A THESIS ON PERFORMANCE ANALYSIS OF VARIOUS MODULATION TECHNIQUES USED IN OFDM WITH THE IMPACT OF FFT FOR 4G NETWORKS.

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Bachelor of Electronics and Communication Engineering Degree

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THESIS PAPER APPROVAL

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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Electronic and Communication Engineering in the field of Telecommunication.

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AN ABSTRACT OF THE THESIS

TITLE: A THESIS ON PERFORMANCE ANALYSIS OF VARIOUS MODULATION TECHNIQUES USED IN OFDM WITH THE IMPACT OF FFT FOR 4G NETWORKS.

Abstract: *Demand of high speed wireless communications is increasing day by day. To meet this demand OFDM (Orthogonal Frequency Division Multiplexing) is popularly used along with various modulation techniques in 4th Generation mobile communications. In this paper the performance of 16 QAM, 64 QAM, 256 QAM analyzed with varying value of FFT of OFDM. The analysis have been done for SER (Symbol Error Rate) with Eb/N0(SNR) using MATLAB.*

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INTRODUCTION

We are now in an era of technology. With the demand of people the communication system is also developed along technology. At first there was only Telegraph. Then after a long time and evaluation some reliable system arrived at 1982 with AMPS and at 1983 TACS. But the systems were analog.

Then GSM (Global System for Mobile Communication) has arrived which was known as the 2nd generation mobile communication. FDM (Frequency Division Multiplex) and TDM (Time Division Multiplexing) was used in this system. But it has some limitations too. It has low data rate. But people need higher mobile data rate and better services. In order to solve the problem, WCDMA (Wideband Code Division Multiple Access) came with 3rdgeneration communication system. It has a better data rate than GSM.

After that 4th generation mobile communication system along with OFDMA is released. This has multicarrier and FDM also.

But we need more efficient system that could make the other systems integrated with itself making some long time useful features. That’s why we need to make the 4th generation network system more upgraded. That system would like to be the most advanced system which would have large bandwidth, high data rate and the exciting features that the previous systems couldn’t provide.

To establish that system we can use OFDM (Orthogonal Frequency Division Multiplex). We also have to integrate the entire previous system into one platform. OFDM (orthogonal frequency division multiplexing) transmission scheme is used to overcome multipath-fading environment with low complexity.

For a parallel-data-transmission scheme, OFDM is one of the most popular techniques reducing the impact of multipath fading which constructs complex equalizers unnecessary. Using overlapping multicarrier modulation technique, almost 50% of bandwidth can be saved. OFDM is implemented here using Fast Fourier Transform (FFT).

In the past years many thesis was publish on OFDM, COFDM, FFT, IFFT. In [1] the performance of BPSK, QPSK and 16 QAM with and without using OFDM was analyzed. In [2] author implemented OFDM system by using FFT and IFFT on transmitter and receiver. In [3] author described about the QAM based COFDM. Coded Orthogonal frequency division multiplexing is a version of OFDM where error correction coding is placed into the signal. 64-point FFTs as a building block for OFDM-based standards is implemented in [4].

CHAPTER 1

EVOLUTION OF MOBILE WIRELESS TECHNOLOGY

1.1 FIRST GENERATION

1G is the original remote phone innovation, PDAs. They were simple mobile phones and were presented in 1980. In 1979, the main cell framework in the world got to be operational by Nippon Telephone and Transmit (NTT) in Tokyo, Japan. In Europe two most prominent simple frameworks were Nordic Mobile Telephone (NMT) and (TACS) other simple frameworks were moreover presented in 1980's over the Europe. Every one of the frameworks offered handover and meandering capacity yet the phone systems were not able interoperate between nations.

This was the fundamental disadvantage of First Generation portable systems. 1G has low limit untrustworthy handoff, poor voice joins and no security since voice calls were played back in radio towers making these calls powerless to undesirable. In USA AMPS was initial 1G standard propelled in 1982. AMPS framework was apportioned a 40 MHZ data transfer capacity inside the 800-900 MHZ recurrence range by the government Communication Commission (FCC). In 1988 extra 10 MHZ transmission capacity, called extended range (ES) was allotted to AMPS. Italy utilized a media transmission framework called RTMI. IN UK, YACS was utilized. France utilized RadioComm 2000.In West Germany, Portugal and South Africa a telecom standard known as C-450 was utilized. 1G innovation supplanted 0G innovation, which highlighted portable radio phones and such innovations as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT).

1. Created in 1980s and finished in mid-1990's

2. 1G was old simple framework and bolstered the first era of simple mobile phones speed up to 2.4kbps

3. Advance cellular telephone framework (AMPS) was initially propelled by the US and is a 1G portable framework

4. Permits clients to make voice brings in 1 nation

1.2- SECOND GENERATION (2G-2.7G)

2G is the Second-Generation remote cellphones, in view of advanced innovations and in mid-1990's. In 1991 2G was dispatched in Finland. 2G gave administrations, for example, content message, picture messages and MMS. 2G has more noteworthy security for both sender and collector. All instant messages are digitally encoded, which takes into account the move of information in a manner that lone expected collector can get and read it. 2G framework utilizes advanced portable access innovation, for example, TDMA and CDMA. TDMA separates signal in time spaces while as CDMA designates every client a unique code to convey over a multiplex physical channel. Diverse TDMA advances are GSM, PDC, iDEN, iS-136. GSM was initial 2G System. CDMA innovation IS-95. GSM (Group Special Mobile) has starting point from Europe.

GSM is the most appreciated standard of all the versatile innovations utilized as a part of more than 212 nations, on the planet. GSM standard makes worldwide meandering extremely normal between cellular telephone administrators, empowering supporters of utilization their telephones in numerous parts of the world. GSM utilizes TDMA to multiplex upto 8 calls for every divert in the 900 and 1800 MHZ groups. GSM can't just convey voice additionally circuit exchanged information at sped upto 14.4kbps. In US FCC additionally unloaded another square of range in the 1900MHZ band. Amid 20 years , GSM innovation has been consistently enhanced to offer better administrations in the business sector. New advances has been created in view of the first GSM framework, prompting some propelled framework , known as 2.5 era (2.5 G) Systems.

1.2.1 GPRS(General Packet Radio Service) 2.5G

GPRS is augmentation of existing 2G systems to have the limit of dispatching bundle based administrations while improving the information rates bolstered by these systems. The term “Second and a half era" is utilized to depict 2G-Systems that have actualized a parcel exchanged area notwithstanding circuit exchanged space. "2.5 G" is a casual term. GPRS gave information rates from 56 Kbps upto 384 Kbps, utilizing database HLR, VLR, EIR, and AuC with HSCSD, GPRS and EDGE innovations. It gives administrations, for example, Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS) and for web correspondence administrations, for example, email and World Wide Wireless Web (WWW) access. GPRS information exchange is ordinarily charged per megabyte of movement exchanged, while information correspondence by means of customary circuit exchanging is charged every moment of association time, autonomous of whether the client really is using the limit or is in an unmoving state. 2.5G systems may bolster administrations, for example, WAP, MMS, SMS portable recreations, and inquiry registry and well web access.

1.2.2 EDGE (Enhanced Data rates for GSM Evolution) 2.7G

GPRS system is advanced to EDGE systems with the presentation of 8PSK encoding. Upgraded Data rates for GSM Evolution, Enhanced GPRS (EGPRS), or IMT Single Carrier (IMT-SC) is a regressive good computerized cell telephone innovation that permits enhanced information transmission rates, as an expansion on top of standard GSM. EDGE was conveyed on GSM systems starting in 2003 at first by Cingular (now AT and T) in the United States. EDGE is institutionalized by 3GPP as a component of the GSM family, and it is an update that gives a potential three-fold increment in limit of GSM/GPRS systems. The particular accomplishes higher information –rates (up to 236.8 Kbits/s) by changing to more refined techniques for coding (8PSK), inside existing GSM timeslots. EDGE innovation is a broadened rendition of GSM. It permits the reasonable and quick transmission of information and data. It is likewise named as IMT-SC or single transporter. EDGE innovation was created and presented by Cingular, which is currently known as AT&T.EDGE is radio innovation and is a piece of third era advancements. EDGE innovation is favored over GSM because of its adaptability to convey parcel switch information and circuit switch information.

