# Design and Implementation of M-FSK for a Software-Defined Underwater Acoustic Modem

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UNDER THE GUIDANCE OF DR. GEORGE SKLIVANITIS

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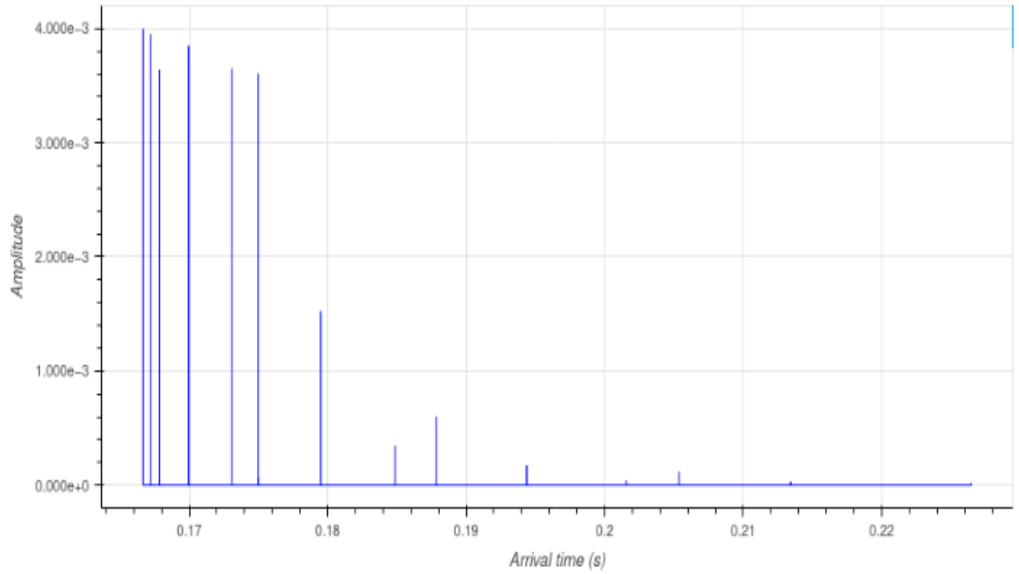
**MARINE AND ENVIRONMENT: COGNITIVE WIRELESS RADIOS FOR MARITIME ROBOTICS**

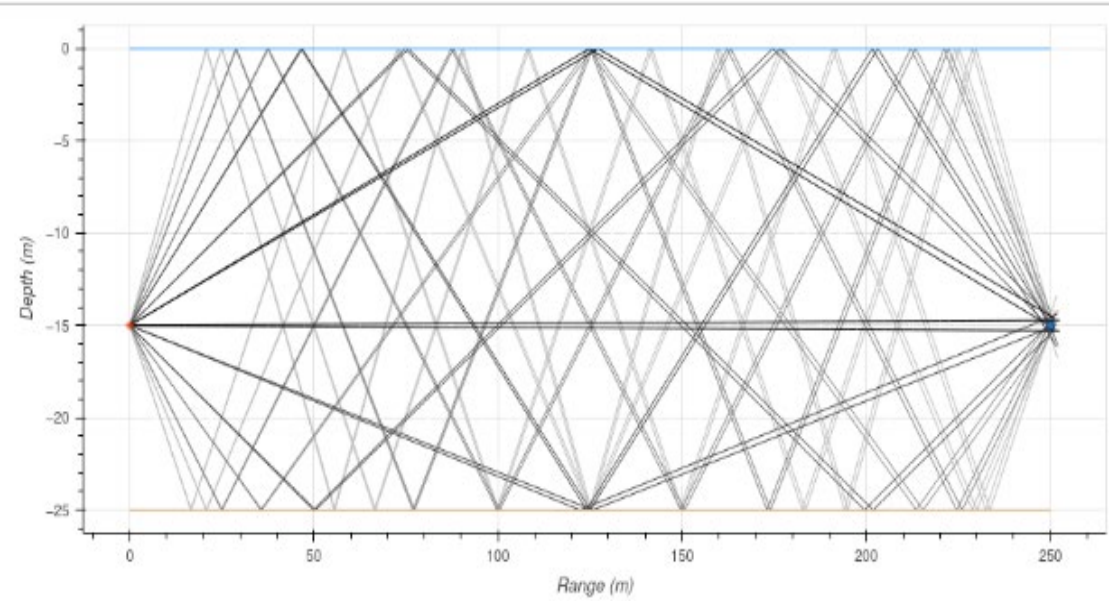
# Simulating the Underwater Acoustic Channel

