International Journal of Research, Science, Technology & Management
e-ISSN: 2455-2240, Volume 9 Issue III, December 2017

Performance Analysis of OFDM Based Under-Water Communication

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Abstract- Underwater communication Networks (UCN) have been of growing interest in recent years. It provide an early warning for natural disasters, aid in surveillance applications for defense purposes, and assist and recovering wrecked ships and aircrafts. Under water acoustic (UWA) communication is widely used in many applications and is a particularly critical technology for underwater exploration activitie. In this paper we will analyse the performance of underwater communication along with the OFDM.

Keywords- Underwater Communications; acccoustic communication, multipath propagation, Efficient modulation, underwater networks.

1. Introduction

Marconi is a first person to explore new field of the wireless industry more than 100 years back. Today life does not appear conceivable without wireless in some structure or the other. Wireless communication is one of the quickest developing commercial ventures [1, 2, 3]. It penetrates each part of our lives. Later progresses in wireless communication systems have expanded the throughput over wireless channels; furthermore the dependability of wireless communication systems has been expanded. The fundamental main impetus behind the quick improvement of wireless communication systems is the guarantee of compactness, portability, and availability. Wired communication is steadier and exceedingly dependable, yet limits the clients to a limited domain. Sensibly, individuals pick flexibility versus restriction. Hence, there is a characteristic inclination towards disposing of wires if conceivable. While, this flexibility is the primary main aim for clients, the punishment for this flexibility is frequently lower quality, protection, security, or lower throughput contrasted with the proportionate wired arrangement. The requests on bandwidth and spectral availability are likewise unending. The need to achieve accurate wireless systems with greater spectral efficiency, higher ease and great mistake execution results in proceeded with exploration in this field.

2. Underwater Communication

There are a few methods for sending and accepting message for underwater communication method and remote underwater communication is one of them. Be that as it may, what is the best answer for underwater communication? What are the most difficult channels for underwater communication? In this part, we will search for the appropriate responses of these inquiries.

2.1 What is Best Option for Underwater Communication?

For remote underwater communication, there are a few means, for example, radio waves, optical waves and acoustics.

Radio waves: The main waves, which can engender any separation in ocean water, are radio waves of additional low frequency (30 Hz– 300 Hz). In any case, such low frequencies require high transmission power and substantial recieving wires.

Optical waves: There isn't excessively languish over weakening, however when scattered, optical waves are amazingly affected and on account of this reason what can engender in water is just lasers of extraordinary power.

Acoustics: For remote underwater communication, one might say that acoustics is the best key arrangement. [4] Having stated, underwater acoustic communication is a system of sending and getting message beneath water [1]. To do such communication, there are a few ways. Due to factors like time varieties of the channel, accessible transmission capacity (little), signal weakening (solid), multiway spread, underwater communicationis troublesome – particularly for long separations. As it were, as a result of emphasized Doppler impact, remove subordinate data transmission, regular foundation noise and frequency subordinate constriction, one might say that these are the reasons of which makes the underwater channel a standout amongst the most difficult channels.

2.2 Reasons of Underwater Channel as Most Challenging Channels

As a result of the reasons, (for example, complemented Doppler impact, separate ward transmission capacity, regular foundation noise and frequency subordinate weakening) which will be portrayed quickly beneath, one might say that these are the reasons of which makes the underwater channel a standout amongst the most difficult channels. [4]

Weakening of Acoustic Propagation

The transmitted signal's vitality isn't totally exchanged to the side of the receiver. For occurrence, some piece of the vitality is exchanged to warm vitality. One might say that a portion of the transmitted vitality achieves alternate sides, not all transmitted vitality achieves the receiver.

