

# The ParaSolar Experience

Group 11

Dylan Petrae CpE

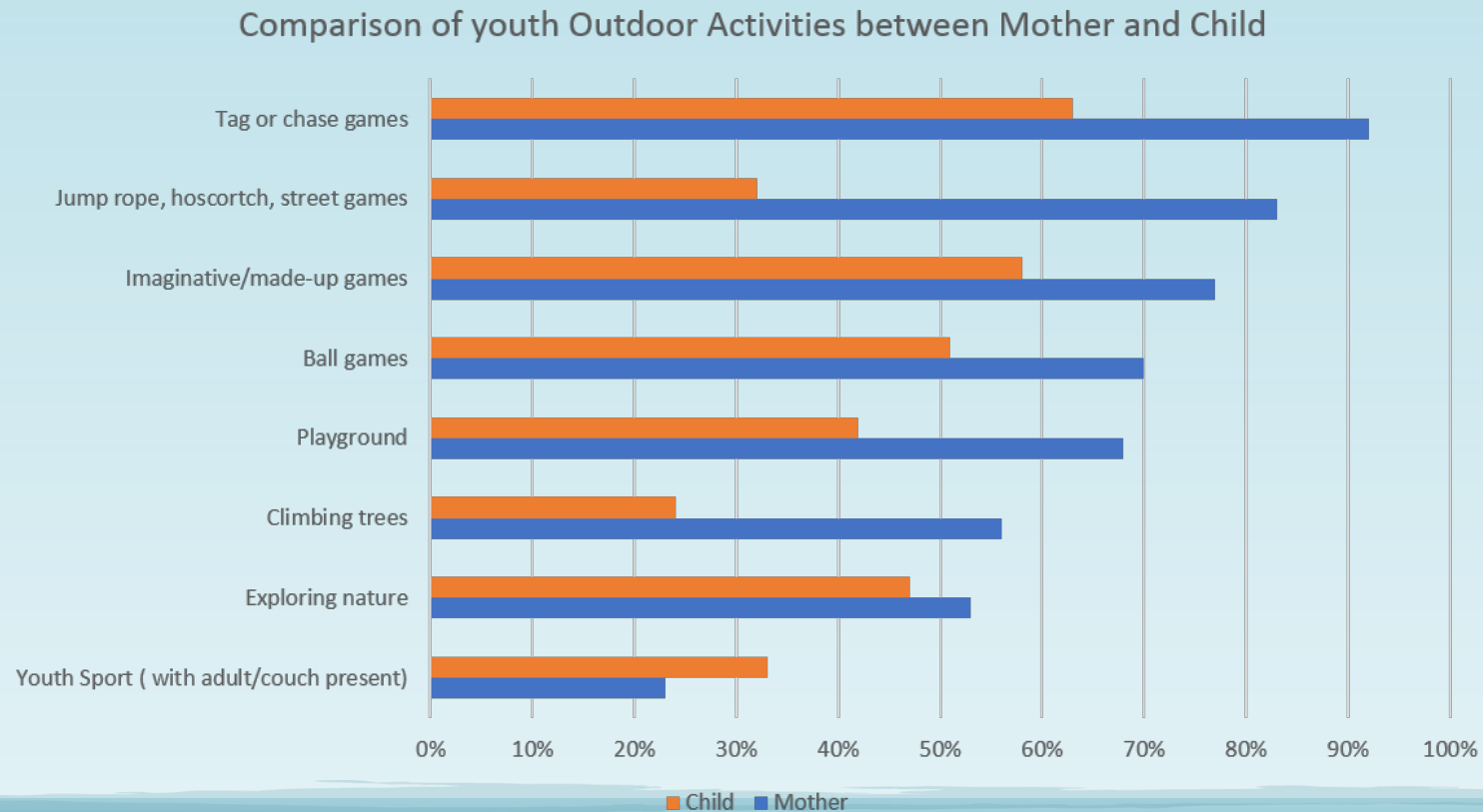
Meghan Perry EE

Casey Mann EE

Jesus Pulido CpE

# Motivation

- Disconnection with Nature: Now vs 1990's



# Motivation

- Side-effects of less outdoor time
  - Clinical Depression
  - Respiratory issues
  - Decrease in work/sleep quality
- Benefits of Nature Connection
  - better psychological well-being
  - superior cognitive functioning
  - speedier recovery from illnesses
  - fewer physical ailments
- Identifying key factors: Power, Entertainment, Connectivity, Information, and Convenience
- Turning these into specifications and goals



# Product Appearance

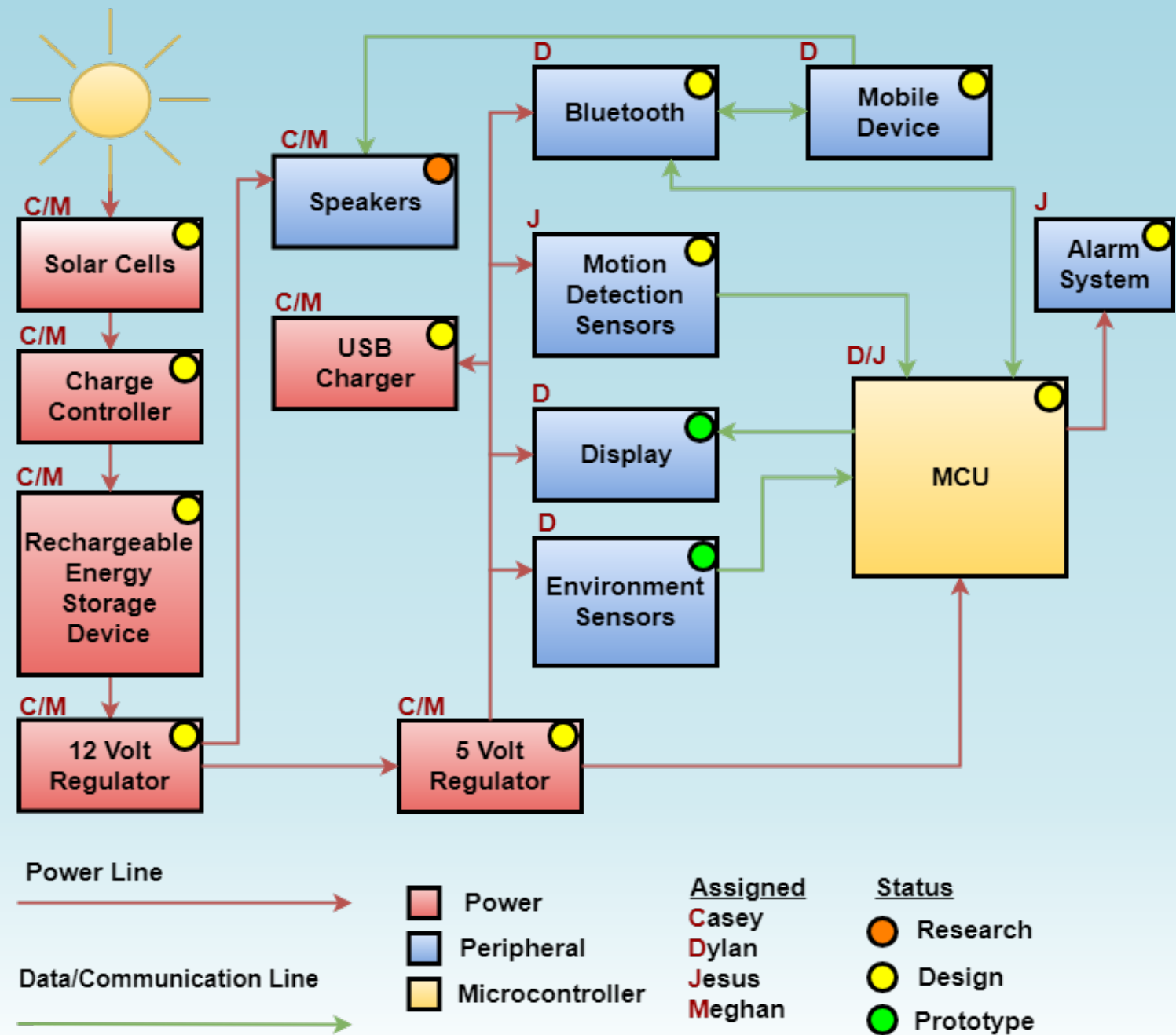
- Modified Tommy Bahama Umbrella
- Modified Coleman Cooler
- Solar Panels on Umbrella
- Hardware Placement on Cooler
- Environmental Factors-Beach:
  - Heat
  - Debris
  - Water



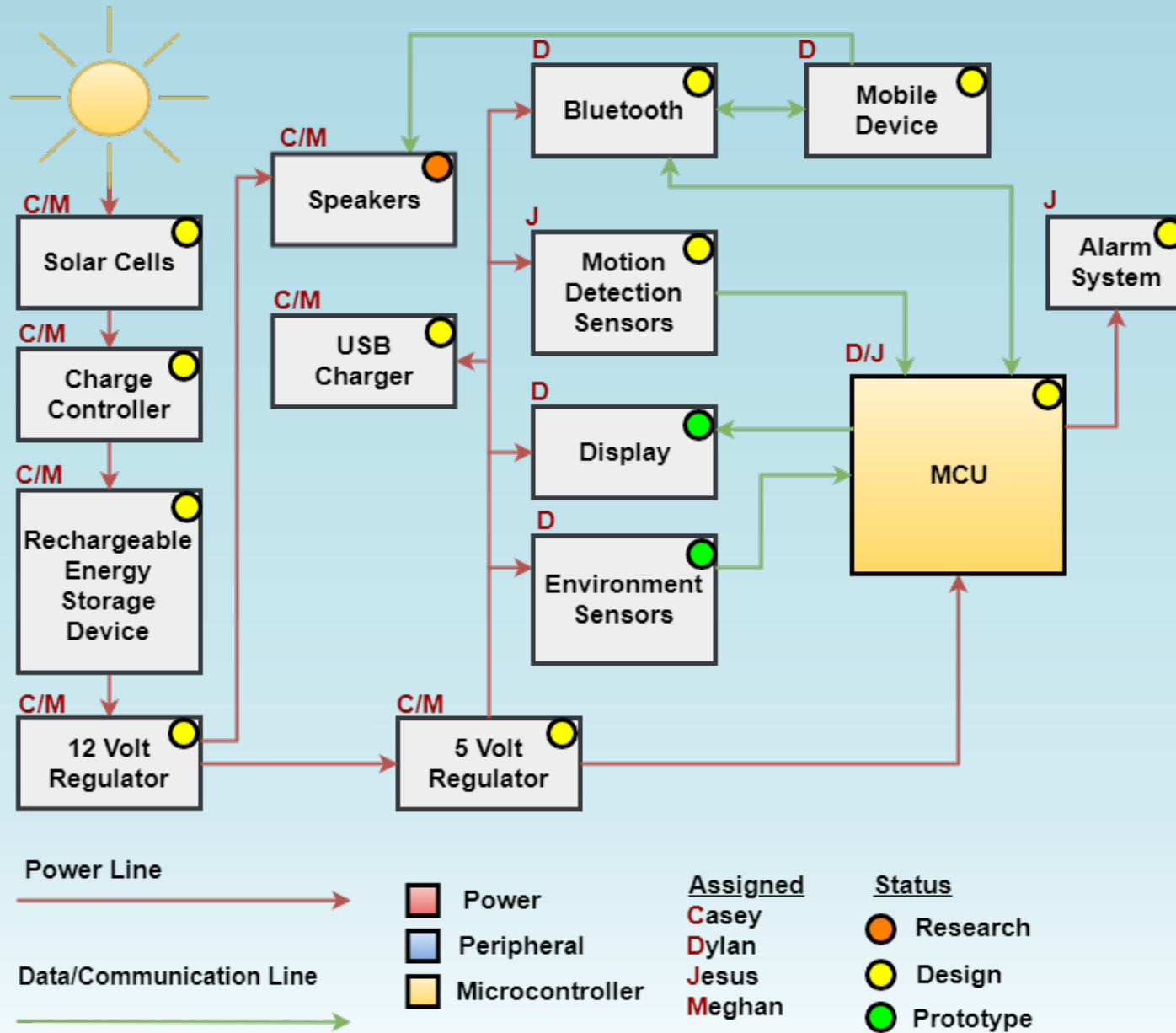
# Goals and Objectives

- To make the project as easy as possible to utilize.
- Must ensure a secure environment for the devices while the user enjoys the outdoors.
- Must provide entertainment and ultimate connectivity with the users handheld devices on multiple platforms.
- The end-product should be low-cost compared to other similar products and it should be lightweight and portable.

