss.

105 **Step 2:** Determine the minimum power backoff (dB) for each disturbed and disturbing link
106 segment from Table 5 Power backoff schedule from main body IEEE Draft 2.4 Power backoff
107 schedule utilising the calculated link segment length from step 1. (e.g., from Table 5; a length
108 of 30 m has a minimum power backoff of 10 dB).

109 **Table 5 Power backoff schedule from main body IEEE Draft 2.4**

Received signal power at MDI on worst pair dBm	Reference length m	Minimum power backoff dB
>0,3	0 to ≤25	10
-1,1 to 0,3	>25 to ≤35	10
-2,3 to -1,1	>35 to ≤45	8
-3,3 to -2,3	>45 to ≤55	6
-4,2 to -3,3	>55 to ≤65	4
-5,0 to -4,2	>65 to ≤75	2
-5,7 to -5,0	>75 to ≤85	0
≤ -5,7	>85	0

110
111 **Editors Note: ≤ and > signs have been added to column 2 in order to avoid ambiguities.**
112 **IEEE 802.3 is kindly asked to confirm.**
113

114 **Step 3:** Determine the insertion loss backoff factor using equation (9)

$$115 \quad IL_bof_j = \min_PBO_disturbing\ link_j - \min_PBO_disturbed\ link \quad (9)$$

117 Where:

118 IL_bof_j is calculated as the difference between the minimum power backoff
119 (dB) of the disturbing link j and the disturbed link segments
120 determined in Step 2.

121 $PBO_disturbing\ link_j$ Is the power back off applicable to the disturbing link j

122 $PBO_disturbed\ link$ is the power back of applicable to the disturbed link

123
124
125 **Step 4:** Determine the $PS\ ANEXT$ and the $PS\ AFEXT$ from the measured $ANEXT$ and $AFEXT$
126 and the insertion loss backoff factor for each disturbed pair $N=1,2,3,4$ of a link segment using
127 equation (10) and equation (11) respectively.

$$128 \quad PS\ ANEXT_N(f) = -10 \times \log_{10} \sum_{j=1}^m \sum_{i=1}^4 10^{\frac{-(AN_pr(f)_{i,j,N} + IL_bof_j)}{10}} \quad \text{dB} \quad (10)$$

$$130 \quad PS\ AFEXT_N(f) = -10 \times \log_{10} \sum_{j=1}^m \sum_{i=1}^4 10^{\frac{-(AF_pr(f)_{i,j,N} + IL_bof_j)}{10}} \quad \text{dB} \quad (11)$$

131
132
133
134
135

136 Where:
 137 $AN_{pr}(f)_{i,j,N}$ is the measured ANEXT of the individual pair combination (1 to 4) of the
 138 disturbing link (1 to m) for each disturbed pair N.
 139 $AF_{pr}(f)_{i,j,N}$ is the measured AFEXT of the individual pair combination (1 to 4) of the
 140 disturbing link (1 to m) for each disturbed pair N.
 141 IL_{bof_j} is the insertion loss backoff factor determined in equation (9)
 142 **Editors note: the terms and indices used in equations (10, 11, 12, 15 and 17) need to be**
 143 **aligned with those in equations (1 and 2)**
 144 **Step 5:** Determine the individual-pair margin for each of the 4-pairs using equation (12).

$$XWn(f) = -10 \times \log_{10} 10^{-\frac{AN(f)}{-10}} + 10^{-\frac{AF(f)}{-10}} + 10 \times \log_{10} 10^{-\frac{AN_{ipl}(f) + 2.5}{-10}} + 10^{-\frac{AF_{ipl}(f)}{-10}} \quad (dB)$$

(12)

