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Adaptive Orthogonal Frequency Division Multiplexing using case switching method for modulation and coding

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***Abstract*— Adaptive communication is one of the prominent technologies for future wireless telecommunication systems. In this technology, transmitter intelligently adapts the transmission parameters like coding scheme, modulation symbol, power etc. with respect to the varying wireless channel state information (CSI). In this way, if channel is having poor transmission conditions then a channel code with smaller code rate and a smaller modulation symbol can be used. Similarly, if channel conditions are good, a comparatively high code rate or even no coding need be used. The aim of this paper is to implement features of the WiMAX OFDM (AOFDM) physical layer specified in IEEE 802.16-2004 in Matlab Simulink. Paper gives an overview about the WiMAX standard and studies the performance of a WiMAX transmitter and receiver, also covering the performance gains of some optional features. Engineers have already combined techniques such as OFDM suitable for high data rate transmission with forward error correction (FEC) methods over wireless channels. In this paper, the system throughput of a working Adaptive OFDM 4th generation is enhanced to existing OFDM 3rd generation system by adapting modulation, coding and interleaving for improving overall performance. The smart use of coding and power allocation in OFDM will be useful to the desired performance at higher data rates.**

***Index Terms*— Adaptive, IEEE 802.16, Simulink.**

I. INTRODUCTION

The Wireless communications industry is in the midst of veritable explosion in Wireless technologies. Once exclusively military, satellite and cellular technologies are now commercially driven by ever more demanding consumers, who are ready for seamless communication from their home to their car, to their office, or even for outdoor activities. With this increased demand comes a growing need to transmit information wirelessly, quickly, and accurately. To address this need, communications engineer have combined technologies suitable for high rate transmission with forward error correction techniques and Adaptive Modulation methods [1]. The latter are particularly important as wireless communications channels are far more hostile as opposed to wire alternatives, and the need for mobility proves especially challenging for reliable communications. For the most part, Orthogonal Frequency Division Multiplexing (OFDM) is the standard being used throughout the world to achieve the high data rates necessary for data intensive applications that must now become routine [2]. Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. Some of the main advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Also one other significant advantage is that the modulation and demodulation can be done using IFFT and FFT operations, which are computationally efficient. Adaptation of Digital modulation can be done as simple as multiplexing methods or using neural network.

In adaptive OFDM many adaptive transmission techniques have been presented in the literature. The combination of adaptive modulation with OFDM was proposed as early as 1989 by Kalet which was further developed by Chow and Czylwik .Specifically the results obtained by Czylwik showed that the required SNR for the BER target 10E-3 can be reduced by 5dB to 15dB compared to fixed OFDM depending on the scenario of radio propagation. The performance of linear block coded modulation is investigated. Three different modulation mode allocation algorithms were discussed and compared. Further studies on the application of interleave and OSTBC modulation and coding is conducted. (Kwang et al. 2009) proposed a multi-user multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) system with adaptive modulation and coding to improve system capacity with maintaining good error performance. The results of computer simulation show the improvement of system capacity in Rayleigh fading channel. (Li Yanxinet al.2007) presented a novel method for demodulating the QAM signals basing on adaptive filtering. The commonly used least mean square (LMS) error adaptive filtering algorithm is employed for studying the demodulating procedure and the performance of the novel adaptive QAM demodulation. The novel adaptive QAM demodulation does not need the adaptive filter completing convergence. Therefore, the sampling rate and processing speed are decelerated. Also, it is indicated that the demodulation method has many advantages over conventional ones, such as the powerful anti-noise ability, the small transfer delay, and the convenient implementation with DSP technology. (Kiyoshi Hamaguchi et al.) Proposed an adaptive modulation system for land mobile communications that can select one of quadrature amplitude modulation levels as a suitable modulation for propagation conditions is described. The main characteristics of the system are a mode in which information

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cannot be transmitted under adverse propagation conditions and a buffer memory for maintaining the data transmission rate. In the paper they confirmed that the basic performances of the adaptive modulation system using the equipment they developed and they found the measured performance was consistent with computer simulation results. Further in this work it was also confirmed that the adaptive modulation system provided a noticeable improvement in spectral efficiency and transmission quality.

