Peak to Average Power Ratio Reduction using Joint Resource Constellation Scheme in MIMO OFDM System

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ABSTRACT:-*Orthogonal Frequency Division Multiplexing (OFDM) with Quadrature Amplitude Modulation (QAM) technique has drawn significant interests in recent years. Mainly, it has been accepted as a potential technique for many digital broadcasting systems. The major drawback is high Peak to Average Power Ratio (PAPR). Many techniques are available to reduce high PAPR such as Partial Transmit Sequence technique, Selective Mapping technique, clipping technique, Tone Reservation and so on. But, it is not very effective to directly employ these methods in QAM based OFDM systems. So, the hybrid of Partial Transmit Sequence (PTS), Clipping with Filtering (CF) method is proposed which deal with the high PAPR problem. In this technique, the input data is partitioned into disjoint sub blocks. Then the signal is applied to a clipper that limits the signal envelope to a predetermined threshold value. Filtering after direct clipping reduces the out of band energy. The proposed method introduces non-uniform phase factor and coded side information using Joint Resource Constellation (JRC) scheme. Hence, the cost and number of bits used for recovering original data becomes drastically reduced.*

KEY WORDS: *OFDM, QAM, PAPR, PTS, CF, JRC, BER.*

1. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a method of digital modulation in which a signal is split into several narrowband channels at different frequencies which are transmitted in parallel mainly used for digital broadcasting systems. Because, the symbol duration of each sub channel is made relatively larger than the delay spread it would minimize the ISI effect.

Moreover, it is spectrally more efficient technique than a conventional single carrier modulation technique. Each sub channel is narrow enough so that it experiences a flat fading although the overall radio propagation environment is frequency-selective. The time dispersion effects are less significant as the as the symbol duration increases. Inter symbol interference (ISI) is eliminated by inserting a cyclic prefix, or guard interval and associated with the OFDM symbol.

Orthogonal frequency division multiplexing advantages are providing high spectral efficiency, robustness to channel fading, immunity to impulse interference. OFDM has several properties, which make it an attractive modulation scheme for high speed transmission links.

But high peak to average power ratio is the major drawback of OFDM systems. This problem results from nature of modulation itself, where multiple sub carriers or sinusoids are combined together to form the signal to be transmitted. PAPR is defined as the ratio of peak power to the average power. The peak power is defined as the power of sine wave with amplitude equal to the maximum envelope value.

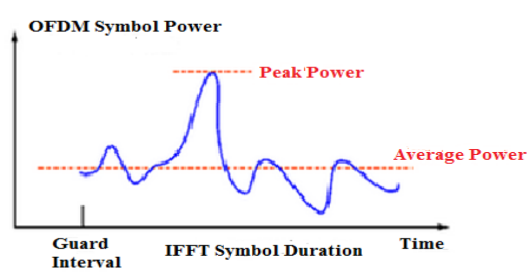

Fig.1 PAPR Estimation

It is expressed as dB and it can be written as,

$$\text{PAPR}\,(x[n]) = \frac{\max\ |x[n]|^2}{E[|x[n]|]} \quad (1)$$

Where, E[.] is the expectation operator.

Many PAPR reduction techniques such as Tone reservation, Peak cancellation, SLM, PTS and so on are introduced as the solution for this problem. But it is not very effective for QAM based OFDM system. The hybrid of Partial Transmit Sequence (PTS), Clipping with Filtering (CF) based QAM modulation technique is proposed to reduce Peak to Average Power Ratio. Here, the input data is divided into several number of non-overlapping sub blocks. Then the signal is applied to a clipper that limits the signal envelope to a predetermined threshold value. Filtering the clipped signal reduces the out of radiation. In this paper, using the same hybrid PTS-CF technique, bit error rate is improved along with better PAPR reduction.

II. RELATED WORKS

Tao Jiang et al., [3] proposed a novel phase offset SLM scheme to reduce PAPR in alamouti coded Multi-Input Multi-Output (MIMO) OFDM systems. In this technique, different phase rotation sequences were multiplied by their corresponding phase offsets at the transmitter. Moreover, a Minimum Euclidian Distance (MED) decoder at the receiver was proposed to recover the phase rotation sequences. The proposed method does not need to reserve bits for the transmission of Side Information (SI), resulting in the increase of the data rate. The P-SLM scheme without SI offers a better Bit Error Ratio (BER) performance when it was compared to the C-SLM scheme with SI transmitted.

E. Hong et al., [6] proposed an efficient technique for reducing PAPR based on Adaptive All-Pass Filters (AAPFs) with space-frequency block coding was used for Multiple-Input Single-Output (MISO) OFDM systems. The AAPF creates phase rotation to reduce the PAPR. With the scattered pilot pattern, the AAPF enables data recovery without side information (SI). The PAPR reduction performance and the BER performance with considered system parameters were comparable to those of the blind SLM (B-SLM) scheme and the Low Complexity SLM (LC-SLM) scheme with SI. The computational complexity is much lower than that of the B-SLM scheme and comparable to that of the LC-SLM scheme.

