The Use of Piezoelectric Actuators in an Energy-Efficient Noise Reduction System

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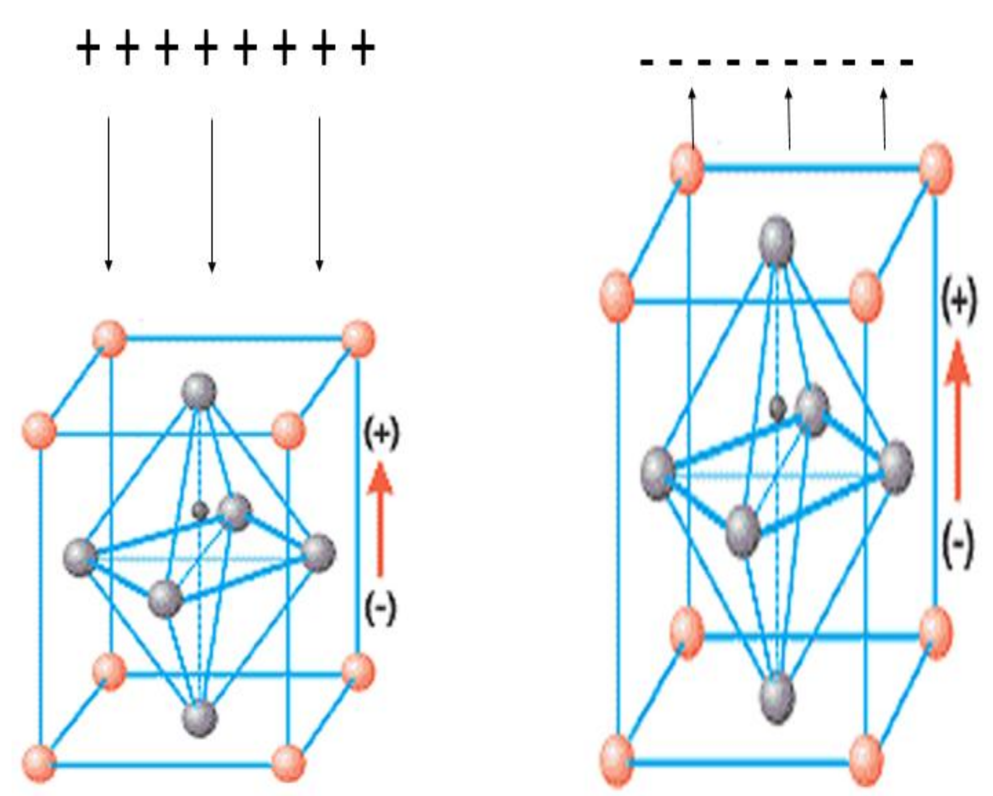
Abstract

The piezoelectric effect allows for conversion between mechanical stress and electrical impulses. By utilizing this phenomenon, a novel method of sound attenuation was explored and tested in which a piezoelectric plate absorbs part of an incoming sound wave. Reversing the process allows a second plate to produce a phase-inverted wave using the absorbed energy, achieving further reduction through destructive interference.

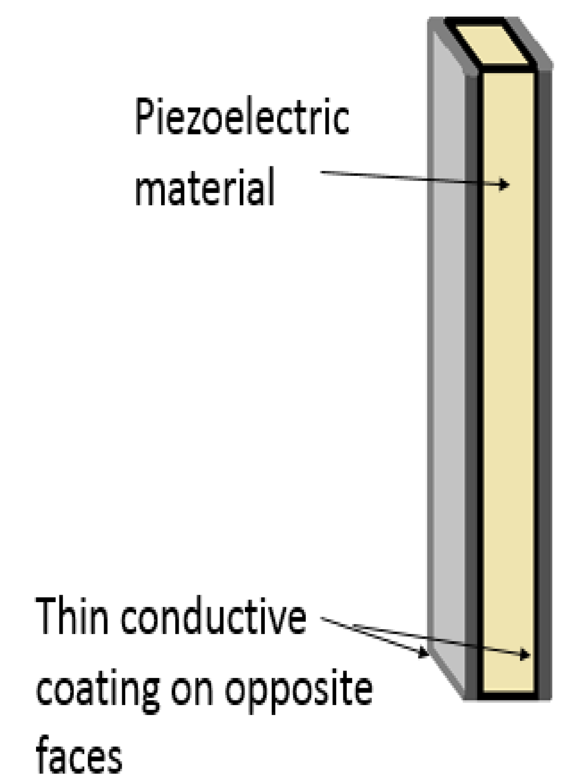
Background

Piezoelectric materials have the property of producing an electric field when mechanical stress is applied to them, a phenomenon known as the piezoelectric effect. Such materials also exhibit the converse piezoelectric effect, in which an applied electric field produces stress. The mechanism of action lies in the crystal structure of these materials, which features an asymmetric distribution of charge. This results in polarization of the material and a direction-dependent response.



