Your Smart Automatic Humidifier

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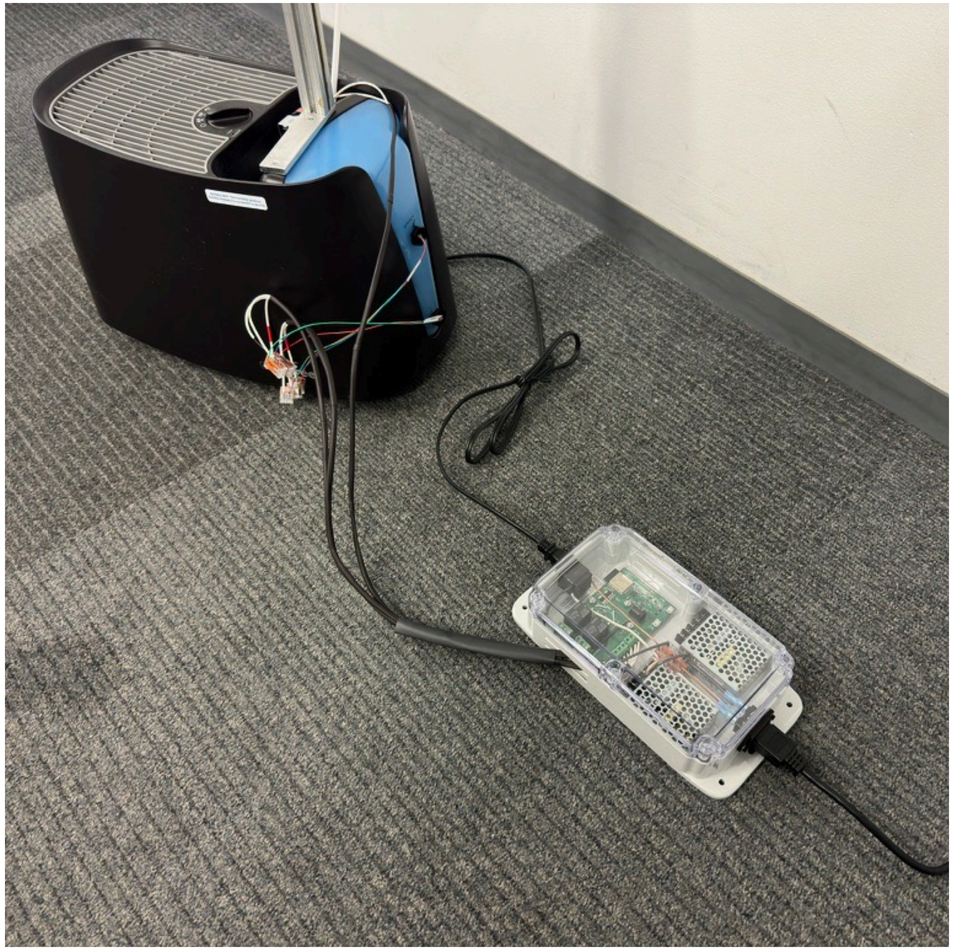
Agenda

- Problem & Solution
- Visual Aid
- High Level Requirements
- Block Diagram
- Webserver and Algorithm
- RV Table
- Project Achievements
- Future Plans



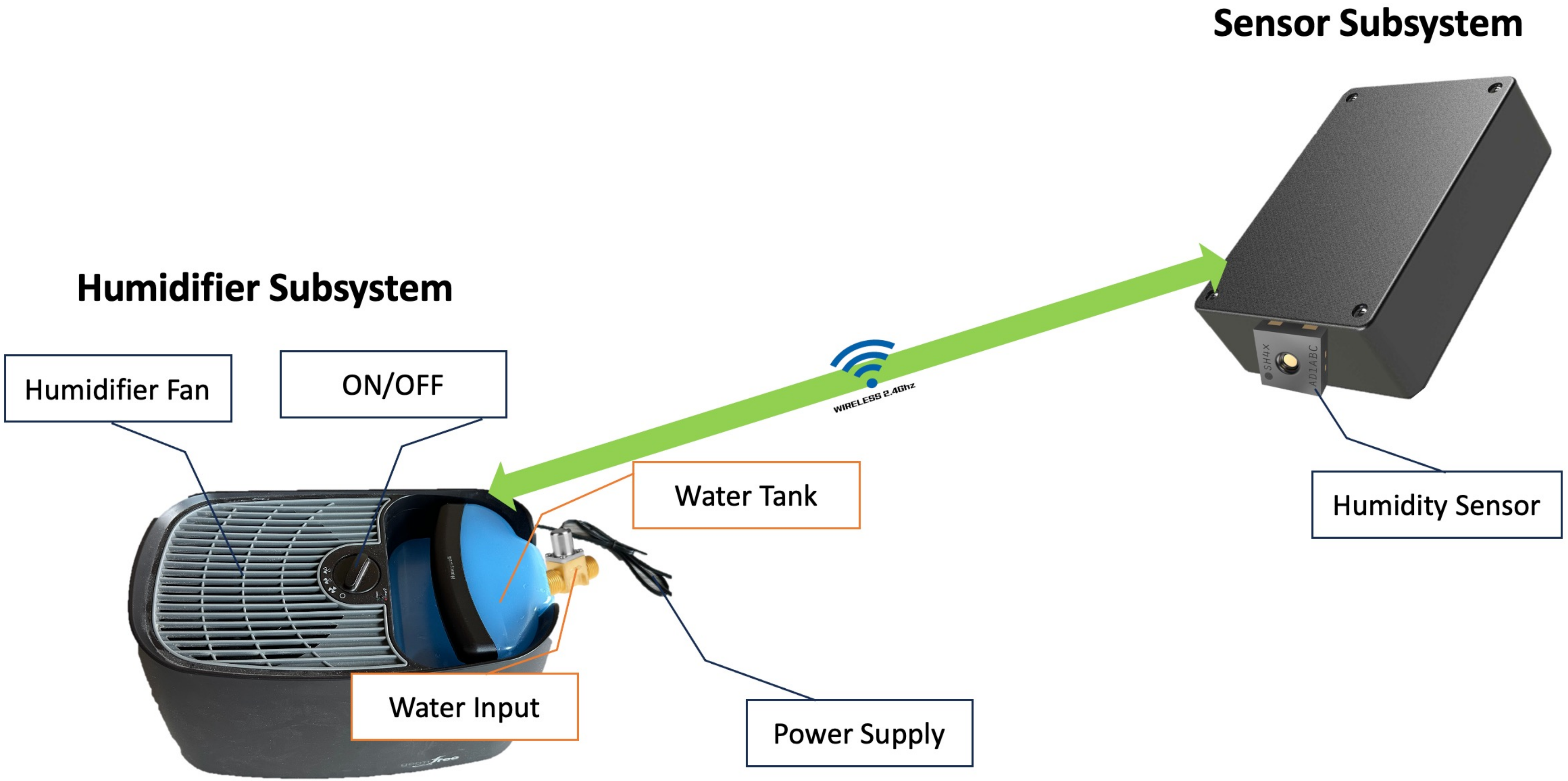
Problem

- Environmental Protection Agency highly suggests 30-50% humidity indoors
- Chemicals, gasses, pollen, mold, and other particles are reduced
- Most cheap humidifiers are bad for the user's health
    - Warm mist – cause nasal passages to swell
    - Ultrasonic – displaces minerals and bacteria
- Manual humidifiers can over/under humidity
- Humidifiers on market need manual water refilling

