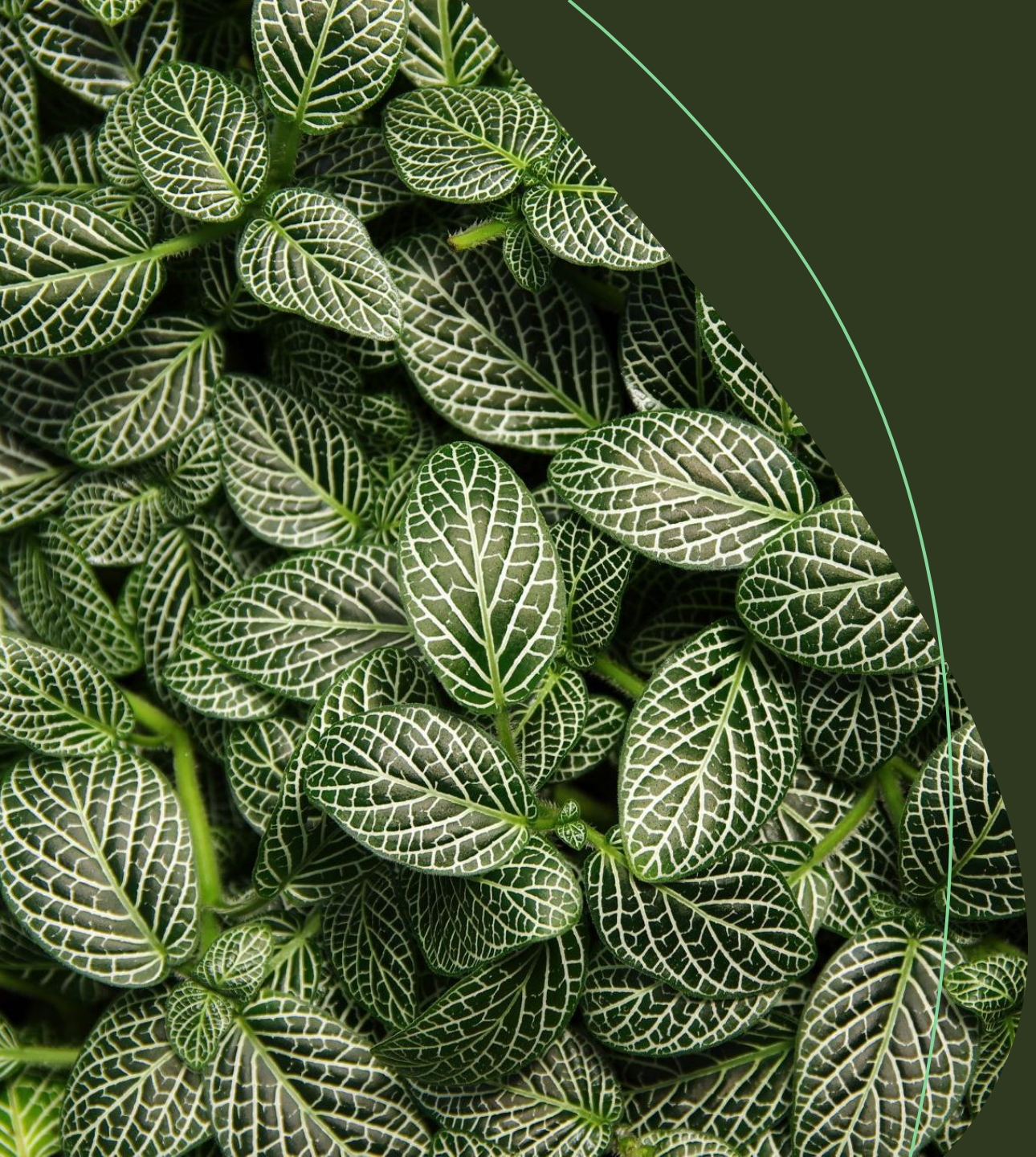


Plant Guardian

Group 11

Tony Chau, CpE

Steven Keller, EE

Keven Hyppolite, EE

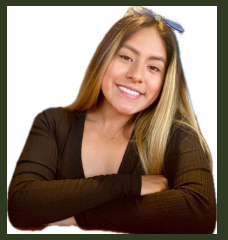
Luz Romero, EE

Tony Chau
Computer
Engineer

Steven Keller
Electrical
Engineer

Keven Hyppolite
Electrical
Engineer

Luz Romero
Electrical
Engineer



Motivation

- Plants contribute to well being by improving air quality, reducing stress, and boosting mood, creativity.
- Busy schedules and frequent travel make consistent plant care difficult, leading to common issues like overwatering, and plant stress.
- A smart watering system ensures plants receive the right amount of water at the right time, helping to maintain their health and longevity without requiring constant attention.
- This project promotes sustainable living, making it easier for people to enjoy the benefits of healthy houseplants in their homes.

Basic Goals

Remote Control Water Pump

- Operates via Bluetooth/Wi-Fi
- Manual Watering from distance
- Ideal for frequent travelers and busy individuals

LED Lights for Plant Growth

- Provides essential spectrum for photosynthesis
- Energy – efficient and long lasting
- Enables plant growth in low light area's

Comprehensive Sensors

- Monitors moisture, temperature, pH, and water levels
- Real – time data accessible through mobile app for informed care

Advance Goals

Advance Settings Page

- Set threshold for moisture, temperature, and pH
- Automated watering adjustment based on user – set parameters

Automated Watering Schedule

- Time-based watering aligned with plant needs.
- Prevents overwatering and underwatering.

Stretch Goals

Notification System

- Alerts for sensor data changes (e.g., low water levels, abnormal temperatures).

Image Classification

- Identifies plant species and provides tailored care recommendations.
- Detects pests or weeds and suggests solutions.

Plant Health Monitoring

- Image recognition for early detection of disease or nutrient deficiencies.

Key Objective

Foundation of Efficient Plant Care

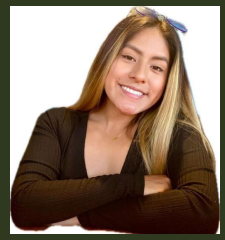
- Basic tools for plant nurturing.

Enhanced Automation

- Advanced customization and intuitive care.

Innovative Monitoring Features

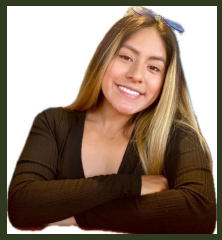
- Comprehensive plant health monitoring and tailored user experience.



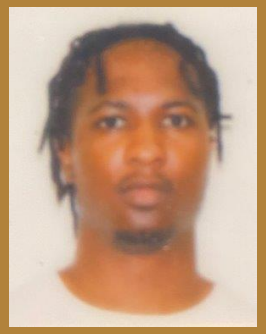
Specifications

Requirements	Specifications	Description
Size of the box	1 meter x 1 meter x 1 meter	Maximum Dimensions of the system excluding any power cables
Power Usage	50W	Power of the entire system excluding any external servers.
Weight	30 pounds	Weight of the system not including the plant or water
Data refresh rate	1 minutes	How often the data id refreshed on the app
pH sensor	95% success rate	Identify if a liquid in the reservoir is an Acid, neutral, or Base. Less than 6 is acidic. 6-8 is neutral. Above 8 is Basic.
Moisture sensor	95% success rate	Detects if soil is wet accurately at least 95% of the time. Below 65% is dry. 65%-85% is normal. Above 85% is wet.
Temperature sensor	95%	Sensor measurement accuracy compared to thermometer. (Degrees)
Water pump control	Within 10s	System will water the plant when triggered
Light control	Every 10s	Captures the real time image of the plant.

Demonstratable Specifications



Attribute	Description	Specifications
Water pump control	Be able to remotely activate water pump.	Operation within 10 sec
Moisture sensor	Detects if soil is wet accurately at least 95% of the time. Below 65% is dry. 65%-85% is normal. Above 85% is wet.	Detection rate 95%
Camera data	Be able to see an image of the plant in the app.	Refresh at least every minute.



