

**ADDITIONAL GUIDELINES FOR 4-PAIR 100 Ω CATEGORY 6 CABLING FOR 10GBASE-T APPLICATIONS**

**DRAFT 1.2**

**December 10, 2004**

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October 8, 2004¶

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18 ADDITIONAL GUIDELINES FOR 4-PAIR 100 Ω CATEGORY 6  
19 CABLING FOR 10GBASE-T APPLICATIONS  
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## FOREWORD

(This foreword is not part of the Telecommunications Systems Bulletin)

At the request of the Institute of Electrical and Electronics Engineers (IEEE) 802.3 Working Group, TIA agreed to create additional guidelines for 4-pair 100  $\Omega$  Category 6 Cabling for 10GBASE-T Applications. The project was assigned to TR-42.7 under Engineering Committee TR-42. The TR-42.7 Sub-Committee cooperated with several groups related to this activity.

- a) TR-42.1 – Commercial Building Telecommunications Cabling Sub-Committee
- b) TR-42.7.1 – Copper Connectors Working Group
- c) TR-42.7.2 – Copper Cable Working Group

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This telecommunications bulletin has been prepared by the TR-42.7 Subcommittee and approved by the Technical Committee TR-42.

There are three annexes in this TSB. Annexes A, B, and C,....

1 **1 INTRODUCTION**

2 The guidelines of this Telecommunications Systems Bulletin contain additional recommendations  
3 for a minimally compliant category 6 cabling system. These recommendations are intended to  
4 further characterize the existing category 6 cabling plant for 10GBASE-T applications.

5  
6 This Telecommunications Systems Bulletin includes field test procedures that can be used to  
7 verify if the installed cabling will meet these new guidelines.

8 *NOTE - The terms "guidelines" and "recommendations" are used interchangeably within*  
9 *this Telecommunications Systems Bulletin.*

10 **2 PURPOSE AND SCOPE**

11 This Telecommunications Systems Bulletin describes additional guidelines for 100 Ω, 4-pair  
12 category 6 cabling that have been installed in accordance with TIA/EIA-568-B.2.-1 to support the  
13 proposed IEEE 802.3an 10GBASE-T standard. These guidelines are intended to provide  
14 additional information on the extended frequency transmission performance of category 6 cabling  
15 from 250 MHz up to 500 MHz. It also characterizes the crosstalk coupling between adjacent 4-  
16 pair category 6 cabling channels referred to as alien crosstalk and provides additional guidelines  
17 for field test equipment and field test methods and alien crosstalk mitigation in support of  
18 10GBASE-T. The transmission recommendations included herein are intended to provide a  
19 means to assess installations of category 6 cabling as specified in TIA/EIA-568-B.-1 and  
20 corresponding addenda up to the extended frequencies and additional parameters needed for  
21 10GBASE-T support.

22  
23 The TSB does not place any normative requirements for existing category 6 installations.  
24

25 **3 REFERENCES**

26 The following standards are referenced in this text. At the time of publication, the editions  
27 indicated were valid. All standards are subject to revision; parties to agreements based on this  
28 TSB are encouraged to investigate the possibility of applying the most recent editions of the  
29 standards indicated. ANSI and TIA maintain registers of currently valid national standards  
30 published by them.

31  
32 ANSI/TIA/EIA-568-B.1, *Commercial Building Telecommunications Standard Part 1: General*  
33 *Requirements*

34  
35 ANSI/TIA/EIA-568-B.2, *Commercial Building Telecommunications Standard Part 2: 100 Ohm*  
36 *Balanced Twisted-pair Cabling Standard*

37  
38 ANSI/TIA/EIA-568-B.2-1, *Transmission Performance Specifications for 4 Pair 100 Ohm Category*  
39 *6 Cabling*

40 **4 DEFINITIONS, ACRONYMS & ABBREVIATIONS**

41 **4.1 Definitions**

42 The generic definitions in this section have been formulated for use by the entire family of  
43 telecommunications infrastructure standards. As such, the definitions do not contain mandatory  
44 requirements of the Standard. Specific requirements are found in the normative sections of this  
45 Standard.

