

Data Compression Technique Combined with IDWT for PAPR Reduction in OFDM System

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Abstract: Orthogonal Frequency Division Multiplexing (OFDM) is one of the most widely used techniques in broadband communication. But main disadvantage of OFDM is high PAPR. Separately IDWT and Data compression coding can reduce PAPR significantly. But we can reduce more PAPR using combination of IDWT and one of Data Compression method i.e. Run Length Coding. In this paper we compare PAPR of combined method of Run-Length Coding and IDWT signal with original signal.

Index Terms - OFDM, PAPR, Run-length Coding, IDWT

I. INTRODUCTION

Single carrier modulation techniques that square measure employed in 3G don not seem to be appropriate for top rate as a result of them suffer from issues like inter symbol interference, time dispersion, selective attenuation etc. to beat these issues multicarrier modulation technique like OFDM is employed. OFDM is extremely engaging technique for top speed information transmission in mobile communications owing to numerous benefits like high spectral efficiency, efficiency, robustness to channel attenuation, immunity to impulse interference, capability of handling terribly robust multi-path fading and frequency selective fading while not needed powerful channel leveling [1]. OFDM is a potential candidate for 4G, wherever speed of information up to 2 GBPS will be achieved.

As we used OFDM in the transmission system, apart from many advantages some drawbacks become apparent in this system. The main factor affecting in multicarrier modulation is a very high peak-to-average power ratio (PAPR). Therefore, nonlinearities might get overcharge by high signal peaks, inflicting inter modulation among subcarriers and, additional crucial, unwanted out-of-band radiation. Large PAPR might cause distortion within the high power amplifier (HPA) as a result of HPA limits the output with sure worth and reduces the power potency of the amplifier. Another drawback of using OFDM is it will increase complexes of the analog-to-digital and digital-to-analog converters [1]- [3]. The primary aim of this paper is to reduce the high peak-to-average power ratio.

Many techniques had been proposed to reduce PAPR in last decades. They are mainly classified in two categories i.e. Distortion method and Distortionless Method. Methods like Clipping and Filtering, Peak windowing, Peak cancellation and active constellation extension are included in Distortion type whereas Selective Mapping and partial transmit sequences. One another type of method is there i.e. using various coding methods to reduce the PAPR like Golay complementary sequences, Huffman Coding, Shapiro-Rudin sequences, Run-length Coding, M-sequences, and Barker Codes.

In general for generating OFDM symbols IFFT is employed, however Wavelet-based OFDM has additionally gained quality within the literature recently. Because of very high spectral containment properties of wavelets, wavelet OFDM will higher combat narrowband interference and is inherently additional sturdy with regard to intercarrier interference (ICI) than ancient FFT realization. Since there's no cyclic prefix gift in wave implementation the information rates will surpass those of FFT implementations. And using a wavelet remodel PAPR reduced considerably. The thought is to assign oftentimes used signal sample values fewer bits, and rarely used sample values additional bits to create associate acceptable compression for the signal to be transmitted was proposed by Huffman[6]. An inventive feature of Huffman secret writing is however the variable length codes are often packed along. Imagine receiving a serial information stream of ones and zeros. If every character is described by eight bits, you'll be able to directly separate one character from consecutive by break eight bit chunks. Here we have a tendency to target combining Huffman secret writing and IDWT techniques for reducing the PAPR.

In this paper Huffman writing is employed to scale back PAPR of OFDM transmitter. The paper is organized as follows. Sections II discusses OFDM System, PAPR and HPA theory. Whereas the proposed technique is explained in section III, simulation results are explained in section IV. Finally, the conclusion is drawn in section V. Dembrani et. al. in [10-13] have proposed the filtering techniques alongwith hardware implementation of the systems. The same can be carried for the future hardware based implementation of the proposed data compression technique combined with IDWT for PAPR reduction in OFDM system

II. OFDM, PAPR AND HPA THEORY

A. OFDM System

I. IFFT Based OFDM System

An OFDM trans-receiver is shown in Fig.1. The inverse transform block will either be IDWT/IFFT and forward transform block may be DWT/FFT. The info generator used could be a wave of bit stream d . It is processed using QPSK or M-ary QAM modulator to map the input file into symbols X_m . These symbols are currently sent through the IFFT block to perform an IFFT operation to get N parallel information streams. Its output in distinct time domain is given by,

$$X_{k(n)} = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} X_m(i) \exp\left(\frac{j2\pi mi}{N}\right) \quad (1)$$

