PERFORMANCE ANALYSIS OF HYBRID MIMO-WiMAX SYSTEMS

DISSERTATION-II

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By

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CERTIFICATE

This is to certify that the Dissertation-II entitled "**Performance Analysis of Hybrid MIMO-WiMAX Systems**" which is being submitted by ***Akanksha Sharma*** in partial fulfillment of the requirement for the award of degree Masters of Technology in Electronics and Communication Engineering to Lovely Professional University, Jalandhar, Punjab is a record of the candidates own work carried out by her under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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DECLARATION

I, Akanksha Sharma, student of M. Tech under the department of School of Electronics and Electrical Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-II report is based on my own intensive research and is genuine.

This Dissertation-II does not, to the best of my knowledge, contain part of my work which has been submitted for the award of my degree either of this university or any other university without proper citation.

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) is mostly considered because of its highly efficient bandwidth capability, its high data rate and ability to prevent multipath fading. It is much suitable technique for parallel transmission and use wireless interoperability for microwave access (WiMAX) on its physical layer. Higher the speed of communication better will be the veracity in it. This broadband is trying its best to get available to every place where they are lagging behind and should be accessible to all as soon as possible. On the other hand, multiple input multiple output (MIMO) techniques are important part of IEEE 802.16e 2005 specifications in adaptable WiMAX systems. From WiMAX technology, we can conquer the current problems of mobile communication systems like precise coverage of area, flat data rate and dearth of security.

In MIMO systems, various techniques like spatial diversity, spatial multiplexing and beam forming is explained in detail with best proper examples and diagrams in a very possible way. Here, explanations of these parameters will help in distinguishing them and make them understand in every possible way. After this, the main topic of this report i.e. MIMO-WiMAX is explained in detail by using Receiver diversity techniques like Maximal Ratio Combining, Selection Combining and Beamforming along with Spatial Multiplexing and Spatial Diversity used with WiMAX and compared with conventional WiMAX to get better results. Analysis has been done between various diversity techniques and multiplexing vs conventional WiMAX. Simulated patterns show the clear differences in BER of each and every technique

Image Transmission is also one of the highlighted topic that is added into this report and given a brief review of how we are transmitting our information through image and how it is getting encoded by using one of the best techniques known as MIMO. By using various M-PSK methods in image transmission helped us to know about much of the advantages and improvement on comparing with previous i.e. conventional WiMAX, Receiver Diversity techniques are employed to find out the best Image received during the whole process and comparison is made.

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LIST OF ABBREVIATIONS

BPSK	Binary Phase Shift Key
BER	Bit Error Rate
CC	Convolution Codes
CP	Cyclic Prefix
CSI	Channel State Information
FEC	Forward Error Control
FFT	Fast Fourier Transform
FDD	Frequency Domain Duplexing
FEC	Forward Error Control
IEEE	Institute of Electrical and Electronics Engineering
IFFT	Inverse Fast Fourier Transform
IP	Internet Protocol
ISI	Inter symbol Interference
LOS	Line of Sight
MRC	Maximal Ratio Combining
ML	Maximum Likelihood
MIMO	Multiple Input Multiple Output
NLOS	Non Line Of Sight
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PPP	Point to Point
PMP	Point to Multipoint
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Key

CHAPTER 1 INTRODUCTION

Evolution, discoveries, inventions for benefit of future generations is a routine of mankind and will be cherished for upcoming years too. One of those inventions that is bringing progress to nation involves 'Wireless Communication'. It is a boon for environment and a futuristic goal for all the inventors and researchers in this domain. Started from eighteenth century and gone with 1915, where first wireless voice transmission was set up in between New York and San Francisco which gave and immense hope to the researchers and users for the betterment of wireless future and going till now with various new inventions. It was first patented by Nikola Tesla and introduced us the wireless world.

All these fundamentals had put enough enthusiasm in everybody about wireless world because of the problems like:-

- Complex wiring problem to the global area where each person can't be connected to everyone around globe and especially to infeasible village areas, outer space, battle field etc.
- Inflexibility in connecting multiple devices, much more maintenance cost and additional costs for rewiring, damage to environment and especially path blockage to protect life from being complex and also from various multipath propagations like refraction, reflection, diffraction, inter symbol and inter carrier interferences etc.

Trending areas in wireless like Wi-Fi, WiMAX, 4G, LTE, 3GPP and much more which had helped people in getting more and better connections throughout worldwide and satisfied their needs which is tremendously making wireless market popular till now. Some of its advantages can be listed as:-

- Cheaper, durable, flexible and most importantly its efficiency makes wireless a better era for communication in various aspects. Whether it can be Bluetooth, handsets, cellular phones, Wi-Fi connectivity in homes which are easy mode of wireless communication.
- Voice over internet protocol which has crossed all the barriers and became trending in today's wireless scenario presenting the future to be brighter where everything is possible

wirelessly. Productivity has been increased so far which enables both businessmen and colleagues to carry out their work anywhere on time.

1.1 OFDM

Orthogonal Frequency Division Multiplexing or OFDM is a vogue technique that is being used for high speed data transfer and in latest wireless broadcast standards providing wide bandwidths. So, we can say, for the conversion of input data streams into N parallel data streams through serial to parallel port of multicarrier modulation i.e. OFDM. If user increases, the need for data increases which ultimately leads to use the currently used wireless communication for multicarrier modulation. Basically, origin of OFDM was from FDM (Frequency Division Multiplexing) which uses guard bands to reduce inter symbol interference between adjacent channels.

There are certain points which differentiate OFDM from conventional FDM:-

- Information is carried by subcarriers.
- Orthogonality of subcarriers.
- To minimize delay spread and Intersymbol interference insertion of guard bands to each symbol is done.

So, in OFDM it is most preferable to use multicarrier modulation as compared to single carrier which covers entire bandwidth. In multicarrier, the bandwidth is distributed among different subcarriers so that each one can carry needed amount of bandwidth and avoids wastage. In addition, conversion of frequency selective channels to flat sub channels is done with proper usage of available bandwidth. Data carried by subcarrier streams (which are generated with the help of DFT) are in such a way that they do not interfere each other as the subcarrier spacing is inversely proportional to symbol time which results in better outcome of signals by rejecting inter carrier interference.

There are certain possible advantages of OFDM which makes it special from others including high spectral efficiency, robustness against multipath propagation, using adequate channel coding and interleaving technique which through which one can recover the lost symbols due to frequency selectivity of channel; computational complexity can be reduced using FFT techniques for the implementation of modulation techniques, also removes co-channel interference and impulsive parasitic noise, makes efficient use of spectrum as carrier is further subdivided into subcarrier on permitting overlap.

On the other side, certain limitations including the amplitude which act as a noise with very large dynamic range and require radio power amplifier with high PAPR (Peak to Average Power Ratio), more sensitive to Doppler shift and frequency synchronization problems and has high Bit Error Rate (BER). Adoption of OFDM is done by various Wi-Fi areas (802.11a, 802.11n, 802.11ac and more) along with WiMAX standards and broadcast standards i.e. DVB & DAB (Digital Audio/Video Broadcast).

1.2 Challenges in OFDM

Despite of many advantages and application areas, the major problems in OFDM system is PAPR, BER, and synchronization at the receiver which restrict the OFDM application areas to some extent.

- **PAPR**

One new problem that comes in OFDM systems is PAPR. The main reason of occurring of PAPR is that there is uniform power spectrum at the input symbol stream of IFFT but at the output side non uniform spectrum is there.

PAPR is defined as the peak signal power versus the average signal power. The PAPR of a signal is expressed by the following formula:

$$PAPR_{db} = 10log\left(\frac{max\ x(t)x*(t)}{E\ x(t)x*(t)}\right) \qquad [1.1]$$

Where ()* represents conjugate operator.

- **Impact of high PAPR on a OFDM system**

OFDM fundamental issue is high PAPR on the grounds that when OFDM signal transmits over an optical fiber channel, because of high PAPR contortions is there brought about by nonlinear gadgets, for example, analog to digital converter, transmission fiber and so forth.

Vast PAPR brings about band mutilation and in addition out of band radiation which the real issue is endured by transmitted OFDM signal. Likewise it builds the trouble for analog -to-digital converter and digital- to-analog converter. It additionally diminishes the efficiency of radio power enhancer. The primary reason of happening the PAPR is that In Multicarrier framework diverse subcarriers are out of phase with each other [6]. At each moment they show distinctive phase with each other. When points achieve maximum value simultaneously then this will result that the output envelope suddenly to shoot up and becomes the reason of causing peak in the output envelope. In multicarrier framework many modulated subcarriers are there so more peak value will be there when contrasted with the average of the entire framework. This proportion is called PAPR. Because of expansive PAPR control speaker ought to be worked with extensive power back –offs brings about costly transmitters and wasteful amplification to come out and considered as a major drawback in OFDM systems.

- **BER (Bit Error Rate)**

BER is the ratio of erroneous bits to the total number of bits that have been transmitted over a *given time period. It is expressed as 10 to the negative power.

It is the major problem in OFDM system because as we reduced the PAPR, BER further goes on increasing at a drastic rate.

$$\text{BER} = \frac{Number\ of\ errors}{Total\ number\ of\ bits\ sent} \qquad [1.2]$$

1.3 WiMAX

In wireless communications, the requisition for the high data rate with unlimited speed access is going to be unstoppable for upcoming generation and leads to much more higher expectations. It is indeed that the services are provided for larger distance coverage up to 50 km or more from central tower along with the advantage that the places which are not wired yet (Indian villages) will get its access termed as “WiMAX” which is intelligibly developed and more matured than Wi-Fi. WiMAX (Worldwide Interoperability for Microwave Access) was described by the WiMAX Forum, set up in June 2001 to have oneness and reliability of the IEEE 802.16 standard, as of now called as Wireless MAN [1]. WiMAX is a trending innovation that grants higher information rates of about 1Gbps over long separations, proficient transmission bandwidth and diminishes obstructions.

IEEE 802.16 viable organization started creating innovations for wireless urban connections in 2000; in 2002 they distributed their first standard for Line of Sight (LOS) availability in 10-66 GHz frequency band (IEEE 802.16c). Uses of this standard included point to point (PPP) and point to multi point (PMP) microwave communication, interconnection between remote areas and to get data to use it in wide area network. This organization then extended the standard for use in the lower frequency range of 2-11 GHz which is permitted for non-line-of- sight (NLOS) connectivity (IEEE 802.16a) [2]. This was redesigned in 2004 (IEEE 802.16d) for smaller frequencies of 2-11 GHz range, focused to give a wideband associations to indoor clients. The IEEE affirmed the 802.16 benchmarks in June 2004, and three working groups were framed to access and rate the guidelines. WiMAX can be utilized for wireless networking like the popular Wi-Fi. WiMAX allows higher information rates over longer separations, productive utilization of bandwidth, and stays away from being mistaken. WiMAX can be termed incompletely an inheritor of the Wi-Fi convention, which is measured in feet, and provide its total time over shorter separations.

In short, operating for agreeable situations of RF communication, the system naturally ventures towards to a more congested mode (burst profile) which means very little amount of bits per OFDM/SOFDMA symbol; with the benefit that power per bit is more and therefore straightforward and precise signal processing can be done. The later Long Term Evolution (LTE) standard is a similar term portraying a parallel innovation to WiMAX that is being created by sellers and transporters as an inverse to WiMAX [3]. WiMAX standard 802.16e provides relevant, firm, compact and versatile wireless broadband connectivity without the requirement of direct observable pathway (LOS) with the base station. It is beneficial if more than hundreds and thousand people can be handled by single base station on comparing with Wi-Fi, where only 20 people get into network. It is not the same as previously used standard in the sense that 802.16e adds the element of versatility to the wireless broadband standard.

Some of the highlighting features of WiMAX are provided as below:-

- Standard: IEEE802.16e.
- Carrier Frequency: Below 11GHz (NLOS), 11-66GHz (LOS).

- Frequency Bands: 2.5GHz, 3.5GHz, 5.7GHz.
- Bandwidth:1.5MHz to 20MHz
- Technology: OFDM and OFDMA
- Data Rate: Up to 70Mbps.
- Distance: 10 KM.

For the brief view of WiMAX model, its basic techniques and stages include Transmitter, channel and receiver. In the transmitter section, binary input data is taken by FEC (Forward error correction) in which after that interleaving is done through which we get frequency diversity. After that the sequence is encoded by convolutional encoder. After the conversion of binary value to symbol value, the digital modulation scheme is applied on them followed by the implementation of Subcarriers by FFT is done and all this process id done in reverse order like the same way it is organized in actual order.

The standard when extended to IEEE 802.16e-2005 popularly called as Mobile WiMAX standard, which provides various solutions for wireless broadband data that provides an ease for meeting of mobile and fixed broadband networks through a common wide area broadband radio access technology and moulded network design. WiMAX provide a way through which anyone can be in touch with other person regardless of their location anytime and anywhere.

1.4 MIMO

Multiple antennas are worn at transmitter and receiver and this collection of arrangement can be called as MIMO (Multiple Input Multiple Output). Simply, it can be framed as different antennas on transmitter side and different antennas on receiver side combine to make a MIMO system. MIMO system specially takes the advantage of spatial diversity which is obtained by spatially detached antennas in multipath dispersed surroundings. MIMO systems can be resolved using numerous ways that can be either diversity gain or coding gain and both play an important role in MIMO. MIMO was presented to satisfy the aspirations for providing reliable great rapid wireless communication connections in severe surroundings. Numerous antennas are used in cellular communication at both transmitter and receiver sides to achieve high data rate through spatial multiplexing. . To increase the reliability of the message signal by sending two or more antennas with different attributes and to combat fading, co-channel interference, for avoiding burst errors, we go for diversity technique along with multiplexing arena.

MIMO systems and its functions are boon for environment providing numerous antennas on both transmitter and receiver side that raises throughput, data rate, spectral efficiency and reliability, by reducing the transmission power requirement, is giving people a better environment in the field of wireless communication. There are various ways for implementation of MIMO through which capacity and diversity gain can be achieved and can combat certain multipath fading effects. It makes use of space dimension and multipath to improve wireless system capacity, range, reliability and efficiency. So, we can say it is an antenna technology that is used in both receiver and transmission equipment for wireless radio communication. There can be much of MIMO configurations like 2x2 MIMO where 2 antennas are used to transmit the signal and two antennas are used to receive and similarly, 4x4 and 8x8 MIMO configurations are used for achieving high data rates and high frequency efficiency.

Here multiple transmitters send unique data to various receivers as shown in Figure 1.1.

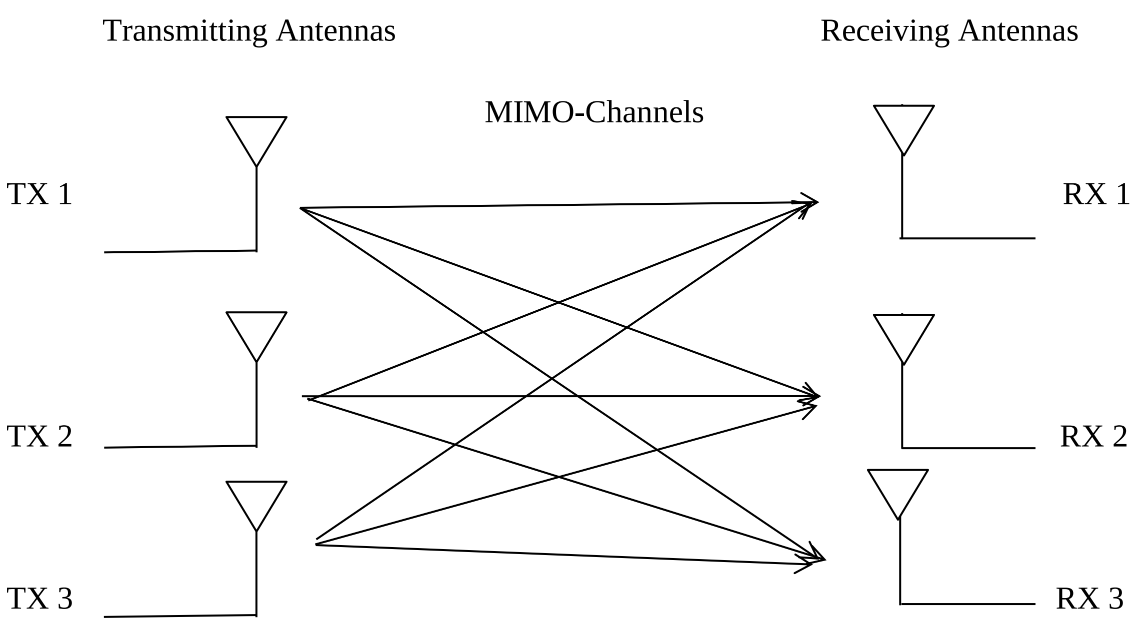


Figure 1.1: Block Diagram of MIMO System

MIMO requires better SNR and increases data rates along with provide high capacity which is directly proportional to antennas. It mainly consists of three categories. There are already many communication systems is used which occupy available bandwidth and now a days bandwidth communication is required and using one antenna at both the ends will not work. So, we move for multiple antennas, where sender and receiver send more than one data signal with same radio channel. It mainly has three categories. Beam forming for controlling the inclination to impart and conceal of radio signals, so that eye on particular signal can be retained excluding other signals. By sending same data to transmitter and receiver so that they experience different fading is spatial diversity. Third category includes spatial multiplexing where different data is set at two different antennas and we get maximum throughput. MIMO includes different techniques that can improve the performance of the MIMO system. With MIMO, the receiver end uses an algorithm or special signal processing to sort out the multiple signals to produce one signal that has the originally transmitted data.

1.5 MIMO-WiMAX

WiMAX based companies are trying to have something better for future prospectus in this field using the term MIMO along with it Using MIMO systems with WIMAX gives better BER performance compared to simple WIMAX. The MIMO schemes under WIMAX technology are determined by space-time coding and spatial multiplexing where each of them perform different functions. The MIMO-WiMAX stage is computationally effective and fit for reproducing space-specific, time-specific and frequency specific fading conditions. The test system can reenact any subjective power-delay profile without expanding the recipients sampling frequency. The test system has the capacity of simulating semi static fading conditions and block fading conditions. The stage was utilized to simulate current coding advances which comprise of Space-Time codes, Space-Frequency codes and Space-Time-Frequency codes.

If performance of WiMAX system is estimated by adaptive modulation then there are bigger chances for BER to improve and also it is mostly seen that in frequency selective fading channel is stirred by ISI in huge number as compared to flat fading. Researchers tried to relay out WiMAX simulations in OPNET which worked very well but it was not capable to take MIMO technique along with it. Companies like Huawei, Intel, etc., are bound in finding better solutions for MIMO based WiMAX systems. Best example is WiBro network in Korea from where Tikona Digital Networks from India offers WiBro service for up to 2Mbits/sec. WiMAX ratify MIMO antenna strategy which shows accompaniment in terms of spectral efficiency and link reliability. Performance of MIMO-WiMAX systems in a multi cell, multisector, and multiuser surroundings is of great impact in WiMAX technology by using single frequency. It provide a new vision and satisfaction to the people, researchers and inventors for better future of WiMAX and its astonishing properties has put the wireless environment to achievable heights with glory and happiness.

After MIMO-WiMAX, Image Transmission is introduced. Image transmission in the arena of wireless communication is considered as a big challenge. When large amount of data is to be transmitted, the need is to transmit it without any distortions and losses in environment. Today, large amount of focus is on quality transmission of visual images perfectly than the increased data rate and reliability through wireless means. Image transmission often gets depraved due difficulties like co-channel interference, distortions in signals, limitations in bandwidth and channels that vary according to time causes much more decrement in image transmission performance. So, various improvement factors are added and perfect visual images can be seen through M-PSK scheme proposed in this topic.

1.6 Objective of Thesis

The main objective of this research is to combine MIMO along with WiMAX under the WiMAX physical layer and to investigate the results with their improved behavior and also study its performance. Specific objectives of the research are:

- **Performance enhancement: -** To study the performance of MIMO-WiMAX for various scenarios of SNR values taken under physical layer of WiMAX and considered the various characteristic elements of WiMAX. Performance enhancement has been done by combining MIMO along with WiMAX i.e. hybrid MIMO-WiMAX compared with conventional WiMAX.
- **Capacity Improvement:** - Capacity is termed as the maximum useful information that is sent and received with less BER. And here, capacity improvement is done by introducing spatial multiplexing in MIMO which also increases the transmitted data rate. The spatial diversity augmented with spatial multiplexing increases the capacity rate on being implemented upon WiMAX physical layer.
- **Diversity Gain:** - Main objective of spatial diversity is to provide diversity gain i.e. less bit error rate and having M input antennas at transmitter and N output antennas at receiver side

i.e. M*N. Diversity gain helps to achieve better transmission and reception through diversity order which is taken into consideration.

- **Efficient Image Reception:** - To analyze and perform image transmission in MIMO-WiMAX for better and efficient image reception using various M-PSK techniques with less count of antennas.

1.7 Organization of Work

In this thesis, we provided and introduced various schemes under WiMAX physical layer as well as various comparisons are made between simulation results which showed that they are contributed in this thesis in well efficient manner. The serial wise orientation of thesis contains seven chapters:

Chapter 1: An introduction to OFDM systems, its challenges are discussed followed by WiMAX, brief introduction to MIMO, strong points about MIMO-WiMAX and then highlighted some points about Image Transmission.

Chapter 2: Literature survey, related work of all the topics chosen in this thesis and their research papers are studied firmly by writing them in proper sequence.

Chapter 3: It includes deep study about the WiMAX and its main purpose in this thesis can be understood by its full study of WiMAX physical layer model, its standards, features, advantages and disadvantages with proper explanation.

Chapter 4: MIMO systems had been introduced starting from its evolution; its techniques which are used under WiMAX physical layer are explained under the subsection and its importance in thesis.

Chapter 5: Research methodology is explained by dividing them into two sections. First one introduces about the full details of MIMO-WiMAX, its implementation along with diagram, second part consists of Image Transmission using different M-PSK schemes with different transmitters and receivers and having different SNR values are explained with the various Diversity Combining techniques used in detail.

Chapter 6: This Chapter is based on Results and Discussions where all results are simulated in Matlab-R2013a along with different comparisons have been made for better results starting from different receiver diversity techniques under WiMAX physical layer then comparison of spatial multiplexing and spatial diversity followed by image transmission using different M-PSK techniques with different SNR values where we receive better images for lesser antennas used.

Chapter 7: Whole thesis is scanned and concluded in this chapter properly along with some glimpse and inspiration for future scope.

CHAPTER 2 LITERATURE REVIEW

2.1 WiMAX

M. S. Murty et al. [4] compared the performances of Wi-Fi and WiMAX technology by including the issues like security, seamless handover, location and emergency services, corporation and QOS etc. along with their performances which showed WiMAX is more secure and reliable. Authentication and confidentiality both are present in WiMAX to provide better connection and communication. It helped in a better way to know about the WiMAX, its working and its comparison with the Wi-Fi and overall a good starting.

To understand basic modulation techniques i.e. binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), amplitude shift keying (ASK), frequency shift Keying (FSK) , On-off keying (OOK), DPSK & 8-PSK etc. are introduced by V. Tilwari et al.[5] Along with modulation techniques, coding rates, cyclic Prefix factors and OFDM symbol on WiMAX PHY layer is studied. Use of Reed Solomon Encoding and Convolutional Encoding is also encountered to analyze BER vs SNR which provides the results that the behavior of all modulation techniques was more or less similar but comparing all for high SNR values, BPSK modulation technique has provided better BER performance.

A. Agarwal et al. [6] focused on the reaction of Block Interleaving on Bit Error Rate Performance (BER) of WiMAX PHY layer. Using Digital Modulation Techniques which showed improvement in FEC system Performance by reducing Burst errors during transmission. Results showed that inter-leaver improves the performance of WiMAX system and increases the latency of communication system. The future work is discussed for further improvement in performance to employ convolution inter-leaving and frequency interleaving etc.

To overcome the problems of 802.16e protocol, S. Divya et al. [7] explained about 802.16 g protocol they equated working principles of 802.16e and 802.16g protocol. Several technologies are used like OFDM, MIMO, SC-FDM which improves spectral efficiency of frequency band. The use of different channel equalizers with STBC are used and analyzed on

WiMAX PHY layer. Results showed error free transmission in it. The information that can be taken is the importance of spectral efficiency related to the energy level for the upliftment of network lifetime because all the mobile devices are powered with battery.

2.2 MIMO

E. Biglieri et al. [8], concentrated on two MIMO profiles (Alamouti STC and 2*2 Spatial Multiplexing scheme) and compared them. In this, adjustment between spatial diversity, obstruction cancellation and spatial multiplexing is discussed followed by analyzing two MIMO options incorporated in details of mobile WiMAX systems. Two MIMO systems incorporated in same WiMAX specifications achieves similar performance when used with same spectral efficiency. Matrix A has high diversity and more robust than channel matrix B. He investigated their execution with ITU pedestrian B channel model with 3 kmph speed of pedestrian and revealed BER of 10^{-4} of two MIMO systems got similar performance. At lower BER values, Matrix A and B gives suitable performances. In ideal conditions, the results of ITU pedestrian reveal that the two plans prompt to comparative execution when they are worked on same spectral efficiency.

The examination of framework level execution of OFDM MIMO wireless LAN with the performance of SISO is done by adding Singular value Decomposition (SVD) with MIMO and channel capacity is developed which results in high throughput of SISO and carrying high traffic load by MIMO considering 5 GHz band and channel bandwidth of 20 MHz .Results at MAC layer the execution of considered framework is upgraded with the assistance of packet scheduling. MIMO systems perform better in indoor environment and equipped for supporting high activity stacks in astounding degree dissimilar to SISO frameworks in open air environment. Appropriate connection to framework interface in view of channel limit is utilized to portray system level performance accurately is proposed and established by K. Peppas et al. [9].

Comparison of Proposed precoding scheme with STBC and antenna selection is done. Obstacles like important feedback aloft, performance deterioration due to slow assessment and more capability to store at mobile devices prevents precoding from wide deployment. The used model of channel is ITU Pedestrian B along with NLOS condition and portable paces of their choices. The quantity of transmission radio wires are 2, 3, and 4. Transmission and reception antenna connections are 0.2 and 0, respectively. The delay in feedback is 2 frames. System bandwidth is 10 MHz and packet size is 512 bits. Used modulation levels are QPSK and 16 QAM, and coding scheme is convolutional codes with code rate 1⁄2 and 2⁄3. MMSE receiver is utilized to recognize numerous spatial streams. Here, 3 to 6 assessments are required to have choices prior to Matrix from codebook as originally there are fifteen codebooks present and each corresponds to individual configurations of antenna and codebook size and feedback delay is remunerated by channel expectation .On adding fifteen antenna/feedback arrangements to vector-based, organized codebooks with low multifaceted design is proposed by Q. Li et al. [10].

