Minimization of PAPR by DFT-spread OFDM for LTE uplink transmission

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***Abstract*- In this paper a method is introduce to reduce peak to average power (PAPR) for Single Carrier Frequency Division Multiple Access (SCFDMA) for different digital modulation types like; Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and 16 Quadrature Amplitude Modulation (QAM) and 64 Quadrature Amplitude Modulation (QAM).**

PAPR is directly related to battery life of the mobile. So PAPR is not a big issue for downlink because station is stationary and does not require battery. However, mobiles are using battery therefore battery life is one of the biggest issues for them. SCFDMA has similar throughput performance and essentially the same overall complexity as OFDMA. A principal advantage of SC-FDMA is the peak-to-average power ratio (PAPR), which is lower than that of OFDMA. SCFDMA is currently a strong candidate for the uplink multiple access scheme in the Long Term Evolution of cellular systems under consideration by the Third Generation Partnership Project (3GPP).

Finally the effect on uplink SCFDMA in terms of PAPR with different number of users and effect of pulse shaping is calculated.

Index Terms-PAPR, LTE, OFDM, DFT,SC-FDMA, BPSK, QPSK, QAM, IFDMA, LFDMA

INTRODUCTION

A. Development and Application of OFDM:

OFDM is a multi-carrier transmission technology in wireless environment, and can also be seen as a multi-carrier digital modulation or multi-carrier digital multiplexing technology. Because of using of orthogonal carrier technology without interference and no guard band between single carriers, OFDM system requires much less bandwidth compared with the conventional frequency division multiplexing (FDM) system, and gets higher bandwidth utilization. Theoretical formation of OFDM and application starts in the area of wireless mobile communication, which is based on Discrete Fourier Transform (DFT).

B. What Is Peak to Average Power Ratio (PAPR)? :

Peak to average power ratio is a signal property that is calculated by dividing the peak power amplitude of the waveform by the RMS value of it, a dimensionless quantity which is expressed in decibels (dB). In digital transmission when the waveform is represented as signal samples, the PAPR is defined as:

$$PAPR = \frac{\max(|S[n]|^2)}{E\{|S[n]|^2\}}, \quad 0 \le n \le N-1 \tag{1.1}$$

Where S[n] represents the signal samples, $\max(|S[n]|^2)$ denotes the maximum instantaneous power and $E\{|S[n]|^2\}$ is the average power of the signal, and E{.} is the expected value operation.

C. Why We Need to Reduce the PAPR?

To estimate the distortion which is caused by non-linearity, it is desired to have a measure of the signal to show its sensitivity to non-linearity. A well-known measure for the multi-carrier signals is peak to average power ratio (PAPR). The higher the PAPR, the more fluctuation in the signal amplitude, so the operating point in the amplifier needs to be set far enough from saturation point and this input back off reduces the efficiency.

IMPLIMENTATION

Results are simulated using MATLAB R2009a. The total number of subcarriers is 256 and the number of subcarriers assigned to each unit or mobile device is 128. This simulation helps in evaluating the performance of PAPR with d different mapping

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schemes and modulation techniques. Our results show the effect of using Discrete Fourier Transform spreading technique to reduce PAPR for OFDMA, LFDMA and IFDMA with N=256 and M=128.

