76 dB SNR Supercardioid Boom Microphone Design Concept

1. Characteristics

- Supercardioid polar pattern
- Ultra compact boom
- Flat frequency response
- Compatible with passive headsets
- Internal pop filter
- 76 dBA SNR
- 5.2 dB DI
- 7.4 dB UI
- Ø10.0 mm x 7 mm

2. Description

This design concept details how to create a boom microphone with extremely high SNR and directionality using the SKR0600. A simple filter is also included which flattens the frequency response of the microphone and makes the MEMS microphone compatible with passive headset connectors designed for ECMs such as in a laptop or desktop computer.

This compact design can be made as small as 1 cm in diameter so that it can fit neatly in designs using retractable booms. This document details the necessary acoustic parameters and components, but the ID is flexible. It can be a cylinder as the renders in this document show, or in a rectangular, pill, or other shape so long as the key dimensions are followed. At the end of this document are measurements taken of a prototype of this design to show the performance.

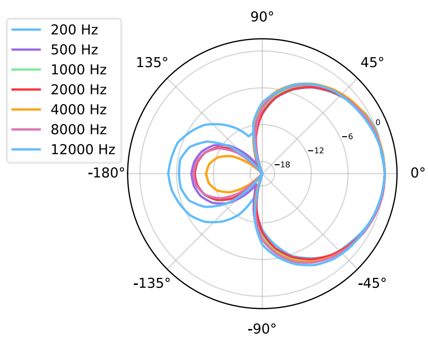


Figure 1: Supercardioid polar pattern

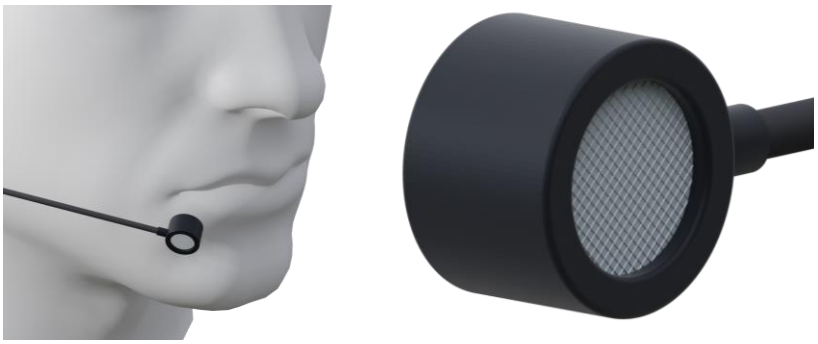


Figure 2: SKR0600-DC-B01 Model

3. Functional Overview

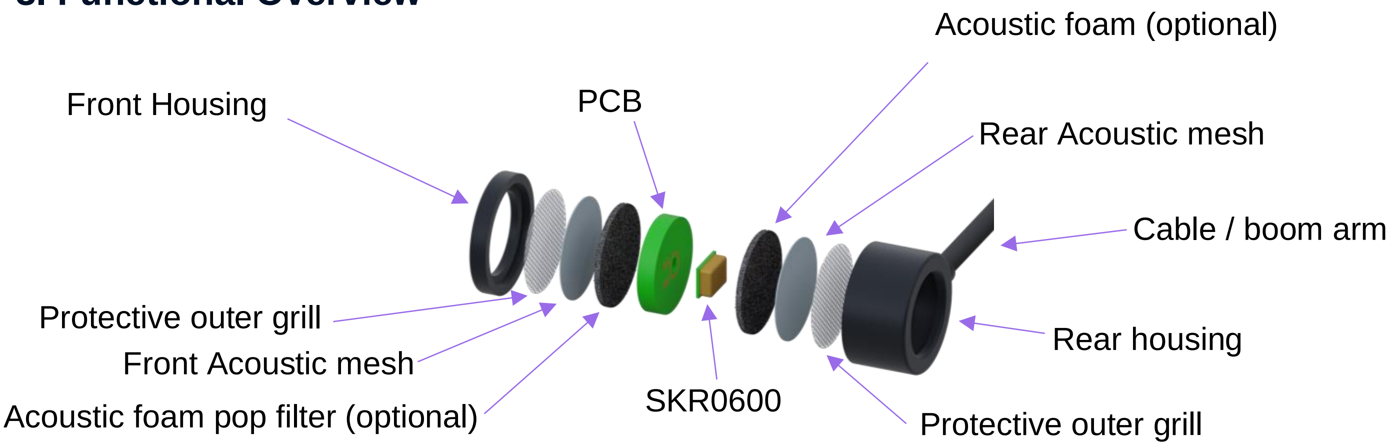


Figure 3: SKR0600-DC-B01 Exploded View

4. Mechanical Overview

4.1 Mechanical Dimensions

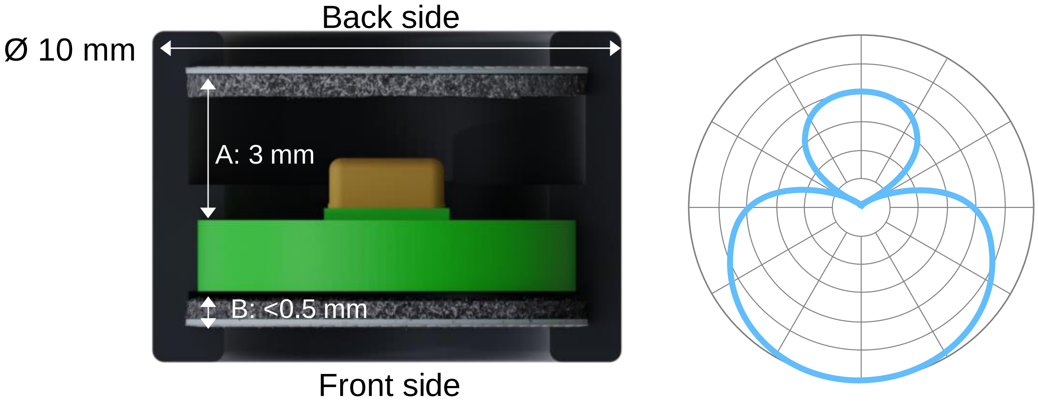


Figure 4: Cross section and polar pattern to show direction

Dimensions		
Label	**Dimension**	**Notes**
