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An Overview of the BER Analysis of PAPR Reduction Methods in the OFDM System

Fehma Aftab [a], *Rishi Sharma* [b]

[a] *M Tech Scholar, Oriental Institute of Science and Technology, Bhopal, India*
[b] *Asst. Professor, Electronics and Communication, OIST Bhopal, India*

A B S T R A C T

The fast data rate provided by OFDM is offset by its high bit error rate and high peak-to-average power ratio (PAPR). Due to its full transmission diversity and increased capacity, the space frequency block coded OFDM system with PAPR reduction techniques (OFDM) has addressed the problem of a high BER. However, a high Peak to Average Power Ratio (PAPR) in an OFDM system amplifies the signal nonlinearly and reduces the system's bit error rate (BER) performance. To combat high PAPR, various PAPR lowering approaches are available. However, these PAPR reduction techniques pay a price in the form of a higher bit error rate. In the proposed work, various PAPR scrambling techniques are compared with regard to BER computation. Detailed description and comparisons of all methods are mentioned in this paper

Keywords: PAPR; BER, OFDM, MIMO, EVM ACLR etc.

1. Main text

The development of mobile communications and wireless Internet access requires a significant demand for sophisticated wireless technologies. Due to unfavourable aspects of wireless environments like co-channel interference, multipath fading, the Doppler Effect, and the need for faster data transmission in order to provide multimedia facilities, high spectral efficiency, and other factors, the evolution of Fifth Generation (5G) increases the challenges of wireless communication design. For current and future wireless communications, multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) emerges as the most promising technology combination [1].It's been a top-notch endeavour to improve the Quality of Service (QoS) and decrease the wait time due to the increased demand for excessively high-quality verbal exchange offers in 4G and 5G. A technique called as Orthogonal Frequency Division Multiplexing (OFDM) is used to get around and meet this criterion. It avoids a number of drawbacks such multipath fading and maintains high information rates, high bandwidth efficiency, and low computational complexity [1].

There is an increasing demand for information transmission. Due to its potential to provide high bandwidth effectiveness and high information rate in both digital audio and video broadcasting wi-fi communication, OFDM technology has gained popularity in the fourth-generation of mobile communication. The core idea behind OFDM is to split a high-data-charge stream into a number of concurrent, lower-data-charge streams by using a number of orthogonal subcarriers. Their spectra will overlap when the subcarriers have excellent spacing and satisfy orthogonality [1,2,3]. By using orthogonal subcarriers, the spectra of the subcarriers were able to overlap, increasing the spectral efficiency. It is possible to recover the signal of either the man or the lady subcarriers despite their overlapping spectrum as long as orthogonality is upheld. These alerts are said to be orthogonal to one another [1] if the sum of two deterministic alarms equals zero. The main issue with OFDM is the excessive peak-to-average strength ratio (PAPR), which distorts the signal if the transmitter uses nonlinear elements like an electricity amplifier, influences the signal, and causes attenuation of the acquired signal [4]. OFDM offers many advantages over service modulation.

If the signal is not to be distorted, numerous components in the transmitter and receiver must have a wide dynamic range because to the excessive PAPR of OFDM. Over a wide range of sign levels, the output amplifier of the transmitter should be very linear. The cost and energy usage of these amplifiers are typically the key design considerations in wi-fi systems [5, 6]. A huge variety of subcarriers with different amplitudes are also present, which has an impact on the radio frequency amplifier's effectiveness as well as the device's excessive peak-to-average energy ratio (OFDM). The bit error rate will decline as a result, raising system costs.

2. OFDM and PAPR

2.1 OFDM system

For 4G and 5G telecommunications requirements, including digital radio broadcasting, digital terrestrial television (DTT), wi-fi neighbourhood region networks (LANs), and more, orthogonal frequency division multiplexing (OFDM) is the most environmentally friendly and widely used multiplexing and modulation science [3]. OFDM structures consist of two components: the transmitter aspect and the receiver aspect. Broadband frequency-selective channels can be used to transmit high rate data using the well-known technology of orthogonal frequency-division multiplexing (OFDM). The high peak-to-average power ratio (PAPR) of OFDM systems, which causes the high-power amplifier to become saturated, is one of their disadvantages. As a result, a high-dynamic range amplifier is required, raising the system's cost.

