UCF Beach Buggy Challenge

Group 1

Robinson Charles

Jared Cozart

Tony Jimogaon

Jose Rosales

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Motivation

- Provide an effective, user friendly way to travel along the beach
- Allow people who have been rendered immobile due to an accident to easily move somewhere where they can be treated
- Demonstrate the viability of a low cost, self-driving, solar powered buggy

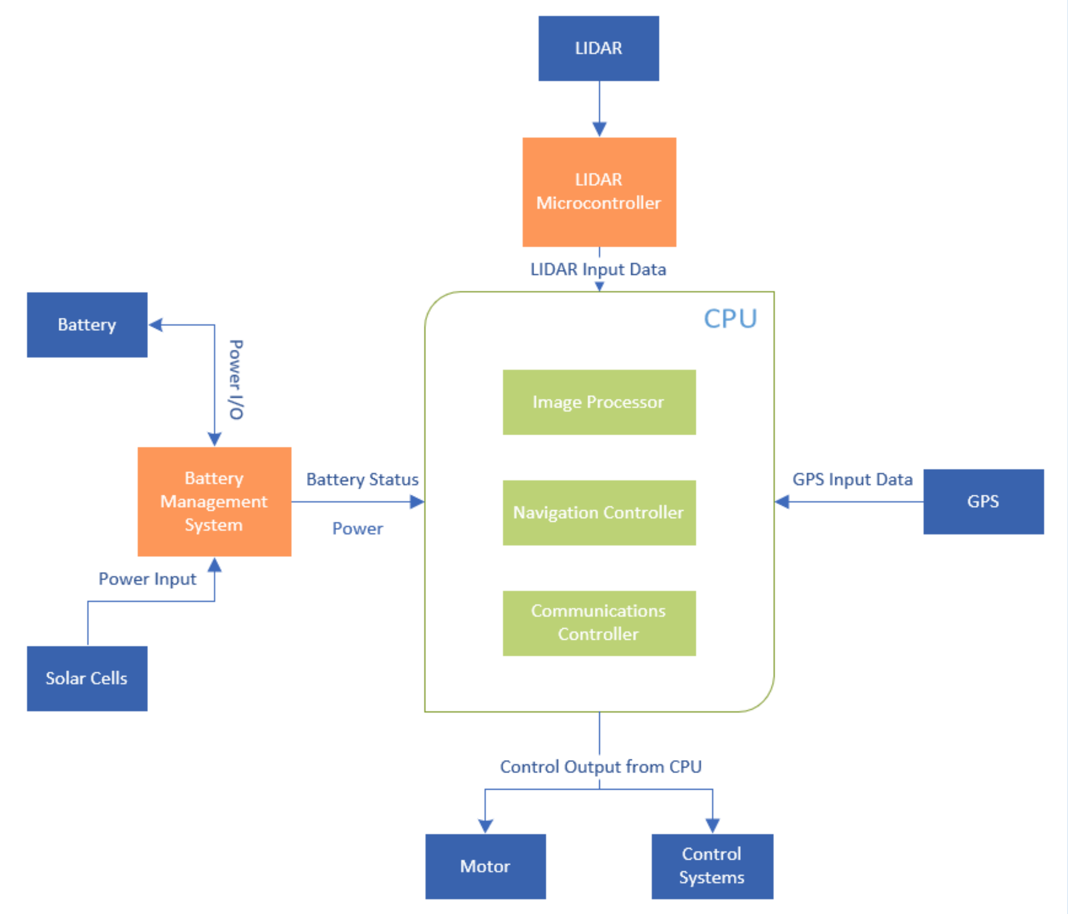
Goals and Objectives

- Buggy should have an ergonomical design capable of comfortably transporting a single passenger
- It should be able to automatically detect objects or persons in its path, and maneuver around them
- It must be able to operate while powered solely by a solar panel mounted on a rear platform
- System needs to be user friendly, involving no input from the passenger once they are onboard

Specifications & Requirements

- Able to travel a 10 mile stretch of beach within 8 hours
- Able to carry a passenger of 120 lbs
- Top Speed of 3 mph
- Entirely solar powered
- Can detect stationary and mobile obstacles
- Does no harm to environment or beachgoers
- Constructed within budget of 2000$

Buggy block diagram



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Single-board computer considerations

- Be able to control and manage multiple software and hardware devices at once:
  - Motor Control
  - Battery Status
  - LIDAR
  - GPS
  - Networking
  - Image processing (OpenCV)
  - Robot Control (ROS)
  - Linux and Python compatible
- Low power (< 15 W)

Single-board computer considerations

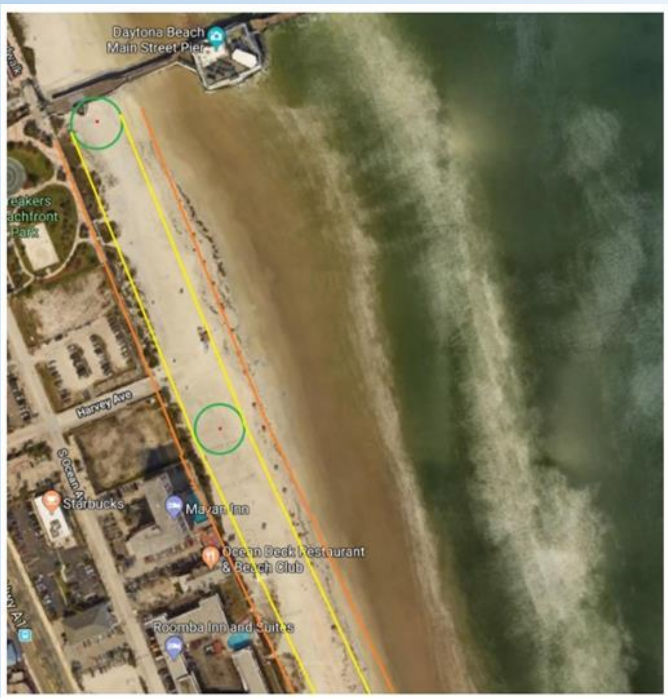
nVidia Jetson TX1

Raspberry PI 3 Model B+

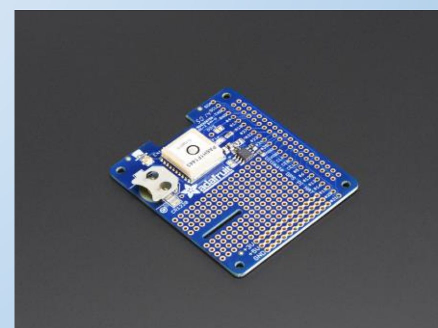
Product	CPU	I/O	Networking	Power Input	Dimensions	Price
nVidia Jetson TX1	4xARM 64-bit Cortex-A57 CPU cores (1.91GHz) + 4xCortex-A53 low-power cores	GPIOs, I2C, I2S, SPI	Ethernet, 802.11ac WLAN, Bluetooth	5.5 V-19.6 V DC (6.5 W-15 W)	170.18mm x 171.45mm	$ 435.90
Raspberry PI 3 Model B+	1.4GHz 64-bit quad-core ARM Cortex-A53 CPU	GPIO, I2C, I2S, SPI	Ethernet, 802.11ac WLAN, Bluetooth	5V @ 2.5A	85mm X 56mm	$ 35.00

