Valens

AN1002: HDBaseT Installation and Cabling Topics

Ver 1.0

Valens First in HDBaseT

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Revision History

Revision	Date	Author	Description
0.1	5/12/12	Danny Raz	Created
1.0	16.12.12	Danny Raz	Release version

Glossary

Term	Definition
HD	High Definition
HDMI	High Definition Multimedia Interface
TMDS	Transition Minimized Differential Signaling
UTP	Unshielded Twisted Pair
STP	Shielded Twisted Pair
FEXT	Far End Crosstalk
NEXT	Near End Crosstalk

Contents

1 Overview

This section includes the following topics:

- Document Scope
- Audience
- Related Materials

1.1 Document Scope

This document provides information on installation and cabling related issues in an HDBaseT video system. It helps understand the common limitations and issues that must be understood when installing an HDBaseT link.

1.2 Audience

- AV equipment Installers using HDBaseT products
- System/Testing engineers involved in designing, manufacturing and testing HDBaseT certified products

1.3 Related Materials

- Valens eVS1 User Manual
- Valens VS100/010 Product Family Datasheet
- VS100 Application Note AN1033 – Update Parameter Tool UM"

2 Understanding HDBaseT Limitations

2.1 Overview

This section includes the following topics:

- System Considerations
- Overview of Video Formats
- Understanding Cables, Cables Grades and Cable Impairments
- Working in Full Reach and Fully Capacity
- Working in Long Reach Mode

2.2 System Considerations

When installing an HDBaseT system, the systems specification must be well defined in order to guarantee correct performance. The following issues must be considered:

- Which video formats should the system support
    - What is the maximum video rate / pixel clock rate?
- What cable types/grades are available
    - Does the installation use existing in-wall cables for an HDBaseT network
    - If yes, what grade? Length?
    - Are the cables laid out in a straight manner?
    - Is there excess cabling?
- Are you using a VS100 or VS010 embedded product?
- Are there any noise sources in the cable environment?
    - Fluorescent lights, Microwave, WiFi AP
- Are patch cables used?
    - What type?
    - How long is the total cable run (including the patches)

This application note will help you understand these issues and avoid unexpected installation related problems.

2.3

2.4 Summery of VS100 and VS010 Capabilities

VS100 can deliver up to 10.2 Gbps of HDMI 1.4 traffic (including HDCP). Table 1 below specifies the VS100 limitations with respect to range, video format and cable grade.

Table 1: VS100 Range Specification

Cable Type	Range	Pixel clock rate	Video Data Rate	Supported Video
CAT5e/CAT6	100 m	<=225 MHz	<= 5.3 Gbps (HD Video)	Up to 1080p, 60 Hz, 36 bpp (data rates lower than 5.3 Gbps or below 225 MHz TMDS clock).
	70 m	>225 MHz	> 5.3 Gbps (Ultra HD Video)	1080p 60 Hz 48 bpp, 1080p 60 Hz 3D, and 4K2K, 30Hz video formats
CAT6a/CAT7(*)	100 m			

(*) refer to **Error! Reference source not found.** for a list of approved cables tested in Valens for ultra-HD 100 meter reach capacity

In

The VS010 family is a low cost alternative to the VS100 chip family. In terms of AV link capacilities, this chip can also deliver 10.2 Gbs f HDMI 1.4 traffic (including HDCP) but for up to 70 meter range. Table 2 below specifies the VS010 capabilities:

Table 2: VS010 Range Specification

Cable Type	Range	Pixel clock rate	Video Data Rate	Supported Video
CAT5e/CAT6	60 m	<=225 MHz	<= 5.3 Gbps (HD Video)	Up to 1080p, 60 Hz, 36 bpp (data rates lower than 5.3 Gbps or below 225 MHz TMDS clock).
	35 m	>225 MHz	> 5.3 Gbps (Ultra HD Video)	1080p 60 Hz 48 bpp, 1080p 60 Hz 3D, and 4K2K, 30Hz video formats
CAT6a/CAT7(*)	70 m	<=225 MHz	<= 5.3 Gbps (HD Video)	Up to 1080p, 60 Hz, 36 bpp (data rates lower than 5.3 Gbps or below 225 MHz TMDS clock).
	40 m	>225 MHz	> 5.3 Gbps (Ultra HD Video)	1080p 60 Hz 48 bpp, 1080p 60 Hz 3D, and 4K2K, 30Hz video formats

2.5 Overview of Video Formats

below, commonly used video formats are specified with their attributes. Ultra-HD formats are highlighted. In these formats, you should be aware to use proper cable if you wish to use a 100 meter cable or limit your installation to 70 meters if you use CAT5e/CAT6 cables.

