CONTROLLABLE AND VARIABLE UNDERWATER ENVIRONMENT FOR LASER PROPAGATION

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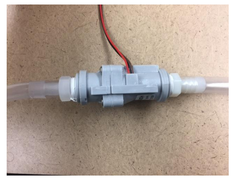
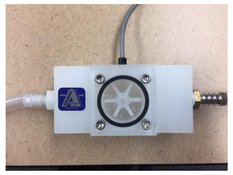
Motivation

In order to accurately characterize an environment for experimentation, it is important to have the ability to control and monitor as many variables as possible. By using an array of controlers, actuators, and sensors, an accurate closed loop system can be created. This closed loop environment can then be used to carry out various research projects, specifically laser propagation research, with widely varying conditions previously unattainable with a single state environment.

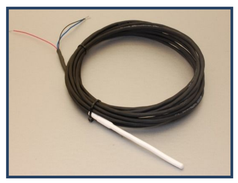
Sensing/Actuating Environmental Characteristics



Flow Sensor 1
Minimum Flow (.26 gal/min)
Maximum Flow (3.72 gal/min)
K-Factor (.00088 gpp)



Flow Sensor 2
Minimum Flow (gal/min)
Maximum Flow (gal/min)
K-Factor (gpp)



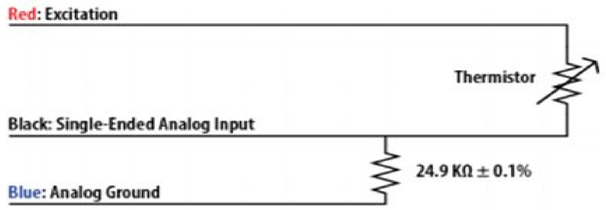
ST-100 Temperature Sensor
Range: 58-158'F
Uncertainty: .15'F (experimentally)
Input: 2.5V Excitation Voltage

Temperature Actuator/Heating Element
Temp Range: 77°F to 210°F ± 0.01°F
Tank Capacity: 4-5 Gallons
Heating Power: 800W
Modulation: Bluetooth, Manual

Salinity calculated both by a weight per volume method (1 gram/ 1 milileter=1%) as well as Practical Salinity Units (10 psu= 1%). Water will start as deionized lab water in order to guarantee no impurities before experimentation.

Calibration

Calibration of temperature probes was conducted by reading the voltage out of the voltage divider via Analog In on the mBed microprocessing unit.



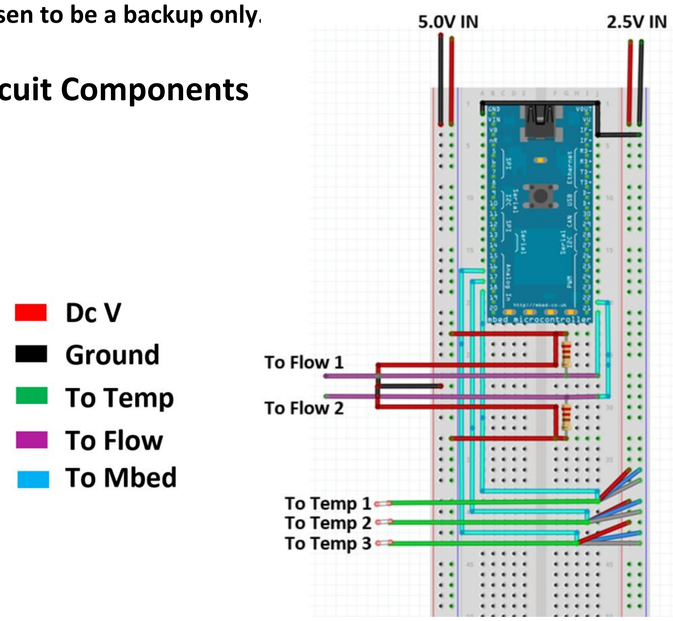
Using the Steinhart-Hart thermistor voltage equation, a measured resistance of the thermistor is then converted into a temperature output reading. Using three known temperatures (70'F, 85'F, 100'F), calibration coefficients were solved to calibrate the temperature sensors accurately.

$$Temp = \frac{1}{a + b * \ln(rt) + c * (\ln(rt))^3}$$

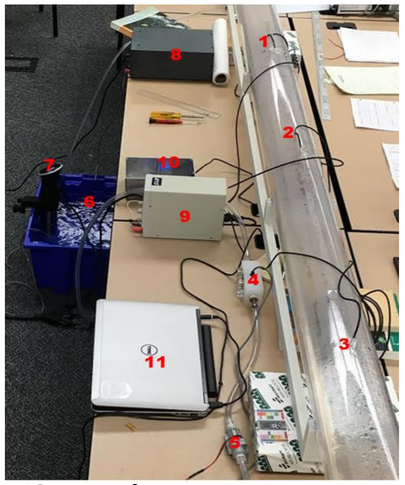
a = 1.253e-03, b = 2.135e-04, c = 1.749e-07

The two flow sensors were selected in order to provide two forms of verification of flow rate into the tank. However, due to the Flow Sensor 1 having a large uncertainty (10%) as well as there being no way to tell if it had already made it past its reliable service life (33000 Liters), Flow Sensor 1 was chosen to be a backup only.

Circuit Components



Tank Setup



1,2,3 - Thermistor Temp Sensors
4, 5 - Flow Sensors
6 - Water Storage Tank with Pump
7 - Heating Unit
8 - Pump Power Source
9 - Thermistor Power Source
10 - MBed Sensing Unit/Housing
11 - Data Acquisition Laptop

Scenarios

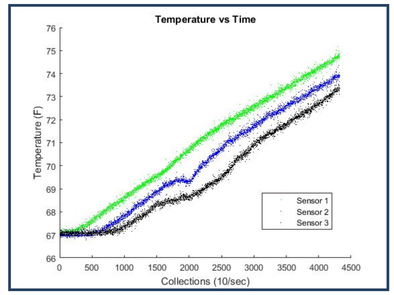
In order to create our create meaningful scenarios, we tried to create situations matching real world conditions. To accomplish this,temperature data was taken from various NOAA buoys. Water speed was categorized as low, medium, or high. The following scenarios were chosen in order to test the range of the sensors.

Scenario 1: Chesepeake Bay - Salinity: 11.17 psu
Temperature: 53.5'F
Water speed: High

Scenario 2: Equitorial Pacific Ocean-Salinity: 34psu
Temperature: 78.6'F
Water speed: Med

Scenario 3:Atlantic Ocean-Salinity 36 psu
Temperature: 67.6'F
Water Speed: Low

Proof of Concept/Initial Testing



Initial testing of the emulator saw the implementation of a steady high rate flow of water increasing from room temperature to approximately 75' F. The results from the temperature probes are shown. Behavior was exactly as expected given the scenario.

Acknowledgements

Professor Avramov-Zamurovic-Weapons and System Department
Norm Tyson and Nick Eagle-Technical Support Division

References

http://www.popsci.com/china-plans-to-defeat-american-lasers-with-smoke
http://www.popsci.com/navy-is-going-to-test-big-laser-soon