3. OFDM

OFDM is a mixture of modulation and multiplexing. Multiplexing by and large alludes to autonomous signals, those delivered by different sources. In OFDM the inquiry of multiplexing is connected to free signals yet these independent or free signals are a sub-set of the one principle signal. In OFDM, the signal itself is first divided

International Journal of Research, Science, Technology & Management
e-ISSN: 2455-2240, Volume 9 Issue III, December 2017

into separate channels, modulated by carriers and then multiplexed to create the OFDM carrier. If the FDM system above had possessed the capacity to utilize a set of subcarriers that were orthogonal to one another, a larger amount of spectral efficiency could have been attained to. The guard bands that were important to allow individual demodulation of subcarriers in an FDM system would never again be fundamental. The utilization of orthogonal subcarriers would permit the subcarriers spectra to overlap, in this way expanding the spectral efficiency. As far as Orthogonality is sustained, it is still conceivable to recover the individual subcarriers signals regardless of their overlapping spectrums. It can be seen that practically a large portion of the bandwidth is spared by overlapping the spectra. As more carriers are included, the bandwidth approaches (N+1)/N Bits per Hz. Bigger number of carriers gives better spectral efficiency. The principle idea in OFDM is Orthogonality of the sub-carriers. The "orthogonal" piece of the OFDM shows that there is an exact scientific relationship between the frequencies of the carriers in the system. It is conceivable to arrange the carriers in an OFDM Signal so that the sidebands of the individual carriers overlap and the signals can still be received without neighbouring carrier‘s interference. The Orthogonality feature of OFDM among the carriers can be sustained if the OFDM signal is characterized by utilizing Fourier transform procedures. The OFDM system transmits a substantial number of narrowband carriers, which are nearly separated. Note that at the central frequency of the each sub channel there is no crosstalk from other sub channels. In an OFDM system, the data bit stream is multiplexed into N symbol streams, each with symbol period Ts, and each symbol stream is utilized to modulate parallel, synchronous sub-carriers. The sub-carriers are dispersed by 1/NTs in frequency, in this way they are orthogonal over the interval (0, Ts). A typical discrete-time baseband OFDM transceiver system is indicated in figure underneath. To start with, a serial-to-parallel (S/P) converter amasses the stream of data bits from the source encoder into gathering of $\log_2 M$ bits, where M is the letter in order of size of the digital modulation scheme employed on each sub-carrier. A sum of N such symbols, Xm, are made. Then, the N symbols are mapped to receptacles of an inverse fast Fourier transform (IFFT). These IFFT receptacles compare to the orthogonal sub-carriers in the OFDM symbol.

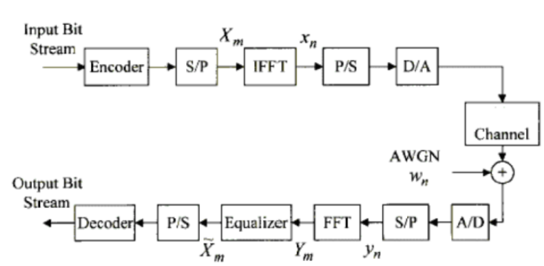

Fig. 1: Baseband OFDM transceiver system.

Therefore, the OFDM symbol can be expressed as

IJRSTM
ISSN ONLINE: 2455-2240
International Journal of Research, Science, Technology & Management
e-ISSN: 2455-2240, Volume 9 Issue III, December 2017

$$x(n) = \frac{1}{N}\sum_{m=0}^{N-1} X_m e^{j\frac{2\pi mn}{N}} \quad 0 \le n \le N-1$$

Where Xm are the baseband symbols on each sub-carrier. The digital-to-analog (D/A) converter then creates an analog time-domain signal which is transmitted through the channel.

At the receiver, the signal is converted back to a discrete N point sequence y(n), corresponding to each sub-carrier. This discrete signal is demodulated using an N-point fast Fourier transform (FFT) operation at the receiver. The demodulated symbol stream is given by:

$$Y(m) = \sum_{n=0}^{N-1} y(n) e^{-\frac{j2\pi mn}{N}} + W(m) \qquad 0 \le m \le N-1$$

Where W (m) corresponds to the FFT of the samples of w (n), which is the Additive White Gaussian Noise (AWGN) introduced in the channel. The fast speed data rates for OFDM are proficient by the simultaneous transmission of information at a lower rate on each of the orthogonal sub-carriers. In view of the low information rate transmission, distortion in the received signal impelled by multi-path delay in the channel is not as noteworthy as contrasted to single-carrier high-data rate systems. For instance, a narrowband signal sent at a high data rate through a multipath channel will encounter more noteworthy negative effects of the multipath delay spread, as the symbols are much closer together. Multipath distortion can also cause inter-symbol interference (ISI) where nearby symbols overlap with each other. This is counteracted in OFDM by the insertion of a cyclic prefix between successive OFDM symbols. This cyclic prefix is discarded at the receiver to cancel out ISI. It is because to the robustness of OFDM to ISI and multipath distortion that it has been considered for different wireless applications and standards.

