

The effect of temperature on the bandwidth of telecommunications cabling in commercial buildings

Focus on the IBDN System 4800LX from NORDX/CDT

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Introduction

One of the most important parameters that define the performance of telecommunications cabling is the channel bandwidth. What distinguishes next generation cabling such as Category 6 and Category 7 from lower Categories is the available bandwidth. In general, the higher the bandwidth, the higher is the data rate capability of the cabling system.

What is bandwidth? For copper cabling, bandwidth is usually expressed in MHz for a 100-meter twisted pair channel. The channel bandwidth is the frequency range where the Signal-to-Noise ratio (SNR) is positive, i.e., the signal level is greater than the noise level in dB. The concept of bandwidth is illustrated in Figure 1. The controlling noise source for most LAN systems today is Near End Crosstalk (NEXT) interference between a transmit pair and a receive pair. When all sources of NEXT are taken into account, the SNR is the same as the Power Sum Attenuation-to-Crosstalk ratio (PSACR) in dB. For a Category 6 channel the objective is to have a PSACR greater than zero over a frequency range up to 200 MHz, which is twice the bandwidth of Category 5 cabling.

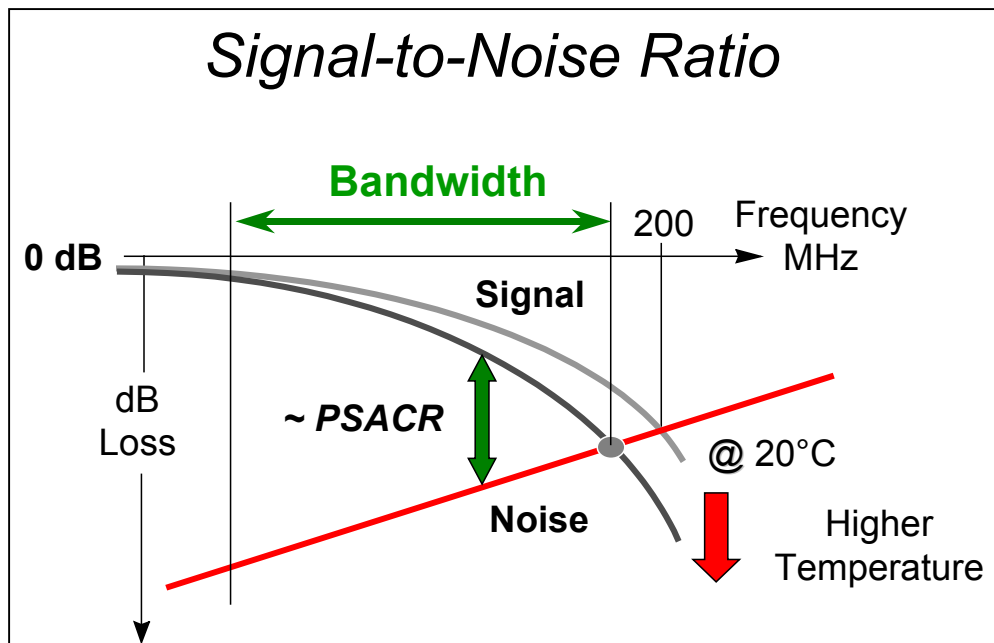


Figure 1 – Relationship of Bandwidth and Signal-to-Noise Ratio

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Bandwidth and Information Capacity

There is a fundamental relationship between the bandwidth of a channel expressed in MHz and the information capacity or data rate expressed in Mb/s. The traffic flow on a major highway is a good analogy to illustrate the concept of bandwidth versus data rate. The bandwidth is similar to the number of lanes of traffic on a highway. The data rate is similar to the traffic flow or the number of vehicle crossings per hour. One way to increase the traffic flow is to widen the highway. Another way is to improve the road surface and to eliminate bottlenecks. Similarly, it is possible to pack more bits of information per Hz of available bandwidth; but it also requires a higher signal-to-noise ratio.

The relationship between bandwidth and information capacity was discovered a long time ago by Claude Shannon, an engineer with Bell Telephone Laboratories. This relationship is called the Shannon limit and determines the maximum information rate for a noisy channel as a function of the available bandwidth and the Signal-to-Noise ratio.

Temperature effects

Cable attenuation is significantly affected by temperature. In the Category 6 standard (TIA/EIA-568-B.2-1, Annex G), it is recommended to reduce the length of a channel if the cable is installed at a higher temperature. For example, if a minimally compliant Category 6 cable is installed at a temperature of 40 °C (104 °F) then the maximum length of cable needs to be reduced to 84 meters in order to maintain the same transmission performance as 90 meters of cable at 20 °C.

Rather than to reduce the cable length, a better alternative is to install a cable with a lower Insertion Loss (Attenuation), such as the 4800LX cable from NORDX/CDT where the Insertion Loss is ~ 12 % lower. The lower Insertion Loss for the 4800LX cable is achieved by using a slightly heavier gauge of copper conductor, approximately 0.6 mm (~23 AWG) in diameter.

