Avoiding the Perils of Electromagnetic Interference

Identifying EMI early in development helps prevent future risk and related high costs after products are shipped and in use.

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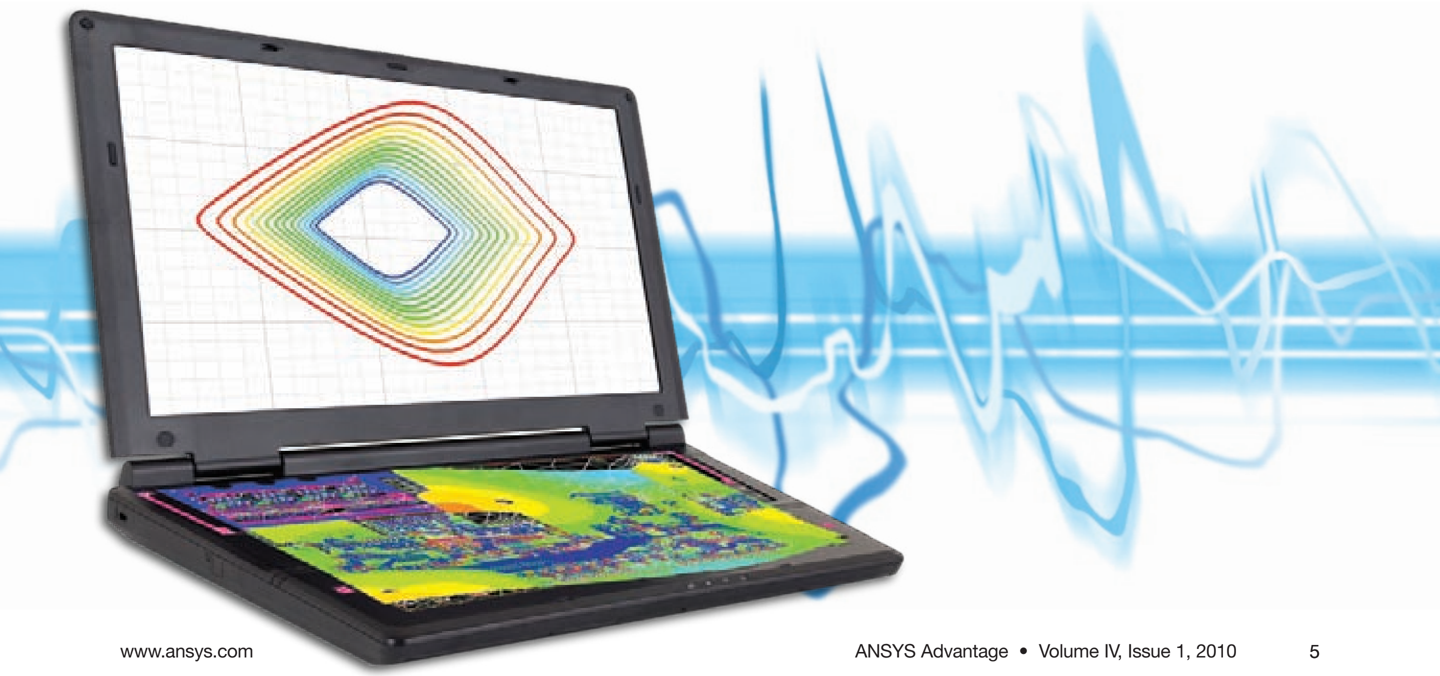
Super-phones, GPS systems, e-readers, pocket-size computers and other electronics-based products unheard of years ago are now commonplace. Furthermore, traditionally all-mechanical products such as cars, planes, home appliances and machine tools now have increasing levels of electronic circuitry. Automobiles in particular have been described as "computers on wheels" because so many functions depend on electronics, including diagnostics, engine control, braking and stability systems. The market for these electronics-based end products is huge, with electronics industry revenue estimated to be $1.8 trillion in 2009.

The business driver for this proliferation of electronics into such a broad range of applications is the success and widespread use of semiconductors. These materials enable products to have greater and greater levels of complex and highly customizable functionality at an affordable cost in smaller and smaller packages. In particular, embedded intelligence in electronics has allowed manufacturers to pack unprecedented levels of features and functions into products, to penetrate new markets with innovative products, and to create unique classes of products that once were unimaginable without today's advanced intelligent electronics.

