

Cabling for Success with DXLink™ Twisted Pair Products



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EXECUTIVE SUMMARY

Cabling For Success with DXLink™

The DXLink product line has grown over the years including new TX, RX, DGX and DVX devices. With new products introduced that support 4K UHD video come some new capabilities, guidelines and specifications.

DXLink™ delivers 10.2 Gb/s throughput over shielded category cable. It accomplishes this by leveraging the transport layer of HDBaseT technology. DXLink is state of the art technology capable of delivering audio / video content at distances up to 80 meters for formats up to 4096x2160 (UHD Series), and up to 100 meters for formats up to 1920x1200 (HD and UHD Series) when properly deployed and configured. The following white paper provides detailed information on how cable quality, cable topology and the environment affect the performance of DXLink systems. In summary, suffice it to say that looping, poor cable end termination, using patch blocks, inadequate grounding of the cable/rack/building and running cables near noisy devices will negatively affect the quality of the signal path and cause issues such as offline events and blinking of video. Below are some helpful guidelines to follow when deploying your DXLink system.

Product line differences:

- 4K UHD DXLink, resolutions up to 4096x2160:
 - Requires the use of shielded Cat6A or Cat7 and High-Speed classified, category 2, HDMI cable.
 - Maximum Cat6A or Cat7 cable length supported is 80 meters.
 - Note: If the UHD model is used in place of a regular HD DXLink board or endpoint and the device will not be passing formats above 1920x1200, the maximum cable length supported is 100m using shielded Cat6 or better. If used in this fashion, passing UHD formats is not supported.
 - For clarity, in this document the UHD cable spec will be referenced as if it is being used in a UHD capacity and reflect Cat6A or better up to a maximum length of 80 meters.
- 2K HD DXLink, resolutions up to 1920x1200:
 - Requires the use of shielded Cat6, Cat6A or Cat7.
 - Maximum cable length supported is 100 meters.
 - For best “it just works” results, shielded Cat6A cable is recommended

For optimal performance:

- Keep the cable runs as short as possible
- Follow cable shielding and termination techniques defined in this document
- Follow Equipment and Building Ground requirements defined in this document
- DXLink twisted pair cable runs for DXLink equipment shall only be run within a common building
- Keep the DXLink cables as isolated as possible from noisy power cables
- Avoid running cables in parallel with power runs, try to cross at 90 degree angles
- Avoid running near noisy devices (motors) or inductive loads
- Avoid tie wrapping and/or tightly bundling DXLink cables together
- Avoid making sharp corners/bends in cable runs
- Minimize “coiling” of the cables
- Minimize patch panels & patch cables (every connection introduces losses)
- Make sure connectors are properly terminated, higher quality shielded cables require more intricate terminations
- If you have a cable deployment scheme running many cables that traverse near large EMI or ESD generators you should use shielded and foiled Cat6A cable S/FTP

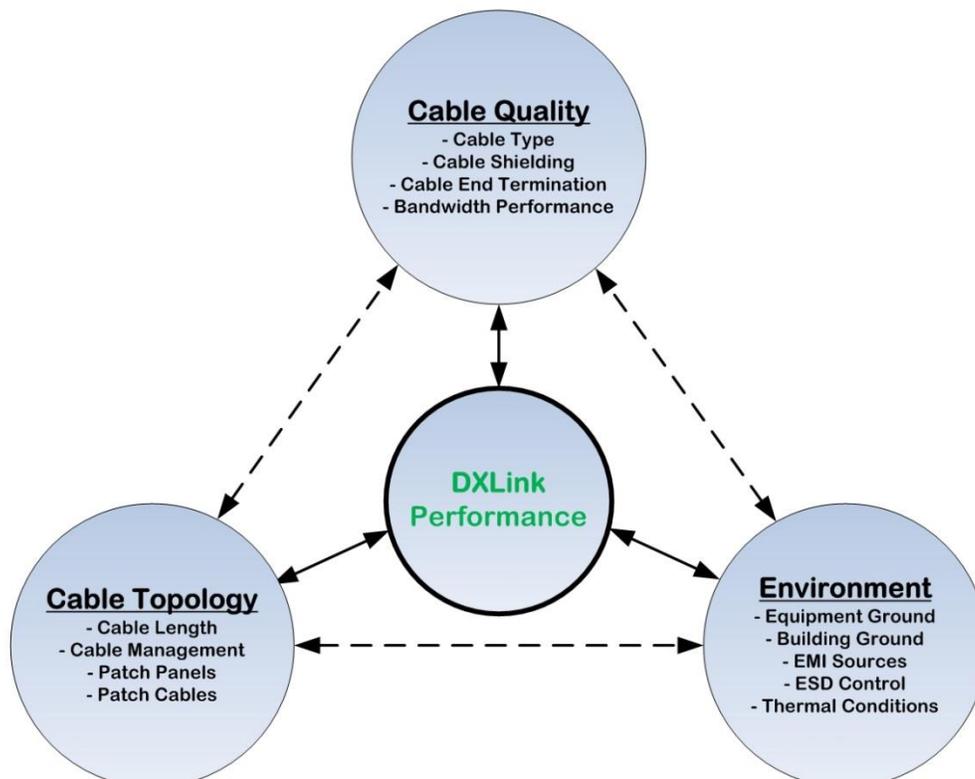
INTRODUCTION

A multitude of aspects contribute to the overall system performance of DXLink products when installing structured cabling solutions. The capabilities of this solution to pass Uncompressed HDMI Video, Uncompressed HD Audio, Ethernet, Serial, IR and Power require a cable bandwidth of 500 MHz or greater for the UHD products and 250 MHz or greater for the HD products, with cabling infrastructure performance that supports throughput of 10 Gb/s. Based on the bandwidth required to transmit this amount of information we recommend following industry standard practices designed for 10 Gigabit Ethernet. In order to perform at its best, the HDBaseT transport layer utilized in DXLink requires specific rules which include management of not only to the cabling system back-bone but also the patch locations and end-point runs. The primary focus of this paper is to review the key challenges and solutions facing the structured copper cabling media required to properly support the DXLink technology in both UHD and HD applications.

