Simulation and Analysis of Energy Efficient Image Processing System for 4G-OFDM Under Rayleigh ad Fading Channel

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Abstract : Multicarrier modulation, and especially OFDM, is one of the remising candidates that uses a set of subcarriers in order to broadcast the information symbols in parallel through the communication channel. It permits the communication system to broadcast the data at a lower rate on plurality of subcarriers and the throughput of multicarrier system remains as single carrier system. This allows us to design a system that supports high data rates, while maintaining symbol span much longer than the channel delay spread, thus reduce the need for complex channel equalization mechanism. To maintain the orthogonality in multi career OFDM communication cycle prefix is used. The drawback of cyclic-prefix insertion is that only a fraction of the received signal power is actually utilized by the OFDM demodulator, implying a corresponding power loss in the demodulation. In addition to this, cyclic-prefix insertion also implies a corresponding loss of bandwidth efficiency. In this research, we have addressed the problem of energy efficient image transmission system for OFDM in which we have used discrete trigonometric transform and discrete wavelet transform based OFDM system. We have also done performance assessment for the given system based on BER and PSNR. Simultaneously the given system has been tested for Rayleigh and fading channel under parametric variation.

Index Terms - DCT, DWT, OFDM, PSNR, Image Compression, AWGN, Fading Channel, QAM

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation scheme, where the frequencies of the subcarriers are demoniacally related. In other words, a multicarrier modulation scheme equipped with orthogonal subcarriers is called OFDM. Let X_k for k=0 to n-1 be the set of complex symbols to be broadcasted by multicarrier modulation, the continuous time domain MCM signal can be expressed as

$$x(t) = \sum_{k=0}^{N-1} Xk\, exp(j2\text{л}fkt) \quad \text{for} \quad 0 \le t \le T_s$$

$$= \sum_{k=0}^{N-1} Xk\varphi k\,(t) \text{for} \quad 0 \le t \le T_s$$

$$\text{where } f_k = f_o + k\Delta f \text{ and}$$

$$\varphi_k\,(t) = \begin{cases} exp(j2\text{л}f_k t) & 0 \le t \le T_s \\ 0 & \text{otherwise} \end{cases}$$

For $k = 0, 1, 2...N-1$. The subcarriers become orthogonal if $Ts\, \Delta\, f = 1$, and such a modulation scheme is called OFDM, where Ts and Δf are called the OFDM symbol duration and the subcarrier frequency spacing respectively. In case of orthogonal subcarriers $x(t)$denotes a time domain OFDM signal.The orthogonality among sub carriers can be viewed in time domain as shown in Fig.1.1 .Each curve represents the time domain view of the wave for a subcarrier. As seen from Fig 1.1, in a single OFDM symbol duration, there are integer numbers of cycles of each of the subcarriers.[1,2]

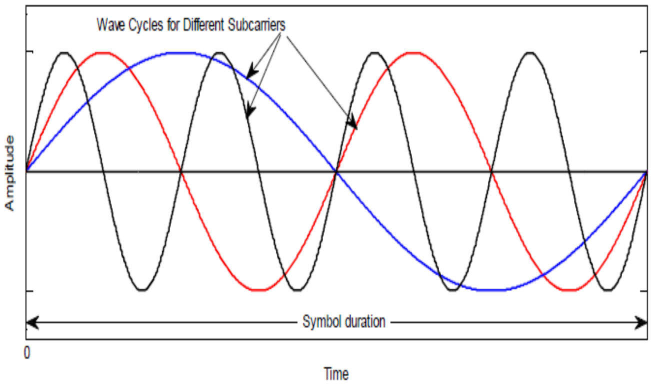


Fig 1.1 Time domain representation of the signal waveforms to show orthogonality among the subcarriers

Because of the orthogonality condition, we have

$$1/T_s \int_0^{Ts} \varphi k(t)\, \varphi j*(t)\, dt$$

$$1/T_s \int_0^{Ts} ej2\pi(fk - fl)\, t\, dt$$

$$= \delta\,[k-l]$$

Where

$$\delta\,[n] = 0 \begin{cases} 1 & \text{if } n=0 \\ 0 & \text{otherwise} \end{cases}$$

