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REDUCTION of PEAK to AVERAGE POWER RATIO in MIMO-OFDM SYSTEM using PRECODING

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Abstract—
OFDM technique is widely used wireless communication because of its high speed data rate transmission with high bandwidth efficiency and its robustness to multi-path delay. MIMO technique to enhance the transmission quality, capacity and BER of system. MIMO-OFDM system, is the combination of MIMO and OFDM technology, can live up to a high data transmission rate with reliability through diversity. Peak to Average Power Ratio is major drawback of OFDM System. Peak to Average Power Ratio (PAPR) hampers the efficiency of the RF amplifier. To Over this Precoding method are used. Precoding is a new method which is having less complexity as compared to the other PAPR reduction techniques. Where modulated data is multiplied with precoding matrix before Inverse Fast Fourier Transform (IFFT).This approach can reduce PAPR considerably without affecting bandwidth efficiency of system and BER performance. The reduction of PAPR in MIMO-OFDM system is obtained using precoding scheme.
Keywords— OFDM, SISO, MIMO, PAPR, Precoding.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing has recently seen rising popularity in wireless applications since it provides an efficient means to mitigate the InterSymbol Interference (ISI) caused by the channel multipath spread and high data rate transmission. This is a multicarrier technique in which modulating the entire data stream with different subcarriers and each of these subcarriers is orthogonal to each other. An OFDM-based system can provides greater immunity to multipath fading. OFDM has been widely considered for digital communication systems such as wireless local area networks and digital audio/video broadcasting services . It is also being considered for future broadband applications and fourth generation transmission technique[10].

The MIMO concept has attracted lot of attention in wireless communications due to its potential to increase the system capacity without extra bandwidth [9]. MIMO systems are a key component of future wireless communication systems, because of their promising improvement in terms of performance and bandwidth efficiency [2]. MIMO is associated with orthogonal frequency-division multiplexing (OFDM) not only increasing the diversity gain and system capacity, but also increasing the spectrum usage efficiency and combating the effects of frequency selective fading effectively. Currently, MIMO-OFDM technology had been adopted in several standards such as IEEE 802.16e, IEEE 802.11n, Long Term Evolution. The main drawback of orthogonal frequency division multiplexing (OFDM) systems is the high peak-to-average power ratio (PAPR), which leads to performance degradation, power inefficiency causes non-linearity at the receiving end [1].

Repeated clipping and filtering, Partial Transmission Sequence (PTS), Selective Mapping (SLM), Tone Injection, Tone Reservation these are some PAPR reduction technique. Clipping and filtering is done repeatedly in order to reduce peak re-growth but at the cost of computational complexity. Partial Transmission Sequence (PTS) has High computational complexity for searching optimal phase factors and required Side information needed to send to receiver. Side information must be additionally included for correct data recovery. Because of this side information, data rate becomes less and spectral efficiency decreases hence degraded BER performance. Selective Mapping (SLM) is more complex than Partial Transmission Sequence (PTS) [1], [4], [5], [6]. TI does not require extra side information at receiver, TI technique is more problematic than the TR technique since the injected signal occupies the frequency band as the information bearing signal. TI increases Computational complexity due to computation of optimal translation vector [6].

Precoding is a new method which is having less complexity compared to the other power

reduction techniques and also it can reduce PAPR considerably and results in no distortion Furthermore, there is no loss in data rate and unlike other techniques, no side information is required [1],[10].

In this paper, a typical OFDM and MIMO system is given in section 2 and 3. The SISO design is given in section 4. PAPR problem is explained in section 5. Section 6 gives the precoding technique for PAPR reduction, Simulation result is given in section 7. and Conclusion is given in section 8.

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. The different carriers are orthogonal to each other, that is, they are totally independent of one another [12].

The OFDM system splits the high speed data stream into a number of parallel low data rate streams and these low rates data streams are transmitted simultaneously over a number of orthogonal subcarriers [11].

