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ENHANCING BER PERFORMANCE FOR OFDM

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Abstract—
Multi Band Orthogonal Frequency Division Multiplexing is one of the advance technology which enhances the performance of OFDM using Ultra Wide Band signals with high precision ranging and low transmitting processing power. Here decreasing the effect of Inter-Symbol-Interference, Reduces Inter Carrier Interference and Narrowband Interference. For this purpose we replace the IFFT (Inverse Fast Fourier Transform) with IDWPT (Inverse Discrete Wavelate Packet Transform) and FFT (Fast Fourier Transform) with DWPT (Inverse Discrete Wavelet Packet Transform), so that the system functionality gates increase. In this we follow the IEEE 802.15.3a standard and would present results obtained for the Bit Error Rate (BER) and compare them with other system like QPSK and BPSK.

Keywords— UWB, MB-OFDM, DWPT, IEEE 802.15.3a, Bit Error Rate.

I. INTRODUCTION

In 2002, the Federal Communications Commission (FCC) allocated a large spectral mask from 3.1 Ghz to 10.6 Ghz for unlicensed use of commercial UWB communication devices [1]. Since then, UWB systems have gained high interest in both academic and industrial research community. UWB was first used to directly modulate an impulse like waveform with very short duration occupying several Ghz of bandwidth [2]. 'Multi-banding' consists in dividing the available UWB spectrum into several sub-bands, each one occupying approximately 500 Mhz (minimum bandwidth for a UWB system according to FCC definition) [3]. By interleaving symbols across different sub-bands, UWB system can still maintain the same transmit power as if it was using the entire bandwidth. Narrower sub-band bandwidths also relax the requirement on sampling rates of adcs consequently enhancing digital processing capability. Multiband-OFDM (MB-OFDM) is one of the promising candidates for PHY layer of short-range high data-rate UWB communications [2]. In present era the enhancement in MB-OFDM System for speed transmission were in progress. So, on this basis I will try to make such system which enhances the performance of MB-OFDM system for short distance communication .

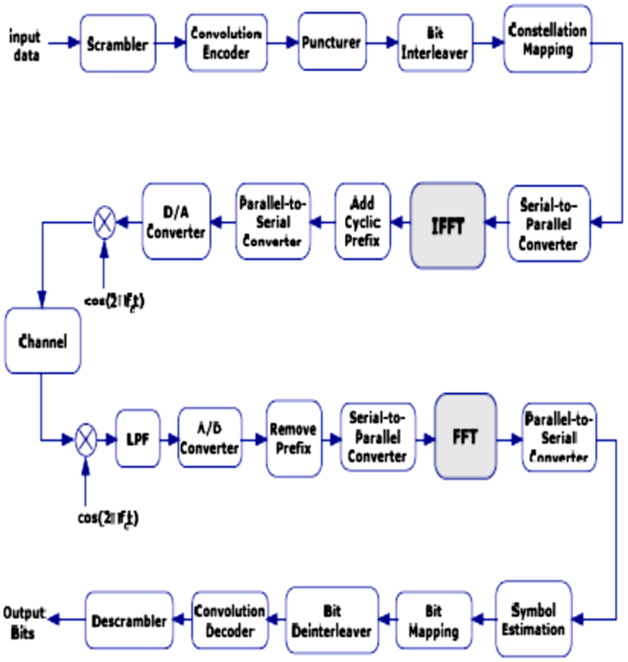

Fig. 1 General Block diagram of multi-band OFDM transmitter and receiver

Above the general block diagram of multi-band OFDM transmitter and receiver is shown.

As the need for high speed communication grows, we turn to broadband communication. Normally for a channel with small width, the frequency response is fairly flat throughout the channel. Also, on the channel there is AWGN (Additive White Gaussian Noise) noise may be present. As the channel width grows, it is difficult to model the channel. Therefore we split the channel into smaller sub-channels. Data transmission over a difficult channel is transformed through the use of advanced signal processing techniques into the parallel transmission of the given data stream over a large number of sub-channels such that each

sub-channel may be viewed effectively as an AWGN channel. Orthogonal Frequency division multiplexing offers an effective way to handle high data rate. The OFDM requires a cyclic prefix to remove ISI. This causes overhead and this overhead may be sometimes much large for the system to be effective. If the modulation and demodulation are implemented by wavelets rather than by Fourier transform then the system get improve his performance. The use of wavelet promises to reduce the ISI and ICI. The wavelet transform offers a higher suppression of side lobes [1].

