

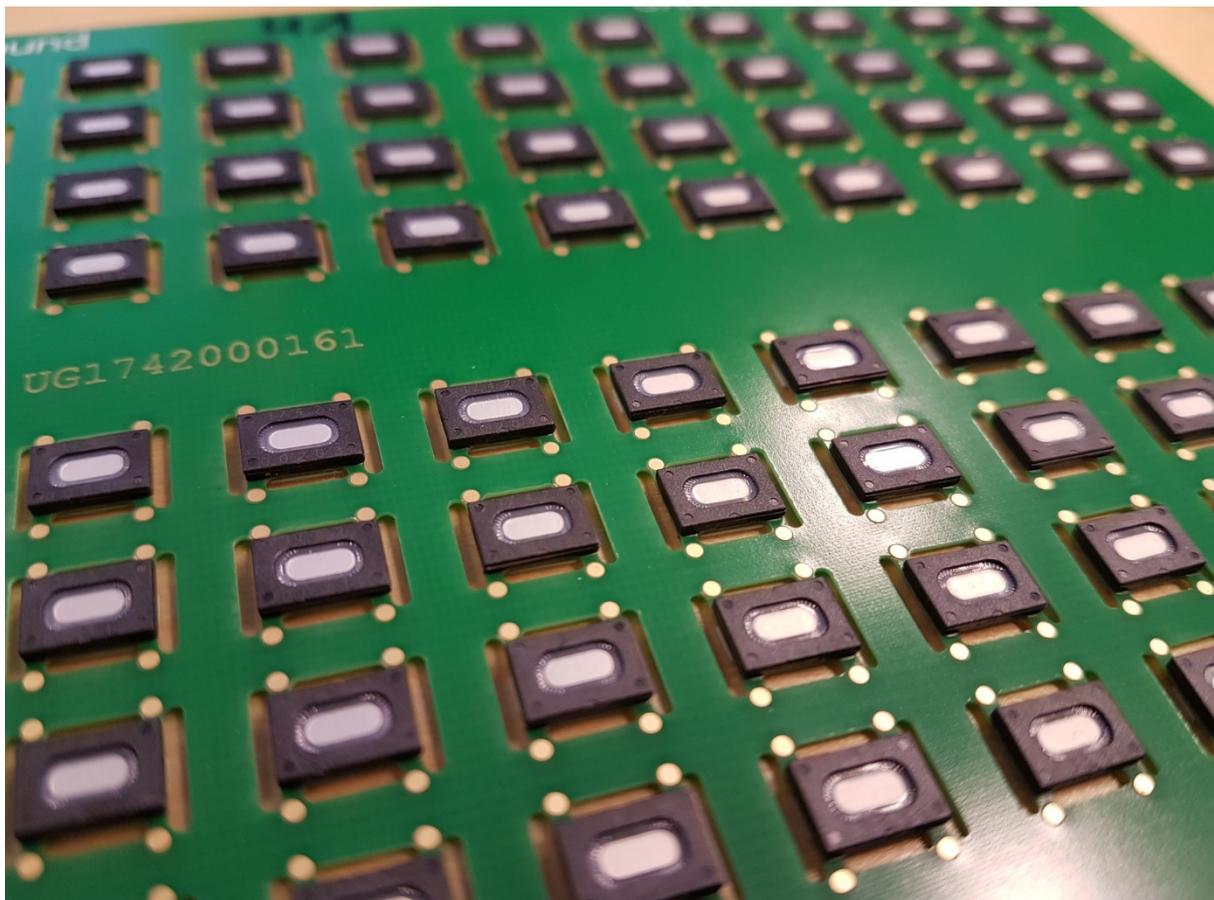
What are the advantages of MEMS loudspeakers?

MEMS-based loudspeakers are a new technology that challenges the status quo of electrodynamic and balanced-armature speakers. A frequently asked question is, how are MEMS speakers better? We strive to answer this question in this article.

First of all, we have to separate general advantages from application-specific advantages.

