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International
Journal
Of Modern Engineering Research (IJMER)

Minimization Of Inter Symbol Interference Based Error in OFDM System Using Adaptive Decision Mechanism by SNR Estimation

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Abstract: *In the wireless multimedia applications OFDM modulation is a promising approach for establishing a high bit rates. Modern OFDM systems uses channel estimation and tracking, instead of differential phase-shift keying (DPSK) it provides a 3-dB SNR loss compared with normal coherent phase-shift keying (PSK). In this article we have improved the performance of OFDM systems in coherent PSK modulation schemes; we implemented a channel estimation technique for OFDM communication. We designed an algorithm based on mean-square-error (MSE) channel estimator by use of calculations based on the time and frequency-domain received signals of the frequency response obtained after passing through time-varying dispersive Rayleigh fading channels distorted with AWGN. We have considered the uncertainty of channel statistics that results in mismatch of the estimator-to-channel statistics and proposed a robust channel estimator that is independent to uncertainty of channel performance statistics. The robust channel estimator response are further used to run a modulation decision scheme logic that can significantly improve the performance of OFDM systems in noisy Rayleigh fading channel by minimizing BER and inter symbol interference.*

Keywords: *Adaptive Decision, OFDM, Fading Channel, SNR estimation, PSK/QAM.*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) [1]–[3] in recent years has collected high popularity due to its performance features like its robustness to multipath delay spread and AWGN noise, it has quality of high data transmission rate with improved bandwidth efficiency, and its application of adaptive equalization and power allocation in between the subcarriers in accordance of the channel conditions. OFDM is used in wire line applications like Asymmetric Digital Subscriber Line [4], broadcasting services Digital Audio Broadcasting [5], Terrestrial Digital Video Broadcasting) [6] and (Terrestrial Integrated Services Digital Broadcasting) [7], high rate wireless LAN standards (ETSI Hiper LAN 2 and IEEE 802.11) and multimedia wireless services like Multimedia Mobile Access Communications [8], [9].

In the non-coherent OFDM system the system complexity is reduced at the cost of 3–4 dB performance loss [10] but in coherent OFDM system channel estimation is a major requirement along with the pilot symbols incorporation in channel estimation. Pilot preambles are pre inserted in all subcarriers forming an OFDM training symbol, these training symbols are transmitted at an appropriate data rate with respect to the time varying response of the wireless channel.

Channel estimation is a very important part in wireless communications systems. Pilot-signal-based channel estimation as discussed above is enormously used in packet-data base communications. In single-carrier systems, optimal periodic or a periodic sequences based channel estimation analyzed in [10]-[11] references. An optimal training sequences for pilot symbols for orthogonal frequency division multiplexing (OFDM) channel estimation were proposed in [12][13]. The Optimal placement location and training symbols energy allocation for single-carrier and OFDM systems are described in [14] for frequency-selective Rayleigh block-fading channel. The training signal placement location is such that it maximizes a lower bound on the capacity training-based signal with the assumption that all pilot symbols have the same energy. It has been found that in OFDM systems, in the frequency domain the optimally best placement location of pilot tones is equal spaced positioning scheme. Optimal design and placement of pilot symbols for frequency-selective block-fading channel estimation are addressed in [15] by considering SISO as well as MIMO single-carrier systems by minimizing the Cramer-Rao bound. The same challenge is also addressed in [16] by maximizing a lower bound on the average capacity.

We have implemented an adaptive decision feedback decision logic scheme for in OFDM using the channel estimates obtained from periodic block-type pilots. We have investigated the performances of seven different modulation scheme by measuring bit error rate for QAM and MPSK variants in the presence of multi-path Rayleigh fading and AWGN niose channels combination as channel models.

In this paper, we have shown the performance of schemes by applying 16QAM (16 Quadrature Amplitude Modulation), QPSK (Quadrature Phase Shift Keying and BPSK (Binary Phase Shift Keying) etc. as modulation schemes with Rayleigh fading. We have designed the MATLAB/Simulink model of the OFDM system using method of pilot channel estimation. In Section III, the estimation of the channel based on block-type pilot arrangement is discussed. In this model the estimation of the channel at pilot frequencies is calculated in the simulation environment and results are analyzed for determining the thresh level of SNR estimate at which a modulation scheme starts to give minimum BER.

