Design and Simulation of a Low-cost Digital Stethoscope

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Abstract

Heart is a vital part of our body and periodic heart checkup is crucial for the heart patients. Heart sound itself carries important features of heart functions, hence, an affordable and user friendly digital stethoscope with wireless connectivity is envisioned as an extremely useful tool for heart patients. Such a tool would enable them to record their heart sound at home and send the data to doctors. However, the challenge is to come up with easy to use and low cost solutions. Our approach couples the acoustic pressure from normal stethoscope to a smartphone microphone in an enclosure that is then digitized and sent. Our novelty lies in conceptualizing the acoustic coupling chamber which is low cost and user friendly. In this paper, we investigate feasibility of this concept by simulating acoustic response of such an enclosure to ensure getting undistorted heart sound. Our work shows promising results.

Basic Design: Figure 1 shows the basic design of the proposed stethoscope. It basically consists of a normal stethoscope and a smartphone microphone coupled in an enclosure box. The enclosure box has two openings to accept the two tubes from original stethoscope and hosts a microphone inside it to directly capture the acoustic pressure waves coming from the stetho-head via the rubber tubes. The enclosure in one hand isolates the background noise to enter the microphone and in other hand makes it an easy to use attachment to quickly couple the microphone to the heart sound. Our proposed design has huge cost advantage over the available digital stethoscope found in market. In addition our design also offers ease of use as the user doesn't have to cut open the microphone, attach any extra electronics or modifying the normal stethoscope. Rather it offers snap-fit type of arrangement where an user can use his/her smartphone, microphone-headset, a normal stethoscope and the enclosure box to quickly make the digital stethoscope without any need for doing special arrangements or re-engineering of any of the components.

Results:Figure 2 shows response of the acoustic enclosure in the range of 10Hz to 400Hz which corresponds to frequency range of usual heart sound. No sharp resonance is found in this range which in turn ensures that the enclosure doesn't introduce any distortion.

Figure 3 shows the response for the enclosure in the range of 3kHz to 4KHz and resonance can be found around 3.2 kHz.
To further support our observation COMSOL eigen frequency analysis is performed around 3.2 kHz and corresponding result is displaced in figure 4.

This clearly shows that the natural resonance frequency of the structure is way off from the heart frequency range and so it guarantees coupling of undistorted heart sound to the microphone.

Reference

1. H.,Wang, J.,Chen,et.al, Heart sound measurement and analysis system with digital stethoscope. In Biomedical Engineering and Informatics, 2009. BMEI'09. 2nd International Conference on (pp. 1-5). IEEE.
2. A.,Harsola, S.,Thale, et.al, Digital Stethoscope for Heart Sounds. In International Conference and workshop on Emerging Trends in Technology (ICWET).

Figures used in the abstract

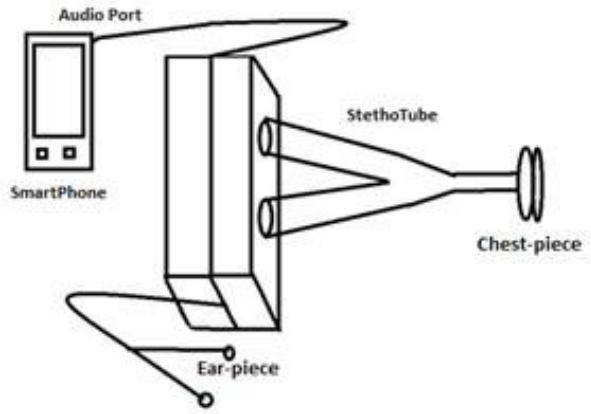

Figure 1: Basic design of the proposed stethoscope.

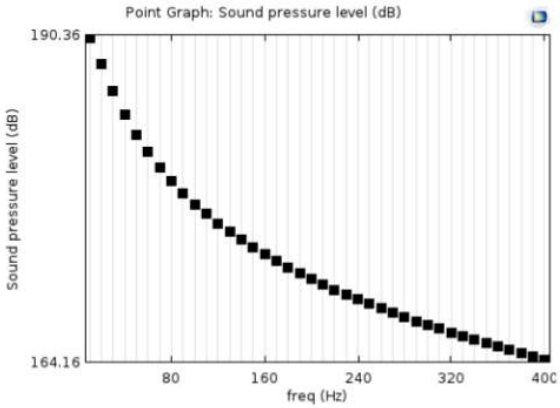

Figure 2: Sound pressure (dB) vs. Frequency domain (10Hz-400Hz).

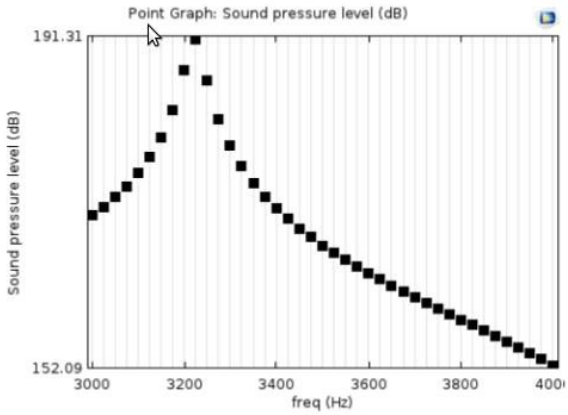

Figure 3: Sound pressure (dB) vs. Frequency domain (3kHz-4kHz).

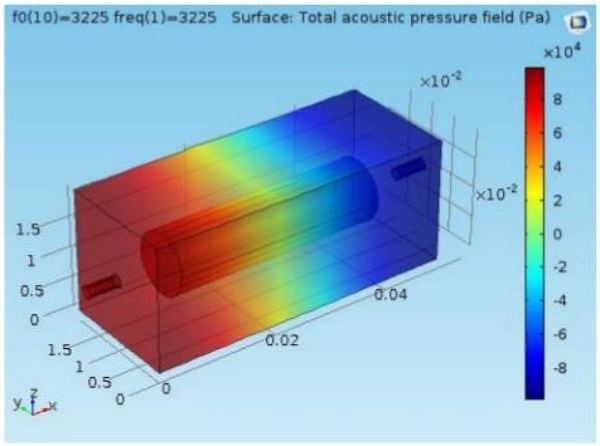

Figure 4: Acoustic pressure field at frequency 3.2kHz.