Lighting Comparison

Feature	LED Light Bulb	Other Lighting Options
Energy Efficiency	75% less energy consumption	Much less efficient, especially incandescent
Lifespan	15,000 to 50,000 hours	Shorter (Incandescent: ~1,000 hours, Fluorescent: ~10,000 hours)
Brightness (Lumens/Watt)	High (80–100+ lumens per watt)	Lower (Incandescent: ~15 lumens/watt, Fluorescent: ~50 lumens/watt)
Initial Cost	Higher	Lower for incandescent and halogen, moderate for fluorescent
Operating Cost	Low (long-term savings)	High (due to shorter lifespan and higher energy usage)
Environmental Impact	No hazardous materials, minimal heat	Incandescent & Halogen: High energy usage, Fluorescent: contains mercury
Color Temperature	Customizable (wide range)	More limited options (especially incandescent)
Dimming Capability	Yes (requires compatible dimmers)	Incandescent and halogen are dimmable, fluorescent not ideal for dimming
Durability	High (resistant to shocks)	Fragile, especially incandescent
Applications	Versatile (residential, industrial, smart systems)	Incandescent: residential, Fluorescent: commercial, Halogen: accent lighting

Water Pump

Feature	Original Pump	VIVOSUN 80 GPH Pump	Homasy 80 GPH Pump
Max Flow Rate	120 LPH	300 LPH	300 LPH
Power Usage	1.125 watts	4 watts	2 watts
Size (inches)	3.94 x 3.15 x 0.39	1.8 x 1.6 x 1.2	1.5 x 1.5 x 1.1
Adjustable Flow Rate	No	Yes	Yes
Noise Level	Quiet	Ultra-quiet	Ultra-quiet
Cost	$9.99	$13.50	$11.00

Power Source

Feature	Barrel Jack	USB-C Power Delivery	Lithium-Ion Battery Pack
Voltage Handling	12V or 24V (fixed)	5V to 20V (adjustable)	3.7V per cell, up to 7.4V or higher
Current Handling	2A - 3A	Up to 5A	Varies (1A - 10A depending on pack)
Portability	Low (requires AC outlet)	Medium (portable with power banks)	High (fully portable)
Power Flexibility	Fixed voltage	Dynamic (varies based on device needs)	Limited to battery voltage
Complexity of Integration	Low (simple plug-in design)	Medium (requires PD controller)	Medium-High (needs charging circuit)
Cost	$0.50 - $4.00	$5 - $10	$15 - $30

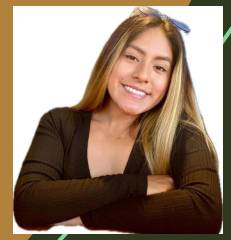
pH Sensor

	GAOHOU pH0 - 14	S - pH - 01	Atlas Scientific EZO - pH
Power Supply (V)	5	3.6 - 30	3.3 - 5
Dimensions	20mm x 10mm	160mm x 30mm	13mm X 20mm
Measuring Range (pH)	0 – 14	0 – 14	0 – 14
Measuring Temperature (C)	0 – 60	-40 – 85	0 – 85
Accuracy	+/- 0.1 pH (25 degrees C)	+/- 0.1 pH	+/- 0.002 pH
Price	$30.99	$139	$45.99

The pH sensor is essential in our plant watering system as it measures soil and water acidity or alkalinity, key factors for plant health. By monitoring pH levels, the system ensures nutrients are effectively absorbed, supporting optimal plant growth and preventing deficiencies.

pH sensor

GAOHOU pH0-14

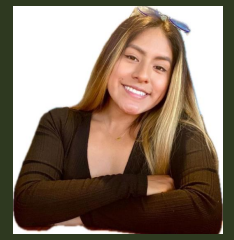


The pH sensor measures the hydrogen ion concentration in a solution using a glass electrode, which generates a small voltage based on the solution's acidity or alkalinity. This voltage is converted into a pH value, ranging from 0 to 14, with lower numbers indicating acidity and higher numbers indicating alkalinity. The sensor is typically used to monitor the pH of the water, ensuring optimal growing conditions for plants.

Temperature Sensor

	TMP117AID	DS18B20	LM35DZ
Sensory Accuracy (degrees C)	0.1 - 0.2	0.5	0.5
Temperature Range (degrees C)	-55 – 150	-55 – 125	-55 – 150
Supply Voltage (V)	1.8 - 5.5	-0.5 - 6	4 - 30
Supply Current (A)	3.5u - 150n	750n - 1m	60u
Price	$2.90	$7.42	$2.03

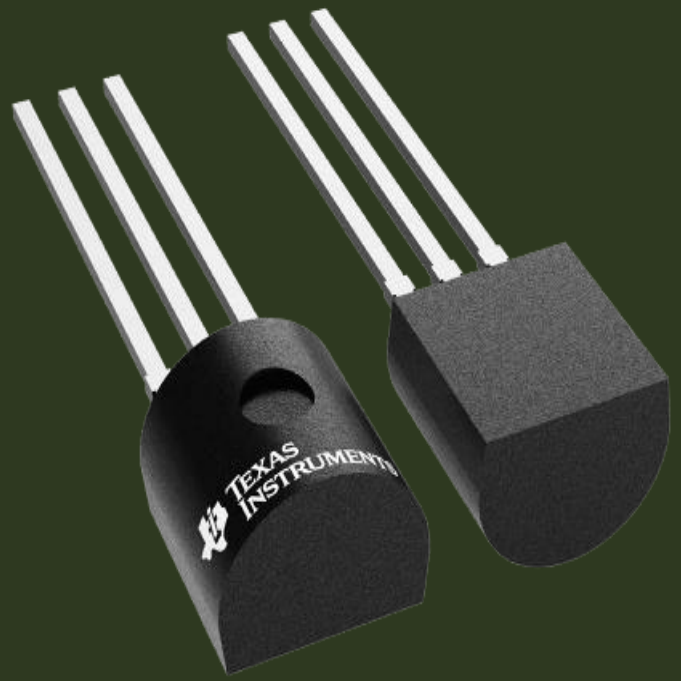
The sensor in our project is essential for monitoring and managing environmental conditions crucial for plant growth, particularly by maintaining the ideal temperature range for indoor plants. It adjusts watering needs based on temperature fluctuations, ensuring efficient water usage and preventing issues like overwatering, root rot, or heat stress, which helps promote healthy and productive plant growth.



Temperature Sensor

LM35DZ/MOPB

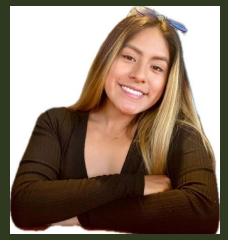
The temperature sensor works by generating a voltage output that is directly proportional to the ambient temperature in Celsius. For every degree Celsius, the output increases by 10 millivolts, allowing accurate temperature measurements without external calibration.



Water Level Sensor

	eTape Liquid Level	HC - SR04	A02YYUW
Sensor Accuracy	+/- 0.5%	+/- 0.3 cm	+/- 1 cm
Sensor Current (A)	500u	15m	15m
Dimensions	127mm x 9.5mm x 0.38mm	20mm x 18mm x 4mm	41mm x 72mm
Sensor Voltage (V)	5	5	3 – 5.5
Price	$59.95	$4.50	$7.90

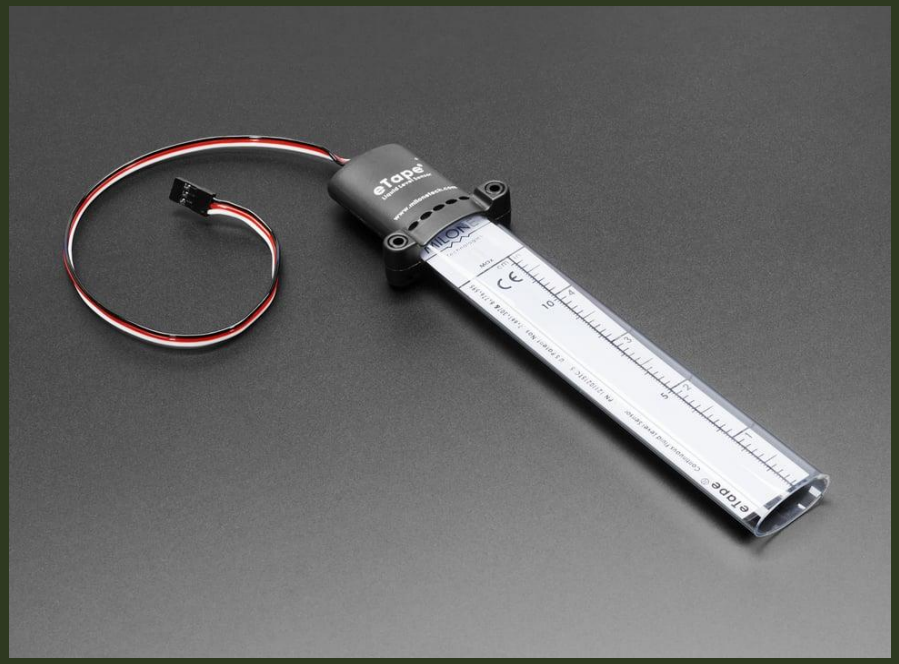
The water level sensor will be placed inside the water gallon next to our smart watering system. It will monitor the water level, alerting the user when the gallon is getting low so they can refill it as needed.



Water Level Sensor

eTape Liquid Level

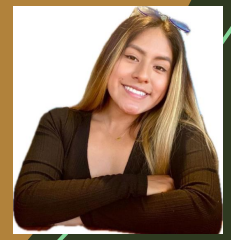
The ETAPE liquid level sensor measures the level of liquid in a container using capacitive or resistive sensing technologies. It detects changes in electrical properties caused by the presence or absence of liquid, providing accurate level readings to monitor and control fluid levels.



