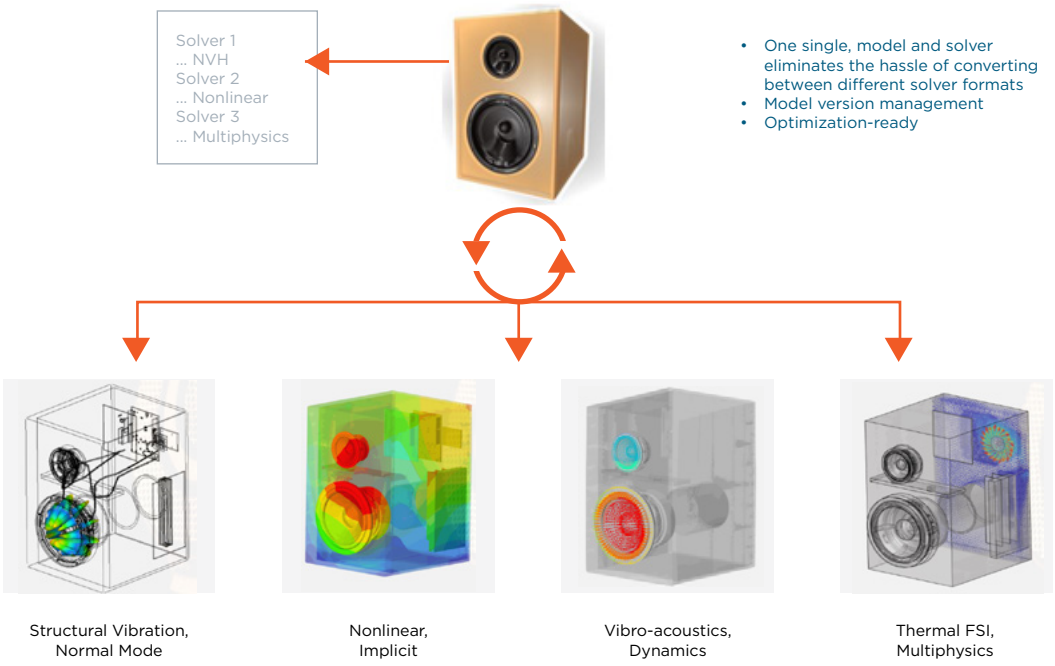
SOUND AND SIMULATION: DESIGNING A SMART SPEAKER

Speaker design and analysis, especially for a more complex product, system, or component, often requires building multiple simulation models. The loudspeaker development process involves multi-physics and multiple sources in parallel, to multiple simulation runs for prototyping, testing, and validation. This results in separate models for nonlinear analysis of strength, thermal analysis and stiffness, noise, vibration, and acoustics. Even though each model isn't always built from scratch, typically the use of different solvers for each attribute will require that models need to be converted from one solver format to another. This practice is not only time consuming but frequently error prone resulting in an inefficient use of engineering time.

Studying a design using structural optimization brings further complexity, potentially adding another software for parameterization of the problem and possibly another product for running the optimization itself. The traditional multi-attribute analysis and optimization process is not just a burden to the engineering team but is also a significant challenge for IT, requiring the management of multiple vendors and ensuring sufficient license availability throughout the development lifecycle. Developing modern-day consumer electronics products requires designers to consider an array of structural, acoustic, and thermal performance factors, and increasingly, IoT connectivity and smart product capabilities as well. The complexity of meshing, model setup, and simulation of multiple physics can be daunting for analysts, and especially for part-time simulation users.

Quality and performance do not need to be compromised over cost when developing electronics products with Altair SimLab™. In the case of developing a smart speaker, multiple analysis processes can be performed by the user on one unified simulation platform. Powered by the proven structural solver Altair OptiStruct™, single model multi-attribute analysis and optimization workflow enables the user to perform linear and nonlinear analysis, vibration, and thermal simulation as multiple subcases of one model with the ability to optimize. This workflow enables a more streamlined design process, eliminates error-prone model translation work between simulation steps, and helps to improve decision making early in the development stage of a product.

