

“OICF Algorithm Based Performance Analysis Of Power Reduction in Electrical Network ”

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ABSTRACT

Generally the power system network is divided into Transmission and distribution networks. The transmission network involves the stepping up of the generated voltage in the generating station and transmits power to the substations through high voltage overhead transmission lines. On the other hand the distribution network involves the step-down of voltages into different levels and distributed to different consumers through low voltage power lines. The transmission and distribution lines are the back bones of power system network. Therefore monitoring and protection of lines is very important

Keyword: Power System, Peak to Average Power Ratio (PAPR), Complementary Cumulative Distribution Function (CCDF), Iterative Clipping and Filtering (ICF), Optimized-Iteration-Clipping-Filtering (OICF), Power Reduction, Electric Power System.

INTRODUCTION

Generally the power system network is divided into Transmission and distribution networks. The transmission network involves the stepping up of the generated voltage in the generating station and transmits power to the substations through high voltage overhead transmission lines. On the other hand the distribution network involves the step-down of voltages into different levels and distributed to different consumers through low voltage power lines. The transmission and distribution lines are the back bones of power system network. Therefore monitoring and protection of lines is very important. The complex power system network is shown in Figure 1.1. It is divided into two infrastructures based on protection and monitoring.

1. POWER REDUCTION TECHNIQUES

Power reduction techniques are a well-known signal processing topic in multi-carrier transmission and large number of techniques appeared in the literature during the past decades. These techniques include amplitude clipping and filtering, coding, tone reservation (TR) and tone injection (TI), active constellation extension (ACE) and multiple signal representation methods such as partial transmit sequence (PTS), selected mapping (SLM) and interleaving. The existing approaches are different from each other in terms of requirements, and most of them enforce various restriction to the system. Therefore, careful attention must be paid to choose a proper technique for each specific communication system. In this section we focus more closely on the PAPR reduction techniques for multi-carrier transmission. In order to evaluate the performance of these techniques, we need to look at the application and existing restrictions of a communication system.

2.Phase Transmit Sequence (PTS)

In the PTS technique, an input data block of N symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected such that the PAPR of the combined signal is minimized. Figure 3.1 show the block diagram of PTS algorithm.

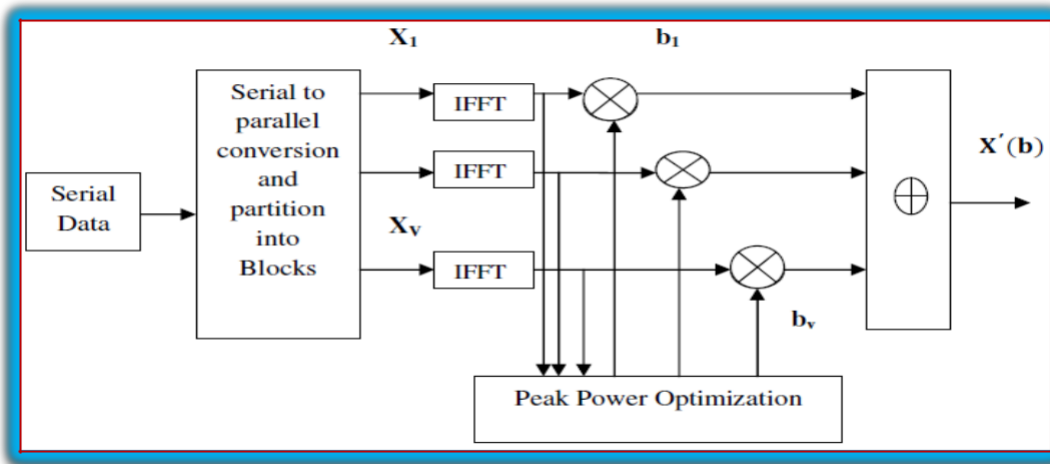


Fig. 1: Block diagram of PTS algorithm

3. Selective Mapping (SLM)

Selective mapping is based on the idea of generating multiple copies of the original signal through some set of codes. The copy with lowest PAPR is chosen for transmission [13]. The side information (index of the transmitted signal) is needed at the receiver to recover the original signal back for demodulation. As the number of subcarriers increases, larger the set of codes required to obtain a decent PAPR (5-6dB). High-computational complexity and need to transmit side-information have been criticized in the original SLM. Many efficient variants have emerged recently.

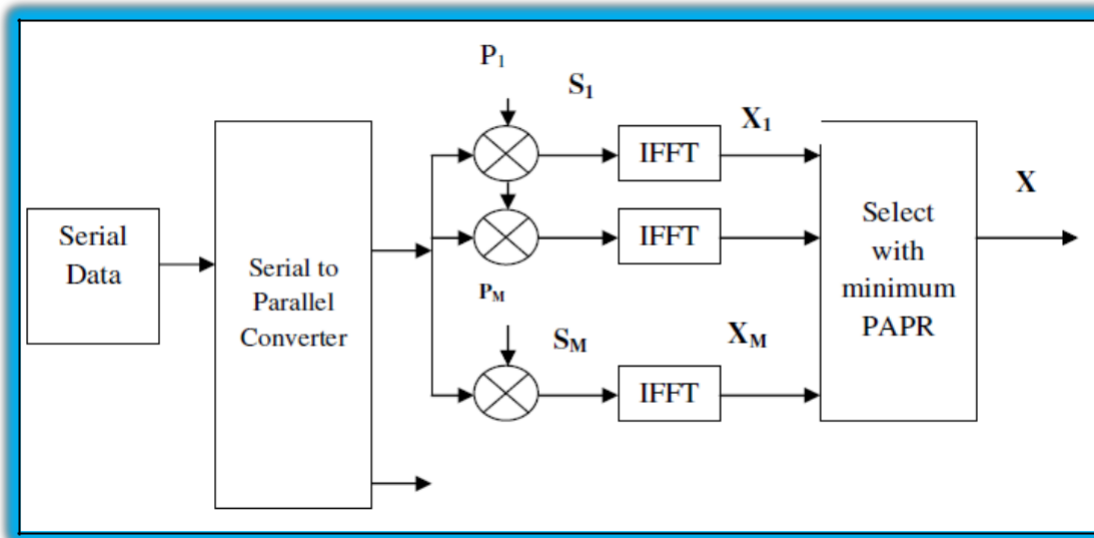


Fig. 2. Basic principles of selected mapping [13]

4. Overall Analysis of Different Techniques

The PAPR reduction technique should be chosen with awareness according to various system requirements.

