Implementation of an optimized DFT- Spread-OFDM technique to minimize PAPR Using QPSK Symbols in 5G technology

B. Kiranmai*, P. Alekhya, T. Hema Sundari, B. Nalini

**Professor, Department of Electronics and Communication Engineering, Lendi institute of engineering and technology,Jonnada, Visakhapatnam, India.*

Abstract

In fast growing world, telecommunication is an emerging technology for the growth of the mankind. Band width is an aid in the communication channel. Due to increase in number of users we have to transmit more number of signals in less bandwidth. This band width range will allow the user to transmit the signal through the channel. Band width range is important for effective communication. For effective transmission high frequency signals have to be transmitted in a limited bandwidth. For that connotation OFDM is used. The main complication in OFDM is PAPR. The signals must have less PAPR for effective transmission. The PAPR for a normal OFDM signal is 45db.In this paper, reduction of PAPR can be achieved by the transmission of QPSK symbols by joint optimization of DFT-Spreading of OFDM signal and constellation rotation angle of the transmission signals. By using this method, we can reduce the PAPR of high data rate signal.

Keywords: MIMO (multiple -input and multiple-output), PAPR (peak- to-average-power-ratio), DFT-Spread-OFDM, QPSK (Quadrature phase shift keying), OFDM (orthogonal frequency division multiplexing), constellation rotation.

1. INTRODUCTION

Now-a-days telecommunication plays a major role in day-to-day basis. Due to increase in number of users we have to transmit more number of signals in less bandwidth. This band width range will allow the user to transmit the signal through the channel. The signal with High frequency requires high band width for transmission. In the case of MIMO, at where more number of antennas is to be placed at both transmitter and receiver sections will increase the complexity of the system. In some Wireless devices, surveillance as well as weather radar systems MIMO technique found to be essential because of its less PAPR, ability to provide high date rate.

To overcome this problem, signals are to be orthogonally. In this OFDM, signals are to be transmitted with 90 degrees phase shift without using guard bands. So, there is a reduction of bandwidth usage. In OFDM, we use more number of carriers which carries low bit data which is reduces selective fading, interference as well as it provides high degree spectral efficiency. The main disadvantage in OFDM is increase in Peak -to- Average Power Ratio (PAPR). This technique will improve the efficiency of the communication system in 5G telecommunication. If signals of different users pass through a limited band width, there is a chance of multiple user interference which leads to the damage of signals. For the reduction of those interferences, different subcarriers are allocated to the different users. But, if the number of subcarriers increases, it is possible to transmission less signals through the channel. In this paper, we proposed a solution which enables the use of discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM) and QPSK Symbols.

In this solution, signals are to be converted into QPSK symbols which have two bits in it and those are processed under DFT-Spread-OFDM and constellation rotation for effective transmission. The main objectives of the project are to improve the efficiency of the wireless communication systems and reduce the signal interference and PAPR of the OFDM signals and improves the signal strength. PAPR of a signal can be reduced by increasing the number of antennas at both Transmitter and receiver sections. But due to this, there is an increase in the complexity and cost of system [1]. PAPR can be reduced by using single carrier OFDM (SC-OFDM) which reduces the error rate and increases the performance. By using this single carrier the transmission of multiple bits in less time will be possible [2]. Gradient descent (GD) method which involves MU pre coding and PAPR reduction is used. It removes multiple user interface (MUI)[3].

The signals which are localized by SC-FDMA systems are broadcasted by using the multi rate signal processing. It is mainly based on power spectral density (PSD), Signal to Interference and Noise Ratio (SINR) and comparison of those results [4]. Allocation of power in OFDM systems will reduce the loss in energy resources and ensures the target Quality-of-Service (QoS) of the served users [5]. The energy efficiency of the OFDM is to be considered by first considering the energy consumption of the circuit. It is to be ascertained that there is a reduction of energy consumption by 20% by performing EE. The efficiency of the signal is to be increased by considering the Convex functions, Convex sets, problem of Convex optimization, Duality and Smooth unconstrained minimization methods, Sequential unconstrained minimization methods of the OFDM signal [6]. The reduction of PAPR is to be done by the combining the constellation rotation and vector pulse shaping and apply those processes to the BPSK symbols [7].