Equation shows that φ_k (t) for k=0 to N-1 is a set of orthogonal functions. Using this property the OFDM signal can be demodulated as

$$= \quad 1/Ts \int_0^{Ts} x(t)ej2\pi fk\, t\, dt$$

$$= \quad 1/Ts \int_0^{Ts} \left(\sum_{l=0}^{N-1} x(t)\varphi k(t)\right) \varphi j*(t)\, dt$$

$$= \sum_{l=0}^{N-1} x\, l\, \delta\,[k-l] = x_k$$

Under optimal conditions the OFDM signal can be demoded without any interference between the subcarriers. But in situation of time dispersive channel, the orthogonality between the subcarriers gets disordered because the demodulator correlation interval for one path will overlie with the symbol boundary of different path.[5,7,12]

Thus, the integration interval will not essentially correspond to an integer number of periods of complex exponentials of that path as the modulation symbols may differ between successive symbol intervals. As a aftereffect, there will not only be inter-symbol interference within a subcarrier but also there will be a interference between subcarriers.[16]

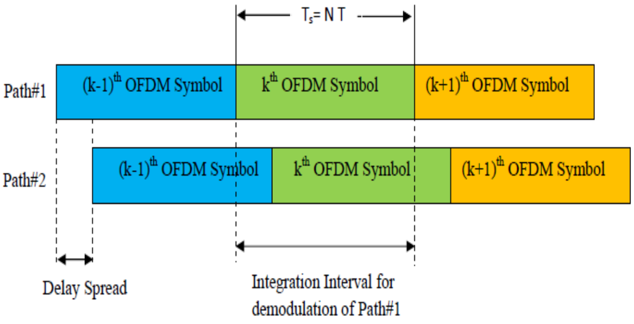
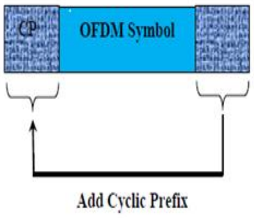


Fig 1.2 Time dispersion and received signals timing



Cyclic prefix insertion

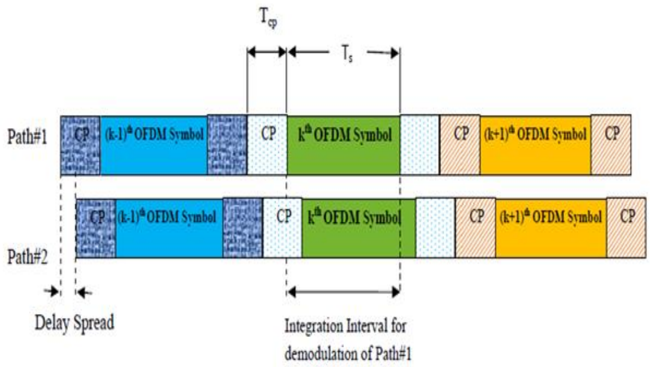


Fig 1.3 Time dispersion and received signal using cyclic prefix insertion

To overcome the problem and to make an OFDM signal truly unresponsive to time dispersion of the radio channel, cyclic-prefix (CP) insertion is typically used. As illustrated in Fig. 1.3 .cyclic-prefix insertion signifies that the last part of the OFDM symbol is duplicated and interpolated at the starting of the OFDM symbol. Cyclic-prefix interpolation is thus increases the length of the OFDM symbol duration from TS to TS+ TCP, where TCP is the length of the cyclic prefix. As illustrated in Fig. 1.2 and Fig 1.3, if the correlation at the receiver side is still carried out over a time interval TS, subcarrier orthogonality will be preserved in case of a time-dispersive channel, as long as the period of the time dispersion is shorter than the length of cyclic-prefix. At the receiver side, the corresponding samples are rejected before OFDM subcarrier demodulation i.e. before DFT processingThe drawback of cyclic-prefix insertion is that only a fraction TS/(TS +TCP) of the received signal power is actually utilized by the OFDM demodulator, implying a corresponding power loss in the demodulation. In addition to this, cyclic-prefix insertion also implies a corresponding loss of bandwidth efficiency.[12.16]

OFDM symbol by using a serial to parallel converter and then a cyclic prefix of suitable length is inserted to combat the effect of ISI. Finally the discrete time OFDM signal is converted into analog OFDM signal and amplified to the desired power level. The obtained signal is transmitted over communication channel. The signal received y(t) at the receiver haste effect of multipath propagation and AWGN(n(t)). The received signal at the receiver is first converted into analog by using the D/A converter and cyclic prefix is removed. The obtained signal is applied to a serial to parallel converter and then subcarrier demodulation is performed by using FFT operation. After that one tap frequency equalization can be utilized to cancel the effect of multipath fading channel and then passed through a parallel to serial converter to obtain serial data signal. Finally, signal is demodulated to get the desired data signal.[10,11]

