SWITCHING MADE EASY

Simulation of thermal, electromagnetic, and capacitive sensor performance plays a pivotal role in product development at KOSTAL which supplies all of the world's leading automobile companies with interior switching modules

By **JENNIFER HAND**

FIGURE 1: A typical premium car line roof module with LED illumination.

"MY NONTECHNICAL friends are astonished at the amount of technology in a seemingly simple product," says Matthias Richwin, senior manager for technology development and quality using simulation at KOSTAL. "They are equally intrigued by the fact that behind every switch in their cars there is a multidisciplinary team of engineers."

Richwin's friends are not unusual. There are drivers everywhere who turn on their headlights or windshield wipers with no awareness of the development effort behind a switch. Yet from freezing winter to sweltering summer, on dull rainy days and in bright sunshine, switches are expected to function consistently for the lifetime of a car.

» SIX DECADES OF ELECTRICAL SWITCHING

CONSIDERATIONS OF STYLE, safety, space saving, and user convenience have been the drivers for 60 years of innovation at the Automotive Electrical Systems division of KOSTAL Group. Since the early days, when the company placed indicator switches by the steering wheel and created integrated-function push buttons, it has registered a wide range of patents. Core product areas include steering wheel column, center console, and roof module systems. Customers include BMW, Daimler, Ford, and the Volkswagen Group.

Richwin explains how simulation became an intrinsic part of the design process at KOSTAL: "We have some specialist tools, such as FEA software for mechanical design, but were increasingly in need of thermal simulation and anticipated a requirement for electromagnetic simulation, so I began to investigate the options. We selected COMSOL Multiphysics because it had by far the best user interface and offered integration with the CAD, electrical design, and manufacturing applications we use. In 2009, we began using the software for the thermal simulation of roof modules." Simulation is now so embedded in new product development at KOSTAL that it is simply considered a common design task and is considered to be key in three areas.

» LIGHTING EFFICIENCY VERSUS HEAT DISSIPATION

THE LIGHTING INSIDE today's cars is complex and highly integrated and has moved far beyond the courtesy light that comes on when a door is opened. The roof module (see Figure 1) in a premium car is likely to house antitheft and satellite navigation systems as well as extras such as ambient lighting.

From left to right: Daniel Klagges, Ingolf Münster and Matthias Richwin.

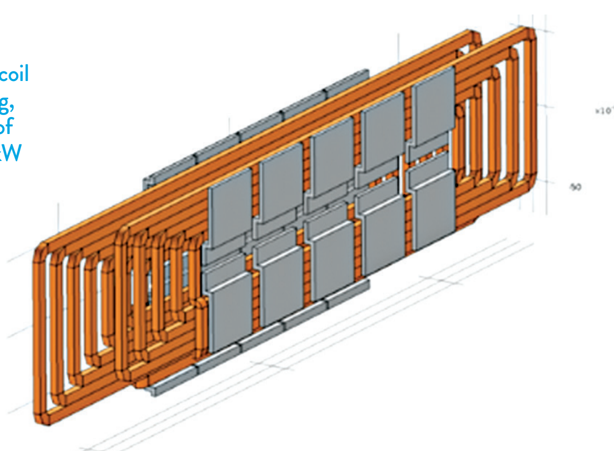

FIGURE 2:
A numerically optimized coil pair for inductive charging, with a system efficiency of approximately 95% at 3 kW of electrical power.

"The industry has moved away from the classic bulb to LED displays," says Richwin. "Although LEDs are much more efficient because they require less power, 90 percent of the heat they dissipate goes into the printed circuit board (PCB) of the roof module. We tackle this particular challenge by using COMSOL Multiphysics to predict thermal behavior and optimize performance. Whereas we previously had to build and test, we can now easily predict performance and, for example, show a customer that a roof module will work at optimal brightness over the whole environmental range."

» BATTERY CHARGING THAT'S CLEAN, CONVENIENT, AND AUTOMATIC

ONE OF THE disadvantages of an electric car is the need to charge it regularly; and as charging typically takes 6 to 7 hours, forgetting to do it one day may mean being stuck without transport the next. The team at KOSTAL therefore expanded on the electric toothbrush concept. Richwin explains: "The idea is to charge a car not by using a cable but by moving it to a charging system. As with a toothbrush and its covered charging base, there are no contacts."

This idea scores on every level—for security, safety, and comfort the driver just parks the car in the same spot every day or night, with no need to even think about handling and plugging in a cable. "We worked on the basis that if a transformer is cut in two and the two halves are moved apart, it would still perform through inductive power transfer, albeit with less efficiency," comments Richwin. "Our task was to optimize the coil in each side so that the end product would be as effective as a cable-based system. We used COMSOL Multiphysics for the electromagnetic simulation (see Figure 2) of different options such as a ground plate partnered with a coil on the underside of the car and a mounting on the wall partnered with a coil placed behind the number plate. It simply would not have been possible to develop this type of product without simulation."

