Well Protected against Electromagnetic Interference

Ensure the Electromagnetic Compatibility of Wireless Devices with Special Plastics

The increasing miniaturization of electronics, in combination with the higher demand for embedded wireless connectivity features, creates challenges regarding electromagnetic compatibility (EMC) via electromagnetic susceptibility (EMS) and generated electromagnetic interference (EMI). Thermoplastic compounds with integrated electrical conductivity offer a potential solution to resolve EMI, EMS and electrostatic discharge challenges. These thermoplastic materials can deliver the appropriate level of electromagnetic shielding for electronics, while providing freedom to design complex geometries and opportunities to streamline processing by avoiding secondary operations.

Connected devices, whether for the healthcare, automotive, telecommunications or consumer electronics market, can experience interference with the main content stream of the radio signals produced. This interference, which can potentially adversely affect device performance, is the phenomenon known as EMI or RFI (radio frequency interference). It is the tendency of electronic devices that are located in close proximity to affect each other's operation in negative ways, such as by creating signal noise.

Complex Problem Definition

Electromagnetic interference has been a challenge in radio-based communications since the work of Guglielmo Marconi approximately 150 years ago, and remains an issue for electronics, packaging and compliance engineers to this day. A principal area of concern – and the focus of this article – is EMI caused by non-ionizing radiation. Standards and testing for EMC ensure that electrical devices are able to operate safely in close proximity with a minimum level of RFI.

Faraday Cage for Sensitive Components

One solution to managing EMI is shielding, which can isolate the devices from their surroundings and from the signals of other devices. In simple terms, shielding involves creating a form of Faraday cage around sensitive components within the device, usually using a metal encasement or similar solution.

However, shielding can be a complex issue to solve, as the majority of connected devices interact directly with wireless infrastructure or indirectly via a consumer device, for example, a smartphone. They rely on a range of radio frequency (RF) bands with differing levels of signal power levels and operate in a range of communication modes. These include short-range wireless communication technologies such as Near-Field Communications (NFC), Bluetooth (BT), WiFi (WLAN), ZigBee and their low-power version of these wireless communication

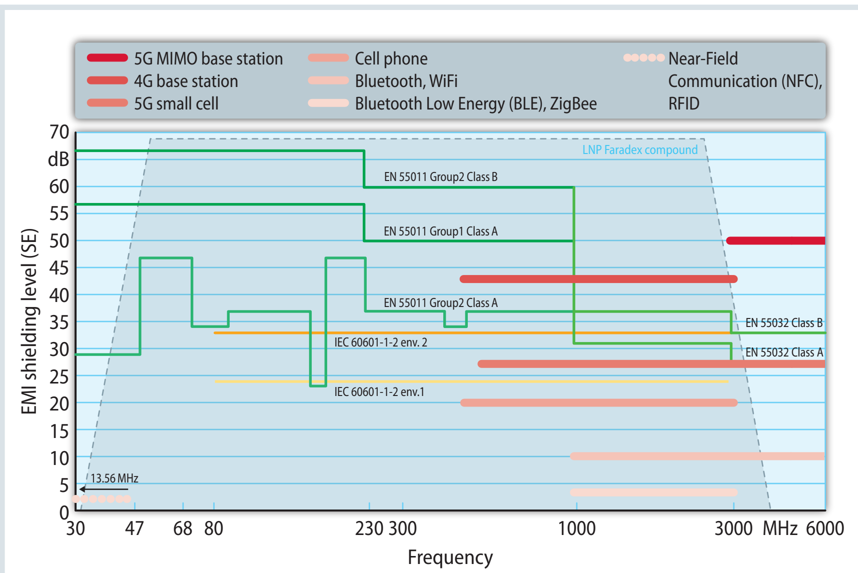

Fig. 1. EMC-radiated emissions limits in terms of shielding effectiveness in dB based on EN 55011:2016, EN 55032:2015 and IEC EN 60601–1–2:2015 with examples of wireless technologies radiating RF power levels. Range of LNP Faradex compound shielding effectiveness is highlighted Source: Sabic; graphic: © Hanser

protocols from ISM (Industrial Scientific and Medical) and SRD (Short Range Devices) license free bands. All create a need for shielding against EMI. **Table 1** identifies the power performance for common wireless devices.

