Implementation of PAPR reduction technique in SFBC based OFDM MIMO systems

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Abstract: OFDM converts frequency selective channels in to collection of flat fading channels by use of cyclic prefix, but sub bands of OFDM are exposed to deep fading and may cause complete loss of sub band information. To cope up with this problem space time block coding is applied in OFDM, however it also introduces redundancy. To avoid problem of fast channel variation in time, the symbols of orthogonal design can be transmitted on neighboring sub carriers of same OFDM symbol rather than on same sub carrier at subsequent time interval this is the basic idea behind space frequency block coded OFDM(SFBC-OFDM).The SFBC system codes across two antennas and over two adjacent subcarriers instead of two consecutive symbol intervals and there fore becomes robust against fast fading distortion in frequency non-selective fading environments.

Multiple-input multiple-output (MIMO) is an attractive technology to improve the wireless system capacity. Therefore, the combination of MIMO and OFDM (MIMO-OFDM) could exploit the spatial dimension capability of a wireless communication system to improve the wireless link performance and system capacity by employing multiple antennas at both the transmitter and receiver ends.

This platform makes our system more effective, it help us to make our system to have minimum distortion thus it can be implemented with combination of different PAPR reduction techniques. This paper is aimed at implementation of different PAPR reduction schemes such as SLM(selective mapping) and PTS(partial transmit sequences) for SFBC OFDM MIMO systems. In the SLM technique, the transmitter generates a set of sufficiently different candidate data blocks, all representing the same information as the original data block, and selects the most favorable for transmission.

The antenna selection criterion is based on fading coefficients at all frequency components. The best fading coefficient is chosen at each frequency for different antennas, and then data is sent on those antennas with the best fading coefficients at that particular frequency this new antenna selection scheme improves the performance of the conventional SFBC-OFDM system, which is a significant achievement.

Key words- frequency selective fading, SFBC, OFDM, STBC,SLM

Introduction

The OFDM technique divides the total bandwidth into many narrow sub-channels and sends data in parallel. It has various advantages, such as high spectral efficiency, immunity to impulse interference and, frequency selective fading without having powerful channel equalizer. But one of the major drawbacks of the OFDM system is high PAPR. OFDM signal consists of lot of independent modulated subcarriers, which are created the problem of PAPR. It is impossible to send this high peak amplitude signals to the transmitter without reducing peaks. So we have to reduce high peak amplitude of the signals before transmitting.

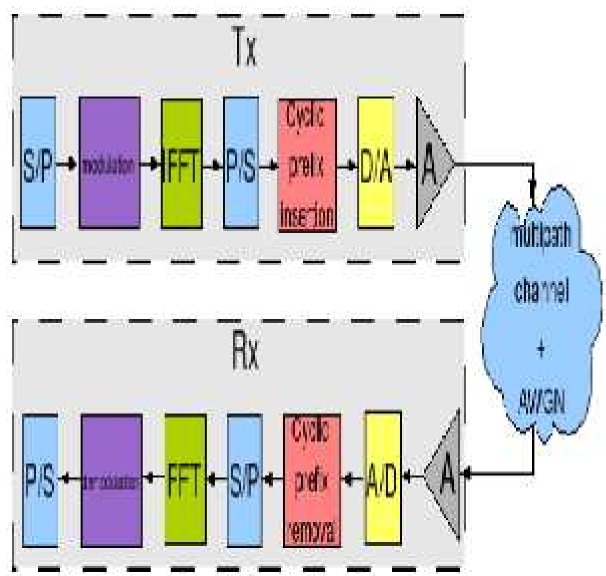


Fig1 BD of OFDM system

Some of the advantages of an OFDM system are as follows:-

- It is computationally efficient to employ the modulation and demo-dulation techniques by using FFT.
- The OFDM signal is robustness in multipath propagation environment and more tolerant of delay spread.
- It is more resistant to frequency selective fading than single carrier transmission systems.
- OFDM system gives good protection against co-channel interference and impulsive parasitic noise.
- Pilot subcarriers are used in OFDM system to prevent frequency and phase shift errors.

Disadvantages of OFDM

- The OFDM signal suffers high peak to average power ratios (PAPR) of transmitted signal.
- OFDM is very sensitive to carrier frequency offset.
- It is difficult to synchronize when subcarriers are shared among different transmitters

MIMO

Multiple-input and multiple-output, is a smart antenna technique based on the use of multiple antennas at both the transmitter and receiver to improve radio link communication performance MIMO can be split into transmit diversity and spatial multiplexing techniques and it depends on the channel condition which MIMO technique to select. Transmit diversity increases coverage and quality of service (QoS) because relies on transmitting multiple redundant copies of a data stream to the receiver; while spatial multiplexing increases the spectral efficiency because transmits independent and separately data streams from each of the multiple antennas. Apart from that, MIMO may be used to reduce co channel interference and provide an array gain, what is called beam forming.

