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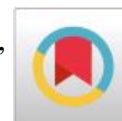
## A REVIEW OF NOVEL APPROACH FOR REDUCTION IN SUB CARRIER PEAK TO AVERAGE POWER RATIO IN ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

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### Abstract:

*In last few decades the demand for multimedia data services has grown up fastly. One of the most promising multicarrier system, Orthogonal Frequency Division Multiplexing (OFDM) allow large number of capacity the number of subcarriers, high data rates and ubiquitous coverage with high mobility. But OFDM is extensively affected by peak to average power ratio (PAPR). Unfortunately, the high PAPR inherent to OFDM signal envelopes will frequently drive high power amplifiers (HPAs) which are operate in the nonlinear region. The nonlinearity of the High Power Amplifier exhibits phase and amplitude distortions, which causes loss of orthogonality between the subcarriers; also (ICI) is introduced in the source signal. This dissertation is basically focused on PAPR reduction in OFDM system and measuring BER in different Modulation Technique. In PAPR reduction Signal companding methods have low complication, high distortion and spectral properties; however, we have limited PAPR reduction capabilities. Partial transmit sequences (PTS) and selected mapping (SLM), have also been considered for PAPR reduction. Such kind of techniques are very efficient and distortion less, Also the SLM is very good technique to the PAPR problem in single carrier system. This method has low complexity as well as it is data independent.*

*In this paper, we are describing a combine technique of SLM and PTS to minimize the PAPR. In PTS scheme, number of sub blocks increases; the IFFT block to be performed for sub blocks also increases. Simulation results have shown that the reductions of PAPR of proposed scheme is more than PTS and SLM methods as well as the difficulty reduced considerably.*

**Keywords:** OFDM (Orthogonal Frequency Division Multiplexing); PTS (Partial Transmit Sequences); ADSL (Asynchronous Digital Subscriber Line); BASK (Binary Amplitude Shift Keying); IFFT (Inverse Fast Fourier Transform); BFSK (Binary Frequency Shift Keying).

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## 1. Introduction

The numbers of mobile users are increasing incredibly in the recent years. Users requirement have grown extensively not just to voice calls but also data calls, video and internet over the mobile devices. The requirement for multimedia data services has grown up rapidly which drives us in the current.

The Orthogonal Frequency Division Multiplexing (OFDM) [9] forms basis for all 4<sup>th</sup> generation wireless communication systems due to its maximum capacity in terms of number of their subcarriers, high data rate at least 100 Mbps and provide more coverage with high mobility. Single carrier systems can increase their data rate by decreasing the symbol time, hereby, increasing the occupied bandwidth. Wideband channels are more responsive to frequency selective fading which require complex equalizers in the receiver to receive the original signal. OFDM overcomes such kind of problem by isolating the wideband channel into a series of narrowband channels causes flat fading. The modern digital multicarrier wireless communication system gives high speed data rate at lowest cost for many users as well as with high reliability. Now currently LTE Advanced is a part of the fourth generation (4G) of mobile communication technology. Still this technology that led to the improvement of LTE Advanced includes WiMAX, WCDMA, and CDMA2000.

Even though OFDM having many advantages but it still suffers from some limitations such as sensitivity to carrier frequency offset and a large Peak to Average Power Ratio (PAPR). The large PAPR is due to the superposition of  $N$  independent equally spaced subcarriers at the output of the Inverse Fast Fourier Transform (IFFT) in the transmitter. A large PAPR is a problem as it requires increased complexity in the word length at the output of the IFFT.

OFDM overcome such problem by the use of following methods. The methods are described below.

## 2. Techniques Use

### 2.1. Companding Techniques

Companding is another popular PAPR reduction scheme. Companding is a composite word formed by combining compressing and expanding. In this scheme, at the transmitter a signal with high dynamic range is applied to a compander and at the receiver a de-companding function (the inverse of companding function) is used to recover the original signal. Initially, it was used in digital communication systems to increase the dynamic range of digital to analog converters (DACs).

The  $\mu$ -law and A-law are the two most popular compressing functions used worldwide. According to Wang *et al.* proposed a scheme a  $\mu$ -law companding scheme to reduce the PAPR of OFDM signal.

$$\hat{x}(n) = \begin{cases} \frac{\mu x(n)}{1 + \ln(\mu)} & |x(n)| \leq \frac{A}{\mu} \\ \frac{A + A \ln\left(\frac{\mu x(n)}{A}\right)}{1 + \ln(\mu)} & |x(n)| > A \end{cases}$$

The  $\mu$  law companding techniques to reduce PAPR with low complexity. In this method, the PAPR of OFDM signals is reduced by increasing the average power of signals while keeping the peak unchanged, but this reduction in PAPR is very limited under certain BER performance constraints Where  $x(n)$  and  $\hat{x}(n)$  is the original and commanded OFDM signal respectively.

