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Analysis of Underwater Acoustic Channel for OFDM System

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***Abstract*— Underwater acoustic channel has the characteristics of severe multipath, rapid variation and estimation of its phase is difficult task. Hence achieving high data rate and reliable communication is a challenge for Underwater Acoustic Channel (UAC). Orthogonal frequency division multiplexing (OFDM) has emerged as a promising modulation scheme for underwater acoustic (UWA) communication. Inter symbol interference (ISI) can be avoided by transmitting a number of narrowband subcarriers by using a guard time.**

This paper deals with the evaluation of Bit Error Rate (BER) of Orthogonal Frequency Division Multiplexing (OFDM) system under different combinations of modulation techniques with convolution channel coding at different coding rates

***Keywords:* - BER, ISI, OFDM, UAC.**

I. INTRODUCTION

Fluctuations due to environmental characteristics include, seasonal changes, geographical variations both in temperature and salinity, seabed relief, currents, tides, internal waves, movement of the acoustic systems and their targets. All this make the underwater acoustic signal to be randomly fluctuating. Because all of these limitations of the underwater channel the selection of the type of modulation and error correction techniques has to be carefully analyzed.

All communication channels are affected by noise, interference or distortion due to hardware imperfections, or physical limitations. In the presence of existing noise and interference, for effective communication selection of proper Codec (Coding Decoding) Technique and Modem (modulation and demodulation) are essential , even if the channel introduces errors by an effective encoding technique, the receiver will detect & correct the errors. Compared to communication in the air, communicating underwater is severely limited because water is essentially opaque to electromagnetic radiation except in the visible band.

The underwater channel is favorable to the range, an acoustic wave can cover ,but it still has many problems that have to be carefully examined when designing an acoustic based transmission system. Some of these limitations or problems are listed below:

- Attenuation because of the absorption of the acoustic waves in water, this limit the distance the sound can cover.
- Small propagation speed of the sound, approximately 1,500 m/s
- Multi-paths due to the reflection on the bottom of the sea and sea surface, multi-paths cause delayed echoes and interference.

II. PROBLEM DEFINITION AND OBJECTIVE

2.1 Problem definition

High data-communication rate and reliable communication is a challenge for Underwater Acoustic Channel (UAC). In order to improve the system's effectiveness and study the effect of multipath, modeling and simulation of communication system, acoustic channel model is of great significance in the communication system.

2.2 Objective

- To study the existing acoustic channel
- To improve SNR and to reduce BER
- To evaluate the performance of error correcting code for different modulations at different code rate.

III. THE UNDERWATER COMMUNICATION CHANNEL

The underwater channel is limited by two well define interfaces, the bottom of the sea and the sea surface.

The transmission of an acoustic signal is always accompanied by multiple paths due to reflection in both of these interfaces. These multiple paths appear as bursts of replicas of the main signal (in high frequencies) or as spatial field of stable interferences (low frequencies). They both are sources of problems when the receiver is trying to get the data from the transmitted signal. Another considerable problem in the acoustic wave is the Doppler Shift. The Doppler Effect [2] is presented as a shift of the apparent frequency after propagation due to the change in the duration of the transmitter-receiver paths during the transmission, it is caused by the relative movement of the transmitter and receiver. Here three kinds of Doppler effect is been considered, those are

1) unintentional transmitter/receiver motion, i.e., drifting, which gives rise to a Doppler scaling factor

2) intentional transmitter/receiver motion, i.e., vehicular motion

3) waves, i.e., surface motion.

