Ocean's Seven

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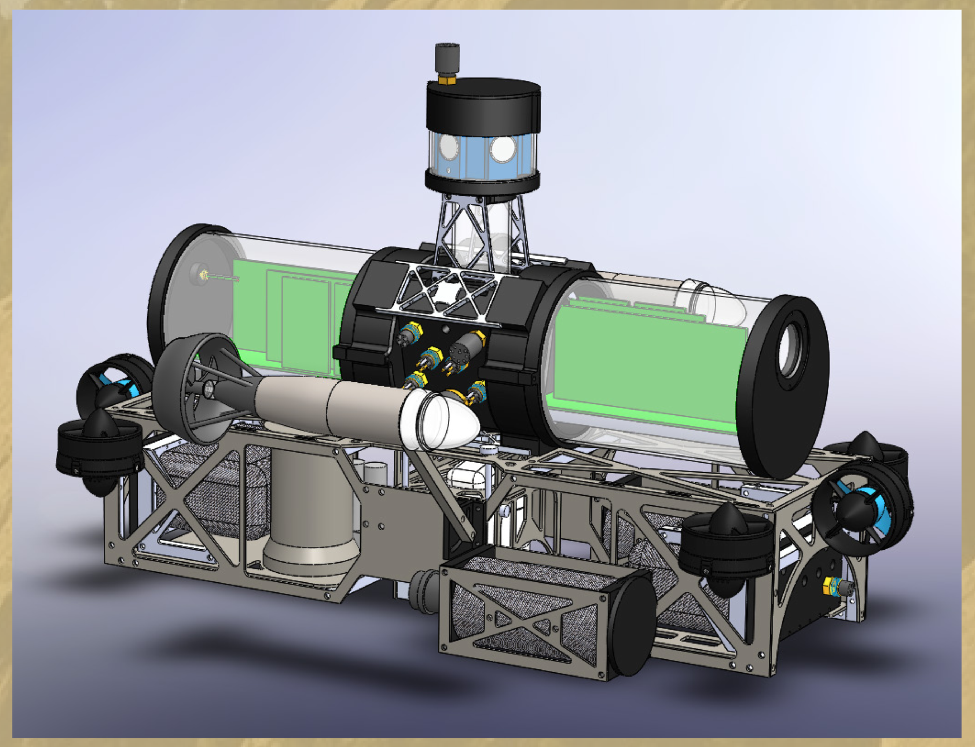
Power, Backplane & Controls System for Leviathan

Controls Requirements

- Pitch, Roll, and Yaw
- Velocity
- Depth

Success Criteria

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



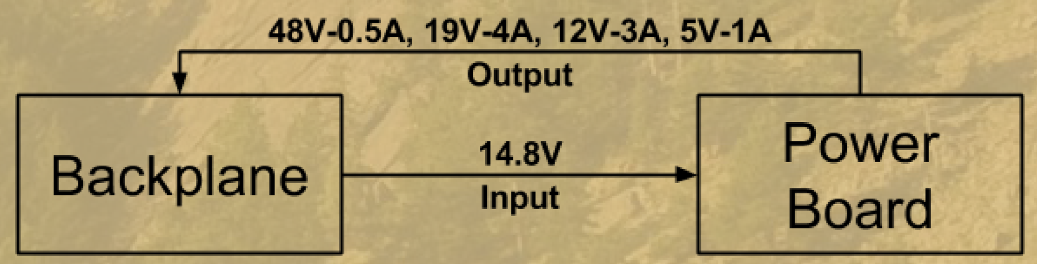
RoboSub Background

The University of Colorado – Boulder Robosub Team has been competing in the AUVSI Robosub Competition for four years.

