CDR Senior Design 2

Automated Hydroponics System

Group E
Christopher Lopez
Hardik Patel
Jarrod Pearman
Luiz Alves

What is Hydroponics?

- Dirt-free, space-saving, water-effective method of growing plants.
- Plants get nutrients and air from a water solution instead of the use of soil.
- Factors that influence plant growth: Temperature (water and air), pH balance, light, and nutrients.

Project Goals and Objectives

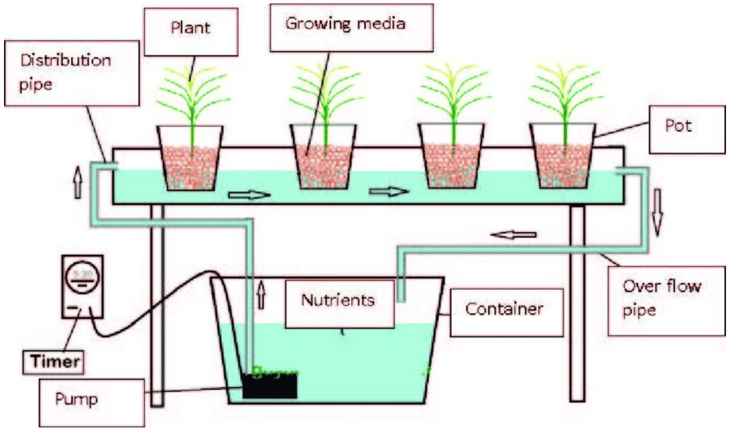
- To build a portable hydroponics system that can be inside a home.
- Have a mobile application for the user to interact with the hydroponic system.
- Real-time values being recorded and displayed to the user.
- Able to support a variety of plant types with preset plant parameters.
- Self sustaining system with little user intervention to operate after initial setup.

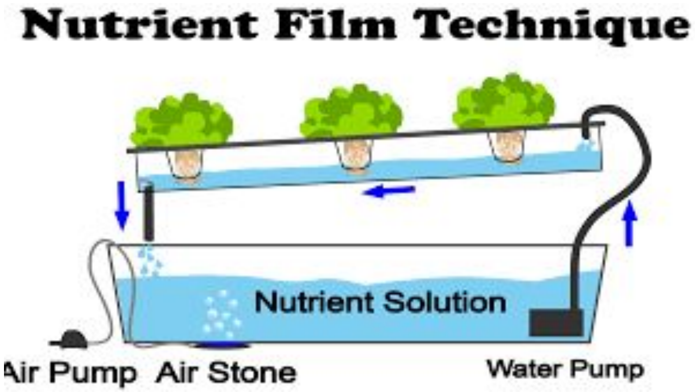
Specification and Requirements

- Fit through a standard door size in width or length (around 34”) and a max height of 5’ (up for change).
- Max weight of 60 pounds.
- This system will run on 120V wall outlet power.
- Budget to be under $800.
- Have the system use Wi-Fi IEEE 802.11ac.

Design Decisions

- The style of hydronics system we settled on was a Nutrient Film Technique (NFT) design
- Decided it was the most optimal form to a hands free monitoring system





Project Design Approach

- Mobile and portable design
- Light intensity adjustability
- LCD to display sensor information
- Enclosed design to keep reservoir clean
- S-Shape design to house more plants
- Food grade PVC-U material for no pollution

Hydroponic System Design

Structural Design:

- Cabinet
  - Water Reservoir
  - Submersible Pump & Peristaltic Pump
  - Electrical Components & sensors
    - Waterproof case to protect from any damage
- Growth Area
  - Four growth channels
  - LED light suspended above
  - Enclosed to prevent outside influence(light, temperature)

Overall Block Diagram

MCU Comparison

	ATmega2560	ATmega328	MSP430fr6989
Operating Voltage	1.8V-5.5V	2.7V-5.5V	1.8-3.6V
Volatile Memory	8 KB	2 KB	2 KB
Non-Volatile Memory	256 KB	32 KB	128 KB
GPIO pins	86	23	83
Clock Frequency	16MHz	16 MHz	16 MHz
Cost	11.99/unit	$3.88/unit	$6.48/unit

Microcontroller

Atmega 2560 MCU

- 16 MHz
- 100 Pins
- 86 GPIO and 32 GPR
- UART, SPI, I2C
- Operating Voltage: 1.8 to 5.5 Volts
- Temperature Range: -40 to 85 °C
- Compatible with Arduino IDE

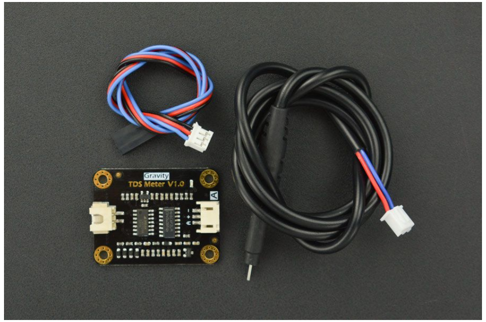
Sensors

- For this Hydroponic system we will be using various sensors in order to automate some of the processes required in hydroponics along with allowing real time monitoring to ensure the user has a good idea of how the system is doing at all times.
- This covers water quality, environment quality, and lighting. Some sensors are directly used in order to provide feedback to the user while others will be used to help improve the automation of specific subsystems.

Sensor Choices

- TDS Sensor
- pH Sensor
- Water Temperature Sensor
- Air Temperature and Humidity
- Light Sensor
- Water Level Sensor
- Distance Sensor

Water Quality



DFRobot Gravity Analog TDS Sensor/Meter

- This sensor will allow us to measure the amount of totally dissolved solids in the water(TDS).
- This is done by sending an electrical signal into the water column.
- The current of the signal can travel through these dissolved solids, mostly dissolved salts, and we can get an indication of the signal strength and determine the level of nutrients within the system.
- We will provide the user with updates on TDS along with any automated or manual changes needed to handle any TDS issues.

