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Differentiating Electromagnetic Waveform Characteristics of Electricity Generated by Standalone and Rectified-Filtered Piezoelectric Cells

Case Study Proposal

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I. INTRODUCTION

Piezoelectric cells generate electricity when mechanical force is applied, producing an alternating current (AC) signal with varying voltage levels. However, this raw electrical output is unstable and changes depending on the applied force. To make the signal more consistent, a rectifier and capacitor can be used to convert the AC output into a more stable direct current (DC) signal.

This study focuses on understanding the differences between the raw AC output of a standalone piezoelectric cell and the rectified, filtered DC output after passing through a bridge rectifier and capacitor. The purpose of this research is to observe and compare these waveforms to better understand how rectification and filtering affect the signal. This study is for educational purposes and aims to provide knowledge about the behavior of piezoelectric waveforms in different circuit setups.

II. MATERIALS USED

The following materials are utilized in the creation of the project.

- Piezoelectric Cells (4 pieces)
- Capacitor (470uf, 10V)
- Bridge Diode (1N4007)
- Soldering lead
- Lead
- Wires
- Analog Discovery 3
- Laptop
- Plywood

III. PROCEDURE

This study focused on determining the shape of the electrical signal produced by a piezoelectric cell when force was applied. The steps included setting up the circuit, connecting the measuring tools, and recording data to ensure accurate and repeatable results.

1. Preparation and Setup

a. Circuit Assembly

- The piezoelectric cells were connected to a bridge rectifier and an electrolytic capacitor in parallel to convert and smooth the voltage.
- The correct polarity was checked to avoid errors in signal measurement.

b. Connecting the Measuring Equipment

- The output terminals of the circuit were securely attached to the Analog Discovery 3 to view the signal.
- The Analog Discovery 3 was connected to a laptop to record and save the data.

c. Setting Up the Testing Area

- The piezoelectric cell was placed on a stable, flat surface to ensure steady force application and reduce vibrations that could affect the readings.

2. Data Collection

a. Standalone Piezoelectric Cell (AC Output)

- Force was applied manually by pressing the piezoelectric cells 20 times with the same amount of pressure to keep the results consistent.
- The Analog Discovery 3 recorded the voltage signal produced by the piezoelectric cell, and the data was saved on the laptop.

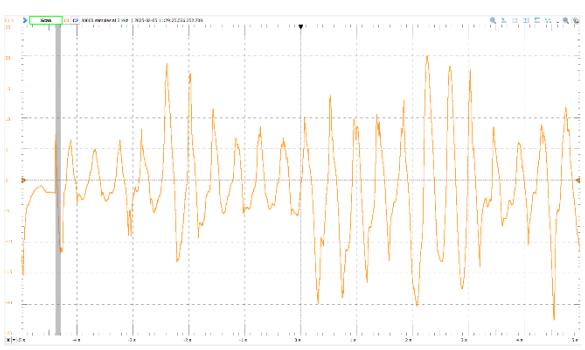
- The process was repeated at least six times to check if the results were consistent.

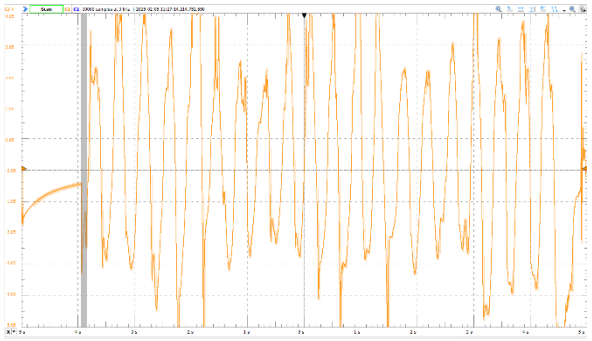
b. Piezoelectric Cell with Rectifier and Capacitor (DC Output)

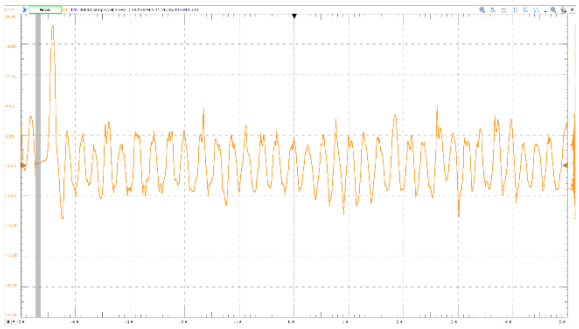
- The same steps were followed, applying force manually by pressing the piezoelectric cell 20 times.
- The Analog Discovery 3 recorded the signal from the rectified and smoothed output, and the data was saved on the laptop.
- The test was repeated at least six times to confirm the consistency of the results.

