Sound of silence

Researchers are developing the speaker of the future in a room from which no sound escapes to the outside world.

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The loudspeaker panels of the future are thinner than a nickel or a quid, as powerful as a floor speaker and can be mounted directly on the wall. The arrays consist of an arrangement of small transducers that convert the electrical signals into acoustic ones (left images).

Close-up of the transducer arrays (images center and right). *© Fraunhofer IDMT*

The massive door seals shut, the lock clicks, then everything is still. Frighteningly still. Thick wedges of mineral wool project like thorns into the room and swallow up every sound. The Acoustics Lab has massive walls of concrete and an independent foundation resting on a layer of rubber. Not a peep can interrupt the investigations here.

Wait – there is something. A quiet muttering? Or is someone singing? The hardly perceptible noise comes from a row of eight small loudspeakers mounted on a tripod in the middle of the room. And that is supposed to be the audio technology of the future? Curious, I follow Dr. Daniel Beer as he goes directly over to the strip of loudspeakers. The quiet muttering does not grow any louder, despite our coming so close. Or at least, not when you remain in the center. Now Beer takes a step to the right and waves me over. I walk over to him and suddenly hear music loud and clear: Marla Glen's "Cost of Freedom". As I take a step back toward the center, the music becomes softer and finally fades away completely. Astonishing! And if you step a little to the left, the voices grow louder: here you can listen to an audio book playing.

Researchers at the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau, Germany, have recently applied for a patent covering the technology that creates differing "Sound Zones". The trick: "All the speakers radiate the same program material – the audio book and the song," explains Dr. Daniel Beer, head of the Electroacoustics Group at IDMT. "Control of the loudspeakers assures that the sound waves are superposed and thereby either amplified or cancelled." This way, beams of high-quality sound are formed that can be precisely directed. Such as in a vehicle, for example. Located in the automobile headliner, the loudspeakers would provide acoustic autonomy for all of the occupants. Parents could relax during a trip listening to music without being disturbed by children's audio books entertaining youngsters in the backseat. Theoretically, an independent sound field can be created for each one of the seats. No wonder the automobile manufacturers have shown great interest in the new Personal Sound Zone technology.

However, the loudspeakers are still too bulky. The speaker enclosures that the demonstrator is constructed from in the Acoustics Lab of IDMT each require a volume of two centiliters – the size of a shot glass. The entire loudspeaker array is 34 centimeters long and four centimeters thick – an arrangement that has not been suitable for incorporation into the roofs of automobiles so far. The speakers therefore have to shrink: "One of the obstacles in miniaturizing the setup is the enclosure," explains Beer. His left hand forms an imaginary space which his right hand approaches closer and closer: "If we make the enclosure too small, the air in the interior acts like an attenuator that restricts the vibration of the membrane. You can imagine it like an air pump that is closed off: the air in the pump cannot escape and the piston that has to move to pump air is stuck. The same thing would happen to the membrane in too small a loudspeaker."

Couldn't you just do without the enclosure? "Theoretically yes," answers the engineer. "Without the enclosure, however, the sound produced by the transducer that transforms the electrical signals into acoustical ones would go in all directions." This would lead to a large loss of sound quality, because the interference of the sound emanating from the front side of the membrane and the rear side would deleate a good part of the low frequency sound waves. In short: the enclosure is necessary. It is a pivotal element of good sound.

How far can it be reduced in size, though? To find that out, Beers' team set up a measurement station in the basement of the Institute to determine the minimum enclosure volume for each transducer. There is a new design on the test pedestal today – especially flat, especially small. Although only 11 mm thick, it contains all of the components needed by a transducer: the membrane with a coil on its rear surface, and the permanent magnets.

Beer rolls up the sleeves of his hoody and powers up the transducer. Because an electromagnetic field now develops around the coil, which is magnetically attracted or repelled by the permanent magnets, the membrane begins to vibrate. "Because the signal current in the coil is moving through the magnetic field of the permanent magnets, the current carrier – the wire of the coil – feels a perpendicular force proportional to the signal current and moves the coil as well as the membrane attached to it."

Software calculates the necessary volume of the enclosure from the vibration behavior. The new transducer requires a volume of one centiliter – about half a shot glass. It has therefore been reduced by half compared to the demonstrator. The volume can even be reduced further using technical tricks: "By using stronger drive that overcomes attenuation by the air, we can save an additional third," explains Beer. The enclosure for the midget transducer is precisely constructed in the Institute's own workshop. Does the miniaturized loudspeaker still deliver the desired performance?

For the acid test, we return to the Acoustics Lab. And again encounter this eerie silence. Beer's voice sounds muted: "Admittedly, it's something you have to get accustomed to. But I like being here. It is the ideal place to test loudspeakers because there are no reflections to disrupt the measurements." The room is almost acustically dead. Almost, because reflections can never be eliminated 100%, despite the thick wedges of mineral wool. So the researchers refer to their lab as "poorly reflecting."

Acid test in the Acoustics Lab

Beer has mounted the loudspeaker on a pedestal that rotates, and he now closes the door – from the outside, because no one may remain inside during testing: sound waves reflecting from a human body could taint the results. He starts the standardized test remotely from the control room next door. He can observe what happens via a camera. The new loudspeaker rotates around its own axis on the stand one degree at a time, then turns facing upward and rotates again until all the directions in the room have been covered. He generates identical tones at every measurement point that sound like the squeal of a guinea pig. A microphone captures this sine-wave sweep tone and sends the signals to a computational unit. Now curves appear on the monitor screen. Beer nods in satisfaction: the radiation pattern is good. "If we improve the little loudspeaker a bit more, it should be powerful enough and loud enough to overcome the road noise." Eight of them located beside one another could then make individualized listening pleasure possible for the occupants of a vehicle, thanks to the Personal Sound Zone technology.

The new mini-speakers are not just suited to mobile sound applications, though. Flat speaker arrays containing dozens of the small sound sources connected can create optimum sound in living and conference rooms. "The sound quality is comparable to high-quality stereo loudspeakers," Beer emphasizes. And thanks to the tiny integrated enclosure, these kinds of flat speakers can be mounted directly on the wall, which opens up completely new applications. You can integrate them into a decorative picture, a flatscreen monitor, or a cabinet door. The sound of the future will no longer distract the eye. ■