

Performance Analysis of DWT, DCT & FFT based OFDM over Noisy Channel Environments for WIMAX

Shalinee Singh Parihar

M.Tech. Scholar

Department of Electronics and Communication Engineering
Sagar Institute of Research & Technology
Bhopal, M.P., India
singh.parihar12345@gmail.com

Virendra Singh

Professor

Department of Electronics and Communication Engineering
Sagar Institute of Research & Technology
Bhopal, M.P., India
virendrasingh1180@gmail.com

Abstract- As the world move in to the future, there is a rising demand for high performance, high capacity and high bit rate wireless communication systems to integrate wide variety of communication services such as high-speed data, video and multimedia traffic as well as voice signals. Orthogonal Frequency Division Multiplexing (OFDM) has made tremendous improvement possible in wireless technology. OFDM is a multicarrier system that provides an efficient means to handle high-speed data streams over a multipath fading environment. Orthogonal frequency division multiplexing (OFDM) is a powerful technology to increase the data rate transmission over mobile wireless channels. The problem with conventional OFDM in which Fast Fourier Transform (FFT) was used to transform and map data onto orthogonal subcarriers is that it was inherently inflexible and had high complexity. Wavelet analysis offers strong advantages over Fourier analysis, as it has a time-frequency domain operation, thus allowing optimal flexibility with less complexity.

In this paper, the performance comparison of DWT based OFDM system is performed with FFT based and DCT based OFDM system under the joint impact of path loss, multipath fading and noise in WiMax environment. The performance comparison of wavelet families such as Haar, Daubechies and Biorthogonal is also performed for different modulation techniques with different path loss methods and concluded that Daubechies based wavelet reduces the BER as compared to other wavelets. The performance of the DWT based OFDM system was analyzed for different modulation techniques with different path loss methods. Thus it is inferred that DWT reduces the BER as compared to DCT and FFT in the OFDM based system and improves the performance in multipath fading environments in the WiMax system.

Keywords – FFT, DWT, DCT, OFDM, WIMAX, Hata Propagation Model, Okumura Propagation Model, BER, SIMULINK

I. INTRODUCTION

OFDM is a wideband wireless digital communication technique that is based on block modulation. With the

wireless multimedia applications becoming more and more popular, the required bit rates are achieved due to OFDM multicarrier transmissions. Multicarrier modulation is commonly employed to combat channel distortion and improve the spectral efficiency. Multicarrier Modulation schemes divide the input data into bands upon which modulation is performed and multiplexed into the channel at different carrier frequencies so that information is transmitted on each of the sub carriers, such that the sub channels are nearly distortion less [1]. In conventional OFDM system, IFFT (Inverse Fast Fourier Transform) and FFT [5-8] (Fast Fourier Transform) are used to multiplex the signals together and decode the signal at the receiver respectively. In this system, the Cyclic Prefix is added before transmitting the signal to channel. But in wavelet based transmission technique has stronger ability of suppressing ISI and ICI than the conventional OFDM scheme [2,9]. A wavelet is a small piece of a wave. Where a sinusoidal wave as is used by Fourier transforms carries on repeating itself for infinity, a wavelet exists only within a finite domain, and is zero-valued elsewhere. A wavelet transform involves convolving the signal against particular instances of the wavelet at various time scales and positions. Hence, wavelet transform as a joint time-frequency domain. The typical application fields of wavelets are like Astronomy, acoustics, nuclear engineering, sub-band coding, signal and image processing. There are some sample applications Identifying pure frequencies, De-noising signals, Detecting discontinuities and breakdown points, Detecting self similarity and Compressing images [9]. Several families of wavelets those are especially useful in practice are like Haar wavelet, it is the first and simplest. It is the discontinuous and resembles a step function and it is represents the same wavelet as Daubechies db1. Daubechies invented compactly supported orthonormal wavelets making DWT practicable. The names of Daubechies family wavelets are written as dbN, where N is the order. Biorthogonal family of wavelets exhibits the property of linear phase,

needed for signal reconstruction. By using two wavelets, one for decomposition and the other for reconstruction instead of the same single one. Reverse Biorthogonal is real wavelets to obtain from the Biorthogonal wavelet pairs [11]. Discrete Wavelet Transform OFDM which transforms discrete time signal to a discrete wavelet. The DWT is used in a variety of signal processing applications such as video compression, internet communications compression, object recognition and numerical analysis. The objectives of this paper are to analyze the performance of the wavelet based OFDM system and compare it with conventional FFT, and DCT based OFDM system in noisy wireless channel for mobile WiMax using different modulation schemes and to increase the range of mobile WiMax and analyze the performance of OFDM.

