ISSN 2320 - 2602
Volume 2, No.5, May 2013
International Journal of Advances in Computer Science and Technology
Available Online at http://warse.org/pdfs/2013/ijacst01252013.pdf

Performance Analysis of DFT Spread OFDM Systems

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ABSTRACT

LTE has adopted DFT-spread OFDMA technique as the uplink multiple access scheme which use single carrier modulation and frequency domain equalization.In this paper, we show the PAPR performance of DFT-spreading technique. In this paper we also included the effect of increasing the number of subcarriers assigned to each user on the PAPR performance of DFT-spreading technique.The performance of PAPR of DFT spreading technique is dependent on the number of subcarriers assigned to each user.

Key words: Interleaved frequency division multiple access (IFDMA), Localized frequency division multiple access (LFDMA), Orthogonal frequency division multiplexing (OFDM), Peak to average power ratio (PAPR).

1. INTRODUCTION

From a communications standpoint, the goal of the transmitter is to maximize the reliable data rate for a given transmit power, or equivalently, minimize the energy required per transmitted bit. Therefore new techniques for digital transmission have developed to meet the increasing demand for higher data rates in communications which can be used in both wired and wireless environments [1]. To meet out the high spectral efficiency and high data rate, an efficient modulation scheme is to be employed. A modulation technique that is increasingly being adopted in the telecommunication field is Orthogonal Frequency Division Multiplexing. OFDM (Orthogonal Frequency Division Multiplexing) is a Multi-Carrier Modulation technique. Research on multi-carrier transmission started to be an interesting research area [4-6]. In OFDM a single high rate data-stream is divided into multiple low rate data-streams and is modulated using subcarriers which are orthogonal to each other ODFM is a good choice for high speed digital communications [3]. In this, the data to be transmitted is spread over a large number of orthogonal carriers, each being modulated at a low rate. The carriers can be made orthogonal by appropriately choosing the frequency spacing between them. OFDM is an advanced modulation technique which is suitable for high-speed data transmission due to its advantages in dealing with the multipath propagation problem, high data rate and bandwidth efficiency. But in OFDM there is a big problem, which is high peak to average power ratio (PAPR), due to which distortion is present in the transmitted signal. Several techniques are present in the literature to minimize the PAPR like Selected Mapping (SLM), Partial Transmit Sequence (PTS), Interleaving Technique, Tone Reservation (TR), Tone Injection (TI), Peak Windowing, Clipping and Filtering, DFT spreading [1]. In this paper we simulate the results using DFT spreading technique, which is also known as SC-FDMA.

1.1 System model:

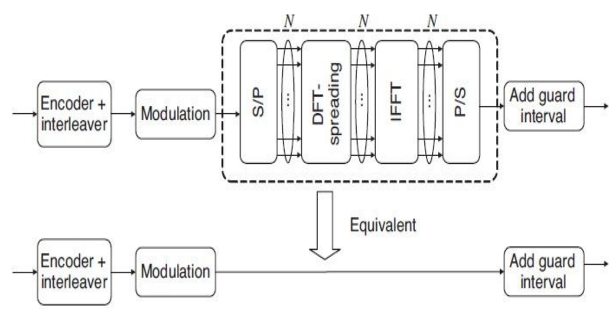

Figure 1: Equivalence of OFDMA system with DFT spreading code to a single-carrier system [2].

Before discussing the DFT-spreading technique, let us consider OFDMA (Orthogonal Frequency-

Division Multiple Access) system. Figure 1 shows, suppose that DFT of the same size as IFFT is used as a (spreading) code. Then, the OFDMA system becomes equivalent to the Single Carrier FDMA (SC-FDMA) system because the DFT and IDFT operations virtually cancel each other. In this case, the transmit signal will have the same PAPR as in a single-carrier system [2].

In DFT spreading, there are two different approaches of assigning subcarriers among users: DFDMA (Distributed FDMA) and LFDMA (Localized FDMA).

