Passive Amplification: Comparing Parabolic Reflection with Density Amplification

Dean R. G. Anderson,
Daniel J. Anderson,
Dean G. Anderson, M.D.

ABSTRACT- Passive amplification at speech frequencies is compared between small parabolic reflectors and density amplifiers. The influence of construction materials is noted.

A parabolic microphone is a microphone that uses a parabolic reflector to focus sound waves onto a transducer in much the same way that a parabolic antenna (e.g. satellite dish) does with radio waves.[1,2]

Pixation Corp. has introduced a new type of passive amplifier: the density amplifier. The density amplifier uses passive compression with air momentum to amplify longitudinal air density fluctuations as sound waves propagate toward the apex of a progressively constricting structure.

Omnidirectional MEMS microphones are used in a variety of consumer products such as smart phones, hearing aids and digital assistants. Microphone equivalent noise reduces speech intelligibility as distance increases between the microphone and the speaker's lips.[3] Passive amplification can mitigate speech intelligibility reduction due to distance and microphone equivalent noise.[4]

Here we compare the insertion gains (dB) for speech frequencies for two different types of passive amplifiers: (1) a parabolic reflector; and, (2) a density amplifier. We also compare how materials of construction influence these insertion gains.

Methods

Passive amplifiers were constructed using: (1) 1.6 mm thick polylactic acid called PLA plastic; and, (2) 3.9 mm thick soft platinum-catalyzed silicone having 8 hardness Shore-A (ASTM D-2240).

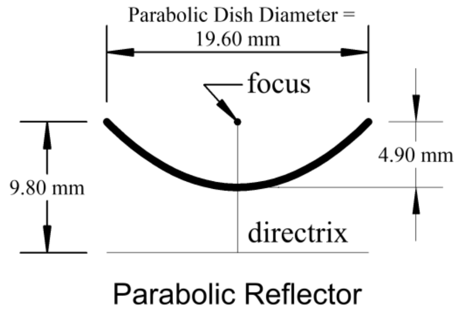


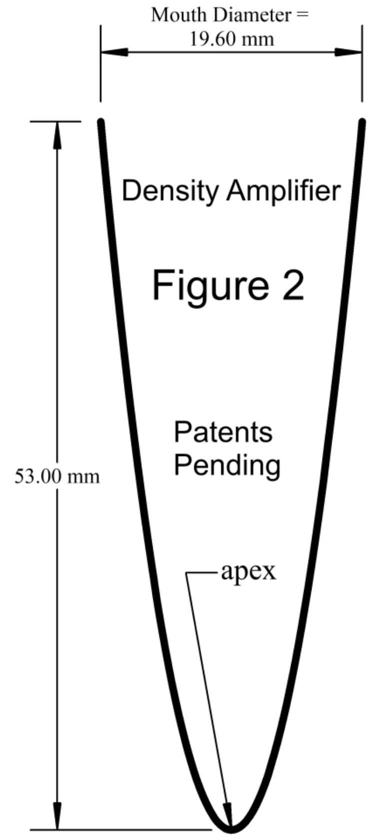
Figure 1

Figure 1 illustrates the parabolic reflector interior surface for both materials. The port opening of an omnidirectional MEMS microphone was positioned facing the parabolic reflector at the focus point.

Figure 2 illustrates the density amplifier interior surface for both materials. The port opening of an omnidirectional MEMS microphone was positioned as close as physically possible to the apex point.

White noise was used for passive amplifier insertion gain measurements for the omnidirectional MEMS microphone with and without a passive amplifier. The white noise had balanced power spectral density. The white noise was attenuated at 48 dB per octave at 1/3 octave speech band limits. The omnidirectional MEMS microphone used the industry standard 24-bit digital I²S interface to report audio signals sampled during every 32 microsecond period (a 31,250 Hz sampling rate). The samples were combined together to determine an audio output measurement with 0.1 dB SPL precision during a 40.96 millisecond period. The average audio output level was determined during a 41.94304 second period with 1,024 sequential measurements.

