F.L.O.W.E.R.S.

Functioning Lighting and Optimal Watering for Environmental Regulation System

Group 20

Meet the Team

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Motivation and Background

- Ease of Use for Non-Gardening Experts
    - Many people are discouraged from plant care due to a lack of knowledge or confidence. This system lowers the barrier to entry by automating key tasks, making gardening approachable for beginners.
- Benefits of Automating a Home Growing System
    - Automation reduces the time and effort needed to maintain healthy plants, allowing users to enjoy the therapeutic and aesthetic benefits of greenery without daily oversight.
- Resource Management/Efficiency
    - By monitoring light and moisture conditions, the system optimizes water and energy usage, reducing waste and increasing sustainability.
- Indoor Accessibility
    - The smart garden system enables successful plant growth indoors, even in environments with limited natural light or irregular maintenance schedules.

Goals and Objectives

Goal 1: Create an Optimized Indoor Growing Environment

- Automatically deliver species-specific water amounts using a pump and solenoid valve system.
- Provide optimal spectral light output for plant growth, including the use of programmable LEDs.
- Use sensor data from light sensors and moisture sensors to create a feedback loop that controls each environment individually
- Simulate natural light cycles through duty cycling and on/off scheduling.
- Measure real-time temperature and humidity for updating the user via the app.
- Transmit multiplexed sensor data to the MCU
- ***Stretch Goal:*** Use ultra-low-power sensors that require infrequent battery replacement; only twice a year under constant use.
- ***Stretch Goal:*** Implement individual ESP32 modules on the soil moisture sensor for wireless communication to the main PCB, using the ESP-NOW protocol for communication

Goal 2: Develop a User Friendly Mobile Application

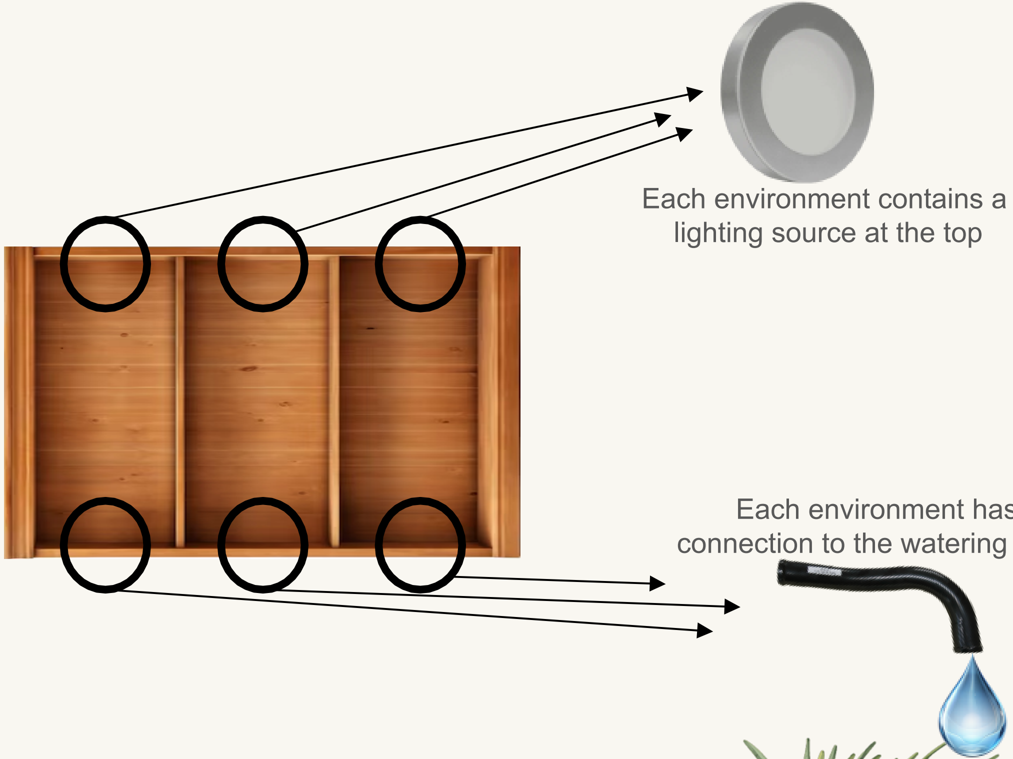
- Allow users to manually input target values for soil moisture and lighting.
- Display real-time sensor data, including moisture and temperature readings.
- Provide preset growth profiles for Florida plants commonly grown indoors.
- Notify the user when sensor values exceed or fall below critical thresholds.
- ***Stretch Goal:*** Adapt watering schedules based on plant growth stage (e.g., seedling, budding, flowering).

Engineering Specifications

Specifications Table	
Parameter	**Requirement**
App Data Refresh Rate	At least once every hour
Soil Temperature Polling Rate	At least once every hour
Soil Moisture Polling Rate	At least once per minute
Number of Environments Maintained Simultaneously	At least 3
Power Consumption (120V LED lights)	Less than 200 Watts
Electronic Solenoid Valve Response Time	Less than 5 seconds
Water Pump Rate	At least 1 GPM (Gallon per Minute)
Water Pump Pressure	At least 40 PSI
Water Pump Power Consumption	Less than 75 watts
Maximum Shelf Size	4'x 6'x3'
15A Breaker Trip Time (12V)	Less than 100 milliseconds
15A Breaker Trip Time (120V)	Less than 100 milliseconds

- From a design perspective, it is important that the feedback sub-systems that ultimately control the environments frequently update
- From the perspective of the user, the most relevant specifications include the number of environments that are maintained simultaneously, as well as safety features like the breaker trip time

How F.L.O.W.E.R.S. Operates: The Physical Unit



Each environment contains a lighting source at the top

The physical unit can simultaneously maintain 3 individual environments, meeting each environment's own needs for watering and lighting

Each environment has a connection to the watering source

How F.L.O.W.E.R.S. Operates: The Physical Unit

x3

3 capacitive soil moisture sensors will be used, one for each environment

The user will be in charge of placing the sensor into each plant pot and switching the sensor into the new plant pot upon swapping the plant in the environment, as well as entering the environmental needs for the plant (light, water, etc.) in the app

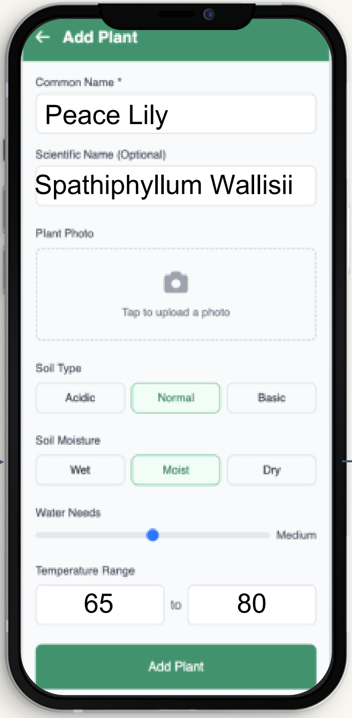
How F.L.O.W.E.R.S. Operates: The Physical Unit

The main PCB will be attached to the back of the environments, connected to each soil moisture sensor with wires

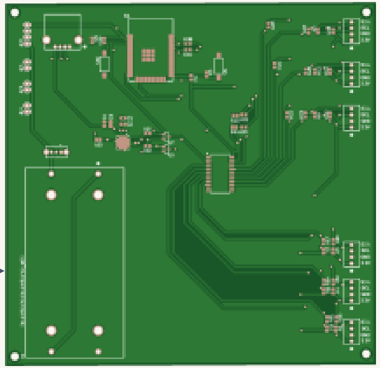
A 3D-printed decorative cover will be attached to protect the PCB and act as branding for F.L.O.W.E.R.S.

