Submersible Ballast Control

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Automated submarine uses:

There are many different uses for submarines. A few of these include:

- Underwater detection
- Security
- Search and rescue
- Air crash investigation

Military: *Discover and terminate underwater mines*

Scientists: *Study lakes, the ocean, and the ocean floor*

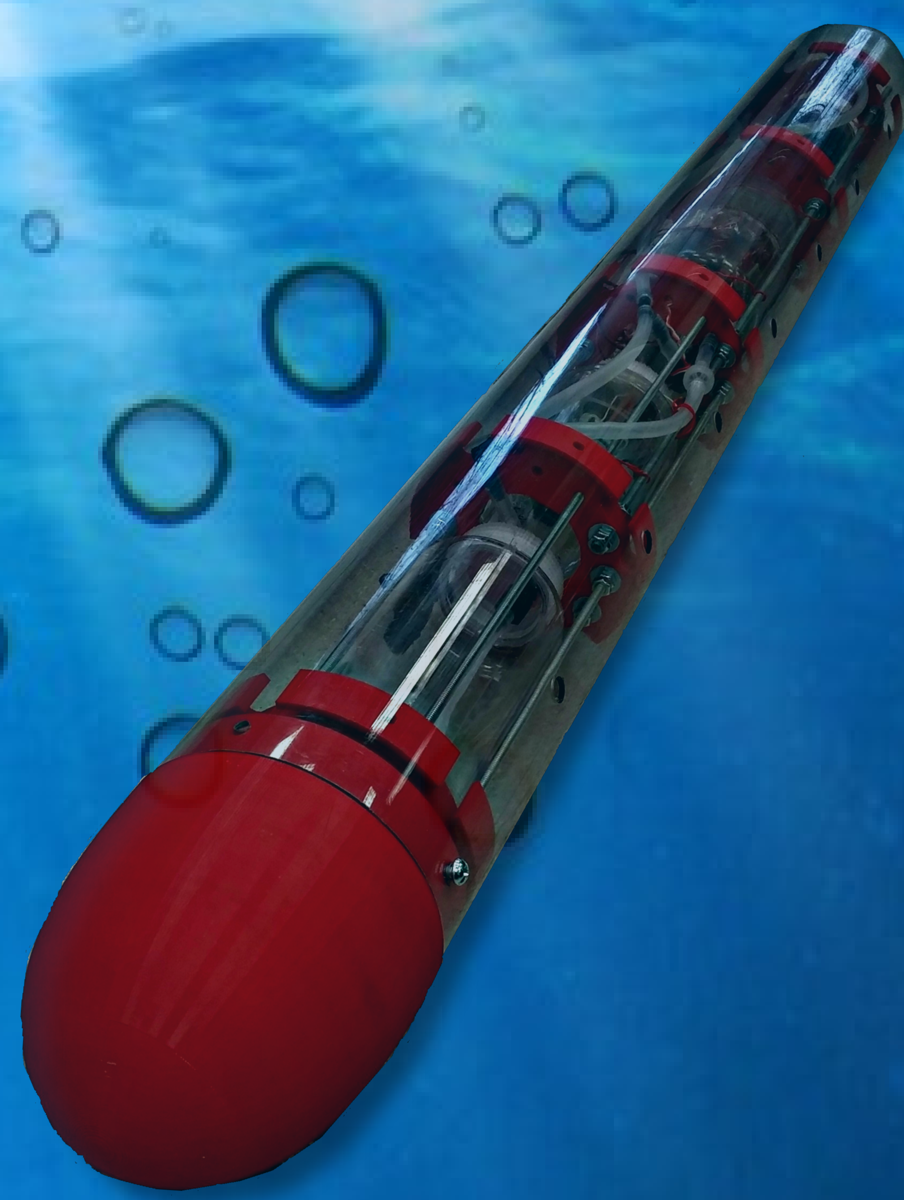
Oil and gas industry: *Make detailed maps of the seafloor before building subsea infrastructure*

Our use:

Testing proportional control using the submarines ballast control system that was built last semester by a previous engineering senior design team.

