International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

Performance Analysis of Spatial Modulation Scheme in Wireless Communication

Shraddha[1], Kanchan Sharma[2]
[1]M.Tech Student,
[2]Asistant professor
[1,2]Department of Electronics & Communication,
Indira Gandhi Delhi Technical University for Women

Abstract- **Wireless communications has become a new field to developing rapidly in our recent life and also creates a big effect on almost all the features of our daily lives. In Wireless communication, spatial modulation is recently developed approach to multiple-input multiple-output. It aims to increase the data rate of a system without increasing the bandwidth requirements. It is more energy efficient than other MIMO systems and needs only a single radio-frequency chain. As we know the performance of spatial modulation in MIMO communication system is dependent on the specific amplitude/phase modulation signal constellation adopted. This paper presents theoretical study with performance analysis of spatial modulation in wireless communication. In first part we expressed our views over spatial modulation how it works and secondly the method used by this schemes. In this literature the review of documentation we are representing the range of BER versus SNR with increasing high data rate using spatial modulation scheme. At last conclude that which will be the best result by comparing BER versus SNR for three type of QAM with high data rate using spatial modulation scheme.**

Keywords- MIMO system, spatial modulation(SM), space shift keying (SSK), Digital modulation technique: Quadrature amplitude modulation (QAM), Bit-error-rate (BER), Signal-to-noise ratio (SNR).

I. INTRODUCTION

MIMO is multiple inputs multiple outputs which uses multiple transmitters and multiple receivers of an antenna to improve the performance of communication. MIMO is responsible for improving wireless system capacity range and reliability in today era. But major drawbacks found in conventional MIMO system are its' high cost, increased complexity and increased power/energy consumption. So, Spatial modulation technique was introduced which helped to overcome above challenges [1]. Spatial modulation(SM) is basically a recent transmission concept which belongs to the fractional RF-MIMO wireless system. SM-MIMO is holding multiple advantages over conventional MIMO Technique. It uses limited number of RF chains which reduce the complexity of the communication [1]. It maps the additional information bits onto a spatial modulation constellation diagram. That's why spatial modulation is responsible for giving high data rate, reduced signal processing and circuit complexity, and also improves energy efficiency [1].

Here we are briefly describe the motivational part of spatial modulation research with a focus on some pioneering papers, through which concept of SM was first proposed. In 2001, A. chau & S. Hang Yu first time introduces "Space modulation on wireless fading channels" where they explained the SSK special form of SM [2]. In 2006, R .Mesleh & H. Haas introduces "Spatial modulation- a new low complexity spectral efficiency enhancing technique" which is a common method and describe the every moment only one antenna will remain active. In 2008, R. Mesleh & H. Haas again introduces "Spatial modulation" in OFDM which explain the compare with Alamouti OFDM &V-BLAST OFDM and also reduce 90% complexity in SM- OFDM [2]. In 2010, R. Mesleh & M.D Renzo introduces "Trellis coded spatial modulation ". In 2011, "Space- time block coded spatial modulation" introduced by E. Basar, U.Aygolu again which explains SM in space-time block coding and coding gain /diversity together [2]. In 2015," performance analysis of spatial modulation (SM) and space-shift keying (SSK) over generalized η−μ fading channels in the presence of Gaussian imperfect channel estimation at the receiver" by Raed Mesleh, Osamah S. Badarneh, Abdel hamid Younis & Harald Haas. In this the η−μ fading channel has Nakagami-m, Rayleigh, one-sided Gaussian, and Nakagami-q (Hoyt) channels as special cases and expression for the pair wise error probability (PEP) is derived along high signal-to-noise ratio (SNR) [2]. In 2017 "Quadrature Spatial Modulation in Correlated η−μ Fading Channels with Imperfect Channel State Information" by Raed Mesleh & Osamah S. Badarneh in which improve the spectral efficiency of the spatial modulation (SM) and closed-form expression for the pair wise error probability (PEP) is derived [2]. Where in 2018 " Enhancing Spatial Modulation System Performance Through Signal Space Diversity " by Saud Althunibat and Raed Mesleh in this they proposed DE-SM scheme is different from Alamouti SM schemes and derives an upper bound of the average BER and achieving transmit diversity gain [2].

