Inexpensive Pressure Transducer for Monitoring Waves in Coastal Systems

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Inexpensive "Do it Yourself" Pressure Sensor for Monitoring Waves in Coastal Systems

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Abstract

In order to learn more about the natural world, there is a growing need to conduct research of increasing scale and/or resolution. During field work, this necessitates the use of high accuracy equipment, which can be expensive and is often lost or damaged during deployment. Consequently, there is growing interest in "do it yourself" (DIY) equipment that is affordable and easy to build without sacrificing performance. The DIY Pressure Transducer (pressure sensor) is one such piece of equipment which provides coastal researchers with a more affordable alternative for monitoring water level fluctuations such as wave height and period. The DIY device built for this study consisted of a simplified Arduino microcontroller and a waterproof housing made primarily from polyvinyl chloride (PVC). In contrast to commercial pressure transducers which can cost thousands of dollars, a DIY transducer can be assembled for under $500. To determine accuracy, DIY transducers were tested against a commercial instrument. In both still and turbulent water, it was found that pressure readings from each DIY device varied by some constant offset from the commercial instrument due to imprecise factory calibration of the MS5803-14BA sensor module used. After accurately recording the offset for each DIY device, the data was corrected and agreeable to the commercial transducer by <1 cm of water depth. Given the affordability and high performance of the DIY sensors tested in this study, future works are planned to deploy dense sensor arrays to monitor the impact of waves on coastal erosion at scales previously not possible.

Project Objectives

Affordability

- The cost of a single sensor should be significantly less than that of a commercial instrument.

Ease of assembly

- There should not be a high skill barrier or initial investment required to build a sensor. Parts should be readily available.

Accuracy

- Sensor readings should be comparable to a commercial instrument.

Energy efficiency

- A DIY pressure sensor should be able to collect data for at least one month when powered by two alkaline D cell batteries.

Methods

External Housing

A	2.54 cm (1 inch) length of 3.81 cm (1.5 inch) diameter PVC.
B	7.62 cm (3 inch) diameter PVC cap.
C	25.4 cm (10 inch) length of 7.62 cm diameter PVC.
D	7.62 cm diameter removeable rubber gripper cap.

- This waterproof housing design is borrowed from another DIY pressure sensor project [1].
- PVC parts are assembled by cementing them together using PVC primer and cement.
- Any potential gaps are sealed using a marine grade sealant.
- To support the goals of affordability and ease of construction, all components are commonly found in local home improvement stores, and no prior knowledge is necessary for assembly of the housing.

