

Vibrational Energy Harvesting For Powering Field Instruments

Team 11 Members

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Introduction

- Increasing demand for sustainable and portable energy
- Battery technological advancement can't compete
- A promising field of research is vibrational energy harvesting
- Truck trailers generate large amounts of vibration
- These environments are perfect for vibration energy harvesting

Project Background

- Many available methods, such as piezoelectric devices, operate for high frequencies.
- Need to harness vibration at low frequencies.
- Common generation method is electromagnetic induction.
- Harness vibration to generate a varying magnetic field.
- Voltage is induced if a conductor is within the magnetic field.

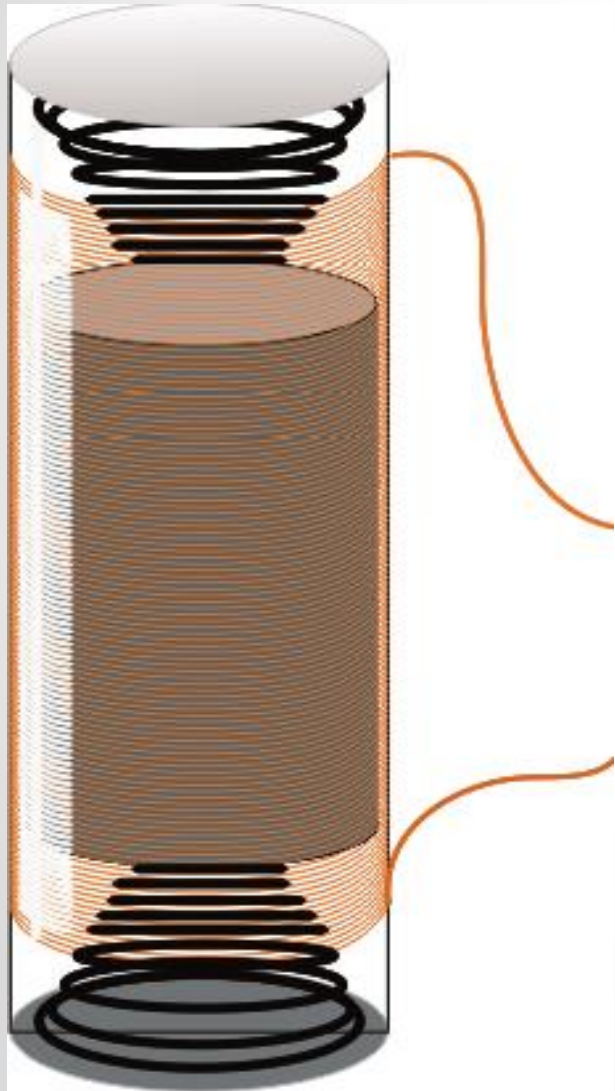
Project Background

- Our harvesting apparatus works ideally for low frequency.
- The converted energy is AC, varying in frequency and magnitude.
- Our powertrain stabilizes the AC to DC values compatible with the rechargeable battery.
- The battery supplies power to IST's field device and our microcontroller.
- Extra power is stored

Design Specifications

- Compatible with VTP-3Dv2
- Rated 3.6V output
- Supply 5mA
- Operate at Low Frequencies (3-4 Hz)
- Rechargeable device
- Attachable / Detachable

Vibration Harvesting Subsystem



- Coiled magnet wire around the outside of cylindrical structure
- Two compressional springs suspending a magnet
- Neodymium magnet is used and attached in between the two compressional springs
- The wire leads will be attached to a powertrain circuit, when apparatus is in use

Design of Electromagnet Apparatus

Specific Parts:

- 2" (diameter) x 2" (height) N52 Neodymium Magnet
- 21" (height) x 2.5" (diameter) PVC pipe {coil height of 3.5"}



Design of Electromagnet Apparatus

Specific Parts:

