Using Piezoelectric Film to Capture Voltage

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Abstract

Piezoelectric Film is an enabling transducer technology with unique capabilities. Piezoelectric Film produces voltage in proportion to compressive or tensile mechanical stress or strain, making it an ideal dynamic strain gage. It makes a highly reliable, low-cost vibration sensor, accelerometer or dynamic switch element. Piezoelectric Film is also ideally suited for high fidelity transducers operating throughout the high audio (>1kHz) and ultrasonic (up to 100MHz) ranges. The Piezoelectric Film can become a power source that can be used to power another device. By flexing the PVDF film a voltage is created, that voltage can then be captured and stored until needed.

Research Objective

Our objective states that we will determine whether or not a correlation exists between wind velocity and voltage output from our Piezoelectric (PVDF) film sensor attached to a High Visibility Marking Flag. In order for us to determine this correlation it is important to isolate and define the variables we want to evaluate during the testing procedure. The independent variable will be the wind velocity in which we will be able to increase and vary the wind velocity using a wind tunnel. The dependent variable will be the voltage output produced in response to the wind velocity. Our approach for collecting the data will be to use a Vernier Differential Voltage Probe to collect and plot the voltage data in the Logger Pro Software.

Background

Inspired by Feynman's concepts, K. Eric Drexler independently used the term "nanotechnology" in his 1986 book *Engines of Creation: The Coming Era of Nanotechnology*, which proposed the idea of a nanoscale "assembler" which would be able to build a copy of itself and of other items of arbitrary complexity with atomic control. Since that time Build it smaller; Build it to operate faster; Build it to use less energy has been the mantra of industry. The batteries have gotten smaller but the energy requirements gotten even smaller. Thus the need to identify a low voltage, low cost renewable power supply.

Methodology

This test is not a pass/fail. It is a data collection test. The test sample will be inserted into a wind tunnel and set at low velocity (1mps). Data will be collected for 10 seconds after the wind tunnel has stabilized. The velocity will be increased in units of 1mps and re-tested. Testing will continue thru 8mps. Repeat the testing three times. The test will terminate in the event that the flag or the base is moved by the wind velocity.