# Overall Hardware Block Diagram



# Microcontroller



# Microcontroller Selection

- ARM Architecture vs. Modified Harvard or Von Neumann Architectures
- Ease of programmability
- Is able to hold several hundred lines of code



# ATmega328p

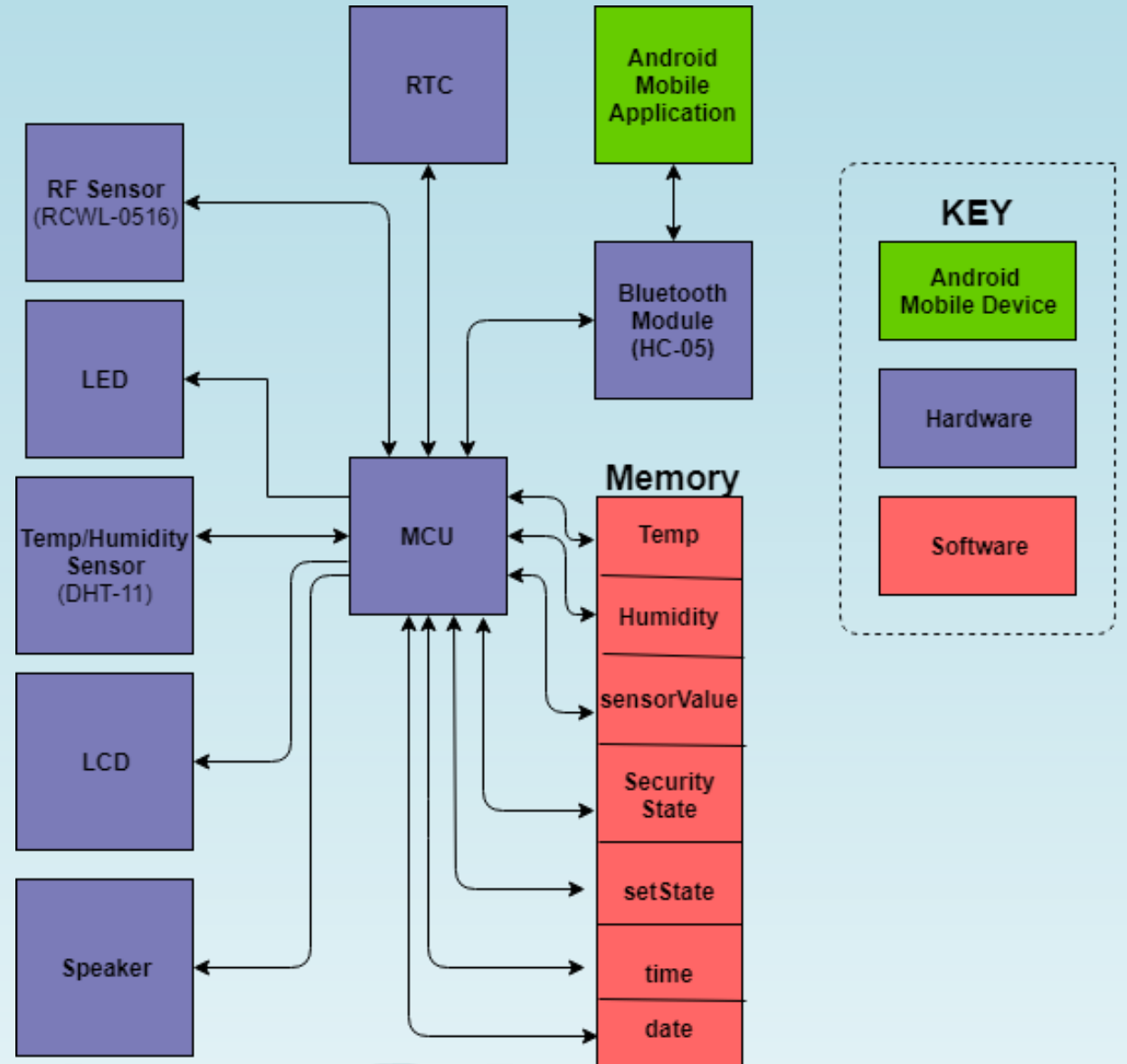
- Based on Modified Harvard Architecture
- Allows for very crude parallel processing
- Most common microcontroller for Arduino projects
- Operating voltage in the range of 1.8 V to 5.5 V
- Very easy to program

# MSP430

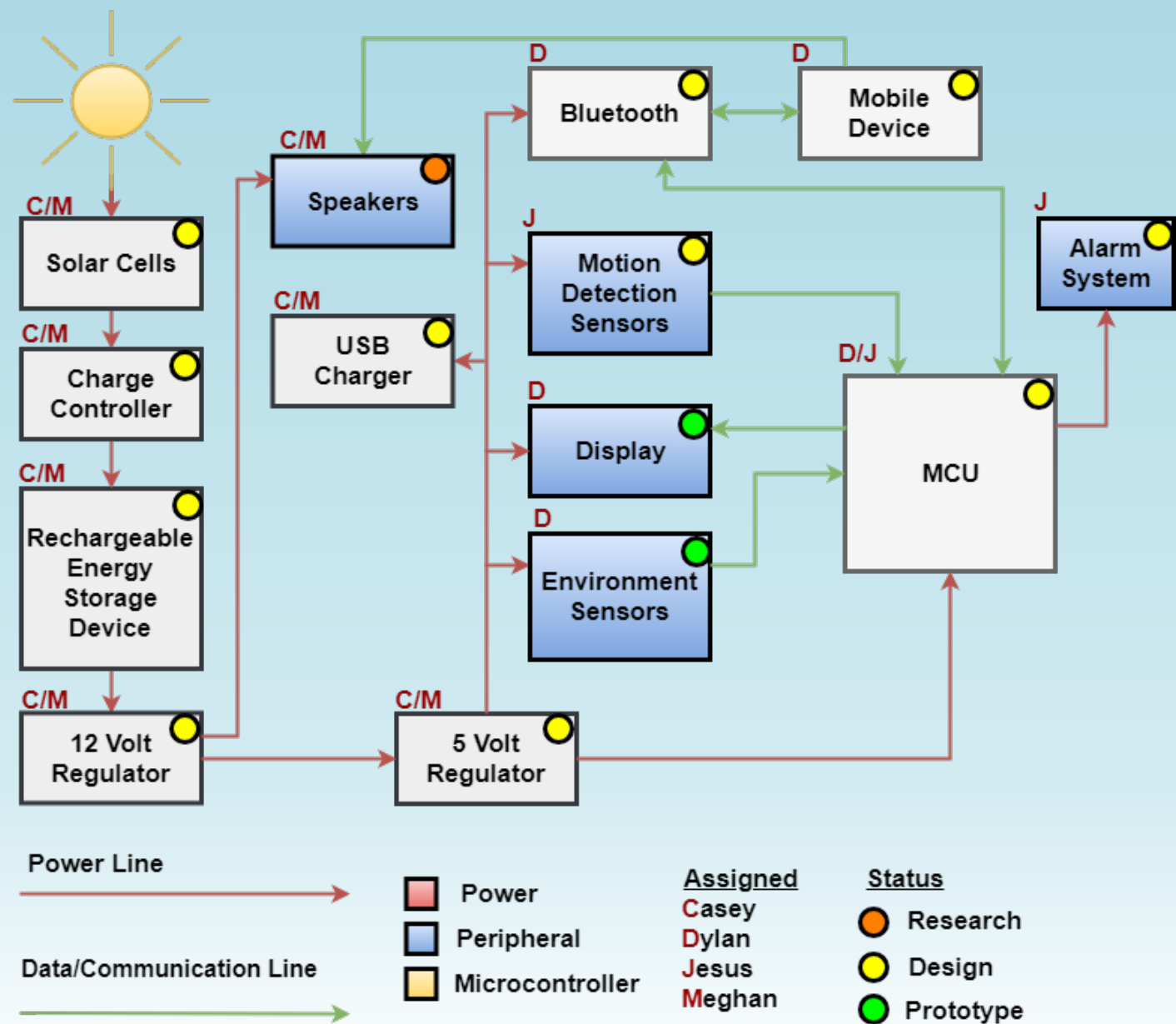
- Based on Von Neumann Architecture
- Excels at sequential processing
- Found mostly on TI LaunchPad
- Operating voltage in the range of 1.8 V to 3.6 V
- Easy to program

# Microcontroller Software

- Bluetooth Serial Connection established
- While security mode is inactive, update date, time, temp, and humidity data to LCD screen every minute
- Listen for signal from mobile device to enable security mode
- While security mode is active, check to see if RF sensor has been triggered every 10 seconds
- If the RF sensor trips, send message to mobile device, informing the user, along with sending tone to speaker



# Peripherals



# Environment Sensors & Display

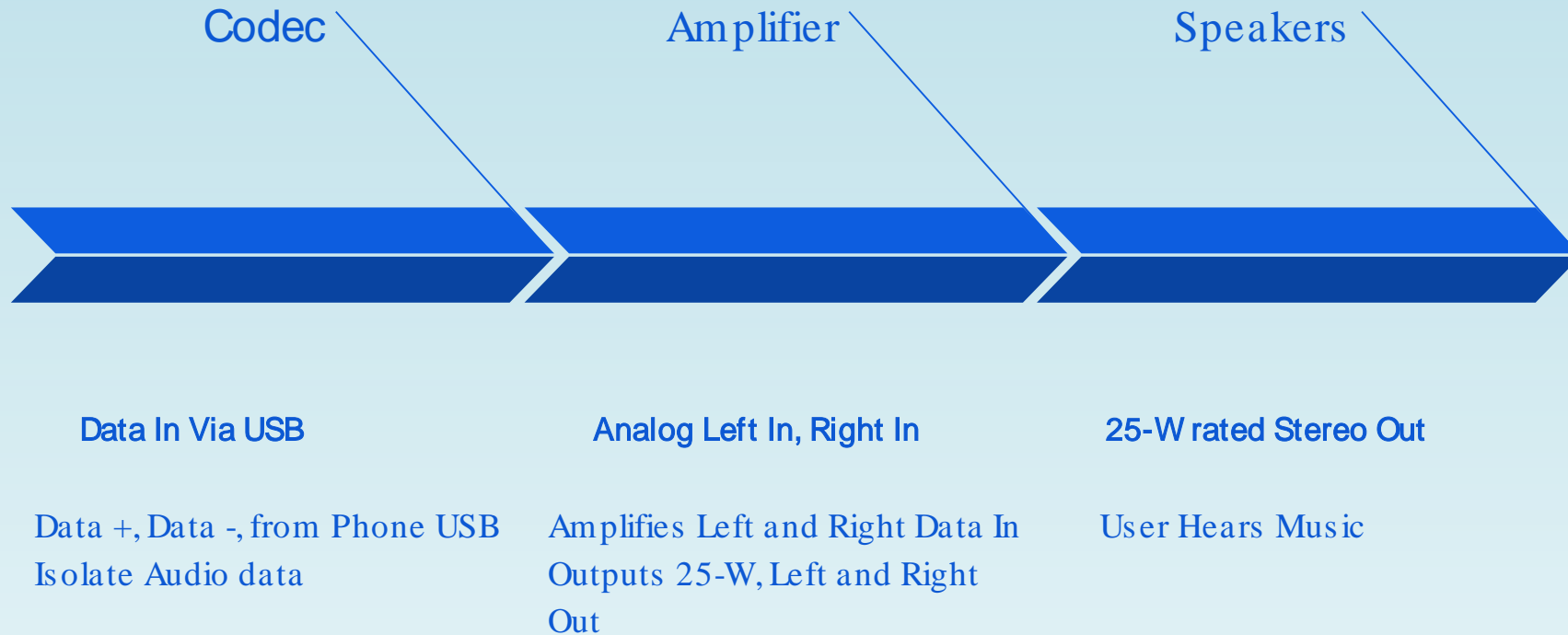
- The temperature and humidity will be recorded
- A real time clock will be used
- Different types of technologies for display
- It needs to be able to function outdoors
- Research led to LCD

# Motion Sensors

- Reliably detected the motion of someone approaching the umbrella
- Some motion detection options:
  - Passive Infrared Sensor
  - Ultrasonic Sensor
  - Microwave Sensor
- Microwave Sensor was used
- Key component for the Alarm system
  - Features a Piezoelectric Buzzer

