Triboelectric Energy Harvesting

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Abstract

In collaboration with the U.S. Army Combat Capabilities Development Command (DEVCOM) Soldier Center, this project seeks to investigate and improve upon the capabilities of triboelectric nanogenerators (TENGs) for future military use. TENGs passively produce electrical energy through the dynamic interaction of materials in the triboelectric series. This project focused on maximizing the power output of TENG designs through the selection of optimal triboelectric materials and the modification of contact surfaces. These TENGs were designed to be integrated into different types of military equipment such as boots, tents, and parachutes. The research of materials, textures, and contact modes improved the power output of the prototypes and informed the iterative development cycle. This project produced two final prototype designs, one boot-integrated and one wind-activated. These prototypes are capable of producing 3.709×10−6 Joules/step and 0.0002531 Joules/second, respectively, the latter providing enough power for running small sensors.

Objectives

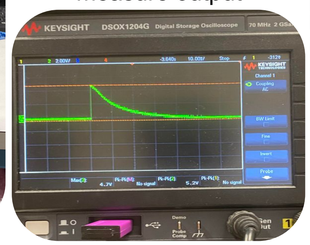
1. Create a TENG that can harness energy from within a boot
2. Create a TENG to harness wind energy for a parachute or tent structure to charge a battery or power a sensor
3. Maximize power output through manipulation of materials and structures of the TENGs

Testing Methodology

1. Create a TENG out of the best performing materials
2. Charge a capacitor with the TENG by stepping or using a blow dryer
3. Connect the probes of the oscilloscope to the capacitor to discharge and measure voltage
4. Convert voltage to Joules using $E = \frac{1}{2} * C * V^2$

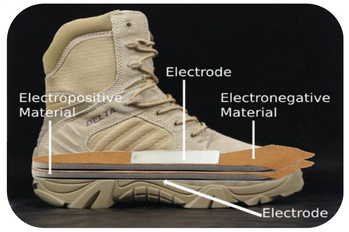
Wind TENG testing setup

Capacitor charged by TENG is discharged to measure output



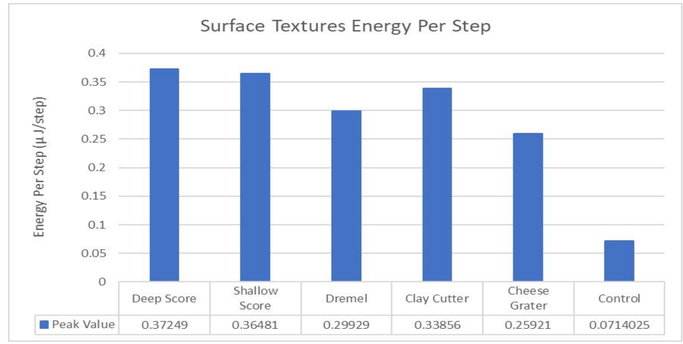
Boot TENG testing setup

Boot Prototype:

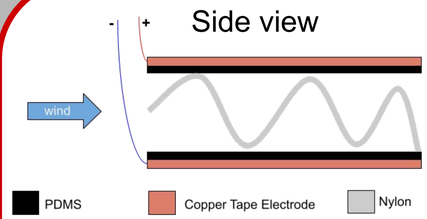


- Used Clay Sculpting Tools, a Cheese Grater, a Dremel and an X-ACTO knife to produce various textures
- Surface textures provided an energy increase from .07μJ/step to at minimum 0.26μJ/step
- Final Prototype was able to reach 3.7μJ/step

Boot Results:



Wind Prototype:

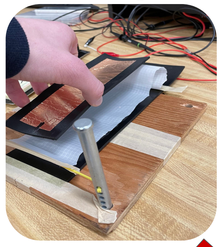


This design only uses 3 materials costing only $4.12.

Progression of one area of TENG design

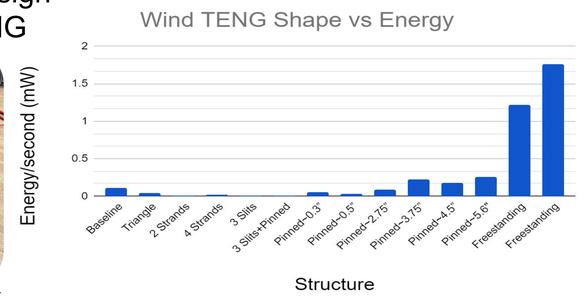
SIngle electrode

Freestanding TENG



Double electrode

Wind Results:



Our final design charged a capacitor to about 600 volts in 10 seconds or about 0.0176 joules which is 1.76 milliwatts.

Applications and Future Work

- Battery charging/energy storage
- Powering small sensors
  - Parachute fatigue data
  - Soldier biometric data
  - GPS location

In the future we recommend that teams explore further power draw testing and overall textile integration.