UCF Beach Buggy Challenge

Group 1

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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

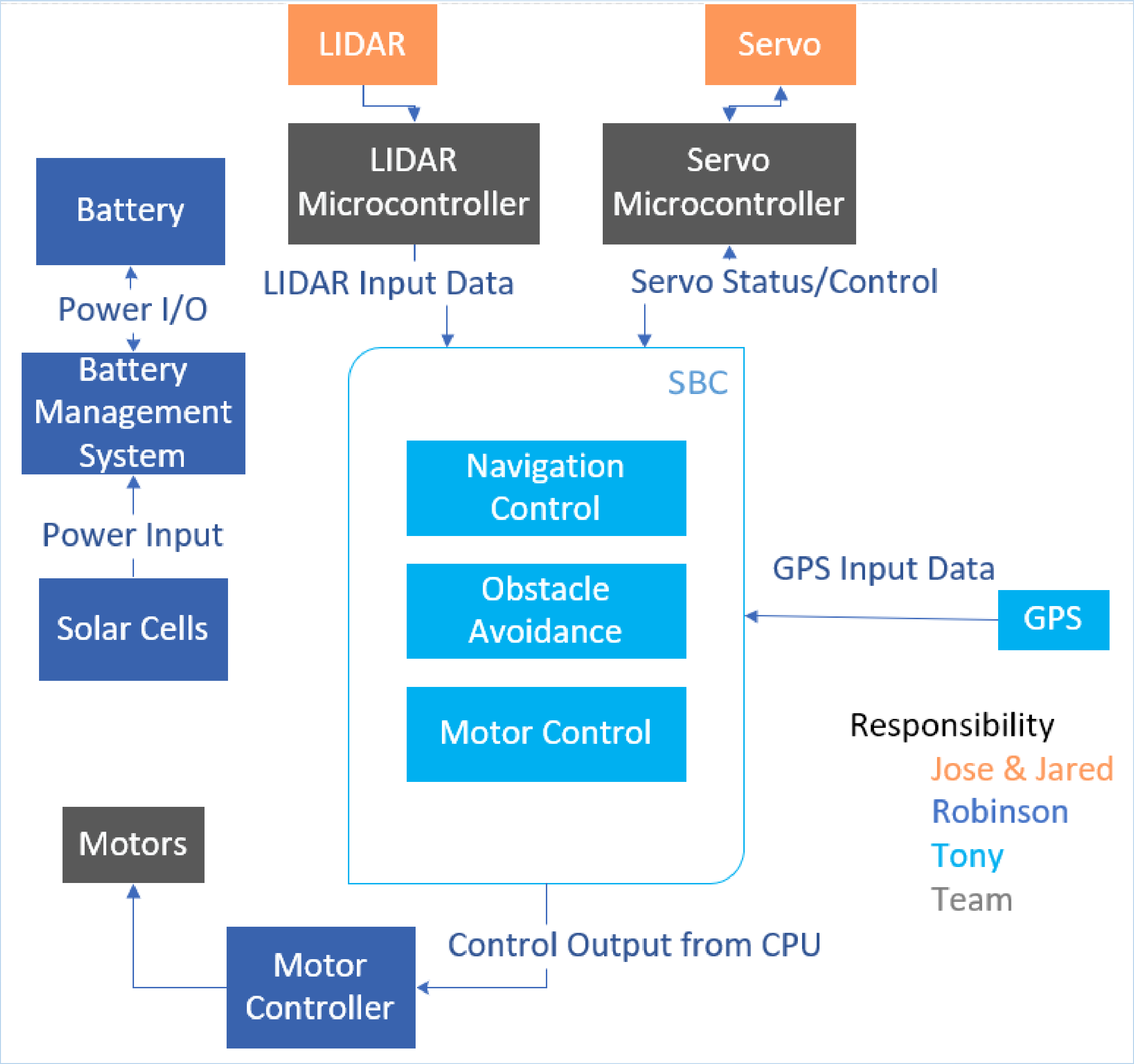
Goals and Objectives

- 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



Single-board computer considerations

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

Single-board computer considerations

nVidia Jetson TX1

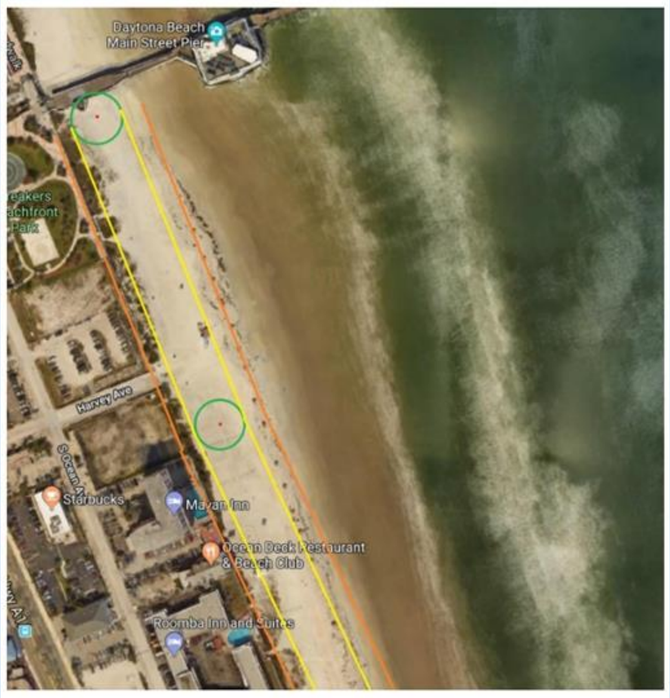
Raspberry PI 3 Model B+

Asus Tinker Board S

Product	CPU	I/O	Networking	Power Input	Dimensions	Price
Asus Tinker Board S	Quad core 32-bit 1.8 GHz ARM Cortex-A17	GPIOs, SPI, I2C	802.11 b/g/n WLAN, Bluetooth	5V @ 2.5A	8.55cm x 5.4cm	$ 60.00
nVidia Jetson TX1	Quad core 64-bit Arm 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+	Quad Core 64-bit 1.4GHz 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



