Bottom Feeder

Group 2

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SR

Description

A remotely operated underwater vehicle that de-risks aquatic exploration and assists in locating and recovering personal effects.

SR

Motivation

- Underwater exploration creates intrinsic risks
- De-risking aquatic activities is a key business goal
- Valuable objects lost in beaches and waterways are frequently metallic
- De-risking metal detection allows individuals and businesses to recover lost items
- An engaging experience in remote underwater exploration allows for people to become excited about conservation and the environment

SR

Goals and Objectives

- Create a remote operated vehicle capable of underwater exploration with a live video feed
- ROV will include metal detection in order to locate lost valuables on aquatic floor
- An appendage on the ROV for retrieval of lost valuables
- An entry-level price point

SR

Specifications and Requirements

Component	Parameter	Design Specification
Batteries	Discharge time	1 hour
Metal detector	Detection range	10 cm
Cameras	Field of view	Omnidirectional
Cameras	Image quality	1080p
Motors	Speed	5 knots
Lights	Brightness	1000 lm
Item collection	Object weight	≤ 5 lbs
Housing	Water resistance depth	10 m
Tether	Length	30 m

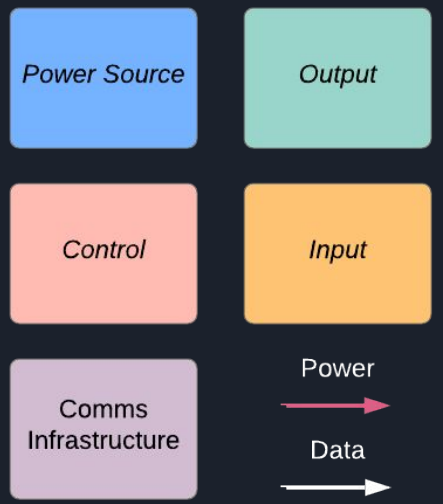
TR

Division of Labor

System	John	Tyler	Sarah	T
Printed Circuit Board	Primary			
Light	Secondary	Primary		
Tether			Primary	
Propulsion	Secondary			Primary
Power	Secondary	Primary		
Cameras	Primary			
Surface Station			Secondary	Primary
Metal Detector	Primary	Secondary	Secondary	

TR

System Block Diagram



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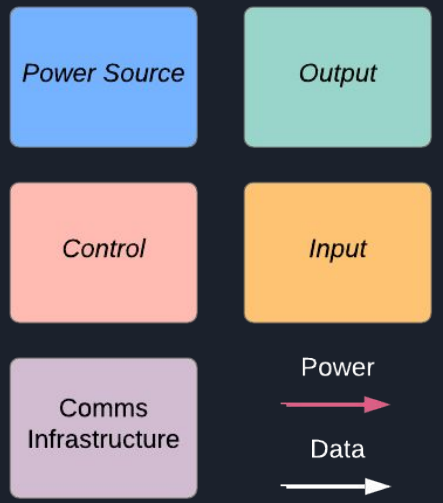
Output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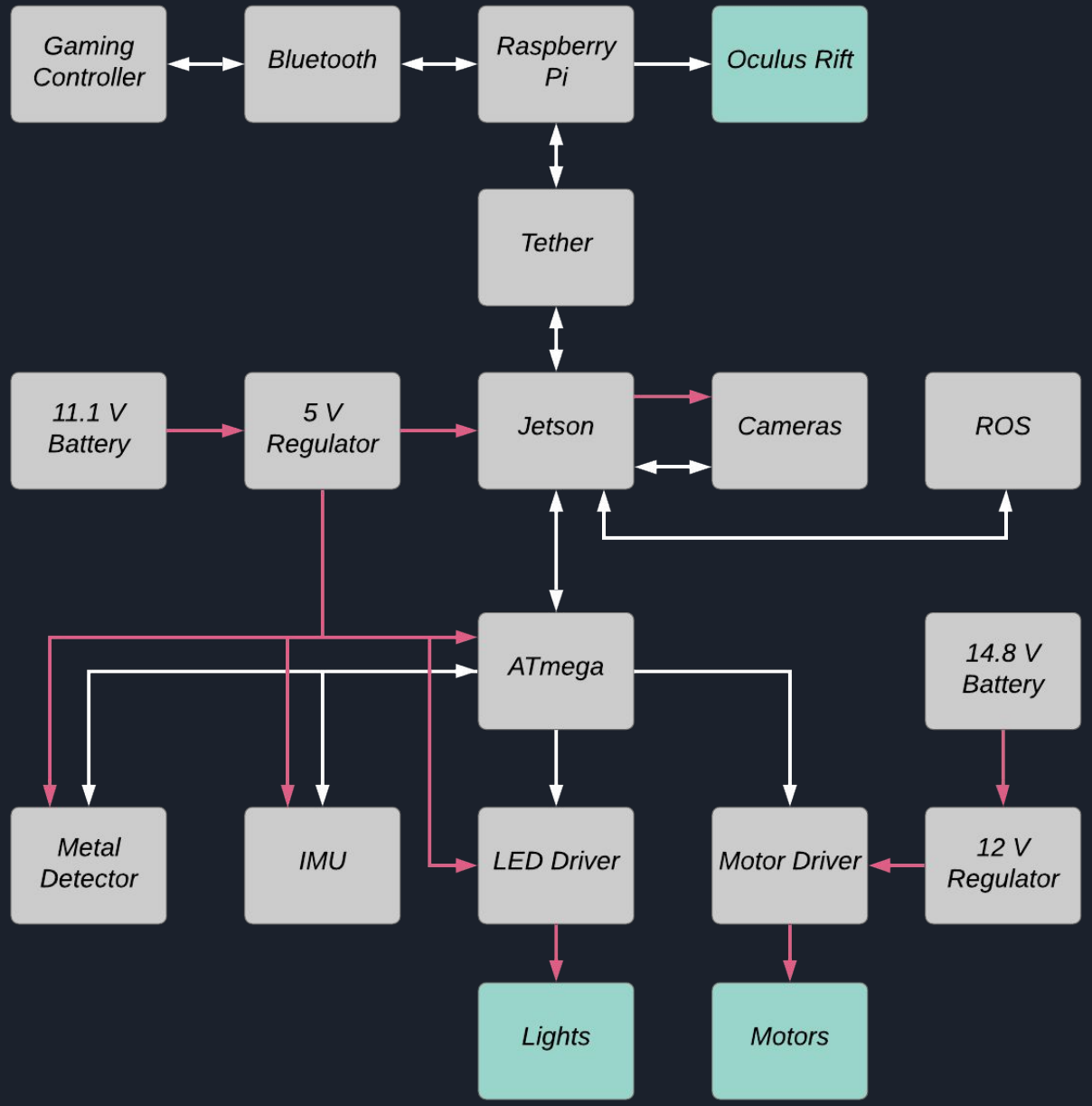
Output
Control
Input
Comms Infrastructure
Power
Data


Gaming Controller
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Raspberry Pi
Oculus Rift
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11.1 V Battery
5 V Regulator
Jetson
Cameras
ROS
ATmega
14.8 V Battery
Metal Detector
IMU
LED Driver
Motor Driver
12 V Regulator
Lights
Motors

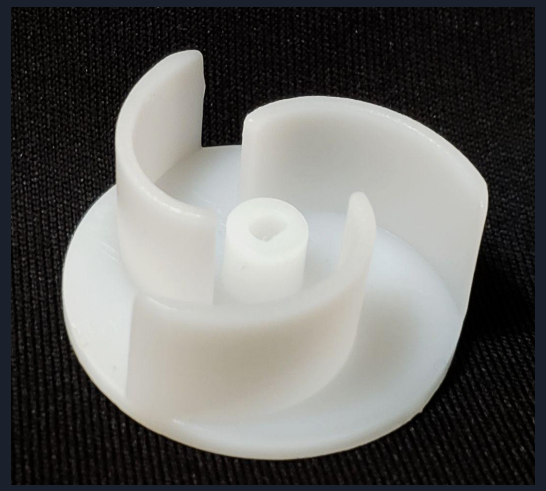
TR

Propulsion

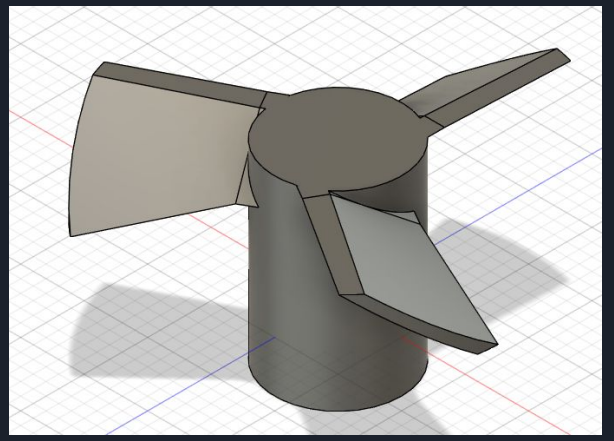
- Connects to microcontroller using L2605 H-Bridge motor drivers.
- Uses two Johnson Mayfair 1000 GPH Bilge Pump Cartridges for forwards and backwards movement.
- Uses two 1100 GPH Bilge Water Pumps for vertical movement.