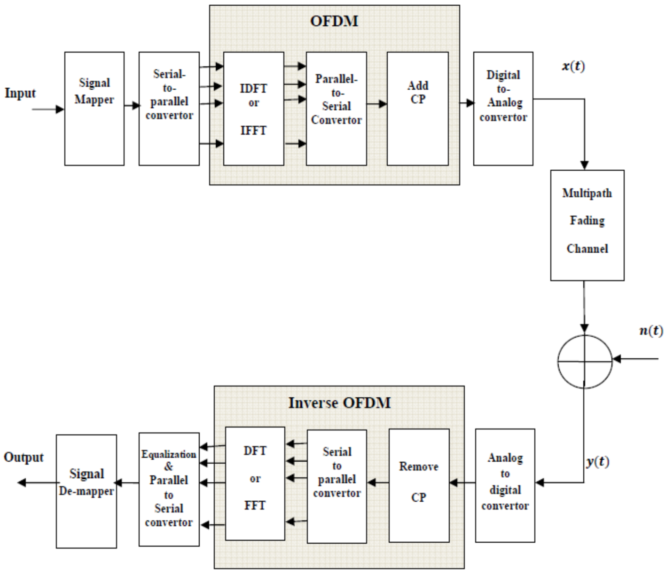


Fig 1.4 OFDM transceiver

OFDM signal received at the receiver is first converted into digital and then applied to serial to parallel converter. After that FFT of the signal obtained from is performed to achieve the subcarrier demodulation. As seen from Fig 3.10, that FFT operation used in OFDM demodulator eliminates the requirement of N co-relaters operating in parallel to demodulate the multicarrier modulator.[21]

II. IMPLEMENTATION OF DCT-OFDM IMAGE PROCESSING

The DCT is a Fourier-related transform, which uses only real numbers. The simplest formula of DCT to transform N real numbers xo……,x_{N-1} into N real numbers X_0,....., X_{N-1} is [17]:

$$X_k = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\pi}{N}(n+\frac{1}{2})(k)\right] ,k=1,........, N-1$$

It is used to convert any sequence from one domain to another base sequence is referred to, and these complex discrete periodic sequence in the case of the Fourier transform. So, to find out if there are some real value of the underlying sequence, will lead an important real value conversion sequence. It ended up in find many other transformations, which are orthogonal transform [12].

In OFDM system, the digital modulation and demodulation can be achieved with an inverse FFT (IFFT) and fast Fourier transform, respectively [2],[10]. NS independent OFDM uses subcarriers to transmit data, rather than a major carrier. Input data is grouped into N bits, where N = Ns × Mn and a Mn of the block to the number of bits used to represent each of the sub-carrier symbols. In order to maintain orthogonality between subcarriers, they need the subcarrier symbol rate Rs integer multiple spaced apart. Subcarrier symbol rate is Rs by the = RC / N relation to the total encoding bit rate Rc of entire system. The output signal of an OFDM can be written as:

$$X(t) = \sum_{n=o}^{N_s-1} c_k e^{2\pi j(n-N_s/2)\frac{t}{T_s}}$$

Where Ck are the complex representations of the subcarrier symbols and Ts is the symbol period.

Complex exponential function set is not to be used to construct unique multi-carrier orthogonal basis baseband signal. A single set of common sine function can be used to achieve multi-carrier modulation orthogonal base (MCM) program, and the program can be synthesized using a discrete cosine transform (DCT)[2].Therefore, I will express plans DCT-OFDM. An output signal of the DCT-based OFDM system can be written

$$X(t) = \left[\left(\frac{2}{N_s}\right)^{\frac{1}{2}}\right]\sum_{n=0}^{Ns-1} \alpha_n \beta_n \cos(n\pi t / T_s)$$

The DCT proposed [48] is the most common known for its use in the JPEG (Joint Photographic Experts Group) is a still image compression standard [49].In this type of compressed image is divided into 8 × 8-pixel section and a two-dimensional DCT is applied independently to each of these fragments. Discrete Cosine Transform (DCT)is provided that can be used in which the frequency content of the signal related to the signal analysis information using a transform. Cosine basis functions of DCT to decompose signals into weighted finite and cosine. The transformation of the equation one-dimensional discrete cosine signal decomposition and rearrangement, X (N), is given in equation, respectively[28].

