GreenSync

A Smart Home Plant Care Optimization System

Group 12

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Our Team

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Project Motivations

- Houseplants are more popular than ever for aesthetics, air quality, and stress relief
- Many die each year from **overwatering, underwatering, or poor sunlight**
- These challenges discourage casual plant owners
- Our team is inspired to design a **smart, reliable care system**
- Applies our ECE skills: microcontrollers, sensors, power, and system integration
- Personal connection: we’ve all struggled with plant care ourselves
- Broader value: supports wellness, sustainability, and future scalability

Project Goals

- Provide an efficient, reliable solution for indoor plant care using automation
- Reduce daily burden of watering through smart sensing & control
- Monitor moisture, sunlight, and growth with real-time feedback
- Enable user engagement with camera-based tracking and time-lapse
- Deliver an intuitive mobile app interface for data & care profiles
- Integrate hardware + software into a modular, extensible system
- Promote sustainability and support scalable multi-plant expansion

Objectives & Features

- 💧 **Watering System**
- Compact relay pump controlled by the MCU
- Responds to soil moisture levels, avoids overwatering
- ☀️ **Lighting System**
- LED grow light for low-sunlight environments
- Automated activation using light sensor input
- 📷 **Camera System**
- Captures daily images with timestamps to create a visual time-lapse
- Enables plant growth tracking with livestream capabilities
- 📱 **Mobile App**
- Displays moisture/light readings + history log
- Plant database with optimized care profiles
- Bluetooth data sync from microcontroller
- 🔌 **System Integration**
- ESP32 manages sensors along with mobile app communication
- Modular design for future expansion into stretch goals

Stretch Goal Features

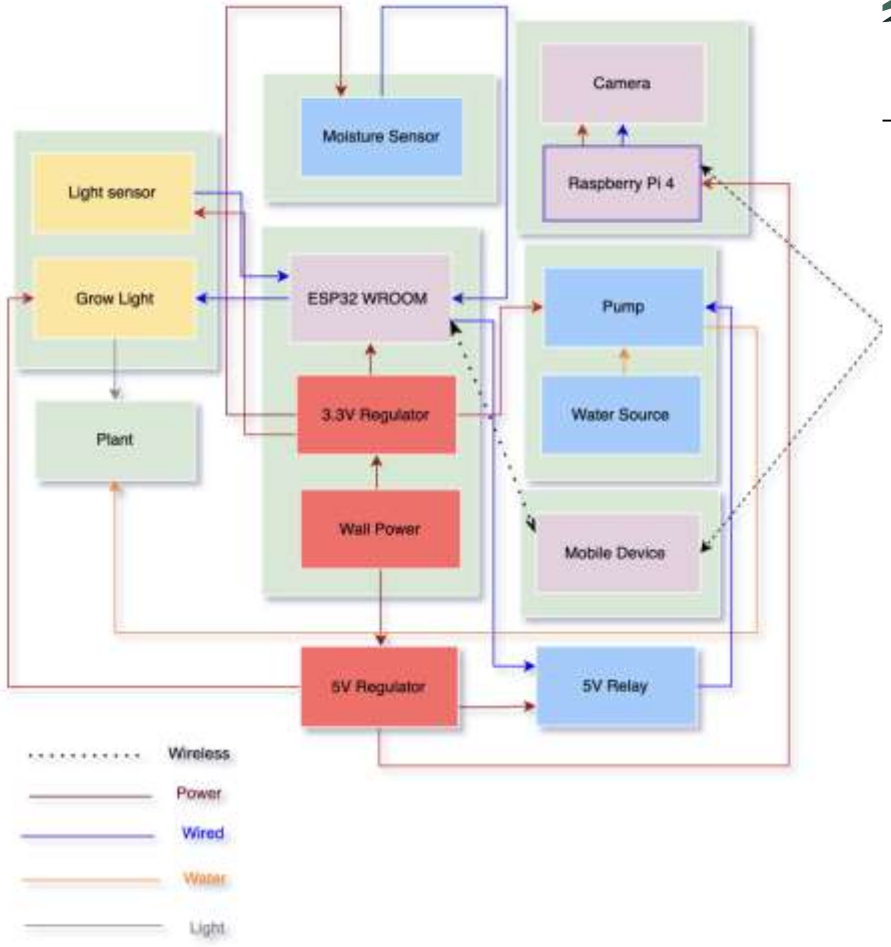
- 📲 **Notifications & Alerts** – Mobile alerts for moisture, light, or stress conditions
- **Environmental Expansion** – Add temperature & humidity sensing
- 🏡 **Enclosed Growth Environment** – Mini greenhouse with climate control
- 🍓 **Edible Plant Support** – Profiles for fruits, vegetables, and herbs
- **Modular Scalability** – Multi-plant setups to create a full home garden
- 📸 **AI Plant Identification** – Auto-recognize species & load care profiles
- ☁️ **Cloud Integration** – Remote monitoring, backups, and trend analysis
- 📈 **Growth Analytics** – Predictive care suggestions from sensor + image data with AI

Engineering Specifications

CATEGORY	PARAMETER	REQUIREMENT
Water System	Soil Moisture Polling Rate	Once per second
	Watering Activation Delay	Less than 3 seconds after threshold is crossed
	Water Delivery Accuracy	±5% of target watering duration
	Water Pump Response Time	Less than 5 seconds
	Moisture Sensor Lifetime	At least 6 months (under standard use)
	Moisture Sensor Accuracy	±5% volumetric water content
Light System	Light Sensor Polling Rate	Once per second
	Grow Light Power Consumption	Less than 20 Watts
	Grow Light Response Time	Less than 5 seconds
Camera System	Image Capture Frequency	Once per day
	Image Resolution	Minimum 1080×720 pixels
	Image Storage Capacity	At least 30 days of daily images (locally)
	Timestamp Accuracy	Within ±1 minute of scheduled capture
	Camera Wake & Capture Time	Less than 10 seconds
User Interface	Data Sync Interval	At least once per hour
	Supported Plant Profiles	Minimum of 5 preloaded species
	Sensor Data Display Delay	Less than 15 seconds after MCU transmits
System Power	System Power Source	12V DC adapter (baseline configuration)
	Operating Temperature Range	10°C to 40°C

GreenSync: The Physical Product

Hardware Flow Diagram



Microcontroller Comparison

MCU	CORE & SPEED	WIRELESS CONNECTIVITY	GPIO & ADC	EASE OF DEVELOPMENT	KEY PROS & CONS
Arduino Uno (ATmega328P)	8-bit @ 16 MHz	None	14 GPIO, 6 PWM, 6 ADC	Very High (beginner-friendly, Arduino IDE)	Great community support, but no Wi-Fi; limited speed and RAM
Raspberry Pi 4 Model B	Quad-core Cortex-A72 @ 1.5 GHz, up to 8 GB RAM	Built-in Wi-Fi & Bluetooth	40 GPIO (digital), no native ADC	High (Linux-based OS, Python, C/C++, huge ecosystem)	Extremely powerful for multimedia & networking, supports high-res camera; higher cost & power usage
ESP8266	32-bit @ 80–160 MHz (Tensilica L106)	Wi-Fi only	Fewer GPIO, 1 ADC	Medium (Arduino & ESP-IDF)	Good for simple IoT, but lacks Bluetooth and limited multitasking
STM32 Blue Pill (STM32F103C8T6)	32-bit @ 72 MHz (Cortex-M3)	None	37 GPIO, 10 ADC channels	Medium–Low (STM32CubeIDE, more complex setup)	Powerful and flexible, but no built-in wireless; higher development complexity
ESP32	Dual-core 32-bit @ up to 240 MHz	Wi-Fi + Bluetooth	Many GPIO, ADCs, PWM, capacitive touch, etc.	High (Arduino, ESP-IDF, camera & sensor support)	All-in-one solution, fast, wireless-ready, multitasking; efficient for IoT like GreenSync