Ø	10 mm	The diameter of the microphone. The SNR performance is proportional to the outer dimension of the shell. Larger diameters will increase SNR, smaller diameters will decrease SNR. The microphone can take any shape, not just circular, but the shortest dimension of the face has the greatest impact on SNR.
A	3 mm	The distance from the back of the PCB to the rear acoustic mesh.
B	<0.5 mm	The distance from the front of the PCB to the front acoustic mesh. This should be as small of a gap as possible. 0.5 mm allows space for an acoustic foam to be used as a pop filter.

4.2 Acoustic Components

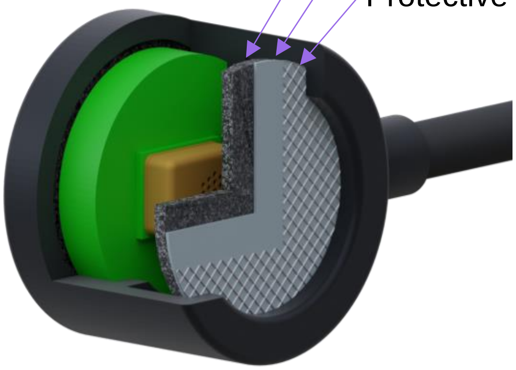


Figure 5: Cutaway showing acoustic interface

Components			
Component	**Paramenter**	**Description**	**Recommended Part**
Protective outer grill	N/A	This metal mesh is used to protect the opening of the microphone. This can be constructed in many ways but must be as acoustically transparent as possible. The goal is to have the opening in the shell to the microphone be as large and unrestricted as possible.	N/A
Front Acoustic Mesh	42 Rayl	Acoustic mesh for ingress protection.	Saati Acoustex 042
Rear Acoustic Mesh	1050 Rayl	Acoustic mesh for shaping the polar pattern. This mesh adds resistance to the rear port of the microphone to create a supercardioid. If this mesh is matched with the front acoustic mesh, it will create a dipole polar pattern.	Saati Acoustex HD10
Acoustic Foam (Optional)	50-80 ppi	This foam can be used for an internal pop filter in the microphone.	

4.3 Acoustic Design Considerations

Acoustic Seal - There must be a proper acoustic seal between the outer shell and the PCB to separate the front and back sides.

