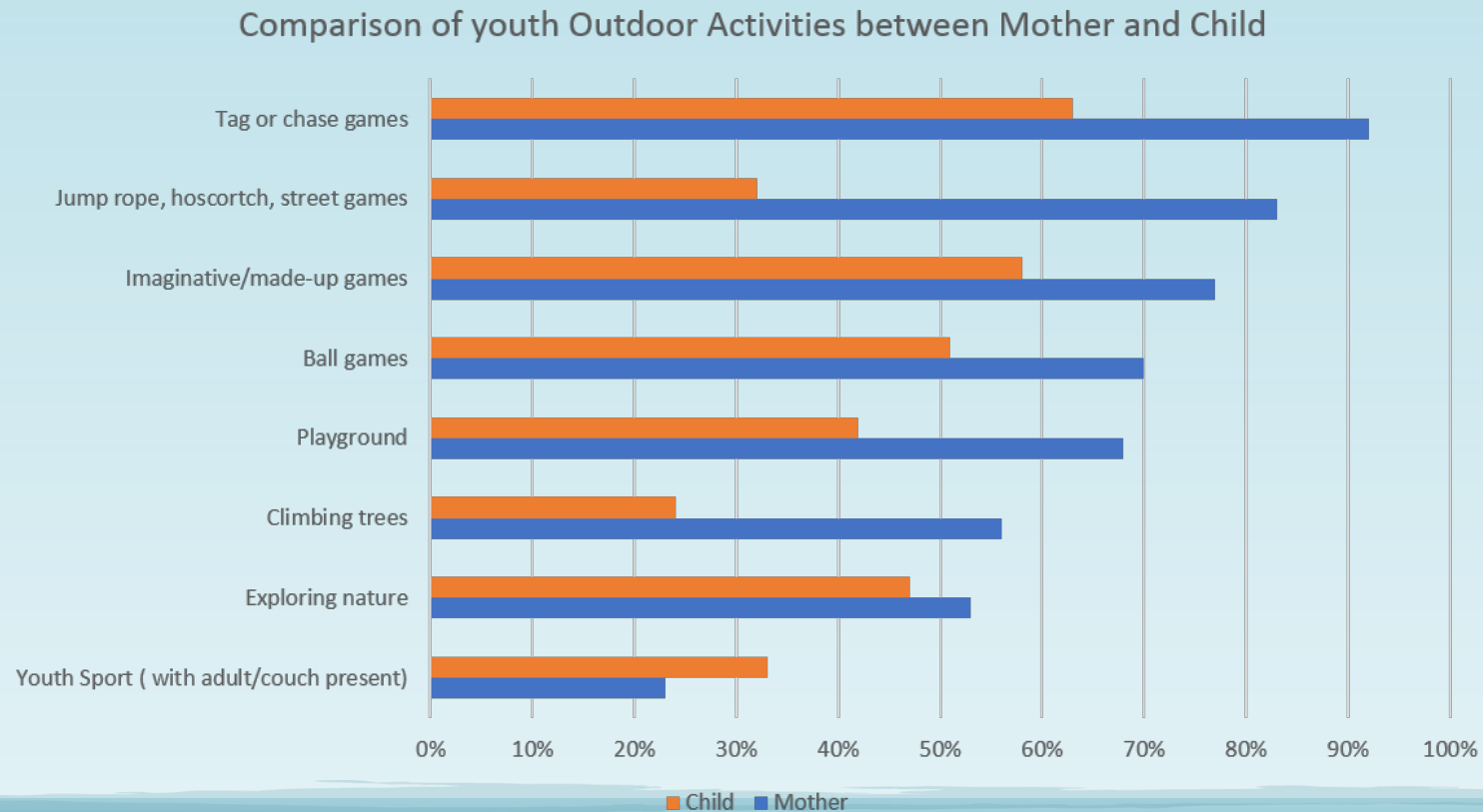# The ParaSolar Experience

Group 11
Dylan Petrae CpE
Meghan Perry EE
Casey Mann EE
Jesus Pulido CpE

Motivation

- Disconnection with Nature: Now vs 1990's

Comparison of youth Outdoor Activities between Mother and Child

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

Market Specifications

- Ease of use

- Ensures a secure environment

- Provides entertainment and environmental updates

- Product should be low-cost compared to other similar products and it should be lightweight and portable.

Engineering Specifications

- Response time for security system shall be less than 5 seconds.

- Voltage and Current output of USB ports (2) will be at least 5V and 1.6A

- System must be able to withstand lowlight conditions and provide power for up to 4 hours.

- Environmental conditions will be measured with no greater error than ±2° temperature and ±5% humidity readings

Overall Hardware Block Diagram
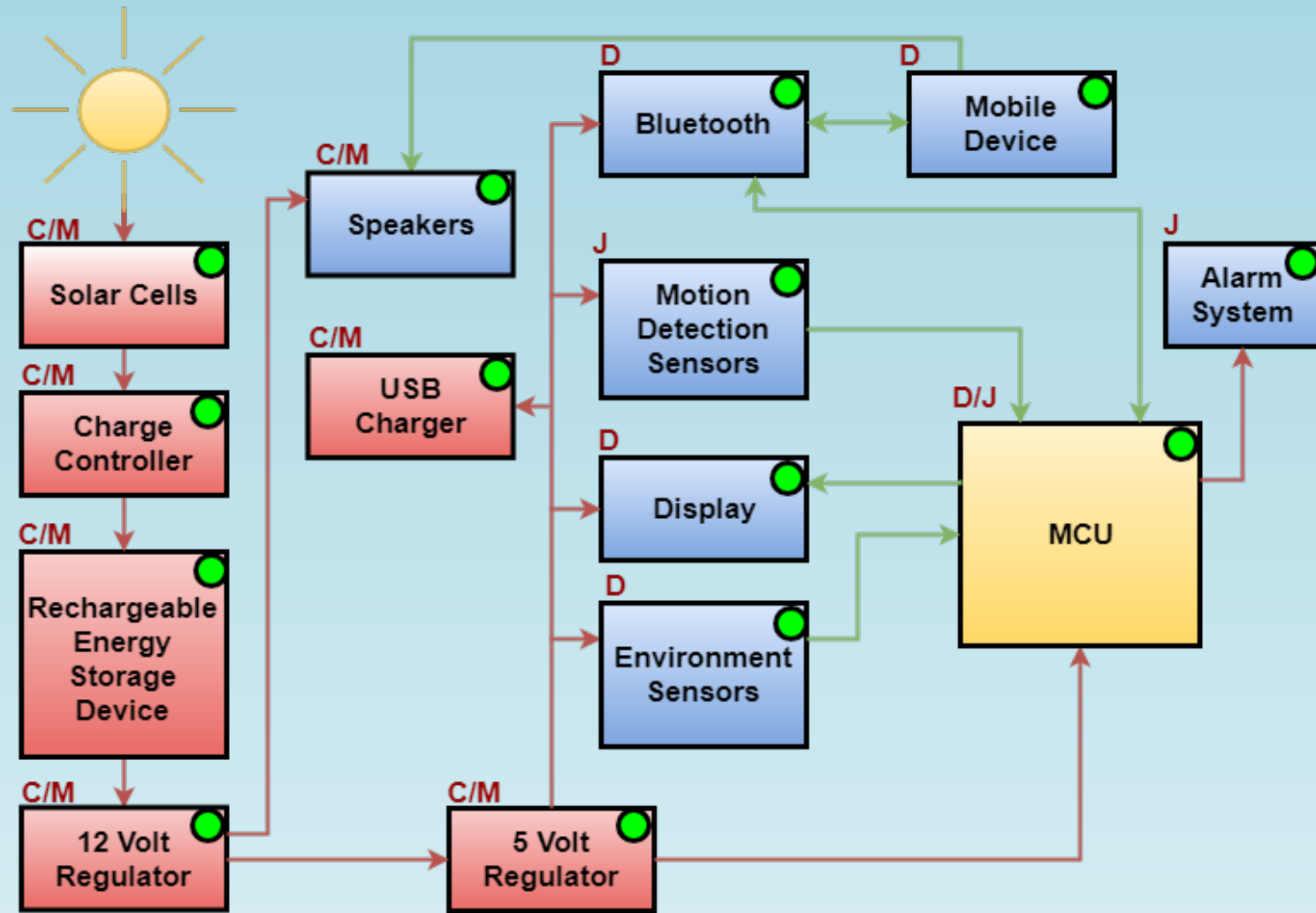
Power Line

Data/Communication Line
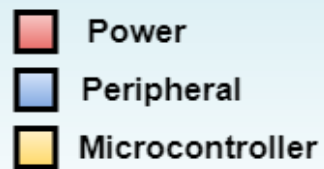
| Power |
| Peripheral |
| Microcontroller |

