FrostRunner

Group 16

FrostRunner

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Project Description

- The FrostRunner project aims to achieve several objectives that revolve around the development of an autonomous cooler that can keep food and drinks at the perfect temperature while on the go.
- With this project, we aimed to make the lives of people who enjoy being out and active more pleasurable, and enjoyable.

Project Motivation

- To design and build a product that addresses the current limitations of most coolers available on the market, which can often be difficult to carry around manually as well as struggle to maintain food and drinks at a consistent temperature.
- Our FrostRunner cooler eliminates these issues with its autonomous movement capabilities and temperature control features.

Project Goals and Objectives

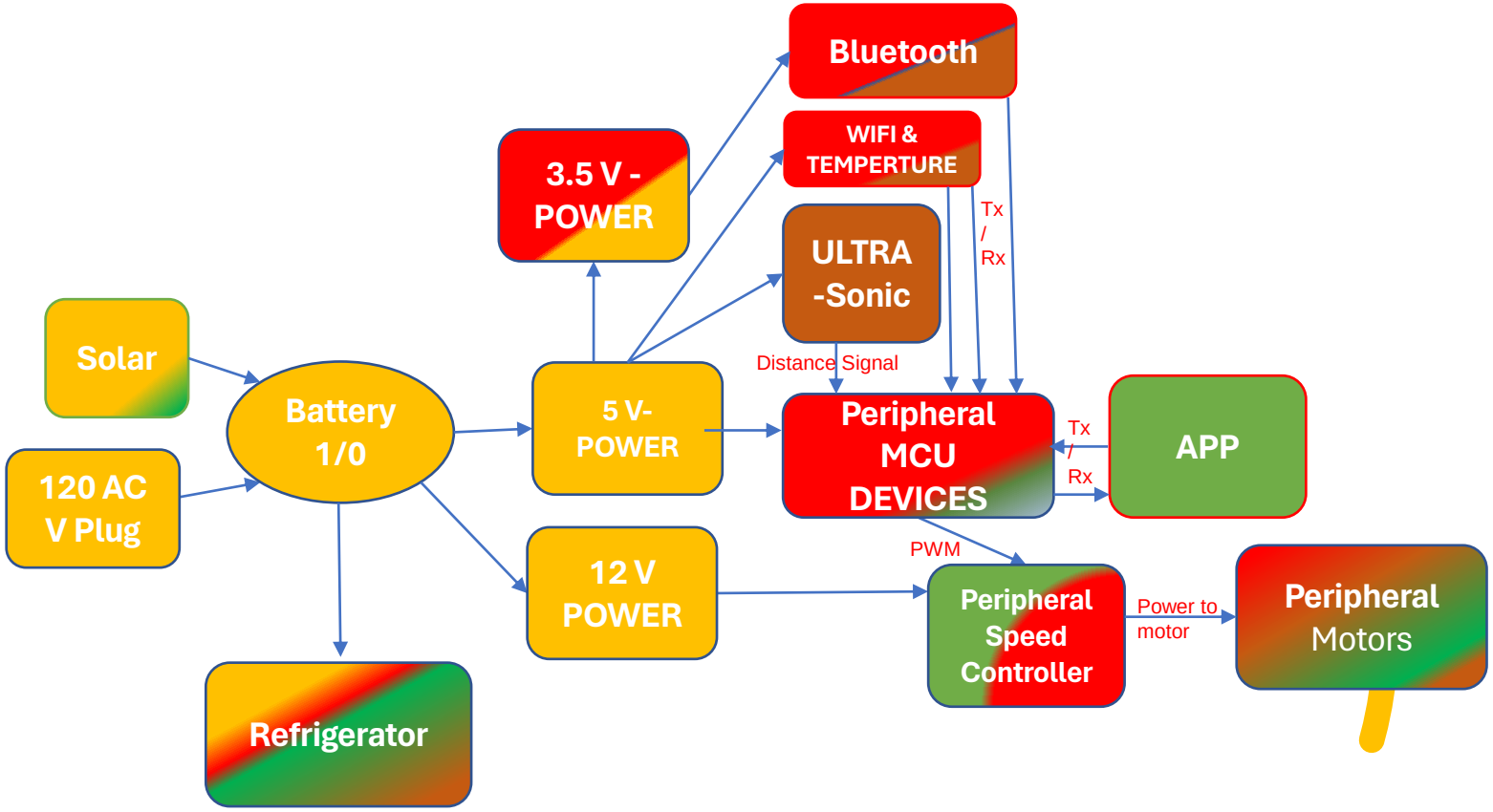
1. Eliminate physical labor associated with carrying cooler
2. Ensure that cooler maintains consistent temperature
3. Develop a smartphone application that seamlessly connects to FrostRunner

Requirement Specifications

Specification	Description	Unit
Vehicle Portability	The vehicle will be designed to easily maneuver itself all while carrying a load. Max load:	≤ 120 lbs.
Temperature Sensor	The cooler will be equipped with a temperature sensor which will be programmed to send the data directly into smartphone app to check at user's request	0-120 degrees Fahrenheit
Cooler capacity	The cooler will be able to hold at least 15 cans and hold a weight of at least 20 lbs.	As per description
Object Avoidance	Proximity sensors for obstacle avoidance. Accuracy min:	95%
Control	FrostRunner can either be controlled manually or using the “summon” feature.	
App User Interface	The user interface will allow user to communicate with FrostRunner	Concise and easy to use
Battery Life	The cooler will have a rechargeable battery run time at max load:	30 minutes
Compatibility	The smartphone app will be made to be compatible with Android device only..	Android
Bluetooth Range	The Bluetooth connectivity will work in open space as far as:	10 meters
Anticipated Project Cost	The total project cost will be lower than $800	< $800

HARDWARE BLOCK DIAGRAM

HARDWARE BLOCK DIAGRAM



BLUE- ISHMAEL PALMER

RED- JOSHUA SAMONTANEZ

GREEN-JEYLER ZABALA

ORANGE- KHALID MOKADEM

FrostRunner Power Generation

SOLAR PANELS -TECHNOLOGY

Specification	Ericsity 100W Solar Panel	Renogy 100W Solar Panel
Max Power at STC	100 Watts	100 Watts
Open Circuit Voltage	24.3 V	24.3 V
Short Circuit Current	5.21 A	5.21 A
Optimum Operating Voltage	20.4 V	20.4 V
Optimum Operating Current	4.91 A	4.89 A
Cell Efficiency	22.00%	22.00%
Module Efficiency	22%	17.80%
Maximum Series Fuse Rating	15A	15A
Cell Type	Monocrystalline (9BB)	Monocrystalline (6.5 x 3.3 in)
Front Glass	ETFE material	Tempered Glass 0.13 in (3.2 mm)

ERICSITY Solar Panels received great feedbacks from our group

FrostRunner
Power Generation

SOLAR PANELS -100W

- We needed Hi power with minimal real estate
- We needed to be lightweight
- Easy to carry / extremely portable
- Ericsity foldable solar panel was choose :
- Because of its Portability and being foldable
- Its Safety as it has no sharp edges compared to traditional solar panels
- Versatility – can be adjusted towards more sunlight if it needs to be

FrostRunner Power Storage

BATTERY TECHNOLOGY

Feature	12v- 7Ah (Li)	Power Wheels 12V (SLA)
Voltage	12 volts	12 volts
Capacity (Ah)	7 Ah	7 Ah
Battery Management System (BMS) Included	Yes, 15A BMS	not included
Operating Temperatures	18°C to 80°C	18°C to 40°C
Weight	2.31 lbs	5.6 lbs
Rechargeability Performance	Generally superior rechargeability	Rechargeable, but not as efficient
Power	Suitable for 100W-500W devices	Suitable for Power Wheels toys
Lifespan	5 years	0.5 to 6 years
Safety	Generally safe with BMS	can release harmful chemicals if damaged

FrostRunner Power Storage

BATTERY 7 A/h

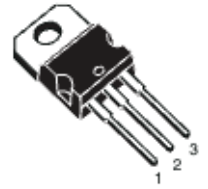
We Choose 12V 7AH Li-Ion, because of the 12 volts, larger capacitance, BMS, weight and reliability

- **Big Benefit for us**: the 7A/h. this is ideal for our power demand to run the motors and refrigerator regardless of solar power for hours.
- stable torque of the motors.
- The Li-ion Technology is ideal for rapid charging and discharging

