RFRD Phase II

TO DESIGN A RADIO FREQUENCY READOUT DEVICE TO USE IN A BOLT ANCHOR SURVEYING APPLICATION.

Team 11
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Contents

NOTE: This template is a work in progress. When in doubt, please consult the project plan assignment document and associated grading rubric.

1 Introduction

1.1 PROJECT STATEMENT

In this project a Radio Frequency Readout device is designed to send and receive data from an RF tag that will be connected to a capacitor sensor.

1.2 PURPOSE

The purpose of this project is to address the time-consuming act of checking each nut for secured tightness on bolts of large lamp posts. Currently, each nut must be manually checked on each post for tightness to prevent a failure in the structure. This process takes a lot of time and cost to check each nut.

To address this problem, this project will use a Radio Frequency Readout Device (RFRD) to read if each nut is tight or needs to be torqued properly. This RFRD will be usable in a vehicle driving next to each structure to reduce the time needed to check each nut. The RFRD will be reading a capacitance value from a passive RF tag. The capacitance value will then allow the user to know if the nut is tight or loose.

1.3 GOALS

The RFRD and RF tag is intended to be used by civil engineers and construction workers on lamp posts and other large structures that require constant inspections to the structures integrity. The main goal is to provide a less time-consuming and cost-efficient way to check for tightness of nuts on structures.

2 DELIVERABLES

To meet these goals, a Radio Frequency Readout Device prototype must be designed to send and receive a signal from an RF tag prototype tag that can measure the capacitance of a bolt and nut.

3 Design

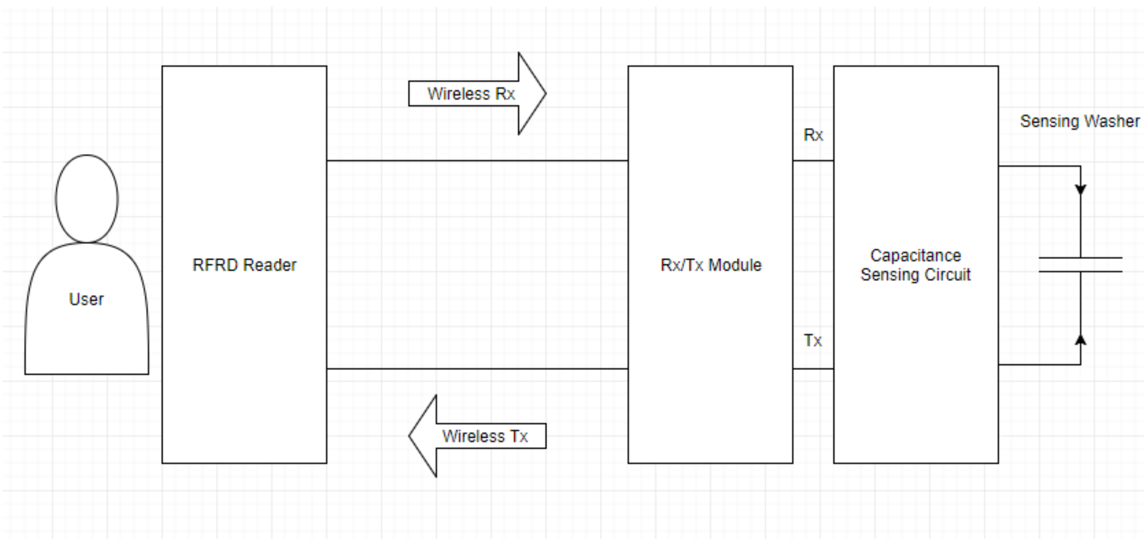
Describe any possible methods and/or solutions for approaching the project at hand. You may want to include diagrams such as flowcharts to, block diagrams, or other types to visualize these concepts.

3.1 PREVIOUS WORK/LITERATURE

This project is a phase II design. The website for Phase I is located at the following: http://may1718.sd.ece.iastate.edu/

We will not be using much of the resources from Phase I. We will aim to use the frequencies that were recommended and simulated by the prior group.