Assigned
- **C**asey
- **D**ylan
- **J**esus
- **M**eghan

Status
- Research
- Design
- Prototype

Microcontroller

Power Line

Data/Communication Line

Power
Peripheral
Microcontroller
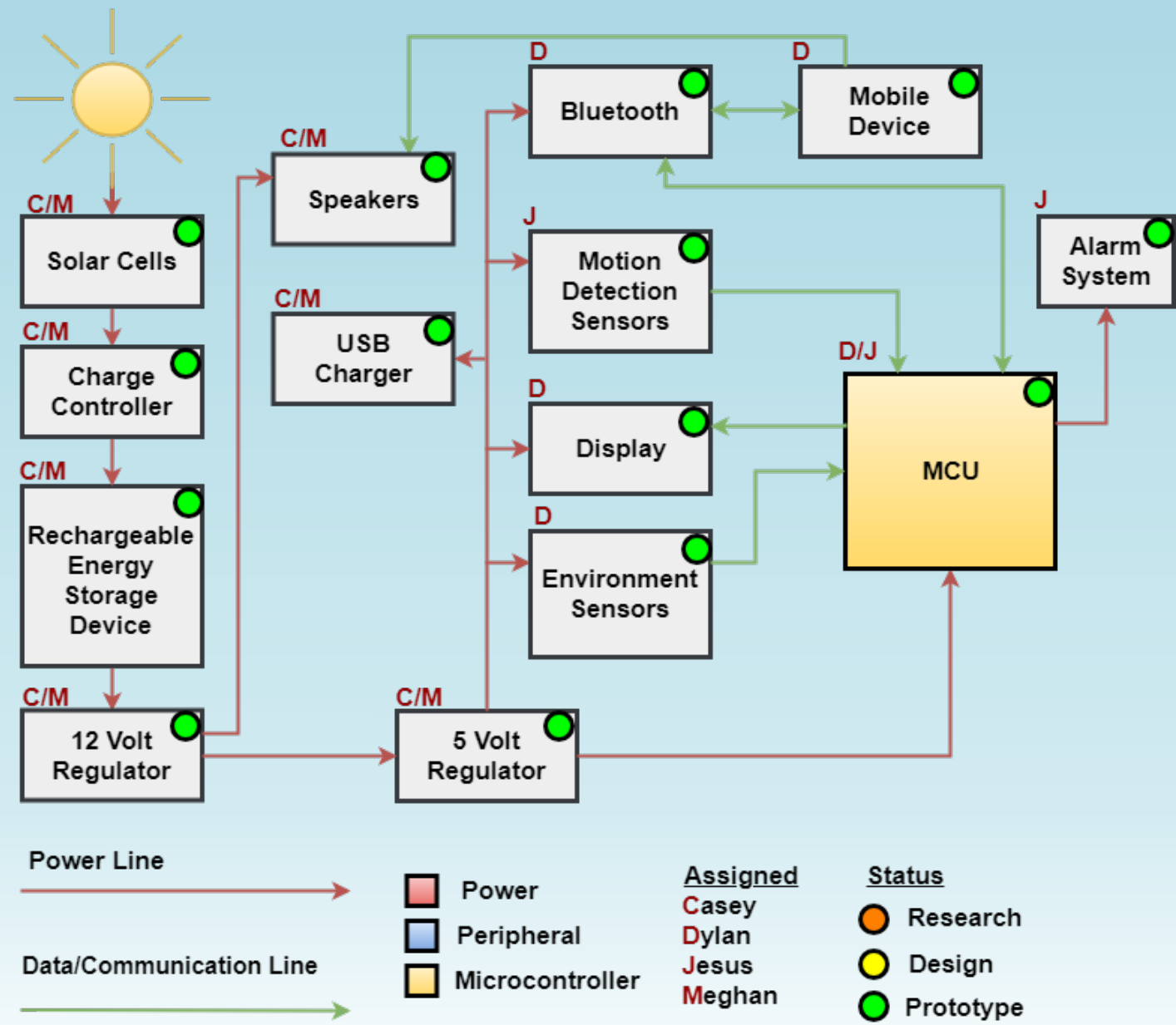
Assigned
Casey
Dylan
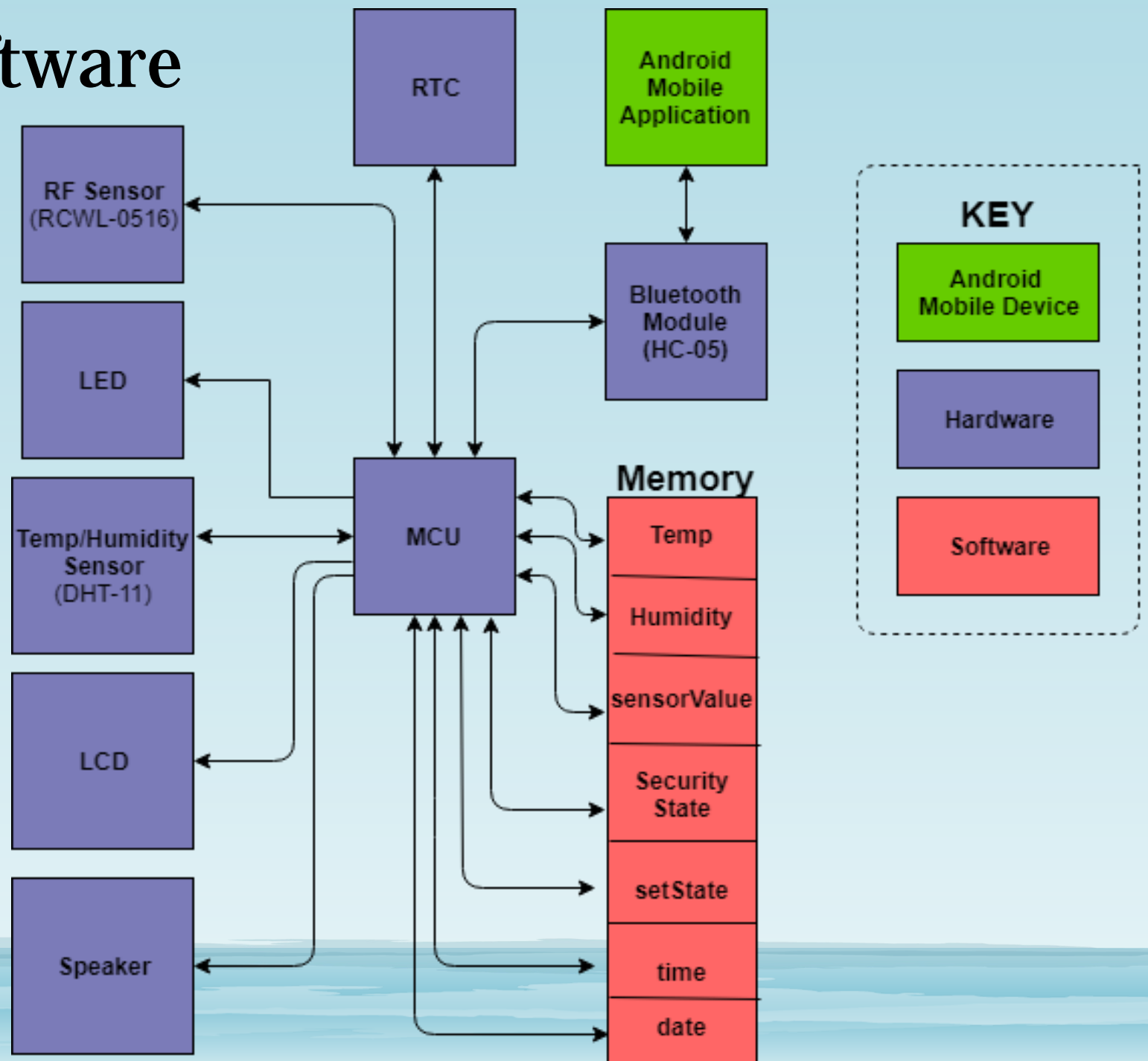**J**esus
Meghan

Status
Research
Design
Prototype

Microcontroller Selection

Microcontroller	Architecture	Operating Voltage (V)	Max Throughput	Flash Memory (KB)	Size (mm²)	Cost ($)
ATmega328p	8-Bit Modified Harvard	1.8 – 5.5	20 MIPS @ 20 MHZ	32	34.54x7.49	1.96
MSP430G2	16-Bit Von Neumann	1.8 – 3.6	16 MIPS @ 16 MHZ	16	26.92x6.60	1.04
MSP432P4	32-Bit ARM Cortex-M4F	1.62 – 3.7	1.22 DMIPS/MHZ	256	15.2x15.2	7.46

