Introduction

This application note demonstrates how combining Soundskrit's latest SKR0600 microphone with a typical omnidirectional microphone creates a high SNR beamformer.

As described in AN-220: Creating Different Polar Patterns, the signals from an omnidirectional microphone and dipole microphone can be combined with varying weights to create a variety of different beam patterns. Additionally, because the beam patterns are created by adding the two microphone signals, the SNR of the beamformer increases relative to any single microphone. The relationship between the different beam patterns and associated SNR is shown.

Test Setup

A SKR0600 dipole microphone and a 67 dB SNR omnidirectional microphone (Knowles Falcon) were placed on a PCB as shown in Figure 1. It should be noted that unlike traditional microphone arrays that require a minimum distance between the microphones, when combining dipole and omnidirectional microphones, the closer the spacing, the better the performance. The closer spacing reduces phase differences resulting in better coherence. This enables the design of high SNR beamformers with a small footprint.

Figure 1: Dipole + omnidirectional microphone PCB

The PCB on which the microphones were mounted had a diameter of 15 mm and a thickness of 1.6 mm. As described in AN-110: Attributes of Soundskrit Microphones, this creates an acoustic path length of ~16.6 mm. Since the SKR0600 is specified with an acoustic path length of 10 mm, the additional length creates a larger pressure difference at the two sound ports, boosting the sensitivity and thus SNR of the microphone >67.5 dB. The PCB was then connected to Soundskrit's development board (the PARDI board seen in figure 2).

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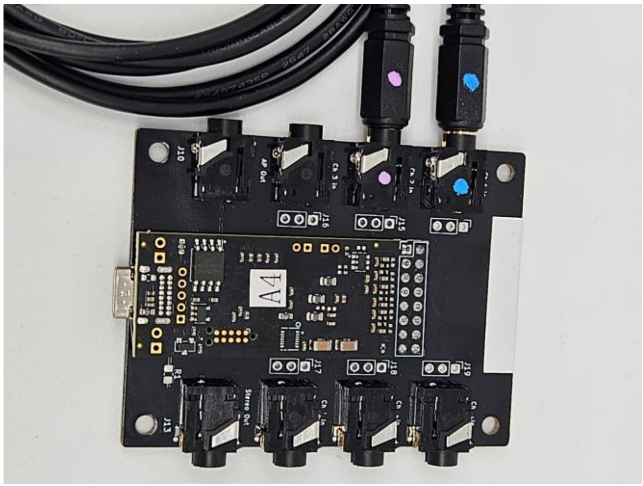


Figure 2: PARDI board

The PARDI board acts as a sound card and allows easy acquisition of the omnidirectional and dipole signals. The two signals can then be equalized in software and combined with varying weights to create a cardioid, hypercardioid, and supercardioid beam pattern. The directivity index, unidirectional index, and SNR of each polar pattern were then measured. The PARDI board was not designed to capture very high SNR signals, so it adds a non-negligible amount of noise to the system. Thus, the measured SNR of the microphones is lower than expected if one were to use a higher performance acquisition system. Nevertheless, the signals were sufficient to create a high SNR beamformer. Figure 3 below shows the equalized omnidirectional and dipole microphone responses.