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GPS considerations

	Adafruit GPS Breakout	GlobalSat BU-353-S4 USB GPS
Channels	66	48
External Antenna	Yes	No
Update Rate	10 Hz	1 Hz
Accuracy	< 3m	< 2.5m
RTC with Battery	Yes	No
Price	$39.95	$ 26.00

- Adafruit hooks directly to TX/RX
    - Can receive and parse raw data
- Has input for external antenna if greater/indoor/overcast accuracy is desired
- USB overhead for GlobalSat

Networking considerations

- Purpose
  - Provide wireless link between buggy and command system
    - Determine status of buggy
      - Logic
      - Location
    - Emergency kill-switch
- Factors to consider
  - Ease of implementation
  - Stability
  - Throughput

Networking considerations

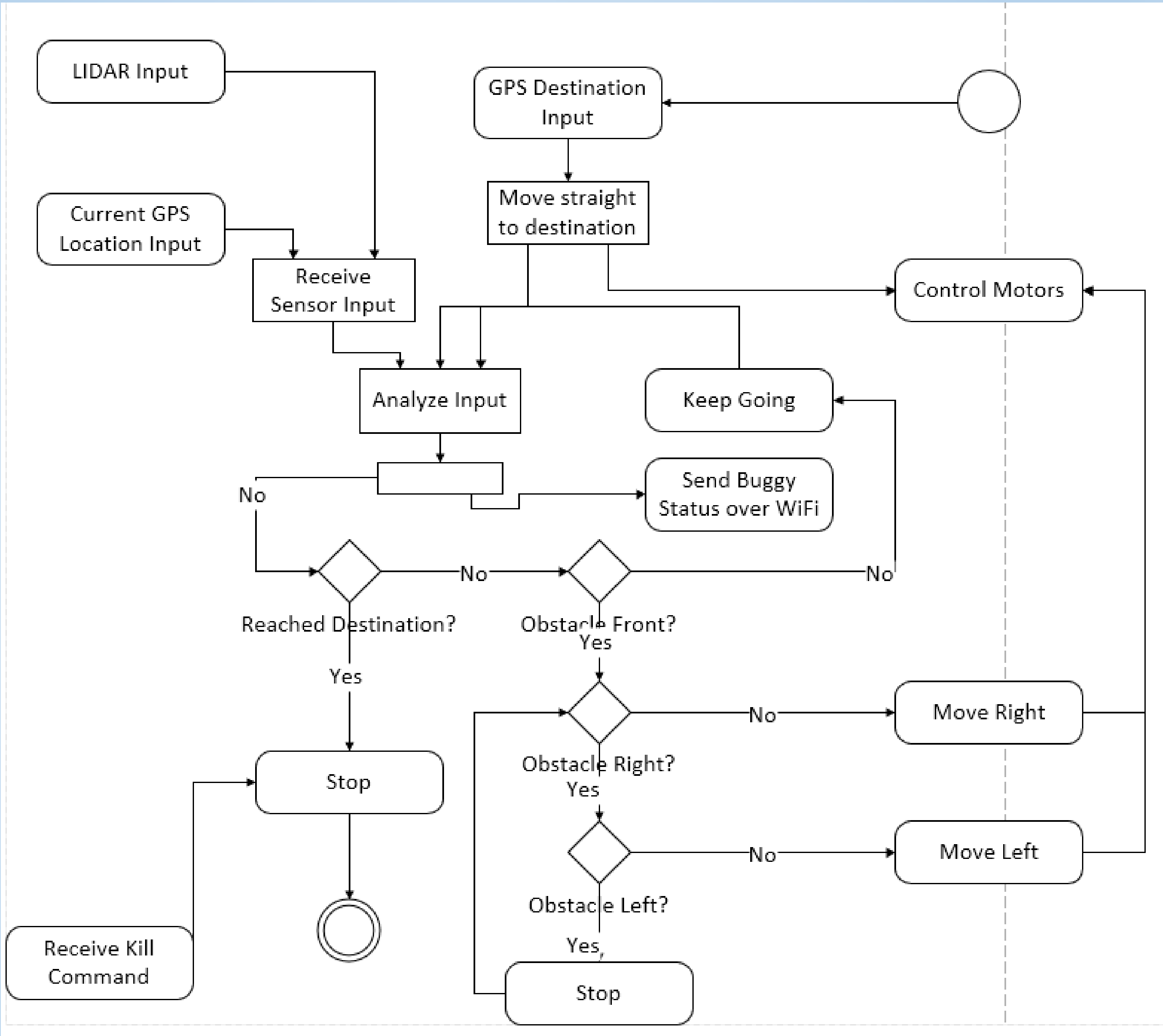
	WiFi	Bluetooth LE	GSM
Frequency	2.4 GHz or 5 GHz	2.4 GHz	Variable
Throughput	500 Mbit/s (802.11ac)	0.27 MBit/s	50 Mbit/s
Range	105 feet	330 feet (theoretical)	Unlimited
Power Consumption	0.5-2 W	0.01-0.50 W	1.5W
LAN Compatible	Yes	No	No

- WiFi easier to implement
- WiFi is more stable
- WiFi is compatible with LAN networks
- WiFi has high throughput