Microcontroller Software

- Security inactive
  - Read peripherals
- Security Active
  - Bluetooth Established
  - Check RF Sensor
  - If tripped, notify user

RTC

Android Mobile Application

RF Sensor (RCWL-0516)

LED

Temp/Humidity Sensor (DHT-11)

LCD

Speaker

Bluetooth Module (HC-05)

MCU

Memory

Temp

Humidity

sensorValue

Security State

setState

time

date

KEY

Android Mobile Device

Hardware

Software

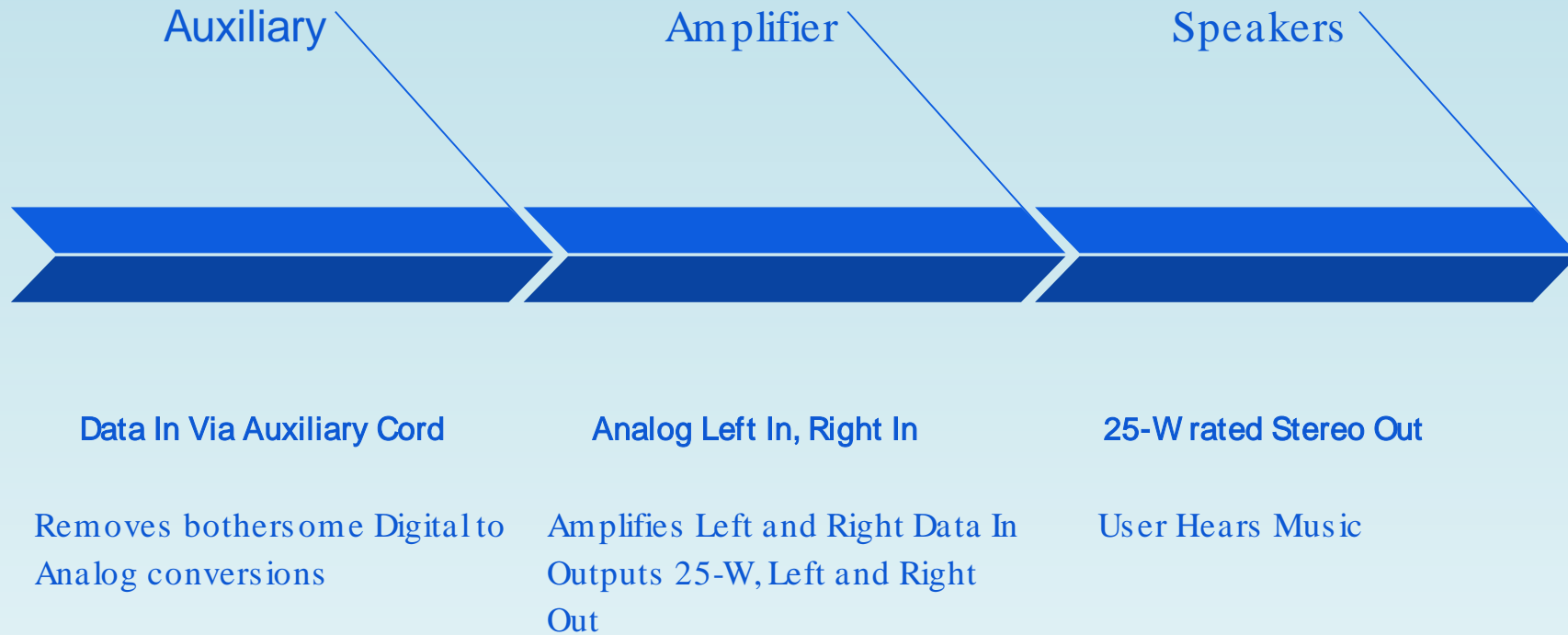# Peripherals
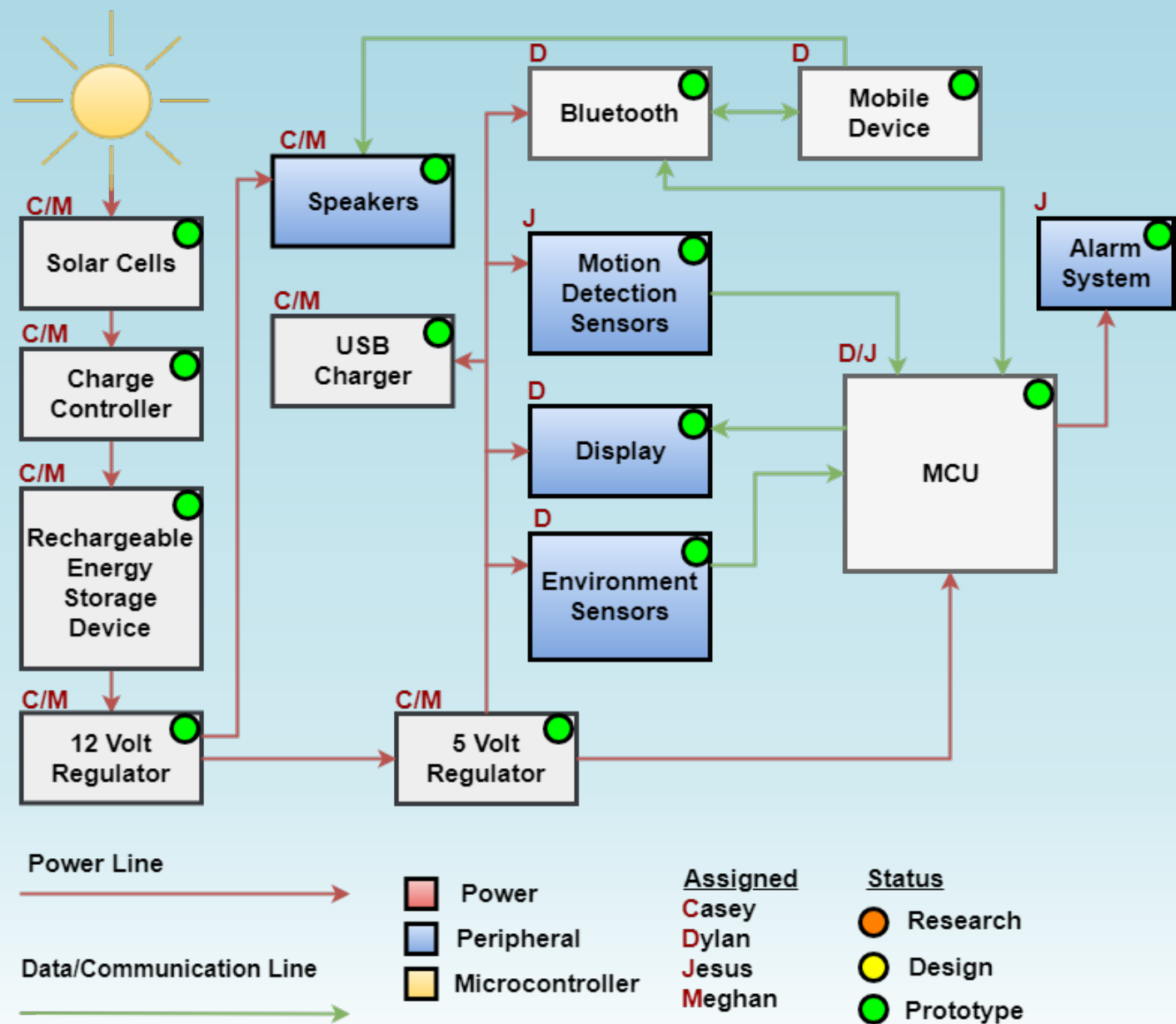
Environment Sensors & Display

- 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 Sensor Selection

Device	Motion Detection Method	Max Detection Range (M)	Field of View (°)	V supply (V)	Cost($)
RE200B	Passive Infrared	6	110	5-12	1.8
HC-SR04	Ultrasonic Sensor	4	15	5	1.49
RCWL-0516	RF Sensor	7	360	4-28	1.79

Speaker System

- **Will satisfy Entertainment factor**

Auxiliary

Amplifier

Speakers

Data In Via Auxiliary Cord

Analog Left In, Right In

25-W rated Stereo Out

Removes bothersome Digital to Analog conversions

Amplifies Left and Right Data In Outputs 25-W, Left and Right Out

User Hears Music

Amplifier Comparison

Amplifier	Add'l Output stage req.	# of Output Channel	Vsupply (V)	Power out	Components needed	Size (mm^2)	Cost($)
LM386	NO	1	4-18	700mW	6	9.60x6.35	0.95
LM358	YES	2	3-32	600mW	5	9.81x6.35	0.85
TL084ACN	YES	4	±18	350mW	7	19.3x6.35	1.10

