Power Reduction in the transmitting amplifier of OFDM system by reducing its Peak to Average Power Ratio (PAPR) and Adaptive Modulations Techniques

[1]Dileep M D, [2] Dr. H V Kumaraswamy
[1]Research Scholar, [2] Professor,
Department of Telecommunications & Engineering
R.V. College of Engineering, Bangalore-560059

Abstract: - Efficiency of Orthogonal Frequency-Division Multiplexing (OFDM) system is improved by reducing the power consumed by its transmitter and also by improving the spectral efficiency. Power usage is reduced by reducing the PAPR of OFDM system and spectral efficiency is improved by Adaptive modulation and coding schemes (AMC). In OFDM system, transmission signals can have high peak values in the time domain since many subcarrier components are added via an inverse fast Fourier transformation (IFFT) operation. As a result, OFDM systems are known to have a high peak-to-average power ratio (PAPR) or Crest factor when compared to single-carrier systems. The high PAPR is one of the most detrimental aspects in an OFDM [2,3] system. High PAPR decreases the signal-to quantization noise ratio (SQNR) of the analog-digital convertor (ADC) and digital-analog convertor (DAC) while degrading the efficiency of the power amplifier in the transmitter. PAPR problem is more of a concern in the uplink since the efficiency of the power amplifier is critical due to the limited battery power in a mobile terminal. The core idea of AMC is to dynamically change the modulation and coding plans dependent upon the channel conditions in order to enhance overall spectral efficiency. Here through Matlab simulations overall battery power usage reductions and improvement in data throughout are shown.

Keywords—OFDM, Adaptive modulation and coding, Partail transmit sequence.

I. INTRODUCTION

OFDM has several advantages over single carrier systems in that OFDM is more robust to multipath induced intersymbol interference (ISI) and has high spectral efficiency. Despite these advantages, OFDM [3] has some disadvantages that need to be addressed for its successful implementation. A major disadvantage of OFDM is that it generates signals with large amplitude variations. This problem is known as the peak-to-average power ratio (PAPR) problem, which degrades the system performance, reduces the efficiency of the high power amplifier (HPA) and also limits the dynamic range of the analogue-to-digital (A/D) and digital-to-analogue (D/ A) converters. This negative effect may outweigh all the potential benefits of OFDM transmission systems in many low-cost applications. Several PAPR reduction techniques have been proposed during the last decade. These broadly fall into three areas, namely, signal distortion techniques, symbol scrambling techniques and coding techniques.

II. PROPOSED METHOD

In the proposed method, the spectral efficiency of the OFDM system is improved by using Adaptive modulation and coding technique (AMC) as illustrated in the figure (1). Here for reducing the power consumed by transmitter of the OFDM system, we are reducing the PAPR [1, 2] of the OFDM signal. For reducing the peak to average power ratio, we are proposing an algorithm called as partial transmit sequence(PTS) as in the flowchart of figure (2).
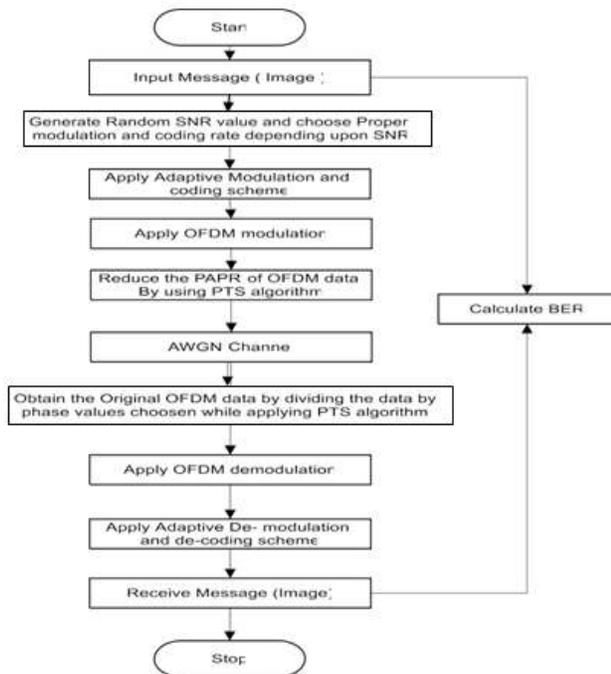
Figure(1) : Flowchart of proposed method

