EMI Shielding Technologies for Consumer Electronics Equipment

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Consumer electronics have become increasingly complex in terms of functionality and the integration of electronics. Combining analog and digital circuitry in close proximity may result in electromagnetic interference (EMI) and subsequent degradation in performance. Spurious emissions from external sources and from the device itself may have negative impact on the device or those electronics around it. This article describes specific EMI shielding needs of consumer electronics equipment, and outlines various technologies available to effectively shield and test electronic devices.

Growth of the Market
In 2005, consumer and communications electronics comprised 27% of a $375 billion U.S. electronics market, with 4% projected annual growth rate over the next five years. Personal electronics applications, such as MP3 players and satellite radios, grew around 200%. Sales of flat panel TVs are expected to surpass cathode ray tube sales by 2009. [1] Gaming consoles, cameras, video equipment, laptop computers, GPS and handheld digital devices are expected to remain in high demand. Automotive electronics are expanding their traditional role inside the passenger compartment into sophisticated engine management, braking, speed control, parking and navigation systems employed throughout the vehicle. Emerging technologies in medical electronics, inventory tracking, etc., all paint a picture of continued growth in the consumer electronics industry, and therefore continuing increased demand for effective EMI shielding solutions from systems designers.

Application Needs of the Electronics Designer
Advances in polymer design and an understanding of how to successfully incorporate conductive particles has resulted in a much wider choice of available shielding materials. This creates a dilemma. On one hand, the choice and diversity of materials means that engineers need not make as many design compromises, and can be confident that a material exists to perform the function required. On the other hand, the same extensive choice can be perplexing to designers for whom EMI shielding design and material selection are not areas of expertise.

To add further complexity, ten years ago appliances were essentially robust electrical pieces of equipment, whereas today they typically contain complex and sensitive digital and analog circuitry in a shrinking size. Couple this to a general trend of more demanding operating conditions – especially for portable appliances designed for outdoor use – and there exists a demanding set of criteria with a strong need for effective EMI shielding.

An individual appliance is likely to have several areas that require some form of EMI shielding. In order to make the
right choice of material for each, the designer needs to consider several factors, including the shielding performance required, mechanical considerations such as closure forces and tolerance build-up, whether the mating parts are dynamic or static, physical aspects (for example the material may be exposed to high shear or compressive forces), environmental concerns such as exposure to moisture and humidity, and perhaps resistance to extreme heat, including flame. [2]

Thought should also be given to the manufacturability and ease of assembly of a particular shielding solution. This is especially true for devices produced in high volume; the trend for manufacturing to move to low labor cost countries in Asia, India and Eastern Europe is a clear indicator of the importance of reducing assembly costs to appliance OEMs.

**Shielding Material Options**

The EMI shielding materials appliance designers have at their disposal can be broken into different groups as follows:

**Metal Gaskets**

All-metal EMI gaskets have been in existence the longest. They are still relevant for a large number of applications, particularly in rack mounted equipment where individual circuits may need to be periodically removed and replaced.

Beryllium copper (BeCu) fingerstock gaskets combine high levels of EMI shielding effectiveness with spring-finger wiping and low closure force properties. BeCu’s high tensile strength and superb electrical conductivity are ideal for shielding over a broad frequency range. Supplied in either standard or custom lengths for high volume applications, strips are available.
in a wide variety of cross-sections. For low compression grounding contacts, individual fingers are available with pressure sensitive adhesive (PSA) for convenient peel-and-stick application. Although the standalone electrical conductivity of fingerstock is unmatched, other factors such as the dimension and number of slots in fingerstock and surface contact area in an assembly can affect the final shielding performance. In such cases, other approaches that use conductive more compliant conductive elastomers may provide better performance.

Other metal gaskets such as PCB card cages, connector and panel shields, and knitted wire mesh exist to provide a solution for static applications that require good shielding performance without the requirement for environmental sealing.

**Molded and Extruded Elastomers**

By combining an elastomer – usually silicone – with a conductive filler such as nickel/graphite, a material is created that provides both EMI shielding and an environmental seal. These materials lead to the even dispersion of the conductive filler within the elastomer, providing uniform physical and electrical performance.

The elastomeric binder and the dispersed conductive filler can be manufactured into almost any shape using molding, extrusion or die-cutting processes. It is also possible to overmold the material onto plastic or metal components, thus providing a one-piece shielded housing that can simplify assembly of an appliance sub-assembly. Form-in-place (FIP) dispensing of elastomer provides faster cure time, low force-deflection and lower overall cost in high-production environments.