Water Quality

Liquid PH Value Detection Regulator Sensor

- This sensor consist of a module and a probe.
- The probe is placed in the water and returns pH readings ranging from 0-14.
- This pH is an indication of the amount of hydrogen ions in the water.
- Different minerals in the water can react differently based on the amount of hydrogen ions in the water, as a result, we want to ensure that the waters pH is an acceptable range for proper growth.
- This provides us with an idea of the amount of available nutrients in the system.

Water Quality

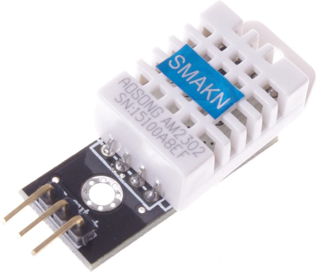
DS18B20 Temperature Sensor Module Kit Waterproof

- This sensor will allow us to measure the temperature of the water in the system.
- The temperature of the water can indicate the level of dissolved oxygen, a plants ability to absorb nutrients, and the potential for various bacteria and fungi to form.
- The temperature of the water will be provided to the user and if the water temperature falls out of range the user will be notified.

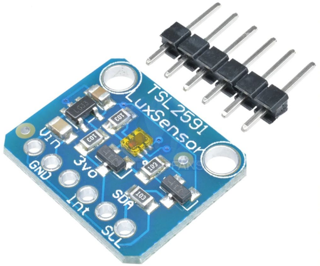
Temperature and Humidity

SMAKN DHT22 / AM2302 Digital Temperature and Humidity Measure Sensor

- This sensor module will allow us to measure both the temperature and humidity of the environment surrounding the plants.
- This is to ensure that we can provide monitoring on the local climate of the system such that the ambient temperature and the level of humidity are within acceptable ranges for plant growth.
- We will provide real time updates in order to ensure the user can appropriately handle any issues that arise.



Light Sensor and Distance sensor



TSL2591 IIC I2C Light Sensor Breakout Module

- This sensor will allow us to monitor the light intensity of the grow lights used and help us keep track of a simulated day night cycle. Based on light intensity the light exposure duration will be modified accordingly such that the plant does not receive too much light or not enough.

HC-SR04 To World Ultrasonic Wave Detector

- We will also be using a distance sensor to monitor the distance between the lighting and the plants themselves. This will be used to monitor the plants height as it grows. Although not a key feature in keeping the plants alive it can be useful for the user to keep track of the plants current state in its growth cycle.

Water Volume Monitoring

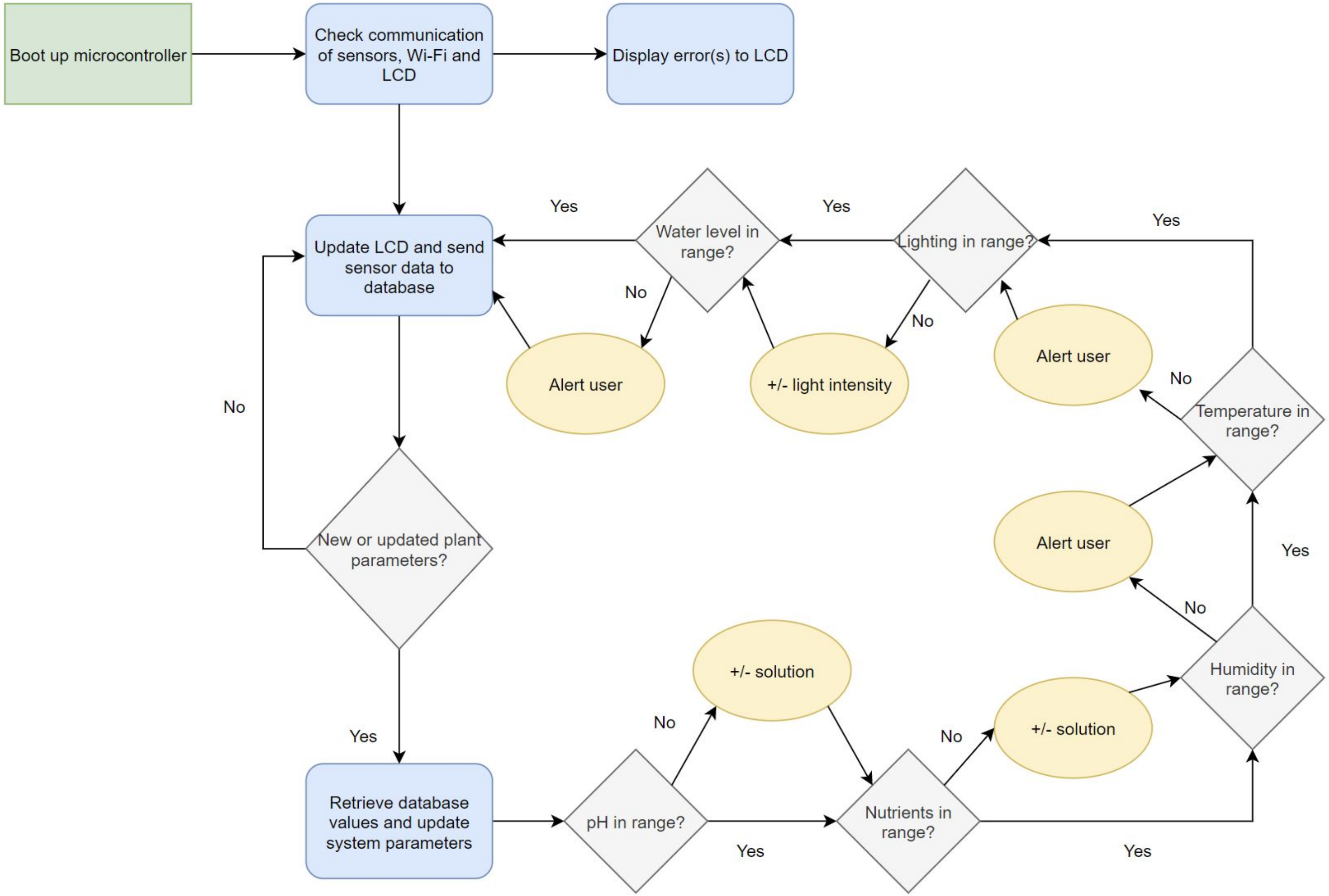
CQRobot Contact Water/Liquid Level Sensor

- We will be using this sensor in order to monitor the water levels within the main reservoir to ensure that there is enough water in the system such that the plants can grow properly.
- Ensure equipment has enough water volume to work.
- We will provide updates to the user in an event that the water level is too low or even too high so they can add or drain water accordingly.

