TOADFISH BEHAVIORAL ROBOT

Jun Ko (kk938@cornell.edu)
Advisor : Dr. Bruce R. Land, Prof. Andrew Bass
School of Electrical and Computer Engineering

Why midshipman toadfish?

The goal of this project is to aid Prof. Bass' research team to study the behavior of vertebrates. Specifically, the midshipman toadfish is studied because they are simple vertebrates and they communicate through acoustics. Therefore, their behavioral response can be studied through their communication.

Goal :

- Create a robot toadfish that mimics toadfish sound
- Generate sound underwater with minimum size
- 100 ~ 200Hz frequency
- 110dB at 15cm away from source

Midshipman Toadfish

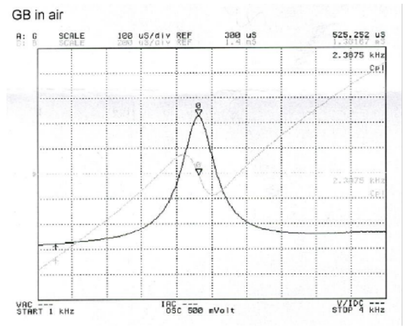
Underwater speaker selection

After experimenting with different speakers, the piezoelectric speaker (SX-53) was chosen for application over regular electrodynamic speakers.

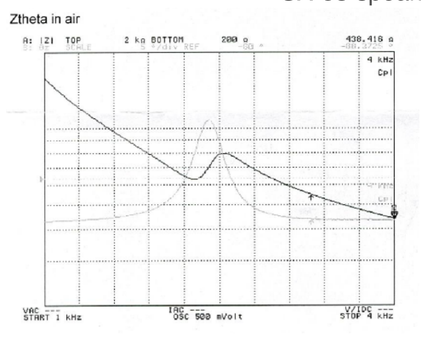
Piezo speaker	Electrodynamic speaker
Smaller size factor	Limitation on size for low freq. sound
Robust in different environments	Not ideal for underwater use
Requires higher voltage/current	Lower voltage/current requirements

The SX-53 has an operating frequency of 100Hz to 5KHz. Its maximum operating voltage is +/- 15V with resonance frequency at 750Hz. It also has a small form factor with a diameter of 2 inches and height of 0.2 inches.

SX-53 speaker



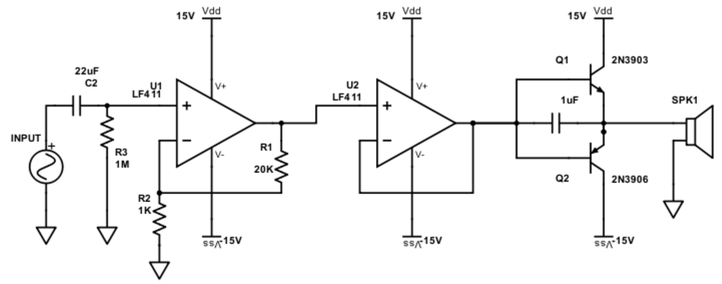
GB characteristic



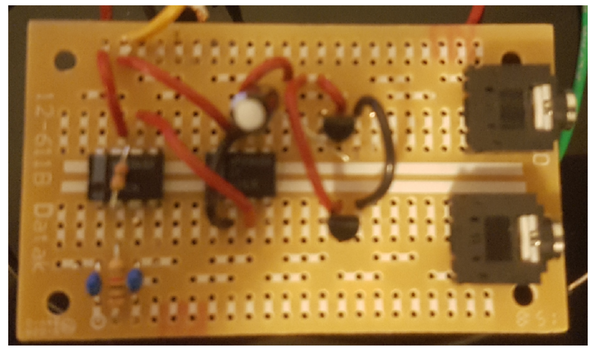
Impedance Characteristic

30Volts Audio driver

Class B Audio Amplifier was used to drive the speaker. Class B is widely used for driving more power to speakers and since one of the main goal is to produce sufficient sound intensity, maximum operating power was generated to drive the speakers.



Class B circuit to drive speaker

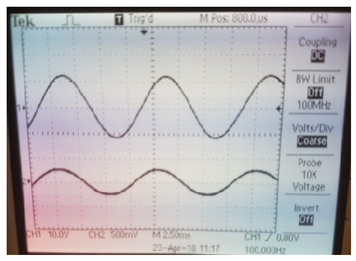


Circuit board on perf board

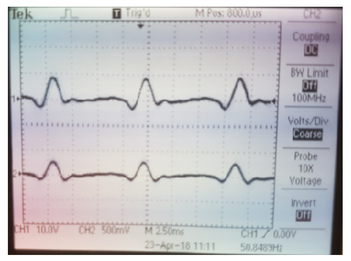
First amplifier is used for voltage gain through the feedback resistors.
Second amplifier is used to drive more current to the speaker through the NPN, PNP transistors.

Small, low distortion & loud

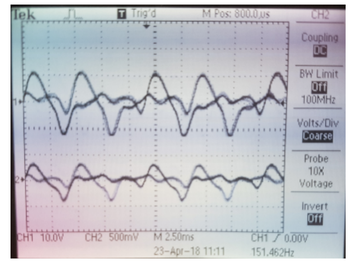
Output waveforms and sound intensity were checked to have minimal distortion



Regular sine waveform



Toadfish grunt waveform



Toadfish nesthum waveform

Sound intensity conversion from air to water:

$$dB = 20\log(p_{air}/p_{water}) = 26dB$$

$$10\log(3600) = 36\,dB$$

Sound file	dB in air	dB after conversion dB re 1uPA
Sine wave (150Hz)	39dB	102dB
Sine wave (200Hz)	46dB	108dB
Toadfish Grunt	51dB	113dB
Toadfish Nesthum	41dB	103dB

Conclusion & Future work

1. May need another speaker more suitable for low frequency sound generation
2. Designing a robot resembling the toadfish
3. Testing with actual toadfish

Acknowledgements

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ABSTRACT

Jun Ko (kk938@cornell.edu)
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The toadfish project aims to build a robot that essentially mimics the behavior of the toadfish. One key distinguishing feature of the male toadfish is its ability to communicate with each other. The toadfish communicates with each other acoustically, by making loud growling or grunting sounds to fend off other male fishes from its nesting sites, or by making nest hums to attract female toadfishes.

Professor Andrew Bass from the Department of Neurobiology and Behavior of Cornell University and his team is trying to understand the aggressive behavior of the toadfish. This project will aid Porf. Bass and his team to learn more about the toadfish. In order to mimic the toadfish, the robot has to produce sound underwater and be able to move around. A piezoelectric transducer (SX53, Sensortech) will be used to generate a sound similar to that of the toadfish. The sound frequency will be in a range between 100 ~ 200Hz with a strength of around 110dB 15cm away from source. The transducer will be encased in a 3D printed toadfish model underwater and peripheral circuitry to drive the transducer will be designed and built outside.

The transducer requires a fairly high voltage (around 30 ~ 40V) in order to produce a large sound. Therefore, a transformer will be used to drive the transducer. Also, an audio synthesizer will be purchased to generate the electric signals for the transducer to produce. An op-amp and possibly a current amplifier will also be used to safely drive the transducer. The first half of the project will focus on setting up the circuitry and producing the large sound underwater. The second half of the project will be focused on creating the toadfish model, encasing the transducer and testing its performance by measuring underwater sound intensities.