PAPR Reduction using Huffman Coding Combined with IDWT for OFDM Transmitter

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ABSTRACT
Orthogonal frequency division multiplexing is very well known technique for high speed data transmission in wireless communication. But the main disadvantage of using the OFDM system is high PAPR. This paper proposes to reduce PAPR using Huffman coding and IDWT. A simulation result shows that using Huffman coding combined with IDWT reduces PAPR about 11dB. Also we have tested the OFDM system for various sub-carriers.

Keywords
Huffman coding, OFDM, PAPR.

1. 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, inflictinginter 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 increases 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 Conding, 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.

2. OFDM, PAPR AND HPA THEORY

2.1 OFDM System

a. 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 Xm. 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,

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

The transformed output (Xk) 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],

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

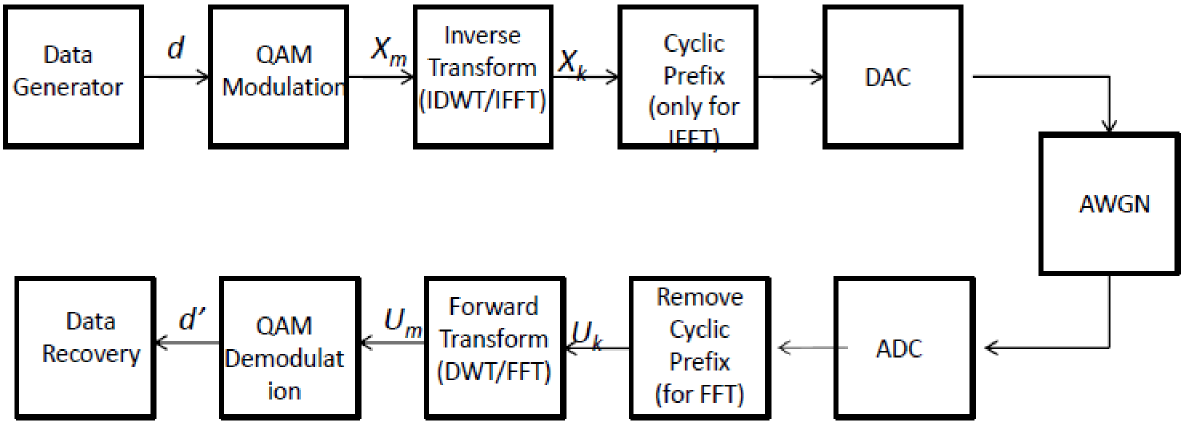

Fig. 1: Trans-receiver model of OFDM using inverse and forward transform blocks for implementation of FFT/ DWT-OFDM.

b. 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 Xm(i). Every Xm(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.

