Smart Greenhouse: an Integrated Hardware and Software Solution

UNIVERSITÀ DEGLI STUDI DI SALERNO

Smart Implementation with IoT Technology

Integrating Technology and Nature: Addressing Global Challenges

In an era where resource constraints and environmental challenges threaten food production, innovative solutions are imperative. This project exemplifies the integration of technology and nature to enhance agricultural productivity, ensuring high-quality yields even in suboptimal conditions.

Environmental Impact

Food production contributes to **26% of global greenhouse gas emissions**, necessitating eco-friendly agricultural practices.

Hannah Ritchie, Pablo Rosado and Max Roser (2022) - "Environmental Impacts of Food Production" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/environmental-impacts-of-food' [Online Resource]

Resource Consumption

Agriculture accounts for **70% of global freshwater withdrawals**. It also occupies **half of the world's habitable land**, underscoring the importance of efficient resource utilization.

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Process Pollution

Agriculture contributes to **78% of global ocean and freshwater eutrophication**. Eutrophication is the **pollution of waterways with nutrient-rich water**.

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Project Overview

General description and goals

Project Overview – Goals

Monitoring

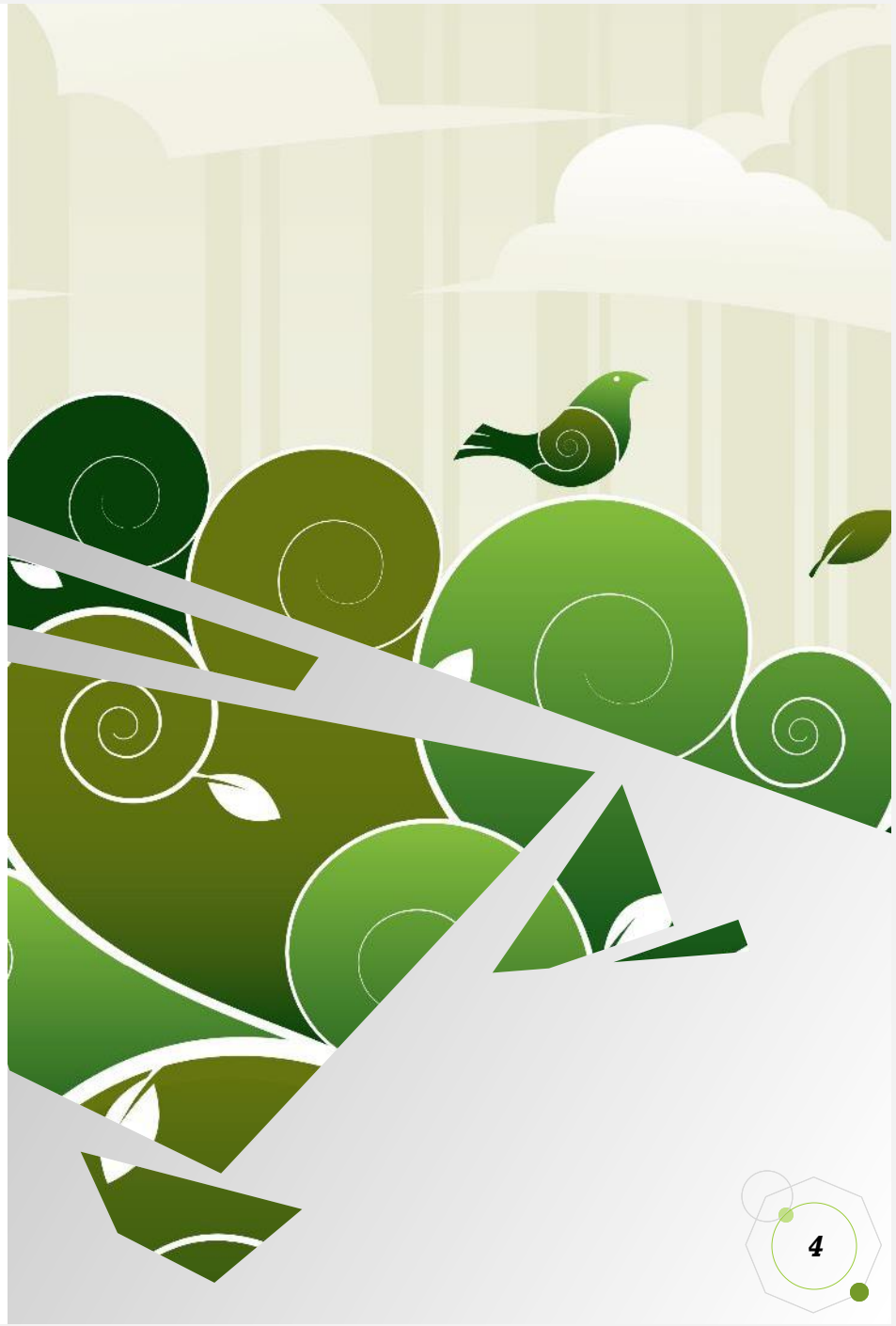
Utilize IoT technology to **collect and analyze data in real time**, enabling constant oversight of critical environmental factors and performance.