GPS

- Purpose
  - To detect current location of buggy
  - To input buggy destination



- Adafruit Ultimate GPS HAT for Raspberry Pi A+/B+/Pi 2
  - 20mA current draw
  - Built in Real Time Clock (RTC)
  - Internal patch antenna
  - Takes over TX/RX pins of PI
  - $44.95



Networking considerations

- Purpose
  - Provide wireless link between buggy and command system
    - Determine status of buggy
      - Power
      - Location
    - Emergency kill-switch
- Factors to consider
  - Ease of implementation
  - Power consumption
  - Range

Networking considerations

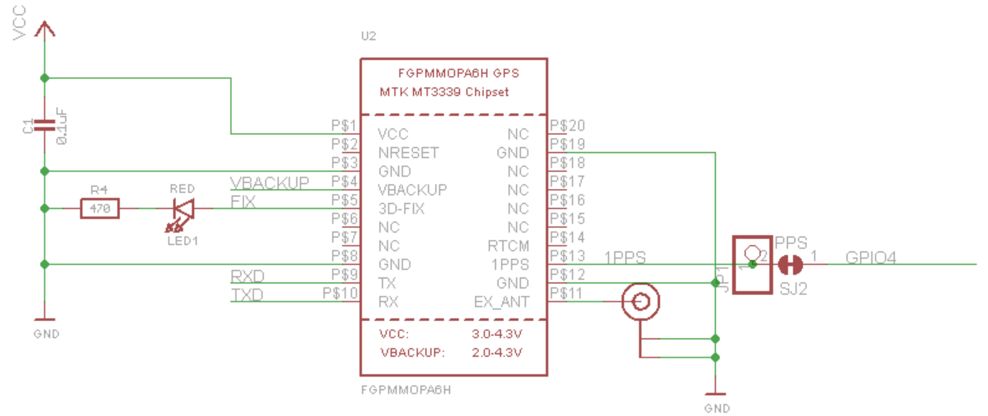
	WiFi	Bluetooth LE
Frequency	2.4 GHz or 5 GHz	2.4 GHz
Throughput	500 Mbit/s (802.11ac)	0.27 MBit/s
Range	105 feet	330 feet (theoretical)
Power Consumption	0.5-2 W	0.01-0.50 W

- Bluetooth easier to implement
- Bluetooth consumes considerably less power
- Do not need high throughput

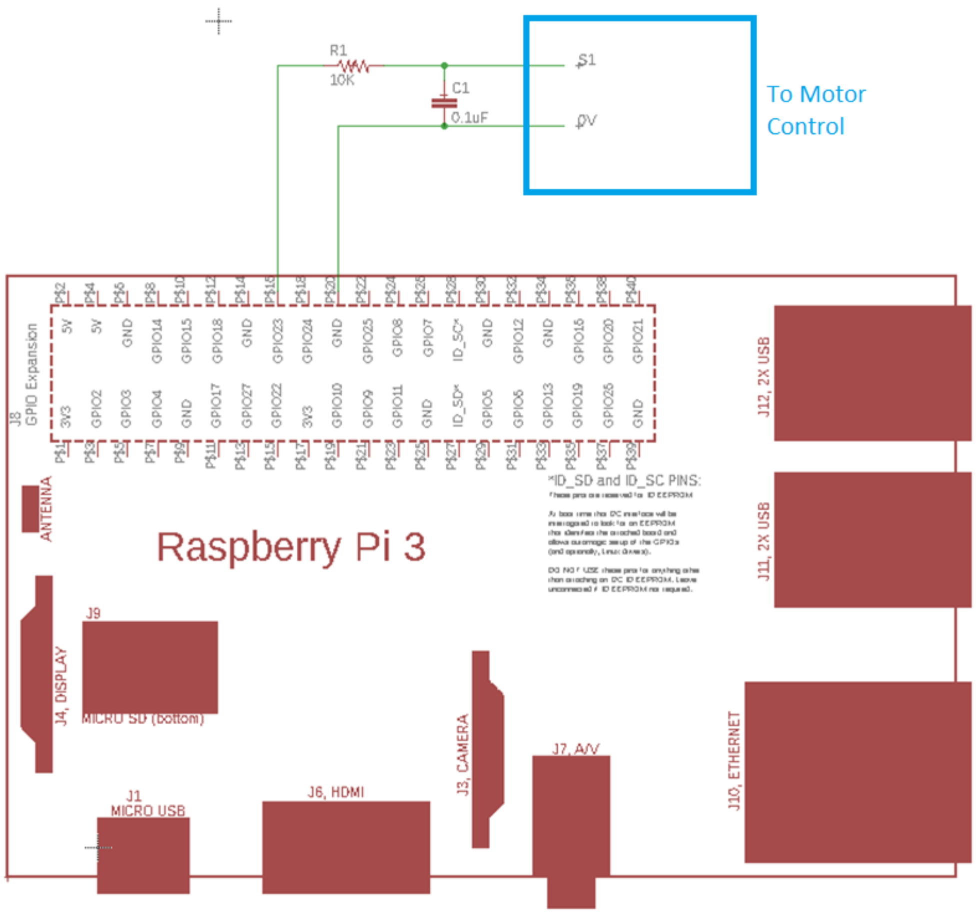
Motor control with PI

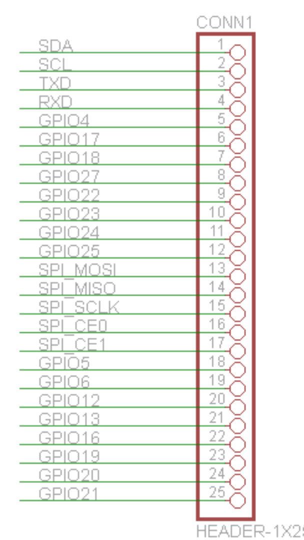
- Sabertooth 2x60 has 4 modes for control, 2 of which are useful for us:
  - Mode 1: Analog Input (Voltage range configurable)
    - < 2.5 V corresponds to backward motion
    - 2.5 V corresponds to no movement
    - > 2.5 V corresponds to forward motion
  - Mode 3: Simplified Serial
    - uses TTL level single-byte serial commands to set the motor speed and direction
    - 1 is full reverse, 64 is stop and 127 is full forward
    - 128 is full reverse, 192 is stop and 255 is full forward (if controlling a second motor)

