Performance measurement of MIMO communication system under variation beam forming condition using water filling technique

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Abstract— The World always wants to use a better wireless network that's why it always needs to be improved. Due to limited range, capacity and data rates of these wireless devices a MIMO (multiple-input multiple-output) system is introduced to overcome these limitations. Multiple-Input Multiple-Output (MIMO) systems have been emerged as a technical breakthrough for high-data-rate wireless transmission. In this paper we analyse the various combinations of different modulation techniques with different beam forming methods. Here we have analysed eight different combinations of modulation techniques and beam forming techniques. In the different modulation techniques we are using BPSK, QPSK, 4 QAM, 16- QAM, FSK and MSK. Similarly the different beam forming techniques are SIMO, MISO, max Eigen mode transmission with water filling power distribution.

Keywords- BPSK, AWGN, SISO, SIMO, MISO, MIMO

1. INTRODUCTION

Wireless System has an endless quest for higher capacity and improved quality as it provides people and machines to communicate with each other irrespective of their location. Fourth generation wireless communication has a very famous slogan "always best connected" which means that the wireless devices should connect to the network at that moment that is best for the user. MIMO is a novel approach for the next generation wireless systems as it provides distinctive solutions for high performance network. Multiple-Input-Multiple-Output also known as MIMO is a very powerful technique for wireless system. MIMO structure consist of multiple antennas at both transmitter and receiver end for improving the communication performance. It provides higher capacity, throughput with improved quality of service without increasing the transmitted power of antennas [1].

We have three types of systems:.

(a)**SISO/SIMO**:

$y(k) = \mathbf{h}(k)x(k) + \mathbf{n}(k)$.

SISO and SIMO are treated together because the SIMO channel can be made equivalent to a SISO channel when the CSI is known at the receiver by performing spatial matched filtering which is information is lossless.

a) **MISO**: $y(k) = \mathbf{h}(k)T\,\mathbf{x}(k) + n(k)$.

b) **MIMO**: $\mathbf{y}(k) = \boldsymbol{H}(k)\mathbf{x}(k) + \mathbf{n}(k)$.

Transmit beamforming (MISO):

A transmit beamforming technique is used matching the channel from the multiple transmit antennas to the receiver.

Receive beamforming (SIMO):

A receive beamforming technique is used matching the channel from the transmit antenna to the multiple receive antennas.

Max eigenmode beamforming (MIMO):Both transmitter and receiver form a beam matched to the underlying structure of the channel (given by the SVD of the channel matrix). Transmit and receive beams are jointly designed and match each other. They form a channel equal to the maximum singular value of the channel.

Eigenmode transmission (MIMO):

For a MIMO system, both transmitter and receiver form multiple beams matched to the underlying structure of the channel (giving by the SVD of the channel matrix). Each transmit beam is matched to a receive beam. Multiple equivalent independent channels are created equal to the singular eigen values of the channel. The power has to be split optimally among the channels. Eigen mode transmission requires a rich scattering environment. The inverse of the Lagrange multiplier can be regarded as a water level. Generally, can be found by the binary method.

Traditional Water-filling Method

Consider an OFDM communication system

$$[m] = h_n x_n[m] + w[m], n = 0,1,..N-1 \quad (1)$$

Where $x_n[m]$, $y_n[m]$, are the output and noise signal in each sub channel, respectively h_n is the channel gain for each sub channel with the total power constraint $P_{total.}$ Assuming the transmit power in each sub channel is $P_{n,}$ the maximum rate of reliable communication Using the OFDM channel is

$$C = \sum_{n=0}^{N-1} \log\left(1+\frac{p_n|h_n{}^2|}{N_0}\right) \; bit/symbol \qquad (2)$$

Where N_o is the power density of the noise. Therefore the power allocation can be chosen so as to maximum the rate in (2) the solution to the optimization problem:

$$C_N := \max_{p_0 \dots\dots\dots p_{N-1}} \sum_{n=0}^{N-1} \log\left(1+\frac{p_n|h_n{}^2|}{N_0}\right) \qquad (3)$$

Subject to

$$\sum_{K=0}^{N-1} P_n = P_{total} \, P_n \geq 0 \quad n = 0 \dots\dots\dots..N-1 \qquad (4)$$

The object function (3) is cover in the power and this optimization problem can be solved by the Lagrange method. Consider the expression

$$\mathcal{L}(\lambda, P_{0\dots}P_{N-1}) := \sum_{n=0}^{N-1} \log\left(1+\frac{p_n|h_n{}^2|}{N_0}\right) - \lambda \sum_{n=0}^{N-1} P_n$$
(5)