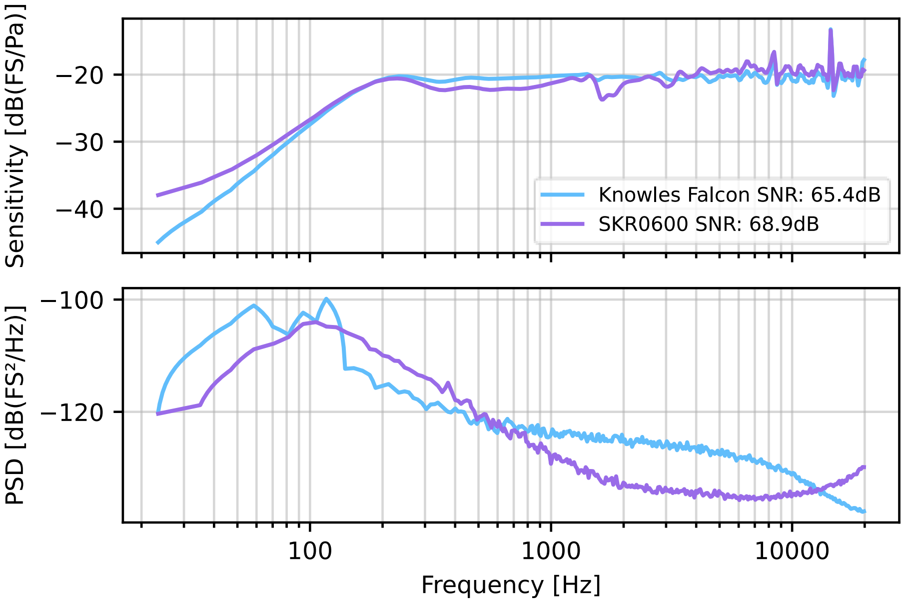


Figure 3: Omnidirectional and dipole microphone responses

As can be seen, the dipole measured ~69 dB while the omnidirectional microphone measured about 65.4 dB SNR. Later in this application note, we show the achievable SNR values if a higher performance acquisition system was used.

Results

The table below shows the directivity index (DI), unidirectional index (UI), and signal-to-noise ratio (SNR) of the various beam patterns created by combining the omnidirectional and dipole microphones.

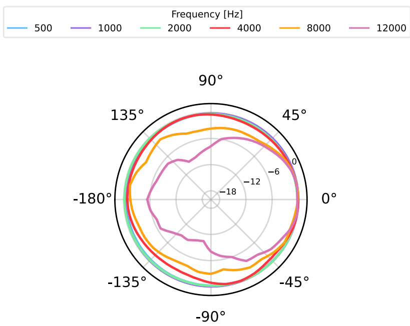
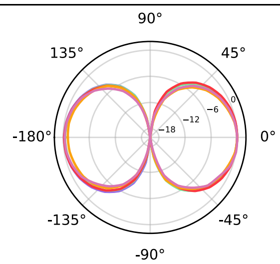
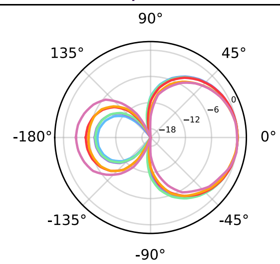
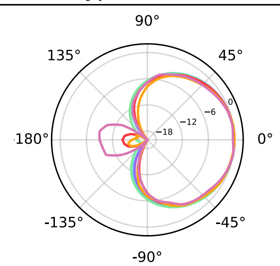
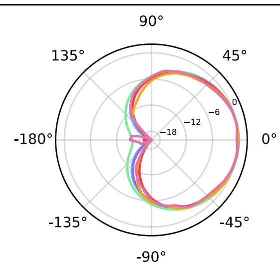
Polar Pattern	DI (dB)	UI (dB)	SNR (dB)	Comments
 *Omnidirectional*	1.0	0.9	65.4	The omnidirectional microphone is the Knowles Falcon on the circular PCB. Due to scattering effects when mounte d on the PCB, omnidirectional microphones become directional at higher frequencies, resulting in a DI >0 dB.
 *Dipole*	5.1	0.2	68.9	The dipole response from the SKR0600 exhibits very consistent directionality across all frequencies. The dipole is great for rejecting noise off to the side and provides a natural proximity boost when used close to a user's mouth.
 *Hypercardioid*	6.0	7.4	70.5	The hypercardioid provides the highest DI out of all the beamformers. It is best suited for removing diffuse background noise and reverb, where unwanted noise is randomly distributed across all directions.
 *Supercardioid*	4.9	8.7	68.8	The supercardioid provides the highest UI of all the beamformers. It is best suited when the unwanted noise is primarily located behind the microphone.
 *Cardioid*	4.5	7.3	68.3	The cardioid beam pattern has a strong null at 180 degrees. It can be strategically placed so that it's null points toward loudspeakers in a device to improve AEC, or towards a nearby wall to reduce potential reflections off the back wall.