Table 1: Comparison of PAPR Reduction Techniques [16]

Reduction Technique	Parameters			Operation required at Transmitter (TX) / Receiver (RX)
	Decrease distortion	Power raise	Defeat data rate	
Clipping and Filtering	No	No	No	TX: Clipping RX: None
Selective Mapping(SLM)	Yes	No	Yes	TX: M times IDFTs operation RX, Side information extraction, inverse SLM
Block Coding	Yes	No	Yes	TX: Coding or table searching RX: Decoding or table searching
Partial Transmit Sequence(PTS)	Yes	No	Yes	TX: V times IDFTs operation RX: Side information extraction, inverse PTS
Interleaving	Yes	No	Yes	TX: D times IDFTs operation, D-1 times interleaving RX: Side information extraction, de-interleaving

5. Iteration Clipping and Filtering

The idea of adjacent channel emissions filtering after clipping has been presented in [2]. As the filtering of clipped signals results in new peaks creation, the method of repeated clipping and filtering has been subsequently proposed in [3][4]. This method is based on the zero padding of the signal in the frequency domain and frequency domain filtering of clipped signal at the output of IFFT. The process of clipping and filtering is repeated several times – according to the author's experiments 4 or 5 times. These repetitions result in huge signal processing - for each frequency domain filtering the pair of FFT and IFFT operation is necessary. Its PAPR reduction performance is approaching the PAPR of repeated clipping and filtering method with arbitrary number of repetitions.

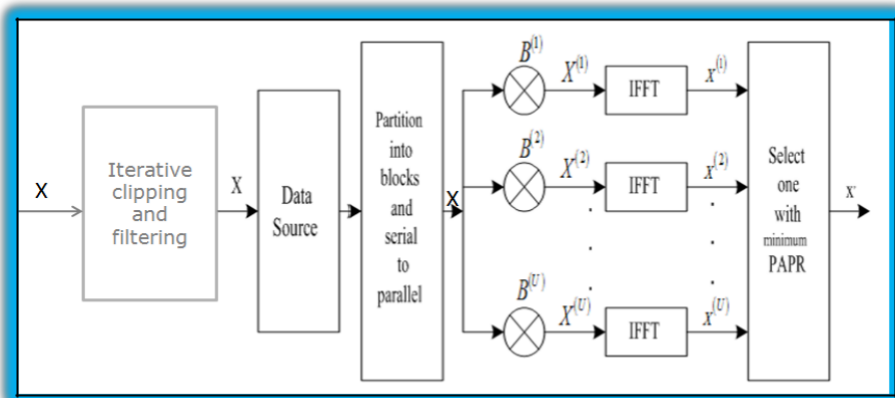


Fig d. 3 Block Diagram of the proposed method.

6. Rician Fading channel

Rician fading best characterizes a situation where there is a direct LOS path in addition to a number of indirect multipath signals between the transmitter and receiver.

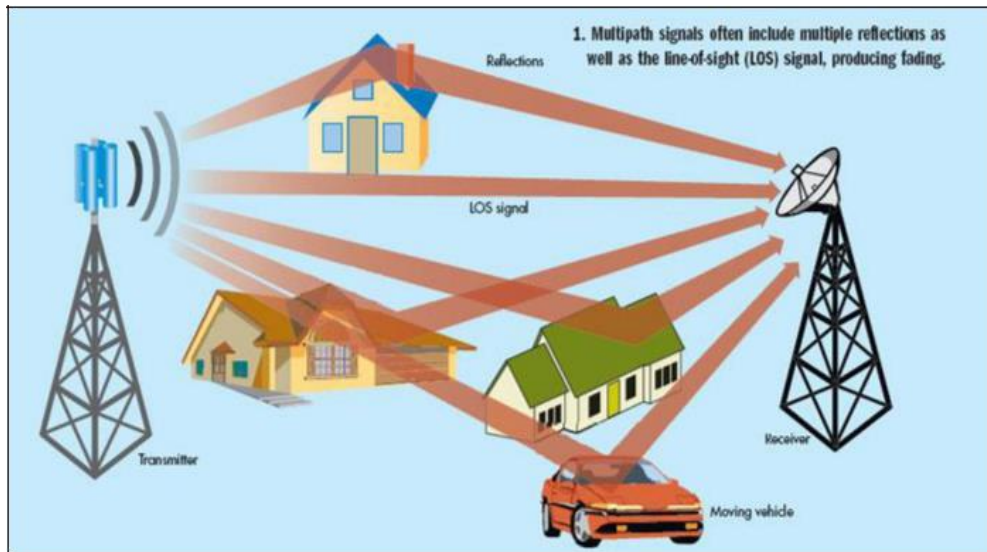


Fig. 5: LOS propagation

7. The features of LOS connections are

The LOS connection is stronger and more stable.

Use higher frequency rising a possible 66 GHz.

Where a fixed antenna point straight at the WiMAX tower from a rooftop or pole,

Huge coverage areas,

Less interference,

LOS requires most of its first Fresnel zone should be free of obstacles

8. Rayleigh Fading Channel

NLOS (indoor, city) Rayleigh fading occurs when there is no multipath LOS between transmitter and receiver and have only indirect path which is called NLOS to receive the resultant waves. The Rayleigh Fading is one kind of model which propagates the environment of radio signal. Rayleigh fading works as a reasonable model when many objects in environment which scatter radio signal before arriving of receiver.

