Lossy Source Coding Method for Paper Reduction in Bpsk Ofdm

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Abstract: OFDM has been considered as the advanced modulation technique to provide higher data rate with several advantages like high spectral efficiency and is most widely used modulation technique in the fourth generation wireless communication. Besides the advantages of the OFDM there are several disadvantages like high Peak to Average power ratio and the Inter carrier Interference. Based on the survey several papers are published in the area by several researchers. In this paper an effort has been made to reduce the Peak to average power ratio. In this work, a new Lossy coding method has been proposed to overcome the drawback of PAPR and the simulation results of the same have been discussed. The proposed method lies in the signal distortion category and hence the Bit error rate also been taken into consideration and has been discussed.

Keywords – BER; BPSK; OFDM; PAPR; Symbol length

I. INTRODUCTION

With the rapid growth in the field of Telecommunication, there is a huge demand for the higher data rate and spectral efficiency. Hence advanced modulation techniques are necessary to provide higher data rate. Orthogonal frequency division multiplexing is a modulation technique in which a large bandwidth will be subdivided into smaller bandwidths and each of these smaller bandwidths are modulated based on the variations in the frequencies . This means that the entire cycle of the OFDM lies within the same symbol period and their contribution to the interference will be zero [1]. There are several advantages of the OFDM techniques. The spectrum can be utilized effectively due to the overlapping of the signals in an OFDM [2]. The cyclic prefix in an OFDM will introduce a guard interval between the signals. This will reduce the interference of the different signals and can easily demodulate the signals [3].

There are several disadvantages of OFDM symbols. One such is Peak to average power ratio. PAPR results in the high peak values. Due to this high peak value, in a very large region we need to operate the power amplifiers. Otherwise, signal distortion will take place allowing the peaks of the signal to enter the non- linear region. Due to this high peak value at the transmitter the power amplifiers gets saturated. This paper is focusing on reducing the PAPR without affecting much the performance of the system. Based on the literature survey several papers are published and different approaches have been used in reducing the PAPR. The different approaches falls under two categories the signal distortion and the signal degradation. Hence we propose a new method called as Lossy source Coding technique which is under the signal distortion category. The digital circuit implementation of the proposed method is described in [10].

The section below describes BPSK OFDM and introduction to the PAPR. In Section 2 simulation results of the BPSK OFDM generation along with the peak value and the PAPR for the different values of the symbol length has been presented. Section 3 describes the proposed new lossy coding method to reduce the PAPR and the simulation results of the same along with the BER have been specified. This is followed by a conclusion.

II. BPSK OFDM

Orthogonal frequency division multiplexing (OFDM) is an frequency division multiplexing (FDM) based on the concept of orthogonality. In FDM, based on the number of the subcarriers, the available bandwidth is equally divided. For N subcarriers $f_i; i = 1, 2, ...N$ say $f_1, f_2.........f_N$ then the available bandwidth is shared between each of these N subcarriers. N subcarriers are orthogonal to each other and hence $f_i = i\left(f_1\right)$ such that f_1 having integral cycles in a symbol duration T .

The generation of an OFDM is given by equation 1, where the symbol $b_n\left(t\right)$ is mapped to the chosen Constellation like BPSK, QPSK or any other higher order modulation.

$$S_{OFDM}(t)=\sum_{n=1}^{N} b_n(t)\cos(2\pi f_n t) \tag{1}$$

From the OFDM symbols generated Peak to average power ratio has been calculated as is discussed in the next section.

2.1 Peak to Average Power Ratio:

OFDM being an multicarrier systems, the carriers will have different phase values. Their peak values will also be different and high as the carriers reach the maximum value at same time. Due to the high peak value signal distortion will take place allowing the peaks of the signal to enter the non- linear region. Among the subcarriers intermodulation distortion takes place and the radiation enter into out of band. Power back offs should be very large to operate the power amplifiers. The result of this is the requirement of the transmitter which is expensive and the distortion in the amplification. The amplifiers get into the saturation regions due to the high value of peak which results in the distortion. Hence reducing the PAPR is an important factor.