It exploits the system with multiple carrier to get high Spectral efficient systems. On other hand, the spotlighting of the Filter Bank-based Multi-Carrier modulation (FBMC) spectrum of the signals with less out-of-band radiation in multicarrier schemes which are very important for the beneficial utilization of spectrum fragments. Consider this fragmentation in 5G or broadband Professional Mobile Radio (PMR) network [8]. 5G multi-carrier transmission schemes based on generalized frequency division multiplexing (GFDM) along with existing optical orthogonal frequency division multiplexing (O-OFDM) for indoor visible light communication (VLC). The main motive of this is to conquer the inherent complication of the of the usage of O-OFDM scheme. Various performance metrics are evaluated and distinguished with this O-OFDM scheme.

It is revealed that the proposed scheme has better spectral and power efficiency. Also its symbol error rate (SER) performance is found to be superior over optical OFDM counterparts under line-of-sight (LOS) optical channel. Simulation results based on SER, PAPR and numerical analysis on spectral efficiency validate the performance of the proposed schemes. General time domain descriptions of localized SC-FDMA systems are relayed by using multi rate signal processing is mainly based on power spectral density (PSD), Signal to Interference and Noise Ratio (SINR) and comparison of those results. The previous examination of the MIMO downlink systems and pre coding design are great and some new precocious systems are designed in more effective manner[9]. The reduction of PAPR is to be done by the combining the constellation rotation and vector pulse shaping and apply those Procedures to the Consists of FFT and IFFT blocks along with the subcarrier.

$$\text{PAPR } \alpha \ (Number\ of\ subcarriers)^2 \tag{1}$$

As there is a reduction of usage of number of subcarriers by using DFT- Spread-OFDM, there will be a reduction in the PAPR of OFDM signal. The PAPR value of the OFDM signal is deducted by using differentmethodsistobecomparedin this project and we are proposing a method by using QPSK symbols. By using this method we can reduce the value of PAPR and also reduces the interference between the signals of users while transmission of those signals through the channel. That method is described in this paper. The PAPR of the OFDM signals by using QPSK symbols is less than that of BPSKsymbols. In order conquer this drawback of the BPSK symbols in this project we are using QPSK symbols which has two bits in a single QPSK symbol. BPSK symbols [9]. But, by using the BPSK symbols as the input of the communication system we can transmit single bits only. In order conquer this drawback of the BPSK symbols.

2. PROPOSEDTECHNOLOGY

We came to know that there were many problems in the effective usage of bandwidth. For that, we are using OFDM signals for transmission of more signals in less band width. But the main problem in the OFDM transmission is PAPR. The transmitted signal will have less PAPR for transmission without any interference. If a signal of different userspasses through a limited band width, there is a chance of multiple user interference which leads to the damage of signals. For the reduction of those interferences, different subcarriers are allocated to the different users. But, if the number of subcarriers increases, it is possible to transmission less signals through the channel.

So, in order to overcome all these drawbacks of the OFDM signals, the PAPR of OFDM signal is to be decreased. There are many methods for deduction of PAPR of the OFDM signal. By using the Multiple Input Multiple Output (MIMO) the reduction of PAPR will be done. But the main drawback of this method is the complexity of the system will be reduced. in this project, the PAPR of a OFDM signal is to be reduced by the joint optimization of DFT- Spread-OFDM and constellation rotation by using QPSK symbols at the input. The reduction of PAPR was done by implementing this method. In this method, first the QPSK signal is generated at the input. That generated QPSK symbols are processed under the constellation rotation for the better transmission. Those signals are passes through the DFT-Spread-OFDM block of system to convert into a single carrier OFDM. This DFT-Spread-OFDM

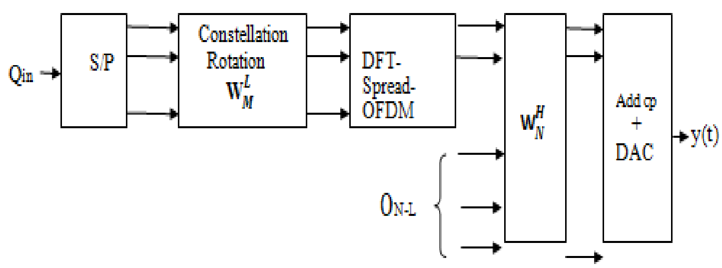

Fig1. Block diagram of L subcarriers used in transmission of QPSK signals

Along with the optimization, performance of the ideal power amplifier is also analyzed. It reduces not only PAPR but also increases the spectral efficiency, effects the SDR (Signal-to-Distortion Ratio) and SINR of the system.