MCU Selection:

ESP32 and Raspberry Pi 4

- ESP32 chosen for **sensors, pump, and grow light control**
- Built-in Wi-Fi & Bluetooth, low power, real-time performance
- Raspberry Pi 4 chosen for **high-resolution camera and streaming**
- Powerful quad-core CPU, strong multimedia and networking support
- Dual-board setup balances **efficiency and advanced processing**
- Scalable design supports **future AI/vision features**

Moisture Sensor Technologies

SENSOR TYPE	MEASUREMENT PRINCIPLE	ACCURACY / PRECISION	DURABILITY	COST & COMPLEXITY	BEST SUITED FOR
Capacitive Sensor	Dielectric permittivity	High	High (non-corrosive)	Low cost, easy integration	DIY & microcontroller projects
Resistive Sensor	Electrical resistance	Low to Moderate	Low (corrodes over time)	Very cheap, very simple	Education, hobby projects
Tensiometer	Soil water tension (suction)	Moderate	Moderate	Moderate cost, analog data	Agricultural studies
TDR/FDR Sensor	Electromagnetic reflection	Very High	High	High cost, complex circuit	Precision irrigation research
Gypsum Block Sensor	Resistance via gypsum block	Low to Moderate	Moderate	Low cost, old tech	Basic systems, field demos
Sensor Array / Multi-Point	Spatial moisture sampling	Varies (multi-point)	High (varies by sensor)	High cost, advanced logic	Greenhouses, large plots

Moisture Sensor Technologies Selection

Capacitive Soil Moisture Sensor

- Chosen for the best balance of **accuracy, durability, and easy integration**.
- Measures moisture via **dielectric permittivity** (no metal-to-soil contact), unlike corrosive resistive probes.
- **Long-term reliability** with reduced maintenance needs.
- **Fast response** and **stable readings** for real-time irrigation control.
- **ESP32-friendly**: works at low voltage with simple **analog/PWM outputs**, streamlining design.
- Though slightly pricier, its **accuracy, robustness, and low power** make it the most **practical, future-proof** option.

Grow Light Technologies Comparison

TECHNOLOGY	ENERGY CONSUMPTION	LIFESPAN	COST	HEAT EMISSION	LIGHTING CONTROL
Fluorescent	Medium	10,000–20,000 hrs	Low	Low–Medium	Limited (On/Off only)
HID (MH/HPS)	High	10,000–24,000 hrs	Medium	High	Limited (Manual Dimming)
LED	Low	50,000+ hrs	Medium	Very Low	Excellent (PWM, Smart Control)
Incandescent	Very High	~1,000 hrs	Very Low	Very High	Minimal (On/Off only)
Plasma	Very High	30,000 hrs	Very High	High	Limited (Complex Drivers)
Infrared (IR)	Medium (Supplemental)	30,000 hrs	High	Medium	Moderate (Spectrum Blending)

Grow Light Technologies Selection

LED

- Chosen for **energy efficiency, long lifespan, and automation compatibility** in a compact smart garden.
- Use **significantly less power** than fluorescent/HID while providing **consistent intensity** and **customizable spectra**.
- **Low heat output** reduces or eliminates extra cooling—ideal for small enclosures.
- Support **PWM dimming** and smart integration for **precise, sensor-driven light scheduling**.
- Enable **fine control of light quality** to promote healthy growth across plant stages.
- Though pricier upfront, their **durability, efficiency, and flexibility** make LEDs the most **practical, future-proof** choice for GreenSync.

Grow Lights

MODEL	POWER DRAW	SPECTRUM	COVERAGE AREA	PROS	CONS	COST
Roleadro LED Grow Light Panel	~45W	Full Spectrum (Red + Blue)	~2' × 2'	Energy-efficient; Good intensity; Affordable	No dimming; External timer needed	\$30–\$40
GE BR30 LED Grow Light Bulb	~9W	Full Spectrum	Single Plant	Compact; Fits standard sockets; Low cost	Limited coverage; No dimming; Low intensity	\$10–\$15
Spider Farmer SF-1000	~100W	Full Spectrum (Premium)	Up to 2' × 2'	High-quality light; Dimmable; Great for automation	High cost; Large for small systems	\$120–\$150
SEZO 16×16 WS2812B LED Panel	~25W (varies by brightness)	RGB Addressable (Custom)	Single Plant / Targeted Lighting control	Fully programmable spectrum & animations; Flexible panel; Compact; Great for combining grow-light + UI status effects	Not true horticulture spectrum; Higher power draw; Can overheat at full white; Needs stable 5V supply	~\$25–\$35

Grow Light Selection:

WS2812B LED

- **Fully programmable RGB spectrum** allows custom lighting levels and visual feedback for the system.
- **Compact and flexible panel** fits into tight enclosures and can wrap around plant zones.
- **Easy integration with ESP32** using standard WS2812B libraries.
- **Affordable compared to horticulture panels** while offering far more control and customization.

Camera

COMPONENT	RESOLUTION (STILL/STREAM)	INTERFACE	CONNECTIVITY	EASE OF INTEGRATION	PROS	CONS	COST
ESP32-CAM (OV2640)	2 MP / ~640×480 stream	UART / SPI	Built-in Wi-Fi & BT	Medium (requires flashing)	Integrated MCU + camera; Wireless; Includes microSD storage	Limited resolution; setup requires flashing	Low ($8–$12)
Arducam Mini (OV2640)	2 MP / ~640×480 stream	SPI	None	Medium-Low (external MCU)	Compact; Flexible for modular systems	Needs separate MCU; extra wiring & coding	Low-Med ($12–$18)
OV5640 Module	5 MP / ~720p–1080p stream	DVP / MIPI	None	Low (special drivers req.)	Higher resolution; Better low-light performance	Complex integration; high processing needs	Med-High ($20–$35)
1080P HD USB Webcam	2 MP / 1080×720 stream	USB	USB	Very High (plug-and-play)	Full HD; Wide-angle; Auto light correction; Built-in mic & cover	Limited to USB hosts (e.g. Raspberry Pi 4)	Med ($25–$40)

Camera Selection:

1080p HD USB Webcam

- **1080×720 resolution** for clear plant monitoring
- Wide-angle lens + auto light correction
- **Plug-and-play USB** → simple integration with Raspberry Pi 4
- □ Privacy cover + built-in microphone for flexibility
- Reliable streaming without burdening the ESP32

Light Sensor

SENSOR	INTERFACE	DYNAMIC RANGE	ACCURACY	POWER USE	PROS	CONS	COST
VEML7700	I^2C	Up to 120,000 lux	High	Low	Wide range; Accurate; Easy integration	Slightly higher cost	Medium
BH1750	I^2C	Up to 65,000 lux	Medium	Low	Affordable; Simple to use	Lower precision; Smaller range	Low
TSL2591	I^2C	Up to 88,000 lux	High	Medium	Dual-channel; Adjustable gain	More complex setup; Higher cost	High
OPT3001	I^2C	Up to 83,000 lux	Very High	Low	Photopic response; Excellent accuracy	Expensive; Less hobby support	High

Light Sensor Selection:

VEML7700

- **Wide 0–120,000 lux range** for both low-light rooms and bright windows.
- **More accurate than BH1750** with no heavy calibration needed.
- **Near-TSL2591/OPT3001 accuracy** at a **lower cost**.
- **Simple I^2C integration** with the ESP32
- **Low power + small footprint** for easy PCB integration.

