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PAPR REDUCTION OF OFDM SIGNALS USING SELECTED MAPPING

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) has become the trendy modulation technique in high speed wireless communications. It is more advantageous over other technologies, but even though its advantages it has some disadvantages also. The high peak-to- average ratio (PAPR) is the main issue which causes non-linearity at the receiving end. The selected Mapping (SLM) technique is one of the advance PAPR reduction techniques for OFDM. In this paper, rows of normalized Riemann Matrix are selected as phase sequence vector for the Selected Mapping (SLM) Technique.

Keyword: Orthogonal Frequency Division Multiplexing (OFDM), Peak-To-Average Power Ratio (PAPR), Selected Mapping (SLM), Riemann Matrix

I INTRODUCTION

New methods for digital transmission have developed to meet up the increasing requirement for higher data rates in communications which can be used in both wired and wireless communication. To meet out the high spectral efficiency and high data rate, a proficient modulation scheme is to be employed [16]. A capable modulation technique that is gradually more used in the telecommunication field is Orthogonal Frequency Division Multiplexing (OFDM). Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is separated into multiple low rate data-streams and is modulated using sub- carriers which are orthogonal to each other [17].

OFDM is a striking technology because it offers high spectral efficiency, gives the immunity to multipath fading, and results in high data rate transmission. The OFDM produce high peak-to-average-power ratio (PAPR) signals as a consequence of the weighted summation of complex valued subcarrier symbols. This high PAPR is usually seen at some time instants when there is a coherent summation of individual subcarrier symbols [1].

The PAPR is the relation among the maximum powers of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. PAPR take place when in a multi- carrier system the different sub-carriers are out of phase with each other. When all the points achieve the maximum value at once; this will cause the output envelope to abruptly shoot up which causes a 'peak' in the output envelope [9].

When N equi-amplitude signals are added with the same phase, they produce a peak power that is N times the average power [8]. The peak power is define as the power of a sine wave with amplitude equal to the maximum envelope value. The PAPR of the transmit signal is defined as

$$\text{PAPR} = \frac{max\,|x(t)|^2}{E\{|x(t)|^2\}}, for\, 0 \leq t \leq NT$$

Where, E{.} denotes expectation operator and $E\{|x(t)|^2\}$ is average power of x(t) as well as T is an original symbol period.

As N increases peak power also increases, this shows that this peak power depends on the no. of carriers.

The happening of high PAPR increases design costs because it results in the need for higher precision analogue-to- digital (A/D) and digital-to-analogue (D/A) converters. Furthermore, large PAPR values usually lead to signal distortion due to the non-linear operation of power amplifiers (PA), and this may degrade system performance in the form of increased bit-error-rate (BER) [5].

In the OFDM transmitter, the linear power amplifiers are being used, so the Q-point must be in the linear region. Due to the high PAPR the Q-point moves to the saturation region thus the clipping of signal peaks takes place which produces in-band and out-of-band distortion. In-band distortion increases the BER at the receiver and Out-off-band distortion sources of spectral re-growth. So to keep the Q-point in the linear region the dynamic range of the power amplifier should be improved, but this decreases its efficiency and also increases the cost. So, our aim should be to decrease this PAPR [8].

Several OFDM PAPR reduction methods exist in the literature. These contains active constellation extension, signal clipping, selected mapping (SLM) [4] and partial transmit sequences (PTS). Between these techniques, SLM is considered the most efficient solution since it is conceptually better in terms of execution, and also offers better PAPR reduction performance compared with other techniques [8].

Table-1 Comparison of PAPR Reduction Techniques

Methods	Average Power increases	Computational complexity	Bandwidth expansion	BER degradation	Side Information
Clipping and filtering	No	Low	No	Yes	No
Coding	No	Low	Yes	No	No
PTS	No	High	Yes	No	Yes
SLM	No	High	Yes	No	Yes
TR	Yes	High	Yes	No	No
TI	Yes	High	Yes	No	No

In SLM, the phases of each complex-valued OFDM subcarrier symbol are modify to produce different signals using a number of phase rotation sequences. Each signal demonstration has a different PAPR level, and the one that has the minimum PAPR value is selected for transmission. The subsequent phase sequences that produce this selected signal may be recognized by what is generally organize as side information (SI) and its value must be known at the receiver, to enable successful reception of payload data. SI recognition may be achieved by transmitting the SI as part of the system's control signalling information, and then decoded at the receiver using a strong detection scheme. Unfortunately, SI transmission is an extra overhead, which reduces overall data throughput and spectral efficiency [8].