TD

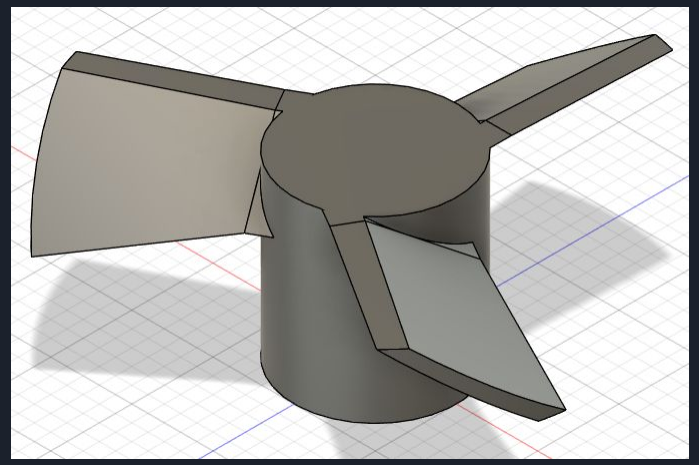
Propulsion



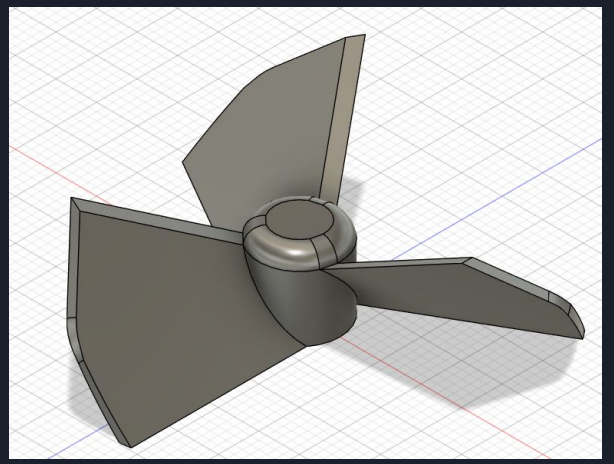
Stock Impeller



Design #1



Design #2



Design #3

TD

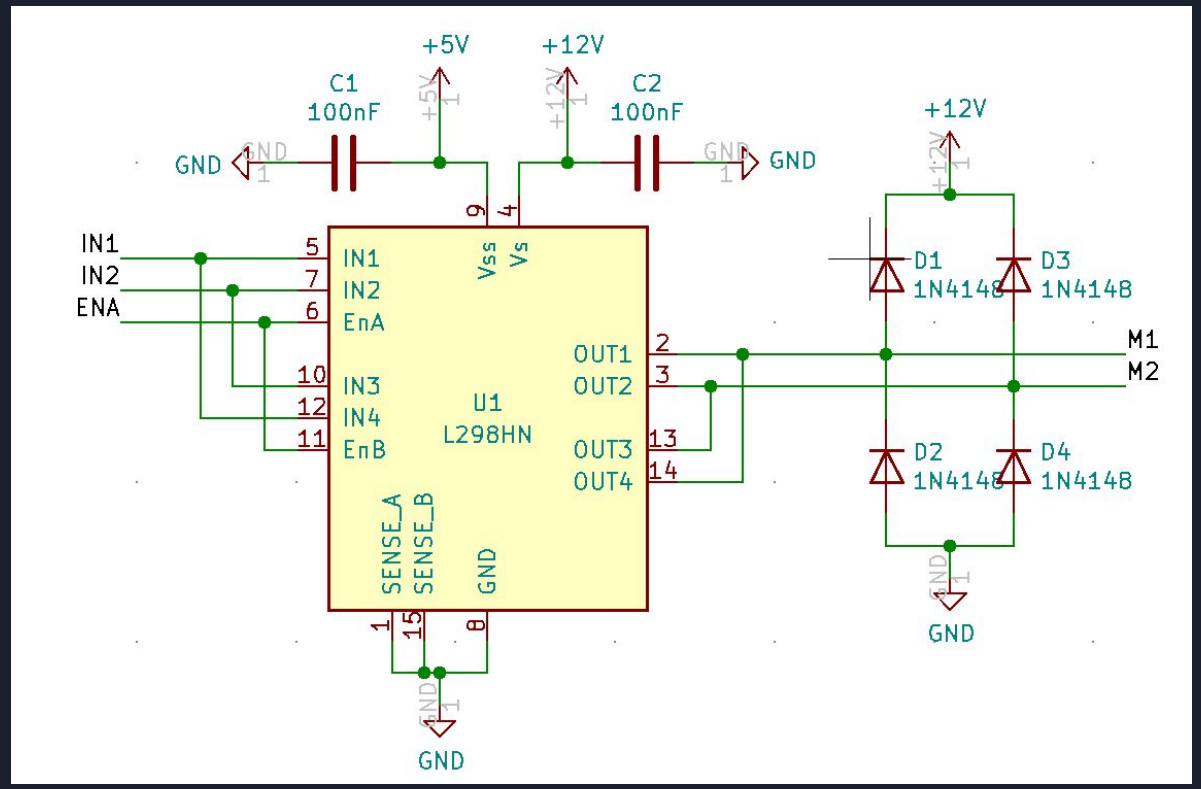
Propulsion - Testing

Load	Voltage (V)	Amperage (A)	Force (lbs)
None	12.0	0.49	0.00
Stock Impeller	12.0	2.18	0.07
Design #1	12.0	2.04	0.57
Design #2	12.0	2.07	0.57
Design #3	9.2	3.1	0.53

TD

L298 Motor Driver Schematic

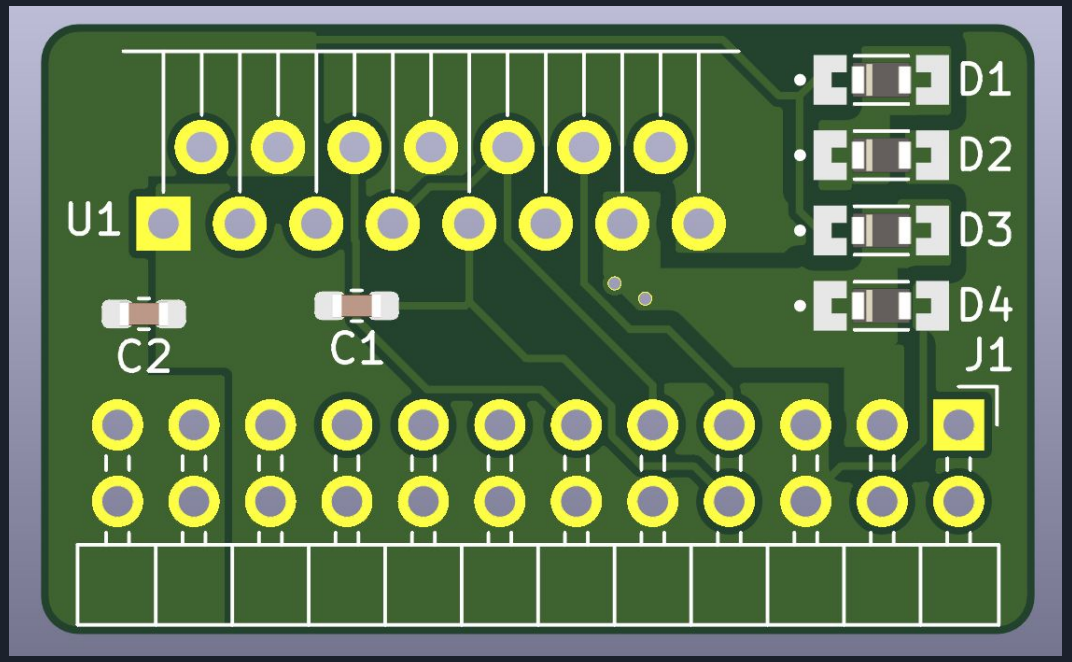
- First driver designed
- Supports up to 1.5A per H bridge
- Thrusters measuring 2A on high
- Configured the driver in parallel
- One dual driver circuit needed per thruster

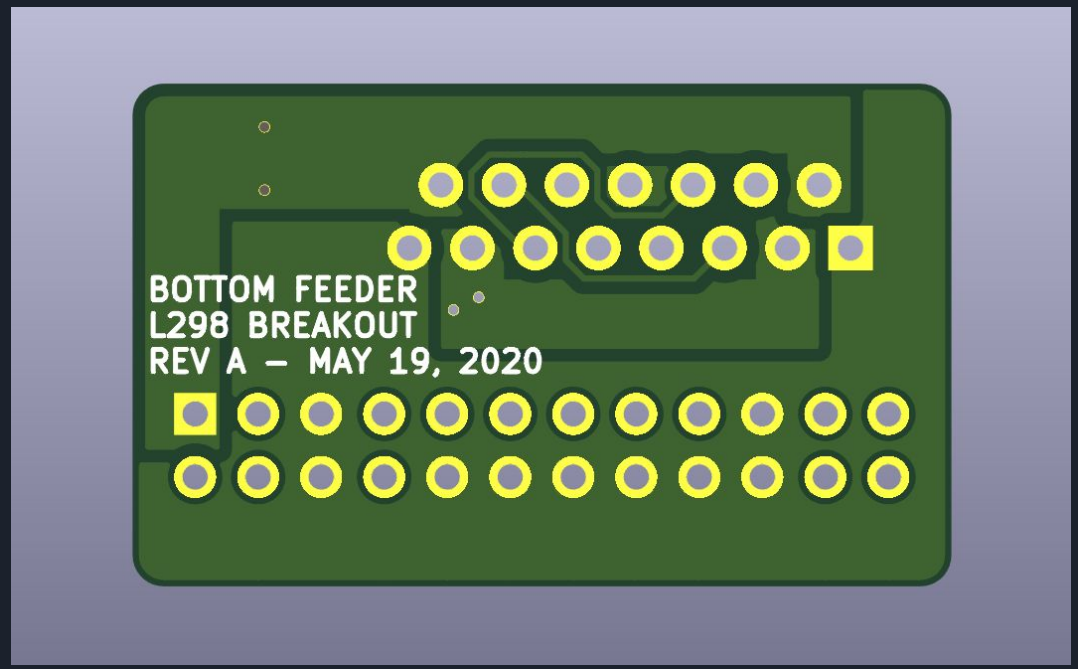


JC

L298 Motor Driver

- The IC does not include reverse polarity protection or over voltage protection
- Back EMF from motors can induce these
- Four diodes create two clamping circuits
- Through hole component extends far beyond board edge

