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ANALYSIS OF ROLL-OFF-FACTOR TO REDUCE THE PAPR IN SC-FDMA SYSTEM

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Abstract- The 3rd generation standard has adopted orthogonal frequency division multiplexing access (OFDMA) in downlink and single carrier-frequency division multiple access SC-FDMA used for the uplink transmissions, which is used single carrier modulation and frequency domain equalization. In this paper, we proposed a roll-off-factor scheme to reduce the peak-to-average power ratio (PAPR) of SC-FDMA signals. Moreover, the scheme can compress the large amplitude of signal, its maintaining the average constant power of signal. Using the Matlab simulation results show that the proposed roll-off-factor scheme can offer better PAPR reduction by properly choosing the control parameters. The proposed our companding scheme transform the original SCFDMA signals into power distributed function. The companding scheme can reduce the large amplitude signals, and its maintaining constant average power.

Keywords- LTE, OFDMA, SC-FDMA, PAPR, roll-off-factor.

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Introduction

The 3rd generation long term evolution (LTE) has adopted orthogonal frequency division multiplexing access (OFDMA) for downlink transmission and single carrier frequency division multiple access (SC-FDMA) for uplink. Peak-to-average-power ratio is a performance measurement that is indicative the power efficiency of the transmitter. This is to compensate for a drawback of OFDM, the PAPR is very high. The require of High PAPR is expensive and inefficient power amplifiers with large scale linearity requirements. The cost is increases of the terminal & drains the battery faster [1]. SC-FDMA, which utilizes single carrier modulation and frequency domain equalization is a technique that has similar performance and essentially the same overall complexity as those of OFDMA system. A salient advantage of SC-FDMA over OFDMA is the lower PAPR because of its inherent single carrier structure. Many researches are still going on to find the impact of different parameters on PAPR in SC-FDMA.

In this paper, we investigate some existing papers and propose a novel nonlinear companding scheme, called 'Power-function companding, is shown in [Fig-1] for further PAPR reduction in SC-FDMA environment. To further reduce the PAPR in SCFDMA, roll-off-factor used to reduce the PAPR in SC-FDMA system.

SC-FDMA there are three methods of assigning the *M* frequency domain modulation symbols to subcarriers: distributed subcarrier mapping (DFDMA), localized subcarrier mapping (LFDMA), and interleaved subcarrier mapping (IFDMA) a special case of distributed FDMA.

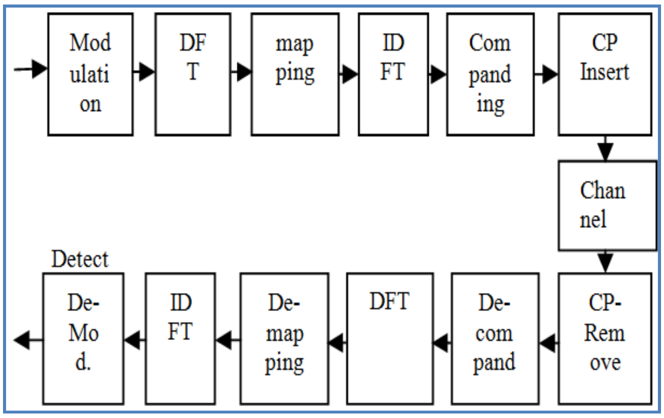

Fig. 1- Block diagram of Transmitter and Receiver SC-FDMA System using Companding Scheme

Localized subcarrier mapping mode, the *M* modulation symbols are assigned to *M* subcarriers adjacent. Distributed mode, the equally spaced symbols across the entire bandwidth. The distributed and localized mapping of DFT precoded data sequence to OFDM subcarriers is sometimes collectively referred to as DFT-spread OFDM. SCFDMA signals have lower PAPR than OFDMA signals.

