Plant Health Monitor

ECE 445 Design Document

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1. Introduction

1.1 Objective:

The main issue with growing plants at home is monitoring their health. Plants regularly dry out or even die if not given the proper attention. Many people do not know the proper way to care for a plant and this project attempts to remedy this problem by giving the grower precise measurements about the plant's health and automating repetitive tasks.

We are planning to make a multi sensor device that can accurately measure various soil health indicators in real time, so the user can get live feedback and can adjust the conditions accordingly. The device will also allow watering of the plant automatically when needed. This would provide the user with a way to conveniently check on and maintain their plants even when they are not around.

A similar product exists on the market but doesn't measure pH and only works with bluetooth. Our project differentiates itself by transmitting data remotely with wi-fi so that the data is displayed on a website. This data would provide the user with a way to conveniently check on their plants even when they are not around, as opposed to bluetooth which only works when the device is nearby. Our automatic watering system also allows the user to leave the plants when they are traveling or away from home for an extended period of time.

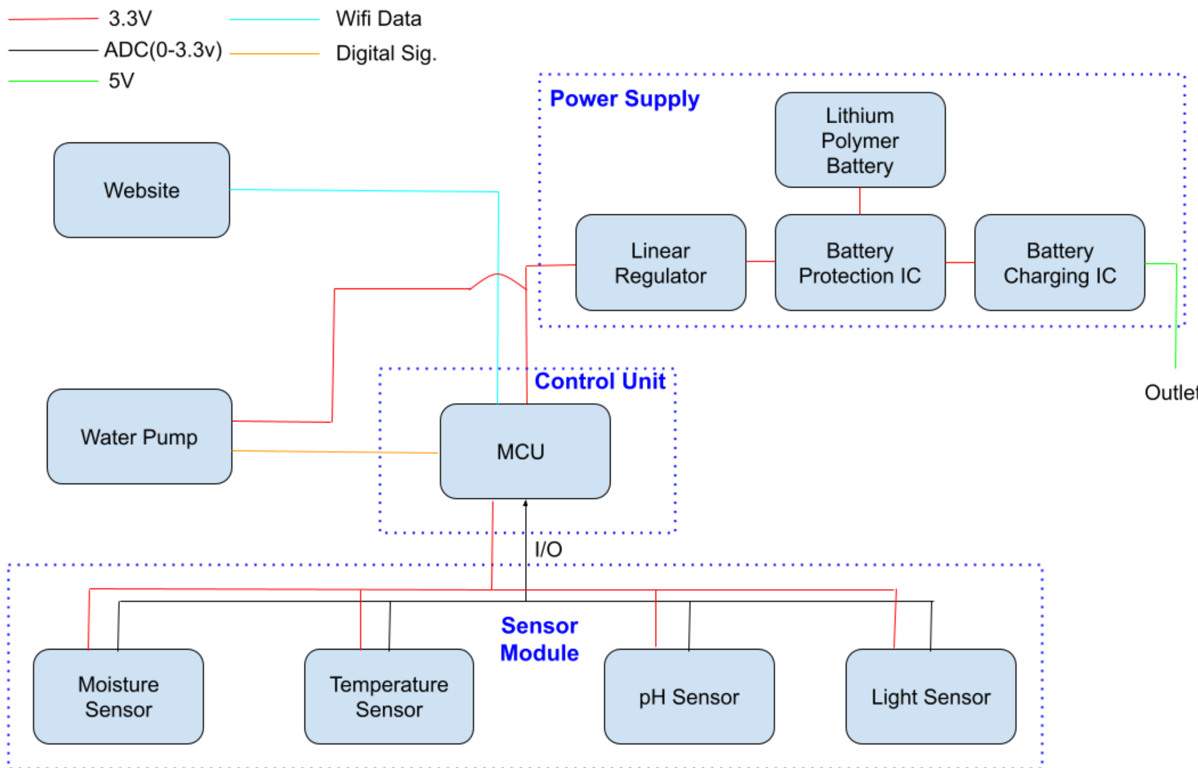
1.2 Background:

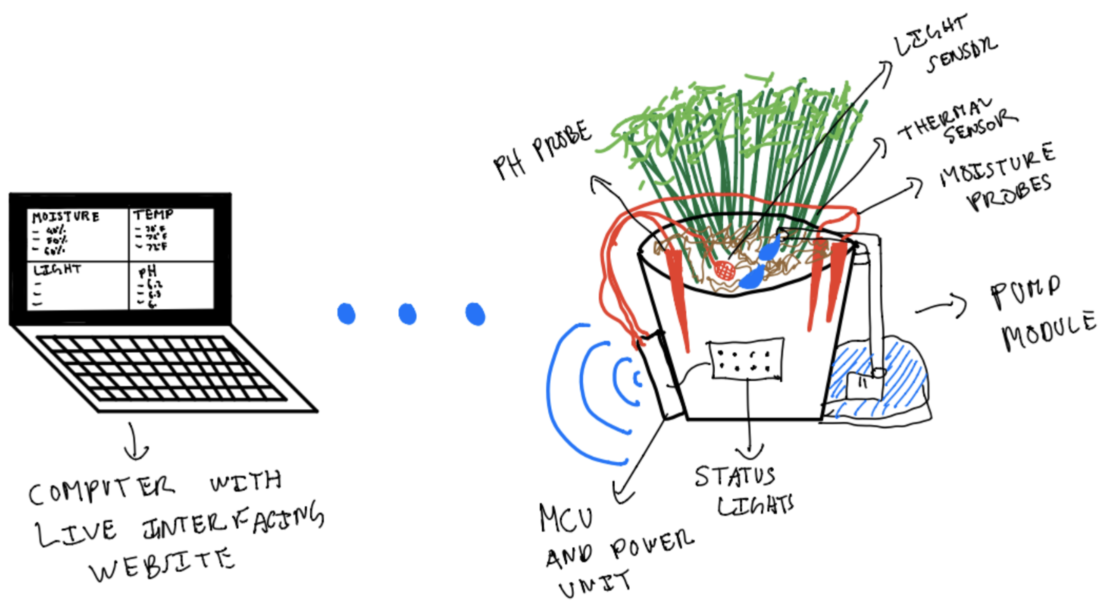
Growing plants at home is a hobby that many people enjoy but maintaining the health of the plants is not always easy. The main problem with plant health usually comes in the form of the soil. This includes bad pH levels and under/over watering the soil. Temperature and insufficient lighting can also be a factor. Our project would remedy this by monitoring each of these conditions. This way people do not have to do their own research into the more difficult aspect of plant growing, soil health. An additional concern for houseplants is travel. Being away from home for extended periods can leave plants dry and withered from the lack of watering and basic care. This project also attempts to remedy that by having an auto watering system and allowing the user to monitor the plant from anywhere.

1.3 High-level Requirements:

- Should be able to get information from the various sensor modules and relay information to the user through Wifi and status lights at least every 5 minutes.
- This project must be able to automatically adjust the moisture level of the soil to achieve a target level within ±10% in 1 hour.
- Must be able to work indefinitely while connected to an outlet and for at least 3-5 days on a full battery charge.

2. Design


3.3V
ADC(0-3.3v)
5V
Wifi Data
Digital Sig.
Power Supply
Lithium Polymer Battery
Linear Regulator
Battery Protection IC
Battery Charging IC
Outlet
Website
Water Pump
Control Unit
MCU
I/O
Sensor Module
Moisture Sensor
Temperature Sensor
pH Sensor
Light Sensor


COMPUTER WITH LIVE INTERFACING WEBSITE
PH PROBE
LIGHT SENSOR
THERMAL SENSOR
MOISTURE PROBES
PUMP MODULE
STATUS LIGHTS
MCU AND POWER UNIT

2.3 Sensors

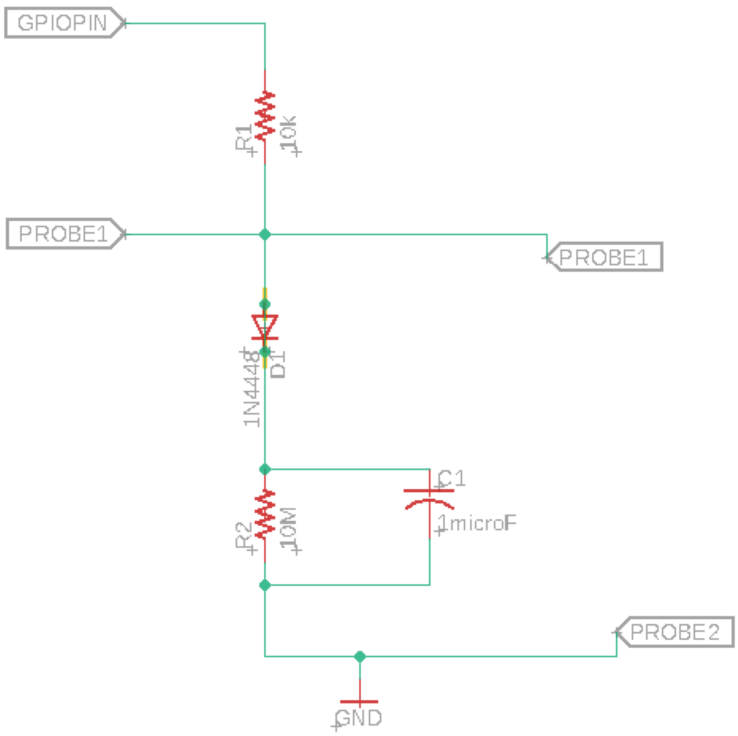
The project has four sensors in total: moisture, light, temperature, and pH. Out of these, the pH and moisture are pressed into the soil, while the light and temperature sensor can just be placed on top of the soil or around the pot. These sensors will all connect back to the MCU and send the respective measurements, which will then be displayed onto the website.