To enhance BER performance it is needed to investigate obstruction, the channel limit of intended MIMO system is high than traditional systems and they are based on novel V-BLAST architecture that is introduced having two schemes i.e. Spectrum Domain Encoding (SDE) & Wavelet Domain Encoding (WDE) that address both reliability and adaptability of the system. SDE based MIMO is not ready to manage non-stationary obstruction and the WDE Based MIMO system could conquer this inadequacy yet somewhat corrupts the execution under stationary impedance. On choosing both cases, the signal which is bearing modulated information would have practically no range at the interloped bands it ought not to be influenced by the obstruction is presented by K. Tan et al. [11].

A transmission scheme is developed to eliminate channel distortion and multipath fading to enhance noise immunity and BER. Various Transmit Diversity schemes that scatter the transmitter in multi measurement to enhance noise immunity and Diversity combining techniques are compared by simulations done by M. Hemalatha et al. [12]. Here, spatial diversity is consolidated with WiMAX and the advantages are joined with space diversity techniques and being analyzed based on bit error rate performance (BER) and performance is compared for SISO and MIMO configurations. In the event of urban situations, when large portion of the receiver antenna is awarded with signals which are weakly faded because of independent fading and also by raising the number of antennas at both transmitter and receiver side, there is still a likelihood that out of them one antenna will receive least faded signal which significantly diminishes the bit error rate, when contrasted with MISO and SISO schemes.

S. P. Alex et al. [13] presented various methods to evaluate MIMO-WiMAX in multi cell, multi sector and multi user environment for single frequency reuse. They used both uplink and downlink where SM of downlink show 10% improvement over SIMO and uplink increase the spectral efficiency by 9% over SIMO system same as beamforming. Along with this, it is also discussed that, in Time Division Duplex (TDD) WiMAX systems, due to beamforming the raise in downlink spectral efficiency can be huge if the delay between channel estimation of uplink that can be seen with more antennas from base station by utilizing uplink beamforming and downlink beamforming is little contrasted with the coherence time of the channel and calculation of post processing SINR for all MIMO schemes is additionally done. Beamforming on uplink yields vast increment in spectral efficiency over SISO.

2.3 MIMO-OFDM

Two MIMO PHY layer changes (STBC) and (SM) are examined and gave high transfer speed viability, turnout and information rates. With the assistance of MATLAB simulations they acquired components to enhance WiMAX PHY layer with high spectral efficiency. In this Model of WiMAX PHY layer is examined followed by simulation consequences of various MIMO designs (STBC,V-BLAST) is dissected for various estimations of data transmission, cyclic prefix, FFT measure, and different modulation techniques. Exactly when SNR is unbelievably greater than 20 dB, both SISO and STBC systems remain essentially at same throughput. So STBC structure conveys the best execution at low and medium estimations of SNR (from 1 to 13 dB), because of their excess amount in poor channel conditions is a proposed conspire given by H. Zerrouki et al. [14].

F. Farhan [15] studied the time synchronization errors in OFDM system, its major effects, and performances with BER and compared with some synchronization algorithms with OFDM system which demonstrated blurring environment and gives great picture of down to earth situations. They highlighted the execution of OFDM in DVB-T (digital video broadcasting terrestrial). Mainly the planning counterbalance issue of OFDM is amended here and by proposed scheme of using cyclic prefix (CP) as a SC (Schmidl and COX) algorithm. It highlights the planning synchronization and also execution correlation through bit error rate. A way to correct timing offset with the assumption that CFO rectification has been made. The line by line investigation is done where each case was concentrated on with various estimation of time-offset samples. Obviously the remade signal constellation grouping with higher SNR esteem takes after the perfect constellation more intently than those with less SNR esteem.

Proposed method of parallel combination scheme to reduce PAPR in MIMO-OFDM system below Rayleigh fading environment which reduces PAPR and complexity of system and maintain BER and maintain data rates along with provide low in-band swells and out of band radiations is proved by K. Pachori et al. [16]. Various traditional and hybrid techniques are used to reduce PAPR where each routine plan have its own benefits and negative marks as far as the out-of-band obstruction, and data rate loss. However, the mixture technique consolidates a few routine plans together and aggregates their advantages in a combinational approach, yet the computational unpredictability in combinational strategy is likewise a noteworthy issue of concern.

Y. J. Liang [17] proposed a strategy to appraise the joint channel and frequency offset for the downlink of composed MIMO-OFDM framework. High standard wireless communication systems, for example, Wi-Fi, WIMAX utilizes multiple – input multiple output orthogonal frequency division and multiplexing to accomplish high information rate and constancy. A typical issue in cellular communication is inter cellular interference because of the versatility of hardest. The distinction in information rate while moving from focus to the limit can be lessens in an arrange multi cellular idea in which different MIMO base stations collaborate to basically shape MIMO framework and accomplish both a more uniform correspondence quality and an expansion in system capacity. Results demonstrate that the proposed estimator performs extremely well for the customary methodologies and centre frequency offset is additionally lessened. The proposed calculation unites rapidly and is more productive regarding computational multifaceted nature of this.

D. Darsena et al. [18] proposed a multiple input multiple output antenna system with space time frequency block coding and 43orthogonal frequency division multiplexing with cyclic prefix. In light of the use of both space time frequencies block coding and OFDM the receiver complexity rises. With a specific end goal to lessen the receiver complexity In MIMO-OFDM with spatial multiplexing the proposed conspire had expected that independent symbols were transmitted over various antennas to expand the information rate. Two sorts of channel shorteners were proposed both were depending on directly compelled minimization of the mean-output energy of the signal at the output of the channel shortener, where the straight constrained were picked ideally to boost the signal to noise proportion either at the input of the space time frequency block coded maximum likelihood decoder. At the point when contrasted and dazzle channel shorteners, the prior one were robust than the later.

To achieve high density with minimum error rate low density parity check codes are being used as for their specialty in error correction performances in many applications. The usage of tanner graph is done which is also called LDPC and has a short cycle which degrades the performance of LDPC decoders. Introduction to Quasi cyclic (QC) LDPC is done along with STBC which increases the diversity gain. Performance analysis of MIMO-OFDM physical layer in WiMAX by using LDPC codes along with various modulation techniques are being used where results showed that higher order modulations are less resilient to noise by M. Cheema et al. [19].

Chouhan S. et al. [20] represented investigation of Space Time Coded (STBC) MIMO systems with evaluating the performance of signal and multiple input multiple output port for WiMAX according to standards given and analyze the transmitter receiver models according to parameters discussed to evaluate which points to result by showing proposed scheme of STBC MIMO-OFDM 2*1 and MIMO-OFDM 2*2 scheme provides better PAPR abatement along with improved efficiency of bandwidth and BER performance with 88% increment as compared to 77% in WiMAX 802.16 that is based on MIMO-OFDM systems.

B. S. K. Reddy [21] highlighted system performance by taking note of various channels named as additive white Gaussian noise (AWGN), multipath fading or frequency-selective channels and flat fading channel and their impacts along with them. By implementing OFDMA downlink PUSC PHY for communication transceiver under IEEE 802.16-2009 Standard by use of Simulink and analyzed how different fading channels influence wireless PHY system. Adaptive coded modulation integration is done along with standard and particular modulation and based on SNR value of received signal code rate value is selected.

The concept of Massive MIMO has been explained by telling its advantages that it can become a good start for faster data rates and data interleavers. The need for random access by devices by pilot sequences is used in channel estimation. Protocols named as pilot access and data transmissions are explained by fulfilling different requirement of 5G services which shows that massive MIMO stops colliding of information in pilots and same pilots can be used without any collidation. Massive MIMO is a great start in evolution of 5G services and will be more better in future prospects is discussed by E. d. Carvalho et al. [22].

2.4 MIMO WIMAX

The MIMO-WiMAX stage is very effective in context of reproducing the conditions like space-specific, time-specific and frequency specific fading. The test system can repeat any subjective profile of power-delay without expanding the recipients of sampling frequency. The test system has given right to simulate semi static fading conditions and block fading conditions. Utilization of stage is done to simulate current coding advancement techniques which comprises of Space-Time codes, Space-Frequency codes and Space-Time-Frequency codes. Prologue to MIMO is as per the IEEE 802.16e-2005 standard (WiMAX). Alongside speaking to genuine MIMO-WiMAX stage to recreate space, time and frequency selective fading conditions and utilized this stage to reenact space-time codes(STC), space-frequency codes(SFC) and space-time-frequency codes(STFC) where STFC demonstrated variety gain contrasted with both STC and SFC by K. P. Maré et al. [23].

The exhibitions of the best full-rate full-diversity 2×2 STC also known as Golden code, on a 2×2 downlink MIMO transmission are given and contrasted with spatial muliplexing. As before this paper, execution situations of such complex code were constrained and environment of WiMAX was not clarified and talked about in well and better way and overcome by this paper. Downlink execution of two full-rate STC's of IEEE 802.16e i.e. Matrix B and Matrix C is talked about which demonstrated that Matrix C has long and complex interpreting and minimum utilized as a part of current WiMAX framework. The results solved numerically demonstrated that the channel coding lessens extensively the upside of Matrix C over the Matrix B, contrasted with the decoded case. And the more strikingly, contingent upon the calculated coding rate and modulation size of Matrix B may even beat Matrix C over SNR range of enthusiasm by R. Kobeissi et al. [24].

This paper breaks down the MIMO choices incorporated into the particulars of portable WiMAX frameworks. Here, Alamouti's STC and its combination with maximum ratio combining (MRC) at the receiver is depicted in detail. Then, Comparison of the two MIMO alternatives and MIMO choices with adaptive modulation and coding by deciding the SNR edges of working areas is done in legitimate way. Results showed Matrix A performs superior as compared Matrix B and throughput is augmented by consolidating MIMO with adaptive modulation and coding by B. Muquet et al. [25].

S. Medhn et al. [26] explains about the cooperative MIMO idea where cooperation is used to amplify and then forward strategy of relaying and along with that MIMO is used which is based on Vertical Bell-Labs Layered Space Time (V-BLAST) architecture. Both cooperation along with MIMO are combined to be used in WiMAX technology. Various receiver diversity techniques like Maximal Ratio Combining (MRC), Selection Combining (SC), Equal Gain Combining (EGC), Minimum Mean Square Error (MMSE), Zero Forcing (ZF) and Maximal Likelihood detection (ML) are discussed where results showed that Co-MIMO provides better results i.e. better Symbol Error Rate performance (SER) as compared to conventional Cooperative diversity and MIMO systems only.

Riche et al. [27] had done investigation using MATLAB simulation i.e. implementing orders of QAM that is mostly used in wired networks. The BER performance using the values 256, 512, 1024, 2048, and 4096 for QAM-Orthogonal Frequency Division Multiplexing (OFDM) signals in the company of Rayleigh and Rician multipath channels with additive white Gaussian noise (AWGN) are simulated and results are carried out. Outcome of this simulation shows that data throughput of a system can be effectively increase by sending bits per symbol in huge quantity or more in number. Due to high BER, throughput increases, which can be resolved by raising the system power.

This paper performs Image transmission with Space Time Block Coding (STBC) and Spatial Multiplexing (SM) and Hybrid MIMO with OFDM model. Hybrid MIMO-OFDM can be called as mixture of SM and STBC with OFDM. With the help of BER, throughput and output of image quality, performance of the above given models is observed. The results demonstrate that Hybrid MIMO-OFDM provides Hybrid MIMO with OFDM models are done. A Hybrid MIMO-OFDM is a combination of SM and STBC with OFDM. The performance of the above mentioned models are measured with respect to BER and Throughput and output image quality. The results demonstrate that Hybrid MIMO-OFDM provides low BER along with high throughput pointed by S. R. Chaudhary et al. [28]

E.T. Tchao et al. [29] presented an idea to effectively spread high capacity 4G-WiMAX network in Ghana by simulating BER in MIMO antenna configurations. Use of Genex-Unet and NEC has presented the radiation pattern of antenna which is used to spread the network and showed the well-established results. In the vicinity of multiple interferers, it is seen that the 4x4 MIMO configurations provides agreeable results than conventional 2x2 MIMO configurations. It is recommended to use 4x4 MIMO antenna configurations with upper side lobes being suppressed after spreading the network in the presence of side lobe emissions which are unsuppressed in the current antenna.

Digital modulations and Convolutional code rates had analyzed various 2x2 MIMO frameworks by B. S. Kumar Reddy et al. [30] that aims to give information about the advantages of using multiple antennas rather than using single antenna under GNU radio. Various channels (Rayleigh, AWGN and Binary symmetric channels) are used through which BER execution is analyzed by varying distinctive encoders, such as Convolutional, RMG and RM coders where the simulated results shows that convolutional encoder has better BER performance as compared with remaining two.

Data rate and performance of the system is highly increased by including multiple input and multiple output (MIMO) in mobile WiMAX system which provides a strong and healthy platform for space, time and frequency selective fading conditions. The MIMO mobile WiMAX system is simulated using MATLAB and its system performance is carried out by using space time block code for different modulation schemes (QPSK,8-PSK,16-QAM,64-QAM) under different channel conditions like AWGN, Rayleigh and Rician for different diversity schemes like Alamouti (2x1), MRC(1x2), MRC(1x4) STBC-ML(3x4). For processing of receiving sognal, MIMO MRC is used. Outcome of all the above techniques, different channel conditions and various schemes shows that better BER performance is achieved by altering SNR values consistently at different channels out of which lower modulation schemes provides effective BER performance as compared to higher modulation schemes used said by C. K. Thadani et al. [31]

A. F. Cattoni et al. [32] proposed Multi-User (MU-MIMO) technique in which combination of high capacity achievable using MIMO channel and advantage of space division multiple access is done for achieving better results through proposed technique. Here, in order to reduce multiuser interference, interference based precoding algorithm is used by doing capacity analysis which leads to the results that above proposed precoding algorithm can lead to significant rise in the channel capacity in a better way.

In this letter, a new multi-user detector based on equal gain combining (EGC) and maximum likelihood (ML) principle is proposed. After envelop detection and frequency de-hopping operations, the proposed algorithm picks up several most possible estimations based on EGC principle and then make final decision via ML detector within the possible searching range. Our simulation results show that this novel EGC-ML detector may noticeably reduce the complexity of ML detector with acceptable bit error rate (BER) performance decrement, when reasonable searching range is chosen by EGC principle is referred as EGC aided ML (EGCML) detector proposed by F. Yang et al. [33]

Proposed piecewise-linear combining method in Maximal Likelihood demodulation is done to find accurately by nonlinear ML coherent and non-coherent detectors by approximating the Decode and Forward (DF) value. A limited diversity order is applied for coherent and non-coherent DF with different relays is also provided, and on comparing DF and AF it is suggested that half of the diversity order of AF will be loosed by DF if it will be having more than one relay. On introducing piecewise-linear combining method, results in tight, closely formed BER approximated values for the non-coherent ML combiner given by D. Chen et al. [34]

Communication of multi antenna base stations (BSs) with single-antenna mobile stations (MSs) under maximal ratio transmission (MRT) in downlink wireless channel is highlighted here. Homogeneous Poisson point process (PPP) is used here to model the location of BSs and Rayleigh random variables are being used to model the channel gains between multiple antennas of each BS and single antenna of each MS. Firstly derived expressions are presented after that the closed-form expressions are obtained from these derived expressions for the successful presentation of results and high spectral efficiency under wireless area network given by G. C. Alexandropoulos et al. [35]. Results show that spatial fading correlation affects the network performance depending on the interplay between the density of BSs and the target SINR threshold and depending on the background noise level, spatial fading correlation may increase or decrease the network throughput, having a phase transition for a certain SINR threshold value.

Assumption is being made where the Bob (legitimate user) and malicious eavesdropper (Eve) are there in which MRC is used at receiver side where Bob gets its data from both relay and source having a mutual communication in between. While using relay selection, higher order of spatial diversity can be used as compared to the conventional methods used in MRC. The valid outcome that came by doing simulations has proved that the theoretical results matches with the calculated numerical results and has provided better security by introducing relay selection as given by T. Li et al. [36].

2.5 Image Transmission

Modelling of particular wireless channel is done i.e. AWGN, Rayleigh and Rician so as to improve BER of the system along with current status of WiMAX system is presented. For image and speech transmission with practical scenario in WiMAX systems, several changes in channel parameters are done on adding antenna diversity principles along with various wireless channels in order to improve BER performance. To do the modelling efficiently for realizing efficient propagation of WiMAX system, more suitable path for long distance i.e. AWGN is chosen here for modelling. Simulation is done in Rayleigh channel model to find out the real time multipath structure of WiMAX model and Doppler shift is applied to improve the performance in the worst possible case. Justification for the line of sight is done by doing modelling WiMAX with Rician channel. And for more improvement in the performance can be done by merging antenna diversity technique with BLAST as well as STBC is discussed by S. Bhavin et al.[37]

To study MIMO advantages in depth, Large MIMO-CDMA system used with image transmission across Rayleigh fading channels are inserted. Evaluation of system is done by MSSIM Index, where quality of the received image is compared by keeping the original image as reference. They proved that if number of antennas is increased then BER simultaneously improved and with introduction of spatial diversity in wireless system ensure connection reliability and high data rate. For spreading purpose Walsh code is being used which are orthogonal and better than PN codes along with the future prospects are being discussed by M. Berceanu at al. [38]

Y. Sun et al. [39] introduced about image transmission achieved through wireless channel by joining joint source-channel coding (JSCC), space-time coding, and orthogonal frequency division multiplexing (OFDM). Here, for coherent detection, perfect channel state information is assumed to evaluate the BER performance of space time coded OFDM based MIMO system built on MIMO fading channel. Then, a fast local search algorithm is applied to optimize the unequal error protection design in JSCC for a given SNR, for different constellation sizes. Through this design, the expected reconstructed image quality can be measured. By using end-to-end system performance evaluation, proposed adaptive modulation scheme is used to pick the best reconstructed image quality for each average SNR offered by constellation size. Proposed adaptive modulation scheme has become effective which is confirmed by simulated patterns of image transmissions.

Various competing MIMO transmission techniques, namely, ODQ, BST, OBST, RO and CO are used to improve the image quality. Here, few transmission techniques of MIMO for image quality over 4G wireless network has been discussed. Results showed that in case of image quality increase with transmitted power, the proposed ODQ techniques are compared with the various MIMO transition techniques such as CO, RO and BST regarding performance parameters like average throughputs and PSNR. From all the algorithms discussed in the paper, it is that these algorithms give much better performance than other algorithms concluded by N. R. Deepak et al. [40]

A. Sadeque et al. [41] employed space time block code (STBC) to reduce the effect of cross-correlation among signals of a multiple-input multiple-output (MIMO) based radar imaging system which are transmitted parallelly. Also, by making use of diversity provided by the transmission technique, requirement of hardware is almost reduced as compared to conventional technology. After performing the above proposed technique and performing them, results shows that the MIMO radar with TR-STBC provide same image resolution just like conventional one but with 60% less antennas.

M. Mhamdi et al. [42] investigated about new idea where embedded images are transmitted over MIMO wireless channel and considered as best communication strategy. Main objective of this report is to guarantee the Quality of Service (QoS) which is required by users for all possible channel states. Two important and major improvements are highlighted. The first one uses Unequal Power Allocation (UPA) and aims at making transmit power effective over the different antennas in order to make the image quality better and perfect at the receiver side. The second improvement is on Joint Source-Channel (JSC) soft-input arithmetic decoding and decreases the error rate at receiver side without including extra redundancy. Here, Robust SPIHT (R-SPIHT) source encoder is considered to produce an embedded bit-stream. Results showed better image quality at the receiver side, along with Signal to Noise Ratio (PSNR) gains, especially at the receiver side realistic noisy channel provided by 3D ray-tracing software quality improvements, with Peak Signal to Noise Ratio (PSNR) gains.

Transmit Antenna Selection (TAS) technique is here organized depending on Maximal Ratio Combining (MRC) scheme where single antenna is used for image transmission. With the use of Rician fading channel, analysis is carried for input image. Involvement of receiver diversity techniques along with the model of feedback is included in proposed TAS/MRC system in Simulink with new version of channel design. While analyzing the BER performance of the number of transmit and receive antennas under rician fading environment and results showed that single transmit antenna selection give improved performance compared to conventional MIMO sytems for image transmission. On increasing the number of transmit antennas improves the system performance further and can make it more result oriented by increasing antennas in TAS with MRC as shown by V. S. Hendre et al. [43]

The need of compatible image to be transmitted in wireless channel is with channel characteristics such as bandwidth. Various noises present during image acquisition that is needed to be removed while doing image formatting and de-formatting process at both transmitter and receiver side respectively. Outcome of using different compression techniques including such as Run Length Encoding (RLE), Precision Run Length Encoding (K-RLE), Discrete Cosine Transform (DCT) and Wavelet transform out of which reduction of data size more effectively is done by K-RLE as compared to RLE. For wireless communication system using 16-HQAM, 16-QAM and Quarter Phase Shift Keying out of which transmission of more data on same channel is provided by 16-QAM and in 16-HQAM where improved performance is a result of median filter and Unequal Error Protection (UEP) with the advantage being more bandwidth efficient is proposed by M. Chandra et al. [44]

Performance of image transmissions over WiMAX networks is done under different fading channels. Purpose is to determine optimum technique in every transmission stage that can be used for obtaining the optimum performance of the image transmission process. The results showed that evaluation of image segmentation into packets that achieves best performance in first scenario. Coding considerations with different packet length including turbo codes used in which ½ turbo code gives best performance. And in modulation variation scenario, BPSK technique performed best sorted by H. Kasban, et al. [45]

WiMAX innovation depends on IEEE 802.16 standard, which is likewise called Wireless MAN. The IEEE 802.16 group was framed in 1998 to build up a common air interface standard for wireless broadband. The group's starting concentration was the advancement of a LOS-based point-to-multipoint wireless broadband system for transaction in the 11-66 GHz millimeter wave band. The principal form of the standard IEEE802.16 was endorsed on December 2001 and it experienced numerous amendments to oblige new elements and functionalities. The present version of the standard IEEE802.16, endorsed on September 2004. In the IEEE802.16-2005, this layer has been adjusted to adaptable OFDMA, where FFT size is variable and can take any of the value: 128, 512, 1024 & 2,048.

The variable FFT size taken into account for precise work of the framework in extensive variety of the bandwidths of channel and various radio conditions; this PHY layer is mostly used by WiMAX for versatile and convenient operations and is additionally alluded to as portable WiMAX. There are few noteworthy inadequacies of WiMAX. Major shortcomings of WiMAX are there which still dilemma are for the engineer's. They are given as:

Data Rates: Portable WiMAX utilizes client premises to fixed WiMAX Equipment (CPE) which is appended to computers (either desktop or laptop or PDA) and an omnidirectional antenna of smaller gain is introduced that is hard to utilize through about.

Bit Error Rate: Normal idea of WiMAX is that, it gives fast information rates inside its greatest range (30 miles).BER increases if WiMAX exceeds the operation of radio signals in more extreme range. So, to get higher information rates, it is better to utilize lower bit rates within short range.

3.1 Features of WiMAX

- Very high peak Data Rates.
- Expandable bandwidth and supported data rate.
- Adaptive Modulation and Coding (AMC).
- Retransmission of Link Layer.
- Platform to TDD and FDD.

- WiMAX uses OFDM.
- User Resource Allocation (both Flexible and dynamic).
- Use of Advanced Antenna Techniques.
- Quality-of-service Support.

3.2 WiMAX Model

In this WiMAX model, its basic techniques and stages include Transmitter, channel and receiver. In the transmitter section, binary input data is taken by FEC (Forward error correction) in which after that interleaving is done through which we get frequency diversity. After that the sequence is encoded by convolutional encoder. Conversion of binary value to symbol value, the digital modulation scheme is applied on them followed by the implementation of Subcarriers by FFT is done and all this process id done in reverse order like the same way it is organized in actual order.
The fundamental part of WiMAX PHY layer is to cipher the binary digits that serve as MAC outlines, and furthermore, to transmit and get these signals over the correspondence media. The WiMAX PHY layer mainly facilitates rapid information, video and interactive media The PHY layer; appeared in Figure3.1, in WiMAX incorporates different useful stages: (i) forward Error Correction (FEC): including; randomizing, channel encoding, rate coordinating, interleaving, and symbol mapping; (ii) OFDM symbol in frequency concern, and (iii) transformation of the OFDM symbol from the frequency domain to time domain.

3.3 Transmitter

The PHY layer transmitter area comprises of Channel encoder and Modulator. Channel encoding stage incorporates Randomization, a brew of internal Reed Solomon code and external convolutional code and puncturing to deliver higher code rate followed by block interleaver and mapped modulated data.

It is a starting phase of WiMAX PHY layer and tells us about the procedure in which whole process is started and carried out further to get valuable data at the receiver side. Started from channel encoding, modulating, interleaving, IFFT, parallel to serial conversion and then adding cyclic prefix to go towards the receiver side and get the original data back by performing all the steps in reverse way as done earlier at the transmitting side. Transmitter plays an important role in any of the block diagram process, where we need to send our data in well-defined manner and reverse in the same way to get original data back.

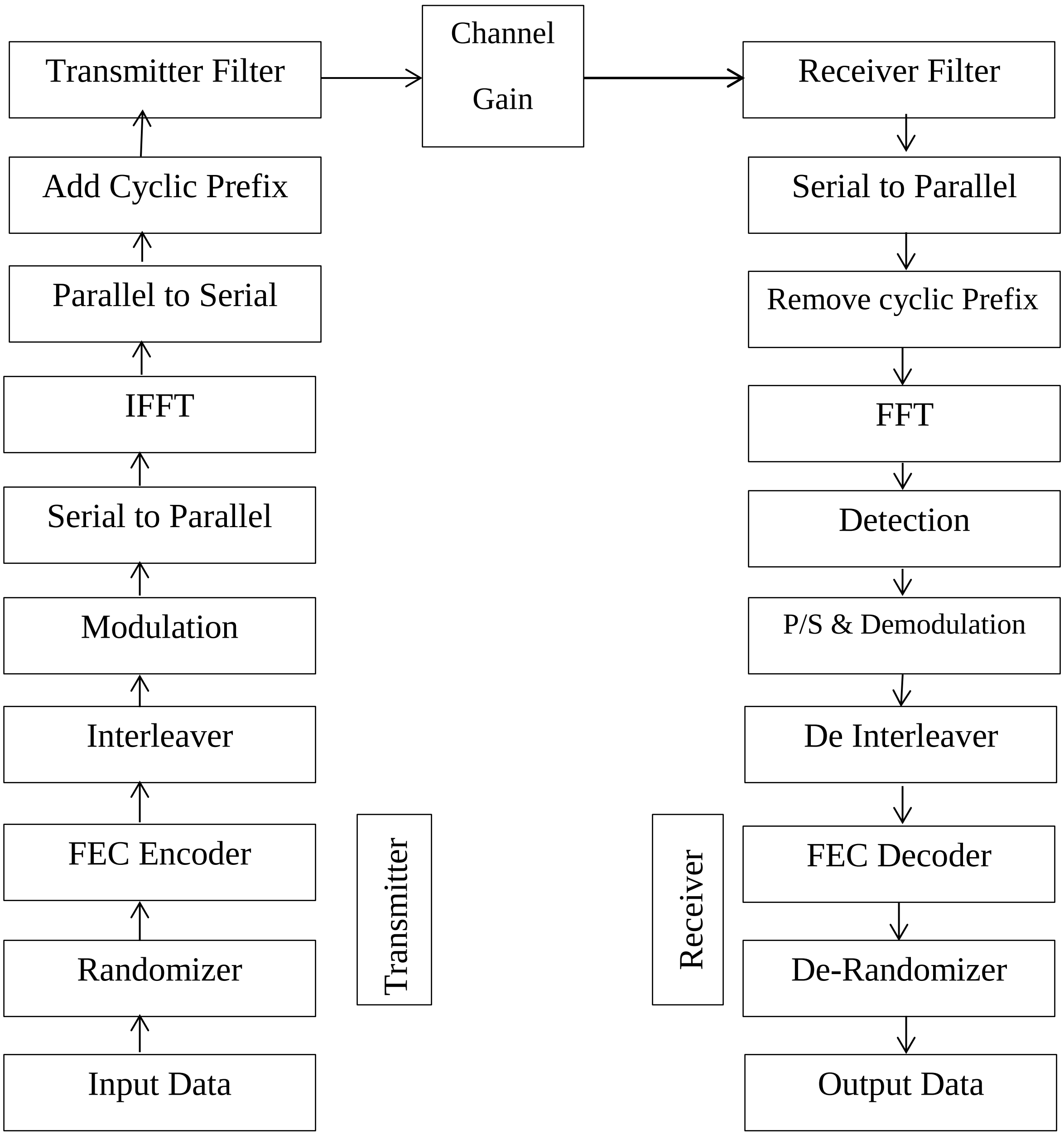


Figure 3.1: WiMAX Model

3.3.1 Randomization

First and for most task in WIMAX physical layer,where randomization is done to remove copied patterns, like long sequence of nulls and ones. Mainly generates random sequence to improve coding performance.

