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Reduction of Roughness in FIR-SR Filter to DESIGN the Higher Order QAM Communication System

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Abstract

This paper presents a method of designing hybrid analog/asymmetrical square-root (SR) FIR filters. In addition to the conventional frequency domain constraints, the proposed method considers time-domain constraints as well, including the inter-symbol interference (ISI) and the opening of the eye pattern at the receiver output. Newly conceived parameter, the “roughness” of the analog/FIR-SR filter impulse response, is taken into account. The error-performance of a system employing a matched SR filter pair, in the presence of receiver timing jitter, is more strongly related to how well the roughness parameter is minimized, than it is to the maximizing of the eye width caused by the Nyquist pulse. QAM conveys a higher information bit rate (bits per second) than a BPSK or QPSK signal. With the hybrid analog/SR FIR filter co-design, examples show that using the proposed method can result in a more robust ISI performance & reduction in PAPR in the presence of the receiver clock jitter.

Keywords: Beamforming , Multiple Input Multiple Output (MIMO), OFDM, receiver clock jitter, square-root filter.

Introduction

Finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time. The square-root (SR) filters[1] are conventionally designed by directly designing the zero-phase Nyquist filter[3] with a nonnegative frequency response, then getting the matched SR transmitter and receiver filters via a spectral factorization of the Nyquist filter polynomial.In this way, the SR filters obtained usually have asymmetric coefficients. The use of symmetric SR filters has been explored and their linear-phase character permitting approximately half as many tap multipliers in relation to filter length makes their use attractive.

A. Existing system

A well-known drawback of OFDM is that the amplitude of the resulting time domain signal varies with the transmitted symbols in the frequency domain. If the maximum amplitude of the time domain signal is large, it may push the amplifier into the non-linear region which breaks the orthogonality of the sub-carriers and will result in a substantial increase in the error rate.

PAPR reduction techniques are associated with costs in terms of bandwidth or/and transmit power. Also, most of them require modifications in both transmitter and receiver which makes it non-compliant to the existing communication standards. Multiple signal representation methods, such as partial transmit sequence (PTS) and selected mapping (SLM) are well-known techniques which reduce the peak amplitude of the OFDM signal by manipulating the phase of subcarriers.

The phase weights are sent asa side information to the receiver to recover the original symbols[1]. A new Precoding PAPR reduction technique is proposed in [2], based on grouping the OFDM subcarriers in clusters and changing the phase of clusters in a manner similar to the PTS method but without the drawback of sending explicit side information. The proposed technique neither requires additional bandwidth nor power.

B. Proposed System

In this paper we consider PAPR reduction techniques for multiple transmit antennas with Space Time Block Codes (STBC) in EM mode, which is the case for both WiMAX and LTE standards. Simulation result shows the probability of high PAPR increases for MIMO comparing to the single antenna.

The beamforming weights also cause extra increase in PAPR; to avoid this, phase-only beamforming is usually used. In a MIMO scenario, the peak amplitude needs to be searched and minimized jointly over all antennas which affects the PAPR characteristics compared to the single antenna system. Also, the coupling between several OFDM symbols on each antenna gives an extra degree of freedom in the minimization algorithm.