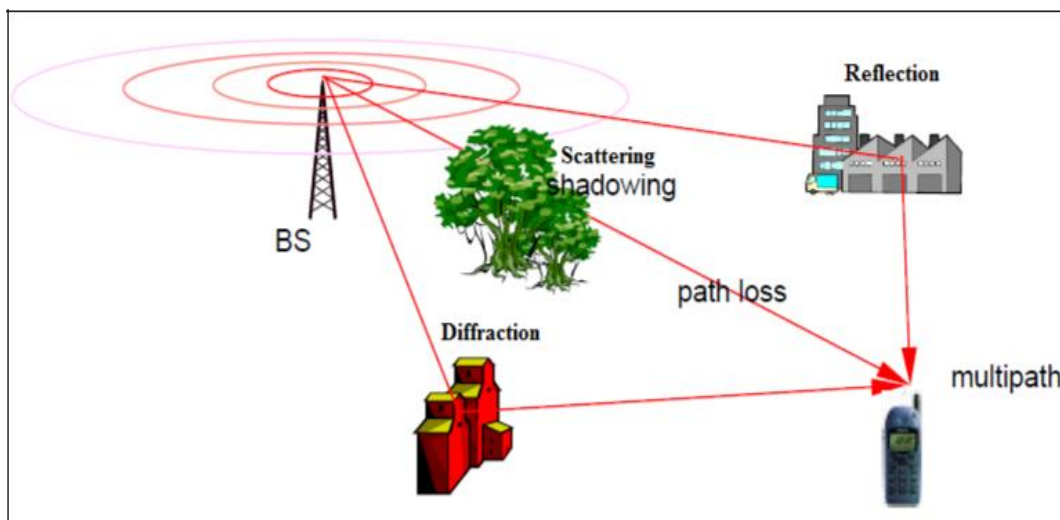


Fig. 6 : NLOS prorogation

When there is no propagation dominant during line of sight between transmitter and receiver on that time Rayleigh Fading is most applicable. On the other hand Rician Fading is more applicable then Rayleigh Fading when there is dominant line of sight. During our simulation we used Rayleigh Fading when we simulate the performance of Bit Error Rate (BER) verses Signal to Noise Ratio (SNR).

9. PAPR Reduction performance for 8-QAM

In this performance we are used different-different subcarriers (N=64, 128, 256 and 512) with 8-QAM-Modulation, also considered clapping ration (CR) γ is still set to 2.11, L=4, PAPR with OFDM signal. Figure 5.6 for N=64, figure 5.7 for N=128, figure 5.8 for N=256 and figure 5.9 for N=512 shows the PAPR, CCDF curves for the signals processed by using the original and simplified OICF algorithms, respectively.

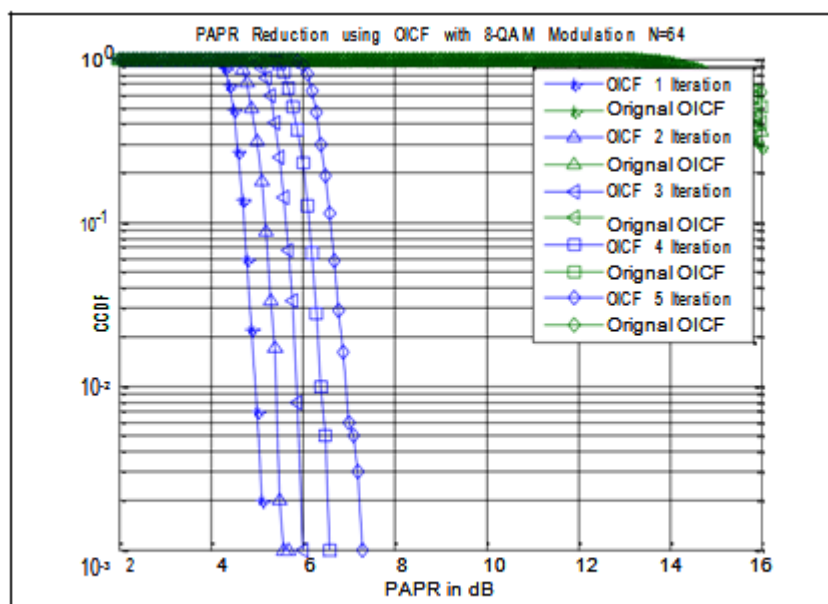


Fig. 5.6: PAPRReduction performance of original and simplified OICF algorithms, 8-QAM, N=64

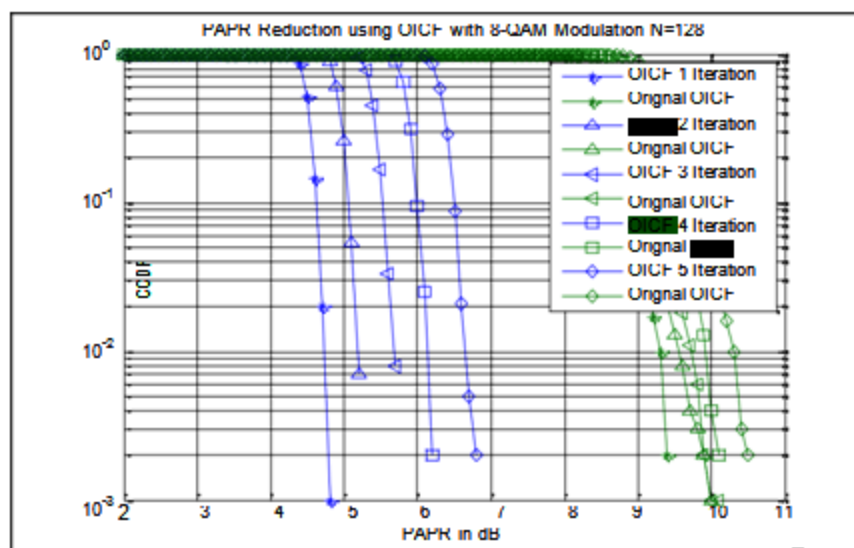


Fig. 5.7: PAPR Reduction performance of original and simplified OICF algorithms, 8-QAM, N=128 subcarriers, L=4 and Y=2.11

