ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

BER Analasis of Wavelet Based OFDMA INLTE using QAM

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1.INTRODUCTION:

OFDM is a wideband wireless digital communication technique that is based on block modulation. With the wireless multimedia applications becoming more and more popular, the required bit rates are achieved due to OFDM multicarrier transmissions. Multicarrier modulation is commonly employed to combat channel distortion and improve the spectral efficiency. Multicarrier Modulation schemes divide the input data into bands upon which modulation is performed and multiplexed into the channel at different carrier frequencies so that information is transmitted on each of the sub carriers, such that the sub channels are nearly distortion less. In conventional OFDM system, IFFT (Inverse Fast Fourier Transform) and FFT (Fast Fourier Transform) are used to multiplex the signals together and decode the signal at the receiver respectively. In this system, the Cyclic Prefix is added before transmitting the signal to channel. But in wavelet based transmission technique has stronger ability of suppressing ISI and ICI than the conventional OFDM scheme.

Two types of modulation schemes are used in this paper which is Conventional and non-convention modulation schemes. BPSK, QPSK and QAM are the parts of conventional modulation schemes whereas Differential BPSK and Differential QPSK are the non-conventional modulation schemes. BPSK is the one of the simplest forms of digital modulation. The phase of the constant amplitude carrier signal moves between zero and 180 degree. Differential PSK is a non-coherent form of phase shift keying which avoids the need for a coherent reference signal at receiver. The non-coherent receivers are easy and cheap to build, and hence are widely used in wireless communications The QPSK is a multilevel modulation technique; it uses 2 bits per symbol to represent each phase. Compared to BPSK, it is more spectrally efficient but requires more complex receiver. In differentially-encoded QPSK (DQPSK), the phase-shifts are 0°, 90°, 180°, -90° corresponding to data ‘00’, ‘01’, ‘11’, ‘10’. This kind of encoding may be demodulated in the same way as for non-differential PSK but the phase ambiguities can be ignored.

QAM is the method of combining two amplitude modulated signals into one channel. It may be an analogy QAM or a digital QAM. Analogy QAM combines two amplitude modulated signals using the same carrier frequency with a 90 degree phase difference. Adaptive channel equalizers utilize channel estimates to overcome the effects of inter symbol interference. Diversity techniques utilize the channel estimate to implement a matched filter such that the receiver is optimally matched to the received signal instead of the transmitted one.

Maximum likelihood detectors utilize channel estimates to minimize the error probability. One of the most important benefits of channel estimation is that it allows the implementation of coherent demodulation. Coherent demodulation requires the knowledge of the phase of the signal. This can be accomplished by using channel estimation techniques. In this paper channel impulse response has been estimated and compared using LS, MMSE and DFT /DWT based estimation techniques. The paper is organized as follows.

2. LITERATURE SURVEY:

Orthogonal frequency division multiplexing (OFDM) is a popular method for high data rate wireless transmission. OFDM may be combined with antenna arrays at the transmitter and receiver to increase the diversity gain and/or to enhance the system capacity on time-varying and frequency-selective channels, resulting in a multiple-input multiple-output (MIMO) configuration.

The paper explores various physical layer research challenges in MIMO-OFDM system design, including physical channel measurements and modelling, analogy beam forming techniques using adaptive antenna arrays, space-time techniques for MIMO-OFDM, error control coding techniques, OFDM preamble and packet design, and signal processing algorithms used to perform time and frequency synchronization, channel estimation, and channel tracking in MIMO-OFDM systems. Finally, the paper considers a software radio implementation of MIMO-OFDM.

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3. Orthogonal Frequency Division Multiplexing:

In OFDM systems, the available bandwidth is broken into many narrower subcarriers and the data is divided into parallel streams, one for each subcarrier each of which is then modulated using varying levels of QAM modulation e.g. QPSK, 16QAM, 64QAM or higher orders as required by the desired signal quality. The linear combination of the instantaneous signals on each of the subcarriers constitutes the OFDM symbols. The spectrum of OFDM is depicted in fig.2-2. Each of the OFDM symbol is preceded by a cyclic prefix (CP) which is effectively used to eliminate Inter symbol Interference (ISI) and the subcarriers are also very tightly spaced for efficient utilization of the available bandwidth. Based on the various advantages that have been mentioned in the preceding sections, OFDMA is considered as an excellent multiple access schemes for the 3GPP LTE downlink. OFDMA uses multiple orthogonal subcarriers each of which is modulated separately. OFDMA distributes subcarriers to different users at the same time so that multiple users can be scheduled to receive data simultaneously; each of these is referred to as a physical resource block (PRB) in the LTE specification.

