Industrial Data Xchange
Operational Excellence Unlocked

IDX TECHNICAL SPECIFICATIONS

EMC, Bonding and Earthing

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1. Introduction

Industrial automation networks such as PROFIBUS, PROFINET, Modbus and other industrial ethernet/serial-based protocols are susceptible to Electromagnetic Interference (EMI). Such external interferences electrical and magnetic, are commonplace within industrial environments and are related to earthing issues and pickup from higher voltage components (such as large machinery, VSD and high-voltage switchgear).

Adherence to established standards to minimise EMI and its effects, during design and installation can significantly reduce this vulnerability and provide an operating tolerance that ensures error free communication.

This purpose of this document is to give the reader an idea of the best Electromagnetic Interference (EMI) compliant installation practices and allow for more resilience to any interference/noise. It provides guidance for the recommended standard for EMI, bonding and earthing that will help with ensuring that the network systems on the plant are installed properly for both greenfield and brownfield installations.

It is not a substitute for such industry standards and related training courses but should be seen as complementary in nature and intention.

2. Types of Interference (noise)

Industrial communication systems are all susceptible to interference which can negatively affect their functionality and performance. It is important to understand the interference source to be able to apply the correct measures to reduce the interference. This section covers two such interferences.

2.1. Electrostatic Interference

An Electrostatic Interference occurs when an electrical field distorts the signal on a transmission cable. This interference can be generated by capacitive coupling from nearby electrical fields.

Electrostatic interference is often caused by higher voltage cables that travel in parallel and in proximity with the communications cables.

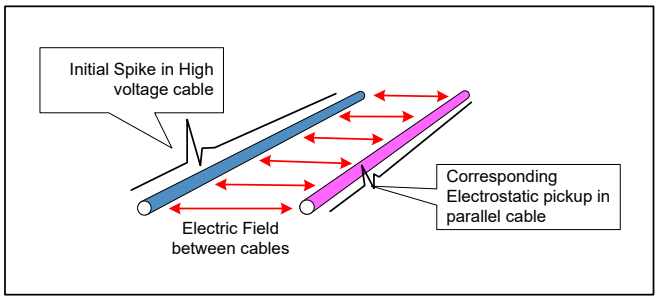


Figure 1: Electrostatic pickup within a

2.2. Electromagnetic Interference

An EMI is a permanent or temporary alteration in an electrical signal detected on the transmission cable or in a device. This interference can be caused by large electrical devices such as big motors, inverters, and arc furnaces as they generate powerful magnetic fields.

These powerful magnetic fields cause a current flow in nearby conductive objects such as the industrial communications systems / or sensitive network device components within the automation installation.

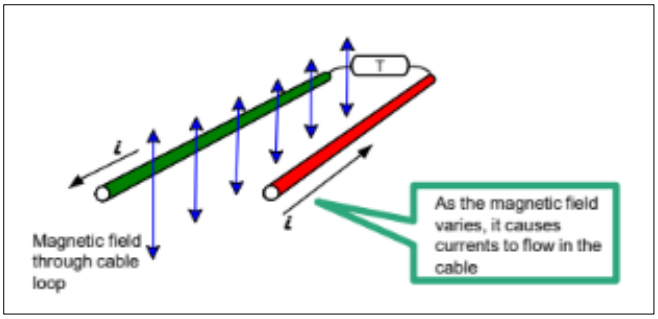


Figure 2: EMI causing a disrupting current flow within communications cables.

This can have a detrimental effect on signal travelling within these components.

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3. Good Design Practices and Mitigation Methods

Maintaining your networks and ensuring that they are healthy and functional is vital to avoid communication errors that may result in downtime that causes financial losses. To avoid such losses the following EMI mitigation standards must be implemented:

3.1. Electrostatic Interference

The effects of electrostatic interference can be reduced by separating cables, which is to increase the distance between cables running parallel to one another. Furthermore, shielding or screening a signal cable helps in reducing the electrostatic pickup.

It is important to note that shielding is only effective when the shield is grounded properly, as it will not be of any benefit otherwise. Running cables within steel or aluminium conduit that is **properly grounded** will further protect the communications cable from interference.