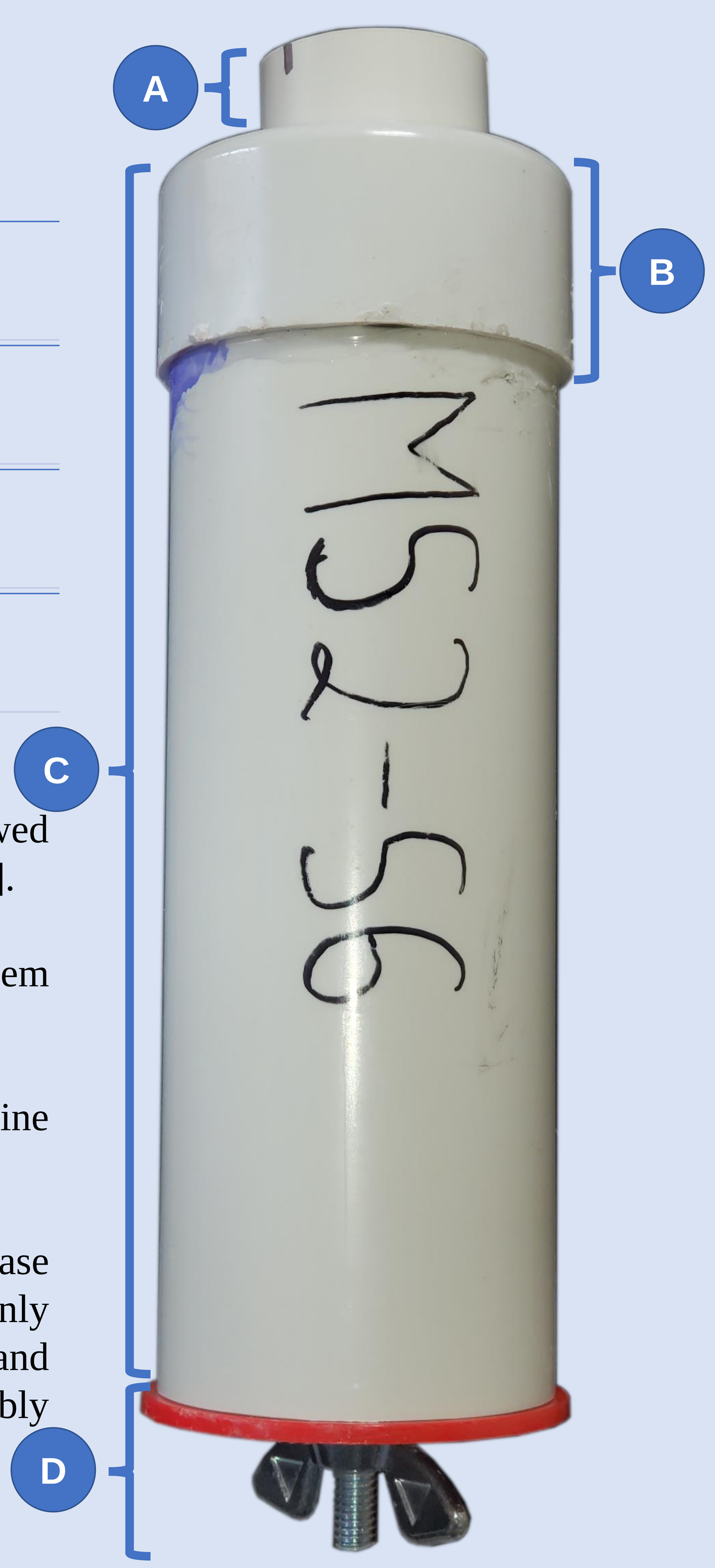


Fig. 1: Assembled Housing

Inside the Housing

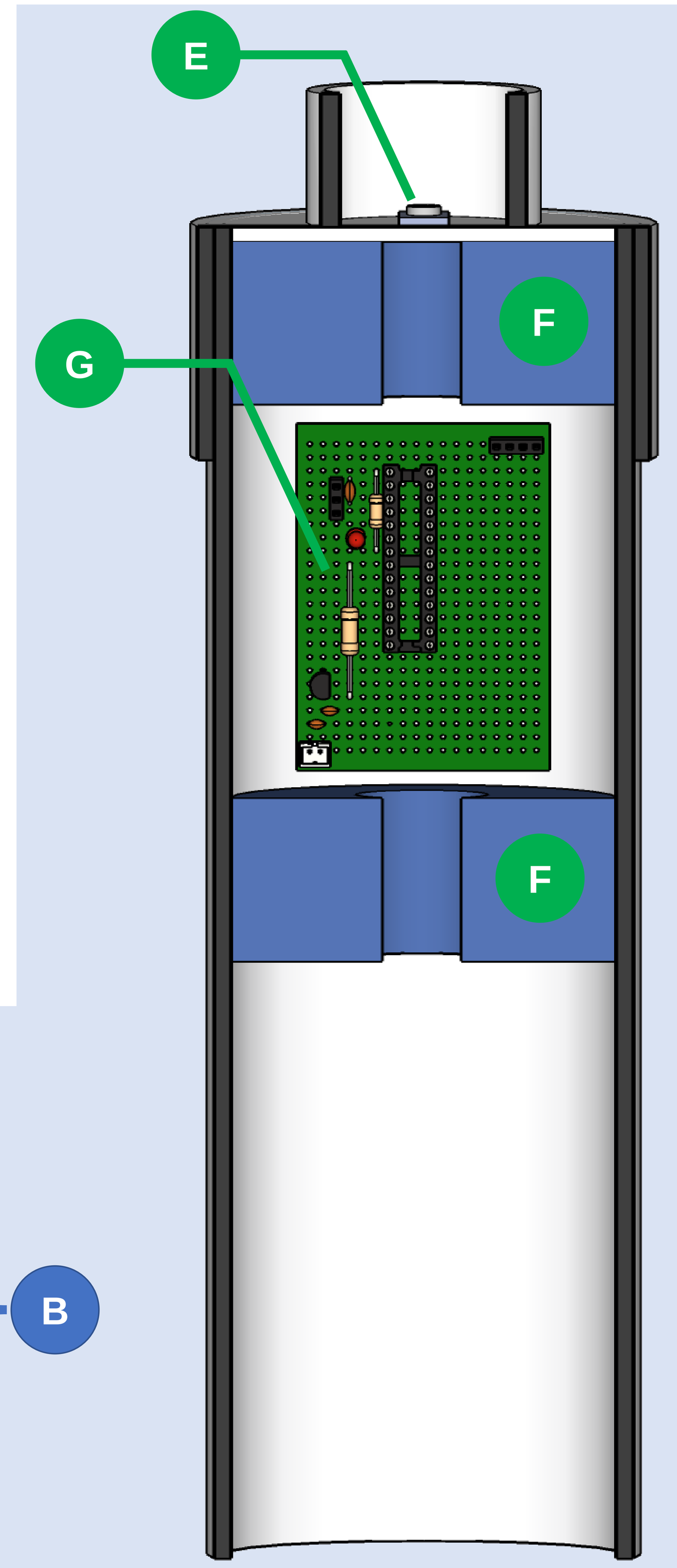


Fig. 2: Modelled Cross Section

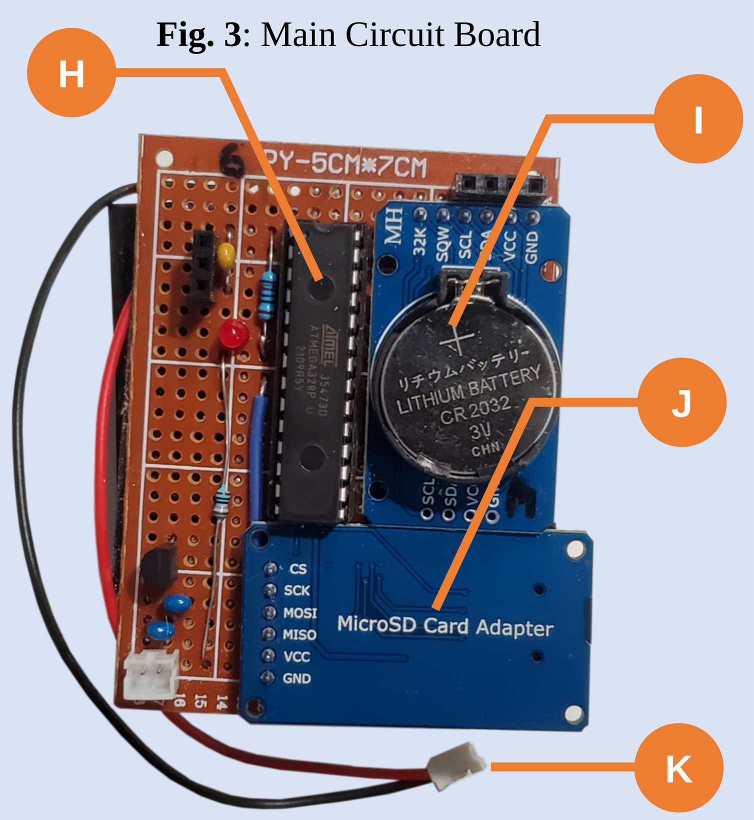
E	MS5803-14BA pressure sensor module responsible for detecting and transmitting absolute pressure and temperature.
F	Polyethylene foam (pool noodle) used to secure electronics and absorb moisture.
G	Main circuit board. This holds the ATmega328P microcontroller responsible for executing code to run the sensor. Two D cell batteries are held on the back.

- During construction of the housing and main circuit board, the external sensor module (E) is connected via four wires (not shown) to the circuit board to communicate sensor readings.
- The exposed electronics of the sensor module are covered in liquid epoxy (not shown) once assembled, leaving only the impermeable sensor port exposed.
- Desiccant is often included at the top and bottom of each sensor to absorb moisture.

Main Circuit Board

H	ATmega328P microcontroller (as used in most Arduino boards).
I	Real time clock (RTC) module with a coin cell battery, allowing the sensor to track time even without a main battery.
J	microSD card module for storing collected data.
K	Power cable connecting battery on back.

Fig. 3: Main Circuit Board



- The circuit board in **Fig. C** is designed to be assembled and soldered together manually; however, some experience with a soldering iron is recommended before attempting to build a board.
- All components used for this research, including those outlined above, can be easily purchased from online retailers such as Digi-Key and Amazon.
- The custom design of the circuit board allows for increased energy conservation.

Initial Results

Affordability

- The cost of materials for a single sensor in this study was less than $500. The commercial instrument

Ease of assembly

- Tools and services necessary for housing construction are commonly available from hardware stores.