II. OFDM SYSTEM MODEL

In the OFDM convolutional code with interleaving is used to combat multipath fading. Coded bits map to a QPSK constellation. The OFDM modulation is performed by an inverse fast Fourier transform (IFFT) and a cyclic prefix (CP) is added to cancel inter-block interference (IBI) and inert-channel interference (ICI). A guard interval of silence is also added to allow the transmitter and receiver to switch from one sub-band to another. The signal is then is fed into a D/A converter and sent to the RF section. At the receiver the signal is sampled after down conversion and filtering. Demodulation is performed using a fast Fourier transform (FFT) followed by one-tap frequency domain equalization and decision. A block of transmit data is scrambled, encoded, interleaved, and quaternary phase shift keying (QPSK)-modulated to form each OFDM symbol. The MB-OFDM system employs a convolutional encoding with four possible code rates: 11/32,1/2, 5/8, and 3/4 [1]. The block diagram for OFDM is as follows

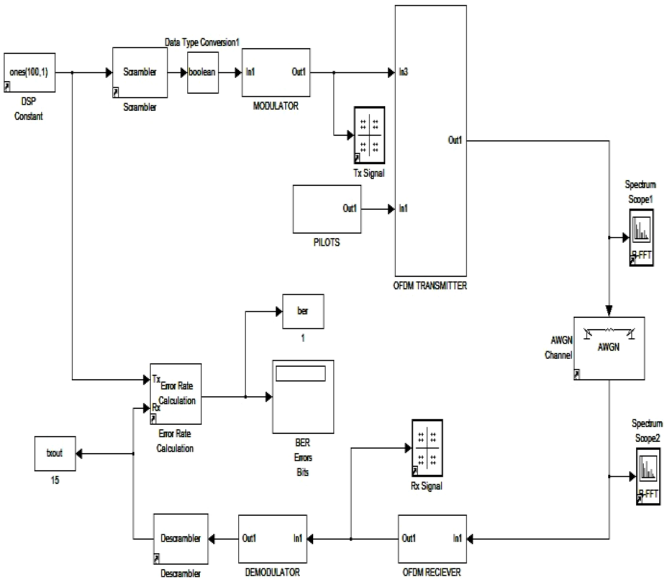

Fig. 2 Block diagram of multi-band OFDM transmitter and receiver

The total number of subcarriers for OFDM modulation in each subband is 128 among which;

TABLE I

BIT RATE FOR OFDM

Sr. No.	Parameters	Bits
1	Data Subcarriers	100
2	Pilot Subcarriers	12
3	Guard Subcarriers	10
4	Nulls Bits	6

After the IFFT, a null suffix of 37 samples is attached to the 128 time-domain samples to form a complete OFDM symbol. The resulting OFDM symbol is 165 samples or 312.5 nsec long, and it is transmitted through a subband determined by the FH pattern. Time and/or frequency domain repetitions are also employed in the OFDM symbol level to enhance the performance. The combinations of the code rate and time/frequency repetition factors (TRF/FRF) determine a set of three supportable data rates, as tabulated in Table II.

TABLE II

BIT RATE FOR OFDM

Modulation	Code Rate	TRF	FRF
QPSK	11/32	2	2
QPSK	3/4	1	1

A. *Encoder*

Encoder is use to decide the encoding rate. For this purpose it takes a single or multi-bit input and generates a matrix of encoded outputs.

Code rate = 3/4, 11/32

Code rate can be varying according to system. The person who design the system he can decide the code rate for the particular system.

B. *Puncture*

It varies code rate. It pad the zeroes at reciver side and remove zeroes at transmitter side.

C. *Interleaver*

It accepts a set of symbols and rearranges them, without repeating or omitting any of the symbols in the set.

D. *Modulator*

Here we can use any method like BPSK / QPSK, QAM. It changes the value of the modulated signal along with the carrier signal.

E. *OFDM:*

This is a method of encoding digital data on multiple carrier frequencies. Also use to prevent ISI.

F. *IFFT (Inverse Fast Fourier Transform)*

IFFT returns the inverse discrete fourier transform (DFT) of vector, computed with fast fourier transform algorithm. If [X] is matrix, IFFT returns the inverse DFT of each column of matrix.

III. DWPT MB-OFDM SYSTEM MODEL

A signal may be represented by a selected set of wavelet packets without using every wavelet packet for a given level of resolution. The construction of a wavelet packet basis starts from a pair of quadrature mirror filters, g_l and g_0, satisfying the following three conditions [3];