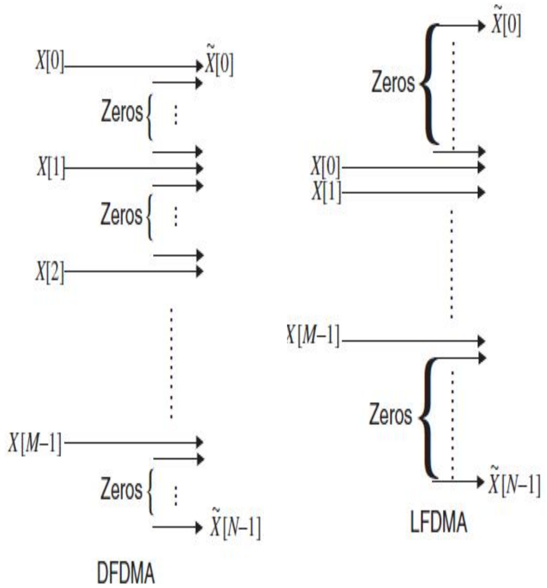

Figure 2: Subcarrier mapping for uplink in OFDMA systems: DFDMA and LFDMA [2]

Figure 2 shows DFDMA distributes M DFT outputs over all N subcarriers with zeros filled in unused subcarriers i.e.(N-M), whereas LFDMA allocates DFT outputs to M consecutive subcarriers in N subcarriers[2]. When DFDMA distributes DFT outputs with equidistance N/M = S, it is referred to as IFDMA (Interleaved FDMA) where S is called the bandwidth spreading factor.

2. SIMULATION AND RESULTS

There are two channel allocation schemes for SC-FDMA systems: the interleaved and localized schemes. In the following simulation results, we compared different allocation schemes of SC-FDMA systems and their performance in PAPR reduction. Figure 3 shows the performance of PAPR while the 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 different mapping 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.

