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A Unitary Pre-coder for Optimizing Spectrum and PAPR Characteristics of SC-FDMA Signal

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Abstract : *Single Carrier Frequency Division Multiple Access (SC-FDMA) is a promising technique compared to Orthogonal Frequency Division Multiple Access (OFDMA) for the uplink transmission because of its low peak to average power ratio .However SC-FDMA is very sensitive to carrier frequency offset(CFO) , which affect the error rate performance of the system adversely .This paper proposes an efficient signal processing technique known as fractional fourier transform (FRFT) for the Single Carrier Frequency Division Multiplexing (SCFDM) over Selective fading channel in the presence of CFO. A clear improvement has been shown in Bit error rate (BER) by using FRFT block in place of FFT block. Simulation results confirm that FRFFT-SCCFDM outperforms FFT-SCFDM as its probability of error can be controlled by varying FRFT angle without significant increase in the complexity .Further, we have compared the FRFT implementation of SCFDM of OFDM and observed a gain of 7db for FRFT-SCFDM over FRFT-OFDM at CFO equal 0.1 .Further no change in PAPR ,no significant increase in complexity with improved BER performance or Quality of Service (QOS) motivates FRFT-SCFDMA to be one of the potential Candidates for uplink transmission*

Keywords: *OFDM, Bit error rate, Fourier Transform ,Peak to average power ratio, Selective fading , SCFDMA , OFDMA , FRFT .*

I. Introduction

Single carrier frequency-division multiple accesses (SCFDMA) has become very popular in wireless communications. After its adoption in the recently developed wireless local area network (LAN) and broadband wireless access (BWA) standards ([1], [2]), this technique is seen today as a strong candidate for future generations of cellular mobile networks. In current systems, SCFDMA is used with time-division multiple access (TDMA), i.e., users sequentially share the available radio resources and all carriers are assigned to the same user during a given MCCDMA symbol. OFDMA can be viewed as a collection of transmission techniques. When this technique is applied in wireless environment, it is referred to as DFT pre coded OFDM. In the wired environment, such as asymmetric digital subscriber lines (ADSL), it is referred to as discrete multi tone (DMT). In OFDM, each carrier is orthogonal to all other carriers. However, this condition is not always maintained in DMT [1]. OFDMA is an optimal version of multi carrier transmission schemes. OFDM started in the mid 60's, Chang proposed a method to synthesize band limited signals for multi channel transmission [2]. The idea is to transmit signals simultaneously through a linear band limited channel without inter channel (ICI) and inter symbol interference (ISI) .

A number of steps can be taken when designing a multi-carrier system to mitigate the effects of fading.

In time domain, the data symbol duration can be made much longer than the maximum excess delay of the channel. This can be done either by choosing max $T_s \gg \tau_{max}$.

In frequency domain, the bandwidth of the sub-carriers can be made small compared to the coherence bandwidth of the channel $B_{coh} \gg W/N_c$. The sub-bands then experience flat- fading, which reduces the equalization to a single complex multiplication per carrier.

II. Scfdma System Model

The word multiple access indicates that there is a precise mathematical relationship between the number of the carriers and number of concurrent users acquired that system. In a normal frequency-division multiplex system, though many sub carriers are spaced only one users can able to accommodate using conventional IFFT transform.

2.1papr In Scfdma

One of the main disadvantages of the SCFDMA systems is the high PAPR of the transmitted signal due to the combination of N modulated SCs. The PAPR for a continuous-time signal, x(t), is defined as:

$$\text{PAPR} = \frac{\max\{|x(t)|^2\}}{E\{|x(t)|^2\}}, \quad 0 \leqslant t < T_u.$$

On the other hand, the PAPR for discrete-time signals can be estimated by oversampling the data sequence d depicted in Fig. 2.3 by a factor L and computing LN-points IFFT of the data block with (L − 1)N zero-padding. The PAPR in this case is defined as:

$$\text{PAPR} = \frac{\max\{|x_n|^2\}}{E\{\|\mathrm{x}\|^2\}}, \quad n = 0, 1, \cdots, LN-1,$$