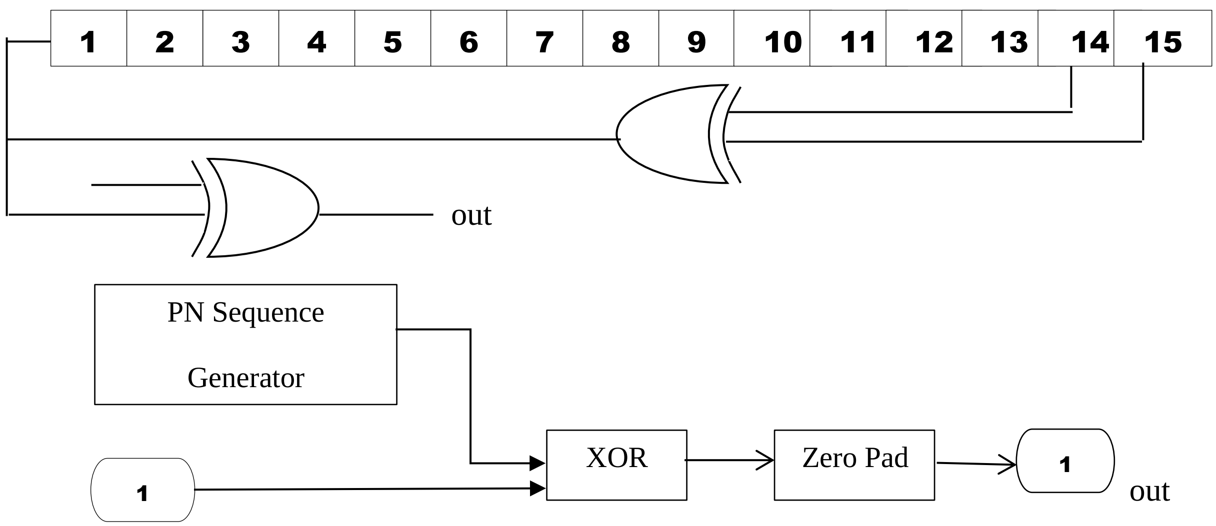


Figure 3.2: Randomization Process Using PN Sequence

Equation (1.1) determines the generator of the Randomizer

$$1+x^{14}+x^{15}=out \qquad [3.1]$$

3.3.2 Forward Error Correction

It encodes data and redundant bit stream to permit receiver to observe and correct errors. Coding system involved in FEC are RS codes, TURBO codes, convolution codes etc.it increases the capacity of channel.

- **Reed Solomon Encoding**

They are symbol error correcting codes. They are a class of non -binary codes having strong error correcting ability. Galois Field is widely used to represent data in error control coding and is denoted by GF. WiMAX uses a fixed RS Encoding technique based on GF(2^8) which is denoted as RS(N = 255, K = 239, T = 8.

Where: N = Number of Bytes after encoding

K = Data Bytes before encoding

T = Number of bytes corrected

N=K+2T

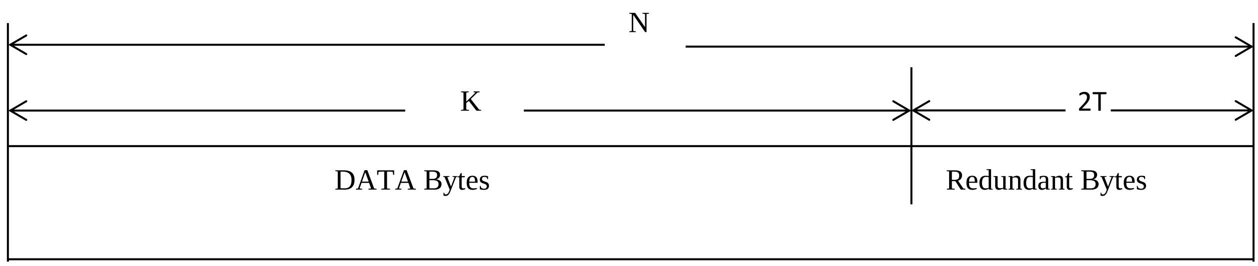


Figure 3.3: Reed Solomon Coding

Eight tail bits are added to the data just before it is shown to the Reed Solomon Encoder stage. This stage requires two polynomials for its operation called code generator polynomial g(x) and field generator polynomial p(x). The code generator polynomial is used for delivering the Galois Field Array whereas field generator polynomial is used to process the abundant information bits which are connected toward the start of the yield information. These polynomials are defined by the standard as below:

Code Generator Polynomial:

$$G(x) = (x+a^0)\,(x+a^1)\,(x+a^2)\,(x+a^3).........(x+a^{2T-1}) \qquad [3.2]$$

Field Generator Polynomial:

$$P(x) = x^8 + x^4 + x^3 + x^2 + 1 \qquad [3.3]$$

- **Convolutional Encoding**

It corrects random errors in data transmission. Here every coded bit is a linear combination of some encoded bits. The input is information bits applied to shift register and output is not only a function of current input but also a function of K-1 inputs. Coding rate is defined as ratio of data rates assigned for substitute frames to maximum data rate that can perfectly be assigned in substitute frame. The output of convolution encoder is then penetrated to eliminate additional encoded bits and number of bits displaced depends on code rate used.

In WiMAX PHY layer every RS block is encoded by paired convolutional encoder, which contains code rate of 1/2 and constraint length of 7. This Encoder contains two binary adders X and Y and uses these two generator polynomials A and B. These generator polynomial codes are shown in equation 3.4 and 3.5 respectively.

$$A = 171 \text{ octal} = 1111001 \text{ binary for } X \quad [3.4]$$

$$B = 133 \text{ octal} = 1011011 \text{ binary for } Y \quad [3.5]$$

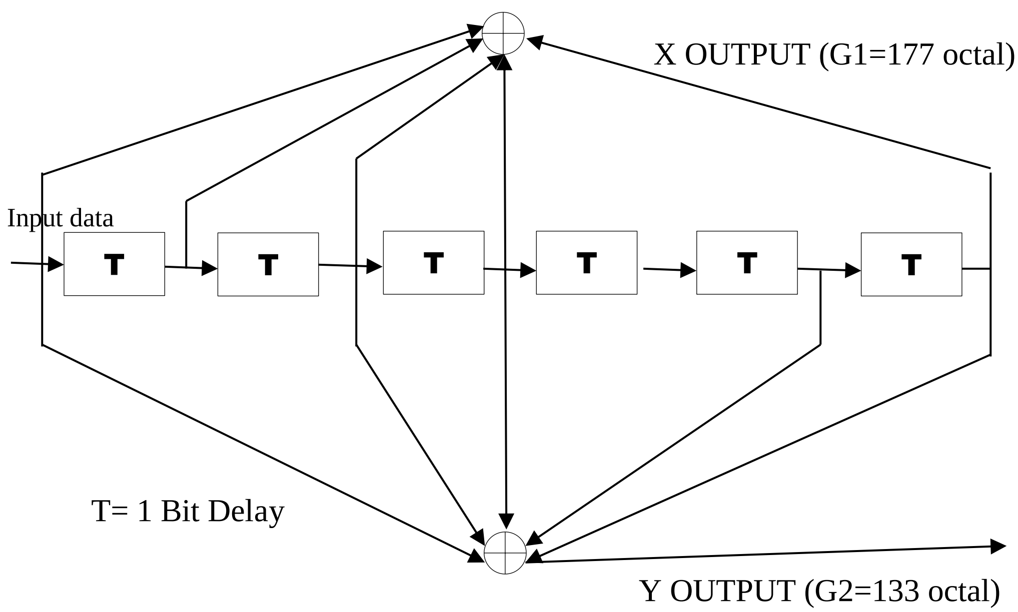


Figure 3.4: Convolution Coding Technique

The output of convolutional encoder is then punctured to remove the additional bits from the encoded stream. The number of bits removed is dependent on the code rate used.

3.3.3 Interleaving

Working on the position of bits rather than state is main aim of Interleaver. It is process to make system more efficient fast by arranging data in chaotic manner before transmission. It reorders the data that is to be dispatched so that bytes of data dispensed over large sequence of data to diminish burst errors. The number of bits in each block is known as interleaving gulf, which represents deferment introduced by interleaver at transmitter side. Block interleaver is a type of matrix in which, to read the data, we go for row and switch to column for writing the data and vice versa.

The first permutation can be defined as:

$$ink = (Ncbps/ 12) * mod (k,12) + floor(k/ 12) \quad [3.6]$$

The second Permutation is defined as:

$$s = ceil (Ncpc/12) \quad [3.7]$$

$$jk = s \text{ x } floor (mk / s) + (ink + Ncbps - floor (12* mk / Ncbps))mod(s) \quad [3.8]$$

Where: Ncpc = Number of coded bits per carrier.

Ncbps = Number of coded bits per symbol.

ink = index of coded bits after permutation.

jk = index of coded bits after second permutation.

3.3.4 Modulation

After interleaving bits are organized into slots. Due to burst errors, large adjacent bits are corrupted. So, mapping is done. Data bits enter serially to constellation mapper and signal is balanced by digital modulating arrangement; such as M-QAM & M-PSK, where M is a number pattern of points in the constellation diagram.

3.3.5 Inverse FFT

It mainly converts symbols from frequency region to time region and serve OFDM subcarrier as a channel in time region for better separation of subcarriers and removing interference in between the symbols. If N no. of subcarriers are used then IFFT receives N no. of sinusoidal and N symbols at a time.

3.3.6 Cyclic Prefix (CP) Addition

It imitates some samples from the end of the symbol in front to add some tautology to symbols. These cloned samples are called Cyclic Prefix. Main purpose is to avoid inter symbol interference caused by multipath propagation effects in the environment which are mainly due to the relative motion between both transmitters and receivers.

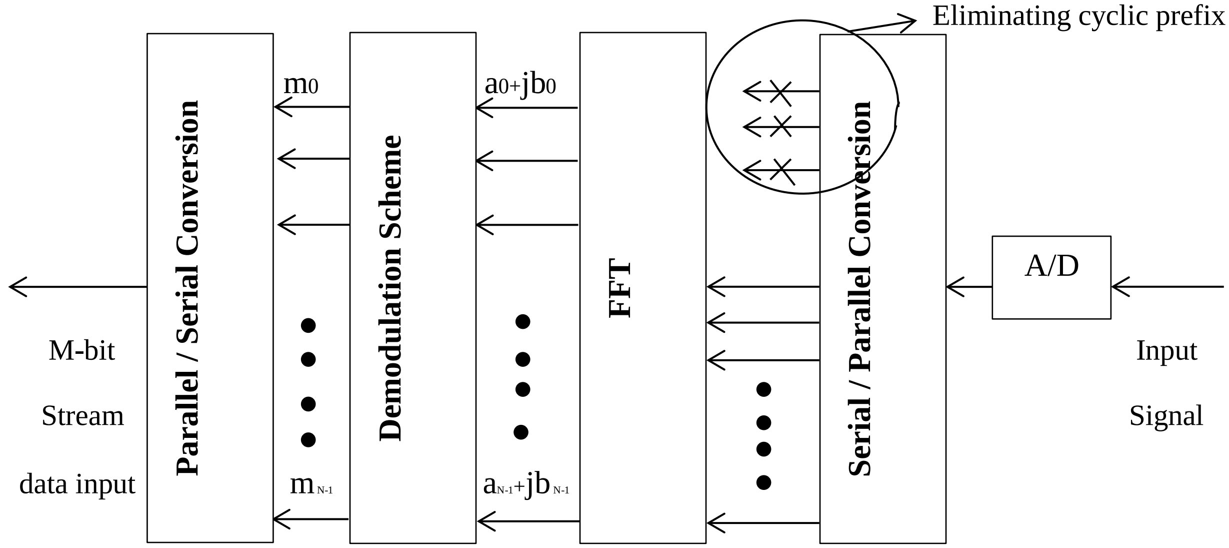


Figure 3.5: Cyclic Prefix

3.4 Receiver

The receiver blocks are basically the inverse of transmitter blocks. They are totally opposite of transmitter block. Main purpose is to obtain original data bits. Cyclic prefix is removed as guard interval is removed. Then FFT is performed and transformed in frequency domain. Then demodulation gives back the original de mapping of the bits, followed by de interleaving and de randomization takes place smoothly to get the original data bits back in a well précised manner as sent before.

3.5 WiMAX Standards

WiMAX standards i.e. IEEE 802.16 family are those which are based on IEEE which shows current version we are using and with new advancements in this field till now and often called as wireless MAN in IEEE. Beating all the previous records of the WiMAX standard, currently used standard named as IEEE 802.16e-2005, and approved in December 2005 has come up with better advantages and ideas that will help reducing all the problems aroused by previous ones. Previously used WiMAX standards that we can eye upon are:-

- All started with 802.16-2001 with fixed broadband access and improved with 802.16.2-2001 and changed with 802.16c-2002 with range of 10-66 GHz.
- Physical layer and MAC layer introduced for 2-10 GHz in 802.16a-2003 and being used currently for 802.16-2004 where local and metropolitan area networks uses fixed broadband access which is then shifted to mobile broadband access systems for 802.16e-2005 which we are also using for our report i.e. MIMO-WiMAX.
- Mobile broadband facilities in local and metropolitan area network were being used in standard named 802.16k-2007 and gone till 802.16-2009.
- 802.16j-2009 was given a name as multihop relay and after that mobile WiMAX release 2 was introduced in 802.16m-2011 which introduced the new version for the WiMAX in market and gave it's a new image by overcoming all the limitations faced by the WiMAX earlier and provided new solutions in the market.
- All the new and current versions are using 802.16-2012 and gone till up to now is 802.16.1a-2013 for high reliability networks and updated on March 6, 2013.

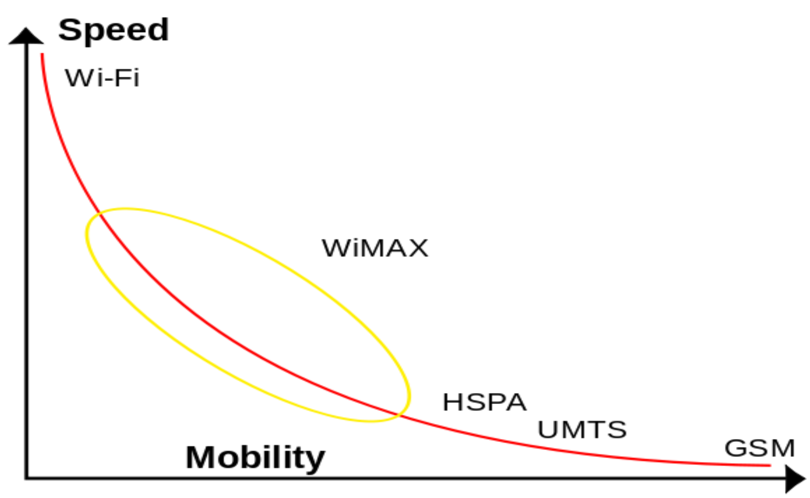


Figure 3.5: Speed vs Mobility of wireless system

3.6 Why only WiMAX?

- **Data Rate**

With the use of OFDM technology that boosts the high channel bandwidth leads to data rates which are more efficient and higher in number. When WiMAX is compared with other wireless systems which are having less users causes WiMAX to show its potential and this shows that WiMAX provides higher data rates.

- **Lifetime**

WiMAX was welcomed in market after six years when 3G was built up and established. This gap created a lot of disturbance as people having knowledge about WiMAX was tend to move further and for rest it was just new and their learning for WiMAX took time. So, those meant to work in both technologies found it better and had created better balance between both and yet established improved versions for future by making its installation quick and fast covering more users.

- **Range**

Mainly WiMAX totally depends on the height and positions of antennas placed in an environment where there should be no interference or disturbance should be there in transferring the information from transmitter to receiver side. It ranges up to 3.5 GHz as compared to 2.1 GHz in 3G. In LOS it supports up to 40-60 kilometers as compared to 3-10 kilometers in NLOS conditions.

- **Quality of Service (QoS)**

WiMAX provides improved quality of service as compared to previous wireless systems. Its main purpose is to provide Quality of Service to users under limited bandwidth consumption and within the limited range to keep the users connected and degraded if more users are there.

- **Cost**

It is more likely to be costlier than previous ones as having limited range. It varies from user to user as if users utilizes WiMAX in processor chips then it is less costly as compared to WiMAX handsets.

3.7 Limitations and Recovery

- Interference issues are being observed with Bluetooth.
- Power is highly consumed in this technology.
- Costly implementation and installation of any new devices and equipment.

- Signals get often disturbed and mixed due to bad weather conditions.

At present, research is still going on to remove various limitations i.e. to increase the speed factor which is visioned to hike upto 100 Mbits/s for mobile devices. Integration of new techniques and possibilities in WiMAX can lead it to have a better future in upcoming generations.

CHAPTER 4 MIMO

MIMO termed as Multiple Input Multiple Output which itself introduces of having multiple inputs at transmitter side and multiple outputs at receiver side to provides better path to the sender to send its signals and receiver to receive it effectively with less interferences and disturbances. Here, all the data that is needed to be sent simultaneously is organized into spatial streams in proper manner. It is said that MIMO has come up with the idea combining SIMO (single input multiple output) and MISO (multiple input single output) technologies which will be discussed later on.

4.1 Background

It all started in 1984, when article named as "Optimum Combining in Digital Mobile radio with Co-channel Interference" written by Jack winters of bell laboratories introduced about MIMO concept and its philosophy to many researchers, professors and users in a better way. It started with the antenna concept which act as conversion platform for transceivers and free space and often called as a metallic object for transmitting and receiving electromagnetic energy.

Antenna radiation patterns, its efficiency, gain, bandwidth and directivity, all are important part of it which tells about each and every movement of antenna along with its advantages and limitations and keep it safe. The matter of advance antenna settings came into picture where the new names and improved technology was introduced like spatial multiplexing, spatial diversity and multi-beam antennas termed as beamforming etc. for supporting upcoming technologies named as 4G, 5G, WiMAX, LTE.

4.2 Introduction to Multiple Input Multiple Output

As discussed above, MIMO is boon for the upcoming technology where there is requirement of multiple antennas at both transmitter and receiver side. Capacity improvement is done by introducing the factor called as Spatial Multiplexing (SM). Data rate can be enhanced including reduction in fading is done by putting Spatial Diversity into limelight, where there is a requirement of low power.. To have a clear view of what is being transmitted to the transmitter; Beamforming concept is used in MIMO to point out the transmitter in particular direction.

4.2.1 Basic Building Blocks of MIMO

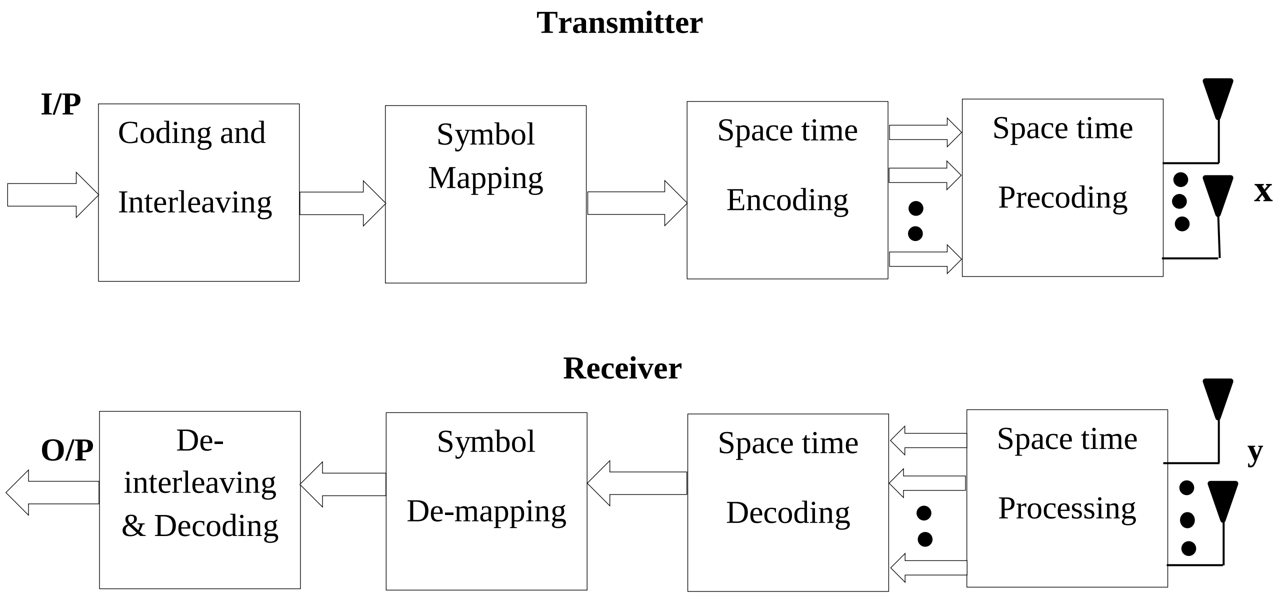


Figure 4.1: Building Blocks of MIMO

From the above figure, x and y represents the transmitters and receivers respectively. It can be quoted that firstly the information is coded and interleaved followed by mapping and resulted data symbols are sent to space time encoding which produces spatial streams which is then sent to antenna where transmitted signal is propagated through channels and received by receiving arrays.

4.3 MIMO Channel and its Capacity

By taking the benefits of multipath propagation and various other components, channel matric is written as:-

$$y = Hx + n \qquad [4.1]$$

Where, y is the received signal, x is termed as transmitted signal and H and n are considered as channel matrices. For better understanding, channel model of MIMO consisting of M_T transmitters and MR receivers forms MT x MR matrix:-

$$H = \begin{bmatrix} H_{1,1} & H_{1,2} & H_{1,NR} \\ H_{2,1} & H_{2,2} & H_{2,NR} \\ H_{MT,1} & H_{MT,2} & H_{MT,NR} \end{bmatrix} \qquad [4.2]$$

Where, $H_{M,N}$ is a channel gain between mth transmitter antenna and nth receiver antenna, where we call mth-column of H as a spatial signature of mth transmit antenna.

And MIMO channel capacity can be expressed in following formula:-

$$C = E_H \left[log_2 det \left(I_{Mr} + \frac{\rho}{Mt} \ HQH^H \right) \right] \quad [4.3]$$

Where, $Q = E[xx^H]$ is input covariant matrix and ρ (SNR) is $\frac{E_S}{N_0}$ where, E_s is total power to be transmitted and N_0 is noise power in each antenna used. So, we can say capacity is totally dependent upon the number of antennas used along with covariance of input and statistics of channel provided. There are always two cases of channel matrix in which first one is termed as un informed transmitter, where it does not have any knowledge about the channel matrix and matrix is considered to be as Identity and second one is informed transmitter having full and proper knowledge about the channel matrix and water filling principle is used for capacity improvement [46].

4.4 MIMO Categories

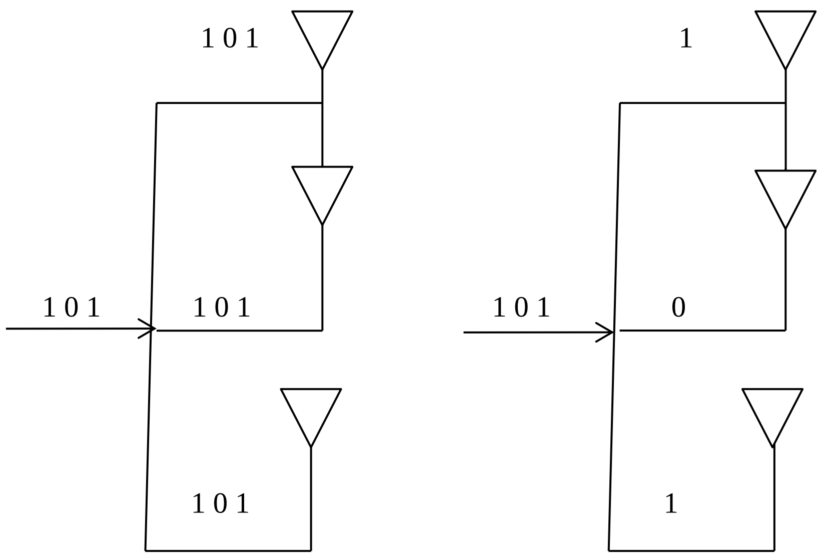
Before defining categories, there are various forms of MIMO from which MIMO was formed and came into picture are given as:-

- Single Input Single Output (SISO)
- Single Input Multiple Output (SIMO)
- Multiple Input Single Output (MISO)

Here, names indicate their performances as written above i.e. SISO having single input at transmitter side and single output at receiver side. Similarly, SIMO indicates that it is having single output at transmitter side and multiple outputs at receiver side followed by MISO which shoes multiple inputs at transmitter side and single output at receiver side. These all forms of MIMO combine together and provide us new technology named as MIMO. MIMO has various advantages and its benefits are boon to environment, society, users, scholars and researchers. It is categorized as under:-

4.4.1 Spatial Diversity

First category of MIMO, that provides two or more inputs at the receiver such that inputs of the fading phenomena are not connected. If one radio path undergoes intense fade at certain time, another autonomous path may have a stable signal at that input. Multiple branches and low correlation between the branches are the particular requirements of diversity.