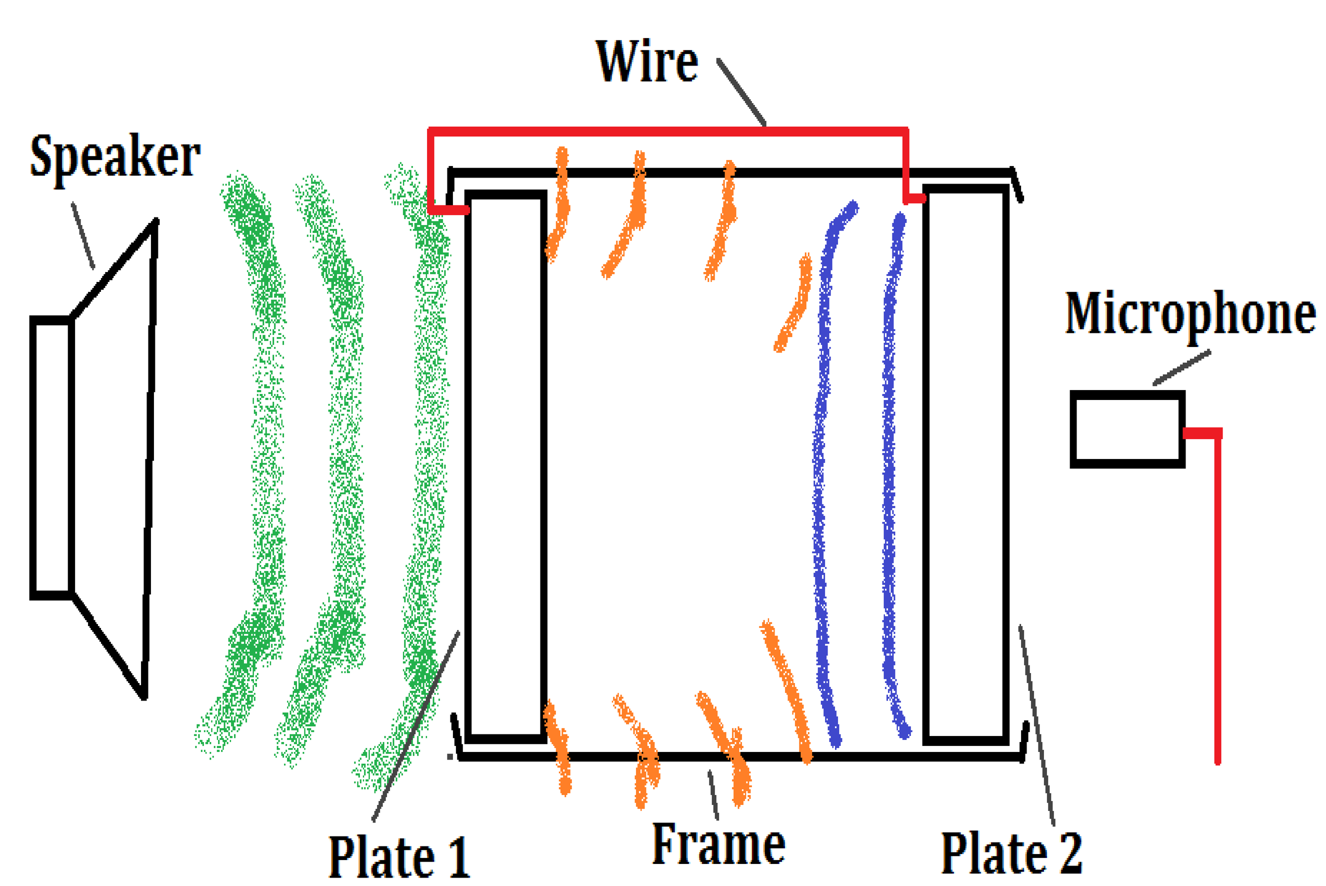
Piezoelectric plates, such as the one shown in the next figure, are used for a variety of purposes (1), including absorbing and emitting sound waves through vibration of plates.

While piezoelectric plates do a good job of absorbing sound waves, the same cannot always be said of the surface they are attached to. This motivated research into developing a two-plate design, as shown below.