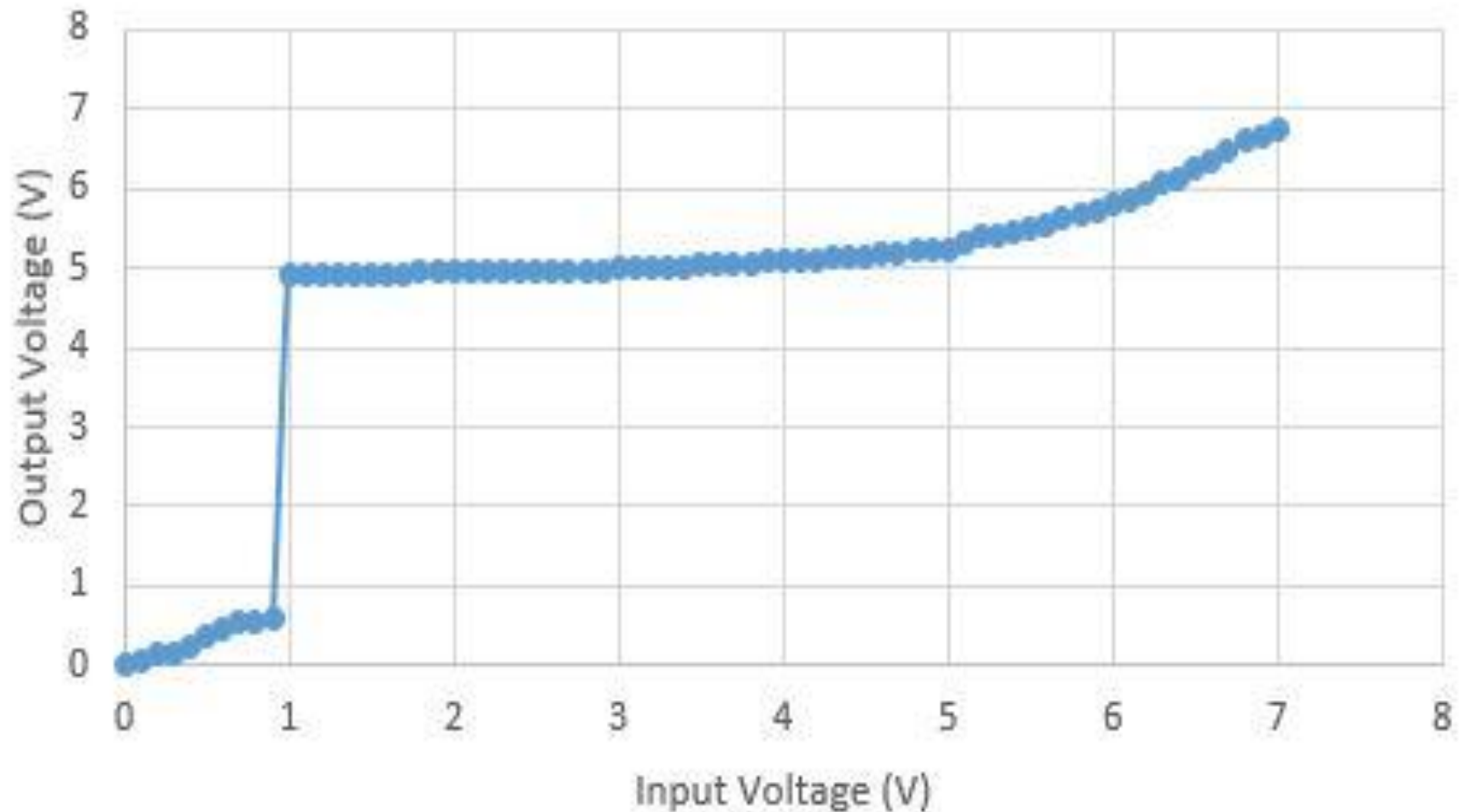
- (4x) 5" Compressional Springs
- (2x) 2.75" (outer diameter) x 2.5" (inner diameter) x 1.25" (height) PVC Caps



Powertrain Subsystem

- Rectifier
 - AC to DC
- Boost converter
 - Step up to 5 Vdc
 - Pass higher voltages

