Noval Approach in Performance Improvement of BER by using Wavelet Transform in OFDM System

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Abstract—The rapidly growing technology has created it attainable for the communication systems to transfer information nearly every place on this planet.In this paper Discrete wavelet transform (DWT), wavelet Packet transform (WPT) and Inverse wavelet Packet transform (IWPT) are broadly considered as an economical approach to exchange FFT within the standard OFDM systems because of its higher time-frequency localization, bit error rate improvement, interference minimization, improvement in bandwidth efficiency and many more benefits.Wavelet based OFDM is utilized in order to get rid of the utilization of cyclic prefix that decreases the information measure wastage and also the transmission power is additionally reduced. The BER performance of the OFDM system had been considerably improved by 4 decibel at BER of 10-2.9 when DWT was utilized in place of standard FFT methodology.

Index Terms— OFDM, DWT, WPT, IWPT, BER.

1. INTRODUCTION

Performance of wireless communication is troublesome jobs in mul-tiple-input/multiple-output system at a lower place fully differ-ent diversity theme in presence of co-channel interference. Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier system with Simultane-ous transmission of data on closely spaced or-thogonal sub-carriers. A cyclic prefix is further to each symbol to combat the delay spread introduced by multi-path channel and therefore the length of cyclic prefix should be at least an equivalent size because the expected channel delay spread. Addition of cyclic prefix minimizes inter-symbolinterference (ISI) [1].

With the rapid climb of electronic communication in recent years, the requirement for high-speed information trans-mission has been exaggerated. The wireless trade faces the matter of providing the technol-ogy that be ready to sup-port a spread of services starting from auditory communi-cation with somewhat rate of a number of kbps to wireless transmission in with somewhat rate up to a pair of Mbps. several systems are projected and OFDM system has gained a lot of attention for various reasons. Though OFDM was 1st projected within the Nineteen Sixties, solely in recent years, it's been recognized as associate degree out-standing methodology for high-speed digital communication system wherever its implementation depends on terribly high-speed digital signal Processing. Since OFDM is distributed within the digital domain, OFDM methodology is versatile for the look method and enough quick in terms of your time to place it within the market [2]. OFDM may be a multicarrier mod-ulation technique. OFDM provides high information measure efficien-cy as a result of the carriers square measure orthogonal to every alternative and multiple carriers share the information among themselves. the most advantage of this transmission technique is their lustiness to channel fad-ing in wireless communication setting. the most objective of this project is to implement associate degreed take a look at an OFDM

Transmitter and receiver employing a FPGA at baseband with separate moving ridge remodel. As a primary step we've got styleed a simula-tion model mistreatment MAT-LAB to examine the performance of the pa-per design [3].

In this paper we tend to investigate the performance of moving ridge (DWT, WPT, IWPT) primarily based OFDM system and compred the results with standered OFDM system. The advantage of this sytem is carrier prefixed (CP) isn't been used thus bury symbole Interferance isn't happens during this sytem. additionally power demand is reduced and Bit error rate (BER) performance is improved.

This paper is organized as follows. In section II we tend to described the FFT primarily based OFDM sytem, moving ridge based mostly OFDM system Model is described in section III. In section IV we've got mentioned the sim-ulation results, finally in section V conclusion and future scope has been mentioned

2. OFDM (ORTHOGONAL FREQUENCY DI-VISION MULTIPLEXING)

OFDM is a popular method used for high data rate wireless transmission. It is a special type of multicarrier modula-tion(MCM) techniques.In OFDM,the data stream is divided into a numberof smaller sub streams which are transmitted using a set of subcarriers. OFDM can be considered as either amodulation technique or multiplexing technique. The subcarriershave the base recurrence detachment required to keep up the orthogonality of their time-area waveforms. Therefore, the accessible transmis-sion capacity is utilized proficiently.

