CHAPTER 3

BER AND PAPR REDUCTION USING OFDM TECHNIQUE

3.1 INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier modulation scheme that has been widely used in many digital broadcasting systems. The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. Because the symbol duration increases for lower rate parallel subcarriers, the relative amount of dispersion in time caused by multipath delay spread is decreased. Inter symbol interference is eliminated almost completely by introducing a guard time in every OFDM symbol. In the guard time, the symbol is cyclically extended to avoid inter carrier interference. The development of OFDM systems can be divided into three parts.

This comprises of

1. Frequency Division Multiplexing,
2. Multicarrier Communication and
3. Orthogonal Frequency Division Multiplexing theory.
3.1.1 Frequency Division Multiplexing

Frequency Division Multiplexing is a form of signal multiplexing which involves assigning non-overlapping frequency ranges or channels to different signals or to each user of a medium. A gap or guard band is left between each of these channels to ensure that the signal of one channel does not overlap with the signal from an adjacent one. Due to lack of digital filters it was difficult to filter closely packed adjacent channels.

3.1.2 Multicarrier Communication

As it is ineffective to transfer a high rate data stream through a channel, the signal is split to give a number of signals over that frequency range. Each of these signals are individually modulated and transmitted over the channel. At the receiver end, these signals are fed to a de multiplexer where it is demodulated and recombined to obtain the original signal.

3.1.3 The General system of OFDM

OFDM is multi channel modulation system employing Frequency Division Multiplexing (FDM) of orthogonal sub carriers and each modulation a low bit rate digital stream.

The Multi channel systems using FDM, the total available bandwidth is divided into non overlapping frequency sub channels. Each sub channel is modulated with separate symbol stream and the N sub channels are frequency multiplexed. Even though the prevention of spectral overlapping of sub carriers reduces or eliminates Inter Channel Interference this leads to an
inefficient use of spectrum. The guard band on either side of each sub channels is a waste of precious bandwidth. To overcome the problem of bandwidth wastage, instead use ‘n’ overlapping sub carriers, each carrying a baud rate of 1/t and spaced 1/t apart. Because of the frequency spacing selected, the sub carriers are all mathematically orthogonal to each other.

This permits the proper demodulation of the symbol streams without the requirement of non overlapping spectrum. Another way of specifying the sub carrier orthogonality condition is to require that each sub carrier have exactly integer number of cycles in the interval ‘t’. It can be the modulation of these orthogonal sub carriers can be represented as the Inverse Fourier Transform. Alternatively, one use a DFT operation followed by low passes filtering to generate the OFDM signal.

3.1.4 Generation of OFDM

The N input complex symbols are padded with zeros to get Ns symbols that are used to calculate the IFFT. The output of the IFFT is the basic OFDM symbol. A number of samples corresponding to this OFDM symbol and the end of the symbol. The same number of samples must be taken form the end of the OFDM symbol and must be inserted at the beginning. The OFDM symbol must be multiplied with the raised cosine window to remove the power of the out of band sub carriers. The OFDM symbol is added to the output of the previous OFDM symbol with a delay of overlap each region of OFDM transmitter and receiver.
3.1.5 Design of OFDM System

OFDM system design as in any other system design involves a lot of trade off and conflicting requirements. The following are the most important design parameters of an OFDM system.

Specification:

- Bit Rate required for the system.
- Bandwidth available.
- BER requirements. (Power efficiency)
- RMS delay spread of the channel

3.1.6 Number of Sub carriers

Once the symbol duration is determined, the number of sub carriers required to calculate the first calculating the sub carrier spacing is just the inverse of the symbol time period. The number of sub carriers in the available bandwidth divided by the sub carrier spacing.

3.1.7 Clipping

One important feature of the peak to average ratio in the OFDM is the fact that percentages of symbols have a very large peak power is less and the percentage decreases with an increase in the number of sub carriers. The simplest possible solution to the peak power problem is clipping in limiting the peak amplitude to some maximum level.

The increase in the out of band radiation is basically of the fact clipping the operation is a multiplication of the OFDM symbol with a
rectangular function is the amplitude is below a threshold and a smaller value if the amplitude is above the threshold. This rectangular waveform increases the out of band radiation and a result of the spectrum has a roll off that inversely proportional to the frequency.

The problems of slow spectrum roll off overcome to some extent, by windowing the rectangular clipping waveform. Several windows are proposed in literature. Some of the most common ones are Gaussian, Cosine, and Hamming etc. Simulation result shows a slight degradation in BER with clipping.