IV. SYSTEM MODEL

Input data

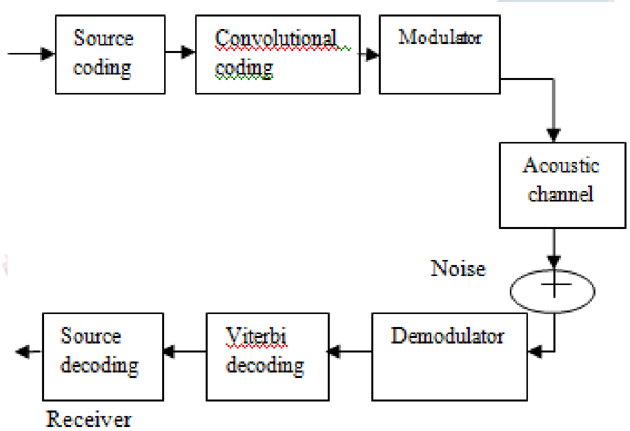

Fig 1: Block diagram of acoustic channel using OFDM

Figure 1 depicts block diagram of acoustic channel implemented using OFDM system.When high-speed binary data is transmitted over a communication link, errors will occur,these errors produce changes in the data's binary bit pattern caused by interference, fading, distortions, noise, or equipment malfunctions, which cause incorrect data to be received. The number of bit errors that occur for a given number of bits transmitted is referred to as the bit error rate (BER). The process of error detection and correction involves adding extra bits to the message data characters at the transmitter (redundant bits) to permit error detection or correction at the receiver. This process is called as channel coding. In this paper convolutional code is used as channel coding, in which codes are generated by passing the information sequence through a finite state shift register. In general, the shift register contains N k-bits stages and m linear algebraic function. generators based on the generator polynomials The input data is shifted into and along the shift register, k bits at a time. The number of output bits for each k bit user input data sequence is n bits. The code rate RC = k/n. The parameter N is called the constraint length and indicates the number of input data bits that the current output is dependent upon. Different modulations used in the system are PSK and QAM.

The signal to noise ratio (SNR) expresses the relative importance of the power contribution of the signal expected and the perturbing noise. The SNR is the principal parameter that affects the performance of a receiver in almost all applications being acoustic or electromagnetic transmissions. We have to make sure that the SNR and the Bit Error Rate (BER) allows us to maintain a robust communication link in which the data transmitted is protected from ambient noise as well as other impairments. BER is a parameter that describes the way a digital communication link behaves and how we can rely on it. Another fundamental parameter in a digital communication link is the Eb/No

In our simulations we will use different modulation techniques and compare the results of each one of them. We have selected 16PSK, 32PSK, 16QAM, 32QAM modulations as they can achieve high data rate with smaller bandwidth. In the acoustic communication channel it is very important to have a robust transmission and also an efficient modulation technique that allows us to improve the amount of data transmitted.

V SIMULATION RESULTS

In simulation, we combine the use of higher order modulation techniques such as 16PSK, 32PSK, 16QAM, 32QAM and Convolution codes at different code rates to find the best combination, i.e which provides less error rate for acoustic channel.