$$\sum_{n=-\infty}^{\infty} g_1(n) = 2 \qquad (1)$$

$$\sum_{n=-\infty}^{\infty} g_1(n) g_1(n-2k) = 2\delta(k) \qquad (2)$$

$$g_0(n) = (-1)^n g_1(L-n-1) \qquad (3)$$

$$\phi_{2n}(x) = \sum_{k\in z} g_1(k)\phi_n(2x-k) \qquad (4)$$

$$\phi_{2n+1}(x) = \sum_{k\in z} g_0(k)\phi_n(2x-k) \qquad (5)$$

$$G_1\{x\}(2n) = \sum_{k\in z} x(k) g_1(k-2n)$$

$$G_0\{x\}(2n) = \sum_{k\in z} x(k) g_0(k-2n)$$

These two operators are used to decompose any discrete function x(n) on the space *1^2(Z)* into two orthogonal subspaces l^2(2Z). In each step two coefficient vectors has a length half of the input vector are produced. Thus, the total data length remains unchanged. The process continues and stops at any desired step. The output coefficient vectors become scalars for the deepest decomposition level. This decomposition process is named as Discrete Wavelet Packet Transform (DWPT) . The transformed coefficient vectors are orthogonal and the original signal x(n) can be recovered from the coefficient vectors by the inverse transform. The wavelet packets function set defined in Eq. (4) and Eq. (5) can also be constructed using the Inverse DWPT (IDWPT) with the dual operators of Eq. (6) and (7) are defined as:

$$G_1^{-1}\{x\}(2n) = \sum_{k\in z} x(k) g_1(n-2k) \qquad (8)$$

$$G_0^{-1}\{x\}(2n) = \sum_{k\in z} x(k) g_0(n-2k) \qquad (9)$$

The process of constructing a wavelet packet function set can be seen via three levels of wavelet packet tree as shown in figure.3.

The good frequency characteristics and greater flexibility of wavelet packet transform make it a choice for MB-OFDM.

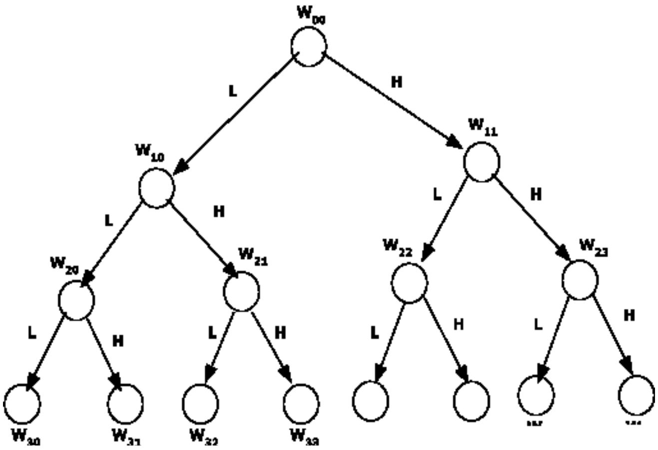

Fig. 3 Three levels of wavelet packet tree

Figure 3. shows the transmitter and receiver part of DWPT MB-OFDM. This differs from the conventional MB-OFDM in the sense that IFFT and FFT block is replaced by IDWPT and DWPT respectively. It can also be seen that cyclic prefix block has been excluded due to use of discrete wavelet packet transform, so this increases the spectral efficiency compared to conventional MB-OFDM. In DWPT MB-OFDM transmitter the data symbols are converted from serial to parallel and then transmultiplexed by IDWPT block at the receiver part the data is converted from serial to parallel and then discrete wavelet packet transform is performed. The suggested discrete wavelet based MB-OFDM improve BER performance of transreceiver.

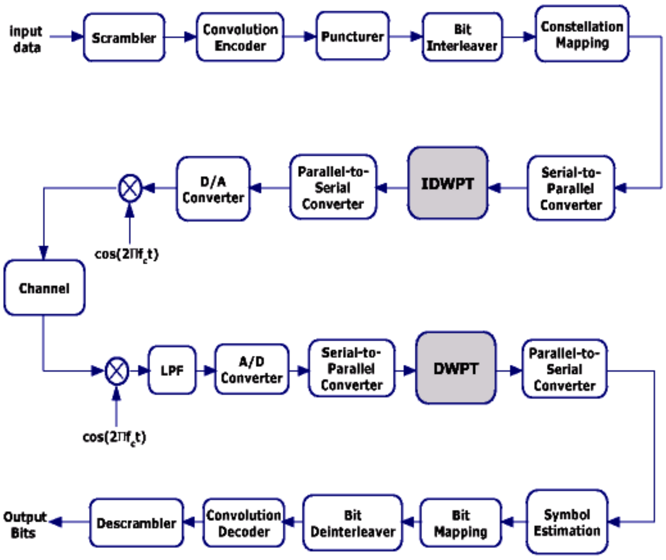

Fig. 3 Block diagram of DWPT MB-OFDM

The parameter for the system as follows

Bandwidth	528MHz
No. of subcarriers	128
Information length	242.5
OFDM Symbol length	312. 5ns
Subcarrier frequency spacing	4.125MHz
Data transmission rate 55Mbps/480Mbps	
Pilot carrier	500
FFT size	128
DWPT size	128
No. of data tones	100
No. of pilot tones	12
No. of guard tones	10
Constellation	QPSK
Wavelet	Haar Transform

In this section the performance of the MB-OFDM based PHY layer is evaluated over different modified realistic indoor UWB channel scenarios as defined in the previous sub-section. This mode employs three sub bands of 528 MHz (3.1-4.684 GHz). All simulation results were obtained using a transmission of at least 500 packets with a payload of 1024 bytes each. In our simulations, when there is no diversity (480 Mbps), a one-tap frequency-domain equalizer is used at the receiver, like that of a conventional OFDM system. However, when frequency-diversity is exploited in the system, Maximal Ratio Combining (MRC) technique is used to combine different diversity branches. Then, a soft Viterbi decoder followed by a de-interleaver is used to recover the binary data.

