Performance simulation of spreading OFDM for underwater communication

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Abstract - *The conservative Orthogonal Frequency Division Multiplexing (OFDM) which reduces errors in Under Water Acoustic Communication but suffers from frequency selective fading near deep fade regions also has high PAPR, selective to carrier offset and drift. In order to overcome this we use spreading Orthogonal Frequency Division Multiplexing (S-OFDM) which uses a property of spread spectrum techniques for multicarrier. In this paper spreading is done by Walsh hadamard (WH) codes, carrier interferometry (CI) codes and also combination of both WH and CI codes for DWT based spreading OFDM using AWGN channel. Spreading technique which overcomes frequency selective fading and multipath fading in turn reduces PAPR and also BER. Simulation results shows for all DWT based spreading OFDM also it is possible for WH-CI spreading based OFDM to achieve a BER of 1.731e-05 at 7dB which improves entire performance, reduces BER and PAPR. Comparison is done for FFT, DWT based Spreading OFDM.*

***Key Words*: UWAC, S-OFDM, Walsh hadamard codes, carrier interferometry (CI) codes, FFT, DWT, BER, PAPR.**

1. INTRODUCTION

Under water acoustic communication is a technique that transmits and receives data underneath water. Under Water Communication (UWC) suffers from multipath transmission, frequency dependent attenuation and low propagation speed. Under Water Acoustic Communication (UWAC) has reduced data rates for low range and has even more reduced data rates for longer ranges [1].

UWASN has restricted power, sinking transmission power which increases life span of network but cost of improved BER and SNR is not sufficient in order to achieve better data transmission. State of convergence as higher capability, LP-DSP in which OFDM transmits signal over a wide range of orthogonal carriers whose performance is strong with spectral competency and sensible data transmission which allows for acoustics channel and also communication theory for OFDM based UWC.

OFDM suffers from frequency selective fading which degrade data on orthogonal carriers near deep fade regions and has high PAPR, selective to carrier offset and drift. Several techniques are implemented to reduce PAPR and comparison in terms of power loss, distortion, data rate loss and extra processing that is found in [2]. In this thesis the performance of WH-SOFDM, CI-SOFDM, FFT-SOFDM, DWT-SOFDM and WH-CI-SOFDM scheme in the underwater acoustic channel is simulated using MATLAB and Simulink simulations.

The next remaining part of thesis is as follows: Section 1 represents the basic of OFDM system and spreading OFDM for under water acoustic channel. Section 2 represents description of simulink model, the underwater acoustic channel and simulations. Section 3 concludes the thesis with complete discussions for simulated results as well comparison is done for spreading techniques. Section 4 represents a complete conclusion of the project.

1.1 Basics of OFDM and Spreading OFDM

In conventional OFDM, the incoming serial binary data is divided into N parallel binary data where, N is total number of subcarriers. N point of IFFT operation of data symbols can be transmitted using binary phase shift keying modulators. In order to retrieve transmitted symbols at the receiver, FFT operation is performed.

Supernatural void present underwater acoustic channel and has distortion in the output of OFDM carrier which results in loss of symbol carried by subcarrier of carrier only. This results in large bit error rates and also reduces overall performance of system. Bandwidth is wasted to accommodate re-transmission of lost data. Hence to overcome error in UWAC which suffers from frequency selective fading near deep fade regions, the other technique used called Spreading OFDM technique(S-OFDM) where, spreading occurs with multicarrier transmission [3].

1.2 Spreading OFDM Techniques(S-OFDM)

The input data symbols are spread over complete bandwidth such that each individual subcarrier forms a linear combination of all the data symbols which is transmitted. If any subcarrier is faded then there is a necessity to recover entire transmitted symbols. At receiver end, number of symbols transmitted and number of symbols received is compared by error rate calculation block. Finally, error rate is calculated for each transmitted and the received data.

1.3 WH-spreading OFDM

Walsh hadamard Transform (WHT) essentially multiplies 2m-length vector with 2m X 2m matrix. Then the coefficient of WHT is always 1 and -1 only. The WH-SOFDM system model is spreading OFDM model with a spreading block is placed before IDWT block operation and a de-spreading block placed after the DWT block operation. In SOFDM, the frequency signal is multiply using WH spreading matrix before it is fed to the IDWT. Less complexity than the IFFT which implies the system complexity is decreased by applying WH spreading.

