Remote Area Monitoring

Group 10 : Wyatt Vining, Johan Castillo, Abhijeet Malviya, Nicholas Gonzalez

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Motivation

- Over 10 million acres of land consumed in 2020 alone
- Forest fires have a lasting impact on both the environment and those living within it
- We as perspective engineers have an opportunity to make an impact

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Goals and Objectives

- Gather Data for the Prevention of Forest Fires
- Create a network of sensing nodes capable of off-grid communications and operation
- Collect the data gathered by each node and aggregate the data in a database. This data may be exported or viewed for a historical representation of the area
- Each sensing node shall adopt a modular design
- All design files will be open source

Hardware Engineering Specifications

Requirement ID	Specification	Value
001	Range	400 Meters Minimum
002	Visual Camera	2MP Sensor SPI Interface
003	Infrared Camera	2MP Sensor SPI Interface
004	Power Reserve	3 Days on a Fully Charged Battery
005	Charging	3 Watt Minimum PV Panel – Wall charging option
006	Physical Dimensions	6in x 6in
007	Wind Speed and Direction	+- 5% Accuracy
008	Humidity Sensor	Accuracy +- 3%
009	Temperature Sensor	Accuracy +- 0.5C
010	Barometer	Accuracy: +-5kpa
011	TVOC Sensor	Detects 1000ppm change in TVOCs
012	Carbon Monoxide Sensor	Detects 1000ppm change in CO
013	GPS Module	15m Radial Accuracy
014	Soil Moisture Sensor	Detects 1 Drop of Conductive Liquid
015	Rain Level Sensor	0.2794mm per step

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Software Engineering Specifications

Requirement ID	Specification	Description
016	Application	Web application to display real time and historical data
017	Map View	Show each node on a map with the status of the node
018	Map Overlay	Display a gradient on the map representing the environmental conditions such as temperature
019	Off-Grid Network	Network for communicating to and from the nodes without relying on established networks such as cellular
020	Database	Store a minimum of 5 years of sensor data
021	Number of Nodes	200

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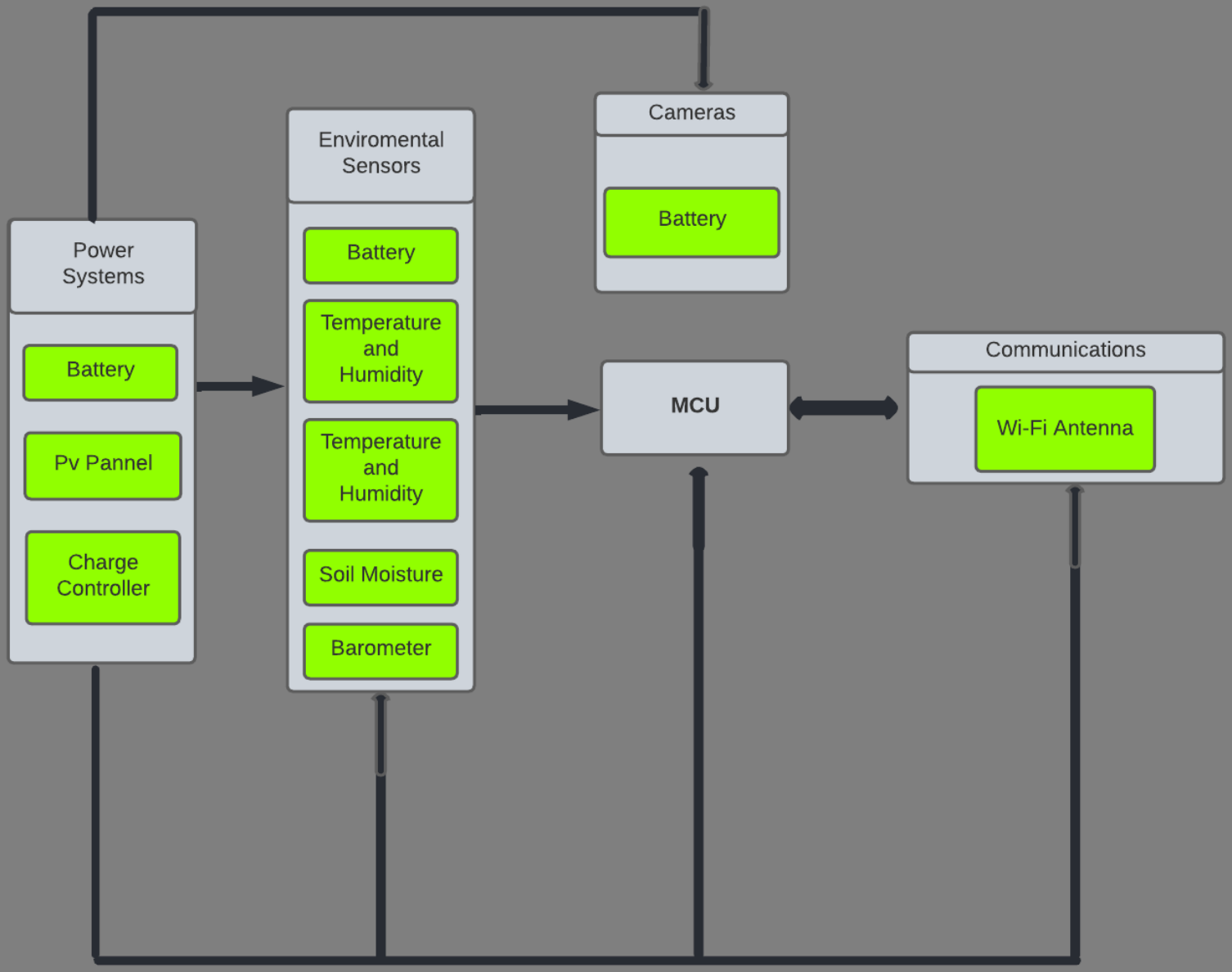
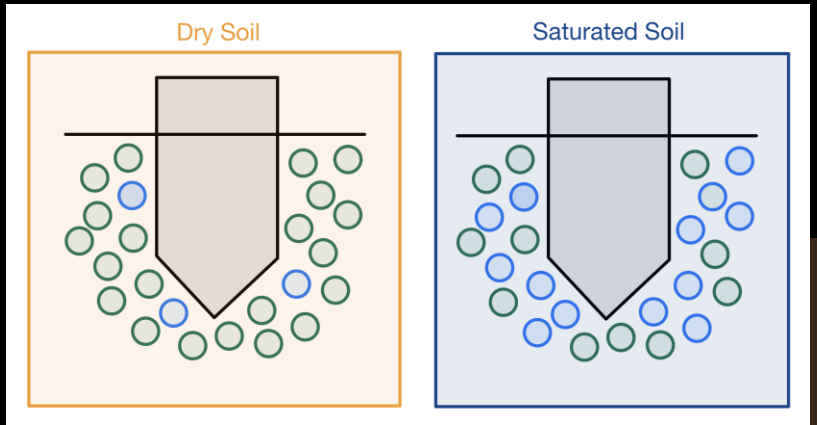
Hardware Block Diagram



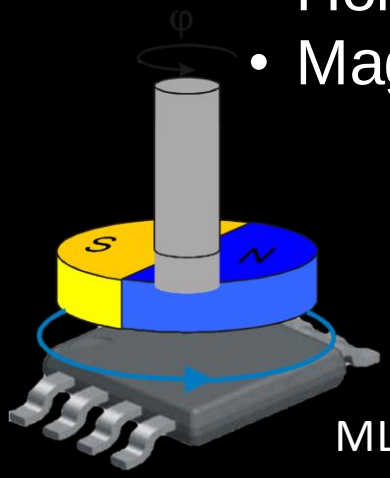
Part Selection – Environmental Sensors

- BME 280
  - Temperature
  - Humidity
  - Atmospheric Pressure
- DS18B20
  - Temperature – Offset for BME280
- CCS811
  - CO2
  - Total Volatile Organic Compounds (TVOC)
- Capacitive Soil Moisture Sensor v2.0
  - Moisture content of the soil



Part Selection – Anemometer

- Wind speed sensor
  - Hall effect magnetic sensor
  - Produces pulses as the magnet passes by the sensor
- Wind direction sensor
  - Melexis MLX90316
  - Absolute position rotary encoder
  - Measures magnetic flux passing through the part
- Compass
  - Honeywell HMC5883L
  - Magnetometer used to measure compass azimuth