Space frequency block coding in OFDM MIMO

To avoid the problem of fast channel variations in time, the symbols of an orthogonal design can be transmitted on neighboring subcarriers of the same OFDM symbol rather than on the same subcarrier of subsequent OFDM symbols. This also reduces the transmission delay However, the channel needs to be about constant over P neighboring subcarriers This is true in channels with low frequency-selectivity or can be accomplished by using a large number of subcarriers in order to make the subcarrier spacing very narrow. An example for nT=2 transmit antennas and Ns=2 subcarriers is given in figure 2. After the mapping according to the orthogonal design on nT streams associated with the transmit antennas, a simple serial to parallel converter can be used for each transmit antenna. Consequently, at the receiver a parallel to serial converter is used after the FFT. Space-frequency block codes avoid the problem of fast time variations. However, the performance will degrade in heavily frequency-selective channels where the assumption of constant channel coefficients (Hi(2m)=Hi(2m+1)) over a space-frequency block code matrix is not justified.

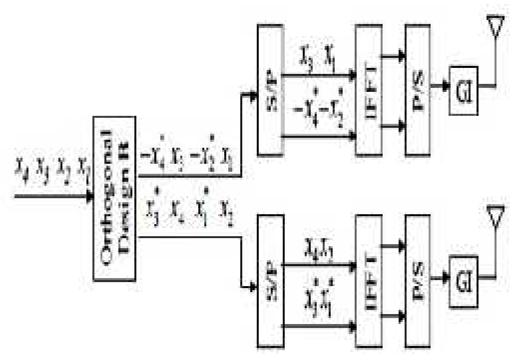


Figure. 2 SFBC in OFDM, with two TX

PAPR

It is defined as the ratio between the maximum power and the average power for the envelope of a baseband complex signal ~s(t) i.e.

$$P\,AP\,R\,\{s(t)\} = \max |s(t)|^2 / E\,|s(t)|^2$$

Also we can write this PAPR equation for the complex pass band signal s(t) as

$$PAPR\{s(t)\} = \max |s(t)|2 / E\{|s(t)|^2\}$$

Analysis of PAPR using CCDF

CDF is Cumulative Distribution function. If Y is a random variable then the CDF of y is defined as the probability of the event {Y ≤ y}. So the Com--plementary Cumulative Distribution Function (CCDF) is defined as the probability of the event {Y > y}. With using this density function it is easy to analyze the PAPR reduction performance. Let us consider x is the transmitted OFDM signal then we got the theoretical CCDF of PAPR i.e. to find the probability of the event {P AP R {x} > γ} which is given as

$$\Pr(PAPR\{x\} > \gamma) = 1 - (1-e^{-\gamma})^N$$

where N is the number of subcarriers. However the PAPR for the discrete-time base-band signal x [n] may not be same as that for the continuous-time baseband signal x (t). In fact, the PAPR for x [n] is lower than that for x (t), simply because x [n] may not have all the peaks of x (t). In practice the PAPR for the continuous-time base-band signal can be measured only after implementing the actual hardware, including digital-to-analog converter (DAC).So there is some way of estimating the PAPR from the discrete-time signal x [n]. It is known that x [n] can show almost the same PAPR as x (t) if it is V -times interpolated (oversampled) where V ≥ 4. The approximate value of the CCDF for the oversampled signal is given as

$$\Pr(PAPR\{x\} > \gamma) = 1 - (1-e^{-\gamma})^{\alpha N}$$

Where α has to be determined by fitting the theoretical CCDF into the actual one.

PAPR reduction techniques

There have been many new approaches dev-eloped during the last few years. Several PAPR reduction techniques have been pro-posed in the literature. These techniques are divided into following two groups.

The signal scrambling techniques are:

- Block coding
- Selective Level Mapping (SLM)
- Partial Transmit Sequences (PTS)

The signal distortion techniques are:

- Clipping
- Peak windowing
- Peak cancellation
- Peak power suppression
- Weighted multicarrier transmission

In the SLM technique, the transmitter generates a set of sufficiently different candidate data blocks, all representing the same information as the original data block, and selects the most favorable for transmission. A block diagram of the SLM technique is shown in Fig. 3. Each data block is multiplied by *U* different phase sequences, each of length *N*, **B**(*u*) = [*bu*,0, *bu*,1, …, *bu*,*N*–1]*T*, *u* = 1, 2, …, *U*, resulting in *U* modified data blocks. To include the unmodified data block in the set of modified data blocks, we set **B**(1) as the all-one vector of length *N*. Let us denote the modified data block for the u^{th} phase sequence **X**(*u*) = [*X*0*bu*,0, *X*1*bu*,1, …, *XN*–1*bu*,*N*–1]*T*, *u* = 1, 2, …, *U*. After applying SLM to **X**, the multicarrier signal Becomes Among the modified data blocks **X**(*u*), *u* = 1, 2,…, *U*, the one with the lowest PAPR is selected for transmission. Information about the selected phase sequence should be transmitted to the receiver as side information. At the receiver, the reverse operation is performed to recover the original data block. For implementation, the SLM technique needs *U* IDFT operations, and the number of required side information bits is ëlog2*U*û for each data block. This approach is applicable with all types of modulation and any number of subcarriers.

