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Research Article

LowPhy module improvization using novel methodology for 5G Technology

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ABSTRACT

In a communication system, OFDM is the best technique for high speed transfer amplification in a communication network. The principal downside in the OFDM system was PAPR (Peak Average Power Reduction Ratio). Since of this large PAPR the device output reduces as the OFDM signal moves through the amplifier. The large PAPR multiplexing device in the Orthogonal Frequency division increases the power output of the RF amplifier and decreases the Non linearity of the HPA characteristics. Block labeling, clipping and filtering, selective mapping (SLM), partial transmitting scheme (PTS), tone reservation, tone injection are built to minimize PAPR. But because of the disadvantages of those techniques we look forward to another technique as companding. By combining the exponential companding and μ-law companding we can reduce the Peak to average power ratio in orthogonal frequency division multiplexing signals. We may decrease PAPR posed in orthogonal frequency division multiplexing, systems by implementing CCDF function on the companding technique.

Keywords: OFDM, PAPR, amplifier, Exponential companding, μ law companding, CCDF.

I. Introduction

OFDM is the primary methodology used in electronic communication network for the transfer of digital data. It can format the data with the same Frequency with specific carrier frequencies. Internal carrier guard bands are also not needed for transmission of the OFDM signal, and the message is transmitted orthogonally, indicating that the subcarriers are orthogonal to each other. The data is separated into parallel streams encrypted on to the sub carriers, and the low symbol rate modulates the subcarriers.
OFDM Signal Amplification and Demodulation use Quick Fourier Transform (FFT). In OFDM the sub carriers are not intersected and the carriers are separated from each other.

A. Block diagram of OFDM

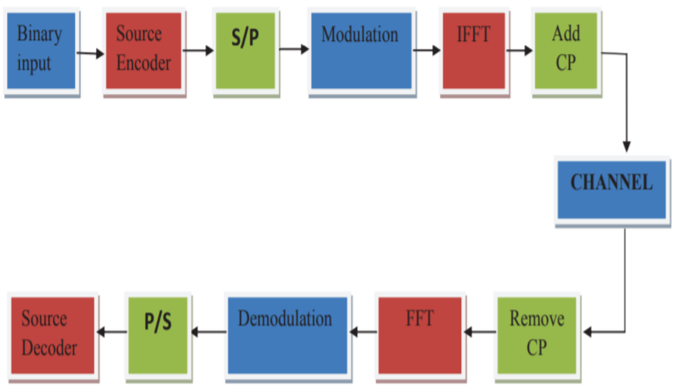


Fig. 1. Block diagram of OFDM transfer system

B. Working principle of OFDM

At transmitter we are giving input as 0's and 1's. So the input is given in the form of 0's and 1's. The serial input data source is converted to the appropriate word size for transmitting and converted to parallel format. The data is then transmitted in parallel during the transmission, by applying every data word to one carrier.

We may use some modulation scheme at the modulation stage, such as BPSK, QPSK. Phases applied to the input signal. IFFT block transforms the domain frequency signal into a time domain signal. In the OFDM communication the cyclic prefix is used. The signal would be added to the Guard Section. So we'll get the amount of an orthogonal sinusoidal signal at the OFDM transmitter output.

At the receiver side decoder and demodulation is used to retrieve the original information. We have used FFT to convert time domain signal into the frequency domain signal. Remove cyclic prefix block is added to remove the guard band. Parallel to serial converter will convert the divided data into the serial and by using source decoder we will get the original information.

C. Wave form of OFDM

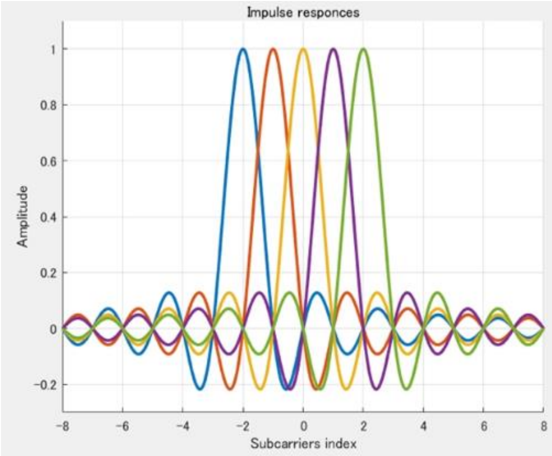


Fig. 2. wave form of OFDM system.