Although other elastomers are sometimes used, silicone is usually the material of choice due to its ability to compress at low closure forces and its excellent compression set performance across a wide temperature range. Designers can expect to achieve shielding effectiveness in the region of 80dB from 100MHz to 10GHz using these types of materials. Extruded conductive elastomer gaskets can be supplied in a wide range of solid and hollow cross-section configurations. With a hollow section, conductive elastomers require even lower force in order for them to be compressed, and they also have larger deflection ranges. This makes them ideal for use in applications such as appliance door sealing where it is often difficult or inconvenient to generate high closure forces and where there may be significant tolerance build-up over long lengths.
**Foam-Based Gaskets**

A more recent development in the EMI shielding market has been the emergence of wrapped foam gaskets. These materials have been developed to provide economical shielding in high volume applications. Typical uses include door, faceplate and backplane shielding/sealing. Some foam based gaskets consist of a conductive nickel-plated nylon material wrapped around and bonded to a soft urethane foam core. This type of material achieves a shielding effectiveness averaging 95dB between 20MHz and 10GHz and requires a closure force of typically less than 1 lb/in (0.175 N/mm). These ultra-low closure forces make foam-based shielding materials suitable for applications such as thin-walled plastic enclosures.

Although foam core gaskets don’t offer the same design flexibility as molded elastomer parts in terms of the shapes that can be achieved, they are available in a significant number of popular profiles such as rectangles, P, C and D-shapes plus kiss-cut parts from a sheet. Light duty PSA affixed to one side can help simplify and improve the accuracy and repeatability of assembly. Multi-planar conductive Z-axis foam EMI gaskets represent the latest innovation in soft foam based EMI shielding technology. A unique integration of electrically conductive fibers into low density foam provides the basis for a performance driven, cost effective EMI shielding solution. This material is manufactured in rolls and is easily converted into product forms applicable for I/O panels, backplanes, connectors, and access panels along with rectangular/ square strip gasket seals, providing high Z-axis conductivity with extremely short ground paths.

For many indoor consumer electronic devices that require shielding, the choice of EMI gaskets will often come down to either fingerstock or fabric-over-foam. Historically, fingerstock has been the gasket of choice, especially in high-end electronics. It is reliable, proven and widely available. However, fabric-over foam gasketing is quickly becoming the preferred choice, due to improvements in the plating adhesion, advances in foam formulations, and the introduction of UL94V-0 rated versions. These gaskets are also easier to handle and less prone to damage during assembly and use.

**Mixed Media Gaskets**

Other types of EMI gaskets are available that use a mix of the above forms. These include gaskets utilizing non-conductive foams or elastomers combined with a mesh or metal gasket and are aptly named combo gaskets. They can provide both effective environmental sealing and EMI shielding. These mixed media gaskets are usually custom made. Other gaskets in this category include silicone sheets with oriented wires and mesh impregnated with neoprene or silicone elastomer. Although these can provide excellent environmental as well as EMI shielding significant pressure must be exerted to achieve this. [3]

**Conductive Plastics**

Injection molded plastics that incorporate EMI shielding
provide an elegant, versatile and assembly-friendly solution. They can be used to provide housings for printed circuit board assemblies, and allow for value-added details such as internal compartments and integrated mechanical fasteners. With their ability to provide an economic solution for many high volume appliance applications, conductive plastics negate the need for secondary operations, reduce weight, and can cut costs by up to 50% compared to die castings, formed metal, machined extrusions and plated plastic parts.

As an example, Chomerics PREMIER™ plastic shielding materials use a blend of polycarbonate and ABS engineered for stable electrical, mechanical and physical performance. Using a proprietary process the base material is filled with long fibers of nickel plated carbon; the process ensures dense dispersion, random orientation and full engagement of the fibers to yield optimum shielding performance.

**Adhesives, Inks and Coatings**

These materials do not generally lend themselves to high volume production unless an automated application process is used to speed throughput and improve repeatability. There are numerous conductive adhesives available, and are typically used to bond other conductive materials such as EMI vents, windows, mesh gaskets, or for filling cracks and seams. Conductive coatings and inks provide EMI shielding, antistatic protection, corona shielding, and surface grounding in a wide range of applications. They can be applied to plastic surfaces by painting or for higher volumes, by using conventional spraying equipment.