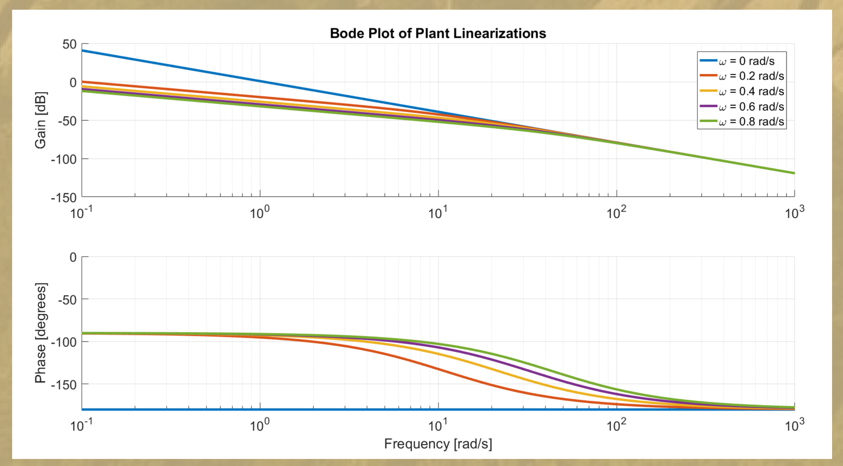
For Robosub competition student teams from around the world build autonomous robotic submarines which compete in a rigorous underwater obstacle course, which simulates real world tasks robots may be expected to perform.

Power Requirements

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



Plant Analysis



Bode Plot of plant dynamics for yaw controller linearized at $\dot{\theta}$ = 0, 0.2, 0.4, 0.6, 0.8

- 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

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

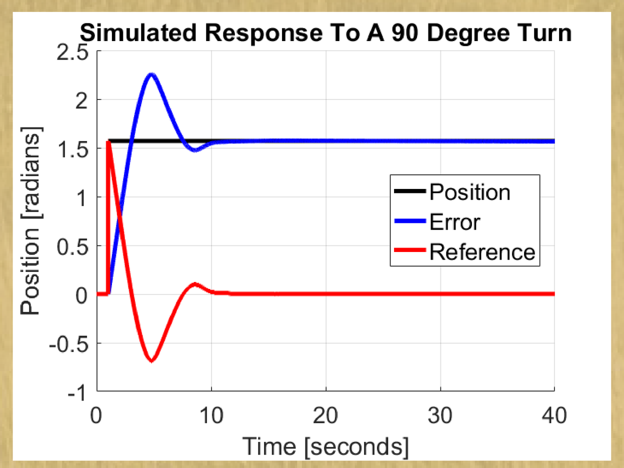
ODE of Plant Dynamics

Controller Design

- Stability concerns for $\dot{\theta} \approx 0$
- Drag: acts as a differential term
- Integrator: unfeasible
  - Third pole at ω = 0 rad/s destabilizes system when $\dot{\theta} \approx 0$ rad/s
  - PM ≈ -90 degrees
- Gain Scheduled Lead Lag Compensator
  - Boost phase margin at ω ≈ 10 rad/s
  - Boost gain margin

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

Final Controller Design



Closed loop step response of plant and controller

Controls Board

Software

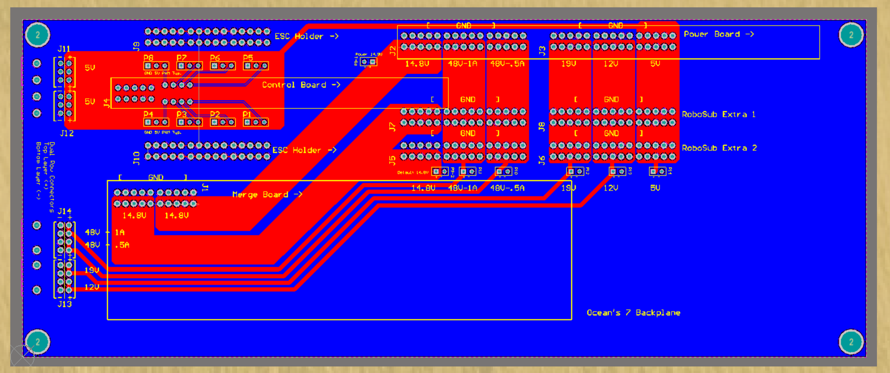
- Makes use of the STMicroelectronics HAL (Hardware Abstraction Layer) libraries
- Implements UART communication, 8 simultaneous PWM signals
- Performs controls algorithms as data is received, ~10-20 Hz