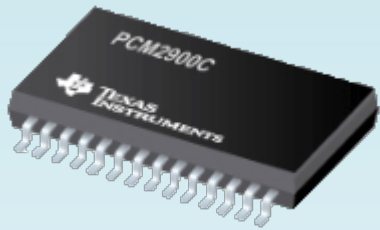
# Speaker System

- Will satisfy Entertainment factor

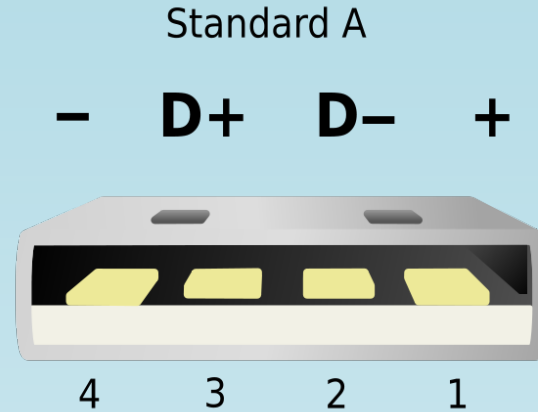


# Audio Codec

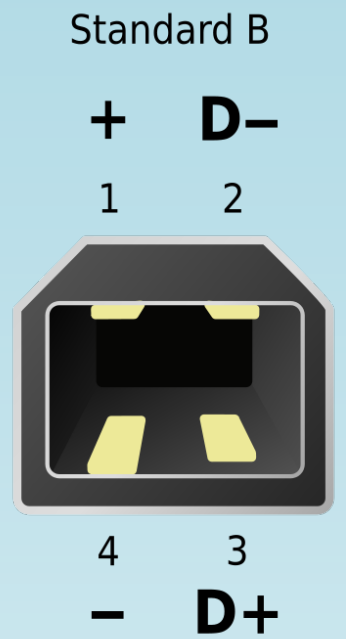
- PCM2900C Stereo Audio Codec
  - No programming required
  - DAC in chip
  - USB full speed protocol compliant



# USB Charging Ports



**USB**



Must be...

- able to charge any hand-held device to 5V and 1.7A.
- compatible with USB Type A ports.
- able to operate at 60°C temperature for extended periods of time.



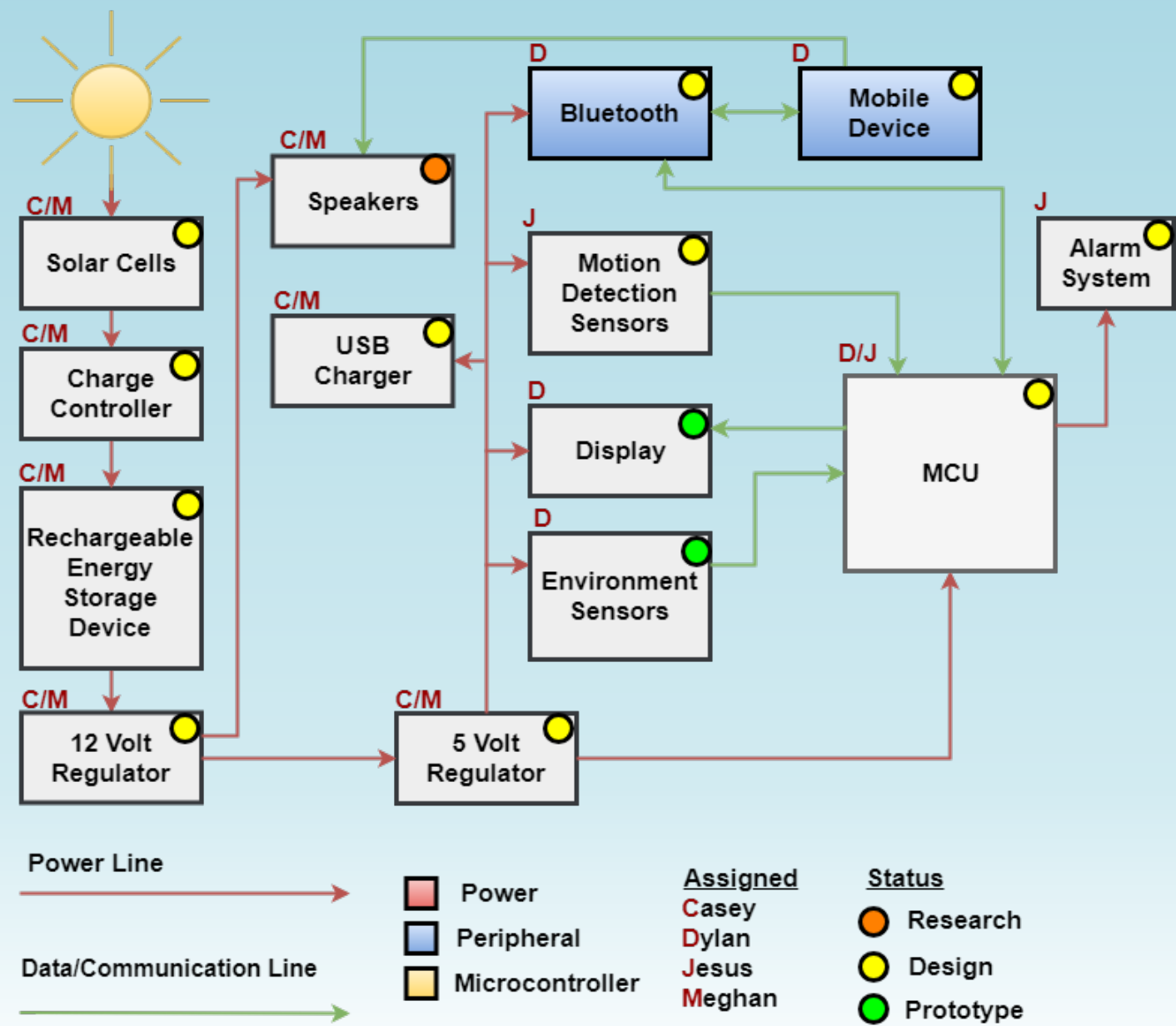
# USB Charging Port Types

- There are three different source types for these specific ports.
  - Standard Downstream Port (SDP)
  - Charging Downstream Port (CDP)
  - Dedicated Charging Port (DCP)

# USB Selection

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  - Dedicated Charging Port (DCP)

# Communication Peripherals



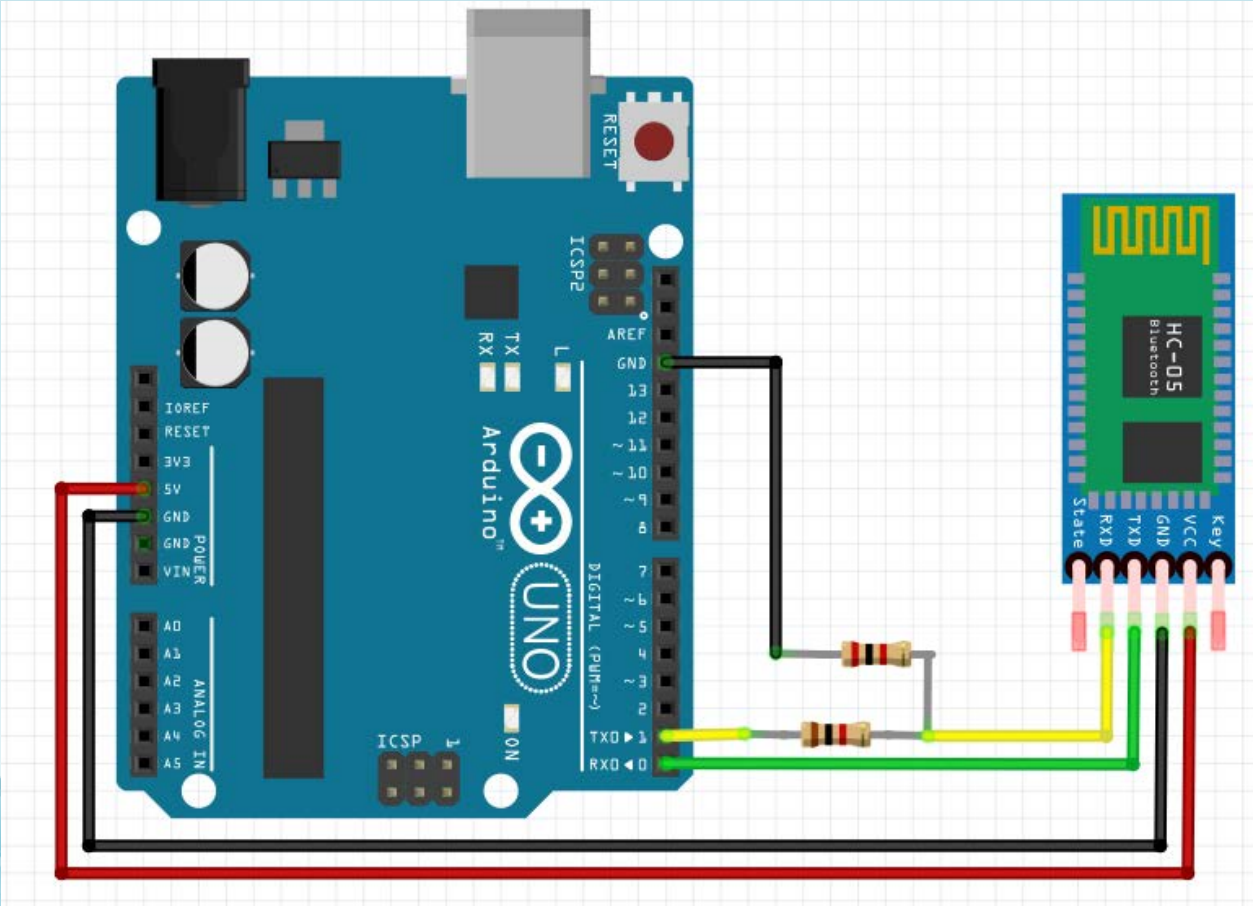
# Selecting Wireless Technology

- Wireless communication needed between the Parasolar system and Android device
- Current Android devices come stock with hardware to support Bluetooth and Wi-Fi out of the box.
- Wi-Fi requires more intervention and set-up from the user
- Bluetooth is more lightweight in terms of energy usage

Wireless Technology	Wi-Fi (802.11)	Bluetooth (802.15.1)
Cost	Cheap (~\$5)	Cheap (~\$5)
Performance	Decent ( 7Mbps)	Slow ( ~ 7Kbps )
Implementation	Complex	Simple
Power Consumption	Medium	Ultra-Low / Low