Raspberry Pi Schematic



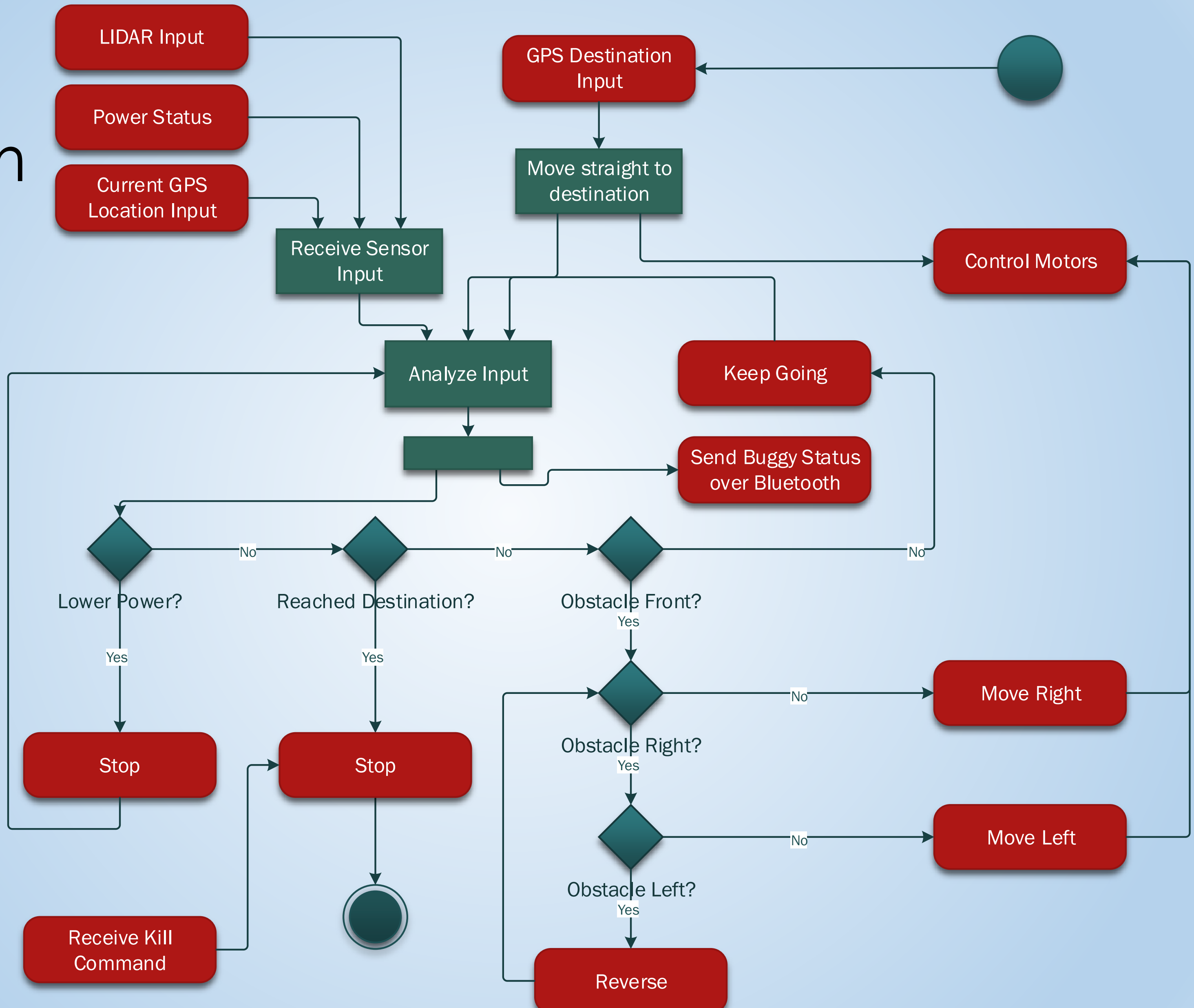
GPS Chipset





GPS Header

UML Activity Diagram



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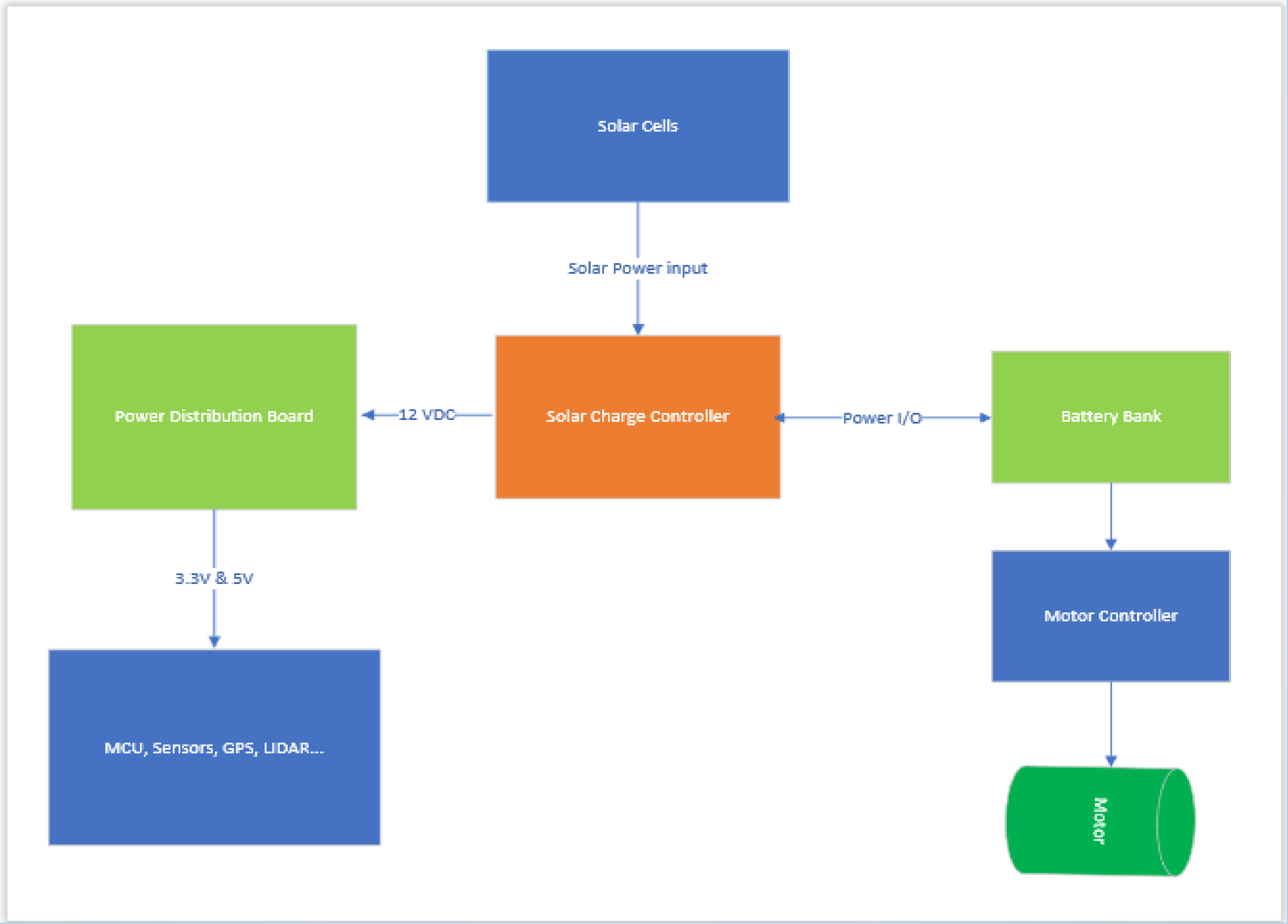
Wiring Diagram



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Solar Cells Selection

		Ramsond SP100	Renogy RNG-100P	Renogy	Grape Solar	Nature Power
Maximum Power (W)		100	100	100	100	100
Peak Voltage (V)		18.5	17.79	18.9	18	17.85
Peak Current (A)		5.41	5.62	5.29	5.56	5.6
Effiency (%)		17	-	-	17.4	-
Cell Technology		Mono	Poly	Mono	Poly	Poly
Number of cells		36	36	36	36	36
Weight (lbs.)		16.5	16.5	16.5	18.11	20.4
Dimensions (in)	L	47	39.7	47	40.16	41
	W	21.63	26.7	21.3	26.37	27
	T	1.56	1.4	1.4	1.37	2
Cost (USD)		140	114.99	124.99	89.99	179.99

Solar Cells

- Peak Voltage: 18V
- Peak Current: 5.56A
- Efficiency:17%
- Weight: 18.1 lbs.
- Max Power : 100W
- Cost: less than $100

