

EE / CprE / SE 492 – sdmay20-10

Power Scraping Module

Week 6 Report

4/2/2020 -4/16/2020

Client: Honeywell FM&T

Faculty Advisor: Gary Tuttle

Team Members/Role:

Jordan Fox — Chief Engineer

Xiangyu Cao — Design Engineer

Andesen Ande — Design Engineer

Ahmed Salem — Test Engineer

Ben Yoko — Test Engineer

Shahzaib Shahid — *Team Leader*

Weekly Summary

During these two weeks we've been gathering different approaches as requested by our client in late April. The datasheet we were provided for our booster module is pretty minimal in describing how it works so we are still trying to figure out if we are able to get a better understanding. We have been working towards the three main deliverables: presentation, poster, and final report. We have been upgrading our last semester design document and will convert to the final report. We finished up the poster rough draft and plan to make some minor changes. We will begin working on our poster during this week.

Past Week Accomplishments

Poster Rough Draft- Andesen and Jordan

POWER SCRAPING MODULE

AN ENERGY HARVESTING DEVICE FOR REMOTE SENSOR NETWORKS

Produced By: Shahzab Shahid, Benjamin Yoko, Andesen Ande, Xiangru Cao, Jordan Fox, Ahmed Salem
Advisor & Client: Dr. Garry Tuttle & Honeywell

STATEMENT OF PURPOSE	CONCEPTUAL SKETCH		
<ul style="list-style-type: none"> > Research and develop a device that will efficiently collect, convert, and store low voltage energy. > The purpose is to provide an alternative self-powered source for devices. > The goal of this project is to take a small, unusable AC voltage as a source and convert it to a usable DC voltage that can power various components in a system. > The project can be used for many wireless applications like remote sensing, battery-free remote sensors for HVAC control and building automation etc. 			
REQUIREMENTS	DESIGN		
<p style="text-align: center; font-weight: bold; font-size: small;">FUNCTIONAL</p> <ul style="list-style-type: none"> > Converting 1.1V AC Peak to Peak Voltage to 2V DC. > The input signal is the only power source for the device. > Use a source or method that can be adjusted from 1.1 V pp to 0.5 volts V pp. > Include a charge indicator in the output of the device. <p style="text-align: center; font-weight: bold; font-size: small;">NON-FUNCTIONAL</p> <ul style="list-style-type: none"> > The system should be as efficient as possible. > Minimize loss > Determine for every hour of energy scraping, how many minutes will we be able to drive a 20mA LED. > Stretch goals <ul style="list-style-type: none"> > Produce output of 5V > Use harvesting device as input 			
TESTING	MODULES		
<table border="0" style="width: 100%; font-size: x-small;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>COMPONENT LEVEL</p> <ul style="list-style-type: none"> > Diode <ul style="list-style-type: none"> > Verify output voltage > Rectification test > Capacitor <ul style="list-style-type: none"> > Verify capacitance > Charge testing of capacitance > Resistor <ul style="list-style-type: none"> > Verify resistance effect </td> <td style="width: 50%; vertical-align: top;"> <p>SYSTEM LEVEL</p> <ul style="list-style-type: none"> > Output test <ul style="list-style-type: none"> > DO output > At least 5V > Function test <ul style="list-style-type: none"> > Power LED > Verify LED time vs charge time > Efficiency test <ul style="list-style-type: none"> > Energy out vs energy in </td> </tr> </table>	<p>COMPONENT LEVEL</p> <ul style="list-style-type: none"> > Diode <ul style="list-style-type: none"> > Verify output voltage > Rectification test > Capacitor <ul style="list-style-type: none"> > Verify capacitance > Charge testing of capacitance > Resistor <ul style="list-style-type: none"> > Verify resistance effect 	<p>SYSTEM LEVEL</p> <ul style="list-style-type: none"> > Output test <ul style="list-style-type: none"> > DO output > At least 5V > Function test <ul style="list-style-type: none"> > Power LED > Verify LED time vs charge time > Efficiency test <ul style="list-style-type: none"> > Energy out vs energy in 	<ol style="list-style-type: none"> 1. Rectification - Schottky diodes to convert the AC input signal into a DC signal. 2. Voltage Boosting - AC-DC booster module: BH4205, increases an intermittent, low-voltage input to a higher voltage. 3. Energy Storage - Store the charge into a long-term storage component (supercapacitor). 4. Charge Indicator - Indicator (using an LED) that the energy storage device is being charged.
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<p style="font-weight: bold; color: #e91e63;">TESTING RESULTS</p> <p style="font-size: x-small;">Each module was tested independently. Below are the results of the booster module:</p> <p style="font-size: x-small;">This shows a square wave output at the terminal of booster with an input of 0.25 V DC and a 10k ohm load. The measured output was 5.69 V which is an approximate voltage gain of 16.</p>	<p style="font-weight: bold; color: #e91e63;">CONCLUSION</p> <table border="0" style="width: 100%; font-size: x-small;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>ACCOMPLISHED:</p> <ul style="list-style-type: none"> > Designed self contained, energy harvesting unit given constraints listed in statement of purpose. > Completed component level testing > Investigated the inner workings of high performance booster module > Explored alternative methods and parts in order to draw comparisons </td> <td style="width: 50%; vertical-align: top;"> <p>FUTURE WORK</p> <ul style="list-style-type: none"> > Complete system integration testing > Detailed analysis of the performance of our system > Find ways to improve the performance including: charge rate and lowest possible voltage input > Strive for stretch goals > Design and fabricate a PCB </td> </tr> </table>	<p>ACCOMPLISHED:</p> <ul style="list-style-type: none"> > Designed self contained, energy harvesting unit given constraints listed in statement of purpose. > Completed component level testing > Investigated the inner workings of high performance booster module > Explored alternative methods and parts in order to draw comparisons 	<p>FUTURE WORK</p> <ul style="list-style-type: none"> > Complete system integration testing > Detailed analysis of the performance of our system > Find ways to improve the performance including: charge rate and lowest possible voltage input > Strive for stretch goals > Design and fabricate a PCB
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Sections Andesen was responsible for: Testing, Test Results, Conclusion, Conceptual Sketch and General layout

