Enabling Factory Automation Systems with EMC/EMI Filter Solutions

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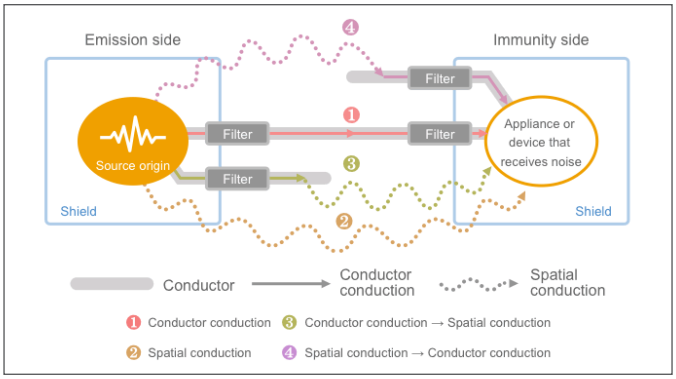
ENABLING FACTORY AUTOMATION SYSTEMS WITH EMC/EMI FILTER SOLUTIONS

While EMC standards and requirements for factory automation and Industrial systems may allow for more relaxed limits than consumer electronics, the latest control and monitoring systems are often heavily computerized and digital. Therefore, they can be more susceptible to EMI than older technologies. Customers of factory automation equipment and industrial operations may also appreciate the option of having lower EMI in their facilities, based on their use of wireless systems, RFID tags, or computerized equipment that may be disrupted. EMC/EMI filters can be a valuable add-on to these system for lowering the EMI levels of the equipment and facilities without significantly impacting the cost, size, or function of sorters, movers, pickers, packers, and other machines or robotics.

The following article provides insight and tips on when and how to best employ EMI filters in both the design and troubleshooting phases of product development. The article will also illuminate how EMI filters positively influence EMI emissions and susceptibility/immunity performance.

Tips on Using EMI Filters in the Design Phase

When approaching a product design regarding conducted emissions and immunity, one item of concern should be leads and wires, which could be carrying power or signals into and out of a device or just within the device.



Aside from ensuring that the leads are adequately attached to the appropriate connection points and that the shielding is effectively connected, there are a limited number of methods to ensure that noise produced by the device won't be emitted from the leads and external noises will not be conducted into the device through the leads. EMI suppression filters are one of the most common and effective ways of attenuating noise and interference signals.

If EMI filters are not used, the device may require much more extensive shielding and redesign. Steps would also have to be taken to effectively connect the cable and cable assembly shielding to each end point. With industrial electronics or machine equipment, this could be a very complex and expensive routing task involving equally complex shielded cable assemblies.

A benefit of proactively addressing EMI concerns is that an EMI filter can often be easily integrated into a devices design, without significantly impacting the overall dimensions, weight, and cost of a product. EMI filters provide more attenuation and can be very compact in size. Size increases depending on power and attenuation requirements of a filter.

The general rule is placing an EMI filter as close to the noise source as possible. This could be on a PCB or for a particular device. The more effective you are mitigating noise propagation within the unit the less chance it has to escape. This also helps reduce the chance that a units EMI noise will cause interference to its own internal circuity. However, there should always be a filter at the power exit/entry point. Any noise within a unit can and will couple onto any wire trying to find an escape path. A filter at the exit/entry point removes this chance and also protects the unit from outside interference.

As many factory automation systems require customized features or various options, a systems provider could prepare a model variation which includes added EMI mitigation. Examples of this would be having availability to add a three-phase filter for the power lines or motor control lines of the equipment. There is sometimes ample space within a factory automation system, or between equipment, to allow for the integration of EMI filters between components or subsystems, further reducing potential interference within complex systems.

When to Use EMC/EMI Filters in the EMI Troubleshooting of Factory Automation Systems

As is often the case, EMI issues aren't addressed until a problem occurs. This could be the anomalous performance of a device, other electronic devices' operation being disrupted, failing EMC testing or regulatory agency reporting. When EMI issues emerge, especially with new products, there is

usually a rush to correct the issue, and the original designers for the device may not be available to provide guidance. In these cases, leveraging EMI filters can be one of the quickest and most cost effective methods of reducing conducted emissions and possibly aiding with radiated emissions and immunity problems.