Where λ is the Lagrange multiplier. The Kuhn-Tucker condition for the optimal solution is

$$\frac{\partial\mathcal{L}}{\partial p_n} = 0 \; if \; p_n > 0, \quad \frac{\partial\mathcal{L}}{\partial p_n} \leq 0 \; if \; p_n = 0 \qquad (6)$$

Define x^*:=max(x,0).the power allocation can be expressed as

$$p_n^* = \left(\frac{1}{\lambda} - \frac{N^0}{h_n{}^2}\right)^+ \text{---(7)}$$

Which is the optimal solution if the Lagrange multiplier λ satisfies the condition.

$$\sum_{n=0}^{N-1} \quad = \left(\frac{1}{\lambda} - \frac{N^0}{h_n{}^2}\right)^+ = P_{total} \quad (8)$$

The inverse of the Lagrange multiplier can be regarded as a water level. Generally, can be found by the binary method.

Formulation and Simulation

In this paper we analyze the various combinations of different modulation techniques with different beam forming methods. Here we have analyzed eight different combinations of modulation techniques and beamforming techniques. In the different modulation techniques we are using BPSK, QPSK, 16-QAM and 16- PSK. Similarly the different beam forming techniques are SIMO, MISO, max Eigen mode transmission with water filling power distribution. In the first four combination of simulation taking number of antenna M=4 and in the next four combination of simulation taking number of antenna M=6.

CASE-1

In the case-1 an uncoded QPSK constellation is used for transmission in each stream of eigenmode transmission with waterfilling. The corresponding bit error rate (BER) is shown Fig. 1. The slope of the uncoded BER curves indicates the diversity gain achieved by each stream. In this example, for the sake of simplicity, we assume an uncoded system, but it is of course highly desirable to have an efficient coding to achieve a low error probability. In our example, the AMC level is selected to maximise the transmission rate under a BER constraint. The BER constraint specifies that the BER should be below10^{-3}. The number of antenna taking M=4

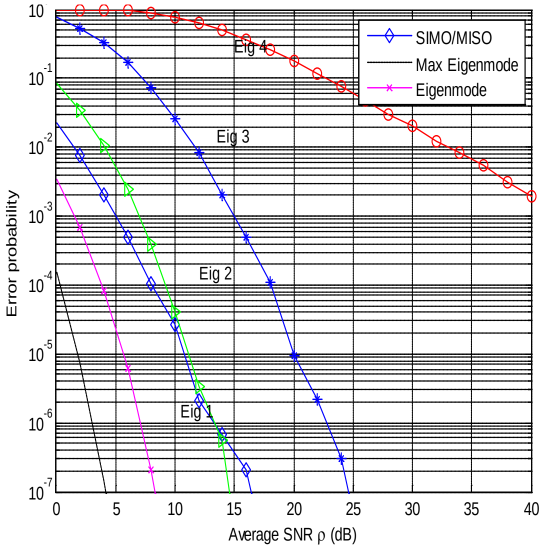

Fig 1 Error probability for QPSK transmission.

In Fig.1 the BER curves with respect to the SNR is drawn for QPSK. In the region below 5 dB, the BER constraint cannot be satisfied, so the system does not transmit. In the region between 5 dB and 25dB, the higher constellation can be transmitted verifying the BER constraint is QPSK, and similarly for the other decision regions. After waterfilling, the post-processing SNR is computed for each stream and the appropriate AMC level is selected accordingly. The same is done for maximal eigenmode transmission and SIMO/MISO.

Case -2

In the case-2 an uncoded BPSK constellation is used for transmission in each stream of eigenmode transmission with waterfilling. The corresponding bit error rate (BER) is shown Fig. 2. The number of antenna taking M=4

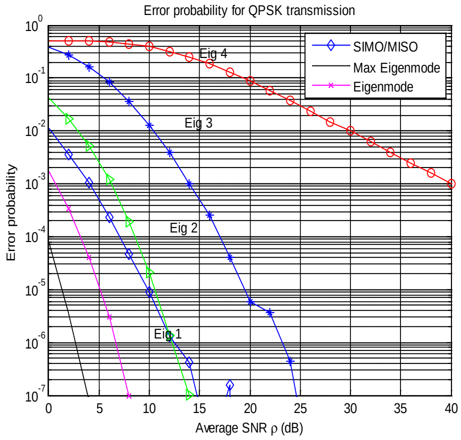

Fig 2 Error probability for BPSK transmission

As par the above figure we can conclude that at 10 dB average signals to noise ratio MISO system provides the lowest error rate i.e. approximately 10^{-6}. But if we increase the SNR upto 40 dB then only Eigen 4 mode will exist and provides the error rate approximately 10^{-3}.