4. Proposed Model

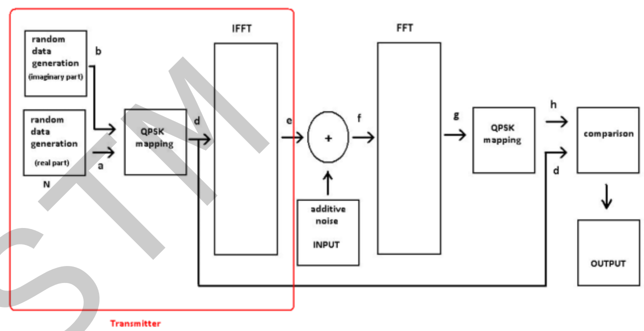

Fig. 2: Proposed OFDM transmitter system.

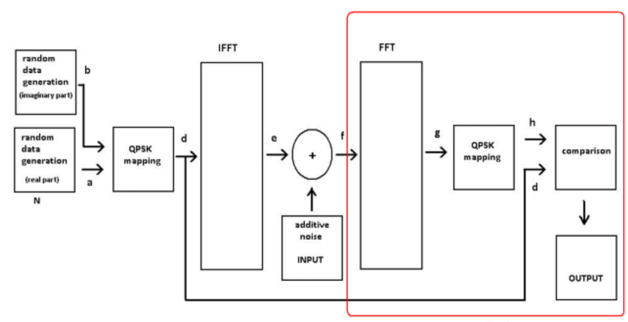

Fig. 3: Proposed OFDM reciever system.

The proposed model for OFDM transmitter and reciever is shown above in the figures. The same is implement using MATLAB coding and simulation.

5. Results

Simulation result is implemented in the Figure 4 below. The x-axis represents SNR in dB (with range from 0 to 25 db) and the y-axis represents BER [-] (with range from 10^-3 to 10^0).

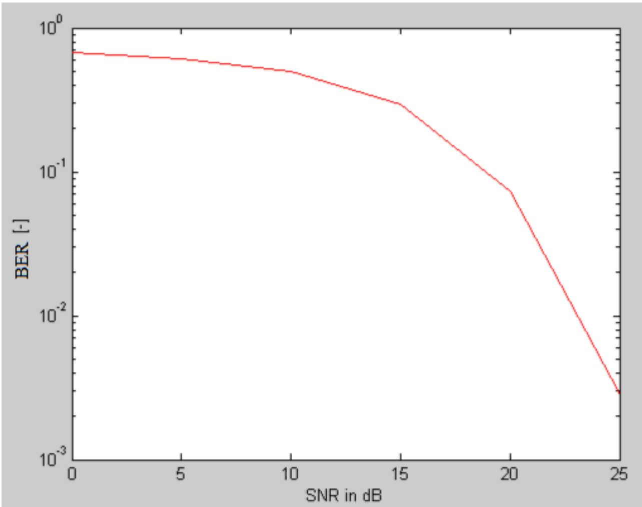

Fig. 4: BER vs SNR (when n=128)

In regards to OFDM block size *n*, if errors are zero, then *BER* is zero. When alldata is wrong, then *BER* will be equal to 1, where 1 represents 100% error. When *SNR* is zero, it is shown that *BER* is very close to 1. Once SNR is increased from 5dB to 10dB, then from 10dB to 15dB, and then again from 15dB to 20dB and so on (until after SNR>25db where BER = 0), BER values decreases. In order words, when *SNR* increases in dB, error and *BER* is decreasing.

Since BER (Symbol error rate) is the ratio of symbol errors to total symbols sent (i.e. Number of symbols received in error/Number of symbols sent). SNR is the signal-to-noise ratio (i.e. it is the average power of signal relative to the average power of noise). Large value of BER indicates low quality of communication (as more errors are encountered). While large value of SNR indicates better communication (as the signal will be getting stronger when compared to the noise and therefore it will be affected to a small extend). As seen in the Figure 4 above, when BER increases (number of symbols received in error is greater than number of symbols sent), we can realize that SNR is indicates worse communication because the signal is getting weaker compared to the noise. And when BER decreases (number of symbols received in error is getting smaller than number of symbols sent), we can realize that SNR is indicates better communication because the signal is getting stronger compared to the noise. This means that according to the Figure 4, the demonstrated simulation result of BER versus SNR is very close in terms of comparison to the theoretical result. Which means this simulation result supports this claim.As shown in the Figure 5 below, OFDM block size *n* is 128 - illustrated with red. When OFDM block size *n* is increased to 256 (illustrated with blue) and then changed to 512 (illustrated with green), *BER* increases as well as error does increase.