The remaining sections of this paper is organized as follows. The section II is sub divided into transmitting and receiving system which consists of transmitter and receiver blocks of the system. Section III consists of the calculation of the upper bound and SINR of the signal. Section IV will provide the resultant waveforms. The conclusion and remarks of this project is mentioned in the section v.

A. Transmitting and Receiving System

The signals which are transmitted at the transmitter section are to be processed under DFT-S-OFSM block along with rotation of those symbols. This constellation rotation helps the system to get the original at the receiver section.

Transmitter:

The fig.1 transmitting section of the QPSK signal represents the block diagram of the transmitter. In this block, the signals which are converted into QPSK symbols are to be given to the first block. This first block performs the operation of serial-to-parallel conversion (S/P) of BPSKsymbolsby€ $\{-1,1\}$ into a series of (b(i)) where I € Z which is a vector of symbol length K, it is to be represented as

$$q^{(i)} \triangleq [q_{0+iK}, q_{1+iK}, \ldots q_{K-1+iK}]^{\tau} \quad (2)$$

We have to consider the first K symbols for the transmission without the loss of conception of the transmitting signals. In the Fig. 1, the complementary zeros symbol of the vector b(0) is represented with b. Again (i) is applied to the rest of the superscript. The symbols are to be presumed that they are same independent and equally distributed. The second block represents the uniform constellation rotation by Θ is to be acted upon the symbol vector b as R(Θ)b, This constellation rotation block is used for retrieval of the original signal at the receiver section. In third block, the DFT-spreading of the OFDM signal is to be performed on R(Θ)b as where R(Θ) isthe representation of K-by-Kdiagonalmatrix of rotation , it is formulated as

$$R(\Theta) \triangleq \text{diag}\{e^{j\theta-0}, e^{j\theta-1}, \ldots, e^{j\theta(K-1)}\} \quad (3)$$

The third block represents the performance of DFT- spreading-OFDM. This block is a combination of FFT and IFFT which is to be performed on the R(Θ)b and W_K^L R(Θ)b which is a L-by-K matrix with entry (a, b) is to be formulated as

$$[W_K^L](a,b) = \frac{1}{\sqrt{K}} \; e^{-j\frac{2\pi(a-1)(b-1)}{K}} \quad (4)$$

For 1≤a≤L and 1≤b≤K. If L=K, then reduces W_K^L to the K-by-K DFT matrix where as the L-by-K is a extended matrix which is achieved by extending the W circularly. The subcarrier allocation for the vector to perform spreading is represented with v as

$$v \triangleq \text{diag}\{p\} \; W_K^L R(\Theta) \quad (4a)$$

the value of p is always a real and the vector is a symmetric vector.

$$||p||^2 = K \quad (5)$$

The fourth block represents the sub-carrier allocation for the symbols which are spread by DFT-S-OFDM block. L number of successive subcarriers are utilized among the N>>L sub-carriers. Without losing of the generality of the signal, we inferred that we use the first L sub-carriers. Thus, the output vector y is represented as

$$y \triangleq W_N^H \begin{bmatrix} a \\ 0N-L \end{bmatrix} \quad (6)$$

where N-by-N is the DFT spreading matrix and 0_{N-L}. It will represent the zero vector of length N-L Will represents the zero vector of length N− L. where as last block represents the single carrier modulation which is performed on the (y (i)) i∈Z. The length of the cyclic prefix is to be combined with corresponding y(i). After that we can obtain discrete-time (DT) signal y[n] by performing parallel-to-serial conversion.

$$y(i) \triangleq y[0i(N+Ncp)], y[1\; i(N+Ncp)] \ldots, y[N-1+i(N+Ncp)]^{\tau} \quad (7)$$

Finally, a continuous-time (CT) signal x(t) is generated by the digital-to- analog conversion (DAC) of the DT signal as

$$y(t) \triangleq \sum_{n\epsilon z} y[n] w(tnT) \quad (8)$$

The interpolation pulse is to be represented with w(t) and its conversion rate is determined as 1/T. That 1/T is the conversion rate. It is assumed that the Nyquist rate is to be considered for the retrieval of the original signal at the end of receiver section. The Nyquist rate of the Continuous Time Fourier Transform(CTFT) of L subcarriers is inhabits in the DFT-Spread-OFDM signal. If the output constellation rotation block is expressed in equation (5) is neither 0 nor $\pi/2$ can reduce the PAPR. so, it is used in this project. This constellation rotation is mainly for the retrieving the original signal at the receiver section. It will give a perfect transmitting signal because of the usage of rotation angle at the transmitting section. Those rotation angle are of different in values.