OVERVIEW

To achieve a high performing and reliable installation, several key factors need to be considered and managed which all have a combined impact. When any one of these factors is not adhered to the likelihood of inconsistent performance or sporadic video, audio and network drop-outs increase, to the point where the products can fail to function at all if faced with several conditions not being met.

Three main areas need to be addressed in order to optimize the performance of DXLink installations. They all have a direct impact on the performance of the overall DXLink system and also have relational impact on each other, such that improving in one area can often provide ability to overcome shortcomings in one of the other areas. A balancing of these three roles will allow for a successful and robust DXLink system.



DXLINK PERFORMANCE

Depending on the link quality between DXLink devices over structured cabling, the product performance can vary from a solid and reliable system to a system which may have intermittent problems or links that fail to function altogether. The most common symptom of poor link quality due to deficiencies in the structured cabling is intermittent momentary dropping of video and audio but can also degrade to the point that end-points fall offline and can even cause a link not to function at all, incurring a failure to link.

This section touches on specific guidelines which can be referenced to ensure success from the beginning of the project all the way through installation providing validation of link quality after the job has been completed.

BASIC CABLE INFORMATION

Pre-installation cable selection should be the first order of business when designing the overall installation. The cable selection should be determined by the combination of these factors: the environment, the length of DXLink cable runs and the planned cable topology. As shown in this document they all play a role in overall system performance.

The primary goal is to ensure a high quality transport path from end-point to end-point while negating any external environmental factors that can impact performance. The minimum required cable to provide a successful system installation is a shielded Cat6A cable for UHD and a shielded Cat6 cable for HD. To ensure robust performance in installations with unmanaged environmental factors, stepping up to shielded Cat6A or Cat7 is recommended. TIA 568-C.2 specifies backbone/horizontal cabling to be 22-24 AWG solid core wires, while patch cords can be between 22-26 AWG and solid core or stranded wire.

STP is used in this document to cover the wide range of Shielded Twisted Pair implementations listed below; the severity of environmental factors should be considered when selecting between them: SF/FTP, S/FTP, F/FTP, SF/UTP, U/FTP and F/UTP

'S' represents Screened braid shielding (also sometimes referenced as 'Sc')

'F' represents Foil shielding

'U' represents Unshielded

'TP' represents Twisted Pair

And notations left of the '/' defines outer cable shielding while right of the '/' defines shielding of the individual wire pairs. Some graphical examples are shown on page 8 of this document.

Note: Not all cable manufacturers use the same definitions regarding shielding nomenclature.

For best performance a shielded Cat6A cable is suggested for HD and required for UHD

We recommend the following (or equivalent) to provide a good price vs. performance point while minimizing environmental susceptibility.

Cat6A F/UTP (shielded and bonded)
 Belden 10GX 10GX62F (Riser)
 Belden 10GX 10GX63F (Plenum)

When using a Cat6 F/UTP cable we recommend the following (or equivalent).

Cat6 F/UTP (shielded cable)
 Belden 2412F DataTwist (Riser)
 Belden 2413F DataTwist (Plenum)

A complete Belden shielded Cat6A cable and cable management solution is available here:

http://www.belden.com/docs/upload/CheatSheet_10GX_FT_Shielded_Systems.pdf

INSTALLED CABLE CHANNEL PERFORMANCE

Once cable is installed there are several factors that can affect link quality such as cable quality, cable termination, grounding techniques, building ground differences, cable length, cable topology, service loops, patch panel quality and quantity, cable kinks, etc... In order to understand how the overall cable paths perform from one end of DXLink to the other end of DXLink, you can utilize tools such as Fluke's DSX-5000 Cable Analyzer and Versiv family to characterize a number of specifications defined by TIA-568-C.2. Any cable type chosen should have its end-to-end installed performance meet the Channel Requirements specified by TIA-568-C.2 with the channel being measured as the disturbed channel in a 6-around-1 bundle ensuring the cables around the channel under test have active signals running. Please keep in mind any tolerance that the cable testing device may have in its reporting and to ensure a passing performance even with the tolerance taken into consideration.

ENOVA DGX LINK QUALITY REPORTING

A post-installation method for determining the link integrity for a given DXLink path is provided if it is connected to an Enova DGX or DGX 100 Series populated with DXLink Input/Output UHD or HD boards. The Enova DGX and DGX 100 Series 64/6400, 32/3200, 16/1600 and 8/800 Enclosures can report measured link integrity values which are useful in evaluating the overall system or troubleshooting paths that are presenting problems. When connected to the Enova DGX Enclosure, reporting of each DXLink Input/Output port can be captured which presents a decibel value for each of the four twisted pairs on a given port. If any of these MSE values reports $\geq -15\text{dB}$ (i.e. -13dB) the link quality is in a range that will negatively affect performance. See [Appendix A](#) for instructions and examples of how link quality reporting through the Enova DGX Enclosure can be acquired.

CABLE QUALITY

CABLE TYPE

AMX requires as a minimum using shielded Cat6A cable for UHD and shielded Cat6 for HD installed per the recommended guidelines in this document.

As you might expect, the higher the quality of the category cable the more robust the DXLink system will perform. The gains to be made in this area are improved bandwidth, improved internal channel parameters, improved external channel parameters and reduced susceptibility to environmental EMI and ESD events.

When using Cat6A STP and Cat7 which meet their correlating TIA-568-C.2 performance requirements, the DXLink runs can fully reach the 80m UHD specification and when using Cat6 STP, Cat6A STP and Cat7 the DXLink runs can fully reach the 100m HD specification when bundled in groups of 6+1 (TIA-568 Alien Crosstalk Bundle). Using the heavier shielded versions of them, such as S/FTP, provide improved resistance to uncontrolled environmental EMI and ESD events.