145
 146
 147 Where:
 148 f is the frequency in MHz
 149 $XWn(f)$ is the individual-pair margin for each of the 4-pairs
 150 $AN(f)$ is the measured *PS ANEXT* Loss in dB in the frequency range ($10 \leq f \leq$
 151 400) MHz determined in equation (10) adjusted for the insertion loss power
 152 backoff.
 153 $AF(f)$ is the measured *PS AFEXT* Loss in dB in the frequency range ($10 \leq f \leq$
 154 400) MHz determined in equation (11) adjusted for the insertion loss power
 155 backoff.
 156 $AN_{ipl}(f)$ is the individual-pair limit line for *PS ANEXT* as specified in clause (5.1.2)
 157 utilizing the measured insertion loss of the individual-pair.
 158 $AF_{ipl}(f)$ is the individual-pair limit line for *PS AFEXT* calculated from the *PS AELFEXT*
 159 equation specified in clause(5.1.3) utilizing the measured insertion loss of the
 160 individual-pair.

161
 162 Note: The 2,5 dB is the *PS ANEXT* allowance for the peak-to-average difference across frequency

163 **Step 6:** Determine the average value "across frequency" of $XWn(f)$ from 10 MHz to 400 MHz,
 164 for each individual-pair of the 4-pair cabling using equation (13).

$$XAWn = \frac{\int_{f=10}^{400} XWn(f) df}{390} \quad (dB)$$

165
 166
 167
 168
 169
 170
 171
 172
 173
 174

(13)

167 Where:
 168 F is the frequency in MHz
 169 $XAWn$ is the average value "across frequency" for the individual-pair number n
 170 ($n=1,2,3,4$)

171 **Step 7:** Determine the individual-pair margin as the minimum of the average value
 172 "across frequency" of each of the individual pairs of the 4-pair cabling determined from step 2
 173 using equation (14).

$$Y_{inp} = \min(XAW1, XAW2, XAW3, XAW4) \quad (dB)$$

(14)

175
 176
 177
 178 Where:
 179 Y_{inp} is the the individual-pair margin
 180 $XAWn$ is the average value "across frequency" for the individual-pair number n
 181 ($n=1,2,3,4$)

182

183 **Step 8:** Determine the power sum of the *PS ANEXT* and *PS AFEXT* for each of the 4-pairs
184 using equation (15).

$$XXn(f) = 10 \times \log_{10} \left(10^{\frac{AN(f)}{-10}} + 10^{\frac{AF(f)}{-10}} \right) \quad (dB)$$

185

(15)

186

187 Where:

188 f is the frequency in MHz

189 $XXn(f)$ is the power sum of the *PS ANEXT* and *PS AFEXT* for each of the 4-pairs

190 $AN(f)$ is the measured *PS ANEXT* Loss in dB in the frequency range ($10 \leq f \leq 400$) MHz
191 determined in equation (10) adjusted for the insertion loss power backoff.

192 $AF(f)$ is the measured *PS AFEXT* Loss in dB in the frequency range ($10 \leq f \leq 400$) MHz
193 determined in equation (11) adjusted for the insertion loss power backoff.

194 **Step 9:** Determine the average of the power sum of the *PS ANEXT* and *PS AFEXT* of the 4-
195 pairs using equation (16).

$$XXavg(f) = \frac{\sum_{i=1}^n XXi(f)}{4} \quad (dB)$$

196

(16)

197 Where:

198 $XXavg(f)$ is the average of the power sum of the *PS ANEXT* and *PS AFEXT* of the 4-pairs

199 XXi is the power sum of the *PS ANEXT* and *PS AFEXT* for pairs i

200 n is the number of individual pairs; $n = 4$

201 **Step 10:** Determine the average margin using equation (17).

$$XA(f) = -XXavg + 10 \times \log_{10} \left(10^{\frac{AN_avgI(f)}{-10}} + 10^{\frac{AF_avgI(f)}{-10}} \right) \quad (dB)$$

202

(17)

203

204 Where:

205 $XA(f)$ is the average margin.

