Abstract: In this paper, we proposed a Peak-to-Average power Ratio (PAPR) reduction technique based on signal scrambling in OFDM signal. Orthogonal Frequency Division Multiplexing (OFDM) is a form of multi-carrier modulation technique. High spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, capability of handling very strong echoes and less nonlinear distortion are among the favourite properties of OFDM. OFDM systems have the inherent problem of a high peak to average power ratio (PAPR) and frequency offset. Different signal scrambling techniques are explained and implemented to minimize the effect of Peak-to-Average power Ratio. Finally, simulation results reveals that the proposed signal scrambling technique outperform over the other exciting techniques.

Keywords: Peak-to-Average power Ratio (PAPR), Orthogonal Frequency Division Multiplexing (OFDM), signal scrambling techniques. Complementary cumulative distribution function (CCDF).

I. INTRODUCTION

OFDM has recently received increased attention due to its capability of supporting high data rate communication in frequency selective fading environments which cause Inter symbol Interference (ISI) [1]. In order to take advantage of the diversity provided by the multi-path fading, appropriate frequency interleaving and coding is necessary. Therefore, coding becomes an inseparable part in most OFDM applications and a considerable amount of research has focused on optimum encoder and decoder design for information transmission through OFDM over fading environments. Orthogonal frequency division multiplexing (OFDM) is one of the most attractive multicarrier modulation schemes for high bandwidth efficiency and strong immunity to multipath fading [6]. OFDM has become tangible reality, it has been employed for wire-line communications and also has been employed in wireless local area network (WLAN) e.g. IEEE 802.11. Other applications of OFDM are digital audio broadcasting (DAB) and digital video broadcasting (DVB) [8]. Communications are already established or being established by IEEE 802.11, IEEE 802.16, IEEE 802.20, and European Telecommunications Standards Institute (ETSI) Broadcast Radio Access Network (BRAN) committees [9]. For wireless applications, an OFDM-based system can be of interest because it provides greater immunity to multi-path fading and impulse noise, and eliminates the need for equalizers, while efficient hardware implementation can be realized using Fast Fourier transform (FFT) techniques [10]. The OFDM has many advantage such as high bandwidth efficiency, robustness to the selective fading problem, use of small guard interval, and its ability to combat the ISI problem. So, simple channel equalization is needed instead of complex adaptive channel equalization. High PAPR has been recognized as one of the major practical problem involving OFDM modulation [5]. This problem results from the nature of the modulation itself, where multiple subcarriers/sinusoids are added together to form the signal to be transmitted [7]. To overcome above mentioned serious drawbacks, several solutions have been proposed, such as clipping with filtering [11], clipping [12], coding [13], interleaving [14], Active Constellation Extension (ACE) [15], Turbo Coded OFDM [16]. In this paper, we proposed a Peak-to-Average power Ratio (PAPR) reduction technique based on signal scrambling in OFDM signal. Simulation result shows the effectiveness of the proposed technique. The paper is organized as follows: In Section II, The OFDM system is explained and drawbacks of OFDM system are explained. In section III, the PAPR in OFDM is introduced. Section IV proposed the different signal scrambling techniques. Section V, steps of proposed technique will be introduced. Section VI, simulation results will be made. Section VII, conclusions will be make.

II. OFDM SYSTEM

Orthogonal Frequency Division Multiplexing (OFDM) is a modulation technique that employs \( N_s \) separate subcarriers to transmit data instead of one main carrier. Input data is grouped into a block of \( N \) bits, where

\[
N = N_s \cdot m_b
\]

(1)

and \( m_b \) is the number of bits used to represent a symbol for each subcarrier. In order to maintain orthogonality between the sub carriers they are required to be spaced apart by an integer multiple of the subcarrier symbol rate, \( R_s \). The subcarrier symbol rate is related to the overall coded bit rate \( R_c \) of the entire system by

\[
R_s = R_c / N_s
\]

(2)

In many OFDM systems a guard time is added to the symbol period. A cyclic extension is applied to each subcarrier signal during the guard period to maintain orthogonality of the sub carriers during timing offsets. The subcarriers are assumed to have no timing offsets, i.e. no multipath delay spread, therefore a guard time has not
been included in the analysis. The output signal of an OFDM transmitter takes on the form

\[ Z(t) = \sum_{m=0}^{N_s-1} C_k e^{2\pi j(m-N_s/2)t/T_s}, \]  

(3)

The complex envelop of the OFDM signal, over T second interval is given by:

\[ S(t) = A_c \sum_{n=0}^{N_s-1} w_n \phi_n(t), \quad 0 > t > T \]  

(4)

A_c where is the carrier amplitude, and w_n is the element of N-elements parallel data vector and the orthogonal carriers are

\[ \phi_n(t) = e^{j2\pi n f_c t} \]  

(5)

The envelope dynamic of signal s(t) can be objectively measured using the parameter called Peak to Average Power Ratio (PAPR) defined as:

\[ \text{PAPR}(s(t)) = \frac{\max\{|s(t)|\}}{E[|s(t)|^2]} \]  

(6)

The PAPR of OFDM signal with N subcarriers sampled at symbol rate is upper-bounded by the value N. Statistically it is possible to characterize the PAPR distribution using its cumulative distribution function (CDF) or complementary cumulative distribution function (CCDF). For the case of OFDM, the following expression for the PAPR CCDF holds as

\[ \Pr(\text{PAPR} > \gamma) = 1 - \left(1 - \exp(-\gamma)\right)^N \]  

(7)

In order to minimize the problems arising from the use of signals with high PAPR in communication transmitters with nonlinearities, several approaches can be successfully used. Each of them has its advantages and disadvantages. As the alternatives, it is possible to either use some of the linearization techniques or some form of the efficiency enhancement techniques.