4. Multiple in Multiple out (MIMO) Antennas:

MIMO antenna technology is one of the key technologies leveraged on by LTE. It is a technology in which multiple antennas are used at both the transmitter and at the receiver for enhanced communication: The use of additional antenna elements at either the base station (eNodeB) or User Equipment side (on the uplink and/or downlink) opens an extra spatial dimension to signal pre-coding and detection. Depending on the availability of these antennas at the transmitter and/or receiver, the following classifications exist.

Single-Input Multiple-Output (SIMO):

A simple scenario of this is an uplink transmission whereby a multi-antenna base station (eNodeB) communicates with a single antenna User Equipment (UE).

Multiple-Input Single-Output (MISO):

A downlink transmission whereby a multi-antenna base stationcommunicates with a single antenna User Equipment (UE) is a scenario.

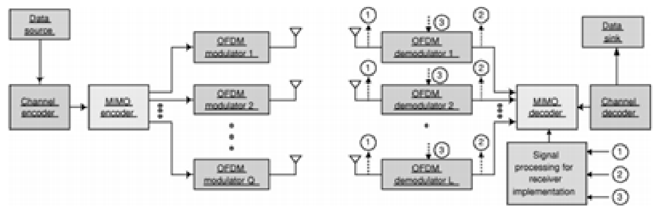
Single-User MIMO (SU-MIMO):

This is a point-to-point multiple antenna link between a base station and oneUE.

Multi-User MIMO (MU-MIMO):

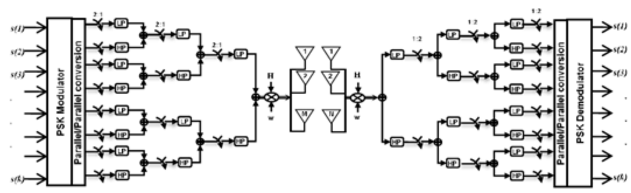
This features several UE‟s communicating simultaneously with a commonbase station using the same frequency- and time-domain resources.

Block Diagram of MIMO:



5.Wavelet based Multi-user OFDM with MIMO:

A Wavelet based OFDM system with beam former and MIMO configuration is explained in this section. The transmitter and receiver part respectively with K=8 number of sub-carriers as an example. We consider this system is in a multi-user environment of K interfering users, where Kth user decorated with number of antennas is communicating with a base station equipped with N number of antennas.



2.4FigureWavelet based Multi-user OFDM with MIMO:

On the transmitter side, first a binary phase shift keying (BSPK) modulator is used for mapping S(k) data stream to the symbol stream x(n) . After the mapping process a parallel- to-parallel (P/P) converter reshapes the modulated data stream into, for example, N = 8 parallel data streams. This P/P converter makes sure that where n is an integer, so that the transmitter can perform inverse discrete wavelet transform (IDWT) and produce one final sequence in stages.

ISSN No: 2348-4845
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Sequential two symbol streams are up-sampled by the up-sampling factor 2, filtered by the wavelet filter or, respectively, and then summed. Output streams are up-sampled by 2, filtered and summed again. The up-sampling and filtering processes continue until one single output stream is obtained. To satisfy the Orthogonality criterion of the wavelet filters we use Quadrature Mirror Filter (QMF) bank. According to QMF, the relationship between both filters is given by, where L is the filter length of the impulse response g (n). After obtaining the output stream (or wavelet coefficients), is multiplied by Beam forming vector and weighted signals are added to form the output signal.Orthogonal frequency division multiplexing (OFDM) has recently become a key modulation technique for both broadband wireless and wire-line applications. It has been adopted for digital audio broadcasting (DAB) and digital terrestrial television broadcasting (DVB). OFDM is a special case of Multicarrier transmission, where a single data stream is transmitted over number of lower rate Sub-carrier. The problem of intersymbol interference (ISI) introduced by multipath channel is significantly reduced in OFDM by using the cyclic prefix (CP) as a guard interval between OFDM blocks.

The proposed work would be a brief overview of IFFT & FFT algorithm to be effectively used in OFDM system. OFDM is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers. The main reason to use OFDM is to increase the robustness against the selective fading or narrowband interference. In single carrier system if signal get fade or interfered then entire link gets failed whereas in multicarrier system only a small percentage of the sub-carriers will be affected. The total signal bandwidth, in a classical parallel data system, can be divided into N non-overlapping frequency sub-channels. Each sub-channel is modulated a separate symbol and then N sub-channels are frequency multiplexed. The general practice of avoiding spectral overlap of sub-channels was applied to eliminate inter-carrier interference (ICI). This resulted in insufficient utilization of the existing spectrum. An idea was proposed in the mid1960's to deal with this wastefulness through the development of frequency division multiplexing (FDM) with overlapping sub-channels. The sub-channels were arranged so that the sidebands of the individual carriers overlap without causing ICI. This principle is shown in Fig 1(B). To achieve this, the carriers must be mathematically orthogonal. From this constraint the idea of OFDM was born.

OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier. OFDM is a special case of FDM.

6. QAM Modulation and Demodulation:
6.1.Quadrature amplitude modulation (QAM)

It is both an analogy and a digital modulation scheme. It conveys two analogy message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analogy modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analogy case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant. QAM is used extensively as a modulation scheme for digital telecommunication systems. Arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel.

Transmitter:

The following picture shows the ideal structure of a QAM transmitter, with a carrier frequency and the frequency response of the transmitter's filter:

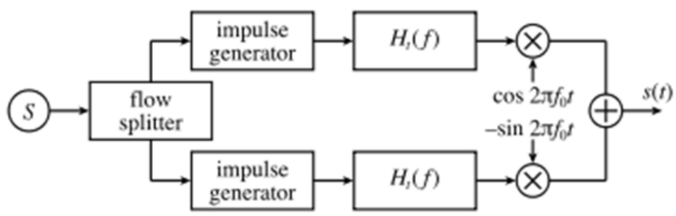

Figure 2.15 The ideal structure of a QAM transmitter.

ISSN No: 2348-4845
International Journal & Magazine of Engineering,
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First the flow of bits to be transmitted is split into two equal parts: this process generates two independent signals to be transmitted. They are encoded separately just like they were in an amplitude-shift keying (ASK) modulator. Then one channel (the one "in phase") is multiplied by a cosine, while the other channel (in "quadrature") is multiplied by a sine. This way there is a phase of 90° between them. They are simply added one to the other and sent through the real channel.

The sent signal can be expressed in the form:

$$s(t) = \sum_{n=-\infty}^{\infty} [v_c[n]\cdot h_t(t-nT_s)\cos(2\pi f_0 t) - v_s[n]\cdot h_t(t-nT_s)\sin(2\pi f_0 t)]$$

where $v_c[n]$ and $v_s[n]$ are the voltages applied in response to the n^{th} symbol to the cosine and sine waves respectively.

Receiver:

The receiver simply performs the inverse process of the transmitter. Its ideal structure is shown in the picture below with the receive filter's frequency response :

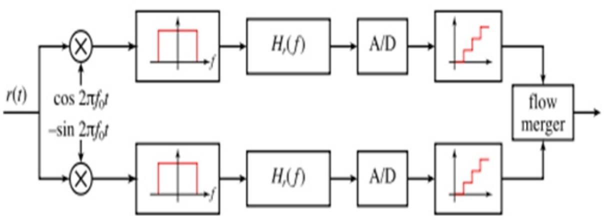
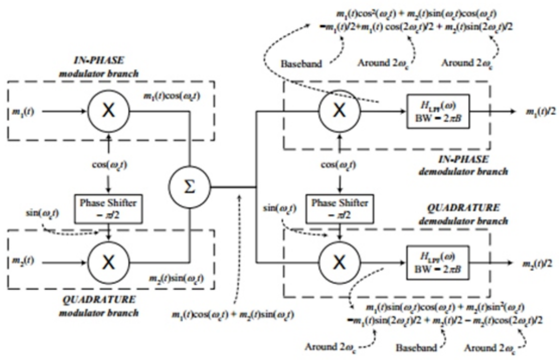


Figure 2.16 The ideal structure of a QAM Receiver

Multiplying by a cosine (or a sine) and by a low-pass filter it is possible to extract the component in phase (or in quadrature). Then there is only an ASK demodulator and the two flows of data are merged back. In practice, there is an unknown phase delay between the transmitter and receiver that must be compensated by synchronization of the receiver's local oscillator; i.e., the sine and cosine functions in the above figure.

In mobile applications, there will often be an offset in the relative frequency as well, due to the possible presence of a Doppler shift proportional to the relative velocity of the transmitter and receiver. Both the phase and frequency variations introduced by the channel must be compensated by properly tuning the sine and cosine components, which requires a phase reference, and is typically accomplished using a Phase-Locked Loop (PLL).