2.3.1 Moisture sensor

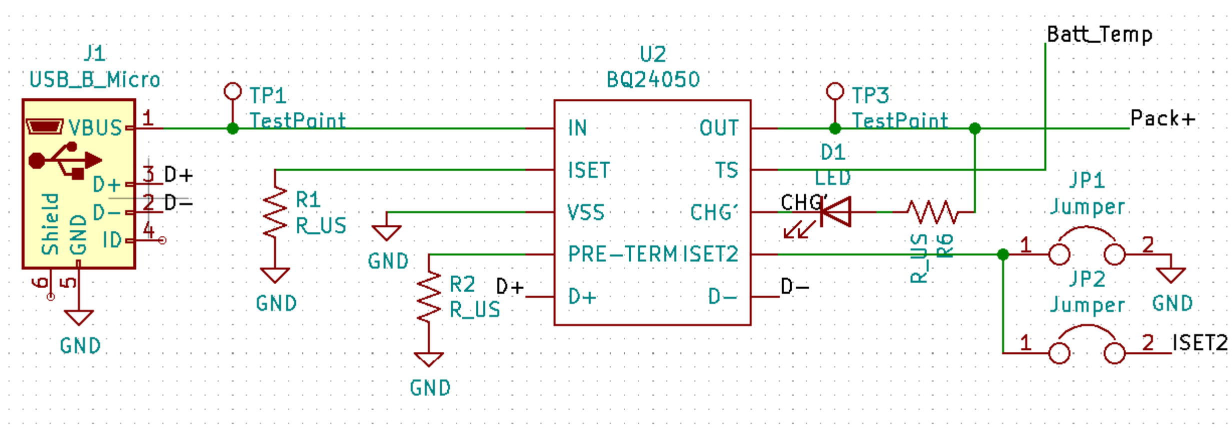
The moisture sensor is going to be made from scratch, and will consist of two metal probes that we press into the soil about one centimeter apart from each other. These probes will be connected to a circuit that we designed which passes a small electrical current through the probes. A measurement of the resistance provided by the soil, which acts as the medium to close the circuit, will give us an idea of the amount of moisture in the soil, as lower the resistance, higher the moisture content, and vice versa.