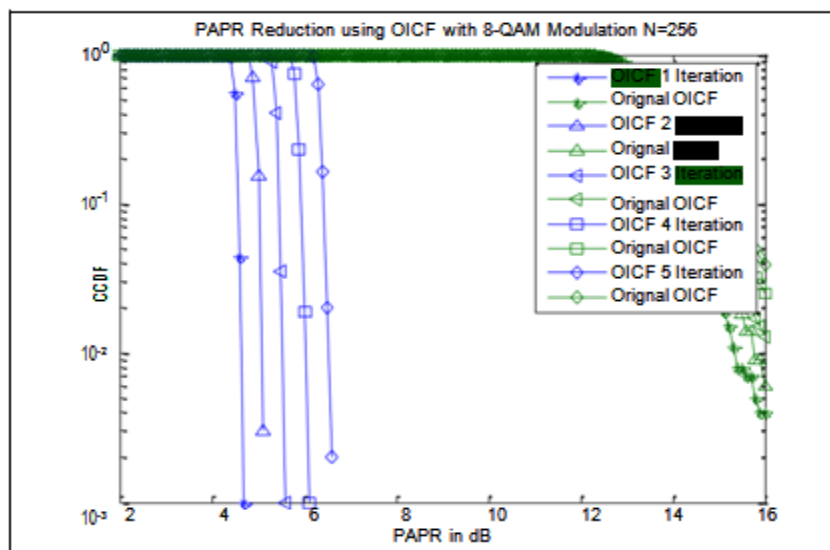


Fig. 5.8: PAPR Reduction performance of original and simplified OICF algorithms, 8-QAM, N=256 subcarriers, L=4 and Y=2.11

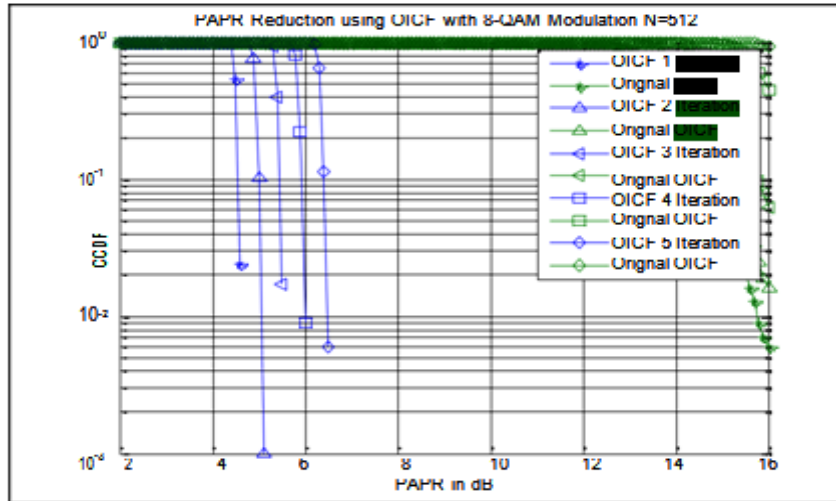


Fig. 5.9: PAPR Reduction performance of original and simplified OICF algorithms, 8-QAM, N=512 subcarriers, L=4 and Y=2.11

Table 2 : Analysis of PAPR Reduction Parameters for 8QPSK Modulation

Used Parameter	Modulation	CCDF	Subcarriers N	CR (Y)	PAPR
Original OICF Iteration	8-QAM	10^{-2}	64	2.11	NA
Simplified OICF Iteration					4.6
Original OICF Iteration			128		9.4
Simplified OICF Iteration					4.65
Original OICF Iteration			256		15.6
Simplified OICF Iteration					4.8
Original OICF Iteration			512		15.6
Simplified OICF Iteration					4.8

10. Simulation Result of PTS Technique

The PAPR reduction performance is performed using Matlab simulation by Matlab 2013a. Based on the principles of PTS algorithm. In this case, we set the number of OFDM symbols 10000, the number of sub-band N equals to 64, and oversampling factor $L=4$. In the Figure 5.10 PAPR reduction performances of PTS Technique with QPSK modulation schemes using AWGN Channel.

Table 3 : Observation Result for PTS Techniques

S. No	Used Parameter	CCDF (Pr)	Original OFDM	PTS-PAPR
01	QPSK Modulation with AWGN Channel		8.6dB	4.0dB
02			9.6dB	4.5dB
03			10.4dB	5.1dB

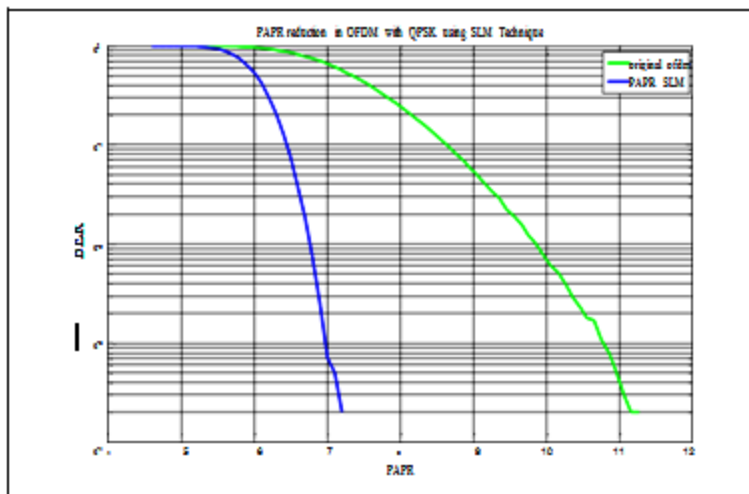


Figure 5.10 PAPR reduction performances of PTS Technique with QPSK modulation schemes using AWGN Channel

11. PTS Technique Result Analysis:

The CCDF of PAPR is obtained by MATLAB simulation. It can be clearly seen that the proposed PTS technique has better PAPR performance when compared to the original OFDM methods. It has been observed that the original signal has a high PAPR value of 10.4 dB. The Partial Transmit Sequence technique (PTS) reduces the PAPR value to about 5.1 dB. The PAPR value of the OFDM signals has been reduced even further to a value of 5.3 dB by our proposed PTS technique

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1.1 Electric Power System in Communications

The power infrastructure includes electric power system, which is a network of electrical components used to generate, supply, transmit and use electric power. An example of electric power system is the network that supplies power to the Residential and Industrial with power for sizable regions, this power system is known as grid. It can be broadly divided into generators that supply power, transmission system that carries power from generating centers to the load centers and the distribution system that feeds power to the nearby homes and industries.

Wireless communication systems can be found all around the world today. WiMAX which represents (World Interoperability for Microwave Access) is a major part of broad band wireless network having IEEE 802.16 standard provides innovative fixed as well as mobile platform for broad-band internet access anywhere in anytime. IEEE 802.16 standard has bandwidth of 2GHz-11GHz for fixed applications and 2-6GHz for mobile applications. Wireless technology enables high-speed, high-quality communication between mobile devices. Potential wireless applications include cell phones, 802.11-based wireless Local Area Networks (LANs), Bluetooth, smart homes and appliances, voice and data communication over the Internet, and video conferencing.