Dipole Polar pattern – To create a dipole polar pattern, use the 42 Rayl mesh for both the front and the back. In this case the spacing (dimensions A and B) should be symmetrical and can both be 1.5 mm.

5. Electrical Design

Directional MEMS microphones have two challenges for use with passive headset circuits such as a laptop headset jack. First, the power scheme for MEMS microphones is different than for an ECM microphone typically found in boom headsets. Second, a directional microphone has a non-flat frequency response which typically is corrected with a software EQ. This circuit addresses both issues. The circuit below implements a '2-wire' configuration to create compatibility with analog headset jacks and has a notch filter to create a hardware EQ to flatten the frequency response. All measurements below in section 6. Test Report were taken with this circuit.

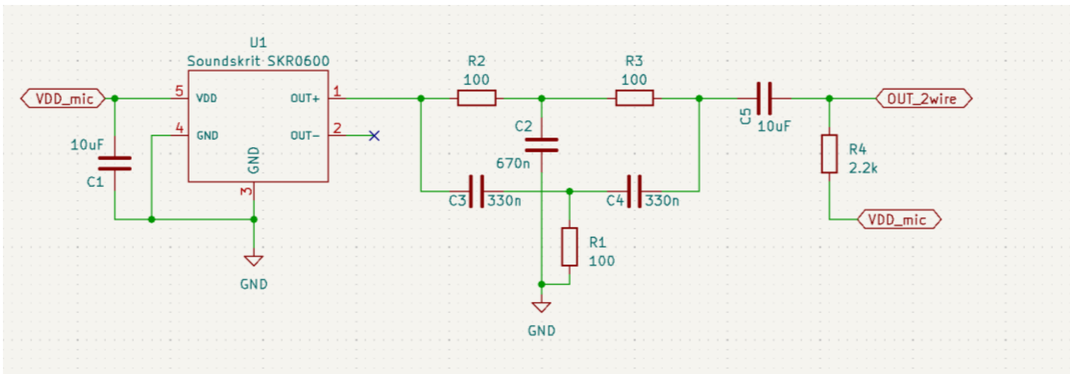


Figure 6: 2-wire and EQ circuit

The 2-wire part of the circuit uses components C1, C5, and R4. ECMs use a single transistor output stage with the DC supply voltage biased on the output. This circuit separates that power out to the dedicated Vdd supply on the MEMS microphone. To learn more about the 2-wire circuit, see our app note AN-520: 2-WIre Configuration to use MEMS with ECM Circuits.

The response of the SKR0600 in the boom housing has a peak around 4 kHz, so the notch filter is designed to flatten this out. The notch filter is made from components, C2, C3, C4, R1, R2, and R3. Rather than an ideal notch filter which affects a narrow frequency band and drastically reduces the sensitivity, the components in this filter were selected to increase the filter bandwidth and reduce the peak in the frequency response to be flat with the rest of the response. The measurement below shows the sensitivity with and without the notch filter.

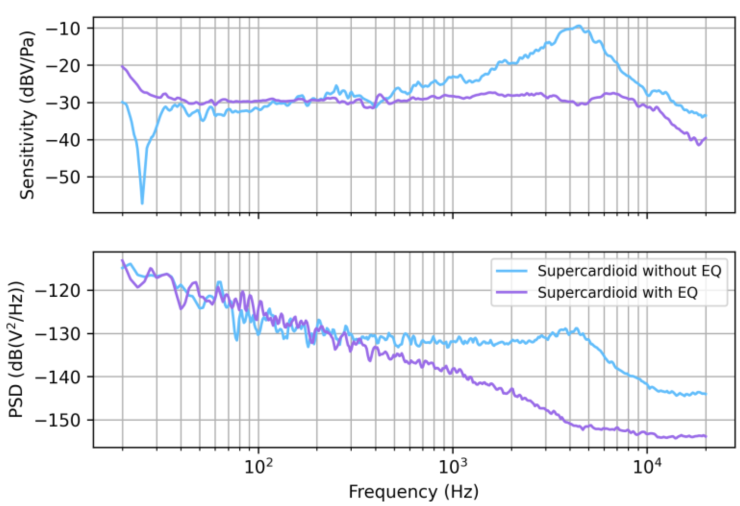


Figure 7: Frequency response with and without EQ circuit

6. Test Report

Measurements below were taken using 3D printed prototypes matching the specifications in this design concept.

