ISSN (Online): 2583-7052

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

Article Title: Efficient PAPR Reduction in Cyclic Prefix with Enhanced Selection Strategy

Efficient PAPR Reduction in Cyclic Prefix with Enhanced Selection Strategy

B. Varsha[1], D. Rene Dev[2], S. Ragul[3]

[1]Department of Electrical and Electronics Engineering, Arunachala College of Engineering for Women, Manavilai, Kanyakumari, India. ponvarshabas19@gmail.com

Associate Professor, Department of Electrical and Electronics Engineering, MVJ College of Engineering, Bengaluru – 560067, drenedev@gmail.com

Department of Electrical and Electronics Engineering, Chettinad College of engineering and technology, ragulsambath22@gmail.com

ABSTRACT

The OFDM system's selective mapping (SLM) technique for reducing Peak to Average Power Ratio (PAPR) seems promising. The fundamental principle of SLM is to create unique send sequences from the same data source and choose the transmit signal with the lowest PAPR. This study presents an enhanced cyclic prefix selection system with a lower PAPR by using selective mapping approaches. With the use of a signal multiplexing technique called orthogonal frequency division multiplexing (OFDM), the available bandwidth is divided into a range of frequencies called sounds. OFDMA technology can be employed anywhere that radio waves are used for data transmission. Input data is moved to the transmitter side for channel encoding. Using in-channel encoding, the digital signal is digitized and superfluous binary digits are eliminated. The signal is then connected to add and remove prefixes in a cyclical manner. Faults between these processes are eliminated by the AWGN channel followed by Hilbert Transform to lower the complexity of the entire process. Finally, by combining the clipping and SLM methods, improved outcomes are attaining in terms of spectral efficiency and PAPR reduction value, while maintaining the performance of channel estimation. MATLAB simulation is employed to evaluate the recommended method.

Keywords: Selective Mapping (SLM), Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio (PAPR), Digital Subscriber Line (DSL), Digital Video Broadcasting (DVB), Bit Error Rate (BER).

1 Introduction

A multicarrier transmission technique called orthogonal frequency division multiplexing is engaged in wired and wireless communication which splits the spectrum's bandwidth among numerous carriers. Next, data was modulated into each carrier, and they were multiplexed orthogonally [1]. Carriers were able to space closely together since there was no interference between them. High spectral efficiency, resistance to co-channel interference, and multipath fading were benefits of utilizing the OFDM method and had significant disadvantages in spite of its benefits [2]. The ratio of an OFDM sample's maximum power within a transmit symbol

ISSN (Online): 2583-7052

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

to its average power within the same transmit symbol is known as PAPR. When N signals with the same phase are combined together, the result is N times the average power, which is an example of high PAPR [3]. Two types of PAPR reduction methods have been introduced to address the high PAPR issue. Techniques for data scrambling and signal distortion made up the first and second categories, respectively. Techniques for signal distortion included peak cancellation, peak windowing, commanding, and clipping and filtering (CF) [4]. A digital transmission technique called OFDM is created in response to the growing need for faster data rates in both wired and wireless communications. It is most frequently utilized in high-speed networks like Digital Subscriber Line (DSL), Digital Video Broadcasting (DVB), and wireless communication because of its high data rate handling capacity [5]. The primary drawback of OFDM technology is its elevated PAPR used to adapt the enormous dynamic range of the linear amplifier caused by such a high PAPR. Therefore, to maintain the High Power Amplifier (HPA) in the linear range, the PAPR must be decreased [6]. These fall into the categories of signal scrambling and distortion techniques. While signal scrambling techniques don't affect the OFDM signal, distortion techniques produce signal distortion and source the Bit Error Rate (BER) to rise after a certain point [7]. High-speed and low-speed data streams are divided via OFDM in order to extend the symbol duration on each subcarrier and lower the ISI caused by time dispersive channels. The informations is sent via a number of uncorrelated sub-channels in traditional FDM [8]. There are guard bands between neighbouring subcarriers and there is no frequency domain overlap between the sub-channels or subcarriers. However, spectral overlapping is conceivable with OFDM due to the orthogonality of subcarriers. In this sense, OFDM makes excellent utilization of the spectrum for a given bandwidth [9]. Convolution coding is typically the first coding method used at the transmitter in order to reduce bit error rate. The high-speed symbol streams are split into low-speed streams using a serial to parallel converter following interleaving, constellation mapping, and pilot insertion [10]. To reduce the system's calculation cost, generate distinct transmit sequences from the same data source using the Hilbert transform. Next, use selective mapping to identify the transmit signal with the lowest PAPR. Finding the channel estimation can be aided by lowering the ISI. The list below demonstrates how the paper is organised: Section I gives a description of the introduction. The recent works are described in Section II. The proposed model and description are explained in Part III. The results are presented in Section IV. In Section V, the conclusion is presented.

