ANSI/TIA/EIA-568-B.2-1

SP-3727-AD1-ATIA/EIA DRAFT STANDARD

Transmission Performance Specifications for 4-Pair 100 W Category 6 Cabling

ANSI/TIA/EIA-568-B.2-1

(Addendum No. 1 to ANSI/TIA/EIA-568-B.2)

Note: Excerpts from this document that relate to category 6 channel and permanent link requirements will be incorporated into ANSI/TIA/EIA-568-B.1-1 (Addendum No. 1 to ANSI/TIA/EIA-568-B.1)

August 24, 2001 – Draft 9a Preliminary

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

NOTICE

This contribution has been prepared to assist the TR-42 Standards Committee. It is offered to the Committee as a basis of discussion and is not a binding proposal on the members of the TR-42.7 Copper Cabling Systems Sub-Committee. The proposed requirements presented in this document are subject to change in form and technical content after more study. Members of the Copper Cabling Systems Sub-Committee specifically reserve the right to add to, or revise, the statements contained herein.

This document is a working draft for review and use by the Copper Cabling Systems Sub-Committee members only. It is intended to serve as the basis for discussion and further development of additional parameters for 100 Ω 4-pair Cabling.

Intellectual Property Statement

The individuals preparing this contribution do not know of patents, the use of which may be essential to a standard resulting in whole or part from this contribution.

TRANSMISSION PERFORMANCE SPECIFICATIONS
FOR
4-PAIR 100 Ω CATEGORY 6 CABLING

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FOREWORD

(This foreword is not part of the Standard)

In 1997, the Telecommunications Industry Association (TIA) developed objectives for a new category of cabling intended to support positive power sum attenuation to crosstalk (PSACR) margins up to 200 MHz. At the request of the Institute of Electrical and Electronics Engineers (IEEE) 802.3 Committee, TIA agreed to specify category 6 cabling systems and components to 250 MHz in order to accommodate transmission equipment designs that utilize digital signal processing (DSP) techniques. 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

It is the intent that the material content related only to category 6 channels and permanent links will be published as addendum 1 to ANSI/TIA/EIA-568-B.1.

TIA standards documents are developed within the Technical Committees of the TIA and the standards coordinating committees of the TIA standards board. Members of the committees serve voluntarily and without commission. The companies that they represent are not necessarily members of the TIA. The standards developed within the TIA represent a consensus of the broad expertise on the subject. This expertise comes from within the TIA as well as those outside of the TIA that have an expressed interest. The viewpoint expressed at the time that this standard was approved was from the contributors' experience and the state of the art at that time. Users are encouraged to verify that they have the latest revision of the standard.

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

There are twelve annexes in this Standard. Annexes A, B, C, E, F, I, K, and L are normative and considered a mandatory part of this Standard. Annexes D, G, H, and J are informative and not considered a part of this Standard.

1 INTRODUCTION

Telecommunications cabling, once specified uniquely for each telecommunications application, has evolved into a generic cabling system. Telecommunications applications now use ANSI/TIA/EIA-568-B.1 to specify their cabling requirements. This has resulted in the continued development of high-speed applications and demonstrated the need for improved transmission performance and higher categories of twisted pair cabling.

The requirements in this Standard are for 100 Ω category 6 cabling systems and components. Category 6 cabling provides higher performance than category 5e and recognizes advances in cabling technology. Category 6 shall be backward compatible with categories 3, 5, and 5e as specified in ANSI/TIA/EIA-568-B.1 and ANSI/TIA/EIA-568-B.2. Applications running on the lower category cabling shall be supported by category 6. For category 6, the modular jack interface shall be maintained at the telecommunications outlet connector in the work area. If different category components are to be mixed with category 6 components, then the combination shall meet the transmission requirements of the lower performing category. See table 1 for a matrix of mated component performance representative of backward compatibility. To ensure generic cabling system performance, component requirements are specified to support interoperability when products from different manufacturers are mated.

Table 1- Matrix of backward compatible mated component performance

		Category of Modular Connecting Hardware Performance			
		Category 3[1)]	Category 5	Category 5e	Category 6
Modular Plug & Cord Performance	Category 3 [1)]	Category 3	Category 3	Category 3	Category 3
	Category 5	Category 3	Category 5	Category 5	Category 5
	Category 5e	Category 3	Category 5	Category 5e	Category 5e
	Category 6	Category 3	Category 5	Category 5e	Category 6

1) Category 3 plug performance requirements are assumed to be less restrictive than category 5e.

Transmission performance depends upon the characteristics of cable, connecting hardware, cords and cross-connect jumpers, the total number of connections, and the care in which they are installed and maintained. This Standard includes laboratory and field test configurations and procedures that can be used to verify that the components, cabling, and installation will meet these new specifications.

The category 6 channel transmission requirements specified in this Standard result in a power sum attenuation to crosstalk ratio (PSACR) that is greater than or equal to zero at 200 MHz.

2 PURPOSE AND SCOPE

This Standard specifies requirements for insertion loss, near-end crosstalk (NEXT) loss, equal level far-end crosstalk (ELFEXT), return loss, propagation delay, and delay skew requirements for 100 Ω 4-pair category 6 cabling, cables, and connecting hardware. This Standard also specifies near-end crosstalk (NEXT) loss and return loss requirements for modular plug cords. For cabling and cable NEXT loss and ELFEXT, both worst pair-to-pair and multi-disturber power sum requirements are specified. Balance recommendations are provided for category 6 connecting hardware and are under study for category 6 cables. In addition to these requirements, category 6 cabling, cables, cords, and connecting hardware shall meet or exceed all the requirements of ANSI/TIA/EIA-568-B.1 and ANSI/TIA/EIA-568-B.2. Compliance with this Standard does not imply compatibility with cabling having nominal impedance values other than 100 Ω.

3 NORMATIVE REFERENCES

The following standards contain requirements that, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision; parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated. ANSI and TIA maintain registers of currently valid national standards published by them.

ANSI/ICEA S-80-576, *Communications Wire and Cable for Wiring Premises*, 1994

ANSI/ICEA S-90-661, *Individually Unshielded Twisted Pair Indoor Cable for Use in Communication Wiring Systems*, 1994

ANSI/TIA/EIA-568-B.1, *Commercial Building Telecommunications Standard Part 1: General Requirements*, 2001

ANSI/TIA/EIA-568-B.2, *Commercial Building Telecommunications Standard Part 2: Balanced Twisted-pair* Cabling *Components*, 2001

ANSI/TIA/EIA-568-B.3, *Commercial Building Telecommunications Standard Part 3: Optical Fiber Cabling* Components, 2000

ASTM D 4566-98, *Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable*, 1998

IEC 60603-7, *Connectors for frequencies below 3 MHz for use with printed boards – Part 7: Detail specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality*, 1996

4 DEFINITIONS, ACRONYMS & ABBREVIATIONS

4.1 Definitions

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

balance: Balance is the ratio of the differential signal output at either end of any pair to a common mode signal input, at either end of the same or a different pair, and vice versa, under specified termination conditions.

insertion loss deviation: The difference between the actual insertion loss as measured on a permanent link or channel and the insertion loss as determined by adding the component losses.

longitudinal conversion loss: A ratio, expressed in dB, of measured differential voltage relative to the common mode voltage on a conductor pair applied at the same end.

longitudinal conversion transfer loss: A ratio, expressed in dB, of measured differential voltage at one end of a conductor pair relative to the common mode voltage applied on any pair at the opposite end or on any other pair on the same end.

modular plug cord: A length of cable with a modular plug on both ends.

power sum attenuation to crosstalk ratio: A ratio, expressed in dB, determined by subtracting the insertion loss from the power sum near-end crosstalk loss.

transverse conversion loss: A ratio, expressed in dB, of the measured common mode voltage on a pair relative to the differential mode voltage on the same pair applied at the same end.

4.2 Acronyms and abbreviations

DUT	Device under test
ILD	Insertion loss deviation
LCL	Longitudinal conversion loss
LCTL	Longitudinal conversion transfer loss
PSACR	Power sum attenuation to crosstalk ratio
SSTP	Fully shielded twisted-pair
TCL	Transverse conversion loss

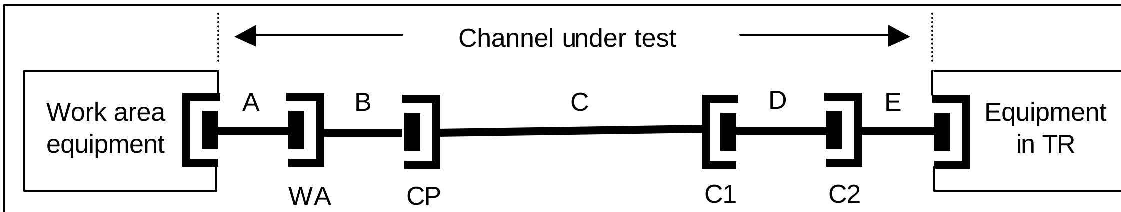
5 TEST CONFIGURATIONS

5.1 Component test configurations

Cable and connecting hardware test configurations and procedures are specified in ANSI/TIA/EIA-568-B.2 with the additional requirements specified within this Standard.

5.2 Cabling test configurations

The channel test configuration is described in ANSI/TIA/EIA-568-B.1. A supplemental schematic representation of the channel test configuration is illustrated in figure 1.



Legend

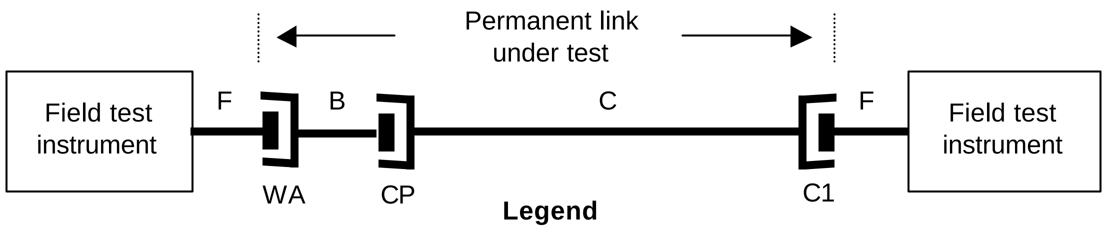
Cables and cords
Work area cord................................A
Optional transition cabling ....B
Horizontal cabling C
Patch cord or jumper cable...............D
Telecommunications room equipment cord.........................E

Connecting hardware
Telecommunications outlet/ connector .... WA
Optional transition/consolidation point connector .... CP
Horizontal cross-connect or interconnect..........................C1, C2

Maximum length
B + C ....90 m (295 ft)
A + D + E ....10 m (32.8 ft)

Figure 1 - Supplemental schematic representation of a channel test configuration

The permanent link test configuration is defined in ANSI/TIA/EIA-568-B.1. A supplemental schematic representation of the permanent link test configuration is illustrated in figure 2.



Legend

Cables and cords
Test equipment cord .... F
Optional transition cabling .... B
Horizontal cabling C

Connecting hardware
Telecommunications outlet/
connector .... WA
Optional transition/consolidation
point connector .... CP
Horizontal cross-connect or
interconnect............................... C1

Maximum length
B + C ....90 m (295 ft)

Figure 2 - Supplemental schematic representation of a permanent link test configuration

6 COMPONENTS

6.1 Recognized cable

The following category of twisted-pair cable is recognized in addition to those identified in clause 4.2.1 of ANSI/TIA/EIA-568-B.2:

Category 6: This designation applies to 100 Ω cables whose transmission characteristics are specified up to 250 MHz.

6.1.1 Horizontal cable

Four-pair 100 Ω UTP and ScTP cables are recognized for use in category 6 horizontal cabling systems. The cable shall consist of 22 AWG to 24 AWG thermoplastic insulated solid conductors that are formed into four individually twisted pairs and enclosed by a thermoplastic jacket. The cable shall meet all of the mechanical requirements of ANSI/ICEA S-80-576 applicable to four-pair inside wiring cable for plenum or general cabling within a building. In addition to the applicable requirements of ANSI/ICEA S-90-661-1994, the physical design of horizontal cables shall meet the requirements of clauses 4.3.3.1 to 4.3.3.6 of ANSI/TIA/EIA-568-B.2.

NOTE – Additional requirements for 100 Ω ScTP cables are located in annex K of ANSI/TIA/EIA-568-B.2.

6.1.2 Backbone cable

Four-pair 100 Ω UTP and ScTP cables are recognized for use in category 6 backbone cabling systems. The cable shall consist of 22 AWG to 24 AWG thermoplastic insulated solid conductors that are formed into four individually twisted-pairs and enclosed by a thermoplastic jacket. The cable shall meet all of the mechanical requirements of ANSI/ICEA S-80-576 applicable to four-pair inside wiring cable for plenum or general cabling within a building. In addition to the applicable requirements of ANSI/ICEA S-90-661-1994, the physical design of backbone cables shall meet the requirements of clauses 4.4.3.1 to 4.4.3.6 of ANSI/TIA/EIA-568-B.2.

NOTE – Additional requirements for 100 Ω ScTP cables are located in annex K of ANSI/TIA/EIA-568-B.2.

6.1.3 Bundled and hybrid cable

Bundled and hybrid cables may be used for horizontal and backbone cabling provided that each cable type is recognized (see clause 6.1.1 of this Standard and clause 4.4 of ANSI/TIA/EIA-568-B.1) and meets the transmission and color-code specifications for that cable type as given in ANSI/TIA/EIA-568-B.2, ANSI/TIA/EIA-568-B.3, and clause 7 of this Standard. Additionally, for all frequencies from 1 MHz to 250 MHz, the total power sum NEXT loss for any disturbed pair from all pairs internal and external to that pair's jacket within the bundled or hybrid cable shall not exceed the values determined using equation (1). Calculated power sum NEXT loss limit values that exceed 65 dB shall revert to a limit of 65 dB.

$$PSNEXT_{bundled\_and\_htbrid,all\_pairs} \geq 41.1 - 15\log(f/100) \qquad (1)$$

NOTES,
1 Hybrid UTP cables (color coded per ANSI/TIA/EIA-568-B.2, clause 4.3.3.3) can be distinguished from multipair UTP backbone cables (color coded per ANSI/TIA/EIA-568-B.2, clause 4.4.3.3) by the color coding scheme and by the transmission requirements.
2 Hybrid cables consisting of optical fiber and copper conductors are sometimes referred to as composite cables.

The individual cables within a bundled cable shall meet the applicable requirements in clause 4 of ANSI/TIA/EIA-568-B.3, clause 4 of ANSI/TIA/EIA-568-B.2, annex K of ANSI/TIA/EIA-568-B.2, annex M of ANSI/TIA/EIA-568-B.2, and clause 7 of this Standard after bundle formation.

6.2 Recognized connecting hardware

The following category of twisted-pair connecting hardware is recognized in addition to those identified in clause 5.4.1 of ANSI/TIA/EIA-568-B.2:

Category 6: This designation applies to 100 Ω connecting hardware whose transmission characteristics are specified from 1 MHz to 250 MHz.

6.3 Cords

Patch cords, equipment cords, and work area cords used for system moves, adds, and changes are critical to transmission performance. Category 6 cords and cordage shall meet the applicable requirements of clauses 6.1 through 6.3 of ANSI/TIA/EIA-568-B.2 and clause 7.2.1.3 and 7.4.4 of this Standard.

7 TRANSMISSION REQUIREMENTS

7.1 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. Insertion loss shall be measured for all pairs for components and cabling in accordance with annex C of ANSI/TIA/EIA-568-B.2 and the ASTM D 4566 attenuation measurement procedure, except the test fixture shall provide for consistent common and differential mode impedance matching for the unjacketed twisted-pairs between the cable jacket and the balun terminations.