MLX90316 with magnet attached to an axle

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Microcontroller

ESP-32 board which is low cost

Can be exposed to high temperature

Built-in wifi antenna

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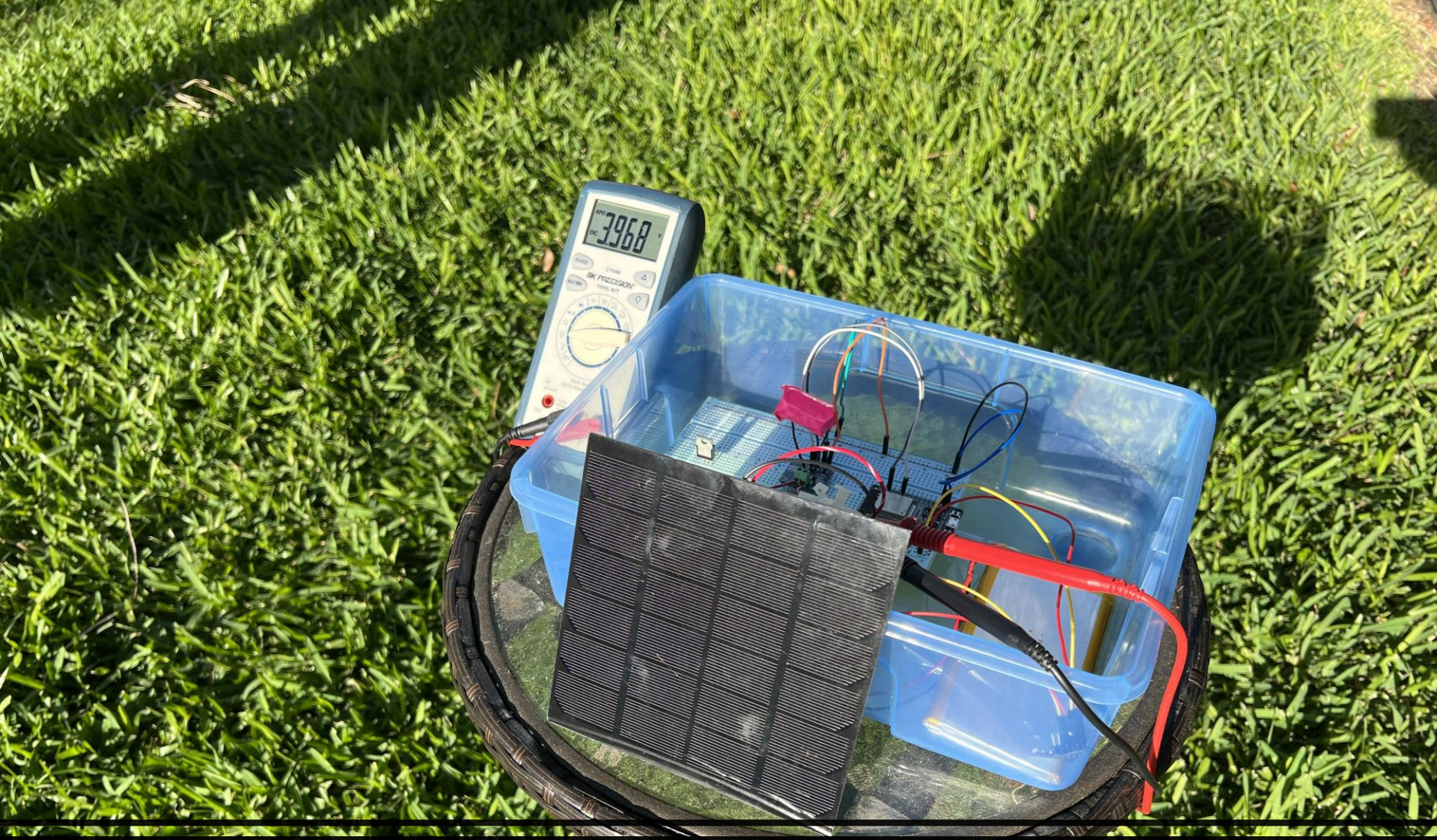

Part Selection – Power Delivery

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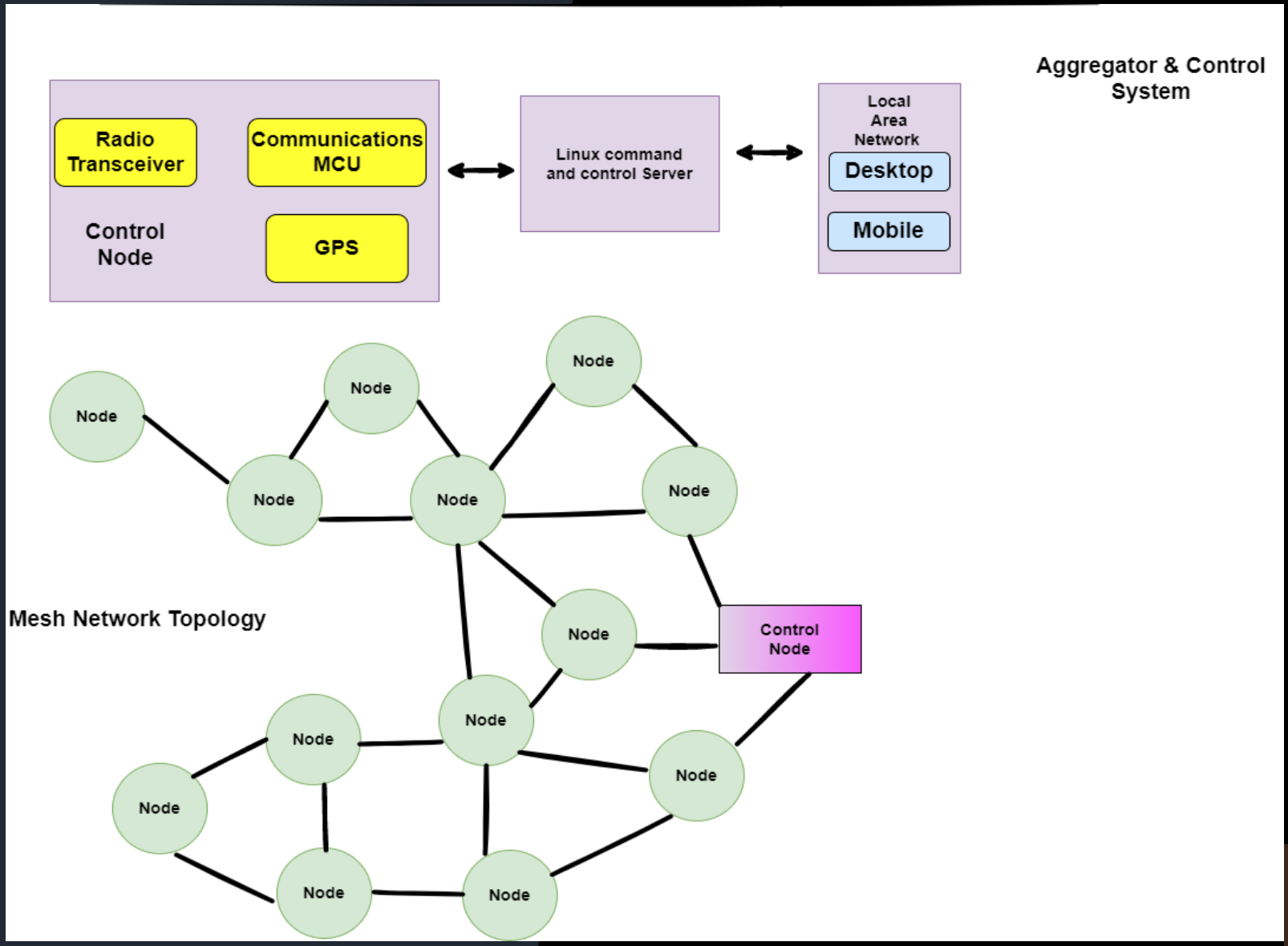
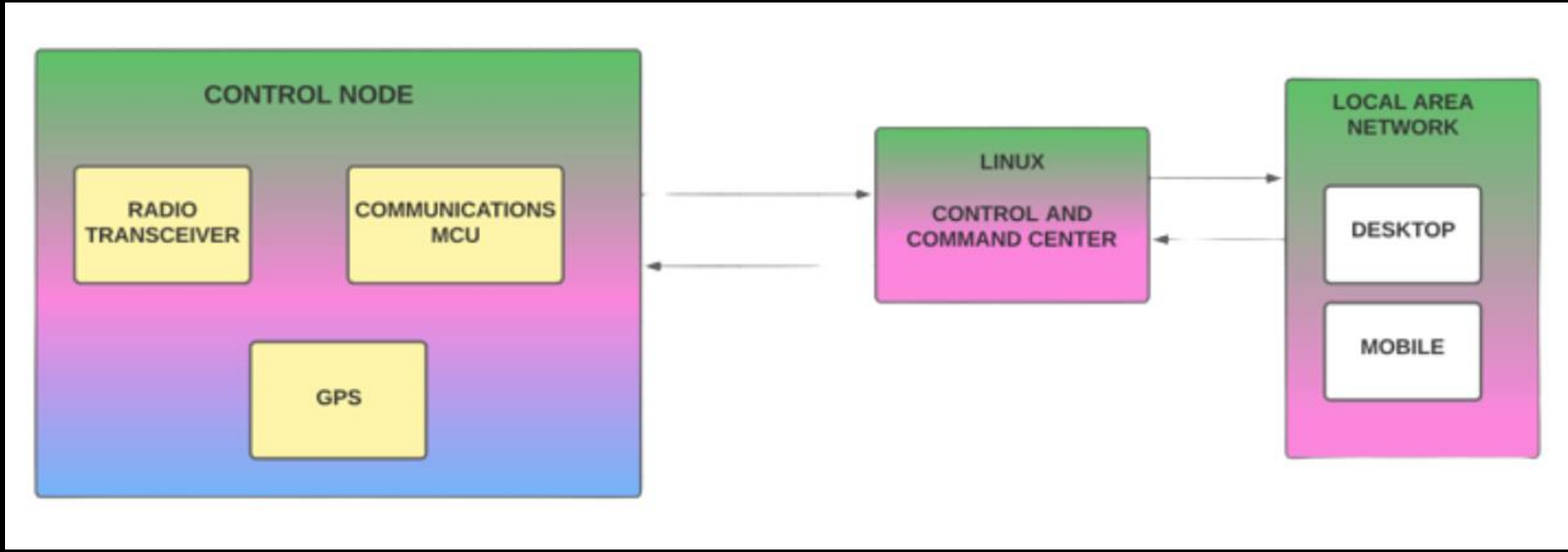
Mesh Network



