Low Cost Underwater Sensing

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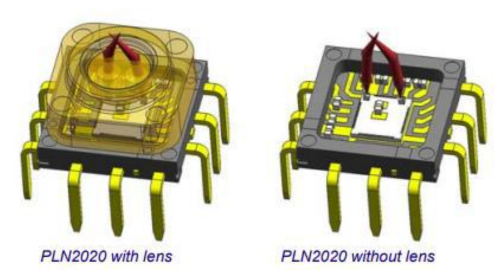
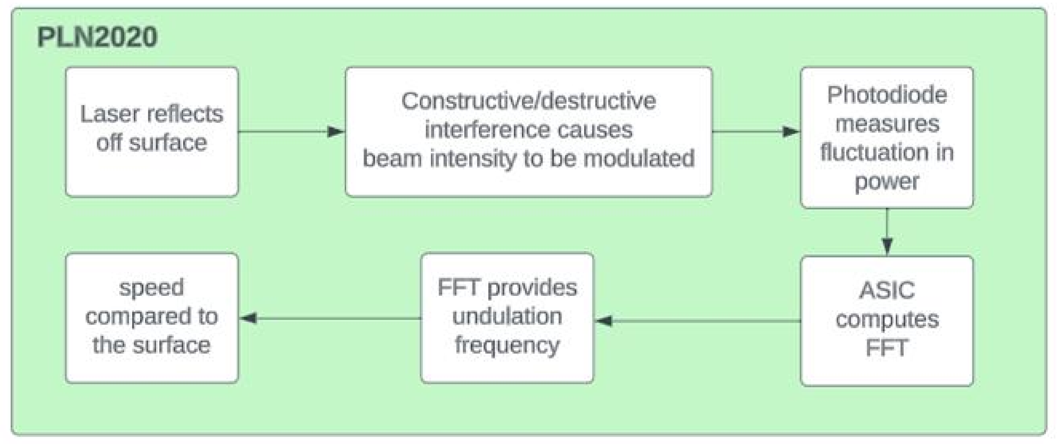
Laser Doppler Mouse Sensor