Solar Charge Controller Selection

	Renogy Rover 20A	Renogy Rover 40A	Tristar TS-60	Tristar TS-60	ZHCSolar
Type of Regulation	MPPT	MPPT	PWM	MPPT	PWM
Load Current Rating	20A	40A	60A	60A	80A
System Voltage	12-24V	12-24V	12-24-48V	12-24-36-48V	12-24V
Output Voltage	12-24V	12-24V	*	8-72V	12-24V
Price	$129.99	$209.99	$220.00	$579.00	$73.00

Solar Charge Controller

- Load Current: 80A
- System Voltage:12-24V
- Output Voltage: 12-24V
- Overcharge protection
- Overcurrent protection
- Reverse polarity protection
- Price: $73.00

Battery Selection

- AH: 155
- Voltage: 12V
- Weight: 86 lbs.
- Price: USD 178.87

Type	Brand	Weight (lbs.)	Dimensions LxWxH(in)	Capacity (AH)	Voltage (V)	Price ($USD)
FLA	USBattery US12VXC	86	13.13 x 7.07 x 11.38	155	12V	$178.87
FLA	Trojan T1275	82	12.96x7.13x11.25	150	12V	$189.95
AGM	Universal Battery	69.9	12.12 x 6.61 x 9.16	100	12V	$164.99
Gel	Renogy	66	13 x 6.8 x 9.0	100	12V	$229.99
SLA	NPP	59.5	12.1 x 6.7 x 8.2	90	12V	$162.99

Motor

	AmpFlow E30-400	Motenergy ME-0907	NPC4200	Motenergy ME-0909
Motor Type	Brushed	Brushless	Brushed	Brushed
Weight	5.9 lbs	22lbs.	15.7lbs.	24lbs.
Voltage	12-24V	12-72V	24-36V	24-48V
Peak current	266A	220A	470A	300A
Peak Torque	11Nm	38 Nm	N/A	N/A
Peak Horsepower	2.1hp	N/A	3.8hp	15hp
RPM	5700rpm @24V	5000rpm	3400rpm	4850rpm
Price	$109	$392	$339	$385
Efficiency	79%	90%	N/A	95%

Motor Controller

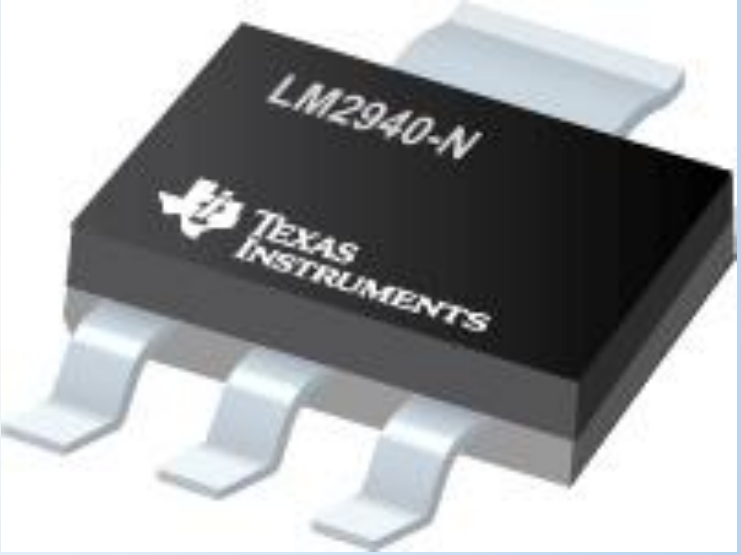
	Sabertooth dual 25A	Sabertooth dual 32A	Sabertooth dual 60A
Price	$124.99	$124.99	$189.99
Weight(g)	90g	125g	240g
DC input(V)	6-30V	6-30V	6-30V
Weight Rating	300 lbs.	300 lbs.	1000 lbs.
Board Size(mm)	65 x 80 x 21 mm	70 x 90 x 25 mm	76 x 89 x 46 mm
Peak Current(A)	25A	32A	120A
Continuous Current(A)	50A	64A	60A

PCB Design

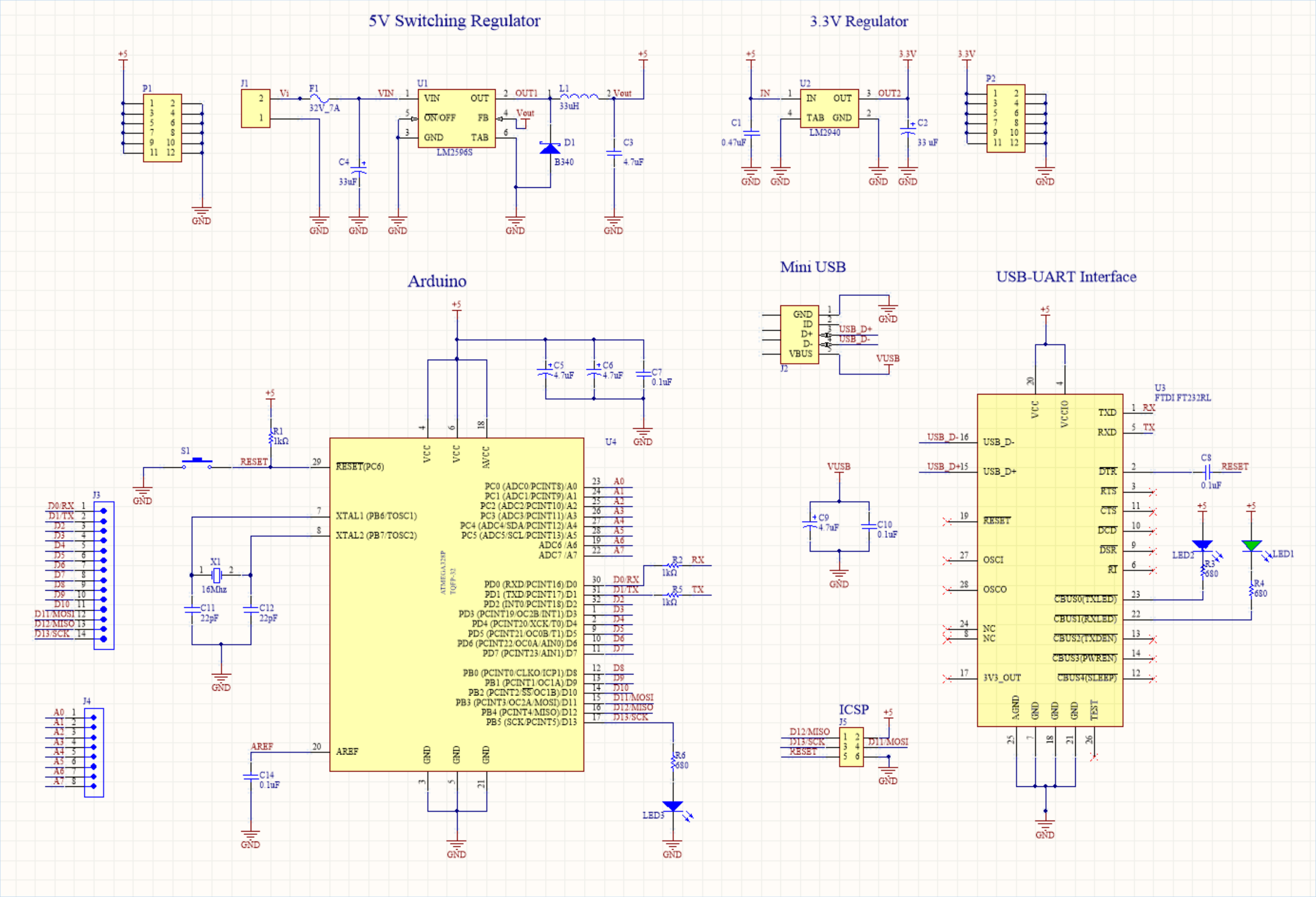
- Use 2 TI chips
- LM2596 & LM 2940
- Input Voltage : up to 40V
- Output Load Current: 3A
- Very Efficient
- Uses 4 only components

