Kent Denver Innovative Scholars Program
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Computer Science + Engineering
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Biomechanics and Energy

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OVERVIEW

Over the last semester, I worked with Finn Cooper to design a mechanism to capture energy from inherent human motion. We decided to pursue this as it represents a conjunction of bioengineering (my intended major) and electrical engineering, which is an area of engineering that I have yet to explore.

RESEARCH/PREPARATION

First, we selected an electrical generation device to generate a voltage to convert into stored work energy. We chose a piezoelectric generator because a slight compression can create a voltage difference fairly easily, then can be stored in a capacitor.

We researched the inner workings of a piezoelectric component, and found that it is essentially just a layer of crystal that vibrates when compressed.

Finally, we decided to use a capacitor as opposed to a battery to store charge, as capacitors are less sensitive to random impulses and don't need charging computers to healthily store energy.

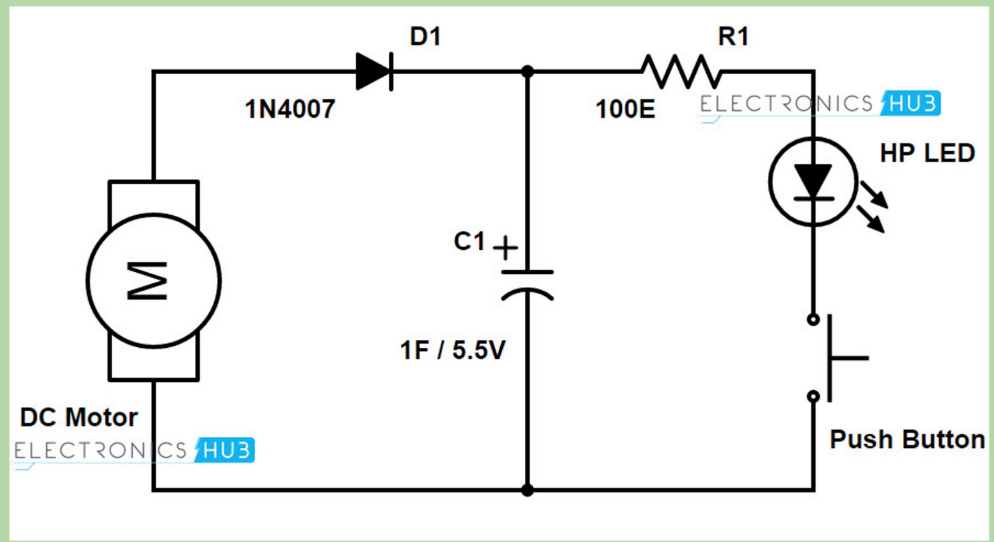

FIGURE 1: Basic Generator Circuit

PROCEDURE/DESIGN

Next, we implemented this into a prototype circuit, and found various issues/made realizations along the way.

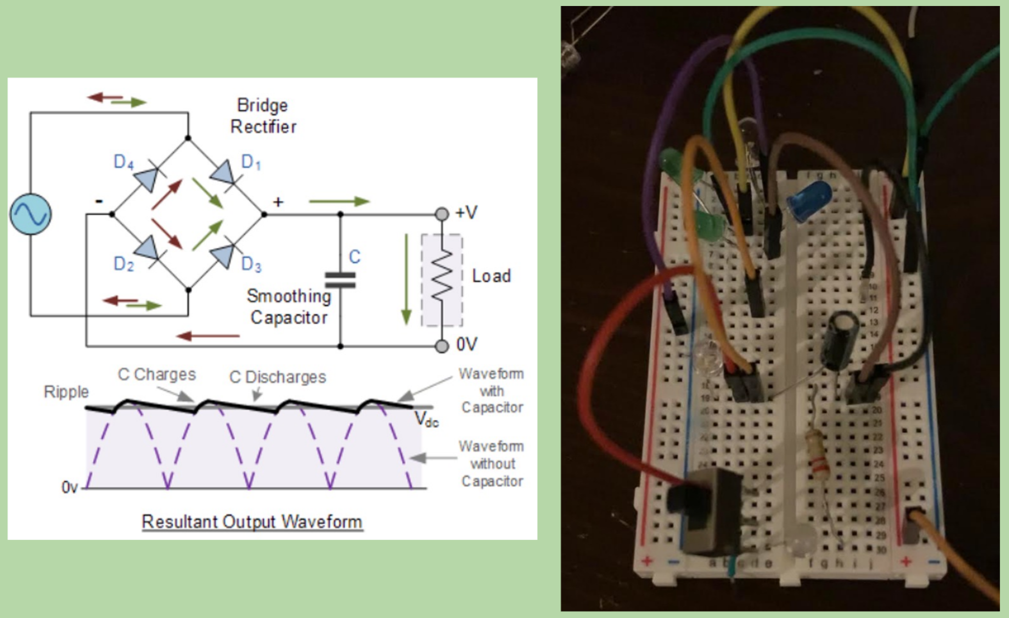

FIGURE 2: Bridge Rectifier Diagram and Implementation

After building a fairly primitive initial circuit to test the piezos, we realized that the piezos were generating a positive voltage on the down press, and a negative voltage on the release of the press. We researched this phenomenon and tried to find a way to capture all of the charge into one capacitor, but found no solution online.