An important use of the OFDM,is to increase system robustness against frequency- selective channels.It is also used to combat the ISI and narrowband interference. In single carrier modulation, one fade or interferer might cause the communication link to fail. Whereas, in OFDM modulation, little share of those subcarriers are plagued by that interferer, and error correcting codes are often accustomed correct the inaccurate subcarriers. Using OFDM reduces the complexity of equalizers used in high data rates applications.

2.1 OFDM Modulator:

Determine shows a block diagram for an OFDM mod-ulator. The first step is to divide the info circulation making use of serial to parallel approach into a quantity of substreams (the number of subcarri-ers), let it equal N. Then, N-point inverse fast Fourier turn out to be (IFFT) is used to transfer the samples into the discrete-time domain. After that, a parallel to serial system is utilized on the ensuing discrete-time area features.

Then a glance once interval that is termed cyclic prefix (CP) is ap-pended to the sequence.The CP is used to mitigate the ISI re-sulted from the channel lengthen spread. The OFDM complex en-velope is obtained via passing the sequence through a digital-to-analog converter (DAC). Then the analog I and Q indicators are upconverted to the RF carrier frequency to be transmitted.

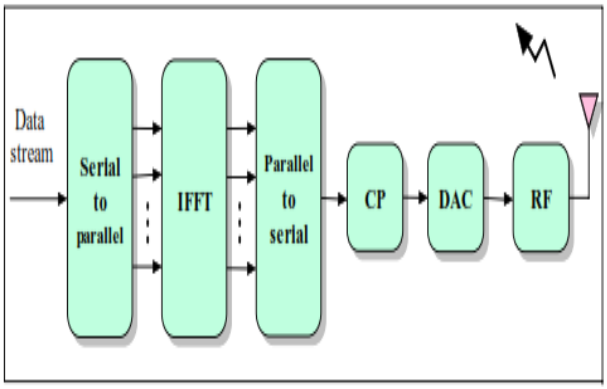

Figure 1: Block diagram for OFDM modulator.

2.2 OFDM Demodulator:

Figure suggests a block diagram for an OFDM demod-ulator. Here the inverse of the modulation operations is implemented. To start with, the acquired signal is downconverted. Then, analog-to-digital converter (ADC) is utilized to participate in the analog to digi-tal conversion, then the guard interval is eliminated. After that, a serial to parallel operation is implemented on the resulted se-quence. Then, the resulted aspects are passed through quick Fouri-er turn out to be (FFT) to get the substreams. These substreams are entered to a parallel to serial approach to get the total transmit-ted circulation.

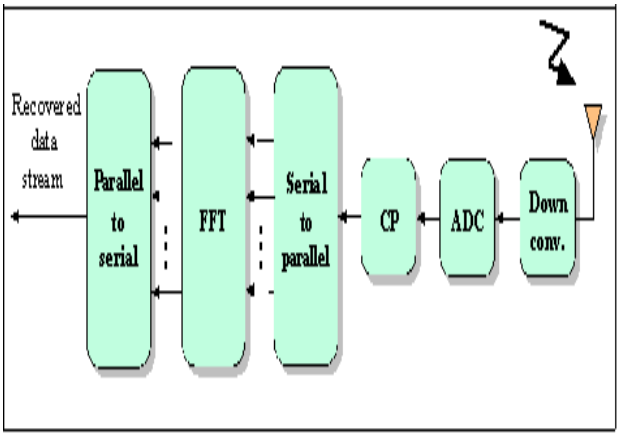

Fig.2 Block diagram for OFDM demodulator

The procedure of communication used cyclic prefix for the removal of channel interference, but it consumed the committed channel for the verbal exchange. The removal of cyclic prefix and look after band is fundamental predicament. For the removing of preserve band used develop into perform for the processing of communi-cation model. The layer decomposing a part of turn out to be func-tion used as shield band and reduces the influence of interference.

3. Wavelet based OFDM system Model

In wireless communication bandwidth play a vital role for successful communication. During the transmission of data, knowledge used a guard band (cyclic prefix) for avoiding a event of interference and collision. For that way cyclic prefix waste the precious bandwidth of spectrum in typical FFT and IFFT carrier signal. Currently during this day we used wavelet transform function for utilization of bandwidthand removal of cyclic prefix.