### 2.2. B. PTS Technique

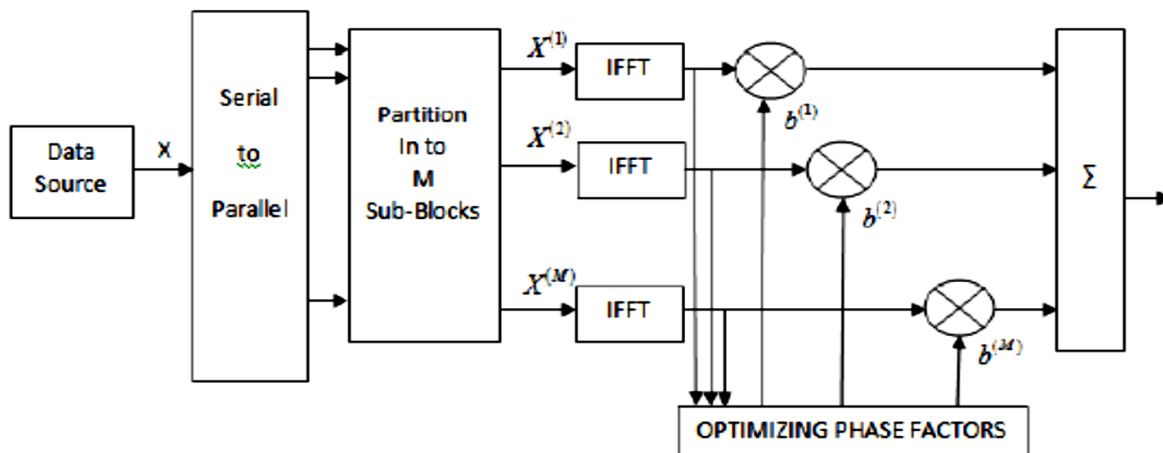
Partial Transmit sequence is basically good technique for reducing peak to average power ratio which is shown in the below diagram. The input data X is classified into M different sub-blocks. The phase factor of subcarriers are weighted that each sub-block. The phase factors are elected that the PAPR of the collected signal is minimized. Below equation are shows that the classification of input data and M different sub block.

$$X^{(m)} = [X_0^{(m)}, X_1^{(m)}, X_2^{(m)}, \dots, X_{N-1}^{(m)}], m = 1, 2, \dots, M$$

The sum of all the sub-blocks constitutes the original signal, by reducing equation when subcarrier which is exiting in other sub block must be zero.

$$X = \sum_{m=1}^M X^{(m)}$$

There are three sub-block partition techniques, namely adjacent partition, interleaved partition, and random partition. The random partition technique is the best choice for PAPR reduction, whereas the interleaved partition has the worst PAPR reduction performance.



The IFFT of has to be multiplied with phase factor, if phase rotation factors have non-zero real and imaginary parts then it requires  $SN$  additional complex multiplications, which will further increase the computation complexity of the PTS scheme. In order to reduce the computational complexity incurred in the computation of  $x$  'phase factor should be pure rotational.

### 2.3. SLM Technique

The probability of PAPR larger than a threshold  $z$  can be written as  $(PAPR > z) = 1 - (1 - \exp -z)$ . Assuming that  $M$  OFDM symbols carry the same information and that they are statistically independent of each other. In this case, the probability of PAPR greater than  $z$  is equals to the product of each independent candidates probability. This process can be written as

$$P_{PAPR_{low} > z} = (P_{PAPR > z})^M = (1 - \exp(-z))^M$$

In selected mapping method, firstly  $M$  statistically independent sequences which represent the same information are generated, and next, the resulting  $M$  statistically independent data blocks  $S_m = [S_{m,0}, S_{m,1}, \dots, S_{m,N-1}]T$ ,  $m=1,2,\dots,M$  are then forwarded into IFFT operation simultaneously.