46  
47 **Alien crosstalk:** A measure of the unwanted signal coupling between adjacent cabling or  
48 components (forward to Definitions Group).  
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- 1 **Alien near-end crosstalk loss:** A measure of the unwanted signal coupling between pairs in
- 2 adjacent cabling from transmitters at the near-end into a pair measured at the near-end (forward
- 3 to Definitions Group).
- 4
- 5 **Power sum alien near-end crosstalk loss:** A computation of the unwanted signal coupling
- 6 between pairs in adjacent cabling from multiple transmitters at the near-end into a pair measured
- 7 at the near-end (forward to Definitions Group).
- 8
- 9 **Alien far-end crosstalk(ffs):** A measure of the unwanted signal coupling between pairs in
- 10 adjacent cabling from a transmitter at the near-end into a pair measured at the far-end (forward to
- 11 Definitions Group).
- 12
- 13 **Power sum Alien far-end crosstalk(ffs):** A computation of the unwanted signal coupling
- 14 between pairs in adjacent cabling from multiple transmitters at the near-end into another pair
- 15 measured at the far-end. (forward to Definitions Group).
- 16
- 17 **Power sum alien equal level far-end crosstalk(ffs):** A computation of the unwanted signal
- 18 coupling between pairs in adjacent cabling from multiple transmitters at the near-end into another
- 19 pair measured at the far-end, and relative to the received signal level (forward to Definitions
- 20 Group).

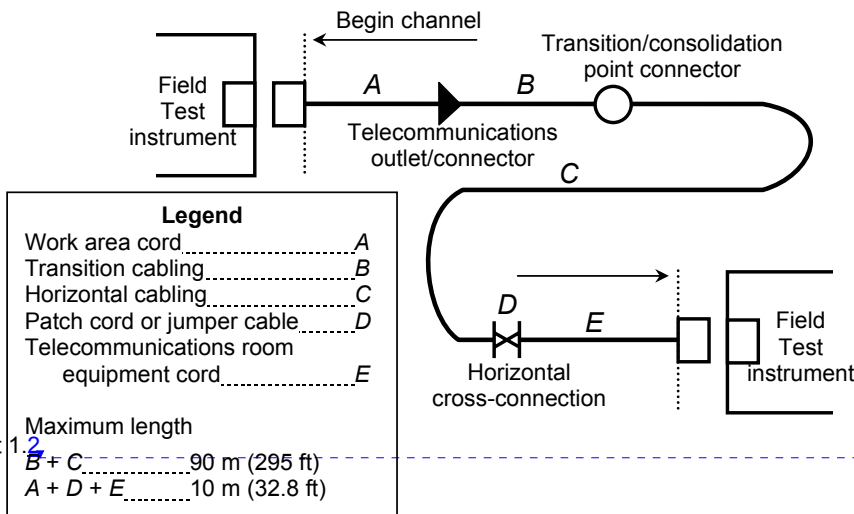
21 **4.2 Acronyms and abbreviations**

- 22 ANEXT Alien Near-end Crosstalk (forward to Definitions Group)
- 23 PSANEXT Power sum near-end crosstalk (forward to Definitions Group)
- 24 AFEXT (ffs) Alien Far-end Crosstalk (forward to Definitions Group)
- 25 PSAFEXT (ffs) Power sum near-end crosstalk (forward to Definitions Group)
- 26 PSAELFEXT (ffs) Power sum alien equal level crosstalk (forward to Definitions Group)

27 **5 TEST CONFIGURATIONS**

28 **5.1 Cabling channel and permanent link test configurations**

29 The channel test configuration is used by system designers and users of data communications  
 30 systems to verify the performance of the overall channel. The channel includes up to 90 m  
 31 (295 ft) of horizontal cable, a work area equipment cord, a telecommunications outlet/connector,  
 32 an optional transition/consolidation connector, and two connections in the telecommunications  
 33 room. The total length of equipment cords, patch cords or jumpers and work area cords does not  
 34 exceed 10 m (33 ft). The channel configuration excludes the connections to the equipment at  
 35 each end of the channel. The channel definition does not apply to those cases where the  
 36 horizontal cabling is cross-connected to the backbone cabling. A schematic representation of the  
 37 channel test configuration is illustrated in figure 1.