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To avoid unwanted effects of SI transmission in SLM- OFDM systems, SI evaluation at the receiver is shown to be possible in [18], without the need for SI transmission. However, these methods use some form of search algorithm that required the rebuilding or knowledge of all candidate phase rotation sequences at the receiver i.e. sequences must be deterministic. An example of accepted deterministic sequences is the Riemann matrix [4], which consists of real-valued (positive and negative) valued elements and as significance, results in severe BER when directly applied in SLM. This is because the direct application of these real-valued elements significantly decreases both the mean and the peak power of the signal. This is why elements of a Riemann matrix must be converted to their binary form using for illustration the signum function, to form what may be called Riemann-binary sequences, which generate 0 and π phase shifts, and give no BER degradation when used in SLM [8].

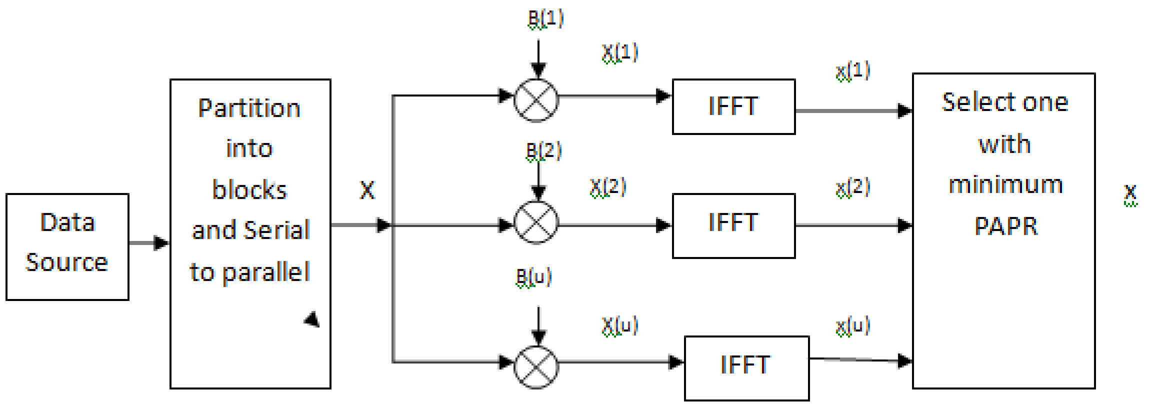

Fig. 1 Block Diagram of SLM

II. PROPOSED APPROACH

Riemann-binary sequences are derived from the rows of a Riemann matrix. This transformation is required because as the direct application of elements of each row in a Riemann matrix normally results in severe BER degradation.

To produce Riemann-binary sequences, a Riemann matrix is constructed as follows. For $1 \leq (i, j) \leq N+1$, let $\boldsymbol{A}(i, j)$ defines the element within the ith row and jth column of an arbitrary $(N+1)\times(N+1)$square matrix $\boldsymbol{A}$. Each (i, j) is computed as [4]

$$A(i,j) = \begin{cases} i-1 \, if \; i|j \\ 1 \, otherwise \end{cases}$$

From A (i, j), an$N \times N$ Riemann matrix $\boldsymbol{R}$ is derived by removing the first row and the first column of $\boldsymbol{A}$. Let (u, k) represent the element in uth row and kth column within a Riemann matrix $\boldsymbol{R}$. Then, if Riemann-binary sequences is the chosen source of SLM sequences, then the uth SLM sequence vector $\boldsymbol{B}u[k]$ is derived from $\boldsymbol{R}(u, k)$ as follows:

$$[k]=\text{sgn}\{\boldsymbol{R}(u, k)\}$$

Where sgn$\{\cdot\}$represents the signum function. In terms of computational requirements, the construction of U Riemann-binary sequence vectors requires NU multiplication and floating-point compare operations.

III. SIMULATION RESULTS

We used MATLAB simulations to calculate the performance of the different phase sequences for the SLM technique. As a performance measure, the complementary cumulative distribution function (CCDF) of the PAPR is used. The OFDM system with different no of subcarriers is simulated with 64-QAM modulation techniques.

