Analysis of Multiband Ultra Wide Band Communication System for WPAN

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ABSTRACT
Ultra wideband technology has great potentials to enhance the wireless technologies as compared to conventional narrow band technology. Because of this fact researchers are attracted towards this band. A report in February 2002 by Federal Communication Commission was issued which was a major breakthrough for UWB Technology. FCC had approved the band of 3.1 GHz to 10.6 GHz for unlicensed use for indoor and outdoor applications in the USA. This paper gives brief introduction of Ultra wide band system, the related works associated with the development of ultra wide band communication system. This paper also gives the problem facing in the ultra wide band communication system. This paper also proposed the new way to overcome the problem associated in UWB communication that is Multiband OFDM system.

Keywords:- UWB, OFDM, FCC, MB-OFDM UWB.

INTRODUCTION

The recent rapid growth in technology and the successful commercial deployment of wireless communications are significantly affecting our daily lives. The transition from analog to digital cellular communications, the rise of third- and fourth-generation radio systems, and the replacement of wired connections with Wi-Fi and Bluetooth are enabling consumers to access a wide range of information from anywhere and at any time. As the consumer demand for higher capacity, faster service, and more secure wireless connections increases, new enhanced technologies have to find their place in the overcrowded and scarce radio frequency (RF) spectrum. This is because every radio technology allocates a specific part of the spectrum; for example, the signals for TVs, radios, cell phones, and so on are sent on different frequencies to avoid interference to each other. As a result, the constraints on the availability of the RF spectrum become more and stricter with the introduction of new radio services.

Ultra-wideband (UWB) technology offers a promising solution to the RF spectrum drought by allowing new services to coexist with current radio systems with minimal or no interference. This coexistence brings the advantage of avoiding the expensive spectrum licensing fees that providers of all other radio services must pay.

There are two main differences between UWB and other narrowband or wideband systems. First, the bandwidth of UWB systems, as defined by the Federal Communications Commission (FCC) is more than 25% of a center frequency or more than 1.5GHz. Clearly, this bandwidth is much greater than the bandwidth used by any current technology for communication. Second, UWB is implemented in a carrier less fashion. Information can also be modulated on UWB pulses by encoding the polarity of the pulse, and/or also by using orthogonal pulses. Conventional narrowband and wideband systems use Radio Frequency (RF) carriers to move the signal in the frequency domain from baseband to the actual carrier frequency where the system is allowed to operate. Conversely, UWB implementations can directly modulate an impulse that has a very sharp rise and fall time. The extremely short duration of UWB pulses spreads their energy across a wide range of frequencies i.e. several GHz. Due to the extremely low emission levels currently allowed by regulatory agencies, UWB systems tend to be short-range and indoors applications.

One of the important considerations for the success of UWB systems is the compatibility and coexistence of such systems with other WLANs or WPANs. The ultra wide bandwidth cannot be assigned exclusively to UWB signals and overlapping with the bands of many other narrowband systems arise. In order to ensure a robust communication link, the issue of coexistence and interference of UWB systems with current indoor wireless systems must be considered. Due to the wideband nature of UWB emissions, it could potentially interfere with other licensed bands in the frequency domain if left unregulated. Industry's first commercial UWB standard employs unlicensed 3.1 − 10.6 GHz authorized by US's Federal Communications Commission (FCC). The assessment of mutual interference between UWB devices and existing narrowband systems during overlay is important to guarantee no conflicting coexistence and to gain worldwide acceptance of UWB technology. Hence, various technical challenges remain as open issues, which need to be confronted to ensure the successful deployment of this upcoming technology.

RELATED WORK

In the recent years, UWB communication has received great interest for short range applications like sensor networks and Personal Area Networks (PAN) [1]. The potential strength of

the UWB radio technique is its wide transmission bandwidth which results in accurate position location, ranging and high multiple access capability. Orthogonal Frequency Division Multiplexing (OFDM) has recently been applied in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency and robustness to multipath delay. Later, the UWB OFDM called Multiband OFDM (MB OFDM), has been preferred communication technique for physical layer in the IEEE 802.15.3a standard which covers wideband communication in Wireless Personal Area Networks (WPANs) [2–5]. The IEEE 802.15.3a subgroup has recently adopted a short range UWB indoor channel model by modifying the wideband S-V model. The key parameters to be considered for UWB channel environments were described by Molisch [6]. Hayar and Vitetta [7] have demonstrated the modified UWB channel model based on ray arrival of two Poisson process. Unfortunately this model failed to model with more accuracy in the ray arrival rate for UWB channel environment.
Liano et al. [8] have reported the parameters of UWB channel model based on frequency domain approach with lognormal statistics. It was reported that the model can be used to derive more accurate channel models in both UWB system design and performance optimization. Earlier the performance of UWB channel in industrial environment was analyzed by Johan et al. [9].

