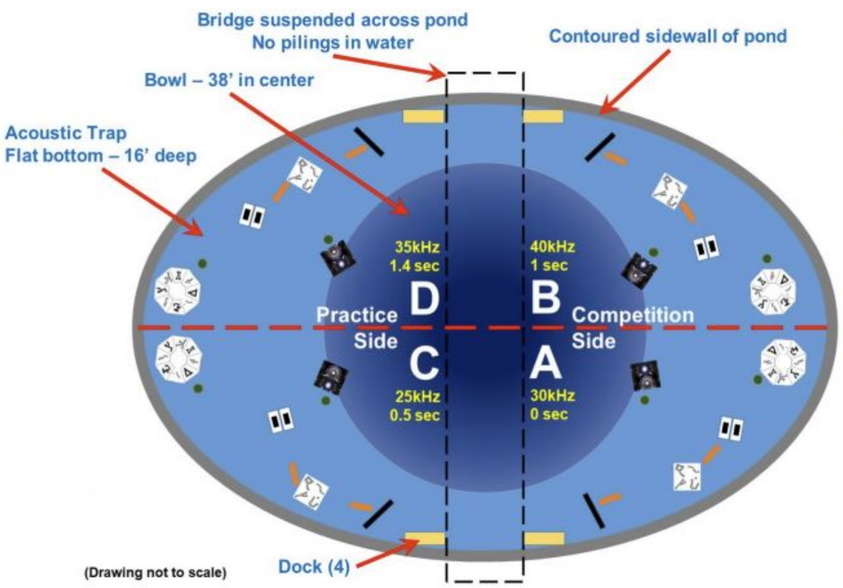
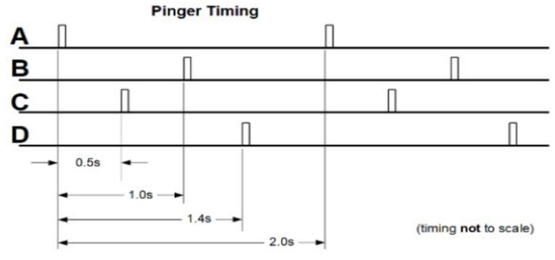
Underwater Acoustic Pinger and Receiver

Kailun Wang, Dr. Rosa Zheng
P.C. Rossin College of Engineering and Applied Science, Lehigh University, Bethlehem, PA

Motivation

robosub

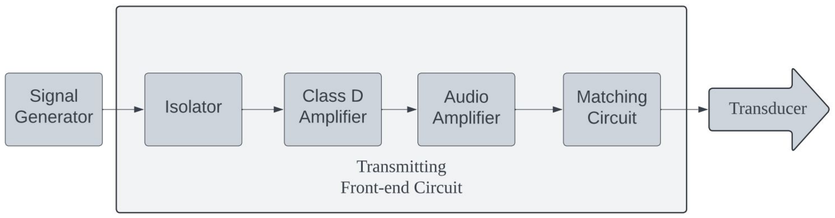


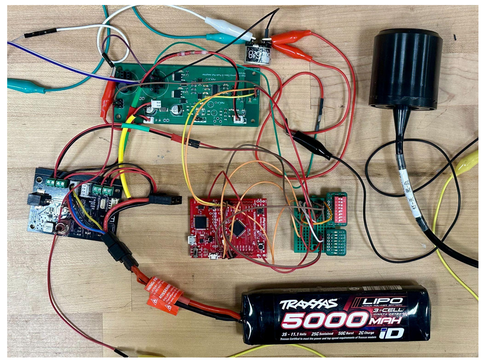


- A- 30 kHz
- B- 40 kHz
- C- 25 kHz
- D- 35 kHz

- **Underwater Acoustic Locator Pinger:** Designed for use in the RoboSub Competition, primarily for mooring recovery tasks. The system helps divers or ROVs to detect and navigate towards the source of acoustic signals.
- **Frequency Pulse Width Modulation (PWM):** Utilizes the Tiva C series microcontroller for generating precise PWM signals. These signals range from 25 kHz to 40 kHz, adjustable in 5 kHz increments.
- **User-Friendly Interface:** Includes a switch for easy frequency selection and a water-activated switch to streamline usability.
- **Class D Amplifier Redesign:** The signal strength and clarity are improved by using a Class D amplifier with a transformer, achieving a higher voltage gain.

Underwater Acoustic Pinger Design



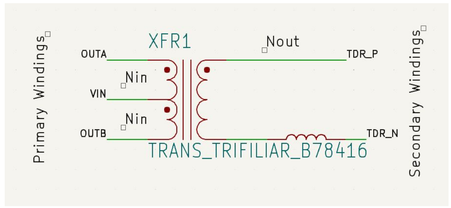


Frequency	PWM-DIV	Pause-Width
25	4	250
30	4	208
35	4	178
40	4	156

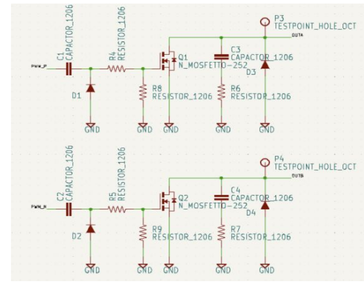
kHz	Switch1	Switch2
40	Closed	Closed
35	Closed	Open
30	Open	Closed
25	Open	Open