# HC-05 Bluetooth Module

**Functionality:** Provide Wireless Communication capabilities between system and Android mobile device

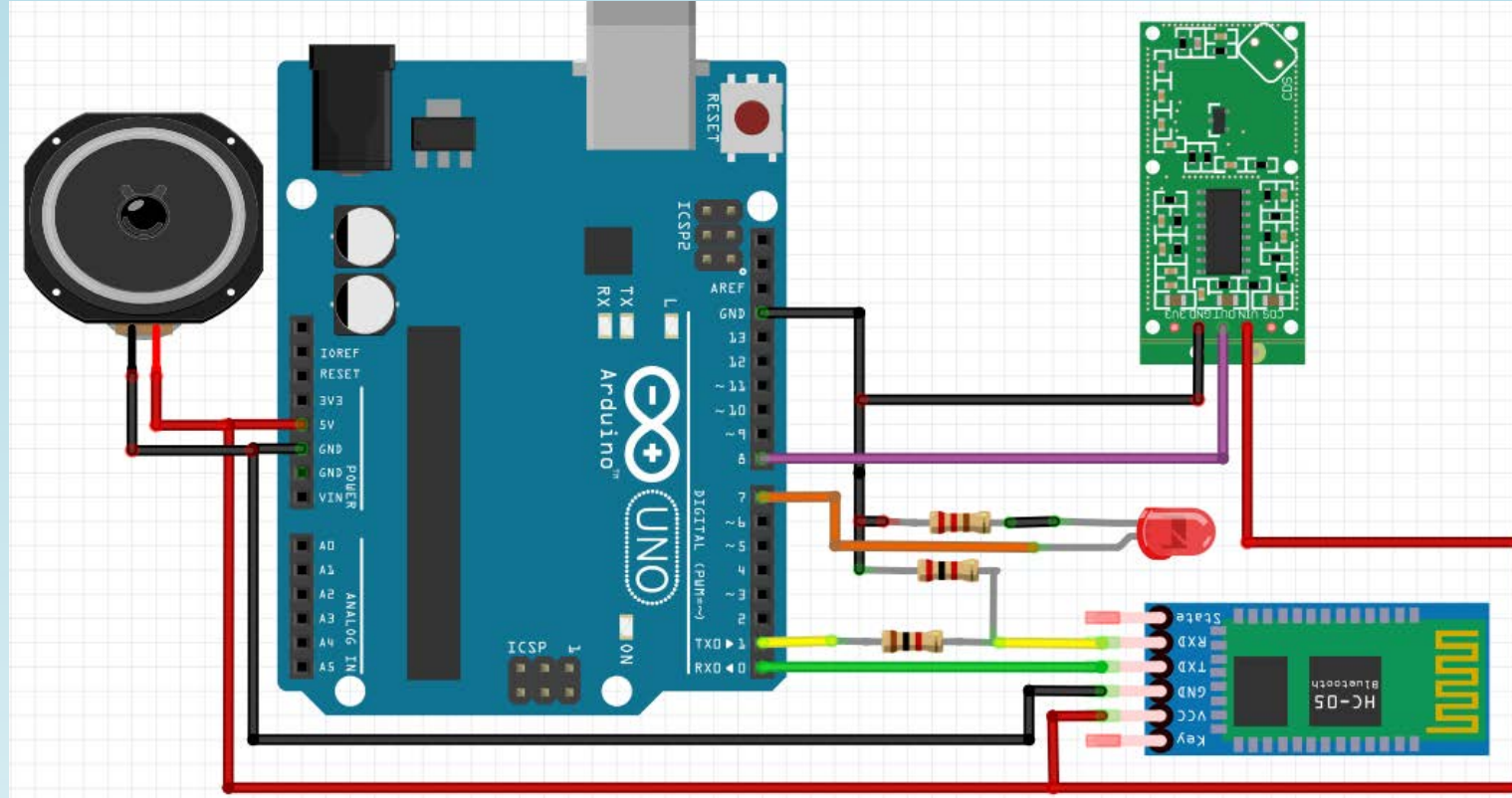


37mm

16mm

Module	HC-05 (ZS-040)
Price	\$6.00
I/O Pins	4 (VCC, GND, RX, TX)
Power Supply	5V
TX/RX Voltage Levels	3.3V
Bluetooth Version	V2.0
Current Draw (Idle)	< 8 mA

# Security System



- Two-way communication is needed between the phone and the system
- The mobile application allows the user to turn on the security system wirelessly.
- The MCU transmits back to the mobile device when the security has been tripped

# Mobile Device Operating System Selection



VS



- **Android**

- **Free to develop**
- **Android Studio IDE**
- **Abundance of documentation**
- **Open Source**
- **Fragmentation**

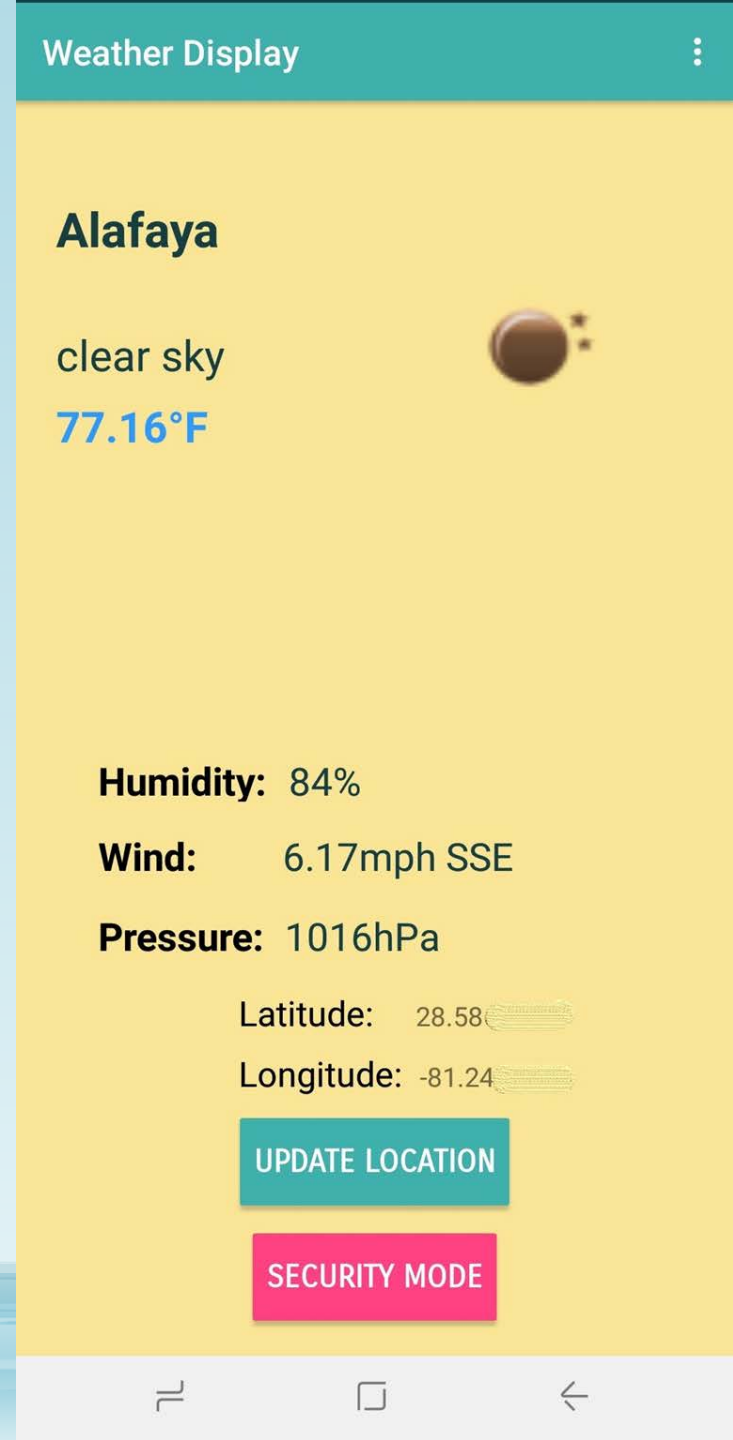
- **iOS**

- **\$99/year**
- **Xcode IDE**
- **Swift**
- **Time Consuming App Review**



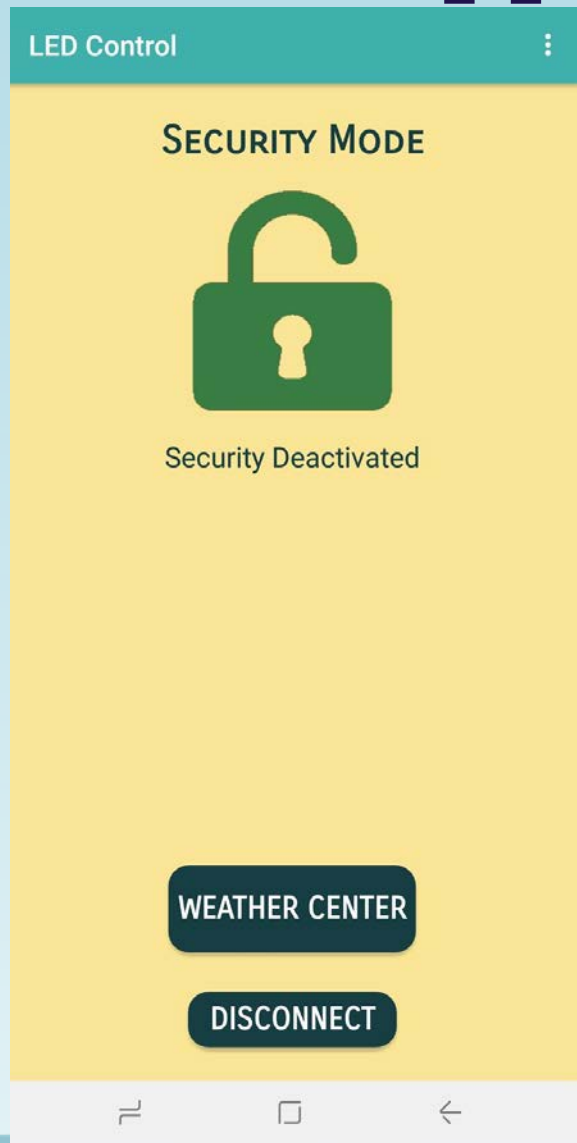
# Mobile Application Functionality

- **Display (shown to right)**
  - **GPS Coordinates**
  - **Weather Center**
    - Current City
    - Current Weather Condition
    - Temperature
    - Humidity
    - Wind Speed and Direction
    - Barometric Pressure
- **Security (shown on next slide)**
  - Wirelessly enable Security Mode
  - Receives notification when the RF Sensor has been tripped