II. RELATED WORK

The wireless communications systems are necessary to be operating in surroundings which is characterized by high carrier frequency, data transmission rate and mobility in noisy and fading channel. It has analyzed that the multicarrier data transmission techniques such as OFDM are best suitable for such channels. Siddeeq Y. Ameen et al. [7] modeled and simulated DWT-OFDM system over Rayleigh selective fading mobile radio channel. Furthermore, a Turbo DWT-COFDM system was proposed to improve the BER performance of system. The type of turbo code used is parallel concatenated convolutional code (PCCC). The simulation results include a comparison between coded and encoded DWT-OFDM system with different parameters. The result shows that the performance of DWT-OFDM system can be greatly enhanced using the turbo code system. Furthermore, the performance of proposed turbo DWT-COFDM system can be further enhanced with the increasing in the number of iterations and input frame length. Deepak Gupta et al. [8] compared the bit error rate (BER) performance of conventional discrete Fourier transform (DFT) - OFDM system with discrete wavelet transform (DWT)-OFDM system and discrete cosine transform (DCT)-OFDM system in an AWGN environment. Several wavelets such as Haar, Daubechie and Symlet are considered. We give the performance with two modulation format such as BPSK and QPSK. Simulation results show that Haar wavelet based scheme yields the lowest average bit error probability and the performance of DFT-OFDM and DWT (Haar)-OFDM with QPSK is better than BPSK modulation format. S.A. Broughton et al. [9] observed complexity of DWT as $O(N)$ which was much less than that of FFT having complexity as $O(N \log 2N)$ and suggested that the wavelet transform could be efficiently applied for the wireless communication systems. Volkan Kumbasar et al. [17] worked on the performance of wavelet based OFDM (WOFDM) is studied and compared to that of conventional

OFDM over multipath Rayleigh fading channels with exponential power delay profile. Results show that WOFDM has better bit error rate (BER) performance than conventional OFDM without cyclic prefix (CP) for all signal-to-noise ratios (SNRs) and also outperforms OFDM with CP for low SNR values in indoor and outdoor environments. Therefore, WOFDM might be an alternative to conventional OFDM since it also has better bandwidth efficiency. Krupali N.Umaria et al. [18] gives comparison between the conventional FFT based OFDM systems with DWT based OFDM system have been made according to some conventional and non-conventional modulation methods over AWGN and Rayleigh fading channel. The different wavelet families have been used and compared with FFT based OFDM system and found that DWT based OFDM system is better than FFT based OFDM system with regards to the bit error rate (BER) performance, especially when it uses conventional modulation schemes and among all wavelet families, the bior5.5 wavelet family is better which give less error compare to others. The results presented in this paper are based on computer simulation performed using MATLAB software. G. Gowri et al. [19] discuss the performance of OFDM systems using the FFT and DWT using the various modulation schemes and different method. The performance of DWT OFDM is assessed by various parameters such as Bit Error Rate (BER), eye diagram, constellation diagram, etc. Meenakshi et al. [20] examined the enactment of ripple (otherwise called as wavelet) based Multi-user MIMO OFDM systems and also compare with the performance of FFT based MIMO OFDM. Wavelet based OFDM has lot of advantages compare to the FFT based OFDM. There is no need for cyclic prefix, flexibility and optimal resolution. Wavelets want existed suitably in almost absolutely the arenas of wireless communication schemes with OFDM. Simulation created examination will be jumble-sale to simulate the double multicarrier schemes, DWT with Haar mother constructed multicarrier in addition the predictable OFDM, less than the consequence of taking multiple antennas scheme, by BPSK also QPSK as dual modulation schemes in additive white Gaussian noise channel (AWGN). Established on the bit error rate presentation to the transmission ability, the DWT constructed multicarrier scheme was establish to be higher to the predictable OFDM scheme. Harpreet Kaur et al. [25] provides the analysis of the performance of discrete Wavelet transform (DWT) based OFDM as an alternative to the conventional FFT based OFDM systems under the joint effect of path loss, multipath fading and noisy environment for mobile WiMax in terms of bit error rate (BER).

III. PROPOSED WORK

From study it was observed that modulation and demodulation techniques used in order to transmit and receive messages using Orthogonal Frequency Division Multiplexing (OFDM) method is one of the most important factors in improving speed, accuracy and efficiency of the overall systems. It is also modulation scheme that decides the robustness of system to noise signals and other issues such as fading and interferences. In this project report a detailed analysis of DWT, FFT and DCT based OFDM performance using various modulation schemes for mobile WiMax, its results and analysis has been presented.

The schematic for block diagram of OFDM is shown in the figure 1 below. In the proposed system, the Fourier Transform (FFT/IFFT) is replaced with the wavelet transform i.e. (DWT/IDWT). Proposed System is designed for wavelet based OFDM under the joint effect of path loss, fading & noise for mobile WiMax for different modulation schemes such as DBPSK, BPSK, QPSK and 64-QAM. In this paper work basically three models are designed for DWT, DCT and FFT based OFDM using convolution encoder. In the proposed model different wavelet families performance are also analyzed and concluded that Daubechies based wavelet reduces the BER as compared to other wavelets families. Figure 2-5 are DWT based OFDM shown under BPSK, QPSK, DBPSK and 64-QAM modulation scheme are designed respectively.