K. SeshadriSastry discussed an OFDM-CDMA system with adaptive modulation schemes for future generation wireless networks are discussed [3]. Results presented there show that adaptive systems can perform better than fixed modulation based systems both in terms of BER and spectral efficiency.

In this paper Adaptive modulation is performed by multiplexing methods and combination of OFDM and Adaptive modulation improves the BER and throughput. This work is conducted in MATLAB version R2012a using Simulink.

II. METHODOLOGY

With an overview of the OFDM system, it is valuable to discuss the mathematical definition of the modulation system. It is important to understand that the carriers generated by the IFFT chip are mutually orthogonal. This is true from the very basic definition of an IFFT signal. This will allow understanding how the signal is generated and how receiver must operate. Mathematically, each carrier can be described as a complex wave:

$$S_c(t) = A_t(t)e^{-j(\omega_c(t)+\emptyset_c(t))} \qquad (1)$$

The real signal is the real part of Sc (t). Ac (t) and φ_c (t), the amplitude and phase ofthe carrier can vary on a symbol by symbol basis. The values of the parameters are constantover the symbol duration period t. OFDM consists of many carriers. Thus the complex signal

Ss(t) are represented by:

$$S_c(t) = \frac{1}{N}\sum_{n=0}^{N-1} A_N(t)\, e^{-j(\omega_n(t)+\emptyset_n(t))} \qquad (2)$$

Where $\omega_n = \omega_o + n\Delta\omega$

This is of course a continuous signal. If we consider the waveforms of each component of the signal over one symbol period, then the variables Ac (t) and φc (t) take on fixed values, which depend on the frequency of that particular carrier, and so can be rewritten:

$$\emptyset_n(t) = \emptyset_n \text{ and } A_n(t) = A_n$$

If the signal is sampled using a sampling frequency of 1/T, then the resulting signal is represented by:

$$S_c(kT) = \frac{1}{N}\sum_{n=0}^{N-1} A_n e^{[j(\omega_o+n\Delta\omega)kT+\emptyset_n} \qquad (3)$$

At this point, in equation 3 it has restricted the time over which analyzes the signal to N samples. It is convenient to sample over the period of one data symbol. Thus the relationship: t=NT. By simplifying the equation 3, without a loss of generality by letting ω0=0, then the signal becomes:

$$S_s(kT) = \frac{1}{N}\sum_{n=0}^{N-1} A_n e^{j\emptyset_n} e^{j(n\Delta\omega)kT} \qquad (4)$$

Now equation 4 can be compared with the general form of the inverse Fourier transform:

$$g(kT) = \frac{1}{N}\sum_{n=0}^{N-1} G\left(\frac{n}{NT}\right)e^{\frac{2\pi}{N}kn} \qquad (5)$$

In Equation 3.4 the function $A_n\, e^{j\emptyset n}$ is no more than a definition of the signal in the sampled frequency domain and s (kT) is the time domain representation. Eqns.4 and 5 are equivalent if:

$$\Delta f = \frac{\Delta\omega}{2\pi} = \frac{1}{NT} = \frac{1}{\tau} \qquad (6)$$

This is the same condition that was required for orthogonally thus one consequence of maintaining orthogonally is that the OFDM signal can be defined by using Fourier transform procedures.

Adaptive Modulation of OFDM is done using SNR variation in adaptive modulation transmission will be disabled when the channel is in deep fade. This mode is introduced because the signal quality is too bad to guarantee a required transmission. Data will be transmitted if the channel quality improved.

Mode Modulation Thresholds
1 BPSK SNR≤15.6 dB
2 FSK 15.6 dB<SNR≤18.6 dB
3 16QAM 18.6 dB<SNR≤21.5 dB
4 32QAM 21.5 dB<SNR≤24.6 dB
5 64QAM SNR>24.6 dB

III. RESULTS AND DISCUSSION

Result Shows the Adaptive Modulation of 4 cases out of six different Modulations. It is observed that as SNR increases Throughput (Mbps) increases and also the sharpness of Constellation diagram increased it indicates BER is reduced.

Figure 1(a) shows the constellation diagram for BPSK with SNR 1dB here only two symbols are used for representation of message signal, right side of axis is for logic symbol zero and Left side is for logic symbol 1. So BPSK has more area for the detector to demodulate the messages.