Water Pump

PUMP TYPE	HOW IT WORKS	AVG. FLOW RATE	BENEFITS	DRAWBACKS	COST
Submersible DC Pump	Uses a small DC motor with an impeller; fully submerged in water	80–240 L/h (depending on size)	Compact; Quiet; Easy to install; Compatible with relays & MOSFETs	Requires submersion; Not self-priming; Limited head height	Low ($3–$10)
Peristaltic Pump	Rotating rollers compress flexible tubing to push water	20–100 mL/min (very low)	Highly precise dosing; Prevents contamination; Only tubing contacts liquid	Slow flow; Higher cost; Tubing wear over time	Moderate ($8–$20)
Diaphragm Pump	Flexible membrane oscillates to create suction & pressure	1–3 L/min	Self-priming; Handles slight debris; Can pump over long distances	Bulkier; Louder than submersible; Moderate power draw	Moderate ($10–$25)
Centrifugal Pump	Spinning impeller creates flow; typically submerged	300–800 L/h (mini versions)	High volume; Efficient for continuous operation; Low maintenance	Not self-priming; Requires submersion or priming; Less precise control	Moderate ($10–$30)
Vibration Pump	Electromagnetic oscillation moves water in pulses	100–200 mL/min	Ultra-compact; Low power; Quiet	Low pressure; Low flow; Limited to small systems	Low ($4–$8)

Hardware Selection: Water Pump

Water Pump Selection:

- Selected Pump: Amazon Mini Water Pump
- Supply Voltage: 5V DC
- Flow Rate: 80 – 120 L/Hour
- Pump Type: Submersible DC Pump
- Maximum Lift: 40 – 110 mm
- Cost: $6.97 for four pumps
- Trade-Offs Considered: Maximum lift affects flow rate, but if pump is leveled it fits design limits
- Reasoning: Selected for cost, ease of use, and performance based off requirements

Power Distribution Table

CATEGORY	LOAD / MODULE	VOLTAGE	TYPICAL CURRENT	PEAK CURRENT	EST. POWER
LED Lighting	WS2812B LED Panel (16×16)	5 V	2–6 A	10–15 A	~10–30 W (varies)
Livestream	Raspberry Pi 4 Model B	5 V	1.5 A	3.0 A	~7.5–15 W
Pump Relay	SRD-05VDC-SL-C Relay Module	5 V	0.07 A	0.07 A	~0.35 W
Water Pump	Mini Submersible Pump	3.3 V	0.15–0.30 A	0.40 A	~0.5–1 W
Microcontroller	ESP32 (controller)	3.3 V	0.10 A	0.25 A	~0.5 W
Moisture Sensor	Capacitive Moisture Sensor	3.3 V	0.01 A	0.015 A	~0.03 W
Light Sensor	Ambient Light Sensor (VEML7700)	3.3 V	0.0002 A	0.001 A	~0.001 W

3.3V Regulator

REGULATOR	INPUT VOLTAGE RANGE	OUTPUT CURRENT	EFFICIENCY @12V	SWITCHING FREQUENCY	COST	PCB SIZE / COMPLEXITY	NOTES (ESP32-FOCUSED)
LM2576-3.3V (TI)	4.75V – 40V	Up to 3A	~80–85%	52 kHz	Mid	Medium (inductor + diode)	Very low noise, extremely stable for ESP32; tolerant to sudden load changes (Wi-Fi spikes + pump starts)
MP2307DN (Monolithic)	4.75V – 23V	Up to 3A	~90–92%	340 kHz	Low	Very small + few parts	High efficiency, but sensitive to layout; can produce higher ripple → risky for ESP32 brownouts/reboots
XL4015 (XL Semi)	4V – 38V	Up to 5A	~88–90%	180 kHz	Very low	Medium	High current, cheap, but noisy output & inconsistent regulation → not ideal for sensitive MCU + sensors

3.3V Regulator Selection:

LM2576

- **Very stable 3.3V output** with low ripple, ideal for the ESP32 and sensors.
- **Handles sudden load spikes** from Wi-Fi transmissions and pump activation without brownouts.
- **Wide 12V tolerance** and strong thermal performance for long-term reliability.
- **Simple, proven design** with predictable behavior and easier debugging than high-frequency regulators.
- **More consistent regulation** than low-cost alternatives

5V Regulator

REGULATOR	INPUT VOLTAGE RANGE	OUTPUT CURRENT	EFFICIENCY @12V	SWITCHING FREQUENCY	COST	PCB SIZE / COMPLEXITY	NOTES (RASPBERRY PI 4 FOCUS)
LM2679S-ADJ (TI)	8V – 40V	Up to 5A	~85–92%	260 kHz	Mid	Medium (inductor + diode)	Perfect for Pi 4: stable 5V, handles 3A spikes, low ripple, excellent thermal headroom + robust under relay/pump surges.
LM2596S-5.0 (TI/OnSemi)	4.5V – 40V	Up to 3A	~75–85%	150 kHz	Low	Medium	*Borderline for Pi 4*: may brown out under boot spikes; higher ripple → risky for USB/camera loads.
TPS5430 (TI)	5.5V – 36V	Up to 3A	~85–90%	500 kHz	Mid	Small footprint	High efficiency but **insufficient current** for Pi 4 + load; 3A limit = no safety margin for spikes.

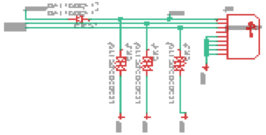
5V Regulator Selection:

LM2679S ADJ

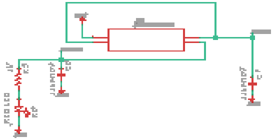
- **5A output** gives safe headroom for the Raspberry Pi 4 and all 5V devices.
- **Handles load spikes** during Pi boot, camera use, and pump/relay activation.
- **Lower ripple** than LM2596 → cleaner, more stable 5V rail.
- **Strong thermal performance** for a 12V → 5V step-down.
- **More reliable regulation** than LM2596 and TPS5430 under high load.

