SCFDMA PERFORMANCE ANALYSIS FOR PAPR REDUCTION WITH DIFFERENT SUBCARRIER MAPPING USING SLM TECHNIQUE AND MODIFIED SLM TECHNIQUE

Sneha Dubey¹, Rekha Gupta²

¹,² Department of Electronics and Communication Engineering, Madhav Institute of Technology and Science, Gwalior, (India)

ABSTRACT

The high PAPR value is a critical issue in OFDM system. The most efficient technique for PAPR reduction is SCFDMA for uplink transmission in communication system. Firstly in this paper, different subcarrier mapping for PAPR reduction is discussed and found from study that LFDMA still has high PAPR value than IFDMA and also found that LFDMA and DFDMA have almost same PAPR value but LFDMA is preferred over DFDMA because the practical performance of DFDMA is more difficult than LFDMA. In this paper the comparison of different subcarrier mapping with SLM technique is performed. From simulated result it has been found that, the PAPR performance of SLM technique for different subcarrier mapping is better than different subcarrier mapping scheme without SLM technique. In SLM technique also LFDMA and DFDMA have same PAPR performance. In all simulation QPSK and 16QAM modulations are used. There is also a modified SLM technique in which new phase sequences are applied. It is found that modified SLM provides improvement in PAPR reduction than conventional SLM technique with phase sequence (U=8) using QPSK and 16QAM modulation.

Keywords: DFDMA, IFDMA, LFDMA, SLM

I. INTRODUCTION

Two most important data transmission are single carrier and multiple carrier data transmission. Low data rate is the disadvantage of single carrier data transmission. But high data rate is the advantage of multiple carrier data transmission. Single carrier frequency division multiple access (SCFDMA) has one most important advantage of low PAPR compared to OFDMA. But after all advancement, SCFDMA has high PAPR value. So to minimize PAPR value different PAPR reduction techniques are used. The impact of PAPR reduction depends upon the method for allocating the subcarriers to every terminal [1]. Three SCFDMA techniques are considered in this work, entitled as localized FDMA (LFDMA), distributed FDMA (DFDMA) and interleaved FDMA (IFDMA). Localized subcarrier mapping in
SCFDMA have higher PAPR value than IFDMA [2]. Localized subcarrier mapping in SCFDMA has almost equal PAPR value to DFDMA [3].

This high PAPR can be reduced by using different PAPR reduction techniques such as Selective mapping [4], Partial transmit sequence (PTS) [5], Comping techniques [6], Precoding techniques [7], Clipping techniques [8].

This paper reflects the evaluation of PAPR performance with different subcarrier mapping techniques. In SCFDMA, Selective mapping techniques is the most important technique for PAPR reduction [9]. This paper also reflects the selective mapping techniques for PAPR reduction. Then comparison of different subcarrier mapping with SLM techniques is performed. But there is also a disadvantage of SLM, is that it has high complexity [10]. But for reducing the complexity of SLM many schemes are proposed [11].

There is also a modified SLM technique in which new phase sequences are applied. It is found that modified SLM technique provides improvement in PAPR reduction than conventional SLM technique with phase sequence (U=8) using QPSK and 16QAM modulation.

The rest of the paper is arranged as follows. In section 2, the SCFDMA system model is defined. Section 3 represents the PAPR of SCFDMA signal. In section 4, SLM technique with different subcarrier mapping is investigated. In section 5, modified SLM technique is analyzed. In section 6, simulation result is discussed. Finally conclusion is drawn in section 7.

II. SCFDMA SYSTEM MODEL

SCFDMA is also known as DFT precoded OFDMA. In the transmitter block binary input sequence which is of the length of M (number of user subcarrier) is modulated by using modulator. In this paper M input sequence is QPSK and 16QAM modulated.

After modulation, subcarrier mapping is used. In this paper three types of subcarrier mapping is used which are: IFDMA, LFDMA, DFDMA. After subcarrier mapping length of the data became N (number of system subcarrier) such that N>M.

2.1. Subcarrier mapping schemes

The performance of SCFDMA framework is chiefly influenced by the kind of subcarrier mapping techniques being used.

The three sub-carrier mapping techniques that are present for allocating M frequency domain symbols to the sub-carriers are: Localized (LFDMA), Distributed (DFDMA) and Interleaved (IFDMA) subcarrier mapping.