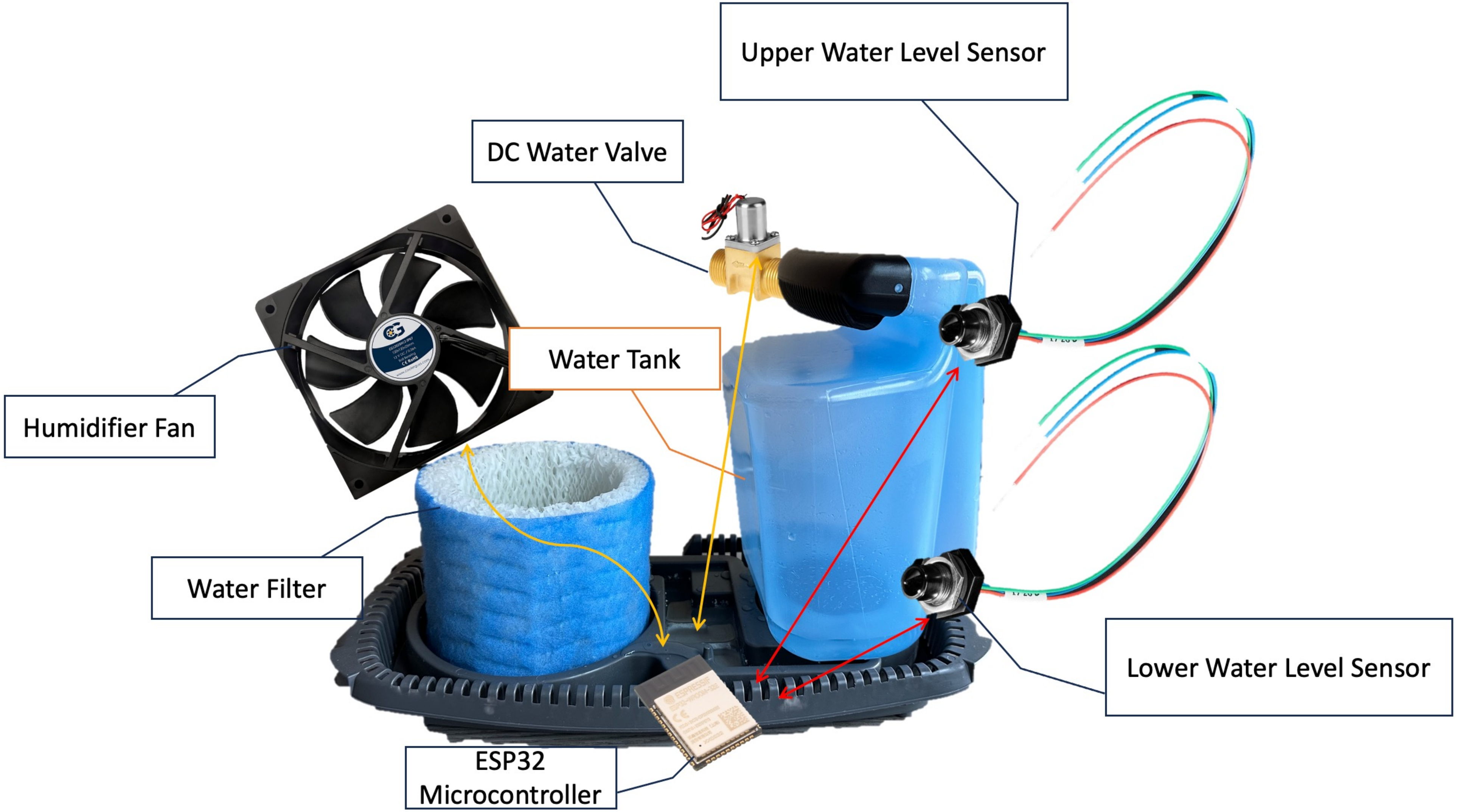
Solution

- Cool mist humidifier
  - Good for health
  - Evaporates water off filter
- Automatic on/off humidifier based on humidity
- Remote humidity sensing via 3 sensors
- Automatic water refill via water valve with water level sensing

Visual Aid


Sensor Subsystem
Humidifier Subsystem
Humidifier Fan
ON/OFF
WIRELESS 2.4Ghz
Water Tank
Humidity Sensor
Water Input
Power Supply

Visual Aid - Component



High Level 1

- Humidifier's ESP32 communication with three different sensors via 2.4GHz Wi-Fi
- Average humidity data from three sensors
- Create temperature dependent humidity calculation algorithm

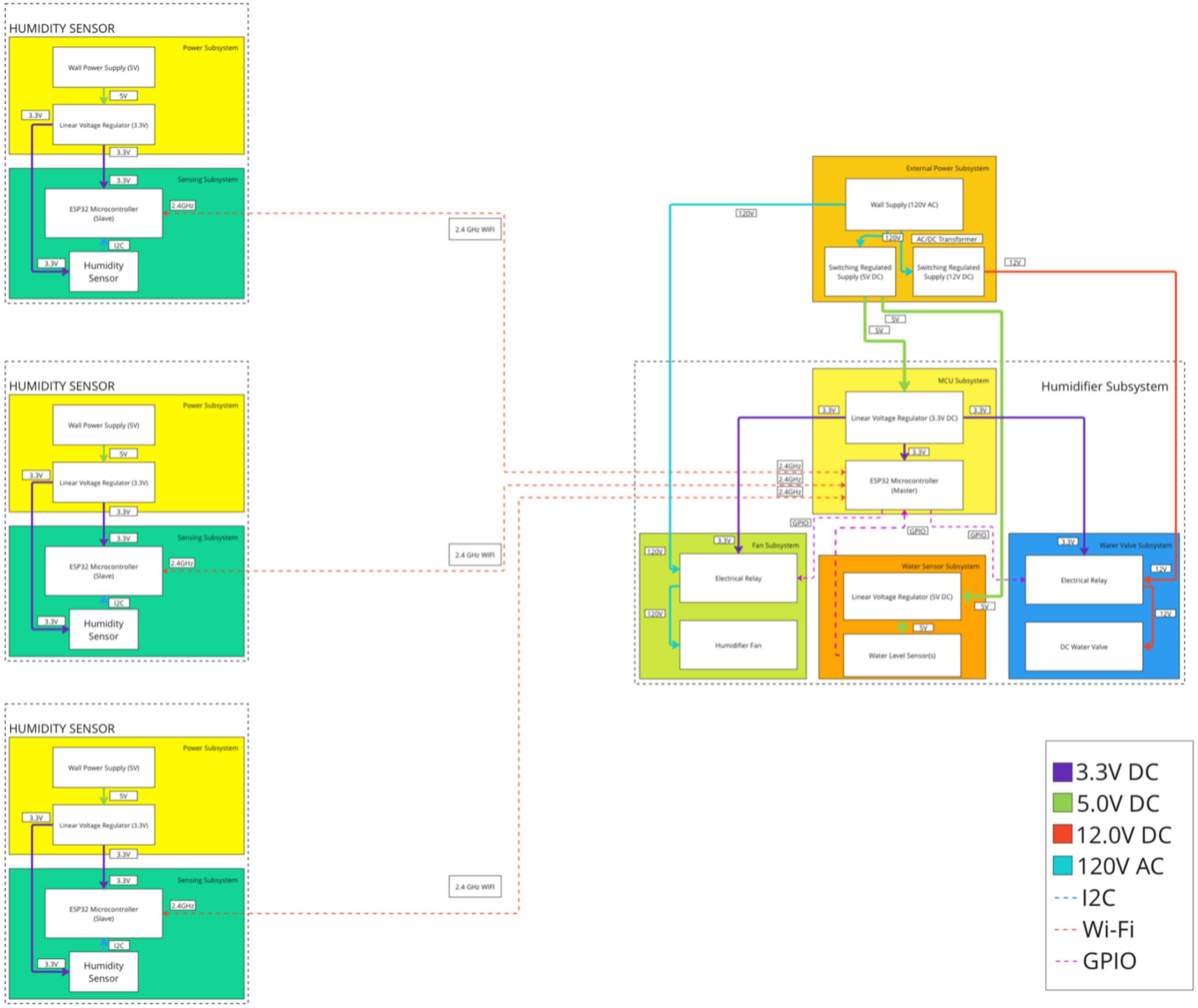
High Level 2

- Open/close valve to refill the water tank
- Two water level sensors GPIO input to ESP32
- Max capacity of the water tank: 4.16 liters
- Filter absorbs around 150 milliliters ± 5 milliliters
- Evaporation rate approximately 173 milliliters per hour (in 40% humidity room)

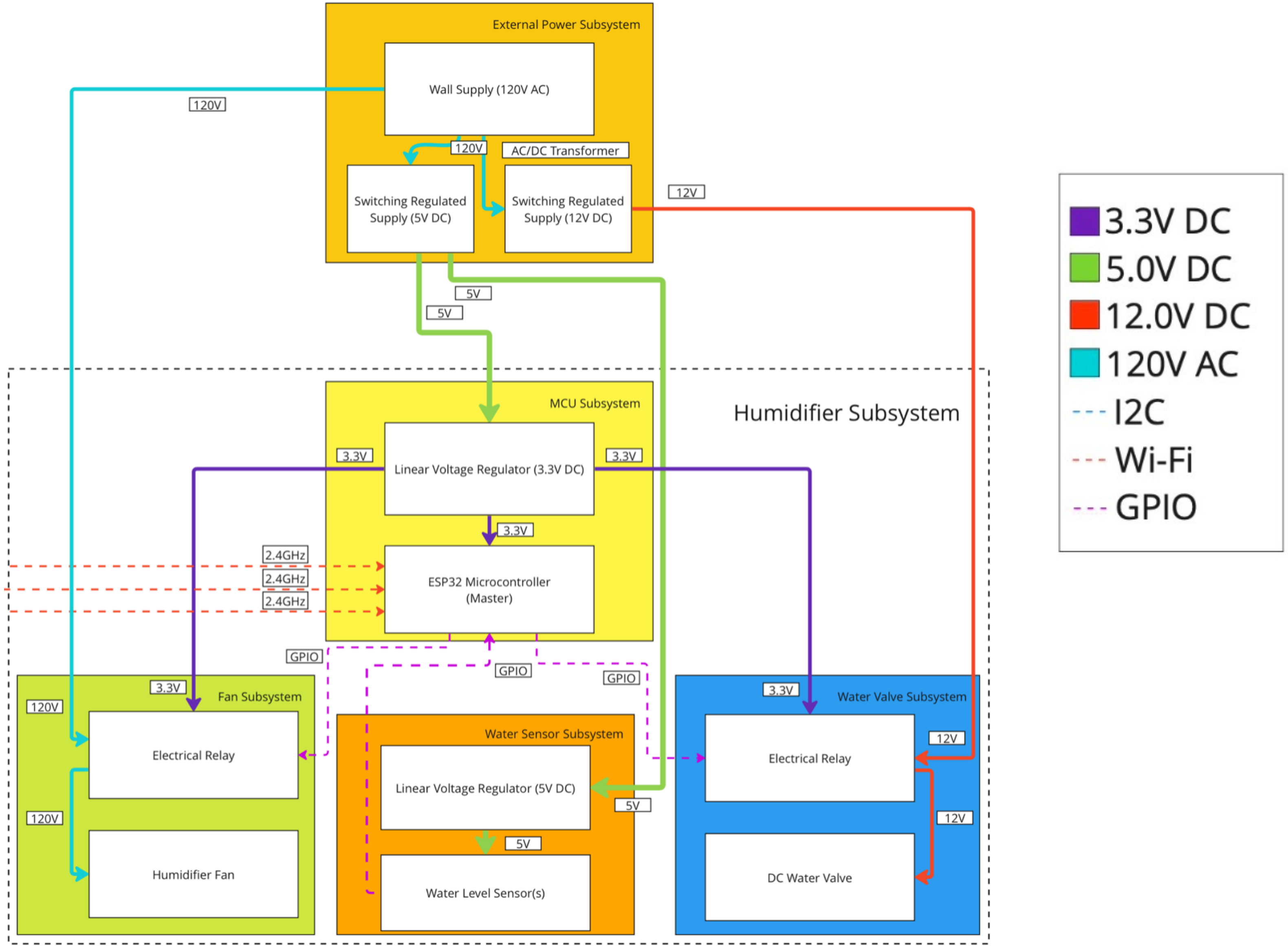
High Level 3

- On/off fan based on pre-configured ideal humidity range, 35% and 50% humidity, based on an algorithm averaging the readings from 3 sensors
- Actuate relay with LED output for ON signal
- Theoretical estimation of 44ns response time to on/off the humidifier’s fan (w/o runtime)
- High voltage (120V AC) components does not interfere with low voltage components (< 12V DC)