7.1.1 Cable insertion loss

For all frequencies from 1 MHz to 250 MHz, category 6 solid cable insertion loss shall meet the values determined using equation (2). Solid cable insertion loss shall be measured at 20 ± 3°C or corrected to a temperature of 20 °C using a 0.4 %/° C correction factor for the measured insertion loss. The values in table 2 are provided for information only.

$$InsertionLoss_{cable,100m} \leq 1.808\sqrt{f} + 0.017 \cdot f + \frac{0.2}{\sqrt{f}} \quad \text{dB/100 m (dB/328 ft)} \qquad (2)$$

For all frequencies from 1 MHz to 250 MHz, category 6 UTP and ScTP stranded cable insertion loss shall meet the values determined using equation (3). The values in table 3 are provided for information only. Stranded cable insertion loss shall be measured at 20 ± 3° C or corrected to a temperature of 20 °C using a 0.4 %/°C correction factor for the measured insertion loss. The values in table 2 are provided for information only.

$$InsertionLoss_{stranded\_cable,100m} \leq 1.2 \cdot InsertionLoss_{cable,100m} \quad \text{dB/100 m (dB/328 ft)} \qquad (3)$$

Table 2 - Category 6 cable insertion loss @ 20 °C ± 3°C (68° F ± 5.5 °F)

For a length of 100 m (328 ft)

Frequency (MHz)	Solid cable insertion loss (dB)	Stranded cable insertion loss (dB)
0.772	1.8	-
1.0	2.0	2.4
4.0	3.8	4.5
8.0	5.3	6.4
10.0	6.0	7.1
16.0	7.6	9.1
20.0	8.5	10.2
25.0	9.5	11.4
31.25	10.7	12.8
62.5	15.4	18.5
100.0	19.8	23.8
200.0	29.0	34.8
250.0	32.8	39.4

NOTE – The solid cable insertion loss value at 0.772 MHz is for reference purposes only.

7.1.2 Connecting hardware insertion loss

For all frequencies from 1 MHz to 250 MHz, category 6 connecting hardware insertion loss shall meet the values determined using equation (4). The values in table 3 are provided for information only. Calculations that result in insertion loss values less than 0.1 dB shall revert to a requirement of 0.1 dB maximum.

$$InsertionLoss_{conn} \leq 0.02\sqrt{f} \ dB \qquad (4)$$

Table 3 – Category 6 connecting hardware insertion loss

Frequency (MHz)	Insertion loss (dB)
1.0	0.10
4.0	0.10
8.0	0.10
10.0	0.10
16.0	0.10
20.0	0.10
25.0	0.10
31.25	0.11
62.5	0.16
100.0	0.20
200.0	0.28
250.0	0.32

7.1.3 Cabling insertion loss

For all frequencies from 1 MHz to 250 MHz, category 6 channel insertion loss shall meet the values determined using equation (8). The values in table 4 are provided for information only.

$$InsertionLoss_{channel} = \sum InsertionLoss_{conn} + \sum InsertionLoss_{cable} + ILD_{channel} \ dB \qquad (5)$$

where:

$$InsertionLoss_{cable} = 1.02 \cdot InsertionLoss_{cable,100m} \ dB\text{, and} \qquad (6)$$

$$ILD_{channel} = 0.0003 \cdot f^{1.5} \ dB \qquad (7)$$

NOTES

1 A 20 % increase in insertion loss is allowed over category 6 horizontal cable insertion loss for work area and patch cords as shown in equation (6).

2 The insertion loss of the channel does not take into consideration the 0.1 dB measurement floor of the connecting hardware insertion loss requirement.

3 The channel insertion loss requirement is derived using the insertion loss contribution of 4 connections.

4 For the purposes of field measurements, calculated channel limits that result in insertion loss values less than 3 dB revert to a requirement of 3 dB maximum (see clause TBD of ANSI/TIA/EIA-568-B.1).

$$InsertionLoss_{channel} \le 1.924\sqrt{f} + .017 \cdot f + \frac{.204}{\sqrt{f}} + .0003 \cdot f^{1.5} \ dB \qquad (8)$$

Table 4 – Category 6 channel insertion loss

Frequency (MHz)	Insertion loss (dB)
1.0	2.1
4.0	4.0
8.0	5.7
10.0	6.3
16.0	8.0
20.0	9.0
25.0	10.1
31.25	11.4
62.5	16.5
100.0	21.3
200.0	31.5
250.0	35.9

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link insertion loss shall meet the values determined using equation (12). The values in table 5 are provided for information only.

$$InsertionLoss_{perm\_link} = \sum InsertionLoss_{conn} + \sum InsertionLoss_{cable} + ILD_{perm\_link} \quad dB \qquad (9)$$

where:

$$InsertionLoss_{cable} = 0.9 \cdot InsertionLoss_{cable,100m} \quad dB\text{, and} \qquad (10)$$

$$ILD_{perm\_link} = 0.00015 \cdot f^{1.5} \quad dB \qquad (11)$$

NOTES

1 The insertion loss of the channel does not take into consideration the 0.1 dB measurement floor of the connecting hardware insertion loss requirement.

2 For the purposes of field measurements, calculated permanent link limits that result in insertion loss values less than 3 dB revert to a requirement of 3 dB maximum (see clause TBD of ANSI/TIA/EIA-568-B.1).

$$InsertionLoss_{perm\_link} \le 1.687\sqrt{f} + .0153 \cdot f + \frac{.18}{\sqrt{f}} + 0.00015 \cdot f^{1.5} \quad dB \qquad (12)$$

Table 5 – Category 6 permanent link insertion loss

Frequency (MHz)	Insertion loss (dB)
1.0	1.9
4.0	3.5
8.0	5.0
10.0	5.6
16.0	7.0
20.0	7.9
25.0	8.9
31.25	10.0
62.5	14.4
100.0	18.6
200.0	27.4
250.0	31.1

NOTE – The permanent link insertion loss requirement is derived using the insertion loss contribution of 3 connections.

7.2 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 transmit signal level. NEXT loss shall be measured for all pair combinations for cables and cabling in accordance with annex C of ANSI/TIA/EIA-568-B.2 and the ASTM D 4566 NEXT loss measurement procedure, except the test fixture shall provide for consistent common and differential mode impedance matching for the unjacketed twisted-pairs between the cable jacket and the balun terminations. Connecting hardware NEXT loss shall be measured for all pair combinations in accordance with annex E. Modular plug cord NEXT loss shall be measured for all pair combinations in accordance with annex K. In addition, since each duplex channel can be disturbed by more than one duplex channel, power sum near-end crosstalk (PSNEXT) loss is also specified for cabling and cables.

7.2.1 Pair-to-pair NEXT loss

7.2.1.1 Cable pair-to-pair NEXT loss

For all frequencies from 0.772 MHz to 250 MHz, category 6 cable NEXT loss, for a length of 100 m (328 ft) or longer, shall meet the values determined using equation (13). The values in table 6 are provided for information only.

$$NEXT_{cable} \geq 44.3 - 15\log(f/100) \quad dB \tag{13}$$

Table 6 - Category 6 cable NEXT loss @ 20 °C ± 3 °C (68 °F ± 5.5° F), worst pair-to-pair

Frequency (MHz)	NEXT loss (dB)
0.150	86.7
0.772	76.0
1.0	74.3
4.0	65.3
8.0	60.8
10.0	59.3
16.0	56.2
20.0	54.8
25.0	53.3
31.25	51.9
62.5	47.4
100.0	44.3
200.0	39.8
250.0	38.3

NOTE - 0.150 MHz is for reference purposes only.

7.2.1.2 Connecting hardware pair-to-pair NEXT loss

For all frequencies from 1 MHz to 250 MHz, category 6 connecting hardware NEXT loss shall meet the values determined using equation (14). Calculations that result in NEXT loss values greater than 75 dB shall revert to a requirement of 75 dB minimum. The values in table 7 are provided for information only.

$$NEXT_{conn} \geq 54 - 20\log(f/100) \; dB \qquad (14)$$

Table 7 – Category 6 connecting hardware NEXT loss, worst pair-to-pair

Frequency (MHz)	NEXT loss (dB)
1.0	75.0
4.0	75.0
8.0	75.0
10.0	74.0
16.0	69.9
20.0	68.0
25.0	66.0
31.25	64.1
62.5	58.1
100.0	54.0
200.0	48.0
250.0	46.0

7.2.1.3 Work area, equipment, and patch cord pair-to-pair NEXT loss

Work area, equipment, and patch cords shall pass the requirements of this clause. Modular plug cords shall be measured in accordance with annex K. The measured NEXT loss of modular plug cords shall exceed the values calculated in equation (15) (TBD).

$$NEXT_{cord\_limit} = -10\log\left(10^{\frac{-NEXT_{connectors}}{10}} + 10^{\frac{-\left(NEXT_{cable} + 2\cdot IL_{conn}\right)}{10}}\right) + RFEXT \qquad (15)$$

where:

$$NEXT_{connectors} = -20\log\left(10^{\frac{-NEXT_{local}}{20}} + 10^{\frac{-\left(NEXT_{remote} + 2\cdot\left(IL_{cable} + IL_{conn}\right)\right)}{20}}\right) \qquad (16)$$

$$NEXT_{local} = NEXT_{remote} = NEXT_{conn} - 20\log\left(\frac{f}{100}\right) \text{ if } 1 \text{ MHz} \leq f \leq 100 \text{ MHz} \qquad (17)$$

$$NEXT_{remote} = NEXT_{remote} - 20\log\left(\frac{f}{100}\right) \text{ if } 100 \text{ MHz} < f \leq 250 \text{ MHz} \qquad (18)$$

$$IL_{cable} = DeRating_{IL} \cdot IL_{cable,100m} \cdot \frac{CableLength}{100} \qquad (19)$$

$$NEXT_{cable} = NEXT_{cable,100m} - 10\log\left(1 - e^{-0.46 \cdot IL_{cable}}\right) \quad (20)$$

where:

f is the frequency in MHz, NEXT is in dB, and cable length is in meters.

$NEXT_{conn,100MHz}$ is the mated NEXT loss at 100 MHz assigned to the local test jack in dB,

For a minimally compliant category 6 test head, $NEXT_{conn,100\ MHz}$ equals 54 dB.

$Atten_{cable,100m}$ is the insertion loss of 100 meters of solid cable as specified in clause 6.1.1.

$Derating_{Atten}$ is the de-rating factor specified for stranded cable in clause 7.1.1.

$Atten_{conn}$ is the insertion loss of a compliant connector as specified in clause 7.1.2.

$NEXT_{cable}$ is the cable NEXT loss computed from the NEXT loss requirements for 100 m cable, the attenuation requirements for 100 m patch cable, the length correction formula in ASTM D-4566, and

$NEXT_{cable,100m}$ is the NEXT loss test limit for 100 m cable as specified in clause 7.2.1.1.

RFEXT is the allowance for reflected FEXT. *RFEXT* = 0.5 dB.

Calculations that result in NEXT loss limit values in excess of 65 dB shall revert to a limit of 65 dB. The values in table 8 are provided for information only.

Table 8 - Example category 6 modular plug cord NEXT loss limits, dB

Frequency (MHz)	2 m cord limit (dB)	5 m cord limit (dB)	10 m cord limit (dB)
1	65.0	65.0	65.0
4	65.0	65.0	65.0
8	65.0	65.0	65.0
10	65.0	65.0	62.9
16	62.0	60.5	59.0
20	60.1	58.6	57.2
25	58.1	56.8	55.4
31.25	56.2	54.9	53.6
62.5	50.4	49.2	48.1
100	46.4	45.3	44.4
125	43.9	43.1	42.4
150	41.8	41.2	40.8
175	40.0	39.6	39.3
200	38.4	38.2	38.1
225	37.0	36.9	37.0
250	35.8	35.8	36.0

7.2.1.4 Cabling pair-to-pair NEXT loss

For all frequencies from 1 MHz to 250 MHz, category 6 channel pair-to-pair NEXT loss shall meet the values determined using equation (10). Calculations that result in NEXT loss values greater than 65 dB shall revert to a requirement of 65 dB minimum. The values in table 9 are provided for information only.

$$NEXT_{channel} \geq -20\log\left(10^{\frac{-NEXT_{cable}}{20}} + 2 \cdot 10^{\frac{-NEXT_{conn}}{20}}\right)\ dB \qquad (21)$$

Table 9 – Category 6 channel NEXT loss, worst pair-to-pair

Frequency (MHz)	NEXT loss (dB)
1.0	65.0
4.0	63.0
8.0	58.2
10.0	56.6
16.0	53.2
20.0	51.6
25.0	50.0
31.25	48.4
62.5	43.4
100.0	39.9
200.0	34.8
250.0	33.1

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link pair-to-pair NEXT loss shall meet the values determined using equation (22). Calculations that result in NEXT loss values greater than 65 dB shall revert to a requirement of 65 dB minimum. The values in table 10 are provided for information only.

$$NEXT_{perm\_link} \geq -20\log\left(10^{\frac{-NEXT_{cable}}{20}} + 10^{\frac{-NEXT_{conn}}{20}}\right)\ dB \qquad (22)$$

Table 10 – Category 6 permanent link NEXT loss, worst pair-to pair

Frequency (MHz)	NEXT loss (dB)
1.0	65.0
4.0	64.1
8.0	59.4
10.0	57.8
16.0	54.6
20.0	53.1
25.0	51.5
31.25	50.0
62.5	45.1
100.0	41.8
200.0	36.9
250.0	35.3

7.2.2 Power sum NEXT loss

Power sum near-end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from all near-end disturbers operating simultaneously. The power sum near-end crosstalk (PSNEXT) loss is calculated in accordance with ASTM D 4566 as a power sum on a selected pair from all other pairs as shown in equation (23) for the case of 4-pair cable.

$$PSNEXT = -10\log(10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10})\ dB \qquad (23)$$

where:

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

NOTE - For channel and permanent link power sum calculations, it is assumed that the pair-to-pair connecting hardware NEXT loss requirements of this Standard are equivalent to a PSNEXT loss performance of 50-20log(f/100) for all frequencies from 1 MHz to 250 MHz. PSNEXT loss for connecting hardware does not need to be separately verified.

7.2.2.1 Cable power sum NEXT loss

For all frequencies from 0.772 MHz to 250 MHz, category 6 cable power sum NEXT loss, for a length of 100 m (328 ft) or longer, shall meet the values determined using equation (24). The values in table 11 are provided for information only.

$$PSNEXT_{cable} \geq 42.3 - 15\log(f/100)\ dB \qquad (24)$$

Table 11 – Category 6 cable power sum NEXT loss @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

Frequency (MHz)	PSNEXT loss (dB)
0.150	84.7
0.772	74.0
1.0	72.3
4.0	63.3
8.0	58.8
10.0	57.3
16.0	54.2
20.0	52.8
25.0	51.3
31.25	49.9
62.5	45.4
100.0	42.3
200.0	37.8
250.0	36.3

NOTE - 0.150 MHz is for reference purposes only.