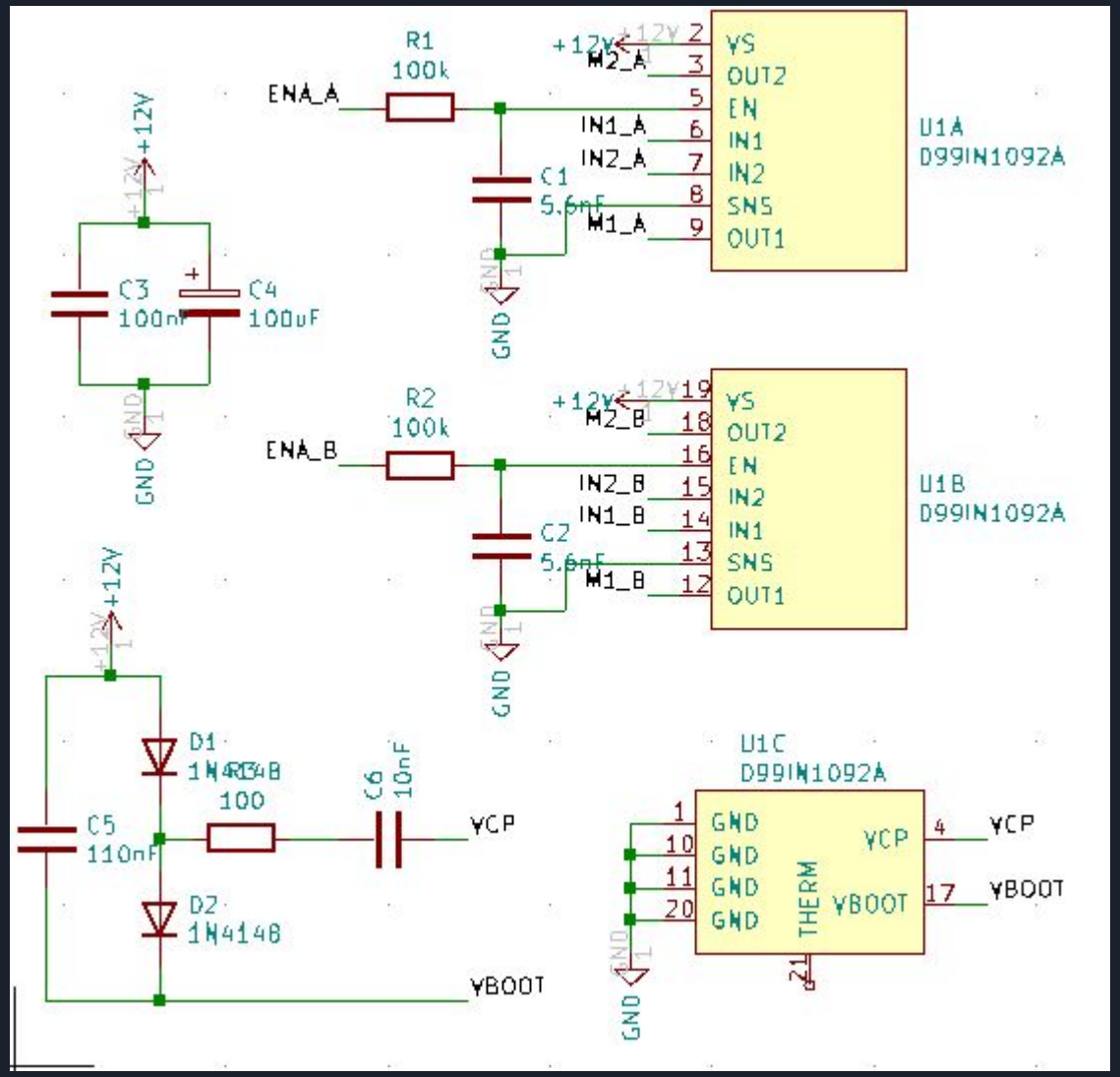




JC

L6205 Motor Driver Schematic

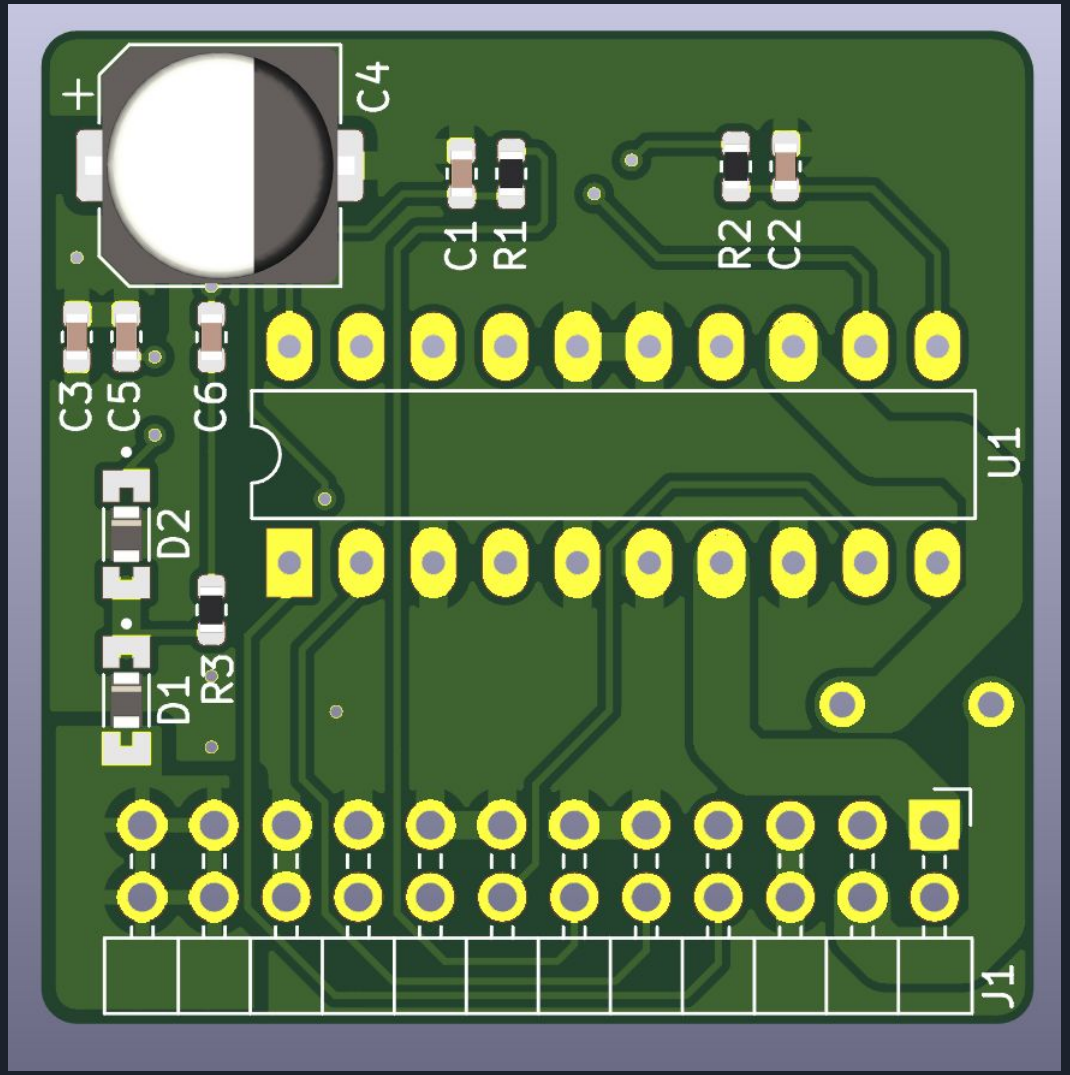
- Second driver designed
- The L6205 provides up to 3A per motor
- It also contains two drivers
- One IC in this case can support two thruster



JC

L6205 PowerDIP Motor Driver

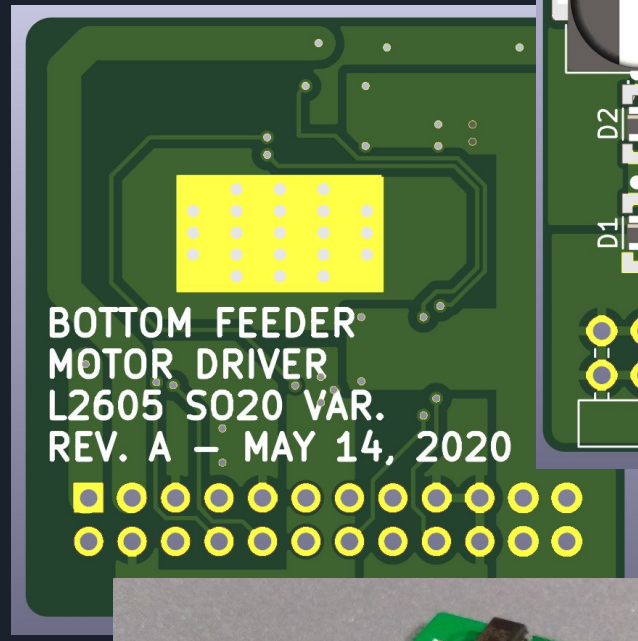
- DIP package laid out as it was the first sample requested and approved
- RC circuits on input for conditioning PWM signals
- IC has overcurrent throttling and shutdown and thermal shutdown
- Freewheeling diodes are integrated, unlike L298

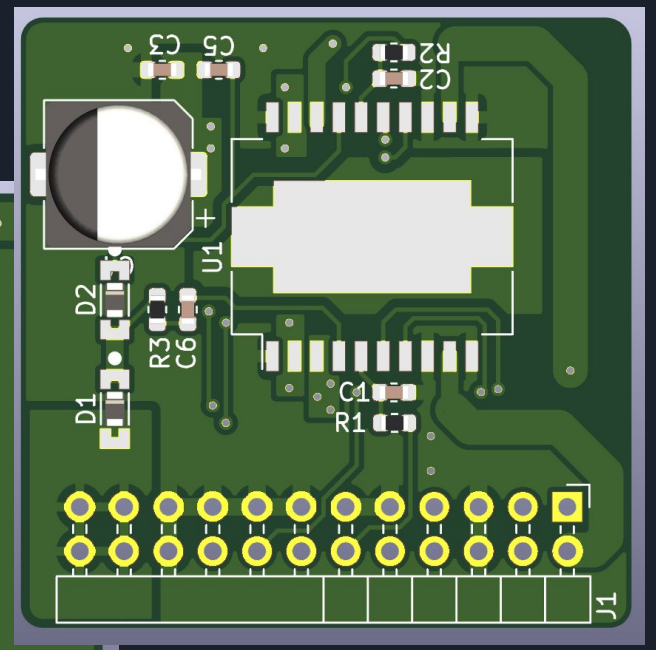


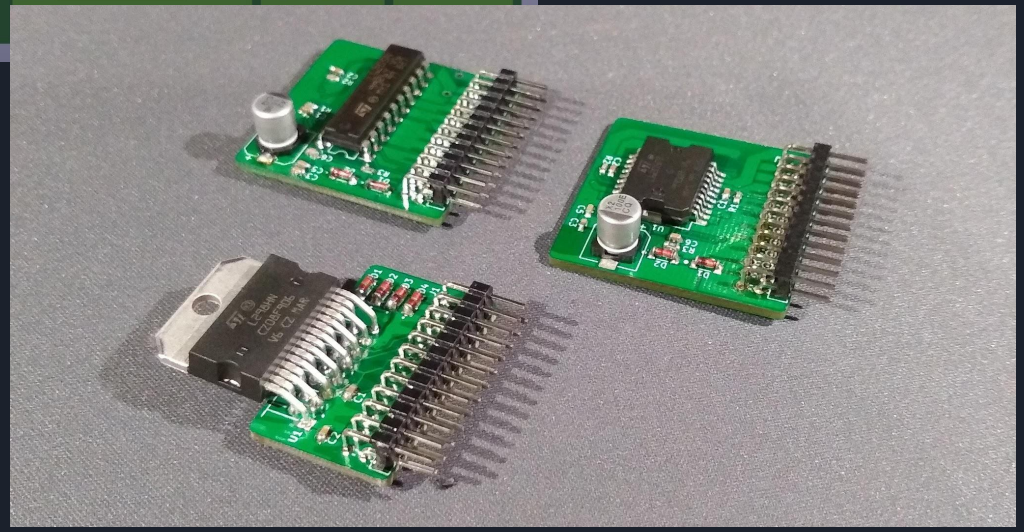
JC

L6205 Power SO20 Motor Driver

- SMD package similar to first but has more thermal relief available through the PCB
- Pin arrangement is different than the DIP package, so two design files were needed
- Large thermal relief plane under IC on both top and bottom copper
- Internap power FETs require a gate voltage above supply voltage, but the IC has an integrated charge pump for DC-DC conversion







JC

Lights

Price:

- Two LEDs on either side of ROV
- Each LED produces > 1000 lm for $7
- comparable LEDs produce < 900 lm for $6 or ~1000 lm for over $20

Function:

- User has On/Off control
- Brightness is based on current through LED
- Output Brightness is tunable on PCB

TR

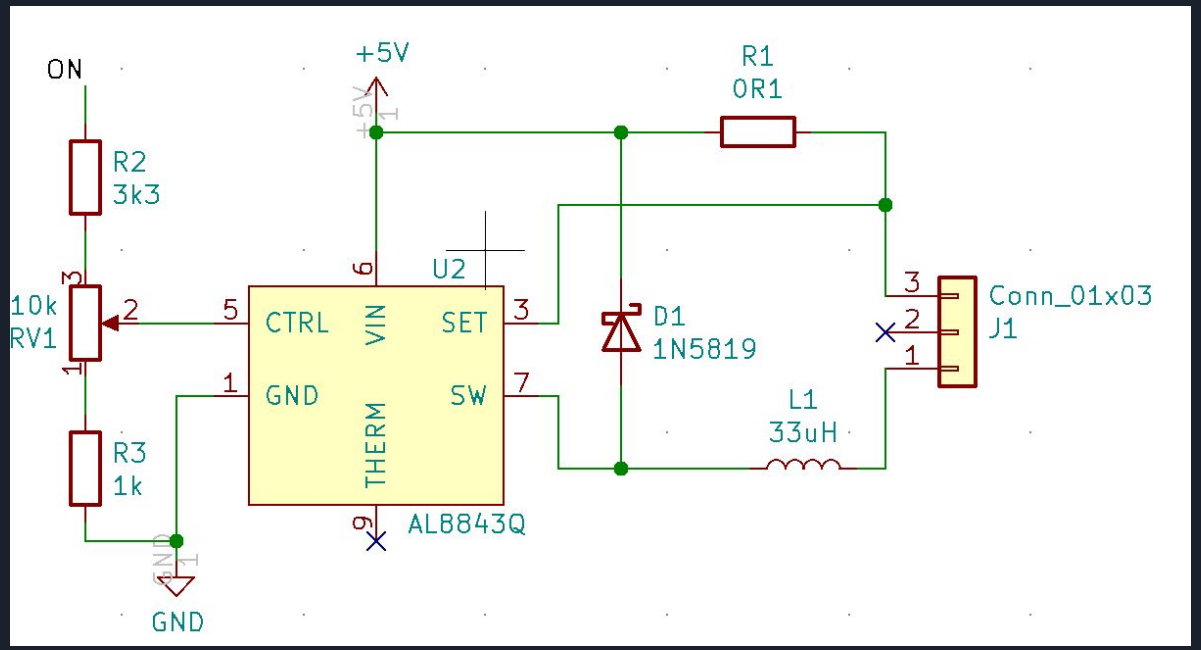
LED Testing

please for the love of all that is holy dont forget to correct this slide

TR

LED Driver Schematic

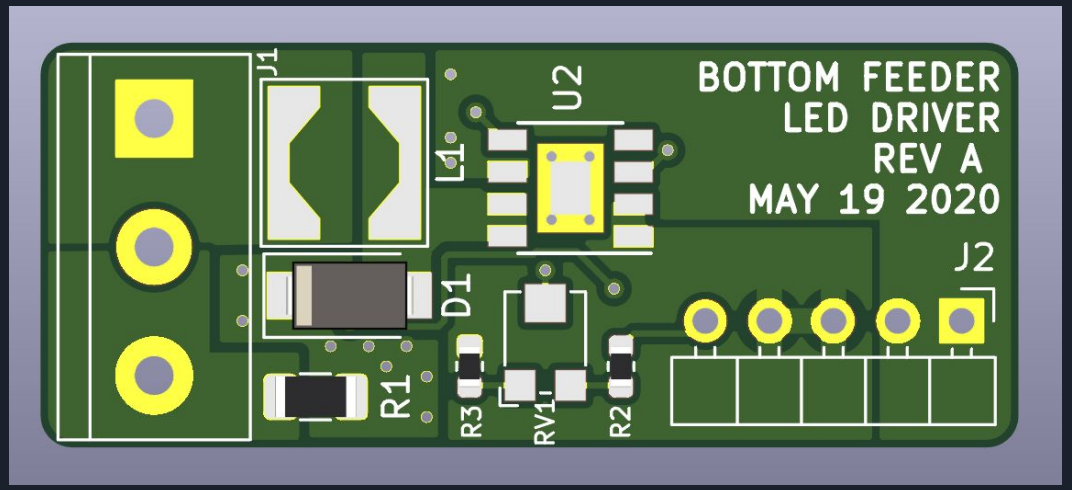
- Based on the AL8843Q LED driver
- CTRL allows analog current control with inputs from 0.4V to 2.5V
- At maximum output, the current is 3A
- Resistor divider creates range from 0.34V to 3.84V
- Testing showed 1A provided enough lighting
- Wasn't able to test before shipping PCBs
- Variable resistor allows for tuning of circuit