In method of transform function we will be used DWT, WPT/ IWPT. Block diagram of DWT and WPT is shown in Fig.3 and Fig.4

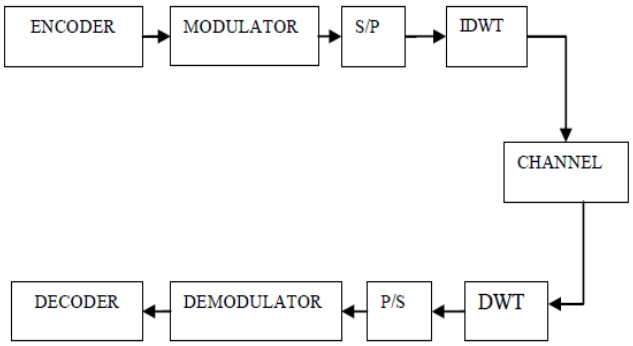

Fig. 3. Block Diagram of encoded DWT-OFDM

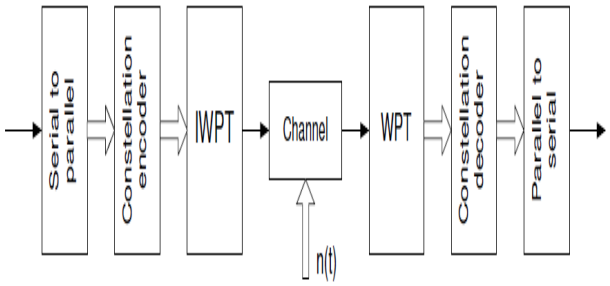

Fig.4 Wavelet packet modulation functional block diagram

3.1 Discreet wavelet Transform

The turn out to be operate works in two modes excessive filter (important points) and low filter (approximation). Here we tend to discuss the operating process of wavelet turn into function rather than ordinary FFT.

The transmitted sign within the discrete domain, x[k], consists of successive modulated symbols, each of which is developed as the sum of M waveforms ϕm[k] in my view amplitude modulated. It can be expressed in the discrete area as:

$$x[k] = \sum_s \sum_{m=0}^{M-1} a_{S,m}\, \varphi_m\,[k - sM] \qquad (1)$$

Whereas, m is a constellation encoded s-th knowledge symbol modulating the m-th waveform. Denoting T the sampling interval, the interval [0, LT − 1] is the one period the place ϕm[k] is non-null for any m ∈ zero,M − 1. In an AWGN channel, the bottom probability of inaccurate symbol selection is carried out if the waveforms ϕm[k] are at the same time orthogonal, i.e

$$\langle \varphi_m[k], \varphi_m[k] = \delta[m - n], \qquad (2)$$

the place h•, •i represents a convolution operation and δ [I] = 1 if I = zero, and zero otherwise. In OFDM, the discrete features φ_m[k] are the recognized M problematic foundation services w[t]exp(j2π m/M kT) constrained in the time domain by means of the window perform w[t].The corresponding sine-shaped waveforms are equally spaced in the frequency domain, every having a bandwidth of 2π/M and are in most cases grouped in pairs of identical significant frequency and modulated by means of a problematic QAM encoded image. In OFDM, the subcarrier waveforms are received through the WPT.

Precisely as for OFDM, the inverse grow to be is employed to make the transmitted image even as the ahead one enables retrieving the data image transmitted. Considering wavelet thought has part of its origin in filter bank conception [4], the processing of a sign by way of WPT is most commonly referred as decomposition (i.E. Into wavelet packet coefficients), whereas the reverse operation is termed reconstruction (i.E. From wavelet packet coefficients) or synthesis.

