Imran Rajwani, Prof. Pravin U. Dere, Dr.Anjali Deshpande. / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
www.ijera.com Vol. 2, Issue 3, May-Jun 2012, pp.1876-1879

OFDMA Based Communication System with Low Peak Average Power Ratio

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ABSTRACT

The next generation mobile communication systems will needs to support high data transmission with less transmitting power in different types of environment as well as different data rates. Orthogonal Frequency Division Multiple Access is the one of the promising multiple access technique by using it we can easily share the available bandwidth among a large number of users by dividing original carrier into number of sub-carriers. The objective of this paper is that how Peak Average Power Ratio (PAPR) will be reduced and what is the difference between the OFDMA and Code Division Multiple Access (CDMA) related to transmitting power. Few important parameters of OFDMA and CDMA are compared by using MATLAB code. Finally simulation results of implementing clipping method for reducing high PAPR in MATLAB are provided.

***Keywords* –** Clipping method, PAPR, Orthogonality.

1. INTRODUCTION

Ever increasing demand for higher data rate is leading to utilization of wider transmission bandwidth. Broadband wireless mobile communications suffer from multipath frequency selective fading. For broadband multipath channels, conventional time domain equalizers are impractical for complexity reason. OFDMA is a multi-user version of the popular Orthogonal Frequency Division Multiplexing (OFDM) digital modulation scheme. For achieving multiple accesses subsets of subcarriers are provided to the individual users in OFDMA. This allows simultaneous low data rate transmission from several users. OR in other way we can say that OFDM is a combination of modulation and multiplexing. In OFDM the question of multiplexing is applied to independent signals but these independent signals are a sub set of the main one signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier [1].

OFDM signal exhibits a very high PAPR. Therefore, RF power amplifiers should be operated in a very large linear region. Otherwise, the signal peaks get into non-linear region of the power amplifier causing signal distortion. This signal distortion introduces inter modulation among the subcarriers and out of band radiation. Thus, the power amplifiers should be operated with large power back-offs. On the other hand, this leads to very inefficient amplification and expensive transmitters. Thus, it is highly desirable to reduce the PAPR [2]. Let's see the similar case for OFDM for e.g. it has 128 carriers with similar PAPR like CDMA then its max PAPR as large as log (128) or 21 dB. It is possible when all 128 carriers combine at their maximum point unlikely but possible. The RMS PAPR will be around half this number or 10-12 dB. The amplitude variation increases in band noise and interferences the BER when the signal has to go through amplifier non linearity's. This makes use of OFDM as problematic as multi-carrier FDM in high power amplifier application. So eliminate or reduced the high PAPR there are several ideas are used to mitigate it like 1) Clipping, 2) Selective mapping, and 3) partial IFFT. So in this paper among all of these here we are implementing the first method by using MATLAB code in which we can just clip the signal at a desired power level. The paper is organized as follows. Section II contains the how the sub-carriers are orthogonal to each other with help of simple mathematical formula while Section III, defining and comparing the both technique with help of few important parameters. Section IV contains the simulation results of reduced PAPR and Section V Concludes the paper.

2. Orthogonality Of Sub-Carriers

The main concept in OFDM is orthogonality of the sub carriers. Since the carriers are all sine/cosine wave, we know that area under one period of a sine or a cosine wave is zero [3].

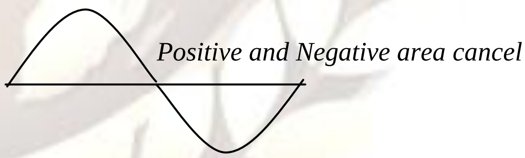

Figure 1: The area under a sine / cosine wave over one period is always zero.

Let's take a sine wave of frequency m and multiply it by a sinusoid (sine or a cosine) of a frequency *n*, where both *m* and *n* are integers. The integers or area under this product is given by in equation:

$$f(t) = sin\, mwt * \sin nwt \qquad (1)$$

By simple trigonometric relationship, this is equal to a sum of two sinusoids of frequencies *(n-m)* and *(n+m)*

$$= \frac{1}{2}\cos(m-n) - \frac{1}{2}\cos(m+n) \qquad (2)$$

$$= \int_0^{2\pi} \frac{1}{2} cos(m-n)\omega t - \int_0^{2\pi} \frac{1}{2} cos(m+n)\, \omega t \quad (3)$$

= 0-0

We can conclude that when we multiply a sinusoid of frequency *n* by a sinusoid of frequency *m/n*, the area under the product is zero. This is key idea to understanding OFDM and it allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other. In essence this is similar to CDMA, where codes are used to make data sequences independent (also orthogonal) which allows many independent users to transmit in same space successfully.

