

# New EMI Shielding Approaches Optimize Wireless Designs

*New generations of EMI shielding methods and materials are keeping pace with new wireless designs to solve traditional problems.*

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Wireless transceivers and transmitters radiate intentional and unintentional electromagnetic (EM) signals. The unintended emissions result from electric (E) and magnetic (H) fields surrounding current-carrying traces, wires and other conductors. The voltage or current switching frequency of the source and its harmonics determines the frequencies of these radiated emissions. Signals radiate into the surrounding area and couple onto nearby signal lines, cables, and other conductors.

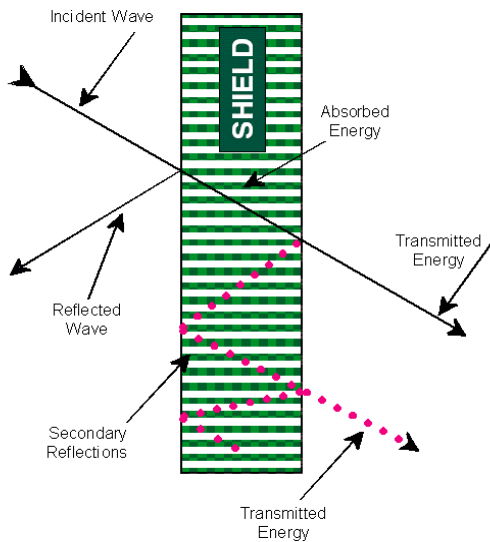
## **Board-Level Control**

Radiated emissions can be minimized through proper circuit design and board layout. Using multilayer printed circuit boards with separate ground planes, and avoiding needlessly fast clock-waveform rise times can also be effective. However, with wireless operating frequencies of 800 MHz and higher, wavelengths are so short that many board circuit traces have lengths that make them act as efficient one-quarter or one-half wavelength antennas. Thus, board level emissions reduction does not eliminate the need for enclosure-level EMI shielding.

## **The Role of Shielding**

EMI shielding of electronic enclosures works on the theory that a highly conductive metal, inserted between the source of EM emissions and circuits needing protection, will attenuate the radiated E-field by reflecting and absorbing a portion of its energy. (*See Figure 1*) The type (reflection or absorption) and amount of attenuation will depend on factors such as the frequency and wavelength of the emissions, the conductivity

and permeability of the metal, and its distance from the source. At high frequencies, thickness of the shield is not much of a factor.



**Figure 1.** Attenuation of Electromagnetic Interference (EMI) by a conductive shield.

An enclosure shield in a wireless device might be a simple metal sheet or foil layer (often called a "shadow shield"), or a six-sided metal or metallized plastic enclosure (referred to as a "Faraday cage"). In wireless systems Faraday shields are most common. These shields must be electrically bonded to the enclosure's chassis ground to be effective. To serve as a Faraday shield, a plastic housing can be metallized by applying a conductive coating, typically using an HVLP (high-volume, low-pressure) spray system. Conductive coatings are commonly formulated from an acrylic resin filled with metal particles. Metal plating provides another system for shielding plastic enclosure parts.

### Apertures as Leakage Paths

Regardless of the theoretical capability of a particular enclosure's EMI shielding, (such as conductive coating, plating, foil or die casting), the actual shielding performance generally depends on the nature of the apertures used for access, cooling systems, input/output (I/O) connectors and power, viewing, and other access needs. Apertures such as slots and seams, whose length approximates the wavelengths of local emissions, will become paths for EMI leakage.

Consider a wireless device operating at 900 MHz. The wavelength of its fundamental operating frequency is about 33 cm. Emissions at the tenth harmonic of a fundamental frequency are very common. In this case, the tenth harmonic is 9 GHz, representing a 3.3 cm wavelength. A Faraday cage shield for this device might degrade if it includes slot apertures of this order of magnitude.

Slot-shaped apertures typically occur at seams in a shielded housing or at interfaces between the ribs or partition walls of a shield and their mating PCB ground

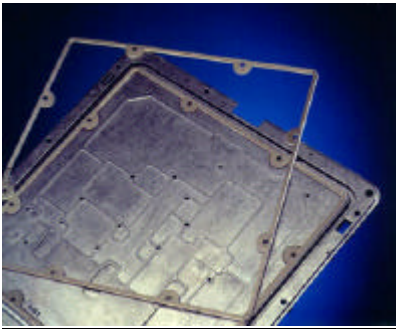
traces. Engineers depend on compressible or deformable conductive EMI gaskets to convert imperfect seams into continuous, low impedance interfaces.

## Using EMI Gaskets

Designers have a growing choice of economical EMI gasket types and applications methods. Conductive elastomers, based on silver- or nickel-plated filler particles, are commonly used where small, precise cross sections are needed. These materials are available formulated for outdoor applications requiring both environmental sealing and EMI shielding. Knitted wire mesh gaskets are often used in die-cast housings due to their ability to bite through surface oxides and contaminants. Knitted or woven conductive fabrics with soft foam cores are useful where gaps are relatively large and closure force is low. And beryllium copper (BeCu) spring fingers are typically used in door seams where shear forces are a concern.