FrostRunner Power

Charge Controller Technology

Feature	MPPT Solar Charge Controller	PWM Solar Charge Controller
Efficiency	up to 95%	75-80%
Charging Voltage Compatibility	Can handle varying panel voltages	Requires panel voltage to match battery voltage
Optimal Power Utilization	Tracks maximum power point, suitable for variable conditions	Provides fixed voltage to the battery
Power Output	Can extract more power from the panel, especially in non-ideal conditions	Provides power but may not maximize panel output
Compatibility with 100W Panel	Yes	Efficiency issues
Battery Compatibility	Suitable for various battery types, including lead-acid and lithium	Suitable for lead-acid batteries, may require additional hardware for lithium



TO-220

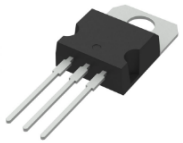
We choose: Esp32 was our mppt charge controller chip of choose due to its advantages in the MPPT Advantages

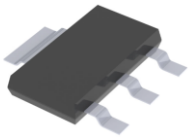
FrostRunner Power

Voltage Regulator Technology

- Linear voltage regulator that can provide a fixed 5V output from a 12/24V input.
- It can handle a maximum input voltage of 24V from the battery and a maximum output current of 1A.

Feature	LM7805 Voltage Regulator	XL7005 and AMS 1117 Voltage Regulator
Output Voltage	Fixed 5V	Adjustable (5V to 65V) dc to dc
Input Voltage	Up to 35V (typically)	Up to 65V
Adjustability	Fixed voltage	Adjustable with PWM Capabilities
External Components Required	Input and output capacitors for stability	external resistors to set voltage and capacitors
Output Current	Up to 1A	1.4amps
Simplicity	Easier to use with fixed 5V output	More complex due to PWM ability
Application	Suitable for applications requiring a fixed 5V supply	Suitable for applications requiring frequent switching.

