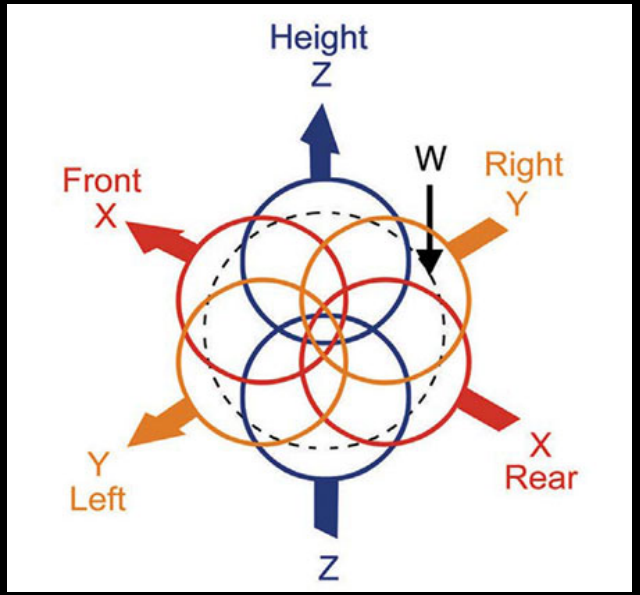
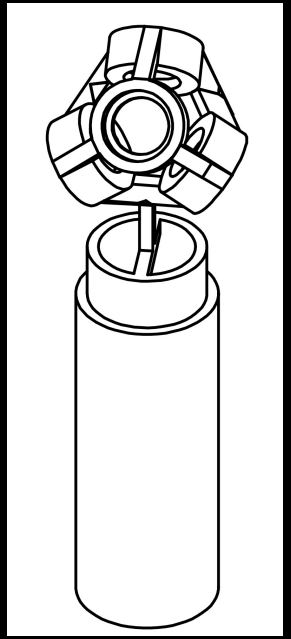
A low-cost, high quality MEMS based FOA mic

Gabriel Zalles

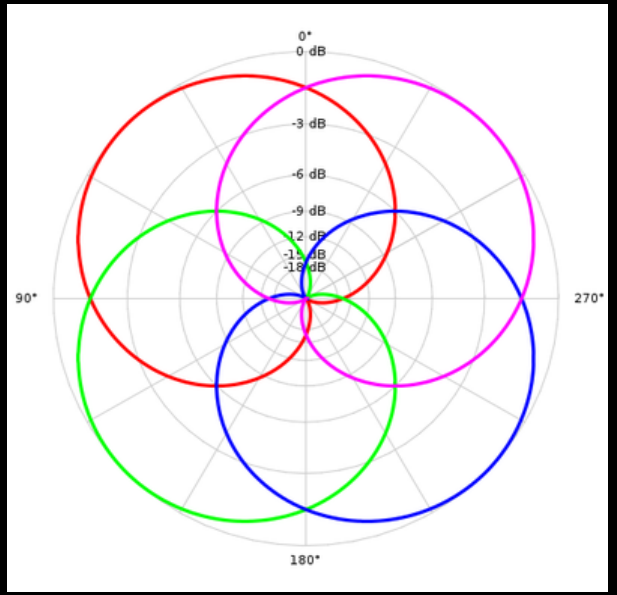
Capture and Reproduction



FOA Pressure Gradients



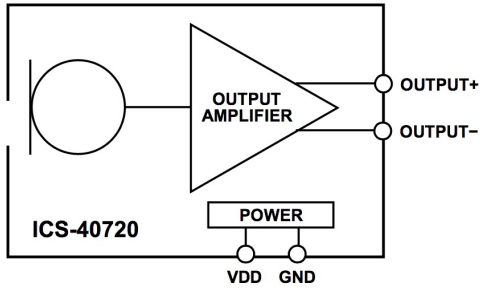
FOA Mic - Assembly Schematic

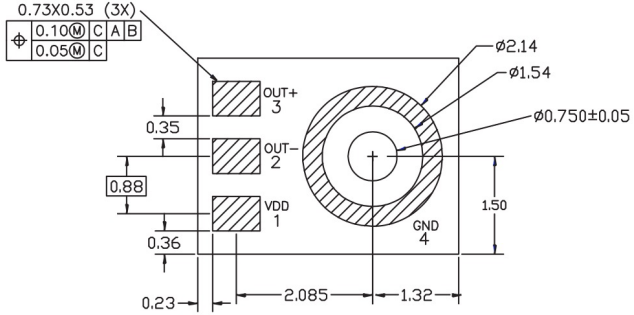


FOA Polar Patterns (2D)