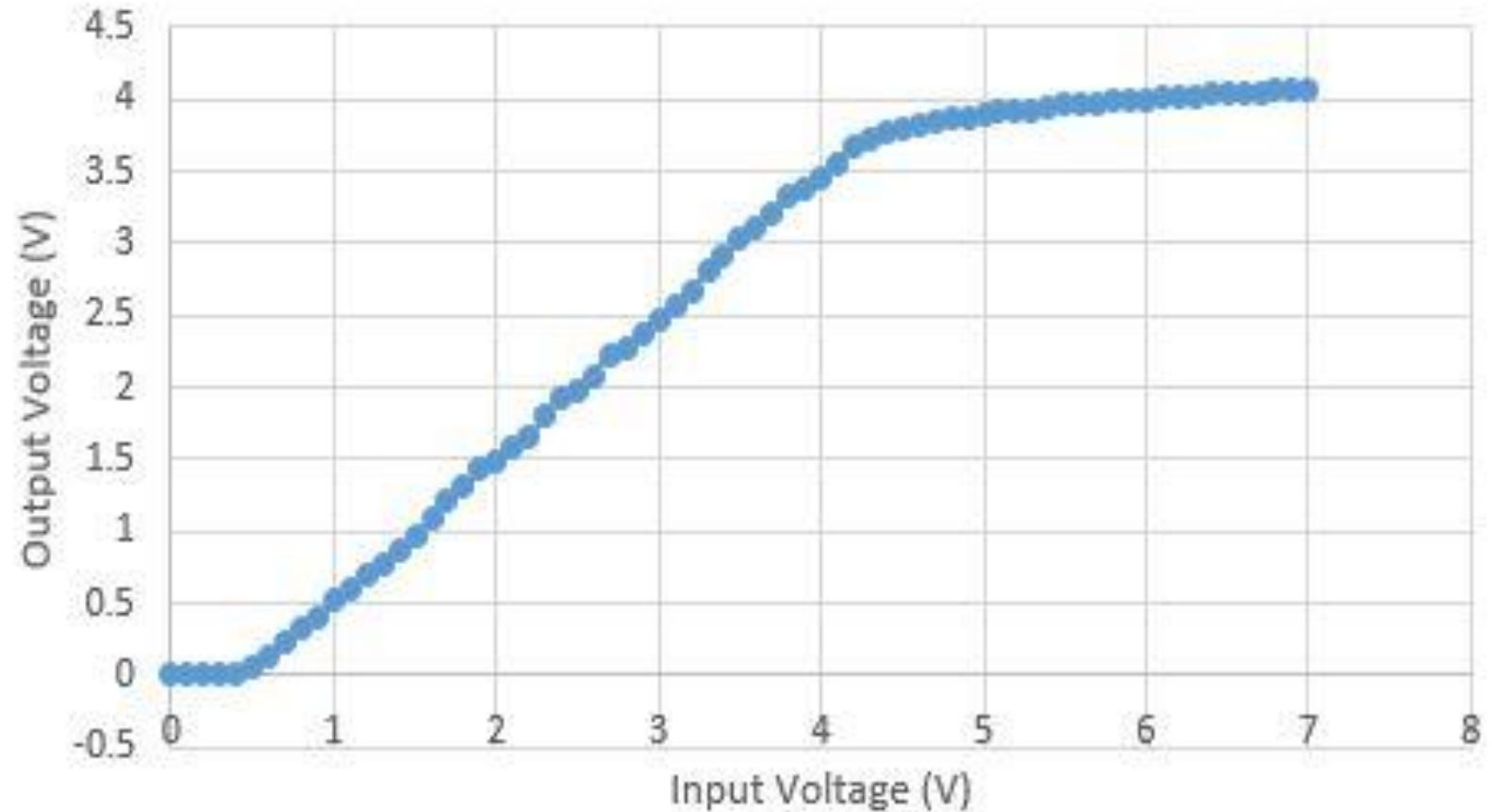
Boost Converter: V_{in} Vs V_{out}



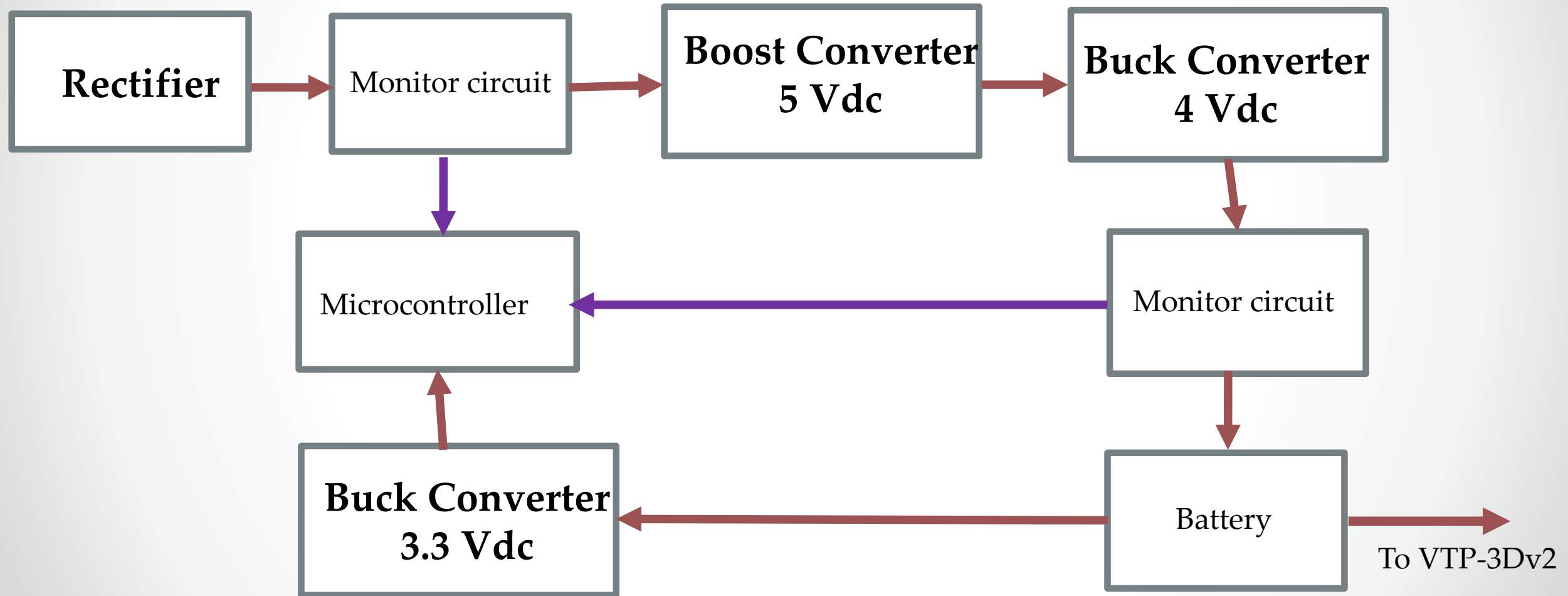
Powertrain Subsystem

- Buck converter
 - Step down to 4 Vdc
 - Pass lower voltages
- Microcontroller
 - Needs power
 - Buck converter
 - Step down to 3.3 Vdc