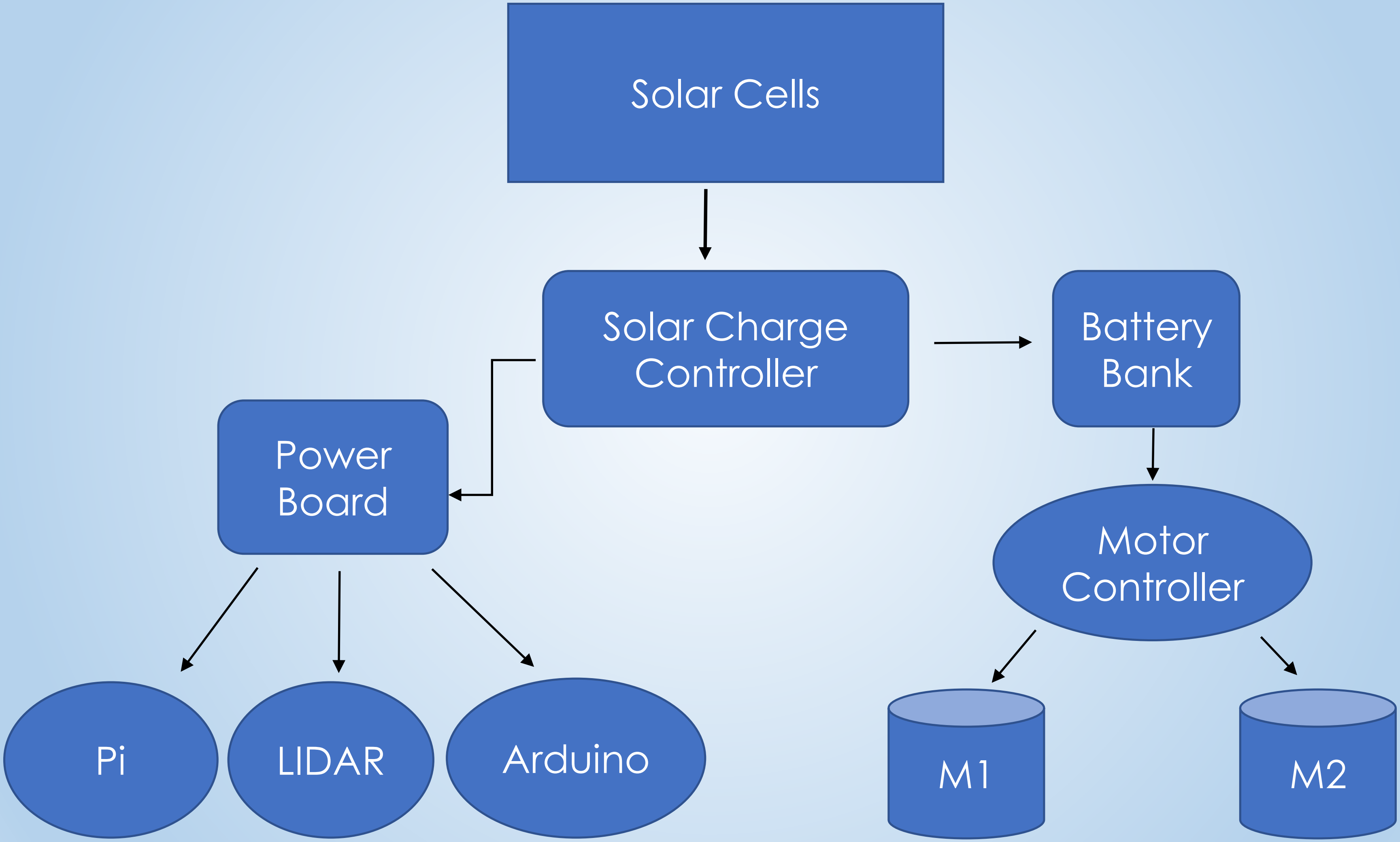
Motor control with PI

- Sabertooth 2x32 has 4 modes for control, 2 of which are useful for us:
  - Mode 1: Analog Input (Voltage range configurable)
    - 0 - 5 V Single direction movement
    - 2^{nd} 0-5 V Pin directs direction of movement
  - 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)

UML Activity Diagram



Power Distribution



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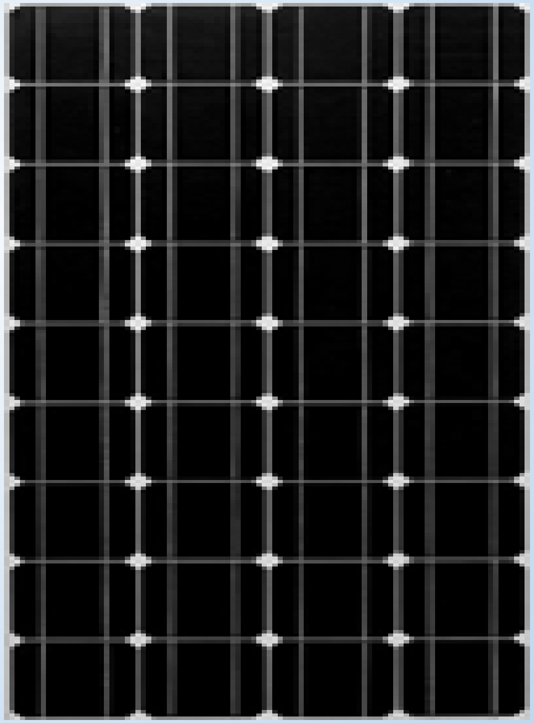
Solar Panel Selection

		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 Panel

- Solar Panel provided by CECS
- Peak Voltage: 18V
- Peak Current: 5.56A
- Efficiency:17%
- Weight: 18.1 lbs.
- Max Power : 200W
- Cost: Free



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: 33
- Voltage: 12V
- Weight: 23.2 lbs.
- Price: USD 64.99