Local Interface/LCD

- We want to provide the user with information that is directly a part of the physical system at all times.
- Decided on a 7 Inch TFT LCD Resistive Touch display that uses a Shield to connect into an ELEGOO MEGA 2560.
- This display will provide us with enough screen real estate such that we can properly display the most important information at all times such that the user can glance at the hydroponic system and get an idea of its current status just by looking at the display.

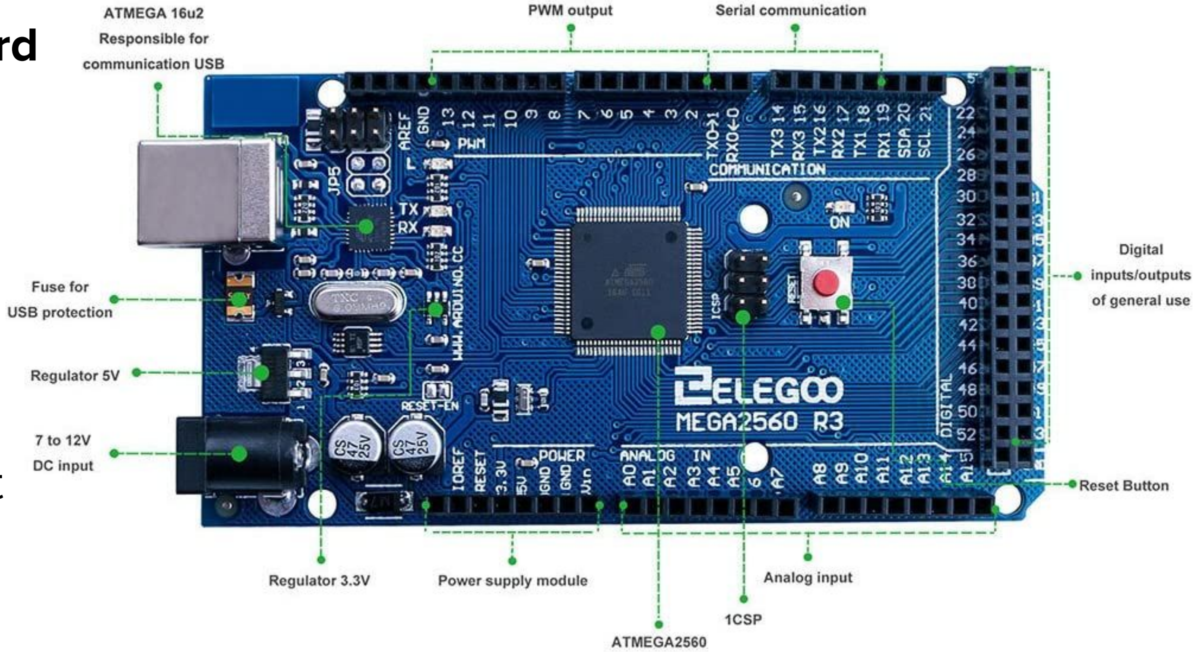
MCU Sensor Flowchart



Development Environment

ELEGOO MEGA 2560 R3 Board

- Arduino IDE
- Program in C
- Large list of libraries
- MCU is an Atmega 2560
- Flexible design layout
- Large Community Support



Water Reservoir

- A core part of hydroponics is the reservoir.
- The reservoir will house the majority of the water volume in the system that will be circulated through the plants and back. The larger water volume helps aid water quality and slow down the effects of evaporation.
- The reservoir also allows us the perfect location in order to place many of our sensors and where the water pumps will be located.
- Potentially will break into 2 parts if sensors and/or pumps are conflicting.

Liquid Dosage System - pH

- In hydroponics there are pH UP and DOWN solutions that are used to help control the pH within the system.
- There will be local containers near the main water reservoir that will contain each of the pH solutions.
- When the pH sensor finds that the pH falls out of acceptable range the system can adjust this automatically with some smaller liquid pumps that will provide an appropriate amount of pH solution until appropriate levels are met.
- The user will me notified and made aware of any further action is needed.

Liquid Dosage System - Nutrient Solution

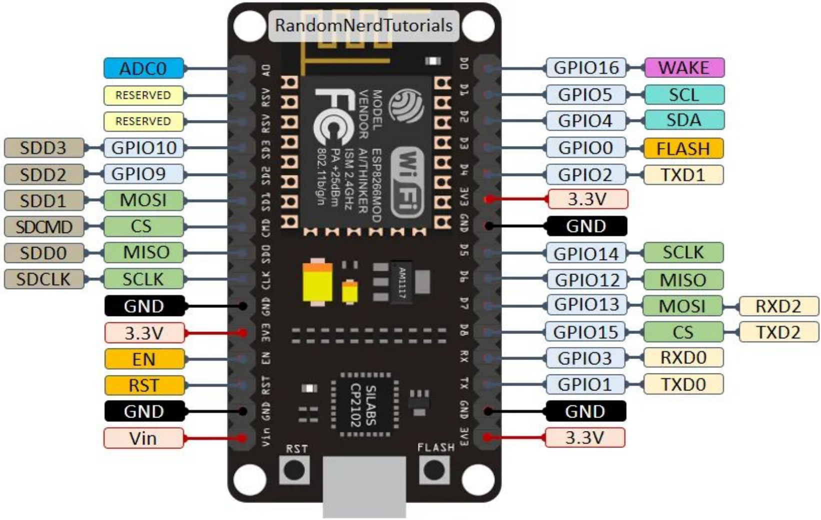
- When nutrients is low in the hydroponics system people often use nutrient solutions in order to help raise the levels in the water to help improve plant health.
- There will be a container containing such nutrient solution that has a pump that can add solution to the system when its low.
- If the TDS sensor finds that the nutrient levels are low the pump will add the appropriate amount. If there is too much nutrients in the system the user will be notified that a water change is recommended.

