Efficient Multicarrier OFDM for Underwater Communication

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***Abstract*—OFDM (Orthogonal Frequency Division Multiplexing) is a multicarrier modulation scheme to solve ISI(Inter Symbol Interference) and ICI(Inter Carrier Interference). OFDM communication combines a large number of low data rate carriers to construct a composite high data rate communication system. To improve bandwidth utilization and data rate of communication an efficient technique has been proposed. Comparison of four, eight and sixteen subcarriers has been performed and as per the BER (Bit Error Rate) efficient model of subcarriers has been taken and performance of OFDM communication has been analyzed**

Keywords — OFDM (Orthogonal Frequency Division Multiplexing), IFFT (Inverse Fourier Transforms), FFT (Fast Fourier Transforms), BER (Bit Error Rate), SNR (Signal To Noise Ratio), Cyclic prefixes.

I. INTRODUCTION

The desire for faster wireless technologies and increase in multimedia applications is the principle driving force behind OFDM's increased popularity. OFDM technique will divide available spectrum in to several subcarriers. By making all subcarriers narrowband they experience flat fading which makes equalization simple. To obtain high spectral density the frequency response of subcarrier are overlapping and orthogonal. The main reason to use OFDM is to increase the robustness against selective fading and narrowband interference.FDM (Frequency Division Multiplexing) is an earlier technique of modulation which includes single carrier. In a single carrier system if system gets fade or interfered then entire transmission link gets failed whereas in multicarrier system only a small amount of subcarrier get affected. OFDM has already been proved to be an efficient modulation technique for land based communication systems efforts are being made for using this technique for underwater communication.

The channel for underwater network is time varying multipath channel causing Inter Symbol Interference (ISI), Inter Carrier Interference (ICI) and fading. Due to the detrimental effect of time and frequency spreading, achieving high data rate in underwater wireless communication is challenging. OFDM in the form of multicarrier modulation technique finds its application in highly dispersive channel and its suitable for achieving high data rate in frequency selective underwater channels. OFDM allows overlapping of subcarriers and hence the available limited channel bandwidth can be efficiently utilized. Using IFFT/FFT techniques implementation of modulation and demodulation is computationally efficient.

A. Representation of FDM and OFDM

In case of Frequency Division Multiplexing the overall bandwidth is allocated to the single carrier. This type of system can be used where less amount of data available to send at the transmission side. If large amount of data need to transmit FDM is not suitable we have to go for OFDM which consist of many number of carriers and each carrier will overlap with each other .The representation is shown in Fig.1.a and Fig.1.b.

Individual channel

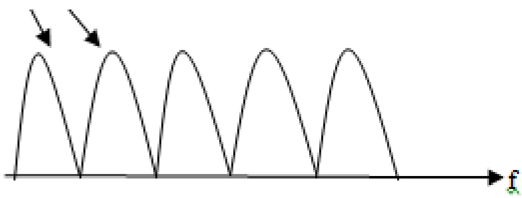

Fig.1.a Frequency Division Multiplexing

Overlapping subcarriers

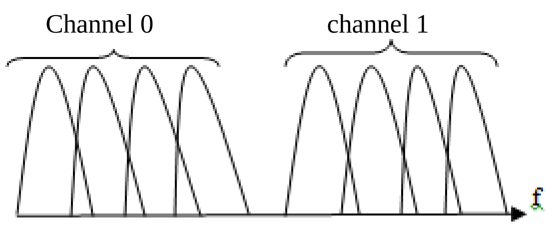

Fig.1.b.Orthogonal Frequency division Multiplexing

B. Orthogonality

In OFDM orthogonality between subcarriers is essential condition to be adopted. It can be achieved by selecting integer number of cycles within given time interval.

Mathematically, each carrier can be described as a complex wave

$$S_c(t) = A_c(t) e^{j[\omega_c t + \phi_c(t)]} \quad (1)$$

The real signal is the real part of S_c (t) both A_c (t) and f_c(t), the amplitude and phase of the carrier , can vary on symbol by symbol basis. The values of the parameters are constant over the symbol duration period t.