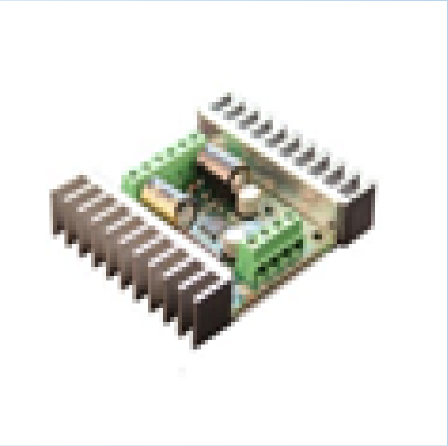
Type	Brand	Weight (lbs.)	Dimensions LxWxH(in)	Capacity (AH)	Voltage (V)	Price ($USD)
FLA	ExpertPower	23.2	7.7 x 5.2 x 6.3	33	12V	$64.99
FLA	USBattery US12VXC	86	13.3x7.07x11.38	155	12V	$179.87
AGM	Universal Battery	69.9	12.12 x 6.61 x 9.16	100	12V	$164.99
Gel	Renogy	66	13 x 6.8 x 9.0	100	12V	$229.99
SLA	NPP	59.5	12.1 x 6.7 x 8.2	90	12V	$162.99

Motor Selection

	AmpFlow E30-400	MY-1020	NPC4200	Motenergy ME-0909
Motor Type	Brushed	Brushed	Brushed	Brushed
Weight	5.9 lbs.	9.03 lbs.	15.7 lbs.	24 lbs.
Voltage	12-24V	12-24V	24-36V	24-48V
Peak current	266A	26.7A	470A	300A
Peak Torque	11Nm	1.91Nm	N/A	N/A
Peak Horsepower	2.1hp	0.7hp	3.8hp	15hp
RPM	5700rpm @24V	2500rpm @24V	3400rpm	4850rpm
Price	$109	$79.99	$339	$385
Efficiency	79%	75%	N/A	95%

Motor Controller

	Sabertooth dual 25A	Sabertooth dual 60A	Sabertooth dual 32A
Price	$124.99	$189.99	$119.99
Weight(g)	90g	240g	125g
DC input(V)	6-30V	6-30V	6-30V
Weight Rating	300 lbs.	1000 lbs.	300 lbs.
Board Size(mm)	65 x 80 x 21 mm	76 x 89 x 46 mm	76 x 89 x 46 mm
Peak Current(A)	25A	60A	64A
Continuous Current(A)	50A	120A	32A

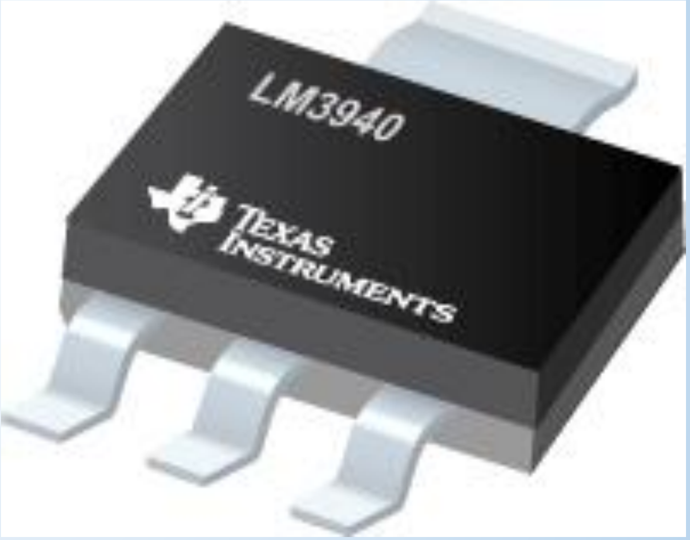


PCB Design

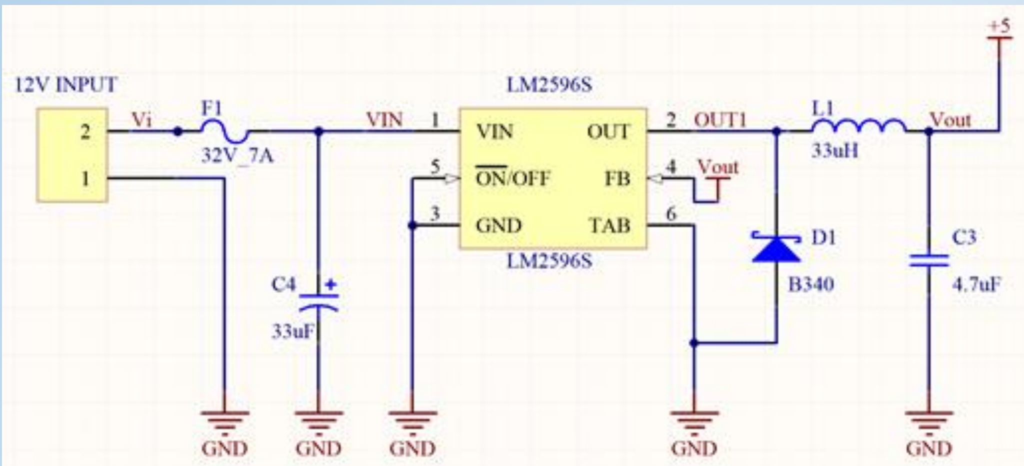
- Use 2 TI chips
- LM2596 & LM 3940
- Input Voltage : up to 40V
- Output Load Current: 3A
- Very Efficient
- Uses 4 only components