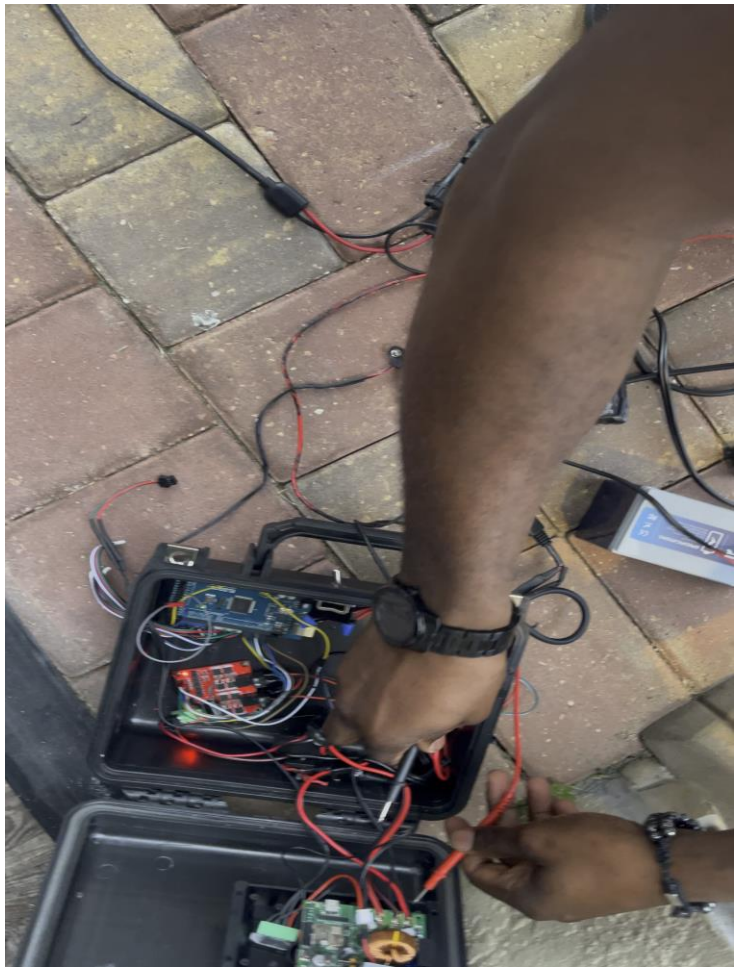




FrostRunner
Power Storage

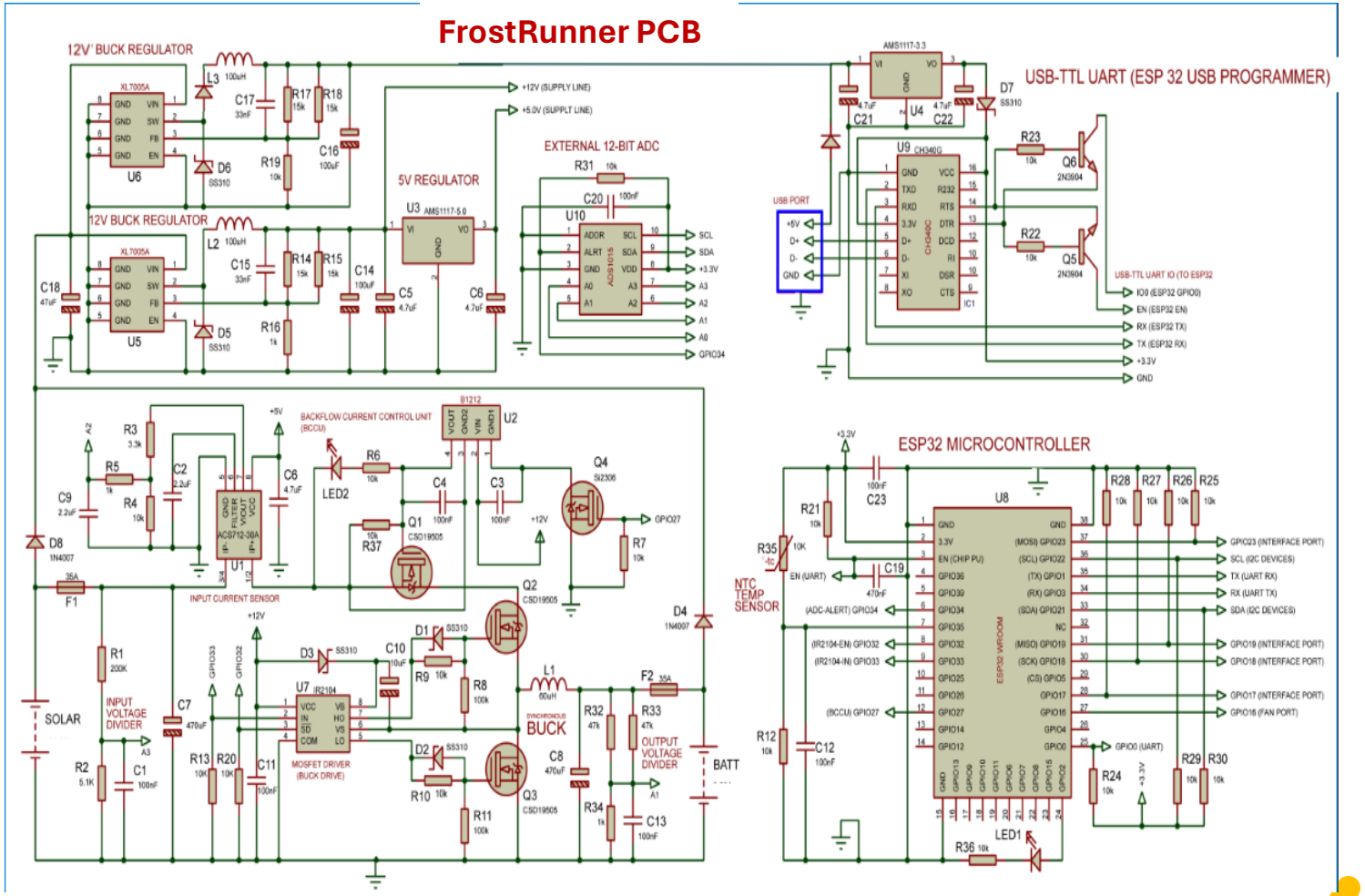
Testing 5 Volt Regulator

Powering ALL the peripheral devices



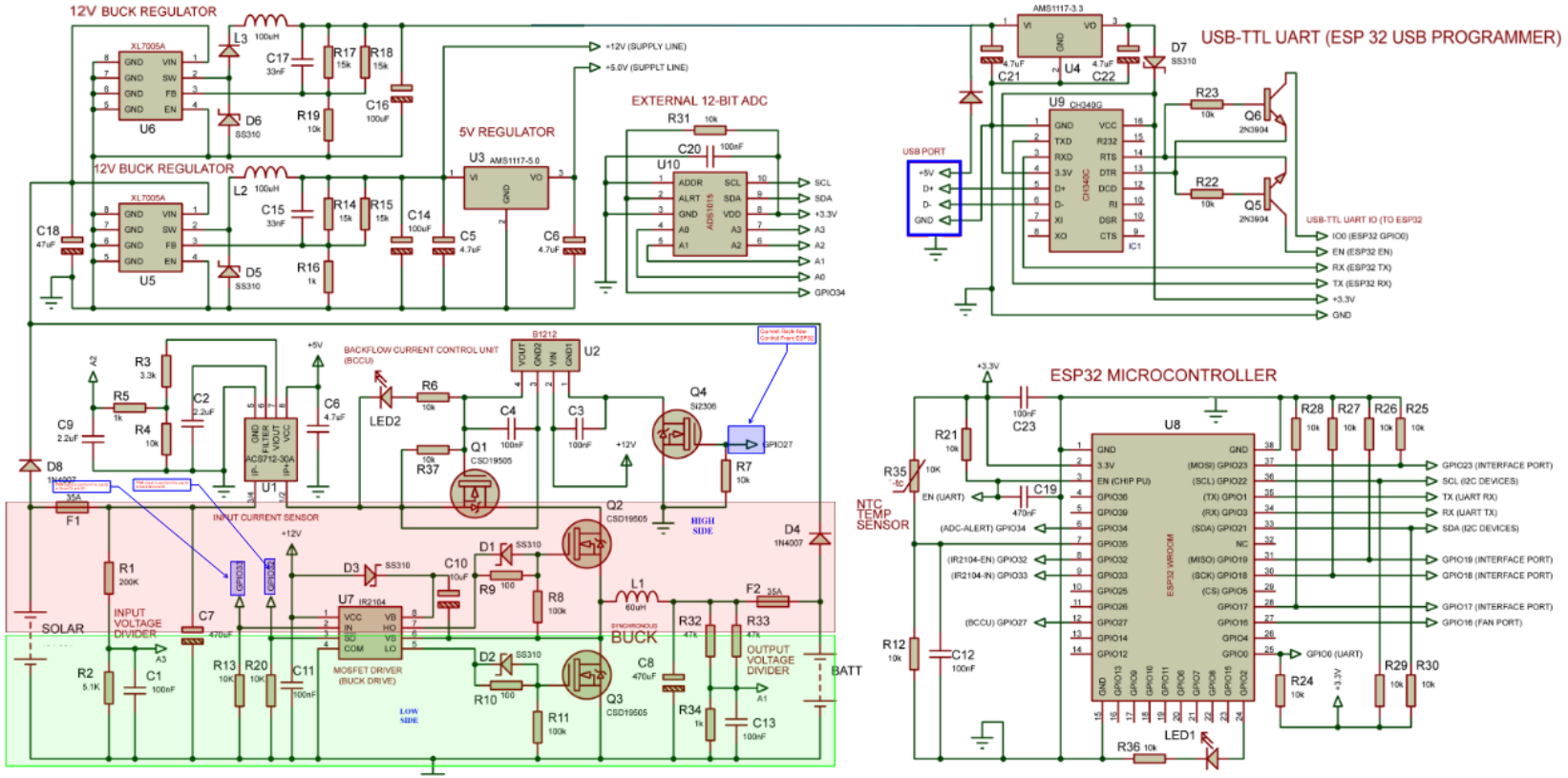
Powering the FrostRunner

PCB Designs