The BER performance is a large portion of the signal is affected by windowing is clipping alone. The required back off for the power amplifier determined by specifying the amount of attenuation for the out of band spectral components relative to the in band spectral components. The windowing offers a 3 –dB gain in the required back off compared to clipping alone.

3.1.8 Sub carriers of OFDM

OFDMA providing each user with a small number of sub carriers to though this technique is similar to FDMA, it avoids the use of large guard bands are use of the prevent adjacent channel interference.

3.1.9 Implementation of OFDM

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carriers are orthogonal to each other, they are totally independent of one to another. This is achieved by placing the
carrier exactly at the nulls in the modulation spectrum of each other. It is a method of digital modulation in which a signal is split into several narrow band channels at different frequencies. It comprises of a total of subcarriers that are balanced utilizing Phase Shift Keying (PSK) or Quadrature Amplitude Modulation (QAM).

In OFDM plan, various parameters are up for thought, for example, the quantity of subcarriers, symbol time, data duration, subcarrier dispersing, and modulation of the subcarrier. The decision of parameters is affected by bandwidth requirements, for example, data transfer capacity, data rate, delay spread, and Doppler values.


**Figure 3.1   Block Diagram of General OFDM System**

A few basics are incompatible. In the research work, to get a delay spread resistance, countless with subcarrier dispersing is the inverse is
valid for a decent flexibility against Doppler spread and noise occur. The OFDM framework utilizes a fundamental rectangular window which prompts generally high out of band radiations. In addition of the information transmission rate of the OFDM framework is diminished by the insertion of the Cyclic Prefix (CP).

Transmitter

1. The information streams are isolated into squares of N images. This part of information is subjected to an Inverse Fast Fourier Transformation (IFFT).

2. The quantity of tests N is been a force of two. The contribution to IFFT is comprised of N tests and in this way the from the IFFT additionally comprises of N characters.

3. Utilizing parallel to serial converter (p/s) the datas are transmitted consistently.

Receiver

1. At the beneficiary, the inverse process, s/p serial to parallel converter is utilized to change over the symbol into parallel vector.

2. At that point FFT Fast Fourier Transform is performed on this vector. The outcome is an assessment of the modulated signal.

Advantage of Digital Implementation

- Digital usage of handsets is much more straightforward and less expensive.
- Efficient "butterfly structures" of FFT are utilized.
- Fast in procedure.
- High affectability to time and recurrence scattering.
Uses

Data transmission over radio telecast stations and remote correspondence stations.

3.1.10 Inter Symbol Interference

- Inter symbol interference (ISI) is an undesirable feature in both wired and wireless communication systems. The pulse communication system while transmitting a signal in the form of pulses over a communication channels.
- The ringing tails of several pulses have overlaps that interfering with the major pulse lobe.
- This interference is called as Inter Symbol Interference or simply ISI.
- It is an important consideration in the transmission of pulses over circuits with a limited BW and Non-linear phase responses.

Inter Symbol Interference is a type of contortion symbol in one data meddles with resulting data. This is an undesirable as the past data have comparable impact as commotion, along these lines making the correspondence less dependable.

It is generally brought about by multipath propagation or the characteristic non direct recurrence reaction of a channel creating progressive data to obscure together. The nearness of ISI in the framework presents blunder in the choice at the recipient output. In this way, in the outline of the transmitting channels, the goal is to minimize the impacts of ISI and in this way convey the computerized information to its destination with the smallest error rate is imaginable.
3.1.11 Inter Carrier Interference

The effect of recurrence balance bringing about Inter Carrier Interference (ICI) accepting an OFDM adjusted image. The OFDM transmission the Doppler shift and phase of frequency counter balances in a OFDM framework causes misfortune in orthogonality of the sub carriers signals. Accordingly, obstruction is seen between subcarriers is known as Inter Carrier Interference (ICI).

Evaluation of OFDM can be enhanced by any of the methodologies implemented:

1. Coding technique use the subcarrier characteristic tones:

Such coding adjusts for blurring plunges on one subcarrier by a decent SNR in another subcarrier.

2. Spreading the data over all tones:

In this approach, every symbol is spread over all sub carriers, so that normal SNR additionally spreads.

3. Adaptive modulation techniques:

Adaptive modulation is a Delta Modulation system which adjusts its step Size to accommodate changing signal condition.

