



Shielded Cable for Ethernet Applications Industrial Environment

Selecting the proper infrastructure for network communications in an industrial environment is important. One commonly asked question is ‘when and how to use shielded cabling’. Shielded cabling is often used in industrial environments to mitigate unwanted interference that finds its way into the Ethernet network cabling. Unshielded cable provides a degree of protection against interference due to the balanced twisted pair design but does not provide the same level of protection as shielded cable. This ‘electrical balance’ allows the cable to minimize the effects of electro-magnetic interference (EMI), the better the balance the more protection from EMI. In industrial areas where interference is abundant the use of shielded cabling provides an added layer of protection.

Theoretically, shielded cable is an ideal solution for managing interference of electrical noise, but this assumes proper design and installation of the physical infrastructure. Improper installation defeats the benefit of using shielded cable and can cause additional problems with other cabling infrastructure and electrical devices. Proper shielded cable installation in concert with appropriate system design practices ensures unwanted interference does not affect network cabling infrastructure. Knowing these basic principles help to identify potential problems and provide knowledge for system design.

Types of Shielded Cable

Common designations for shielded and unshielded Ethernet cables, per ISO/IEC 11801:

UTP Unshielded Twisted Pairs	F/UTP Overall Foil Shield with Twisted Pairs	S/UTP Overall Braid Shield with Twisted Pairs	SF/UTP Overall Foil and Braid Shields with Twisted Pairs	S/FTP Overall Braid Shield with Individually Foil Shielded Twisted Pairs

M.I.C.E. Table

		Increased Environmental Severity →		
	Mechanical • Shock • Vibration	M ₁	M ₂	M ₃
	Ingress • Water • Dust	I ₁	I ₂	I ₃
	Climatic Chemical	C ₁	C ₂	C ₃
	Electromagnetic	E ₁	E ₂	E ₃
		Office	Industrial →	



Shielded Cable Applications

The primary application for shielded cable is environments that contains electrical noise sources near communication cabling. The environment the cable is being installed will mostly determine whether to use shielded or unshielded cable. The ANSI/TIA-1005-A standard details the MICE rating (Mechanical/Ingress/Climatic-Chemical/Electromagnetic) system. MICE is an effective tool that provides helpful guidelines for quantifying the amounts of environmental stresses like electrical noise per classification. For more information on MICE refer to the standard or the Panduit MICE guide material found on the Panduit website.

Reasons to use shielded cable

1. Mandated by company specification or local area requirement
2. Data transmission is critical and infrastructure is located near plant floor environment
 - a. It is generally assumed that data transmission lines near the plant floor environment are exposed to some level of environmental stress
3. Motion control and high-speed automation applications
 - a. Many motion control vendors require or recommend shielded cable
4. Known electrically noisy environment that does not require high flexibility
 - a. NOTE: Shielded cables are not as flexible as unshielded cables in high vibration installations; these cables can fail sooner than unshielded high flex cable
5. MICE level of E2 or E3
 - a. E2 and E3 MICE levels reflect severe levels of noise interference

What is Electrical Noise?

Electrical noise in the form of Electromagnetic interference (EMI) and Radio Frequency Interference (RFI) are common in industrial environments. These forms of electrical noise can disturb the transmission of Ethernet network cabling. Sources of electromagnetic interference include; electric motors, variable frequency drives, contactors/relays, welding, fluorescent lighting, and radio communications. These devices are used in industrial environments and often located in the same space as Ethernet network infrastructure. Electromagnetic interference can affect the network cabling through inductive, magnetic, or capacitive coupling. Electrical noise can also be transmitted through common node grounds. However, you don't have to understand all these principles in deep detail to develop a well-designed physical infrastructure.