Software Block Diagrams



Webserver - Database

- Benefits of a Document Based Database
  - Flexible Data Model
  - Scalability
  - Ease of Use for Developers

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User Interface - Maps

- Users can judge where there may be a higher risk of forest fires
- Displays important nodes such as the latitude, longitude, and the date when the data was being taken.
- Plotly Python Open Source Graphing Library Maps are going to be used to make those maps
- We plan to use different types of maps and layers to display the nodes

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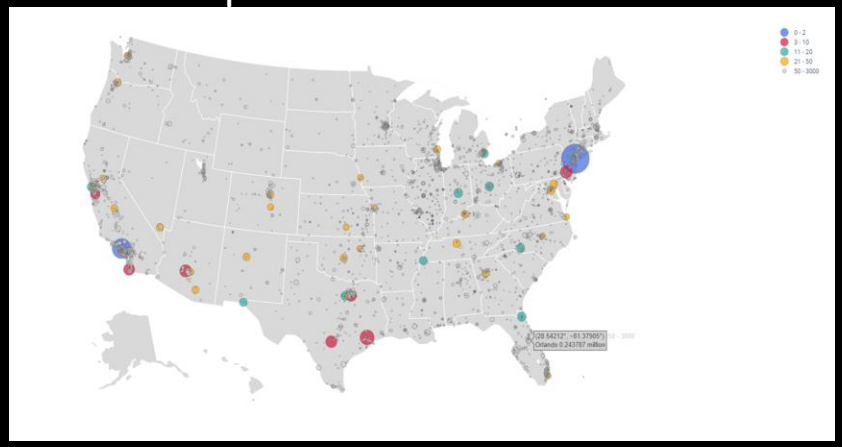
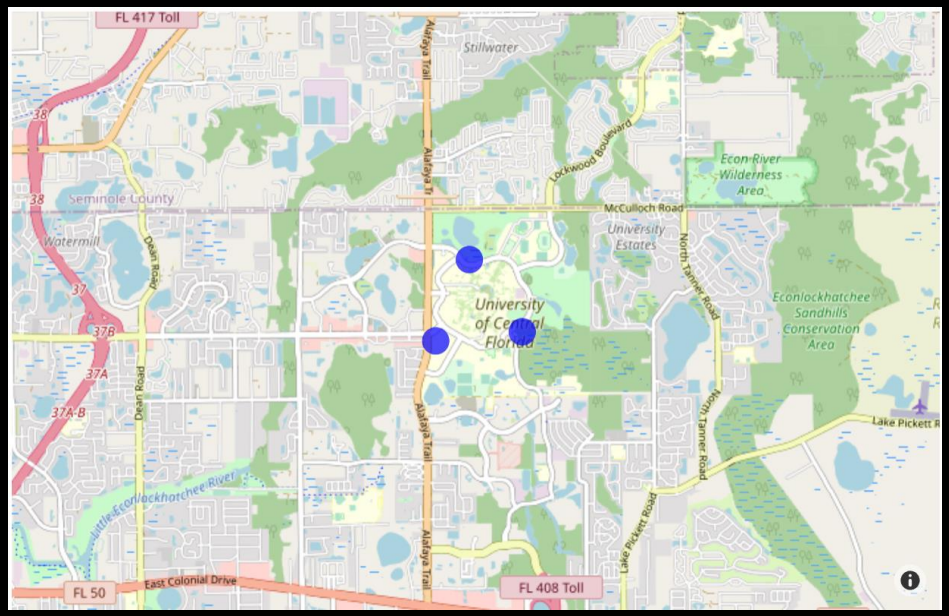
Example Maps

Density Heatmap

Bubble Map



Scatter Plot – Location of Nodes



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Software (Graphs)

- Using plotly, a data visualization framework, to represent graphs
- Data can be viewed for each node by the user to get a better understanding of the area
- Flexible for users to sensor data as the system will query the network
- Basic graphs of different variables represented through data taken from first prototype

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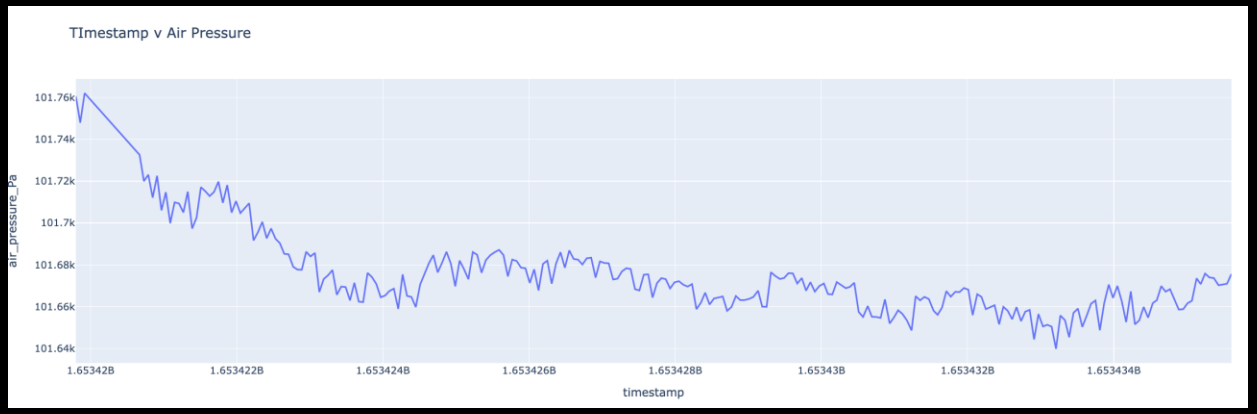
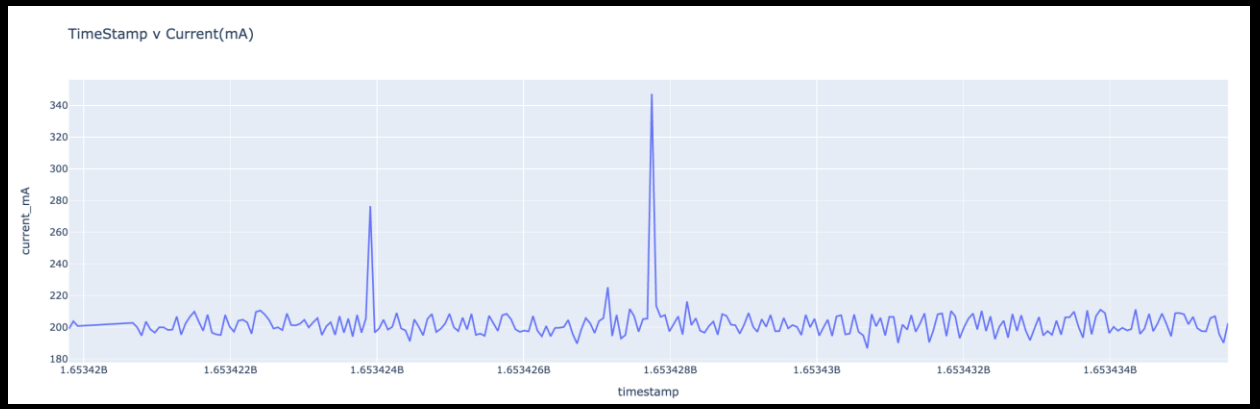
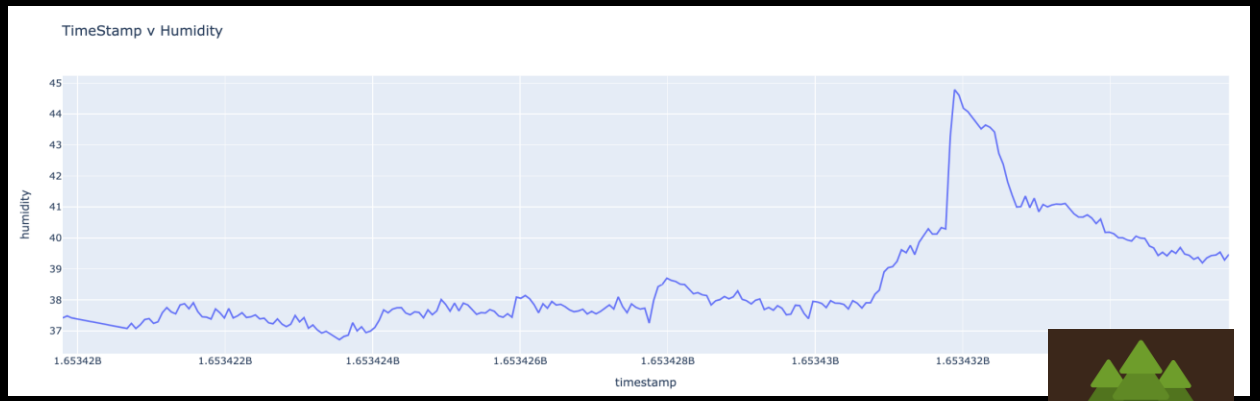
Variables: Air Pressure, Current, Humidity

Graphs of different variables]