The transformed output (X_k) is currently appended with cyclic prefix. The cyclic prefix (CP) is an accessorial before transmission, to mitigate inter symbol interference impact. It is typically twenty fifth of the last a part of the initial OFDM symbol and this information going through an AWGN channel with a correct input power set. At the receiver, the reverse operation is completed to get the initial information back. The Cyclic Prefix is removed and processed within the FFT block and eventually gone through demodulator for information recovery. The output of the FFT in frequency domain is given by[7],

$$U_{m(i)} = \sum_{i=0}^{N-1} U_{k(n)} \exp\left(\frac{-j2\pi mi}{N}\right) \quad (2)$$

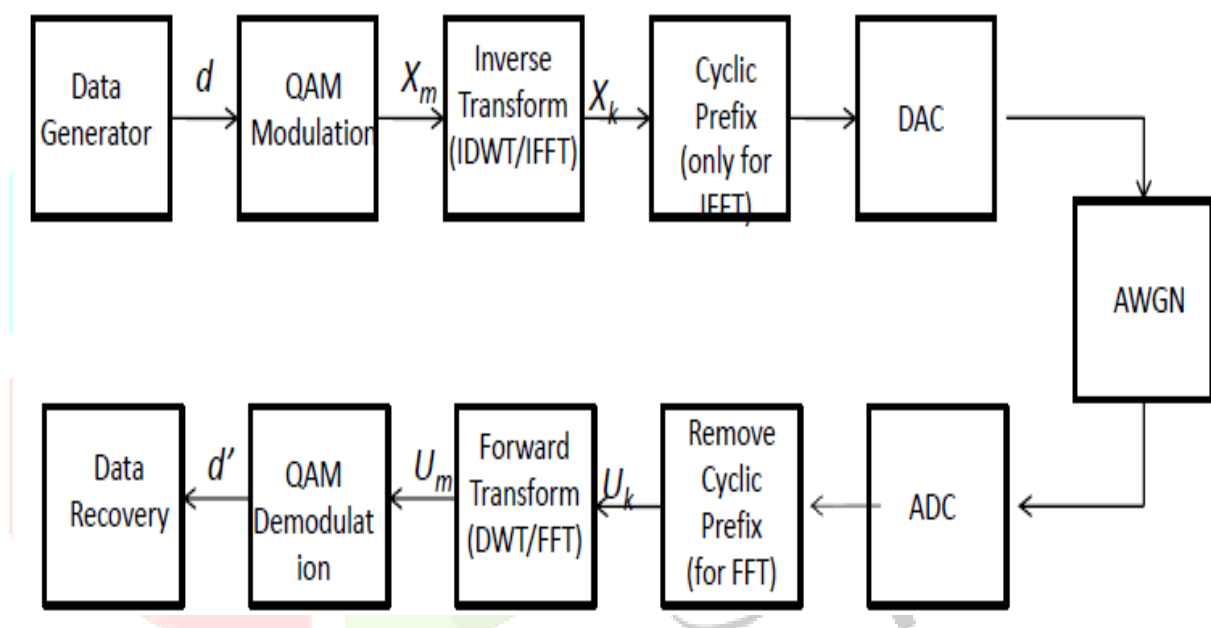


Fig. 1: Trans-receiver model of OFDM using inverse and forward transform blocks for Implementation of FFT/ DWT-OFDM.

II. DWT Based OFDM System

In the trans-receiver model shown in Fig.1, at the transmitter, the input wave maps on the information to the modulator (16-QAM), thereby changing knowledge dk into symbols $X_m(i)$. Every $X_m(i)$ is initially converted to the serial representation having a vector XX which is able to next be converse into CA. Then, the signal is up-sampled (zero padding) and filtered by the LPF coefficients or approximated coefficients. Since our aim is to possess low frequency signals, the modulated signals XX perform circular convolution with LPF filter whereas the HPF filter conjointly perform the convolution with zeroes padding signals CD respectively. The HPF filter contains detailed coefficients or wavelet coefficients. This information is given as an input to IDWT block whereby a selected wavelet (Haar) is chosen for the simulation and is found to have a higher performance in comparison to FFT OFDM. At the receiver, DWT and demodulator (16-QAM) are accustomed recover back the information [7]. At the receiver, DWT and (16-QAM) demodulator are accustomed recover back the first information as shown in Fig.3.