2 Recent Works

J. Liu *et al* [2019] [11] have proposed an OFDM systems' online Equalization and channel estimation against fading channels and the nonlinear distortion caused by a high-power amplifier (HPA) are achieved by a single hidden layer feed forward network (SLFN) completely complex extreme learning machine (C-ELM). Computer simulations show that the suggested approach may accurately acquire channel information and withstand nonlinear

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

distortion and fading even in the absence of pre-training or a feedback channel between the receiver and transmitter. Furthermore, the strong proposed scheme's capacity for generalization is analyzed and compared with the DNN, and long-term simulations in a range of fading channels comprehensively test its robustness.

W. Jin *et al* [2020] [12] have proposed a Hybrid OFDM-Digital Filter Multiple Access (OFDM-DFMA) PONs, which multiplex multiple gapless OFDM channels at different radio frequencies, a single FFT operation-based pipelined DSP procedure in the OLT is used to simultaneously de-multiplex/demodulate all OFDM signals from various ONUs without the need for digital matching filters. Experimental results show that regardless of the ONU spectral locations, reducing the ONU-embedded digital filter length from 256 to 16 only results in a <1 dB reduction in the receiver sensitivity.

J. Lian *et al* [2019] [13] have proposed modulation strategy that is well-suited to the nonlinear response of illumination light-emitting diodes is needed for a novel optical wireless communication technology. High-speed data transmission for VLC can be achieved with the promising approach of OFDM. Nonlinear signal distortion from clipping, however, may arise from the illumination sources' nonnegative transmitted signal constraint and peak transmitted power limitation.

Y. X. Dong *et al* [2019] [14] proposed hybrid discrete Fourier transform (DFT)-spread OFDM-digital filter multiple access (DFMA) passive optical networks (PONs) are being used. Here, individual DFT-spread OFDM signals from various optical network units undergo digital signal processing-based digital filtering, and an individual fast Fourier transform operation and its follow-up data recovery procedures are executed in a pipelined fashion in the optical line terminal. In particular, compared with the hybrid OFDM-DFMA PONs, the proposed PONs boost the upstream system power budget by more than 3 dB and decrease the minimum required digital-to-analog converter/analog-to-digital converter quantization bits by at least 1 bit.

Yan Chen *et al* [2019] [15] have proposed a pilot reuse-based channel estimation for massive MIMO with in-phase and quadrature-phase imbalances (IQI). In the first stage, an augmented real-valued representation for the incoming signal is created by applying relative compensation to separate the real and imaginary components. Next, using the obtained augmented real-valued representation, the minimal mean square error (MMSE) estimate for the effective channel which is comprised of the wireless channel coefficients and the IQI matrix must be calculated. To cut down on pilot overhead, pilots are repurposed. The effective channel estimate mean square error (MSE) lower bound is found. Inspired by the best circumstances for achieving the lower bound, by suggesting a pilot scheduling algorithm. Lastly, a method based on least squares is offered to determine the relative IQI compensation coefficients.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

3 Proposed Work Explanation

This research proposes to use selective mapping techniques to create an improved cyclic prefix selection scheme with a lower PAPR. The available bandwidth is split up into several frequencies, or tones, using a multiplexing technology called OFDM. Wherever radio waves are used to transfer data, OFDM technology is utilized. Input data is moved to the transmitter side for channel encoding. Channel encoding is used to eliminate unnecessary binary digits from the digital stream. When the signal for cyclic prefix addition and removal is ready, connect it Errors between these methods are removed via the AWGN channel. Errors between these methods are removed via the AWGN channel. To reduce the overall process complexity, the basic Hilbert transform method is applied. The final step is to combine the SLM and clipping approaches, which maintain the effectiveness of channel estimation while reducing the PAPR and spectral efficiency.