Cai Li et al., [7] proposed a constellation reshaping method to reduce high PAPR in OFDM system. Here, Reshaped Quadrature Amplitude Modulation (R-QAM) constellation was generated in which the minimum distance of the R-QAM was the same as that of the traditional QAM constellation. The mean square errors between the constellations of the received data and each R-QAM rotated by different phase rotation factors were calculated at the receiver and the phase rotation factor with the minimum mean square error was selected to recover the original data without SI. Therefore, the flexibility in phase rotation choice and the ability to avoid data rate loss make the R-PTS and R-SLM methods more suitable for good BER performance in OFDM systems.

Jianping Wang et al., [17] proposed the Segmental Clipping for the PAPR reduction of the orthogonal frequency division multiplexing with Offset Quadrature Amplitude Modulation (OQAM) technique which has drawn significant interests in recent years. However, most of the existing OFDM peak-to-average power ratio reduction schemes cannot be used in the OFDM-OQAM system directly. Here, a modified scheme called Overlapped Segmental clipping (OS-Clipping) was proposed to deal with the high PAPR problem specifically in the OFDM-OQAM system. For the proposed OS-clipping scheme, the input signals were divided into a number of overlapped segments and then the clipping operation was processed on each segment. Simulation results shows that the modified scheme used in the OFDM-OQAM system provided better performance than conventional clipping scheme.

Yang Zhou et al., [9]proposed a novel multi-points square mapping combined with PTS to reduce PAPR of OFDM signals without side information. The MSM scheme used four constellation points that were vertexes of a square to represent one data and it decreases spectrum utilization in OFDM systems. Moreover, the reserved subcarriers may be interfered in a frequency selective fading channel as a result, BER may increase largely. Simulation results shows that the proposed M-PTS scheme has better bandwidth efficiency and BER performance when compared with that of the conventional PTS (C-PTS) scheme.

Y.Wang et al., [4] proposed an efficient nonlinear companding scheme to reduce the peak-to-average power ratio of orthogonal frequency division multiplexing signals. By transforming the statistics of original signals into a specified distribution form along with remaining an unchanged average output power level, this scheme can achieve significant reduction in PAPR as well as an improved BER performance simultaneously.

III. PROPOSED METHOD

The proposed method is improving the bit error rate by using hybrid of partial transmit sequence and clipping with filtering technique along with better PAPR reduction and the work flow is shown below.

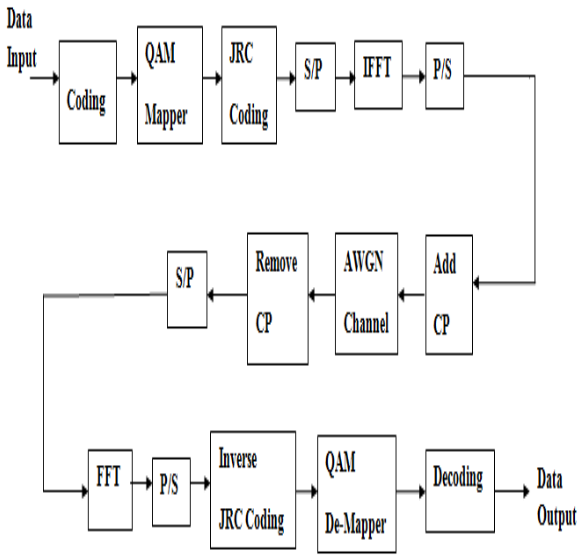

Fig.2 Flow of Work

Fig.2 shows the work flow for the proposed system. There are several steps to implement the proposed methodology to improve bit error rate performance with PAPR reduction.BER is the percentage of bits that have errors relative to the total number of transferred bits over a given time period, usually expressed as ten to a negative power.

The binary input data is first encoded by a forward error correction code. Some redundancy to the sequential binary data is introduced in order to overcome the effects of noise and interference. The encoded data is then mapped onto QAM constellation points. Then, the mapped data is applied to JRC coding in order to set the threshold value for PTS and CF reduction techniques.

In proposed work, the input data is partitioned into a number of disjoint sub blocks and each sub block is phase shifted by a constant factor. Then it is applied to a clipper that limits the signal envelope to a predetermined threshold value if the signal exceeds that level. Filtering after clipping preserves the spectral efficiency by eliminating the out-of-band distortion and it also improves the BER performance.

Then, the serial symbol data is converted into several parallel symbols before IFFT, using Serial to Parallel Converter (S/P) to be divided among the individual sub-carriers. Then the signal is transformed by using Inverse Fast Fourier Transform (IFFT) for efficient implementation. The IFFT provides a time domain OFDM signal at the transmitter side and the Fast Fourier Transform (FFT) at the receiver. After the IFFT before cyclic prefix insertion, the OFDM symbols are converted to serial symbols for transmission using Parallel to Serial Convertor (P/S).

