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AN IMPROVED MIMO-OFDM WITH MODIFIED LDPC ENCODER DECODER FOR UNDER WATER COMMUNICATION

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ABSTRACT – The shallow water acoustic communication, a typically high bit error rate channel characterized by poor communication quality and propagation delay, is one of the most challenging environment for transmission of signal. In this proposed work we introduce a multiple input multiple output (MIMO) with orthogonal frequency division multiplexing (OFDM) with low complex modulation techniques and also less complex coding techniques to communicate our signal in shallow water acoustic communication. In the last decade there are many different under water acoustics communication technique which are presented, so here a new technique is presented that is based on MIMO-OFDM with BPSK, QPSK and other modulation techniques. Binary phase shift key (BPSK) technique is less complex as compared to other modulation techniques as we know that in underwater the band width is very less only 5 khz, due to which BPSK consume low bit error rate (BER) as well as low signal to noise ratio (SNR).The proposed technique will be simulated with the help of MATLAB R2013b. The future results will show better bit error rate (BER) and frame error rate (FER) as compared to previous methods.

Keywords— **BSWAC, UWAC, FER, BER. MIMO, OFDM, LDPC.**

I. INTRODUCTION

During the last years, underwater communication has become a dynamic field of analysis as there's still a huge gap between the communication technology for terrestrial and underwater application [1-4]. Researchers and scientists have overtimes placed a considerable work discovering the underwater world. The provision in underwater technology helps robot to know higher concerning subordinate in underwater abode that has completely dissimilar setting in terms of its landscape, creatures, composition and physics. The rising demand for analysis of underwater application has drawn the interest of many sectors and industries round the world; government, primarily based or non-public sector. Among the sectors that benefited a lot from the development of this technology are military, oil and gas industries, fisheries, underwater instrumentation corporations, analysis agency etc. Works like seismic observance, underwater golem operation, underwater police investigation and detection, ocean exploration, ocean mapping and information assortment are becoming easier because of this improvement [1-4]. Communication is the most significant method in underwater technology. The strategy permits the information transfer between transmitter and receiver or additional teams. This information is used for navigation, plan of action ways, monitoring, identification etc. Communication may be recognized either by wired or wireless association. Each strategies have their own benefits and downsides, reckoning on the appliance. The current trend has opted wireless communication because the most well-liked manner, particularly once it involves contend with the depth, that word association isn't sensible or not possible.

Underwater acoustics is the study of the propagation of sound in water and therefore the interaction of the mechanical waves that represent sound with the water and its boundaries. The water could also be within the ocean, a lake or a tank. Typical frequencies related to underwater acoustics are between ten Hertz and 1 MHz. The propagation of sound within the ocean at frequencies below ten Hertz is typically

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unimaginable since it can not penetrate deep into the seabed, whereas frequencies higher than one MHz is seldom used because they are absorbed quickly. Underwater acoustics are typically referred to as hydro acoustics. The field of underwater acoustics is closely associated with a variety of alternative fields of acoustic study, together with measuring instruments, transduction, acoustic signal process, physical science, earth science, Bioacoustics, and physical acoustics.

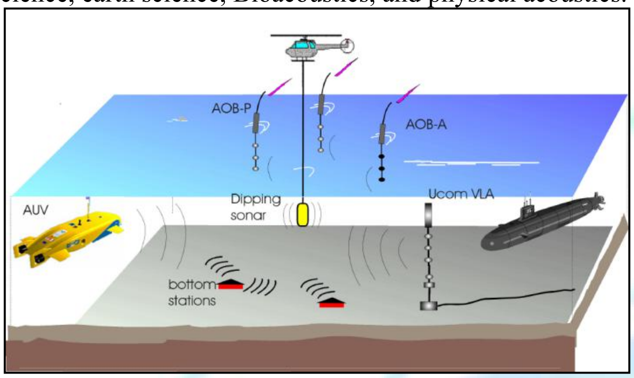

Figure 1. Underwater Acoustic Communication

The relatively slow propagation velocity of acoustic waves, combined with multipath propagation that can include multiple water surface and seabed interactions, results in channel impulse responses that spread over many tens or even many hundreds of transmitted symbols, even at modest data rates. Moreover, the presence of surface and internal waves combined with the movement of communicating vehicles introduces Doppler and fading effects that may be an order of magnitude greater than those experienced in wireles selected magnetic channels. Hence, UWA links fall under the class of doubly dispersive channels with large dispersion both in time and frequency [32].