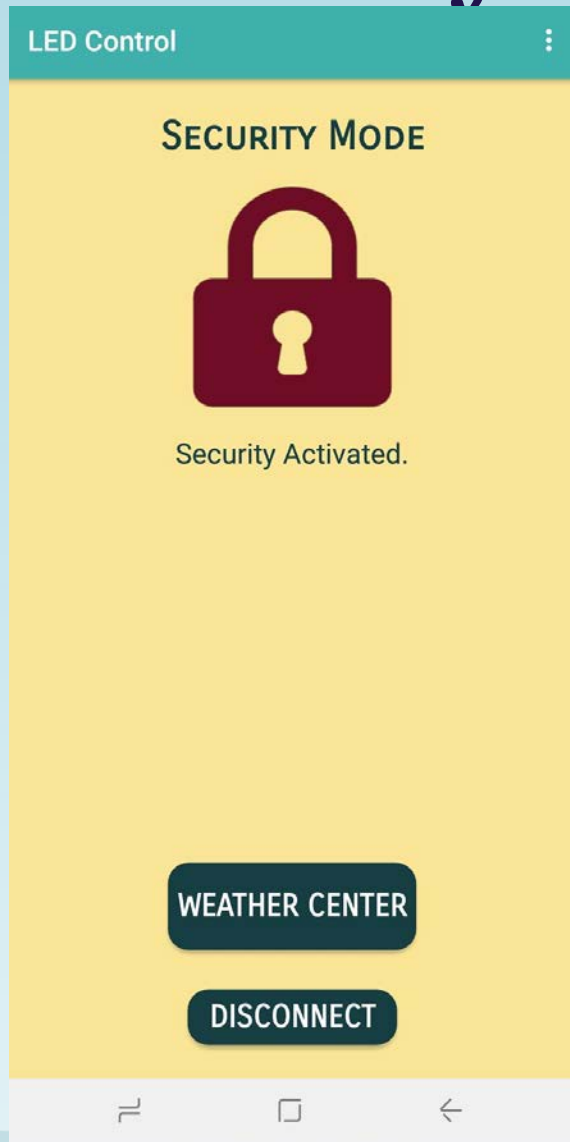




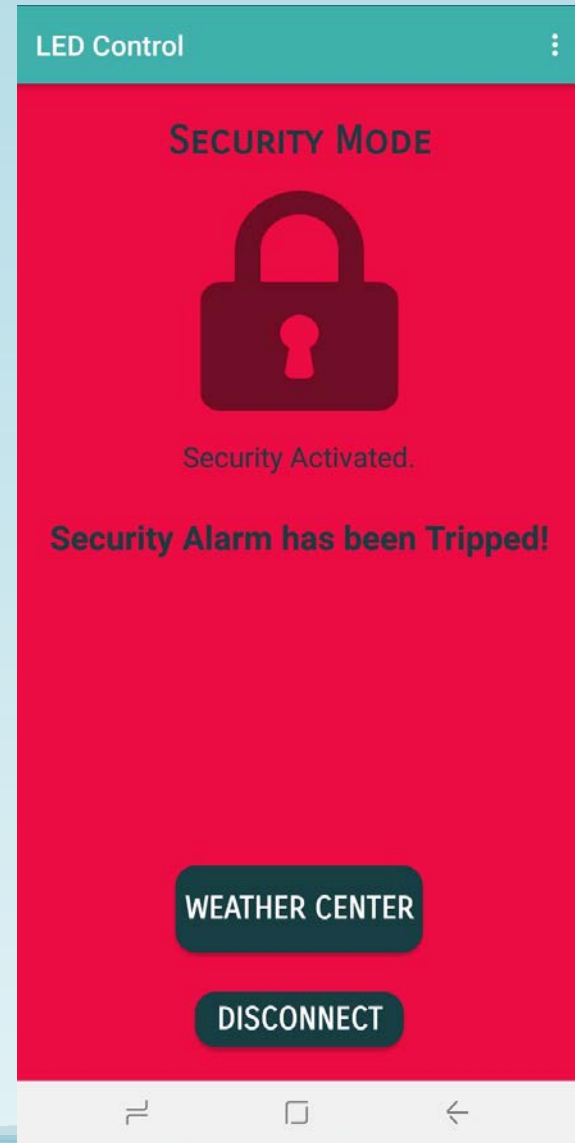
# Mobile Application Security Mode



**Security Mode is Inactive**

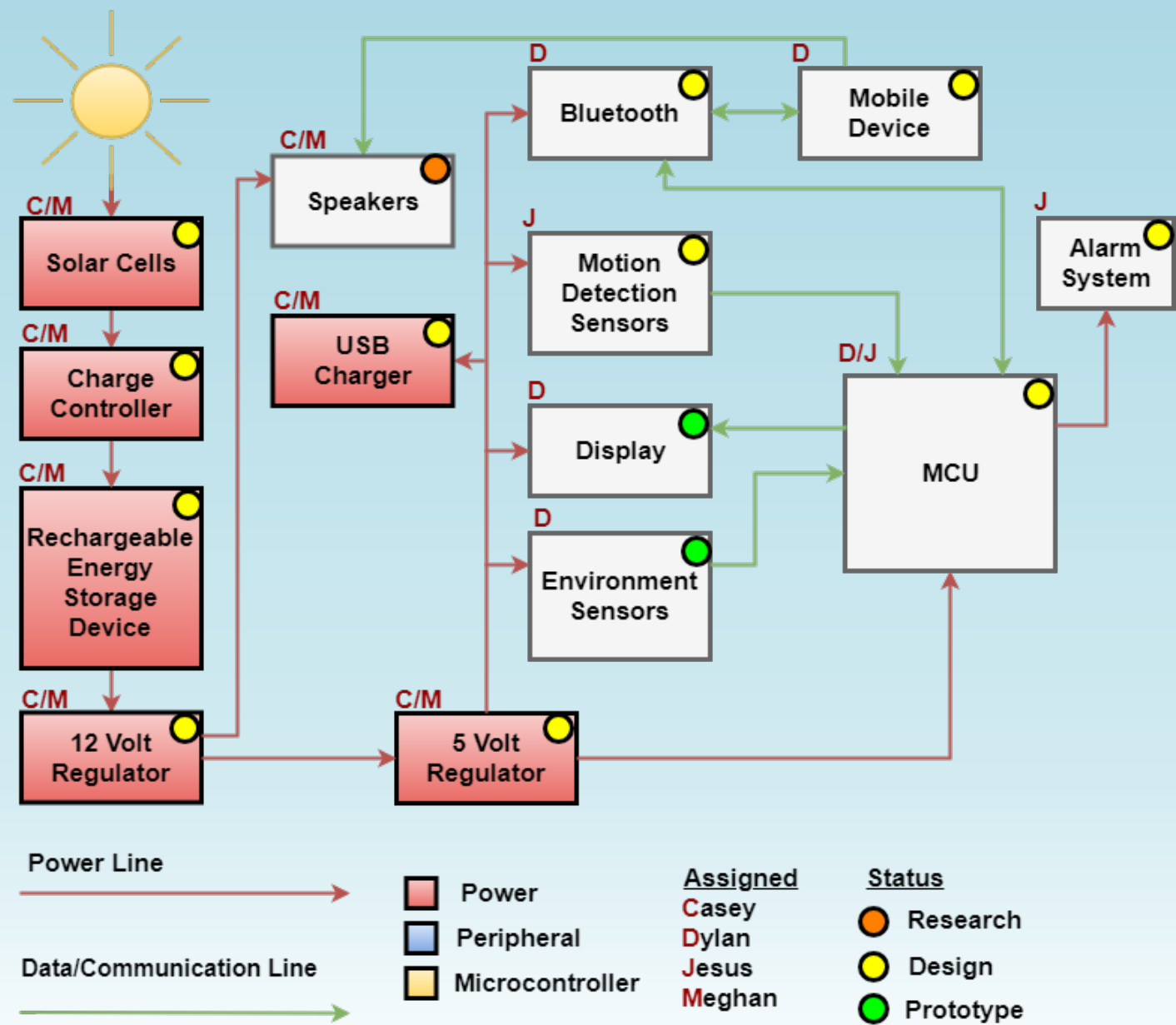


**Security Mode is Active, but  
has not been tripped**



**Security Mode is Active  
and has been tripped**

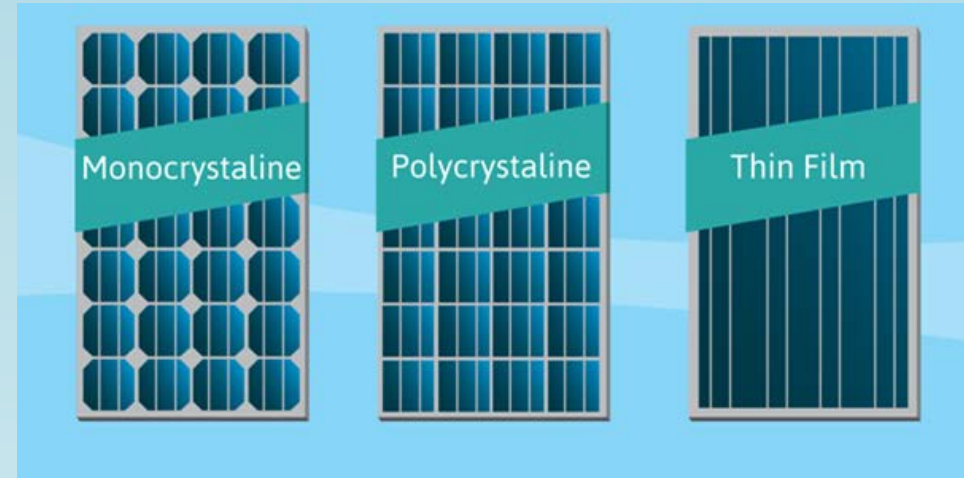
# Power



# Solar Cell Criterion

Must be...

- lightweight
- cost efficient
- able to supply at least 16 Watts of power in order to sustain a sufficient charge on the energy storage device.
- able to perform efficiently when subjected to high temperatures
- able to retain a high efficiency rate when subjected to low light conditions.



	Cost per Cell (Dollars)	Wattage (W)	Size (mm)	Weight (g)	Heat Resistivity (°C)	Low Light Performance
<b>Jiang A-Si Flexible Solar Cell</b>	19.99	1	196 X 87 X 0.1	27	0~70	Yes
<b>BCMaster Polysilicon Solar Cell</b>	1.12	1	110 X 60 X 2.5	13.6	-20~85	Yes
<b>Solopower Lightweight Thin Flexible CIGS Solar Cell</b>	7.99 uncoated	1.5	368 X 40 X 0.3	9.07	unknown	Yes
<b>Viko Cell Mono Series Monocrystalline Solar Cell</b>	1.55 uncoated	2.7	125 X 125 X 0.5	unknown	unknown	Yes

## Solar Cell Comparison

Note: Costs labeled with the word “uncoated” require user to provide a form of housing or coating of the cell and will substantially raise the cost of the product.

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## Solar Cell Selection

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# Battery

Must...

- have a high gravimetric energy density
- have a relatively fast charge time to maintain a certain level of convenience.
- be able to hold a charge without experiencing any substantial amount of self-discharge.
- be able to maintain a high level of performance when subjected to high temperatures reaching up to 60°C.

	NiCd	NiMH	Lead Acid	Li-ion	LiPo
<b>Gravimetric Energy Density (Wh/kg)</b>	45-80	60-120	30-50	110-160	100-130
<b>Cycle Life</b>	1500 <sup>2</sup>	300 -500 <sup>2,3</sup>	200 - 300 <sup>2</sup>	500 - 1000 <sup>3</sup>	300 – 500
<b>Charge Time (hours)</b>	1	2-4	8-16	2-4	2-4
<b>Overcharge Tolerance</b>	moderate	low	high	Very low	Low
<b>Self Discharge (per month)</b>	20% <sup>4</sup>	30% <sup>4</sup>	5%	10% <sup>5</sup>	~10% <sup>5</sup>
<b>Operating Temperature (°C)</b>	-40 - 60	-20 - 60	-20- 60	-20- 60	0- 60

## Battery Comparison

Note: The pricing for the battery did not end up playing a pertinent role when choosing a battery. Therefore it was not included in the table.

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<b>Charge Time (hours)</b>	1	2-4	8-16	2-4	2-4
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<b>Operating Temperature (°C)</b>	-40 - 60	-20 - 60	-20- 60	-20- 60	0- 60

## Battery Selection

12V DC Li-ion battery pack for a total cost of \$29.45



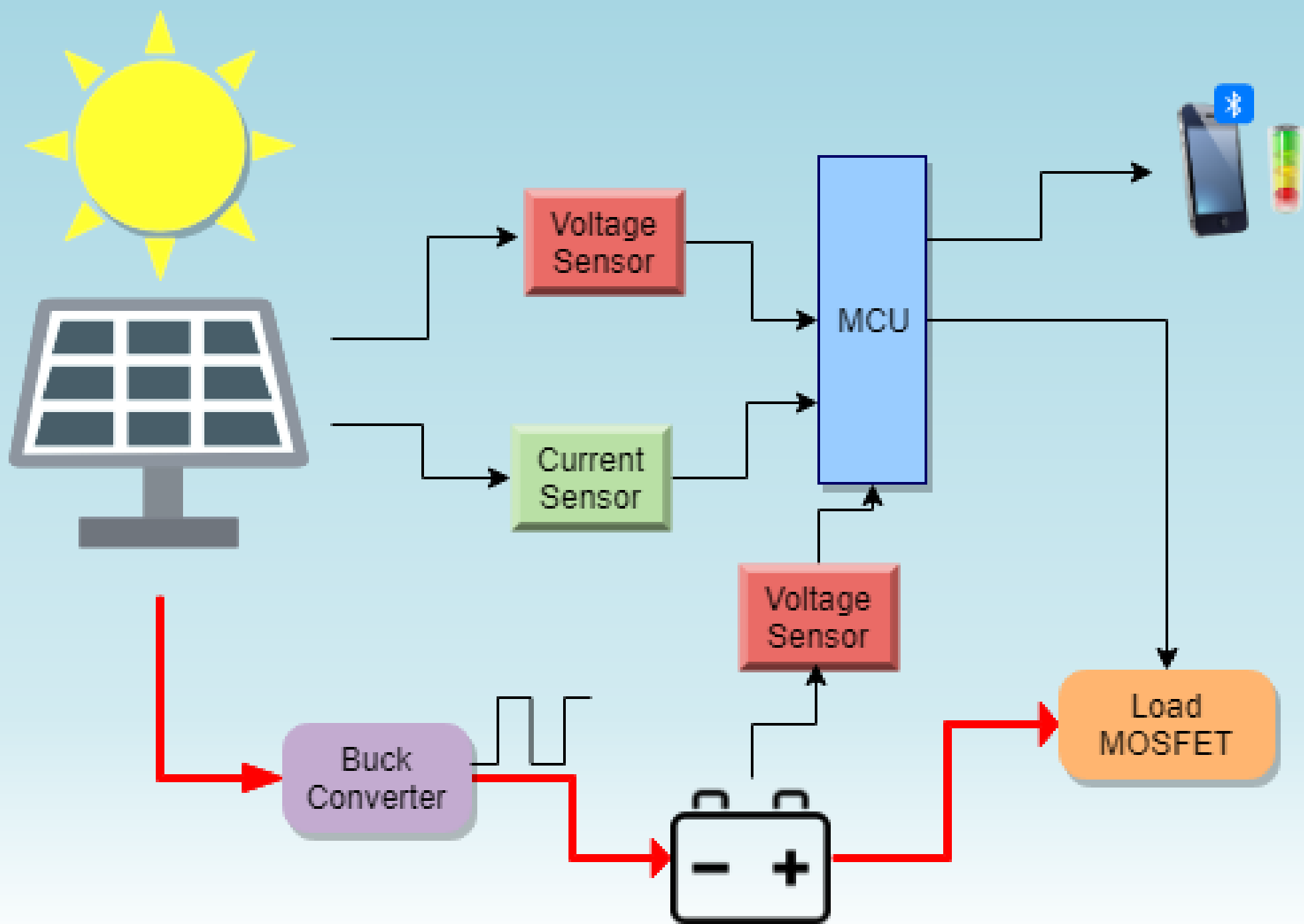
# Solar Charge Controller Criterion

Must be...