Block Diagram

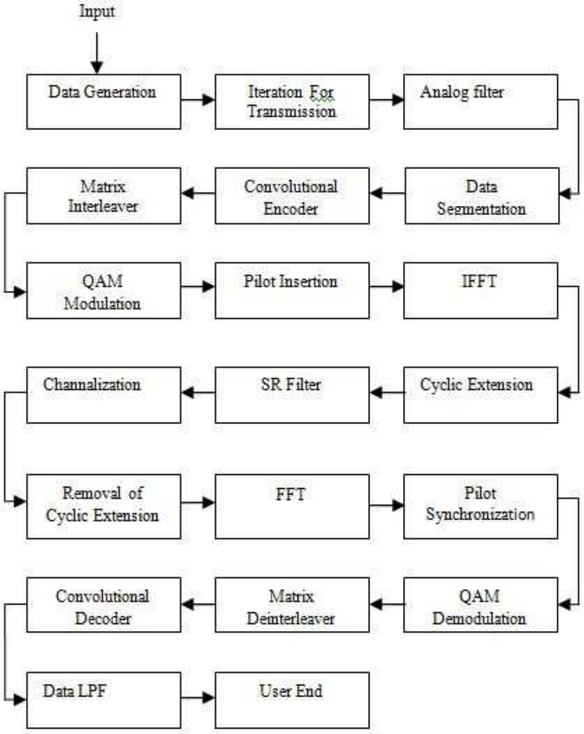


Fig.1.Block Diagram

A. Practical Implementations

In practical implementations where there exist interference and noise in the channel, the recovered receiver clock signal will suffer from some amount of timing jitter, which will deteriorate the error performance. The present work is the first to consider the difference between the two jitter-induced interference situations. Hence, a comprehensive method to deal with the interference caused by the ADC‘s timing jitter[7] in the system is proposed. On the other hand, there are analog filters and a digital-to analog converter (DAC) in the system. Fig.1. shows a typical digital communication system in which Sm(s) and An(s) represent the smoothing filter and the anti-aliasing filter, respectively. In a design strategy that considers both the analog portion and timing jitter was presented. In the transmitter, the cascade of the DAC, Sm(s), and any block other than the SR filter ht[n] is called the non-FIR portion u(t). In the receiver, the cascade of An(s), the analog-to-digital converter (ADC), and any block other than the SR filter hr[n] is called the non FIR portion v(t). Then time-reversal of the discrete-time equivalence at the transmitter to compensate for the nonlinear phase distortion of analog parts is applied. To compensate the nonlinear phase response of the analog parts, the Nyquist filter is used. Next, a composite method for designing an asymmetrical SR filter is proposed.

The method takes the filter‘s stop band gain, the system‘s tolerable ISI, the system‘s eye opening, and the magnitude response of analog components into account simultaneously. Unlike the proposed method does not require v(t)=u(−t) and does not explicitly compensate for the sin(x)-over-x spectrum of the DAC. On the other hand, compensating for the effect of the DAC[9] is implicitly considered in the problem formulation. An adaptive equalizer in the receiver is so powerful against random channel distortions that no deterministic method can be used to compensate for them. In the case of pulse-shaping filters, the stop band attenuation, ISI, and eye opening are well formulated. Therefore, by optimizing a performance index, the SR filters designed by the proposed method guarantees that the required system performance (for example, the ISI) is met, whereas an adaptive equalizer does not. On the other hand, when the channel contains some random distortions, the SR filters designed by the proposed method can work with an adaptive equalizer to improve the quality of the received signal.

B. Zero ISI Digital Communication System

A matched pair of square-root (SR) filters of a Nyquist filter used in the transmitter and the receiver of a band-limited digital communication system can provide zero inter-symbol interference (ISI). In practice, the SR filters are realized in FIR form. Conventionally, the SR filters are designed by directly designing the Nyquist filter with a non-negative frequency response (ignoring the linear-phase factor) [2and then getting the matched SR transmitter and receiver filters by performing a spectral factorization on the Nyquist filter polynomial. Although zero ISI is theoretically desired, in practice, it is not always necessary. In recognition of the “tolerable ISI” was also proposed.

C. Square Root Algorithm

Here, we propose a different formulation such that the design of the symmetric FIR SR filters is in second-order form. In practical implementations where there exist interference and noise in the channel, the recovered receiver clock signal will suffer from some amount of timing jitter, which will deteriorate the error performance. Therefore, we have proposed the design of Nyquist pulses that lead to a wide eye width as a means to cope with the receiver timing jitter problem. We have employed a systematic technique to compensate for the effects of the analog parts. We have constructed an FIR channel model for the DAC, the analog filters, and the ADC. Then, a time-reversed FIR channel model was cascaded within the system to make the overall phase response approximately linear..