Buck Converter: V_{in} Vs. V_{out}



Powertrain Subsystem



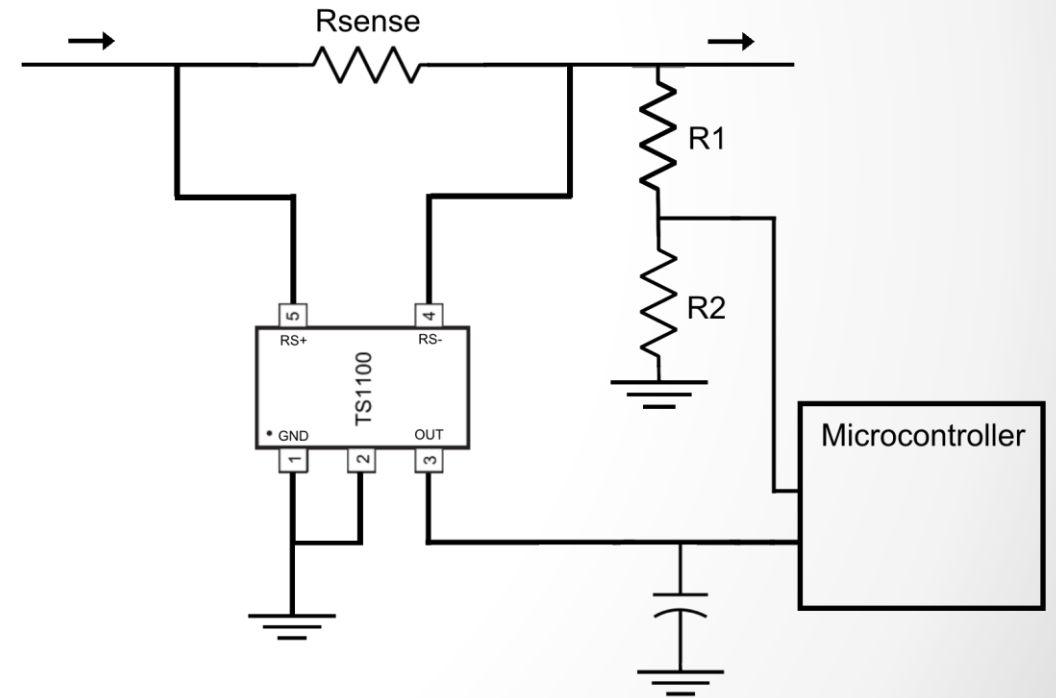
Energy Storage and Supply Subsystem

- Our battery is rated at 3.7V with a capacity of 2250mAh
- Lithium-ion for high energy density and low discharge rate
- The field device, VTP-3Dv2, draws 5mA at 3.6V from 4 AA batteries
- The microcontroller draws below 500uA at 3.3V from the battery



Monitoring Subsystem

- Voltage and current measured in order to calculate power delivered
- Circuit has current sense resistance and voltage divider
 - Current sense amplifier enables microcontroller to measure current
 - Voltage divider lowers voltages to safe values



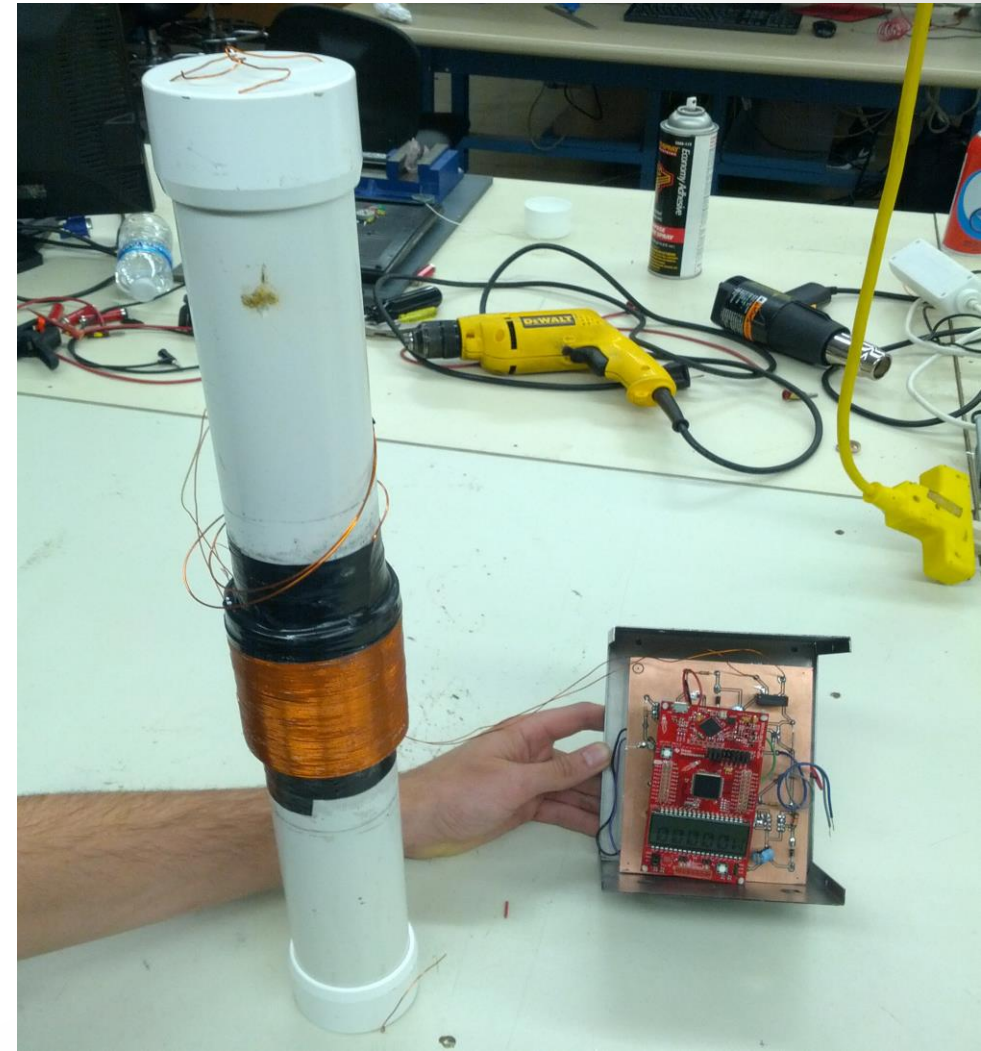
Microcontroller

- TI MSP430FR6989 integrated in Launchpad
 - 12-bit analog-to-digital converter
 - 6-digit LCD for displaying results
 - Real Time Clock for accurate time intervals
- Calculate RMS values for voltage and current