In underwater environments, acoustic wave is most prefered over radio and optical waves as data carrier, since latter suffer from high attenuation and severe scattering correspondingly within the medium of water. As per the characteristics of acoustic wave propagation, in shallow water, reflective waves are (echo) generated at the surface or at the bottom due to hurdles coming in its path; there is sound refraction caused by speed variations with depth [10, 18]. Each mechanism can cause multipath impact on underwater acoustic communications. Primary outcome of this multipath impact is the relative low propagation speed of acoustic waves in water (c = 1500 m/s), that usually ends up in comparatively giant delay unfold. So as to beat the difficult underwater acoustic communication, there are important researches dedicated to this space since late Nineteen Eighties. In these works, totally different modulation schemes like non-coherent frequency-shift keying (FSK), coherent phase-shift keying (PSK), direct-sequence spread spectrum (DSSS), etc., are adopted.

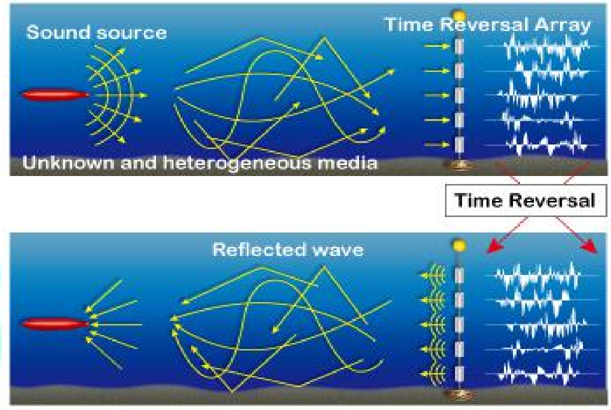

Figure 2: Reflection Of Signals In Underwater Communication Environment

In underwater environments, acoustic wave is most prefered over radio and optical waves as data carrier, since latter suffer from high attenuation and severe scattering correspondingly within the medium of water. These waves has low attenuation, bandwidth, and data rate as compared to other waves, but has large transmission range. Comparison table of these waves is shown below. As electromagnetic waves propagate poorly in sea water, acoustics provide the most obvious medium to enable UWAC. High-speed communication in the underwater acoustic channel (UWAC) is interesting due to limited bandwidth, extended multi-path, refractive properties of the medium, severe fading, rapid time-variation and large Doppler shifts.

1.2 Motivation

Underwater acoustic communication was 1st introduced throughout warfare II particularly for military wants. Underwater communications these days have a growing would like in a variety of civil and business applications like device in offshore oil business, observance pollution in environmental systems, communication among diverse underwater vehicles and mapping of the ocean bed for detective work objects and also for discovering new resources.

The ability to speak effectively underwater has numerous applications for marine researchers, oceanographers, marine business operators, offshore oil business and defence organizations. Magnetic attraction waves propagate poorly in ocean water, acoustics provide the foremost obvious selection of medium to change underwater communications. Underwater acoustic (UWA) communications have been a tough downside attributable to distinctive channel characteristics.

1.3 MIMO-OFDM

The major challenges in future wireless communications system design are increased spectral potency and improved link responsibility. The wireless channel constitutes a hostile propagation medium that suffers from weakening (caused by harmful addition of multipath components) and interference from different users. Diversity provides the receiver with many (ideally independent) replicas of the transmitted signal and is thus a strong means to combat weakening and interference and there by improve link responsibility. Common sorts of diversity are time diversity (due to physical spread) and frequency diversity (due to delay spread). In recent years the utilization of abstraction (or antenna) diversity has become very popular, that is because of the fact that it can provide replicas with no loss in its spectral potency. Receiver diversity, that is, the utilization of multiple antennas on the receive facet of a wireless link, may be a well-studied subject [1].