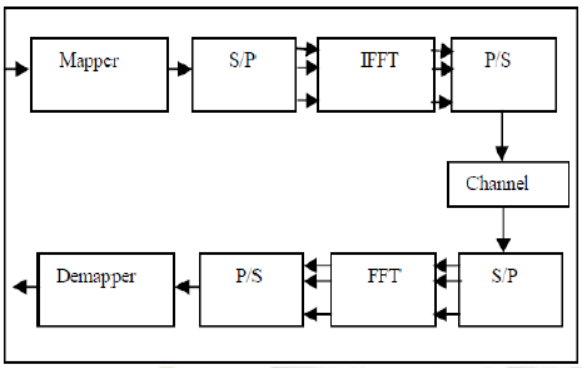

Fig 1. Block Diagram of OFDM system

Fig. 1 illustrates the block diagram of an OFDM system [11]. A large number of closely spaced orthogonal subcarrier is used to carry data each data is modulated with modulation scheme QPSK at low symbol rate. Inverse Fast Fourier Transform converts OFDM signal from frequency domain to time domain, to avoid Intersymbol Interference we provide cyclic prefix to the system. Then transmit data to the receiver through channel [12].

III. MULTIPLE INPUT MULTIPLE OUTPUT

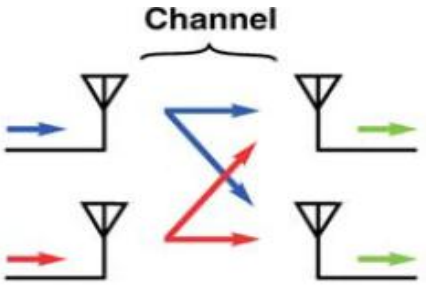

Fig 2. MIMO without precoding.

A standard 2 × 2 MIMO spatial multiplexing scheme, shown in Figure 2, assumes the wireless channel will provide four separate connections between transmit and receive antennas. Each channel connection, shown as an arrow in the figure, represents a unique combination of all transmission paths including the direct Line of Sight (LOS) path, should one exist, and the numerous multipaths created by reflection, scattering and diffraction from the surrounding environment. Depending on the resulting channel conditions, the MIMO system may not be able to properly recover the transmitted data streams (layers) if the SNR is too low at any of the receive antennas.

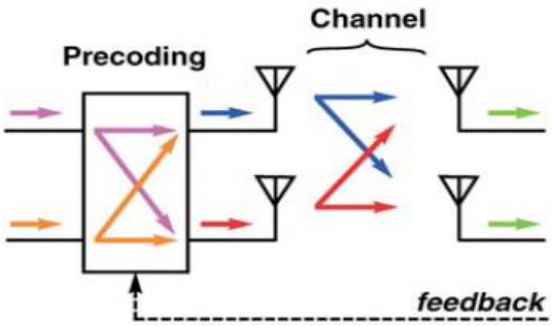

Fig 3. MIMO with Precoding.

With the addition of precoding, as shown in Figure 3, the transmitter, having knowledge of the current channel conditions, can effectively combine the layers before transmission with the goal of equalizing the signal reception across the multiple receive antennas. Precoding schemes have been specified for spatially-multiplexed and transmit-diversity applications[7].

Adding more antennas in transmitter and receiver used to improved link quality and reliability throughput between transmitter and receiver or both [3].

IV. SINGLE INPUT SINGLE OUTPUT

Currently, working is done on IEEE 802.11a wireless LAN SISO System, in which 100 bits input data are given (having all ones).

At transmitter side, the modulator subsystem is in charge of the following tasks:

- Convolutional coding (o/p is 300 bits) and puncturing using 1/2 code rate.
- Data Interleaving.
- QPSK Modulation.

OFDM transmission uses

- 122 subcarriers (100 bits data subcarrier, 12 pilots,10 guard subcarriers)
- 128-point IFFTs
- 16-sample cyclic prefix add.

The AWGN Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real, this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal. This block inherits its sample time from the input signal.

At Receiver side, the OFDM receiver subsystem performs the following tasks:

- Remove Cyclic prefix which are added in the transmission side.
- Remove the zeros which are added for the IFFT and reorder the subcarriers.
- Remove the pilots and guard subcarriers.

The demodulator subsystem performs the following tasks (it performs the inverse tasks of the modulator subsystem)

- Demodulation of the signal.
- Deinterleaver.
- Opposite of the puncturing.
- Viterbi decoding (It is used to decode the convolutional codes with a trace back depth of 34), and then original 100 bits data are archived.

Error Rate Calculation:

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source [13].

V. PEAK TO AVERAGE POWER RATIO

Peak to Average Power Ratio occurs when in a multicarrier system the different subcarriers are out of phase with each other. At each instant they are different with respect to each other at different phase values. Due to presence of large number of independently modulated subcarriers in an OFDM system, the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak to Average Power Ratio.