The benefits of these increasing grades of cable type provide significant improvement in both internal and external channel parameters. Specifically of note are:

INTERNAL CHANNEL PARAMETERS

- Insertion Loss / Max Attenuation: The measure of signal loss that occurs from transmitter to receiver.

- Often referred to as the cable bandwidth, typical factors that affect insertion loss include conductor size, insulation and jacket material type, frequency bandwidth, number of patch connections and cable length.
- **Return Loss:** The measure of how much signal gets reflected back to the source due to impedance variations in the Channel.
 - Typical factors that affect Return Loss include variations in twist rates and discontinuities in impedance.
- **Near End Crosstalk (NEXT):** The measure of unwanted signal coupling between pairs in the same cable.
 - Power Sum NEXT (PSNEXT) is the sum of unwanted signal coupling between multiple pairs in the same cable.
- **Equal Level Far End Crosstalk / Attenuation to Crosstalk Ratio, Far End (ELFEXT/ACRF):** The measurement of unwanted signal coupling between pairs in the same cable when a disturbing signal is sent from one end and received by the transceiver on the opposite end, including attenuation loss due to insertion loss.
 - Power Sum ELFEXT / Power Sum Attenuation to Crosstalk Ratio, Far End (PSELFEXT/PSACRF) is the sum of unwanted signal coupling between multiple pairs in the same cable when the disturbing signals are sent from one end and received by the transceiver on the opposite end..
 - Typical factors in the severity of these internal crosstalk measurements are the cable internal insulation and pair to pair separation.

EXTERNAL CHANNEL PARAMETERS

- **Alien Crosstalk** is the most significant external parameter that affects signal and channel performance. Both near end and far end crosstalk can detract from robust functionality and specifically include the Power Sum scenarios described above where multiple cables contribute crosstalk to the channel under evaluation.
 - **Power Sum Alien NEXT (PSANEXT)** is the effect of multiple Alien/External cable channels injecting NEXT on a given cable.
 - **Power Sum Alien ELFEXT / Power Sum Alien ACRF (PSAELFEXT/PSAACRF)** is the effect of multiple Alien/External cable channels injecting ELFEXT/ACRF on a given cable.
- **Alien Crosstalk** can significantly be reduced or mitigated by:
 - The use of higher grade cables such as Cat6A STP and Cat7 cabling.
 - Separating the cables from each other for portions or the entire cable run.

CABLE SHIELDING

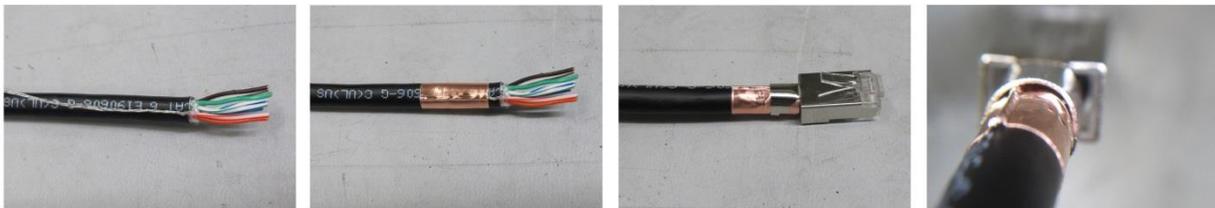
Properly managed STP cable will provide numerous benefits, with the double shielded version such as S/FTP and F/FTP giving even greater protection against unmanaged environmental disturbances. When utilizing shielded cable, the entire system and building ground should be managed to ensure end-to-end common ground reference levels and continuity. Some specific benefits of STP include:

- It will provide shielding from Alien forms of crosstalk, as covered in the cable type section, which reduce or eliminate noise from adjacent or bundled cables.
- It will provide a significant improvement in immunity to environmental EMI and ESD events that might be occurring in the area of the DXLink TX, DXLink cable runs, DXLink Enclosure or DXLink RX.
 - This added immunity will generally eliminate possible video or network drops due to events of this nature by the virtue of keeping the large area events that are radiated through the air from coupling onto the high-speed DXLink signals and circuitry.

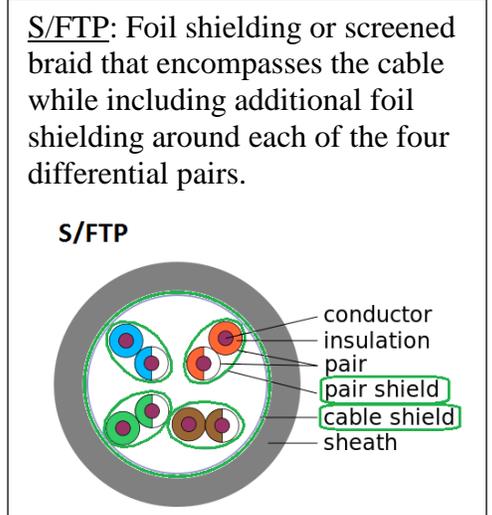
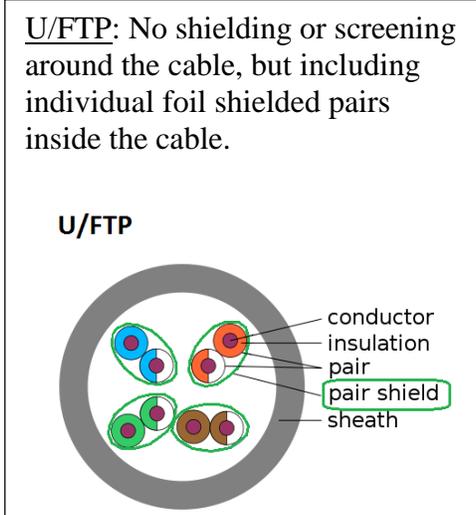
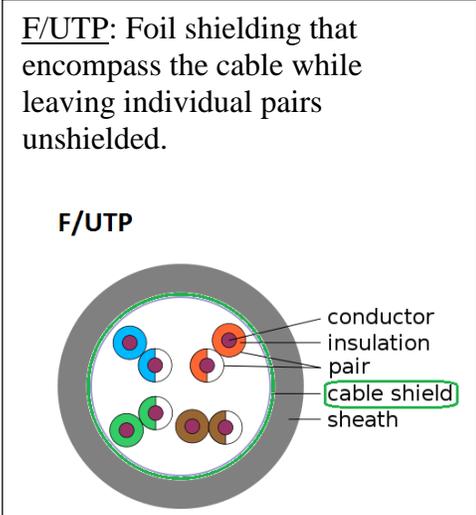
CABLE END TERMINATION

