Replacing ECMs with Premium MEMS Microphones

About this document

Scope and purpose

This document provides reasons to replace electret condenser microphones (ECM) with premium MEMS microphones.

Intended audience

Infineon XENSIV™ MEMS microphone customers.

Table of contents

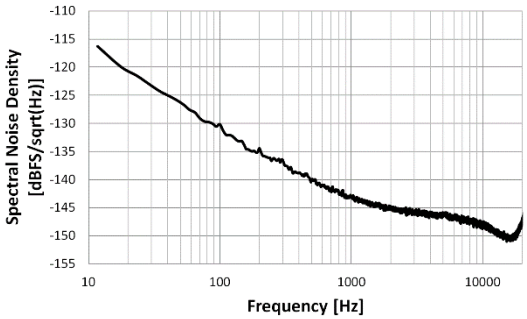
Abstract

Mobile phones and many other consumer electronics devices have switched from electret condenser technology over to micro-electro-mechanical microphones, from ECMs to MEMS. Due to the great improvements in MEMS technology, the change is happening also in applications with high performance requirements. The performance/size and performance/cost ratios of modern MEMS microphones, as well as their reliability, have reached levels at which any remaining reasons to stick with ECMs have vanished.

New High SNR Digital MEMS Microphones versus ECMs

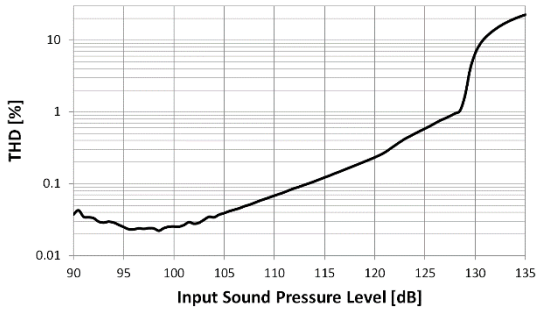
Performance: SNR and AOP

The performance of MEMS microphones has improved tremendously in the past 10 years. The signal to noise ratio (SNR) of Infineon's IM69D130 microphone is over 10 dB higher than MEMS microphones which were available in the market 10 years ago. High SNR improves modern sound capturing systems in many ways:



- Better far field audio signal pick-up
- Capturing of low volume audio and whispers

The ability of microphones to capture high sound pressure level (SPL), quantified by the acoustic overload point (AOP), has also increased dramatically. The 130 dB_{SPL} AOP of IM69D130 is well suited to the varied acoustic conditions and environments of modern devices.



AOP is defined as the acoustic input level which results in 10% total harmonic distortion (THD) at the output. 10% THD is already audible and unpleasant to the listener, meaning this legacy standard does not fully reflect the audio quality expected of modern devices. Most audio equipment such as professional headphones and studio microphones are specified so that the AOP refers to a 1% THD level.

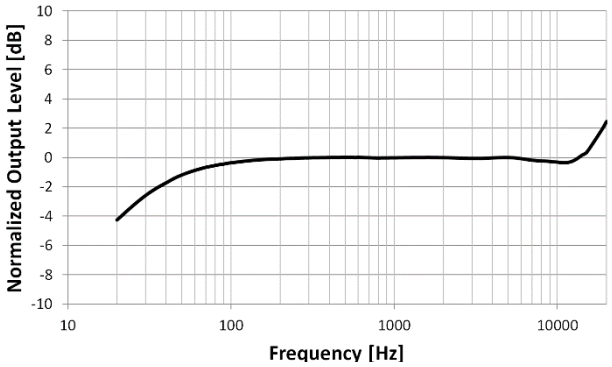
The THD of IM69D130 is below 1% up to input levels as high as 128 dB_{SPL}. Maintaining low THD is important in cases where even moderate distortion causes reduced system performance or audible signal quality degradation: speech-controlled systems (in which voice commands may have to compete with music from adjacent speakers) and noise cancellation systems function better when the distortion level in the incoming signals is low. Recording of music or other such content is benefitted by low distortion. The AOPs of moderately priced ECMs tend to be low and the THD levels rise significantly already at relatively low sound pressure levels.