Sections Jordan was responsible for: Statement of purpose, Function/Non-functional, Modules, Selecting/Editing images, Styling

Edits suggestions:

- Include operational environment section
- Shorten phrases
- Take out conclusions
- Rewrite statement of purpose
- Take out component level testing

Alternative Approach Findings- Ben

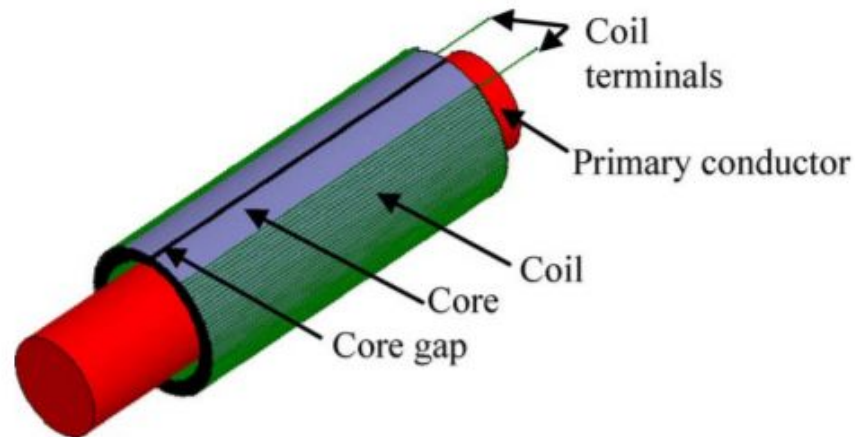


Fig. 1. Multiturn coil on a magnetic core around a current carrying conductor.