Main Board

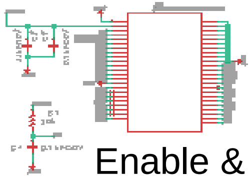
USB – Micro B



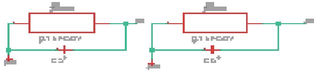
5V to 3.3V Regulator



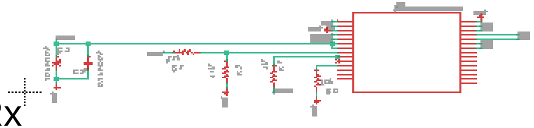
ESP32



Enable & Boot

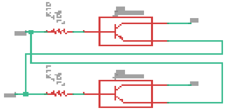


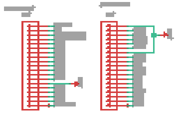
CP2102



Rx/Tx to Tx/Rx

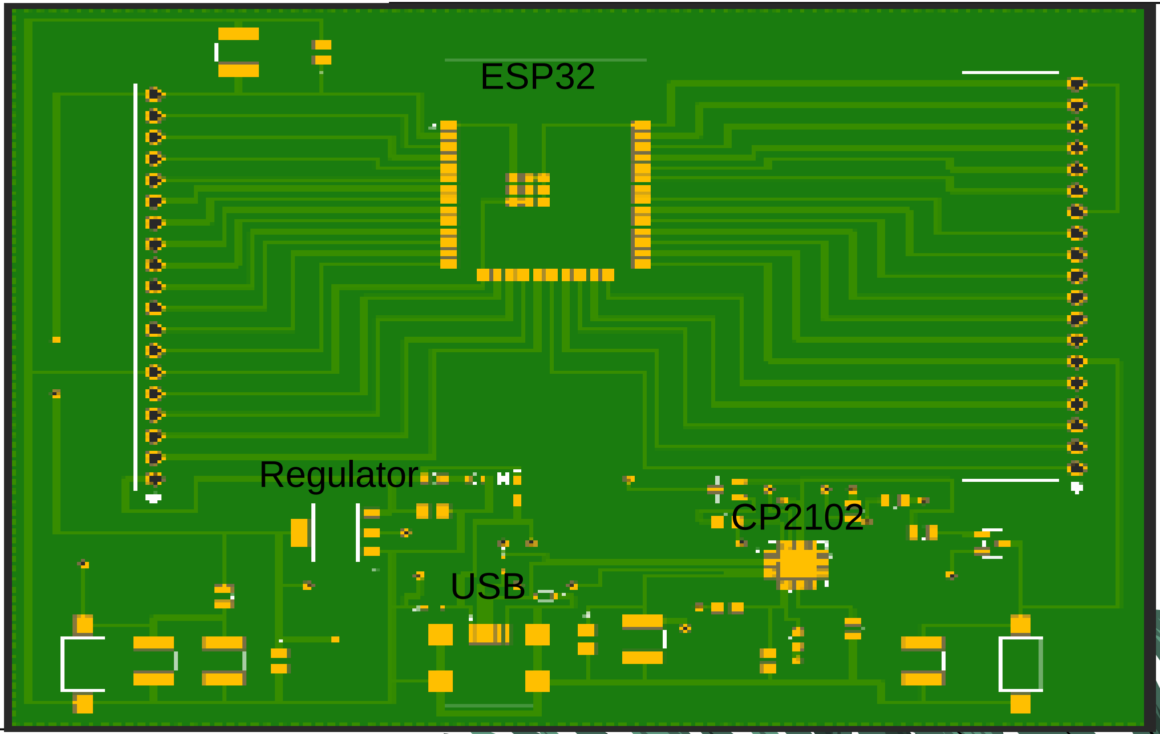
RTS/CTS



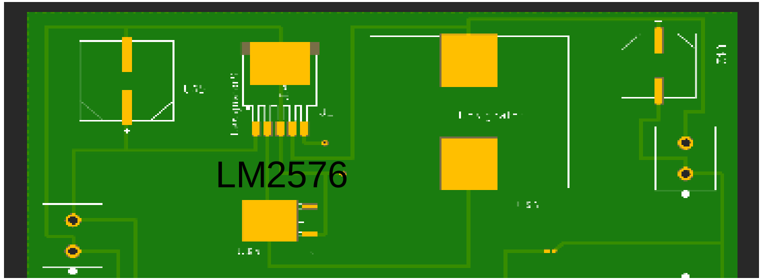


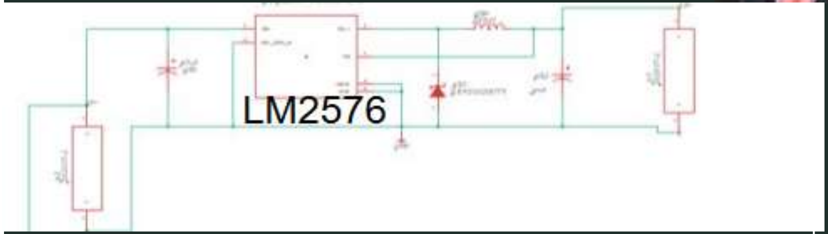
Connector Pins

Main Board Layout

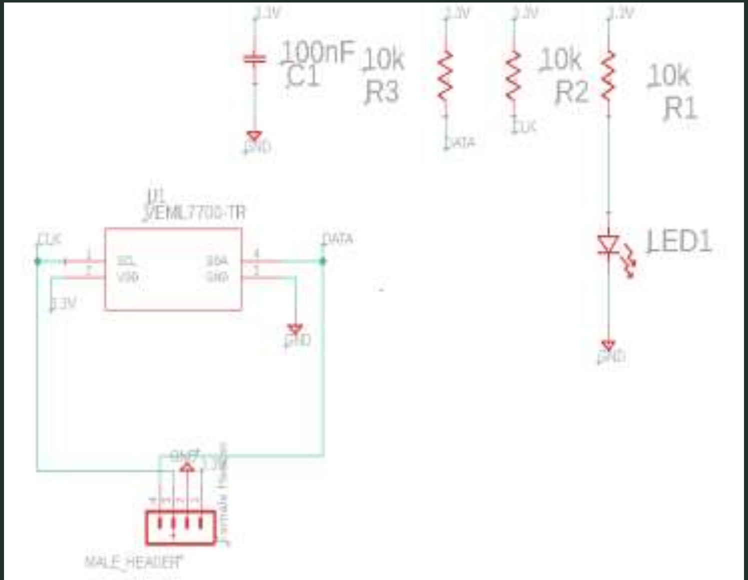


