

MIMO-OFDM for high rate underwater communication

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ABSTRACT

A future wireless communication system demands for high quality internet and multimedia services with mobility. In underwater environment there is a deficiency of frequency spectrum due to this there rises a need for wireless systems that have higher capacity and reliability. The combination of multiple input multiple outputs with orthogonal frequency division multiplexing is a method which fulfills this requirement. In the present work we have designed a simulink model in which the MIMO part takes care of the data rate and the OFDM part takes care of the reliability of the system.

1. Introduction

Today, everything in the world, whether on the surface of the earth or in the deep space is virtually connected by wireless technologies. Water occupies 70% of our planet and so is one of the important frontier but it is surprisingly left out. Wireless technology has so far not been able to penetrate underwater. The technique of sending and receiving messages below water is called Underwater communication. It is very challenging to obtain high speed in underwater communication due to limited bandwidth, Doppler shift, fading, multipath propagation. Underwater environment is very unstable. In underwater communication acoustic waves are used instead of electromagnetic waves. In order to increase the transmission rate either the bandwidth or the spectral efficiency or both needs to be increased. Spectral efficiency can be effectively increased by using MIMO technique. Terrestrial communication such as mobile communication demands high transmission rate.

1.1 MIMO

MIMO is an antenna technology which uses multiple antennas at source and destination. The signal can take many paths between a transmitter and a receiver. These multiple paths introduce interference. MIMO technique uses these additional paths to advantage. The two main formats for MIMO are given below :

Spatial Multiplexing:- Spatial multiplexing increases the data throughput capacity by utilizing different paths of antennas to carry the additional traffic.

Spatial Diversity: Spatial diversity improves SNR and also improves the reliability of the system.

Advantages of MIMO over SISO/MISO are:

1. MIMO increases diversity by reducing the effect of fading.
2. MIMO increases the spectral efficiency.
3. MIMO increase the system's capacity.

1.2 OFDM.

OFDM is a form of multicarrier modulation. In OFDM signals there are closely spaced modulated carriers. Each of the modulated subcarrier contains numbers of parallel data streams. These parallel data streams are modulated at a low symbol rate. When any form of modulation is applied to a carrier, sidebands spread out either side. The sub carrier frequencies in OFDM are orthogonal to each other because of which the crosstalk between the sub-channels is reduced and there is no need of inter-carrier guard bands. OFDM has the ability to cope with severe channel conditions without complex equalization filters. Synchronization between transmitter and receiver is a must in OFDM.

1.3 MIMO OFDM

Wireless communication system faces the challenge of fading, scarce bandwidth and restricted power. MIMO is known for increasing the capacity and range in wireless communication. OFDM supports adaptive modulation and has high spectral efficiency. MIMO along with OFDM provides a solution to the problem of multipath fading and constrained resources. Combination of MIMO-OFDM provides high data rates as well as high spectral efficiency.

2. Design of underwater communication system

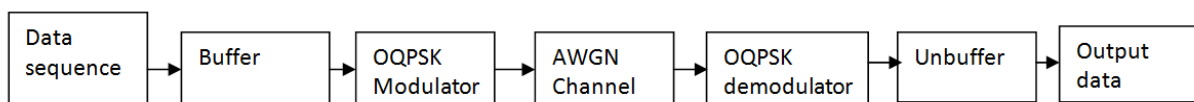


Figure 1 Block Diagram of Under Water communication system

This section illustrates the design and implementation of underwater communication system, built on Matlab/simulink. For implementing the underwater part we have used Zigbee as it accomplishes the conditions for underwater communication. In underwater communication the device used should be low battery powered and should be able to reduce the data rate, also it should be low cost these conditions are fulfilled by Zigbee. The output data from above water is given to the transmitter of the underwater network, which is further given to Unipolar to Bipolar Converter to convert the unipolar input signal to a bipolar output signal. Then the data rate is divided to 500Kbps and modulated using the OQPSK technique. OQPSK is a variant of phase-shift keying modulation and uses

