ENERGY HARVESTING OF THE HUMAN BODY VIA PIEZOELECTRIC & THERMOELECTRIC PRINCIPLES

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AFFILIATIONS

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ABSTRACT

This research aims to delve into energy alternatives for biomedical applications by utilizing waste energy from our bodies. The focus of this study is based on two types of energy harvesting: Piezoelectric and Thermoelectric generators. The findings of this investigation showcase an average voltage generation per step of the PEG of 52.3mV and a TEG voltage average of 7.89V @ΔT<10°C. Even so, the applications of the designed circuits are restricted by their low current generation. For that matter, the contributions of this investigation are intended to serve as a stepping-stone for future developments in human energy harvesting for biomedical applications.

OBJECTIVE

The main objective was to design and build a piezoelectric and thermoelectric circuit and perform a comparative analysis. This was partly done by determining the charging capabilities of the PZT and its relation to time. Whereas the TEG, aimed to reach the DC-DC Boost threshold of 12V stepped-up voltage, thereby improving time duration and average voltage.

METHODOLOGY

Piezoelectric Generator:

- Circuit built consisted of the piezoelectric material, a diode rectifier bridge and a shunt capacitor.
- PZT characterization was performed via manual bending and a simulated gait cycle.
- Software was implemented to analyze the electrical input and output produced by the PZT circuit.

Thermoelectric Generator:

- Composed of three TEG modules in parallel with a micro DC-DC Boost converter unit and a shunt capacitor at the output.
- Heatsinks and thermal pads were outfitted to improve performance.
- Final configuration analysis was based on overall voltage, time and power output.

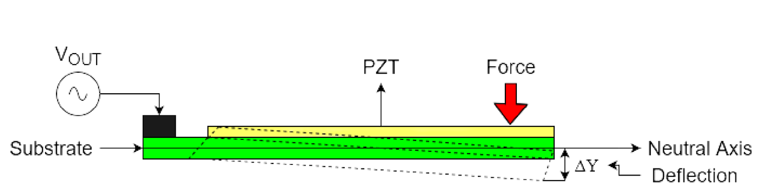

Figure 1a.

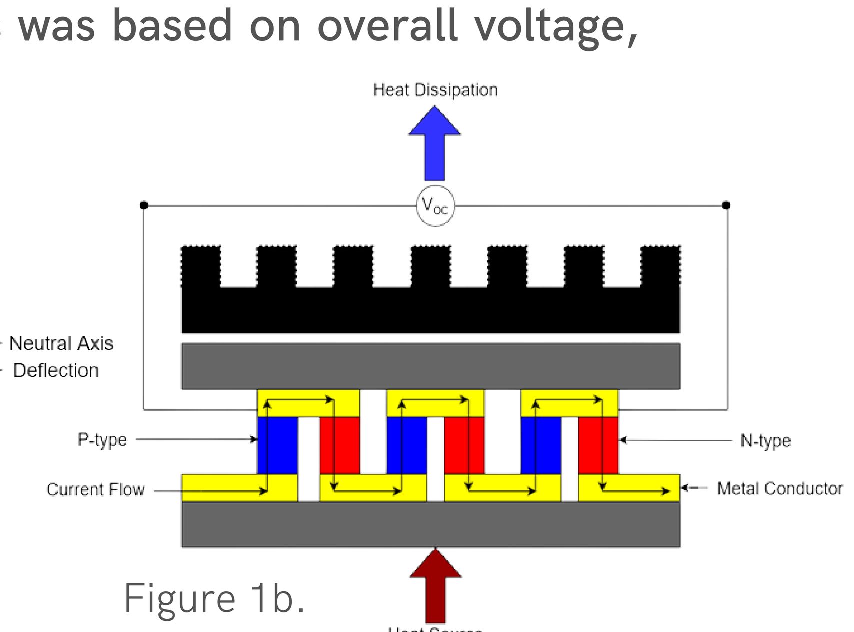

Figure 1b.