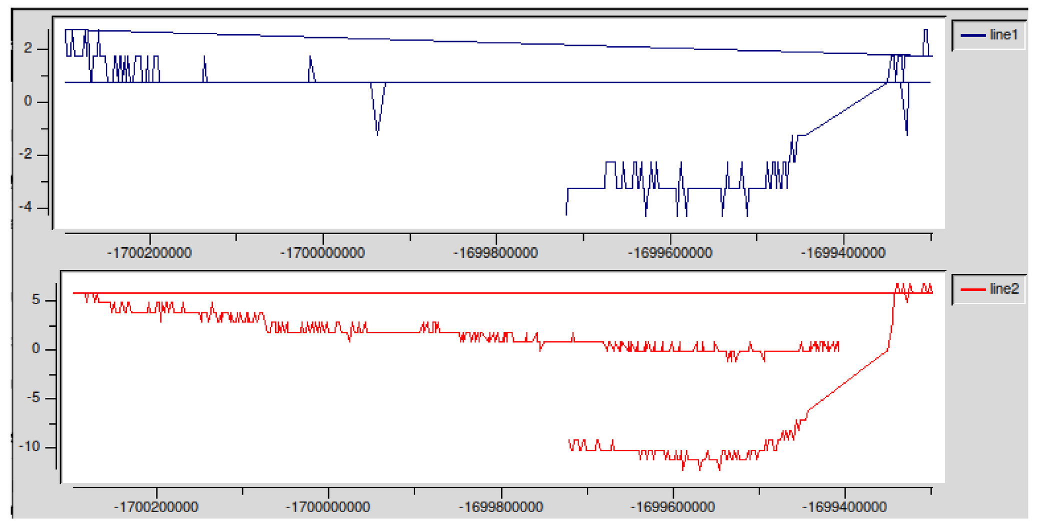


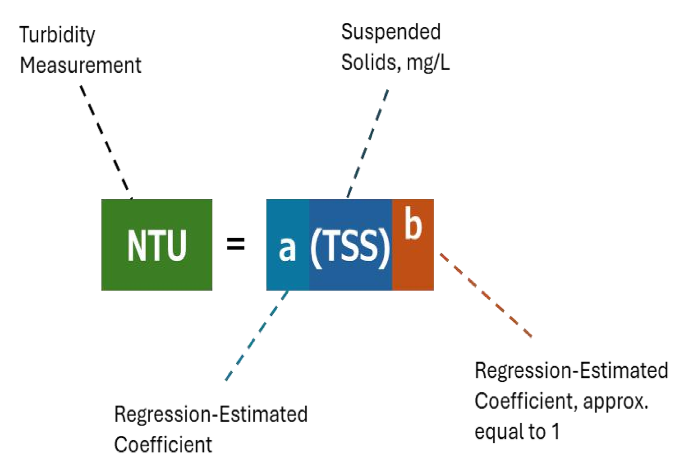
Laser emitted from the PLN2020 Dual-beam Laser Doppler sensor reflects off planar surfaces with sufficient turbidity, then recombines in the cavity of the sensor to find the doppler velocity.



Correct operation of the sensor relies on the number of particles in the liquid, or its *turbidity.* This restricts the sensor from functioning in highly opaque liquids

Dry Testing Results





Using a driver written in tcl and Ubuntu's xinput, we were able to collect data on a dry surface. The graph above describes the pixel position measured on the x-axis (top) and y-axis (bottom)

Limitations

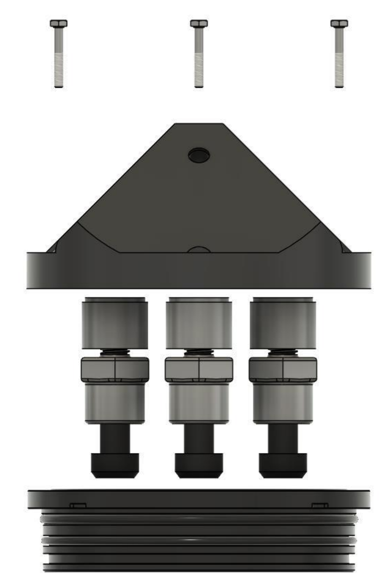
During our first run of testing underwater, we discovered the following issues with the sensor:

1. Substantial data requires the liquid to have a planar surface for recognizable reflection, otherwise requires a great amount of turbidity.
2. There is no guarantee of focal point preservation between the interface of the sensor lens and the liquid the measurement is being done in. This makes measurement unreliable.
3. It is hard to characterize reflected energy as velocity, because the scattering is random and unpredictable.

Analysis

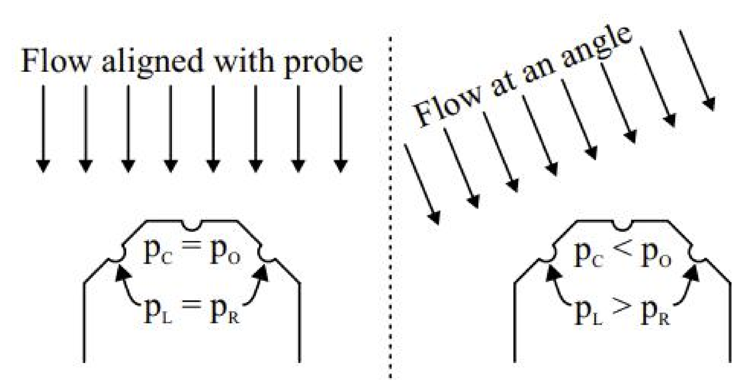
Results show that the operation of this sensor could not be done reliably, and the turbidity required for measurement is high and unrealistic of the use case we intend for this sensor, that being under the ocean. There is promising research showing the study of soap films is possible and useful for characterization of eddies. However, for the purpose of this project, we decided to explore other cheap options of measuring velocities of turbulent flow under the ocean.