Three types of signal loss:

1. Spreading
2. Scattering
3. Absorption as heat

Weaker signal, as well as “echoes” at a receiver node from **delayed paths**



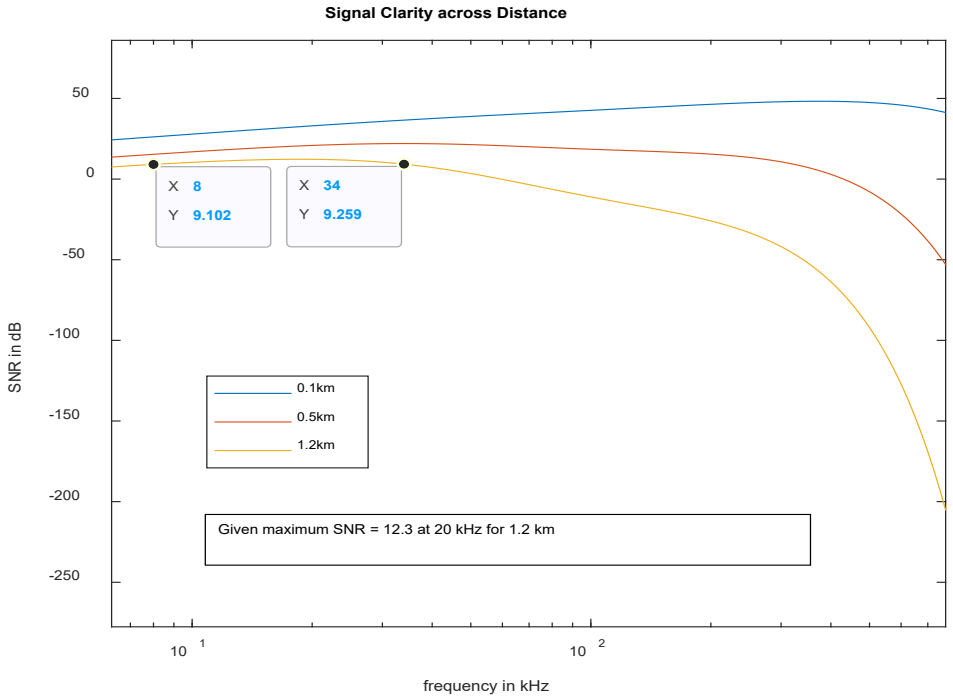



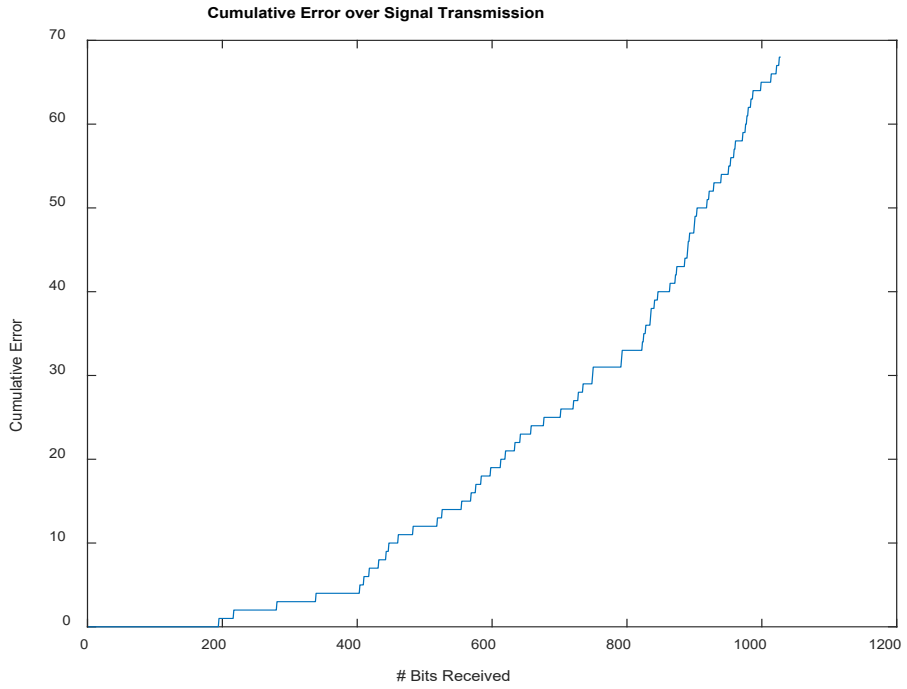
# Underwater Wireless Communications Challenges