If you noticed, you would see that so far we have always used a carrier that is c(t) = cos(ωCt) to modulate the message signals both in AM and DSBSC. There is nothing special about using a cosine instead of a sine carrier. In fact, we can transmit two signal using the same carrier frequency but using cos(ωCt) for one of the message signals and sin(ωCt) for the other signal. These transmitted signals if transmitted over the same channel would not interfere with each other and can be demodulated. Consider the following block diagram of a Quadrature Amplitude Modulation (QAM) and Demodulation system:



QAM Modulator/Demodulator

Figure: QAM modulater /De modulater

Wavelet Based Channel Estimation:

A wavelet is a small piece of a wave. Where a sinusoidal wave as is used by Fourier transforms carries on repeating itself for infinity, a wavelet exists only within a finite domain, and is zero-valued elsewhere.

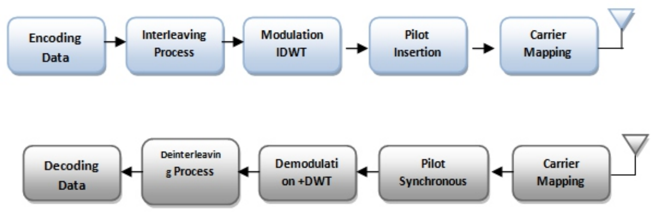


Figure: Block Diagram: DWT Based OFDM

A wavelet transform involves convolving the signal against particular instances of the wavelet at various time scales and positions. Hence, wavelet transform as a joint time-frequency domain. The typical application fields of wavelets are like Astronomy, acoustics, nuclear engineering, sub-band coding, signal and image processing. There are some sample applications identifying pure frequencies, De-noising signals, Detecting discontinuities and breakdown points, Detecting self-similarity and Compressing samples.

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IMPLEMENATION PROCESS: QUADRATURE AMPLITUDE MODULATION (QAM):

QAM is both an analogy and a digital modulation scheme. It conveys two analogy message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analogy modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the final waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analogy case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant. QAM is used extensively as a modulation scheme for digital telecommunication systems.

QAM PROCESS:

Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. It is widely used because it offers advantages over other forms of data modulation such as PSK, although many forms of data modulation operate alongside each other.Quadrature Amplitude Modulation, QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation.

A motivation for the use of quadrature amplitude modulation comes from the fact that a straight amplitude modulated signal, i.e. double sideband even with a suppressed carrier occupies twice the bandwidth of the modulating signal. This is very wasteful of the available frequency spectrum. QAM restores the balance by placing two independent double sideband suppressed carrier signals in the same spectrum as one ordinary double sideband suppressed carrier signal.

ANALOGUE AND DIGITAL QAM:

Quadrature amplitude modulation, QAM may exist in what may be termed either analogue or digital formats. The analogue versions of QAM are typically used to allow multiple analogue signals to be carried on a single carrier. For example it is used in PAL and NTSC television systems, where the different channels provided by QAM enable it to carry the components of chrome or colour information. In radio applications a system known as C-QUAM is used for AM stereo radio. Here the different channels enable the two channels required for stereo to be carried on the single carrier.Digital formats of QAM are often referred to as “Quantised QAM” and they are being increasingly used for data communications often within radio communications systems. Radio communications systems ranging from cellular technology as in the case of LTE through wireless systems including WiMAX, and Wi-Fi 802.11 use a variety of forms of QAM, and the use of QAM will only increase within the field of radio communications.

Digital / Quantised QAM basics:

Quadrature amplitude modulation, QAM, when used for digital transmission for radio communications applications is able to carry higher data rates than ordinary amplitude modulated schemes and phase modulated schemes. As with phase shift keying, etc, the number of points at which the signal can rest, i.e. the number of points on the constellation is indicated in the modulation format description, e.g. 16QAM uses a 16 point constellation. When using QAM, the constellation points are normally arranged in a square grid with equal vertical and horizontal spacing and as a result the most common forms of QAM use a constellation with the number of points equal to a power of 2 i.e. 4, 16, 64 . . . .By using higher order modulation formats, i.e. more points on the constellation, it is possible to transmit more bits per symbol. However the points are closer together and they are therefore more susceptible to noise and data errors.Normally a QAM constellation is square and therefore the most common forms of QAM 16QAM, 64QAM and 256QAM.The advantage of moving to the higher order formats is that there are more points within the constellation and therefore it is possible to transmit more bits per symbol. The downside is that the constellation points are closer together and therefore the link is more susceptible to noise.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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As a result, higher order versions of QAM are only used when there is a sufficiently high signal to noise ratio.To provide an example of how QAM operates, the constellation diagram below shows the values associated with the different states for a 16QAM signal. From this it can be seen that a continuous bit stream may be grouped into fours and represented as a sequence.