Wireless

- Considered Wifi and Bluetooth to transfer data.
- Decided on wifi for the increased range and rate of data transfer.
- Provides capability to connect to the hydroponic system outside of the user’s home.
- Designed to work with a cloud database to work in junction with the hydroponic system.

ESP8266 WiFi Module Specification

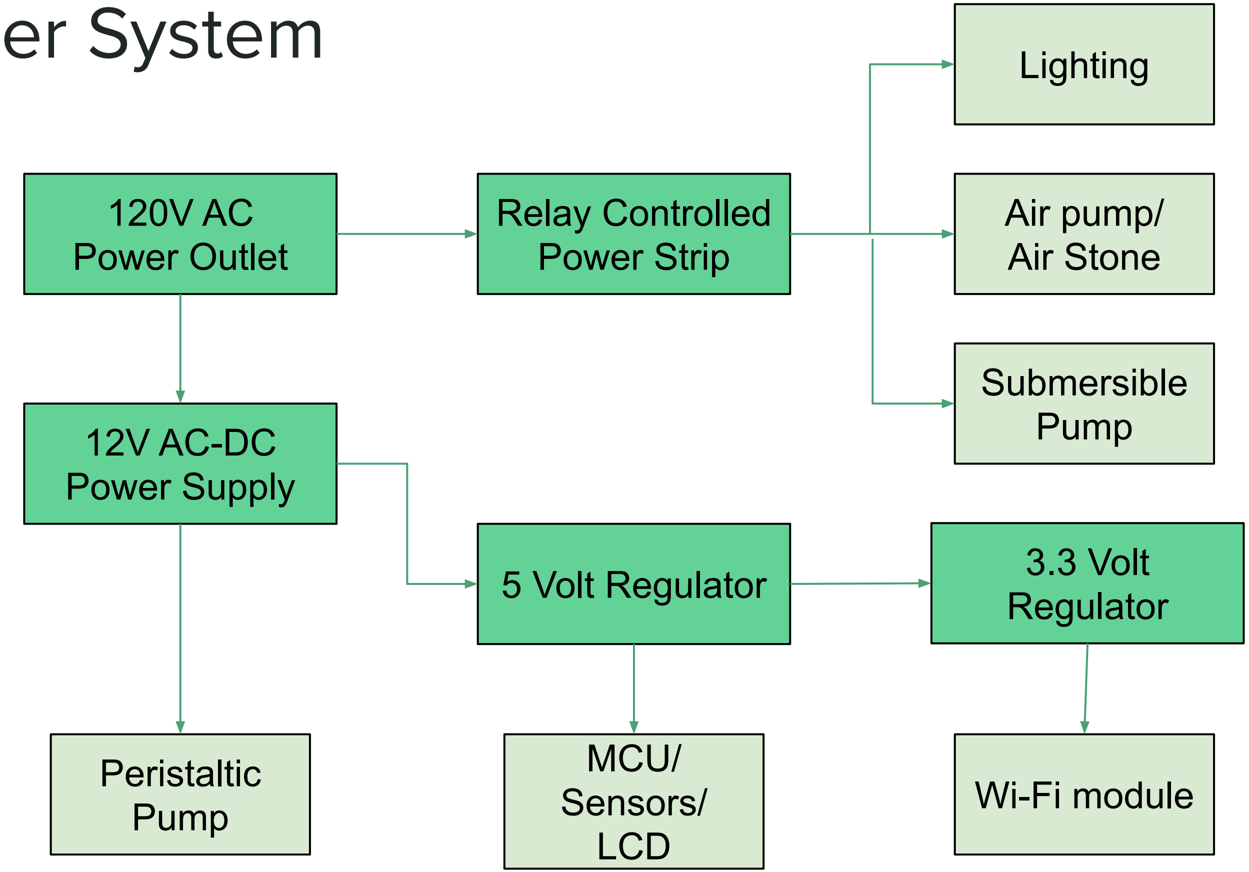
- Uses 2.4GHz RF band
- Operating Voltage: 3.3V
- Can be used as a Wireless Access Point or a Wireless device.
- Uses TX/RX pins to transmit and receive from the MCU.
- Able to host a HTML webpage.
- SPI Communication.



Power Considerations

- No Solar
  - Solar Cells are expensive and hard to implement.
  - Solar Cells don't work indoor.
- Battery Supply vs 120V AC Outlet
  - Batteries eventually die and need to be replaced.
  - Using a battery is more expensive than power from wall outlet.
  - Rechargeable batteries take a lot of time to charge thus are not user friendly.
- Since our hydroponics system is an indoor system and doesn't need to be portable, using the wall outlet power is the best and cheapest option for us.