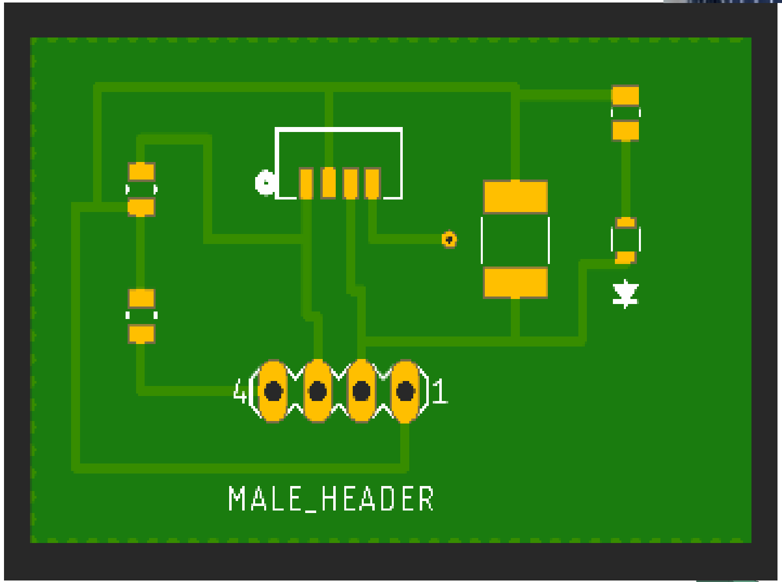
3.3V Power Supply



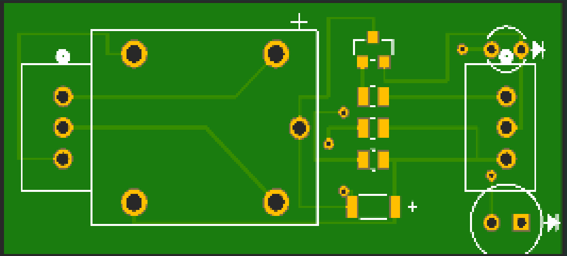


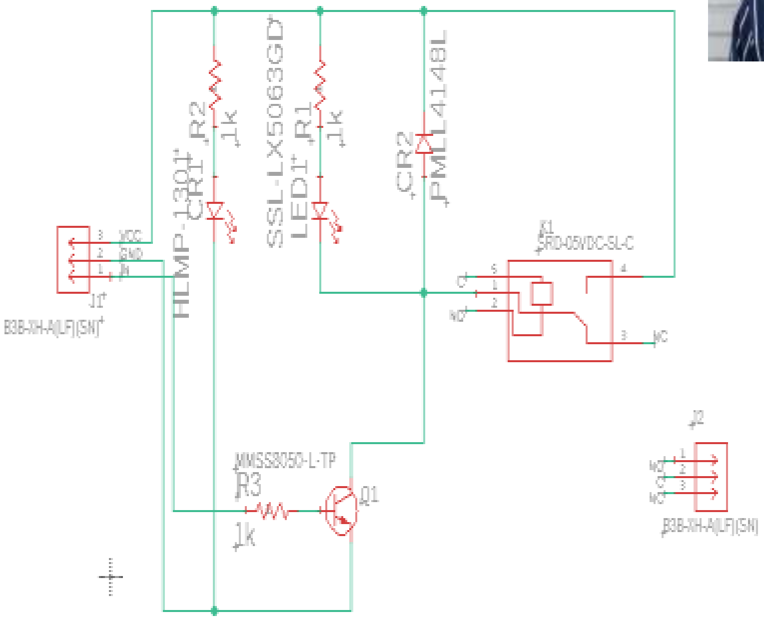
Light Sensor





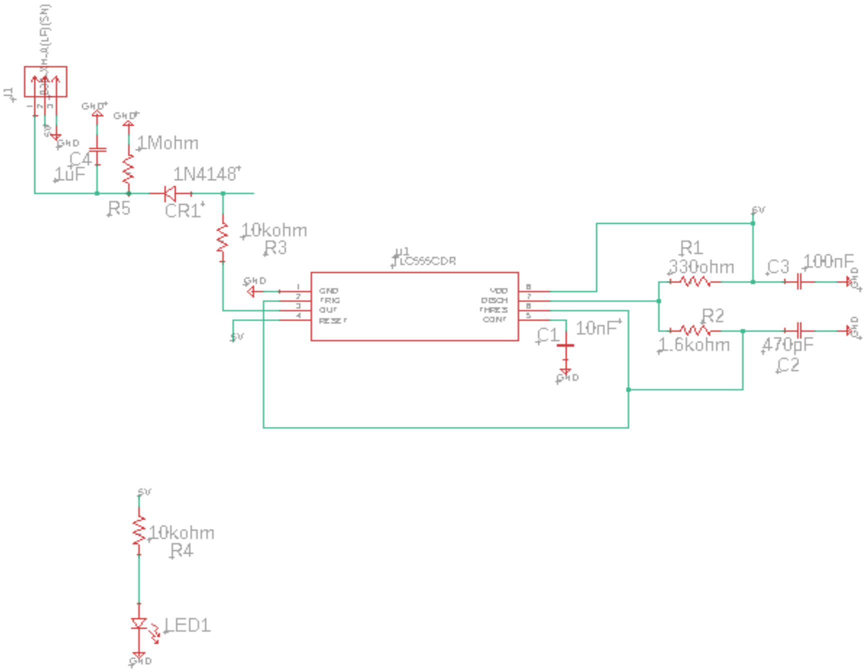
5V Relay

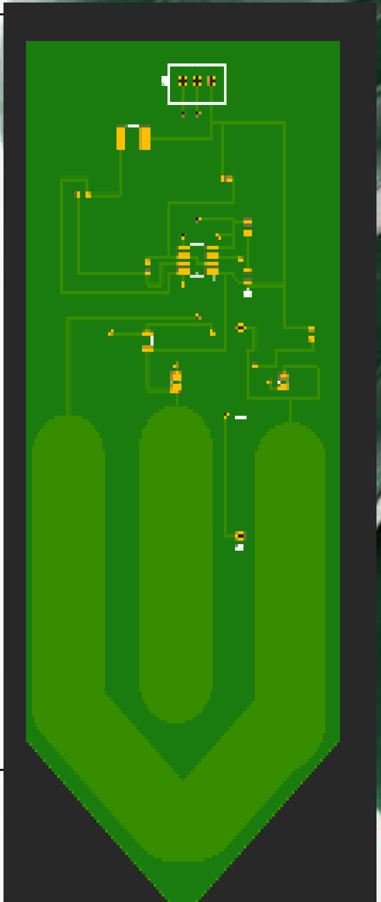


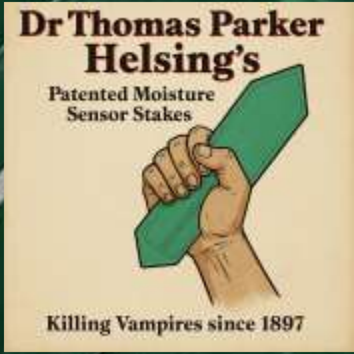


VCC
GND
IN
J1
B3B-XH-A(LF)(SN)
HLMP-1301
CR1
R2
1k
SSL-LX5063GD
LED1
R1
1k
CR2
PMLL4148L
K1
SRD-05VDC-SL-C
NC
MMSS8050-L-TP
R3
1k
Q1
J2
B3B-XH-A(LF)(SN)

Moisture Sensor





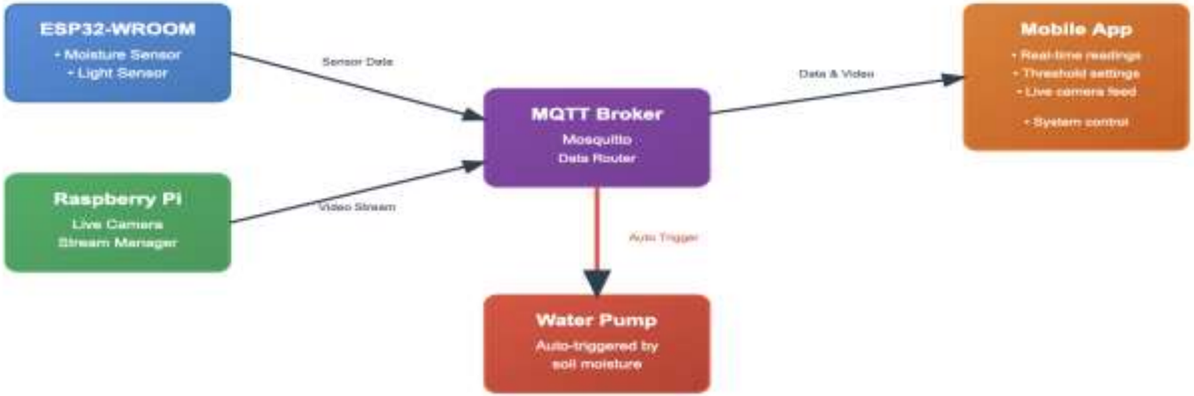


Why a Mobile App?