D. Advantages of OFDM

- Immunity to selective fading
- interference can be recovered quickly
- Spectrum efficiency
- Resilient to ISI

E. Disadvantages of OFDM

- High peak to average power ratio
- Sensitive to carrier offset and drift
- Requires multiple local oscillators

F. Applications of OFDM

- Digital audio broadcasting
- Asymmetric digital subscriber line
- Hiperlan2
- Wireless ATM-transmission system

G. What is PAPR

Peak to average reduction in power is described as the ratio of the maximum peak power to the average transmitted signal strength.

$$PAPR = \frac{P_{peak}}{P_{average}} = \frac{max\,[|x_n|^2]}{E[|x_n|^2]} \quad (1.1)$$

Where x_n = An OFDM signal after IFFT

Owing to this large PAPR ratio the amplifier's output capacity is declining.

So, the main aim of this project is to reduce the high PAPR ratio in OFDM system. By reducing the amplitude of the signal or by decreasing the power we can reduce the high PAPR.

Because of this high PAPR the linearity of the output power of the amplifier becomes non linear. That is shown in below diagram.

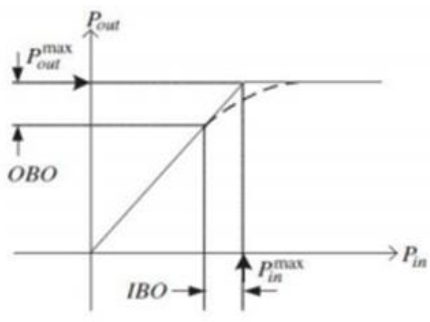


Fig. 3. characteristics of HPA

H. Cause for the occurrence of the PAPR

The PAPR happens because at any instance in time the subcarriers are out of step with each other and collinear to each other, they become distinct and separate. As all the sub carrier signals concurrently hit the maximum value, this will allow the output to unexpectedly go to the peak value at the output envelope.

Wide numbers of sub carriers are modulated; the peak value is thus very high relative to the device average value. We may name this ratio "max to average power reduction factor"

II. Literature Survey

H.P. Moose[1] mentioned regarding OFDM in 1994 is a multi-carrier transmission strategy for large communications systems of data rates. The OFDM concept relies on the delivery of high-speed data across a broad variety of low-speed carriers. The carriers are intimately related, and the Strong Fourier transformation (FFT) produces separation of frequencies between them. The OFDM originates from the Multiplexing Frequency Division (FDM), which communicates over various carrier frequencies with even more than one small-rate signals. Signal isolation at the receiver is accomplished in FDM by bringing the signals far sufficiently apart, such that the channel spectra will not interfere.

Dae woo Lim, Jong Seon No, seok joong Heo [2] in 2009 discussed methods for combating OFDM's key drawback, its extreme peak-to-average power ratio (PAPR), which induces signal distortion while going through High Power Amplifier and Digital-to-Analog Converter, resulting in lower average level of power. And for the latter question several other approaches have to be applied. Many researchers have suggested several approaches to address. The PAPR issue that involves technique of block coding, technique of filtering and clipping, technique of selective mapping , technique of partial transmission (PTS), tone reservation and tone injection.

H. Imai and H. Ochiai [3] in 1997 were explained about block coding technique. In this technique they have used QPSK modulation. The fundamental idea of this technique is to send the symbols which are having the low peak power for transmission. If there are N subcarriers and they are represented in 2N bits for the modulation. The transmitted bits are divided into half and allocated to the sub blocks, the remaining half bits again divided into half and this process is continued until N bits are allocated to the N sub carriers. This long series of information is partitioned and assigned to half sub blocks and that blocks are encoded. This coding also gives the error correction capability, for that they have used different coding techniques that are Hamming, Shannon fano, etc.

