Low Complexity Adaptive Mapping PAPR Reduction Technique in OFDM Systems

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Abstract—Selective Mapping Technique(SLM) is commonly used to reduce the Peak to Average Power Ratio(PAPR) in Orthogonal Frequency Division Multiplexing (OFDM) systems. However SLM technique employs several Inverse Fast Fourier Transform (IFFT) operations which leads to computational complexity. This paper proposes adaptive mapping method involves in generation of appropriate phase sequences from input modulated signal and uses two IFFT and one FFT operation at the transmitter. MATLAB simulation results shows the performance of the proposed method is slightly inferior than that of conventional SLM however requires less number of IFFT operations and achieves less computational complexity

Keywords— Orthogonal Frequency Division Multiplexing (OFDM) , Peak to Average Power Ratio(PAPR), Selective Mapping Technique(SLM) , Fast Fourier Transform (IFFT) , Complimentary Cumulative Distribution Function (CCDF)

I INTRODUCTION

OFDM has been considered as an attractive multicarrier modulation technique for recent wireless communication systems such as LTE, WiMAX (Worldwide Interoperability for Microwave Access) etc., It provides spectral efficiency and robustness to channel interference and easy to implement by using Fourier Transform operation. However one of the drawback is high PAPR ratio of the transmitted signal. To reduce PAPR ratio of the transmitted signal many PAPR reduction techniques such as Clipping , SLM, PTS ,Tone reservation, Pre-coding techniques are proposed in the literature[1-3].

Selective mapping technique is a popular technique reduces PAPR ratio without distorting OFDM signal. SLM technique requires several IFFT operations thereby increases computational complexity. To reduce computational complexity there have been low complexity SLM PAPR techniques proposed in the literature[4-7] as mentioned below.

L. Yang *et al.,* proposed modified widely linear(MWL-SLM) scheme, through partition one complex signals into two real signals and combining the linear properties of the Fourier Transform, at most $4M^2$ candidate signals can be obtained but only require M IFFT operations.

Muhammad Ajmal Khan *et al.,* proposes a new low complexity PAPR reduction technique using biased subcarrier technique provides PAPR performance without degrading bit error performance.

L. Yang *et al.,* proposed a low complexity scheme by use of time domain sequence superposition technique where two IFFT operations performed can achieve similar performance as the conventional SLM scheme.

Generating the phasing sequence for SLM is an important task , Irukulapati *et al.,* proposed new phase sequence based on Riemann matrix for SLM method.

Proposed technique requires only two N point IFFT and One N point FFT at the transmitter reduces computational complexity.

II Selective Mapping Technique (SLM)

In selective mapping technique [8] as shown in Fig. 1 in which each input data block X=[X(0),X(1).......X(N-1)] is component wise multiplied with individual U phase sequences $B^u = [B^u_0, B^u_1, \dots\dots\dots B^u_{N-1}]^T$

where $B^u_v = e^{j\varphi^u_v}$ and $\varphi^u_v \in [0,2\pi]$ for v=0,1,......N-1 and u=1,2,....U

generates modified candidate signal

$$X^u = [X^u[0], X^u[1] \dots\dots X^u[N-1]]^T$$

All U phase rotated OFDM candidate signal represent the same information. Then time domain OFDM candidate signals are obtained by performing IFFT operation on each signal are $x^u = IFFT[X^u]$

Among all phase rotated candidate signal ,the one with lowest PAPR is selected and transmitted. Thus SLM requires U IFFT operations and information about the phase sequence need to be sent as side information to the receiver to recover the original signal. Therefore it requires $\log_2 U$ bits of side information.

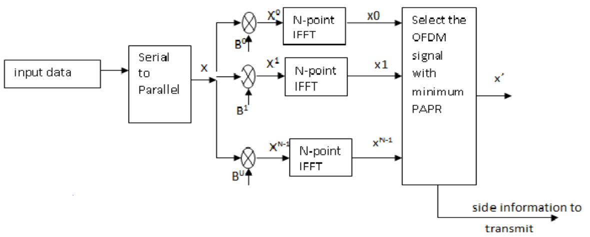

Fig.1 Block diagramof SLM Method

III Proposed adaptive mapping technique

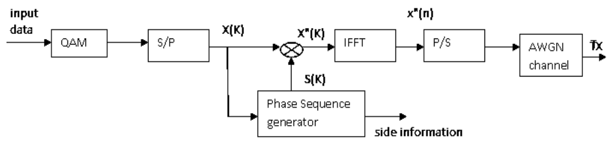

Fig.2 Block diagram of proposed adaptive mapping technique

The phase sequences for proposed approach is obtained from frequency domain modulated signal $X=[X_0,X_1,X_2$-----------$X_{N-1}]$ as $S=[S_0,S_1,S_2$----$S_{N-1}]$ where $S=e^{j(2n+1)\pi/4}$ and $n\in[0,3]$.The phase sequences are generated from phase sequence generator as shown in the Fig.2(a)