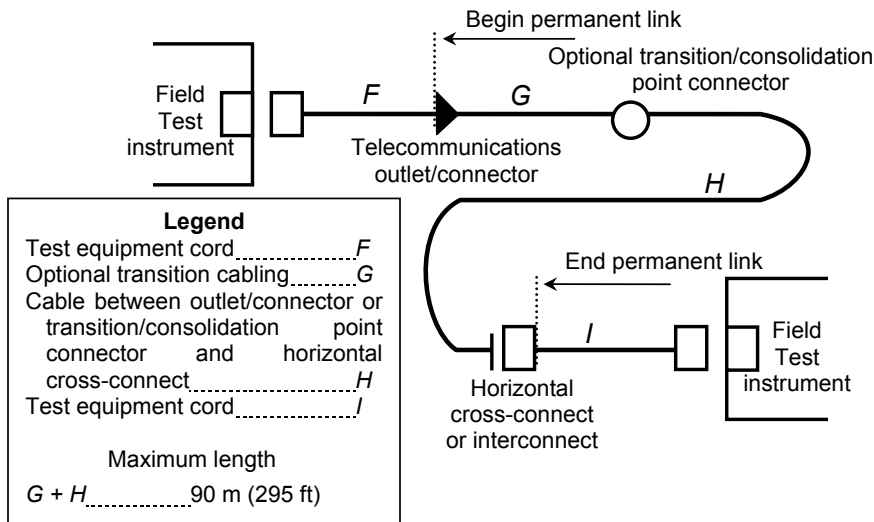


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**Figure 1 Schematic representation of a channel test configuration**

The permanent link test configuration is used by installers and users of data telecommunications systems to verify the performance of permanently installed cabling. The permanent link consists of up to 90 m (295 ft) of horizontal cabling and one connection at each end and may also include an optional transition/consolidation point connection. The permanent link configuration excludes both the cable portion of the field tester cord and the connection to the field test device. A schematic representation of the permanent link test configuration is illustrated in figure 2.



**Figure 2 Schematic representation of a permanent link test configuration**

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**5.2 Alien Crosstalk test configurations (ffs)**

**6 TRANSMISSION PARAMETERS**

**6.1 Insertion Loss**

Insertion loss is a measure of the signal loss resulting from the insertion of cabling or a component between a transmitter and receiver. It is often referred to as attenuation. Insertion loss is the ratio of signal power at the receiver end to the input power determined from measured voltages, expressed in dB.

**6.1.1 Cabling insertion loss**

**6.1.1.1 Channel Insertion Loss**

For all frequencies from 1 MHz to 250 MHz, the category 6 channel insertion loss meets the values determined using equation (1) as specified in TIA/EIA-568-B.2.-1.

$$INSERTIONLOSS_{channel} \leq 1.924 \times \sqrt{f} + 0.0173 \times f + \frac{0.204}{\sqrt{f}} + 0.0003 \times f^{1.5} \text{ dB} \quad (1)$$

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For all frequencies ( $250 < f \leq 500$ ) the insertion loss of the channel should meet the values determined using equation (2).

$$INSERTIONLOSS_{channel} \leq 1.05 \left( 1.82 \times \sqrt{f} + 0.0169 \times f + \frac{0.25}{\sqrt{f}} \right) + 4 \times 0.02 \times \sqrt{f} \quad \text{dB (2)}$$

**6.1.1.2 Permanent Link Insertion Loss**

For all frequencies from 1 MHz to 250 MHz, the category 6 permanent link meets the values determined using equation (3) as specified in TIA/EIA-568-B.2.-1. For all frequencies ( $250 < f \leq 500$ ) the insertion loss of the permanent link should meet the values determined using equation (3).

(TBD) dB (3)

**6.1.3 Insertion Loss Scaling**

To ensure reliable 10GBASE-T operation, a minimum signal to noise ratio (SNR) is necessary. The PS ANEXT loss guideline of 6.4.2 can be relaxed based on a reduction in the maximum insertion loss specified in 6.1.1. The insertion loss reduction can be achieved by scaling the length of the cabling insertion loss.

The scaled Category 6 channel insertion loss is defined by equation (4):

$$Scaled\_IL\_channel \leq \frac{Length\_m}{100} \times 1.05 \left( 1.82 \times \sqrt{f} + 0.0169 \times f + \frac{0.25}{\sqrt{f}} \right) + 4 \times 0.02 \times \sqrt{f} \quad \text{dB (4)}$$

**6.1.4 Insertion Loss of a Category 6 channel of 55 meters**

For all frequencies from 1 MHz to 250 MHz, the category 6 insertion loss of a 55 meter channel meets the values determined using equation (5). For all frequencies ( $250 < f \leq 500$ ) MHz the category 6 insertion loss of a 55 meter channel should meet the values determined using equation (5).

$$Scaled\_IL\_channel(55\ m) \leq \frac{55}{100} \times 1.05 \left( 1.82 \times \sqrt{f} + 0.0169 \times f + \frac{0.25}{\sqrt{f}} \right) + 4 \times 0.02 \times \sqrt{f} \quad \text{dB (5)}$$

**6.1.5 Insertion Loss of a Category 6 permanent link of (TBD meters)**

For all frequencies from 1 MHz to 250 MHz, the category 6 insertion loss of a (TBD) meter permanent link meets the values determined using equation (6). For all frequencies ( $250 < f \leq 500$ ) MHz the category 6 insertion loss of a 55 meter channel should meet the values determined using equation (6).

