Group 30

Florida Solar Vehicle Project

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Motivation

Solar Beach Buggy

Build a completely autonomous vehicle which can traverse the beach terrain without disturbing wild life or other beach goers and runs completely off of solar energy.

Solar Energy

Solar energy is the most abundant renewable energy source available in Florida.

Advances in technology each year.

More Options

Ride-sharing would no longer be dependent on a driver, allowing cars to drive unlimited by an operator.

Autonomous vehicles can transport physical goods without the need for human oversight

Safety

Over 37,000 people died in motor vehicle crashes in 2017.

Distracted drivers are dangerous drivers.

Goals and Objectives

To design and build a solar powered vehicle that is able to traverse an obstacle course and be fully autonomous while detecting and avoiding both stationary and moving objects, persons, or obstacles.

1

Electrical/ Computer Team

Design, test, and build solar panel power distribution to motor and electronics sub systems.

Connect and program ultrasonic sensors using PCB, to be utilized with computer software.

Integrate all hardware and software to work with each Mechanical Engineering vehicle.

2

Computer Science Team

Program and test software using Robot Vision and SLAM (Simultaneous Location and Mapping) algorithms to detect and avoid objects.

Integrate detection software with hardware components to move vehicle.

3

Mechanical Team

Design, build, and test frame of vehicle, so it will be able to withstand 120lbs along with all the hardware and software components and solar panels.

Requirements

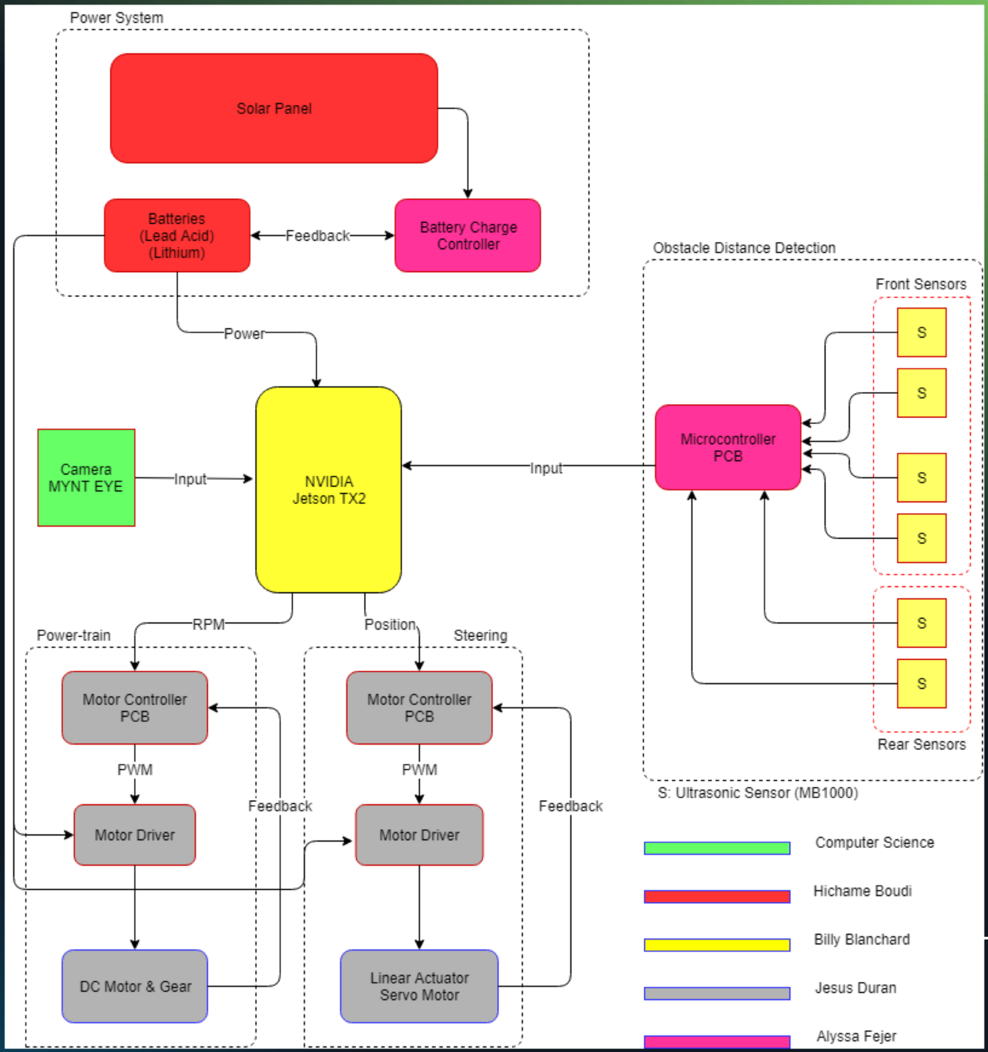
Description	Value
Vehicle run time	≥ 20 mins
Capable of transporting one passenger	≤ 120lbs
Top allowable speed	5 mph
Run completely on solar energy	100% Solar
Vehicle should not cause harm to environment	N/A
Navigate autonomously	N/A
Detect and avoid both stationary and moving obstacles	≥ 6 x 4 inches
Total cost	≤ $1500.00

Specifications

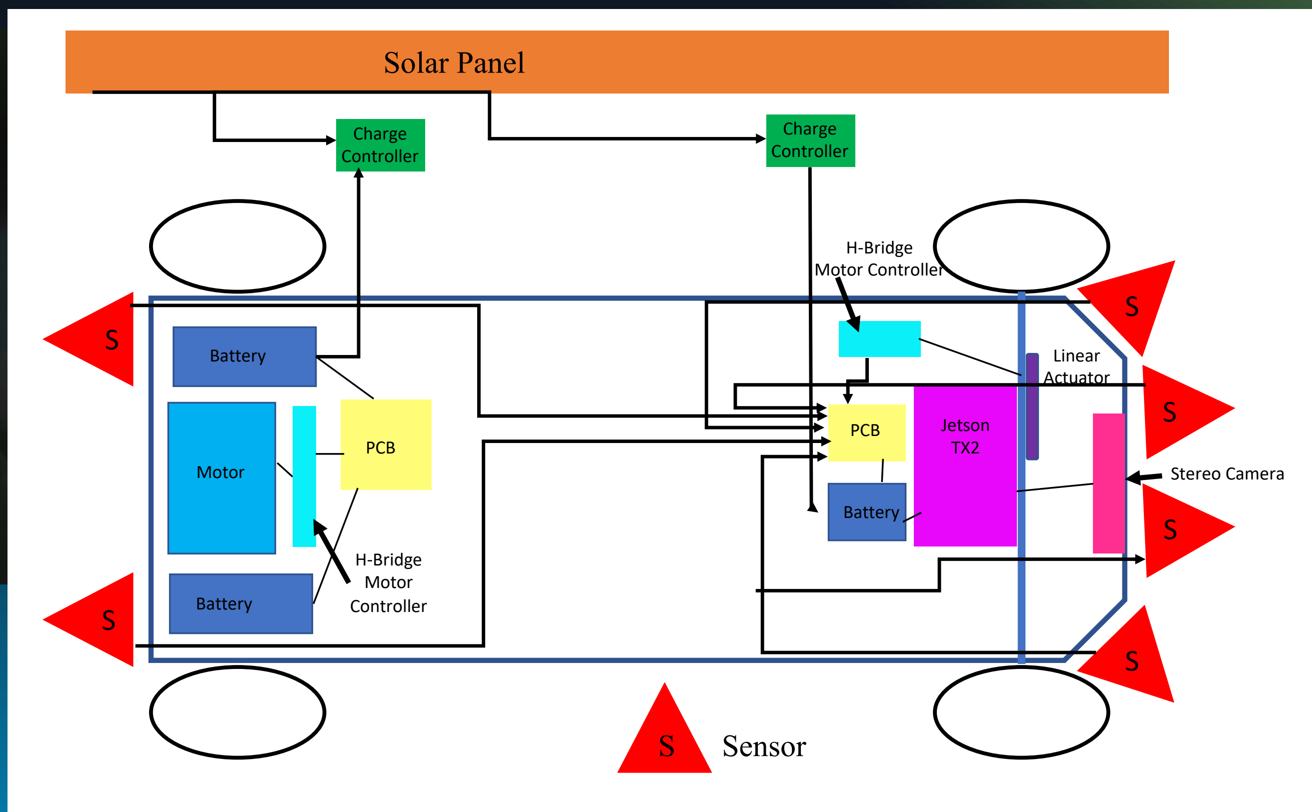
Description	Value
Solar panel power output	≥ 300W
Store solar energy on batteries	3 units
Detect objects within distance range	3 – 8 ft
Ultrasonic sensors for object detection	6 units
PCB with integrated MCU	3 units
Camera for object recognition	1 unit
High performance CPU/GPU	1 unit
SLAM for path planning	N/A

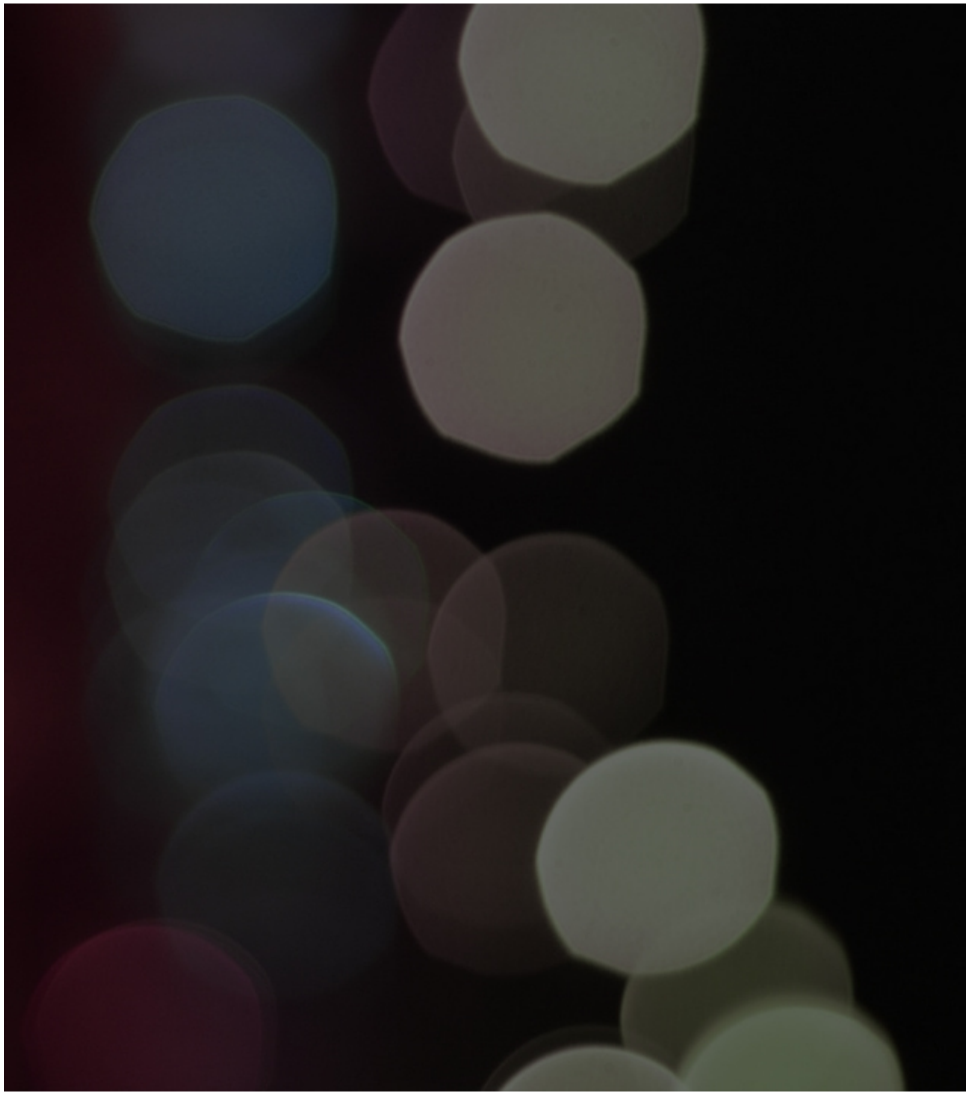
Overall Block Diagram

- GPU – Jetson TX2
- Sensors – Ultrasonic Sensors
- Camera – Stereo Camera with IMU Sensor
- Motor Controller – PCB
- Motor Driver – H-Bridge



