Peak To Average Power Ratio Reduction in Precoded Orthogonal Frequency Division Multiple Access Uplink System

Rakhi Jain, Ajay Kumar Yadav

***Abstract*— Mobile worldwide interoperability for microwave access (Mobile WiMAX) is a broadband wireless solution that enables the convergence of mobile and fixed broadband networks through a common wide area radio-access (RA) technology and flexible network architecture. Since January 2007, the IEEE 802.16 working group (WG) has been developing a new amendment of the IEEE 802.16 standard i.e. IEEE 802.16 m as an advanced air interface to meet the requirements of ITU-R/IMT-Advanced for 4 G systems. The mobile WiMAX air interface adopts orthogonal frequency division multiple access (OFDMA) as multiple access technique for its uplink (UL) and downlink (DL) to improve the multipath performance. All OFDMA based networks, including mobile WiMAX experiences the problem of high peak-to-average power ratio (PAPR). This thesis presents: Discrete-Cosine transform matrix (DCTM) precoding based random-interleaved OFDMA uplink system, Selecting mapping (SLM) based DCTM precoded random-interleaved OFDMA uplink system and Partial Transmit Sequence (PTS) based DCTM precoded random-interleaved OFDMA uplink system respectively, for PAPR reduction in mobile WiMAX systems. PAPR of the proposed systems is analyzed with the root-raised-cosine (RRC) pulse shaping to keep out of band radiation low and to meet the transmission spectrum mask requirement.**

***Index Terms*—RA, Mobile WiMAX, ITU-R/IMT, UL, DL.**

I. INTRODUCTION

Since the very genesis of man, communication[1] has been one of the main aspects in human life. Previously various methods like sign languages were implemented for this purpose. As various civilizations started coming into existence, many innovative ideas came to the minds of the people – special birds and human messengers were employed to meet these challenges. As ages rolled by, post system developed and transportation vehicles like trains and ships were used to maintain link between people miles apart. But by the turn of the nineteenth century, a great leap in communication system was observed when wireless communication[1] was introduced.

After the advent of wireless communication huge change has been observed in the lifestyle of people. Wireless communication which was initially implemented analog domain for transfer has is now-a-days mostly done in digital domain. Instead of a single carrier in the system multiple sub-carriers are implemented to make the process easier.

The demand of high data rate services has been increasing very rapidly and there is no slowdown in sight. We know that the data transmission includes both wired and wireless medium. Often, these services require very reliable data transmission over very harsh environment. Most of these transmission systems experience much degradation[2] such as large attenuation, noise, multipath, interference, time variance, nonlinearities and must meet the finite constraints like power limitation and cost factor. One physical layer technique that has gained a lot of popularities due to its robustness in dealing with these impairments is multi-carrier modulation technique. In multi-carrier modulation, the most commonly used techniques Orthogonal Frequency Division Multiplexing (OFDM)[4]; it has recently become very popular in wireless communication.

Manuscript received April 15, 2015.
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II. ELECTRONIC COMMUNICATION SYSTEM

Electronics communication system has revolutionized the face of the world. Communication with someone a mere century back was only possible by physical mode. But now that can be done just by clicking a switch on the telephone pad or by just a click of the mouse. Even live television report, live games telecast could not be possible without wireless communication

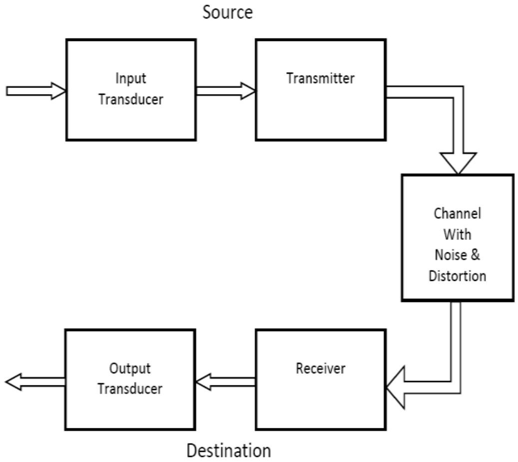


Fig 1. A block diagram representation of electronic communication system

III. MULTIPATH CHANNELS

The transmitted signal faces various obstacles and surfaces of reflection, as a result of which the received signals from the same source reach at different times. This gives rise to the formation of „echoes" which affect the other incoming signals. Dielectric constants, permeability, conductivity and thickness are the main factors affecting the system.

