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The PAPR reduction by using SLM and clipping in high speed OFDM systems

Thorramamidi Mounika
Assistant ant Professor, Department of ECE, Sree Dattha Institute of Engineering and Science, Mail: mounikat111@gmail.com

Vulpala Madhavi
Assistant ant Professor, Department of ECE, Sree Dattha Institute of Engineering and Science, Mail: vulpala.madhavi@gmail.com

Abstract

The goal of this paper is to analyze PAPR reduction performance in 5G communication. 5G communication technology is beyond 4G and LTE technology and To reduce the PAPR several PAPR reduction techniques have been proposed Tone injection and companding are two promising techniques, which are used in PAPR reduction of multicarrier communication system. In this paper a combined scheme of tone injection and companding is used, which gives significant performance improvement compared to the tone injection and companding techniques taken separately. Simulation is performed to analyses the PAPR and BER performance of FBMC-FMT and FBMC-SMT system. Also a new clipping based PAPR reduction scheme is proposed in this paper. For this scheme simulation is performed to analyze the PAPR performance of FBMC-FMT, FBMC-SMT and FBMC-CMT system. All the simulations are performed in MATLAB.

Key words: *Peak to average power ratio, SLM, OFDM, MATLAB,*

I. INTRODUCTION

Most of these transmission systems experience much degradation such as large attenuation, noise, multipath, interference, time variance, nonlinearities and must meet the finite constraints like power limitation and cost factor. In multi-carrier modulation, the most commonly used technique is Orthogonal Frequency Division Multiplexing (OFDM); it has recently become very popular in wireless communication[1]. Unfortunately, the major drawback of OFDM transmission is its large envelope fluctuation which is quantified as Peak to Average Power Ratio (PAPR). Clipping and Filtering is one of the basic technique in which some part of transmitted signal undergoes into distortion. If we go for the Partial Transmit Sequence (PTS) and Selected Mapping (SLM) technique, the PTS technique has more complexity than that of SLM technique. All of the techniques has some sort of advantages and disadvantages [2]. Clipping and Filtering is one of the basic technique in which some part of transmitted signal undergoes into distortion. This Selected Mapping is one of the promising technique due to its simplicity for implementation which introduces no distortion in the transmitted signal. It has been described first in i.e. to be known as the classical SLM technique. This technique has one of the disadvantage of sending the extra Side Information (SI) index along with the transmitted OFDM signal.

The concentration of this paper work is specially upon the Selected Mapping technique. Here the three important analysis of this technique has been done. Out of them one is, how to avoid the transmission of extra information along with the OFDM signal which will be discussed in the section Avoiding the SI index Transmission. Another one important analysis of this technique is how to reduce the computational complexity. Also one important analysis is to be done about the mutual independence between the alternative phase vectors used in this technique. One technique also being proposed which has an advantage of reducing the PAPR simultaneously reducing the computational complexity in comparison to that of the Classical SLM. In addition to this the proposed technique also avoids the sending of extra SI index.

1. Multipath Channel

The transmitted signal faces various obstacles and surfaces of reflection, as a result of which the received signals from the same source reach at different times. This gives rise to the formation of echoes which affect the other incoming signals. Dielectric constants, permeability, conductivity and thickness are the main factors affecting the system. Multipath channel propagation is devised in such a manner that there will be a minimized effect of the echoes in the system in an indoor environment. Measures are needed to be taken in order to minimize echo in order to avoid ISI (Inter Symbol Interference).

2. Multicarrier Transmission Schemes

In a single carrier system, a single fade causes the whole data stream to under go into the distortion i.e known as the frequency selective fading. To overcome the frequency selectivity of the wideband channel experienced by single-carrier transmission, multiple carriers can be used for high rate data transmission. In multicarrier transmission [3], a single data stream is transmitted over a number of lower rate subcarriers. The below figure shows the basic structure and concept of a multicarrier transmission

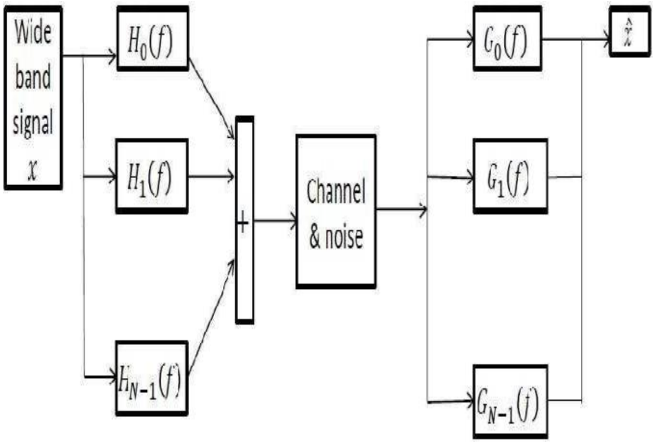


Fig. 1 Multicarrier filter bank

3. OFDM Transmission Scheme

Orthogonal frequency division multiplexing (OFDM) transmission scheme is a type of multichannel system which avoids the usages of the oscillators and band- limited filters for each subchannel. It divides the frequency spectrum into sub-bands small enough so that the channel effects are constant (flat) over a given sub-band. Then a classical IQ (In phase Quadrature phase) modulation (BPSK, QPSK, M-QAM, etc) is sent over the sub-band. If it designed correctly, all the fast changing effects of the channel disappear as they are now occurring during the transmission of a single symbol and are thus treated as flat fading at the receiver.

The orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. The problem of overhead carrier spacing required in Frequency . The problem of overhead carrier spacing required in Frequency Division Multiplexing (FDM) can be recovered. So this multicarrier transmission scheme[4] allows the overlapping of the spectra of subcarriers for bandwidth efficiency

4. Inter Symbol Interference

Inter symbol interference (ISI) is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon as symbols have similar effect as noise, which makes the communication as some sort of unreliable. It is usually caused by multipath propagation or the inherent nonlinear frequency response of a channel causing successive symbols to blur together. The presence of ISI in the system introduces error in the decision device at the receiver output.

Presence of Doppler shifts and frequency and phase offsets in an OFDM system causes loss in orthogonality of the sub-carriers. As a result, interference is observed between sub-carriers. This phenomenon is known as inter - carrier interference (ICI)

Filter bank multi carrier is a technique in which a bank of filters are used in transmitter and receiver side. Transmitter filter is called synthesis filter bank and receiver filter is called analysis filter bank. Interestingly, FBMC is the multicarrier technique, which was developed prior to OFDM. Change is the first person who came with the idea of FBMC in the 1960s and also presented the conditions required for signalling a parallel set of pulse amplitude modulated (PAM)symbols going through a bank of overlapping vestigial side-band (VSB) modulated filters. A year later, Saltzberg extended the idea of change and showed how the method could be modified for transmission of quadrature amplitude modulated (QAM) symbols. Saltzberg showed that we can achieve the maximum spectral efficiency in FBMC system if a half-symbol space delay between the in-phase and the quadrature phase components of QAM symbols is maintained.

5. Staggered modulated multitone (SMT)

Staggered modulated multitone is an FBMC generation method which uses offset quadrature amplitude modulation (OQAM). OQAM is a form of quadrature amplitude modulation (QAM). In which we choose a root-Nyquist filter with symmetric impulse response for pulse- shaping at the transmitter side and the same filter at the receiver side in a multichannel QAM system, and we introduce a half symbol delay between the in-phase and quadrature-phase components of QAM symbols. This makes it possible to get baud-rate spacing between adjacent subcarrier, and we can still recover the information symbols, which is free from inter symbol interference (ISI) and inter carrier interference (ICI). In this method, unlike OFDM no cyclic prefix is required for resolving ISI and ICI. So OQAM method is more bandwidth efficient than OFDM. In SMT method as shown in fig. 2 N parallel data streams are first given to N filters and then in phase and quadrature phase components are staggered in time by half symbol duration, T/2.Output of these filters are then modulated with N subcarriers, whose frequencies are separated by 1/Tspace.