The amount of PAPR reduction for SLM dependsof the phase sequences.
on the number of phase sequences *U* and the design

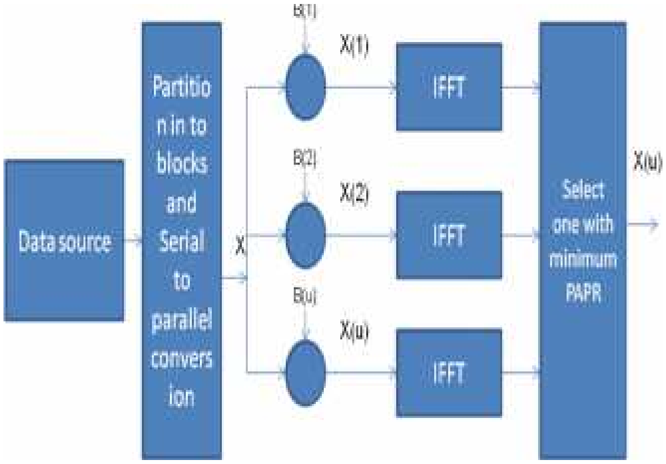


Fig.3 Selective mapping technique

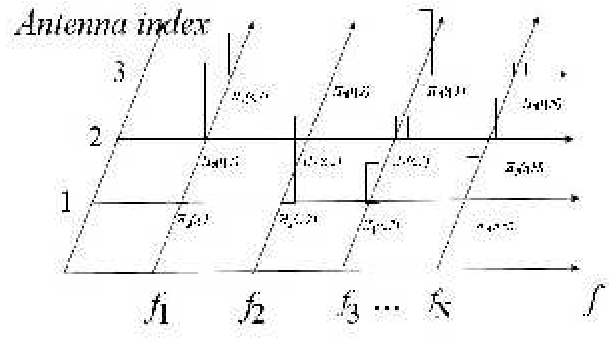


Fig.4 antenna selection scheme

Antenna selection scheme

In this scheme, antenna selection is done at each frequency component instead of using Frobenius norms. At each frequency, the channel coefficients are arranged in descending order and the best of them are chosen to transmit the data.

At frequency

f_1 : if H_2 [n, 1]> H_3 [n, 1]> H_1 [n, 1] ,then antennas 2 and 3 are selected.

f_2 : if H_1 [n, 1]> H_2 [n, 1]= H_3 [n, 1] ,then antennas 1 and 2 or 3 are selected.

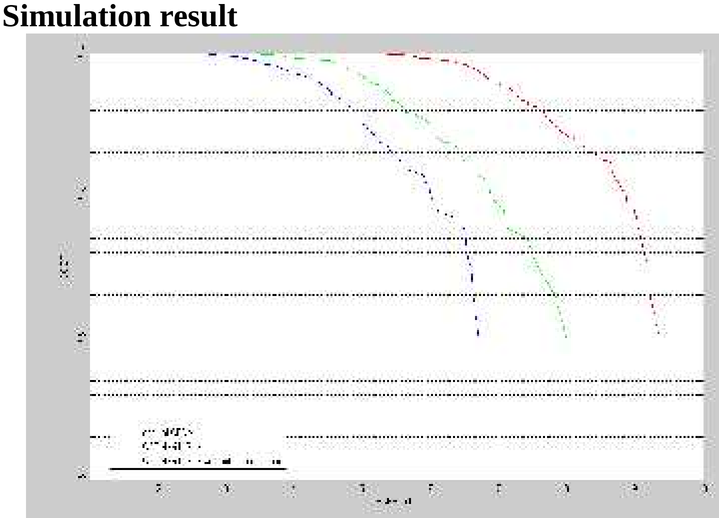
f_3 : if H_3 [n, 1]> H_1 [n, 1]> H_2 [n, 1] ,then antennas 3 and 1 are selected.

f_N : if H_1 [n, 1]= H2 [n, 1]> H3 [n, 1] ,then antennas 1 and 2 are selected.

Simulation Parameters used

Modulation technique	QPSK
No of subcarriers	64
No of OFDM symbols	Less than 1000
Oversampling factor	4
PAPR reduction scheme	Selective mapping(SLM)
Channel used	Rayleign channel
No of Tx and Rx	2Tx & 2Rx
Antenna selection	2 out of 4 antennaes

Simulation result



Here there is reduction of PAPR when we use SLM at transmitter side,in this case approx 1.3 dbs of reduction is observed when we use antenna selection then we have reduction of PAPR of about 2.7 dbs as compared to original OFDM

Conclusion:

Thus we have concluded that SLM is an effective technique to reduce PAPR of OFDM system since OFDM have wide range of applications this is useful technique, also antenna selection plays important role in increasing performance of system.

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