Piezoelectric-Based Energy Harvesting

Gregory Aliaga and Dr. B. Chang

UNIVERSITY OF NEW HAVEN

SURF

Mission Statement:

To Study An Alternative Form To Harvest Energy By Means Of Road Application Using Piezoelectric Materials

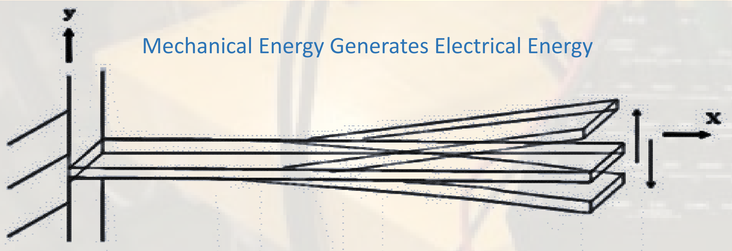
Introduction

Why Use Piezoelectricity To Harvest Energy?

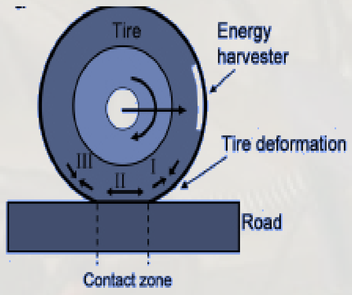
- **Alternative Renewable Energy Source**
- **Long Lasting And Durable**
- **Energy Can Be Use Instantly Or Stored In Battery For Later Use**
- **Unique Actuation In Versatile Applications**

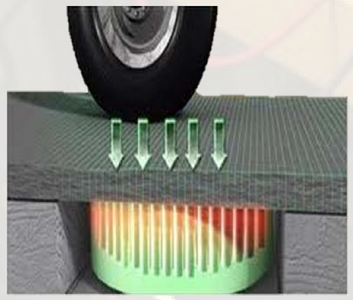
Basic Concept

Mechanical Energy Generates Electrical Energy



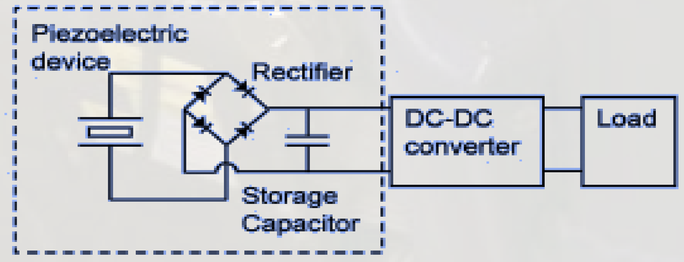
Conceptual Design





Vehicle Tire Transmits Weight Onto The Road Then To The Piezoelectric Components

Circuitry



Design Challenges

- Concept Application
- Feasibility
- Mechanical Properties/System Vibration
- Determining proper material based on publication
- Determining proper material based on size
- Overcoming Low Current Output
- Proper Boundary Condition For Best Effective power output

Prototype

For Simplicity, LabView Softwarte was not used since field testing was conducted outside of building.

Instrumentation:

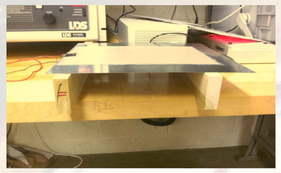
- Oscilloscope
- Resistance Box
- Piezo Film sheets (8” x 11”)

Attachments:

- Steel Plate (To Allow Vibration)
- Foam Panels (For protection)

Boundary Conditions:

Cantilever Condition: For This Orientation One Side Was Clamped To Simulating In Sided Fixed

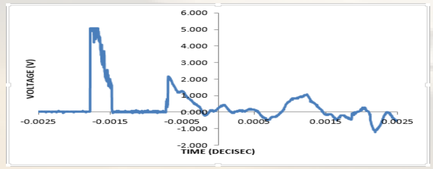


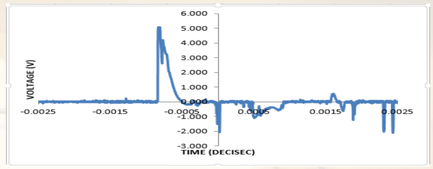
Simply Supported Condition: Both Sides Were Left Free To Rotate And Have No Moment Resistance

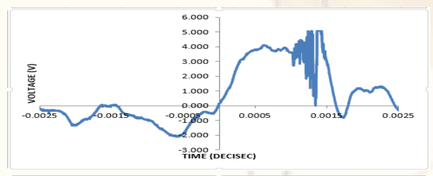
Both Fixed Ends: The Components Were Fixed At Both Ends Using Clamps On Both Ends, Restrained From Rotation

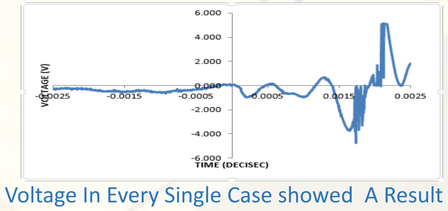
No Boundary: The Components were left flat on the ground with no boundary conditions using self weight