The rest of this paper is organized as follows: In section II, we have given a brief description about spatial modulation. In section III, we explain about space shift keying .In section IV, we explained about performance analysis of SM using flowchart and working. In section V, simulation of SM, in section VI we have result and at last in VII we conclude this paper with our observation.

II. SPATIAL MODULATION

Spatial Modulation has been recently introduced as a new modulation concept for wireless MIMO system. It help in reducing the cost and complexity of multiple antenna without disturbing the system performance and provide high data rates [1]. This can be done only adopting the simple modulation and coding mechanism need as follows:

1) It has one transmit antenna which is activated for data transmission. This help to avoid inter channel interference, and use only one RF chain for data transmission w.r.t to conventional MIMO schemes.

2) Source of information used spatial position of each transmit-antenna. This is done by one-to-one mapping between each antenna index and information bits is transmitted in form of block which results in a coding mechanism. As one antenna is active, due to which SM gives high data rate [1].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

At transmitter,it has binary source through which bit stream is emiited.Binary source then divided these bit stream into blocks with each bits containing $\log_2(N_t)+\log_2(M)$[1].SM mapper processed th each block which splits each of them into two subblocks that is $\log_2(N_t)$ and $\log_2(M)$ bits each as given in figure 2.1 .First subblock here select the antenna which is turned on for transmission of data where all oother transmitted antennas will remain silent at the tinme interval.In second subblock is used to select a symbol in the signal constellation diagram[1].

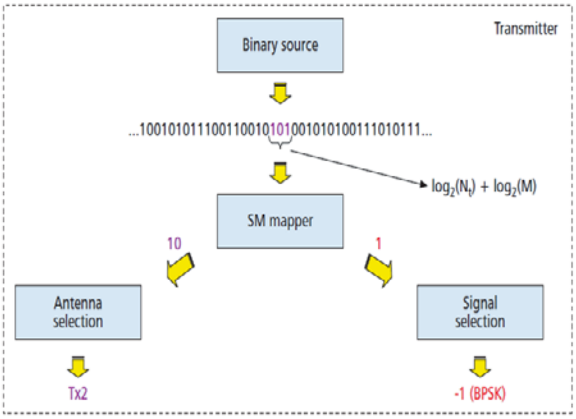


Fig 2.1 Transmitter

In figure 2.2, signal produced by the active antenna will pass through a wireless channel. In antenna array as we know there are different spatial positions occupied by transmitter antenna, so each antenna will experience different propogation.This happen because only one antenna is active and other antenna are not active at any time instance due to which any one signal is achieved at receiver[1].

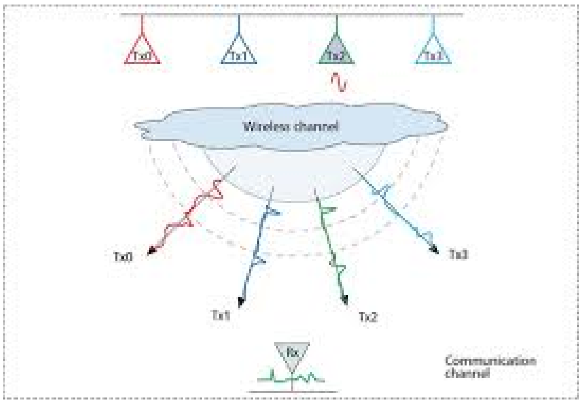


Fig 2.2 wireless channel

Receiver is responsible for detecting the signal coming from the transmitter as given in figure 2.3. Here channel impulse response (N_t N_r) used to be estimated which is depend upon the number of transmitting and receiving antennas. Where ML detector which is used at receiver help in computing the Euclidean distance (M N_t N_r) between the receiver and set of possible signals modulated by wireless channel and select the closest one .Through this all transmitted block are able to decoded and we are able to recovered the original bits[1].