four distinct values of the phase to transmit. The input signal may be bits or integers. Here we use bits for transmission. Then the signals were transmitted over an additive white Gaussian noise. Ocean consists of two types of noises, man-made noise and the ambient noise. As far as the sea-surface and the area around the shore is considered man-made noise is dominating, but at the deep sea level ambient noise is dominating. The ambient noise sources can be described as having continuous spectrum and Gaussian statistics. Therefore, AWGN is best suitable for underwater applications[12]. At the receiver side, OQPSK demodulator is used for demodulating the received signals.

3. Design of terrestrial communication system

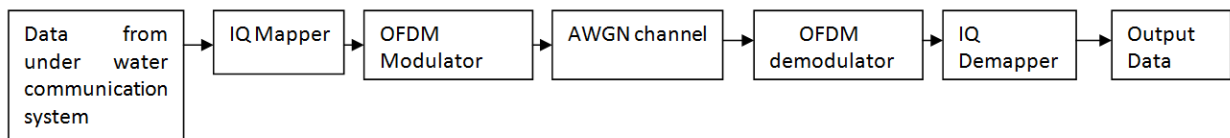


Figure 2 Block diagram of terrestrial communication

Model of above water or terrestrial communication consists of OFDM with 64 QAM. The output of underwater communication system is given to the QAM through data source. The output from QAM mapper is then modulated using OFDM modulation. OFDM is a unique example of multi carrier transmission. OFDM can be considered either as a modulation technique or a multiplex technique. When used as a multiplex technique, a single data stream is transmitted over a number of lower rate subcarriers. The total bandwidth will be $B=N.\Delta f(\text{Hz})$ In the block of OFDM modulator we have used multiport selector in which Output specified rows or columns to one or more output ports. ISI and ICI can be avoided by using cyclic prefix. The cyclic prefix serves as a guard against ISI and ICI. OFDM signal uses cyclic prefix to operate reliably. Cyclic prefix

decreases the inter symbol interference. The cyclic prefix is created such that the each OFDM symbol is preceded by a copy of the end part of the same symbol [4]. IFFT and cyclic prefix was performed on the signal and the signal was passed through AWGN channel.

At the receiving end, cyclic prefix added at the transmitter are removed to get back the original signal values. FFT operation is also performed on the received signal to convert it back to frequency domain. The demodulation operation was performed using 64 QAM demodulator on the received FFT complex signal into integer values. Bit error ratio is the ratio of no. of errors to the no. of bits transmitted.