3.2 PROPOSED SYSTEM FLOWCHART



3.3 ASSESSMENT OF PROPOSED METHODS

Capacitive Sensor:

We have decided to use a relaxation oscillator to measure capacitance across the washers.

A relaxation oscillator is an integrator in series with a comparator. This oscillator will create a PWM output that changes the period of the waveform linearly with the value of capacitance. We decided to pursue this circuit due to the low power, high gain bandwidth, and accuracy of measurement for this design.

We decided we will need to measure capacitances in the ranges of 20 pF to 50 pF. This will be an optimal range for our design per IEEE paper "Limitations of a Relaxation Oscillator in Capacitance" by Yili Liu, Song Chen, Masakatsu Nakayama, and Kenzo Watanabe.

We have decided for our design, we will be using STMicroelectronics op amps. Once we have an idea of how much power we can receive wirelessly, we will choose op amps accordingly.

Our biggest constraint for our relaxation oscillator design is the amount of power we can harvest from our Power Harvesting circuitry.

Power Harvesting:

We plan on using an inverted-F antenna in our design. We will need a rectifier circuit to follow the antenna. We are determining how much power we will be able to receive to power our relaxation oscillator circuit.

TX/RX Module:

We plan in using a very low power microcontroller that will be housed on the tag for creating a RFRD protocol.

RFRD Reader:

We plan on using a software controller radio transmitter to simulate the reader for our design. This will allow us to do testing of our design.

3.4 VALIDATION

Capacitive Sensor:

We will confirm our capacitive sensor design using the following procedure:

1) Confirm design with professor.

2) Simulate design using PSPICE.

3) Spec out components for our design and generate a BOM (Bill of Materials).

4) Fabricate design on a perfboard. (Can't use breadboard due to high capacitive coupling effects).

5) Demo perfboard.

6) Fabricate design on a PCB with surface mount parts.

7) Demo PCB.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

The reader should be able to read the tag from a meter away. The capacitance measuring should be able to read capacitances from 1pF to 50pF with an accuracy of 0.1pF. The tag will be powered wirelessly from the reader and will need to be a low power circuit.

4.2 NON-FUNCTIONAL

The tag will need to be able to withstand the weather and temperature fluctuations from being outside, although this is an aspect of the project we don't intent to be involved with.

4.3 STANDARDS

The main standards that we will have to be concerned with while working on this project are the standards from the FCC regarding frequencies that are used to send power and data.

5 Challenges

The most challenging aspect of this project will be finding the parameters that will allow us to power the tag using the reader from about a meter and using a very small amount of power to measure the capacitance. We will have to extensive research to understand these aspects of the project.