II. OFDMA System Design And BER Minimization

2.1. OFDM Transceiver without Channel Estimation

In an OFDM transceiver communication design without any channel estimation there is no insertion of pilot symbols. Hence, 200 out of 256 carriers are allocated for data, in which number of used sub-channels (FFT size) is 256. The main parameters for this design can be shown in Table 1.

Simulation parameters	parameter value
Bandwidth (MHz)	10
Fs (MHz)	11.2
FFT	Size 256
Left Guard Interval	28
Right Guard Interval	27
DC Carrier Index	Central
Used Carriers	201 (Including a DC carrier)
Data Carriers	200
Cyclic Prefix	1/8

In our basic OFDM simulink model, extra functional blocks are also added to form mobile system module as shown in Fig 1. This blocks model is implemented according to IEEE 802.16-2005. To study the effect of Doppler shift and multipath fading, a multipath channel is be added to the system shown in figure 2.

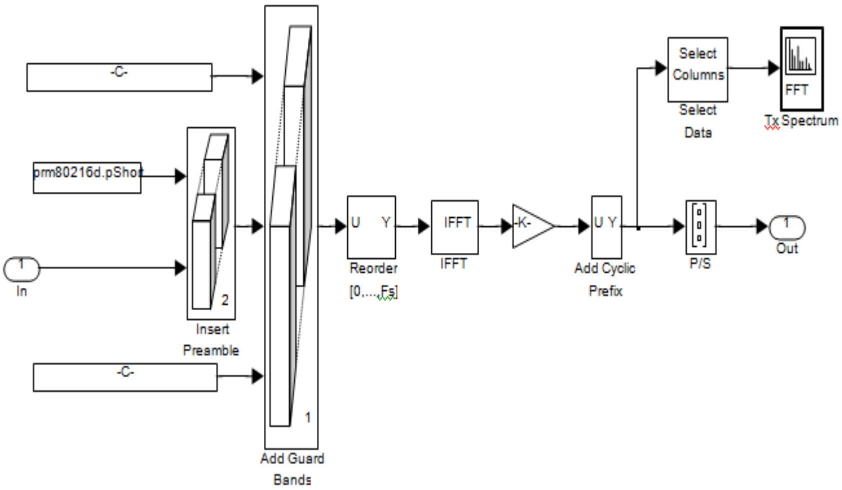

Fig 1: Simulink Model of designed OFDM system

We have used MATLAB/Simulink contains Rayleigh and AWGN Channel model. We have thus tested the data distortion effects by multipath propagation in Non line of sight transmission, environment. In Fig 3 the OFDMA system with modulation mapping scheme is shown with adding multipath Rayleigh and AWGN channel in which ITU- channel models are used. The parameters of Multipath Rayleigh fading channel in our model are :

Maximum Doppler shift (Hz): A positive scalar that indicates the maximum Doppler shift.

Sample time: The period of each element of the input signal. It is set to 1/1152.

Delay vector (s): A vector that specifies the propagation delay for each path.

Gain vector (dB): A vector that specifies the gain for each path. Normalize gain vector to 0 dB overall gain: Checking this box causes the block to scale the Gain vector parameter so that the channel's effective gain (considering all paths) is 0 decibels.

Initial seed: The scalar seed for the Gaussian noise generator.