Single Model Multi-attribute Design Flow



Learn more at:
altair.com/optistruct

With SimLab's single-model workflow, users can manage multiple product designs all within a single simulation platform.

Vibration

Testing for noise, vibration, and harshness issues during smart speaker development is a critical step in ensuring that a speaker model will satisfy pre-determined quality and sound targets. Full frequency, multiphysics, and acoustic simulation can be performed in SimLab for users to successfully assess and update their designs.

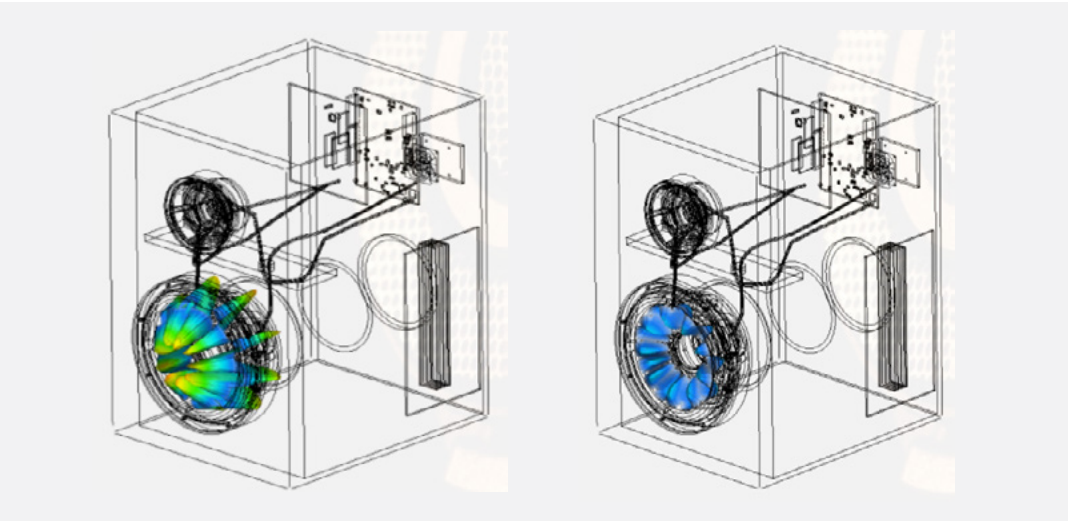


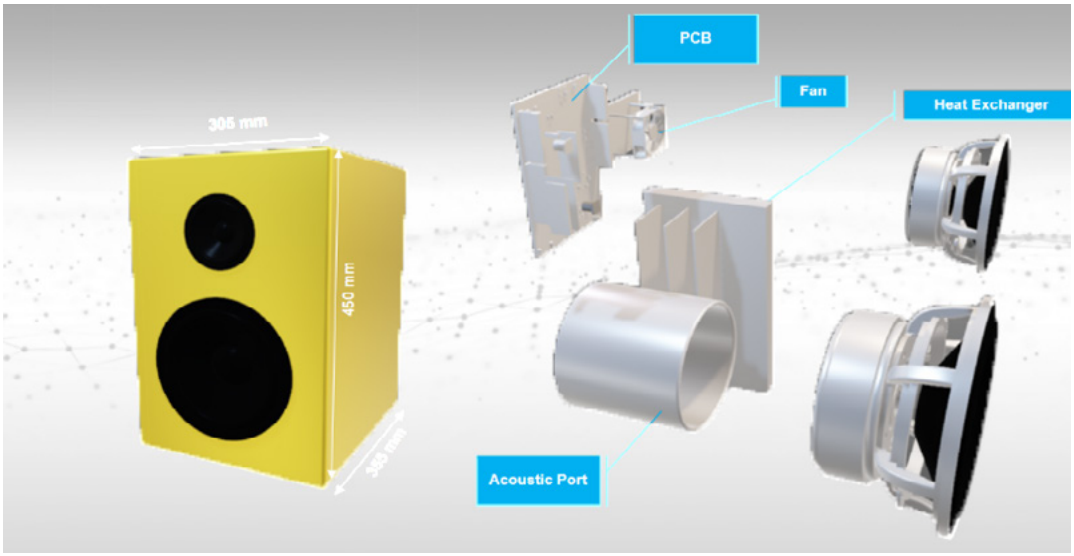
Image demonstrating a vibration analysis being performed using Altair SimLab"

