EE/CPRE/SE 491 WEEKLY REPORT 03

Introduction

Date: February 16- March 1
Group Number: 21
Project Title: Battery-less IoT Devices
Advisor: Dr. Henry Duwe
Clients: Dr. Nathan Neihart, Dr. Daji Qiao

Team Members:

Derek Nash – *Meeting Scribe, Power Systems Engineer, Test Engineer*

Matt Goetzman – *RF Systems Engineer, Test Engineer*

Mohamed Gesalla - *RF Systems Engineer, Test Engineer*

Adithya Basnayake – *Report Manager, Power Systems Engineer, Test Engineer*

Mohammed-Al-Mukhaini – *Meeting Facilitator, Embedded Systems Engineer, Test Engineer*

Bradley Rhein – *Embedded Systems Engineer, Test Engineer*

Weekly Summary

During this week, our team aimed to meet a few times to construct antenna prototypes, take Wi-Fi measurements using different antennas to validate the Wi-Fi measurements that were taken previously using the mobile app. Furthermore, our team planned to test the accuracy and consistency of the MSP-430 microcontroller in sampling and converting voltage reading to temperature. Also, we looked into finding optimal diodes for our rectifier circuit . Finally, we intended to meet with both our clients along with our advisor.

Past Week Accomplishments 02/16 - 02/22

This week we met with one of our clients for the first time (Dr. Neihart). In our meeting with Dr. Neihart, the main discussion point was the antenna design for the harvesting circuit as well as the rectifier circuit design. He gave us some ideas for antenna types that we can consider for the design. This week, our team looked into finding some components such as diodes, COAX cable for antenna design and MSP-430 controller.

The following table shows the component list that we put together for our prototypes and the reason for choosing each part

Component	Reason chosen
HSMS-286x Series Surface Mount Microwave Schottky Detector Diodes	This series of DC biased detector diodes have been designed and optimized for use within frequency bandwidth that works for the frequency band of our Wi-Fi signal (2.4GHz). And they have a low voltage drop which is ideal for our rectifier circuit design as we need a high power output
SMS7630-061: Surface Mount, 0201 Zero Bias Silicon Schottky Detector Diode	
CDC7630/7631 and DDC2353/2354 Series: Zero Bias Silicon Schottky Barrier Detector Diodes	
Coaxial Cable	We choose this cable because it is a very conductive copper cable as well as it has an impedance of 50 ohms. It was used for making the prototype antennas
SMA connector	We chose this connector because it is a coaxial rf connector and it can be combined with the coaxial cable to build the antenna.

Table 1: Component list

Past Week Accomplishments 02/22 - 03/01

This week, the team met with Dr. Daji Qiao, who gave us valuable feedback and suggestions for our microcontroller function implementation. Also, our team split and met as three different groups.

Embedded Systems Team

The embedded systems team met and implemented c-codes to test the accuracy and consistency of the MSP-430 microcontroller. The team effort consisted of trying to use A10 pin in the MSP-430 with reference to internal 1.5 Vref in order to start its sampling and conversion automatically. Mainloop of MSP430 waits in

LPM0(Low power mode) to save power until ADC10 conversion complete, ADC10 interpreters will force exit from any LPMx in Mainloop. Result is converted to Temperature represented in C that has proven accurate and consistency. The team was able to apply this in two different platforms (energia and Code composer) where similar readings were observed of the temperate. The hope is to use this information to save in to our F ram memory that would be access once our controller leaves the low power mode to the active mode after collecting enough power harvested to be powered on.