EDGE moves information in less seconds on the off chance that we contrast it and GPRS Technology. For instance a common content record of 40KB is moved in just 2 seconds when contrasted with the exchange from GPRS innovation, which is 6 seconds. The greatest favorable position of utilizing EDGE innovation is one doesn't have to introduce any extra equipment and programming with a specific end goal to make utilization of EDGE Technology. There are no extra charges for misusing this innovation. In the event that a man is an ex GPRS Technology client he can use this innovation without paying any extra charges.

1.3 THIRD GENERATION

3G is the third era of cell telephone principles and innovation, superseding 2G, and going before 4G. It depends on the International Telecommunication Union (ITU) who planned an arrangement to execute worldwide recurrence band in the 2000 MHZ range, which will bolster a solitary, universal remote correspondence standard for all nations all through the world. This plan is called International Mobile Telephone 2000 (IMT-2000) Standard. 3G advancement for CDMA frameworks lead to Cdma 2000. A few variations of CDMA 2000 depend on IS-95 and IS-95B advances. 3G developments for GSM IS-136 and PDC System lead to wideband CDMA (WCDMA), likewise called Universal Mobile Telecommunication Service (UMTS), W-CDMA depends on GSM system.

CDMA 2000 and W-CDMA, will stay fundamental 3G innovation mainstream. Third Generation Partnership Project (3GPP) has proceeded with that work by characterizing a versatile framework that satisfies the IMT-2000 standard. 3G advances empower system administrators to offer clients a more extensive scope of more propelled administrations while accomplishing more noteworthy system limit through enhanced phantom productivity. Administrations incorporate wide region remote voice communication, video calls, and broadband remote information, versatile TV, GPS (worldwide situating framework) and video conferencing all in a portable domain. 3G has the accompanying improvements more than 2.5G and past systems:

1. Upgraded sound and video gushing.
2. Several Times higher information speed.
3. Video-conferencing support.
4. Web and WAP scanning at higher rates.
5. IPTV (TV through the Internet) support.

1.3.1 HSDPA (High-Speed Downlink Packet Access) 3.5G

High-speed Downlink Packet Access(HSDPA) is a portable communication convention, likewise called 3.5G (or "3½ G"), which gives a smooth transformative way to UMTS-based 3G systems taking into consideration higher information exchange speeds. HSDPA is a bundle based information administration in W-CDMA downlink with information transmission up to 8-10 Mbit/s (and 20 Mbit/s for MIMO frameworks) over a 5MHz data transfer capacity in WCDMA downlink. HSDPA usage incorporates Adaptive Modulation and Coding (AMC), Multiple-Input Multiple-Output (MIMO), Hybrid Automatic Request (HARQ), quick cell seek, and propelled collector plan.

1.3.2 HSUPA (High-Speed Uplink Packet Access) 3.75G

The 3.75G allude to the innovations past the very much characterized 3G remote/versatile advancements. High-speed Uplink Packet Access (HSUPA) is an UMTS/WCDMA uplink advancement innovation.

The HSUPA portable broadcast communications innovation is straightforwardly identified with HSDPA and the two are complimentary to each other. HSUPA will improve propelled individual to-individual information applications with higher and symmetric information rates, similar to versatile email and constant individual toperson gaming. Customary business applications alongside numerous purchaser applications will profit by upgraded uplink speed. HSUPA will at first help the UMTS/WCDMA uplink up to 1.4Mbps and in later discharges up to 5.8Mbps.

CHAPTER 2

DIFFERENCE AMONG DIFFERENT MOBILE WIRELESS TECHNOLOGY

Feature	**NMT**	**GSM**	**UMTS (3GSM)**
Technology	FDMA	TDMA and FDMA	W-CDMA
Generation	1G	2G	3G
Encoding	Analog	Digital	Digital
Year of First Use	1981	1991	2001
Roaming	Nordics and several other European countries	Worldwide, all countries except Japan and South Korea	Worldwide
Handset interoperability	None	SIM card	SIM card
Common Interference	None	Some electronics, e.g. amplifiers	None

Signal quality/coverage area	Good coverage due to low frequencies	Good coverage indoors on 850/900 MHz. Repeaters possible. 35 km hard limit.	Smaller cells and lower indoors coverage on 2100 MHz; equivalent coverage indoors and superior range to GSM on 850/900 MHz.
Frequency utilization/Call density	Very low density	0.2 MHz = 8 timeslots. Each timeslot can hold up to 2 calls (4 calls with VAMOS) through interleaving.	5 MHz = 2 Mbit/s. 42Mbit/s for HSPA+. Each call uses 1.8-12 kbit/s depending on chosen quality and audio complexity.
Handoff	Hard	Hard	Soft
Voice and Data at the same time	No	Yes GPRS Class A	Yes

CHAPTER 3

4th GENERATION TECHNOLOGY

4G is an idea of operability between various sorts of systems, which is about rapid information exchange for example, 0-100MBPS of either the server or the information collector set is moving at a velocity of 60 Kmph. On the off chance that the server furthermore, the recipient is stationary, the information exchange would be a least of 1GBPS. 4G is the cutting edge remote systems that will supplant 3G arranges some of the time in future. In other setting, 4G is essentially an activity by scholastic, R and D labs to move past the impediments and issues of 3G which is having inconvenience getting sent and meeting its guaranteed execution and throughput.

Expected issues considered to be resolved in these 4G mobile technology which are as under:

- It is considered to implant IP highlight in the set for more security reason as high information rates are send and get through the telephone utilizing 4G versatile innovation.

- 4G versatile innovation will be ready to download at a rate of 100Mbps like portable access and less portability of 1GBps for neighborhood access of remote

- Instead of half and half innovation utilized as a part of 3G with the mix of CDMA and IS-95 another innovation OFDMA is presented 4G. In OFDMA, the idea is again of division various gets to yet this is neither time like TDMA nor code separated CDMA rather recurrence area evening out procedure symbolizes as OFDMA.

- CDMA sends information through one channel yet with the division of time in three openings. While CDMA likewise sends information through one channel distinguishing the collector with the assistance of code. Though in 4G versatile innovation OFDMA is going to present in which information bundles sends by partitioning the channel into a limited band for the more noteworthy proficiency contains an unmistakable component of 4G portable innovation

. • IEEE 802.16m is preparing for the IEE802.16e involving the 4G brand will characterize it as WMBA (Wireless Mobile Broadband Access). This is a plain pointer for the web accessibility. The execution is in advancement to maintain a strategic distance from the call obstruction if there should arise an occurrence of information download from a site. It will propose 128 Mbps downlink information rate and 56Mbps uplink information rate which is an additional conventional stride in 4G versatile innovation. The administration will restrain as the accessibility of hotspot is condition for the web availability.

- Parallel with WiMAX, LTE is planned to join in 4G mobiles. It is additionally a remote innovation for the broadband access. The contrast amongst WiMAX and LTE is that LTE goes for the IP Address. It takes after the same TCP/IP idea acquired from systems administrationinnovation. Confined for the IP addresses it will give incredible security and additionally high information transferability, keep away from idleness, being able to modify the data transmission. LTE is good with CDMA so ready to back n forward the information in the middle of both systems.

- 3GPP Organization is going to present two noteworthy remote guidelines; LTE and IEEE802.16m. Previous is conceded consent for the further procedure while second is under thought and that will end up being a piece of 4G versatile innovation.

- IPv6 is affirmed by Version as a 4G standard on June 2009.

CHAPTER 4

Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal frequency-division multiplexing (OFDM) is a technique for encoding advanced information on different bearer frequencies. OFDM has formed into a well-known plan for wideband advanced correspondence, utilized as a part of utilizations, for example, computerized TV and sound telecom, DSL Internet access, remote systems, powerline systems, and 4G versatile interchanges.

