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Performance Analysis of 64-TQAM by Transmitting Image Over AWGN Channel

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Abstract:- Orthogonal Frequency Division Multiplexing (OFDM) technique allows simultaneous transmission of multiple signals over a single communication link, thus increasing the efficiency of the link. Quadrature Amplitude Modulation (QAM) is an attractive technique to achieve high transmission rate without increasing bandwidth. Also orthogonal systems have the property that as the number of orthogonal signals/channels increases, the performance graph becomes better. Due to this OFDM and QAM system were combined and has been used over decades showing the better performance. Triangular-QAM is a new modulation technique and the work done so far indicates it is better than Square-QAM. Thus if TQAM is combined with OFDM, there should be a performance increase overall. In this thesis the TQAM-OFDM system is simulated and performance is compared with the SQAM-OFDM systems with the help of quality of image transmitted over the systems, constellation diagrams and BER curves.

Keywords:- *SQAM, TQAM, BER, OFDM, Constellation.*

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a multiplexing technique in which orthogonal carriers are used for transmitting data. In OFDM the data to be transmitted is divided into many parallel bit streams and these streams are then imposed on orthogonal subcarriers generated by any of the Discrete Fourier Transform, e.g FFT,DCT.OFDM has been in use in many application from decades. Some examples of OFDM application are Digital Audio Broadcasting(DAB) and High Rate Digital Subcarrier Line(HDSL). IEEE 802.11 defines OFDM specification to be used. The modulation scheme used in OFDM include QAM or PSK. In [15] modeling and performance analysis of QAM-OFDM system has been done. Sung-Joon Park in [3] introduced Triangular Quadrature Amplitude Modulation and concluded that two dimensional triangular constellation are better than Square QAM as the constellation is more compact. The Power gain of 0.46dB and 0.55 dB is possible for 16-ary and 64-ary signal set.In [5] and [6] the optimum bit mapping for TQAM minimizing bit error is proposed. In [4] performance of TQAM over AWGN is analyzed. In this paper we have used irregular bit mapping and binary bit stream is mapped on to the signal constellation.

A colored image is transmitted over the 64TQAM-OFDM system and quality of image is analyzed.

We have transmitted same image over OFDM channel using 64-SQAM modulation and 64-TQAM modulation. The image is converted into binary data stream before being inserted into the OFDM system. In TQAM signal points are placed at the vertex of triangles. Value of the angle θ can be varied. We have plotted BER plot and constellation diagram.

Rest of the paper is organized as follows. In section II the bit mapping is explained. In section III OFDM system used in simulation is described. Section IV describes Simulation and results. In section V Conclusion is made and in Section VI Future Scope is explained.

II. TRIANGULAR QUADRATURE AMPLITUDE MODULATION

TQAM is a non uniform Quadrature amplitude Modulation technique in which signal points are present the vertex of a contiguous triangle. The bit mapping that we have used is symmetrical about both x-axis and y-axis. Bit mappimg for 64 –ary is obtained by extending signal points of 16-ary on both the axis. Fig[1] and Fig[2] shows the bit mapping for 16-ary and 64-ary TQAM.

Fig 1

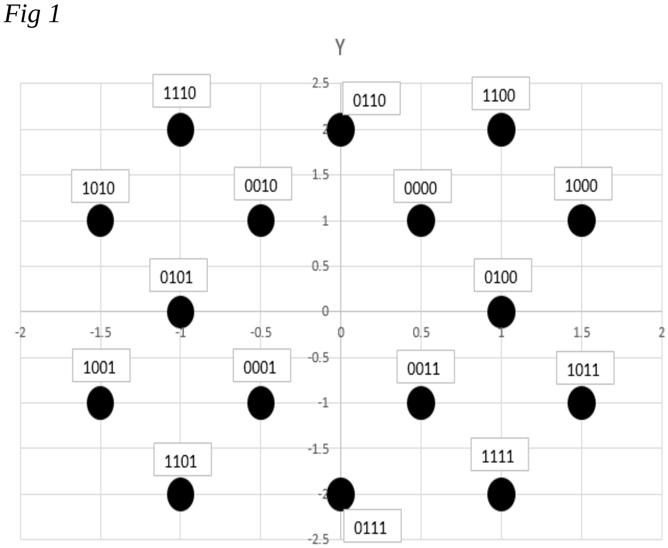

Fig 1: Bit Mapping for 16-TQAM

Fig 2

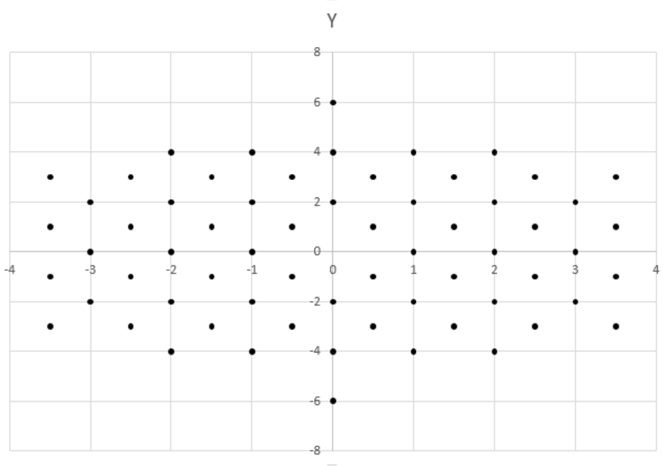

Fig 2: Bit Mapping for 64-TQAM

If d_{min} is the minimum distance between adjacent symbol, then average energy per symbol of M-ary SQAM, $E_{s,avg}$ and TQAM $E_{t,avg}$ is given by:

$$E_{s,avg} = \frac{2(M-1)d_{\min}^2}{12} \qquad (1)$$

$$E_{t,avg} = \frac{(7M-4)d_{\min}^2}{48} \qquad (2)$$

Where, M is order of modulation.