Here, we report simulation results over CM3 and CM4 NLOS channel scenarios as shown in figures 4 and for different data rate. In 55 Mbps mode, MB-OFDM system enjoys both intra and inter-sub-band frequency diversity. This combined with powerful channel coding rate (11/32) and bit-interleaving, makes the system robust to a frequency-selective channel.

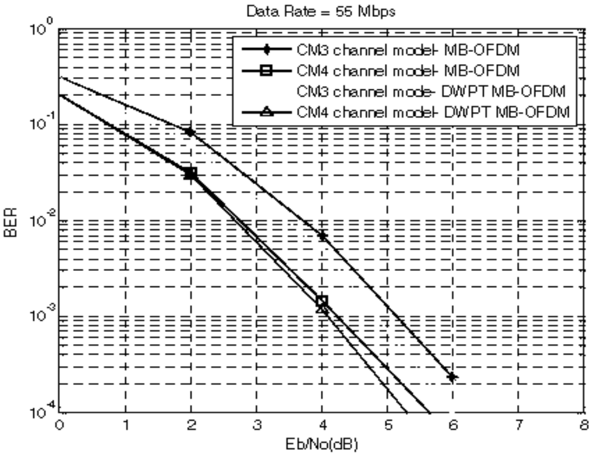

Fig.4. Performance of MB-OFDM and DWPT MB-OFDM in UWB CMS, CM4 for 55 Mbps data rate.

As shown in figures it can be observed that at low data rate (55 Mbps) both MB-OFDM and DWPT MB-OFDM performs better than high data rate of 480 Mbps. Further interesting results can be observed at data rate of 55 Mbps. These observations were verified by means of extensive simulations and according to that MB-OFDM system performs better in CM4 channel model than CMS NLOS channel model. Similar performances are observed in case of DWPT MB-OFDM system. Again At low SNR's, the performance of both DWPT MB-OFDM system and MB-OFDM system are almost same. But at high SNR's, DWPT MB-OFDM provides IdB SNR improvement than MB-OFDM.

Data Rate = 480 Mbps

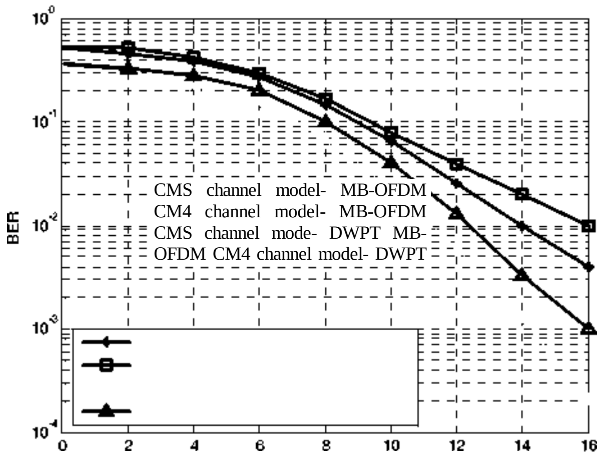

Fig.5. Performance of MB-OFDM and DWPT MB-OFDM in UWB CMS, CM4 for 480 Mbps data rate.

Further performance degradation can be observed for 480 Mbps data-rate mode, where neither intra nor inter-sub-band diversity is available. At low to medium SNR's, however, the similar performances are observed as shown in figure 5. This result can be explained by considering the fact that at high .

SNR's DWPT MB-OFDM outperforms both in CMS and CM4 channel model. At 10"^{2} BER floor DWPT MB-OFDM performs all most SdB and 4dB SNR improvement for CMS and CM4 channel model respectively. As expected DWPT MB-OFDM has better performance over CMS with smaller delay spread than CM4.

IV. CONCLUSION

By comparison of two system the Performance of DWPT OFDM system has been carried out in this paper and The channel models analyzed here are standard UWB channels considering realistic multipath resolution and operating frequencies. Also DWPM improves the spectral efficiency due to the exclusion of cyclic prefix at the start of each symbol unlike the conventional one. Thus it can be concluded that DWPT MB-OFDM system provides very good technical solution to be used as UWB PHY layer for short-range high data-rate wireless applications.

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