Moisture Sensor

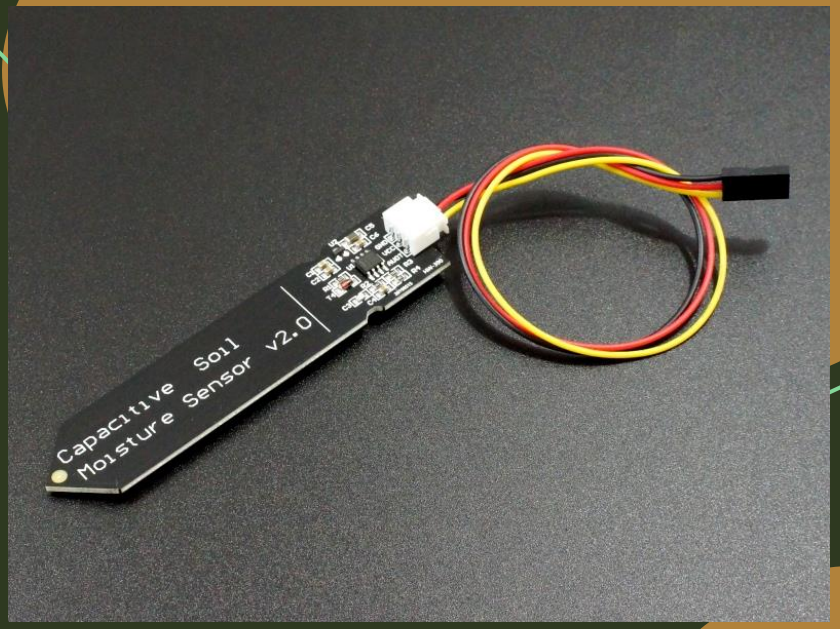
	Grove - Moisture Sensor	Adafruit STEMMA	DFRobot Capacitive Soil
Operating Voltage (V)	3.3 - 5.5	3 - 5	3.3 - 5.5
Output Voltage (V)	0 – 3	3.3 - 5	1.2 - 2.5
Operating Current (A)	35m	20m	30m
Dimensions	60mm x 20mm x 8mm	20mm x 18mm x 4mm	120mm x 28mm
Price	$3.30	$7.50	$8.74

The moisture sensor is crucial for optimizing plant watering systems by providing real-time feedback on soil moisture, which helps prevent overwatering and promotes healthy plant growth. It enables automated, precise watering schedules tailored to the needs of different plants, conserves water and adapts to changing environmental conditions.



Moisture Sensor

DFRobot Capacitive Soil

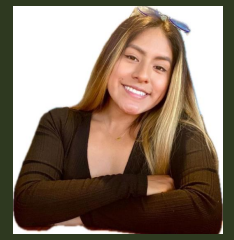


The DFRobot Capacitive Soil sensor measures soil moisture using capacitive sensing with metal probes that detect changes in the soil's dielectric constant. This measurement is converted into an electrical signal and output via an analog signal to the microcontroller, providing real-time soil moisture data.

Relay Sensor

	Keyes Relay Modules	SRD-05VDC-SL-C	SainSmart 2 - Channel
Operating Voltage (V)	220	5	5
Max AC Voltage (V)	250	250	30
Max AC Current (C)	10	10	10 @ 250V
Dimensions	50mm x 40mm x 20mm	19mm x 15.5mm	80mm x 55mm x 25mm
Price	$6.12	$4.59	$7.99

The relay sensor is crucial in our plant watering system for automating the control of water pumps, valves, and other devices based on sensor inputs, which enables precise watering schedules tailored to plant needs. By interfacing with moisture or water level sensors, it optimizes water usage, reduces manual effort, and enhances system reliability, contributing to healthier plants and efficient water conservation.



Relay Sensor

SRD-05VDC-SL-C

The SRD-05VDC-SL-C relay is a reliable, compact, and cost-effective solution for controlling high-power devices. Operating at a low 5V DC input, it can switch up to 250V AC and handle 10A of current. Its small size makes it ideal for integration into tight spaces, and it is commonly used in microcontroller-based projects for automation tasks. These features make it a versatile choice for both hobbyists and professionals.

Voltage Regulator

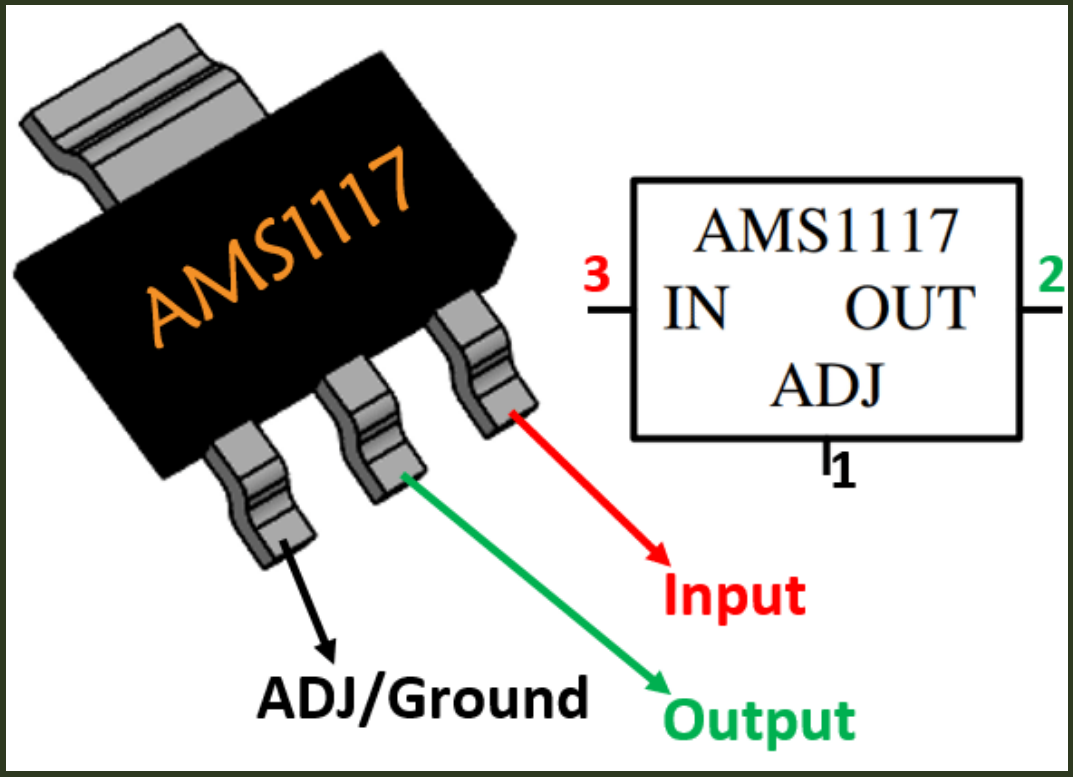
	LM7805	LM317	AMS 117 - 05
Operating Voltage (V)	35	37	5
Output Voltage (V)	5	1.2	5
Operating Current (A)	1.5	1.5	5m
Operating Temperature (C)	0 – 125	0 – 125	0 – 125
Price	$0.58	$0.76	$0.47

The voltage regulator is vital in the "Plant Watering System" as it ensures stable voltage levels, protecting sensitive components like sensors and actuators. By maintaining a consistent output voltage, it supports accurate sensor readings and reliable operation, contributing to efficient water management and overall system performance.

Voltage Regulator

AMS 1117-05

The AMS 1117-05 operates by using an internal feedback mechanism to regulate the output voltage. It compares the output voltage to an internal reference voltage and adjusts the pass transistor's resistance to maintain a consistent 5V output, compensating for fluctuations in the input voltage and load conditions.



