How EMC/EMI Filters Address Medical Device and Equipment EMI Challenges During Product Development

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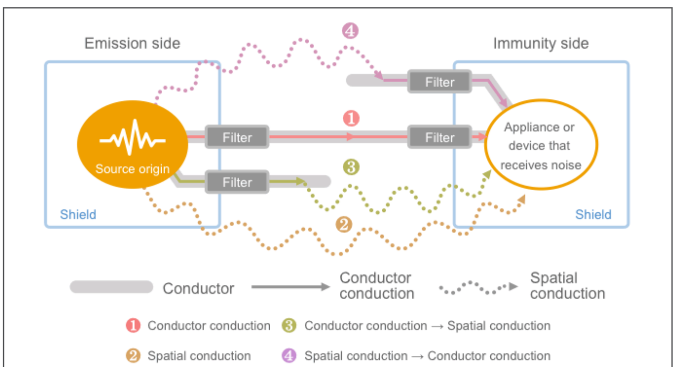
HOW EMC/EMI FILTERS ADDRESS MEDICAL DEVICE AND EQUIPMENT EMI CHALLENGES DURING PRODUCT DEVELOPMENT

Medical equipment and devices, such as ultrasound systems and ventilators, are required to perform at a high level of reliability. Due to the nature of a medical environment, they also must be able to withstand substantial amounts of interference without creating any interference. With lives on the line, EMC/EMI filters are a critical component in ensuring that medical electrical equipment and medical products optimally perform from an EMI perspective. There are also several standards, such as the IEC 60601 standards, which govern many aspects of medical device and equipment operation based on the medical use of a device.

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. 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. Some varieties of EMI filters, known as inlet filters or power entry modules, can replace the IEC inlet or power entry module and provide enhanced EMI conducted emissions/immunity protection. Chassis mount 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. For 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.

When to Use EMC/EMI Filters in the 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.

During the design phase when there is pressure for a short turnaround, leveraging EMI inlet filters or filtered power entry modules can be one of the most rapid ways to reduce conducted emissions without having to make significant product design changes. Installing inlet filters and power entry modules can also be a quick check in determining the weak point of an EMI issue as a controlled test, as no other changes need to be made to a product to use these filters.

Even though most medical equipment products must pass rigorous internal testing before approaching standards tests, there are sometimes issues beyond the IEC/EN 60601 standards for medical diagnostic units and laboratory equipment that could be valuable to consider. One of these possibilities, is that the medical diagnostic equipment may be in laboratories or portable use where greater interference and other highly sensitive equipment is kept. Though an individual device may not be a critical interferer on its own, the compounded EMI from a large number of devices, some of which may have fallen out of specification from use or damage, could overwhelm the standard EMI mitigation designed into the product.

In these cases, and others where the utmost medical equipment accuracy and reliability is of concern, it may be necessary to increase the amount of EMI filtering down at the inlet or power entry. This is possible through multi-stage EMI filters with greater levels of attenuation. Custom solutions may also be desirable, which can be made to account for specific interferers, if the interference is a known issue. EMI filters, especially inlet filters and power entry modules, can be employed as retrofits to current models, or rapidly replace the current models used if needed.

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.

It is likely that during the design of medical devices and equipment the product developers will have included the various emissions testing in their planning, along with EMI mitigation techniques specifically addressing these areas. With the increasingly electrical complexity, wireless connectivity, and advanced computerization of modern medical equipment and devices, there are far more variables and operation conditions, some of which may be unknown while the product is being developed. A method of preventing these unpredicted emissions could be to have redundant prevention, and possibly even prevention that reduces emissions far below the EMC testing standards criteria.

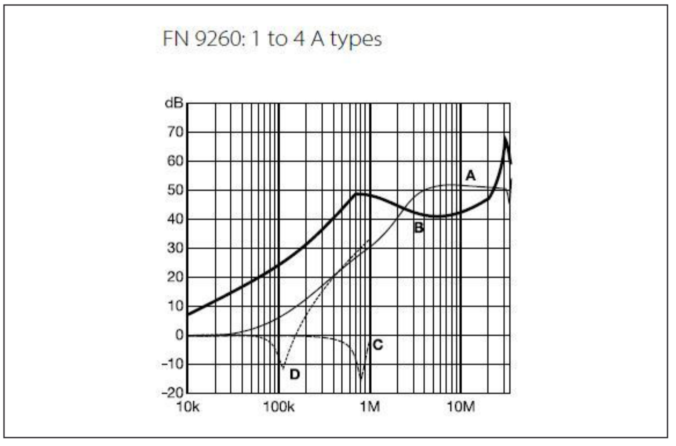
EMC/EMI FILTERS AND RADIATED EMISSIONS

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 FN9260 1A or 4A general purpose power entry module with fuse.

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 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.

To help not relay 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 them 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 in line 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

The value of EMC/EMI filters for medical equipment and devices from an electrical perspective has been outlined in this article. That is not where the decision of a EMI mitigation solution ends, however. As these filters also impact the overall device design, usability, and patient experience, it is important that these filters provide optimal performance, while minimizing their impact on the overall dimensions, handling, and experience of the device. Hence, when selecting filters for EMI mitigation of medical devices, the size, weight, and position of the device all come into play. Ultra-compact EMC/EMI filters, which are also reliable, may be essential in guaranteeing quality and ease of performance, along with the level of reliability that patients demand.

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