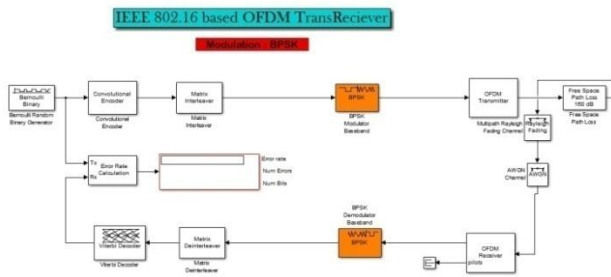


Figure 2: BPSK based OFDM Transceiver for WiMax

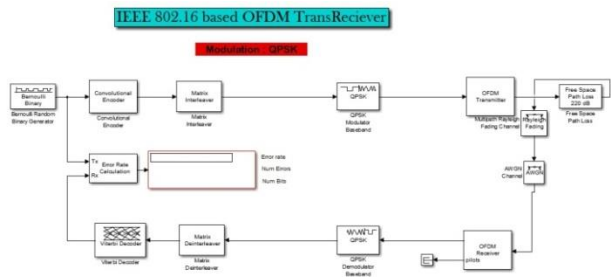


Figure 3: QPSK based OFDM Transceiver for WiMax

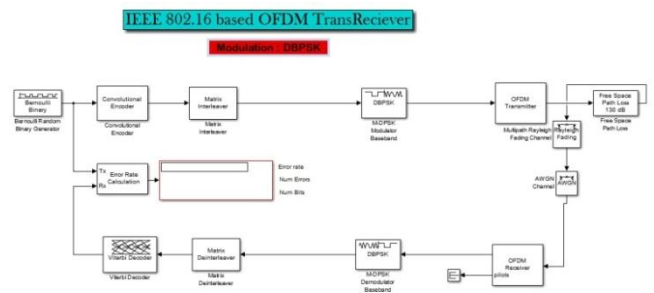


Figure 4: DBPSK based OFDM Transceiver for WiMax

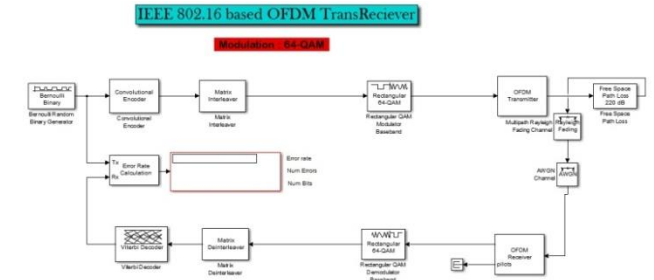


Figure 5: 64-QAM based OFDM Transceiver for WiMax

IV. RESULT ANALYSIS

The simulation environment is designed for wavelet based OFDM under the joint effect of path loss, fading & noise for mobile WiMax for different modulation schemes such as BPSK, QPSK, DPSK and 64-QAM. In the proposed system the channel will be modeled by a Rayleigh Fading model followed by AWGN as the additive noise for different Path loss models such as Hata Propagation model and Okumura model. The simulation parameters are presented in Table I.

Table I: WiMax System Parameters

Frequency band	2 GHz, 2.3GHz
Distance between transmitter and receiver antenna height	1–10 km
Transmitter antenna height	100 m, 150m
Receiver mobile terminal	5 m
Environment	Semi-Urban, Urban

Comparative analysis of BER vs SNR for DWT, DCT and FFT based OFDM for WiMax for different modulation scheme are shown below:

Case I: BPSK Modulation Scheme based OFDM by using Hata Propagation Model

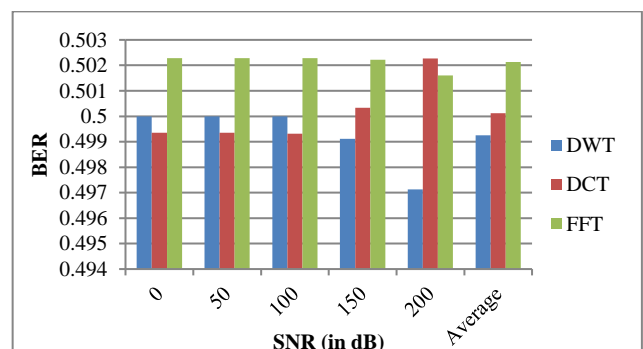


Figure 6: BER vs SNR graph for BPSK Modulation Scheme for Suburban using Hata Propagation Model