Channel andreceiver:

The received signal consists of impulse response of the channel along with white Gaussian noise. That received signal is to be modulated and that received signal is to be represented as follows

$$r(t)=h(t)*y(t)+z(t) \qquad (9)$$

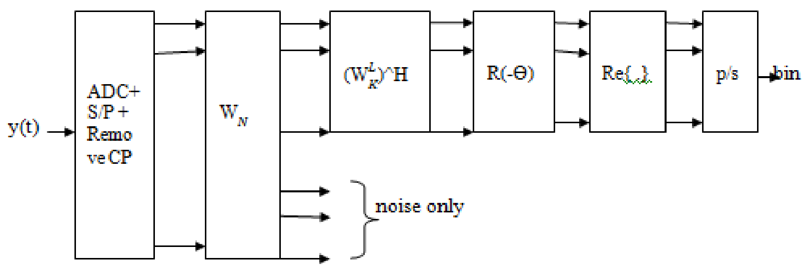

fig2. receiver block diagram of the l sub-carrier ofM ≤ L BPSK symbols

The receiver block diagram of this OFDM system is consists of constellation de rotation along with the real part operation of the received signal. The first block of the receiver section consists of CT signal r(t) which is rectified and filtered by w*(-t). The output of this block is a uniformly sampled FD channel equalization operations.

With the rate of 1/T. The resultant of the first block is to be given to the next block which is used to convert the signals from analog to digital signals. In analog to digital conversion, first K symbols are considered and the remaining are to be left for next. After the conversion of symbols from serial to parallel ,the carrier signals which consists of carrier prefix is to be removed. The resultant signal is the discrete time signal r which is of length N is to be indicated as

$$r=Hy+z \qquad (10)$$

$$r=HGR(\Theta)b+z \qquad (11)$$

In the above equation a N-by-N matrix is to be represented with H and z is a Gaussian noise which has a length (0N, σ2IN) for some σ2 > 0 with IN of N sized matrix is to be represented. In this second blocky is to be multiplied previously with WN to generate a signal with first L elements. Consider $\tilde{H}$ is a L-by-L matrix in which the first L columns and of the diagonal matrix W_N . So, the resultant signal from the second block is f^

$$F\hat{} = \tilde{H}\,\mathrm{diag}\,\{s\} W_I^L R(\varphi)b + \hat{z} \qquad (12)$$

where $\hat{z}$ ~ CN (0L , σ^2L). The third and forth blocks performs the constellation derotation and removal of DFT- Spread-OFDM for the receiving signal to generate

$$r\hat{} = R(-\Theta)(W_K^L)\hat{}H\ \ \mathrm{diag}\{p\sim\}f\hat{} \qquad (13)$$

The block five will perform the operation on r^ which distinguish real part of the signal. So, the output of the fifth block is used to detect the original signal at the end of the receiver section. The next section will calculate the upper bound case of the OFDM signal along with its PAPR calculation for the AWGN channel.

B. FORMULATION AND PERFORMANCE

The performance of the system is to be increased by using the DFT Spreading technique along with QPSK symbols is to be improved by the optimization of the constellation rotation and DFT Spreading. The formulae for the implementation of this system are to be determined in this section.

Upper Bound and Calculation PAPR:

The calculation of PAPR is entirely depends upon the upper bound of the OFDM signal. The PAPR of the transmitting signal is to be defined as ratio of the peak power of the signal to the average power of the transmitting signal.

$$\text{PAPR} = 10\log10 \left(\frac{Peak\ power}{Averege\ power}\right) \quad (14)$$

Where peak power is the maximum power and the average power is the mean power. In single channel system the PAPR is equal to zero which is similar to 0db. It is a very less power deviation.

