STUDY AND ANALYSIS PRECODED ORTHOGONAL FDMA UPLINK SYSTEM

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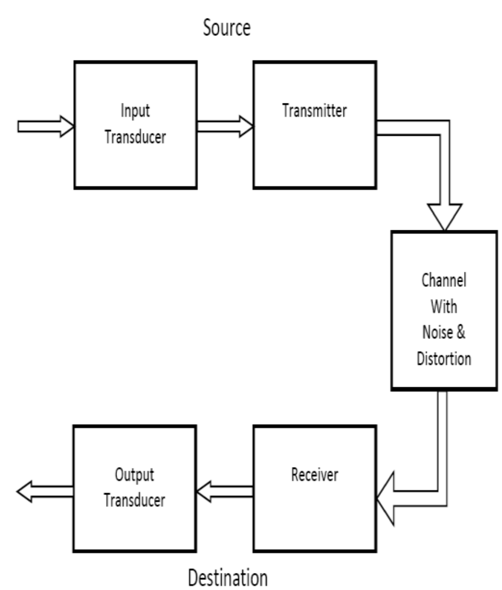
ABSTRACT

This paper aims to 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.

I. INTRODUCTION

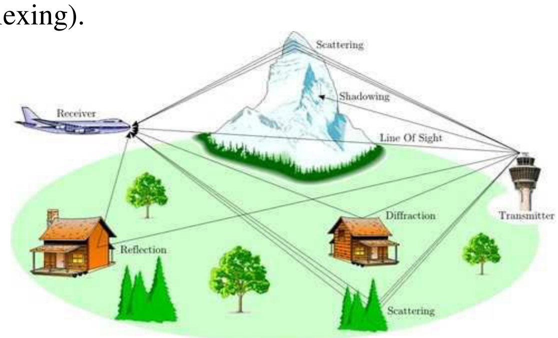
The demand of high data rate services has been increasing very rapidly and there is no slowdown in sight. We know that the data transmission includes both wired and wireless medium. Often, [1] these services require very reliable data transmission over very harsh environment. Most of these transmission 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[3] techniques Orthogonal Frequency Division Multiplexing (OFDM)[4]; it has recently become very popular in wireless communication.

Unfortunately the major drawback of OFDM transmission is its large envelope fluctuation which is quantified as Peak to Average Power Ratio (PAPR)[5].Since power amplifier is used at the transmitter, so as to operate in a perfectly linear region the operating power must lies below the available power. For reduction of this PAPR lot of algorithms have been developed. All of the techniques have some sort of advantages and disadvantages. Clipping and Filtering is one of the basic technique in which some part of transmitted signal undergoes into distortion. Also the Coding scheme reduces the data rate which is undesirable.[6] If we consider Tone Reservation (TR) technique it also allows the data rate loss with more probable of increasing power. Again the techniques like Tone Injection (TI) and the Active Constellation Extension (ACE) having criteria of increasing power will be undesirable in case of power constraint environment. If we go for the Partial Transmit Sequence (PTS) and Selected Mapping (SLM) technique[7], the PTS[8] technique has more complexity than that of SLM technique.



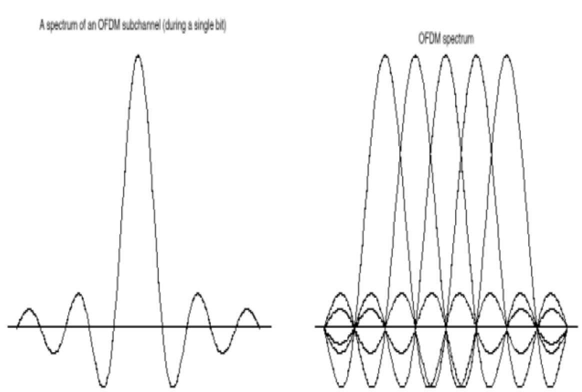
II. MULTICARRIER TRANSMISSION SCHEMES

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[9] 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,[10] 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).



