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Peak to average power ratio reduction in OFDM system using hybrid technique

Amritpal Singh*, Harjit Singh

Department of Electronics and Communication Engineering, Guru Nanak Dev University, Regional Campus, Gurdaspur, Punjab, India

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ABSTRACT

There are many benefits of utilizing OFDM like robustness and high spectral efficiency against ISI but still there are some disadvantages. The main problem that arises in OFDM systems is high PAPR. There are many techniques available for reduction of PAPR like tone reservation (TR), clipping and filtering, partial transmit sequence (PTS), active constellation scheme, interleaving and selected mapping (SLM). Clipping and filtering are the easiest techniques but they are not suitable when large number of sub-carriers are present. The most common techniques used for PAPR reduction are PTS and SLM. PTS and SLM algorithms have achieved good performance in PAPR reduction. A new method is proposed in this paper which is hybrid combination of PTS and SLM and this method has also reduced the PAPR from 6 to 5. The results are compared with the already available techniques and this method achieves better results.

1. Introduction

Recently, the interest for services of the multimedia information has become radically which drive us in the time of 4th generation which is a system of wireless communication. This necessity of service of multimedia in which there are large number of users and also having bounded spectrum, advanced technologies of digital wireless communication system which are having efficient bandwidth and also robust to environment of multipath channel called multicarrier communication system. The modern digital multicarrier wireless communication system give data rate at high speed at least cost for numerous users and also with high reliability. In system of single carrier, single carrier possess the whole bandwidth of communication while in system of multicarrier, the available bandwidth of communication is partitioned by numerous sub-carriers. So that every sub-carrier has smaller bandwidth as contrasted with system of single carrier's bandwidth. These wonderful features of technique of multicarrier attract us to study Orthogonal Frequency Division Multiplexing (OFDM). OFDM frames premise for all 4G wireless systems of communication because of its huge limit regarding number of subcarriers, high rate of data in overabundance of 100 Mbps and omnipresent scope with high mobility.

2. Orthogonal frequency division multiplexing

The necessity of high data rate draws the great attention in multi-carrier system. It should be capable to operate smoothly in environment of high carrier frequency, high data transmission rate and mobility. The studies have shown that OFDM fulfil the multicarrier system necessities. OFDM is a multi-carrier modulation (MCM) technique in which complex data symbols (i.e., BPSK, QPSK, QAM, MPSK etc.) are transmitted in parallel after modulating them over orthogonal sub-carrier. In single carrier (SC) system, one complex data is transmitted using one carrier and in this parallel transmission, $\boldsymbol{N}$ complex data is transmitted over $\boldsymbol{N}$ sub-carrier. Here the effective data rate of the system is same as of SC system. The parallel transmission increases the time period of symbol and the comparative amount of separation in time caused by multipath delay decreases.

In OFDM system, the orthogonality among sub-carriers is maintained by using inverse Fast Fourier Transform (IFFT) as shown in figure. A guard band is inserted between successive OFDM symbols. Insertion of guard band in OFDM symbols can be done by three methods-cyclic prefix, cyclic suffix and zero padding. By adding guard band in OFDM symbols, OFDM convert wideband frequency selective channel into collection of parallel narrowband flat fading channel, one channel across each subcarrier. Thus it removes Inter-Symbol Interference (ISI). Due to features like high immune to multipath fading, high data transmission rate and requirement of less complex equalizer, OFDM has been exploited by many high data rate broadband wireless communication systems of present generation [1], [2].

* Corresponding author. Tel.: +15146915896.
E-mail addresses: amritpalsdhunna@gmail.com (A. Singh), hs_kahlona@yahoo.com (H. Singh).

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3. Advantages of OFDM system

The advantages of OFDM system are as follows:

1. *Saving of bandwidth:* The OFDM system is more bandwidth efficient in comparison to Frequency Division Multiplexing (FDM). in FDM technique numerous distinct carriers are spaced apart without overlapping where in OFDM system the sub-carrier overlap each other due to orthogonality features. Due to overlapping of sub-carriers the usage of bandwidth reduced drastically and also reduced the guard bands for the separation of sub-carriers.
2. *Easy to implement modulation and demodulation:* The challenging problem in a MCM system is to implement bank of modulators at the transmitter side and demodulators at the receiver side. The concept of "Data transmission" can be efficiently implemented using IFFT and FFT instead of bank of modulators at the transmitter side and demodulators at the receiver side respectively.
3. *Easy equalization:* In a single carrier system, equalization make frequency channel flat but equalization amplify noise greatly in frequencies domain where channel response is poor. As a result, single carrier performance is affected due to high attenuation in some bands since all used frequencies are given equal importance. In OFDM system, wideband channel are divided into flat fading sub-channels, it reduces the equalization complexity in the receiver. So, it is possible to use maximum likelihood decoding with reasonable complexity.
4. *Protection against intersymbol interference:* The extended symbol time (due to lower data rate) makes the signal less susceptible to effect the channel such as multipath propagation which introduces Inter Symbol Interference (ISI). The use of cyclic prefix between consecutive OFDM symbols makes it immune to ISI. Also, it is less sensitive to sample timing offsets than single carrier system.

