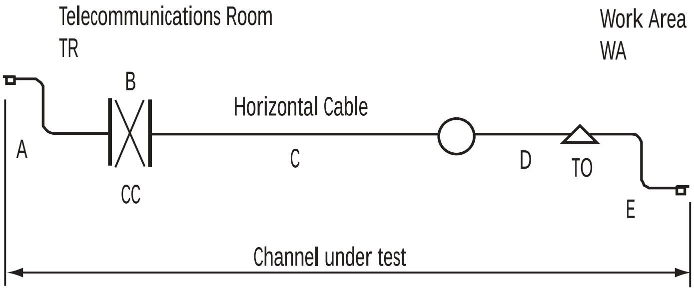
What Really Changes With Category 6

Category 6, the standard recently completed by TIA/EIA, represents an important accomplishment for the telecommunications industry. Find out which is the actual difference between Category 5e and Category 6 structured cabling systems in terms of transmission performance.

Since Category 6 standard completion and approval by TIA were finally announced at the end of June, 2002, many notes and articles were published to celebrate such a breakthrough; unquestionably of major importance for the telecommunications industry. Nevertheless, nothing definite in technical terms was shown to the market professionals. The purpose of this article is to show exactly, in terms of transmission performance electrical parameters, the actual differences between Category 5e and Category 6 systems, and what it means when put into practice.

First of all it is important to make clear that Category 6 is an addendum to ANSI/TIA/EIA-568-B.2. Therefore, this is not a new separate standard, but the first addendum to Part 2 of '568-B standard set which is a standard for the telecommunications cabling in commercial buildings *(Commercial Building Telecommunications Cabling Standard).* Officially we are referring to TIA document whose code is **ANSI/TIA/EIA-568-B.2-1-2002** : *"Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components – Addendum 1: Transmission Performance Specifications for 4-pair 100-ohm Category 6 Cabling"*, approved on 06/20/2002.

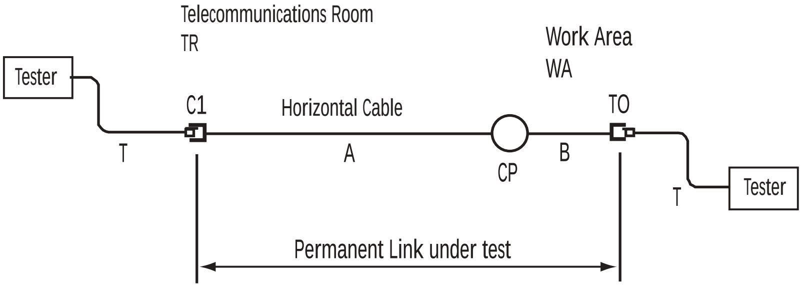
Let us go straight to the point. To begin with, both categories (5e and 6) of cabling performance for telecommunications can only recognize two configurations to perform certification tests for the installed cabling: Permanent Link and Channel. Therefore, the Basic Link configuration is no longer a configuration recognized for system testing since the publication of Category 5e standard. Figures 1 and 2 show both test configurations recognized for Categories 5e and 6. It is important to notice that in the channel test configuration, all patch cords as well as the user cord in the work area are considered. However, the permanent link model considers the horizontal cabling only, not including the patch cords, equipment cords, and work area cords. The certification tests, in this case, should be performed with adapters and cords provided by the manufacturer of the field tester used.



Cables and Cords		Connecting Hardware
Active Equipment Cord:	A	CC: Hardware Cross-connect
Cross-connect Patch Cord:	B	CP: Consolidation Point
Horizontal Cable:	C	TO: Telecommunications Outlet
Transition Cable (opt.):	D	
Work Area Cord:	E	

Maximum Allowable Lengths
C + D = 90 m (max)
A + B + E = 10 m (max)

Figure 1: Channel test configuration



Cables and Cords		Connecting Hardware	
Test Cords:	T	Telecommunications Outlet:	TO
Horizontal Cabling:	A	Consolidation Point:	CP
Transition Cable:	B (opc.)	Horizontal Cross-Connect:	C1

Maximum Length
A + B = 90 m (max)

Figure 2: Permanent link test configuration

The cables recognized by Category 6 standard are the same (mechanically) as those of Category 5e, that is, twisted pair cables (balanced) with gauges between 26 AWG and 22 AWG, including thermoplastic insulation for all solid wires, grouped into four groups of pairs surrounded by a sheath that is also made up of thermoplastic insulation. The insulation thickness can not exceed 1.22 mm, and the colour code of the pairs follows the already known standard used since the structured cabling technique was first used, that is, the colour of the pairs should be green / white, orange / white, blue / white, and brown / white. The cable outside diameter must be smaller than 6.35 mm. These characteristics are in compliance with ANSI/ICEA S-80-576 standard. Both cables have a characteristic impedance of 100-ohm and may be unshielded (UTP, Unshielded Twisted Pair) or shielded (ScTP, Screened Twisted Pair).