Both absorption and added ambient noise are **frequency – dependent**

→ optimal transmission band dependent on **distance**

Interference **stacks up** later in received signal with more echoes

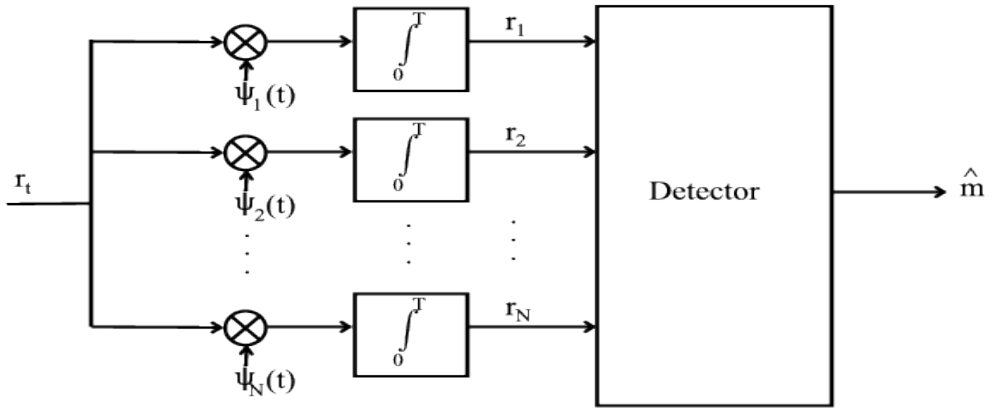


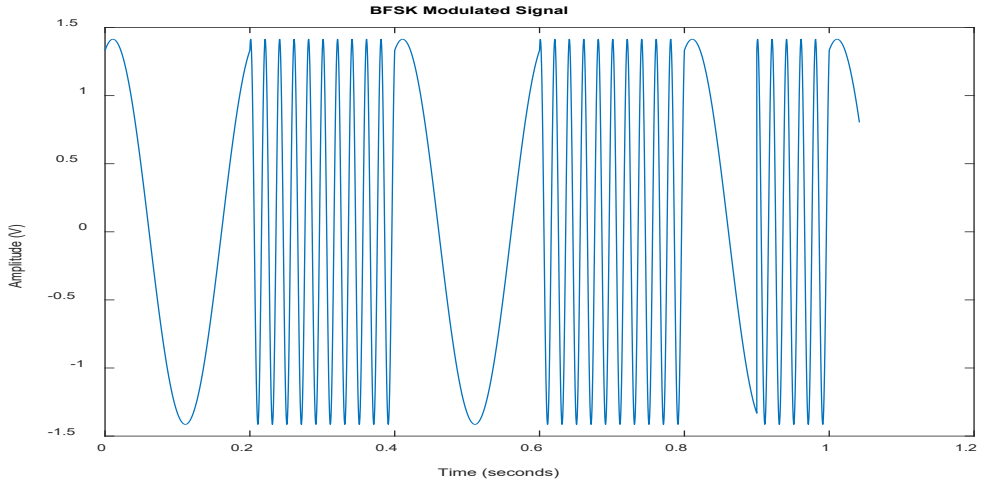



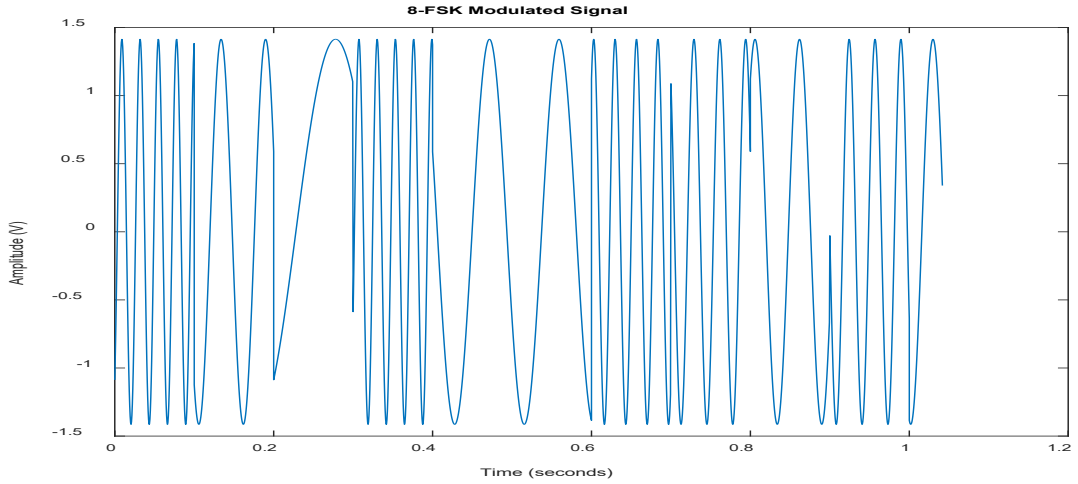
# Building a Reliable Low-Complexity Underwater Wireless Link

Higher data rates require **more** bandwidth but **very limited** band to use underwater