206 $XXavg$ is the average of the power sum of the *PS ANEXT* and *PS AFEXT* of the 4-pairs

207 $AN_avgI(f)$ is the average limit line for *PS ANEXT* as calculated using equation (18).

208 $AN_avgI(f)$ is derived using the *PS ANEXT* constant that is the minimum of the individual-
209 pair *PS ANEXT* constants.

210

$$AN_avgI(f) = (\min(PS\ ANEXT\ constant) + 3,5) - 10 \lg \frac{f}{100} \quad (dB) \quad 1 \leq f \leq 100$$

212

$$AN_avgI(f) = (\min(PS\ ANEXT\ constant) + 3,5) - 20 \lg \frac{f}{100} \quad (dB) \quad 100 < f \leq 500$$

214

(18)

215 where
 216 f is the frequency in MHz.
 217 $AF_{avg}(f)$ is the average limit line for $PS AFEXT$ calculated using equation 19).
 218 $AF_{avg}(f)$ is derived by adding the measured IL from the pair with the minimum
 219 $PS AELFEXT$ constant to the $PS AELFEXT$ limit line using the $PS AELFEXT$
 220 constant that is the minimum of the individual-pair $PS AELFEXT$.
 221

$$222 \quad AF_{avg}(f) = (\min(PS AACR - Fconstant) + 4) - 20 \lg \frac{f}{100} + ILmin(f) \quad (dB)$$

223 $1 \leq f \leq 500$ 19)

224 **Step 11:** Determine the average margin as the average value across frequency of $XA(f)$ using
 225 equation (20).

$$226 \quad Y_{avg} = \frac{\int_{f=10}^{400} XA(f) df}{390} \quad (dB) \quad (20)$$

227 Where:

228 f is the frequency in MHz
 229 XA is the average margin
 230 Y_{avg} is the average value "across frequency" of $XA(f)$ from 10 MHz to 400 MHz

231 **Step 12:** Determine the alien crosstalk margin as the minimum value of the individual pair
 232 margin (equation (14)) and the average margin (equation (17)) using equation (21).

$$233 \quad YL = \min(Y_{inp}, Y_{avg}) \quad (dB) \quad (21)$$

233

234 The alien crosstalk margin YL shall be greater than zero.

235 5.1.5 Examples of implementations at key IL(250)

236 Table 4 provides examples of channel lengths that will support 10GBASE-T in reliance on the
 237 minimum performance of class E and class F as specified in ISO/IEC 11801:2002 and the
 238 noise levels specified in 5.1.2 and 5.1.3

239 **Table 6- Examples of implementations at key insertion loss**

Channel length m	Class	length of fixed cable + cord m + m	Noise constant at 100 MHz dB	
			PS ANEXT	PS AACR-F
IL at 250 MHz = 20,3 dB				
55 ^a	E	42,8 + 10	47	33,7
55 ^a	F	45,8 + 10		
IL at 250 MHz = 33,8 dB				
100 ^a	E	83,5 + 10	60	37
100 ^a	F	90 + 10		
IL at 250 MHz = 35,9 dB				
100 ^a	E	90 + 10	62	37,9
100 ^a	F	90 + 10		
^a not exactly 55 m and 100 m respectively but formulae not so length sensitive				

240

1 **Annex 4 - IEEE 802.3an link segment specification with SC 25 terminology and**
2 **equations proposed by SC 25/WG 3**

3 **5.1 Alien (Exogenous) crosstalk**

4 **5.1.1 General**

5 Power-Sum Alien NEXT (*PS ANEXT*) and Power-Sum Alien attenuation to crosstalk ratio far
6 end (*PS AACR-F*) are specified in the following clause, in accordance with 10GBASE-T.

7 NOTE Formulae used in 5.1.2 and 5.1.3 for alien crosstalk limits are numerically different to those currently used
8 by IEEE 802.3an; however they are technically equivalent, more concise and better suited for a cabling document.