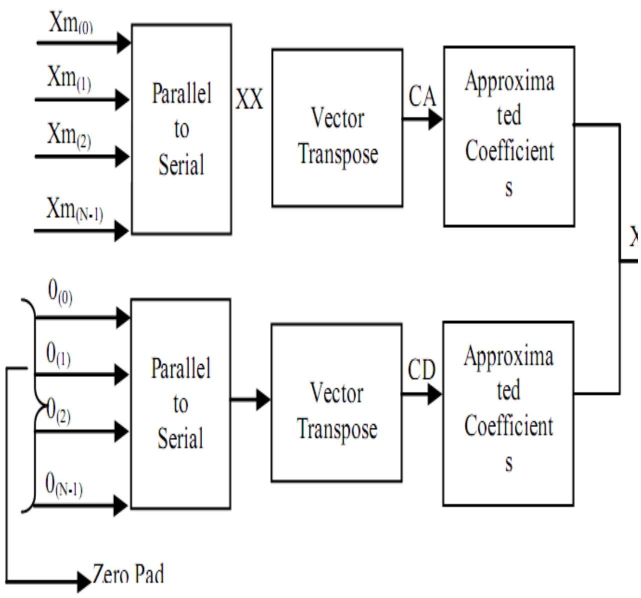

Fig. 2 IDWT Internal Structure

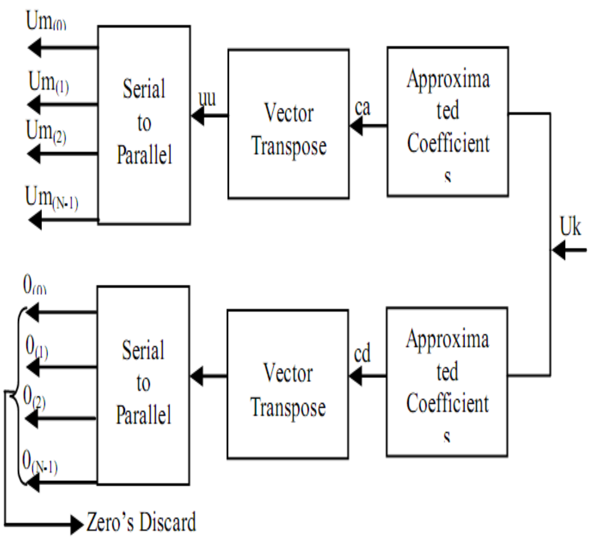

Fig.3 DWT Internal Structure

The PAPR is denoted by[8]

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

Where E {■} 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.

2.2 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(.) is AM/AM conversion and Φ(.) is AM/PM conversion.AM/AM and AM/PM for Rapp's model is as follows.

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

$$\Phi(v) = 0$$

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 $2 \le p \le 3$.

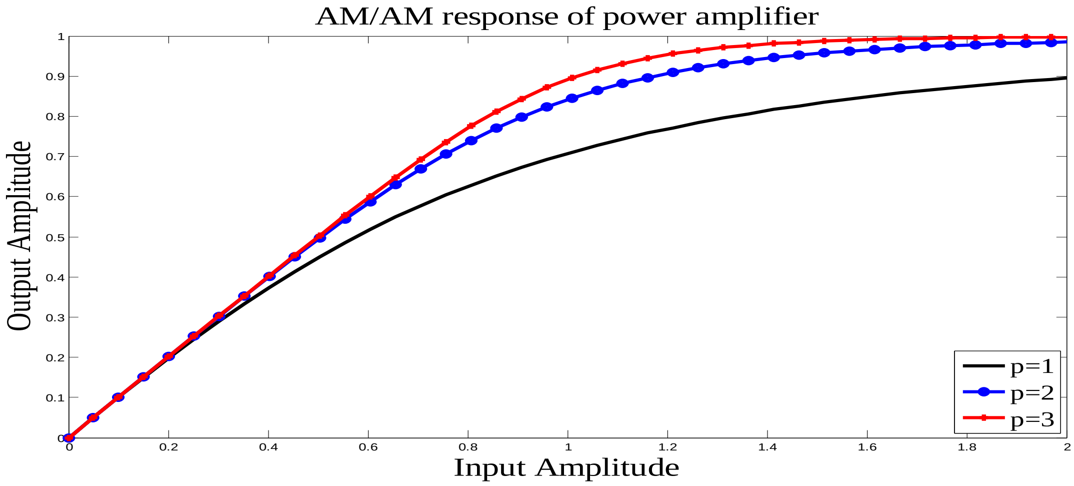

Fig.4 Effect of *p* on power amplifier for *p* = 1, 2 and 3

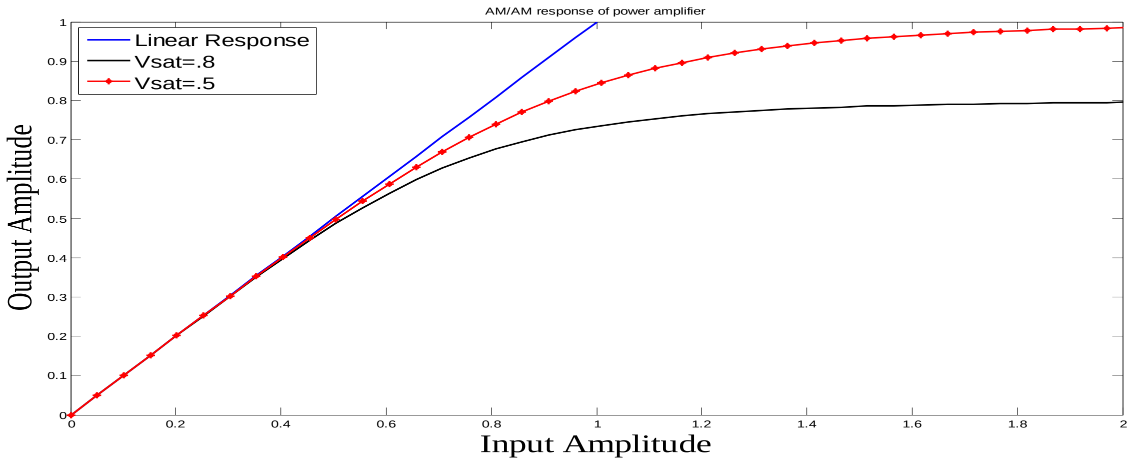

Fig.5 Effect of v_{sat} on power amplifier for v_{sat} =0.8 and 0.5

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].