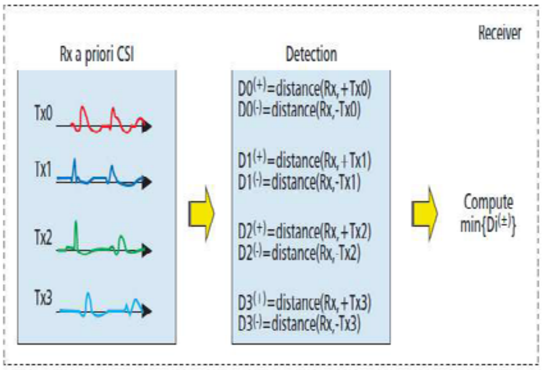


Fig 2.3 Receiver

In figure2.4 system model of SM is shown which is consisting of a MIMO wireless link which have N_t transmit and N_r receiver antennas. In SM mapper a random sequence of independent bits b is entering which maps [1]

$$m=\log_2(M\, N_t)$$

to a constellation vector which is given as,

$$x=[x1\ x2\ldots\ldots\ldots\ldots x\ N_T].$$

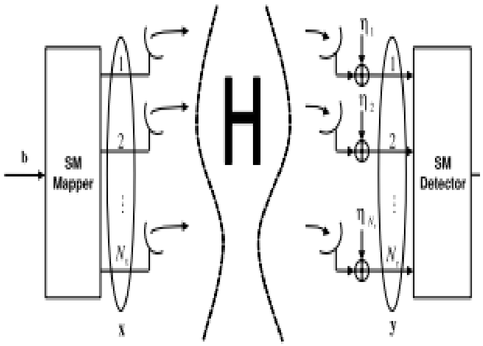


Fig 2.4 Spatial modulation transmission

During transmission in SM only one antenna remains active hence only one of the x, in x is nonzero. After this
Signal will transmit over a wireless channel which H and also introduce an N_r –dim additive white Gaussian (AWGN) noise which is given as [4],

$$[\eta_1\eta_2\ldots\ldots\ldots\eta N_r]^T \qquad (1)$$

Here received signal will be given as,

$$y=\sqrt{\rho}\ Hx\ +n \qquad (2)$$

$\rho\rightarrow$ average signal to noise ratio (SNR) at each receive antenna.

In SM Detection there is some rule based on MRC which is given by [4],

$$\hat{j}=\arg\max zj \qquad \text{, as a estimated antenna (3)}$$

$$\hat{q}=D(zj) \qquad \text{, as a symbol index (4)}$$

$D\rightarrow$ Constellation demodulator function

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

As we are using here one to one mapping hence demapper will obtain an estimate of the transmitted bit by taking j and q as inputs [4].

III. SPACE SHIFT KEYING (SSK)

In any communication system main priority is to transmit information from one place to another with less possible error and complexity. We know MIMO stands for multiple inputs multiple outputs in which multiple antennas are used on both at the transmitter side and at the receiver side. MIMO technology is responsible for improving the spectral efficiency without increasing the bandwidth and transmits power. Also combat the effects of multiple fading by using different diversity schemes such as space diversity [3]. In MIMO the basic idea is that the signal on the transmit antenna and receive antenna are connected in such a way that can improve quality or data rate for each user. New scheme for MIMO system is introduced in order to reduce the signal processing complexity at the receiver side which is known as Space shift keying (SSK).In SSK only one RF chain is required. Also only corresponding transmits antenna is made active which is transmitting [3].

Advantages of SSK over conventional MIMO are: Reduced hardware cost, Less RF chain required, less detection complexity, Simple transceiver requirements. SSK is basically a special case of spatial modulation concepts. In this for better performance by channel fading is exploited for MIMO over conventional amplitude/phase modulation (APM) techniques. Spatial modulation MIIMO system to convey the information uses transmit antenna index and symbol modulation. Where to reduce signal processing complexity at receiver side a new scheme for MIMO system is introduced known as SSK. In SSK, only one transmits antenna is active at any time instant [3]. Due to which there is no need for inter antenna synchronization and number of radio frequency (RF) chain is reduced which is its one of the good advantage. Also SSK is made robust to nonideal channel conditions as compared with spatial multiplexing.SSK modulation exploits only the spatial constellation diagram for data modulation, which results in very low complexity modulation concept for MIMO system. In SSK modulation, blocks of information bits are mapped into the index of single antenna, which is switched on for data transmission where the other antennas radiate no power. Also the message sent by transmitter can be decoded at the receiver side [3].