4. Results

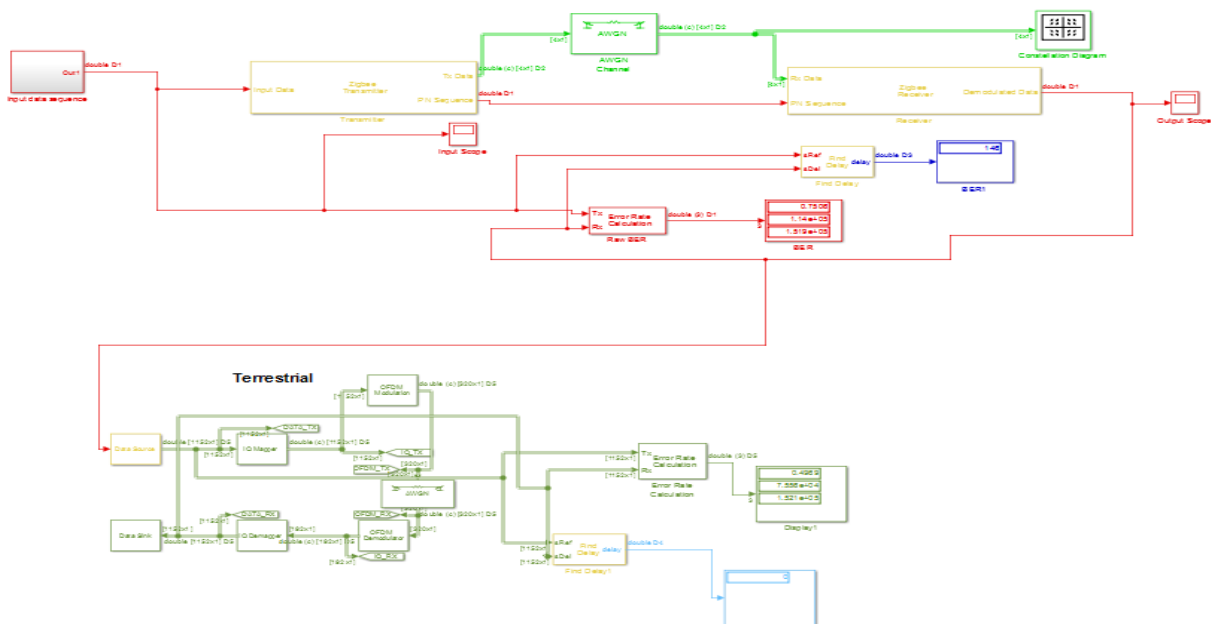


Figure 3 Simulink model of proposed MIMO-OFDM system

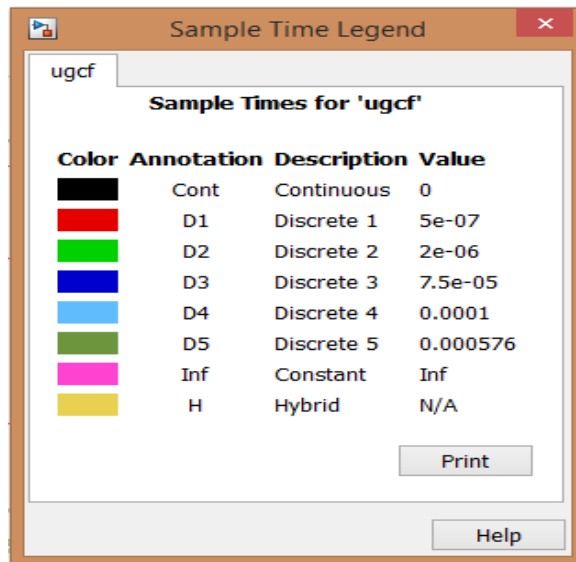


Figure 4 Sample Time of Synchronised underwater and above water communication

Figure 3 shows the simulink model of the proposed underwater and above water communication network. Figure 4 shows the sample time of synchronised underwater and above water communication network. The red lines represent the sample time of 5e-07 i.e. the data rate is 2 Mbps. The light green line represents the sample time of 2e-07 i.e. data rate of 500 Kbps. The input data is given to the under water

communication system and here it is converted into 500 Kbps as can be seen from the light green lines in figure 3. At the output of underwater system we again get red lines i.e. the data rate of 2 Mbps. Thus the desired data rate of 2 Mbps is successfully transmitted through the underwater channel and recovered at the receiving section of underwater communication.