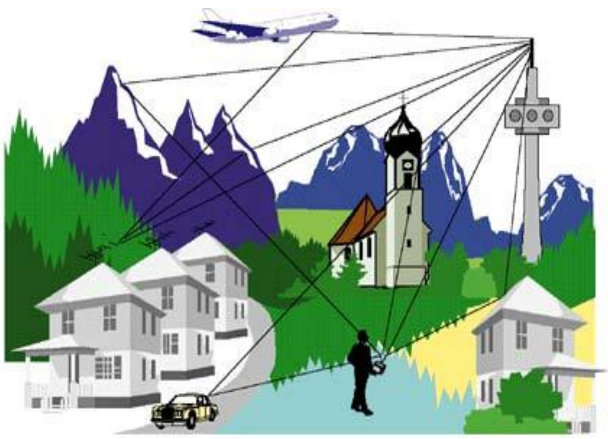


Fig 2 .Multipath Channel Propagation

IV. Multicarrier Transmission Schemes

In a single carrier system, a single fade causes the whole data stream to undergo into the distortion i.e known as the frequency selective fading. To overcome the frequency selectivity of the wideband channel experienced by single-carrier transmission, multiple carriers can be used for high rate data transmission. In multicarrier transmission, a single data stream is transmitted over a number of lower rate subcarriers. Using this multicarrier transmission the frequency-selective wideband channel can be approximated by multiple frequency-flat narrowband channels. Let the wideband be divided into N narrowband sub channels, which have the subcarrier frequency of f_k, $k = 0, 1, ..., N - 1$. Orthogonality[3] among the sub channels should be maintained to suppress the ICI (Inter Carrier Interference) which leads to the distortion less transmission. So in this transmission scheme the different symbols are transmitted with orthogonal sub channels in parallel form. If the oscillators are being used to generate the subcarriers for each sub channel, the implementation of this transmission scheme becomes complex. To avoid this complexity one important transmission scheme comes into picture that is the OFDM (Orthogonal Frequency Division Multiplexing).

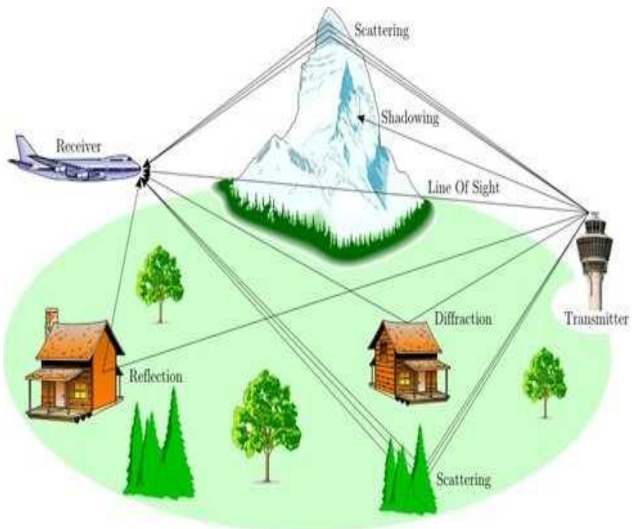
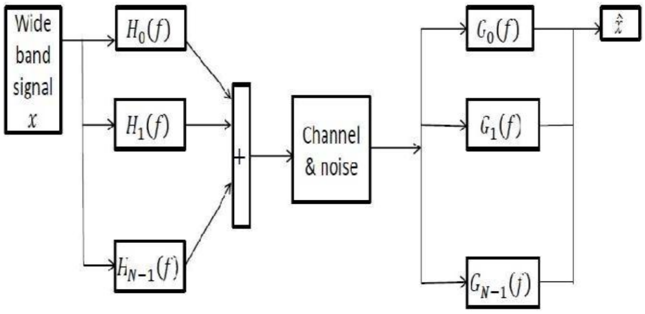


Figure.3 :Multipath Propagation



V. Orthogonal Frequency Division Multiplexing (OFDM) Transmission Scheme

Orthogonal frequency division multiplexing (OFDM) transmission scheme is a type of multichannel system which avoids the usages of the oscillators and bandlimited filters for each subchannel. The OFDM technology was first conceptualized with subsequent symbols. This is an unwanted phenomenon as the previous symbols have similar effect as noise, which makes the communication as some sort of unreliable. It is usually caused by multipath propagation or the inherent nonlinear frequency response of a channel causing successive symbols to blur together. The presence of ISI in the system introduces error in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI and thereby deliver the digital data to its destination with the smallest error rate possible.