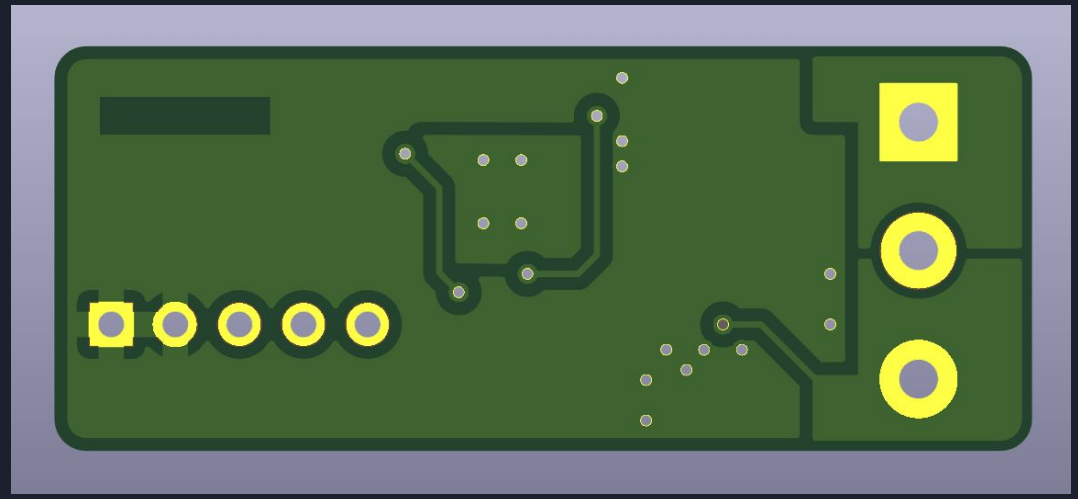


JC

LED Driver Prototype

- Following datasheet's advice, we placed the conditioning inductor and freewheeling diode as close as possible to IC
- Board has extra, middle, screw terminal to allow fast fastening of a series LED circuit
- Single LED can be connected to 1 and 3
- Two LEDs can be joined at middle terminal





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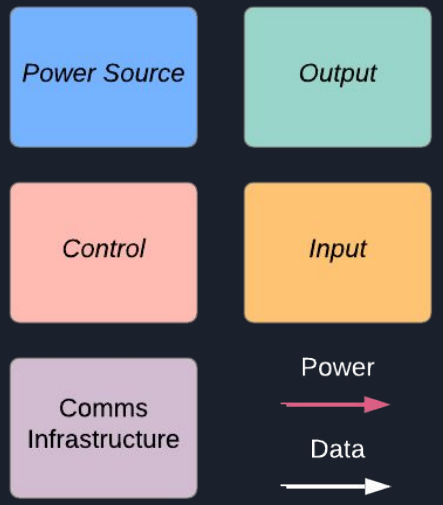
Input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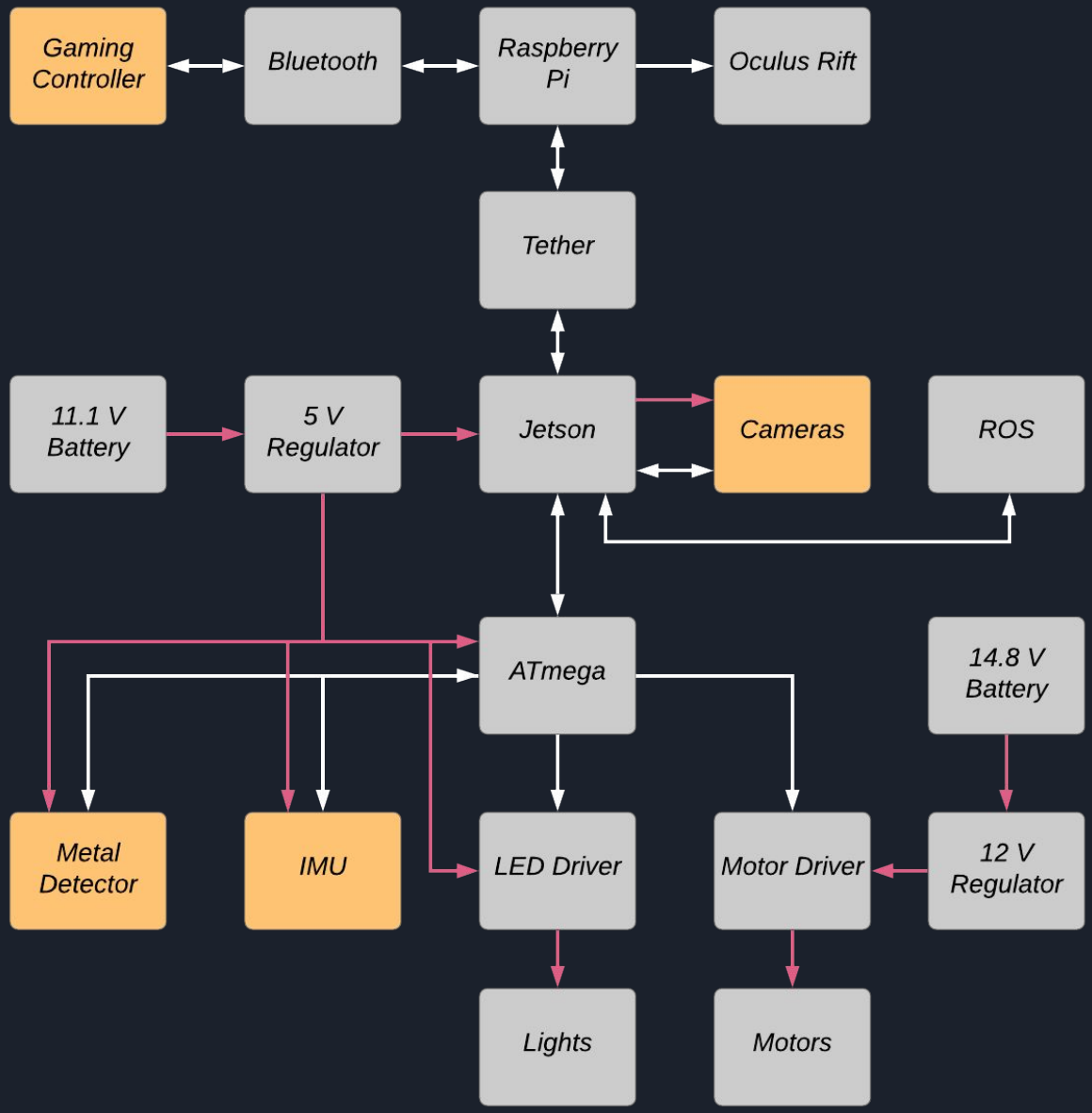
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LED Driver
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12 V Regulator
Lights
Motors

TR

Cameras

- The Sony IMX219 sensors allow for 3264 by 2464 image capture
- 200 degree field of view on lens
- Allows for omnidirectional video capture with only two cameras

JC

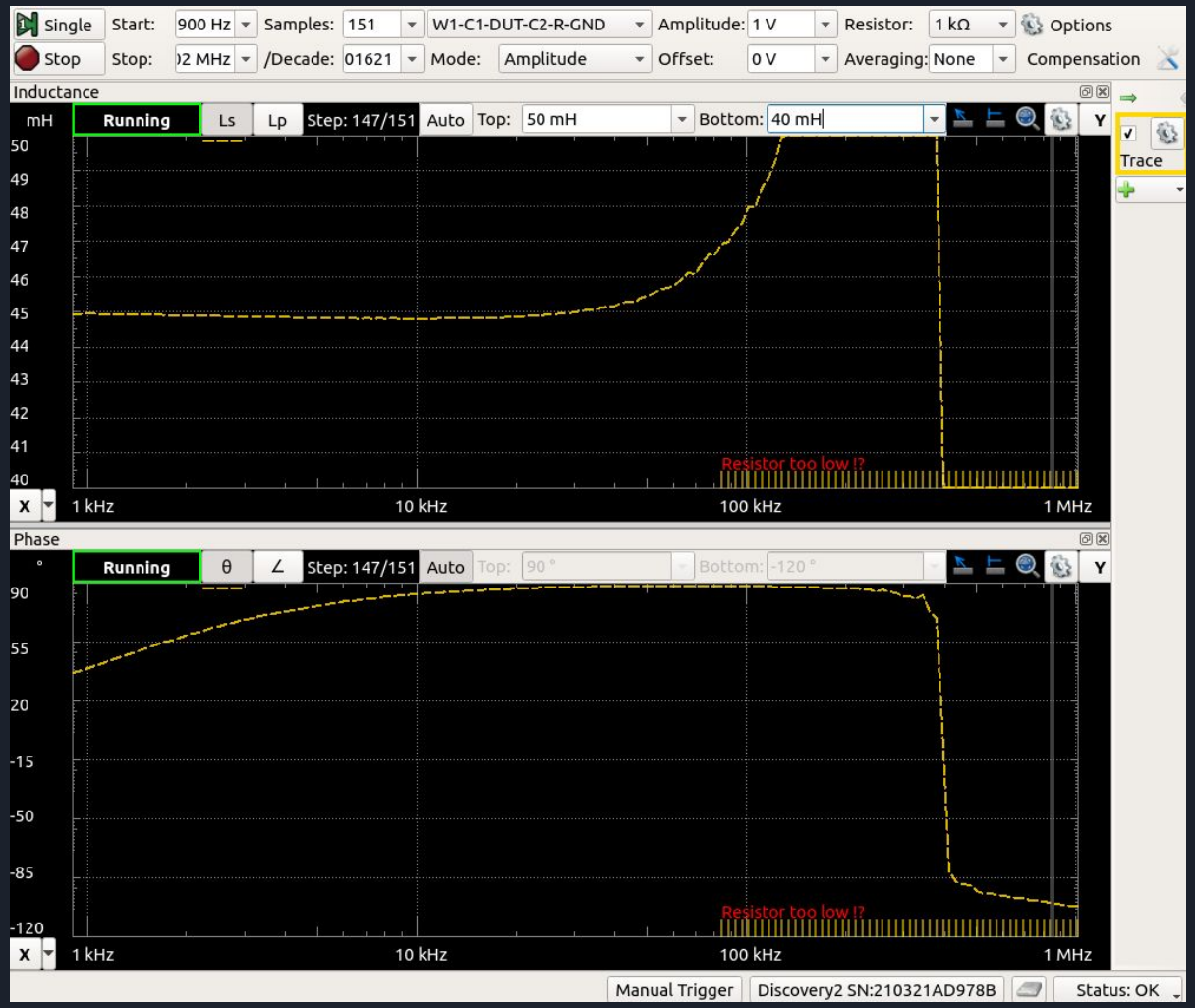
Metal Detector Prototyping

A 200 turn coil at a diameter of 50mm was built for testing.

