ELECTRICAL AND COMPUTER ENGINEERING
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Electric Bike Battery Regeneration Using Piezoelectric Harvesting

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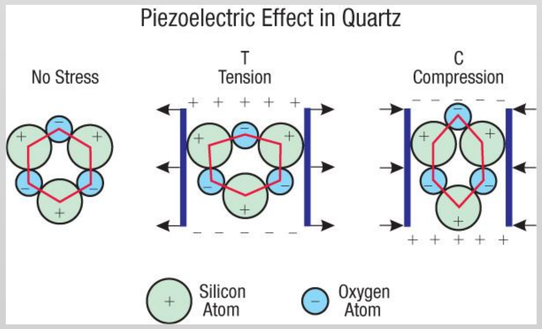
Piezoboys Worldwide

Abstract

As urban areas get more densely populated, the development of an energy efficient and eco-friendly transportation solution becomes more necessary. This is why our team at Piezoboys Worldwide has set out to provide an alternative to the standard model of low-power motorized vehicles by designing a piezoelectric insert that can be implemented within a bike tire, converting mechanical energy into electricity as you ride. This technology provides greater electrical yield as the amount of force and revolutions per minute that the tire undergoes increases. Our goal is to improve the functionality of electric bikes for use in urban areas where traffic is a growing concern. After conducting a survey of urban commuters, we found the biggest deterrent for bike riding was visibility and safety. To address this issue, we want to guarantee a large enough power output to be capable of powering lights to greatly increase visibility of the rider. In our research we found this method capable of providing enough electricity to power small electronics such as lights and offer battery charging capabilities.

Piezoelectrics

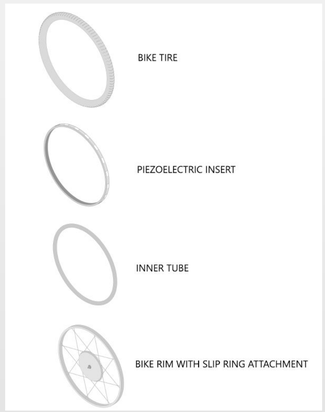


The purpose behind the application of piezoelectricity is to convert mechanical energy from the actuation of a material into energy that can be repurposed. The piezoelectric component's harvested energy is directly proportional to the mechanical energy applied. Piezoelectricity returns a high, consistent voltage but comes with the disadvantage of low individual amperage.

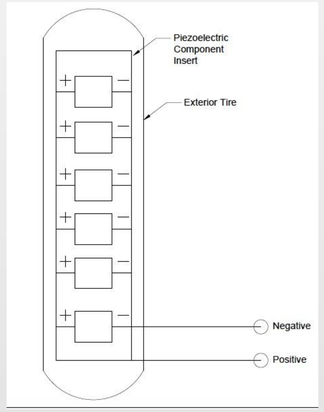
Final Design

Conceptual Design

Exploded Axon



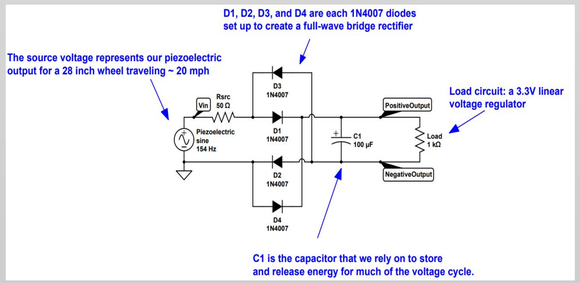
Piezoelectric Insert Configuration



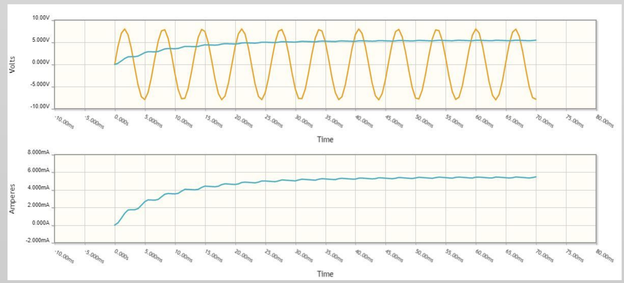
- Our final conceptual design will have 75 quartz piezoelectric plates in parallel, increasing the bridge rectifier output to ~ 5V DC, 375 mA
- From the bridge rectifier, the output voltage goes to a 3.3V voltage regulator which limits the piezoelectrics variable output to a constant 3.3V DC
- After the voltage regulator, the output goes to a 3.3V to 12V step up transformer which connects to the input of our rechargeable battery

Results

SPICE Simulation



Transient Response



- The SPICE simulation shows the full-wave bridge rectifier transforming the 8V AC / 154 kHz signal from a single piezoelectric element into a ~ 5V DC, 5 mA output
- Adding multiple piezoelectric components in parallel sums the current of each individual element
- Our final output with 75 piezoelectric plates will be 12V DC, ~375mA

Engineering Requirements

- Harvesting circuit output voltage must match required input voltage specifications of the battery
- Piezoelectric elements must be able to endure conditions comparable to that of an everyday rider
- Output must be large enough to power lights or small electronics
- Design of tire insert should not interfere with the functionality of the wheel

Bill of Materials

Part Name	Quantity	Cost
3.3V to 12V step-up transformer	1	4.59
12V rechargable 6000mAh battery	1	33.89
Piezoelectric harvesting plate	75	73.45
3.3V voltage regulator (LD1117V33)	1	1.95
Slip Ring	1	17.99
1N4007 Diode	4	1.32
100 microFarad Capacitor	1	0.47
Bikes Lights	1	11.12
TOTAL		**$144.78**

Conclusion

In our testing, we found the electric potential to be smaller than what is required to power an electric motor, but more than enough to power peripheral electronics such as lights and can successfully charge a battery over a long period of time. With all this taken into account, the piezoelectric harvesting design does not produce enough energy to power an electric bike on its own due to low output currents, but could be used as a supplemental hybrid charging design to extend the battery life of electric bikes. The greatest advantage to this design is that the only input required to yield an output is mechanical work.

Acknowledgements

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