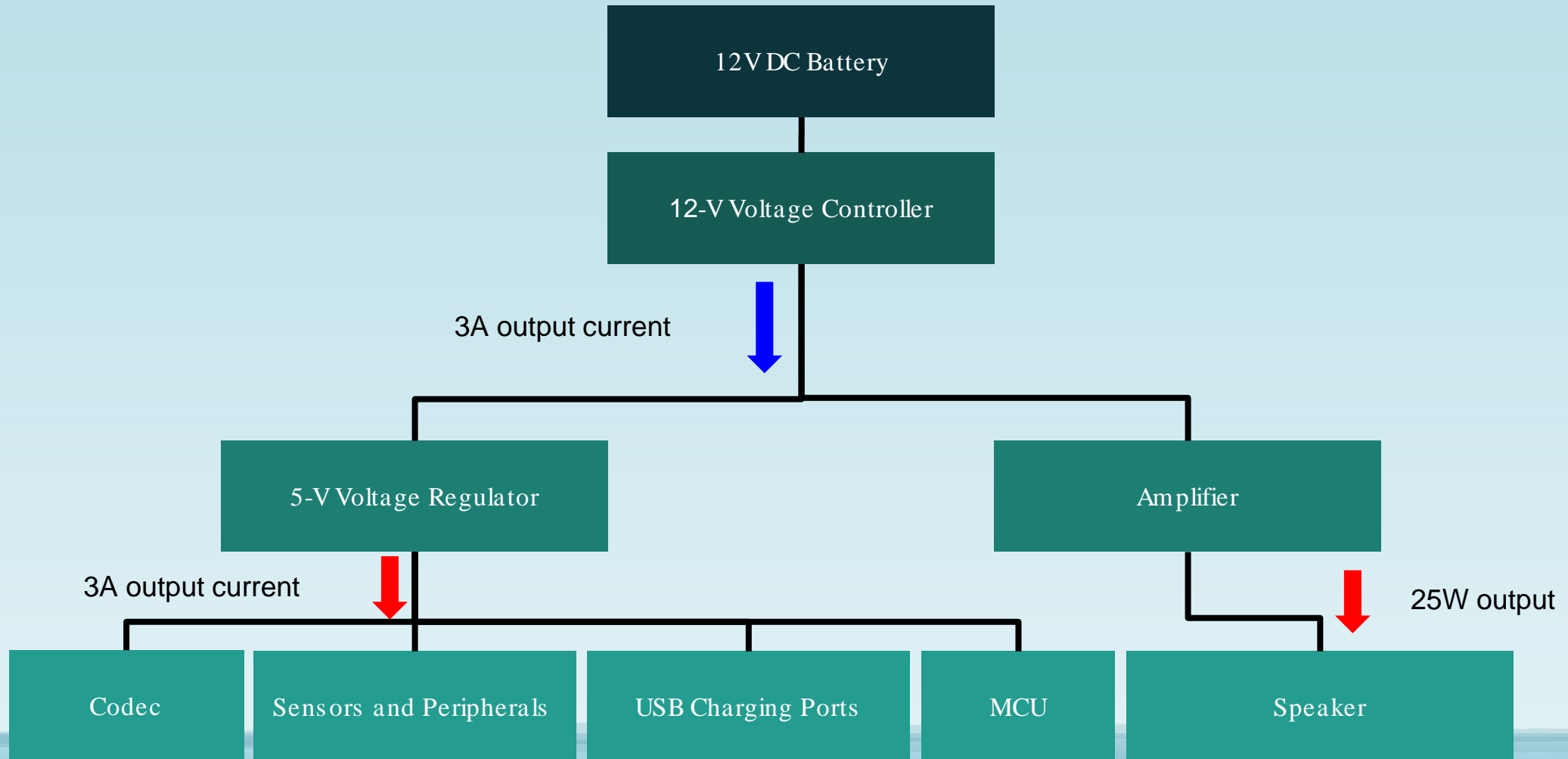
- compatible with the battery and with the solar panels used in this application.
- designed to maximize power output.
- able to reduce the possibility of the battery being drained out through the solar panels when not being charged.

# Maximum Power Point Tracking

- MPPT converters use a microcontroller.
- Converts excess voltage into current.
- Time required for a full charge to decrease significantly.
- The final function of a solar charge controller is preventing reverse current flow.
- For this project a MPPT solar charge converter has been designed and we are in the process of building and testing the prototype.



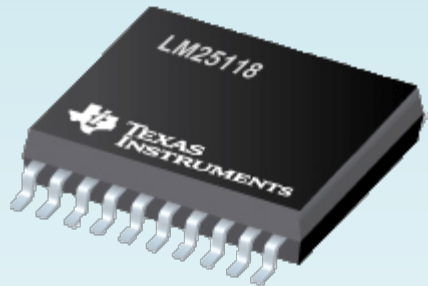
# Power Distribution



# LM25118 Controller    LM2576 Regulator

Buck-Boost Switching  
regulator controller

Notable features: Thermal  
shutdown, current limit  
shutdown, wide voltage  
range



$V_{in}$ : 3-42V

$V_o$ =12V

$I_o$ = 3A

Buck Switching Regulator

Notable features: no heat sink  
required, simplified design,  
current limit/thermal  
shutdowns