For the given values;

In case of OFDM block size n=128, SNR in dB is 25 when BER is zero;

In case of OFDM block size n=256, SNR in dB is 29 when BER is zero;

In case of OFDM block size n=512, SNR in dB is 31 when BER is zero.

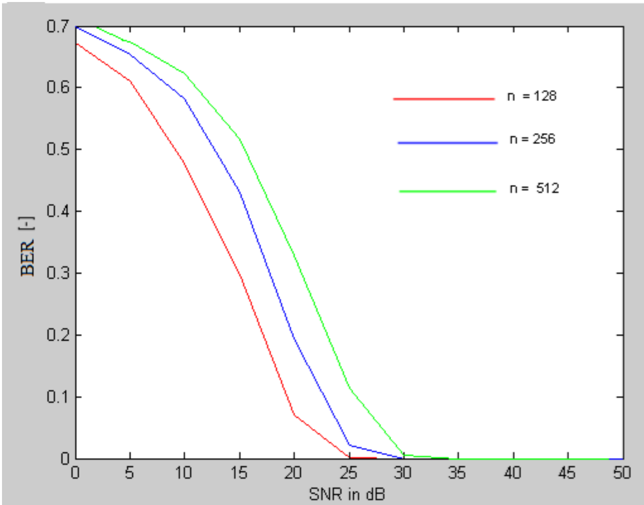

Fig. 5: BER vs SNR (when n= 128, n=256, n=512)

As seen above, when subcarriers *n* increases, error increases in relation to that *BER* increases.

As seen in the Figure 6 below, when we assume that – for instance- BER value is 0,4, here there are the SNR values in dB such as;

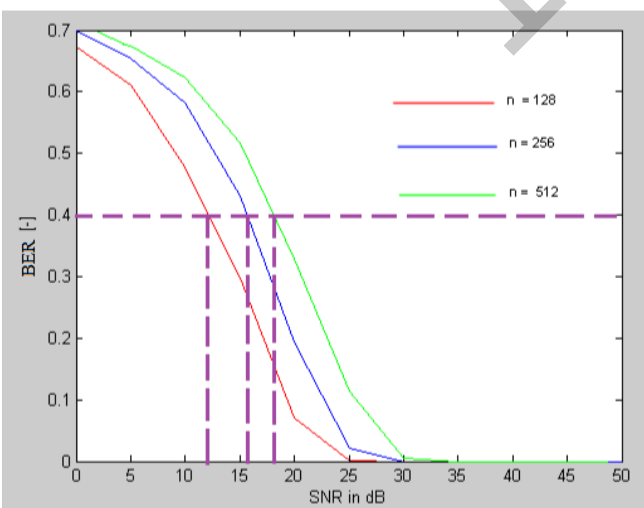

Fig. 6: SNR values at point BER 0.4 [-] for (n= 128, n=256, n=512)

In case of OFDM block size n=128, SNR is 12dB at point where BER is 0.4

In case of OFDM block size n=256, SNR is 16dB at point where BER is 0.4

In case of OFDM block size n=512, SNR is 18dB at point where BER is 0,4

In other words, bit error rate remains the same at the same point when there are more subcarriers, we need better signals because bandwidth is bigger in this simulation example.

6. Conclusion

A simulation, and in addition an investigation about OFDM modulation for system having underwater communication, is made in this disBERtation with respect to present day modulation process for system having underwater communication. The modulator and demodulator device is appeared and an investigation explore made for present day modulation process for system having underwater communication. The bit error rate (BER) is considered as the fundamental parameter. The simulation is executed as a SNR versus BER correlation for transmission and receiving of signals which are modulated.

Vast estimation of BER demonstrates low nature of communication as large errors are experienced. While vast estimation of SNR demonstrates better correspondence as the signal gets more strengthen when contrasted with the