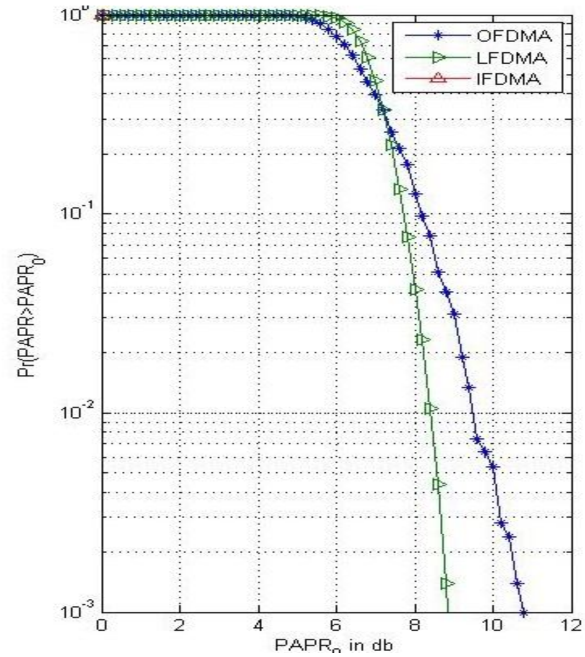

Figure 3(a): BPSK

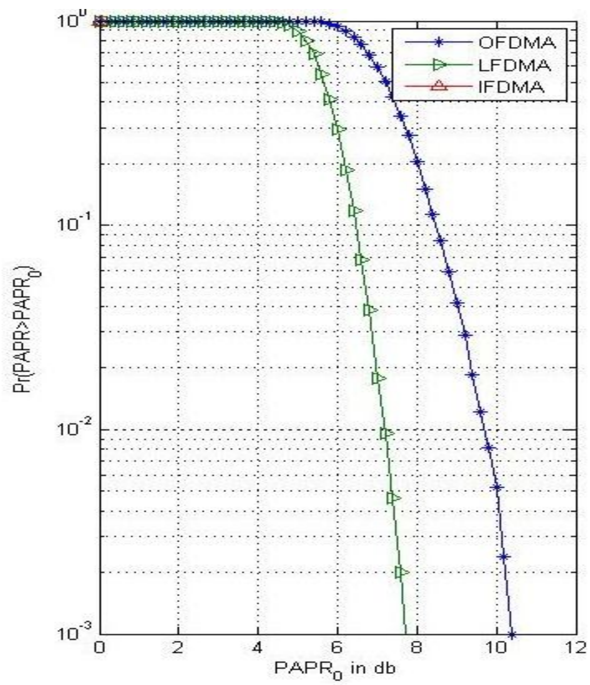

Figure 3 (b): QPSK

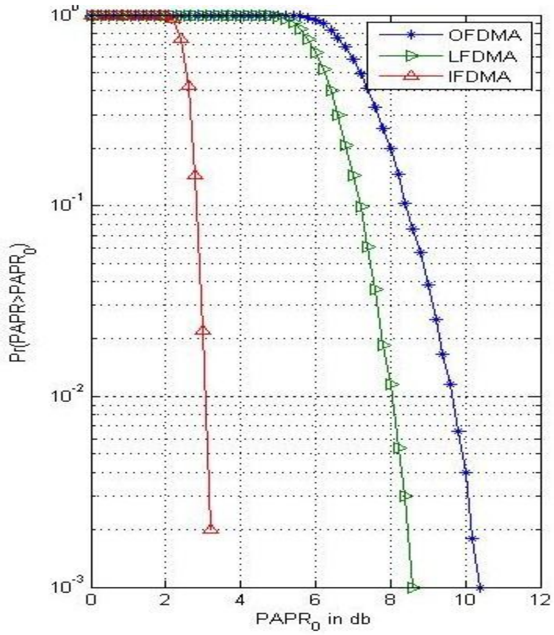

Figure 3 (c): 16 QAM

A comparison is shown in Figure 3(a), 3(b), 3(c) and 3(d) using BPSK, QPSK, 16QAM, 64QAM modulation techniques respectively.

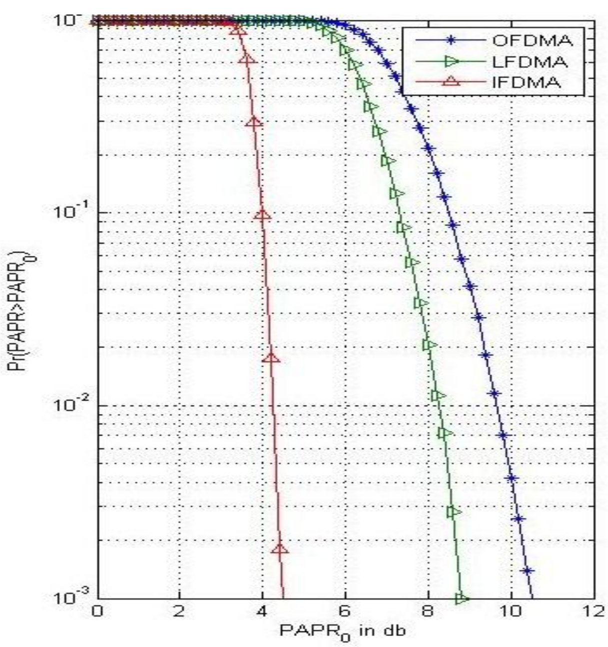

Figure 3 (d): 64 QAM

The performance is improved using DFT spreading technique for example in figure 3 (d) 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.

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 4(a), 4(b), 4(c) shows the effect of number of subcarriers on OFDMA, LFDMA, and IFDMA respectively. We are showing these results using 16QAM modulation technique.