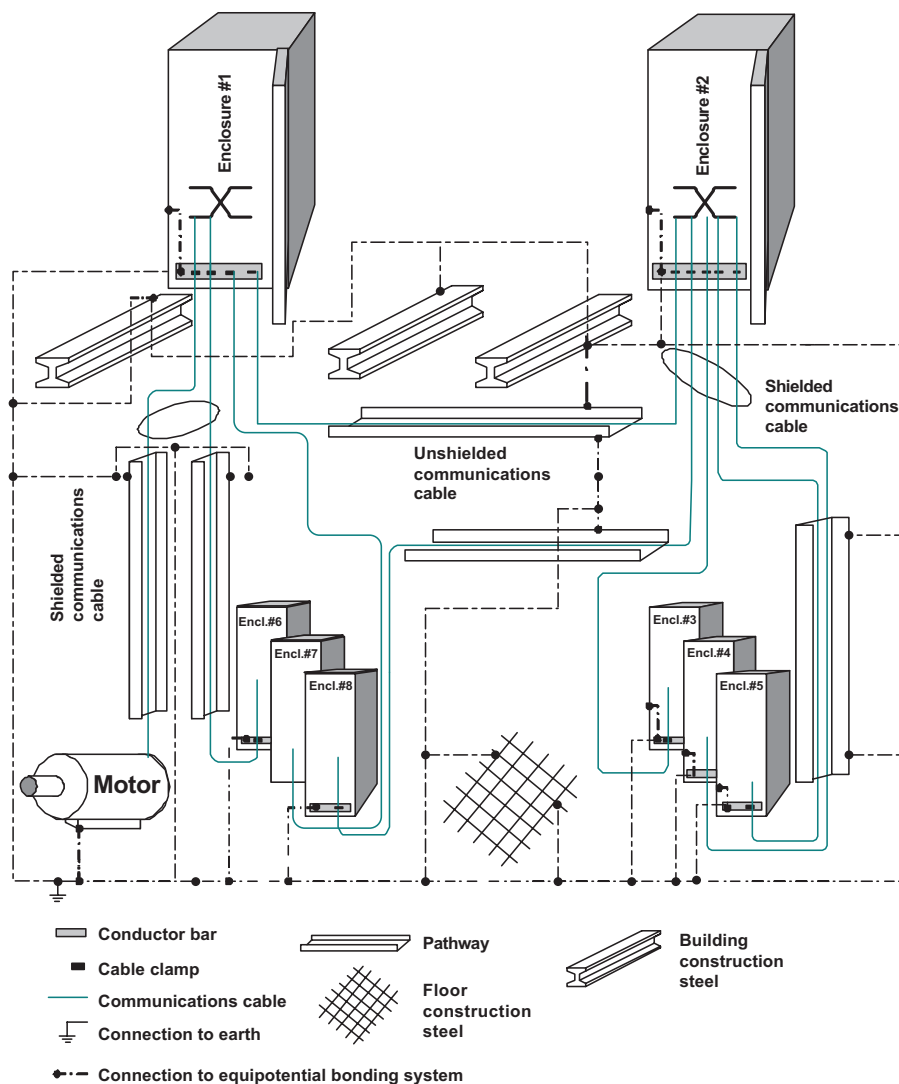
Physical separation with air space and/or isolation barriers are effective but at certain points Ethernet network cabling is still exposed to the noise hazard. Determining the source of the noise in a control system can be difficult and require significant amount of test equipment and time. Therefore, following best practices in the design of the physical infrastructure saves valuable time and resources while guaranteeing better performance.

Grounding & Bonding Systems

Ground and bonding systems are integral parts of Ethernet communication infrastructure, but it is not an absolute science. Each application has its own unique environmental noise and grounding situations that requires best practices and experience to understand. Improper grounding and bonding can conduct noise that disrupts the transmission of the Ethernet packets. There are several standards to reference and a chart of common standards is provided in the additional resources section at the end of this document. One of the standards that focuses on industrial installations is ANSI/TIA-1005-A "Telecommunications Infrastructure Standard for Industrial Premises". Compliance to this and other related standards aid in designing a trouble-free system with optimum performance. There are two common types of grounding systems, equipotential/mesh & star grounding, which are commonly referenced in the standards.