Consider the peak power is a^2 and the average power is also a^2

$$\text{PAPR} = \frac{a^2}{a^2} = 1 \quad (15)$$

In the case of Orthogonal Frequency Division Multiplexing the peak power is a^2 and the average power is estimated as a mean of a^2 and number of signals. The PAPR in this case has more power consumption

$$\text{PAPR} = \frac{a^2}{\frac{a^2}{N}} = \text{N} \quad (16)$$

The transmitting signal will have a PAPR with the given (Θ, p) is to be represented as

$$\text{PAPR}\ (\Theta, p) \triangleq \frac{N}{K} \max |y[n]|^2 \quad (17)$$

In the case of discrete time complex signals y[n], where the value of n is {0, 1, 2 . . . N-1} and the magnitude of the signal is $||P^2|| = K$, and the average power of the signal is represented as

$$E\ \{||y||^2\} = tr(GR\ (\Theta)\ E\ \{bb^H\}\ R\ (\Theta)^H\ G^H \quad (18)$$

$$= tr\ (RR^H) \quad (19)$$

$$= ||S^2|| = K \quad (20)$$

The probability of the PAPR is to be calculated to the signal by exemplifying the constellation for different angles are to be calculated. Those angles are given to the signal to make it rotate according to the given angle.

3.RESULTS AND DISCUSSIONS

This section represents the resultant waveforms of the calculation of PAPR of the different signals of different modulation. The PAPR of a normal transmitting signal is 45 db. If we use OFDM signal for the transmission then the PAPR is 14 db. The graph which is drawn against bit error rate and the signal to interference noise ratio is

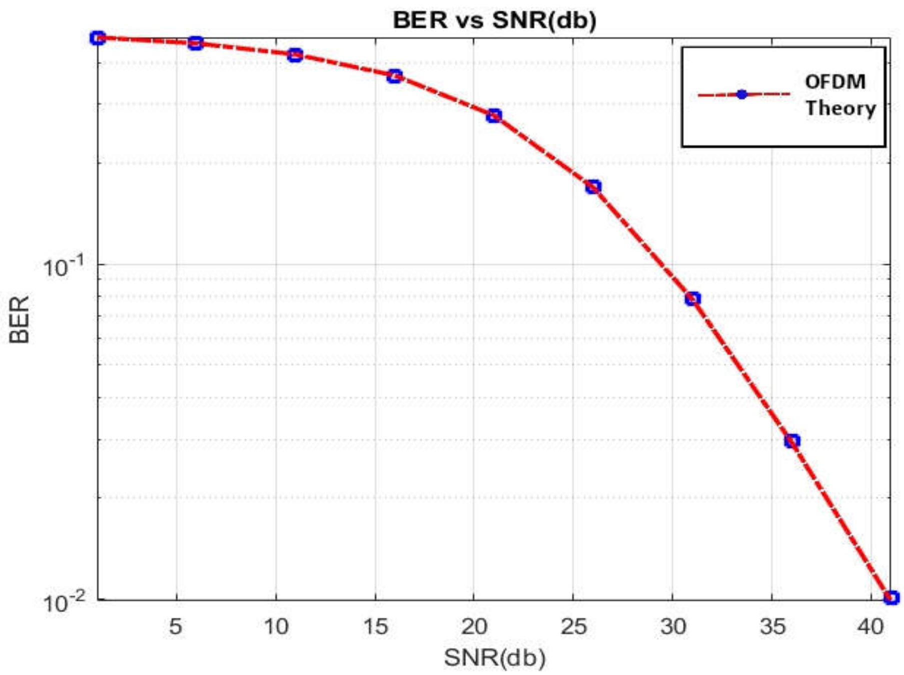

Fig 3. Bit error rate vs signal to nose ratio for a transmitting OFDM

The calculation of PAPR value for the basic OFDM signal will consider the bit error rate of the signal and signal to noise ratio.

