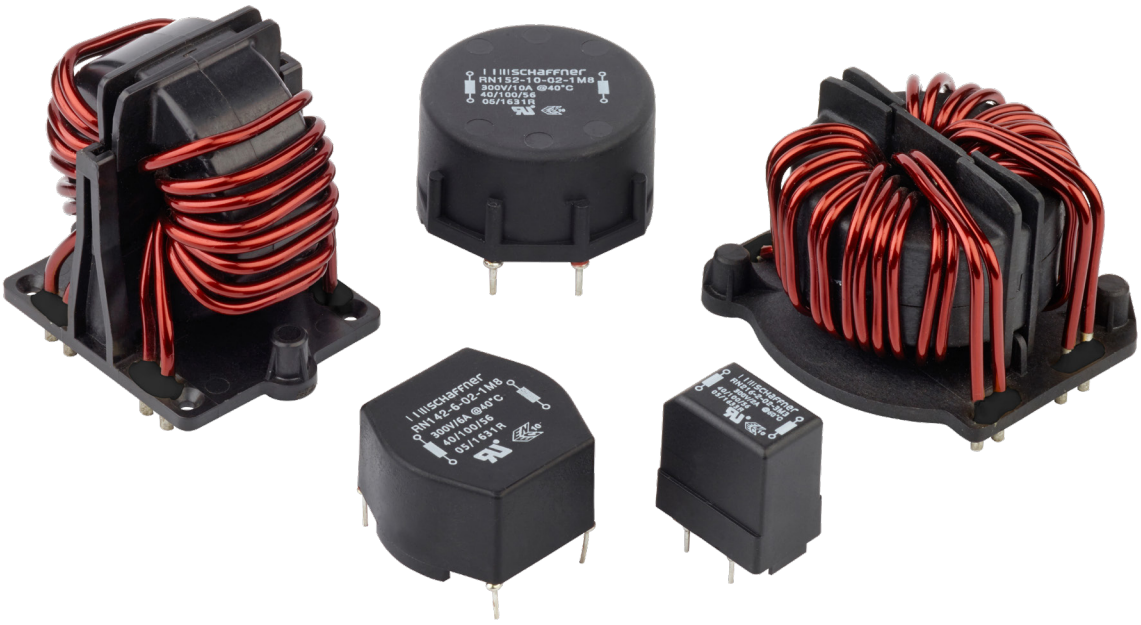
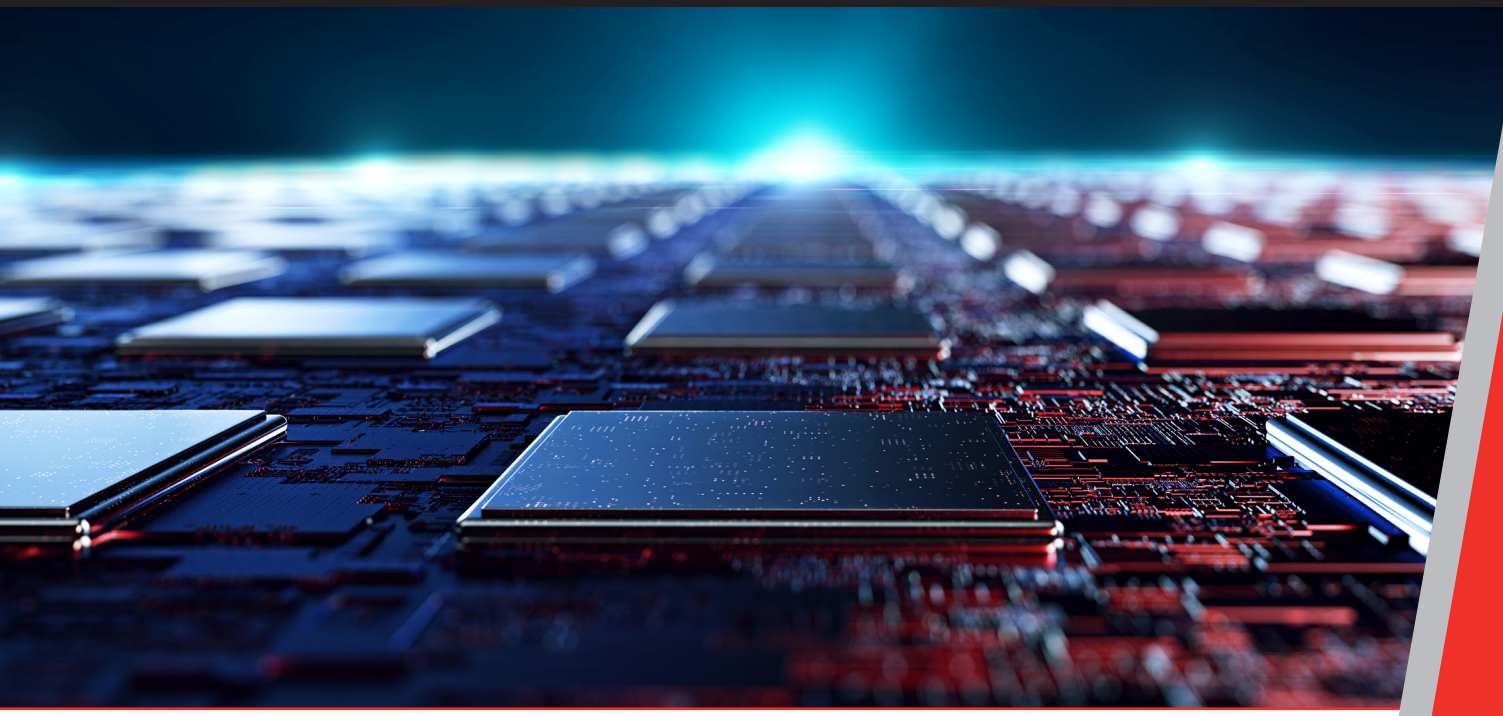
schaffner
shaping electrical power



