Design and Testing of Front-End Circuits for High Frequency Acoustic Signals

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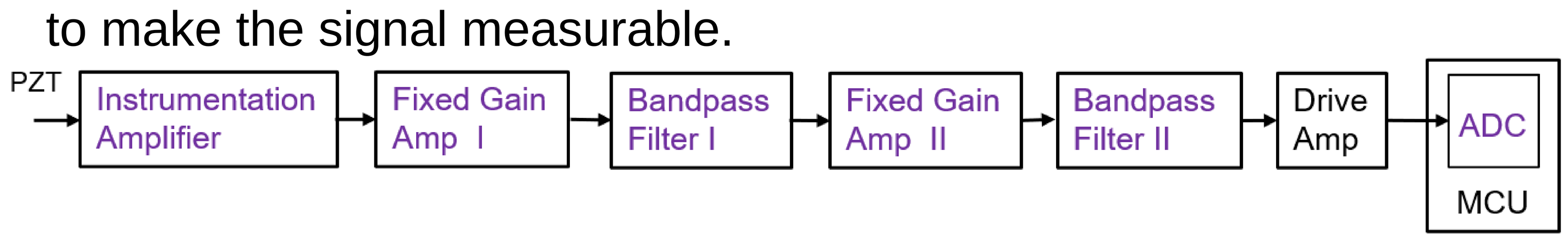
Introduction

- To amplify the transmission signal that is typically small for underwater communication.
- Capture the tiny signal the antenna send out underwater and amplify to make the signal measurable.



- Combining two Fixed gain Amplifier into one with a gain of 44dB.
- Reduce the components needed and keep the output identical. Since only one 8th order filter is used to limit the carrier frequency, it is less stable comparing with the previous design,

Filter Design

- To make the receiving board capable of capture 160kHz transmission signals.
- Design the 4807-4 with bandwidth to be 28kHz, center frequency at 160kHz and 90kHz stop band frequency for the smooth curve.

