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ENSURING COMPONENT RELIABILITY: EMI PROTECTION AND THE AUTOMOTIVE INDUSTRY

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Today's cars are incorporating more and more electronics into vehicles, from engine control units to anti-collision controls to driver information to entertainment systems that enhance the overall driving experience with Bluetooth, GPS, and Wi-Fi. With these demands for comfort and safety come more headaches for design engineers. The failure of a $30,000 to $40,000 car due to a part or component is unacceptable, especially when that failure could result in injury or even death.

Component reliability is an important factor that cannot be glossed over. It is easy to understand that the more complex the system, the harder improved reliability is to achieve. However, cost considerations are also important to carmakers. When using components by the millions, a few pennies can make a considerable difference to bottom-line profit. Therefore, suppliers of specialized shielding products are being relied upon to lend their expertise to car manufacturers.

Obtaining increased reliability means designing properly for the intended harsh environment. Better known environmental issues include extreme temperatures, vibration, shock, humidity, salt-fog, and corrosive solvents/atmosphere. The typical automotive temperature range is from -40°F to 257°F. Vibration requirements can be up to 3 g's and shock levels up to 20 g's. These can be even higher if a component is mounted directly onto the engine block. One aspect of the environment that is not mentioned very often is the concern of electromagnetic interference (EMI). With the increased utilization of electronic systems, EMI is becoming a more important aspect of vehicle design (Fig. 1).

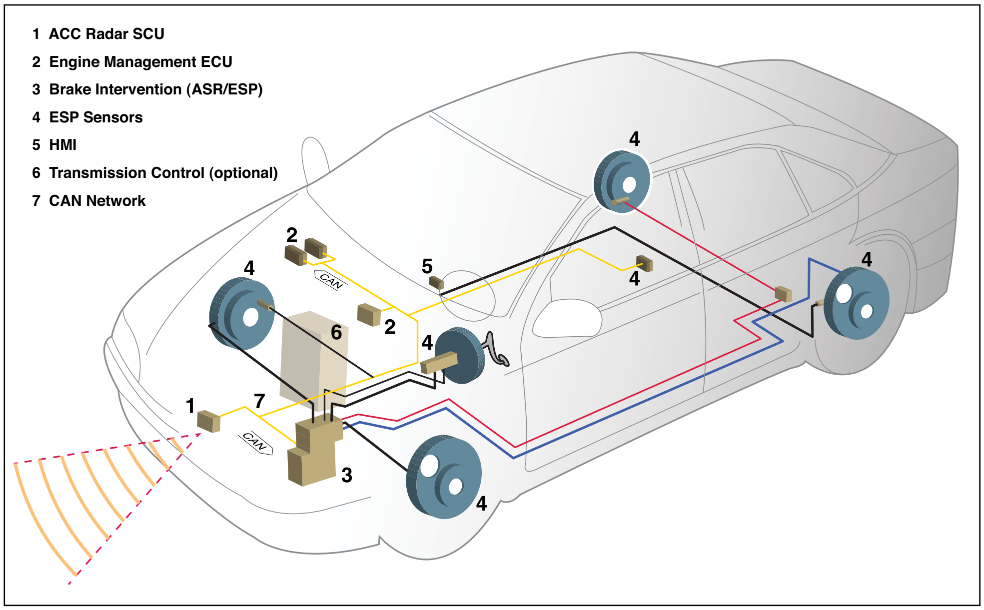

Figure 1: *Overview of EMI-sensitive automotive systems.*

Vehicle EMI Environments

Electromagnetic noise emission and immunity issues can range from simple annoyance such as static noise in radio reception to as severe as the loss of anti-skid braking capability. EMI is generated by each system and can cause disruption to the operation of nearby or other interconnected systems. The major source of most EMI is an embedded microprocessor and its digital circuitry with fast risetime signals. Emission levels are normally measured at a 1-meter distance. Therefore, emission levels as seen by closely spaced units (i.e., only centimeters apart) could be even higher than indicated by the measurement data. In turn, such unintentional radiators as interconnecting cables, wires, and printed circuit boards radiate these frequencies. However, just as big a concern is interference or immunity due to externally generated EMI such as cellphone towers or overhead high-voltage power lines. Another source of EMI is the vehicle's electrical system—various relays, solenoids, ignition system, voltage sags from engine starting, inductive load kickbacks, and alternator load dump.

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Radiated source levels can range from a few volts per meter to as high as several hundreds of volts per meter. This is the reason why many car manufacturers specify a 200 v/m radiated immunity level (the typical radiated immunity level of many commercial electronics systems is only about 3 v/m). This increased amount of protection is usually required to allow most electronics systems to operate in harsh automotive environments.

ESD (electrostatic discharge) is yet another source of EMI. The human driver and their interaction with a car's interior generate ESD. The ESD event can cause electromagnetic field radiation that can couple into nearby electronics, or the energy can be directly conducted into a component causing damage. ESD levels as high as 15 kV are not out of the ordinary.