The fundamental difference between these cables are their frequency responses; more demanding for Category 6. The main electrical differences between Category 5e and Category 6 cables and systems are shown throughout this article.

Insertion Loss (Attenuation)

Insertion loss or attenuation is the signal power loss along its propagation through the channel (the term “channel” herein is used to refer to a transmission line and has no relation to the channel configuration for the realization of certification tests, as defined by ‘568-B standard, and previously described).

The term “insertion loss” now replaces the term “attenuation”, however, in practice there is no difference. The first started to be used as a replacement for the second in the standard documents to stress that the attenuation of the signal that propagates between a transmitter and a receiver in a communication system occurs due to the insertion of cable runs and connectors between them.

Table T1 below compares the values of this parameter for Category 5e and 6 cables.

Frequency (MHz)	Category 5e UTP Cable, solid Attenuation (dB)	Category 6 UTP Cable, solid Attenuation (dB)
0.772	1.8	1.8
1.0	2.0	2.0
4.0	4.1	3.8
8.0	5.8	5.3
10.0	6.5	6.0
16.0	8.2	7.6
20.0	9.3	8.5
25.0	10.4	9.5
31.25	11.7	10.7
62.5	17.0	15.4
100.0	22.0	19.8
200.0	—	29.0
250.0	—	32.8

Table T1: Attenuation of UTP cables, Categories 5e and 6, 100 m

In Table T1, both cables considered have solid wires. Those cables are the ones used in the horizontal cabling and backbone runs. The stranded cables are not being considered here and have transmission characteristics different from the solid cables. The insertion loss values shown for each frequency are for the same cable length Of 100 meters.

By analyzing Table T1, we can conclude that Category 6 cables show better transmission characteristics for the attenuation parameter with relation to those of Category 5e. We may notice that by reading the attenuation values for 100 MHz frequency. Category 5e cables attenuate the signal transmitted by them in 22.0 dB while Category 6 cables attenuate the signal in 19.8 dB for this same frequency. For reference purposes only, a 22 dB attenuation means that 0.6% of the transmitted signal power is received by the receiver circuit. Yet a 19.8 dB attenuation corresponds to a received power of approximately 1.1% of the transmitted signal. Such differences may seem small, but in practice they are significant.

The expression below may be used for calculating the insertion loss of Category 5e cables, for different values of frequency between 0.772 MHz and 100 MHz.

$$Attenuation_{cable,100m} \leq \left(1{,}967\sqrt{f}\right) + 0{,}023.f + \frac{0{,}050}{\sqrt{f}} \quad (\text{dB/100m}) \qquad [1]$$

To determine Category 6 cable attenuation between 0.772 and 250 MHz, the expression below should be used:

$$Attenuation_{cable,100m} \leq \left(1{,}808\sqrt{f}\right) + 0{,}017.f + \frac{0{,}2}{\sqrt{f}} \quad (\text{dB/100m}) \qquad [2]$$

The expressions [1] and [2] above are applicable to solid wires only, and to frequency ranges defined for each corresponding performance category.

Table T2 below shows the insertion loss values for the connecting hardware (connectors, blocks, patch panels, etc.) for Categories 5e and 6.

Frequency (MHz)	Category 5e Attenuation (dB)	Category 6 Attenuation (dB)
1.0	0.1	0.10
4.0	0.1	0.10
8.0	0.1	0.10
10.0	0.1	0.10
16.0	0.2	0.10
20.0	0.2	0.10
25.0	0.2	0.10
31.25	0.2	0.11
62.5	0.3	0.16
100.0	0.4	0.20
200.0	—	0.28
250.0	—	0.32

Table T2: Connecting hardware attenuation for Categories 5e and 6

According to the values shown in Table T2, we may also notice that the attenuation due to the connecting hardware in a channel is smaller for Category 6 systems than Category 5e systems.

All values shown in previous tables are the worst case, that is, attenuation values shown by the worst pair of the four pairs of UTP cables.

Table T3 shows the insertion loss values for Category 5e and Category 6 cabling systems.

Frequency (MHz)	Category 6 Channel 100 m Attenuation (dB)	Category 6 Permanent Link 90 m Attenuation (dB)
1.0	2.2	2.1
4.0	4.5	4.0
8.0	6.3	5.7
10.0	7.1	6.3
16.0	9.1	8.0
20.0	10.2	9.0
25.0	11.4	10.1
31.25	12.9	11.4
62.5	18.6	16.5
100.0	24.0	21.3
200.0	—	31.5
250.0	—	35.9

Table T3: Insertion loss for Category 5e and 6 channels

For the construction of Table T3, the channel configuration is considering the four-connector model, which is the most complete channel model accepted by the standard. The numbers shown refer to the worst-case channel insertion loss values.