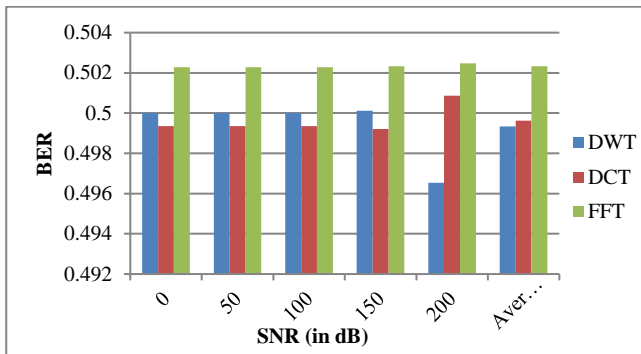


Figure 7: BER vs SNR graph for BPSK Modulation Scheme for Urban using Hata Propagation Model

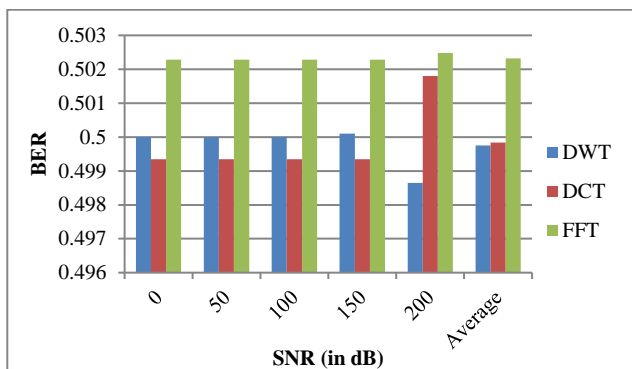


Figure 8: BER vs SNR graph for BPSK Modulation Scheme for 100m transmitter height in Suburban using Hata Propagation Model

Case II: BPSK Modulation Scheme based OFDM by using Okumura Propagation Model

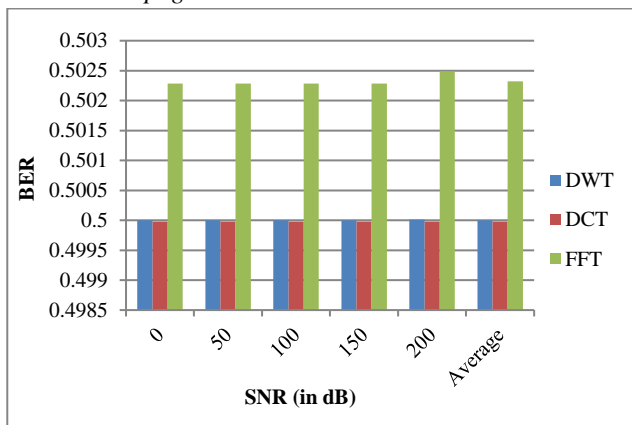


Figure 9: BER vs SNR graph for BPSK Modulation Scheme for Suburban using Okumura Propagation Model

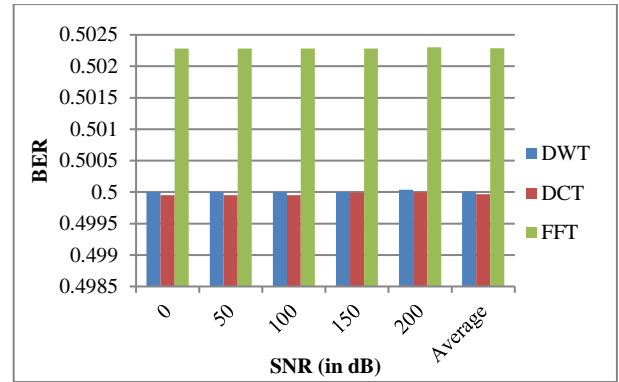


Figure 10: BER vs SNR graph for BPSK Modulation Scheme for Urban using Okumura Propagation Model

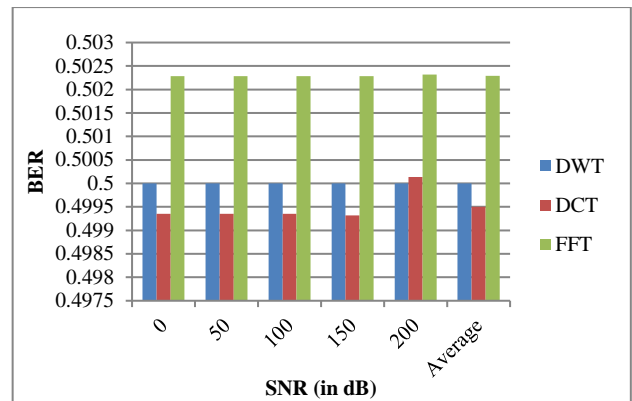


Figure 11: BER vs SNR graph for BPSK Modulation Scheme for 100m transmitter height in Suburban using Okumura Propagation Model