Driven by mobile wireless applications, wherever it's difficult to deploy multiple antennas within the handset, the utilization of multiple antennas on the transmit facet combined with signal process and cryptography has become acknowledged under the name of space-time continuum cryptography [2–4] and is presently a full of life space of analysis. The utilization of multiple antennas at each ends of a wireless link (multiple-input multiple-output (MIMO) technology) has recently been incontestable to possess the potential of achieving extraordinary knowledge rates [5–9]. The corresponding technology is understood as abstraction multiplexing [5,9] and provides increase in spectral efficiency. Most of the previous implimentation of MIMO wireless has been restricted to narrowband systems. Besides abstraction diversity broadband MIMO channels, however, provide higher capability and frequency diversity due to delay unfold. Orthogonal frequency division multiplexing (OFDM) [11, 12] considerably reduces receiver quality in wireless broadband systems. The utilization of MIMO technology together with OFDM, i.e., MIMO-OFDM [8, 9, 13], thus appears to be an attractive resolution for future broadband wireless systems.

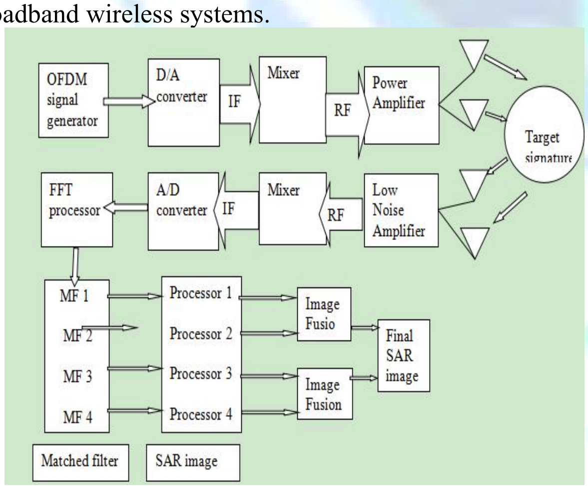

Figure 3: Block Diagram Of MIMO-OFDM

II. PROPOSED METHOD

In the upcoming years MIMO has drifted enormous amount of attention of researchers in the field of wireless communication. By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. Due to OFDM's unique strength in handling high-speed transmission over long dispersive channel with low equalization complexity which thereafter simplifies equalization in MIMO systems, combination of MIMO-OFDM is very advantageous for communication.

Proposed method consists of three section:

- Transmitter
- AWGN Channel
- Rrceiver

MIMO-OFDM is the efficient solution for transmitting and receiving the data over the long distance. The sub-carrier frequency has been chosen in our proposed OFDM transceivers so that cross-talk between the sub-channels are eliminated, hence the inter carrier guard bands are not required and we have also used such type of guard band for eliminating the cross-talk between channels. This greatly simplifies the planning of each the transmitter and also the receiver; in contrast to standard FDM, a separate filter for every sub-channel isn't required.The orthogonally allows for efficient modulator and demodulator implementation using the FFT algorithm. Now a days OFDM transceivers is popular for wideband communications since low-cost MIMO OFDM transceivers, requires very accurate frequency synchronization between the receivers and have low complexity. Pipelined FFT processor is proposed for MIMO-OFDM.

2.1 Proposed Method Of Transmitter And Receiver End For UWAC

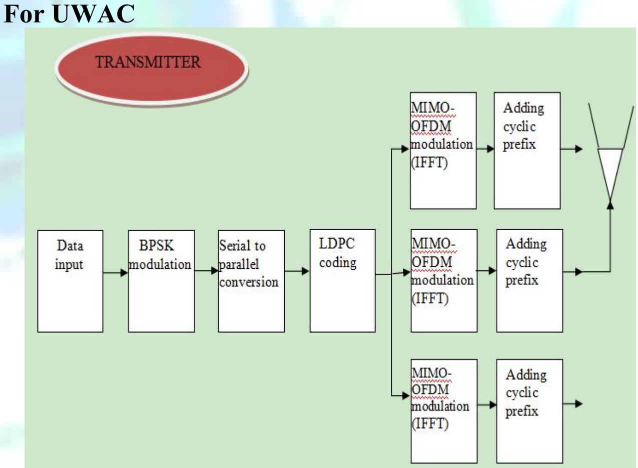

Figure 4: Block Diagram Of Transmitter End

Transmitter section consist of following blocks-

- Data Input block
- BPSK modulation block
- Serial to Parallel converter block
- LDPC coding block
- OFDM modulation (IFFT) block
- Add cyclic prefix code block