Depending on the gasket type, installation can be accomplished with pressure sensitive adhesive (PSA) tapes, clip-on strips, friction fit into grooves, vulcanizing onto covers or plastic retainer frames, or through robotic form-in-place dispensing.

For EMI gasketing of enclosure parts, such as wireless handsets, one of the more recent applications of conductive elastomers is in automated form-in-place EMI gasketing systems. (*See Figure 2*) These robotic systems dispense conductive elastomer compounds onto metal or metallized plastic housings with exceptional accuracy and strong adhesion. Dispensing systems are programmable in three axes, compensating for uneven surfaces on injection molded plastic or cast metal housings.



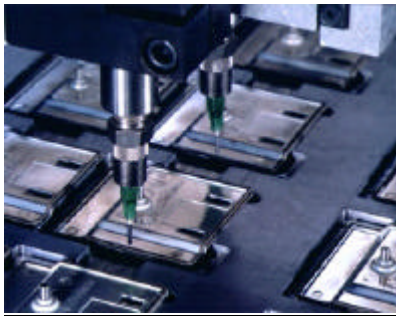
**Figure 2.** Foam-based EMI gaskets include conductive fabric, metal foil or wire mesh over soft foam cores to provide shielding under low closure forces.

The small cross sections of robotically dispensed gasket beads allow their use on flanges as narrow as 0.030 inch (0.76 mm) wide. This allows tighter package designs, providing more space for circuit board components. Form-in-place EMI gaskets can be applied with height tolerances of just  $\pm 0.004$  inch ( $\pm 0.10$  mm) onto the most common wireless housing substrates.

Hollow or solid extruded conductive elastomers are typically used along the perimeters of wireless enclosure doors, covers and panels. These gaskets can serve as both EMI and environmental seals, making them especially suited for outdoor applications. Elastomer extrusions accommodate low closure forces and many mounting

systems. Versatile conductive elastomer formulations include UL 94V-0 flammability rated and corrosion resistant materials. Certain conductive fillers can bite through thin surface oxides or chromate conversion coatings on cabinet flanges, providing better electrical contact.

For applications where cabinetry closure force is limited or large gasket deflection is required, the EMI gasket of choice is often a foam core product. (*See Figure 3*) Foam-based EMI gaskets generally feature a core made from open or closed cell urethane or thermoplastic EPDM. A conductive jacketing material surrounds the foam core. Jacket materials now in use include plated woven fabric, knitted silver-plated nylon yarn, fiberglass-reinforced foil, and knitted wire mesh.



**Figure 3.** Robotic form-in-place shielding technology dispenses conductive elastomer EMI gaskets in precise pathways on narrow or uneven package surfaces. This allows tighter package design and frees room for PCB space.

Foam core EMI gaskets are becoming as versatile as conductive elastomers. They can be formed in a wide variety of shapes, including continuous strips and intricate die-cut patterns for shielding I/O connector panels. Versions are available with UL 94V-0 flammability ratings. Foam-based gaskets are typically supplied with pressure-sensitive adhesive backing, simplifying their application. Like elastomers and metal spring fingers, they can be supplied as peel-and-stick pads for grounding applications.

Knitted wire mesh gaskets, long proven in thousands of shielding applications, continue to be adapted to wireless shielding design needs. Gaskets knitted from tin-plated steel wire provide a spring-like resilience when groove-mounted in cast metal enclosures. Today's wire mesh gaskets can deflect 80% under low closure forces, allowing the use of less expensive enclosure fastening systems.

Metal finger stock gaskets combine high levels of EMI shielding effectiveness with spring-finger wiping action and low closure properties. Typically made from beryllium copper (BeCu), these gaskets use linear serrated fingers and are available in gasket strips or in individual pieces for grounding applications. Finger stock gaskets are highly resilient and resistant to compression set. They are commonly used on base station doors where shear forces are encountered.

## **Board-Level Shielding**

For shielding at the PCB level, one of the most promising new shielding techniques uses a small metal-plated plastic shielding cover. (*See Figure 4*) The cover is mounted

over troublesome circuits directly onto one end of a PCB. It features an integral conductive elastomer mounting gasket, which deflects sufficiently to maintain a continuous low impedance path. The elastomer gasket is molded directly onto the plastic cover's nickel-copper-plated flange area.



**Figure 4.** Small plated plastic shielding covers mount directly onto PCB ground traces. Covers provide EMI isolation between circuits and prevent the escape of radiated emissions.

This board shield provides EMI isolation and prevents the escape of radiated emissions. It can also replace the use of one or more metal shielding "cans", which are typically mounted into fences that are soldered onto PCB ground traces - a system that can be both pricey and time-consuming.

Specially formulated elastomers are also being precision-molded onto thin-wall plastic spacer frames to provide grounding of circuit boards inside small wireless packages. In these applications, ground traces on a pair of cell phone boards are aligned, and the conductive elastomer gasket makes a continuous ground connection.

The choice of an EMI shielding system is greatly influenced by mechanical packaging issues. Compression-deflection properties, environmental requirements, mating surface finishes, and gasket installation methods are among the most important. As wireless devices and equipment become more densely packaged, and as operating frequencies increase, manufacturers of EMI shielding materials will continue to be challenged to develop satisfactory and low-cost new product systems.

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