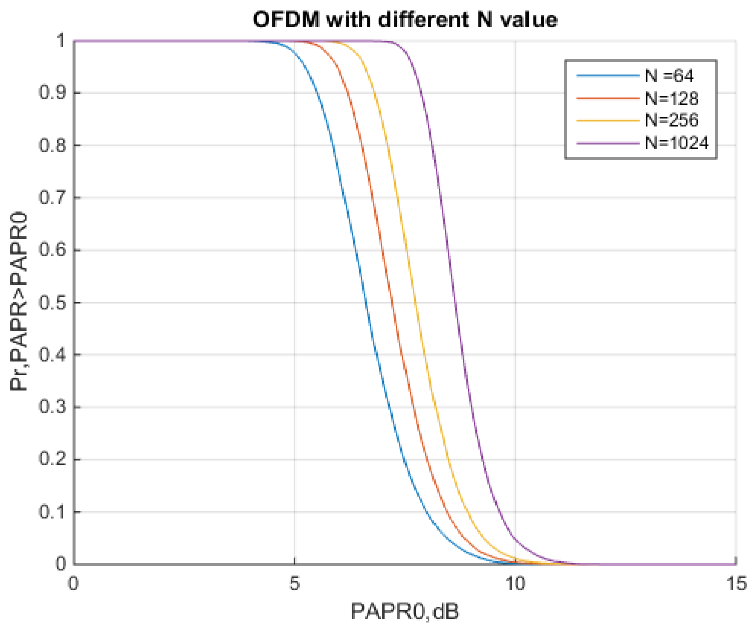

Figure-2: OFDM with Different N Values

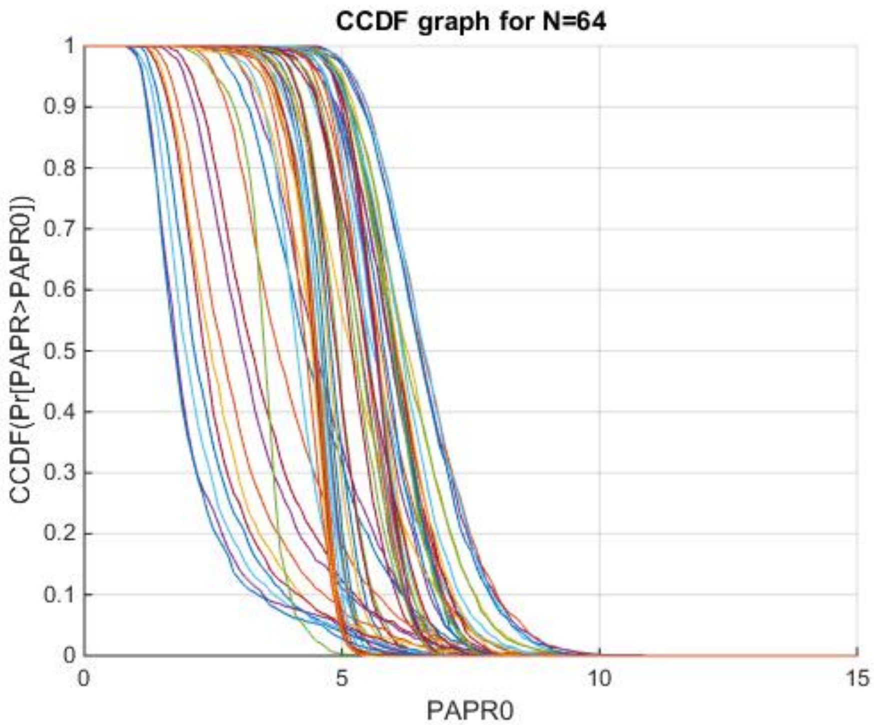

Figure-3: Figure shows variations in PAPR with different phase sequences obtained from the Riemann Matrix. The Minimum PAPR is achieved using the 61th row of the Riemann matrix in this case

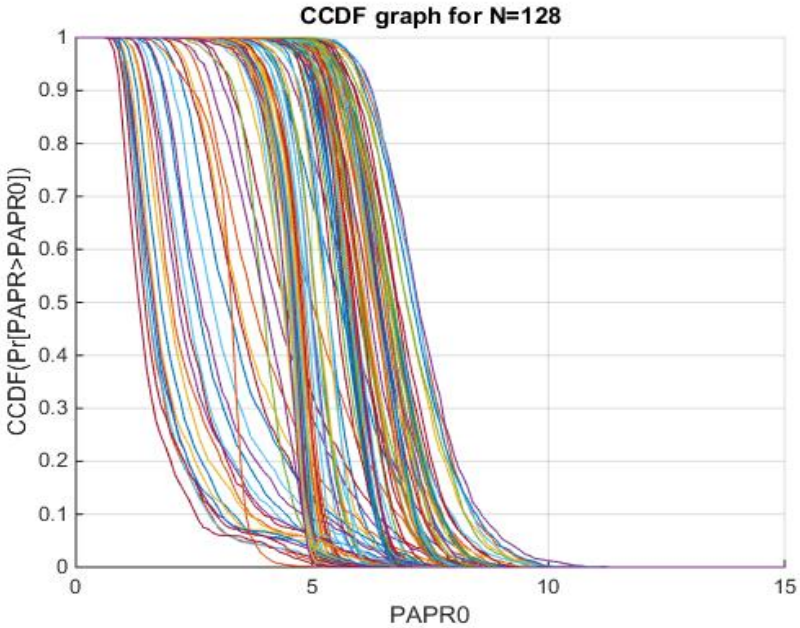

Figure-4: Figure shows variations in PAPR with different phase sequences obtained from the Riemann Matrix. The Minimum PAPR is achieved using the 1200th row of the Riemann matrix in this case.