Communication Peripherals

Solar Cells

Charge Controller

Rechargeable Energy Storage Device

12 Volt Regulator

Speakers

USB Charger

5 Volt Regulator

Bluetooth

Mobile Device

Motion Detection Sensors

Display

Environment Sensors

MCU

Alarm System

C/M
D
J
D/J

Power Line

Data/Communication Line

- Power
- Peripheral
- Microcontroller

Assigned
- **C**asey
- **D**ylan
- **J**esus
- **M**eghan

Status
- Research
- Design
- Prototype

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 set-up

- Bluetooth lightweight for energy

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

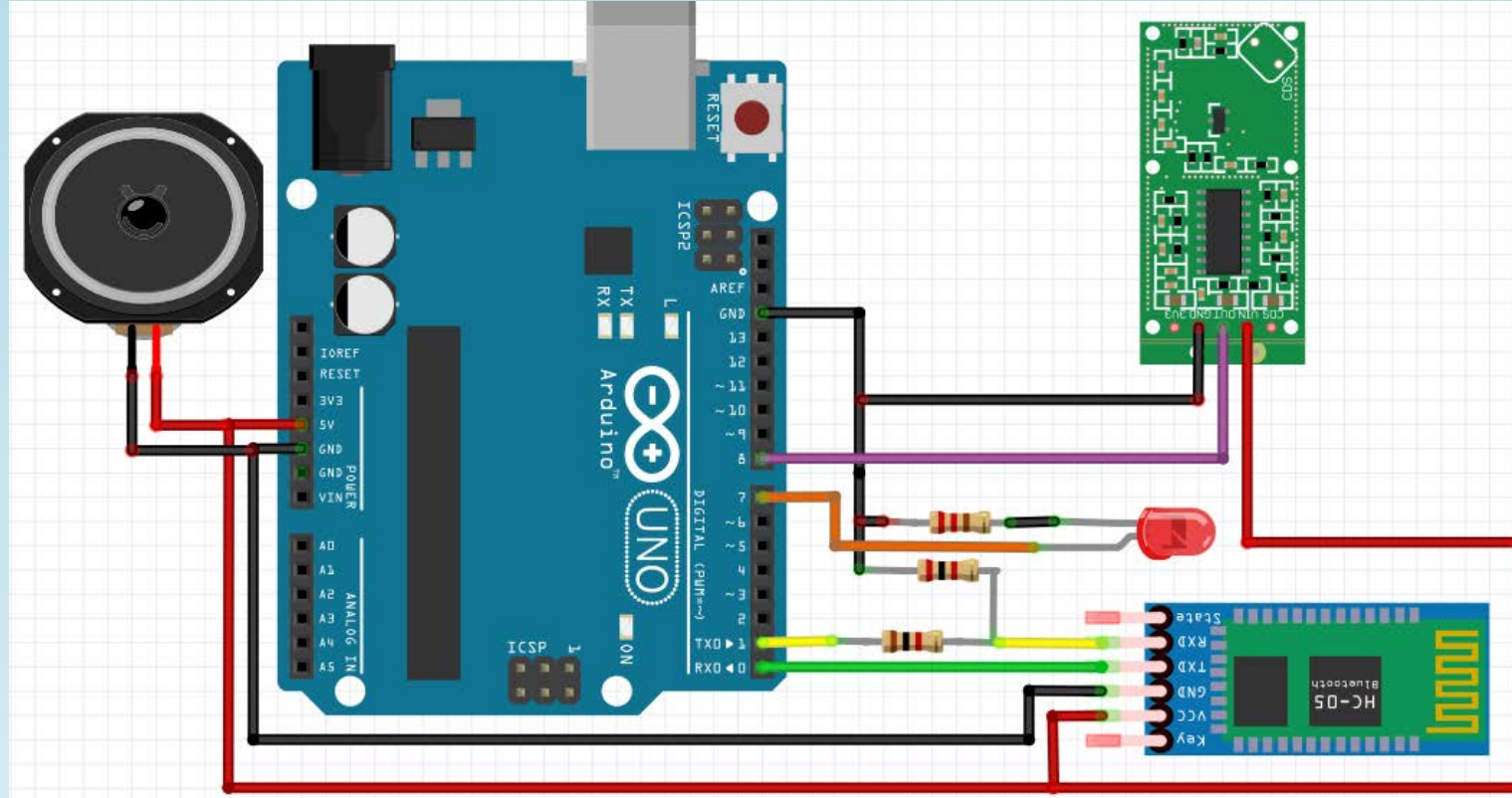**Functionality:** Provide Wireless Communication capabilities between system and Android mobile device
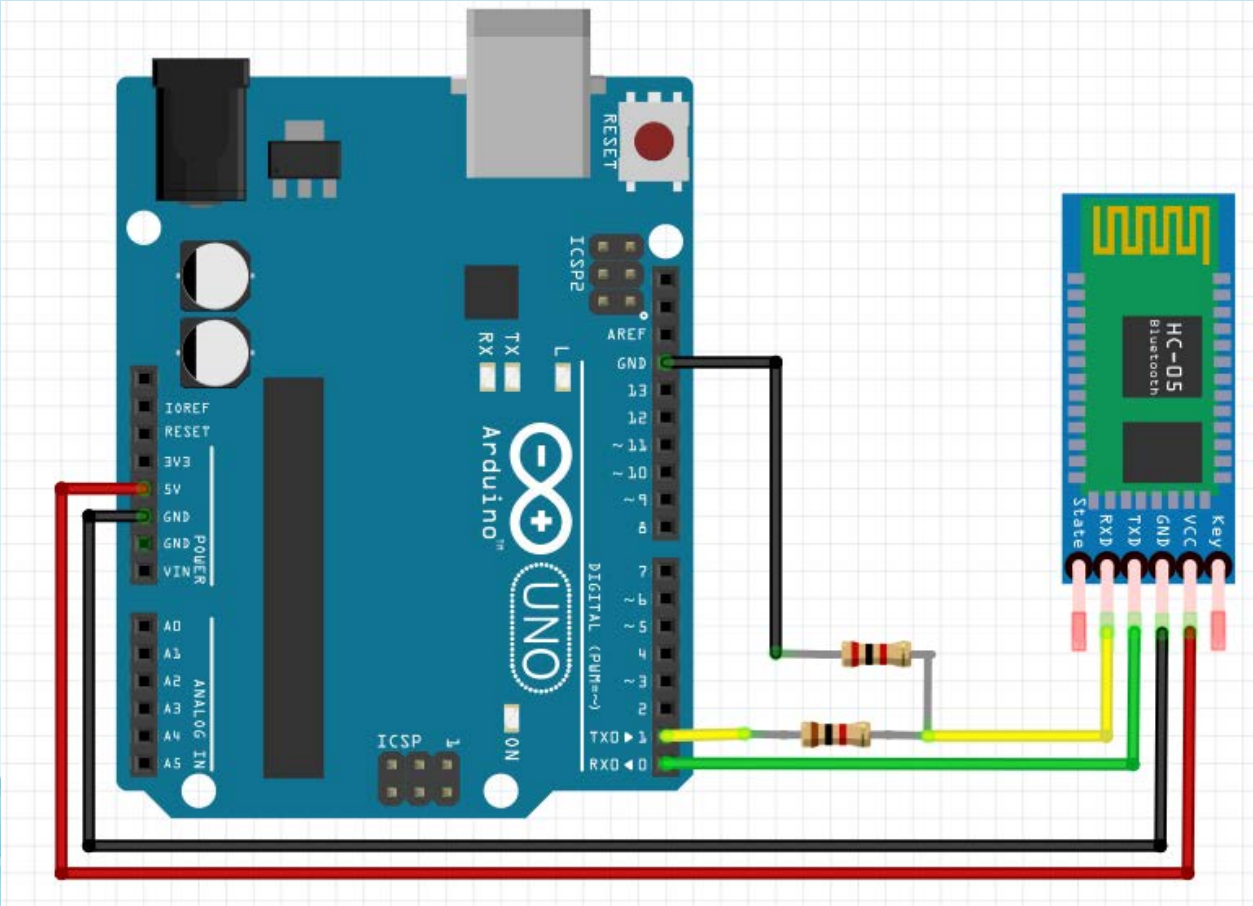
37mm