Seung Hee Han, Jae Hong Lee [4] in 2005 was explained Simple and easiest technique to reduce the PAPR is clipping, it won't allow the signal amplitude above the clip level. It exhibits the noise and that noise is called as clipping noise or clipping distortion. And also expands the signal spectrum it causes interfering and it causes degradation of the BER. Clipping and filtering is removes the expanded components in spectrum. Filtering requires reducing the frequency production. After the clipping operation Filtering operation will be performed.

Bauml, R., Fischer, R., and Huber, J. [5] in 1996 was written that in the selective mapping technique the data coming from the source is serial but, the serial to parallel converter will convert data from serial to parallel. For Example the original data is X after the S/P converter the data is dividing to sub vectors [x1,x2,………xm] and this sub vectros are multiplied with the different phase values [p1,p2,…..pm] before the IFFT operation. Each vector should muiltiply with the each phase value independently. This sub vectors and the phase values are having the same length. After this the IFFT is applied to the siganl that translates time domain data to frequency domain. The last step is to compare all the individual signals and the signal which are having the lowest PAPR that signal is send for the transmission.

Manoranjan RaiBharti, Kamal Singh, Sudhanshu Jamwa [6] in 2012 was explained about partial transmit technique (PTS). Partial transmit techniques is one of the most efficient technique for reduction of the PAPR. The data blocks are separated into sub-blocks in this methodology. Such sub-blocks must independently execute IFFT procedure to transform fourier transform to time domain. This converted time domain sub blocks are multiplied with the weighing factor for phase rotation individually. The last step is selecting the low PAPR value signals add them and send for the transmission.

B. Krongold, D. Jones [7] in 2004 proposed a technique to reduce PAPR that is Tone reservation. This technique is reserving the small tones and those tones are called peak reduction carriers for reducing the PAPR. Both tones are applied to each other's input signal, which are orthogonal. The amount of PAPR reduction based on the number of assigned tonalities and the position of the designated tones. By reserving small tones at the transmitter we can reduce the maximum PAPR. This method is less complex. After reserving the tones the carriers are set as peak channel for reduce the peaks. Before the IFFT peak channel carriers and data carriers are added. After the IFFT operation the carriers are send for the transmission.

Md. Zulfiker Mahmud, Md. Ibrahim Abdullah, Md. Shamim Hossain, Md. Nurul Islam [8] in 2011 was explained about one of the PAPR reduced technique as Tone Injection. This form of tone injection is used to minimize PAPR by growing the scale of the constellations. This method contrasts the data points of the original constellation with the data points of the enlarged constellation to increase the size of the constellation. That means data points found in the details are mapped into the expanded constellation. Drawbacks to this strategy are the encoding to data points on the receiver side is harder and needs more IFFT operations.

Lekhraj Udaigiriya and Sudhir Kumar Sharma [9] in 2015 were proposed ah technique as complementary cumulative distribution function (CCDF) curves for the reduction of the PAPR reduction. It focuses only on the power levels and power characteristics. It provides distortion less signal without degradation of BER. This is the application they were performed on the companding techniques to achieve better results on the PAPR. The proposed techniques are having the disadvantages because of that they were applied this CCDF function on companding techniques.

Yong-Hua, and Yang Yang, Tao Jiang [10] in 2005 were explained about companding technique as exponential companding. In this section, we suggest a new non-linear companding technique, dubbed "exponential companding," which can effectively reduce the PAPR of distributed Orthogonal Frequency Division Multiplexing signals by transforming the amplification statistics of such signals into linear distribution. The latest scheme also has the benefit of retaining an overall continuous power output.

X. Wang, T. T. Tjhung, and C. S. Ng [11] in 1999 proposed another technique as μ law technique to reduce the PAPR. μ law companding has two operations one is compressor and another one is expander. Compressor is placed after the IFFT block in the transmitter and the expander is placed before the FFT block in the receiver. It compresses the signal according to the give value. If the value of μ is high then the compression level also high. And it is the memory less technique it will compress the signal based on current value not on the past values. The companding transformation is applied in the transmitter to amplify the high peaks and amplify the low amplitudes of an OFDM signal, thereby reducing the PAPR. The decompanding approach is applied at the receiver when extracting the OFDM signal from the extended signal using inverse companding function. Companding is an enticing method for the reduction of PAPR of OFDM signals due to its less complexity.