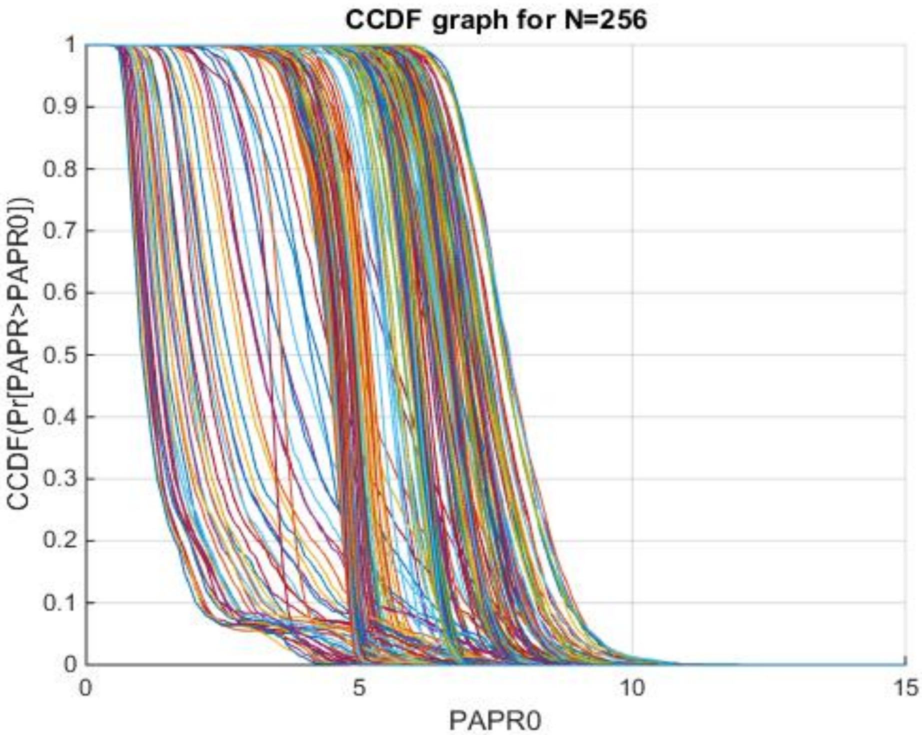

Figure-5: Figure shows variations in PAPR with different phase sequences obtained from the Riemann Matrix. The Minimum PAPR is achieved using the 240th row of the Riemann matrix in this case.

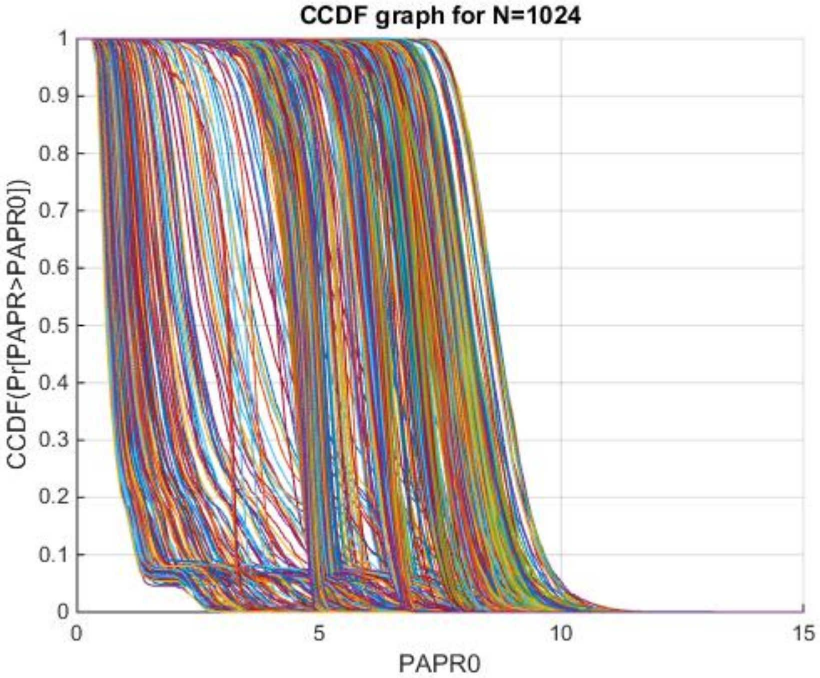

Figure-6: Figure shows variations in PAPR with different phase sequences obtained from the Riemann Matrix. The Minimum PAPR is achieved using the 1012th row of the Riemann matrix in this case.

IV. CONCLUSION

The evaluation of PAPR performance is done by CCDF graph. PAPR increases due to number of sub-carriers as shown in the simulation result in figure 2. Here we explored the Selected Mapping (SLM) technique and generated phase sequences by making use of the Riemann matrix. Results in figure (3, 4, 5, 6) demonstrate that the PAPR is much reduced by the help of the Riemann matrix.

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