Prototyping of a 5G Ad-Hoc Cellular System on Hardware Kits

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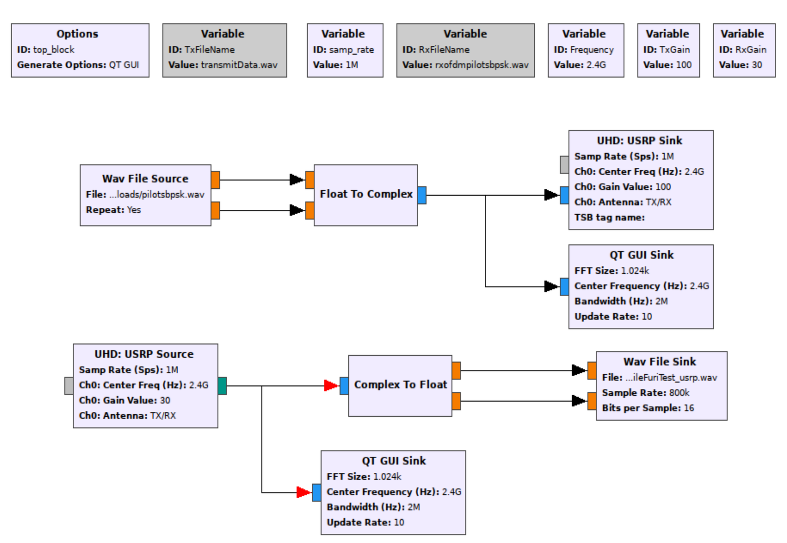
Introduction

Fifth generation (5G) cellular network boasts device-to-device communication, by bypassing a base station and allowing for direct communication between devices. 5G implemented as an ad-hoc network, is capable of self-correction by continuously reconfiguring itself, which protects the network against interference. Also, a network can be created at any time or location where multiple devices are present. Ultimately, if this cellular system is properly implemented it would benefit a massive number of users, both fixed and wireless.

Methodology

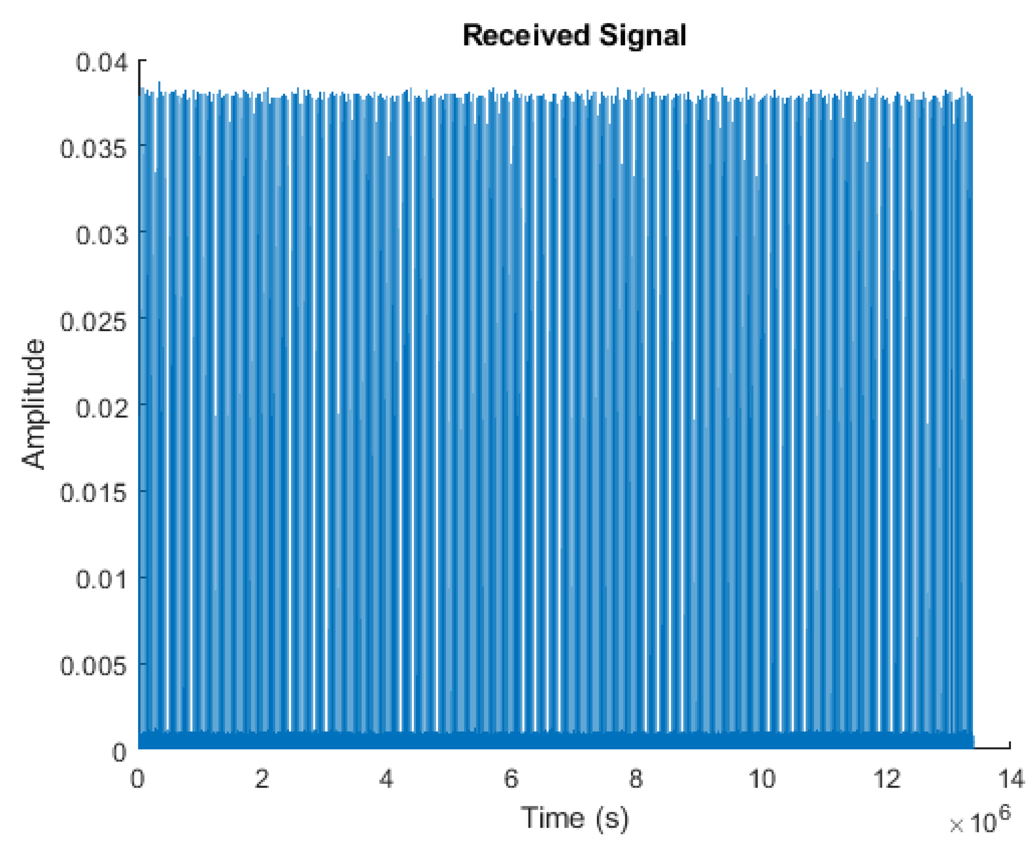
Two USRP B200 kits were connected to a Raspberry Pi 4 B+, one as a transmitter and the other as a receiver, to create a testable Single Input Single Output (SISO) system. A flow-graph for the system was produced in GNURadio Companion and altered using Python code. The results were then analyzed in MATLAB.