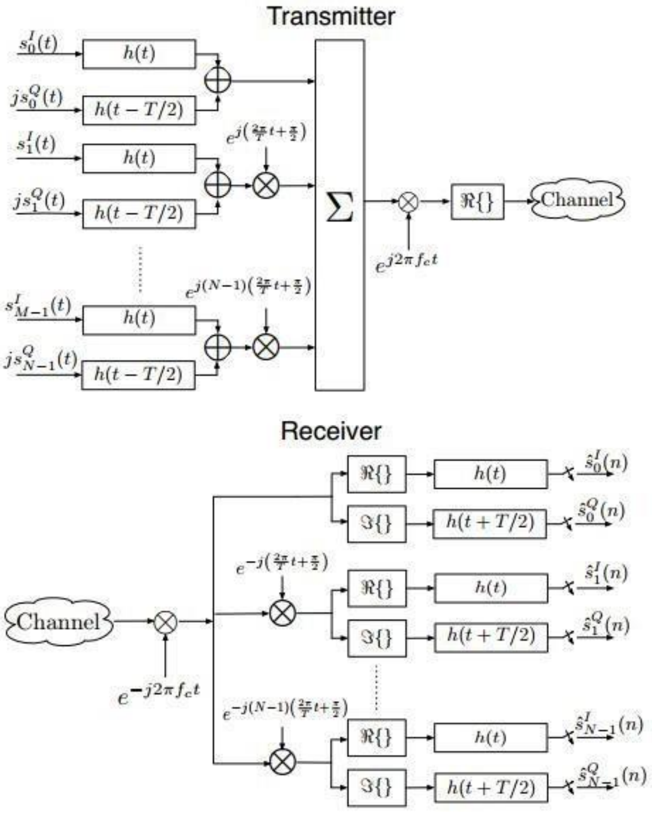


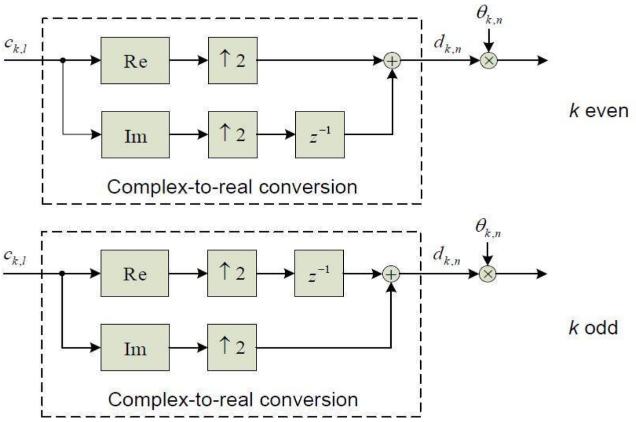
Fig. 2. Structure of SMT system

OQAM Pre-Processing and post processing blocks are required for generation of FBMC signal by SMT method . Pre-processing block which transforms signal from QAM to OQAM is shown in Fig. 3. Here first operation is complex to real conversion, where real and complex part of input symbol ck,l is separated into two new symbols dk,2l and dk,2l+1. Sub-channel number determines the order of these new symbols, i.e., for even and odd number of sub-channelsconversion is different.

Fig.3 OQAM Pre-Processing section

$$\mathrm{PAPR}(\mathbf{x}) \triangleq \frac{\max_{0\leq t\leq N-1}|x_t|^2}{\mathrm{E}\left[|x_t|^2\right]},$$

In Fig. 4 post processing block is shown and there are two structures for post processing as shown . First input data is multiplied by $\theta k^{*},n$ sequence and then real part of this signal is taken. After that real to complex conversion is performed, where two successive complex valued symbols (with one multiplied by j) gives a real symbol $\hat{c}k ,n$. Here sample rate is decreased by 2. In this way we can convert QAM signal to OQAM signal for generation of FBMC by SMT method and also convert back from OQAM to QAM signal.



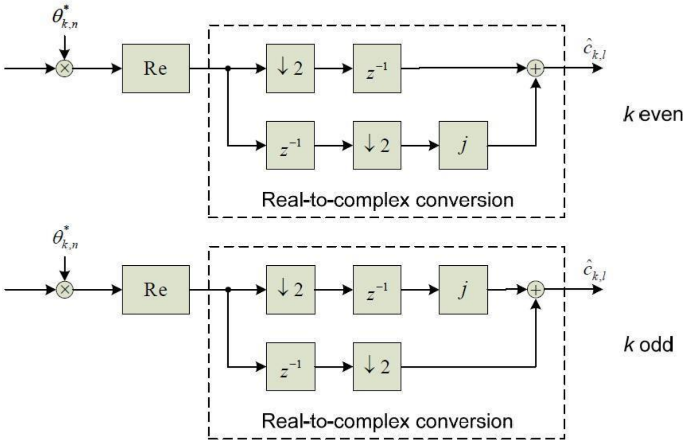


Fig. 4 OQAM post processing block

II. METHODOLOGY

In the continuous time domain, an OFDM signal xt of N carriers can be expressed as

$$x_t = \frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} X_n e^{j2\pi n\Delta f t}, \quad 0\leq t\leq T,$$

where Xn is the data symbol of the nth subcarrier, N is the number of subcarriers, Δf is the frequency between subcarriers, and T = 1/Δf is the OFDM symbol duration. This OFDM signal can be expressed by the vector form, x = [x0, x1, ... , xN−1] T which is corresponds to the IFFT of X = [X0,X1, ... ,XN−1] T. The PAPR of OFDM signal sequence x is defined as the ratio between the maximum instantaneous power and its average power[5], which can be written as

where E[·] denotes the expectation operator. In the conventional SLM scheme, K alternative input symbol sequences S(i) , 1 ≤ i ≤ K, are generated by the component-wise vector multiplication of the input symbol sequence X and K phase sequences γ(i) = [b (i) 0 , b (i) 1 ,
... , b(i) N−1] T , 1 ≤ i ≤ K; that is,

$$
\begin{aligned}
\mathbf{S}^{(i)} &= \left[S_0^{(i)}, S_1^{(i)}, \ldots, S_{N-1}^{(i)}\right]^T \\
&= \mathbf{X} \otimes \boldsymbol{\gamma}^{(i)} \\
&= \left[X_0 b_0^{(i)}, X_1 b_1^{(i)}, \ldots, X_{N-2} b_{N-2}^{(i)}, X_{N-1} b_{N-1}^{(i)}\right]^T, \\
&\qquad\qquad\qquad 1 \le i \le K,
\end{aligned}
$$

$$
\mathbf{s}^{(1)} = \mathrm{IFFT}\left[\mathbf{S}^{(1)}\right] = \mathbf{Q}\mathbf{S}^{(1)} = \mathbf{Q}\mathbf{X},
$$

where ⊗ denotes the component-wise multiplication of two vectors. b (i) μ = exp(jϕ(i) μ) is the rotation factor, n = 0, ... , N −1. ϕ(i) μ is homogeneous distributed in [0, 2π). To simplify the array multiplication in (3), we let γ(1) = [1, 1, ... , 1]T and choose b (i) k , 2 ≤ i ≤ K, k = 0, 1, ... , N − 1, in vector γ(i) from the set {±1, ±j}. Then, all K frames are transformed into the time domain using the IFFT, and the one with the lowest PAPR is selected for transmission. Just as other PAPR reduction schemes, conventional SLM also has its disadvantages: firstly, the selected signal index, called side information (SI), must also be transmitted to allow for the recovery of the original data block at the receiver side, which will inevitably lead to a decrease in data rate. Secondly, in order to improve the PAPR reduction performance of SLM scheme, we have to increase the number of phase sequences. However, the computational complexity of SLM scheme linearly increases as the number of phase sequences increases, which corresponds to the number of IFFTs required to generate the alternative OFDM signals.