How to Suppress Emissions and Enhance Immunity with EMI Filtering



www.schaffnerusa.com

TABLE OF CONTENTS

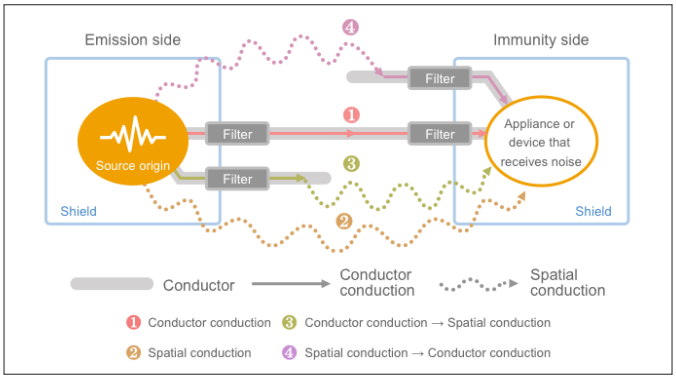
HOW TO SUPPRESS EMISSIONS AND ENHANCE IMMUNITY WITH EMI FILTERING

EMI filters have become an invaluable tool to ensure electronic products pass electromagnetic compliance (EMC) testing allowing a product to be introduced to market. EMI filters can be designed into a product during the early design and prototyping phase, which is an optimal time to account for product dimensions prior to manufacturing. Nevertheless, for many product design engineers, the benefits of an EMI filter are discovered as a result of EMC issues encountered during testing. EMI filters can suppress conducted emissions, radiated emissions and enhance the products immunity.

The following article provides insight and tips on when and how to best employ EMI filters in both the design and trouble-shooting 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.

When to Use EMI Filters in the EMI Troubleshooting Phase

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, especially with multi-phase power, motor, or turbine systems, space and wiring complexity can pose its own

set of problems. In this case, three-phase filters and three-phase filters with neutral, may be an optimum solution for reducing routing complexity and providing the most EMI suppression. As in the design phase when there is pressure for a short turnaround, leveraging EMI filters can be one of the most rapid ways to reduce conducted emissions without having to make significant product design changes.

How EMI Filters Impact EMI Emissions Evaluated in EMC Testing

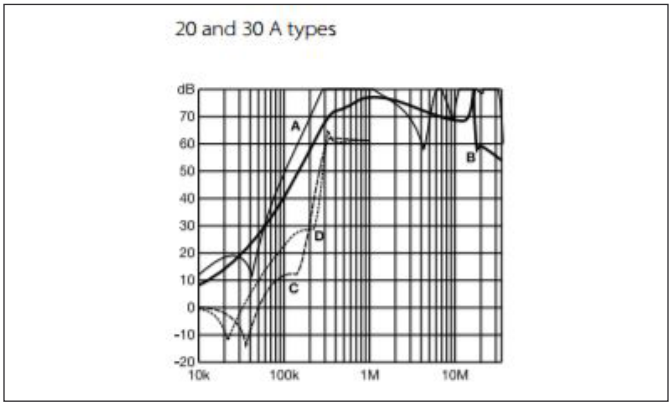
Beyond conducted emissions, an EMI filter may also provide some benefits to other compliance testing features, and aspects of performance which may not yet be covered by compliance standards. For example, EMI filter attenuation may extend below the 150 kHz frequency used in many commercial standards. 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.

EMI FILTERS AND RADIATED EMISSIONS

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.

Typical Filter Attenuation

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



For example, the figure above shows the filter attenuation plot of a Schaffner FN350 Compact EMC/RFI filter for motor drives (20 and 30 A type). It can be inferred from the plot that filter attenuation, of a reasonably high level, is available beyond 30 MHz. Moreover, many EMI filters can be designed to meet a specific need, and the cost of leveraging a single EMI filter compared to multiple solutions may just be advantageous compared to having to account for the design-in of multiple solutions.

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 EMI Filters Impact EMI Susceptibility/ Immunity Evaluated in EMC Testing

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.

Rather than relying on 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.

Conclusion

EMI suppression filters are highly versatile EMI mitigation devices. While they may be intended and specified for the suppression of conducted emissions, they can also be utilized for mitigating and enhancing a devices immunity. Valuable in both the design and troubleshooting phases of product development, various EMI filter designs can be incorporated into a device at the board level, assembly level, or even as an aftermarket retrofit. Lastly, EMI filters may even be customized by a manufacturer to serve the unique needs of a wide range of applications, and are often the last hope for product designers struggling to meet EMC testing requirements and reduce the noise from interfering equipment.

SCHAFFNER
shaping electrical power

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

Product Types
- Ecosine active
- EMI
- Power quality

Responsible For
- USA
- Brazil
- Canada
- Mexico