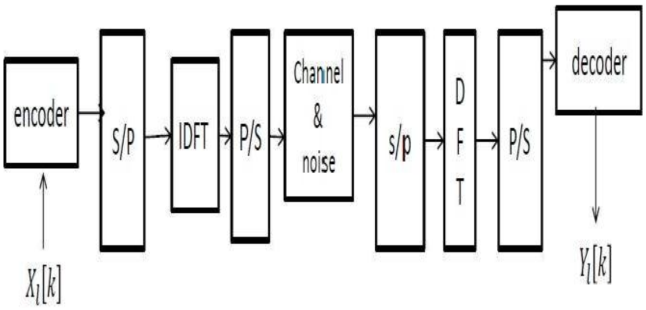


Figure 4:OFDM transmission scheme

VI. DESIGN ANALYSIS

OFDMA Uplink System

In OFDMA uplink systems the baseband modulated symbols are passed through serial-to-parallel (S/P) converter which generates complex vector of size *M*. We can write the complex vector of size *M* as follows:-

$$X = [X_0, X_1, X_2, ...X_{M-1}]^T$$

Then the subcarrier mapping of these constellations symbols can be done on in one of the subcarrier mapping mode: interleaved mode, random-interleaved mode or in localized mode respectively. After the subcarrier mapping, we get frequency domain samples: $\hat{X}_M : m = 0,1,\ldots,N-1$. Mathematically, the subcarrier mapping in interleaved mode can be done as follows:-

$$\hat{X}_m = \begin{cases} Y_{\frac{m}{\hat{Q}}}, m = \hat{Q}.k \\ 0 \end{cases}$$

where, $0 \le m \le N-1$, N=Q.M and $0 \le \hat{Q} \le Q$ is the spreading factor.
N: System subcarriers,
M : User subcarriers,
Q : Subchannels/Users, (*Q*=*N*/*M*),

The *kth* subcarrier of each group is assigned to the *kth* user with index set $(\gamma_{q,1}, Q+\gamma_{q,2} .... (M-1)Q+\gamma_{q,M-1})$, where $(\gamma_{q,1}, \gamma_{q,2}, \cdots \gamma_{q,M-1})$ are independent and identically distributed random variables with uniform distribution on (q=0,1…Q-1).

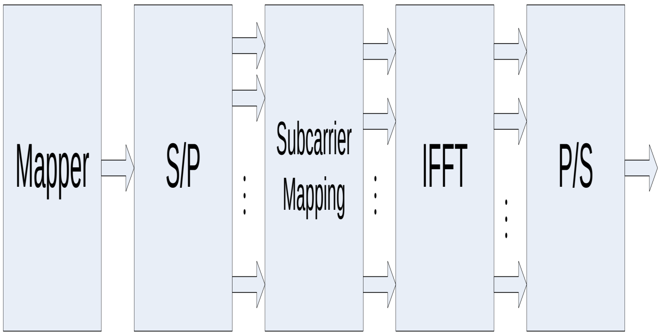


Fig 5 Random-Interleaved OFDMA uplink system

VII. DCTM PRECODING BASED RANDOM INTERLEAVED OFDMA SYSTEM

DCTM precoding based random-interleaved OFDMA uplink system. In this system, a DCT precoding matrix *D* of dimension *N*=*L*×*L* is applied to the constellation symbols to lower the autocorrelation of input sequence for the IFFT to reduce the PAPR.

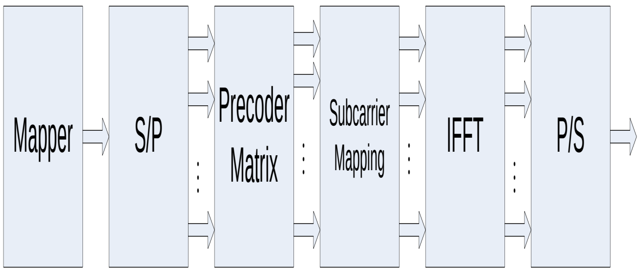


Fig 6 DCTM Precoding based Random Interleaved OFDMA

In the DCTM precoding based random-interleaved OFDMA systems, baseband modulated data is passed through S/P convertor which generates a complex vector of size *M* that can be written as follows:

$$X = [X_0, X_1, X_2, ... X_{M-1}]^T$$

VIII. SIMULATION RESULTS

CCDF comparison of PAPR for the DCTM precoded random-interleaved OFDMA uplink system with the WHT precoded random-interleaved OFDMA uplink systems and the conventional random-interleaved OFDMA uplink systems. At clip rate of 10^{-3}, with user subcarriers *M*=16 and system subcarriers *N*=512, the PAPR is 10.1 dB, 9.2 dB and 7.8 dB respectively, for the conventional random-interleaved OFDMA uplink systems, WHT precoded random-interleaved OFDMA uplink systems and DCTM precoded random-interleaved OFDMA uplink systems using QPSK modulation