Figure 2: *Designed around today's most challenging EMI shielding applications, board level shielding (BLS) from Orbel is available in one-piece, two-piece, multi-cavity, and custom configurations.*

EMI Protection Design Techniques

All of the EMI issues discussed above have preferred protection techniques depending on the particular system and its design, and the type of noise source. Many times more than one technique must be used to provide the required amount of EMI protection. These techniques can be implemented at one or more design levels as well. The various levels are the IC level, printed circuit board level, module or enclosure level, and interconnect level:

IC Level: The IC is generally the source of most noise, so it makes sense to want to "attack" the problem at this level. However, waiting for the chip manufacturer to respond is not very practical in spite of many vendors attempting to quiet their device. In contrast, to obtain better performance, designers tend toward faster clocks and faster risetimes. Chip manufacturers are incorporating spread-spectrum clock techniques, adding ground planes, and using internal decoupling capacitors at the chip level to improve the EMI aspect of the chip. Otherwise, the use of board level shielding (BLS) (Fig. 2) is necessary as discussed below.

Printed Circuit Board Level: Techniques involve partitioning, board stackup, use of isolating vias, and routing. Other techniques that involve some added component costs include high frequency grounding of the board, filtering techniques, absorbers, and use of BLS to isolate the noisy components. If BLS is designed-in at the design stage, minimal impact to schedule and cost can be accomplished.

Proper technique starts as early as component placement. Critical circuits (i.e., clock circuits, clock drivers, etc.) and functions should be grouped together that result in the shortest trace lengths between components. Consider the use of multilayer boards with the use of many ground planes. Design high-speed traces as transmission lines. Make use of proper and adequate filtering and decoupling components. Add placements for filtering components, but place jumpers or "zero-ohm resistors" to hold their place and add the real components only if testing show their need.

Module or Enclosure Level: Use of a shielded box or enclosure is considered by many to be a very expensive technique. Presently, conductive plastics or paint or plating are the typical approaches to shielding at the enclosure level that are somewhat expensive. However, with today's newer shielding products, this need not be the case. Use of board level shields, conductive fabrics (Fig. 3), finger-stock gaskets (Fig. 4), and thermoformed plastics are some examples. For many occasions, the use of a shielded enclosure

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Figure 3: *Ideal for the control of EMI, conductive fabric gaskets from Orbel are manufactured from a polyurethane foam core and wrapped with nickel-plated copper-conductive fabric.*

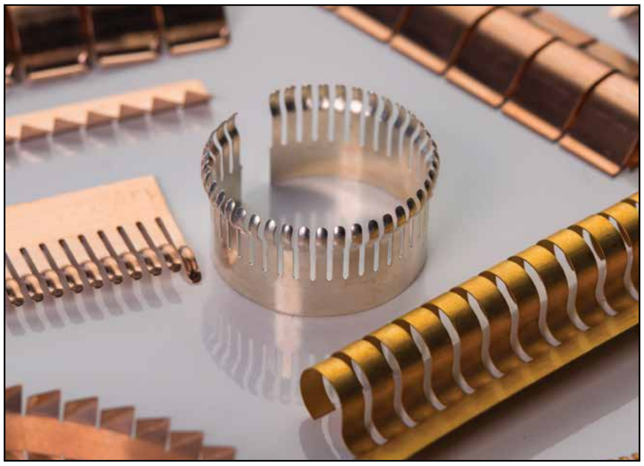

Figure 4: *High-performance finger-stock gaskets from Orbel deliver the industry's highest EMI shielding effectiveness and are available in a variety of materials.*

may be the only viable solution for certain types of EMI problems. However, it is not the shielding material that usually decides the amount of useful shielding. Sheet metal can provide well over several hundreds of dB attenuation as even thin layers of conductive paint or plating (i.e., up to 60 dB), but it is the leakages from openings (i.e., seams) and other holes or apertures that really determine the final shielding effectiveness. So, the use of gasketing becomes important. The consideration for the proper selection of what type of gasket is dependent on the environment. If environmental sealing is required, use of an electrically conductive gasket or EcE should be used. If corrosion to atmosphere or solvents is a concern, then the type of elastomer used can be a concern. Here, silicon and neoprene are examples of materials available.

Interconnect Level: Cables are particularly vulnerable when it comes to weight and cost issues. Cables are probably the next source of electromagnetic radiation after the circuit board. However, adding shielding to the possible hundreds of feet of wire harnesses in a vehicle is a huge weight penalty and cost factor. Use of filter connectors can be used to solve the problem, but then these too are expensive. The use of clamp-on ferrites is also costly and includes a weight factor as well as shock and vibration issues. If filtering is required, the best approach is to add filter components at the board I/O interface. For very high frequencies, the use of absorber cable covers may also be an option.

About Orbel Corporation

Since 1961, Orbel's custom design and manufacturing process has enabled unique engineered solutions for a variety of applications and industries. From conception through delivery, Orbel offers today's most effective EMI/RFI shielding, photo-etched precision metal parts, precision metal stampings, and electroplated metal foils. Areas of specialization include aerospace, telecommunications, electronics, microwave/RF, medical, automotive, and manufacturing. For more information, visit **Orbel.com** or call **610-829-5000**.