Table (1):
Criteria for the selection of coding rate and
modulation and demodulation scheme for different
SNR values

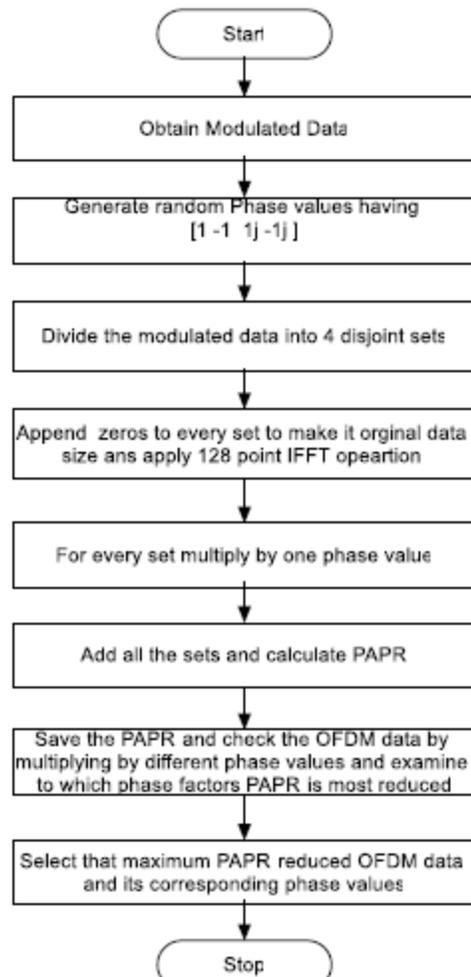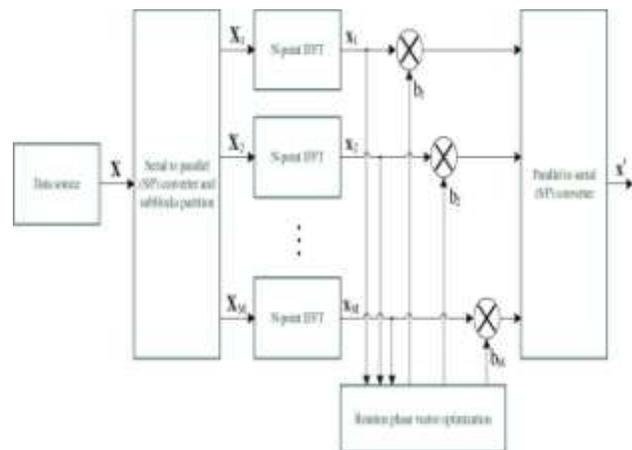| SNR Range (dB)	Modulation Scheme	Coding Rate
0 to 6	BPSK	2/3
7 to 13	QAM − 4	2/3
14 to 16	QAM − 16	2/3
17 to 19	QAM − 32	3/4
20 to 22	QAM − 64	3/4
23 to 25	QAM − 128	3/4
26 to 30	QAM − 256	3/4

Figure (2): PTS algorithm flowchart

Figure (3) illustrates PTS algorithm

The IFFT operation used in OFDM is given in (1)

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) \, e^{j2\pi nk/N} \quad \text{-----------} \ (1)$$

where n = 0, 1, 2, 3,........N-1
N is the FFT size
The PAPR of an OFDM signal is calculated by using (2)

$$PAPR = \frac{\max(abs(Zn)^2)}{\frac{1}{N}\sum_{n=1}^{N} abs(Zn)^2} \quad \text{------------------} \ (2)$$

where N is the length of the OFDM signal
Zn is the OFDM Signal Coefficient n represents the index of the OFDM signal.
The table (1) shows the criteria for the selection of coding rate and modulation and demodulation scheme for different SNR values.