Figure 4: Table of beam patterns with associated performance

Theoretically Achievable Values

When creating a beamformer using omnidirectional and dipole microphones, the noise levels of each microphone will affect the SNR of the combined beamformer. Since each beam pattern assigns different weights to the dipole and omnidirectional microphones, the noise levels of individual microphones impact some beam patterns more than others. For example, the cardioid beam pattern is more affected by the SNR of the omnidirectional microphone than the hypercardioid.

When using the SKR0600, any typical omnidirectional microphone on the market can be used to create any of the beam patterns above. To aid in the selection of the appropriate omnidirectional microphone, Figure 5 below plots the theoretical SNR for each beam pattern when using omnidirectional microphones of different SNR values. Here, the SKR0600 is assumed to be mounted on a PCB like the one shown in Figure 1, giving 69 dB SNR for the dipole.

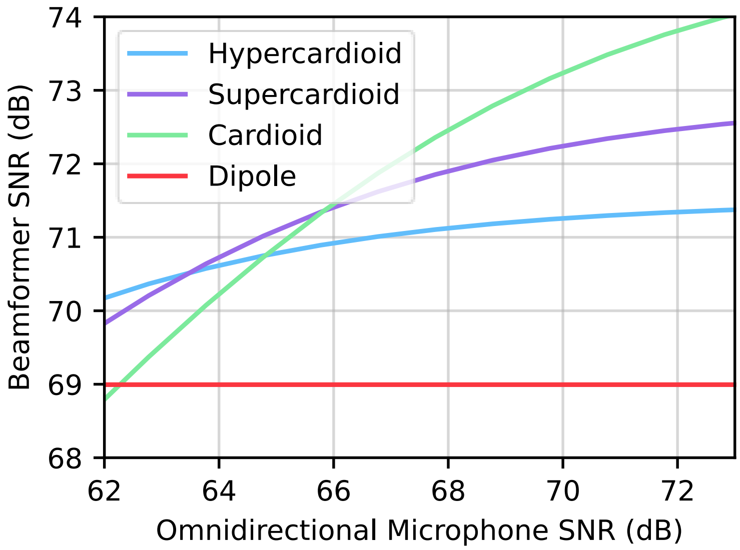


Figure 5: SNR of beam patterns when using different SNR omnidirectional microphones

As shown, the higher the SNR of the omnidirectional microphone paired with the SKR0600, the higher the SNR of the combined beamformers. However, increasing the SNR of the omnidirectional microphones has diminishing returns on increasing the overall beamformer performance.

Conclusion

The SKR0600 can be combined with standard omnidirectional microphones to provide flexibility to audio capture systems. The two microphone signals can be combined to create any number of different beam patterns with consistent directionality across the audible spectrum. Furthermore, with a sufficiently performant omnidirectional microphone, beamformers with an SNR well over 70 dB can be easily achieved.