OFDM is a frequency-division multiplexing (FDM) plan utilized as a computerized multi-bearer adjustment technique. An expansive number of firmly divided orthogonal sub-transporter signs are utilized to convey data[1] on a few parallel information streams or channels. Every sub-bearer is tweaked with an ordinary regulation plan, (for example, quadrature abundancy adjustment or stage shift scratching) at a low image rate, keeping up aggregate information rates like customary single-transporter balance plans in the same data transmission.

The essential favorable position of OFDM over single-transporter plans is its capacity to adapt to extreme channel conditions (for instance, constriction of high frequencies in a long copper wire, narrowband impedance and frequency-particular blurring due to multipath) without complex adjustment channels. Channel adjustment is improved on the grounds that OFDM might be seen as utilizing numerous gradually tweaked narrowband flags instead of one quickly balanced wideband sign. The low image rate makes the utilization of a watchman interim between images reasonable, making it conceivable to dispose of intersymbol impedance (ISI) and use echoes and time-spreading (on simple TV these are noticeable as ghosting and obscuring, separately) to accomplish a differences pick up, i.e. a sign to-clamor proportion change. This component likewise encourages the outline of single frequency systems (SFNs),where a few adjoining transmitters send the same flag all the while at the same frequency, as the signs from different inaccessible transmitters might be joined productively, instead of meddling as would commonly happen in a conventional single-bearer framework.

4.1 Idealized system model of OFDM

This section describes a simple idealized OFDM system model suitable for a time invariant AWGN channel.

Transmitter:

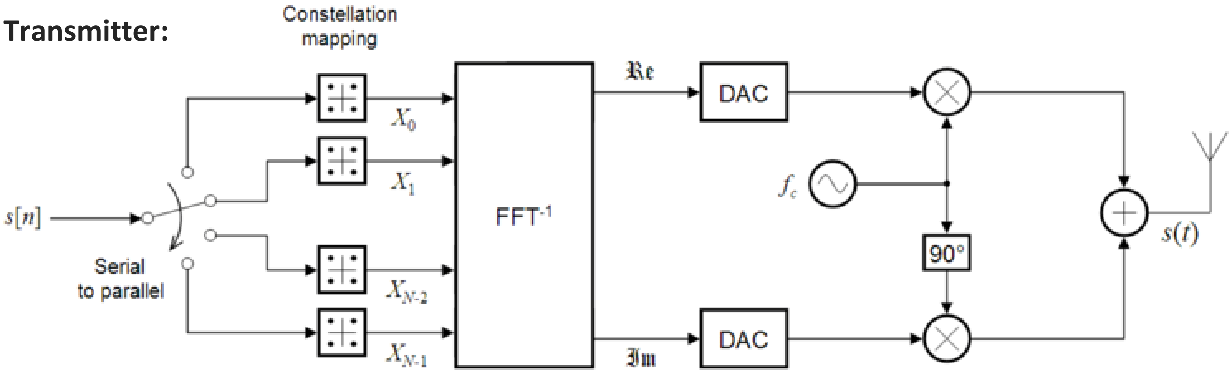

Figure 4.1.1- Digital to Analog Converter

An OFDM bearer sign is the entirety of various orthogonal sub-transporters, with baseband information on every sub-bearer being autonomously regulated generally utilizing some sort of quadrature amplitude modulation (QAM) or phase shift keying (PSK). This composite baseband sign is ordinarily used to tweak a primary RF transporter.

A converse FFT is registered on every arrangement of images, giving an arrangement of complex time-space tests. These specimens are then quadrature-blended to passband in the standard way. The genuine and nonexistent parts are initially changed over to the simple space utilizing digital to analog converters (DACs).

Receiver:

The recipient grabs the sign r(t), which is then quadrature-blended down to baseband utilizing cosine and sine waves at the transporter recurrence. This likewise makes signals focused on 2fc, so low-pass channels are utilized to dismiss these. The baseband signs are then tested and digitized utilizing analog-to-digital converters (ADCs), and a forward FFT is utilized to change over back to the recurrence space.

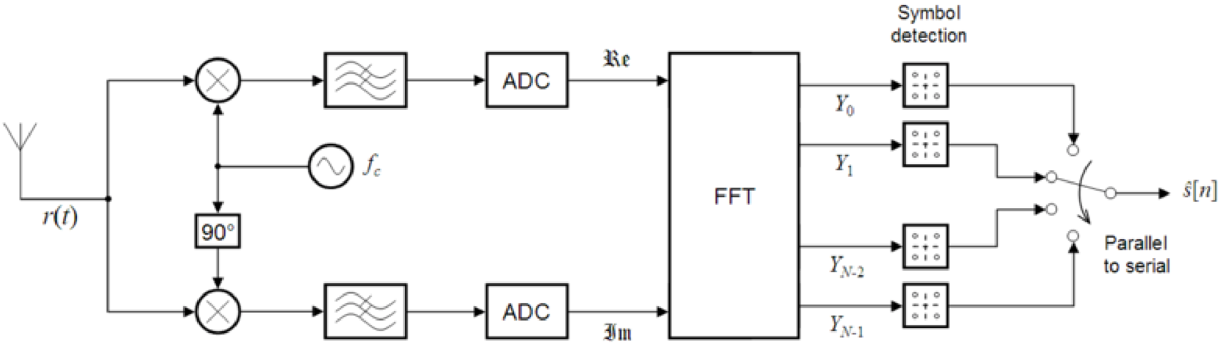

Figure 4.1.2- Analog to Digital Converter

4.2 Advantages and Disadvantages of OFDM

ADVANTAGES:

- Makes efficient use of the spectrum by allowing overlap.
- By dividing the channel into narrowband flat fading subchannels, OFDM is more resistantto frequency selective fading than single carrier systems are.
- Eliminates ISI and IFI through use of a cyclic prefix.
- Using adequate channel coding and interleaving one can recover symbols lost due to thefrequency selectivity of the channel.
- Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.
- It is possible to use maximum likelihood decoding with reasonable complexity.
- OFDM is computationally efficient by using FFT techniques to implement the modulationand demodulation functions.

- Is less sensitive to sample timing offsets than single carrier systems are.
- Provides good protection against cochannel interference and impulsive parasitic noise.

DISADVANTAGES:

- The OFDM signal has a noise like amplitude with a very large dynamic range; therefore itrequires RF power amplifiers with a high peak to average power ratio.
- It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT.

CHAPTER 5

FAST FOURIER TRANSFORM

A fast Fourier transform (FFT) calculation figures the discrete Fourier transform (DFT) of a succession, or its opposite. Fourier examination changes over a sign from its unique area (regularly time or space) to a representation in the recurrence area and the other way around. A FFT quickly processes such transformations by factorizing the DFT lattice into a result of scanty (for the most part zero) variables.

Fast Fourier transforms are generally utilized for some applications as a part of designing, science, and arithmetic. The essential thoughts were advanced in 1965, yet a few calculations had been inferred as ahead of schedule as 1805. In 1994, Gilbert Strang portrayed the FFT as "the most vital numerical calculation of our lifetime" and it was incorporated into Top 10 Algorithms of twentieth Century by the IEEE diary Computing in Science and Engineering.

5.1 Overview

There are various FFT calculations including an extensive variety of science, from basic complex number-crunching to gathering hypothesis and number hypothesis; this gives a review of the accessible strategies and some of their general properties, while the particular calculations are portrayed in auxiliary articles connected underneath.

The DFT is gotten by breaking down a grouping of qualities into segments of various frequencies. This operation is helpful in numerous fields (see discrete Fourier transform for properties and uses of the transform) however figuring it specifically from the definition is regularly too ease back to ever be functional. A FFT is an approach to register the same result all the more rapidly: processing the DFT of N focuses in the guileless way, utilizing the definition, takes O(N2) arithmetical operations, while a FFT can figure the same DFT in just O(N log N) operations. The distinction in pace can be gigantic, particularly for long information sets where N might be in the thousands or millions. Practically speaking, the calculation time can be decreased by a few requests of extent in such cases, and the change is generally relative to N/log N. This colossal change made the estimation of the DFT commonsense; FFTs are of extraordinary significance to a wide assortment of utilizations, from computerized signal handling and unraveling fractional differential conditions to calculations for snappy increase of expansive whole numbers.

