Acoustic Energy Harvesting using Helmholtz Resonator with Tapered Neck

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Introduction: The proposed acoustic energy harvester makes use of the increased amplification rate of a Helmholtz resonator due to the tapered nature of its neck.

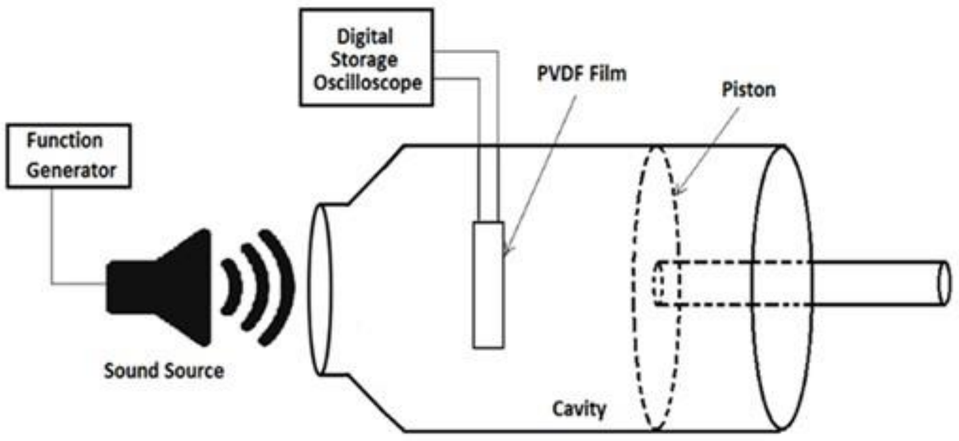


Figure 1. Schematic of the Energy Harvester

Computational Methods: The pressure amplification factor, G of the resonator is

$$G = \frac{p_c}{p_i} = 2\pi\sqrt{V\frac{L^3}{S^3}}$$

The smoother area change from the neck towards the cavity will reduce the flow of resistance of the sound waves and will increase the sound absorption capacity of the Helmholtz resonator.

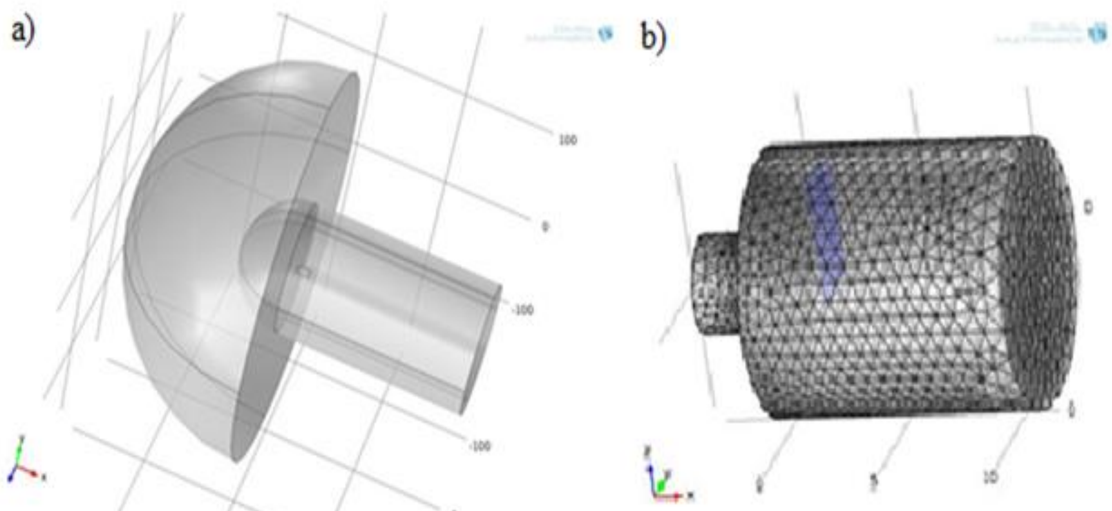


Figure 2. a) Global model of the harvester b) Helmholtz resonator with tapered neck having PVDF cantilever beam placed inside

Results: A sound wave of 95dB fed directly to the Helmholtz resonator with tapered neck (tapering angle 21^0) of resonant frequency 284 Hz produces an output voltage of 396 mV (Figure 6) which closely resembles the simulation results (Figure 5).