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
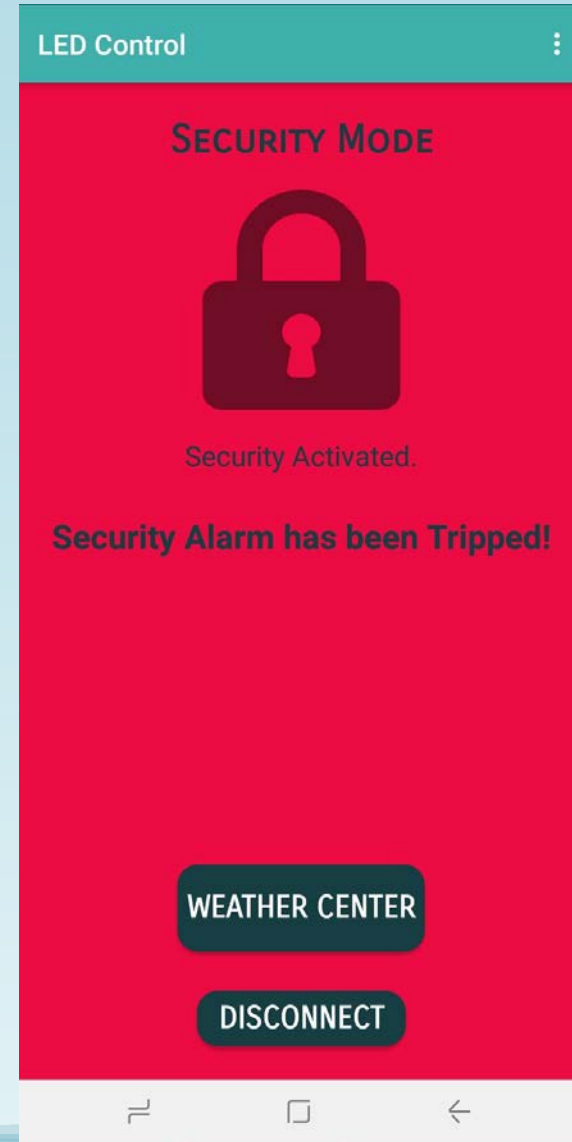 - Receives notification when the RF Sensor has been tripped
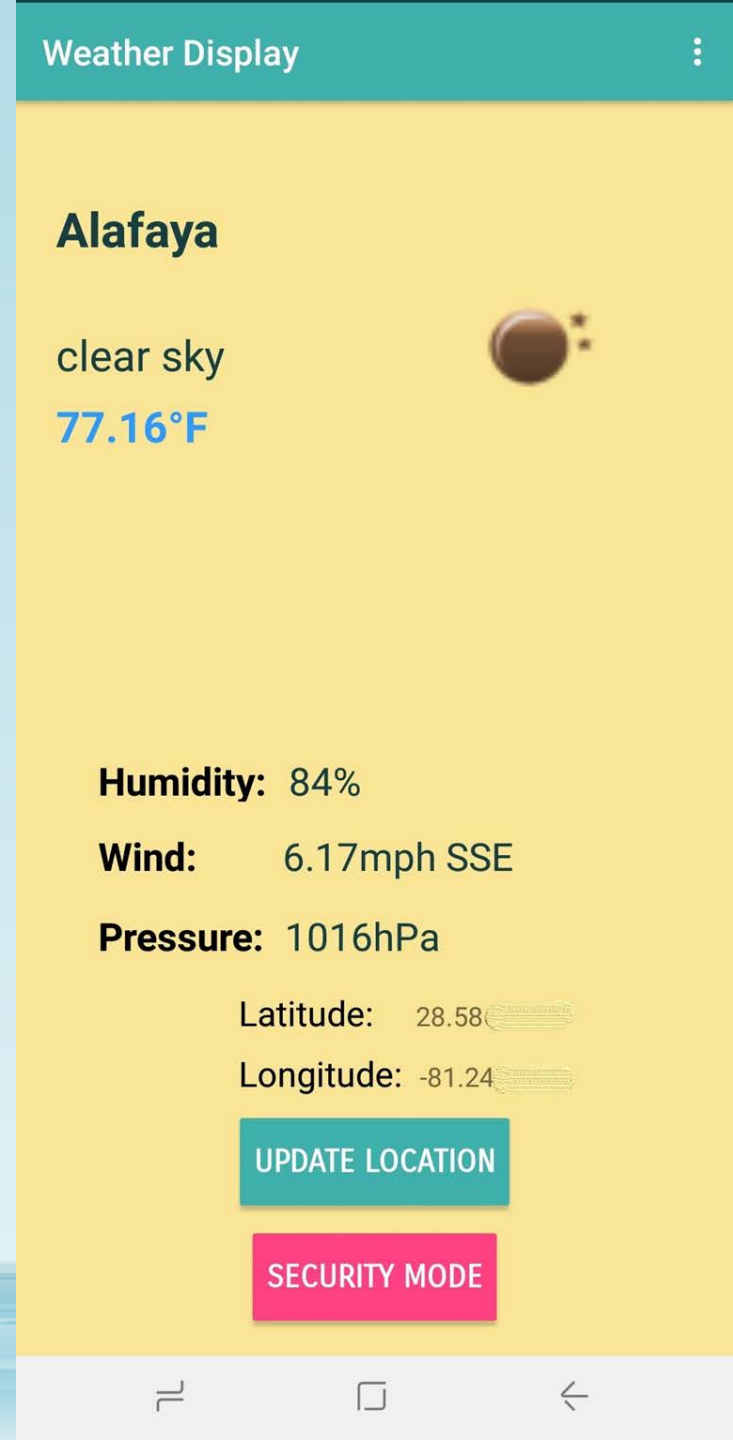
Mobile Application Security Mode
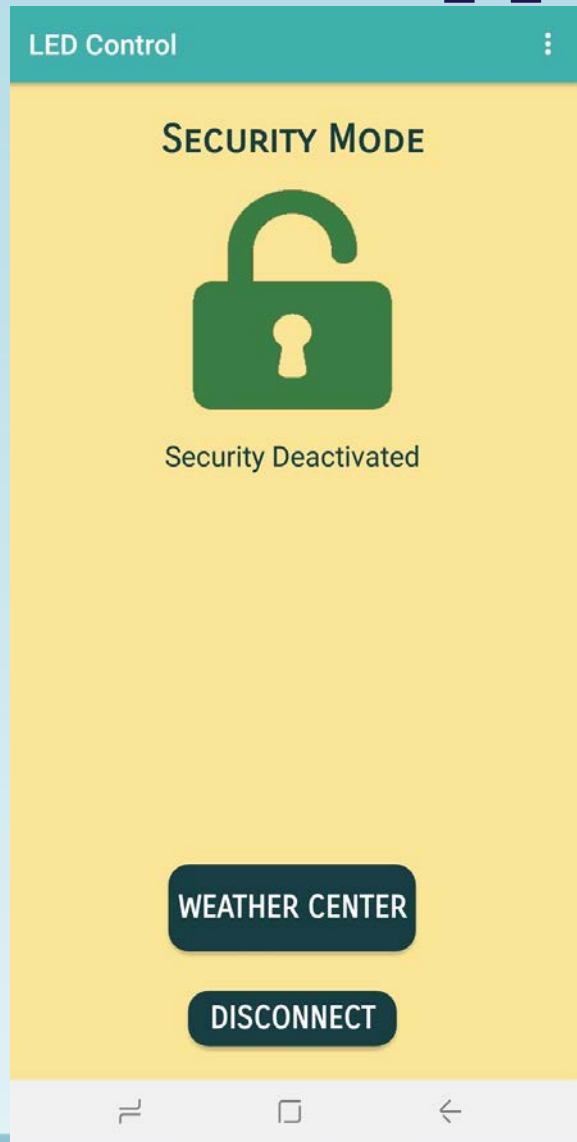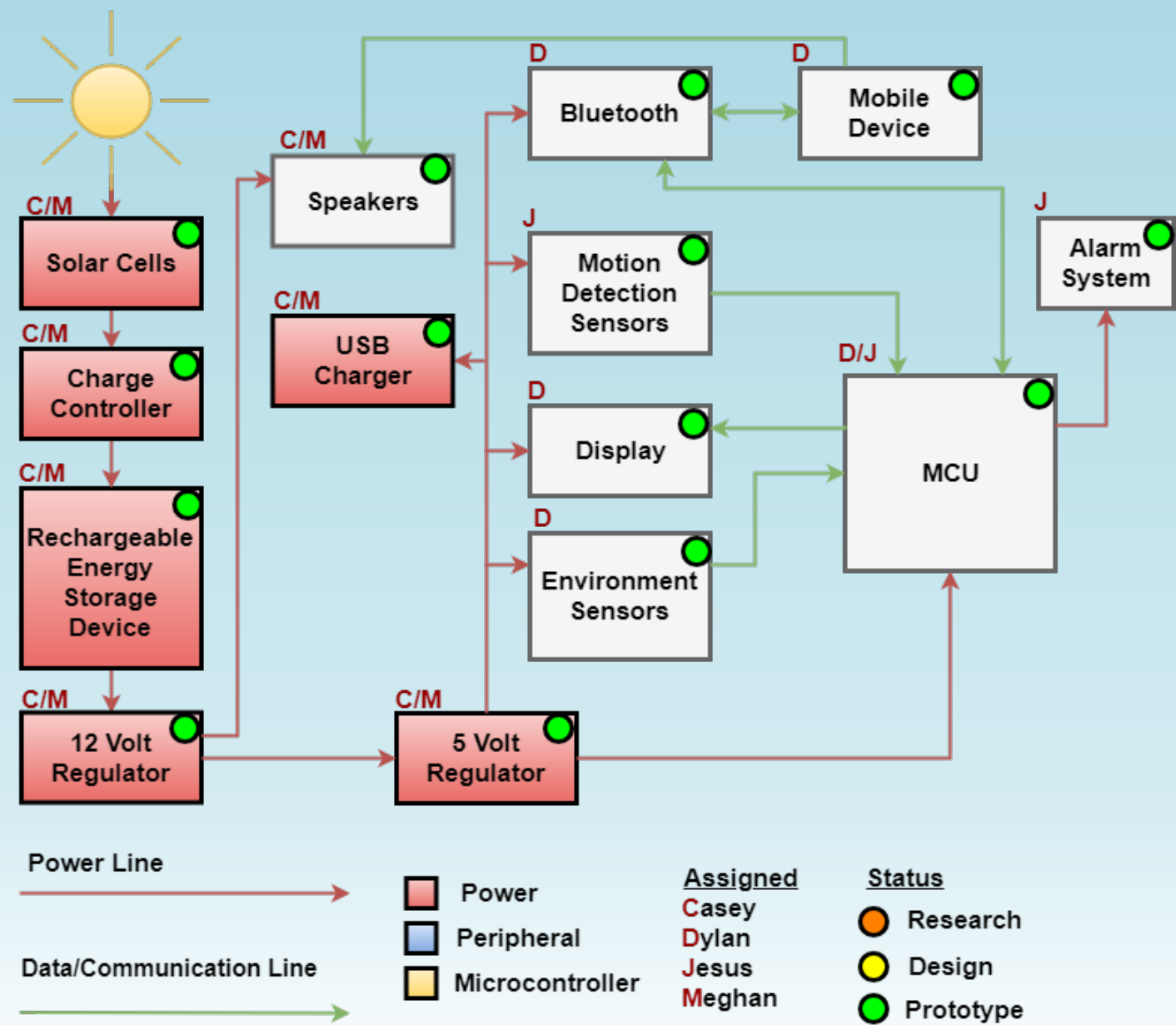

