RUTGERS–NEW BRUNSWICK
Wireless Information Network Laboratory
School of Engineering

Internet of Plants: Low-Power Monitoring of Plant Health for Next-Gen Agriculture

A custom sensor hub collecting four complementary measurements of plant stress.

Ansel Kurien[UG], Cy Westbrook[UG]
Advisors: Aggelos Bletsas, Richard Howard

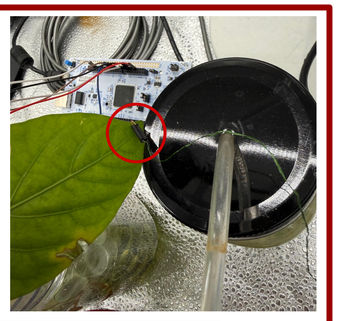
Abstract

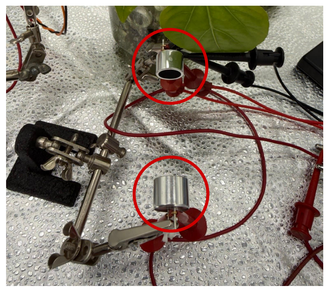
This project explores a low-power platform that combines differential temperature, Normalized Difference Vegetation Index (NDVI), and ultrasonic sensing to monitor plant stress. A custom sensor hub automates data collection and supports active and backscatter communication for scalable deployment.

Sensors Explored

Differential Temperature

- Measures leaf temperature relative to an inert reference.
- Tracks stress-related temperature changes over time.



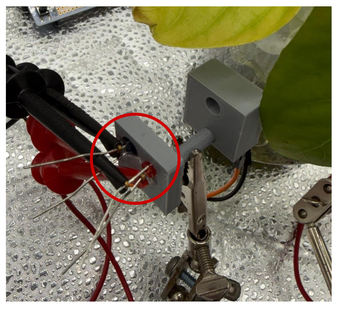


Active Ultrasonic

- Sweeps ultrasonic frequencies through the leaf.
- Measures signal attenuation to estimate water content.

NDVI Sensing

- Sends red and near-infrared light through leaf.
- Compares transmission to estimate chlorophyll content.



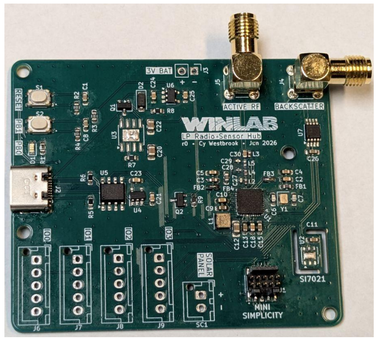
Passive Ultrasonic

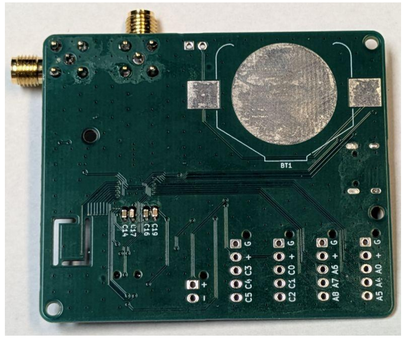
- Records ultrasonic clicks near the plant.
- Filters background noise to identify stress-related activity.

Radio Sensor Hub

A custom PCB enables low-power sensing and backscatter communication for sensor data.
Features:

- EFR32FG23 MCU
- Integrated 915 MHz radio
- RF switch for backscatter
- Si7021 temperature/humidity sensor
- Solar and coin-cell power
- Sensor I/O ports
- USB logging and debugging



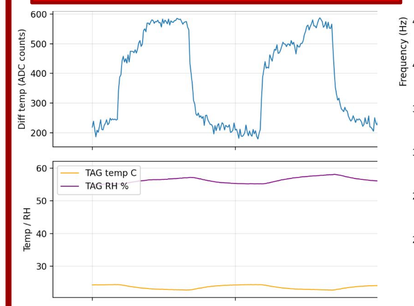


About Backscatter Radio

Backscatter encodes sensor data by rapidly switching the antenna and shifting reflected waves to an offset frequency. Reusing an incoming signal avoids power-hungry RF transmission.

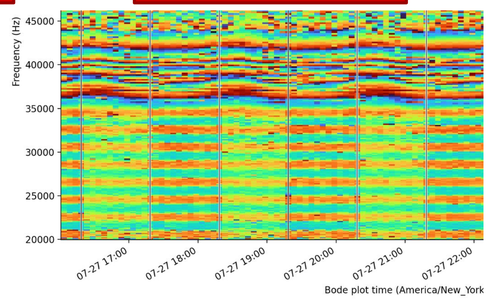
Results

Differential Temperature



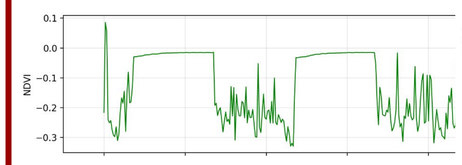
Differential temperature captured small leaf-to-reference changes across plant stress cycles.

Active Ultrasonic



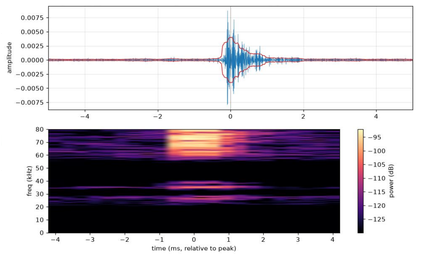
Active ultrasonic measured frequency-dependent attenuation through the leaf, indicating changes in water content.

NDVI Sensing



NDVI compared red and near-infrared transmission to track changes in chlorophyll content.

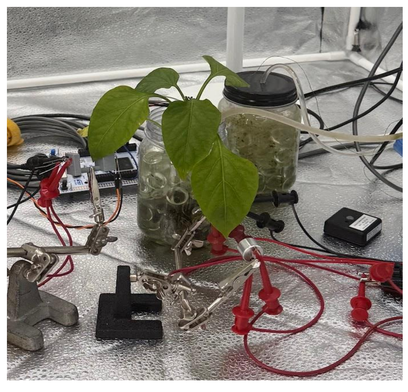
Passive Ultrasonic



Passive ultrasonic captured stress-dependent click activity near the plant stem.

Testing Chamber

- Automated pumping cycles hydrate and drain the plant, causing plant stress
- Raspberry Pi records synchronized sensor data.
- Light-sealed chamber maintains controlled conditions.



Future Work

- Connect chamber sensors directly to the radio hub.
- Build weatherproof enclosures for sensors and electronics.
- Manufacture preassembled hub PCBs at mass scale.
- Deploy the sensor network in large agricultural environments.

WINLAB
WIRELESS INFORMATION NETWORK LABORATORY