PCB Designs

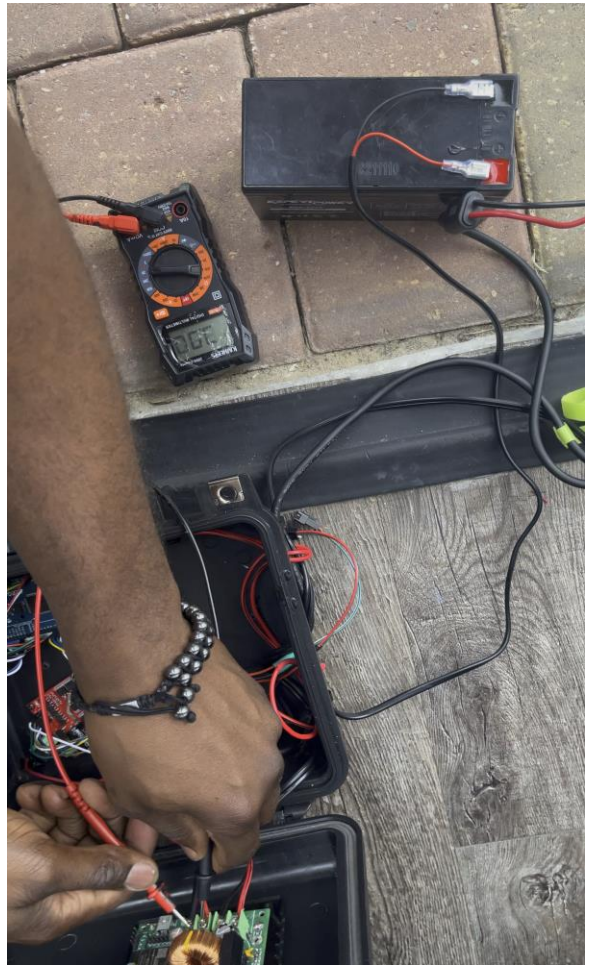
FrostRunner PCB



Frost Runner Power Storage

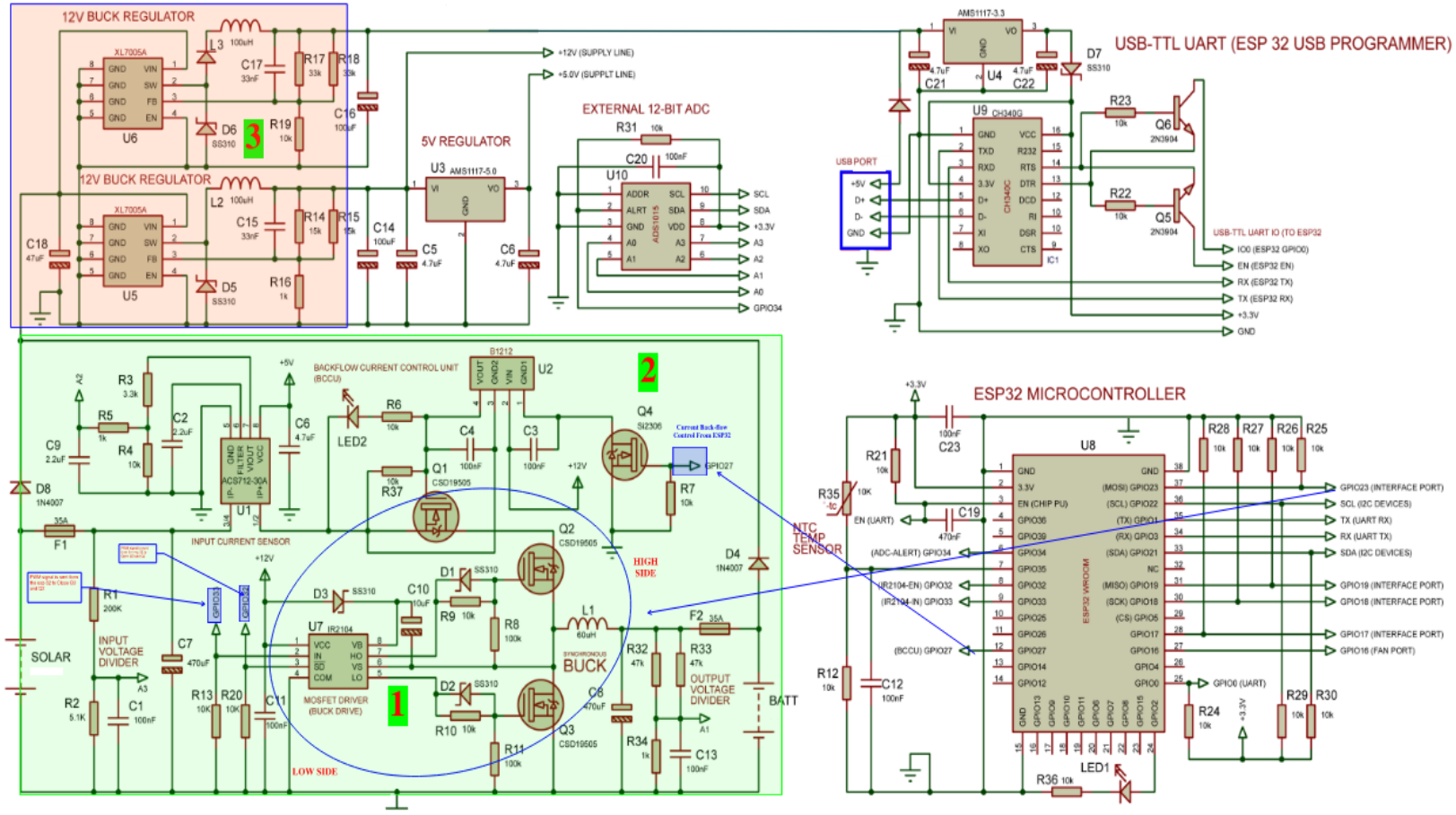
Testing Power Delivery System

We Choose 12V 7AH Li-Ion, because of the 12 volts, larger capacitance, BMS, weight and reliability