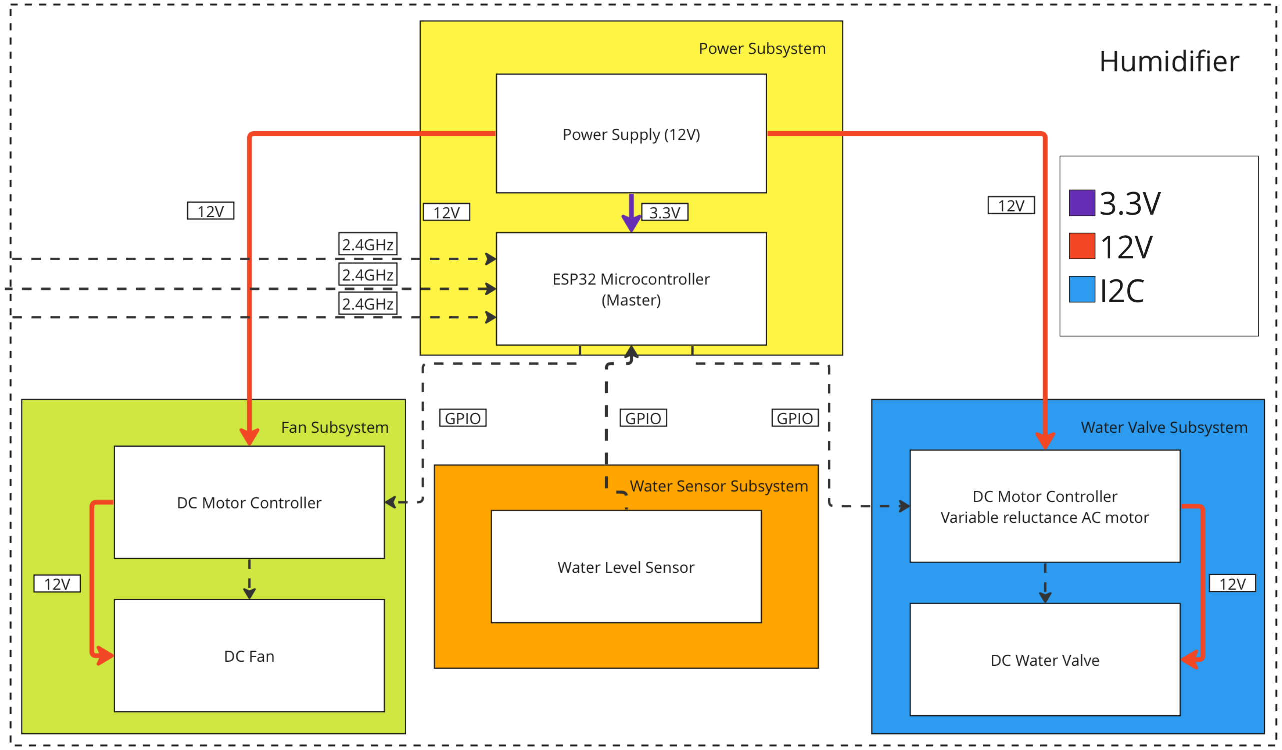
Block Diagram



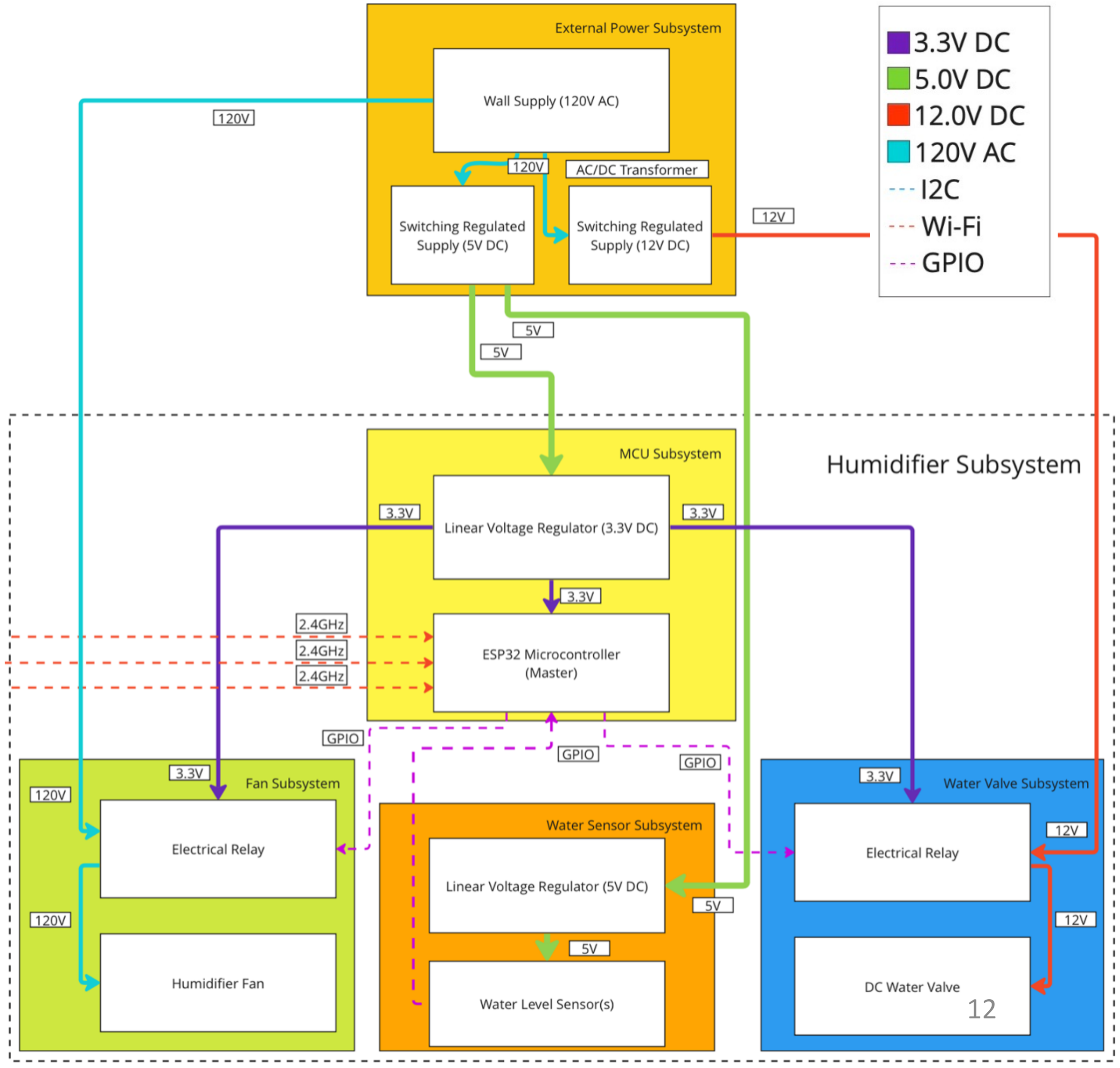
Block Diagram - Humidifier



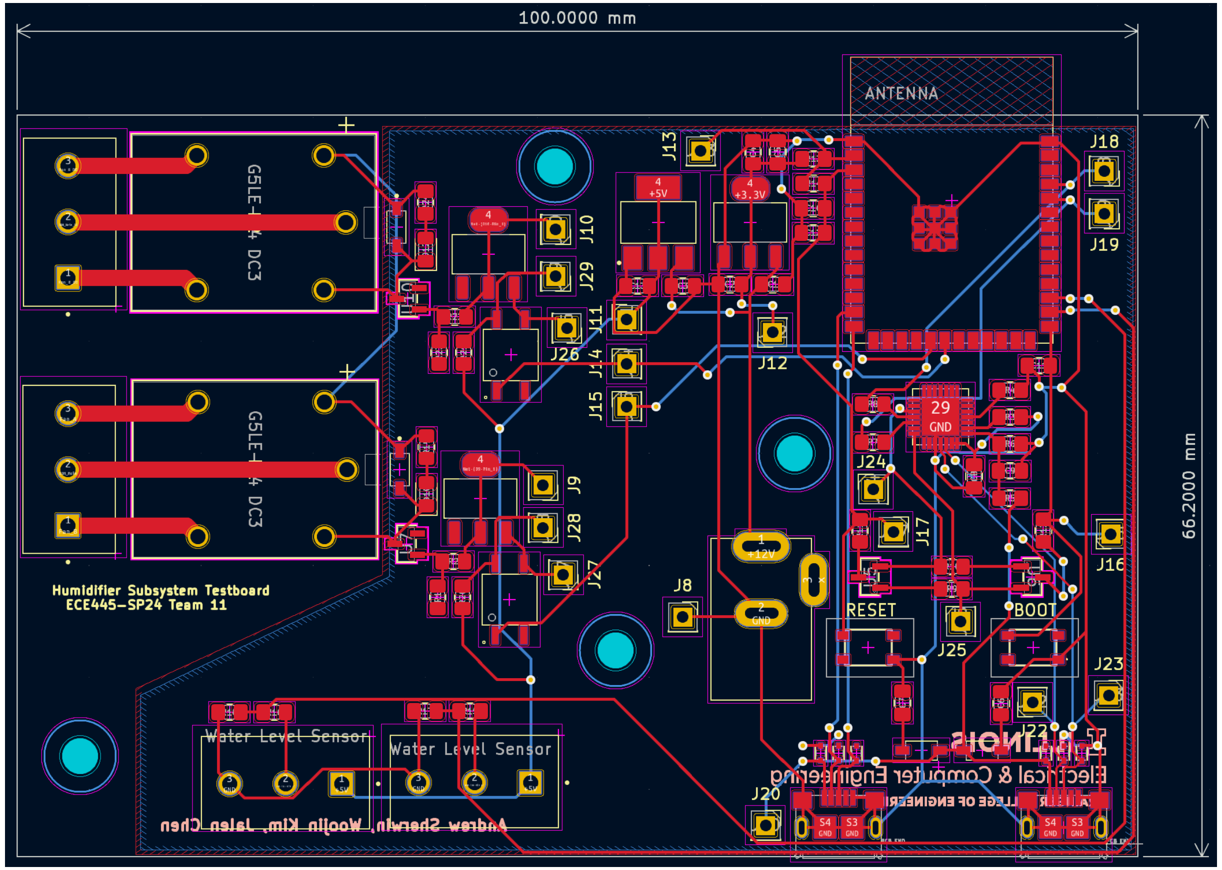
Current vs Original Humidifier Subsystem