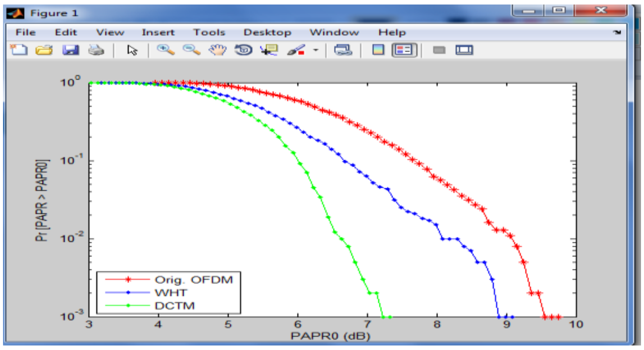


Fig 7. CCDF Comparison of PAPR of the DCTM precoded random-interleaved OFDMA uplink system

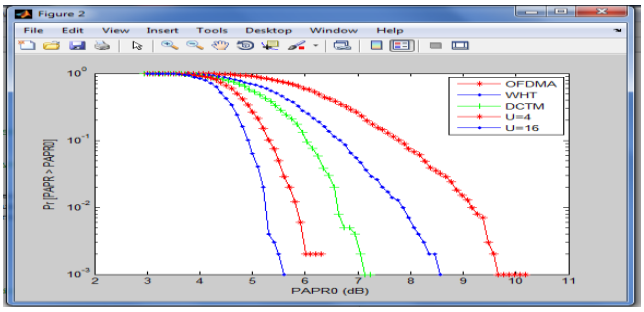


Fig.8 CCDF Comparison of PAPR of the DCTM precoded random-interleaved OFDMA uplink system and SLM based DCTM

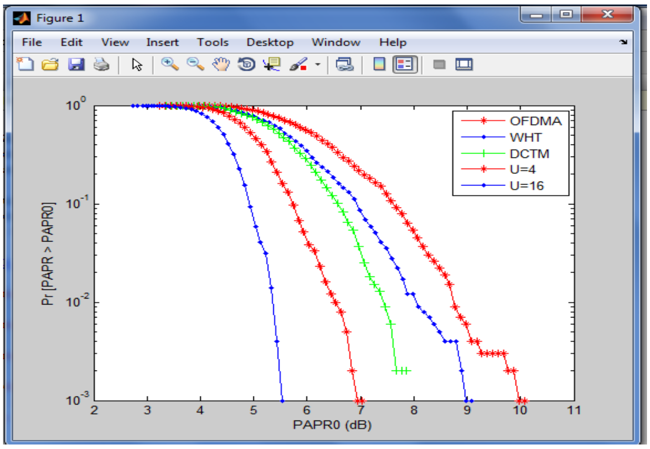


Fig.9. CCDF Comparison of PAPR of the DCTM precoded random-interleaved OFDMA

IX. CONCLUSION

In this paper, the precoding based systems: DCTM precoded random-interleaved OFDMA uplink system, SLM based DCTM precoded random-interleaved OFDMA uplink system and PTS based DCTM precoded random-interleaved OFDMA uplink system[10] have been proposed for PAPR reduction in mobile WiMAX systems. Computer simulation shows that, the PAPR of the both proposed uplink systems have low PAPR than the WHT precoded random-interleaved

OFDMA uplink systems and conventional random-interleaved OFDMA uplink systems. Proposed systems are also efficient, signal independent, distortionless and do not require any complex optimizations. Additionally, these uplink systems also take the advantage of the frequency variations of the communication channel and can also offer substantial performance gain in fading multipath channels. Thus, it is concluded that proposed DCTM precoding based uplink systems are more favorable than the WHT precoded random-interleaved OFDMA uplink systems and conventional random-interleaved OFDMA uplink systems for the mobile WiMAX systems.

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