Power System

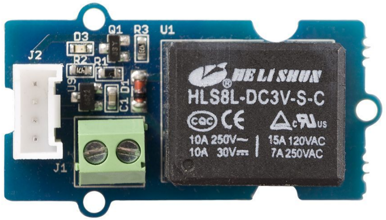


Power Supply

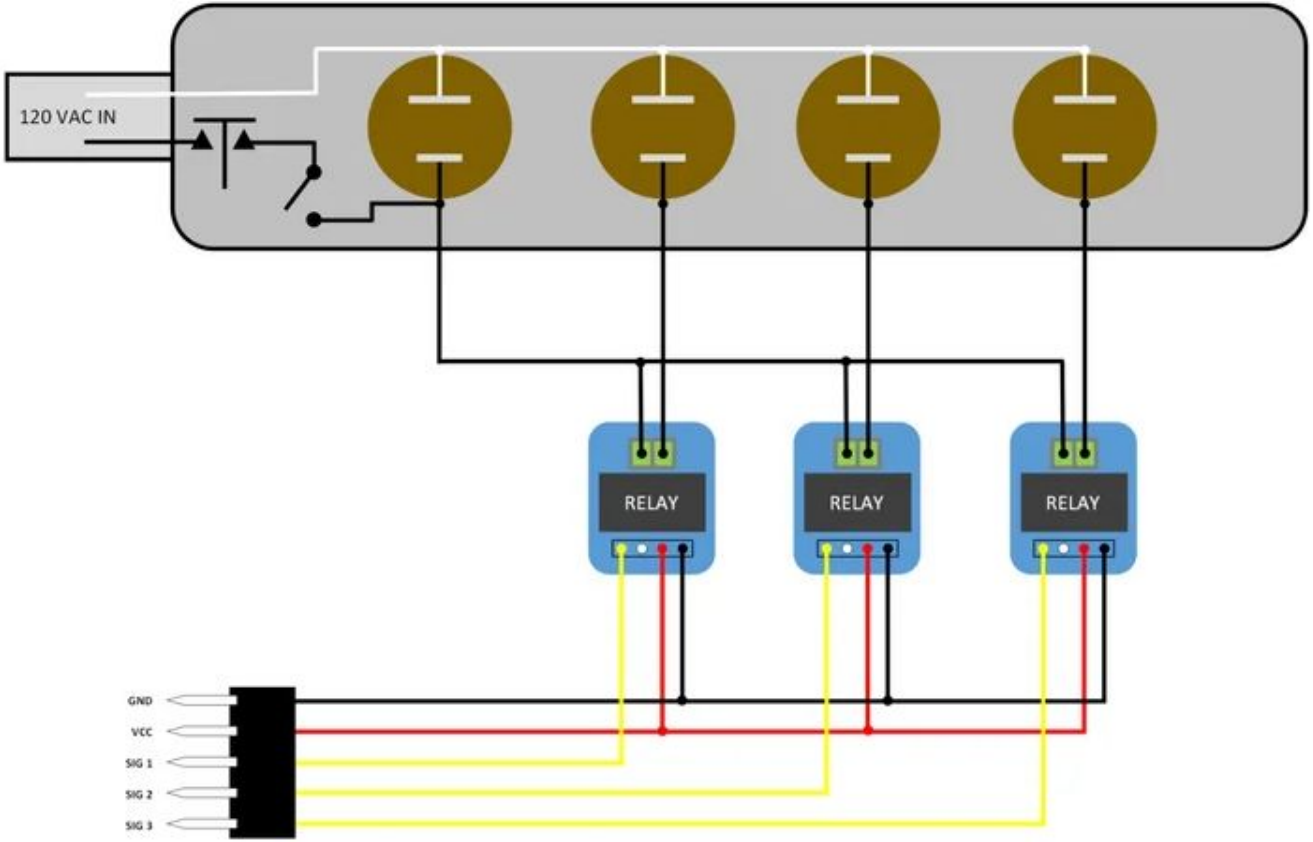
- Regulated Power Supply with 2.1mm barrel jack which converts wall outlet AC power to regulated 12V DC.
- It will be used to power the PCB. PCB will further use the linear voltage regulators to obtain 3.3V and 5V.
- Peristaltic Pumps will also be powered at 12V DC.

Relay Controlled Power Strip

- Grove-Relay module is a digital normally-open switch. A small voltage applied to the relay causes the relay to switch on, which allows the current to flow through the connected load.
- It will connect to the MCU with control lines to control the lighting, air pump, and submersible pump according to the plants needs.

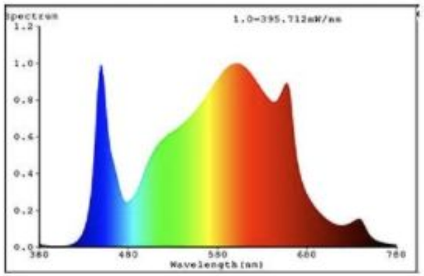


Relay Implementation Design



Lighting System

- Full spectrum lighting for maximum yield
- Controlled light intensity for different plants
- Mounted at the top of the system
- 300 LEDs
- White 3000k
- Red 660nm



Submersible Pump

- The water pump is responsible for circulating nutrient solution in the reservoir and sending it to the plants with the use of tubing.
- Active Aqua Grow Flow Submersible pump
    - 251 Gallons per hour
    - 120 VAC
- It will plug into the relay controlled power strip and will turn on/off on a regular interval.
- Great for indoor and outdoor use.
- Low power consumption.

Air Pump & Stone

- Air pump helps create dissolved oxygen in the water for the plants and it also helps prevent algae and disease growth in the reservoir.
- Air pump will sit outside and connect to the air stone inside the water reservoir. The air pump takes oxygen from the air and channels it into the air stone, which emits hundreds to thousands of tiny bubbles into the reservoir.

Sunlight Supply Eco Air 2 Adjustable Air Pump

- 126 GPH
- 2 Outlets

VIVOSUN 5 Inch Air Stone Disc

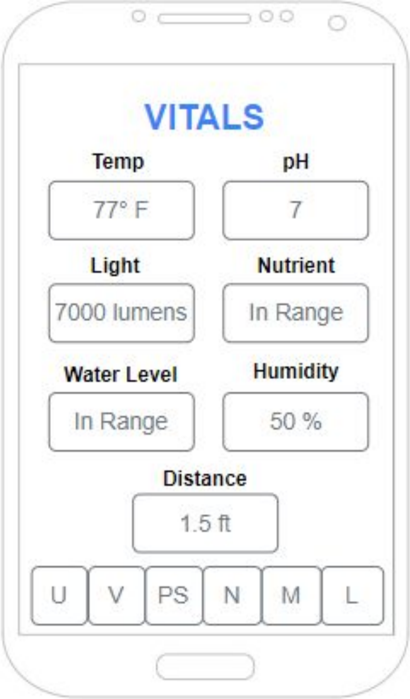
- Produces bubbles for oxygen replacement.
- Extends the life of nutrient solutions.

