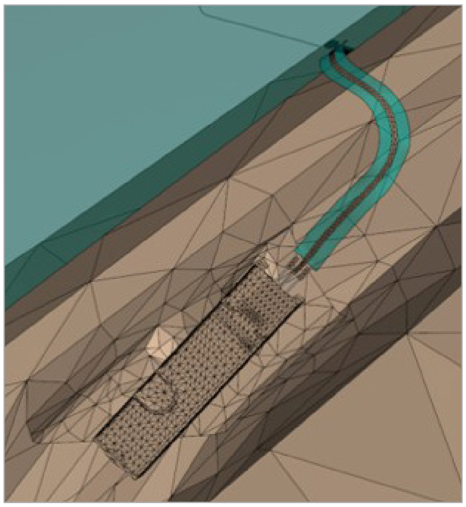
Optimizing the Layout of Passenger Car Glass Antennas



Key Highlights

Industry
Automotive

Challenge
Layout optimization of FM, DAB, RKE & TV-antennas in multilayer windscreens.

Altair Solution
FEKO windscreen analysis & multiport method for efficient modelling and analysis of different configurations.

Benefits
- Improved antenna performance at early vehicle development phase.
- Mature antenna layout for EMC emission testing.

Integrating antennas in windscreens has become popular due to the enhanced aesthetics and the increased antenna surface area that enables improved reception. However, the design of such antennas is a complex procedure, requiring the ability to analyze electromagnetic interactions between thinly layered dielectrics, thin embedded wires and the surrounding vehicle body.

German automotive technology leader, Daimler, has a long standing relationship with Altair for vehicle antennas and electromagnetic compatibility (EMC) simulation and was one of the first manufacturers to change its windscreen antenna development from a measurement-driven to a simulation-driven process. This change in approach has enabled the creation of mature antenna layouts with high levels of performance at an early development phase. Simulated EMC emission tests determine coupling to the windscreen antennas.

Layout Optimization for Multiport Antenna Systems

In the frequency range of FM-, DAB- RKE- and TV-antennas, the vehicle body forms part of the antenna. This leads to the glass antennas often having to be adapted or redesigned for each car line and variant. Different glass types (e.g. single vs. multi-layer) also have an influence on the antenna performance, and different configurations can change the impedances of the multiport antennas. Additionally, different antenna concepts are needed for different vehicle types; for example, additional antennas will be required in a convertible windscreen as the rear screen is not available (figure 1).

Keywords: Vehicle glass antennas, FEKO, Multiport Method, FM-antenna, DAB-antenna, RKE-antenna, TV-antenna, EMC emission testing CISPR25

"The antenna optimization procedure developed by Altair ProductDesign, using FEKO's Windscreen Analysis Tool, has become a standard process for all windscreen antenna layouts of new car lines."

Antenna systems contain different antennas with mutual coupling, making it very inefficient and time consuming to optimize the FM-, DAB-, RKE- and TV antennas independently. Wanting to make the optimization process of its multi-port antenna more efficient, Daimler turned to Altair for assistance. Aside from the range of variations to consider, further challenges included precise modelling of multilayer glass and its influence on the antenna. Typical multilayer configurations contain two glass layers and a thin PVB-layer, IR glass variants often contain very thin metallic layers. Using traditional modelling approaches (tetrahedral or triangle meshes) for these structures is very complex and results in millions of unknowns. Altair ProductDesign suggested that these issues could be addressed with a jointly developed windscreen antenna analysis method within HyperWorks' electromagnetic suite, FEKO. The solution would have to represent the dielectric properties of multiple layers analytically, enabling a very efficient simulation of windscreen antennas. In addition, the complete system must be considered for the evaluation of the different antennas. To do this efficiently, Altair ProductDesign implemented multi-port post-processing, which allowed different port configurations to be re-evaluated without re-running the solver. The method would be extremely helpful when considering amplifier configurations for different variants.