III. Methodology

A. Complementary Cumulative Distribution Function (CCDF)

In PAPR reduction CCDF is the main method we are using. It focuses only on the power levels and power characteristics. It provides distortion less signal without degradation of BER. This is the application we are performing on the companding techniques to decrease the PAPR. The proposed techniques are having the disadvantages because of that we are applying this CCDF curves on companding.

Power = I^2+Q^2

Where I= In phase component of the signal

Q= Quadrature component of the signal

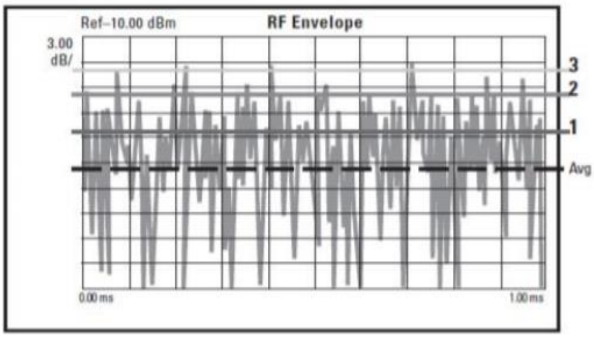


Fig. 4.Construction of CCDF curves

The above diagram shows the CCDF curves of the OFDM signal. The signal presented in the fig is difficult to quantify because of the distortion. So, we need to extract the required information signal. We can extract the signal from this distortion by applying CCDF on it. It only spends the time at power level or above the power level with respect to the average value. Each line showing in fig is power level above the average value.

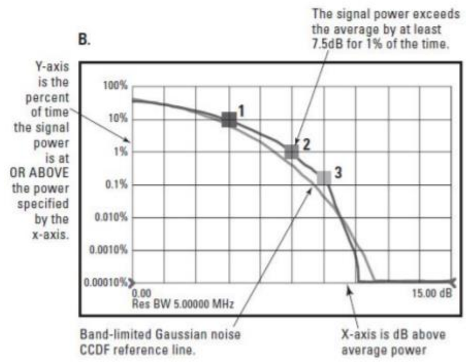


Fig. 5.CCDF curves on OFDM signal

Fig 3.2 shows that the OFDM signal after applying of CCDF curves. X axis is power in dB and Y axis is percent of time signal power is above or at average power. For example at l% of time the peak power exceeds the average power by 7.5dB. So in this project we have used that CCDF curves to decrease the high PAPR present in orthogonal frequency division multiplexing system at the transmitter.

Those proposed techniques are more efficient are attractive to decrease the PAPR but, the problem in that is if we apply those technique individually we are facing some issues about distortion or BER performance. We can apply CCDF for those techniques individually to get the better results than the previous.

The main title of this project is A HYBRID PAPR REDUCTION TECHNIQUE IN OFDM SYSTEM that means combing of two or more techniques. Our idea is to combine companding techniques and apply a CCDF curves on it. We have done that application by using simulation Tool MATLAB software.

B. Proposed PAPR reduction techniques

The suggested strategies to developing the high PAPR in OFDM system are companding techniques. The companding transformation is applied in the transmitter to amplify the high peaks and amplify the low amplitudes of a OFDM signal, thereby reducing the PAPR. The decompanding approach is applied at the receiver when extracting the OFDM signal from the extended signal using inverse companding function. Companding is an enticing method for rising OFDM PAPR signals due to its less complexity.

Companding strategies come in two forms.

1) μ law companding technique
2) Exponential companding technique

C. μ-law companding

μ law companding has two operations one is compressor and another one is expander. Compressor is placed after the IFFT block in the transmitter and the expander is placed before the FFT block in the receiver. This compander will compress the large signal and the expander will expands the small signal.

Fig. 6. Block diagram of μ law companding

The above diagram is the block diagram of μ law companding technique. At the transmitter first the data is enters through the modulator and then the data will converted into parallel streams through serial to parallel convertor. If any large signal is there the compressor will compress that signal. Next block is Digital to Analog convertor will convert the digital data to the analog data.

