UCF

STANDARD SMALL SATELLITE RESEARCH PLATFORM FOR LIFE SCIENCE RESEARCH

Critical Design Review
Senior Design 2

Group 30
February 18, 2022

ORGANIZATIONAL CHART

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PROJECT OBJECTIVE AND GOALS

Mission Statement: Develop a plant habitation system to produce high-yield plants and reduce crew time operation using data gathered from sensors that monitor the conditions of the plant habitation system.

Goals:

- The ability to grow supplemental food through plant crops would allow humans to explore deep space with long-term missions.
- Growing food will also provide a solution to rid the constant costly supply of packaged food from Earth that is currently the standard for a permanent presence in space.
- The data will successfully be gathered and transferred to the database from the humidity sensor, temperature sensor, pH sensor, and camera units.
- The web app will display the sensor information and images of the plant outlining ideal conditions for plant growth.

PROJECT OBJECTIVE AND GOALS

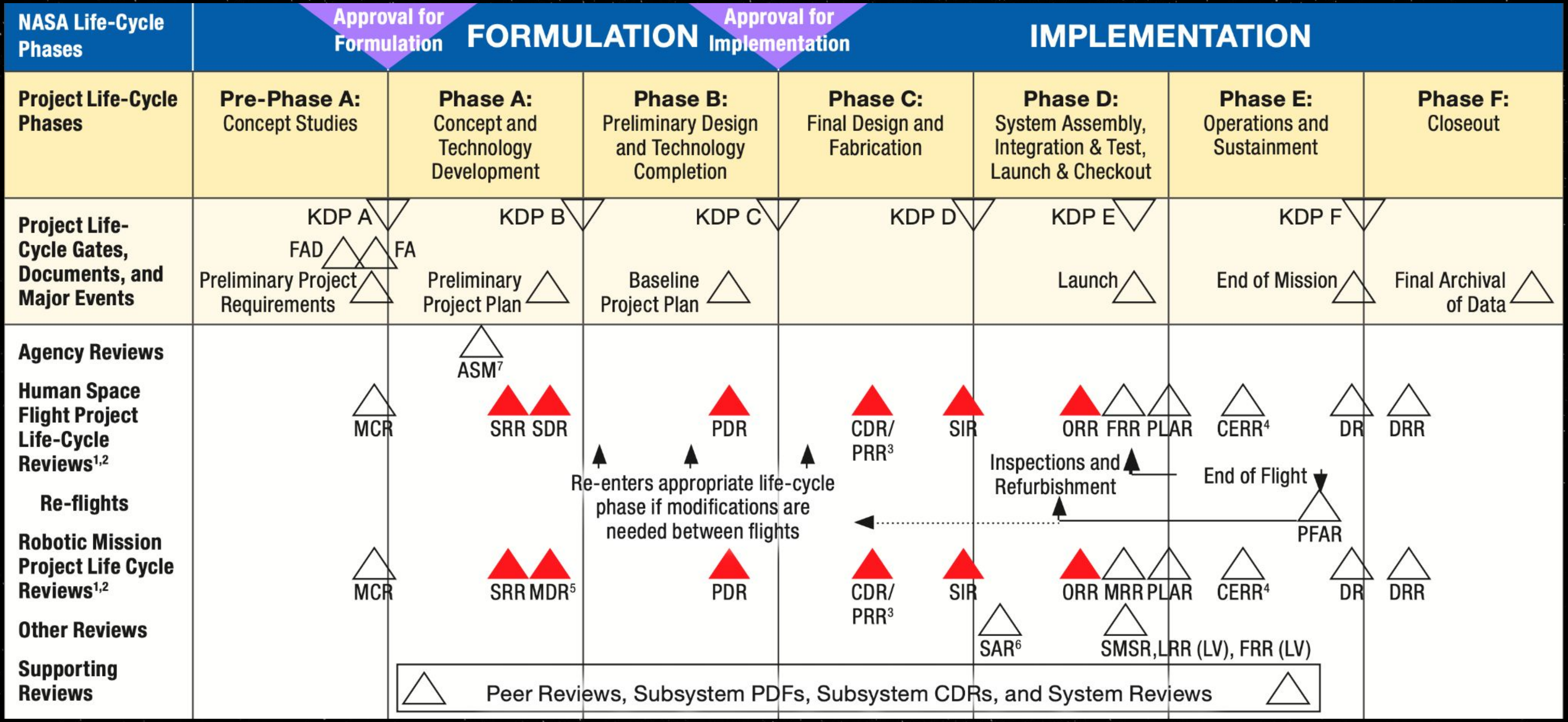
Mission Statement:

Our mission is to design an environmental monitoring system for plants in microgravity.

Goals:

- The data will successfully be gathered and transferred to the database from the humidity sensor, temperature sensor, pH sensor, and camera units.
- The web app will display the sensor information and images of the plant outlining ideal conditions for plant growth.

