Essential Considerations for Electronic Packaging

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THE NATURE OF ELECTRONICS

Electronic packaging performs five essential functions. It provides the structure which physically supports the circuit boards. It cools the electronics and maintains the proper temperature range and air quality for operation. It provides and distributes power. It enables communication with other electronic devices via I/O cabling. Electronic packaging also furnishes proper shielding to make the electronic device electromagnetically compatible with other electronic devices.

When choosing an electromagnetically compatible electronic enclosure, one must consider an enclosure's shielding effectiveness (SE) over the frequency range under consideration, the type of shielding material used to seal the enclosure, and the level to which the enclosure performs each of the other electronic packaging functions.

In the natural course of operation, electronics emit electromagnetic energy, which, like light and radio waves, has the ability to travel as radiated energy. It also has the ability to travel as current when the radiated energy encounters a conductor. These conductors then emit radiation. Consequently, electronic "noise" is not only emitted from the device itself, but also via the cables attached to it (Figure 1).

Electronic devices are not able to distinguish between the authentic signals they receive and the bogus signals picked up as noise from other devices. Because electromagnetic energy can be conducted as well as radiated, electromagnetic interference (EMI) is transmitted via several channels (Figure 2). When a device is packaged properly so that it is sufficiently resistant to EMI and it will not generate EMI to neighboring devices, it is said to have electromagnetic compatibility (EMC).

Electronic enclosures that are designed from the bottom up integrate essential functions.

The ideal electronic package is a seamless, solid sphere fabricated from highly conductive material such as copper, aluminum, or silver. Unfortunately, this solution is not only impractical, but also provides EM shielding at the expense of the other four functions which the package must also perform. The best packaging solution is the alternative which maximizes SE economically without hindering effective cooling power distribution or I/O functions.

SHIELDING EFFECTIVENESS

Shielding effectiveness is a measure of an enclosure's ability to prevent EMI from affecting the device it houses or the electronic devices around it. Because electromagnetic energy behaves differently at different frequencies, the SE of an enclosure is frequency dependent. Therefore, any measure of SE should be stated in terms of the corresponding frequency. To completely describe the SE of an enclosure, it is necessary to plot a curve of SE versus frequency. An example for one shielded cabinet is shown in Figure 3.

Typically, SE is measured in decibels (dB). The dB is a logarithmic measure of efficiency. As such, SE is described by the following expression:

$$SE = 20 \log \left(\frac{\text{Pwr. measured outside encl.}}{\text{Pwr. radiated from inside encl.}} \right)$$

It is important that all results describing the SE of an enclosure under consideration be derived using a standard method. In the U.S., MIL-STD-285 is the standard test procedure that suppliers of electronic enclosures most often use to evaluate the SE of their products. MIL-STD-285 describes the test procedures for making these measurements and is the baseline for making comparisons between enclosures.

Manufacturers of electronic equipment are also concerned with another document, FCC Rules & Regulations, Part 15. This document specifies the allowable level of energy permitted to escape the device. This is an absolute level measured in mV, as opposed to a relative measure such as dB. The differentiation of efficiency versus absolute performance is an important distinction. It can be restated as the difference between the enclosure and the complete system.

Electronic enclosures are empty boxes which cannot emit any energy and do not represent or behave like the finished device. They cannot pass or fail the FCC requirement since they cannot affect other devices on their own. But the finished system, which is an active device, is capable of interfering with other devices. Therefore, it is the finished system which must be evaluated under the FCC requirement. Thus, suppliers of electronic enclosures cannot claim that their products pass FCC regulations; they can only give the SE for the enclosures.