IV. SIGNAL SCRAMBLING TECHNIQUE

Signal scrambling techniques are all variations on how to scramble the codes to decrease the PAPR [5]. Coding techniques can be used for signal scrambling. Golay complementary sequences, Shapiro-Rudin sequences, M sequences, Barker codes can be used efficiently to reduce the PAPR. However with the increase in the number of carriers the overhead associated with exhaustive search of the best code would increase exponentially. More practical solutions of the signal scrambling techniques are block-coding, Selective Level Mapping (SLM) and Partial Transmit Sequences (PTS). Signal scrambling techniques with side information reduces the effective throughput since they introduce redundancy. Different Signal Scrambling Techniques are

- Block Coding Technique
- Sub Block Coding Technique
- Selected Mapping
- Partial Transmit Sequence (PTS)
- Interleaving
Standard Arrays of linear Block Codes  
Tone Reservation  
Tone Injection  
Active Constellation Extension  
Hadamard Transform Method

V. PROPOSED TECHNIQUES

The proposed algorithm can be described in following steps:

Step-1: The sequence of data bits is modulated using 16-QAM to produce sequence symbols $I_0, I_1, \ldots$.

Step-2: These symbol sequences are divided into blocks of length $256/N$. Here, $N(256)$ is the number of subcarriers.

Step-3: Take IFFT and multiply each sub-block by choosing the random phase sequence from $[1, -1, j, -j]$.

Step-4: Output of Each block is multiplied (point wise multiplication) by $U$ different phase sequence vector from $[1, -1, j, -j]$.

Step-5: Transform the output of each block into time domain by taking IFFT.

Step-6: Select the one, which has the minimum PAPR.

VI. SIMULATION RESULTS

In this experiment, Peak-to-Average power Ratio (PAPR) reduction technique based on signal scrambling in OFDM signal is explained based on complementary cumulative distribution function (CCDF). The PAPR reduction of the proposed scheme is examined by computer simulation using matlab 7.11. In the simulation we consider an OFDM signal with $N = 256$ subcarriers, 16-QAM mapping, using Signal Scrambling Technique. Table 1 shows the simulation parameters.

<table>
<thead>
<tr>
<th>Simulation parameters</th>
<th>Type/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subcarriers (N)</td>
<td>256</td>
</tr>
<tr>
<td>Number of sub blocks (M)</td>
<td>2, 4, 8, 16, 32</td>
</tr>
<tr>
<td>Oversampling factor(L)</td>
<td>4</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>16 QAM</td>
</tr>
<tr>
<td>Phase factor</td>
<td>$[1, -1, j, -j]$</td>
</tr>
</tbody>
</table>

The complementary cumulative distribution function (CCDF) of the PAPR for the transmitted signal are plotted, where the PAPR technique being employed by the Partial Transmit Sequence (PTS) technique. It is evident from these results that the PAPR can be improved by using Partial Transmit Sequence (PTS) technique. Fig. 3 shows the CCDF of PAPR using Partial Transmit Sequence (PTS) technique with $M=2$ sub blocks and $Number of subcarriers N=256$. Fig. 4 shows the CCDF of PAPR using Partial Transmit Sequence (PTS) technique with $M=4$ sub blocks and $Number of subcarriers N=256$. Fig. 5 shows the CCDF of PAPR using Partial Transmit Sequence (PTS) technique with $M=8$ sub blocks and $Number of subcarriers N=256$. 

![Fig. 3 CCDF of PAPR in Partial Transmit Sequence (PTS) technique versus original technique with M=2 sub blocks and Number of sub carriers N=256](image1)

![Fig. 4 CCDF of PAPR in Partial Transmit Sequence (PTS) technique versus original technique with M=4 sub blocks and Number of sub carriers N=256](image2)

![Fig. 5 CCDF of PAPR in Partial Transmit Sequence (PTS) technique versus original technique with M=8 sub blocks and Number of sub carriers N=256](image3)
In this paper, we proposed a Peak-to-Average power Ratio (PAPR) reduction technique based on signal scrambling in OFDM signal. The proposed scheme is used for PAPR reduction in OFDM system and compared the proposed scheme with original scheme. The simulation results show that the proposed scheme offer better PAPR reduction. The simulation result show that as the number of sub blocks increases, the performance increases. The proposed scheme is compared with original scheme. It has been investigated that the performance of proposed technique gives better results for 2, 4, 8, 16, sub-blocks and equivalent result for 32 sub-blocks.

VII. CONCLUSIONS

In this paper, we proposed a Peak-to-Average power Ratio (PAPR) reduction technique based on signal scrambling in OFDM signal. The proposed scheme is used for PAPR reduction in OFDM system and compared the proposed scheme with original scheme. The simulation results show that the proposed scheme offer better PAPR reduction. The simulation result show that as the number of sub blocks increases, the performance increases. The proposed scheme is compared with original scheme. It has been investigated that the performance of proposed technique gives better results for 2, 4, 8, 16, sub-blocks and equivalent result for 32 sub-blocks.

REFERENCES