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BER ANALYSIS OF SM-MIMO AND CHANNEL ESTIMATED SM-MIMO

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ABSTRACT

This paper presents a comparison of BER of conventional spatial modulated(SM) multiple input multiple output (MIMO) and channel estimated SM-MIMO. The conventional SM-MIMO multicast system was analyzed on correlated and non-correlated channels. After evaluating the results, we investigate the same for SM-MIMO with channel estimation. Finally simulations are exploited for the evaluation of BER of conventional SM-MIMO and channel estimated SM-MIMO multicast systems and validate the analyses.

KEYWORDS: Spatial modulation, multiple input multiple output, correlated, uncorrelated, channel estimation, multicast system.

INTRODUCTION

Spatial modulation(SM) in MIMO has gaining more attention now a days. Actually SM is a new modulation concept which utilizes spatial and signal constellations for conveying information bits. The distinguishing feature of SM is that at any time instant only one antenna get active, so the power consumption has reduced to a great extent compared to the MIMO system in which all the antennas are active for all the time instances. In SM, a block of any number of information bits is mapped into a constellation point in the signal domain and a constellation point in the spatial domain. At each time instant, only one transmit antenna of the set will be active. The other antennas will transmit zero power. Therefore, ICI at the receiver and the need to synchronize the transmit antennas are completely avoided. At the receiver, maximum likelihood (ML) decoding is used to estimate the transmit antenna number and the symbol. These two estimates are used by the spatial demodulator to retrieve the block of information bits. Thus SM acts as a promising candidate for the emerging MIMO systems.

SPATIAL MODULATION

At the transmitter of SM what is happening is that, the incoming bits of information are divided into blocks of $\log N_t$ + $\log M$ blocks where N_t is the no of transmitting antennas and M is the size of the complex signal constellation diagram. Then an SM mapper splits each of them into sub blocks of $\log N_t$ and $\log_2 M$ bits each. The first block represents the antenna from which the transmission has occurred and the second sub block indicate the data.

An example for N_t=4 and M=2 is shown below:

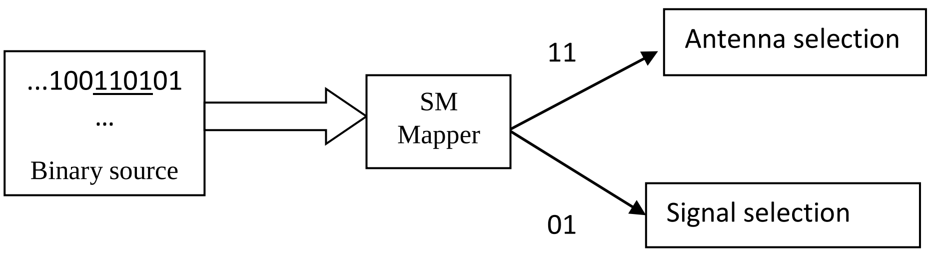

Figure 1: working of SM

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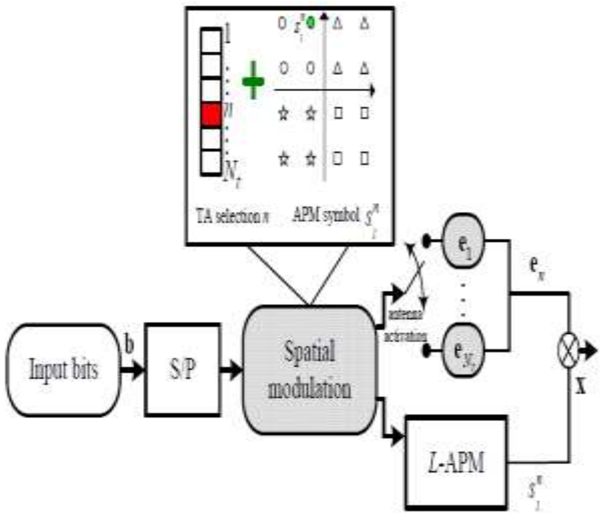

Figure 2: SM bit to symbol mapping rule [10].

At the receiver by using maximum likelihood detector the antenna index and symbol are retrieved.