Voltage With Respect To Time



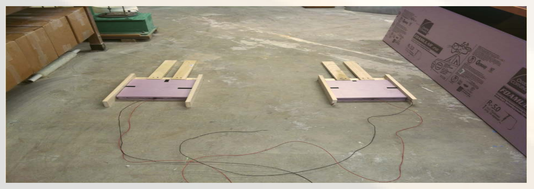






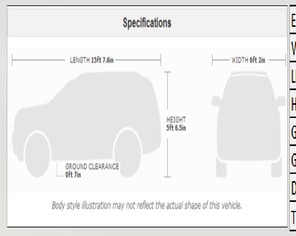
Note: After The Four Boundaries Were Tested, The Output Voltage In Every Single Case showed A Result Peak Voltage of 4.81V From Which 3.40V Is Effective Voltage, Therefore For Simplicity No Boundaries Set Up Was Chosen

Field Testing

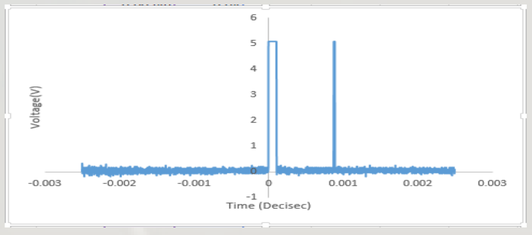


Field Testing Was Performed at Buckman Hall By The Docking Area. The Following Vehicle Model Drove Over built Ramp Making A Stop And Go Simulation.

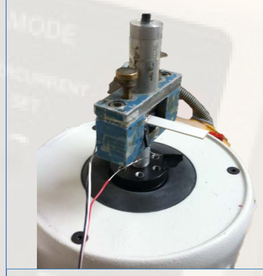
Results: Results Showed A Max Effective Voltage (RMS) of 3.59V At Which Depending On the Resistance Applied Could Reach A Maximum Power Output Of 12.9 Watts



EXTERIOR MEASUREMENTS	
WIDTH (FT)	6.17
LENGTH (FT)	15.63
HEIGHT (FT)	5.54
GROUND CLEARANCE (FT)	0.58
GROSS WEIGHT (LBS)	5051
DRIVE TYPE	ALL WHEEL DRIVE
TIRE WIDTH (FT)	0.75



Initial Phase



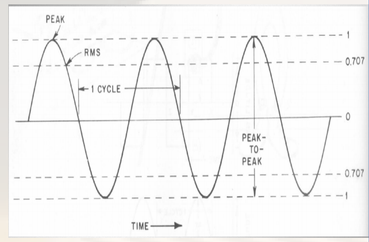
Instrumentation:

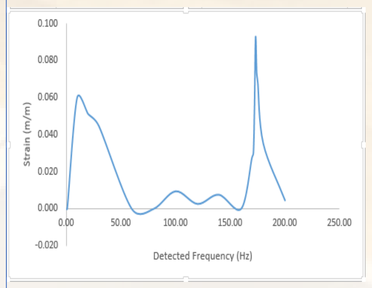
- LDS Shaking Unit
- Resistance Box
- Oscilloscope
- Generator Wiring
- Cantilever Beam PZT-5H (Lead Zirconate Titanate)
- LabView Software

Analysis

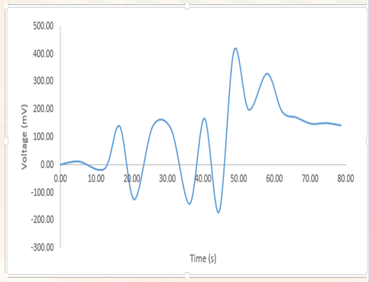
Material Dimensions And Properties Of Piezoelectric Cantilever Beam

Property	Symbol	Value
Length (mm)	L	35
Width (mm)	b	10
Structure thickness (mm)	t_s	0.1
Structure density (kg/m³)	ρ_s	8960
PZT thickness (mm)	t_p	0.2
PZT density (kg/m³)	ρ_p	7800
PZT modulus (GPa)	c_p	72
PZT dielectric constant	K_3^T	3500
PZT strain constant (m/V²)	d_{31}	-270×10⁻¹²





Tested Natural Frequency Agrees With Theoretical Natural Frequency At 170 Hz



Highest Effective Voltage Of 410mV Occurred At The Same Time (48.62s) As The Natural Frequency

At The Highest Recorded Frequency, Different Levels Of Resistance Were Documented

Future Work:

- Focus On Design To Allowed Proper Vibration And Therefore Generate Power For A Larger Time Frame
- Simulate A More Realistic Street Scenario
- The Use OF Different Vehicles

Acknowledgements:

Advisor: Dr Byungik Chang

Instrumental Assitance: Dr Samuel Daniels

Field Testing Area: Chief Of Police Mark DeLieto

Special Thanks To The SURF Program For Allowing me To be Part OF Such Outstanding Program.