The input signals slope is large step size is to increase and reducing slope overload effects. The other hand step size is decreased if the message is changing slowly decreases in power level and reducing noise.
The transmitter knows the SNR on each of the sub carriers, it can select the balance and coding rate modulation is adaptively. In this way on carrier signal with low SNR, the transmitter will send images utilizing more grounded encoding and a littler adjustment letters in order. Additionally the force allocated to each subcarrier can be changed.

### 3.1.12 Peak to Average Power Ratio (PAPR)

OFDM signal comprises of various freely modulated the subcarrier signal, which extensive Peak-to-Average Power (PAP) ratio when included intelligently. At the point when N symbols are included with the same stage, they deliver a crest power that is N times of the average power.

### 3.1.13 Reduction Techniques in PAPR

To reduction of the PAPR, a few methods have been proposed, which fundamentally can be isolated into three classifications.

1. Signal Distortion method, which reduction of the amplitudes non linearly misshaping the OFDM signal at or around the peaks. Illustrations are Clipping and Filtering, Compounding, Peak signal.
2. Probabilistic methods and Multiple signaling, which work in one of two ways. The modification parameters are streamlined to minimize Peak to Average Power Ratio. Cases are Selective Mapping (SLM), Partial Transmit Sequence (PTS), and Tone Reservation.
3. Coding method is use a special forward error correction Reverse error correcting codes to use the OFDM signals in the large Peak to Average Power Ratio (PAPR).
3.1.14 Classification of PAPR Reduction Techniques

**Figure 3.2** PAPR reduction techniques
There are numerous PAPR diminishment strategies comprehensively arranged in three sorts.

1. Signal Distortion method

2. Probabilistic methods and Multiple signaling

3. Coding method

3.1.15 Signal Distortion method

The PAPR by distorting the transmitted OFDM signal before it goes through the signal distortion techniques. The most commonly used the signal distortion systems filter, and peak windowing, companding, peak cancellation. These strategies of the PAPR significantly present both in band limiting, prompting to improve the BER.

The fact of the OFDM transmitted signal may have increase the PAPR, and the high size and low amplitude in a majority of the signal performance will depends upon the low amplitude mapping signals. It is conceivable to drive out the high peaks without significantly distortion of the signal. Consequently, PAPR decreased to the bearable improve in BER performance.

3.1.16 QAM Quantization

Constellation diagram is very useful QAM in digital modulation systems. The group of stars focuses are typically organized in a square network with equivalent vertical and flat dispersing different designs are conceivable (e.g. Cross-QAM). Since in digital telecommunications the
information is generally double, the quantity of focuses in the lattice is typically a force of \( (2, 4, 8 \ldots) \). The QAM is normally square, some of these are uncommon the most well known structures are 16-QAM, 64-QAM and 256-QAM. By moving to a higher request group of conceivable to transmit more bits per image.

These outcomes in a higher bit error rate and higher request QAM can convey a larger number of information and less dependably than lower request QAM, for consistent mean group of constellation energy. Utilizing higher request QAM without expanding the bit error rate requires a higher sign to proportion SNR by improving signal rate, decreasing BER and noise level.

The symbol rates past those offered by 8-PSK are required, it is more common to move to QAM it accomplishes a more separation between contiguous focuses in the IQ plane by appropriating the focuses all the more equally. The convoluting component is that the focuses are no more all the same demodulation effectively recognizes both stage and sufficiency as opposed to the simple stage.

The 64-QAM and 256-QAM are frequently utilized as a part of advanced digital TV and link modem applications. In the United States, 64-QAM and 256-QAM are the ordered balance plans for advanced link as institutionalized by the international standard.

3.1.17 Peak Windowing

The peak windowing a edge are hard-restricted, peak windowing points of confinement such high peak encoding the capacity called a window capacity function. Numerous window capacities can be utilized as a part of
this procedure the length of they have great spectral properties. The most usually utilized window capacities incorporate Hamming, Hanning and Kaiser Windows. To decrease PAPR, a window capacity is adjusted to the signal examples in a manner that is duplicated by the signal peaks its higher amplitudes are increased by lower signal distortion around the peak windowing. This activity signal peaks in a much contrasted with hard clipping, noise decreased.

3.1.18 Companding Transformer

Companding changes are regularly connected to signals to enhance the required number of bits per second. Since OFDM and discourse signals carry on correspondingly as in high peak happen continues, same companding changes can likewise be utilized to the OFDM signals in PAPR. Other than having moderately low computational unpredictability contrasted with other PAPR diminishment methods, companding the quantity of subcarriers. Additionally, companding does not require side data and does not decrease bit rate. The implementation and the companding change an appealing PAPR reduction technique. The PAPR reduction got by companding changes comes with the cost of improve the BER.