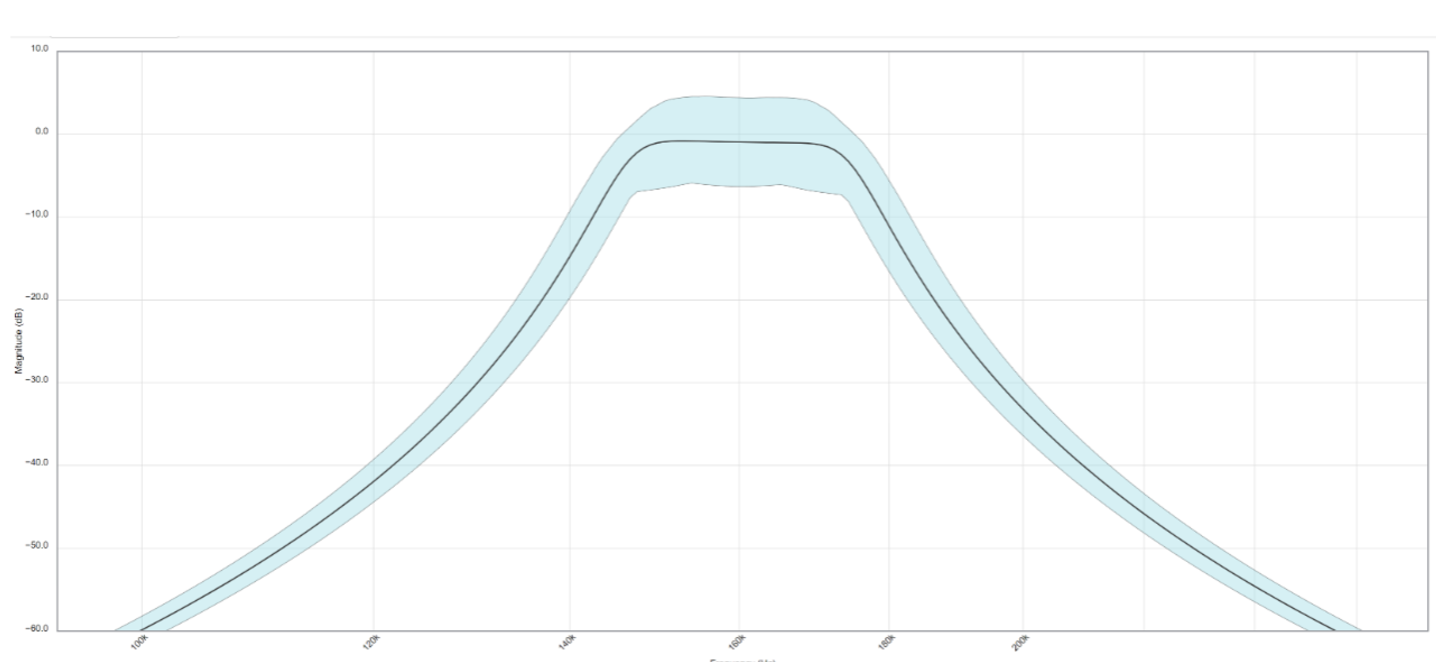


Fig. 1: 4807-4-curve using analog device filter design tool, frequency 160kHz

Simulation

- Use Itspice for simulation and re-create each parts (instrumentation, fixed gain, and bandpass filter) in the Itspice.
- Select ADA4807-4 as OP amp for most accurate simulation results.
- Verify the generated parameters of the filter design tools.

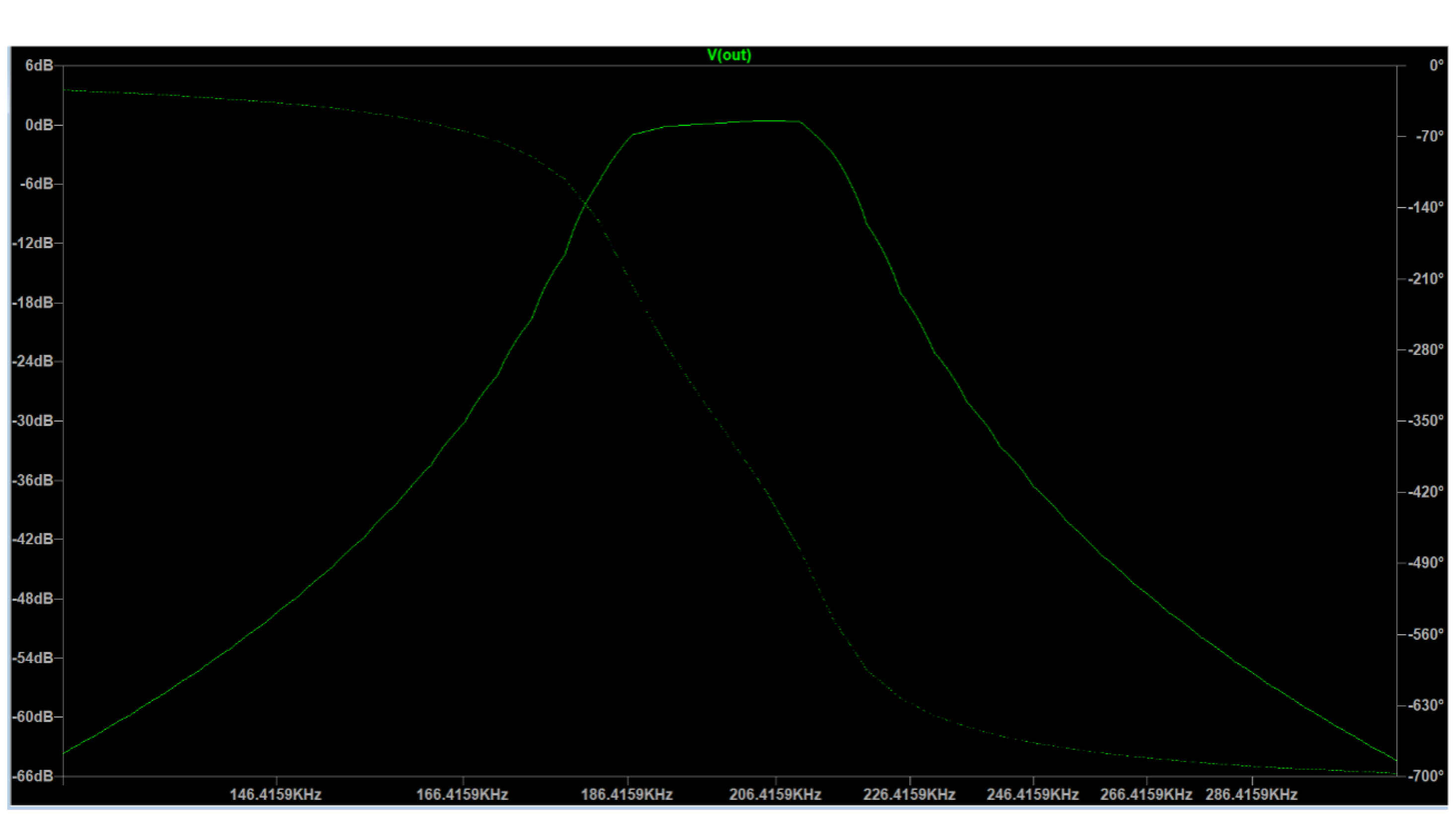


Fig. 2: Itspice 4807-4 simulation for the given parameters of the 8th order filter

