Title: Why do we need higher bandwidth & more performance head room in data cables?

Author: Mohammad Shahid Khan (Technical Manager), A.Srinivasa Kumar (Associate Manager - PLM & AE)
Company: Sterlite Technology Limited, Gurugram (Haryana) India.
+91-8155020836 shahid.khan@sterlite.com

Presenter: Mohammad Shahid Khan
Main Subject Matter: A horizontal cabling performance parameter and best practices.

Abstract

Deployment of new applications over local area network (LAN) cable technologies is moving forward at a lightning pace. With the emerging applications demand it has become very critical to select the right design of cable meeting current and upcoming applications needs. Structured cabling installations with lesser control and aggressive execution schedule, many times results in poorly installed systems. Structured cabling design planning includes pathways, containments and other necessary best practices which are very critical to achieve better headroom results in installed SCS (Structured Cabling System).

1. Introduction

Let's understand dynamics around, project site field conditions, errors done during execution and how system integrations skill gap variability may impact installed cable performance. Considering field constraints and competitive market trend also changing .Now a day's major quality OEM confirming guaranteed minimum 4- 6 dB headroom margin compliant to 90meter ANSI TIA-568- C.2 horizontal link performance .The same information getting incorporated in various large tender specifications ultimately eliminating many small players with limited capability to deliver such high performance margins absorbing certain level of field efficiency loss.

Keywords: SCS: Structured Cabling System, OEM: Original Equipment Manufacturer, LAN: Local area network, dB: decibel, CCA: Copper Clad aluminium; PoE: Power over Ethernet; HDBaseT, RL: Return Loss, NEXT: Near end cross talk

2. Background

It's very important for cable manufacturers they should contribute towards the work to bring right standardization through policy initiative and stop use of inferior designs CCA and less headroom inferior products in new passive network Installation. Larger goal is to promote maximum deployment of high efficiency, higher bandwidth new generations Cat6a onwards design cables which will be enabling future ready networks with proper implementations best practices followed .

Good cable design and installation in networks includes smart city networks, command center, data center and enterprise networks have a significant impact on network performance, capacity, and cost. While Cabling accounts for 2-5% of Network investment its life expectancy can be upwards of 10-15 years.
We know that up to 50% of a network's problems can be traced to the cabling infrastructure issues. Good cabling discipline and well-designed networking infrastructure can significantly improve the network performance and improve availability.

Selecting the proper good quality cables up front provides assurance on the correct life-cycle choices for the network reliability, scalability and availability.

2.1 Technology

First of all let's understand parameter decibel (dB) which is baseline by all testing engineer to compare and evaluate cabling system performance. Transmission performance is most commonly specified in units of dB.

A decibel described as the input to output ratios of either power as shown below.

$$\mathrm{dB} = \mathrm{decibel} = 10 \log \mathrm{base}10\ [P1/P2]$$

where,

P1= measured power in Watts

P2=reference power in Watts.

In order to examine how the decibel function operates is to assume a reference one watts and measured value is 0.5 Watt.

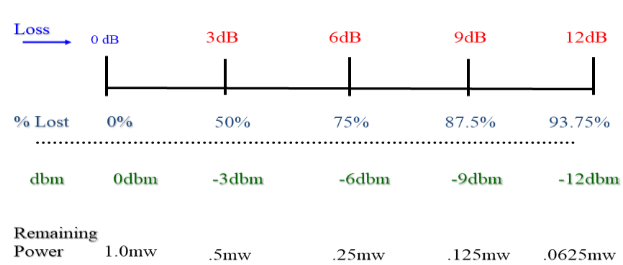

Figure-01 Representing Signal dB loss with %Power loss

That Translates to:

With 3 dB attenuation would converts to 50% of the signal power being lost along a transmission line!

With 3 dB crosstalk would converts to 50% of the signal power being allowed to couple onto adjacent pairs!

With 3 dB return loss would converts to 50% of the signal power being reflected back on a transmission line!

2.2 Test Results Observations and Findings:

Return loss (RL) is a very important noise measurement defined for local area networks and LAN components. It is the loss of power in the signal returned/reflected by a discontinuity in a transmission line. In the field, return loss performance mainly depends on how the installer installing the cable. When the field installer does not follow proper installation practices, there are more chances for a drastic decrease in the RL headroom and sometimes even RL failure. So, the cable manufacturing requires careful attention while designing the cables such that even after poor installation practices in the field, RL should not fail with extra headroom available. This brings the importance of manufacturing higher headroom cables by the cable manufacturers.