How F.L.O.W.E.R.S. Operates: Incorporating the Software

1 The user places the plant into the environment, and inserts the soil moisture sensor



2 The user enters the vironmental needs including soil moisture

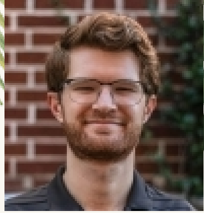


3 The info is sent to the main PCB and the ESP32 will handle polling the soil moisture sensors and sending the water, if needed

Technology Selection: Main PCB MCU

Features	*ESP32-Wroom-32*	*ATmega328P*	*MSP430*	*RP2040*
CPU Cores	Dual-Core Xtensa LX6	Single Core	Single Core	Dual ARM Cortex-M0+
I/O Pins	38 GPIO	23 PIO	24 PIO	30 GPIO
Analog Inputs	18 channels (12-bit ADC)	8 channel (10-bit ADC)	8 Channel (10-bit)	3 Channel (12-bit ADC)
PWM	16 Channels	6 Channels	8 Channels	16 Channels
Communication Protocols	SPI, UART, I2C, I2S,	UART, I2C, SPI	UART, I2C, SPI	UART, SPI, I2C
Wi-fi capability	802.11 b/g/n	N/A	N/A	N/A
Bluetooth Capability	BR/EDR and Bluetooth LE	N/A	N/A	N/A
Power Consumption	10μA Deep Sleep	0.2mA Active Mode	230μA Active Mode	30mA Active
Memory	4M Byte	32Kbyte	16K Byte	2M Byte
RAM	4M Byte	2KByte	512 Byte	264k Byte
Operating Voltage	3.0V-3.6V	1.8V-5.5V	1.8V-3.6V	3.3V

Technology Selection: Soil Moisture Sensing



	VWC	Water Tension	Single-Point	PCB Design
Water calculation	Uses dielectric permittivity of the soil	Uses tensiometer to measure soil suction	At a specific point takes the conductivity of soil	Uses traces as capacitor plates to measure soil moisture
Sensitivity	Affected by soil type and salinity	Soil texture	Contact to soil and soil	Soil make up and salinity
Output Value	Percentage	kPa	Binary or Resistance Value	Voltage or Digital Signal
Measurement Depth	Multiple depths	Near roots	Fixed at a single point	Few cm depth
Accuracy	High	N/A	Low	Moderate can improve with calibration
Cost	High	High	Low	Low

Hardware Selection: I2C Bus Multiplexer

	PCA9547
Channels	8
Operating Voltage	2.3-3.6V
Current Draw	20uA (typical)
Stand By Current	0.1uA (typical)
Cost	$1.79

Hardware Selection: Temp/Humidity Sensor

	AHT 20	SHT 45	DHT 11
Temp Range	-40 to 85 °C	-40 to 125 °C	0 to 50 °C
Humidity Range	0 to 100% RH	0 to 100% RH	20-80% RH
Voltage	2.2V to 5.5V	1.08V to 3.6V	3.3V to 5.5V
Interface	I2C	I2C	Single Wire
Response Time	~8 sec	<0.5 sec	~10 sec
Accuracy	±0.3 °C/±2%RH	±0.1 °C/±1%RH	±2 °C/±5%RH

Hardware Selection: Light Sensor

	BH1750	VEML7700	TSL2591
Range (lx)	0-100k	0-120k	0-88k lux
Resolution	1 lux	0.0036 lux	0.000377 lux
Power	~0.36 mW	~0.51 mW	~0.6 mW
Current Draw	0.12 mA	0.17 mA	0.2 mA
Standby Current	0.01 µA	0.8 µA	2 µA
Cost	$3.29	$1.25	$1.67

Hardware Selection: Capacitive Sensor

	Resistive Sensor	**Capacitive Sensor**
Measurement method	Measures the soil resistance between two probes	Measures capacitance from soil permittivity
Output Type	Analog	Analog
Voltage	3.3V to 5V	3.3V to 5V
Accuracy	Low	Medium

Hardware Selection: Water Pump

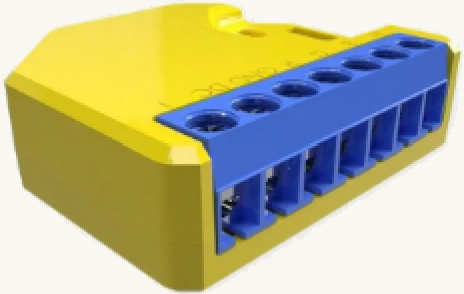
Water Pump Selection Summary:

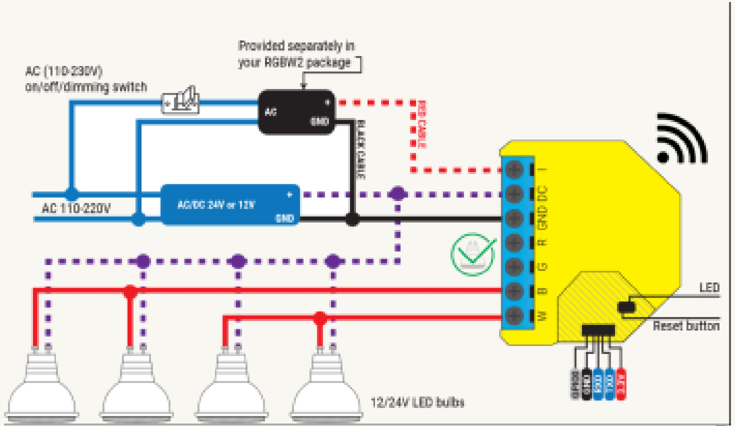
- Selected Pump: Model R3526144D
- Supply Voltage: 12V DC — consistent with overall system requirements
- Flow Rate: Delivers 3.0 GPM — Beyond Sufficient for needs
- Pump type- Demand Pump
- Maintained Pressure: 50 PSI — sufficient for our vertical planter system
- Cost: $49.99 — lowest-cost option
- Trade-offs Considered: Slightly lower pressure compared to others, but acceptable within design limits. In fact, a flow regulator will still be used
- Rationale: Chosen for its optimal balance of performance, simplicity, and budget compatibility

Model Number	R3526144D	Delavan Powerflo 7822FS	Everflo EF2200
Cost	$49.99	$81.37	$77.47
GPM	3.0	2.2	2.3
Sustained PSI	50	60	70
Supply Voltage	12V	12V	12V

LED Driver/ Wireless Relay

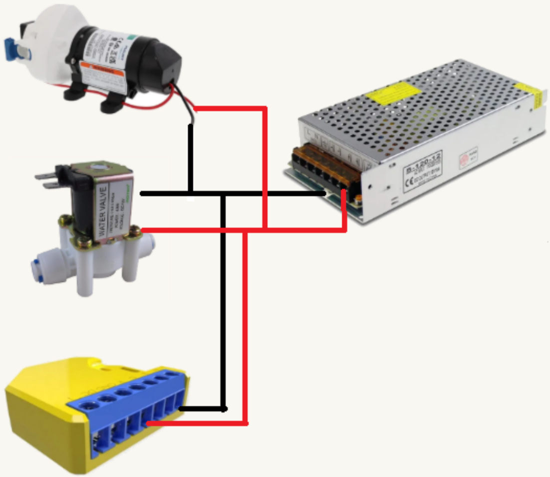
- For this project, we have chosen to control both the lights and solenoid valves wirelessly.
- For the solenoid valves, this was done for positioning, as it allows the main PCB to be physically disconnected from the valves, allowing easier placement of both.
- For the lights, not only was positioning important, but our design fundamentally requires the ability to dim the lights to supply optimal light intensity to the plants. Furthermore, the power requirements of the lights gave strong incentive to use wall power (120VAC) to power them.
- Therefore we needed a device that was controllable from the ESP32 wirelessly (via MTTQ), could handle the power rating of three simultaneous LED lights, and could function as both a relay (on/off) for the valves and an LED dimmer (via PWM) for the lights. Furthermore, since both the valves and the LED's were 12V devices, the output of our device needed to be 12V. The Shelly RGBW2 was the only device found that had all of these traits for a reasonable price.



