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Spatial Modulation- A High Spectral Efficient Technique

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Abstract*— Spatial modulation scheme introduced in present times has proved advantageous in context of wireless MIMO communication systems. Furthermore, it also increased spectral efficiency and throughput. In this paper we have presented the simulation results of a SISO wireless communication $(N_t = 2, N_a = 1, N_r = 1)$ with quadrature phase shift keying (QPSK). The performance is shown in the graphical form of BER (bit error rate) vs SNR (signal to noise ratio).

Keywords *— Spatial Modulation, QPSK (Quadrature Phase Shift Keying), Single Input Single Output.*

I. INTRODUCTION

To achieve high data rate in wireless communication domain, many modulation schemes and adaptive coding techniques are proposed like STCs, spatial modulation, PSKs and etc[1]-[9]. In the present antenna diversity's MIMO, spatial Modulation is widely used approach in which antenna indexing is used. Power consumption in wireless networks has been a major issue. But, spatial modulation technique has low power consumption compared to other schemes. At the receiver side there is only one unit, reducing the complexity at receiver side [2], [5]. Hence, due to the high energy efficiency and low detection complexity, spatial modulation is regarded as a candidate technique for future wireless communication systems, especially for large-scale MIMO [6], [8].

Increasing the order of modulation increases the bits to be transmitted. In QPSK system, at a time 2 bits are modulated on the basis of its constellation diagram.

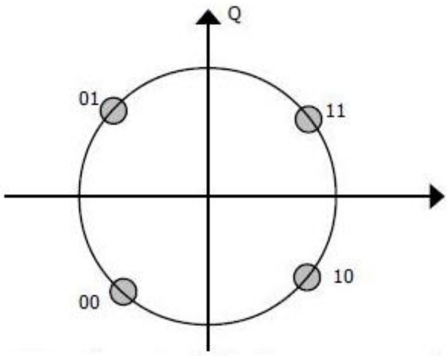

Fig.1 Constellation diagram of QPSK

Each adjacent symbol only differs by one bit, sometimes known as quaternary or quadrature PSK or 4-PSK, or 4-QAM [7].QPSK uses four points on the constellation diagram, equi-spaced around a circle. With four phases, QPSK can encode two bits per symbol shown in the diagram to minimize the BER- twice the rate of BPSK. Analysis shows that this may be used either to double the data rate compared to a BPSK system while maintaining the bandwidth of the signal or to maintain the data rate of BPSK but half the bandwidth needed [10][11].

At the receiver, the detection algorithm needs to find out the modulated symbol and index of selected antenna by a joint exhaustive search for recovering the information data. The most obvious and efficient way to reduce complexity is to restrict maximum-likelihood (ML) search space [10].

In Further sections, the system model, simulation results and finally the paper is concluded in last section.

II. SYSTEM MODEL

SM is also a spatial multiplexing MIMO technology. It has N_t transmitted antennas and N_r receives antennas, and the modulation order is M. At present, two transmit antennas and one receive antenna are used. The order of modulation is four.

In the process of transmission, from the bit stream, at a time 3 bits are selected. First bit is used for antenna indexing and rest of the 2 bits are modulated by mapping process. At a time only one antenna is active and respective indexed bit is transmitted during one time slot.

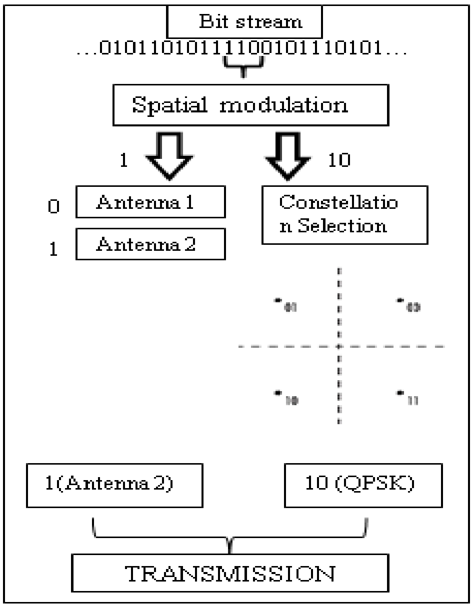

Fig.2 Transmit antenna and QPSK in Spatial Modulation [11].