PCB Design

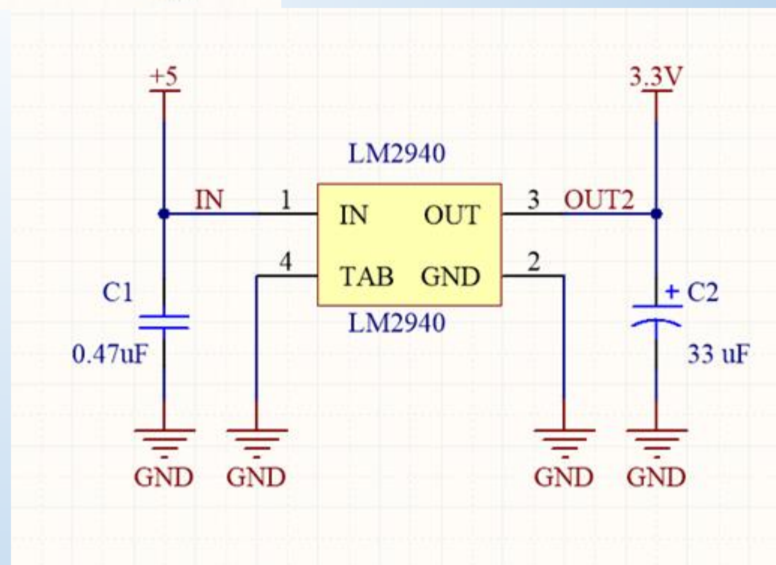
- Input Voltage Range: 6V-26V
- Drop out Voltage: 0.5V at 1A
- Features
- Overvoltage shut down >26V
- Thermal shut down
- Short Circuit Current Limit