Figure 3 shows graphically the IL response for Cat. 5e and Cat. 6 channels.

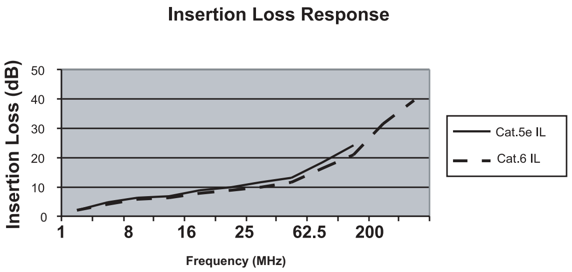


Figure 3: Insertion Loss response for Category 5e and 6 channels

Near End Crosstalk Loss (NEXT Loss)

Near End Crosstalk (or NEXT) is an interference of a signal, which propagates through a pair coupled into an adjacent pair at the nearest end of the interfering source (the end where the signal was generated or transmitted). When such interference occurs between close pairs of different cables, we call it an Alien Crosstalk phenomenon.

It is worth to highlight here that, by its nature, the Near End Crosstalk (NEXT) is not subject to the cable run length between a given transmitter and receiver. So it is expected that the values obtained for this parameter do not suffer important variations as function of the channel length.

It is also important to observe that all transmission electrical parameters, invariably, show worse values as higher is the frequency considered. So, in terms of interference, the higher the frequency, the higher the noise coupled by the interfered pair, or the smaller the electrical insulation between the interfering pair and the interfered pair. NEXT Loss or Near End Crosstalk loss “parameter” refers precisely to the insulation between the pairs in the event of an interference caused by NEXT. The higher the value of such “parameter” the greater the insulation between the considered pairs, and therefore, the smaller the interference by Near End Crosstalk (NEXT). The opposite is also true. Figure 4 presents the interference mechanisms by Near End Crosstalk (NEXT) and Far End Crosstalk (FEXT).

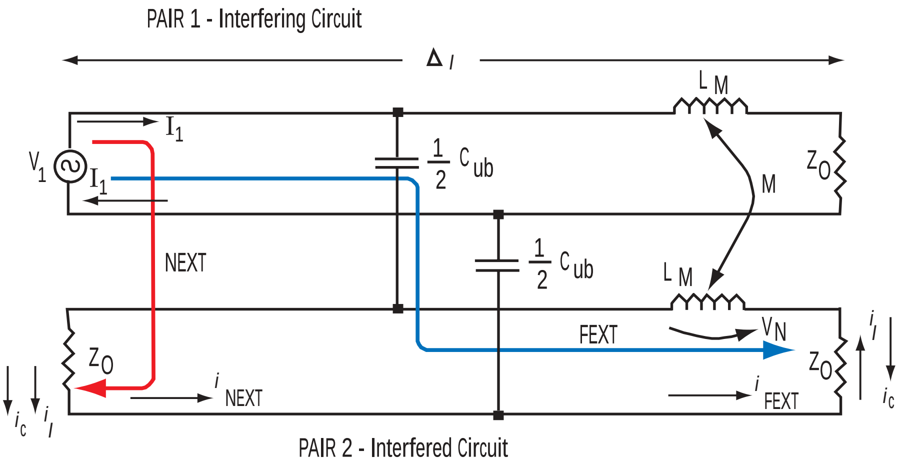


Figure 4: Interference mechanisms by NEXT and FEXT

There are two standardized methodologies for the Near End Crosstalk loss test, the pair-to-pair test and the powersum test. In the first case, the test is performed considering that only one pair is transmitting a signal at a given time, and the remaining pairs are not being used. In such condition, we may determine which is the interference level between each two-pair combination inside a four-pair UTP cable.

The powersum test evaluates the sum of the interfering signals propagating simultaneously through three pairs of the cable over the idle fourth pair. The powersum test is a better indicator of the interference ratios among the pairs inside a cable, because it takes into consideration that it is being used to its utmost limit (at least in terms of number of pairs inside the cable).

Table T4 shows the pair-to-pair Near End Crosstalk loss values as a function of the frequency for Category 5e and 6 solid UTP cables.

Frequency (MHz)	Pair-to-Pair NEXT Loss (dB) Category 5e Cable, solid	Pair-to-Pair NEXT Loss (dB) Category 6 Cable, solid
0.150	—	86.7
0.772	67.0	76.0
1.0	65.3	74.3
4.0	56.3	65.3
8.0	51.8	60.8
10.0	50.3	59.3
16.0	47.2	56.2
20.0	45.8	54.8
25.0	44.3	53.3
31.25	42.9	51.9
62.5	38.4	47.4
100.0	35.3	44.3
200.0	—	39.8
250.0	—	38.3

Table T4: Pair-to-pair NEXT loss values for Category 5e and 6 UTP cables

The values shown in Table T4 are the worst case, that is, for the pair combination causing the worse interference ratio due to Near End Crosstalk of an UTP cable. We may notice, then, that Category 6 cables provide a greater insulation in regards to NEXT interference (higher value of NEXT Loss) than Category 5e cables. An example is the NEXT loss values at 100 MHz frequency, which is 35.3 dB for Category 5e cables, and 44.3 dB for Category 6 cables.