PROJECT LIFE CYCLE



STRETCH GOALS

- Use Computer Vision to better the data and automate how it looks
- Use synthetic data to boost automated image-based plant phenotyping
  - Compare the number of leaves of plants from the dataset to the plant for better health and growth
  - Use 10,000 top down images of Arabidopsis plants
  - Use dataset provided by Leaf Segmentation Challenge of the Computer Vision Problems in Plant Phenotype
- Include an Ethylene sensor to monitor gas environment and plant response to hormone

PLANT: ARABIDOPSIS THALIANA

PLANT: ARABIDOPSIS THALIANA

Aspect	Description
Grown Size	~ 20 – 25 centimeters
Life Cycle	Short life cycle about six to eight weeks from germination to seed maturation
Grown Mass	~ 2.5 grams
Watering frequency	TBD
Light frequency	TBD

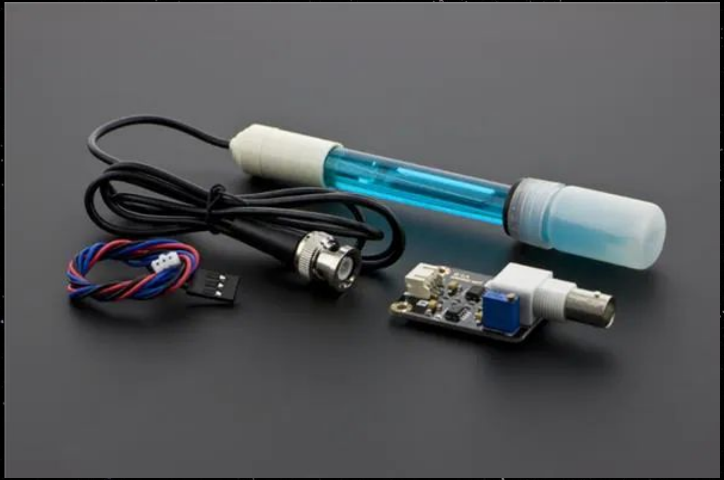
CONSTRAINTS

Constraint	Description
Volume	10 cm x 10 cm x 10 cm per unit with units ranging between 1U, 2U, 3U, or 6U.
Weight	< 1.33 kg or 3 lbs per U
Operational Time	5 months
Budget	$1600
Testing	UCF Senior Design Lab

HARDWARE REQUIREMENTS

Component(s)	Parameter(s)	Specification(s)
pH Sensor	Response time, Power	Measure pH at least 2-3 times per hour 3.3V - 5V
Cameras	Resolution, Power	720p - 1080p 3.3V - 5V
Temperature Sensor	Accuracy, Power	± 2°C 3.3V - 5V
Humidity Sensor	Accuracy, Power	± 3% 3.3V - 5V

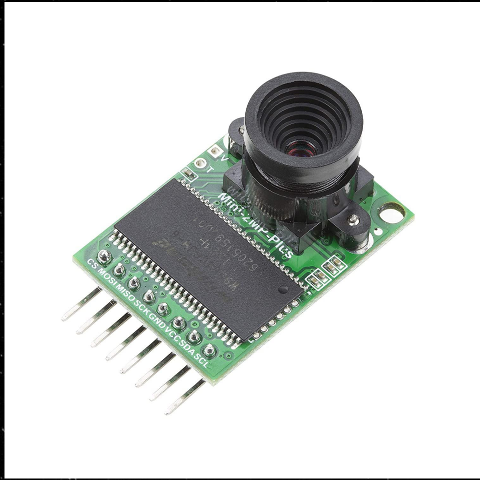
PH SENSOR - SEN0161



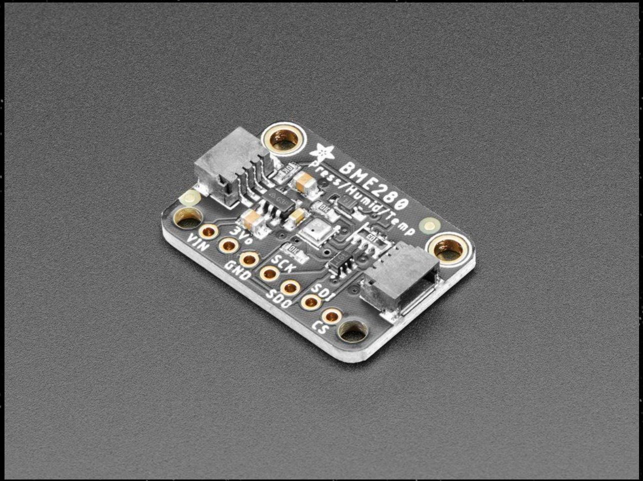
- Used to determine if the plant is in optimum range for yield (5.1-7.6)
- <2 minute response time
- Set for long use and re-use
- 3.3V - 5V