Testing was done with the below mentioned CAT6 cables design having different packaging type i.e., Reel-in-a-box (Figure-03) and Reelex (Figure-04) using the DSX-5000 Network Analyser equipment (Figure-02).

1) Cat6 U/UTP 23AWG - Higher Headroom Design
2) Cat6 U/UTP 23AWG - Lower Headroom Design and
3) Cat6 U/UTP 24AWG

Figure-02 : DSX-5000 Network Analyzer

Figure-03 : Reel-in-a-box

Figure-04 : Reelex

In order to verify the cable performance, the following five different testing methods have been used while conducting the test one after another starting from 1 to 5.

1) In Coil condition (Figure-05)
2) In Laid condition (Figure-06)
3) By taking the cable over an accumulator (Figure-07)
4) By bending the cable slightly at various positions (Figure-08) and
5) By bending the cable too much (Figure-09) at various positions more than the maximum allowed cable bending radius.

Figure-05 : Coil Condition

Figure-06 : Laid condition

Figure-07: On Accumulator

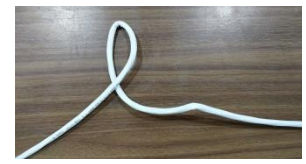

Figure-08 : Cable bent slightly

Figure-09 : Cable bent too much

The Return Loss headroom obtained while conducting the test in all the five different testing conditions for all the designs are as shown in the Figure-10 for Reel-in-a-box type packaging and in the Figure-11 for Reelex type packaging respectively.

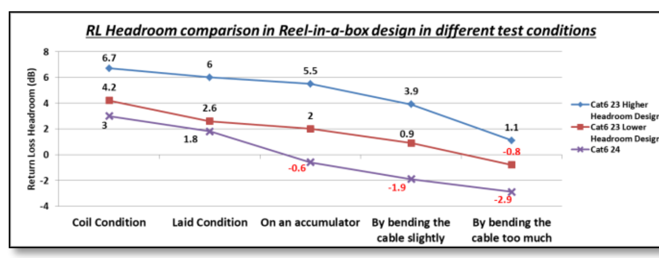

Figure-10: RL Headroom comparison in Reel-in-a-box design in different testing conditions

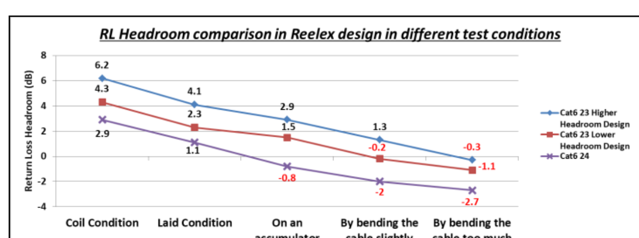

Figure-11: RL Headroom comparison in Reelex design in different testing conditions

Cable Type	Coil Condition		Laid Condition		On an accumulator		By bending the cable slightly		By bending the cable too much	
	Reel-in-a-box	Reelex	Reel-in-a-box	Reelex	Reel-in-a-box	Reelex	Reel-in-a-box	Reelex	Reel-in-a-box	Reelex
Cat6 23 Higher Headroom Design	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Marginal Pass	Marginal Pass	Fail
Cat6 23 Lower Headroom Design	Pass	Pass	Pass	Pass	Pass	Pass	Marginal Pass	Fail	Fail	Fail
Cat6 24	Pass	Pass	Pass	Marginal Pass	Fail	Fail	Fail	Fail	Fail	Fail

Figure-12: Summary of Test Results

DSX-5000 Test Graphs showing RL Headroom:

Each graph in the Figure-12, Figure-13, Figure-14 & Figure-15 shows the Return Loss headroom results when tested in different testing conditions in the same order as explained earlier i.e., from Figure-05 to Figure-09.