Finally, at the receiving end, OFDM symbols  $x_m = [x_1, 2, \dots,]T$  in discrete time-domain are acquired, and then the PAPR of these  $M$  vectors are calculated separately. Eventually, the sequences  $x_d$  with the smallest PAPR will be elected for final serial transmission. Fig.1 illustrates the basic structure of selected mapping method for suppressing the high PAPR. This method can significantly improve the PAPR performance of OFDM system. The reasons behind that are: Data blocks  $S_m = [S_{m,0}, S_{m,1}, \dots, S_{m,N-1}]T$ ,  $m=1,2,\dots,M$  are statistical independent, assuming that for a single OFDM symbol, the CCDF probability of PAPR larger than a threshold is equals to  $p$ . The general probability of PAPR larger than a threshold for  $k$  OFDM symbols can be expressed as  $p^k$ .

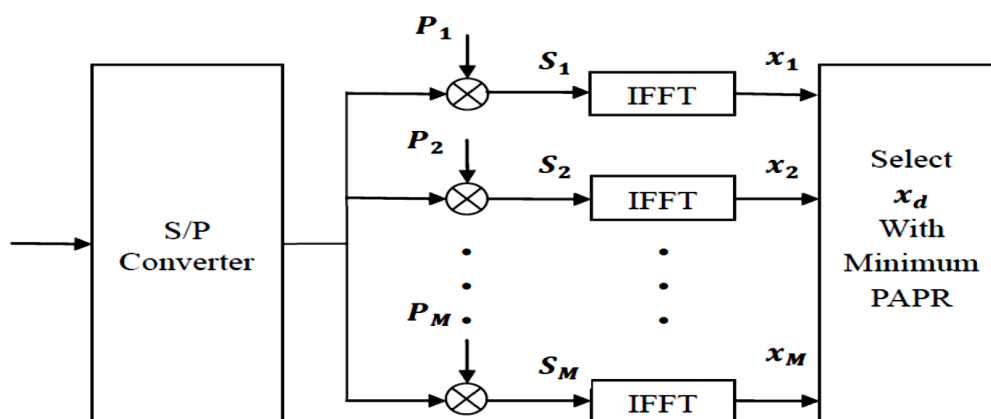


Figure 1: The diagram of proposed scheme

It can be verified that the new probability obtained by SLM algorithm is much smaller compared to the former. Data blocks  $S_m$  are obtained by multiplying the original sequence with  $M$  uncorrelated sequence  $P_m$ .

### 3. Related Work

#### 3.1. Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal Frequency DM systems is continuously developing and in decade it developed most, particularly in European country where various projects and prototypes were initiated such as System de Television En Radio diffusion Numerique (STERNE), digital Terrestrial Television broadcasting (dTTb), etc. This made European standard to accept OFDM. Dispersive channels problem is removed by OFDM, but there are few more problem like time interval and frequency selective, fading frequency synchronization, and the Peak to Average Power Ratio (PAPR).

Now a day's OFDM has developed to such a point where it has now been used for various communication applications such as Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB) in European Countries. For wireless networking physical layer modulation is considered which follow two standards IEEE agronomy of Institute of Electrical and Electronic Engineers 802.11a (in United States), Hiperlan2 (in Europe). OFDM takes its place in the next generation of communication systems because of its high data rates and low complexity. Coded OFDM (COFDM) is a practical form of OFDM where redundant bits are inserted into the bit stream at the transmitter. These specially chosen bits allow powerful error correction codes in the receiver to reduce the BER. The more bits used for error correction the better the error correction properties; however the useful data rate is decreased.

Types of error correction codes used for example DAB-OFDM are Trellis Coded Modulation (TCM) combined with frequency and time interleaving. In practice all the following technologies use some form of COFDM.

#### 3.2. Digital Audio Broadcasting

Digital Audio Broadcasting (DAB) using OFDM has been standardized in Europe and is the next step in evolution beyond FM radio broadcasting providing interference free transmission. The standard for DAB is known as Eureka-147 and is a multi-service digital broadcasting method transmitting at around 1.5Mbps in the 1.536 MHz band. In DAB between 192 and 1536 carriers are used with Differential Quadrature Phase Shift Keying (DQPSK), which allows the system to avoid channel estimation techniques.

The very long symbol time means that large echoes can be tolerated and that the redundancy due to the CP is not that great. Large echoes are expected as the broadcasting is over large distances so that long delay paths will be present. The PAPR is a problem but as DAB only uses DQPSK modulation it is more impervious to noise generated through saturation of the amplifier. The DAB data payload contains audio, data associated with audio, and other optional data services.

