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Improved SLM Technique using Reiman matrix for PAPR Reduction of LTE-OFDM Networks

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Abstract—Orthogonal frequency division multiplexing (OFDM) is an attractive, promising and emerging technique which achieves high data rate in mobile multipath channels. LTE was the first technology to use OFDM. There are many more advantages of OFDM which includes immunity to multipath fading. High Peak to Average Power Ratio(PAPR) is the main disadvantage of OFDM-LTE Networks. This paper describes how PAPR is reduced by Selective Mapping Technique (SLM) and how we can improve SLM Technique using Reiman Matrix .
Keywords- PAPR, OFDM, CCDF, SLM

I. INTRODUCTION

OFDM is a powerful modulation technique being used in many new and emerging broadband communication systems, such as digitalaudiobroadcasting (DAB), high-definition television(HDTV),wirelesslocalarea network(IEEE802.11a and HIPERLAN/2) and Wimax (IEEE802.11). However, becauseOFDMsignals aremulticarrier signals that consist of many orthogonal subcarrierswithrandom phaseandamplitude, they havelargePAPRthatrequiresalinear high-power-amplifier(HPA)withanextremelyhighdynamicrange,whichis expensiveandinefficient. Furthermore, nonlinearity in amplifierproduces intermodulation products between different subcarriers and results in increased BER [1].

Various aaproacheshavebeenproposedtodealwiththePAPRproblem such as Clipping, RepeatedClipping-and-Filtering (RCF), Coding, CompandingTransformation, Interleaving, Activeconstellationextension (ACE), SelectiveMapping (SLM), Tone Reservation (TR), Partial Transmit Sequence(PTS),andsoon[1].The simplest scheme is Selective Mapping (SLM), which reduces thePAPRupto a sufficient level and limits the out-of band power to a low level , the computational complexity also very low.[3].In this technique data is been divided into several independent data blocks which contains same information as the original data block ,then among these converted symbols, one with lower PAPR is selected for transmission . Herebaseband transmission is assumed.

II. DEFINITIONOFOFDMSIGNALSANDPAPR

OFDM signal can be formed by ablockofNsymbols,{X_k,k=0,1,…,N-1},with each symbol modulating oneofasetofsubcarriers, $\{f_n, n = 0, 1, \ldots\ldots, N-1\}$withequalfrequencyseparation 1/T (required for the orthogonality of the subcarriers), whereTis theoriginalsymbolperiod. This can be simply done by inversediscreteFouriertransform (IDFT) for generatingthemulticarriersymbols. TheIDFTofvector $X[k] = [X_0, X_1, \ldots\ldots X_{N-1}]$ resultsinT/N spaceddiscretetimesignal$x[n] = [x_0, x_1, \ldots\ldots x_{N-1}]^T$. Thus, thetransmittedsignalis

$$x_n = \frac{1}{\sqrt{N}} \int_{k=0}^{N-1} \exp j \frac{2\pi kn}{N} \qquad 0 \le k \le N-1 \qquad (1)$$

The PAPRofthetransmittedsignal is the ratio of peak power to the average power of the signal and canbewrittenas[12]

$$PAPR = \frac{\max\limits_{0 \le n \le k-1} |x_n|^2}{E\{|x_n|^2\}} \qquad (2)$$

For analysis of PAPR reduction techniques the most widely used performance measure is Complementary Cumulative Distribution function (CCDF), which gives the probability that thatthePAPRof adatablockexceeds agiventhreshold z. TheCCDFof thePAPRof adatablockof N symbolswithNyquistratesamplingisderivedas

P(PAPR□z)□ 1□P(PAPR□z)□ 1□(1□e□z)^N
□ □ □

III. SLM TECHNIQUE

The classical SLM technique was described in [2]. According to this technique we generate phase sequences. The input sequences are multiplied by these phase sequences to obtain converted data sequences and then among these sequences PAPR is calculated for each sequence and then those with lower PAPR are transmitted.[2] The block diagram is shown below

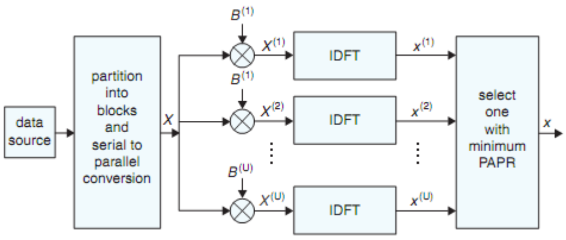

Figure1: Block diagram of SLM Technique[2]

Complexity in the above SLM technique is that because we are generating random phase sequences , so the converted data block has only those sequences which have lower PAPR which needs to be tracked by the receiver to identify those sequences which are sent .This information of sent data blocks is called SI index or side information which needs to be sent along with the information thereby reducing the data rate. This is the main disadvantage in classical SLM method.