5.2 Definition and speed

A modulated multicarrier communication system transmits Nc complex-valued source symbols Sn, n = 0,...,N_c − 1, in parallel on to N_c sub-carriers. After source and channel coding, interleaving, and symbol mapping, the source symbols may be obtained. Converting serial-to-parallel in the OFDM symbol duration the source symbol duration T_d of the serial data symbols results

$$T_s = N_c\, T_d$$

The theory of OFDM is to modulate the N_c sub-streams on sub-carriers with a interval of

$$F_s = 1/T_s$$

For getting orthogonality among the signals on the Nc sub-carriers we have to guess a rectangular pulse shaping. The Nc and the parallel modulated source symbols Sn, n = 0,...,Nc − 1, referring as an OFDM symbol. The complex envelope of an OFDM symbol with rectangular pulse shaping has the form

$$\mathrm{x(t)} = 1/Nc \sum_{n=0}^{Nc-1} \mathrm{S_n e^{j2\pi fnt}},\ \ 0 \leq \mathrm{t} < Ts$$

The sub-carrier frequencies (Nc) are located at

$$fn = n/Ts, \qquad n = 0,...,Nc - 1.$$

In future we have to design such a network which is spectral efficient and link reliable. Fading is the main from which propagation medium suffers much because of multipath components destructive addition.

In OFDM there the signal use multi carrier. But there is no overlapping between them. There is also guard band used for preventing ISI (Inter Symbol Interference).

The FFT prevents the Inter Subcarrier Interference ICI.

5.3 Applications

FFT's importance gets from the way that in sign preparing and picture handling it has made working in recurrence space similarly computationally doable as working in temporal or spatial area. A portion of the important uses of FFT incorporates,

1. Quick large integer and polynomial multiplication
2. Proficient matrix-vector multiplication for Toeplitz, circulant and other structured matrices
3. Sifting algorithms
4. Quick algorithms for discrete cosine or sine transforms (example, Fast DCT used for JPEG, MP3/MPEG encoding)
5. Quick Chebyshev approximation
6. Quick discrete Hartley transform
7. Illuminating difference equations

5.4 Future Research Area

Enormous FFTs: With the blast of huge information in fields, for example, cosmology, the requirement for 512k FFTs has emerged for certain interferometry figurings. The information gathered by tasks, for example, MAP and LIGO require FFTs of several billions of focuses. As this size does not fit into principle memory, alleged out-of-center FFTs are a dynamic territory of research.

Inexact FFTs: For applications, for example, MRI, it is important to figure DFTs for nonuniformly dispersed lattice focuses and/or frequencies. Multipole based methodologies can process estimated amounts with element of runtime increase.

Bunch FFTs: The FFT may likewise be clarified and deciphered utilizing bunch representation hypothesis that takes into consideration further speculation. A capacity on any smaller gathering, including non cyclic, has an extension as far as a premise of irreducible network components. It stays dynamic zone of examination to discover proficient calculation for playing out this change of premise. Applications including productive round symphonious development, breaking down certain markov forms, apply autonomy etc.

Quantum FFTs: Shor's quick calculation for whole number factorization on a quantum PC has a subroutine to process DFT of a paired vector. This is actualized as arrangement of 1-or 2-bit quantum entryways now known as quantum FFT, which is successfully the Cooley–Tukey FFT acknowledged as a specific factorization of the Fourier framework. Expansion to these thoughts is at present being investigated.

CHAPTER 6

SNR & SER

6.1 SIGNAL TO NOISE RATIO

Sign to-noise ratio (contracted SNR or S/N) is a measure utilized as a part of science and designing that analyzes the level of a coveted sign to the level of foundation noise. It is characterized as the proportion of sign energy to the noise power, frequently communicated in decibels. A proportion higher than 1:1 (more noteworthy than 0 dB) demonstrates more flag than noise. While SNR is normally cited for electrical signs, it can be connected to any type of sign, (for example, isotope levels in an ice center or biochemical motioning between cells).

The sign to-noise ratio, the data transmission, and the channel limit of a correspondence channel are associated by the Shannon–Hartley hypothesis.

Sign to-noise ratio is at times utilized casually to allude to the proportion of helpful data to false or immaterial information in a discussion or trade.

Symbol error rate is the ratio of the number of error symbol at receiving end to the total number of bits transferred.[7] SNR is Signal to noise ratio. SNR is used to measure the comparison of the lever of desired signal to the background noise.

$$\text{SNR} = 10log_{10}\,10\left(\frac{P_{Signal}}{P_{Noise}}\right)$$

6.2 Digital Signal

At the point when estimation is digitized, the quantity of bits used to speak to the estimation decides the greatest conceivable sign to-noise ratio. This is on the grounds that the base conceivable clamor level is the error brought on by the quantization of the sign, in some cases called Quantization commotion. This commotion level is non-direct and flag subordinate; diverse counts exist for various sign models. Quantization clamor is displayed as an analog error signal summed with the sign before quantization ("additive noise").

This hypothetical most extreme SNR accept a flawless information signal. In the event that the info sign is as of now loud (as is generally the case), the sign's noise might be bigger than the quantization clamor. Genuine analog-to-digital converters likewise have different wellsprings of commotion that further abatement the SNR contrasted with the hypothetical most extreme from the admired quantization clamor, including the purposeful expansion of dither.

Despite the fact that clamor levels in a digital framework can be communicated utilizing SNR, it is more basic to utilize Eb/No, the vitality per bit per commotion power phantom thickness.

The modulation error ratio (MER) is a measure of the SNR in a digitally tweaked signal.

6.3 SYMBOL ERROR RATE

A critical execution metric in computerized interchanges is the image mistake rate (SER). The convexity of the SER in the signal to noise ratio (SNR) assumes a basic part in different improvement issues. Curved SERs have a negative first subsidiary and a positive second subordinate with admiration to the SNR. In the event that all the progressive subordinates of the SER likewise exchange in sign (alluded to as complete monotonicity), then it is conceivable to express the SER as a positive blend of rotting exponentials, which has applications in SER investigation over blurring channels, as portrayed in. This serves as the inspiration to investigate the complete monotonicity (c.m.) properties of the SER of self-assertive multi-dimensional constellations.

One-dimensional and two-dimensional constellations have been adopted in many communication systems in the literature, and investigations into the properties of the SER of these constellations have revealed the convexity of the SER with respect to the signal-to-noise ratio (SNR) under impairing additive white Gaussian noise (AWGN). Some special cases of two dimensional constellations such as M-ary phase shift keying (M-PSK) and M-ary quadrature amplitude modulation (M-QAM) have SERs which are known to be completely monotone functions of the SNR, which is a stronger condition than convexity. On the other hand, constellations of dimensionality greater than two (which we refer to as “higher dimensional constellations” henceforth) have found practical applications in satellite communications and more recently, in optical communications. Investigations of the convexity properties of the SER of such constellations are relatively scarce in the literature. It is known that the second derivative of the SER of a constellation of dimensionality greater than two is non-negative at sufficiently high SNR.

CHAPTER 7

MODULATION TECHNIQUE (QAM)

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog 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) analog modulation scheme. The two carrier waves of the same frequency, 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 analog 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.

Like all modulation plans, QAM passes on information by transforming some part of a transporter signal, or the bearer wave, (as a rule a sinusoid) because of an information signal. On account of QAM, the adequacy of two influxes of the same frequency, 90° out-of-phase with each other (in quadrature) are changed (regulated or keyed) to speak to the information signal. Sufficiency adjusting two transporters in quadrature can be identically seen as both abundancy regulating and phase tweaking a solitary bearer.