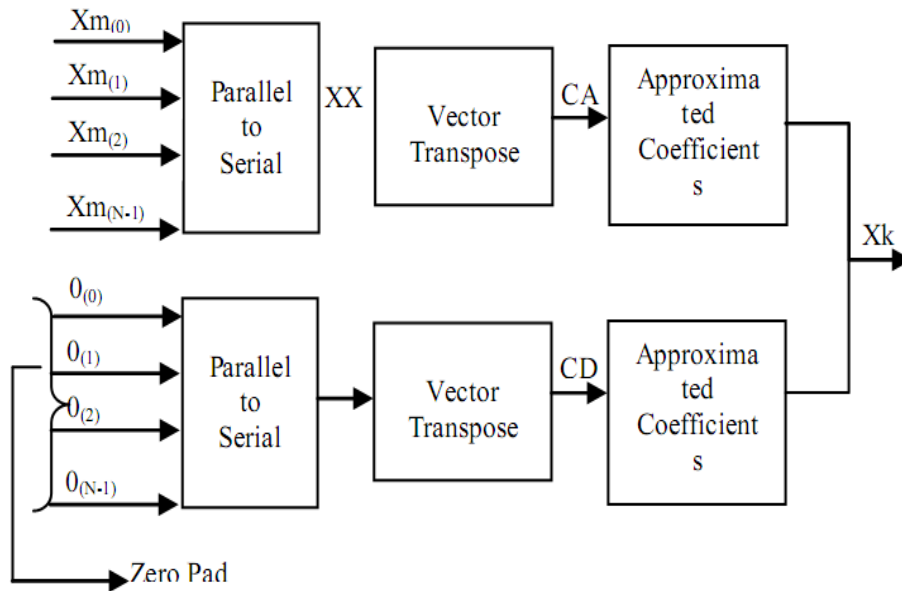


Fig. 2 IDWT Internal Structure

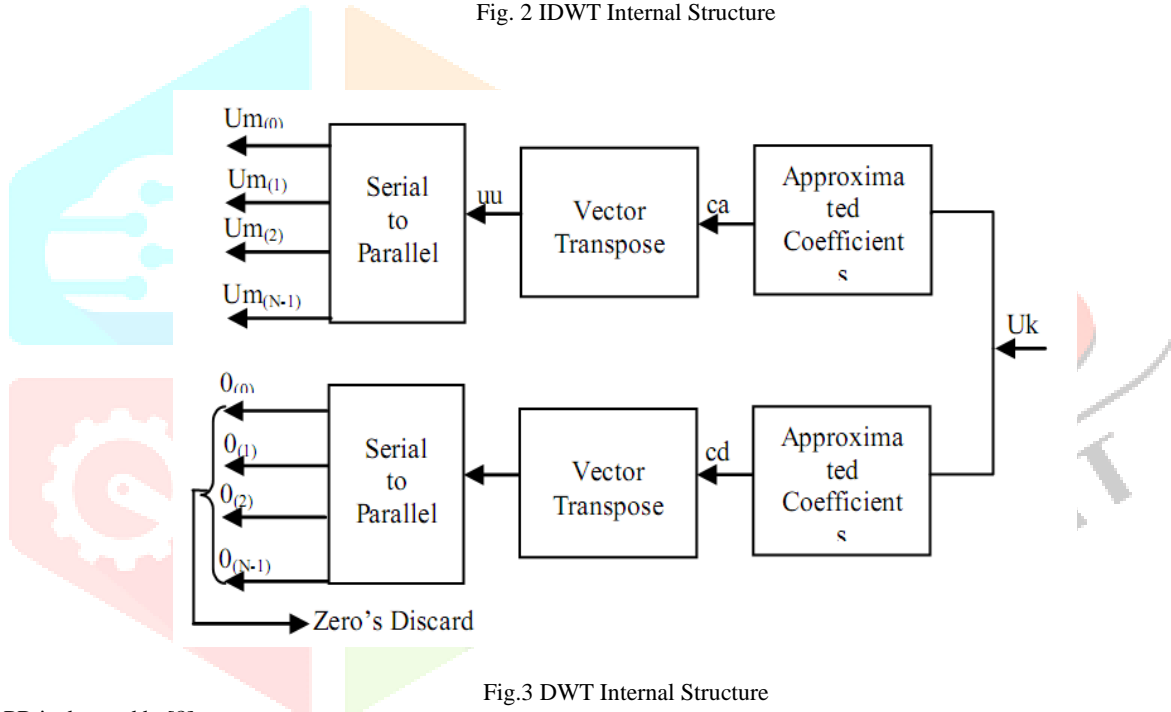


Fig.3 DWT Internal Structure

The PAPR is denoted by[8]

$$PAPR = \frac{\max \{ |x(t)|^2 \}}{E[|x(t)|^2]} \quad (3)$$

Where $E \{ \blacksquare \}$ denotes mathematical expectation. The cumulative distribution function (CDF) of the PAPR is one of the most commonly used criteria for PAPR reduction. The complementary of CDF (CCDF) is commonly used instead of the CDF itself. The CCDF of the PAPR denotes the Probability that the PAPR of a information block exceeds a given threshold.

B. HPA

For the real implementation, high power amplifier (HPA) is used before transmission into bandpass channel. Memoryless Solid State Power Amplifier (SSPA) is commonly used for OFDM systems. This paper uses SSPA Rapp’s amplifier model. Suppose we have input signal as [9]

$$y_{in}(t) = v(t) \exp[j\phi(t)] \quad (4)$$

and the amplifier output is given by

$$y_{out}(t) = G[v(t)] \exp\{j(\phi(t) + \Phi[v(t)])\} \quad (5)$$

where $G(\cdot)$ is AM/AM conversion and $\Phi(\cdot)$ is AM/PM conversion. AM/AM and AM/PM for Rapp’s model is as follows.

$$G(v) = \frac{g_0 v}{\left[1 + \left(\frac{v}{v_{sat}}\right)^{2p}\right]^{\frac{1}{2p}}} \tag{6}$$

$$\Phi(v) = 0$$

where g_0 is amplifier gain, v_{sat} is the input saturation level and p is the smoothness transition factor from linear into saturation region. The AM/AM transfer function for various value of p is shown in Fig.4 and AM/AM response of power amplifier for various value of v_{sat} is shown in Fig. 5. However, the smoothness factor is usually $2 \leq p \leq 3$.