Table T5, below, shows the same interference ratios for powersum NEXT Loss (PS-NEXT Loss).

Frequency (MHz)	Powersum NEXT (dB) Loss Category 5e Cable, solid	Powersum NEXT (dB) Loss Category 6 Cable, solid
0.150	74.7	84.7
0.772	64.0	74.0
1.0	62.3	72.3
4.0	53.3	63.3
8.0	48.8	58.8
10.0	47.3	57.3
16.0	44.2	54.2
20.0	42.8	52.8
25.0	41.3	51.3
31.25	39.9	49.9
62.5	35.4	45.4
100.0	32.3	42.3
200.0	—	37.8
250.0	—	36.3

Table T5: Powersum NEXT loss values for Category 5e and 6 UTP cables

The electrical insulation between the pairs for the powersum NEXT loss condition is smaller, as expected, that is, in such a condition the Near End Crosstalk interference is greater, and therefore the safe limits for ensuring certain more demanding applications (full duplex applications for instance) may be determined taking as a reference this Near End Crosstalk loss test method.

It is also clear here that Category 5e cables are more susceptible to Near End Crosstalk interference than Category 6 cables. For instance, we may take the values for both at a frequency of 100 MHz. For Category 6 cables the PS-NEXT loss is 42.3 dB (greater insulation) and for Category 5e cables 32.3 dB (smaller insulation).

Table T6 shows the PS-NEXT values for Cat. 5e and Cat. 6 cabling channels.

Frequency (MHz)	Category 6 Channel 100 m Attenuation (dB)	Category 6 Permanent Link 90 m Attenuation (dB)
1.0	>57	62.0
4.0	50.5	60.5
8.0	45.6	55.6
10.0	44.0	54.0
16.0	40.6	50.6
20.0	39.0	49.0
25.0	37.3	47.3
31.25	35.7	45.7
62.5	30.6	40.6
100.0	27.1	37.1
200.0	—	31.9
250.0	—	30.2

Table T6: PS-NEXT loss values for Category 5e and Category 6 channels

Figure 5 shows, graphically, the PS-NEXT responses for Cat. 5e and Cat. 6 channels.

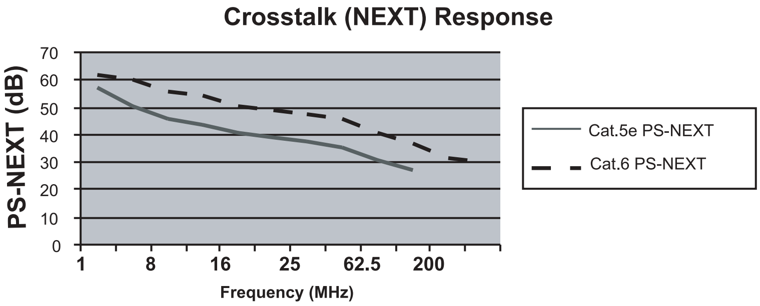


Figure 5: PS-NEXT Loss responses for Category 5e and 6 channels

For illustration purposes only, Table T7 shows the PS-NEXT values for Category 6 channel (cable and connecting hardware) and permanent link configurations.

Frequency (MHz)	Category 6 Channel 100 m PS-NEXT (dB)	Category 6 Permanent Link 90 m PS-NEXT (dB)
1.0	62.0	62.0
4.0	60.5	61.8
8.0	55.6	57.0
10.0	54.0	55.5
16.0	50.6	52.2
20.0	49.0	50.7
25.0	47.3	49.1
31.25	45.7	47.5
62.5	40.6	42.7
100.0	37.1	39.3
200.0	31.9	34.3
250.0	30.2	32.7

Table T7: Pair-to-pair ELFEXT values for Category 5e and Category 6 UTP cables with 100 metre in length

The PS-NEXT loss test limits are more restrictive than those for the channel configuration to ensure that permanent link cabling configurations may be extended to the channel configuration by adding cabling components that meet the minimum specifications established by the standards. When a consolidation point (CP) is present in a permanent link, according to the model used for the PS-NEXT calculation for the worst case condition, we will have PS-NEXT margins below the minimum measurement accuracy for the permanent link configuration. The PS-NEXT performance may be improved, then, if a minimum distance of five meters is kept between the consolidation point (CP) and the telecommunications outlet (TO).