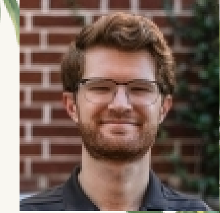


Hardware Selection: AC to DC Converter

- We have 4 unique devices that require 12V power, being the solenoid valves, the Shelly RGBW2, the LED lights, and the water pump.
- Due to battery size limitations, we found it most practical to use wall power to power these devices
- Therefore, an AC to DC converter would be needed to both bring down the 120V wall power to 12V, and also rectify it to DC



Specific AC to DC converter	XINCOL AC to DC Converter 12V 500W	inShareplus 12V 500W Power Supply	Makerele MS-500	MEAN WELL SE-600	ALITOVE 12V 50A 600W Power Supply
Meets Power Reqs?	Yes	Yes	Yes	Yes	Yes
Heat Diss.?	Poor	Excellent	Excellent	Excellent	Moderate
Footprint	11.43" (L) × 6.18" (W) × 2.57" (H)	10.2" (L) × 3.39" (W) × 2.16" (H)	8.61" (L) × 7.43" (W) × 4.88" (H)	9.72" (L) × 5.00" (W) × 2.50" (H)	9.41" (L) × 6.05" (W) × 2.93" (H)
Supports 120V AC at input?	Yes	Yes	Yes	Yes	Yes

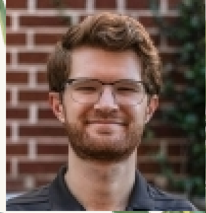


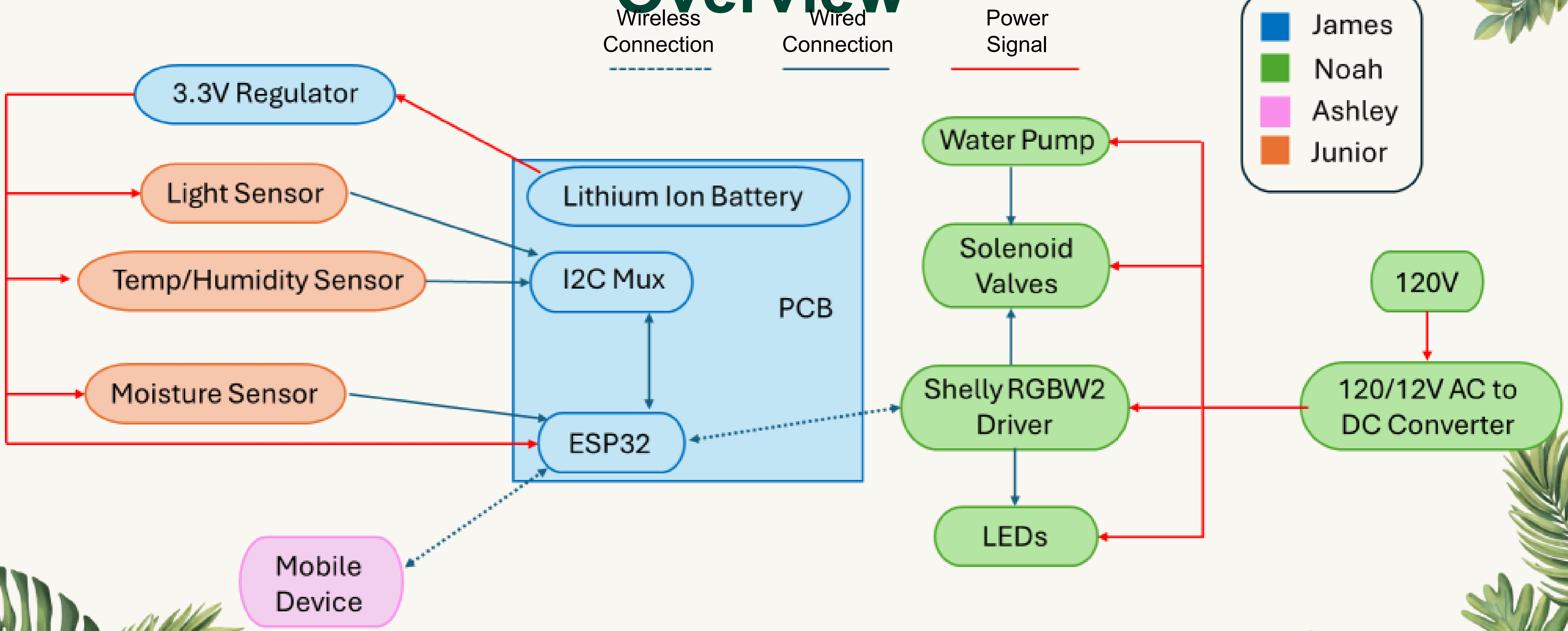
Hardware Selection: Battery

PKNERGY

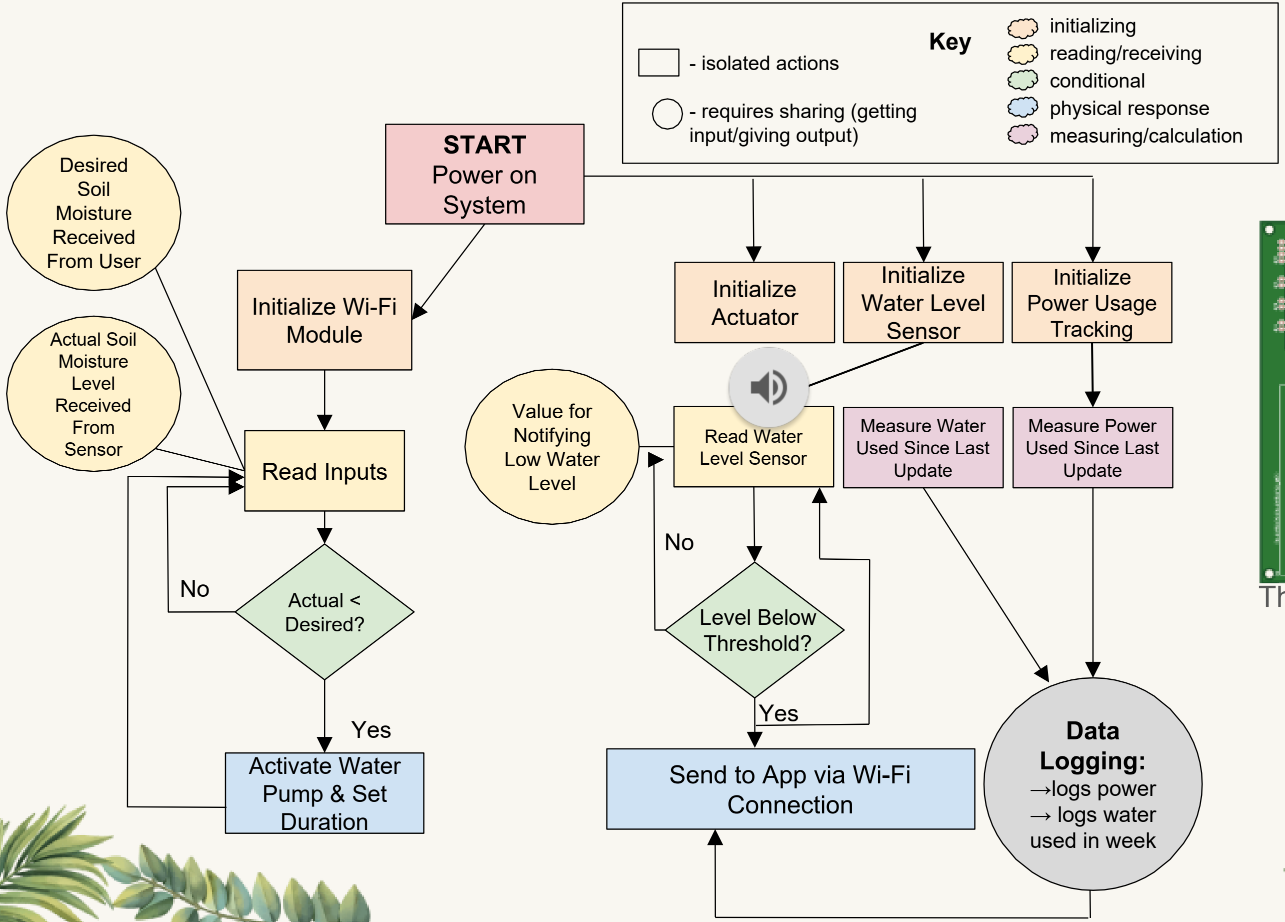
	18650 Lithium Ion
Nominal Voltage	3.7V
Capacity	5000mAh
Cost	$4.99

