Soil Analyzer

ECE 445 Design Document

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1 Introduction

1.1 Objective

Throughout the last century, small farms have become far and few between, while corporate farms seem to continue to grow larger and larger[1]. The United States average farm acreage is 444 acres[2], but there are hundreds of farms that are triple this acerage. In addition to farms covering large amounts of land, they are all very unique. Farms can be placed in areas where there is either ample or limited amounts of water[3]. With such a large area to manage, there is no possible way for a farmer to know the condition of their entire field. With constant monitoring of soil moisture, a farmer can keep their crop at an effective moisture level. This prevents over watering, and can help conserve water in places where water usage is limited, which is important, especially since agriculture is responsible for 80-90% [4]of freshwater usage.

Our goal is to boost farming effectiveness, reduce water waste, and ensure that crops survive during uncertain weather patterns. We plan to first prove that it is possible to establish an array of devices throughout a field to record soil quality, and then communicate this data to a central hub to be analyzed. We initially hope to accomplish this with simple moisture sensors which will collect water content measurements of the soil. If we can accomplish having this very simple data collected and then analyzed, we hope that our design can be furthered by modularly adding more expensive and complex sensors to collect various other soil quality analytics.

1.2 Background/Visual Aid

An agriculture company called 360 Yield Center has created “360 SOILSCAN” [5], a device which can be fit in the back of a pickup truck. The soil samples then have to be collected by hand and then brought to the device in the truck to be tested. A very similar device, has also been made by Agrocares[6]. This device is instead handheld and requires the user to scan each quadrant of their field to test soil quality. Although these have all the expensive soil testing sensors, they don’t eliminate the hassle of checking soil quality throughout an entire field. It still requires the farmer to perform the laborious task of going into the field and checking every quadrant of land for its soil contents. This would have to be done every time the farmer would like their field soil quality surveyed.

Our device would ensure that no matter the size of the farm, or where these farms are located, it would enable the farmer to always have an idea of the soil moisture level. With this information, they could then make appropriate decisions for their field, whether that would be adding more nutrients to a certain quadrant, or adding an exact amount of water.

In Figure 1, you can see our vision for this device. We hope to have it be evenly spread into fields. From there we hope to establish a simple hub to receive data at a remote location the farmer can choose. These devices aren't intended to be too large so that deployment and collection, when necessary, is very easy. This would also invite ease of replacing devices for repair.

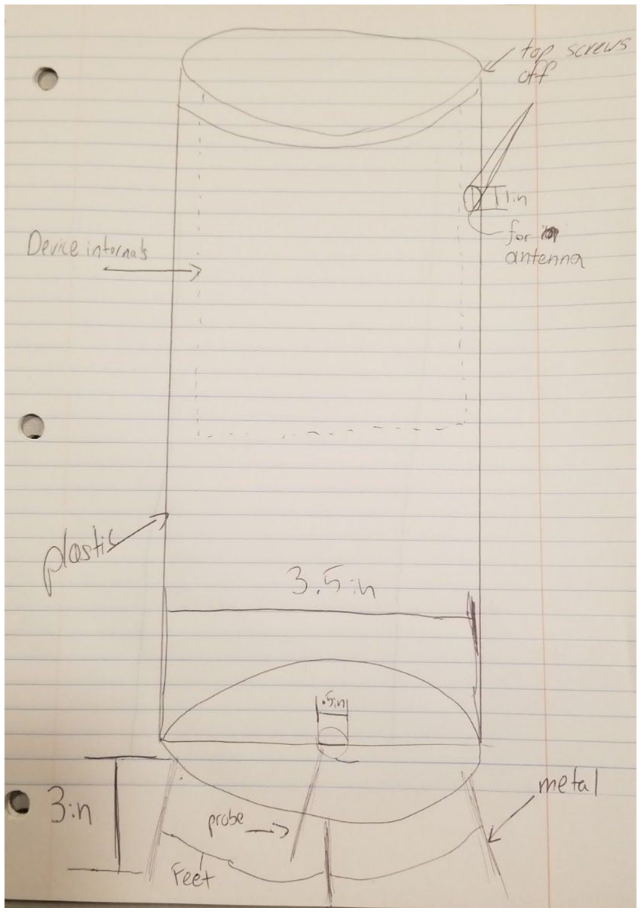


Figure 1.