Attenuation to Crosstalk (NEXT) Ratio - ACR

Attenuation to Crosstalk Ratio is not exactly a transmission parameter, but a mathematical relation between two parameters – Attenuation and Crosstalk, specifically the Near End Crosstalk (NEXT) in this case. We can also anticipate that the ELFEXT (Equal Level Far End Crosstalk) is virtually the same parameter relation but considering the Far End Crosstalk (FEXT) in place of NEXT now. Although ACR is not usually specified by the applicable standards, it may be very useful to evaluate the level of performance of a given cabling system. It can also be used to classify as well as qualify cabling system's performance from different vendors by comparing their ACR responses. The better the ACR (higher number) the better the system performance.

We can also refer (roughly) to ACR as the SNR (Signal to Noise Ratio) of a given cabling system. To be more precise in this definition we should say that ACR is a good SNR indicator when the interference considered is the one from NEXT couplings. Likewise ELFEXT should be considered as the SNR of a given cabling system when the interference of most concern is the one from the FEXT coupling. Both parameter ratios are important in terms of interference response of telecommunications cabling systems.

Figure 6 shows that ACR is the difference between the values of Attenuation and NEXT for a given frequency within a frequency range. Graphically, ACR can be interpreted as the separation between the parameters Attenuation and NEXT within a frequency range. Higher the separation, better the system performance of a given channel or more "noise-free" the channel will be.

For ACR positive (ACR>0) the communication can be guaranteed. When the ACR is equal to zero (ACR=0) we can say, theoretically, there is a state of uncertainty, i.e., the communication can not be either guaranteed or not. In practice the communication is not possible under this condition. For a negative ACR (ACR<0), the communication cannot be established at all.

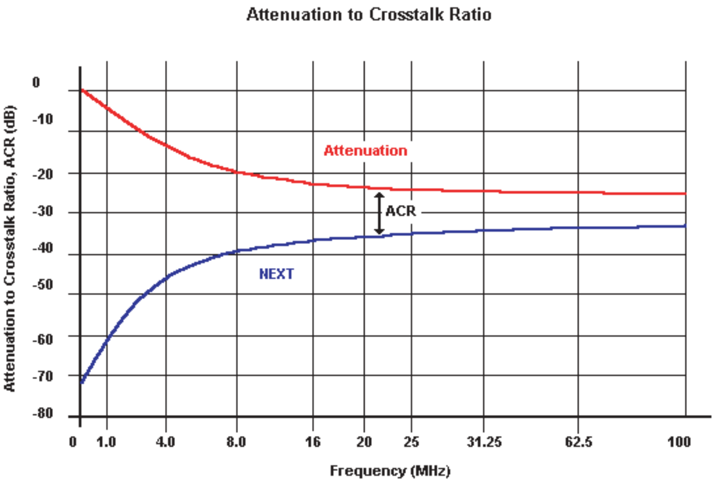


Figure 6: Attenuation to Crosstalk Ratio — Graphics

Table T8 shows the PS-ACR response for Category 5e and 6 channels.

Frequency (MHz)	Category 5e Channel PS-ACR (dB)	Category 6 Channel PS-ACR (dB)
1.0	54.8	59.9
4.0	46.0	56.5
8.0	39.3	49.9
10.0	36.9	47.7
16.0	31.5	42.6
20.0	28.8	40.0
25.0	25.9	37.2
31.25	22.8	34.3
62.5	12.0	24.1
100.0	3.1	15.8
200.0	—	0.4
250.0	—	-5.7

Table T8: PS-ACR response for Category 5e and 6 channels

Figure 7 shows, graphically, the PS-ACR response for Category 5e and 6 channels.

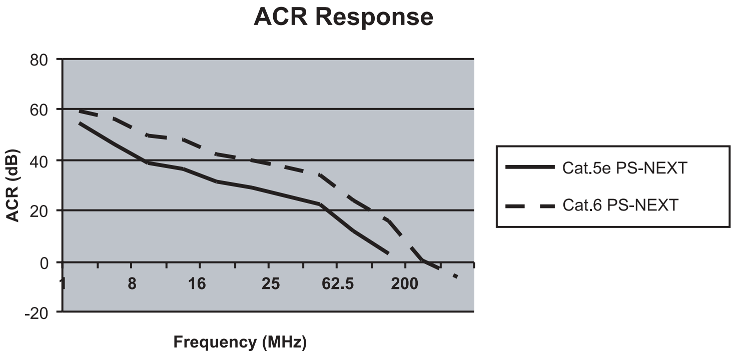


Figure 7: PS-ACR response for Category 5e and 6 channels

Far End Crosstalk Loss (FEXT Loss)

Far End Crosstalk or FEXT is the interference of a signal that propagates through a pair coupled into an adjacent pair at the farthest end from the interfering source (the end where the signal is received). When this interference occurs between close pairs of different cables, we call it an Alien Crosstalk phenomenon, whereas the crosstalk in this case is the interference caused by the Far End Crosstalk (FEXT). Figure 3 shows the interference mechanism of Far End Crosstalk (FEXT).

