

Stop the Noise:

The Importance of Being (Properly) Shielded

Electrical Interference or noise is the bane of all complex (and high speed) industrial electronics system and product designers. And why not? In Industrial controls systems, for example, it's estimated that well over 50 per cent of all system hardware failures are caused in part by electrical noise. This is not just an issue for microprocessor based systems. With today's infinitely more complex communications and control systems that incorporate higher transmission and switching speeds, the implications of noise related failures are increasing exponentially. There is growing industry concern as well as increasingly more rigid regulations related to electrically radiated emissions, and EMC (Electromagnetic Compatibility). How to shield power and signal cables has never been a bigger issue. Based on the ever increasing distances that signal and control communications are required to travel, cables are the system components most highly exposed to interference. In fact, EMC and effective shielding have become just as critical as any other design concern, particularly in mission critical applications such as: medical, defense, industrial machinery, sensing and control, and communication.

Consider the challenges of those who design medical devices or ultra-sophisticated defense systems - or any application where system failure is not an option. How do they guarantee 100 per cent protection from potentially "fatal" interference?

In the real world, 100 per cent protection from electrical noise is not a realistic goal, largely due to the fact that noise sources are endless and ever changing. A more realistic objective is to work towards guaranteeing system performance, signal integrity and by understanding and implementing protection techniques from those types of noise most likely to be encountered.

Doing so requires planning, of course, and understanding how wire and cable will be affected by noise and then determining which type of shielding is most appropriate - given application and working environment. After all, it makes little sense to save a few dollars on shielding when a single failure could cost thousands. Conversely, why invest in triple-laminate foil and high coverage braided shielding (arguably the most effective shielding for both high and low conducted EMI) when moderate protection is sufficient?

As someone once put it: "Shielding is not a black art - choosing the right shielding is simply a matter of knowledge and foresight."

A Place to Start

When a particular installation is prone to EMI/RFI/ESI interference, as most applications are, from either internal or external sources, some form of cable shielding will be required. There are basically four types of noise which will affect the wiring or cabling of an instrument or control circuit: conducted EMI, radiated EMI, ESD and RFI. Once it has been determined that noise will pose a problem, it is then necessary to understand if the noise environment is of a low, medium or high level.



The table below gives general guidelines as to the areas which are subject to these generalized noise levels:

Noise Level	Sources of Noises	Typical Locations
High	Electrolytic processes, heavy motors, generators, transformers, induction heating, relay controls, power lines and control wire in close proximity	Heavy processing plants such as steel mills and foundries
Medium	Wiring near medium-sized motors, control relays	Average manufacturing plants
Low	Wiring located far from power lines, motors; motors <5 hp; no induction heating, arcs, control or power relays nearby	Storage areas, labs, offices and light assembly operations

Understanding frequency - The common denominator

The electrical frequency of the interference is the common denominator that runs throughout the various types of EMI likely to be encountered in any given application.

Protection against EMI is addressed by either a copper braid or an aluminum foil, or both depending on the frequency of the signal likely to be encountered. Low frequency signals, normally associated with applications such as discreet signaling, 16 gauge control circuits and power circuitry, generally operate up to around 100 KHz.

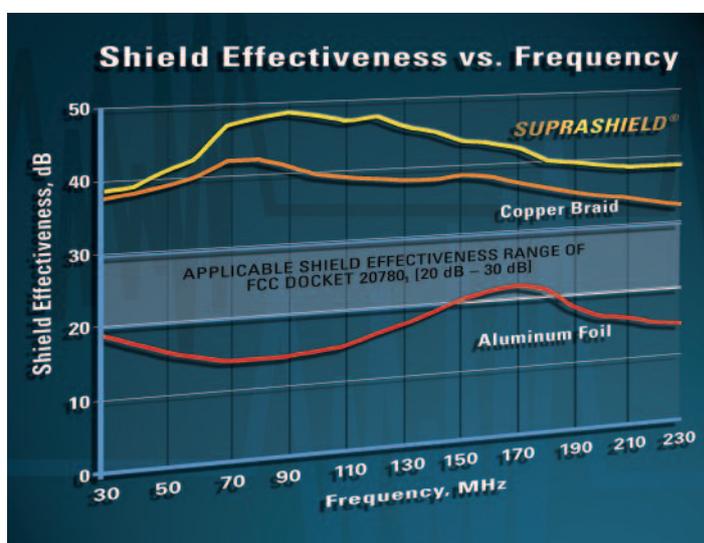
Cables carrying these types of signals employ a copper braid shield to protect the signal's integrity.