1.3 High-Level Requirements

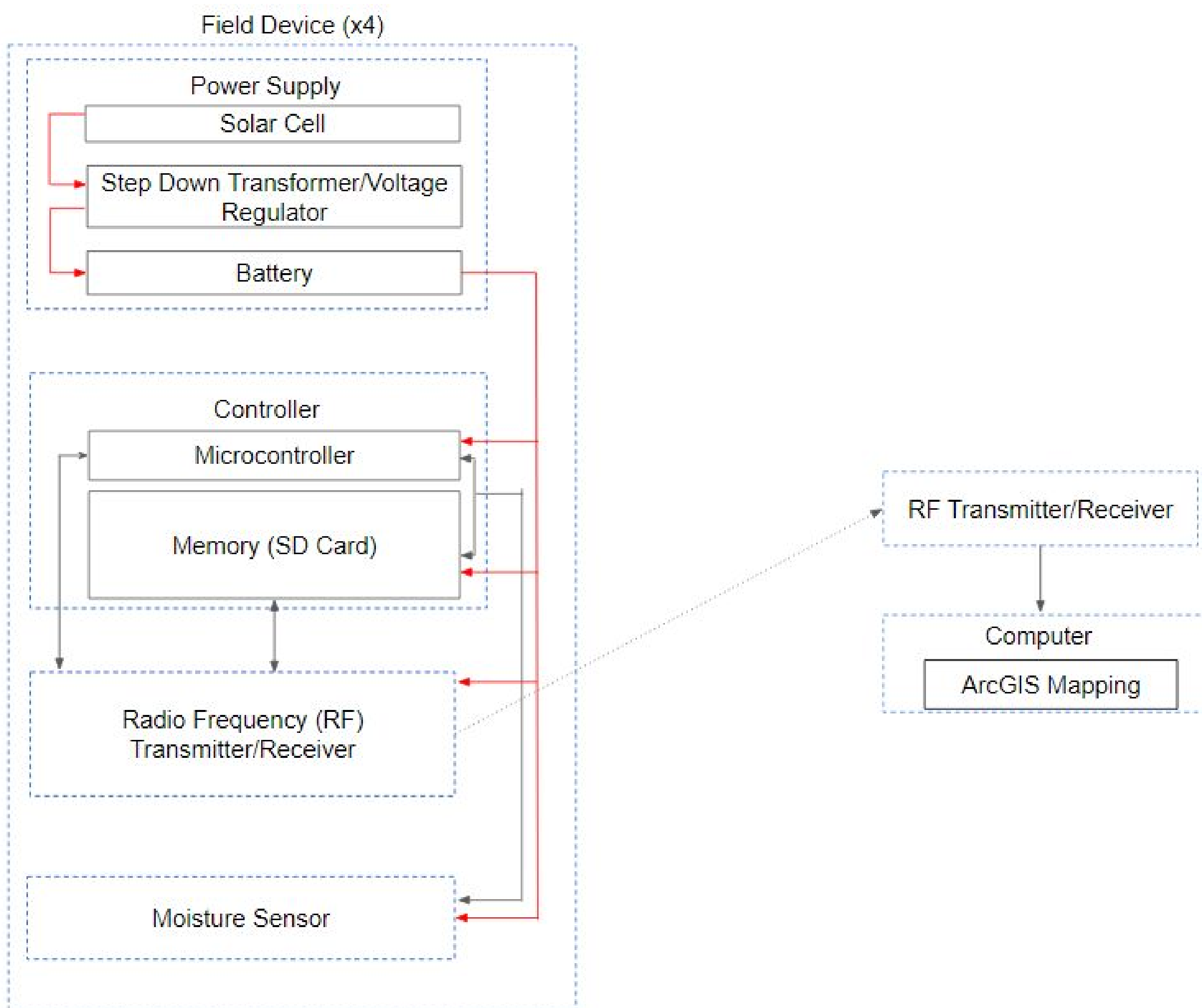
1. The system will be able to communicate wirelessly either as a relay system through 4 separate nodes or directly to the main hub.

2. Each node must have a minimum data broadcast range of at least 5ft.

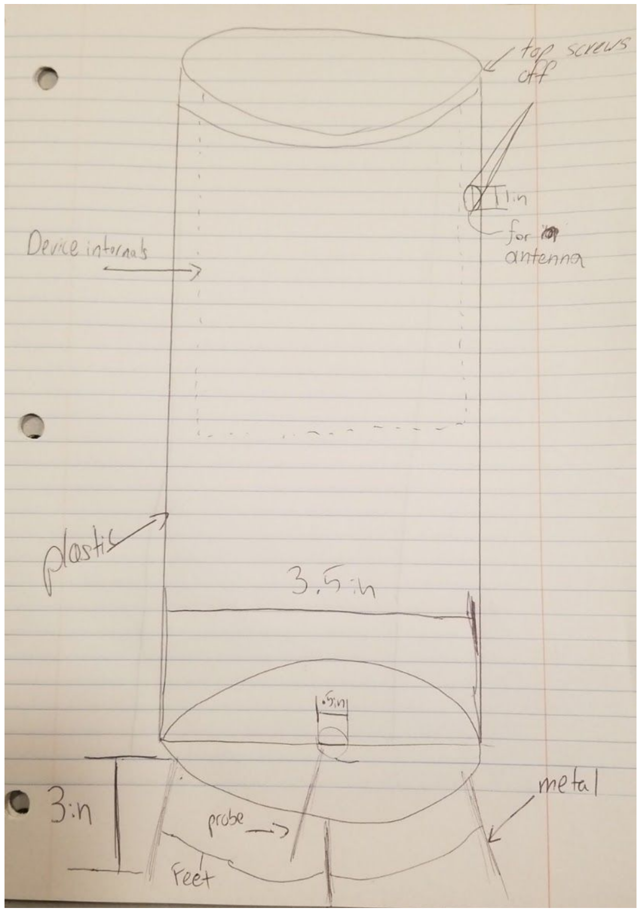
3. Each individual node will be able to be powered on at any moment from a battery large enough to store adequate charge for 24hr — recharged daily by solar panels.