SM-MIMO SYSTEM

The system model that used in our work is shown below. The system consists of one transmitter and K receivers. The transmitter is employed with N_t number of transmitting antennas and each receiver consists of N_r number of receiving antennas. The SM mapper in the transmitter maps the incoming data symbols to the SM type symbols. Then this signal is transmitted to all the receivers. The signal model can be given as[1]

$$y_k = \sqrt{\rho} H x_i + n_k \qquad \text{………… (1)}$$

Where H is the channel matrix of order $N_r \times Nt$, x_i is the complex transmitted SM type signal, ρ is the average signal to noise ratio (SNR), y_k is the complex received signal. BER of the system is defined by

$$E\{p_s\} = E\{\max P_e(k)\} \text{ [1]}$$

Where p_s= max $p_e(k)$ and $p_e(k)$ is given by [1]

$$P_e(k) \le \sum_{i=1}^{i=Nc} \sum_{j=1, i\ne j}^{Nc} \frac{N(i,j) Q(\sqrt{\frac{\rho}{2}} \| H(k)x_i - H(k)x_j \| 2)}{N_c \log N_c}. \qquad \text{……….. (2)}$$

Where $p_e(k)$ is the error probability, where Q(.) is the Q-function, N_c is the total number of constellation points and N(i,j) is the number of bits in error when x_i is erroneously detected as x_j .

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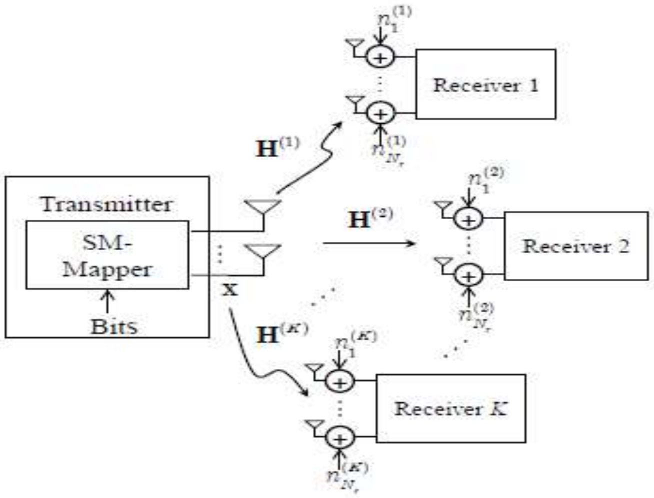

Figure 3: system model

BER ANALYSIS OF SM-MIMO

i. SM-MIMO systems in uncorrelated Rayleigh fading channel

In the uncorrelated case the channel is given by $H^{(k)}=H^{k}{}_{w}$, where $H^{k}{}_{w}$ is the standard uncorrelated channel matrix. By defining an upper bound for the union bound given by (2) and taking expectation, BER of system can be obtained [1]. Then it is given by [1]

$$P_e(k) \leq \sum_{i=1}^{i=Nc} \sum_{j=1, i\neq j}^{Nc} \frac{N(i,j)E\{\max .Q(\sqrt{\frac{\rho}{2}}\|H(k)x_i - H(k)x_j\|2)\}}{N_c \log N_c}. \quad \ldots\ldots\ldots (3)$$

$$E(p_s) \leq \sum_{i=1}^{i=Nc} \sum_{j=1, i\neq j}^{Nc} \frac{N(i,j)}{N_c \log N_c} \cdot \sum_{n=0}^{K-1} \frac{\binom{K-1}{n} \cdot \Gamma(n+2)}{K \wedge n+1} \cdot \frac{1}{2}\left[1-\mu_{k,i,j} \sum_{l=0}^{n+1} \binom{2l}{l} \left(\frac{(1-\mu \wedge 2_{k,i,j})}{4}\right)^{\wedge l}\right] \quad \ldots\ldots\ldots (4)$$

ii. SM-MIMO systems in correlated Rayleigh fading channel

In this case channel model is given by $H(k) = R_r^{1/2}\ H^{(k)}w\ R_t^{1/2}$ R_r and R_t are the receive and transmit correlation matrices respectively. Correlation coefficient used in the work is 0.7. The BER in this case is analyzed in three cases [1] i) Transmit correlation only i.e $R_r= I_{Nr}$ ii) Receive correlation only i.e $R_t= I_{Nt}$ iii) Double sided correlation

iii. Channel estimated SM-MIMO

Channel estimation is indispensible for MIMO communication. It is done for knowing the channel properties of a communication channel. It describes how a signal propagates from the transmitter to the receiver. The CSI makes it possible to adapt transmissions to current channel conditions, which is crucial for achieving reliable communication. In the work pilot based estimation method is used for estimating the channel. All other operations for analyzing BER are same as that explained above.