Orthogonal Frequency Division Multiplexing (OFDM) is an efficient method of data transmission for high speed communication systems. However, the main drawback of OFDM system is the high Peak to Average Power Ratio (PAPR) of the transmitted signals. Coding, phase rotation and clipping are among many PAPR reduction schemes

1.2 Technologies for Power System Protection and Monitoring

The technologies that can be used for protection and monitoring of network are wired (Guided Media) and wireless communications (Unguided Media).

1.2.1 Wireless Communication

Wireless telecommunications is the transfer of information between two or more points that are not physically connected. Distances can be short, such as a few meters for television remote control, or as far as thousands or even millions of kilometers for deep-space radio communications. It provides both flexibility and cost savings in deployment and maintenance compared to wire line deployments. Wireless can be deployed anywhere and anytime. Wireless-based systems have been used in industries similar to the electric power system such as oil and gas. For example, British Petroleum has successfully deployed Wireless-HART, which is an extension of the HART protocol. It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking.

1.2.2 Wireless Communication systems

- a. Wireless Broadcast systems, in which the user is always at the receiver end, Examples of such systems as AM/FM radio, television, direct-to-home (DTH) etc.
- b. Wireless networks, where multiple users can exchange their information, being a transmitter or a receiver independently. These types of system are mainly based on cellular infrastructure examples, mobile telephone network and universal mobile telecommunication system (UMTS), wireless LAN, and mobile internet etc.

1.2.3 Wired Communication systems

- a. Twisted Pair wire lines, unshielded twisted pair (UTP) and shielded twisted pair (STP), for conventional landline telephone system, 10BaseT Ethernet cabling, etc.
- b. Coaxial cable for closed circuit TV (CCTV) and cable TV network, Ethernet 10Base2, 10Base5 cabling etc.
- c. Optical fiber for long distance communication, B-ISDN, Fiber distributed data interface (FDDI, local area network (LAN), synchronous optical network (SONET) etc.

1.3 WiMAX Technology

Wireless communication systems can be found all around the world today. WiMAX which represents World Interoperability for Microwave Access is a major part of broadband wireless network having IEEE 803.16 standard provides innovative fixed as well as mobile platform for broadband internet access anywhere in anytime. The IEEE 803.16 group subsequently produced 803.16a, an amendment to the standard, to include NLOS applications in the 3GHz-11GHz band, using an orthogonal frequency division multiplexing (OFDM)-based physical layer. Additional to the MAC layer, such as support for orthogonal frequency division multiple access (OFDMA), were also included. Further revisions resulted in a new standard in 2004, called IEEE 803.16-2004, which replaced all prior versions and formed the basis for the first WiMAX solution.

1.3.1 Frequency Band Difference of WiMAX

The original WiMAX standard, IEEE 803.16, specifies WiMAX in the 10 to 66 GHz range. 803.16a added support for the 3 to 11 GHz range, of which most parts are already unlicensed internationally and only very few still require domestic licenses. There is a frequency band differences between two of them. WiMAX uses licensed spectrum whereas Wi-Fi uses unlicensed spectrum.

WiMAX can operate in licensed spectrum as well as unlicensed spectrum .Following spectrum band are particularly used.

- (a) **Licensed 3.5 GH Spectrum:** Licensed spectrum of range 3.5 to 3.7 GH is used in USA.
- (b) **Licensed 3.5 GH Spectrum:** 3.4 to 3.7 range of spectrum is used throughout rest of the world especially in Europe and originally used for wireless local loop.
- (c) **Unlicensed 3.5 GH:** For fixed location wireless services an unlicensed spectrum of range 3.65 to 3.7 is used in USA.
- (d) **Unlicensed 5GH Band:** Another unlicensed spectrum ranging 5.150 to 5.350 and 5.470 to 5.835 GH is also used in USA.

1.4 Average Power Ratio

Peak to average power ratio (PAPR) is a signal property that is calculated by dividing the peak power amplitude of the waveform by the RMS value of it, a dimensionless quantity

which is expressed in decibels (dB). In digital transmission when the waveform is represented as signal samples, the

PAPR is defined as in equation 1.1.

$$\text{PAPR} = \frac{\max(|S[n]|^2)}{E\{|S[n]|^2\}}, 0 \leq n \leq N-1 \quad 1.1$$

Where $S[n]$ represents the signal samples, $\max(|S[n]|^2)$ denotes the maximum instantaneous power and $E\{|S[n]|^2\}$ is the average power of the signal [1].

1.5 Reduce of PAPR

Non-linear devices such as digital to analog converters (DAC) and high power amplifiers (HPA) exist in almost all communication links and demand for data transmission over longer (Distant) ranges. At the same time higher power efficiency of the amplifiers, require the amplifiers to operate in a more non-linear region, In general, there is a trade of between linearity and efficiency.

In single-carrier modulation the signal amplitude is somehow deterministic, except for the pulse shaping filter effect, so the operating point in the amplifier can be determined accurately without destructive non- linear impairments. But in the multi-carrier systems like OFDM (Orthogonal frequency division multiplexing), the envelope of the time domain signal will change with different data symbols. Accordingly, the input power amplitude will change with a noticeable variance in specified operating point and the non-linearity effect causes distortion. Distortion acts as noise for the receiver, and also the signal constellation rotates due to phase conversion. Moreover, the out-of-band distortion of subcarriers is the result of non-linearity impairments, which causes cross talk since the subcarriers are not orthogonal any more.

To estimate the distortion which is caused by non-linearity, it is desired to have a measure of the signal to show its sensitivity to non-linearity. A well-known measure for the multi-carrier signals is peak to average power ratio (PAPR).

1.6 PAPR Reduction in OFDM Systems

There is several PAPR reduction techniques published in literature. Excellent overview of popular peak to average power (PAPR) reduction techniques is given in. Some of them are as follows.