2.2 Ccdf Of The Papr

The CCDF is widely used to assess the performance of PAPR reduction techniques which is defined as the probability that the PAPR is greater than a reference value denoted as PAPR0. Fig. 3.1 depicts the CCDF of the PAPR of the OFDM signals with N = 1024 SCs and different oversampled factor, L = 1, 2 and 4. It is clear that the PAPR does not increase considerably after L = 4. Therefore, an accurate PAPR estimation for the discrete model requires an oversampling factor L > 4. It has been shown that the difference between the continuous-time and discrete-time PAPR is negligible for L = 4 [12].

A straightforward estimated expression for the CCDF of the PAPR of an OFDM signal is with a large number of SCs and the real and imaginary parts of N-point IFFT output samples have a mutually independent and uncorrelated Gaussian probability distribution function with zero mean and a variance of σ2 = E{|xn|2}/2.

F(z) = 1 − exp(−z).

Furthermore, the CCDF of the PAPR can be given by,

CCDF = Pr(PAPR > PAPR0) = 1 − F(PAPR0)N = 1 − (1 − exp(−PAPR0))N.

Dynamic channel allocation in SCFDMA transmission scheme advantages

- Makes efficient use of the spectrum by allowing overlap.
- By dividing the channel into narrowband flat fading sub-channels, SCFDMA is more resistant to frequency selective fading than single carrier systems are.
- Eliminates PAPR problems (ISI) through use of successive channel allocations.
- Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.
- Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.
- It is possible to use maximum likelihood decoding with reasonable complexity, OFDMA is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.

III. Proposed Optimization Model

The proposed pre coded model will calculate the PAPR rate grid by each allocation grid and identify the best location for deploying the modulated symbols. The grid size can be determined according to the constraint of computational cost. A larger grid will reduce the computational cost but will find a location with lower network capacity. It gives an example where the candidate region is partitioned into several grids and a location will be identified for deploying the relay for achieving the maximal network capacity.

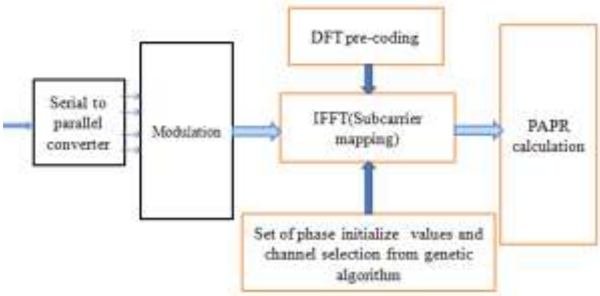

Fig. 2. Proposed parametric optimization model

STEP1: partition the region into equal size of sub regions.
STEP2: Deployed PAPR calculation in each partition

STEP3: for (i=1:no.of sub regions)
if (Pi is closer to BS)//pi relay placement location
skip:
else;
set low faded bright region
STEP4: for all possible sub carriers in bright region: Select point which leads maximum network capacity.
Evaluate its PAPR.
SETP5: change the channel allocation order based on its metrics.

3.1 Genetic optimization model

Required PAPR and BER rate is accomplished through appropriate gene selection and its time domain signal using an Inverse Fourier Transform.

Chromosomes

The original motivation for the GA approach was a biological analogy. In the selective breeding of plants or animals, for example, offspring are sought that have certain desirable characteristics—characteristics that are determined at the genetic level by the way the parents' chromosomes combine. In the case of GAs, a population of strings is used, and these strings are often referred to in the GA literature as chromosomes.

The recombination of strings is carried out using simple analogies of genetic crossover and mutation, and the search is guided by the results of evaluating the objective function f for each string in the population. Based on this evaluation, strings that have higher fitness (i.e., represent better solutions) can be identified, and these are given more opportunity to breed. It is also relevant to point out here that fitness is not necessarily to be identified simply with the composition f(c(s)); more generally, fitness is h(f(c(s))) where is a monotonic function.