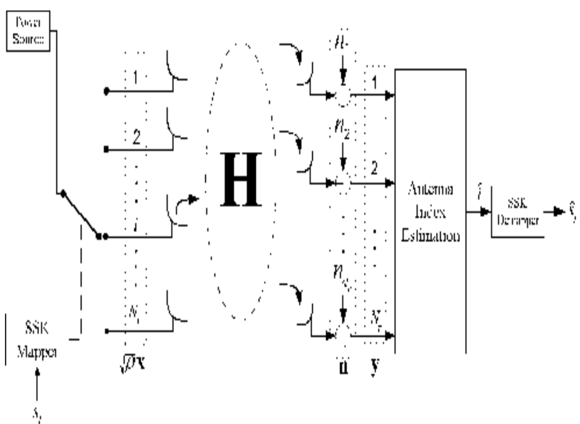


Fig 3.1 Block diagram of SSK

As from above figure, consider a MIMO system with N (t) transmit antenna and N(r) received antenna. In this each transmit antenna is assigned to one data symbol in the constellation. We can also say that at each interval only one transmits antenna is active and power transmitter from other antenna will be zero. Here received signal vector can be expressed as [3],

$$y = \sqrt{\rho}\ Hx + n \qquad (5)$$

Where,

$H \rightarrow N(r)N(t)$ Channel matrix

$\rho \rightarrow$ SNR

$n \rightarrow$ White Gaussian Noise vector

As in SSK at each transmit interval only one antenna remain active for transmission for every symbol which is transmitted. So transmit vector represents as [3],

$$x = (0\ 0\ \ldots\ldots 0\ 1\ldots.0\ 0)^{T.} \qquad (6)$$

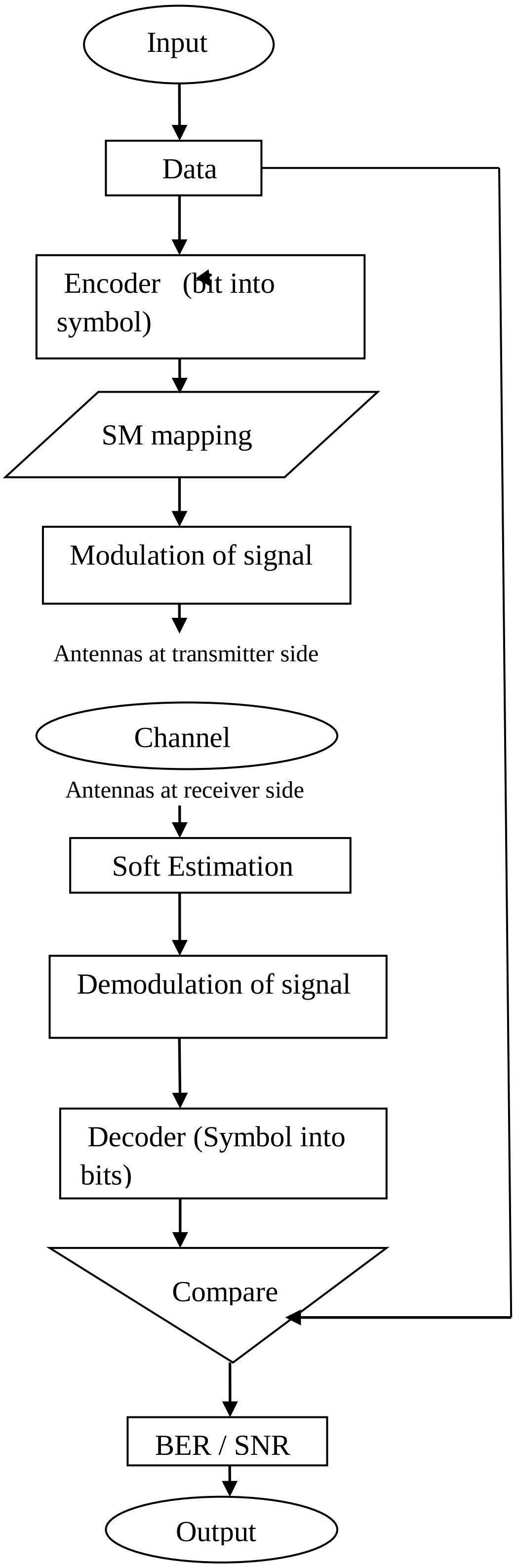
This shows one out of N_t component is 1.Here detector is to determine the index of the active antenna at transmitter side .In detector the antenna index can be determined by deciding which column of channel matrix is received.