1.6.1 Iteration Clipping and Filtering:

The idea of adjacent channel emissions filtering after clipping has been presented in [2]. As the filtering of clipped signals results in new peaks creation, the method of repeated clipping and filtering has been subsequently proposed in [3][4]. This method is based on the zero padding of the signal in the frequency domain and frequency domain filtering of clipped signal at the output of IFFT. The process of clipping and filtering is repeated several times – according to the author's experiments 4 or 5 times. These repetitions result in huge signal processing - for each frequency domain filtering the pair of FFT and IFFT operation is necessary. Its PAPR reduction performance is approaching the PAPR of repeated clipping and filtering method with arbitrary number of repetitions.

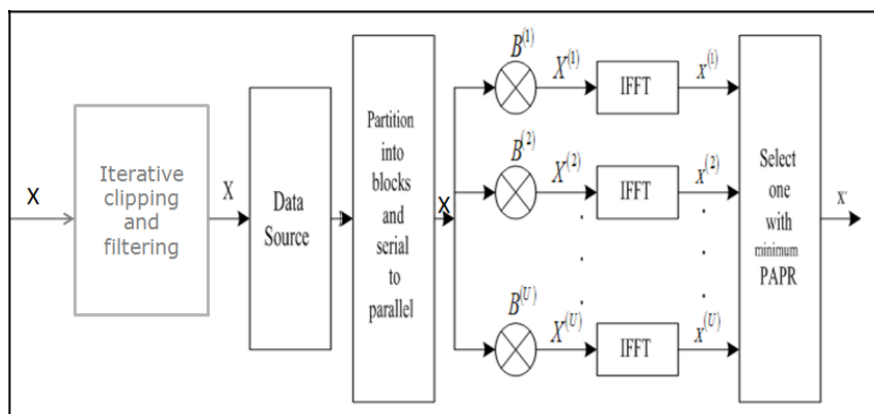


Fig. 1.2: Block diagram of the proposed method.

1.6.2 Optimized-Iteration-Clipping-Filtering (OICF) Scheme

As mentioned earlier, iterative clipping and filtering (ICF) of $2K+1$ IFFT/FFT operations, where K is the number of iterations, is necessary to obtain the desired clipped signal. Proposed an efficient and fast algorithm for ICF. In target clipped signal was produced through one iteration (of 4 IFFT/FFT operations) with some additional processing (two vector subtractions). They assumed the clipped peaks as a series of parabolic pulses, which is true for large clipping threshold. The processing overhead might still be considerable due to the oversampling (by a factor ≥ 4) of original OFDM data block. In this section, a new scheme one iteration of clipping and filtering (OICF) is presented. As the name implies, this approach produces the desired clipped signal through one iteration with almost no additional processing. The OICF scheme employs a scaling of the original clipping threshold. We have derived an empirical expression based on re-growth of

Clipped-filtered pulses, which relates the original clipping threshold to new scaled one. The simulation results show that the performance of OICF is comparable to the conventional method for large clipping threshold.

1.7 OFDM

OFDM is a modulation technique which offers quite a few interesting features to mitigate frequency-selective channel impairments [4]. Huge bandwidth savings is possible due to the orthogonality among subcarriers. The high-data rate is divided into several low-data rate streams which modulate orthogonal subcarriers. The narrow band signals are multiplexed together and sent through the channel. At the receiver, the signal is de-multiplexed in reverse order creating low-data rate streams which form the original high-data rate signal. Advantage of OFDM system is the efficient channel estimation/equalization as the broadband frequency-selective channel is split into several flat-fading channels due to narrow- band subcarriers. Service providers can use granularity (due to several narrow band

subcarriers) available to offers variety of data rate depending on the service types (e.g. data, voice, video, etc) and Quality of Service (e.g. reliability, priority, etc). Discrete-time OFDM signal can be written as in equation 1.4.

1.8 POWER REDUCTION TECHNIQUES

Power reduction techniques are a well-known signal processing topic in multi-carrier transmission and large number of techniques appeared in the literature during the past decades. These techniques include amplitude clipping and filtering, coding, tone reservation (TR) and tone injection (TI), active constellation extension (ACE) and multiple signal representation methods such as partial transmit sequence (PTS), selected mapping (SLM) and interleaving. The existing approaches are different from each other in terms of requirements, and most of them enforce various restriction to the system. Therefore, careful attention must be paid to choose a proper technique for each specific communication system. In this section we focus more closely on the PAPR reduction techniques for multi-carrier transmission. In order to evaluate the performance of these techniques, we need to look at the application and existing restrictions of a communication system.

1.8.1 Phase Transmit Sequence (PTS)

In the PTS technique, an input data block of N symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected such that the PAPR of the combined signal is minimized. Figure 3.1 show the block diagram of PTS algorithm.

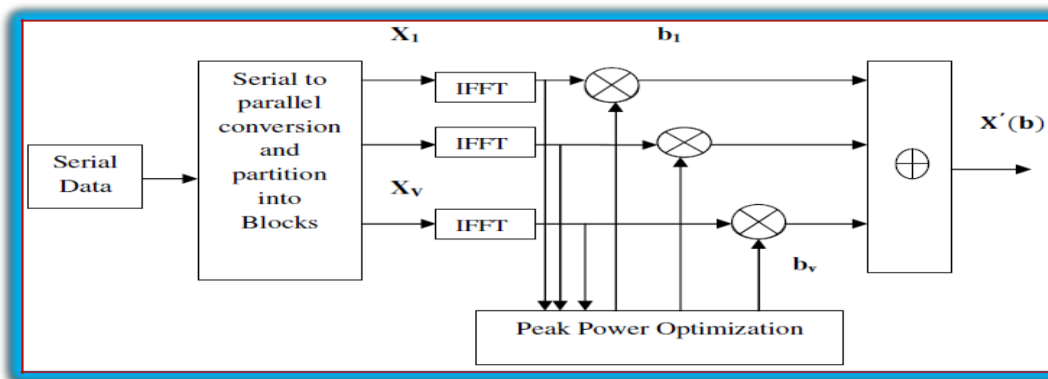


Fig. 1.3: Block diagram of PTS algorithm [12]

In conventional PTS approach, it requires the PAPR value to be calculated at each step of the optimization algorithm, which will introduce tremendous trials to achieve the optimum value. Furthermore, in order to enable the receiver to identify different phases, phase factor is required to send to the receiver as sideband information (usually the first sub-block 1, is set to 1). The optimization is achieved by searching thoroughly for the best phase factor. Theoretically, $\mathbf{b} = [1, 2, \dots,]$ is a set of discrete values, and numerous computation will be required for the system when this phase collection is very large.