D. MIMO-OFDM

A basic point to point MIMO communication system consists of Mt transmit antennas and Mr receive antennas. Space-time block codes (STBC) are designed to form the transmission blocks which exploit both diversity and multiplexing gain in MIMO. In MIMOOFDM, the transmit sequences of multiple antennas are mapped to parallel symbols and then modulated by the IFFT operation to form the OFDM transmit blocks. Accordingly, the concept of time in the MIMO STBC is analogous to frequency in a MIMO-OFDM system and it is referred to as space frequency block codes (SFBC) in this paper.

As the transmit symbols are divided over different time slots in STBCs, in MIMO-OFDM the whole OFDM band is divided into several sub-bands and each sub-band is called a cluster.

The main objective of the this project is the development of an efficient compression algorithm for scanned document compression, based on a recently proposed paradigm for image coding, referred to as the Multidimensional Multi scale Parser (MMP) algorithm. MMP is a block-based encoder. Block classification is used to segment image blocks into smooth and non-smooth blocks. It has been successfully used in the compression of other signals.

E.MIMO-PTS in Eigen-Beamforming Mode

Each OFDM block is divided intoM disjoint sub-blocks, each of size N × 1. Note that in our proposed technique sub-blocks are chosen as cluster units, so M = C. After taking IFFT of these sub-blocks, a big matrix of size N × M is formed for each OFDM block, with IFFT samples of sub-blocks in columns.

Since the IFFT is a linear operation, the beamforming weights can be applied before or after IFFT summation. However, it is easier to explain when Wc are multiplied after sub-block partitioning and IFFT operation, as depicted in Fig.1. The PAPR weights are subsequently applied afterwards, and they are common between different antennas but different for contributing OFDM blocks on each antenna. Finally, sub-blocks of different weighted OFDM symbols are summed together to construct the final sub-blocks. The summation of final sub-blocks gives the transmit OFDM sequence. It is clear from Fig.1 that now the PAPR depends on the transmit sequences over all antennas rather than just one, as in single antenna case. To formulate the optimization problem, we can write $z_{i,q} = B(q)\ \mathrm{diag}(w(q,i))\psi(q)$ which is the contribution of the OFDM block q on the ith antenna output.

F. Formulation of the Phase Optimization Problem

In order to minimize the PAPR, the phase weights are selected by minimizing the largest sample of OFDM sequence. The optimization problem can be formulated as $\Psi = \arg\min_{\varphi q,m} \max_{i,n} |s_{i,n}|^2$, (6) where $\Psi = [\psi(1),\psi(2), \cdots \psi(M_t)]$ and $\psi = \mathrm{vec}(\Psi)$. This is a minimax optimization problem when the objective function is $f_{max}(\psi) = \max_{i,n} |s_{in}|^2$.

G. Solving the Minimization Problem

In PTS the optimum weights are selected by performing an exhaustive search among the quantized set of phase options, which limits the number of sub-blocks and eventually the PAPR reduction gain. A practical gradient-based algorithm is proposed in [2] which is modified and adapted for the phase optimization problem of the PAPR reduction in multiple antenna system. SQP proceeds based on solving a set of sub problems created as a quadratic model of the objective, subject to a linearization of the constraints. Accordingly, at each major iteration, a quadratic function is defined at the current solution. The Jacobian matrix of the constraints are used for linearization of the current constraints in original problem around ψk . The minimization direction d is the optimal direction to move in order to minimize the largest sample

The peak-to-average power ratio (PAPR) is a related measure that is defined as the peak amplitude squared (giving the peak power) divided by the RMS value squared (giving the average power)

$$PAPR = \frac{|x|_{\mathrm{peak}}{}^2}{x_{\mathrm{rms}}{}^2} = C^2$$

A peak-to-average ratio meter (Par meter) is a device used to measure the ratio of the peak power level to the time-averaged power level in an electrical circuit. This quantity is known as the peak-to-average ratio (p/a r or PAR). Such meters are used as a quick means to identify degraded telephone channels.Par meters are very sensitive to envelope delay distortion. They may also be used for idle channel noise, nonlinear distortion, and amplitude-distortion measurements.The peak-to-average ratio can be determined for many signal parameters, such as voltage, current, power, frequency, and phase.

