

Simcenter Active Sound Design for automotive

Solution brief

Siemens Digital Industries Software

The Simcenter™ Testlab™ software portfolio for sound quality engineering includes a solution for active sound design for automotive. It's an advanced sound quality engineering tool for design, validation, tuning and deployment of interior sound enhancement for hybrid/electrical vehicles (HEVs) and internal combustion engine (ICE) vehicles, and for mandatory exterior acoustic vehicle alert system (AVAS) sounds. It's based on state-of-the-art sound synthesis techniques. It's complemented with hardware to evaluate and tune sound signatures in real-time in the target (or mule) vehicle, or on a vehicle simulator.

Creating an immersive driving experience

With engine downsizing, weight reduction, cylinder deactivation and electrification of the powertrain, the sound characteristic inside the vehicle has changed. An often-heard remark about HEVs is they have great acceleration, but they lack the sound perception and emotion that drivers expect to hear.

At the same time, legislators have imposed legal requirements for AVAS to be installed in quiet vehicles to warn pedestrians when driven at lower speeds.

New active sound design teams are taking up the challenge to design, validate and implement these sounds. They emerge as cross-functional teams, sharing expertise from different domains. On one hand there are the noise, vibration and harshness (NVH) experts that engineer interior and exterior sound quality by working on acoustic transfer paths, using isolation material for masking noise and shaping engine orders with structural modifications.

On the other hand, there are the sound designers that have mastered expertise from the audio domain. They design and compose sounds that match a certain brand image of a product.

The Simcenter Active Sound Design solution combines these two expert domains into a single software and hardware solution. Design, validate, tune and deploy both exterior and interior sound to comply with legislation and match the expected sound perception.

Challenges

- Develop compliant AVAS sound that is also a recognizable brand sound
- Enhance interior noise to match required sound quality perception

Solutions

- Use Simcenter Testlab Sound Designer
- Validate inside the vehicle with the Vehicle Unit
- Use AVAS unit to synthesize sound
- Interface to vehicle's CAN bus with CAN Gateway

Results

- Design, validate or tune sound signatures in studio or target vehicle
- Design sound ready for production on Tier-1 audio supplier hardware
- Mask acoustic issues late in the development cycle

Solution focus

A single environment to design, validate, tune and deploy active sound

Simcenter Testlab Sound Designer is used to create sound signature models that are parametrized in function of vehicle parameters, allowing you to design complex sound scenarios that fit an auto original equipment manufacturer (OEM) brand and still deliver differences between vehicle models.

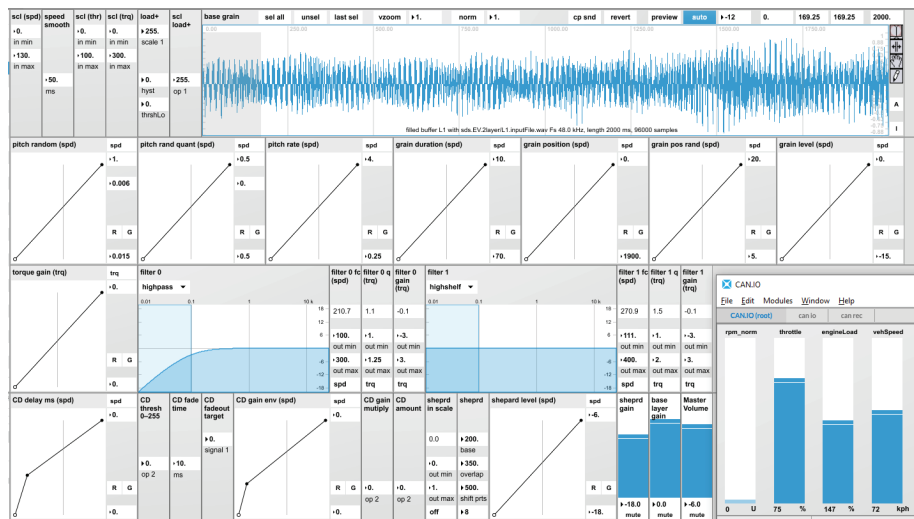
These sound signatures can then be validated directly inside the vehicle. This can be the target vehicle, or, as it is often not available, a mule vehicle.

All parameters used to synthesize the sound can be changed in real-time, allowing the user to tune the sound in a real dynamic driving environment.

The final sound signatures can then be deployed on the audio amplifier hardware of any Tier-1 supplier. Several major audio chips from Analog Devices (ADI), Texas Instruments (TI) and ARM are already supported, while the solution can be extended for custom audio hardware platforms. This makes Simcenter Testlab Sound Designer a vendor-neutral solution, as it does not depend on the fast-changing reality of which Tier-1 audio supplier gets to deliver the hardware.

Designing sound signatures

Sound signatures can be easily designed and fine-tuned using graphical controls. They are parametrized in function of dynamic vehicle parameters: speed, engine torque, throttle, revolutions per minute (RPM), gear. Synthesizing is then done in real-time either in the studio or the sound lab while driving in the vehicle or on a vehicle simulator. Parametrization is done by user input, predefined driving profile or with a CAN interface with the vehicle or simulator.



Simcenter Testlab Sound Designer - from design to deployment for production in one tool.

Simcenter Testlab Sound Designer enables the creation of unique signatures for hybrid/electric vehicles in several sound layers that use one of the following two methods: granular synthesis and/or engine order synthesis.