IV. PERFOMANCE ANALYSIS

Flowchart

Here we are analysis the performance of spatial modulation in wireless channel. We know spatial modulation(SM) provides high data rate using less RF chains and without increasing the bandwidth of the system [1]. SM is also responsible for low complexity to the system even using number of antenna. According to the flow chart we describe the working and algorithm used in this paper [8]. From flowchart we can see data is entering to the encoder in which number of bits is stimulated and converts into symbol. Then SM mapping is done after which signal get modulated at transmitter side and pass the signal through a channel using number of antennas at the receiver side. Channel used here is Rayleigh fading channel. Soft estimation is done here means calculation part, after which pass the signal for demodulation. Then again symbols are converted into bits using decoder. At last but not least we plot a graph by comparing the range for bit-error-rate (BER) versus signal to noise ratio (SNR) for different type of QAM by using Matlab programming [8].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018



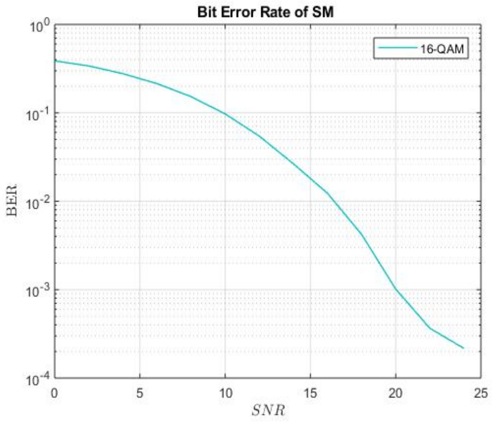
Working

According to a given flowchart here data is first sending in form of bits which get converted into symbol. We know about different Digital modulation techniques one of them is QAM, which stands for Quadrature amplitude modulation.QAM is a form of modulation technique used for modulating data signal onto a carrier signal for radio communication [6]. Mostly QAM is used because it has advantages over other modulation techniques such as PSK .In QAM phase of two carriers is shifted by 90 degree which are modulated and output we get as a result is consist of amplitude and phase variation both. Here we are using basic QAM operation signal some mathematical formula. In this both amplitude and phase get change as per theory, also we can say that two signals are generated which are 90 degree out of phase with each other and after which we sum them [7] .This will generate a sum of both waves, which provide resultant amplitude and a phase. There are two RF signal which is given as, I in phase and Q Quadrature signal [6].

We use QAM widely in digital data communication and for its applications. There is variety form of QAM; some of them which we are using here 16 QAM, 64 QAM and 256 QAM [7].In this we are using M-QAM where in first case we are taking M=16 which is a modulation order of M-QAM scheme. Number of transmitters taken as $N_t = 4$ and number of receivers taken as $N_r= 4$.Number of spatial modulation symbols will be calculated as 6 bits .And number of bits stimulated will be calculated as 60000 [8].We can understand it by taking an example like assume data will be taken as 010101, then using SM it will divide that data into two blocks; 0101 as for antenna and 01 for symbols. As we know number of modulation order will be calculated as 2^4 which mean 16 QAM .And antennas can be assumed as 00, 01, 10, and 11.Through SM mapping one antenna will remain active and other will kept silent. Data get modulated and pass through wireless channel to the receiver part .Where soft estimation is used and data get demodulated. Symbol converts into bits using decoder. In telecommunication transmission, the bit error rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power. For example, a transmission might have a BER of 10 to the minus 6, meaning that, out of 1,000,000 bits transmitted, one bit was in error. The BER is an indication of how often a packet or other data unit has to be retransmitted because of an error. Too high a BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be resent. Where signal-to-noise ratio (SNR) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. SNR is defined as the ratio of signal power to the noise power, often expressed in decibels At last we compare the performance of BER and SNR.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