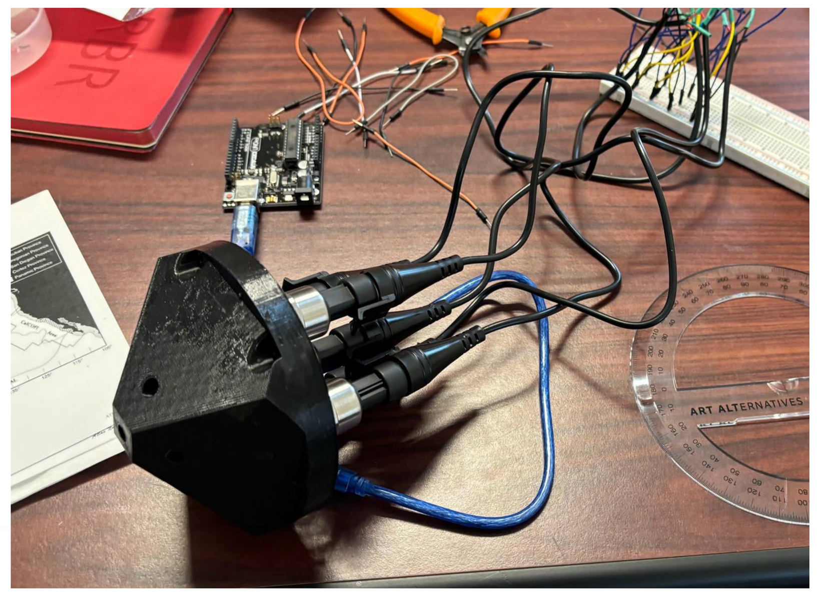
Pressure Sensor

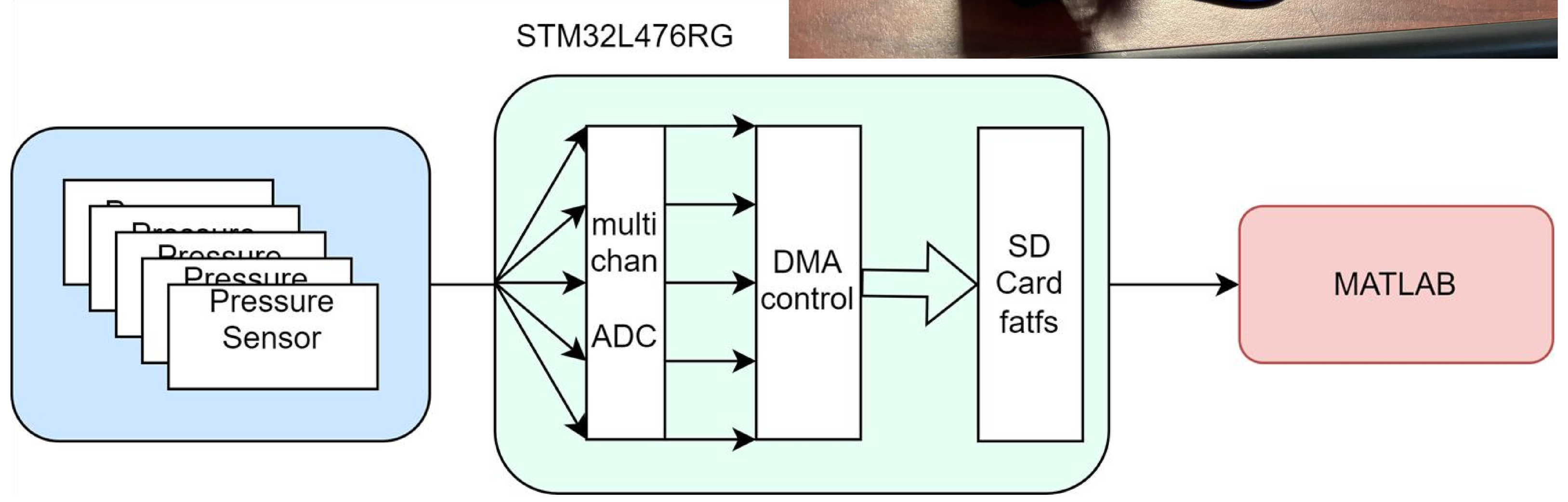


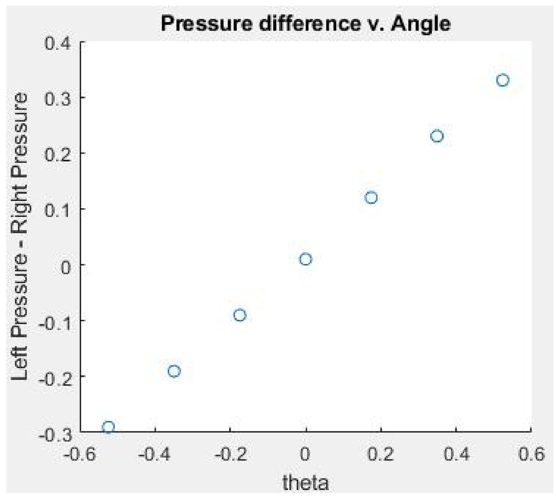
Pressure being applied to the side sensors of the probe can be characterized as one-dimensional velocity per pair of sensor, when measured differentially against the middle sensor.