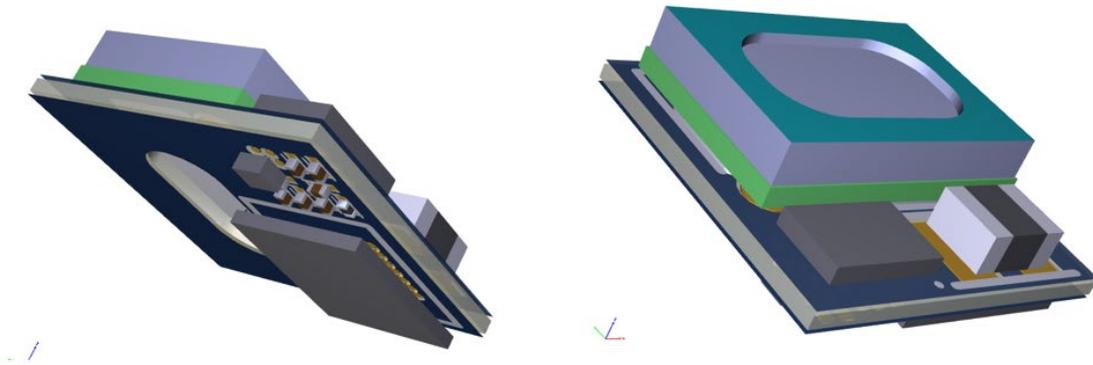
The general advantages of MEMS loudspeakers are:

- Seamless integration in an electronic PCB; in fact, the speaker itself is built on a PCB substrate. The speakers can be easily integrated in a PCB with the whole electronic of wireless earbuds, headphones, wearables, etc.



- Integration of the amplifier and of the MEMS speaker on the same PCB substrate. USound provides audio modules with analog and digital interface; this dramatically shortens the times needed to design audio products. The

audio modules include programmable filters that can be changed to easily tune the audio. The firmware delivered with the audio module includes different sets of filters that pre-considers several use cases.



- Lower power consumption. Despite the fact that MEMS speaker requires higher voltage levels compared to electrodynamic speakers, the overall power consumption is lower. The MEMS speaker, due to the own intrinsic high impedance, demands a lower driving current. Below, you can see the driving current of the MEMS speaker measured in an IEC coupler at 94dB SPL with 3 different methods. Included also the current consumption of a reference balanced armature and electrodynamic speakers.

Measurement USound Ganymede (MEMS)	Current Consumption [mA]
IEC 60268-1	0.28
Pink Noise	0.57
1 kHz Signal	0.11

Measurement Knowles 26824 (BA)	Current Consumption [mA]
IEC 60268-1	0.46
Pink Noise	0.76
1 kHz Signal	0.33

Measurement Samsung HS330 (ED)	Current Consumption [mA]
IEC 60268-1	1.43
Pink Noise	1.84
1 kHz Signal	1.92

The low current consumption makes the MEMS speaker the perfect companion for all audio wireless application like true wireless earbuds.

The power consumption of MEMS speakers can be further reduced taking advantage of their capacitive load. Electrically, MEMS speakers behave like capacitors, therefore the main portion of power is reactive and can be re-used in the system. USound's new digital power amplifier can recover a significant percentage of the reactive power.

	Knowles 26824	Samsung HS330	Ganymede
Active Power*	50.5 %	89.9%	7.0 %
Reactive Power**	49.5 %	10.1%	93 %

Application-specific advantages

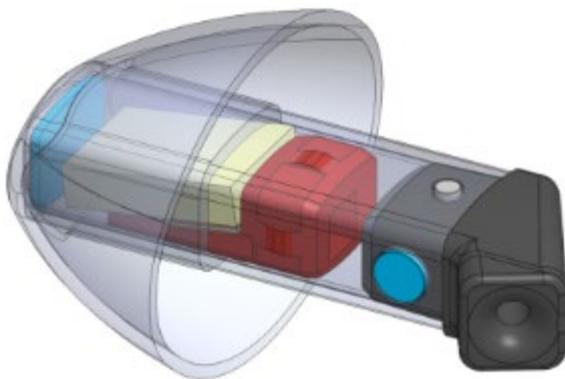
The application-specific advantages must be separated into two main kinds of applications:

- occluded-ear applications, where the speaker, mounted in an earbud, sits inside the ear canal. In this kind of application, the ear exclusively captures the sound emitted by the loudspeaker; external sounds are attenuated by the sealing of the earbud.