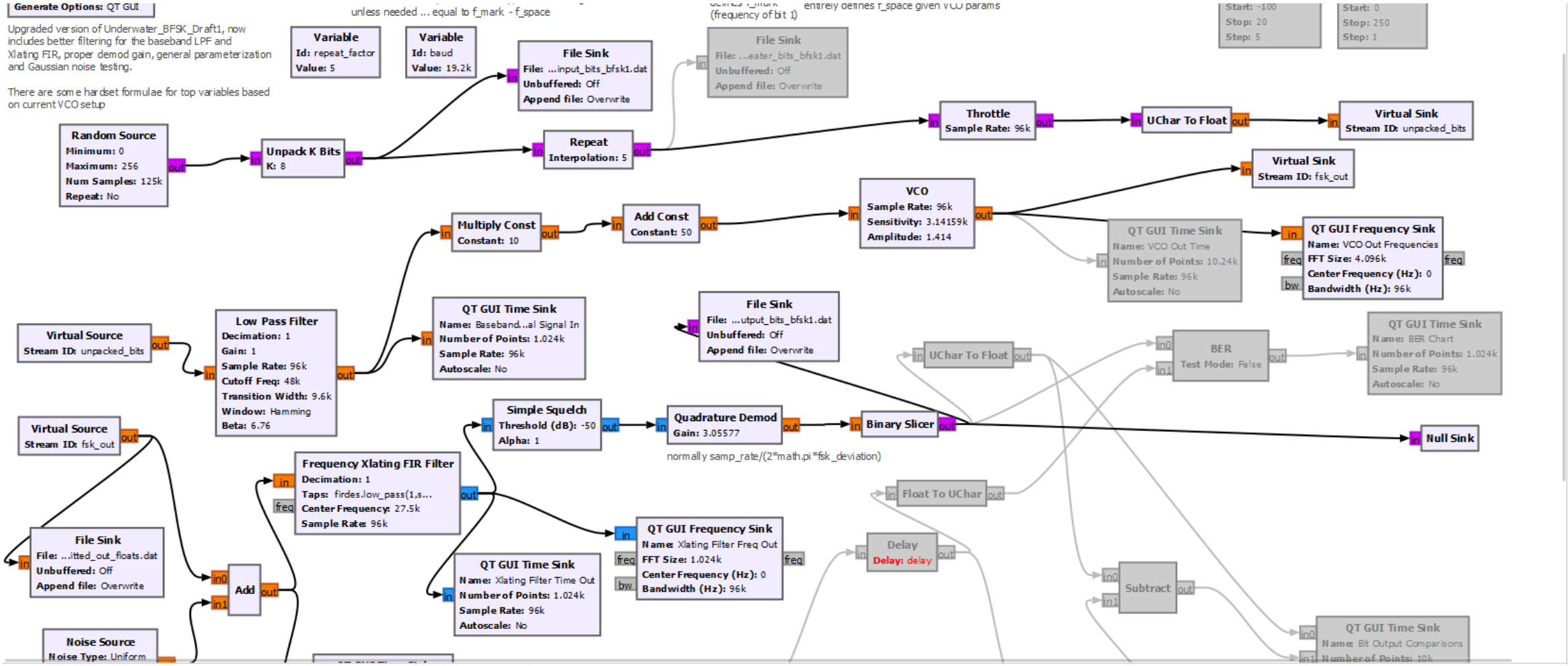
**Idea**: more symbols available to convey info at cost of higher error and **more work** to clean up signal