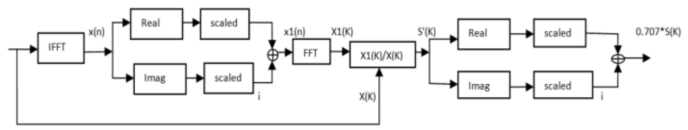

Fig.2(a) Block diagram of phase sequence generator

The proposed algorithm is as follows

Step 1:Partition the original time domain input data block x(n) into real and imaginary vectors and scaled to new set

$$x(n)=IFFT\{X(K)\} \quad (1)$$

where n =0,1,2,.....N-1 and X(K) mapped input data block $X(K)=[X_0,X_1,X_2$-----$X_{N-1}]$

$$x'(n)=\begin{cases}1 & real(x(n))\geq 0\\ -1 & real(x(n))<0\end{cases}$$

$$x''(n)=\begin{cases}1 & imag(x(n))\geq 0\\ -1 & imag(x(n))<0\end{cases}$$

$$x1(n)=x'(n)+ix''(n) \quad (2)$$

Step 2: Obtain the frequency domain complex vector X1(K) by performing FFT operation on equation (2)

$$X1(K)=FFT\{x1(n)\} \quad (3)$$

Step 3: Phase sequences of unit amplitude is obtained from component wise dividing the X1(K) by X(K)

$$S'(K)=X1(K)/X(K) \quad (4)$$

further the complex signal S'(K) partitioned into two vectors and scaled down version as follows

$$S_R=\begin{cases}1, real(S'(k))\geq 0\\ -1, real(S'(k))<0\end{cases}$$

$$S_I=\begin{cases}1, imag(S'(k))\geq 0\\ -1, imag(S'(k))<0\end{cases}$$

$$S(K)=\frac{1}{\sqrt{2}}\{S_R+iS_I\} \quad (5)$$

the phase sequences as set of $\{\pm 0.707 \pm 0.707j\}$ uniformly distributed over $[0,2\pi]$ as shown in Fig.2

Step 4: Each input data block of length N is multiplied by component wise with the phase sequences generating a new set of sequences as

$$X''(K)= X(K)*.S(K) \quad (6)$$

Step 5:Obtain the time domain signal x"(n) by performing N point IFFT operation as

$$x''(n)=IFFT\{X''(K)\} \quad (7)$$

and transmitted over the channel.

IV Simulation Results

Performance of proposed technique is evaluated using MATLAB. Complimentary Cumulative Distribution Function (CCDF) plots are the metrics used to evaluate PAPR performance.

The CCDF plots are obtained for 256 subcarriers of 16QAM modulated signal of 500 frames.

The number of phase selection for conventional SLM are m = 4,8 and 16 respectively compared with proposed technique. The Fig. [3-5] shows the performance of proposed technique is better than OFDM and comparable with SLM . The computational complexity of the proposed technique is less compared with that of SLM. PAPR for all the three methods at 10^{-4} are tabulated as shown in the Table 1. The SLM technique is practically difficult where as proposed can practically implemented easily. The BER performance and power spectral density as shown in Fig.6 and Fig. 7

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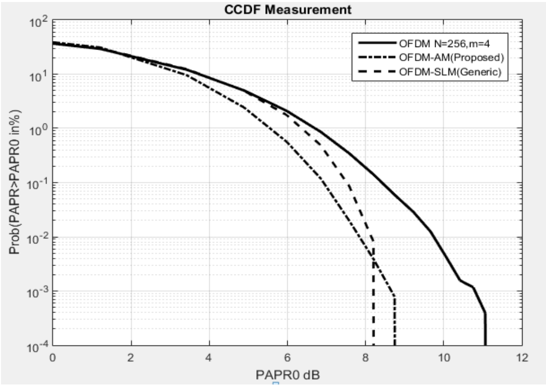