- free-field applications, where the speaker is placed outside the ear and the ear is free to capture sound coming from additional sources other than the loudspeaker itself.

Advantages for occluded-ear applications

- The main advantage is the overall small form factor. This considers the dimension of the loudspeaker and of the back and front volume that, with the MEMS speaker, can be kept to the minimum. The image below shows the ear tips of Megaalite our reference design for USB-C earbuds.
- Combining the low power consumption with the small overall form factor showcases the main advantage for wireless earbuds: The small form factor allows the usage of larger batteries and the lower power consumption drain less current from the battery, resulting in an overall extended battery life.

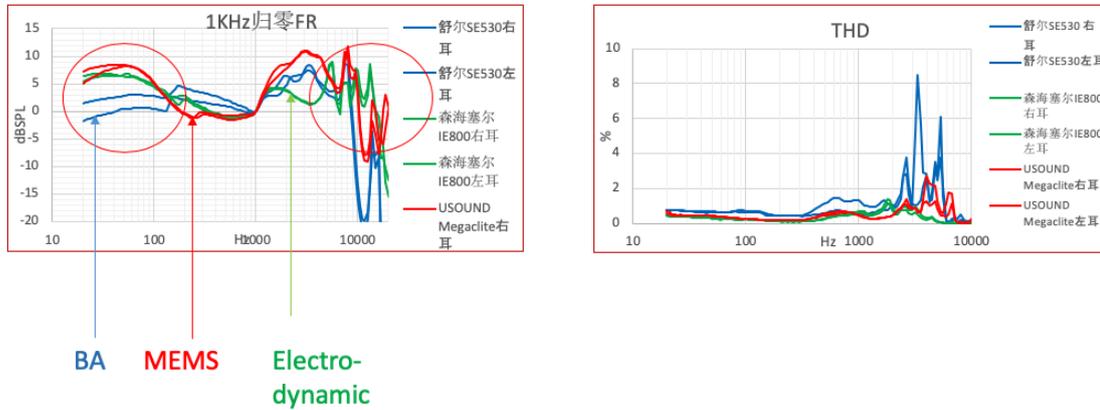


- The large bandwidth achieved by a single driver MEMS. Below a test report made by a major Chinese audio company that compares USound MEMS-based earbuds with two top-notch brands. The results clearly show that a single MEMS driver can easily compete with an electrodynamic and multi-driver balanced armature configuration. This makes the MEMS speaker a compelling technology for true-wireless earbuds. The combination of low power consumption, small form factor and the widest possible bandwidth

provides unprecedented advantages for true wireless manufacturers and end-users.

Test signal : 20~20KHz swept-frequency signal

Signal Amplitude : Shure SE530 & Sennheiser IE800@1mW USOUND demo@300mv



➤ Objective test conclusion :

USOUND MEMS loudspeaker reaches the same level as Sennheiser at low bass

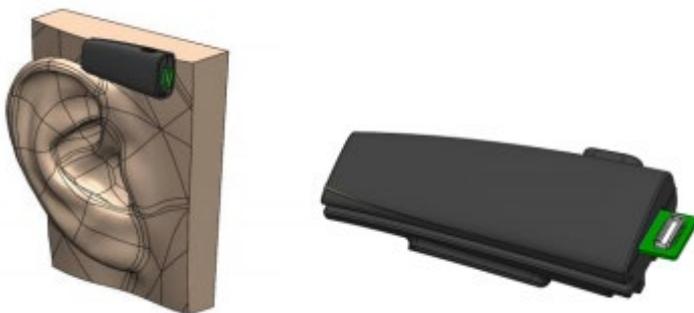
USOUND MEMS loudspeaker reaches the same level as Shure BA at high frequency