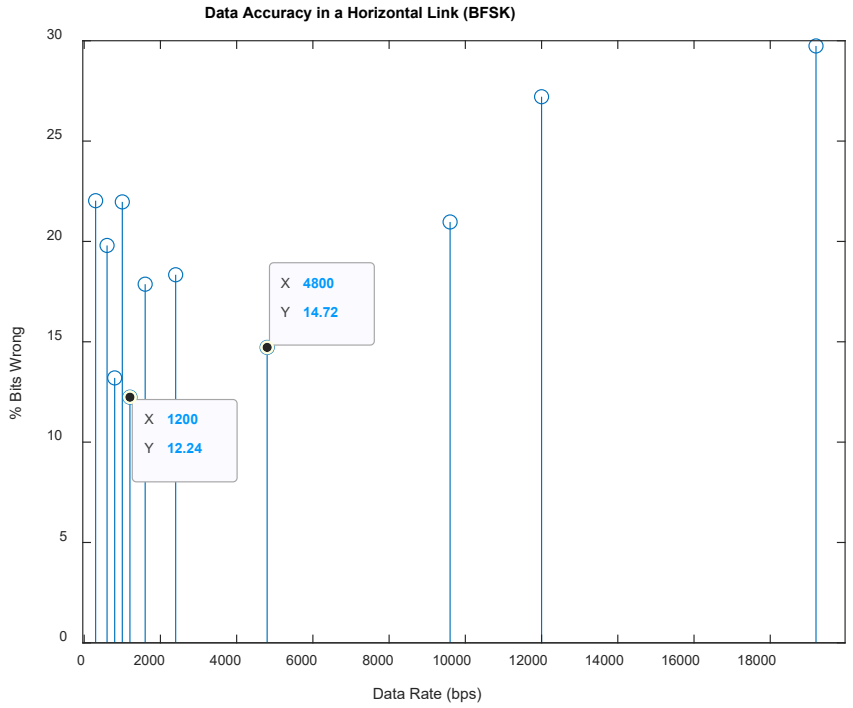



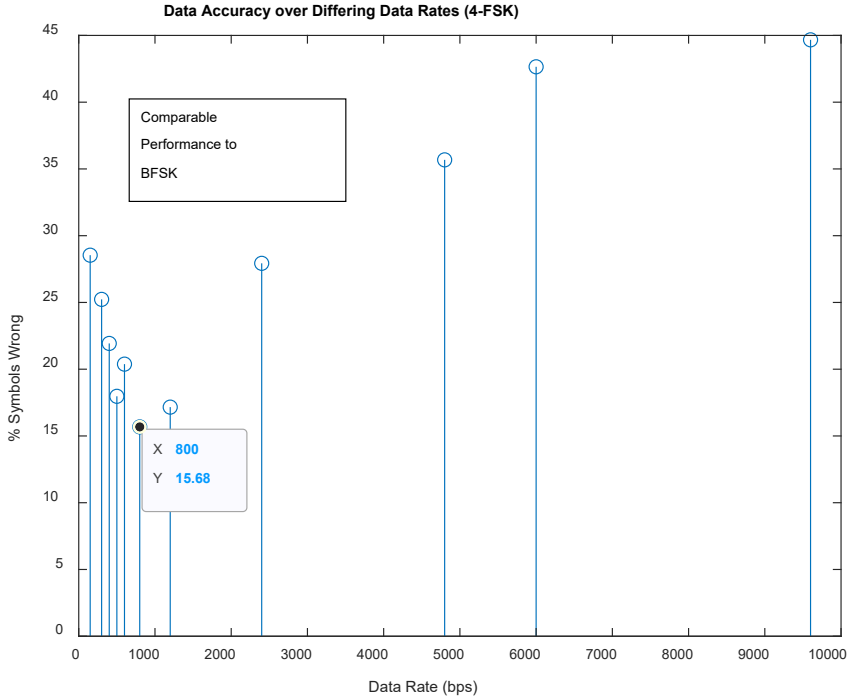



# GNU Software-Defined Radio Simulation



# Experimental Results & Bellhop