7.2.2.2 Cabling power sum NEXT loss

For all frequencies from 1 MHz to 250 MHz, category 6 channel power sum NEXT loss shall meet the values determined using equation (25). Calculations that result in NEXT loss values greater than 62 dB shall revert to a requirement of 62 dB minimum. The values in table 12 are provided for information only.

$$PSNEXT_{channel} \geq -20\log\left(10^{\frac{-PSNEXT_{cable}}{20}} + 2 \cdot 10^{\frac{-PSNEXT_{conn}}{20}}\right)\ dB \quad (25)$$

Table 12 – Category 6 channel power sum NEXT loss

Frequency (MHz)	PSNEXT loss (dB)
1.0	62.0
4.0	60.5
8.0	55.6
10.0	54.0
16.0	50.6
20.0	49.0
25.0	47.3
31.25	45.7
62.5	40.6
100.0	37.1
200.0	31.9
250.0	30.2

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link power sum NEXT loss shall meet the values determined using equation (26). Calculations that result in NEXT loss values greater than 62 dB shall revert to a requirement of 62 dB minimum. The values in table 13 are provided for information only.

$$PSNEXT_{perm\_link} \geq -20\log\left(10^{\frac{-PSNEXT_{cable}}{20}} + 10^{\frac{-PSNEXT_{conn}}{20}}\right)\ dB \quad (26)$$

Table 13 – Category 6 permanent link power sum NEXT loss

Frequency (MHz)	PSNEXT loss (dB)
1.0	62.0
4.0	61.8
8.0	57.0
10.0	55.5
16.0	52.2
20.0	50.7
25.0	49.1
31.25	47.5
62.5	42.7
100.0	39.3
200.0	34.3
250.0	32.7

7.3 ELFEXT and FEXT loss

FEXT loss is a measure of the unwanted signal coupling from a transmitter at the far-end into neighboring pairs measured at the near-end. FEXT loss is the ratio of the power coupled from a disturbing pair into the disturbed pair relative to the input power at the opposite end of the transmission lines determined from measured voltages. This ratio is expressed in dB. ELFEXT shall be calculated for all pair combinations for cables and cabling in accordance with annex C of ANSI/TIA/EIA-568-B.2 and the ASTM D 4566 FEXT loss measurement procedure, except the test fixture shall provide for consistent common and differential mode impedance matching for the unjacketed twisted-pairs between the cable jacket and the balun terminations. Connecting hardware FEXT loss shall be measured for all pair combinations in accordance with annex E. In addition, since each duplex channel can be disturbed by more than one duplex channel, power sum equal level far-end crosstalk (PSELFEXT) is also specified for cabling and cables.

7.3.1 Pair-to-pair ELFEXT

7.3.1.1 Cable pair-to-pair ELFEXT

For all frequencies from 1 MHz to 250 MHz, category 6 cable ELFEXT, for a length of 100 m (328 ft), shall meet the values determined using equation (27). The values in table 14 are provided for information only.

$$ELFEXT_{cable} \geq 27.8 - 20\log(f/100) \; dB \qquad (27)$$

Table 14 - Category 6 cable ELFEXT @ 20 °C ± 3 °C (68 °F ± 5.5 °F), worst pair-to-pair

For a length of 100 m (328 ft)

Frequency (MHz)	ELFEXT (dB)
0.772	70.0
1.0	67.8
4.0	55.8
8.0	49.7
10.0	47.8
16.0	43.7
20.0	41.8
25.0	39.8
31.25	37.9
62.5	31.9
100.0	27.8
200.0	21.8
250.0	19.8

NOTE - 0.772 MHz is for reference purposes only.

7.3.1.2 Connecting hardware pair-to-pair FEXT loss

For all frequencies from 1 MHz to 250 MHz, category 6 connecting hardware FEXT loss shall meet the values determined using equation (28). Calculations that result in FEXT loss values greater than 75 dB shall revert to a requirement of 75 dB minimum. The values in table 15 are provided for information only.

$$FEXT_{conn} \geq 43.1 - 20\log(f/100)\ dB \qquad (28)$$

Table 15 – Category 6 connecting hardware FEXT loss, worst pair-to-pair

Frequency (MHz)	FEXT loss (dB)
1.0	75.0
4.0	71.1
8.0	65.0
10.0	63.1
16.0	59.0
20.0	57.1
25.0	55.1
31.25	53.2
62.5	47.2
100.0	43.1
200.0	37.1
250.0	35.1

7.3.1.3 Cabling pair-to-pair ELFEXT

For all frequencies from 1 MHz to 250 MHz, category 6 channel ELFEXT shall meet the values determined using equation (29). The values in table 16 are provided for information only.

$$ELFEXT_{channel} \geq -20\log\left(10^{\frac{-ELFEXT_{cable}}{20}} + 4 \cdot 10^{\frac{-FEXT_{conn}}{20}}\right)\ dB \qquad (29)$$

Table 16 – Category 6 channel ELFEXT, worst pair-to-pair

Frequency (MHz)	ELFEXT (dB)
1.0	63.3
4.0	51.2
8.0	45.2
10.0	43.3
16.0	39.2
20.0	37.2
25.0	35.3
31.25	33.4
62.5	27.3
100.0	23.3
200.0	17.2
250.0	15.3

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link ELFEXT shall meet the values determined using equation (30). The values in table 17 are provided for information only.

$$ELFEXT_{perm\_link} \geq -20\log(10^{\frac{-ELFEXT_{cable}}{20}} + 3 \cdot 10^{\frac{-FEXT_{conn}}{20}})\ dB \quad (30)$$

Table 17 – Category 6 permanent link ELFEXT, worst pair-to-pair

Frequency (MHz)	ELFEXT (dB)
1.0	64.2
4.0	52.1
8.0	46.1
10.0	44.2
16.0	40.1
20.0	38.2
25.0	36.2
31.25	34.3
62.5	28.3
100.0	24.2
200.0	18.2
250.0	16.2

7.3.2 Power sum ELFEXT

Power sum equal level far-end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from all far-end disturbers operating simultaneously. The power sum equal level far-end crosstalk (PSELFEXT) loss is calculated in accordance with ASTM D 4566 as a power sum on a selected pair from all other pairs as shown in equation (31) for the case of 4-pair cable.

$$PSELFEXT = -10\log(10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10})\ dB \quad (31)$$

where:

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

NOTE - For channel and permanent link power sum calculations, it is assumed that the pair-to-pair connecting hardware FEXT loss requirements of this Standard are equivalent to a PSFEXT loss performance of 40.1-20log(f/100) for all frequencies from 1 MHz to 250 MHz. PSFEXT loss for connecting hardware does not need to be separately verified.

7.3.2.1 Cable power sum ELFEXT

For all frequencies from 1 MHz to 250 MHz, category 6 cable power sum ELFEXT, for a length of 100 m (328 ft), shall meet the values determined by equation (32). The values in table 18 are for reference only.

$$PSELFEXT_{cable} \geq 24.8 - 20\log(f/100) \ dB \quad (32)$$

Table 18 - Category 6 cable power sum ELFEXT @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

For a length of 100 m (328 ft)

Frequency (MHz)	PS ELFEXT (dB)
0.772	67.0
1.0	64.8
4.0	52.8
8.0	46.7
10.0	44.8
16.0	40.7
20.0	38.8
25.0	36.8
31.25	34.9
62.5	28.9
100.0	24.8
200.0	18.8
250.0	16.8

NOTE - 0.772 MHz is for reference purposes only.

7.3.2.2 Cabling power sum ELFEXT

For all frequencies from 1 MHz to 250 MHz, category 6 channel power sum ELFEXT shall meet the values determined using equation (33). The values in table 19 are provided for information only.

$$PSELFEXT_{channel} \geq -20\log\left(10^{\frac{-PSELFEXT_{cable}}{20}} + 4 \cdot 10^{\frac{-PSFEXT_{conn}}{20}}\right) \ dB \quad (33)$$

Table 19 – Category 6 channel power sum ELFEXT

Frequency (MHz)	PSELFEXT (dB)
1.0	60.3
4.0	48.2
8.0	42.2
10.0	40.3
16.0	36.2
20.0	34.2
25.0	32.3
31.25	30.4
62.5	24.3
100.0	20.3
200.0	14.2
250.0	12.3

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link power sum ELFEXT shall meet the values determined using equation (34). The values in table 20 are provided for information only.

$$PSELFEXT_{perm\_link} \geq -20\log\left(10^{\frac{-PSELFEXT_{cable}}{20}} + 3 \cdot 10^{\frac{-PSFEXT_{conn}}{20}}\right)\ dB \qquad (34)$$

Table 20 – Category 6 permanent link power sum ELFEXT

Frequency (MHz)	PSELFEXT (dB)
1.0	61.2
4.0	49.1
8.0	43.1
10.0	41.2
16.0	37.1
20.0	35.2
25.0	33.2
31.25	31.3
62.5	25.3
100.0	21.2
200.0	15.2
250.0	13.2

7.4 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 the ratio of the reflected signal power to the input power determined from measured voltages, expressed in dB. Cable and cabling return loss shall be measured in accordance with annex C of ANSI/TIA/EIA-568-B.2. Connecting hardware return loss shall be measured in accordance with annex D for all pairs. Modular plug cords shall be measured in accordance with annex K for all pairs.

7.4.1 Horizontal cable return loss

For all frequencies from 1 MHz to 250 MHz, category 6 horizontal cable return loss, for a length of 100 m (328 ft), shall meet the values determined using the equations specified in table 21. The values in table 22 are provided for information only.

Table 21 - Category 6 horizontal cable return loss @ 20°C ± 3°C (68° F ± 5.5° F)

For a length of 100 m (328 ft)

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 10$	$20 + 5\log(f)$
$10 \leq f < 20$	25
$20 \leq f \leq 250$	$25 - 7\log(f/20)$

Table 22 - Category 6 solid cable return loss @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

For a length of 100 m (328 ft)

Frequency (MHz)	Return loss (dB)
1.0	20.0
4.0	23.0
8.0	24.5
10.0	25.0
16.0	25.0
20.0	25.0
25.0	24.3
31.25	23.6
62.5	21.5
100.0	20.1
200.0	18.0
250.0	17.3

7.4.2 Stranded cable return loss

For all frequencies from 1 MHz to 250 MHz, category 6 stranded patch cable return loss, for a length of 100 m (328 ft), shall meet the values determined using the equations specified in table 23. The values in table 24 are provided for information only.

Table 23 - Category 6 stranded cable return loss @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

For a length of 100 m (328 ft)

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 10$	$20+5\log(f)$
$10 \leq f < 20$	25
$20 \leq f \leq 250$	$25 - 8.6\log(f/20)$

Table 24 - Category 6 stranded cable return loss @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

For a length of 100 m (328 ft)

Frequency (MHz)	Return loss (dB)
1.0	20.0
4.0	23.0
8.0	24.5
10.0	25.0
16.0	25.0
20.0	25.0
25.0	24.2
31.25	23.3
62.5	20.7
100.0	19.0
200.0	16.4
250.0	15.6

7.4.3 Connecting hardware return loss

For all frequencies from 1 MHz to 250 MHz, category 6 connecting hardware return loss shall meet the values determined using the equations specified in table 25. The values in table 26 are provided for information only.

Table 25 - Category 6 connecting hardware return loss

Frequency (MHz)	Return Loss (dB)
$1 \le f < 50$ $50 \le f \le 250$	30 dB $24 - 20\log(f/100)$ dB

Table 26 – Category 6 connecting hardware return loss

Frequency (MHz)	Return loss (dB)
1.0	30.0
4.0	30.0
8.0	30.0
10.0	30.0
16.0	30.0
20.0	30.0
25.0	30.0
31.25	30.0
62.5	28.1
100.0	24.0
200.0	18.0
250.0	16.0

7.4.4 Work area, equipment, and patch cord return loss

For all frequencies from 1 MHz to 250 MHz, category 6 work area, equipment, and patch cord return loss shall meet the values determined using the equations specified in table 27. The values in table 28 are provided for information only.

Table 27 - Category 6 modular patch cord return loss

Frequency (MHz)	Return Loss (dB)
$1 \le f < 25$ $25 \le f \le 250$	$24+3\log(f/25)$ $24-10\log(f/25)$

Table 28 - Category 6 work area, equipment, and patch cord return loss

Frequency (MHz)	Return loss (dB)
1.0	19.8
4.0	21.6
8.0	22.5
10.0	22.8
16.0	23.4
20.0	23.7
25.0	24.0
31.25	23.0
62.5	20.0
100.0	18.0
200.0	15.0
250.0	14.0

7.4.5 Cabling return loss

For all frequencies from 1 MHz to 250 MHz, category 6 channel return loss shall meet the values determined using the equations specified in table 29. The values in table 30 are provided for information only.

Table 29 – Category 6 channel return loss

Frequency (MHz)	Return Loss (dB)
$1 \le f < 10$	19
$10 \le f < 40$	$24-5\log(f)$
$40 \le f \le 250$	$32-10\log(f)$

Table 30 – Category 6 channel return loss

Frequency (MHz)	Return loss (dB)
1.0	19.0
4.0	19.0
8.0	19.0
10.0	19.0
16.0	18.0
20.0	17.5
25.0	17.0
31.25	16.5
62.5	14.0
100.0	12.0
200.0	9.0
250.0	8.0

For all frequencies from 1 MHz to 250 MHz, category 6 permanent link return loss shall meet the values determined using the equations specified in table 31. The values in table 32 are provided for information only.

Table 31 – Category 6 permanent link return loss

Frequency (MHz)	Return Loss (dB)
$1 \le f < 3$	21+4log(*f*/3)
$3 \le f < 10$	21
$10 \le f < 40$	26-5log(*f*)
$40 \le f \le 250$	34-10log(*f*)

Table 32 – Category 6 permanent link return loss

Frequency (MHz)	Return loss (dB)
1.0	19.1
4.0	21.0
8.0	21.0
10.0	21.0
16.0	20.0
20.0	19.5
25.0	19.0
31.25	18.5
62.5	16.0
100.0	14.0
200.0	11.0
250.0	10.0

7.5 Propagation delay/delay skew

Propagation delay is the time it takes for a signal to propagate from one end of a conducting pair in cabling, cables, or connecting hardware to the opposite end of that pair. 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 shall be measured for all pairs for cables in accordance with the ASTM D 4566 phase constant measurement and the phase delay and velocity calculations, except the test fixture shall provide for consistent common and differential mode impedance matching for the unjacketed twisted-pairs between the cable jacket and the balun terminations. Delay skew shall be calculated from the propagation delay measurements.

7.5.1 Cable propagation delay

For all frequencies from 1 MHz to 250 MHz, category 6 cable propagation delay shall meet the values determined using equation (35). The values shown in table 33 are for information only. See annex L of ANSI/TIA/EIA-568-B.2 for the derivation of equation (35).

$$delay_{cable} \leq 534 + \frac{36}{\sqrt{f}} \quad ns/100\ m \tag{35}$$

Table 33 - Propagation delay and delay skew for category 6 cable @ 20 °C ± 3 °C (68 °F ± 5.5 °F)

Freq. (MHz)	Max. Delay (ns/100 m)	Min. Velocity of Propagation (%)	Max. Delay Skew (ns/100 m)
1	570	58.5 %	45
10	545	61.1 %	45
100	538	62.0 %	45
250	536	62.1 %	45

7.5.2 Cabling propagation delay

In determining the category 6 channel and permanent link propagation delay, the propagation delay contribution of each installed mated connection is assumed to not exceed 2.5 ns from 1 MHz to 250 MHz.

The maximum propagation delay for a category 6 channel configuration shall be less than 555 ns measured at 10 MHz.

The maximum propagation delay for a category 6 permanent link configuration shall be less than 498 ns measured at 10 MHz.

7.5.3 Cable propagation delay skew

For all frequencies from 1 MHz to 250 MHz, category 6 cable propagation delay skew shall not exceed 45 ns/100 m at 20 °C, 40 °C, and 60 °C. In addition, the propagation delay skew between all pairs shall not vary more than ± 10 ns from the measured value at 20 °C when measured at 40 °C and 60 °C. Compliance shall be determined using a minimum 100 m of cable.

7.5.4 Cabling propagation delay skew

In determining the channel and permanent link propagation delay skew, the propagation delay skew of each installed mated connection is assumed not to exceed 1.25 ns.

The maximum propagation delay skew for a category 6 channel configuration shall be less than 50 ns measured at 10 MHz.

The maximum propagation delay skew for a category 6 permanent link configuration shall be less than 44 ns measured at 10 MHz.

7.6 Balance

Balance ensures that the appearance of undesired signal coupling modes is minimized and is related to the emission and immunity characteristics of the cabling. Balance parameters such as LCL and TCL are expressed in dB as the ratio of the signal measured at the device under test (DUT) output port relative to the signal entering the DUT input port. LCL should be measured for all connecting hardware pairs in accordance with annex D.

NOTE – Measurements of LCL and TCL are reciprocal due to symmetry.

7.6.1 Longitudinal conversion loss (LCL)

7.6.1.1 Cable LCL

Cable balance recommendations are under study.