2.1.1. Interleaved FDA

Each user has assigned M numbers of subcarrier. Total numbers of subcarriers are denoted by N (where N>M). When IFDMA allocates DFT outputs with equidistance N/M=S, it is depicted as IFDMA where S is called the bandwidth spreading factor.
Fig. 1: Interleaved FDMA

Fig (1) represents the value of $M=4$ (Number of user subcarrier assigned by each users $Y_m(0)$ $Y_m(1)$ $Y_m(2)$ $Y_m(3)$) is allocated to $N=12$ (Number of system subcarrier). So spreading factor is $N/M=S$ which is equal to 3

2.1.2. Distributed FDMA

Each user has assigned $M$ numbers of symbols. Total numbers of subcarriers are denoted by $N$ (Where $N>M$). The number of zeros in DFDMA will be $N-M$. Drawback of DFDMA is that it loses user diversity.

Fig. 2: Distributed FDMA

2.1.3. Localized FDMA

Multi user diversity is achieved by using LFDMA in frequency selective channel. Every user transmits data on a set of adjacent subcarriers. Each users has assigned $M$ numbers of subcarriers are denoted by $N$. LFDMA distributes DFT outputs to $M$ successive subcarrier in $N$ subcarriers (where $N>M$).

Fig. 3: Localized FDMA

III. PAPR OF SCFDMA SIGNAL

In SCFDMA, FFT and IFFT both operations are performed. In SCFDMA, We can compose the perplexing vector of size $M$ as $X=[X_0, X_1, X_2, ..., X_{M-1}]^T$. The complex baseband SCFDMA signal with subcarriers can be composed as:

$$x_k = \frac{1}{\sqrt{M}} \sum_{n=0}^{N-1} X_k e^{-j2\pi \frac{n}{N}}$$, $n=0, 1, ..., M-1$

(1)

Where $j=\sqrt{-1}$

The PAPR ratio is defined as the ratio between the maximum power and average power of transmitted signal $x_k$ is defined as:
PAPR = \frac{\max(|x|^2)}{E[|x|^2]} \quad (2)

\mathbb{E}[|x|^2] \text{ is average power of transmitted signal. Degradation of efficiency with high value of PAPR is a major problem in wireless communication system. PAPR in } \text{dB is expressed as:}

PAPR (dB) = 10 \log_{10}(PAPR) \quad (3)

**IV. SLM TECHNIQUE WITH DIFFERENT SUBCARRIER MAPPING**

Fig (4) exhibits the block diagram of the SLM based uplink system. First, data stream is changed from serial to parallel form which is represented as \( X = [X_0, X_1, X_2, \ldots, X_{M-1}]^T \). Each converted data is multiplied by \( U \) number of phase sequences. Each phase sequence has the length sequence of \( M, B(u) = [b_{u,0}, b_{u,1}, \ldots, b_{u,M-1}]^T, (u=1,2,\ldots,U). \) So after multiplying data stream with phase sequences the result will be \( X^{(u)} = [X_0 b_{u,0}, X_1 b_{u,1}, \ldots, X_{M-1} b_{u,M-1}] \).

Where \( u=1, 2, 3 \ldots U. \)

Then these blocks of data are DFT precoded which can be written as:

\[ Y_m^{(u)} = \sum_{l=0}^{L-1} P_{m,n} X_l^{(u)} \quad m=0,1,\ldots,L-1 \quad (4) \]

The Precoding network \( P \) which is characterized as a Precoding Matrix having dimension \( N \times N \), can be composed as:

\[
P = \begin{bmatrix}
P_{00} & P_{01} & \ldots & P_{0(N-1)} \\
P_{10} & P_{11} & \ldots & P_{1(N-1)} \\
\vdots & \vdots & \ddots & \vdots \\
P_{(N-1)0} & P_{(N-1)1} & \ldots & P_{(N-1)(N-1)}
\end{bmatrix}
\]

(5)

Where \( P_{m,n} \) means DFT precoding matrix of \( m \)th row and \( n \)th column such as, \( P_{m,n} = e^{-j \frac{2\pi mn}{N}} \) where \( m \) and \( n \) are integers from 0 to \( N-1 \).