MIMO with Diversity (Improves Reliability)   MIMO with spatial Multiplexing (Increases data rate)

Figure 4.2: MIMO System with Diversity and Multiplexing

All connected properties of the radio channel are used as average to provide multiple independent copies of the same signal. Assuming two antennas at transmitter side and we use them to send same data. Since these two antennas are set far enough from each other, the same data are transmitted to receiver via different paths that is experiencing different signals called as spatial diversity or transmit diversity. It combats channel fading and provides reliable communications.

The main idea behind this technique is that, when two or more independent signals are taken, these signals fade in such a manner such that some signals are less attenuated. This diversity technique receives multiple replicas of the transmitted signal at the receiver as same information is transmitted through different antennas such that the received signal is the coherent combination of the transmitted signals but with small correlation in fading statistics. Diversity techniques improve the robustness of the wireless communication link in terms of BER by exploiting the multiple paths between transmitting and receiving antennas.

4.4.2 Spatial Multiplexing

Mainly used for high throughput with spatial multiplexing, numerous information streams are transmitted at similar time. They are transmitted on same channel but by various antennas. They are combined at the receiver via MIMO signal processing. Here, data reliability is not fixed. Data rate of the system increases as each spatial channel hoist separate information. And compared to Orthogonal Frequency Division Multiplexing (OFDM) technique, where, different frequency sub channels carry different parts of the adjusted data.

But in spatial multiplexing, if there is strong collision, several independent sub channels are generated in the same assigned bandwidth. Thus the compounded growth is useful in both bandwidth and power. It increases channel capacity at high SNR and add complexity and expenses at both transmitter and receiver. This spatial multiplexing technique includes layered architectures that improve the capacity of the MIMO system. One such technique is known as V-BLAST which was developed by Bell Laboratories. Here, the number of receiving antennas must be equal to or greater than the number of transmit antennas such that data can be transmitted over different antennas.

4.4.3 Beamforming

Beamforming is the third technique of MIMO systems that exploits the knowledge of the channel at the transmitter end. Beamforming make use of fading channels and improves gain of received signals and communication system. Beamforming enlarges the performance of mobile communication at average ranges. At short ranges, the SNR will support the maximum data rate because of high signal power. At long ranges, beamforming does not propound a significant gain over a non-directional antenna, and data rates will be similar to non-beam formed transmissions.

Beamforming make use of antenna array and to make best use of signal strength, signal processing techniques are used. Beamforming provides gain which is in between diversity and multiplexing gain. In single-layer beamforming, same signal is being emitted from the transmitting antennas with appropriate phase angle and gain weightings such that the transmitted signal power is maximized at the receiver side. The main benefits of beamforming technique are increasing the received signal gain, by making signals add up constructively that are emitted from different antennas, and reducing the multipath fading effect which is caused when the transmitted signal passes through the channel.

So, these are the three techniques helpful in making MIMO a more powerful and provide better opportunities to users without any complications in near future.

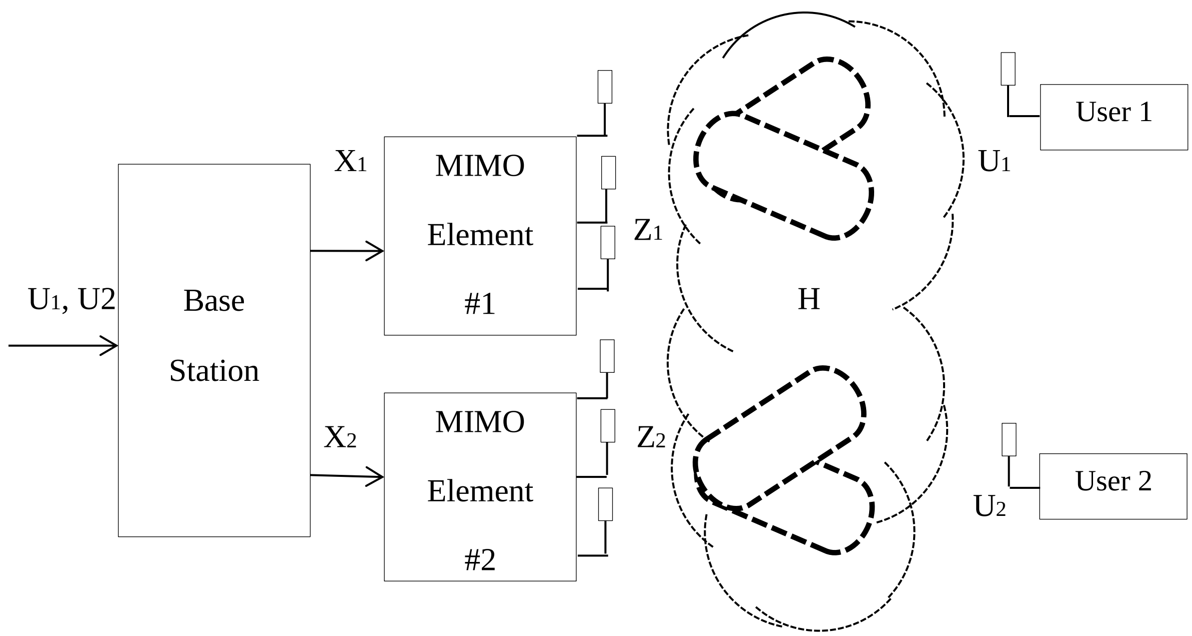


Figure 4.3: MIMO System with Adaptive Beamforming

4.5 Benefits of Using Multiple Antennas

Some of the newly used techniques can be added with conventional techniques used already to improve the performance and some of the benefits of using multiple antennas are:-

- Wi-Fi (Wireless Fidelity)
- WiMAX
- Cellular Networks
- Ultra-wideband (UWB)
- Satellite Systems and Tracking
- Digital Television System (DTV)
- Satellite Radio

CHAPTER 5 RESEARCH METHODOLOGY

Two techniques are proposed in this thesis report for improvement in data rate, capacity, to get faster speed, to reduce several interferences crossing the barrier and to make overall system better, in which first one is named as MIMO-WiMAX which includes all diversity combining techniques and other MIMO categories used and second is Image Transmission. Both topics are discussed in their own manner and precise way one by one:-

5.1 Diversity Combining Techniques

It is vital to consolidate the uncorrelated blurred signs which were acquired from the diversity branches to get legitimate diversity advantage. The brushing framework ought to be in such a way, to the point that enhances the execution of the communication systems. Diversity combining likewise expands the signal-to-noise ratio (SNR) or the power of received signal. For the most part, the combining ought to be connected in receiver part; in any case it is likewise conceivable to apply in transmission.

Square-law non-coherent combining is employed frequently in diversity reception when non-coherent modulation methods are used. The demodulator outputs of all diversity branches are squired and summed to form a decision variable when used squire-law pre-detection combining. The system performance is decreased in non-coherent combining comparing to coherent combining and the degradation is called combining loss.

5.1.1 Maximal Ratio Combining (MRC)

This is an extremely valuable procedure to affray channel fading. It is a matchless combining process which accomplishes the finest execution change contrasting with different strategies. The MRC is a regularly utilized combining method to enhance execution in a noise restrained linked systems where the AWGN and the fading are autonomous amongst the diversity branches. But the MRC employment needs summing circuits, weighting and co-phasing [47]. In the MRC combining technique, before summing or joining, the signals from various diversity branches are co-phased and weighted. The weights must be picked as relative to the individual signals level for maximizing the combined carrier-to-noise ratio (CNR). The connected weighting to the diversity branches must be balanced bestowing to the SNR. In MRC, all the branches are utilized at the same time. Each of the branch signals is weighted with a pick up element relative to its own particular SNR.

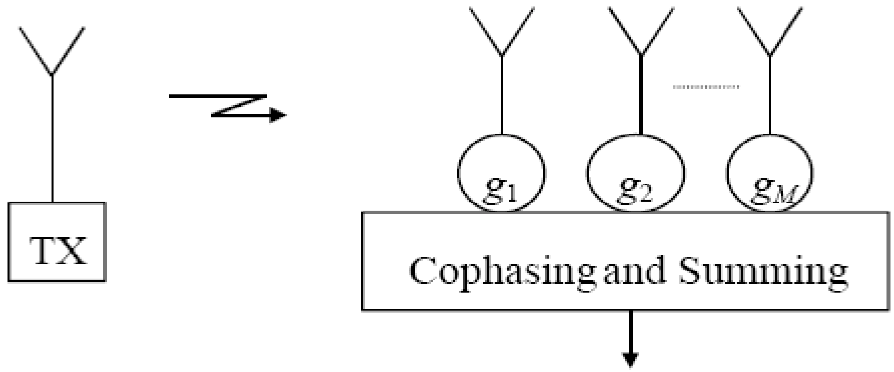


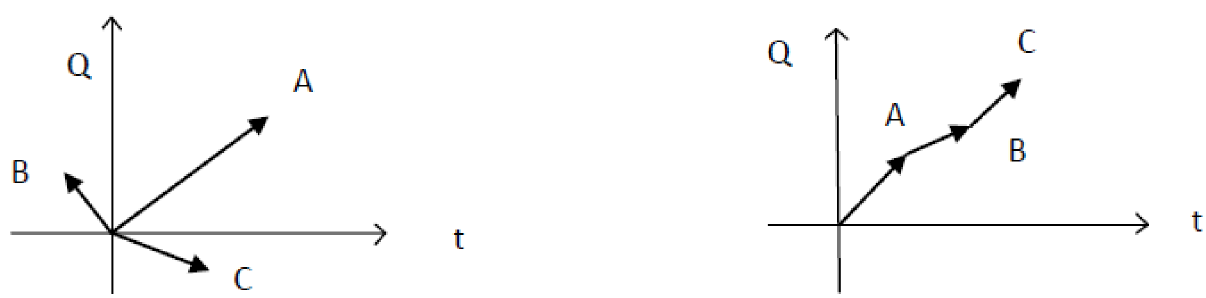
Figure 5.1: Maximal Ratio Combining

We have points of interest over other combining methods. Like, MRC combining can be substantial regardless of the possibility that individual SNRs are little. For two recipients, MRC gives almost 10dB improvement at 1% BER, while selection diversity 2-3dB. MRC is ideal arrangement Accept culminate channel learning, which is liable to estimation blunders which thusly rely upon SNR.

It is practical to utilize MRC in transmission procedure of transmit diversity. But in this case the transmitter should get proper assessed information about the sub-channels state between single receive antenna and multiple transmit antennas. However, it is not attainable to weight transmissions from different antennas optimally for every receiving antenna, in a combined transmit-receive diversity channel. In addition, if obstruction is constrained in a communication system, then there is a plan which joins the diversity branches with a view to exaggerate the signal-to-interference-plus-noise ratio may allow much better performance than MRC provides. The presumption is substantial for spatially white Gaussian clamor on the off chance that we can watch commotion control at the collector where simply warm clamor is accounted. In the event that we utilize a similar sort reception apparatus component then the warm commotion power is uncorrelated and level with for every branch.

5.1.2 Equal-Gain Combining (EGC)

MRC is the best assorted qualities consolidating however the plan requires extremely costly outline at receiver circuit to modify the gain in each branch. It needs a proper pattern for following the mind for complex fading, which extremely hard to accomplish for all intents and purposes. However, by utilizing a basic phase lock summing circuit, it is not much difficult to execute an equal gain combining The EGC is like MRC with a special case to exclude the weighting circuits. The work enhancement is little bit lessened in EGC than MRC because there is offhand to combine the signals with obstruction and noise, along with the signals in upgraded quality which are not having interference and noise free [48]. EGC's typical technique is to soundly join the individual signal branch however; it non-intelligently consolidates a few agitated segments as indicated in figure:



(1) Non-coherent branch signal (2) Coherent Combining

Figure 5.2: Equal Gain Combining

5.1.3 Selection Combining (SC)

Very high frequency (VHF), ultra-high frequency (UHF) or versatile radio applications are not reasonable for MRC and EGC. Acknowledgment regarding co-phasing circuit with multipath fading and irregular stage of surroundings is not that much easy. SC is more appropriate contrasting with MRC and EGC in mobile radio application because of simple implementation procedure. In SC, the diversity branch with most elevated signal level must be chosen. In this way, the primary calculation of this technique is on the basis of rule to choose the best signal amongst all signals at receiver side. If there is even a fast multipath fading environment, the steady operation effortlessly can be accomplished. It is tentatively demonstrated that the execution change accomplished by the selection combining is simply little lower than execution enhanced accomplished by a perfect MRC. Accordingly the SC is the most utilized diversity technique in wireless communication.

The general type of choice joining needs screening of every diversity branch and choose the finest one (the one which has the highest SNR) for revelation. So, we can say that SC is not a consolidating strategy rather a determination methodology at the applicable diversity. However, as system has to select the best antenna in a very short time, so measuring the signal is difficult. By choosing the connection with the highest SNR is directly related to choose the connection with highest received power when average noise power is similar in every branch. Along these lines, it is commonsense to choose the branch which has the biggest signal structure, noise and impedance. On the off chance that there is an accessibility of input data about the channel condition of the diversity branch; the selection combining additionally can be utilized a s a part of transmission.

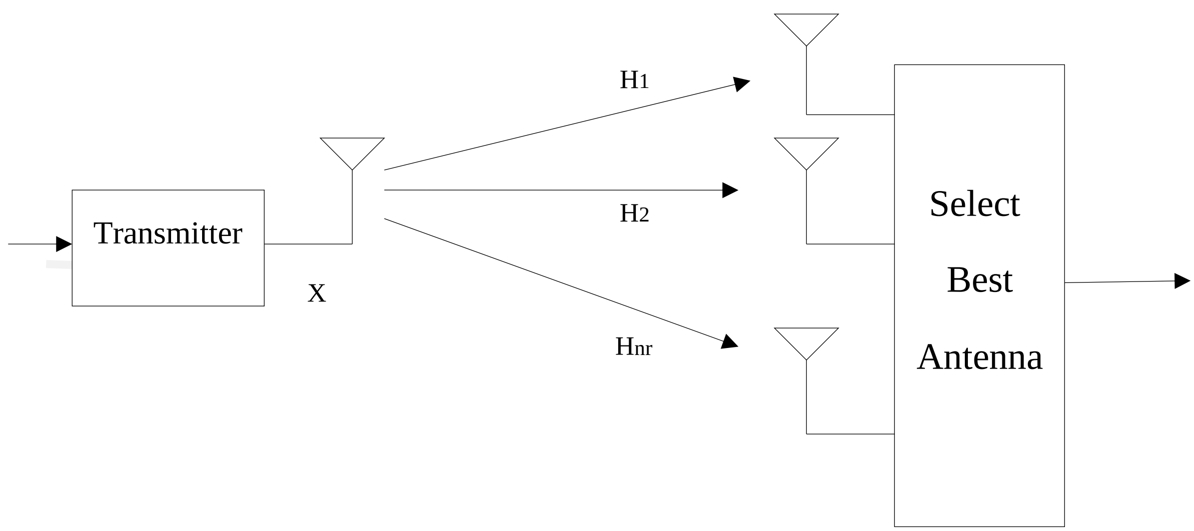


Figure 5.3: Selection Combining

5.2 Beamforming

Mainly, to focus energy towards one receiver, we prefer Beamforming. Beamforming is the third technique of MIMO systems that make use of the intelligence of the channel on transmitter side. Beamforming make use of fading channels and improves gain of received signals and communication system. Beamforming enlarges the performance of mobile communication at average ranges. At short ranges, the SNR will support the maximum data rate because of high signal power. At long ranges, beamforming does not propound a significant gain over a non-directional antenna, and data rates will be similar to non-beam formed transmissions.

Beamforming make use of antenna array and to make best use of signal strength, signal processing techniques are used. Beamforming provides gain which is in between diversity and multiplexing gain. Principle advantages of beamforming system include expanding the receiver signal growth, also signals include productively that are emitted from different antennas, and reducing the multipath fading effect which is caused when the transmitted signal passes through the channel.

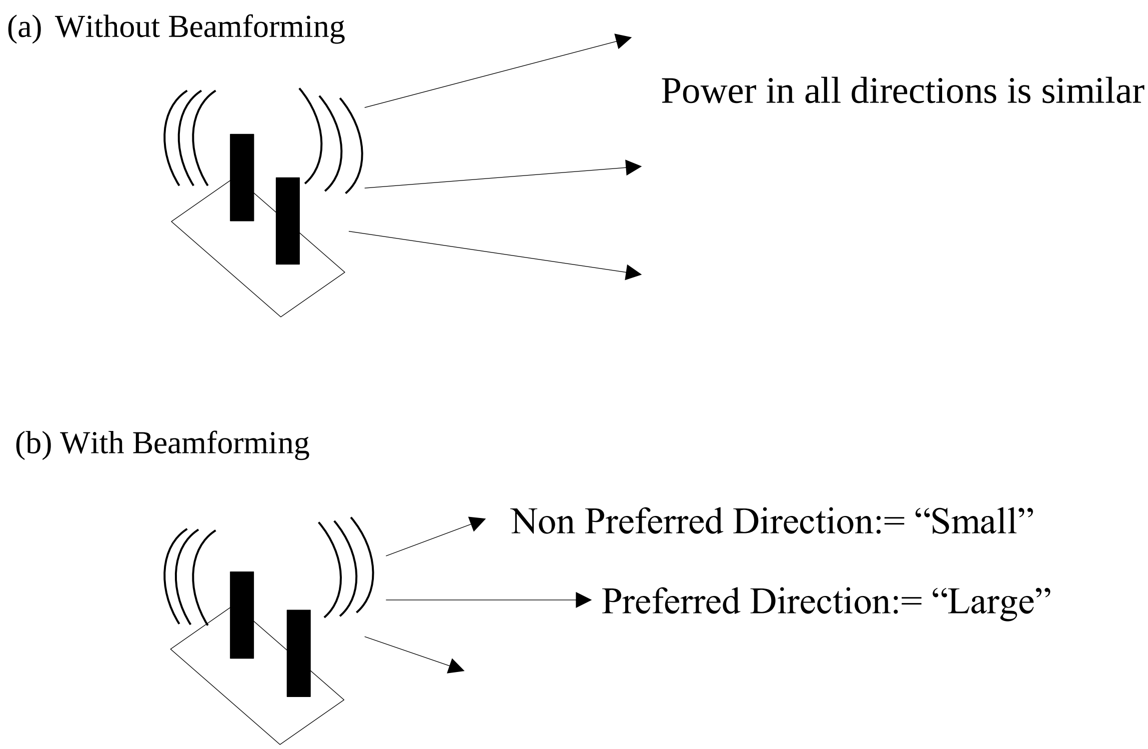


Figure 5.4: Beamforming (with & without)

5.3 SPATIAL MULTIPLEXING

This type of MIMO is utilized to give extra information limit by using the diverse ways to convey extra activity, i.e. expanding the information throughput ability. For the most part utilized for high throughput with spatial multiplexing, various information streams are sent at comparative time. By using distinctive antennas, they are transmitted on same channel. They are combined at the receiver through MIMO signal. Here, information reliability is not settled.

Information rate of the framework increments as each spatial channel raise isolate data and, contrasted with Orthogonal Frequency Division Multiplexing (OFDM) method, where, distinctive frequency sub channels convey diverse pieces of the balanced information, but, in spatial multiplexing, if there is solid impact, a few free sub channels are created in the same relegated data transfer capacity.

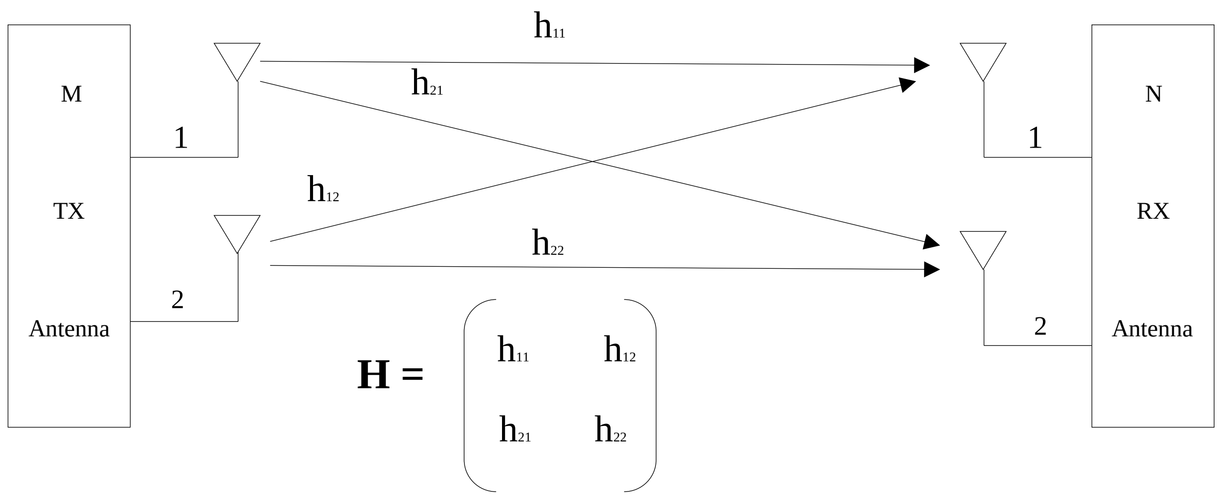


Figure 5.5: MIMO 2x 2 Antenna Configurations

Along these lines the obsolete development is helpful in both data transfer capacity and power. It expands channel capacity at high SNR and includes unpredictability and costs at both transmitter and receiver. This spatial multiplexing procedure incorporates layered models that enhance the limit of the MIMO framework. One such method is known as V-BLAST which was created by Bell Laboratories. Here, the quantity of receiving antennas must be equivalent to or more prominent than the quantity of transmit antennas with the end goal that information can be transmitted over various antennas.

5.4 MIMO-WiMAX

WiMAX based companies are trying to have something better for future prospectus in this field using the term MIMO along with it Using MIMO systems with WIMAX gives better BER performance compared to simple WIMAX. The MIMO schemes under WIMAX technology are determined by space-time coding and spatial multiplexing where each of them performs different functions. WIMAX includes Matrix A and Matrix B MIMO as shown in Figure 5.6.

1. **MATRIX A (reliable communication)**
    - Improves SNR at receiver side.
    - Expand cell radius.
    - Use of high order modulation to increase transmission speed.
    - Better throughput.
2. **MATRIX B (increased channel capacity)**
    - Unconventional data streams over each antenna.
    - Perfect signal conditions.
    - Use of data rate according to the number of antennas used.

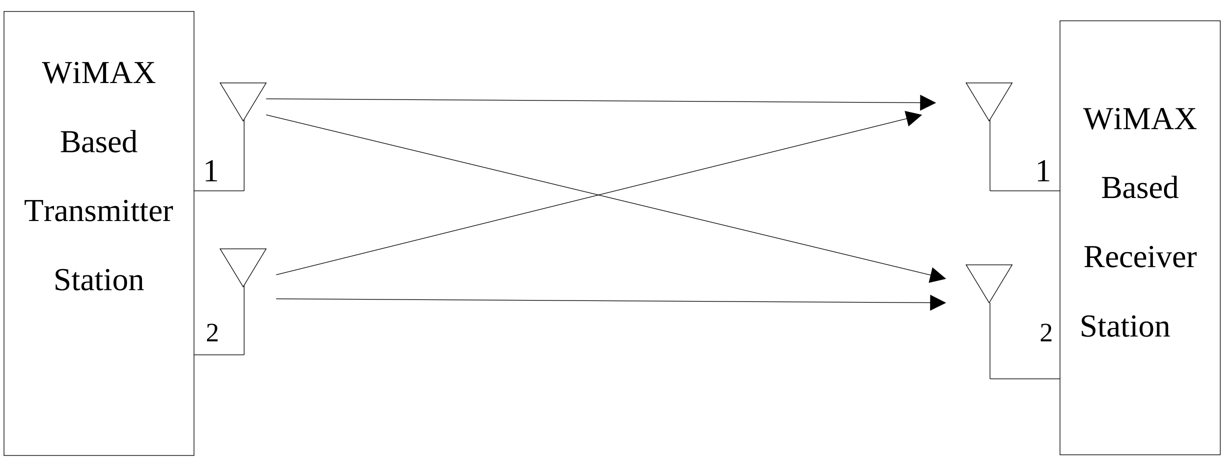


Figure 5.6: MIMO-WiMAX system communication

At low BER values, Matrix A has good performance due to expansion in diversity arrangement and Matrix B at SNR values grows the turnout. By using various MIMO schemes in WIMAX system, best BER performance can be maintained through adaptive MIMO switching and by using this, it make use of both MATRIX A and MATRIX B type of modulation [49]. If we simulate modern coding techniques space time coding (STC), space frequency coding (SFC), space time frequency coding (STFC) on MIMO-WIMAX platform then it contains link between antenna at transmitter and receiver and huge multipath delays. MIMO-WIMAX provides many directions in which independent result can occur and to use them exclusively to find maximum diversity from the channel.

If performance of WiMAX system is estimated by adaptive modulation then there are bigger chances for BER to improve and also it is mostly seen that in frequency selective fading channel is stirred by ISI in huge number as compared to flat fading. Researchers tried to relay out WiMAX simulations in OPNET which worked very well but it was not capable to take MIMO technique along with it [50].

Companies like Huawei, Intel, etc., are bound in finding better solutions for MIMO based WiMAX systems. Best example is WiBro network in Korea from where Tikona Digital Networks from India offers WiBro service for up to 2Mbits/sec. WiMAX ratify MIMO antenna strategy which shows accompaniment in terms of shadowing efficiency and network ability. Performance of MIMO-WiMAX systems in a various cells, various sectors, and multiuser surroundings is of great impact in WiMAX technology by using single frequency.

- **Advantages**
  - Meets the demand of LOS (Line of Sight) in microwave communications against NLOS and multi fade paths.
  - Increase spectral efficiency compared to SISO systems.
  - Adjustable sub-channelization and Adaptive Modulation and Coding (AMC) enable MIMO-WiMAX technology to enhance system description, capacity, better BER, throughput and efficiency.

5.6 Image Transmission

Image transmission in the arena of wireless communication is considered as a big challenge. When large amount of data is to be transmitted, the need is to transmit it without any distortions and losses in environment. Today, large amount of focus is on quality transmission of visual images perfectly than the increased data rate and reliability through wireless means. Image transmission often gets depraved due difficulties like co-channel interference, distortions in signals, limitations in bandwidth and channels that vary according to time causes much more decrement in image transmission performance. So, various improvement factors are added and perfect visual images can be seen through M-PSK scheme proposed.