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CAT5e/CAT6	60 m	<=225 MHz	<= 5.3 Gbps (HD Video)	Up to 1080p, 60 Hz, 36 bpp (data rates lower than 5.3 Gbps or below 225 MHz TMDS clock).
	35 m	>225 MHz	> 5.3 Gbps (Ultra HD Video)	1080p 60 Hz 48 bpp, 1080p 60 Hz 3D, and 4K2K, 30Hz video formats
CAT6a/CAT7(*)	70 m	<=225 MHz	<= 5.3 Gbps (HD Video)	Up to 1080p, 60 Hz, 36 bpp (data rates lower than 5.3 Gbps or below 225 MHz TMDS clock).
	40 m	>225 MHz	> 5.3 Gbps (Ultra HD Video)	1080p 60 Hz 48 bpp, 1080p 60 Hz 3D, and 4K2K, 30Hz video formats

2.6 Overview of Video Formats

Table 3: Commonly Used Video Formats and Their Attributes (most data is taken from CEA-861-E standard)

Rate FPS	Hactive	Vactive	Color Depth	Prog/ Inter	Htotal	Hblank	Vtotal	Vblank	rate Gbps	Pixel Freq MHz
24	1280	720	24	P	3300	2020	750	30	1.4	59
25	1280	720	24	P	3960	2680	750	30	1.8	74
30	1280	720	24	P	3300	2020	750	30	1.8	74
24	1920	1080	24	P	2750	830	1125	45	1.8	74
25	1920	1080	24	P	2640	720	1125	45	1.8	74
30	1920	1080	24	P	2200	280	1125	45	1.8	74
50	720	576	24	P	864	144	625	49	0.6	27
50	1280	720	24	P	1980	700	750	30	1.8	74
50	1920	1080	24	I	2640	720	1125	23	1.8	74
50	1440	576	24	I	1728	288	625	25	0.6	27
50	1440	288	24	P	1728	288	312	24	0.6	27
50	1440	288	24	P	1728	288	313	25	0.6	27
50	1440	288	24	P	1728	288	314	26	0.7	27
50	2880	576	24	I	3456	576	625	25	1.3	54
50	2880	288	24	P	3456	576	312	24	1.3	54
50	2880	288	24	P	3456	576	313	25	1.3	54
50	2880	288	24	P	3456	576	314	26	1.3	54
50	1440	576	24	P	1728	288	625	49	1.3	54
50	1920	1080	24	P	2640	720	1125	45	3.6	149
50	2880	576	24	P	3456	576	625	49	2.6	108
50	1920	1080	24	I	2304	384	1250	85	1.7	72
60	640	480	24	P	800	160	525	45	0.6	25
60	720	480	24	P	858	138	525	45	0.6	27
60	1280	720	24	P	1650	370	750	30	1.8	74
60	1920	1080	24	I	2200	280	1125	23	1.8	74
60	1440	480	24	I	1716	276	525	23	0.6	27
60	1440	240	24	P	1716	276	262	22	0.6	27
60	1440	240	24	P	1716	276	263	23	0.6	27
60	2880	480	24	I	3432	552	525	23	2.6	54
60	1920	1080	24	P	2200	280	1125	45	3.6	149
60	2880	480	24	P	3432	552	525	45	2.6	108
100	1920	1080	24	I	2640	720	1125	23	3.6	149
100	1280	720	24	P	1980	700	750	30	3.6	149

Rate FPS	Hactive	Vactive	Color Depth	Prog/ Inter	Htotal	Hblank	Vtotal	Vblank	rate Gbps	Pixel Freq MHz
100	720	576	24	P	864	144	625	49	1.3	54
100	1440	576	24	I	1728	288	625	25	1.3	54
100	1920	1080	24	P	2640	720	1125	45	7.1	297
120	1920	1080	24	I	2200	280	1125	23	3.6	149
120	1280	720	24	P	1650	370	750	30	3.6	149
120	720	480	24	P	858	138	525	45	1.3	54
120	1440	480	24	I	1716	276	525	23	1.3	54
120	1920	1080	24	P	2200	280	1125	45	7.1	297
30	4096	2160	24	P	2200	280	1125	45	1.8	74
30.0	4096	2160	24.0	P					8.1	297

2.7 Understanding Cables, Cable Grades and Cable Impairments

2.7.1 Cable Shield Types

Figure 1 shows three cable types designated U/UTP, F/UTP and S/FTP.