High pressure acoustic signals do not only come from loud music. In many use cases such as smartphones or noise-cancelling headsets, it is necessary to operate outdoors, where low frequency wind noise can easily overload traditional microphones, causing clipping. This is not only unpleasant to listen to, but can also cause reduced performance of active noise cancellation algorithms.

The IM69D130 has a dynamic range of 105 dB. This is enabled by the fully differential dual back plate sensor, the ultra-low-noise preamplifier and a highest performance sigma delta analog to digital converter (ADC). ECMs with this performance level tend to be very expensive and large.

Frequency Response

MEMS technology enables achieving a very wide frequency response. The small, lightweight membrane has a high resonance frequency, enabling the reception of very high frequencies. The -3 dB cut-off point of IM69D130 is 28 Hz, allowing capture of almost the entire frequency range of the human ear. The flat frequency enables balanced, high fidelity sound capturing. The frequency response of ECMs tend to be limited and irregular, with a high-mid frequency bias due the lower resonance frequencies of their sensor membranes.

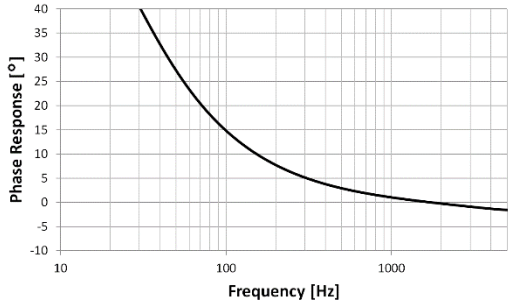


Digital Interface

Digital interfaces are very robust to electrical noise sources encountered in long signal chains, enabling disturbance-free microphone signals. MEMS microphones are available with PDM interfaces that make the microphone implementation easier, more reliable and faster than analog ECMs. With digital microphones there is less need to design and execute disturbance mitigation. PDM is supported widely by the systems used in consumer electronics devices. The digital signal chain of the IM69D130 is designed for low latency operation (6 µs at 1 kHz) which does not compromise system performance.

Using board mounted MEMS microphones allows for better control of routing and shorter traces. This enables improving the interference immunity of the system even further.

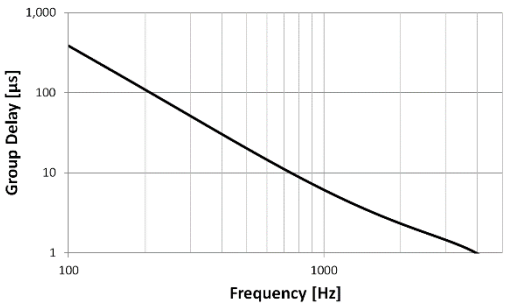
Matching and Stability



Modern MEMS microphones use highly accurate semiconductor production processes, allowing for better part to part matching than is seen in ECMs. MEMS microphones are also very stable over time and over variation in environmental conditions, such as humidity and temperature. In some cases, ECMs can be purchased as matched pairs but even that does not improve their short or long term matching to the level of MEMS microphones.

Infineon MEMS microphones use a charge pump to deliver the biasing voltage of the MEMS. The charge pump output level is calibrated during factory production to guarantee a sensitivity matching of ±1 dB in all microphones. This ensures that MEMS components don't change their properties due to environmental factors and that accuracy is maintained throughout the lifetime of the device. Infineon's high-performance microphones are sensitivity and phase matched (±1 dB and ±2°, respectively) to support even the toughest beamforming requirements. Microphone accuracy affects the performance of capturing arrays: speech recognition systems, background noise cancellation, accuracy of directional capturing beams, accuracy of stereo soundscapes, etc.