PCB Design

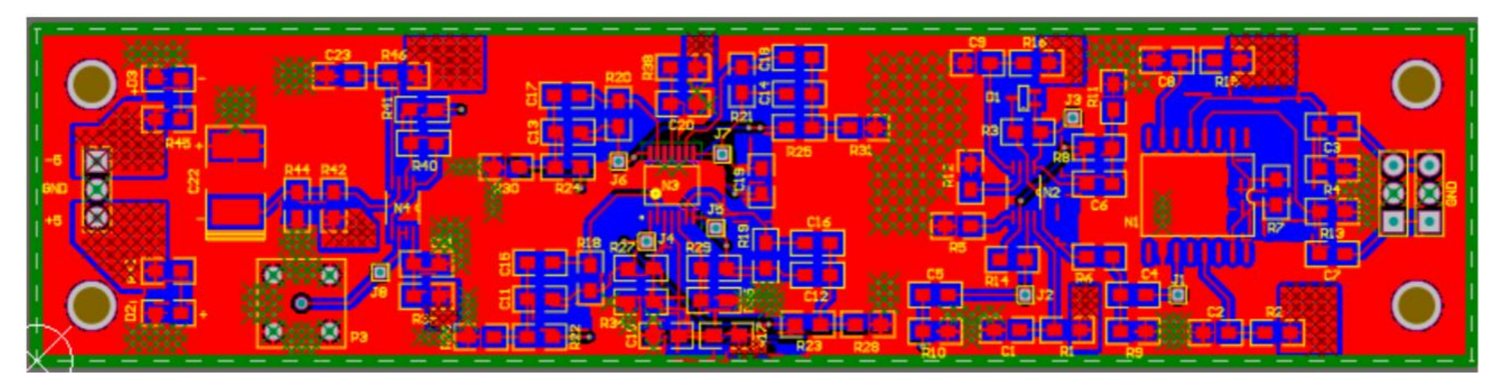


Fig. 3: PCB view of the designed 160kHz board

Testing and Results

- Hand soldering all the resistors, capacitors and chips onto the empty PCB board.
- Powering the circuit and starting the Instrumentation Amplifier.
- Use a voltage convertor to convert the battery voltage to 5V.
- Let the function generator give a small voltage input with a frequency of 160Khz and use an oscilloscope to monitor the AC response of the board. Altering the input peak to peak voltage to find the minimum input voltage 2mVpp.
- Slightly increase from 107kHz to 200kHz with a gap of 2, Divide X by the input voltage to get the gain and converting those voltages to dB by using 20log(x).