Hardware Integration Diagram





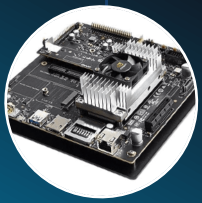
Computation System

Computer Comparisons

- CPU : ARM Quad-Core @ 2GHZ + NVIDIA Denver2 Dual-core @ 2GHZ (6 total cores)
- GPU: 256 Core Pascal @ 1300MHz
- RAM : 8GB
- Camera: 5MP(Onboard)
- Storage: 32GB
- POWER: 7.5W
- Cost: $299

Jetson TX2

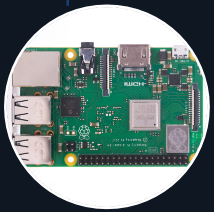
Nvidia



- CPU: ARM Cortex Quad-core @ 1.2GHz
- GPU: Broadcom-IV @ 400MHz
- RAM: 1GB
- Camera: None
- Storage: 32GB
- Power: 6W
- Cost: $35

Raspberry Pi 3 B+

Raspberry Pi

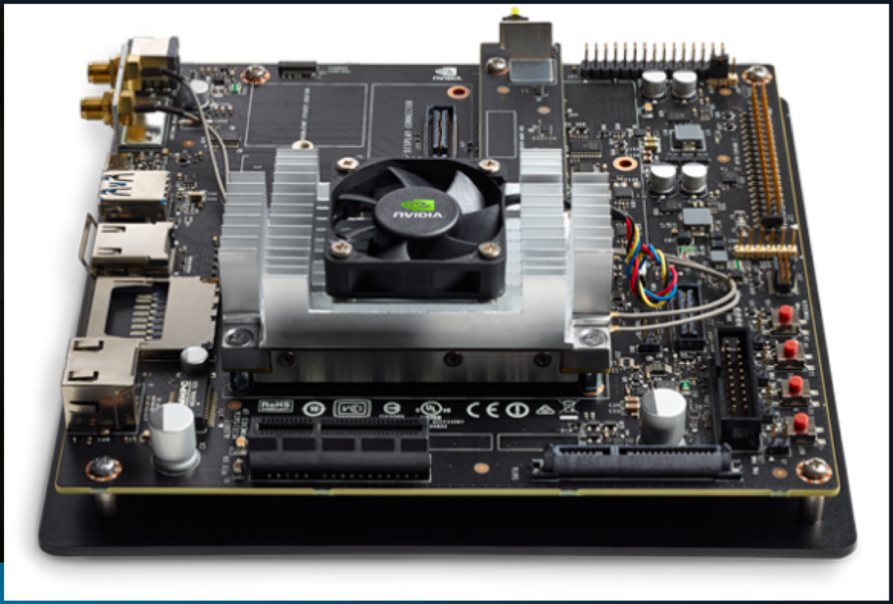


- CPU : ARM Cortex-A57(Quad-Core) @ 1.73GHZ
- GPU: 256-core Maxwell @ 998MHz
- RAM : 4GB
- Camera: 5MP(Onboard)
- Storage: 16GB
- POWER: 10W
- Cost: $199

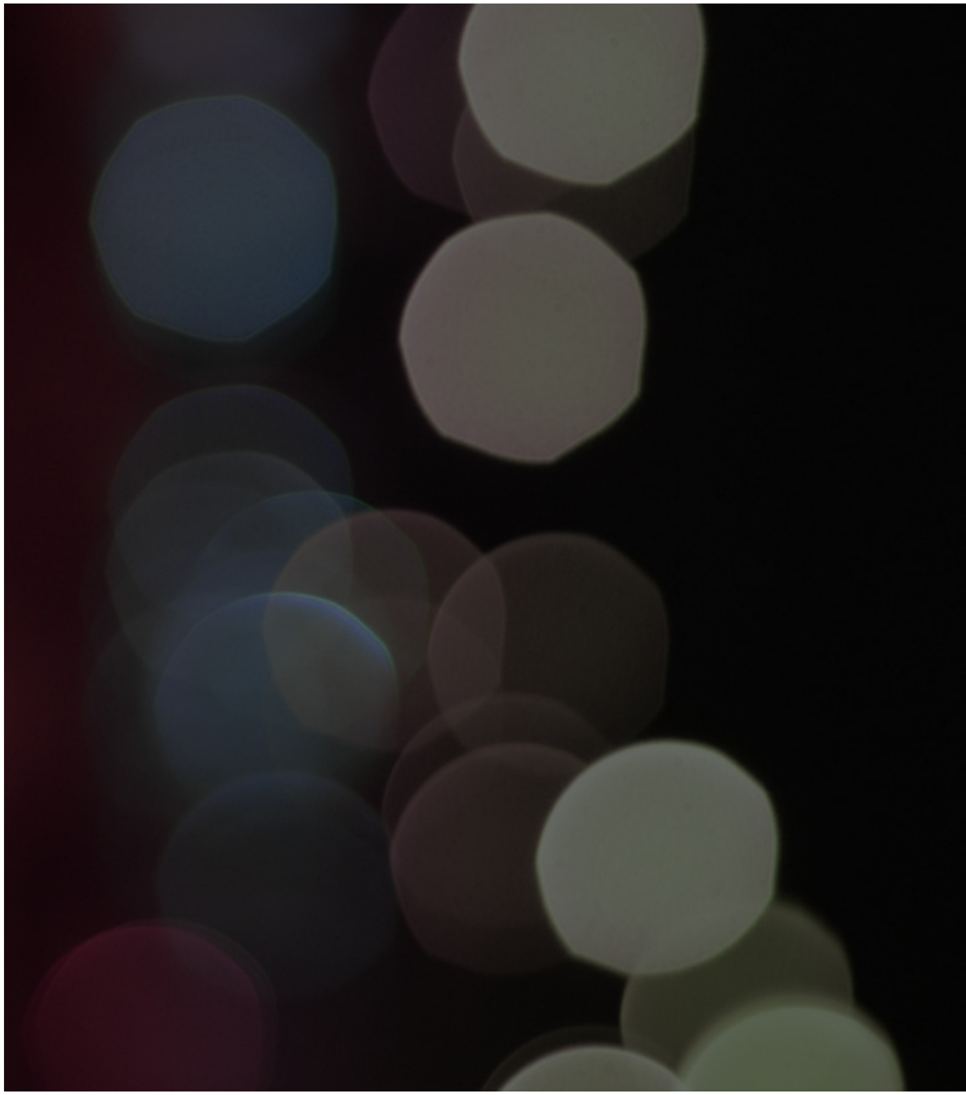
Jetson TX1

Nvidia

NVIDIA Jetson TX2



- The TX2 is not meant for basic robots or drones, but for those that need heavy computing vision applications, which in turn require good GPU performance.
- Two Profile Settings:
  - Max-P (Performance)
  - Max-Q(Balanced)
- Every component on the module including the power supply is optimized to provide highest efficiency at this point.



Motor Subsystem

Components

- 24V Brushed DC Motor
- 500W Output
- 21A Current
- 1.5N.m Torque
- 200lbs Max load

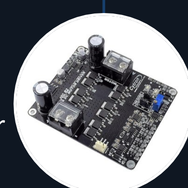
Motor

MY1020 Motor

- Single DC Motor Driver
- Fully NMOS H-Bridge
- 30A Continuous Current
- 80A Peak Current (1 second)
- 3.3V and 5V logic level input
- PWM Freq. up to 20KHz

H-Bridge

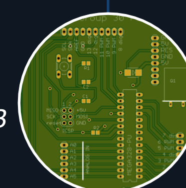
Cytron Motor Driver



- 8-Bit Core Size
- 32KB Flash Program Memory Size
- 2K x 8 RAM
- 16MHz Clock (Crystal)
- 32 GPIO Pins

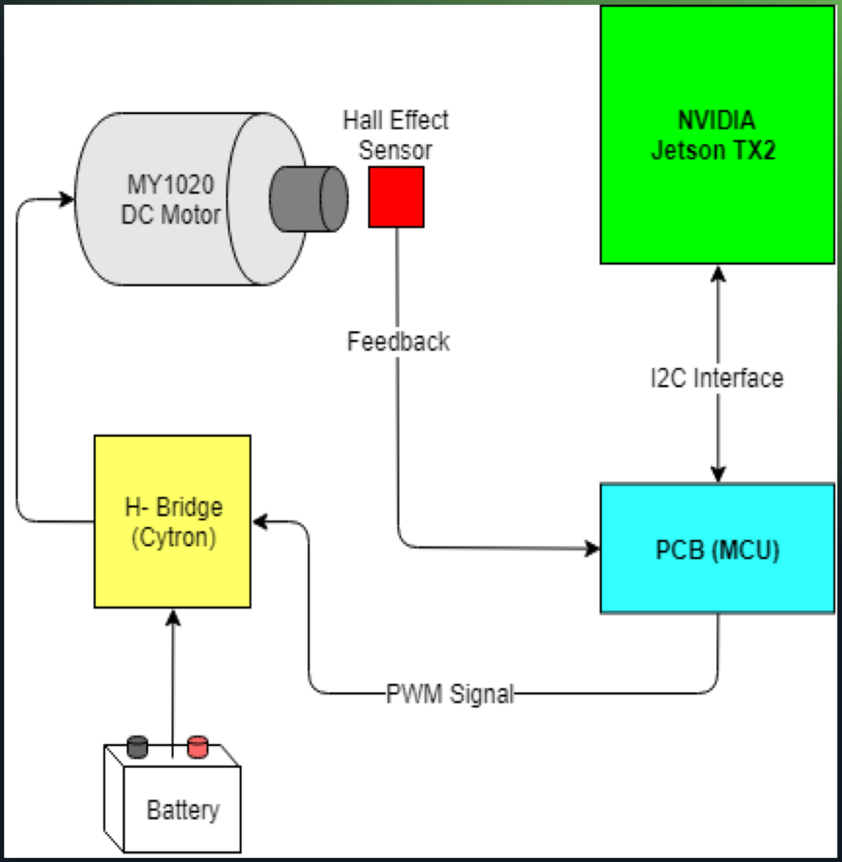
MCU

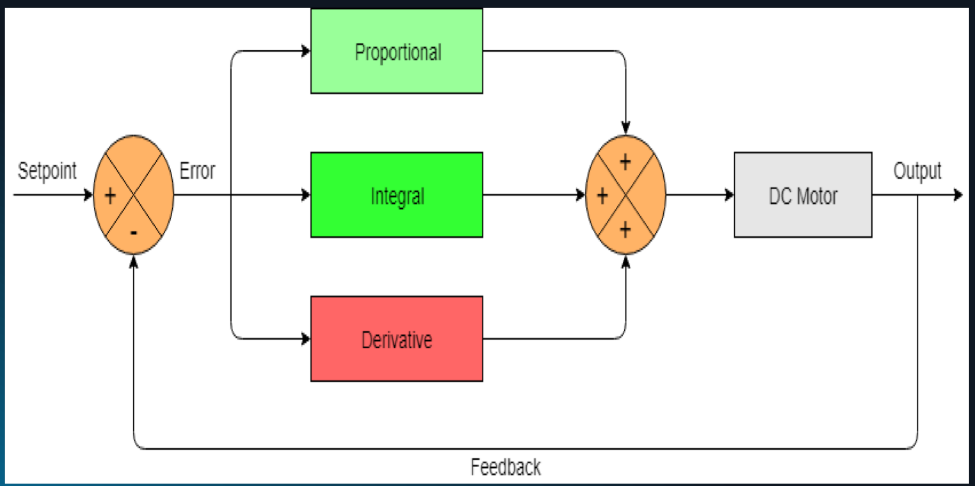
ATMEGA328p on PCB



Layout

- Motor Control will be carried by the MCU implementing a PID controller
- The motor driver will connect to two 12V batteries in series and drive the motor using PWM
- The Parallax Melexis 90217 Hall-Effect sensor will provide the feedback to the PID controller
- The MCU will receive the Setpoint (RPM) and direction from the Jetson TX2 using I2C interface