Growth

Support the cultivation of robust, healthy plants through a **smart, automated environment that adapts to changing conditions** for optimal growth.

Efficiency

Optimize resources such as water and energy, ensuring sustainable growth while reducing waste and costs.



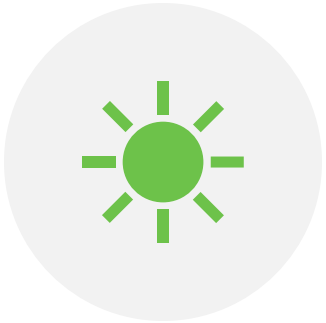
Project Overview – Main Functionalities

Temperature and Humidity Control

Maintaining optimal temperature and humidity levels within fixed ranges to support healthy plants growth

Soil Moisture Control

Keeping under control soil moisture to achieve the best balance for plants and avoid water waste



Light Level Control

Managing light levels to supply a well-balanced amount of light in terms of time and intensity

Air Circulation and Pollution Control

Ensuring fresh air circulation, also to avoid high levels of potentially harmful gas particles

Real-time Data and Commands

Providing live monitoring and remote control for seamless system management with UI dashboard

Project Overview – Sensors and Actuators

Arduino UNO Rev4 WiFi

DHT11

MQ-135

BH1750FVI

YL-69

ACS712

LCD 1602 I2C

WS2812B LEDs

5V DC Fan

5V DC Pump

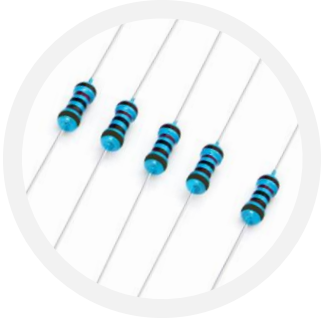
MG90 Servo

Project Overview – Key Electronics

Ensuring Reliable Performance, Electrical Protection and Smooth Operations

Transistors

Act as switches to control the fan and pump. Enable high-current devices using microcontroller signals.



Resistors

Protect sensitive components and regulate current.

Diodes

Prevent backflow of current to protect the microcontroller. It also prevent unintentional polarity inversion.

Electrolytic Capacitors

Stabilize voltage fluctuations caused by sudden changes in load.

Ceramic Capacitors

High-frequency noise suppression. They filter out electrical noise and ensure stable operation to rapid voltage changes.