In contrast, ECM structures are biased using a fixed charge on the electret, which is applied during the manufacturing process to set the sensitivity. This charge is not renewed after the microphone is shipped, and escapes from the electret material over time. Charge loss is accelerated by environmental factors such as temperature and mechanical shock. In the case of surface mount components, the reflow process they ungergo causes a drop in the charge. The loss of charge cannot be accurately predicted and causes sensitivity loss and compromised frequency response.



High-quality MEMS microphones, such as Infineon's IM69D130, of the same make and model, are more **closely** matched in sensitivity, phase response, frequency response, and SNR than a matched pair of ECMs. The process of using paired microphones is logistically cumbersome and it typically increases the price of the components; it adds costly testing and matching steps, and the need to track and handle known pairs in system manufacturing. Having matched pairs does not mitigate the problem of changing ECM properties over time. The poor momentary and lifetime accuracies of ECMs makes them poorly suited for applications that require high accuracy of sensitivity and phase, such as arrays.

100% of the parameters in Infineon's data sheets are tested to ensure that the high accuracy level is maintained at all times.

Quality and Reliability

Microphones are subjected to harsh usage conditions such as dropping, temperature changes, and other potential hazards, especially in portable devices such as smartphones and wearables. Infineon's high-quality robust MEMS sensor technologies endure everything the device has to endure. The high reliability and quality of the microphones are verified with industry standard testing during component development and mass manufacturing.

Small Size

The small sizes of MEMS microphones enable many improvements in device design:

- For a single omnidirectional microphone application, the performance/size ratio offered by Infineon's MEMS microphones is clearly superior than traditional ECM technologies
- The higher performance density means that the same, or even higher, microphone performance is available in a greatly reduced package size
- Reduced microphone size can allow for optimization of system size or parameters, e.g. reduced bezel width
- Microphone implementation in tight places where ECMs may not fit
- The smaller height or width of a MEMS microphone may suit the implementation better
- Small size and cost allows for easier and cheaper implementation of microphone arrays
- Multiple MEMS microphones can replace an ECM while maintaining a small implementation size
- Two or more microphones can be used to create a variable directivity microphone system; the added versatility helps optimize the capturing capabilities of multi-purpose devices in all their use cases

Directivity and Versatility

Multiple omnidirectional MEMS microphones can be used to create directional capturing systems, enabling very versatile solutions which adapt to multiple use cases. Fixed directionality ECMs can be replaced by adaptable MEMS arrays. Cases in which versatility is needed include:

- Teleconference with one person using the device vs. multiple participants using the same device
- Capturing sounds from the front of the camera vs. behind the camera (narration by the camera operator, or creating a cardioid mic pattern to focus on the front of the camera)
- Capturing the sound of the object in the film frame vs. capturing the ambient soundscape

The versatile directivity can be achieved without significantly increasing the size of the implementation when compared to directional ECM capsules. A simple switchable-directionality system can be formed with two small MEMS microphones. Using three or four MEMS microphones and simple electronics enables creating a multi-directional capturing system with a wide variety of directivity patterns: mono, directional mono (cardioid, figure-of-8, etc.), audio zoom (variable directional pattern), adaptive beam steering, stereo, directional stereo, multi-channel surround, etc. The accurate performances of MEMS microphones enable very high array performances. Using omnidirectional microphones for directional systems also enables improving signal quality in windy conditions by choosing the microphone with the cleanest output and/or switching to an omnidirectional mode. This is not as easily achieved with directional ECMs.

Production

MEMS microphones are compatible with standard consumer electronics production processes and methods. Some ECMs must be hand soldered onto the device circuit board, which is an expensive manufacturing requirement. MEMS microphones can be mounted in the existing solder reflow stage and do not require special treatment or handling steps.

MEMS microphones are typically supplied on tape & reel.

For further advice on mounting MEMS microphones, please refer to App Note AN557.

Revision history

Document version	Date of release	Description of changes
V1.0	2018-10-05	Initial release