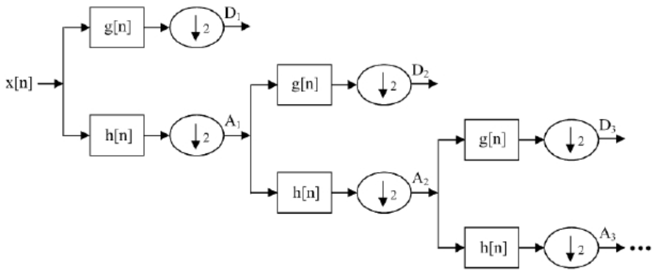


Figure 1.Discrete wavelet transform block diagram

$$X(0) = \sqrt{2} / N \sum_{n=0}^{N-1} x(n)$$

$$x(n) = \frac{1}{\sqrt{2}} X(0) + \sum_{k=1}^{N-1} X(k) \cos \frac{\pi k(2n+1)}{2N}$$

Similar two-dimensional DCT, instead of applying a dimension to be applied twice in trans - form of this method, but; once in the horizontal direction, one in the vertical direction, and then multiplying the resulting term. Mathematically, this operation is shown in the x and y respectively horizontal and vertical space equation and respectively u and v are the horizontal and vertical frequencies. JPEG compression standard in effective use of this algorithm to compute the DCT 8 × 8-pixel image segment and a set of 2-D cosine basis functions represent different correlation values between the frequency space.[22]

III. IMPLEMENTATION OF DWT-OFDM IMAGE PROCESSING

Discrete wavelet transform (DWT) is one very effective tool, when used in the signal frequency analysis. Wavelet transform can be defined as a spectral estimation technique, which can be expressed as any general function infinite series of sub-waves and. Time scale signals DWT representation can be achieved using digital filtering techniques. For the signal x (n) of the multi-resolution decomposition method is shown in Fig. 1.5Discrete wavelet transform is a continuous low-pass and signal x (n) of the high-pass filter calculation. Each step includes two digital filter and two down sampler consists of two high-pass filter g [] is the mother wavelet and discrete low-pass filter h [.]Is its mirrored version. Detail coefficients and the low-pass filter at the output of the sample at each level of the high-pass filter disturbs the approximation coefficients. The approximation coefficients is further decomposed and the process continues, as shown.The standard equation of Discrete Wavelet Transform is given as-

$$w_{m,n} = \langle x(t), \psi_{m,n} \rangle = a_0^{m/2} \int f(t) \psi(a_0^m(t) - nb_0) dt$$

where sub wavelets is given by-

$$\psi_{m,n}(t) = a_0^{m/2} \psi(a_0^m(t) - nb_0) \qquad m,n \in Z$$

There are a number of basic functions that can be used as the mother wavelet for Wavelet transform. While choosing the mother wavelet the characteristics of the signal should be taken into account since it produces the different wavelets through translation and dilation and hence determines the characteristics of the resulting transform. Figure illustrates the commonly used wavelet functions.[13] The wavelets are chosen on the basis of their shape and ability to analyze the signal for a particular application.DWT based on OFDM is an effective way to replace the conventional FFT in OFDM systems. DWT is used in order to remove the use of a cyclic prefix, which reduces the waste of bandwidth and transmission power is reduced by using a wavelet transform. Wavelet -OFDM channel spectrum accommodates more than FFT OFDM. In the wavelet transform, the signal of interest is decomposed into a set of basic waveforms, known as wavelets, which provides a road through surveys analyzing the signal wavelet coefficients. DWT for multiple types of applications have become very popular with engineers, technical specialists and mathematicians. Wavelet transform basis functions in time and frequency, and having two domains which makes the wavelet transform used in various applications localized in different resolutions powerful tools. Different resolution corresponds to behavior analysis and transformation of power.

