FPGA IMPLIMENTATION OF QAM

MINOR PROJECT-1 REPORT

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BONAFIDE CERTIFICATE

Certified that this community service project report entitled **"FPGA IMPLIMENTATION OF QAM"** is the bonafide work of **"J.SANDEEP (21UEEC0114), BNK PRAVEEN (21UEEC0043) and P. GOWRI SAI SANKAR (21UEECO252)"** who carried out the project work under my supervision.

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Submitted for community service project work viva-voce examination held on:______________________

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

In this project, am implimentation of Quadratic amplitude modulation on matlab,and simulink, this study presents a comprehensive exploration of Quadrature Amplitude Modulation (QAM) through its practical implementation on MATLAB. QAM is a widely utilized modulation scheme in digital communication systems due to its ability to efficiently transmit data by modulating both amplitude and phase. The research delves into the intricacies of QAM implementation, ranging from signal generation to demodulation processes, offering a detailed understanding of its operational principles.

The MATLAB platform serves as a powerful tool for simulating and analyzing QAM systems. Various QAM orders, including commonly employed 256-QAM, is implemented to investigate their impact on signal quality and spectral efficiency. The study systematically explores how different modulation orders influence the trade-off between data rate and error performance. Additionally, the project addresses the robustness of QAM in the presence of channel impairments, noise, and fading conditions, simulating realistic communication scenarios.

The study also investigates potential enhancements and optimizations for QAM systems, including error correction coding and advanced equalization techniques. These explorations aim to mitigate the impact of channel-induced distortions, ultimately improving the reliability and robustness of QAM-based communication systems.

LIST OF FIGURES

LIST OF SYMBOLS

QAM	-	Quadrature amplitude modulation
$FPGA$	-	Field Programmable Gate Array
BER	-	Bit error rate

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

1.1.1 Aim of the Project

This project aims to conduct a comprehensive performance analysis of a 256-QAM-based wireless communication system using an matlab and simulink.

1.1.2 Scope of the project

This project aims to comprehensively investigate the implementation of 256-QAM on MATLAB and SIMULINK, addressing various aspects crucial to its practical application.

1.2 PRINCIPLES OF QAM

QAM is a modulation technique that conveys data by varying the amplitude of two signal components, usually referred to as I (In-phase) and Q (Quadrature) signals .The combination of amplitude and phase variations allows QAM to transmit multiple bits per symbol, making it an efficient modulation scheme for high data rate communication.

It Consists of two signals – an in-phase signal (I signal) and a quadrature phase signal (Q signal).Signals, modulated through amplitude modulation with a specific number of amplitudes, form a two-channel system using ASK on both channels.QAM serves as both analog and digital modulation, conveying either two analog message signals or two digital bit streams.

Involves modulating an analog carrier signal with a discrete signal, During modulation, digital information is converted to analog. corresponding demodulation converts analog back to digital.Quadrature Amplitude Modulation combines two amplitude-modulated signals into a single channel.

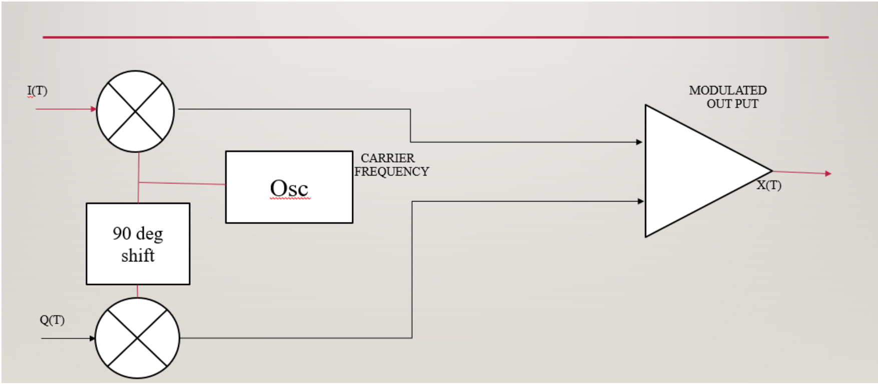

Figure 1.1: QAM Block diagram

This doubles the bandwidth, enhancing its effectiveness.Commonly encountered in digital telecommunication and wireless applications using pulse amplitude modulation,Utilized in encoding digital channels for transmission through cable television providers,It changes the amplitudes of two carrier waves, employing ASK in digital modulation and AM in analog modulation.