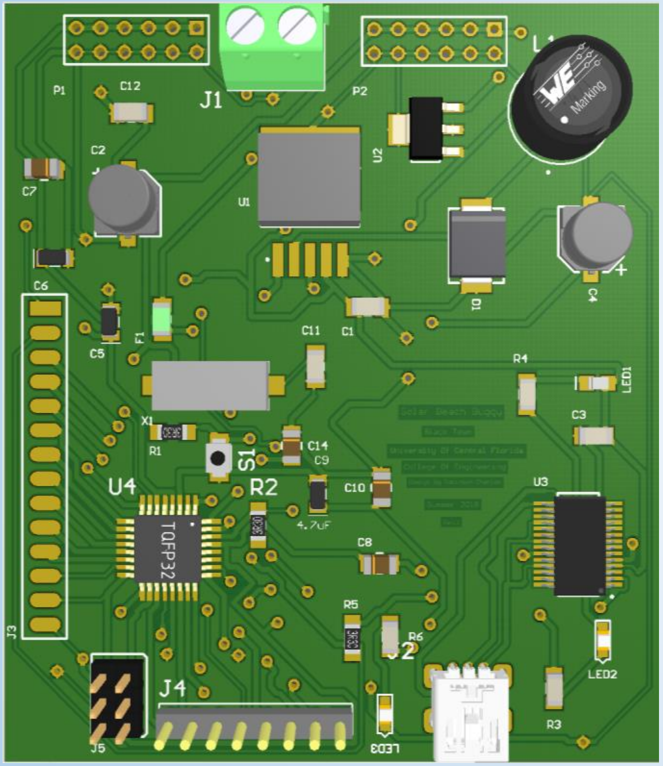
PCB Design

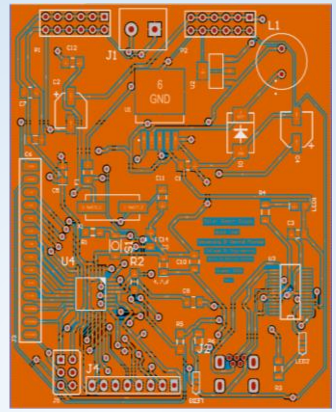
- Input Voltage Range: 6V-26V
- Drop out Voltage: 0.5V at 1A
- Features
- Overvoltage shut down >26V
- Thermal shut down
- Short Circuit Current Limit

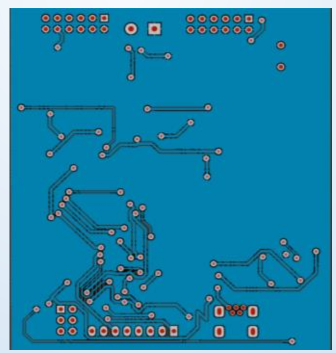


PCB Schematics







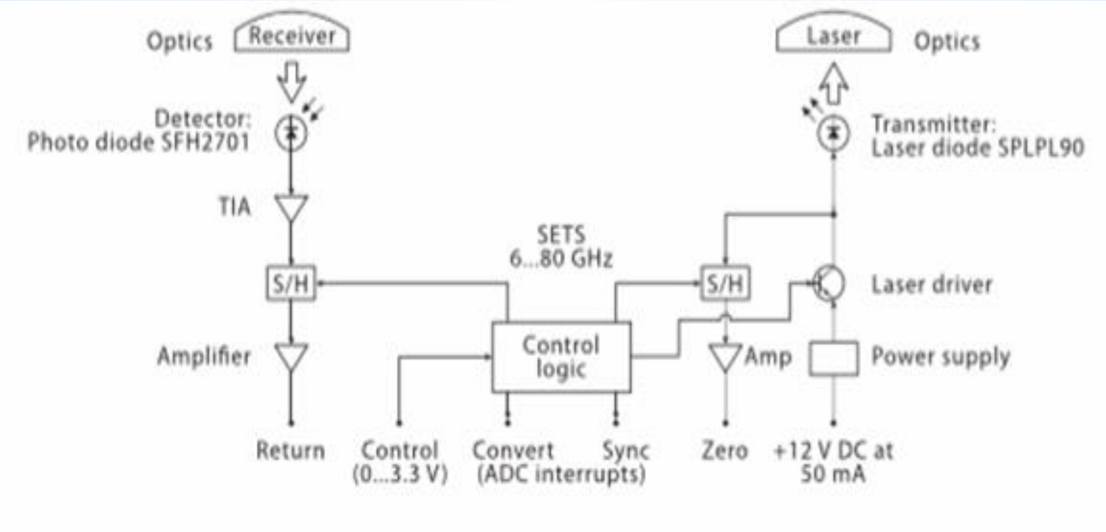


Top & Bottom Layer

- On the left: 3D View
- Top right : Top Layer
- Bottom right: Bottom Layer

LIDAR Overview

The Lidar module will consist of two components: A laser emitter which will periodically emit a pulse of light, and a receiver module, which will focus a portion of the laser light reflected back. The return signal is processed by an Arduino.

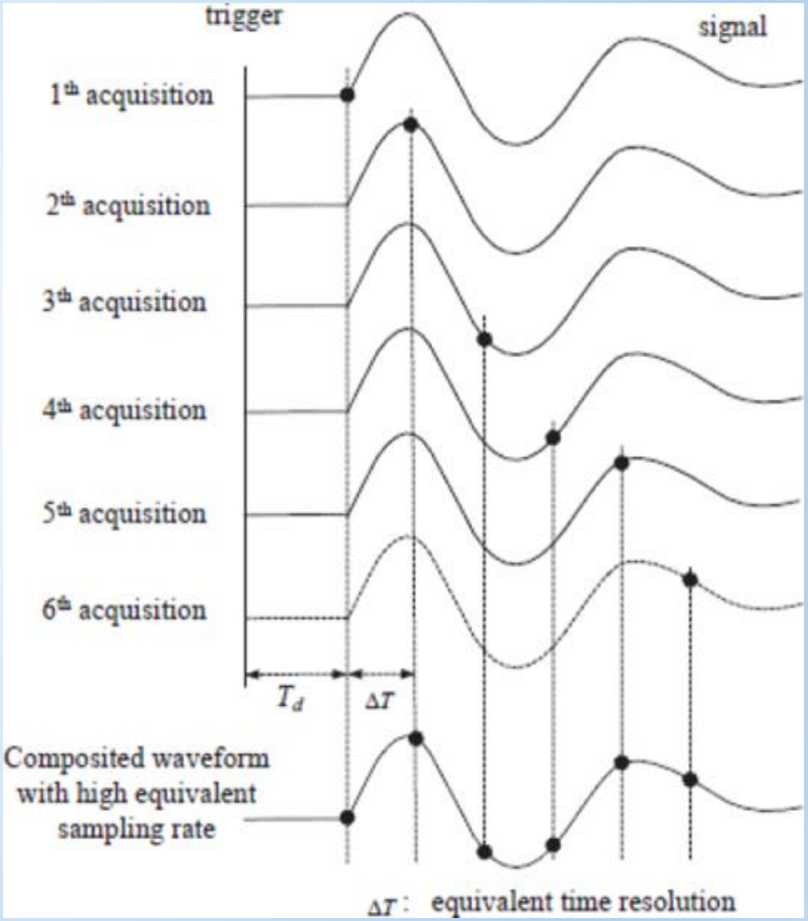


Design Challenges

- The laser needs to be pulsed using a very short current pulse of tens of amps
- The detector needs to pick up a weak return signal and amplify it to a level well above any background noise, and high speed amplifiers are expensive and consume a lot of power
- The time between the outgoing laser pulse and the return signal needs to be measured with very high accuracy.
- Collimating optics for the outgoing signal and collection optics for the return signal are needed to make the system work over a reasonable distance