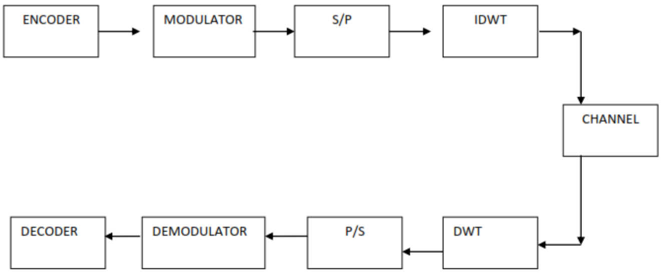


Figure 2.DWT-OFDM System block diagram

The data generator first generates a serial random data bits stream. This data stream is passed through the encoder which consists of Convolutional encoder followed by the bit interleaver. The bits are first interleaved with help of convolution encoder and interleaver and then the data is processed using modulator to map the input data into symbols based on the modulation technique used. The DWT-OFDM symbol *st* can be represented as equation below [21],

$$s(t) = \sum_{j} \sum_{k} wj,k(t)\psi j,k(t) + (t) + \sum_{k} a_{J,k}\varphi_{J,k}$$

The orthogonality of these carriers relies on time location *(k)* and scale index *(j)*. This symbol is clearly the weighted sum of wavelet and scale carriers which is similar to the Inverse Wavelet Transform (IDWT). In DWT-OFDM, the input data is processed same as in FFT-OFDM but the advantage in this case is that the cyclic prefix is not required because of the overlapping nature of wavelet properties. The data is processed in the IDWT block, whose output can be given as equation (4.2),

$$d\,(k) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} D^{m}{}_{n} 2^{m/2}(2k^{m}-n)\ (4.2)$$

where k is the number of subcarriers ($0 \le k \le N-1$), Dmn are the wavelet coefficients which represents the signal in scale and position on time-axis and $\psi(t)$ is the wavelet function with compressed factor m times and shifted n times for each subcarrier [27]. At the receiver side, the process is reversed. The output of discrete wavelet transform (DWT) is represented by equation below-

$$D_{m}{}^{n} = \sum_{k=0}^{N-1} (k) 2^{m/2}\psi(2^{m}{}_{k}-n)\ (4.3)$$

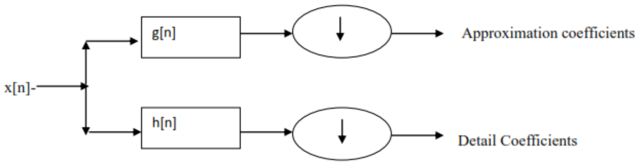


Figure 3.Discrete wavelet transform Coefficients

Discrete wavelet transform is used in a variety of signal processing applications, such as Internet communication compressed video image, target recognition and numerical analysis. The main advantage over the Fourier transform of the wavelettrans form is that it is discrete in time and scale. The transformation is achieved through the use of filters. Analysis of a filter is a low pass filter (LPF),and the other is a high-pass filter (HPF). Each filter consists of a down-sampler, the converter efficiency. In the wavelet-based OFDM (DWT-OFDM), the time window is replaced with complex exponential wavelet "operators", different scales (j)and position on the timeline (k) is. Through translation and expansion of these functions to produce a unique feature called "waveletmother." [28] and expressed as ψ (t).[23]

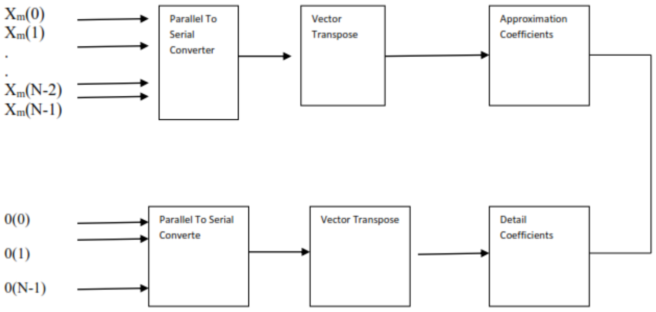


Figure 4.OFDM Transceiver Model

These carriers orthogonal time depends on the position (k)and scale index (J).Waveletoperators showed better than complex time-frequency localization index [18],while DWT-OFDM implementation complexity of comparable FFT- OFDM. These orthogonal basis functions, if scale an unlimited number of considerations. In order to obtain a limited number of scales, the zoom function is used. Now DWT-OFDM symbol may be considered and weighted wavelet and scale carrier near the inverse wavelet transform (IDWT).