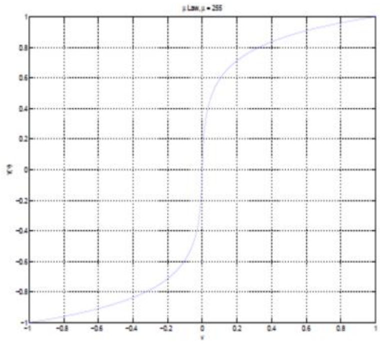


Fig. 7. μ **law companding graph**

This is the example for the instantaneous companding. It compresses the signal according to the value given. If the value of μ is high then the compression level also high. The Fig 4.1 is the graph with the μ value is 255. And it is the memory less technique it will compress the signal based on current value not on the past values.

$$\gamma(v) = \frac{\log_2(1+\mu v)}{\log_2(1+\mu)}, v>=0 \quad (4.1)$$

$$\gamma(v) = -\gamma(-v), v<0 \quad (4.2)$$

Based on the above formula the signal will be compressed.

The PAPR formula for companding technique

$$PAPR_{comp} = \max_{0\leq n\leq N-1} \frac{N\ln(1+\mu[P_{peak}]^{0.5})}{\sum_{n=0}^{N-1}\ln(1+\mu[P_n(t)]^{0.5})} \quad (4.3)$$

The CDF is given by

CDF=

$$[\frac{\ln(1+\mu)}{\mu\sigma^2}(\left(1-e^{\frac{-x^2}{2\sigma^2}}\right)+\mu\left(\text{erf}\left(\frac{z}{\sqrt{2\sigma}}\right)-\sqrt{\frac{2}{\pi}}ze^{\frac{-x^2}{2\sigma^2}}\right))]^\wedge N \quad (4.4)$$

CCDF= 1-CDF (4.5)

D. Exponential companding

In this segment we introduce a new nonlinear companding method, called "exponential companding," which can efficiently minimize the PAPR of transmitted (companded) OFDM signals by converting the statistics of such signals 'amplitudes towards a standardized distribution. The latest scheme also has the benefit of carrying the nonlinear companding process at a steady average power point.

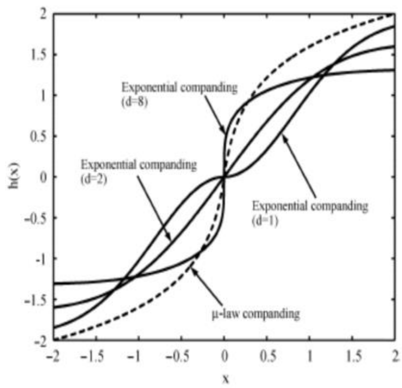


Fig. 8. Exponential companding graph

The companded signals transmitted amplitudes and competencies equally, for the situations d=1and d=2. If, the suggested feature will concurrently compact broad input signals and extend tiny signals. Whereas the companding system will only magnify minor signals and does not alter the signal peaks, resulting in higher overall performance signal strength values.

The discrepancies between exponential companding functions are, as shown, ignorant of when d>=8.

The CDF of the companded signal is

$F_{t_n}(x)$= Prob{t_n|<=x} (4.6)

= Prob{t_n^d<=x^d} (4.7)

= x^d/α (4.8)