Case III: QPSK Modulation Scheme based OFDM by using Hata Propagation Model

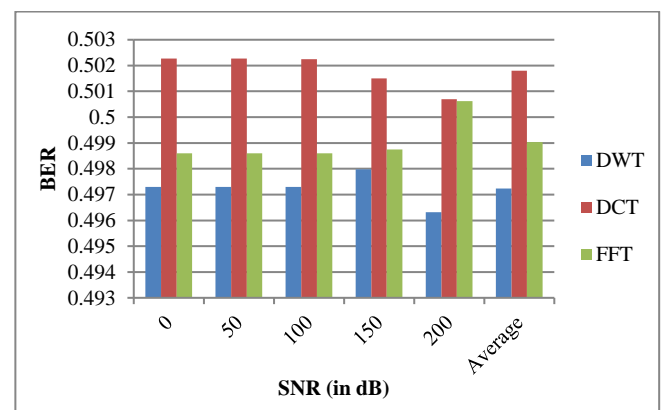


Figure 12: BER vs SNR graph for QPSK Modulation Scheme for Suburban using Hata Propagation Model

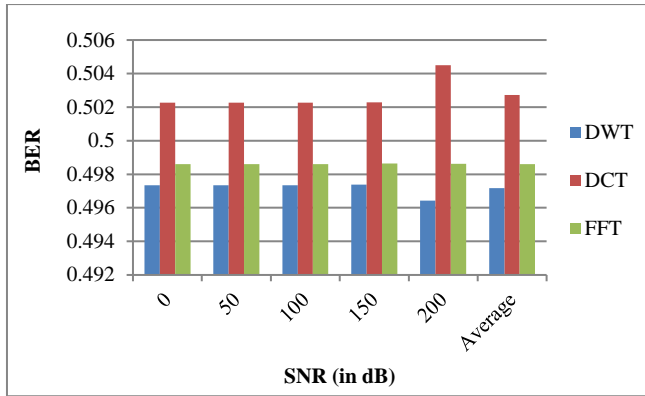


Figure 13: BER vs SNR graph for QPSK Modulation for Urban using Hata Propagation Model

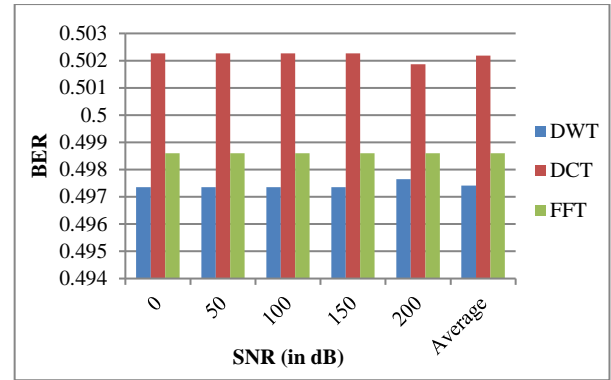


Figure 16: BER vs SNR graph for QPSK Modulation Scheme for Urban using Okumura Propagation Model

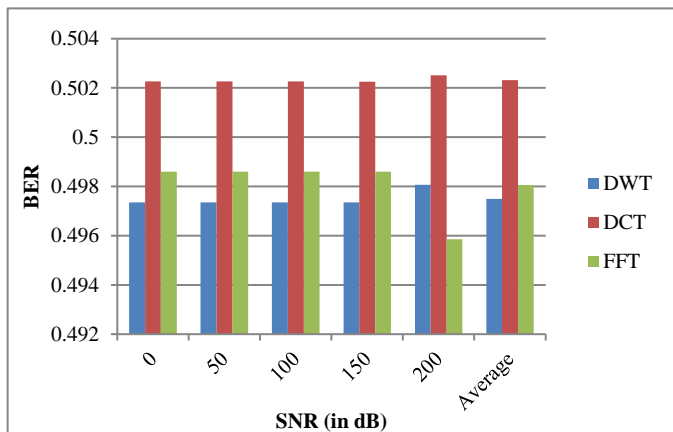


Figure 14: BER vs SNR graph for QPSK Modulation Scheme for 100m transmitter height in Suburban using Hata Propagation Model

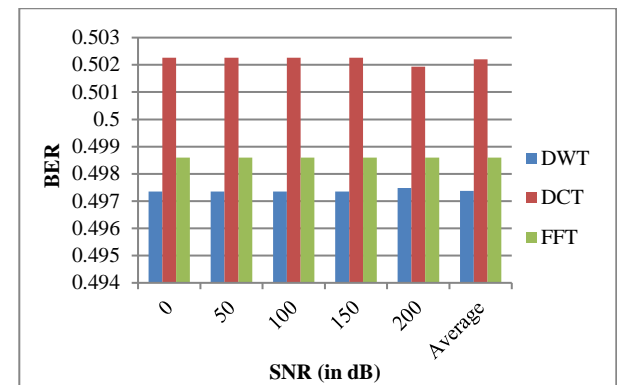


Figure 17: BER vs SNR graph for QPSK Modulation Scheme for 100m transmitter height in Suburban using Okumura Propagation Model