Android App

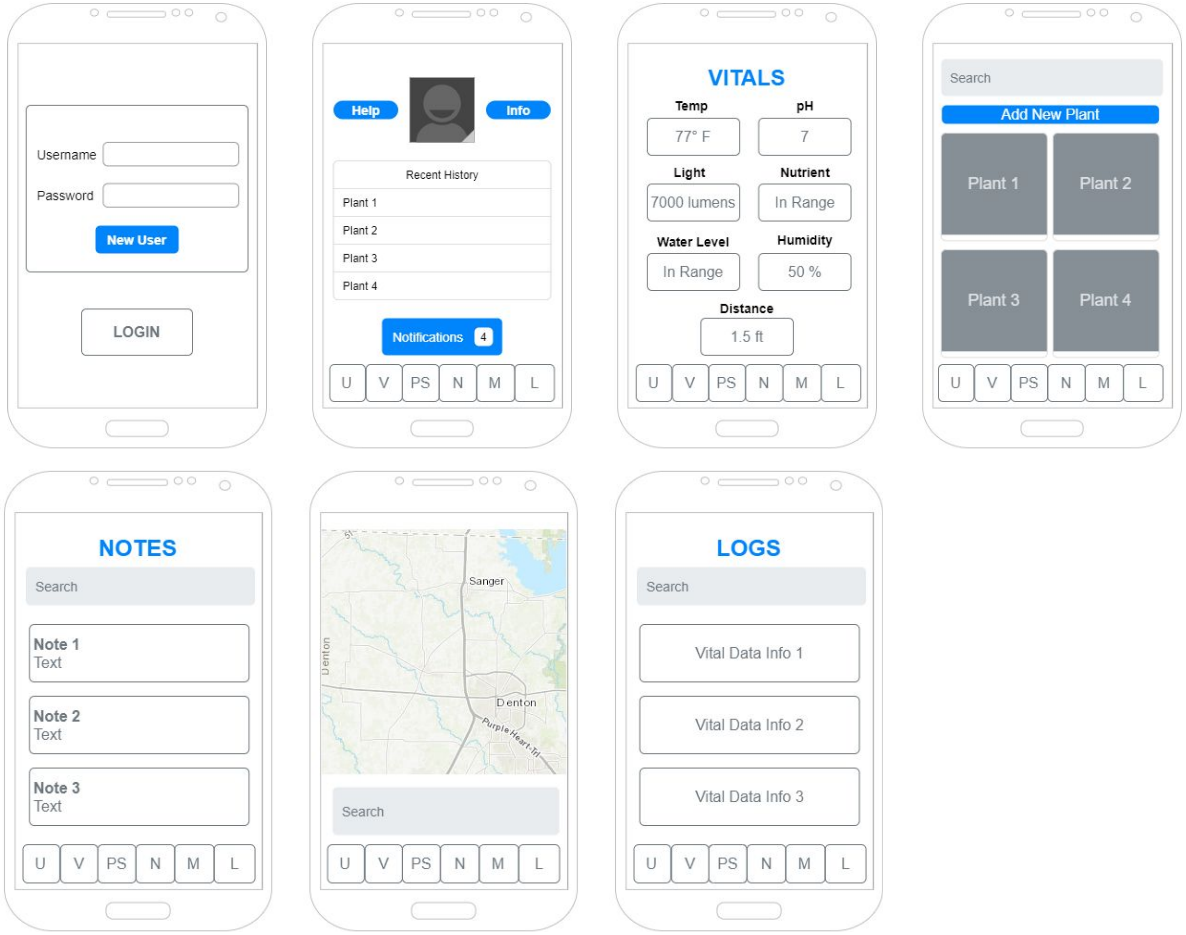
- Decided with Android Studio for extensive documentation, cloud integration and advanced emulation.
- Will be coded mainly in Java for ease of use within the team.
- Web technologies will be used to connect to the cloud and other files within the app.

App Goals

- User accounts to keep data separate for each hydroponic system.
- Dedicated plant vitals page to display current reading from the hydroponic system.
- A plant lookup page to set parameters for a specific plant that can be modified to the users' liking.
- A notes page to jot down observations or anything related to the system.
- Google maps to display local hydroponic stores for supplies.
- A log page to see vitals progress through time.