The simulation results show that the performance of OICF is comparable to the conventional method for large clipping threshold.

1.9 Clipping and Filtering

One of the simple and effective PAPR reduction techniques is clipping, which cancels the signal components that exceed some unchanging amplitude called clip level. However, clipping yields distortion power, which called Clipping noise, and expands the transmitted signal spectrum, which causes interfering. Clipping is

nonlinear process and causes in-band noise distortion, which causes degradation in the performance of bit BER and out-of-band noise, which decreases the spectral efficiency [11]. Clipping and filtering technique is effective in removing components of the expanded spectrum. Although filtering can decrease the spectrum growth, filtering after clipping can reduce the out-of-band radiation, but may also cause some peak re-growth, which the peak signal exceeds in the clip level.

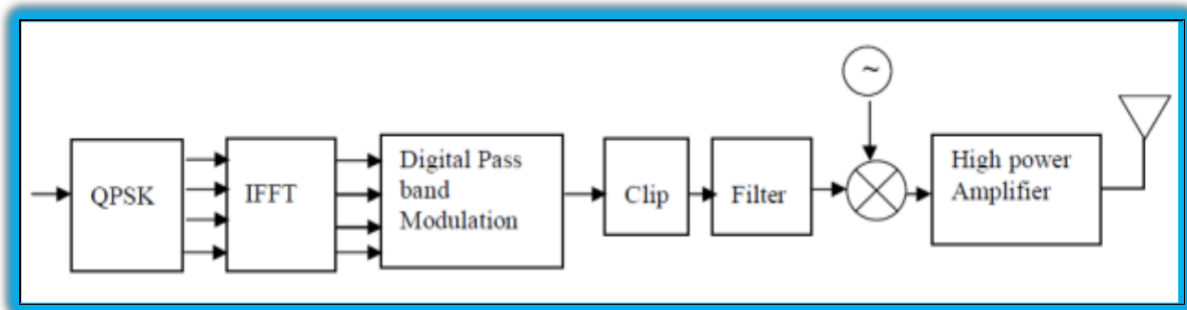


Fig. 1.4 Block diagram of a PAPR Reduction scheme using clipping and filtering [11].

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 [12]. But without performing interpolation before clipping causes it out-of-band. To avoid out-of-band, signal should be clipped after interpolation. However, this causes significant peak re-growth. So, it can use iterative clipping and frequency domain filtering to avoid peak re-growth.

1.10 METHODOLOGY

The energy efficiency of various OFDM systems, such as optical, mobile, Wireless and WiMAX systems, has been analyzed in this paper. High peak to average power ratio that may appear in modulation process is one of the main problems in OFDM systems. The influence of subcarriers number and modulation techniques to the peak-to-average power ratio in different OFDM based systems has been studied. The results of analysis are presented in numerous figures and tables. The main goal is to provide a comparative study that can be used for an optimal system selection with predefined power consumption requirements.

1.10.1 Orthogonal Frequency Division Multiplexing (OFDM)

The concept of Orthogonal Frequency Division Multiplexing (OFDM) has been known since 1966, but it only reached sufficient maturity for deployment in standard systems during 1990s. OFDM is an attractive modulation technique for transmitting large amounts of digital data over radio waves. 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 has been proposed in the literature for reducing the PAPR in OFDM systems.

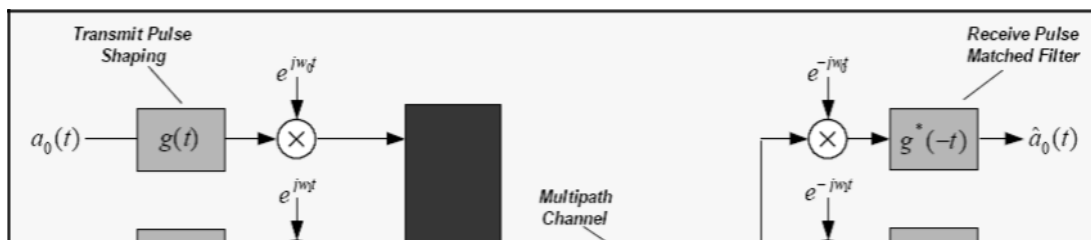


Fig. 1.5: OFDM is a multiplexing Technique [6].

1.11 SIMULATION RESULTS

To simulate the above OFDM system for PAPR reduction we used MATLAB R2013a, to compare the performance of the original and proposed algorithms, we consider an OFDM system with 128 subcarriers with QPSK modulation. The studies have suggested that the oversampling factor $L = 4$ can provide sufficiently accurate PAPR results. Our algorithm will be compared first with the original OICF algorithm and then with several existing clipping and filtering techniques and another PTS algorithm considered. During our simulation we used cyclic prefix to minimize the Inter Symbol Interference (ISI) on the basis of Quadrature Phase Shift Keying modulation techniques and AWGN and multipath fading channel communication channel. With the help of modulation techniques we got the parameters PAPR versus CCDF and Bit Error Rate (BER) versus Signal to Noise Ratio (SNR).

1.11.1 Analysis parameter in PAPR Reduction

We are considered following analysis parameter in reduction of pick to average poer ration or power reduction as shown in the table 1.1.

Table 1.1 Analysis parameter in PAPR Reduction

S. No.	Parameter	Value
01	Mesured	Power in dB
02	Modulation	QPSK, 8-QAM
03	Channel	AWGN & Raylight
04	Oversampling Factor	4
05	Claping Ration	2.10

1.10.2 PAPR Reduction performance for QPSK

In this performance we are used different-different subcarriers (N=64, 128, 256 and 512) with QPSK-Modulation, also considered claping ration (CR) γ is still set to 2.11, L=4, PAPR with OFDM signal. Figure 5.1 for N=64, figure 5.2 for N=128, figure 5.3 for N=256 and figure 5.4 for N=512 shows the PAPR, CCDF curves for the signals processed by using the original and simplified OICF algorithms, respectively.

