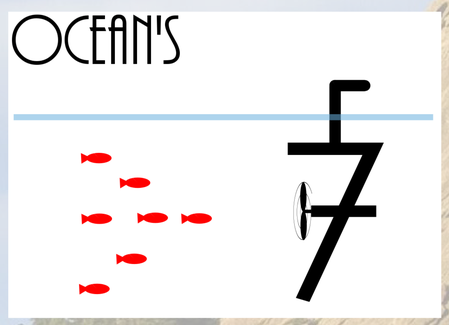
University of Colorado Boulder

Ocean's Seven

Hasan Alahmed, Abbigail Caballero, Kyle Harlow, Daniel Henderson,
Yuvin Kokuhennadige, Cassandra Noice

Sponsored by the CU Robotics Club



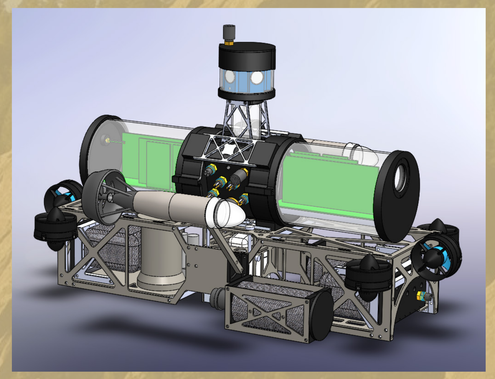
Power, Backplane & Controls System for RoboSub

Controls Requirements

- Pitch, Roll, and Yaw
- Velocity
- Depth

Success Criteria

- Settle Time: 5 seconds
- Overshoot: 10%
- Reject Step Disturbance

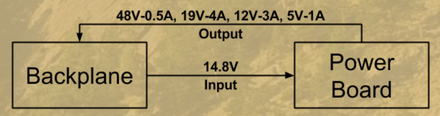


RoboSub Background

Activated charcoal fingerstache kitsch distillery man braid. Food truck lyft intelligentsia heirloom hot chicken. Schlitz artisan kitsch, blue bottle roof party air plant lumbersexual four loko neutra. Cornhole polaroid selfies hexagon twee chartreuse, mixtape salvia semiotics cold-pressed roof party forage chia. Narwhal asymmetrical hashtag paleo, pok pok art party pitchfork cornhole flannel beard pop-up butcher

Power Requirements

- Receives a 14.8V line from the backplane board.
- Must deliver five different power outputs to the backplane.

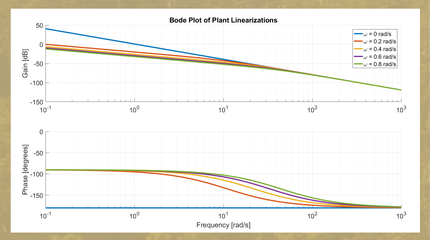


Plant Analysis

- Drag makes system non-linear, therefore harder to develop a controller
- Linearize Plant around specific operating points thetadot
- Develop controllers individually and use gain scheduling

$$m\ddot{\theta} = U - \frac{1}{2}\rho C_d A\dot{\theta}^2$$

caption 1



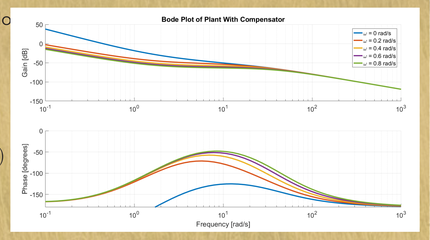
caption 2

Controller Design

- Stability concerns for thetadot ~= 0
- Drag: acts as a differential term
- Integrator: unfeasible
  - Third pole at omega = 0 rad/s destabilizes system when omegado ~= 0 rad/s
  - PM ~= -90 degrees
- Gain Scheduled Lead Lag Compensator
  - Boost phase margin at omega ~= 10 rad/s
  - Boost gain margin

$$c(s) = \frac{(s+2.68)(s+1)}{(s+37.32)(s+0.01)}(69.64 + 176.89|\dot{\theta}|)$$

caption 3



caption 4

Controls Board

Software

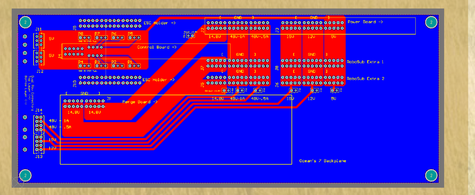
- Makes use of the STMicroelectronics HAL (Hardware Abstraction Layer) libraries
- Implements UART communication, 8 simultaneous PWM signals
- Performs controls algorithms as data is received, ~10-20 Hz

Hardware

- Custom PCB
- STM32F767Z1 ARM M7 microcontroller
- FT232 UART/USB converter to communicate with robosub main PC
- Power conversion: 5V to 3.3V
- JTAG programming interface

Backplane

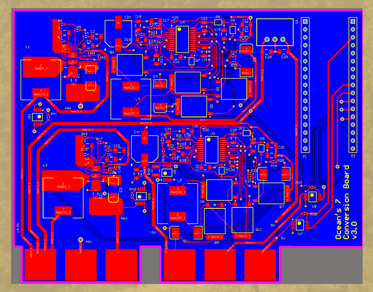
- Provide connectivity and stability to merge board, ESC holders, control board and power conversion board.
- Takes in 14.8V at 40A from current merge circuit.
- Delivers 5V, 12V, 19V, and 48V from the power conversion board to the controls system, CPU, and sensors.
- Provide PWM from the controls system to ESCs.



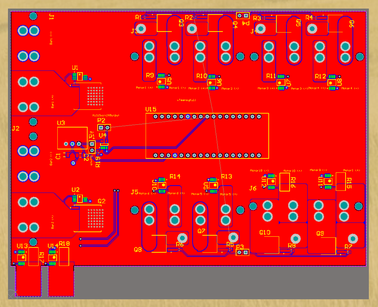
PCB layout for the Backplane

Power Board

Pabst skateboard snackwave gastropub, kale chips listicle freegan iceland. Kogi four dollar toast sustainable, butcher roof party XOXO PBR&B church-key brunch direct trade. Pour-over normcore whatever, kogi mumblecore plaid blue bottle pok pok. Photo booth trust fund succulents



PCB layout for the Power board



PCB layout for the Merge board

Merge Board

- Current controlled positive high voltage ideal diode controller (Current merge circuit) to get a 200A output from two 100A batteries at 14.8V.
- 14.8V, 140A output for motors through kill switch to turn off the motors for safety.
- Current sensing using current shunt monitors and Arduino microcontroller.