

Actran Helps Reduce Time to **Optimize Design of Active Pedestrian Alerting System by 50%**

Based on an interview with **Jinmo Lee,**
Senior Research Engineer,
Hyundai Motor Company



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Hyundai active pedestrian alerting system

Industry Challenge

At moderate to high speeds, the only external noises typically generated by electric vehicles are caused by wind resistance or tire noise. As a consequence, electric vehicles present a risk to pedestrians and cyclists, especially those who are visually or hearing impaired or listening to headphones.

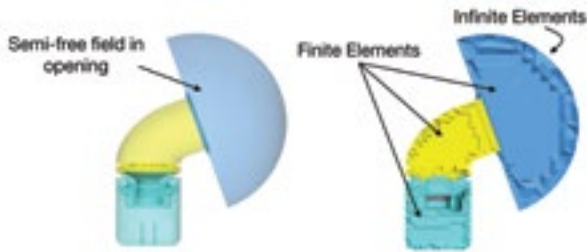
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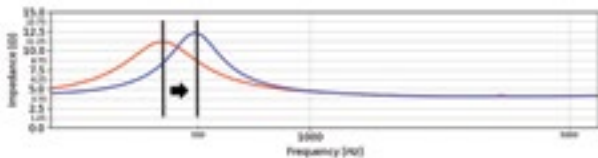
Regulations have been issued in both the United States and the European Union requiring that newly manufactured electric vehicles make an audible noise when traveling at low speeds. These regulations have differing requirements for the amplitude and frequency content of the warning sound.

In recent years, Hyundai has developed active pedestrian alerting system (APAS), which utilize sound focusing technology for emitting alerting sound only to a pedestrian in danger. The present APAS system allows automatic detection of a pedestrian using ADAS camera and louder sound emission to target position without arousing city noise pollution issue. In designing APAS, Hyundai engineers must be concerned with meeting both regulatory requirements, providing sufficient pedestrian awareness, and avoiding emitting excessive sound that will reduce the comfort of vehicle passengers.

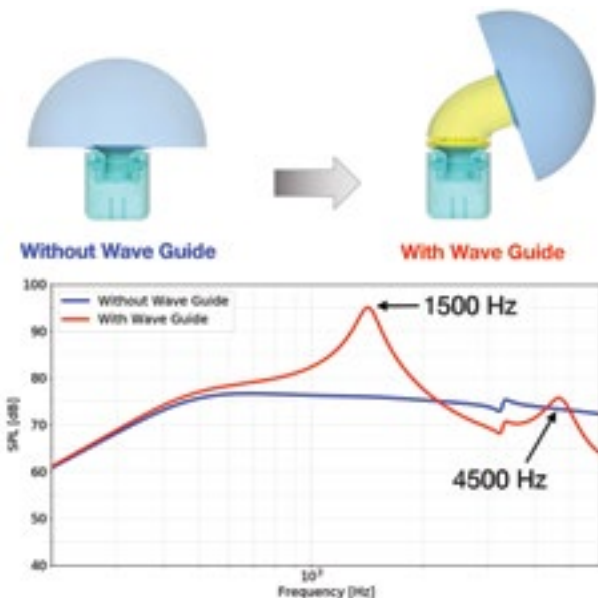
In the past, when sound played a big role in the design, Hyundai engineers relied on physical testing to evaluate alternative design approaches. It was necessary to



Finite element model of speaker



Influence of speaker enclosure on spectral characteristics



Influence of waveguide on spectral characteristics

build a prototype for each potential design, which takes a month or two. The amount of data provided by physical testing is also limited. “With physical testing we can only measure the amplitude of the sound at various locations so we have to guess at the mechanisms by which the sound is generated and transmitted,” said Jinmo Lee, Senior Research Engineer at Hyundai Motor Company. “This makes it difficult to determine the best way to improve the design.”

MSC Solution

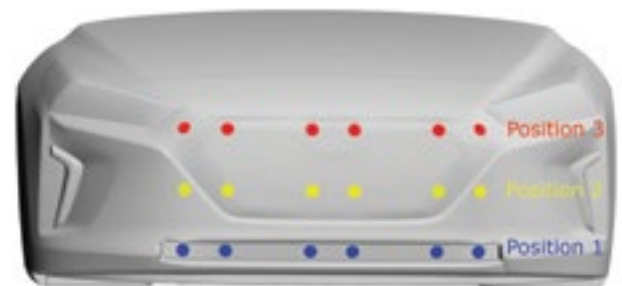
1. APAS Modeling

Hyundai engineers used MSC Actran to model the speaker using a Thiele/Small(T/S) parameter model based on specification sheets provided by speaker manufacturer and coupled with a finite element model representing both the inside cavity of the speaker and the sound radiation space.