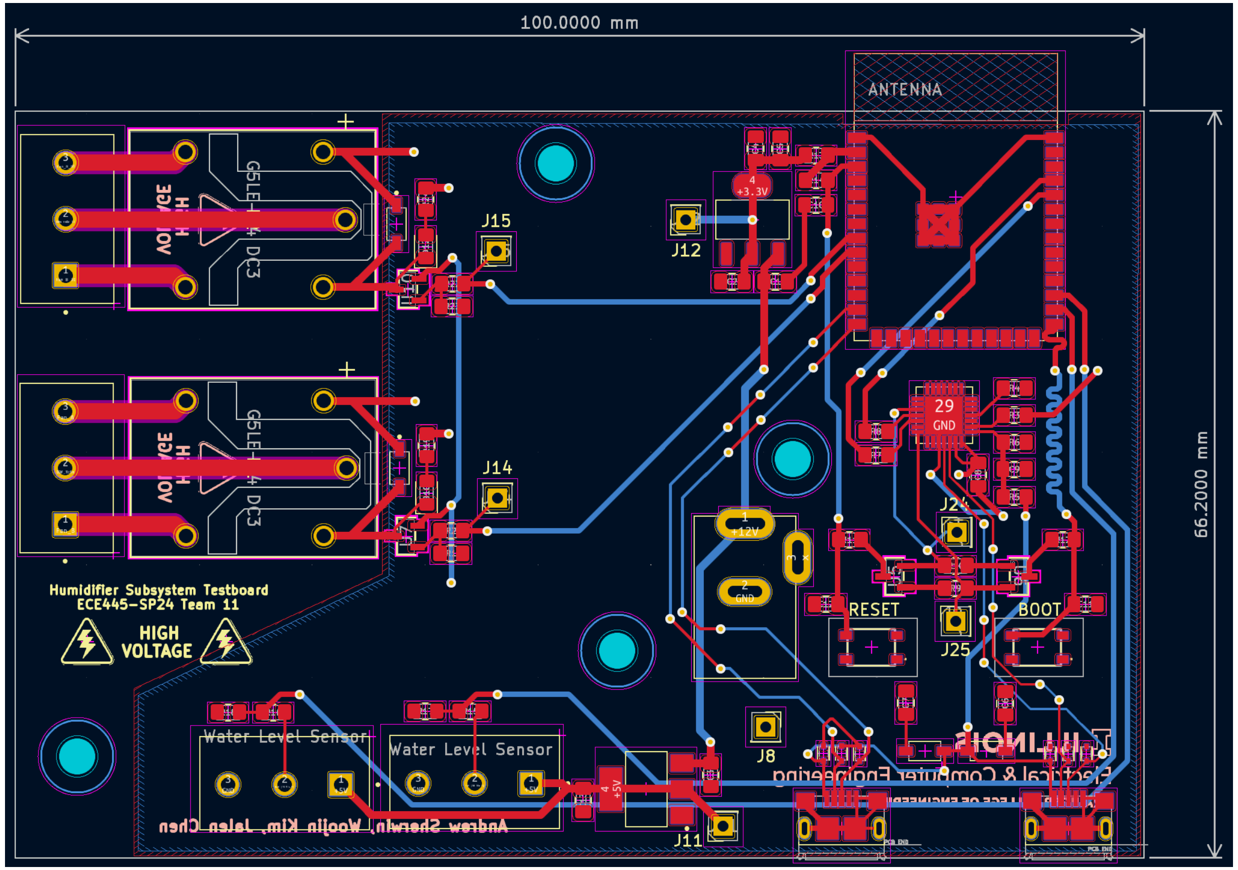
Original Block Diagram – Project Proposal