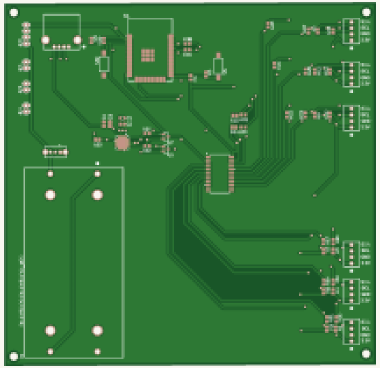
Hardware Block Diagram Overview





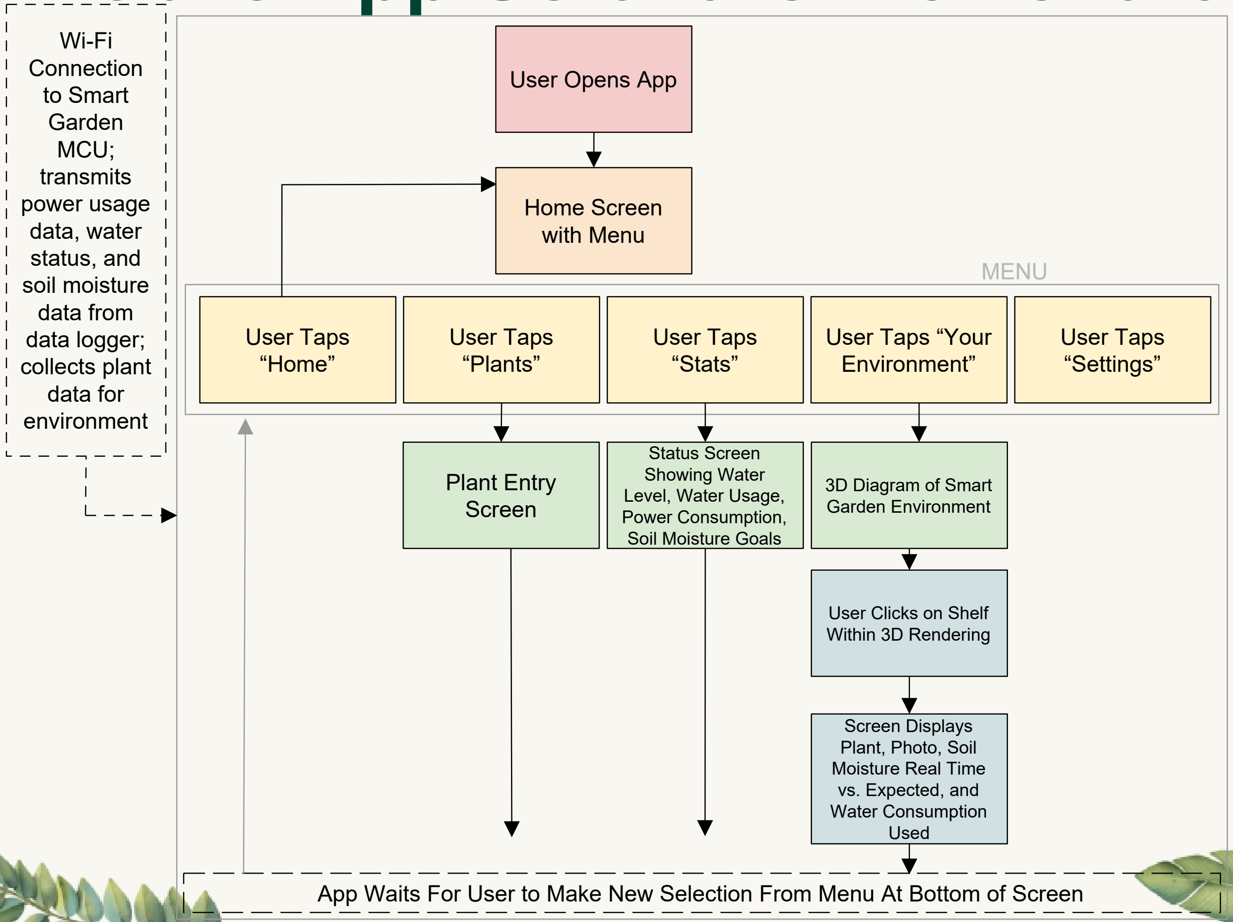
Embedded Software Flowchart



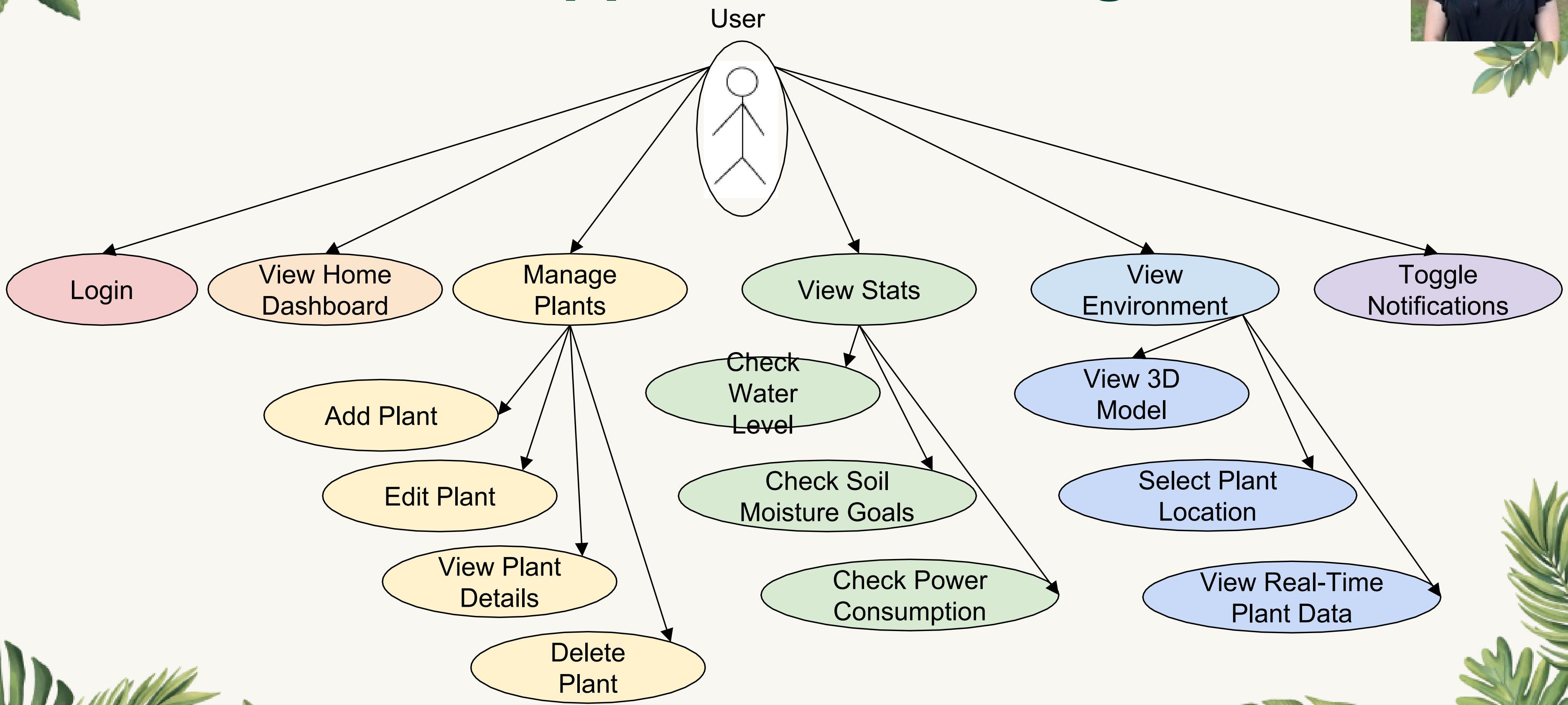


This is the logic which drives the main ESP32

Mobile App Software Flowchart



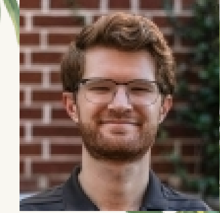
Mobile App Use-Case Diagram



ESP32 Communication - Mobile App

Initial Wi-Fi Connection and Setting Up Two-Way Communication for the MCU and app

- When first powered on, the ESP32 on the main PCB is placed into Access Point mode
- The app will prompt the user to “Setup Smart Garden”
- User will enter the SSID (Wi-Fi network name) and input the password
- The app automatically connects to ESP32’s temporary access point, identified by an individual, automatically assigned identifier (ex. SmarGarESP-0001)
- The app will send an HTTP POST request including the credentials of the Wi-Fi network
- The ESP32 will save the SSID and password before switching to STA (station mode – no more access point mode), and connecting to the user’s Wi-Fi network
- The two-way communication connection will be considered successfully established and communicate real time updates via MQTT



ESP32 Communication - MCU

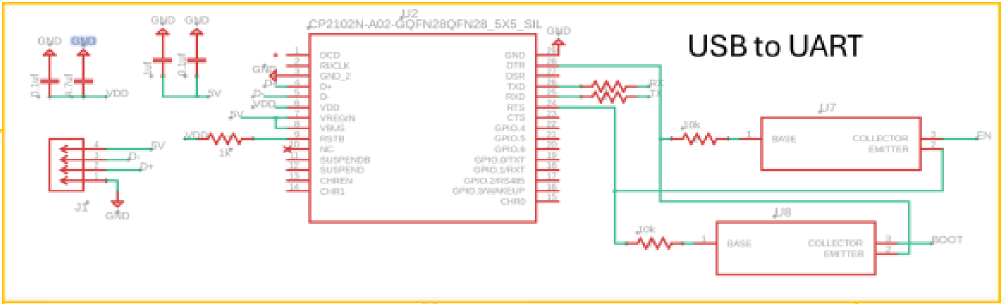
- I2C is used to relay communication from Temp/Humidity sensors and Light sensors to I2C bus to ESP32.