» SMARTPHONE EXPECTATIONS

RICHWIN CITES ANOTHER industry trend—minimizing the use of mechanical switches, as these are both complicated and vulnerable to fluid entry. At the same time, customers used to smartphones and tablets now expect similar touchpad-style sensors in a

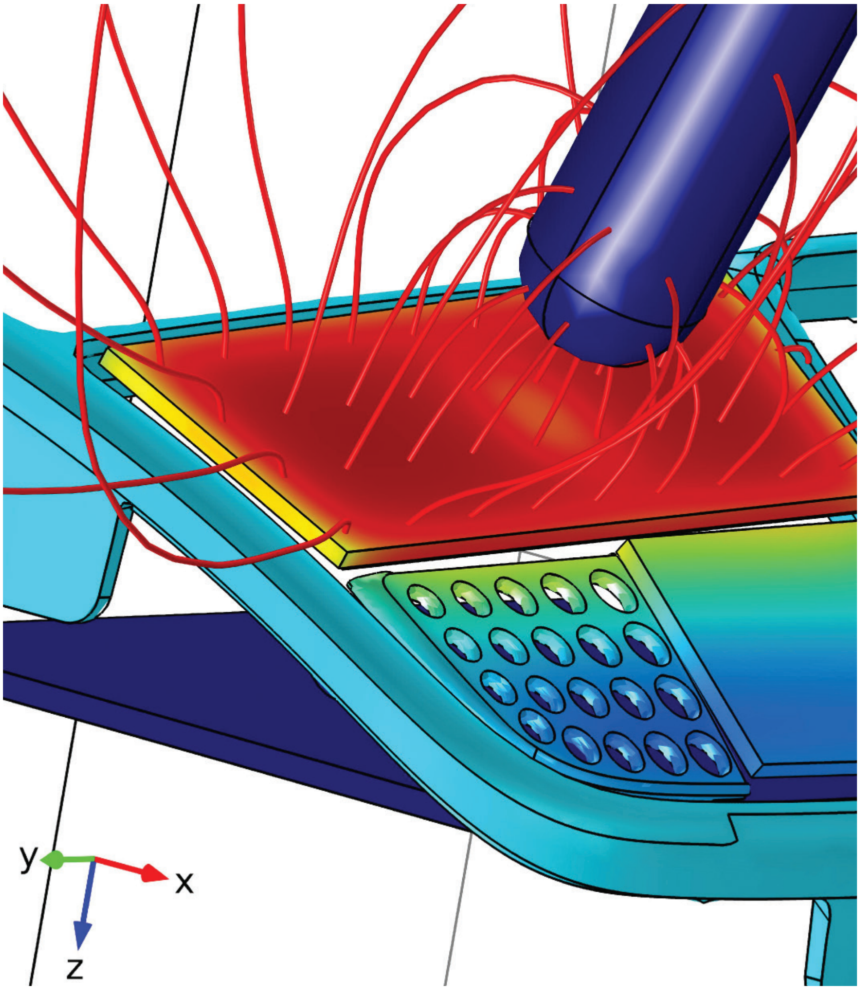

FIGURE 3: Modeling the electrostatic properties of a capacitive sensor system with a finger dummy.

car. The transfer of this technology into cars is, however, not straightforward. Interaction with a smartphone is strongly visual; the user must look at a screen. In a car, though, there must be nothing that distracts the driver from driving, so user feedback has to be nonvisual. In addition, the environment of a car is complex because its interior is densely packed with driver interface functions. Extremes of temperature, moisture, and dust according to location and climate pose further demands on components.

According to Richwin, capacitive sensors present various challenges: "We have to consider the potential for many different sizes of fingers and thumb pads and the presence of additional material, such as a glove or hand cream. Then we have to decide on the level of sensitivity: whether we want proximity, whereby a finger has not yet touched a surface but is within a few centimeters; actual touch; or a combination, in which the sensor first detects the approach of a finger and then registers the touch."

> *"It is in innovative areas such as inductive power transfer and capacitive sensor design that simulation becomes truly indispensible because the alternatives are impossibly expensive or time consuming."*
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> **—MATTHIAS RICHWIN, SENIOR MANAGER, TECHNOLOGY DEVELOPMENT & QUALITY—SIMULATION AT KOSTAL**

The general aim is to make the sensor covering as thin as possible, which means that the team is looking for reliable and predictable performance from a plastic surface that is just 1 millimeter thick. Simulation is used to maximize sensitivity by optimizing the dimensions of the sensor, which lies on the PCB (see Figure 3). KOSTAL Group is also developing new surface materials, for example, premanufactured plastic foil on which the conductive structure could be printed to allow more flexibility and increase reliability.

» *SIMULATION SPURS INNOVATION*

RICHWIN SAYS, "The use of COMSOL Multiphysics enables us to check the feasibility of a technical concept very quickly, then optimize the quality, robustness, and cost of a product in development. We also save money by reducing the number of physical prototypes. However, it is in innovative areas such as inductive power transfer and capacitive sensor design that simulation becomes truly indispensible, because the alternatives are impossibly expensive or time-consuming." ◎