V. SIMULATION OF SM



5.1 BER versus SNR for the case of a 16QAM using SM

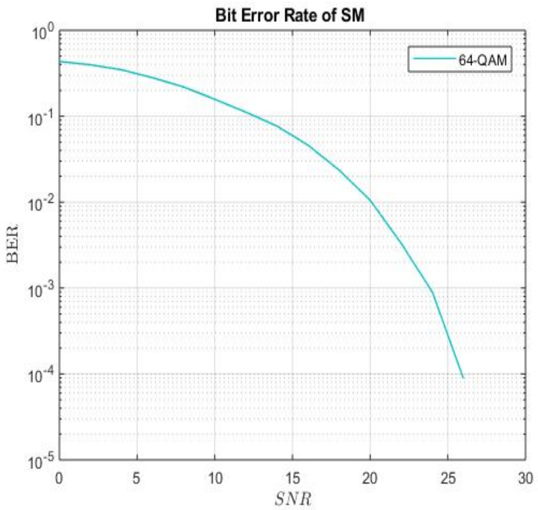


Fig 5.2 BER versus SNR for the case of a 64QAM using SM

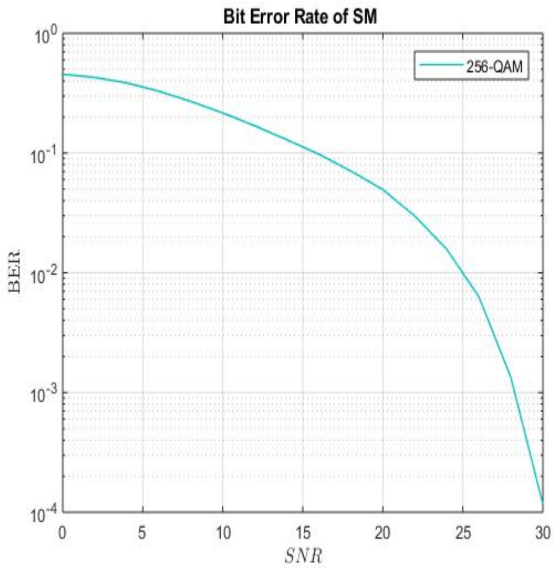


Fig 5.3 BER versus SNR for the case of a 256QAM using SM

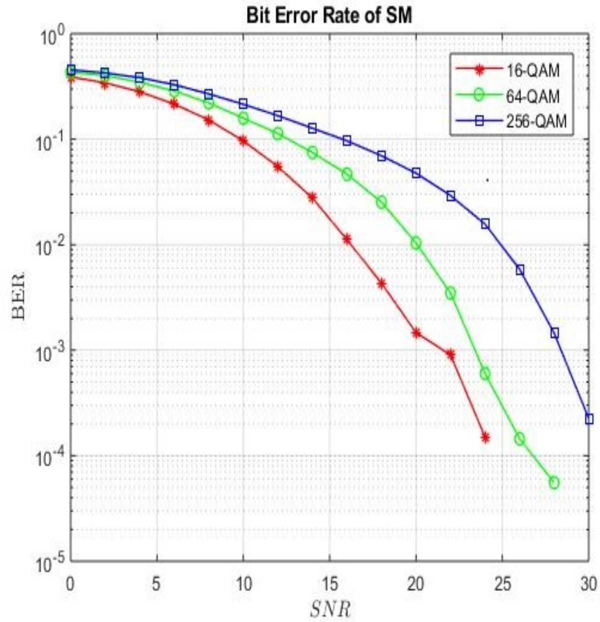


Fig 5.4 BER versus SNR for the case of a 16QAM, 64QAM, 256 QAM using SM

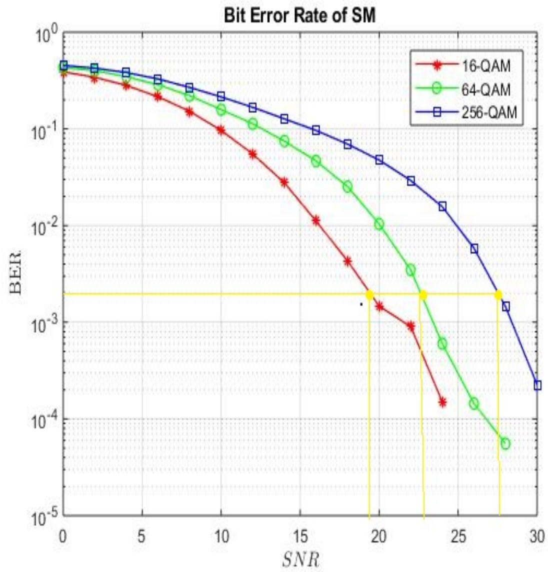


Fig 5.5Comparing average BER versus SNR and can see result at same value of BER = approx 10^3 but different range of SNR providing high data rate for 16 QAM, 64QAM, 256QAM.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

VI. RESULT

We are representing the range of BER versus SNR with increasing high data rate using spatial modulation scheme. At last provide the best result by comparing BER versus SNR for three type of QAM with high data rate using spatial modulation scheme. Here we analysis the performance of spatial modulation and comparing average BER versus SNR and at same value of BER = approx 10^3 but different range of SNR providing high data rate for 16 QAM, 64QAM, 256QAM.From fig 5.5 we can say 256QAM is best result because with increasing the range of SNR ,data rate is also increasing.

VII. CONCLUSION

Spatial modulation(SM) is a technique which gives high data rates by combining digital modulation and multiple antennas.SM is also responsible for low complexity in designing of MIMO wireless system, due to this we need single RF chain rather than multiple RF chain. Through this we conclude that SM offers better error performance than conventional schemes.