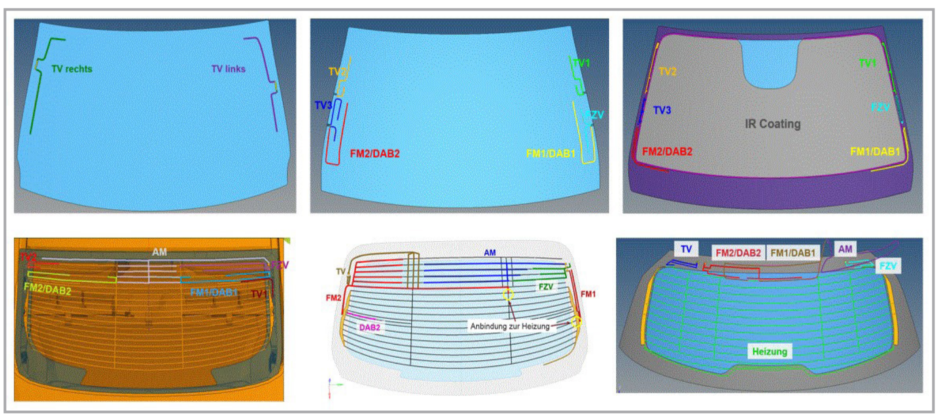


Figure 1: Different antenna layouts in windscreens and rear screens

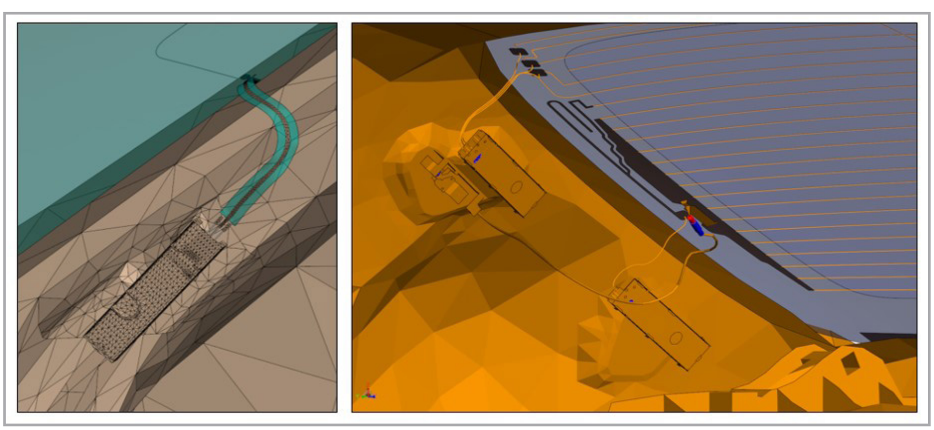


Figure 2: Amplifier and cable connection models for windscreen antenna simulation

Optimization Using FEKO Windscreen Analysis

First, the antenna geometry of the initial layout was modelled within the vehicle model. The multiple layer glass structure was represented using FEKO and the antenna structures were placed at arbitrary layers. The ground path from the amplifier PCB across the amplifier housing to the