**Conductive Windows**

Any barrier placed between an emitter and a susceptor that diminishes field strength of the interference is an EMI shield. Shielding requirements for display windows can vary from moderate to severe. In most applications, shielding effectiveness below 20dB is considered marginal due to long-term environmental effects on the mating surfaces of...
enclosures and shielding gaskets and barriers. Stainless steel is often used for wire mesh in optical shielded windows, combining high light transmission with high shielding. Lower mesh counts and thinner wire diameter provides higher light transmittance, while higher mesh counts and thicker wire diameter provides better EMI attenuation.

Copper as a conductive wire mesh is softer than stainless steel and is very reflective. Its advantages are high shielding and conductivity, with lower cost. Plastic using transparent conductive coated films, such as indium-tin-oxide (ITO) or multilayer conductive coatings, combines high visible light transmission, uniform electrical conductivity and excellent environmental stability. Also, there is no matrix of wires to interfere with the display as with the above meshes. However, the latter offers lower shielding and less consistent attenuation than wire mesh. [4]

Compliance Testing and Certification

Consumer electronic equipment falls under a wide range of global test standards. The primary markets driving test standards are the U.S., Canada and the European Union (EU). Other market areas can subsequently be reviewed, such as Japan, Taiwan, Australia/New Zealand, etc. For the purpose of this section, major appliances and electric tools are not considered consumer electronics.

Usually, the further along a product is in development, the more extensive/difficult/costly are the changes necessary to correct compliance issues. There are two separate critical paths for safety and EMI/EMC certification compliance programs.

For EMI/EMC, the primary test standards for consumer electronics are for Information Technology Equipment (ITE) and Audio Video Equipment. The Federal Communications Commission (FCC Part 15) and Industry Canada (ICES 003) regulate the radiated and conducted emissions for this type of equipment in the United States and Canada, respectively. In Europe, radiated and conducted emissions are regulated by EN 55022 for ITE, and by EN 55013 for Sound and Television Broadcast receivers and associated equipment.

The EU also regulates the immunity requirements for consumer electronics. Requirements for ITE fall within EN 55024. Sound and Television Broadcast receivers and associated equipment falls under the immunity requirements of EN55020. Both of these “product family standards” provide test levels and methods for immunity tests covering electrostatic discharge (ESD), radiated immunity, conducted transient immunity, conducted surge immunity, conducted RF immunity, magnetic field immunity and voltage fluctuation/dip immunity. These standards are designated as EN 61000-4-X or IEC 61000-4-X where “X” is the type of test. For example, the electrostatic discharge test is designated as EN 61000-4-2 or IEC 61000-4-2. There are a number of revisions/amendments to some of these standards. It is best to work with the test facility to determine the accurate series of test standards for your equipment.

In the EU, two other test standards exist for the control of power line harmonics and flicker. The standards for power line harmonics, EN 61000-3-2 (IEC61000-3-2), and flicker, EN 61000-3-3 IEC61000-3-3), have wide applicability and are also required for CE marking.

For EMI/EMC, the first item on the critical path is to have a test run for radiated and conducted emissions. Once a device meets these requirements, the remaining tests typically fall into place with minor issues, if any. These recommendations are for devices and/or systems which already exist. If a device is still in the design phase, it is still best to have a paper review done with regard to the same aspects.

For safety compliance, consumer electronic equipment follows the requirements of UL 60950-1 in the United States and CSA 22.2 No 60950-1 in Canada for ITE. Consumer audio/video equipment follows the requirements of UL 6500 in the United States and CSA C22.2 #1 and C22.2 No. 60065 in Canada. In Europe, EN 60950-1 (IEC 60950-1) is for ITE, and audio/video equipment follows the requirements of EN 60065 for
CE marking to the Low Voltage Directive. In all cases, the standards review a product’s electrical and mechanical safety.

The primary item for safety compliance in the critical path is to have a construction review performed on your device. This should be done by a qualified safety engineer familiar with the standards and requirements. This review should center on the materials used to build the device and the critical safety components.

**Summary**

Choosing the right gasket requires knowledge of both electrical and mechanical requirements. Shear forces, environmental effects, compression set, method of application and pricing are just some of the factors influencing choice of gasket which is best for a particular application. Materials must be both cost-effective as well as compliant with environmental regulations (RoHs, WEEE, etc.), and capable of being safely disposed of or recycled at end of life. For appliance design engineers who do not deal with EMI shielding on a day-to-day basis, the learning curve can be very steep unless they seek guidance and application support from reputable shielding material manufacturers and EMC/safety testing service providers. □

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**References**


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