SR

Metal Detector Prototype Analysis

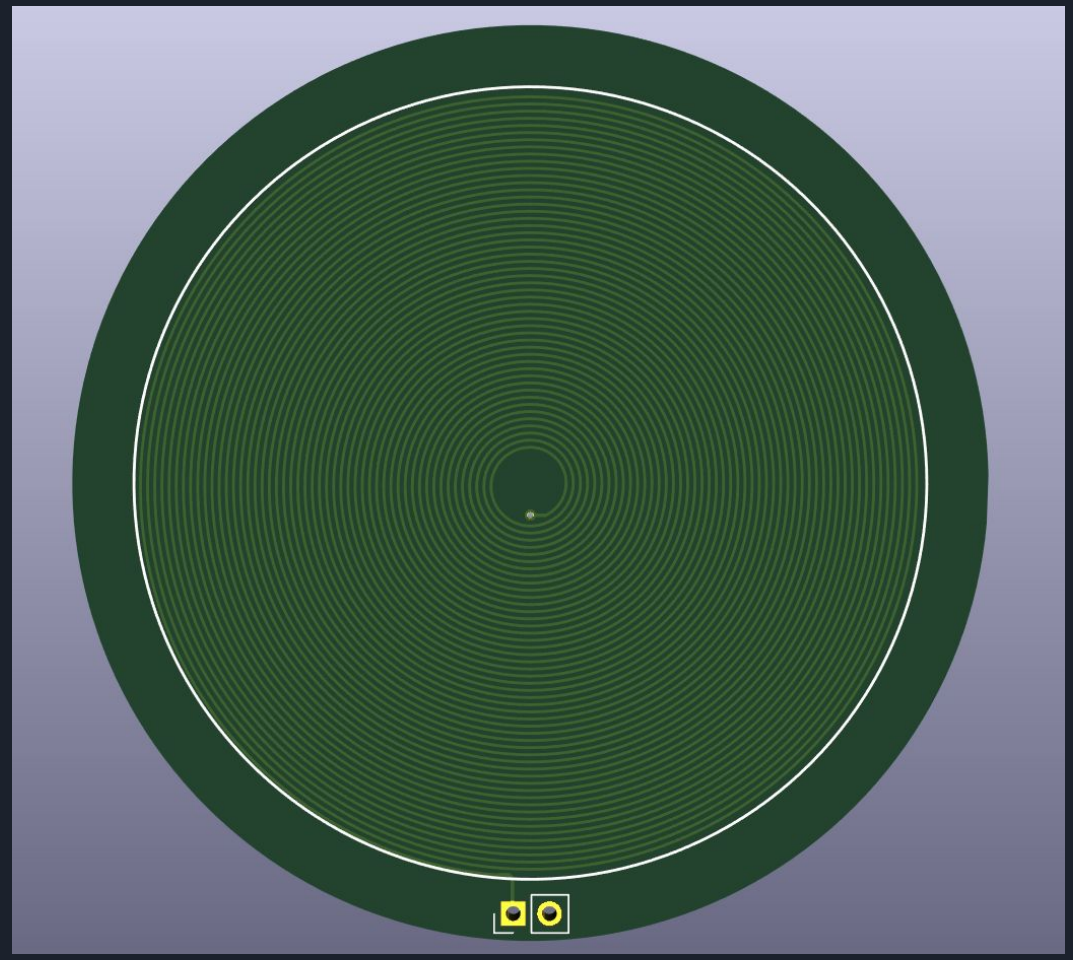
- The hand wound coil is shown to have an inductance of 44.7mH.
- With a pair of pliers 1 cm from the coil, the inductance becomes 47.6mH
- This is a 6.4% increase in inductance and will impact the oscillation frequency



JC

Metal Detector Coil

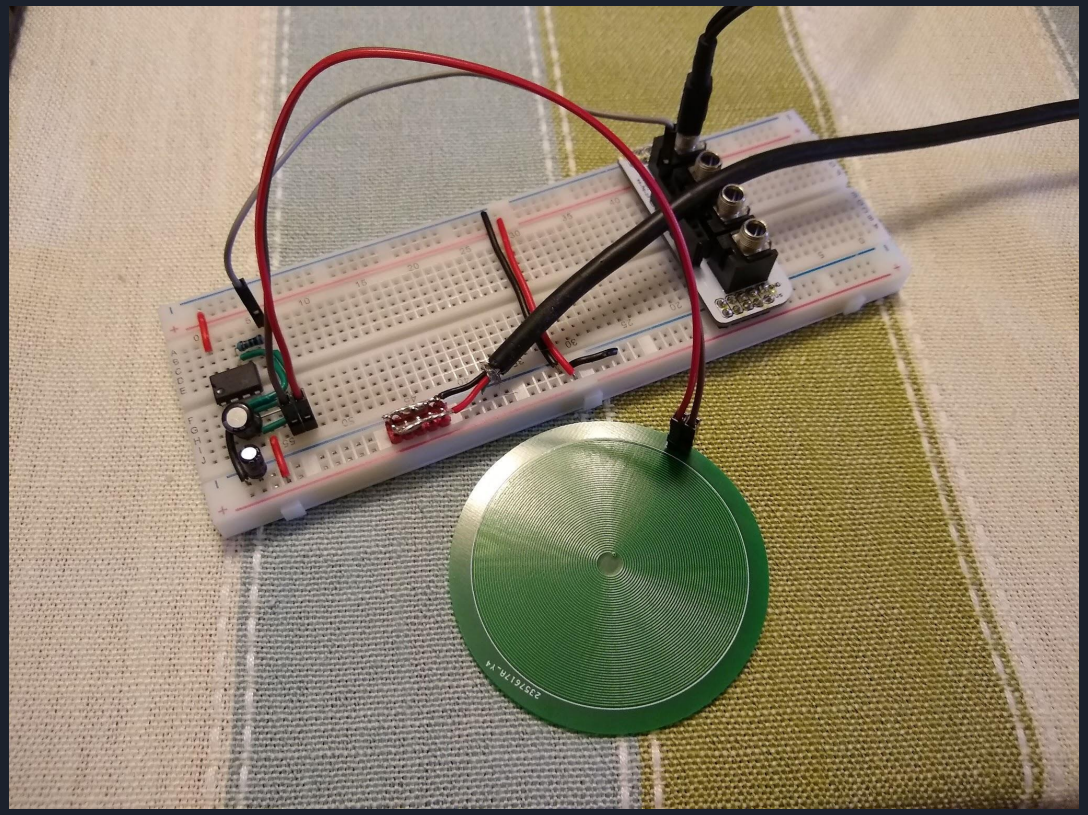
- A 100 turn coil was laid out to provide a more rigid, repeatable, and uniform test unit.
- A two layer PCB forces us to lay out the coil in a spiral, with each turn being a different radius than its neighbor.
- The inner coils contribute to the system's sensitivity less than the outer coils



JC

Metal Detector PCB Coil Assembled

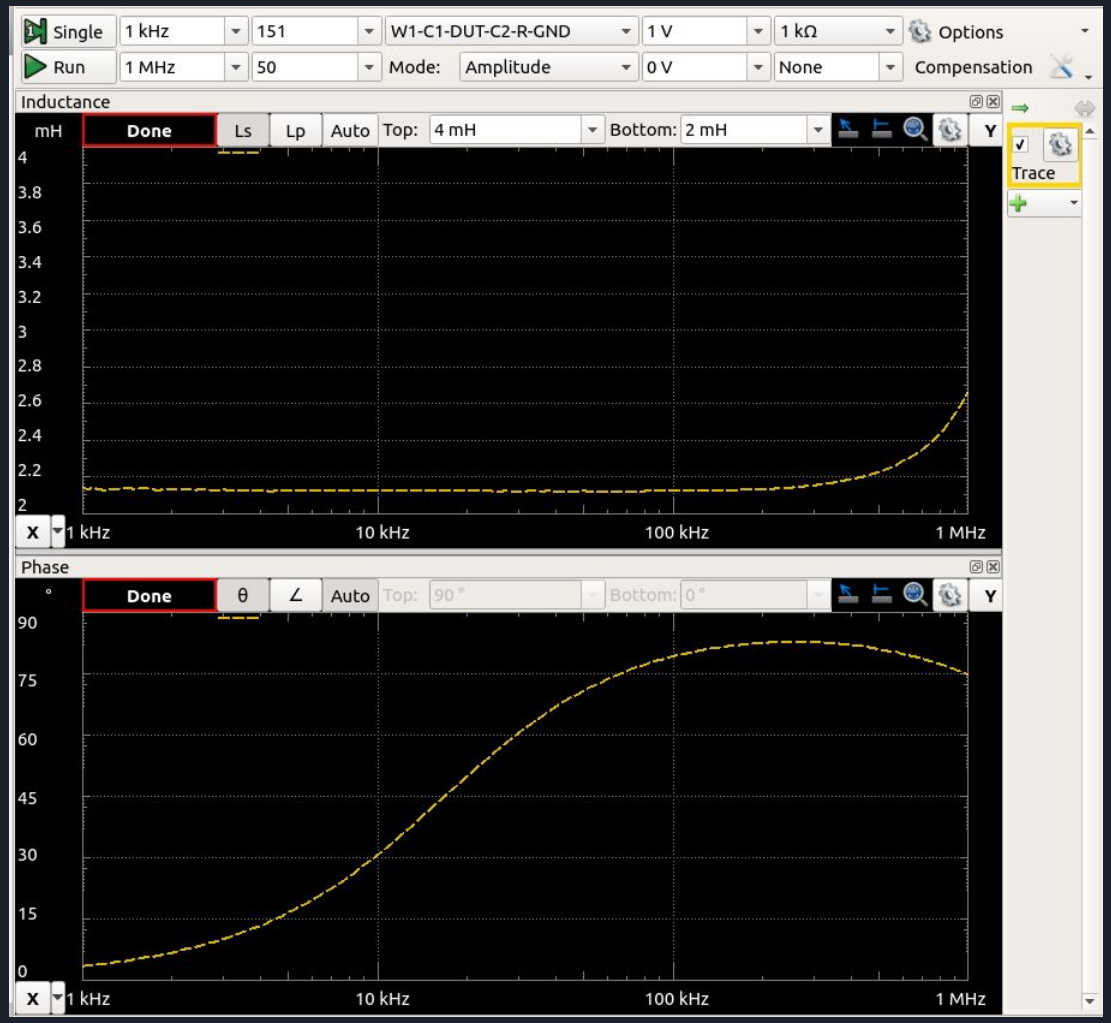
The breadboarded oscillator continues to function with the new PCB coil.



JC

Metal Detector PCB Coil Testing

- The PCB coil is shown to have an inductance of 2.12mH
- With a pair of pliers 1cm away, we see an inductance of 2.31mH
- This is an 8% increase in inductance, and should affect a change in the oscillator

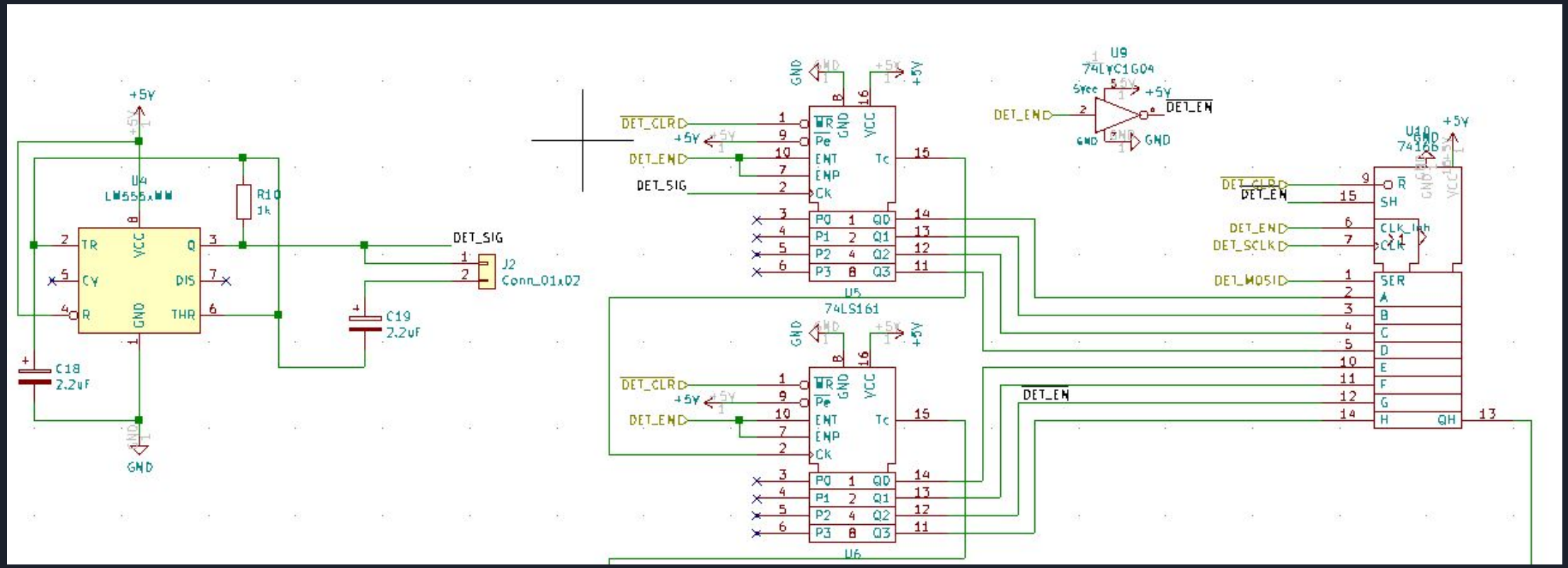


JC

Metal Detector Driver

Discrete. 16 bit pulse counter with serial output for measuring oscillator frequency