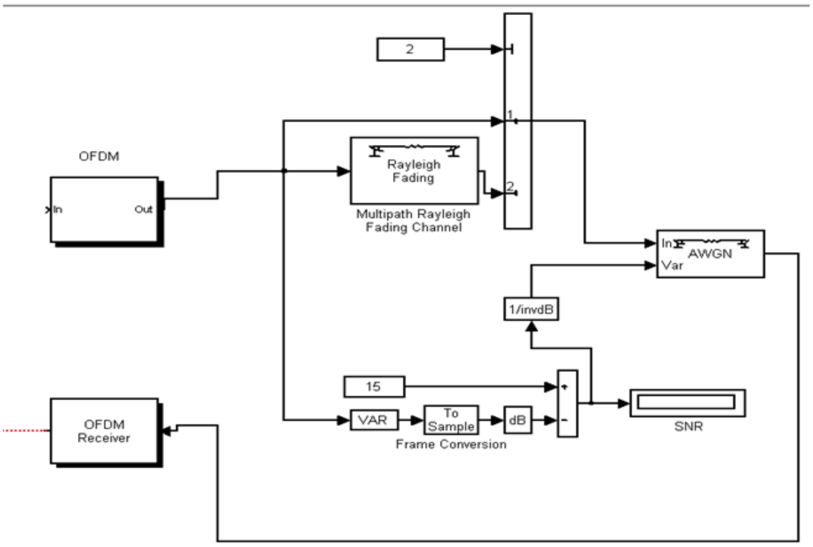

Fig 2: Channel Model consist of Rayleigh fading prior to AWGN channel.

Thus, the modified OFDMA transceiver system as shown in Figure 3 has pilot symbols (on pilot subcarriers) embedded in between the data symbols (on data subcarriers), which provides the channel information at the receiver. However, at the receiver, the values of channel estimation are interpolated over the data subcarriers whereas data symbols are decoded. In both time and frequency domain, the interpolation depends much on subcarrier spacing, symbol time and pilot location. The interpolation will not be accurate if the channel characteristics are changed significantly between pilot subcarriers. The model simulation is carried out at fixed step discrete configuration with the SIMULINK environment using communication blocksets. The system in the simulation is subjected to AWGN channel and Rayleigh fading with AWGN at different SNR.

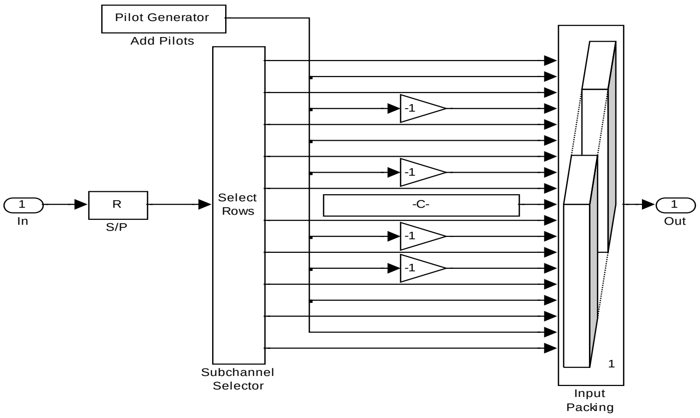

Fig 3: Pilot insertion to the modulated data block prior to OFDM.

III. Results And Discussion

We have developed our simulation model for investigating physical layer performance of IEEE 802.16e (WiMax communication model) using simulink tool of MATLAB 2010.We have improved the performance of OFDM technique by using channel SNR and response estimation. We have considered 3 cases. In 1st case, we have considered 7 different modulation scheme related to PSK I/O Mapping in presence of AWGN only and AWGN with multipath Rayleigh fading. In 2nd case, we have applied OFDM methodology on all 7 cases to check the benefit of OFDM based multi carrier system in reducing inter symbol interference to improve multipath propagation in mobile wireless communication system. In 3rd case we have develop a model that can evaluate a model that can evaluate channel SNR and it attenuation factor along with phase delay for every frame using the error in preamble symbol insert prior to OFDM application. This case include an adoptive decision mechanism control block that can switch over in between different PSK modulation scheme in order to get a final modulation scheme. For developing adoptive decision mechanism, we investigated the result of case1 case 2 for selecting the value of SNR at which each of 7 modulation scheme starts to show minimum bit rate(BR). We have take different modulation scheme named as BPSK ,QPSK ½,QPSK3/4,16QAM1/3,16 QAM ¾,64QAM2/3,64QAM3/4 and our result consist of scatter plots, BER values at different SNR for energy modulation scheme.

