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MIMO-OFDM Communication System Design using 256 HQAM

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***Abstract:** In this paper, we have proposed a higher order QAM i.e. 256-HQAM where non-uniform signal constellation with hierarchical oriented OFDM modulator is used to provide lesser BER and higher efficiency in the compressed image data at lower channel Signal to Noise Ratio (SNR). Hierarchical quadrature amplitude modulation (HQAM) enables unequal priority transmission with the help of irregularly spaced constellations Hierarchical Quadrature Amplitude Modulation (HQAM), a modification of QAM, offers Unequal Error Protection (UEP) to the transferred bits for increasing the protection to the transferred bits as well as it is also efficient in bandwidth and power. A Hierarchical modulation is a better method for achieving a high quality and high speed in digital image transmission in a band-limited fading channel. The Hierarchical QAM (HQAM) constellation give unequal priorities of error protection of the most important information of the image content. An information theoretical approach is applied to analyse the performance of proposed technique. Using the approach, it is quantitatively evaluated how much the proposed technique outperforms. Analytical BER and PSNR of reconstructed image of HQAM formats, which include uniform and non-uniform constellations, over AWGN environments, have been examined. The performance of proposed and existing technique has been evaluated.*

***Keywords**: - LP, HP, Modulation, HQAM, Constellation.*

I. INTRODUCTION

Like all modulation schemes, QAM conveys data by changing some aspect of a carrier signal, in response to a data signal. In the case of QAM, the amplitude of two waves, 90 degrees out-of-phase with each other (in quadrature) is changed to represent the data signal. Amplitude modulating two carriers in quadrature can be equivalently viewed as both amplitude modulating and phase modulating a single carrier. QAM provides higher transmission efficiency by utilizing both amplitude and phase variations [2,11]. However it requires higher transmission bandwidth due to its equal error protection to transmitted bits. So this may lead to cliff effect. Cliff effect describes sudden loss of digital signal reception. Unlike analog signals, which gradually fade when signal strength decreases, or electromagnetic interference or multipath increases, a digital signal provides data which is either perfect or nonexistent at receiving end. Hierarchical QAM divides incoming data stream into two parts i.e HP (High priority) and LP(Low priority) bits. Here extra protection is provided to high priority or sensitive bits than on lower sensitive bits. The data streams of hierarchical modulation vary in their susceptibility to noise. In other words, the service coverage areas differ in size. The better-protected data stream is referred to as the High-Priority (HP) stream; the other one is referred to as the Low Priority (LP) stream[2,7]. Compared with non-hierarchical modulation, the HM data stream with the lower data rate can be used to supply a larger coverage area, whereas the coverage area of the data stream with the higher data rate is only insignificantly smaller than for the corresponding non-HM variant. This subdivision alone can be of practical benefit. It is possible to enlarge the coverage area of the HP stream even further by changing the modulation parameter α at the expense of the robustness of the LP stream. This is done on changing the modulation parameter α. α is the ratio of distance between the points between quadrants to the distance between the points within the quadrant in the constellation diagram. When α. increases, the distance of constellation points between quadrants increases and within quadrant decreases. Thus improvement of HP performance is done at the expense of LP. It is expected that by increasing α. , BER of HP bits decreases and LP increases. Energy ratio of two streams is $(1+\alpha)^2$.

II. HIERARCHICAL 256-QAM

Hierarchical modulations were initially proposed to provide different classes of data to users in different wireless reception conditions [1-3]. The first sub-channel (HP) is formed by the two most significant bits (MSBs) of the four bit symbol, and the second sub-channel (LP) is formed by the two least significant bits (LSBs) of the symbol. Bits transmitted via the HP sub-channel are received with a lower probability of error than those transmitted via the LP sub-channel [3-6]. The splitting of the symbol into sub-channels leads to improved Bit Error Rates (BER) for the channels that carry the most important information of the video. The bits from the H.264 video source encoder that are most sensitive in terms of picture quality are assigned in the HP sub-channel and the remaining bits assigned in the LP sub-channel. To improve the transmission efficiency of the System, higher error protection can be applied to the most important data of the coded video data by using 16-HQAM with $\alpha > 1$, where alpha is the ratio of between the minimum distance between quadrants (d1) and minimum distance between points inside each quadrant (d2) and so is given by

$$\alpha = d1/d2 \qquad (1)$$

In this case the performance of the HP will be improved at the expense of LP. 16-QAM constellation naturally forms two different-integrity sub-channels. Fig.1 show the constellation of 256-HQAM modulation, where d1 and d2 are the minimum distance between points inside each quarter.