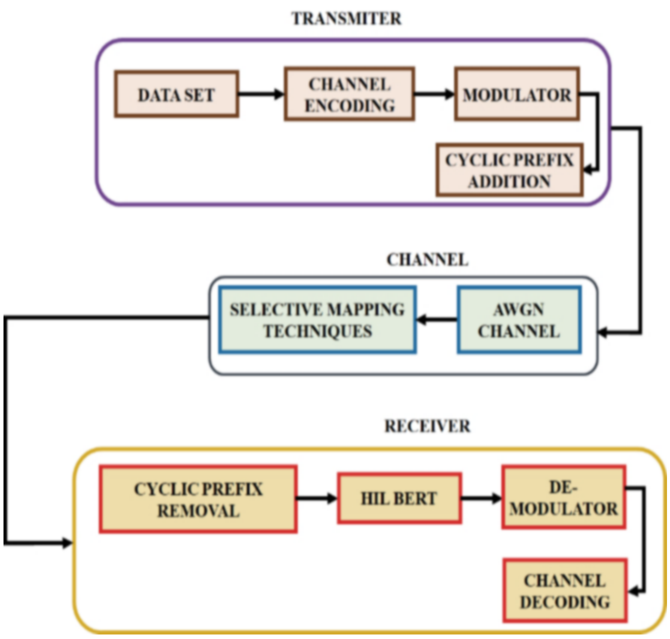

Figure 1: *Proposed Block diagram*

3.1 Transmitter

The IQI is modelled in an asymmetric form described at the transmitter and/or receiver. According to this concept, amplitude and phase mismatches occur at the Q branch while the branch functions optimally. It is thought that the IQI parameters vary between blocks and remain constant inside a single transmission block.

ISSN (Online): 2583-7052

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

Article Title: Efficient PAPR Reduction in Cyclic Prefix with Enhanced Selection Strategy

3.1.1 IQI Imbalance at the Transmitter

In consideration with OFDM systems where transmitter (base station) and the receiver (user equipment) have a single antenna. Figure 4.2 illustrates how gain and phase mismatches between the routes linking the oscillator signals to I and Q mixers of the RF front-end cause frequency independent IQI in the analog front-end of the UE. Symbols for phase and gain mismatches are and 2θ, respectively. Assuming that the base stations broadcast signal is IQI-compensated, meaning it doesn't send IQI, the received IQI-impaired signal's TD baseband form as follows.

$$\gamma_{IQI}(t) \equiv I_{IQI}(t) + jQ_{IQI}(t) = \mu r_{(t)} + \upsilon\gamma^{*}(t) \tag{1}$$

$$\gamma(t) = h(t)s(t) + n(t) \tag{2}$$

$$\mu = \frac{1+\epsilon exp(j\theta)}{2} \tag{3}$$

$$\upsilon = \frac{1-\epsilon exp(-j\theta)}{2} \tag{4}$$

N represents the notation for total number of training symbols in a row. Utilizing the training symbol information, the goal is to estimate the phase and gain imbalances, (and θ), and then provide the estimated parameters to the IQI compensation.

3.2 Channel Encoding

In digital communication systems, channel encoding is frequently used to minimize bit errors and shield digital data from noise and interference. The main method of channel coding is to add superfluous bits to the transmitted information stream on purpose. As stated in Source encoding, removing superfluous binary digits from the digitized signal is one of the objectives of the source encoder.

3.3 Modulator

In order to enable a modulator in wireless transmission is an electrical circuit that superimposes a high-frequency (carrier) signal on a low-frequency (information) signal. This is due to the fact that higher frequency transmissions are received by shorter aerials, which are more beneficial than longer ones. Information signals can either be digital or analog.

3.4 Cyclic Prefix Selection

The OFDM cyclic prefix has a rather simple fundamental idea. There are two primary use for the cyclic prefix. The guard interval provided by the cyclic prefix removes inter-symbolic interference from the preceding symbol. This method supports simple frequency domain processing, like channel estimation and equalization.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

3.5 Channel

In an OFDM system, channel estimation is crucial. By optimizing the bit error rate of the system, it helps increase the capacity of orthogonal frequency division multiple access (OFDMA) systems. A single channel uses several sub-carriers on nearby frequencies in OFDM, a subtype of frequency division multiplexing. Moreover, an OFDM system's subcarriers overlap to increase spectral effectiveness.