We limit our evaluation to WPT that can be outlined via a suite of FIR filters. Despite the fact that it might be possible to use exclusive wavelets as well, those can not be carried out with the aid of Mallet's fast algorithmic rule [5] and as a consequence their excessive complexity makes them in poor health-fitted to mobile conversation. The synthesis discrete wavelet packet transforms. Constructs a sign as the sum of M = 2^j wave-varieties. Those waveforms can be constructed by using J successive iterations each and every such as filtering and up-sampling operations. Noting h••i the convolution operation, the algorithm may also be written as:

$$\begin{cases} \varphi_j, 2m[k] & = \langle h_{lo}^{rec}[k], \varphi_j - 1, m\left[k/2\right]\rangle \\ \varphi_j, 2m+1[k] & = \langle h_{hi}^{rec}[k], \varphi_j - 1, m\left[k/2\right]\rangle \end{cases}$$

$$\text{With } \varphi_{0,m}[k] = \begin{cases} 1 & for \quad k = 1 \\ 0 & otherwise \end{cases} \forall m$$

where j is that the new release index, 1 ≤ j ≤ J and m the undulation index zero ≤ m ≤ M − 1. Using normal notation in discrete sign processing, ϕj, m [k/2] denotes the upsampled-via-two variant of ϕj, m [k]. For the decomposition, the reverse operations ar performed, leading to the comple-mentary set of fundamental blocks constituting the wavelet packet become depicted in determine 4. In orthogonal wavelet techniques, the scaling filter and dilatation filter type a building reflect filter pair. Consequently competencies of the scaling filter and wavelet tree depth is enough to design the wavelet grow to be [4]. It's also fascinating to notice that for orthogonal WPT, the inverse develop into (evaluation) makes use of waveforms that ar time-reversed types of the ahead ones. In communique concept, that is comparable to using a matched filter to notice the initial transmitted waveform.

A particularity of the waveforms constructed via the WPT is that they're longer than the develop into measurement. Therefore, OFDM belongs to the family of overlapped transforms, the beginning of a new symbol being transmitted before the

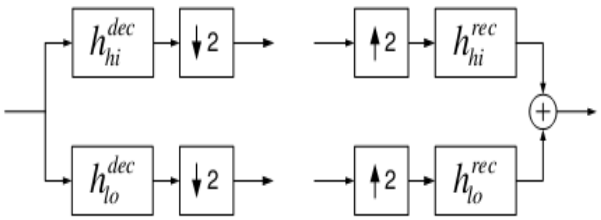

Fig. 4 Wavelet packet elementary block decomposition and reconstruction

Previous one(s) ends. The waveforms being M -shift or-thogonal, the inter-symbol or-thogonality is maintained regardless of this overlap of consecutive sym-bols. This makes it possible for taking expertise of accelerated frequency domain localization offered by means of longer waveforms whereas fending off approach ability loss that by and large results from time domain spreading. The waveforms length are almost always derived from a targeted analysis of the tree algorithmic rule. Explicitly, the wavelet filter of size L_0 generates M waveforms of size

$$L = (M-1)(L_0-1) + 1. \quad (3)$$

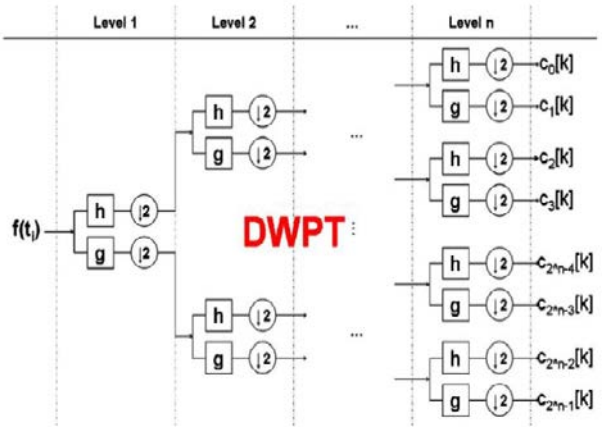

Fig. 5 Implementation of discrete wavelet packet transform (DWPT).

