

# Performance of SLM and TR method based on Efficiency for PAPR reduction in OFDM systems

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## Abstract

In this paper, we are focusing on the basic OFDM system performance w.r.t Signal-to- Noise Ratio (SNR), Bit Error Rate (BER) and throughput. Further, we have simulated the Peak-to-Average Power Ratio (PAPR), which is severe drawback of OFDM, with PAPR reduction methods such as Selected Mapping (SLM) and Tone Reservation (TR) [1]. We have compared SLM and TR methods on the basis of CCDF and Transmitted Power Efficiency. The simulation results are based on Cumulative Complementary Distribution Function (CCDF) parameter along with the transmitted power efficiency [2]. From the simulation results we can say that the reduction in PAPR through SLM is better than TR as well as the SLM shows outstanding efficiency during this simulation.

**Keywords:** OFDM, BER, PAPR, Tone Reservation, Selected Mapping, Transmission Efficiency.

## Introduction

Orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments.

The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization. Multipath generates two effects: frequency selective fading and inter-symbol interference (ISI). The most important disadvantage of OFDM systems is that highly linear RF amplifiers are needed. When N signals are added with the same phase, they produce a peak power that is N times the average power. In order to avoid nonlinear distortion, highly linear amplifiers are required which cause a severe reduction in power efficiency [1]. In order to reduce PAPR, we have proposed Selected Mapping (SLM) [3] and Tone Reservation (TR) [4][5] methods.

## Throughput Performance of OFDM System

The OFDM throughput simulation is shown in Fig.1. We can see that throughput of QPSK is having overall higher throughput. By observing the simulation results of higher modulation schemes, we have considered QPSK modulation method for the further simulation.

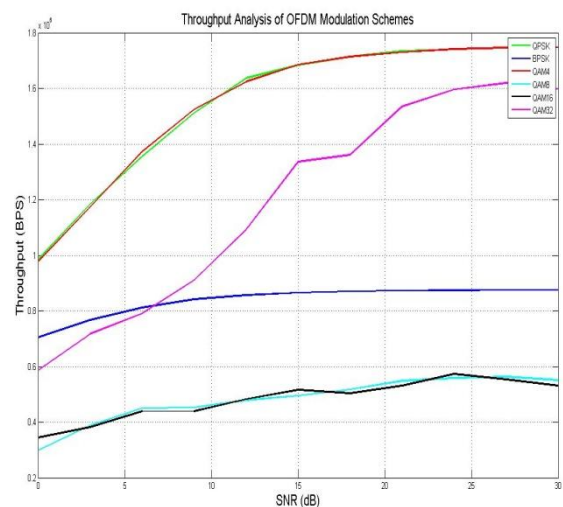


Figure 1: Throughput Performance of OFDM Schemes

## Peak-to-Average Power Ratio

The Peak-to-Average Power Ratio is the result of the variations of high peaks of the sub-carriers in OFDM spectrum. A large PAPR increases the complexity of the analog-to-digital and digital-to-analog converter and reduces the efficiency of the radio – frequency (RF) power amplifier. Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system [1].

The PAPR is defined as

$$\frac{\max_{0 \leq t < NT} |x(t)|^2}{1/NT \int_0^{NT} |x(t)|^2 dt}$$

### Selected Mapping

The basic Selected Mapping (SLM) technique is to generate a set of data blocks at the transmitter end which represent the original information and then to choose the most favourable block among them for transmission. The input data sequences are multiplied by each of the phase sequences to generate alternative input symbol sequences. Each of these alternative input data sequences is made the Fast Fourier Transform (FFT) operation and then the one with the lowest PAPR is selected for transmission [1][3].

### Tone Reservation

Here we propose a Tone Reservation (TR) method to reduce PAPR in OFDM systems. This method includes the reservation of the small number of sub-channels (tones), which do not carry information data and are reserved for peak cancellation.

This restricts the data –bearing vector, and the reserved tone vector to lie in disjoint frequency subspaces, i.e., they cannot both be non-zero at given tone. The addition of these reserved tones to a data-bearing signal results in a new composite signal. Since symbol demodulation is performed in the frequency domain on a tone-by-tone basis, the reserved sub-channels can be discarded at the receiver, and only the data-bearing sub-channels are used to determine the transmitted bit stream [4][5].

### Simulation Results

We have simulated SLM and TR methods by considering CCDF and Power Efficiency parameters. Further, the following parameters of OFDM system are taken into account for simulation. Table 1 shows considered parameters for SLM and Table 2 shows considered parameters for TR.

