Evaluation Of The Performance Of UWB MB-OFDM System Under Four Indoor Channel Models Of IEEE802.15.4a Under Noisy Channel Conditions

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Abstract: This Paper evaluates, the operations of Ultra-Wideband (UWB) system based Multiband-Orthogonal Frequency Division Multiplexing (MB-OFDM) channel models at Indoor conditions. In recent days the UWB plays vital role for short-range of communication with remarkably high speed. The main focus on channel models created from Modified S-V model. The MB-OFDM is utilized in wireless communication in recent years owing to its high transmitting speed as well as excellent immunity in multiple paths. UWB OFDM based system is designed representing physical layer in IEEE 802.15.4a standard. The UWB provided channel models in support of both LOS and NLOS of indoor residential, office, industrial, outdoor, and one open outdoor environment (NLOS). The four indoor channel models are observed with simulation results that elaborates the UWB indoor Channel Models performance of IEEE802.15.4a.

Keywords: Multiband OFDM, Channel Response, UWB, LOS and NLOS, four indoor

1. INTRODUCTION

Nowadays Ultra-Wideband is an up-coming technology in Wireless Networks, radar and medical engineering fields. It has vital importance in short range of applications like sensors fields and personal area networks. It has wide transmission bandwidth results in accurate positioning, ranging with high capability for multiple access [20,22].Its exceptionally troublesome to identify by unauthorized users, pretend like noise to other systems. Its highly secured that it could pass through walls and doors[19].The system performance is resulted by its multiple path channel environments. The UWB and multicarrier system of OFDM are combined with multi band technique and information is modulated in each band to occupy the receiving end with multiple path energy. The UWB contains two modes of modulation Such as the Impulse Radio (IR) and Multi-band OFDM [10]. They have numerous advantages and could be applied in different fields in medical area. MB-OFDM mode of UWB can be utilized in low range, high speed data communications. For IR mode, by using low-power very-short pulses (sub-nanosecond interval), the conventional carrier free impulse like waveforms duration with few pico seconds were used. In impulse radio, the information signal is directly modulated as impulses. One pulse denotes one bit using PAM or PPM modulation technique. Time or DS hopping based multiple users support are used in impulse radio based systems.

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In Multiband Operation each band with 500 MHz of 3.1 to 10.6 GHz tends to interleave data between few bands. So it looks like wideband but in reality we are processing only a slice of spectrum. So manufacturing of low cost devices is achievable [21]. MB-OFDM technique combines OFDM which performs well in highly dispersive UWB channel. While designing a system by ordinary OFDM using single band, the OFDM symbols are sent over different bands and multiple access is done by frequency hopping [22].

1.1 Multi-Band OFDM UWB System

The MB-OFDM UWB based system divides the entire bandwidth into sub bands each with least bandwidth of 500MHz that forms short interval signals[17]. Its essential to provide low power and high pace of data transmission. Its broadly used in digital wireless home network, office and defense applications. In spite of its unique features, numerous functional areas have emerged for UWB like Short-range communications with extremely high data rates (up to 500 Mbit/s).Its used in Sensor networks with low speed communications which combines with precise ranging and geolocation [3].In Radar systems, with the extremely high spatial resolution and obstacle penetration capabilities.

1.2 About This Work

The IEEE 802.15.4a UWB channel model defines nine sets of parameters for different environments [12]. IEEE 802.15.4a channel modeling subgroup provides several models for various frequency ranges and environments. For the UWB system frequency range from 2 to 10 GHz, they provide 8 channel models for both LOS and NLOS environment conditions. In this work, the channel modeling is explained for different channel models then the four indoor channel models of IEEE802.15.4a is implemented .The performance of UWB MB-OFDM communication system is evaluated using simulation results that elaborates study on the characteristics of indoor residential LOS, residential NLOS, indoor office LOS and indoor office NLOS models.

2. CHANNEL MODELING

The Ultra-Wideband MB-OFDM is obtained from the model represented in [1] is implemented using matlab. The IEEE802.15.4a Channel Models have been incorporated that were described in [4] Modified Saleh-Valenzuela Model proposed [7] is much adaptable model in designing various channels in UWB communication systems. The UWB channel modeling depends on measurements of indoor transmitting environments. The vital features of the channel have extremely high multipath profile and non-Rayleigh fading amplitude characteristics. The extremely larger bandwidth in UWB provides various Indoor Channels compare with the conventional wireless environment. The Received Signals are multipath because of adjacent objects arriving to cluster gets reflected. The UWB systems have multipath components higher compare with other wireless channels. Since it has wide bandwidth of waveforms, various parts of same objects arise many multiple paths and each path would be part of cluster. Henceforth the multiple paths that reach at receiver end in clusters. Within every cluster are multiple consequent arrivals called as rays. Depending on S-V Model[23], IEEE 802.15.4a modeling the channel provides the following four indoor channel models (CM):Residential LOSNLOS, Office LOS, NLOS, Outdoor LOS The model of channel is designed for residential environments depending upon the measurements that occupies the extend from 7-20m. The model developed from indoor office environment which occupies the range of 3-28m.The outdoor environment is formed on the range from 5-17m up to 3-6GHz.