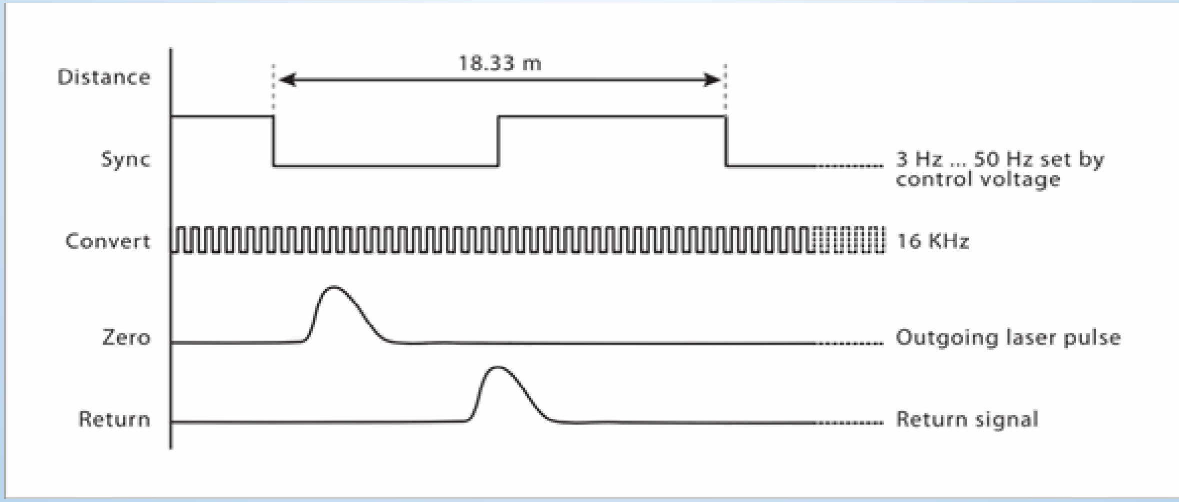
SETS (sequential equivalent time sampling):

The time between the outgoing laser pulse and the return signal needs to be measured with very high precision in order to calculate the distance. The SETS circuit slows down these signals so that they can be viewed on a much lower frequency.



Timing Strategies:

- The real-time span of the timer in our timing circuit is approximately 122 ns, which corresponds to about 18.33m
- For the square sync signal, the falling edge marks the end of one measurement and the start of another. The period of the sync signal can be altered by a change in the control voltage input, which alters the timing and results in a faster or slower expanded timebase.



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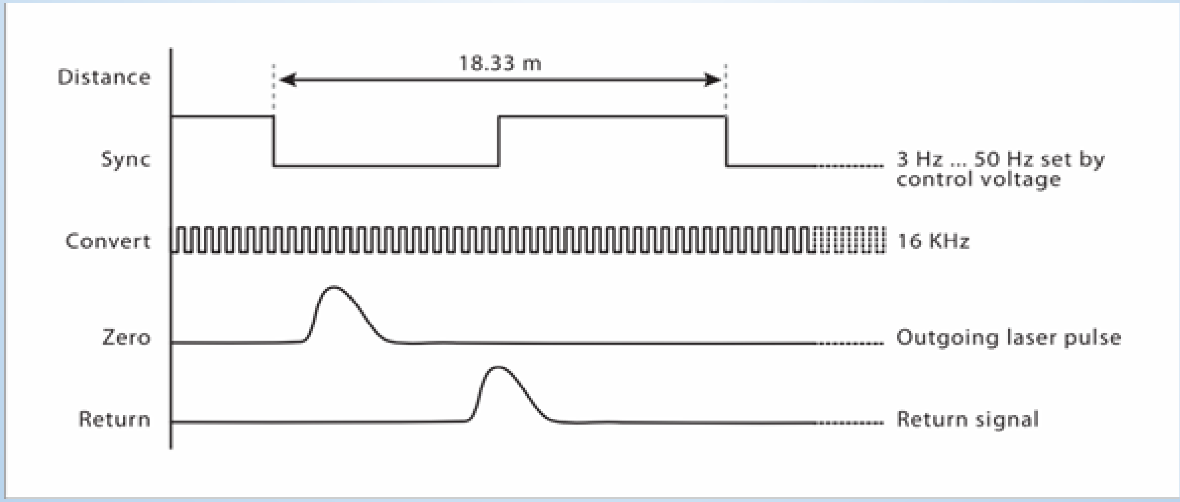
Timing Strategies:

It takes about ten nanoseconds after the signal to fire the laser is sent before the laser actually starts producing light, so there is a noticeable delay on the expanded timebase between the falling edge of the sync and the moment when the laser pulse is seen on the zero output

