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Analysis of Ultra Wide Band OFDM Communication System through IEEE802.15.4a in Wireless Communication

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Abstract: This paper uses simulation to evaluate the performance of a UWB communication system with an accurate channel model. A cost-effective prototype model of a real-time UWB communication system. This paper presents a UWB multiband OFDM system for various frequency ranges.Channel subgroups provide various models for the various frequency ranges of IEEE 802.15.4a. The UWB frame repeats from 2 to 10 GHz and provides 8-channel models for indoor and outdoor LOS (line-of-sight) and NLOS (no-line-of-sight) environmental conditions.The uniqueness of Task Group 4a channel models and UWB-enabled frameworks are reviewed and evaluated against a number of channel models.

Keywords: Multiband OFDM, Channel Response, UWB, LOS and NLOS.

1. INTRODUCTION

In the recent years UWB is getting more attention as it plays vital role in wireless communication compare to other technologies [1-3]. Its capable to replace the high speed data cables in various environments. The importance of UWB over the various kinds of transmission of signals make its highly prioritize over the other in communication field [4-6]. One of the fastest emerging radio technologies in the modern scenario is Ultra-wideband (UWB) with some unique and smart features. It is used in fields like wireless communications, radar, and medical engineering [7-8]. The UWB has high speed and low power consumption with less implementation losses [9]. The UWB was utilized in earlier stage as carrier free impulse communication systems in radar. Later its widely used from military to commercial usages. These technologies cover 500MHz or more than 20% of the center frequencies in the 3.1-10.6GHz bandwidth with a transmit power of 41.3dBm/MHz. Bandwidth transmission has several advantages, such as full range, enhanced regenerative

fading, better obstacle penetration, stealth behavior, anti-jamming, anti-jamming, and coexistence with narrowband (NB) systems [11].
To generate receiving and handling UWB signals presents noteworthy difficulties that require new research in flag age, transmission, engendering, preparing, and framework designing [12]. The spectrum includes for example IEEE802.11a spectrum (Narrow band) but the EIRP is very small for interference. Standards: IEEE 802.15.3a, ECMA consequently require high information rate and low information rate. The UWB Technology is widely used in wireless and indoor communication systems [13].

Modulations of UWB

The modulation techniques of UWB that are used for wide range of frequencies are Impulse Radio (IR) and Multi-band OFDM [14].It has several benefits and can be utilized in various fields in medical area. Single band operation is carried out in impulse radio, where single pulse is denoted using PAM or PPM modulation [15]. Multiband operation is involved in Multi-band OFDM where QPSK and DCM are recently used as modulation schemes. MB-OFDM UWB systems operating in the 3.1–10.6 GHz frequency band are distributed over 14 frequency bands with a bandwidth of 528 MHz [16]. Further they are subdivided into five band groups in which three bands are assembled in first four bands group and last two bands in collected in fifth group.The system has two modes of operation: time-frequency interleaving (TFI) and fixed-frequency interleaving (FFI) [17]. Initially it operates in one sub band and switches to next sub band during a short interval. Every sub band of OFDM transmit data symbol.

Channel Modeling

In Matlab, the Simulink model of UWB MB-OFDM is based on the model presented in [4].The IEEE802.15.4a. Channel Models included were described in [18].The Saleh-Valenzuela (S-V) model proposed in [19] is an existing model for designing different channel models for UWB communication systems [20]. Based on the S-V model, Workgroup 4a Channel Modeling Subgroup developed residential LOS, residential NLOS, office LOS, office NLOS, outdoor LOS, outdoor NLOS, industrial LOS industrial NLOS and open outdoor environment NLOS channel models, decided [21]. This depends on two parameter classes, such as inter-cluster parameters and intra-cluster parameters. Cluster arrival times and ray arrival times are described by two Poisson processes.

The Modified Saleh-Valenzuela Model (S-V)

In this study, we design a modified Saleh-Valenzuela model to simulate the IEEE 802.15.4a UWB 9-channel model under different environments. As a combination of two Poisson processes, we maintain one Poisson process for cluster reachability. When a ray arrives inside a cluster, a combination of two Poisson processes is used.

Simulation and Outputs

The following model diagram in Simulink shows a high-level overview of an MB-OFDM UWB transmitter and receiver design using the IEEE 802.15.4a channel model.

