Selecting an EMI Filter

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Electromagnetic interference (EMI) is a common problem in electronic circuits that can cause signal degradation, malfunctions, and data loss.

To mitigate the effects of EMI, power line filters are often used. However, selecting the right power line EMI filter is crucial to ensure its effectiveness in reducing EMI. This essay will explore several factors that need to be considered in detail when selecting a power line EMI filter, including understanding EMI in electronic circuits, the importance of power line filters, and the factors to consider when choosing the right filter.

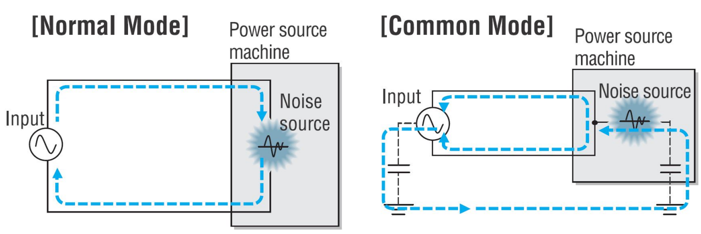

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Figure 1. Types of Conducted Noise

Propagation Paths of Noise (Inductive, Conductive and Radiated)

Understanding electromagnetic interference (EMI) in electronic circuits is essential when selecting a power line EMI filter. EMI refers to the unwanted electromagnetic signals that interfere with the proper functioning of electronic devices. There are three types of EMI, including inductive, conducted and radiated interference. Inductive refers to the noise that is induced due to electromagnetic or electrostatic induction caused by a power line or a signal line of a peripheral device when it is placed near a lineor pattern in which noise current flows and propagates through the line. Conduction refers to noise that propagates through a power lineor PCB tracing. Radiated refers to the noise radiated by an antenna or a conductor or PCB trace behaving as an antenna that propagates noise energy through the air.

Types of Conductive Noise (Differential and Common Mode)

Conducted EMI travels along power and signal lines, while radiated EMI is emitted as electromagnetic radiation. Common mode EMI occurs when unwanted signals appear on both conductors of a balanced transmission line, while differential (normal) mode EMI occurs when the unwanted signals appear on only one conductor as illustrated in figure 1. Various factors can cause EMI, such as switching circuits, power lines, and radio frequency signals. Switching circuits, for example, generate high-frequency harmonics that can couple into nearby circuits. Power lines, on the other hand, can act as antennas and pick up external EMI sources. Radio frequency signals from nearby transmitters can also induce EMI in electronic circuits. It is crucial to understand the different types and sources of EMI to effectively select a power line EMI filter that can address the specific interference issues.

Are EMI Filters Required with AC/DC Power Supplies?

AC/DC power supplies are designed and tested to meet conducted and radiated safety agency limits with margin. The margin depends on the manufacturer, but Cosel has a strict requirement that our AC/DC power supplies have an aggressive margin between the actual measured noise and the safety agency limits. As an example, the Cosel PCA600 AC/DC 600 watt power supply has a greater that 13.0 db margin, however even with the large margin it is possible in a system with other noise generating circuitry, the system may fail EMI requiring additional EMI filtering.

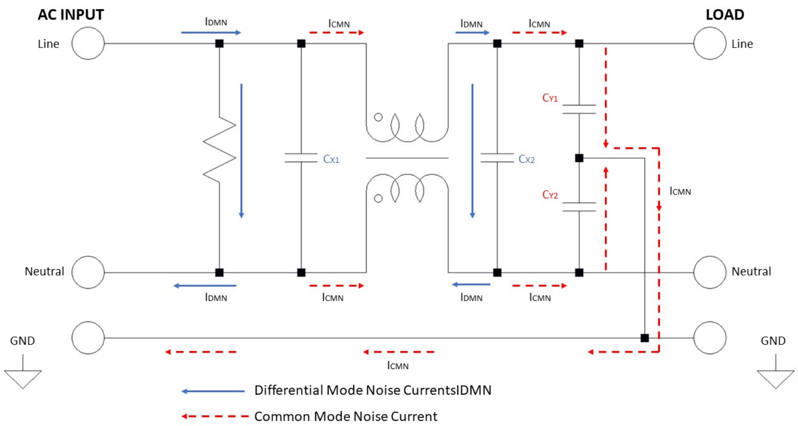

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Figure 2. Differential & Common Mode Noise Currents in a 1-Stage EMI Filter

Power line filters are designed to attenuate unwanted EMI conductive noise signals and protect electronic devices from interference. Power line filters work by providing a low-impedance path for the unwanted EMI signals to flow as shown in figure 2, effectively diverting them away from the sensitive electronic circuits and preventing the noise from conducting into the AC power lines. By reducing the amplitude of the EMI signals, power line filters can significantly improve the signal integrity and reliability of electronic devices. The selection of the right power line filter depends on the specific requirements and characteristics of the electronic circuit and the frequency of noise being generated. Typically the higher frequency conducted noise is common mode. Figure 3 is an example of the attenuation characteristics of a 1 stage and a 2 stage single phase EMI line filter. Figure 4 is a schematic comparison of a 1 stage to a 2 stage EMI filter.