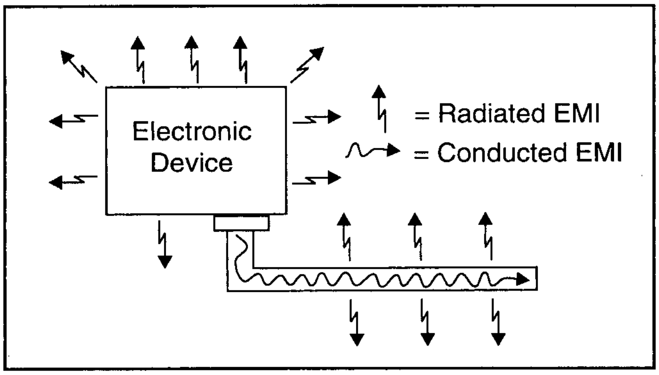

***Figure 1.** Radiated and Conducted EMI Emitted via Cable.*

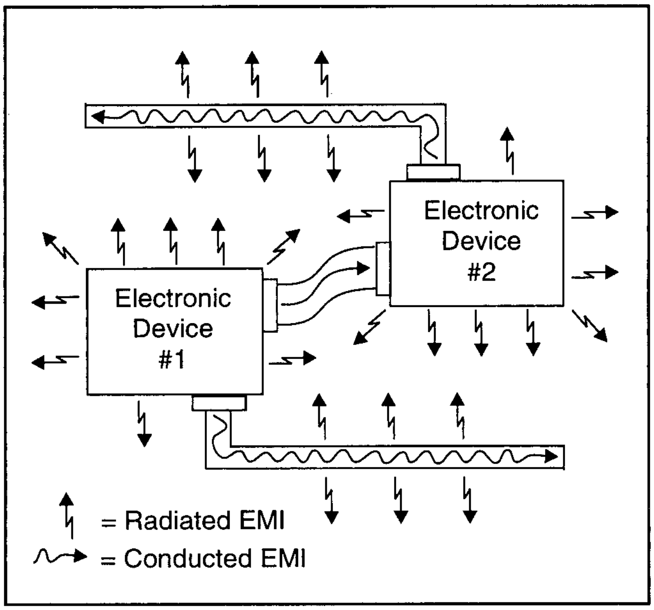

***Figure 2.** Radiated and Conducted EMI Emitted via Several Channels.*

Along these same lines, enclosures are typically tested in standard configurations. However, in real-life applications, modifications are inevitable. Because it is difficult to predict the effect of the modifications on the SE of the enclosure, changes to the unit generally invalidate the test results to some degree. An enclosure which has been designed to accommodate the functions of electronics packaging will not require modification that would substantially reduce the SE of the enclosure. Features could include an integral bottom-to-top cooling feature and provisions for shielded I/O cables (Figure 4).

Shielding is accomplished at several levels of electronics packaging, and slightly different techniques are used for different types of electronics. For commercial 19" rack-mounted electronics, it is often desirable to achieve EMC through a shielded rack. This application poses a particularly challenging obstacle for those in the industry. Some commercially available solutions have acceptable SE but are not cost effective, or compromise the other functions that the enclosure must perform. Others are standard product offerings that have had the shielding added as an afterthought. The challenge that the market presents is to offer a cost-effective shielding enclosure which is easily cooled and lends itself to I/O and power entry and distribution. Only a bottom-up design effort, where all factors can play an equal role in the development, will result in a solution which maximizes each of the electronic packaging functions.

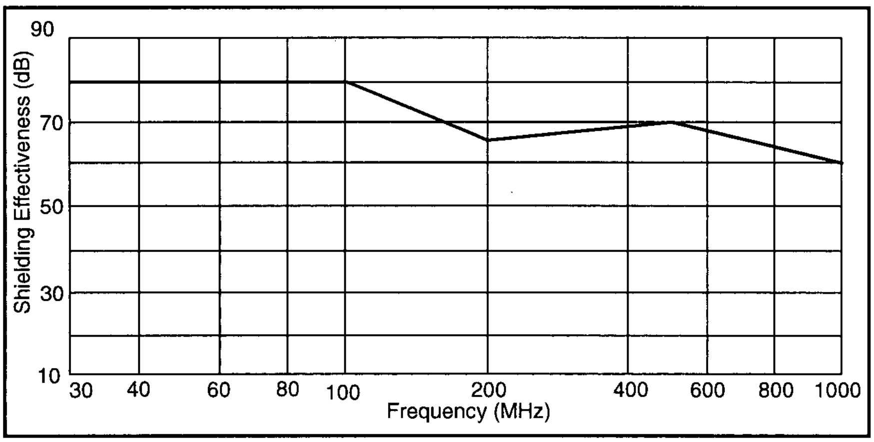

***Figure 3.** Shielding Effectiveness vs. Frequency.*

SHIELD INTEGRITY

One particularly important aspect of shielding 19" rack enclosures involves the large doors typically associated with this type of package; they may be full-length or partial doors. Doors must be shielded around their perimeter, and the seals must be able to withstand many cycles of opening and closing. Therefore, when comparing enclosures with similar SE, another factor in the decision is the reliability of the