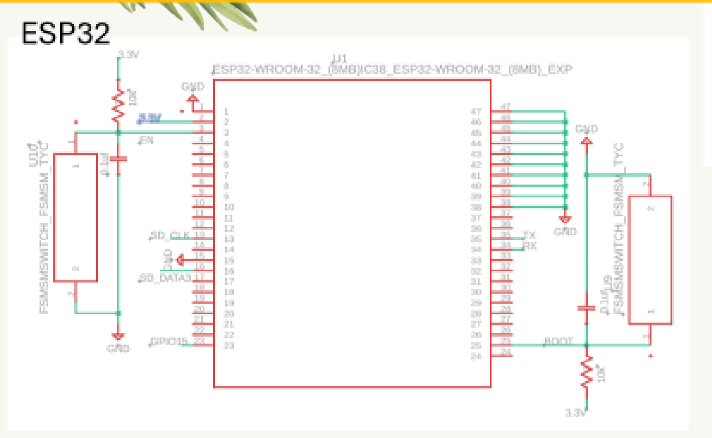
- The capacitive moisture sensor will be wired directly to the ESP32 GPIO pins, and the raw voltage values will be converted to digital readings by the on-chip ADC.

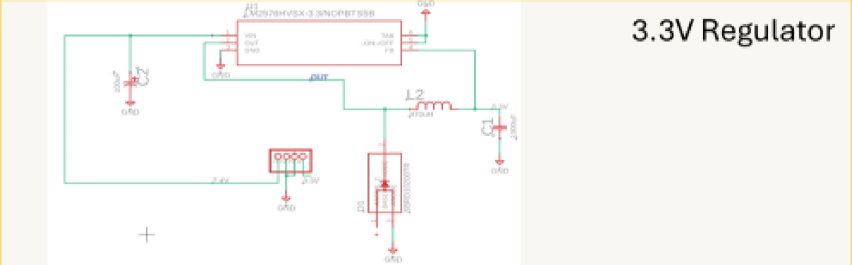
- User will host a Wi-Fi connection which the ESP32 will connect to allowing for real-time monitoring of the condition of each plant (see previous slide).

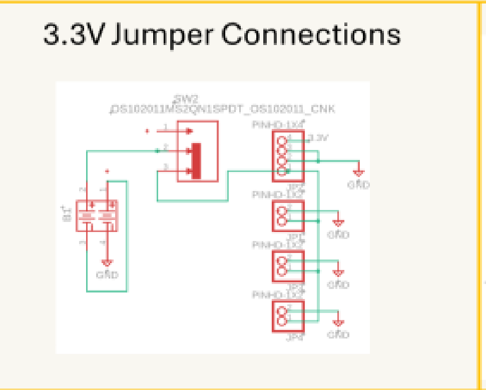
- The ESP32 will control both the water pump and the LED light strips using the Shelly RGBW2. Communication between the ESP32 and the Shelly will be facilitated by using the ESP32 as an MQTT broker, and sending MQTT commands to the Shelly