$$IBO = 10\log\{\frac{v_{sat}^2}{E\{|x|^2\}}\} \quad (8)$$

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

3. PROPOSED SYSTEM

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

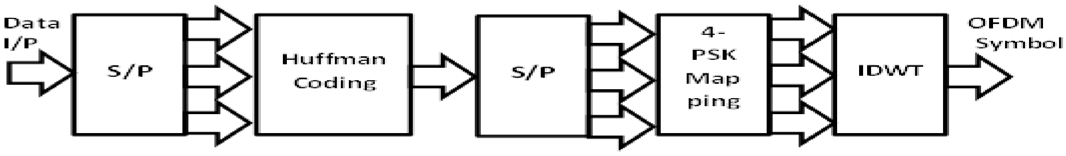

Fig.6 Proposed System Model

To implement Huffman coding, the compression and uncompression algorithms should agree on the binary codes used to represent every character. This may be handled in one of two ways. The best is to use a predefined coding table that is always an equivalent, despite the information being compressed. A lot of complicated schemes use coding optimized for the actual information getting used. This requires that the coding table be enclosed within the compressed file to be used by the uncompression program. Both ways are common.

Now think about a Huffman encoded information stream, wherever every character will have a variable range of bits. To separate one character from the next, the correct choice of the Huffman codes that modify the right separation is required. This can be illustrated in the given example. Suppose we've to encrypt ABRACADABRA string. The characters A,B,C,D and R having probabilities shown in Table (1). Since the character A is the most common, we will represent it with a single bit, the code: 0. Following second common characters are B and R having same chances that may represented by 3 and 2 bits respectively, the code:100 and 11 respectively. This continues to the least frequent character D, being assigned bits, 1011. As shown in this illustration, the variable length codes are resorted into eight bit groups. All the 8 bits groups are placed one by one in the form of serial strings of 1s and 0s at the time of uncompression. Look closely at the cryptography table (1), and see however every code consists of 2 parts: number of 0s before a 1 and binary code which is not compulsory after the 1. This permits the binary information stream to be separated into codes while not the necessity for delimiters or alternative marker between the codes.

Table(1) : Example Encoding Table

Letter	Probability	Huffman Code
A	0.4545	0
R	0.1818	11
B	0.1818	100
C	0.0909	1010
D	0.0909	1011

For the implementation of Huffman coding, the binary codes used to represent each character depend upon the compression and uncompression algorithms. For this purpose either a predefined encoding table or the optimized encoding for the particular information being used. We are using second technique, in which one will send the encoding table as side information without affecting the efficiency of bandwidth. This is because, due to the transmission of side information the compression obtained by the Huffman coding will counteract the increase in data rate.

During encoding a less number of bits is assigned to frequently occurring symbols rather than the less probably occurred symbols, for eliminating the same symbols being repeated. This will also prevent the coherent addition of multicarrier signals which cause the unwanted very high peak while rearranging the stream of bits among symbols with fixed number of bits. Because of this reason the Huffman encoding will reduce the PAPR, when it is applied to OFDM system.

The OFDM transmitter is shown in Fig.(6), which uses Huffman coding. The input information is converted to parallel symbols. As the encoding completed, that data is converted to parallel stream for symbol mapping. The IDWT stage generates the OFDM composite time signal which does not require the cyclic prefix. The number of bits can be reduced by avoiding the use of cyclic prefix. The reduction in number of bits further reduces the PAPR.

4. 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.