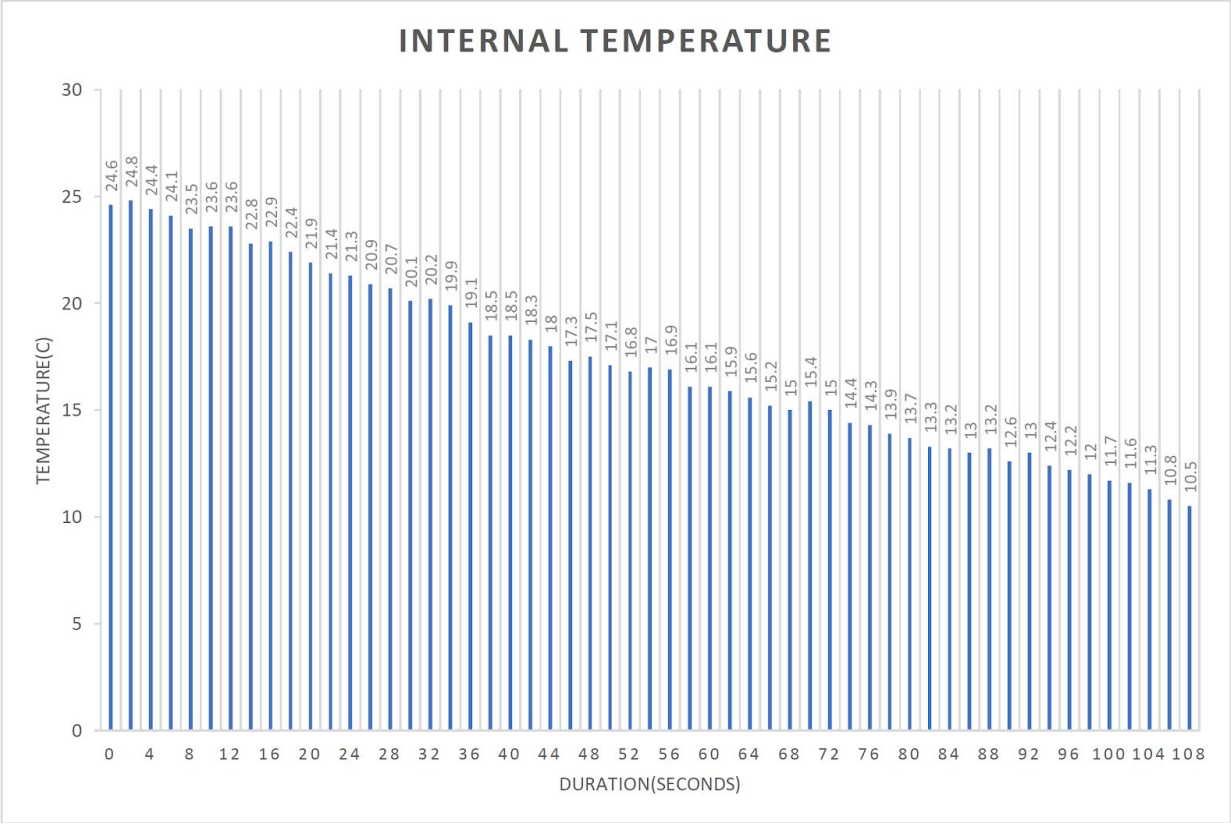

Figure 01: MSP-430 Internal temperature readings

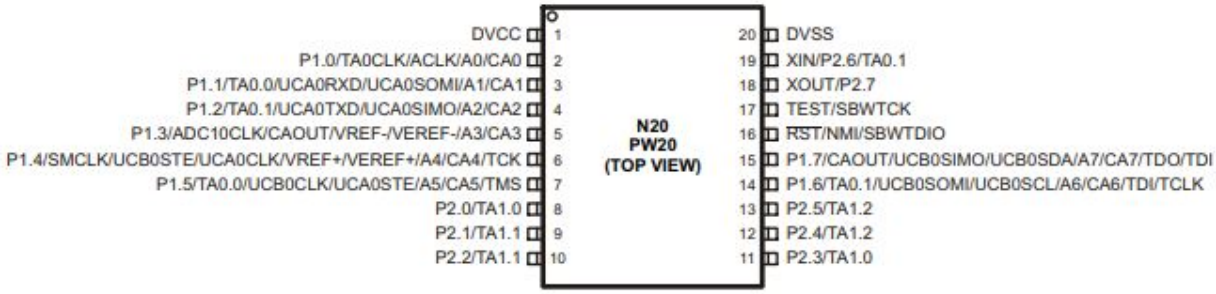

Figure 02: MSP-430 pin layout

RF and Antenna Team

Our RF and antenna design team met and built prototypes of monopole and dipole antenna. The team used a coaxial cable and sma connectors to build a monopole and a dipole antennas. The team designed a half wavelength dipole antenna. This prototype has not been validated yet due to lack of access of measurement equipment; however, the team has coordinated with with Dr. Neihart to get access to the spectrum analyzer for measurements. Even though we have not taken any measurements yet we suspect that this design might have some deficiencies because there will be impedance mismatching issues due to the ground plate of the sma connector working as a reflector. Also, our antenna is not a balanced system because the two ends of the dipole antenna have different lengths which will lead to difference in the current flow.