But there is a catch. Designing this expanding range of smart products requires careful consideration of fairly complex electromagnetic field effects to avoid major problems in high-speed data channels. Multifunction cell phones, Wi-Fi-enabled laptops and other transmitting devices can interfere with surrounding equipment if the flurry of traffic on these data superhighways is too strong or too crowded in a narrow frequency range.

Moreover, unintended electromagnetic interference (EMI) from high levels of data being switched at very fast speeds in these electronic products has the potential to cause malfunctions within the device as well as in surrounding equipment. Interference with signals on high-speed data channels in these products can cause all manner of problems, from nuisances such as background noise on wireless phones to potentially disastrous signal anomalies in critical control circuitry in cars, planes and medical equipment, for example.



So widespread and potentially damaging are the effects of EMI that electronics-based products must meet increasingly strict government, international and industry electromagnetic compatibility (EMC) standards. Failure to comply with these regulations carries stiff penalties and may result in products being banned in certain countries or being at the center of government investigations, so manufacturers understandably are always concerned that their products meet these standards. Determining EMC/EMI is not usually a straightforward calculation, however, in large part because of the transient nature of electromagnetic emissions, which can depend on interdependent electrical, mechanical and thermal factors.

Optimizing a design and ensuring that emissions do not exceed permissible thresholds are difficult multidisciplinary engineering challenges involving considerable trade-offs. In developing a high-end computer server, for example, the design team must decide on air vent placement by balancing thermal and EMC effects, since the air vent can improve air circulation but also provide an escape path for electromagnetic waves. Likewise, heat sinks can increase heat transfer from chips into the air, but they will also increase product weight, size and electromagnetic emissions, because heat sinks behave like internal antennas. Likewise, fans increase air circulation but also heighten electromagnetic background noise.

Predicting electromagnetic emission levels without the use of simulation is extremely difficult due to the complexity of the large numbers of internal and external signals impacting the electronics device or system. Without simulation, calculations are done using gross approximations and oversimplifications that can lead to incorrect results. Such results become evident only when compared to tests on the actual hardware prototypes, performed late in the design cycle. At this point, several build–test–redesign iterations usually must be performed before emission levels are lowered sufficiently. During this late development stage, design changes become extremely expensive, and delays can lead to revenue losses. As the windows of opportunity close, competitors win the race to get products to market first.

Worse yet, companies may totally neglect to perform sufficient levels of electromagnetic simulation during development, instead using the technology as a forensic tool in analyzing the causes of malfunctioning products after they are built, shipped, sold and in use by customers. In these cases, costs can become gigantic for warranty modifications, product recalls, lawsuits, damaged brand value and unfavorable publicity that can haunt a company for years. Costs measured in the billions of dollars can occur. No firm with electronics-based products is immune — no matter how large it is, how long it has been in business, or how favorable its image in the eye of the public.

One of the most effective ways of avoiding such preventable calamities is to use electromagnetic emission and signal propagation tools up front in development before hardware is built. In these early stages, engineers have time to analyze potential problems, evaluate alternative designs, and make changes relatively inexpensively and in a timely manner. Moreover, engineering simulation tools that account for electrical, thermal, mechanical, magnetic and fluid effects can be used in parallel to optimize product performance in light of these various interrelated physics while ensuring that applicable EMC standards are met.

Using an integrated suite of such tools, engineers can accurately predict EMC/EMI levels as well as trace any problem back to the physical layout of the device. Then key parameters in the models can be changed and the designs studied in a series of simulations performed until electromagnetic emissions are within acceptable limits. Using such a process, engineers can explore what-if scenarios and arrive at an optimized design. The article “Simulation-Driven Design for Hybrid and Electric Vehicles” in this issue describes such technologies and how they can be applied in identifying and correcting EMC/EMI problems early in design.

In this way, companies can utilize electromagnetic simulation in saving time and money over prototype testing and, perhaps most important, in avoiding the massive perils of electromagnetic emission problems surfacing in products already in use. Indeed, the return on investment for using simulation technology in such a front-end approach is huge. The alternative is certainly a risk not worth taking when the benefits of Simulation Driven Product Development have been so clearly demonstrated at companies with the good sense and foresight to leverage such a well-proven technology in the design cycle. ■