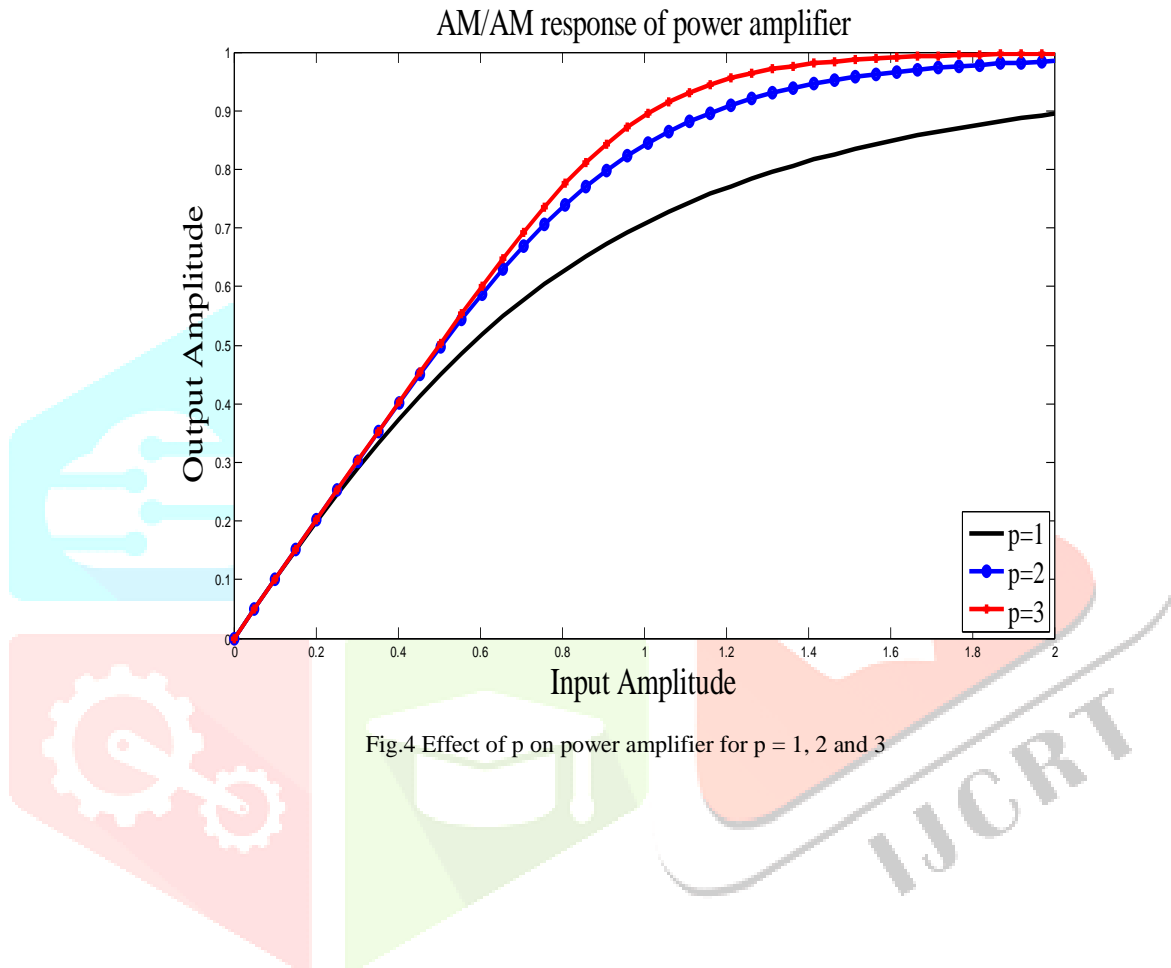


Fig.4 Effect of p on power amplifier for p = 1, 2 and 3

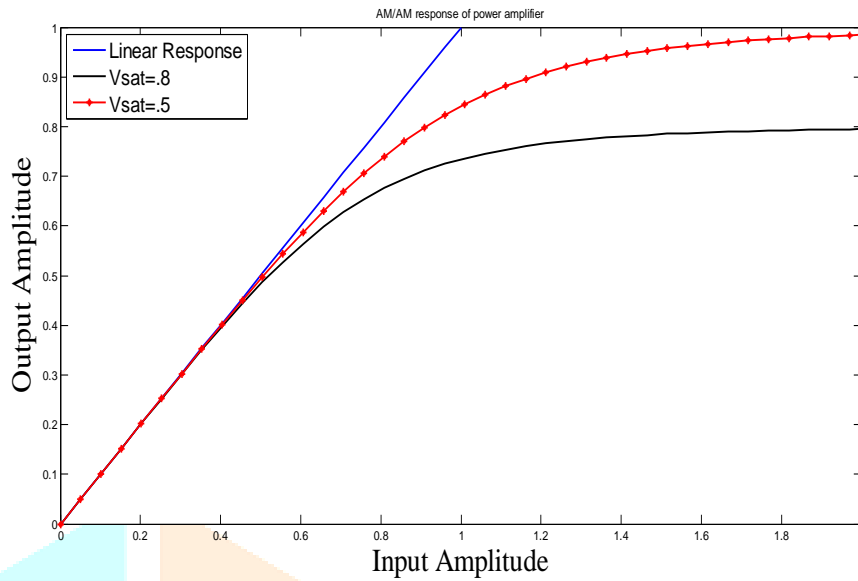


Fig.5 Effect of v_{sat} on power amplifier for $v_{sat}=0.8$ and 0.5

Amplifier is a nonlinear device, so it is necessary to work in its linear region. The range of linear region of an amplifier is defined by input backoff (IBO). IBO is given by [6].