1. A Novel SLM Scheme

Over the last decade, various methods have been used to improve the drawbacks of conventional SLM technique. Some scholars have invented blind SLM algorithms so that no side information (SI) needs to be sent . But more concerning improving direction is focused on reducing the computational complexity of SLM scheme. Wang and Li have invented a new scheme to reduce PAPR, its applications however, are only suitable for space-frequency block coding (SFBC) MIMO-OFDM system. Yang et al. have introduced a method of combining the originally time domain sequence linearly with its cyclically shifted sequences to generate the new candidates, but only achieved poorer PAPR reduction performance[6]. Hill et al. have combined cyclic shifts of the IFFT subblock output with PTSs to improve the PAPR reduction performance . Wang and Ouyang have proposed to use a low-complexity method to replace IFFTs in the SLM scheme , even using random phase rotation vector and cyclically shifting to enhance the PAPR reduction performance , which gives us a good idea to further improve its algorithm[7]. In this section, a novel SLM scheme is proposed which is based on the matrix transformation in . Unlike the shifting algorithm in , our scheme uses cyclically shifting to replace the fixed coefficient linear addition in and further improves this algorithm to generate more sequences. Moreover, this algorithm is also different from PTS/CSS in which cyclically shifting the data signal instead of increasing the phase rotations after they were phase rotated to reduce PAPR. The most practicability of our scheme is that it has lower computational complexity than the conventional scheme, the schemes under the similar PAPR reduction performance. According suppose that s(1) is the IFFT output signal s(i) , i = 1, corresponding to the frequency-domain signal with WN = $e^{-j2\pi/N}$, we can easily obtain

$$\mathbf{Q} = \frac{1}{N}\begin{pmatrix} 1 & 1 & 1 & \cdots & 1 \\ 1 & W_N^{-1} & W_N^{-2} & \cdots & W_N^{-(N-1)} \\ 1 & W_N^{-2} & W_N^{-4} & \cdots & W_N^{-2(N-1)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & W_N^{-(N-1)} & W_N^{-2(N-1)} & \cdots & W_N^{-(N-1)(N-1)} \end{pmatrix}$$

where Q is the IFFT matrix given by

$$\mathbf{X} = \mathbf{Q}^{-1}\mathbf{s}^{(1)},$$

Where where Q^{-1} denotes the inverse of Q. According to the matrix theory, can be re-expressed as

$$\mathbf{S}^{(i)} = \mathbf{R}_i\mathbf{X},$$

$$\mathbf{R}_i = \begin{pmatrix} b_0^{(i)} & & & 0 \\ & b_1^{(i)} & & \\ & & \ddots & \\ 0 & & & b_{N-1}^{(i)} \end{pmatrix}$$