4. Disadvantages of OFDM system

Despite of several advantages, OFDM systems also have major problems like-

1. High Peak to Average Ratio (PAPR) of transmitted signal: Presence of a large number of subcarriers with varying amplitude results in a high peak to average power ratio (PAPR) of the system with large dynamic range, which in turn effects on the efficiency of the RF amplifier.
2. Synchronization (timing and frequency) at the receiver: Symbol Timing Offset (STO) and Carrier Frequency Offset (CFO) affects on the performance of OFDM system. Correct timing between FFT and IFFT is required at the receiver side. OFDM system is highly sensitive to Doppler shifts which affect the carrier frequency offset, resulting in ICI.

5. Applications of OFDM system

After the use of IFFT/FFT technique, the implementation of OFDM becomes more convenient. The applications of OFDM are divided into two categories-wire-line and wireless application. The wire-line application such as-

1. Asymmetric Digital Subscriber Line (ADSL) broadband access through plain old telephone service (POTS) copper wiring [3].
2. Multimedia over Coax Alliance (MOCA) home networking [4].

The wireless applications are as explained below:

1. IEEE 802.11 a/g/n [5–7].
2. IEEE 802.15.3a [8].
3. IEEE 802.16 d [9].
4. IEEE 802.20 [10].
5. Digital Audio Broadcast (DAB) systems [11].
6. Digital Video Broadcast (DVB) terrestrial TV systems [12].
7. HIPERLAN/2 [13]

6. Related work

Lots of research work has been done in the area of PAPR reduction. Many techniques have been proposed for the reduction of PAPR. Some important work in this area is as follows:

Ref. [14] exhibited a novel arbitrary phase updating algorithm. The phase of every subcarrier is updated by an arbitrary increment till the PAPR goes underneath a certain level of threshold. The impact of diverse distributions for the increments of phase and the fluctuations of distributions on the mean and variance of PAPR and also the number of iterations to achieve the threshold are examined. In this strategy, after fruitful updating of the shifts of the phase, the level of threshold is reduced and the variance of the increments of the phase is altered. The results of the simulation of the algorithm show nearby agreement. The random phase updating algorithm with vigorous threshold provides the best results and also has the ability to reduce the mean power variance of signal of OFDM by a variable of 7 db.

In paper [15], proposed a novel algorithm for reduction of PAPR of OFDM system, dependent on a scheme of companding. In this strategy, a compressing polynomial is attached to block of IFFT at the transmitter and at the receiver, the block of FFT is joined with a reverse extending function in which iterative Jacobi's method is utilized for equations solving. The proposed technique involves low complexity at the transmitter in correlation with other algorithms of PAPR reduction. It likewise obliges less increment in SNR for the same BER contrasted with other methods of companding. A tradeoff between performance and complexity can set the order of polynomial compressing and the number of iterations for the algorithm proposed at the receiver.

In Ref. [16], authors proposed a selected mapping algorithm to conquer this problem. The frames of candidate OFDM transmitted on antennas are decayed to be real and imaginary part, therefore an adequately expansive number of alternative transmit signals are given, accordingly better performance of PAPR can be accomplished contrasted with traditional algorithm of SLM. Also, the computational complexity of proposed algorithm hold unaltered by utilizing the property of conjugate symmetry of real sequence. The results of simulation demonstrate that the proposed algorithm beats the traditional algorithm of SLM in MIMO-OFDM systems.

Paper [17] concentrated on use of Partial Transmit Sequence (PTS) for reduction of PAPR. As traditional technique of PTS needs a comprehensive searching over all the combinations of the given phase factors, which brings about increase in the computational complexity exponentially with the number of the sub-blocks. As the process of looking of ideal phase factors can be categorized as combinatorial optimization with few constraints and variables, the author presented a novel scheme, which is dependent on the approach of non linear optimization, known as simulated annealing, to look for ideal combination of phase factors with low complexity. To approve the analytical results, extensive simulations have been carried out, demonstrating that the proposed schemes can accomplish considerable reduction in computational complexity while maintaining good reduction in PAPR.