Case IV: QPSK Modulation Scheme based OFDM by using Okumura Propagation Model

Case V: DBPSK Modulation Scheme based OFDM by using Hata Propagation Model

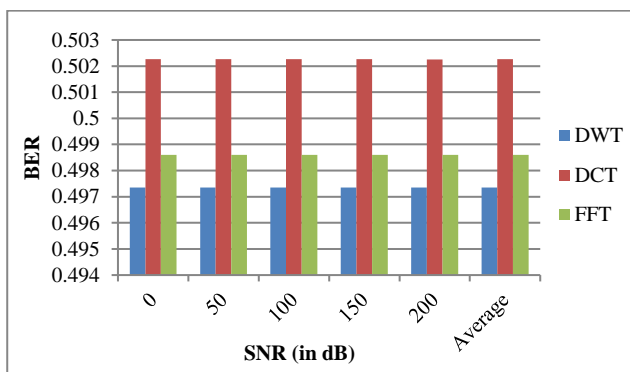


Figure 15: BER vs SNR graph for QPSK Modulation Scheme for Suburban using Okumura Propagation Model

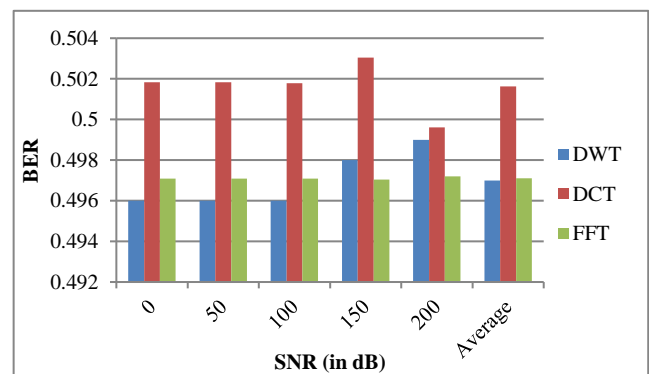


Figure 18: BER vs SNR graph for DBPSK Modulation Scheme for Suburban using Hata Propagation Model

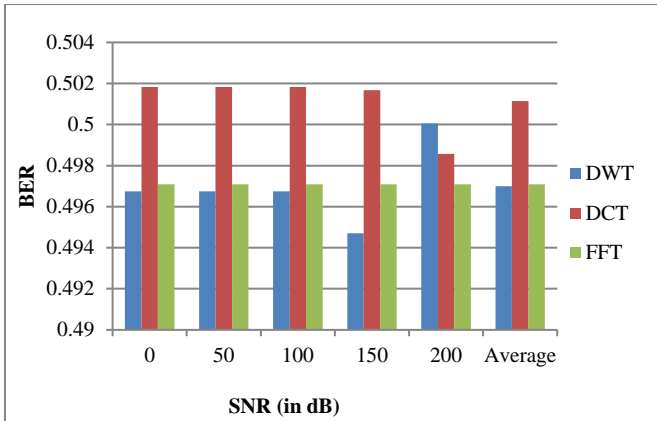


Figure 19: BER vs SNR graph for DBPSK Modulation Scheme for Urban using Hata Propagation Model

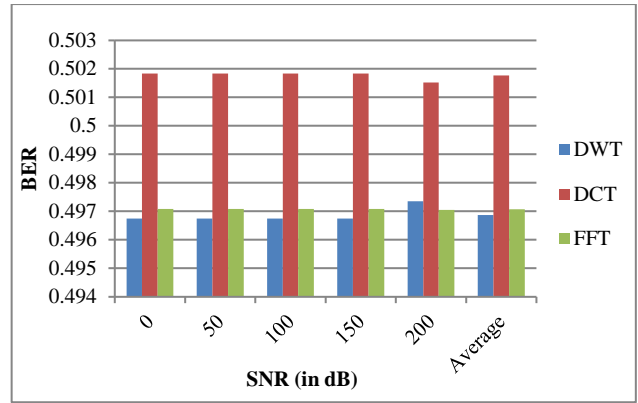


Figure 22: BER vs SNR graph for DPSK Modulation Scheme for Urban using Okumura Propagation Model

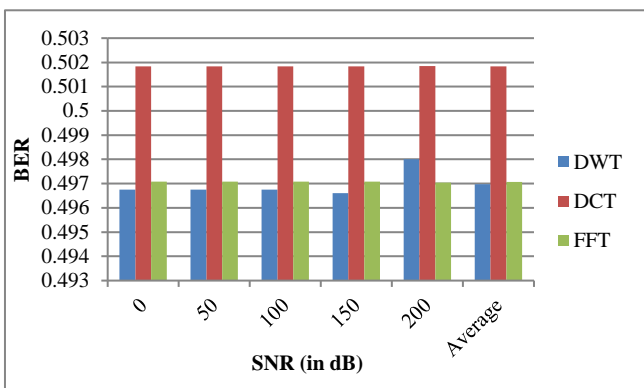


Figure 20: BER vs SNR graph for DPSK Modulation Scheme for 100m transmitter height in Suburban using Hata Propagation Model

