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ANALYSIS FEATURES PARAMETERS OF POLARIZATION-ORTOGONAL ANTENNAE FOR MIMO SYSTEM

Introduction

In radio, multiple-input and multiple-output, or MIMO is the use of multiple antennae at both the transmitter and receiver to improve communication performance.

Main disadvantage of Wi-Fi system with MIMO technology is loss of energy due to polarization effects, and then parameter of receiver antenna isn't equal to parameter of signal. It is interesting to increase bit rate (BR) and decrease bit error rate (BER) in wireless communication by use the orthogonal polarization antennae. In this case the total loss of energy may decrease.

Essence

MIMO technology with orthogonal polarizing channels additional provides increase signal to noise ratio and therefore increase in bit rate in wireless [1].

In radio, multiple-input and multiple-output, or MIMO is the use of multiple antennae at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology (fig. 1).

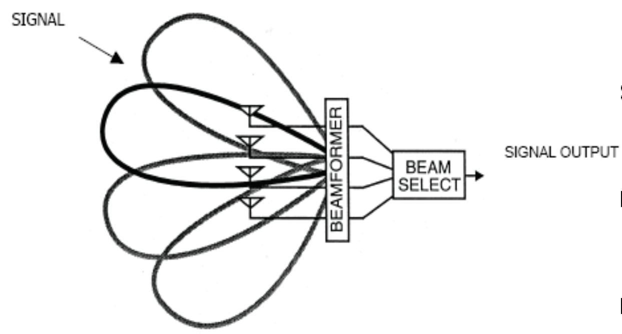

Fig. 1. Multiple antenna

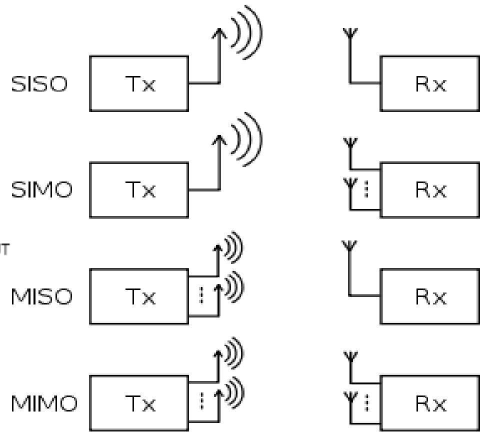

Fig. 2. MIMO smart antenna technology

MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties, MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wi-Fi), 4G, 3GPP Long Term Evolution, WiMAX.

The signal on the receiving party is recorded as follows:

$$X = H \cdot S + Z, \quad (1)$$

where S – matrix of transmitted signals;

Z – matrix of a self-noise of the receiving elements of the antenna;

X – matrix of the received signals;

H – transformer matrix of the signals.

Most the simple and widespread matrix H is the Allamouti matrix.

Real antennae in MIMO technology can be represent like two input (top) and one output (bottom) antennae in Fig. 3 and this antennae can use at orthogonal polarization for better signal to noise ratio (SNR).

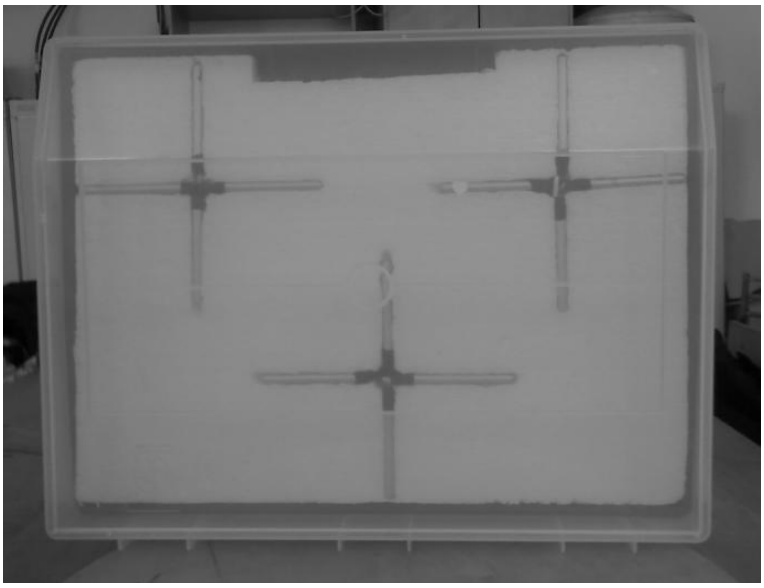

Fig. 3. Real experimental polarization antenna for MIMO

Its explain result of analysis differences of signal and noise polarizing parameters. Polarization is spatial − temporal characteristics of electromagnetic waves, it notes the spatial pattern of targeting vector voltage electric or magnetic field over the rotor vibration. For homogeneous plane wave vector voltage electric and magnetic fields lie in the plane perpendicular to the direction of wave motion. Depending on whether parameters change (angle of orientation − β and angle of ellipse α) with the influence of polarization diagrams at time or remain constant, electromagnetic waves are divided into three groups: 1- completely polarized (polarization factor m=1); 2 − partially polarized ($0<m<1$); 3 – neutral or chaotic (m=0). Consider the wave of elliptical polarization in the free linear basis and E_x E_y orthogonal projection of the electric field vector E in form

$$E_x(t) = E_0 \cdot \exp\{j(\omega \cdot t + \varphi_x)\}, \quad (2)$$

$$E_y(t) = E_0 \cdot \exp\{j(\omega \cdot t + \varphi_y)\}. \quad (3)$$

Represent wave in matrix form:

$$\vec{E}_w(t) = \left(E_x(t) \quad E_y(t)\right)' . \quad (4)$$

Polarization ellipse is defined by its shape (α), orientation axis (β) relative coordinate system selected and direction of rotation vector of the ellipse. The total form of wave is next

$$\vec{E}_w(t) = \begin{pmatrix} \cos(\beta) & \sin(\beta) \\ -\sin(\beta) & \cos(\beta) \end{pmatrix} \cdot \begin{pmatrix} \cos(\alpha) & -j\sin(\alpha) \\ -j\sin(\alpha) & \cos(\alpha) \end{pmatrix} \cdot \begin{pmatrix} E_0 \\ 0 \end{pmatrix} \cdot \exp\{j(\omega \cdot t + \varphi_0)\}. \quad (5)$$