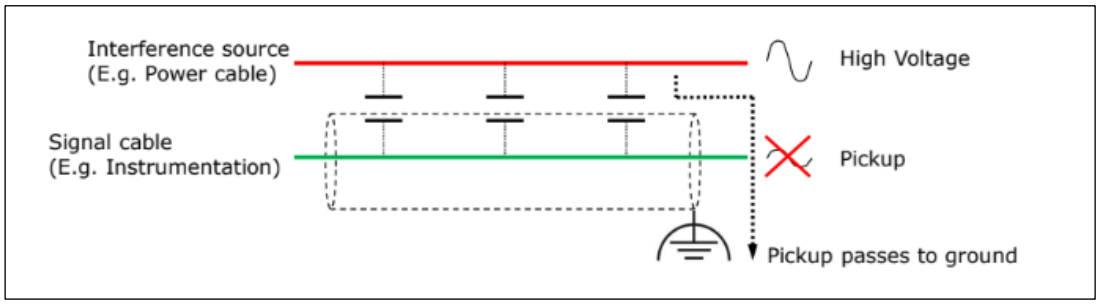


Figure 3: The shielding of industrial communications cable aids in the protecting the data signals from interference when it is properly grounded.

3.2. Electromagnetic Interference

Using twisted pair cables reduces the effects of electromagnetic interference on the transmission cable. The effects of EMI can be significantly reduced by screening the cable with an earthed conductor and keeping it away from the source of the magnetic field. One other way to reduce any interference both magnetic and electrostatic is by installing an earthed, and magnetically resistant steel tray or conduit.

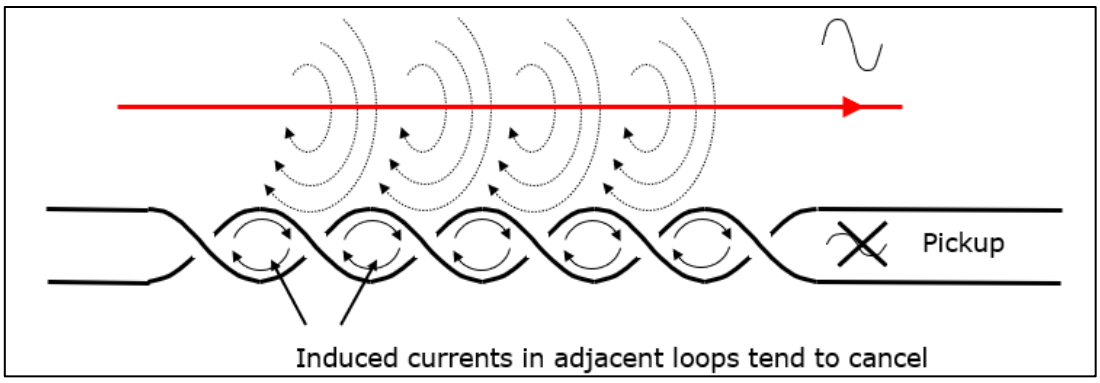


Figure 4: Twisted pair cable aids in cancelling out the induced current flow on the

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3.3. Cable Separation

Cables that run parallel to one another and are of different categories increase the chances of interference pickup. Industrial Ethernet and Fieldbus cables are sensitive to higher voltage cables and therefore need to be shielded and separated from interference causing cables. They should be separated according to the following cable categories:

Category I: • Fieldbus and LAN (i.e., AS-I, Ethernet, etc.) • Shielded cables for digital data (i.e., printer, etc.) • Shielded cables for low voltage (≤25V) analogue and digital signals • Low voltage power supply cables (≤60V) • Coaxial signal cables	**Category II:** • Cables carrying DC voltages (>60V and ≤400V) • Cables carrying AC voltages (>25V and ≤400V)
	Category III: • Cables carrying DC and AC voltages (>400V) • Telephone cables
	Category IV: Cables of categories I to III at risk from direct lighting strikes (i.e., connections between components in different buildings)

Table 1: Cable categories based on potential carry.

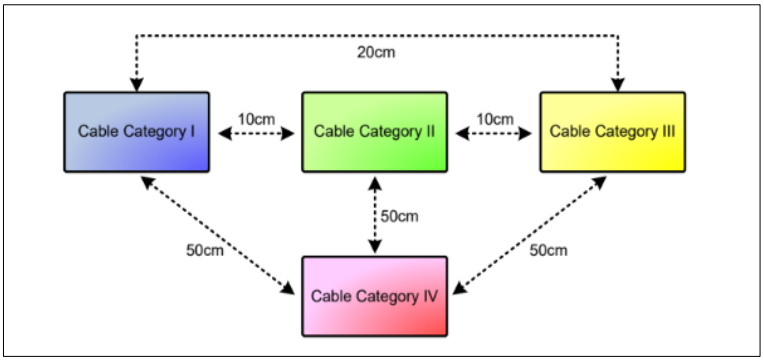


Figure 5: Cable categories separation distance guidelines.