Termination techniques for using shielded cable need to be applied correctly for STP cable benefits to be realized and keep from introducing negative effects. Not only do the cables include shielding components which need to be terminated correctly, but the diameter of the cable itself will be larger and in some cases require the use of shielded punch-down connectors to properly terminate.

- Bonding to ground at both ends of the cable is required.
 - Bonding throughout the run, including patch panels and patch cables to achieve a true end to end ground connection is necessary.
 - A full 360 degree shielding termination is required to ensure ground connection is robust and will not make intermittent contact when stresses are applied to the cable once installed. We recommend use of a copper tape to be wrapped around the cable end with the grounded drain wire and possibly foil shielding placed underneath the copper tape as shown below. The copper tape used here is a 3/4" wide [3M 1181](#) brand, part number 80011181049. This will ensure a low impedance connection at each interconnect point. The series of pictures below show the recommended termination process with the final picture showing that even when the cable has stresses applied; the 360 degree shielding will ensure contact between the cable shielding and the shielded RJ-45 plug.



- A low impedance connection at the equipment rack ensuring a solid tie between equipment and the rack itself as well as between rack and the buildings main ground buss bar is needed.
- Shielded or screened cable can reduce the effects of EMI and ESD on DXLink transmission, but they require equal grounding of the screen at both ends of the cable. A difference in ground potential between the termination points of the cable could cause the cable to act as an antenna, virtually negating all benefits hoped to be gained. But with good grounding techniques applied to all components of the DXLink system, including the cable drain wires, lost packets and dropped video can be mitigated.



Source: http://en.wikipedia.org/wiki/Twisted_pair

BANDWIDTH PERFORMANCE

The minimum bandwidth needed for supporting proper functionality in tandem with a controlled environment and quality cable installation should meet the TIA 568-C.2 horizontal cable specifications. The DXLink UHD product line requires Cat6A at specification of 500 MHz while the DXLink HD product line requires Cat6 at specification of 250 MHz.

The indicator of a cable’s bandwidth performance is the Insertion Loss specification, also referred to as Max Attenuation. DXLink products require that this cable spec meet the TIA 568-C.2 standard of 500MHz with no more than 45.3 dB loss using shielded Cat6A for UHD, and 250MHz with no more than 32.8 dB loss using shielded Cat6 for HD.

Freq. (MHz)	Max. Attenuation (dB/100 m)
1	2.100
4	3.800
8	5.300
10	5.900
100	19.100
200	27.600
250	31.100
300	34.300
350	37.200
400	40.100
450	42.700
500	45.300
550	47.700
600	50.100
625	51.200

Source: <http://www.belden.com/techdatas/english/10GX63F.pdf>

Note: The bandwidth of the cable alone will not guarantee robust performance in any installation as the overall performance is a factor of the three main categories referenced in this document as Cable Quality, Cable Topology and Environmental Factors.

CABLE TOPOLOGY

CABLE LENGTH

DXLink maximum cable length and cable type is specified per product series, HD or UHD.

- 4K UHD DXLink:
 - Requires the use of shielded Cat6A or Cat7 and High-Speed classified, category 2, HDMI cable.
 - Maximum cable length supported is 80 meters.
 - Note: If the UHD model is used in place of a regular HD DXLink board or endpoint and the device will not be passing formats above 1920x1200, the maximum cable length supported is 100m using shielded Cat6 or better. If used in this fashion, passing UHD formats is not supported.
 - If this device is later determined to require passing of UHD formats, the cable would need to be replaced to meet the UHD specification defined above.

- For clarity, in this document the UHD cable spec will be referenced as if it is being used in a UHD capacity and reflect Cat6A or better up to a maximum length of 80 meters.
- 2K HD DXLink:
 - Requires the use of shielded Cat6, Cat6A or Cat7.
 - Maximum cable length supported is 100 meters.
 - Supports formats up to 1920x1200.
 - For best “it just works” results, shielded Cat6A cable is recommended

Many contributing factors can impact the DXLink signal performance over long distances of category cable. Conduit density, loops, bends, kinks, patch panels and patch cables are the areas addressed in the following section.

Following a standard 10G Base-T Ethernet cabling topology is recommended:

- UHD Product Line: 5m (patch) → 70m (Horizontal cabling) → 5m (patch)
- HD Product Line: 5m (patch) → 90m (Horizontal cabling) → 5m (patch)

Better signal performance can be achieved if the DXLink system cabling does not include patch cords, panels, unnecessary cable length or couplers which will contribute to signal degradation.

DXLink Product Type	Supported Video Signal Format	Cable Type Supported	Maximum Cable Length
UHD	Up to 4096x2160	Shielded Cat6A or Cat7	80m
HD	Up to 1920x1200	Shielded Cat6, Cat6A or Cat7	100m
*UHD as HD Transport	Up to 1920x1200	Shielded Cat6, Cat6A or Cat7	100m

Figure 1 Table – DXLink product type video format and cable support table.

*When a UHD DXLink Input/Output Card or End-Point is used in place of an HD DXLink product to pass formats up to 1920x1200 it supports the HD format and cable supported specifications. Running in this capacity it will not support passing 4k video formats.