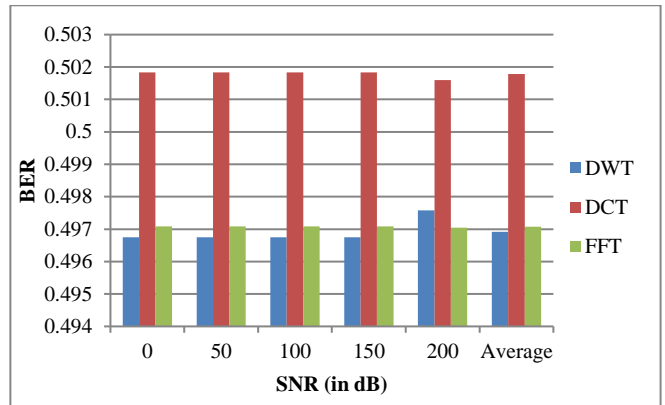


Figure 23: BER vs SNR graph for DPSK Modulation Scheme for 100m transmitter height in Suburban using Okumura Propagation Model

Case VI: DBPSK Modulation Scheme based OFDM by using Okumura Propagation Model

Case VII: 64-QAM Modulation Scheme based OFDM by using Hata Propagation Model

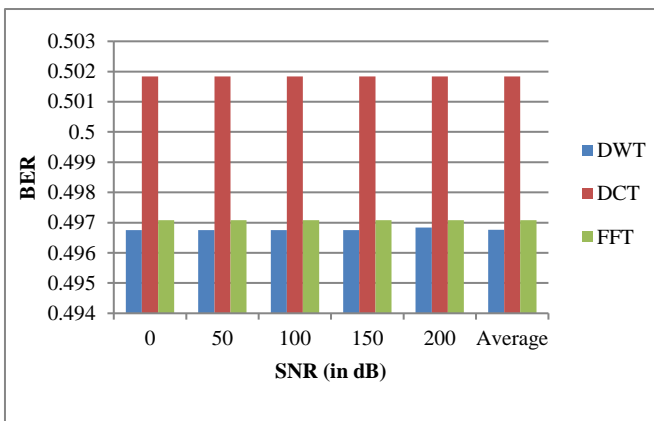


Figure 21: BER vs SNR graph for DBPSK Modulation Scheme for Suburban using Okumura Propagation Model

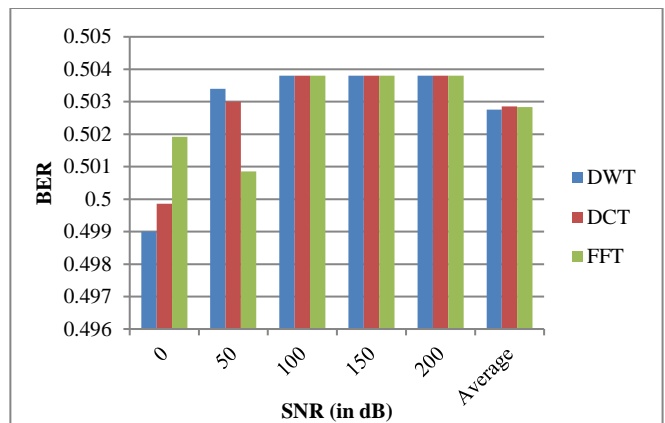


Figure 24: BER vs SNR graph for 64-QAM Modulation Scheme for Suburban using Hata Propagation Model

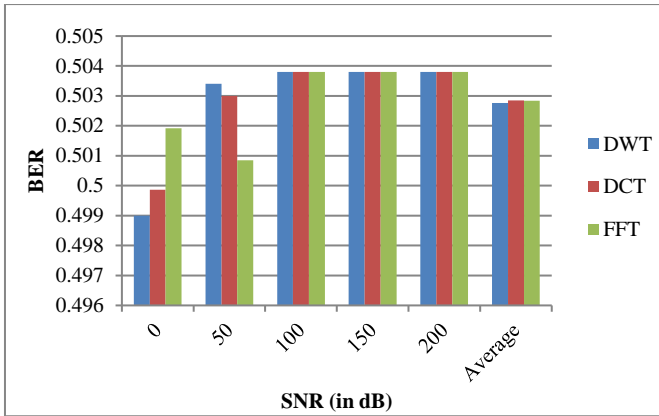


Figure 25: BER vs SNR graph for 64-QAM Modulation Scheme for Urban using Hata Propagation Model