- **Preferred by users** → people expect mobile phone integration for convenience
- **Accessible anywhere** → monitor and control plants remotely, not limited to local access
- **Better than a website** → faster, optimized for touch, works offline or with low connectivity
- **Better than onboard UI** → avoids clunky buttons/screens, reduces hardware complexity
- **Just better**: improves engagement, provides feedback, and encourages plant care consistency

System Architecture

- ESP32-WROOM collects data from moisture & light sensors
- Raspberry Pi manages the live camera stream
- Data and video are sent to the mobile app through MQTT (Mosquitto broker)
- App shows real time readings, thresholds, and live camera feed
- Pump is triggered automatically based on soil moisture levels



User Interface

UI OPTION	COMPLEXITY	COST	CONNECTIVITY	PROS	CONS
Mobile App	High	Medium	Wi-Fi / BLE	Intuitive GUI; Full control and monitoring; Real-time updates	Requires app development; Dependent on smartphone
Web Dashboard	Medium	Low–Medium	Wi-Fi	Platform-independent; Accessible via any browser	Needs stable network; Requires web development skills
Serial Console	Very Low	Low	USB (Local only)	Ideal for debugging; Simple and lightweight	Not user-friendly; Requires physical connection
Physical Interface	Low	Low	None	Reliable; No network needed; Easy for basic control	Limited functionality; No advanced monitoring

Development (IDE Choice)

Arduino IDE (for ESP32-WROOM programming):

- Chosen for its simplicity, large community, and fast prototyping
- Allowed us to quickly test sensors, pump control, and breadboard setups
- Wide library support made integration easier

Android Studio (for mobile app development):

- Chosen for building a native Android app with full customization
- Provided tools to integrate MQTT communication and live camera feed
- Flexible UI design to keep the app beginner-friendly and intuitive

Comparison:

- PlatformIO (VS Code): more advanced features, but slower for quick testing
- ESP-IDF: professional and powerful, but too complex for our timeline
- Other mobile app builders (e.g., MIT App Inventor) were too limited for MQTT + camera

Programming Languages

LANGUAGE	IDE / ENVIRONMENT	USED FOR	REASON / BENEFIT
C / C++	Arduino IDE / PlatformIO	ESP32 firmware	Fast, efficient, low-level control for sensors and Wi-Fi.
Dart	Flutter	Mobile app + UI	Cross-platform, modern UI toolkit, easy MQTT integration.
Python	Raspberry Pi OS / VSCode	Camera streaming, automation	Simple, powerful libraries for imaging + rapid prototyping.
Shell (Bash)	Raspberry Pi Terminal	System setup, services, scripts	Automation of Pi startup tasks, lightweight and reliable.

Communication Protocol

PROTOCOL	MESSAGE STYLE	BANDWIDTH USAGE	BEST USE CASE	NOTES
MQTT	Publish / Subscribe	Very low	IoT sensors + async control	Lightweight, reliable, ideal for ESP32 handles drops, low power, easy scaling
HTTP/REST	Request / Response	High	Simple cloud APIs	Easy to implement but slower + heavier not great for constant sensor updates
WebSockets	Full-duplex stream	Medium	Live video, dashboards	Real-time continuous data, higher load more complex than MQTT for microcontrollers
CoAP	UDP request/response	Very low	Ultra-low-power IoT battery devices	Similar to HTTP but tiny; harder to set up, less tooling than MQTT

Comm Protocol Selection

MQTT

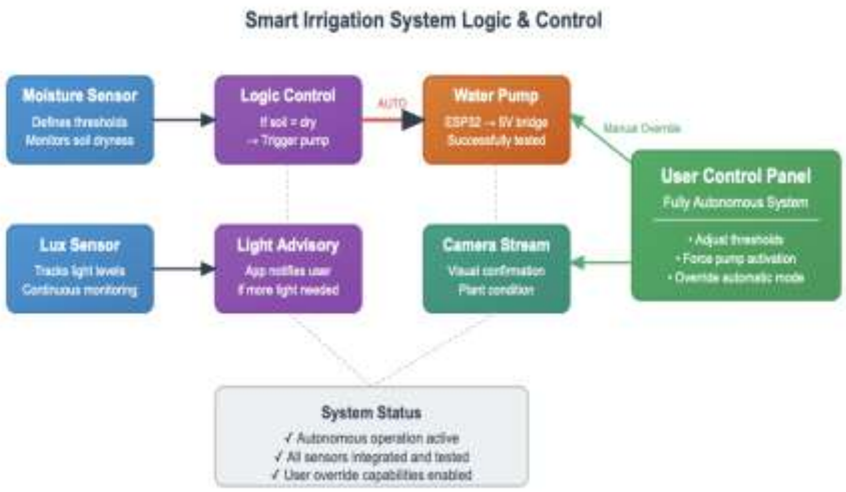
- Developed a smart plant care system combining hardware + software
- Mobile app integrated with MQTT services (Mosquitto.org)
- Hardware includes live camera, light (lux) sensor, soil moisture
- sensor, and a water pump
- Controlled by ESP32-WROOM, tested successfully on a breadboard
- System is autonomous but can also be controlled from the app

Mobile App & MQTT

- Mobile app is the main interface for users
- Provides real time dashboard: soil moisture, light levels, live camera feed
- Uses MQTT with Mosquitto.org for fast, lightweight communication
- MQTT chosen over HTTP → lower latency, event driven updates
- Supports both automatic operation and manual control from the phone

Sensor Integration & Autonomy

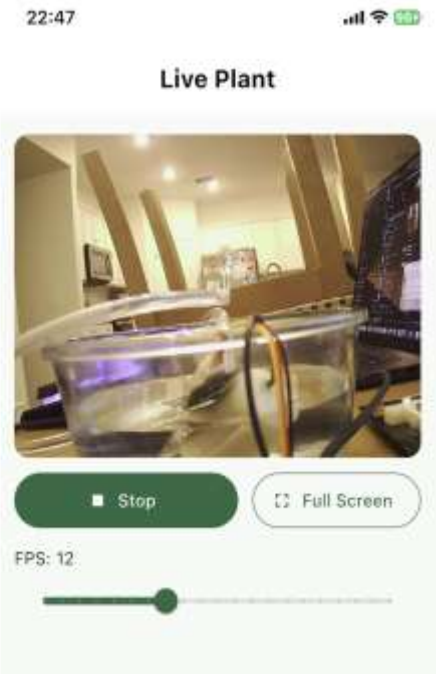
- Moisture sensor defines thresholds → triggers pump only when soil is dry
- Lux sensor tracks light → app advises user if plant needs more exposure
- Pump control tested successfully with ESP32 bridge to 5V rail
- Camera stream integrated to confirm plant condition visually
- Fully autonomous system, but user can adjust thresholds or force actions