In figure 1(b) QPSK divides constellation graph to four parts because it is having 4 symbol messages hence area present for demodulation is less than that of BPSK but Throughput is more compare to BPSK but must be operated in higher SNR or else more symbols will end up with error.

Similarly 64QAM in figure 5.3c&d message are represented by 16 symbol so constellation are divided into 16 parts operates in higher SNR and gives good throughput.

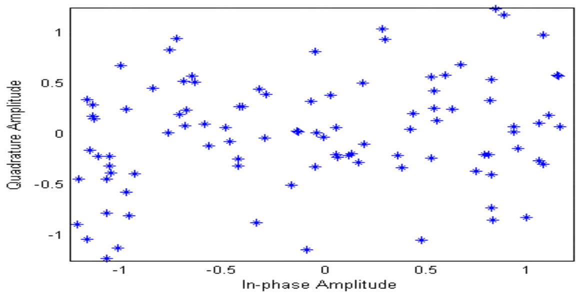

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Figure 1(a) WiMax BPSK Constellation diagram for SNR 1dB

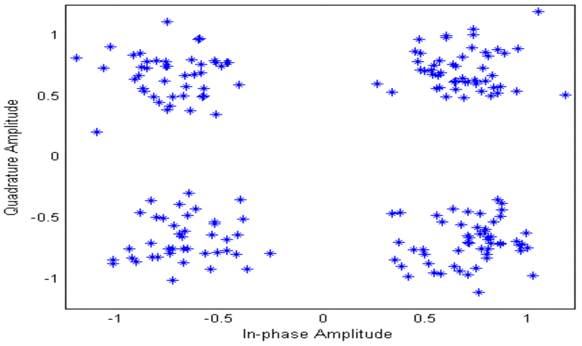

Figure 1(b) WiMax QPSK CD SNR15dB and Rate ID 3Mbps.

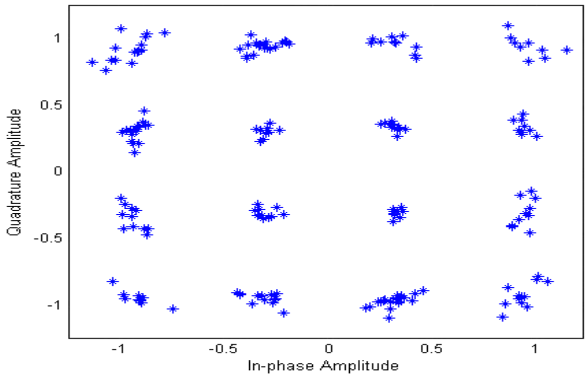

Figure1(c) WiMax 64QAM3/4 Constellation Diagram SNR 30dB Rate ID 4Mbps

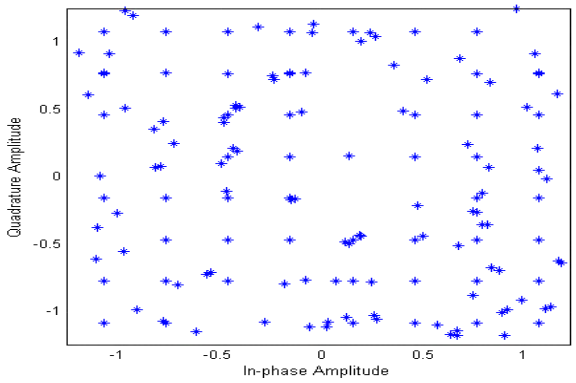

Figure1(d) WiMax64 QAM 2/3ConstellationDiagramSNR 35dB Rate ID 5Mbps

1. Power spectral density

Power spectral density is the very important term represents the operation bandwidth in communication system. The spectrum of a time-series or signal is a positive real function of a frequency variable associated with a stationary stochastic, or a deterministic function of time, which has dimensions of power per hertz (Hz), or energy per hertz.Figure 2 shows the energy spectrum at the transmitter , figure 3 shows the PSD for different SNR initially for low SNR received power is around -80dB and also it is very difficult to identify the BW of the spectrum as SNR is increased the power received improves and so bandwidth. See figure 3e the received power is -80dB and BW match with that of transmitted end.