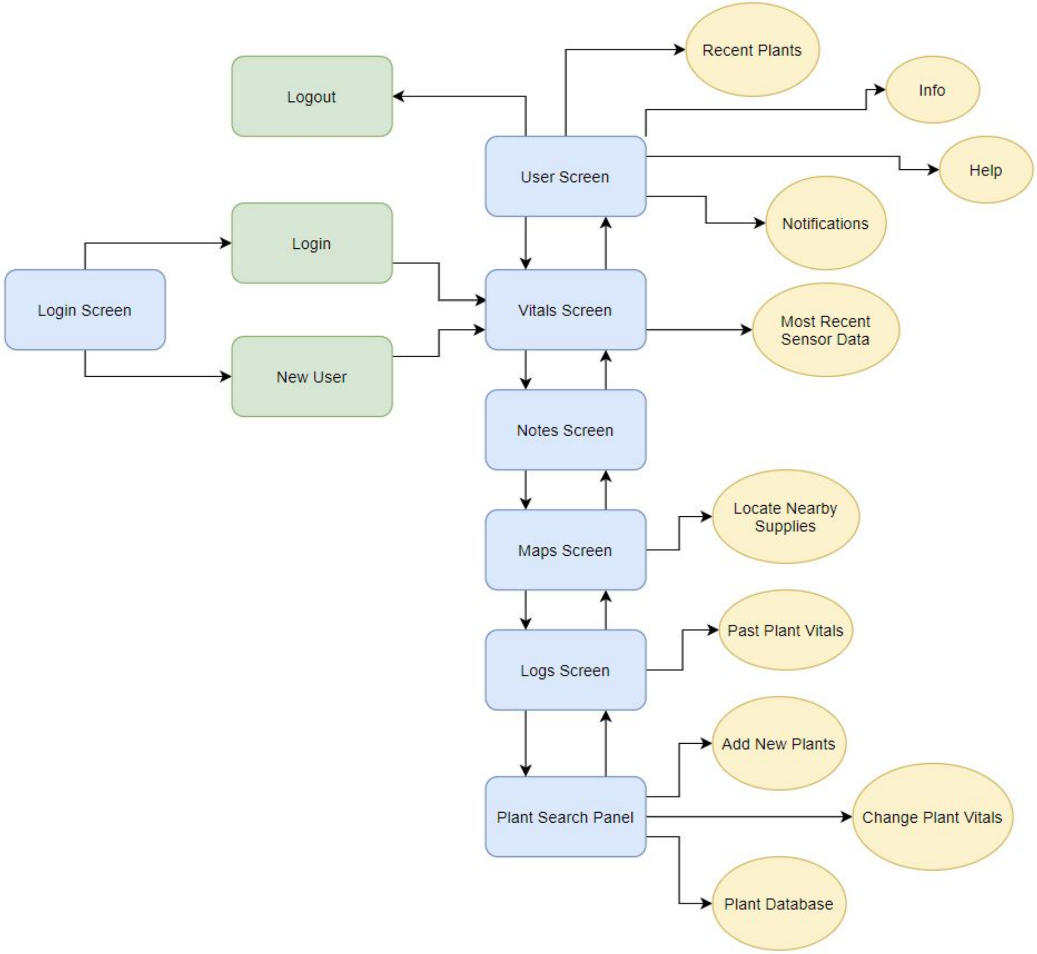


App Layout



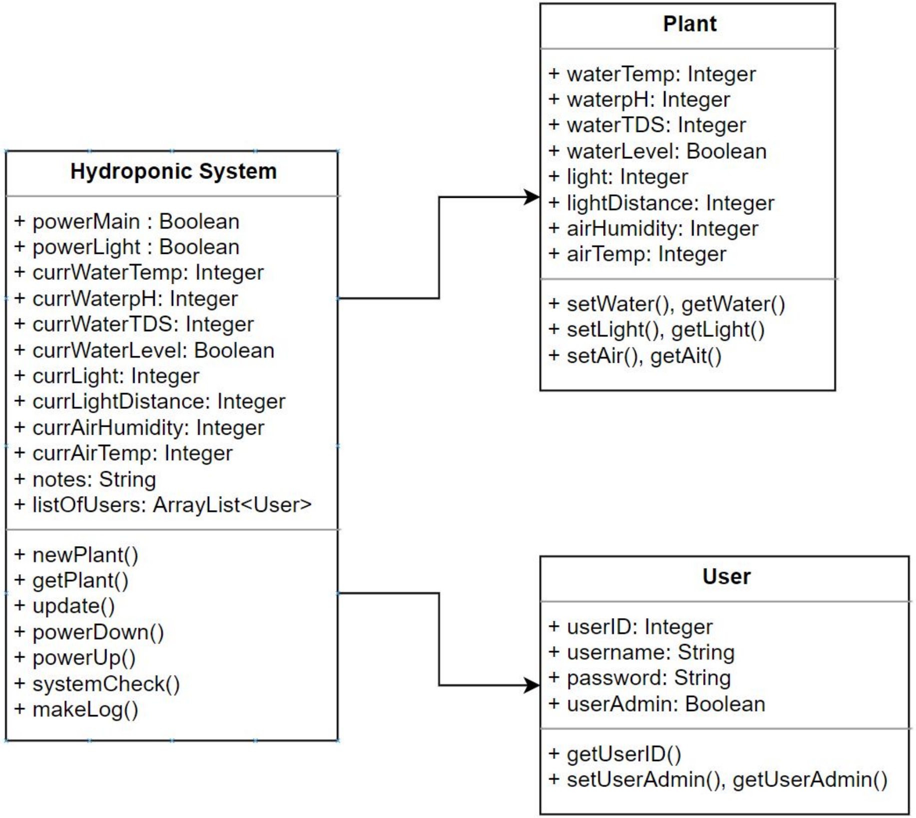
Username
Password
New User
LOGIN
Help
Info
Recent History
Plant 1
Plant 2
Plant 3
Plant 4
Notifications 4
VITALS
Temp
pH
77° F
7
Light
Nutrient
7000 lumens
In Range
Water Level
Humidity
In Range
50 %
Distance
1.5 ft
Search
Add New Plant
Plant 1
Plant 2
Plant 3
Plant 4
NOTES
Search
Note 1
Text
Note 2
Text
Note 3
Text
Sanger
Denton
Purple Heart Trl
Search
LOGS
Search
Vital Data Info 1
Vital Data Info 2
Vital Data Info 3
U V PS N M L