To increase throughput, wireless communications use one of the following three strategies: (1) higher order modulation schemes, (2) wider channel bandwidth, and (3) more spatial streams. Of course, wireless LAN (WLAN) is no exception. While still in predraft status today, 802.11ac will likely be the next wireless LAN specification that we see in consumer products. Like previous standards, 802.11ac builds on similar strategies of higher order modulation types, wider bandwidth, and more spatial streams to increase data rates over existing 802.11n products.

III. HIGHER ORDER MODULATION TYPES

Increasing the order of a modulation type is one of the simplest ways to increase throughput in high signal-to-noise ratio (SNR) environments. In systems using quadrature amplitude modulation (QAM), the throughput of the physical channel is directly related to the QAM "order." For example, a 16-QAM channel is capable of four bits per symbol [8], since two is the maximum number of bits that can be represented by four unique symbols [$\log_2(16) = 4$]. Similarly, a 64-QAM channel yields six bits per symbol. The new IEEE 802.11ac specification is one of the first consumer wireless standards to allow to 256-QAM. While 256-QAM and even 1,024-QAM have already been adopted by some wireline communications systems such as DOCSIS 3.0 digital cable, nothing more complex than 64-QAM has ever been adopted in a mass market consumer product until now.

The 256-QAM format yields eight bits per symbol and [$\log_2(256) = 8$], thus providing a 33 percent higher throughput than the 64-QAM scheme from 802.11a/g/n. In Figure 1, we can observe the constellation plot of a 256-QAM signal. The capability of a digital communications channel to use a higher order modulation type such as 256-QAM requires that a sufficiently high SNR be sustained. Thus, in practical use, the 256-QAM modulation type is used only in scenarios where the transmitter and receiver are in reasonably close proximity.

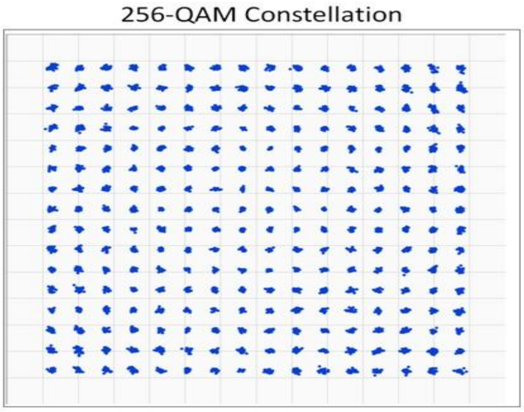


Figure 1-HQAM constellation diagram [1]

As we look forward to 802.11ac, we can observe that physical layer changes from 802.11a/g/n such as higher order modulation types, wider channel bandwidths, and more spatial streams each individually will result in higher theoretical data throughput. Table I, we compare some of these fundamental characteristics between each standard.

Table I. Several techniques to increase data throughput in Digital communications systems