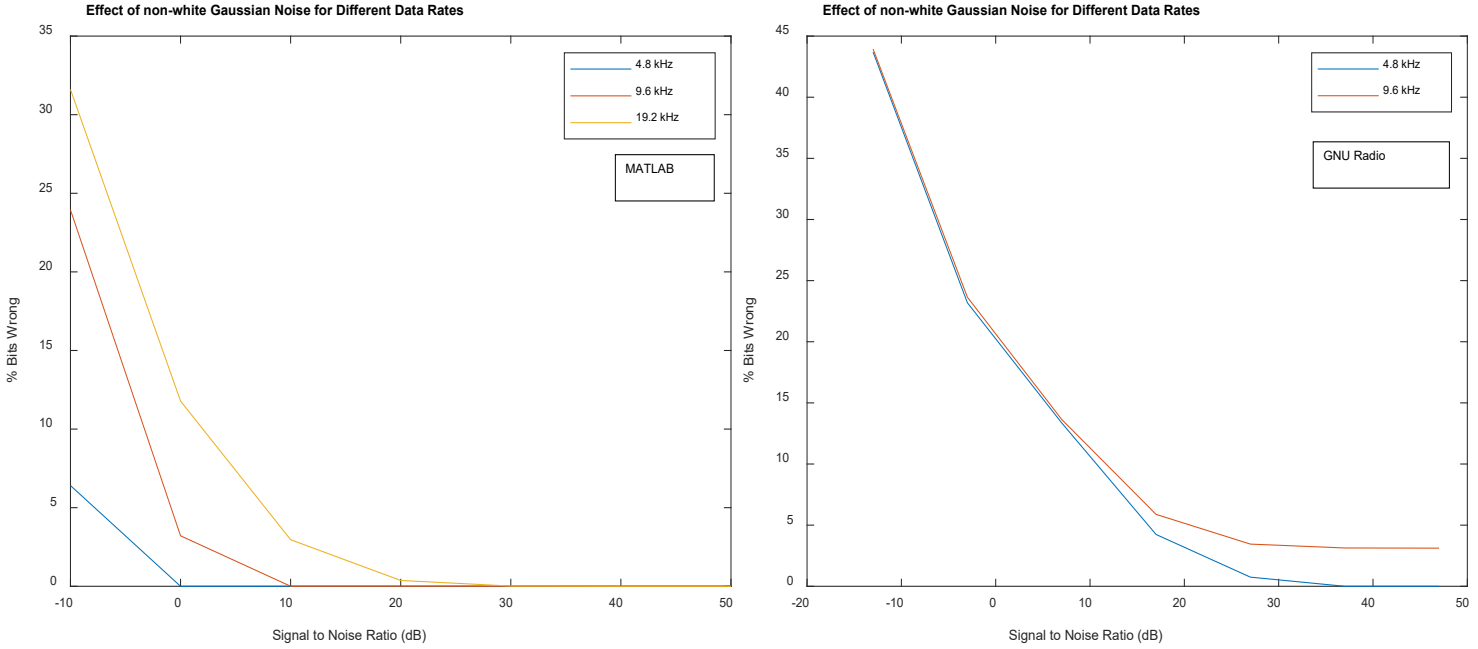



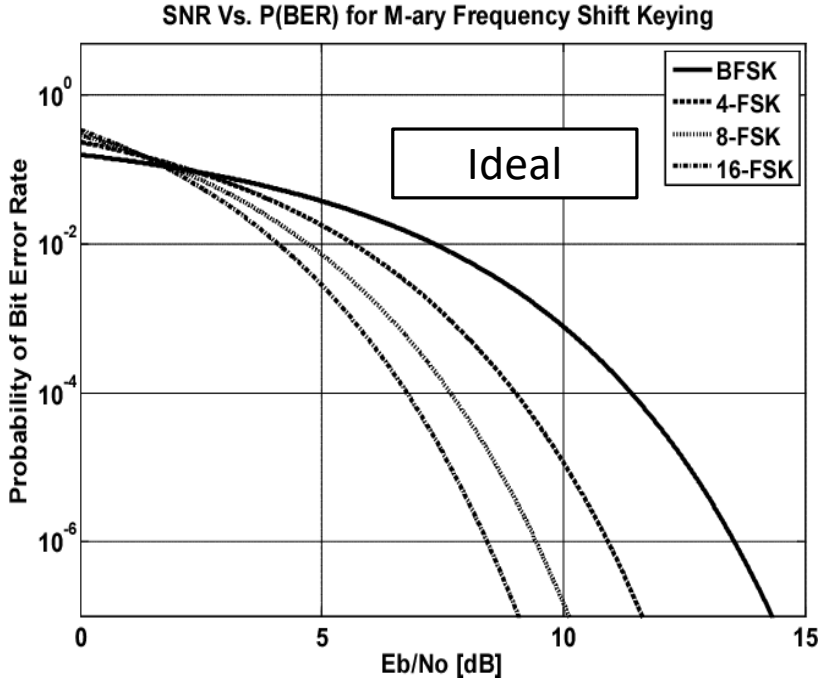

Taken with TX/RX depth 15 m, seafloor depth 25 m, RX range of 250 m, $f_{reference}$ = 25000 Hz, $n_{bits}$ = 10e6

# Experimental Results & Bellhop

## Estimation differences between MATLAB and GNU Radio

MATLAB yielded higher accuracy for same signal quality (SNR)