The analysis of Nakagamim fading channels have been presented by Mehbodniya and Aissa [10]. The performance of the Nakagamim fading channels has been analyzed using binary phase shift keying time hopping technique. The channel estimation was found to play an important role for the development of multiband OFDM systems and the performance of the fading distribution over UWB channel have been analyzed using Kalman filter based channel estimation which removes noise from multipath components.
Foersher et al. [11] have presented the analyses of different channel estimation techniques for wireless MB OFDM systems. Least Square (LS), Least Minimum Mean Square Error (LMMSE) and Kalman filter algorithms were considered for Comb type, Pilot type and Blind type channel estimation. The mathematical models for both discrete and extended Kalman filter (EKF) algorithms were developed by Welch and Bishop [12]. It was reported that, performance of discrete Kalman filter (DKF) was better is compared to extended Kalman filter (EKF).

Recently Riazual Islam and Sup Kwak [13] have developed Winner-Hopf interpolation aided Kalman filter based channel estimation technique for MB-OFDM UWB systems in time varying dispersive fading channel environment. It has been found that the winner-hopf interpolation in Kalman filter algorithm improves the smooth tracking of channel state information. However, the interpolation technique could not improve that the accuracy for fast time varying channel. Keeping the above facts, the modified S-V model with Nakagami fading distribution for modeling UWB channel environment is proposed in the present work.

PROBLEM FORMULATION

The classical UWB systems had the main disadvantage of very wide bandwidth [14] which enhances the problem of building analog and RF circuits with large bandwidth, high speed ADCs for processing the signal and complex circuitry to deal the multi-path energy in multipath path environments. This problem was overcome by pulsed multi-band [15] approach which divides the spectrum into smaller sub bands more than 500 MHz or comparative excess 0.2. Single carrier modulation techniques are used to transmit information on each sub-band. The UWB system maintains the same transmit power by interleaving the symbols across the sub-bands. The smaller sub bands results in the effective bandwidth is reduction which in turn reduces the complexity of the design and hence cost. This improves the overall spectral flexibility.

SYSTEM MODEL

The IEEE 802.15 working group develops personal area network (WPANs),while Task group 3 develops standard to deliver data rates from 20 Mbps to 55 Mbps over short range(less than 10 meters) for WPANs. This data rate was insufficient for many applications like H.323/T.120 Video conferencing (188+ Mbps to 1.4+ Gbps), Home Theatre (43 Mbps to 56 Mbps), Interactive Application (e.g. gaming) etc, hence Task Group 3a was formed to design models for applications needing high speed physical layer i.e. data rates between 55 Mbps and 480 Mbps over short ranges of less than 10 meters.

A MULTI-BAND OFDM

The MB-OFDM system is designed employing frequency hopping technique in which the bands are hopped using Time Frequency Code (TFC) known to both transmitter and receiver. In this model of MB-OFDM system, guard interval (9.5 ns) for each OFDM symbol is used. This guard interval ensures that there is sufficient time for the transmitter and receiver to switch to the next carrier frequency. A zero-padded prefix of 60.6 ns is taken. This zero padded prefix provides both robustness against multi-path and eliminates the need for power back-off at the transmitter. Here, 128-point inverse fast Fourier transform (IFFT) is taken. The OFDM symbol duration is 242.4 ns.

Many companies have responded physical layer proposals to IEEE 802.15.3a as of march 2003.Texas Instruments [16], Xtreme Spectrum [17] and Intel [18] are among the 29 companies, whose unique design choices make them different from the others. The parameters taken for simulation is based on the specification are listed in Table I.

Table 1 Key Characteristic of MB-OFDM System

RF transmission bandwidth	528 MHz
Frequency hopping ("Mode 1 device")	3 sub-bands (3.43, 3.96, 4.49 GHz centers)
Error correction coding	Convolution with puncturing
Code rate	R=5/8
Modulation	Quaternary Phase Shift Keying (QPSK)
OFDM transmission	128-point IFFT; zero-DC
Number of Data Subcarriers used	100
Number of defined pilot carrier	12
Number of undefined pilot carrier	10
Number of Cyclic Prefix	32
Cyclic prefix duration	60.61ns (32/528MHz)
Guard interval Duration	312.5
Time spreading	2x (across frequency hops)
Multipath resistance from cyclic prefix	60 ns

B. SIMULATION MODEL

he indoor model based on IEEE 802.15.3a is studied in Simulink. The different code rates are considered as per Table I. The system considered for OFDM signal generation and transmission is similar to the traditional OFDM systems but performance analysis of QPSK modulation techniques has been studied.