That is…

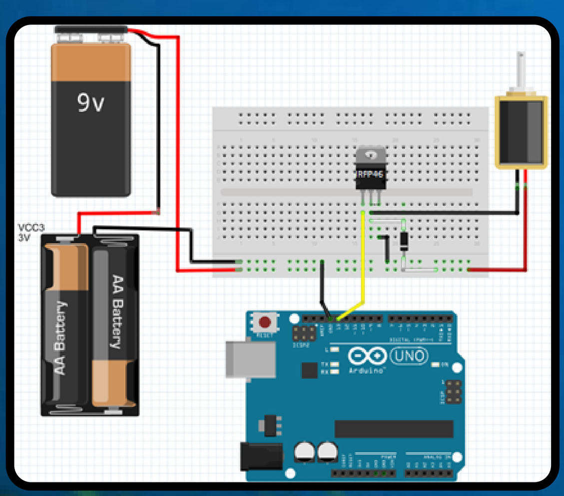
Getting this system to sink to a specific depth with a resolution of ±10 cm.

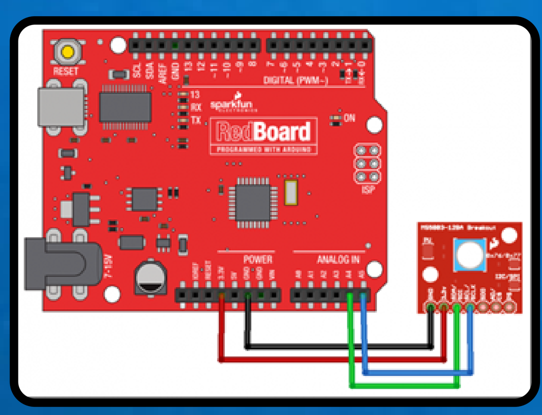


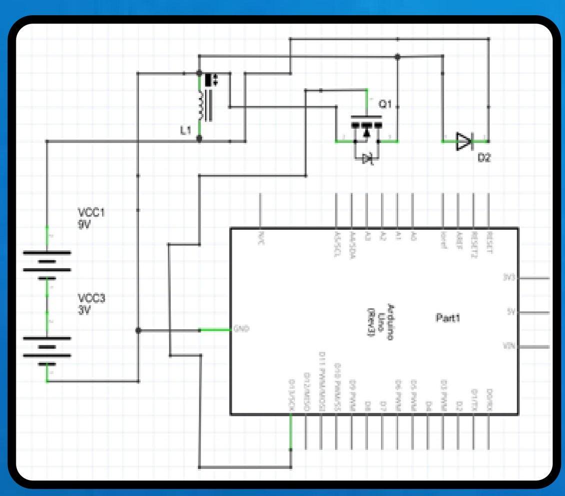
The Set-up:

- Arduino Uno R3
- Pressure sensor
- Solenoid valve circuit
- Two pump circuits

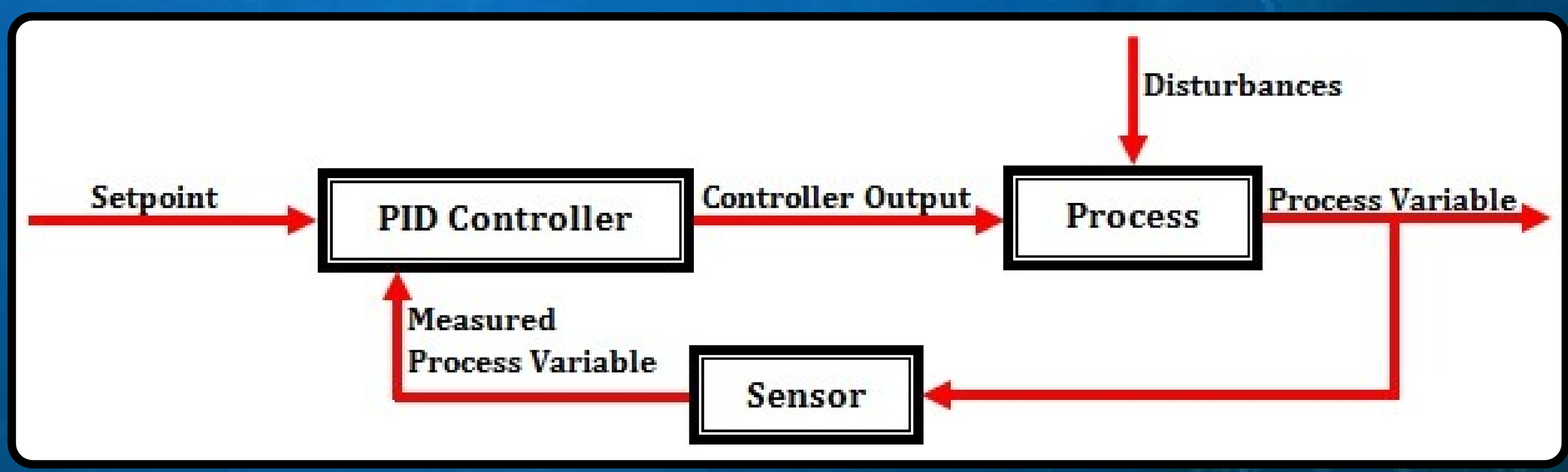
Using a Arduino microcontoller, the system was automated to respond to a set target depth. The submarine was submerged in a tank 1 meter deep, and wires were tethered from the submarine to an outside power source. Using an LED for verification, the pumps and solenoid valve turned off and on, depending on if it hit the target depth or not.







