Optimizing EMI Shielding for Wireless Systems

EMI, or electromagnetic interference, is a familiar, though not always understood, occurrence. EMI results from spurious signals generated by electronic systems, (or by nature, such as lightning), that adversely affect circuits within the same, or nearby electronics. The trend toward faster, smaller wireless systems has engineers seeking better EMI control methods for their designs and budgets.

Cause and effect

Unintentional EM emissions result from electric (E) and magnetic (H) fields that surround current-carrying traces, wires and other conductors. The voltage or switching frequency of the source, as well as its harmonics, determines the EM frequencies. As operating speeds exceed 900 MHz, wavelengths are so short that very small (<2mm) slots in an enclosure become doorways for these troublesome emissions. They can also interact with circuit board traces having lengths that make them act as efficient one-quarter or one-half wavelength antennas.

Base-level treatments

Proper PCB layout offers the most cost-effective approach to dealing with radiated EMI issues, whether preventing emissions or providing immunity. Careful layout and separation of traces and components on a PCB can reduce cross talk. A number of software programs can help design engineers analyze potential EMI problems at this level.

It is rare, however, when board layout alone resolves EMI problems. Some form of EMI suppression is typically needed. This is especially true with the trend toward single board handsets where high-speed components are clustered together. Adding filters and attenuator beads onto a PCB can offer some emission control, as well as using multi-layer boards with separate ground planes. But most high frequency systems require some form of EMI shielding at board level or as part of the enclosure.

In simple terms, an EMI shield is a conductive barrier set between an EMI source and an area needing protection from it. The shield both reflects and absorbs electromagnetic waves. At the relatively high frequencies of wireless electronics, these are mainly electric waves, which an effective EMI shield will absorb.

Cans and covers

A shield might be used on a single-board phone, where components such as oscillators and high speed ICs must be shielded from each other. Board level shielding is often provided using a conductive can or cover mounted over radiating or susceptible PCB components. Stamped metal cans soldered onto boards are a common shielding approach. These are typically made from tinplated sheet steel, and can be integrated into pick and place component loading systems.

While solder mounted cans hinder component access, versions with removable lids are now available. However, like similarly mounted components, the solder is susceptible to cracking from tension or shock on the circuit board. Because of this, metal cans may be less compatible than other shielding solutions with phones designed for back-pocket flexibility.

New molded plastic covers provide greater flexibility and easy pin mounting. These covers have a conductive coating or plated surface and feature integral conductive elastomer gaskets for shielding components or entire cell phone PCBs. The gaskets mate with board traces and, together with a PCB's conductive back plane layer, they provide a 360-degree shielding solution (called a Faraday shield).

In place of plating or paint, a thin, continuous layer of molded-in-place conductive elastomer can provide a shielding surface. The elastomer can also be molded into detailed wall patterns for isolating components from each other under the cover.

Spacer gaskets

In multiple board phones, a common shielding approach uses spacer-type EMI gaskets of plastic and conductive elastomer. Spacer gaskets provide an EMI barrier between components to protect against cross talk. They also act as a ground path between a PCB and another board or a metallized cover. The molded elastomer gasket mates with board traces or other conductive surfaces. Using tools such as finite element analysis (FEA), the gasket profiles are designed with deflection and compression ranges that provide maximum performance.

A typical spacer gasket's conductive elastomer provides shielding effectiveness of 100 dB at 500 MHz and 80 dB at 10 GHz. The elastomer material is especially durable for high speed molding equipment and for installation procedures. Prototypes of plastic/elastomer spacer shields can be created within days.

Form-in-place gaskets

For limited spaces and high volume applications, automated form-in-place EMI gaskets of conductive elastomer can be applied in very small cross sections. The gaskets are robotically dispensed on metal or metallized housing flanges as narrow as .030 inch, with placement accuracy of 0.001-inch. The most capable of these dispensing systems feature non-stop, 3-axis motion to accommodate the uneven surfaces common in casting or injection molded parts.

A variety of FIP conductive elastomers are available to accommodate different requirements. Moisture cure material can be handled in hours and cures overnight. For substrates (e.g., housing parts) that tolerate elevated bake temperatures, complete gasketed parts are ready to ship in less than a half-hour. Shielding performance is typically 75 to 10 dB from 200 MHz to 10 GHz.

Drop testing on some cell phone models has also demonstrated that conductive elastomer perimeter seals provides some absorption properties.

Table 1 compares typical cell phone shielding systems:

Table 1

Shielding Type	Metal Cans	Plastic Covers	Spacer Gaskets	Form-in-Place Gaskets
Application	Soldered over PCB components	Pin or screw mount over PCB components	Component shielding and PCB grounding. Pin or screw mount	Cross talk and perimeter shielding.
Features	Pick and place assembly. Difficult removal.	Conductively plated or painted. Conductive elastomer molded to cover.	Conductive elastomer over-molded on plastic frame.	Robotic dispensing on thin walled enclosures parts.
Shielding Effectiveness	80-100 dB	80-100 dB	80-100 dB	75-100 dB
Advantages	In line application.	Removable. Cover individual components or entire PCBs	Easy assembly	Fast programming for new applications.