U/UTP: A balanced cable type with four twisted-pair conductors surrounded by a cable sheath

F/UTP: A balanced cable type with all four twisted conductor pairs enclosed by a metal foil surrounded by a cable sheath

S/FTP: A balanced cable type with each of the four-twisted conductor pairs enclosed by a foil screen and a braid screen. All is surrounded by a cable sheath

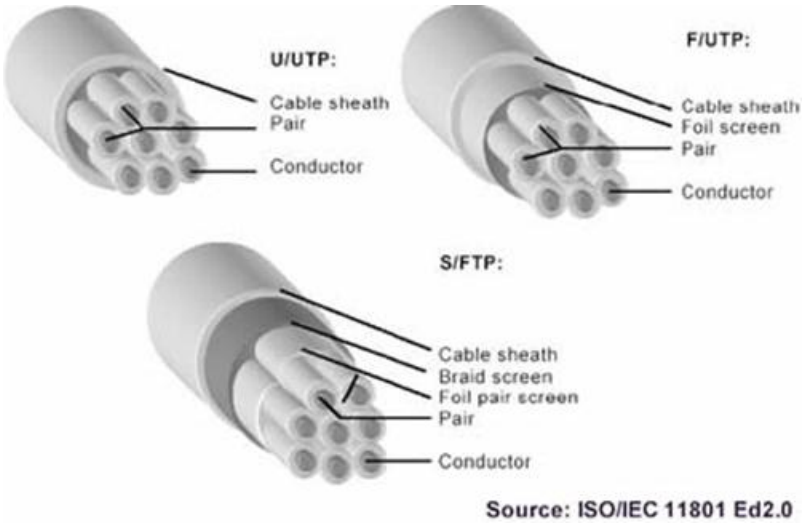


Figure 1: CATx Cable Types

2.7.2 Cable Grades

CAT5e/CAT6:

Class E cabling specification (also referred to as Cat5e and Cat6) defines balanced cabling characteristics over a maximum bandwidth of 250 MHz.

The improved performance of Cat6 over Cat5E is attributed mainly to better insulation, thus lowering Attenuation, NEXT and FEXT impairments in cables and connectors.

Cat6A

CAT6A is sometimes referred to as Class EA. This class cable is defined to work at frequencies up to 625MHz. It reduces the NEXT and FEXT impairments by 80%, and has 27% better Insertion loss. CAT6A features increased diameter (0.31inch vs. 0.22inch), and an installed separator for controlling the pair positions within the cable.

Cat6A also has an increased twist rate and varied twist rates between the four pairs, thus improving signal coupling.

CAT7

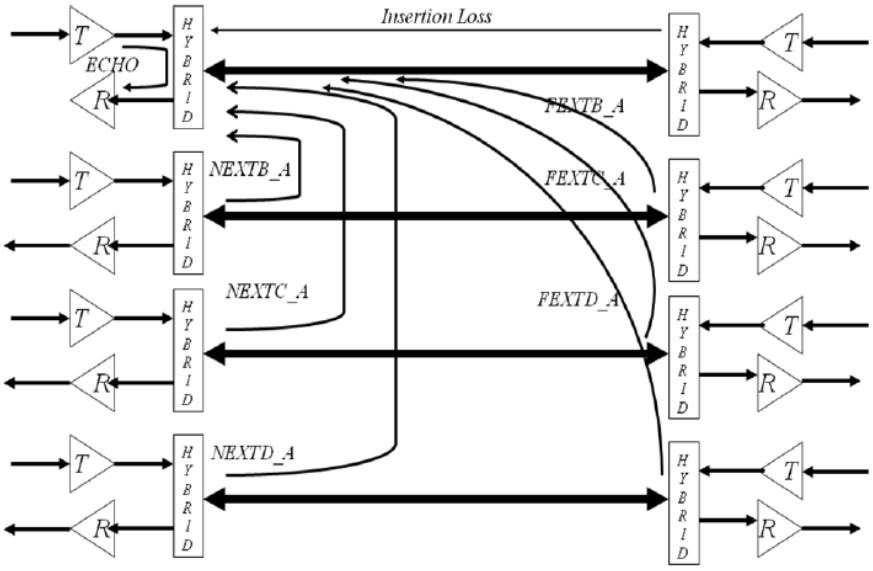
Category 7 S/FTP cabling specification (also referred to Class F) defines balanced cabling characteristics over a maximum bandwidth of 1000 MHz.