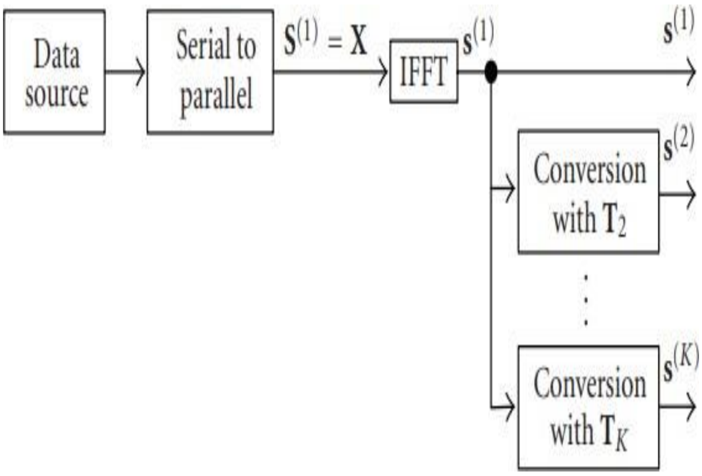


Fig 6 Idea of conversion with Tr for IFFT computation

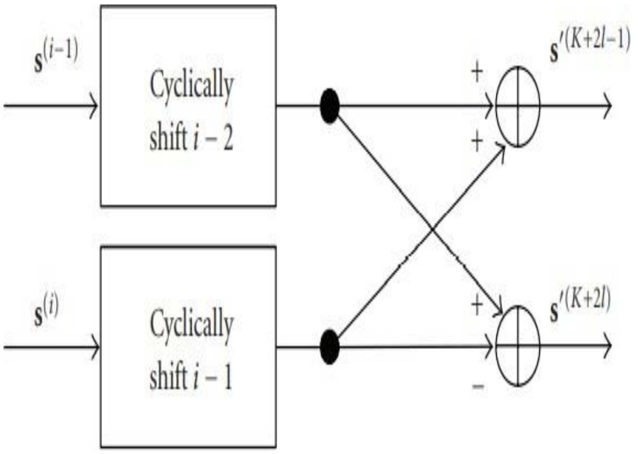


Fig 5 Cyclic Shifting For Generation Of New Sequence

Algorithm of cyclically shifting for generating new sequencesis referred to as the phaserotation matrix corresponding to the phase sequences $\gamma^{(i)}$. Let $s^{(t)}$ be a IFFT output signal $s^{(i)}$, $2 \leq i \leq K$, then we can get

$$\mathbf{s}^{(t)} = \mathrm{IFFT}\left[\mathbf{S}^{(t)}\right] = \mathbf{Q}\mathbf{S}^{(t)} = \mathbf{Q}\mathbf{R}_t\mathbf{X}.$$

we can rewrite

$$\mathbf{s}^{(t)} - \mathbf{T}_t\mathbf{s}^{(1)},$$

where $T^t = QR^tQ-1$ is a conversion matrix. Then, all the IFFT output signals s(i) , $1 \leq i \leq K$, can be expressed by (4) and (10), as shown in Figure 5. In order to achieve large PAPR reduction, a large number of candidate signal sequences should be required, but it will increase computational complexity, because each alternative OFDM signal sequence should be generated by equation. In K(K−1) additional alternative OFDM signal sequences from K IFFTed alternative signal sequences without performing IFFT are generated by linear combination, and cm and cn are two fixed coefficient 1/ √ 2 and ±(1/ √ 2)j. To generate these sequences, we should use 2N(K − 1) multiplications and N(K2 − K) additions, where N is the number of subcarriers and K is the number of IFFTed alternative signal sequences. By simulation experiments, however, we find that if we cyclically shift K IFFTed sequences regularly and linear combine them to generate K(K−1) additional sequences, the PAPR performance of the SLM scheme will generally be the same as even slightly better than that of which can be seen in Figure 6[7]. Furthermore, the number of complex multiplications and complex additions is N(K − 1) and N(K2 − K), respectively. The algorithm of cyclically shifting and linear combinationis described in Figure

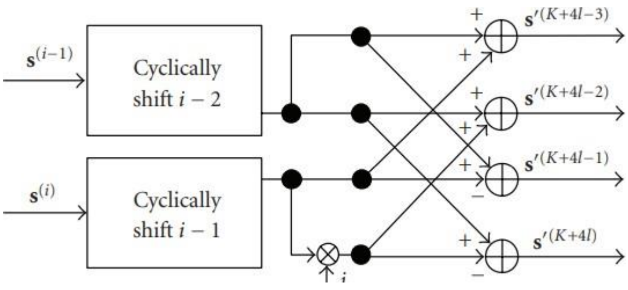


Fig 7 Algorithm of improved cyclically shifting for generate new sequences

Let $s^{(i-1)}$ and $s^{(i)}$ be the two arbitrary K IFFTed alternative signal sequences, the linear combination of these two sequence can be given as

where circular(s(i−1), i − 2) denotes right cyclically shifting s(i−1) by i − 2, which canbe expressed as

$$\mathbf{s}'^{(K+2l-1)} = \text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right) + \text{circular}\left(\mathbf{s}^{(i)}, i-1\right),$$

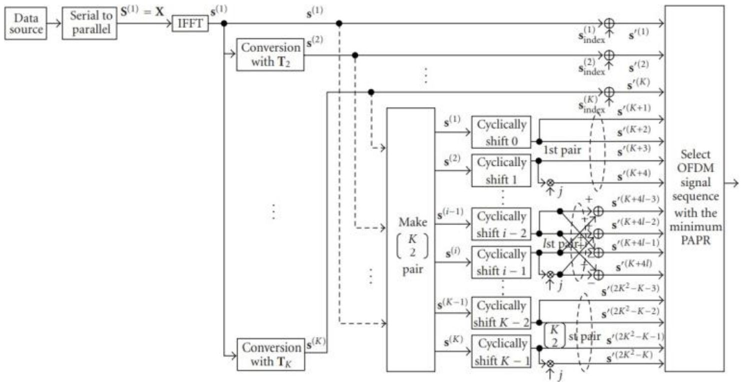
$$\text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right)$$

$$\Big),$$

$$= \left[\mathbf{s}_{i-2}^{(i-1)}, \mathbf{s}_{i-1}^{(i-1)}, \ldots, \mathbf{s}_{N-1}^{(i-1)}, \mathbf{s}_{0}^{(i-1)}, \mathbf{s}_{1}^{(i-1)}, \ldots, \mathbf{s}_{i-4}^{(i-1)}, \mathbf{s}_{i-3}^{(i-1)}\right]^T$$

$$= \mathbf{E}_{i-2} \cdot \mathbf{s}^{(i-1)},$$

and circular(s(i) , i − 1) can be done in the same manner. In addition, we can improve this algorithm to increase the number of signal sequences, as shown in Figure 7.