IV. SIMULATION RESULTS USING PARAMETERS OF LTE WITH RIEMANN MATRIX

In this paper the side information which is sent to the receiver along with data symbols i.e converted data block is replaced by rows of Reimann Matrix [6] .which is obtained by removing the first row and first coloumn of the matrix A where

$$A(i,j) = i - 1 if i divides j$$
$$= -1 otherwise$$

□ □ □

If the Reimann Matrix (R) is of size M ×M .The entries in the normalised Reimann Matrix (B) will be $(1/M)R$[7]

We assume the transmission channel as a quasi-static frequency selective Rayleigh fading with equal power taps. We also assume the use of nonlinear solid state power amplifier (SSPA) [5] at the transmitter output.

The parameters of LTE that are to be used are given as follows:

$$N = Number of Data subcarriers = \{70, 720\}$$

$$CyclicPrefix = \begin{cases} round\left(\frac{N}{8}\right) for N = 70 \\ round\left(\frac{N}{32}\right) for N = 720 \end{cases} \quad (4)$$

The modulation schemes to be used for the simulation work are QPSK and 16 QAM.[7]
During the calculation of PAPR for the different data sub carriers used in LTE we have to consider the over sampling factor. As the actual data transmission is in Analog form but we are analyzing here in digital form. So to get perfect PAPR the oversampling factor is to be considered.

$$x(n) = \frac{1}{\sqrt{N_s}} \sum_{k=0}^{N-1} X(k) e^{\frac{j2\pi nk}{N}} \quad (5)$$

Where $x(n)$is the discrete time base band OFDM signal and $\frac{N_s}{N}$is the oversampling ratio. This is also known as the $N_s$point inverse fast Fourier transforms(IFFT). Here the power amplifier was considered before transmitting the OFDM signal having minimum PAPR. For the simulation model of power amplifier use Rapp's model of solid state power amplifier (SSPA) [5] with a smoothness parameter $p = 3$, small signal gain $v = 1$ and an input back off (IBO) of 7 db. For the channel assume $Z = 5$ equal power taps with time domain coefficient $h'_z$is a complex zero mean Gaussian sample representing the fading experienced by the zth tap. Also consider the noise to be added has mean □ $= 0$ and variance$\sigma^2 = N_0$, where N_0 denotes the power spectral density (PSD) of the additive white Gaussian noise (AWGN).[8]

So, the sequences are first mapped to constellation points depending upon the modulation used to produce symbol sequences and then these symbols are divided into data blocks same as the number of subcarriers say N. Then these subcarriers are multiplied by phase sequences generated by rows of Rimann matrix , symbols are transformed to time domain by IDFT ,selecting from the data block which has lower PAPR and then the information is sent.

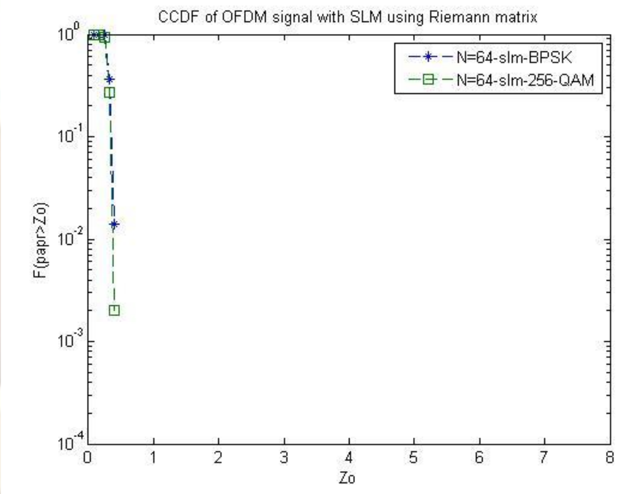

Figure 1 CCDF for the PAPR obtained using new SLM technique for the data subcarriers of LTE

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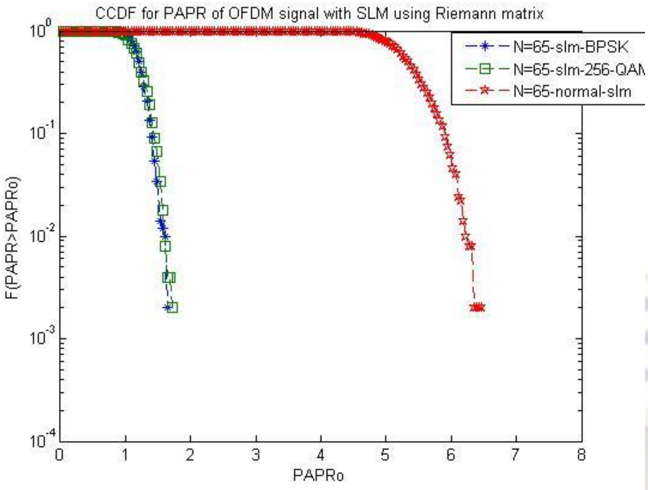

Figure 2CCDF for the PAPR comparison of SLM Technique with Reimann and Classical SLM Technique

V. CONCLUSION

In LTE our aim is to get high data rate simultaneously with a long range of communication. So by using the physical layer as OFDM we will get high data rate with decreasing of PAPR using SLM technique with Reimann Matrix. This technique not only reduces the PAPR of OFDM but also give increased data rates with no side information sent along with the information symbols.

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