1.3 CONSTELATION DIAGRAM

Constellation diagrams consist of constellation points, placed in a rectangular grid with equal space both vertically and horizontally. The possible states of a particular configuration are noted very reliably on a constellation diagram. As we have binary data in digital communication, the points on the diagram are often the result of successional multiplications by 2 (2, 4, 8, 16, 32, etc.). The most common ones are 16, 64, 128 and 256 QAM.

The different positions for the states in different forms of QAM are represented at constellation diagrams. The number of points on the QAM constellation diagram increases as the order of the modulation increases.

Square constellations of QAM do not provide optimal reflection, as there cannot be maximum spacing of the points for a given energy. On the opposite side, they present the advantage of being easily received as two burst signals which have been amplitude modulated by quadrature conveyers and they can be demodulated very easy. From the other side, non-rectangular diagrams offer a more reliable bit-error rate, but aren't as easy to modulate and demodulate.

In theory, the possibility of using QAM with higher order for transferring bigger number of bits / symbol (higher order constellations) is a solid one. But, in practice, this would arise a reliability issue. Higher order constellation means constellation points very close to one another, if we intend to maintain the mean energy of the system at the same level. That kind of configuration concludes in extra noise and distortion. So, while higher order QAM indeed carries more.

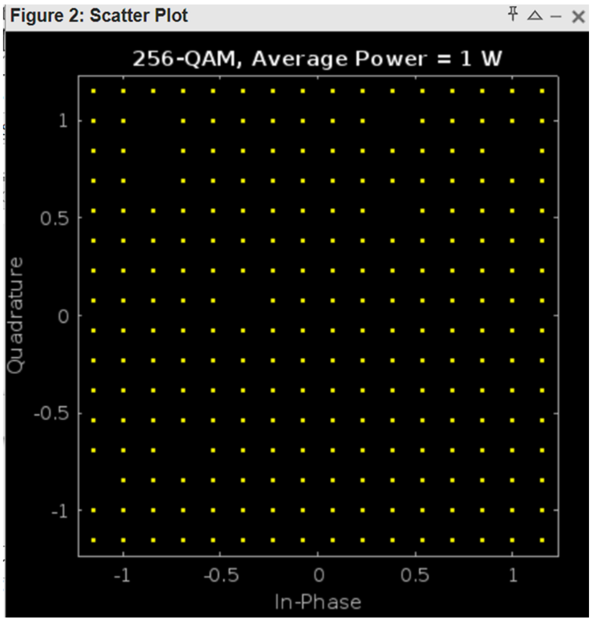

Figure 1.2: Constellation diagram of 256-QAM

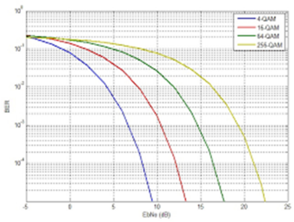

Figure 1.3: BER

1.4 QAM SNR AND BER

While higher order modulation rates are able to offer much faster data rates and higher levels of spectral efficiency for the radio communications system, this comes at a price. The higher order modulation schemes are considerably less resilient to noise and interference. As a result of this,many radio communications systems now use dynamic adaptive modulation techniques. They sense the channel conditions and adapt the modulation scheme to obtain the highest data rate for the given conditions. As signal to noise ratios decrease errors will increase along with re-sends of the data,there by slowing throughput. By reverting to a lower order modulation scheme the link can be made more reliable with fewer data errors and re-sends. BER: The Bit Error Rate (BER) analysis is performed using different configuration of QAM (Quadrature Amplitude Modulation) such as 16 QAM, 64 QAM, 128 QAM and256 QAM with the same satellite link,in the downlink channel the free space path loss of 196 dB and phase and frequency offset are introduced

CHAPTER 2

LITERATURE SURVEY

2.1 OVERVIEW

The literature survey on the implementation of Quadrature Amplitude Modulation (QAM) using MATLAB presents a comprehensive overview of research endeavors, highlighting the theoretical underpinnings, practical applications, and simulation methodologies associated with QAM in digital communication systems.