Higher frequency signals, such as can be found in all data cables and industrial networking circuitry, require an aluminum foil around the twisted pairs in order to effectively protect against signal degradation. Regardless of the frequency, there are four key areas of signal interference that are addressed by shielding and these are:

1. **Conducted EMI** - Noise signals transmitted via electrical conduction paths (i.e. wires, ground planes, etc.). Cable cross talk is common in unshielded cables and can cause potentially catastrophic system failures
2. **Radiated EMI** - Electric and magnetic fields transmitted through space from source to receptor. Commonly radiated by sources such as motors, magnetic sources, generators and transformers
3. **Electrostatic Discharge (ESD)** - Electrostatic charge is most commonly created by the contact and separation of two materials, causing the transfer of electrons between them. An ESD event starts with a very slow buildup of energy, followed by a very rapid breakdown. It is this fast breakdown that causes EMI problems in modern electronic systems. The energy discharge yields EMI frequencies in the hundreds of megahertz. The high speed and frequency of the ESD energy can damage circuits, bounce grounds and cause upsets through electromagnetic coupling
4. **Radio Frequency Interference (RFI)** - Electromagnetic radiation emitted by electrical circuits carrying rapidly changing signals as a by-product of their normal operation. RFI interference can be minimized with effective cable grounding and shielding systems

Shielded Cable Construction

A shielded cable is an electrical cable of one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal), a non-braided spiral winding of copper tape, or a layer of conducting polymer. Usually, this shield is covered with a jacket. The shield acts as a Faraday cage to reduce electrical noise from affecting the signals, and to reduce electromagnetic radiation that may interfere with other devices. The shield minimizes capacitive and inductive coupling from other electrical sources. In single conductor signal cables, the shield may act as the return path for the signal and is usually connected only at the signal source. In multi-conductor cables the shield should be grounded only at the source end, and will not carry circuit current.



Maximum Protection

At Alpha Wire, we've worked to develop a series of shielding constructions to match the needs of our customers.

For maximum protection we believe that a tinned copper braid, a drain wire and a tri-laminate aluminum foil offers the most complete protection against electrical noise across the full frequency range. Through exhaustive testing, we've learned that braided shielding, although essential for protection, can be unnecessary beyond a certain point. When the cable is in a static application, a braid providing 70 per cent coverage gave excellent results. In fact, the results were appreciatively no different with construction up to 98 per cent braid coverage. Flexible cables, however, have specific shielding requirements resulting from the stresses of motion and flexing. For applications that introduce a flexing environment to the cable the tests showed that a denser braid construction of 85 per cent coverage was an optimum level especially when combined with foil shield tape.

Moderate Protection

For moderate protection, especially at low frequencies (up to 15 KHz) a 85 to 90 percent coverage copper braid is an appropriate choice. A braid shield will provide effective EMI/RFI resistance for applications such as power, control, and data applications. The braid made be made of tinned copper or bare copper.

In order to achieve moderate protection at frequencies greater than 15 KHz, a dual layer aluminum/polyester shield is commonly used. Generally speaking, a foil shield is less costly than a braid or foil plus braid shield and at the same time delivers excellent protection from high frequency noise. A drain wire is used with foil shields in order to facilitate making the electrical connection between the shield and the circuit ground.

Conclusion

This much we know: proper shielding is essential for systems to operate as designed and for systems to meet new, stricter emissions requirements. Wire and cable are particularly susceptible to interference/noise because of their length which essentially can make them radiating antennae.

If we bear this in mind, the question becomes which type of shielding is appropriate taking into consideration the application, the environment and the cost? To answer this question, engineers should first determine the type of noise interference (EMI, ESD, RFI) likely to be encountered and the level of the interference. From these parameters the style of shielding construction can be determined.

Ultimately, too much shielding is expensive and unnecessary; too little shielding is just plain foolish.

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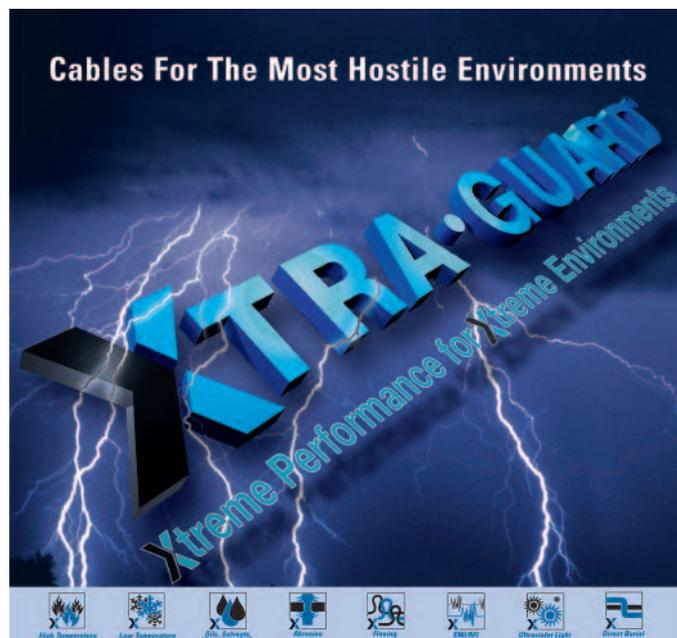
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