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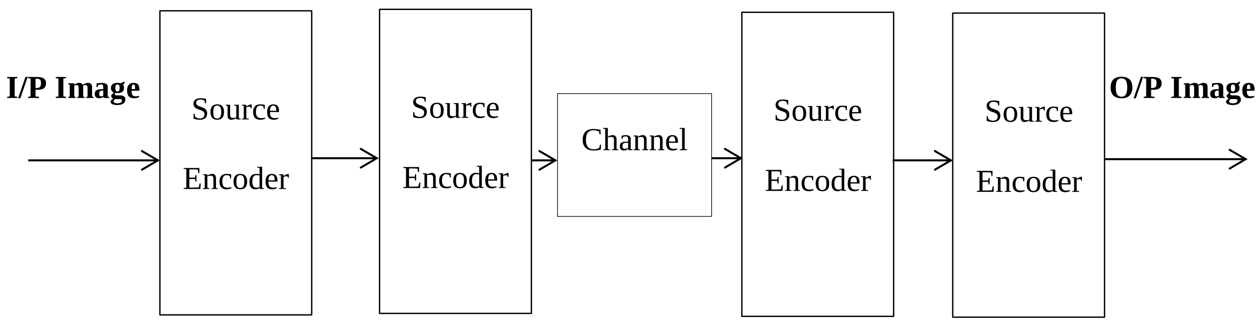
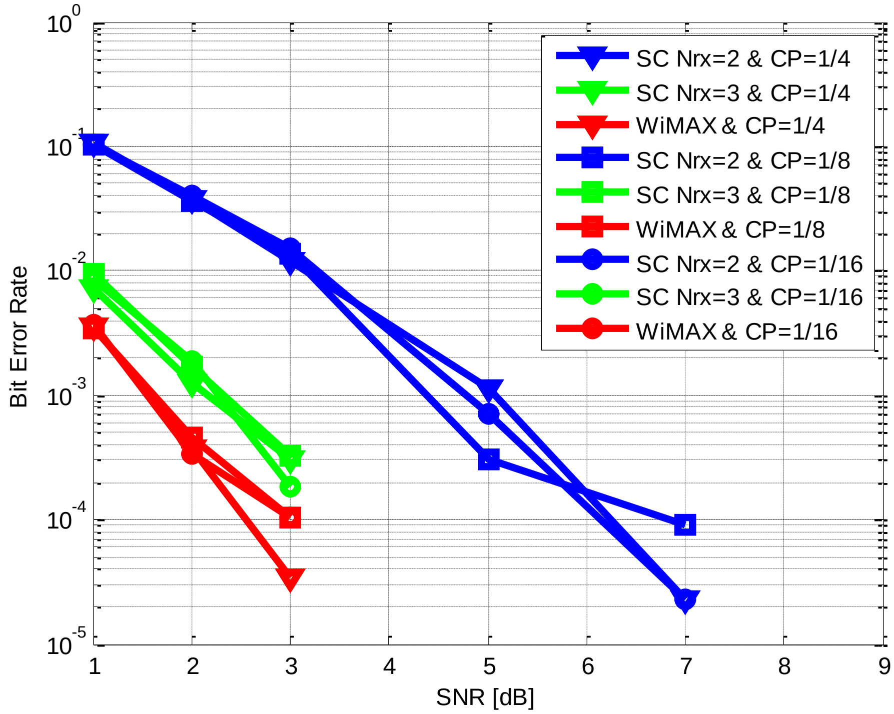


Figure 5.7: Block Diagram of Image Transmission

6.1 Selection Combining – WiMAX vs Conventional WiMAX

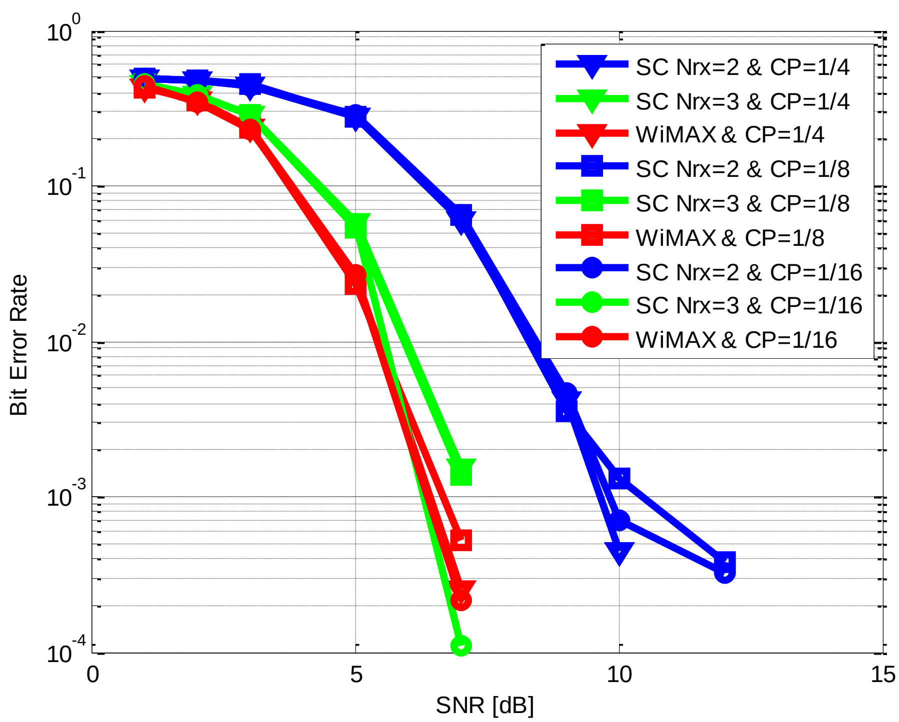
Analysis of Selection Combining-WiMAX vs conventional WiMAX has been done in this over various Modulation rates i.e. BPSK1/2, QPSK1/2, QPSK1/4, 16-QAM1/2, 16-QAM3/4, 64-QAM2/3 & 64-QAM 3/4 and different cyclic prefix values i.e. 1/4,1/8,1/16 and taken both AWGN and Rayleigh channel in this means there is a direct LOS communication between each transmitting and receiving end with no environmental attenuation or fading.

Taking two receiver antennas i.e. Nrx = 2 and Nrx = 3 of SC and WiMAX and compared these three and overall results showed that BER (Bit Error Rate) decreases in all cases which is a biggest advantage. In Figure 6.1(a), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for BPSK1/2 is done over different values of SNR. Here, from the SC discussed above will select best antenna and will decrease the delay. It is also clear from simulation results that SNR required to achieve BER of is decreasing from 7 dB to 3dB for all three cases. Similarly in Figure 6.1(b), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for QPSK1/2 is done where BER is decreasing from 13 dB to 7 dB for three cases. In Figure 6.1(c), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for QPSK1/4 is done where BER decreases from 13dB to 10 dB for all three cases. In Figure 6.1(d), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for 16-QAM1/2 is done where BER decreases from 13 dB to 4 dB for all three. In Figure 6.1(e), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for 16-QAM3/4 is done where BER decreases from 17dB to 7dB for all three cases. In fig 6.1(f), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for 64-QAM2/3 is done where BER decreases from 20dB to 5dB for all three cases. In Figure 6.1(g), BER verses SNR of Selection Combining-WiMAX vs conventional WiMAX for 64-QAM3/4 is done where BER decreases from 23dB to 4dB for CP=1/4 and CP=1/16 and BER decreases from 25 dB to 9 dB for CP=1/8.



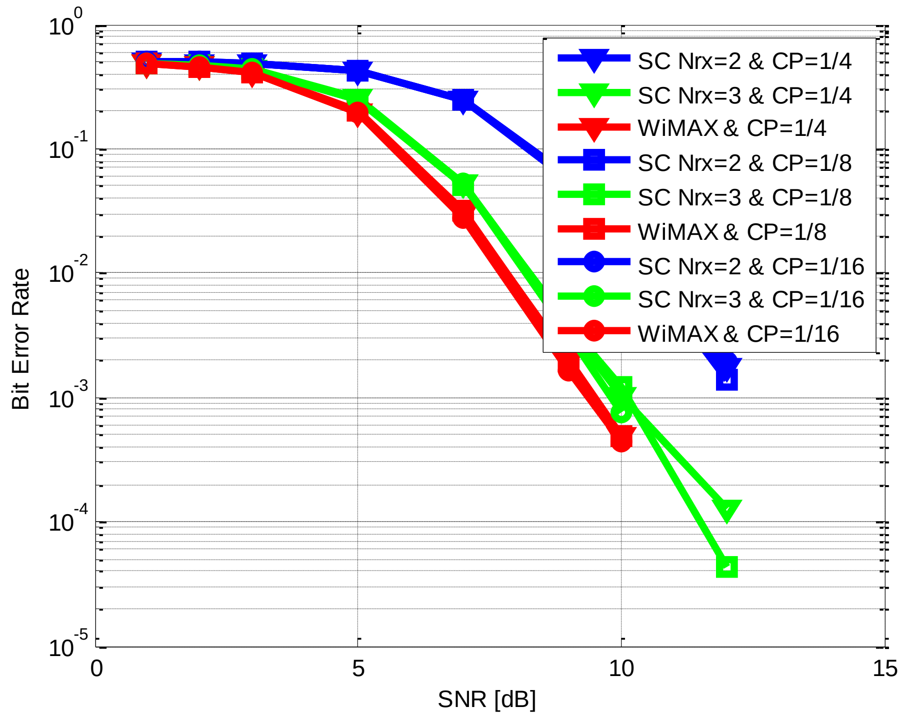
Bit Error Rate
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(a)



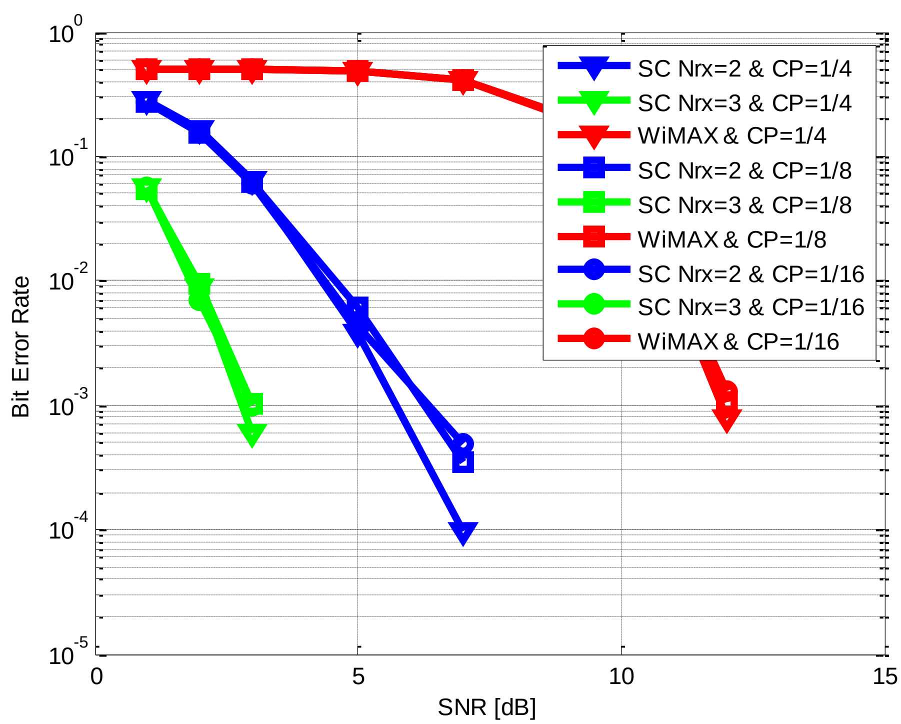
Bit Error Rate
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(b)



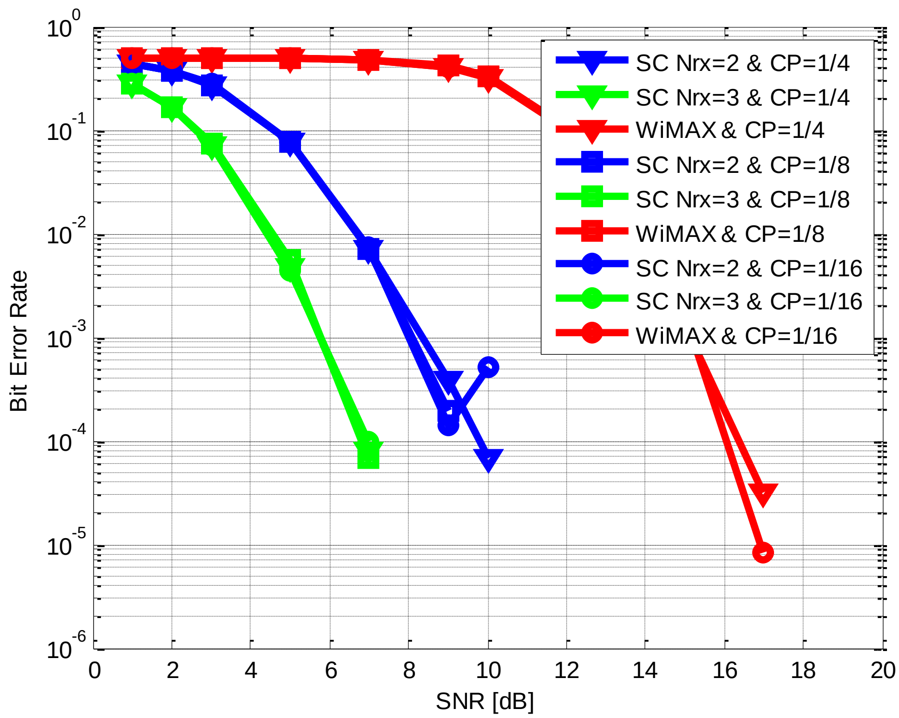
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
Bit Error Rate
0
5
10
15
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(c)

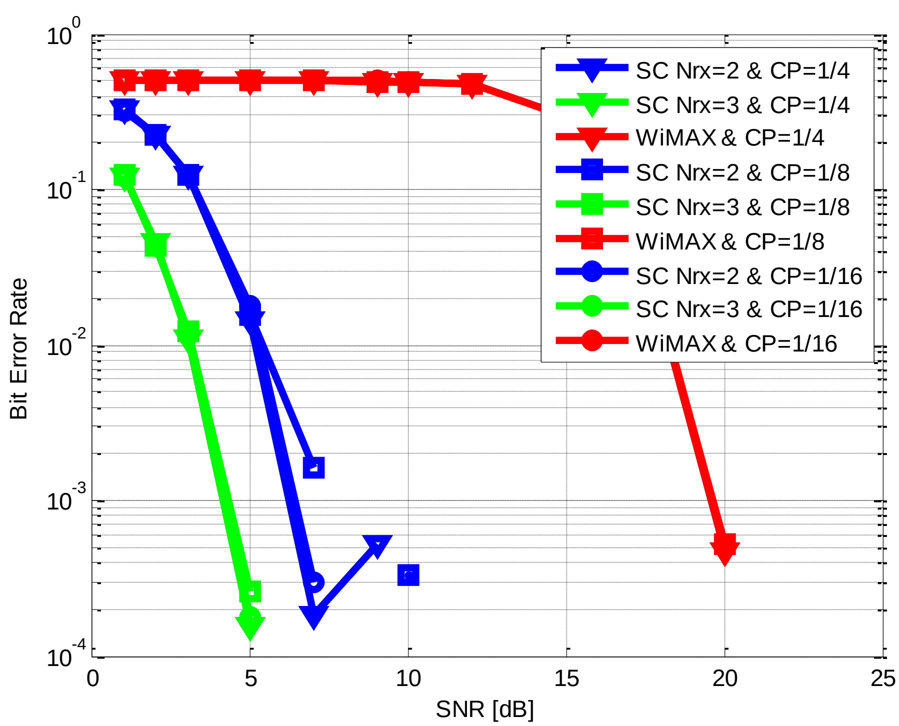


10^0
10^-1
10^-2
10^-3
10^-4
10^-5
Bit Error Rate
0
5
10
15
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

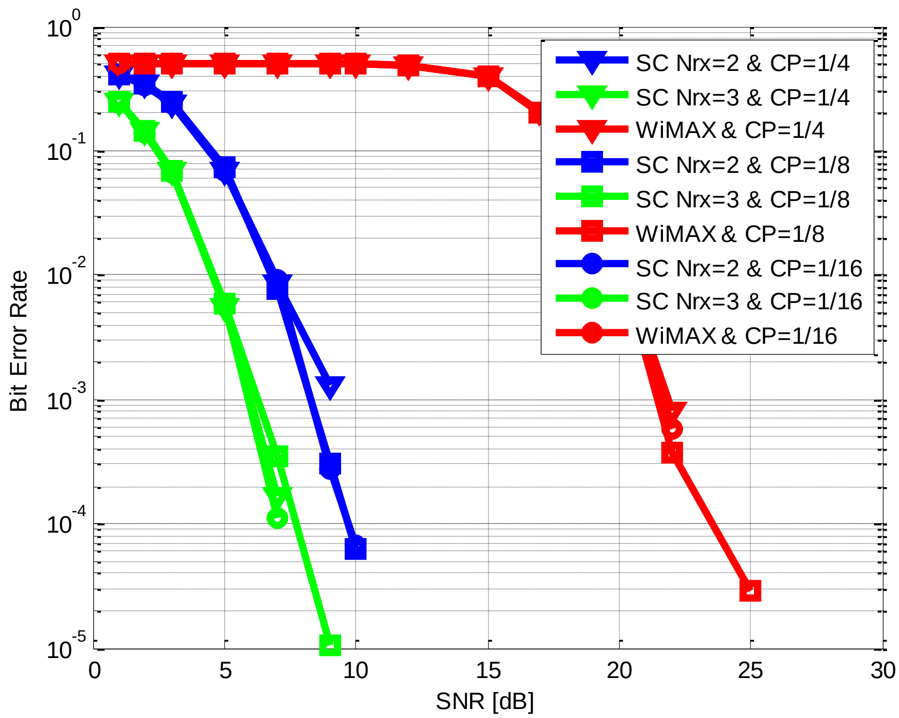
(d)


Bit Error Rate
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(e)


Bit Error Rate
SNR [dB]
SC Nrx=2 & CP=1/4
SC Nrx=3 & CP=1/4
WiMAX & CP=1/4
SC Nrx=2 & CP=1/8
SC Nrx=3 & CP=1/8
WiMAX & CP=1/8
SC Nrx=2 & CP=1/16
SC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(f)



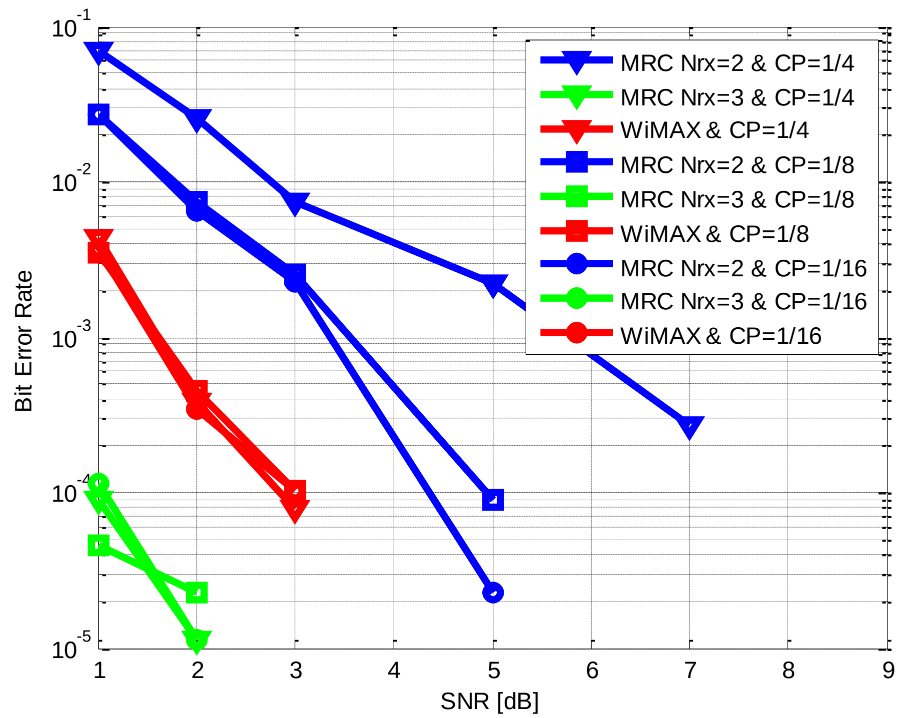
(g)

Figure 6.1 (a-g): BER versus SNR comparison of Selection Combining-WiMAX vs Conventional WiMAX for a) BPSK1/2 (b) QPSK1/2 (c) QPSK1/4 (d) 16-QAM1/2 (e) 16-QAM3/4 (f) 64-QAM2/3 (g) 64-QAM3/4

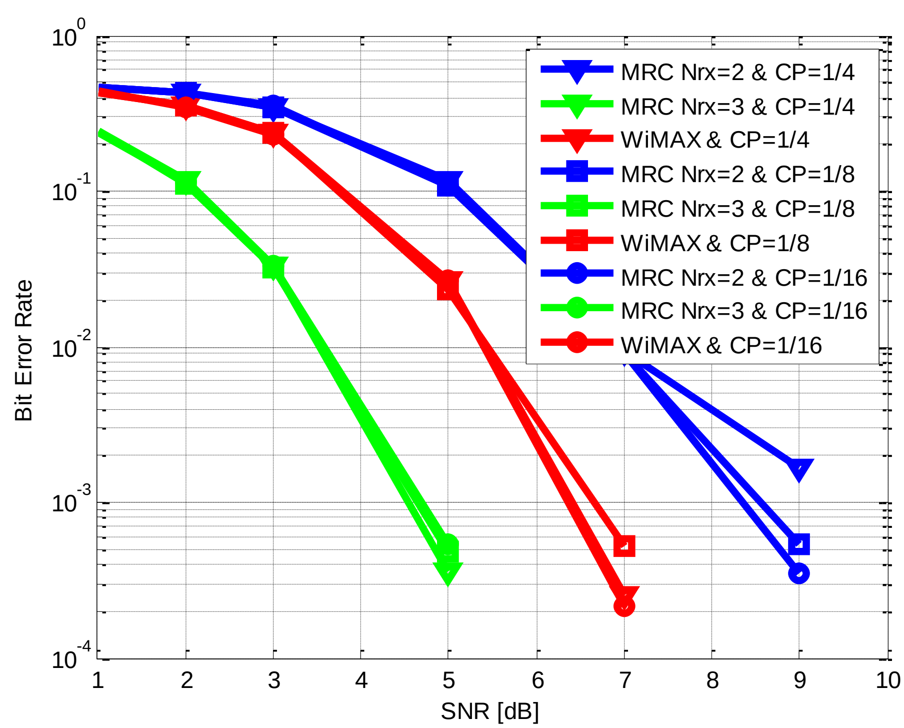
6.2 Maximal Ratio Combining - WiMAX Vs Conventional WiMAX

Analysis of Maximal Ratio Combining-WiMAX vs conventional WiMAX has been done in this over various Modulation rates i.e. BPSK1/2, QPSK1/2, QPSK1/4, 16-QAM1/2, 16-QAM3/4, 64-QAM2/3 & 64-QAM 3/4 and different cyclic prefix values i.e. 1/4, 1/8, 1/16 and taken both AWGN and Rayleigh channel in this means there is a direct LOS communication between each transmitting and receiving end with no environmental attenuation or fading.

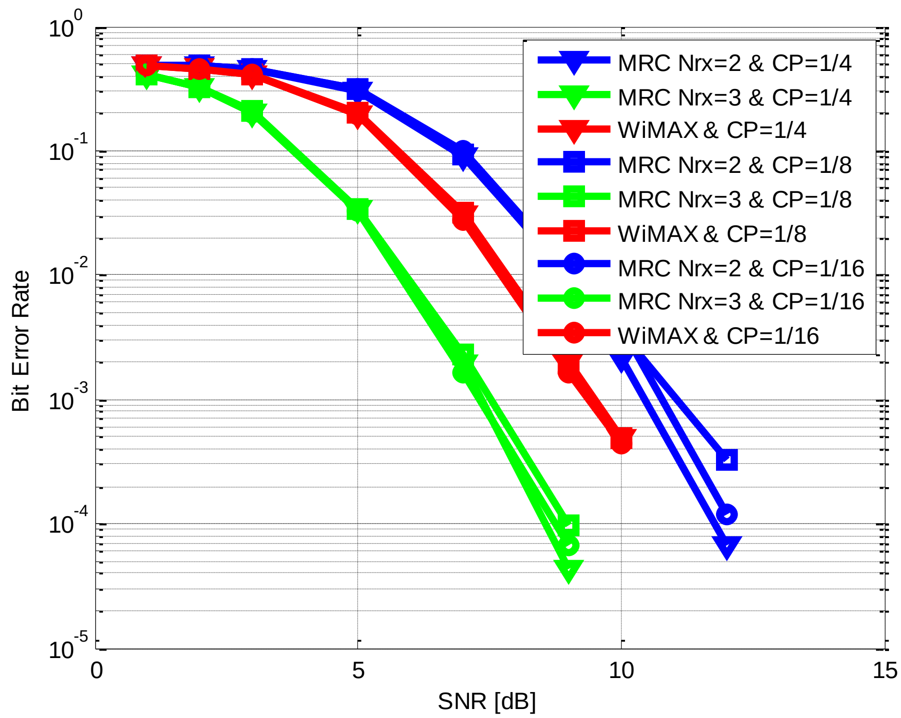
Taking two receiver antennas i.e. Nrx = 2 and Nrx = 3 of MRC and WiMAX and compared these three and overall results showed that BER (Bit Error Rate) decreases in all cases which is a biggest advantage. In Figure 6.2(a), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for BPSK1/2 is done over different values of SNR. Here, from the MRC discussed above it is a best diversity technique which is mostly considered as BER is very small in this case and mainly it combats fading and improves the performance of noise in a limited area by co-phasing and summing up. Here, BER decreases from 5dB to 2dB in all three cases in order to achieve better results at the output. Similarly, in Figure 6.2(b), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for QPSK1/2 is done where BER is decreasing from 9 dB to 5 dB for three cases. In Figure 6.2(c), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for QPSK1/4 is done where BER decreases from 13 dB to 9 dB for all three cases which gives better performance for the system. In Figure 6.2(d), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for 16-QAM1/2 is done where BER decreases from 12 dB to 1 dB for all three. In Figure 6.2(e), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for 16-QAM3/4 is done where BER decreases from 17dB to 5dB for CP=1/8 & 1/16 and for CP=1/4 BER decreases from 17 dB to 7dB. In Figure 6.2(f), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for 64-QAM2/3 is done where BER decreases from 20dB to 4dB for all three cases. In Figure 6.2(g), BER verses SNR of Maximal Ratio Combining-WiMAX vs conventional WiMAX for 64-QAM3/4 is done where BER decreases from 23dB to 5dB for CP=1/4 and CP=1/16 and BER decreases from 25 dB to 5 dB for CP=1/8. So, these all analysis are in case of Maximal Ratio combining, where it has to choose best antenna and BER also decreases at a sufficient rate for CP=1/4,1/8,1/16. While comparing with conventional WiMAX, there is much decrease in BER which provides the better system at the receiver end. Often this helps in improving our BER for more better and efficient continuation of system and provides results for the betterment of society. Less BER leads the system configurations in efficient way and provides better results.


MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16
Bit Error Rate
SNR [dB]

(a)

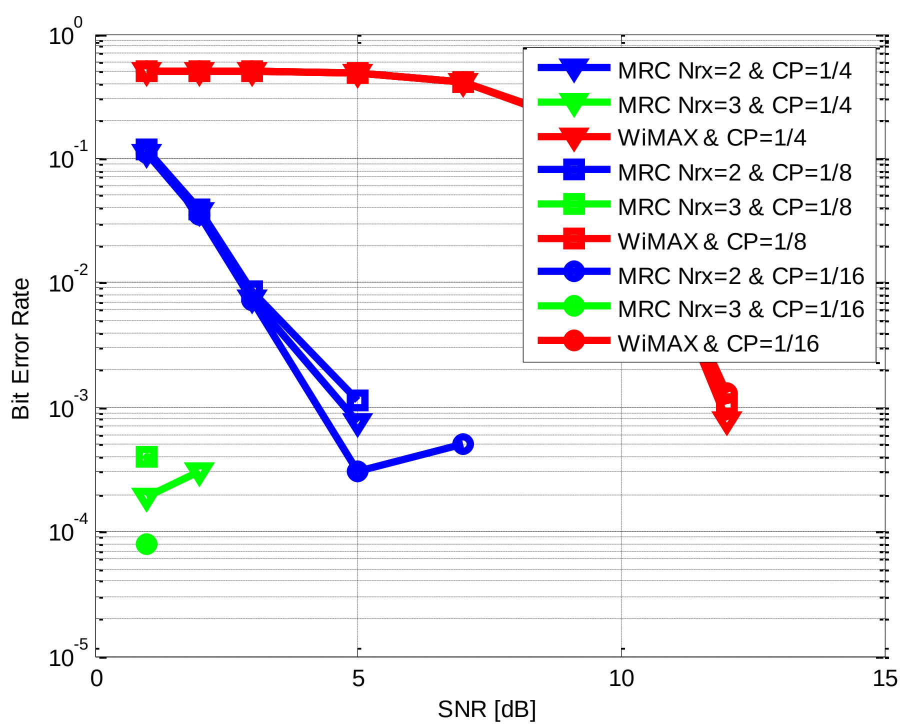

MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16
Bit Error Rate
SNR [dB]

(b)



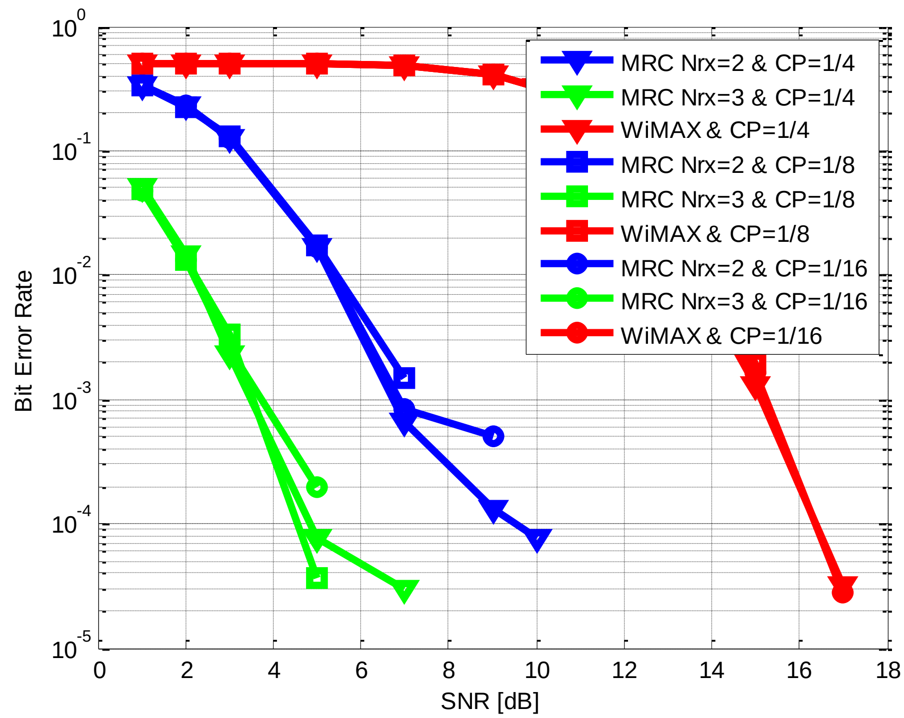
Bit Error Rate
SNR [dB]
MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(c)



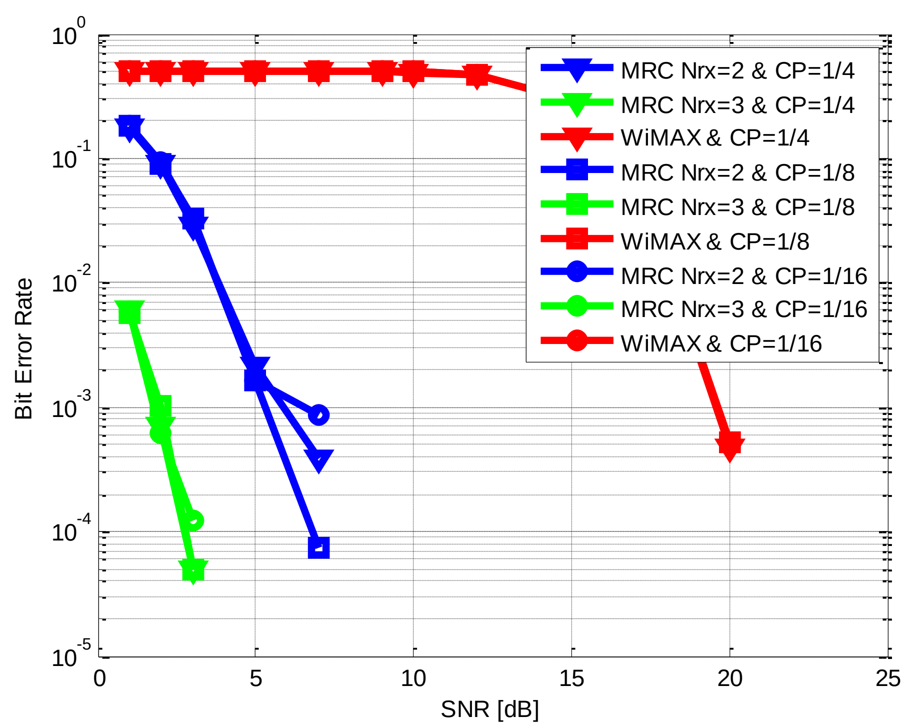
Bit Error Rate
SNR [dB]
MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(d)



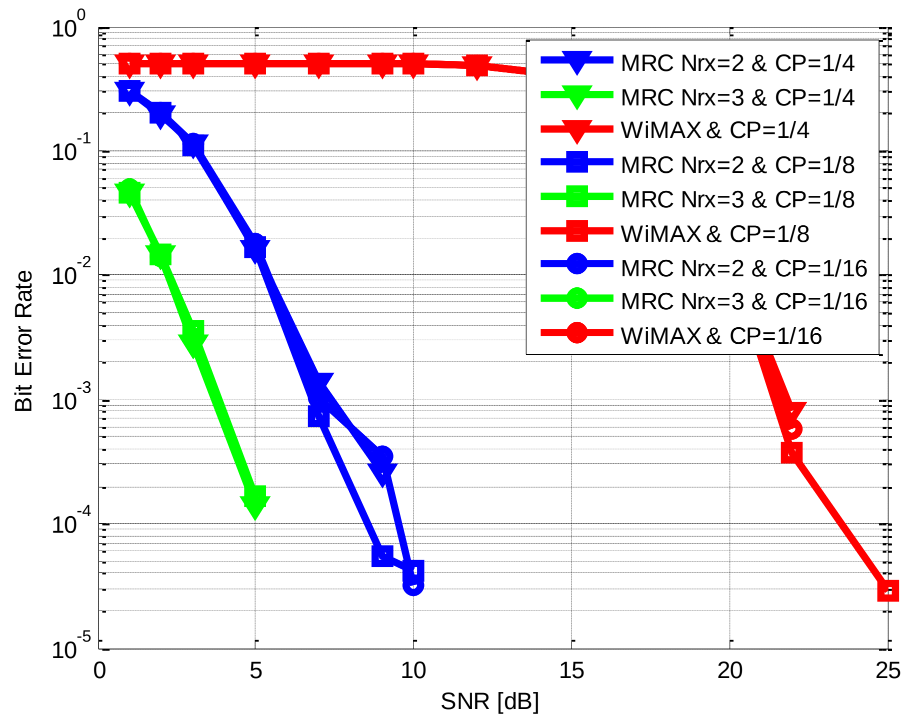
Bit Error Rate
SNR [dB]
MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(e)



Bit Error Rate
SNR [dB]
MRC Nrx=2 & CP=1/4
MRC Nrx=3 & CP=1/4
WiMAX & CP=1/4
MRC Nrx=2 & CP=1/8
MRC Nrx=3 & CP=1/8
WiMAX & CP=1/8
MRC Nrx=2 & CP=1/16
MRC Nrx=3 & CP=1/16
WiMAX & CP=1/16

(f)

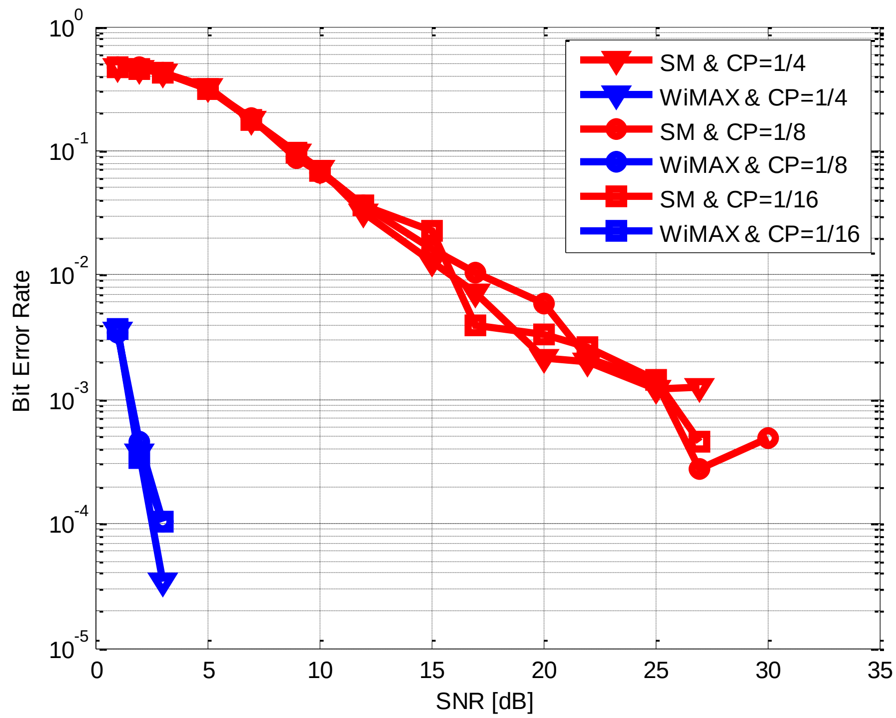


(g)

Figure 6.2 (a-g): BER versus SNR comparison of Maximal Ratio Combining-WiMAX vs Conventional WiMAX for (a) BPSK1/2 (b) QPSK1/2 (c) QPSK1/4 (d) 16-QAM1/2 (e) 16-QAM3/4 (f) 64-QAM2/3 (g) 64-QAM3/4

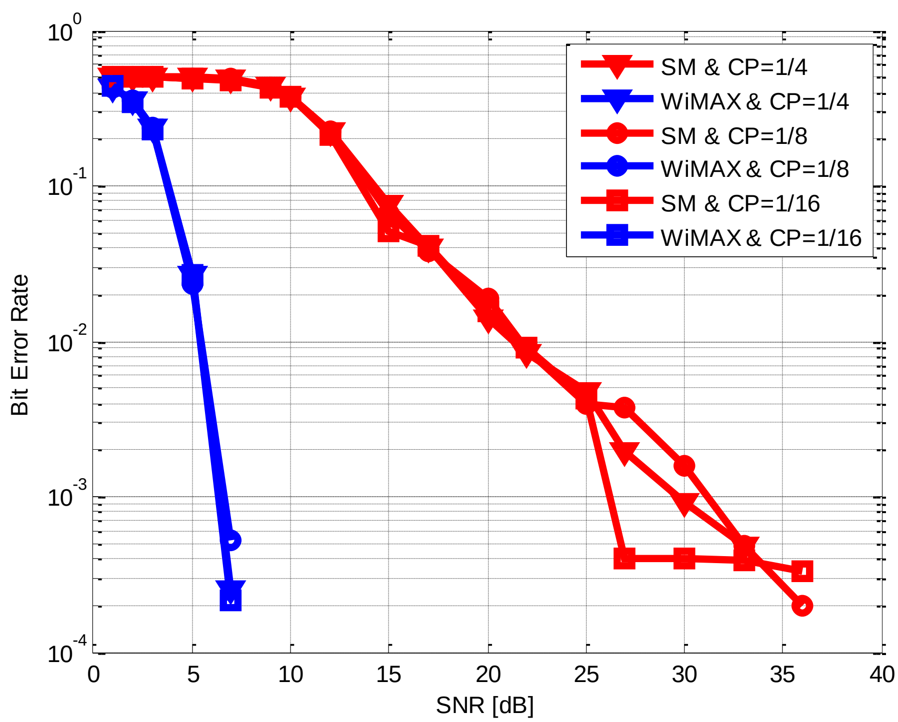
6.3 Spatial multiplexing-WiMAX vs. Conventional WiMAX

Performance analysis of spatial multiplexing augmented WiMAX and conventional WiMAX has been shown in Figure 6.3. In these simulations, various Modulation rates i.e. BPSK1/2, QPSK1/2, QPSK1/4, 16-QAM1/2 and different cyclic prefix values i.e. 1/4, 1/8, 1/16 are taken into consideration. The results are simulated in Rayleigh environment. For the spatial multiplexing, two transmit and two receiving antennas i.e. Ntx = Nrx = 2 are considered. Overall results depict that BER is increasing in case of spatial multiplexing augmented WiMAX in comparison to conventional WiMAX. But, this increase in BER is at the expense of increased capacity by twice as compared to conventional WiMAX.



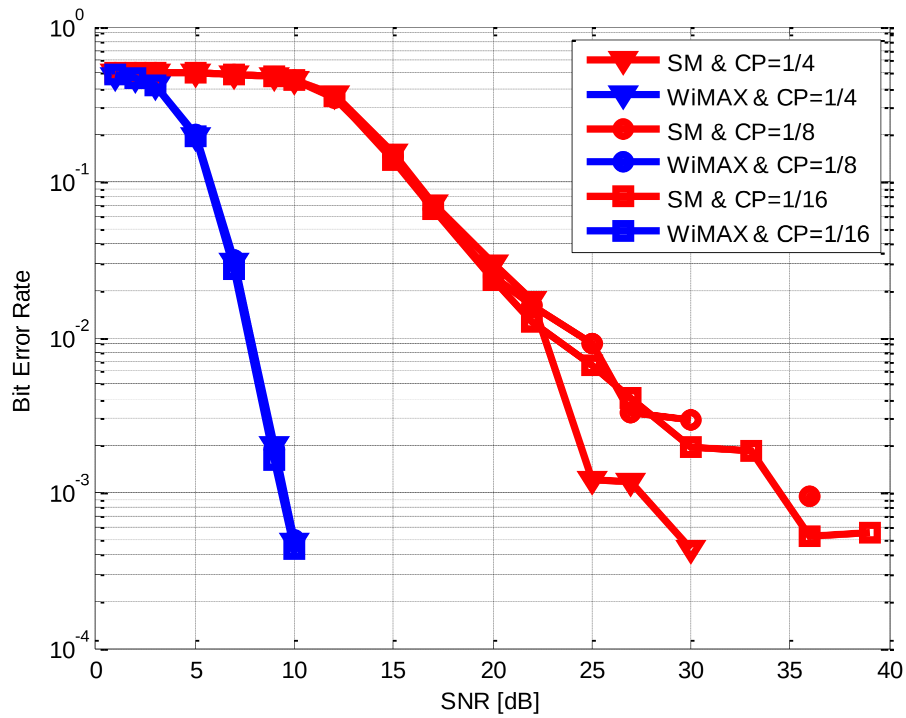
Bit Error Rate
SNR [dB]
SM & CP=1/4
WiMAX & CP=1/4
SM & CP=1/8
WiMAX & CP=1/8
SM & CP=1/16
WiMAX & CP=1/16

(a)



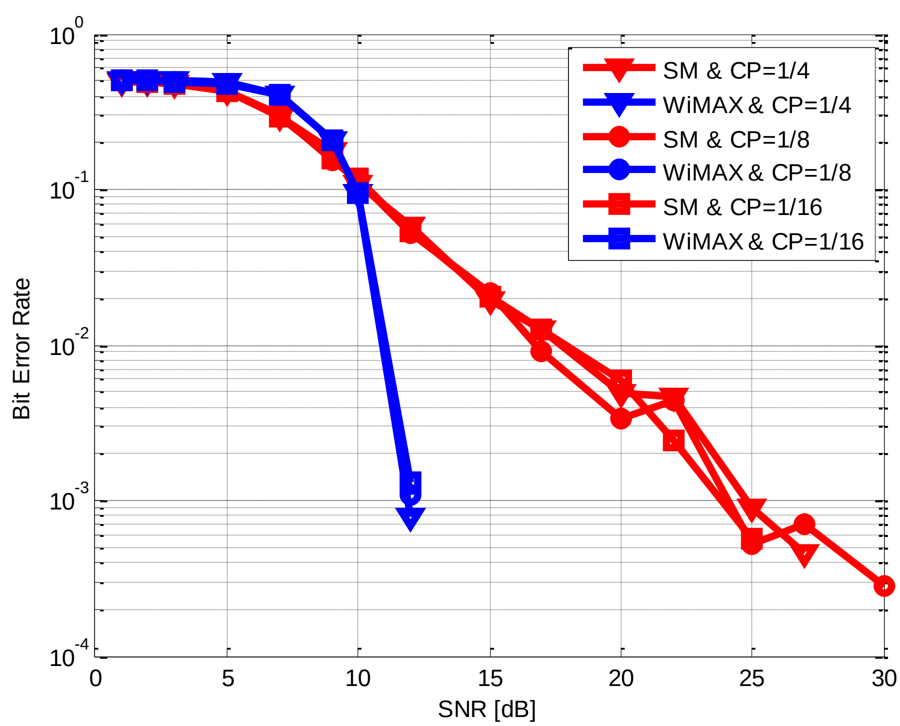
Bit Error Rate
SNR [dB]
SM & CP=1/4
WiMAX & CP=1/4
SM & CP=1/8
WiMAX & CP=1/8
SM & CP=1/16
WiMAX & CP=1/16

(b)



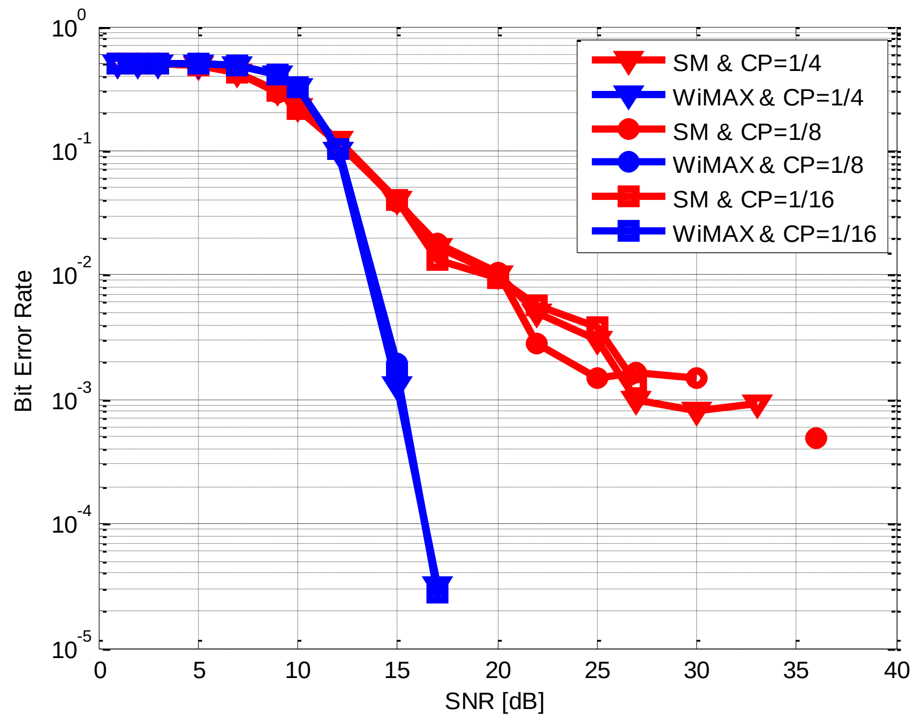
Bit Error Rate
SNR [dB]
SM & CP=1/4
WiMAX & CP=1/4
SM & CP=1/8
WiMAX & CP=1/8
SM & CP=1/16
WiMAX & CP=1/16

(c)



Bit Error Rate
SNR [dB]
SM & CP=1/4
WiMAX & CP=1/4
SM & CP=1/8
WiMAX & CP=1/8
SM & CP=1/16
WiMAX & CP=1/16

(d)



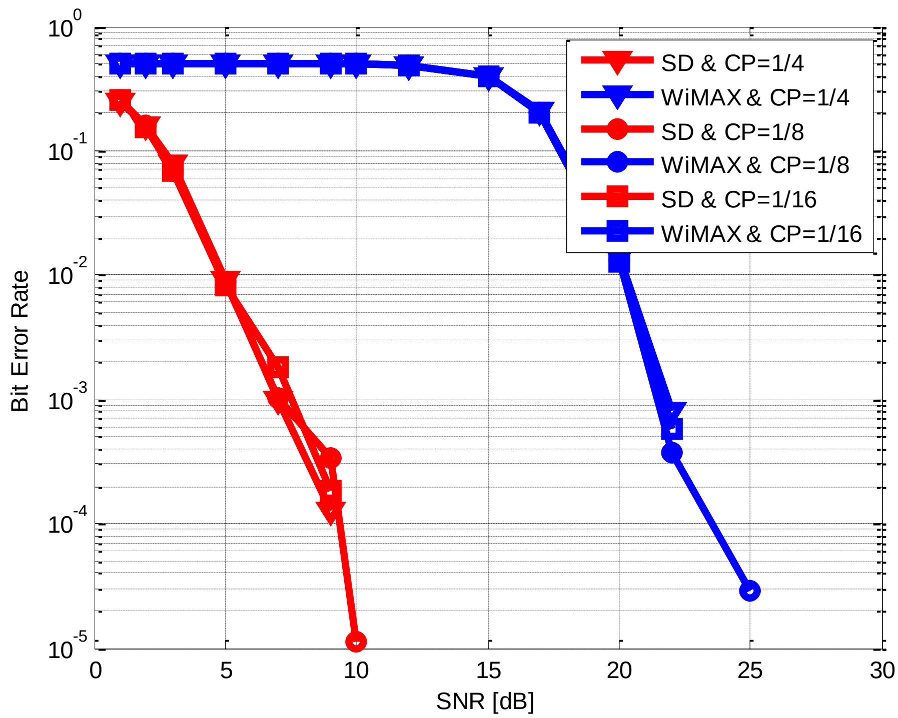
(e)

Figure 6.3 (a-e): BER vs. SNR of Spatial Multiplexing vs. Conventional WiMAX for a) BPSK1/2 (b) QPSK1/2 (c) QPSK1/4 (d) 16-QAM1/2 (e) 16-QAM3/4

6.4 Spatial diversity-WiMAX vs. Conventional WiMAX

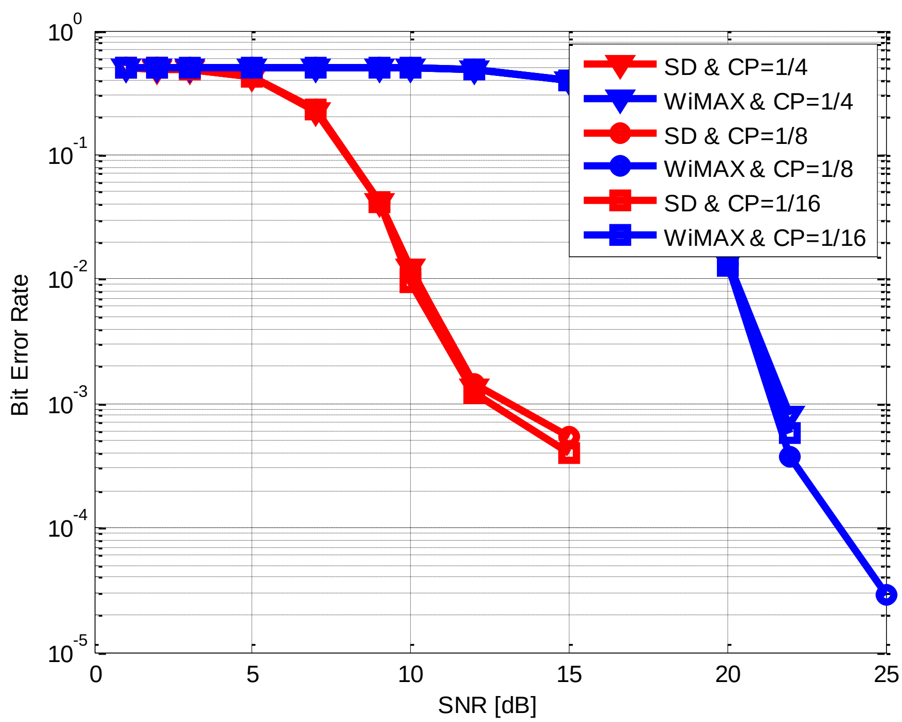
Performance analysis of spatial diversity augmented WiMAX, and conventional WiMAX has been shown in Figure 6.4. In these simulations, various Modulation rates i.e. BPSK1/2, QPSK1/2, QPSK1/4, 16-QAM1/2 and different cyclic prefix values i.e. 1/4, 1/8, 1/16 are taken into consideration. The results are simulated in Rayleigh environment. For the spatial diversity Alamouti scheme with two transmit antennas and two receiving antennas i.e. Ntx = Nrx = 2 is considered. Overall results showed that BER is decreasing in the case of spatial diversity augmented WiMAX in comparison to conventional WiMAX.

But, this decrease in BER is at the expense of increased system complexity due to the use of 2 antennas for transmitting the same information as compared to conventional WiMAX where only 1 antenna is used at both transmitter and receiver side. In the case of spatial diversity augmented WiMAX, to achieve the same BER approximately 15 dB less SNR is required.