1.4 CI-SOFDM

A new scheme multi-carrier modulation into Under Water Acoustic channels which is called Carrier Interferometry OFDM (CI-SOFDM) [4]. CI-SOFDM has reduces PAPR. The implementation of CI-SOFDM is complicated also it has been proved that CI-SOFDM improves BER is 4.808e-05, and also improves performance and reduces PAPR.

1.5 WH-spread CI-SOFDM

The two level of orthogonal spreading applied to OFDM of AWGN channel, WH-spread CI-SOFDM is simulated. The input data symbols are transmitted first to WH matrix also spread by WH matrix, and the output is obtained [5], and then used to execute CI-SOFDM. Even though system complexity is increased and performance is increased and depends on frequency and phase. This new model combines the spreading property of WH with phase characteristics property of CI signal to achieve still lower BER i.e., 1.731e-05 compared to only CI-SOFDM i.e. 4.808e-05.

2. Simulink model

The figure of a Simple FFT based OFDM with AWGN channel is shown in fig- 2.1 Random data is given as input to channel encoder where convolution encoder is used, spreading block is included before the IFFT block and similarly de-spreading is included after FFT. Where in FFT based OFDM number of bits transmitted is equal to the number of bits received. The performance of BER 0.0001769 is achievable at 7.031 dB SNR. PAPR is watched to be disseminated from around +4.5dB at +10dB. In fig-2.2 the performance of BER 7.115e-05 is achievable at 7.031 dB SNR. From fig-2.3 the performance of BER 0.0001827 is achievable at 7.031 dB SNR. From fig-2.4 the performance of BER 7.5e-05 is achievable at 7.031 dB SNR.from fig-2.5 the performance of BER 4.808e-05 is achievable at 7.031 dB SNR. From fig-2.6 the performance of BER is 1.731e-05 is achievable at 7.031 dB SNR.

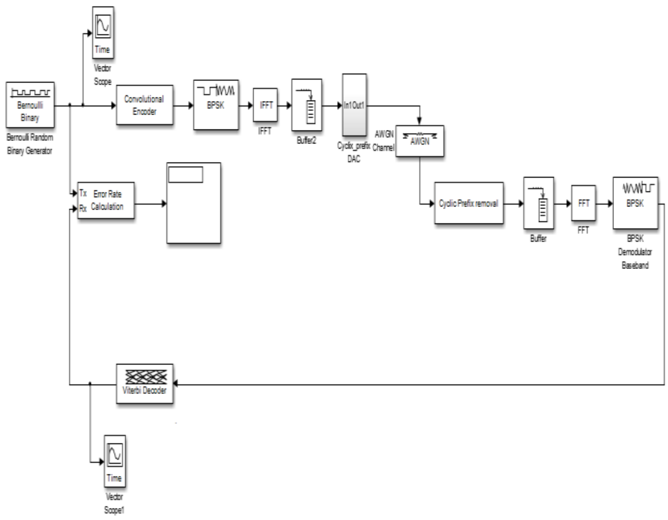

Fig-2.1: Simple FFT based OFDM with AWGN channel

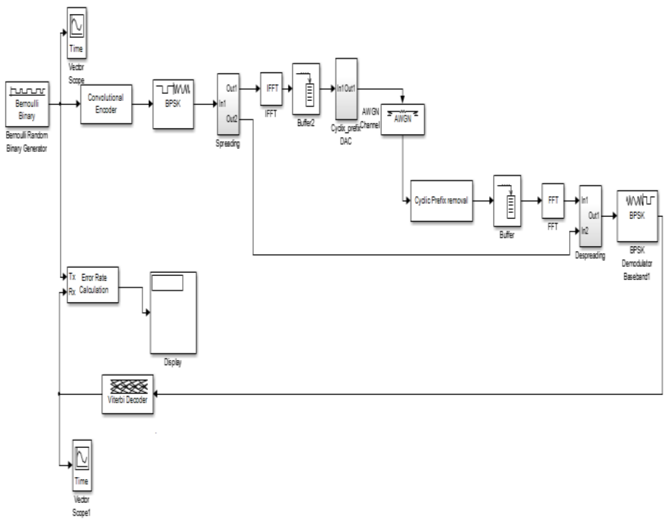

Fig-2.2: Simulink design of simple FFT based spreading OFDM with AWGN channel.