3.6 Additive White Gaussian Noise

An AWGN channel model, where the only thing preventing communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude, is commonly employed. This formula determines the maximum spectral efficiency of the AWGN channel as a function of SNR. The randomness of noise distorts signals and jeopardizes electrical systems' dependability. Noise generators thus help to measure a system's responsiveness to noise by injecting an average number of errors into the system via an AWGN channel.

3.7 Selective Mapping Techniques

From a single input signal, the SLM process produces several duplicate signals, each of which replicates the original data. A few rotation factors are multiplied by this signal duplication. Phase rotation factors make up the multiplication factors, and IFFT modifies the signals that follow. After then, the signal with the lowest PAPR is sent out. The rotation vectors serve as extra data that enhance signal recovery. The primary flaw in the conventional SLM approach is that it requires an additional step in order to obtain a low PAPR.

3.8 Receiver

This useful book provides an approachable overview of receiver design for orthogonal frequency-division multiplexing (OFDM), a technology that enables the carrying of digital data by many carriers.

3.9 Cyclic Prefix Removal

An OFDM receiver removes the cyclic prefix before sending the packet data to FFT for demodulation. The transmission method, frame structure, and higher-level protocol all affect the cyclic prefix length of next-generation wireless networks, which leads to extremely dynamic configurations.

3.10 De-Modulator

An OFDM input signal is demodulated by the OFDM demodulator system object using an FFT operation that produces N parallel data streams. It consists of a parallel-to-serial conversion after a bank of N correlations, one for each OFDM subcarrier. A device that recovers the

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

modulation (data, audio, video, etc.) by removing the modulating signal from the carrier or carriers. It is the part of modems that, after receiving analog signals as input, produces digital data as an output.

3.11 Decoder

A device known as a decoder is one that takes an input signal that has been coded and converts it into two lines of output—the original signal and the coded signal. An AND gate is used as a basic decoding element since it only produces a high output when all inputs are high. After correcting the channel gain and residual CFO, the next step is to transfer the FFT result to the actual data bits. This is how a packet is encoded in reverse. Regardless of the actual modulation, the SIGNAL field is always BPSK modulated and encoded in the first OFDM symbol following the lengthy preamble.

4 Results and Discussion

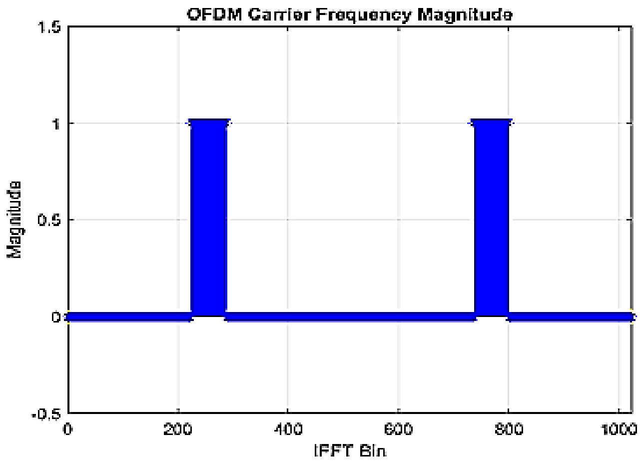

Figure 2: *Vector OFDM signal*

Figure 2 displays an OFDM signal. The modulation index is used to modify the input nonlinear waveforms. Increasing the modulation index results in less signal noise. Modifying the subcarriers also reduces the noise. The bit rate error in lead communication polarizations is shown in Figure 3; the recommended method reduces the error bit rates. Increasing the modulation index also resulted in a drop in the error rate.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