Model Analysis

Every physical object has a natural frequency (vibration cycles per second), at which it prefers to vibrate when left alone. These are called the "resonance frequencies". Resonance occurs at a specific frequency where virtually no dampening occurs. This type of frequency is an important aspect to consider and analyze during the design phase of a smart speaker.

To determine the vibration characteristics of the model, modal analyses were demonstrated on the speaker. SimLab provides the functionality to perform frequency, transient, and squeak and rattle analyses during simulation.

In this example, a modal analysis was applied to the speaker membrane to observe the vibration levels at different locations of the speaker assembly and diagnose any causes of failure. Once results were analyzed, the speaker design was optimized by minimizing acceleration at the PCB measurement point. To do so, 1D topology optimization was applied to improve the connection strategy from the PCB to the cabinet.

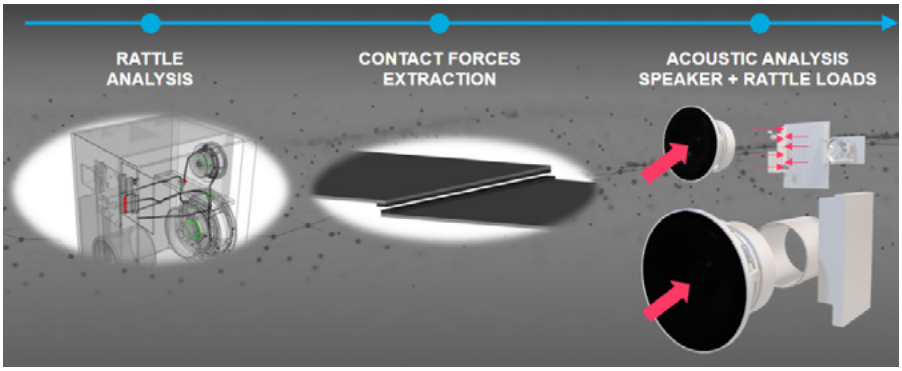


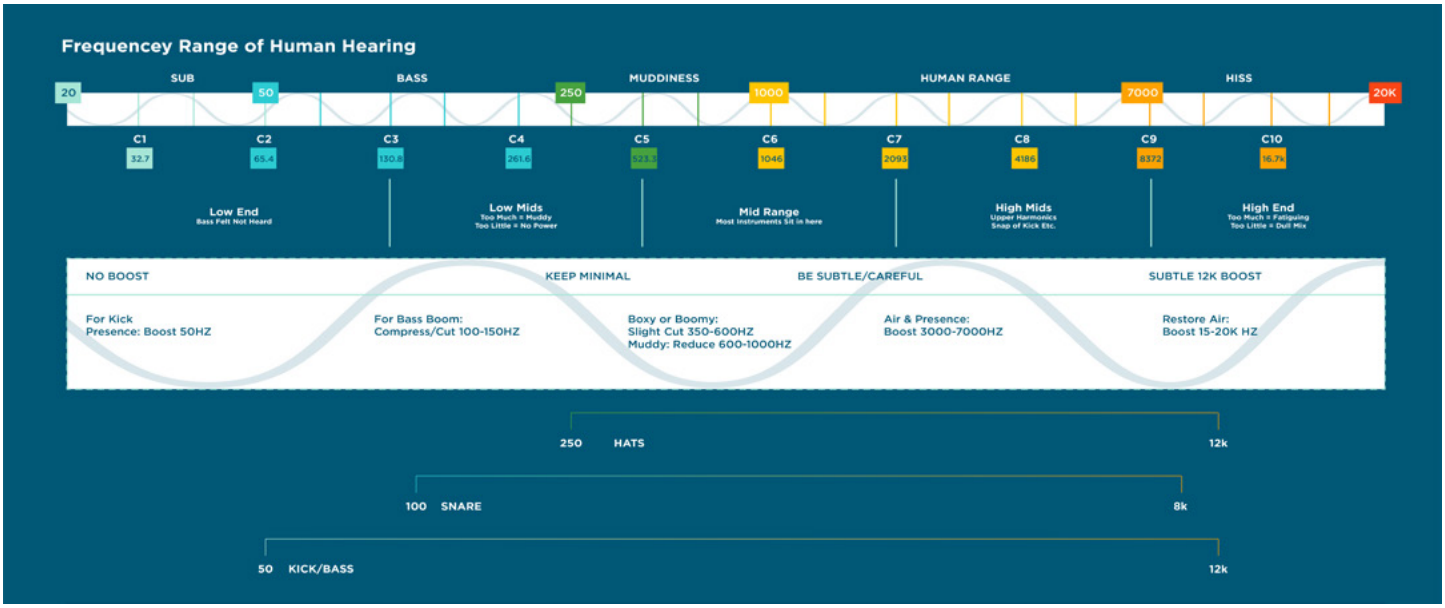
Multiple response points on the assembly were observed during the frequency analysis, including the cabinet, heat exchanger, and the fan.