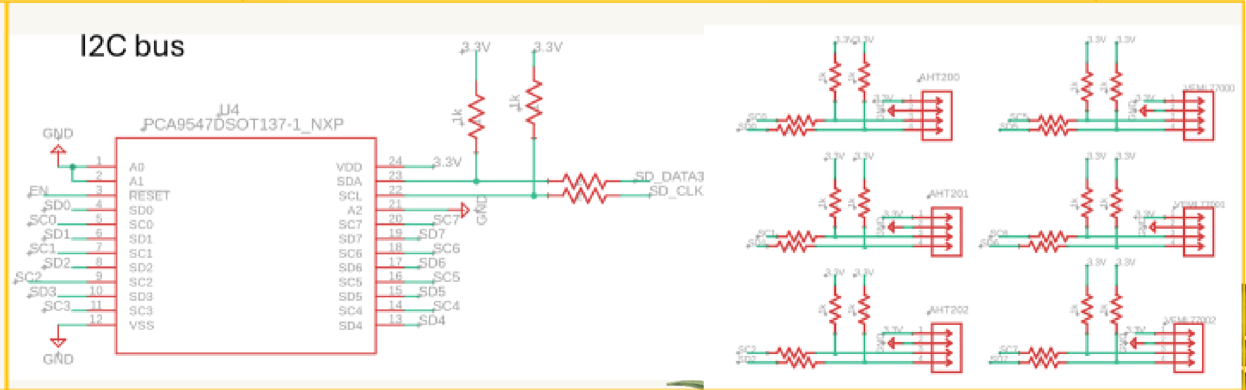
Main Board/3.3V Reg



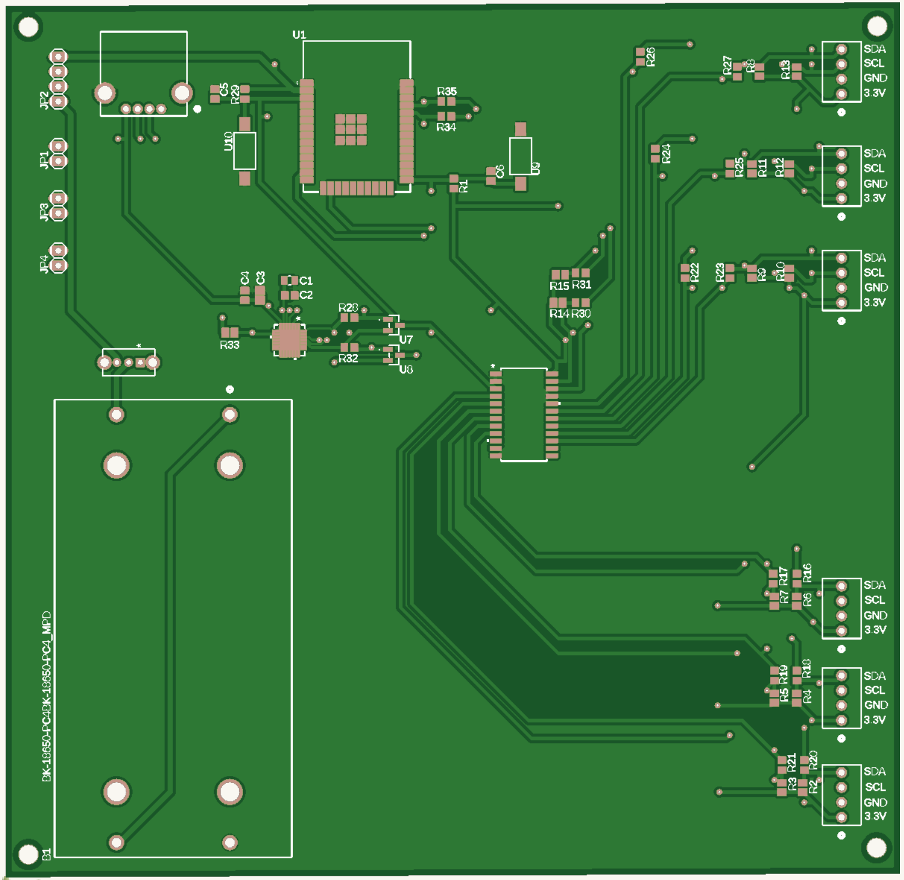


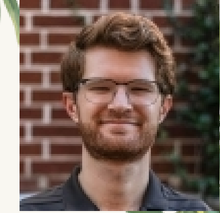






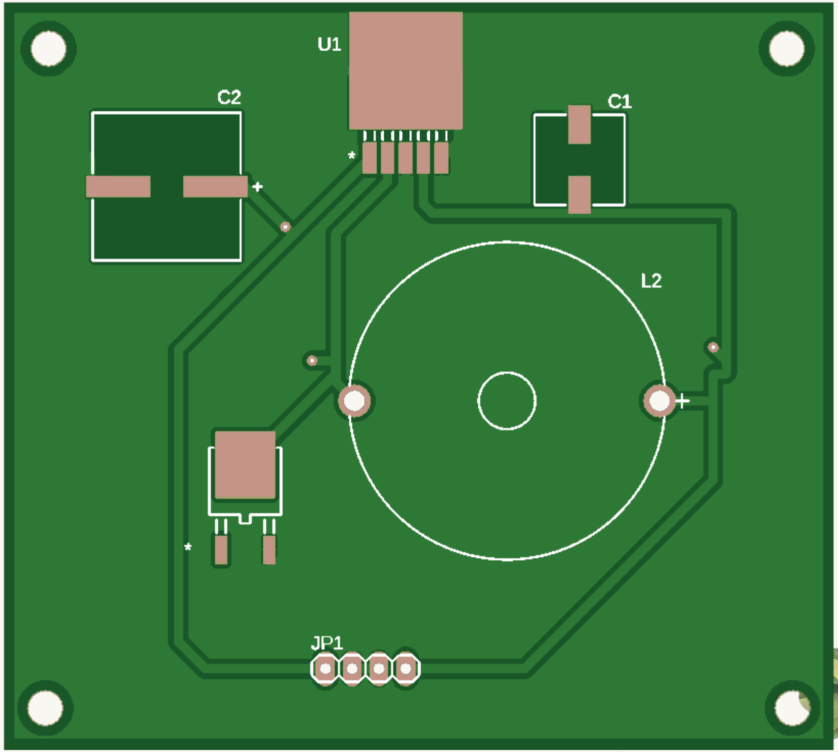
Main Board Layout





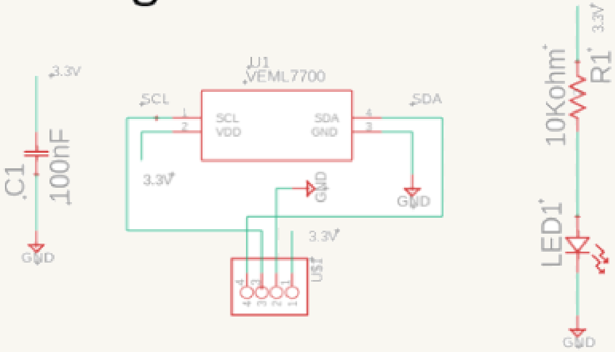
3.3V Regulator Layout

- One 3.3V regulator will be used to power the ESP32 on the main board.
- Three 3.3V regulators will be wired directly to the soil moisture sensors.
- A total of four regulators will be built that will each be supplied a Vin of 7.4V from the two lithium ion batteries on the main board.

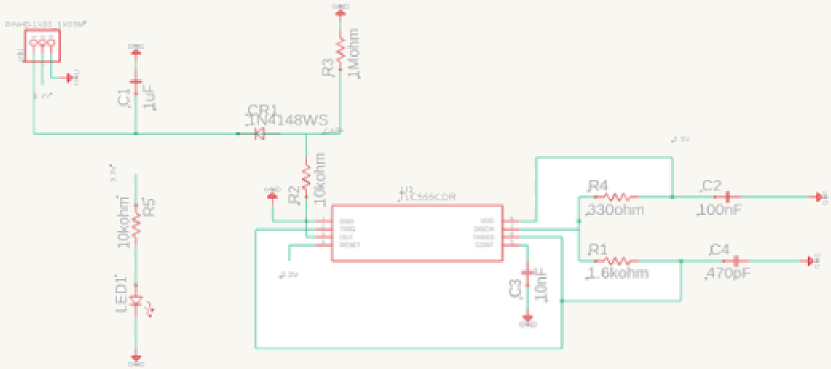


Sensors

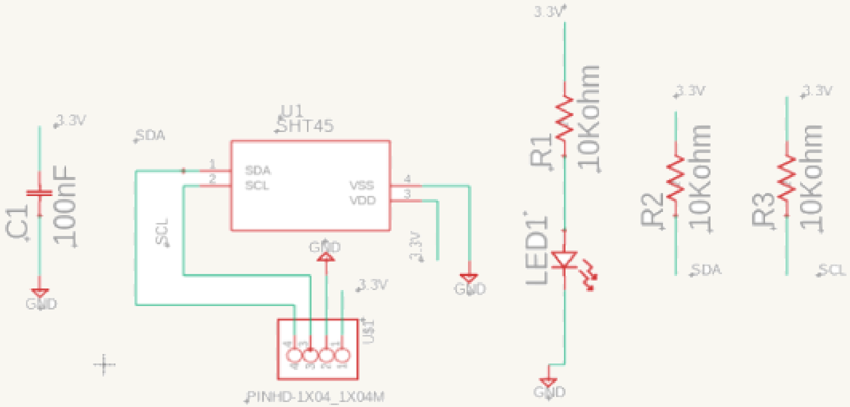
Light Sensor



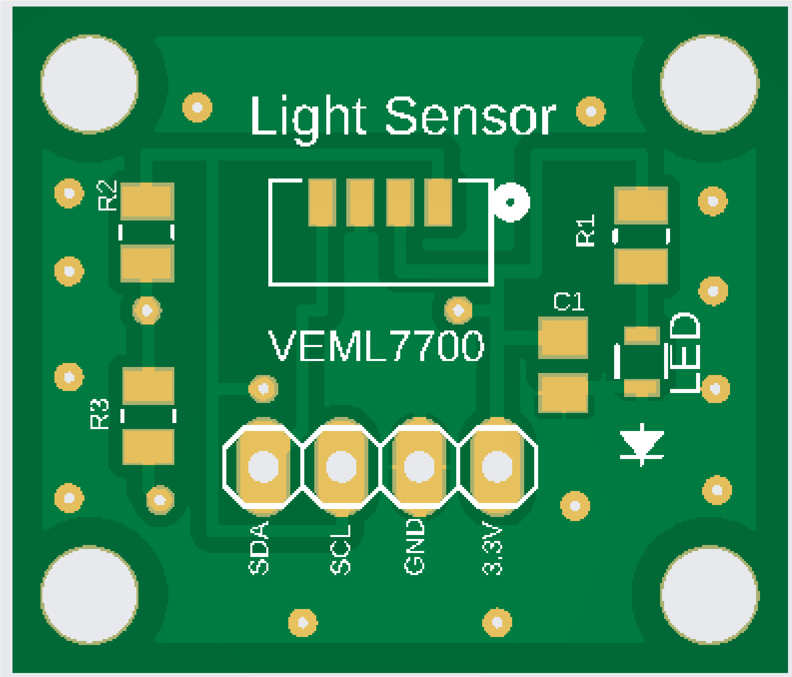
Moisture Sensor



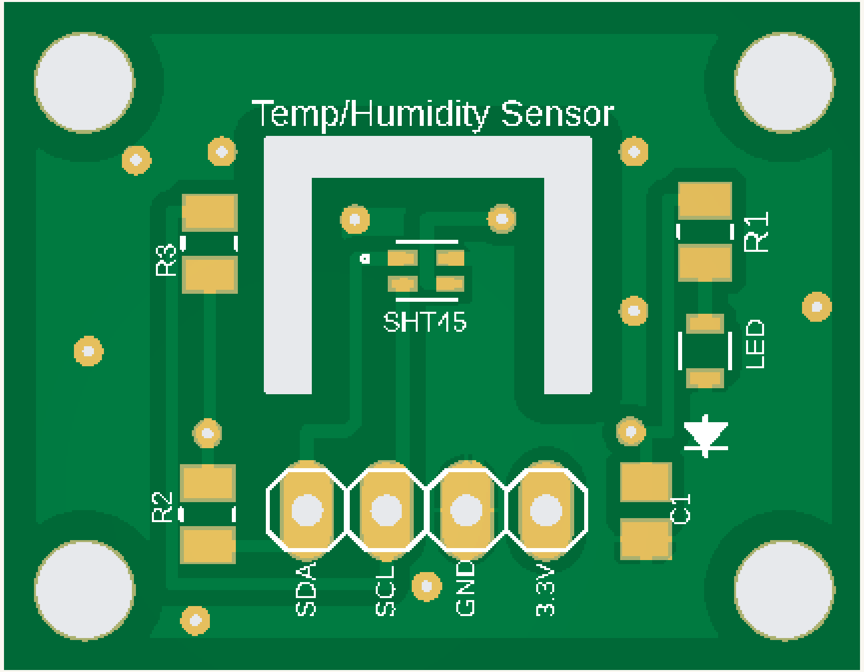
Temp/Humidity Sensor



Light Sensor Layout



Temp/Humidity Sensor Layout



Moisture Sensor Layout

Budget Table

Item	Projected Cost	Actual Cost
Circuit Components	$150	$300
PCBs	$100	$200
Shelving unit for plants	$165	$175
PVC/Solenoid valves/Pump	$125	$150
LEDs/LED Driver	$80	$90
120V/12V AC to DC converter	N/A	$50
Dev boards	$30	$40