Project Overview – Technical Choices

VS

Transistors

- ✓ Compact, ideal for tight space
- ✓ Extremely fast, enabling precise control
- ✓ Efficient for energy-sensitive projects
- ✓ Solid-state design ensures longevity
- ✓ Supports PWM for fine-tuned device control
- ✓ Generally low cost

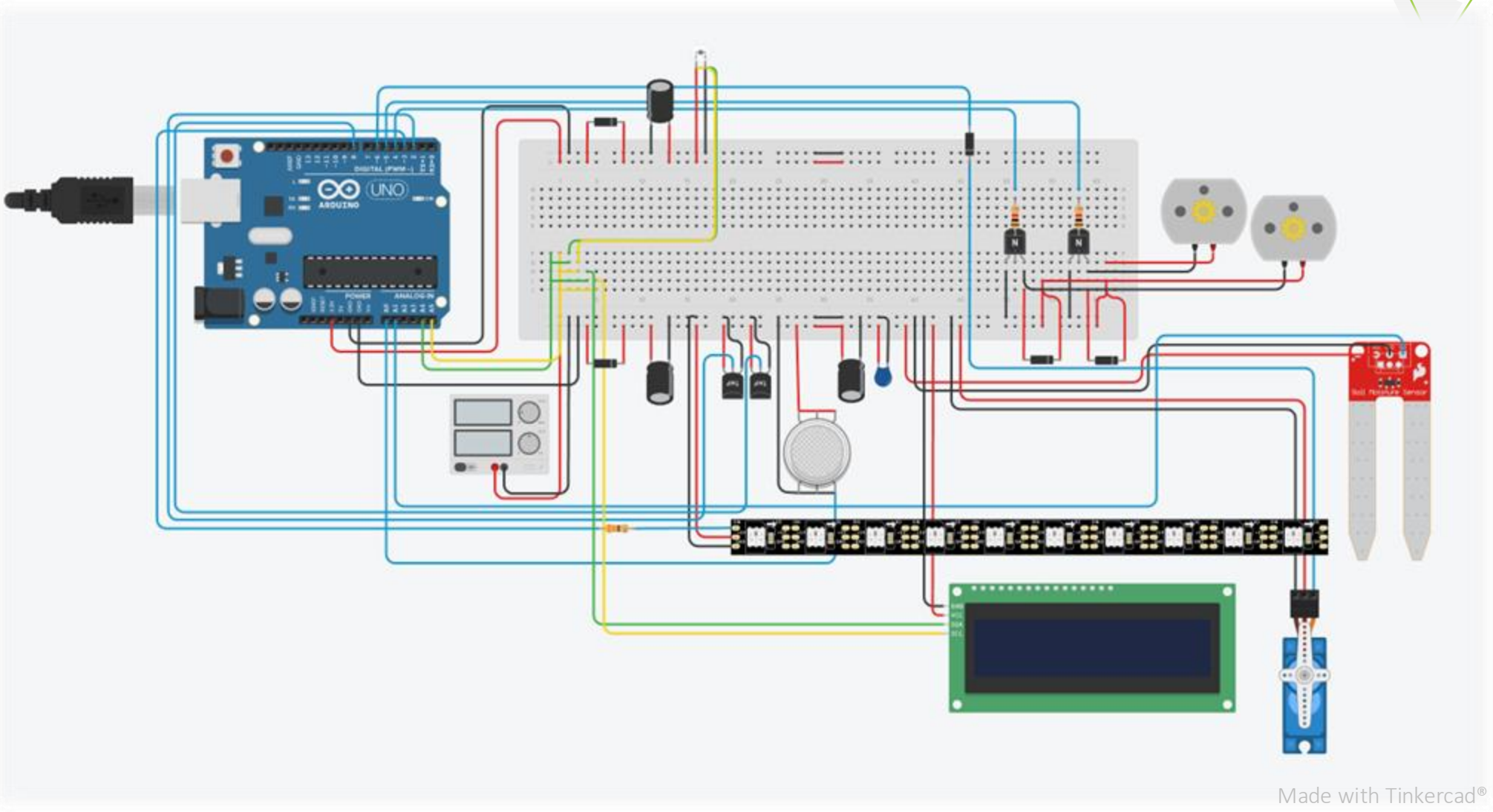
Relay Modules

- ✗ Larger, requiring more space
- ✗ Slower due to mechanical movement
- ✗ High power consumption
- ✗ Mechanical parts prone to wear and tear
- ✗ Limited to on/off switching
- ✗ Higher prices