Design: Water flows into the flow and by using the difference of pressure compared to the middle sensor, velocity can be obtained. The signal goes through an STM32L4 with multi-channel ADC using DMA, and to an SD card for logging, then to MATLAB for post-processing.







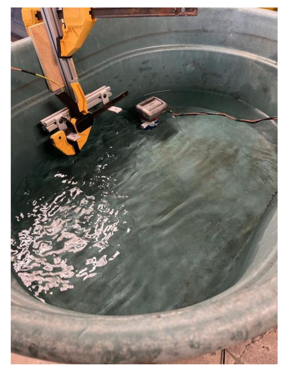


Analysis

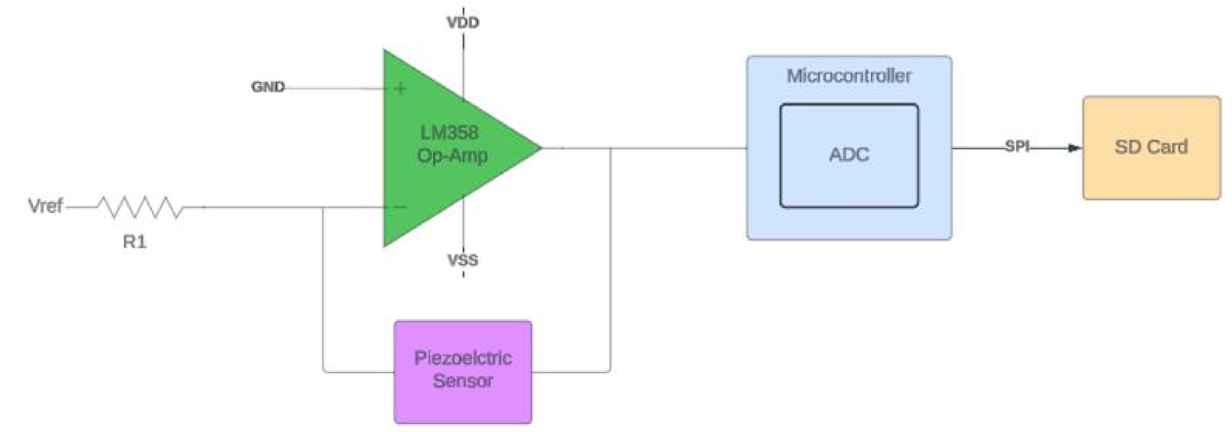
Our current sensor array uses 30 psi sensors with a resolution +/- 0.1 psi. In testing, with a large enough flow velocity, output voltage can be measured reliably. However, since we aim to use this device for small and fine-grained measurements of turbulence, future work would involve using more sensitive sensors or switching to a design that uses differential pressure.