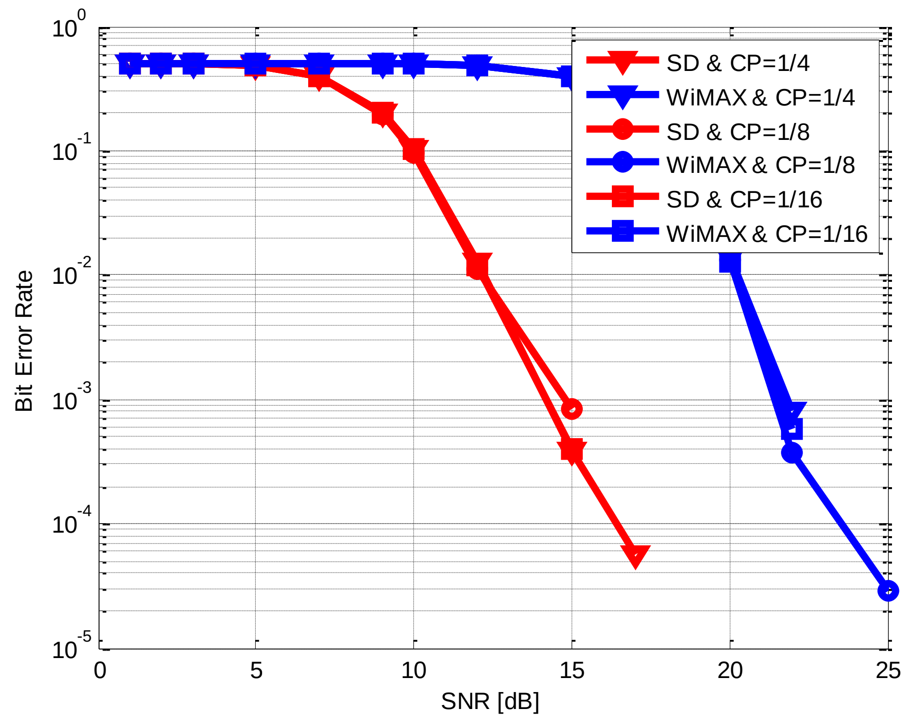
Bit Error Rate
SNR [dB]
SD & CP=1/4
WiMAX & CP=1/4
SD & CP=1/8
WiMAX & CP=1/8
SD & CP=1/16
WiMAX & CP=1/16

(a)

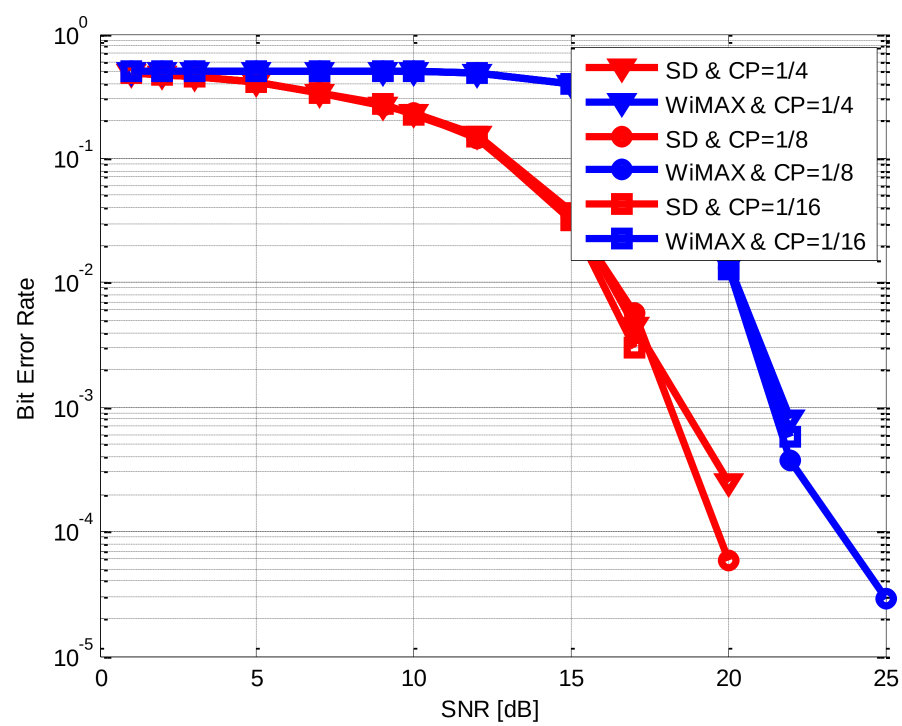


Bit Error Rate
SNR [dB]
SD & CP=1/4
WiMAX & CP=1/4
SD & CP=1/8
WiMAX & CP=1/8
SD & CP=1/16
WiMAX & CP=1/16

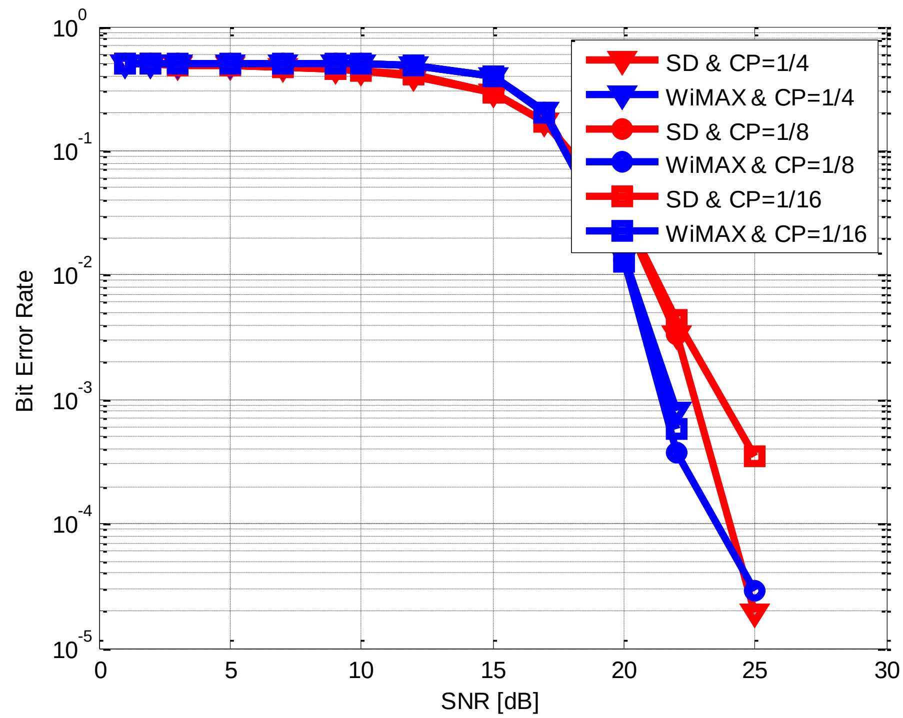
(b)


Bit Error Rate
SNR [dB]
SD & CP=1/4
WiMAX & CP=1/4
SD & CP=1/8
WiMAX & CP=1/8
SD & CP=1/16
WiMAX & CP=1/16

(c)


Bit Error Rate
SNR [dB]
SD & CP=1/4
WiMAX & CP=1/4
SD & CP=1/8
WiMAX & CP=1/8
SD & CP=1/16
WiMAX & CP=1/16

(d)



(e)

Figure 6.4 (a-e): BER vs. SNR of Spatial Diversity vs. Conventional WiMAX for (a) BPSK1/2 (b) QPSK1/2 (c) QPSK1/4 (d) 16-QAM1/2 (e) 16-QAM3/4

6.5 Image Transmission

This involves the performance of the image transmission in well possible way. The M-PSK (QPSK, 16-PSK, 64-PSK) modulation schemes are used and accordingly BER is compared. This type of image transmission helps in sending better quality image along with better performance having various transmitters and receivers. Diversity combining techniques like MRC, SC etc. is used along with Beamforming of different values. Various values of SNR had been taken i.e. (40, 50, 60) dB to get specified results. The original image which has been taken as input is shown below:-

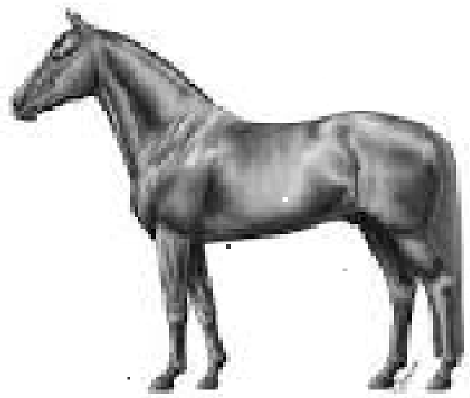
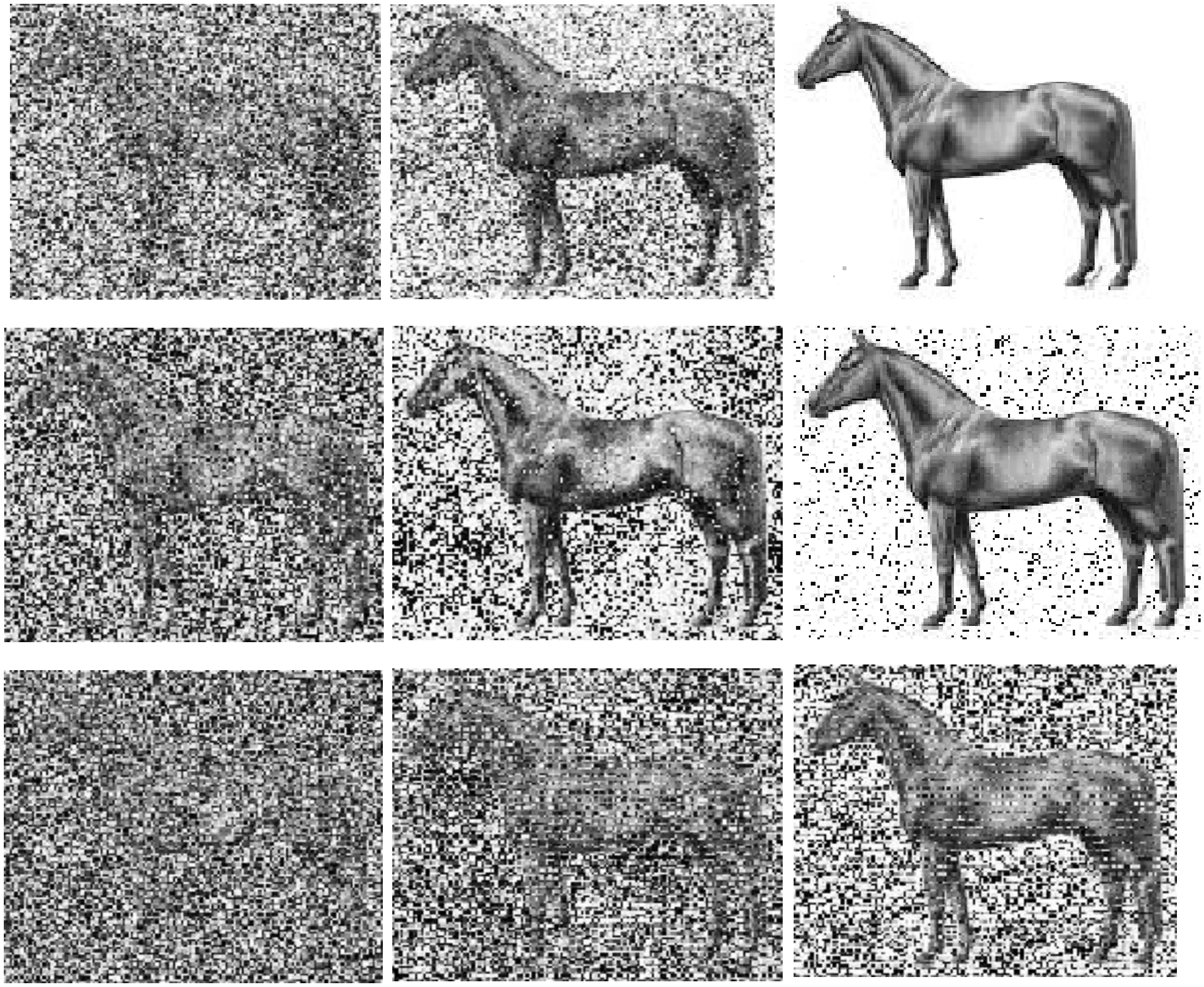


Figure 6.5: original image

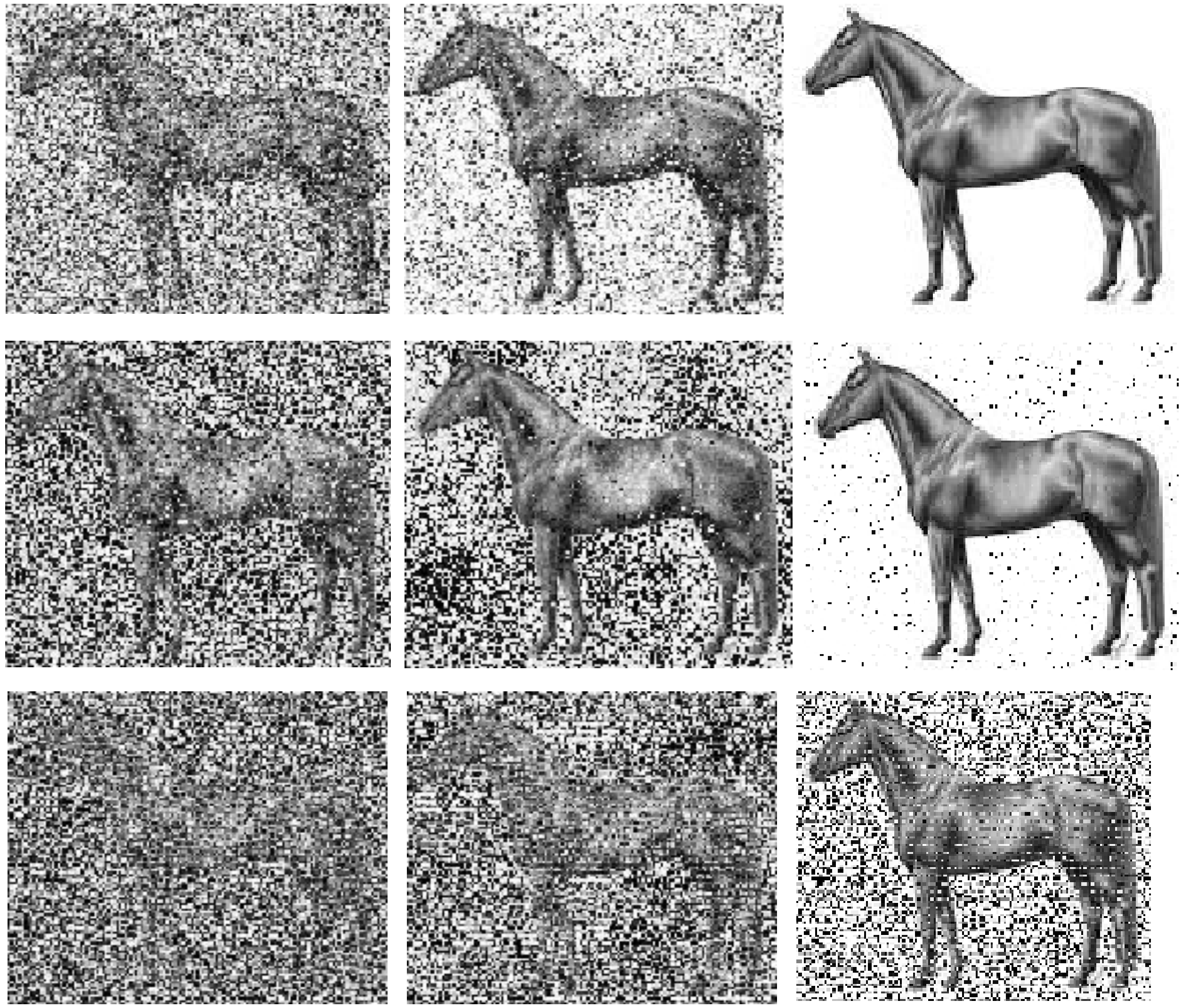
6.5.1 Beamforming

Analysis of Beamforming has been done in this over various Modulation rates i.e. QPSK, 16-PSK and 64-PSK with different transmitter values i.e. Ntx= 2, 3, 4 and various SNR values i.e. (40, 50, 60) and results are plotted. Various images are received based on their performances and modulation rates provided to them as shown in figure 6.6 (a-c).

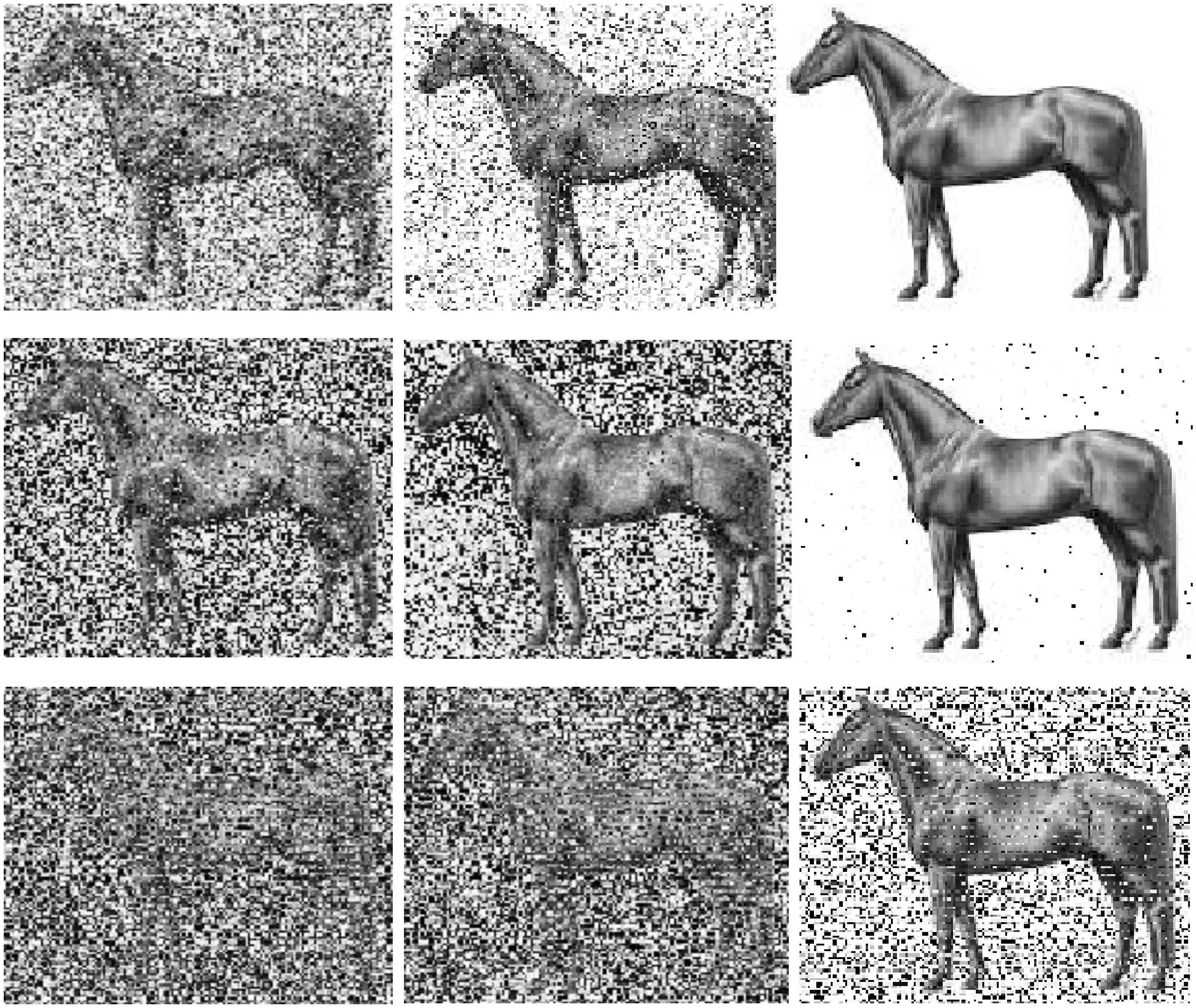
The plot in Fig.6.6 (d) shows BER vs. SNR performance of the image received by using various transmitters and with every modulation technique used. Overall results from the simulations shown tells that BER (Bit Error Rate) is providing the best result in case of QPSK and least is in case of 64-PSK. Various others simulations had already been carried out in using this case which hasn't provided that much improvement in the BER vs. SNR performance of the image received by using various modulations techniques and criterias.



(a)



(b)



(c)

Figure 6.6 (a-c): Received images of Beamforming for (a) Ntx=2 (b) Ntx=3 (c) Ntx=4

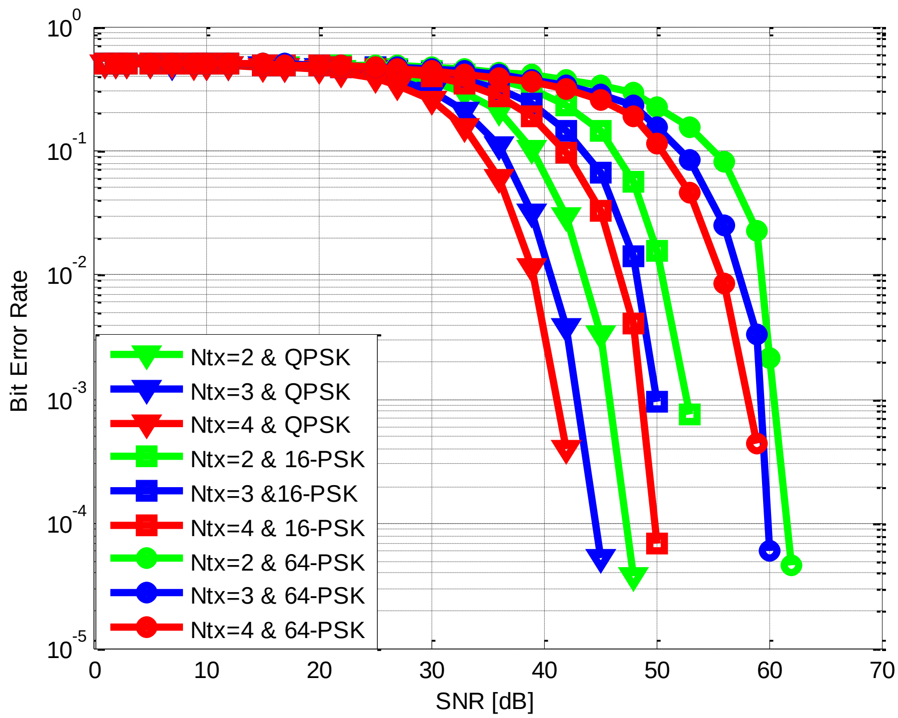
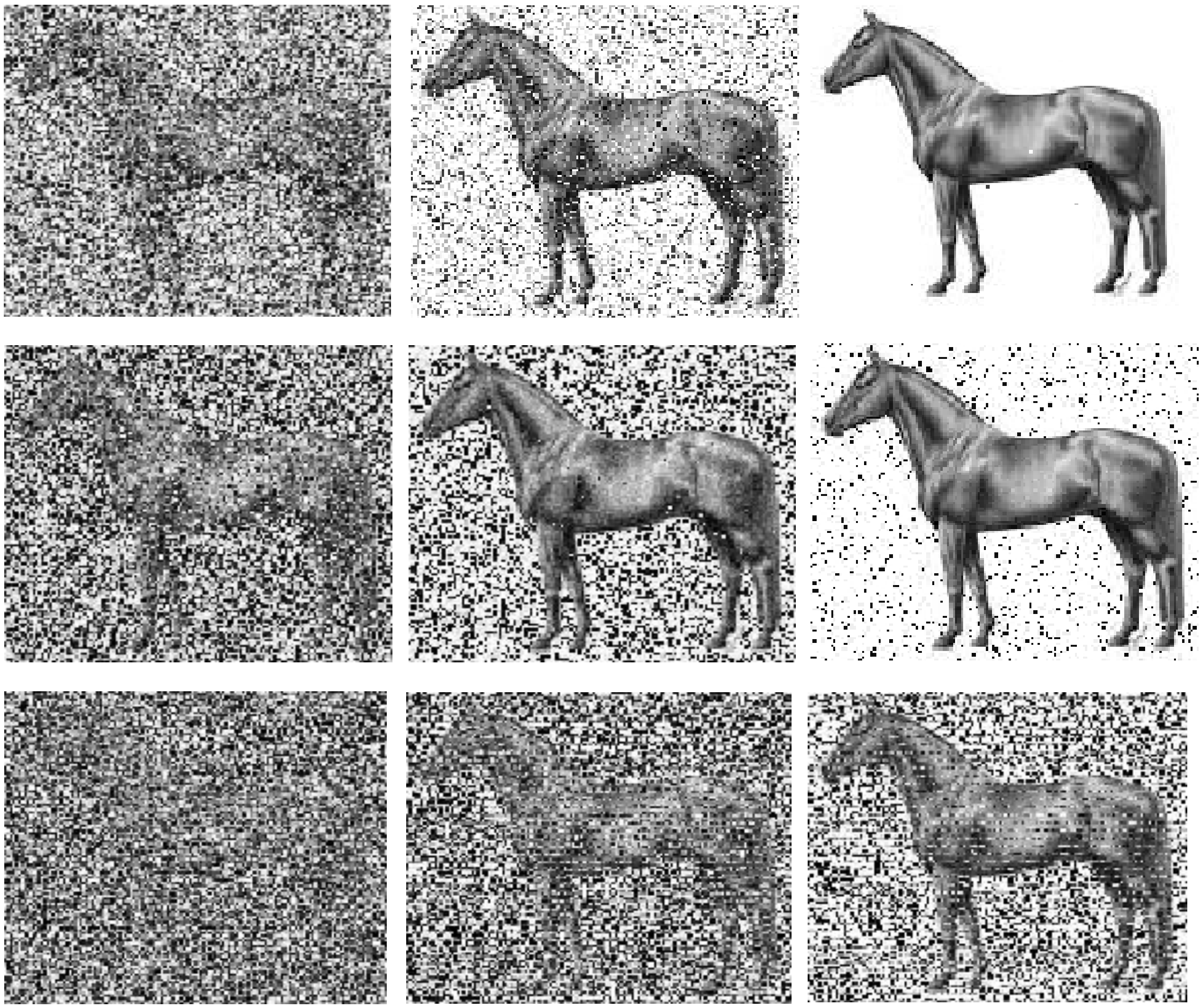


Figure 6.6 (d): BER vs SNR of beamforming with modulation rates of 4, 16, 64-PSK

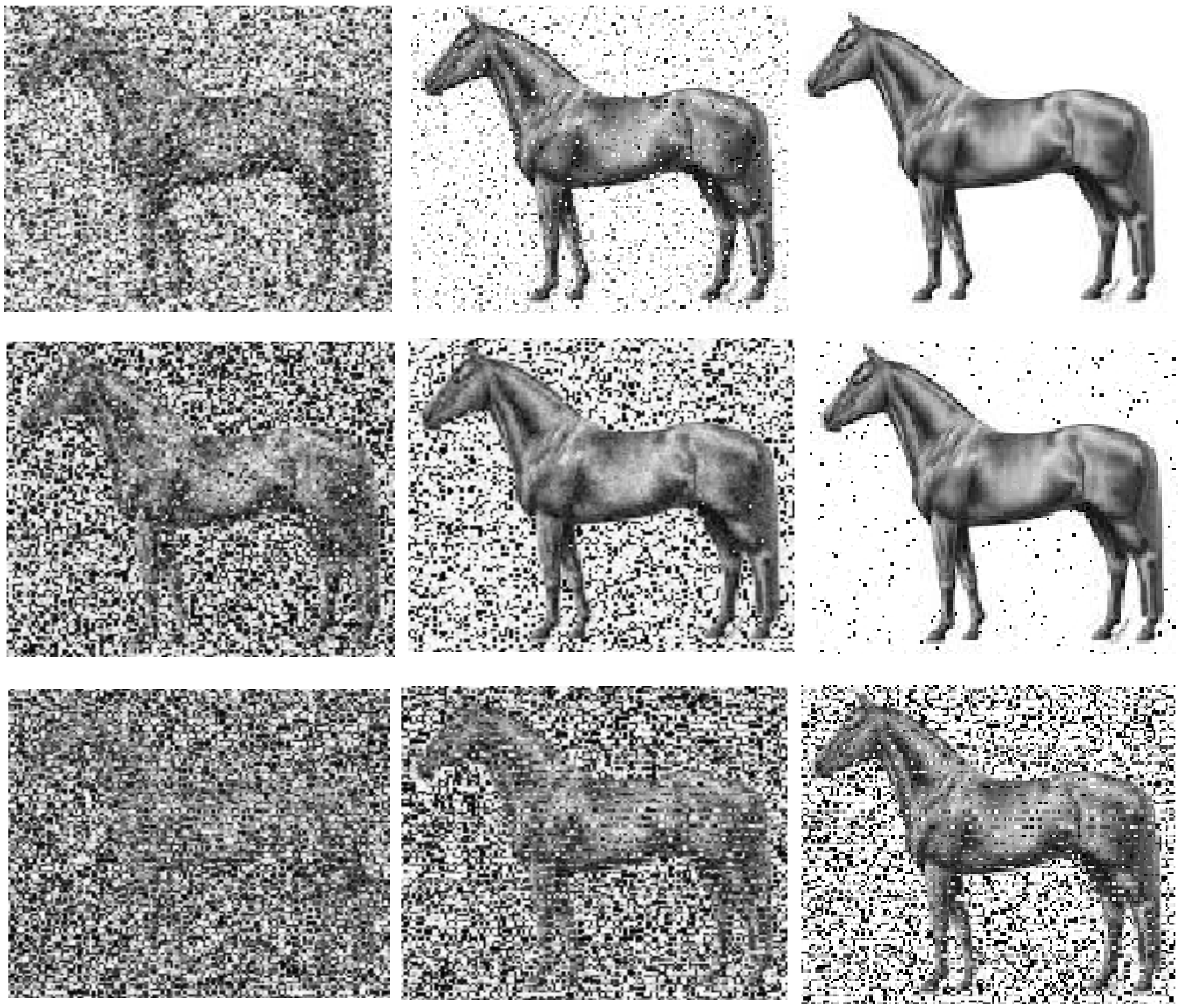
6.6.2 Maximal Ratio Combining

Analysis of MRC has been done in this over various Modulation rates i.e. QPSK, 16-PSK and 64-PSK with different transmitter values i.e. Nrx= 2, 3, 4 and various SNR values i.e. (40, 50, 60) and results are plotted. Various images are received based on their performances and modulation rates provided to them as shown in figure 6.7 (a-c).