IV. Performance Analysis

In this section, we present MATLAB simulation results to illustrate the PAPR reduction performance of both precoder and genetic scheme. For BER analyses the MS is equipped with higher order mapping and serves M = 16 pre coding is employed to avoid the MUI. Moreover, the complementary cumulative distribution function (CCDF) is employed to show the statistical properties of PAPR. In order to make the peak power fully reduced, we propose genetic scheme to iteratively perform with the maximum PAPR as shown in Fig 2. The pre coder scheme only reduces the peak power on low size FFT, resulting in much higher complexity than the genetic scheme. With a part of the saved computational resources, the genetic scheme could continue to reduce the peak power iteratively. Thus, the BER reduction can also achieve with better PAPR reduction performance than the pre coded scheme with lower complexity as shown in Fig 3.

Since genetic consider generate all possible combinations of weighting factor set in the IFFT block and both BER and PAPR optimization is combinely achieved. Finally the merits of genetic based model for parameter optimization over precoded matrix model in terms of iterative complexity reduction and performance is proved as shown in table 1.

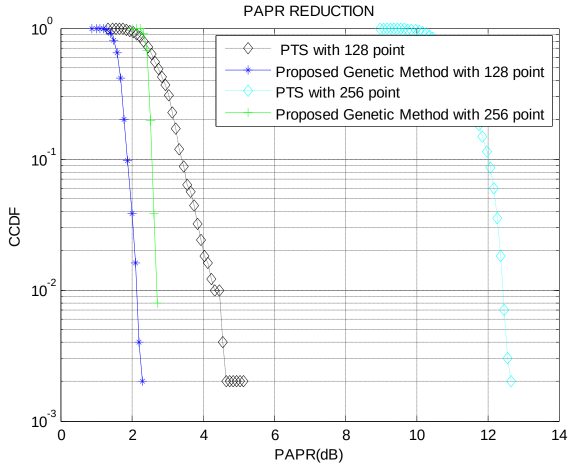

Fig. 3: pre-coder vs. genetic PAPR analyzes over various IFFT sizes.

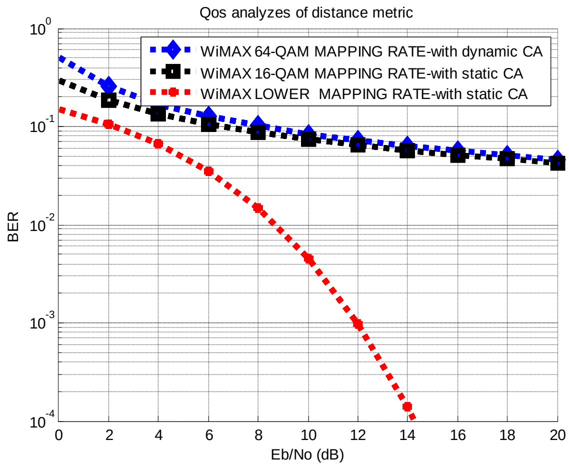

Fig. 4: BER performance analyzes using dynamic channel allocation.

V. Conclusion

In this thesis, we carried out performance metrics of genetic scheme over BER reduction with maximum PAPR reduction in SCFDMA systems. In most cases the PAPR of SCFDMA systems mainly depends on the maximum PAPR of all transmit symbols, the proposed pre-coded scheme can able to achieve significant PAPR reduction with low complexity. In simulation results we proved that the genetic scheme achieves better PAPR reduction with lower complexity than the all other existing pre coded scheme. The concept of multi objective optimization and variations that have been noticed is consistent in genetic approaches with appropriate initialization methods, fitness definition, and selection and are obviously replacement strategies used in crossover and mutation. We can add information such as age, or artificial tags, to chromosomes; in order to reduce complexity further.

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