Creating a shielding enclosure

Enclosure shielding for cell phones has evolved from plated metal to plated plastic to today's robotically painted and EMI gasketed parts. Complete systems apply a thin (typically .002-inch) resin with a conductive filler, such as silver-plated-copper. The best of these resins provide uniform coverage and conductivity, with strong abrasion resistance.

High volume coating applications are made with high volume/low pressure (HVLP) spray systems. When these are integrated with automated form-in-place EMI gasket equipment, ready to use shields are produced with fast turnaround and lower total cost than multiple step production methods.

Shielding larger enclosures

The precise, narrow EMI gasketing provided by automated FIP systems is not limited to handset applications. As base stations and other devices shrink in size and grow in volume, these thin, low profile FIP gaskets may offer the best approach. One example is seen on a metal cover for a base station enclosure. The cover features a complex pattern of interior walls. The mating surfaces of these walls require conductive gaskets to provide current continuity for internal shielding. The robotic system gives the lowest applied cost EMI gasket solution.

Several types of EMI gaskets are available for large enclosures. Each offers benefits and drawbacks when compared by price, performance and other key features. A brief description of common gasket types is shown in Table 2.

However, the best route to an effective solution is to consult with applications engineers at one or more EMI shielding providers. Besides being versed in design and material options, they are sensitive to the demands of wireless systems design.

Table 2

Gasket Type	Conductive Elastomers	Metal Fingerstock	Fabric over Foam	Wire Mesh
Application	Aperture and seam shielding. Environmental seals. Adhesive, clip-on, fastener and pressure mount.	Seam shielding and grounding contacts. Adhesive, clip-on and fastener mount.	Apertures, seams and grounding contacts. Adhesive and fastener mount	Lengths and fabricated shapes. Adhesive, clip-on and fastener mount
Features	Elastomers filled with silver-plated-glass, silver-plated-copper and nickel-coated graphite. Extruded strips, molded and die-cut shapes.	Mainly Be-Cu in linear rows and pieces.	Metal plated fabric or knitted yarn over foam core. Lengths and flat die-cut shapes.	All metal or knitted over elastomer core for softer compression and weather sealing.
Shielding Effectiveness	80-100 dB	80-120 dB	80-100 dB	75-100 dB
Advantages	Versatile - numerous formula and shape choices	High levels of shielding. Best in shear applications.	Low compression requirements. Lightweight. Economical.	Resilient. Larger cross sections and shapes.

The need for grounding

Without proper grounding, metal components in a cell phone, base station or other wireless device can become radiating sources of EMI. This includes any conductive materials used for shielding. Conductive gaskets and small contact points can commonly ground separate parts within a system.

Examples of grounding points include metal fingers attached to cans on a handset PCB. The soft-compression fingers provide a conductive path to ground the PCB to the conductive phone housing. Fingers or conductive "buttons" can also be mounted directly on PCB traces for board grounding. Buttons are made from conductive fabric-over-foam or elastomers.

Inside a switching cabinet, on OEM uses conductive, frame shaped gaskets to ground a series of connectors. The gaskets are made from aluminum foil wrapped over soft foam cores. Mounted onto the cabinet back plane, they provide both grounding and shielding at the connector/back plane interface.

Optimizing your shielding provider

Beyond offering a range of material and design solutions, shielding providers are playing a larger part in managing EMI control for wireless OEMs. This includes serving as lead vendors to provide ready-to-install, custom parts. Automated shielding solutions are becoming faster, more versatile and more localized around the world.

In the lead vendor set-up, a supplier provides custom shielding parts created in diverse manufacturing steps. One example is a shielding cover designed for a cell phone. The shielding supplier manages the plastic molding, conductive plating or painting, EMI gasketing and various hardware assembly operations provided by several vendors. The result is a single, high quality part delivered to the wireless OEM. The end customer enjoys lower inventories and a shortened supply chain -- and can focus more on its own core competencies.

Automated processes, such as robotic form-in-place gasketing, have dramatically lowered shielding costs in high volume wireless packages. These systems are being installed in some wireless OEM facilities and integrated into their product assembly. Many cans and covers are now applied by pick and place robotics.

When not actually inside the OEM's facilities, shielding providers have deployed local manufacturing and warehousing in wireless production centers around the world. The OEMs are assured of available parts without inventory and import concerns. These shielding materials are part of the locally produced content of their products, which falls under government mandates within certain countries.

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