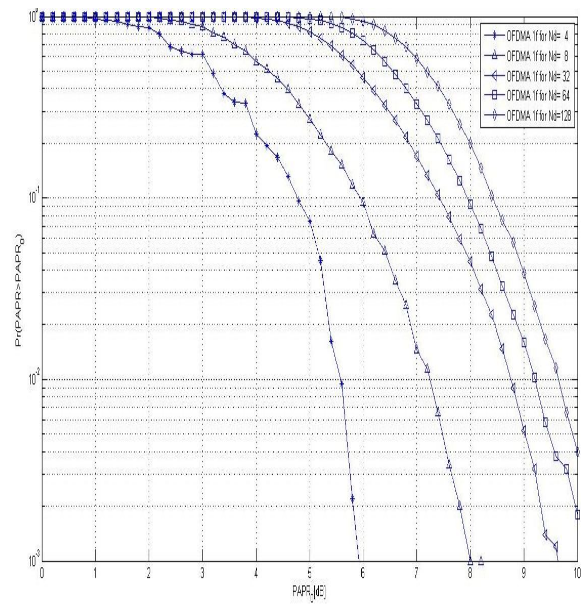

Figure 4(a): PAPR performance of DFT-spreading technique when the number of subcarriers varies in OFDMA.

It is clear from figure 4(a) and 4(b), 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.

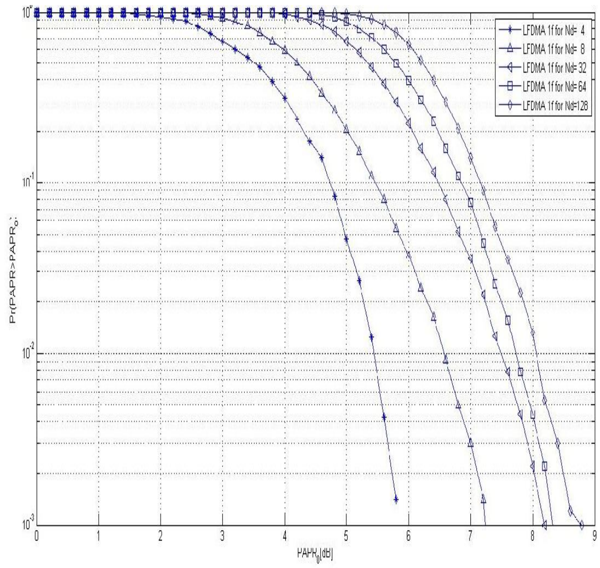

Figure 4(b): PAPR performance of DFT-spreading technique when the number of subcarriers varies in LFDMA

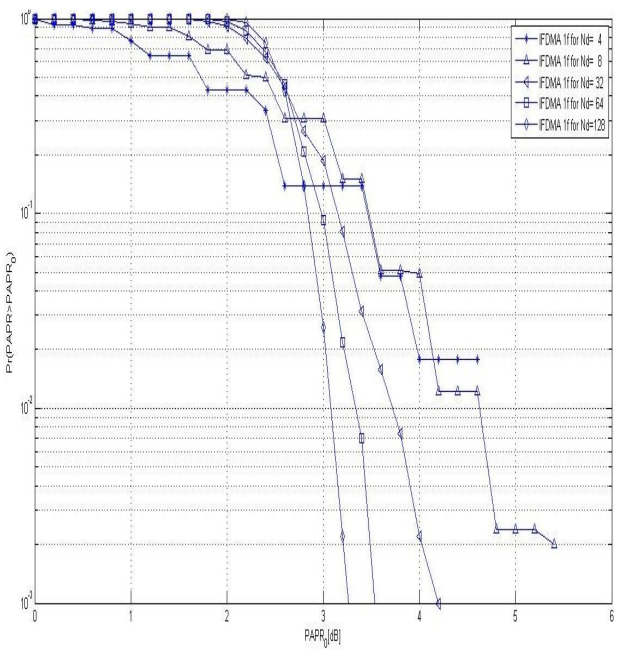

Figure 4(c): PAPR performance of DFT-spreading technique when the number of subcarriers varies in IFDMA

But figure 4(C) 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.

3. CONCLUSION

In this paper we analyzed the performance of DFT spread OFDM method for reducing the PAPR in OFDM. The simulation results shows IFDMA method is best among the OFDMA, LFDMA and IFDMA. But the disadvantage of IFDMA scheme is that we are losing user diversity.

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