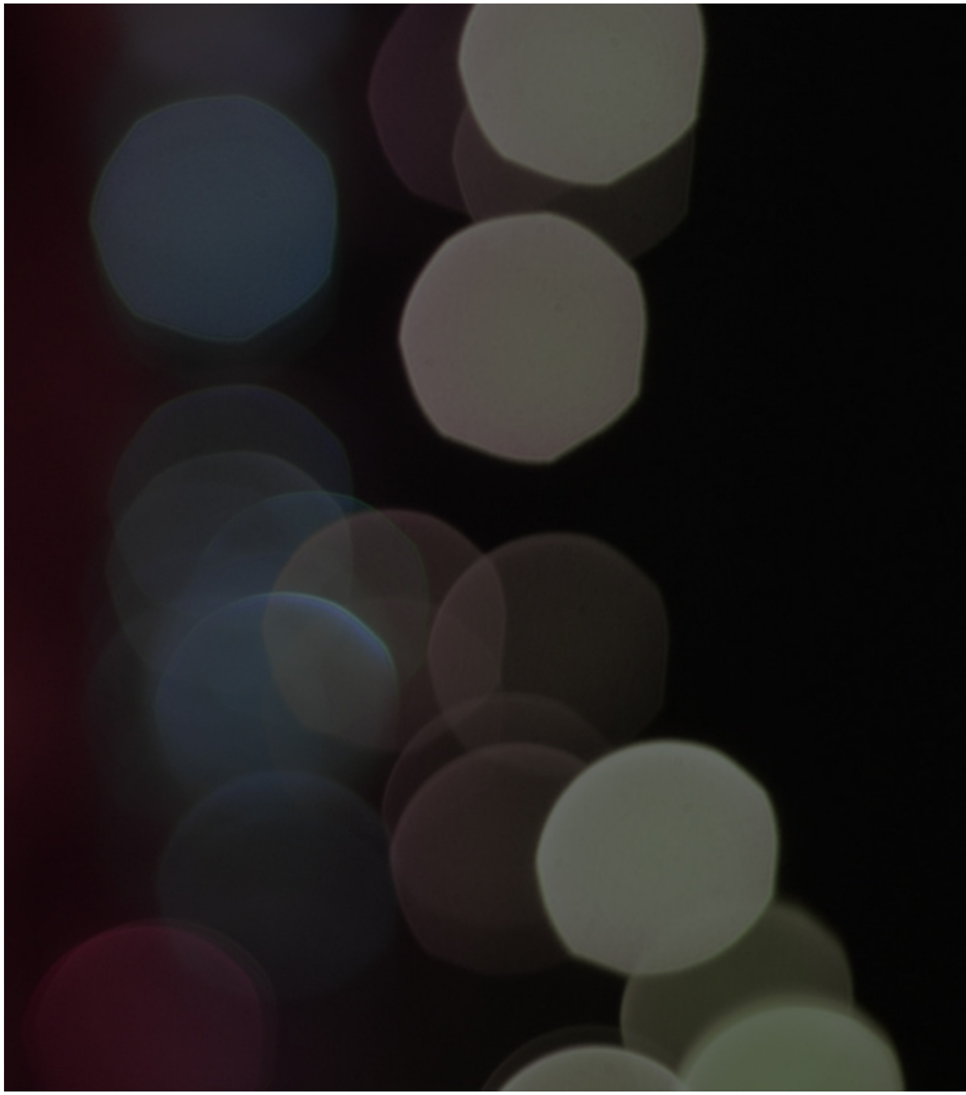
PID Control

Purpose

- It is a well-established control loop feedback mechanism widely used on industrial control systems that require continuous modulated control
- Maintain Speed of the vehicle under different loads
- Smooth and gradual acceleration

Implementation

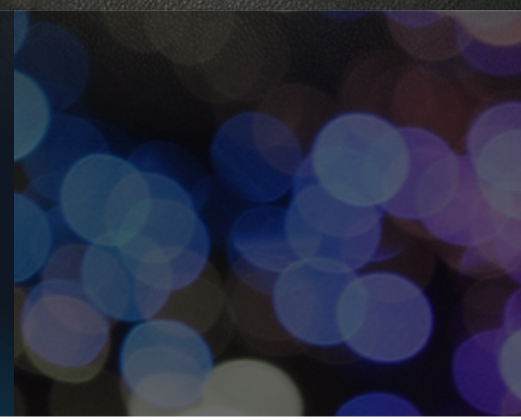
- Arduino PID library by Brett Beauregard
- The PID constants Kp, Ki, and Kd were tuned by introducing Setpoint changes and observing the system response
- Additional tuning might be necessary when field testing



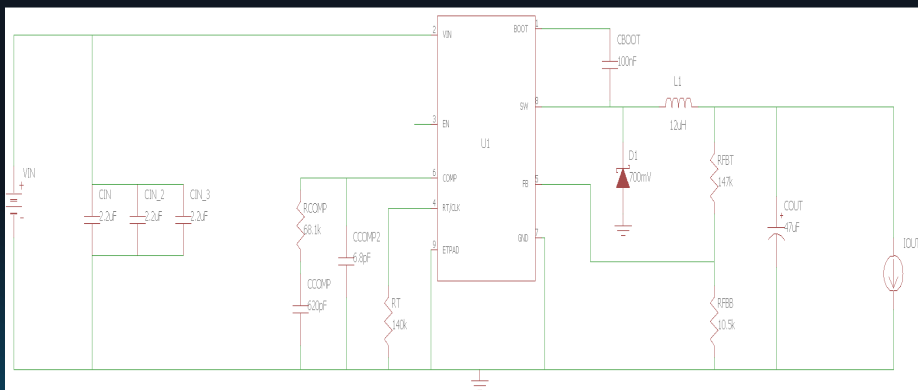
Steering Subsystem

Linear Actuator

- 12VDC 8” stroke
- 3A max current
- 110 lbs max dynamic load
- 500 lbs static load
- Built-in potentiometer feedback system



TPS54340 Step-Down Converter



Power Requirements

Voltage Regulator

- Voltage regulator will connect to two 12V Lead-Acid batteries connected in series (24V Output) to regulate power delivered to linear actuator
- Input: 15V to 30V
- Output: 12V at 3A
- 94.5% Efficiency

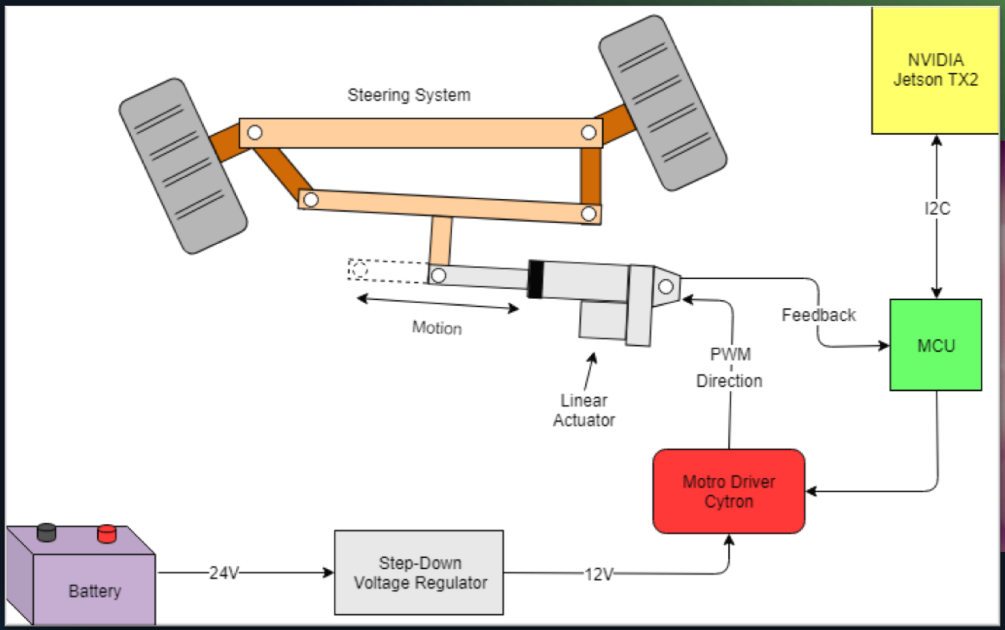
H-Bridge

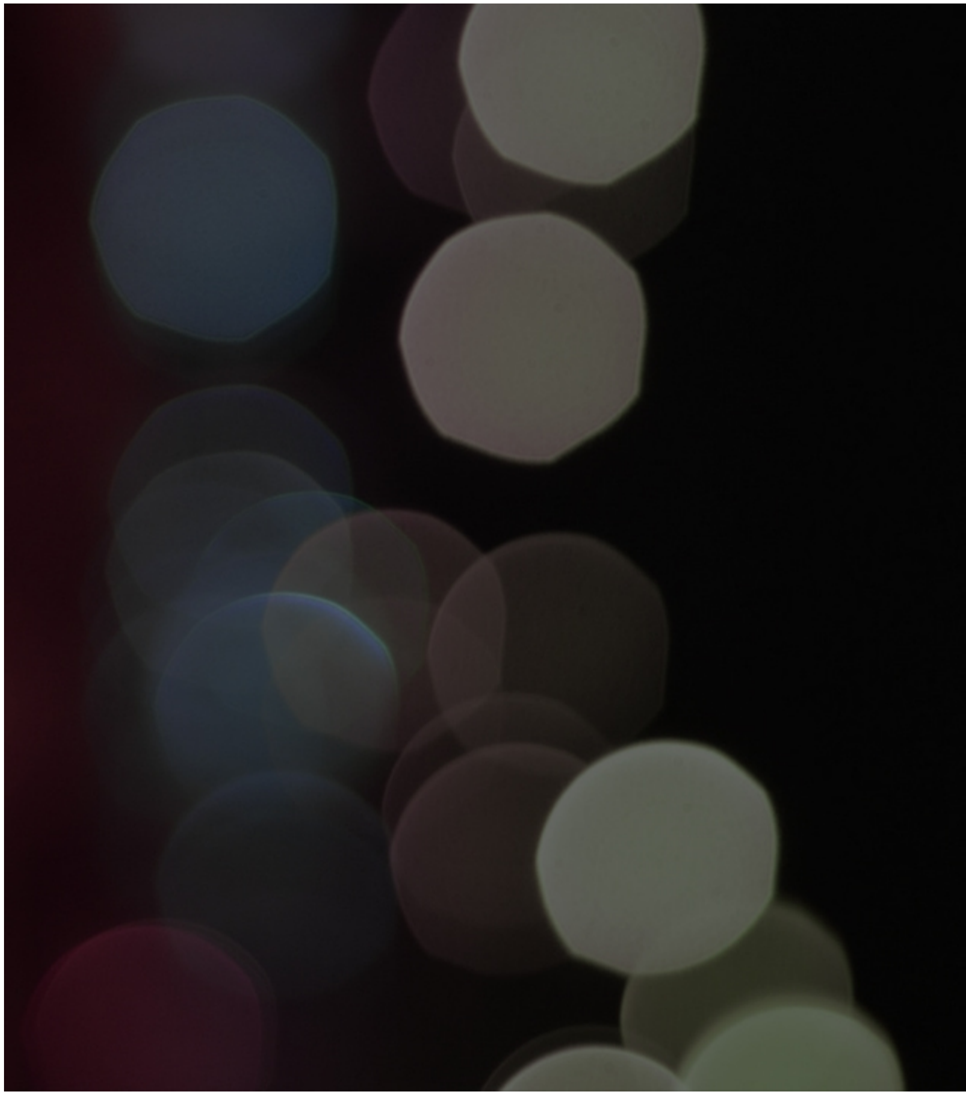
- H-Bridge will be used to switch the polarity of the voltage applied to the linear actuator to extend and retract the shaft
- The Cytron 30A 5-30V Single Brushed DC Motor Driver is an economic H-bridge with the power capabilities required for the linear actuator.

