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Designing and Comparative Analysis of Image Transmission using Techniques HQAM and QAM

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Abstract: ***In transmission of compressed images, image compression algorithms introduce error extension effects and significantly reduce the received image quality. Channel coding can be used to provide protection against these errors but it demands increased bandwidth. Asymmetric modulation methods like QAM and QPSK provide alternative means of equal error protection to all the coded bits without increasing the bandwidth. This paper surveys the suitability of Hierarchical QAM (HQAM) where non-uniform signal constellation is used to provide different degrees of protection to the significant and non-significant bits in the compressed image data. 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. This paper surveys about different image transmission techniques for achieving a high quality and high speed in digital image transmission in a band-limited fading channel***

Keywords: OFDM, QAM, HQAM

1. Introduction

The block diagram of multicarrier O-OFDM transmission is presented in Fig. 1. Here, R_b coded input bits are mapped onto R_s complex-valued M-QAM symbols in order to modulate the information-carrying frequency domain subcarriers. In general, N subcarriers form the OFDM frame. Each subcarrier occupies a bandwidth of 1/NT, where T is the sampling period, in a total OFDM frame double-sided bandwidth of B=1/T . Here, the bandwidth utilization factor is denoted by , G_b Where G_B= (N-2)/N in DCO-OFDM and G_B=0.5 in ACO-OFDM. Both systems have the symmetry imposed on the OFDM frame, in order to ensure a real-valued time domain signal. While in DCO-OFDM the information-carrying subcarriers populate the first half of the frame, leaving the 0-th and the N/2-th subcarriers set to zero, in ACO-OFDM every even subcarrier is set to zero. Both schemes can utilize bit and power loading of the frequency domain subcarriers, in order to optimally adapt the signal to the channel conditions. For a desired bit rate, R_b, the Levin-Campello algorithm [1, 2] can be applied, in order to minimize the required electrical SNR. The average electrical power of the G_BN symbols on the enabled subcarriers amounts to $P_{s(elec)}/G_B$, where $P_{s(elec)} = E_{b(elec)} R_b$=(sigma)^{2}for an average electrical bit energy of $E_{b(elec)}$ and an OFDM symbol variance of (sigma)^2. The OFDM symbol is obtained by the IFFT of the OFDM frame. Therefore, follows a real-valued zero-mean Gaussian distribution with a variance of (sigma)^2 for a large number of subcarriers according to the CLT. In general, a cyclic prefix (CP) is appended atthe beginning of every OFDM symbol to mitigate inter-symbol interference (ISI) and inter-carrier interference (ICI). A large number of subcarriers and a CP transform the dispersive optical wireless channel into a flat fading channel over the subcarrier bandwidth, reducing the computational complexity of the equalization process at the receiver to a single-tap equalizer [3]. However, since the CP is shown to have a negligible impact on the information rate of an OWC system, it is omitted in the derivations for the sake of simplicity. The nonlinear transfer characteristic of the LED transmitter can be compensated by pre-distortion with the inverse of the nonlinear transfer function. The pre-distorted OFDM symbol is subjected to a parallel-to-serial (P/S) conversion, and it is passed through the digital-to-analog (D/A) converter.

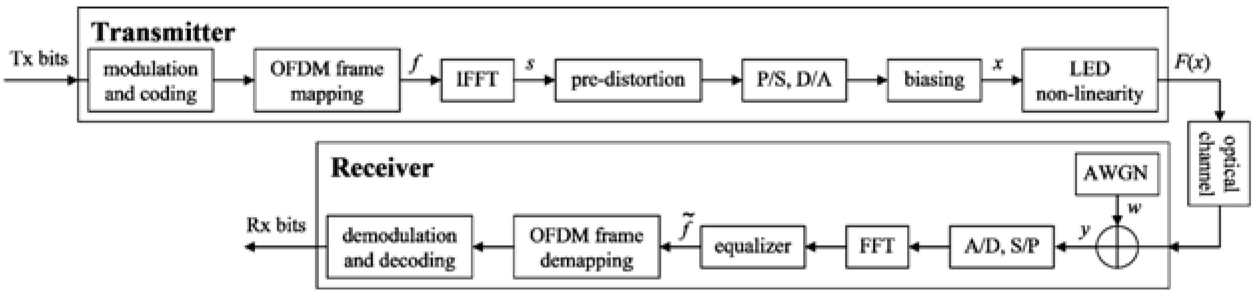


Figure 1: Block diagram of optical OFDM transmission.

2. Model of Image Transmission System

The essentials of the image transmission system considered here are shown in Fig. 2. The source encoder encodes the source image using appropriate image compression technique. For the protection of coded image in Fig. 2 channel encoder add redundancy to the coded image by using appropriate channel coding technique. Modulator modulates the coded image and transmits through wireless channel. QAM is invariably used as the modulation technique [4]. The channel introduces noise and distortion to the transmitted image. The demodulator receives the image data with error and demodulates it. After channel decoding, the coded image is decompressed. There are two major constraints in transmission of images over wireless channels. First there are fluctuations in the channel bandwidth for this reason the image data must be compressed. Second, there is a high probability of channel error for this reason the image data must be protected from errors in order to maintain image quality.