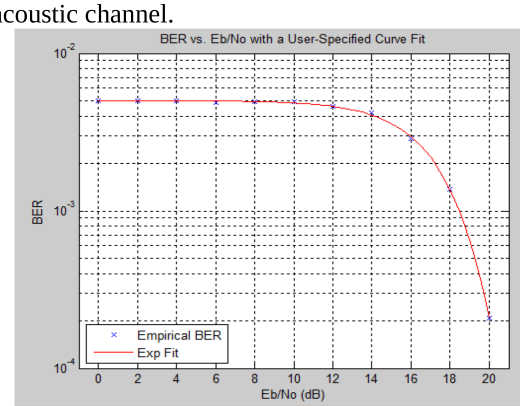

Fig 2: BER performance of 16PSK modulation at rate of 1/2

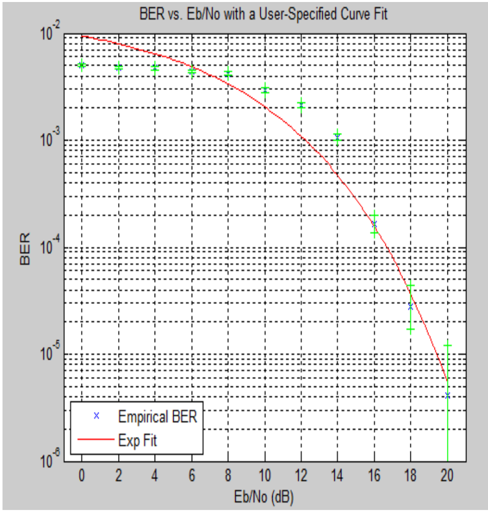

Fig 3 :BER performance of 16PSK modulation at rate of 1/3

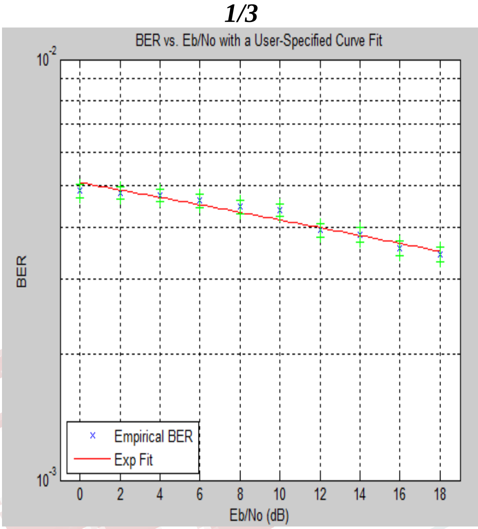

Fig 4: BER performance of 32PSK modulation at rate of 1/2

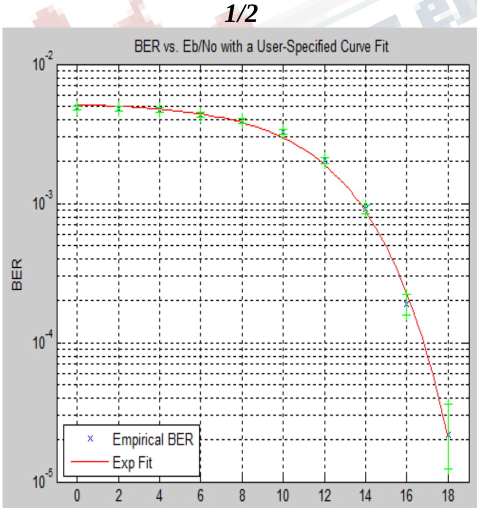

Fig 5: BER performance of 32PSK modulation at rate of 1/3

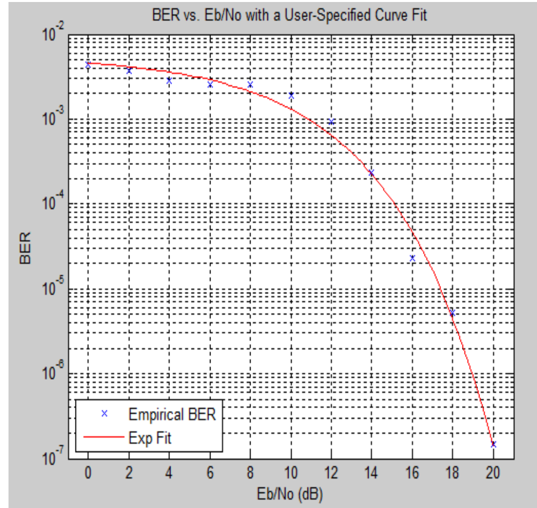

Fig 6:BER performance of 16QAM modulation at rate of 1/2

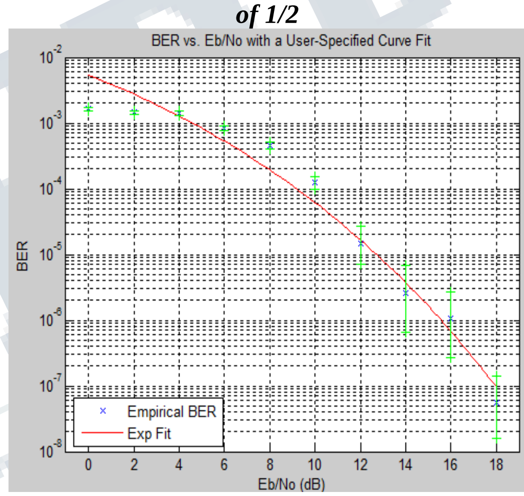

Fig 7: BER performance of 16QAM modulation at rate of 1/3

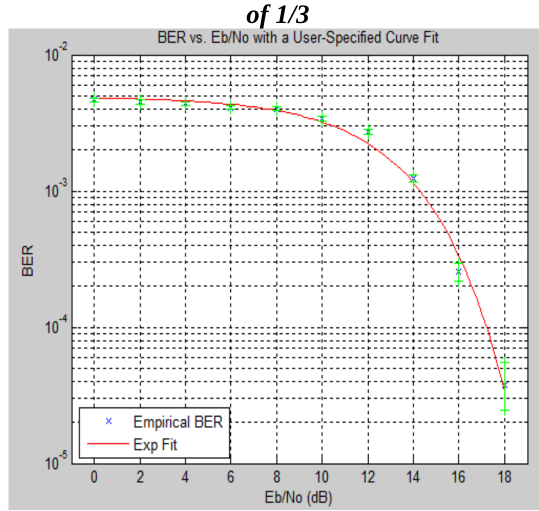

Fig 8: BER performance of 32QAM modulation at rate of 1/2

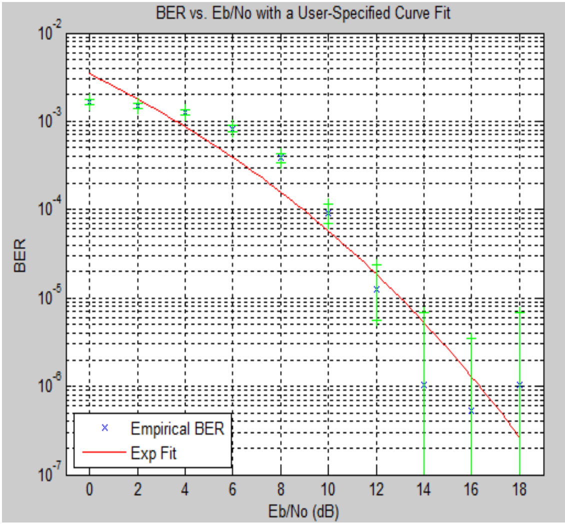

Fig 9: BER performance of 32QAM modulation at rate of 1/3

Table 1: Comparison of BER at SNR=18db for different modulations which is analysed from figure 2 to figure 9 has been tabulated

Modulation	Code rate=1/2	Code rate=1/3
16PSK	1.584e-003	1.995e-005
32PSK	1.778e-003	1.258e-005
16 QAM	2.518e-006	7.943e-008
32QAM	1.778e-005	1.122e-006