The OFDM symbol generated contains N orthogonal carriers as given by the equation (2) as

$$S_{OFDM}(t)=\sum_{n=1}^{N} b_n(t)\cos(2\pi f_n t) \tag{2}$$

Where $b_n(t)$ is in the polar form takes the value of +N and –N.
From equation (2) it is observed that

$$S_{OFDM}(t)=\begin{cases}\sum_{n=1}^{N}\cos(n2\pi f_1 t) & \forall b_n(t)=1\\ -\sum_{n=1}^{N}\cos(n2\pi f_1 t) & \forall b_n(t)=-1\end{cases}$$

(3)

Where f_1 is the fundamental frequency component.. The maximum peak value of the OFDM symbol is N2. Peak powers for the four combinations are similar. The four combinations are the entire bit in the combination is one, the entire bit in combination is zero, and alternating bits ones and zeros are similar. Hence the maximum value of the peak power is N2. This is same for any symbol length.

2.2 BPSK OFDM Simulation Study

OFDM symbols are generated for varying symbol lengths. For the BPSK OFDM symbol of length N, the possible number of the combinations is 2^N. Consider N= 6. The Fig 1 describes the OFDM symbol generated and the IFFT for the combination of 000000. Fig 2 describes the OFDM symbol generated and the IFFT for the combination of 110011.