CAMERA - ARDUCAM MINI

- 2 x 2MP cameras
- I2C/SPI
- 3.3V - 5V
- Low power mode
- Arduino library



TEMPERATURE/HUMIDITY/PRESSURE SENSOR - BME280



- Accuracy:
  - Temperature: ± 1.0°C
  - Humidity: ± 3%
  - Pressure: ± 1 hPa
- I2C/SPI
- Adafruit libraries

POWER REQUIREMENTS

- Electrical Power System(EPS)

- Estimated Power Production
  - 19.2 watts per panel
  - 38.4 W total

- Average Payload Power Available
  - 10-30 W
  - 3.3 V, 5 V outputs

- Projected Battery Size
  - Average capacity 40-100 Wh
  - 6-12 V and Battery raw

MICROCONTROLLER

Atmel Mega 2560:

Flash Memory: 256 KB of which 8 KB is used by bootloader

SRAM: 8 KB

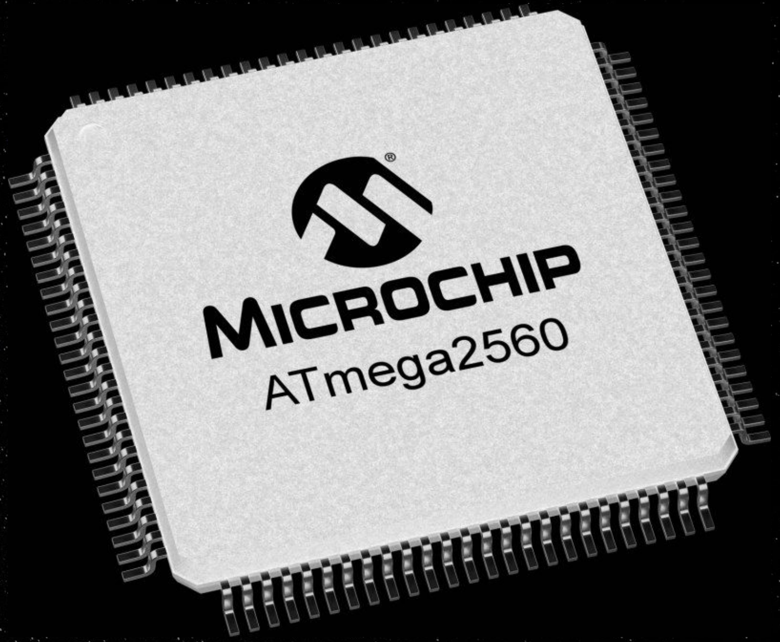
EEPROM: 4 KB

Clock Speed: 16 MHz

Digital IO: 54 pins (15 can be used as PWM outputs)

Analog IO: 16 pins

Communications: 4 UARTs (hardware serial ports)



HARDWARE DESIGN

Voltage Converter:

12V-22V to 3.30V @ 3A

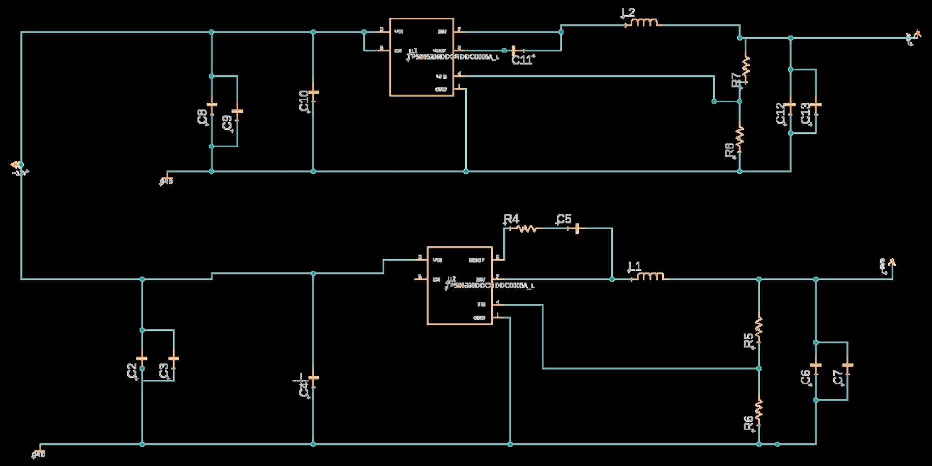
Topology: Buck converter

Total power OP: 9.9W

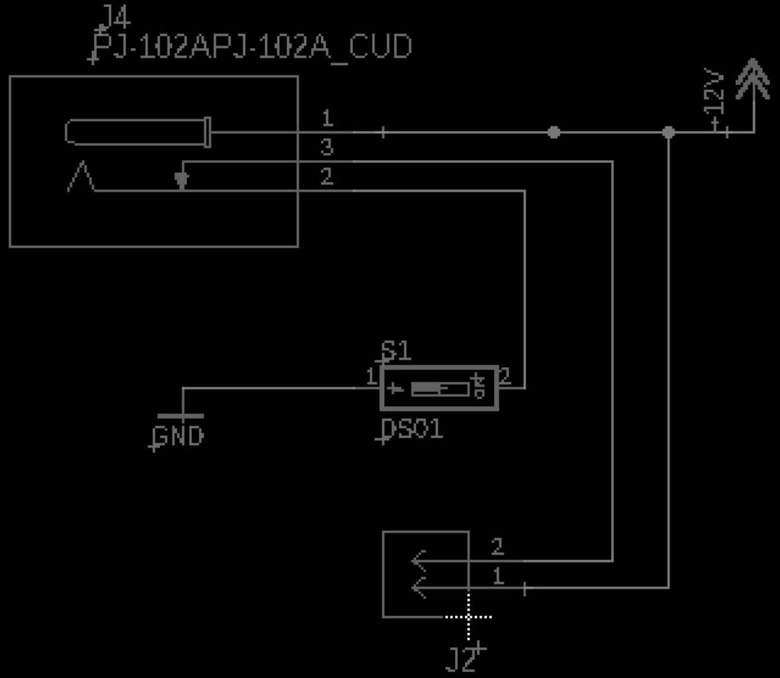
11V-14V to 5.00V @ 5A

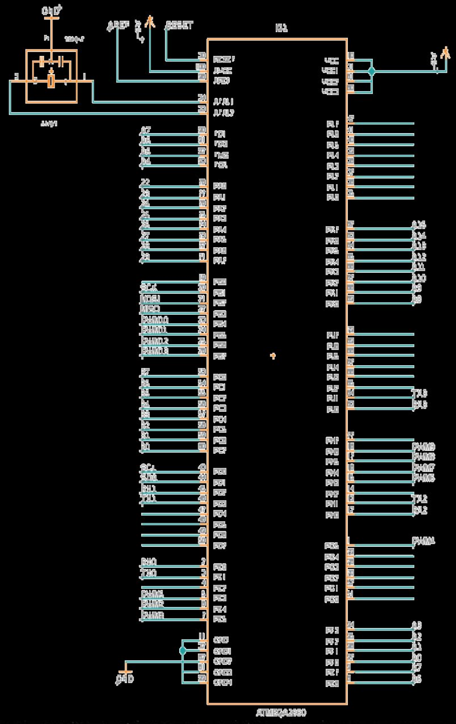
Topology: Buck converter

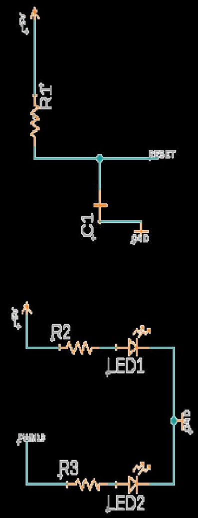
Total power OP: 25W



HARDWARE DESIGN







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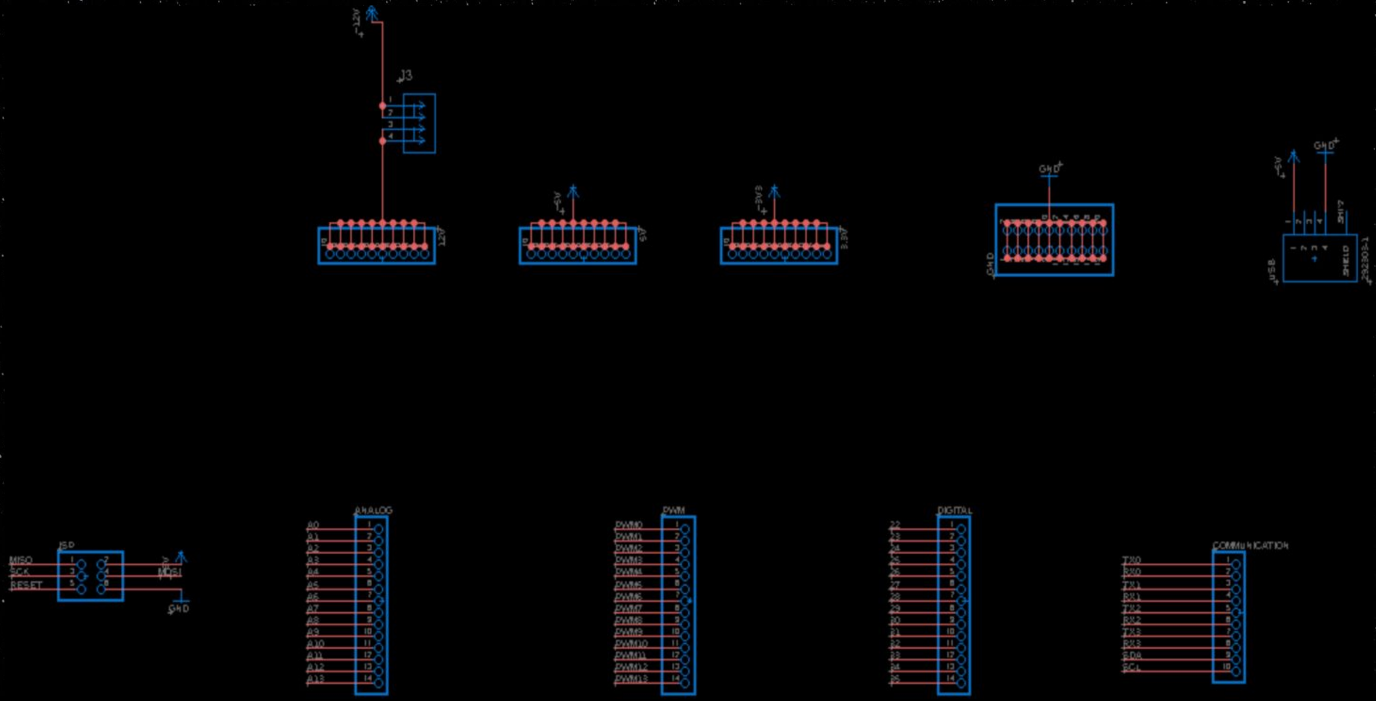

