Case study

Simulating and validating loudspeakers – From simple model to product

How Foxconn engineers validated simulation methodologies for loudspeakers

Foxconn's team of engineers carefully executed a deliberate approach to validate simulation models for loudspeakers. Their end goal was to achieve the ability to optimise designs for production conditions in the finished product.

Loudspeakers are ubiquitous. They are an essential component of any product that produces sound. Although the principle behind their functioning is simple, they are intricate devices. Loudspeakers transform electrical signals into sound using a driver system, which creates a piston-like motion that drives a diaphragm. The diaphragm, in turn, moves air and produces the sound.

To create sound, several different components, such as the magnetic pole, the voice coil, the spider, the diaphragm, the dust cover, and the frame, need to work together to deliver incredible sound in various sizes and as part of a multitude of products.

Simulating all these systems is possible but expensive. However, there are models that can replace these components with methods that provide better performance while maintaining accuracy.

Figure 1. Process of validating and simulating loudspeakers.

Foxconn engineer Chen Yuzhen wanted to validate one such methodology, which utilises the Thiele-Small parameters, to validate a loudspeaker model progressively, from simple model to completed product.

The Thiele-Small parameters are a series of measurable properties that describe the performance of the driver system and include electromagnetic and mechanical parameters. The simplified model consists of these seven parameters and a solid model of the coil and diaphragm. However, the required conditions of this model are linear performance and the one-dimensional motion of the coil, and the motion of the object will deviate from linearity in a high-frequency environment, causing the response of this model to be inaccurate at high frequencies.

Thiele-Small models can be easily created within Actran, and their integration allows engineers to take advantage of other types of modelling as well, such as porous materials, perforations, etc.

Building the models (and momentum)

For the simple model, Foxconn's engineers first built a solid 2D model to compare with a Thiele-Small model and then used this model to create a 3D reference model. Finally, they added a cavity to build a simplified loudspeaker setup.

A comparison was made, first between the 2D model and the Thiele-Small model, and it was found that they agreed very well until 1000 Hz, but the Thiele-Small model agrees better with expectations overall. As a next step, a 3D reference model is built, and it's compared with one that includes a cavity to model a simplified but complete loudspeaker setup. The two models agree well, bringing more confidence to the process.

Once the simplified model was validated, an example loudspeaker system was modelled, and its performance was compared with measurements. The performance of the model agreed well with the measured one up to 8500 Hz, with the model identifying the resonance peaks due to the presence of two air chambers.

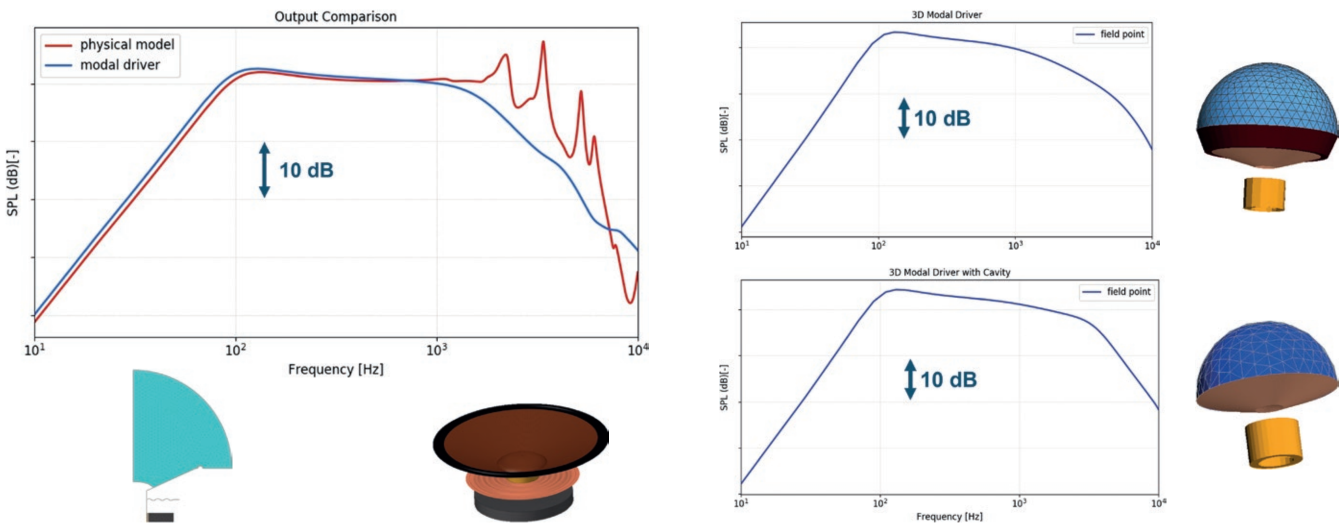

Figure 2. Validation of loudspeaker models. Left: 2D solid model vs. 3D Thiele-Small model. Right: 3D reference model with and without cavity.