Table 1 shows the performance of BER for different modulations at the code rate of 1/2 and 1/3 at the SNR of 18 db. From the above statistics the best modulation is 16QAM at the code rate of 1/3 which could be used for acoustic channel.

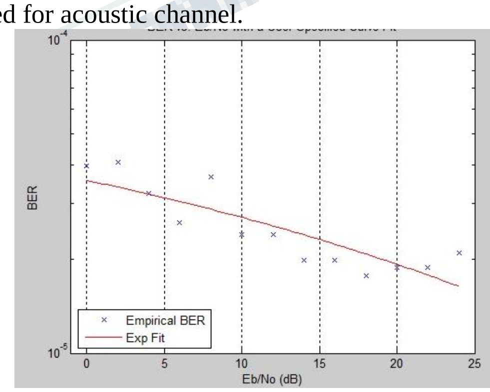

Fig 10: BER performance of acoustic channel using qam16 at the code rate of 1/3

In fig 10, SNR at 20db is 1.2302e-005,which is the required BER to achieve efficient communication using acoustic channel.

CONCLUSION

OFDM is a very promising solution for the UAC, it is very efficient when the noise is spread across the bandwidth. OFDM transmits several carriers instead of a single modulated carrier. Higher SNR are allocated with higher data rate, and so lower data rate will be used in carriers with smaller SNR values. From Table1 by comparision we can conclude that 16QAM modulation at 1/3 code rate is showing a less error rate, so this is best suited for acoustic channel. By using this combination we can achieve required bit error rate in acoustic channel which is shown in fig 10.

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