3.1.19 OFDM signal of Cancellation

In this topic, a peak cancellation of OFDM waveform is produced, scaled, and subtracted from the OFDM signal at those show high peak signal. The generate waveform is band constrained to certain peak cancellation conditions that are not used to transmit information. The peak cancellation can be completed after the IFFT square of the OFDM transmitter by subtracting the peak cancellation waveform from the OFDM signal at point a potential higher than a specific edge is distinguished.
3.1.20 Probabilistic Techniques and Multiple Signaling

These strategies work in one of two ways. One path is to create various changes of the OFDM standard and transmit the one with least PAPR. The other path is to adjust the OFDM signal by presenting phase shifts, including peak reducing carrier signals, or changing heavenly the constellation points. The modification parameters are enhanced to minimize PAPR.

3.1.21 Selective Mapping

Selective Mapping (SLM) is a generally straightforward way to deal with decrease PAPR. The fundamental thought is to create an arrangement of adequate diverse OFDM images \( x(n) \), \( 0 \leq n \leq m-1 \), each of length \( n \), all indicate to the same data as the first OFDM image \( x \), then transmit the one with the minimum PAPR.

Figure 3.3  Cancellation diagram in OFDM transmitter
Data about the sequence selected to the transmitted decode as a side data to allow original signal at the receiver, which reduction of information transmission rate.

3.1.22 Sequence of Partial Transmitter

Then the IFFT for each sub-block is computed and weighted by a phase factor. The objective now is to select the set of phase factors, that minimizes the PAPR. In the process of selecting the optimum phase factors, search is usually limited to a finite number of elements to reduce search complexity.

In Partial Transmit Sequence (PTS), information of length $n$ is divided into various disjoint sub blocks. The IFFT for every one of these sub blocks is registered independently and after that weighted by a stage variable. The stage variables are chosen so as to minimize the PAPR of the joined sign of all the sub-blocks. At that point the IFFT for every sub block is registered.
and weighted by a stage variable. The target now is to choose the arrangement of stage variables that minimizes the PAPR. During the time spent selecting the ideal stage variables, is typically restricted to a finite number of components to look many of the side blocks.

![Block diagram of PTS transmitter](image)

**Figure 3.5** Block diagram of PTS transmitter

### 3.1.23 OFDM Interleaved

One approach to produce different OFDM signals that convey the same data is to utilize interleaves. This method is like SLM however interleaves are utilized instead of phase sequences. An interleave is a block of images and permutes or reorders them in a specific way. To accomplish a significant decline in PAPR, various leavers are utilized to create an arrangement of adequate distinctive stages from the first information data.
Changes can be performed on images or bits. The IDFT is computerized for every one of the similar changes independently to create different OFDM signals. At that point the OFDM signal with the small PAPR is decided for transmission. To incorporate the first information in the PAPR transmission of various M OFDM signals, m - 1 bury leavers and M IDFT square block are required.

**Figure 3.6** Block diagram of interleaved transmitter

### 3.1.24 Raised-cosine filter

The raised cosine channel is a channel as possible utilized for minimize the digital modulation technique of the inter symbol impedance (ISI). Its name originates the way of non zero bit of the recurrence range of its least complex type of cosine capacity of raised up to the horizontal axis. The raised cosine channel is an every now and again utilized for digital modulation as a part of channel capacity to minimize Inter Symbol Interference (ISI). Its name originates from the way that the non-zero part of the range of simplest spectrum (x = 1) is a cosine capacity, "raised" up to bi directional axis. Pulse shaping is the process of various in the waveform of transmitting pulse.
3.2 PROPOSED METHODOLOGY

The proposed method is improving the data rate by using Segmental Partial Transmit Sequence and the work flow is shown below.

![Flow of Work for proposed system](image)

**Figure 3.7 Flow of Work for proposed system**

Figure 3.7 shows the work flow of the proposed system. There are several steps to implement the proposed methodology to improve data rate with PAPR reduction. Data rate is defined as the ratio of the number of bits that are conveyed or processed per unit time which is represented in the unit of bps.
Quadrature Amplitude Modulation

The Amplitude Shift Keying (ASK) advanced analog communication or Amplitude Modulation (AM) systems. Quadrature Amplitude Modulation (QAM) is the PSK methods in one symbol form the other phase. But all the symbols are transmitted in same amplitude. The direct modulation of carriers in quadrature is involved therefore the system is called QAM. The QAM achieves higher data rates than FSK or PSK using a combination of amplitude and phase modulation. The amplitude and phase of the carrier signals are varied in the binary input signal.