User Interface – Node Management

- We will give the user the ability to view the status of the nodes.
- User can add, remove, and edit nodes.
- Includes settings to control how the system functions.

node_id	status	lat	lon	node_config	date_created	date_last_modified	connection_status
4144723677	active	28.60615	-81.202271	null	1653944775.782081	1653944775.782081	Disconnected
2222631472	inactive	28.597974	-81.195426	null	1654013593.650321	1654013593.650321	Disconnected
2222631473	active	28.59694	-81.206624	null	1654013814.956522	1654013814.956522	Connected
2222817205	Not Configured	-	-	-	-	-	Connected

Nodes List – Prototype Website

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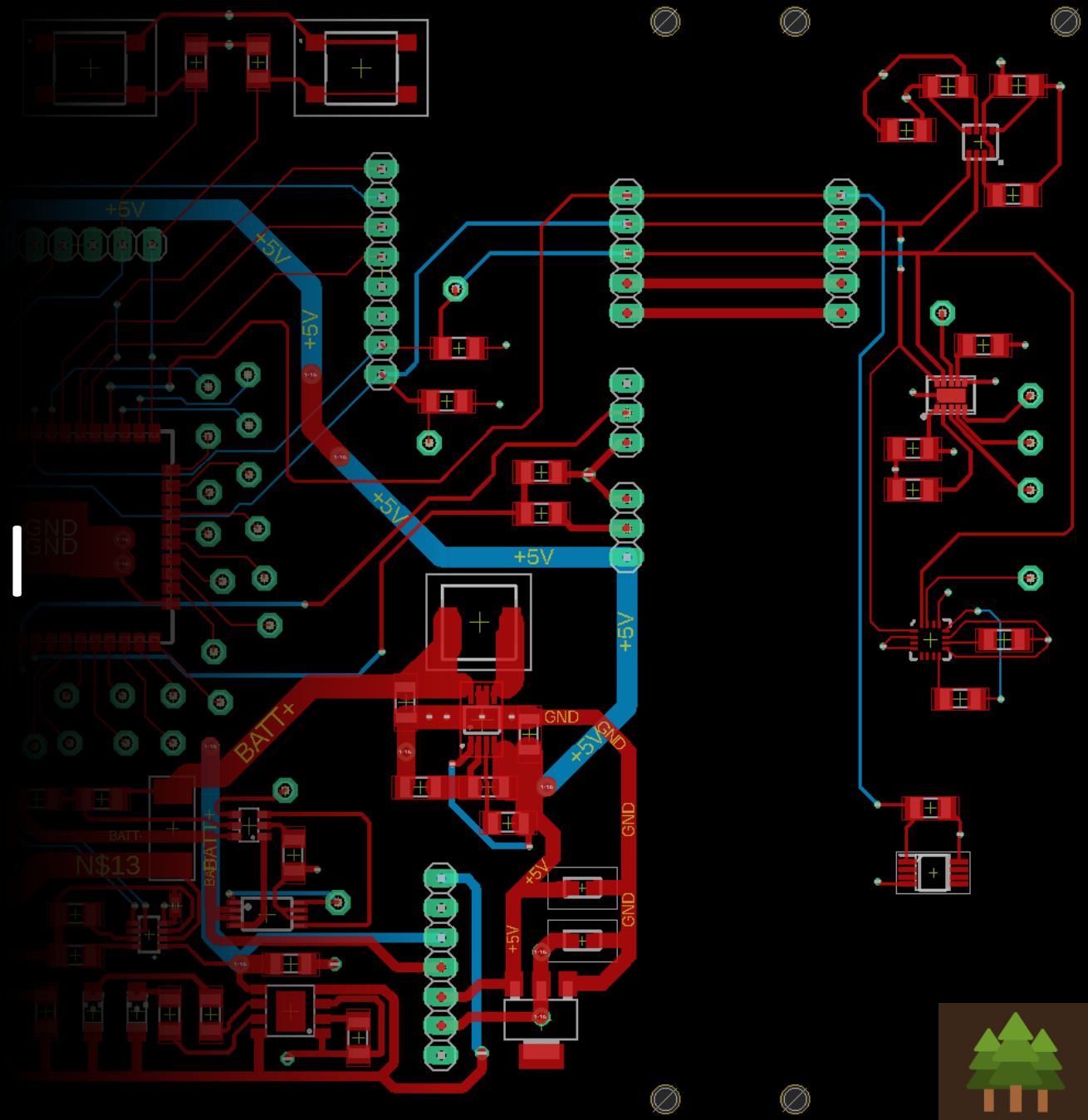
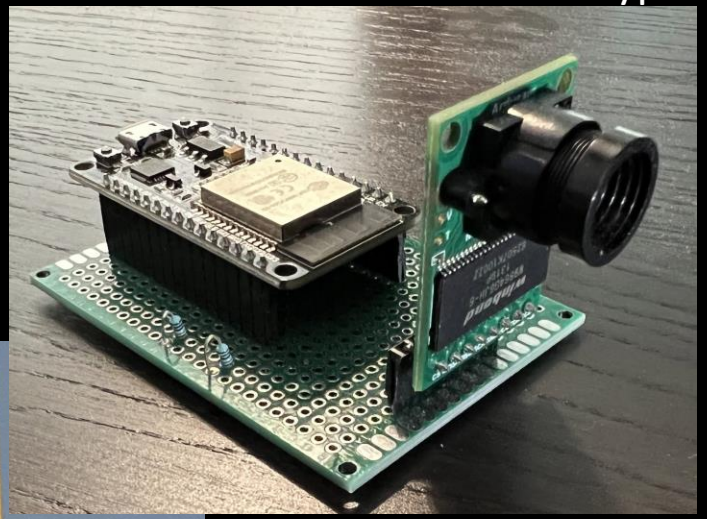
Electrical Design

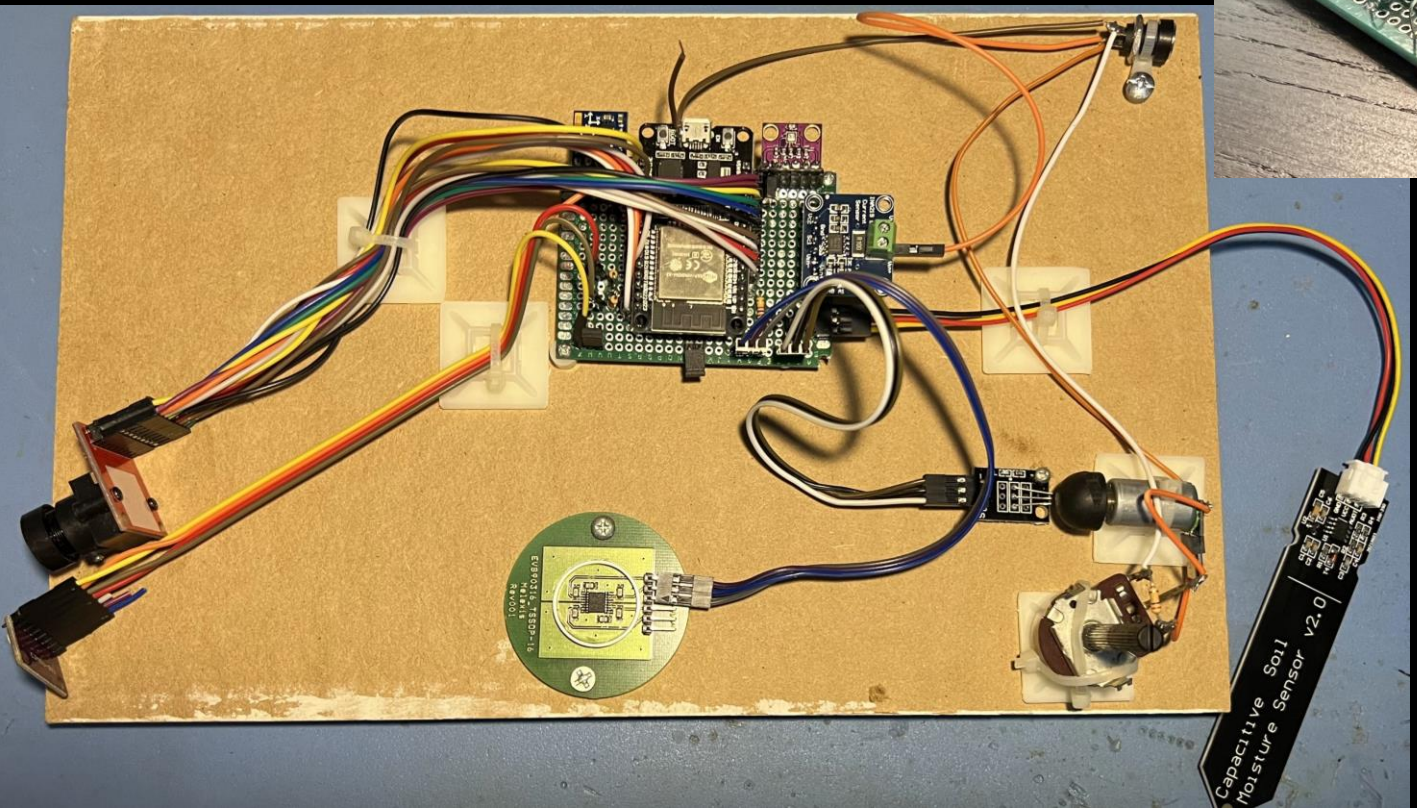


Development Prototypes

- Developmental Prototypes used to:
  - Test individual components
  - Test software and hardware integration
  - Validate electrical designs