Figure 1. Meet with our mentor and discuss our line of research

Figure 2. Research and Design the test flag

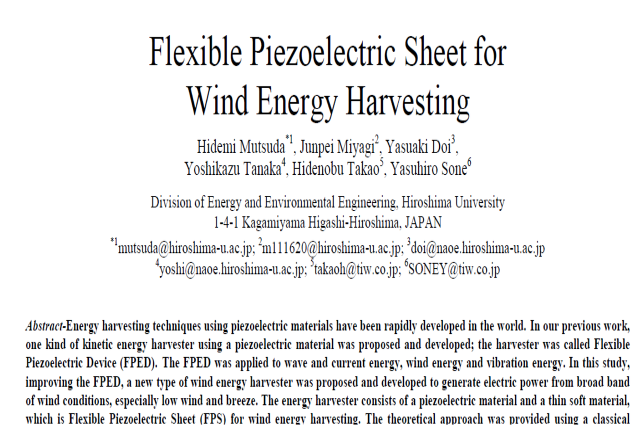

Flexible Piezoelectric Sheet for Wind Energy Harvesting

Figure 3. Build the test models

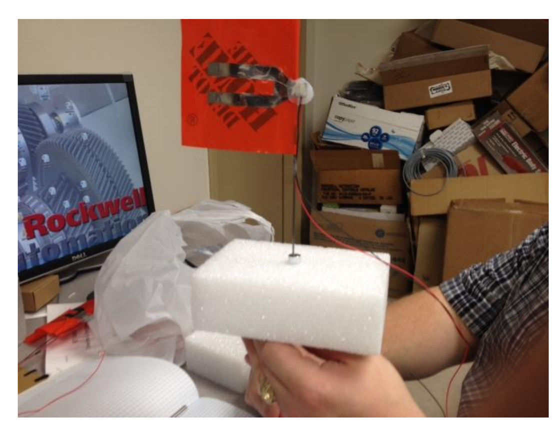


Figure 4. Mount the test model in the Wind Tunnel

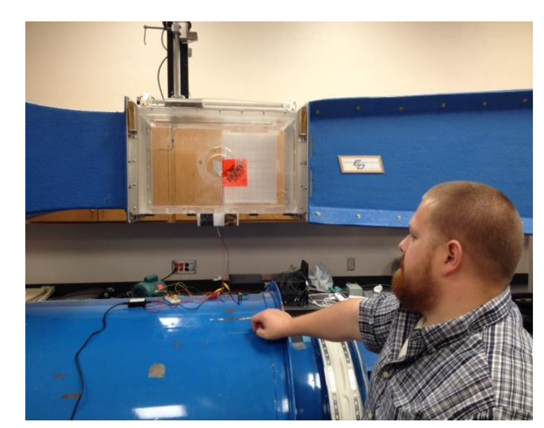


Figure 5. Add the sensor hardware to interface with the computer

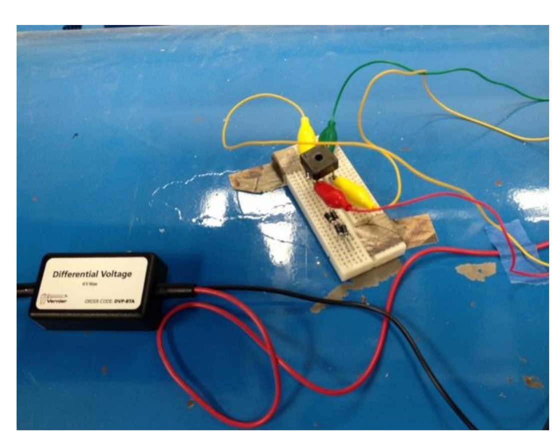


Figure 6. Set up the wind tunnel

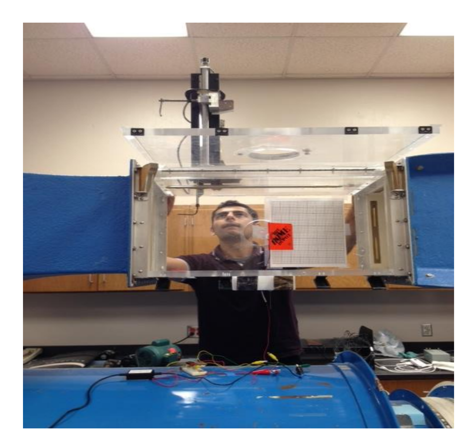
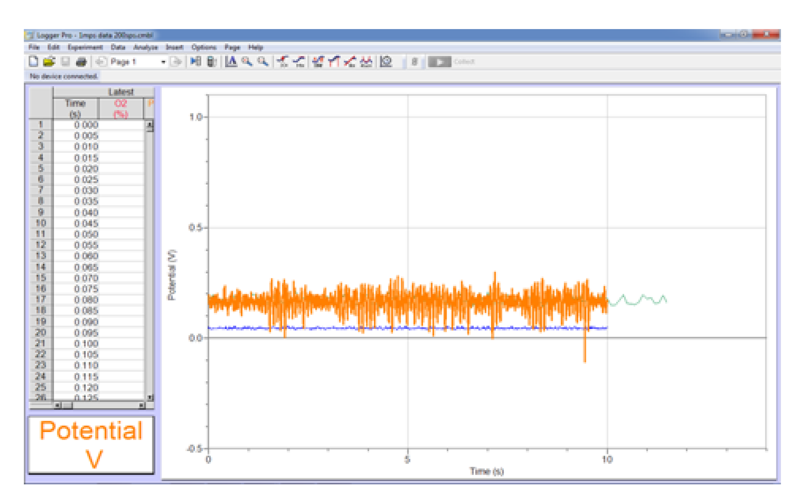


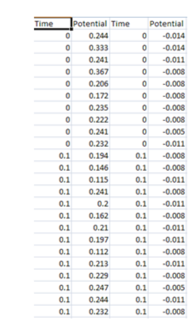
Figure 7. Calibrate Sensor



1mps wind velocity (trial 1 & 2) with base line data

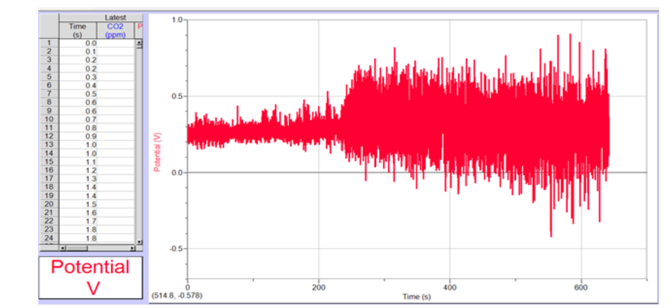
Results and Conclusions

We began collecting the data. 10 seconds for each 1mps of wind velocity increase. Our range was between 0-mps and 8-mps (18 mph)