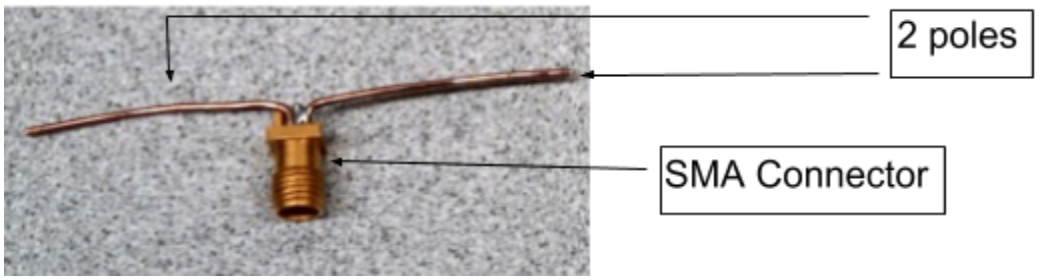

Figure 03 : Dipole Antenna

This team also built a monopole antenna also using an sma connector and a coaxial cable. This antenna will be tested using spectrum analyzer.

Figure 04: Monopole Antenna

Power Circuit Team

Our circuit design team came up with a rectifier circuit to convert the AC voltage output from the Antenna circuit to DC voltage and multiply the power output to gain sufficient energy to power the microprocessor. Following shows the circuit diagram for the initial rectifier design called the Greinacher voltage doubler which is ideal for energy harvesting circuits. This design will be implemented with schottky diodes mentioned in the table above and will be built once we acquire these diodes.

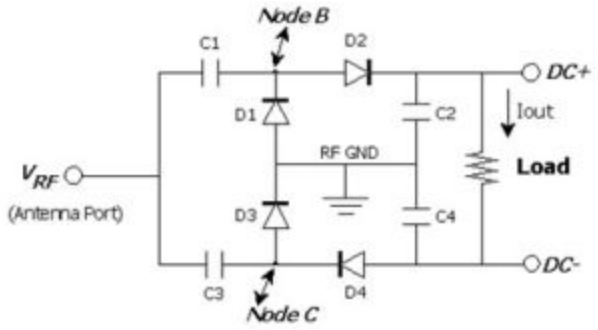

Figure 05: Greinacher voltage doubler circuit

Pending issues

The RF team could not coordinate access to the power circuits lab this week to measure Wi-Fi signal captured using the prototyped antennas . However, the team has established a discussion with Dr. Neihart and will be able to access the lab next week.

Individual Contributions

Team Member	Contribution	Weekly Hours
Derek Nash	Researched and shared an alternate method of measuring Wi-Fi signal strength. Researched PCB assembly sites, voltage multipliers, and FCC regulations on routers.	5
Matt Goetzman	Researched and designed a half wavelength dipole and a monopole antenna, looked into previous labs for research into PIFA antennas. Researched baluns and impedance matching techniques.	5
Mohamed Gesalla	Designed and built monopole and dipole antennas. And looked into different designs that will be building in the incoming days Measured Wi-Fi signal in different locations Wrote the weekly status report	8

Adithya Basnayake	Researched and designed rectifier circuits and looked into diodes that can be used in our rectifier circuit. Reviewed the weekly status report.	6
Mohammed-Al-Mukhaini	Explored possible ways of powering up and storying data under low power modes in MSP430. First step this week was to read internal temperature readings from the microcontroller these results would be used to the F RAM memory	8
Bradley Rhein	Wrote C and assembly level code for temperature sensing. Tested and verified code with Mohammed. Next steps are storing values into FRAM and placing the MSP430 into low power mode.	5

Plans for the upcoming week

Validating accuracy of dipole and monopole antennas built this week and look into prototyping other viable antenna options for the energy harvesting circuit. Build and test physical prototype of the rectifier circuit designed this week.

Summary of Weekly Advisor Meeting

During our meeting with Dr. Neihart and Dr. Henry Duwe, they advised us to retake measurements of Wi-Fi signal at multiple access points at different Wi-Fi usage densities. They also suggested that we look into the implementation of impedance correction circuit and start up circuit. In our meeting with Dr. Daji Qiao and Dr. Henry Duwe, they asked us to look into energy duty cycle of the MSP-430 and continue testing antennas and wifi in a more controlled environment possibly using our own router.