ISIT 2009, Seoul, Korea, June 28 - July 3, 2009

Analysis of PAPR Reduction Performance of SLM Schemes with Correlated Phase Vectors

Seok-Joong Heo, Hyun-Seung Joo, Jong-Seon No
Department of Electrical Engineering & Computer Science
Seoul National University, INMC
Seoul 151-744, Korea
Email: seokjoong.heo@gmail.com, joohs@ccl.snu.ac.kr, jsno@snu.ac.kr

Dae-Woon Lim
Department of the Information & Communication Engineering
Dongguk University
Seoul 100-715, Korea
Email: daewoonlim@gmail.com

Dong-Joon Shin
Department of Electronics & Computer Engineering
Hanyang University
Seoul 133-791, Korea
Email: djshin@hanyang.ac.kr

***Abstract*—The peak to average power ratio (PAPR) reduction performance depends on the phase vectors of selected mapping (SLM) scheme where the alternative input symbol vectors are generated by multiplying an input symbol vector by phase vectors. Thus, the symbol powers of alternative orthogonal frequency division multiplexing (OFDM) signals obtained by inverse Fourier transforming the alternative input symbol vectors become correlated. In this paper, the relationship between the correlations of component powers of alternative OFDM signal vector and the correlations of phase vectors are evaluated. Then, the complementary cumulative distribution function (CCDF) of PAPR in SLM scheme is derived using multivariate gamma distribution. The derived CCDF coincides exactly with the simulation result for peak reduced OFDM system with SLM.**

I. Introduction

Recently, orthogonal frequency division multiplexing (OFDM) has been widely used as one of the core technique for the wireless communication systems such as wireless local area network (WLAN), wireless metropolitan area network (WMAN), digital audio broadcasting (DAB), and digital video broadcasting (DVB). Due to its robustness in the frequency selective fading channel, OFDM is an attractive technique for the high data rate transmission. However, an OFDM signal has very high peak-to-average power ratio (PAPR) which causes the signal distortion, i.e., the in-band distortion and the out-of-band radiation when it passes through the nonlinear device such as high power amplifier (HPA). Therefore, high PAPR induces the degradation of bit error rate (BER) and thus, the PAPR reduction is one of the most important research interests for the OFDM systems.

Selected mapping (SLM) [1] is a widely used PAPR reduction scheme and to improve the PAPR reduction performance of SLM scheme, we have to increase the number of phase vectors. The computational complexity of the SLM scheme linearly increases as the number of phase vectors, which corresponds to the number of inverse fast Fourier transforms (IFFTs) required to generate the alternative OFDM signals. In order to improve the PAPR reduction performance of SLM scheme, the conditions required for the phase vectors have been studied in [2] and [3], which are aperiodicity and orthogonality. However, the relationship between the correlated phase vectors and PAPR reduction performance of the OFDM signals has not been investigated.

In this paper, the PAPR reduction performance of the SLM scheme with correlated phase vectors is analyzed. In Section II, the OFDM system and SLM scheme are explained. Section III includes the analysis of the complementary cumulative distribution function (CCDF) of PAPR for SLM with correlated phase vectors. In Section IV, the numerical results are provided to confirm the analytical results. Finally, the conclusions are given in Section V.

II. System Description and PAPR

In this section, the baseband OFDM system and SLM scheme are introduced.

A. OFDM System

Let $\mathbf{A}=[A_0\ A_1\cdots A_{N-1}]^T$ denote an input symbol vector in the frequency domain, where A_k and N represent the complex data of the kth subcarrier and the number of subcarriers in the OFDM system, respectively. Let a_n represent the Nyquist-rate sampled output of OFDM signal using the N-point inverse discrete Fourier transform (IDFT) and let x_n and y_n be the real and imaginary parts of a_n given as

$$a_n = x_n + jy_n = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} A_k e^{j\frac{2\pi k}{N}n},\quad n=0,\ 1,\cdots,N-1 \tag{1}$$

where x_n and y_n are asymptotically independent and identically distributed (i.i.d.) as N increases. It can also be expressed as a vector form $\mathbf{a}=\mathbf{QA}=[a_0\ a_1\cdots a_{N-1}]^T$ where $\mathbf{Q}$ is the $N\times N$ IDFT matrix. As N increases, x_n and y_n approach Gaussian random variables with zero mean and variance σ^2 by the central limit theorem. Then, the envelope $|a_n|$ become Rayleigh distributed random variables.

Let $\mathbf{p}=[p_0\ p_1\cdots p_{N-1}]^T$ denote the symbol power vector of OFDM signal $\mathbf{a}$ in the time domain, where $p_n=|a_n|^2=a_n a_n^* = x_n^2+y_n^2, 0\le n\le N-1$. To analyze the distribution of component powers p_n, $0\le n\le n-1$, we assume that a_n's are statistically independent for large N. The power p_n of component a_n of OFDM signal vector which are

978-1-4244-4313-0/09/$25.00