III. OFDM THEORY

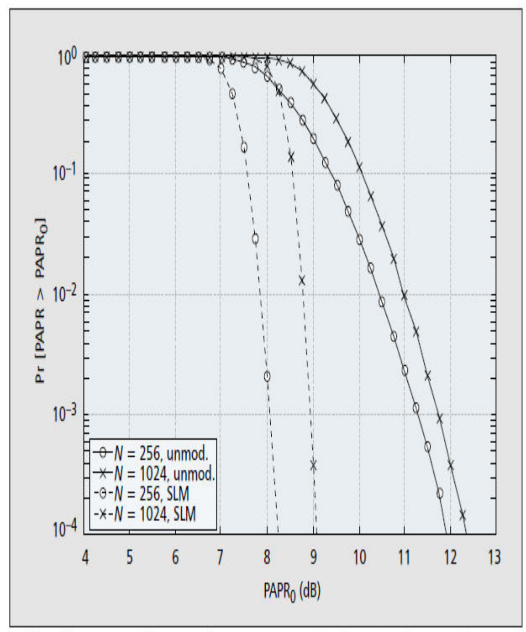
Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carriers are orthogonal to each other, that is, they are totally independent of one another. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other. [11]

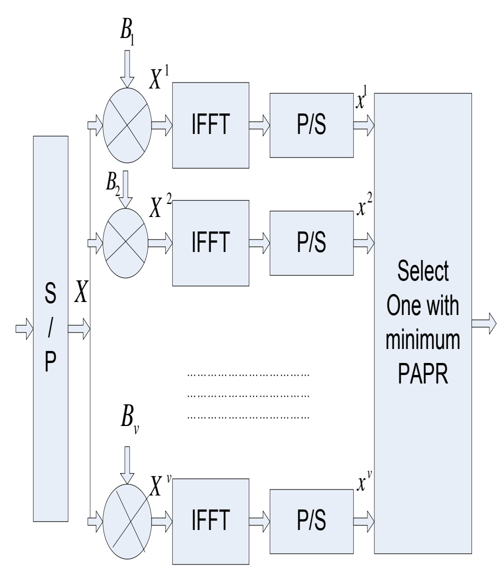


The CCDF Of The PAPR

The cumulative distribution function (CDF)[8] of the PAPR is one of the most frequently used performance measures for PAPR reduction techniques. In the literature, the complementary CDF (CCDF) is commonly used instead of the CDF itself. The CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a given threshold. In a simple approximate expression is derived for the CCDF of the PAPR of a multicarrier signal with Nyquist rate sampling. From the central limit theorem, the real and imaginary parts of the time domain signal samples follow Gaussian distributions, each with a mean of zero and a variance of 0.5 for a multicarrier signal with a large number of subcarriers. Hence, the amplitude of a multicarrier signal has a Rayleigh distribution, while the power distribution becomes a central chi-square distribution with two degrees of freedom.[12] The CDF of the amplitude of a signal sample is given by

$F(z) = 1 - \exp(z)$.





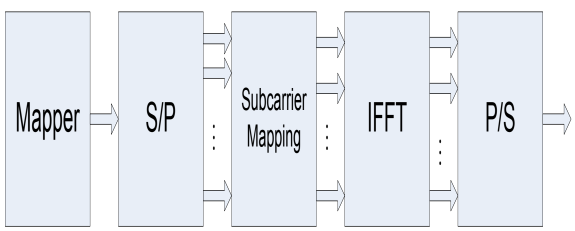
IV. DESIGN ANALYSIS

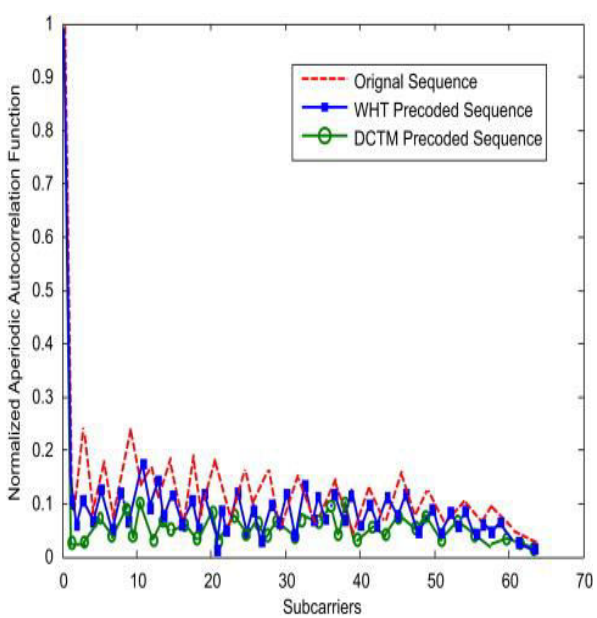
OFDMA Uplink System

Fig.6.1 illustrates the block diagram of the OFDMA uplink systems[12]. 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:-