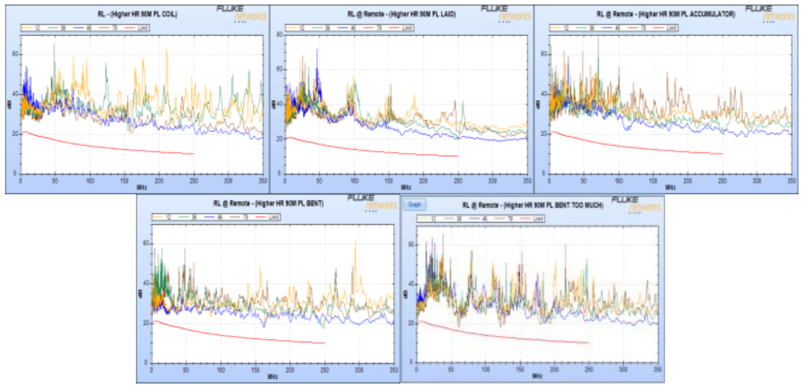

Figure-12: Cat6 U/UTP 23AWG – Higher Headroom Design (Reel-in-a-box)

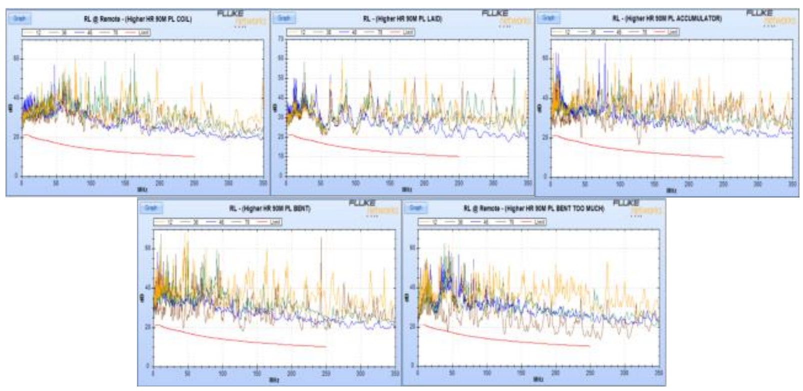

Figure-13: Cat6 U/UTP 23AWG – Higher Headroom Design (Reelex)

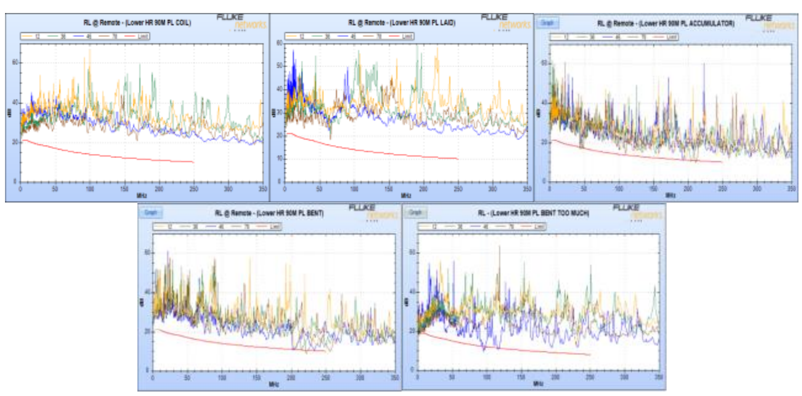

Figure-14: Cat6 U/UTP 24AWG (Reel-in-a-box)

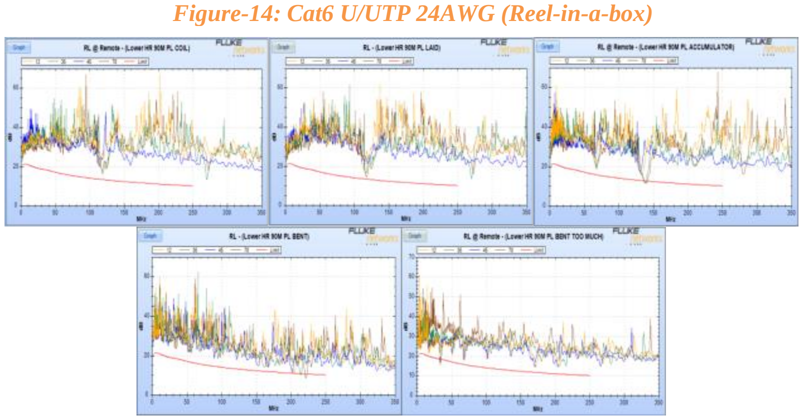

Figure-15: Cat6 U/UTP 24AWG (Reelex)

Hence it's important for the manufacturer to design robust cable with higher margins well supported by stringent process and quality control during manufacturing eliminating possible contributors of signal losses. Same time it's equally important that best practices to be followed during installations to avoid additional losses in the network.