Schematics

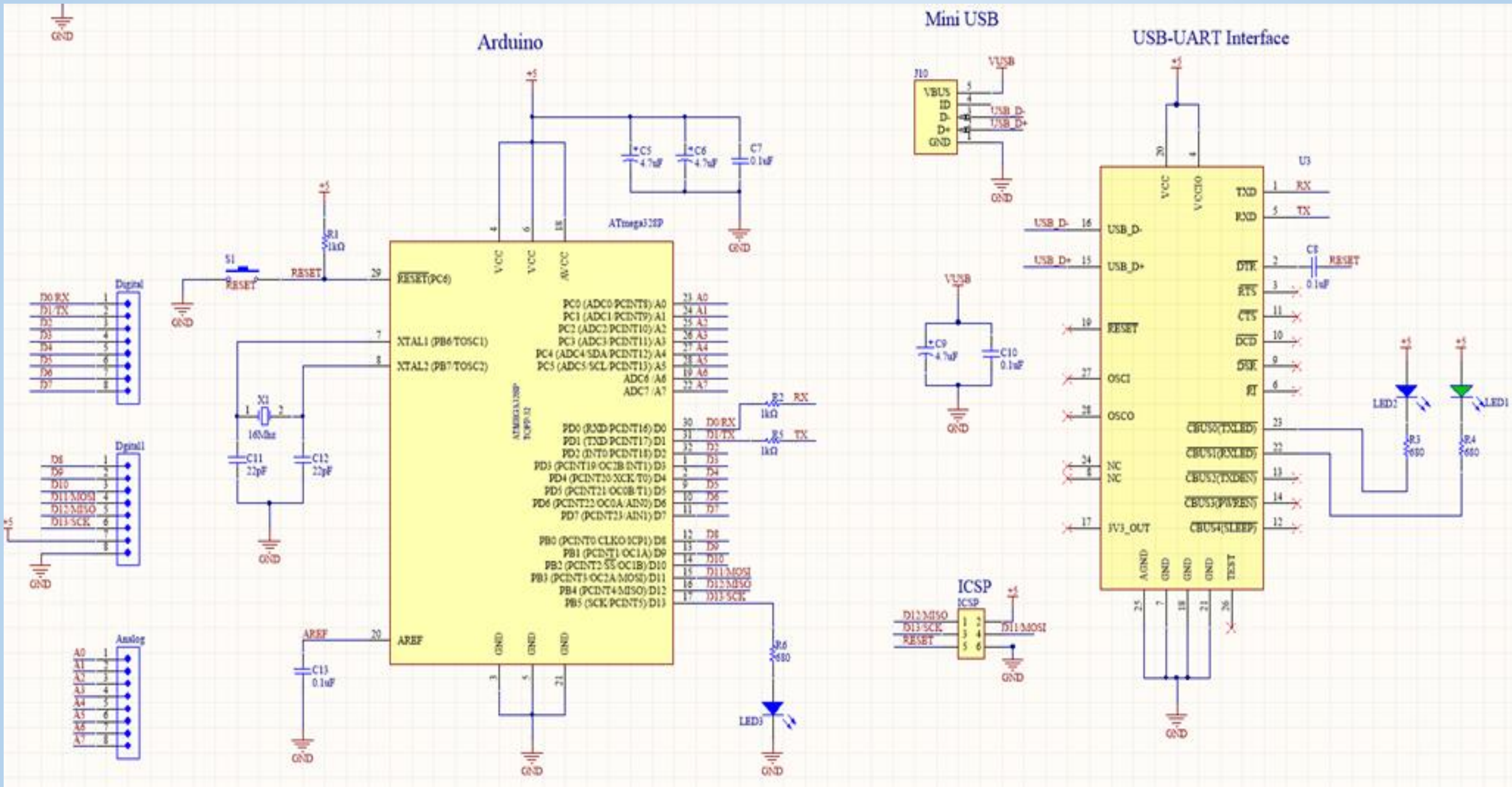


- 5V Switching Regulator

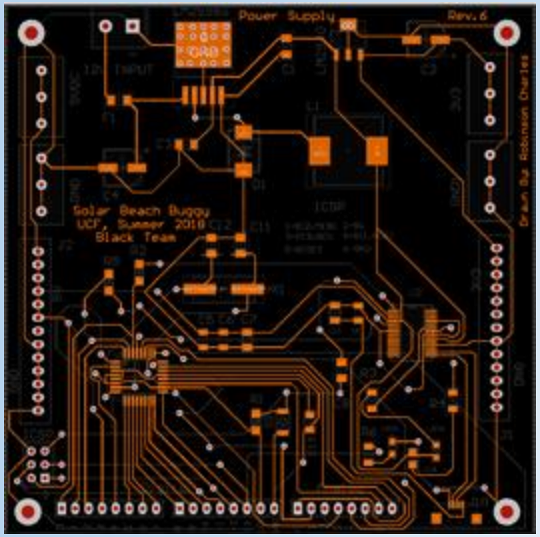


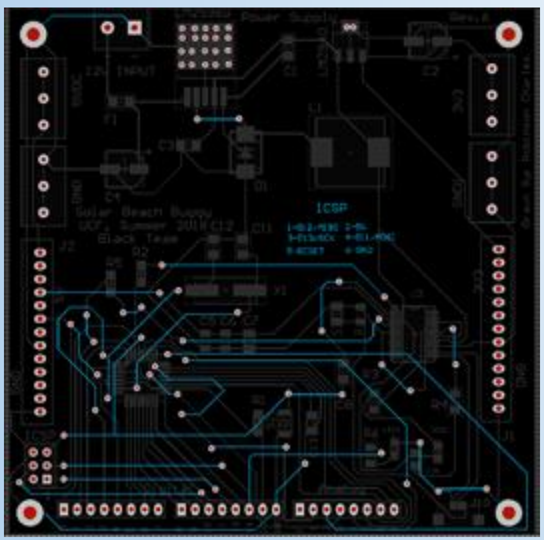
- 3.3V Voltage Regulator

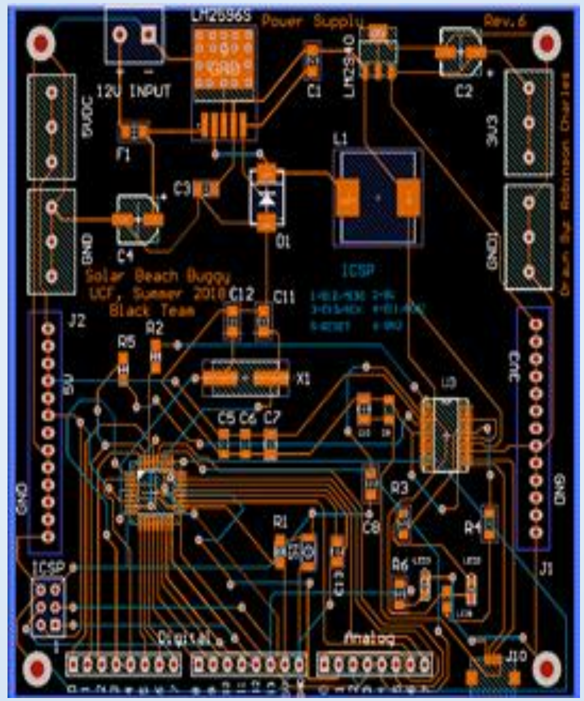
Schematics



• Microcontroller Circuit



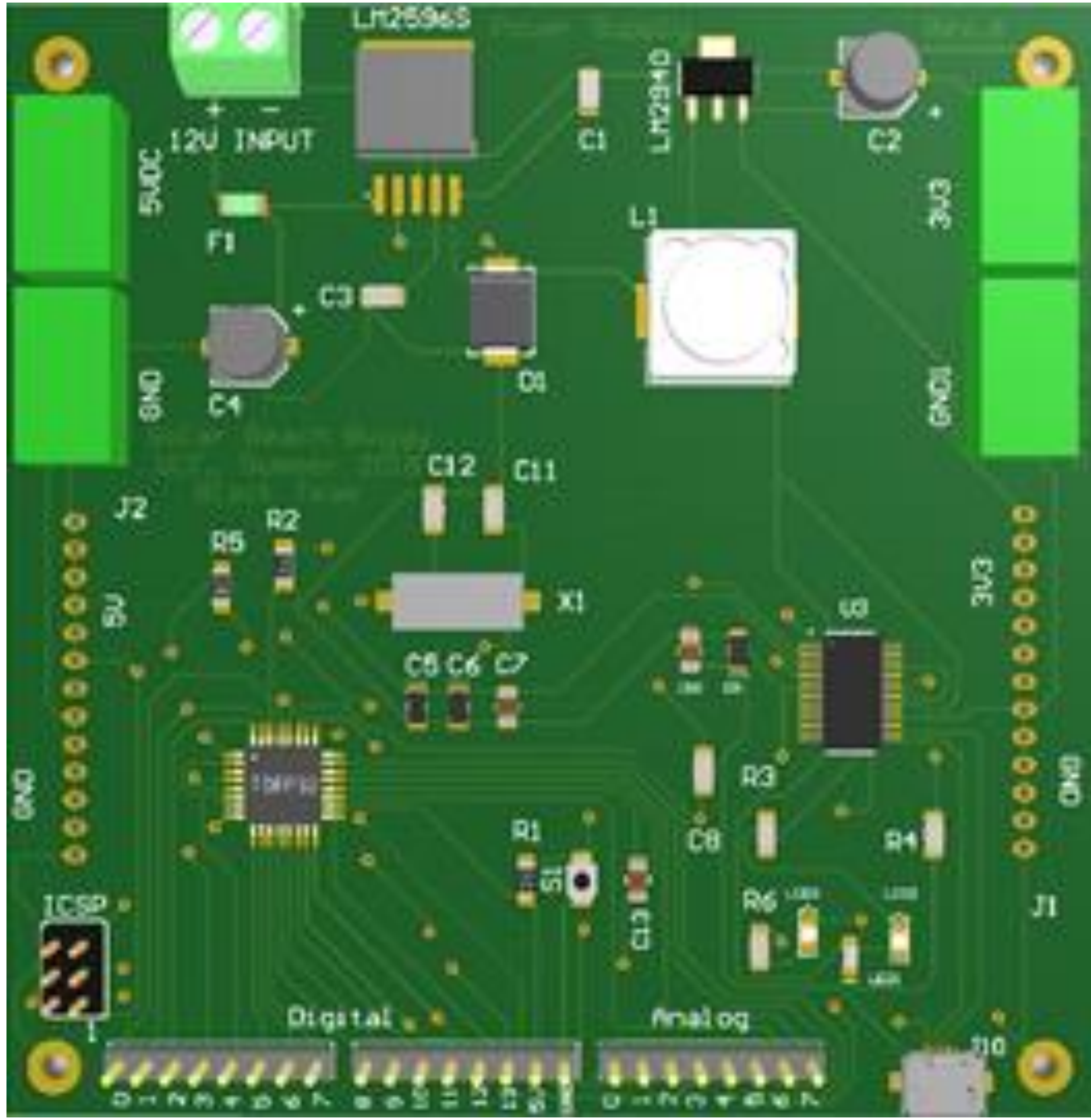




Top & Bottom Layer

- Right : both Layer
- Top Left: Top layer
- Bottom left: Bottom Layer