This approach is application specific: energy harvesting for wireless sensors for power systems. The principle concept shown above is called an energy coupler that takes a multiturn coil on a magnetic core around a current carrying conductor (power line conductor). AC power can be collected electromagnetically and is then fed into a voltage multiplier to produce a DC output. From our research we found that several energy harvesting devices end up using some type of voltage multiplier configuration. A voltage multiplier and charge pump were alternative routes we considered going instead of using a transformer. However we ended up finding a self-contained unit with impressive performance. What we gained from this is the perspective of in the context of remote sensor networks what are performance differences from specialized units versus general application boosters like our current module.

Link: https://scholarcommons.sc.edu/cgi/viewcontent.cgi?article=1004&context=elct_facpub

Design Document

- Section 1- Shahzaib -a little grammatical editing but no major changes
- Section 2- updated proposed design - Shahzaib
- Section 3 - Task Decomposition - Ben
- Section 4- update roles/responsibilities, updated budget tables, revised project timeline- Ahmed
- Section 5 - updated booster testing, even testing that was unsuccessful Cao
- Section 6 - no changes at this time - Jordan

Current understanding of our booster module:

Both of our booster modules work by utilizing a transformer-oscillator stage. When enough energy input is given to the modules to power an oscillator that will then take the DC input signal and oscillate it. That input signal will then drive the primary winding core of a transformer which will produce a voltage gain of about 75-150. The module uses a RC network and MOSFET to control the oscillator-transformer cycle at a frequency determined by the input impedance. The reason this module is impressive is the variability in input sources: thermal, mechanical, solar, electro-magnet, etc. Other reasons include being able to acquire <0.1 V and 100 μ A while not using any power when off. This leads to a device that can capture energy intermittently and at energy levels that would normally go to waste.

The main distinction of these two booster modules we bought are the impedance matching characteristics. One module has a nominal input impedance of 50 ohms while the other has 950 ohms. We mistakenly forgot to set the function generator to the appropriate impedance (50 ohms) and we believe had we done that our supercapacitor would have charged as intended. We have a good general understanding of how it works, it's intended use-cases, and expected performance. We want to strive for the clearest and most in-depth understanding we can. Our client has requested that in our final presentation we mention the operation of the booster module when introducing it. Our faculty advisor felt the datasheet was brief and suggested we reach out to the chip design company or find similar designs to enhance our understanding.

Individual Contributions

<u>Name</u>	<u>Estimated Hours this week</u>	<u>Estimated Hours Cumulative</u>
Jordan Fox	1	19.5
Xiangyu Cao	3	24.5
Andesen Ande	2	21.5
Ahmed Salem	1	18
Ben Yoko	1.5	23.5
Shahzaib Shahid	3	24.5

Plans for the upcoming week

- Edit each other's work on design document- name of editor
 - Section 1- Andesen
 - Section 2- Andesen
 - Section 3-Cao
 - Section 4 -Jordan
 - Section 5 Shahzaib
 - Section 6-Ahmed
- Make poster revisions- Andesen
- Meeting with client on 4/22- all team members
 - Discuss alternate approach findings
 - Update on date and time of final presentation. Ask if there's anything more he requires from us and if current understanding of the booster module is sufficient.

Final Report - Use updated design document and make additions

- Revised Project Design - Shahzaib
- Implementation details - Ahmed
- Testing Process and testing results - Cao
- Context -Ben
 - Related products
 - Related literature

- Appendix I -Cao
- Appendix II - Andesen

Presentation

Make any changes necessary and practice what to say. Do a run through it April 24th.

- Problem Statement-Ahmed
- **High Level Overview- Client requested 1 specific example-Ahmed**
- Functional Requirements-Andesen
- Technical Considerations and Constraints-Andesen
- Potential Risks and Mitigations - Ben
- **Design Plan - Make a design to keep or not.**
- System Design - Shahzaib
- Functional Decomposition -Ahmed
- **Component Selection-Make a decision to keep or not.**
- **Functional Test Plan-Describe how we tested. -Jordan**
- Capacitor Testing - Ben
- Rectification Testing - Cao
- **Booster Testing-update slide - Shahzaib**

Likely additions:

- Where we left off testing/accomplishments-Cao
- Any conclusions about performance or expectation-Ben
- Alternative approaches we considered-Shahzaib
- Future works-Andesen