3. Applications

With emerging Information & Communication Technologies changing data cable physical layer needs. The latest applications demands higher bandwidth and these bandwidth intensive applications require speed beyond 1 GB/s in existing Local Area Network (LAN) infrastructures. Cat5 restricted to 100 MHz bandwidth and speed maximum to 1gigabits per seconds only.
Enhanced future ready horizontal LAN cabling infrastructure required to avoid productivity loss due to network bottleneck. Technology already moved towards Cat6A cables complaint to 500 MHz bandwidth and 10G speed as minimum specification for all new LAN horizontal cabling networks installations.

Twisted pair data cabling has been continuously evolving addressing the need of higher bandwidth and speed requirements .Telecommunication Industry association (TIA) recently released

TIA 568-C.2-1 Balanced twisted- pair Telecommunication cabling component standards announce addendum on minimum requirement for Category 8 four pair shielded balanced twisted pair copper cabling up to two connectors and will support up to 30 meters only. This will be addressing need of data centre cabling providing 25G/ 40G speed Data Centre for server to server connection and end of row or middle of row design.

Below listed applications demands higher headroom designs and Cat6a as recommended option for connectivity.

ISO/IEC 11801-5 (Data Centre) and 11801-6 (Distributed services) already specify Class Ea /Cat6A minimum

4-Pair PoE applications: TSB-184-A recommends installing Category 6A to achieve best thermal performance, largest bundle sizes and supports 10GBASE-T.

New Generation Wi-Fi: The next-generation IEEE 802.11ac having Wave 2 devices will require data rates close to 2 Gb/s in the immediate future. For new installations, the best viable solution to support Wave 2 802.11ac wireless devices and higher speed 802.11ax devices in the future is Category 6A.

ISO/IEC 11801 Edition3 Class Ea is the minimum recommended to support applications with data rate greater than 1Gigabit per second

HDBaseT: Technology enables transmitting uncompressed full HD video, audio, Ethernet, control and power up to 100 m over balanced twisted-pair cabling with modular RJ-45 connectors Cat6A Cable is design of choice

TIA-1179-A Healthcare under revision recommends minimum copper cabling requirement is Category 6A

TIA-4966 Education Requires Category 6A for new Installation

3.1 Advantages

Implementing high performance cable design in network we achieve many advantages as listed below.

1. Network efficiency- high performance, reliable, stable solution
2. Scalability- fast and easy provisioning of connectivity equals a more efficient deployment of system equipment
3. Effective overall operation
4. Minimize cabling system risks
5. Helps lower IT up gradation costs
6. Standards futuristic compliant passive infrastructure.

4. Recommendation for Higher performance

4.1 Field Implementations best practices

Untwisting dramatically affects NEXT and RL – the less untwist the better – right up to the termination point. Must keep maximum amount of pair untwist to about 13mm for CAT 5, 5E, and 6mm on CAT 6A ,Cat6 or lesser as specified by the manufacturer.

Bending radius for UTP no less than 4x (4-PAIR) and Sc TP no less than 8x of cable diameter. Cable should not be pulled through a length of conduit exceeding 30m (100 ft) Limit 90º bends in conduit to 2

Support cables every 4 - 5 ft (1200mm - 1500mm), Avoid sharp objects, turns and corners.

Use a pulley or a third man at turns and corners; Do not “jerk” cable

Excessive compression of the cable adversely affects the cable’s characteristics both physically and electrically. To prevent unwanted compression of the cable installer should avoid stepping on the cable; avoid the over-tightening of cable ties.

Do not overload cable pathways – the weight of the cable bundle may crush cables underneath and possibly pull the pathway away from its attachment. 24 cables in a bundle are safe. Pull all cable at same time, if possible, Use a partner at the entry point

Use lubricants if necessary (do not use petroleum-based), Pull in a continuous manner without stopping; Do not pull a terminated cable through the conduit.

If pull boxes are used, pull to the first box, coil up the cable, then feed it back into the pull box and then pull through to the next one.
Avoid laying cable near noise sources, such as; electrical wiring, electric motors, fluorescent lighting, copiers and other EMI/RFI (Radio frequency Interference) devices.