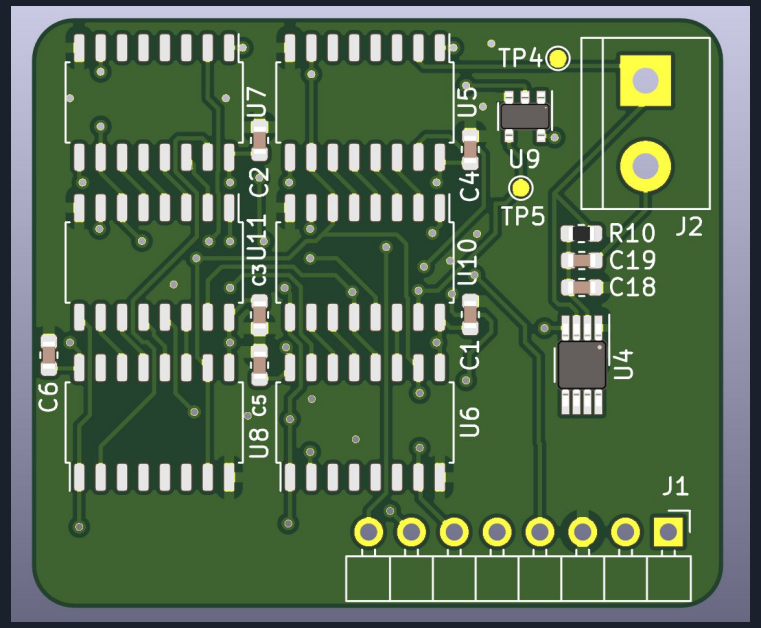
Digital interface allows for longer transmission distances than separating the coil from the oscillator would

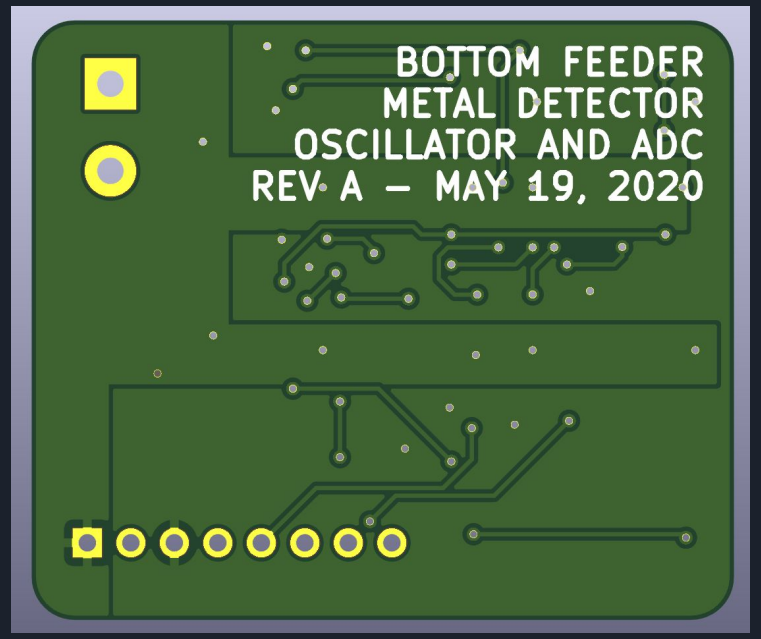


JC

Metal Detector Breakout Driver

- The oscillator portion has been tested and functions as expected.
- In an effort to future-proof the design, a 12V line was added to the connector, although this was not needed in our case
- This modular board is breadboard compatible allowing for system tuning and distributed work due to COVID-19

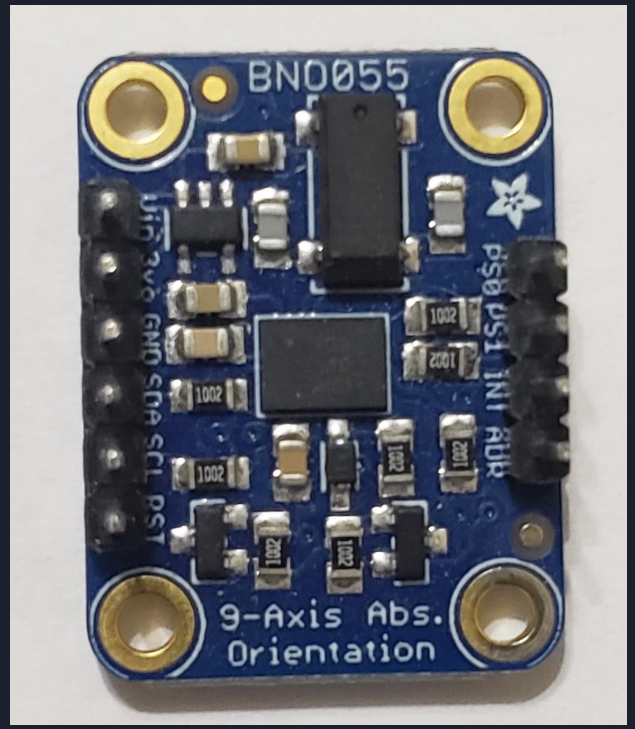




JC

Inertial Measurement Unit - BNO055

- Gives orientation information to help ROV keep level while in use
- I2C communication with microcontroller
- Powered using 5V line from microcontroller



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Inertial Measurement Unit - Testing

Orientation Sensor Raw Data Test

Current Temperature: 32 C

Calibration status values: 0=uncalibrated, 3=fully calibrated

X: 0.00 Y: 0.00 Z: 0.00	CALIBRATION: Sys=0 Gyro=0 Accel=0 Mag=0
X: 295.19 Y: 2.56 Z: 89.31	CALIBRATION: Sys=3 Gyro=3 Accel=3 Mag=3
X: 285.00 Y: -2.56 Z: 82.31	CALIBRATION: Sys=3 Gyro=3 Accel=3 Mag=3
X: 272.44 Y: -8.94 Z: 73.62	CALIBRATION: Sys=3 Gyro=3 Accel=3 Mag=3
X: 259.50 Y: -15.31 Z: 66.37	CALIBRATION: Sys=3 Gyro=3 Accel=3 Mag=3
X: 243.56 Y: -22.19 Z: 54.75	CALIBRATION: Sys=3 Gyro=3 Accel=3 Mag=3

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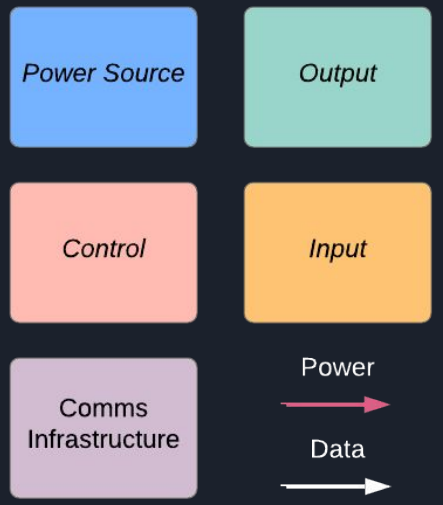
Control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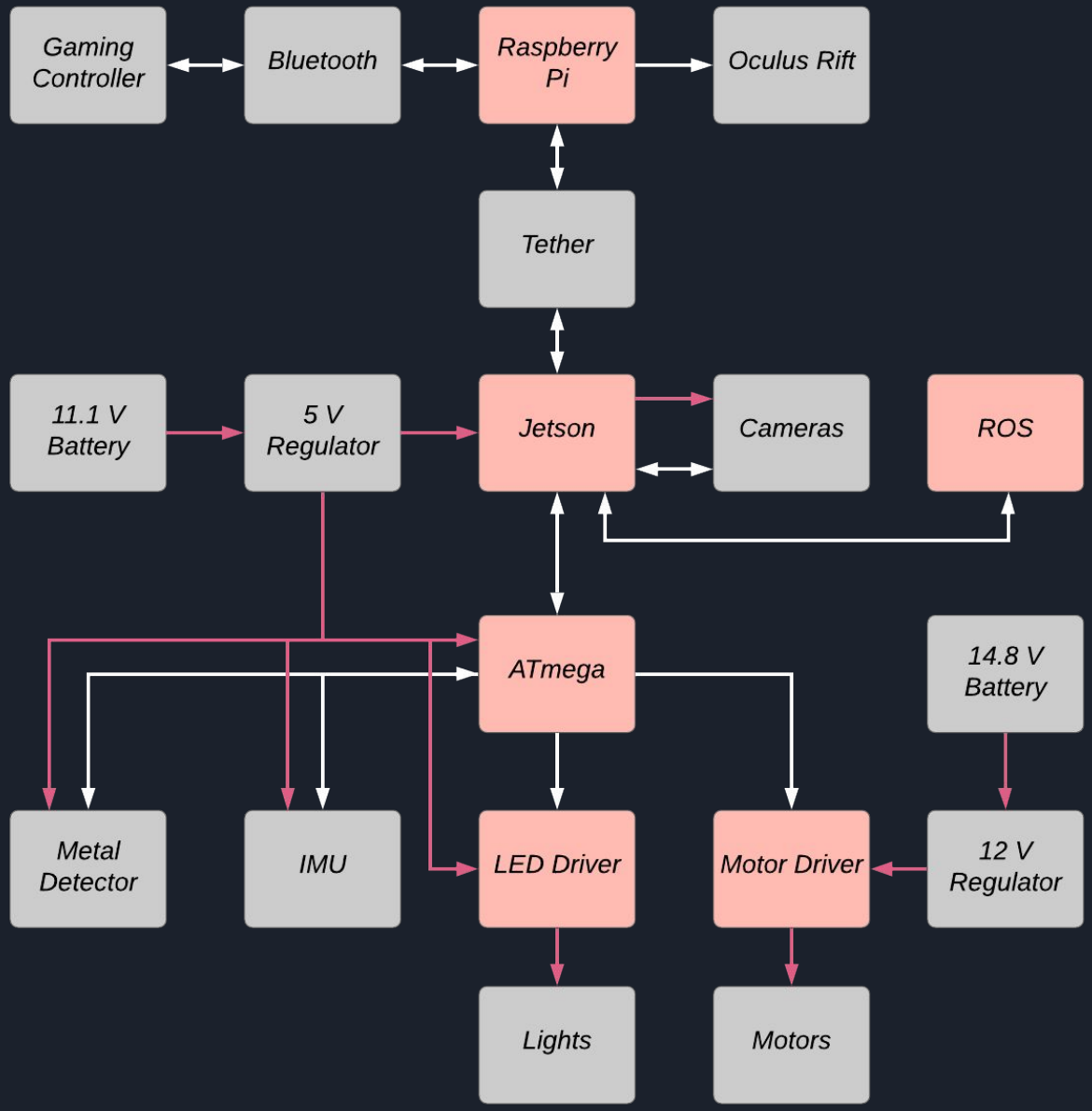
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14.8 V Battery
Metal Detector
IMU
LED Driver
Motor Driver
12 V Regulator
Lights
Motors

TR

Nvidia Jetson Nano

- Main onboard computer for ROV
- Handles all video capturing and processing
- Sends video feed to surface station
- Receives input commands from surface station and relays them to microcontroller
- Relays sensor information from microcontroller to surface station

TD

Robot Operating System (ROS)

- Standard for robotics software development
- Low-level framework for interprocess communication
- Plug and play libraries
- Using ROS Melodic Morenia built on Ubuntu 18.04
- ROS code is written using Python or C++

http://wiki.ros.org/melodic

TD

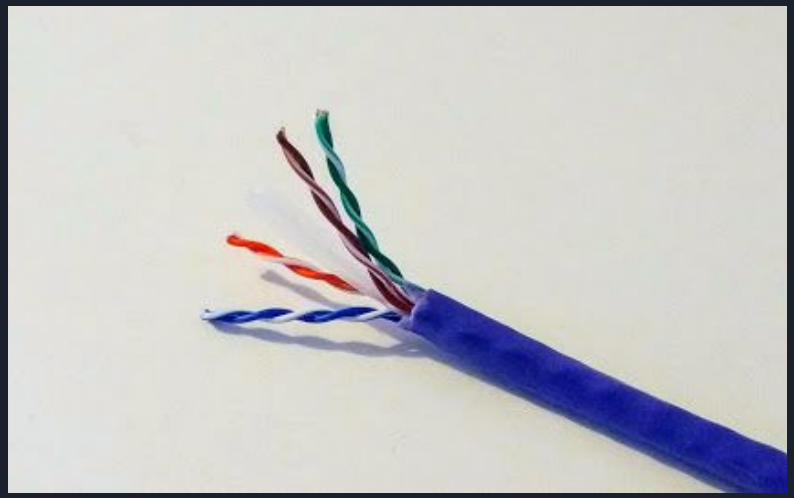
Microcontroller - ATmega2560

- Connects to ROV using UART
- Sends control signal to motor driver boards
- Receives sensor data
- Programmed using an AVR programmer