III. OFDM SYSTEM MODEL

In this paper we have kept all the parameters of OFDM system as per IEEE 802.11 specification. The modulation scheme used is TQAM. We have used 64- TQAM as high order modulation scheme tend to provide less bit error rate.

In SQAM perfect gray coding is possible but on TQAM perfect gray coding is not possible. The reason behind this is that in SQAM a signal point can have maximum four neighbours. But in TQAM maximum 6 neighbours are possible due to hexagonal decision boundary.

IV. SIMULATION RESULTS

TQAM-OFDM system is developed , analyzed and simulated in MATLAB version 7.6.The performance results of system in AWGN channel are obtained using OFDM parameters listed in table I.

Parameter	Value
FFT size	64
Number of used subcarriers	52
FFT Sampling frequency	20MHz
Subcarrier spacing	312.5kHz
Used subcarrier index	{-26 to -1, +1 to +26}
Cylic prefix duration	0.8us
Data symbol duration	3.2us
Total Symbol duration	4us
Modulation	TQAM

Table 1. OFDM Specification

A. ***Input image***. Below is the image that is transmitted over the channel.

*B. **Gray scale image.** Above image is converted into gray image. Below is the gray scale image:*

C. ***Image at the receiver***. Image is received at different snr. Below table shows the image received:

Images

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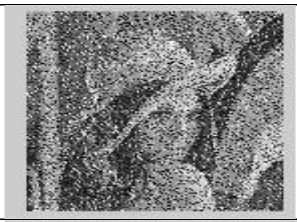
The image quality clearly indicates better performance of OFDM with TQAM modulation than with SQAM

SNR (db)	SQAM	TQAM
10		
15		
20		
25		

The image is transmitted over OFDM channel at different snr and it is found that received image quality is much better for TQAM than SQAM

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D. . Constellation diagram

Constellation diagram at moderate snr (i.e snr=10) are compared for SQAM and TQAM and are shown in figures below. For the same minimum distance we find that scatterplot for TQAM is more concentrated than for SQAM showing better power efficiency.

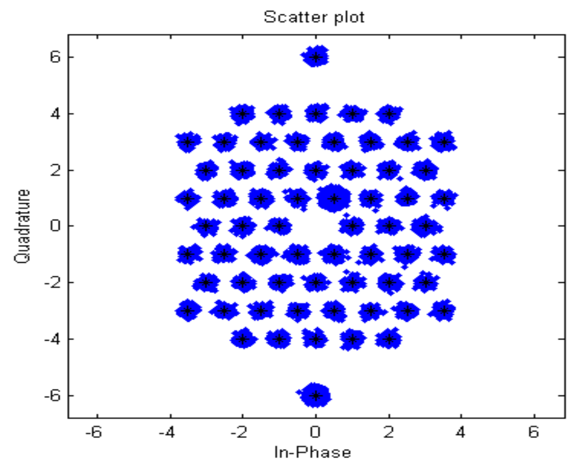


Fig: Constellation diagram of 64- TQAM

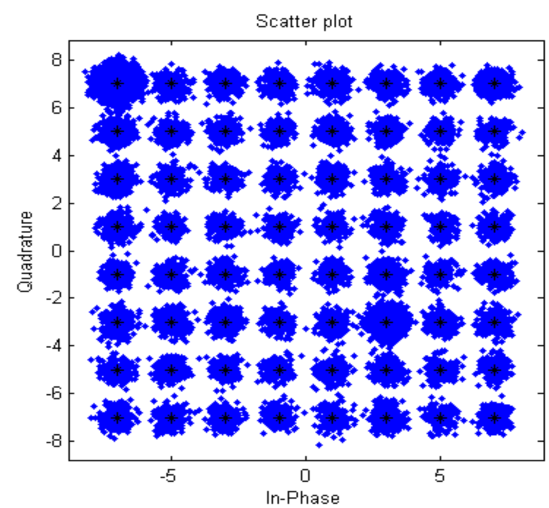
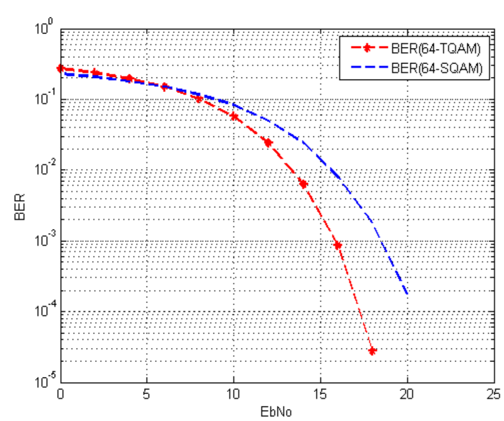


Fig: Constellation diagram of 64-SQAM

The comparison is made between BER plot of 64-TQAM and 64-SQAM. Performance is found better with the increase in snr.



V. CONCLUSION

Triangular Quadrature Amplitude Modulation is studied and performance analysis was done by transmitting an image over OFDM system at different snr and found that the received image quality is much better than can be achieved with square Quadrature Amplitude Modulation. BER plot indicate a much improved performance of TQAM. The constellation signal points are found more concentrated in TQAM than in SQAM, indicating less bit error. Concentrated constellation also indicates better power utilization.

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