Phase modulation (analog PM) and phase-shift keying (digital PSK) can be viewed as a unique instance of QAM, where the extent of the adjusting sign is a steady, with just the phase differing. This can likewise be stretched out to frequency modulation (FM) and frequency-shift keying (FSK), for these can be viewed as an exceptional instance of phase modulation

7.1 Ideal structure

Transmitter:

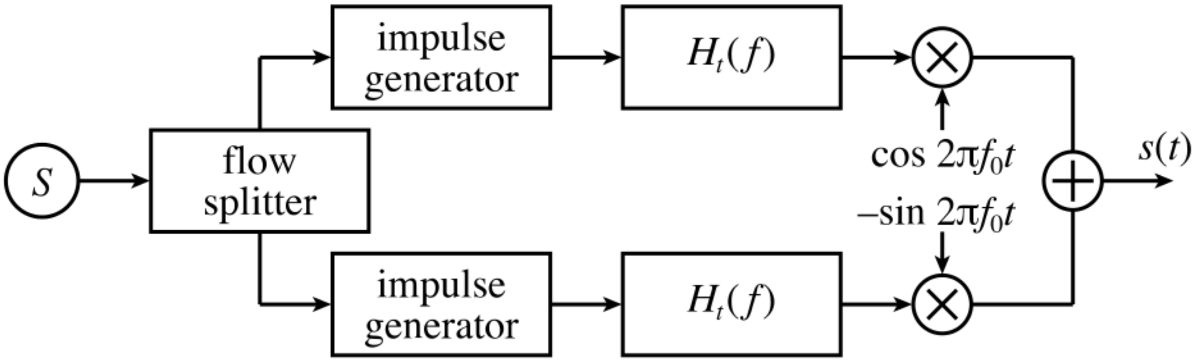

Figure 7.1.1- Transmitter

Receiver:

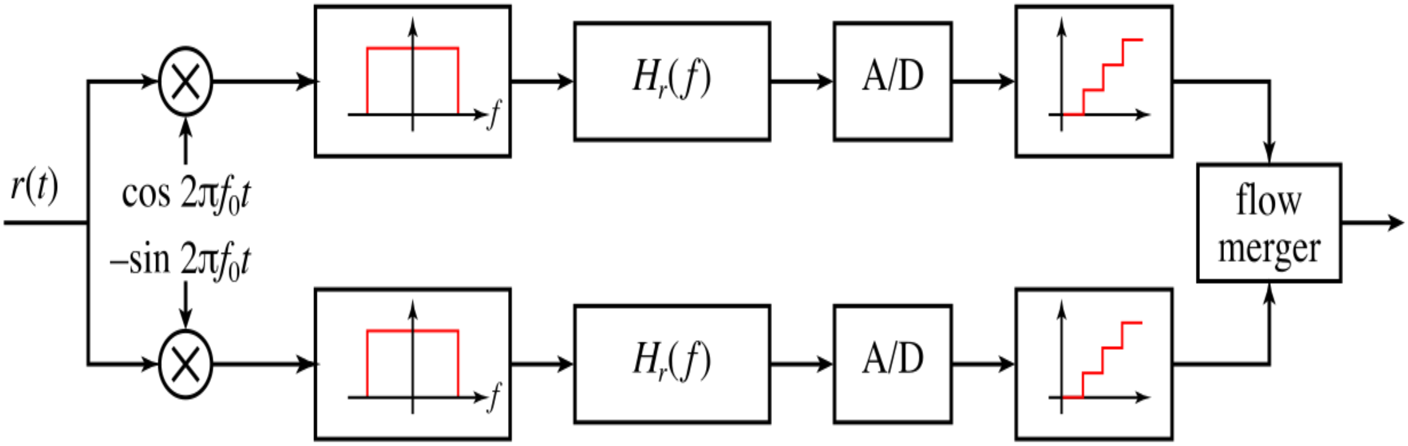

Figure 7.1.2 - Receiver

7.2 Generalized Equation

For the high efficiency we choose QAM with OFDM for 4th generation network.

The two carriers are known as in-phase carrier (I) and quadrature phase carrier (Q) .

M-QAM signal can be defined as

$$S_m\,(t) = A_m\,.\,g(t)\,\cos\,(2\pi f_c t +\ \theta_m) \qquad \text{m=1, 2, …,M}$$

Where , $S_m(t)$= Bandpass signal

f_c= Carrier Frequency

$g(t)\ = Real\ valued\ pulse$

A_m= Amplitude of m^{th} signal

$\theta_m\ =$ Angle of m^{th}signal

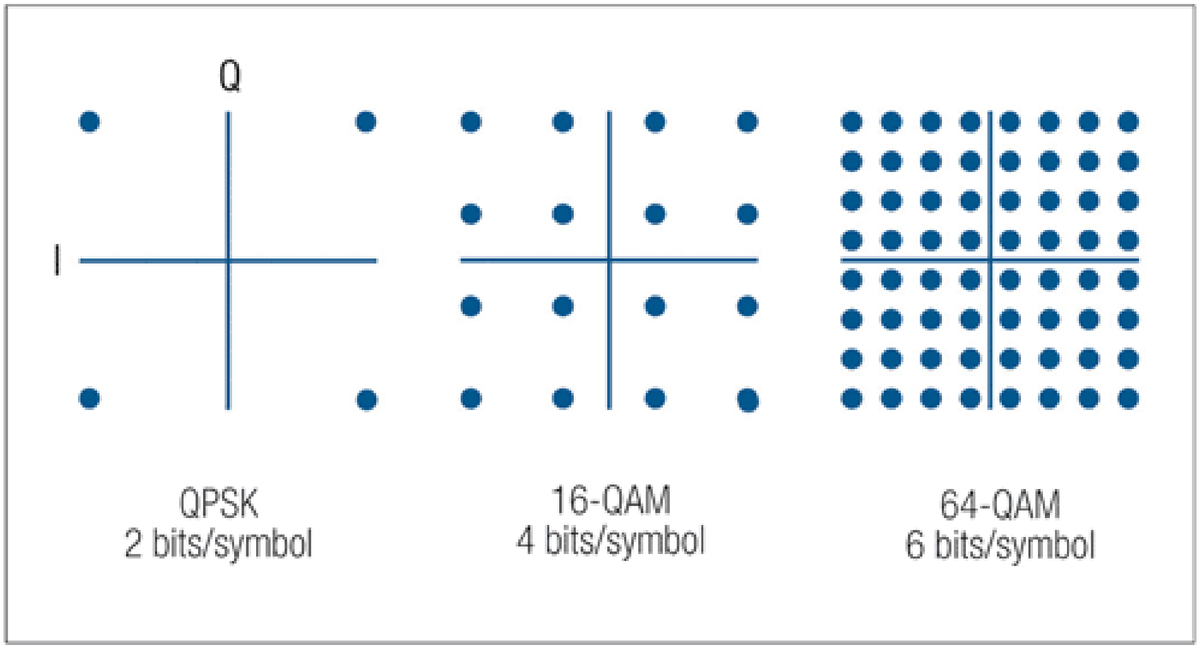

Figure 7.2- Different Types of QAM Constellation point

CHAPTER 8

MATLAB & CODES

8.1 Introduction to MATLAB

A large number of architects and researchers overall use MATLAB to investigate and plan the frameworks and items changing our reality. MATLAB is in car dynamic wellbeing frameworks, interplanetary rocket, wellbeing observing gadgets, shrewd force matrices, and LTE cell systems. It is utilized for machine learning, signal handling, picture preparing, PC vision, correspondences, computational account, control outline, apply autonomy, and a great deal more.

Math, Illustrations and Programming

The MATLAB stage is advanced for tackling building and investigative issues. The network based MATLAB dialect is the world's most normal approach to express computational arithmetic. Worked in illustrations make it simple to envision and pick up bits of knowledge from information. An unlimited library of prebuilt tool stash gives you a chance to escape with calculations crucial to your space. The desktop environment welcomes experimentation, investigation, and revelation. These MATLAB apparatuses and abilities are all thoroughly tried and intended to cooperate.

Scale, Coordinate and Deployment

MATLAB helps you take your thoughts past the desktop. You can run your investigations on bigger information sets and scale up to groups and mists. MATLAB code can be coordinated with different dialects, empowering you to convey calculations and applications inside web, venture, and generation frameworks.