It is worth mentioning here that, due to its nature, the Far End Crosstalk (FEXT), unlike the Near End Crosstalk (NEXT), is subject to the entire cable run length between a given transmitter and receiver. Therefore, it is expected that the values obtained for this parameter undergo important variations as function of the channel length. Likewise the Near End Crosstalk loss, the FEXT Loss "parameter" refers exactly to the insulation between the pairs in the event of an interference caused by FEXT. The higher the value of such "parameter", the greater the insulation between the considered pairs, and consequently, the smaller the Far End Crosstalk (FEXT) interference. The opposite is also true.

However, the parameter that is more expressive than the Far End Crosstalk loss is the Equal Level Far End Crosstalk (ELFEXT), to represent the FEXT interference ratios in structured cabling systems. The ELFEXT is actually a ratio between two transmission parameters, or yet, the difference (in dB) between the FEXT values and the attenuation values measured for a given frequency. Likewise the Near End Crosstalk loss test, the ELFEXT may be evaluated by the pair-to-pair or powersum method.

Table T9 shows the pair-to-par ELFEXT values as a function of the frequency for Category 5e and 6 UTP cables.

Frequency (MHz)	Pair-to-Pair ELFEXT (dB) Category 5e Cable, solid	Pair-to-Pair ELFEXT (dB) Category 6 Cable, solid
0.772	—	70.0
1.0	63.8	67.8
4.0	51.8	55.8
8.0	45.7	49.7
10.0	43.8	47.8
16.0	39.7	43.7
20.0	37.8	41.8
25.0	35.8	39.8
31.25	33.9	37.9
62.5	27.9	31.9
100.0	23.8	27.8
200.0	—	21.8
250.0	—	19.8

Table T9: Pair-to-pair ELFEXT values for Category 5e nd 6 UTP cables with 100-metre in length

Once again one can see that the insulation between the pairs of UTP cables reduces as the frequency increases, proving that, for high frequencies, the Far End Crosstalk interference ratios are more important. Likewise we may notice that Category 6 cables offer a greater insulation for Far End Crosstalk than Category 5e cables. In any frequency within the range of interest, the ELFEXT value for Category 6 cables is numerically higher than that for Category 5e cables at the same frequency.

Table T10 shows the powersum ELFEXT Loss (PS-ELFEXT) values as a function of the frequency for Category 5e and 6 channels.

Frequency (MHz)	PS-ELFEXT (dB)Loss (dB) Category 5e Channel	PS-ELFEXT (dB)Loss (dB) Category 6 Channel
0.772	—	—
1.0	54.4	60.3
4.0	42.4	48.2
8.0	36.3	42.2
10.0	34.4	40.3
16.0	30.3	36.2
20.0	28.4	34.2
25.0	26.4	—
31.25	24.5	30.4
62.5	18.5	24.3
100.0	14.4	20.3
200.0	—	14.2
250.0	—	12.3

Table T10: PS-ELFEXT Loss values for Category 5e and 6 channels

The PS-ELFEXT behavior is similar to the ELFEXT, however, with lower numerical values. This was already expected, since upon the evaluation of the PS-ELFEXT all pairs are contributing to the FEXT interference ratios, therefore, the interference levels increase, and the insulation between the pairs decreases.

Figure 8 shows, graphically, the responses for PS-ELFEXT Loss for Categories 5e and 6 channels.

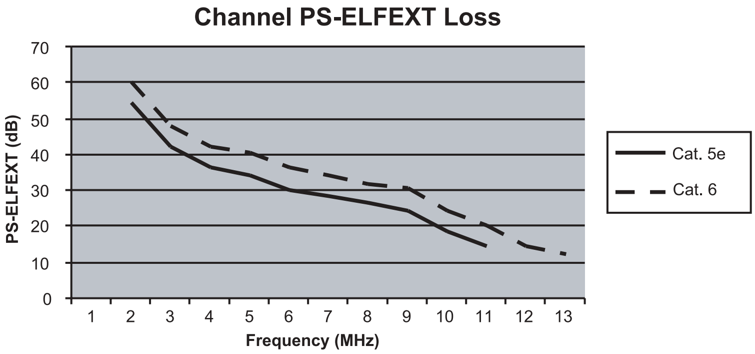


Figure 8: PS-ELFEXT Loss for Cat. a5e and Ct. 6 channels

Return Loss

The return loss measures the amount of signal returned back to the transmitter due to the impedance mismatch between the cable and the connecting hardware in a structured cabling system. Poor terminations between cables and connectors generate high level reflections that harm the power transfer between the transmitter and the receiver in a communications system. Consequently, appropriate installation practices shall always be followed to minimize such a problem.