Humidifier Subsystem PCBs

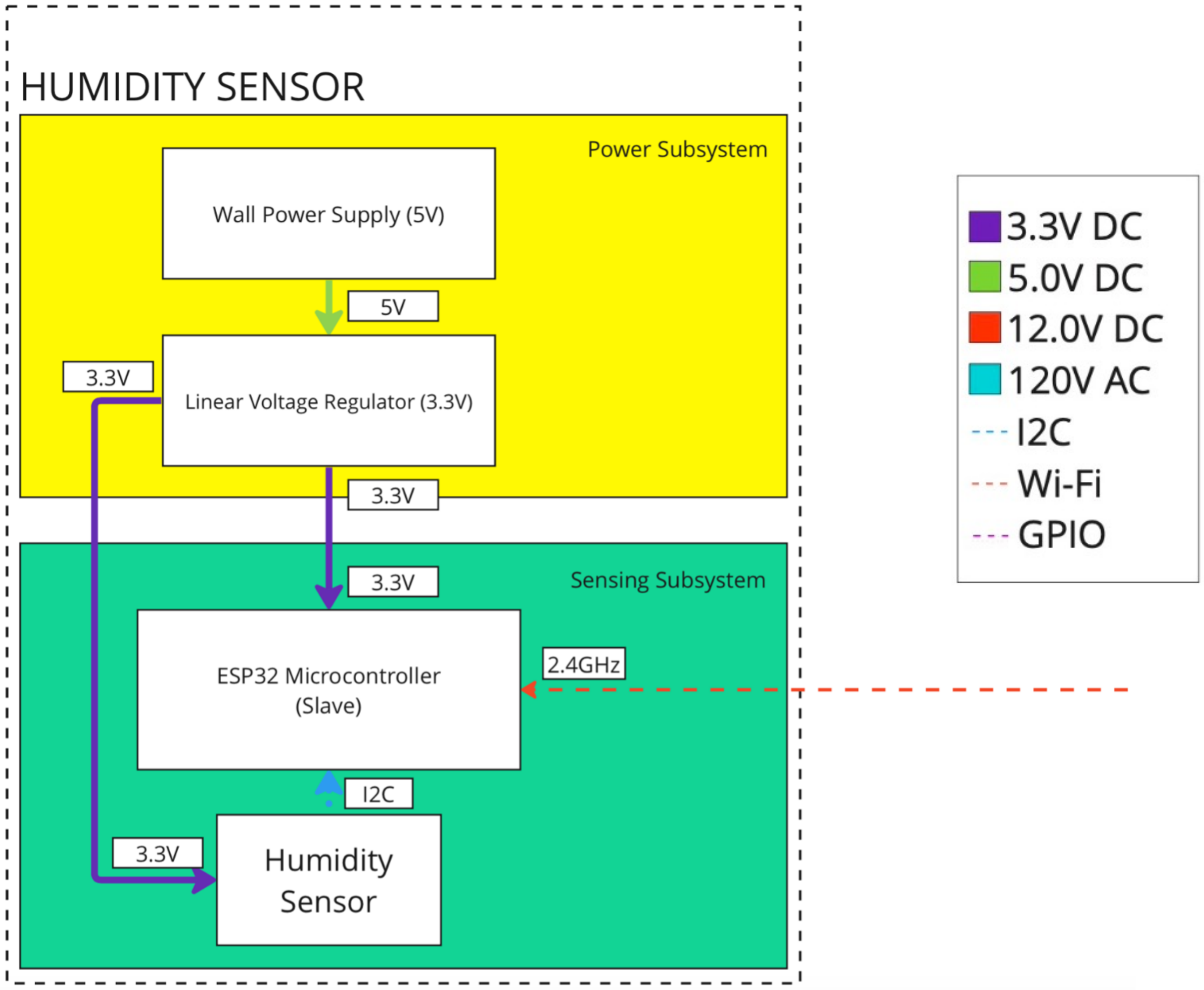


Humidifier PCB Rev0

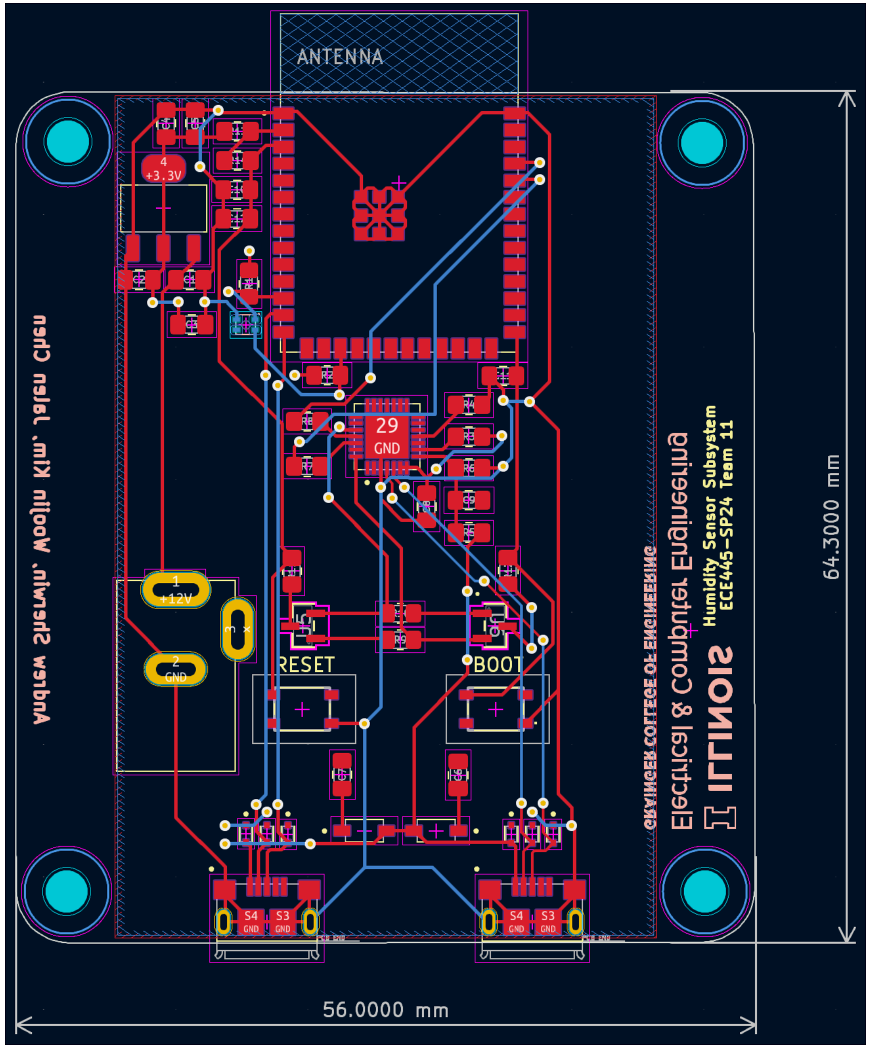


Humidifier PCB Rev4

Block Diagram - Sensor

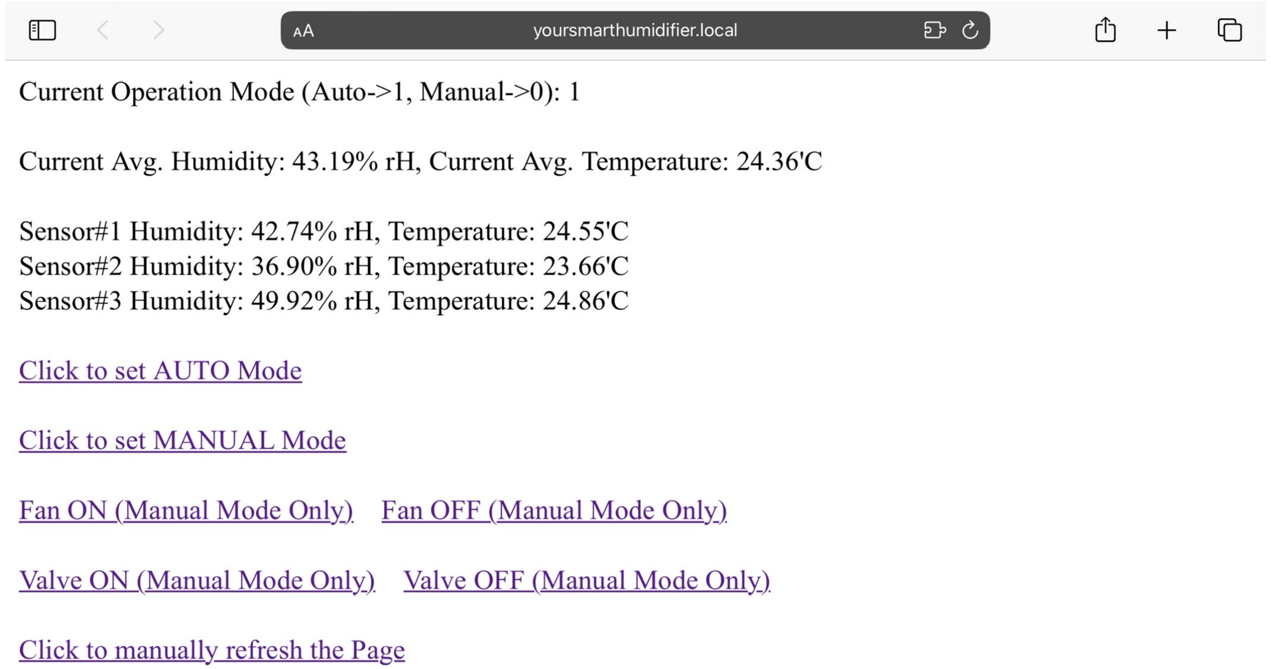


Sensor Subsystem PCBs



Humidifier PCB Rev0

Web Server & Algorithm



- WiFi access with mDNS

- Auto/Manual Mode

(Fan/Valve off when Auto->Manual)

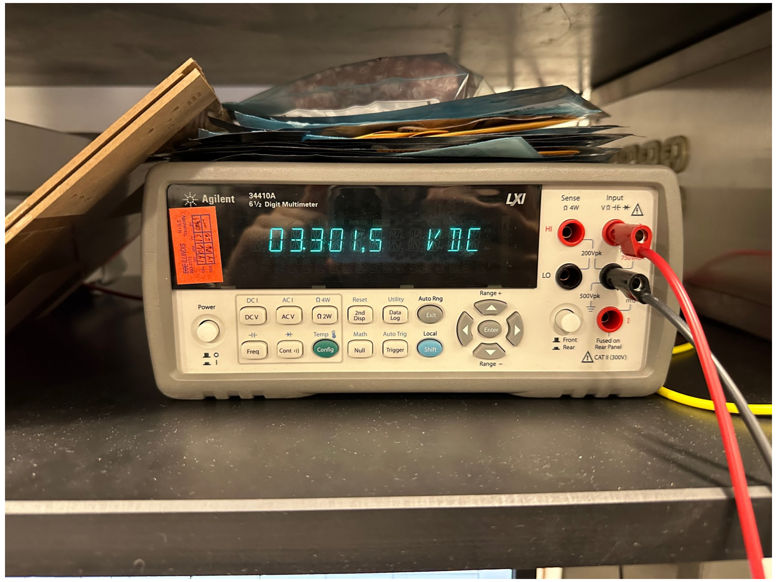
- Signal Loss Detection
- Refreshes every 2s

- Warmer air can handle more moisture
- -> new Humidity target based on average temperature

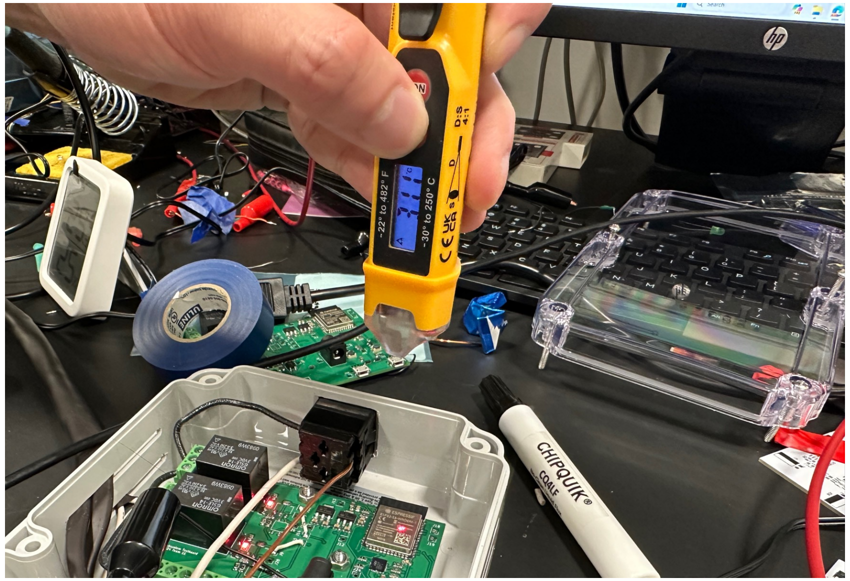
(if avg. Temp < 20'C -> 35~42.5% Rh)
(if avg. Temp > 22'C -> 42.5~50% Rh)
(else, 35~50% Rh)

RV Table – Central Humidifier Subsystem (1)

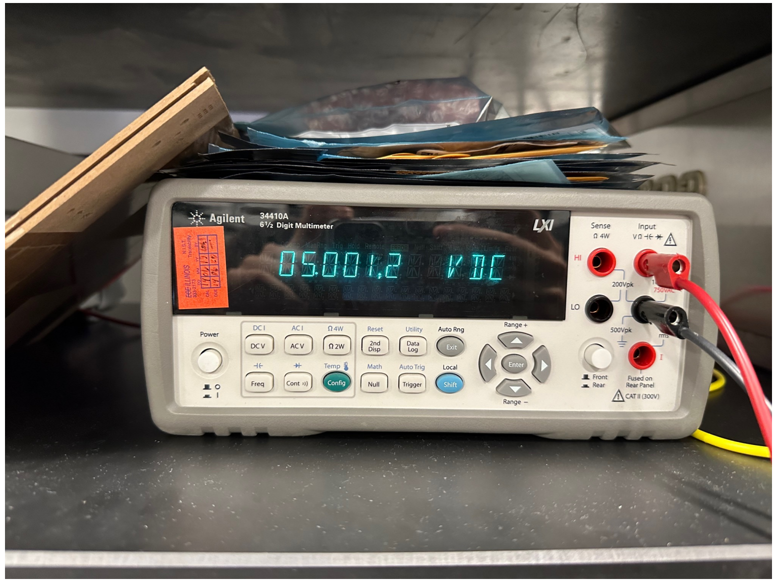
Requirements	Verification
• **Provide 3.3V +/- 0.5% from an input voltage of 5V +/- 0.1% DC source** • **Thermal stability maintains below 120'C**	• Use multimeter to test and take average voltage output over 1-hour to test stability • Monitor heat dissipation with thermal laser gun over an average of 1-hour use time, expected +/- 5'C under load