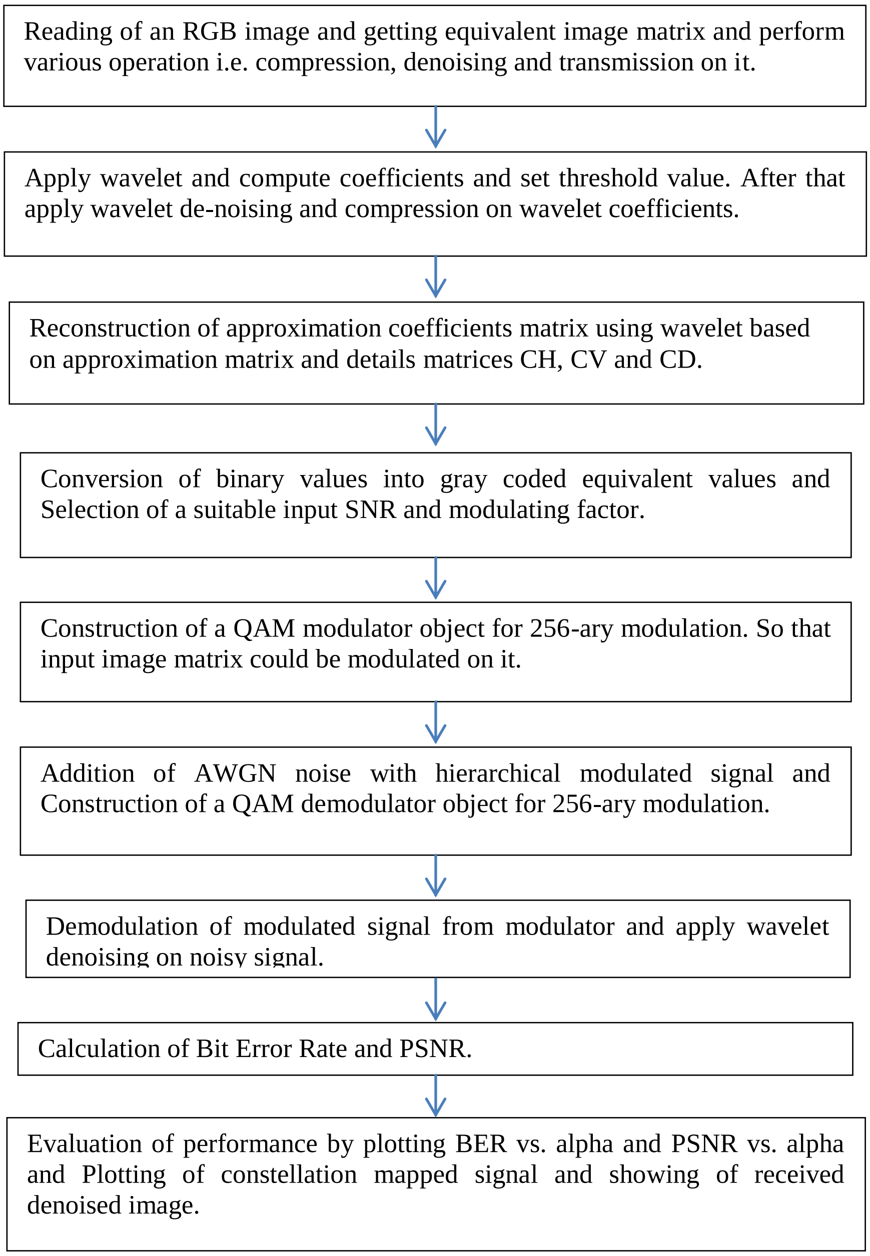
	802.11a/g	**802.11n**	**802.11ac**
Configuration of Antenna n	1x1 SISO	4x4 MIMO	8x8 MIMO
Modulation order	BPSK to 64-QAM	BPSK to 64-QAM	BPSK to 256-QAM
Bandwidth of channel	20 MHz	20 MHz and 20+20 MHz	20, 40, 80, 80 + 80, and 160 MHz
Year	1999 (802.11a) 2003 (802.11g)	2009 (draft)	2011 (draft)
Throughput (Max.)	54 Mbit/s	600 Mbit/s	6.93 Gbit/s

As we observe in Table I, each of the past two evolutions of Wi-Fi have resulted in roughly an order of magnitude improvement in theoretical data throughput. This is no different with 802.11ac, which has the potential to provide up to 6.93 Gbit/s data rates.

IV. COMPARISON OF QAM AND HQAM:

1. Quadrature Amplitude Modulation (QAM) is a big name for a relatively simple technique. QAM provides equal error protection to the transmitted bits by assigning equal priority to both the significant and non-significant bits of data; hence it is classified as equal error protection (EEP) method of modulation [12]. This, however, is not desirable in case of image transmission where unequal error protection (UEP) is needed. Performance can be increased even more by putting extra protection on the highly sensitive bits than low sensitive bits using unequal error protection (UEP) schemes. Hierarchical QAM which is a modification of QAM, has the property of providing un-equal protection and can, therefore, be used to advantage in transmission of images over wireless erroneous channels [12]. HQAM provides better transmission and Moderation in value of modulation parameter results in increase in PSNR and low BER [9]. HQAM provides more coverage area for important information. It also provides better degree of protection.