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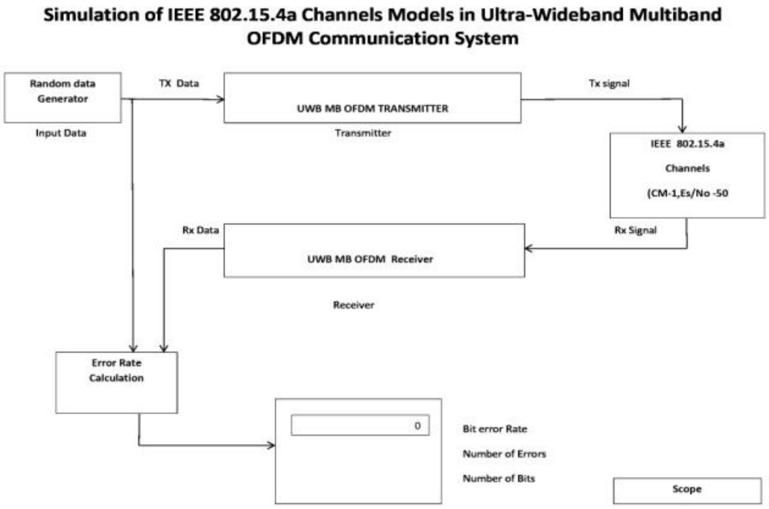
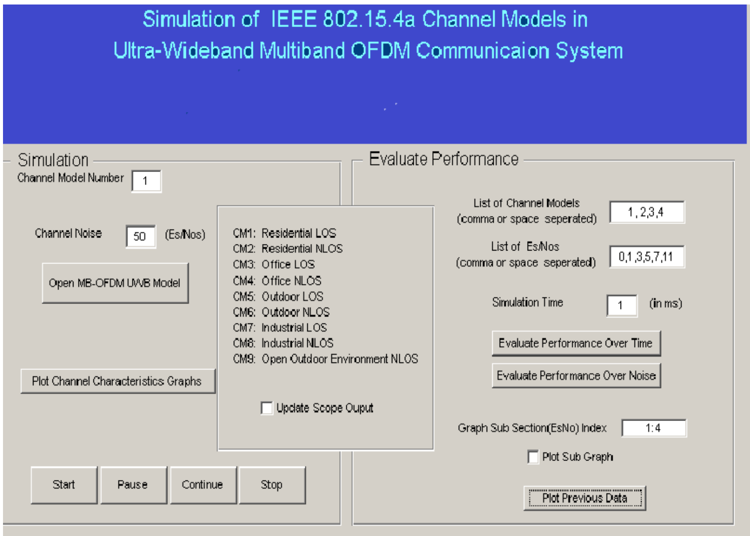


Fig.1. The Simulink Model

In Simulink models the channels are implemented among the transmitting and receiving ends of MB-OFDM. The parameters of channel model and other parameters are constrained by matlab based graphical user interface (GUI). Using the following user interface, the experiments can be run in an iterative fashion to log the output parameters and to plot the different channel characteristic graphs as well as performance graphs. The following figure shows the Matlab user interface with options. The MB-OFDM packet contains packet/frame synchronization, channel estimation, header and payload-specific OFDM connection code.The preface comes in two forms:The standard preamble consists of (24) packet or frame sync symbol times and (6) channel estimation symbol times. The simulation used 100 data subcarriers of OFDM symbols and 122 subcarriers of a 128-point FFT.


Simulation of IEEE 802.15.4a Channel Models in
Ultra-Wideband Multiband OFDM Communicaion System

Simulation
Channel Model Number 1
Channel Noise 50 (Es/Nos)

CM1: Residential LOS
CM2: Residential NLOS
CM3: Office LOS
CM4: Office NLOS
CM5: Outdoor LOS
CM6: Outdoor NLOS
CM7: Industrial LOS
CM8: Industrial NLOS
CM9: Open Outdoor Environment NLOS

☐ Update Scope Ouput

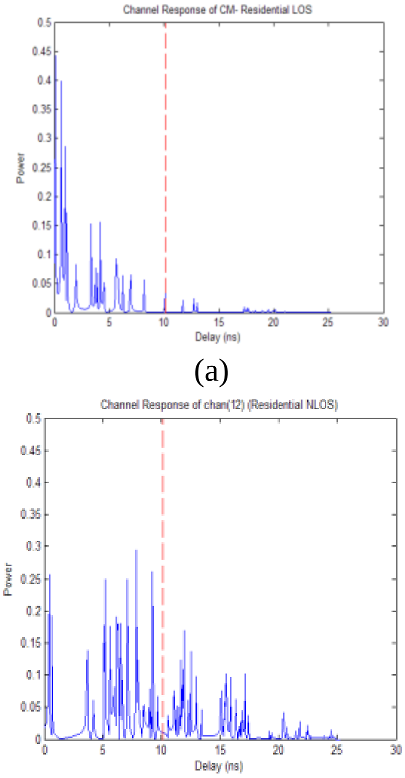
Evaluate Performance
List of Channel Models (comma or space seperated) 1, 2,3,4
List of Es/Nos (comma or space seperated) 0,1,3,5,7,11
Simulation Time 1 (in ms)
Graph Sub Section(EsNo) Index 1:4
☐ Plot Sub Graph