ICS-40720

FUNCTIONAL BLOCK DIAGRAM





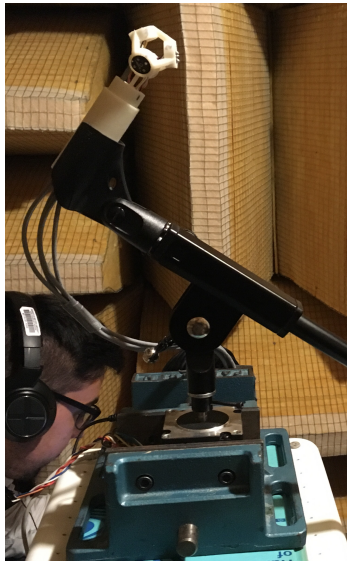
Pros:

- Enhanced RF performance
- 70 dBA SNR
- 124 dB SPL Acoustic Overload Point
- Low-cost
- Smaller than traditional electret counterparts.
- Great part-to-part consistency.
    - 2 dB Sensitivity Tolerance

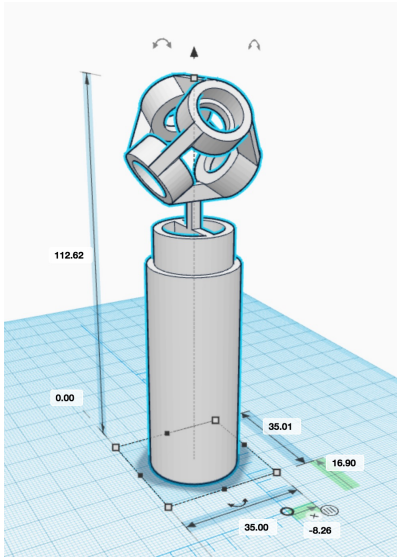
Cons:

- Analog
    - Requires ADC
- Unsuitable polar response for FOA.
    - Omni
- Unbalanced frequency response.
    - Above 10 kHz