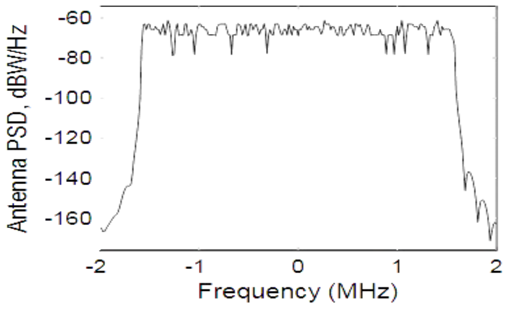

Figure 2 PSD at transmitter end

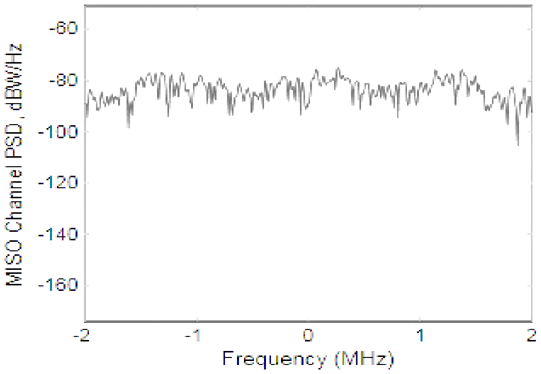

Figure 3(a) PSD Reciver side 5dB SNR

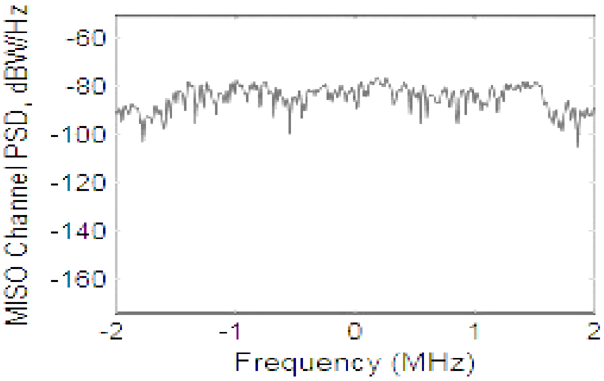

Figure 3(b) PSD Reciver side 10dB SNR

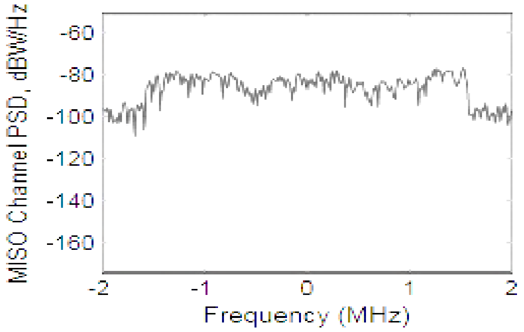

Figure 3(c) PSD Receiver side 15dB

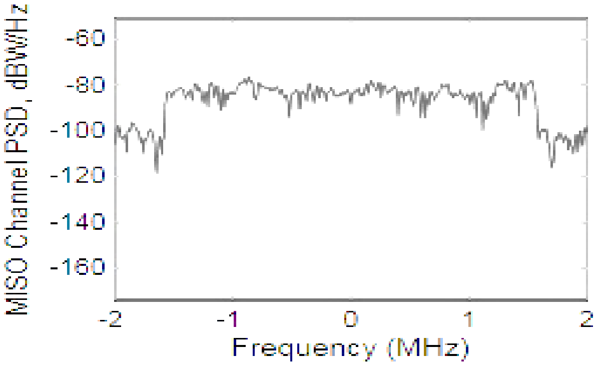

Figure 3(d) PSD Receiver side 20dB

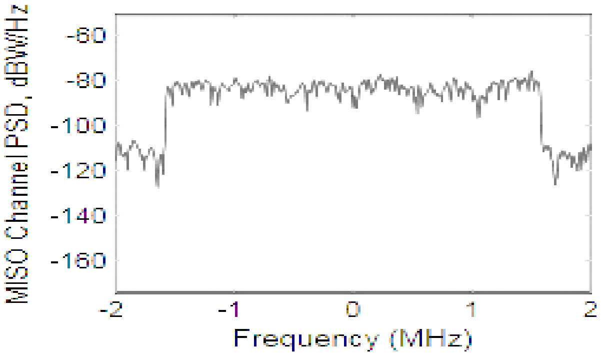

Figure 3(e) PSD Receiver side 30dB SNR

1. BER Performance

Bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unitless performance measure, Figure 4 shows the BER vs. SNR plot for different modulation scheme. There is the gradual Variation in BER in case of Adaptive modulation as shown in figure 4(b). as SNR is increased throughput increases. The performance can be further improved by speeding up the switching methods and using adaptive MIMO antennas.