CABLE MANAGEMENT

- **Cable management solutions**
 - There are several off-the-shelf cable management systems which provide a full offering of compatible components to help ensure appropriate installation and management of category cable infrastructures. These will provide solutions to cable routing, cable end termination, punch down connectors, patch panels, patch cables and even pre-terminated horizontal back-bone cables among other items.
 - One such offering that has been shown effective for both performance and installation practices is offered here by Leviton:
 - http://www.leviton.com/OA_HTML/SectionDisplay.jsp?section=37719&minisite=10251

- **Specifications for shielded category cables**

Definition: Shield – A metallic layer placed around a conductor or group of conductors.

These specifications apply to F/UTP, U/FTP, S/FTP plus other shielded cable types in a bundle:

- Maximum conduit fill density will be no more than 60%.
- At all termination points along the shielded cable’s path, the copper tape or foil must make 360 degree contact with the shielded connector’s housing (e.g., RJ-45 conductive housing).
- All patch cords, panels, and couplers must be shielded in the cable run.
- A low impedance connection must be maintained over the full length of the shielded cable run.
- DXLink twisted pair cable runs for DXLink equipment shall only be run within a common building.
 - Common building is defined as: Where the walls of the structure(s) are physically connected and the structure(s) share a single ground reference.
- Additional care must be taken during installation not to kink the cable which can deform the conductors, thereby degrading the cable’s performance.
- Avoid tie wraps. If tie wrap use is absolutely necessary, then they should only loosely surround the cables. Cinching the tie wraps around a bundle will deform the cable conductors and negatively affect performance.
- Use loose Velcro™ wraps to bundle cable, only if it is necessary.
- Use 10G Base-T horizontal wire management techniques.
- Service loops are sometimes required as a means to store excess cabling. We do not recommend service loops as they increase the total length of the cable run, and the loop will wrap the cable back on itself which will increase crosstalk. If you must store excess DXLink system cabling do not use a loop, but instead use an “S” pattern.
- Bend radiuses tighter than the manufacturer’s recommendations and kinks (even straightened out kinks) created during installation will have a negative impact on the cable’s performance.
 - Excessive bends or kinks can deform the cable’s conductors, which will degrade the cable’s performance.
 - Excessive bends or kinks can deform the cable, which can alter the cable’s pair balance leading to noise immunity performance losses.
 - Kinked cable (even straightened out kinks) might perform adequately for Ethernet applications, but will have a much larger effect on DXLink system cabling.

It is our recommendation that any category cables with an excessive bend radius or kinks are treated as a damaged cable. Deformed category cables will limit the cable’s ability to properly pass a 10 Gb/s signal.

PATCH PANELS

Recommended panel practices:

- Utilize patch panel designed for the shielded cable class you are installing.
- Ensure the patch panel itself is well grounded to the buildings ground bus.
- Use proper strain relief to keep from damaging cable terminations.
 - Cable management combs may be desirable.

- Do not place patch panels near large EMI or ESD generators.

PATCH CABLES

Recommended Patch cable/cord practices:

- As defined by the TIA standard, patch cables are intended to be relatively short cables.
- Ensure the patch cable is the same cable type or better than the horizontal back-bone cabling.
- Do not install low quality patch cables as they will become the weakest link and negate the integrity and quality of the rest of the installation and horizontal cabling infrastructure.
 - Patch cables must also be shielded and properly terminated.
- 5 Meters is the maximum length supported when using high quality patch cables.

ENVIRONMENT

Environmental factors play an important role in determining the success of a DXLink installation, especially when the cable runs are over 30 meters. Some factors could result in an installation suffering intermittent failures or being inoperable if not carefully considered during the project development phase. Factors could include:

- Grounding
 - Equipment Grounding
 - Building Ground Integrity
- Electrostatic discharge (ESD) of excess static in the category cable jacket or when excess static electricity is discharged by a human hand through one of the DXLink components.
- Electromagnetic interference (EMI) generated by proximity electrostatic discharges, or by operating electrical motors.
- Ambient operating conditions surrounding the system installation.

Note: EMI and ESD, can be greatly reduced through the use of well balanced, shielded cables with grounded connectors, and keeping the cable runs as short as possible. Internal testing has shown that unbalanced and improperly grounded or terminated cable runs and equipment will lead to erratic behavior including network, audio and video losses.

GROUNDING

Transmission of DXLink data over twisted pair copper wire (differential mode) requires well balanced cable and terminations at both ends of the twisted pair to minimize the effects of the common mode hostile sources described in the EMI and ESD sections of this paper. Obtaining perfect balance becomes increasingly difficult as the length of the cable increases, making the cable less immune to EMI and ESD sources. Shielded or screened cable will reduce the effects of EMI and ESD on DXLink transmission, but they require equal grounding of the screen at both ends of the cable. A difference in ground potential between the termination points of the cable will cause the cable to act as an antenna, virtually negating all benefits hoped to be gained. But with good grounding techniques applied to all components of the DXLink system, including the cable drain wires, lost packets and dropped video can be overcome.

The following two sub-sections are discussed thoroughly and practically inside of the document link provided below from Commscope which when understood and followed will provide a quality installation and robust DXLink performance. It incorporates practices defined in the National Electric Code (NEC) NFPA 70 which defines grounding and bonding as well as providing requirements of the grounding of a building's electrical system. The linked document also incorporates practices defined in the TIA J-STD-607 Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

<http://www.commscope.com/Docs/Bonding-and-Grounding-AMP-NETCONNECT-Copper-Cabling-Systems-WP-320116-AE.pdf>

- Equipment Grounding
 - Follow requirements defined in TIA STD-607.
 - The standard can be purchased through [IHS here](#).
 - The grounding of ALL equipment used in a DXLink installation is required.
 - Grounding is recommended to be provided through a low impedance connection to equipment racks which in-turn should be heavily tied into the buildings electrical ground system.
- Building Ground Integrity
 - Follow requirements defined in NEC NFPA 70.
 - The standard can be accessed free through [NFPA here](#).
 - The entire building should have a common ground potential.