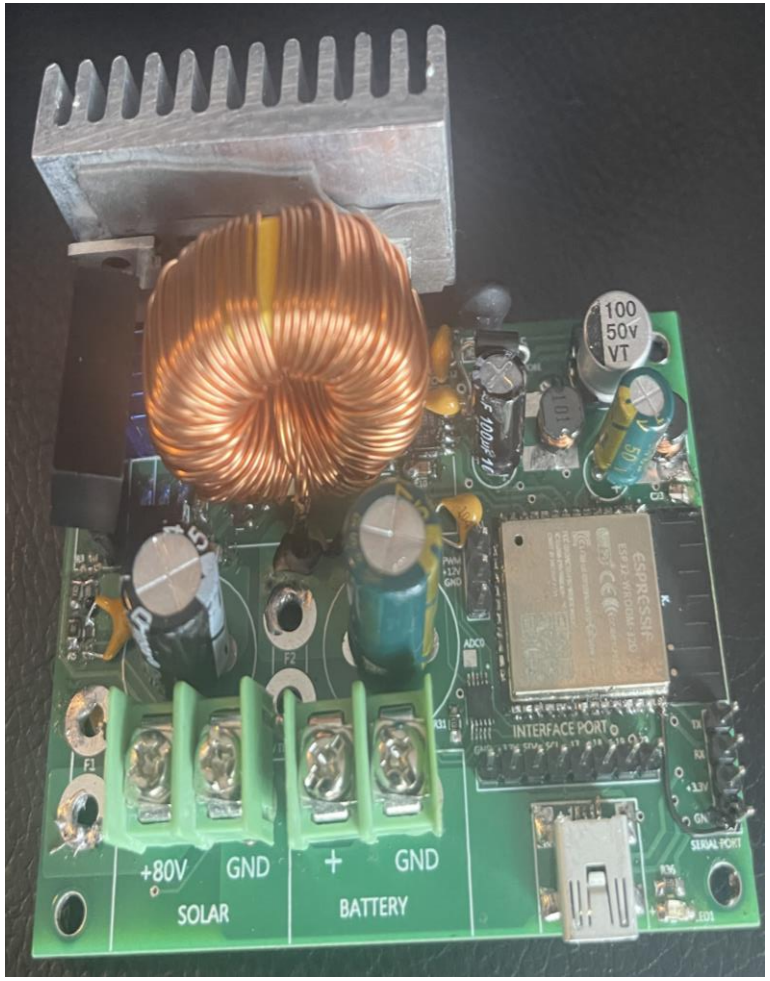


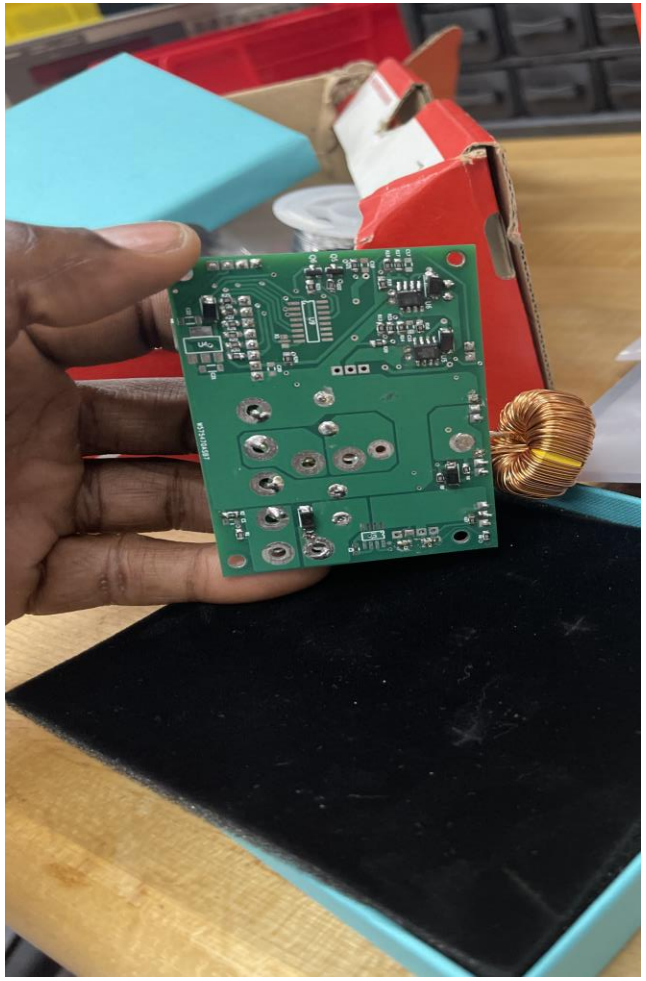
PCB Designs

FrostRunner PCB



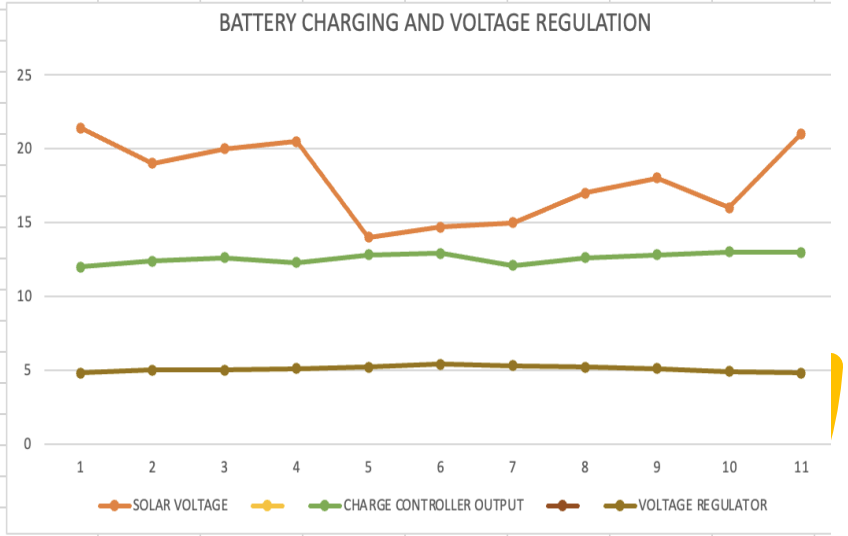
Final PCB



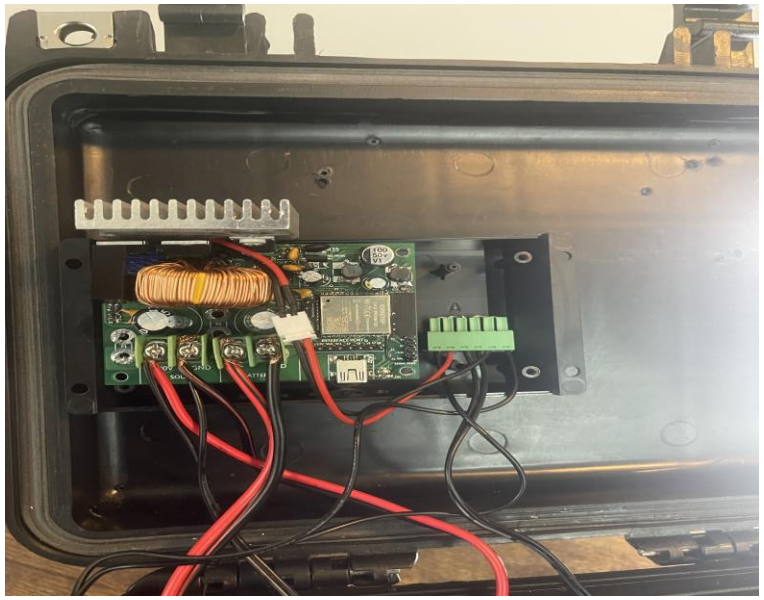


PCB Testing Results

	SOLAR VOLTAGE	CHARGE CONTROLLER OUTPUT	VOLTAGE REGULATOR
	21.4	12	4.8
	19	12.4	5
	20	12.6	5
	20.5	12.3	5.1
	14	12.8	5.2
	14.7	12.9	5.4
	15	12.1	5.3
	17	12.6	5.2
	18	12.8	5.1
	16	13	4.9
	21	12.99	4.8
mean	17.68460338	12.58555649	5.069307751
average	17.87272727	12.59	5.072727273
Median	18	12.6	5.1
max	21.4	13	5.4
min	14	12	4.8
STD Dev	2.692987527	0.349428104	0.195401684



FrostRunner PCB Enclosure



PCB Testing Results

Vehicle

- Powered by 225 Watt Motors Which means that the combined power of both motors is 50 watts (25W + 25W).
- Single Steering motor 12V 25 Watt
- 3 mph maximum speed
- 105-pound weight capacity-Tested
- Dimensions: 39.25"(L) x 26"(W) x 26"(H)

1st Key Specification

Over 100-lbs tested

Cooler

Igloo	Domende Refrigerator.
Insulated with Ultratherm™ foam to keep contents cold	Compressor that provides fast and deep cooling to -4F !!
Non-Powered	Power- **B**attery protection mode (12/24V) (60 Watt Rev.)
8.4 pounds	27 pounds
No Cooling	-4 degrees to 68 degrees Fahrenheit
14.2"D x 25.71"W x 14.25"H	14.4"D x 22.4"W x 19.7"H
None	Battey Monitoring

Communication System

Two types of wireless communication are compatible with FrostRunner, but only one device is needed for wireless communication.

1. Wi-Fi. (esp32)
2. Bluetooth. (HC-06)

Bluetooth vs. Wi-Fi

Comparison	Bluetooth	Wi-Fi
Speed	Only 3 Mbps for Bluetooth	At least 54 Mbps for Bluetooth
Location detection	Somewhat more reliable	Somewhat less reliable
Proximity detection	More Accurate	Less accurate
Power usage	Bluetooth was designed to use less power	Required directly connected to power source

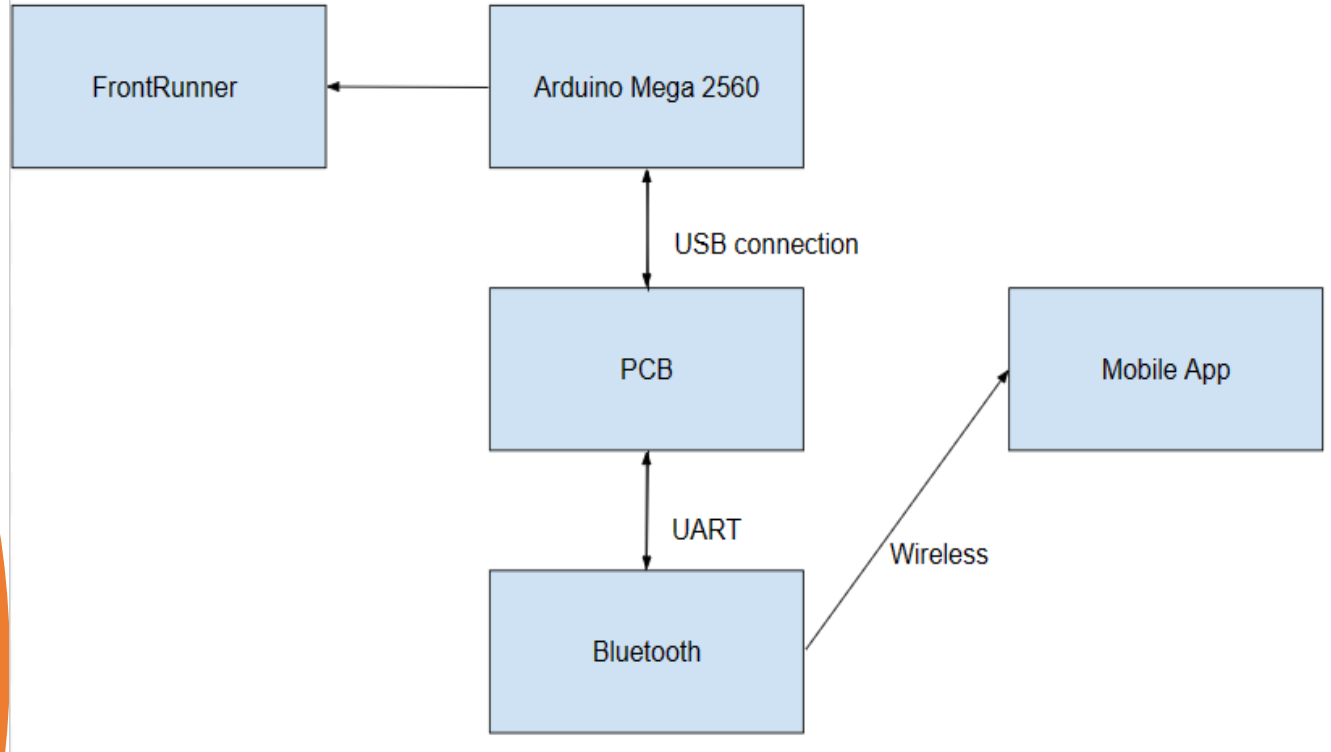
Bluetooth Specifications (HC-06)

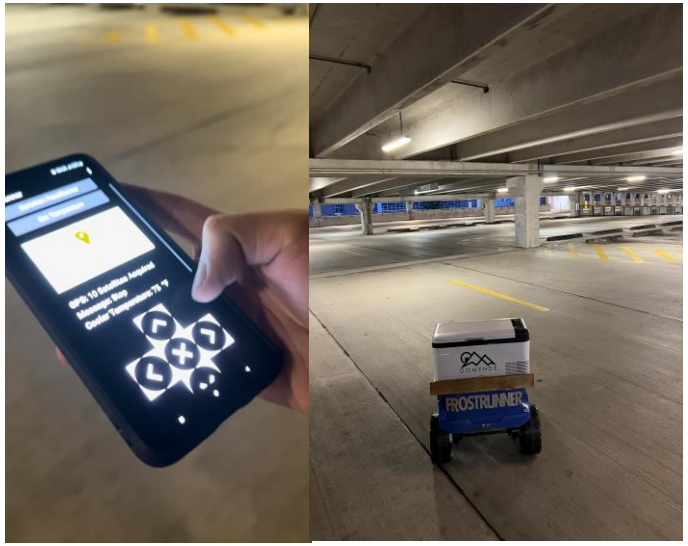
Feature	Details
Version	2.0
Class	2
Cost	$9.99
Band	2.40Ghz - 2.50Ghz
Interface	UART, USB
Current	40 mA
Power supply	3.3 to 6 V
Output power	6dBm

Communication System Requirements And Solutions

Requirements	Solutions
Well - equipped Bluetooth module that supports Bluetooth communication.	we have chosen a well module Bluetooth that is available in the market(HC-06)
Bluetooth-enabled device with the capability to initiate and manage Bluetooth connections. (Smartphone)	Any smartphone nowadays comes with an integrated Bluetooth.
Stable power supply to operate the Bluetooth module	A 12V battery is well installed in FrostRunner.
An Application on smart phone to communicate with FrostRunner over Bluetooth.	An application phone was developed for this project