This fig 4 shows that our input data is random data source generated using Bernoulli generator block having sample time 8.3333e-008 and sample per frame 864.The Bernoulli generator block pass to the modulation bank. It consist of 3 main operations coding interleaving and modulation using PSK or QAM mapping. Data generated from Bernoulli generator is padding by zero's to construct the frame 64 prior to encoding.

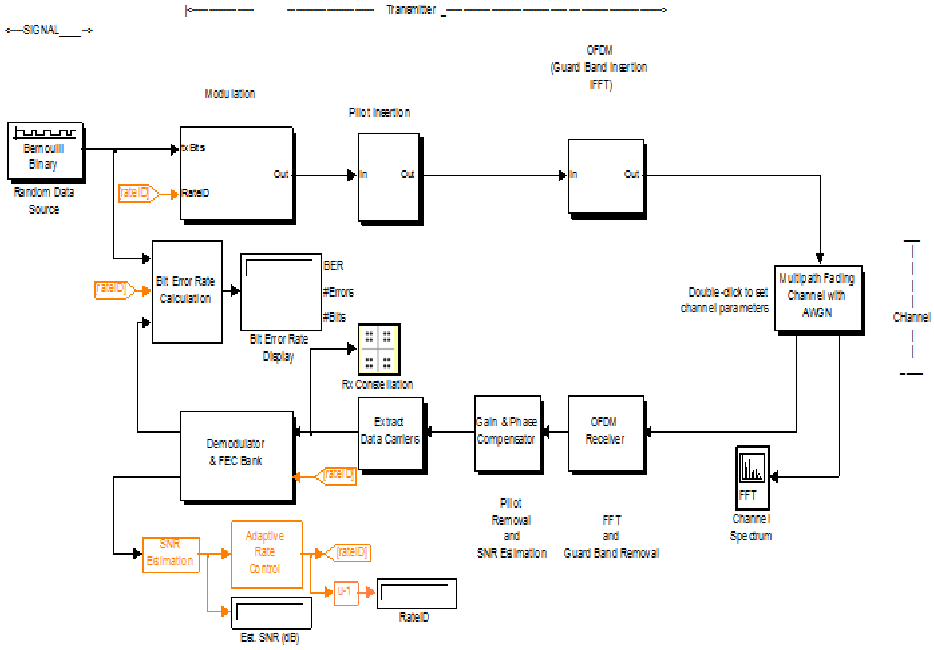

Fig. 4 Complete OFDM simulink model for SNR channel estimation and adaptive decision mechanism

The encoder consist of the poly2trellis structure having specification (7, [171 133]).It represent that, this encoder will generate to 2 encoded schemes as per the octal number representation of 177,133 XOR gate connection. In this way after encoding, we get the packet of bits 1048 that is double of size of packet bits or interleaving ,the number of subchannel are taken as 16 with Ncbps=192 and Ncpc=1.These interleaving signals are pass through the BPSK modulation having the output packet size. For different modulation scheme the polytrellis structure is same ,but the parameter of interleaver is changed allow with the padding data showing in following table 1.

Modulation Scheme and rate id	No. of subchannels	No. of coded bits per subchannel (Ncbps)	No. of coded bit per subcarrier(Ncpc)
BPSK (0)	16	192	1
QPSK ½(1)	16	384	2
QPSK ¾(2)	16	384	2
16 QAM1/2(3)	16	768	4
16 QAM3/4(4)	16	768	4
64 QAM 2/3(5)	16	1152	6
64 QAM ¾(6)	16	1152	6

Table 1: Configuration for different modulation scheme

We have shown our results in tabular form for all three cases. Table1 shows the obtained in our model when no channel estimation and OFDM is applied.

We have changed the SNR of AWGN channel in presence of noise and also in noise along with fading. Both results for all the seven modulation schemes are shown in this table.