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

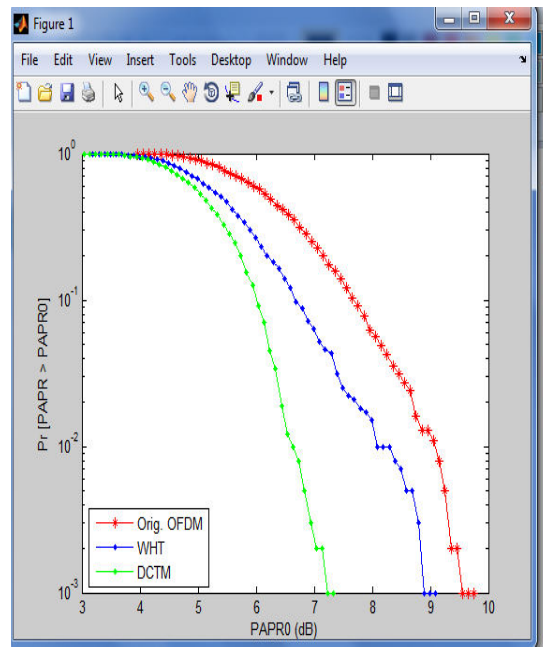
Then the subcarrier mapping of these constellations symbols can be done on in one of the subcarrier mapping mode: interleaved mode, random-interleaved mode or in localized mode respectively. After the subcarrier mapping, we get frequency domain samples: $\hat{X}_M : m = 0,1,\ldots,N-1$. Mathematically,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

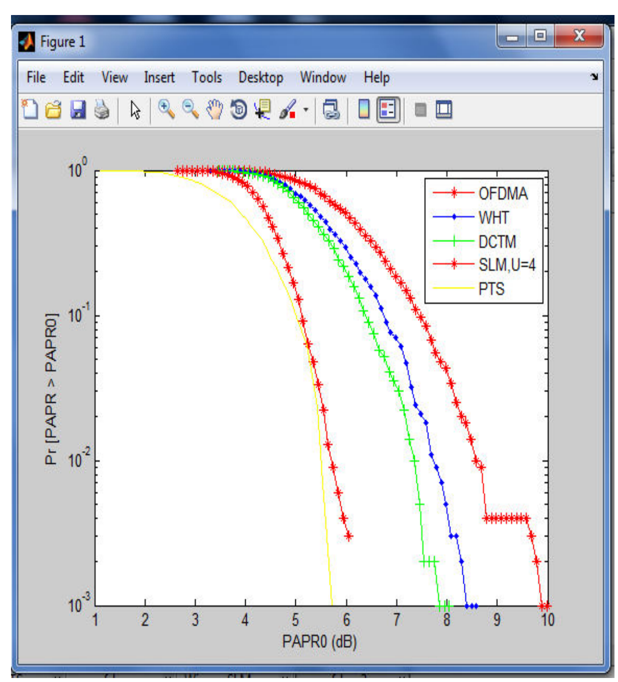




To verify the contribution of DCTM, we consider OFDMA uplink system for QPSK modulation. Fig.6.5 shows that the periodic autocorrelation function of randomly generated QPSK sequence with the length 64 is given, which are normalized by the length. Thus the maximum value is 1 which is the average power of the sequence. It is obvious from the figure that three autocorrelation functions have different side lobe value. If the side lobes of autocorrelation have higher values, then the input sequence is highly correlated and its PAPR is high. The high correlation in the input to IFFT causes the subcarriers to align in-phase. After summing these in-phase functions, the output might have high amplitude resulting in higher PAPR. The side lobe value of the proposed DCTM precoded sequence is smaller than the WHT precoded sequence and no precoded sequence (i.e. original sequence). Therefore, it is concluded that if we apply DCTM to the IFFT input sequence, it lower the correlation relationship of the random interleaved OFDMA input sequence, thus PAPR is reduced.

V. SIMULATION RESULTS





VI. 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 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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