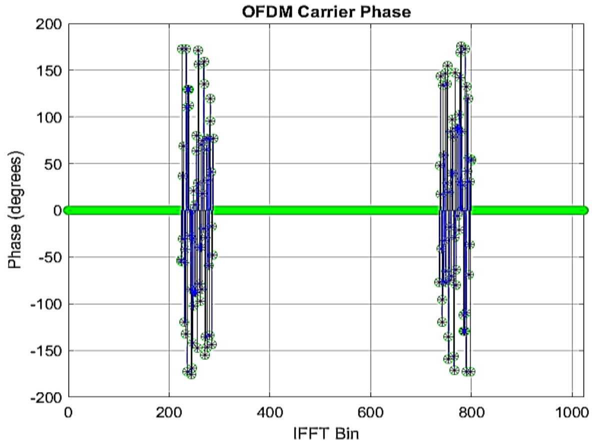

Figure 3: *OFDM Carrier phase*

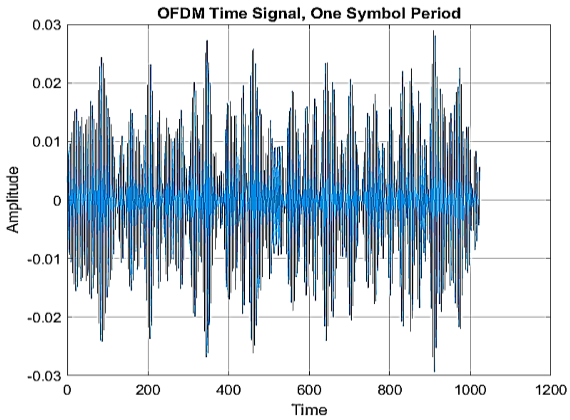

Figure 4: *Time Signal, One Symbol Period*

The frequency of a signal determines how many times it repeats in a second, as seen in Figure 4. The unit of measurement for frequency is Hz, or cycles per second. This means that a signal at 100 Hz has 100 cycles, or periods, in a second; so, its period is 0.01 seconds.

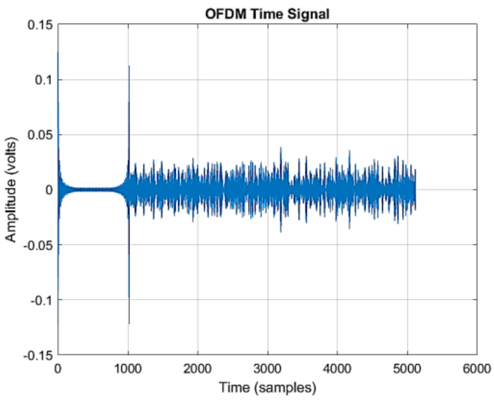

Figure 5: *OFDM Time Signal*

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

The figure 5 shows to finish the OFDM signal, the Guard Interval (GI), which lasts for 0.8 seconds, is appended to the start of the OFDM waveform. An output of this is a 4-hour (3.2 + 0.8) "single" OFDM symbol. Repeating the operation creates additional OFDM symbols for the remaining input data bits.

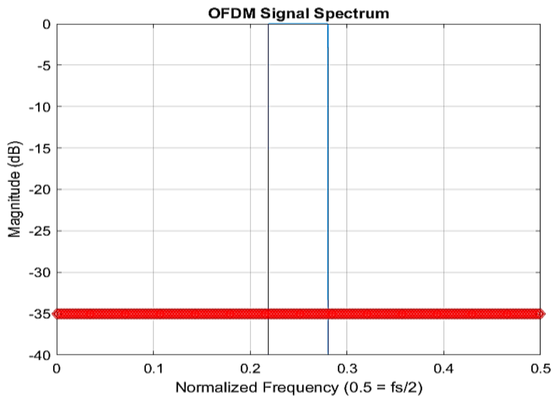

Figure 6: *OFDM Signal Spectrum*

The orthogonal frequency-division multiplexing (OFDM) system, which transmits data as a collection of orthogonal narrowband signals known as subcarriers, is illustrated in Figure 6. OFDM uses single carrier modulation and transfers data at speeds that are comparable to those of QAM.