Overall Design

- Vibration apparatus generates power
- Powertrain circuit converts input power
- Microcontroller monitors power flowing into battery



Future Improvements

- Apparatus
 - Make smaller, make cheaper
 - Tune oscillation frequency to resonate more.
- Powertrain
 - Improve converter efficiency
 - Research new parts that are optimal for the application.
 - Reduce forward voltage in diodes
 - Reduce the stages.

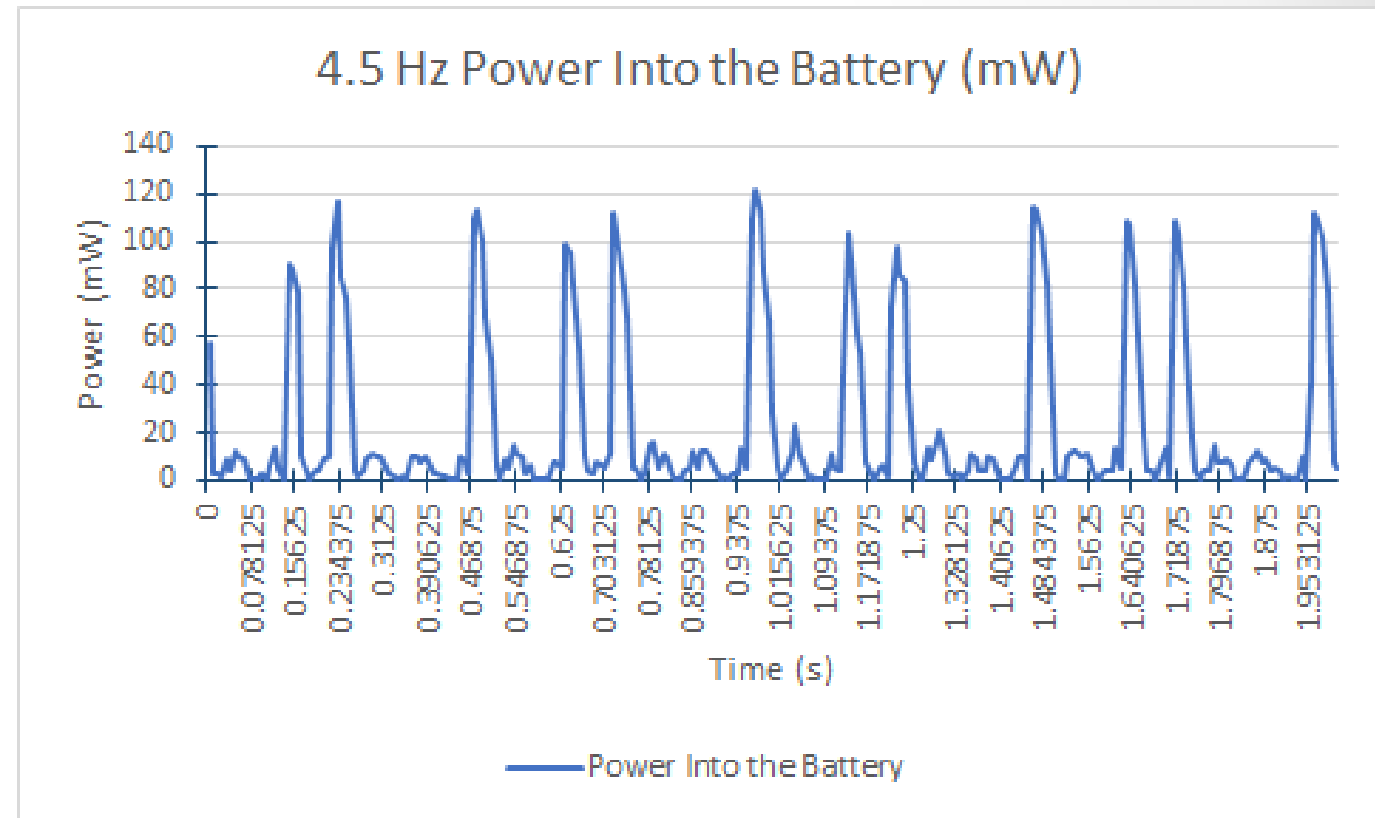
Powertrain Data

- Took measurements at four different nodes:
 - After Boost (5Vdc)
 - After Buck (4Vdc)
 - Battery (3.6Vdc)
 - After Buck (3Vdc)