2.1 The Saleh-Valenzuela Multipath Model (S-V)

The Saleh-Valenzuela(S-V) Model which is proposed in [6] is a conventional model for designing different channel models of UWB systems. Therefore Modified S-V model is proposed for modeling the channels. Depending on S-V Model, task group 4a channel modeling subgroup determines Residential LOS, Residential NLOS, Office LOS, Office NLOS, Outdoor LOS, Outdoor NLOS, Industrial LOS Industrial NLOS and Open Outdoor Environment NLOS channel models[6] . This Model considers two independent single Poisson models that engaged in the deciding the arrival time. The first Poisson model provides the very first path of arrival time of each path cluster and second model verdict the arrival time of the paths (or rays) within each cluster. Following the terminology in [7], the authors of [3] define T_l= time of arrival of the very first path of the l-th cluster;

$\tau_{k,l}$ = the time delay of the k-path within the l-th cluster respect to time of arrival of first path , T_l;

Λ =mean arrival rate of the cluster;

λ = mean rate of arrival of ray, i.e. rate of arrival of path in each cluster. we have $\tau_{0l} = T_l$.The distribution of cluster data with arrival time and the Rayleigh arrival time are given by

$p(T_l|T_{l-1}) = \Lambda \exp[-\Lambda(T_l - T_{l-1})]$, l >0 ……. (1)

$p(T_{k,l}|T_{(k-1)l}) = ƛ_1 \exp[-ƛ_1(T_{k,l} - T_{(k-1)l})]$, k>0

The magnitude of the k-th path and the l-th cluster is represented by β_{kl}. It is Rayleigh distributed with a mean given by

$$\overline{\beta^2{}_{kl}} = \overline{\beta^2(0,0)}\, \exp(-T_l/\Gamma)\exp(-\tau_{kl}/\lambda), …….(2)$$

Here $\overline{\beta^2(0,0)}$ is denoted as the average power of the arrival of the first cluster.

2.2 The Modified Saleh-Valenzuela Model (S-V)

In this work, modified Saleh-Valenzuela model is designed to simulate the nine channel models of IEEE 802.15.4a UWB for different environments. It is a combination of two Poisson process, here the single Poisson process is maintained for the cluster arrival rate. The combination of the two Poisson process is utilized for the ray arrival time within the clusters.

$$P(Tk_{,l}|T_{(k-1)l}) = \beta ƛ_1 \exp[-ƛ_1(T_{k,l} - T_{(k-1)l})] + (\beta-1) ƛ_2 \exp[-ƛ_2(T_{k,l} - T_{(k1)l})],\ k>0 \quad ……. (3)$$

Where β is the mixture probability.

$ƛ_1, ƛ_2$ are ray arrival rates.

3. The Mat lab Simulation

The following is the Simulink model of the MB-OFDM UWB transmitter and receiver design with the IEEE 802.15.4a channel models.