Research Question

Can a localization proof-of-concept without GPS be prototyped and then implemented to create a self-correcting 5G ad-hoc cellular network that will connect both fixed and wireless users, regardless of location?

Results



Test Details and Results:

Raspberry Pi 4 B+ → Tx/Rx

Kits: USRP B200

Frequency = 2.4Ghz

Sample Rate = 1Ghz

Transmitter Gain = 100 dB

Receiver Gain = 30 dB

Total Frames = 347

Average BER = 0.0044297

Figure 1 & 2: The OFDM received signal of the SISO system yielded a clean plot of the signal, with a observable pattern. The Average Bit Error Rate (BER) was close to zero. This can only be achieved at lower sample rates. As the sample rate was increased, the noise and BER also increased.

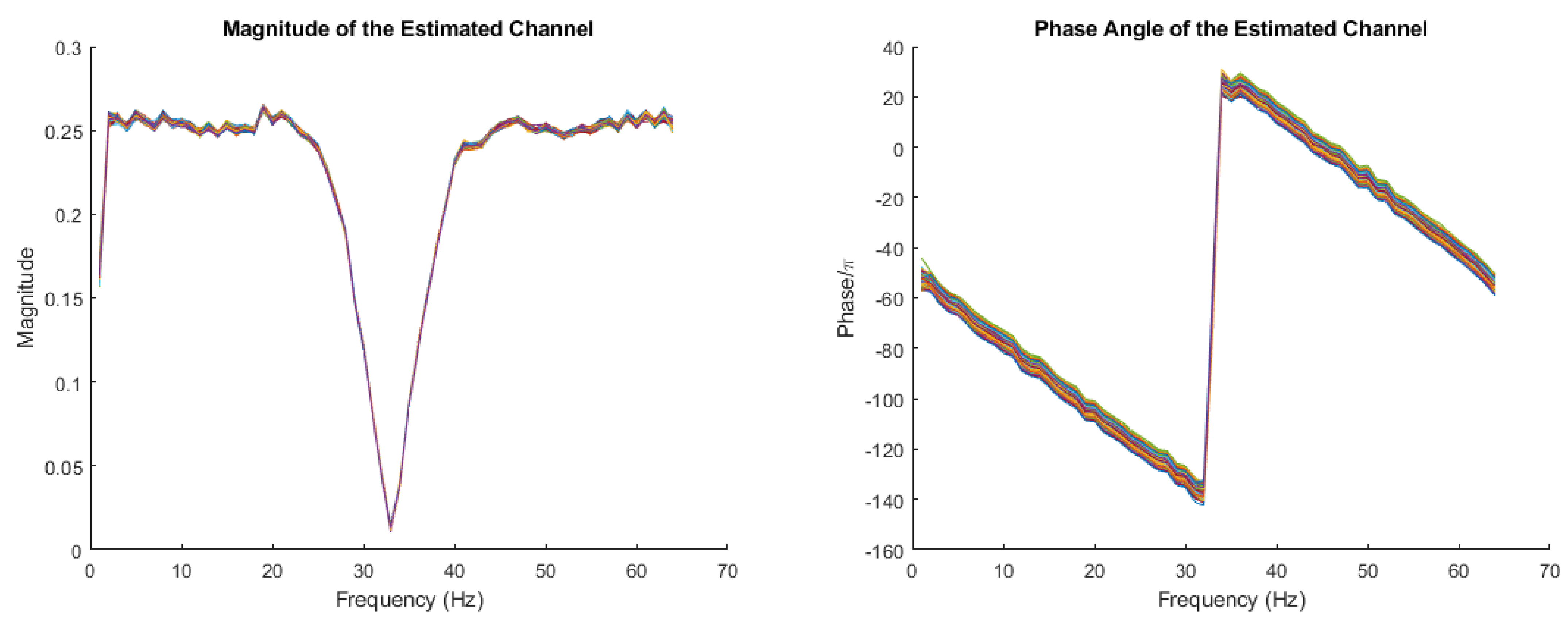


Figure 3 & 4: The curves of the above plots are superimposed on top of each other for all frames proving that the channel estimation of the system is accurate. The system was tested on the same and different computers, but the local oscillators (LO) of the kits only remained synchronized when the kits used the same computer and flow-graph.

Conclusion

Through multiple tests, the results of the SISO system proved that a low BER can only be observed at lower sample rates. Higher sample rates were observed to produce more noise and a higher BER. The accuracy of the OFDM channel estimation was successfully demonstrated. This estimation will be beneficial in achieving accurate and desirable results for BER when moving to SIMO and MIMO testing. Unfortunately, the system's LO synchronization could, so far, only be achieved on the same computer and flow-graph, which poses an issue for a localization proof-of-concept.

Future Work

Continuing forward from the SISO test phase results, one of the future endeavors for this project will be to implement a GPS system to synchronize the clocks and local oscillators of the kits, which will be used during other testing phases. The other will be to develop a system using the kits together with a Raspberry Pi 4 B+ , as the controller, to develop a cellular network wherein autonomous decision making and independent communication between nodes can be achieved and expanded upon.

References

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