7.6.1.2 Connecting hardware LCL

For all frequencies from 1 MHz to 250 MHz, category 6 connecting hardware LCL should meet the values determined using equation (36). The values in table 34 are provided for information only.

$$LCL_{conn} \geq 28 - 20\log(f/100) \text{ dB} \quad (36)$$

Table 34 – Category 6 connecting hardware LCL

Frequency (MHz)	LCL (dB)
1.0	68.0
4.0	56.0
8.0	49.9
10.0	48.0
16.0	43.9
20.0	42.0
25.0	40.0
31.25	38.1
62.5	32.1
100.0	28.0
200.0	22.0
250.0	20.0

7.6.2 Longitudinal conversion transfer loss (LCTL)

7.6.2.1 Cable LCTL

Cable balance recommendations are under study.

7.6.2.2 Connecting hardware LCTL

Connecting hardware LCTL recommendations are under study.

Annex A Cabling (field) measurement procedures (normative)

A.1 General

Field test measurements shall be made in accordance with annex I of ANSI/TIA/EIA-568-B.2 unless otherwise noted.

A.2 Frequency range

Field test measurements shall be conducted from 1 MHz to 250 MHz.

Annex B Test instruments (normative)

B.1 Accuracy requirements for level III field testers

The level III requirements in this annex are stated separately for baseline performance and the category 6 permanent link and channel configurations. The field tester performance for the permanent link shall apply to the performance at the reference plane for the permanent link as shown in figure 2 and the field tester performance parameters for the channel shall apply to the performance at the reference plane for the channel as shown in figure 1.

B.1.1 Measurement performance requirements: baseline category 6 test instrument

Table B.1 - Minimum requirements: baseline level III field tester measurement accuracy

Parameter	**Attenuation/ insertion loss**	**NEXT loss/ PSNEXT loss**	**ELFEXT/ PSELFEXT**	**Return loss**	
Amplitude range	3 dB over test limit	3 dB over test limit [1)] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit [2)] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit	*dB*
Amplitude resolution	0.1				*dB*
Frequency range	1 –250 MHz				
Frequency resolution	1 MHz	150 kHz, 1 MHz to 31.25 MHz 250 kHz, 31.25 MHz to 100 MHz 500 kHz; 100 MHz to 250 MHz			
Dynamic accuracy	± 0.75 [3)]		± 1 [4)]		*dB*
Source/load return loss	20-12.5log(*f*/100), 20 dB max.				*dB*
Random noise floor	75 – 15log(*f*/100), 85 dB max.				*dB*
Residual NEXT		65–20log(*f*/100) [5)]			*dB*
Residual FEXT			65–20log(*f*/100) [5)]		*dB*
Output signal balance		40-20log(*f*/100) [6)]			*dB*
Common mode rejection		40-20log(*f*/100) [6)]			*dB*
Tracking				± 0. 5	*dB*
Directivity				27-7log(*f*/100), 30 dB max.	*dB*
Source match				20	*dB*
Termination return loss				20-15log(*f*/100), 25 dB max.	*dB*

1) The dynamic range for NEXT loss and FEXT loss is 65 dB maximum + 3 dB.
2) The dynamic range for PSNEXT loss and PSFEXT loss is 62 dB maximum + 3 dB.
3) Dynamic accuracy requirements shall be tested up to the specified dynamic range for NEXT loss and FEXT loss.
4) Dynamic accuracy ELFEXT assumes a dynamic accuracy requirement of ± 0.75 dB for FEXT loss, which shall be tested, and that dynamic accuracy performance for attenuation and FEXT loss add to the ELFEXT requirement shown.
5) The verification of residual NEXT loss and FEXT loss is up to 85 dB maximum. It is assumed that the frequency response changes at a rate of 20 dB/decade.
6) The 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 rate of 20 dB/decade.

B.1.2 Measurement performance requirements: category 6 permanent link

Table B.2 - Minimum requirements: permanent link level III field tester measurement accuracy (includes the permanent link adapter)

Parameter	Attenuation/ insertion loss	NEXT loss PSNEXT loss	ELFEXT PSELFEXT	Return loss	
Amplitude range	3 dB over test limit	3 dB over test limit [1)] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit [2)] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit	*dB*
Amplitude resolution	0.1				*dB*
Frequency range	1 –250 MHz				
Frequency resolution	1 MHz	150 kHz, 1 MHz to 31.25 MHz 250 kHz, 31.25 MHz to 100 MHz 500 kHz; 100 MHz to 250 MHz			
Dynamic accuracy	± 0.75 [3)]		± 1 [4)]		*dB*
Source/load return loss	18-12.5log(f/100), 20 dB max				*dB*
Random noise floor	75 – 15log(f/100), 85 dB max				*dB*
Residual NEXT		60–20log(f/100) [5)]			*dB*
Residual FEXT			65–20log(f/100) [5)]		*dB*
Output signal balance		37-20log(f/100) [6)]			*dB*
Common mode rejection		37-20log(f/100) [6)]			*dB*
Tracking				± 0. 5	*dB*
Directivity				25-20log(f/100)	*dB*

				25 dB max.	
Source match				20-20log(f/100), 20 dB max.	*dB*
Termination return loss				16-15log(f/100), 25 dB max.	*dB*

1) The dynamic range for NEXT loss and FEXT loss is 65 dB maximum + 3 dB.
2) The dynamic range for PSNEXT loss and PSFEXT loss is 62 dB maximum + 3 dB.
3) Dynamic accuracy requirements shall be tested up to the specified dynamic range for NEXT loss and FEXT loss.
4) Dynamic accuracy ELFEXT assumes a dynamic accuracy requirement of ± 0.75 dB for FEXT loss, which shall be tested, and that dynamic accuracy performance for attenuation and FEXT loss add to the ELFEXT requirement shown.
5) The verification of residual NEXT loss and FEXT loss is up to 85 dB maximum. It is assumed that the frequency response changes at a rate of 20 dB/decade.
6) The 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 rate of 20 dB/decade.

B.1.3 Measurement performance requirements: category 6 channel test configuration

Table B.3 - Minimum requirements: channel level III field tester measurement accuracy (includes the channel adapter)

Parameter	Attenuation/ insertion loss	NEXT loss PSNEXT loss	ELFEXT PSELFEXT	Return loss	
Amplitude range	3 dB over test limit	3 dB over test limit [1] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit [2] PP: 65 dB max. PS: 62 dB max.	3 dB over test limit	*dB*
Amplitude resolution	0.1				*dB*
Frequency range	1 –250 MHz				
Frequency resolution	1 MHz	150 kHz, 1 MHz to 31.25 MHz 250 kHz, 31.25 MHz to 100 MHz 500 kHz; 100 MHz to 250 MHz			
Dynamic accuracy	± 0.75 [3]		± 1 [4]		*dB*
Source/load return loss	18-12.5log(f/100), 20 dB max.				*dB*
Random noise floor	75 – 15log(f/100), 85 dB max.				*dB*
Residual NEXT		54–20log(f/100) [5]			*dB*
Residual FEXT			43.1–20log(f/100) [5]		*dB*
Output signal balance		37-20log(f/100) [6]			*dB*

Common mode rejection		37-20log(f/100) 6)			*dB*
Tracking				± 0. 5	*dB*
Directivity				25-20log(f/100), 25 dB max.	*dB*
Source match				20-20log(f/100), 20 dB max	*dB*
Termination return loss				16-15log(f/100), 25 dB max	*dB*

1) The dynamic range for NEXT loss and FEXT loss is 65 dB maximum + 3 dB.

2) The dynamic range for PSNEXT loss and PSFEXT loss is 62 dB maximum + 3 dB.

3) Dynamic accuracy requirements shall be tested up to the specified dynamic range for NEXT loss and FEXT loss.

4) Dynamic accuracy ELFEXT assumes a dynamic accuracy requirement of ± 0.75 dB for FEXT loss, which shall be tested, and that dynamic accuracy performance for attenuation and FEXT loss add to the ELFEXT requirement shown.

5) The verification of residual NEXT loss and FEXT loss is up to 85 dB maximum. It is assumed that the frequency response changes at a rate of 20 dB/decade.

6) The 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 rate of 20 dB/decade.

B.1.4 Accuracy requirements for length, propagation delay and delay skew

The accuracy of the delay skew measurement is shown in table B.4.

Table B.4 - Length, propagation delay, and delay skew accuracy requirements

Performance Parameter	Length	Propagation Delay	Delay Skew
Accuracy	± (1 m + 4 % of reported value)	± (5 ns + 4 % of reported value)	± 10 ns

B.2 Procedures for qualifying field test instruments

B.2.1 General

Unless otherwise specified, the procedures for qualifying field tester parameters in TIA/EIA-568-B-2 shall apply.

B.3 Error models

Unless otherwise specified, the field tester error models in TIA/EIA-568-B-2 shall apply.

B.4 Expected accuracy

The worst-case accuracy of a level III field test instrument can be calculated by inserting the requirements specified in clause B.1 into the error models referenced in clause I.6 of ANSI/TIA/EIA-568-B.2. The actual accuracy may be significantly better than these worst-case models suggest. For detailed accuracy information, refer to the manufacturer's specifications.

Annex C Cabling measurement requirements (normative)

C.1 General

This annex describes additional requirements by which 4-pair 100 Ω category 6 cabling systems are to be measured from 1 MHz to 250 MHz using laboratory equipment.

C.2 Test setup and apparatus required

For general requirements, refer to ANSI/TIA/EIA-568-B.2. Additional requirements that are appropriate for testing up to 250 MHz are specified in this annex. Baluns shall be RFI shielded and shall comply with the specifications listed in table C.1.

Table C.1 - Test balun performance characteristics

Parameter	Frequency (MHz)	Value
Impedance, primary [1)]	$1 \leq f \leq 250$	50 Ω unbalanced
Impedance, secondary	$1 \leq f \leq 250$	100 Ω balanced
Attenuation	$1 \leq f \leq 250$	2.0 dB maximum
Return loss, bi-directional [2)]	$1 \leq f < 3$ $3 \leq f \leq 250$	15 dB minimum 20 dB minimum
Return loss, common mode [2)]	$1 \leq f \leq 250$	20 dB minimum
Power rating	$1 \leq f \leq 250$	0.1 watt minimum
Longitudinal balance [2), 3)]	$1 \leq f < 100$ $100 \leq f \leq 250$	60 dB minimum 50 dB minimum
Output signal balance [2)]	$1 \leq f \leq 250$	50 dB minimum
Common mode rejection [2)]	$1 \leq f \leq 250$	50 dB minimum

1) Primary impedance may differ, if necessary, to accommodate analyzer outputs other than 50 Ω.
2) Measured per ITU-T (formerly CCITT) Recommendation G.117 with the network analyzer calibrated using a 50 Ω load.
3) This parameter is measured at the center tap input with the balanced terminals and ground connected together through two 50 Ω resistors in a "Y" or equivalent configuration line to line and a 25 Ω resistor to ground. The primary balun input should be connected to a 50 Ω termination.

NOTES

1 Shields and screens, if any, should be bonded (low inductance connections) to the local and remote measurement grounds.

2 Worst case return loss conditions generally occur at 1 MHz when the length of the cabling is approximately 50 m (160 ft), and at high frequencies when the distance between two connectors at the near end of the link is approximately the half wavelength of the frequency of measurement.

3 The connection of the local and remote grounds through the network analyzer is not expected to have a significant influence on the measured results.

4 It is recommended that all DUTs have test interfaces at the nominal 100 Ω impedance level to minimize measurement errors due to reflections. It is further recommended that all DUTs have sockets with 2.5 mm (0.1 in) spacing applied to the ends of their test leads to facilitate a consistent interfacing with the baluns.

Annex D Connecting hardware balance measurement procedures (informative)

D.1 General

This annex describes LCL measurement, calibration, and termination procedures for 4-pair category 6 connecting hardware over the frequency range of 1 to 250 MHz. The transmission tests described in this annex typically require the use of a network analyzer or equivalent, coaxial cables, baluns, UTP test leads, and impedance matching terminations. Each set-up component shall be qualified to a measurement bandwidth of at least 1 to 250 MHz. Test equipment design, calibration and fixturing should be such as to ensure a measurement noise floor of 20 dB below the required measurement limit.

D.2 Connecting hardware balance measurements

Connecting hardware LCL should be tested in both directions. Test plugs used for mating to 8-position modular outlets should fall within the range of de-embedded test plug NEXT loss values shown in annex E (TBD).

D.2.1 Connecting hardware LCL calibration

LCL calibration is performed in three steps.

STEP 1: The coaxial test leads attached to the network analyzer are calibrated out by performing short, open, load, and through measurements at the point of termination to the balun. An example of the test lead through connection is shown in figure D.1

Figure D.1 – Coaxial lead attenuation calibration

STEP 2: The attenuation of the differential signals of the test balun is measured by connecting two identical baluns back-to-back with minimal lead length as shown in figure D.2. Notice that the baluns are positioned so as to maintain polarity and they are bonded (firmly attached, e.g. clamped) to a ground plane. The measured insertion loss is divided by 2 to approximate the insertion loss of one balun for a differential signal. The calculated insertion loss is recorded as $IL_{bal,DM}$.

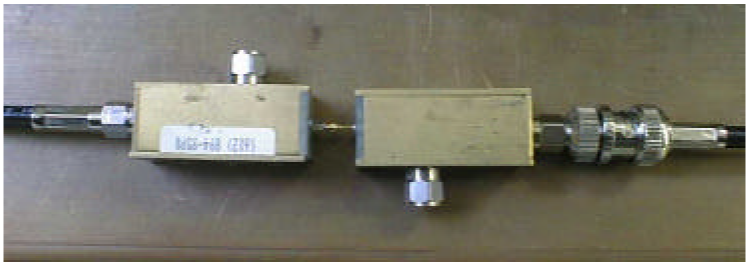


Figure D.2 – Back-to-back balun insertion loss measurement

STEP 3: The attenuation of the common mode signals of the test balun is measured by connecting the common mode port terminals to the differential output terminals of the test balun as shown in figure D.3. Notice that the output terminals of the test balun are short-circuited and connected to the inner conductor of the coaxial test lead. The outer shield of the coaxial test lead should be properly bonded to the ground plane as shown in figure D.4. The measured insertion loss is recorded as $IL_{bal,CM}$.

Figure D.3 – Output terminal connection

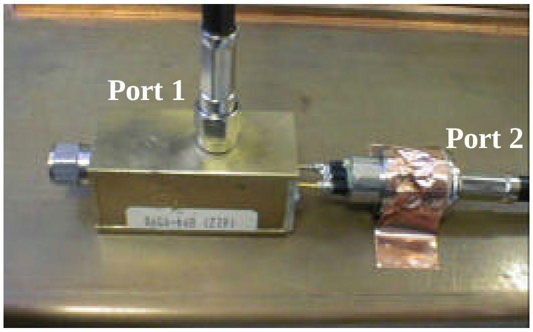


Figure D.4 – Outer shield grounding position

D.2.2 Connecting hardware LCL measurement

The connecting hardware pair under test should be connected to the differential mode balun output terminals. All unused near-end pairs should be terminated with both 50 Ω and 100 Ω differential mode (wye) precision, 0.1 % chip resistor networks or baluns as shown in figure D.5. All far-end pairs should be terminated with both 50 Ω common and 100 Ω differential mode (wye) precision, 0.1 % chip resistor networks as shown in figure D.5. The near-end terminating resistor networks should be bonded and connected to the measurement ground plane. The far-end resistor networks should be bonded together. The DUT should be positioned 2 inches from the ground plane on the near-end. The near-end test leads connecting the DUT to the balun and terminations should be no longer than 75 mm (3 in) and they should be oriented orthoganally to each other to minimize coupling.