AWGN Channel

An apptibe nose channel simming white Gaussian noise to the signal that permits through it. we are able to produce an AWGN channel in a very model exploitation the common AWGN channel system

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object, the AWGN channel block, or the AWGN function.

AWGN channel noise level

The relative power of noise in an AWGN channel is often represented by quantities such as-

- Signal-to-noise ratio (SNR) per sample. this is often the particular input parameter to the AWGN operate.Ratio of bit energy to noise power spectral density (Eb / No).
- This quantity is used by BER tool and performance evaluation functions in this tool box.
- Ratio of symbol energy to noise power spectral density (Es / No).

Relation between Eb / No and Es / No

The relationship between Es / No and Eb / No, both expressed in dB, is as follows:

$$E_s / N_0 (dB) = E_b / N_0 (dB) + 10 \log_{10}(k) \tag{2.1}$$

K denoted the number of sumbol of data.

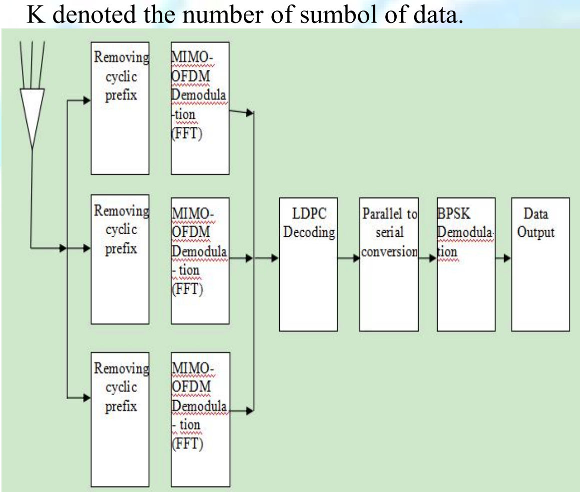


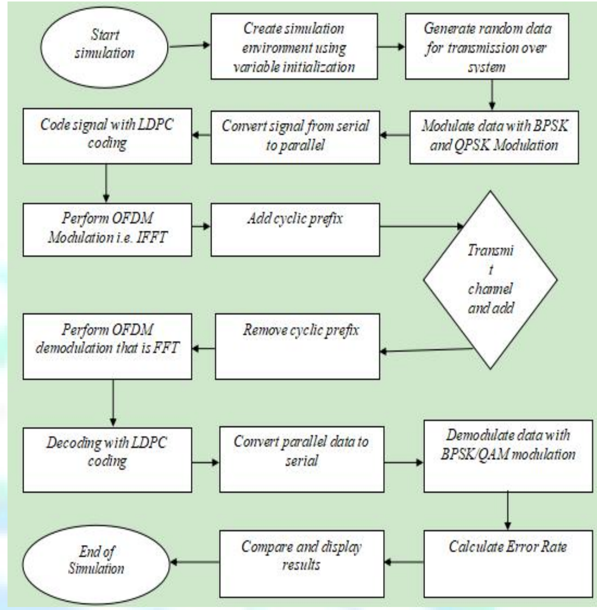
Fig. 5:Block Diagram Of Receiver End

RECEIVER SECTION:

- Receiver end consist of following blocks-
- Remove cyclic prefix code bock
- OFDM demodulation (FFT) block
- LDPC decoding block
- Parallel to serial converter block
- BPSK demodulation block
- Data output block.

The block diagrams of transmitter (figure 16) and riceiver (figure 5) of the proposed methodology is then implemented on simulation tool.