OFDM consists of many carriers. Thus the complex signals S_s (t) in Fig.1.c is represented by

$$s_s(t) = \frac{1}{N}\sum_{n=0}^{N-1} A_n(t) e^{j[\omega_n t + \phi_n(t)]} \qquad (2)$$

II. FOURIER BASED OFDM

Maintaining orthogonality between subcarriers is te key factor in generating OFDM signal. The signal is generated by firstly choosing the spectrum required based on input data and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is calculated using modulation scheme used. Here we concentrated on PSK (Phase Shift Keying) modulation scheme.

An efficient implementation of OFDM transmitter and receiver can be built with the IFFT (Inverse Fourier Transform) and FFT (Fast Fourier Transform) , respectively. The structure FFT IFFT implementation is shown in Fig.2. The figure Fig.3 shows the block diagram of the OFDM system. In this system we have to give random bits as an input. By using PSK modulation technique we have to generate the symbols. To get number of subcarriers to inculcate we have to provide appropriate IFFT order. Cyclic prefix is added at each symbol length to avoid ICI (Inter Carrier Interference) and ISI (Inter Symbol Interference).

The definition of N-point Fourier transform is

$$X_p[k] = \sum_{n=0}^{N-1} x_p[n] e^{-j(2\pi/N)kn} \qquad (3)$$

And the N-point Inverse Fourier Transform is given by

$$x_p[n] = \frac{1}{N}\sum_{k=0}^{N-1} X_p[k] e^{j(2\pi/N)kn} \qquad (4)$$

An OFDM transreceiver system shown in Fig.2. .The inverse and forward transform blocks concerned more attention. The data generator is producing random binary form it is first being processed by constellation mapping. BPSK modulator is used for this work to map the raw binary data to appropriate BPSK symbols. These symbols are then input in to IFFT block. This involves taking N parallel stream of symbols(N being the number of subcarriers used in the transmission of data) and performing an IFFT operation on this parallel stream.To maintain orthogonality during channel transmission cyclic prefix is added to OFDM frame.

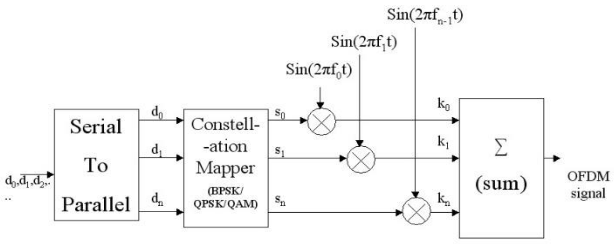

FIG.2. FFT IFFT Implementation of OFDM

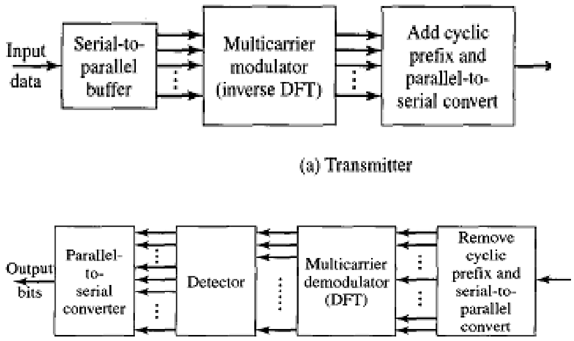

Fig.3. Block diagram of OFDM

III. IMPLEMENTATION

By developing three models, four carriers, eight carriers and sixteen carriers OFDM. For each model the assumption of total number of bits to be transmitted are 256 number of bits .

A. Specification of each models

For four carriers

N(number of bits for transmission	256
Subcarriers	4
Carrier frequency	16bps
Bandwidth	256bps
Block size	16
SNR	30
Modulation order	16
Cyclic prefix length	6.4

For eight carriers

N(number of bits for transmission)	256
Subcarriers	8
Carrier frequency	4bps
Bandwidth	256bps
Block size	4
SNR	30
Modulation order	256
Cyclic prefix length	1.6

For sixteen carriers

N(number of bits for transmission)	256
Subcarriers	16
Carrier Frequency	1bps
Bandwidth	256bps
SNR	30
Modulation order	65536
Block size	1
Cyclic prefix length	1

IV BER CALCULATION

By calculating bit error rate for four, eight and sixteen carriers using formula number of errors by total number of data bits sent at the transmitter. Below table shows the value of BER for each carrier tabulated.

For N=256

Carriers	**BER**
Four	16
Eight	85
Sixteen	110

If we assume the value of SNR for each model we can get the perfect accuracy of the system.