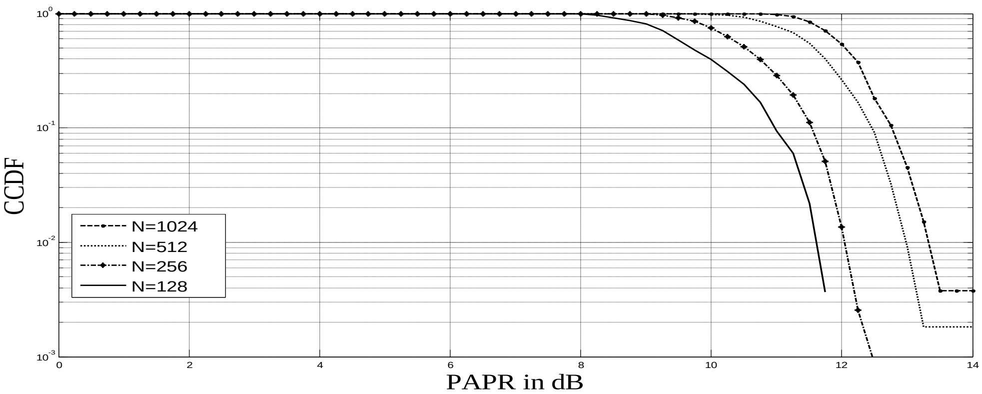

Fig. 7 Comparison of PAPR for different Subcarriers N=1024,N=512,N=256, N=128

When we compare the three systems i.e system with only IFFT, using Huffman Coding and IFFT and third one using Huffman Coding combined with IDWT. We found that the use of Huffman coding reduces the PAPR significantly with about 2dB for CCDF(PAR) $\leq 10^{-2}$. But as we use IDWT instead of using IFFT the PAPR reduces PAPR about 11dB CCDF(PAR) $\leq 10^{-3}$. In Fig.8, 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.

The Fig. 9 shows the SNR Vs BER comparative analysis of or OFDM system using only IFFT, using IFFT and Huffman Coding and using Huffman Coding combined with IDWT. Fig.10 shows the power spectrum density for the proposed system. It shows the effect of SSPA on systems with and without Huffman coding

The performance of Huffman coding depends on the compression ratio of Huffman coding itself. The higher the compression ratio the higher the PAPR reduction .Since this system compression ratio is 1.05.As the compression ratio increases the PAPR reduction increases significantly.

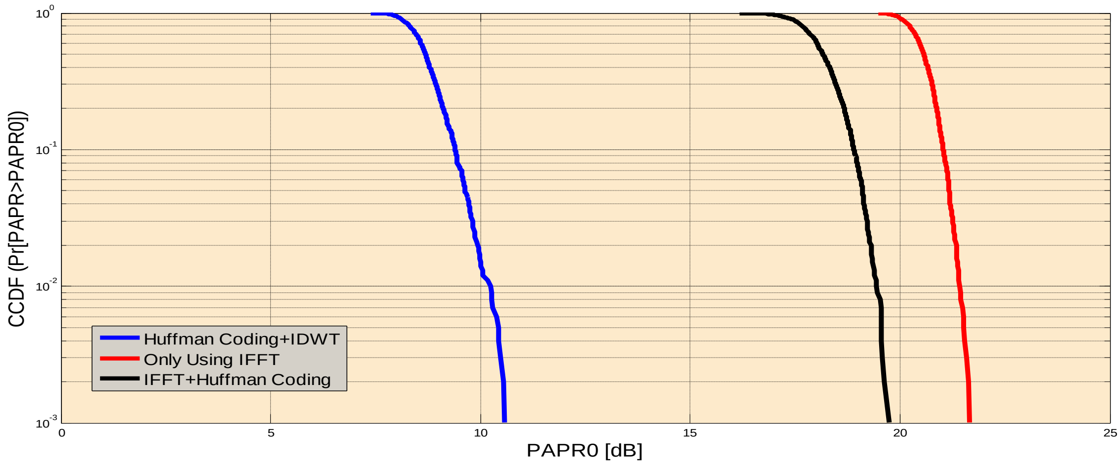

Fig. 8 CCDF Vs PAPR for OFDM system using only IFFT, using IFFT and Huffman Coding and using Huffman Coding combined with IDWT