- Circuit board assembly is more difficult and time consuming due to the great deal of soldering required.

Accuracy

- Uncalibrated sensors were found to vary by a constant offset as significant as 20 mbar (~20 cm of water depth) from the commercial sensor.
- After calibration, sensors were found to be agreeable to the commercial instrument within less than 1 cm of water depth, which is the expected value [3].

Energy efficiency

- DIY sensors have been tested to sample continuously for up to two months without a full battery drain. Further improvements could potentially extend this to a year or more of operation [1, 2].

Future Works

- Additional research is underway to improve the DIY pressure sensor built in this study. A newer model will make use of the ESP32 microcontroller, a more modern piece of hardware with wireless connection capabilities, as opposed to the ATmega328P. Ease of assembly will be improved by utilizing prefabricated development boards, with sufficiently low sleep current draw, as opposed to the lengthy process of soldering custom circuit boards. Other variants of the MS5803 pressure sensor will also be investigated for improving the accuracy of measurements.
- Ultimately, the DIY pressure sensor is intended to be used to measure the effects of boat wakes on coastal erosion. The device's affordability allows researchers to deploy sensors in greater density to achieve higher resolution data without risking high value equipment.

References

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[2] Lyman, T. P., Elsmore, K., Gaylord, B., Byrnes, J. E., & Miller, L. P. (2020). Open Wave Height Logger: An open source pressure sensor data logger for wave measurement. Limnology and Oceanography: Methods, 18(7), 335-345.

[3] Temple, N. A., Webb, B. M., Sparks, E. L., & Linhoss, A. C. (2020). Low-cost pressure gauges for measuring water waves. Journal of Coastal Research, 36(3), 661-667.