3.3V linear regulator output



Temperature reading with laser



5V linear regulator output

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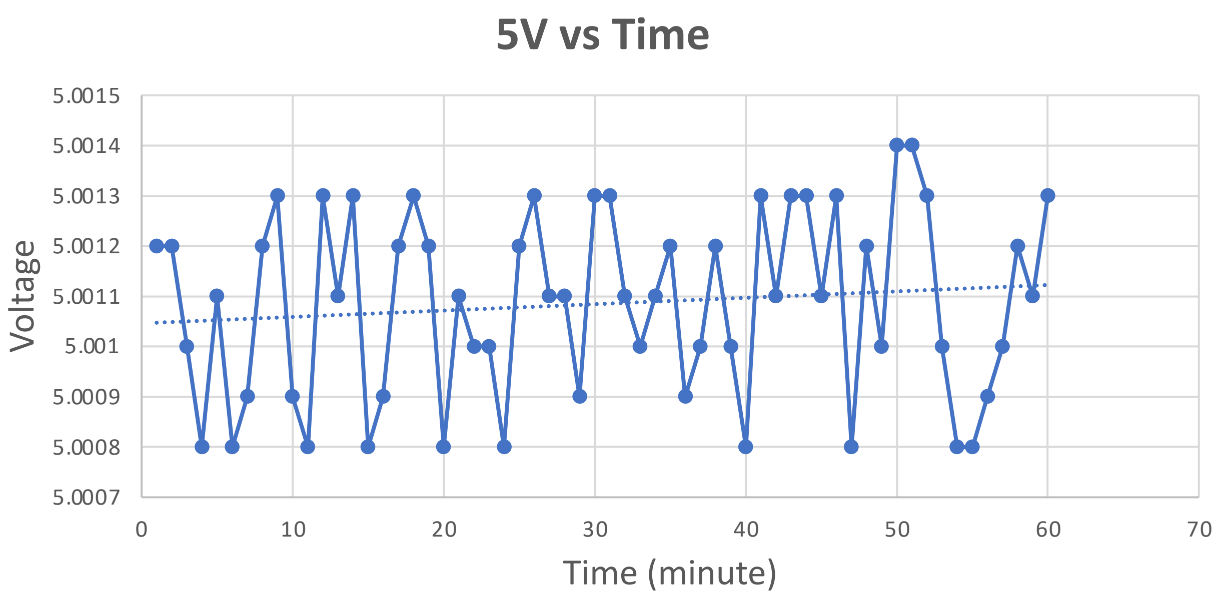

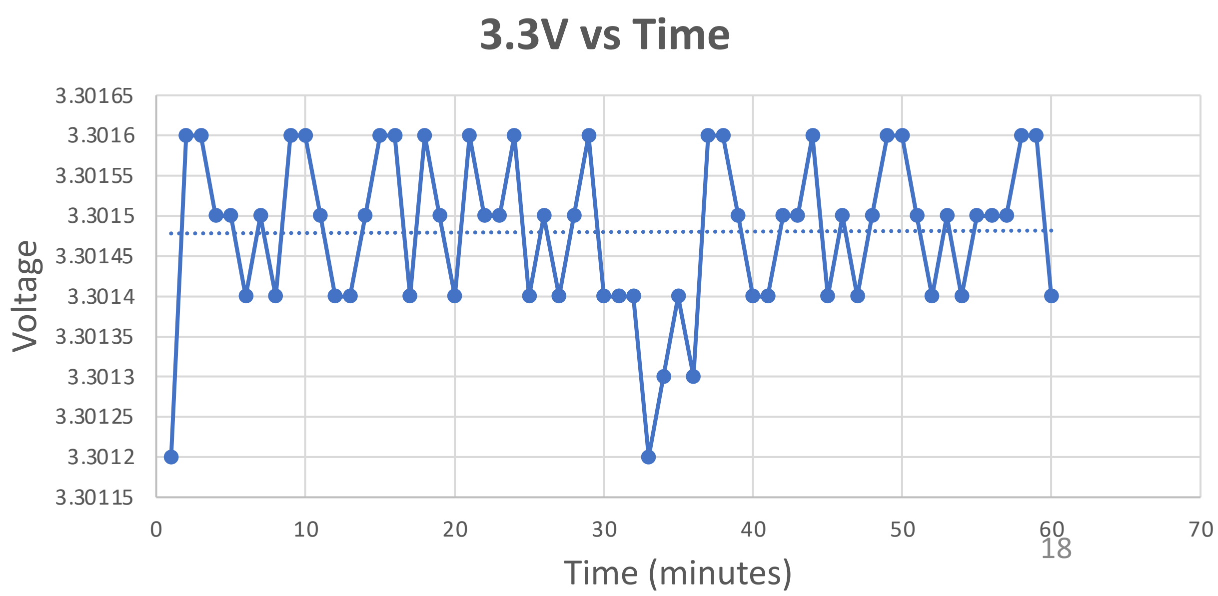

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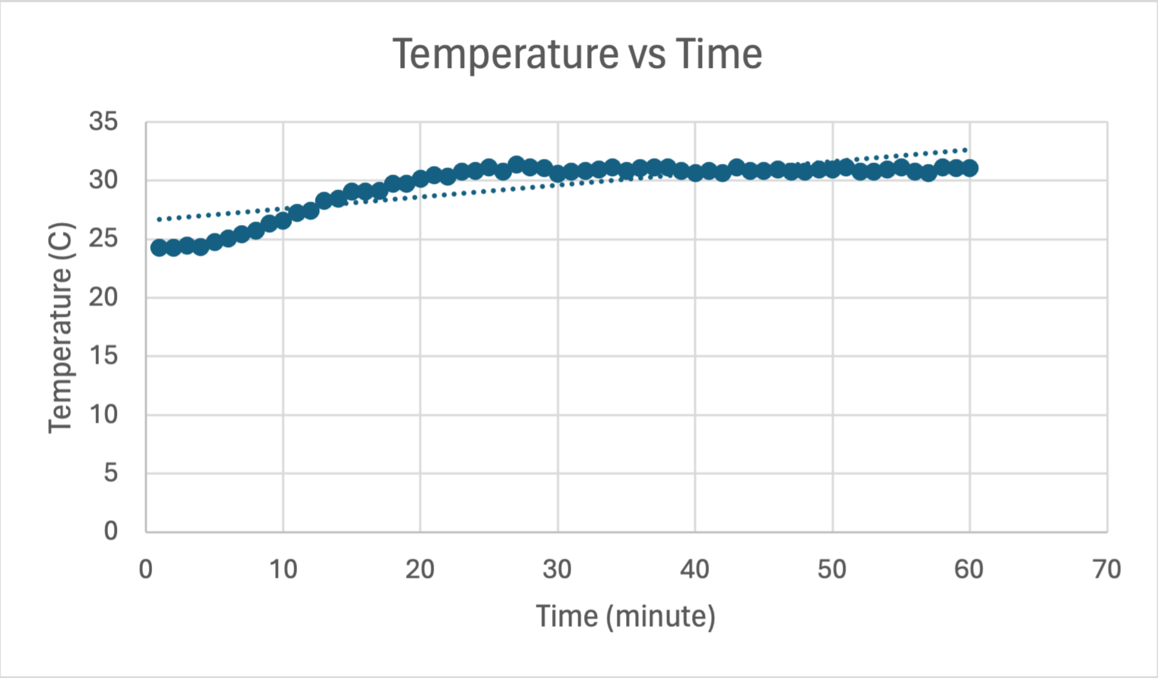
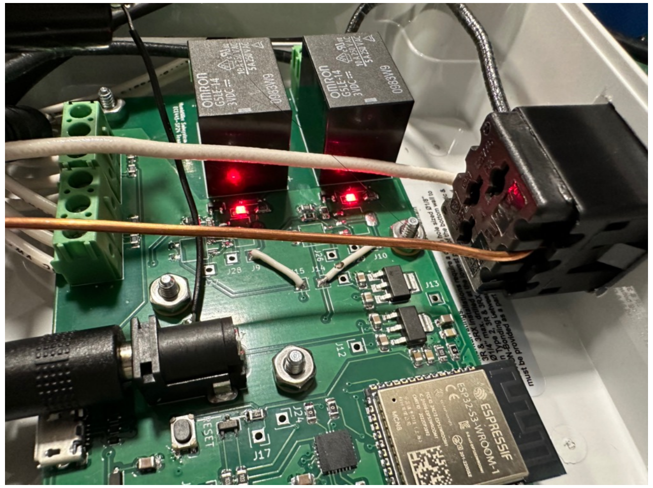
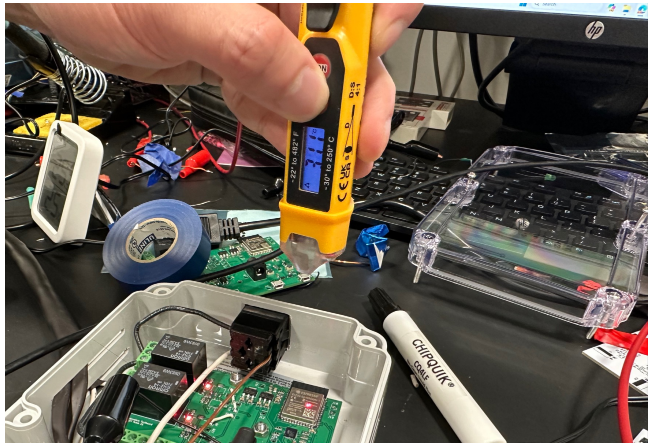