Acoustic Analysis

Generally, internal and external acoustic radiation problems are solved based on inviscid flow with a linear pressure density relation. Acoustic modeling in finite and semi-infinite domains is essential in the prediction of quantities such as external and radiated noise in vibro-acoustic problems. Infinite elements are a popular way of modeling unbounded acoustic domains. Acoustic infinite elements are used here to simulate the external sound pressure on the receiver which is modeled as plate here to represent the boundary of the room.

In addition to speaker aesthetics, sound quality and noise reduction performance are key drivers of the end-product's perceived value and price point. Vibro-acoustic analysis is necessary for understanding what the final product will ultimately sound like. In this step, SimLab was utilized to test the speaker for rattling and sound pressure levels, then to correct any errors that were found in the overall design.





This graph demonstrates the relationship between sound and frequency.

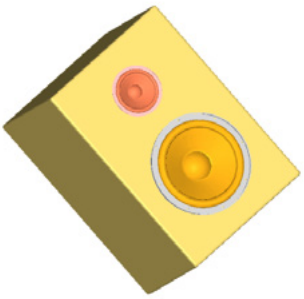
When it comes to speakers, a key component that needs to be observed during development is sound type versus frequency. Depending on the product, each sound type whether it is bass, treble, or any others, will fall into a certain frequency range to produce the most optimal sound for the speaker. With the aid of Altair's simulation tools, frequency response can be measured to investigate the range of frequencies a speaker will be able to reproduce, as well as find the most optimal sound levels for a speaker product.

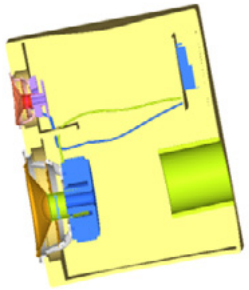
For more information about Altair's role in electronics design, visit: **altair.com/electronics**

Abusive Loads

OptiStruct provides a rapidly expanding and efficient set of nonlinear analysis features including drop test simulation, large displacement testing, preload temperature testing, contacts, and non-linear material analysis.

Speakers of all kinds, whether they have smart capabilities or not, are designed with the intent to be able to withstand large drops and displacements. SimLab allows users to digitally simulate these types of tests, improving design confidence and reducing costly physical testing and redesign iterations.