Wireless Communication Comparison

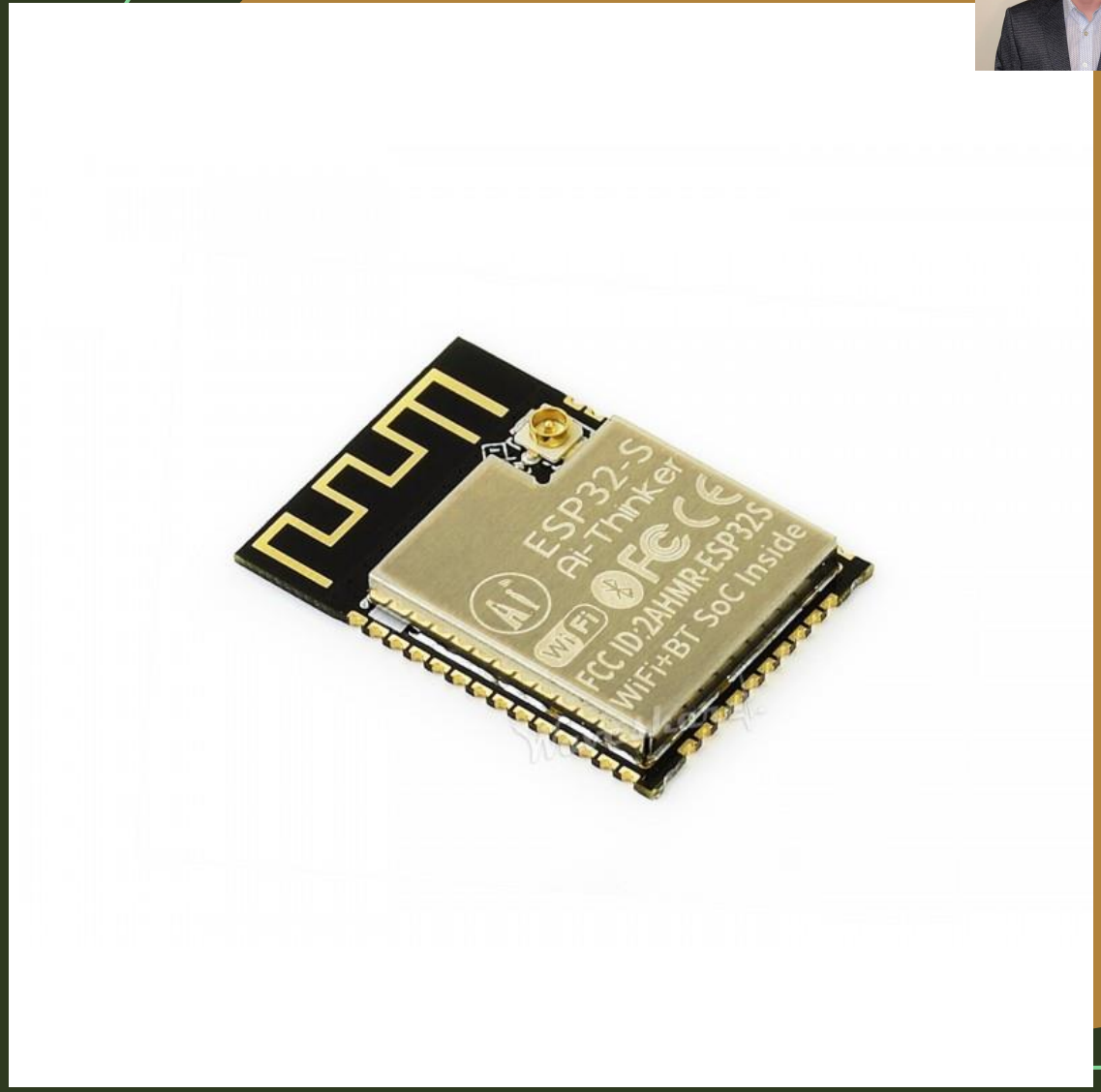
Specification	Wifi (802.11n)	Bluetooth	BLE	LoRaWAN
Max Distance (m)	50	10	10	15k
Data Rate	150 mbps	3 mbps	1 mbps	22 kbps
RF Band (Hz)	2.4 g or 5g	2.4 g	2.4 g	915 M

MCU Comparison

Specification	ESP32 - S	STM32H74XI	MSP430	Raspberry Pi 0 w
RAM	Internal 520KB External SRAM 4MB SRAM	1 MB	4 KB	512 MB
CPU Frequency (Hz)	160 M	480 M	16 M	1 g
Operation System	freeRTOS	N/A	N/A	Raspian (Linux)
Dimensions	10mm x 11mm	14mm x 14mm	23.3mm x 9.4mm	65mm x 30mm
Costs	$3.00	$20.00	$3.00	$15.00
Manufacturer	Expressif	STMicroeletronics	Texas Instruments	Raspberry Pi Foundation

MCU Selection

- Has WIFI chip built in
- Enough storage
- Easiest to integrate onto a PCB

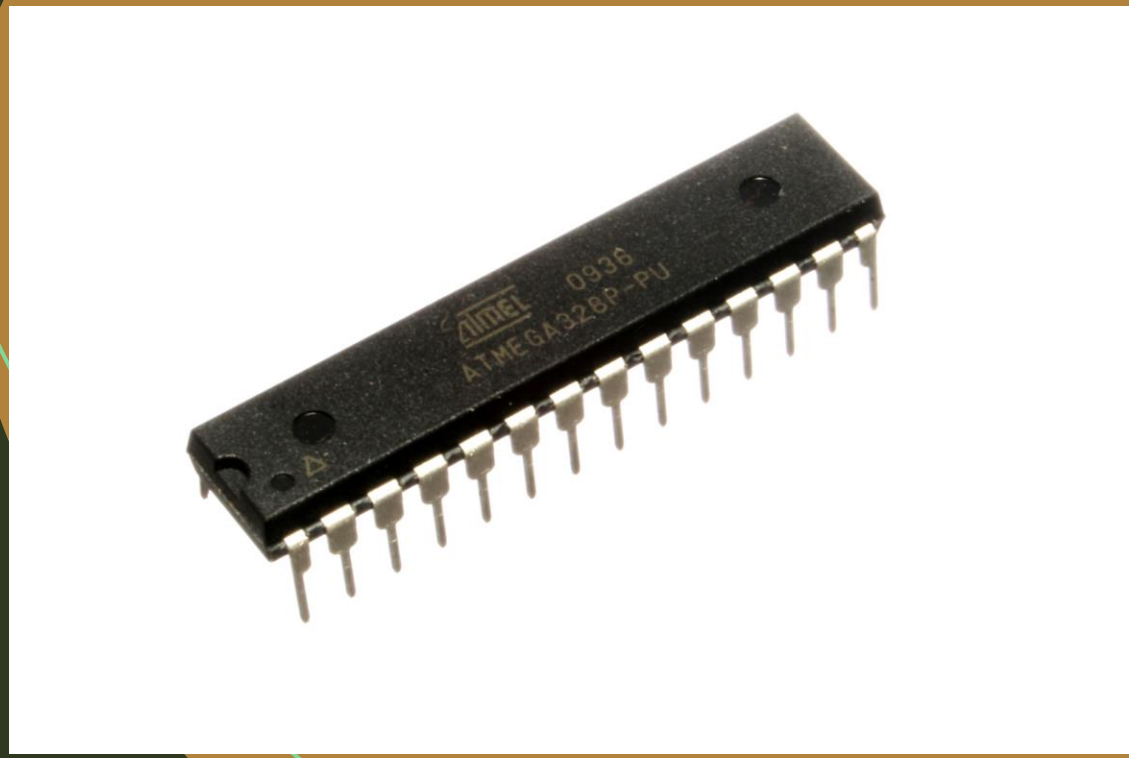


Secondary MCU Comparison

Specification	ATMEGA328	IMXRT1062DVJ6	RP2040
I/O	1 UART, 1 I2C, 14 Digital Pins, 8 Analog Pins	8 UART, 3 I2C, 55 Digital Pins, 18 Analog Pins	2 UART, 2 I2C, 25 Digital Pins, 4 Analog Pins
Clock Speed (MHz)	20	600	133
Cost	$2.63	$16.00	$1.00
Dimensions	7.1mm x 7.1mm	10mm x 10mm	7mm x 7mm
Manufacturer	Atmel	NXP USA Inc	Raspberry Pi Foundation

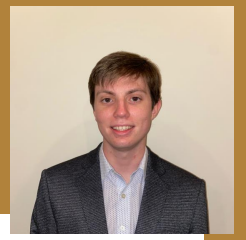
Secondary MCU Selection

- Had enough IO and easy to program



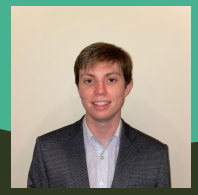
Camera Comparison

Specification	*OV2640*	*OV5640*	*OV7725*
Pixels (px x px)	1600 x 1200	2592 x 1944	640 x 480
Cost	$3.00	$4.00	$5.00
MAX Supported FPS	60	120	60
Max Power (mW)	140	420	120