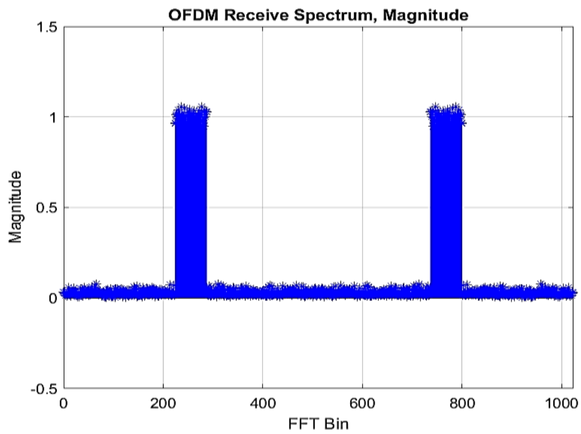

Figure 7: *OFDM Receive Spectrum, Magnitude*

To comprehend how OFDM functions, the receiver must be inspected, as figure 7 illustrates. This is a bank of demodulators that converts each carrier to DC. By integrating the resultant signal over the symbol period, the data from that carrier is recovered. The demodulators are used to demodulate the other carriers as well.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

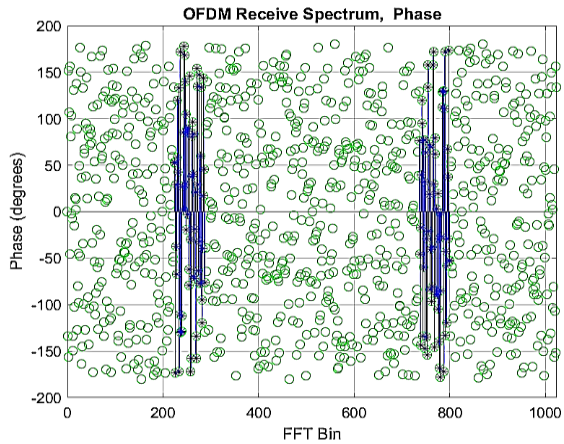

Figure 8: *OFDM Receive Spectrum, Phase*

As shown in Figure 8, the bit stream representing the data to be transferred when utilizing OFDM is divided into multiple streams. Many orthogonal subcarrier signals with overlapping spectra that are closely spaced apart are delivered; bits from the incoming stream are modulated into each carrier to enable the simultaneous transmission of multiple bits.

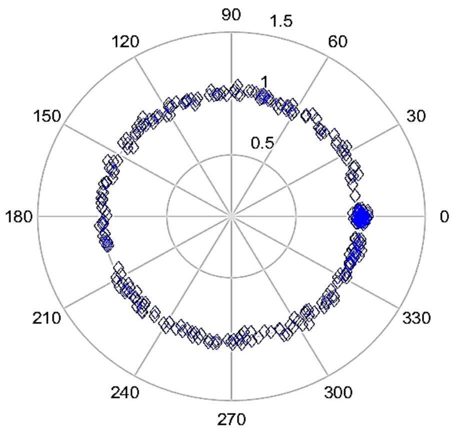

Figure 9: *Semi Logical Graph*

Graph 9 has a linear scale because the x-axis ticks are spaced uniformly. It is simpler to graph exponential functions using a semi-log graph.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

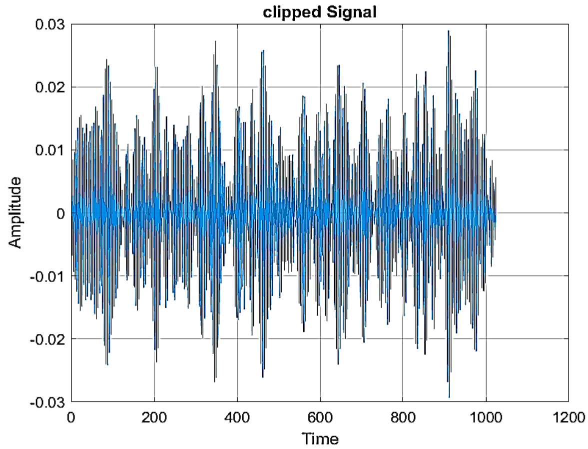

Figure 10: *Clipped Signal*

A signal is said to be "clipping" if it simply "cuts" or "clips" at the amplifier's maximum output level, as Figure 10 shows. When an excess signal is simply turned off, it becomes a distorted square-wave-type waveform, exceeding the amplifier's capability.