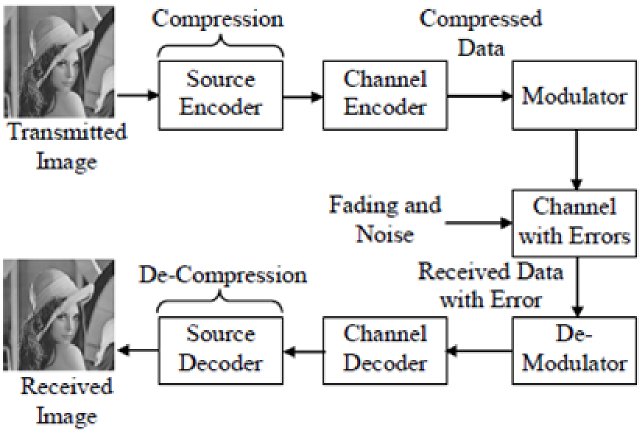


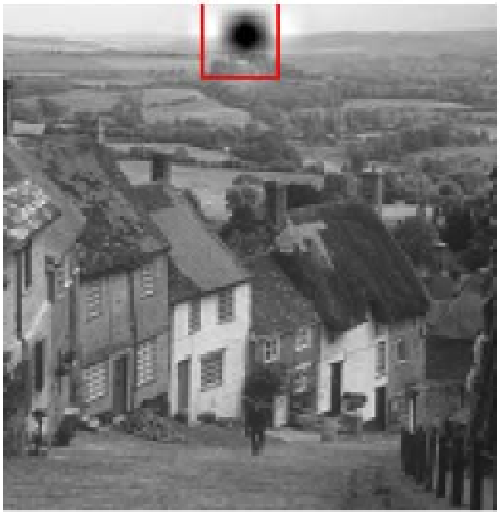
Figure 2: Model of image transmission system [4].

3. Effects of Noise and Distortion in Image Transmission

The most common type of noise that is encountered in image transmission system is the Salt and pepper noise (special case of impulse noise) [9], where a certain percentage of individual pixels in digital image are randomly digitized into two extreme intensities (maximum and minimum). Faulty memory locations or transmission through erroneous channels can result in the received image being corrupted with this type of noise [8]. The effect of salt and pepper noise on the received image is shown in Fig. 3(a).

(a)

(b)



(c)

(d)

Figure 3: (a) Effects of Salt & pepper noise (b) Effects of error in critical bits (c) Effects of error in sign bit (non-critical bit) (d) Effects of error in refinement bits [4]

Distortion in images occurs when errors cause local variations in image scale and coordinate location of the image pixels. The distortion is more severe when the errors occur in critical (significant/high priority) bits of the received signal. For errors in non-critical bits (sign bits/low priority bits and refinement bits/low priority bits) the distortion is not that severe. This can be seen from Fig. 3(b), 3(c) and 3(d). Fig. 3(b) corresponds to the case when the errors are in significant bits while Fig. 3(c) and 3(d) result when the error is in sign or refinement bits. Thus in image transmission it is necessary to give more protection to significant bits as compared to the insignificant bits rather than giving equal protection to all the bits [4].

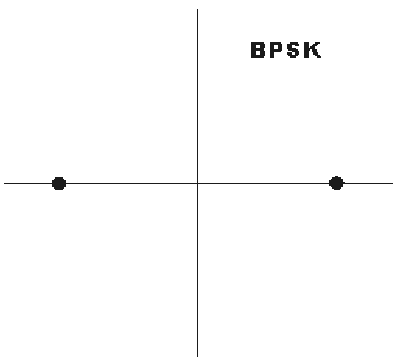
4. QAM and HQAM

Quadrature Amplitude Modulation (QAM) is a big name for a relatively simple technique. For a given channel bandwidth, QAM transmits more information as compared to BPSK and QPSK. However, 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. When a phase or frequency modulated signal is amplified in a 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 [5]. The signal constellation diagrams are shown in Fig. 4. It can be seen from the Figure that 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 [6, 8]. 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 [4].