Both speaker (JBL Control 1 Pro) and microphone were pole mounted (16 mm diameter poles) 1.1 meters above a carpeted floor. The microphone and speaker were separated by 28 cm and positioned asymmetrically in an otherwise reverberant residential room.



Insertion gain for a passive amplifier with an omnidirectional MEMS microphone was computed by subtracting audio output levels determined for the omnidirectional MEMS microphone without a passive amplifier from the audio output levels determined using the same omnidirectional MEMS microphone with a passive amplifier. The audio output levels determined for the omnidirectional MEMS microphone without a passive amplifier were measured with the omnidirectional MEMS microphone port opening facing the speaker. The audio output levels determined for the omnidirectional MEMS microphone with a passive amplifier were determined with the same omnidirectional MEMS microphone with its port opening positioned at the focus point and facing the parabolic reflector or with its port opening positioned as close as physically possible at the interior apex of the density amplifier.

Results

Midband 1/3 octave speech frequencies and insertion gain measurements using the methods just described are reported in Table 1.[5]

Discussion

The parabolic reflector dish diameter and the density amplifier mouth diameter are the same in this study. The same frequencies, testing setup, and omnidirectional MEMS microphone were used for all data reported here.

The materials of construction did not appear to affect the parabolic reflector insertion gain measurements.

The materials of construction appear to have a significant effect on the density amplifier performance.

The passive amplifier insertion gain performance for a density amplifier was significantly better than the performance for a parabolic reflector with an equally sized diameter. The superior performance of the density amplifier suggests that the operating mechanism is not simply reflecting and focusing sound waves on a transducer.

Commercial parabolic microphones typically have dish diameters greater than 20 cm and are used for distant recording (20 or more meters) in diverse applications such as: (1) nature recording; (2) sporting events; (3) surveillance; and, (4) drone detection.[6] However, a 20 cm dish is not practical for consumer electronic systems such as hearing aids, smart phones, vehicle infotainment systems, or smart speakers.

Speech intelligibility is important for many portable electronics applications where the distance between the microphone and the speaker's lips is in the range of 1 to 3 meters.[7] Insertion gain measurements reported for the 19.6 mm soft silicone density amplifier indicate there is a solution for speech intelligibility issues for the 1 to 3 meter listening range.

A density amplifier is not limited by the shape pictured in Figure 2. Similar density amplifier performance can be obtained with many variations of cones and/or polyhedral surfaces which result in progressively constricting structures.

Conclusions

Pixation has developed a new type of microphone, the density amplifier microphone.

The density amplifier microphone has the potential to meet intermediate range (1 to 3 meter) consumer needs.

Contact pixation@pixation.com for additional information.

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[6] e.g. www.anti-drone.eu, www.JonyJib.com, www.kloverproducts.com, www.wildtronics.com
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Table 1

Midband 1/3 Octave Speech Frequency (Hz)	PLA Plastic Parabolic Reflector Insertion Gain, G(dB)	Soft Silicone Parabolic Reflector Insertion Gain, G(dB)	PLA Plastic Density Amplifier Insertion Gain, G(dB)	Soft Silicone Density Amplifier Insertion Gain, G(dB)
8000	10.1	10.1	17.3	24.4
6300	8.7	8.5	15.2	21.6
5000	6.2	6.1	19.2	22
4000	3.8	3.7	13	15.7
3150	2.2	2.2	14.4	14.9
2500	1.9	1.8	22.2	22.1
2000	1.5	1.5	22.6	22.1
1600	0.7	0.7	14.2	14.3
1250	0.5	0.4	6.8	8.1
1000	0.5	0.5	4.3	5.7
800	0.4	0.4	3	4.5
630	0.3	0.3	2.2	3.6
500	0.3	0.3	1.7	3.1
400	0.3	0.2	1.5	3.1
315	0.2	0.1	1.2	2.9
250	0.2	0.2	1.2	2.9
200	0.3	0.3	1	2.5
160	0.3	0.3	0.9	2.3