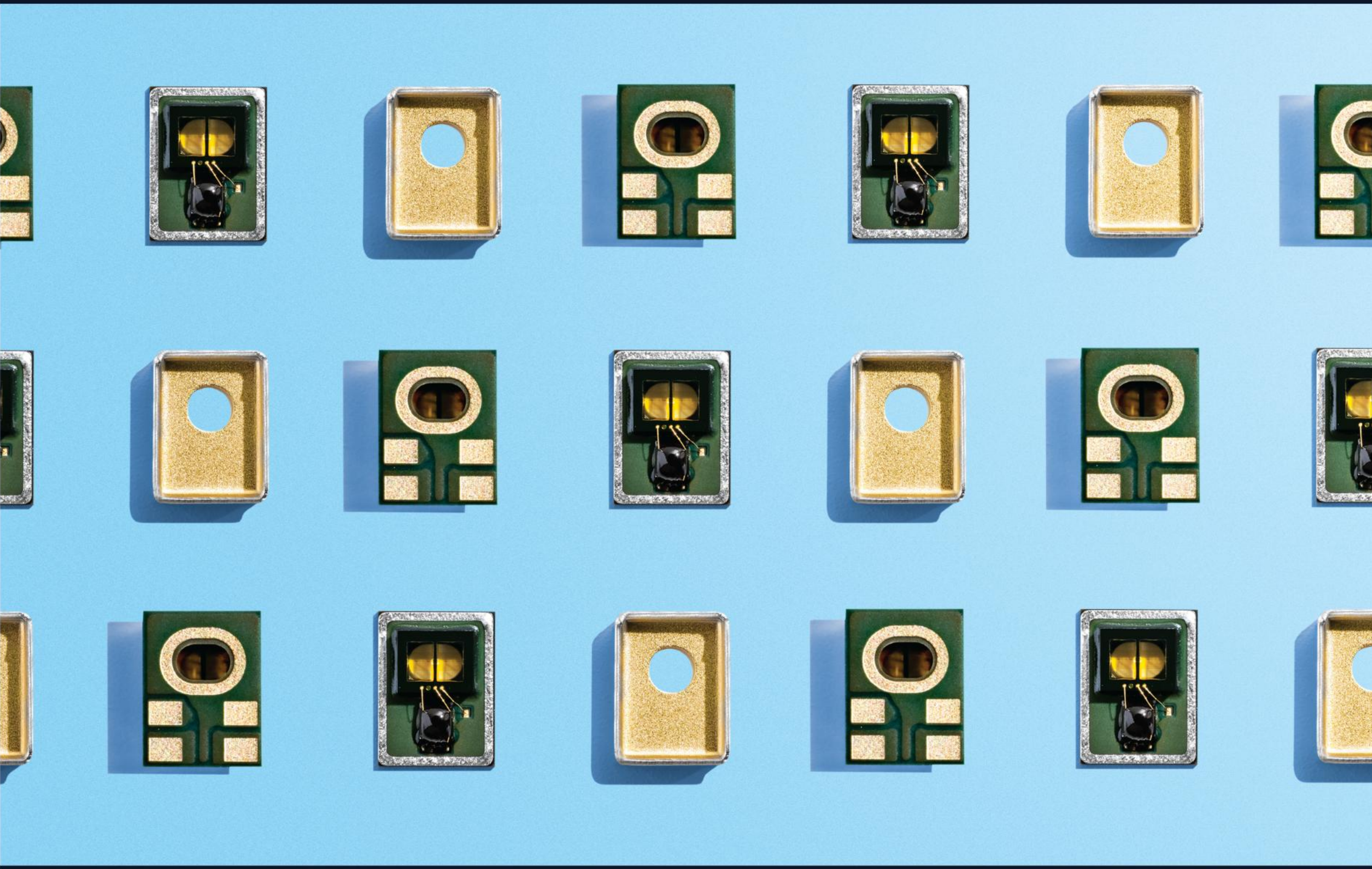
Additional Support

For further information on Soundskrit's products, visit our website at http://www.soundskrit.ca where you can find more application notes, datasheets, and purchasing information. If you have any questions or need technical support, please reach out to applications@soundskrit.ca.

Revision Label	Revision Date	Sections Revised
-	March 2023	Initial release
B	February 2025	Minor improvements for clarity

Soundskrit developed the first high-performance directional MEMS microphone on the market, leveraging years of research in bio-inspired MEMS based on how spiders and other insects in nature hear. In combination with Soundskrit's in-house audio processing algorithms, directional microphones can be used to capture and isolate any sound in an environment with a fraction of the size, power, and computation of traditional omnidirectional-based microphone arrays.

Soundskrit was founded in 2019 and is headquartered in Montreal, Quebec with an R&D facility in Ann Arbor, Michigan.



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