8.2 CODES

For FFT size 32:

```
function compute_symbol_error_rate_qam_ofdm_awgn()

close all; figure
EsN0dB  = [0:33]; % symbol to noise ratio
M   = [16 64 256]; % 16QAM/64QAM and 256 QAM
color_vec1 = {'b-','m-','g-'};
color_vec2 = {'ks-','rx-','cd-'};
for (jj= 1:length(M))
    k      = sqrt(1/((2/3)*(M(jj)-1)));
    simSer(jj,:) = compute_symbol_error_rate(EsN0dB, M(jj));
    theorySer(jj,:) = 2*(1-1/sqrt(M(jj)))*erfc(k*sqrt((10.^(EsN0dB/10)))) ...
                  -                    (1-2/sqrt(M(jj))                    +
1/M(jj))*(erfc(k*sqrt((10.^(EsN0dB/10))))).^2;
    semilogy(EsN0dB,theorySer(jj,:),color_vec1{jj});
    hold on
    semilogy(EsN0dB,simSer(jj,:),   color_vec2{jj});
end
axis([0 33 10^-5 1])
grid on
legend('theory-16QAM',  'sim-16QAM',  'theory-64QAM',  'sim-64QAM',  'theory-
256QAM', 'sim-256QAM');
xlabel('Es/No, dB')
ylabel('Symbol Error Rate')
title('Symbol error probability curve for 16QAM/64QAM/256QAM using OFDM');
return ;

function [simSer] = compute_symbol_error_rate(EsN0dB, M);

% ofdm specifications
nFFT = 32; % fft size
nDSC = 52; % number of data subcarriers
nConstperOFDMsym = 52; % number of bits per OFDM symbol (same as the number
of subcarriers for BPSK)
nOFDMsym = 10^4; % number of ofdm symbols

% modulation
k = sqrt(1/((2/3)*(M-1))); % normalizing factor
m = [1:sqrt(M)/2]; % alphabets
alphaMqam = [-(2*m-1) 2*m-1];

EsN0dB_eff  =  EsN0dB   +  10*log10(nDSC/nFFT)  +  10*log10(64/80);  %  accounting
for the used subcarriers and cyclic prefix

for ii = 1:length(EsN0dB)

   % Transmitter
   ipMod       =       randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam)       +
j*randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam);
```

```
   ipMod_norm = k*reshape(ipMod,nConstperOFDMsym,nOFDMsym).'; % grouping into
multiple symbolsa

   % Assigning modulated symbols to subcarriers from [-26 to -1, +1 to +26]
   xF      =      [zeros(nOFDMsym,6)      ipMod_norm(:,[1:nConstperOFDMsym/2])
zeros(nOFDMsym,1)        ipMod_norm(:,[nConstperOFDMsym/2+1:nConstperOFDMsym])
zeros(nOFDMsym,5)] ;

   % Taking FFT, the term (nFFT/sqrt(nDSC)) is for normalizing the power of
transmit symbol to 1
   xt = (nFFT/sqrt(nDSC))*ifft(fftshift(xF.')).';

   % Appending cylic prefix
   xt = [xt(:,[49:64]) xt];

   % Concatenating multiple symbols to form a long vector
   xt = reshape(xt.',1,nOFDMsym*80);

   % Gaussian noise of unit variance, 0 mean
   nt = 1/sqrt(2)*[randn(1,nOFDMsym*80) + j*randn(1,nOFDMsym*80)];

   % Adding noise, the term sqrt(80/64) is to account for the wasted energy
due to cyclic prefix
   yt = sqrt(80/64)*xt + 10^(-EsN0dB_eff(ii)/20)*nt;

   % Receiver
   yt  =  reshape(yt.',80,nOFDMsym).';  %  formatting  the  received  vector  into
symbols
   yt = yt(:,[17:80]); % removing cyclic prefix

   % converting to frequency domain
   yF = (sqrt(nDSC)/nFFT)*fftshift(fft(yt.')).';
   yMod              =              sqrt(64/80)*yF(:,[6+[1:nConstperOFDMsym/2]
7+[nConstperOFDMsym/2+1:nConstperOFDMsym] ]);

   % demodulation
   y_re = real(yMod)/k;
   y_im = imag(yMod)/k;
   % rounding to the nearest alphabet
   % 0 to 2 --> 1
   % 2 to 4 --> 3
   % 4 to 6 --> 5 etc
   ipHat_re = 2*floor(y_re/2)+1;
   ipHat_re(find(ipHat_re>max(alphaMqam))) = max(alphaMqam);
   ipHat_re(find(ipHat_re<min(alphaMqam))) = min(alphaMqam);

   % rounding to the nearest alphabet
   % 0 to 2 --> 1
   % 2 to 4 --> 3
   % 4 to 6 --> 5 etc
   ipHat_im = 2*floor(y_im/2)+1;
   ipHat_im(find(ipHat_im>max(alphaMqam))) = max(alphaMqam);
   ipHat_im(find(ipHat_im<min(alphaMqam))) = min(alphaMqam);

   ipHat = ipHat_re + j*ipHat_im;
```

```
   % converting to vector
   ipHat_v = reshape(ipHat.',nConstperOFDMsym*nOFDMsym,1).';

   % counting the errors
   nErr(ii) = size(find(ipMod - ipHat_v ),2);

end
simSer = nErr/(nOFDMsym*nConstperOFDMsym);

return;
```

For FFT size 64:

```
function compute_symbol_error_rate_qam_ofdm_awgn()

close all; figure
EsN0dB  = [0:33]; % symbol to noise ratio
M   = [16 64 256]; % 16QAM/64QAM and 256 QAM
color_vec1 = {'b-','m-','g-'};
color_vec2 = {'ks-','rx-','cd-'};
for (jj= 1:length(M))
    k      = sqrt(1/((2/3)*(M(jj)-1)));
    simSer(jj,:) = compute_symbol_error_rate(EsN0dB, M(jj));
    theorySer(jj,:) = 2*(1-1/sqrt(M(jj)))*erfc(k*sqrt((10.^(EsN0dB/10)))) ...
                  -                      (1-2/sqrt(M(jj))                     +
1/M(jj))*(erfc(k*sqrt((10.^(EsN0dB/10))))).^2;
    semilogy(EsN0dB,theorySer(jj,:),color_vec1{jj});
    hold on
    semilogy(EsN0dB,simSer(jj,:),   color_vec2{jj});
end
axis([0 33 10^-5 1])
grid on
legend('theory-16QAM',  'sim-16QAM',  'theory-64QAM',  'sim-64QAM',  'theory-
256QAM', 'sim-256QAM');
xlabel('Es/No, dB')
ylabel('Symbol Error Rate')
title('Symbol error probability curve for 16QAM/64QAM/256QAM using OFDM');
return ;

function [simSer] = compute_symbol_error_rate(EsN0dB, M);

% ofdm specifications
nFFT = 64; % fft size
nDSC = 52; % number of data subcarriers
nConstperOFDMsym = 52; % number of bits per OFDM symbol (same as the number
of subcarriers for BPSK)
nOFDMsym = 10^4; % number of ofdm symbols

% modulation
k = sqrt(1/((2/3)*(M-1))); % normalizing factor
m = [1:sqrt(M)/2]; % alphabets
alphaMqam = [-(2*m-1) 2*m-1];
```

```
EsN0dB_eff = EsN0dB + 10*log10(nDSC/nFFT) + 10*log10(64/80); % accounting
for the used subcarriers and cyclic prefix

for ii = 1:length(EsN0dB)

   % Transmitter
   ipMod = randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam) +
j*randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam);
   ipMod_norm = k*reshape(ipMod,nConstperOFDMsym,nOFDMsym).'; % grouping into
multiple symbolsa

   % Assigning modulated symbols to subcarriers from [-26 to -1, +1 to +26]
   xF = [zeros(nOFDMsym,6) ipMod_norm(:,[1:nConstperOFDMsym/2])
zeros(nOFDMsym,1) ipMod_norm(:,[nConstperOFDMsym/2+1:nConstperOFDMsym])
zeros(nOFDMsym,5)] ;

   % Taking FFT, the term (nFFT/sqrt(nDSC)) is for normalizing the power of
transmit symbol to 1
   xt = (nFFT/sqrt(nDSC))*ifft(fftshift(xF.')).';

   % Appending cylic prefix
   xt = [xt(:,[49:64]) xt];

   % Concatenating multiple symbols to form a long vector
   xt = reshape(xt.',1,nOFDMsym*80);

   % Gaussian noise of unit variance, 0 mean
   nt = 1/sqrt(2)*[randn(1,nOFDMsym*80) + j*randn(1,nOFDMsym*80)];

   % Adding noise, the term sqrt(80/64) is to account for the wasted energy
due to cyclic prefix
   yt = sqrt(80/64)*xt + 10^(-EsN0dB_eff(ii)/20)*nt;

   % Receiver
   yt = reshape(yt.',80,nOFDMsym).'; % formatting the received vector into
symbols
   yt = yt(:,[17:80]); % removing cyclic prefix

   % converting to frequency domain
   yF = (sqrt(nDSC)/nFFT)*fftshift(fft(yt.')).';
   yMod = sqrt(64/80)*yF(:,[6+[1:nConstperOFDMsym/2]
7+[nConstperOFDMsym/2+1:nConstperOFDMsym] ]);

   % demodulation
   y_re = real(yMod)/k;
   y_im = imag(yMod)/k;
   % rounding to the nearest alphabet
   % 0 to 2 --> 1
   % 2 to 4 --> 3
   % 4 to 6 --> 5 etc
   ipHat_re = 2*floor(y_re/2)+1;
   ipHat_re(find(ipHat_re>max(alphaMqam))) = max(alphaMqam);
   ipHat_re(find(ipHat_re<min(alphaMqam))) = min(alphaMqam);
```

```
   % rounding to the nearest alphabet
   % 0 to 2 --> 1
   % 2 to 4 --> 3
   % 4 to 6 --> 5 etc
   ipHat_im = 2*floor(y_im/2)+1;
   ipHat_im(find(ipHat_im>max(alphaMqam))) = max(alphaMqam);
   ipHat_im(find(ipHat_im<min(alphaMqam))) = min(alphaMqam);

   ipHat = ipHat_re + j*ipHat_im;

   % converting to vector
   ipHat_v = reshape(ipHat.',nConstperOFDMsym*nOFDMsym,1).';

   % counting the errors
   nErr(ii) = size(find(ipMod - ipHat_v ),2);

end
simSer = nErr/(nOFDMsym*nConstperOFDMsym);

return;
```