The crest factor or peak-to-average ratio (PAR) is a measurement of a waveform, calculated from the peak amplitude of the waveform divided by the RMS value of the waveform

$$C = \frac{|x|_{\mathrm{peak}}}{x_{\mathrm{rms}}}$$

Consider a sinusoidal signal

$x(t) = \sin(2\pi f t)$ having the period T.

The peak value of the signal is

$\max\left[x(t)x^*(t)\right] = +1$.

The mean square value of the signal is,

$$E\left[x(t)x^*(t)\right] = \frac{1}{T}\int_0^T \sin^2(2\pi f t)$$

$$= \frac{1}{2}$$.

Given so, the PAPR of a single sine tone is,

$$papr = \frac{1}{\left(\frac{1}{2}\right)} = 2$$.

The peak to average power ratio for an OFDM system with K sub carriers and all sub carriers are given the same modulation is,

$$papr = \frac{K^2}{K} = K$$.

Conclusion

For a multiple transmit antenna system, exploiting the cluster beamforming weights which is a general feature in 4G communication systems. The proposed technique comes with interesting unique properties, making it a very appealing method especially for standard constrained applications as LTE and WiMAX. The PAPR reduction gain is significant compared to other techniques while no side information is sent to the receiver, so the throughput is not affected. The transmitted power and bit error rate does not increase. An optimization technique for finding the best weights was proposed. The PAPR reduction problem was formulated as a minimax problem that was solved by deriving the gradient and modifying the SQP algorithm to solve the optimization. The proposed algorithm minimizes the PAPR over all antennas and time slots in a STBCMIMO system resulting in a PAPR reduction of more than 7dB for a four antenna MIMO system.