RV Table – Central Humidifier Subsystem (2)

Requirements	Verification
• **ESP32 communication with remote sensor ESP32 utilizing 2.4GHz Wi-Fi**	• Verify functionality of ESP32 Wi-Fi component by creating an access point, and accessing access point to remotely turn on LED lights • Verify communication between two ESP32 boards by sending command to turn on LED light from one ESP32 board • Verify thermal performance of ESP32 chip during operation by probing with a laser thermal gun



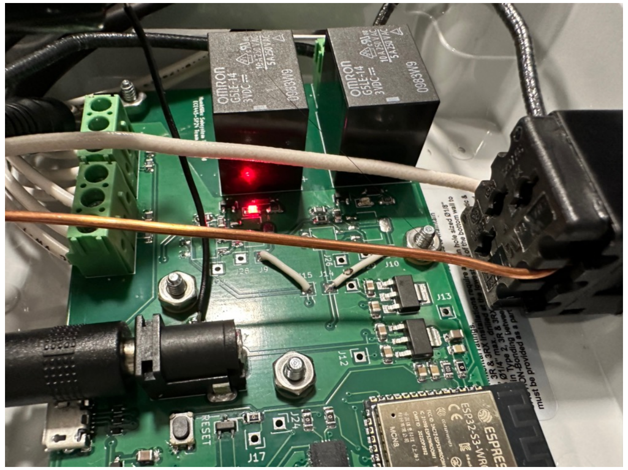
LED light control example



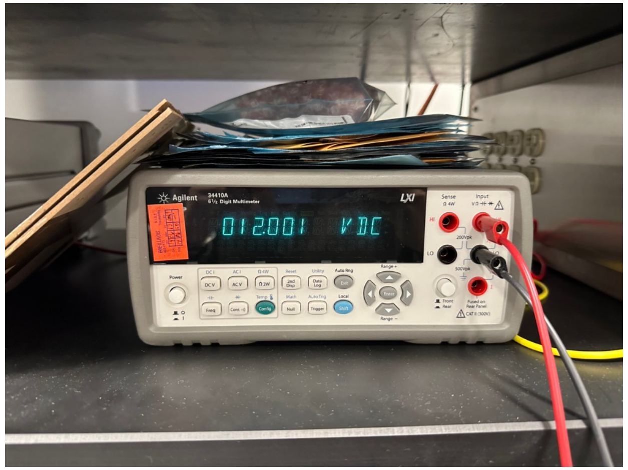
Temperature reading example

RV Table – Central Humidifier Subsystem (3)

Requirements	Verification
• **ESP32 control of activation and deactivation of water valve** • **ESP32 control of activation and deactivation of fan**	• Verify functionality of ESP32 communication with DC relay by sending activation signal to water valve/fan DC relay controller, and when signal is received, DC relay controllers output a lit LED light • Probe the output voltage of the DC relay controllers to make sure it is 12V +/- 0.5%



LED light when valve is on

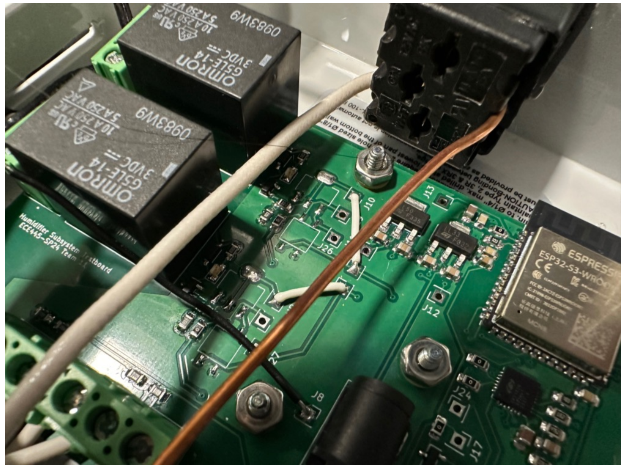


12V output to water valve

RV Table – Central Humidifier Subsystem (4)

Requirements	Verification
• **ESP32 detects signals from two water-level sensors**	• Contact/No Contact water to the water-level sensors and check through Arduino IDE to see if ESP32 receives contact/no contact signal from the two water-level sensors • Water level sensor low signal when in contact with water, and high signal when not in contact with water

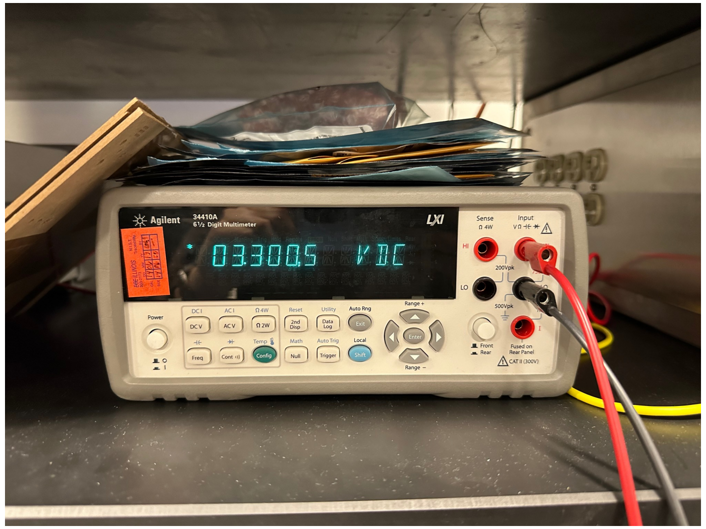
Water level sensor contact water



Water-valve off when water detected

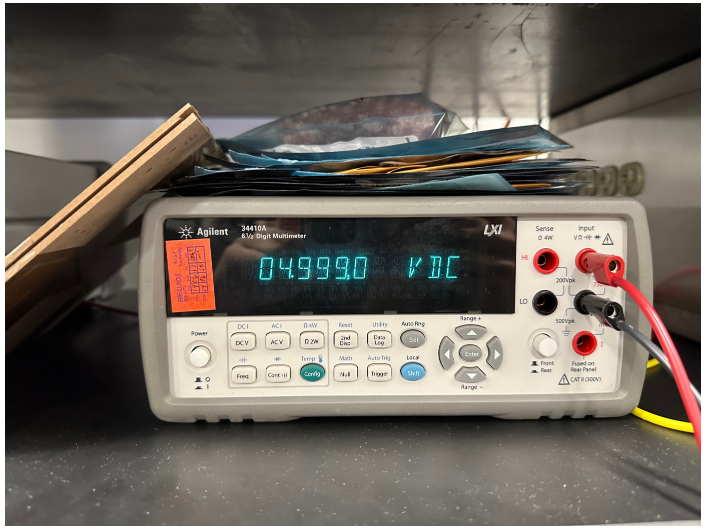
RV Table – Humidity Sensor Subsystem (1)

Requirements	Verification
• **Provide 3.3V +/- 0.5% from an input voltage of 5V +/- 0.1% DC source** • **Thermal stability maintains below 120’C**	• Use multimeter to test and take average voltage output over 1-hour to test stability • Monitor heat dissipation with thermal laser gun over an average of 1-hour use time, expected +/- 5’C under load