Case-3

In the case -3 we are using 16 - QAM modulation technique with M=4, number of transmitter and receiver antenna.

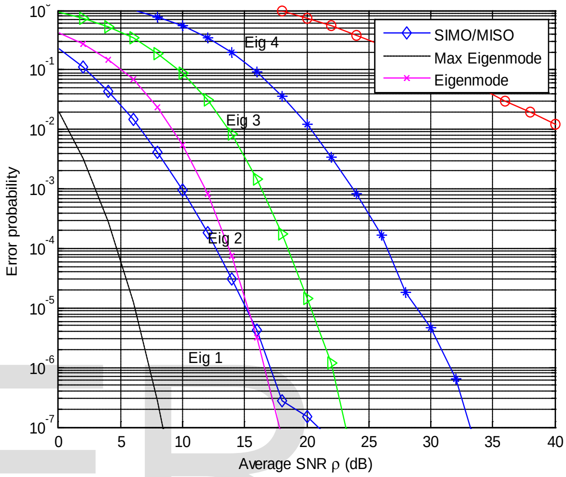

Fig 3 Error probability for 16-QAM transmissionAs par the above figure we can conclude that from 10 to 20 dB average signals to noise ratio MISO system provides the lowest error rate i.e. approximately 10^{-3} - 10^{-6}. But if we increase the SNR upto 40 dB then only Eigen 4 mode will exist and provides the error rate approximately 10^{-2}.Case-4

In the case -4 we are using 16 – PSK modulation technique with M=4, number of transmitter and receiver antenna.

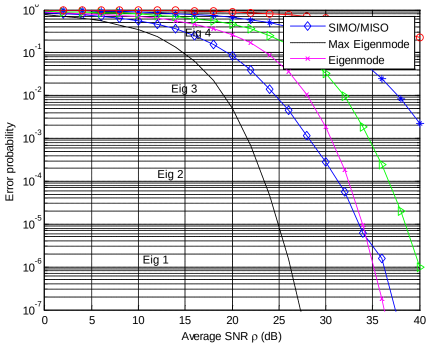

Fig 4 Error probability for 16-PSK transmission

As par the above figure we can conclude that at 25 dB average signals to noise ratio Maximum Eigen mode system provides the lowest error rate i.e. approximately 10^{-5}. But if we increase the SNR upto 40 dB then Eigen 2 mode will provides the lowest error rate approximately 10^{-6}.

Case -5

In the case -5 we are using 16-PSK modulation technique with M=6, number of transmitter and receiver antenna. The bit error curve is shown in Fig. 5

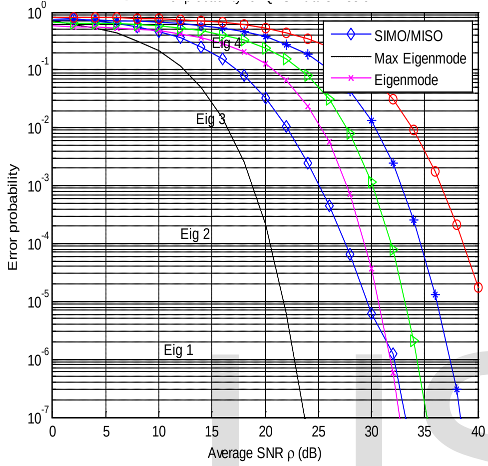

Fig 5 Error probability for 16-PSK transmission.

As par the above figure we can conclude that at 20 dB average signals to noise ratio SIMO system provides the lowest error rate i.e. approximately 10^{-1}. But if we increase the SNR up to 40 dB then only Eigen 4 mode will exist and provides the error rate approximately 10^{-4}.

Case -6

In the case -6 we are using 16-QAM modulation technique with M=6, number of transmitter and receiver antenna.

The bit error curve is shown in Fig. 6

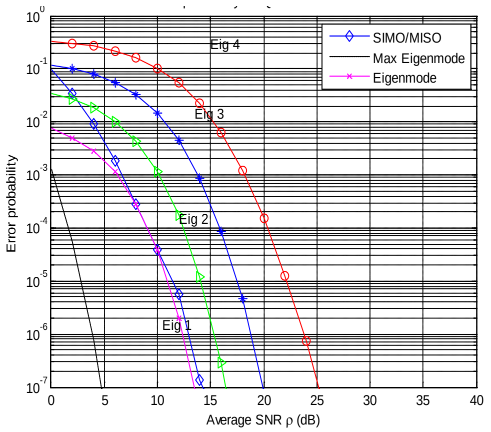

Fig 6 Error probability for 16-QAM, M=6, transmission.