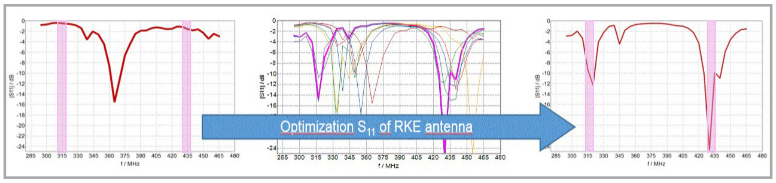


Figure 3: Dual band optimization of RKE antenna

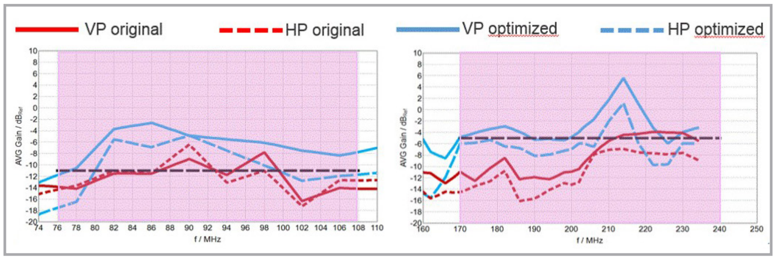


Figure 4: Optimization of FM/DAB antenna

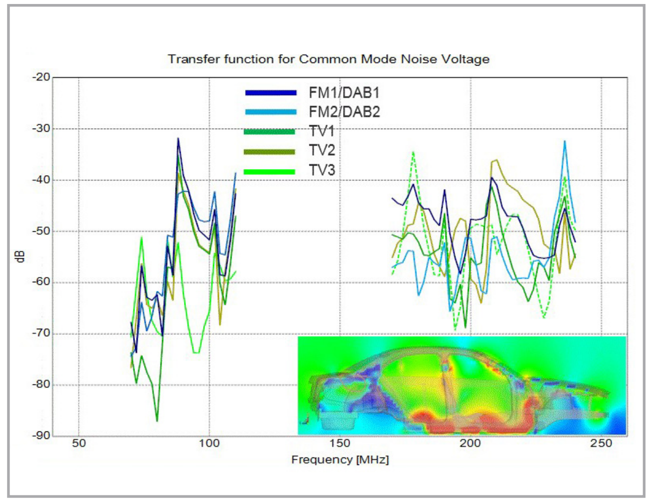


Figure 5: Common mode cable radiation and coupling into vehicle antennas

vehicle body was included in the model. The connection between antenna and amplifier was realized with single wire cables or with conductive tape (figure 2). At passive ports (e.g. EMC filter), impedance boundary conditions were described as discrete networks (e.g. in touchstone format). For the antenna evaluation, there were different specifications and goal functions, e.g., the layout of an RKE antenna was optimized for the reflection coefficient (S11) at the operating frequencies 315 MHz and 434 MHz. Figure 3 shows the different S11 graphs during the optimization process. The starting layout had only a single resonance at the wrong frequency. The final solution showed good dual band behavior.

For FM-, DAB- and TV-antennas it proved more useful to maximize the realized gain at specified frequencies and elevation angles to visualize the current distributions and understand which antenna parts should be changed during the optimization process. For the vehicle simulation, Method of Moments (MoM) could be applied up to roughly 450 MHz. For the higher TV bands, it proved more efficient to switch to the Multi-Level Fast Multipole Method (MLFMM). Usually, the antenna system includes one dual band RKE antenna, two FM/DAB antennas and three TV antennas. All six of these antennas were evaluated at each frequency in a single simulation using the the multiport method. The limited degrees of freedom meant it was not possible to design a perfect broadband antenna for all frequency bands, and for FM, DAB and TV, diversity antennas were needed to compensate for this behavior.

The models created for antenna optimization were reused for EMC vehicle simulations. For emission analysis according to the CISPR-25 standard, the antennas acted as the victim for the electromagnetic noise, and only the EMC source (e.g. cable harness) needed to be added. For frequencies up to 250 MHz, radiated emissions from cables were the most critical noise source in the vehicle EMC analysis. FEKO offers a MTL (Multiconductor Transmission Line) and a combined MoM/MTL implementation to model different types of cables and cable harnesses.

For the different cable harness port configurations, the multiport method was very efficient. For example, with a single simulation, Altair ProductDesign could evaluate multiple noise sources or compute the radiated emissions for different cable routing simultaneously.

Optimized Antenna Performance & High Design Maturity

Figure 4 shows typical results of the average gain of an FM/DAB antenna, including the vertical and horizontal polarization of the initial design (red curves) and the optimized design (blue curves) which has up to 8 dB better performance. The antenna optimization procedure developed by Altair ProductDesign, using FEKO's Windscreen Analysis Tool, has become a standard process for all windscreen antenna layouts of new car lines and is realized in close cooperation with glass suppliers. The process ensures a highly mature antenna layout and also allows for the evaluation of the electromagnetic noise at the antenna port for different emission scenarios, which helps to identify worst case EMC scenarios.

Figure 5 shows the simulated common mode radiation of a cable. The coupling into the vehicle antennas is compared for different antenna ports. Since the number of vehicle variants is ever increasing for Daimler – and simultaneously the number of hardware prototypes is reduced – this variety can only be managed efficiently with the use of simulation technology.

Find out more at: **altair.com**

Visit the Altair library of

Success Stories

at www.altair.com

About Altair

Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held and headquartered in Troy, Michigan, USA the company operates globally to serve customers in a diverse range of industries including automotive, aerospace, defense, meteorology, architecture and construction, energy, electronics, and consumer goods.

www.altair.com

About Altair ProductDesign

Altair ProductDesign is a global, multi-disciplinary product development consultancy of designers, engineers, scientists, and creative thinkers. As a wholly owned subsidiary of Altair, the organization combines its product development expertise with proprietary simulation technologies to deliver innovation and automate processes; helping clients find the optimum balance between performance and cost to bring profitable products to market, faster.

www.altairproductdesign.com

About HyperWorks

HyperWorks is the most comprehensive open-architecture simulation platform, offering technologies to design and optimize high performance, efficient and innovative products. HyperWorks includes modeling, analysis and optimization for structures, fluids, multi-body dynamics, electromagnetics and antenna placement, model-based development, and multiphysics. Users have full access to a wide suite of design, engineering, visualization, and data management solutions from Altair and its technology partners.

www.altairhyperworks.com

Altair

Altair Engineering, Inc., World Headquarters: 1820 E. Big Beaver Rd., Troy, MI 48083-2031 USA
Phone: +1.248.614.2400 • Fax: +1.248.614.2411 • www.altair.com • info@altair.com