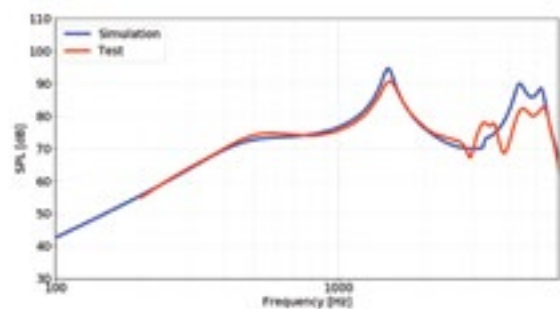
The acoustic pressure and acoustic impedance in the area of the vehicle were then computed by Actran up to 6000 Hz.

2. Use Simulation Results to Optimize Speaker Design

A series of parametric studies were performed with Actran to investigate the effect of key design variables on sound emissions. EU and US regulations require at least one warning sound frequency to be delivered under 1600 Hz and 800 Hz respectively. APAS speakers have a small driver unit so low frequency sound emission in the low frequency range is the most difficult target to



Three candidate locations for speaker installation



Speaker test results vs. simulation results

achieve. At the same time, the experimental analysis showed that a frequency below 400 Hz transmits well into the vehicle interior, affecting the passengers' comfort level. A frequency scan with and without the enclosure showed that the installation of an enclosure changes the acoustic impedance from 400 Hz to 490 Hz, which meets regulations while maintaining passenger comfort.

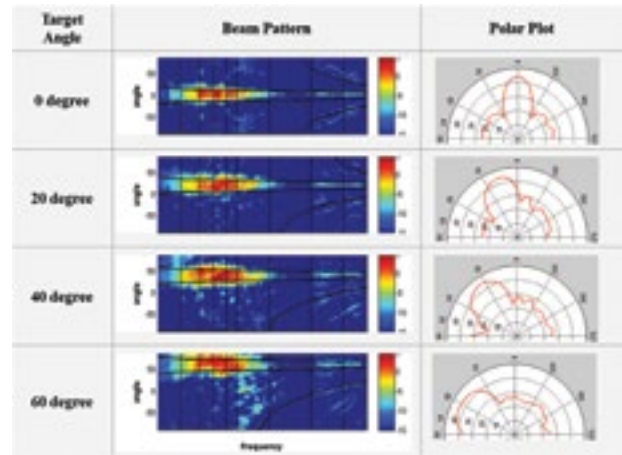
The waveguide, which protects the speaker from liquids in the environment, also plays an important role in acoustic tuning. The waveguide was designed using Actran acoustic duct feature to enhance mid-frequency 1500 Hz sound transmission and the space between the speaker inner cover and the driver was optimized to enhance sound pressure level near 4400 Hz.

The vertical location of the speaker on the bumper was also investigated by including the front surface of the vehicle and the ground in the simulation. The simulation results showed that the lowest position provides the best alerting sound performance by providing a higher SPL and relatively flat spectral behavior. The simulation also showed the lower position minimizes the potential for destructive interference by sound reflected from the ground.

Results and Correlation

The simulation results were validated by conducting a 1-volt sine sweep test for both the actual speaker and the simulations. As shown in the figure above, the spectral behavior of sound at 1 meter from the speaker predicted by simulation matches the physical measurements nearly perfectly.

By using Actran to optimize cavity and duct resonances, Hyundai engineers were able to design the speaker to handle low, mid and high frequencies as needed to meet both US and EU regulations while at the same time minimizing speaker size and power consumption. "The simulation results provided by



Actran were much more comprehensive than information generated by physical testing, which helped Hyundai engineers quickly iterate to an optimized design in about half the time that would have been required using traditional build and test methods," Lee said.

A physical prototype was constructed of the full APAS after it had been optimized with Actran simulation. The physical testing results showed that the design met all design requirements by complying with regulatory requirements, maximizing sound radiation performance with a small speaker and providing excellent sound focusing performance.

About Hyundai

The Hyundai Motor Company, along with its 32.8% owned subsidiary Kia Motors and its 100% owned subsidiary Genesis Motors, is the third largest vehicle manufacturer in the world. Hyundai operates the world's automotive assembly plant in Ulsan, South Korea with annual production capacity of 1.6 million vehicles. Employing more than 110,000 employees worldwide, Hyundai sold more than 4.5 million vehicles globally.