9 For a detail description of how to proceed for compliance in case some limits of alien noise
10 are not met see clause 5.1.4.

11 **5.1.2 Power Sum alien NEXT (PSANEXT)**

12 The following limits shall be met:

- 13 ▪ One limit to be met by all pairs
- 14 ▪ Another limit of +2,25 dB for the average of the four pairs in the channel. Average
15 *PS ANEXT* is calculated by averaging the individual *PS ANEXT* calculations in decibels at each
16 frequency point. The average applies to all pairs of the disturbed channel.

17 The allowable *PS ANEXT* is inter-related to the insertion loss of the channel and is based
18 upon the calculated or measured insertion loss at 250 MHz as detailed below.

19 To support 10GBASE-T the *PS ANEXT* for each pair in a channel shall meet the limits
20 computed, to one decimal place, using the formulae Table 1. The limits shown in Table 2 are
21 derived from the formulae at key frequencies.

22 The *PS ANEXT* requirements shall be met at both ends of the cabling.

23 *PS ANEXT_k* of pair *k* is computed as follows:

$$24 \quad PS ANEXT_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-ANEXT_{l,i,k}}{10}} \quad (1)$$

25 where

26 *k* is the number of the disturbed pair in the disturbed channel;

27 *i* is the counter of the disturbing pairs in the disturbing channel *l*;

28 *l* is the summing counter of the disturbing channels;

29 *N* is the number of disturbing channels

30 *n* is the number of disturbing pairs in each of the *N* channels;

31 *ANEXT_{l,i,k}* is the alien near end crosstalk loss coupled from pairs *i* of disturbing channel *l*
32 to the disturbed pair *k*.

33 NOTE Pairs external to the channel are all those pairs surrounding the channel that belong to other channels and that could
34 disturb each pair in the channel (ffs)

35 The average *PS ANEXT* of all wire pairs is computed by averaging the values of each wire
 36 pair expressed in dB as in equation(2).

$$37 \quad PS ANEXT_{avg} = \frac{1}{4} \sum_{k=1}^4 PS ANEXT_k \quad (2)$$

38 **Table 1- Formulae for PS ANEXT limits for a channel**

Frequency MHz	Minimum PS ANEXT dB	
$1 \leq f \leq 100$	$27,48 + IL(250)/1,04 - 10\lg(f/100)$	For every pair
$100 < f \leq 500$	$27,48 + IL(250)/1,04 - 15\lg(f/100)$	
$1 \leq f \leq 100$	$29,73 + IL(250)/1,04 - 10\lg(f/100)$	For the average of the 4 pairs per disturbed channel
$100 < f \leq 500$	$29,73 + IL(250)/1,04 - 15\lg(f/100)$	

Where *IL*(250) is channel insertion loss at 250 MHz in dB rounded to one decimal place
IL(250) values less then 6,3 dB revert to a value of 6,3 dB
 For pass/fail evaluation of measured *PS ANEXT* performance, calculated values greater than 67 dB shall revert to a minimum requirement of 67,0 dB.

39 **Table 2 – PS ANEXT limits for a channel at key frequencies**

Frequency (MHz)	Minimum PS ANEXT dB					
	1,0	16,0	100,0	250,0	500,0	
<i>IL</i> (250) = 20,3 dB	67,0	55,0	47,0	41,0	36,5	For every pair
<i>IL</i> (250) = 33,8 dB	67,0	67,9	60,0	54,0	49,5	
<i>IL</i> (250) = 35,9 dB	67,0	70,0	62,0	56,0	51,5	
<i>IL</i> (250) = 20,3 dB	67,0	57,25	49,25	43,25	38,75	For the average of the 4 pairs per disturbed channel
<i>IL</i> (250) = 33,8 dB	67,0	67,0	62,25	55,25	51,75	
<i>IL</i> (250) = 35,9 dB	67,0	67,0	64,25	58,25	53,75	

NOTE The IEEE 802.3an *PSNEXT* constants are shown in bold.