Table 1: displays system parameters for DAB. [16]

Parameters	Mode		
	I	II	III
Application	SFN	Terrestrial	Satellite
Modulation	DQPSK	DQPSK	DQPSK

<b>Total number of subcarriers</b>	1536	384	192
<b>OFDM symbol duration</b>	1246 $\mu$ S	312 $\mu$ S	156 $\mu$ S
<b>Guard interval</b>	246 $\mu$ S	62 $\mu$ S	31 $\mu$ S
<b>Frequency range</b>	$\leq 375$ MHz	$\leq 1.5$ GHz	$\leq 3$ GHz

### 3.3. Bit Error Rate (BER)

In this we discuss BER acronym of Bit Error Ratio or Bit Error Rate is defined as the number of bit errors divided by the total number of transferring bits during a studied time interval. Usually we define BER one unit less than it's presented, and it is measured in percentage.

$$BER = \frac{\text{No. of bit errors recieved}}{\text{Total number of bits transmitted}}$$

### 3.4. Signals-To-Noise Ratio (SNR)

SNR or S/N is acronym of Signal to noise ratio which is a measured by the comparison of the level of a desired signal to the level of background noise. It is also defined as the ratio of signal power to the noise power.

Usually SNR is measured in decibels (dB). When the SNR is greater than 0 db or higher than 1:1 that indicate less noise and more signal.

$$SNR = \frac{P_{signal}}{P_{noise}}$$

Here  $P_{signal}$  is power ratio and  $P_{noise}$  is considered as background noise.

## 4. System Model and Simulation

To simulate the OFDM system a MATLAB test bench is created and simulated the BER performance with following parameters. In this chapter the performance of OFDM system over different Modulation Scheme has been observed. The analysis is based on the study of comparing Bit Error Rate (BER) and Signal to Noise Ratio (SNR) in Rayleigh channel, also PAPR Reduction Technique are Introduced. The comparative BER performance with different level for QUADRATURE AMPLITUDE MODULATION and PAPR for different modulation schemes.

### 4.1. Ber VS Snr Performance for Bpsk Modulation in Rayleigh CHANNEL

OFDM has been simulated under Rayleigh channel for BPSK Modulation technique. The BER vs SNR graph is plotted.

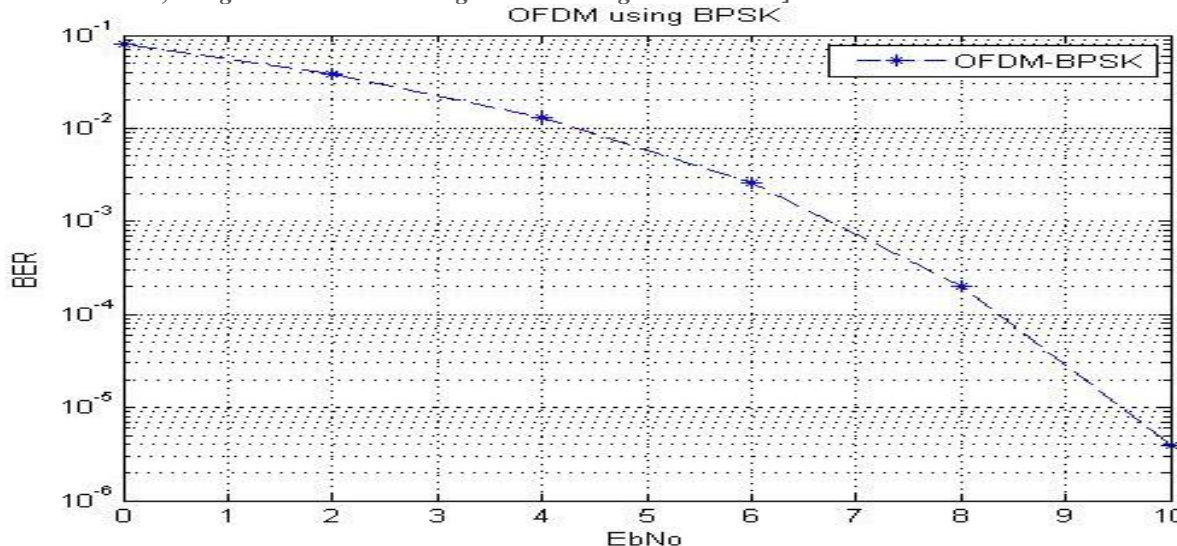


Figure 2: BER v/s SNR graph for BPSK modulation in Rayleigh communication link

The above simulation graph shows the performance analysis of BPSK modulation technique in OFDM.

