Flood IrrEEgation Control System

Tyler Dale, Nicolas Garcia, Ellen Halverson, Kenneth Harkenrider, Trenton Kuta[1]

1 Department of Physics, University of Notre Dame, Notre Dame, IN, 46556, USA

Introduction

Flood irrigation is a common practice in the southwestern United States. It involves opening a valve to release water at a high volumetric flow rate. As this water moves through a farmer's field, it takes the form of a thin film, gradually moving across all the land to be farmed. As it stands, flood irrigation is demanding on farmers and can cause property damage, wasted water, or ruined crops if done improperly.

Purpose

In order to avoid overwatering crops, a farmer practicing flood irrigation must walk out to his or her field at regular intervals for up to 36 hours during the flood process. Every time, he or she must monitor the distance the water has traveled. When the water has traveled a sufficient distance, the farmer must walk to the valve and manually turn off the water. Since flood irrigation is typically done every two to three weeks, it can be a draining process that takes energy out of the farmer and prevents him or her from getting much needed rest. Furthermore, flood irrigation can only be done when given permission by water authorities. This further takes away a farmer's ability to make his or her own schedule, making flood irrigation more inconvenient. Therefore, this system was designed to make the flood irrigation process less demanding on the farmer, giving him or her more time and freedom.



Figure 1 – Garcia Family Farm

Requirements

- Create a pylon, which has the ability to sense the presence of water and is charged by a solar panel. This pylon must be able to communicate its current state with the hub via Wi-Fi.
- Create a central hub responsible for collecting data regarding the status of the pylons; with this data, the hub communicates with a valve control in addition to outputting the irrigation status to the farmer.
- The valve must be able to communicate with the central hub. When the farmer directs the valve to open or close, it must be done immediately.
- In order for the farmer to monitor the progress of the field, a web app will be created that allows the farmer to view the statuses of all affiliated valves and pylons as well as send commands to them.

Overall Design

To begin watering the field, the farmer can open the valve remotely via the app or central hub. Instead of manually walking out to his/her field to check water levels, the farmer will be notified by a hub-centered network of pylons when the water reaches its desired level. These pylons will electrically sense water and communicate with the central hub when the water screen has reached them. The farmer can monitor the progress of the field either from the website or from the user interface on the hub, which will both be updated automatically. This way the farmer can focus his attention on other things and interact with the system minimally while irrigating. Because the process is wireless, the farmer will not have to be confined to his or her property around the clock. Once the water has reached the correct location in the field, the farmer will be able to close the valve from the website or hub. The system can also be set such that a valve automatically closes when a particular pylon gets wet.

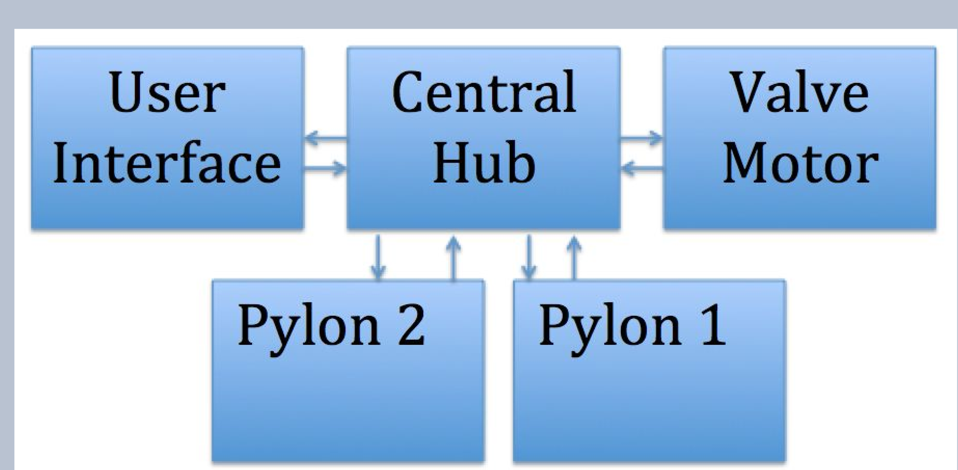

Figure 2 – Flowchart for the Entire System

Communications Systems

Wireless communication is crucial to the function of this system. The central hub consists of a Raspberry Pi microcomputer hooked up to a router. All active pylons and valves are stored as text files on the Raspberry Pi. The Raspberry Pi reads information from all the pylons and valves approximately every 30 seconds and sends appropriate commands when necessary via MQTT. This system is entirely autonomous. Additionally, the app (discussed below) can communicate with the central hub. To increase range, the Raspberry Pi is hooked up to a wire utilizing 9 dBi antennas and both the pylon and valve utilize 2 dBi antennas.