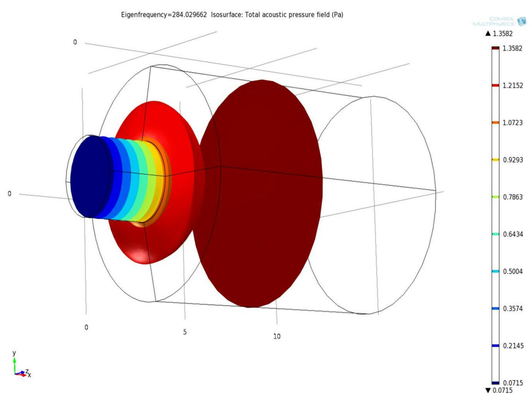


Figure 3. Total acoustic pressure inside the resonator

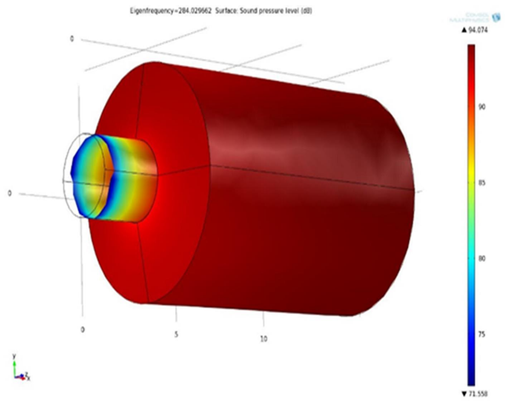


Figure 4. Sound pressure level inside the resonator

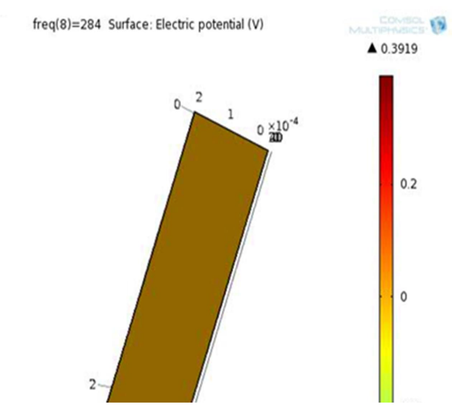
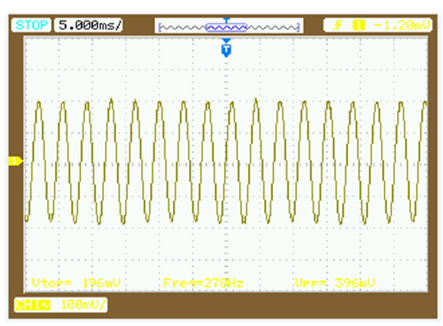


Figure 5. Harvested Output voltage (Simulation)



Frequency= 278Hz,
Vmax = 396mV

Figure 6. Output voltage measured using DSO

Conclusions: When the resonator was geometrically tuned with piezoelectric cantilever the ratio of voltage obtained from the resonator with tapered neck to that of the resonator without tapered neck was about 0.60. After a particular value of slope of the tapered section the output starts decreasing as the tapered region hinders the plane waves inside the resonator.

References:

1. S K Tang, On Helmholtz Resonator with tapered necks, J.Sound and Vib., Vol. 279, pp.1085-1096, (2005).
2. Bin Li, Jeong Ho You, Simulation of Acoustic Energy Harvesting Using Piezoelectric Plates in a Quarter-wavelength Straight-tubeResonator, Proceedings of the 2012 COMSOL Conference in Boston, (2012).