IV. COMPARISON BETWEEN QAM CONSTELLATIONS

Quadrature Amplitude Modulation (QAM) is both analog and digital modulation scheme. It conveys two analog message signals or two digital bit stream, by changing (modulating) the amplitude of two carrier using amplitude shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. Two carriers, usually sinusoids, beyond phase with each other to 90 °, and thus is referred to as an orthogonal vector or quadrature component - hence the name of the program. Modulated wave are added, and the resulting waveform is a phase modulation (PM) and amplitude of both phase shift keying (PSK) and amplitude shift keying (ASK), or a combination thereof (in the case of simulation of bottom). In the case of a digital QAM, it is used for a limited number of at least two phases and amplitudes of the at least two. PSK modulator QAM principle is commonly used design, but not to be considered as QAM amplitude modulated carrier signal is constant. QAM modulation scheme is widely used as a digital t separate the real and imaginary parts, and are 90 degrees out of phase. Serial to parallel converter converts the serial data input parallel phase and quadrature components of the phase 90 degrees, so that the real part imaginary part can be separated and faster transmission from, you can achieve the conversion. Technical QAM constellation mapping involves the use of signal components constellation. A constellation is represented by a digital modulation scheme such as quadrature amplitude modulation or phase shift keying modulation signal. Send denoted by the symbol as a complex and modulating cosine and sine carrier signals a real part and an imaginary part (respectively), the symbol can be sent with two carriers at the same frequency.[14,23,3]

V. SIMULATION AND RESULTS.

Results of the proposed work can be classified into following broad categories-

- Implementation of DCT for image transmission and image compression.
- Implementation of DWT for image transmission and image compression.
- Implementation of Parametric variation in DCT based image transmission system.
- Performance Analysis of simulated PAPR reduction methods.
- Development of graphical user interface (GUI) for the overall process.

Performance analysis of the proposed system is done on base of following two parameters-

a) Plot of Peak Signal to Noise Ratio (PSNR).

b) Plot of Bit Error Rate (BER).

- PSNR Output- The plot of peak signal to noise ratio for the image is given as follows-

Image – Lena.jpg (Standard Image)

Channel- AWGN (White Gaussian Noise)

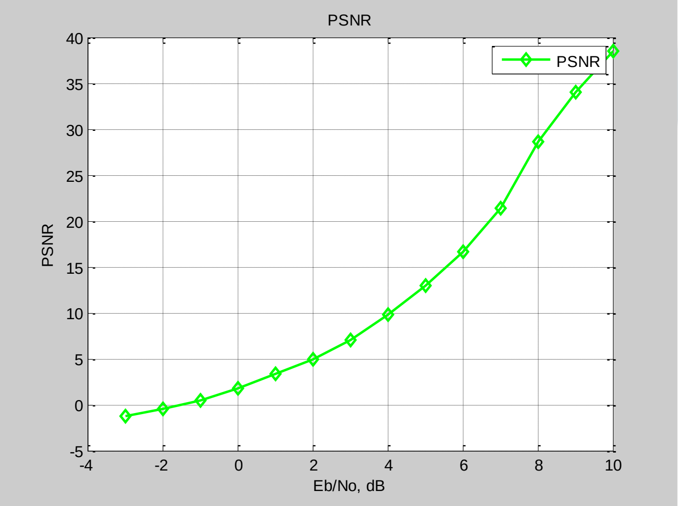


Figure 1.9-Plot of Peak Signal to Noise Ratio(PSNR) in DCT-OFDM

- BER Output- The plot of bit error rate(BER) for the image is given as follows-

Image – Lena.jpg (Standard Image)

Channel- AWGN (White Gaussian Noise)

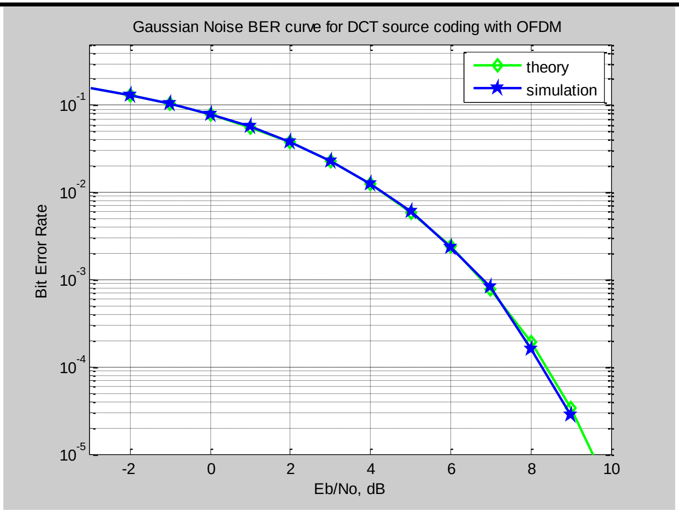


Figure 1.10-Plot of bit error rate (BER) in DCT-OFDM

Figure 1.9 shows the plot of peak signal to noise ratio(PSNR) for images of JPEG, bitmap (bmp), PNG types. Desired file/image can be entered through this command window for execution. Figure 1.10 shows the plot of bit error rate (BER) for images of JPEG, bitmap (bmp), PNG types. Desired file/image can be entered through this command window for execution. Performance analysis of the proposed system is done on base of following two parameters-

c) Plot of Peak Signal to Noise Ratio (PSNR).

