Design Tips

Bruce Archambeault, Associate Editor

Welcome to Design Tips! This issue, we'll move away from printed circuit boards and discuss shielding of air vent areas, the effects of thermal cooling, and how to increase airflow without reducing shielding!

Please send me your most useful design tip for consideration in this section. Ideas should not be limited by anything other than your imagination! Please send these submissions to bruce.arch@ieee.org. I'll look forward to receiving many "Design Tips!" Please also let me know if you have any comments or suggestions for this section, or comments on the Design Tips articles.

You will also find "Design Tid-Bits" at the end of the Design Tips Article. These Tid-Bits are intended to be a very short description of EMC design best practices and cover a wide range of EMC design issues. Please send your contributions to bruce.arch@ieee.org.

Shielding of Air Vent Holes

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As EMC engineers, we are very familiar with metal shields. However, the question about the size of the openings within a shield continues to raise questions with designers.

There are two classes of openings within a metal shield: the openings for air vents and the openings associated with imperfect connection between mating portions of the enclosure. This design tip will focus more on the air vent openings.

It is well known that the size of the openings must become smaller as frequencies increase within an enclosure. With hundred's of Megahertz and even ten's of Giga-Hertz common in many products, the issues between smaller openings for EMC and larger openings for cooling are often critical issues for products. Recently, when EMC concerns forced air vent openings to become smaller reducing the amount of air flow for thermal cooling, the thermal solution was to increase the fan speed to compensate for the reduced air flow. However, this fan speed increase also increased the audio frequency noise and resulted in a non-compliant product. Clearly, there must be a compromise between EMC, thermal and acoustics. If any one of these requirements is not met, the product cannot ship to customers! EMC engineers can no longer work only on EMC-related concerns, and ignore all other criterion.

But there are certain laws of physics that we cannot overcome. The opening size of apertures, the number of apertures, and the frequencies of interest will result in a very specific amount of shielding. We need a way to increase shielding without decreasing hole size!

One such possibility is to create thicker metal material. Honeycomb air filters have been used for many years to make a significant increase in shielding for air vents. While they provide high levels of shielding, they also are expensive, they take more physical space and they add significant air pressure impedance and turbulence to the cooling air, making them less than perfect from a system level point of view.

Since many air vent EMC filters are stamped into metal, there is the possibility of creating a thicker/deeper hole by stacking stamped metal sheets. Other manufacturing techniques can be used to create these deeper holes as well. In order to analyze the effect of thicker shields, a number of Finite-Difference Time-Domain simulations were performed to show the relative difference between various air vent hole sizes, material thickness (depth of holes), and frequency. Figure 1 shows an example the shielding results of such a series of simulations for a total air vent area of 15 cm x 15 cm with 5 mm x 5 mm holes, and 1 mm metal between the holes. The difference in the amount of shielding for material thicknesses (hole depth) from 1 mm to 10 mm is shown.

Rather than show a series of plots similar to Figure 1, Figure 2 shows a summary of the variation of the shielding seen at 1 GHz for various hole sizes. The overall area where the air vent holes are placed remained at 15 cm x 15 cm for all cases, and the number of holes were adjusted to fit the hole size into the overall space allowed. Naturally, as the hole size increased, the percentage of open area (for air to flow) increased, resulting in lower airflow backpressure and increased cooling.

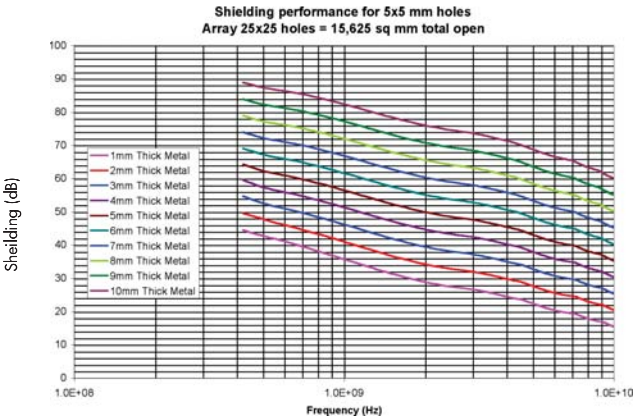

Figure 1 Shielding performance for 5mm x 5mm holes with various thicknesses of metal

One of the main reasons for plots such as Figure 2 is to make design decisions on engineering trade-offs. For example, let's suppose that previous product testing has shown that a product using 4 mm x 4 mm holes (with a single metal sheet thickness of 1 mm) needs 40 dB of shielding at 1 GHz. However, because of thermal constraints, the hole size should be increased to 7 mm x 7 mm, Figure 2 shows that if the depth of the holes (thickness of the metal) is increased to 4 mm, then the required 40 dB of shielding at 1 GHz is maintained.

Summary

The results in Figures 1 and 2 show the trade-offs available to design engineers to increase airflow, improve cooling, and to maintain electromagnetic shielding performance. These results show the relative shielding performance for an air vent area of 15 cm x 15 cm. Other overall areas will have different levels of shielding, but the trends shown in this Design Tip will be consistent.

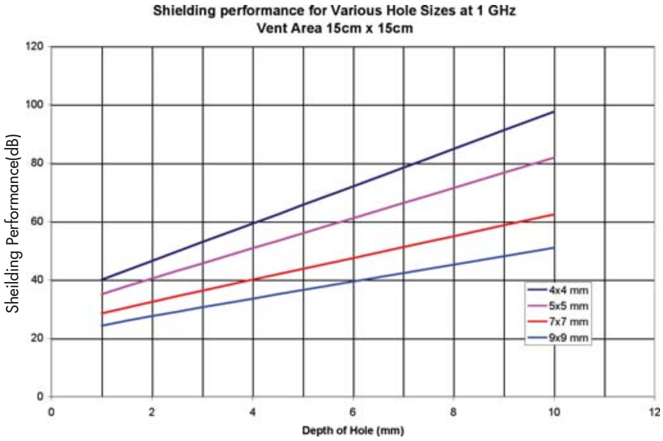

Figure 2 Shielding performance at 1 GHz for various hole sizes and thicknesses.

Design Tid-Bit

Insufficient consideration of signal return current is one of the main causes of poor EMI performance in printed circuit boards (PCBs). The main causes of poor return current design is often the high-speed signal trace changing layers in the PCB and effectively changing the reference layer where the return current must flow. Maintaining a return via that connects the two return planes within five times the plane-to-plane distance will help minimize the return current spread and, therefore, the EMI noise between the planes. The closer the return via is to the signal via, the lower the EMI noise created by this signal via.

--- Bruce Archambeault