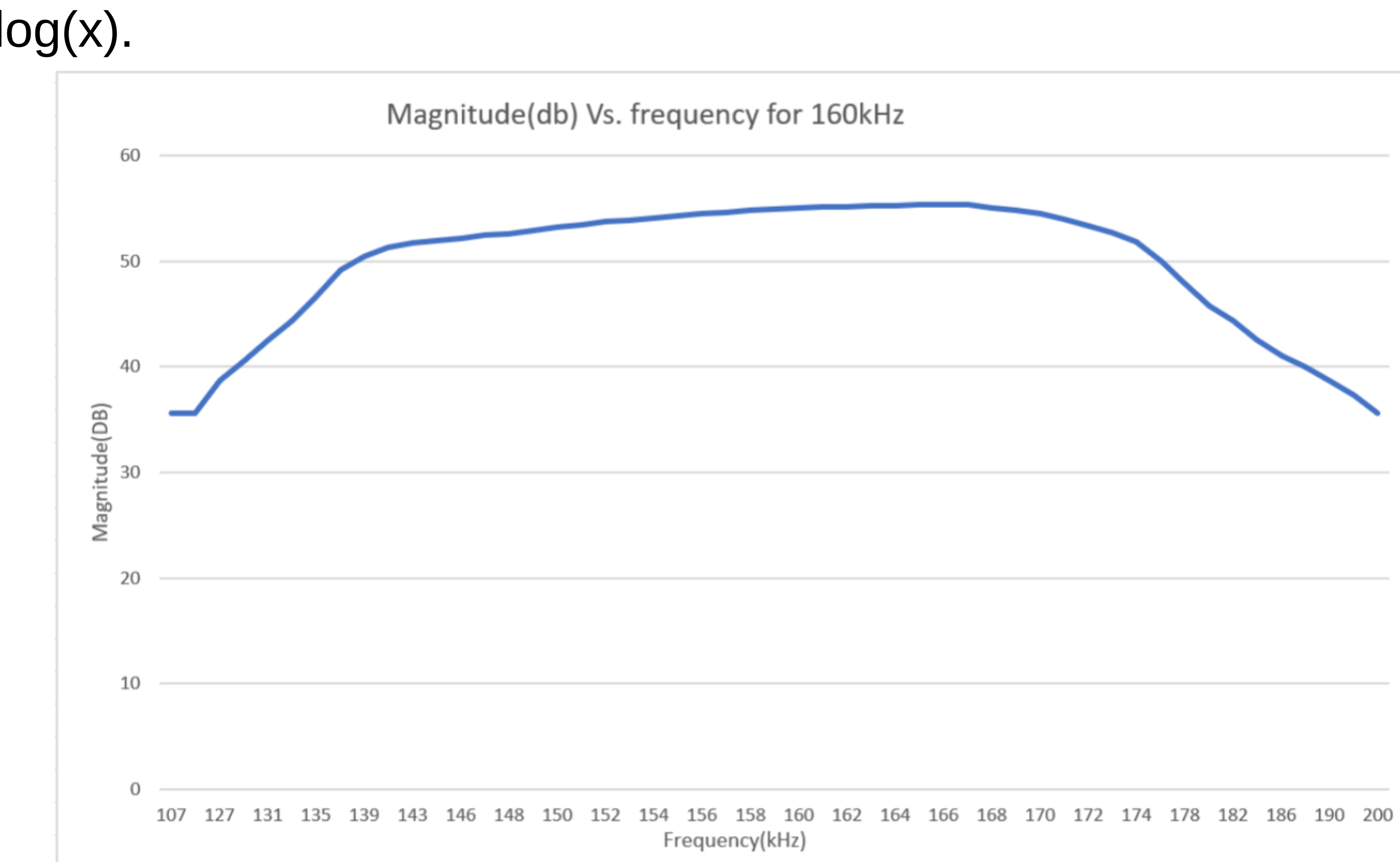


Fig. 4: DB vs Frequency graph with 40 data points

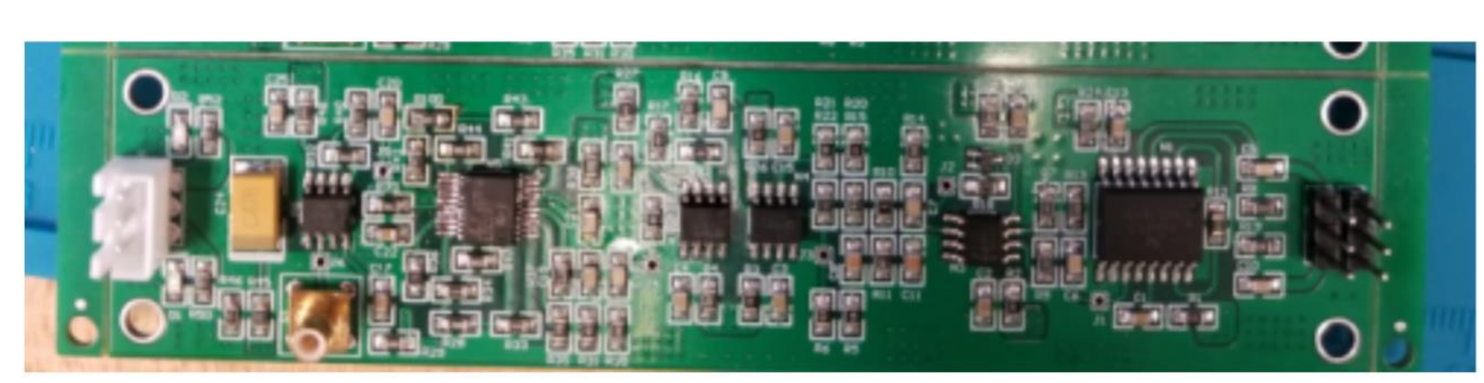


Fig. 5: 160kHz board soldered

Conclusion and future

- The graph is the similar as predicted but not as good as simulation.
- Would work properly as the graph is in the acceptance range of error.
- The results proved our new design to be feasible of receiving very tiny signal at given frequency range.
- Building a system containing FPGA, Class D amplifier, transducer and this receiving board for signal transmission.

Reference

- Yukang Xue. 2020. Experimental Evaluation of Low-Noise Amplifiers for high-frequency acoustic receivers. In Proceedings of . ACM, New York, NY, USA, 6 page

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