↓2 stands for 2 times down-sampling

Daubechie's wavelet family [6] for example, the size Lo is equal to twice the wavelet vanishing order N. For the order two Daubechie's wavelet, L is equal to 4, and as a consequence a 32 subcarrier WPT is com-posed of waveforms of length ninety four. This is as a consequence about thrice longer than the corresponding OFDM image, assum-ing no cyclic prefix is used.

The construction of a wavelet packet basis is wholly outlined by way of the wavelet scaling filter; as a result its alternative is valuable. This filter handiest determines the specified characteristics of the remodel. In multicarrier systems, the primary attribute of the waveform composing the multiplex sign is out-of-band vigour. Although in an AWGN channel this stage of out-of-band vigour has no result on the procedure performance because of the ortho-gonally condi-tion, this is quite often the fundamental fundamental source of interference once propagation via the channel explanations the orthogonally of the transmitted signal to be misplaced. An undulation with bigger frequency area localization can also be obtained with longer time help. Then again, it is attention-grabbing to make use of wave-forms of quick period to be certain that image duration is far shorter than the channel coherence time. Similarly, brief wave-varieties require much less memory, restrict the modulation-demodulation prolong and want less computation. These two specifications, much like good localization each in time and frequency area, cannot be chosen independently. Ac-tually, it can be been proven that inside the case of wavelets, the bandwidth-period.

In the end, a minor difference between OFDM and OFDM-WPT remains to be emphasized. Within the previous, the set of wave-forms is of course outlined inside the tricky domain. OFDM, on the opposite hand, is tradi-tionally defined inside the actual domain however are typi-cally additionally outlined within the complicated domain, solely depend-ing of the scaling and dilatation filter coefficients [5]. In view that the most important most commonly encountered WPT are outlined in the real do-fundamental, it can be naturally led the authors to each and every mensuration inside the frequency and time area are taken considering that the area for the period of which lots of the vigor of the signal is localized. Use pulse amplitude modulation for every subcarrier. It is nonetheless pos-sible to translate the M actual waveform straight within the com-plex domain. The resulting complex WPT is then composed of 2M waveforms forming an orthogonal set.

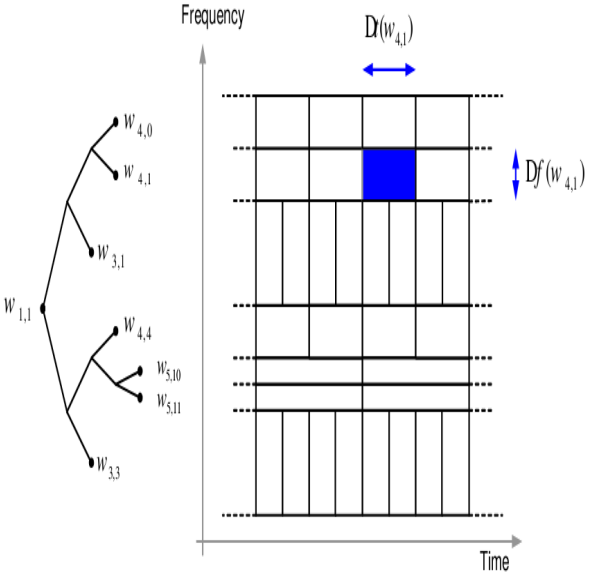

Fig.6 Time-Frequency plane division with semi-arbitrary wavelet packet tree pruning

From a communique perspective, one of these feature is usable for systems that ought to help a couple of data streams with completely dif-ferent transport prolong requirements. A logical channel requiring slash transport extend could create use of a wider subcarrier, where-as some signaling information is also carried inside of a narrower bandwidth. Notably, those narrow sub-carriers could also be used for synchronization cause in an effort to take potential of longer symbols that desire a small range of bandwidth. Or else, the authors have carried out some

study work on the opting for the transform tree according to the channel impulse response inside the frequency area. Preliminary outcome haven't proven im-portant improvement in turn into complexity versus hyperlink BER, however additional work on this trouble stays in development [7]. OFDM offers a a lot larger stage of flexibility than present multicarrier modulation schemes.