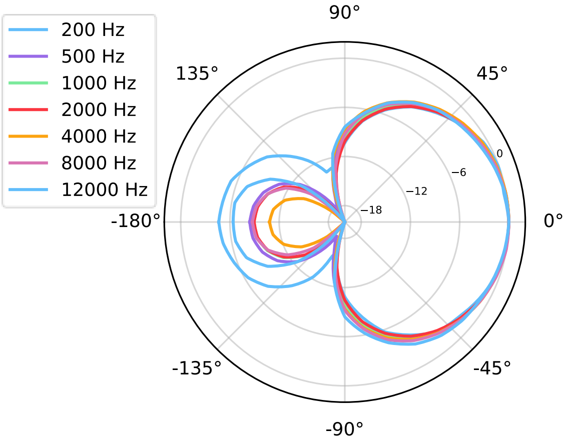


Figure 6.1: Pickup pattern vs. frequency

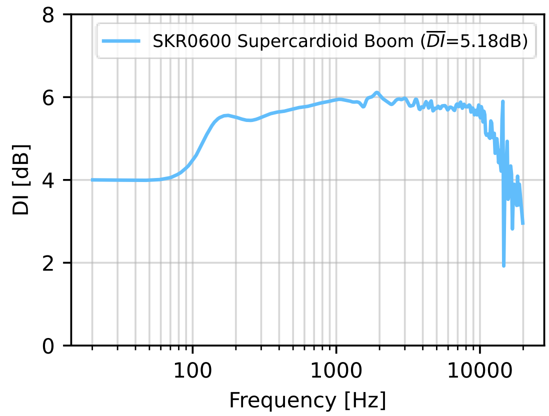


Figure 6.2: Directionality index vs frequency

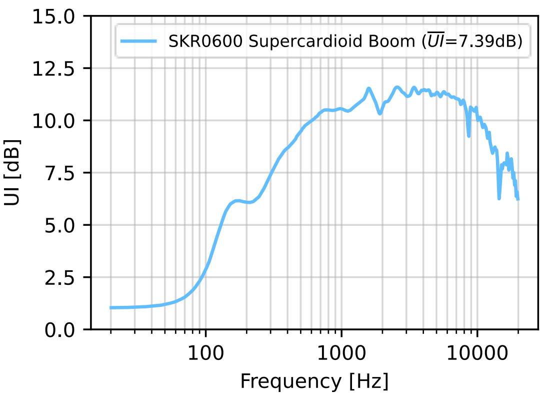


Figure 6.3: Unidirectionality index vs frequency

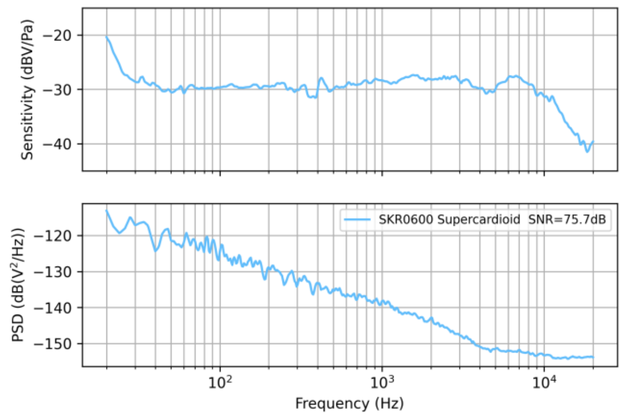


Figure 6.4: Sensitivity and PSD vs frequency at 5 cm[1]

[1] Taken at 5 cm with the EQ circuit described in section 5. Electrical Design

7. Device and Documentation Support

7.1 Datasheets

Saati Acoustex 042

Saati Acoustex HD10

SKR0600 Datasheet

7.2 Application Notes

AN-100: Comparing Soundskrit Directional Microphones to Omnidirectional Microphones

AN-110: Attributes of Soundskrit Directional Microphones

AN-210: Designing Linear Arrays with Directional Microphones

AN-520: 2-WIre Configuration to use MEMS with ECM Circuits

7.3 Additional Support

For additional design and applications support, please reach out to applications@soundskrit.ca.