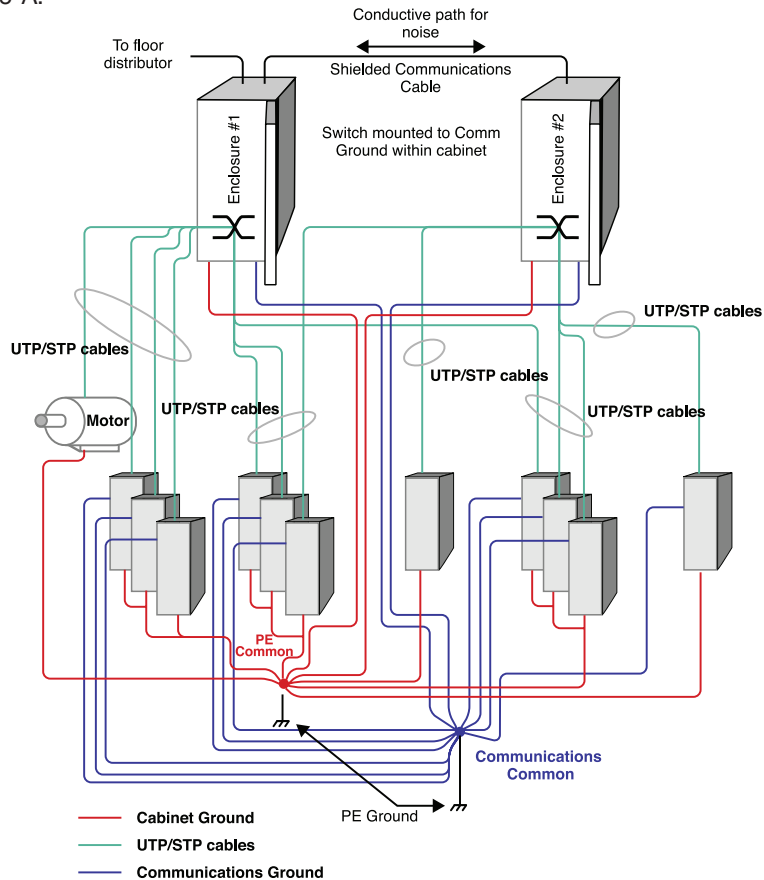
Equipotential/Mesh Grounding System

The basis of this grounding system is to provide a low impedance path to ground (earth) between all the devices in the system. This method minimizes the electrical potential difference between the devices and therefore reduce the risk of ground loops. This system requires the use of properly sized equalization conductors. The purpose of an equalization conductor is to provide a path between devices for noise currents to flow so that current does not flow on the shield of the shielded communication cable. Sizing of these conductors is illustrated in chart form in ANSI/TIA-1005-A. A matrix of bonding and equalization conductors, 'mesh grounding', will properly carry the currents so that it does not interfere with other devices. Refer to the diagram below for an illustration of this system.



Star Grounding System

The basis of this system is to create a separate bonding system for communication commons. This setup can be utilized to mitigate ground loops in systems where equal grounding potential is not practical. Implementing this type of system will require isolation of grounds and therefore the design may include different types of ground bars that are isolated from a back panel or enclosure. This type of grounding system allows the use of RC (resistor capacitor) device terminations. Star grounding image below taken from ANSI/TIA-1005-A.



RC Device Termination

The use of an RC device termination (aka hybrid bonding or RC filter/ground/network) allows high frequency noise to pass through the loop and blocks the lower frequencies that may be present because of ground potential differences. To properly dissipate the noise many of today's industrial end devices (excluding network switches) include an RC device termination as shown below. RC device termination helps to open ground loops by providing a low impedance path at high frequencies and high impedance path at low frequencies for the shield termination, this reduces ground noise currents.

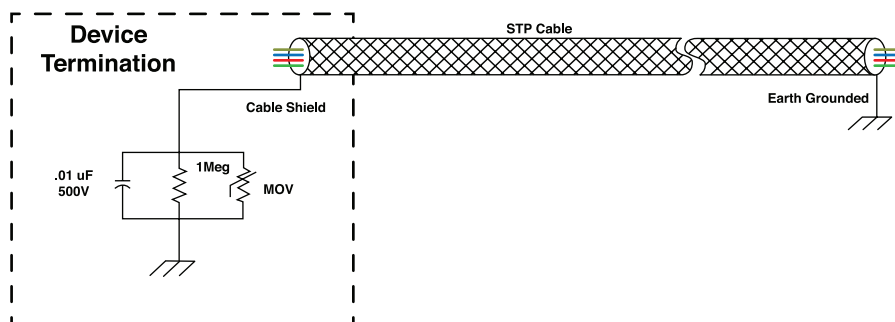
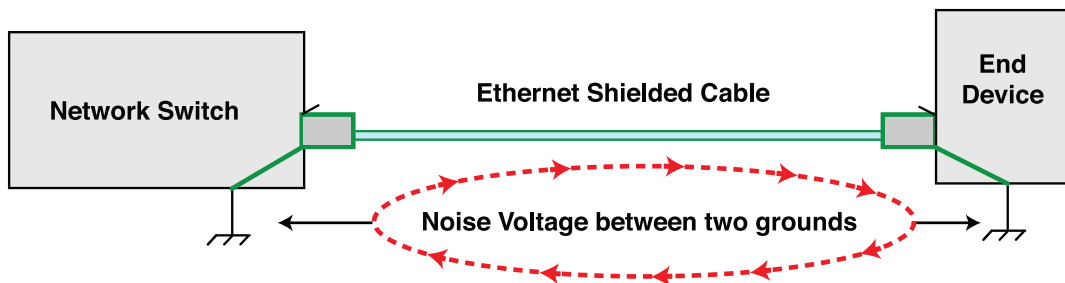


Diagram from ANSI/TIA-1005-A showing device termination.