3. Important Parameters

BER [4]: In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. It is the number of bit errors divided by the total number of transferred bits during a studied time interval.[5] Both the multiple access technique has an approximate same and less BER for different input data rates.

Delay: In a network based on packet switching, transmission delay is the amount of time required to push all of the packet's bits into the wire. In other words, this is the delay caused by the data-rate of the link. Transmission delay is a function of the packet's length and has nothing to do with the distance between the two nodes. This delay is proportional to the packet's length in bits, It is given by the following formula: $DT = N / R$ where DT is the transmission delay N is the number of bits, and R is the rate of transmission (say in bits per second).

In fading the reflected signals that are delayed added to the main signal and cause either gains in the signal strength or deep fade. And by deep fades, we mean that the signal is nearly wiped out. The signal level is so small that the receiver cannot decide what was there. The maximum time delay that occurs is called the delay spread of the signal in that environment. This delay spread can be short so that it is less than symbol time or larger. Both cases cause different types of degradation of the signal. The delay spread of the signal changes as the environment is changing as all cell phone users know. So Table I&II show the delay values of OFDM for 8 and 16 bit is less than the CDMA.

Throughput [6]: In communication networks, throughput or network throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot. The most computationally demanding operation in an OFDM transceiver is the FFT/IFFT calculation. When designing an FFT, area is traded against speed. The most area efficient method to implement an FFT is to use a timeshared butterfly and a memory, i.e. a micro-programmed processor. However, there are two drawbacks with this approach; latency is large and throughput is low. Latency is critical if the system is designed for real-time applications, which is expected in future OFDM systems. To decrease latency and increase throughput, a pipelined FFT architecture is used [7].

From Table I & II we can easily conclude that as the input data will increase or the number of user's are more, than the value of throughput rapidly decreases (≈1) but in case of OFDM only slightly (0.063 i.e. less than 0.1) reducing the value of throughput.

PAPR: The peak-to-average power ratio (PAPR) is a measurement of a waveform, calculated from the peak amplitude of the waveform divided by the RMS value of the waveform OR in another way If a signal is a sum of N signals each of max amplitude equal to 1v, then it is conceivable that we could get a max amplitude of N that is all N signals add at a moment at their max points. Then PAPR is defined as

$$R = [x(t)]^2 / P_{avg} \qquad (4)$$

Table I&II gives a comparative performance analysis of CDMA and OFDMA with respect to these designs Parameters.

Table I Comparative table for 8 – bit

Parameter	I/P bits	OFDM	CDMA
BER	8 - bits	0.10938	0.09722
Delay		94.1176	1225
Throughput		0.875	3.4286
PAPR		≈ 0.27	1

Table II Comparative table for 16 - bit

Parameter	I/P bits	OFDM	CDMA
BER	16 - bits	0.05078	0.06481
Delay		182.857	525
Throughput		0.8125	2.5714
PAPR		≈ 0.383	1

4. Simulation Results

One of the major drawback of OFDMA is high PAPR is reduced by using MATLAB code. For clipping 'For' loop are used.

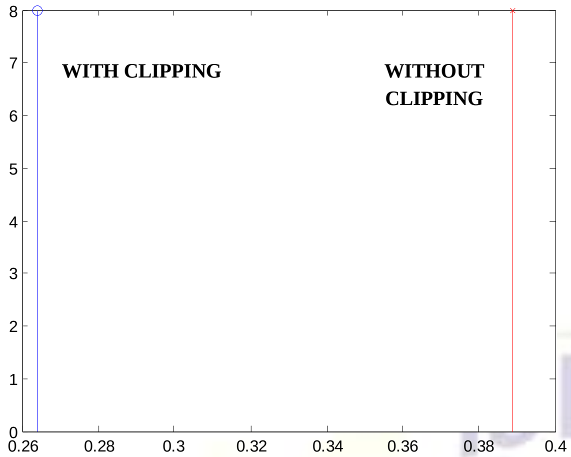

Figure 1: PAPR of OFDM for 8- bit with and without clipping. (On X - Average power, Y- number of input bits)