Working Principles of the Piezoelectric Generator (Figure 1a) and Thermoelectric Generator (Figure 1b)

DATA

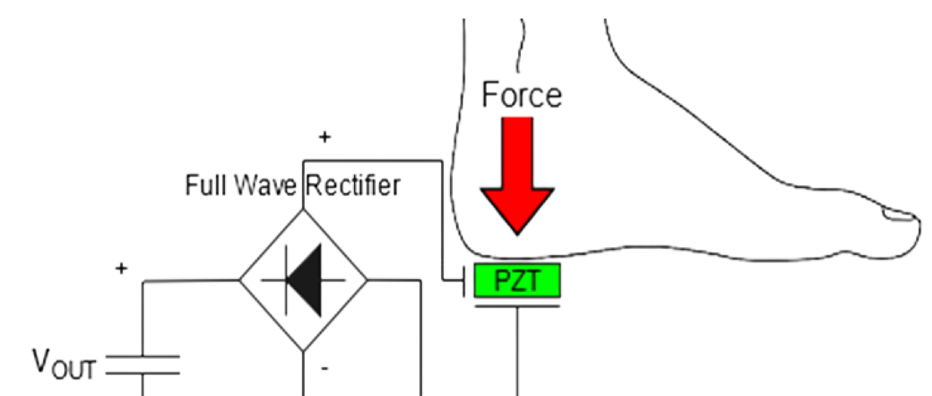

Figure 2a. Piezoelectric Experimental Setup

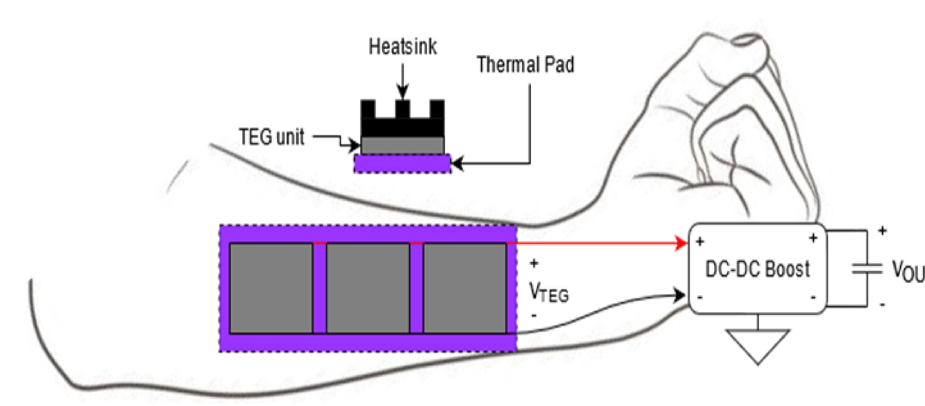