OFDM transceiver

The idea of OFDM is to divide the available bandwidth into several sub-carriers. It becomes more resistant to frequency selective fading as the number of subcarriers rises, while data rates are also rising. However, the number of sub-carriers cannot be increased arbitrarily as this would result in a more complex machine structure and longer image intervals, which would render transmission more susceptible to the time incoherence of the channel.

Weinstein and Ebert employed the implementation of OFDM modulation via Inverse Discrete Fourier Transform (IDFT) and demodulation via Discrete Fourier Transform (DFT) to address the issue of the device's complex design. To illustrate this considers one OFDM image with N one-of-a-kind subcarriers and anticipate that s(t) is sampled at each time interval Ts=N (Figure 1).

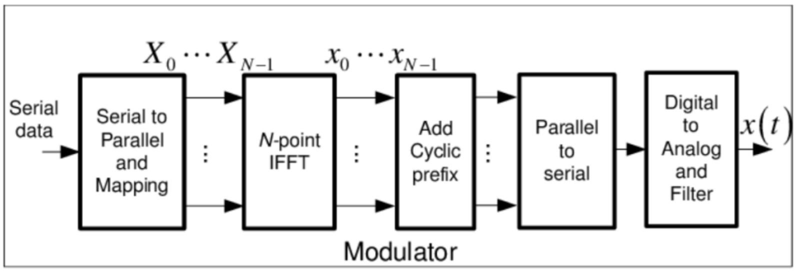

Fig -1: OFDM Modulation block diagram

OFDM machine transmitter

The data that needs to be broadcast via the channel using the OFDM system is the incoming serial data. With the help of a serial to parallel converter, the serial records are converted into N unique parallel record streams. These symbols can be manipulated using unique modulation techniques and provided as an entry to the IFFT block [3]. A parallel to serial converter is used to convert the parallel data into serial records after the IFFT block provides the digital time area sign for the input. In order to eliminate the effects of ISI brought on by channel dispersion, the cyclic prefix is introduced between two OFDM symbols. Digital to analogue converters are now used to translate this digital time sign into an actual time waveform. Using a mixer or modulators, the accessible baseband sign is up converted into an RF ignore band sign. With the aid of the channel model, the phenomenon of noise and multipath surroundings can be anticipated. Multipath environments can be created by adding attenuated and delayed copies of the OFDM signal, while noise can be produced by adding a small amount of random information to the OFDM image.

OFDM receiver

The obtained OFDM signal is demodulated at the receiver end, and samples are taken using analog-to-digital converters to obtain the digital time area signal. The digital time area sign is demodulated using FFT, and the transmitted data can be retrieved by using an image demapper [4] (Figure 2).

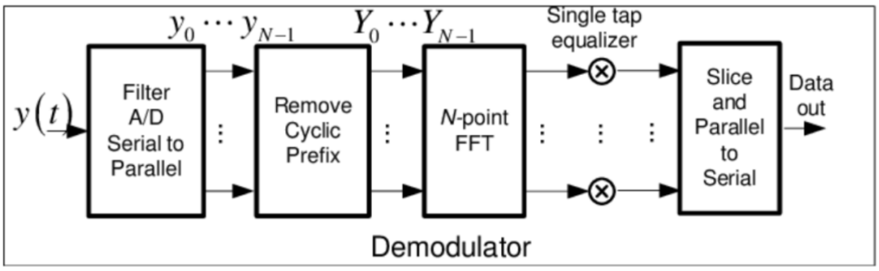

Fig- 2: OFDM System receiver.

Characteristics

Numerous features of OFDM tempt developers to design a variety of desired applications. Even OFDM reveals a number of advantages over the typical serial modem home setups, including the following:

A. ***Implementation difficulty:*** When compared to a single service device for a specific extend spread, the complexity is significantly reduced.

B. ***Resistance to narrow band interference:*** In a single service, an interferer can break the communication link, but in a multicarrier system, only a small number of subservices are impacted.

C. ***Spectral efficiency***: Because orthogonality allowed a huge range of sub providers to fit into a relatively small spectral area, it will improve spectral efficiency.