The execution of the simulation algorithm is explained step by step as follows:



2.2 Tools Required

2.2.1 Introduction of MATLAB

Communications Toolbox extends the MATLAB technical computing environment with functions, plots, and a graphical user interface (GUI) for exploring, designing, analysing, and simulating algorithms for the physical layer of communication systems.We can execute Communications Toolbox functions from the MATLAB command line, the BER Tool, GUI, and with your custom MATLAB scripts and functions. The MATLAB editor/debugger and graphical user interface development environment (GUIDE) accelerate the development of your system simulations.

Communications Toolbox helps you create algorithms for commercial or defence systems, such as mobile handsets and base stations, wired and wireless local area networks, and digital subscriber lines. You can also use it in research and education for communication systems engineering.

Key Features

- High-level language for technical computing.
- Development environment for managing code, files, and data.
- Interactive tools for iterative exploration, design, and problem solving.
- Functions for designing the physical layer of communications links, including source coding, channel coding, interleaving, modulation, channel models, and equalization.
- Graphical plots for visualizing communications signals, such as eye diagrams, constellations, and channel scattering functions.

- Graphical user interface for comparing the bit error rate of your system with a wide variety of proven analytical results.
- Standard channel models COST 207, GSM/EDGE, and HF ionospheric, for rapidly evaluating system performance under a wide variety of propagation conditions.
- Channel visualization tool for visualizing and exploring time-varying communications channels.

2.2.2 The MATLAB Language

The MATLAB language supports the vector and matrix operations that are fundamental to engineering and scientific problems. It enables fast development and execution. With the MATLAB language, you can program and develop algorithms faster than with traditional languages because you do not need to perform low-level administrative tasks, such as declaring variables, specifying data types, and allocating memory.

In many cases, MATLAB eliminates the need for 'for' loops. As a result, one line of MATLAB code can often replace several lines of C or C++ code. At the same time, MATLAB provides all the features of a traditional programming language, including arithmetic operators, flow control, data structures, data types, object-oriented programming (OOP), and debugging features.

MATLAB lets you execute commands or groups of commands one at a time, without compiling and linking, enabling you to quickly iterate to the optimal solution. For fast execution of heavy matrix and vector computations, MATLAB uses processor-optimized libraries. For general-purpose scalar computations, MATLAB generates machine-code instructions using its JIT (Just-In-Time) compilation technology. This technology, which is available on most platforms, provides execution speeds that rival those of traditional programming languages.

III. SIMULATION AND RESULT

This Block For simulation of different methods in general, we use MATLAB R2012b (8.0.0.783) software. The testing channel is artificially corrupted by AWGN adaptive white Gaussian noise by using MATLAB. Basic configuration of our system where we have checked performances are quantitatively measured by the BER and FER as defined in given equations, respectively. In the clattering channel the BER is principally expressed as a operate of the normalized carrier-to-noise quantitative relation measure that is denoted by Eb/N0, (energy per bit to the noise power spectral density ratio), or Es/N0 (energy per modulation image to noise spectral density).

Correlation between EsNo and EbNo (SNR)

$$Es/No = Eb/No\ (dB) + 10\log10(k) \tag{3.1}$$

Where k is the number of information per symbol

Es/No =ratio of symbol energy to noise power spectral density

And Eb/No = ratio of bit energy to spectral power density

For system with QPSK modulation and AWGN channel, the BER as the function of the Eb/N0 is given by:

$$BER = \frac{1}{2} erfc \sqrt{E_b / N_0} \tag{3.2}$$

The Bit Erro Rate curves to describe the functionality of a binary information communication system. while in WL comm., Bit Error Rate (dB) vs. Signal to Noise Ratio (dB) is used.