Table 1 shows the Cable Insertion Loss Factor relative to the Category 6 standard that is required to maintain the same transmission performance at higher temperatures compared to the reference temperature of 20 °C.

Allowance for Cable Temperature

Temperature		Cable Ins. Loss Factor	Ins. Loss @ 100 MHz (dB)	Cable Length (m)	Length de-rating (m)
(°C)	(°F)				
20	68	100 %	19.8	90.0	0.0
25	77	98.9 %	19.6	89.0	1.0
30	86	96.6 %	19.1	87.0	3.0
35	95	95.0 %	18.8	85.5	4.5
40	104	93.3 %	18.5	84.0	6.0
50	122	88.3 %	17.5	79.5	10.5
60	140	83.3 %	16.5	75.0	15.0

Table 1 – a) Length de-rating as a function of temperature for Cat 6 cable
b) Insertion Loss for Cat 6 low loss cable without length de-rating

Cable Installation

Cables are often installed in ceiling spaces, air plenums and riser shafts where the environmental temperature can be much higher than in air-conditioned offices. A recent study performed by the Lawrence Berkeley National Laboratory at the University of California showed that air temperatures in plenum spaces of medical buildings could reach as high as 120 °F (49 °C) on a hot day in the middle of summer. Cable temperatures in warehouses and factory environments may be even higher.

What does this mean for Category 6 cabling systems that are installed under reasonable worst-case temperature conditions? It means a significant number of channels could fail the Category 6 limits that are programmed into the field testers unless 1) a lower Insertion Loss cable is installed or 2) the cable length is reduced from a maximum of 90 meters to about 80 meters.

NORDX/CDT Category 6 System

NORDX/CDT currently has two product offerings that satisfy the objectives of the Category 6 standard currently under development at TIA:

- The IBDN System 2400, which is comprised of IBDN 2400 Cable, PS6+ cords and GigaBIX or GigaFlex PS6+ Modular Connectors. The 2400 system exceeds the requirements of the Category 6 specification with an available bandwidth of 250 MHz at 20 °C.

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- The IBDN System 4800LX, which is comprised of IBDN 4800LX Cable, PS6+ cords and GigaBIX or GigaFlex PS6+ Modular Connectors. The 4800LX system goes significantly beyond the requirements of the Category 6 specification with an available bandwidth of 300 MHz at 20 °C.

The key parameters that determine the transmission performance of a system are the Signal-to-Noise Ratio (dB) and the Bandwidth (MHz). The transmission performance for the different system offerings from NORDX/CDT is graphically illustrated in Figure 2 below relative to the TIA standards (Category 5e and Category 6). All these systems provide additional bandwidth and headroom beyond the minimum requirements of the standard.

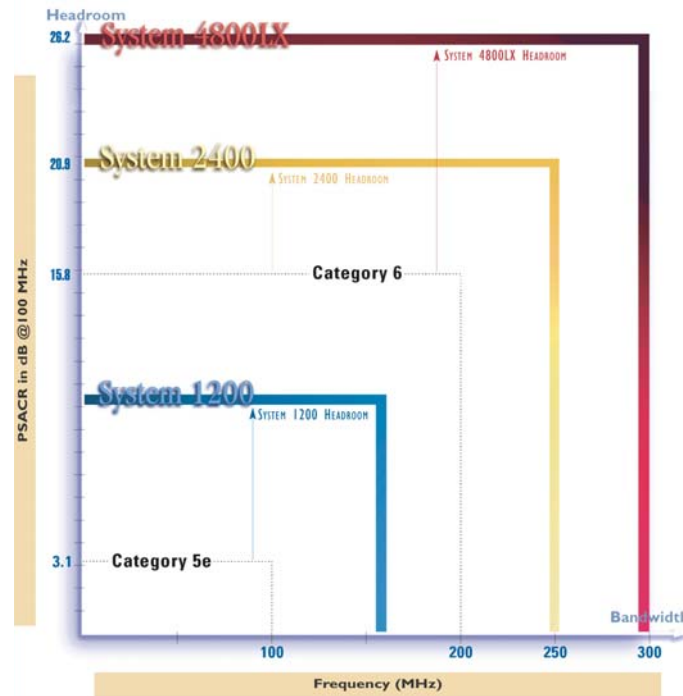


Figure 2 - IBDN Gigabit Systems Performance

Recommendation

NORDX/CDT recommends the use of lower loss cabling that meets the bandwidth objective of 200 MHz for Category 6 cabling at a reasonable worst-case temperature of 40 °C. The IBDN 4800LX system exceeds this objective. It also satisfies the intent of the IEEE LAN equipment developers that have stated “improved attenuation” is more important than crosstalk for next generation cabling systems.

For more information on NORDX/CDT and IBDN products, please call: **1-800-262-9334**
Or visit us on the Net at: www.nordx.com