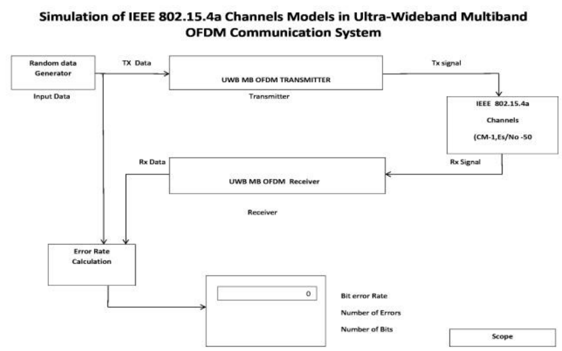

Figure 1.*The Simulink Model*

The Channel model has been implemented between transmitter and receiver. A graphical User Interface has been created to manage channel model parameters and other parameters. It is used to observe the characteristics of the channel. The MB-OFDM packet contains combination of OFDM Symbols with Packet/Frame Sync,Estimation of channel, along Header, and then Payload. The Packet/Frame Sync and Channel Estimation forms the Preamble. The preamble appears in two forms: the Standard Preamble consists of (24) Packet/Frame Sync symbol-times and (6) Channel Estimation symbol-times. The System Model of the transmitter given in IEEE 802.15.4a based standard proposal is shown in the simulink model where the input data after get scrambled is encoded by the convolutional encoder. Then the encoded signal is interleaved and mapped into QPSK values then interference symbol is almost eliminated and later IFFT modulation is performed and finally to the receiving end which implements the reversal process the Cyclic processing and channel estimation/compensation are necessary to moderate the effects of multiple path channel dispersion. Channel's frequency coherence, and thus progress noise averaging [2].) It does not compensate for channel magnitude variations across the OFDM tone set because such schemes are computationally expensive and also unnecessary for QPSK. In this simulaiton, we used 100 data subcarriers in OFDM symbol and 122 subcarriers, 128 point FFT. In OFDM symbol construction, we used 6 channel estimation preamble symbol time 3 Packet sync sequence symbol time and 6 Frame sync sequence symbol time 6 and 5 Guard period symbol time.

3.1 The Performance Metrics

The Following are the three performance metrics that we considered for evaluating the impact of the nine different channel models on the UWB MB-OFDM communication system.

3.1.1 BER vs Es/No

We know that Eb/No is defined as the ratio of the signal energy transmitted per bit to the spectrum density of noise. BER is the percentage of errors bits to the total amount of bits that's transmitted, received or processed over a given time period. We used Bit-error rate (BER) vs Es/No curves to analyze and visualize the working of UWB communication system under different channels or channel models.ERR vs Es/No ERR the count of total bit errors or lost bits in the communication. We used EER vs Es/No curves to analyze and visualize the operations of the UWB communication system under different channels or channel models. Total Bits vs Eb/N0The Total received Bits vs Es/No curves to observe the performance of the UWB communication system under different channels. This work, uses the above three metrics to visualize and understand the channel model's behavior on an UWB MB-OFDM communication system.

4. The Results and Discussion

The following are the average performance of the UWB MB-OFDM system with 1ms Simulation. This 1ms simulation will generate 3201Frames of data and will transmit and receive all those frames in ideal condition. In this experiment, the number of received bits at the end of the receiver will mainly depend on the channel model in use.

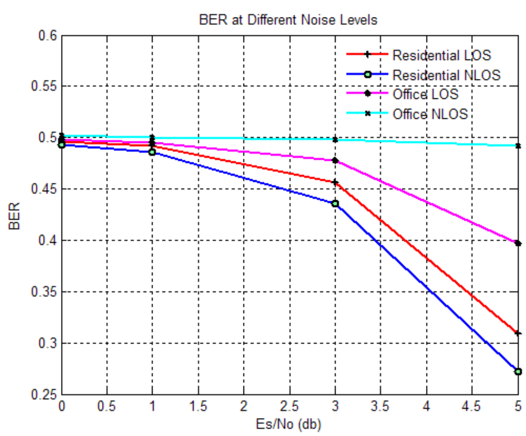

Figure 2. *Performance in Terms of BER at Low Es/No*

The graph shows BER at different Eb/No levels. The office LOS and office NLOS channel models the system was able to receive only lesser data bits compare to Under residential LOS and residential NLOS .The figure 3 shows BER vs Es/No and it shows that all the channel models will provide lower bit error rate.

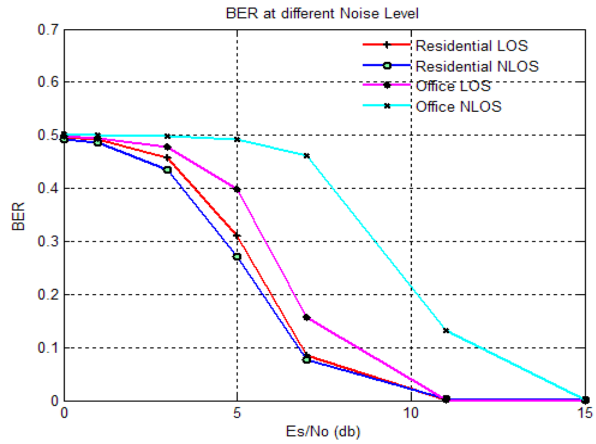

Figure 3. *Performance in Terms of BER at Low and High Eb/No*

The office LOS and office NLOS channel models has high error rate.

