



## **Audi's sound philosophy is bringing acoustic harmony into the car**

- **Vehicle as acoustic space with special challenges**
- **Sonos will be a new partner for the compact segment**
- **Outlook: immersive 3-D sound for a holistic sound experience**

**Ingolstadt, May 6, 2021 – Natural, holistic, and perfectly attuned to each model: At Audi, the sound of the audio system is among the central attributes of quality. To that end, the premium brand regards sound and acoustics as far more than just the quality of infotainment. Customers want an environment in their car that excites and inspires them at the same time. An acoustic space without disruptive background noise, with signal, alert, and informational sounds that are harmonically attuned to each other, and unobtrusive activation noises.**

### **What noises do people perceive in the car and where do those noises come from?**

The sonic backdrop in a car comes from a mixture of a wide range of noises and sounds. The usual driving noises like the sound of the engine and the tires rolling on the pavement when the car is in motion are heard just as constantly as the aeroacoustic noises caused by the airstream in the chassis. In addition, there are also temporary noise sources: window lifters whir gently or the door snugly clicks shut. Signal and informational sounds ideally convey functional messages unobtrusively – typical blinker clicks are one of these as well as acoustic feedback from touch operation in the MMI display. Buttons and switches should make gentle but distinct sounds when they are activated. Intrusive warning sounds only demand passengers' full attention when necessary.

### **How does Audi trace the sources of undesired noise?**

Audi thinks about the subject of noise reduction holistically. Experts from various specialties – from complete-vehicle and chassis development to quality assurance – work together for that purpose in what we call the Rustle and Rumble team. The specialists test and assess every new Audi model on the road and on the vibration track, but also on the hydropulse equipment (see photos). That is a servo-hydraulic four-stamp test stand that makes the vehicle vibrate: Disruptive noises like rattles and squeaks in the passenger compartment are caused by vibrations in the low frequencies up to 50 Hertz. We test the vibrational responses of individual components or the entire chassis in order to investigate and localize noise sources. Noises can't



always be heard in the place where they arise. Vehicles' vibro-acoustic balance has noticeable consequences for drivers' comfort level.

### **Are there acoustic differences between combustion engines and electric cars?**

Unlike a combustion engine, an electric engine hardly causes any oscillations, vibrations, or mechanical noises. In an environment like that, noises that were not previously all that perceptible can move to the foreground. That includes aeroacoustics as well as the rolling of the tires. Audi makes a huge effort to minimize all these disruptive influences as much as possible when they arise. For example, all the areas where disruptive noise could be conveyed in the chassis of the Audi e-tron are specially isolated and decoupled. This means that design-related openings and cavities within the chassis are filled with microfiber fleece. Textile fabric and microfiber fleece also line the wheel wells to absorb sound. On top of that, relevant surfaces like the flooring are coated with a special material. That has the effect of making sheet metal vibrate less.

On the front wall, a complex multi-coat sequence insulates the noise against passing from the front end into the interior. In the rear, a similar construction accounts for the new vehicle architecture with an additional rear axle drive. On top of that, the electric motors are enclosed in noise-reducing capsules. Even the underfloor cladding is designed to absorb sound. In the interior, foam-backed carpeting maintains the quiet. The second important factor for the relaxed atmosphere inside the Audi e-tron is its highly developed aeroacoustics. Normally, wind noise becomes the most prominent when a car reaches speeds of 85 km/h (52.8 mph) and above. That noise remains quite low in the Audi e-tron and barely penetrates into the interior because the door seals, exterior mirrors, and water-catching strips have been intensively fine tuned. Passengers can have a relaxed conversation even at high speeds. The windshield comes standard with double glazing. Audi also offers acoustic glazing for the side windows as an option.

### **Does Audi also harness possibilities for amplifying sounds in the car or actively counteracting them?**

Active acoustics measures have become a lot more important in recent years. With active noise cancellation (ANC), for example, a certain portion of the engine sound can be reduced with cancellation sound. The system is based on ANC microphones (see diagram using the A8 as an example), which are built into the roof lining and measure the sound level in the interior. A control device reverses the disruptive sound waves and emits neutralizing sound waves through the subwoofers. On the other hand, the Audi SQ5 TDI even has actuators in the exhaust system



to emphasize desired sounds. These particularly robust speakers allow the sound of the engine to have a more present and dynamic effect, as desired. A sporty sound effect can also be dynamically generated in the e-tron GT electric sports car via the audio system in drive select mode.

### **How can an atmosphere that is experienced as pleasant and not disruptive take shape in the car?**

This is where the sound developers come in. They deal with all the sounds and – if necessary – adjust, suppress, or emphasize them. That’s because every individual sound contributes to the acoustic harmony in the car. Apart from many noise sources, every vehicle also poses special challenges as an acoustic space: the passengers sit in different positions and the space volume changes depending on the number of people inside. One vehicle has a panoramic roof, another doesn’t. In addition to that, interior materials like textile or leather covers reflect or dampen the sound differently. Not least of all, the time it takes sounds to go from the speakers to listeners’ ears differs.