Position Control and Feedback

Layout and Interface

- Uses ATMEGA328p microprocessor on a PCB for Motor control
- Communication
  - I2C Interface between MCU and Jetson TX2
  - MCU Receives position data from the Jetson TX2
  - MCU sends current position to the Jetson TX2
- Feedback
  - Uses built-in potentiometer to get the position of the linear actuator's shaft





Sensor Subsystem

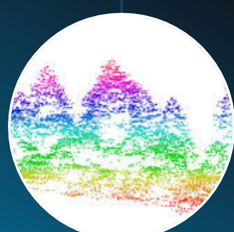
Sensor Types

- Data can be collected quickly and with high accuracy.
- Elevation in a dense forest
- Not affected by extreme weather.

Most expensive of its kind
Range of view becomes limited
Shorter shelf life

High Operating cost
Degraded at high sun angles or huge reflections
Ineffective during heavy rain or low hanging clouds
Very large datasets to interpret.

LiDAR – Light Detection and Ranging



- Can read up to 30 feet with a wide beam in any weather
- Very Cheap ~< $30
- Requires no dataset
- Returns distance
- Work well when facing obstacles head-on

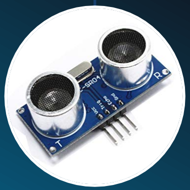
Ultrasonic Sensor

Sensor Comparison

- 5VDC Operating Voltage
- 15mA Operating Current
- 40 KHz Frequency
- 4m Max Range
- 2cm Min Range
- 30 deg. Working Angle

HC-SR04

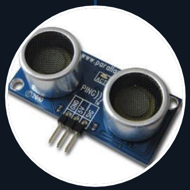
OSEPP Electronics



- 5VDC Operating Voltage
- 30mA Operating Current
- 40 KHz Frequency
- 3m Max Range
- 2cm Min Range
- 40 deg. Working Angle

Ping)))

Parallax

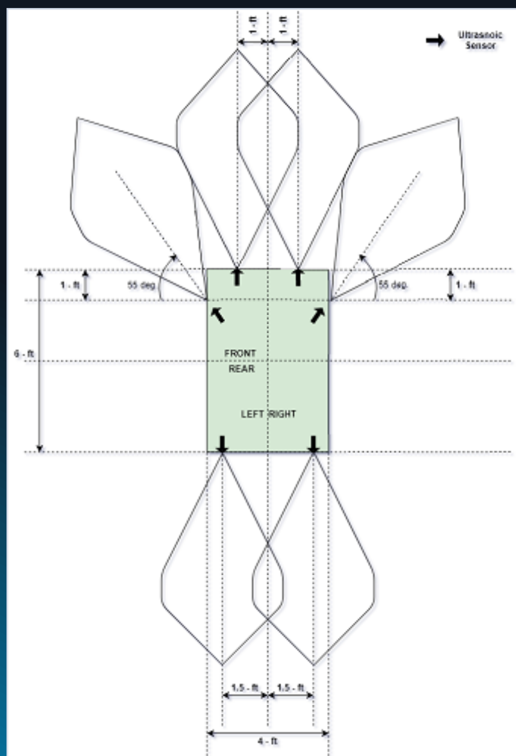


- 2.5 – 5.5VDC Operating Voltage
- 2 - 3mA Operating Current
- 42 KHz Frequency
- 6.45m Max Range
- 0cm Min Range
- 54.6 deg. Working Angle

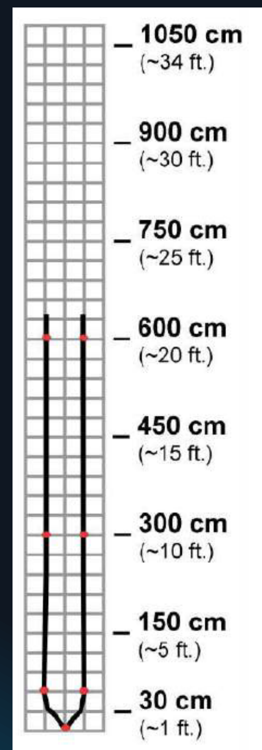
MB1000

MaxBotix

TOP VIEW



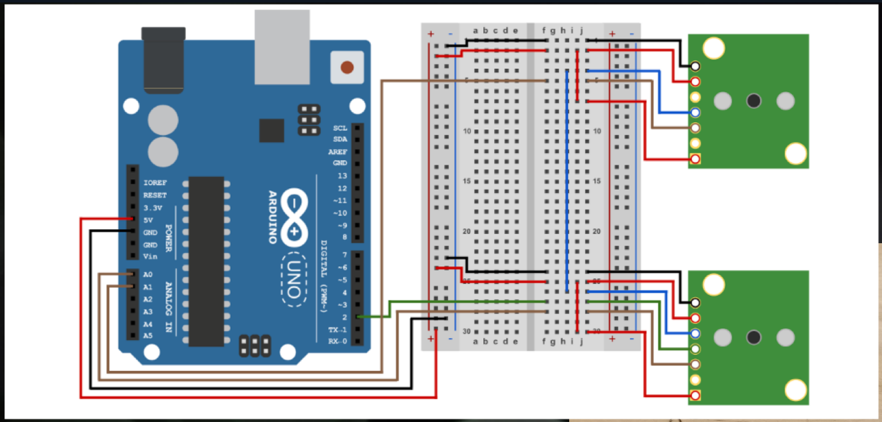
MAX RANGE

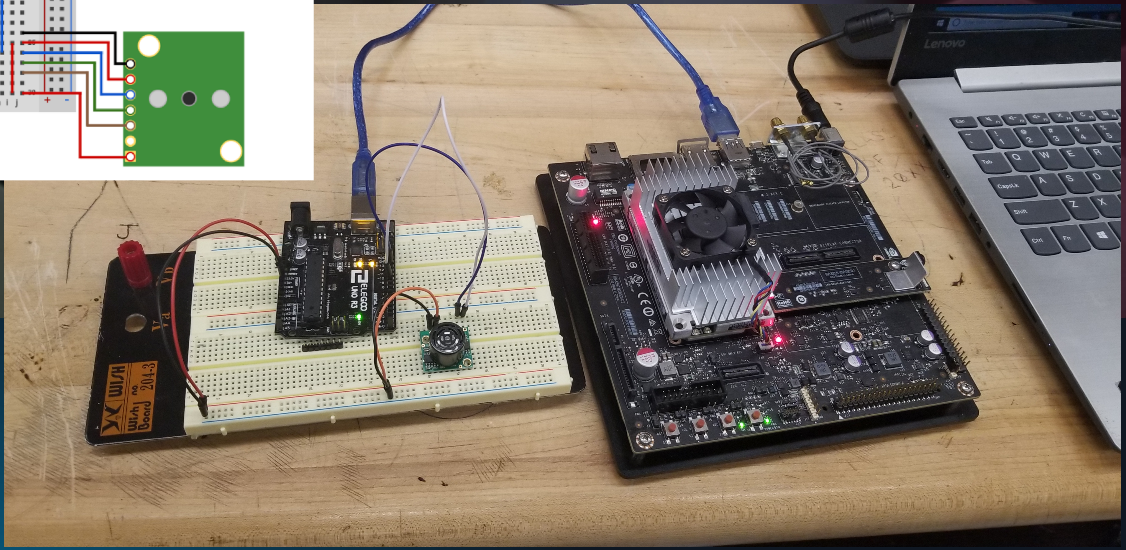


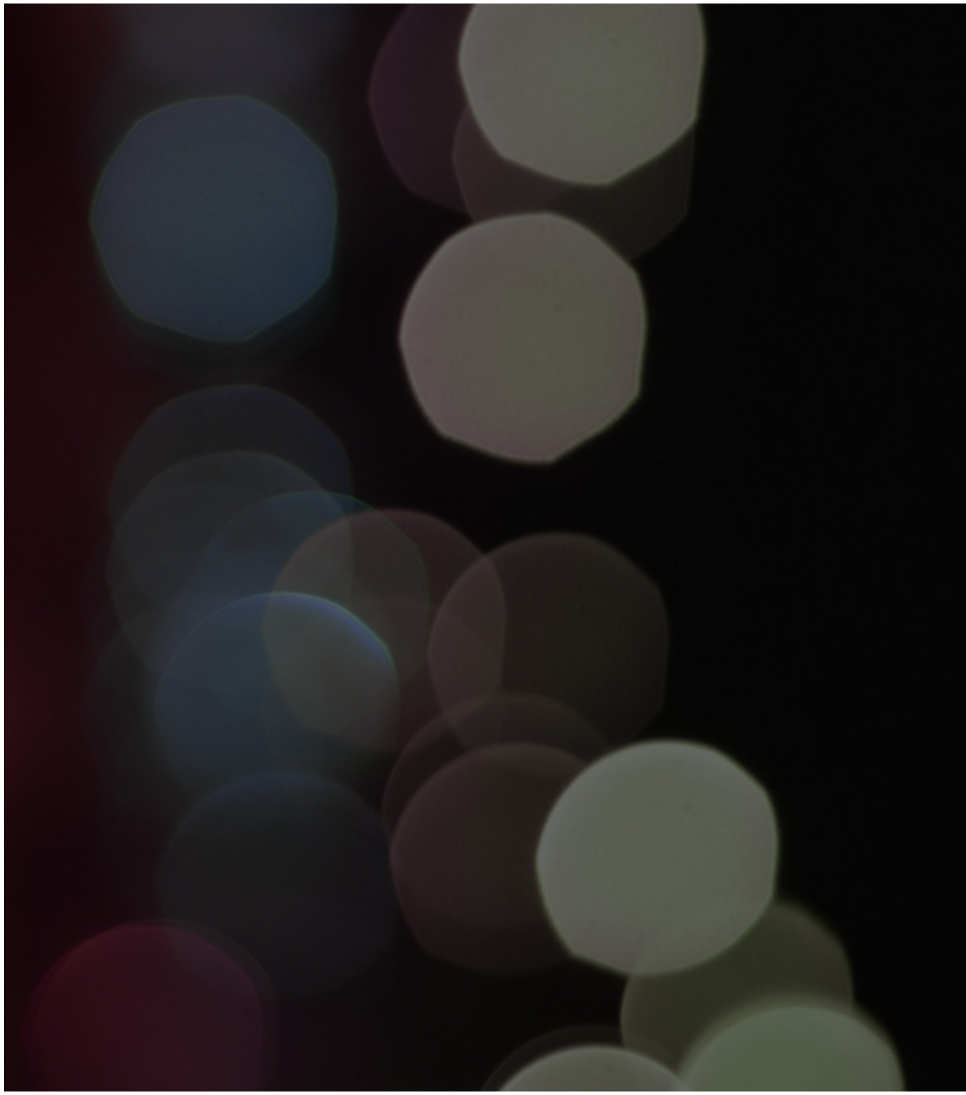
MaxBotix MB1000

- 2.5v - 5.5v Operating power
- Can detect objects from 0 to 6.45 meter (~21 ft)
- PWM, analog, and analog RS232 serial output formats
- MB1000 has widest range of all LV-MaxSonar-EZ series. Ideal for people detection.
- Up to 67 degrees detection angle