Communication Diagram



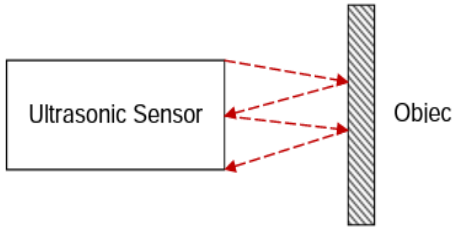


Ultrasonic Sensors

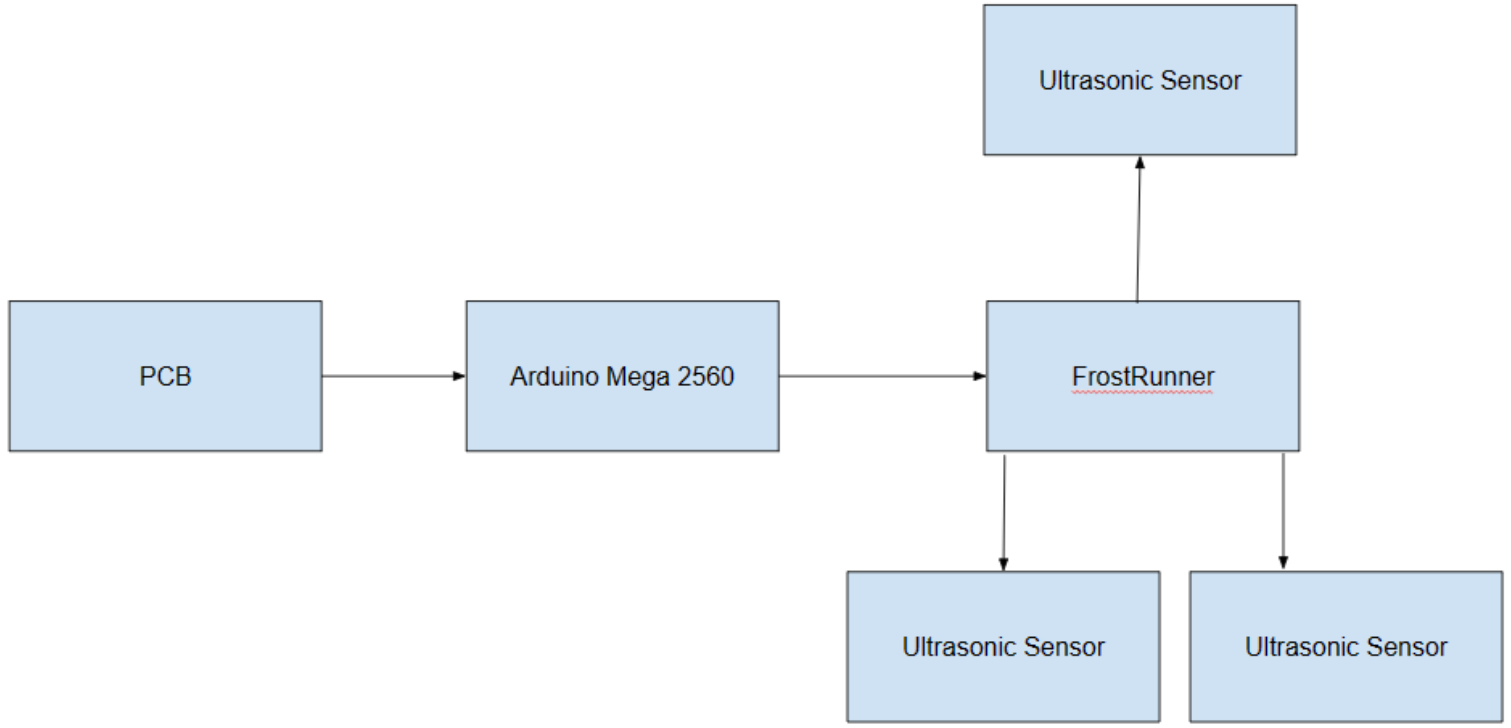
It is used to detect obstacles and avoid collisions.

Operates at a frequency of 40kHz and can detect obstacles up to 1 meter away.

Three sensors are installed (Two in front and one in back) to detect obstacles

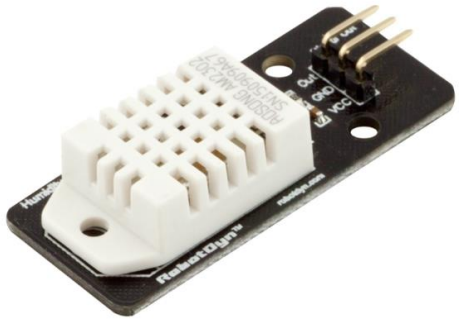


Ultrasonic Sensors Diagram

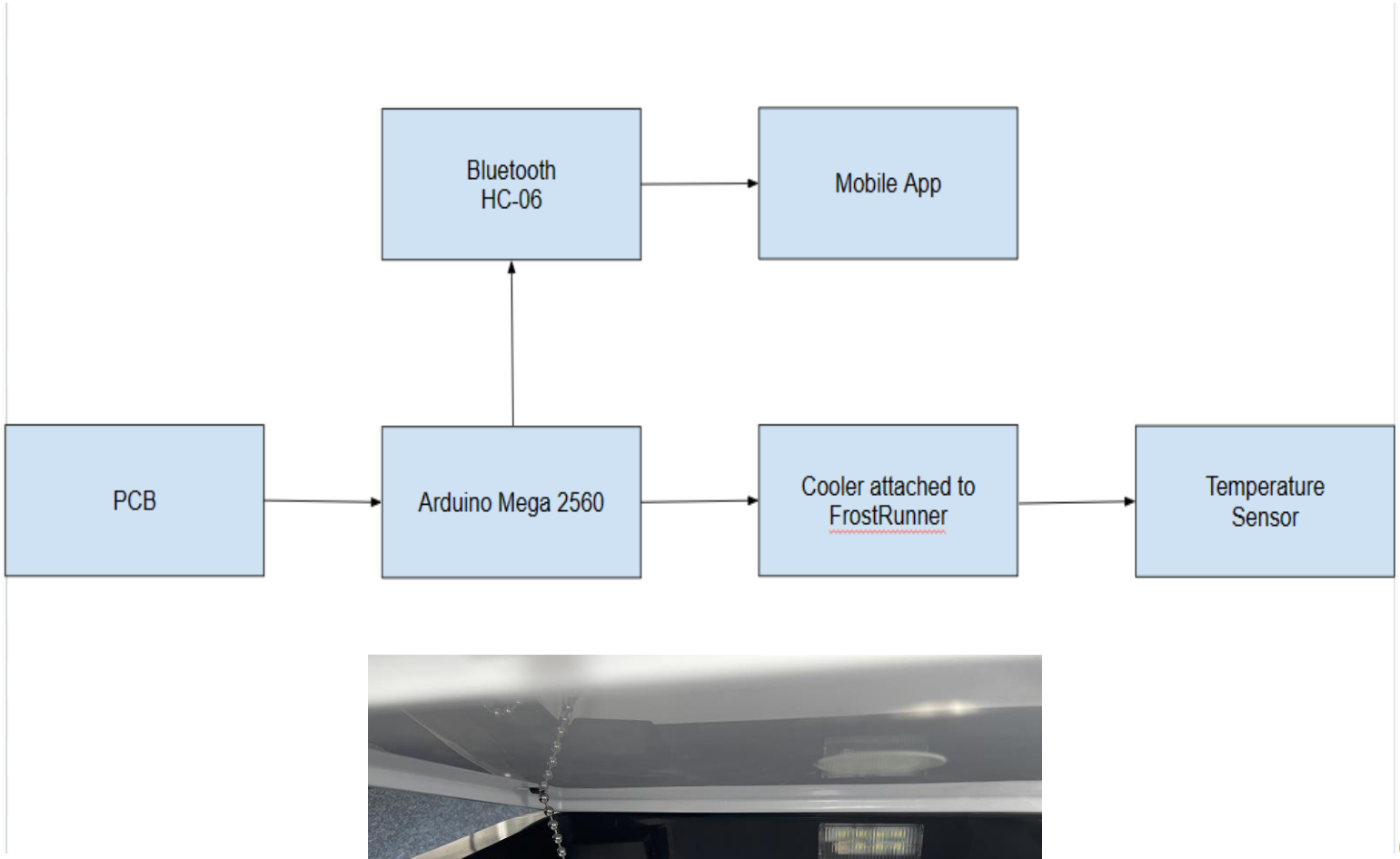


Temperature Sensor (DHT-11)