$$IBO = 10 \log_{10} \left\{ \frac{v_{sat}^2}{E\{|x|^2\}} \right\} \tag{8}$$

Where $E\{|x|^2\}$ is the average of input power

III. PROPOSED SYSTEM

The proposed system use of RLE combined with IDWT is shown in Fig. 6

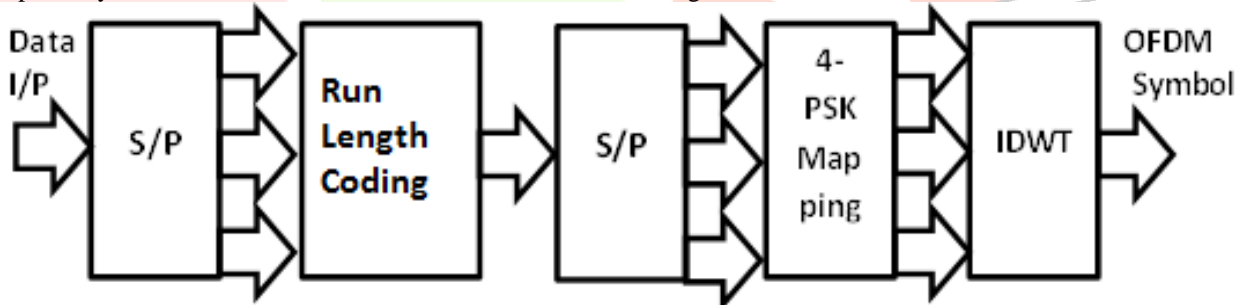


Fig.6 Proposed System Model

RLE is a lossless compression method that is used as source coding. RLE codes are divided into two sections which are run length and the data themselves. A special character such as \$ is usually used. The format of RLE is (Sc, Y, D) where Sc is the special character, Y is the run length, and D is the data [7], [8]. For the simulation we omit the special character because there is no need to use the special character. The function of the special character is just to separate between RLE codes.

For example, a source emits the following data: ffffaaaahhhh. The RLE codes for the data is: \$4f\$5a\$5h. If a symbol is represented by one byte, the original message contains 14 bytes while the coded message just contains 9 bytes. Thus, the compression ratio is $14/9 = 1.6$. The compression ratio is not too significant because of lossless compression.[9]

When we applied RLE to OFDM system. After modulation symbols send are encoded by using RLE. After encoding we get two information one is 'run length' and second is 'data' that repeated. We transmit 'run length' as side information. The 'run' is sent in line with the "data" so that they can be decoded at the receiver.

