An Overview of PAPR Reduction Technique for OFDM Signals by using Selective Mapping Technique (SLM)

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Abstract— Orthogonal Frequency Division Multiplexing (OFDM) is a promising technique used in the wireless broadband communication systems these days. It is a form of multi-carrier modulation technique. High spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, capacity to handle very strong echoes and very less nonlinear distortion are the properties of the OFDM. One major disadvantage of OFDM is that the time domain OFDM signal which is a sum of several sinusoids leads to high peak to average power ratio (PAPR). Number of techniques have been proposed in the literature for reducing the PAPR in OFDM systems. In this paper, we discuss about the selected mapping technique (SML) for reducing the PAPR and the simulation result shows the PAPR reduction of OFDM signals.

Keywords— **CCDF, IFFT, OFDM, MIMO, Peak-to-Average Power Ratio, PAPR, SLM, Selection Mapping Technique.**

I. INTRODUCTION:

It is widely expected that future mobile communication systems will apply multicarrier OFDM transmission due to the fact that it allows for high bandwidth efficiency. Additionally, multicarrier transmission ensures high flexibility in transmission resource assignment, which is very desirable for future rich repertoire of expected services featuring diverse data transmission rates and QoS requirements. However, despite many advantages of OFDM, there are some drawbacks of it as well. Among them, a high value of Peak-to-Average Power Ratio (PAPR) is the one, which draws attention of many scientists [1]. In this case some instantaneous power output might increase greatly and become far higher than the mean power of system. To transmit signals with such high PAPR, it requires power amplifiers with very high power scope. These kinds of amplifiers are very expensive and have low efficiency-cost [2]. If the peak power is too high, it could be out of the scope of the linear power amplifier. This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance degradation. If no measure is taken to reduce the high PAPR, MIMO-OFDM system could face serious restriction for practical applications [3-4]. PAPR can be described by its complementary cumulative distribution function (CCDF) [5]. The OFDM system is based on parallel communication, where the data sequence is converting to N parallel sequences, which modulates N orthogonal sub-carriers. **Error! Reference source not found.** shows the block diagram of an OFDM modulator and demodulator [6].

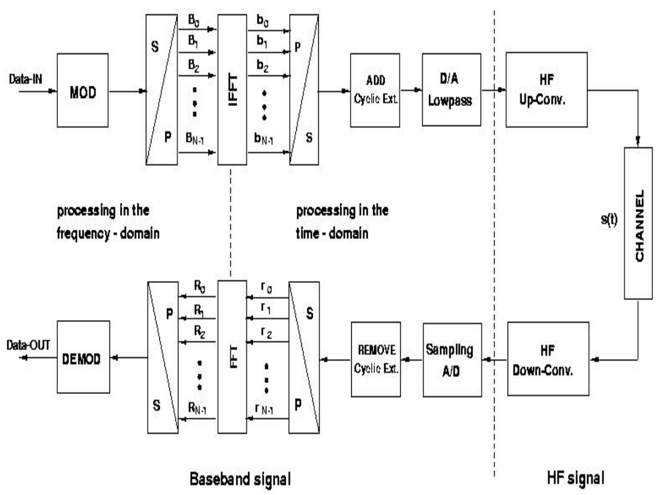

Figure 1: A typical OFDM system model

II. OFDM TRANSMISSION:

The minimum frequency separation for two sinsoidals with arbitrary phases to be orthogonal is 1/T, where T is the symbol period. In Orthogonal Frequency Division Multiplexing, multiple sinusoidals with frequency separation 1/T is used. The sinusoidals used in OFDM can be defined as

$$g_k(t) = \frac{1}{\sqrt{T}} e^{\frac{j2\pi kt}{T}} w(t) \qquad (1)$$

Where k=0,1,2,…..,k-1 correspond to the frequency of the sinusoidal and w(t)=u(t)-u(t-T) is a rectangular window over [0,T]. We now have understood that OFDM uses multiple sinusoidals having frequency separation 1/T where each sinusoidal gets modulated by independent information. The information a_k is multiplied by the corresponding carrier $g_k(t)$ and the sum of such modulated sinusoidals form the transmit signals. Mathematically, the transmit signal is, the interpretation of the above equation is as follows:

$$S(t)=a_0g_0(t)+a_1g_1(t)+\dots\dots\dots+a_{k-1}g_{k-1}(t)$$

$$=\sum_0^{k-1} a_k g_k(t)$$

$$=\frac{1}{\sqrt{T}}\sum_0^{k-1} a_k e^{\frac{j2\pi knt}{T}} w(t) \qquad (2)$$

Each information signal a_k multiplies the sinusoidal having frequency of k/T. Sum of all such modulated sinusoidals are added and the resultant signal is sent out as s(t). The sampled version of the above equation is

$$s(nT)=\frac{1}{\sqrt{T}}\sum_0^{n-1} a_k e^{\frac{j2\pi knT}{T}} w(t) \qquad (3)$$

It is reasonable to understand that above operation corresponds to an inverse Discrete Fourier Transform (IDFT) operation. [7]

III. PEAK TO AVERAGE POWER Ratio(PAPR) for OFDM signal:

The peak to average power ratio for a signal x(t) is defined as

$$PAPR=\frac{\max\,[x(t)x*(t)]}{E\,[x(t)x*(t)]} \qquad (4)$$

Where $()^*$ corresponds to the conjugate operator [8]. Expressing in deciBels,

$$PAPR_{dB}=10\log_{10}(PAPR) \qquad (5)$$

PAPR OF A COMPLEX SINUSOIDAL SIGNAL:

Consider a sinusoidal signal $x(t)=e^{2\pi ft}$ having the period T. The peak value of the signal is

$$\max[x(t)x*(t)] = +1 \qquad (6)$$

The mean square value of the signal is

$$E[x(t)x*(t)] = \frac{1}{T}\int_0^T \exp^{4\pi ft}=1 \qquad (7)$$

Given so, t

he PAPR of a single complex sinusoidal tone is, PAPR=1[8].

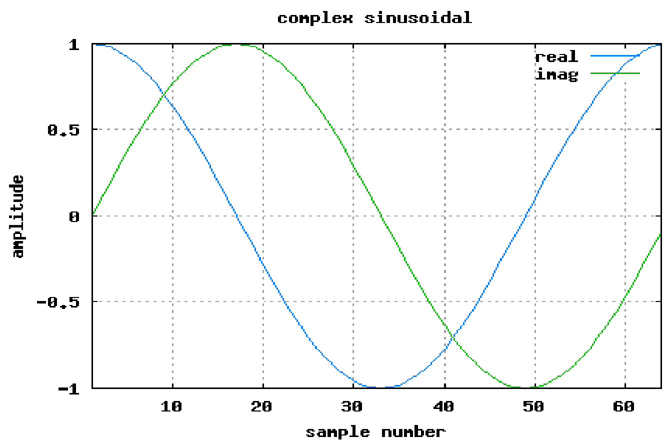

Figure 2: PAPR of a complex sinusoidal

IV. COMPLEMENTARY Cumulative Distribution Function (CCDF)

The Cumulative Distribution Function (CDF) is one of the most regularly used parameters, which is used to measure the efficiency of any PAPR technique. Normally, the Complementary CDF (CCDF) is used instead of CDF, which helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold. The CCDF of the PAPR of the data block is desired in our case to compare outputs of various reduction techniques [7-8].

V. SELECTION MAPPING Technique (SLM):

The paper, by Bauml et.al., [10] proposes a method for the reduction of peak to average transmit power of multicarrier modulation systems with selected mapping in 1996. In selected mapping (SLM) method a whole set of candidate signals is generated representing the same information, and then the most favorable signal as regards to PAPR is chosen and transmitted. The side information about this choice needs to be explicitly transmitted along with the chosen candidate signal. SLM scheme is one of the initial probabilistic approaches for reducing the PAPR problem, with a goal of making occurrence of the peaks less frequent, not to eliminate the peaks. The scheme can handle any number of subcarriers and drawback associated with the scheme is the overhead of side information that needs to be transmitted to the receiver [9-10].