Siemon has provided an informative discussion of the benefits of shielded cable:

http://www.siemon.com/us/standards/Screened_and_Shielded_Guide_1_Overview_and_History.asp

DXLink signals can be carried over long distances; equipment connected to AC power at one end of the system may not be at the same ground potential as equipment at the other end of the system if guidelines provided by NEC (National Electrical Code) and TIA-607 (Generic Telecommunications Bonding and Grounding/Earthing for Customer Premises) are not followed.

ELECTROSTATIC DISCHARGE (ESD)

ESD is a type of EMI, but in this paper we are treating indirect ESD and direct ESD events separately. Direct ESD events refer to any electrostatic discharge that takes place directly to the DXLink system, where the system includes all components: DXLink receivers and transmitters, cables, and racks. ESD is defined as the transfer of excess electrons (charge) from one surface at some electrical potential to another surface at a different potential. The most common method of generating a charge is when different materials are rubbed against each other, transferring electrons; this is known as triboelectric generation. An example of triboelectric generation occurs when a person walks across a carpeted floor wearing shoes with soles made of a different material than the carpet.

An example of the voltage potential created by various activities under two ranges of relative humidity is provided in the following table by the Electrostatic Discharge Association, North Central Regional Tutorial Program (<https://esda.org/about-esd/esd-fundamentals/part-1-an-introduction-to-esd/>):

Examples of Static Generation

Typical Voltage Levels

<i>Means of Generation</i>	<i>10-25% RH</i>	<i>65-90% RH</i>
Walking across carpet	35,000V	1,500V
Walking across vinyl tile	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

As this table indicates, the relative humidity of the air surrounding the activity can affect the amount of potential; the drier the air the greater the potential. Note that the materials indicated in this table have insulative properties, meaning they do not permit the flow of electrons. The potential on insulative materials can exist for a long time if not placed in contact with a material having a different potential. When a material with high potential created during these activities contacts a material that has very low potential, such as when a person walking across a carpeted floor touches a metal door knob, the potential is rapidly dissipated causing an electromagnetic pulse and possibly the familiar spark (shock!). This occurs regularly during the installation of a DXLink system:

- Triboelectric generation of potential on cable outer jackets when they are installed may be dissipated when the jacket comes in contact with a metal surface, such as a cable raceway.
- Potential on the cable jackets may also be dissipated when the cable's terminated ends are connected to the DXLink receivers/transmitters.
- An installer touches the metal frame of a DXLink system component, dissipating any charge built up while walking across the floor.

When a potential is dissipated directly to the system, the path it takes varies so it is difficult to predict exactly what effect it will have on the DXLink transmission. AMX has conducted experiments which show static discharges with voltage potential of $\pm 3.5\text{kV}$ and greater applied directly to system components cause sufficient disruption to the transmission that result in momentary lost video. This is probably due in part to EMI (discussed below) and to propagation of the voltage throughout the component being discharged to.

Note: AMX equipment used in DXLink installations is protected against damage from ESD events.

ELECTROMAGNETIC INTERFERENCE (EMI)

Of the many forms of EMI, the greatest disruption to a DXLink installation is generated by

1) Electrical motors 2) Proximity ESD events and 3) Alien crosstalk from adjacent cables. The third form is covered in another section of this paper and will not be discussed here.

ELECTRICAL MOTORS

The second form, EMI generated by electrical motors operating in proximity to a DXLink system cable run, is greatly reduced by the use of twisted wire pairs provided the twisted pairs are well balanced. However, EMI transients generated when cycling power to the motor could propagate quickly through cable located nearby causing momentary loss of data, ultimately resulting in loss of video, audio or network connection. The good news here is these EMI sources have fixed locations and their operation is well understood; avoid placement of DXLink system cable runs close to large motors (e.g. heat pumps, elevators, lifts) and keep the runs perpendicular to power line cables.

PROXIMITY ESD EVENTS

Proximity ESD events are severe EMI occurrences produced when static electricity is discharged close to a DXLink system cable run – no direct contact with the cable is made, but the resulting electrostatic field can induce voltages in the category cable and cause momentary interference with transmission of the DXLink stream. In a typical Ethernet installation lost packets are simply retransmitted, but in a DXLink installation the lost packets are perceived by the user as dropped video, audio or network connection. In the real world, certain DXLink installations can be prone to the effects of proximity ESD events; examples are casinos where electrostatic air cleaners are used, and carpeted conference centers.

AMX has conducted testing to empirically quantify the effect of real-world ESD events on transmission of DXLink data: the test configuration is shown in Figure 2. In this testing a Schaffner ESD generator was used to apply controlled static discharges to various locations around the DXLink switcher, and to locations connected to ground along the length of the cable run. Various cable types (shielded, unshielded, Cat5e, Cat6, Cat6A) and cable configurations (straight one-way run, straight two-way run, loosely coiled, with and without patch cables) were tested using discharge voltages between +/-2kV and +/-8kV. Results from this testing showed that discharge voltages as low as 4kV at a distance of ~4 meters from the cable run can be responsible for causing video to flicker.