V. PROPOSED METHODOLOGY



VI. IMPLEMENTATION AND RESULTS

We have implemented a simulation using the proposed technique for transmission and reception of gray scale image. All simulations are performed using MATLAB 2010a. A simulation has been performed to transmit and reception of an image. Also, Bit Error Rate for proposed schemes is calculated with Signal to Noise Ratio. A graph has been plotted between BER and different values of alpha. Figure 2 shows the original transmitted image. Figure 3 shows reconstructed compressed image using DWT. Figure 4 shows received image. Figure 5 is for plotting the BER values for different values of alpha. Figure 6 is for plotting the PSNR values for different values of alpha. Plot is gradually increasing with increasing values of alpha. Figure 7 shows the constellation diagram for 256 HQAM and mapping of input signal on constellation respectively.

Figure 2: Original Image

Figure 3: Reconstructed compressed Image

Figure 4: Received Image

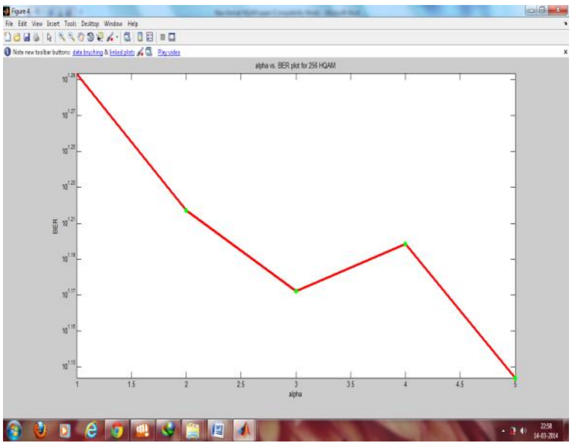


Figure 5: BER vs. alpha

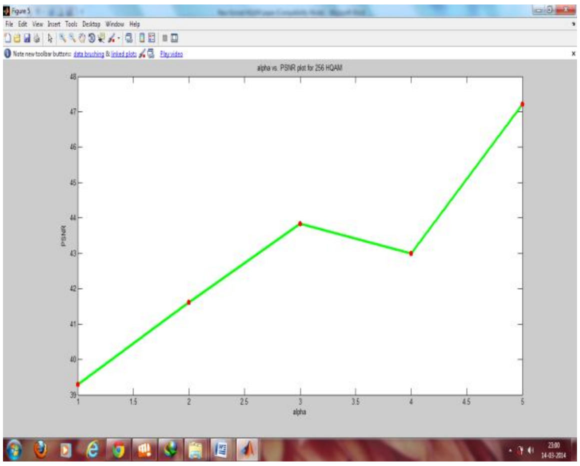


Figure 6: PSNR vs. Alpha

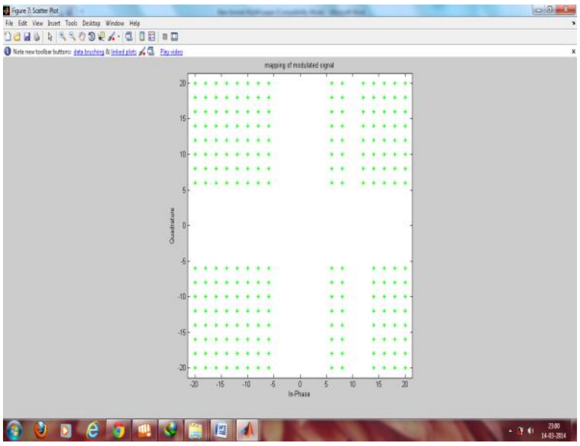


Figure 7: constellation diagram

VII. CONCLUSION

QAM gives very high efficiency for transmission. Also, it provides low BER by utilizing both amplitude and phase variations, in multimedia transmission. QAM requires higher transmission bandwidth due to its equal protection of high and low priority data bits. Hierarchical QAM (HQAM) has an important advantage that it overcomes this problem by providing more protection to the higher priority bits and less protection to the lower priority bits of the multimedia data. Also, proposed technique resolves the problem which occurs due to variable bit rate ratio and fixed allocated capacities for the high priority (HP) and low priority (LP) data layers by introducing 256 HQAM arrangement with hierarchical oriented OFDM modulator. This system not only lowers down the BER, but also increases the PSNR of received image. Thus proposed technique being a major modification of QAM technique provides a more efficient means of image transmission over erroneous wireless channel without any additional hardware.

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