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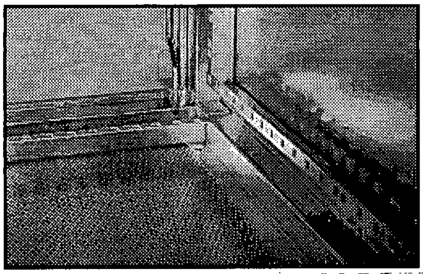

Figure 4a. *16-Gauge Perforated Steel Top and Bottom Cover Plates.*

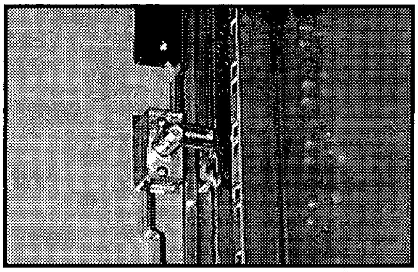

Figure 4b. *Single Latch with 3-point Locking Mechanism for Easy Opening and Closing.*

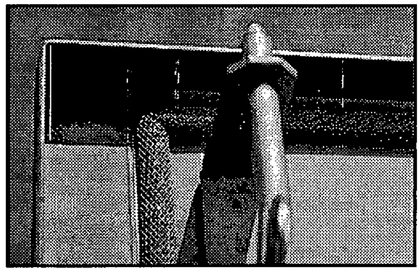

Figure 4c. *Conductive Foil Tape and Silver Knitted Wire Foam Core Gasketing.*

gasket. Keeping in mind that the SE of an enclosure was determined under laboratory conditions with a new enclosure, it is important to consider how effective the seal will be after the enclosure has been in the field. Gaskets must be stable as well as durable. This is particularly true for the door seals. Door seals are compressed and relaxed each time the door is cycled and rely on proper door alignment. The type of gasket used in an enclosure is an important consideration in the enclosure selection process. Some seals may lose their effectiveness over time. The shielding material may lose its shape or resiliency. Gaskets that have a memory may form unreliable seals over time, especially if they have not been utilized properly. Metal finger-style gasketing, such as those fabricated from beryllium copper (BeCu), can easily deform or get caught and bend accidentally during use. Further, they contribute to excessive compression force which may cause doors to be difficult to latch or unlatch.

Hinge mechanisms are also important. The hinges are responsible for keeping the door properly aligned after many cycles. A reliable hinging scheme is also necessary to keep the seal properly compressed along the hinge side of the door. Preferably, all this should be accomplished with hinges that are attractive or hidden. A hidden multi-hinge design incorporated into the door is one example.

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Another consideration is RF shielding material whose production is unfriendly to the environment. This is especially true of plating. Environmental regulations are making the use and disposal of the solvents involved in zinc plating very expensive. Ideally, a shielded enclosure utilizes more modern techniques such as conductive foil tape.

Most engineers in the industry are aware that electronics are becoming smaller and more densely packaged. The resulting increased heat density, power dissipation, and number of I/O signals make shielding increasingly difficult. But many engineers are not aware that, because electronics equipment is considered vital to the smooth operation of many organizations and communities, the trend toward hardened 19" enclosures is growing stronger. The burden is then on the electronics manufacturer to find a source for such an enclosure.

CONCLUSION

Typically, packaging suppliers have addressed some essential functions but not all. The result is that units do not look alike or are not mechanically compatible and cannot be easily ganged. Units that have been designed from the bottom up anticipate this trend. These types of units offer both the shielding, cooling and power functions as integral options, not mutually exclusive features. The consistent appearance and modularity eliminate many problems for the electronics manufacturer.

The growing trend toward increasing density of electronics necessitates that electronics enclosures perform more effectively. Requirements such as cooling and seismic reinforcement are considered just as important as EM shielding. Similarly, previous techniques for shielding are being replaced with newer, more effective, and less costly solutions. Careful examination of the shielding techniques, especially around the door, is important when choosing an enclosure, and it is best to have an estimate of the required shielding effectiveness. Finally, the ability of the enclosure to lend itself to I/O, power entry, and flexible internal mechanical configuration with minimal modifications must be a key concern.

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