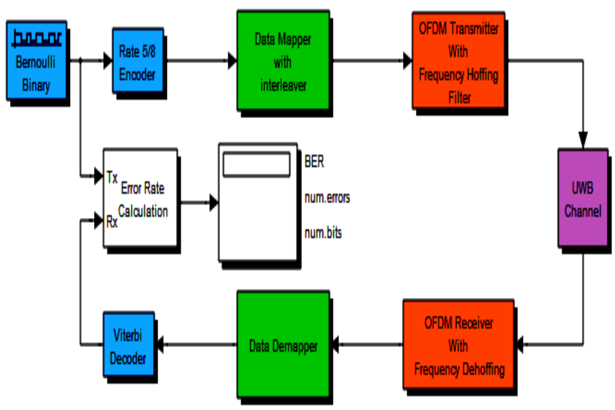


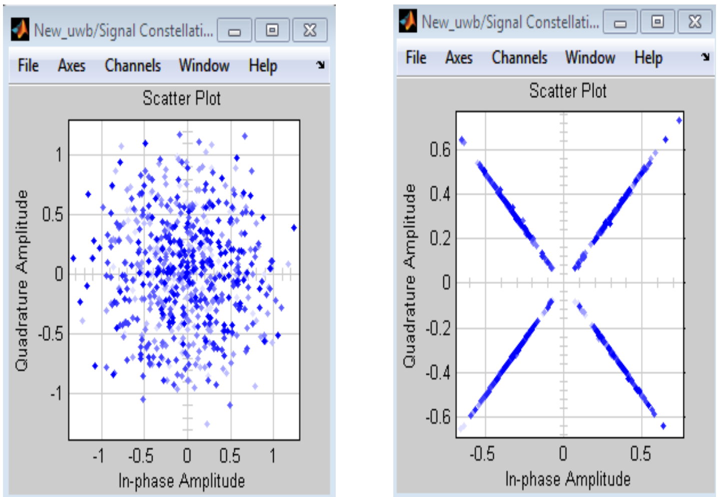
Figure 1: SIMULINK model of MB-OFDM based UWB system.

The Performance analysis shows that the QPSK modulation gives better results than other. The simulations have also been carried out for higher order QPSK systems and it is found that as the order is increased the BER performance becomes poorer. All of the four S-V channel models with different data rates and different modulations have been studied and the BER comparisons of the best results have been shown.

RESULT ANALYSIS

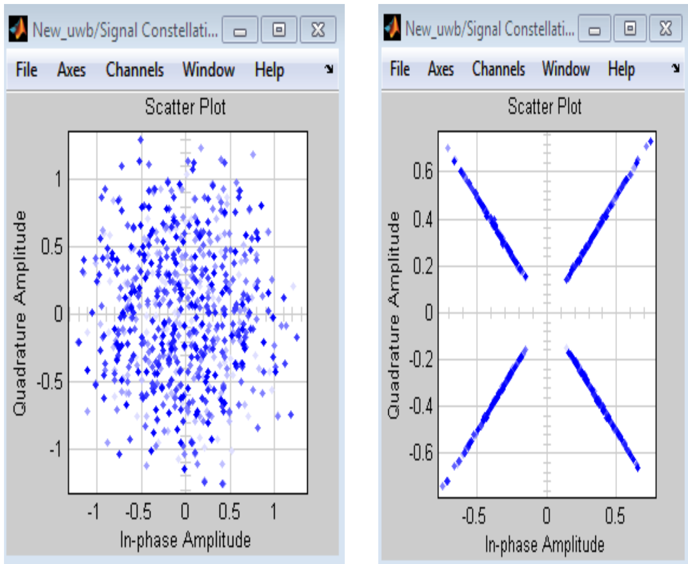
As OFDM symbols are transmitted using one of the sub -ands in a particular time slot. The sub-band selection at each time slot is determined by a TFC. The band is split into 3 sub-bands each with bandwidth of 528MHz. One can see how the time-frequency interleaving is achieved by only using one of the 528MHz sub-bands at a time.

The performance analysis given in Figure 2 to Figure 5 shows the BER performance of the MB-OFDM system with constant data rate changing the modulation schemes for four of the S-V channel models.