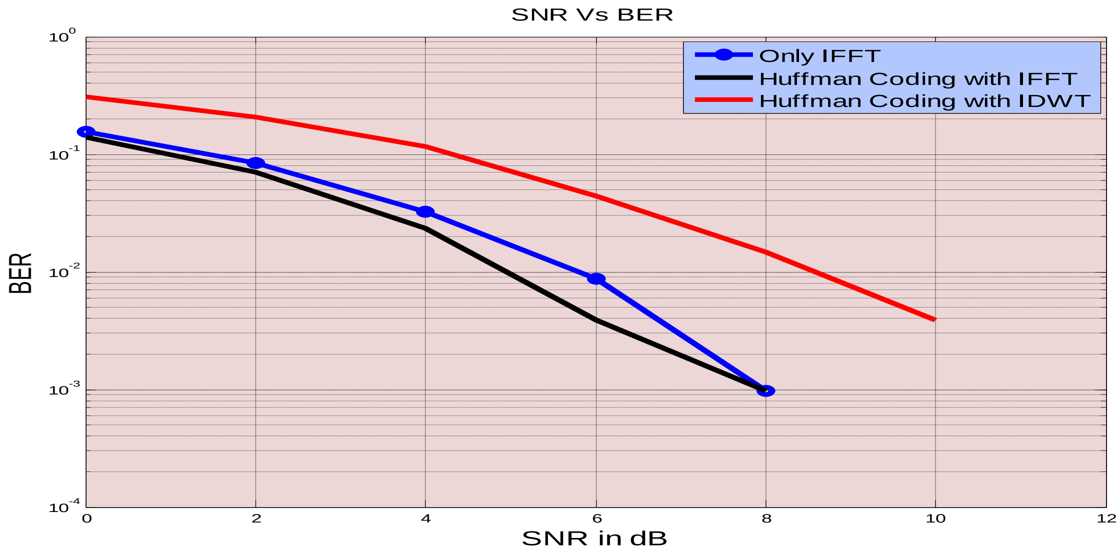

Fig. 9 SNR vs BER for or OFDM system using only IFFT, using IFFT and Huffman Coding and using Huffman Coding combined with IDWT

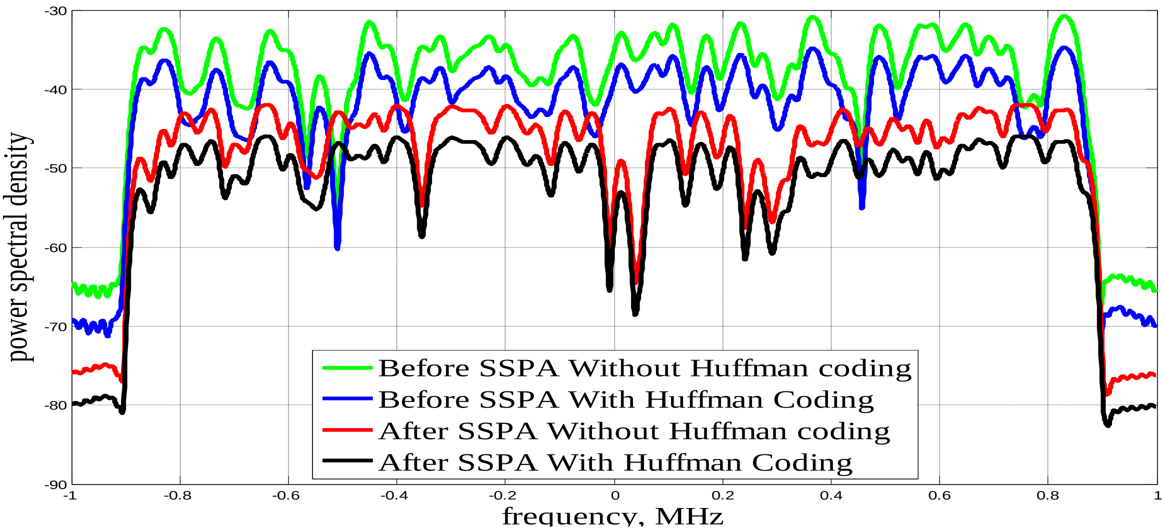

Fig.10 Power Spectrum Density

5. CONCLUSION

We have concluded that the use of Huffman coding reduced the PAPR significantly about 2 dB. However, the Huffman coding combined with IDWT reduces PAPR up to 11dB. It also improves the SSPA response after Huffman coding. The advantage of Huffman 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.

6. REFERENCES

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