Camera Testing Node Prototype





Sensor Testing Node Prototype

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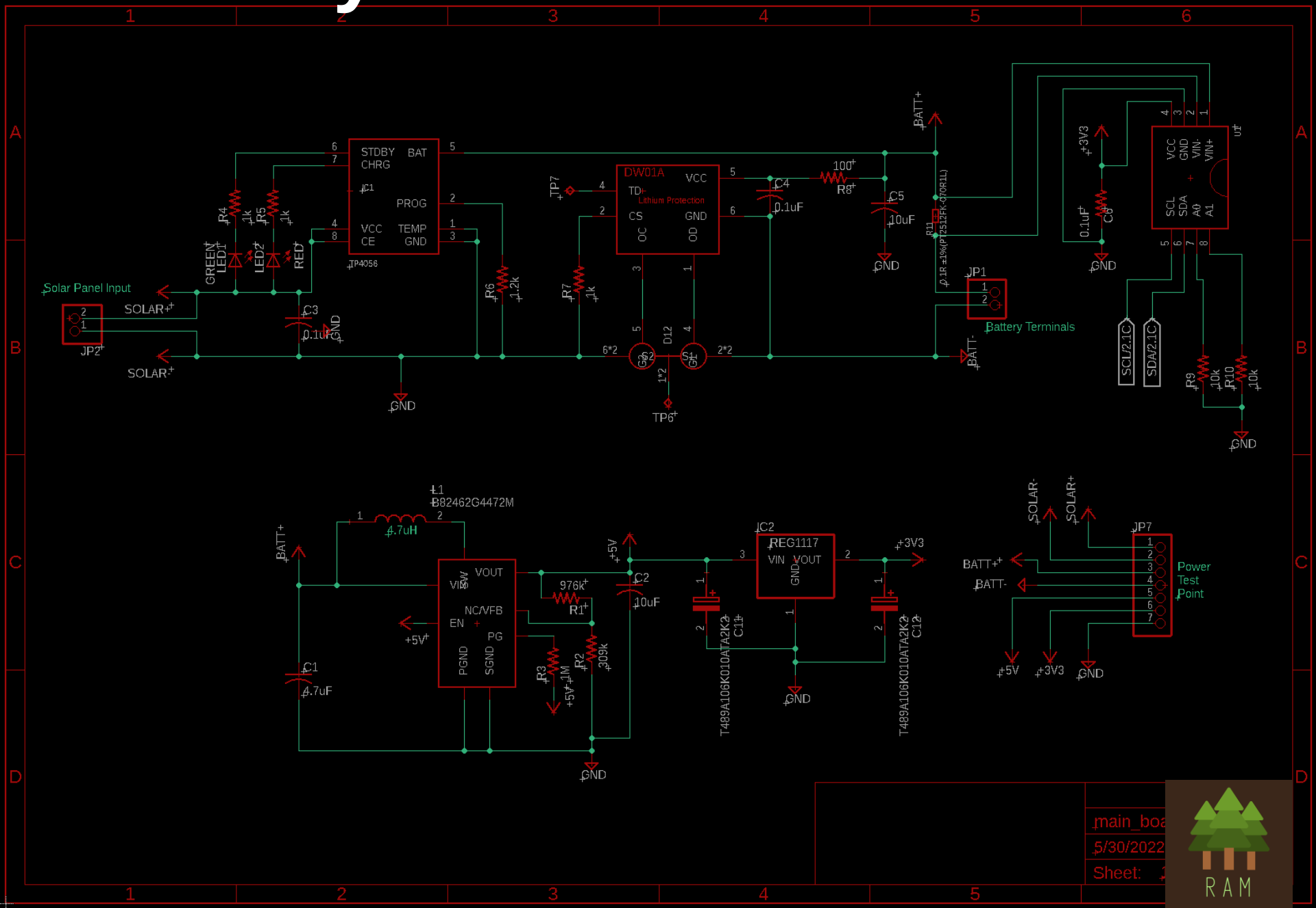
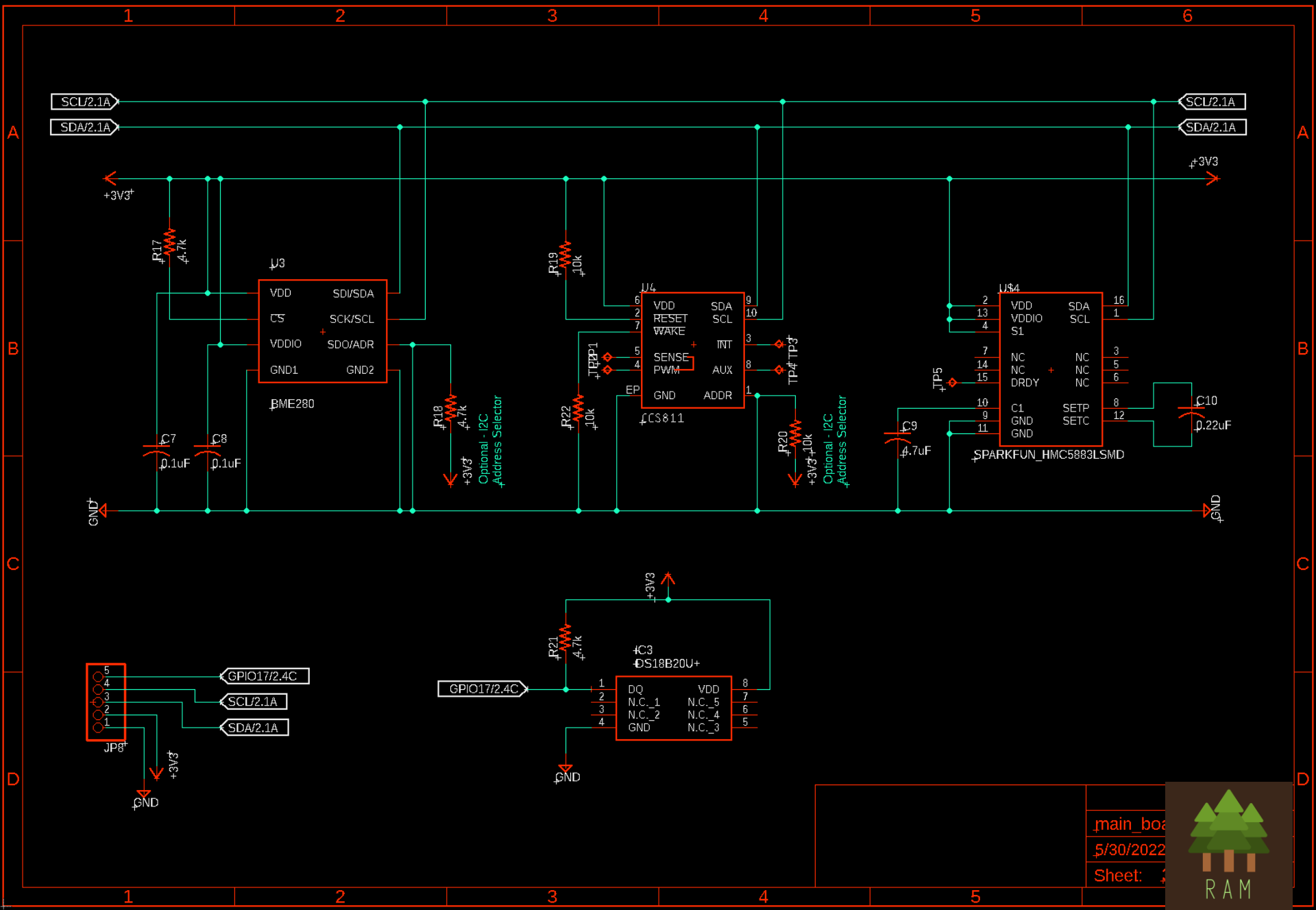
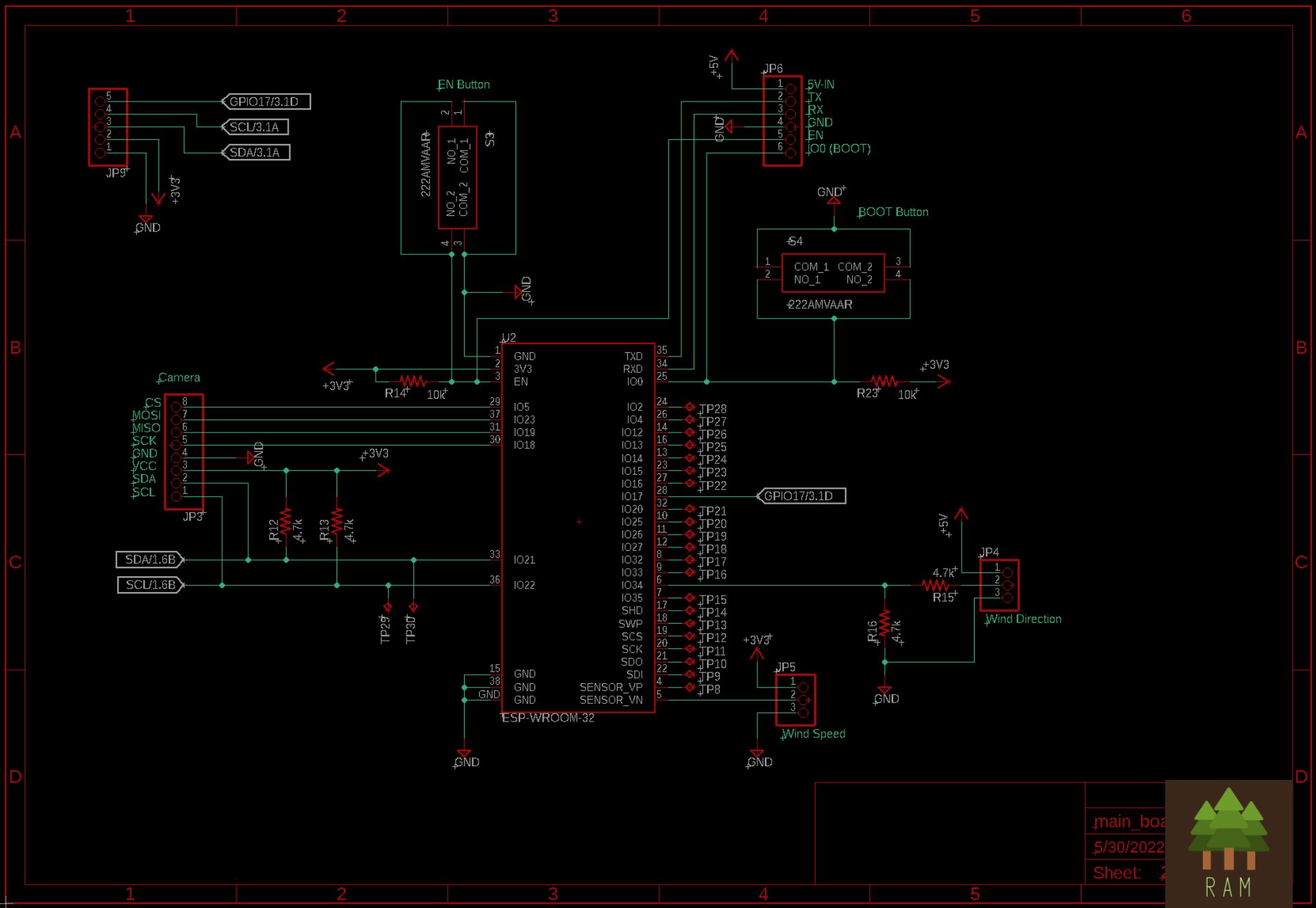
Power Systems