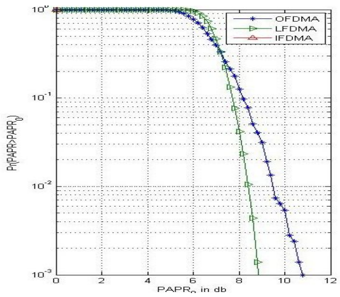

Figure1: BPSK

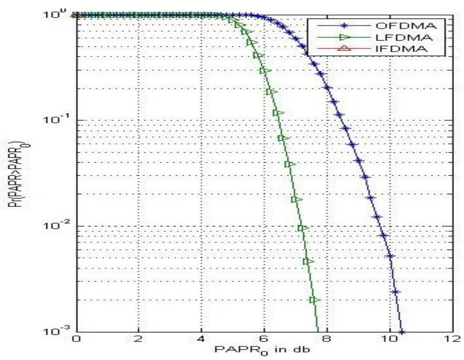

Figure 2: QPSK

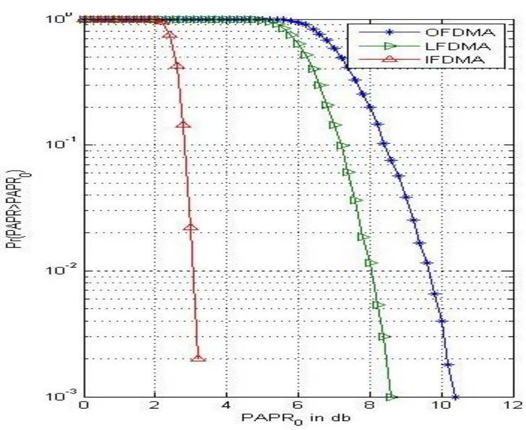

Figure 3: 16 QAM

The performance is improved using DFT spreading technique for example in figure 4. The value of OFDMA is 10.4db, value of LFDMA is 8.8db and value of IFDMA is 4.4db. This shows that in IFDMA which utilize the DFT spreading technique reduces the PAPR by 6db. Such reduction shows the significant improvement in the performance of PAPR. So we can say that the IFDMA and LFDMA techniques are better than the OFDMA in the uplink transmission

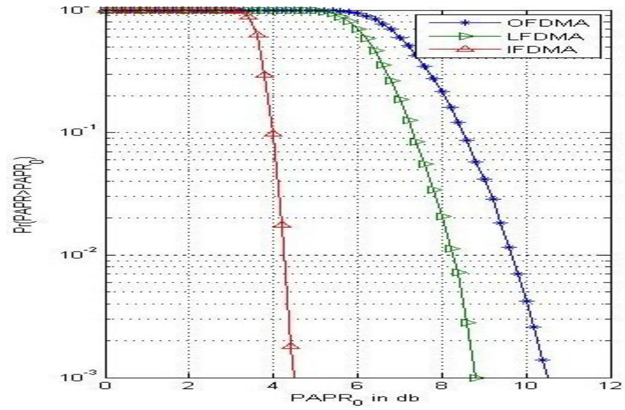

Figure 4: 64 QAM

Now, let us see how the PAPR performance of DFT spreading technique is affected by the number of subcarriers (M) that are allocated to each user. Figure 1, 2 and 3 shows the effect of number of subcarriers on OFDMA, LFDMA, and IFDMA respectively. We are showing these results using 16QAM modulation technique.

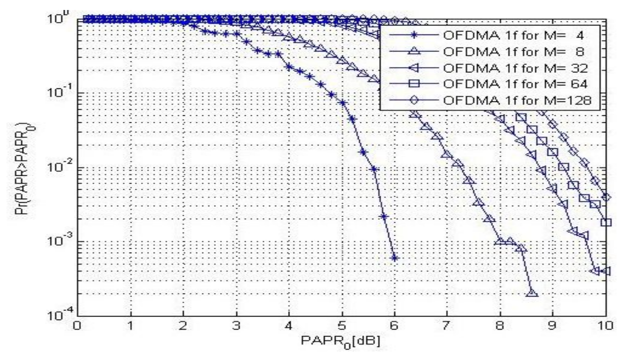

Figure 5: PAPR performance of DFT-spreading technique when the number of subcarriers varies in OFDMA.

It is clear from figure 1 and 2 as the number of subcarriers (M) is increasing the PAPR is increasing. But for M=128 the PAPR in OFDMA much greater than the LFDMA.