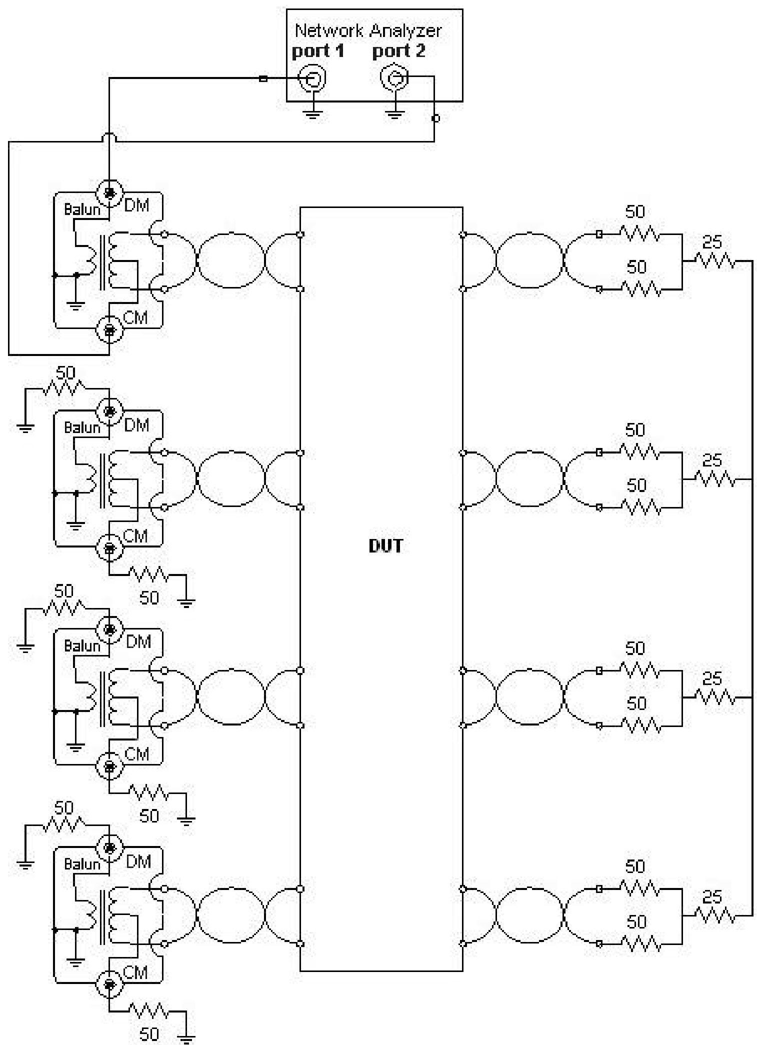


Figure D.5 – Network analyzer test setup for measuring LCL and TCL

An S21 measurement between the differential and common mode test ports of the balun is performed. To maintain consistency, port 1 of the network analyzer should be connected to the differential mode input of the test balun, while port 2 of the network analyzer should be connected to the common mode terminal of the test balun. The measured raw balance data is recorded as IL_{meas}.

The connecting hardware LCL, corrected to remove the insertion loss of the test setup and to allow for the turns ratio of the test balun, is determined using equation (D-1).

$$LCL = IL_{meas} - IL_{bal,DM} - IL_{bal,CM} + 3\ dB \qquad \text{(D-1)}$$

Annex E Connecting hardware measurement procedures (normative)

E.1 General

The specifications provided in this annex supplement the transmission test requirements provided in annex B of ANSI/TIA/EIA-568-B.2. Test equipment design calibration and fixturing should ensure a noise level 30 dB below the required measurement limit over the frequency range of 1MHz to 250 MHz.

Connecting hardware shall be tested in both directions for NEXT loss and return loss compliance. FEXT loss shall be tested for the 12 pair combinations in one test direction. NEXT loss compliance shall be validated using differential with common mode terminations.

E.2 Test setup and apparatus

Each set-up component shall be qualified to a measurement bandwidth of at least 1 to 250 MHz.

E.2.1 Test balun characteristics

Test baluns shall comply with the specifications in clause C.2. Baluns for use in testing connecting hardware shall have 2.5 mm (0.1 in) spacing on the balanced 100 Ω ports. This may be achieved through the use of an adapter when using baluns that do not inherently exhibit this geometry. When adapters are used, they shall be considered to be part of the balun. In this case, the assembly of the balun and adapter shall meet the requirements of clause C.2. It is recommended that all DUTs, including reference plugs, reference jacks, and test plugs, have sockets with 2.5 mm (0.1 in) spacing applied to the ends of their test leads to facilitate a consistent interfacing with the baluns.

E.2.2 Impedance matching terminations

Common mode with differential mode balun terminations shall be used on all active pairs under test. Common mode with differential mode resistor terminations shall be used on all inactive pairs at the near-end for NEXT loss tests and at the near- and far-ends for FEXT loss tests. Differential mode resistor terminations may be used at the far-end of all ports for NEXT loss tests, however common mode with differential mode resistor terminations are also recommended for use at the far-end. Balun terminations may be used on the far-end of all pairs and the near-end of all unused pairs provided that their differential mode and common mode return loss performance characteristics meet the minimum performance of the specified resistor networks.

E.2.2.1 Test fixture common mode impedance match

The test fixture shall provide for consistent common mode impedance matching for the test leads between the device under test and the balun terminations either by the use of individual pair shields, slots cut in a ground plane or pyramid shaped structure, differentially excited coaxial leads, or other means.

E.2.2.2 Balun terminations

Baluns used for termination shall comply with the requirements of clause C.2. The common mode termination resistor applied to the common mode port of the balun shall be 50 Ω ± 1 %.

E.2.2.3 Resistor terminations

Resistive terminations shall be as specified in clause B.5.2 of ANSI/TIA/EIA-568-B.2.

E.2.2.4 Assessing impedance matching termination performance

The performance of impedance matching terminations shall be verified by measuring the return loss of the termination at the interface to the device under test. For this measurement, a one port calibration is required using the calibration reference load. The return loss of the load termination shall be 20 dB or better over the frequency range of the measurement. (There is a relaxation of the return loss requirement to 15 dB from 1 to 3 MHz.)

NOTE – Resistive terminations are preferred.

E.3 Modular outlet test considerations

Because of variations that are inherent to terminating cables to modular plugs, the test plug used to qualify modular outlet performance must be carefully controlled. Plug requirements shall be verified using the same fixturing and termination requirements specified for other component tests. Test plugs need only be verified in one test orientation, with the cable end of the plug designated as the near-end. Qualified test plugs are used to characterize mated connecting hardware performance from both the near-end and far-end measurement orientations.

E.3.1 Test plug construction

Modular test plugs for category 6 outlet qualification may be constructed from any solid or stranded modular plug or plug assembly. The methodology described in annex D of ANSI/TIA/EIA-568-B.2 may be used to more repeatedly construct test plugs that satisfy the minimum transmission requirements of this annex. In addition, 2.5 mm (0.1 in) spaced sockets should be connected to the wire pairs and wire length should be measured to the top of the sockets.

E.3.2 Test plug qualification

E.3.2.1 Test plug de-embedded NEXT loss

De-embedded NEXT loss shall be measured in accordance with annex D of ANSI/TIA/EIA-568-B.2 with the following exceptions:

1. The de-embedded reference jack specified in clause D.5.7 of ANSI/TIA/EIA-568-B.2 shall be constructed by mounting a Stewart Connector part number SS-650810-A vertical PWB mountable jack onto a Stewart Connector part number R090199, Rev. B PWB with controlled impedance traces leading to mounting places for resistors. Trim the jack wire leads that project through the PWB to the top of the solder. The top of the solder shall not be more than 1.0 mm (0.04 in) above the PWB. Resistor loads shall consist of 0805 (2012 m) package size or smaller 0.1 % resistance tolerance chip resistors. An alternative reference jack may be used if equivalence is demonstrated.
2. The reference jack vectors specified in tables E.1 shall be used in place of the measured and calculated jack vectors specified in equations (D-1) and (D-2) of clause D.5.8 of ANSI/TIA/EIA-568-B.2.
3. The calibration shall be conducted with the reference plane at the balun ports and port extension shall be used to extend the reference plane to the interface point between the plug and the jack as described in clause E.3.2.4.

Table E.1 – Category 6 de-embedded real and imaginary reference jack vectors

Pair	**Re_J – Real coefficient of reference jack vector, (V/V) (TBD) (f = frequency in MHz)**
3,6 – 4,5	$= 5.40 \cdot 10^{-13} \cdot f^4 + 1.30 \cdot 10^{-8} \cdot f^2 - 7.70 \cdot 10^{-7} \cdot f$
1,2 – 3,6	$= -4.00 \cdot 10^{-11} \cdot f^3 + 3.00 \cdot 10^{-8} \cdot f^2 - 8.00 \cdot 10^{-7} \cdot f$
3,6 – 7,8	$= -1.30 \cdot 10^{-13} \cdot f^4 + 4.50 \cdot 10^{-8} \cdot f^2$
1,2 – 4,5	$= +1.00 \cdot 10^{-7} \cdot f^2$
4,5 – 7,8	$= +7.00 \cdot 10^{-8} \cdot f^2$
1,2 – 7,8	$= -1.00 \cdot 10^{-13} \cdot f^4 + 2.20 \cdot 10^{-8} \cdot f^2$
	Im_J – Imaginary coefficient of reference jack vector, (V/V) (TBD) (f = frequency in MHz)
3,6 – 4,5	$= 4.00 \cdot 10^{-11} \cdot f^3 + 2.70 \cdot 10^{-8} \cdot f^2 - 3.90 \cdot 10^{-6} \cdot f$
1,2 – 3,6	$= -3.00 \cdot 10^{-11} \cdot f^3 - 7.00 \cdot 10^{-9} \cdot f^2 + 5.00 \cdot 10^{-6} \cdot f$
3,6 – 7,8	$= -1.60 \cdot 10^{-11} \cdot f^3 - 3.00 \cdot 10^{-9} \cdot f^2 + 2.56 \cdot 10^{-5} \cdot f$
1,2 – 4,5	$= -1.40 \cdot 10^{-8} \cdot f^2 + 6.72 \cdot 10^{-5} \cdot f$
4,5 – 7,8	$= +2.00 \cdot 10^{-11} \cdot f^3 - 1.00 \cdot 10^{-8} \cdot f^2 + 4.73 \cdot 10^{-5} \cdot f$
1,2 – 7,8	$= -5.00 \cdot 10^{-11} \cdot f^3 + 2.00 \cdot 10^{-9} \cdot f^2 + 8.80 \cdot 10^{-6} \cdot f$

NOTE - The reference jack vector coefficients in table E.1 were derived from average measurements collected using a 4-balun test fixture set-up with common mode terminations applied to all near-end pairs.

For the 3,6-4,5 pair combination there is one central test plug range and an upper and lower test plug limit as shown in table E-2. For the 1,2-7,8 pair combination there is one test plug range. For all other pair combinations, there are two worst case test plug requirements for each pair combination. All test plugs, except for that used for the 3,6-4,5 central test plug, shall perform at or outside the specified limit from 10 MHz to 250 MHz. With the exception of the 1,2-7,8 pair combination over the frequency range of 10-250 MHz, no test plug shall be below the lower limit at one frequency point and above the upper limit at another frequency point.

NOTES,

1. It is desirable to minimize slope deviation from 20 dB/decade.
2. It is desirable to minimize the amount by which the test plug is outside the test limit.
3. The use of a reference jack as specified will improve measurement consistency when using the same reference jack design. Refer to annex H for information on verification of the reference jack design and the accuracy of the jack vectors

Plugs which exhibit worst case performance on one pair combination should be within the limits on all other pair combinations. However, it is not necessary to have 12 plugs if more than one worst case condition is covered by a particular plug.

Table E.2 – Category 6 de-embedded test plug NEXT loss limits

<table>
<tr><th rowspan="2">Pair combination</th><th rowspan="2">Frequency range (MHz)</th><th colspan="3">Total Range</th><th rowspan="2">Phase [1), 2), 6)] (degrees)</th></tr>
<tr><th>Lower limit NEXT[3)] loss (dB)</th><th>Central limit NEXT [4)] loss (dB)</th><th>Upper limit NEXT [5)] loss (dB)</th></tr>
<tr><td>3,6-4,5</td><td>10-250</td><td>≥ 36.4-20log(f/100)</td><td>≥ [37.0 ± 0.2] -20log(f/100)</td><td>≤ 37.6-20log(f/100)</td><td>-90 ± (1· f/100)</td></tr>
<tr><td></td><td></td><td colspan="2">Lower limit NEXT loss[4)] (dB)</td><td>Upper limit NEXT [3)] loss (dB)</td><td></td></tr>
<tr><td>1,2-3,6</td><td>10-250</td><td colspan="2">≥ 46.5-20log(f/100)</td><td>≤ 49.5-20log(f/100)</td><td>-90 ± (3· f/100)</td></tr>
<tr><td>3,6-7,8</td><td>10-250</td><td colspan="2">≥ 46.5-20log(f/100)</td><td>≤ 49.5-20log(f/100)
(TBD)</td><td>-90 ± (3· f/100)
(TBD)</td></tr>
<tr><td></td><td></td><td colspan="2">Lower limit NEXT loss for positive phase</td><td>Lower limit NEXT loss for negative phase</td><td></td></tr>
<tr><td>1,2-4,5</td><td>10-250</td><td colspan="2">≥ 57-20log(f/100)</td><td></td><td>90 ± (30· f/100)</td></tr>
<tr><td>1,2-4,5</td><td>10-250</td><td colspan="2"></td><td>≥ 70-20log(f/100)</td><td>(any phase)</td></tr>
<tr><td>4,5-7,8</td><td>10-250</td><td colspan="2">≥ 57-20log(f/100)</td><td></td><td>90 ± (30· f/100)</td></tr>
<tr><td></td><td></td><td colspan="3">Lower limit NEXT loss</td><td></td></tr>
<tr><td>4,5-7,8</td><td>10-250</td><td colspan="3">≥ 70-20log(f/100)</td><td>(any phase)</td></tr>
<tr><td>1,2-7,8</td><td>10-250</td><td colspan="3">≥ 60-20log(f/100)</td><td>(any phase)</td></tr>
<tr><td colspan="6">1) When the measured plug NEXT loss is greater than 70 dB, the phase requirement does not apply.</td></tr>
<tr><td colspan="6">2) Due to measurement accuracy considerations, phase measurement requirements below 50 MHz are specified for information only.</td></tr>
<tr><td colspan="6">3) When lower limit NEXT loss calculations result in values greater than 70 dB, there shall be no lower limit for NEXT loss.</td></tr>
<tr><td colspan="6">4) When central limit NEXT loss calculations result in values greater than 70 dB, there shall be no upper central for NEXT loss.</td></tr>
<tr><td colspan="6">5) When upper limit NEXT loss calculations result in values greater than 70 dB, the upper limit NEXT shall revert to a limit of 70 dB.</td></tr>
<tr><td colspan="6">6) When phase calculations result in values less than ± 0.5 degrees, the phase limit shall revert to a limit of ± 0.5 degrees.</td></tr>
</table>

NOTE – An alternative procedure for qualification of test plug NEXT loss may be used if equivalent or better accuracy can be demonstrated.

E.3.2.2 Test plug de-embedded FEXT loss

De-embedded FEXT loss shall be measured in accordance with annex F. For each of the six (6) pair combinations, the measured test plug de-embedded FEXT loss shall fall in the ranges shown in table E.3.

Table E.3 – Category 6 de-embedded test plug FEXT loss limits

Pair combination	Frequency range (MHz)	Total Range		Phase 1), 2) (degrees)
		Lower limit FEXT loss4) (dB)	Upper limit FEXT 3) loss (dB)	
3,6-4,5	10-250	≥ 46-20log(f/100) (TBD)	≤ 56-20log(f/100) (TBD)	-60 ± (30· f/100) (TBD)
1,2-3,6	10-250	≥ 46-20log(f/100) (TBD)	≤ 56-20log(f/100) (TBD)	-70 ± (30· f/100) (TBD)
3,6-7,8	10-250	≥ 46-20log(f/100) (TBD)	≤ 56-20log(f/100) (TBD)	-70 ± (30· f/100) (TBD)
1,2-4,5	10-250	≥ 55-20log(f/100) (TBD)		any phase
4,5-7,8	10-250	≥ 55-20log(f/100) (TBD)		any phase
1,2-7,8	10-250	≥ 55-20log(f/100) (TBD)		any phase

1) When the measured plug FEXT loss limit is greater than 70 dB, the phase requirement does not apply.