40
 41 Values of *PS ANEXT* at frequencies for which the measured channel insertion loss is below
 42 4,0 dB are for information only.

43 **5.1.3 Power sum alien attenuation to crosstalk ratio far end (PS AACR-F)**

44 To support 10GBASE-T the following limits shall be met.

- 45 • One limit to be met by all pairs
- 46 ▪ Another limit of +4 dB for the average of the four pairs in the channel. Average *PS AACR-F*
 47 *F* is calculated by averaging the individual *PS AACR-F* calculations in decibels at each
 48 frequency point. The average applies to all pairs of the disturbed channel.

49 The *PS AACR-F* for each pair combination of a channel shall meet the limits computed, to
 50 one decimal place, using the formulae of Table 3. The limits shown in Table 4 are derived
 51 from the formulae at key frequencies.

52 $PS AFEXT_k$ of pair k is computed as follows:

$$53 \quad PS AFEXT_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-AFEXT_{l,i,k}}{10}} \quad (3)$$

54 where

55 k is the number of the disturbed pair in the disturbed channel;

56 i is the counter of the disturbing pairs in the disturbing channel l ;

57 l is the summing counter of the disturbing channels;

58 N is the number of disturbing channels

59 n is the number of disturbing pairs in each of the N channels;

60 $AFEXT_{l,i,k}$ is the alien far end crosstalk loss coupled from pairs i of channel l to the pair k .

61 $PS AACR-F_k$ of pair k is computed as follows:

$$62 \quad PS AACR - F_k = PS AFEXT_k - IL_{avg} \quad (4)$$

63 where

64 i is the counter of the disturbing pair;

65 k is the counter of the disturbed pair;

66 IL_{avg} is the average insertion loss of all 4 pairs of the disturbed channel in dB. When
67 required, it shall be measured according to IEC 61935-1 and calculated per
68 equation (5).

$$69 \quad IL_{avg} = \frac{1}{4} \sum_{k=1}^4 IL_k \quad (5)$$

70 NOTE Pairs external to the channel are all those pairs surrounding the channel that belong to other channels and
71 that could disturb each pair in the channel (ffs).

72 The average $PS AFEXT$ of all wire pairs is computed by averaging the values of each wire
73 pair expressed in dB as in equation (6).

$$74 \quad PS AFEXT_{avg} = \frac{1}{4} \sum_{k=1}^4 PS AFEXT_k \quad (6)$$

76 The $PS AACR-F_{avg}$ is computed per equation (7).

$$77 \quad PS AACR - F_{avg} = PS AFEXT_{avg} - IL_{avg} \quad (7)$$

78

Table 3- Formulae for PS AACR-F limits for a channel

Frequency MHz	Minimum PS AACR-F dB	
$1 \leq f \leq 500$	$22,22 + IL(250)/2,29 - 20\lg(f/100) - 10\lg(L/100)$	For every pair
$1 \leq f \leq 500$	$26,22 + IL(250)/2,29 - 20\lg(f/100) - 10\lg(L/100)$	For the average of the 4 pairs per disturbed channel

Where $IL(250)$ is channel insertion loss at 250 MHz in dB to one decimal place, L is physical channel length in m
 $IL(250)$ values less than 10,0 dB shall revert to a value of 10,0 dB; L reverts to 2,77 m
For the purpose of field measurements $L = 2,77 \cdot \sqrt{f}$, where f is the frequency in MHz.
The average measured $IL(250)$ of all wire pairs of the disturbed channel is used in limit calculations applicable to all wire pairs.
For pass/fail evaluation of measured PS AACR-F performance, when the PS AFEXT exceeds $72-15\lg(f/100)$ or 67,0 dB, the calculated PS AACR-F result shall be for information only.