2.7.3 Cable Impairments

To understand the limitations of an HDBaseT system, we explain below the main impairments that occur during high throughput transmission over a CATx cable.

In CATx cables there are four twisted pair channels. Each one of the four receivers suffer from impairments resulting from the three remote transmitters of the neighboring channels, and from all four transmitters on the near-end side.

The following diagram shows impairments created over the four twisted pair channels (designated A, B, C and D from top to bottom) in a single CATx cable:



Where:

- *Insertion Loss (IL) - Attenuation of a signal traveling down a single pair in the cable.*
- *FEXT (Far End Cross Talk) impairments caused by the far - end transmitters of channels D (bottom channel), C and B onto the receiver of channel A (top left).*
- *NEXT (Near End Cross Talk) impairments: From the near - end transmitters of channels D, C & B onto the receiver of channel A.*
- *Echo impairment: caused by an echo of the near end side transmission of channel A onto the receiver of channel A.*

Figure 2: Single cable impairments

When installing a bundle of cables, additional impairments effects are introduced. This is shown in Figure 3 below:

Figure 3: Multiple Cable Impairments

- Alien NEXT (ANEXT): The interference that comes out on the near end of the other pairs, when a signal is injected on a pair in the central cable.

- Alien FEXT (FEXT): The interference that comes out on the far end of the other pairs, when a signal is injected on a pair in the central cable.

2.8 Working in Full-reach and Full capacity

In order to support the Ultra-HD formats listed in table **Error! Reference source not found.**, you must guarantee that either cable lengths are <= 70 meters or a CAT6a/CAT7 cable are used if a full reach of 100 meter reach is required.

The following cable models were successfully tested at Valens QA labs. We recommended these cables for use in cases when full-reach and full capacity are required (i.e. video formats with TMDS clock rate >225 MHz). You may use similar or superior grade cables but we strongly recommend testing them in advance.

Table 4: Recommended Cables for Ultra-HD video at 100 Meter range

Type	P/N	Manufacturer	
CAT7 S/FTP	FR-LSZH	Teldor	http://www.teldor.com/
CAT6A H-STP	HFFR	Teldor	http://www.teldor.com/
CAT.7	2170475	Earthline	http://products.lappgroup.com/online-catalogue/data-communication-systems-for-ethernet-technology/

2.9 Working in Long Reach Mode

The VS100 chip family support long reach mode. When this mode is applied, a more robust modulation technique is used in order to enhance range while compromising on maximum supported rate. If your system is not required to support video rates higher than 3 Gbps (i.e. 1080p, 24 bpp, 60 Hz or video formats not exceeding a pixel clock rate of 148 MHz), you may activate long reach mode and enjoy longer cable reach of 150 meters with a CAT5e/CAT6 cable.

To configure the VS100RX and VS100TX for working in long reach mode, please refer to "Valens VS100 Application Note AN1033 – Update Parameter Tool UM"

NOTE:

Working in long reach mode is not an HDBaseT certified mode. Interoperability issues may occur when connecting equipment from different vendors.

3 Field / Lab Issues

3.1 Overview

This section includes the following topics:

- Cable Layout
- Using Patch Cables
- Measuring Cable Length on Existing Cabling
- Field RJ45 Termination
- Working with Bundles
- Lab Testing Cable Setups

3.2 Cable Layout

It is recommended to stretch a cable to its full length between the HDBaseT Transmitter and Receiver devices. Random rolls of excess cable will degrade the performance and should be avoided.

However, sometimes the cable is rolled randomly in small turns for convenience (mainly for demo or testing purposes). Note that the maximum lengths will be reduced in this scenario.