2) Due to measurement accuracy considerations, phase measurement requirements below 50 MHz are specified for information only.

3) When upper limit FEXT loss calculations result in values greater than 70 dB, there shall be no upper limit for FEXT loss.

4) When lower limit FEXT loss calculations result in values greater than 70 dB, the lower limit FEXT shall revert to a limit of 70 dB.

E.3.2.3 Test plug differential and differential plus common mode verification

For increased consistency between laboratories, the difference between the measured test plug de-embedding NEXT loss using differential mode terminations and the measured test plug de-embedding NEXT loss using differential with common mode terminations shall fall within the ranges shown in table E.4 for each of the six pair combinations. Test plug differential and differential with common mode NEXT loss consistency shall be measured in accordance with annex I.

Table E.4 – Test plug differential and differential with common mode consistency

Pair combination	Frequency range (MHz)	Test plug limit (dB) MAG_{cm_dm}
3,6-4,5	10-250	$\leq 65 - 20\log(f/100)$
1,2-3,6	10-250	$\leq 65 - 20\log(f/100)$
3,6-7,8	10-250	$\leq 65 - 20\log(f/100)$
1,2-4,5	10-250	$\leq 70 - 20\log(f/100)$
4,5-7,8	10-250	$\leq 70 - 20\log(f/100)$
1,2-7,8	10-250	no requirement

E.3.2.4 Test plug delay and port extension

The test plug delay and port extension procedure improves phase angle measurements by reducing delay uncertainty. The procedure specifies a 2-port measurement of time delay differences between a reference plug and a 150 mm (6 in) through calibration standard. Assumptions made in deriving these differences include NEXT loss round-trip lengths, through versus reference plug lead lengths, and plug lead length symmetry.

E.3.2.4.1 Calibration and reference plane location

A full 2-port calibration with the baluns connected back-to-back using dual pins that are as short as possible for the through calibration or a full 2-port calibration with the baluns in fixed positions (not back to back) using a through connection shall be performed to establish the reference plane location at the balun port. Follow the equipment manufacturers procedures for full 2-port calibration. The phase shall be calibrated per the network analyzer manufacturer's instructions in order to account for the length of the through calibration device.

E.3.2.4.2 Port extension time constant calculation

The time constant for the port extension shall be determined in the following manner:

1. Construct a de-embedding reference plug per the requirements of annex D of ANSI/TIA/EIA-568-B.2 and cut off the resistors.
2. Construct a de-embedding reference jack per the requirements of clause E.3.2.1, but place 76 mm (3 in) long twisted-pair leads (qualified the same way as the twisted-pair test leads for the de-embedding reference jack) on the PWB in place of the resistors. Ensure that tip and ring conductors are connected correctly through all steps.
3. Set the network analyzer to measure S21 delay.
4. Set the network analyzer averaging function to a minimum of 4X.
5. Set the network analyzer smoothing function to 10 %.
6. Set the network analyzer IFBW to 300 Hz or less.
7. Perform a full 2-port calibration as described in clause E.3.2.4.1.
8. Mate the de-embedding reference plug constructed in step 1 to the de-embedding reference jack constructed in step 2. Measure and record the delay on all four pairs from plug to jack (i.e. measure the delay of pair 1 by connecting pair 1 of the plug to port 1 and pair 1 of the jack to port 2).
9. Mate the test plug to the de-embedding reference jack constructed step 2. Measure the delay on all four pairs as described in step 8.
10. Determine the average of the delays measured at 50 MHz and 100 MHz for the reference plug and test plug.
11. Calculate the difference in delay between the test plug and the reference plug for each pair combination as shown for pair 1 to pair 2 in equation (E-1).

$$\Delta Delay_{1\rightarrow 2} = [AVGDelay_{50,100}tp1 + AVGDelay_{50,100}tp2] - [AVGDelay_{50,100}rp1 + AVGDelay_{50,100}rp2] \quad \text{(E-1)}$$

12. Connect a twisted-pair test reference lead that is twice the length of the reference plug lead length (measured from nose to tail) and constructed of the same material through between the baluns and measure the delay of the test lead.
13. Determine the average delay of the reference test lead from 50 MHz through 100 MHz.
14. Calculate the port extension time constant for each pair as shown in equation (E-2)

$$PECons_{pair} = \Delta Delay_{pair} + \frac{AVGDelay_{50,100}through\_lead}{2} \quad \text{(E-2)}$$

15 When the test plug NEXT loss is measured per annex D of ANSI/TIA/EIA-568-B.2, the following steps shall be done after calibration:

1 Turn the port extensions of the network analyzer on.
2 Enter the port extension constant for each port (1 and 2) of the network analyzer corresponding to the results for each pair from step 14.
3 The tp-rj data and the TIA jack vector data reference planes are now be aligned.

E.4 NEXT loss

E.4.1 NEXT loss testing

Modular connector performance on all pair combinations shall be qualified with the full set of 12 test plugs specified in table E.2. With the exception of the upper and lower test plugs specified for the pair combination terminated on pins 3,6-4,5, mated modular connector NEXT loss shall satisfy the requirements of equation (13). When mated to test plugs compliant with upper and lower test plug requirements specified for the pins terminated on pairs 3,6-4,5, mated modular connector NEXT loss shall meet the values determined using equation (E-3).

$$NEXT_{conn} \geq 52.5 - (f/100) \text{ dB (TBD)} \qquad \text{(E-3)}$$

E.4.2 NEXT loss measurement accuracy

This test procedure is expected to yield a mated NEXT loss accuracy of ± 3 dB (TBD) at 100 MHz and ± 6 dB (TBD) at 250 MHz.

E.5 FEXT loss

E.5.1 FEXT loss testing

Modular connector FEXT loss performance shall be qualified using test plugs that satisfy the ranges specified in table E-3.

E.5.2 FEXT loss measurement accuracy

This test procedure is expected to yield a mated FEXT loss accuracy of ± 1 dB (TBD) at the category 6 connecting hardware limits.

E.6 Return loss

E.6.1 Return loss test lead considerations

A 76 mm (3.0 in) maximum length twisted-pair lead shall be used to connect the device under test to the network analyzer balun interface. For connecting hardware return loss measurements, the twisted-pair lead shall have a return loss of greater than 27 dB for all frequencies from 1 to 250 MHz, relative to the calibration resistor specified in annex B of ANSI/TIA/EIA-568-B.2.

E.6.2 Return loss measurement accuracy

Measurement accuracy is highly affected by the accuracy of the reference load and return loss properties of interconnect leads. Refer to annexes H and I of ANSI/TIA/EIA-568-B.2 for guidelines on estimating measurement accuracy, establishing values for directivity, tracking, and source match and return loss of terminations.

Annex F De-embedded FEXT loss test procedure (normative)

F.1 Scope

This annex specifies the de-embedded FEXT loss measurement procedure for 100 Ω UTP modular test plugs used in characterizing the performance of eight-position modular (IEC 60603-7 compatible) connecting hardware. The procedures specified in this annex supplement the de-embedding NEXT loss test method that is provided in annex D of ANSI/TIA/EIA-568-B.2. Test equipment design calibration and fixturing should ensure a noise level 30 dB below the required measurement limit over the frequency range of 1 MHz to 250 MHz. When implemented properly, this qualification procedure assures that accurate and repeatable transmission test measurements will be performed with minimal variations between test facilities and personnel. It should be noted that the same plug qualification requirements apply to transmission testing in either direction. The test equipment, baluns, and fixtures used to measure de-embedded FEXT loss shall meet all requirements of annexes C and E. It is recommended that all DUTs, including reference plugs, reference jacks, and test plugs, have sockets with 2.5 mm (0.1 in) spacing applied to the ends of their test leads to facilitate a consistent interfacing with the baluns.

NOTE – An alternate procedure for qualification of test plug FEXT loss may be used if equivalent or better accuracy can be demonstrated. One such procedure, using a coaxial termination reference jack, is provided in informative annex J.

F.2 Applicability

For the purposes of this Standard, a modular test plug consists of short lengths of solid or stranded UTP twisted-pair conductors with a modular plug terminated on one end. Modular test plugs may be constructed from cross-connect (patch) and equipment cords.

F.3 General test plug requirements

Because of variations that are inherent to terminating twisted-pair cables to modular plugs (and to a lesser extent, modular jacks), the following requirements and guidelines have been developed to verify modular connecting hardware performance. The de-embedding procedure is expected to yield a mated FEXT loss accuracy of ±1 dB at the category 6 connecting hardware test limit.

F.4 De-embedding reference FEXT plug test lead construction

De-embedded reference FEXT plugs are constructed from solid twisted-pair conductors from category 6 (or better) cross-connect wire. All twisted-pairs shall be of the same color, design, and twist rate. Caution shall be used to minimize air gaps between the conductors of the pair. These twisted pair lengths shall have return loss in excess of 35 dB from 1 MHz to 100 MHz when measured using a terminating reference 100 Ω load as specified in clause B.5.2 of ANSI/TIA/EIA-568-B.2.

The de-embedded reference FEXT plug is shown in figure F.1.

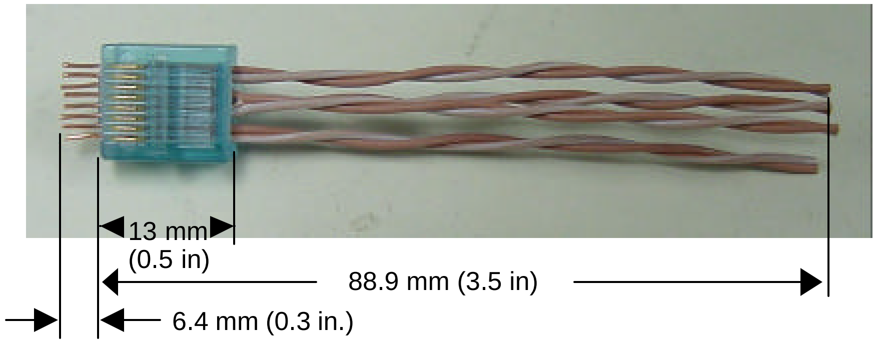


Figure F.1 – De-embedding reference FEXT plug without sockets

To construct the reference FEXT plug, take a standard plug body that conforms to the dimensional requirements of IEC 60603-7 in which the 8 conductors are parallel for 13.0 mm (0.5 in) and at the same height. Mill off the back end, where the strain relief is, so that the plug is 13.0 mm (0.5 in) long from the plug nose where the contacts are to the back of the plug. Using a 1.0 mm (0.04 in) diameter drill, drill 8 conductor paths through the nose, so that the individual wires can be extended through the nose. Untwist 19.4 mm (0.8 in) of one end of four 88.9 mm (3.5 in) long twisted-pair wires. Strip off 6.4 mm (0.3 in) of insulation from the untwisted end and place the leads in the plug. They shall be inserted far enough so that 6.4 mm (0.3 in) extends from the nose of the plug. All of the insulation on all 8 wires extending from the nose of the plug shall be removed. All of the twisted-pair lead length coming out of the back of the plug shall remain twisted. The pair terminated on pins 3,6 will have to be split apart, but the pair should be bent together as soon as practical after it exits from the back of the plug. On the back end of the plug, insert the pair terminated on pins 3,6 toward the locking tab and the pair terminated on pins 4,5 away from the locking tab.

Set the plug blades into the wires. Verify continuity.

Remove some insulation from the ends of the four twisted-pair test leads so that the total length from the nose of the plug to the end of the insulation, as shown in figure F.2, is 76.2 mm (3.0 in). Install sockets at 2.5 mm (0.1 in) centers to the ends of the twisted-pair test leads as shown in figure F.2 and trim the excess bare conductors so that the overall length of the twisted-pair test leads measured from the nose of the plug to the top of the socket pin is 76.2 mm (3.0 in).

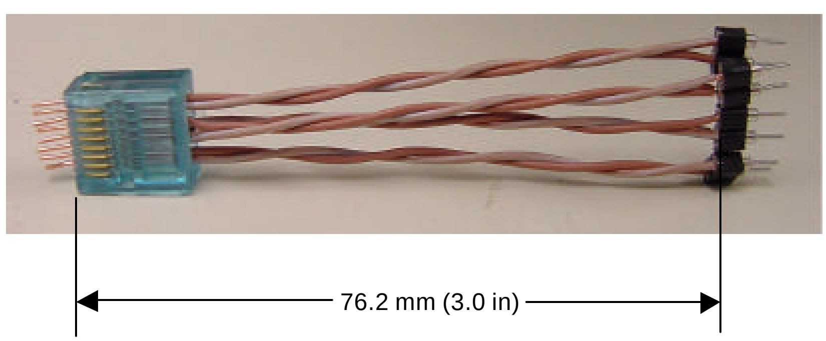


Figure F.2 – De-embedding reference FEXT plug with sockets

F.5 De-embedding reference FEXT plug mated to PWB

Carefully solder the twisted-pair conductors extending from the nose of the reference FEXT plug onto a Stewart Connector part number R022299, Rev. B PWB with 100 ohm controlled impedance traces. An equivalent PWB may also be used. Exercise caution not to bridge solder between the PWB solder pads. Keep the solder joints small and uniform as shown in figure F.3. Cut the excess twisted-pair lead length off as close to the PWB as possible.

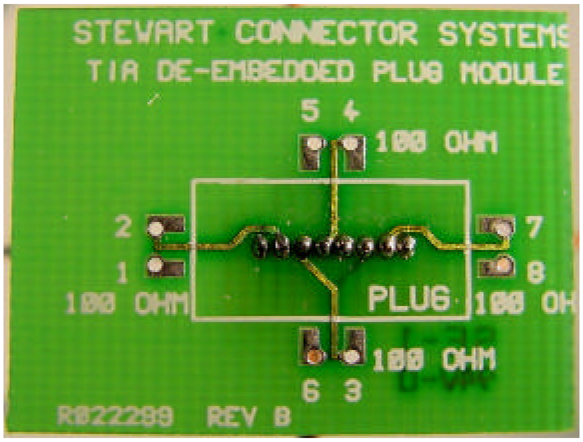


Figure F.3 – Reference FEXT plug mated to PWB

F.6 De-embedding reference FEXT plug test lead orientation

Position the twisted-pair test leads pairs apart as they exit from the plug body at an angle of 45 ° as shown in figure F.4. Pair 3,6 should be bent towards the plug tab, and pair 4,5 should be bent towards the plug blades. Apply a small amount of hot glue to the back end of the plug to secure the twisted-pair test leads in place.

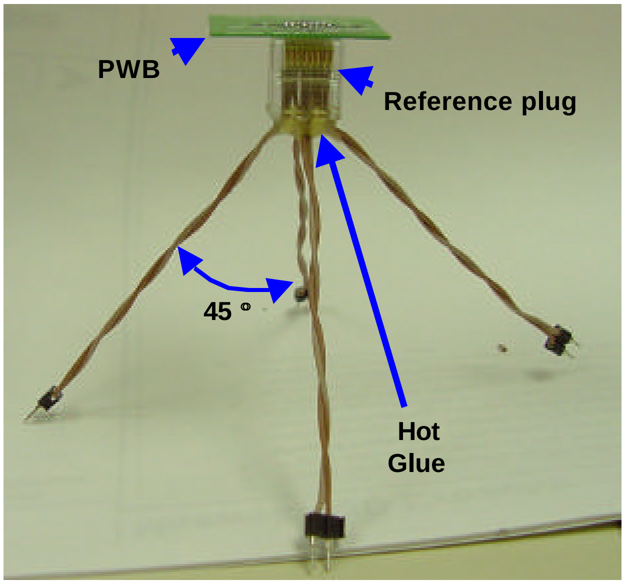


Figure F.4 – Reference FEXT plug test lead position

F.7 FEXT reference plug assembly

Solder four 76.2 mm (3.0 in) twisted-pair conductors to the top of the reference FEXT plug assembly as shown in figure F.5. Install 2.5 mm (0.1 in) spaced SIP IC sockets to the ends of the twisted-pair test leads.