USOUND MEMS loudspeaker THD performance is good at full frequency

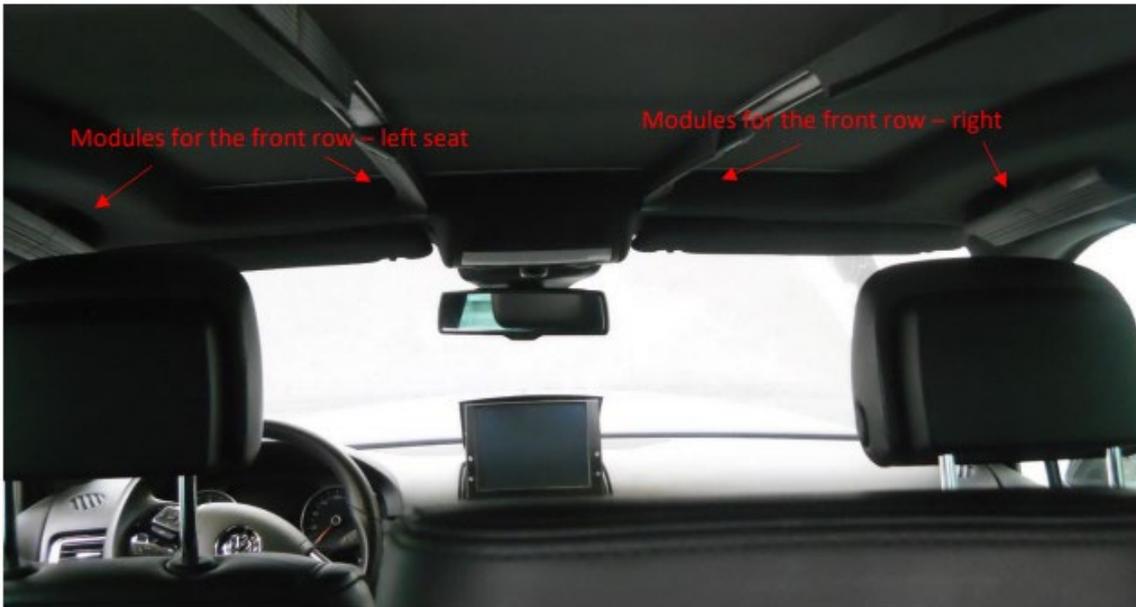
Advantages for free-field applications

For free-field applications, the small form factor is not suitable for full-bandwidth applications. Nonetheless, MEMS speakers offer unique advantages as a high-quality tweeter with extended bandwidth in the ultrasonic region (up to 80kHz).

- The small form factor is suitable for all kinds of wearable applications. In 2019, USound started marketing an audio module for AR/VR glasses that includes a fully digital audio system. This system includes an electrodynamic woofer and a MEMS tweeter and provides, compared to single-driver systems, much brighter sound and a unique feature that focus the sound around the user's ears and attenuates the level of the audio signal even at a very short distance from the ear, guaranteeing a good degree of privacy.



- Another application that takes advantage of the thin form factor of MEMS speakers lies in arrays, e.g., in automotive sound systems. A modular array such as USound's reference design Harpalyke can be mounted directly in the car ceiling, removing often bulky and heavy tweeters from the car. Not only does the MEMS audio system reduce weight and frees space in the car, but the audio is oft a crisper and brighter quality, thus providing a unique listening experience.



Final thoughts

MEMS speakers are a new technology and their full potential will be revealed step by step. Already now, this technology provides unique features and compelling advantages compared to electrodynamic and balanced armature speakers. In the fast-evolving audio market, early adopters of MEMS technology can provide unbeatable advantages to their end-users.