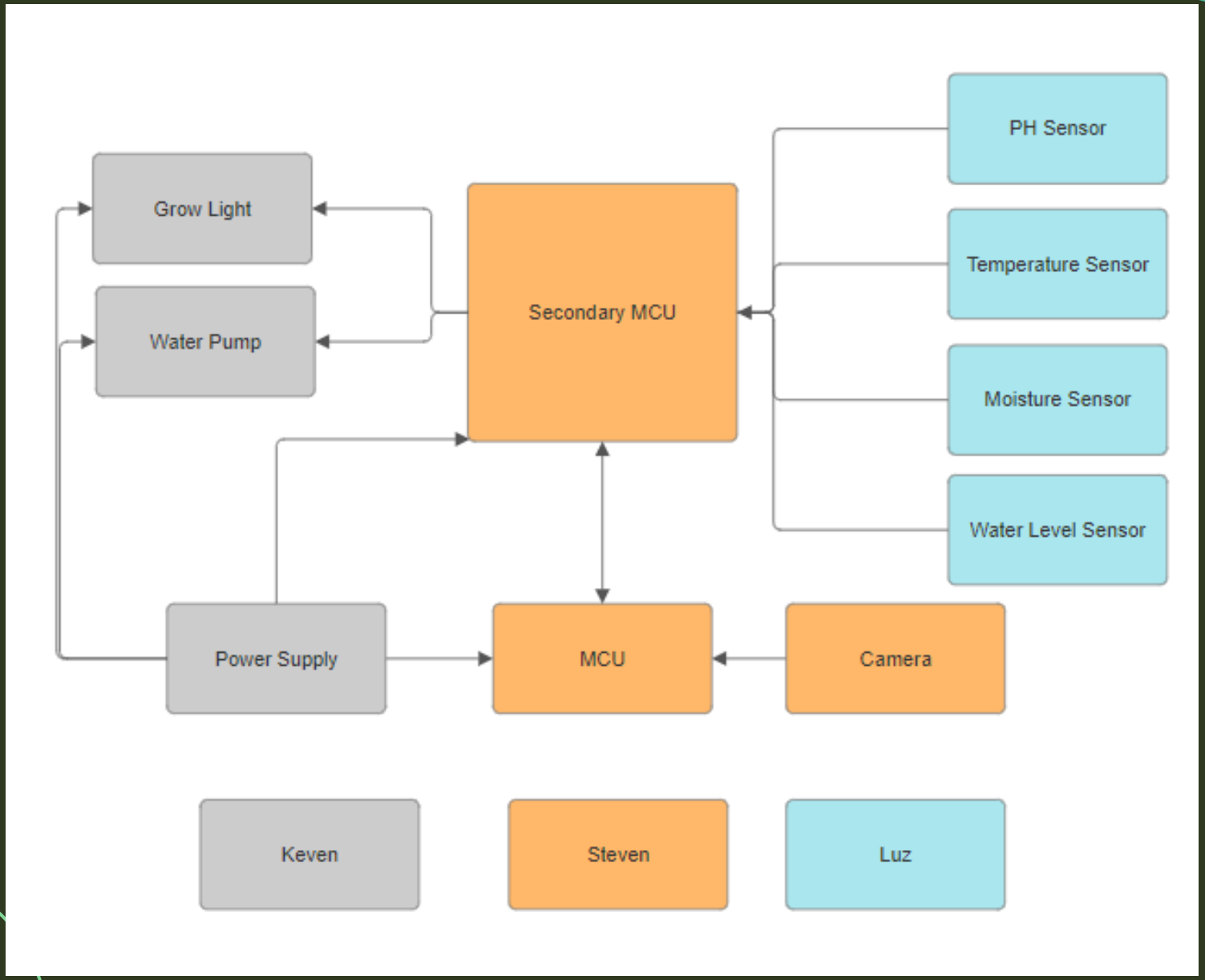


Camera Selection

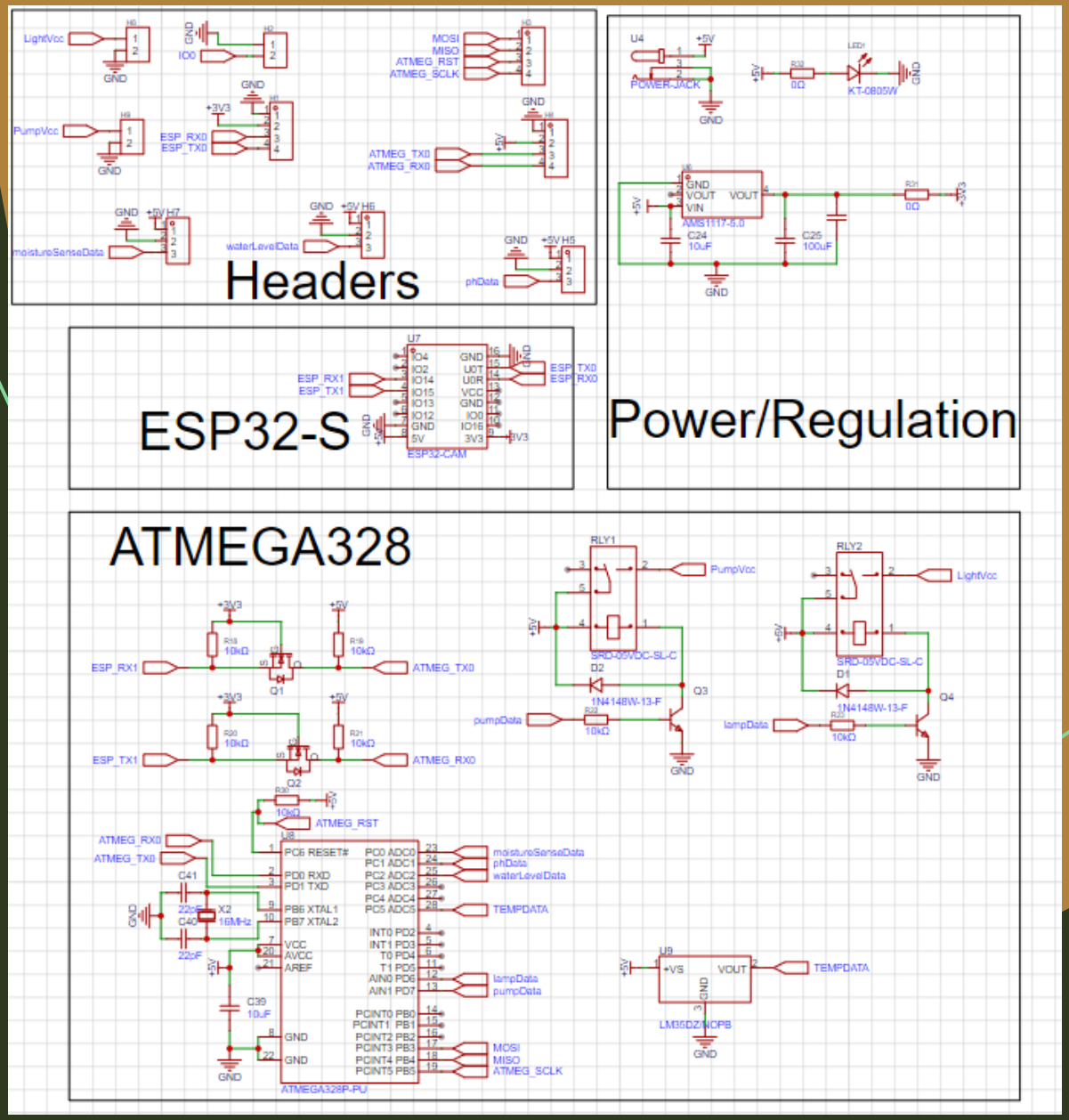
- Selected for its lower cost and ease of availability