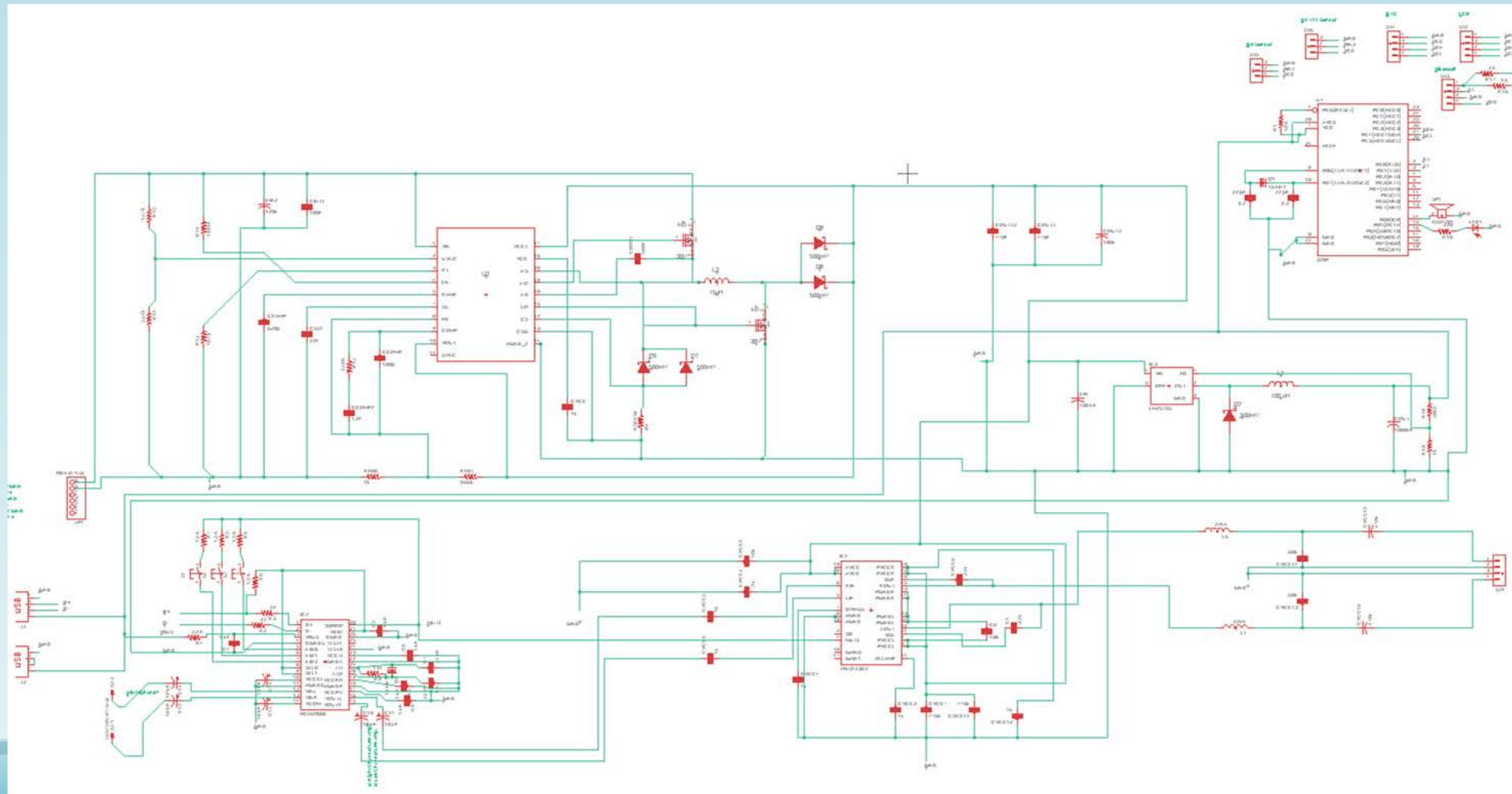


$V_{in}$ : 1-40V

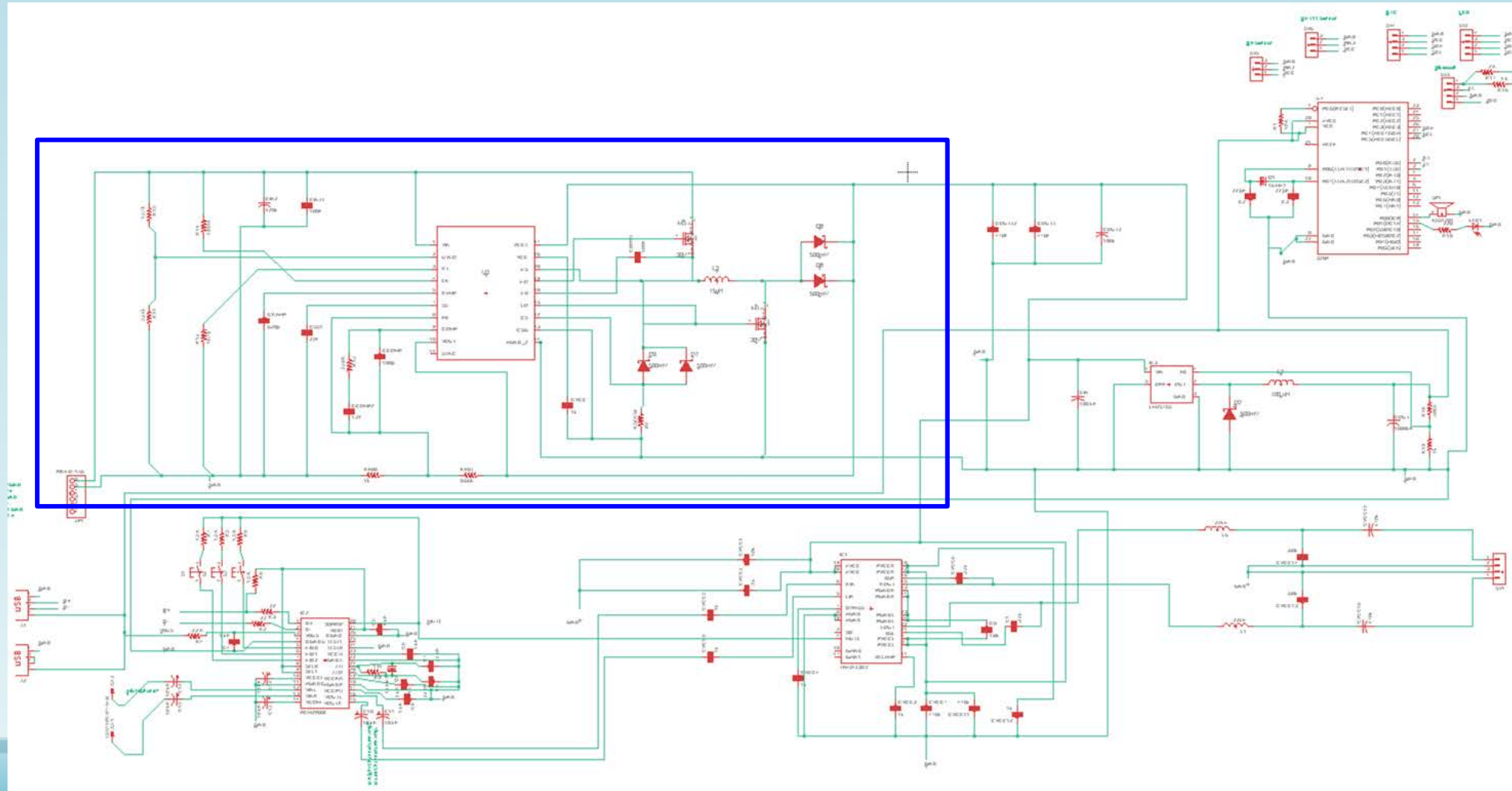
$V_o$ =3.3V,5V,12V,15V

$I_o$ = 3A

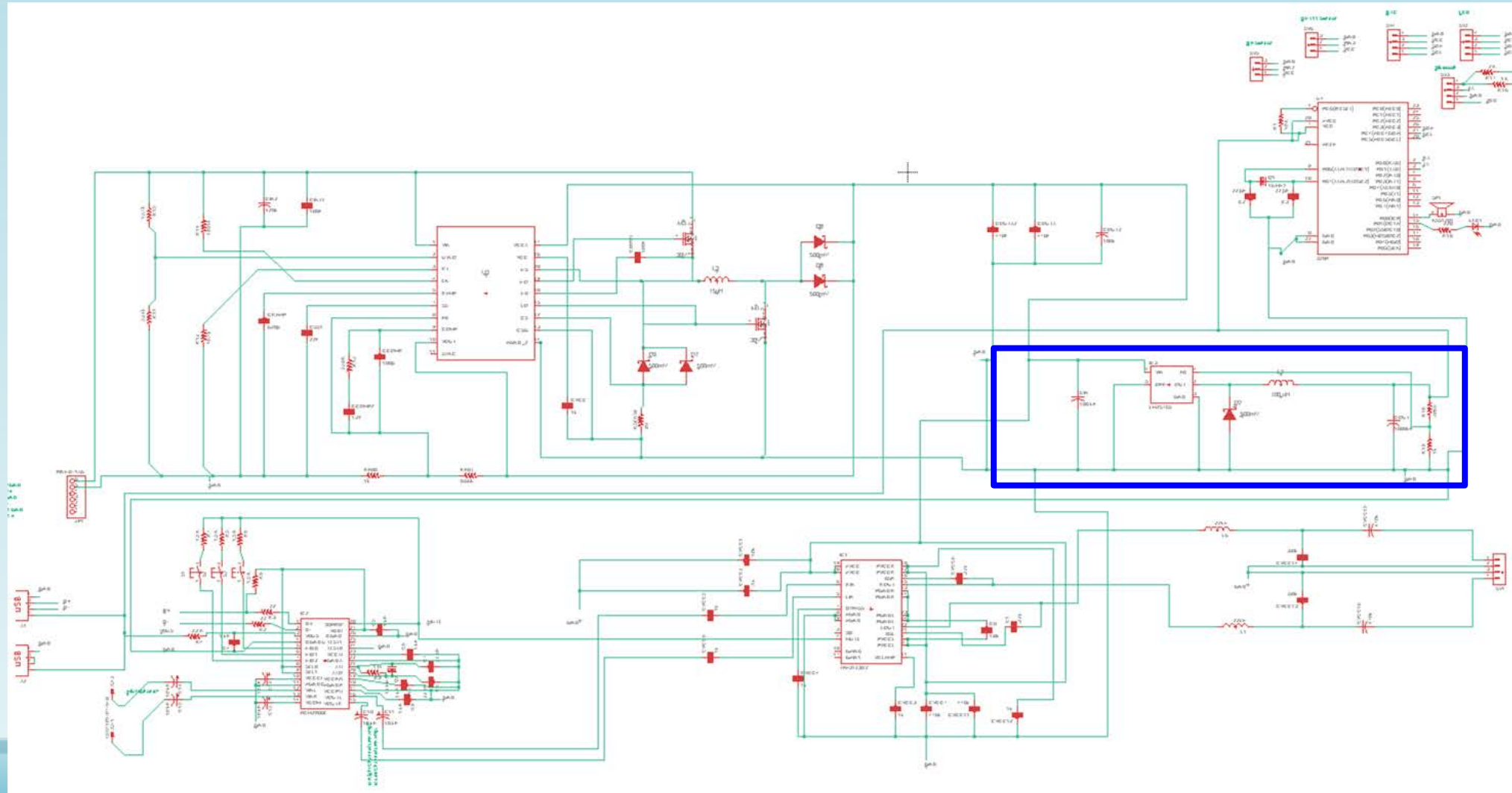
# PCB Schematic



# PCB Schematic - 12V Voltage Controller

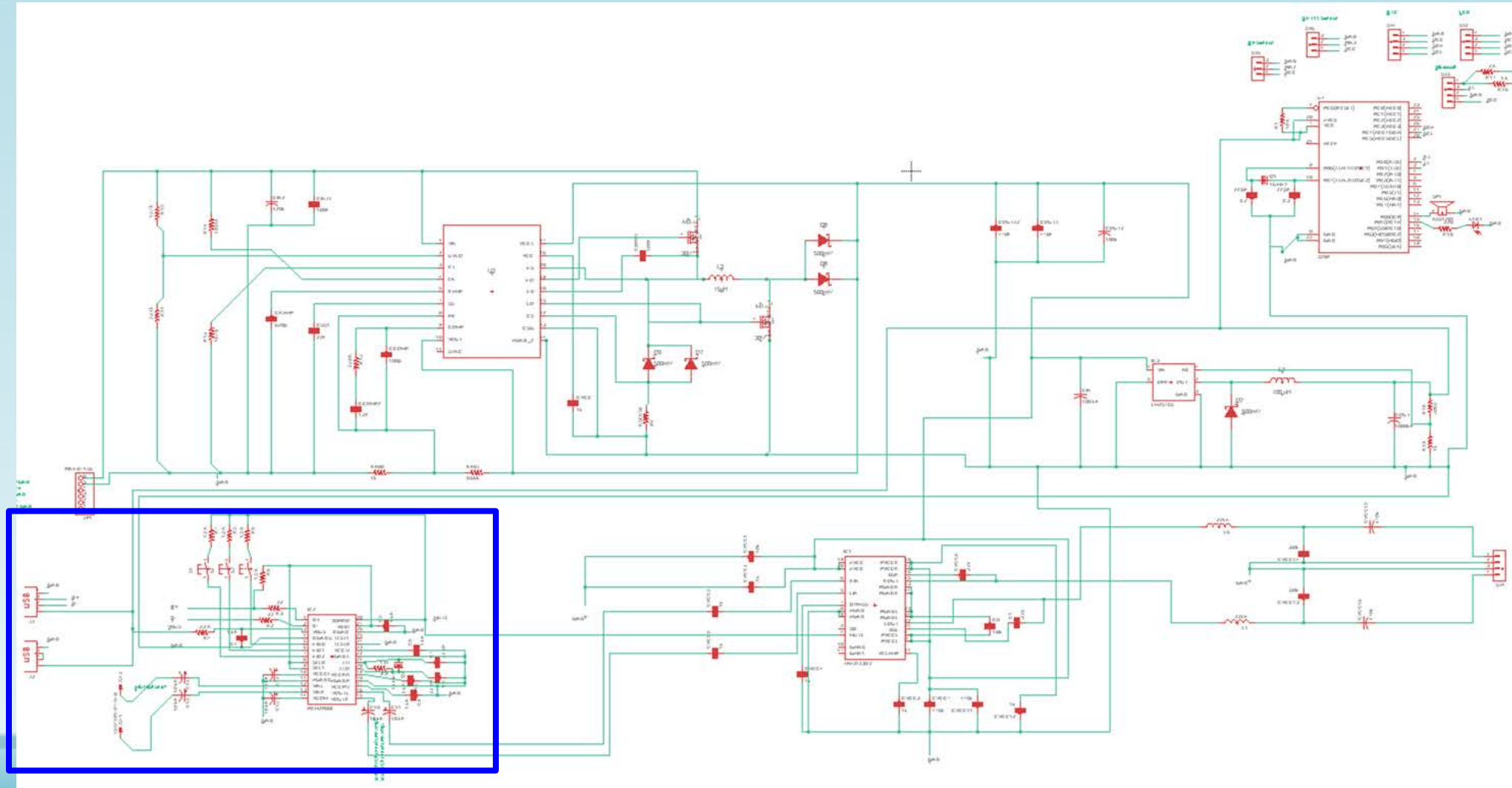


# PCB Schematic- 5V Voltage Regulator

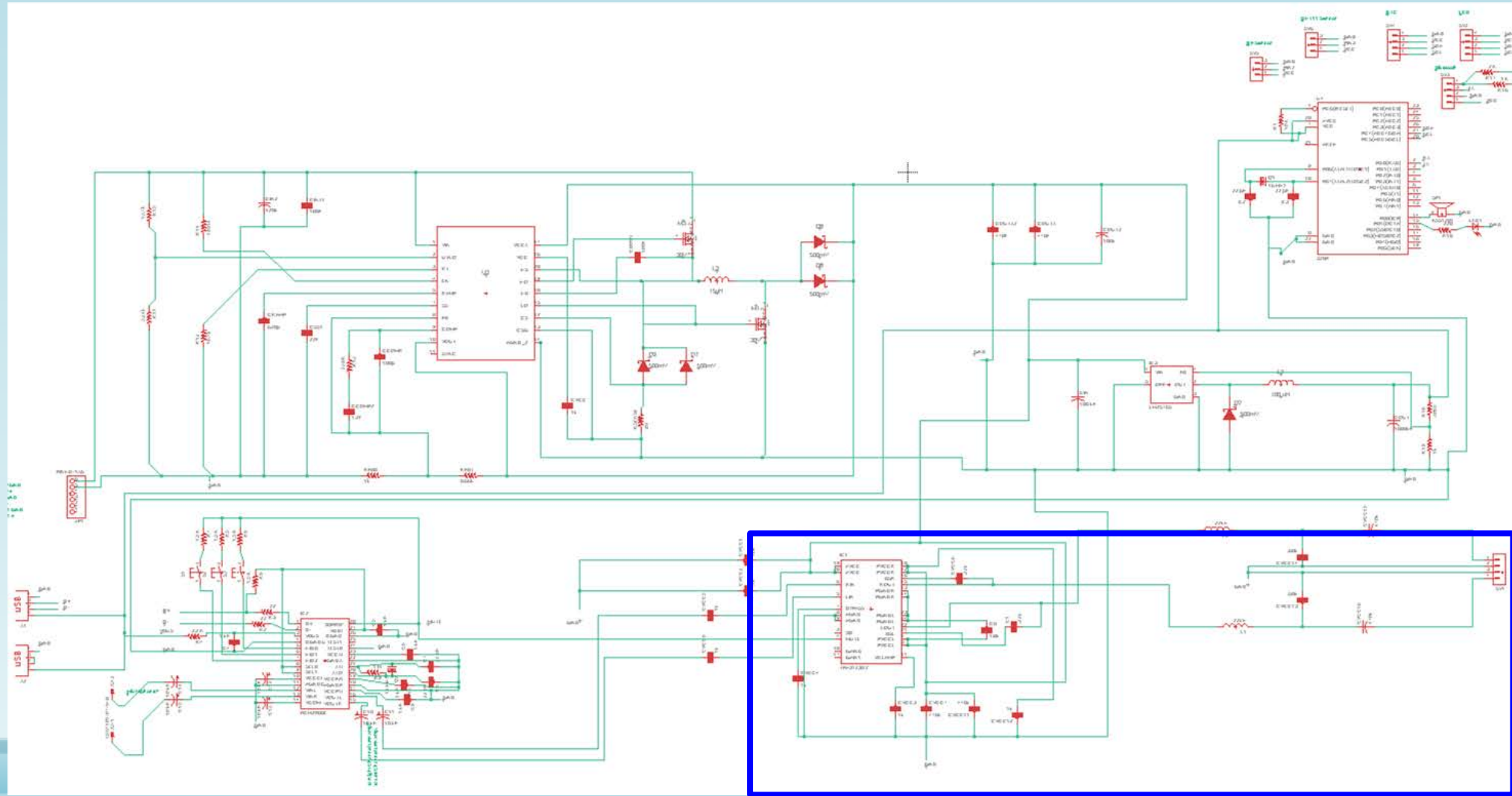




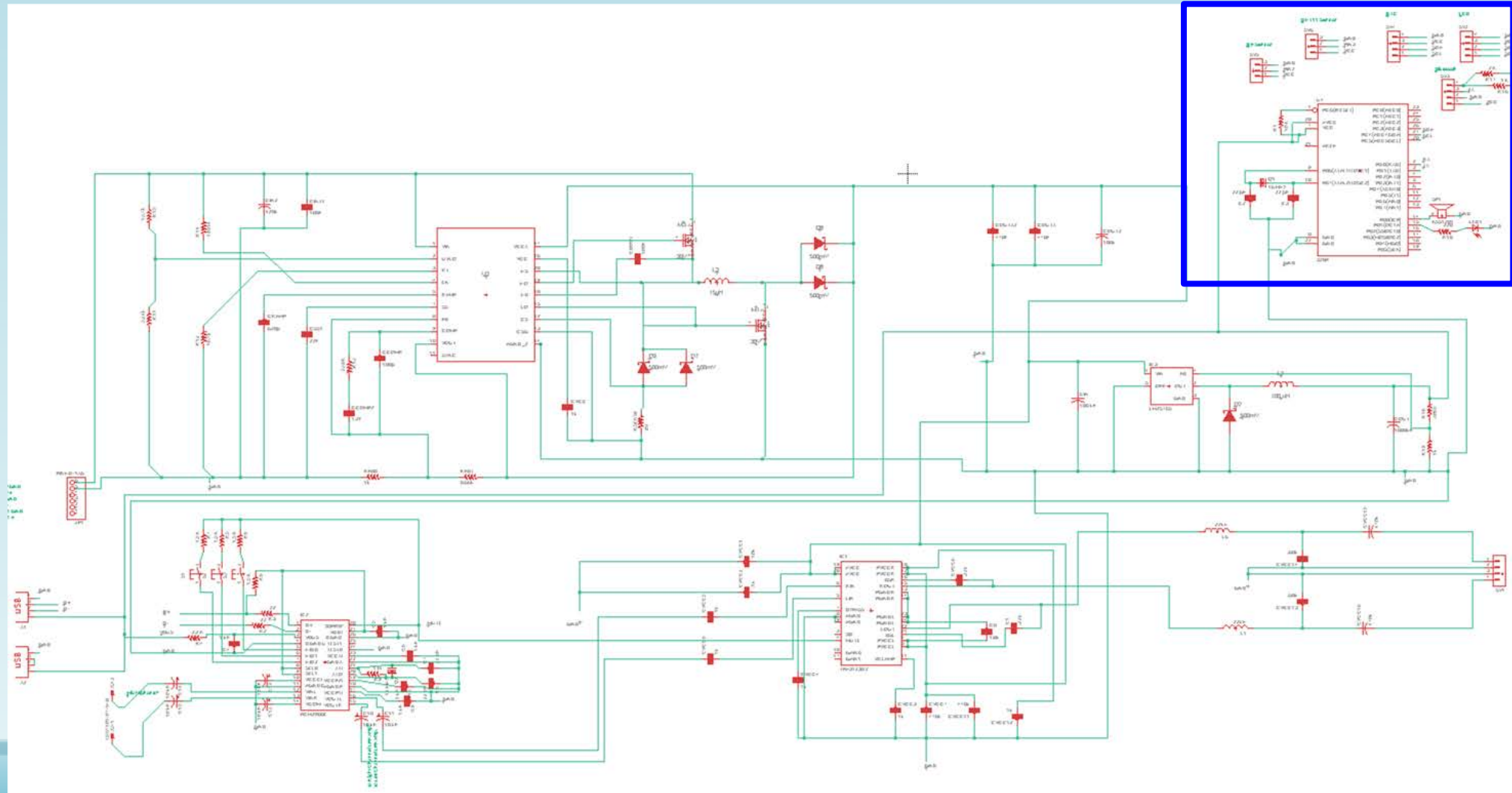
# PCB Schematic- Audio Codec



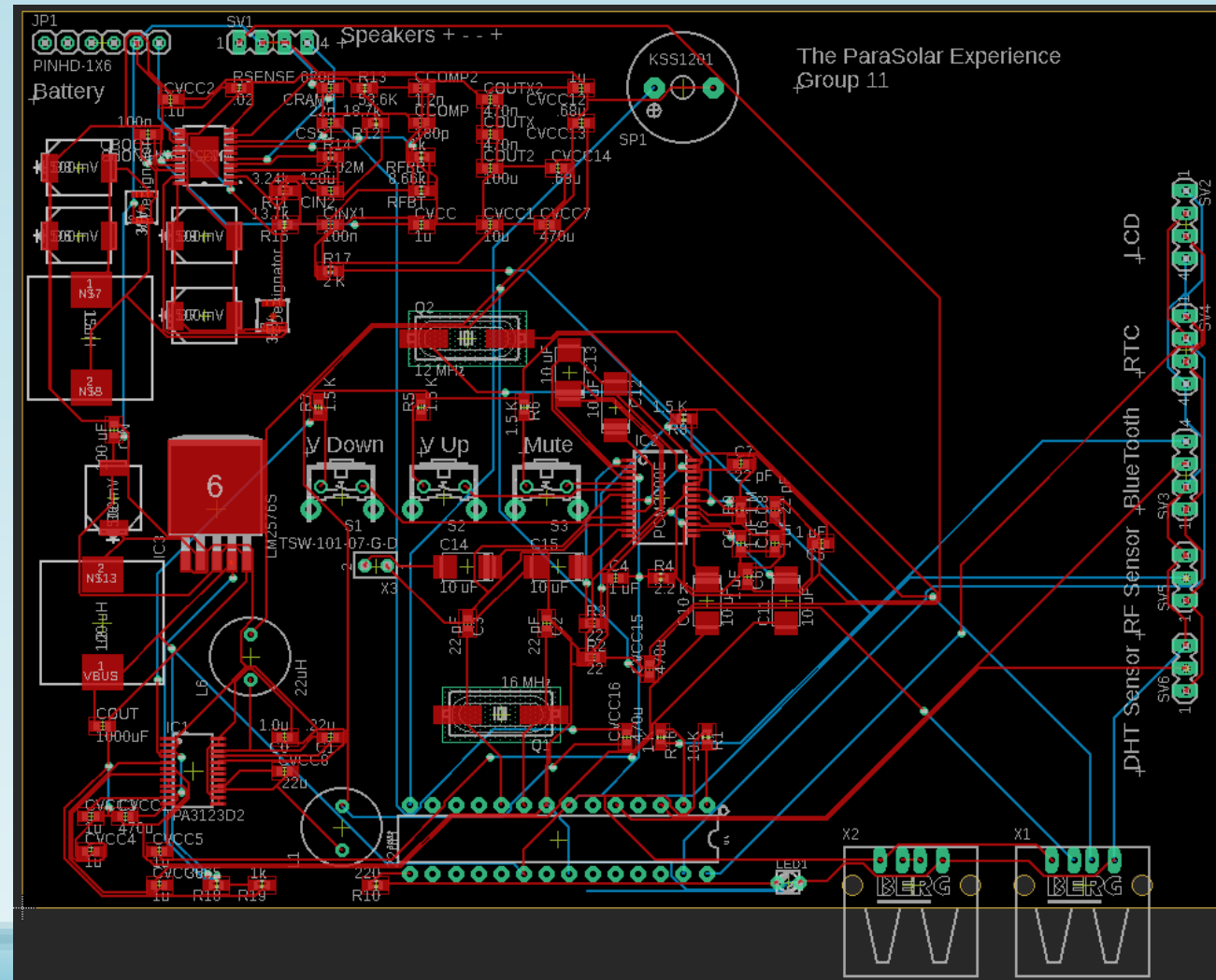
# PCB Schematic- Amplifier



# PCB Schematic- MCU and Peripherals

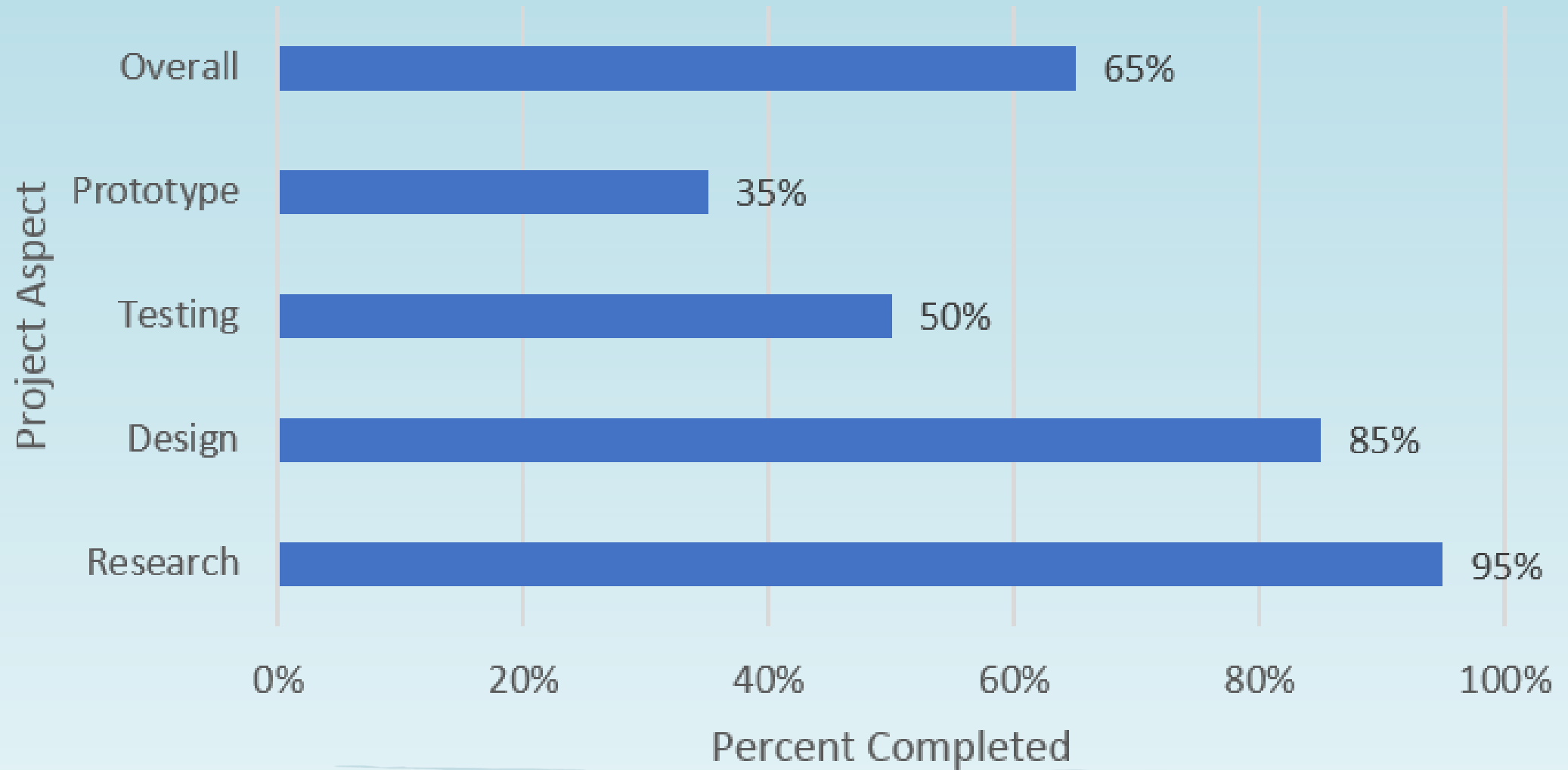


# PCB Footprint



# Administrative Content

# Progress Report



# Work Distribution

Name	Power Distribution	Battery Charge System	PCB Design	Security System	Software (MCU & Android App)
Dylan			Secondary	Secondary	Primary
Meghan	Secondary	Primary	Secondary		
Casey	Primary	Secondary	Primary		
Jesus			Primary	Primary	Secondary

# Budget

Total (Actual): \$168.14

Item	Quantity	Price Estimate (total)
Beach Umbrella	1	\$20
Battery	1	\$30
MCUs	2	\$15
Solar Panels	20	\$16
LCD Display	1	\$12
Speakers	2	\$25
LEDs	1	N/A
Temperature and Humidity Sensor	5	\$8.99
Proximity Sensor	5	\$9.50
Bluetooth module	1	\$5.65
Custom PCB	5	\$20
Waterproof/Particle materials for encasement	N/A	Free- 3D Printed
USB Type A Female Ports	2	\$3
RCLs,Transistors and ICs for Designs	N/A	\$30
Trips to the beach?	Many	As much as it takes



Questions?