(TBD) dB (6)

**6.2 NEXT loss**

NEXT loss is a measure of the unwanted signal coupling from a transmitter at the near-end into neighboring pairs measured at the near-end. NEXT loss is expressed in dB relative to the received signal level. In addition, since each duplex channel can be disturbed by more than one

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1 duplex channel, power sum near-end crosstalk (PSNEXT) loss is also provided.

2 **6.2.1 Cabling Pair-to-pair NEXT loss**

3 **6.2.1.1 Pair-to-pair NEXT Loss Channel**

4 For all frequencies from 1 MHz to 250 MHz, the category 6 channel pair-to-pair NEXT loss meets  
5 the values determined using equation (7) as specified in TIA/EIA-568-B.2.-1.

6  
7

$$8 \quad NEXtchannel \geq -20 \times \log_{10} \left( 10^{\frac{44.3-15 \log_{10}\left(\frac{f}{100}\right)}{-20}} + 2 \times 10^{\frac{54-20 \log_{10}\left(\frac{f}{100}\right)}{-20}} \right) \text{dB} \quad (7)$$

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10

11 For all frequencies between (250 < f < 330) MHz the channel pair-to-pair NEXT loss should meet  
12 the values determined using equation (7).

13

14 For all frequencies (330 ≤ f ≤ 500) MHz the channel pair-to-pair NEXT loss of the cabling should  
15 meet the values determined using equation (8).

16

$$17 \quad NEXtchannel \geq 31 - 50 \times \log_{10} \left( \frac{f}{330} \right) \text{dB} \quad (8)$$

18 **6.2.1.2 Pair-to-pair NEXT Loss Permanent Link**

19 For all frequencies from 1 MHz to 250 MHz, the category 6 permanent pair-to-pair NEXT loss  
20 meets the values determined using equation (9) as specified in TIA/EIA-568-B.2.-1.

21

$$22 \quad NEXtpermanent\_link \geq -20 \times \log_{10} \left( 10^{\frac{44.3-15 \log_{10}\left(\frac{f}{100}\right)}{-20}} + 10^{\frac{54-20 \log_{10}\left(\frac{f}{100}\right)}{-20}} \right) \text{dB} \quad (9)$$

23

24 For all frequencies between (250 < f < 300) MHz the permanent pair-to-pair NEXT loss should  
25 meet the values determined using equation (9)-TBD.

26

27 For all frequencies (300 ≤ f ≤ 500) MHz the permanent pair-to-pair NEXT loss of the cabling  
28 should meet the values determined using equation (10)-TBD.

29

$$30 \quad NEXtpermanent\_link \geq 34 - 48 \times \log_{10} \left( \frac{f}{300} \right) \text{dB(TBD)} \quad (10)$$

31 **6.2.2 Power sum NEXT loss**

32 Power sum near-end crosstalk loss takes into account the combined crosstalk (statistical) on a  
33 receive pair from all near-end disturbers operating simultaneously. The power sum near-end  
34 crosstalk (PSNEXT) loss is calculated in accordance with ASTM D4566 as a power sum on a  
35 selected pair from all other pairs as shown in equation (10) for the case of 4-pair cable.

$$36 \quad PSNEXT = -10 \log_{10} \left( 10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10} \right) \text{dB} \quad (11)$$

37

38 where:

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1 X1, X2, X3 are the pair-to-pair crosstalk measurements in dB between the selected pair and the  
 2 other three pairs.  
 3

4 **6.2.2.1 Cabling power sum NEXT loss**

5 **6.2.2.1.1 PSNEXT Loss Channel**

6 For all frequencies from 1 MHz to 250 MHz, the category 6 channel power sum NEXT loss meets  
 7 the values determined using equation (12) as specified in TIA/EIA-568-B.2.-1.  
 8

$$9 \quad PSNEXT_{channel} \geq -20 \times \log_{10} \left( 10^{\frac{42.3 - 15 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 2 \times 10^{\frac{50 - 20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (12)$$

10 For all frequencies (250 < f < 330) MHz the channel power sum NEXT loss should meet the  
 11 values determined using equation (11).  
 12