And LFDMA incurs higher PAPR compared to IFDMA [1,2]. So IFDMA is more desirable than LFDMA in terms of power PAPR efficiency, LFDMA in terms of throughput is superior when channel dependent scheduling is utilized. Thus, LFDMA has been widely implemented in LTE. In this paper, we mainly consider LFDMA, and it is necessary to further reduce the PAPR in LFDMA mode. In this paper investigate and analyze the PAPR performance of SC-FDMA.

PAPR of SC-FDMA System

The transmitter, a baseband modulator transforms the binary input to a multi-level sequence of complex numbers in one of several possible modulation formats, such as (QPSK) quandary phase shift keying, and (QAM) quadrature amplitude modulation, etc. The modulated symbols are performed an *M*-point discrete Fourier transform (DFT) to produce a frequency representation [3],

$$S_k = \sum_{m=0}^{M-1} Sm\, e^{-\frac{j2\pi mk}{M}} \tag{1}$$

where Sm (m = 0, 1, … , M - 1) represents modulated source symbols, and Sk (k = 0, 1, … , M-1) represents M samples of Sm of the DFT. The subcarrier mapping, as Xn (n = 0, 1, … , N-1) the represented in frequency domain samples, and xn (n = 0, 1, … , N-1) is the time domain symbols after N-point inverse discrete Fourier transform (IDFT) of Xn (n = 0, 1, … , N-1). The power of SC-FDMA signal xn can be calculated as,

$$|X_n|^2 = \frac{1}{N}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} X_u X_v \exp\left(\frac{j2\pi(u-v)n}{N}\right) \tag{2}$$

The PAPR of *x*(*t*) transmit signal is defined as follows,

$$\mathrm{PAPR}(1) = \frac{\max|x(t)|^2}{E[|x(t)|^2]} \tag{3}$$

The rectangular pulse shaping, symbol rate sampling will give the same PAPR as the continuous case since SC-FDMA signal is modulated over a single carrier.

Power Function Companding Scheme

A Power-function companding scheme that can effectively reduce the PAPR of transmitted SC-FDMA signals. Moreover, the new scheme has the advantage of maintaining a constant average power through the companding operation. Therefore, the efficiency of the amplifier can be improved [4].

The LFDMA signal in the time domain has exact copies of input time symbols with a scaling factor of 1/Q at sample positions that Q of multiples of integer. The values are weighted sums of all the time symbols in the input block. Assume the input information symbols Sm (m = 0, 1, … , M - 1) are statistically independent and identically distributed. Based on the central limit theory, Sk (k = 0, 1, …, M-1) can be approximated as a complex Gaussian process when the number of DFT point is large (e.g. M ≥ 64). With equation (5) in mind, the time domain symbols xn (n = 0, 1, …, N-1) also can be approximated as a complex Gaussian process when the sample index is not integer multiples of Q [5]. For simplicity, we approximately regard the time domain symbols xn (n = 0, 1, … , N-1) as a complex Gaussian process. The amplitude, or modulus, of SC-FDMA signal xn is given by

$$|x_n| = \sqrt{\mathrm{Re}^2\{x_n\} + \mathrm{Im}^2\{x_n\}} \tag{4}$$

The proposed power-function companding scheme is given by

$$t_n = m(x_n) \tag{5}$$

where *xn* (*n* = 0, 1, … , *N*-1) is the original SC-FDMA signal and *tn* (*n* = 0, 1, … , *N*-1) is the companded signal, the proposed companding function *m*(*x*) only input signals changes the amplitudes. Let the companded SC-FDMA the amplitude of signal have a power function distribution in the interval [0, *T*]. Where α is the control parameter, which controls the companded signal distribution shape.

Computer Simulation

PAPR of using Complementary Cumulative Distribution Function, the probability that PAPR(1) is higher than a certain PAPR(1) value PAPR0 (Pr{PAPR(1)>PAPR0}), is calculated by Monte Carlo simulation. CCDFs of PAPR for LFDMA is evaluated. 10^5 uniformly random data points were generated to acquire the CCDF of PAPR. In the simulations, the total number of subcarriers *N* was set to 256, input data block size *M* to 64, and QPSK modulation, without pulse shaping applied. The CCDF performance of the proposed scheme with α = 0.1, 0.2, 0.4, 0.6, 0.8, 0.98 respectively.