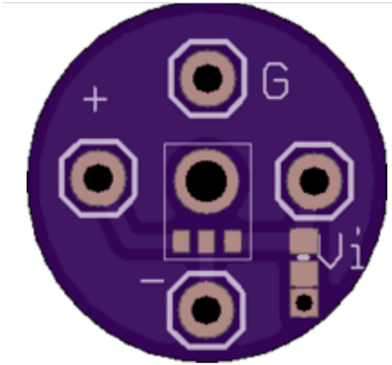
Design



Rotating Mount

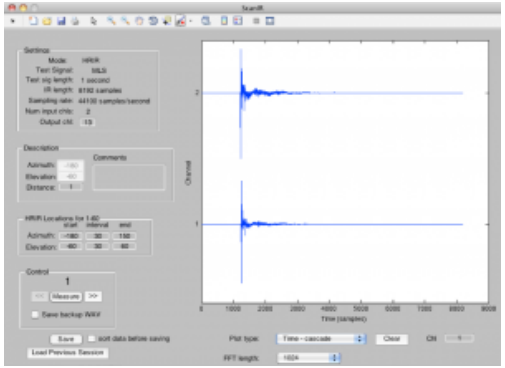


CAD Model



Custom PCB

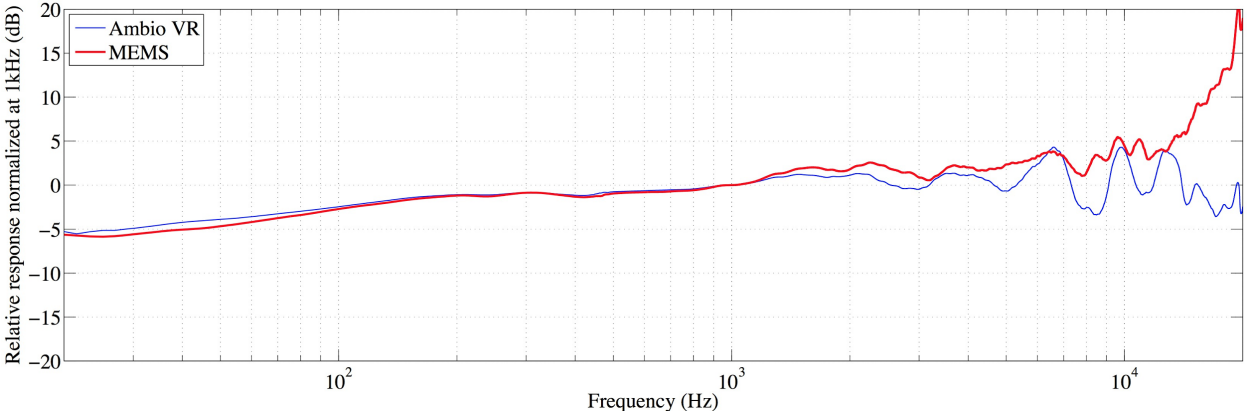
Automatic Rotating Microphone Mount (ARMM)



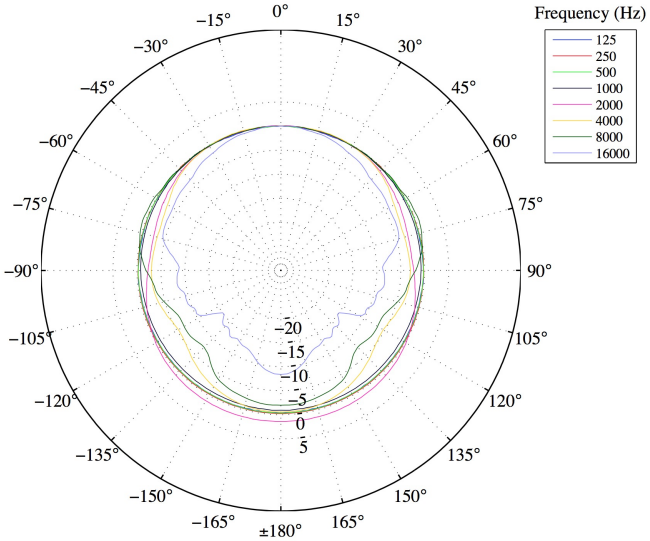
ScanIR

- Low-cost
- High resolution (1.8°)
- Ultra accessible
- Open source
- Reproducible