Sensor Wiring and Testing



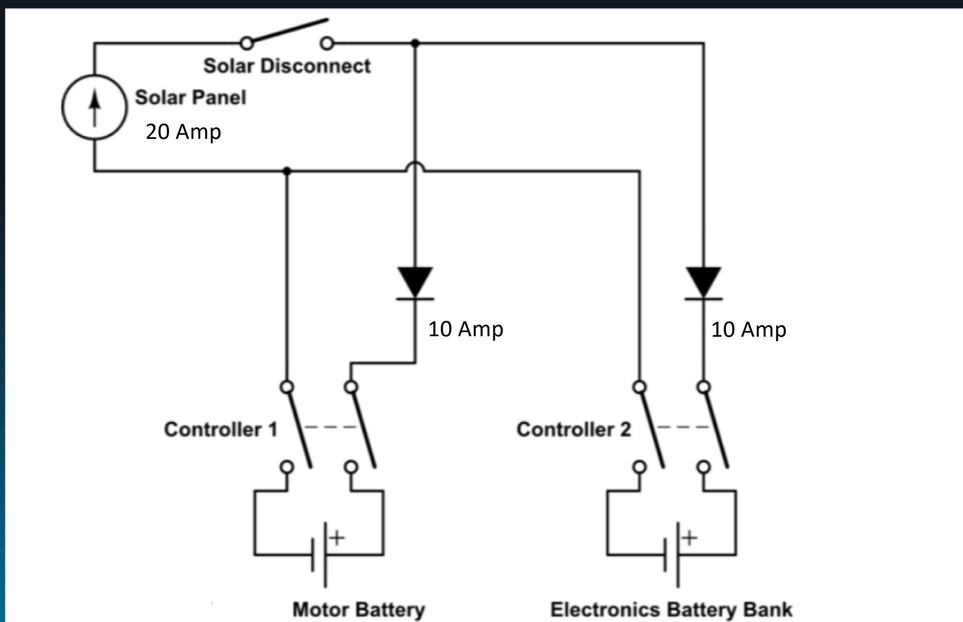




Solar Power Subsystem

Solar Panels

- Each ME group is in charge of purchasing the solar panels for their vehicle.
- Used to recharge batteries for motor and software subsystems.
- Max power needed to properly charge the Lead Acid Batteries for the Motor Subsystem is 24V.
  - Minimum Solar Panel Voltage is 24V

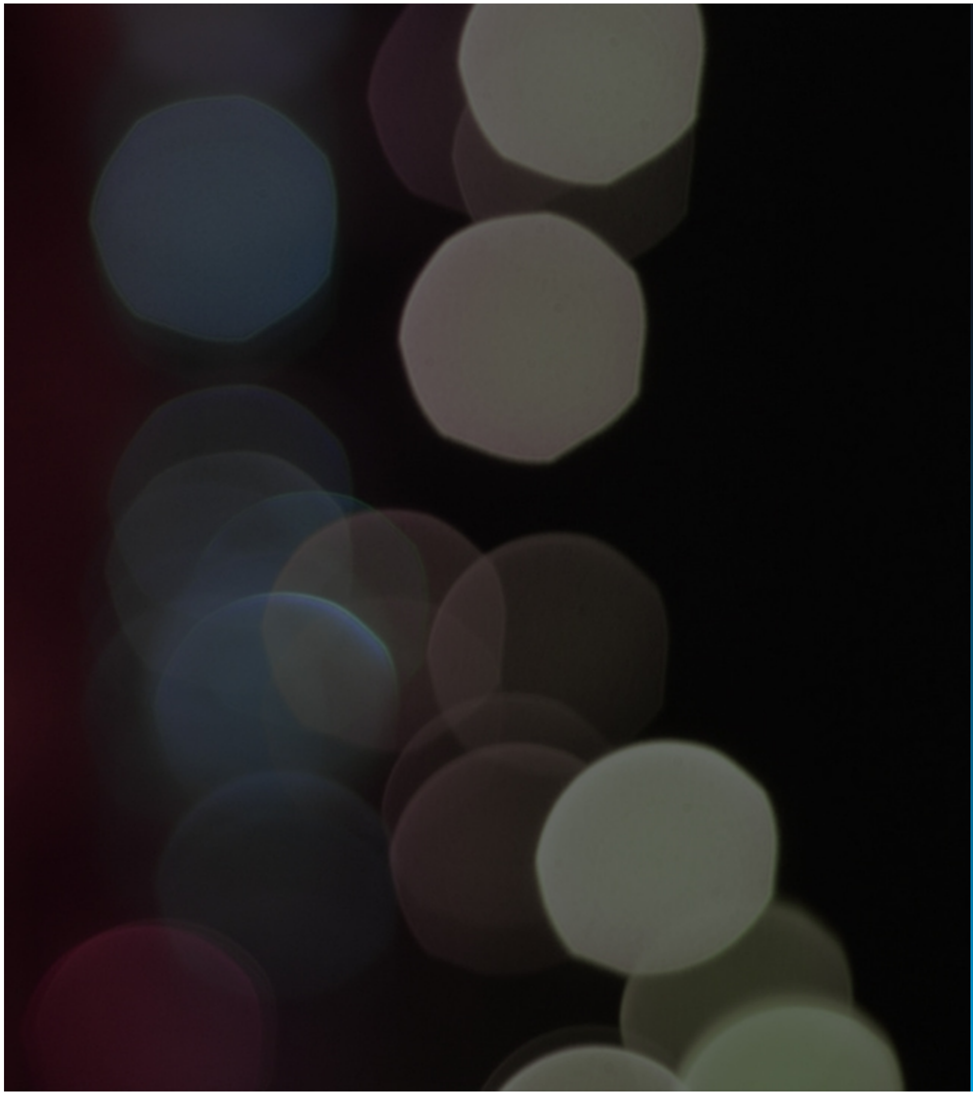


Charge Controllers

- Motor supplied by two 12V batteries connected in series to distribute 24V of power
  - MPPT (Maximum Power Point Tracking)
- Jetson supplied by one 14.8V lithium iron phosphate (LiFePO4) battery
  - PWM (Pulse Width Modulation)