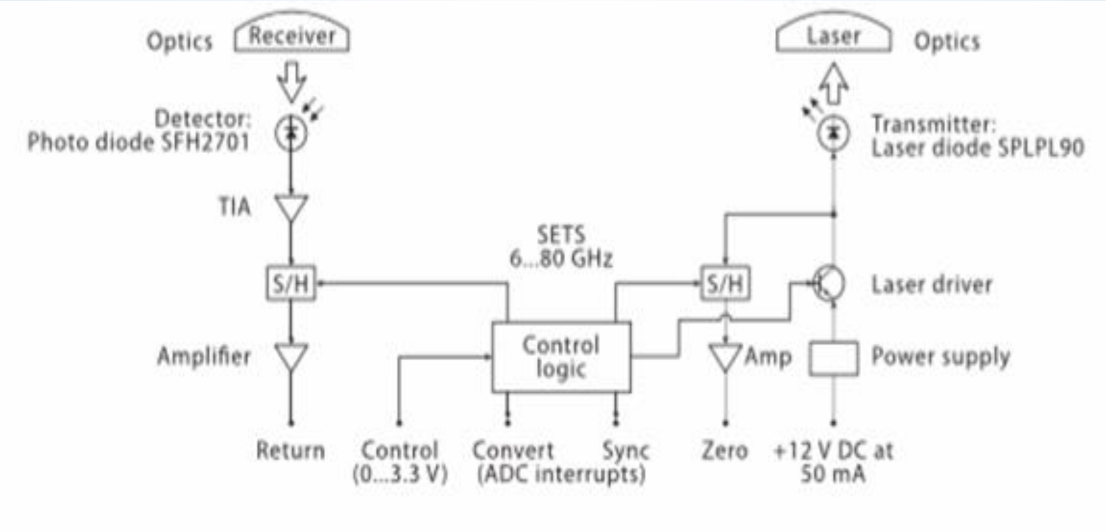
3D View



LM2596S
12V INPUT
5VDC
F1
C1
LM2940
C2
3V3
L1
C3
C4
D1
GND
GND1
J2
C12
C11
R5
R2
X1
C5 C6 C7
U3
R3
R1
C8
R4
R6
J1
ICSP
Digital
Analog
J10

LIDAR Overview

The Lidar module consists 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.



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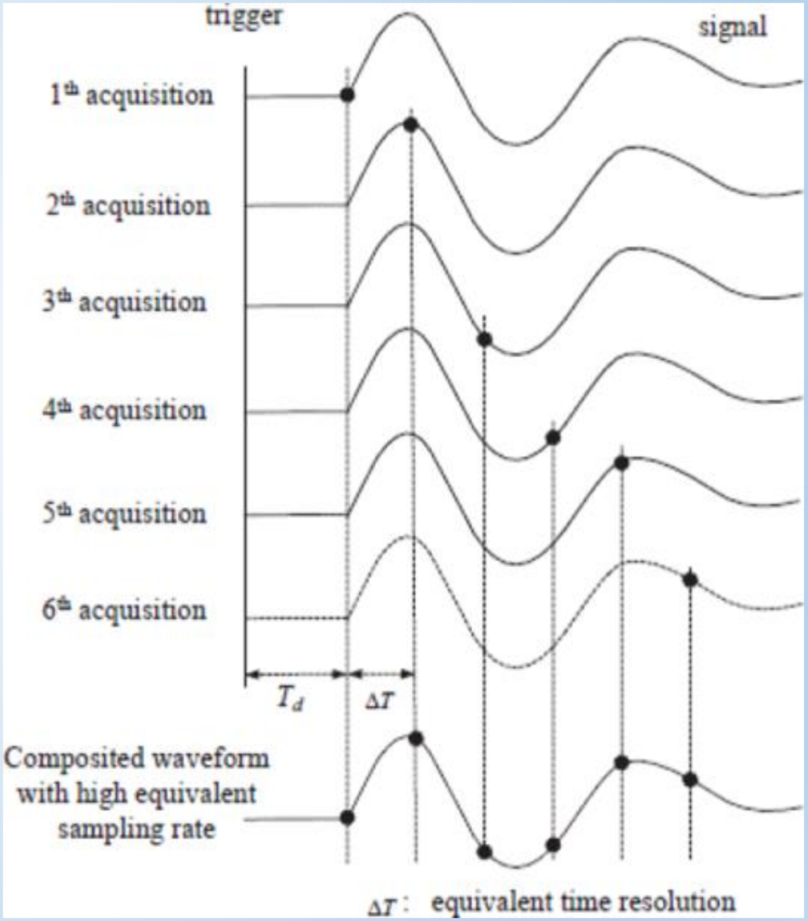
Design Challenges

