HEXAGON

Case study

Marquardt

Acoustic simulation of automotive switches

Marquardt has worked together with Hexagon's acoustic experts to analyse the acoustic performance of an automotive switch with the help of acoustic simulation. The simulations allowed Marquardt engineers to gain valuable insight on how the switch sounds and lays the groundwork for wider adoption of acoustic simulation within Marquardt.

Switches are everywhere in our daily lives. From turning on an oven to starting a car, switches are the way to activate and deactivate devices. Besides being reliable and durable, the look and feel a switch has and the sound it makes when pressed or turned contribute heavily to the product being considered premium and so designers pay close attention to how the switch behaves mechanically when activated. Increasingly, the sound a switch makes has become important and companies are striving to create switches that make sounds that are pleasant, satisfying and consistent with their sonic brand.

Marquardt, a family-run company founded in 1925 and based in Rietheim-Weilheim, Germany, is one of the world's leading manufacturers of electromechanical and electronic switches and switching systems. The products of the mechatronics expert are used by many well-known customers in the automotive industry and include operating components, vehicle access, driver authorization systems and battery management systems. The company's systems are also used in household appliances, industrial applications and power tools. Marquardt Group employs approximately 10,200 members of staff worldwide at 21 locations in four continents. The company generated 1.3 billion euros sales revenue in the fiscal year 2021. Each year, Marquardt invests around ten percent of its revenues in research & development.

Challenge

Marquardt's design process for switching components comprises typically of three phases: early design and concept validation, early prototyping for design verification and production-ready components. Marquardt has been using simulation for many years as part of the concept validation and design verification parts of the design process to ensure the highest quality with reasonable costs. As Michael Stiefel, Functional Lead for CAE Mechanics notes, "we need to do the digital validation prior to having physical samples to be able to steer the design into the right direction while everything is still existing virtually, as testing loops and engineering changes can become costly."

Figure 1. A Marquardt automotive switch

> **"As automotive OEMs pay more and more attention to acoustics, the acoustic development of switching components is getting increasingly important. How do they sound and how do they feel? What kind of click or not click do they produce?"**
>
> **Michael Stiefel,**
> Functional Lead for CAE Mechanics

Acoustics is a new capability that the mechanical development department seeks to investigate and for this reason they turned to Hexagon for help to understand what can be simulated reliably, how fast and what kind of design measures can be validated with simulation. A tact switch box geometry was used to validate the process with the idea being of creating a physical counterpart. The main objective of the study was to understand better sound propagation and what can be modified to achieve the required result. "We need to understand, what geometry changes do change the sound pressure level over the required frequency range? How is the sound changing if we modify structure components, interface contact point, materials or damping components? And then we need to understand how to effectively modify things, which is something that would be very possible with Actran", notes Mr. Stiefel.

Simulating the switch box and getting insight

The switch box is simulated in semi-free-field conditions, with the box comprising of a plastic part and a PCB. Since the frequency range of interest is between 100 and 15000 Hz in third octave bands, automated adaptive meshing is used to generate appropriate meshes for the various frequency bands. This results in huge savings in computational time with minimal user intervention. The excitation is a force with an amplitude based on a ramp function that has been transformed to the frequency domain via a Fourier transform. The results are then provided in the form of frequency response functions in third octave bands, maps to visualise the sound propagation, directivity plots and sound files so that engineers and designers can hear the sound of the product without having to build a physical prototype.

Regarding the post-processing information that Actran was able to provide, Mr. Stiefel notes “Sound directivity was something that we didn’t have in mind, but now it definitely will play a role in our design choices. Regarding auralisation, most people do not pay attention to charts because the correlation between such a graph and an actual sound is very difficult for a human being. So, the sound files that were provided were really helpful to compare with measurements and in the end, really close to what we actually had in reality”.

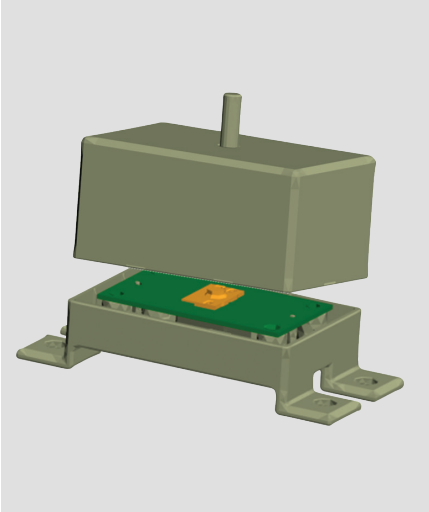

Figure 2. Model of a switch box

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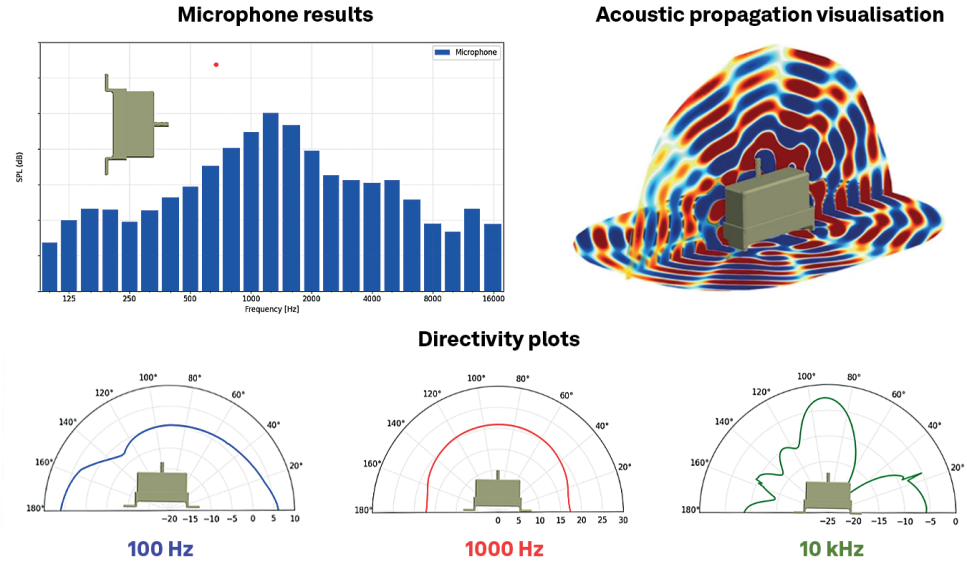

Figure 3. Results of the switch study. Frequency response function at the microphone (top left), map of the acoustic propagation (top right), directivity plots at various frequencies (bottom).

Marquardt’s engineers worked closely together with the Hexagon team in order to provide results of the simulation that would help guide them through this new process. Mr. Stiefel comments: “The collaboration between our and the Hexagon team was very efficient with fast response times. We had very beneficial discussions on a technical level where the Hexagon team would immediately help us and improve what we had as an expectation, if we had certain expectations that wouldn’t be true. As a result, we reached the target we were hoping for and it was all done in time.”

Future steps

The project for analysing and measuring this switch has been completed successfully, with the team gaining valuable insight that they plan to integrate in future projects. For this to happen, the team has to lay the groundwork to ensure that the right resources are in place. Mr. Stiefel comments: “We hope that in the future we can work on acoustic topics even better and with greater detail and then apply what we learned out of this initial project in in terms of design changes, force changes, material changes, but also in terms of things we could do with this particular simulation with Actran.”

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Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

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