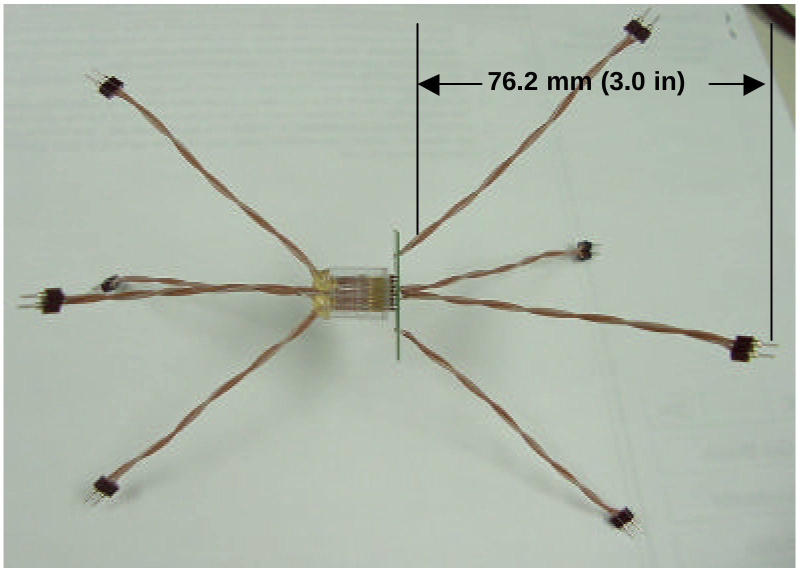


Figure F.5 – Reference FEXT plug assembly

F.8 FEXT reference plug measurement

Measure the FEXT loss of the test plug on all 12 pair combinations as described below.

F.8.1 FEXT reference plug measurement set-up

Common and differential mode terminations shall be applied to at least one end of the reference plug assembly. Test baluns at both the near-end and far-end shall be bonded to a continuous ground plane. Measurements shall be collected using either an 8-balun or a 5-balun test set-up.

F.8.2 FEXT reference plug measurement calibration

Test equipment shall be calibrated using a full 2-port calibration. The thru calibration reference shall be constructed from a 152.4 mm (6.0 in) segment of the same twisted-pair material used for the FEXT reference plug test leads with IC sockets attached to each end as shown in figure F.6.

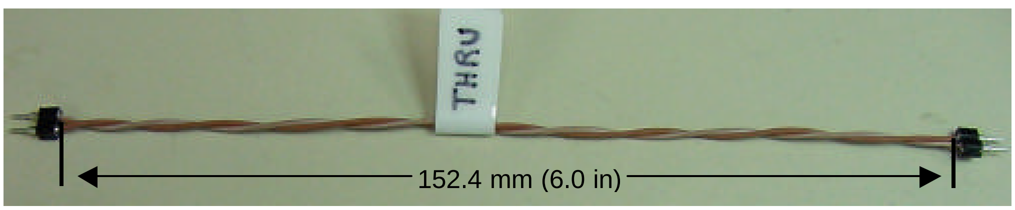


Figure F.6 – Thru calibration reference

F.8.3 FEXT reference plug data

Data shall be collected using a linear sweep with measurement points at 1 MHz interval from 1 to 250 MHz. Measure the real and imaginary FEXT loss vector of the de-embedding reference plug assembly for all 12 pair combinations.

F.9 FEXT reference jack assembly

Solder four 76.2 mm (3.0 in) twisted-pair test leads to the back of the de-embedded reference jack/PWB assembly specified in clause E.3.2.1 as shown in figure F.7. Install 2.5 mm (0.1 in) spaced SIP IC sockets to the ends of the twisted-pair test leads. Trim the jack wire leads that project through the PWB to the top of the solder. The top of the solder shall not be more than 1.0 mm (0.04 in) above the PWB.

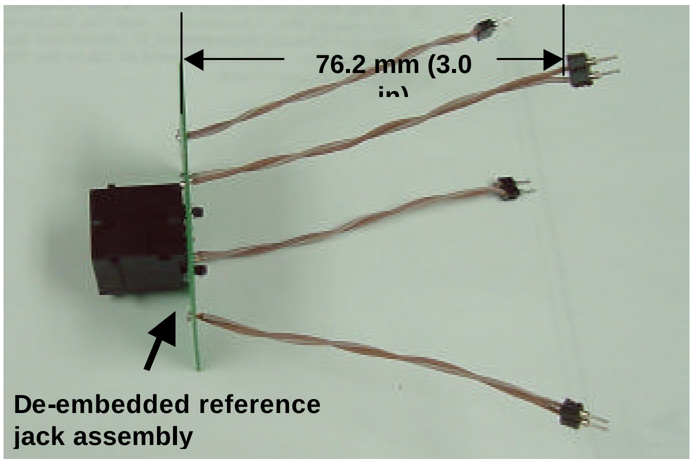


Figure F.7 – Test leads connected to de-embedded reference jack/PWB assembly

F.10 De-embedding reference jack FEXT assembly measurement

Carefully un-solder the reference FEXT plug from the PWB and clip the left-over solder ends to the edge of the plug. Measure the FEXT loss of the de-embedding reference FEXT plug mated to the de-embedding reference jack assembly for all 12 pair combinations as shown in figure F.8.

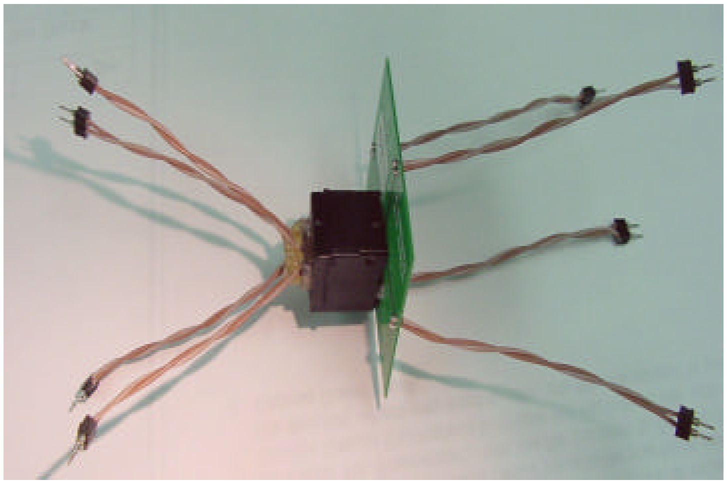


Figure F.8 – Reference FEXT plug mated to reference jack/PWB assembly

Calculate the FEXT loss vector of the reference FEXT jack as the difference between the mated plug and jack/PWB assembly vector and the reference plug vector at each measurement frequency. The FEXT loss components of the unmated reference jack, Re_J and Im_J, are calculated using equations (F-1) and (F-2).

$$\mathrm{Re}_j = (\mathrm{Re}_{PJ} - \mathrm{Re}_P) \quad \text{(F-1)}$$

$$\mathrm{Im}_J = (\mathrm{Im}_{PJ} - \mathrm{Im}_P) \quad \text{(F-2)}$$

F.11 Test plug FEXT measurement

Test plug FEXT measurements shall be collected using the same method as test plug NEXT measurement specified in clause D.5.9 of ANSI/TIA/EIA-568-B.2.

Annex G Cable installation in higher temperature environments (informative)

G.1 General

Cables may be installed in return air plenums, in ceiling spaces, riser shafts and non air-conditioned buildings such as warehouses and manufacturing plants where the temperature can be significantly higher than 20° C. In order to ensure compliance with the channel insertion loss specified in clause 7.1.3, the horizontal cable distance may need to be reduced below 90 meters depending upon the average temperature of the environment over the length of the cable, the insertion loss margin of the installed cabling, and the insertion loss temperature coefficient of the cable.

G.2 Allowance for cable temperature

Table G.1 shows the maximum horizontal cable length de-rating at various temperatures assuming a cable insertion loss temperature coefficient of 0.4 % per degree Celsius.

Table G.1 – Maximum horizontal cable length de-rating factor for different temperatures

Temperature (°C)	Temperature (°F)	Maximum horizontal cable length (m)	Length de-rating (m)
20	68	90.0	0
25	77	89.0	1.0
30	86	87.0	3.0
35	95	85.5	4.5
40	104	84.0	6.0
45	113	82.5	7.5
50	122	81.0	9.0
55	131	79.5	10.5
60	140	78.0	12.0

NOTE - This table assumes that the channel includes 10 meters of patch and equipment cords at 20° C.

G.3 Installation example

If a cable is installed in an environment where the temperature averaged over the length of the cable can be as high as 40° C, then the maximum horizontal cable distance should be reduced from 90 meters to 84 meters.

Annex H De-embedding reference NEXT jack design verification procedure (informative)

H.1 Scope

The performance of a particular laboratory de-embedded reference NEXT jack design can be compared to the reference jack vectors specified in clause E.3.2.1 by using the de-embedding procedures specified in D.5 of ANSI/TIA/EIA-568-B.2.

H.2 Measurement sampling plan

The performance of a particular laboratory de-embedded reference NEXT jack design can be verified by determining the NEXT loss vector of multiple jack samples using one reference plug. A reference jack design sample size of 20 pieces is recommended. The performance of the measured jack vector for all samples is averaged and the standard deviation for the sample lot is computed. Averages and standard deviations should fall within the ranges specified in table H.1.

Table H.1 – Reference jack, plug, and fixture sample variation

Reference jack NEXT vector pair combination	2 Sigma repeatability at 100 MHz	2 Sigma repeatability at 250 MHz
3,6 – 4,5	± 0.8 dB	± 0.8 dB
1,2 – 3,6	± 0.8 dB	± 1.3 dB
3,6 – 7,8	± 1.4 dB	± 1.8 dB
1,2 – 4,5	± 1.1 dB	± 1.9 dB
4,5 – 7,8	± 1.2 dB	± 1.2 dB
1,2 – 7,8	± 10.3 dB	± 5.6 dB

De-embedded reference jacks whose variances fall outside of the ranges specified in table H.2 should be discarded. The reference jack selected for collecting de-embedded measurements should perform as consistently to the specified reference jack vector on all pair combinations as possible to ensure most repeatable results.

Table H.2 – Reference jack sample variation

Reference jack NEXT vector pair combination	2 Sigma repeatability 10-250 MHz
3,6 – 4,5	± 0.3 dB
1,2 – 3,6	± 0.6 dB
3,6 – 7,8	± 0.9 dB
1,2 – 4,5	± 0.9 dB
4,5 – 7,8	± 0.7 dB
1,2 – 7,8	± 1.7 dB

Annex I Test plug NEXT loss verification procedure (normative)

I.1 Scope

This annex specifies a measurement procedure for qualifying the difference between the de-embedding NEXT loss of a test plug terminated with differential mode only and differential plus common mode terminations in a particular test plug

I.2 Develop jack vectors

To develop the jack vectors, a reference plug as described in annex D of TIA/EIA-568 B.2 is constructed. It is recommended to build several reference plugs. Due to the inherent difficulties in constructing this type of plug, assembling several plugs and taking the average of their measurements can result in a higher measurement confidence level.

Follow the de-embedded test procedure outlined in annex D of ANSI/TIA/EIA-568-B.2 to develop the jack vectors. The testing should be done in two configurations. The first configuration employs differential plus common mode terminations on all of the near-end pairs. The second configuration employs the use differential mode only terminations on the near-end pairs. The result is two jack vectors: one for differential only terminations and one for differential plus common mode terminations.

> NOTE - It is not recommended to use the specified jack vector for this measurement. It is further expected that greater accuracy will be achieved if the same reference plug is used for both jack vectors.

I.3 Test plug differential and differential plus common mode consistency measurement

De-embedded NEXT loss performance for all six (6) pair combinations of the test plug is measured with both differential mode only terminations and differential plus common mode terminations.

I.4 Differential to differential plus common mode consistency calculation

The differential to differential plus common mode consistency of the test plug is calculated using equations (E-1) through (E-7).

$$RE_{cm} = RE_{tpcm} - RE_{jvcm} \quad \text{(E-1)}$$

$$IM_{cm} = IM_{tpcm} - IM_{jvcm} \quad \text{(E-2)}$$

$$RE_{dm} = RE_{tpdm} - RE_{jvdm} \quad \text{(E-3)}$$

$$IM_{dm} = IM_{tpdm} - IM_{jvdm} \quad \text{(E-4)}$$

$$RE_{cm\_dm} = RE_{cm} - RE_{dm} \quad \text{(E-5)}$$

$$IM_{cm\_dm} = IM_{cm} - IM_{dm} \quad \text{(E-6)}$$

$$MAG_{cm\_dm} = 20\log\sqrt{(RE_{cm\_dm})^2 + (IM_{cm\_dm})^2} \quad \text{(E-7)}$$

where:

cm = common mode,
dm = differential mode,
tp = test plug measurement,
jv = jack vector,
cm_dm = common to differential mode consistency values, and
MAG_{cm_dm} = differential to differential plus common mode NEXT loss consistency

Annex J Coaxial termination reference jack (informative)

J.1 Test plugs for connecting hardware

J.1.1 Scope

This clause specifies an alternate test procedure for qualifying 100 Ω UTP modular test plugs that are intended for the transmission performance verification of eight-position modular (IEC 60603-7 compatible) connecting hardware. Construction techniques and qualification of both coaxial termination reference jacks and modular test plugs are provided. When implemented properly, this qualification procedure ensures that accurate and repeatable transmission test measurements are performed with minimal variations between test facilities and personnel. It should be noted that the same plug qualification requirements apply to transmission testing in either direction.

J.1.2 Applicability

For the purposes of this Standard, a modular test plug consists of short lengths of solid or stranded UTP twisted-pair conductors with a modular plug terminated on one end. Modular test plugs may be constructed from cross-connect (patch) and equipment cords.

J.1.3 General test plug and reference jack requirements

Because of variations that are inherent to terminating twisted-pair cables to modular plugs (and to a lesser extent, modular jacks), the following requirements and guidelines have been developed to verify modular connecting hardware performance. The verification procedure is expected to yield a mated NEXT loss accuracy of ±1.5 dB (TBD) at the category 6 connecting hardware test limit.

J.1.4 Coaxial termination reference jack for NEXT loss test plug measurements

The NEXT of test plug should be tested using a coaxial termination reference jack. The construction of the coaxial termination reference jack is described in clause J.1.5

J.1.5 Coaxial termination reference jack construction

The coaxial termination reference jack should be constructed following a series of steps as described below:

1) Cut eight mini coaxial cables at a length of 81.1 mm (3.2 in). The mini coaxial cables should have an outside diameter of .86 mm (0.03 in) and should comply with MIL C-17 specification. (PE-034SR is an example of one such cable).

2) Strip the copper shield for a distance of 2.5 mm (0.1 in) from each end of the coaxial cables.

3) On one end, the near-end, solder the eight coaxial cables together approximately 2.5 mm (0.1 in) away from the edge of the outer conductor as shown in figure J.1.

4) At the same end, the near-end, bend the eight inner coaxial conductors at an angle of 90 degrees as shown in figure J.1.