Frame Error Rate (FER) can also be calculated using BER as a parameter and is given by

$$FER = 1 - (1-BER)4 \quad \text{(in this case)} \tag{3.3}$$

Or,

$$FER = \frac{\text{Number of error frames}}{\text{Total numberoftransmittedfremes}} \times 100 \tag{3.4}$$

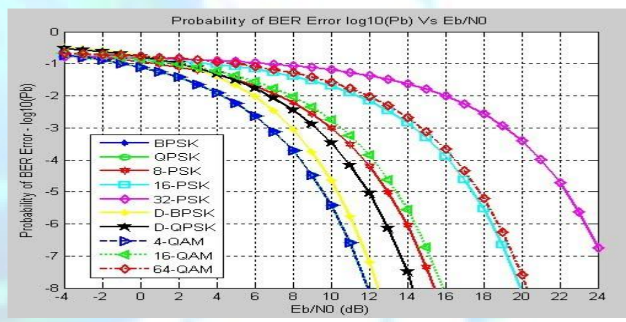


Figure 6: Comparisons BER With SNR Of Different Modulation Techniques

In figure 6, we compared different type of modulation technique which are BPSK, QPSK, 8-PSK, 16-PSK, 32-PSK, D-BPSK, D-QPSK, 4-QAM, 16-QAM, 64-QAM. In this figure we have shown the comparison of BER ,compare BER with SNR, in the x-axis we have to take SNR and y-axis we take BER of different modulation techniques

Bit Error Rate VS. Signal To Noise Ratio

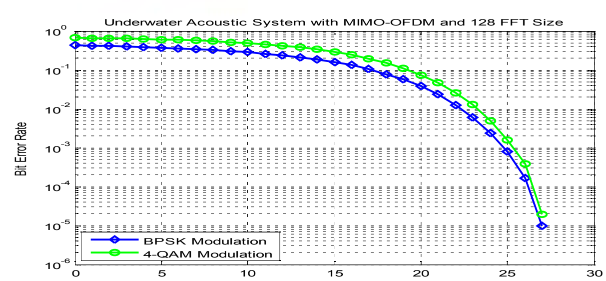


Figure 7: BER Vs SNR Graph For 128 Bit FFT Size Of OFDM System By Applying MIMO-OFDM System And The Modulated With BPSK And QAM Techniques

The Ist result (see Fig. 7) graph shows Frame Error Rate vs. Signal to Noise Ratio graph for one twnty eight bit FFT size of proposed system. We applied MIMO-OFDM system and then modulated with BPSK and QAM techniques. From the above results it can be concluded that the shallow water communication better works with the combination of MIMO-OFDM technology, the BPSK modulation, LDPC coding as compared to QAM counterpart

Table 1: Calculation Of BER With Different SNR Of BPSK And QAM For 128 Frames

S. No.	SNR E_b/N_o (dB)	BER (Bit Error Rate)	
		BPSK	QAM
1	0	0.4296	0.4691
2	5	0.3743	0.6097
3	10	0.2885	0.4898
4	15	0.1603	0.2918
5	20	0.0383	0.7534
6	25	0.0008	0.0016

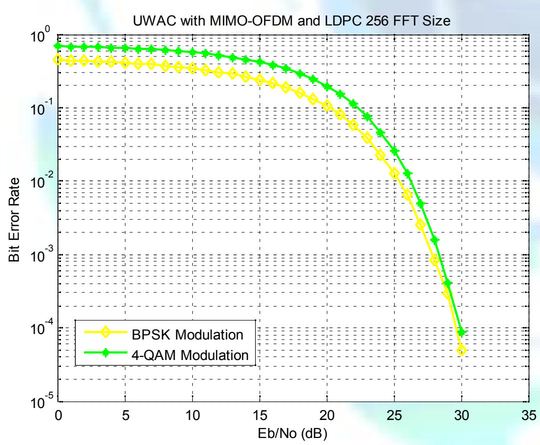


Figure 8: BER Vs SNR Graph For 256 Bit FFT Size Of OFDM System By Applying MIMO-OFDM System And The Modulated With BPSK And QAM Techniques

The IInd result (see Fig. 8) graph shows Frame Error Rate vs. Signal to Noise Ratio graph for one twnty eight bit FFT size of proposed system. We applied MIMO-OFDM system and then modulated with BPSK and QAM techniques. From the above results it can be concluded that the shallow water communication better works with the combination of MIMO-OFDM technology, the BPSK modulation, LDPC coding as compared to QAM counterpart.