Reflections will always occur at points containing a junction of cables and connectors, but it is important to make sure that they are the least possible.

The applications operating in full duplex mode are more susceptible to problems due to reflections in the channel than the half duplex applications. This occurs because the reflected signal that returns to the transmitter (which also operates as a receiver in these systems) may have enough power to be misinterpreted as a valid information by it. In such an event, we will have a communication error and a retransmission will be necessary, reducing the application performance level due to the cabling system.

Table T11 shows the expressions used to calculate the return loss for Category 5e and 6 solid UTP cables.

Frequency (MHz)	Return Loss (dB)
Between 1 and 10	20 + 5log (f)
Between 10 and 20	25
Between 20 and 250	25 – 7log (f / 20)

Table T11: Expressions to calculate the return loss for Category 5e and 6 cables

Curiously, the return loss values for both performance categories 5e and 6 cables are exactly the same up to 100-MHz frequency. This occurs due to the fact that both cables have the same characteristic impedance of 100 ohms with a tolerance of 15% (from 85 to 115 ohms). Likewise the connecting hardware impedance for Category 5e and 6 is within such a range of values, therefore, the return loss shows the same behavior for both system categories. Table T12 below shows the return loss referential values for both cable categories for 100-metre cable length.

Frequency (MHz)	Return Loss (dB) Category 5e Cable, solid	Return Loss (dB) Category 6 Cable, solid
1.0	20	20
4.0	23	23
8.0	24.5	24.5
10.0	25.0	25.0
16.0	25.0	25.0
20.0	25.0	25.0
25.0	24.3	24.3
31.25	23.6	23.6
62.5	21.5	21.5
100.0	20.1	20.1
200.0	—	18.0
250.0	—	17.3

Table T12: Return loss referential values for Category 5e and 6 cables

The following expression [3] may be used to determine the return loss values as a function of the reflected signal voltage level.

$$RL = 20.\log \frac{V_r}{V_i} \quad \text{(dB)} \qquad [3]$$

Where,

V_r is the reflected signal voltage level, in volts;
V_i is the incident signal voltage level, in volts.

From expression [3] we may then construct Table T13, which shows the return loss values as a function of the reflected signal voltage level.

Reflected signal voltage level, V_r (V)	Return Loss (dB)
0.1	20.0
0.2	13.9
0.3	10.4
0.4	7.9
0.5	6.0
0.6	4.4
0.7	3.1
0.8	1.9
0.9	0.9
1.0	0

Table T13: Return loss values as a function of the reflected signal voltage level for an incident voltage, V_i, of 1V

Therefore, the higher the return loss numerical value (in dB), the smaller the intensity of the signal reflected back to the transmitter, and the better the characteristics of the cable or channel transmission. Actually, by observing Table T10, we may notice that the values for this parameter are relatively high and are between 17.3 and 25.0 dB, what represents respectively the transmitted signal levels due to the impedance mismatch in the order of 14% and 5%. We may also notice that this parameter shows a non-linear variation behavior in regards to the frequency (see figure 9).

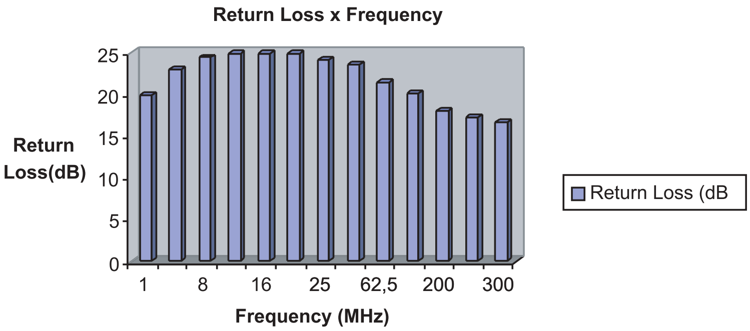


Figure 9: Return loss behavior as a function of the frequency for Category 5e and 6 cables

Thereby, we can notice that the return loss shows a better behavior for average frequencies (within the range of interest), showing worse values for both very low and very high frequencies. This behavior is valid for cables, not for channels however.

In summary, there are no differences in terms of response in regards to this parameter for the cable and system categories considered herein.

Table T14 and T15 shows the expressions used to calculate the return loss for Category 5e and Category 6 channels.

Frequency (MHz)	Cat. 5e Channel Return Loss (dB)
Between 1 and 20	17
Between 20 and 100	17 – 10log (*f* / 20)

Table T14: Return Loss for Category 5e channels

Frequency (MHz)	Return Loss (dB)
Between 1 and 10	19
Between 10 and 40	24 — 5log (*f*)
Between 40 and 250	25 – 7log (*f* / 20)

Table T15: Return Loss for Category 6 channels

Table T16 shows the values for Return Loss for Category 5e and 6 channels.