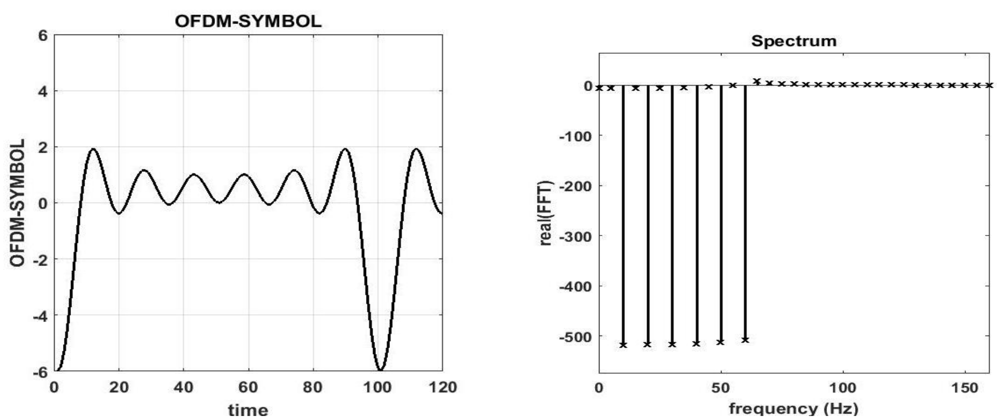

Fig 1: OFDM symbol and spectrum for the bit pattern 000000

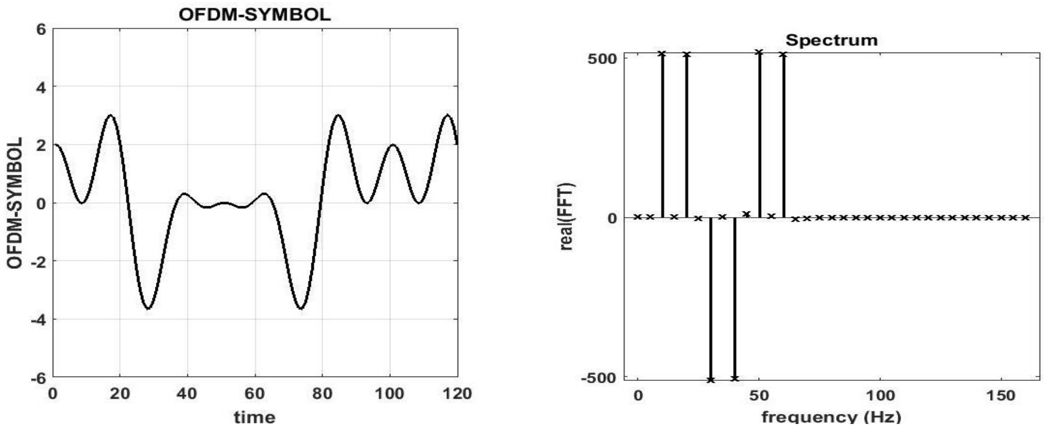

Fig 2: OFDM symbol and the spectrum for the bit pattern 110011

The figures 1 and 2 are few examples of the BPSK OFDM symbols generated. The repetition of the experiment is carried out for the other sets of the combinations. The Peak power and the PAPR of the combinations are discussed in the section below.

2.3 Peak Power and PAPR

For the OFDM symbols generated as described in the section II, for various symbol lengths PAPR is calculated. It was observed that the maximum value of the Peak to average power ratio is 12.01 and the minimum value of the Peak to average power ratio is 3.21. In the examples considered in the section II, out of 64 for N= 6, only 4 bit combinations has a maximum value of the PAPR with respect with the left out combinations. Bit combinations which have maximum value of PAPR are 000000, 010101, 101010, and 111111. Hence, irrespective of the value of N in the OFDM symbol, the maximum value of N is obtained only for the four combinations as described and in all the other bit combinations, the instantaneous value of PAPR is less than the maximum. The same procedure is repeated for the various lengths of the symbols from 6 to 12. The observation of the combinations with the high PAPR remains the same as expected. Hence, reducing PAPR is very much necessary. Hence lossy coding method is proposed to reduce the PAPR in the OFDM symbols generated. The proposed method is described in the section III. For the 2N distinct symbols for N= 6, the Peak Power and the PAPR calculated is shown in the graph of Fig 3.