In general, RFI becomes significant at frequencies above 30 MHz, with typical levels of radiated emissions in units of electric field strength. Consumer electronics and healthcare-related EMC standards classify corresponding devices in a number of categories, according to their intended use environment. They also define immunity levels and limits to radiated RFI across a wide frequency range. **Figure 1** summarizes some of these limits in comparison with the radiated power levels of certain wireless technologies.

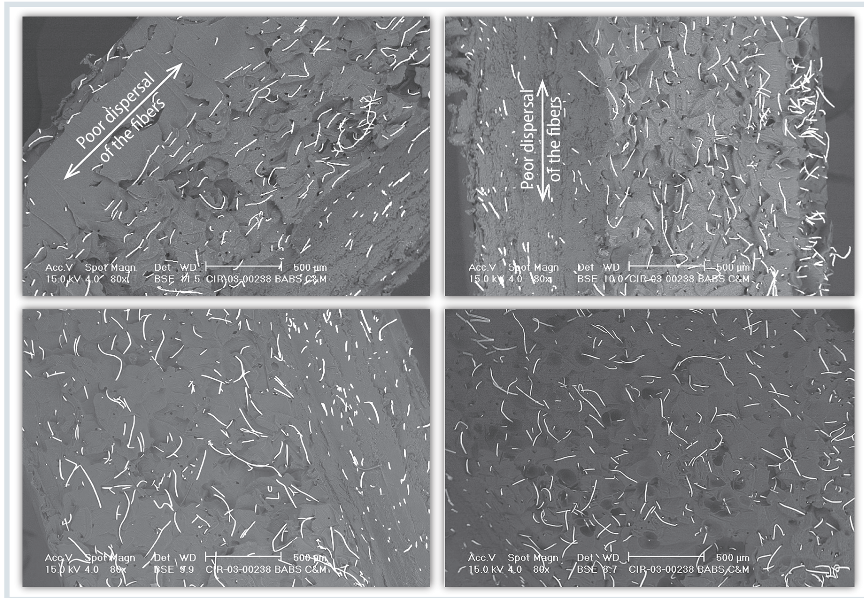

Fig. 2. SEM analysis illustrates inferior dispersal (above) and good dispersion (bottom) of conductive fibers in molded polycarbonate parts. The distribution can be optimized by appropriate processing parameters and injection molding machines (PC resin) © Sabic

Light-Weighting Alternatives to Aluminum

Shielding effectiveness (SE) indicates the capacity of the material to act as a shield against internal or external EMI, thereby providing protection by cancelling the electric field that the device is exposed to or is generating. It is determined by the material's overall conductivity level, wall thickness and target frequency range.

Conventional approaches to providing EMI shielding have relied on metal enclosures, usually using aluminum alloys; this method currently accounts for more than half the market. However, increasing miniaturization and the growing engineering complexity of connected devices, along with the demand to make them lighter and less intrusive, are posing challenges and highlighting design limits. Weight becomes a greater consideration, with even the lightest aluminum alloys likely to be unsuitable – not to mention costly. In addition, the increasing complexity and sensitivity of these devices, combined with reductions in design space, could render them more susceptible to interference. Therefore, other solutions are needed to meet these evolving demands.

Some manufacturers have explored alternative approaches for providing shielding, such as metal coatings, vacuum metallization and conductive paints on plastic enclosures. While these methods can be effective, they are less so than metal enclosures and rely on secondary processes following initial production. These steps add system cost and complexity and increase the overall environmental footprint of the products. In addition, not all thermoplastics may be suitable for such secondary treatments.

Inherent EMI Shielding

A viable solution, therefore, is to use a polymer that can provide EMI shielding as an integral and inherent property of the resin. This provides a high degree of shielding and, by reducing the need to accommodate secondary treatments, allows greater flexibility in design. LNP Faradex compounds, developed by Sabic's Specialties business, Riyadh, Saudi Arabia, provide EMI shielding performance as an embedded, intrinsic property of the resin and the molded part.