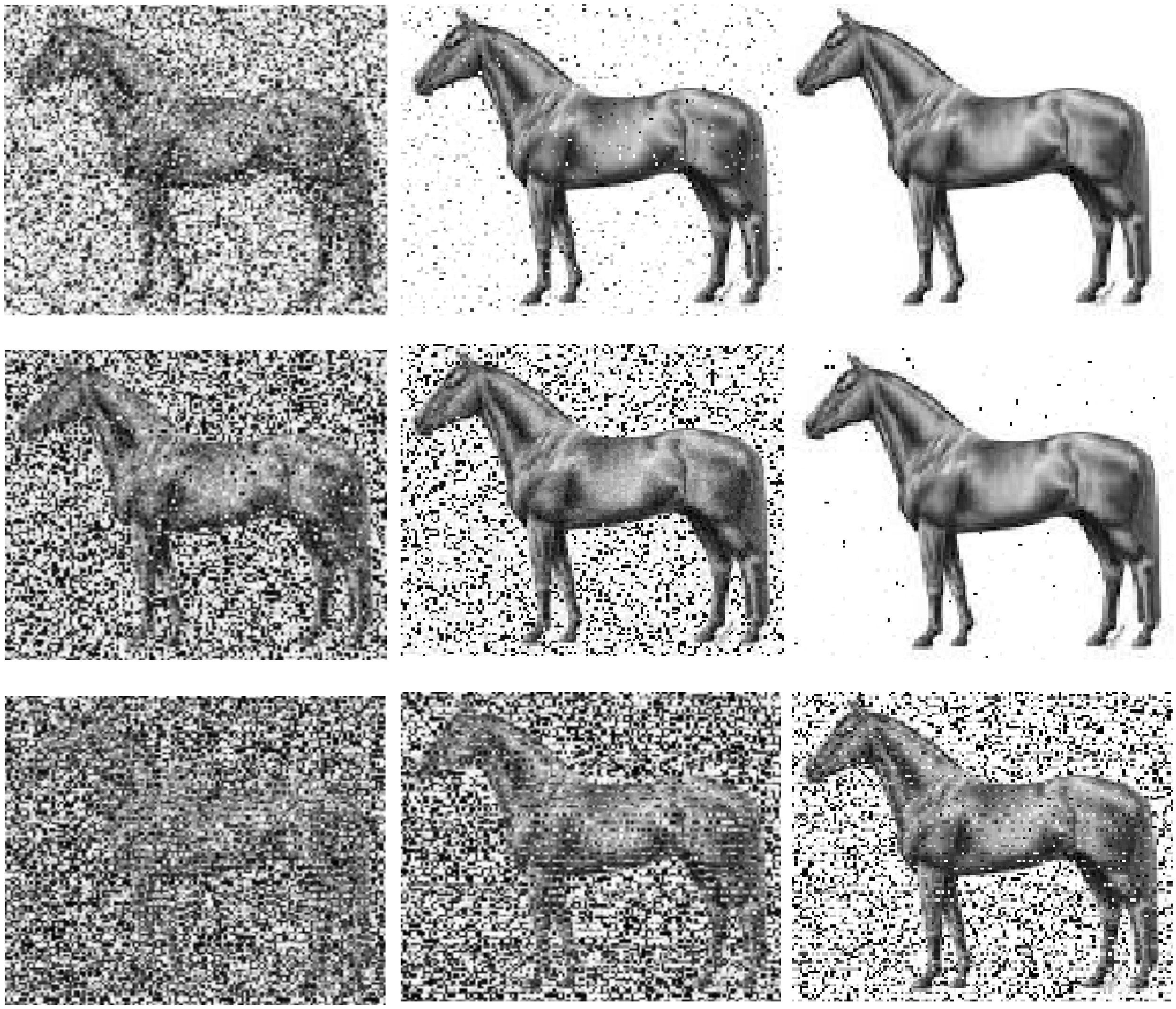
The plot in Fig.6.7 (d) shows BER vs. SNR performance of the image received by using various receivers and with every modulation technique used. Overall results from the simulations shown tells that BER (Bit Error Rate) is providing the best result in case of QPSK and least is in case of 64-PSK.



(a)



(b)



(c)

Figure 6.7 (a-c): Received images of Maximal Ratio Combining for (a) Nrx=2 (b) Nrx=3 (c) Nrx=4

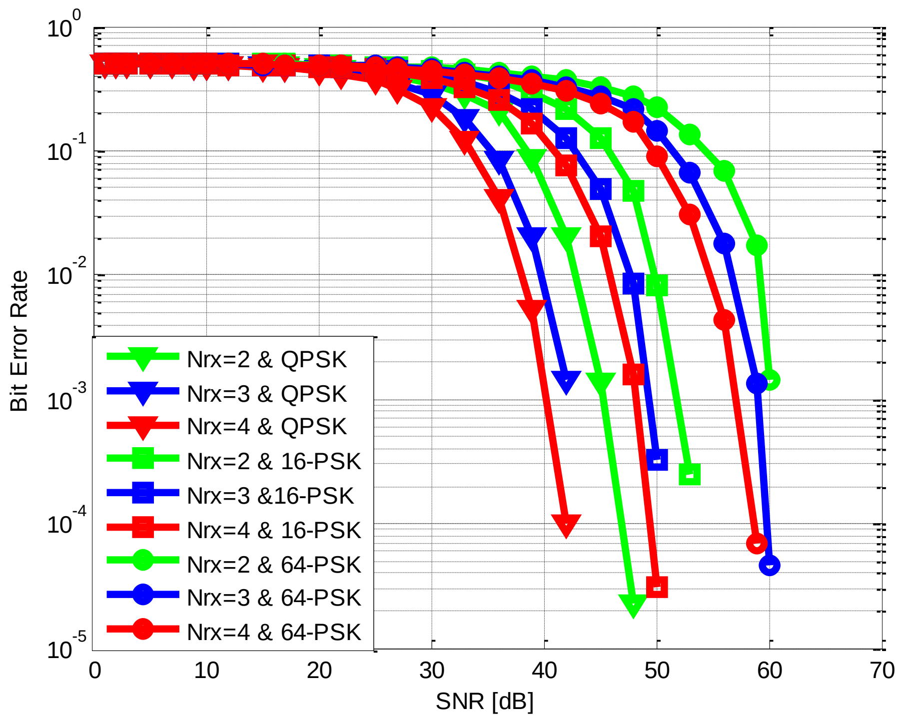
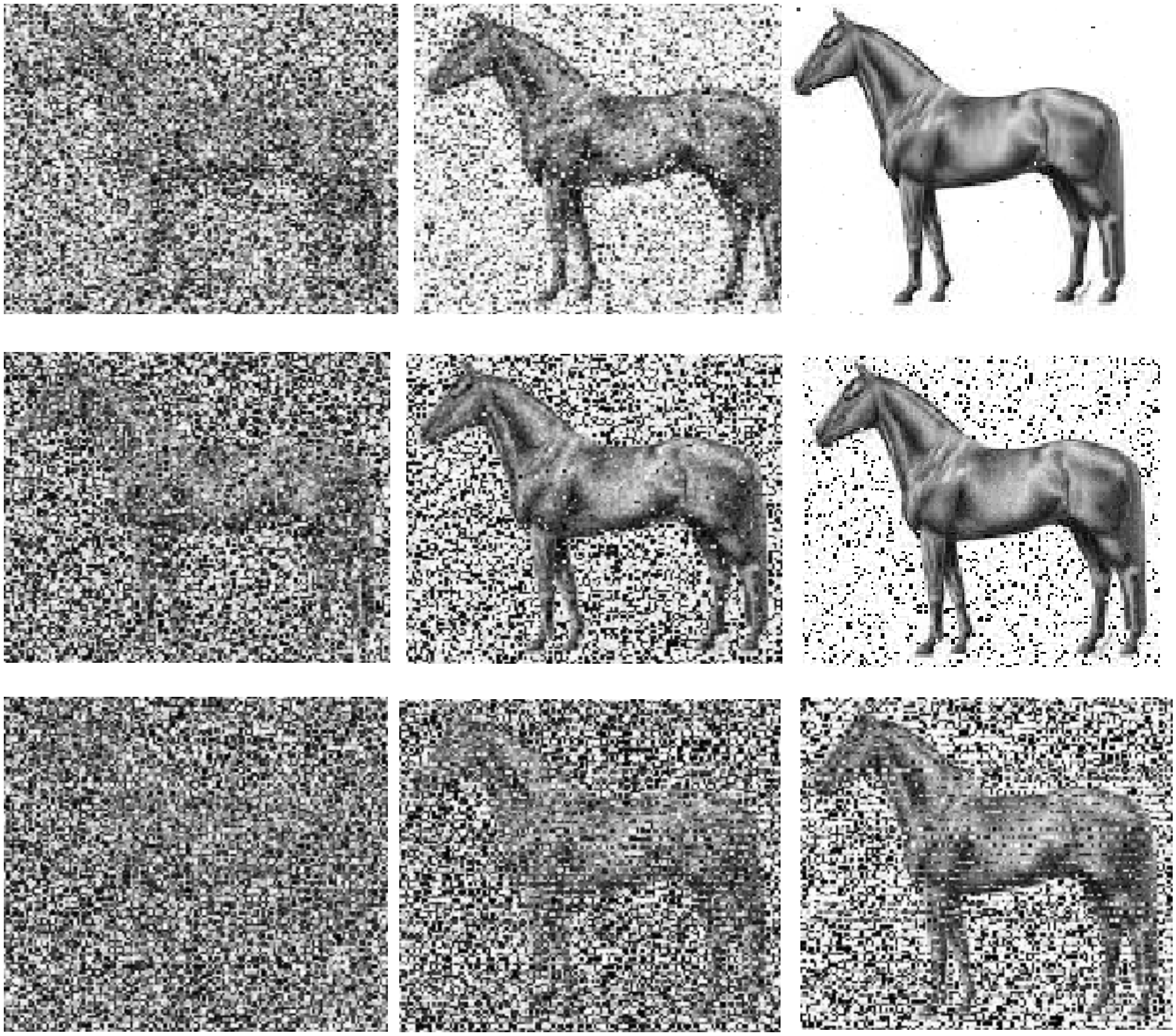


Figure 6.7 (d): BER vs SNR of MRC with modulation rates of 4, 16, 64-PSK

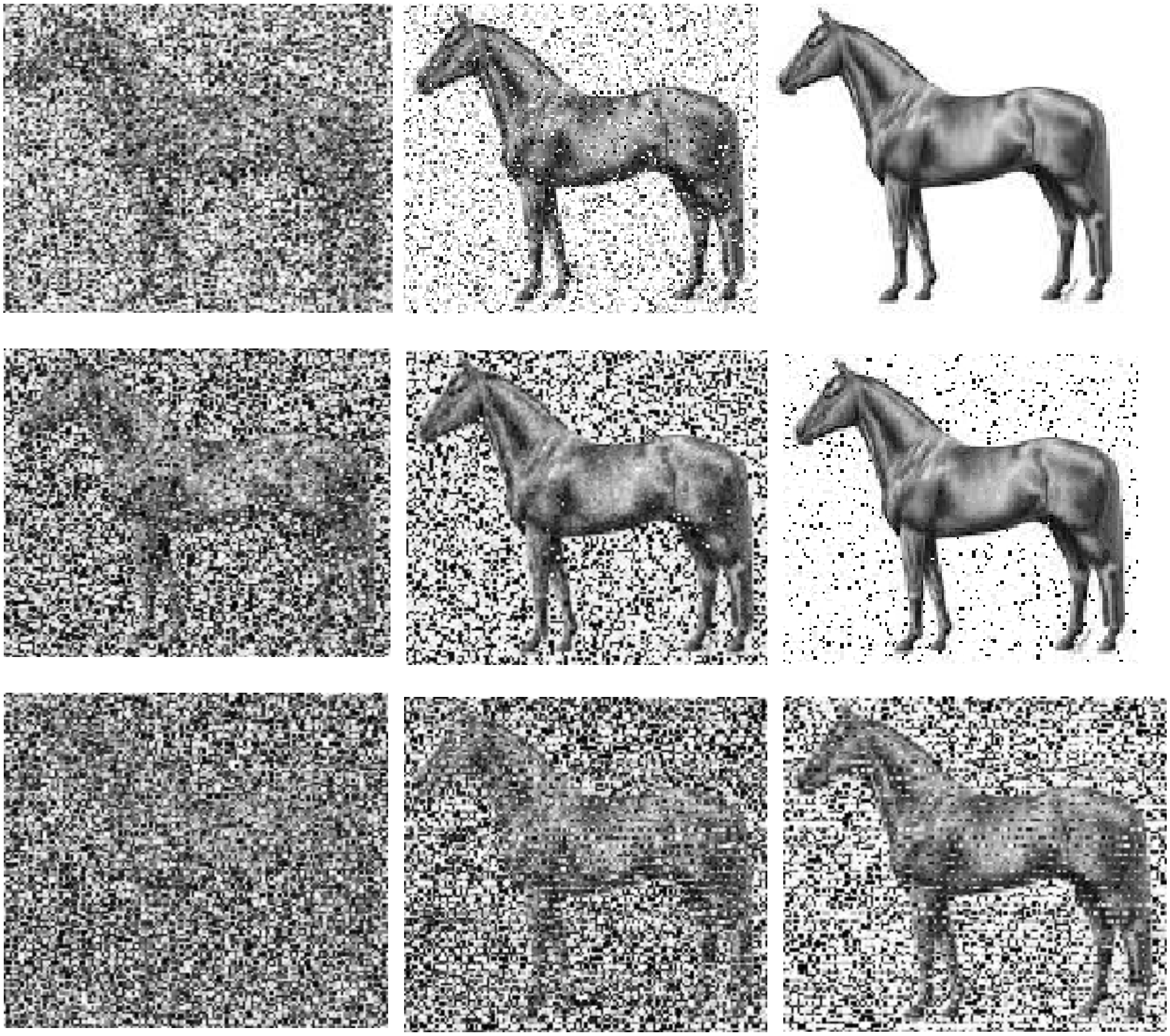
6.6.3 Selection Combining

Analysis of MRC has been done in this over various Modulation rates i.e. QPSK, 16-PSK and 64-PSK with different transmitter values i.e. Nrx= 2, 3, 4 and various SNR values i.e. (40, 50, 60) and results are plotted. Various images are received based on their performances and modulation rates provided to them as shown in figure 6.8 (a-c).

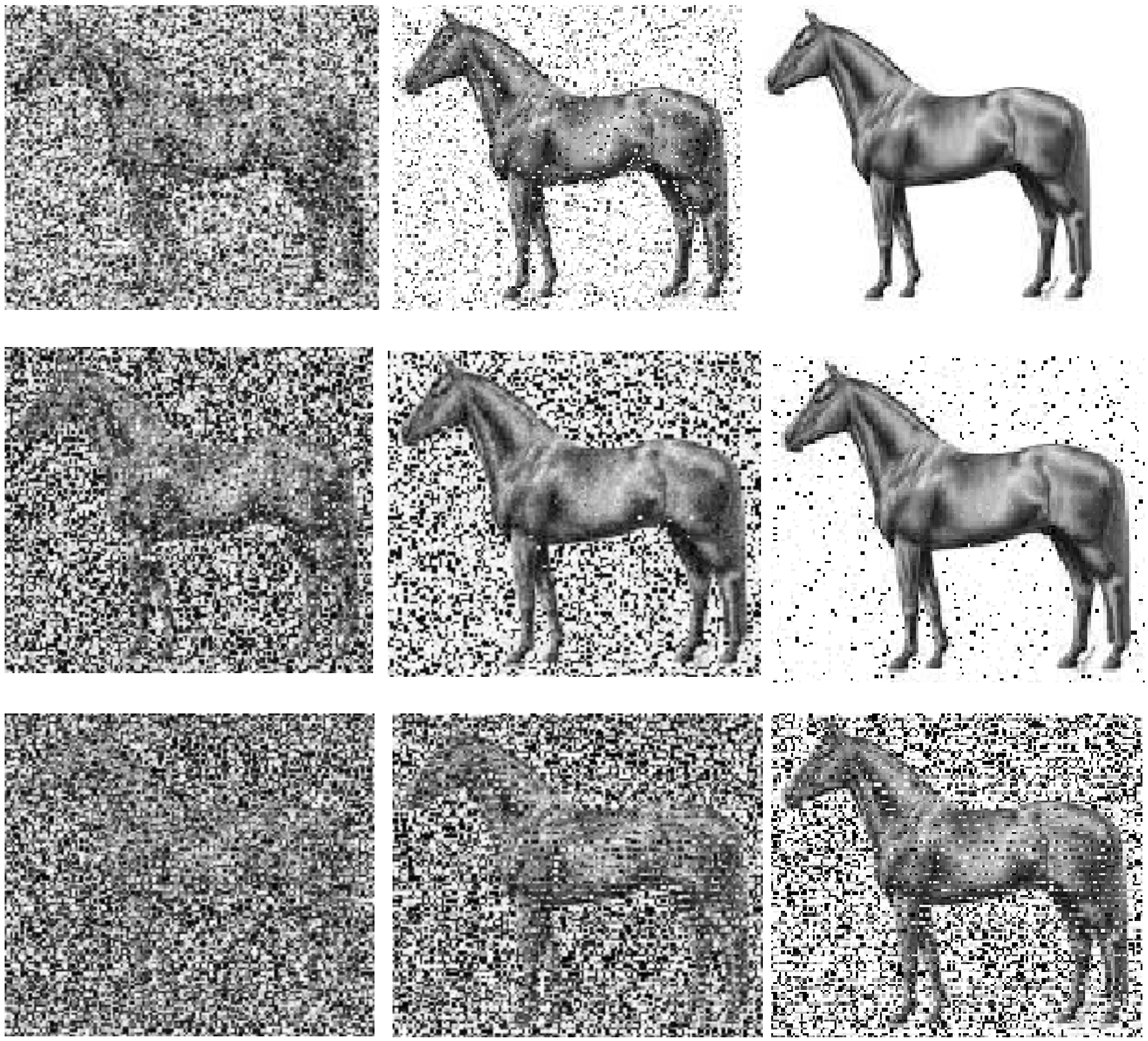
The plot in Fig. 6.8 (d) shows BER vs. SNR performance of the image received by using various receivers and with every modulation technique used. Overall results from the simulations shown tells that BER (Bit Error Rate) is providing the best result in case of QPSK and least is in case of 64-PSK



(a)



(b)



(c)

Figure 6.8 (a-c): Received images of Selection Combining for (a) Nrx=2 (b) Nrx=3 (c) Nrx=4

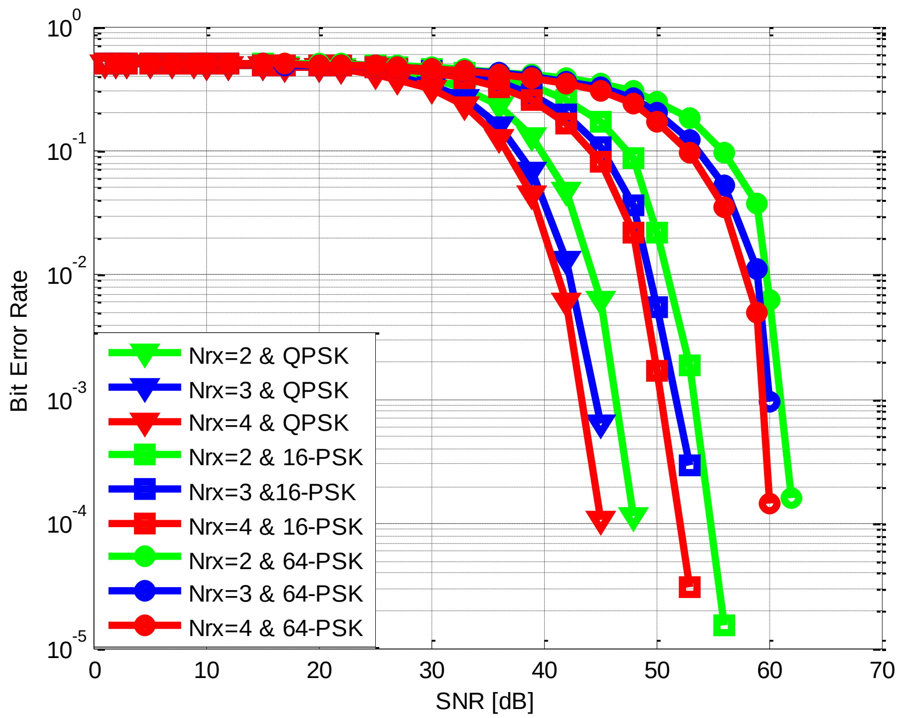


Figure 6.8 (d): BER vs SNR of SC with modulation rates of 4, 16, 64-PSK

CHAPTER 7 CONCLUSION & FUTURE SCOPE

Here, the implementation of various techniques of receiver diversity incorporated with WiMAX and comparison of it with conventional WiMAX schemes in MATLAB which helps us to know about the better BER vs. SNR comparison. Various receiver Diversity schemes like MRC & SC is discussed in detail and compared with conventional WiMAX to get better results. Highlighting the combination of MIMO along with WIMAX and their consequences by explaining its role in removing multipath fading channels, having better capacity, coverage, throughput, efficiency and BER. This hybrid combination of receiver diversity and WiMAX can give an SNR advantage of 10-20 dB with a number of antennas varying from 2 to 3. The implemented MIMO-WiMAX technique still needs some more innovation in it. More Diversity scheme like thresholding and equal gain combining can also be used to implement in MATLAB for better performance of BER. Usage of Spatial Multiplexing, Spatial Diversity and Beamforming will be plus point for MIMO-WiMAX to get better results.

After that, different convolution code rates and different modulation techniques under the Rayleigh channel model with spatial diversity and spatial multiplexing augmented WiMAX are compared with conventional WiMAX technique. It can be seen from the simulation results that in the case of spatial diversity, it offers high diversity gain and reliability i.e. less BER as compared with WiMAX and more throughput in case of spatial multiplexing having high BER when compared with WiMAX. Any one of the above-mentioned techniques i.e. spatial multiplexing or spatial diversity will be appended with WiMAX to enhance its performance in terms of capacity or reliability. Various other algorithms and techniques suitable to get informative results adds an advantage.

At last, for better and efficient image transmission, M-PSK schemes are used with different transmitters and receivers having different SNR values. Different BER for different SNR values are performed and their differences can be seen from the results shown above. Basically, QPSK > 16-PSK > 64 –PSK is the performance of the simulated results which proves that the BER is having the best configuration in case of QPSK and least in case of 64-PSK. Further, images which are received are of proper quality as they are transmitted well. Adding to this, the image results shows that the proper quality images only contains less number of transmitters and receivers and less SNR values which is a biggest advantage in this case. As less number of transmitters will cause less complexity on both sides and actual image which is to be received comes out in proper way.

The noise effect can be measured from the images being received and we can say that 64-PSK with SNR value of 60 is having much noise in it. It can be concluded that the noise effect reduces as we are increasing the SNR value and clarity in the images can be seen. Outcome that provides us knowledge about less BER if we raise SNR value, have been checked and verified for the SNR values of (40, 50 and 60). So, from the results, it is clear that, there is less BER in case of QPSK and more in case of 64-PSK which also states that the requirement of signal power is minimum for QPSK and more for 64-PSK.

In this, several other additional PSK techniques can be used to make it more efficient and result oriented. Moreover, increasing the number of antennas will not help that much but still, it can go up to some limit in which we can get better results at the end. For better and clear image at the receiver side, various compression algorithms, techniques and mathematical results can be implemented in this. Using Spatial Multiplexing and Spatial Diversity at different values of cyclic prefixes can also help us to get clear images at receiver side.

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