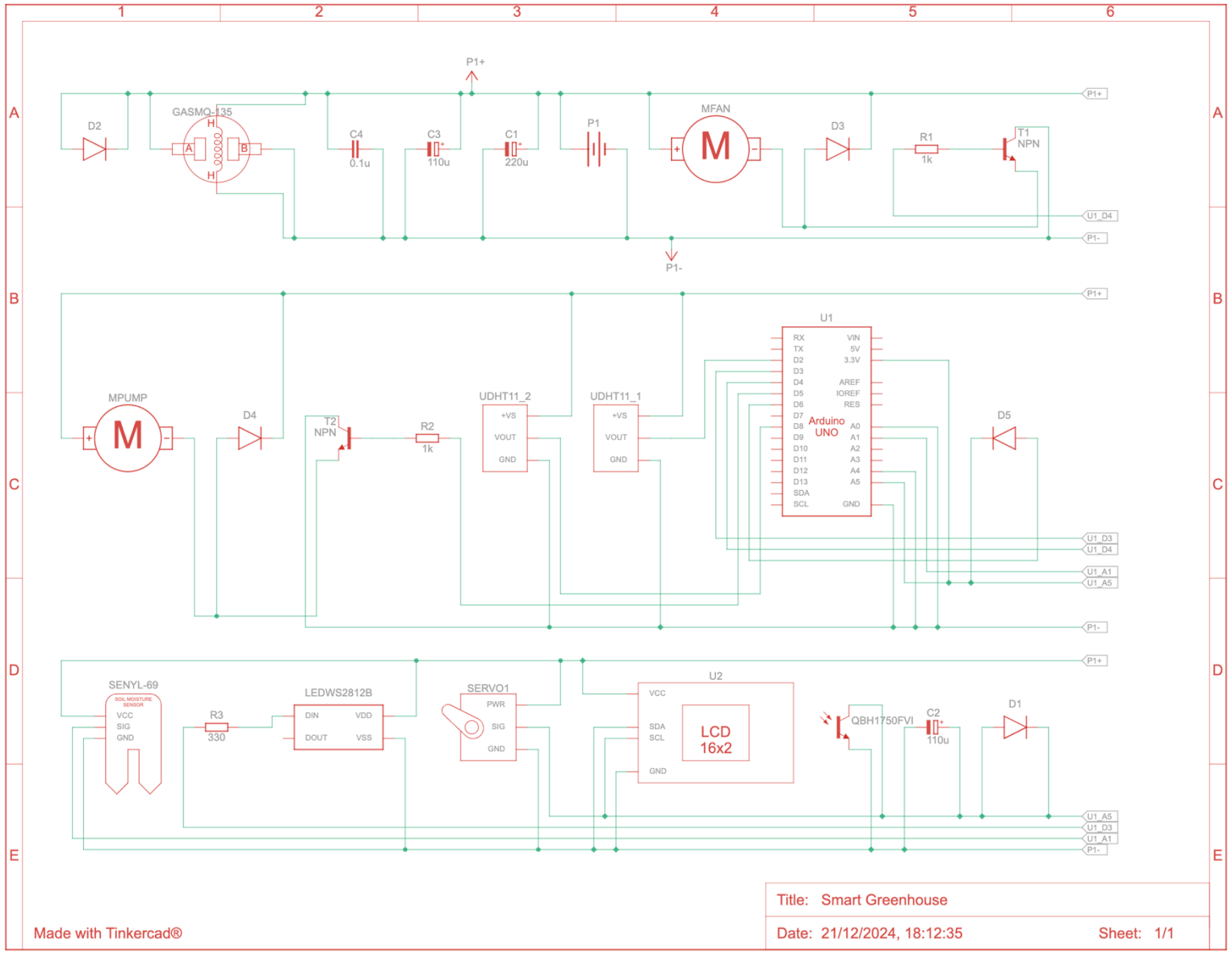
Project Prototype

Circuit and Schematic

Project Prototype – Circuit



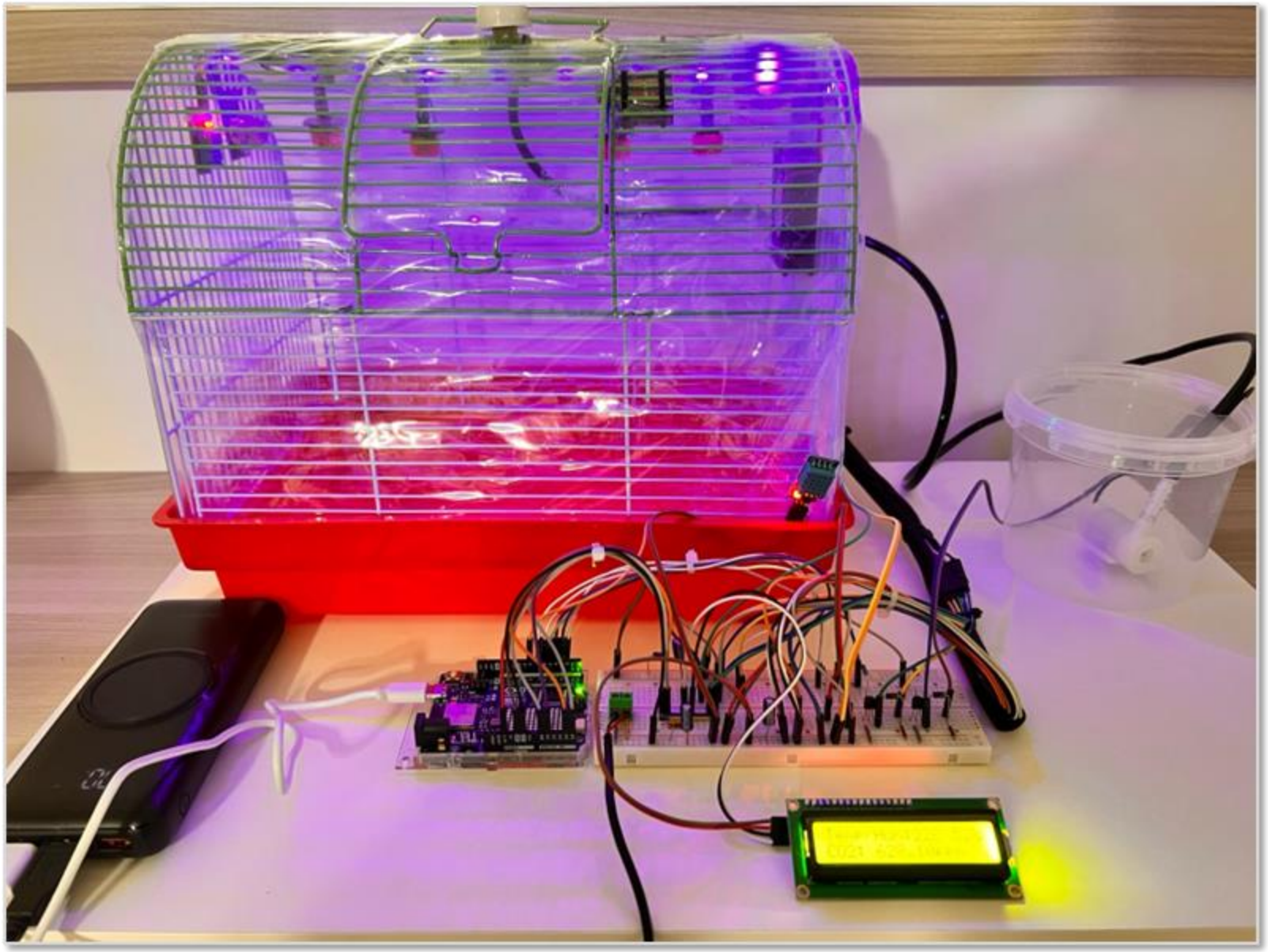