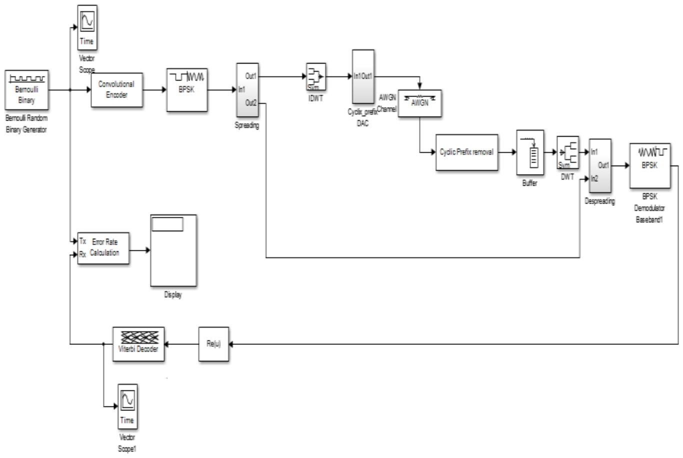

Fig-2.3: Simulink design of simple DWT based spreading OFDM with AWGN channel.

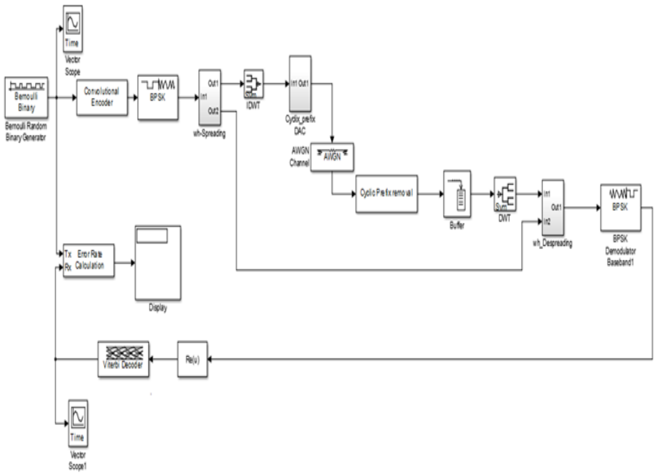

Fig-2.4: Simulink of Walsh Hadamard spreading based OFDM with AWGN channel

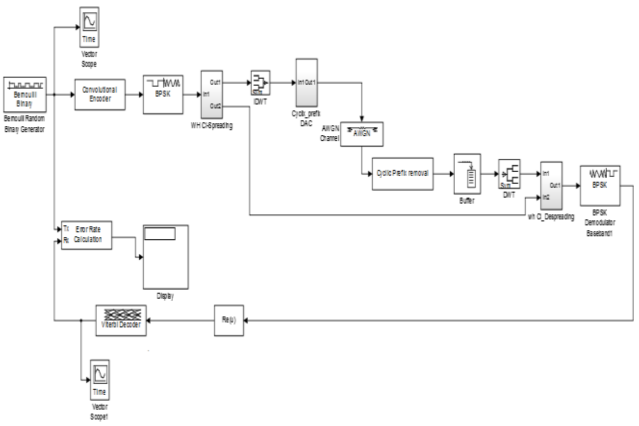

Fig-2.5: Simulink of Carrier interferometry spreading based OFDM with AWGN channel.

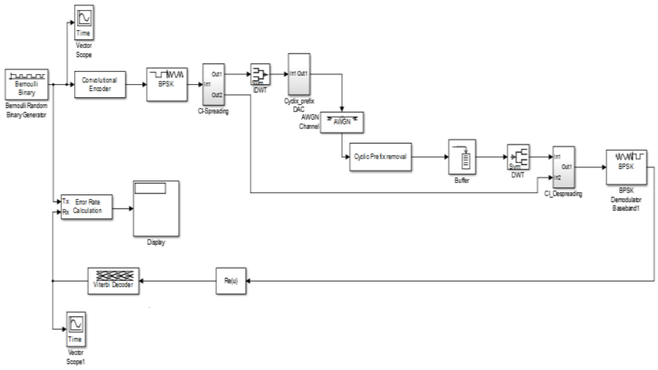

Fig-2.6: Simulink model of Carrier interferometry and Walsh hadamard technique based on OFDM with AWGN channel.