After precoding, subcarrier mapping of precoded signal is performed. Suppose the type of subcarrier mapping is LFDMA. The subcarrier mapping in the Localized mode can be written as:

\[
\tilde{P}_m^{(u)} = \begin{cases}
Y_m & 0 \leq m \leq M-1 \\
0 & M \leq m \leq N-1
\end{cases}
\]

(6)

Where \( N \) is the number of system subcarrier, \( M \) is the number of user subcarriers.

After all these processes, mapped data is IFFT precoded. Resultant data is represented by \( x(1), x(2), x(3) \ldots x(u). \)

After IFFT operation, PAPR with minimum values are selected.
Dependability of SLM techniques for PAPR reduction is on \( U \), which is the number of phase sequences and also on selection of output data with the lowest PAPR value.

V. MODIFIED SLM TECHNIQUE

In modified SLM technique, all processes will be same as conventional SLM technique except that we have changed the phase sequences. Earlier in SLM technique, we have used phase sequences \([B(1), B(2)] = [1, -1]\). In the modified SLM technique, we have used phase sequences \([B(1), B(2), B(3), B(4)] = [1, -1, j, -j]\) and then data is converted from serial to parallel form. By the modified SLM unit, transformed data is processed. Then FFT, subcarrier mapping and IFFT operations of data is performed. After all these processes, one with lowest PAPR value is selected.

VI. SIMULATION RESULT

For evaluating the PAPR reduction performance, we have carried out wide ranging simulation using MATLAB for SCFDMA system. SCFDMA system with \( N=256 \) subcarriers was used for the simulation with QPSK and 16QAM modulation. The parameters used for simulation are given below in table:

Table 1. Parameters for simulations
In Fig.1 there is a comparison of the results for different subcarrier mapping techniques in SCFDMA. In case of IFDMA the PAPR have smallest value, whereas PAPR is almost same in case of LFDMA and DFDMA for any modulation schemes.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation</td>
<td>QPSK, 16QAM</td>
</tr>
<tr>
<td>Number of user subcarriers (M)</td>
<td>64</td>
</tr>
<tr>
<td>Number of system subcarriers (N)</td>
<td>256</td>
</tr>
<tr>
<td>Number of iterations</td>
<td>10000</td>
</tr>
<tr>
<td>Phase sequences</td>
<td>U=4, 8, 16</td>
</tr>
<tr>
<td>Subcarrier mapping</td>
<td>IFDMA, LFDMA, DFDMA</td>
</tr>
</tbody>
</table>

**Fig.1. PAPR of SCFDMA systems using 16QAM modulations Scheme with N=256, M=64**

Fig.2, Fig.3 and Fig.4 shows the comparisons of PAPR for the different subcarrier scheme (IFDMA, DFDMA, LFDMA) with SLM techniques for U=4, 8 and 16 and M=64 and N=256 with 16QAM modulation.
Fig. 2. PAPR of SLM SCFDMA systems using 16 QAM modulation Scheme with $N=256$, $M=64$ and $U=4$.

Fig. 3. PAPR of SLM SCFDMA systems using 16 QAM modulations Scheme with $N=256$, $M=64$ and $U=8$. 
In Fig. 4, we have executed the new phase sequence of modified SLM for U=8 with QPSK modulation. We compared the result with earlier SLM technique and it is found that modified SLM gives lower PAPR value than conventional SLM.

Figure 5. CCDF Plot of PAPR for PROPOSED Method using QPSK LFDMA Scheme with N=256, M=64 and U=8
In Fig.6, there is a comparison of Modified SLM, conventional SLM and original SCFDMA for U=8 with 16QAM modulation. On comparison, it is clear that modified SLM gives lower PAPR value than conventional SLM and original SCFDMA.

![CCDF Plot of PAPR for PROPOSED Method using 16QAM LFDMA Scheme with N=256, M=64 and U=8](image)

**VII. CONCLUSION**

In this paper, we have inspected the performance of SCFDMA with SLM techniques. Also we have analyzed the performance of SCFDMA with modified SLM techniques and compared it with conventional SLM techniques. Based on all analysis, it is clear that the PAPR for IFDMA is significantly lower than the LFDMA and DFDMA. PAPR performance of LFDMA and DFDMA is nearly same. We evaluated the performance of the modified SLM system and concluded that modified SLM gives better PAPR performance than conventional method. Comparing Fig.5 and Fig.6, it is clear that QPSK modulation gives better performance than 16QAM.

**REFERENCES**