Project Prototype – Schematic



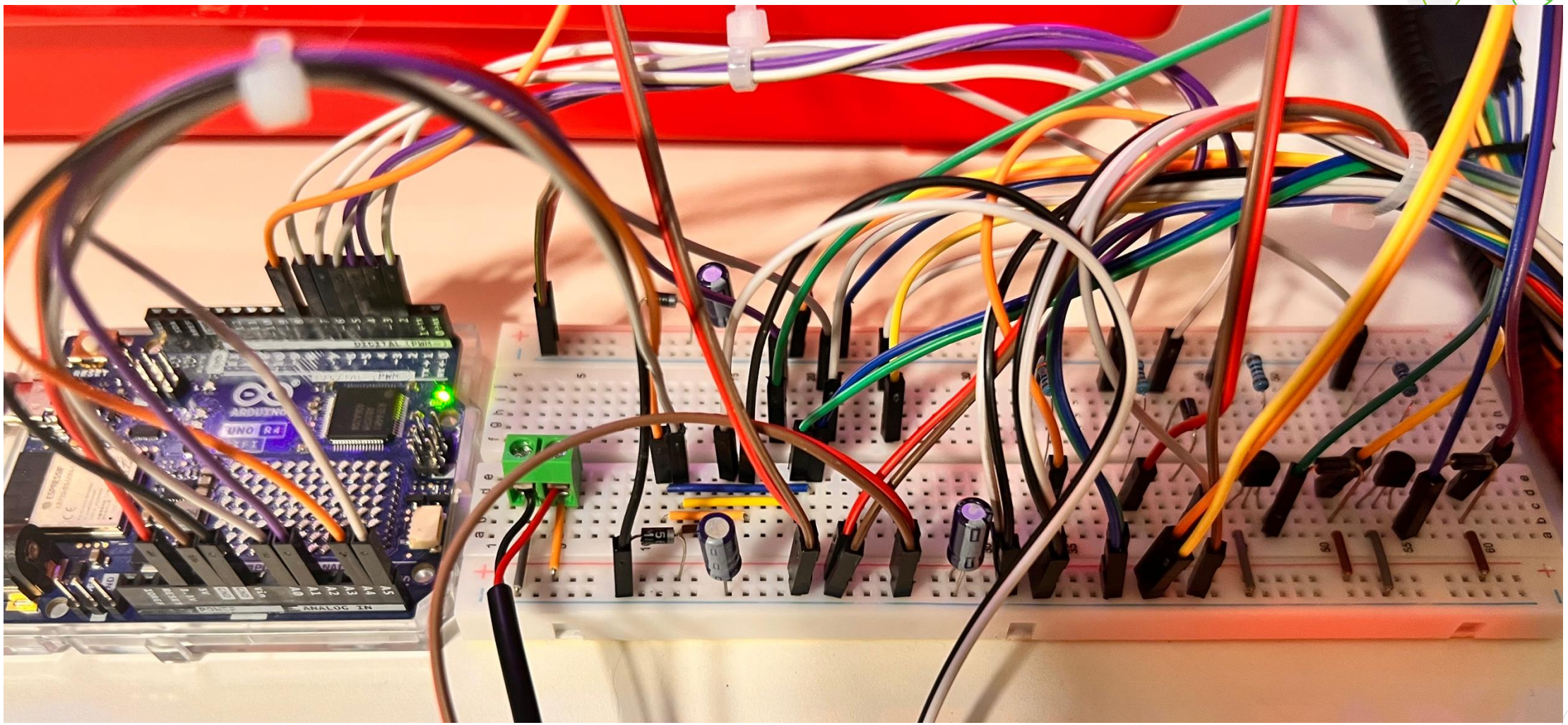
Project Implementation

Final project circuit and implementation

Project Implementation – Final Implementation



Project Implementation – Final Implementation



IoT Key Functionalities

WiFi Connectivity

MQTT protocol for lightweight, reliable messaging (from/to Thingsboard)