TABLE I
SM MAPPING TABLE

Transmitted bits	Antenna Index	Modulated Signal
000	0	+1
001	0	+1j
010	0	-1
011	0	-1j
100	1	+1
101	1	+1j
110	1	-1
111	1	-1j

The system model can be formulated as

$$\mathbf{y} = \mathbf{H}_\mathbf{i} s + \mathbf{n} \qquad (1)$$

Where $\mathbf{H}_\mathbf{i}$ denotes the complex channel gain between the active transmit antenna and the receive antenna, $\mathbf{n}$ denotes Additive White Gaussian Noise (AWGN) with zero-mean and variance σ^2, s is the selected symbol from the constellation set $\mathbf{X}$. $1 \leq i \leq N_t$, $s \in \mathbf{X}$

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III. DETECTION

After the bit transmission, the transmitted bits should be correctly detected. For the detection of antenna index bit, the formula used is [11],

$$i = \operatorname{argmax}\left|yH_i^*\right| \quad \text{, where } i \in [1 - N_t] \qquad (2)$$

i indicates the antenna number on which data with maximum strength is received.

The transmitted symbol will be estimated as follows [11]:

$$s = \operatorname{argmin}\left\|y - s_i H_i\right\|^2 \text{ , where } i \in \mathbf{x} \qquad (3)$$

s gives the detected symbol and $\mathbf{x}$ is the constellation matrix, the final symbol received is detected.

For QPSK in spatial modulation system, the antenna indexing on the receiver side, corresponding to the antenna indexing on the transmitter side is shown in table II, where X1 is the antenna bit index.

TABLE II - ANTENNA BIT INDEX DETECTION

ANTENNA	X1
1	[0]
2	[1]

The antenna index and symbol are concatenated to form the entire data that is received. The error can be found by generating an error matrix by subtracting the transmitted signal matrix from the received signal matrix. If one or more than one elements of the error matrix are not equal to 0, then an error is said to have been received at the receiver.

IV. SIMULATION RESULTS

In the given simulation result, the performance of the spatial modulation with 1 X 1 system out of two transmit antennas and one receiver is shown. The graph of BER vs SNR is given below.

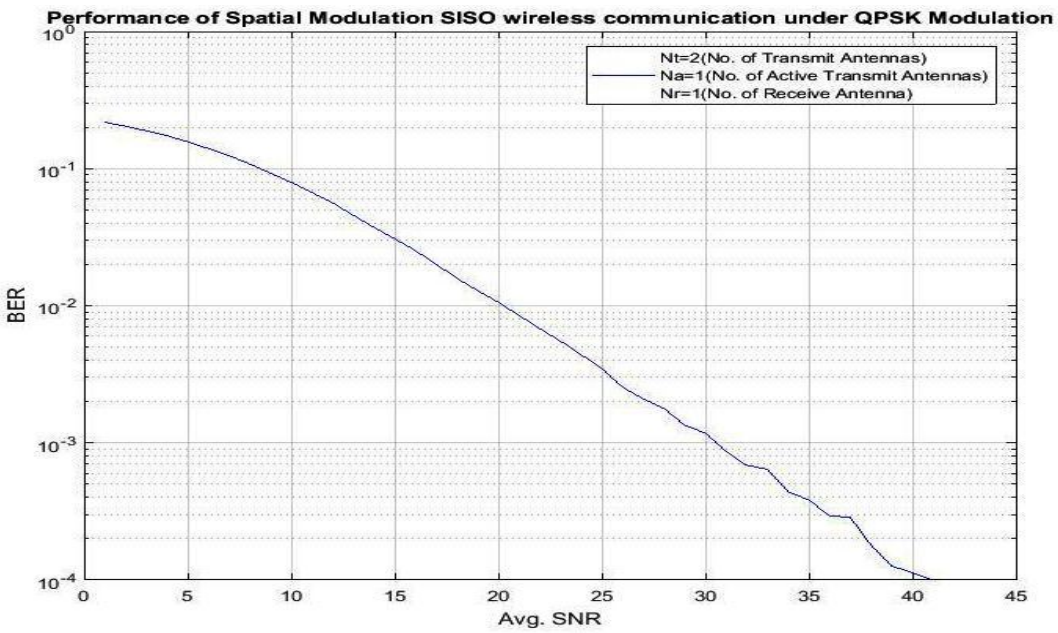

Fig.3 BER Vs. Avg SNR for Spatial Modulation with Single Transmit and Single Receive antenna under QPSK Modulation

From above fig. 3, BER performance of audio and video communication are 10^{-2} and 10^{-3}. There is minimum 20dB SNR required to achieve the audio communication and minimum 30 dB SNR required achieving the video communication.

V. CONCLUSION

From the above study, we conclude that using antenna diversity and spatial modulation technique and increasing the order of modulation, bit error rate (BER) can be reduced with decrease in SNR level. Due to decrease in SNR level power consumption is also less.

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