Case 1:

SNR	AWGN(BER) WITHOUT FADDING							AWGN (BER)WITH FADDING						
	BPSK	QPSK 1/2	QPSK ¾	16QAM 1/2	16QAM 3/4	64QAM 2/3	64QAM 3/4	BPSK	QPSK 1/2	QPSK 3/4	16QAM ½	16QAM 3/4	64QAM 2/3	64QAM 3/4
5	0	0.02526	0.2669	0.487	0.4959	0.4998	0.4939	0.496	0.4987	0.4981	0.4986	0.4997	0.4998	0.4997
10	0	0	0.0002778	0.1231	0.4676	0.4886	0.4937	0.501	0.4985	0.4977	0.4986	0.4996	0.4996	0.4997
15	0	0	0	0	0.3122	0.3056	0.4136	0.495	0.4985	0.4976	0.4987	0.4996	0.4996	0.4998
20	0	0	0	0	0	0	0.0169	0.495	0.4988	0.498	0.4987	0.4998	0.4997	0.4997
25	0	0	0	0	0	0	0	0.497	0.4984	0.4978	0.499	0.4997	0.4997	0.4996
30	0	0	0	0	0	0	0	0.499	0.4979	0.4988	0.4988	0.4998	0.4997	0.4996

Table 1: Communication Model Performance without applying OFDM

Case 2:

SNR	AWGN(BER WITH OFDM) WITHOUT FADDING							AWGN (BER WITH OFDM)WITH FADDING						
	BPSK	QPSK 1/2	QPSK 3/4	16QAM 1/2	16QAM 3/4	64QAM 2/3	64QAM 3/4	BPSK	QPSK 1/2	QPSK 3/4	16QAM ½	16QAM ¾	64QAM 2/3	64QAM 3/4
5	0	0.08437	0.3461	0.4927	0.495	0.4977	0.5012	0.3033	0.4927	0.4979	0.4988	0.5027	0.4998	0.4998
10	0	0	0.00066	0.2174	0.4322	0.4921	0.4998	0.4371	0.5062	0.4977	0.5004	0.4962	0.5005	0.4984
15	0	0	0	0.09633	0.01348	0.3754	0.4492	0.5163	0.4987	0.5005	0.4969	0.5019	0.4993	0.5014
20	0	0	0	0	0	0.00150	0.04265	0.5428	0.5003	0.4977	0.4976	0.4992	0.4998	0.5033
25	0	0	0	0	0	0	0	0.5519	0.3485	0.3913	0.505	0.5022	0.4998	0.5018
30	0	0	0	0	0	0	0	0.3788	0.4938	0.4284	0.4993	0.5031	0.5008	0.5002

Table 2: Communication Model Performance with applying OFDM but without gain and phase compensation

Case 3**:**

	AWGN WITH Adaptive decision scheme			
SNR	Without fading		With fading	
	BER	RATid	BER	RATid
5	0.001249	0	0.1173	0
10	0	1	0.02536	0
15	0	3	0.03427	1

20	0	3	0.0117	1
25	0	5	0.01081	3
30	0	6	0.01227	2

Table 3: Communication Model Performance with applying OFDM with gain and phase compensation and adaptive modulation decision.

We can see that in table 2 we have applied OFDM using IFFT-FFT in the pilot inserted symbol. But since we have not utilized the information obtained by channel estimation that is why there is no improvement in system performance. On applying gain and phase compensation along with adaptive decision mechanism we can see that the modulation rate id is changing and increases as we increase the SNR in order to maintain a modulation scheme at which we get minimum BER.

IV. Conclusion

In this paper, a design analysis for the pilot based channel estimation is performed for OFDM communication system. Our model uses the channel estimation based SNR prediction from the pilot arrangement preamble with or without adaptive modulation scheme decision mechanism. Channel estimation based on pilot arrangement is applied by giving the channel estimation methods at the pilot frequencies and the investigation of the Rayleigh channel with AWGN channel at data frequencies response is performed. The simulation results are obtained for three different cases using MATLAB/SIMULINK environment. The performance of our model gives a minimum BER of the range of 0.01 at different SNR. This was expected because the pilot arrangement helps in the tracking of fast fading channel and adaptive decision scheme utilizes the mean-square error between the interpolated points and their actual values to choose a modulation id that provides minimized BER.

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