The two carrier waves, normally sinusoidal, are out of stage with each other by 90° and are in called Quadrature Phase Shift keying. QAM modulation sufficiencies of two waves, 90° out-of-stage with each other are changed to the information signal. The last waveform is a both of Phase Shift Keying (PSK) and Amplitude Shift Keying (ASK), or of Phase Modulation (PM) and amplitude modulation. Initial step is to outline the general OFDM signal by utilizing either Quadrature Amplitude Modulation or Phase shift keying method.

At that point the filter signal is separately divided into a many segments, every section having a few quantities of symbol block by utilizing S-PTS system. In the previous framework, by utilizing this system, they reduced PAPR reduction. The symbol rate is divided of lower "L" number in the portion length.
Additive white Gaussian noise (AWGN):

A fundamental model utilized as a part of data hypothesis to the impact of numerous procedures that happen in nature. The modifiers indicate particular attributes:

- 'Additive' in light of the fact that it is added to any commotion that may be characteristic for the data framework.
- 'White' is to thought that it has uniform force over the band for the data framework. It is a similarity to the shading white which has uniform outflows at all frequencies in the range of communication.
- 'Gaussian' in light of the fact that it has a typical appropriation in the time area with normal time space estimation is zero.

AWGN is utilized as a channel model as a part of which the main drawbacks to correspondence is a direct expansion of wideband or background noise a steady and a Gaussian dispersion of adequacy. The model does not represent selectivity, impedance, nonlinearity or scattering. It produces basic and scientific models which are valuable for picking up knowledge into the basic conduct of a framework before these other framework are considered.

3.3 MODIFICATION WORK

In proposed work, improving the data rate with reduction of large PAPR by providing \( l=2,4,8 \) and so on in the segment length. Some disjoint blocks are there, which are multiplied with phase rotation sequence. In general, an M-array QAM scheme enables the transmission of \( n = l^2 \) independent symbols over the same channel bandwidth. From that, the data rate will be improved using

\[
L^2 = n \quad (3.1)
\]
The exhaustive search method is used to achieve the optimal phase combination. Then the signal is transformed by using Inverse Fast Fourier Transform (IFFT) for efficient implementation. Then the signal is transferred to the receiver side through Additive white Gaussian noise channel which is a good model for many satellites and space communication. The reverse operation is done to get the original information. In the proposed system BER and PAPR values are reduced.

3.4 RESULT AND DISCUSSION

- The Simulation result output between Bit Error Rate (BER) and Signal to Noise Ratio (SNR) using 16-QAM, and 32-QAM, 64-QAM Modulation technique comparisons, 64-QAM Provides better improvement in signal to noise ratio and BER Reduction.
- The output between Cumulative Distribution Function (CCDF) using 16-QAM, and 32-QAM, 64-QAM Modulation technique comparison, 64-QAM provides better improvement in PAPR Reduction.

3.5 SIMULATION RESULTS

16 QAM Modulation systems

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<th>BER</th>
<th>SNR</th>
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</tr>
<tr>
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<td>4</td>
</tr>
<tr>
<td>10^-2</td>
<td>8</td>
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Table 3.1 Comparison of BER Values with 16 QAM Modulations
### 32 QAM Modulation systems

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<tr>
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<td>6</td>
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<tr>
<td>$10^{-2}$</td>
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Table 3.2 Comparison of BER Values with 32 QAM Modulations

### 64 QAM Modulation systems

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<td>24</td>
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</tbody>
</table>

Table 3.3 Comparison of BER values with 64 QAM Modulations

### Comparison Graphs

![Comparison chart of BER values with 16 QAM, 32 QAM, 64 QAM Modulation techniques](image)

Figure 3.8 Comparison chart of BER values with 16 QAM, 32 QAM, 64 QAM Modulation techniques
3.6 CONCLUSION

In this research work modified scheme called S-PTS Algorithm is used for reduction of BER and PAPR with low complexity by using 64-QAM modulation Technique, the input signal is divided into numerous segments for transmitting the data is, through Additive White Gaussian Noise (AWGN) channel receives the original signal with reduced value of Bit Error Rate (BER) and PAPR. The better result using QAM is the higher order modulation and able to carry more bits of information per symbol. By selecting a higher order format of QAM, the data rate of a link can be increased. Using 128-QAM, 256-QAM can improve the data rate and reduce as much as possible in BER and PAPR.