For FFT size 64:

```
function compute_symbol_error_rate_qam_ofdm_awgn()

close all; figure
EsN0dB  = [0:33]; % symbol to noise ratio
M   = [16 64 256]; % 16QAM/64QAM and 256 QAM
color_vec1 = {'b-','m-','g-'};
color_vec2 = {'ks-','rx-','cd-'};
for (jj= 1:length(M))
    k      = sqrt(1/((2/3)*(M(jj)-1)));
    simSer(jj,:) = compute_symbol_error_rate(EsN0dB, M(jj));
    theorySer(jj,:) = 2*(1-1/sqrt(M(jj)))*erfc(k*sqrt((10.^(EsN0dB/10)))) ...
                  -                      (1-2/sqrt(M(jj))                      +
1/M(jj))*(erfc(k*sqrt((10.^(EsN0dB/10))))).^2;
    semilogy(EsN0dB,theorySer(jj,:),color_vec1{jj});
    hold on
    semilogy(EsN0dB,simSer(jj,:),   color_vec2{jj});
end
axis([0 33 10^-5 1])
grid on
legend('theory-16QAM',  'sim-16QAM',  'theory-64QAM',  'sim-64QAM',  'theory-
256QAM', 'sim-256QAM');
xlabel('Es/No, dB')
ylabel('Symbol Error Rate')
title('Symbol error probability curve for 16QAM/64QAM/256QAM using OFDM');
return ;

function [simSer] = compute_symbol_error_rate(EsN0dB, M);
```

```
% ofdm specifications
nFFT = 128; % fft size
nDSC = 52; % number of data subcarriers
nConstperOFDMsym = 52; % number of bits per OFDM symbol (same as the number
of subcarriers for BPSK)
nOFDMsym = 10^4; % number of ofdm symbols

% modulation
k = sqrt(1/((2/3)*(M-1))); % normalizing factor
m = [1:sqrt(M)/2]; % alphabets
alphaMqam = [-(2*m-1) 2*m-1];

EsN0dB_eff = EsN0dB  + 10*log10(nDSC/nFFT) + 10*log10(64/80); % accounting
for the used subcarriers and cyclic prefix

for ii = 1:length(EsN0dB)

   % Transmitter
   ipMod = randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam) +
j*randsrc(1,nConstperOFDMsym*nOFDMsym,alphaMqam);
   ipMod_norm = k*reshape(ipMod,nConstperOFDMsym,nOFDMsym).'; % grouping into
multiple symbolsa

   % Assigning modulated symbols to subcarriers from [-26 to -1, +1 to +26]
   xF = [zeros(nOFDMsym,6) ipMod_norm(:,[1:nConstperOFDMsym/2])
zeros(nOFDMsym,1) ipMod_norm(:,[nConstperOFDMsym/2+1:nConstperOFDMsym])
zeros(nOFDMsym,5)] ;

   % Taking FFT, the term (nFFT/sqrt(nDSC)) is for normalizing the power of
transmit symbol to 1
   xt = (nFFT/sqrt(nDSC))*ifft(fftshift(xF.')).';

   % Appending cylic prefix
   xt = [xt(:,[49:64]) xt];

   % Concatenating multiple symbols to form a long vector
   xt = reshape(xt.',1,nOFDMsym*80);

   % Gaussian noise of unit variance, 0 mean
   nt = 1/sqrt(2)*[randn(1,nOFDMsym*80) + j*randn(1,nOFDMsym*80)];

   % Adding noise, the term sqrt(80/64) is to account for the wasted energy
due to cyclic prefix
   yt = sqrt(80/64)*xt + 10^(-EsN0dB_eff(ii)/20)*nt;

   % Receiver
   yt = reshape(yt.',80,nOFDMsym).'; % formatting the received vector into
symbols
   yt = yt(:,[17:80]); % removing cyclic prefix

   % converting to frequency domain
   yF = (sqrt(nDSC)/nFFT)*fftshift(fft(yt.')).';
   yMod = sqrt(64/80)*yF(:,[6+[1:nConstperOFDMsym/2]
7+[nConstperOFDMsym/2+1:nConstperOFDMsym] ]);
```

```
    % demodulation
    y_re = real(yMod)/k;
    y_im = imag(yMod)/k;
    % rounding to the nearest alphabet
    % 0 to 2 --> 1
    % 2 to 4 --> 3
    % 4 to 6 --> 5 etc
    ipHat_re = 2*floor(y_re/2)+1;
    ipHat_re(find(ipHat_re>max(alphaMqam))) = max(alphaMqam);
    ipHat_re(find(ipHat_re<min(alphaMqam))) = min(alphaMqam);

    % rounding to the nearest alphabet
    % 0 to 2 --> 1
    % 2 to 4 --> 3
    % 4 to 6 --> 5 etc
    ipHat_im = 2*floor(y_im/2)+1;
    ipHat_im(find(ipHat_im>max(alphaMqam))) = max(alphaMqam);
    ipHat_im(find(ipHat_im<min(alphaMqam))) = min(alphaMqam);

    ipHat = ipHat_re + j*ipHat_im;

    % converting to vector
    ipHat_v = reshape(ipHat.',nConstperOFDMsym*nOFDMsym,1).';

    % counting the errors
    nErr(ii) = size(find(ipMod - ipHat_v ),2);

end
simSer = nErr/(nOFDMsym*nConstperOFDMsym);

return;
```

CHAPTER 9

SIMULATION & RESULT

For FFT size 32:

Parameter	**Value**
FFT size. nFFT	32
Number of used subcarriers. nDSC	26
FFT Sampling frequency	20 MHz
Subcarrier spacing	625 kHz
Used subcarrier index	{-13 to -1, +1 to +26}
Cylcic prefix duration, Tcp	0.8µs
Data symbol duration, Td	1.6µs
Total Symbol duration, Ts	2.4µs