Feature	Details
Cost	$5.00
Supply voltage	3 to 5 V
Operating system	0 to 50 C
Output current	2.5 mA
Body size	15.5 mm x 12mm 5.5 mm
Pins	3



Temperature Sensor Diagram



Sensors Requirements and Solutions

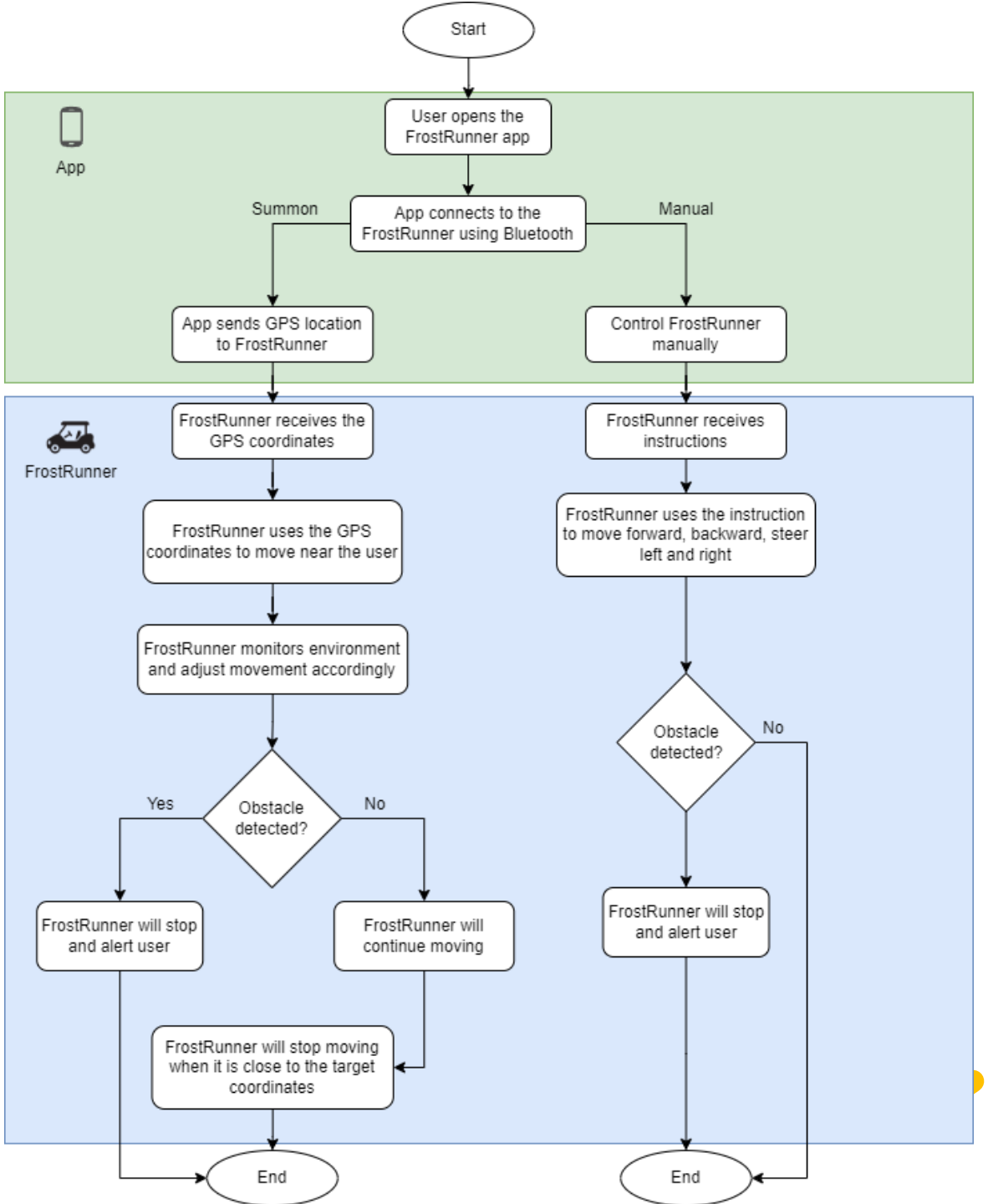
Requirements	Solutions
Sensors should be compatible with microcontroller	Ulrasonic and temperature sensors are working great with Arduino Mega board.
Mounting ultrasonic sensors in the back and front of FtostRunner to detect objects.	We specified this as our engineering key Specification, we also ran 10 trials to show sensors work properly (final Demo)
Power supply	A 12-volt battry is supplying the power int FrostRunner
Proper wiring connection between sensors and FrostRunner's control system	We used 16AWG wires, which is 4.016 mΩ/foot, which is perfect for FrostRunner since we are using 3 Ft of wire for all our sensors wring.

2nd Key Specifications

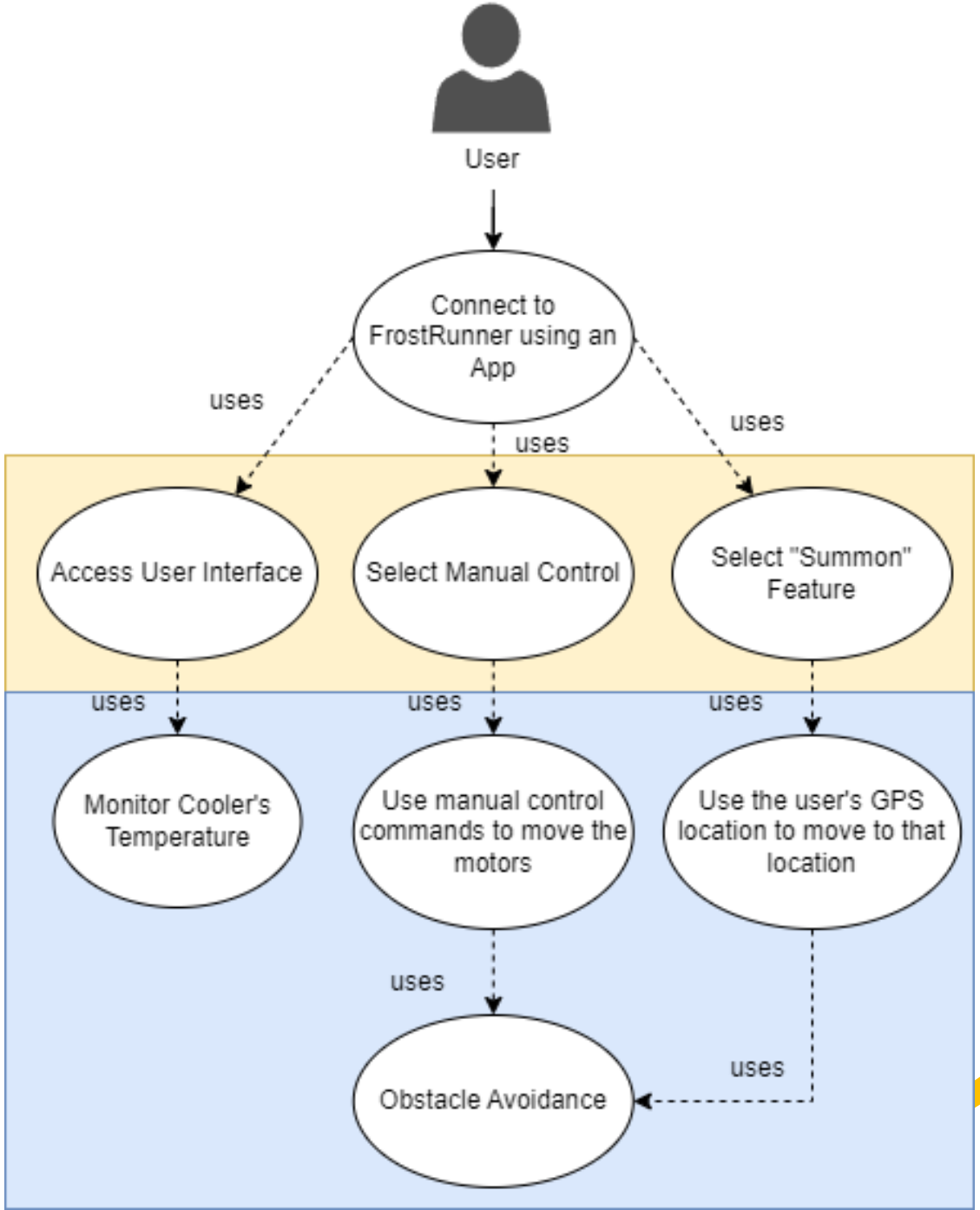
Temperature Monitoring and Control:

Real-time monitoring of the cooler’s temperature. Can be controlled using the FrostRunner app

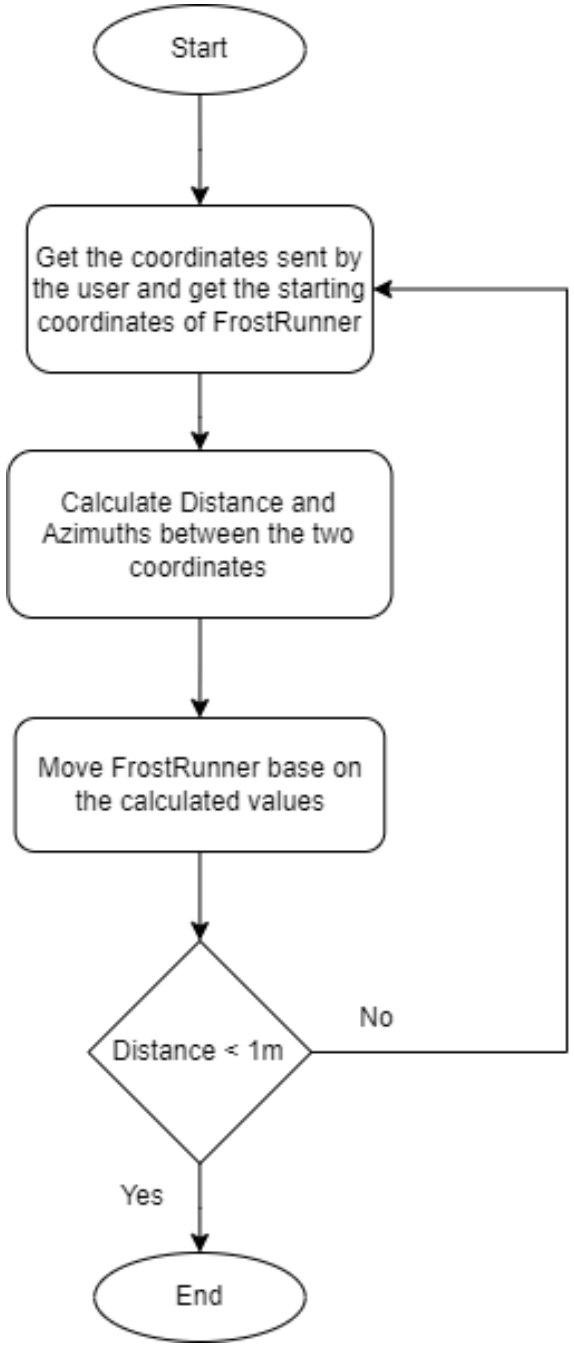
Software Block Diagram



Use Case


User
Connect to FrostRunner using an App
uses
uses
uses
Access User Interface
Select Manual Control
Select "Summon" Feature
uses
uses
uses
Monitor Cooler's Temperature
Use manual control commands to move the motors
Use the user's GPS location to move to that location
uses
uses
Obstacle Avoidance

“Summon” Feature Algorithm



Limitations

Limitations:

- The GPS coordinates sent by the phone may lack precision as the phone only sends up to 6 decimal numbers.
- The GPS module might take time to acquire a stable signal, especially in cloudy conditions or when there’s no clear view of the sky.
- After several steering maneuvers, the steering axle may require realignment.

Solutions:

- We’ve added moving average filter for the GPS coordinates to help us with the low precision.
- We’ve incorporated obstacle detection at the front and back to prevent the FrostRunner from crashing.

3rd Key Specifications

Obstacle Detection

FrostRunner will automatically stop when it detects an obstacle in front of the sensors

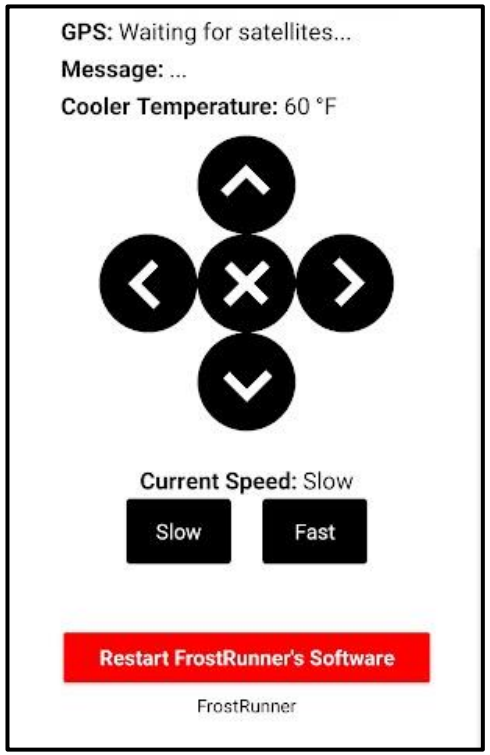
Mobile App Overview

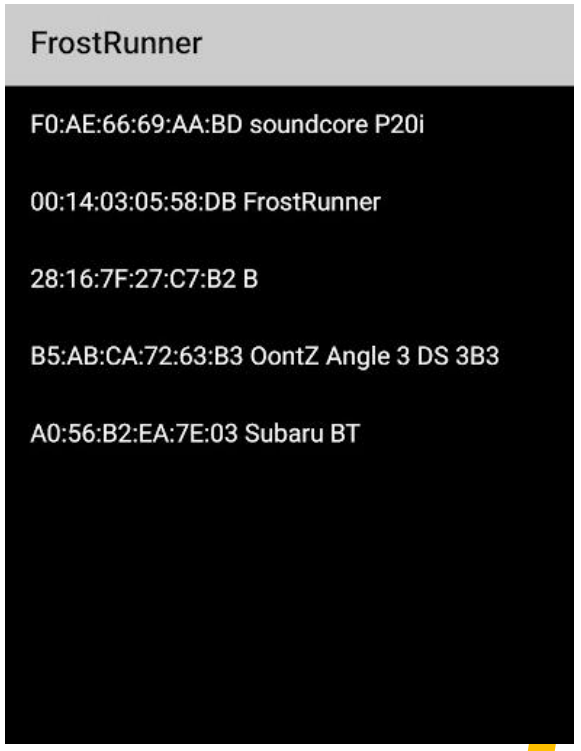
- The mobile app is a crucial component to the project as it will grant the user control over the FrostRunner vehicle.
- Once a connection between a smartphone device and the vehicle has been established via the app, the user will have the ability to choose between 2 navigation options, autonomous GPS following, and remote control.

Mobile App Features

- Bluetooth connection
- Cooler internal temperature display
- Summoning navigation
- Remote control navigation
- Real-time GPS display
- Different vehicle speed options

Mobile App User Interface





Limitations

- The mobile application runs strictly on Android devices

Bill of Materials

Items	Price
Robot Car Kit	$50.00
Ride-on Truck	$250.00
GPS Module	$10.00
Bluetooth Module	$10.00
DC Motor Controller	$15.00
Temperature Sensor	$10.00
Wires and Connectors	$50.00
Cooler	$169.00
Charge Controller	$35.00
Solar Panel	$105.00
Cooler Platform	$25.00
Total Cost	$729.00

Workload Distribution

Power Module and PCB	Wireless communication/ Sensors module	High-level software	Mobile App Development
Ishmael	Khalid	Joshua	Jeyler

Challenges Faced

- Steering Alignment of wheels on power wheel base.
- GPS is not precise and needs to be calibrated on start up.
- Keeping the FrostRunner portable and lightweight.
- Building a reliable PCB that will regulate the battery charge and provide different levels of voltage to the FrostRunner.
- Weather Conditions halted FrostRunner testing in many occasions.

Any Questions?