2 Design

To have a fully functioning design, we have separated our design into four sections: a power supply, a control unit, a RF communicator, and moisture sensors. The purpose of our power supply is to provide power to our device during an 8 hour period doing the day. The control unit is to manage sensor data, data transfer/reception, and memory storage. The RF communicator should be able to both send and receive data using RF. The moisture sensor should be able to take real time data from the soil 2 times a day and report it to the control unit. We will be creating four of these devices, and place them a distance of 5 feet from each other.



Our physical design will have all electronics encased in a waterproof tube with an RF antenna protruding from the side of the case. The solar panels will be underneath a clear waterproof dome at the top of the probe. The bottom of the waterproof tube will have a three legs that will be inserted into the dirt in or to hold the device upright. The moisture sensor will be placed in the center of the bottom of the device.



2.1 Power Supply

The power supply should provide constant power to the device. A solar panel will collect energy from the sun, pass it through a regulator/step down, so that it can charge the battery safely. The battery should then be able to provide consistent power to the rest of the project.

Requirements: Must be able to supply between 3-5 volts to the entire device.

2.1.1 Solar Cell

The solar cell will capture energy from the sun and then pass it through to the voltage regulator/step down so that the battery can be charged.

Requirements: Needs to provide >500mA and ~5volts to charge the battery.

2.1.2 Charge Controller

This charge controller must be able to disconnect battery from solar panel, when battery is fully charged. The charge controller must also have a maximum power point tracker circuit to maximize the power from the solar panel.

Requirement: Must be able to shut off power to battery when fully charged and have a built in power point tracker circuit.

2.1.3 Battery

The battery must be large enough to provide power even when the solar panels are unable to provide a charge to them.

2.1.4 Dual Step-Down DC/DC Converter

The step down converter must have an operating voltage around 12 volts and must be able to output about 3 volts of power to the rest of our circuit.

Requirements:Must be able to step down from 12volts to ~3volts

2.2 Control Unit

This block is responsible for controlling the other parts of this project including the transmitter/receiver, memory, and sensory functions.

2.2.1 Microcontroller

We are picking between using the STM32 and STM8 chips. We hope to have this chip control the data communication, and memory access of this device. We would also like to have it responsible for accessing the data output of the probe.

2.2.2 Memory (SD)

The microSD card will store the data after each probe. It will also allow the device to perform the other functions.

2.3 RF Transmitter/Receiver Node

Data will be sent between devices and the hub by using RF signals. It will be used to make an array out of the devices so that the devices can be spread out across a field to maximize data collection.

2.3.1 RF Antenna

Will extend the effective range of each transceiver to accomplish the necessary 5ft minimum.

2.3.2 Transceiver

Data will be sent between devices and the hub by using RF signals. It will be used to make an array out of the devices so that the devices can be spread out across a field to maximize data collection. Be able to receive and transmit ~1GB of data that contain moisture levels and position. It should also be able to receive and send data at the same time.

2.3.4 RF Microcontroller

This chip will control the data communication, and memory access of this device. We would also like to have it responsible for accessing the data output of the probe.

2.4 Moisture Sensor

This will collect all the data from the ground. It will be used to probe at certain intervals during the day for weeks. Must be able to provide data asynchronously, whenever it is called from the microcontroller

3 Cost

4 Schedule

5 Ethics and Safety

References

[1]https://www.farm-equipment.com/articles/15960-number-of-us-farms-declines-while-size-of-farms-increases
[2]http://usda.mannlib.cornell.edu/usda/nass/FarmLandIn/2010s/2018/FarmLandIn-02-16-2018.pdf
[3]https://www.wired.com/story/midwest-farms-face-an-intense-crop-killing-future/
[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2610175/
[5]https://www.360yieldcenter.com/products/360-soilscan/
[6] https://www.agrocares.com/en/products/scanner/
[?]https://www.solarpoweristhefuture.com/how-to-charge-a-battery-with-a-solar-panel.shtml#targetText=Depending%20on%20the%20size%20of,pointed%20directly%20at%20the%20sun.