Table 4 - PS AACR-F limits for a channel at key frequencies and lengths

Frequency MHz	Minimum PS AACR-F dB					
	1,0	16,0	100,0	250,0	500,0	
$IL(250) = 20,3$ dB; $L = 55$ m	65,7	49,6	33,7	25,7	19,7	For every pair
$IL(250) = 33,8$ dB; $L = 100$ m	64,8	52,9	37,0	29,0	12,2	
$IL(250) = 35,9$ dB; $L = 100$ m	64,7	53,8	37,9	29,9	8,1	
$IL(250) = 20,3$ dB; $L = 55$ m	65,7	53,6	37,7	29,7	19,7	For the average of the 4 pairs per disturbed channel
$IL(250) = 33,8$ dB; $L = 100$ m	64,8	56,9	41,0	33,0	12,2	
$IL(250) = 35,9$ dB; $L = 100$ m	64,7	57,6	41,9	33,7	8,1	

Note: The IEEE 802.3AN constants are shown in bold.

5.1.4 Alien crosstalk margin computation**5.1.4.1 General**

84 Editors note: This clause is a one to one transcription from IEEE 802.3 an Draft 3.0 chapter 55.7.3.3. Only the
85 references and the equation numbers were adapted accordingly, and the necessary backoff Table 19 copied into.

86 The objective of alien crosstalk margin computation is to further characterise the alien
87 crosstalk coupling. The alien crosstalk margin computation ensures the total combined
88 *PS AFEXT* and *PS ANEXT* coupled into a duplex channel is limited in order to maintain the
89 minimum signal to noise ratio. The alien crosstalk margin computation can be applied in the
90 event that the *PS ANEXT* limits specified in clause (5.1.2) or the *PS AACR-F* limits specified
91 in clause (5.1.3) are not met. The alien crosstalk margin is specified for each of the individual
92 4-pairs as well as the average "across the 4-pairs".

5.1.4.2 The alien crosstalk margin is determined by the following algorithm:

94 Determine the length of the disturbed channel and the disturbing channel using equation (8)
95

$$96 \quad L = 2,77 \cdot IL_{avg} \quad (8)$$

97
98 Where:

99 IL_{avg} is the average measured insertion loss at 250 MHz "across the 4-pairs" of each
100 disturbed and disturbing channel.

101 L is the length in meters for each disturbed and disturbing channel segment
102 derived from the measured insertion loss.

103 Determine the minimum power backoff (dB) for each disturbed and disturbing channel from
104 Table 5 Power backoff schedule from main body IEEE802.3 10GBASE-T. Power backoff
ISO/IEC JTC 1/SC 25/WG 3n779Ax4.doc page 16

105 schedule utilising the calculated channel length from equation 8. (e.g., from Table 5; a length
106 of 30 m has a minimum power backoff of 10 dB).

107 **Table 5 Power backoff schedule from main body IEEE802.3 10GBASE-T.**

Received signal power) at MDI on worst pair dBm	Reference length m	Minimum power backoff dB
>0,3	0 to ≤25	10
-1,1 to 0,3	>25 to ≤35	10
-2,3 to -1,1	>35 to ≤45	8
-3,3 to -2,3	>45 to ≤55	6
-4,2 to -3,3	>55 to ≤65	4
-5,0 to -4,2	>65 to ≤75	2
-5,7 to -5,0	>75 to ≤85	0
≤ -5,7	>85	0

108 **Editors Note: ≤ and > signs have been added to column 2 in order to avoid ambiguities.**
109 **IEEE 802.3 is kindly asked to confirm.**

110 Determine the insertion loss backoff factor using equation (9)

111
112
$$IL_bof_l = min_PBO_disturbing_link_l - min_PBO_disturbed_link$$

113 **(9)**

114 Where:

115 IL_bof_l is calculated as the difference between the minimum power backoff
116 (dB) of the disturbing channel j and the disturbed channels.
117 $PBO_disturbing_link_j$ is the power back off applicable to the disturbing link j
118 $PBO_disturbed_link$ is the power back of applicable to the disturbed link

119 Determine the $PS\ ANEXT_bof$ and the $PS\ AFEXT_bof$ from the measured $ANEXT$ and $AFEXT$
120 and the insertion loss backoff factor for each disturbed pair $k=1,2,3,4$ of a channel using
121 equation (10) and equation (11) respectively.