13 For all frequencies (330 ≤ f ≤ 500) MHz the channel power sum NEXT loss of the cabling should  
 14 meet the values determined using equation (12).  
 15  
 16

$$17 \quad PSNEXT_{channel} \geq 28 - 42 \times \log_{10} \left( \frac{f}{330} \right) \text{ dB} \quad (13)$$

18 **6.2.2.1.2 PSNEXT Loss Permanent Link**

19 For all frequencies from 1 MHz to 250 MHz, the category 6 permanent link power sum NEXT loss  
 20 meets the values determined using equation (14) as specified in TIA/EIA-568-B.2.-1.  
 21

$$22 \quad PSNEXT_{permanent\_link} \geq -20 \times \log_{10} \left( 10^{\frac{42.3 - 15 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 10^{\frac{50 - 20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (14)$$

23 For all frequencies between (250 < f < 300) MHz the permanent link power sum NEXT loss  
 24 should meet the values determined using equation (14)-TBD.  
 25  
 26

27 For all frequencies (300 ≤ f ≤ 500) MHz the permanent link power sum NEXT loss of the cabling  
 28 should meet the values determined using equation (15)-TBD.  
 29

$$30 \quad PSNEXT_{permanent\_link} \geq 31.4 - 40 \times \log_{10} \left( \frac{f}{300} \right) \text{ dB(TBD)} \quad (15)$$

31 **6.3 ELFEXT and FEXT loss**

32 FEXT loss is a measure of the unwanted signal coupling from a transmitter at the far-end into  
 33 neighboring pairs measured at the near-end. FEXT loss is the ratio of the power coupled from a  
 34 disturbing pair into the disturbed pair relative to the input power at the opposite end of the  
 35 transmission lines determined from measured voltages. This ratio is expressed in dB.  
 36

37 ELFEXT is expressed in dB as the difference between the measured FEXT loss and the insertion  
 38 loss of the disturbed pair. In addition, since each duplex channel can be disturbed by more than  
 39 one duplex channel, power sum equal level far-end crosstalk (PSELFEXT) is also specified for  
 40 cabling and cables.

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### 1 6.3.1 Cabling pair-to-pair ELFEXT

#### 2 6.3.1.1 Pair-to-pair ELFEXT Channel

3 For all frequencies from 1 MHz to 250 MHz, the category 6 channel ELFEXT meets the values  
 4 determined using equation (13) as specified in TIA/EIA-568-B.2.-1. For all frequencies ( $250 < f \leq$   
 5  $500$ ) the category 6 channel ELFEXT of the channel should meet the values determined using  
 6 equation (16).  
 7

$$8 \quad ELFEXT_{channel} \geq -20 \times \log_{10} \left( 10^{\frac{27.8-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 4 \times 10^{\frac{43.1-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (16)$$

#### 9 6.3.1.2 Pair-to-pair ELFEXT Permanent Link

10 For all frequencies from 1 MHz to 250 MHz, the category 6 permanent link ELFEXT meets the  
 11 values determined using equation (14) as specified in TIA/EIA-568-B.2.-1. For all frequencies  
 12 ( $250 < f \leq 500$ ) the category 6 permanent link ELFEXT of the permanent link should meet the  
 13 values determined using equation (17).  
 14  
 15

$$16 \quad ELFEXT_{permanent\_link} \geq 20 \times \log_{10} \left( 10^{\frac{27.8-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 3 \times 10^{\frac{43.1-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (17)$$

### 17 6.3.2 Power sum ELFEXT

18 Power sum equal level far-end crosstalk loss takes into account the combined crosstalk  
 19 (statistical) on a receive pair from all far-end disturbers operating simultaneously. The power sum  
 20 equal level far-end crosstalk (PSELFEXT) loss is calculated in accordance with ASTM D4566 as  
 21 a power sum on a selected pair from all other pairs as shown in equation (18) for the case of 4-  
 22 pair cable.  
 23

$$24 \quad PSELFEXT = -10 \log_{10} \left( 10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10} \right) \text{ dB} \quad (18)$$

25

26

27 where:

28

29 X1, X2, X3 are the pair-to-pair crosstalk measurements in dB between the selected pair and the  
 30 other three pairs.