3.3V linear regulator output

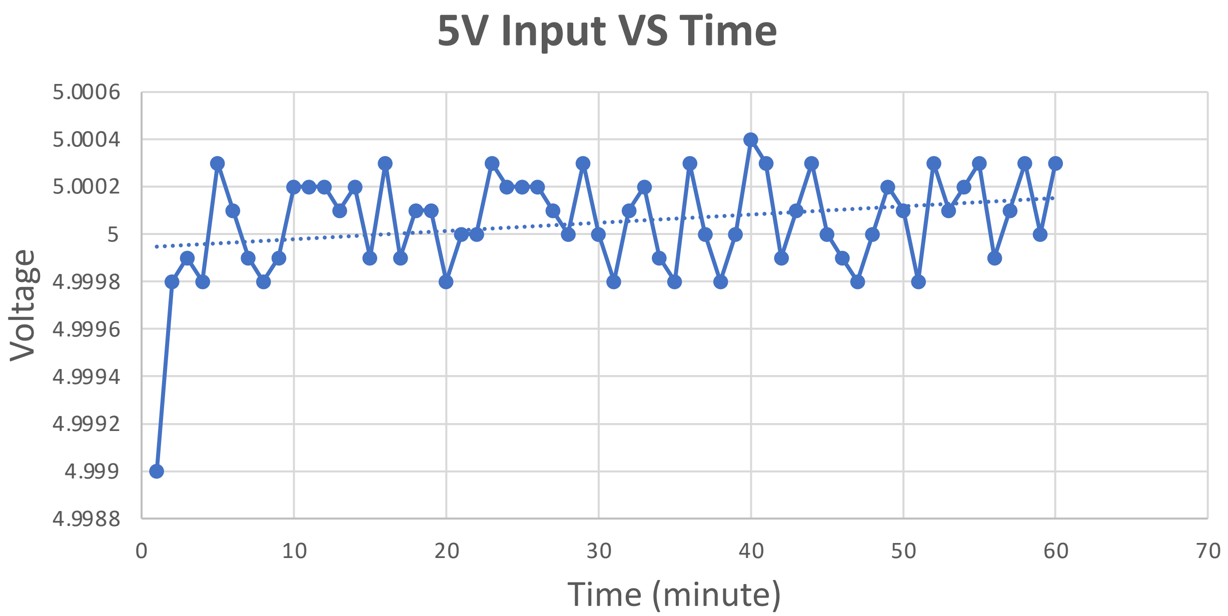

Temperature reading with laser

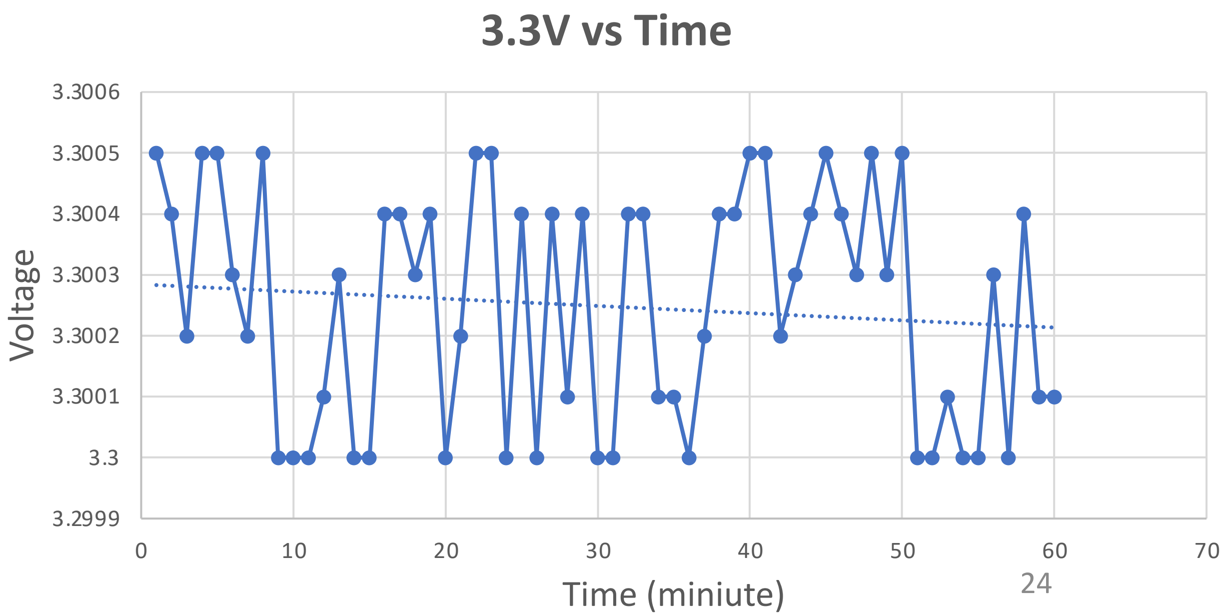


5V linear regulator output

RV Table – Humidity Sensor Subsystem (1)

Requirements	Verification
• **Provide 3.3V +/- 0.5% from an input voltage of 5V +/- 0.1% DC source** • **Thermal stability maintains below 120'C**	• Use multimeter to test and take average voltage output over 1-hour to test stability • Monitor heat dissipation with thermal laser gun over an average of 1-hour use time, expected +/- 5'C under load





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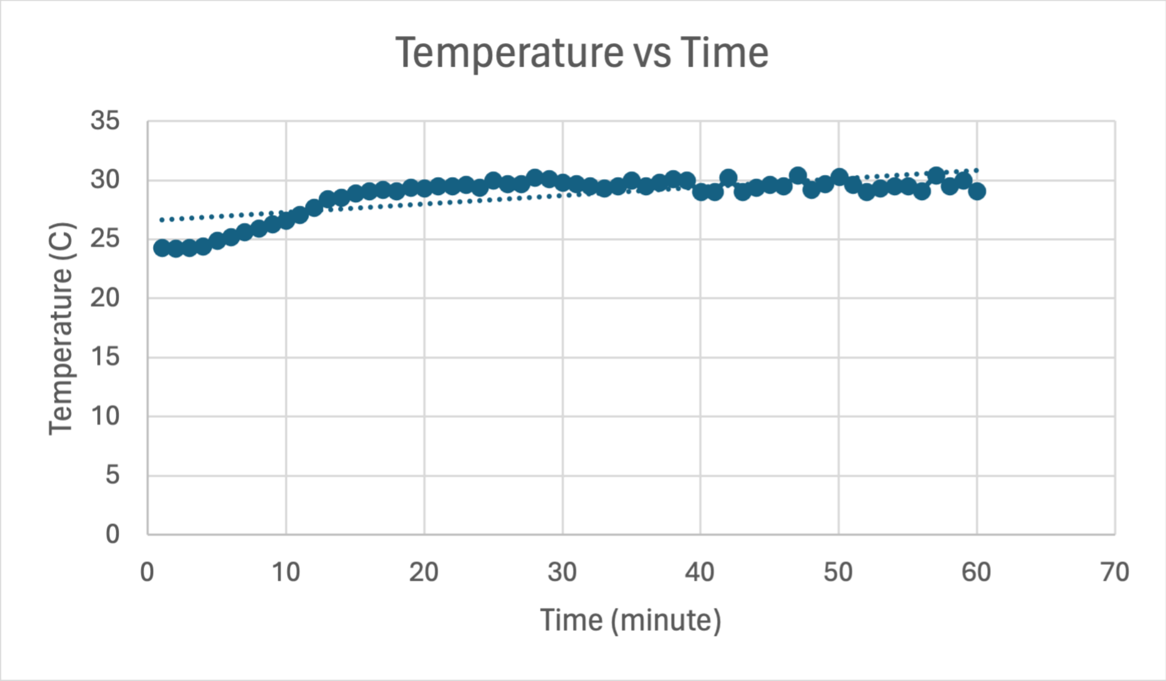
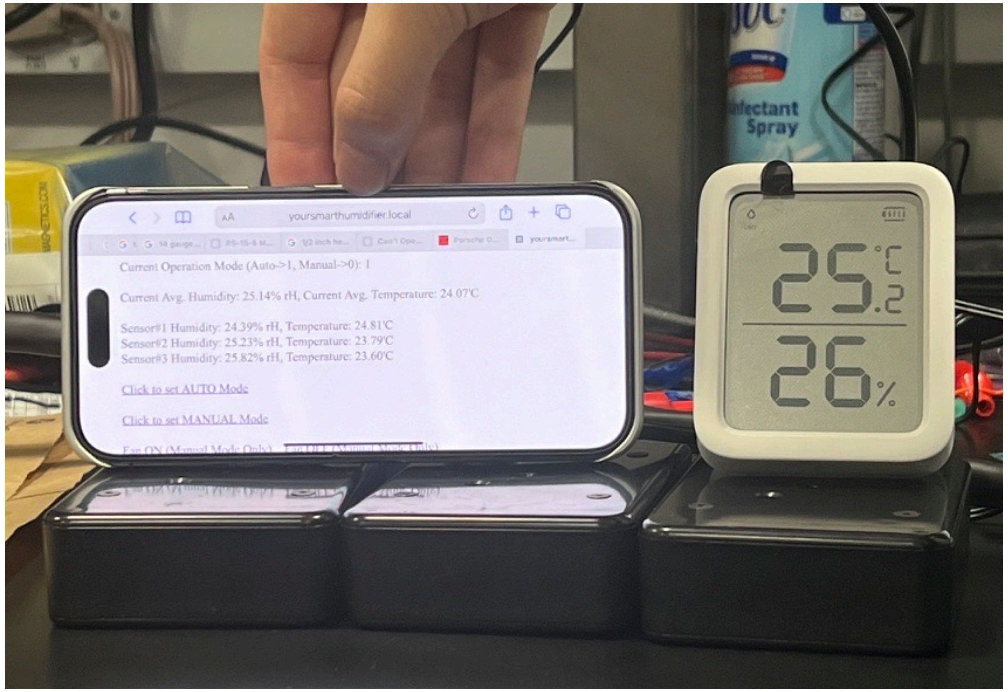


RV Table – Humidity Sensor Subsystem (2)

Requirements	Verification
• **ESP32 communication with humidity sensor receiving humidity data at least once in a minute** • **Humidity sensor measuring humidity data at least between 25% - 55%**	• Verify communication between ESP and humidity sensor Arduino IDE by checking humidity data ESP32 receives • Compare the humidity data received by ESP32 to the commercial humidity sensor and check if the humidity is within +/- 3% • Make the air dry/moist to see if the sensor can measure humidity between 25% - 55% • Exhale on sensor to see humidity levels are raised • Compare humidity reading with reference humidity reader



Commercial humidity and temperature sensor verification

Project Achievements and Successes

- Sensor Subsystem reads temperature and humidity data from SHT45
- Sensor Subsystem communicates with Humidifier Subsystem with Wi-Fi
- Humidifier Subsystem successfully activates humidifier
- Humidifier Subsystem successfully reads from water level sensors
- Humidifier Subsystem successfully activates water valve

- Bonus:
  - User Interface through access point to control Humidifier Subsystem
  - Reliability tested for 4 weeks, running 24/7

Challenges

- No failures on current design
- Hardware
  - Initial 12V input to PCB was too high for Linear Voltage Regulator
  - Relay design
    - Isolation, creepage, clearance
  - Optocoupler
  - SHT45 location and isolation
  - Modular overall design
- Software
  - Concurrent multi-node communication

Conclusion and Future Plans

- Integrate with Amazon Alexa, Apple HomeKit, and Google Assistant
- Change linear voltage regulator to buck converter
- Further compact PCB
  - Remove ESP32 programming components
- Create original AC/DC Converter if budget allows
- Improve PCB enclosure design
- Improve UI design
- Potentially remove water level sensor and water valve
  - Making product modular for all manual humidifiers

"Students learn the most then they struggle with challenges" - Minh Do

Your Oasis Awaits: Refresh, Rejuvenate, Breathe

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