$$\mathbf{E}_{i-2} = \begin{pmatrix} & 1 & & \\ & & \ddots & \\ & & & 1 \\ 1 & & & \\ & \ddots & & \\ & & 1 & \end{pmatrix} \begin{matrix} \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} N-(i-2), \\ \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} i-2, \end{matrix}$$

Fig 8 Block diagram of the novel SLM scheme.The improved linear combination of these two sequences can be given as

$$\begin{aligned}\mathbf{s}'^{(K+4l-3)} &= \text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right) + \text{circular}\left(\mathbf{s}^{(i)}, i-1\right)\\ &= \text{IFFT}\left[\mathbf{E}_{i-2}\mathbf{S}^{(i-1)} + \mathbf{E}_{i-1}\mathbf{S}^{(i)}\right],\end{aligned}$$

$$\begin{aligned}\mathbf{s}'^{(K+4l-2)} &= \text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right) + j\cdot\text{circular}\left(\mathbf{s}^{(i)}, i-1\right)\\ &= \text{IFFT}\left[\mathbf{E}_{i-2}\mathbf{S}^{(i-1)} + j\mathbf{E}_{i-1}\mathbf{S}^{(i)}\right],\end{aligned}$$

$$\begin{aligned}\mathbf{s}'^{(K+4l-1)} &= \text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right) - \text{circular}\left(\mathbf{s}^{(i)}, i-1\right)\\ &= \text{IFFT}\left[\mathbf{E}_{i-2}\mathbf{S}^{(i-1)} - \mathbf{E}_{i-1}\mathbf{S}^{(i)}\right],\end{aligned}$$

$$\begin{aligned}\mathbf{s}'^{(K+4l)} &= \text{circular}\left(\mathbf{s}^{(i-1)}, i-2\right) - j\cdot\text{circular}\left(\mathbf{s}^{(i)}, i-1\right)\\ &= \text{IFFT}\left[\mathbf{E}_{i-2}\mathbf{S}^{(i-1)} - j\mathbf{E}_{i-1}\mathbf{S}^{(i)}\right],\end{aligned}$$

thus, 4× K 2 = 2K2−2K additional alternative OFDM signal sequences can be generated from cyclically shifting and linear combining algorithm without new IFFT operations. Furthermore, the information of the phase sequence used for the transmitted signal must be conveyed to the receiver in the SLM scheme. In the novel SLM scheme, the input symbol sequence X consist of Xdata and Xindex which are the data symbol sequence and the index symbol sequence. The index signal is represented as xindex+ = IFFT(Xindex), 1 ≤ i ≤ 4 and is added after IFFT of Xindex. Finally, the number of total 2K2 −K signal sequences can be written as[8]

$$\left\{\begin{aligned}&\underbrace{\mathbf{s}^{(1)}, \mathbf{s}^{(2)}, \ldots, \mathbf{s}^{(K)}}_{K},\\ &\underbrace{\mathbf{s}^{(1)} + b\mathbf{E}_1\mathbf{s}^{(2)}, \mathbf{s}^{(1)} + b\mathbf{E}_2\mathbf{s}^{(3)}, \ldots, \mathbf{E}_{K-2}\mathbf{s}^{(K-1)} + b\mathbf{E}_{K-1}\mathbf{s}^{(K)}}_{2(K^2-K)}\end{aligned}\right\},$$

where $b \in \{1, j, -1, -j\}$, for $i = 1$,

$$\begin{aligned}\mathbf{s}^{(1)} &= \text{IFFT}\left[\mathbf{S}^{(1)}_{\text{data}}\right] + \text{IFFT}\left[\mathbf{S}^{(1)}_{\text{index}}\right]\\ &= \mathbf{Q}\mathbf{X}_{\text{data}} + \mathbf{Q}\mathbf{X}_{\text{index}},\end{aligned}$$

for $2 \le i \le K$,

$$\begin{aligned}\mathbf{s}^{(i)} &= \text{IFFT}\left[\mathbf{S}^{(i)}_{\text{data}}\right] + \text{IFFT}\left[\mathbf{S}^{(i)}_{\text{index}}\right]\\ &= \mathbf{Q}\mathbf{R}_i\mathbf{X}_{\text{data}} + \mathbf{Q}\mathbf{R}_i\mathbf{X}_{\text{index}},\end{aligned}$$

and for $K + 1 \le i \le 2K^2 \quad K$ and $1 \le m < n \le K$,

$$\begin{aligned}\mathbf{s}^{(i)} &= \text{IFFT}\left[\mathbf{E}_{m-1}\mathbf{S}^{(m)}_{\text{data}} + b\mathbf{E}_{n-1}\mathbf{S}^{(n)}_{\text{data}}\right] + \text{IFFT}\left[\mathbf{S}^{(i)}_{\text{index}}\right]\\ &= \left(\mathbf{E}_{m-1}\mathbf{Q}\mathbf{R}_m + b\mathbf{E}_{n-1}\mathbf{Q}\mathbf{R}_n\right)\mathbf{X}_{\text{data}} + \mathbf{Q}\mathbf{R}_i\mathbf{X}_{\text{index}}.\end{aligned}$$

III. PEAK TO AVERAGE POWER RATIO

1. Introduction to PAPR

High PAPR is an important issue in FBMC system which reduces the efficiency of power amplifier used in the circuit. PAPR problem in any MCM system arises because of the fact that the output symbol of MCM system is the summation of symbols modulated on different subcarriers and there is a probability that all symbols have same phase which leads to a very high peak compared to the average value of the symbol. PAPR of an FBMC system is defined as the ratio of peak power to the average power[9].