Use Case



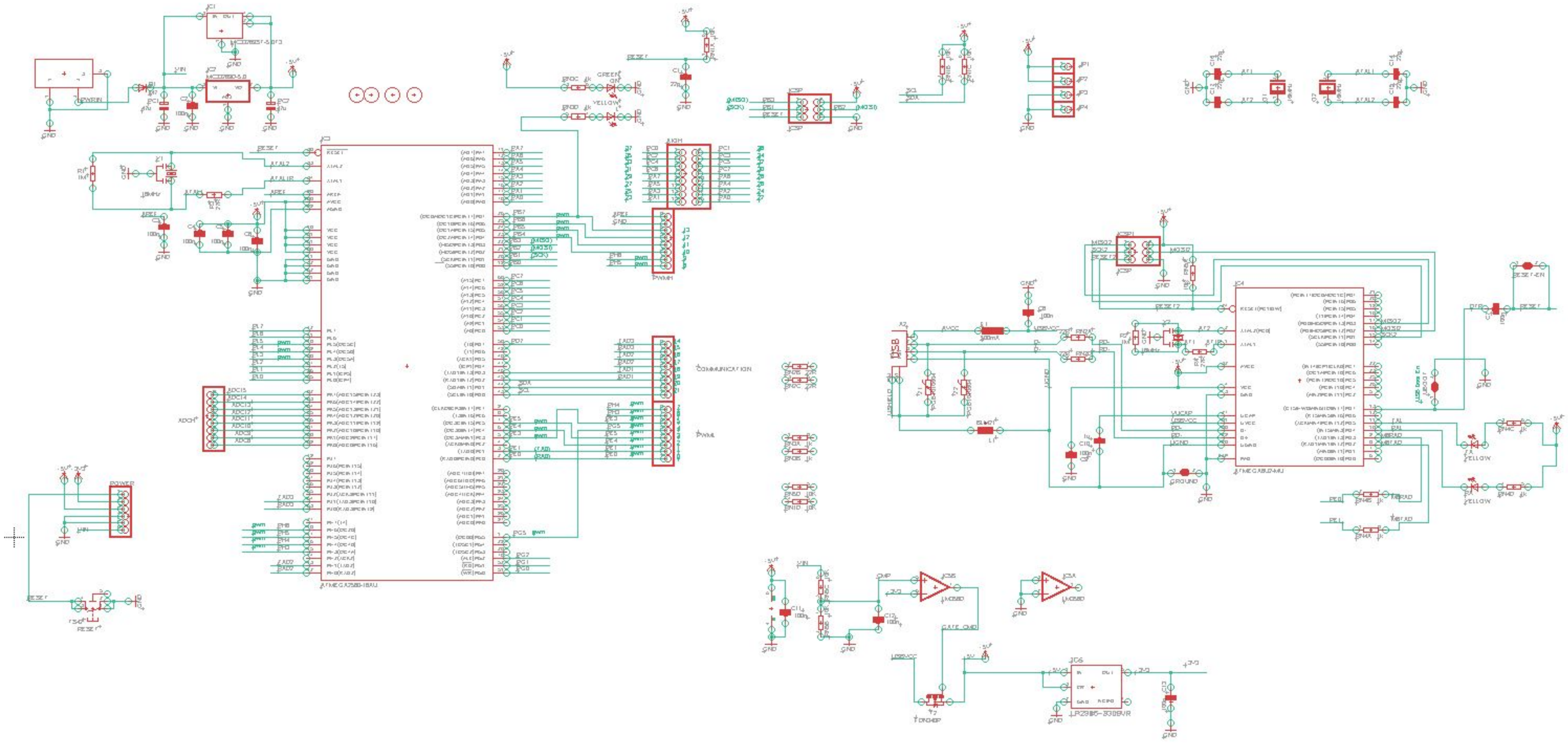
Recent Plants
Logout
Info
User Screen
Help
Login
Notifications
Login Screen
Vitals Screen
Most Recent
Sensor Data
New User
Notes Screen
Locate Nearby
Supplies
Maps Screen
Past Plant Vitals
Logs Screen
Add New Plants
Plant Search Panel
Change Plant Vitals
Plant Database

Class Diagram



Printed Circuit Board Design

Using the ATMega2560 Development Board as a baseline, we will create a board around the needs of our system.



PCB Communication and power needs

All of our sensors will utilize serial communication to minimize the amount of necessary pins on the board. Necessary connections and other info can be found below.

- TSL2591 Light Sensor (Pins: 5Vin, GND, two digital for i2C Communication. I2C - Unique Address 0x29)
- Gravity: Analog TDS Sensor (Pins: GND, 5Vin, Analog IN to board)
- HC-SR04 Ultrasonic Sensor (Pins: 5Vin, Trigger Pulse Input (digital PWM), Echo Pulse output (digital), Ground)
- DS18B20 Temp Sensor (Pins; 5Vin, GND, one digital pin), requires 4.7k pull-up resistor between signal and power

PCB Serial Communication and power needs

All of our sensors will utilize serial communication to minimize the amount of necessary pins on the board. Necessary connections and other info can be found below.

- DHT-22 Digital Temperature and Humidity Sensor (Pins: 3.3Vin, Digital, GND), 10k pull up between power and signal if not received with board.
- ESP8226 WiFi Module
  - Serial Programming Header (Pins: DTR, TXO, RXI, 3V3, NC, GND)
  - I2C Header (Pins: GND, 3v3, SDA, SCL)
  - General I/O Header (Pins; GND, VIN, Enable, ADC, XPD, 5 general I/O)
- PH meter (Pins: Analog IN, 5 Vcc, GND)

Design Constraints

- COVID-19 has limited the amount of face-to-face time available as a group.
- As this is not a sponsored project, we were limited in budget to what members could reasonably afford.
- Due to being a two semester long project, design decisions were made that can be implemented within a reasonable timeframe and with good alternatives if they failed.

Project Budget

Our project budget is $500 with a breakdown of price estimation as shown in the accompanying table.

Atmega 2560 Microcontroller	$15
Arduino Mega	$30 (including power supply)
Peristaltic pump	$25
pH sensor	$15
Temperature Sensor	$10
Distance sensor	$5
Water level Sensor	$20
Light sensor	$7
TDS sensor	$20
WiFi chips	$20
LCD	$20-$30
LED Lights	$100
PCB construction	$50
Assorted electronic parts	$50
Construction Materials	$100

Current Completion by Section