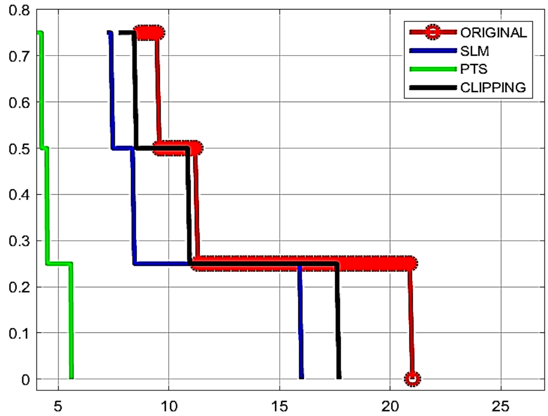

Figure 11: *Transmission Signal*

Transmission lines is used to convey digital signals via serial or parallel communication, as seen in figure 11. In serial communication, a value's corresponding set of bits is sent one after the other down a single transmission line.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

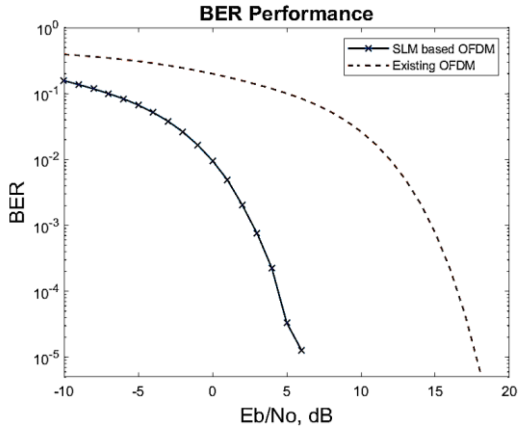

Figure 12: *BER Performance*

Figure 12 illustrates the application of bit-error-rate (BER) performance analysis to space-frequency-block-coded OFDM communication systems operating in impulsive environments across wireless fading channels.

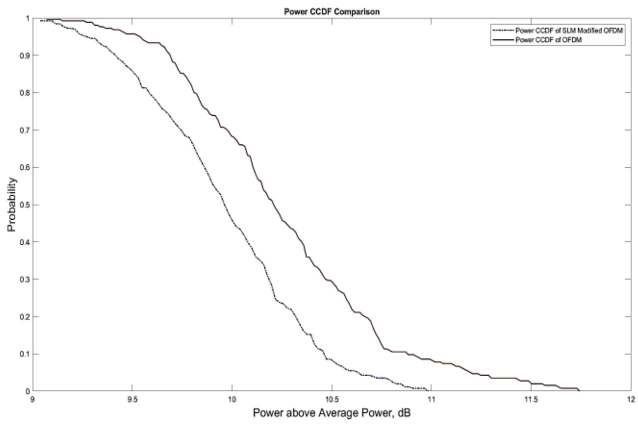

Figure 13: *CCDF Comparison*

Figure 13 shows the performance of the CCDF. The CCDF is a useful tool in many fields, including as engineering, physics, and telecommunications. It is often used to model and investigate the behavior of extreme events, such as large values of X that occur infrequently but have a significant impact.

5 Conclusion

In this study, selective mapping techniques were used to create an improved cyclic prefix selection strategy with a lower PAPR. The peak-to-average power ratio of the orthogonal frequency division multiplexing system is low. Reducing PAPR, by variety of widely accessible methods is employed, such as coding, selective level mapping, amplitude clipping, and active constellation extension. Because coding creates redundant data, it significantly

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

reduces bit rate. For the active constellation extension, a higher transmission power is required. The optimal methods among all the alternatives are the clipping approach and SLM. The SLM and clipping techniques are combined in this study to preserve channel estimation performance while achieving good spectral efficiency and PAPR reduction value.

Reference

1. Yixian Dong; Roger Philip Giddings; Jamming Tang, Year: 2018, "Hybrid OFDM-Digital Filter Multiple Access PONs", Journal of Lightwave Technology, Vol: 36, no: 23, pp. 5640 – 5649.

2. Omaro Fawzi Abdelhamid Gonem; Roger Philip Giddings; Jianming Tang, Year: 2021, "Timing Jitter Analysis and Mitigation in Hybrid OFDM-DFMA PONs", IEEE Photonics Journal, Vol: 13, no: 6, pp. 1 – 13.

3. Abdulai Sankoh; Wei Jin; Zhuqiang Zhong; Jiaxiang He; Yanhua Hong; Roger Philip Giddings; Iestyn Pierce; Maurice O'Sullivan; Jeffrey Lee; Tim Durrant; Jianming Tang, Year: 2020, "Hybrid OFDM-Digital Filter Multiple Access PONs Utilizing Spectrally Overlapped Digital Orthogonal Filtering", IEEE Photonics Journal, Vol: 12, no: 5, pp. 1 – 11.