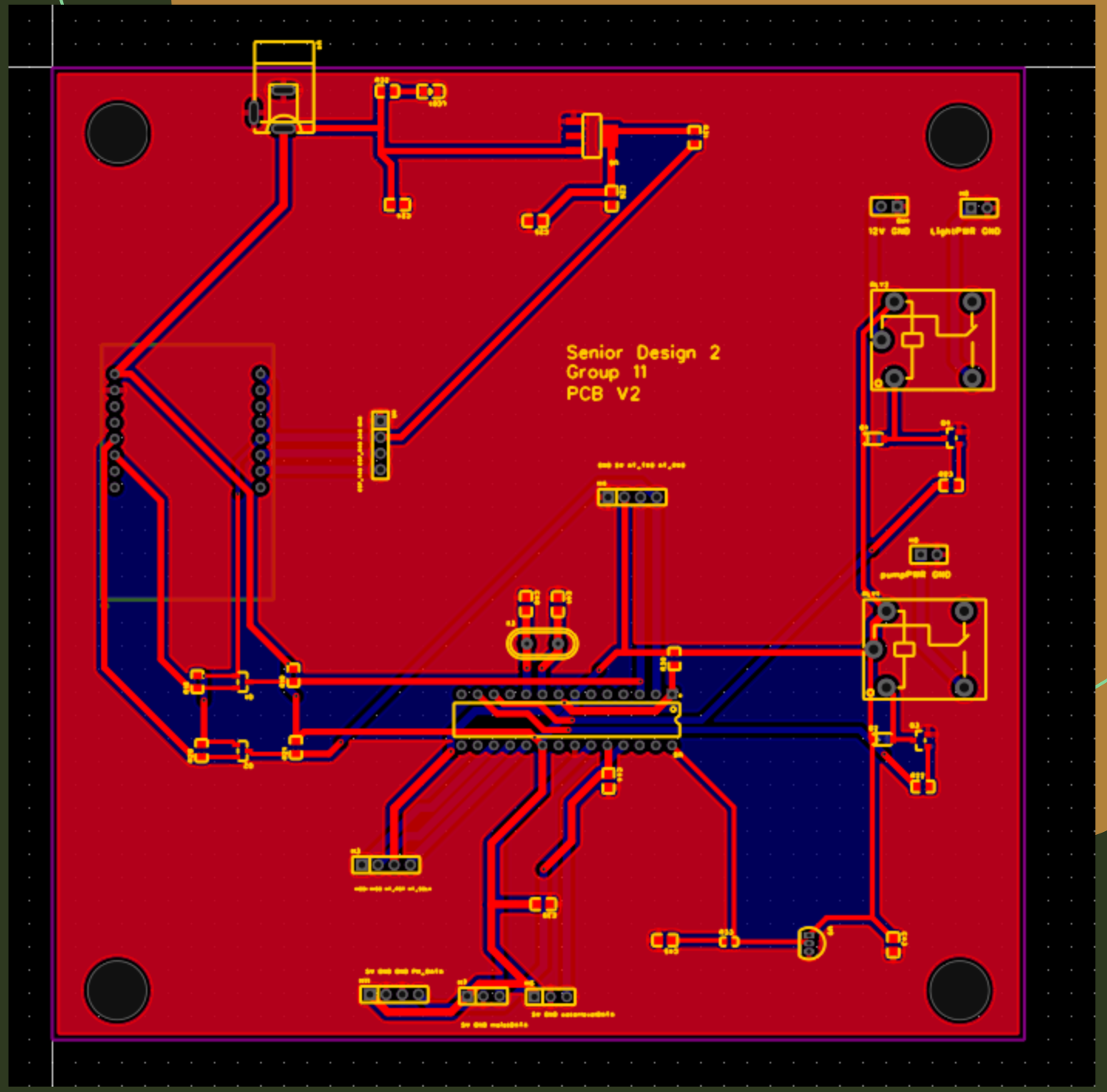
Hardware Design



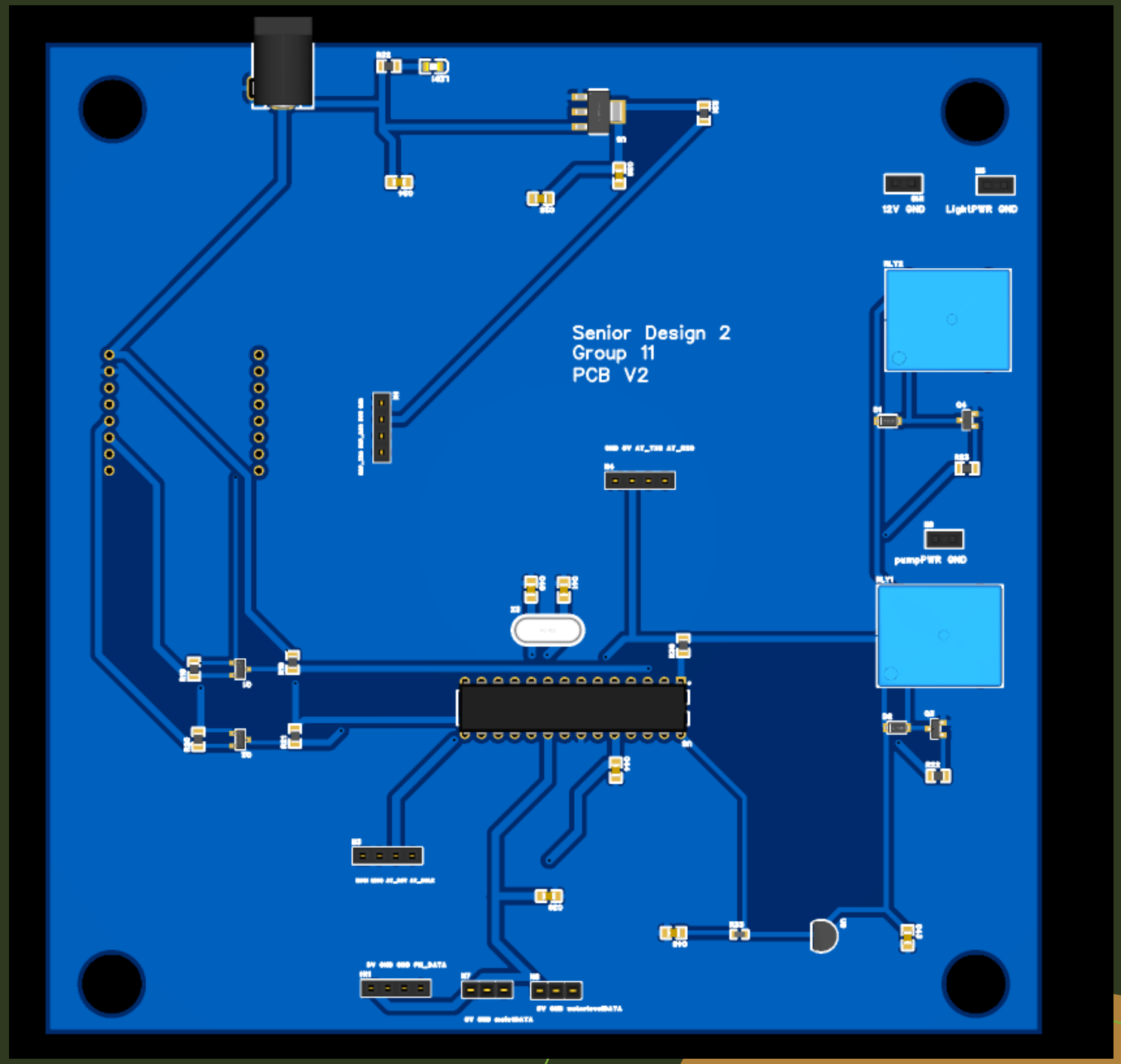
Board Schematic



PCB Layout


Senior Design 2
Group 11
PCB V2
12V GND
LightPWR GND
pumpPWR GND

PCB Render


Senior Design 2
Group 11
PCB V2
12V GND
LightPWR GND
pumpPWR GND

Software Design

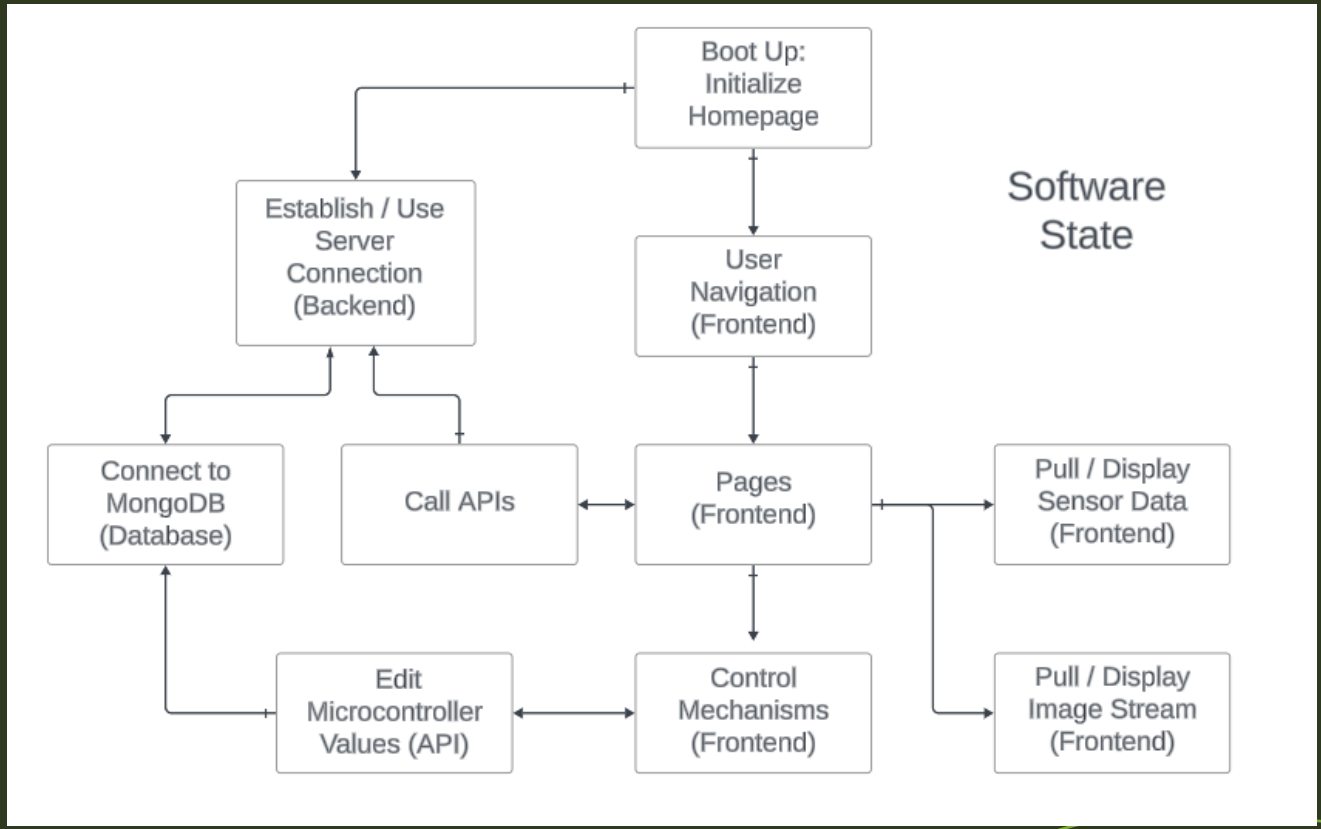
Tony Chau, CpE

Steven Keller, EE

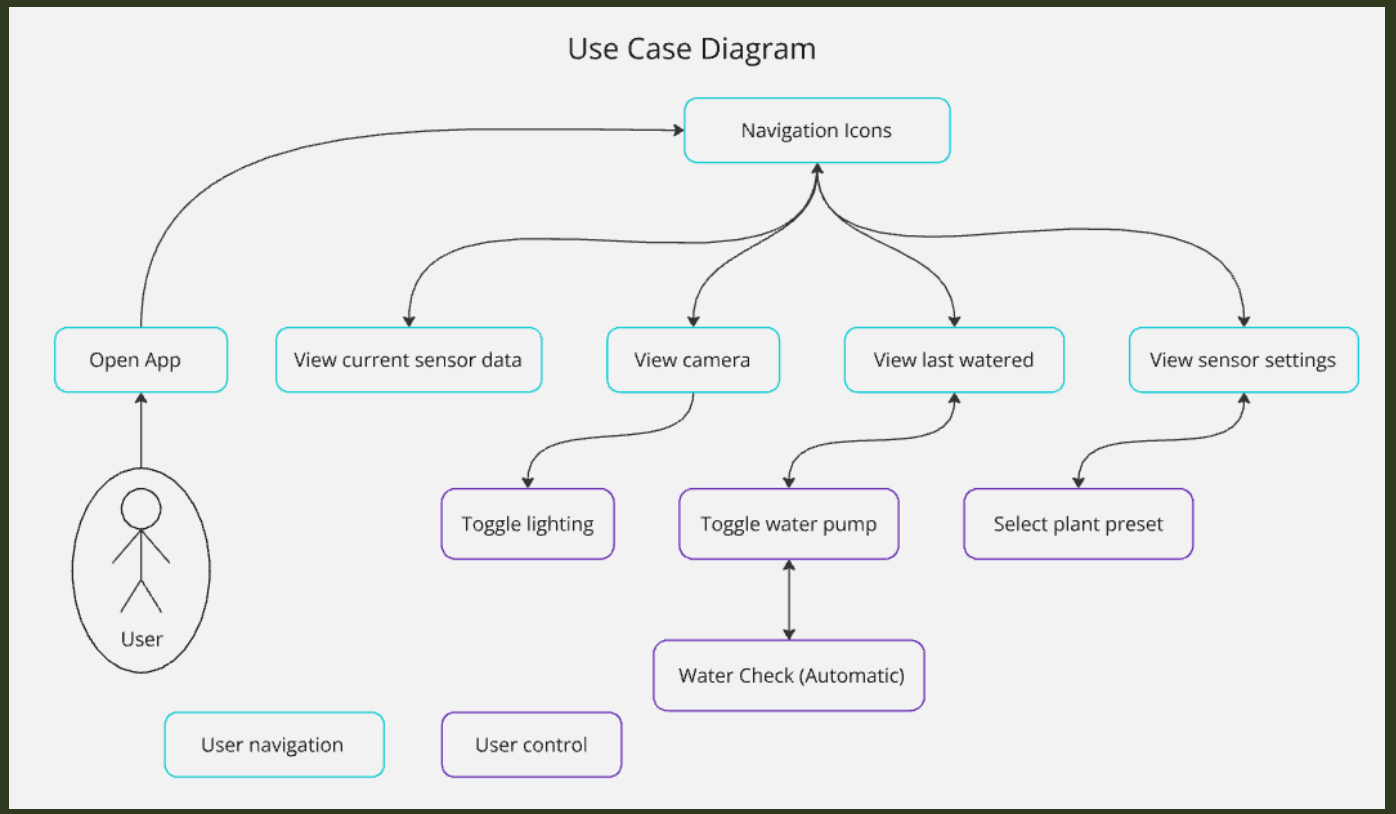
Software Design Purpose

The plant guardian system will include a mobile app that will allow for **remote user interaction** with the system. It will include certain interactive buttons that can enable various devices such as the water pump or let the user view sensor data. The mobile app will allow for an interactive user experience compared to a standalone system.

Software Structure (Flowcharts)



Software Structure (Flowcharts)



Software Design Overview

Software Design Choices:

- **Accessibility –** Comfortable user experience
- **Testability** - Debugging
- **Comfort** - Learnability