3.4. Using Cable Trays, Metal Conduit and Channels

Much like the cable separation guidelines above, cable trays aid in the separation of cables that are arranged beside each other. The separation categories must still be maintained even when run through the channel.

The individual channels with cables must be separated using metal partitions that are electrically connected to the low-channel by a low-resistance and low-inductance contact. The trays must have flexible bonding links and protect against corrosion. The cable channels must be earthed to the building earth system.

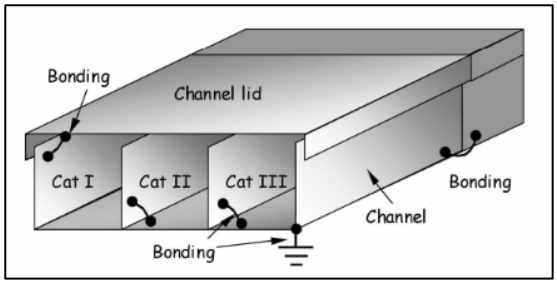


Figure 6: Cable tray with bonded metal partitions for the separation of various categories of cables.

In instances where cables of different categories cross (this should be avoided as far as possible), they should cross at a right angle. All cables entering the wiring cabinet should be earthed using clamps as close to the point of entry as possible.

This method of wiring will take the high-frequency interference to the round through the cabinet rather than through the Fieldbus cables.

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You can also run network cables in aluminium or steel trunking/conduit, which if properly grounded should protect the cable completely from sources of electrostatic and magnetic interference. This will also protect cables mechanically running outside of the building or across potential walkways.

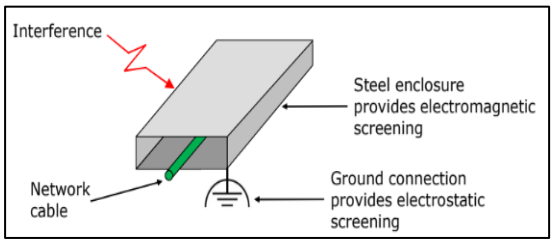


Figure 7: Running cable in grounded metal conduit for EMI protection.

In some cases, there may be a need to run a cable over long distances in which case a fiber optic cable should be used. Fiber optic cable is best for this set-up as it is immune to interference, provides electrical isolation and offers communication over long distances.

3.5. Bonding and Shielding

Inclusive of the mitigation methods above, bonding and shielding work well in mitigating the effects of EMI on network systems. When grounding and shielding are done effectively, any interference picked up gets directed to the ground and the data on the network does not get compromised by the interference generated. This section covers the different types of shielding and bonding possible in a network system.

3.5.1. Bonding

Successful bonding in the plant equipment will reduce the voltage flowing on the network thus ensuring the safety of humans and the endurance of equipment on the plant. There is a distinction that is made between Protective Earth (PE) intended to ensure the safety of humans and Functional Equipotential (FE) bonding of devices that are not safety-relevant, but more for the good operation of communications and sensitive electronic equipment.

Protective Earth Conductor (PE)

Earthing or bonding of equipment is essential for safety reasons. Such earthing systems are often called Safety Earth or Protective Earth (PE). Protective earthing is designed to protect people from electric shocks due to wiring faults which would otherwise cause equipment or structures to become “live”. The protective earth will divert the dangerous current to the ground and cause a fuse to blow or contact breaker to trip in the case of a fault.



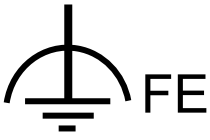
Protective, Equipotential Bonding

A different setting applies for electrically passive, but touchable, conductive parts of the plant, (i.e., a handrail or a roller conveyor). Here no PE terminal is present. However, it is often required to connect these parts of the plant to the protective equipotential bonding system.

The reason is if a handrail is connected to the protective equipotential bonding system, then (in the case of an error such as a phase connected to the handrail) a fault current can trigger a protective device (like a fuse or circuit breaker) and switch off the circuit.

Functional Equipotential Bonding (FE)

The Functional Earth is provided as a clean reference voltage for unbalanced analogue or digital signals or power supplies. The FE wiring should generally be separate from the PE but should be connected at just one point, which is used as the zero-volt reference.



Modern systems such as PROFIBUS, PROFINET and ASi use balanced transmission, which does not require reference earth. But we quite often see a FE connection on networked devices. This is used to provide a zero-volt reference for unbalanced input and output signals, for example with 24V digital signals or 0 to 5V or 4-20 mA analogue signals. The FE should be considered as a zero-volt reference for these signals and should be connected to the PE at one point only.