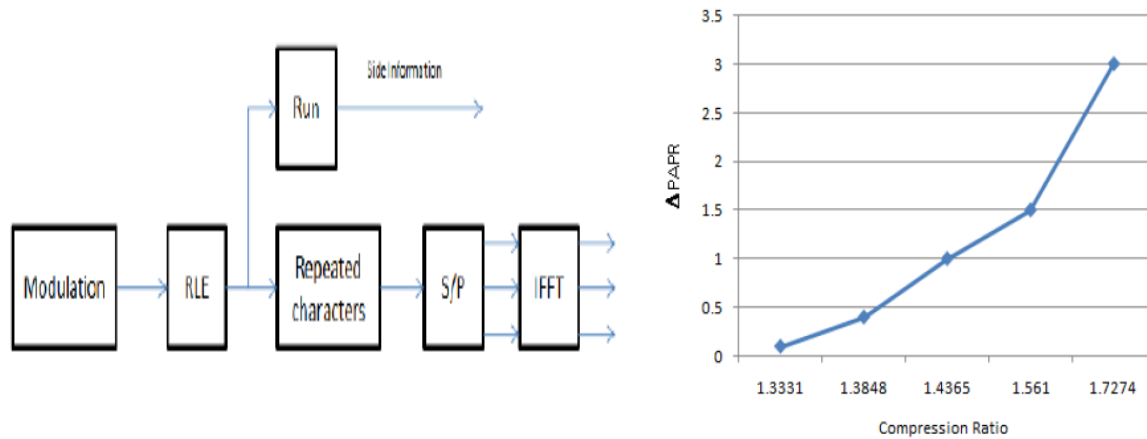


Fig.7 (a) OFDM transmitter using RLE (b) Compression ratio

OFDM transmitter using RLE is shown in Figure 7 (a). In that repeated data converted to parallel stream and IFFT is carry over there. After IFFT symbols can be transmit as OFDM symbols. From above discussion, the main part of this coding is compression ratio. Comparatively compression ratio for Huffman coding is better than for Arithmetic coding and for RLE. Because in arithmetic coding as the message length increases the binary expansion value also increases. But in Huffman coding, that symbols having more probability we assign small bit symbol and for low probability we assign large bit symbols because of that compression ratio for Huffman coding is better. And in RLE the main problem is as there are continuous stream that can be compressed but if there is message that continuously changing for that compression using RLE is not significant. Figure shows the relation of compression ratio and PAPR. As the compression ratio increases the PAPR reduces. But compression of certain data have also some limit, and we need lossless data compression therefore up to certain limit we can compress data.

IV. SIMULATION RESULTS

We have taken random data for testing purpose because the signal is of any type. The first simulation result shows the comparison of various subcarriers used for OFDM system and effect on PAPR.

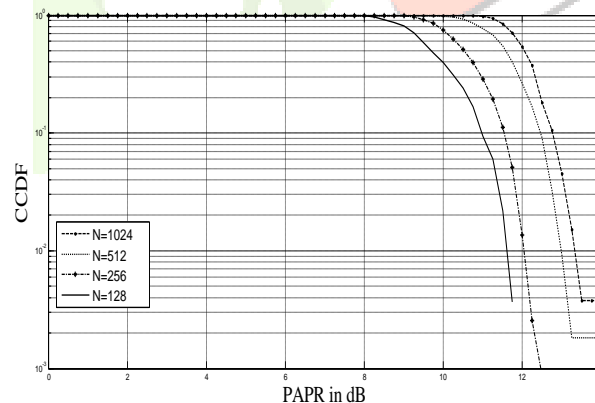


Fig. 8 Comparison of PAPR for different Subcarriers N=1024,N=512,N=256, N=128

When we compare the three systems i.e system with only IFFT, using RLE Coding and IFFT and third one using RLE Coding combined with IDWT. We found that the use of RLE coding reduces the PAPR significantly with about 2dB for CCDF(PAPR) $\leq 10^{-2}$. But as we use IDWT instead of using IFFT the PAPR reduces PAPR about 11dB CCDF(PAPR) $\leq 10^{-3}$. In Fig the comparative graph of CCDF vs PAPR for the all these three systems is shown. As we reduce the subcarrier the results will be improved.

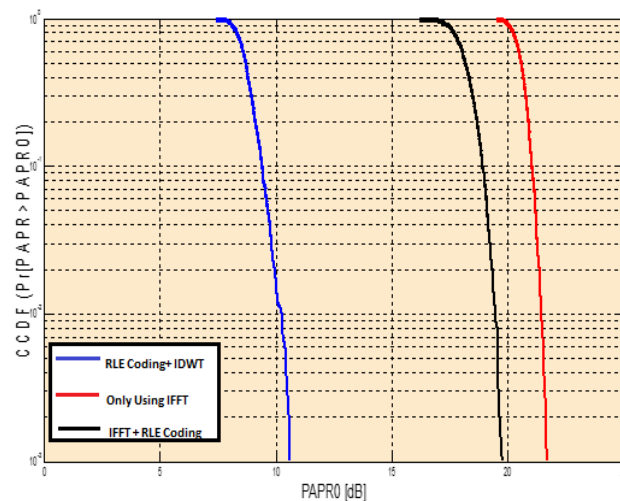


Fig 9. CCDF Vs PAPR for OFDM system using only IFFT, using IFFT and RLE Coding and using RLE Coding combined with IDWT

V. CONCLUSION

We have concluded that the use of RLE coding reduced the PAPR significantly about 2 dB. However, the RLE coding combined with IDWT reduces PAPR up to 11dB. The advantage of RLE coding depends on the compression ratio. And by using IDWT the cyclic prefix can be removed, as we remove the cyclic prefix the number of bits also reduces and that reduces the PAPR. For more improvement in the PAPR compression ratio must be increased. But it has certain limitation therefore for more reduction in PAPR we should combine it with another method of PAPR reduction.

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