Fig.3 CCDF performance of proposed SLM and OFDM system for N=256,m=4

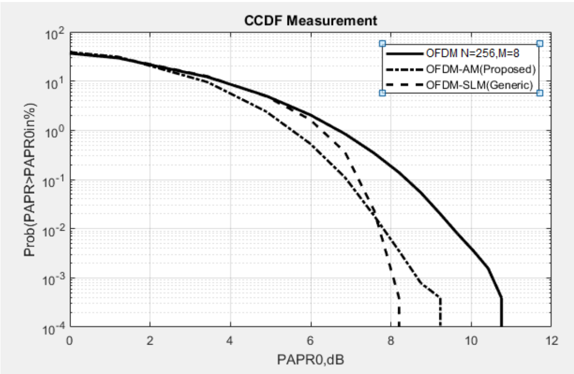

Fig.4 CCDF performance of proposed,SLM and OFDM system for N=256,m=8

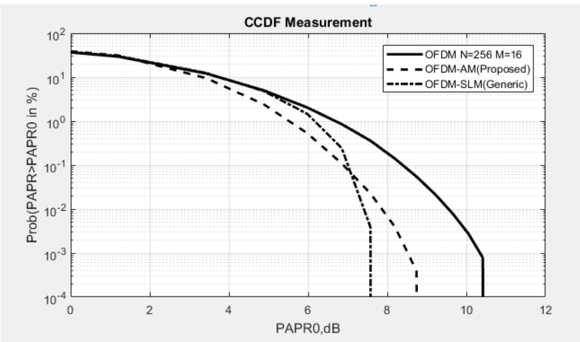

Fig.5 CCDF performance of proposed,SLM and OFDM system for N=256,m=16

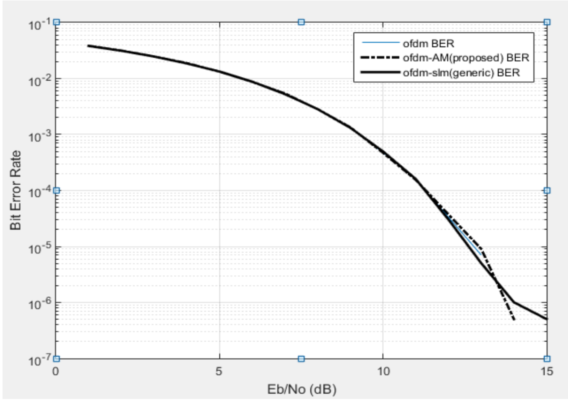

Fig.6 BER performance of proposed,SLM and OFDM system

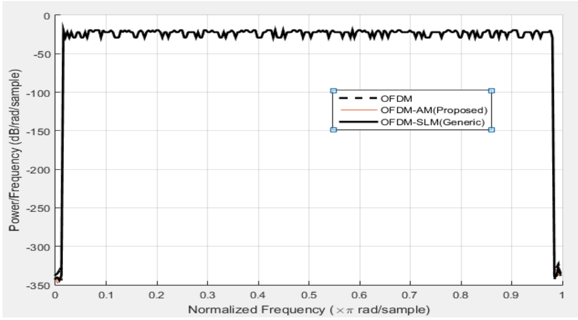

Fig.7 Power Spectral Density of proposed, SLM and OFDM system

Table.1 PAPR Performance of OFDM, Adaptive Mapping and SLM

No.of sub carriers N= 256 with m=4	PAPR (dB)
OFDM(conventional) OFDM (proposed Adaptive Mapping) OFDM - SLM (Generic)	11.1905861379766 8.85302582046171 8.40329669968082
No.of sub carriers N= 256 with m=8	PAPR (dB)
OFDM(conventional) OFDM (proposed Adaptive Mapping) OFDM - SLM (Generic)	10.4871517572708 8.75203649932610 7.93665767007991
No.of sub carriers N= 256 with m=16	PAPR (dB)
OFDM(conventional) OFDM (proposed Adaptive Mapping) OFDM - SLM (Generic)	10.8139282091960 8.58352666682509 7.62373180232027

V Conclusion

This paper proposed a low complexity adaptive mapping technique which includes a phase sequence generator and requires 2 IFFT operations and one FFT operations at the transmitter. The simulation results shows that performance of proposed technique is better than OFDM and comparable with that of SLM. The computational complexity is greatly reduced in the proposed system.

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