Sensing System for Leaf Respiration: Measuring Vital Signatures in Plants

Ira A. Fulton Schools of Engineering
Arizona State University

Shiv Sugath, Ryan Ruvolo, Jaden Le

Introduction

- Monitoring plant vital signals is essential for environmental and agricultural research
- There is no widely accessible, reliable method for real-time plant-level monitoring

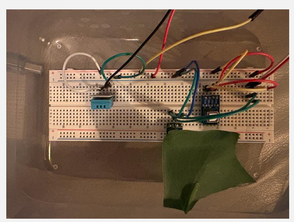
Our Approach

- Develop a low-cost, portable sensing system
- Enable real-time monitoring of CO_2, temperature, humidity, and light
- Provide a control system for regulating environmental conditions

Design Process

Prototype Development

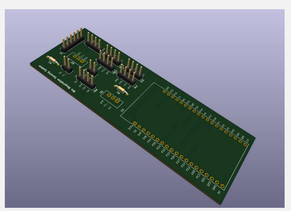
- Breadboard implementation to integrate sensors and ESP32
- Validated communication and initial data collection



Prototype

PCB Design

- Custom PCB developed for compact, reliable integration
- Improved wiring, stability, and scalability



PCB Design

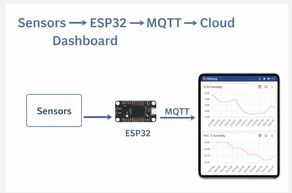
System Design

System Architecture

- ESP32 microcontroller control and communication
- Dual I^2C for multi-sensor integration

Sensors:

- CO_2: SCD41
- Temperature/Humidity: HDC1080
- Infrared Temperature: MLX90614
- Light (PAR): RS485 sensor



System Pathway

Communication & Data Flow

- Sensors -> ESP32 -> MQTT -> Cloud Dashboard
- Local data backup via microSD

Mechanical System

- Enclosed chamber to isolate a leaf
- Designed for controlled airflow and microclimate stability

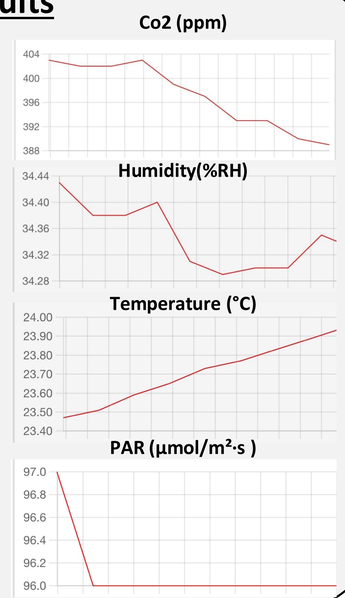
Results

Data Logging

- Real-time data recorded
- Reliable MQTT transmission to cloud dashboard
- Successful logging of CO_2, temperature, humidity, and PAR

Power Performance

- Low-power ESP32-based system
- Supports up to 24-hour battery operation



Field Implementation

Applications

- Plant respiration monitoring in agricultural research
- Studying gas exchange under varying environmental conditions
- Environmental monitoring in controlled or natural ecosystems

Advantages

- Low-cost alternative to commercial systems
- Portable and battery-powered
- Real-time wireless monitoring

Field Deployment

- Greenhouse testing for controlled experiments
- Long-term field deployment in natural environments

Conclusion

A portable, low-cost sensing system for leaf respiration was successfully designed and implemented. The system integrates multiple environmental sensors with an ESP32 microcontroller to enable real-time monitoring of key variables including CO_2 concentration, temperature, and humidity. Wireless communication through MQTT allows for efficient data transmission and remote access, while the modular design supports scalability and future expansion.