#### 31 6.3.2.1 Cabling power sum ELFEXT

##### 32 6.3.2.1.1 Power sum ELFEXT Channel

33 For all frequencies from 1 MHz to 250 MHz, the category 6 channel power sum ELFEXT meets  
 34 the values determined using equation (16) as specified in TIA/EIA-568-B.2.-1. For all frequencies  
 35 ( $250 < f \leq 500$ ) the category 6 channel power sum ELFEXT should meet the values determined  
 36 using equation (19).  
 37

$$38 \quad PSELFEXT_{channel} \geq -20 \times \log_{10} \left( 10^{\frac{24.8-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 4 \times 10^{\frac{40.1-20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (19)$$

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**6.3.2.1.2 Power sum ELFEXT Permanent Link**

For all frequencies from 1 MHz to 250 MHz, the category 6 permanent link power sum ELFEXT meets the values determined using equation (17) as specified in TIA/EIA-568-B.2.-1. For all frequencies (250 < f ≤ 500) the category 6 permanent link power sum ELFEXT should meet the values determined using equation (20).

$$P_{SELFEXT_{permanent\_link}} \geq 20 \times \log_{10} \left( 10^{\frac{24.8 - 20 \log_{10} \left( \frac{f}{100} \right)}{-20}} + 3 \times 10^{\frac{40.1 - 20 \log_{10} \left( \frac{f}{100} \right)}{-20}} \right) \text{ dB} \quad (20)$$

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**6.4 Alien NEXT loss**

Alien NEXT loss is a measure of the unwanted signal coupling between pairs in adjacent cabling from transmitters at the near-end into a pair measured at the near-end. Alien NEXT loss is expressed in dB relative to the received signal level. In addition, since each duplex channel can be disturbed by more than one duplex channel, power sum Alien near-end crosstalk (PS ANEXT) loss is also provided.

Editors Note: Alien NEXT Measurement procedure is under study.

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**6.4.1 Pair-to-pair ANEXT loss (ffs)**

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**6.4.1.1 Cabling pair-to-pair ANEXT loss**

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**6.4.1.1.1 ANEXT Channel Equation** (21)

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**6.4.1.1.2 ANEXT Permanent Link Equation** (22)

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**6.4.2 Power sum Alien NEXT loss**

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Power sum Alien near-end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from near-end disturbers in adjacent cables operating simultaneously. The power sum near-end crosstalk (PSANEXT) loss is determined by summing the power of the individual pair-to-pair differential Alien NEXT loss values over the frequency range 1 MHz to 500 MHz as follows in equation (21):

$$-10 \times \log_{10} \sum_{i=1}^n 10^{\frac{-AN(f)_i}{10}} \quad (\text{dB}) \quad (23)$$

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where

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AN(f)<sub>i</sub> is the magnitude in dB of PS ANEXT loss at frequency f of pair combination i

i is the pair-to-pair combination (1 to n)

n is the number of pair-to-pair combinations between adjacent cables

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**6.4.2.1 Power sum Alien NEXT loss for a Category 6 channel of 100 meters**

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For a 10GBASE-T 100 meter Category 6 channel with the maximum insertion loss specified in 6.1 the PS ANEXT loss between the disturbed duplex channel and the disturbing duplex channels in adjacent cabling should meet the values determined using equation (24).

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$$\begin{aligned}
 & \text{PS ANEXT} > \left\{ \begin{array}{l} 62 - 10 \cdot \log_{10}(f\text{MHz}/100) \quad 1 \text{ MHz} \leq f \leq 100 \text{ MHz} \\ 62 - 15 \cdot \log_{10}(f\text{MHz}/100) \quad 100 \text{ MHz} < f \leq 500 \text{ MHz} \end{array} \right\} \quad (24)
 \end{aligned}$$

**6.4.2.2 Power sum Alien NEXT loss Adjustment**

The adjusted PS ANEXT loss requirement is determined by first calculating the PS ANEXT\_constant and utilizing the constant in the PS ANEXT limit line model.

The PS ANEXT\_constant is defined by the following equation (25):

$$\text{PSANEXT\_Constant} = 62 - (\text{Cat6\_IL\_250MHz} - \text{SCat6\_IL\_250MHz}) \times \frac{15}{15.6} \text{ dB} \quad (25)$$

where

Cat6\_IL\_250MHz is the Category 6 insertion loss at 250 MHz for a 100 meter channel

SCat6\_IL\_250MHz is the scaled Category 6 insertion at 250 MHz

**6.4.2.2 PS ANEXT for a Category 6 channel of 55 meters**

For a 10GBASE-T 55 meter Category 6 channel with the maximum insertion loss specified in 6.1.3 the PS ANEXT loss between the disturbed duplex channel and the disturbing duplex channels in adjacent cabling should meet the values determined using equation (26).