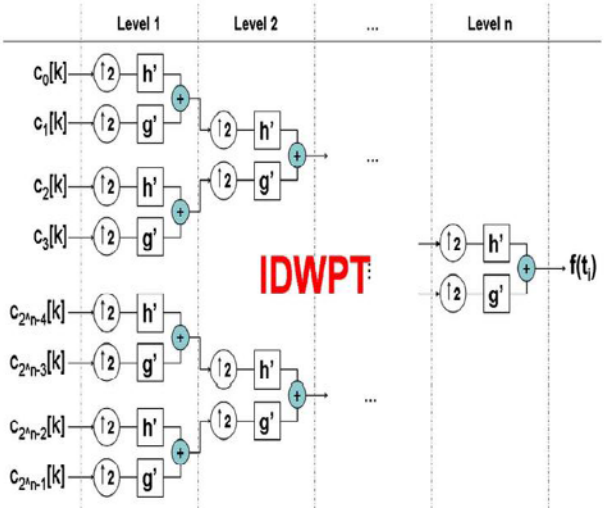

Fig. 7 Implementation of inverse discrete wavelet packet transform (IDWPT). ↑2 stands for 2 times up-sampling

From a communique perspective, this sort of function is usable for programs that have to support more than one information streams with distinctive transport extend requirements. A logical channel requiring diminish trans-port extend might make use of a wider subcarrier, even as some signaling information would be carried inside a narrower band-width. Chiefly, those narrow sub-carriers could be used for synchronization reason with a purpose to take advantage of longer symbols that require a small quantity of bandwidth. On the other hand, the authors have applied some study work on the settling on the turn into tree according to the channel impulse response in the frequency domain. Preliminary outcome have not proven signif-icant improvement in change into complexity versus link BER, however further work on this dilemma continues to be ongoing [7]. Altogether, OFDM grants a so much better stage of flexibility than current multicar-rier mod-ulation schemes. This makes OFDM a candidate of choice for reconfigurable and adaptive systems such are those prone to compose the subsequent generation of wireless communica-tion contraptions.

4. SIMULATION RESULT

We compare the performance of the adaptive technique with the orthogonal frequency division multiplexing (OFDM) systems. The key idea of adaptive is to employ the reduction of co-channel interference. Adaptive OFDM aims at providing either BER performance enhancement or power-efficiency improvement over conventional OFDM by incorporating different Transformation Techniques. Here give a parameter table for simulation. Here we demonstrate the result of BER and SNR

Table 1: Simulation Parameter

Modulation scheme (FFT/DWT/WPT/IWP)	**M-QAM**
Number of subcarrier for OFDM	124
Symbol length	4/16/64
Channel state estimation	Perfect
Signal estimation	Correlated
Channel	Rayleigh fading chanel

4.1 BER analysis with 4-QAM

The Bit Error Rate (BER) with bit size 4 can be observed in Fig. 8In this result we can analyzed that performance of SNR is improving successively while using Discrete wavelet transform (DWT), Wavelet packet Transform (WPT) and Inverse Wavelet packet Transform (IWPT).

By taking the value of SNR of all the systems at a particu-lar value of BER, the performance of FFT, DWT, WPT and IWPT OFDM system can be evaluated in AWGN channel. The BER of $10^{-2.9}$ is obtained at SNR of 10.5 dB by using FFT based OFDM, SNR of 12 dB by using DWT based OFDM , SNR of 13.5 dB by using WPT based OFDM and SNR of 14.9 dB by using IWPT based OFDM. Hence, there is a significant improvement is shown in the performance of the system by using different wavelet Transforms. The numerical observation results is shown in Table 2