In the case that an EMI issue surfaces during pre-compliance testing, many of the same steps mentioned in the prior section can be implemented. Caught early enough, designers have the benefit of sampling, trying different techniques to discover the interference source/sources and trying methods to reduce their emissions and enhance immunity. Probes and clamps can be used to locate problem sources and also allow for the injection of signals to locate weak spots in the design. Temporary shielding, such as metal tape, can also be used to determine if the EMI issue is shielding related.

However, a design team short on time, may not have the liberty to explore all of the options. Installing EMI filters in line with the signal and power leads can quickly demonstrate if the EMI issue is related to the lead wires and cables. The versatile mounting and compact size of some EMI filters may even allow for their easy integration into the device, thus minimizing the amount of redesign needed.

Occasionally, customers of factory automation systems will report disturbances or other equipment failures after introducing new systems. These disturbances and interference could be caused by, or induced, to the new equipment or older factory equipment that is not outfitted with EMI mitigation technologies. In these cases, diagnosing the problems can be time consuming and extend the setup time of the new equipment. Facilities relying on automation to reduce costs and enhance efficiency are likely to be very incentivized to solve these problems as fast as possible and with limited impact to their ROI. EMI filters can be useful tools in troubleshooting these complex systems, as they can be placed at the outputs of suspected interferes until the EMI generator is identified.

How EMC/EMI Filters Impact EMI Emissions Evaluated in EMC Testing

Beyond conducted emissions, an EMI filter may also provide some benefits to other compliance testing features, and aspects of performance which may not yet be covered by compliance standards. For example, EMI filter attenuation may extend below the 150 kHz frequency used in many commercial standards. This can be useful to know when noise and interference generated below 150 kHz is causing performance or interference that may go unaccounted for. The following is a brief illumination on how EMI filters may impact other EMC emissions testing.

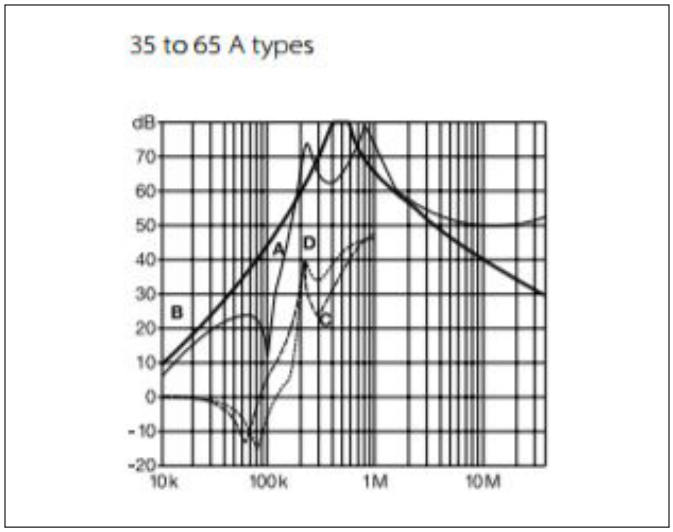
EMC/EMI FILTERS AND RADIATED EMISSIONS

EMC/EMI Filters are typically designed to attenuate noise and interference signals in the frequency range from 150 kHz to 30 MHz as this is the range most compliance standards focus. That being said military standards and some other industry standards extend their range to 10 kHz or below. In this case you will need to look closer at the filter choice. While 30MHz is typically considered the frequency where industry considers conducted emissions turn into radiated emissions this is not always the case and you may require a filter to attenuate noise above 30MHz. There are also specialized filters that can attenuate into the GHz range. EMI filters typically provide a large frequency range of attenuation that can help meet the various standards and provide protection to your unit from unforeseen noise in the field of operation.

For example, the figure below shows the filter attenuation plot of the Schaffner FN3270, a compact EMC/RFI filter for industrial motor drive applications. It can be observed from the FN3270 attenuation plot that the filter provides high attenuation from 10 kHz to 30 MHz, but also likely provides attenuation well above 30 MHz frequencies.