We realized after some more testing that we were simply creating an AC current, and just needed to build an AC to DC converter, known as a bridge rectifier. We used LEDs (light emitting diodes) to better understand how this arrangement of components worked.

ANALYSIS AND FINAL PRODUCT

After creating a working circuit prototype, we looked to scale up our project, and called a custom piezoelectric generator company to find larger and more fitting generators.

Unfortunately, we found that this is effectively not possible using piezoelectric generators, as they, by nature, do not produce meaningful work energy.

I was curious about the math, so I ran a capacitor charge calculation using 10 presses and found that we were generating 2 E -6 amps of current, or 2 millionths of what we were aiming for.

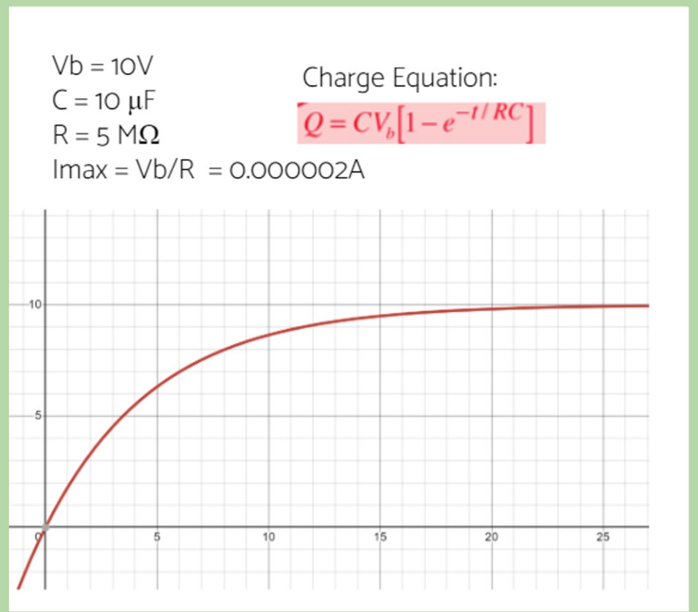

FIGURE 3: Capacitor Charge Graph and Calculation

Given that we were limited by even the ideal piezoelectric generator system, we decided to pivot and pursue a different method of energy capture using a DC motor.

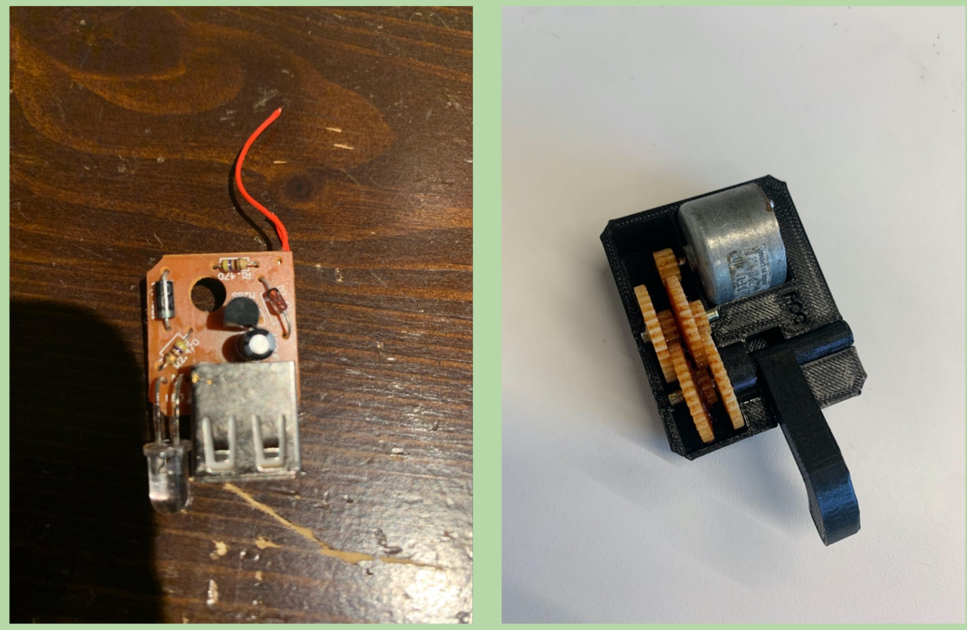

FIGURE 4: PCB and gearbox

We designed a gearbox and lever system that spins a generator motor at a 1:81 gear ratio using 3D printed parts designed in Autodesk Inventor.

Additionally, this generator came with a premade PCB, which had a very similar layout to our earlier circuits that didn't have a bridge rectifier.

In our case, we would want to make our own PCB with a bridge rectifier instead of using this premade circuit, as we would be generating positive voltage on a step down and negative voltage on the passive return.

Using this setup, a person taking approximately 4000 steps/day could generate enough energy to charge a phone once (about 3000 mAh), which we concluded accomplishes our criteria.

CONCLUSION/NEXT STEPS

After learning so much about circuits and electrical engineering, I realized I'm just scratching the surface of the field, and really want to spend more time deepening my knowledge and my experience with circuits. To this end, I plan on creating an analog computer using circuits during my senior project,. I look forward to continuing my exploration of biomechanics and electrical engineering well past my high school career!