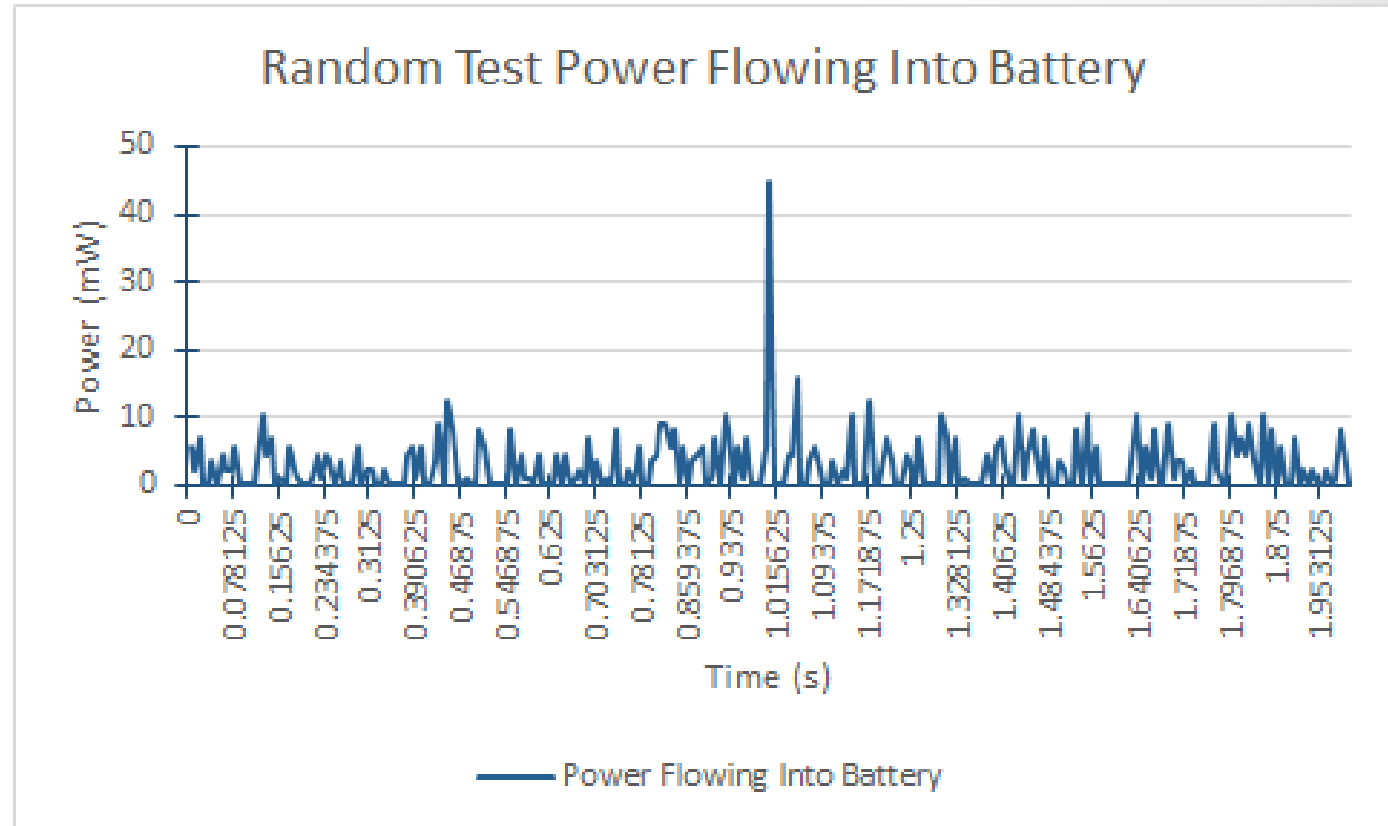
Overall Device Data

- Power measurements taken 128 times per second by microcontroller
- Frequency sweep was done
- 4.5Hz found to be most stable output