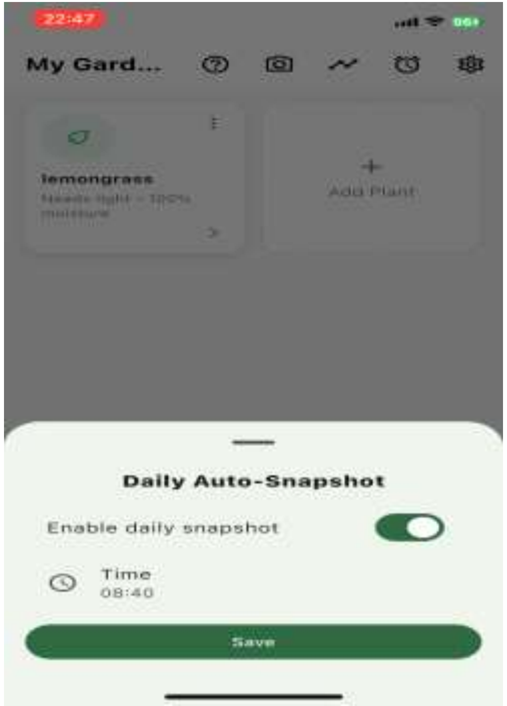
Camera Livestream Testing

Livestream on Raspberry-pi

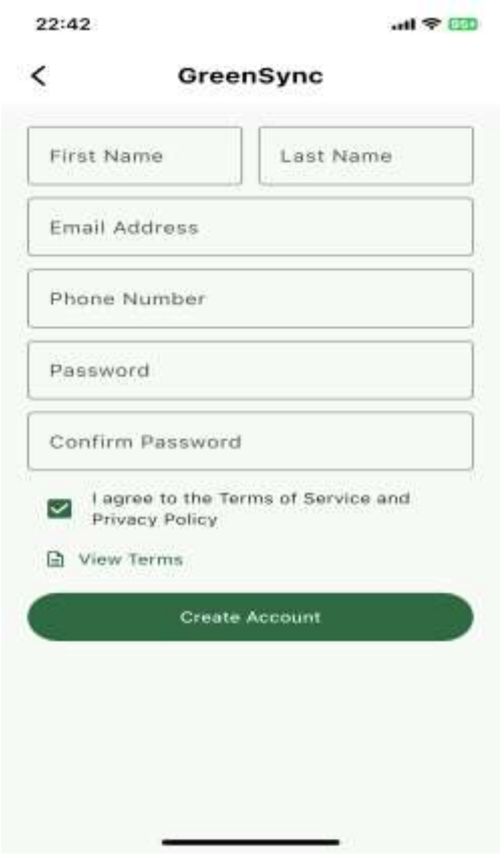
Livestream on our Mobile Application



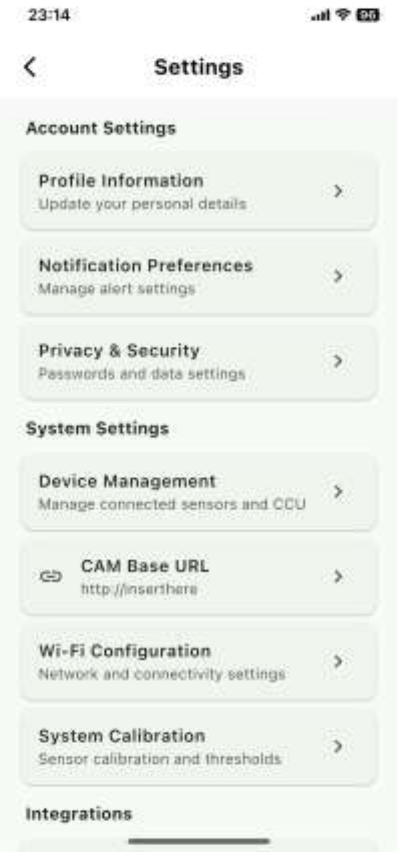
Daily snapshot



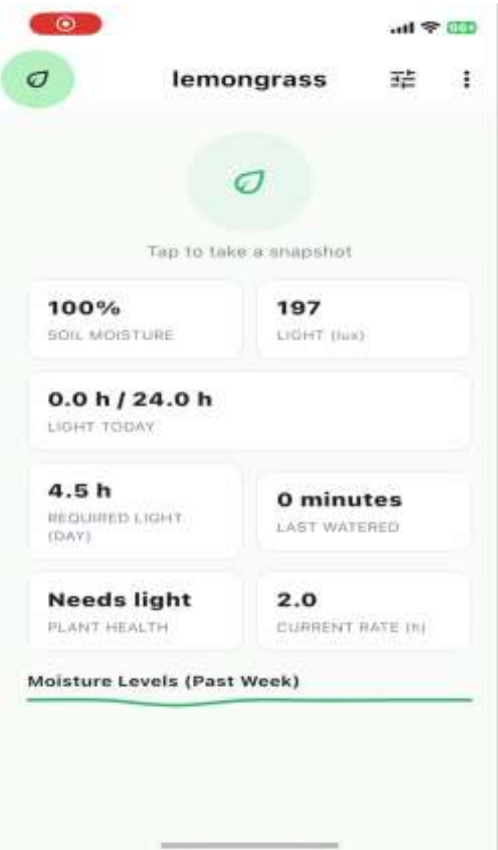
Official Mobile application



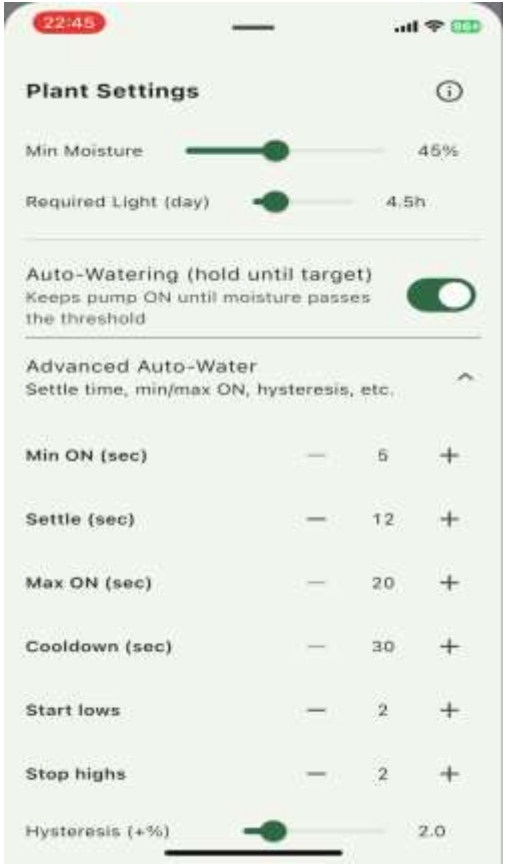
Official Mobile application Cont.