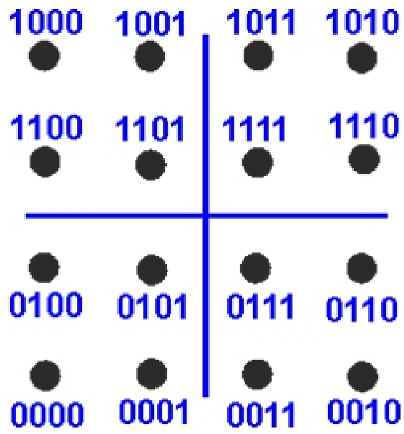

Figure 4.1Bit sequence mapping for a 16QAM signal

Normally the lowest order QAM encountered is 16QAM. The reason for this being the lowest order normally encountered is that 2QAM is the same as binary phase-shift keying, BPSK, and 4QAM is the same as quadrature phase-shift keying, QPSK.Additionally 8QAM is not widely used. This is because error-rate performance of 8QAM is almost the same as that of 16QAM - it is only about 0.5 dB better and the data rate is only three-quarters that of 16QAM. This arises from the rectangular, rather than square shape of the constellation.

QAM advantages and disadvantages:

Although QAM appears to increase the efficiency of transmission for radio communications systems by utilising both amplitude and phase variations, it has a number of drawbacks. The first is that it is more susceptible to noise because the states are closer together so that a lower level of noise is needed to move the signal to a different decision point. Receivers for use with phase or frequency modulation are both able to use limiting amplifiers that are able to remove any amplitude noise and thereby improve the noise reliance. This is not the case with QAM. The second limitation is also associated with the amplitude component of the signal. When a phase or frequency modulated signal is amplified in a radio transmitter, there is no need to use linear amplifiers, whereas when using QAM that contains an amplitude component, linearity must be maintained. Unfortunately linear amplifiers are less efficient and consume more power, and this makes them less attractive for mobile applications.

RESULT and CONCLUSION:
BER PERFORMANCE EVALUATION:

By using MATLAB performance characteristic of DFT based OFDM and wavelet based OFDM are obtained for different modulations that are used for the LTE, as shown in figures. Modulations that could be used for LTE are QPSK, 16 QAM and 64 QAM (Uplink and downlink). QPSK does not carry data at very high speed. When signal to noise ratio is of good quality then only higher modulation techniques can be used. Lower forms of modulation (QPSK) does not require high signal to noise ratio.

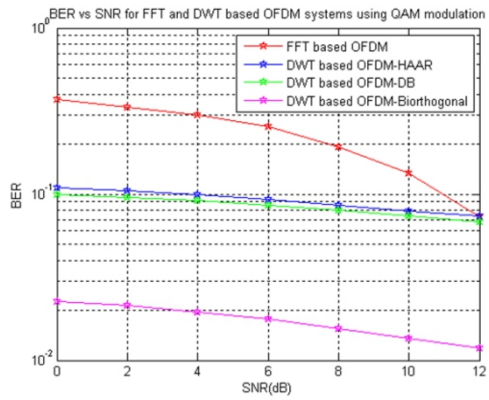

Figure 6.1 Comparison Analysis of FFT vs. Wavelet for HAAR; DB; Biorthogonal Process Using 16QAM

CONCLUSION AND FUTURE SCOPE:

The behaviour of DWT-OFDM for LTE system and FFT-OFDM for LTE system is studied and simulation is done for the same. DWT based analysis is suggested as an alternate for FFT based analysis. . Unlike Fourier transform based system which requires cyclic prefix, during transmission cyclic prefix is not needed in wavelet based analysis.16-QAM modulation is used in the simulation process. Haar function is used in the wavelet analysis as it provides a better performance when compared with the other wavelet functions. For the OFDM the parameters for LTE specifications of sub-channel spacing 15 kHz and a bandwidth 10 MHz has been used. The results were plotted in terms of BER and EbNo.

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Through comparison of the results it is clear that DWT-OFDM for LTE system is superior when compared to that of FFT OFDM for LTE system. The error rate can be minimized by using DWT-OFDM for LTE when compared to FFT OFDM for LTEIn this Project weanalysed the performance of wavelet based OFDM system and compared it with the performance of DFT based OFDM system. From the performance curve we have observed that the BER curves obtained from wavelet based OFDM are better than that of DFT based OFDM. We used three modulation techniques for implementation that are 16 QAM ; 64 QAM and 256 QAM which are used in LTE. We Have Used daubechies2, HAAR and Biorthogonal Wavelets all are provide their best Performances at Different Intervals of SNR .

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