Phone Application

For simplicity, the entire system can be controlled using a mobile app. The app reads from and writes to the files on the Raspberry Pi to monitor and command devices in the field. This is beneficial to the system as a whole because it provides a cosmetically pleasing and real-time interface with which the farmer can keep an eye on the system.

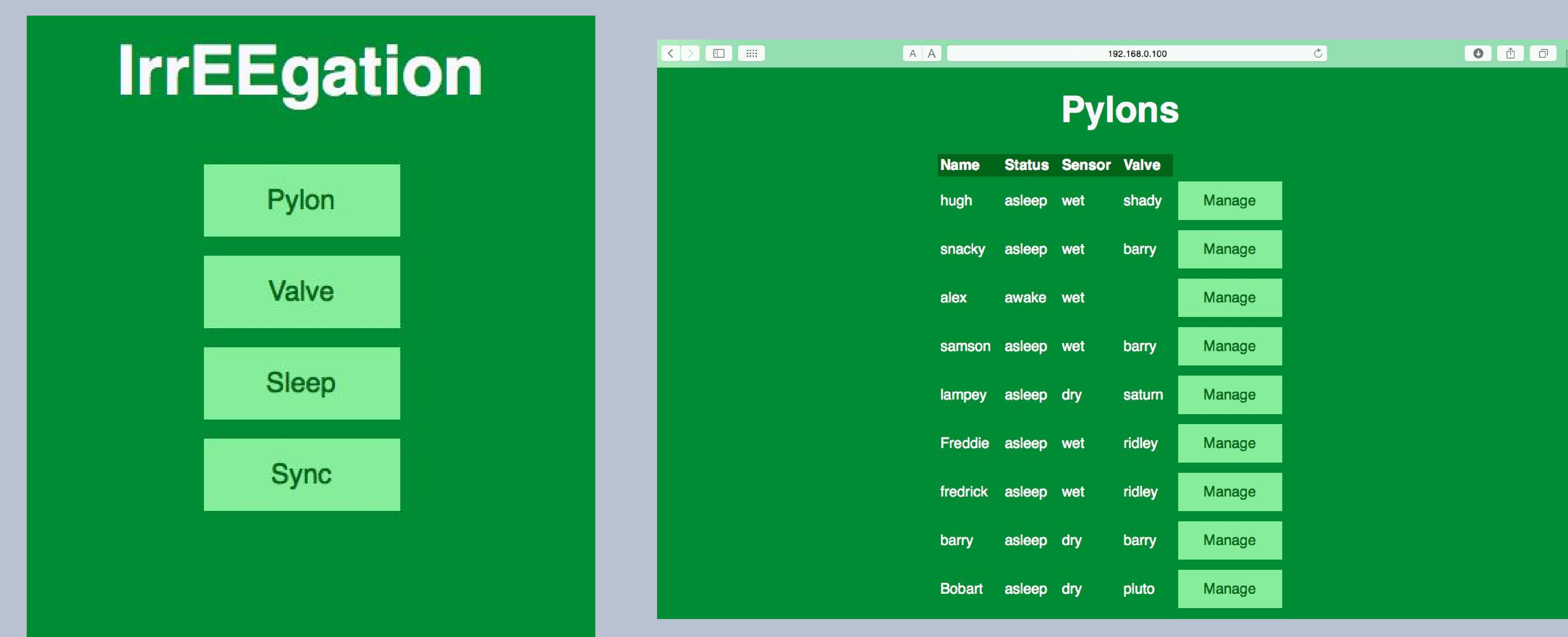

Figure 3 – Phone Application

Physical Hardware

Because the system is designed to operate outdoors, the greatest consideration regarding physical hardware is to ensure that it functions under inclement weather (strong winds, heavy rain, etc.). The IC boards for both the pylon and valves are encased in watertight PVC enclosures that guard the circuitry from water damage. Additionally, an iron stake is used to protect the pylon in the ground, ensuring it does not move due to inclement weather. Both the pylon and the motor are automatically charged by a 1.5 W solar panel, ensuring the systems do not lose power. A 12 V linear actuator is used as the motor. The hub is encased in a 3D printed box that encloses all circuitry and offers an LCD touch screen to make commands.

Figure 4 – Pylon Hardware

Circuit Design

Two separate IC boards were used for the pylon and valve because the valve board has the added capability of controlling a servo motor, which can open and close the water valve. The ESP8266 microcontroller was used to power each board because it incorporates Wi-Fi capabilities. Both utilized a solar charging circuit powered by the LT3652 chip and have the ability to sense moisture. Additionally, both have flash memory capabilities and utilize DC-DC conversion.