4. Z. Q. Zhong; W. Jin; S. Jiang; J. X. He; D. Chang; Y. H. Hong; R. P. Giddings; X. Q. Jin; M. O'Sullivan; T. Durrant; J. Trewern; G. Mariani; J. M. Tang, Year: 2021, "Concurrent Inter-ONU Communications for Next Generation Mobile Fronthauls Based on IMDD Hybrid SSB OFDM-DFMA PONs", Journal of Lightwave Technology, Vol: 39, no: 23, pp. 1542 – 1555.

5. J. Lian; M. Brandt-Pearce, Year: 2019, "Clipping-Enhanced Optical OFDM for Visible Light Communication Systems", in Journal of Lightwave Technology, Vol: 37, no: 13, pp. 3324 – 3332.

6. Likai Zhu; Jianying Zhou; Jian Wang; Qun Zhang, Year: 2019, "Pre-Equalization and Bandwidth Limitation for a 100-G-Baud 32 QAM All-Silicon Transmitter", in IEEE Photonics Technology Letters, Vol: 31, no: 17, pp. 1453 – 1456.

7. Christopher Mollén; Junil Choi; Erik G. Larsson; Robert W. Heath, Year: 2017, "Uplink Performance of Wideband Massive MIMO with One-Bit ADCs", IEEE Transactions on Wireless Communications, Vol: 16, no: 1, pp. 87 – 100.

8. Qingfeng Ding; Yindi Jing, Year: 2018, "Receiver energy efficiency and resolution profile design for massive MIMO uplink with mixed ADC", IEEE Transactions on Vehicular Technology, Vol: 67, no: 2, pp. 1840 – 1844.

9. Panos N. Alevizos, Year: 2018, "Low-complexity multiuser QAM detection for uplink 1- bit massive MIMO", IEEE Communications Letters, Vol: 22, no: 8, pp. 1592 – 1595.

International Journal of Advanced Trends in Engineering and Management (IJATEM)
Vol. 02 (12), December 2023, pp. 55-68

Article Title: **Efficient PAPR Reduction in Cyclic Prefix with Enhanced Selection Strategy**

10. Hengtao He; Chao-Kai Wen; Shi Jin, Year: 2018, "Bayesian optimal data detector for hybrid mmWave MIMO-OFDM system with low-resolution ADCs", IEEE Journal of Selected Topics in Signal Processing, Vol: 12, no: 3, pp. 469 – 483.

11. Jun Liu; Kai Mei; Xiaochen Zhang; Dongtang Ma; Jibo Wei, Year: 2019, "Online Extreme Learning Machine-Based Channel Estimation and Equalization for OFDM Systems", in IEEE Communications Letters, Vol: 23, no: 7, pp. 1276 – 1279.

12. W. Jin; Z. Q. Zhong; J. X. He; A. Sankoh; R. P. Giddings; Y. H. Hong; I. Pierce; M. O'Sullivan; C. Laperle; J. Lee; G. Mariani; T. Durrant; J. M. Tang, Year: 2020, "Experimental Demonstrations of Hybrid OFDM-Digital Filter Multiple Access PONs", IEEE Photonics Technology Letters, Vol: 32, no: 13, pp. 751 – 754.

13. Jie Lian; Maïté Brandt-Pearce, Year: 2019, "Clipping-Enhanced Optical OFDM for Visible Light Communication Systems", in Journal of Lightwave Technology, Vol: 37, no: 13, pp. 3324 – 3332.

14. Y. X. Dong; W. Jin; R. P. Giddings; M. O'Sullivan; A. Tipper; T. Durrant; J. M. Tang, Year: 2019, "Hybrid DFT-Spread OFDM-Digital Filter Multiple Access PONs for Converged 5G Networks", Journal of Optical Communications and Networking, Vol: 11, no: 7, pp. 347 – 353.

15. Yan Chen; Li You; Xiqi Gao; Xiang-Gen Xia, Year: 2020, "Channel Estimation With Pilot Reuse in IQ Imbalanced Massive MIMO", IEEE Access, Vol: 8, pp. 1542 – 1555.