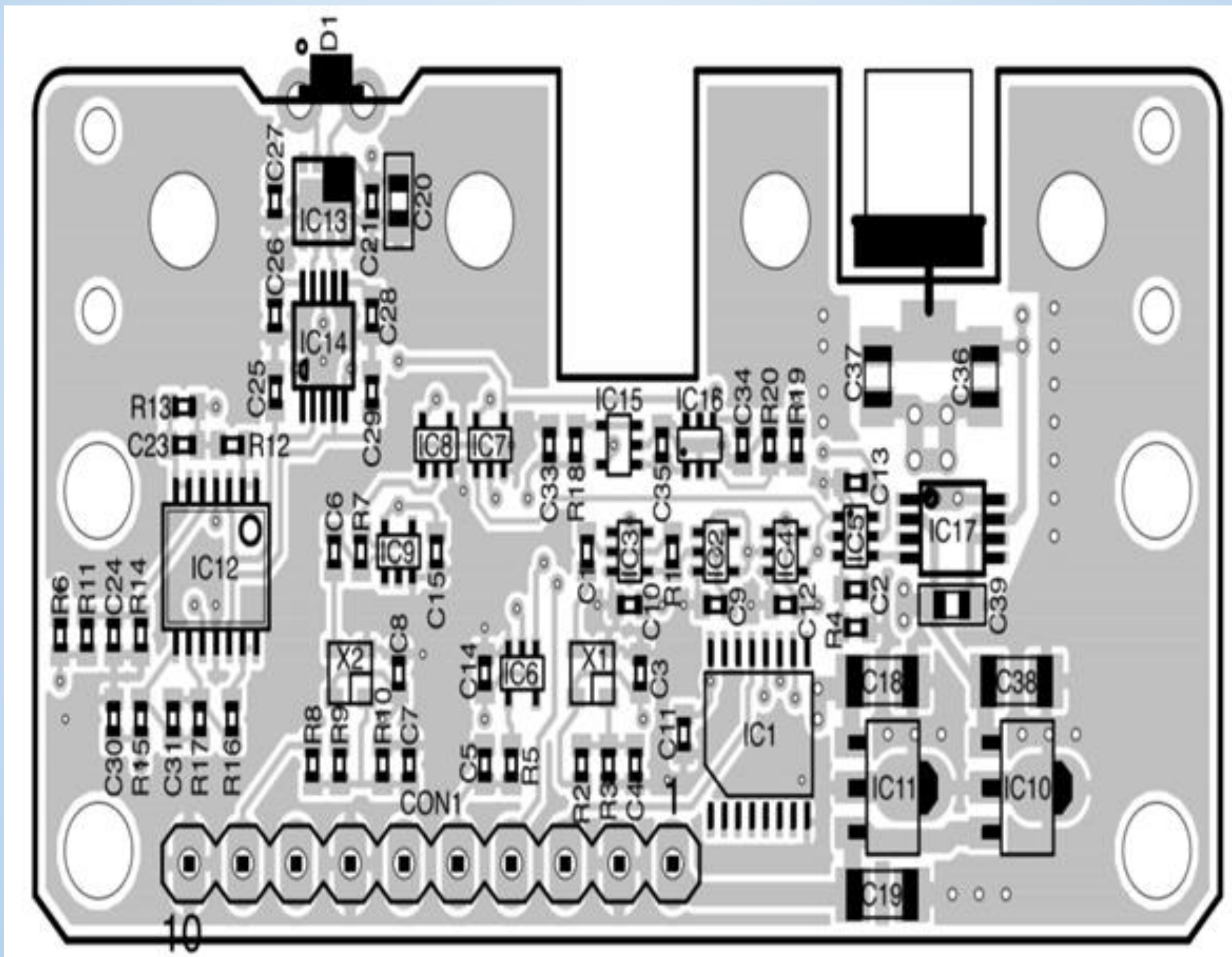
distance_to_target = ((time_to_return - time_to_zero) /sync_period) * 18.33m



LIDAR Specs

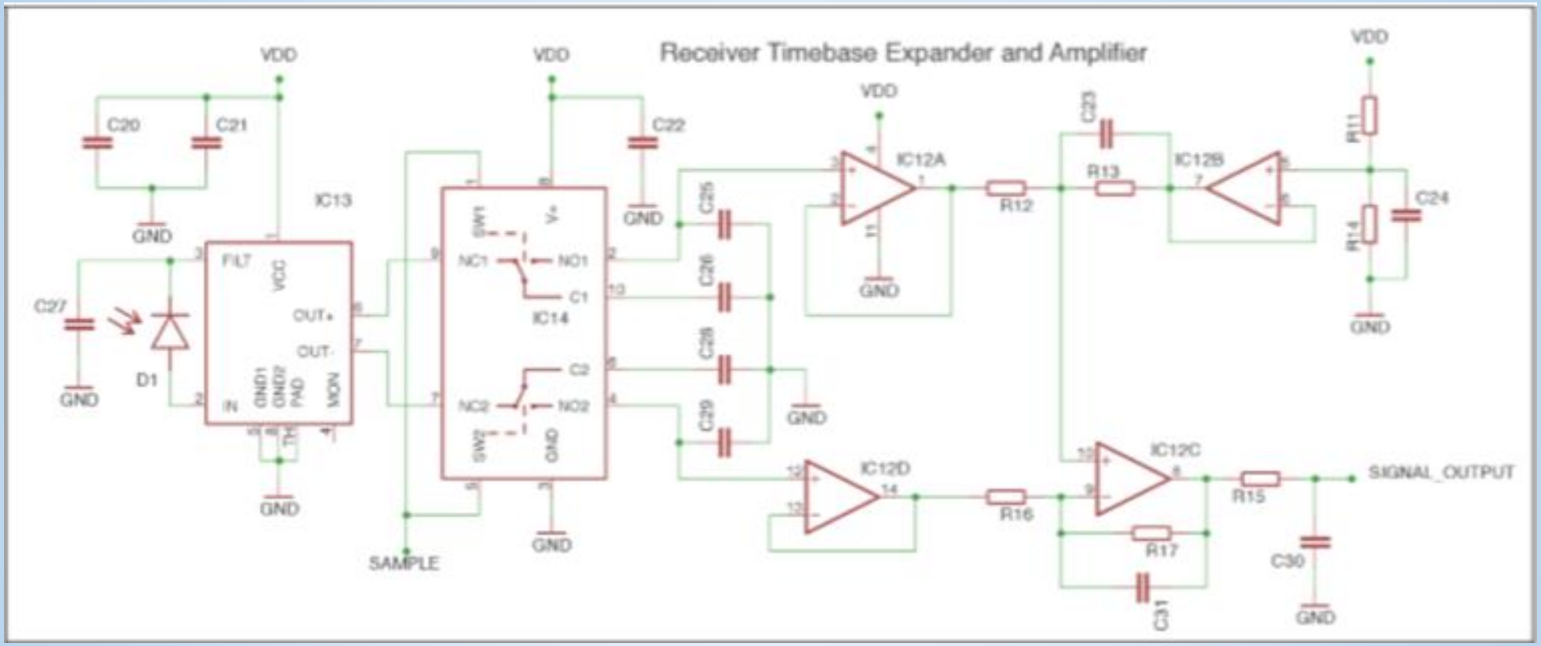
- Range: .5-9m
- Update rate: 3-50 readings per second
- Power supply voltage: 12V
- Power supply current: 50mA
- Dimensions: 27 x 56 x 65 mm
- Weight: 57g
- Laser Power: 14 W (peak), 6mW (average)