- 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

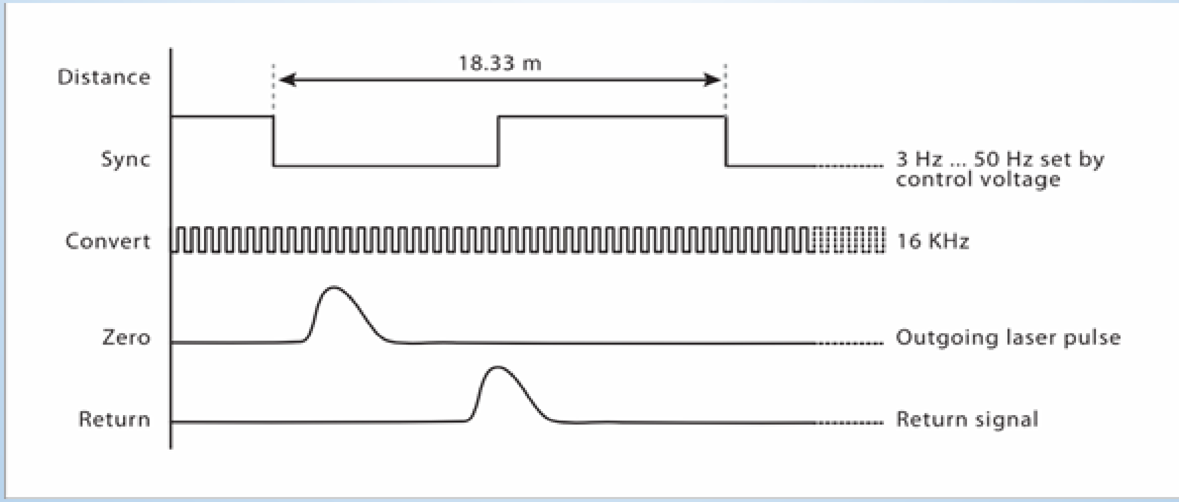
SETS (sequential equivalent time sampling):

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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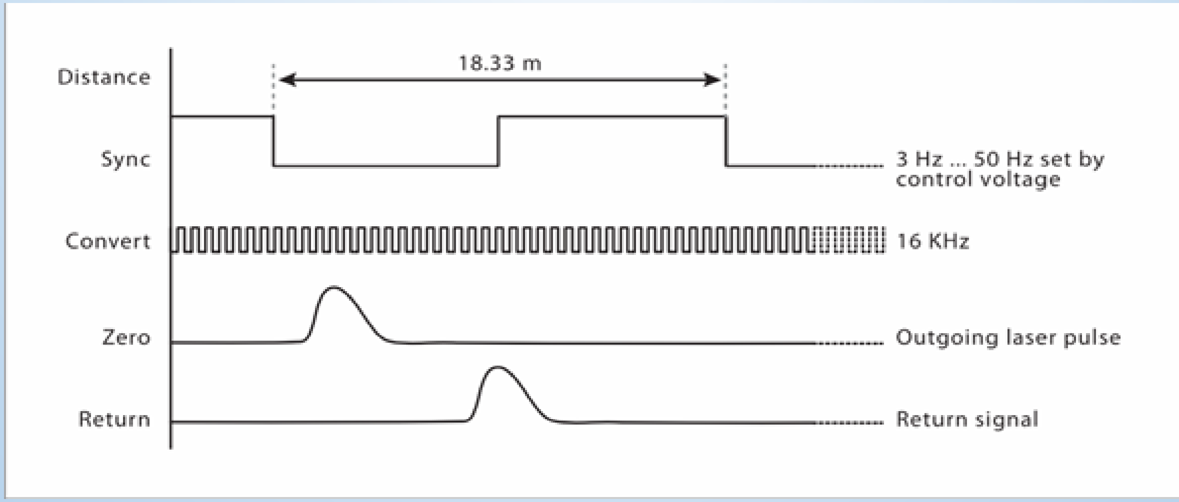
Timing Strategies:

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 Module Selection

- Developmental difficulties made it necessary to purchase a commercial Lidar module
- It was necessary to choose one that would be small and cheap yet have enough range to work outside where ambient light is an issue

LIDAR Specs

- Range: .3-12m
- Update rate: up to 100Hz
- Applicable voltage range: 4.5-6V
- Power supply: .12W
- Dimensions: 42 x 15 x 16 mm
- Weight: 6.1g

LIDAR Specs

Distance/m	1	2	3	4	5	6
Detection range side length/mm	40	80	120	160	200	240

The table above shows the side length of detection range the farther the object is from the sensor.

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 dependent on favorable weather conditions
- The sweep speed of the Lidar is relatively slow.
- The GPS is not accurate enough in calculating the heading of the buggy due to its low speed.

Budget & Financing

Item	Supplier	Quantity	Unit Price	Total Cost	Item	Supplier	Quantity	Unit Price	Total Cost
Misc. Resistors and Capacitor s	Digikey	~100	Varies	$95.49	12V Deep Cycle Battery	Amazon	2	$64.99	$129.98
LDO Voltage Regulators	Mouser	3	$1.59	$4.77	24V Motor	Amazon	2	$79.99	$159.98
Raspberry Pi	Adafruit	1	$35.00	$35.00	80A Charge Controller	Amazon	1	$72.88	$72.88
GPS HAT	Adafruit	1	$44.96	$44.96	GPS Breakout	Adafruit	1	$39.95	$39.95
Active GPS Antenna	Adafruit	1	$12.95	$12.95	Servo Motors	RobotMar ketplace	1	$11.49	$11.49
Adapter Cable	Adafruit	1	$3.95	$3.95					
Passive GPS Antenna	Adafruit	1	$3.95	$3.95					
16GB Micro SD card	Amazon	1	$8.55	$8.55					
32A Motor Driver	Amazon	1	$119.95	$119.95	**Total**				**$743.85**

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Questions?