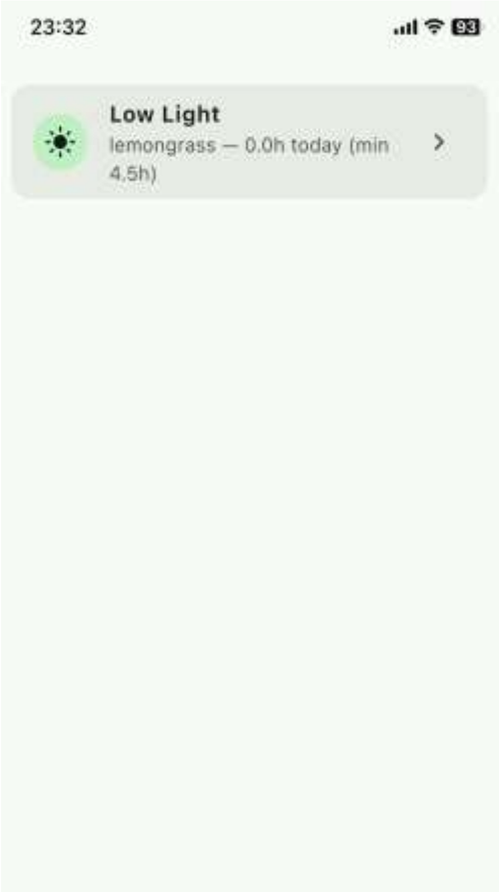


Official Mobile application Cont.



Official Mobile application Cont.





Grow Light Testing

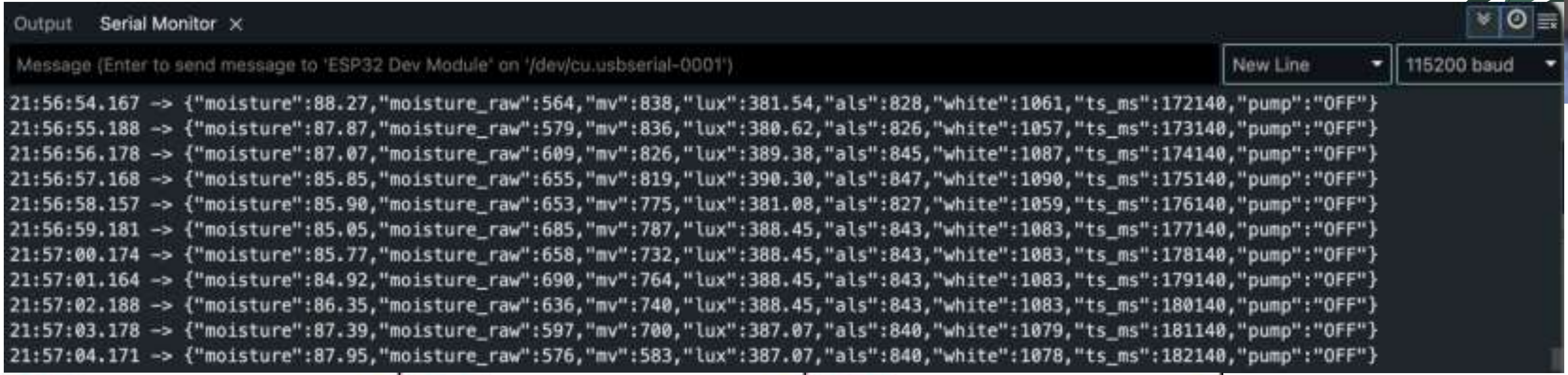
Testing Grow Light manually with a response time less than 5 sec through the GreenSync App (Off)

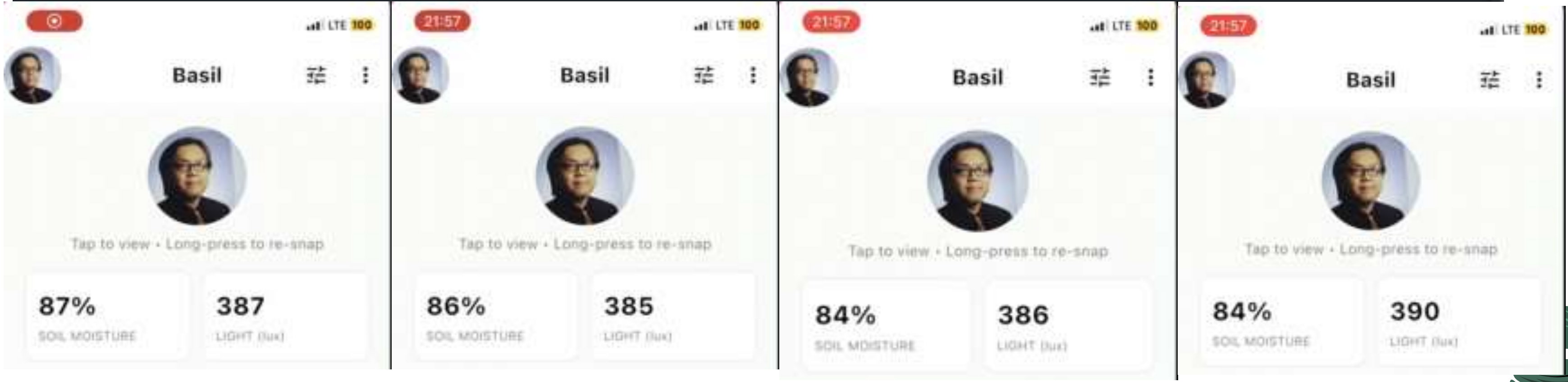
Testing Grow Light manually with a response time less than 5 sec through the GreenSync App (On)

Water Pump Testing

Test #	mL of Water Dispensed	Response < 5?
Test 1	175 mL	Yes
Test 2	176 mL	Yes
Test 3	175 mL	Yes
Test 4	174 mL	Yes
Test 5	175 mL	Yes

Light Sensor & Moisture Sensor Testing with App & Arduino IDE





Challenges

- UCF’s firewall blocking majority of MQTT brokers
- How to interpret data sheets and integrates parts.
- Wire maintenance has been difficult
- Routing of trace lines to prevent inductance on Regulators
- Overheating of 5V regulator due to through hole design
- Time management and conflicting schedules.

Name	Primary Role	Secondary Roles
Roman Luknicki	Lead, Live-Streaming Camera	Power Supply PCB Design
Rohit Goeptar	Mobile Application Interface	Firmware Development System Integration, & Testing
Victor M. Arteaga-Cuenca	Firmware Development	Mobile Application Interface, Environmental Sensing Subsystem
Thomas Parker	PCB Design	Enclosure

Bill of Materials

CATEGORY	COMPONENT	DESCRIPTION	COST (USD)
PCB Design	PCB Designs & Parts	Custom circuit board designs and electronic components	$200.00
Main Controller	Raspberry Pi 4b	Primary computing unit for farm control system	$120.00
LED Lighting	PicoFarm LED	Sponsored grow light system for plant cultivation	Sponsored
Water Pump	Submersible Water Pump	Automated watering system pump for irrigation	$6.97
Microcontroller	ESP32	WiFi-enabled microcontroller for sensor management	$10.00
Camera	USB Webcam	Visual monitoring and plant growth documentation	$30.00
Moisture Sensor	Moisture Sensor	Soil moisture detection for automated watering	$12.00
Light Sensor	Light Sensor	Ambient light level monitoring and LED control	$11.00
Test Camera	ESP32-CAM	Secondary camera module for testing and backup imaging	$6.00
Enclosure	Enclosure	Protective housing for electronic components	$30.00

End Game Aftermath

Buy this guy korean BBQ for losing my bet

Thank You :D