Table 2: Calculation Of BER With Different SNR Of BPSK And QAM For 256 Frames

S. No.	SNR E_b/N_o (dB)	BER (Bit Error Rate)	
		BPSK	QAM
1	0	0.4993	0.6971
2	5	0.4093	0.6522
3	10	0.3464	0.5767
4	15	0.2364	0.4231
5	20	0.104	0.1981
6	25	0.0127	0.02611

Frame Error Rate VS. Signal To Noise Ratio

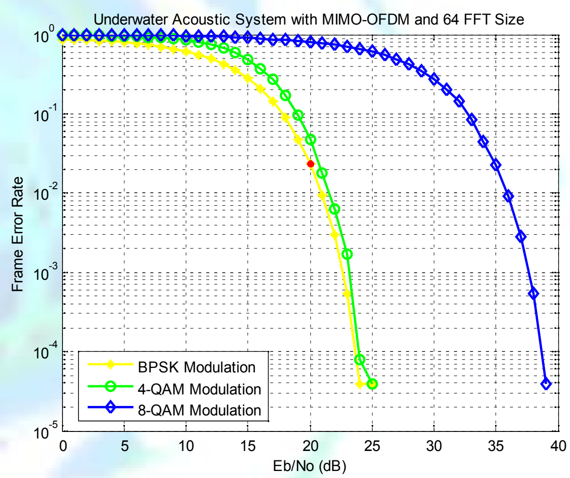


Figure 9: FER Vs. SNR Graph For 64 Bit FFT Size of OFDM System By Applying MIMO-OFDM System And The Modulated With BPSK And QAM Technique

The Ist result (see Fig. 9) graph shows Frame Error Rate vs. Signal to Noise Ratio graph for sixty four bit FFT size of proposed system. We applied MIMO-OFDM system and then modulated with BPSK and QAM techniques. From the above results it can be concluded that the shallow water communication better works with the combination of MIMO-OFDM technology, the BPSK modulation, LDPC coding as compared to QAM counterpart.

Table 3: FER, Comparison Of Proposed Work With Previous Work

	YEAR	TITLE	METHOD	FER	Proposed Method (FFT = 64)			Proposed Method (FFT 256)		
					BPSK	4 QAM	8 QAM	BPSK	4 QAM	8 QAM
1	IEEE 2016	OFDM Rake Reception SWAC (33)	OFDM (16 kbps)	0.82	0.02	0.04	0.7	0.3	0.5	0.9
2	IEEE 2016	OFDM Rake Reception SWAC (33)	OFDM AND DS RAKE (16 kbps)	0.35	0.02	0.04	0.7	0.3	0.5	0.9
3	IEEE 2016	OFDM Rake Reception SWAC (33)	SS (2 kbps)	0.19	0.02	0.04	0.7	0.3	0.5	0.9

Table 4: BER, Comparison Of Proposed Work With Previous Work

	YEAR	TITLE	METHOD	SNR	BER	Proposed Method (FFT = 64)		
						BPSK	4 QAM	8 QAM
1	IOSR 2014	MIMO OFDM in UWC [31]	OFDM	20	0.025	0.058	0.012	0.33
2	IOSR 2014	MIMO OFDM with ALAMOUTI SCHEME in UWC [31]	OFDM + ALAMOUTI SCHEME	20	0.05	0.058	0.012	0.33

IV. CONCLUTION

In this research, proposed work, we introduced a combination of multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM) with low complex modulation techniques and also less complex coding techniques to communicate our signal in shallow water acoustic communication. We analyzed various modulation technique on the basis of two parameters, BER and FER. The proposed technique will be simulated with the help of MATLAB R2016b. From the simulation results we conclude that the system with the BPSK modulation gives better results as compare to 4 QAM and 8 QAM modulation with respect to Bit Error Rate and Frame Error Rate even when FFT size is varied. And when data efficiency is considered, QAM is better than BPSK. The simulation results are also compared with previous research work which verifies low BER and FER of proposed methodology.

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