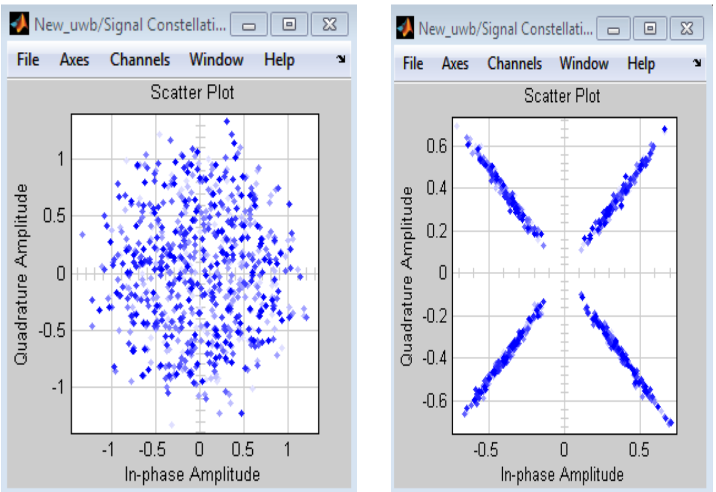
(a) **(b)**

Figure 2 (a) Scattered plot of transmission of UWB for CM1 model
(b) Scattered plot of receiver of UWB for CM1 model



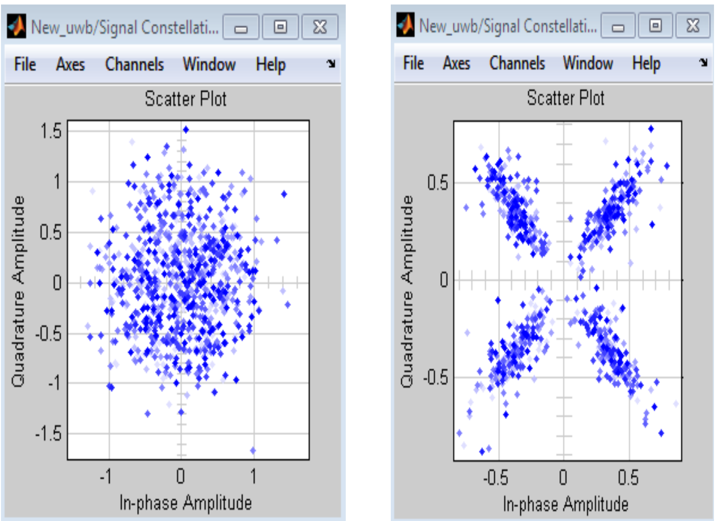
(a) **(b)**

Figure 3 (a) Scattered plot of transmission of UWB for CM 2 model
(b) Scattered plot of receiver of UWB for CM 2 model



(a) (b)

Figure 4 (a) Scattered plot of transmission of UWB for CM 3 model
(b) Scattered plot of receiver of UWB for CM 3 model



(a) (b)

Figure 5 (a) Scattered plot of transmission of UWB for CM 4 model
(b) Scattered plot of receiver of UWB for CM 4 model

For our initial floating-point reference, we set the channel SNR to a high value (60 dB), which helps us isolate the impact of fixed-point effects on symbol distortion.
Figure 2 to 5 shows two scopes from the UWB simulation:

(I) The power spectrum of the baseband-equivalent received signal, over all three sub-bands,

(II) The signal constellation after channel phase estimation and compensation

The DC null in the power spectrum is from the OFDM transmission, but the rest of the spectrum approximately follows the frequency-selective fading characteristic of the multipath channel. The dynamic range over the OFDM tone set is about 30 dB, which is also evident in the magnitude-spread of the phase-compensated signal constellation. A clean "X" indicates almost perfect phase compensation.

CONCLUSIONS

Ultra wideband characteristics are well-suited to short-distance applications, such as PC peripherals. Due to low emission levels permitted by regulatory agencies, UWB systems tend to be short-range indoor applications. Due to the short duration of UWB pulses, it is easier to engineer high data rates; data rate may be exchanged for range by aggregating pulse energy per data bit (with integration or coding techniques). The work in this paper includes the baseband implementation and performance analysis of the MB-OFDM UWB system. The implementation and the performance analysis help us to achieve High data rates. The high data rates are consistent with the increasing need to synchronize and stream the ever-increasing amounts of media, video and other forms of data present in the everyday lives of ordinary people. The baseband implementation of the MB-OFDM UWB system follows the standard proposal IEEE 802.15.3a in a straight forward manner. The result of simulation show that for fixed-point realization, receiver's digital baseband and viterbi decoder use 12 bit can fulfill the requirement. The future scope of the project is to implement WiMedia and Wireless USB have published specifications and authorized networks of certification laboratories. In addition, the technology has room to grow with the higher data rates and energy-saving improvements defined in WiMedia 1.5

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