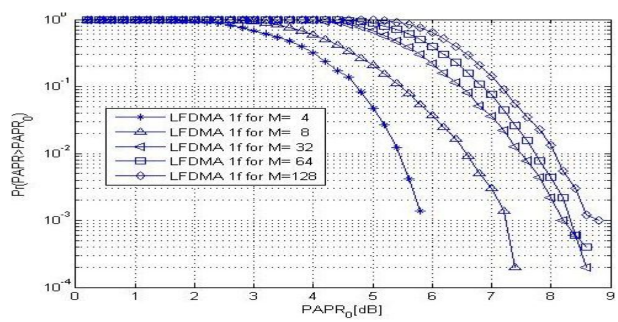

Figure 6: PAPR performance of DFT-spreading technique when the number of subcarriers varies in LFDMA.

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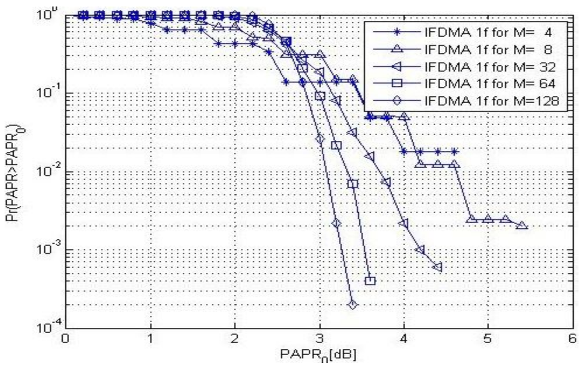


Figure 7: PAPR performance of DFT-spreading technique when the number of subcarriers varies in IFDMA

But figure 7 shows that the performance of the IFDMA is different than the OFDMA and the LFDMA, in IFDMA PAPR is decreasing as the number of subcarriers (M) is increasing

Pulse Shaping:

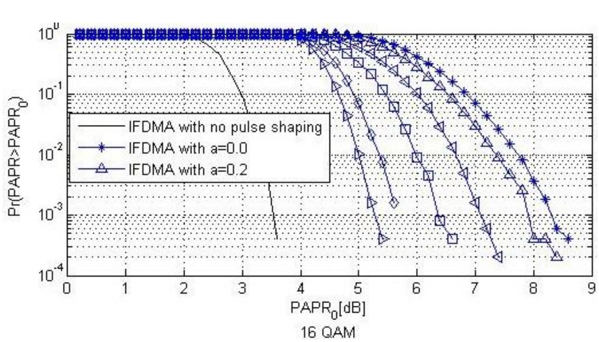
The idea of pulse shaping is to find an efficient transmitter and a corresponding receiver waveform for the current channel condition. The raised-cosine filter is used for pulse shaping because it is able to minimize inter symbol interference (ISI). In this section we show the effect of pulse shaping on the PAPR. Figure 4.5 shows the PAPR performance of both IFDMA and LFDMA, varying the roll-off factor of the raised cosine filter for pulse shaping after IFFT. The roll-off-factor is a measure of excess bandwidth of the filter

The raised cosine filter can be expressed as:

$$p(t) = \frac{\sin(\pi t / T)}{\pi t / T} \cdot \frac{\cos(\pi \alpha t / T)}{1 - 4\alpha^2 t^2 / T^2}$$

Where T is the symbol period and ∝ is the roll-off factor (measure of excess bandwidth).

Figures 7 and 8 imply that IFDMA is more sensitive to pulse shaping than LFDMA. The PAPR performance of the IFDMA is greatly improved by varying the roll-off factor from 0 to 1. On the other hand LFDMA is not affected so much by the pulse shaping