d) Plot of Bit Error Rate (BER).

- PSNR Output- The plot of peak signal to noise ratio for the image is given as follows-

Image – Lena.jpg (Standard Image)

Channel- AWGN (White Gaussian Noise)

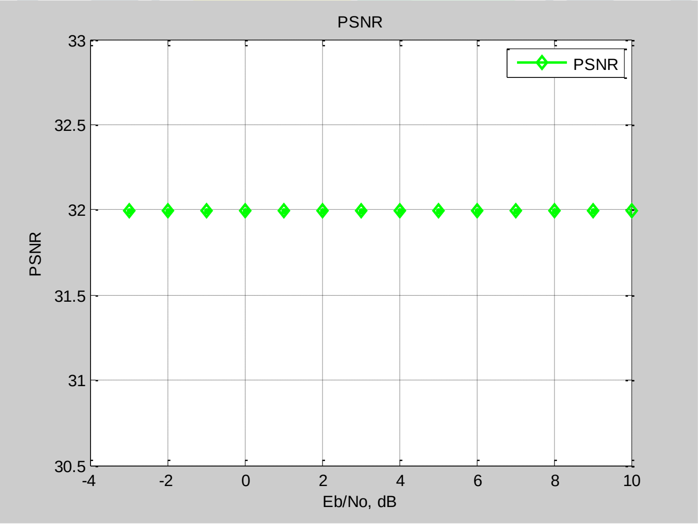


Figure 1.11 Plot of Peak Signal to Noise Ratio(PSNR) in DWT-OFDM

- BER Output- The plot of bit error rate(BER) for the image is given as follows-

Image – Lena.jpg (Standard Image)

Channel- AWGN (White Gaussian Noise)

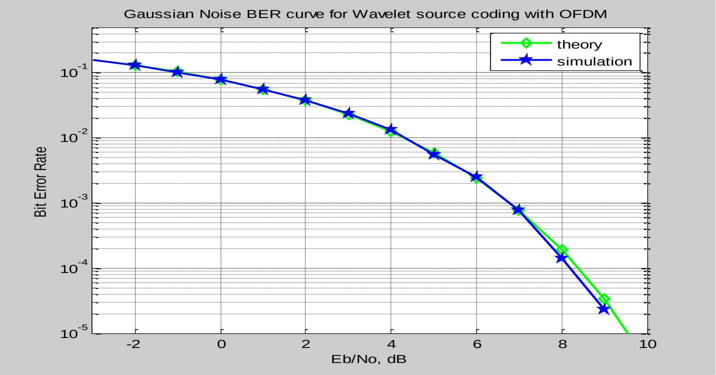


Figure 1.12-Plot of Peak Signal to Noise Ratio(PSNR) in DWT-OFDM

Implementation of parametric variation is done on following basis. We have opted for transmission of image in RGB or Grayscale, encoding and channel selection Parametric variations can be done with the help of GUI and with the permission to change above mentioned entities for our research process. The type of transmitted and received image can be either grayscale or RGB type color or binary color. We can implement coding such as convolution encoding in our research process.

Types of channel used for image transmission are of two types in this case.

a) AWGN channel

b) AWGN with fading

Types of compression ratio are also classified into two subtypes in our research.