As par the above figure we can conclude that at 10 dB average signals to noise ratio SIMO and Eigen – 1 mode system provides the lowest error rate i.e. approximately 10^{-4}. But if we increase the SNR upto 25 dB then only Eigen 4 mode will exist and provides the error rate approximately $10^{-7.}$ In this scheme we cannot increase the SNR above 25 dB.

Case-7

In the case -7 we are using QPSK modulation technique with M=6, number of transmitter and receiver antenna.

The bit error curve is shown in Fig. 7

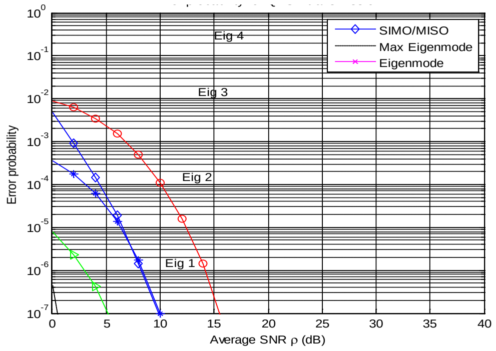

Fig 5.1 Error probability for QPSK, M=6 transmission.

As par the above figure we can conclude that from 10 to 20 dB average signals to noise ratio MISO system provides the lowest error rate i.e. approximately 10^{-3} - 10^{-6}. But if we increase the SNR upto 40 dB then only Eigen 4 mode will exist and provides the error rate approximately 10^{-2}.

Case-8
In the case -8 we are using BPSK modulation technique with M=6, number of transmitter and receiver antenna.

The bit error curve is shown in Fig. 8

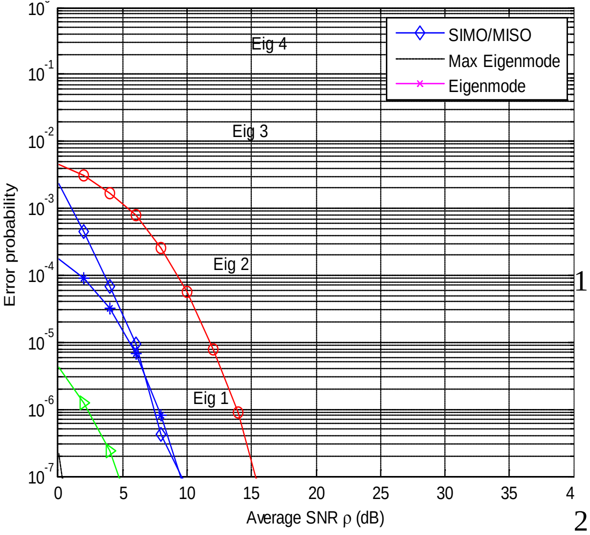

Fig 8 Error probability for BPSK transmission for M=6.

As par the above figure we can conclude that from 10 to 20 dB average signals to noise ratio MISO system provides the lowest error rate i.e. approximately 10^{-3} - 10^{-6}. But if we increase the SNR upto 40 dB then only Eigen 4 mode will exist and provides the error rate approximately 10^{-2}.

Conclusion

The following conclusions can be made by observations

- At 10 dB SNR and M=4, SIMO/MISO technique and BPSK modulation scheme is the best for transmission having 10^{-5} BER.
- At 20 dB SNR and M=4, Eigenmod-3 technique and QPSK / BPSK modulation schemes are the best choice for transmission having 10^{-5} BER.
- At 30 dB SNR and M=4, SIMO/MISO technique and 16-PSK modulation scheme is the best for transmission having 10^{-3} BER.
- At 10 dB SNR and M=6, SIMO/MISO technique and QPSK modulation scheme is the best for transmission having 10^{-7} BER.
- At 20 dB SNR and M=6, Eigenmod-3 technique and 16-QAM modulation scheme is the best for transmission having 10^{-7} BER.
- At 30 dB SNR and M=6, SIMO/MISO technique and 16-PSK modulation scheme is the best for transmission having 10^{-5} BER.
- When we increases the number of Tx & Rx antenna the bit error rate performance improved significantly.

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