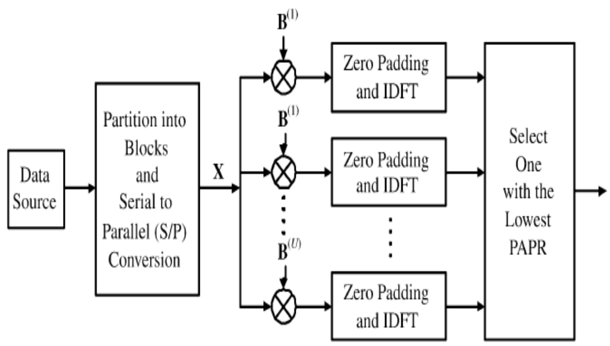

Figure 3. The Block Diagram of Selected Mapping Technique

The CCDF of the original signal sequence PAPR above threshold $PAPR_0$ is written as $Pr(PAPR>PAPR_0)$. Thus for K statistical independent signal waveforms, CCDF can be written as $[Pr(PAPR>PAPR_0)]^R$. So the probability of PAPR exceed the same threshold. The probability of PAPR larger than a threshold Z can be written as

$$P(PAPR<Z)=F(Z)^N=(1-\exp(Z))^N \quad (8)$$

Assuming that M-OFDM symbols carry the same information and that they are statistically independent of each other. In this case, the probability of PAPR greater than Z is equals to the product of each independent probability. This process can be written as

$$P\{PAPR_{low}>Z\}=(P\{PAPR>Z\})^M=((1-\exp(-Z))^N) \quad (9)$$

In selection mapping method, firstly M statistically independent sequences which represent the same information are generated, and next, the resulting M statistically independent data blocks $S_m=[S_{m,o},S_{m,1},\ldots.S_{m,N-1}]^T$ for m=1,2,...,M are then forwarded into IFFT operation simultaneously. $X_m=[x_1,x_2,\ldots.x_N]^T$ in discrete time-domain are acquired and then the PAPR of these M vectors are calculated separately. Eventually, the sequences x_d with the smallest PAPR is selected for final serial transmission [5]. Fig-3 shows the basic block diagram of selection mapping technique for suppressing the high PAPR.

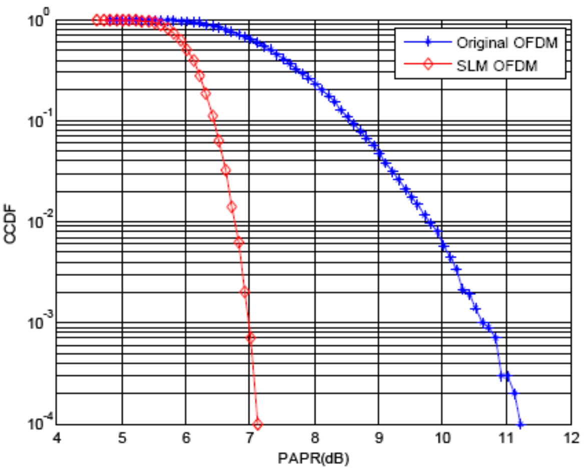

Figure 4: PAPR reduction using SLM

VI. CONCLUSION

OFDM has been seen as the core technique of the future communication systems because it has many advantages .OFDM transmission has many favorable features, such as robustness against multipath fading and narrow-band interference, high spectral efficiency and simple channel estimation and equalization, which are why it is an attractive method for wireless communication systems. One of the challenging issues for Orthogonal Frequency Division Multiplexing (OFDM) system is its high Peak-to-Average Power Ratio (PAPR). High peak-to-average power ratio (PAPR) of the transmitted signal is a major drawback of orthogonal frequency division multiplexing (OFDM). In this paper, we analyze the OFDM and PAPR of an OFDM signal. SLM technique is a very efficient technique for reducing PAPR. Simulation results show that the proposed SLM method for PAPR reduction.

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