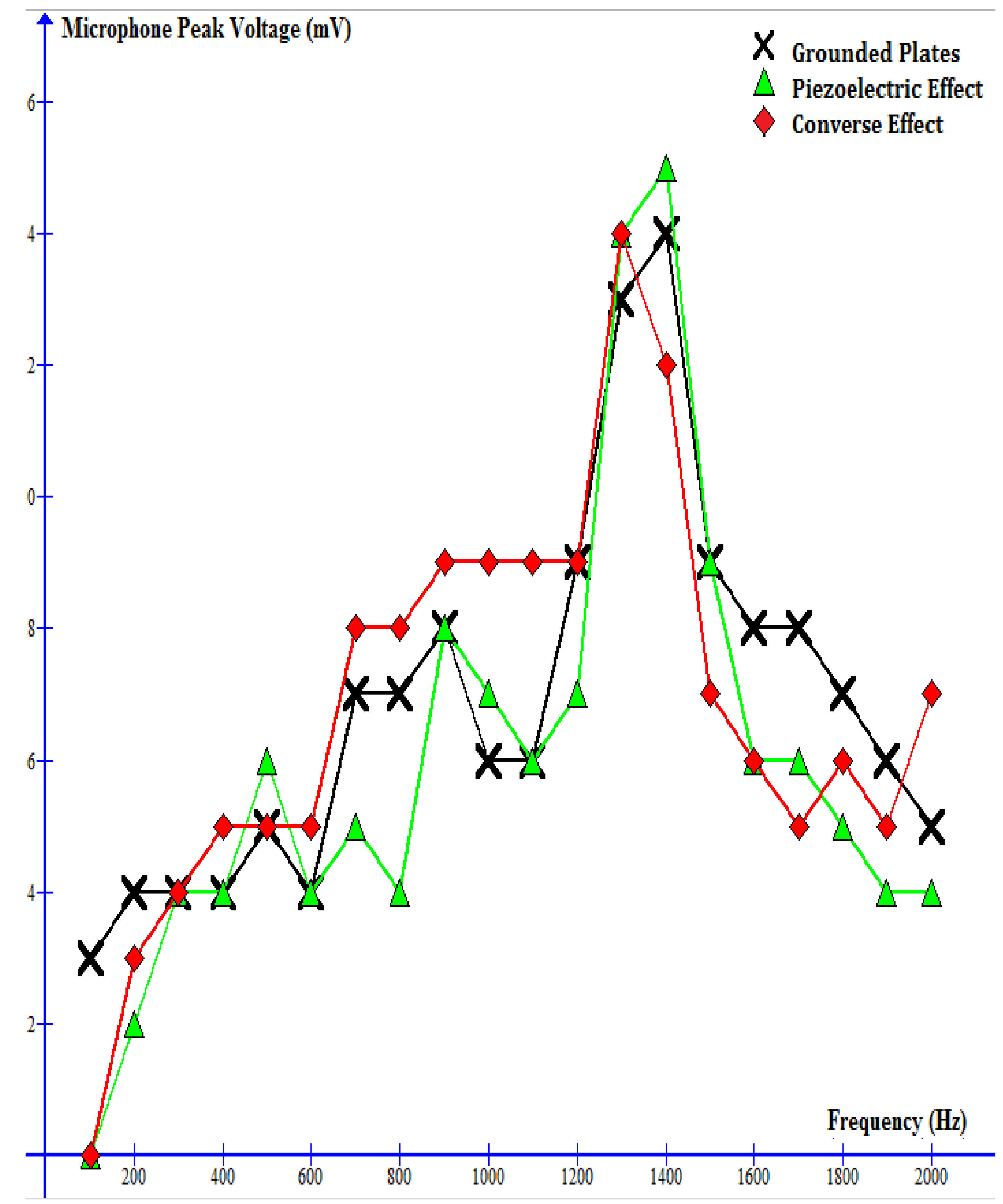
In this system, some sound is expected to make it past the first plate. The energy absorbed by this plate is sent as an electric signal to the second plate. The second plate uses this to output a new sound wave in order to cause destructive interference between the plates.

Experiments



A microphone was used to collect sound waves which passed through the plates in order to determine the effectiveness of the sound damping. The plates were wired so as to separately test the piezoelectric effect (sound absorption) and the converse effect (production of the new wave), and isolate these from other effects which may have contributed to noise reduction. Sound frequencies from 100 to 2000 Hz were tested.

Results



The signal received by the microphone while testing the piezoelectric effect was generally smaller than when the plates were grounded, as expected.

However, the signal during the converse effect test was generally larger, particularly at low to mid frequencies. It is believed that the electrical signal received by plate 2 caused both sides of the plate to vibrate, which did cause destructive interference between the plates but also caused plate 2 to send an additional wave into the microphone.

Analysis of plate 2 is expected to provide additional insight regarding the behavior of this system, and may offer a solution to the issue of the sound wave produced.

References

1. Piezoelectric Materials and Applications.
http://classroom.materials.ac.uk/casePiez.php