The optimal dispersion of conductive fiber in the molded part is critical to achieving maximum shielding performance. Sabic has conducted extensive molding studies to optimize fiber dispersion by selecting appropriate injection molding conditions. Equipment best practices include using a general-purpose screw with a compression ratio at a maximum of 2.5:1 and a "free flow" screw tip to reduce fiber breakage. Mixing screws should not be used. A shot size between 40 % and 70 % of barrel capacity and a slow-to-medium injection speed to minimize shear and fiber breakage are recommended. During recovery, back pressure should be less than or equal to 344 kPa and low screw rotation should typically fall between 30 and 60 rpm. Higher melt temperatures can minimize viscosity while optimizing fiber attrition and improving surface finish.

Adequate Injection Molding Technology

Regarding mold design, sprue bushings and full round tool runner systems with generous dimensions and no sharp corners are recommended, as well as the use of a minimum 1.8 mm gate openings. Hot runner systems can be used, but torpedo-shaped hot runners can cause high fiber attrition. A hardened tool steel, like 1.2344/1.2738, or H13, is recommended. Note that Sabic has observed minimal effect on tool wear from the stainless-steel fibers in LNP Faradex compounds.

The benefits of the recommended finishing features and processing parameters can be clearly seen in **Figure 2** using a polymer-solid molded part made of a polycarbonate compound. The upper SEM images show poor dispersal of the fibers in the gate area and at the end of the flow path. In the lower SEMs, the optimized fiber vs. resin concentration can be seen after practical application of the test results to maximize the Faraday cage effect.

Weight Savings and Greater Freedom of Design

As well as simplifying the process of providing shielding, LNP Faradex compounds can offer other important benefits, as summarized in **Figure 3**. Because they do not require secondary processes, these materials offer manufacturers considerably wider design freedom. For example, wireless medical devices can be manufactured using more-complex 3D shapes, offering greater comfort and convenience for patients. These attributes allow further downsizing of electronics components and can increase the level of circuitry integration (e.g. scanning wireless camera embedded in a pill for digesting system check), making them suitable for instance in size and shape for certain sensitive applications while still enabling wireless data transfer for monitoring. The performance properties of LNP Faradex compounds may also help to improve device development efficiency by enabling the design freedom associated with the use of plastics vs. other materials. Additionally, these compounds provide the opportunity to reduce both the weight of the final device and its assembly costs.

Faradex compounds deliver the right balance of EMI shielding and mechanical, thermal and fire-retardant properties (direct flame/heat exposure per NFPA 1901–12, 1.7) to address customer needs and eliminate costly and time-consuming processes required by other materials in order to meet EMC requirements (CE/EN 50081–2:1992, EN 50082–2, FCC Part 15, etc.).

As part of its portfolio, Sabic also offers a biocompatible grade, LNP Faradex NS003XXW compound, which is pre-assessed according to ISO 10933 and may be used for certain healthcare applications. The demand for connected devices in multiple sectors is expected to grow rapidly for the foreseeable future, driven by trends such as the growth of the Internet of Things, the drive toward fully electric autonomous vehicles, and efforts to reduce healthcare costs through greater use of outpatient and home care. In such a dynamic environment, a biocompatible plastic with inherent EMI shielding properties can provide device manufacturers with a cost-effective material solution. ■

Table 1. Typical RF power performance for common wireless devices expected to interfere with healthcare environments Source: Sabic

Bulk shielding method	Weight reduction	Relative costs	Schielding effective-ness	Recycl-ability	Waste generation	Design flexibility
Conductive compounds LNP Faradex compounds	●	▲	▲	▲	●	●
Plating methods	●	■	▲	■	■	▲
Conductive spray coats	●	▲	▲	■	▲	▲
Metalization	●	■	▲	■	▲	▲
Metal enclosures	■	●	●	●	●	■

● Positive ▲ Moderate ■ Negative

Fig. 3. Comparison of key features for the different shielding methods and materials © Sabic

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