TD

Tether

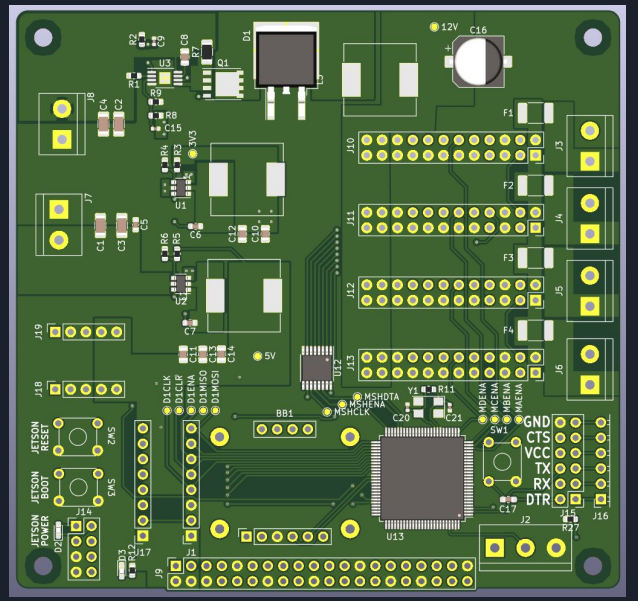
- More than 30 meters of stranded Cat 6 Ethernet cable will be used for signaling.
- Chosen for cost-efficiency

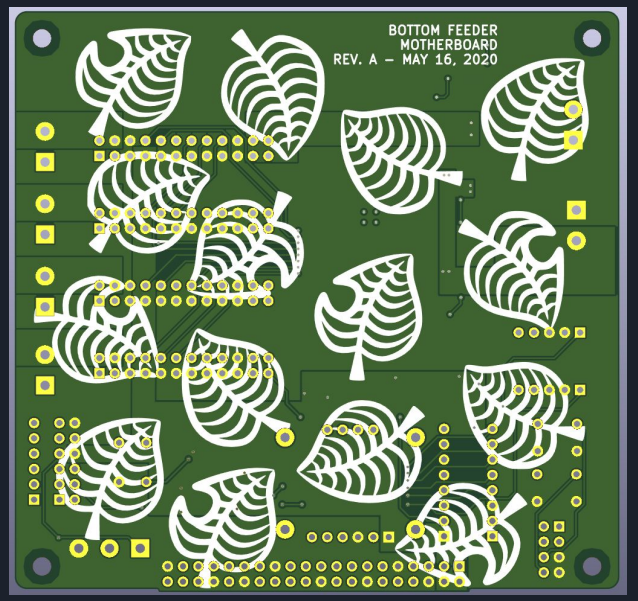


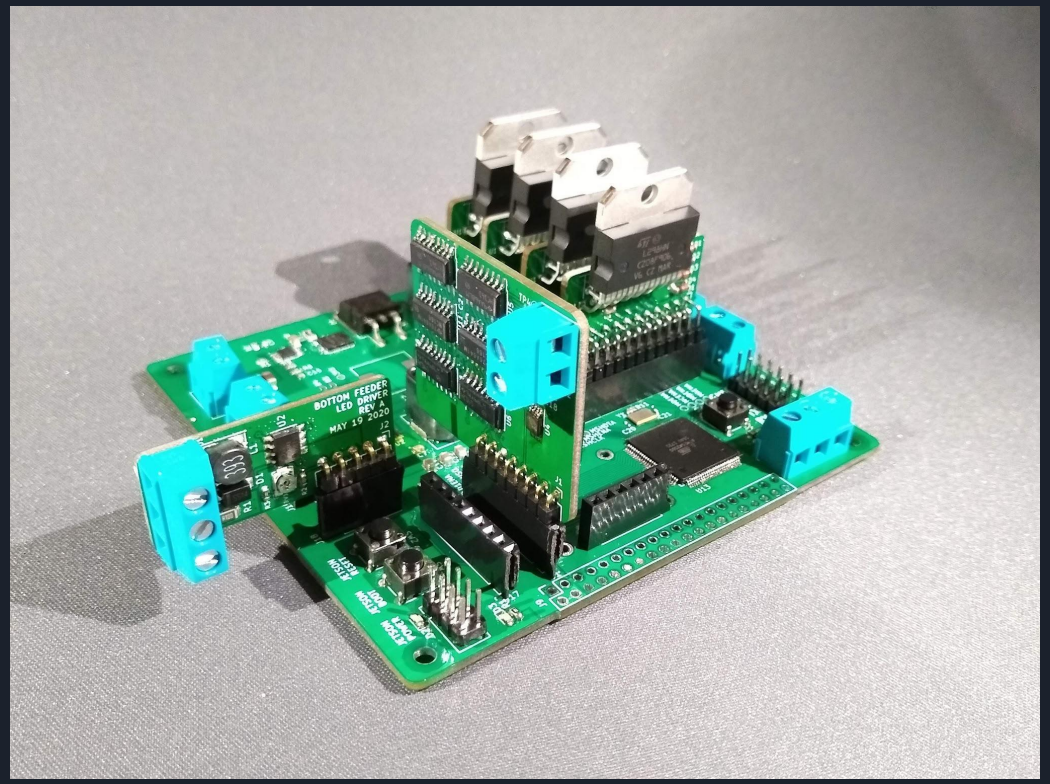
SR

Main Logic Board

- Breakout connectors for all modules
- Included Jetson control features
- ATmega programmable via ICSP







JC

Extra Mechanical Components

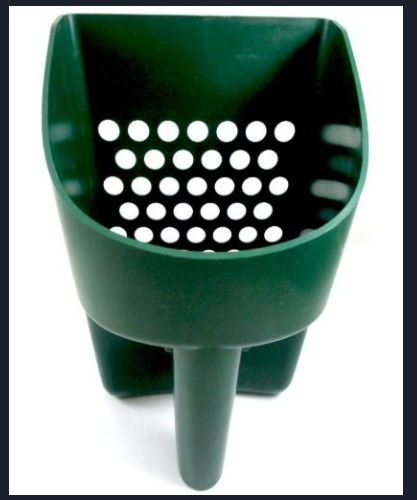
(to be purchased)

Housing/frame

- Electrical components will be held in a waterproof, sealed, modified box.
- Frame will be made from PVC
- Cost-efficient materials chosen

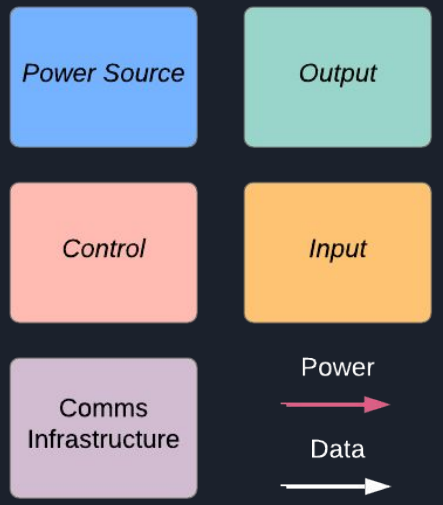
Object Retrieval

- Scooping device attached to the bottom of our ROV



SR

Power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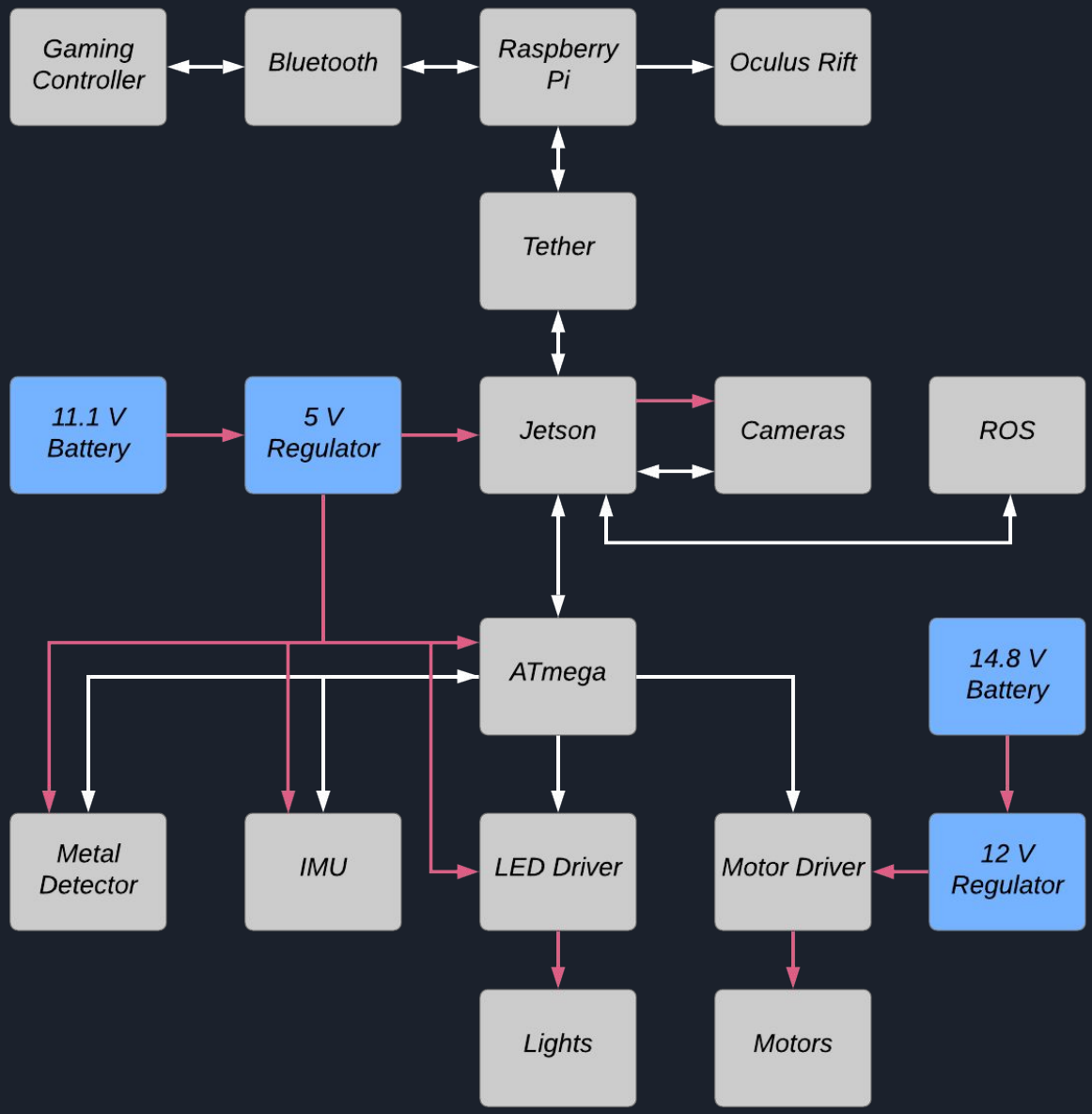
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IMU
LED Driver
Motor Driver
12 V Regulator
Lights
Motors