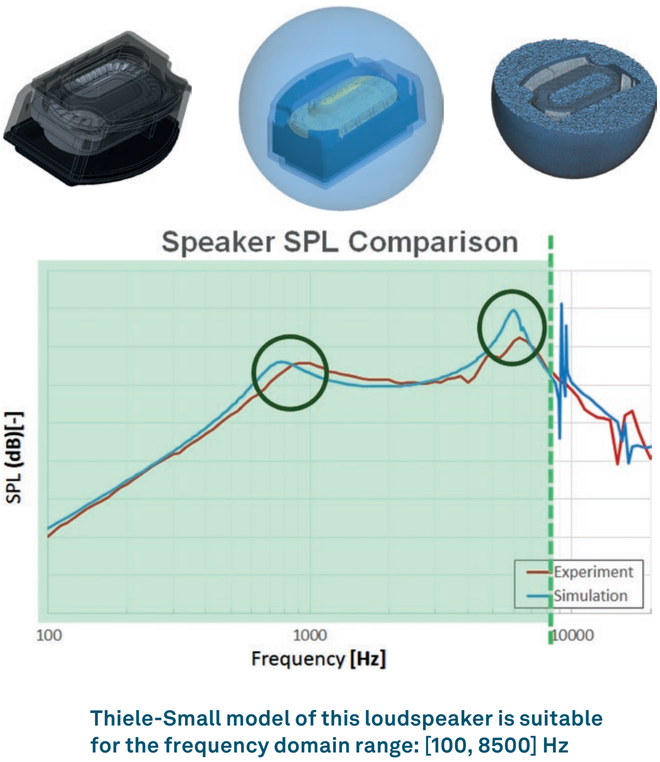

Figure 3. Validation of example model with measurements.
Top: Speaker geometry (left), Speaker Actran model (middle),
Mesh cutout (right).

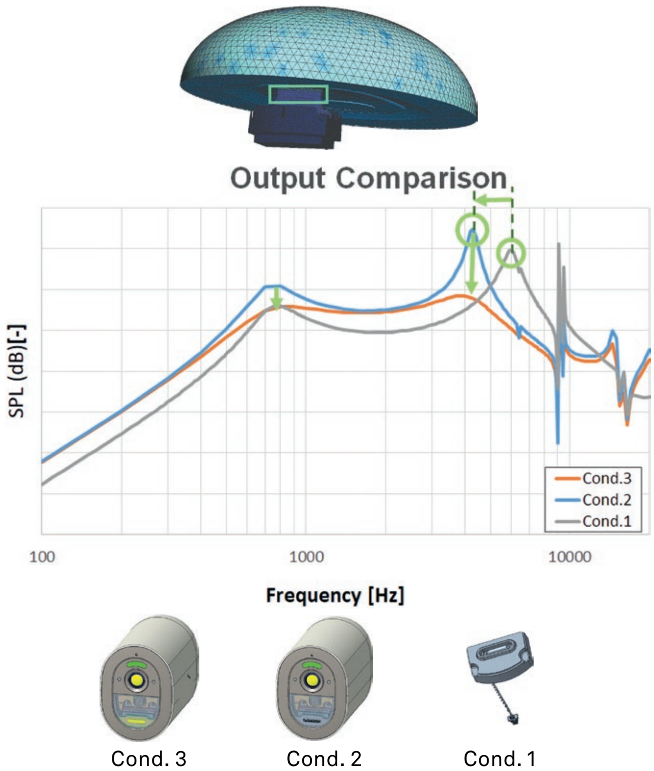

Figure 4. Top: Actran model of installed speaker.
Bottom: Speaker performance under different configurations.

Simulation of the final product

The final step of the process is applying it at the product level to analyse it and evaluate the addition of various measures that would allow for better performance.
In this case, three environments are simulated:
(1) the speaker is directly connected to the outside of the device, (2) the speaker is placed within the enclosure, and (3), like the previous one, there is a mesh within the enclosure. A perforated plate model is used within Actran to avoid meshing the cloth.

Even though there were no measurements for these models, they provided a lot of insight into how the speaker performs as part of a complex environment and where performance can be gained. By validating models and building a process, Foxconn engineers gained confidence in Actran for accurately and affordably simulating loudspeakers at the component and system levels.

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