A very high Peak to Average Power Ratio (PAPR) exhibits major obstacle is that the OFDM signal. Therefore, RF power amplifiers should be operated in a very large linear region. Otherwise, the signal peaks get into non-linear region of the power amplifier which causing signal distortion. This signal distortion introduces intermodulation among the subcarriers and out of band radiation. Thus, the power amplifiers should be operated with large power back-offs. On the other hand, this leads to very inefficient amplification and expensive transmitters. These large peaks cause saturation in power amplifiers, leading to intermodulation products among the subcarriers and disturbing out of band energy. Therefore, it is desirable to reduce the PAPR [8].

VI. PRECODING TECHNIQUE FOR PAPR REDUCTION

Initially the entire data stream is given for base band modulation. In conventional OFDM scheme, directly giving the modulated data into IFFT block to generate OFDM signals. In precoded OFDM technique, the modulated data is multiplied with a precoding matrix (shaping matrix) in which wave shaping of modulated data is achieved before IFFT operation. No handshake is needed between the transmitter side and the receiver side. A predefined precoding matrix is used in OFDM system and having same precoding matrix for all OFDM blocks will also avoid all processing needed in block-based optimization methods. Each entries of the precoding matrix should be carefully designed in such a way to reduce PAPR [1], [10].

VII. SIMULATION RESUIT

The incoming bits are modulate by using QPSK Modulator. The modulate data are converted from serial to parallel sub streams. The parallel sub streams of mapped data are allowed to pass through IFFT block and transmit to the receiver through AWGN channel. The simulation parameters are mentioned in Table 1.

TABLE 1
SIMULATION PARAMETERS

Sr. No	Parameters	Value
1	Simulation Tool	MATLAB
2	No. of Sub carriers	128
3	Length of cyclic prefix	16
4	Modulation Type	QPSK
5	FFT Size	128
6	Antenna configuration	SISO(1 X 1)

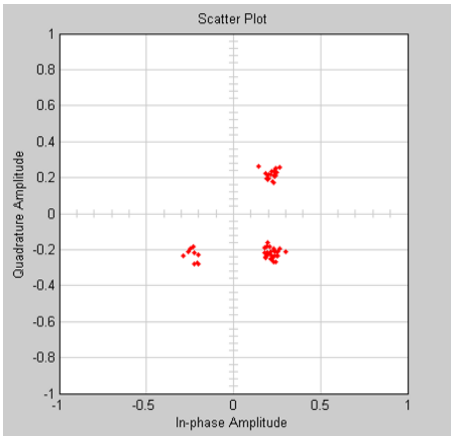

Fig 4: Received signal SNR 30 db

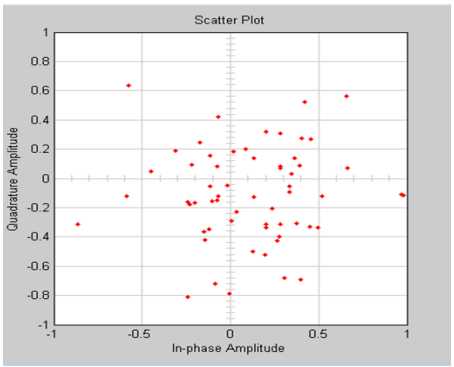

Fig 5: Received Signal SNR 10 db

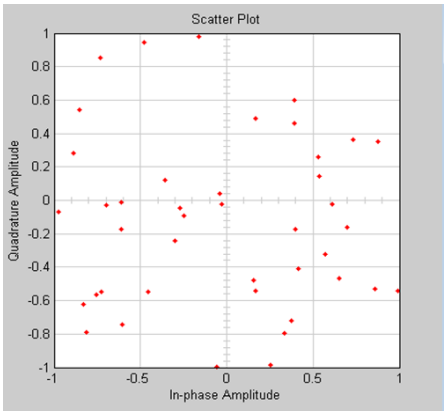

Fig 6: Received Signal SNR 1 db

VIII. CONCLUSION

The figures show the results of the simulations. In them, the difference of the received signals due to the SNR(Signal to Noise Ratio) value set can be seen. lower the ratio between the signal and the noise, the more is the received signal affected by the noise. As a result of this the BER(Bit error rate) increases.

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