Installing the cable in a closed metallic pathway such as conduit will help reduce the effects of EMI.

If installed in an open or non-metallic pathway, maintain a minimum distance of 130mm away from fluorescent fixtures, including ballasts.

Avoid areas where the cables will be exposed to high temperatures, such as lighting, heat, open flame, etc. High temperatures affect attenuation

Avoid laying cable in areas with excessive moisture such as damp basements and areas where steam will form condensation on the cable.

When pulling the cable avoid twisting it. Use a grip or a pull string attached to a swivel to minimize any twists and avoid putting any kinks in the cable.

5. Conclusions

Network infrastructure has grown over the period of time and critical performance parameters needs to be continuously enhanced, monitored and control to achieve consistent network performance. Business Applications have become demanding; and there is a continuous need to deliver differentiated services. Cable design with lower headroom margin e.g. 2 dB or less is more prone to marginal pass or even fail results at project sites. There are certain levels of variability in the skill set of system integrators resources working at project sites.

To cope up with above mentioned critical factors, cable design with higher headroom meeting and exceeding ANSI /TIA-568.C.2 Horizontal link performance margin, will enable passive network for its suitability to address present and future business communication needs.

There are many applications driving physical layer to deploy good quality higher category cables considering minimum Category 6A designs. Based on the study of above mentioned new applications bandwidth and performance demand we can conclude that lower category cables cannot be recommended for new installation. Higher headroom Cat6 and Category 6A onwards cables design supports robust and scalable cabling infrastructure that will enable end users to spend less time in fault management and concentrate more on important business activities.

Moving forward extended study will be conducted to evaluate the performance parameters of different Cat6A cables design.

6. References

[1] ANSI/TIA-568-C.2-Balanced Twisted-Pair Telecommunications Cabling and Components Standards
[2] ISO/IEC 11801 Information technology –Generic cabling for customer premises
[3] Guidelines and Best Practices for the Installation and Maintenance of Data Networking Equipment Version 1.0
[4] ANSI/BICSI 005-2016, Electronic Safety and Security (ESS) System Design and Implementation Best Practices
[5] White Paper on Category 6A The cabling of choice for new installations George A. Zimmerman CME Consulting, Inc.
[6] http://www.ethernetalliance.org/roadmap
[7] Information on Field testers' requirement covered by ANSI/TIA-1152
[8] Case Study: http://www.flukenetworks.com/knowledge-base/dtx-cableanalyzer/case-study-6-return-loss-fails-dtx-cableanalyzer-due-cable

7. Acknowledgments

Special thanks to Mylaraiah J N Director, Enterprise Sales, India & SAARC for his technical contributions to the content as well as his review of the final document.

8. Author

Mohammad Shahid Khan
Sterlite Technologies Limited
Iffco tower, second floor, Sector -29, Gurugram (Haryana), India

Mr.Mohammad Shahid Khan is a Technical Manager with Sterlite Tech. Md.Shahid Khan is an Electrical Engineering graduate works primarily with the telecommunications cable categories product line management and applications engineering. He is subject matter expert passive cabling solutions- for more than seventeen plus years .Certified in LAN passive network infrastructure having in-depth understanding of concepts, new applications and effectively employs the standards and design techniques in line with the global standards. Having expertise in spearheading numerous passive large IT Infrastructure based projects and ensuring the successful completion of projects in compliance to the design and quality parameters. In PLM role do exploring the possibility of development, based on the solution and field exposure, monitoring the change and strategizing models. Proven skills in managing technical consulting support, work in sync with the corporate set parameters for achieving business goals.

Co-Author

A.Srinivasa Kumar
Sterlite Technologies Limited
Survey No.33/1/1, Waghdara Road, Dadra
U.T. of Dadra & Nagar Haveli, India.

Mr.A.Srinivasa Kumar is an Associate Manager in PLM & AE with Sterlite Tech. He works primarily with the Structured Data cables product line management and applications engineering. He has over 2.6 years of experience as Lead in Quality Control & Quality Assurance of Structured Data Cables. In his tenure as the Lead QC & QA, he has built direct relationships with many of the suppliers, customers and has actively involved in many major projects for improving the quality of the product. He has also played a key role in the end-to-end execution of newly developed products. He holds Bachelor's Degree in Electrical & Electronics Engineering.