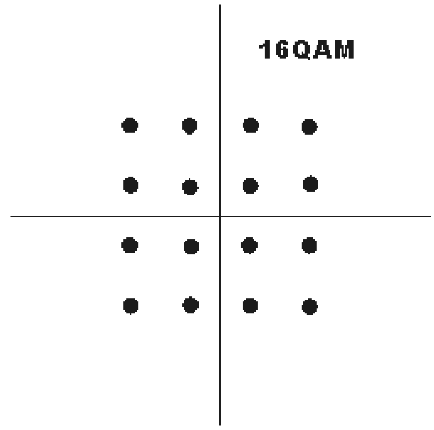
Hierarchical Quadrature Amplitude Modulation (HQAM) is more spectrally efficient and dc-free modulation scheme [7]. It provides different degree of protection to the transmitted data bits, in which the high priority (HP) data bits are mapped to the most significant bits (MSB) and the low priority (LP) data bits are mapped to the least significant bits (LSB) of the modulation constellation points. Using HQAM will, therefore, result in improved image quality compared with QAM specially at low channel SNR conditions, since the highly sensitive HP data bits are mapped to the MSBs with low bit error rate (BER) in HQAM.

5. Constellation Diagrams for QAM

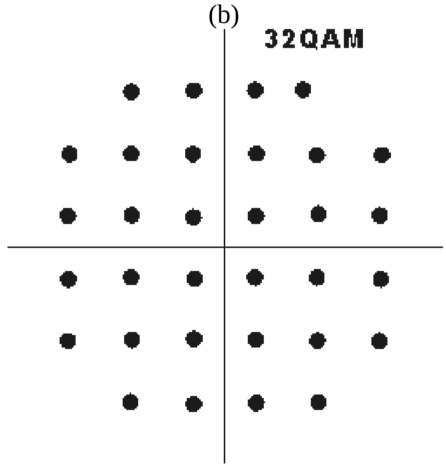
The constellation diagrams show the different positions for the states within different forms of QAM, quadrature amplitude modulation. As the order of the modulation increases, so does the number of points on the QAM constellation diagram.
The figure 4 shows the constellation diagrams for a variety of formats of modulation



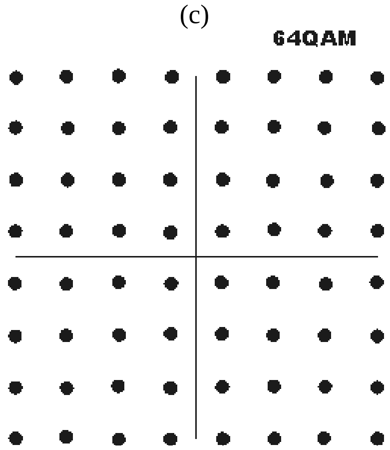
(a)



(b)



(c)



(d)

Figure 4: Constellation Diagrams (a) BPSK (b) 16 QAM (c) 32 QAM (d) 64 QAM

The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol. By selecting a higher order format of QAM, the data rate of a link can be increased. The table I give a summary of the bit rates of different forms of QAM and PSK.

Table 1: Bit rates of different forms of QAM and PSK

Modulation	Bits per symbol	Symbol Rate
BPSK	1	1 x bit rate
QPSK	2	1/2 bit rate
8PSK	3	1/3 bit rate
16QAM	4	1/4 bit rate
32QAM	5	1/5 bit rate
64QAM	6	1/6 bit rate

6. Conclusion and Future Work

From above studies, we can conclude that Quadrature amplitude modulation (QAM) is a digital modulation technique in which both the amplitude and phase of a carrier are modulated to convey digital information. Actually, it takes two signals with the same frequency that are 90 degrees out of phase (i.e., in quadrature) and modulating their amplitude to convey information. Each signal carries equal part of the bit stream. At the receiver they are separated, the bits are read and then recombined to create the original bit stream. If each of the base signals has 8 defined amplitude levels, each signal can carry 8 bits per amplitude shift. Combining the two signals produces 256 unique 8-bit combinations, an encoding scheme known as 256-QAM. A constellation diagram is used to depict the encoding scheme. Constellation is labelled a bit differently, however, with the horizontal axis representing the In-phase Plane (I-Plane), and the vertical access representing the Quadrature-Phase Plane (Q-Plane), the names given to the two base signals. A major advantage of QAM is that, it spreads the constellation points more evenly across the graph. But a main disadvantage of QAM is that does not provide different degree of protection to the partitioned bit stream i.e. LSB and MSB.

Whereas, HQAM is a simple and efficient approach in which a non-uniform signal space constellation is used to give different degrees of protection. The advantage of this method is that different degrees of protection are achieved without an increase in bandwidth; in contrast to channel coding that increases the data rate by adding redundancy. One major drawback of conventional HQAM is that there are fixed allocated capacities for the high priority (HP) and low priority (LP) data layers (e.g. for 64-HQAM, 33% for HP and 66% for LP). However, in data partitioning, the corresponding parts of the coded data do not necessarily produce a constant bit-rate ratio. Therefore, conventional HQAM is not well suited to such application without either accepting delay or losing HP protection. To overcome this problem, a 256 HQAM arrangement is done with hierarchical oriented OFDM modulator for the digital image transmission, which does not use the concept of unequal error protection.

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