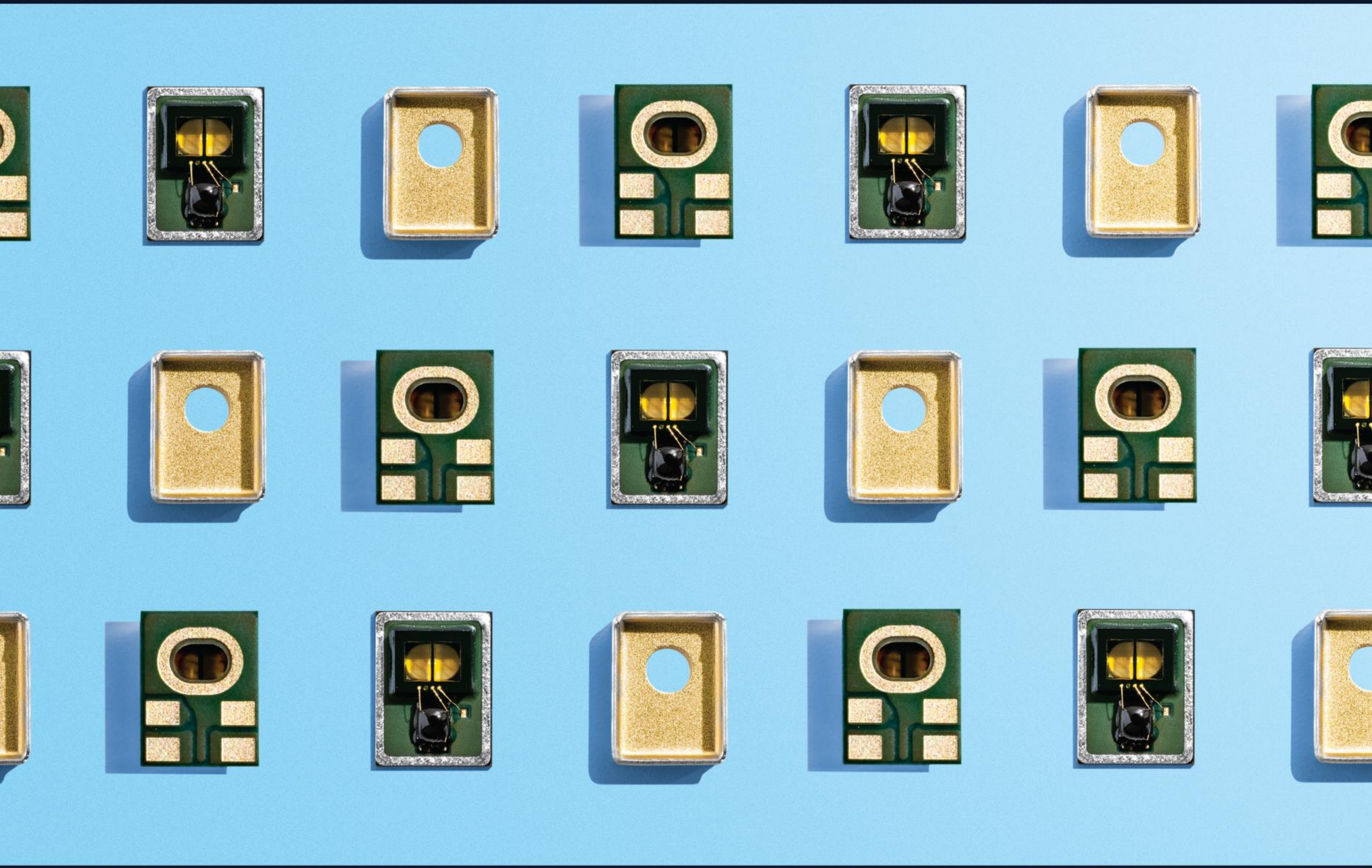
Soundskrit offers a suite of software algorithms to take full advantage of the utility our microphones provide. With a range from lightweight linear DSP tools to multichannel, machine learning based processing, we have a solution to meet any performance requirements. For more information, contact us or head to soundskrit.ca/software

8. Revision History

Revision Label	Revision Date	Sections Revised
-	April 2024	Initial release

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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Hear the impossible.