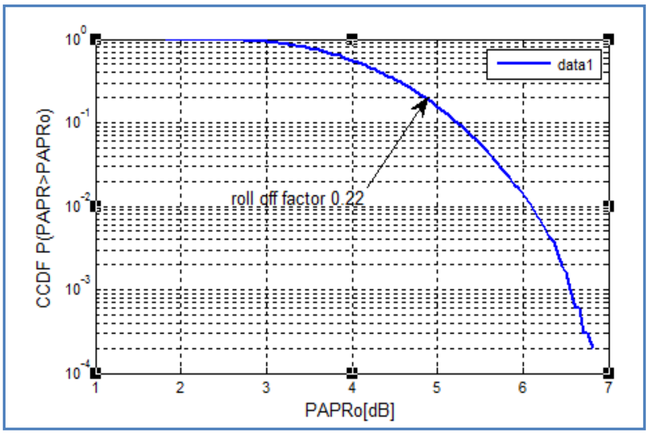

Fig. 2- Comparison of CCDF of PAPR for IFDMA with M=256, N=64 and roll of factor α=0.22

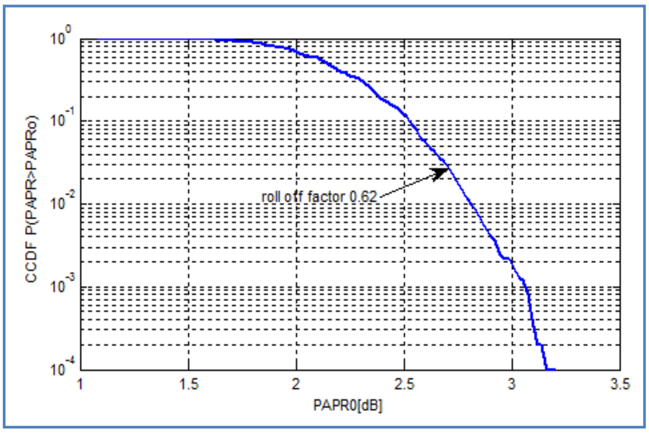

Fig. 3- Comparison of CCDF of PAPR for IFDMA with M=256, N=64 and roll of factor α=0.62

[Fig-2], [Fig-3] and [Fig-4] shows the impact of rolloff factor α on the PAPR when using raised cosine pulse shaping. The rolloff factor from 0 to 1 increases and PAPR reduces significantly for IFDMA.

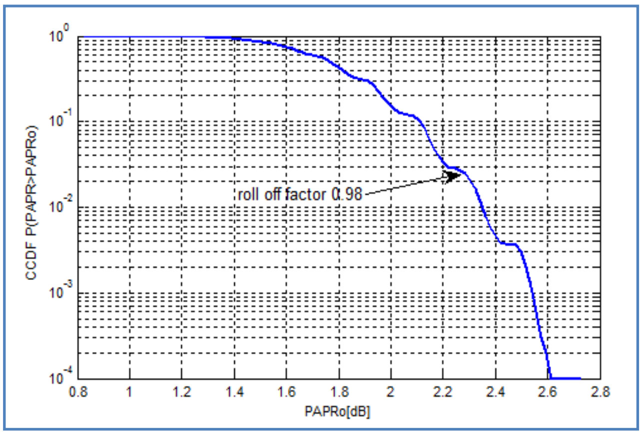

Fig. 4- Comparison of CCDF of PAPR for IFDMA with M=256, N=64 and roll of factor α=0.98

Conclusion

A Power-function companding scheme for peak-to-average power ratio reduction of SC-FDMA signals, Its achieve an effective PAPR reduction performance by properly choosing the variable parameter -α of the companding scheme. Simulation results demonstrate the correctness of the proposed scheme. The new scheme also has the advantage of maintaining a constant average power level in the nonlinear companding operation.

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