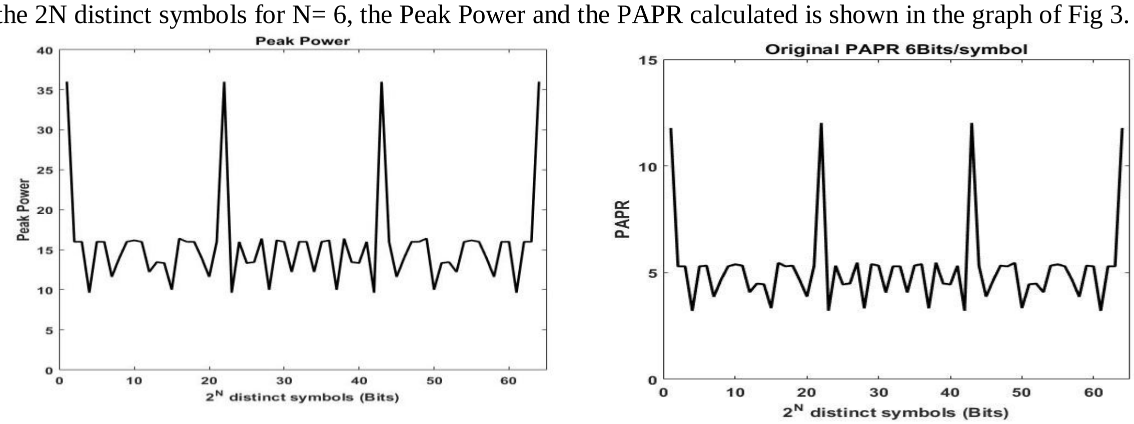

Fig 3: Peak Power and the PAPR for N= 6

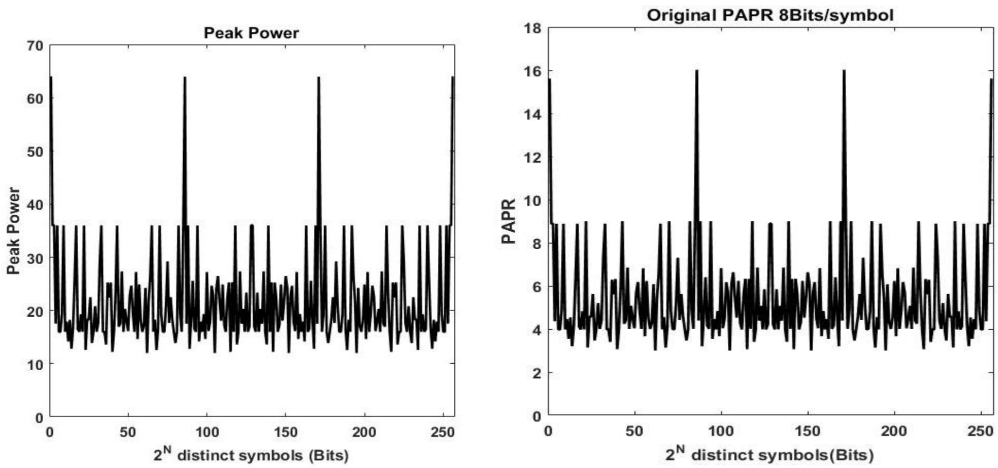

Fig 4: Peak Power and the PAPR for N= 8

For the 2N distinct symbols for N= 8, the Peak Power and the Peak to Average Power Ratio calculated is shown in the graph of Fig 4. For the 2N distinct symbols for N= 10, the Peak Power and the Peak to Average Power Ratio calculated is shown in the graph of Fig 5.