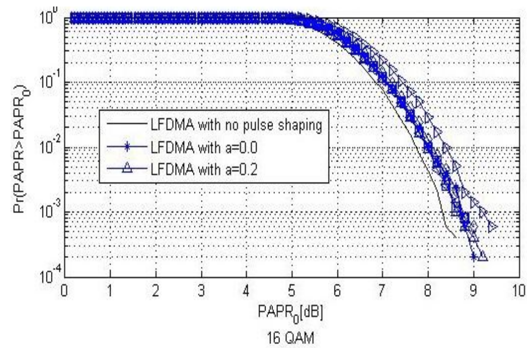
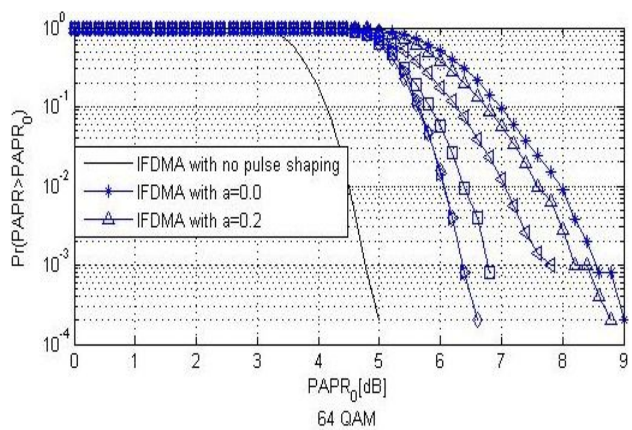


Figure8: Pulse shaping effects on IFDMA and LFDMA for 16 QAM

Figure 8.explains the pulse shaping effects on IFDMA and LFDMA for 16 QAM whereas figure 9.explains the pulse shaping effects on IFDMA and LFDMA for 64 QAM. Results show that PAPR in IFDMA decreases as the roll-off factor increases. The variations can be seen easily. But in LFDMA the changes occur due to pulse shaping are neglect table.



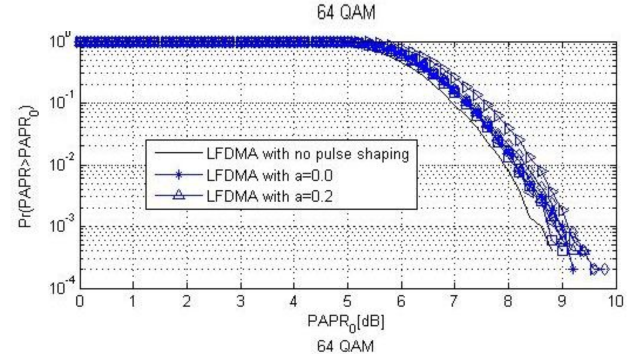


Figure 9.Pulse shaping effects on IFDMA and LFDMA for 64 QAM

It is important to note that IFDMA has a trade-off relationship between excess bandwidth and PAPR performance because any excess in bandwidth increases as the roll-off factor increases. Excess bandwidth of a filter is the bandwidth occupied beyond the NY Quist bandwidth.

CONCLUSION

In this paper a method for PAPR reduction in LTE system has been introduced, which is based on the DFT spread method. DFT spread method is further classified into two methods known as LFDMA (localized FDMA) and IFDMA (interleaved FDMA). We conclude that single carrier-FDMA is a better choice on the uplink transmission for cellular systems. Our conclusion is based on the better efficiency due to low PAPR and on the lower sensitivity to frequency offset since SC-FDMA has a maximum of two adjacent users. From results it can also be concluded that the performance of IFDMA is far better than the LFDMA.

The advantage of LFDMA is that it achieves multi user diversity in frequency selective channel if each user is assigned subcarriers that have high channel gain. The disadvantage of this scheme is that it eliminates the chance of getting frequency diversity in the channel. It also requires channel state information (CSI) to map the data into the best adjacent symbols.

In interleaved FDMA (IFDMA) the subcarriers that are assigned to terminals are equal distant to each other. The disadvantage of this scheme is that we are losing user diversity.

We have shown the importance of the trade-off relationship of IFDMA between excess bandwidth and PAPR performance due to the fact that any excess in bandwidth increases as the roll-off factor increases. Our results show The PAPR performance of the IFDMA is greatly improved by varying the roll-off factor. On the other hand LFDMA is not affected so much by the pulse shaping

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