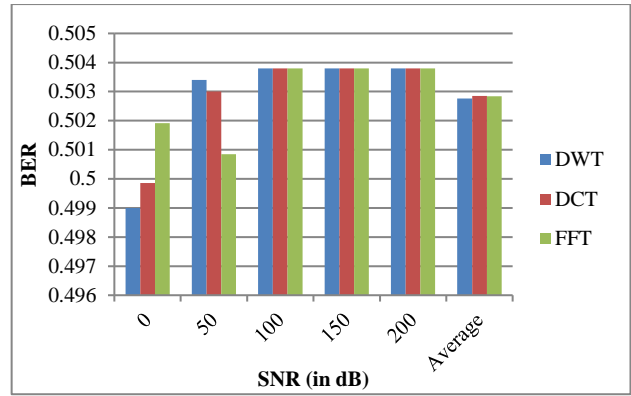


Figure 21: BER vs SNR graph for 64-QAM Modulation Scheme for Urban using Okumura Propagation Model

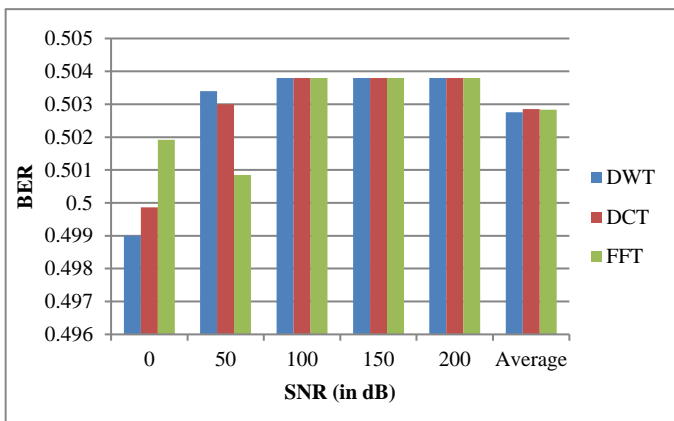


Figure 26: BER vs SNR graph for 64-QAM Modulation Scheme for 100m transmitter height in Suburban using Hata Propagation Model

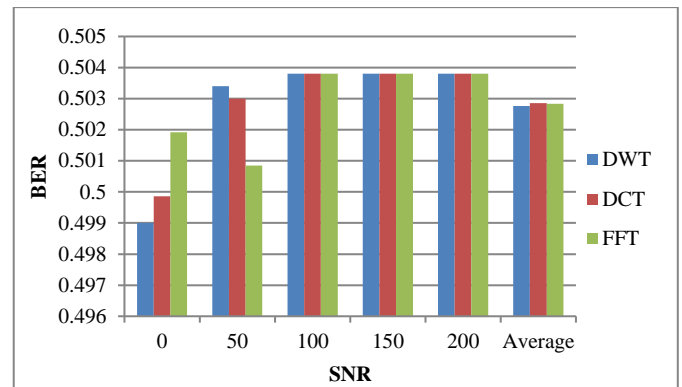


Figure 22: BER vs SNR graph for 64-QAM Modulation Scheme for 100m transmitter height in Suburban using Okumura Propagation Model

Case VIII: 64-QAM Modulation Scheme based OFDM by using Okumura Propagation Model

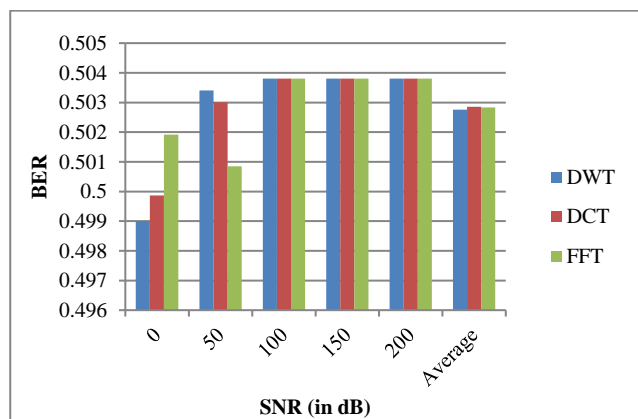


Figure 20: BER vs SNR graph for 64-QAM Modulation Scheme for Suburban using Okumura Propagation Model

V. CONCLUSION

In this paper, the performance comparison of DWT based OFDM system is performed with FFT based and DCT based OFDM system under the joint impact of path loss, multipath fading and noise in WiMax environment. The performance comparison of wavelet families such as Haar, Daubechies and Biorthogonal is also performed for different modulation techniques with different path loss methods and concluded that Daubechies based wavelet reduces the BER as compared to other wavelets. The performance of the DWT based OFDM system was analyzed for different modulation techniques with different path loss methods. Thus it is inferred that DWT reduces the BER as compared to DCT and FFT in the OFDM based system and improves the performance in multipath fading environments in the WiMax system.

In future this work can be extended to evaluate the performance of OFDM process with other adaptive modulation techniques in fading channels like Ricean fading channel. To improve the BER performance some channel coding techniques such as Reed-Solomon code, Convolutional code can be used with proposed OFDM model.

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