122
$$PS\ ANEXT_bof_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-\left(ANEXT_{l,i,k} + IL_bof_l\right)}{10}} \quad \text{dB} \quad (10)$$

123
$$PS\ AFEXT_bof_k = -10 \lg \sum_{l=1}^N \sum_{i=1}^n 10^{\frac{-\left(AFEXT_{l,i,k} + IL_bof_l\right)}{10}} \quad \text{dB}$$

124 **(11)**

125 Where:

126 $ANEXT_{l,i,k}$ is the measured ANEXT of the individual pair combination l (1 to 4) of the
127 disturbing channel (1 to n) for each disturbed pair k;

128 $FNEXT_{l,i,k}$ is the measured AFEXT of the individual pair combination l (1 to 4) of the
129 disturbing channel (1 to n) for each disturbed pair k;

130 k is the number of the disturbed pair in the disturbed channel;

131 i is the counter of the disturbing pairs in the disturbing channel l ;

- 132 l is the summing counter of the disturbing channels;
 133 N is the number of disturbing channels
 134 n is the number of disturbing pairs in each of the N channels, $n = 4$;
 135 IL_{bof_l} is the insertion loss backoff factor determined in equation (9)

136 The total alien crosstalk $PS AXtalk_k$ of each individual pair k is computed per equation (12)

137

$$138 \quad PS AXtalk_k = -10 \lg 10^{\frac{-PS ANEXT_{bof_k}}{10}} + 10^{\frac{-PS AFEXT_{bof_k}}{10}} \quad \text{dB} \quad (12)$$

139
 140 Compute the individual pair margin limit using equation (13).

$$141 \quad PS AXtalk_{limit_k} = -10 \lg 10^{\frac{-\left(PS ANEXT_{limit_k} + 2.5\right)}{10}} + 10^{\frac{-PS AACR - F_{limit_k} + IL_{avg}}{10}}$$

142 where: (13)
 143

- 144 $PS ANEXT_{limit_k}$ is the minimum PS ANEXT for any pair in a channel per Table 1.
 145 $PS AACR - F_{limit}$ is the minimum PS AACR-F for any pair in a channel per Table 3.
 146 IL_{avg} is the average insertion loss across the 4-pairs.

147
 148 Note: The 2,5 dB is the $PS ANEXT$ allowance for the peak-to-average difference across frequency

149 Determine the individual-pair margin for each of the 4-pairs using equation 14.

150

$$151 \quad PS AXtalk_{margin_k} = PS AXtalk_k - PS AXtalk_{limit_k} \quad (14)$$

152 The average individual pair margin for each frequency interval m with upper frequency
 153 $f_{high,m}$ and lower frequency $f_{low,m}$ is given by equation (15).

$$155 \quad PS AXtalk_{AVGmargin_{k,m}} = PS AXtalk_{margin_k} \left(f_{high,m} - PS AXtalk_{margin_k} \left(f_{low,m} \right) \right) \frac{f_{high,m} - f_{low,m}}{2}$$

156 (15)
 157
 158

159 The average value “across frequency” is from 10 MHz to 400 MHz, for each individual-pair of
 160 the 4-pair cabling is computed summing all average margins in each frequency interval in the
 161 10 MHz to 400 MHz frequency range using equation (16).

$$162 \quad PS AXtalk_{AVGmargin_k} = \frac{\sum PS AXtalk_{AVGmargin_{k,m}}}{390} \quad (16)$$