Security Mode is Inactive
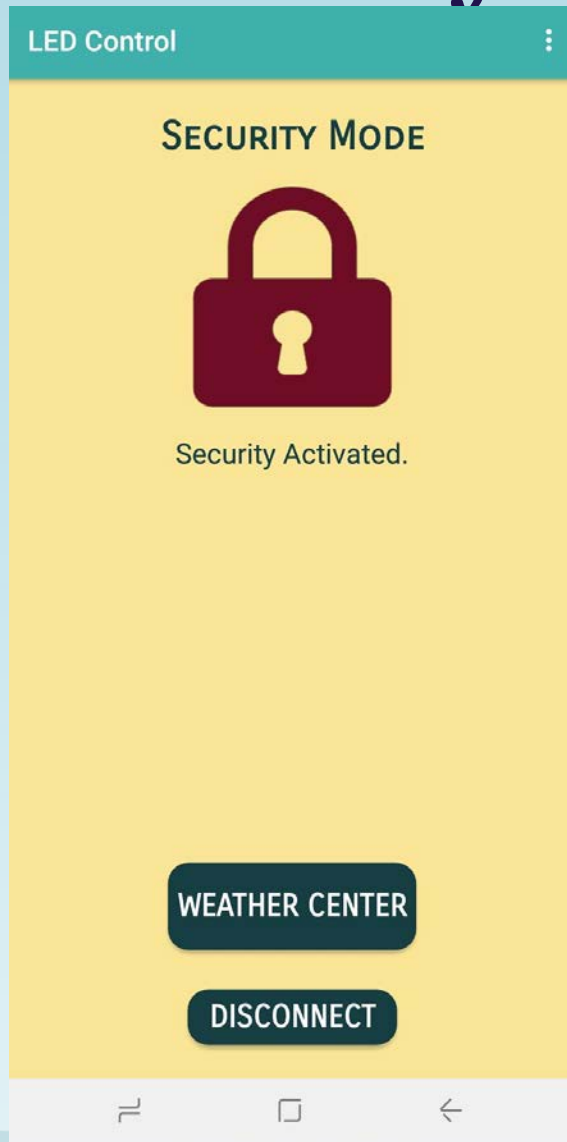
Security Mode is Active, but has not been tripped

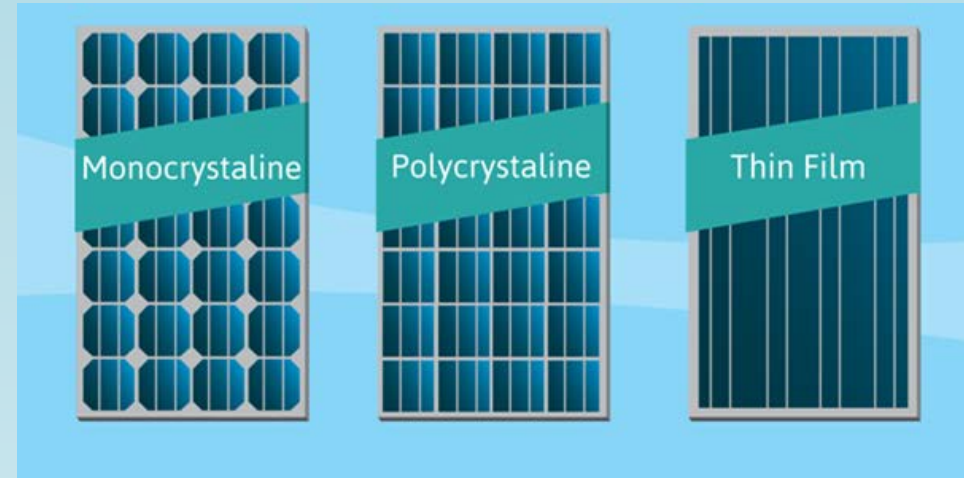Security Mode is Active and has been tripped

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)
Jiang A-Si Flexible Solar Cell	19.99	1	196 X 87 X 0.1	27	0~70
BCMaster Polysilicon Solar Cell	1.12	1	110 X 60 X 2.5	13.6	-20~85
Solopower Lightweight Thin Flexible CIGS Solar Cell	7.99 uncoated	1.5	368 X 40 X 0.3	9.07	unknown
Viko Cell Mono Series Monocrystalline Solar Cell	1.55 uncoated	2.7	125 X 125 X 0.5	unknown	unknown

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.

	Cost per Cell (Dollars)	Wattage (W)	Size (mm)	Weight (g)	Heat Resistivity (°C)
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Solar Cell Selection

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

Battery

Must...

- have a high gravimetric energy density
- have a relatively fast charging time
- hold a charge without experiencing any substantial amount of self-discharge.
- maintain a high level of performance when subjected to high temperatures.

	NiCd	NiMH	Lead Acid	Li-ion	LiPo
Gravimetric Energy Density (Wh/kg)	45-80	60-120	30-50	110-160	100-130
Cycle Life	1500^2	$300\text{ -}500^{2.3}$	$200\text{ - }300^2$	$500\text{ - }1000^3$	$300 – 500$
Charge Time (hours)	1	2-4	8-16	2-4	2-4
Overcharge Tolerance	moderate	low	high	Very low	Low
Self Discharge (per month)	$20\%^4$	$30\%^4$	5%	$10\%^5$	$\sim10\%^5$
Operating Temperature (°C)	-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.