$$\text{PS ANEXT} > \left\{ \begin{array}{l} 47 - 10 \cdot \log_{10}(f\text{MHz}/100) \quad 1 \text{ MHz} \leq f \leq 100 \text{ MHz} \\ 47 - 15 \cdot \log_{10}(f\text{MHz}/100) \quad 100 \text{ MHz} < f \leq (\text{TBD} \leq 500) \text{ MHz} \end{array} \right\} \quad (26)$$

**6.5 Alien FEXT and Alien ELFEXT loss (ffs)**

Note: TR42.7 has adopted the PSAELFEXT equation (27) for the purpose of modeling category 6 cable for all frequencies from 1 MHz to 500 MHz.

$$\text{PSAELFEXT} \geq X - 20 \times \log_{10} \left( \frac{f}{100} \right) \text{ dB}$$

Where: X = TBD dB

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(27)

**6.6 Return Loss**

Return loss is a measure of the reflected energy caused by impedance mismatches in the cabling system and is especially important for applications that use simultaneous bi-directional transmission. Return loss is expressed in dB relative to the reflected signal level.

**6.6.1 Cabling Return Loss**

**6.6.1.1 Channel return loss**

For all frequencies from 1 MHz to 250 MHz, the category 6 channel return loss meets the values specified in table 1 as specified in TIA/EIA-568-B.2.-1 table 29. For all frequencies (250 < f ≤ 500) the category 6 channel return loss should meet the values in Table 1.

**Table 1 Category 6 channel return loss**

Frequency (MHz)	Return Loss (dB)
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$1 \leq f < 10$	19
$10 \leq f < 40$	$24 - 5\log_{10}(f)$
$40 \leq f \leq 250$	$32 - 10\log_{10}(f)$
$250 < f < 400$	$32 - 10\log_{10}(f)$
$400 \leq f \leq 500$	6

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**6.6.1.2 Permanent link return loss**

For all frequencies from 1 MHz to 250 MHz, the category 6 permanent link return loss meets the values specified in table 2 as specified in TIA/EIA-568-B.2.-1 [table 31](#). For all frequencies ( $250 < f \leq 500$ ) the category 6 channel return loss should meet the values in Table 2.

**Table 2 Category 6 permanent link return loss**

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 3$	$21 + 4\log_{10}(f/3)$
$3 \leq f < 10$	21
$10 \leq f < 40$	$26 - 5\log_{10}(f)$
$40 \leq f \leq 250$	$34 - 10\log_{10}(f)$
$250 < f < 400$	$10 - 20\log_{10}(f/250)$
$400 \leq f \leq 500$	6

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**6.7 Propagation delay/delay skew**

Propagation delay is the time it takes for a signal to propagate from one end to the other. Propagation delay skew is a measurement of the signaling delay difference from the fastest pair to the slowest. Propagation delay and propagation delay skew are expressed in nanoseconds (ns). Propagation delay and propagation delay skew are measured for all pairs for cables in accordance with ASTM D4566. Propagation delay and propagation delay skew is measured for all pairs for cabling in accordance with annex D of ANSI/TIA/EIA-568-B.2.

**6.7.1 Cabling propagation delay**

The maximum propagation delay for a category 6 channel configuration is less than 555 ns measured at 10 MHz as specified in TIA/EIA-568-B.2.-1.

The maximum propagation delay for a category 6 permanent link configuration is less than 498 ns measured at 10 MHz as specified in TIA/EIA-568-B.2.-1.

**6.7.2 Cabling propagation delay skew**

The maximum propagation delay skew for a category 6 channel configuration is less than 50 ns as specified in TIA/EIA-568-B.2.-1.

The maximum propagation delay skew for a category 6 permanent link configuration does not exceed 44 ns as specified in TIA/EIA-568-B.2.-1.

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1 **Annex A**

2 **Annex A Cabling (field) measurement procedures (TBD)**

3 **Annex B**

4 **Annex B Test instruments**

5

6 **B.1 Accuracy requirements for level IIIe field testers**

7 The level IIIe requirements in this annex are stated for baseline performance, permanent link and  
 8 channel configurations. The field tester performance for the channel and permanent link applies  
 9 to the performance at the reference plane as shown in TIA/EIA-568-B-2.1 figures 1 and 2  
 10 respectively.

11

12 The methods to compare results from field testers with those obtained using laboratory  
 13 equipment as defined in TIA/EIA-568-B.2, Annex J Comparison measurement procedures  
 14 (normative) apply. The observed accuracy from comparison methods is in harmony with  
 15 predicted measurement accuracy from performance parameters as defined in this annex.

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17 **B.1.1 Measurement performance requirements**

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19 The requirements in this annex apply in addition to those stated in TIA/EIA-568-B.2-1. Where  
 20 requirements are tighter, the tighter requirements apply.