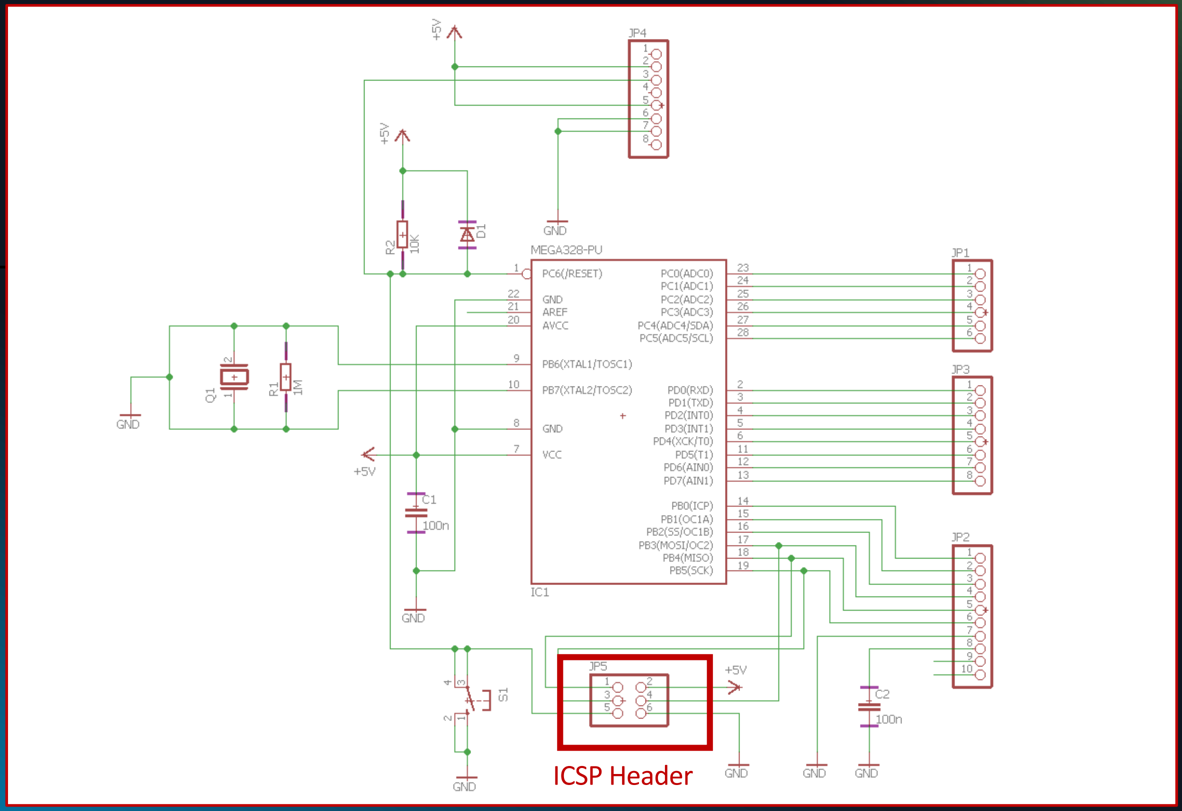
Solar Power Testing/ Integration

AMET,

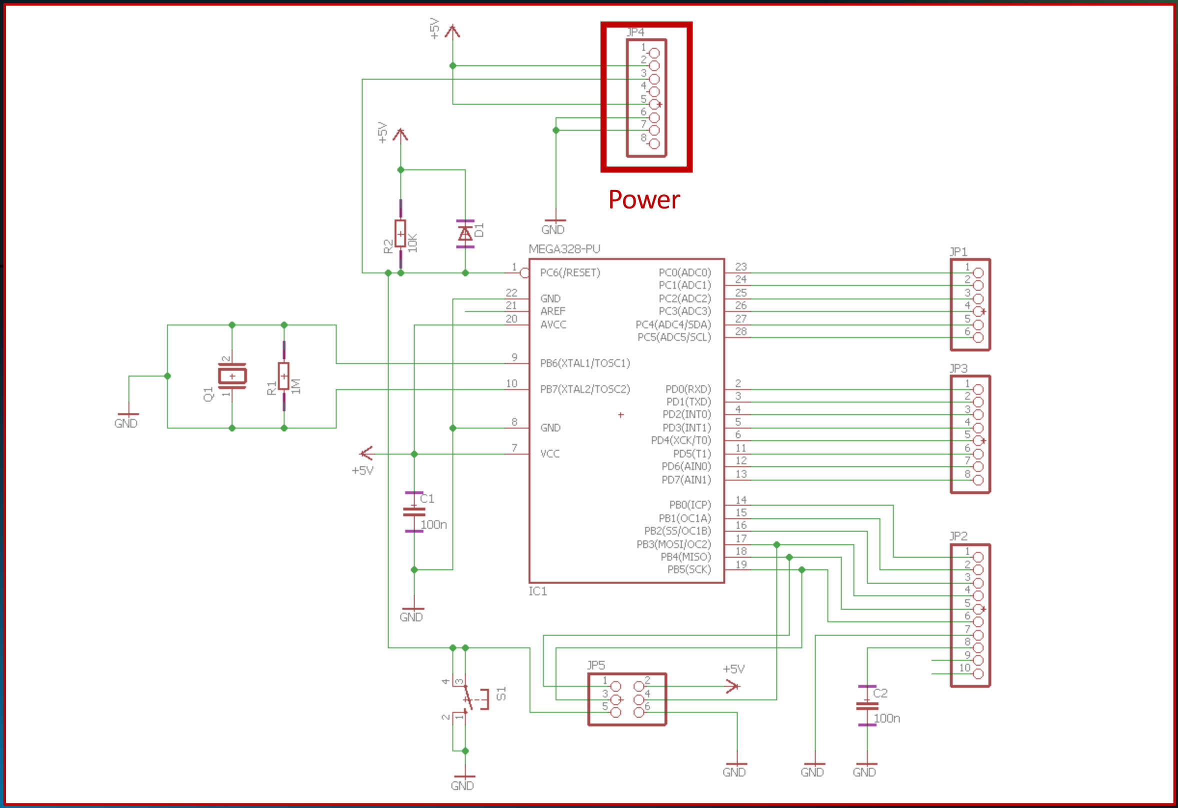


PCB

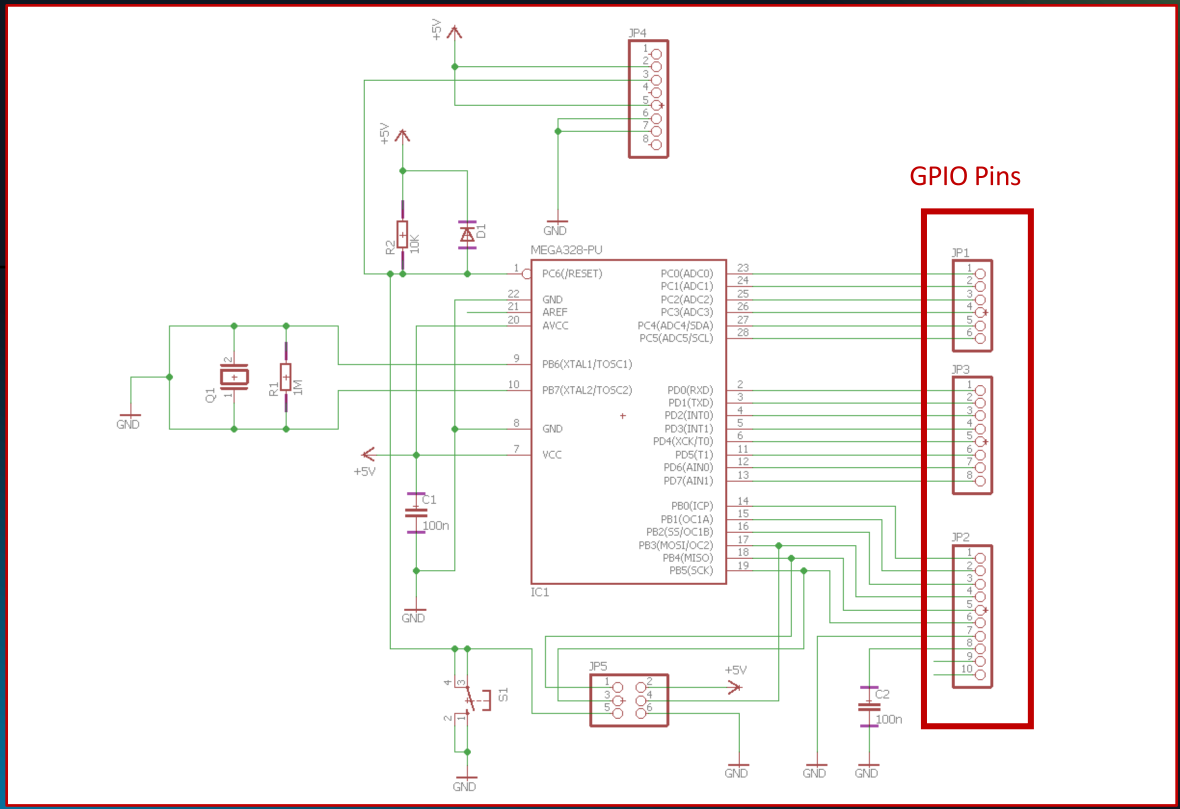
PCB Schematic



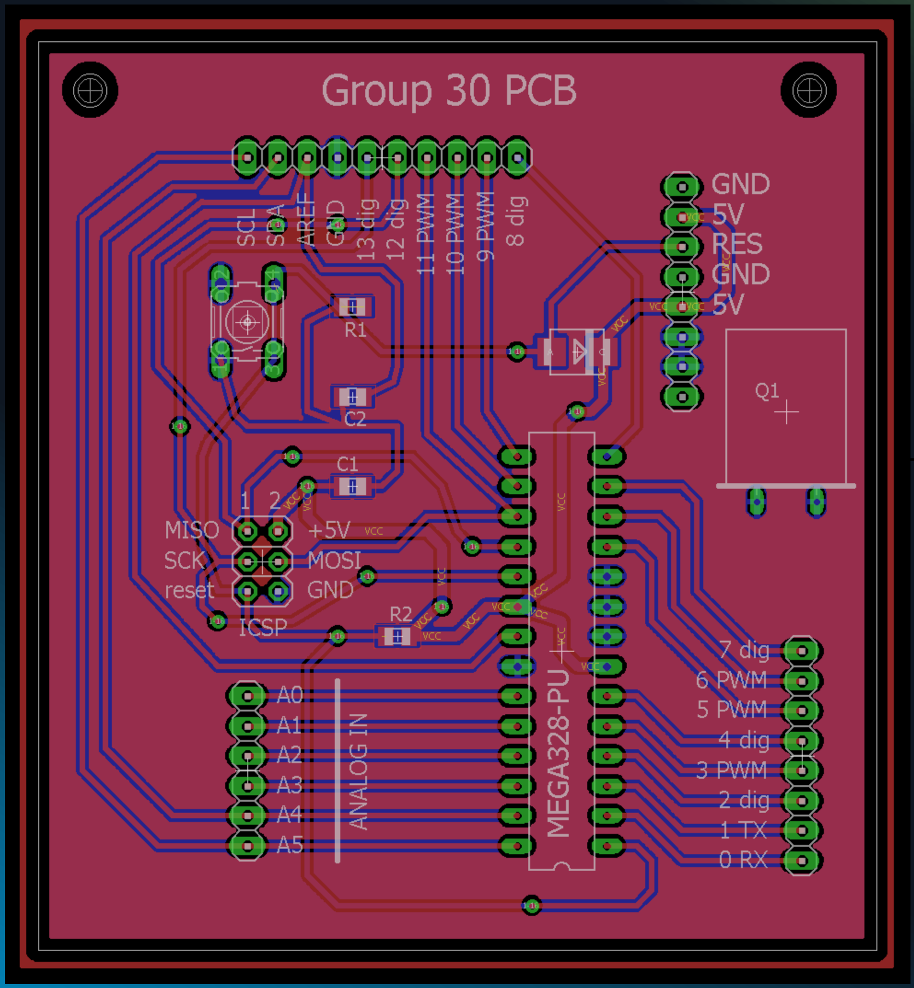
PCB Schematic



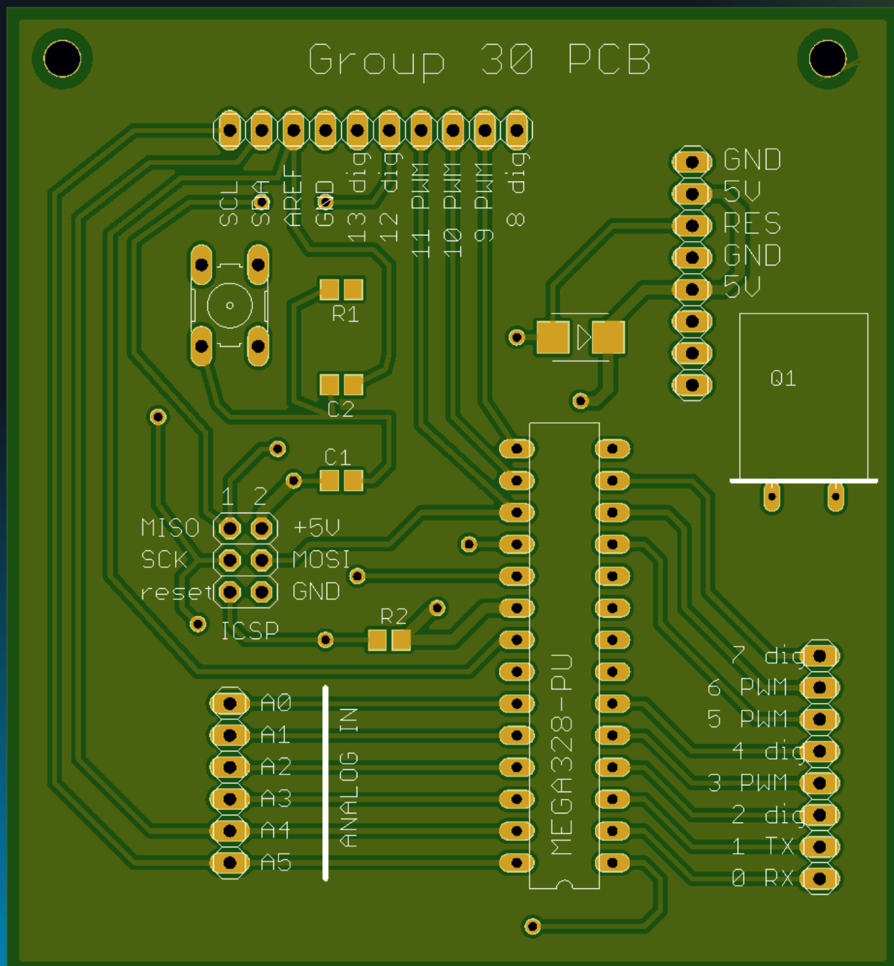
PCB Schematic



PCB Layout



Group 30 PCB
SCL
SDA
AREF
GND
13 dig
12 dig
11 PWM
10 PWM
9 PWM
8 dig
GND
5V
RES
GND
5V
R1
C2
C1
Q1
MISO
SCK
reset
+5V
MOSI
GND
ICSP
R2
A0
A1
A2
A3
A4
A5
ANALOG IN
MEGA328-PU
7 dig
6 PWM
5 PWM
4 dig
3 PWM
2 dig
1 TX
0 RX