$$PulseWidth = \frac{SysClock}{(Frequency \times PWMDiv) \times 2}$$

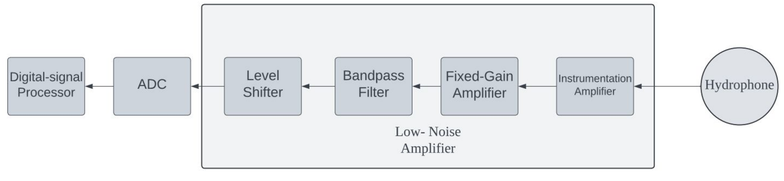
Sys_Clock= 50 MHz

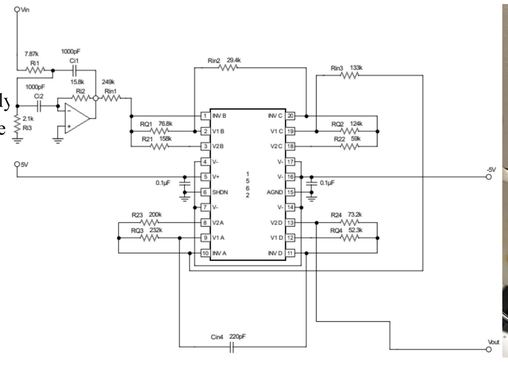


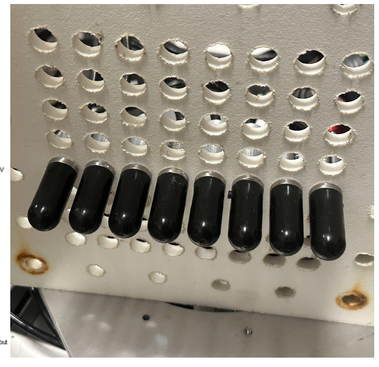
$$Vout = Vin \times \frac{Nout}{Nin}$$



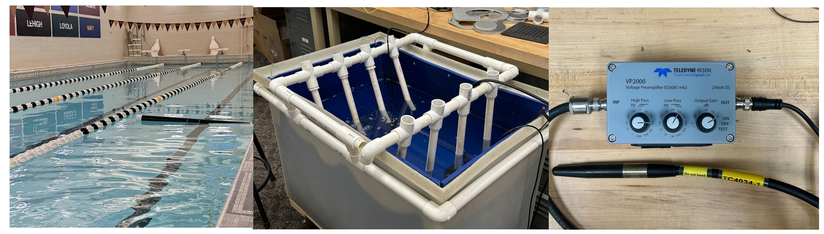
Milti-Hydrophone Receiver Design







Experiment Results



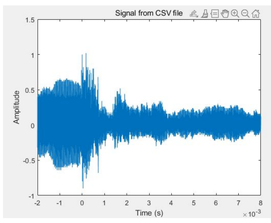


Figure A

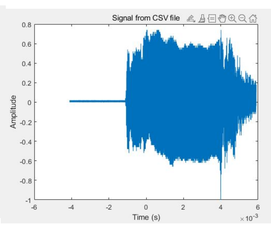


Figure B

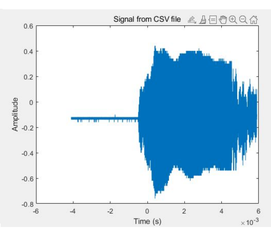


Figure C

20ft: 2.3V peak-to-peak. (Figure A)
40ft: 1.8V peak-to-peak. (Figure B)
60ft: 1.2V peak-to-peak. (Figure C)

Algorithm: Fast Fourier Transform (FFT)

```
1: Fs = 1/(t(2)-t(1));  % Sampling frequency
2: L = 199995;     % Number of samples
3: Y = fft(x);    % Fourier Transform of the signal
4: P2 = abs(Y/L);  % Two-sided spectrum P2
5: P1 = P2(1:L/2+1); % Single-sided spectrum P1
6: P1(2:end-1) = 2*P1(2:end-1);
7: f = Fs*(0:(L/2))/L;   % Frequency domain
```

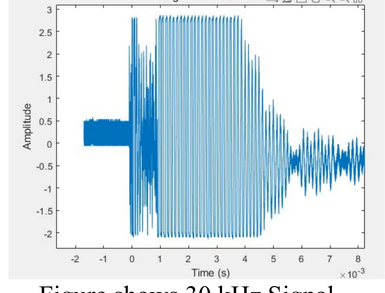
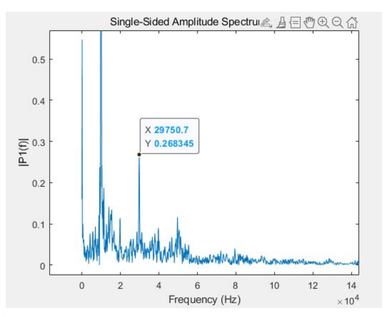


Figure shows 30 kHz Signal



The Tiva C microcontroller has effectively produced signals in the 25 kHz to 40 kHz range and amplified them to ±4 V in a water tank, demonstrating a strong signal generation capability. Through FFT analysis, the precise frequencies of the transmitted signals were identified. The next phase will involve integrating this system into a tube for real-world testing in a swimming pool to assess performance and reliability in variable conditions.

Reference

[1] Robosub 2023 Team Handbook, https://robonation.org/app/uploads/sites/4/2023/06/2023-RoboSub_Team-Handbook_v2.0.pdf

[2]F. Sun, X. Zhu, Y. Xue, J. Li and Y. R. Zheng, "Front-end Circuits for Ultra-High-Frequency Underwater Acoustic Communication Systems," OCEANS 2022, Hampton Roads, Hampton Roads, VA, USA, 2022, pp. 1-7, doi: 10.1109/OCEANS47191.2022.9977257. keywords: {Meters;Transmitters;Roads;Oceans;Power amplifiers;Receivers;Pulse width modulation},