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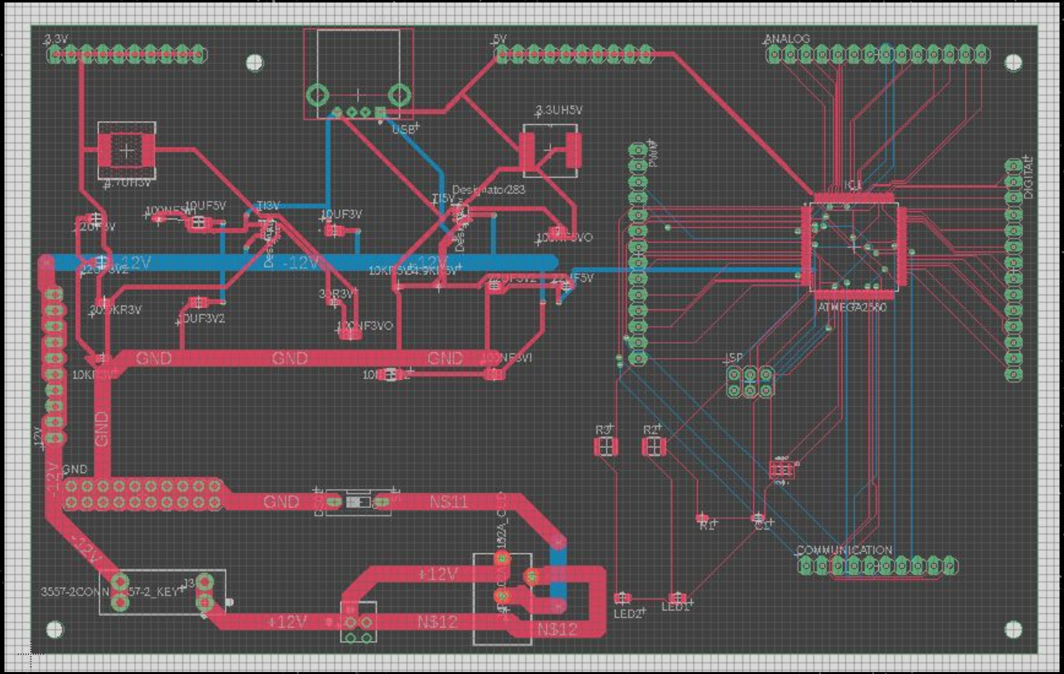
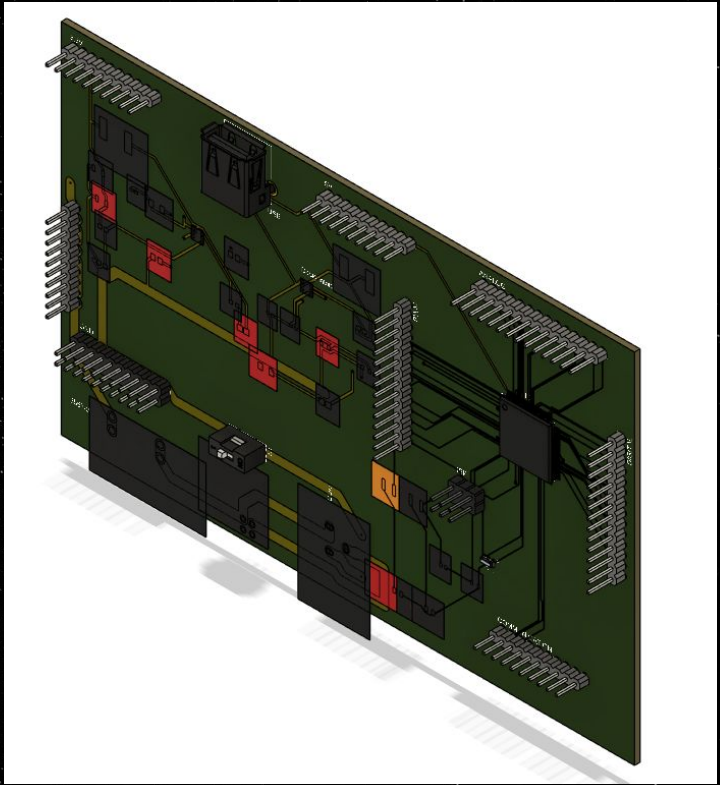