Cyclic Prefix (CP) is the periodic extension of the last part of an OFDM symbol that is added to front of symbol in the transmitter and removed at the receiver in order to eliminate the effects of the Inter Symbol Interference (ISI). Then the signal is transferred to the receiver side through Additive White Gaussian Noise (AWGN) channel which is a good model for many satellites and deep space communication. The reverse operation is done to get the original information.

IV. PARAMETERS

Here, the system performance is evaluated based on following parameters:

CCDF:

It is called Complementary Cumulative Distributive Function which is the most important parameter used to calculate the PAPR. It provides the probability of the OFDMsignal's envelope exceeding a specified PAPR threshold withinthe OFDM symbol.

$$CCDF[PAPR(x_n(t))] = prob[PAPR(x_n(t) > \delta)] \quad (2)$$

Where, PAPR $(x_n(t))$is the PAPR of the n^{th} OFDM symbol and
$\delta$is threshold.

BER:

It is called Bit Error Rate which is the ratio of number of bit errors to the total number of transmitted bits. The specific BER is achieved in terms of signal to noise ratio (SNR) based on performance of a modulation technique. The relation between BER and SNR is written as

$$BER = (1/SNR) \wedge k \quad (3)$$

Where, k is represented as subcarrier.

SNR:

In analog and digital communications, Signal-to-Noise Ratio, often written S/N or SNR, is a measure of signal strength relative to background noise. SNR is defined as the ratio of the power of signal (meaningful information) and the power of background noise (unwanted signal) usually measured in decibels (dB).

Data rate:

It is nothing but speed at which the data transmitted per unit time. The unit of data rate is bps. It is expressed as,

Data rate = 2 x BW x $\log_2$ L(4)

Where, BW is represented as Bandwidth.

The relation between data rate and signal to noise ratio is written as,

Data rate = BW $\log_2$ (SNR)(5)

V. SIMULATION AND RESULT

In this section, the proposed method was evaluated based on the PAPR reduction and the BER performance. For comparison purposes**,** simulation results were obtained for the original OFDM system. Here, high PAPR is reduced by using hybrid of PTS and CF technique in OFDM system and the output is shown below.

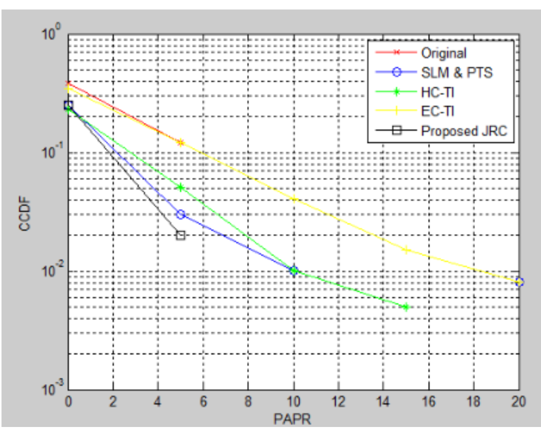

Fig.3 Plot between CCDF and PAPR

Fig.3 shows the output between CCDF and PAPR. Generally, we know that OFDM signal is modulated by using Phase Shift Keying or Quadrature Amplitude Modulation. Here, QAM is used as a modulation. The simulation parameters used in proposed method are given in Table.1 and PAPR value for HC-TI and JRC is compared below.

TABLE 1: Simulation Parameter

Number of Subcarrier (N)	64,128,256,512
Oversampling Factor	8
Modulation used	QAM
Passage Number(M)	2,4,8,16
Maximum Symbols	1000

TABLE 2: Simulation Result

Scheme	**CE-TI**	**SLM**	**PTS**	**EC-TI**	**HC-TI**	**JRC**
PAPR	8.25 dB	8.07 dB	8.24 dB	6.56 dB	6.15 dB	5 dB
Power Increase	1.31 dB	No	No	0.49 dB	No	No
Average Runtime	198.4 ms	18.3 ms	75.6 ms	11.6 ms	11.3 ms	11.3 ms
Number of FFTs	200	24	128	24	24	24
Side Information	No	Yes	Yes	No	No	No

Fig.4 BER performance for hybrid PTS-CF

Fig.4 shows BER performance for hybrid PTS-CF based QAM modulation. It achieve BER improvement over the original OFDM signal due to the constellation extension, BER performance of proposed method with N = 256, L = 8, and QAM in the Additive White Gaussian channel. With BER =1×10−3 when Eb/N0 = 5 dB.

VI. CONCLUSION

Multicarrier systems are proving better in transmission than single carrier systems. OFDM is a digital multi-carrier modulation method where a large number of closely spaced orthogonal subcarriers are used to carry data. One of the serious drawbacks of OFDM system is that the composite transmit signal can exhibit a very high PAPR when the input sequences are highly correlated. This paper describes several important aspects related to the PAPR & its overall effect on the OFDM system & several techniques adopted by the system according to the requirement. These techniques can be used to reduce the PAPR at the cost of loss in data rate, transmit signal power increase, BER performance degradation, computational complexity increase, and so on**.**

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