D. ***Immunity to frequency selective fading***: Each subcarrier has a small bandwidth compared to the signal's typical bandwidth. It breaks up a single frequency selective fading channel into several almost flat fading channels.

2.2 PAPR

When introduced into the same sector at IFFT, the OFDM sent signal was noted for having excessive height strength. These indicators cause out-of-band radiation when they excite the HPA's nonlinear characteristics, which also distort the indicators in nearby bands and its regions. The effectiveness of HPA is decreased by this increased height energy, which also lowers the OFDM system's overall effectiveness. One often used parameter is PAPR, which is used to estimate the distortion that is caused by nonlinearity.

3. Related Work

According to [Mohammed, T. Ismail, A. Nassar, and H. Mostafa, 2021]: The effectiveness of the orthogonal frequency division multiplexing (OFDM) approach depends on the lowering of the high peak-to-average-power ratio (PAPR). Excessive PAPR contributes to harmonic distortions caused by nonlinear clipping, which lower system reliability. This study proposes a novel method for lowering the high PAPR in OFDM with minimal impact on system performance. By compressing large signals and expanding small signals, the technique uses the image adjust (IMADJS) function to lower the high PAPR of transmitted OFDM signals. The advantage of maintaining a steady average power level before and after companding is offered by the IMADJS technique in contrast. The proposed (IMADJS) technique is compared to well-known companding methods including the -law, absolute exponential (AEXP), and the new error function (NERF). Bit error rate (BER), power spectral density (PSD), average power performance measures, and PAPR are used in the comparison. Simulation results show that the PAPR's shortcomings were greatly reduced by the IMADJS technique. Additionally, the PAPR is lowered by 2:81dB.

[T. Kageyama, O. Muta, and H. Gacanin, 2020]: Presents a performance analysis of an adaptive peak cancellation (PC) method to lower the high peak-to-average power ratio (PAPR) for OFDM systems while maintaining the out-of-band (OoB) power leakage and an in-band distortion power below the target level. In this study, the error vector magnitude (EVM) and increase of adjacent leakage power ratio (ACLR) are recursively approximated using the detected peak amplitude. The current analytical framework for OFDM-based systems includes theoretical bit error rate (BER) representations and the determination of the best peak threshold in accordance with predetermined EVM and ACLR requirements. Additionally, based on theoretical design, the best peak detection threshold is chosen in order to maintain the predetermined distortion level. As a result, their degradations are limited to the previously established limits that correspond to the desired OoB radiation. By maximising the PC signal's windowing size, a peak-cancellation signal with a target OoB radiation and in-band distortion can be created practically. The improvements in feasible BER and PAPR with the PC approach in eigen-beam space division multiplexing are demonstrated by numerical results.

2019 [Y. Wang, M. Wang, and Z. Xie] One of the main problems with orthogonal frequency division multiplexing (OFDM) systems is high peak to average power ratio (PAPR). When an OFDM signal with a high PAPR runs through an HPA, it will experience severe nonlinear distortions, which will reduce the HPA's power efficiency and raise the bit error rate (BER) across the board. In this research, we examine PAPR optimisation with error vector magnitude (EVM) constraints to achieve the OFDM signal with reduced PAPR and better BER. Present a novel strategy based on the linearized alternative direction method of multipliers (LADMM) to deal with the PAPR optimisation, as opposed to the second order conic programming (SOCP) scheme with high complexity described in the literature. A quick and effective technique with FFT/IFFT complexity in each iteration is the suggested LADMM algorithm. We then run simulations after demonstrating the convergence of the LADMM algorithm. Results from simulations show that the LADMM algorithm not only achieves greater PAPR reduction but also improved BER.