163 The minimum average margins of all pairs is given by equation (17).

164
$$PS\ AXtalk_AVGmargin_{pair} = \min \left(PS\ AXtalk_AVGmargin_1, PS\ AXtalk_AVGmargin_2, PS\ AXtalk_AVGmargin_3, PS\ AXtalk_AVGmargin_4 \right) \text{ dB} \quad (17)$$

165
166 Where:

167 $PS\ AXtalk_AVGmargin_{pair}$ is the individual-pair average alien crosstalk margin

168 Determine the average of the power sum of the $PS\ ANEXT$ and $PS\ AFEXT$ of the 4-pairs
169 using equation (18).

170
$$PS\ AXtalk_{avg} = \frac{\sum_{k=1}^4 PS\ AXtalk_k}{4}$$

171 (18)

172 Compute the average margin limit using equation (19).

173
$$PS\ AXtalk_limit_{avg} = -10 \lg 10 \frac{- \left(PS\ ANEXT_limit_k + 3.5 \right)}{10} - \frac{PS\ AACR - F_limit_k + IL_{avg} + 4}{10} + 10$$

174 (19)

175 where:

176 $PS\ ANEXT_limit_k$ is the minimum $PS\ ANEXT$ for any pair in a channel per Table 1.

177 $PS\ AACR - F_limit$ is the minimum $PS\ AACR-F$ for any pair in a channel per Table 3.

178 IL_{avg} is the average insertion loss across the 4-pairs.

179
180 Note: The 3,5 dB is the $PS\ ANEXT$ allowance for the peak-to-average difference across frequency and averaged
181 over 4 pairs.

182 The average all pairs margin for each frequency interval m with upper frequency $f_{high,m}$ and
183 lower frequency $f_{low,m}$ is given by equation (20).

184
$$PS\ AXtalk_AVGmargin_{avg,m} = PS\ AXtalk_margin_{avg} \left(f_{high,m} - PS\ AXtalk_margin_{avg} \left(f_{low,m} \right) \right)^{\frac{f_{high,m} - f_{low,m}}{2}}$$

185 (20)

186

187 The average value “across frequency” is from 10 MHz to 400 MHz, for each individual-pair of
188 the 4-pair cabling is computed summing all average margins in each frequency interval using
189 equation (21).

190
$$PS\ AXtalk_AVGmargin_{avg} = \frac{\sum PS\ AXtalk_AVGmargin_{avg,m}}{390}$$

191 (21)

192 Determine the overall alien crosstalk margin as the minimum value of the individual pair
193 margin (from equation (17)) and the average margin from equation 21 using equation (22).
194

195 $PS\ AXtalk_AVGmargin_{overall} = \min PS\ AXtalk_AVGmargin_{pairs}, PS\ AXtalk_AVGmargin_{avg}$ dB

196 (22)

197

198 The alien crosstalk margin $PS\ AXtalk_AVGmargin_{overall}$ shall be greater than zero.

199 **5.1.5 Examples of implementations at key IL(250)**

200 Table 4 provides examples of channel lengths that will support 10GBASE-T in reliance on the
 201 minimum performance of class E and class F as specified in ISO/IEC 11801:2002 and the
 202 noise levels specified in 5.1.2 and 5.1.3

203 **Table 6- Examples of implementations at key insertion loss**

Channel length m	Class	length of fixed cable + cord m + m	Noise constant at 100 MHz dB	
			PS ANEXT	PS AACR-F
IL at 250 MHz = 20,3 dB				
55 ^a	E	42,8 + 10	47	33,7
55 ^a	F	45,8 + 10		
IL at 250 MHz = 33,8 dB				
100 ^a	E	83,5 + 10	60	37
100 ^a	F	90 + 10		
IL at 250 MHz = 35,9 dB				
100 ^a	E	90 + 10	62	37,9
100 ^a	F	90 + 10		
^a not exactly 55 m and 100 m respectively but formulae not so length sensitive				

204