- Granular synthesis creates a rich and lively sound based on a designed or recorded sound sample. It is then parametrized in function of vehicle speed or torque
- Order synthesis allows you to design sound signatures emulating or enhancing combustion engines. This can be accomplished by starting from scratch or using an existing engine sound and synthesizing the delta between the existing noise and the desired target

Granular synthesis comes from the music industry and as such is well known to sound designers. It does not aim to replicate the mechanical properties that make combustion sound so characteristic. The chosen sound sample, typically no longer than 2 seconds, can come from anywhere. It can be the natural sound of a rolling ocean wave or a wild animal. It can be a recording of a musical instrument, combustion engine or a purely composed synthetic sound. As long as the sample reflects the brand sound and positive perception of future vehicle buyers, granular synthesis is able to elevate it to an entirely new vehicle sound. Parameters that sound designers

can change include grain position and duration, pitch change of the grain and a certain randomness to make sure one never has the perception of listening to a looped sample.

Engine order synthesis has been around for quite some time. It synthesizes sine waves with different phases in function of vehicle RPM or speed. This can be done based on recorded engine orders or shaped orders and for different engine loads. Best results are obtained if a certain "dirtiness" or "randomness" is added. Engines never run at exact RPMs and modeling different variances into the synthesis greatly increases the liveliness and naturalness of the sound. Even adding effects of additional components, such as backfires, further increases the realism and directly addresses the emotions of drivers. The result will sound just like a combustion engine, but it can take a long time to get it right.

Finally, after combining two of these synthesis layers, several advanced methods can be added such as a Shepard layer for low frequency content. They enable synthesized sounds to be perceived as natural and rich.

During the design, Simcenter Testlab Sound Designer can be used to mix sound signatures on top of a recorded driving sound, using drive cycle data. This is done using a dedicated drive simulator module, which replays predefined or recorded drive profiles.



Vehicle unit allows longer term evaluations.



AVAS unit.



Real-time tuning.

Validation and tuning

Whatever sounds great in the studio or on a simulator must be validated in the vehicle. This is done in different phases.

First, the personal computer (PC) can be interfaced with the vehicle using a Simcenter Testlab Sound Designer CAN Gateway. This connects the vehicle's CAN bus to the PC. The sound synthesis is still done on the PC and the audio output can be connected to the vehicle's head unit, or an additional speaker system. The parameters determining the sound synthesis remain editable in real-time on the PC application, just as during the initial design of the sound in the studio.

Next, for final tuning and longer-term evaluations, a dedicated Simcenter Testlab Sound Designer Vehicle Unit is used. The sound signatures for in-vehicle enhancement then runs on the audio digital signal processor (DSP) of this vehicle unit. It's typically connected directly to the vehicle's CAN bus. Its audio output is directly connected to the vehicle's speaker system. The vehicle unit

runs without a PC but interfaces with the Simcenter Testlab Sound Designer application for uploading sound signatures and real-time modifications of the sound synthesis parameters.

Deploying for production

It's important to start with the end in mind: The final validated and tuned sound signature needs to run in a production vehicle. Several options are possible, and all are supported with Simcenter Testlab Sound Designer. In all cases, the synthesis engine needs to be interfaced with the audio DSP chip of the selected Tier-1 supplier of the head unit or audio amplifier. Several versions of ADI Sharc, NXP ARM and TI are supported and extendable to others. More complex sound signatures require chips with enough memory and processing capacity. This solution runs in parallel with other applications such as audio multimedia, navigation, phone integration or active noise cancelation.

Frontloading AVAS compliance

AVAS sound signatures in Simcenter Testlab Sound Designer are typically based on granular synthesis. AVAS design includes vehicle integration steps to account for the influence of the sound of the system and housing of the AVAS speaker, as well as the impact of the mounting location. This ensures that after integration in the final prototype, the AVAS sound is evaluated for minimum noise testing in the same way as it was designed.

A dedicated AVAS check software module is used to evaluate the sound against legal requirements. It supports the major standards in Europe (United Nations Economic Commission for Europe, UN ECE Regulation 138), United States (Federal Motor Vehicle Safety Standards, FMVSS 141) and its derivatives in China and Japan. Together they support sound designs that are not only pleasant and brand-aware, but also comply with legislation from the start. This is accomplished by measuring the transfer function between the AVAS speaker location and the pass-by noise (PBN) microphone and loading that into the Simcenter Testlab Sound Designer software. A matrix with green and red cells indicates if each required check and standard passes the applicable criterion. This is an efficient way to front-load compliance.



AVAS check front-loads compliance with standards.

Simcenter Testlab Sound Designer works in conjunction with a dedicated Simcenter Testlab Sound Designer AVAS unit, developed in cooperation with a Tier-1 audio supplier. This unit includes the speaker and audio DSP to generate the AVAS sound and interfaces with the vehicle using CAN. For real-time tuning and vehicle integration of the AVAS sound signatures, the Simcenter Testlab Sound Designer CAN Gateway is used. The integration work typically includes tuning the effect of the speaker on the exterior sound perception.

In a later phase, for longer term evaluations, the AVAS unit can be connected directly to the vehicle's CAN bus. Dedicated CAN message identifications can be selected to communicate with the device. Implementation for production vehicles is done in the same way as for interior sound: The AVAS signature has to be transferred to the selected audio amplifier or self-contained AVAS unit.

Comprehensive active sound design

Simcenter Testlab Sound Designer allows the creation of unique sound signatures for hybrid and electric vehicles. The solution runs the full active sound design process from first design to delivery for implementation in production vehicles, capable of running on any audio amplifier.

These active sounds create the immersive experience for the next generation of vehicles on the streets.

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