Figure 4(c) shows the importance of forward error correction coding and interleaving. Blue color dot shows the non-coded adaptive OFDM it performance poorly right from 3dB to 30dB. In Adaptive OFDM modulation the performance varies with respect to SNR but overall BER is always less than that of non-Adaptive.

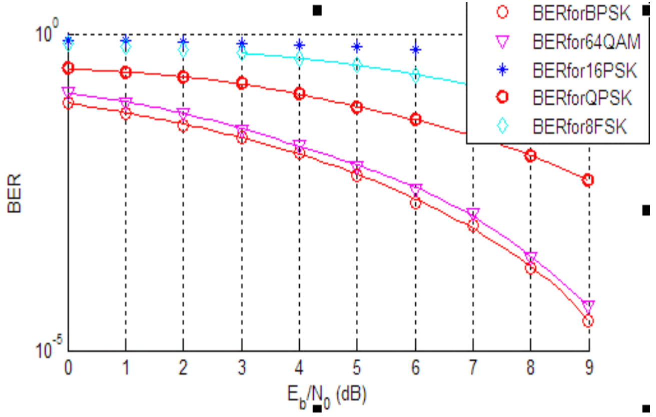

Figure 4(a) BER of different modulation scheme without adaptation

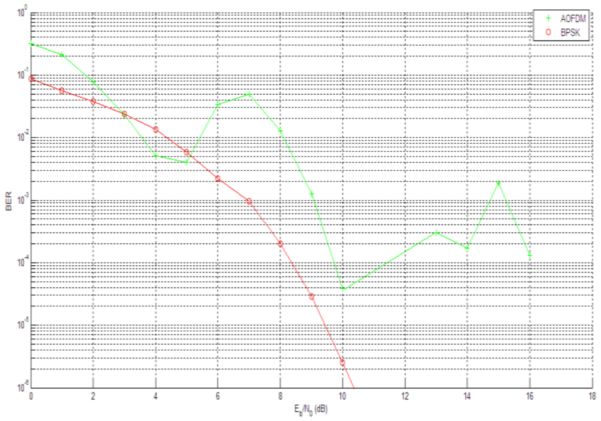

Figure 4(b) BER of Adaptive and non-adaptive modulation

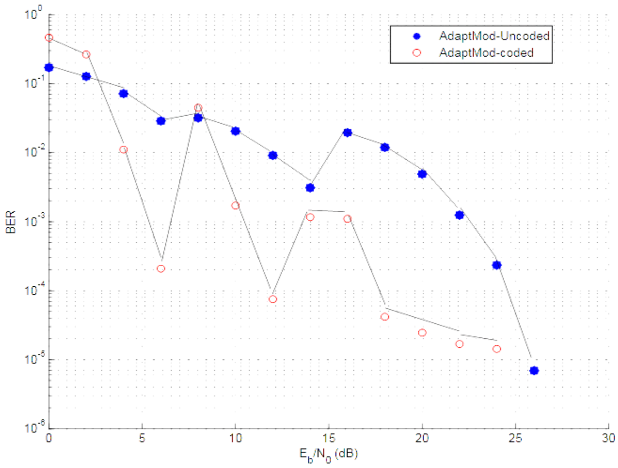

Figure 4(c) BER performance of Adaptive OFDM with and without coding.

IV. CONCLUSION

From this paper it is found that Adaptation of digital modulation and coding gives the good result of BER with respect to non-adaptive methods, Throughput can be increased by high SNR and hence increases spectral efficiency. Because of the use of OFDM for modulation mobility is also increased. This paper implements the physical layer of IEEE 802.16e which was designed by IEEE standards for mobile WiMax in 2004, literature gives the hint of adaptation of antennas MIMO and also in power allocation.

There is lots of scope in future for improving the speed of adaptive algorithm by using
Neural network,
Fuzzy logic
Genetic algorithm for these modulation coding
Using smart antennas and power allocation algorithm like beam-forming can improve the existing systems.

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