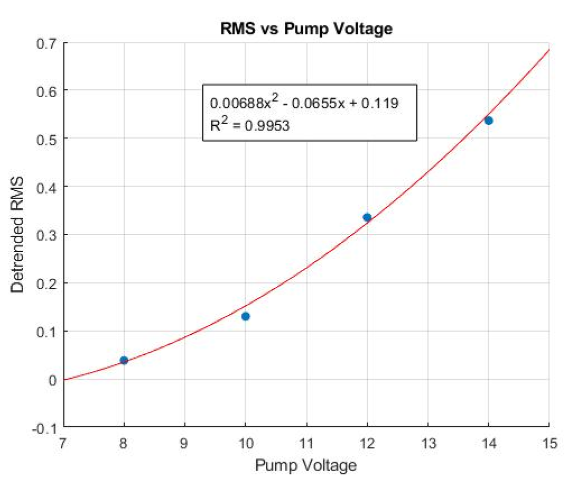
Piezoelectric Sensor

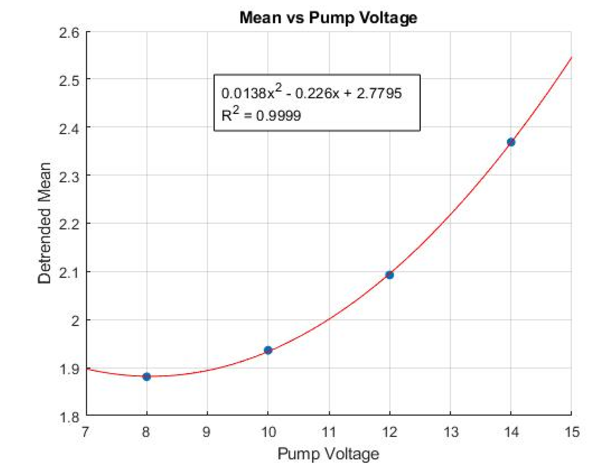
Bending or flexing of the sensor will change the electrical resistance of the piezoelectric material.

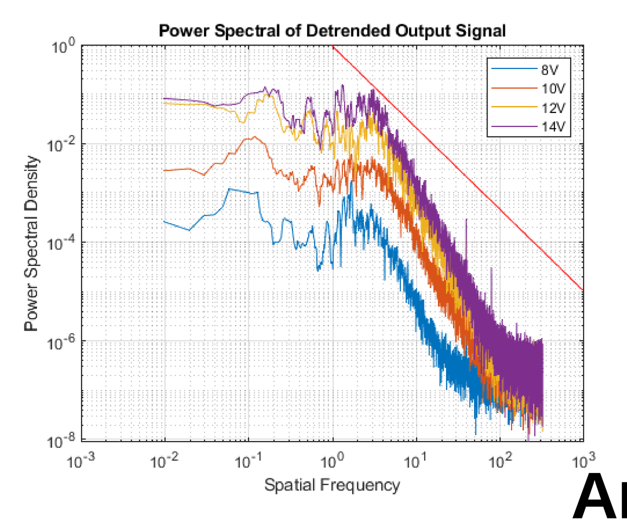


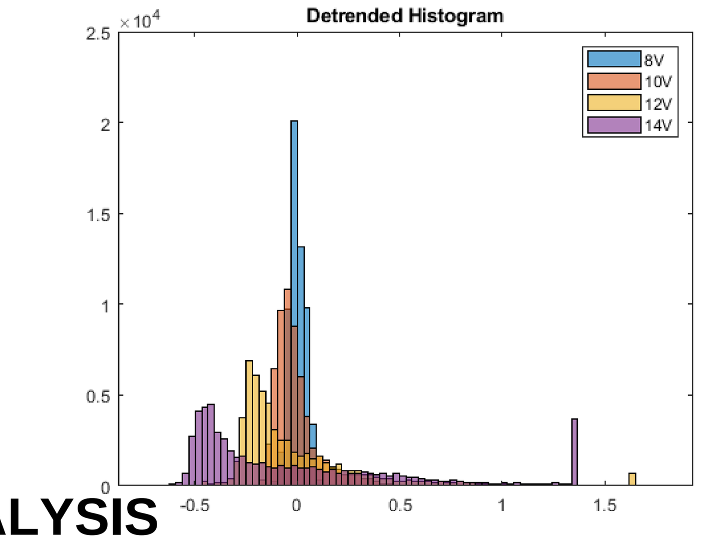
Design: Water forces a bend in the flex sensor, causing a change in resistance and consequentially a change in the op-amp's gain to the signal. Signal goes through microcontroller ADC and into SD card for logging.











Analysis

Results show that for varying pump voltages the sensor outputs distinguishable and separable values. Linearly increasing the pump voltage causes a quadratic trend in the RMS and mean of the output signal. Additionally, the sensor clearly shows that for higher pump voltages (14V) that distribution of data is greater than that of a lower pump voltage (8V). This agrees with intuition that higher water speeds (pump voltage) will cause higher turbulence and thus more spread-out velocity values compared to slower moving water with less turbulence.

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