PCB Final Product

Manufacturer

- JLCPCB

Cost

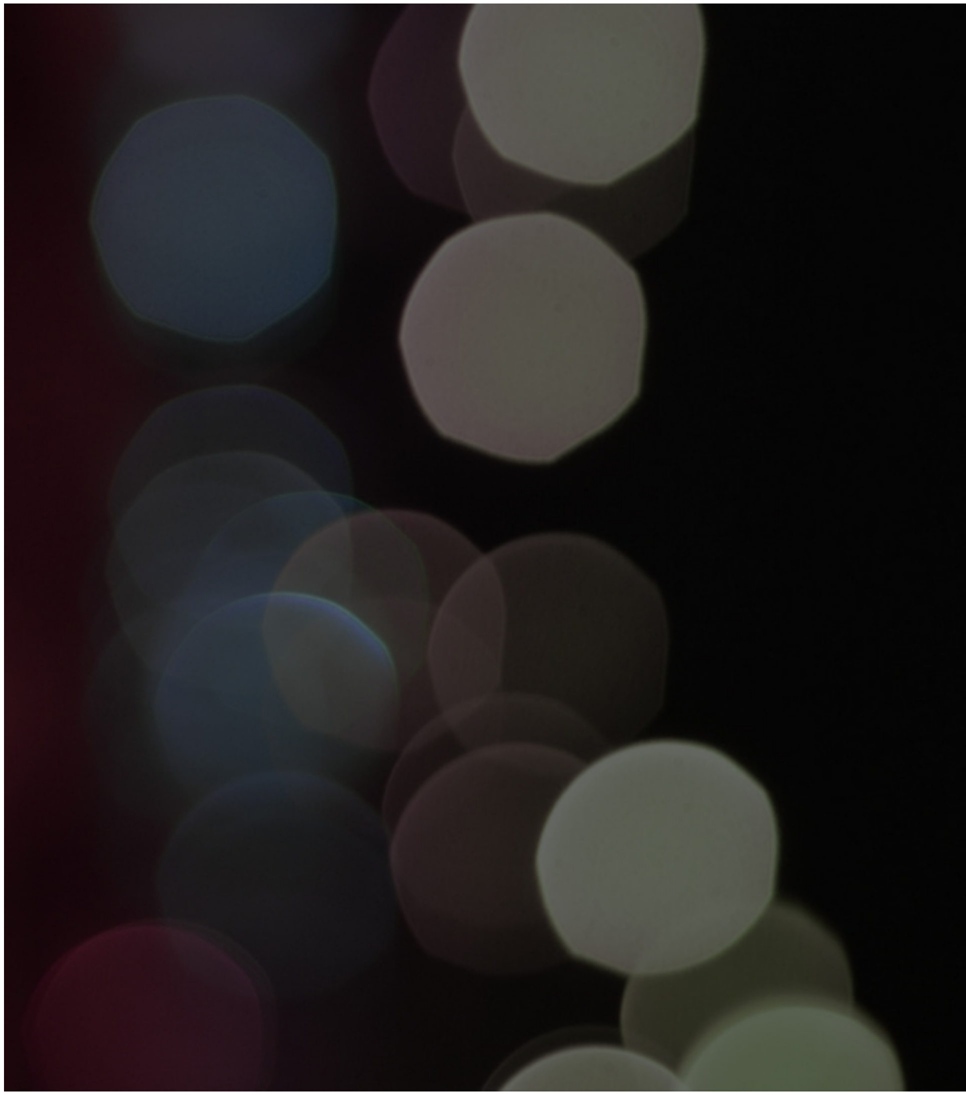
- $2.00 for 10 PCBs + Shipping

Components (Digi-Key)

- 4 x ATMEGA328P-PU
- 4 x 16MHz Crystal
- 4 x 1KΩ Resistor
- 4 x 1MΩ Resistor
- 8 x 0.1µF Capacitor
- 4 x S1Bxxxx Diode (100V 1A)
- 4 x SW400 Switch

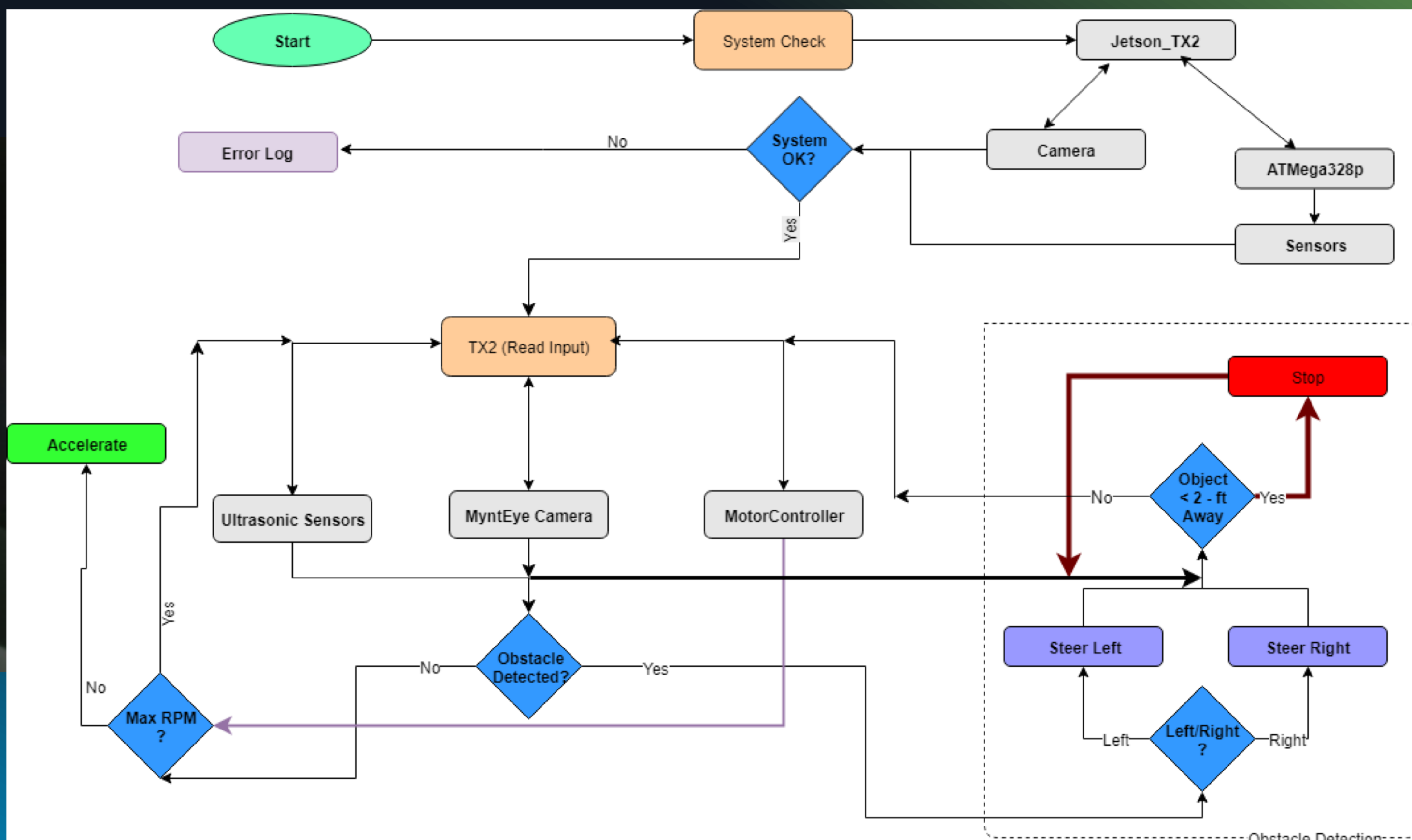
Total Cost

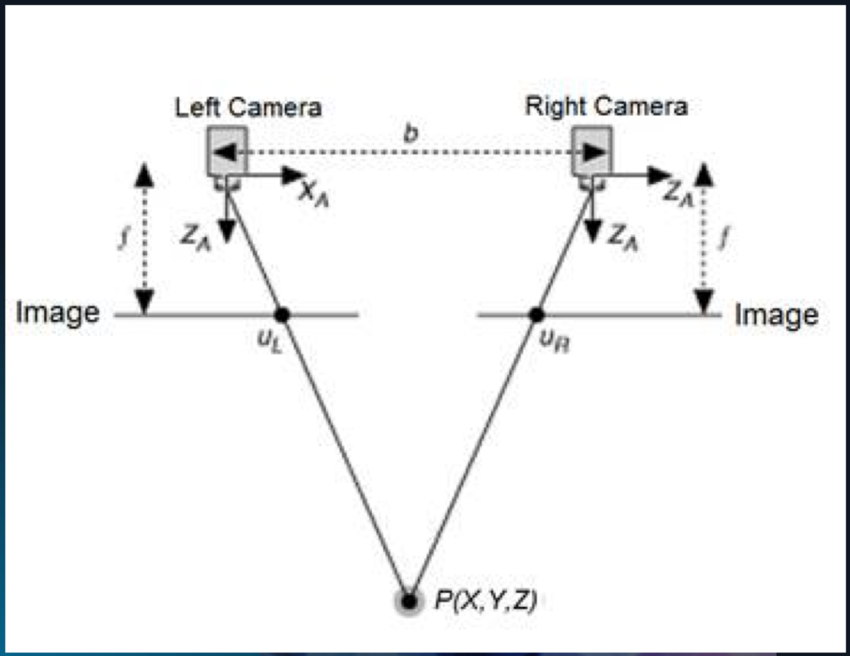
- $53.99



Software Subsystem

ASM Using ROS





Stereo Camera

- Utilizes two cameras to mimic human sight to measure distance
- Triangulation is used to measure the distance between the same point in each view of the camera

Mynt Eye Camera

- Six axis IMU combined with frame synchronization provide accuracy at less than one millisecond.

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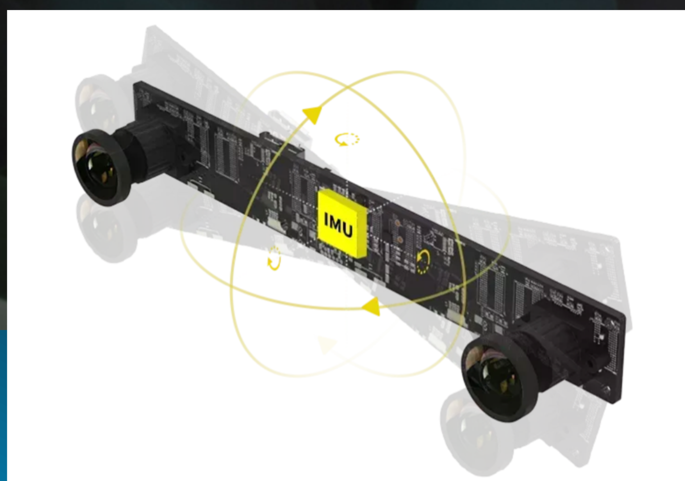
CONSECTETUER ADIPIS

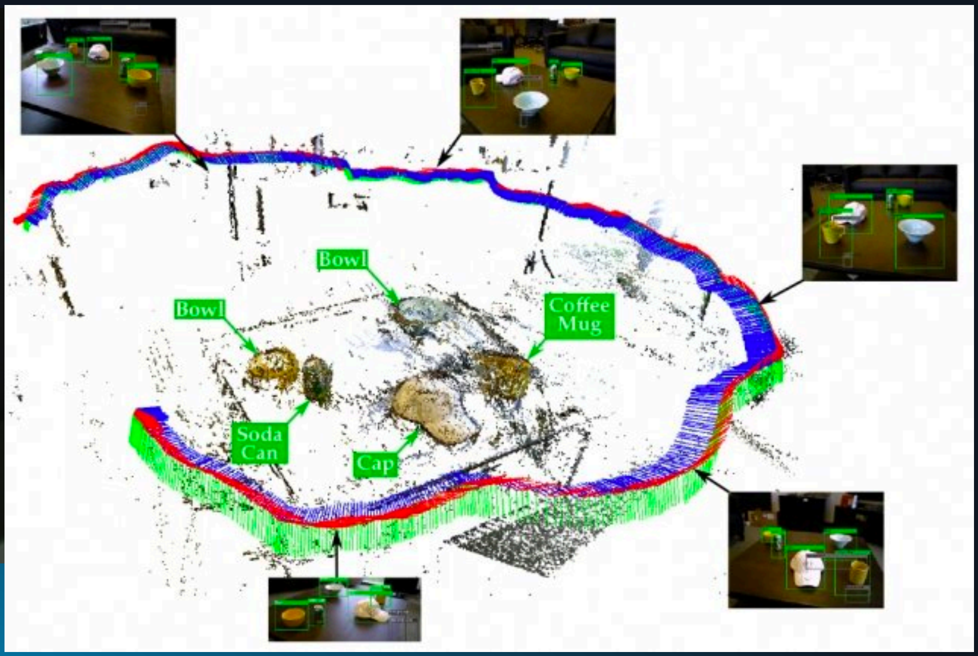


- Depth sensing with a flexible range between 0.5 to 20 meters
- Precision with a wide field of view at 140 degrees