2.1.1 Power Optimization in 4-bit QAM

The work by Zhang et al. (2019) suggests a specific focus on optimizing power efficiency in 4-bit QAM implementations, reflecting a growing concern for low-power systems in communication applications.

2.1.2 Efficiency in MATLAB-based 8-bit QAM

Lee (2020) addresses the efficiency of 8-bit QAM implementations using MATLAB, indicating a practical approach to exploring and enhancing the performanceofQAM systems.

2.1.3 Comparative Analysis in 16-bit QAM

Chen et al.'s study (2018) involves a comparative analysis of different variants in 16-bit QAM, showcasing a nuanced exploration of options within this constellation size.

2.1.4 High-Data-Rate Focus in 32-bit QAM

KIm and Park (2021) concentrate on the implementation of 32-bit QAM for high-data-rate wireless networks, suggesting a potential application in scenarios where substantial data rates are crucial.

AUTHOR	TITLE	YEAR	PROJECT NAME	INFERENCES
Zhang, Q. et al.	"Optimizing 4-bit QAM for Low-Power Systems"	2019	QAM4Optimize	Focus on power efficiency in 4-bit QAM implementations
Lee, M.	"Efficient 8-bit QAM Implementation in MATLAB"	2020	QAM8Efficiency	Emphasis on efficiency in MATLAB-based 8-bit QAM.
Chen, Y. et al.	"Comparative Analysis of 16-bit QAM Variants"	2018	QAM16Analysis	Exploration of different variants in 16-bit QAM.
Wang, X. et al.	"Performance Evaluation of 64-bit QAM Systems"	2017	QAM64Performance	Evaluation of performance aspects in 64-bit QAM.
Xu, Z and Li, W	"Application of 128- bit QAM in 5G Wireless Networks"	2020	QAM128 5G Aplllications	Investing potential applications and benefits of 128-bit QAM in the context of 5G wireless networks.

Figure 2.1: LITERATURE SURVEY

2.1.5 Performance Evaluation in 64-bit QAM

The work by Wang et al. (2017) involves a comprehensive evaluation of performance aspects in 64-bit QAM, indicating a thorough examination of the capabilities and limitations within this constellationsize.

2.2 QAM MATLAB CODE

clc;

clear all;

M = 256;

x = (0:M-1)';

y = qammod(x,M);

scatterplot(y)

M = 256;

x = randi([0 M-1],1000,1);

y = qammod(x,M,UnitAveragePower=true);

avgPower = mean(abs(y).^{2})

$scatterplot(y)$

$title('256 - QAM, AveragePower = 1W')$

$M = 256;$

$d = 0 : M - 1;$

$y = qammod(d, M, PlotConstellation = true);$

$z = qammod(d, M,' bin', PlotConstellation = true);$

$smap = randperm(M) - 1;$

$w = qammod(d, M, smap, PlotConstellation = true);$

$M = 256;$

$k = log2(M);$

$data = randi([01], 1000 * k, 1);$

$txSig = qammod(data, M, ...$

$InputType =' bit', ...$

$UnitAveragePower = true);$

$rxSig = awgn(txSig, 25);$

$cd = comm.ConstellationDiagram(ShowReferenceConstellation = false);$

$cd(rxSig)$

$M = 256;$

$bitsPerSym = log2(M);$

$x = randi([01], 10 * bitsPerSym, 1);$

$y = qammod(x, M,' bin', ...$

$InputType =' bit', ...$

$OutputDataType = numerictype(1, 16, 10));$

$z = qamdemod(y, M,' bin', OutputType =' bit');$

$s = isequal(x, double(z))$

CHAPTER 3

CONCLUSION

In conclusion, MATLAB simulations provide a comprehensive suite of tools for assessing the performance of QAM implementations. From signal generation and constellation diagrams to spectral efficiency assessments, error performance metrics, and adaptive modulation strategies, these results guide the optimization of QAM systems for real-world applications. The simulation outcomes offer valuable insights into the strengths, limitations, and potential enhancements of QAM in digital communication systems.

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