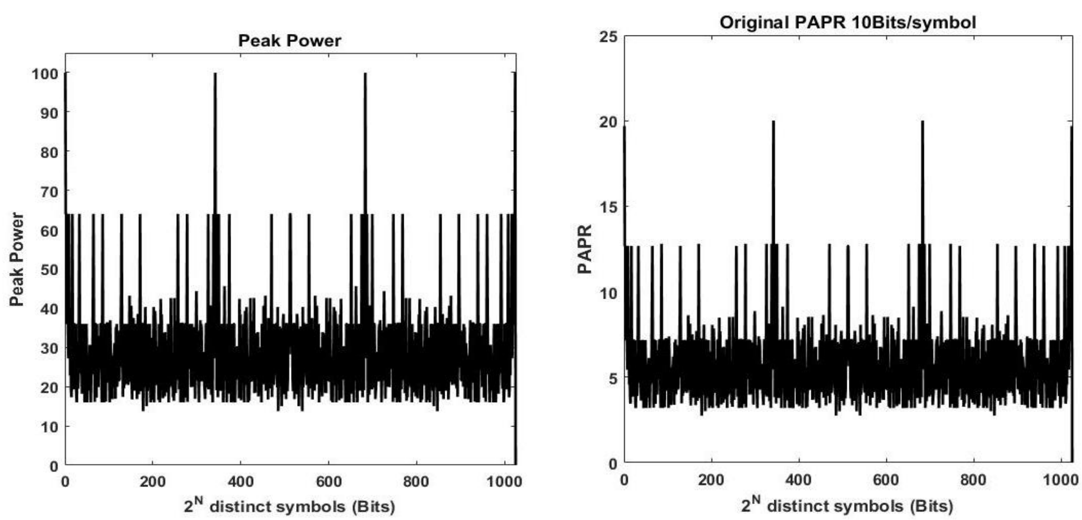

Fig 5: Peak Power and the PAPR for the symbol length of 10

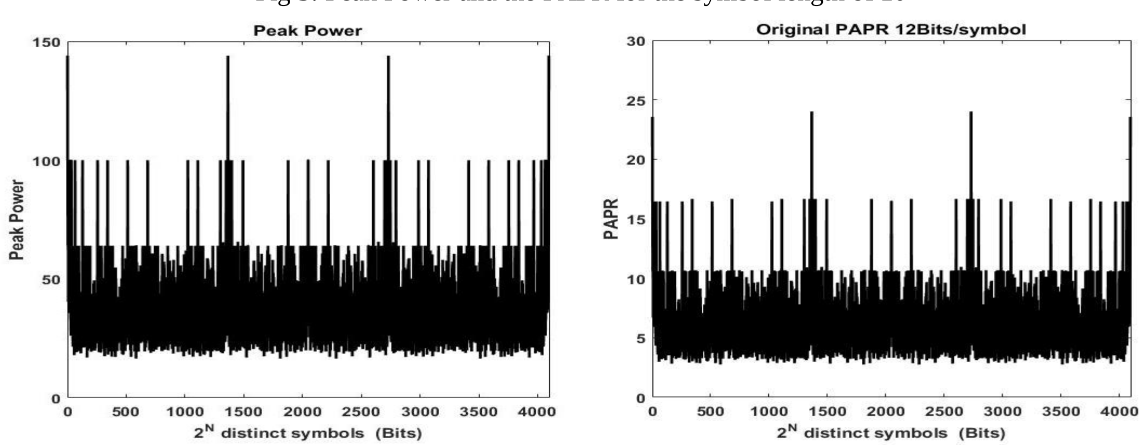

Fig 6: Peak Power and the PAPR for N= 12

For the 2N distinct symbols for N= 12, the Peak Power and the Peak to Average Power Ratio calculated is shown in the graph of Fig 6. The Peak Power and the Peak to Average power ratio calculated as given by the equations 2 to 4 for the varying lengths of the symbols 6 to 12 are described in the figures 3 to 6. Hence the maximum value of the Peak power is N2 as described.

III. PROPOSED METHOD

PAPR is the major concern of any OFDM symbol generated for any symbol length and has to be addressed as discussed in section II. Only 4 bit combinations out of the total possible combinations have high peak power. This observation has been verified in MATLAB and the results of the simulation are presented in the section II. This observation has been verified for the varying lengths of the symbols for the value of N ranging from 6 to 12. Our lossy coding algorithm is based on avoiding the transmission of these four combinations of the bit pattern by changing the LSB bit of the four combinations from bit 1 to bit 0 and from bit 0 to bit 1 [9]. The main idea is to not to transmit the combinations which has high value of the Peak to average Power ratio and based on changing the LSB bit from 1 to 0 and from 0 to so that the pattern is changed in terms of other patterns. This will reduce the Peak to Average power Ratio. Though the coding method reduces the PAPR, since we are changing the LSB bit of the patterns with the High value of Peak to Average power Ratio it introduces error in the transmission. This error we specify it as Bit Error Rate (BER). Out of the total bits transmitted the number of the bits that is in error will give the BER for the pattern. But practically the length of the OFDM symbol will be large and with the larger value the occurrence of the Bit error will be reduced [9].

For N=6, the range of the patterns are 000000 to 111111. OFDM symbols are generated for all the patterns and the peak values are computed and it lies between 9.5 and 36. For the four patterns with all the bits 0, with all the bits being 1 and the alternating bits being 1 and 0's has peak value of 36 and the left out patterns peak value lies in between 16.3 to 9.5. if we change the LSB bit of the patterns from 000000 to 000001 the Peak value will be reduced from 36 to 16 with the error rate. BER is calculated assuming the symbols are occurring with equal probability.

For N= 6, the amount of the PAPR reduced by the lossy source coding method is specified in the Fig 7. For N=8, the maximum value of PAPR is 16.01 and the amount of the PAPR reduced is 8.99 by the lossy source coding method is specified in the Fig 8.