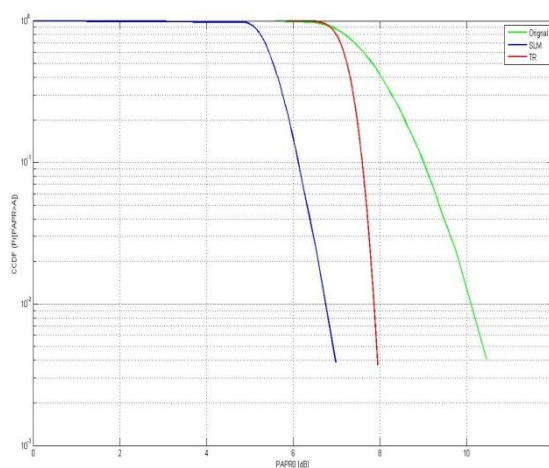
<b>FFT SIZE</b>	64
<b>CHANNEL LENGTH</b>	16
<b>SAMPLE RATE</b>	4
<b>MODULATION</b>	QPSK
<b>PHASE VECTOR SET</b>	1, -1, 1j, -1j
<b>MAXIMUM SYMBLOS</b>	1e5

**Table 1. Parameters Considered for Selected Mapping**

<b>FFT SIZE</b>	64
<b>MODULATION</b>	QPSK
<b>MAXIMUM SYMBLOS</b>	1e5
<b>TOTAL SUB-CARRIERS</b>	128
<b>RESERVED TONES</b>	30, 40, 50

**Table 2. Parameters Considered for Tone Reservation**

The simulation of our proposed work is done by taking above parameters into picture. As shown below, Fig. 3 shows the CCDF based a result which helps in observing the particular reduction in PAPR. From Fig. 2, we say that the reduction in PAPR by SLM is more than that of TR. i.e the SLM reduces PAPR value up to 37% more than TR.



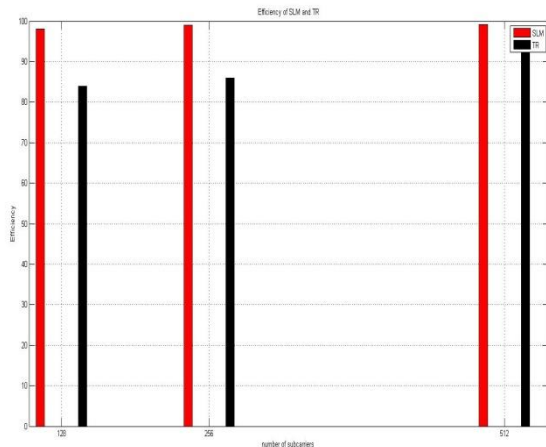
**Fig. 2 Combined CCDF Performances of SLM and TR**

The obtained values for PAPR are shown in Table. 3

<b>Original Value of PAPR</b>	10.81 dB
<b>PAPR reduction due to SLM</b>	7.54 dB
<b>PAPR reduction due to TR</b>	7.91 dB

**Table 3. Obtained Results of PAPR for SLM and TR**

Secondly, our further simulation is based on transmission efficiency parameter. The simulation results in Fig. 3 show that SLM has tremendous percentage of efficiency than TR. But, as the number of sub-carriers increases, the TR efficiency nearly equals the SLM.



**Fig. 3 Obtained Efficiency of SLM and TR**

Number of Sub-Carriers	Power Efficiency for SLM	Power Efficiency for TR
128	96%	85%
256	98%	87%
512	98%	93%

**Table 4. Operational Efficiency of SLM & TR**

Table 4 shows the actual performance in terms of efficiency of Selected Mapping and Tone Reservation methods for different number of sub-carriers. As the number of sub-carriers increases, Tone Reservation shows better power efficiency. But, for all the considered sub-carriers, Selected Mapping is best responsive.

**Conclusion**

OFDM is the best solution for high speed requirement. But, on the other hand, the drawback of OFDM system is high value of PAPR. In this paper, we have simulated PAPR reduction techniques, Selected Mapping and Tone Reservation. The simulation is done on the basis of CCDF and Transmission Efficiency. As well as, we have studied the behavior of various OFDM modulation schemes w.r.t throughput. From the simulations of OFDM, we have considered the QPSK modulation for our simulation. The simulation results shows that SLM method reduces the PAPR value up to 37% than that of TR. Furthermore, calculations of operational efficiency of both the methods are showing that SLM outperforms better in case of PAPR reduction and Transmitter Efficiency.

**References**

- [1] Nicola Marchetti, Muhammad ImadurRahman, Sanjay Kumar and Ramjee Prasad, “ OFDM – Principles and Challenges”, 2009.
- [2] Tao Jiang, Member, IEEE and Yiyang Wu, Fellow, IEEE, “An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals”, *IEEE Transactions Broadcast*, Vol.54, No.2, pp. 257-268, June 2008
- [3] R.W.Bauml, R.F.H. Fischer and J.B. Huber, “Reducing the peak-to-average power ratio of multicarrier modulation by selected mapping”, *Electronic Letters*, Vol. 32, No. 22, 24October, 1996.
- [4] Kangwoo Park and In-Cheol Park, “Low-Complexity Tone Reservation for PAPR Reduction in OFDM Communication Systems”, *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, Vol.20, No.10, October 2012
- [5] S. Janaaththan, C. Kasparis, and Barry G. Evans, “A Gradient Based Algorithm for PAPR Reduction of OFDM using Tone Reservation Technique”.