Figure 2b. Thermoelectric Experimental Setup

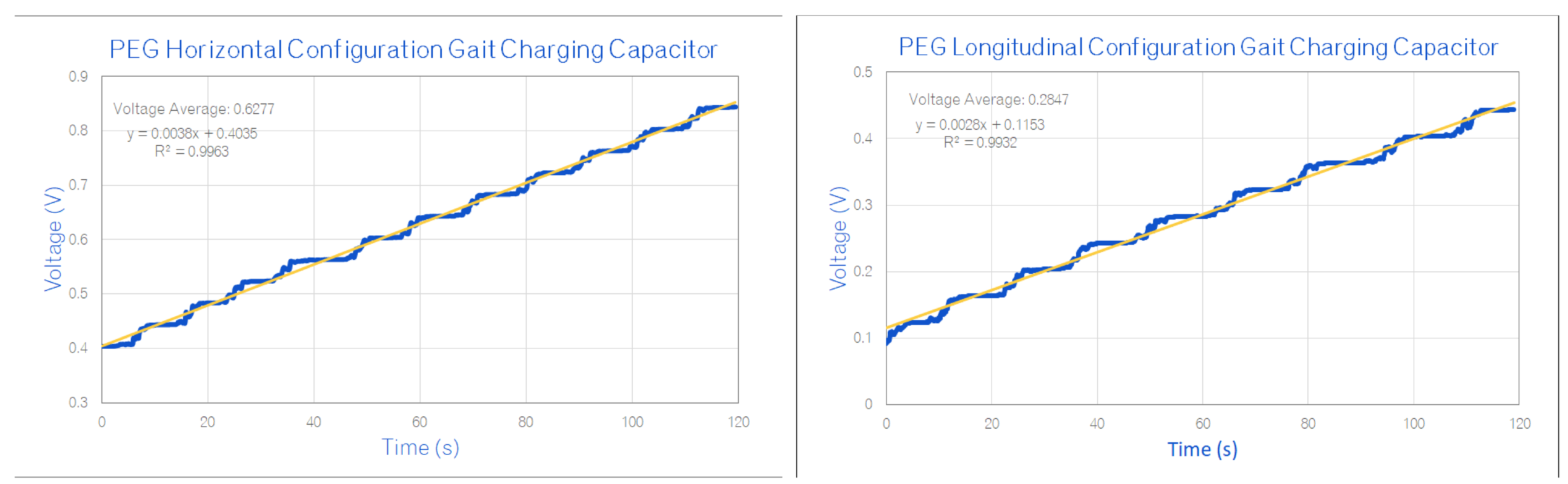

Figure 3. Electric activity caused by simulated gait cycle

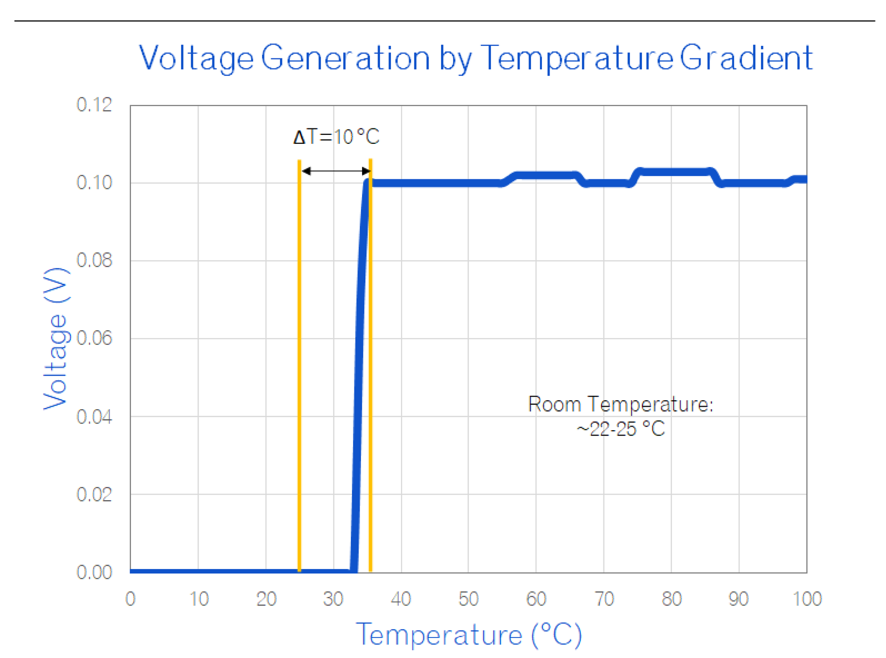

Figure 4a.

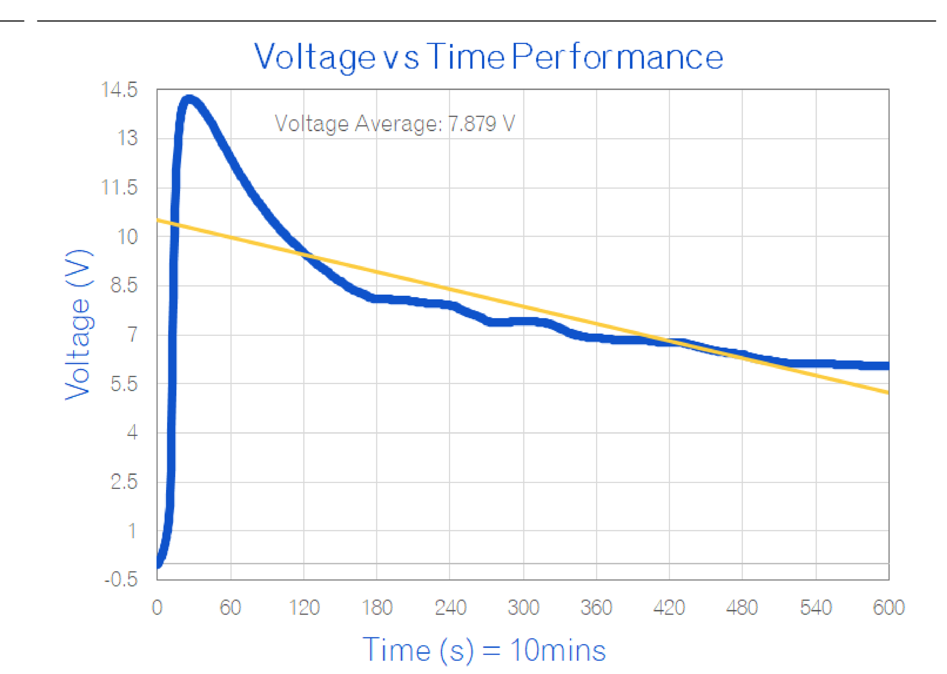

Figure 4b.

