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.

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.

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.

References