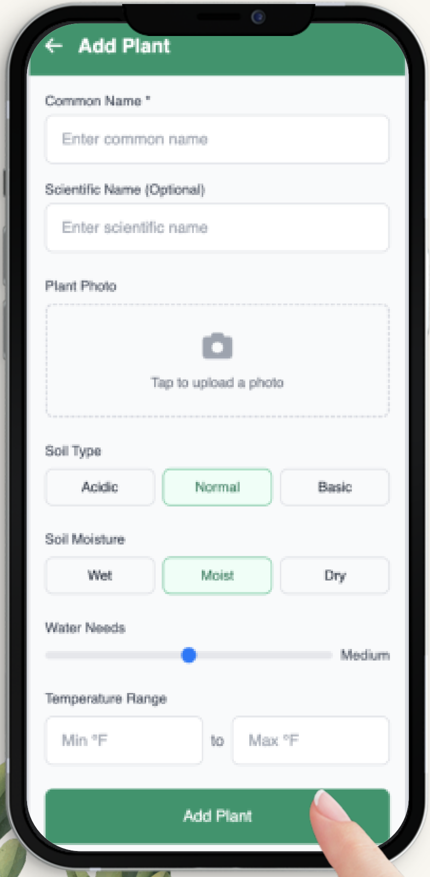
Software Technologies

These were the largest contributors to our project, helping us push F.L.O.W.E.R.S. to continue growing.

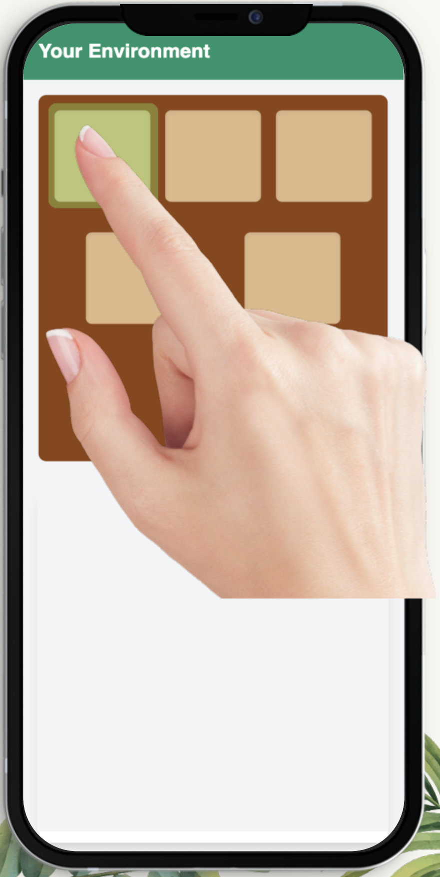
Mobile Walk-Through

Home Page (on App open)

User Taps “Add Plant” Quick Key, Fills out Info, and “Add Plant”



The Plant is Added to the “Environment” page in the designated environment.



The User selects the environment they want to view and the information for the selected environment loads onto the page

Testing – Soil Moisture Values

In order to determine the threshold for the soil moistness, we tested the soil moisture in a fully submerged cup of water as well as exposed to only air to determine the numeric range which the ESP32 would need to use to determine “wet” soil versus “dry” soil.

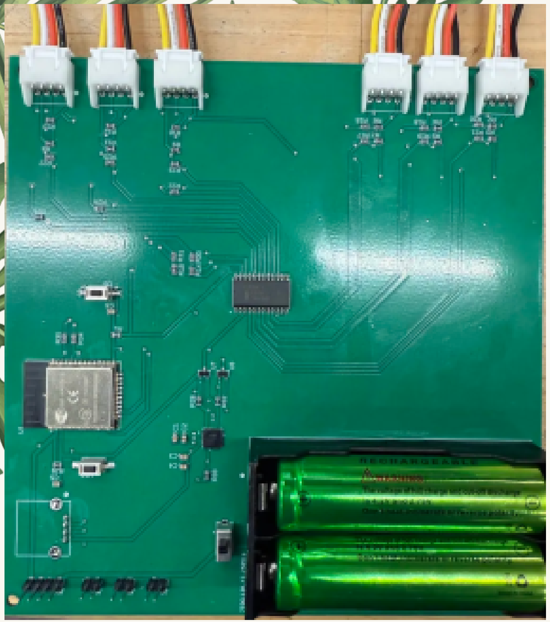
Since the testing this far only involved pure water and air, the range in soil would be expected to be an even smaller set of values.

```
Moisture value: 930
Moisture value: 933
Moisture value: 933
Moisture value: 931
Moisture value: 933
Moisture value: 976
Moisture value: 931
Moisture value: 938
Moisture value: 939
Moisture value: 935
Moisture value: 930
Moisture value: 931
Moisture value: 933
Moisture value: 926
Moisture value: 919
Moisture value: 930
Moisture value: 928
Moisture value: 931
Moisture value: 928
Moisture value: 930
Moisture value: 937
Moisture value: 1058
Moisture value: 2035
Moisture value: 2511
Moisture value: 2526
Moisture value: 2524
Moisture value: 2510
Moisture value: 2494
Moisture value: 2509
Moisture value: 2519
Moisture value: 2490
Moisture value: 2522
Moisture value: 2514
Moisture value: 2513
Moisture value: 2512
Moisture value: 2519
```

900s-early 1000s range will indicate fully submerged in water

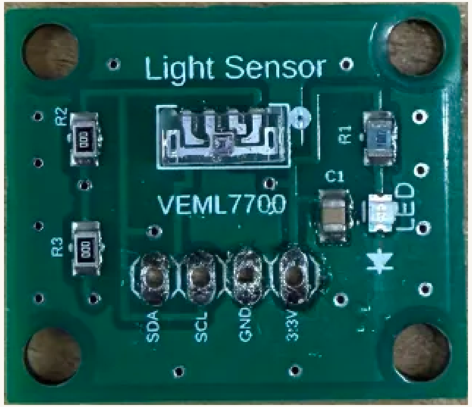
2000s+ range will indicate the soil moisture is exposed to air

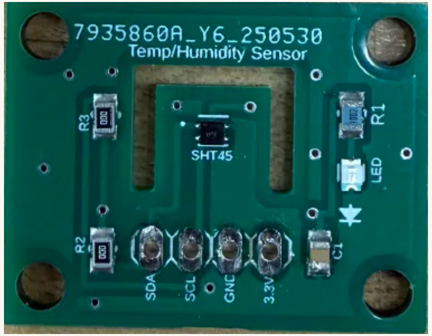
From here, we expect the range of soil to be from the 1000s to the 2000s where:
1000 - fully saturated soil
1250 - moderately saturated soil
1500 - average watered soil
1750 - fairly dry soil
2200 - completely dry soil