[T. Kageyama, H. Gacanin, and O. Muta, 2020] In this study, an improved peak cancellation method for massive multi-input multi-output (mMIMO) orthogonal frequency division multiplexing (OFDM) is presented. The approach cancels out an in-band distortion caused by peak cancellation by using more transmit antennas. A compensation signal is created and broadcast using additional antenna elements, and the receiver cancels out the in-band distortion. Deep peak cancellation is therefore feasible without compromising bit error rate performance. The suggested method is also applied to non-linear precoded mMIMO-OFDM systems, where the perturbation vector cancellation signal is superimposed over the compensation signal to allow for demodulation of the received signal without the need for non-linear processing to eliminate the perturbation vector. Therefore, the iterative calculation to correct for an in-band distortion is not necessary using the suggested method. In comparison to the state-of-the-art, our results demonstrate the effectiveness of the suggested strategy in terms of peak-to-average power ratio (PAPR) features, signal to noise and distortion power ratio (SDNR), bit error rate (BER), and throughput.

[F. Gagnon, F. Sandoval, and G. Poitau, 2019] A well-liked modulation method for wireless communication, coded orthogonal frequency-division multiplexing (COFDM), ensures accurate data delivery over unreliable wireless channels. However, the high peak to average power ratio (PAPR) that results from its implementation is a significant drawback. Transmission mistakes can be prevented by using forward error correction (FEC) in an orthogonal frequency division multiplexing (OFDM) system. However, the chosen code may have an effect on PAPR's value. With the inverse fast Fourier transform (IFFT) block in the COFDM system, the signal's autocorrelation, the evaluation of the complementary cumulative distribution function (CCDF) of PAPR, and the bit error rate (BER), the goal of this paper is to analyse the effect of FEC on the PAPR for the COFDM system. Based on a Markov chain model, the autocorrelation of the COFDM system is computed. We can draw a conclusion about the factors to take into account while selecting the codes for the PAPR performance in the COFDM system based on the findings.

[R. Nissel and M. Rupp, 2018]: A unique modulation system that combines the benefits of single-carrier frequency division multiple access (SC-FDMA) with filter bank multi-carrier (FBMC)-offset quadrature amplitude modulation. We create a brand-new precoding technique based on a trimmed discrete Fourier transform (DFT) in conjunction with one-tap scaling on top of a traditional FBMC system. The suggested method provides substantially lower out-of-band emissions and the same peak-to-average power ratio as SC-FDMA but does not call for a cyclic prefix. Additionally, our approach restores complex orthogonality and significantly shortens the ramp-up and ramp-down phases of FBMC, enabling low latency transmissions. Our scheme's computational complexity is only two times greater than pure SC-FDMA. Our statements are validated by simulations over doubly selective channels, and they are further backed by available MATLAB code. It should be noted that a modified SC-FDMA transmission method can be understood equivalently as trimmed DFT-spread FBMC. The specifications for the prototype filter, in particular, are less stringent than in traditional FBMC systems. In many ways, the novel trimmed DFT spread FBMC transmission system performs better than SC-FDMA. It has significantly reduced OOB emissions, requires no CP, and is more resilient in doubly-selective channels. Additionally, because MIMO may be used simply, our technique even beats traditional FBMC if the channel is roughly frequency-flat. Pruned DFT spread FBMC could be used for uplink broadcasts in wireless communications and M2M communications, where the strong time-frequency localization ensures that complex user synchronization is not required. Equations and formulae should be typed in Math type, and numbered consecutively with Arabic numerals in parentheses on the right hand side of the page (if referred to explicitly in the text). They should also be separated from the surrounding text by one space.

4. Conclusion

We have examined and contrasted 6 PAPR reduction methods in this research. It was once determined that, of the above-mentioned strategies, none of them is best for the OFDM system and completely effective in lowering PAPR. A variety of additional factors, like maintaining records rate, computational complexity, BER, and signal strength must also be taken into consideration before choosing the best PAPR technique. After analysing the current conventional approaches, it is advised to propose a height to common energy ratio (PAPR) reduction technique and to sketch a network or model to support it for OFDM architectures.