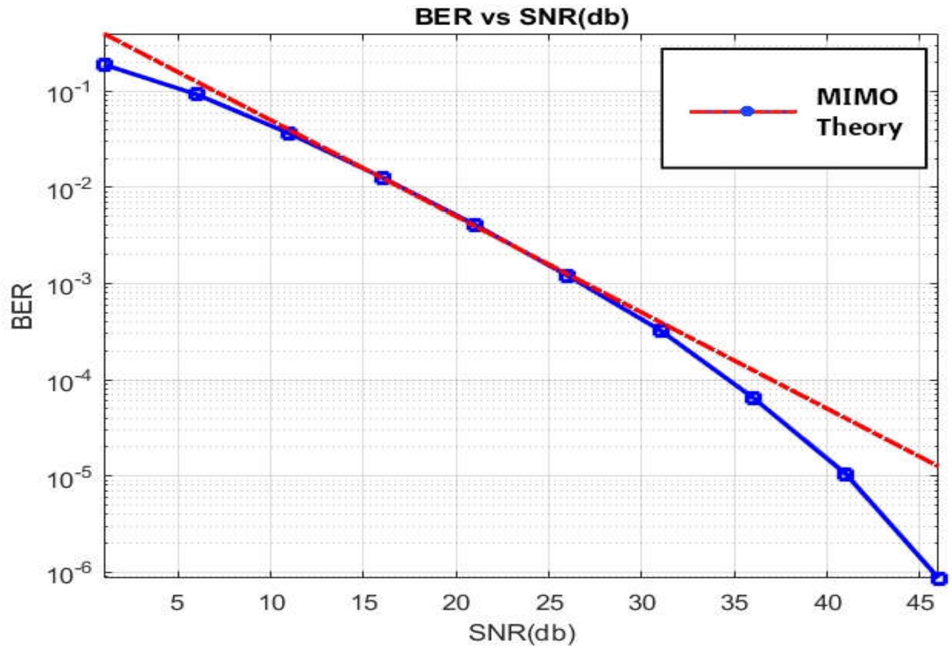

Fig4. BER VS SNR for the MIMO systems for calculation of PAPR at different combinations of values.

The value of this graph is 40db .we have to reduce the value in order to decrease the value of the PAPR. The signals which have less PAPR value will have more efficiency.

The PAPR value in the MIMO systems is less compared with theoretical PAPR value. The method which is determined in the MIMO systems is placing of more number of antennas at both transmitter and receiver section. It will reduce the PAPR but complexity of the system increases. Instead of this we can use DFT-spreading technique to reduce the value of PAPR. The PAPR value for the DFT- spread- OFDM is

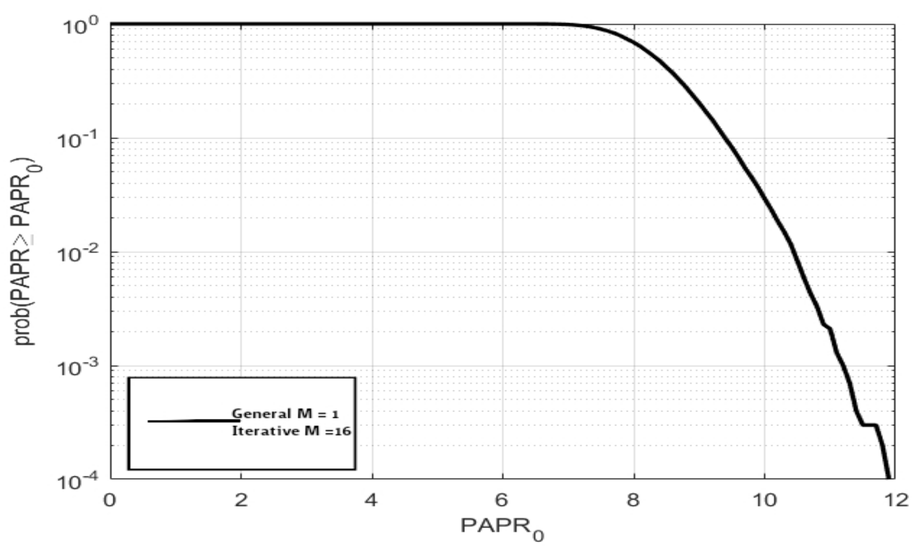

Fig 5. CCDF of PAPR of BPSK symbols for DFT-Spread-OFDM signal which has a combination of various rotation angles.

The BPSK symbols which consists of single bits in it. Those are given as a input for the system which consists of DFT-Spread-OFDM system along with a constellation rotation of various combination of angles. This method reduces the value of PAPR to 12 db. In this project we implemented a technique which gives PAPR value less than 12 db.

