Impact of Clipping and Filtering on Peak to Average Power Ratio of OFDM System
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Abstract—Orthogonal Frequency Division Multiplexing (OFDM) is an emerging field of research in the field of 4G broadband wireless communications due to its robustness against multipath fading and relatively simple implementation. Peak to Average Power Ratio (PAPR) is the limiting factor for an OFDM system as it consists of a large number of independent subcarriers as a result of which the amplitude of such a signal can have high peak values which degrades the system performance. Such a signal when amplified by a Power Amplifier without processing results spectral regrowth and intermodulation among subcarrier. Hence this non linearity destroys the orthogonally of the OFDM signal and introduces out-of-band radiation and in band distortions causing significant performance degradation. The clipping and filtering method is analysed which is an efficient and simple method to reduce the PAPR. We have shown the effects of clipping and filtering on the performance of OFDM, including the power spectral density, the crest factor, and the bit-error rate.

Keywords: OFDM, PAPR, clipping, filtering, crest factor

I. INTRODUCTION

OFDM is a multi-carrier modulation (MCM) technique with densely spaced sub-carriers in which data-transmission is done by dividing a high-bit rate data stream into several parallel low bit-rate data streams and using these low bit-rate data streams to modulate several carriers. So multicarrier transmission combat with selective fading and impulsive parasitic noise. So recent communication services such as IEEE 802.11 wireless LAN, Integrated Services Digital Broadcasting for Terrestrial (ISDB-T) uses multicarrier transmission with selective fading and impulsive parasitic noise. Hence this non linearity destroys the orthogonally of the OFDM signal and introduces out-of-band radiation and in band distortions causing significant performance degradation. The clipping and filtering method is analysed which is an efficient and simple method to reduce the PAPR. We have shown the effects of clipping and filtering on the performance of OFDM, including the power spectral density, the crest factor, and the bit-error rate.

II. MATHEMATICAL MODEL

Mathematical definition of the OFDM modulation system: An OFDM carrier signal is the sum of a number of orthogonal sub-carriers with each sub-carrier being independently modulated commonly using some type of quadrature amplitude modulation (QAM) or phase-shift keying (PSK). If N sub-carriers are used, and each sub-carrier is modulated using M alternative symbols, the OFDM symbol alphabet consists of M^N symbols. Each carrier can be presented as a complex waveform like:

\[ S_c(t) = A_c(t)e^{j(\omega_0 t + \phi_0 t)} \]  

\[ A_c(t) \text{ is amplitude of signal } S_c(t) \]  

\[ \Phi_0(t) \text{ is phase of signal } S_c(t) \]  

The complex signal can be described by

\[ S_c(t) = \frac{1}{N} \sum_{n=0}^{N-1} a_n e^{j(\omega_0 t + \theta_n t)} \]  

\[ n \text{ is the number of OFDM block.} \]  

\[ S_c(kt) = \frac{1}{N} \sum_{n=0}^{N-1} a_n e^{j(\omega_0 + \omega \Delta n) k t + \phi_n} \]  

\[ A_n \text{ is baseband symbol} \]

\[ \Delta n = 0 \ldots N-1 \]

\[ \text{At } \omega_0 = 0 \]

\[ S_c(kt) = \frac{1}{N} \sum_{n=0}^{N-1} A_n e^{j(\omega n t + \phi_n)} \]  

\[ S(kt) = \frac{1}{N} \sum_{n=0}^{N-1} G(n) e^{j(\Delta f n k t)} \]  

\[ \Delta f = \frac{\omega_0}{2\pi} = \frac{1}{N} \]  

Both are equivalent if

\[ \Delta f = \frac{\omega_0}{2\pi} = \frac{1}{N} \]  

Where \( \tau \) is the symbol duration period

The OFDM signal can be defined by Fourier Transform. The Fast Fourier Transform (FFT) can obtained frequency...
of-band radiation, but may also cause some peak re-growth, which the peak signal exceeds in the clip level. The technique of iterative clipping and filtering reduces the PAPR without spectrum expansion. However, the iterative signal takes long time and it will increase the computational complexity of an OFDM transmitter.

\[ PAPR = \frac{\text{average signal power}}{\text{peak signal power}} \]

The input symbol stream of the IFFT should possess a uniform power spectrum, but the output of the IFFT may result in a non-uniform or spiky power spectrum. Most of transmission energy would be allocated for a few instead of the majority subcarriers. This problem can be quantified as transmission energy would be allocated for a few instead of the majority subcarriers. This problem can be quantified as the PAPR measure of the transmitted waveform.

PAPR is best described by its statistical parameter; crest factor (CF) as

\[ CF = \sqrt{\frac{\text{peak signal power}}{\text{average signal power}}} \]

The above power characteristics can also be described in terms of their magnitudes (not power) by defining the crest factor (CF) as Pass band condition: CF=$\sqrt{\text{PAPR}}$.

PAPR is defined as the ratio of peak signal power and average signal power, mathematically

\[ \text{PAPR} = \frac{\max|\psi(n)|^2}{\mathbb{E}[|\psi(n)|^2]} \]

Where \( t \in [0,T] \)

The clipping severity is quantified by clipping ratio \( \zeta \) which is defined as the ratio of the threshold to the average signal power \( P_i \) (that of before clipping),

\[ \zeta = \frac{A_{\text{max}}}{P_i} \]

Note that clipping always reduces the average power of the signal. It results in PAPR reduction, clipping also introduces signal distortions resulting in emissions in adjacent channels and in increased bit error rate. This undesirable effect can be suppressed by low pass filtering of clipped signal, which results in a new growth of the PAPR.

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VI. RESULT AND ANALYSIS

PAPR is very sensitive to the choice of modulation in a particular OFDM system. PAPR increases if we deal with the modulations in which amplitude of basic functions changes as in QAM. But same amplitude basis functions correspond to low PAPR. But this clipping expands the signal and thus ISI occurs. Here the trade-off is made then by passing the clipped signal through the filter. Now the
PAPR is a bit increased but on the brighter side interference is minimized.
PAPR=7.1642, No of iterations =0
PAPR=6.526, No of iterations=5

![Fig. 3: PAPER vs. CCCF WITH AND WITHOUT ICF](image1)

![Fig. 4: SNR vs. SER](image2)

VII. CONCLUSION

Thus, the developed model can be used as a research tool (or educational tool) to perform deepens study and investigation to improve OFDM systems performance.

REFERENCES