### **How does 3-D sound work?**

The term 3-D sound describes a sound that acoustically reflects all three dimensions of a space. When audio recording was invented, sound was reproduced via one speaker – mono. Stereophonic sound is not possible that way and the sound is flat. In the 1960s, stereophonic sound was established: two microphones record the music from different positions. When it is played back, the recorded audio information – mono signals – is allocated to two different channels and played correspondingly via a left and a right speaker. That produces a sense of spacial sound, the stereo effect. The term “1-D” refers to that stereo sound.

Then “2-D” means surround sound: This multi-channel technology has been widespread since roughly the turn of the millennium. The music comes from a subwoofer and several speakers from the front, the back, and the sides – depending on the number of speakers, there’s a distinction between the 5.1 and the 8.1 standard. Nonetheless, on that level, every sound effect is assigned to only one speaker or only a particular group of speakers.

You need an additional sound source that is not on the same level to get 3-D sound. Since the current Q7 model generation was introduced in 2016, Audi has offered Bang & Olufsen sound systems with 3-D sound, which also reflects the spatial dimension of height. The systems use several additional broadband speakers for that, which are built into the A-pillar and, as in the A8 and Q8, also into the B-pillar as well as the roof liner. The interior becomes a big stage where



the music develops just as it was recorded in the hall. There's an algorithm behind this technology that Audi developed together with the Fraunhofer IIS. The Symphoria 2.0 3-D algorithm computes the information from stereo or 5.1 recordings for the third dimension and processes it for 3-D speakers. That makes sound effects flexibly placeable in the room. In the Bang & Olufsen advanced sound systems, as the highest configuration level in the full-size class, a 1,920 Watt strong amplifier works with a digital signal processor and 24 channels together with 23 speakers. That technology makes the passenger compartment acoustically larger. But Audi does not skimp on sound quality in the compact class either. On the contrary, it only adapts the technical concept to the spatial conditions. In the A1, for example, there are four mid-range speakers built into the dashboard that are directed vertically upward and use the windshield as a reflective surface. That way, high quality 3-D sound can be achieved even in a car in the compact class – which is quite exceptional in that class.

### **What role does digitization play in sound development?**

Attunement to a corresponding vehicle model is a central element of sound development. Audi has developed the soundCUBE for these special requirements. This audio software solution significantly reduces the variety of versions and the associated development time. With the soundCUBE, Audi is providing its partner companies with a framework that features its own functional configuration and a uniform operational and sound philosophy – in brief: an optimal development environment. Partner companies only have to integrate that framework, which, in a manner of speaking, defines the Audi DNA. That way, step by step, Audi can get the best modern sound from the existing hardware by using software that is constantly optimized.

Another innovation is the use of boosters that are operated via a uniform audio bus. Background: the sound is generated by software in the main unit of the current MIB 3 infotainment generation. In the premium sound system, boosters provide the additional service of controlling the high performance speakers. That also simplifies the system architecture.

In its ultra-modern digital sound lab, Audi is virtually refining new sound solutions. Using true-to-life simulations, the experts tweak the sound tuning for various series even before a prototype exists. That makes it possible to analyze each individual seat's sound configuration in the virtual reference room in order to ensure the best possible individual listening experience for every passenger in their respective sweet spot.

### **How does Audi benefit from the new partnership with Sonos?**

With the Q4 e-tron, Audi is making use of a new hi-fi partnership while remaining faithful to its natural, unadulterated sound: Audi made that choice for its high end sound systems in order to



be better able to meet customers' desires. While Bang & Olufsen, with its brilliant sound pattern, is a perfect fit for the demands of the mid- and full-size models, as a new partner for Audi, Sonos, with a bass-heavy sound, appeals specifically to a younger target group. Consequently, that sound brand fits perfectly with the new compact SUV, which is Audi's point of entry into the electric future. The dynamic sound and tuning philosophy that is linked with Sonos will be rolled out mid-year in other models in the compact class.

**Next big thing: What are Audi's audio developers working on at the moment?**

Even now, Audi's sound specialists are in the sound lab, intensively occupied with the holistic sound experience of tomorrow. What we call immersive 3-D sound is at the center of that. With conventional 3-D surround sound, sounds are allocated to particular speakers according to particular algorithms. Unlike this channel-oriented playback, immersive 3-D sound is object-oriented. In a process like that, the sounds in the audio files are already linked with metadata that contain the precise information as to how and where the corresponding sound should be heard in the actual space – a perfect reflection of the acoustic situation during recording. Immersive sound is the focal point of completely new entertainment experiences that affect all the senses. But it is only when people in the future, in an automatically driven car, are able to stop being dedicated to the task of driving that they will have all their senses free to be able to completely enjoy a sound experience like that.

The next big step: the future distribution of the 5G high-speed mobile communication standard is opening up new, high-quality streaming channels. Until now, a lot of people have used their smartphones in the car as the primary receiver for audio streaming services. It's convenient: the recording is simply transferred to the car using Bluetooth. But because the bandwidth for Bluetooth wireless technology is limited, there is a bottleneck that is sometimes accompanied by a loss of sound quality. In the near future, for the first time, Audi will use the car itself as a receiver – via the built-in SIM card and a high-performance receiver module for real multi-channel audio streaming. From the Audi sound engineers' perspective, it's another milestone on the road into the future.



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