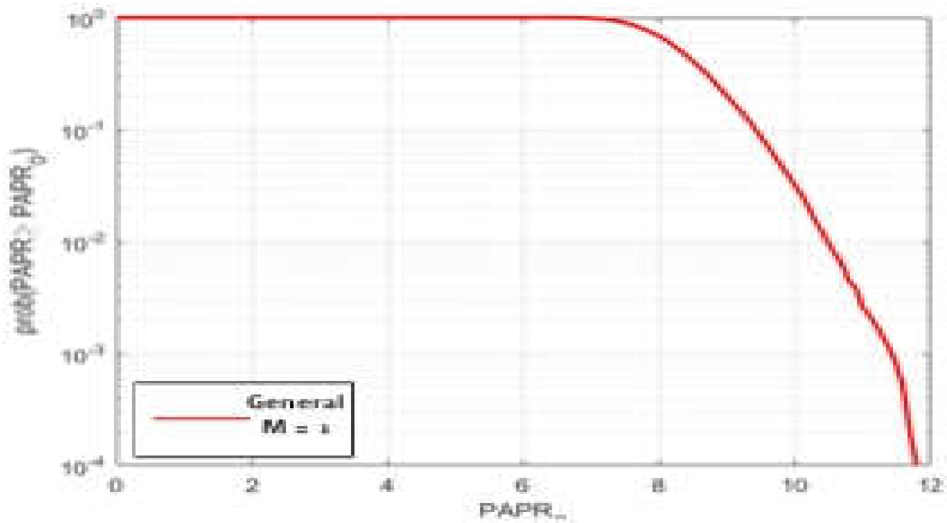

Fig 6. PAPR for the QPSK symbols along with DFT-Spreading technique.

By considering the constellation rotation of different angles along with the DFT-Spreading technique will give the better PAPR value. The PAPR value for different constellation rotation angles which are applied to the FFT and IFFT block will give the better result.

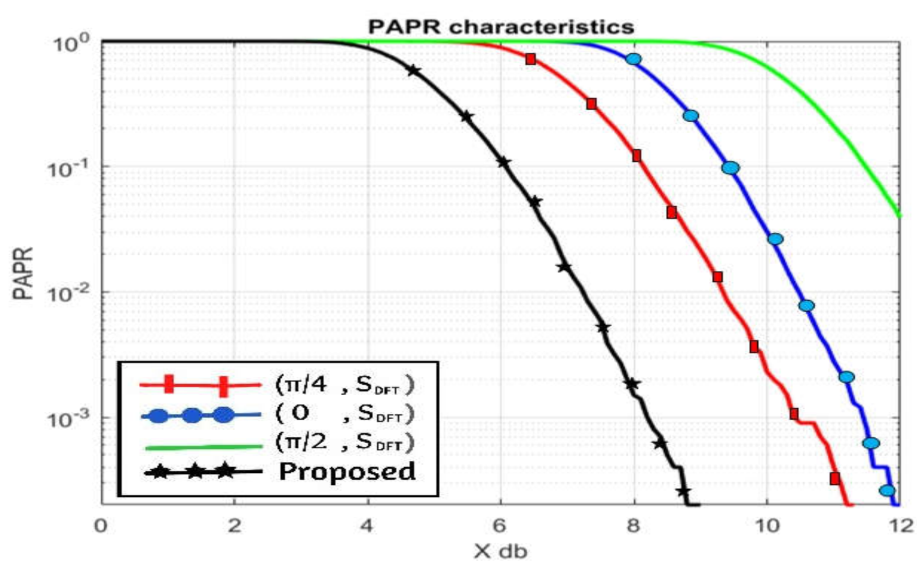

Fig 7. PAPR for the QPSK symbols along with different constellation rotation angle.

By considering the different constellation rotation angle we can estimate the better PAPR value for transmission of signal without any noise interference and we easily retrieve the original signal at the end of the receiver section. In this paper the proposed method with a constellation rotation angle of real value will give the PAPR value 8.3db . this method reduced the value of PAPR and it is very useful for effective transmission of the OFDM signal.

4. CONCLUSIONS

In this project, we are using a joint optimization of DFT-Spread-OFDM and QPSK symbols are to be used for the reduction of PAPR value and less bandwidth usage. So efficiency of system increases then system performance improved. As there is an increase in the advancement of technology, more number of signals is to be transmitted through lees band width. This project is mainly implemented for the reduction of band width usage and signal interference. The minimization of PAPR can be reduced significantly using DFT-Spread-OFDM for the transmitting signal and applying constellation rotation in order to minimize the complexity. The SINR formulation is also derived at the receiver section for the retrieval of original signal at the receiver section. It reduces not only the PAPR but also the spectral re growth and signal interference.

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