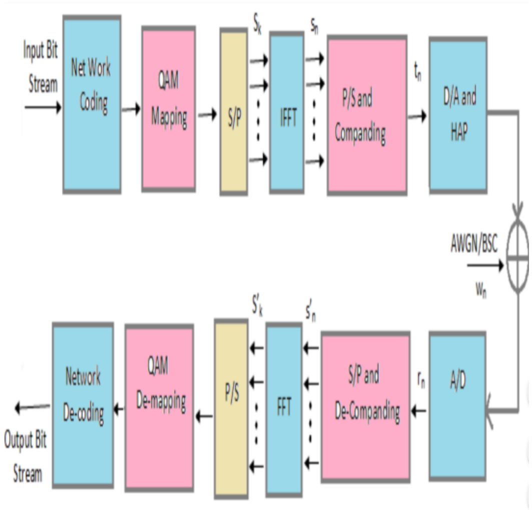


Fig. 9. Block diagram of Exponential companding

E. Performance analysis of Bit Error Rate on companding signals

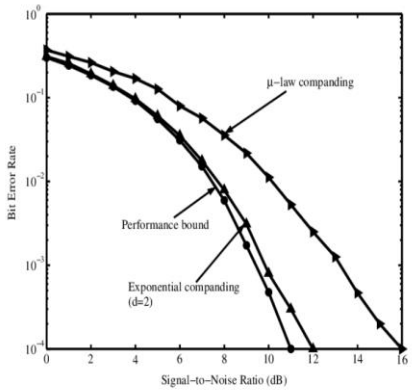


Fig. 10. Bit Error Rate of the companded signal in AWGN channel

Above diagram shows the relationship between the BER (bit error rate) and SNR (noise signal ratio). Companding gives the high SNR and increases the performance of the BER by compress or expands the OFDM signal.

IV. Results and Discussions

A. Partial Transmit Scheme (PTS)

The first curve showing with the blue color is PAPR of the original OFDM signal. By applying partial transmit scheme (PTS) small amount of PAPR is reduced that is shown in red color curve.

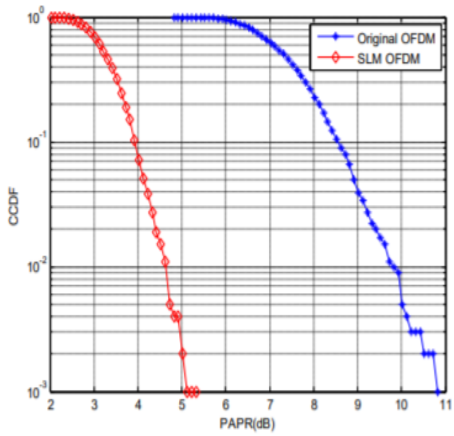


Fig. 11. Reduced PAPR curve after applying PTS technique

Advantages of PTS

- Less distortion
- Less complex

Disadvantages of PTS

- Degradation of BER performance
- Side information is required

B. Selective Mapping Technique (SLM)

The curve showing with the blue color is PAPR of original OFDM signal. The curve showing with the red color is reduced PAPR by applying selective mapping technique (SLM). It reduced the large amount of PAPR better than the Partial technique scheme (PTS).

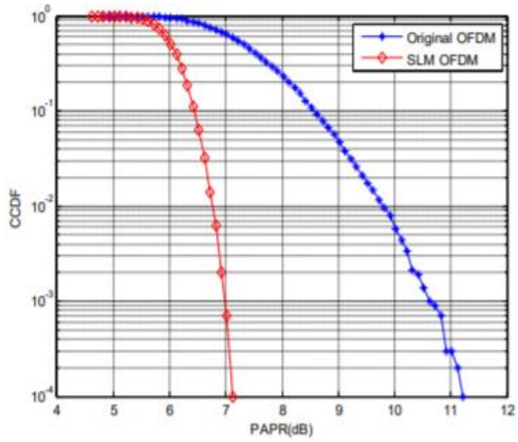


Fig 5.2: Reduced PAPR curve after applying SLM technique

Advantages

- No distortion
- It is not depending on number of carriers

Disadvantages

- Degradation of BER performance
- Side information is required.

C. Clipping and Filtering

PAPR is reduced by using clipping and filtering it is easier and best technique to reduce the PAPR in OFDM. The curve showing with the blue color is PAPR of original OFDM signal. The curve showing with the red color is reduced PAPR by applying clipping and filtering. Because of non linear process of clipping it produce out of band interference (OBI).