In general, the PAPR of a complex envelope d[n] with length N can be written as

$PAPR\ = (\max\{|d[n]|\}\ /E\{|d[n^2]|\})$

Where d[n] is amplitude of d[n] and E denote the expectation of the signal.

2. Effect of High PAPR

The linear power amplifiers are used in the transmitter side of any communication system. For linear power amplifier the operating point should be in the linear region of operation. Because of the high PAPR the operating point moves to the saturation region hence [10], the clipping of signal peaks occurs which generates in-band and out-of-band distortion.

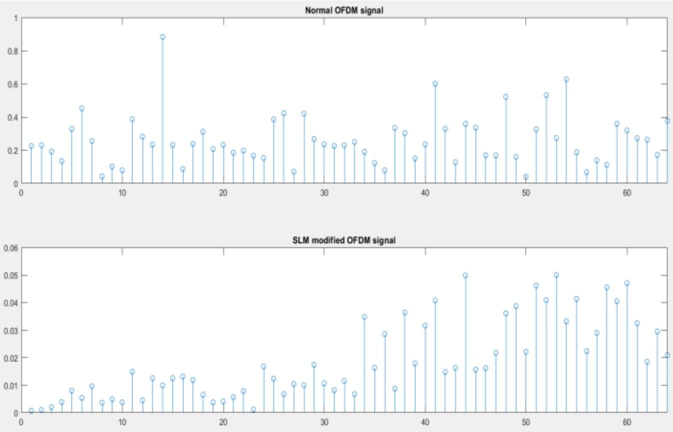
So, we should increase the dynamic range of the power amplifier to keep the operating point in the linear region which reduces efficiency and enhances the cost of the power amplifier. Hence, a trade-off exists between nonlinearity and efficiency. So, we should reduce PAPR value to improve the efficiency of the power amplifier.

3. PAPR Reduction Techniques

There are so many techniques presents for the reduction of PAPR. Some of the important PAPR reduction techniques are illustrated below:

4. Clipping and Filtering

This is one of the simplest technique used for PAPR reduction. Clipping[9] is a technique in which the amplitude of the input signal is limited to a predetermined value. Let x[n] represent input signal and xc[n] denote the clipped version of x[n], which can be expressed as



$$x_c[n] = \begin{cases} -A & x[n] \leq -A \\ x[n] & |x[n]| < A \\ A & x[n] \geq A \end{cases}$$

Where A is the clipping level. However, this technique has the following drawbacks:

Clipping causes signal distortion, which results in degradation of Bit Error Rateperformance.

Out-of-band radiation also occurs in clipping, which is responsible for interference between adjacent channels. Filtering can be used to reduce this out-of-band radiation.

Filtering of the clipped signal brings the peak re growth. That means the signal level may exceed the clipping level after filtering operation because of the clipping operation. So we came to know that distortion occurs during the transmission of data in clipping and filtering technique.

5. Active Constellation Extension (ACE)

ACE technique is similar to Tone Injection technique. According to this technique , some of the outer signal constellation points in the data block are dynamically extended towards the outside of the original constellation[11] such that PAPR of the data block is reduced. In this method also power increase of transmitted signal take place.

6. Companding

In Companding technique, we enlarge the small signals while compressing the large signals so that the immunity of small signals from noise will increase . This compression is carried out at the transmitter end after the output is taken from IFFT block. There are two types of companders: µ-law and A-law companders [11] Compression of the signal reduces high peaks, so in this way PAPR reduction of input signal take place. This is a simple and low complexitymethod for PAPR reduction.

IV. SIMULATION RESULTS

Simulation have done in MATLAB, The input and output waveform results shown in Figure 9,10,11.