6 Timeline

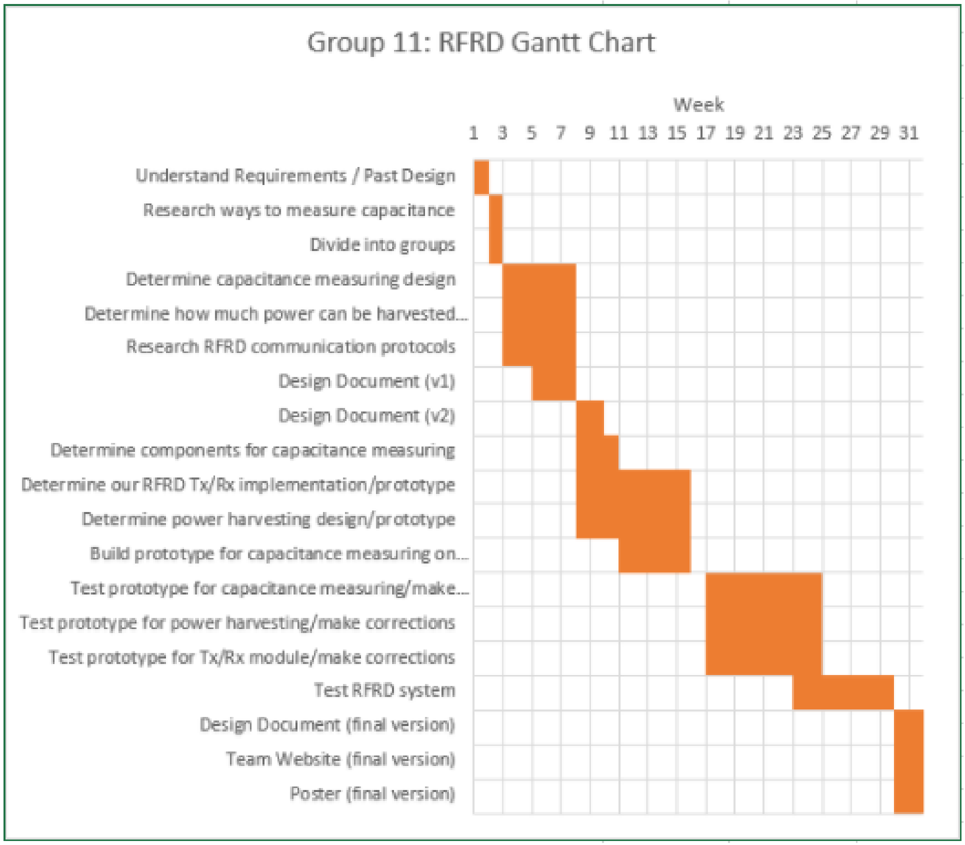
6.1 FIRST SEMESTER

Our goal for the first semester of this project is to have created a circuit that can be used to measure the capacitance across the bolt's plates, have a proof of concept for the power harvesting and antenna aspect of the project, and have an understanding of how we want to communicate between the reader and the tag. Bailey Akers and Colin Sunderman will be working on creating the capacitance measuring circuit. Lyle Bishop and Pengyu Qu will be working on the power harvesting and antenna. Nathan Mulbrook will work on the communication between the reader and the tag.

6.2 SECOND SEMESTER

In the second semester of this project we will be taking our designs from the first semester and testing them. We will test to see if the capacitance measuring circuit can measure capacitance correctly and with the proper accuracy. We will test if we can power the tag with the reader and if we can use the reader to receive a signal from the tag. If the designs don't work or can't reach our given parameters we will research, design, and create a new protoype. Once these aspects of the lab are complete we will work on making the reader work from a greater distance and allowing it to send data to the cloud.

Gantt Chart:


Group 11: RFRD Gantt Chart
Week
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Understand Requirements / Past Design
Research ways to measure capacitance
Divide into groups
Determine capacitance measuring design
Determine how much power can be harvested...
Research RFRD communication protocols
Design Document (v1)
Design Document (v2)
Determine components for capacitance measuring
Determine our RFRD Tx/Rx implementation/prototype
Determine power harvesting design/prototype
Build prototype for capacitance measuring on...
Test prototype for capacitance measuring/make...
Test prototype for power harvesting/make corrections
Test prototype for Tx/Rx module/make corrections
Test RFRD system
Design Document (final version)
Team Website (final version)
Poster (final version)

7 Conclusions

Above all, the main goal for this project is to use a RFRD(Radio Frequency Reader Device) to check if every bolt of the large lamp is tight. We will enable an easier way to check these bolts. To achieve this goal, we need to design a RFRD device that could send and receive the signal from a tag and we need a reader to read the signal. We need a team that is doing power harvesting for the tag. Capacitance is very important in this project so I think it is very important to do capacitance measurement.

This is a two semester project, in the first semester, we are going to go through the basic theorems and the find the reasonable parameters and in the second semester we will make a prototype and test it.

8 References

List all the sources you used in understanding your project statement, defining your goals and your system design. This report will help you collect all the useful sources together so you can go back and use them when you need them.

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.