Proper Installation of Shielded Cable

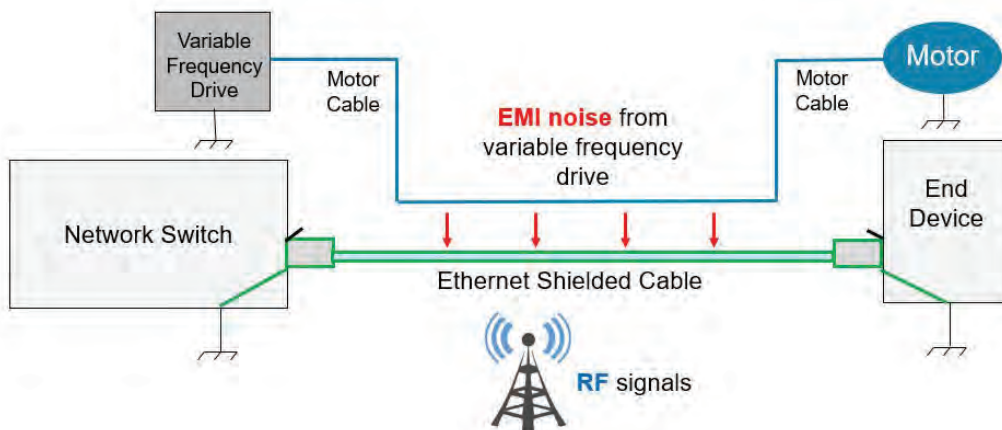
Planning the Ethernet cable infrastructure prior to installation provides opportunity to implement the best design possible. The design includes: cable pathways, ducting, grounding, bonding, patch panels, cable types, and much more. Shielded Ethernet cable contains a conductive 'shield' layer around the overall cable and/or the individual twisted pairs (refer to additional resource section at the end of this document for more detail on types of shields). Use of shielded twisted pair Ethernet cables is an effective method to dissipate electrical noise interference through the shield. The use of shielded connectors is recommended when using shielded cables. This practice allows the shield to be properly bonded from one end of the system to the other with ground connections only on the ends of the entire link.

There are two common problems that occur with shielded cabling in industrial applications. These problems are avoided with proper installation. First, shielded cable that has the shield terminated in different locations having a potential difference can cause a 'ground loop' causing unwanted current to flow through the shield due to the potential difference. This is illustrated in the diagram below.

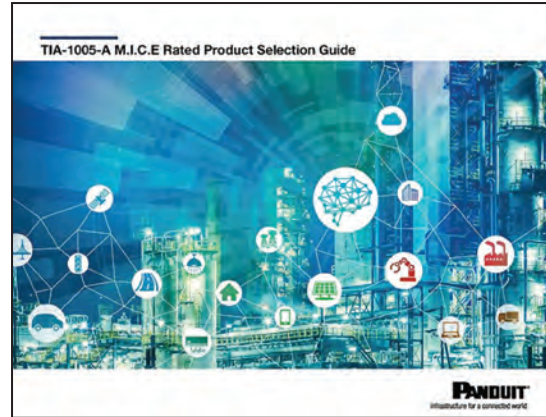
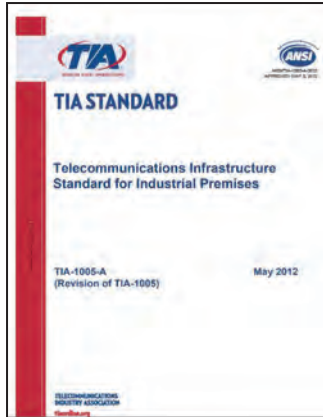


If the shield connections are not close in proximity, there could be a significant ground potential difference and hence a ground current could flow!

Second, electrical noise (EMI or RF) can be coupled onto unprotected Ethernet communications cable and disrupt the transmission signal. The shield conductor in a shielded cable provides a return path for the disruption signal. The shield will protect the Ethernet transmission conductors from the interference by returning the interference signal to the source.



Key Resources



Additional Resources

Standards to Reference

Region of the World	North and South America	Europe (Cenelec)	Europe, Other Areas of the World
Generic Premise Cabling Standard	ANSI / TIA-568 Series	EN 50173-1	IEC / ISO 11801 Series
Industrial Premises Cabling Standard	ANSI / TIA-1005-A	EN 50173-3	IEC / ISO 24702
Grounding and Bonding Systems	ANSI / TIA-607-C	EN 50174-2	IEC / ISO 60364-5

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