3. Results and discussion

In this paper simple binary phase shift keying modulation has been used and IFFT-FFT based OFDM has been implemented for 52 subcarriers.FFT, FFT-SOFDM, DWT-SOFDM, WH-SOFDM, CI-SOFDM, and WH-CI-SOFDM have been simulated for AWGN channel.BER and PAPR performances of the different variants of modified OFDM have been evaluated over underwater acoustic channel using SIMULINK in MATLAB.

Fig-3.1 shows the plot of BER vs. SNR for OFDM and different spreading OFDM schemes applied to underwater acoustic channel. The error rate is observed at 0.0001519 for FFT, Similarly error rate of spreading FFT is observed at 7.115e-05. Error floor of spreading DWT is observed at 7.885e-05.

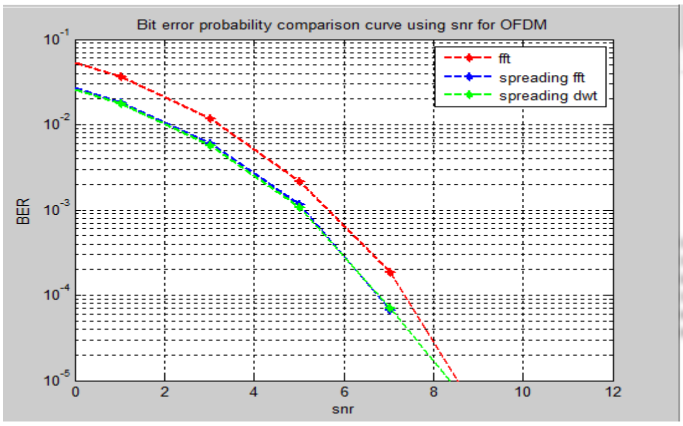

Fig-3.1: Comparison of FFT, spreading FFT and spreading DWT.

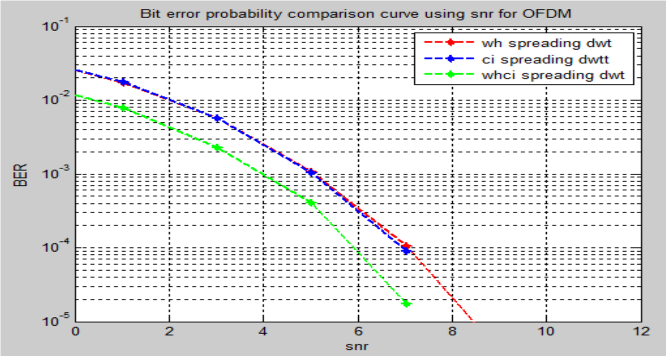

Fig-3.2: Comparison of WH, CI, and WH-CI spreading based OFDM Using AWGN channel.

In fig-3.1, the BER vs. SNR ratios of FFT and Spreading FFT and Spreading DWT. The Bit error rate of Spreading DWT is less Comparing with FFT based spreading and FFT, bit error rate of spreading DWT is 7.115e-05 at 7dB.Simulation results illustrate for WH-SOFDM is 7.115e-05. Whereas for CI-SOFDM and WH-CI SOFDM the error rate is observed at 4.808e-05 and 1.731e-05. On comparison we found that an attempt to further improvement of BER performance the two level orthogonal spread OFDM i.e., (WH-CI-SOFDM) with same specifications are applied to under water acoustic channel. This increases the overall system performance and increases the system complexity. Fig-3.2 shows BER vs. SNR of WH, CI, WH-CI Spreading based OFDM using AWGN channel. We found that WH-CI spreading based OFDM is having less Bit error rate.

4. Conclusion

The model is developed using simulink block in Matlab. From the above results, it may be concluded that the bit error rate of WH-CI-SOFDM is less compared with DWT, WH spreading, CI-spreading. Spreading overcomes frequency selective fading and multipath fading. This improves the overall performance of the system and PAPR. The bit error rate of WH-CI-SOFDM is 1.731e-05 at 7dB as compared with CI spreading is 4.808e-05 And WH spreading is 7.5e-05 Thus achieving less bit error rate than the existing one.

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