Performance Analysis of Underwater Wireless Optical Communication System (UWOC)

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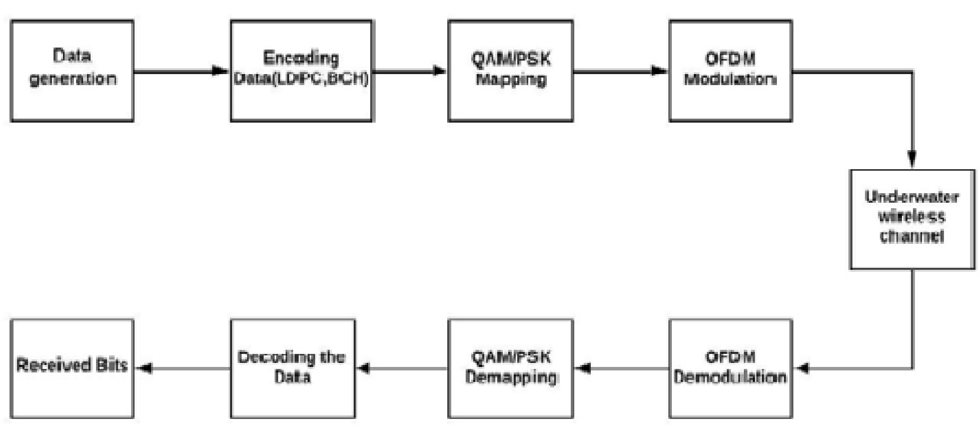
MOTIVATION

Underwater optical wireless communication (UOWC) systems have received a great deal of attention due to the advantages of a much higher data rate, security, and a much lower latency compared to the traditional underwater acoustic communication systems. And performance of the RF system is also degraded much severely by the turbulence caused by the air bubbles and the temperature variations than by salinity of water. Although the transmit length is relatively short as the light beam suffers from absorption, scattering and turbulence induced fading, UOWC is still a promising technology in many applications. Still UWOC is not used to its full capacity, even today it is unexplored in many areas. Therefore working on this topic will be more useful for us students and also we can contribute our work towards this part of communication system.

Scope of the Project

The underwater environment is a very harsh and dynamically changing communication channel. The optical properties seawater is strongly affected by Absorption, scattering, and turbulence. The two main processes affecting light propagation in water are Absorption and scattering, which both depend on wavelength λ. The primary objective of this project is to simulate an impulse function for an Underwater wireless channel for with primary factors affecting the channel are scattering and absorption. From the simulated impulse function, we transmit a different kind of signals, namely OFDM with QAM and OFDM with PSK ,and record Bit error rate(BER) of these different signals and analyze and compare their performance. Moreover, we analyze the maximum distance that can be achieved by the transmitted signal. And to reduce the bit error rate, we deploy different encoding techniques such as LDPC and BCH encoding and try to reduce the bit error rate of the received signal.

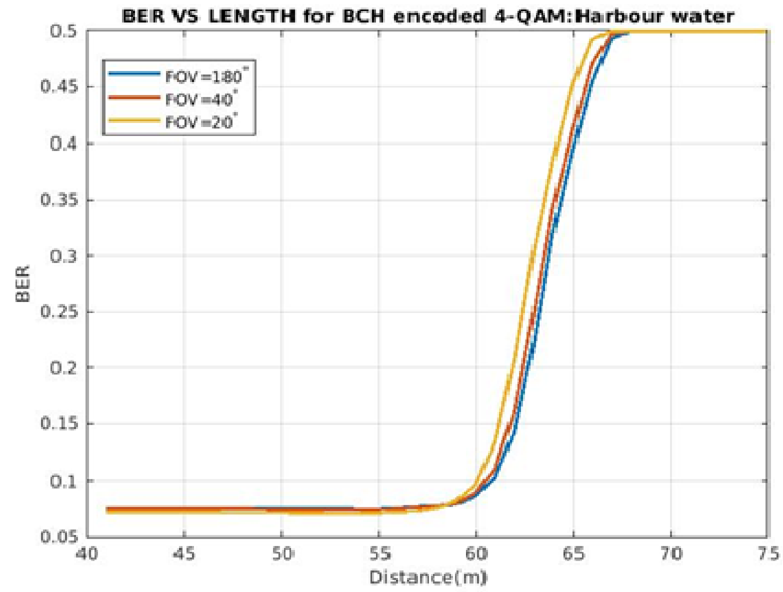
Methodology



Initially, we start with the generation of data; the data points we used for this experiment is 32400 bits. For the data point, we randomly assign 0's and 1's up to 32400 bits. After the data generation, we then encode the data using LDPC and BCH techniques. We then simulate the water channel using the CEAPF channel impulse response function[2]. It depends on three real world parameters which are Absorption, scattering coefficients and the length of the channel. Then we transmit this OFDM signal into the simulated water channel. In the receiver, we first demodulate the received OFDM signal. After the signal decoding, we move to find the Bit error rate of the received signal. For this purpose, we compare every bit received against every bit transmitted. With this cycle, by increasing the length of the channel after each iteration, we can find the maximum transmitting length and BER of a signal on a particular channel.

Results

S. no	Modulation	Modulation order	Encoding	BER(HARBOUR)	BER(COASTAL)	Max.distance(m) HARBOUR	Max.distance(in m) (COASTAL)
1	QAM-OFDM	4	BCH	0.0717	0.0525	62	161.9
2	QAM-OFDM	4	LDPC	0.1739	0.126	62	161.9
3	QAM-OFDM	4	NIL	0.1343	0.0601	62	161.9
4	PSK-OFDM	4	BCH	0.1238	0.0617	1982	4076
5	PSK-OFDM	4	LDPC	0.1739	0.1231	1982	4076
6	PSK-OFDM	4	NIL	0.1725	0.08451	1982	4076
7	QAM-OFDM	16	BCH	0.307	0.2786	62	161.9
8	QAM-OFDM	16	LDPC	0.4919	0.49858	48	161.9
9	QAM-OFDM	16	NIL	0.3378	0.3099	62	161.9
10	PSK-OFDM	16	BCH	0.3615	0.3021	1982	4081
11	PSK-OFDM	16	LDPC	0.2786	0.2264	1982	4081
12	PSK-OFDM	16	NIL	0.3753	0.3235	1982	4081



Conclusion

From the observation table, it is clear that encoding the data can reduce Bit Error Rate, and out of the three encoding techniques used, BCH encoding can reduce BER the most. Among all the combinations, PSK-OFDM modulation, along with BCH encoding, seems to be the most prolonged travelling signal with every less BER. Even though encoding techniques reduce the error rate of the signals to a considerable amount, they can still be reduced by applying Equalization methods such as Least Mean Square (LMS), Volterra equalizer, and so on. Thus there is still scope to reduce the errors in the signals.

References

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[2] YIMING LI, M. S., & LI, X. (2018). Impulse response modeling for underwater optical wireless channels. *applied optics* (pp. 4815-4823). china: Optical Society of America.

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