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RESULTS AND DISCUSSION

In this section we use simulations to validate the analysis. In the simulations, we adopt the Rayleigh fading channel model and the uncorrelated channels can be directly obtained by assuming the transmit and receive correlation matrices are identity matrices. We adopt the exponential correlation model for the correlation matrices. For example, considering the receive correlation matrix Rr with correlation coefficient α, the element $(Rr)_{ab}$ in the ath row and bth column of Rr is given by[1]

$$(Rr)_{ab} = \begin{cases} \alpha^{a-b}; & \text{if } a > b \\ \alpha^{b-a}; & \text{if } a < b \end{cases}$$

In fig. 4 ordinary SM-MIMO and channel estimated SM-MIMO are compared. From the figure it is clear that SM-MIMO with channel estimation has much more better performance. Fig.5 shows the comparison of different correlations without channel estimation.

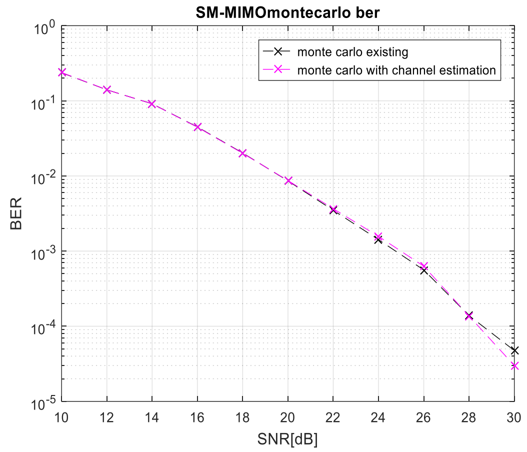

Figure 4: BER comparison of ordinary SM-MIMO and channel estimated SM-MIMO

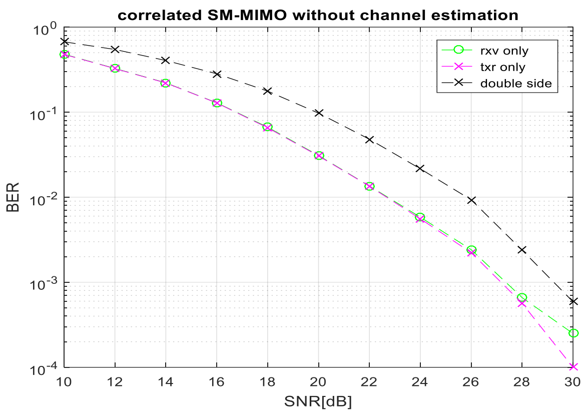

Figure 5: correlated SM-MIMO without channel estimation

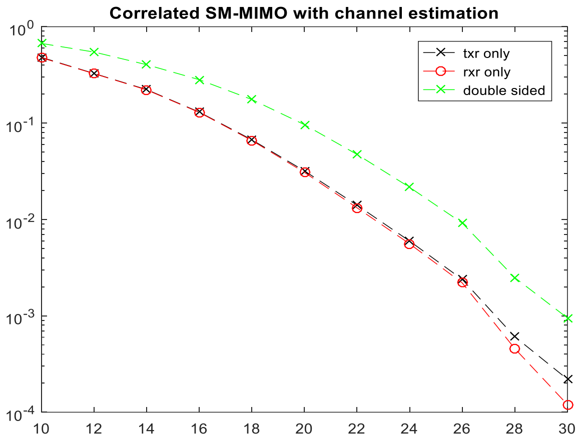

Figure 6: correlated system with channel estimation

Fig 6 indicates the performance of correlated system with channel estimation. It’s evident from the figures that BER is between 10^{-3} and 10^{-4} .

CONCLUSION

In this work we investigated the BER performance of the multicast SM-type MIMO and channel estimated SM-MIMO systems in Rayleigh fading channels. Both of the systems are evaluated in correlated and uncorrelated channels. After analyzing the system without channel estimation, system with channel estimation was investigated and it was clear from the result that system employed with channel estimation has better performance than the existing system.

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