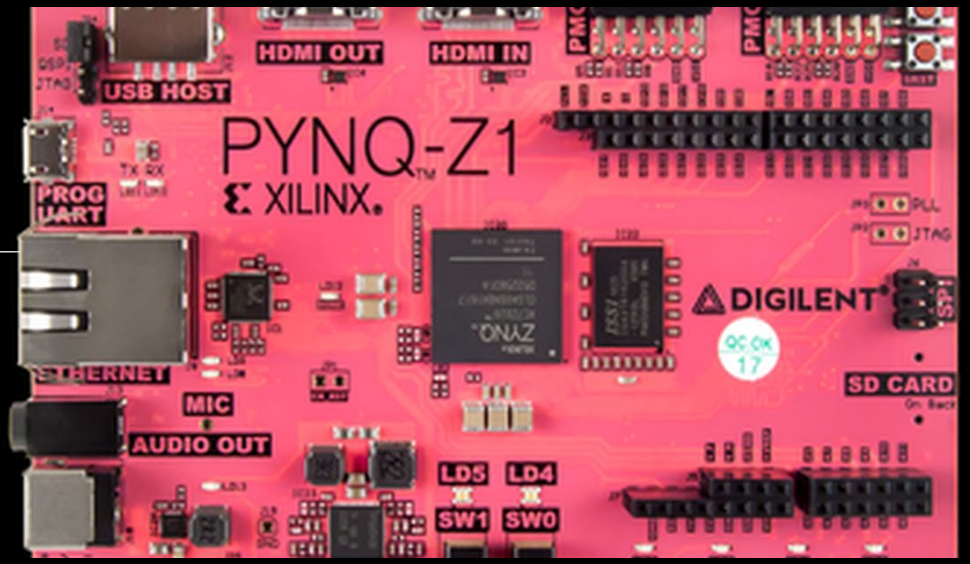



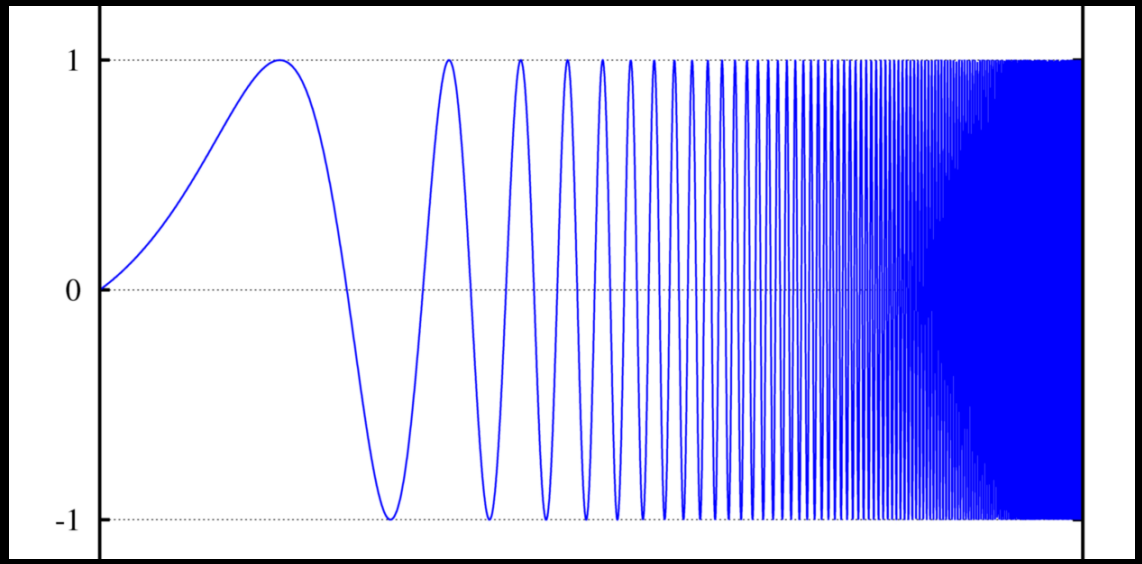
# Future Work

Hardware Implementation of Modem with PYNQ FPGA

Backscatter / Relay Receiver Model

Analysis of Chirped Basis Waveform



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