Results

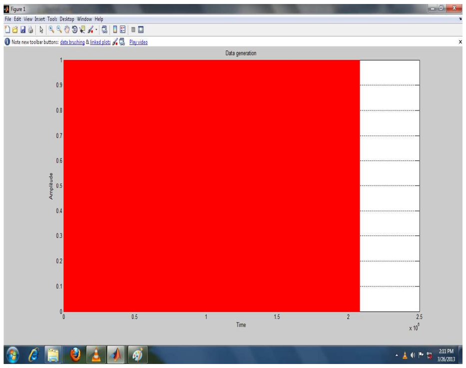


Fig.1. Data generation

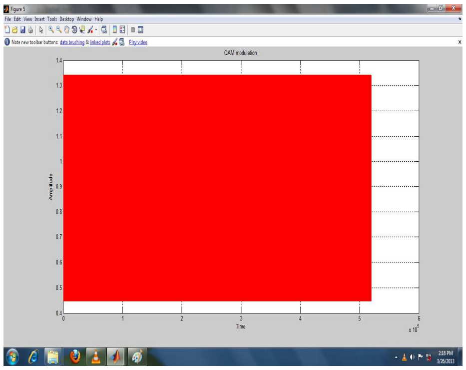


Fig.2.QAM Modulation

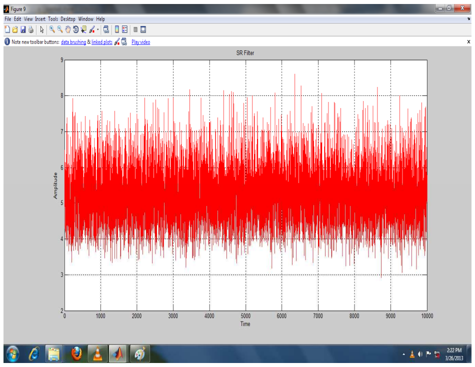


Fig.3. SR filter

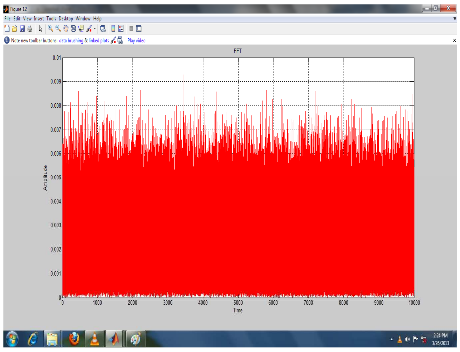
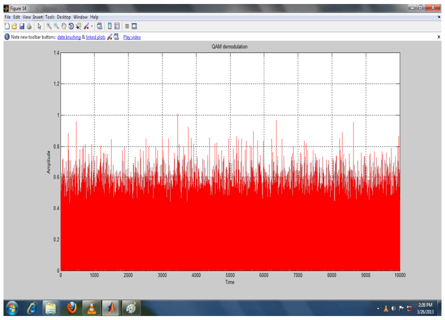


Fig.4. FFT



Fig,5. QAM Demodulation

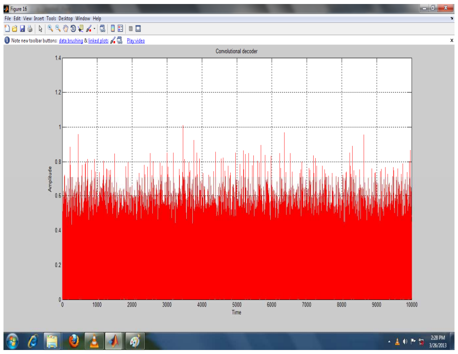


Fig. 6. Convolution decoder

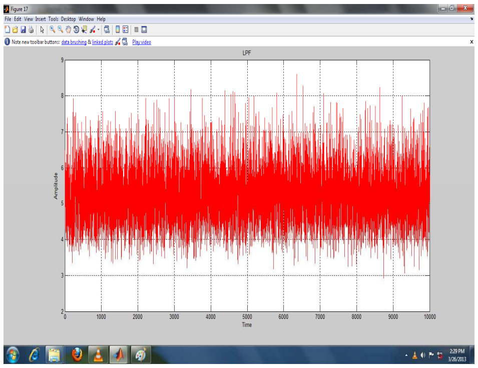


Fig. 7.LPF

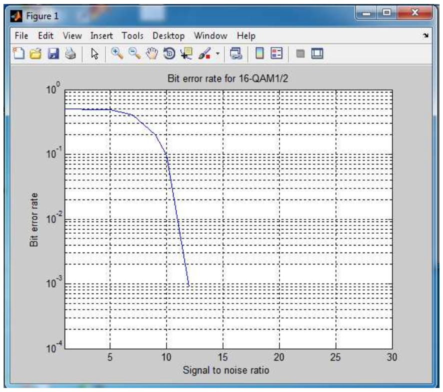


Fig.8. Bit error rate for 16-QAM 1/2

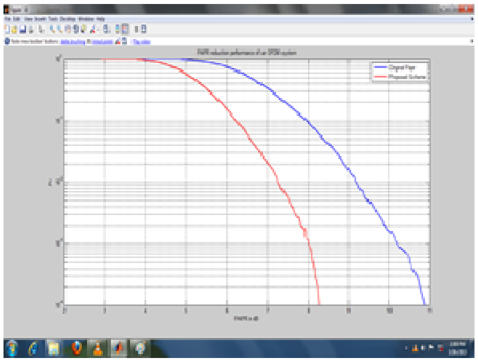


Fig.9.PAPR reduction performacne

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