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The third reason for earthing is to provide a grounding of the cable screen to guard against the pickup.

For balanced transmission systems like PROFIBUS and PROFINET, the screen should be connected to the earthing system at both ends.

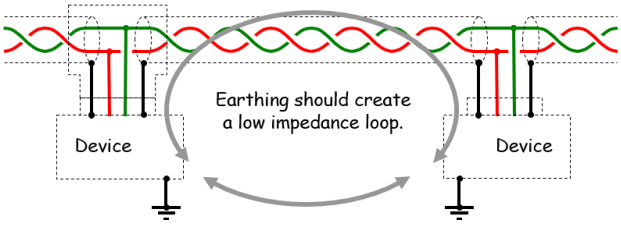


Figure 8: Active shielding enabled through multiple grounding of Industrial Network cables to functional earthing points.

The various methods of earthing systems are listed below, of which Type D-Mesh earthing is the best to implement within structures housing industrial automation and communications systems:

Type A: Star

Due to the usually long transmission paths, star-topology systems feature high impedance between two devices. These high impedances cause poor discharge of electromagnetic disturbances coupled into the system. Type A systems are the least suitable equipotential bonding systems.

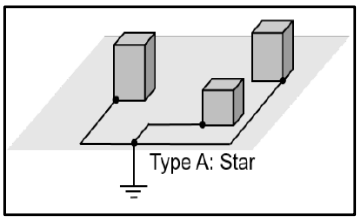


Figure 9: Equipotential bonding standard type A: star.

Type B: Ring

Although ring topology reduces the length of the protective conductors between two devices, the lines may still feature high impedances which may affect or even prevent proper discharge of electromagnetic disturbances.

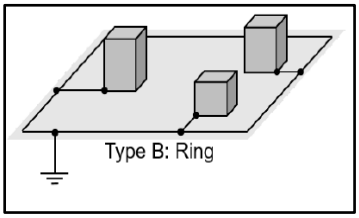


Figure 9: Equipotential bonding standard type B: ring.

Type C: Locally Meshed

In the plant area, all metal parts (i.e., cabinets, frames, supports, and cable systems) are locally meshed forming a meshed equipotential bonding system that features a low impedance due to its large number of short and parallel transmission routes.

A network with this kind of meshing of all conductive objects is called a Bonding Network (BN).

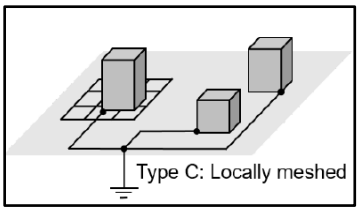


Figure 11: Equipotential bonding standard type C: locally meshed.

Type D: Meshed

The equipotential bonding system of type D has meshed equipotential bonding lines distributed over the entire building.

Therefore, a common system should be laid over several levels of the building.

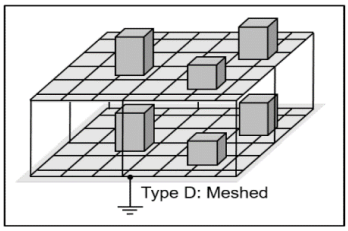


Figure 10: Equipotential bonding standard type D: meshed.

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3.5.2. Shielding

Shielding is a crucial additional protective measure that must be implemented on the plant to prevent any injected interference onto the network system. There are two types of shielding to protect against disturbance, namely active and passive shielding, practically however we only utilise active shield in most cases.

Active Shielding

Due to the low material thickness of cable shields, the active shielding effect is used. For active shielding to work, it is necessary to connect the cable shield to the common bonding network (CBN) at several points to establish a current circuit.

If the cable shield is connected to the common bonding network (CBN) at only one point, the capacitive coupling will occur if there is a potential difference between a cable and the shield.

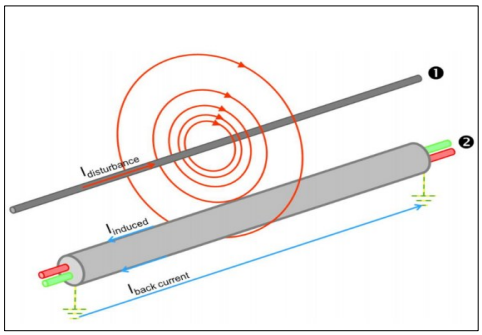


Figure 11: Active shielding enabled through multiple grounding points of the shield.