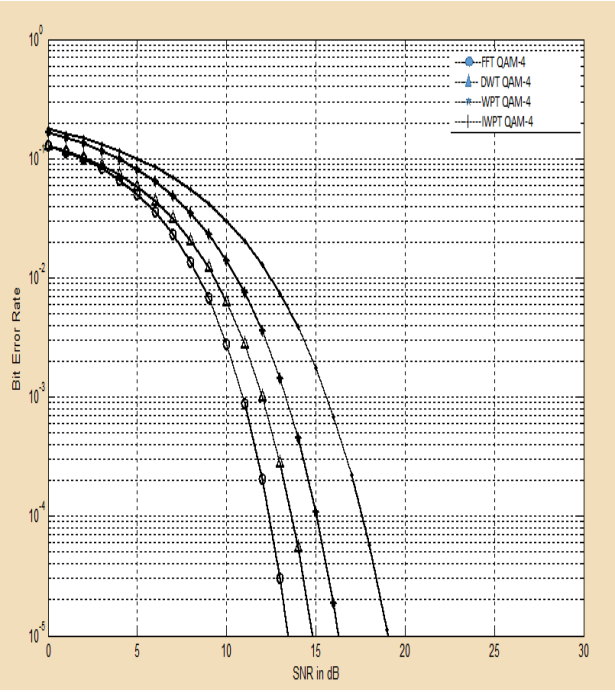

Fig.8 Comparison of BER with different Transform for bit

size 4.

Table 2: Simulation Results for 4-QAM

S.No.	Technique	BER	SNR (dB)
1	FFT	$10^{-2.9}$	10.5
2	DWT	$10^{-2.9}$	12
3	WPT	$10^{-2.9}$	13.5
4	IWPT	$10^{-2.9}$	14.9

4.2 BER analysis with 16-QAM

The Bit Error Rate (BER) with bit size 16 can be observed in Fig. 9. In this result we can analyzed that performance of SNR is improving successively while using Discrete wavelet transform (DWT), Wavelet packet Transform (WPT) and Inverse Wavelet packet Transform (IWPT).

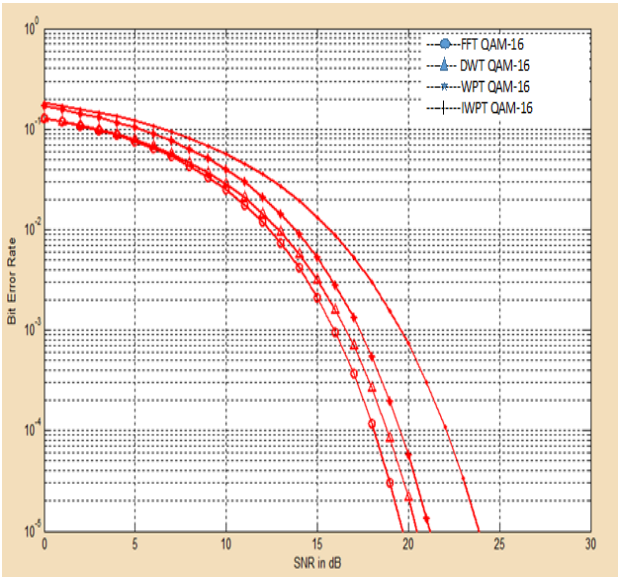

Fig.9 Comparison of BER with different Transform for bit size 16.

By taking the value of SNR of all the systems at a particular value of BER, the performance of FFT, DWT, WPT and IWPT OFDM system can be evaluated in AWGN channel. The BER of $10^{-2.9}$ is obtained at SNR of 15 dB by using FFT based OFDM, SNR of 16 dB by using DWT based OFDM , SNR of 17 dB by using WPT based OFDM and SNR of 19 dB by using IWPT based OFDM. Hence, there is a significant improvement is shown in the performance of the system by using different wavelet Transforms. The numerical observation results is shown in Table 3.