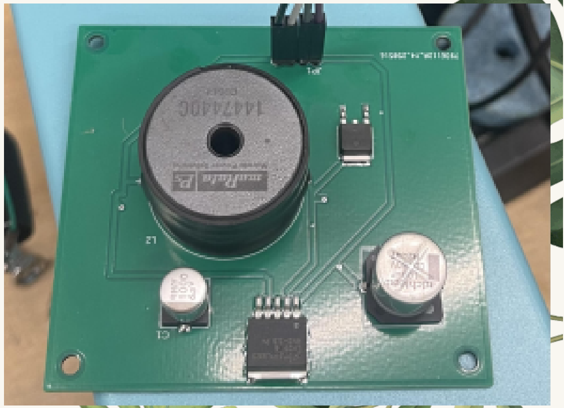


Completed Hardware Components

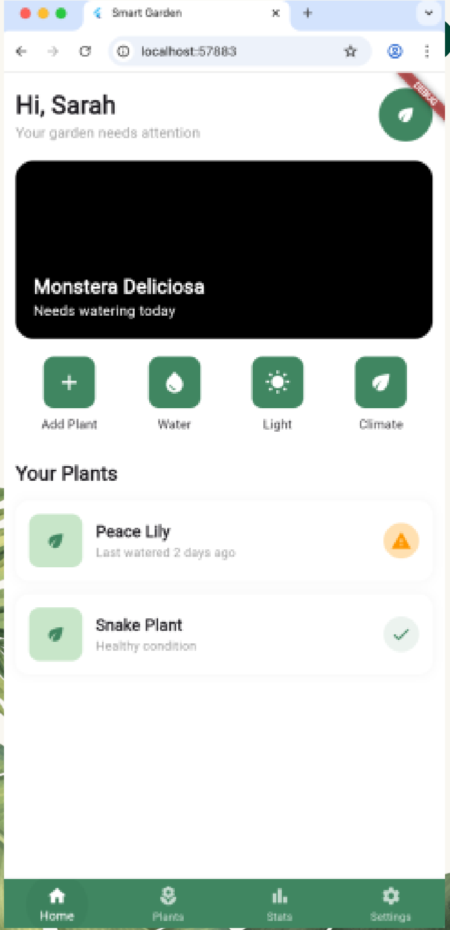
- Main PCB Board
- 3.3V Regulator
- Moisture Sensor Board
- Light Sensor Board
- Temp/Humidity Sensor Board
- Shelly RGBW2 acquired
- Water Pump acquired and tested
- Solenoid Valves acquired and tested
- AC to DC converter acquired

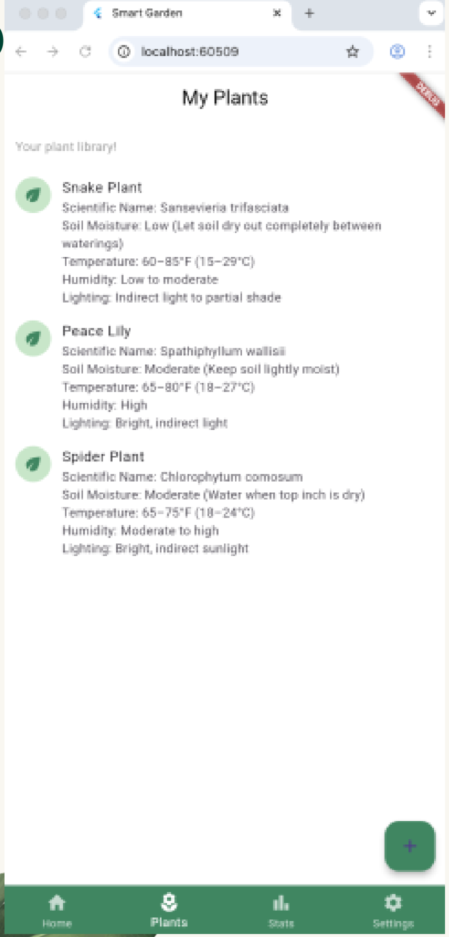


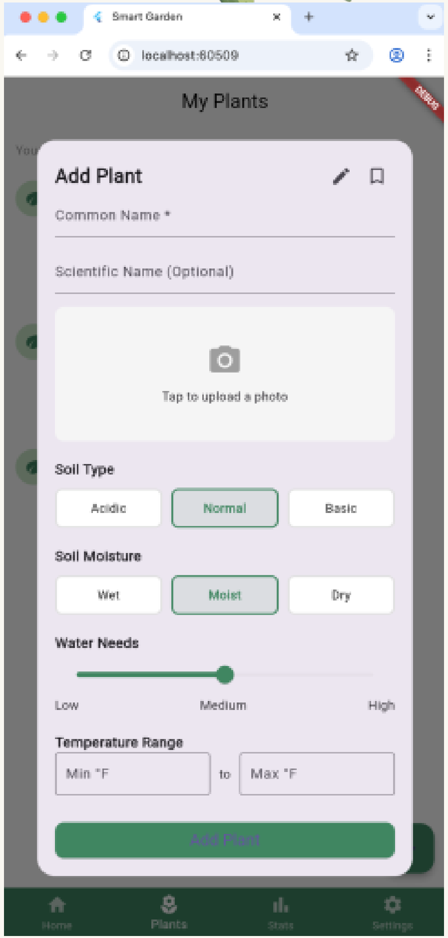


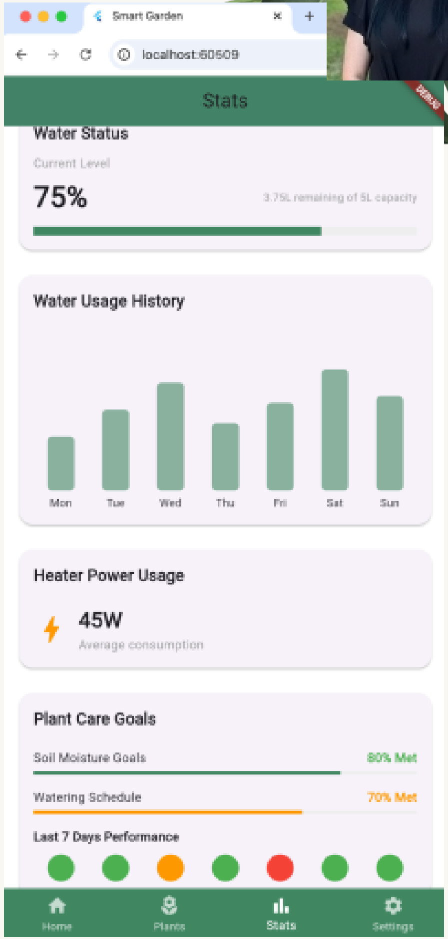


Completed Software









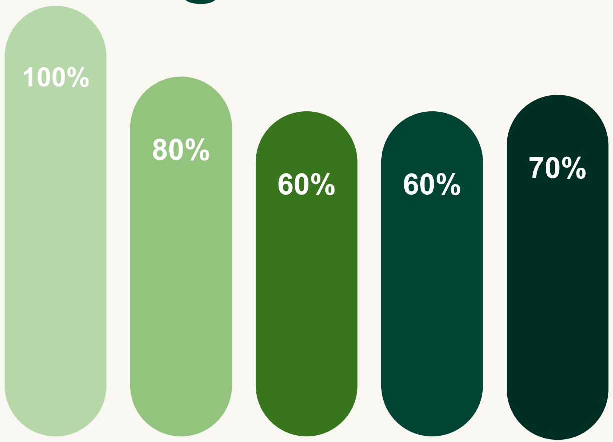
Progress Check - Software

- [x] Mobile App - “Home” tab
- [x] Mobile App - “Plants” tab Outline and basic implementation
- [x] Mobile App - “Stats” tab
- [x] Mobile App - “Settings” tab
- [x] ESP32 - Soil Moisture, Lighting Sensor, Humidity/Temp Sensor implementation
- [ ] Deploy the app to mobile environment
- [ ] Complete the MQTT / ESP32 initialization and two way communication connection
- [ ] Mobile App - “Your Environment” tab
- [ ] Final data storage implementation (plant library)

Progress - Hardware

- ✔ All PCBs have been acquired, and all components have been soldered on the respective boards
- ✔ Regulators have been tested
- ✔ Water Pump, AC to DC converter, and all solenoid valves have been acquired and tested
- Wire, configure, and test the temp/humidity and light sensors
- Wire the Solenoid Valves and the LED lights to the Shelly RGBW2, and confirm successful operation (see software progress for MQTT configuration)
- Calibrate Moisture sensor values using actual soil and associate these values with a given water pump flow rate

Progress, Cont.



Research
Design
Testing
Prototyping
Total

Progress Report

The progress breakdown by category and how much of the project completion remains. Considering the completion of each category, the total amount of project completion needed to meet all of our goals and objectives is about 20%.

Thanks !

Thank you for your time and for listening to how our project has **grown**.