REFERENCES

[1] Marco Di Renzo, Harald Haas, Ali Ghrayeb, Shinya Sugiuraand and Lajos Hanzo, "Spatial Modulation for Generalized MIMO: Challenges, Opportunities, and Implementation" IEEE Commun. Mag. Vol. 102, No. 1, pp 56-82 January 2014.

[2] Istanbul technical university "performance improvement of spatial modulation in multipath fading channel"[online]https://www.slideshare.net/arvinmoeini/spatial-modulation.

[3] Mehdi Maleki,Hamid Reza Bahrami,Sajjad Beygi,Mohammadmehdi Kafashan, and Nghi H. Tran."Space Modulation With CSI: Constellation Design and Performance Evaluation",IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 62, NO. 4, MAY 2013

[4] J. Jeganathan, A. Ghrayeb , and ,L. Szczecinski, ‘‘Spatial modulation: Optimal detection and performance analysis,’’ IEEE Commun. Lett., vol. 12, no. 8, pp. 545–547, Aug. 2008.

[5] Marco Di Renzo, Harald Haas "Space Shift Keying (SSK) Modulation: On the Transmit Diversity / Multiplexing Trade-Off." ICC 2011, Jun 2011, Kyoto, Japan. pp.1-6, 2011

[6] N. Vlajic,"Analog Transmission Digital Data: ASK, FSK, PSK, QAM",CSE 3213, Fall 2010(https://web.stanford.edu/class/ee102b/contents/DigitalModulation.pdf)

[7] Radio-Electronics.Com launched in September 2004(https://www.radioelectronics.com/recinformation/about-us.php)

[8] Rajab Legnain in Carleton University "computes the BER of the SM for the case where the channel coefficients are modeled as uncorrelated Rayleigh fading channel" in 2011.