	NiCd	NiMH	Lead Acid	Li-ion	LiPo
Gravimetric Energy Density (Wh/kg)	45-80	60-120	30-50	110-160	100-130
Cycle Life	1500^2	$300 - 500^{2.3}$	$200 - 300^2$	$500 - 1000^3$	$300 - 500$
Charge Time (hours)	1	2-4	8-16	2-4	2-4
Overcharge Tolerance	moderate	low	high	Very low	Low
Self Discharge (per month)	$20\%^4$	$30\%^4$	5%	$10\%^5$	$\sim 10\%^5$
Operating Temperature (°C)	-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.
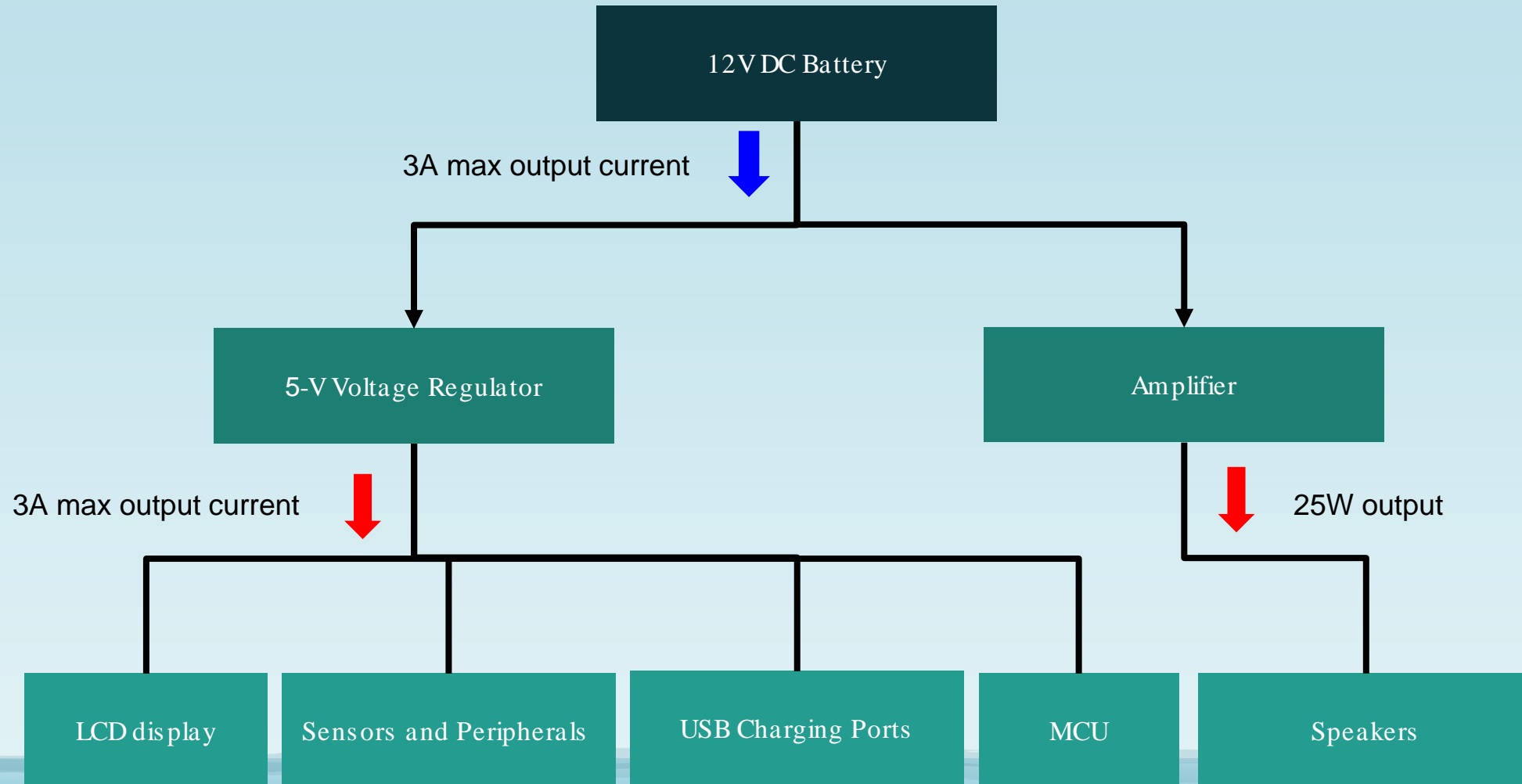
Maximum Power Point Tracking

- 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.

