Acoustic Energy Harvesting Using Helmholtz Resonator with Tapered Neck

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Abstract

In acoustic energy, harvesting energy is captured from external noise sources, controlled and stored for various applications. Despite the prevalence of acoustic energy a major challenge of energy harvesting is the low power density. Acoustic Energy Harvester consists of a resonator, an acoustic transducer and a storage device. When acoustic resonator is excited by an incident wave at its resonant frequencies, acoustic energy in the form of standing resonant waves is collected inside the resonator. The most commonly used acoustic resonators are the Helmholtz resonators. They comprise of a cavity connected to a neck having length and cross sectional diameter much smaller than that of the cavity. A Helmholtz resonator is modeled as a mass spring system, where volume of air in neck oscillate as a mass and the air inside the cavity expand and contract like a spring. The volume of the cavity and neck dimensions of the resonator determines the natural frequency of the device.
In this paper an effort has been made to increase the amplification rate of the Helmholtz resonator by structural modification of its neck thereby increasing the output voltage of energy harvester (figure1).

An acoustic energy harvester using Helmholtz Resonator with tapered neck has been developed an analyzed using COMSOL Multiphysics®. A unimorph PVDF beam inserted at a fixed distance from the tapered neck is vibrated to convert acoustic pressure into voltage. In COMSOL Multiphysics®, pressure acoustics-piezoelectric-structural mechanics physics has been used for frequency analysis. The input acoustic plane wave is simulated by background acoustic pressure.

Results
The eigen frequency of the resonator for the designed dimensions has been studied using the software. At resonance the total acoustic pressure and sound pressure level is lowest at the neck of the resonator and is increasing towards the cavity end (figure 2 and figure 3 respectively). A PVDF strip is inserted at a distance of 32mm from the neck of the resonator. Helmholtz resonator with tapered neck is designed with a slope of 210 and at resonance frequency of 280 Hz , it produces an output voltage of 396 mV.

Energy harvesting efficiency was maximized by matching and tuning mechanical resonance of the piezoelectric strip and acoustic resonance of the Helmholtz resonator. The voltage observed

from resonator with tapered neck was about 60% more than that of the resonator without tapered neck. After a particular value of the slope of the tapered section the output starts decreasing. Hence by optimizing the slope of the tapered section of the neck the maximum possible output power can be obtained from the acoustic energy harvester.

Figures used in the abstract

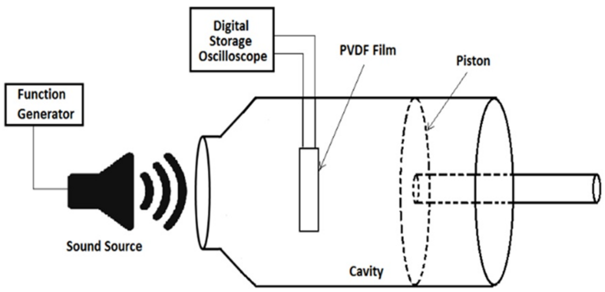

Figure 1: Figure1. Schematic of proposed energy harvester.

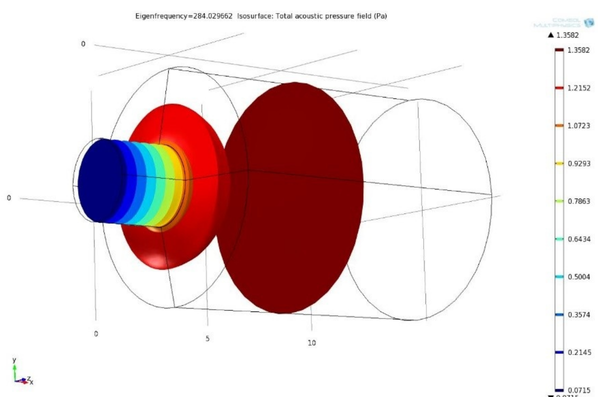

Figure 2: Figure 2. Total acoustic pressure inside the resonator.

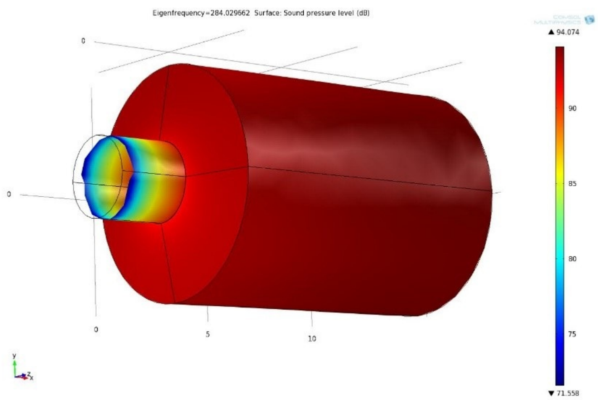

Figure 3: Figure 3. Sound pressure level of the resonator.