PCB



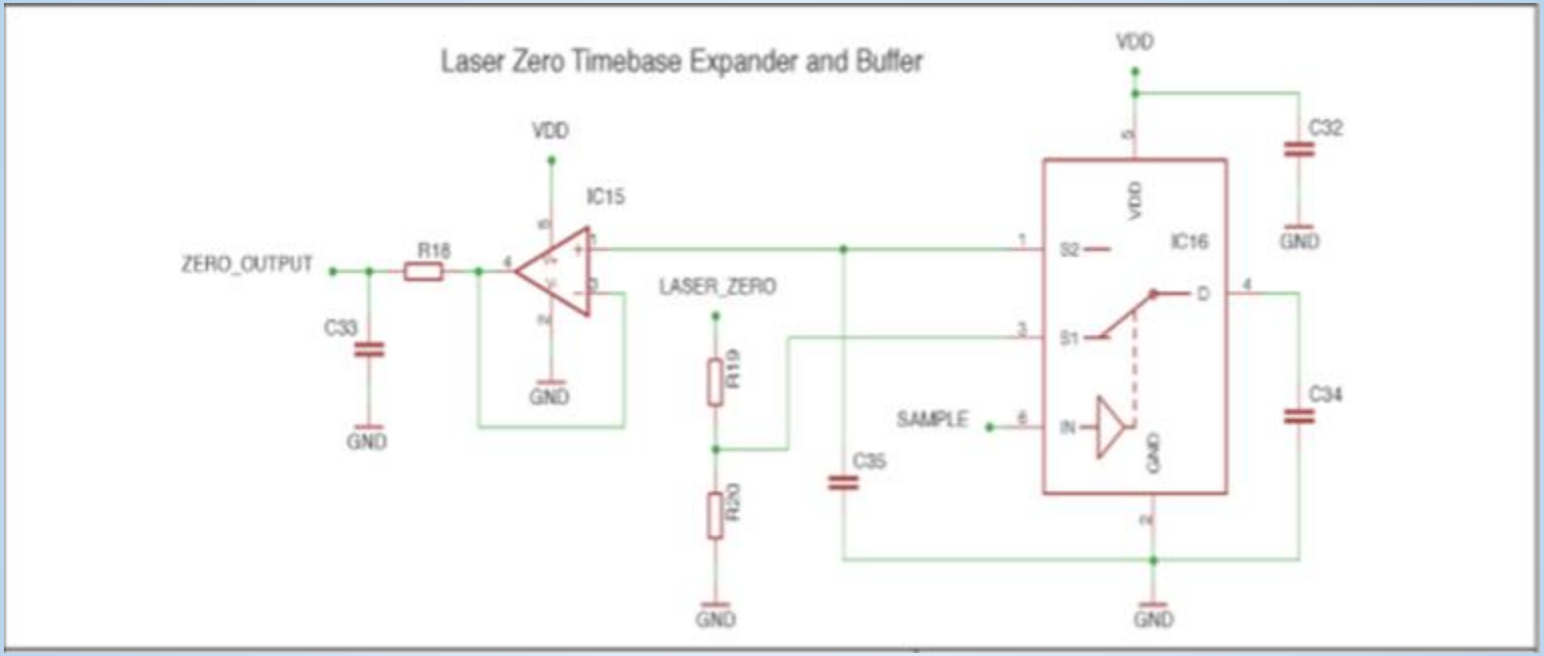
D1
C27
IC13
C20
C21
C26
IC14
C28
C25
C29
R13
C23
R12
IC8
IC7
IC15
IC16
C34
R20
R19
C37
C36
C33
R18
C35
C13
IC17
C6
R7
IC9
C15
IC12
R6
R11
C24
R14
IC3
IC2
IC4
IC5
C10
R1
C9
C12
R4
C2
C39
X2
C8
C14
IC6
X1
C3
C18
C38
IC1
C11
IC11
IC10
R8
R9
R10
C7
C5
R5
R2
R3
C4
C30
R15
C31
R17
R16
CON1
1
10
C19

Receiver Circuit diagram



The current pulse first goes through a transimpedance amplifier, labeled as IC13, which turns the input current signal into an input voltage. This voltage then goes through the sequential-equivalent-timing circuits to slow down the voltage before it is amplified and then outputted

SETS Circuit diagram



Once the signal travels through a laser driver, it must be also be sent to a sequential-equivalent-timing circuit and through an amplifier so that it can be outputted for timing purposes.

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Administrative Content

Work Distribution

Member	CPU	Battery Management	LIDAR
Tony	X	⍟	
Robinson	⍟	X	
Jose			X⍟
Jared			X⍟

X - Primary
⍟ - Secondary

Issues

- Due to the importance of solar power to the system, it is incredibly dependent on favorable weather conditions
- The fixed speed of light means that the Lidar system will only be effective within a fairly limited range

Budget & Financing

Item	Supplier	Quantity	Unit Price	Total Cost	Item	Supplier	Quantity	Unit Price	Total Cost
Misc. Resistors and Capacitor s	Digikey	~100	Varies	$130.75	Charge Controller	Amazon	1	$72.99	$72.99
LDO Voltage Regulators	Mouser	3	$1.59	$4.77	Motor Driver	Amazon	1	$189.00	$189.00
Raspberry Pi	Adafruit	1	$35.00	$35.00	GPIO	Amazon	1	$7.44	$7.44
GPS HAT	Adafruit	1	$44.96	$44.96	Deep Cycle Battery	Infinigi	2	$188.78	$377.56
Active GPS Antenna	Adafruit	1	$12.95	$12.95	Motor	RobotMarket place	2	$109.00	$218.00
Adapter Cable	Adafruit	1	$3.95	$3.95	Laser Diode	Questcomp	1	$15.00	$15.00
Passive GPS Antenna	Adafruit	1	$3.95	$3.95					
16GB Micro SD card	Amazon	1	$8.55	$8.55	**Total**				**$1124.8 7**

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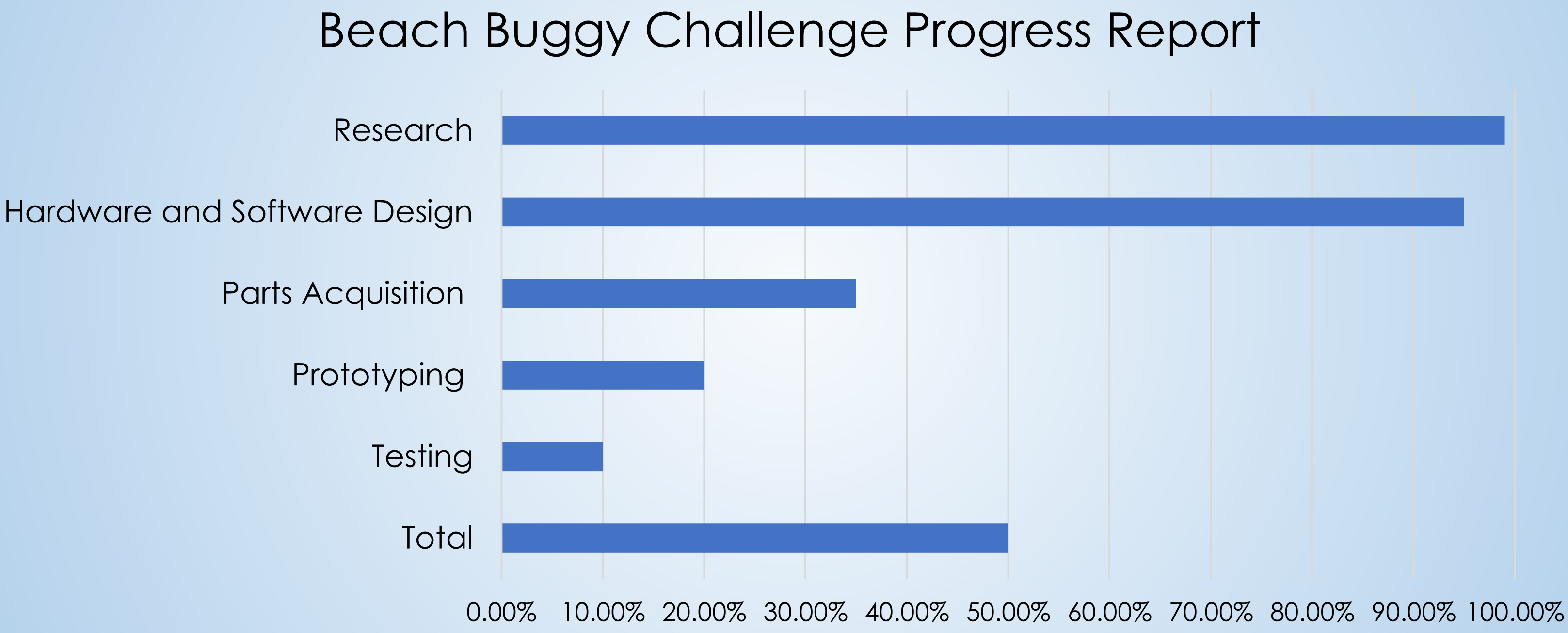
Current Progress



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Questions?