Fig. 9 SLM Modified Output

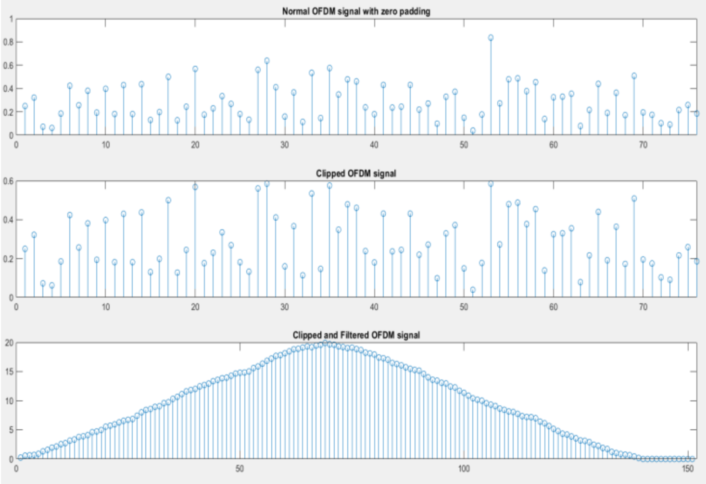


Fig 10 Clipping and Filtered OFDM Signal

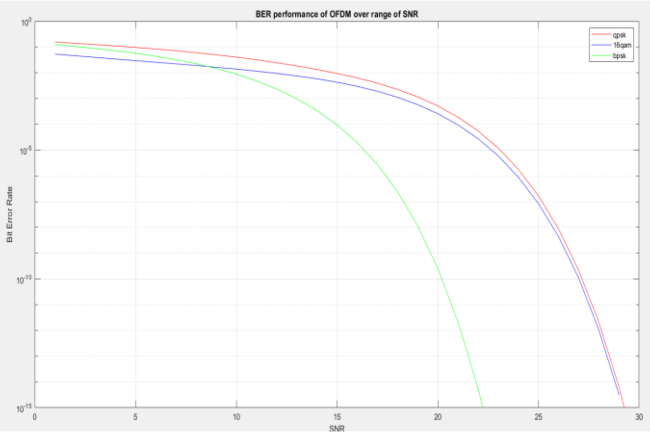


Fig 11 BER Performance OFDM Signal

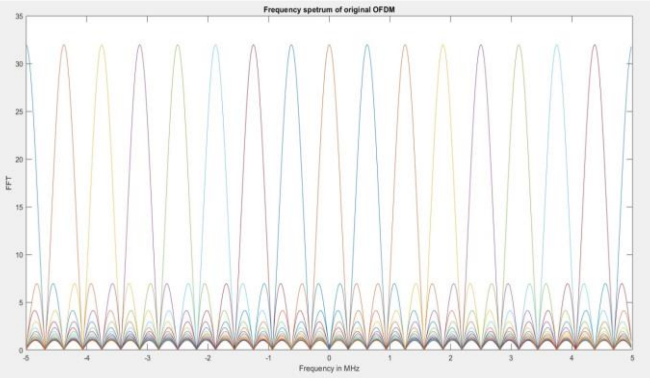


Fig 12 OFDM FFT samples

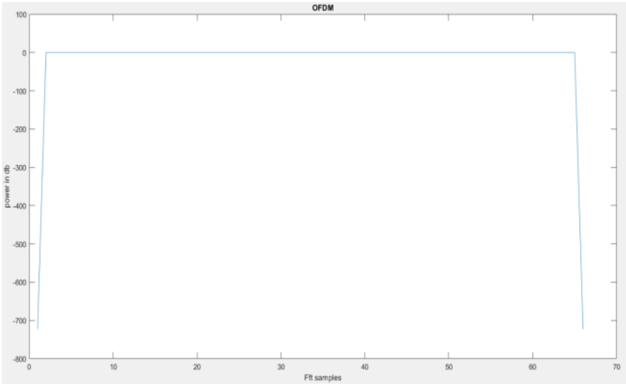


Fig 13 Frequency Spectrum of Original OFDM

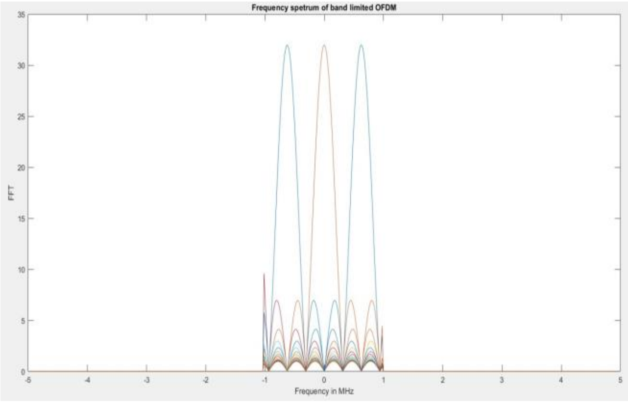


Fig 14 Frequency Spectrum of Sub band spectrum

CONCLUSION

FBMC is a promising waveform candidate for 5G technology which gives high spectral efficiency and low out of band radiation required for 5G communication. There are several PAPR reduction techniques proposed for mcm system. Tone injection and companding are two techniques for PAPR techniques. Here a combined scheme of these two techniques is proposed which gives significant PAPR performance improvement compared to those two techniques. Simulation is performed and results are plotted in the form of CCDF plot. Results shows that PAPR performance improves as we combine tone injection and companding techniques. FBMC is generated by using FMT and SMT methods, also 4-QAM and 16-QAM modulated input signals are used for simulation. Comparing the simulation results we can conclude that PAPR performance is almost same for FMT and SMT methods and there is a significant performance improvement as we increase the constellation size with normalization. Also a significant performance improvement is observed as we increase the constellation size with a normalization.

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