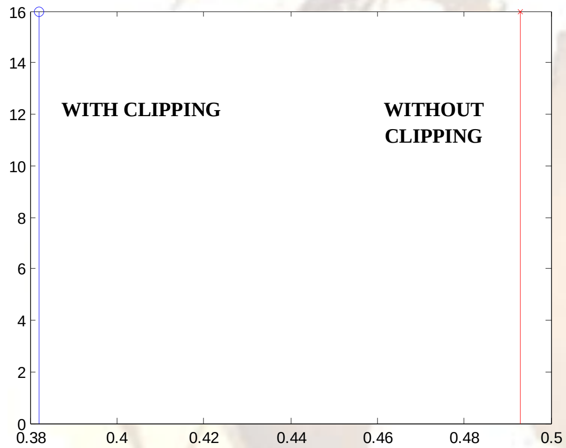

Figure 2: PAPR at 16- bit with and without clipping for OFDM

Form the fig 1&2 it shows two vertical lines red and blue which indicates the value of without clipped and clipped PAPR respectively for 8 and 16 bits as an input for OFDM. The simulation results are plotted between the average power and number of input bits. Similarly fig 3&4 shows the average PAPR values for same number of bits for CDMA. By changing the number of input bits we can measure the performance of OFDMA and CDMA.

5. Conclusion

In this paper we are trying to eliminate (decreases) high PAPR which was consider as a major drawback [8] or as a future work for OFDMA. Table I, II and fig 1 to 4 shows that performance evaluation and advantages of OFDMA system over CDMA. By using clipping method the PAPR decreases but at the same time inter carrier interference (ICI) is slightly increases.

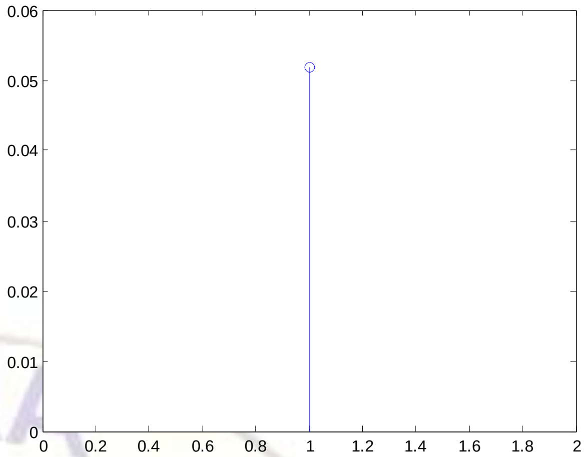

Figure 3: PAPR of CDMA for 8- bit

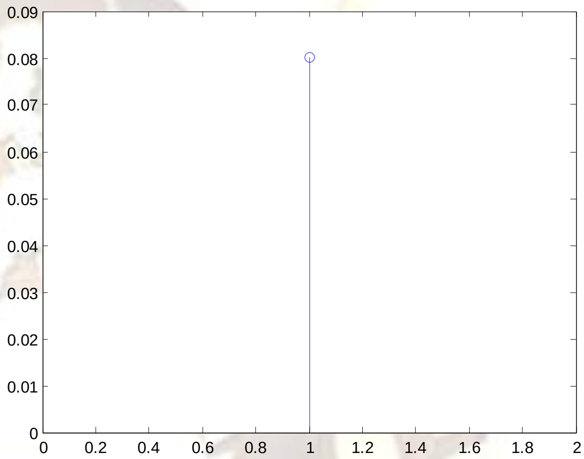

Figure 4: PAPR of CDMA for 16 - bit

However as well as in spite of all the utilities of OFDMA, there are certain obstacles in using OFDM in transmission system in contrast to its advantages. Firstly there will be future scope to implement the other methods for reducing high PAPR as mention in introduction.

Secondly is very sensitive to frequency errors caused by frequency differences between the local oscillators in the transmitter and the receiver. Hence carrier frequency offset causes a number of impairments including attenuation and rotation of each of the subcarriers and ICI between Sub-carriers. In the mobile radio environment, the relative movement between transmitter and receiver causes Doppler frequency shifts; in addition, the carriers can never be perfectly synchronized. These random frequency errors in OFDM system distort orthogonality between subcarriers and Thus ICI occurs. A Number of methods have been developed to reduce this sensitivity to frequency off set.

Thirdly there are multiple input and output at transmitter and receiver side which introduces the delay, cyclic prefix is removed and instead of that FFT pipelined structure are to be proposed.

Fourthly dealing with co-channel interference from nearby cells is more complex in OFDM than in CDMA. It would require dynamic channel allocation with advanced co-ordination among adjacent base stations.

As future work we desire to consider each of these problems so that some enhancement of the existing OFDMA solution could be made.

6. Acknowledgement

The authors are heartily thankful to all those people whose previous work I referred for the completion of my project work and special thanks to my project guides.

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