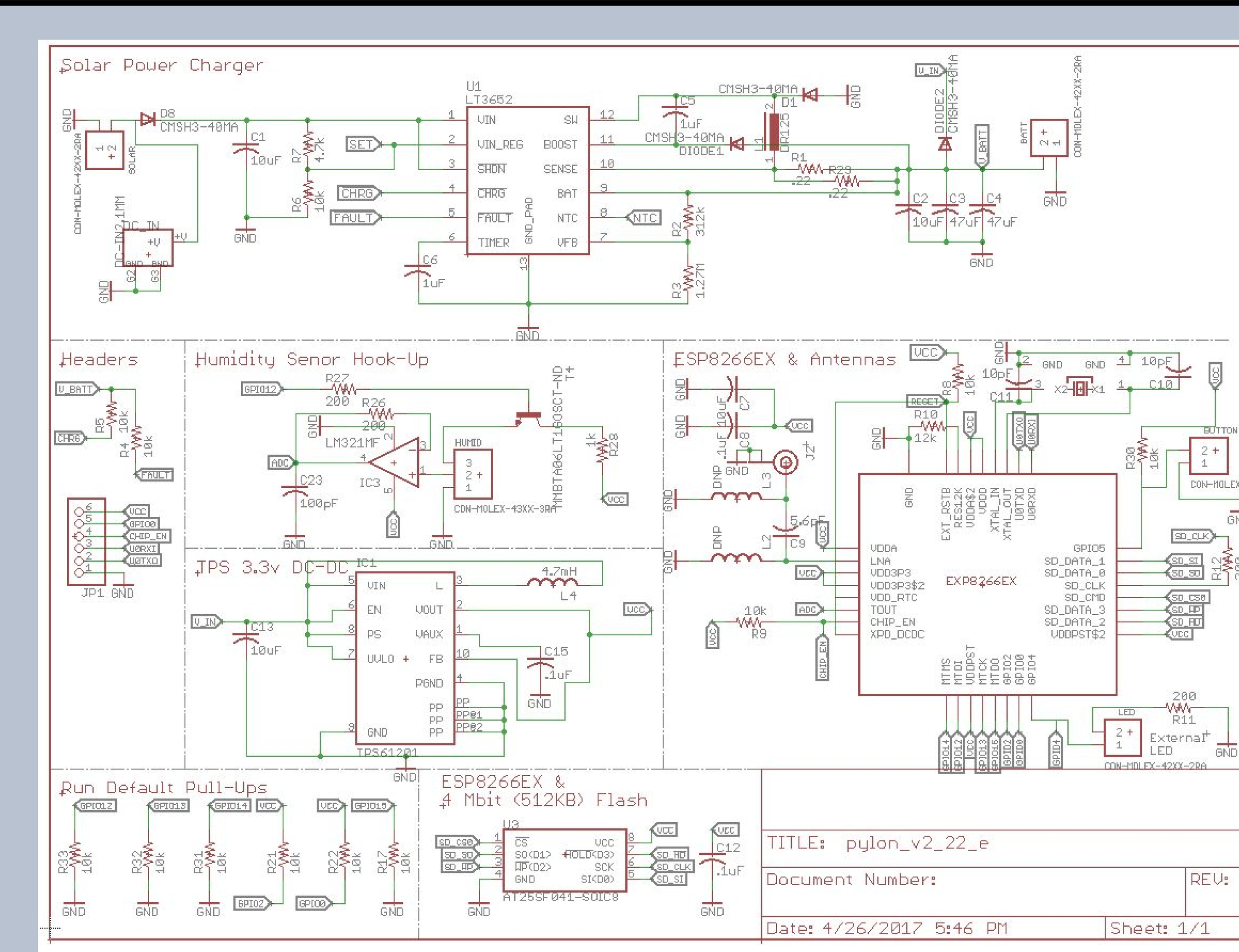

Figure 5 – Schematic of the Pylon Circuit

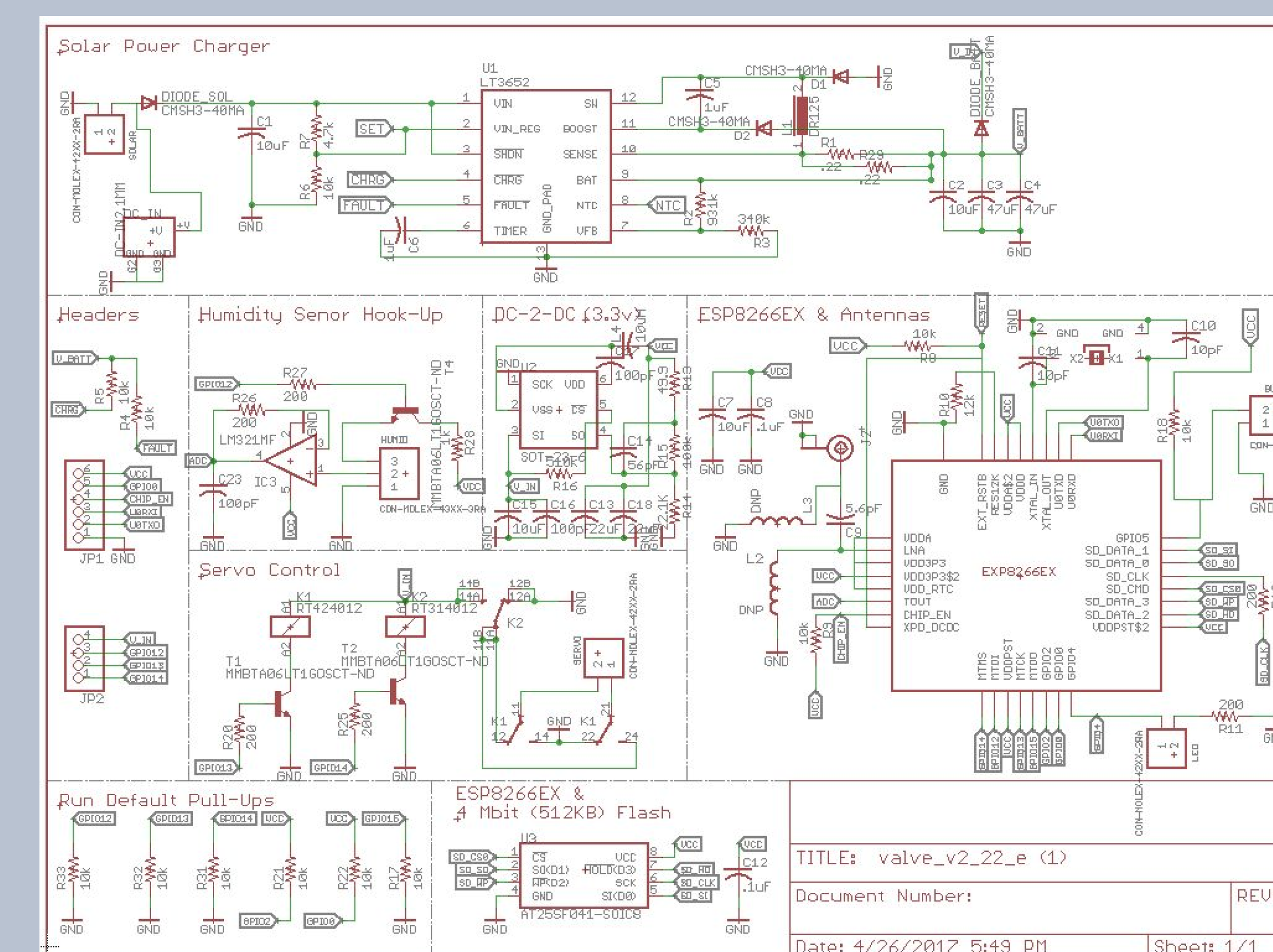

Figure 6 – Schematic of the Valve Circuit

Testing Results

One of the major challenges the team faced was the large size of the field. Therefore, the team conducted a wide variety of tests to expand the Wi-Fi range and ensure each pylon would be able to communicate with the the central hub. To do this, the team tried antennas with different gains on the router and the pylon board. Eventually, three 9 dBi antennas on the router and an external antenna on each of the pylons yielded sufficient range to cover the size of the field.

Initially, the desired features were demonstrated through pre-made IC boards. Using the pre-made boards, the team tested the functionality of the system's code and worked through any issues which arose from the MQTT server or the connectability of the valve and pylon.

Simultaneously, the team began designing a board unique to the problem at hand. The board design had over 20 iterationsthe finalized two-board design system was chosen.

Once these boards arrived, their functionalities were tested. The initial board design had to be altered to ensure the reset pin was connected to the GPIO16 pin. To test the new design, the team used wires and made a surface alteration to the board. Also, another important function that had to be tested was ability for the solar panel to charge the battery. With the preliminary board design, the solar charger had the incorrect voltage and therefore was not charging. Changing the resistor values in the supporting circuitry in the updated board should be sufficient for charging the battery.

Conclusion

This system effectively minimizes human error in the flood irrigation process and lightens the burden on the farmer. The major change that would need to be made for this system to be marketed is the incorporation of more realistic motor capable of opening and closing a large valve. Nonetheless, this project was a success and has the potential to benefit many men and women in farming communities across the southwest United States.