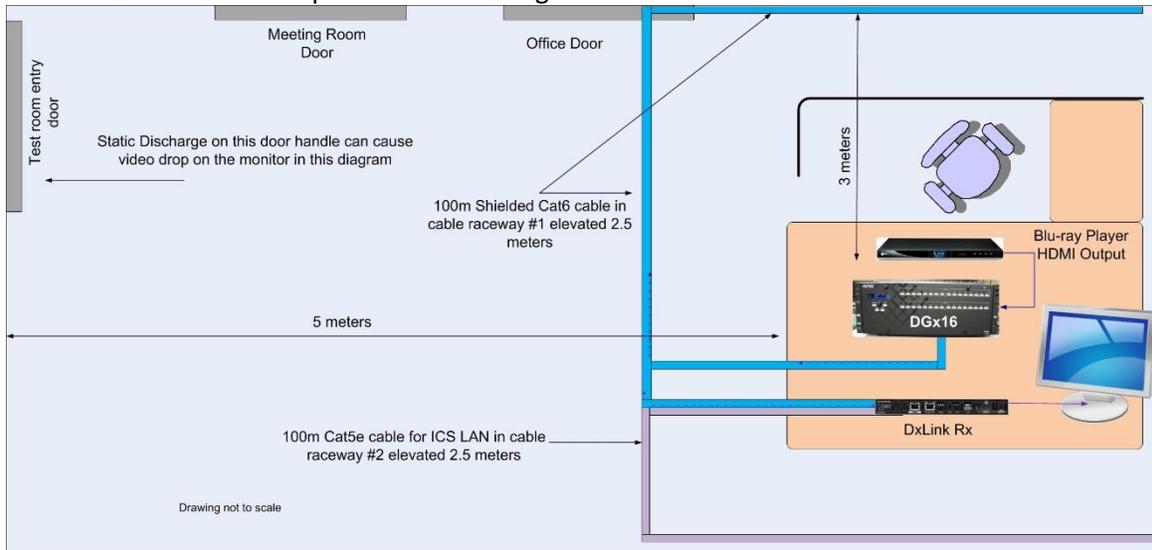


Figure 2 - Proximity ESD Event Test Diagram

Conclusions from this testing are that DXLink system susceptibility to EMI generated by proximity ESD events is related to the length of the cable run (shorter runs are less susceptible), the size of the event and distance from it to the cable, and the type of cable. Controlling these parameters and using properly terminated and bonded, shielded cable can mitigate the susceptibility.

AMBIENT OPERATING CONDITIONS

Temperature - Cable manufacturers specify their cables in different ways, but most will provide specifications for both installation temperature and operating temperature. To minimize damage to the cables, these specifications should be well understood before attempting to install a DXLink system cable run.

Humidity - As was demonstrated above, relative humidity has a distinct effect on the voltage generated during an ESD event which in turn can have an effect on the quality of the transmitted DXLink signal when the event occurs in proximity to an unshielded cable.

CONCLUSION

DXLink products can provide a wealth of features and benefits for your installation. Ensuring a properly shielded and terminated transmission medium plus a well-grounded system for distribution of signals will allow for a successful and robust solution.

For more information on DXLink products, contact your AMX Representative or visit www.amx.com.

APPENDIX A

Enova DGX Link Quality Reporting

Link quality measurements can be reported by the Enova DGX DXLink Input and Output boards to help determine the quality of the link established between a DXLink Input board and connected TX or a DXLink Output board and connected RX. The reporting information can potentially identify cable runs that will cause performance issues due to items such as poor cable quality, inadequate termination, and excessive length or patch cables discussed in this White Paper.

Link Quality Reporting for Enova DGX 100 Series using integrated Master's built in web server

If your system has DXLink Input with FW v1.4.0.18 or higher and DXLink Output with FW v1.4.0.12 or higher, which launched with the Enova DGX 800/1600/3200/6400 series under Firmware Upgrade Kit v3.0.10 or higher (released on December 15 2015) you will have access to the individual input & output port link quality values when connected to the CPU's LAN 100/1000 port and access the integrated Master's built in web interface. With this capability you will be able to view the link quality of a given cable run and determine if there are potential cabling issues which could cause performance issues.

The reporting is gathered and presented by the Enova DGX 100 Series CPU and accessed using the integrated Master's built in web interface, subsequently referred to as the Web GUI.

To gain access to the Web GUI you should follow the instructions in the Enova DGX 100 Series Hardware Reference Manual under the **System Configuration Interface Setup** section to establish communication with the CPU. Once you have established communication through the Web GUI, use the following instruction and accompanying screen shots to guide you in obtaining the MSE Link Quality report. This manual can be found at:

<http://www.amx.com//assets/manuals/EnovaDGX100Series.HardwareReferenceManual.pdf>.

1. **After establishing CPU communication using the Web GUI:**
 - a. **Log in to System Configuration.**
 - i. **Note: If this is the first time you are logging into the System Configuration, the default Username/Password is administrator/password.**
 - b. **From the main menu bar at the top of the screen, select Switcher>Configuration. The Configuration page appears.**
 - c. **On the left side of the screen select the DXLink Input or Output channel to see its configuration options.**
 - i. **Refer to areas marked with number 1 in the image below.**
 - d. **On the right side of the screen, select the DXLink Details button for the selected channel.**
 - i. **Refer to area marked with number 2 in the image below.**

Enova DGX Switcher Configuration Welcome, administrator [Logout](#)

AMX Home Network Security System Modules **Switcher**

Switching **Configuration** Status

Auto Take Legend

Inputs

1 DX4K-C	2 DX4K-C	3 DX4K-C	4 DX4K-C
5	6	7	8
9	10	11	12
13	14	15	16

Outputs Select All Deselect All

9 DX4K-C	10 DX4K-C	11 DX4K-C	12 DX4K-C
13	14	15	16
17 DX4K-C	18 DX4K-C	19 DX4K-C	20 DX4K-C
21	22	23	24

Clear Take

Selected

Input: 1

Outputs: 1-25

Output 17 Configuration

Config Viewer: Recent Inputs Only Outputs Only

Video **Audio**

Output 17 **DX4K-C** **4K**

Output Name: Restore to Default

Video Details

DXLink 4K HDMI RX

DXLink Details

General

Scaling: Auto Manual Bypass

Resolution:

Show only EDID Display Supported (DS)

Aspect Ratio: Maintain Stretch Zoom Anamorphic

Save EDID

Display Settings

Video Mute

Video Freeze

Test Pattern: Off

Blank Color: Blue

Allow Display Sleep

Display Sleep Delay (s):

On-Screen Display

Enable OSD

OSD Color: Black

OSD Position: Top Left

Image Adjustments

Brightness:

Contrast:

- e. Refer to the image below for an example of what is brought up when you select DXLink Details. The circled area is the location of the reported MSE Value, referred to as DXLink Quality.
 - i. Note: The number shown is the worst pair MSE (Mean Square Error) Value/DXLink Quality measured across the 4 twisted pairs of the cable and one can safely assume that the measured value across the other 3 pairs is equal or better than the reported number. The more negative a number the better.