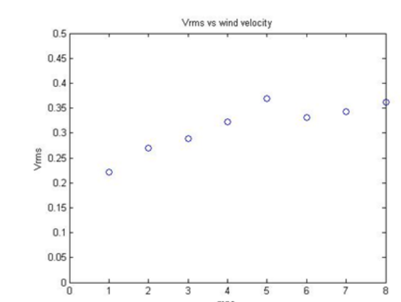


Time	Potential	Time	Potential
0	0.244	0	-0.014
0	0.333	0	-0.014
0	0.241	0	-0.011
0	0.367	0	-0.008
0	0.206	0	-0.008
0	0.172	0	-0.008
0	0.235	0	-0.008
0	0.222	0	-0.008
0	0.241	0	-0.005
0	0.232	0	-0.011
0.1	0.194	0.1	-0.008
0.1	0.146	0.1	-0.008
0.1	0.115	0.1	-0.011
0.1	0.241	0.1	-0.008
0.1	0.2	0.1	-0.011
0.1	0.162	0.1	-0.008
0.1	0.21	0.1	-0.011
0.1	0.197	0.1	-0.011
0.1	0.112	0.1	-0.008
0.1	0.213	0.1	-0.011
0.1	0.229	0.1	-0.008
0.1	0.247	0.1	-0.005
0.1	0.244	0.1	-0.011
0.1	0.232	0.1	-0.008

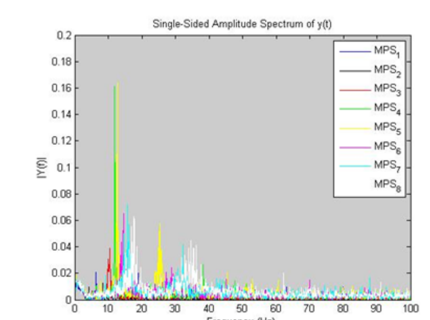
We also ran a continuous test increasing the mps every 60 seconds but running the program continiously. Notice the jump at 4mps.



We placed the data extrapolated from Matlab into an Excel spreadsheet and printed the graph **Note:** voltage is represented as RMS Voltage



We also used Matlab to look at the amplitude of the voltage signal. Again it showed the highest amplitude between 4-5 mps.



Our goal for this research was to see if there was a correlation between wind speed and the amount of voltage that we could produce. Based on the data we collected, we feel that not only is there a correlation but that between 4 and 5 meters per second the ability of our sample peaked out the amount of voltage it could produce. Given time we could have trialed other sample shapes, areas, thicknesses to explore the optimum film and wind speeds for maximum voltage capture. Based on frequency vs amplitude 4-5 mps appears to maximize flag movement.

References & Acknowledgements

Priya, S. Advances In Energy Harvesting Using Low Profile Piezoelectric Transducers. *Journal of Electroceramics*, 167-184.
Flexible Piezoelectric Sheet for Wind Energy Harvesting. *International Journal of Energy Engineering (IJEE), Vol. 4*, PP. 67-75.
Voigt, W. (1910). *Lehrbuch der kristallphysik (mit ausschluss der kristalloptik)*. Leipzig: B.G. Teubner.
Research: New Piezoelectric Materials. (n.d.). . Retrieved July 2, 2014, from http://www.science20.com/news_account/research_new_piezoelectric_materials
HowStuffWorks "How does the lighter in a BBQ grill work?". (n.d.). *HowStuffWorks*. Retrieved July 2, 2014, from http://www.howstuffworks.com/question383.htm
Piezoelectricity. (2014, June 19). *Wikipedia*. Retrieved July 2, 2014, from http://en.wikipedia.org/wiki/Piezoelectricity
HowStuffWorks "How Wearable Technology Works". (n.d.). *HowStuffWorks*. Retrieved July 2, 2014, from http://www.howstuffworks.com/gadgets/high-tech-gadgets/computer-clothing.htm
Measurement Specialty WWW.measspec.com/ Sensor types/piezo/products

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