Frequency (MHz)	Return Loss (dB) Category 5e Channel	Return Loss (dB) Category 6 Channel
1.0	17.0	19.0
4.0	17.0	19.0
8.0	17.0	19.0
10.0	17.0	19.0
16.0	17.0	18.0
20.0	17.5	17.5
25.0	16.0	17.5
31.25	15.1	17.0
62.5	12.1	14.0
100.0	10.0	12.0
200.0	—	9.0
250.0	—	8.0

Table T16: Return Loss values for Category 5e and 6 channels

Figure 10 shows, graphically, the responses of Category 5e and 6 channels for Return Loss.

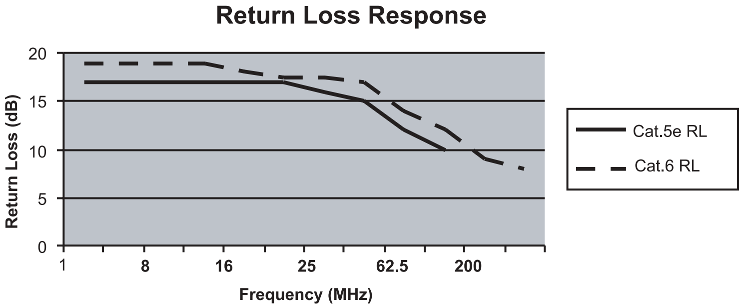


Figure 10: Return Loss response for Category 5e and 6 channels

Propagation Delay and Delay Skew

Propagation delay is the time that the signal takes to propagate (normally given in ns) through a cable run between a given transmitter and receiver. This parameter is directly associated with the primary cable parameters (resistance, inductance, capacitance, and conductance). The constructive aspects are then of fundamental importance for determining the propagation delay characteristics of a cable.

Delay skew expresses the difference (in time) between the propagation delays of the fastest and the slowest pairs inside a four-pair UTP cable. The significance of evaluating a delay skew in structured cabling systems is important due to the applications that use all four UTP cable pairs to transmit and receive information that, in this case, is partitioned into four different "packets" which must be received within a predetermined time interval by both the active equipment interface and the application protocol.

Therefore the cabling system should show a delay skew below the threshold established by the application. The expression [4] may be used for determining the propagation delay for Category 5e and 6 cables.

$$propagation\,delay_{\mathrm{cable}} \le 534 + \frac{36}{\sqrt{f}} \quad \mathrm{ns/100m} \qquad [4]$$

Where f is the frequency of interest, in MHz.

Table T17 shows the propagation delay and delay skew referential values for Category 5e and 6 cables.

Frequency (MHz)	Maximum propagation delay (ns/100 m)	Minimum propagation speed (%)	Maximum 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

Table T17: Propagation delay and delay skew referential values for Category 5e and 6 cables

Once again we found out that the requirements for both, Category 5e and Category 6 are the same for these parameters.

Conclusions

By analyzing the frequency responses for the various performance parameters shown in this article, we conclude that, in general, Category 6 cabling system transmission characteristics are higher than those of Category 5e systems.

The same occurs for the parameters associated with electromagnetic interference – EMI - (Near End Crosstalk, NEXT, and Far End Crosstalk, FEXT), so as we have shown here, the insulation between the pairs is greater for Category 6 cables than for Category 5e ones. However, it is important to highlight that the UTP cables are not provided with any type of protection against high-level external induced noises. In other words, we can conclude that Category 6 cables are less susceptible to internal noise (from NEXT or FEXT) than Category 5e cables. In fact, none of them is totally immune against external noises; the effective way to obtain such characteristic is by using appropriate shielding techniques. What we can actually affirm is that Category 6 cables show a much better behavior in regards to internal interference ratios between their pairs. Off course balanced cables are less susceptible to noise than parallel wires, but for a number of environments it's not effective enough for EMC (Electromagnetic Compatibility).

Another important difference between Category 5e and Category 6 systems is the available bandwidth, which for Category 6 systems is greater (theoretically) than the double of that available in Category 5e systems, that is, 250 MHz for Category 6 and 100 MHz for Category 5e. An important note, however, is that according to '568-B.2-1 standard, the PS-ACR (Powersum Attenuation to Crosstalk Ratio) must be positive up to, at least, 200 MHz for Category 6 cabling systems (PS-ACR parameter was not addressed in this article).

In conclusion, the installation of Category 6 structured cabling systems offers the possibility of implementing existing and future high speed data applications by means of offering a wider bandwidth and better transmission characteristics with relation to the Category 5e systems. However, we should bear in mind that, for an equal less demanding application (as Ethernet at 10 and 100 Mb/s), the end-user will notice either a very small or no difference at all in terms of processing response.

It is still worth mentioning that the system quality (cables and further components), as well as the installation service quality are extremely important for getting the maximum performance available. This is applicable to any standardized performance category.