3.3 Using Patch Cables

The total run of an HDBaseT cable installation may include up to two patch cables, typically as connections to RJ45 wall jacks. This is referred to as a three-segment installation. This is shown in figure 4.

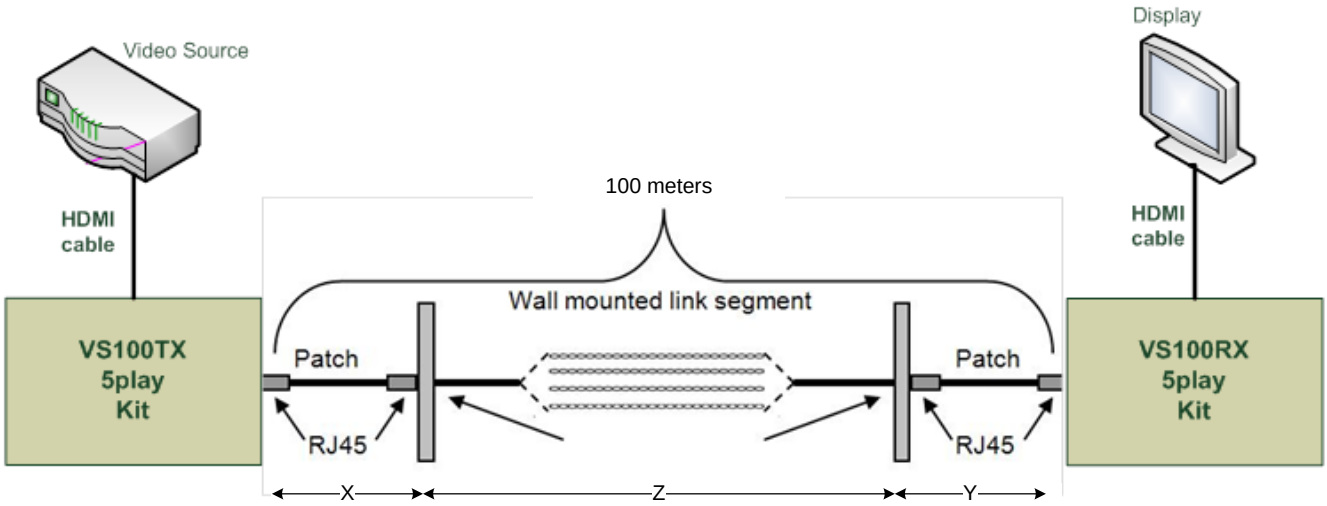


Figure 4: Three-segment Installation

The HDBaseT standard specifies the following configuration for the three-segment cable installation:

Cables Length:

- X = Left side patch cable length ≤ 5 [meter]
- Y = right side patch cable length ≤ 5 [meter]
- Z = wall segment ≤ 100 – X – Y [meter]

3.4 Measuring Cable Length on Existing Cabling

Cable lengths can be measured in the field using either a professional test equipment (like fluke DTS Cable Analyzer) or by using the VS100 length measurement feature. To learn more about reading the cable length using the VS100 length measurement feature, refer to the VSMS User Manual or the AN1004 on host interface.

3.5 Field RJ45 Terminations

One of the advantages of transmitting AV over a CATx cable is the ability to terminate the cable in the field during the installation. We strongly recommend eliminating excess cable length to avoid turns and corners that may degrade the signal link quality and affect the range or video quality.

The VS100 chip family supports three RJ45 configurations:

- Straight
- Crossover
- Semi-crossover

This is shown in the figure below:

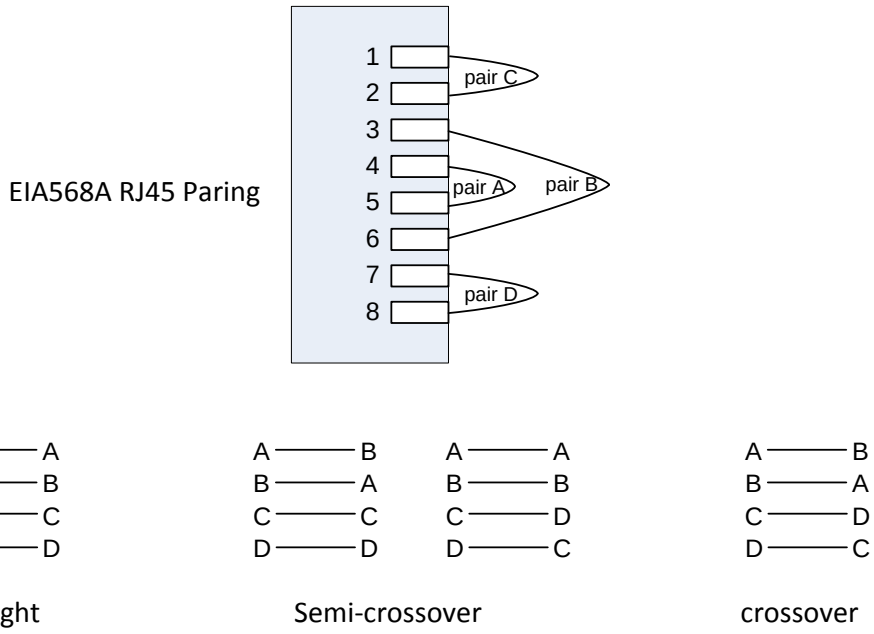


Figure 5: Supported RJ45 Configurations

3.6 Working with Bundles

HDBaseT alliance defines the maximum number of cables in a bundle use case to be six. Table 5 below defines the maximum number of cables in a bundle as a function of cable type & the overlapping length.

Table 5: HDBaseT Cable Permit able Number of Cables in a Bundle

Type	30m	50m	70m	100m
Cat5e/6	6	4	2	1
Cat6a/7	6	6	6	6

The following three cable types shown in Figure 6 are recommended to support the HDBaseT over bundling of several cables.

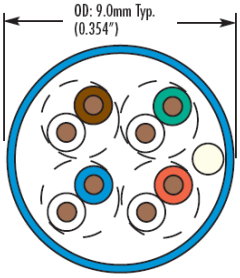
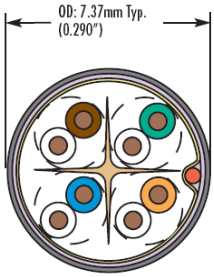
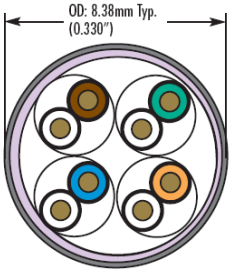
Media	Augmented Category 6A UTP	Augmented Category 6A F/UTP	Category 7/Class F S/FTP
Cable Construction			
Alien crosstalk	Exhibits compliant alien crosstalk due to core separation design	Exhibits virtually zero alien crosstalk due to overall foil construction	Exhibits virtually zero alien crosstalk due to fully shielded construction
Installation Notes	Larger overall diameter must be taken into consideration when calculating conduit and pathway fill	Grounding of the foil in one location from the patch panel in the telecommu-nications closet to the TGB is required	Grounding of the shield in one location from the patch panel in the telecommunications closet to the TGB is required
Work Area Interface	Standard 8-position Modular (RJ-45 style)	Standard 8-position Modular (RJ-45 style)	Quadrant-Pair Isolated Connector (non RJ-45 style)
Maximum Recommended Conduit Fill	60%	60%	60%

Figure 6: Cable types Recommended For Bundles

The following installation practices improve alien crosstalk headroom when using Cat5E/6 cables:

- Do not "comb" of "pinstripe" cables in the first 20 meters.
- Separate path and equipment cords in the first 20m.
- Avoid tie-wraps.
- Use horizontal wire management techniques (e.g. route odd ports to upper management and even ports to lower management).
- Loosely place cables in vertical wire management.
- Reduce maximum conduit fill density to 40%.

Implementation of these practices is not required for any augmented Cat6a F/UTP (sometimes referred to as ScTp) or Cat7 S/FTP (fully shielded) cabling systems. In addition, these practices do not need to be applied when using augmented Cat6a UTP systems, such as those with cable diameter design enhancements that increase cable-to-cable separation.

3.7 Lab Testing Cable Setups

3.7.1 Rolled Cable FEXT (Far End Cross-Talk)

In a typical installation the cable is stretched to its full length between the HDBaseT transmitter and receiver. However in some cases, especially in demonstrations or in a lab environment, the cable is rolled randomly in small turns for convenience. The randomly rolled UTP cable suffers additional signal impairments (compared to a straight cable) and therefore the maximal operating reach might be reduced.