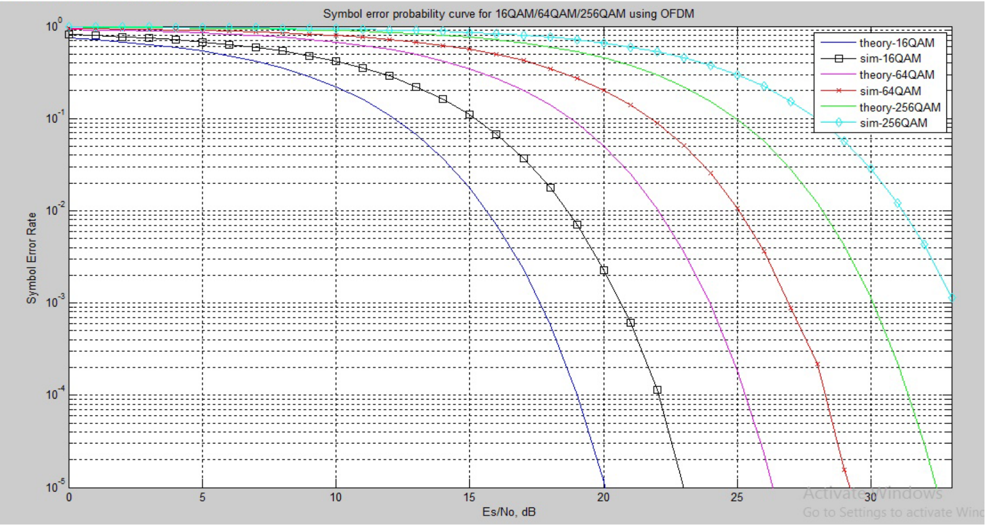

Figure 9.1- Theoretical and Simulation Curve of SNR vs. SER for 16, 64 and 256 QAM with FFT size 32

There in Figure 9.1 we see the difference between 16QAM/ 64QAM/ 256QAM at the value of nFFT =32. There for nFFT =32 16 QAM has the less symbol error rate at 20 db for theoretical value and 26db for simulation value.

For FFT size 64:

Parameter	**Value**
FFT size. nFFT	64
Number of used subcarriers. nDSC	52
FFT Sampling frequency	20MHz
Subcarrier spacing	312.5kHz
Used subcarrier index	{-26 to -1, +1 to +26}
Cylcic prefix duration, Tcp	0.8µs
Data symbol duration, Td	3.2µs
Total Symbol duration, Ts	4µs

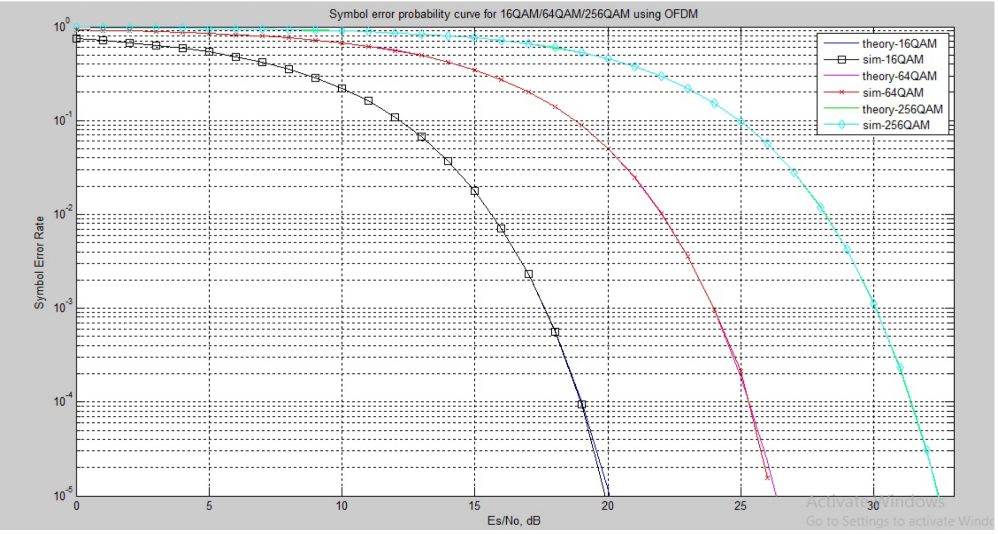

Figure 9.2- Theoretical and Simulation Curve of SNR vs. SER for 16, 64 and 256 QAM with FFT size 64

In Figure 9.2 the theoretical and simulation value of 16 QAM is the best one comparing to 64 QAM and 128 QAM. There 16 QAM has the error rate at 20 db at error rate of less than10^0.

For FFT size 128

Parameter	**Value**
FFT size. nFFT	128
Number of used subcarriers. nDSC	104
FFT Sampling frequency	20 MHz
Subcarrier spacing	156.25 kHz
Used subcarrier index	{-52 to -1, +1 to +52}
Cylcic prefix duration, Tcp	0.8µs
Data symbol duration, Td	6.4µs
Total Symbol duration, Ts	7.2µs

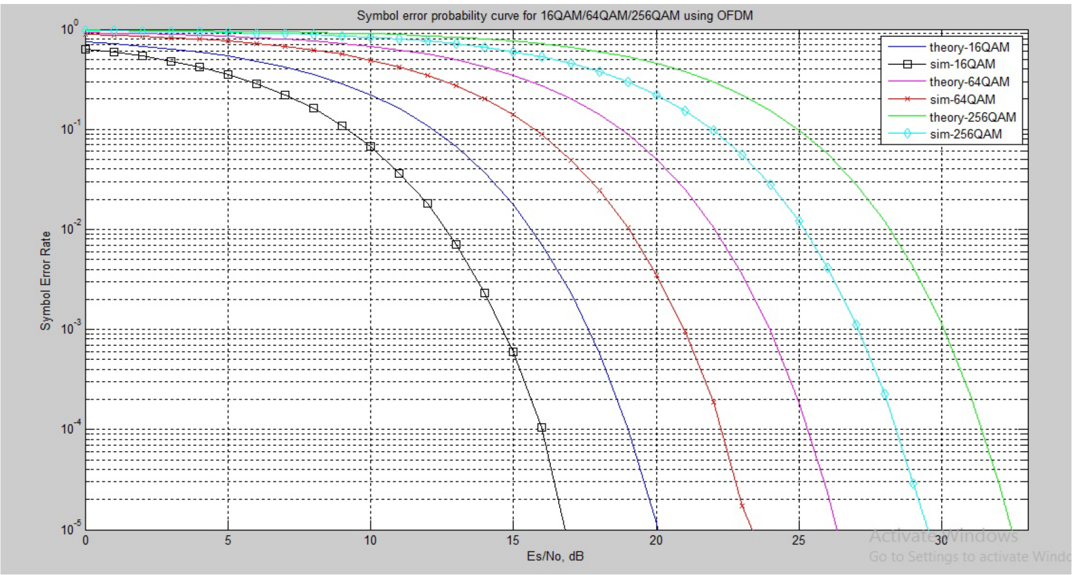

Figure 9.3- Theoretical and Simulation Curve of SNR vs. SER for 16, 64 and 256 QAM with FFT size 128

We propose nFFT =128 for QAM modulation in OFDM. In Figure 9.3 256 QAM has error at 29 an 33 db respectively for theoretical and simulation value. 64 QAM error is a smaller than 10^0 at 24 and 26 db respectively for for theoretical and simulation value. But in case of 16 QAM symbol error rate is $10^{-0.5}$ at 20 and 17 for theoretical and simulation value.

So we can say that in OFDM the modulation technique will be 16QAM with the nFFT value of 128. That will help us to reduce the symbol error rate.

CONCLUSION

The main aim of this paper is to analysis modulation techniques (16 QAM, 64 QAM, 256 QAM) used in OFDM varying the value of FFT. In this analysis we generate the symbol error rate vs. SNR graph of 16,64 and 256 QAM with simulation and theoretically in various FFT values. For the FFT size of 64 the simulating and theoretical curve of these modulation are almost same. In simulation 16 QAM with FFT size 128 is the best and 256 QAM with FFT size 32 is the worst. But in theoretically 16 QAM is the best. This analysis is useful for eliminating ISI using cyclic prefix and to make the modulation computationally efficient using OFDM with different value of FFT.

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