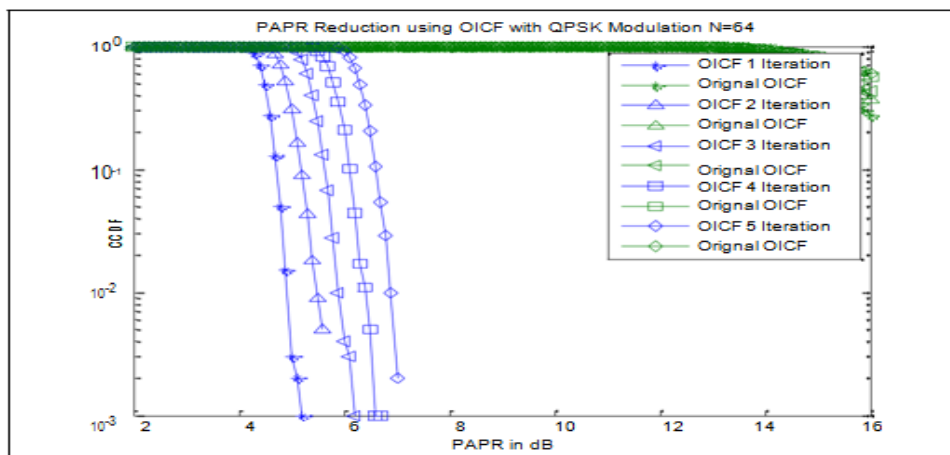


Fig. 1.6: PAPR Reduction performance of original and simplified OICF algorithms, QPSK, N=64 subcarriers, L=4 and $\gamma=2.11$

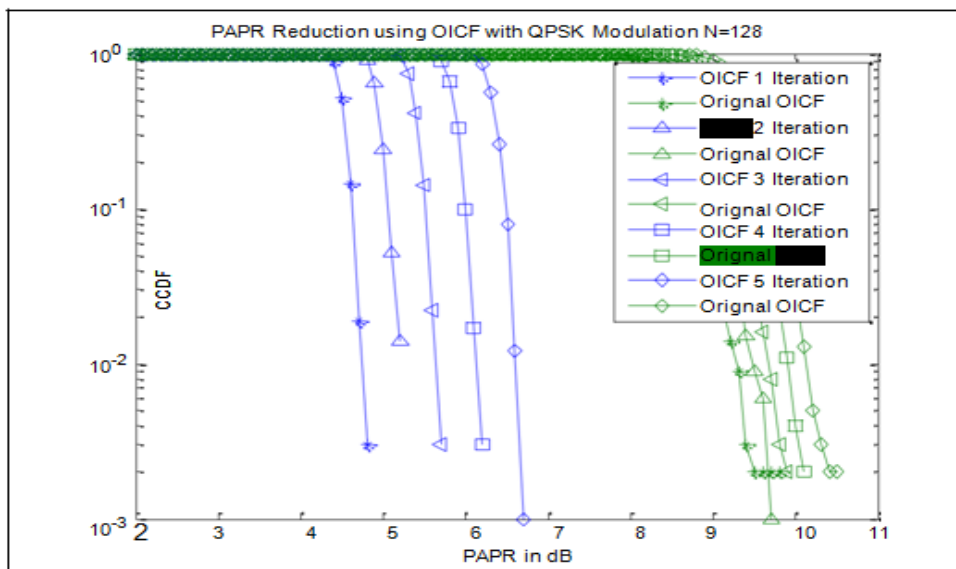


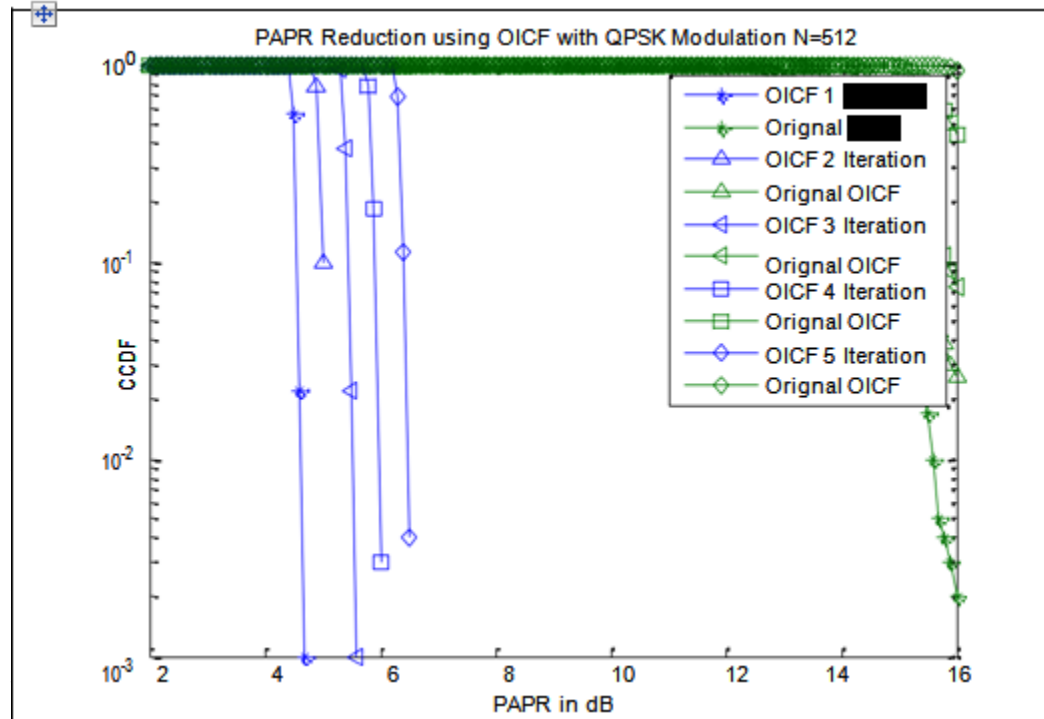
Fig. 1.7 PAPR Reduction performance of original and simplified OICF algorithms, QPSK, N=128 subcarriers, L=4 and $\gamma=2.11$

CONCLUSION

The communication network of an electric power system has the important role of conveying information for ensuring a stable supply of electricity. The communication network of an electric power system has the important role of conveying information for ensuring a stable supply of electricity. This information is used to adjust output from power stations, and to prevent power outages from spreading to wider areas when they occur. OFDM is a very attractive technique for multicarrier transmission and has become one of the standard choices for high speed transmission over a communication channel.

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