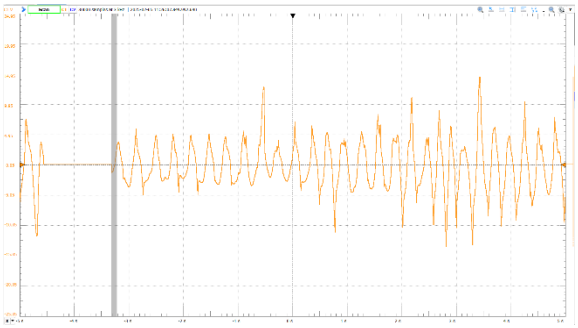
III. RESULTS

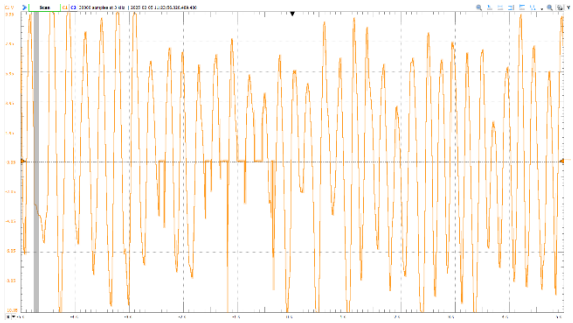
Obtained outputs for and Rectified-Filtered Piezoelectric Cells