The X axis indicates the SNR value and Y axis is the logarithmic representation of BER. When SNR value is 2 then BER is 0.038. As we increase the value of SNR to 10, we found a huge drop in BER ratio i.e. 0.0000384. Hence as we increase the SNR then BER reduces and at log scale of  $10^{-5.4}$ , it becomes 0.

Table 2. Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for BPSK modulation Technique.

Table 2: BER performance for BPSK modulation [11]

Signal-to-Noise Ratio (in dB)	BER
0	0.0804211538461539
2	0.0387692307692308
4	0.0128923076923077
6	0.00259807692307692
8	0.000201923076923077
10	3.84615384615385 e <sup>-0.6</sup>
12	0

For 0db SNR the BER is 0.0804211538461539 & for 12 db SNR, BER is 0 and it is found that there is a huge drop in BER ratio.

#### 4.2. $\mu$ Law Companding

The  $\mu$  law is the most popular compressing function used. In this technique we reduce PAPR of OFDM Signal. Time Domain OFDM signal  $[x(n)]$  is applied to a  $\mu$  compressor to produce a companded OFDM signal.

The X axis indicates the PAPR value and Y axis is the logarithmic representation of CCDF.

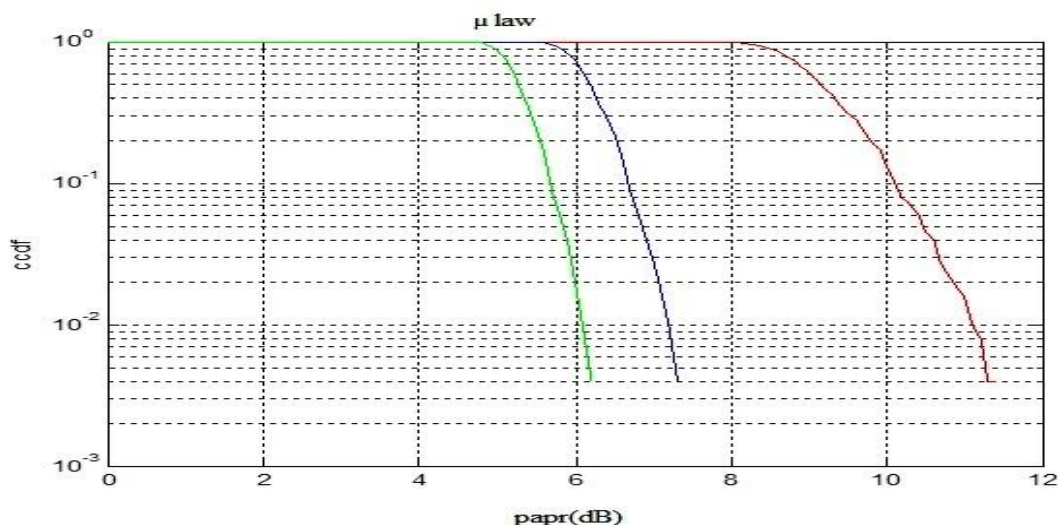


Figure 3: PAPR vs. CCDF in  $\mu$  LAW COMPANDING [5]

## 5. Conclusion and Discussion

The work is undertaken in this thesis firstly discusses the OFDM system and fading channel. The implementation of OFDM model is presented with the analysis of the capabilities of OFDM in Rayleigh fading channel. The simulation uses MATLAB and the effect of different modulation schemes has been evaluated over OFDM system.

On comparing the variations of the BER for different SNR in the MATLAB simulation, it is observed that the PAPR value for different modulation schemes and it is found that the 64-QAM modulation scheme shows lowest PAPR while the BPSK scheme shows the largest PAPR among all systems.

Finally it is concluded that the OFDM system with BPSK scheme is suitable for low capacity short distance applications. While the OFDM with QAM modulation techniques are useful for large capacity and long distance applications which slightly increase the BER.

The OFDM promises to be a suitable multiplexing technique for high capacity wireless communication application.

### 5.1. Scope of Further Research

- 1) The future aspect easily takes modified values of different parameters and simulate according to low power consumption and low BER which is the key technology for further 4G applications.
- 2) Design of optimal Power with minimum interference power may be tried to provide further improvement in performance.



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