Table (2):
OFDM Specifications

Frame size	64 samples
FFT size (N)	128 subcarriers
Gaud band size (G)	22 samples
Modulation scheme	Adaptive modulation scheme as described by Table (1)
Coding method	Convolutional code and viterbi decoding
Coding rate	2/3 and 3/4 coding rate

The table (2) shows the OFDM specifications used in the implementation process.
To measure variation of PAPR values in the OFDM signals, complementary cumulative distribution function (CCDF) is calculated. The CCDF of PAPR values (x) of OFDM data is given by (3). where x represents the PAPR values. X represents a particular PAPR value.
Once CCDF is calculated, PAPR v/s CCDF is plotted as shown in the results section. For reducing the PAPR of the
OFDM data, partial transmit sequence (PTS) algorithm is as in figure (3).

$$CCDF(x) = \Pr(x > X) \quad \text{------------} \ (3)$$

where x represents the PAPR values.

X represents a particular PAPR value.
Once CCDF is calculated, PAPR v/s CCDF is plotted as shown in the results section. For reducing the PAPR of the OFDM data, partial transmit sequence (PTS) algorithm is as in figure (3).

III. RESULTS

The Matlab simulations are shown in this section. We have considered a digital image as input data. This data is converted into binary format. For a particular SNR value, a particular modulation scheme and coding rate is selected according to Table (1). Convolutional coding and viterbi decoding algorithm is used here with 2/3 and 3/4 coding rates. Once coding is applied on the binary data, grouping of bits is done for modulation. After modulation, data is divided into frames 64 symbols; 128 point IFFT operation is applied to perform OFDM operation. For this frame, PAPR is calculated. Thus an array of PAPR values are calculated for all the OFDM frames to plot the CCDF v/s PAPR values. For simulating the channel conditions, SNR is considered from 0 dB to 30 dB.
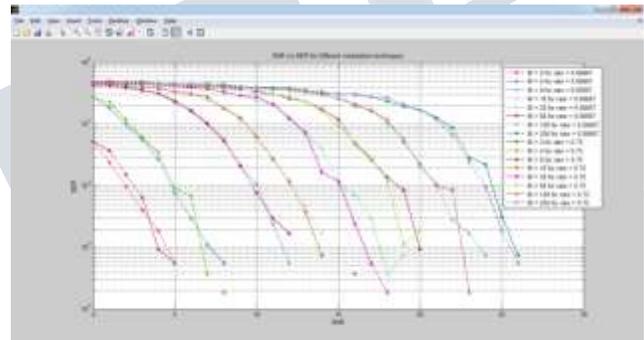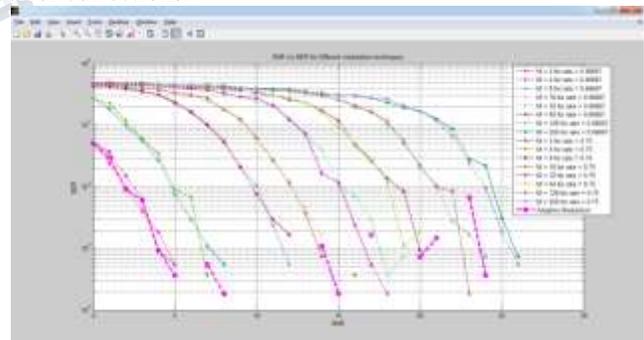

Figure (4)

Figure(4) says the BER plot of different modulation techniques for 2/3 and 3/4 rates of convolutional coding and viterbi decoding methods of error corrections.