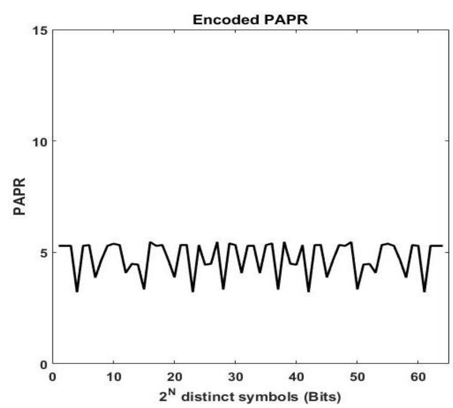

Fig 7: Encoded PAPR for N= 6

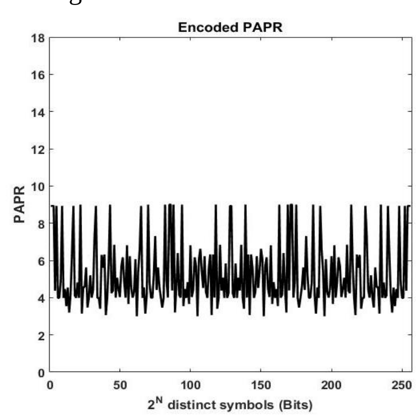

Fig 8: Encoded PAPR for N= 8

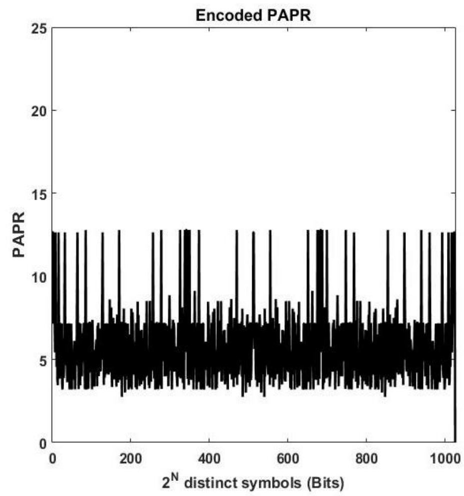

Fig 9: Encoded PAPR for N= 10

For N= 10, the maximum value of PAPR is 20.01 and the amount of the PAPR reduced is 12.79 by the lossy source coding method is specified in the Fig 9. For N= 12, the maximum value of PAPR is 24.01 and the amount of the PAPR reduced is 16.66 by the lossy source coding method is specified in the Fig 10.

Hence as described in the figures 7 to 10, significant reduction in the PAPR has been achieved with the lossy source coding method and the amount of the reduction achieved has been specified in the graphs with the BER introduced as specified in the table 1[8].

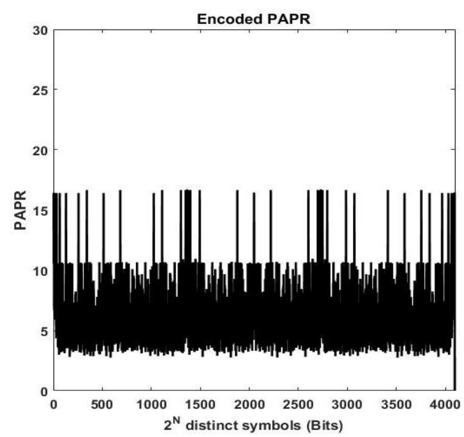

Fig 10: Encoded PAPR for N= 12

Table1: BER for varying lengths of the symbol

Symbol Length	Bit Error Rate
6	10 x 10-3
8	1.9x10-3
10	0.39x10-3
12	0.08x10-3

The BER based on the method proposed by changing the bit from 1 to 0 and 0 to 1 for N=6 is 0.01 and the BER for N= 8 is 1.9 x 10-3. Similarly the BER, N= 10 and 12 are 3.9 x 10-4 and 8 x 10-5 respectively as given by the table 1. BER is calculated assuming that the probabilities of occurrence of the symbols are equal. But practically the length of the OFDM symbol will be large and with the larger value the occurrence of the Bit error will be reduced.

IV. CONCLUSION

The simulation results of the PAPR reduction of an OFDM symbols are discussed and presented. The observation was that out of the total possible combinations of the varying lengths of the symbols four combinations as specified has a high value of PAPR. To reduce the PAPR in OFDM symbol a new Lossy coding method has been proposed.

the proposed method has bit error rate introduced. With the proposed method the reduction in the PAPR achieved with the amount of the changes happened in the bits resulting in an error has been specified. The hardware implementation of the same has been published in [10]. We are in the process of repeating the same experiment by considering QPSK as the modulation technique for OFDM symbol generation and compare the proposed method with the other methods of signal distortion and observe the application of this proposed method on 1D and 2D symbols.

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