For future use, a PID code was written using the following logic:

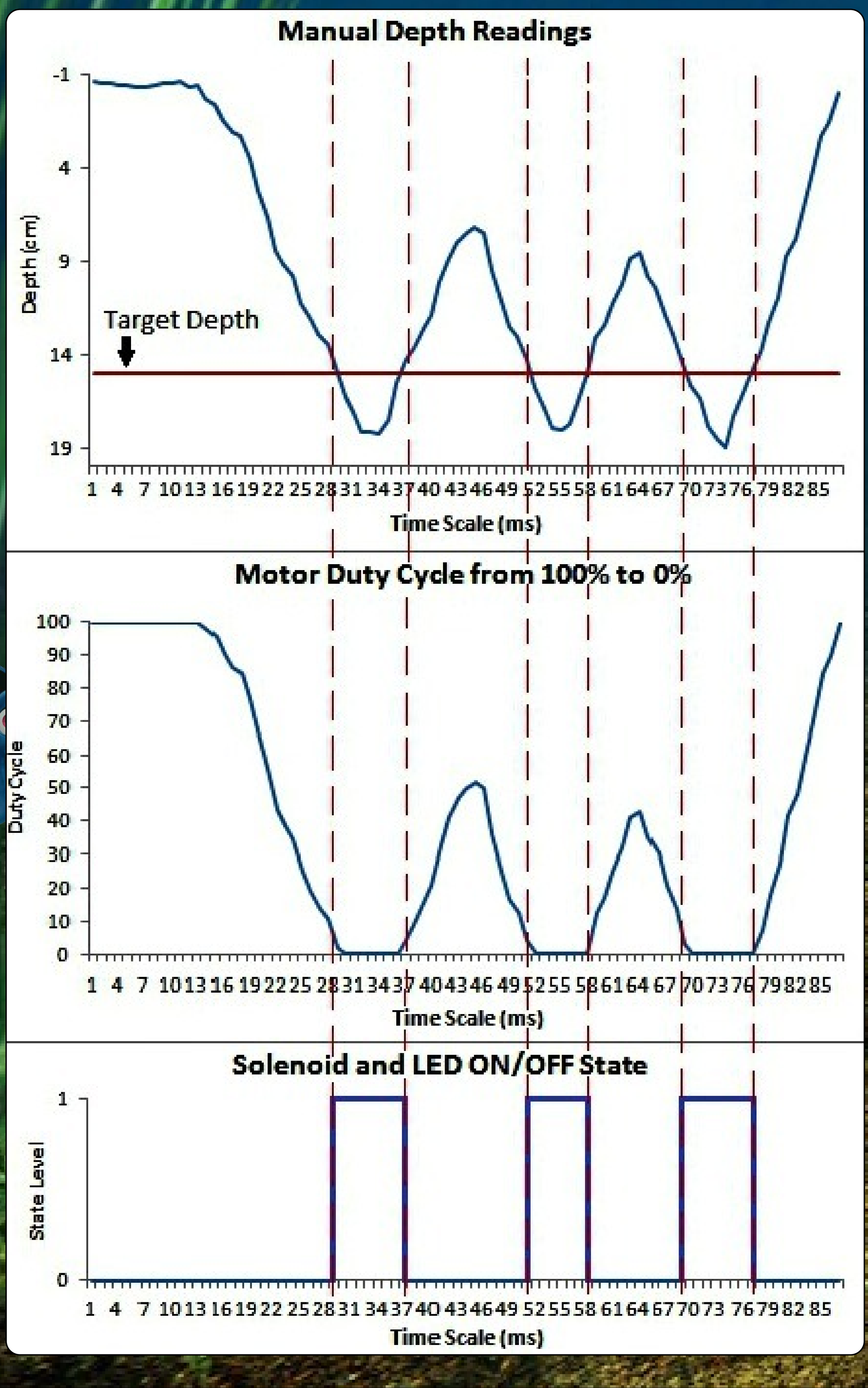


Effects of Increasing a Parameter Independently					
Parameter	Rise time	Overshoot	Setting time	Steady-state error	Stability
K_p	Decrease	Increase	Small change	Decrease	Degrade
K_i	Decrease	Increase	Increase	Eliminate	Degrade

PID Controller						
Command to Device		Proportional		Integral		Bias (Prevents output being 0)
Output(t)	=	$(K_p * c(t))$	+	$(K_t * \int_0^t c(t)dt)$	+	bias
Output	=	$(K_p * c)$	+	$(K_t * (K_{t\text{-prior}} + c^* {}_{\text{iteration\_time}}))$	+	bias

Data and Results:

When the submarine stayed above 15 cm, the LED stayed off, which means the pumps are on, and the solenoid valve is off. Once the submarine was pushed down below the 15 cm mark, the LED turned on, showing the pumps turned off, and the solenoid valve turned on. As it is lowered and raised, the LED turns off and on, proving our code design was successful.



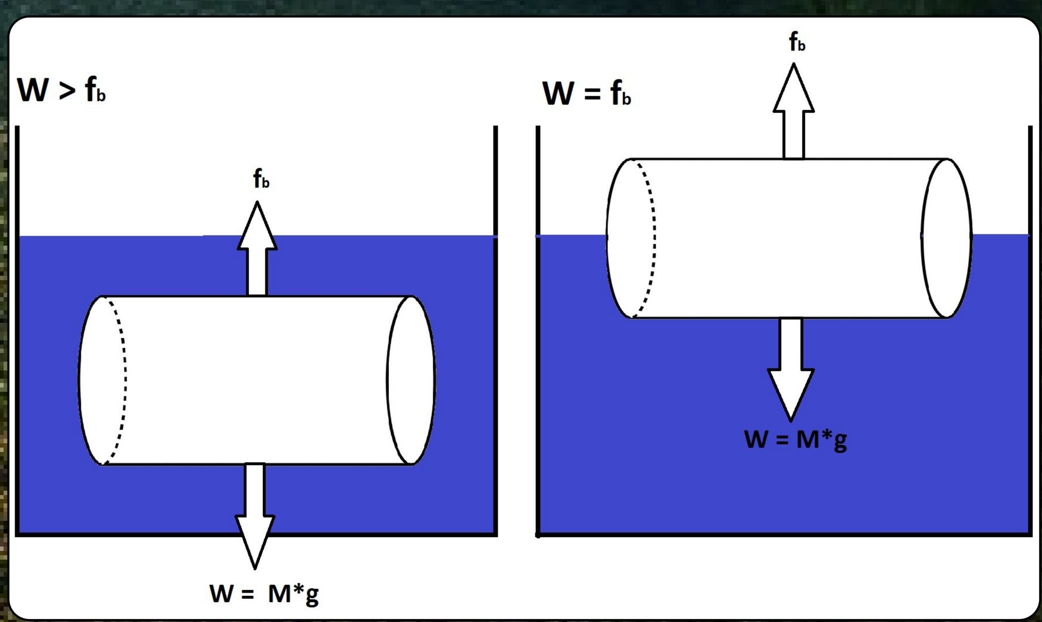
Duty cycle equation:

$$\frac{Target\ depth - Current\ depth}{Target\ depth} * 100$$

Above target depth: LED and Solenoid valve = 0 (OFF)

Below target depth: LED and Solenoid valve = 1 (ON)

Submarine has to overcome the buoyancy constant for the system dynamics to work



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