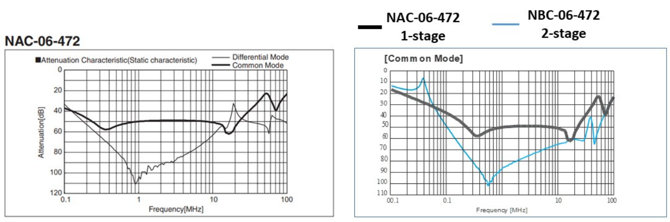

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Figure 3. Examples of typical Differential & Common Mode Noise Attenuation in a 1 stage & 2 stage Filter

Rated Voltage and Current

When choosing the right power line filter, several factors need to be considered to ensure its effectiveness in reducing EMI. The frequency range and bandwidth requirements of the electronic circuit play a crucial role in determining the suitable power line filter. Different filters have different frequency response characteristics, and it is important to select a filter that can effectively attenuate EMI signals within the desired frequency range. The frequency range of interference that needs to be filtered out must be determined first, then a filter that effectively targets and suppresses the unwanted differential mode and common mode signals can be selected.

Additionally, voltage and current rating of the EMI filter needs to be considered when selecting a filter. The rated voltage is the maximum line voltage (nominal value) allowable to be used. As the rated voltages for some parts used within an EMI filter are high in reality, however, voltages higher than the rated voltage of the EMI filter may be used without causing any trouble. In fact, the rated voltages of filter components are oftenhigher, inwhichcasethefiltercanhandle actual voltages that exceed its ratings. In the case of some EMI filters, the maximum operating voltages are defined by specifications for them, separately from rated voltages.

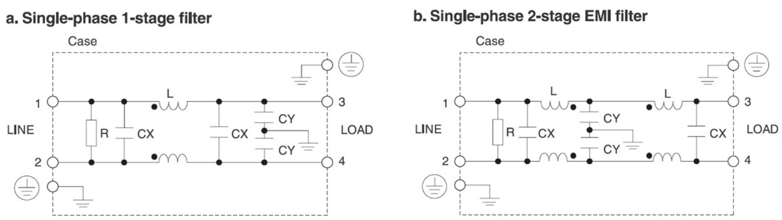

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Figure 4. Single Phase 1-Stage and 2-Stage EMI Filter Schematics

Using EMI filters at voltages lower than their rated voltages do not pose any problems. For example, an EMI filter with a rated voltage of AC 250V can be used for power lines of AC 100V. As for line frequency, EMI filters for AC power supply lines have been basically designed to be used with the commercial frequency (50 Hz/60 Hz). Note that EMI filters for AC power lines can also be used for DC power supply lines.

The rated current is the maximum load current (nominal value) that can be continuously carried. If the ambient temperature is high, typically above 50°C or 60°C, the load current capability of an EMI filter needs to be derated. The filters referenced in figure 3 have a maximum ambient temperature of 75°C and should be derated to 60% of the maximum 55°C rated current level of 6 amps. Currents higher than the rated current are allowed to flow in EMI filters for a short period of time only. Inrush current (Up to 40A or 10 times the rated current with a length of a few milliseconds) from devices such as a general switching powers our ce does not cause any problems, but relatively long and/ or repetitive peak current draws can result in the average current exceeding the filter's rating.

Leakage Current

Leakage current flows through the Y capacitors Cy1 and Cy2 shown in figure 2 into the ground terminal of an EMI filter when the filter is connected to an AC power line. Generally, as the Y Capacitors Cy1 and Cy2 are increased the common mode noise levels are reduced and the leakage current is increased. The Y capacitance and the leakage current limit is specified for all Cosel single phase input and three phase input filters. Please see the Cosel data sheets for details.

EMI Filters in N+1 Redundant Applications

In N+1 redundant applications, where there are multiple redundant power supplies or components, potential EMI issues can arise. These issues can be particularly challenging when designing EMI/RFI filters for such redundant systems, however a single filter could be used to meet the safety agency EMI requirements. A component failure in a single EMI filter would be a single point of failure. With a differential mode X-capacitor or a common mode Y-capacitor, failing in an electrical short circuit could result in a system failure. The same would apply should the common mode inductor failure result in an open circuit. Therefore for a true N+1 redundant system more than one EMI filter is required.

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