Automation Algorithms

Sensors trigger actuators based on **real-time environmental data**

Remote Control

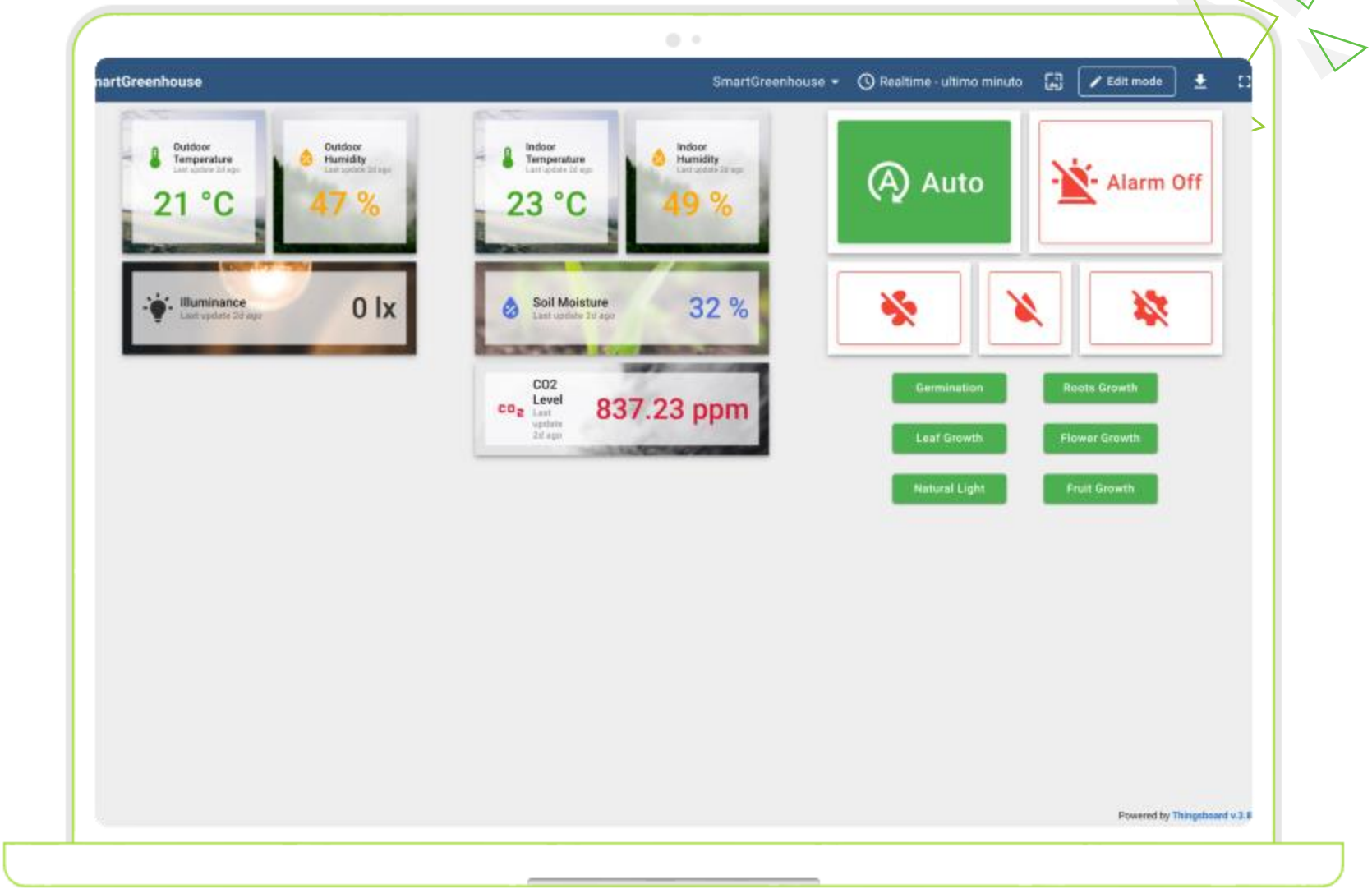
Remote commands to override automation

Smart Dashboard

Thingsboard dashboard to keep **everything under control.**

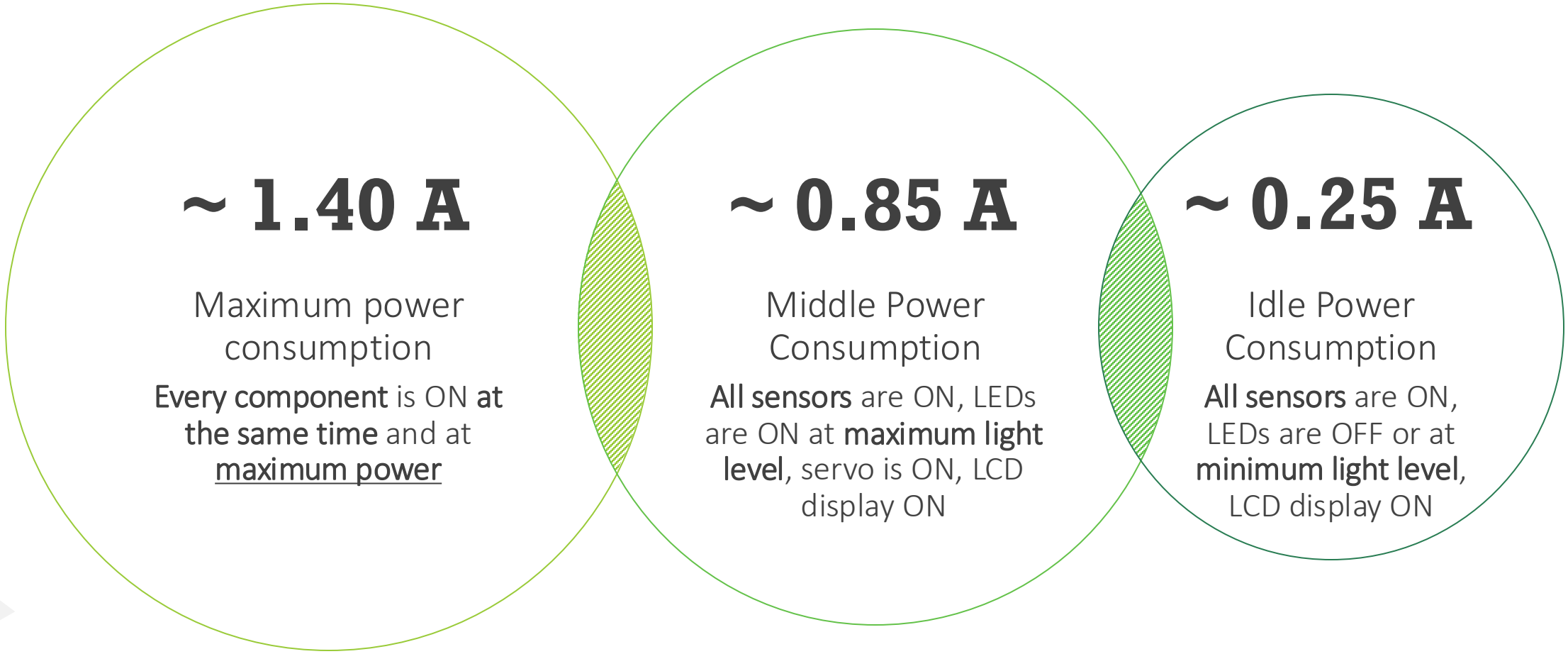
Functionalities:

- Monitoring temperature, humidity, soil moisture, CO2 level and light level.
- Auto or Manual Mode
- Fan, Water Pump, Servo ON/OFF switches
- Light preset controls to adapt to plant cycles
- Alarm mode



Power Consumption

Based on ACS712 sensor readings and calculated projections, considering the power consumption of each individual component.



Conclusion

Final thoughts and considerations

- A **comprehensive and efficient system** for managing a greenhouse environment.
- Demonstrates the power of **IoT** and **automation** in fields such as agriculture.
- **Low power** consumption.
- Opportunity for future improvements, such as **AI integration** for predictive analytics or **solar panel** implementation for power supply.

Thank You

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