DXLink 4K HDMI RX
✕

DXLink Quality:
-19

Firmware Version:
v2.1.66

Friendly Name:

IP Address:
192.168.1.52

Subnet Mask:
255.255.255.0

MAC Address:
00:60:9F:9E:52:59

Device:
0

System:
0

Auto-Setup

Note: System Auto-Setup is currently disabled. You can go to Status page to enable it.

Auto-setup Status:
Disable

DIP Settings

f. The following table shows the -dB value ranges and their typical performance levels.

MSE Value	Cable Quality
Unlinked	No cable connected
0dB to -8dB	Unusable – Likely no link made
-9dB to -11dB	Bad – Likely no video
-12dB to -14dB	Poor – Frequent video drops
-15dB to -17dB	OK – Rare video drops
-18dB to -20dB	Good – Stable
-21dB to -23dB	Ideal – Very robust

Link Quality Reporting for Enova DGX 100 Series using ICSP commands to the 5002 device

If your Enova DGX is a 100 series (v3.0.10 or higher) you can also access the Link Quality MSE values programmatically using ICSP commands to the 5002 device.

SEND_COMMAND 5002:x:0, ""?DXLINKIN_QUALITY"" where **x** is the Input Channel to query

SEND_COMMAND 5002:y:0, ""?DXLINKOUT_QUALITY"" where **y** is the Output Channel to query

Response: Line 1 (11:48:49):: Command From [5002:5:1]-[DXLINKOUT_QUALITY--18] showing an MSE value of -18dB for output channel 5

Legacy Link Quality Reporting over Enova DGX Serial or USB Port

If your system has DXLink Input with FW v1.0.3.1 or higher and DXLink Output with FW v1.0.4.1 or higher, which are included in the Enova DGX FW KIT upgrade v 1.2.5.1 or higher (released on 8/21/2012) you will have access to the individual input & output port statistical reporting from the CPU's Serial or USB port. With this capability you will be able to view the link quality of a given cable run and determine if there are potential cabling issues which could cause performance issues. Another metric which can be viewed in this reporting is the cable length which has a +/-10% tolerance and is reliable at 25 meters and above.

The reporting is gathered and presented by the Enova DGX's CPU and accessed using the SHELL command mode over the DB-9 serial port or mini-USB port using a terminal program.

To gain access to the SHELL you should follow the instructions in the Enova DGX product manual under the **Installation and Setup Chapter – Attaching an External Serial Controller** section to establish communication with the CPU. Once in communication, the commands shown below with values reported will guide you into the SHELL and show examples of how to get the MSE Link Quality reporting.

2. After establishing CPU communication with a terminal program:

- a. Press “CTL+C” (Control and C) to enter the command SHELL, you should see a prompt of ‘DGX_SHELL>’.
 - i. Note: The SHELL interface will time-out after a brief period and return to the BCS interface so if you don't enter the commands before the time-out you'll need to re-enter the SHELL with the “CTL+C” key combination.
- b. Type “show stats” followed by <Enter>, you should get a statistic report for all DXLink Input and Output boards in the enclosure.
- c. The MSE (Mean Square Error) value is included in this information and **BOLDED** below. The data for all 4 twisted pairs of each cable/port are displayed with the dB values below. The BER and DSP Reset reporting that is presented with the MSE is not currently meaningful for diagnostic purposes.
- d. The following table shows the -dB value ranges and their typical performance levels.

MSE Value	Cable Quality
Unlinked	No cable connected
0dB to -8dB	Unusable – Likely no link made
-9dB to -11dB	Bad – Likely no video
-12dB to -14dB	Poor – Frequent video drops
-15dB to -17dB	OK – Rare video drops
-18dB to -20dB	Good – Stable
-21dB to -23dB	Ideal – Very robust

```
DGX_SHELL>show stats
```

```
MCPU:
```

```
  i2c failure count: 2
```

```
  reboot count: 10
```

```
BCPU1:
```

```
Ch1-[DxLink In] BER Video:10^(-0), Audio:10^(-0), Blank:10^(-0), Ctrl:10^(-10)
```

```
Ch1-[TX] Cable Length: 90 (Meters), 295 (Feet)
```

```
Ch1-[DxLink In] MSE Chan A:-19db, Chan B:-18db, Chan C:-18db, Chan D:-20db
```

```
Ch1-[DxLink In] DSP Reset Count: 0
```

```
Ch2-[DxLink In] BER Video:10^(-0), Audio:10^(-0), Blank:10^(-0), Ctrl:10^(-10)
```

```
Ch2-[TX] Cable Length: 80 (Meters), 262 (Feet)
```



Ch2-[DxLink In] MSE Chan A:-20db, Chan B:-20db, Chan C:-20db, Chan D:-21db

Ch2-[DxLink In] DSP Reset Count: 0

Ch3-[DxLink In] BER Video:10[^](-0), Audio:10[^](-0), Blank:10[^](-0), Ctrl:10[^](-10)

Ch3-[TX] Cable Length: 33 (Meters), 108 (Feet)

Ch3-[DxLink In] MSE Chan A:-21db, Chan B:-21db, Chan C:-22db, Chan D:-22db

Ch3-[DxLink In] DSP Reset Count: 0

Ch4-Unlinked.

Ch4-Unlinked.

Ch4-Unlinked.

Ch4-Unlinked.