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Table 3 Level IIIe field tester accuracy performance

Parameter	Baseline field tester	Field tester with Level IIIe permanent link adapter	Field tester with Level IIIe channel adapter	
Dynamic range	3 dB over test limit PP NEXT and FEXT 65 dB PS NEXT and FEXT 62 dB			dB
Amplitude resolution	0.1			dB
Frequency range and resolution	1 – 31.25 MHz: 150 kHz 31.25–100 MHz:250 kHz 100 MHz – 250 MHz:500 kHz 250 MHz – 500 MHz: 1 MHz			MHz
Dynamic Accuracy NEXT	± 0.75			dB
Dynamic Accuracy ELFEXT	± 1.0 (FEXT dynamic accuracy is tested to ± 0.75 dB)			dB
Source/load return loss	20 – 12.5 log(f/100), 20 dB max. 12.5 dB min	18 – 12.5 log(f/100), 20 dB max., 12 dB min		dB
Random Noise Floor	75 – 15 log(f/100), 85 dB max			dB

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Residual NEXT	$65 - 20 \log(f/100)$ (measured to 85 dB max)	$60 - 20 \log(f/100)$ (measured to 85 dB max)	$54 - 20 \log(f/100)$ (measured to 85 dB max)	dB
Residual FEXT	$65 - 20 \log(f/100)$ (measured to 85 dB max)	$65 - 20 \log(f/100)$ (measured to 85 dB max)	$43.1 - 20 \log(f/100)$ (measured to 85 dB max)	dB
Output Balance Signal	$40 - 20 \log(f/100)$ (measured to 60 dB max)	$37 - 20 \log(f/100)$ (measured to 60 dB max)		dB
Common Rejection Mode	$40 - 20 \log(f/100)$ (measured to 60 dB max)	$37 - 20 \log(f/100)$ (measured to 60 dB max)		dB
Tracking	$\pm 0.5$ dB	1 MHz – 250 MHz: $\pm 0.5$ dB 250 MHz – 500 MHz: $\pm \{0.5 + 0.000667 \cdot (f-250)\}$ dB		dB
Directivity	(applicable when IL > 3dB) 1 MHz – 300 MHz: $27-7\log(f/100)$ , 30 dB max. 300 MHz – 500 MHz: 23.7 dB	$25-20\log(f/100)$ , 25 dB max, 15 dB min		dB
Source Match	20 dB	20-20log(f/100), 20 dB max, 12 dB min		dB
Return loss of Termination	(applicable when IL > 3dB) $20-15\log(f/100)$ , 25 dB max., 12.5 dB min	16-15log(f/100), 25 dB max, 12 dB min		dB

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2 **Table 4** Explanation of Notes for Level IIIe specifications

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Note	Description
1	The dynamic range for pair-to-pair NEXT and FEXT is 65 dB minimum.
2	The dynamic range for power sum NEXT and power sum FEXT is 62 dB minimum.
3	Dynamic accuracy is tested up to the specified dynamic range for NEXT and FEXT.
4	Dynamic accuracy ELFEXT assumes a dynamic accuracy requirement of $\pm 0.75$ dB for FEXT, which is tested, and that the dynamic accuracy performance for insertion loss and FEXT add to the ELFEXT dynamic accuracy shown. It is assumed that the dynamic accuracy performance for ACR equals the dynamic accuracy for ELFEXT.
5	The verification of residual NEXT and FEXT is up to 85 dB maximum. It is assumed that the frequency response changes at a 20 dB/decade rate.
6	Performance verification of Output Signal Balance and Common Mode Rejection is up to 60 dB maximum. It is assumed that the frequency response changes at a 20 dB/decade rate.
7	Permanent link adapter NEXT loss is between the lower and upper ranges of test plugs

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	as specified for category 6 in IEC 60603-7. Compliance with this requirement can also be demonstrated by performing a comparison test as in TIA/EIA-568-B.2, Annex J. In this case, a reference plug qualified per IEC 60603-7 is used to obtain the reference laboratory measurement.
8	Permanent link adapter FEXT loss is between the lower and upper ranges of test plugs as specified for category 6 in IEC 60603-7. Compliance with this requirement can also be demonstrated by performing a comparison test as in TIA/EIA-568-B.2, Annex J. In this case, a reference plug qualified per IEC 60603-7 is used to obtain the reference laboratory measurement.

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2 **Annex C**

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3 **Annex C Alien Crosstalk Mitigation (ffs)**

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