Typical Filter Attenuation

Per CISPR 17; A = 50Ω/50Ω sym; B = 50Ω/50Ω asym; C = 0.1Ω/100Ω sym; D = 100Ω/0.1Ω sym



DISCONTINUOUS INTERFERENCE

In some instances, the noise or interference may not be continuous in the time-domain. These types of transient signals and interference can be especially troublesome to account for, as the origin may be unknown, or a result of necessary device operation. An example of this could be transients created from power fluctuations or devices changing operation, such as the kick-on of a motor and bridge circuits or a burst transmission from an intermittent communications device.

The response of these emissions in the time-domain can also be represented in the frequency domain, typically the faster the transients change power, voltage, or current levels, the frequency domain shows broader and higher amplitudes. Hence, EMI filters may also be able to help in reducing some of the emissions from discontinuous interference. An EMI filter

would only help in this case, if the discontinuous interference were conducted through the leads of the device and re-emitted from the wires or cables, not if the interference is radiated.

How EMC/EMI Filters Impact EMI Susceptibility/ Immunity with Automation Equipment

Electronic susceptibility/immunity involves external noise and interference impacting the performance of a device. The ingress of external noise sources can include natural noise such as the sun and lightning or virtually every electronic device and electrical infrastructure system in operation. All may generate fields or signals that can reach a device and cause failures. The diversity of signals in frequency, power, and time, can make "immunizing" a device very difficult. To pass immunity testing you may have experienced designers with deep domain knowledge, you may follow and use good practice guidelines, or just have a lot of luck.

To help not rely on just luck, EMI filters may help with some immunity issues, and can sometimes be used in the field to tackle EMI issues related to troublesome devices. For some EMI immunity issues, the unwanted noise or signal energy is coupled into a device through the leads, even the shielding of a cable can be a potential conduit under certain conditions. A filter can work in both directions and provide attenuation to that incoming signal either blocking it or redirecting it safely away.

This phenomenon can be observed during some EMC testing. Typically, an EMC testing facility will first test emissions, then test immunity. While solving some conducted emission issues with EMI filters, the inclusion of EMI filters has been observed to also help with immunity issues. Depending on the configuration of an EMI filter and the frequency of the external EMI, capacitors and inductors within a filter may still reflect or absorb, the signal energy, which enhances immunity.

As an example an EMI filter will help to some degree with conducted immunity and fast transient testing. Some of the signal energy, which extends into the kilohertz and megahertz frequencies, will be absorbed or reflected by an EMI filter. This will only occur with EMI that is conducted through the device leads, and if the EMI filter is incorporated inline with the leads and shielding. Immunity testing aspects, won't be affected by an EMI filter if they are conducted into a device from unprotected leads or radiated into the device.

A method of protecting an electronic device in the field could be retrofitting another interfering device with an EMI filter. This could be the wires or cables of the interfering device that connect or are radiating to the affected device.

In complex automated factories, potentially with hundreds of high power EMI generators, it may be easier and more cost effective to focus on protecting the more sensitive "victim" equipment or control systems. For example, it may be less expensive to install filters in the motor controller, rather than at the motor itself. EMI filters with integrated chokes can help enhance the immunity of sensitive computerized, digital, or analog control and monitoring systems. Control system racks are often built into large shielded housings, but may have less rigorous shielding protecting the control system components from EMI generated within the rack itself. Therefore, EMI filters at the power, control, and signal lines of control systems can reduce the noise levels within the control system housing, preventing malfunction and possible false alarms/readings.

Conclusion

With a larger margin allowed by EMC standards with industrial equipment and factory automation systems, the noise and interference in factories and work sites can be overwhelming to the increasingly computerized and digital industrial devices. EMI filters can be both a proactive tool for preventing damage and interference to sensitive equipment, and as a handy troubleshooting solution for ongoing problems that impact the bottom line. There are many EMI filter types that can be rapidly customized to unique needs, as the mix of factory automation electronics becomes more diverse and complex.

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SCHAFFNER EMC INC.
52 Mayfield Avenue
Edison, New Jersey 08837
+1 800 367 5566
+1 732 225 4789
usasales@schaffner.com
www.schaffnerusa.com

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