A .BER plots for each carrier

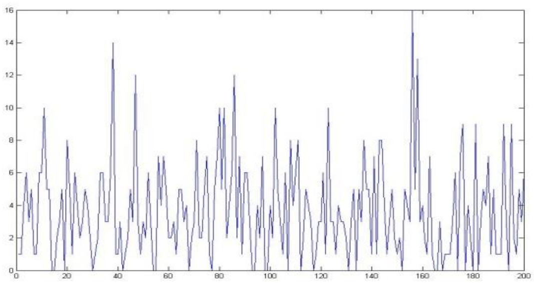

Fig.4.a BER plot for four carrier OFDM

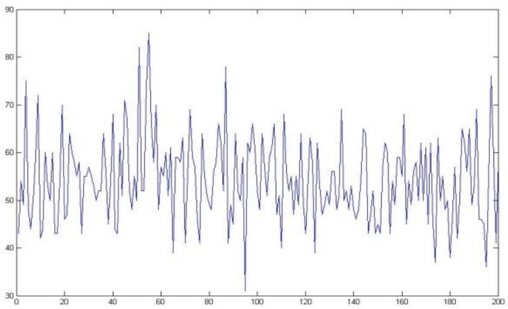

Fig.4.b. BER plot for eight carrier OFDM

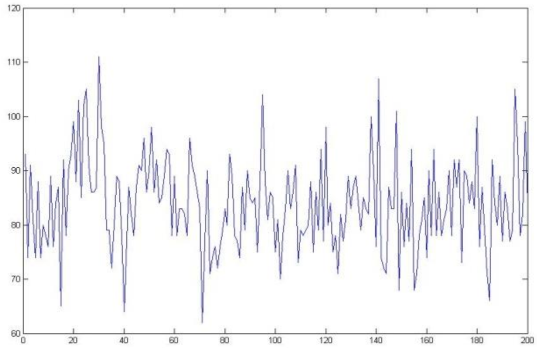

Fig.4.c. BER plot for sixteen carriers OFDM

V. VLSI IMPLEMENTATION

By considering eight carriers for vlsi implementation the module is designed and results are verified the . The carrier frequency assumed is 10Mhz. The designed module is module is shown below

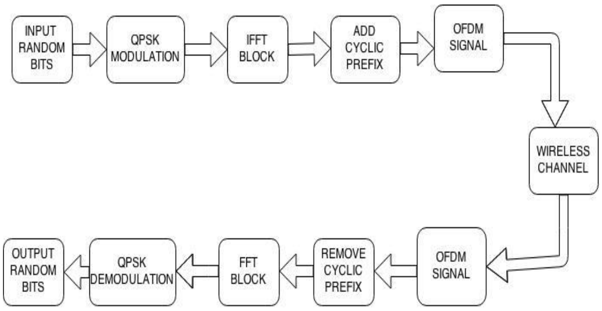

Fig.5.a. Block diagram Ofdm.

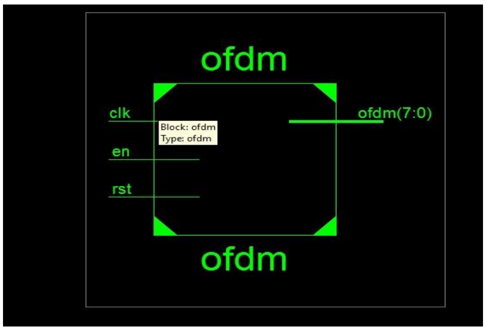

Fig.5.b. VLSI design implementation.

Fig.5.c. Simulation results.

VI .RESULTS

CLOCK	1	1	1
RESET	0	0	0
ENABLE	0	0	0
INPUT[7:0]	00110000	11000000	00001111
EVEN[3:0]	0100	1000	0011
ODD[3:0]	0100	1000	0011
OFDM[7:0]	00110000	11000000	00001111
EVEN[3:0]	0100	1000	0011
ODD[3:0]	0100	1000	0011

VII. CONCLUSION

The main aim of the project is to design OFDM by comparing OFDM models with different number of sub carriers. The different blocks of OFDM are implemented on MATLAB 7.10 and Xilinx 12.1.The BER plots are tested for different number of subcarriers and found that eight carrier is the model with less number of BER compare to other model and eight carrier model is taken for VLSI design and simulation results are tested and verified with the inputs.

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