Objective Evaluation



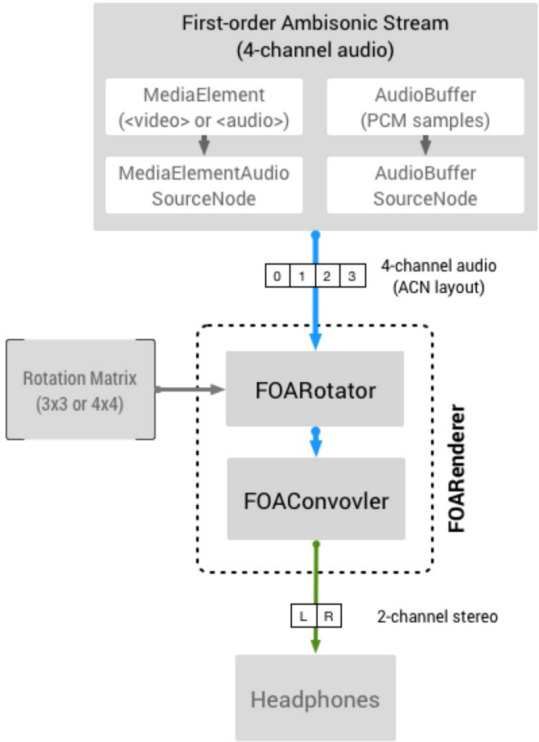
Frequency Response Comparison



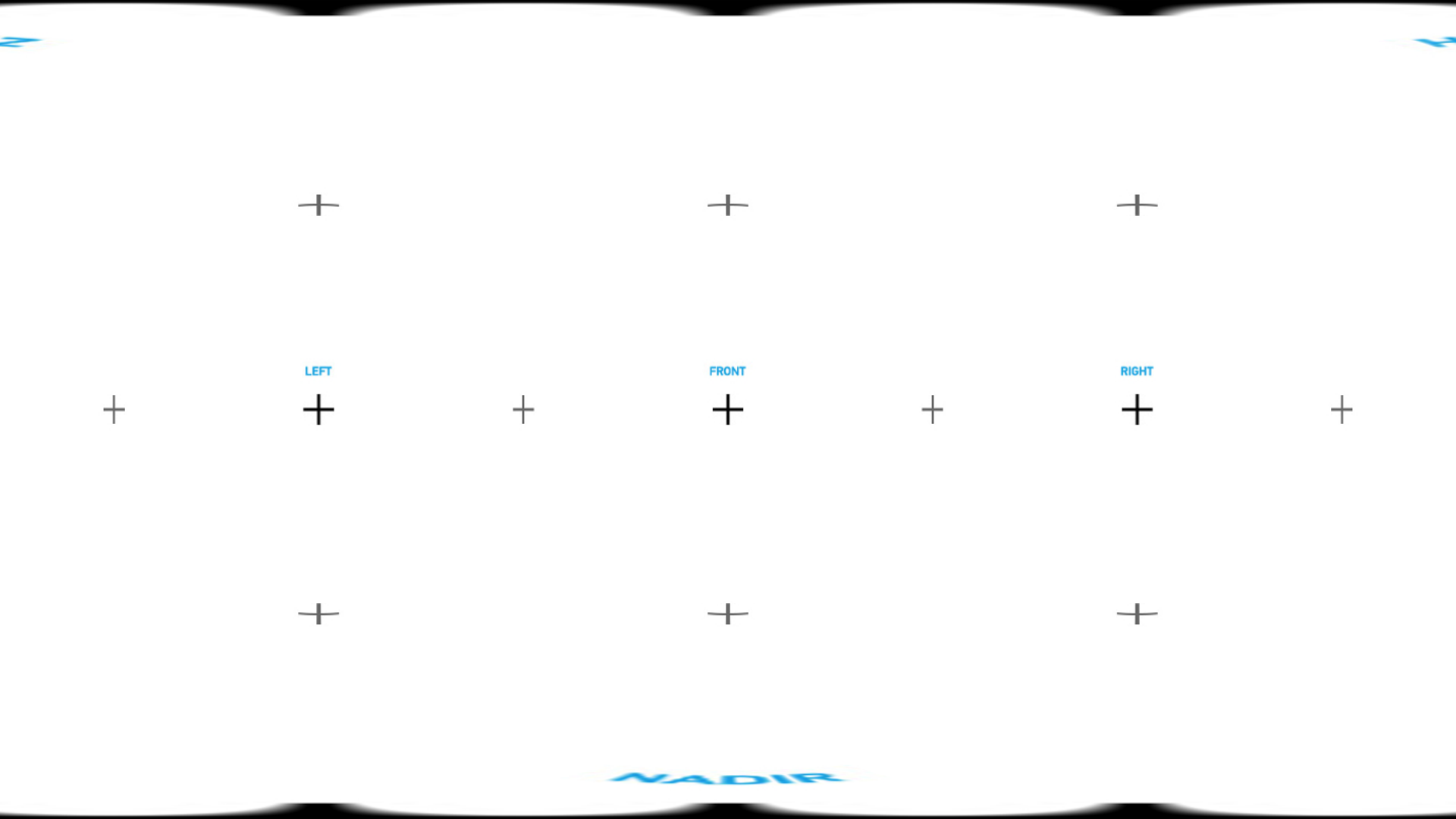
Polar Response MEMS Capsule

Subjective Evaluation

NYU Research Lab

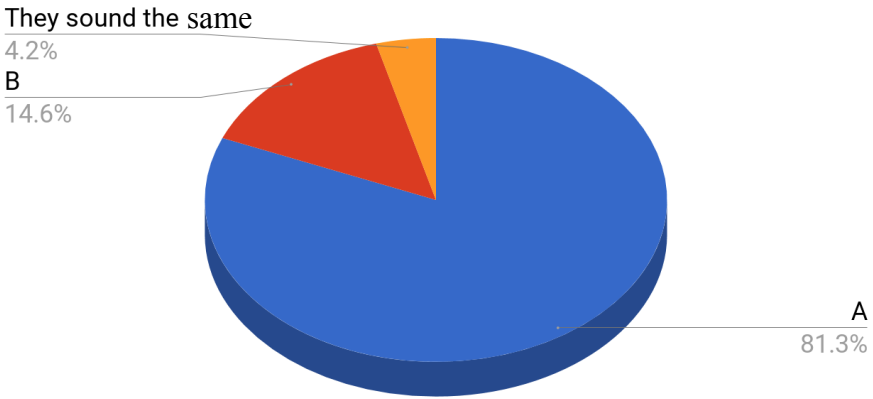


Omnitone

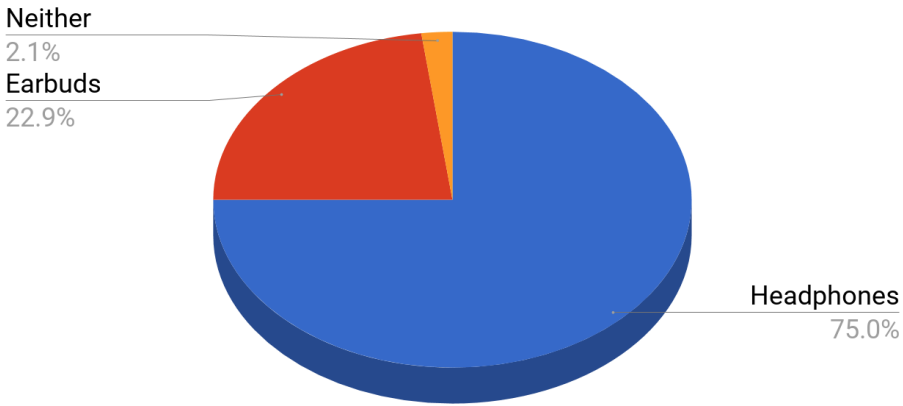

LEFT
FRONT
RIGHT
NADIR

Results

Which recording do you prefer? (A = Ambeo, B = MEMS)



Were you wearing over-the-ear headphones or earbuds?



Results (Cont.)

"Does the performance appear to take place in an appropriate spatial environment? Does it sound natural?"

"Please rate from 1 to 5 how clearly the details of the performance can be perceived"

"Rate the accuracy of the timbral reproduction for both recordings"

Where 5 is optimal and 1 is subpar.

	Ambeo		MEMS	
	Mean	*Std*	*Mean*	*Std*
Naturalness	3.38	1.16	2.94	1.16
Clearness	3.81	0.78	3.50	0.84
Accuracy	3.78	0.83	3.00	1.11

Discussion

Qualitative MEMS Mic Analysis:

- Perceived weak low-end.
- Brash high frequency response.
- Perceived higher noise floor.
- Lower average score across descriptors.

Quantitative MEMS Mic Analysis:

- Similar low-end response to reference.
- Mostly omnidirectional across frequency bands.
- Low-cost, open source and fairly accessible.

**Sennheiser Ambeo used as reference.*

Why this matters.

- Education
- Democratizing immersive audio
- Demystifying microelectronics

Tiny SphEAR - CCRMA

Zylia

Future Work

- Mark II MEMS FOA Mic
  - More coincident capsules
  - Low pass filtering
  - More cardioid like polar pattern
  - Phantom power
- ARMM
  - Flexible and scalable design
  - More documentation
  - Easier to replicate

Conclusion

- Positives:
  - MEMS featured good low end response.
  - Extremely affordable.
  - Better than expected SNR.
  - Pick and place + reflow = fast construction.
- Negatives:
  - Cardioid response still needed for FOA.
  - Ambisonics is still mostly a headphone experience.

Acknowledgements

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And many, many more.