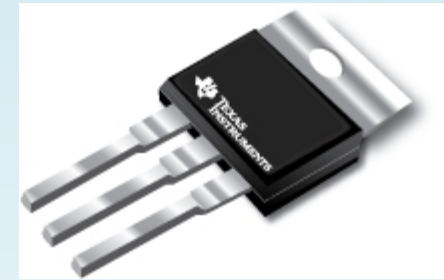- For this project a MPPT solar charge converter has been designed and implemented.
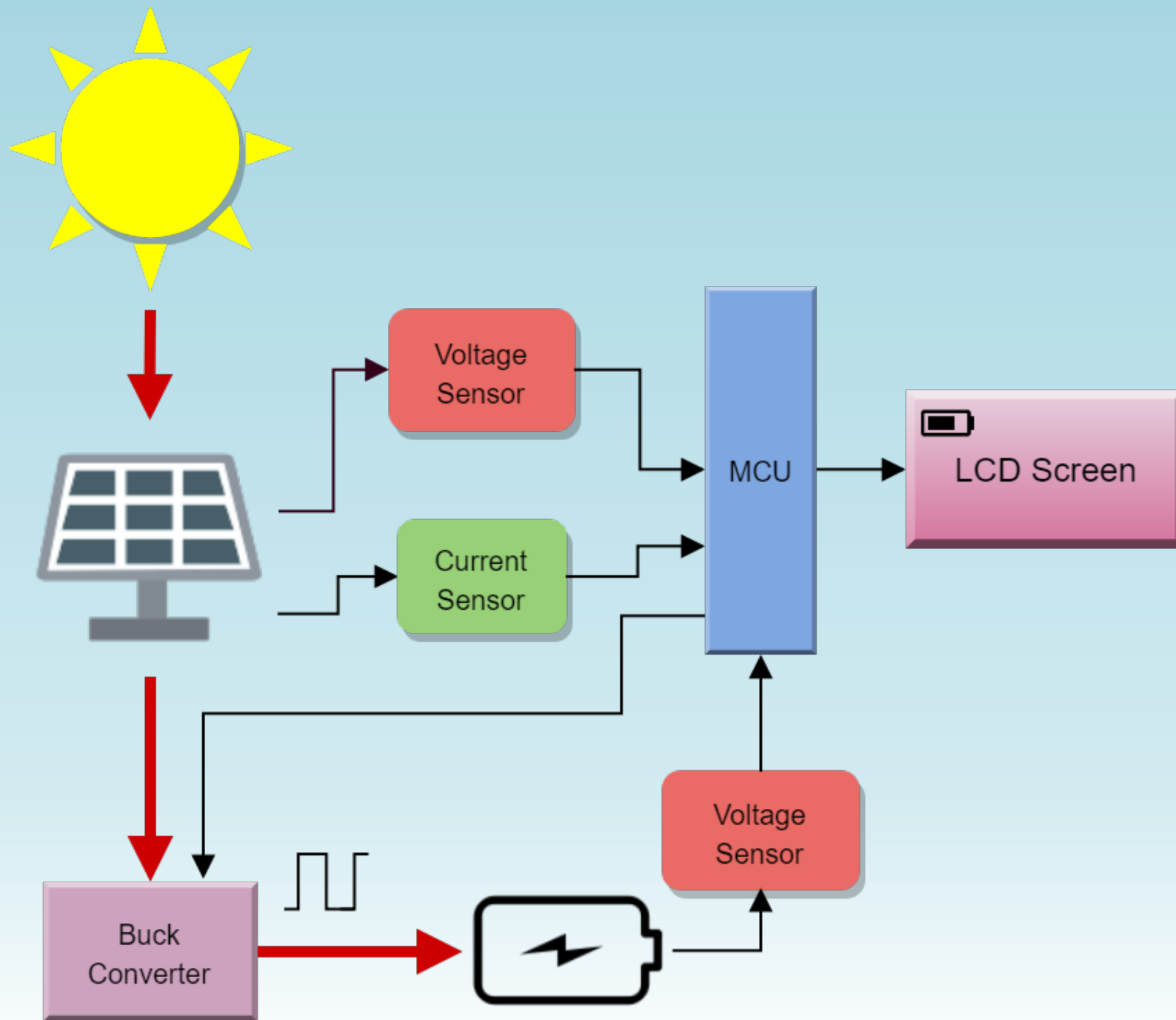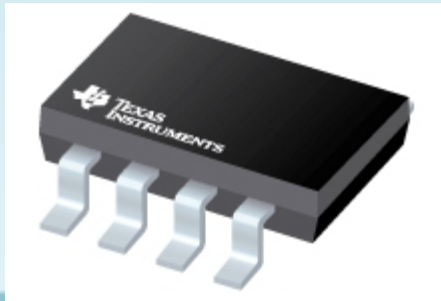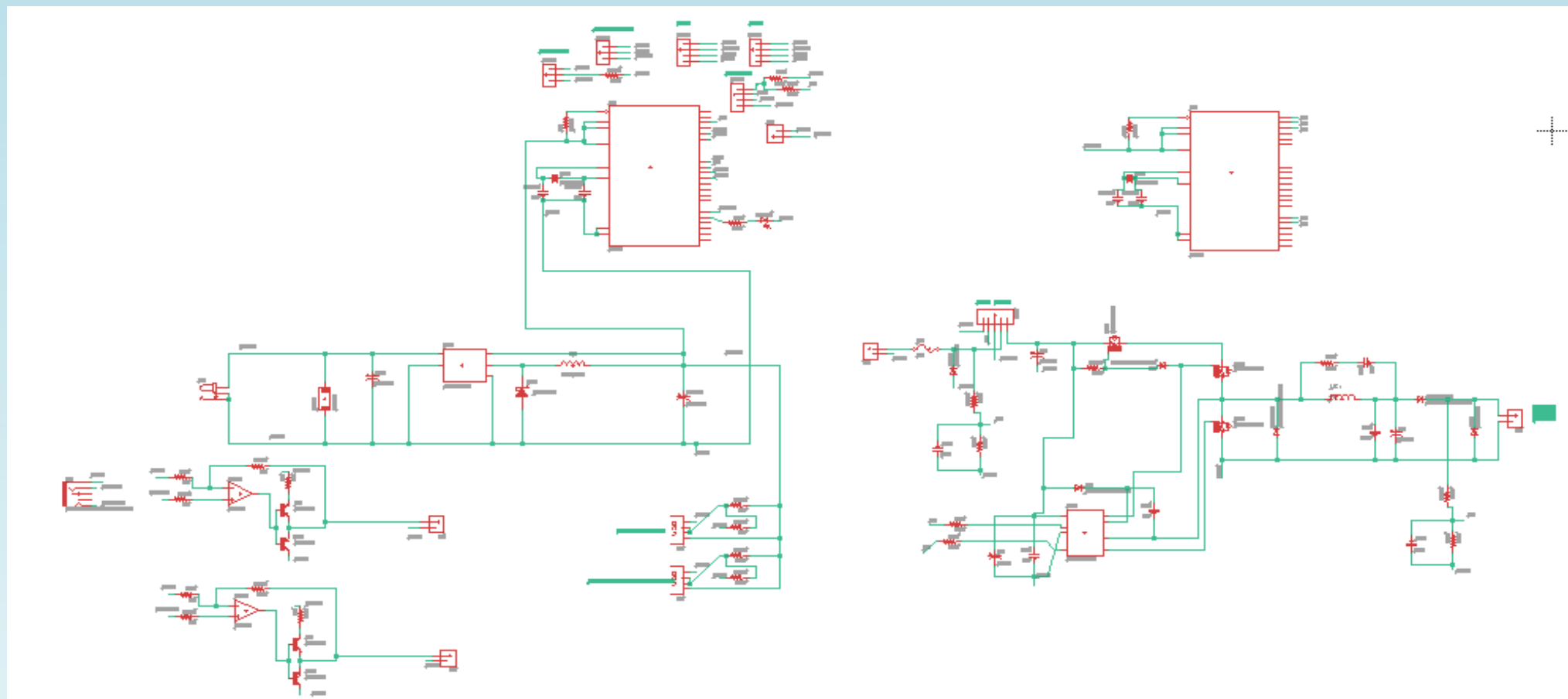
Power Distribution
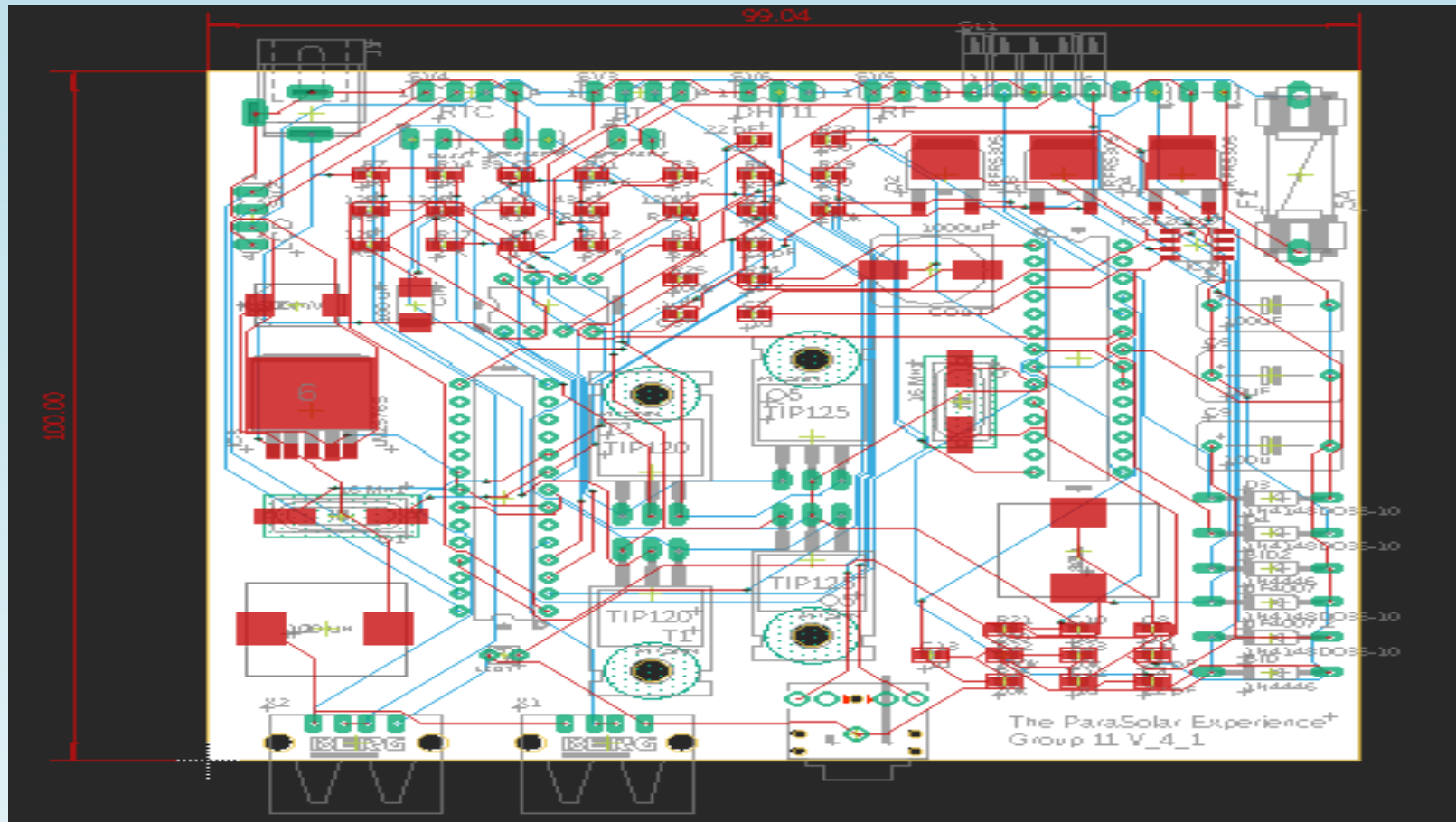
5V Voltage Regulation (Texas Instruments)

Regulator	Type	Vout(V)	Vin(V)max	Iout(A)max	Size (mm^2)	Cost($)
LM7805	Linear	5	<35	1.5	10.16x14.351	N/A
LM2576	Switching	3.3,5,12,15	1-40	3	10.16x8.42	N/A
TPS563210	Hysteresis	.76-7	4.5-17	2,3	1.6x2.90	N/A

PCB Schematic

PCB Footprint

Administrative Content

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): $152.96

without bulk pricing

Item	Quantity	Price (total)
Beach Umbrella	1	$20
Cooler	1	$14.99
Battery	1	$30
MCU	1	$5
Solar Panel	20	$16
LCD Display	1	$12
Speakers	2	$17
LEDs	3	$2
Temperature and Humidity Sensor	1	$1.75
Proximity Sensor	1	$1.90
Bluetooth module	1	$5.65
Custom PCB	1	$2.00
Waterproof/Particle materials for encasement	N/A	Free
USB Type A Female Ports	2	$3
PCB Resistors, Capacitors, and ICs	N/A	$21.67

Demonstration

- Shall include....

  - Bluetooth communication/Security Mode via Phone Application

  - USB Charging via USB Type-A port

  - Auxiliary input to Speakers

  - Self-powering to entire product

  - Environmental and system information updates via LCD screen

Questions?