Figure(5)

Figure (5) shows the comparative plot for the adaptive modulation scheme and QAM-M schemes with M = 2, 4, 8,16,32,64,128,256 array values.
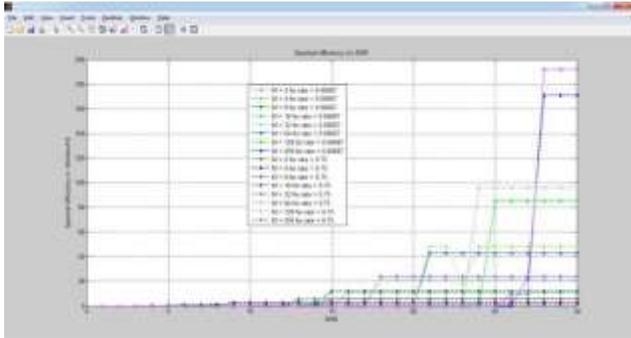
Figure (6)

Figure (6) shows the comparative study of throughput plot for different modulation schemes for 2/3 and 3/4 rates of convolutional coding and viterbi decoding methods of error corrections.

Figure (7)

Figure (7) shows the comparative study of throughput plot of adaptive modulation scheme for 2/3 and 3/4 rates of convolutional coding and viterbi decoding methods of error corrections.
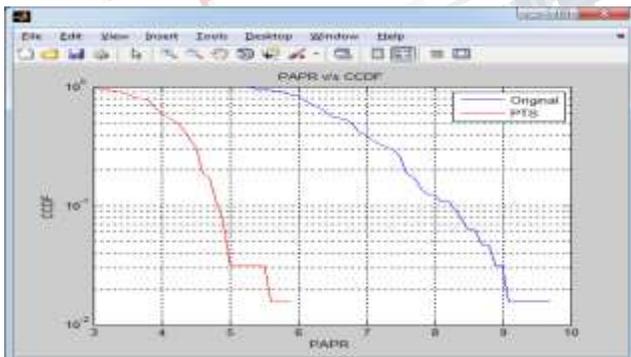

Figure (8)
Figure (8) shows the PAPR plot of the ODDM reduced by the Partial transmit sequence method.
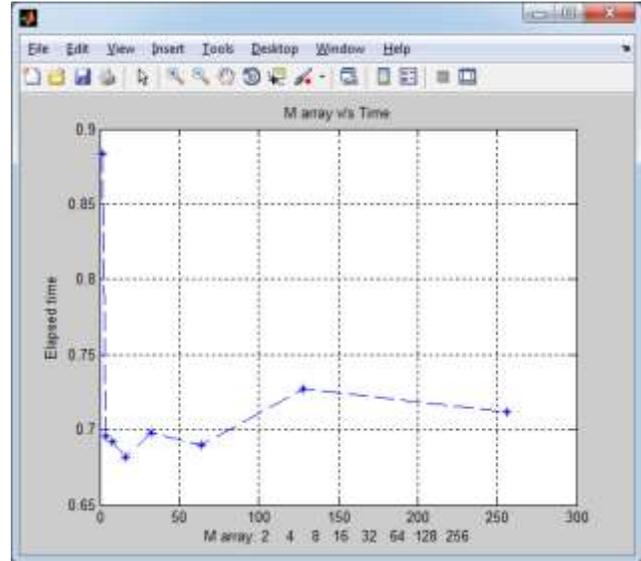

Figure (9)

Figure (9) shows the elapsed time (in sec) versus different modulation schemes such as M = [2 4 8 16 32 64 128 256]. Here M = 2 case is taking more time when compared to other methods. Here the plot shows that QAM System with M = 2 is taking more time with respect to other methods since in every symbol only one bit is transmitted. So to increase the speed of transmission we are going for the higher modulation schemes.

IV CONCLUSION

In this paper we have improved performance of the OFDM system with respect to the limiting the power usage at the transmitter end by reducing the PAPR factor of the OFDM system using the PTS technique and providing the improved spectral usage by adopting the adaptive modulation coding scheme.

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