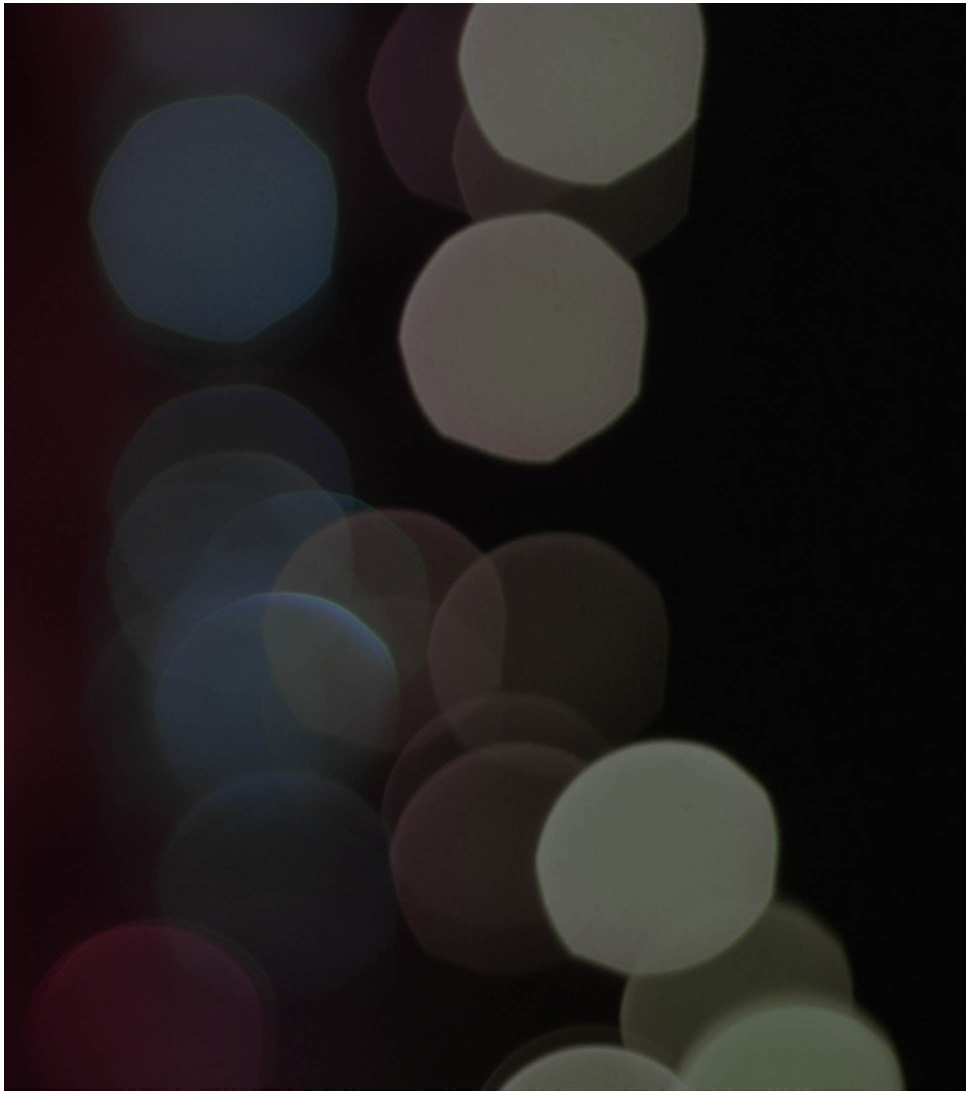
Simultaneous Localization and Mapping (SLAM)

- Computational problem of constructing or updating a map of an unknown environment while simultaneously keeping track of an agent's location within it.
- SLAM creates critical points of interest to build a map of the environment around it and then maps an optimal path.

Object Detection and Avoidance



- Camera will use computer vision to recognize objects in path to create path optimization
- Sensors with camera will assist with object detection after path has been created.

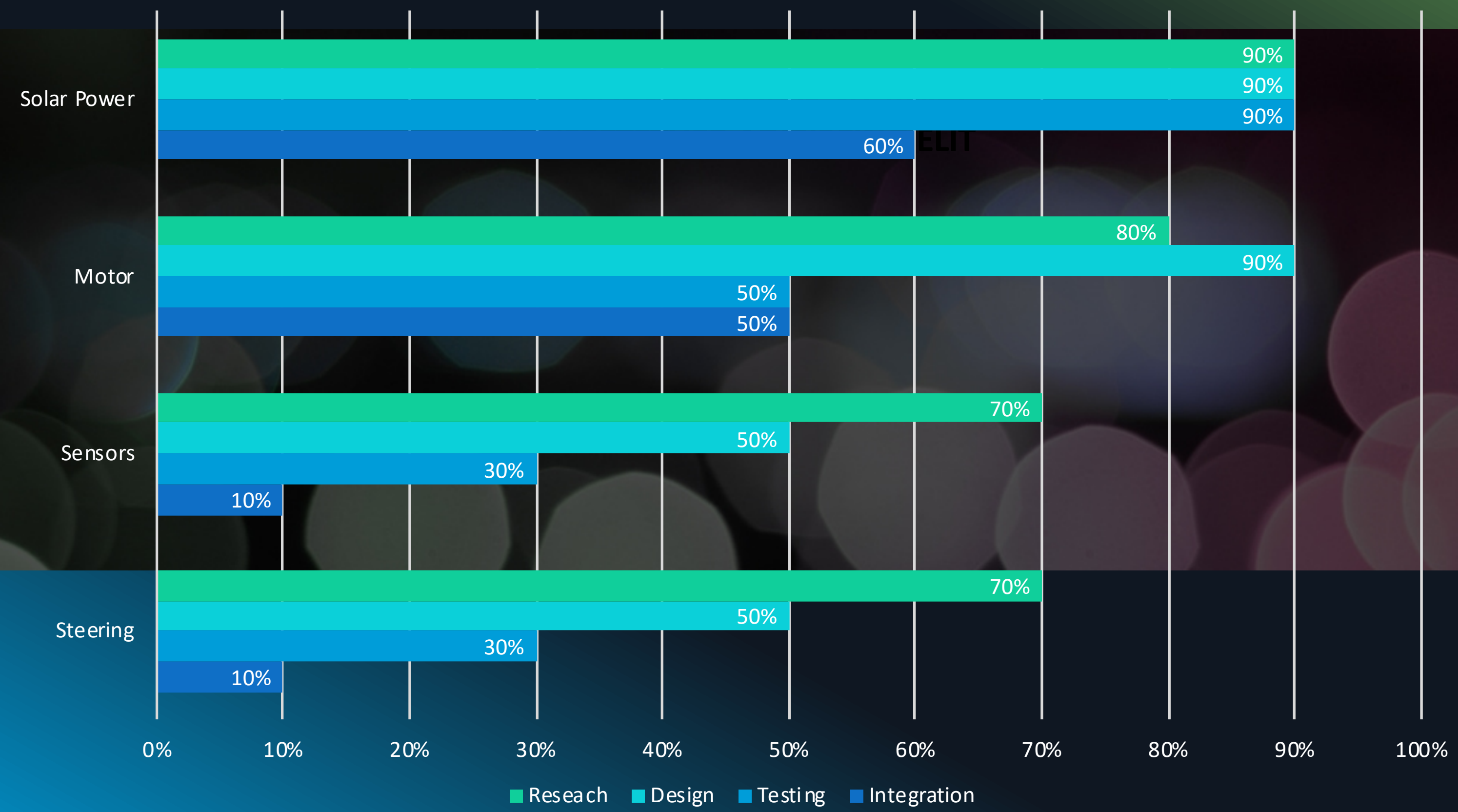


Administrative Content

Work Distribution

Subsystem	Lead	Support
Solar Power	Alyssa Fejer	Billy Blanchard
Motor	Jesus Duran	Hichame Boudi
Sensors	Billy Blanchard	Alyssa Fejer
Steering	Hichame Boudi	Jesus Duran

Project Progress



FINANCIALS

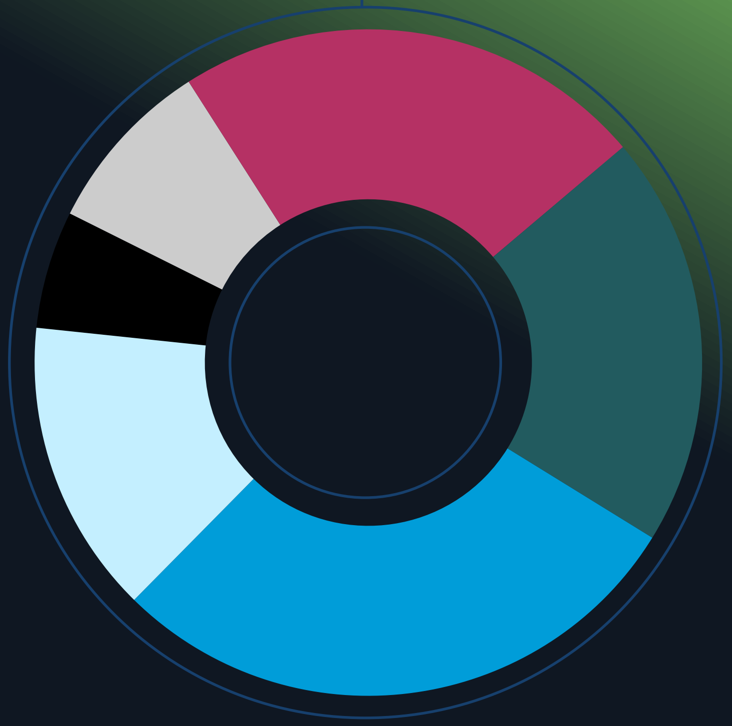
Duke Energy sponsored $1500 for the Hardware/Software System

Product	Quantity	Cost Per Unit	Total
NVIDIA Jetson TX2	1	$331.18	$331.18
Lead-Acid Battery Pack	1	$39.78	$39.78
Lithium Iron Phosphate (LiFePO4) Battery	1	$58.09	$58.09
Solar Panel	1	(Donated) $0	$0
MaxBotix MB1000	6	$27.95	$170.69
Mynt Eye Camera	1	$263.88	$263.88
Cytron Motor Driver	2	$44.00	$88.00
DC Motor	1	$75.00	$75.00
MPPT Charge Controller	1	$49.59	$49.59
PWM Charge Controller	1	$56.98	$56.98
Miscellaneous	-	-	$366.81
TOTAL	-	-	$1,500.00

Challenges

The biggest challenge for this project has been the communication across all three disciplines and the changes to the scope of the project along the way.

- Previous Knowledge
- Project Restrictions
- Changes to Scope
- Work Distribution
- Communication
- Prototype



Demo Links

Prototype Vehicle

Motor Test

Steering Test