Drop test simulation on Altair SimLab™

Thermal

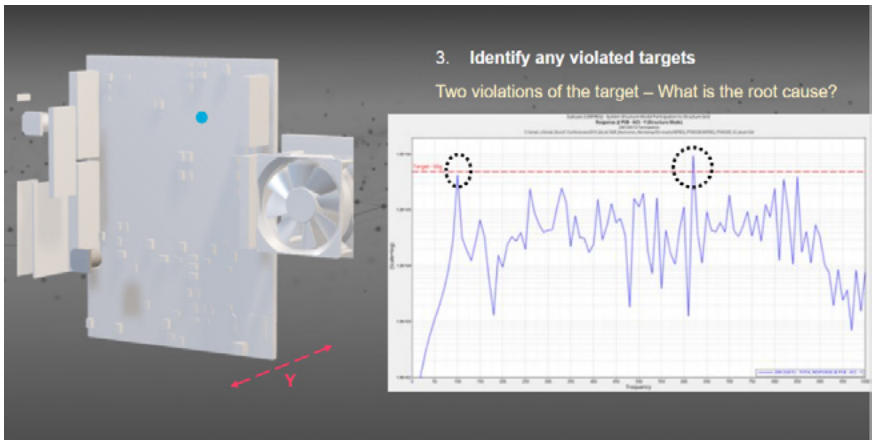
Many factors are considered during a thermal analysis for electronics, from computational fluid dynamics to the elimination of thermal effects of electronic systems, such as the printed circuit board (PCB). Within OptiStruct, thermal flow analysis can be conducted on the design of a smart speaker to test fluid materials, heat load, inlet flow, fan cooling effects, and other key contributing variables.

Smart Speaker Optimization

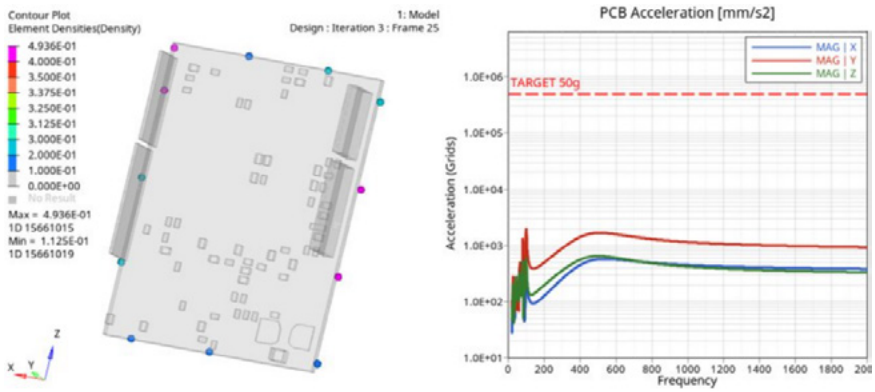
Within the SimLab platform, users can simultaneously run thermal analyses on a smart speaker model while also testing its impact on the product's structural behavior. Multiphysics analysis and optimization are made easier by utilizing one common model.

Common acoustic issues that arise when designing a speaker, such as squeak, rattle, and buzz, can be addressed and resolved early in the product development cycle.

In this example, a squeak and rattle design of experiments (DoE) study was performed.



During the study, areas of design that did not meet performance targets were discovered.



After performing a vibration analysis, connection points on the speaker were optimized to improve acoustics.

Working with Altair

SimLab is a process-oriented multidisciplinary simulation environment to accurately analyze the performance of complex assemblies. Multiple physics including structural, thermal and fluid dynamics can be easily setup using highly automated modeling tasks, helping to drastically reduce the time spent creating finite element models and interpreting results. Altair's robust, accurate and scalable solvers can run either locally, on remote servers or in the cloud.

An intuitive and self-explanatory graphical user interface covers all aspects of the modeling process. Instead of tedious geometry clean-up, work is performed directly on the geometry – imported and updated via the bi-directional CAD coupling - by defining mesh specifications for individual regions.

For electronics and consumer goods manufacturers, new product lines, more efficient operations, higher quality, and faster time-to-market are all within reach with the help of Altair SimLab. Altair has the technology and product development expertise to help you realize your smart product development vision from ideation to launch and in-service operation.

Learn more at altair.com/simlab