a) 10 % coefficient

b) 50 % coefficient

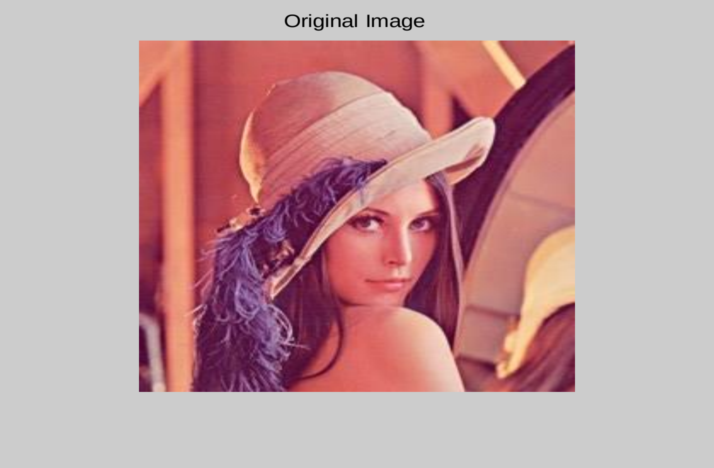


Figure 1.13 Original Image in Parametric Variation

Figure 1.14. Compressed Image in Parametric Variation

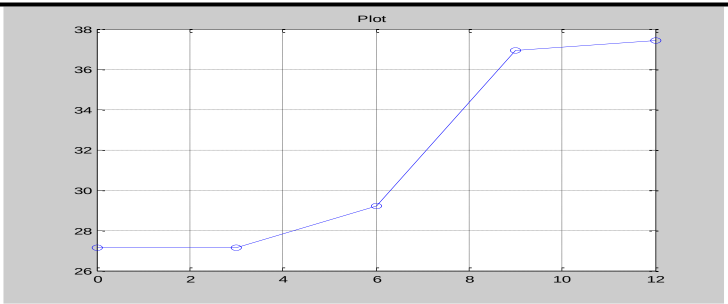


Figure 1.15 -PSNR in Parametric variation

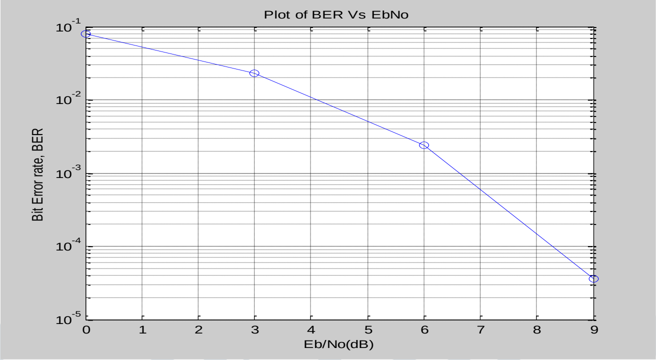


Figure 1.16 - Plot of BER in Parametric Variations

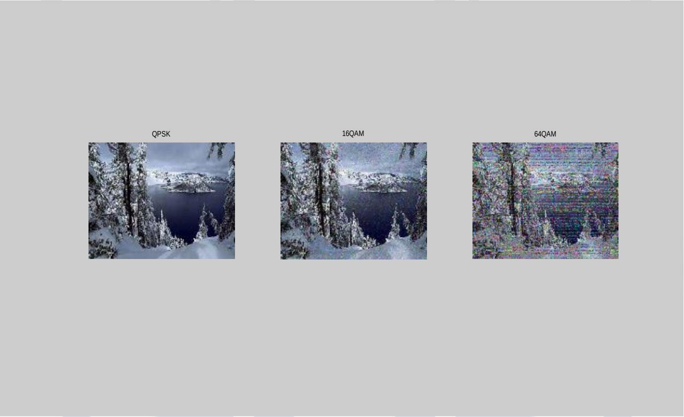


Figure 1.17 - Comparison between modulations

It is evident from the comparison that QPSK shows good result and better SNR as compared to other QAM techniques so we have implemented QPSK modulation based system for our research. For ease of access and working we have developed mat lab based graphical user interface for the overall process.We have developed both script as well as figure file for old versions (Before R2012b) for GUI. We have also developed matlab direct launching applet for the new versions which can be installed in the matlab for ease of access.

Figure 1.18- GUI (Graphical user interface) for research work

VI. CONCLUSION

In In this research work initially we have formulated DCT-OFDM based image transmission and compression system .The BER performance of DCT based OFDM system has been compared with DWT based system and the simulations have been carried out using MATLAB. The values of PSNR and BER for both techniques were compared. In DCT-OFDM, we have better result in terms of PSNR for same image , DWT-OFDM can be used as an alternative method .The results in DWT was inferior as compared to DCT in some extent. We have formulated convolution encoding and compression ratio variations in DCT-OFDM system. The modulation techniques were also compared and QPSK given the best result out of them. We have also simulated our algorithm for both AWGN and Fading channel.

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