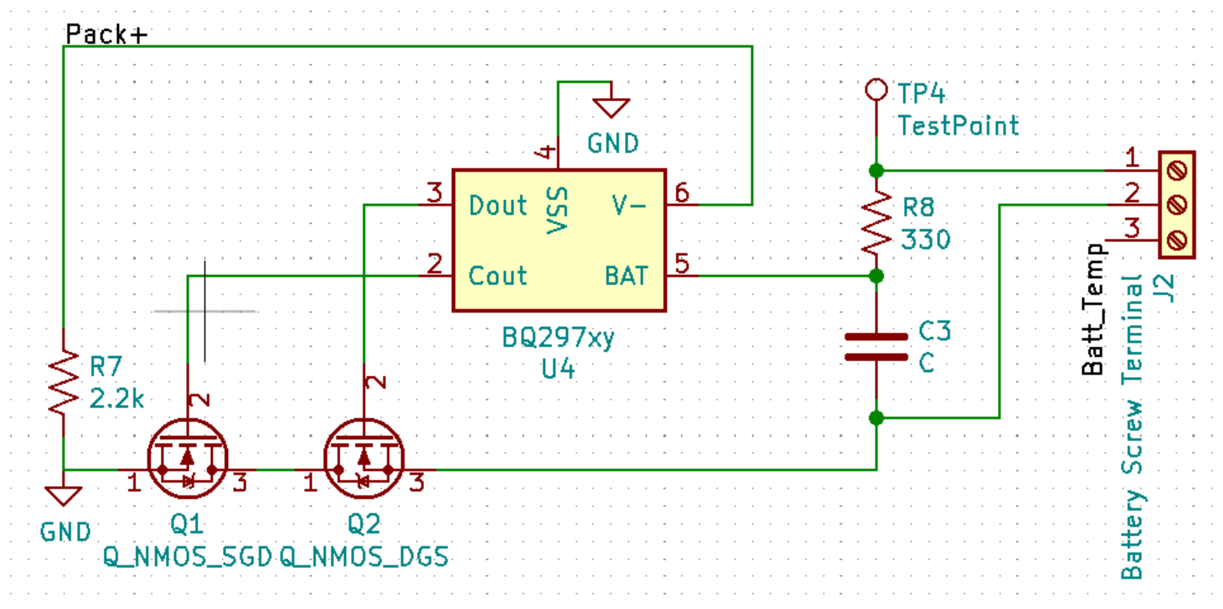
Requirement	Verification
1. Subsequent moisture readings of the same soil sample must be accurate within 10% of previous readings. 2. Must be able to send values to the website within 10 seconds after the data is measured, and sample the soil once every minute.	1. a. Place the sensor probes in water and then just in the air to get the ‘wet’ and ‘dry’ measurements. We will now get values in between these two numbers when we place it in soil. b. Calibrate the sensor measurements using multiple soil samples, each made with specific amounts of water, and ensuring we get consistent results. All readings should be within 10% even if the probe is reinserted. 2. a. Connect the sensor to the ESP32 with our circuit and write code to pull data from the sensor. Start with basic measurements and then test qualitatively with different soil samples. b. Test the time delay by checking for the time difference between changing values that we know. Ex - Switch the probe from soil pot to a jar of water and see how long it takes for the

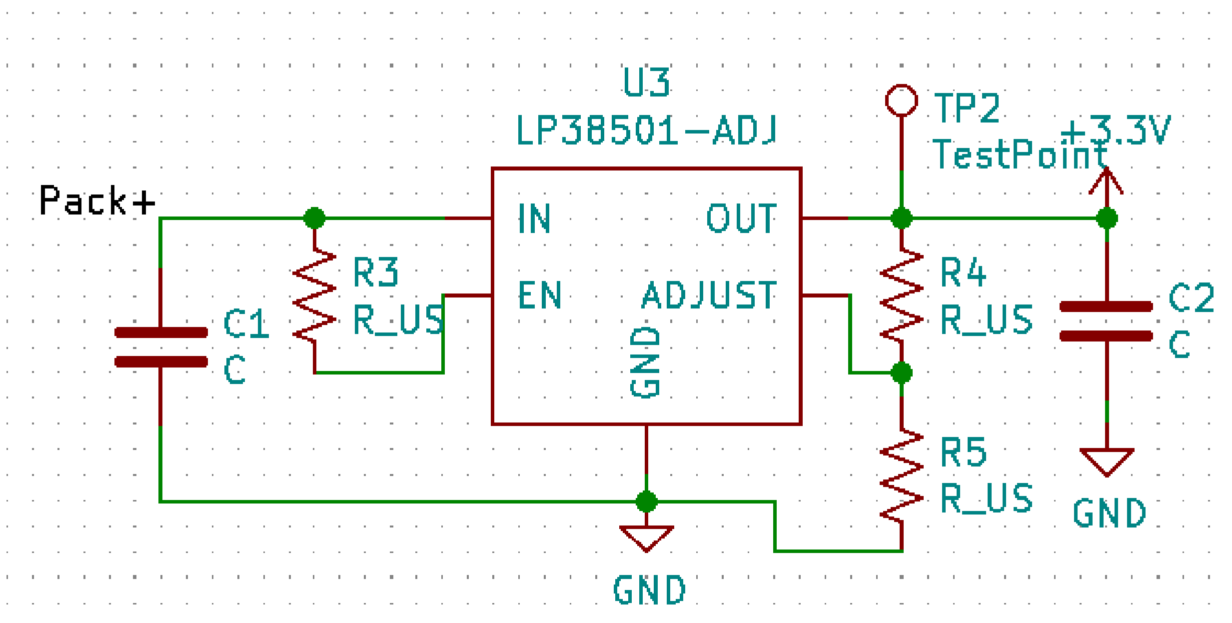
	value to reflect this change.