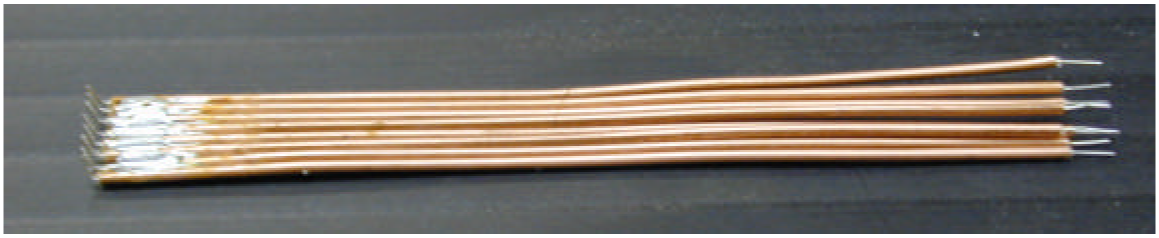


Figure J.1 – Eight coaxial pairs, stripped, soldered and prepared for assembly

5) Split the coaxial cables into pairs (1-2, 3-6, 4-5, 7-8) by bending at an angle of 45 degrees to each other as illustrated in figure J.2

6) At the opposite end, the far-end, solder 1.5 mm (0.06 in) ±0.1 % precision, chip resistors on the inner conductors of the coaxial cable pairs

7) At the far-end, solder the coaxial shield of each coaxial cable pair together approximately 2.5 mm (0.1 in) away from the resistor termination

8) Place the coaxial cable assembly carefully on the plastic housing and fix the assembly to the plastic housing with hot melt glue. Ensure that the bent inner conductors are aligned over the raised protrusions, the "teeth" of the plastic housing before applying the glue.

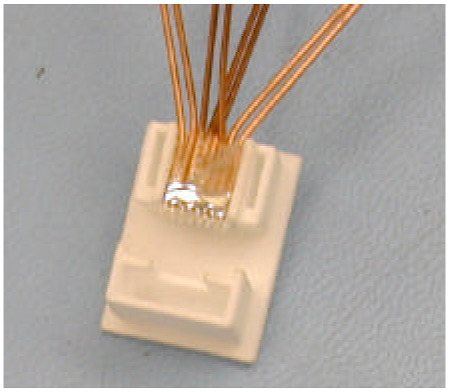


Figure J.2 –Coaxial termination assembly mounted on the plastic housing

NOTE: The plastic housing serves as the coaxial termination jack interface. The drawing for the plastic housing is shown in figure J.3.

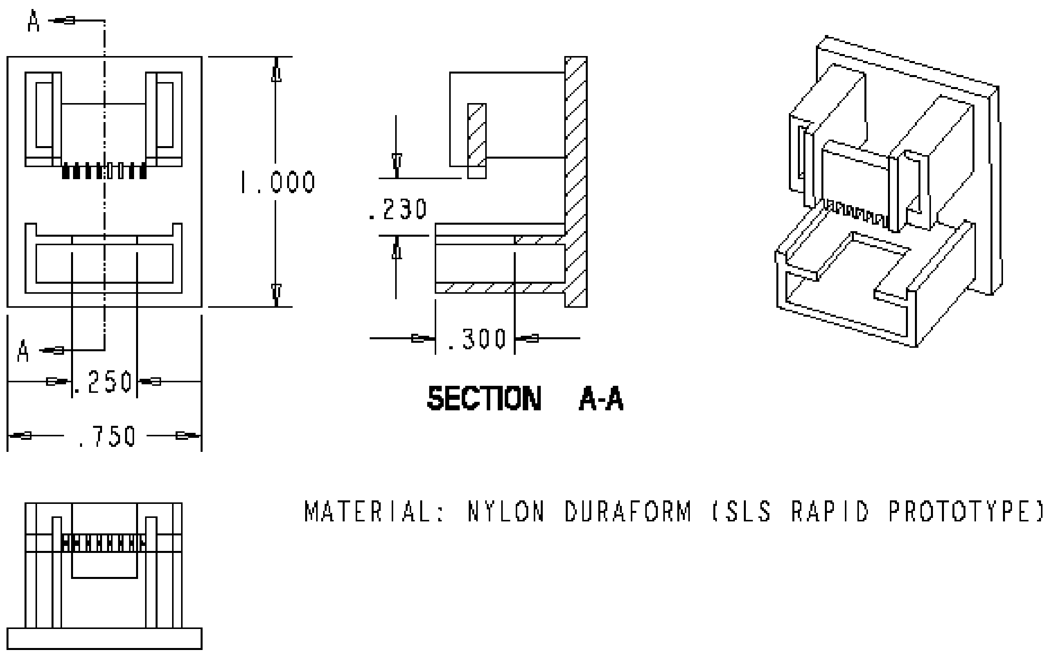


Figure J.3 – Dimensional drawing of the coaxial termination plastic housing

9) The sequence for terminating a test plug is illustrated in figures J.4 through J.6.

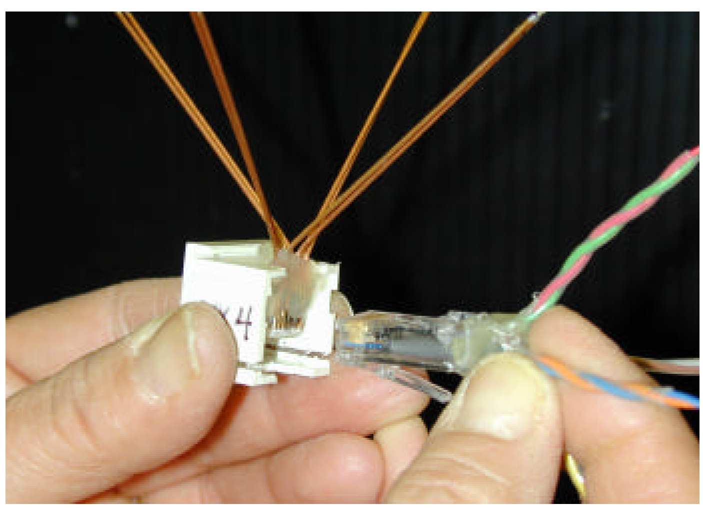


Figure J.4 – Align the opening of the plastic housing with the test plug

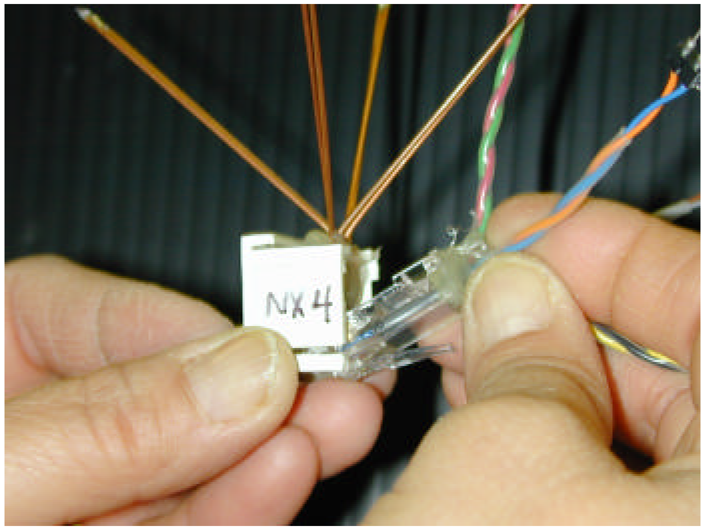


Figure J.5 – Tilt the plug at 45 degrees and carefully slide into the housing

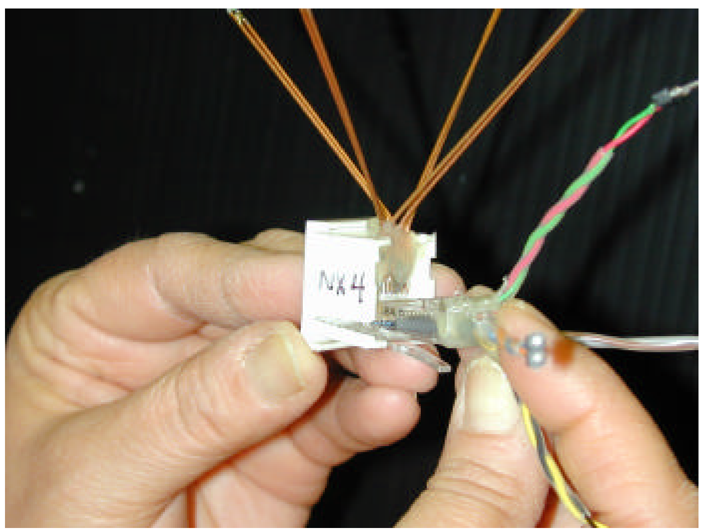


Figure J.6 – Straighten the plug and latch into place inside the housing

10) The mated test plug / coaxial termination reference jack is inserted in a test fixture consisting of four baluns that are mounted on a ground plane. An example of a test setup with a network analyzer is illustrated in figure J.7.

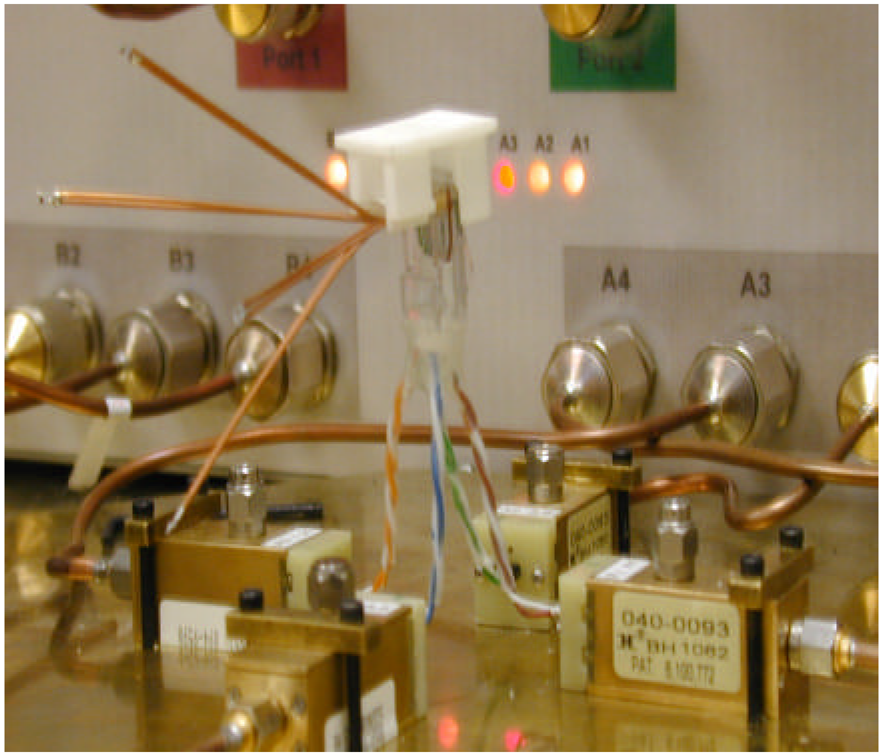


Figure J.7 – Mated plug termination assembly mounted in test fixture

J.2 Coaxial termination reference jack qualification

A set of three coaxial reference jacks should be constructed. When used to measure the NEXT loss on all six pair combinations for the same test plug, the variation in NEXT loss between measurements should be less than (TBD) mV/V over the specified frequency range.

Annex K Modular plug cord test procedure (normative) (TBD)

K.1 General

The following procedure shall be used when testing modular plug cords. Measure the NEXT loss of the configuration shown in figure K.1 using test heads qualified per annex L. The test head used at each end of the test configuration shall be of the same design.

K.2 Network analyzer test configuration

The network analyzer configuration for modular plug cord testing is described in figure K.1. Preferably, four baluns should be used to connect the modular plug cord under test to the network analyzer through 100 Ω SSTP interface cable and test heads that are qualified in accordance with annex L. Common mode terminations for all near-end pairs shall be applied as shown. Four baluns may be used at the test interface as shown, however, two baluns with differential plus common mode resistive terminations on the unused near-end pairs are preferred to reduce the effect of reflected crosstalk. Balun cases shall be bonded to a ground plane.

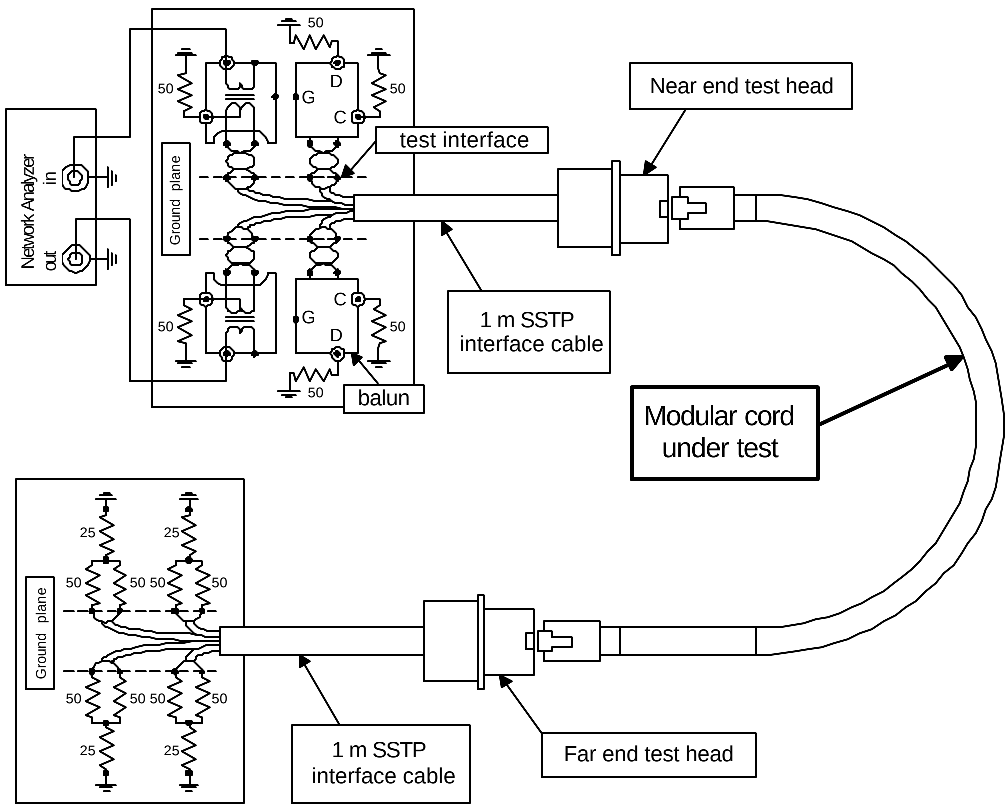


Figure K.1 - Network analyzer configuration

K.3 Modular plug cord test procedure

A minimum of 100 data points per decade shall be measured for each pair combination. Pass or fail qualification shall be determined by comparing the resulting sweeps to the NEXT loss limits calculated per clause 7.2.1.3 for the applicable frequency range. A minimum of 200 data points per decade is required to qualify cords longer than 10 m (32 ft). The pass or fail margin and the frequency at which it occurs shall be reported for each pair combination.

Patch cords shall additionally be qualified for return loss according to the requirements of clause 7.4.4.

> NOTE - Figure K.1 depicts SSTP interface cables for the modular plug cord test setup. A length of 1 m (3 ft) may be required to reduce effect of terminations on measured NEXT loss response, and to allow the use of time-domain methods to extract the localized performance of the near-end and far-end connectors. Time domain limits, however, are not specified in this standard due to the variability in observed response that is a function of the sampling rate transform algorithms (if employed).

Annex L Category 6 modular cord test head requirements (normative) (TBD)

L.1 Test plugs for category 6 modular cord test head qualification

Test plugs used for category 6 modular cord test head qualification shall conform to the requirements of annex E.

L.2 Category 6 modular cord test head NEXT loss

Category 6 modular cord test heads shall meet the requirements of clause 7.2.1.2 when tested according to the requirements of annex E and the additional requirements of this annex.

L.3 Category 6 modular cord test head return loss

Category 6 modular cord test heads shall meet the requirements of clause 7.4.3 when tested according to the requirements of annex E.

L.4 Category 6 modular cord test head FEXT loss

Category 6 modular cord test heads shall meet the requirements of clause 7.3.1.2 when tested according to the requirements of annex E.