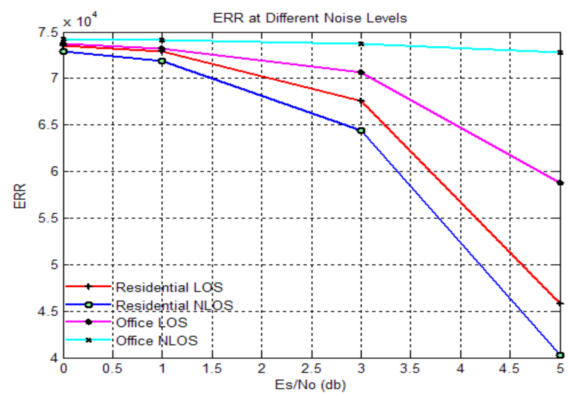

Figure 4*. Performance in Terms of ERR at Low Eb/No*

Figure 4 tells that, at high Es/Nos (low Noise) all the channel models will lead to low error.

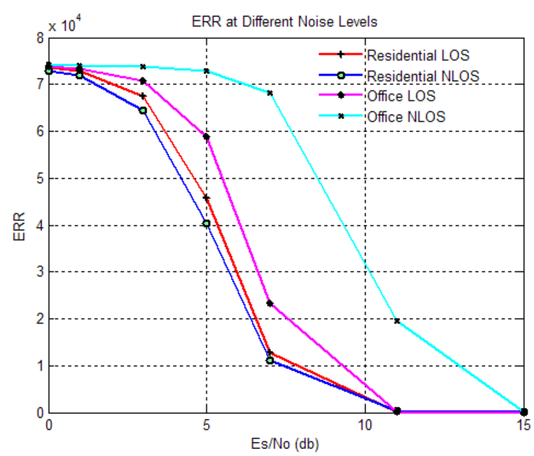

Figure 5.*Performance in Terms of ERR at Low and High Eb/No*

The following graphs shows under the office LOS and office NLOS channel models was able to receive only lesser data bits.

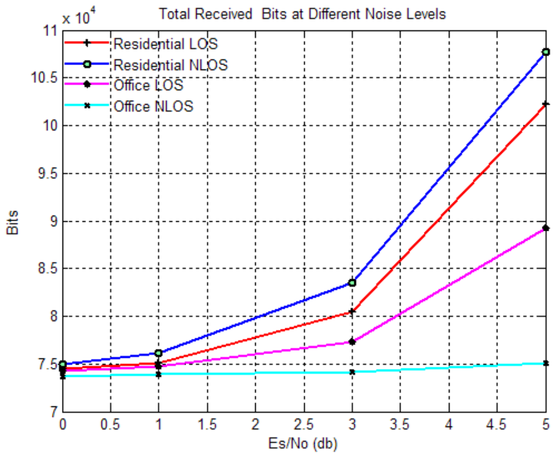

Figure 6.*Performance in Terms of Total Received Bits at Low Eb/No*

Figure 6 shows that, at high Es/No (low Noise) all the channel models will receive higher data bits.

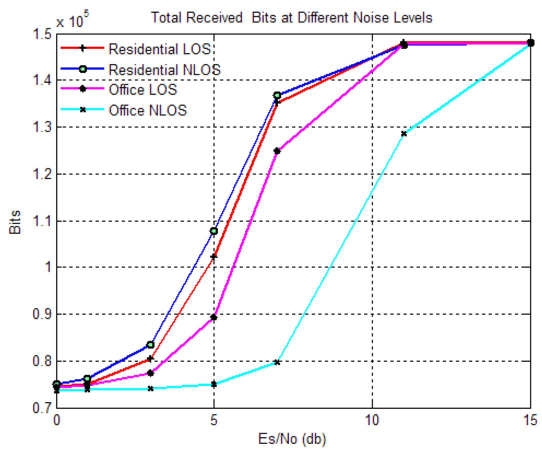

Figure 7.*Performance in Terms of Total Received Bits at Low and High Eb/No*

5. Conclusion

In this work the performance of the MB-OFDM UWB system under four indoor channel models of IEEE 802.15.4a was investigated and specification has been evaluated. The results show the real challenges needed for the design of short range (near) LOS and NLOS communication scenario of office environment. Under the office environment the BER is very high and poor performance is visualized in LOS and NLOS communication. The UWB communication system provides better performance under residential LOS and NLOS environments. Our future works will address the benefits, application and technical challenges in designing transmitters and receivers of personal area network (PAN) and body area network(BAN). The issues in designing channel models for PANs and BANs and propose techniques for improving the performance of MB-OFDM UWB transmitter/receiver will be discussed.

6. Acknowledgement

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