HARDWARE SUCCESS AND CHALLENGES

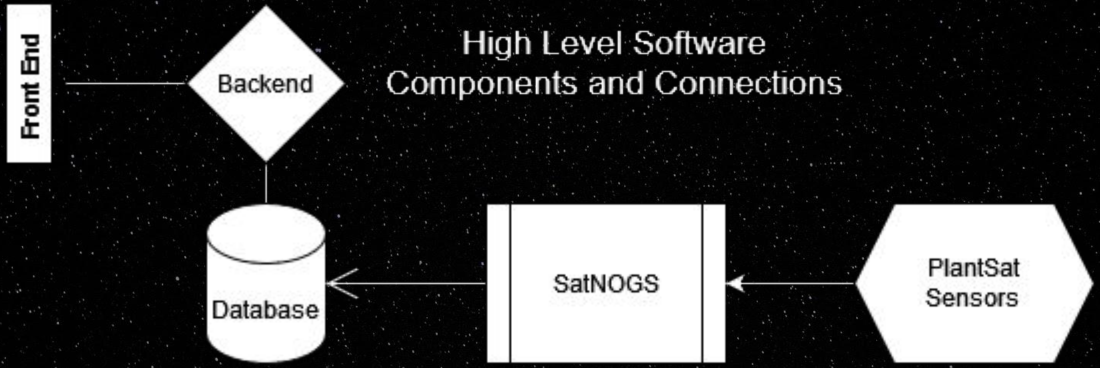
Successes

- Future Expandable
- Reliable platforms with built in libraries and safeties
- Open source hardware and software

Difficulties

- Radiation Hardened and Harsh Environment product cost and accessibility
- Space restrictions for payload
- Non redundant systems

SOFTWARE SIDE - OVERVIEW



- Easily manage and compare data for scientists.
- Website, Database, and API

WEB REQUIREMENTS

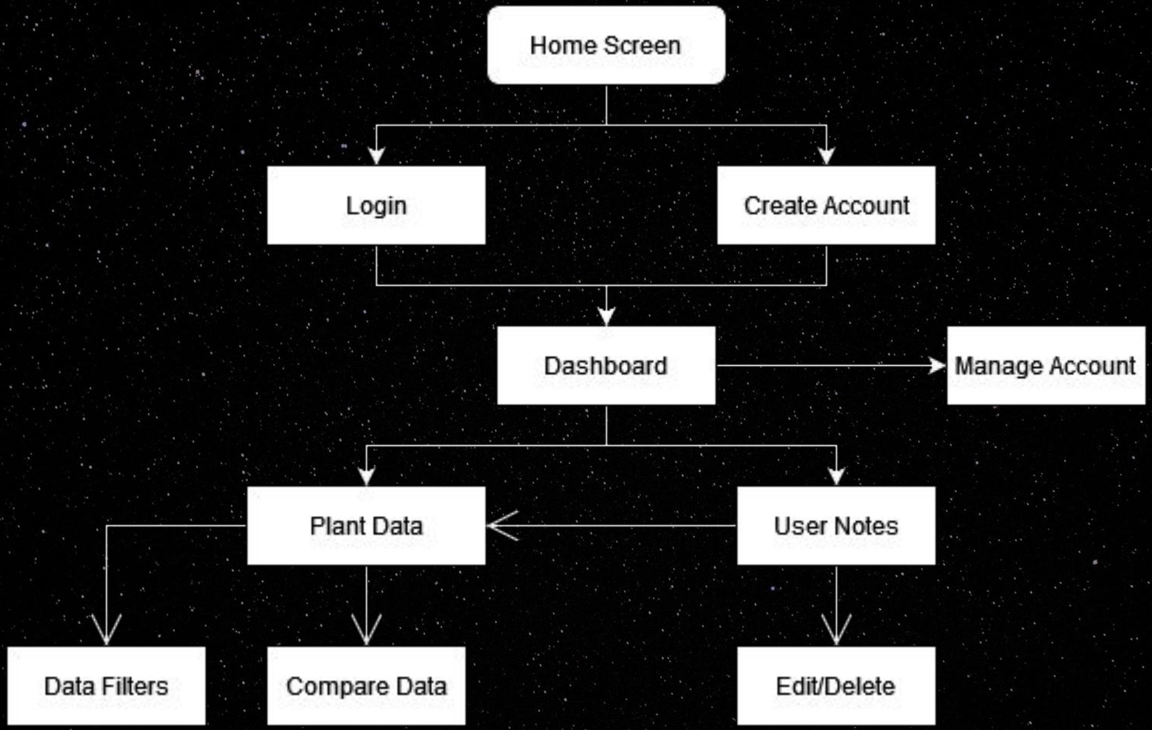
Users can log in to see:

- History
- Documents
- Photographs

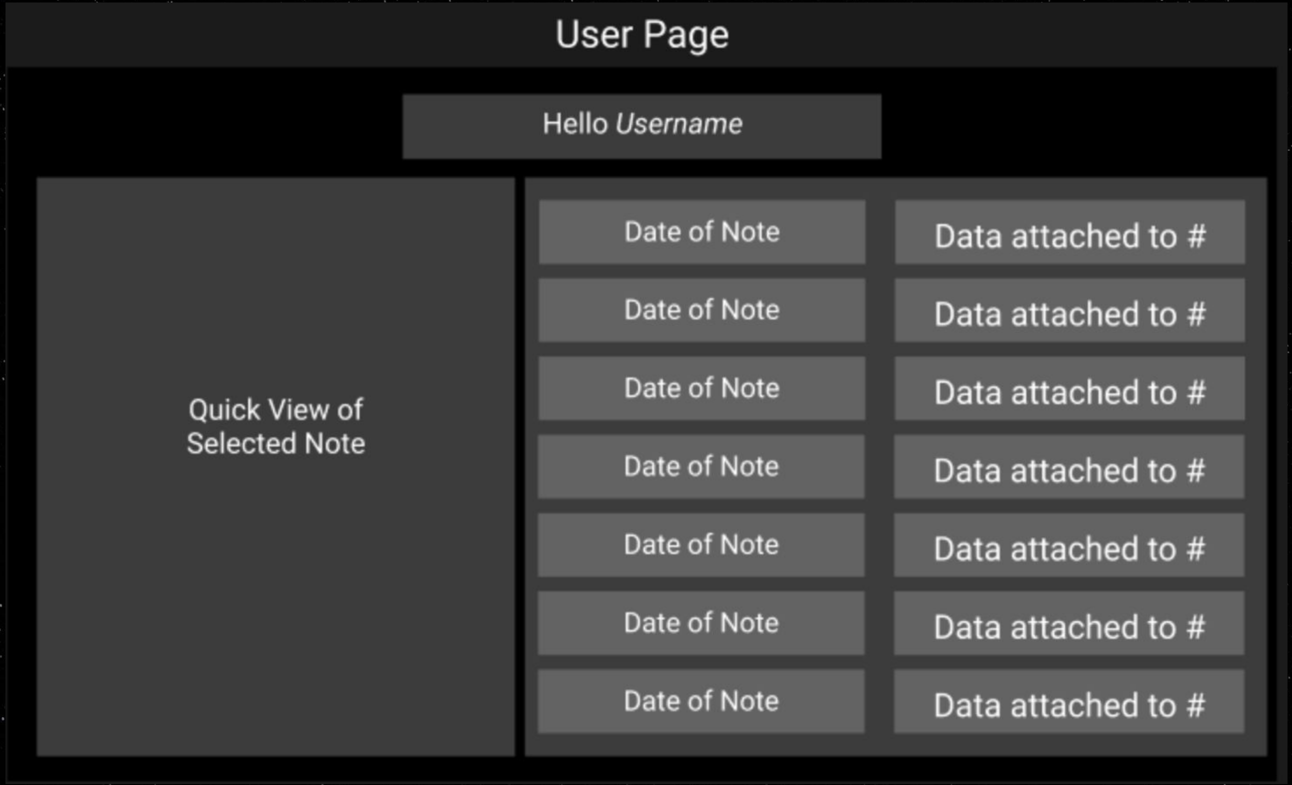
Notes/Documents:

- Compare
- Edit
- Delete

FRONTEND BLOCK DIAGRAM



USER PAGE


User Page
Hello *Username*
Quick View of Selected Note
Date of Note
Data attached to #
Date of Note
Data attached to #
Date of Note
Data attached to #
Date of Note
Data attached to #
Date of Note
Data attached to #
Date of Note
Data attached to #
Date of Note
Data attached to #