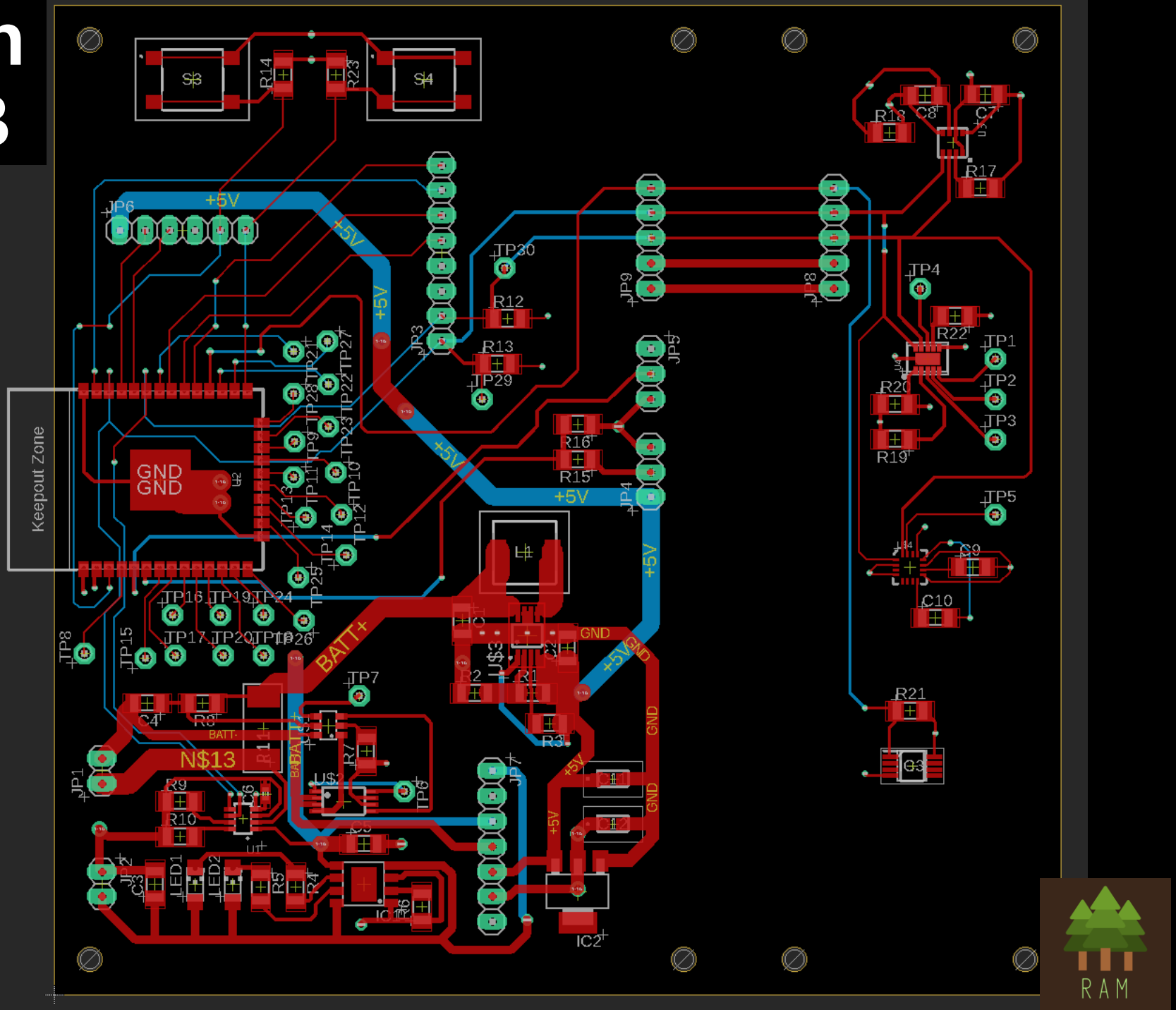
Sensors


SCL/2.1A
SDA/2.1A
+3V3
R17
4.7k
U3
VDD
SDI/SDA
CS
SCK/SCL
VDDIO
SDO/ADR
GND1
GND2
BME280
C7
0.1uF
C8
0.1uF
R18
4.7k
Optional - I2C Address Selector
R19
10k
U4
VDD
RESET
WAKE
SENSE
PWM
GND
EP
SDA
SCL
INT
AUX
ADDR
CCS811
TP1
TP2
TP3
TP4
R22
10k
R20
10k
U$4
VDD
VDDIO
S1
NC
NC
DRDY
C1
GND
SDA
SCL
NC
NC
NC
SETP
SETC
GND
SPARKFUN_HMC5883LSMD
TP5
C9
4.7uF
C10
0.22uF
GND
JP8
GPIO17/2.4C
SCL/2.1A
SDA/2.1A
R21
4.7k
IC3
DS18B20U+
DQ
N.C._1
N.C._2
GND
VDD
N.C._5
N.C._4
N.C._3
main_boa
5/30/2022
Sheet:

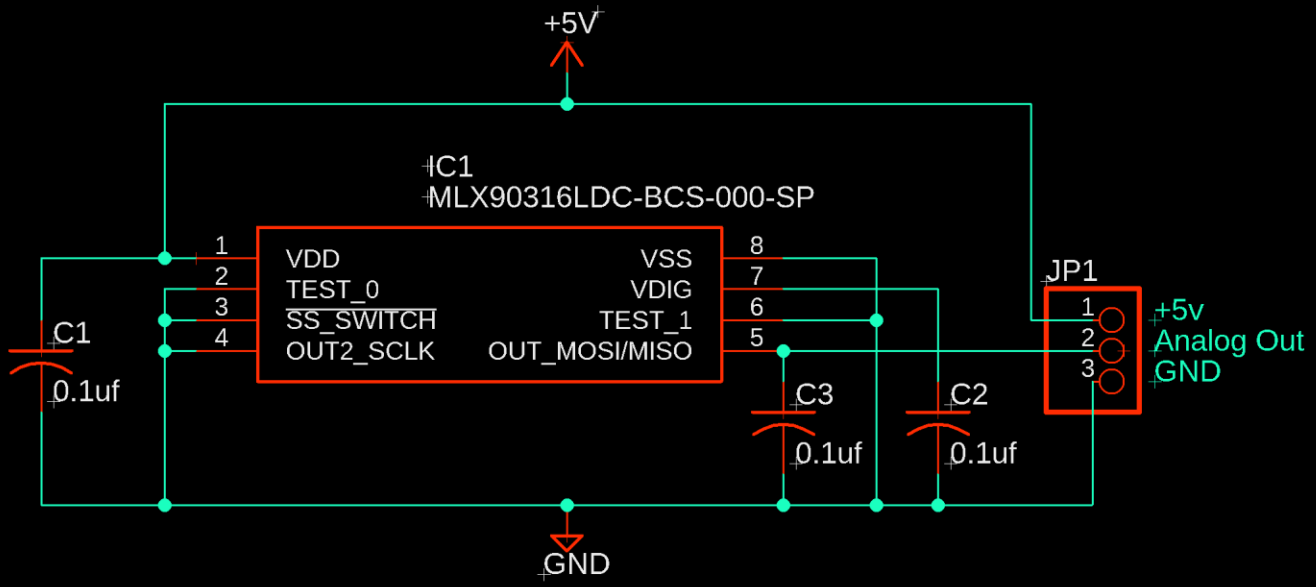
Microcontroller



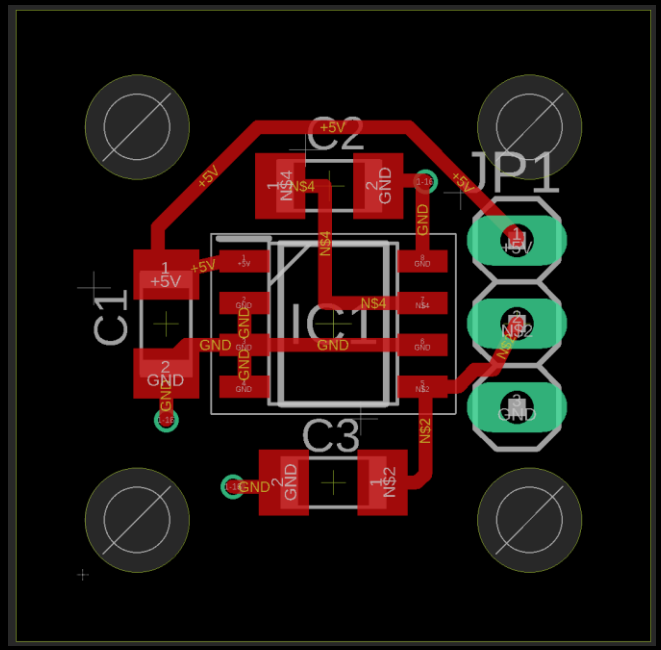
Main PCB


Keepout Zone
+5V
GND
BATT+
R14
R23
R18
C8
C7
R17
JP6
JP9
JP8
JP5
JP4
JP3
TP30
R12
R13
TP29
TP4
R22
TP1
TP2
TP3
R20
R19
R16
R15
TP5
C9
C10
R21
TP16
TP19
TP24
TP17
TP20
TP8
TP15
TP7
N$13
R9
R10
LED1
LED2
R5
R4
C3
JP1
JP2
JP7
IC2
R2
R1
R3
GND
+5V
BATT-

Wind Direction Sensor



- External module to minimize magnet interference on compass sensor
- Small footprint for easier mechanical design
- Allows for iteration and changes without the need to modify the main PCB



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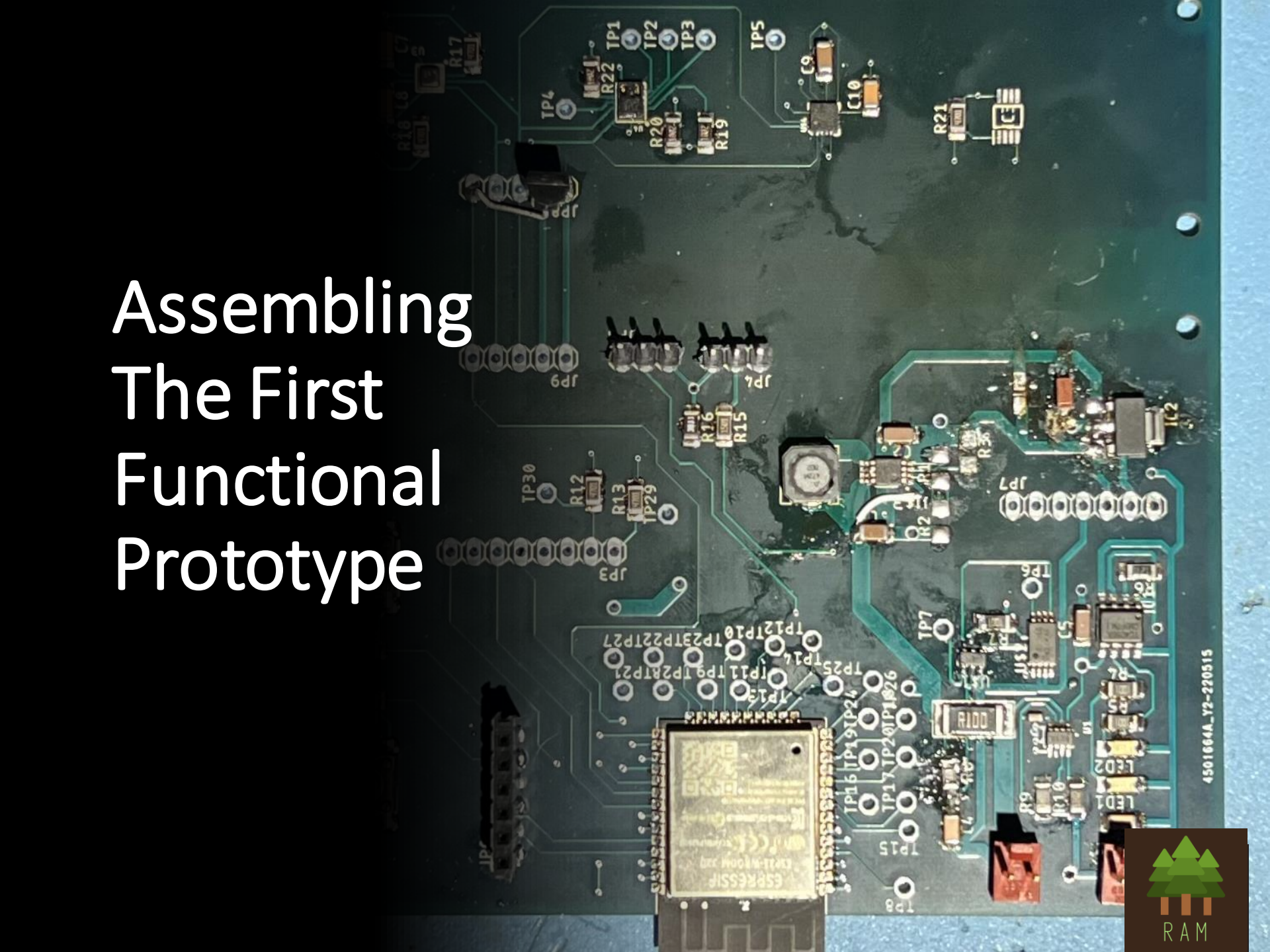
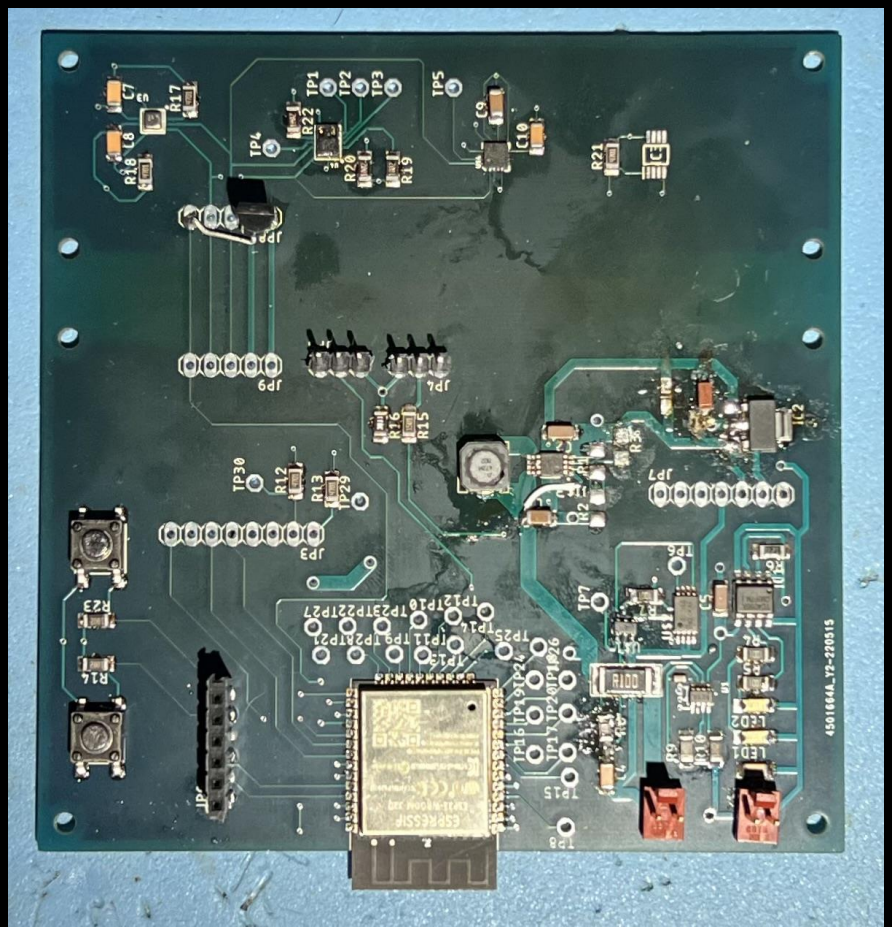
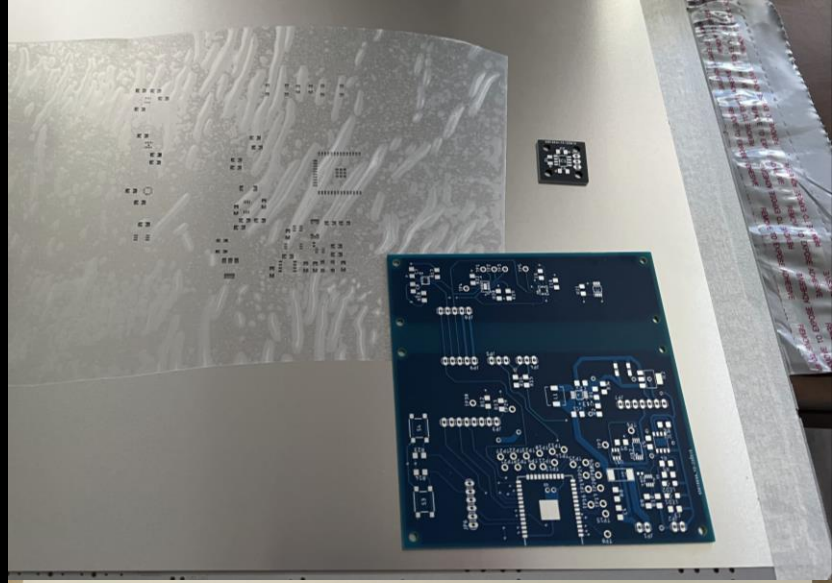
Assembling The First Functional Prototype