2.4 Power system schematics







2.4 Tolerance Analysis

One important tolerance to consider is the size of the battery pack and the estimated power usage of the device. One of the most important aspects of this project is the ability of the device to collect data constantly and report it to the user. It would be detrimental to the goals of this project if it could not operate without intervention for significant periods of time. Part of this includes operating for 3-5 days off of a fully charged battery, as is stated in the third high level requirement. Variations in the operation of the circuit and the requirements monitored could cause the average power consumption of the device to exceed a level that could be supplied by the chosen battery for the desired timeframe. For this reason the maximum average power consumption of each block will be calculated and compared to the battery's capacity.

The pump chosen is 3W, and can pump 200L per hour. The daily target for pumping water is 1L, as described by the design requirements. There is no datasheet available for this pump, so it will be assumed that the pump may pump at half speed while using 3W depending on the height difference between the basin and the plant. The battery capacity required to run this pump is estimated in equation 1.

$$6\,WH/200\,L \;=.03\,WH/day$$
$$.03\,WH\,/\,3.3V \;=\; 9.09\,mAH/L \;=\; 9.09\,mAH/day$$
$$Capacity \;=\; 9.09\,mAH/day \;*\; 5\,days \;=\; 45.45\,mAH$$

Equation 1

The ESP32 S2 microcontroller will also be a significant sink of power, especially when communicating using wifi. For this reason, it will be programmed to only transmit data through wifi every 5 minutes, or when there is significant change in the data being measured. The datasheet specifies a current consumption of 200mA max for 802.11n wifi transmit. When the modem is sleeping, power use is specified as 12 mA, and when in light sleep the MCU will use 450 uA. It will be assumed that the entire signal consists of a transmit (higher power use) and lasts for 10 seconds every 5 minutes. These 5 minutes will also include 10 seconds of modem-sleep mode to collect measurements, and 280 seconds of light sleep. These values are used in another battery estimate which is shown in equation 2.

$$I_{avg} \;=\; 200\frac{10}{300} \;+\; 12\frac{10}{300} \;+.45\frac{280}{300} \;=\; 7.486\,mA$$
$$Capacity \;=\; 7.486mA \;*\; 5\,days \;*\; 24\,hours \;=\; 898.4\,mAH$$

Equation 2

Finally, we can sum these two values to get an estimate of the power used. This is only a measure of the power needed at the output of the linear regulator though. The power dissipated by the regulator must be included in the estimate. This is done in equation 3, where it is assumed that the battery voltage is always at a maximum of 4.2V which will yield minimum efficiency for the regulator.

$$Efficiency \;=\frac{V_{out}}{V_{in}} = \frac{3.3}{4.2} =.786$$
$$Capacity_{min} \;=\frac{(898.4+45.45)mAH}{.786} =\; 1200\,mAH$$

Equation 3

The use of a 2000 mAH battery would guarantee that the device could function for 5 days. In this analysis, it was shown that the most power that could reasonably be used in the given amount of time, with tolerances included, is 1200 mAH. This helps us ensure that we meet our third high level requirement.

4. Ethics and Safety

Our main safety concern is the battery portion of the project. Improper use of rechargeable battery components can lead to them overheating or even exploding, so we plan to ensure that the electrical connections to the battery portion don't draw more power than the safe level and make sure that the cell voltage doesn't decay below the safe limit. We are using a Voltage and Current protection IC to further ensure that the power doesn't exceed the limit. We will also be conducting charge and discharge tests with the battery and will also be following the given charging suggestions and battery requirements from the safety guidelines for the course.

The project also involves water being pretty close to the electrical components because of the automatic watering mechanism. This created the need for some way to ensure that these components, especially the batteries, don't come in contact with the water. For this, we plan to have some sort of 3D printed housing for the electrical components. This is also to ensure that they don't come in contact with the soil and just the sensor probes do. We are also going to try and have silicone waterproofing for these 3D printed cases, so that we can plug the holes for the wires going in and out of it.

There are some ethical considerations from the IEEE Code of Ethics that we are keeping in mind while working on this project. The main one is #1: 'to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment;'.

We know that there are certain harmful metals like cadmium and arsenic that can enter the soil or deposit itself on the plant through various sources like cigarette smoke and water. This is a big issue for home plants since a majority of these tend to be herbs and small vegetables and fruits that people use in their food. Exposure to such harmful materials can cause health complications to the grower in the long run. Our product aims to safeguard their health and safety by using the pH sensing technology to ensure that the soil pH is maintained at a safe 6.5-7 range. The use of a peristaltic pump will also allow the water to be pumped without risk of contamination.

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