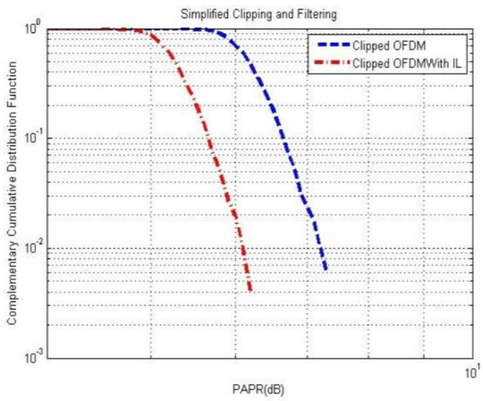


Fig 5.3 Reduced PAPR curve after applying clipping and filtering

Advantages

- Simple approach
- No side information is required

Disadvantages

- More distortion
- Degradation of BER performance

D. Comparison of proposed reduction techniques of PAPR

The below diagram shown that the comparison between the reduced techniques of PAPR. PAPR is reduced with the distorted signal. Blue color curve is the PAPR of original OFDM signal. Red color curve is the PAPR signal after applying the Partial Transmit Technique (PTS). Black color curve is the PAPR signal after applying the Selective Mapping Technique (SLM).

Pink color curve is the PAPR signal after applying the clipping and filtering technique.

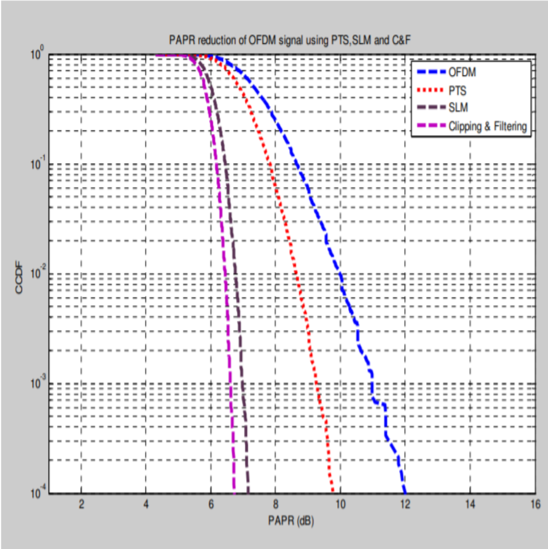
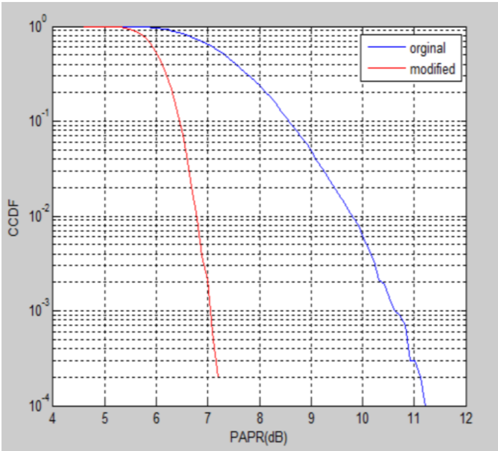


Fig 5.4: comparison of different PAPR reduced techniques

E. PAPR is reduced by using companding techniques

The below diagram is the simulated output of the CCDF curve to decrease the PAPR. The color curve in blue reveals the strong PAPR of the initial OFDM signal. The red color curve shows the decreased PAPR after applying the CCDF curves on the companding techniques.

By adding the exponential technique and μ-law technique we have reduced the PAPR by using the CCDF function. This produces stronger outcomes than the methods suggested, such as Clipping, SLM, PTS.



F. Reduced PAPR of OFDM signal using companding techniques

We have simulated the above graph by using MATLAB R2013a software. Advantage of this companding technique is it improves the better performance of the BER and decreases the OBI. Disadvantage of companding technique is loss of data rate.

V. Conclusion

We've identified the OFDM definition and the OFDM issues. We summarize the definition for PAPR which is the key problem in OFDM but they have reduced the PAPR using developed techniques. But we have to look with another CCDF definition because of the disadvantages of such strategies. By integrating all the strategies and carrying out CCDF activity on them, we simulated and obtained the results for the signal amplification with the less peak-to-average power reduction ratio. This work has two directions PAPR reduction technique should define best solution in terms of output enhancement and extend for less transmission distortion. Data speeds are small and channel use is effective. Future scope of this project can be in different ways. Based on the idea of this project it was found that the above all proposed techniques are not fully specified for reduction of

PAPR because of the disadvantages. The companding techniques also have the disadvantage of loss of data rate. So before taking the techniques to reduce the PAPR we have to take the factors like BER performance, data rate, distortion, complexity into consideration.

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