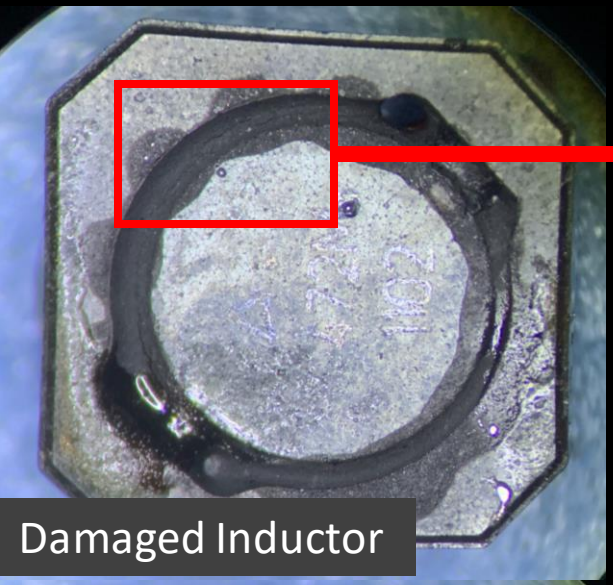
SMD Manufacturing

- Need minimum of 3 boards to demonstrate the mesh network
- All components are SMD
- Used a Stencil with precisely cut holes of all the solder pads to apply solder paste to the PCB through the stencil



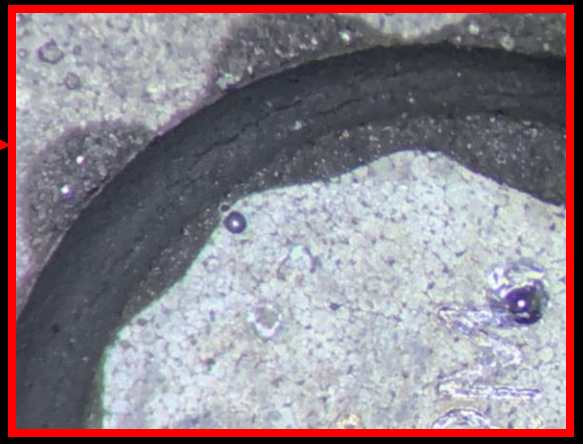


Manufacturing Challenges



Damaged Inductor

The filling around the coils of the inductor cracked due to excessive heat



New Inductor

The new inductor has no cracking or other evidence of damage

- Future Improvements:
  - Use a less aggressive profile for reflow
  - Hand solder the inductor

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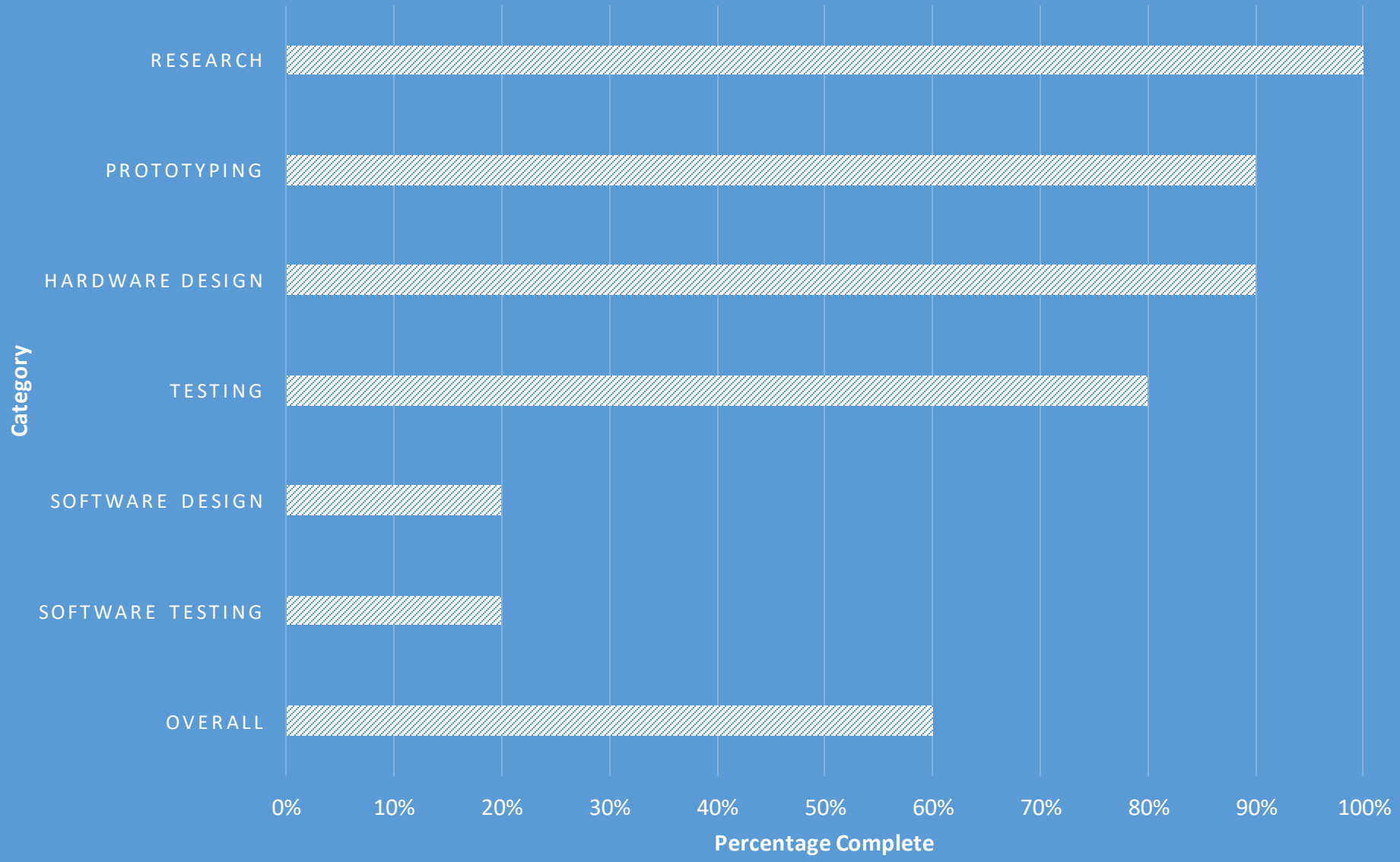
Budget

Part Number	Part Name	Manufacturer	Mfg. Part #	Quantity	Unit Cost
001	MCU-ESP32	Espressif Systems	ESP32-WROOM-32-N4	3	$8.00
002	BME280 - Temperature/ Humidity/ Pressure	Bosch Sensortec	BME280	3	$9.01
003	DS18B20 Digital Temperature Sensor	SUNFOUNDER	DS18B20	3	$12.99
004	CCS811 Air Quality Sensor	Digilent, Inc.	CCS811	3	$24.99
005	Current Sensor – INA219A	Texas Instruments	INA219A	3	$2.63
006	Solar Charge Controller – TP4056	JMoon Technologies	TP4056	3	$30.00
007	Battery Protection – DW01A	Unbranded	DW01A	3	$7.99
008	IC Part for Eval Board	Melexis	MLX90316KDC-BCG-300-SP	1	$6.71
009	Solar Panel	Solar Panel	6v 500mA PV	2	$15.99
010	Battery	Miisso	10000mAh	2	$16.99
011	3.3V Voltage Regulator	Texas Instruments	UA78M33CKVURG3	1	$0.92
012	5V Voltage Regulator	BINZET	B00J3MHRNO	1	$9.98
013	ArduCam Mini 2 MP	Arducam	OV2640	2	$8.99
014	Hall effect sensor	Module	OH3144	1	$1.62
Total					$156.81

Work Distribution

Name	Hardware Prototype	Electrical Design	Backend Software	Frontend Software	Node Software	Data Visualization
Wyatt	X	X	X		X	
Gabriel	X	X	X			
Abhijeet	X			X		X
Nick		X		X		X

PROJECT PROGRESS



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Questions?

Remote Area Monitoring

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