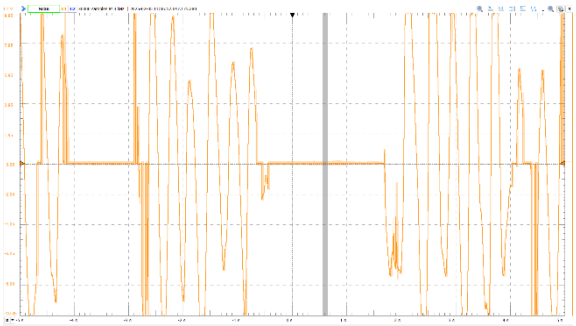








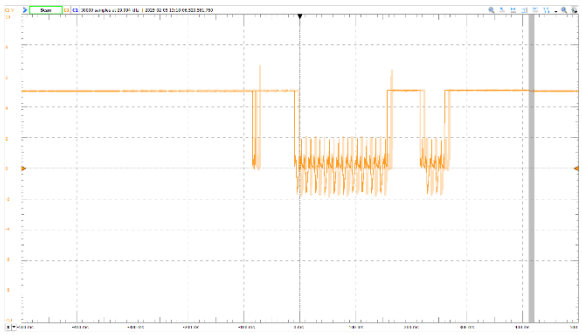


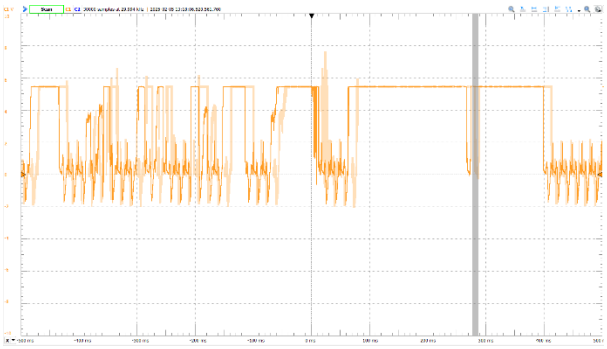


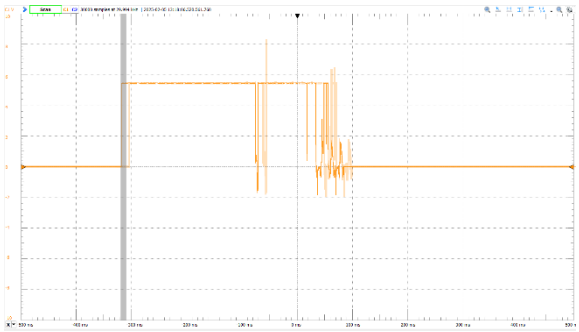
The recorded waveform shows the raw AC voltage from a standalone piezoelectric cell when force is applied. Since piezoelectric materials create electricity when pressed or bent, the signal goes up and down in an uneven pattern, matching the applied force. The changing height of the waves means the force was not always the same. The signal also has

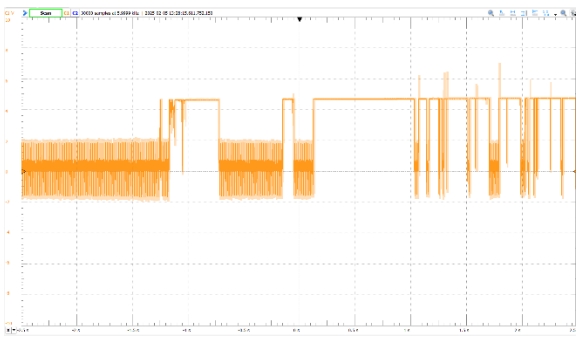
many small waves mixed together, showing that it is not a smooth pattern. The way the wave moves above and below zero proves that the voltage changes direction, which is normal for AC output. This waveform shows how the piezoelectric cell produces electricity when pressed by hand, but the signal is not steady.

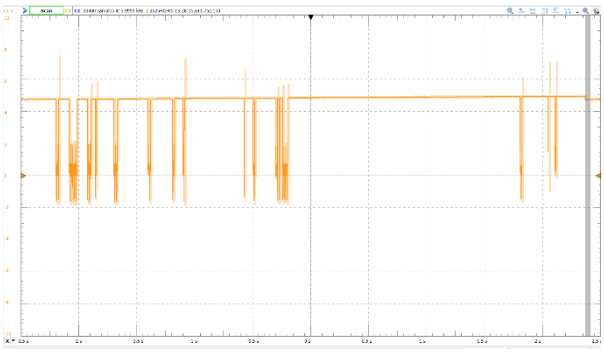
Obtained outputs for Standalone Piezoelectric cells











The waveform shown is the rectified and filtered output of the piezoelectric cell. Unlike the AC signal, this one mostly stays above zero, showing that the bridge rectifier has successfully converted it into a one-directional voltage. However, there are still small rapid changes near the baseline, meaning the capacitor is helping to smooth the voltage but cannot remove all fluctuations. These small variations might be caused by how the capacitor charges and discharges, the voltage drop from the diodes, or differences in the force applied to the piezoelectric cell.

There are also sudden drops and shifts in the signal, which happen when the pressure on the piezoelectric cell changes. The flat parts of the waveform at higher voltages mean the capacitor is holding and releasing charge, helping to keep the voltage steady. However, the occasional dips show that the filtering is not perfect. This is expected because the input force is not always the same. Even with these small issues, the circuit successfully converts the piezoelectric output into a more stable DC voltage than the raw AC signal.

IV. CONCLUSION

This study determined the waveform characteristics of electricity generated by a standalone piezoelectric cell (AC output) and a piezoelectric cell with a rectifier-capacitor circuit (rectified-filtered DC output). The results are as follows:

1. **Standalone Piezoelectric Cell (AC Output)**

   The raw output showed an unsteady waveform with changing amplitudes, and an alternating current (AC) signal. The voltage shifted between positive and negative values depending on the applied force, leading to an inconsistent output.

2. **Rectified and Filtered Piezoelectric Cell (DC Output)**

   After incorporating a bridge rectifier and capacitor, the output remained mostly above zero, confirming successful AC-to-DC conversion. The capacitor reduced voltage fluctuations, but small variations persisted due to mechanical force inconsistencies, diode voltage drops, and capacitor discharge behavior, and shifts in the waveform reflected variations in applied pressure, indicating that the piezoelectric output is highly dependent on mechanical input.

Appendix: Experimental Setup and Documentation