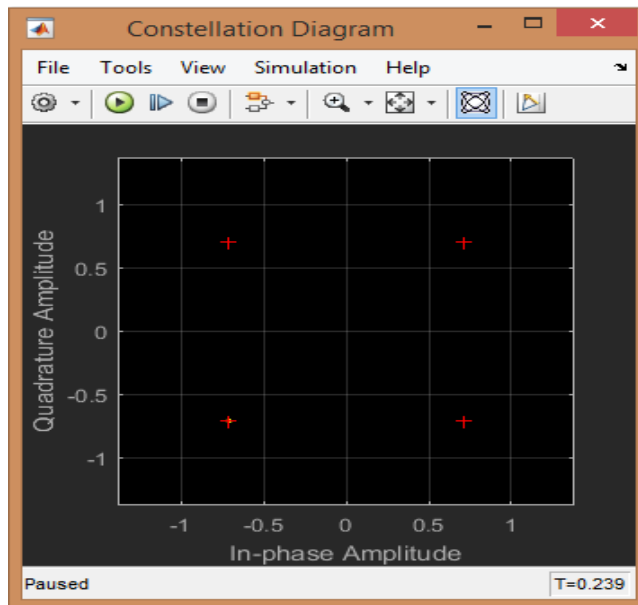


Figure 5 Constellation diagram of QPSK

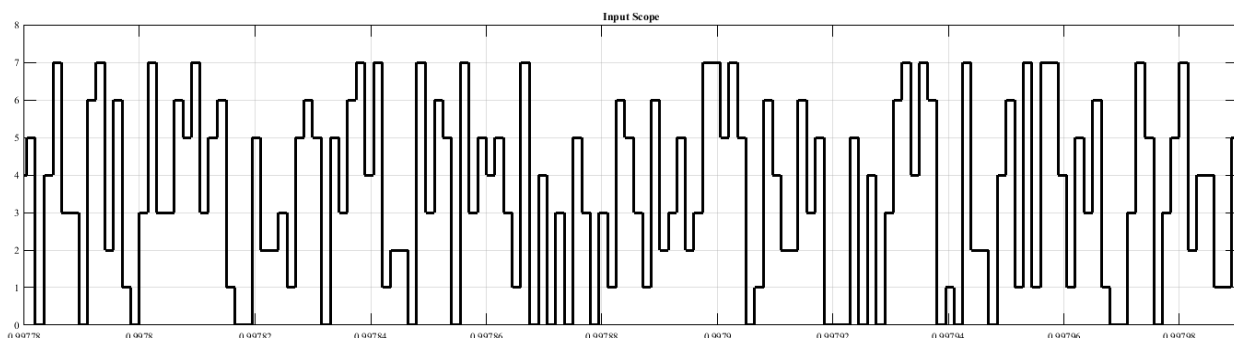


Figure 6 Input waveform of Underwater transmitter

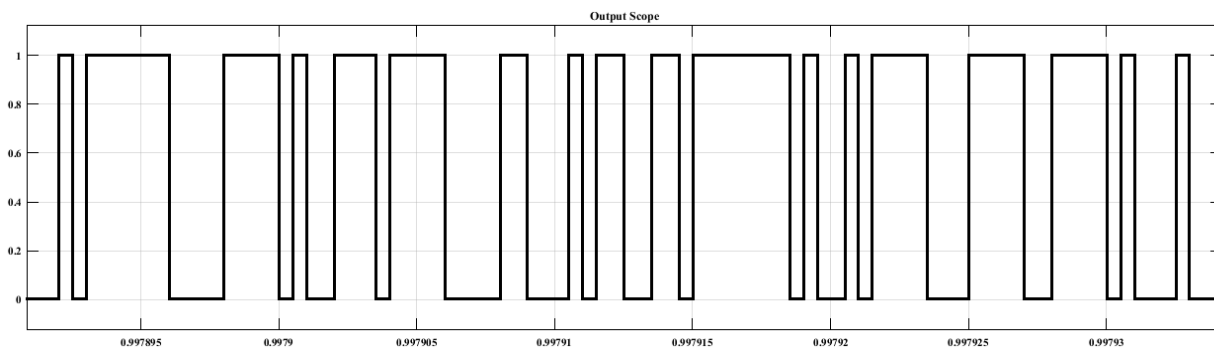


Figure 7 Output waveform of underwater communication system

5. Conclusion

In wireless signal transmission Orthogonal frequency division multiplexing is the most recent method. MIMO is an advanced technique that can carry more data traffic using same bandwidth. These two approaches when used individually do not give higher output. But the combination of these two techniques can improve the reliability and capacity of

the communication system. A low power underwater communication model capable of reaching a maximum of 2 Mbps data rate was presented. proposed model achieves 2 Mbps data rate without increasing the total transmit power or bandwidth.

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