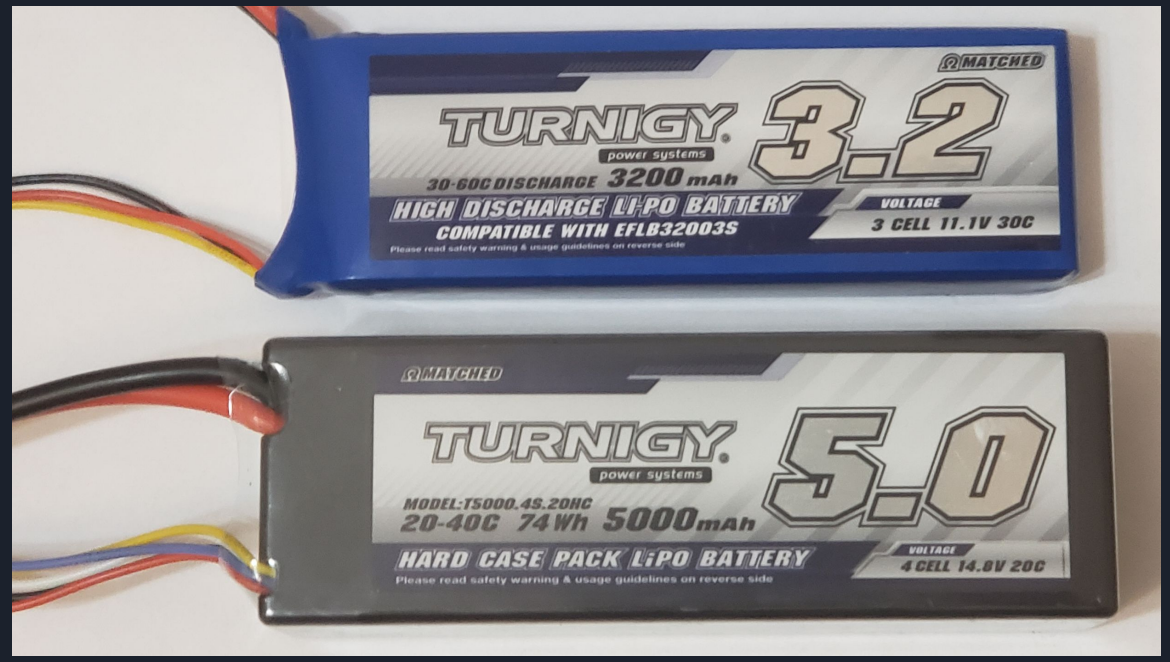
TR

Batteries

- We are using 2 different batteries on the submerged system
- Top battery: Used for lower power devices ($23)
- Bottom battery: Used for higher power devices ($38)
- A single comparable battery would cost ~$100

Top powers: Lights, IMU, Jetson

Bottom powers: Motors, Metal Detector



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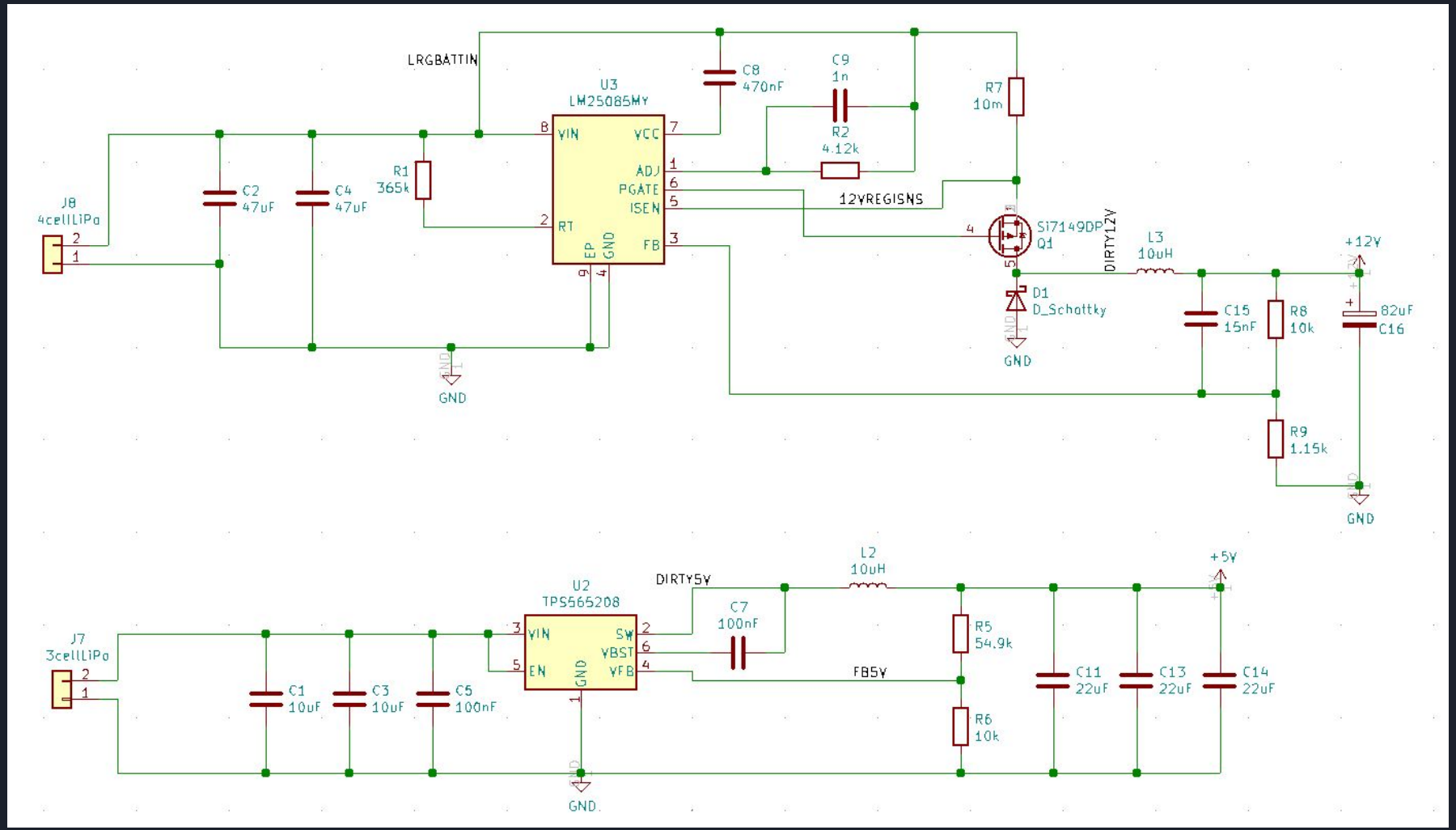
Regulators

- TI WEBENCH Power Designer was used for Supply Design
- 12V supply capable of delivering 10A
- 5V supply capable of delivering 3A



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Financing to date

Part	Cost	Total Cost
Jetson Nano and related parts	$151.03	$151.03
Cameras	$103.39	$254.42
RJ45 components	$23.23	$277.65
Pressure Sensor	$23.80	$301.45
Bilge pumps and components	$93.50	$394.95
LEDs and Reflectors	$35.24	$430.19
Batteries	$65.50	$495.69
PCB	$53.25	$548.94
Mouser Components	$101.28	$650.22
Miscellaneous	$40.00	$690.22

Financing to end of Project (projected)

Part	Cost	Total Cost
Housing	$40	$730.22
Frame	$20	$750.22
Scooper	$12	$762.22
V2 PCB	$60	$822.22
Mouser Components	$100	$922.22
Miscellaneous	$50	$972.22
Grand Total	$972.22	

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Constraints

Economic

- COVID-19 pandemic stunted potential sponsorships.
- Completely self-funded and a need for budget components while still meeting expected criteria.

Environmental

- Important to push production and the recycling of electronics towards a sustainable endpoint.
- Modular systems help.

Legal

- Metal detecting is prohibited in national parks and other federal lands.
- There are several laws pertaining to metal detecting and our team must ensure that we have permission to use our ROV in any desired location.

Constraints Continued

Health and Safety

- Lithium Polymer in batteries. Special care is needed to make sure they don't become submerged in water or pierced.
- The head mounted display can create feelings of vertigo or nausea. Special care must be taken.
- Electrical components must never be exposed to the water, otherwise electrocution may occur.

Manufacturability

- Our housing must be able to handle the force being exerted on it underwater.
- Electrical components must stay dry.
- Buoyancy needs to be considered for stability. Neutral buoyancy desired.
- Motor placement must also be considered for structural stability.

Ethical

- It's important that when we're exploring waterways that the natural ecosystem remains undisturbed.

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Table of Related Standards

Standard Type	Description
Battery	IEEE 485-2010 recommended practice for sizing lead-acid batteries
PCB	IPC-a-610 and IPC-A-630
Bluetooth	Bluetooth 5.0, data transfer speed of 2Mbps
H.264 AVC	H.264 supports up to 4k and 8k video playback
360 Video Formats	The photosphere is warped into an equirectangular projection
RoHS	RoHS 3 contains substance limitations of hazardous materials such as lead < 1000 ppm
CAT-6	Sixth generation of twisted pair Ethernet cabling and proceeds its predecessors in cross talk and system noise
I^2C	I^2C supports up to 1008 slave devices and communicates at a rate of 100kHz or 400kHz.
UDP/IP	Used for video playback. Headers have four two byte fields
STL	Gives the geometry of the surface of an object's surface

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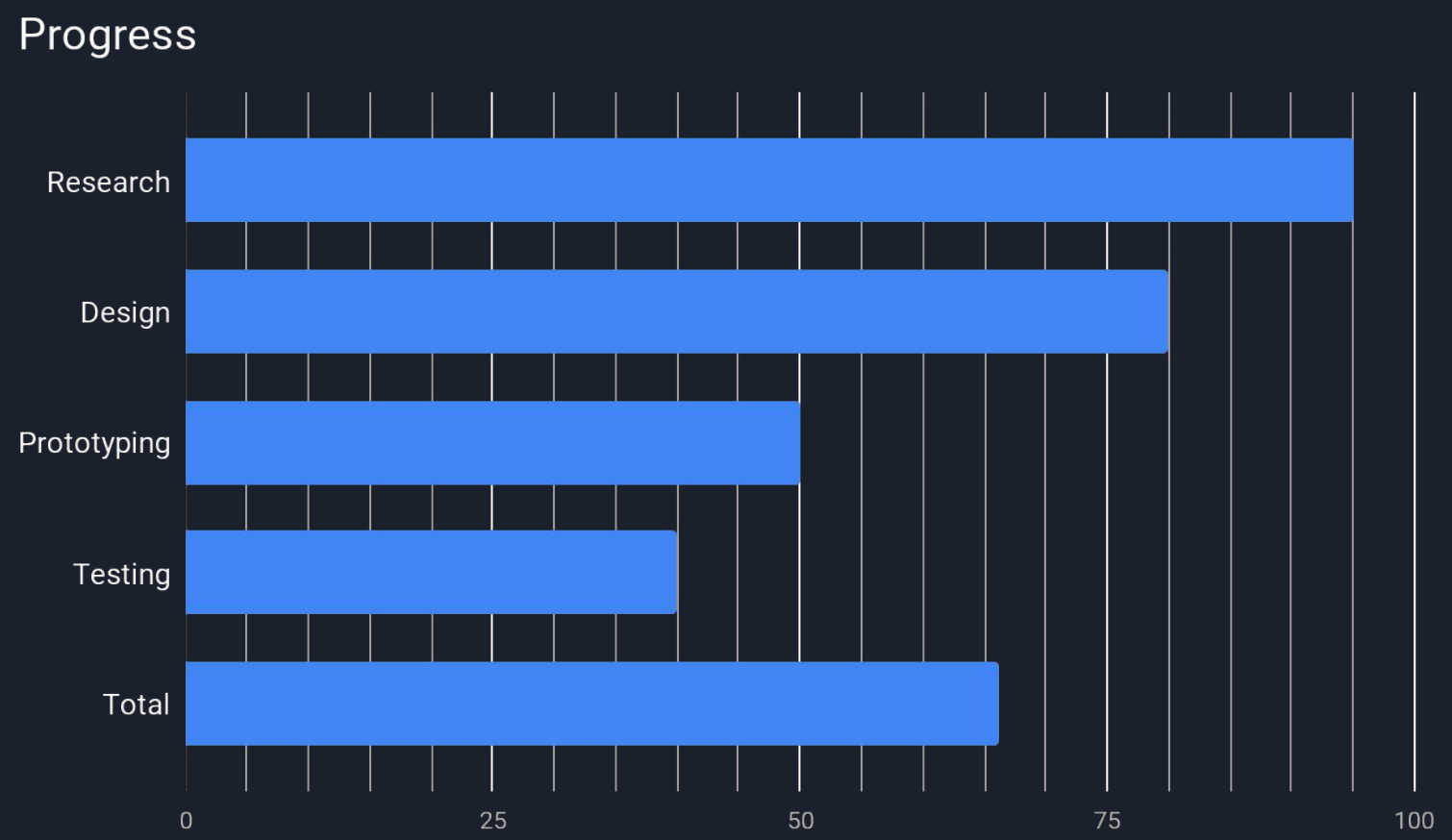
Percent Done by Category



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Plans for Completion

Week of	Objectives
6/1/2020	CDR due 6/4, V1 Prototypes assembled and testing begins
6/8/2020	Project Summary due 6/12
6/15/2020	All additional parts to be ordered
6/22/2020	V2 PCB ordered
6/29/2020	V2 PCB assembly
7/6/2020	Housing and waterproofing
7/13/2020	8 Page Conference Paper and Committee Form due 7/17
7/20/2020	Final presentation due 7/20, Presenting 7/21-7/22
7/27/2020	Final document due 7/28

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Questions?

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