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

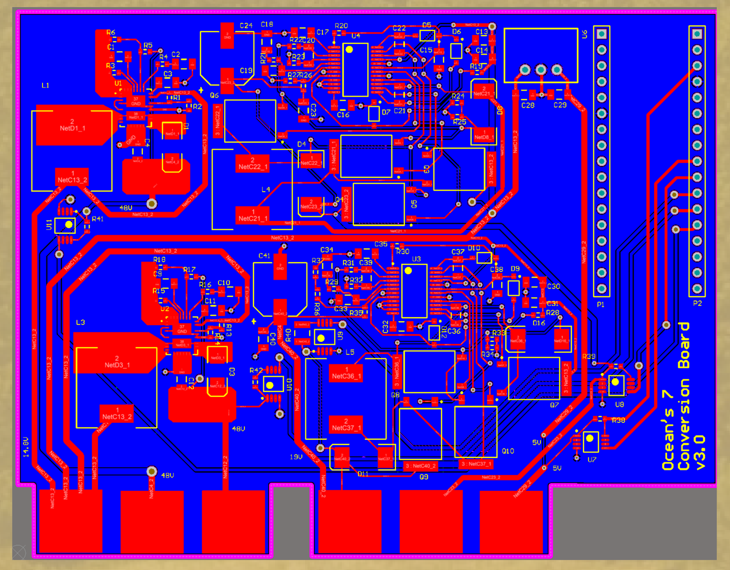
- Provide connectivity and stability to merge board, ESC holders, control board and power conversion board
- Takes in 14.8V at 40A from current merge circuit
- Delivers 5V, 12V, 19V, and 48V from the power conversion board to the controls system, CPU, and sensors
- Provide PWM from the controls system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



PCB layout for the Backplane

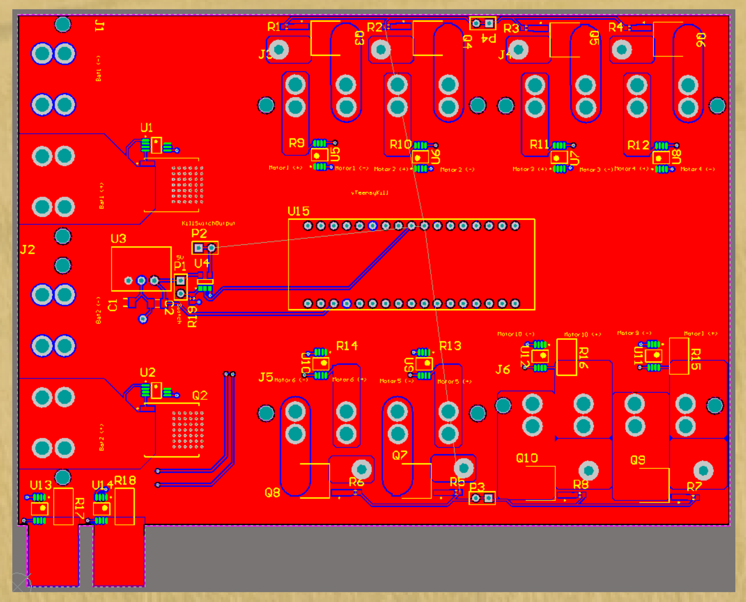
Power Board

- 5V with maximum current draw of 1A for digital components
- 12V with maximum current draw of 3A for electromechanical actuators
- 19V with maximum current draw of 4A for main computer
- 48V with maximum current draw of 0.5A for Doppler Velocity Logger (DVL)
- 48V with maximum current draw of 0.5A for a camera through Power over Ethernet (PoE)
- Current sensing using current shunt monitors and Arduino Micro



PCB layout for the Power board

Merge Board



PCB layout for the 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 Micro