These are the deciding factors which lead us to choose the software in creating the Plant Guardian system.

Software Design Choices (User Interface)

- We used Figma to begin our project, as opposed to starting from a blank slate.

Figma and other web designers	Hard code
• Visually create an app design online • Allow for team collaboration and communication • Easy to access and modify	• Create an app design and reiterate through the process with trial and error • Difficult to share • Difficult to visualize from code.

UI Mockup (Created in Figma)

HomePage

Plant Guardian

Welcome!

SensorPage

Plant Guardian

Current Moisture:

Current Temperature:

Current Water Level:

Current pH:

CameraPage

Plant Guardian

Click to Toggle Lighting

WaterPage

Plant Guardian

Last Watered: July 4th, 9:00 A.M

Click to Manually Water

SettingsPage

Plant Guardian

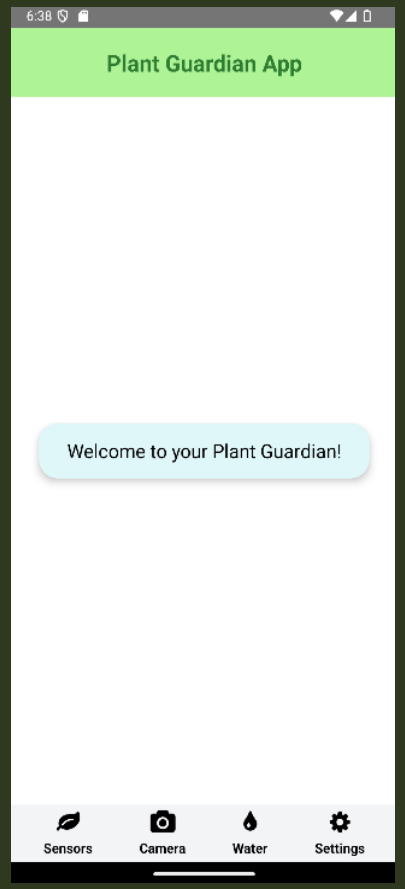
Desired Moisture: 460

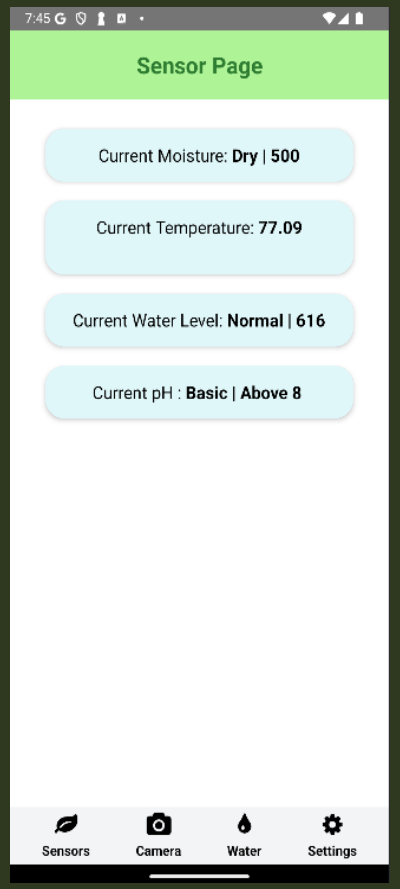
Desired Degrees: 56 F

Desired Water Level: ...