Table 3: Simulation Results for 16-QAM

S.No.	Technique	BER	SNR (dB)
1	FFT	$10^{-2.9}$	15
2	DWT	$10^{-2.9}$	16
3	WPT	$10^{-2.9}$	17
4	IWPT	$10^{-2.9}$	19

4.3 BER analysis with 64-QAM

The Bit Error Rate (BER) with bit size 64 can be observed in Fig. 10. In this result we can analyzed that performance of SNR is improving successively while using Discrete wavelet transform (DWT), Wavelet packet Transform (WPT) and Inverse Wavelet packet Transform (IWPT).

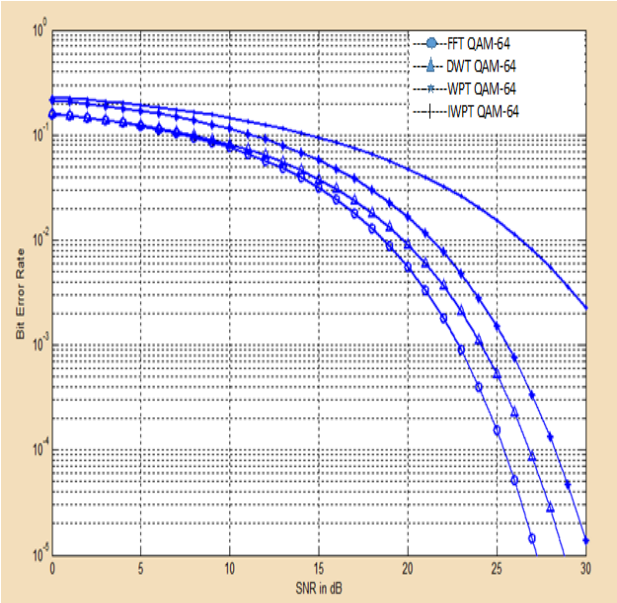

Fig.10 Comparison of BER with different Transform for bit size 64.

By taking the value of SNR of all the systems at a particular value of BER, the performance of FFT, DWT, WPT and IWPT OFDM system can be evaluated in AWGN channel. The BER of $10^{-2.9}$ is obtained at SNR of 23 dB by using FFT based OFDM, SNR of 24 dB by using DWT based OFDM , SNR of 24.5 dB by using WPT based OFDM and SNR of 30 dB by using IWPT based OFDM. Hence, there is a significant improvement is shown in the performance of the system by using different wavelet Transforms. The numerical observation results is shown in Table 5

Table 5 : Simulation Results for 64-QAM

S.No.	Technique	BER	SNR (dB)
1	FFT	$10^{-2.9}$	23
2	DWT	$10^{-2.9}$	24
3	WPT	$10^{-2.9}$	24.5
4	IWPT	$10^{-2.9}$	30

5. CONCLUSION

Initially the BER performance of FFT based OFDM system has been compared with different wavelet Transform based system and the simulations have been carried out using MATLAB.FFT based OFDM system using 4-QAM, 16-QAM and 64-QAM modulation technique under

AWGN channel has been considered as the benchmark and compared with the FFT, DWT, DWP and IWPT OFDM system. An improvement of SNR has been achieved at 10-2.9.Afterwards, all the Transform techniques are compared to find the best among all. The IWPT outperforms all the other Transform. The BER for all the wavelet families is mentioned in table 2, 3, 4.

6. FUTURE SCOPE

Finally it is important to underline that wavelet theory is still developing .It is expected that more is still to be pointed out as the knowledge of this recently proposed scheme gains more interest .There are many possibilities for future work in this area, and are summarized as follows:

- Diversity Scheme on Wavelet based OFDM: improved transmission integrity may be achieved with aid of diversity. Space, time, frequency diversities are the most physical diversities to be exploited.
- Equalization techniques: equalization techniques and channel estimation on wavelet based realization could also be an area to be addressed.
- The initiative could be extended to address Orthogonal Wavelet based Codes for Multiple access schemes.

To sum up researches done in wavelets and their application for communication engineering is still at its infant stage and there are growing number of areas that upcoming researchers are invited to explore.

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