Table I Comparison of different PAPR algorithms

S. No	*PAPR Reduction*	*Subcarrier*	*PAPR at 10-4*	*BER at 20 dB SNR*
1	(SC-FDMA) with filter bank multi-carrier (FBMC)-offset quadrature amplitude modulation.	N=512	12 dB	$10^{-2.4}$
2	Coded orthogonal frequency-division multiplexing (COFDM)	N=512	8.2 dB	$10^{-1.4}$
3	Massive multi-input multi-output (mMIMO) orthogonal frequency division multiplexing (OFDM)	N=512 with U=16	9 dB	10^{-2}
4	Linearized alternative direction method of multipliers (LADMM)	N=512 with U=16	8.8 dB	10^{-2}
5	Adaptive peak cancellation (PC) method using EVM and ACLR	N=512 with U=16	9.1 dB	10^{-2}
6	Image adjust (IMADJS) function	N=512 with Subblock M=4	8 dB	$10^{-1.5}$

References

Yao Y, Ma S, Hu J (2013) A PAPR discount scheme with residue range machine for OFDM. EURASIP Journal on Wireless Communications and Networking, pp. 1-11.

Bingiham J (2014) Multicarrier modulation for records transmission: an thought whose time has come. IEEE Commun Mag 28(5): 5-14.

Han SH, Lee JH (2015) An overview of peak-to-average strength ratio discount methods for multicarrier transmission. IEEE Wirel Commun 12(2): 56-65.

Lee BM, Kim Y (2013) An adaptive clipping and filtering approach for PAPR discount of OFDM signals. Circuits, Systems and Signal Processing 32(3): 1335-1349.

Wang YC, Luo ZQ (2021) Optimized Iterative Clipping and Filtering for PAPR Reduction of OFDM Signals. IEEE Trans Commun 59(1): 33-37.

Jeon HB, Shin DJ (2021) A low complexity SLM scheme the use of additive mapping sequences for PAPR discount of OFDM signals. IEEE Trans Broadcast 57(4): 866-874.

Chen Ye (2018) PAPR discount of OQAM-OFDM indicators the use of segmental PTS scheme with low complexity. IEEE Trans Broadcast 60(1): 141-147.

Li CP, Wang SH (2019) Novel low complexity SLM schemes for PAPR discount in OFDM systems. IEEE Trans Signal processing 58(5): 2916- 2921.

Yu P, Jin S (2015) A low complexity tone reservation scheme based totally on time area kernel matrix for PAPR discount in OFDM systems. IEEE Trans Broadcasting 61(4): 710-716.

Yasir R, Seshadri M (2020) Peak-to-average energy ratio discount in OFDM schemes: a survey and taxonomy. IEEE Communications Surveys and Tutorials 15(4).

Lee BM, Kim Y (2017) An adaptive clipping and filtering approach for PAPR discount of OFDM signals. Circuits, Systems and Signal Processing 32(3): 1335-1349.

A. Mohammed, T. Ismail, A. Nassar and H. Mostafa, "A Novel Companding Technique to Reduce High Peak to Average Power Ratio in OFDM Systems," in IEEE Access, vol. 9, pp. 35217-35228, 2021, doi: 10.1109/ACCESS.2021.3062820.

T. Kageyama, O. Muta and H. Gacanin, "Enhanced Peak Cancellation with Simplified In-Band Distortion Compensation for Massive MIMO-OFDM," in IEEE Access, vol. 8, pp. 73420-73431, 2020, doi: 10.1109/ACCESS.2020.2986280.

Y. Wang, M. Wang and Z. Xie, "A PAPR Reduction Method with EVM Constraints for OFDM Systems," in IEEE Access, vol. 7, pp. 171830-171839, 2019, doi: 10.1109/ACCESS.2019.2956348.

T. Kageyama, O. Muta and H. Gacanin, "Performance Analysis of OFDM With Peak Cancellation Under EVM and ACLR Restrictions," in IEEE Transactions on Vehicular Technology, vol. 69, no. 6, pp. 6230-6241, June 2020, doi: 10.1109/TVT.2020.2982587.

F. Sandoval, G. Poitau and F. Gagnon, "Optimizing Forward Error Correction Codes for COFDM With Reduced PAPR," in IEEE Transactions on Communications, vol. 67, no. 7, pp. 4605-4619, July 2019, doi: 10.1109/TCOMM.2019.2910811.

R. Nissel and M. Rupp, "Pruned DFT-Spread FBMC: Low PAPR, Low Latency, High Spectral Efficiency," in IEEE Transactions on Communications, vol. 66, no. 10, pp. 4811-4825, Oct. 2018, doi: 10.1109/TCOMM.2018.2837130