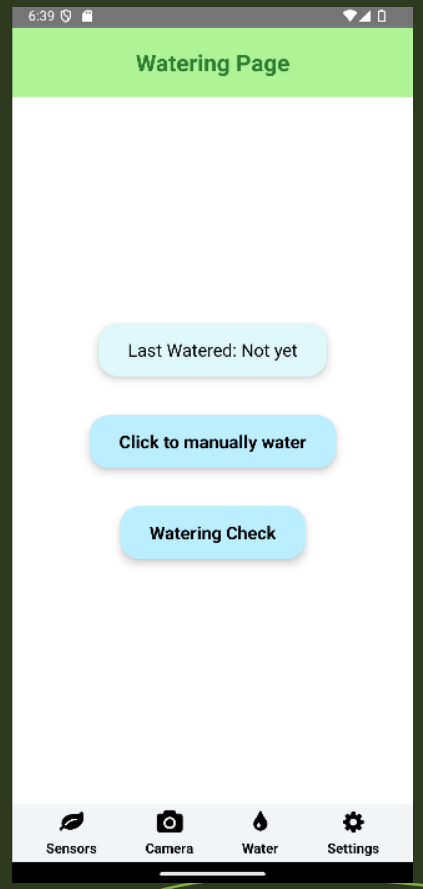
Desired pH: 7

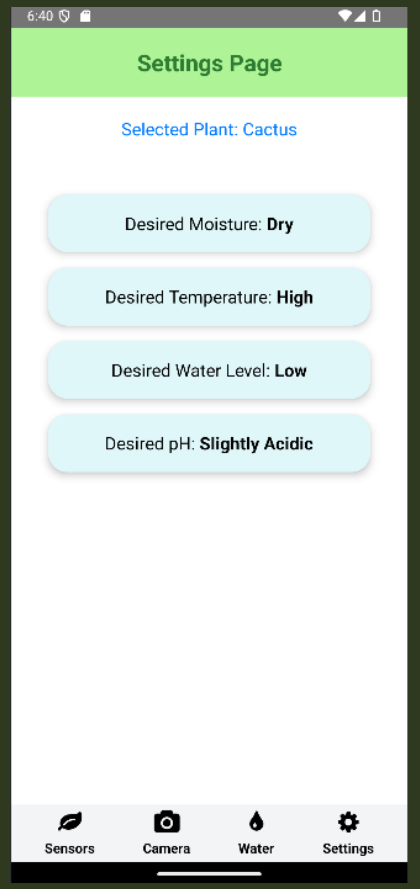
Final UI


Plant Guardian App
Welcome to your Plant Guardian!
Sensors
Camera
Water
Settings


Sensor Page
Current Moisture: Dry | 500
Current Temperature: 77.09
Current Water Level: Normal | 616
Current pH : Basic | Above 8
Sensors
Camera
Water
Settings


Camera Page
Turn on lighting
Sensors
Camera
Water
Settings


Watering Page
Last Watered: Not yet
Click to manually water
Watering Check
Sensors
Camera
Water
Settings


Settings Page
Selected Plant: Cactus
Desired Moisture: Dry
Desired Temperature: High
Desired Water Level: Low
Desired pH: Slightly Acidic
Sensors
Camera
Water
Settings

Software Design Choices (MERN Stack)

- MERN
  - MongoDB – NoSQL Database
  - Express – API framework, middleman
  - React – Frontend management
  - Node – Javascript and backend
- Entirely integrated in Javascript
- Great for data intensive tasks
- Cross platform

Database Considerations

- Ultimately the database – MongoDB, is what convinced us to move forward with the MERN stack.

MongoDB	Firebase	Apache
• Amazing for large storage • Great for querying and filtering through data • No SQL database • Integrates into the MERN stack • Large scalability potential • No cost	• Real time database • No SQL database • Integrated into Google Cloud and its services • Not highly scalable, cost depends on size.	• Well established SQL database that specializes in relational data • Rigid and unoptimized for handling data in real time

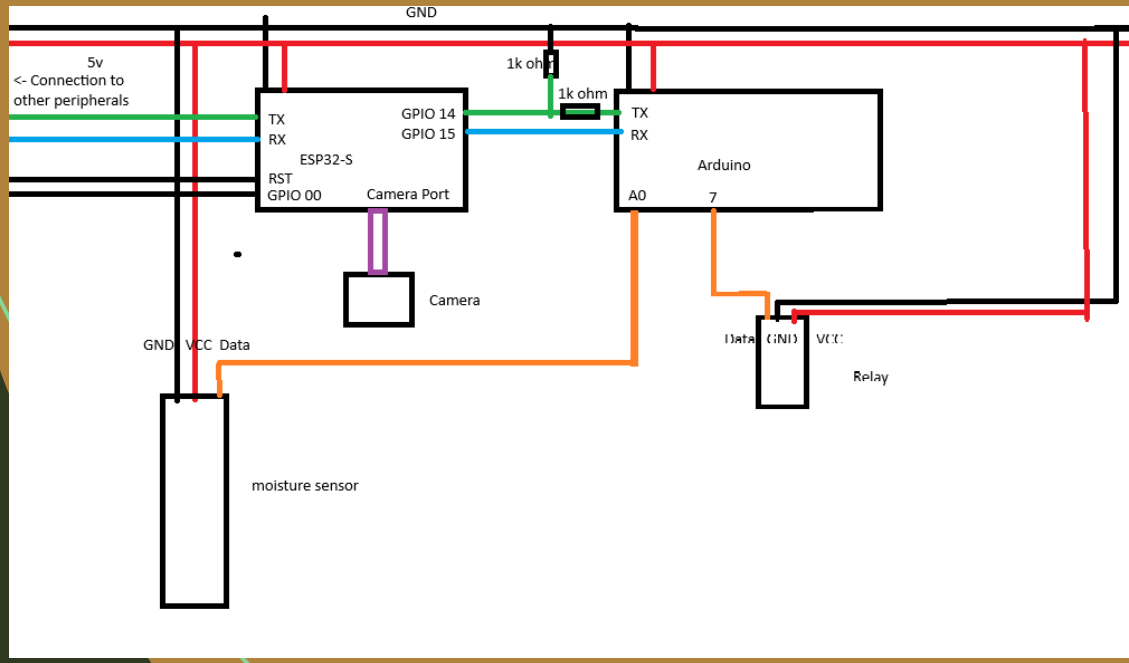
Software Platform Choices

- We chose to utilize Android as the deployment process due to compatibility with personal computers

Android	Apple (IoS)	Web app
• Android device specific, slightly less popular • Varying screen sizes • Flexible deployment process in the Google Play Store • Works with Windows and Linux devices	• Apple device specific, much more popular • Strict development tools only usable with apple devices • Steep cost to license, pay to publish • Used for profitability	• Independent platform • Accessible from any device, but must tune to all devices • No store approval or deployment process • Inflexible for real time operations

Prototyping and Testing

- Used thermometer to test temperature sensor
- Used hand held PH detector to test PH sensor
- Used hand held moisture meter to verify moisture sensor
- Tested internet connectivity with the ESP32-S and successfully displayed a camera stream
- Full hardware integration test by seeing monoDB populated with sensor data
- Pump and Light latency tests via enabling and disabling in app
- All tests found to be within specification



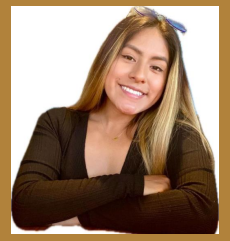
Difficulties Faced

- Changed out grow light due to proprietary communication
- Swapped out temperature sensor due to footprint size
- Moved ESP32-S and Camera to dev board
- Changed design to include second MCU due to IO Limitation

Budget

Item	Estimated	Actual Cost
Relay Module	$10	$6.12
pH sensor	$35	$30.99
Temperature sensor	$15	$2.03
Water level sensor	$9	$59.95
Moisture sensor	$12	$7.50
LED	$7.19	$15
MCU (ESP32)	$10	$10
ATEMGA328	$10	$9
DC Water Pump	$13	$13
Phone	$70	$50
PCB	$30	$120
Wood Box	$100	$131
Total	$321.19	$454.59

Total	$454.59
Total Estimate	$321.19



Work Distribution

Section	Primary	Secondary
App Interface	Tony Chau	Steven Keller
App Backend	Tony Chau	Steven Keller
MCU Firmware	Steven Keller	Tony Chau
MCU	Steven Keller	Tony Chau
Wifi	Steven Keller	Tony Chau
Camera	Luz Romero	Steven Keller
Power Regulation	Keven Hyppolite	Luz Romero
Growth Lamp	Keven Hyppolite	Luz Romero
Water Pump	Keven Hyppolite	Luz Romero
Moisture Sensor	Luz Romero	Keven Hyppolite
Water Level Sensor	Luz Romero	Keven Hyppolite
PH Sensor	Luz Romero	Keven Hyppolite
Temperature Sensor	Luz Romero	Keven Hyppolite

Progress and Plan for Completion

Project Progress

- System Design Completed
- Power Source Selected
- PCB Layout Finalized & Currently being manufactured
- Automation Control Established
- Testing and Prototyping Underway
- User Interface Development

Project Plans

- Complete Prototype testing
- Finalize App Interface
- Refine Automation Algorithms
- Prepare for Manufacturing
- User Feedback and Iteration
- Launch and Scale

Questions?