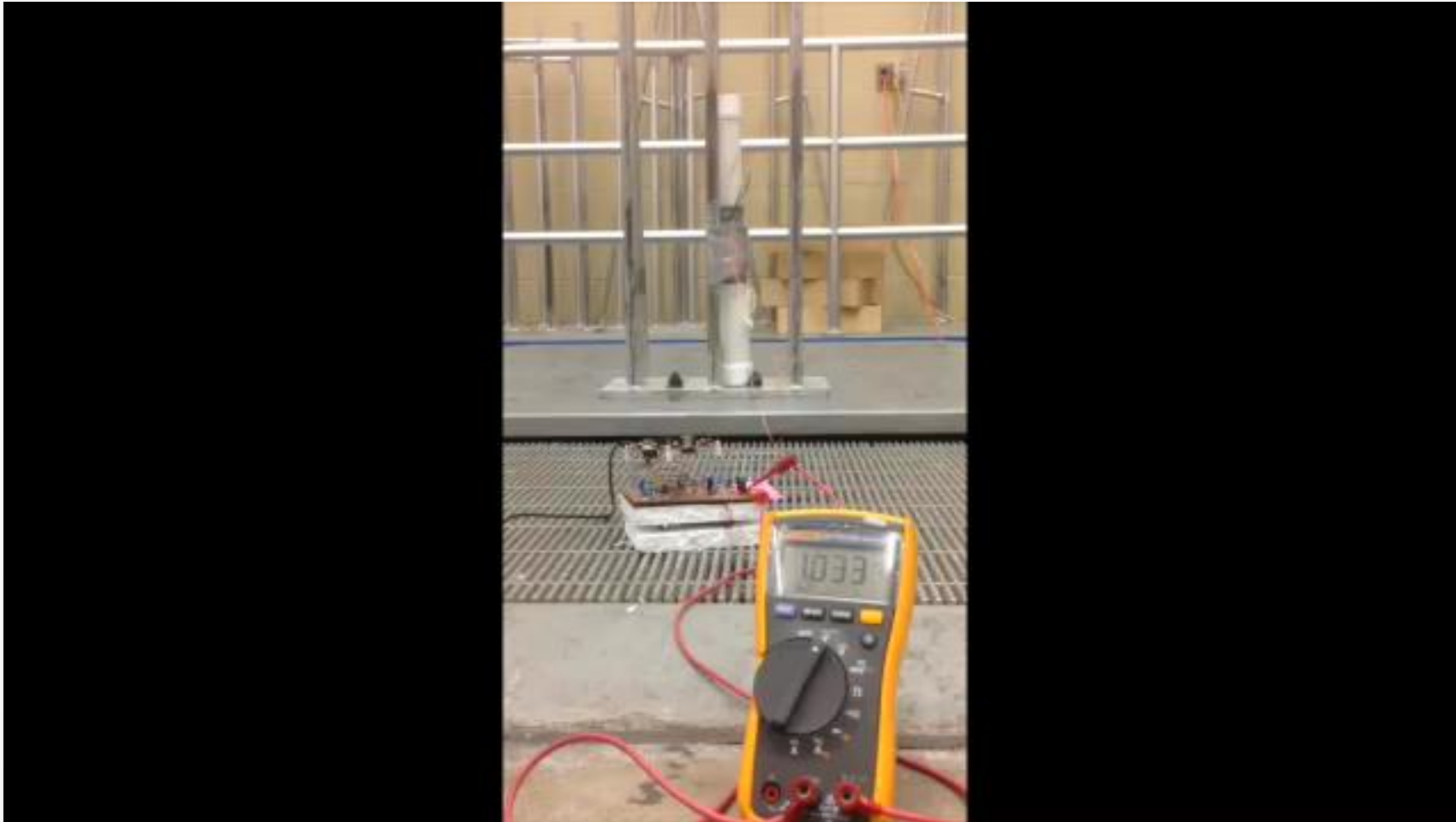


Overall Device Data

- 5 minute ISTA 3A over-the-road truck trailer test
- 56% of the time threshold voltage was reached



Testing Video



Questions?