If the cable shield has two or more connections to the common bonding network, there is an additional shielding effect against magnetic fields. When exposed to magnetic fields, a voltage is induced due to multiple connections of the cable shield to the common bonding network. The induced voltage allows a current ($I_{induced}$) to flow in the cable shield as shown in the figure below.

The induced current flow produces a counter-induction with a 180° phase shift to the initial induction of the magnetic field. Inside the cable, the magnetic field of disturbance and the magnetic field of counter induction overlay each other. This overlay produces an area that is nearly free from any fields in the middle of the cable. For this reason, cable shields should be connected to the common bonding network at least at both ends, to achieve a sufficient shielding effect against magnetic fields and alternating electromagnetic fields.

Typically, the network cable is grounded within network connectors such as M12, PROFIBUS Connectors, RJ45 industrial ethernet connectors.

Passive Shielding

An effect is solely achieved by using shielding material of sufficient thickness. The minimum material thickness required for the shielding effect depends on two factors:

Firstly, the frequency of the disturbance and, secondly, the magnetic permeability of the material in the presence of magnetic fields. If the shield has the required material thickness, eddy currents can occur inside the shield. The eddy currents generate a field that is oriented oppositely to the disturbing field.

This nearly eliminates the disturbing effect, however, this shielding effect is normally not provided by cable shields, as their material thickness is insufficient and instead is usually achieved by metal-type cable ducts with separators and covers or steel tubes.

4. Greenfield and Brownfield Installation Considerations

Whether on a new plant installation or an already existing plant, the relevant standard recommends the use of only meshed, equipotential bonding system of type D. The goal of using a meshed equipotential bonding system is to reduce the line impedance between two devices.

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For this purpose, as many parallel and electrically conductive connections as possible are needed between the devices of the plant. As this would induce a tremendous cabling effort if only cables were used, the meshing is in parts realised by using the metal parts of the plant such as pipes, frames, cabinets, and cable ducts.

On a new or modernised plant, the meshed equipotential bonding system of type D can be easily implemented. For plants with already existing equipotential bonding systems in star or ring topology, there are suggestions for improvement by additional connections.

The improvement consists in adding equipotential bonding conductors between the devices, which are represented by thick lines in figure 13.

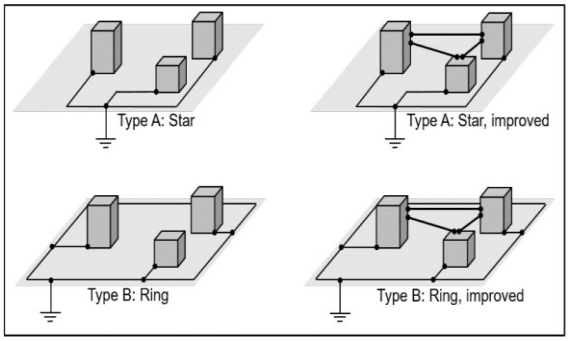


Figure 12: How to improve type A and B bonding on brownfields.

5. Additional Considerations

As previously stated, this document serves in no way as a replacement for relevant training for site personnel or as an alternative to standards published by International Associations such as International Organisation for Standardisation (ISO) and PROFIBUS and PROFINET International (PI).

5.1. Staff Training

It is recommended that for the sustainability and efficiency of network systems, all site personnel, system integrators, and service providers responsible for the design, installation, and maintenance of the systems used on the plants should attend relevant training. This is crucial to empower personnel to install and maintain systems according to the specification with good network availability consideration in mind, as well as to gain the knowledge to conduct effective and efficient fault finding on failed systems.

5.2. Industry Standards and Technical References

EMC standards and norms define the terms, rules, and test methods for EMC. These standards specify the limits and minimum test levels for electromagnetic emissions and immunity of electromechanical and electronic products. Listed below are most common basic standards.

Specifications	Standard
Earth-moving and building construction machinery	ISO 13766-1:2018 to ISO 13766-2:2018
Electrical Interference by Conduction and Coupling	SAE J1113/12
Electromagnetic compatibility	IEC 61000-1-1 to IEC 61000-6-7
Measurement of electromagnetic emissions	IEC 61967-1 to IEC 61967-8
Protection against lightening	IEC 62305-1 to IEC 62305-4
Telecontrol equipment and systems	IEC 60870-2-1

About Industrial Data Xchange:

Industrial Data Xchange (IDX) provides industrial ICT products, services, solutions and training that connect plant infrastructure and transform complex data into actionable insights, supporting smarter decisions and operational excellence.

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