Fig.2. The Matlab User Interface

MB-OFDM Transmitter and Receiver

In Transmitter, input data bits are first passed across scrambler which randomizes the bit sequence to eliminate the power spectrum of transmitted data. It is then fed into encoder for error correction to add redundant bits for reinforcement of actual message. Again it is further coded by Conventional encoder. The interleaver is kept to secure the data from burst error while transmission. Interleaver bits are flow across constellation mapper to map onto different subcarriers incorporating QPSK, BPSK, QAM techniques. IFFT converts the magnitude and phase of each component spectrum into a time-domain signal. Convert multiple complex data points to the same number of points in the time domain.The OFDM attains its Orthogonally in this pivotal stage. .

In Receiver side, cyclic prefix of transmitted signal is removed and passed on to perform Fast Fourier transform. De-Interleaver rearranges the bits into original form. This penultimate signal is transmitted to Viterbi decoder. Finally, the symbols are decoded by removing the parity symbols. The final step in this process is to transmit the signal to a descrambler, where the original data bits are recovered from the scrambled bits.



(a)

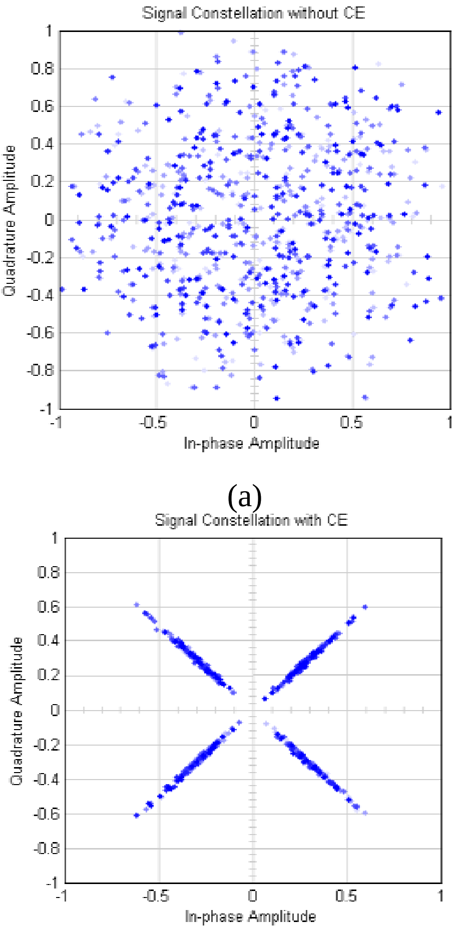
(b)

Fig.3a and 3b The Channel Response

The signal intensity got through a multiple path channel is measured by delay parameter as a component of time delay. The estimation is done effectively and can be utilized to extract certain channel's parameters, for example, the delay spread. The mean value over multiple points of channels impulse response is planted by power delay profile.

QPSK Signal Constellations in the Signal Space

Channel Estimation (CE) error reduces the system activities. Without CE or without a correct CE method, data will get seriously distorted and would degrade performance. The QPSK Signal Constellations of the received frame (Frame No:198) without channel estimation are given below.



(a)

(b)

Fig. 4 (a) and (b) The QPSK constellation without Channel Estimation and with channel estimation (frame 198)

Total Bits is the total received bits at the receiving end. Using the received bits vs Es/No curves, we analyze and visualize the performance of the UWB communication framework on different channels or channel models. In this task, we will visualize the above three metrics and understand the behavior of the channel model in UWB MB-OFDM communication system.The outcome with respect to these three metrics are displayed in the above section. Some of the graphical outputs such as channel response, frequency domain tx signal and rx signal, the qpsk constellation with and without ce are shown in this work.

2. CONCLUSION

This paper describes the performance of the UWB transmitter, receiver and the channel models. The Specification of IEEE 802.15.4a nine channel model is implemented successfully. The channel response and power decay profile of the nine channel models have been analyzed. The signal constellations of received signal with and without channel estimation algorithm are visualized. The frequency spectrum of the transmitted and received signals is experimented.

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