DATA PAGE

Quick Filters

Open Advanced Filters

Data 1 Label	Data 2 Label	Data 3 Label	Data 4 Label	Data 5 Label	Data 6 Label	Data 7 Label	Data 8 Label
Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8
Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8
Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8
Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8
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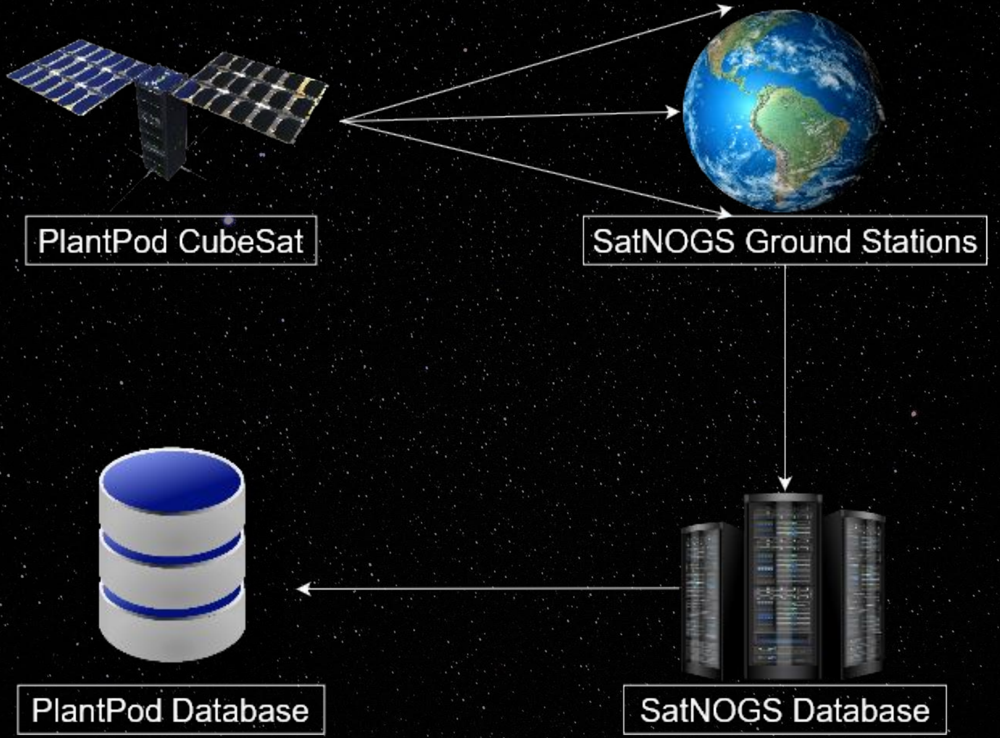
Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8

COMPARISON DATA PAGE

DATA PATH


PlantPod CubeSat
SatNOGS Ground Stations
SatNOGS Database
PlantPod Database

TECHNOLOGIES USED

Websites & Apps	Web	Modified MERN Stack
GitHub	JavaScript	SQLite3
VSCode	CSS	ExpressJS
DigitalOcean	HTML	ReactJS
		NodeJS

WEB APPLICATION HOSTING

	Digital Ocean	GitHub
Price	Free $100 from Github Education	Free
Purpose	Virtual Machine Hosting	Collaboration

SOFTWARE SUCCESS AND CHALLENGES

Successes

- Useful libraries for React
- Hosting on DigitalOcean as a Droplet

Difficulties

- Transfer of data from physical sensors into database
- Swapping project focus from ISS module to satellite form

TEAM ORGANIZATION

	Discord weekly meetings
	Trello board
	Google Drive
	GitHub

CURRENT PROGRESS AND DIVISION OF LABOR

Assignment	Assignee	Percentage
Frontend, Backend, Database	Shivani	55%
API, Backend, Database	Noah	50%
System Design Processes, Product Realization Processes, Technical Management Processes	Nicolas	40%
Select, Test, and Integrate Sensors	Raquel	40%
Design PCB, Test, and Integrate Electrical components	Matt	45%

BUDGET AND FINANCE

Excluding shipping and handling expenses.

Motivation	Item	Amount	Cost	Total
Prototype	pH Sensor	2	$29.50	$59.00
Prototype	Camera Sensor	2	$25.99	$51.98
NASA Tech Gap	Electrical Conductivity Sensor	2	$14.95	$29.90
Prototype	PCB	1	$23.56	$130.67
Prototype	Temp/Humidity/Gas Sensor	1	$18.95	$18.95
Prototype	Petri Dish	1	$12.99	$12.99
Prototype	Battery	1		$0.00
Prototype	Frame	1	$250	$250.00
Testing	Frame	3	$50	$150.00
Testing	Arabidopsis Seeds	1	$16.10	$16.10
	Total			$719.59

NEXT STEPS

Hardware

- Interfacing with sensor array
- Ensuring all hardware components align within requirements
- Testing sensors in plant growth medium

Software

- Allowing user to compare two sets of data
- Processing and displaying images
- Testing Machine Learning algorithm on camera modules with test images

WE ARE READY FOR YOUR QUESTIONS.