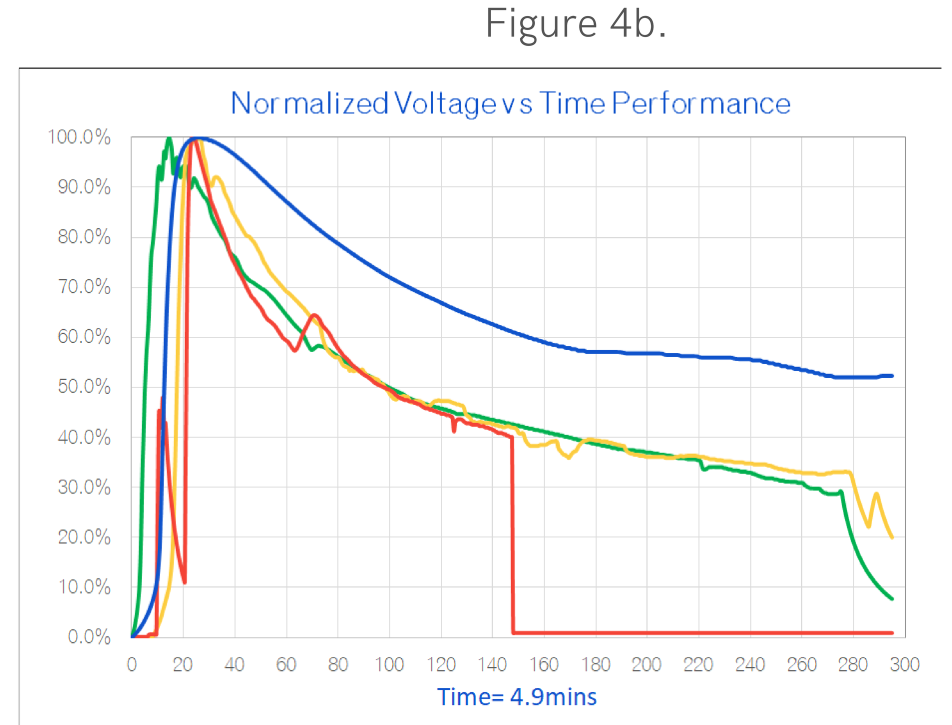

Figure 4c.

TEG unit characterization (Figure 4a), Final Configuration (Figure 4b) and Normalized Voltage Performance Tests (Figure 4c)

RESULTS & ANALYSIS

Piezoelectric Generator	
Voltage per Step (V)	0.0523
Current per Step (μA)	0.0671
Energy Generated per Step (μJ)	36.00
Thermoelectric Generator	
Voltage (V)	Peak: 14.19 Avg: 7.89 @ΔT<10°C
Current (μA)	Peak: 2.89; Avg. 30
Time Duration (min)	Max: ~28; Min: 11

- The PEG is a costly investment, but it is not temperature dependent or decaying and can charge a capacitor indefinitely. Moreover, a horizontal configuration of the PZT proved to be more effective in voltage generation.
- Cost of TEG units are cheaper, but require a boost converter which adds to the overall circuit price. Furthermore, improving the maintenance of the ΔT~10°C gradient proved beneficial for longer time voltage production.
- However, both generators are subject to limited current generation and it is the main constriction for higher power output.

CONCLUSION

These generators are functional examples of energy harvesting with a factor of limited current generation. Examining both options, their functionality is limited by their power output. This application confers to the constraints of low ΔT TEGs and general use PZTs commercially available. Thus, these limitations are apparent to this context, alternate measures can be attempted to overcome such obstacles in the future.

ACKNOWLEDGEMENTS & REFERENCES

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Additional Information