Rolling a cable randomly causes the coupling between the various turns to create additional paths for cross talk. Therefore, the FEXT impairment is increased. This phenomenon does not occur in STP or FTP cables due to the shielding that prevents such coupling.

Figure 7 illustrates three measurements taken with the same 100m CAT5E cable using a FLUKE-DTX cable analyzer.

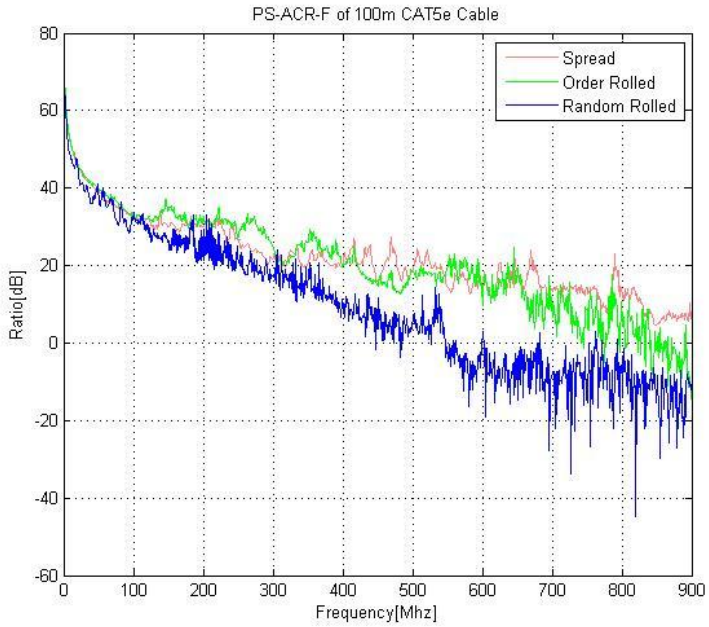


Figure 7: Power accumulated FEXT vs Cable usage

In the 1st measurement the cable was spread along a 100m straight line. In the 2nd measurement it was rolled in a random way and in the 3rd it was rolled in an orderly manner. The FLUKE-DTX tested the ratio between the signals' attenuation and the Power Sum FEXT (PS-ACR-F) for each of the 4 twisted pairs.

In this example it is apparent that the PS-ACR-F of the randomly rolled cable (marked Random Rolled) is degraded by approximately 10dB to 20dB with respect to a spread cable (marked Spread). The reduction in the Signal to Noise Ratio (SNR) results in reduced performance (higher BER).

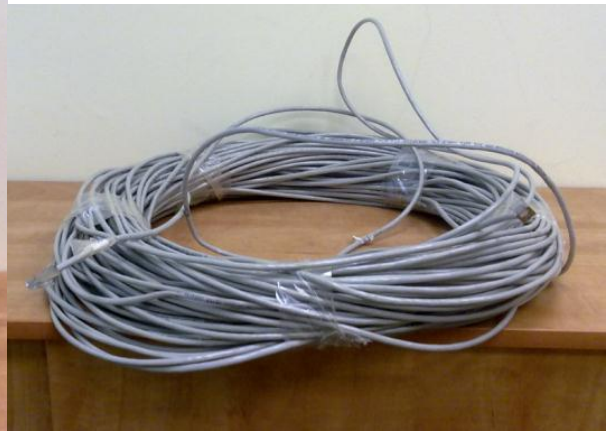
Since there are many ways to roll such a long cable the level of performance degradation cannot be predicted

Therefore, to be on the safe side, when a CAT5E cable is randomly rolled it is recommended to limit its length to approximately 50 meters.

3.7.2 Recommended Lab Orderly Rolling

It is recommended to roll the cable around a fixed radius drum in an orderly manner. This is shown on the left hand side of Figure 8. When the turns are made in order the coupling between the various sections that occur in a randomly rolled cable is reduced. Rolling a CAT5E cable around a 70cm fixed diameter plastic drum has just a minor effect on the FEXT when compared to a fully stretched cable.

Order Rolled (3rd experiment)



Random Rolled (2nd experiment)

Figure 8: Orderly and randomly Rolling a Cable