Input signal for real experimental polarization antenna for MIMO (fig. 3) is represented by

$$\vec{E}_{in}(t) = \left(E_{1x}(t), \quad E_{1y}(t), \quad E_{2x}(t), \quad E_{2y}(t)\right)' . \quad (6)$$

Difference of polarization parameters between antennae and real signal described by loss of energy factor

$$P_{loss} = \cos^{-1}\left(\vec{E}_s, \quad \vec{E}_{in}\right). \quad (7)$$

Depends on Bit Rate (C) to SNR and polarization loss at real as shown in fig. 4 solved by formula

$$C = F \cdot \log_2(1 + SNR). \tag{8}$$

Results of comparison real experiment and computerized result

Results of comparison real experiment of Alamouti/MRC algorithms [2] with 2x2 multiplexing without orthogonal polarization antennae are in Fig. 4. We find, that BER is close to 0.01 at 10dB SNR for spatial multiplexing – QPSK and ML receiver (maximum likelihood).

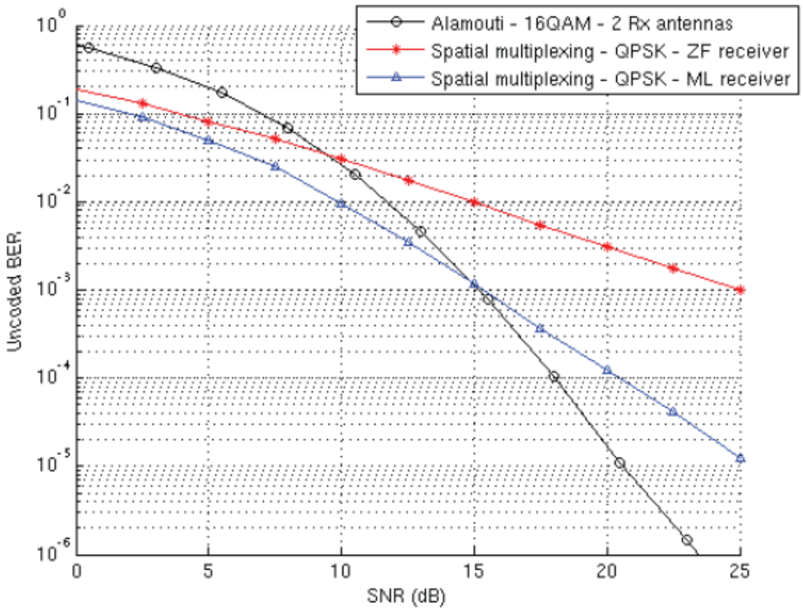

Fig. 4. Comparison of Alamouti/MRC with 2x2 multiplexing

Computerized results with orthogonal polarization antennae with parameters – angle of orientation – β=70^0 and angle of ellipse α=15^0 and polarization factor m=0.9) are in Fig. 5. Here we will show the spatial multiplexing – QPSK and ML receiver (PM 6dB loss) without orthogonal polarization antennae [3] and (PM) with orthogonal polarization antennae. We find that BER are close to 0.098 at 10dB SNR and polarization loss energy at 6 dB. We find too, that BER are close to 10^{-5} with orthogonal polarization antennae and without polarization loss energy.

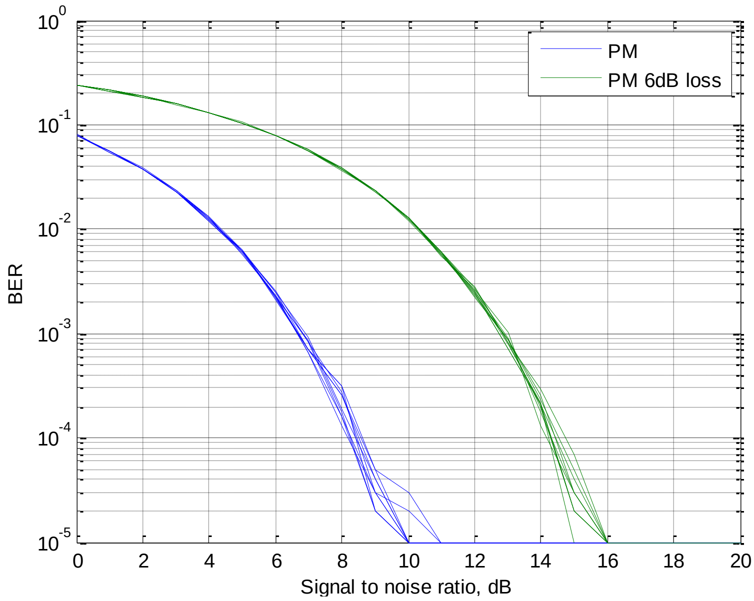

Fig. 5. Depends on BER to SNR

BR computerized results for same conditions are show in Fig.6. Analysis of the graphs are indicates that at SNR 10 dB BR is close to 11Mb/s with polarization losses of energy then BR is equal to 20MB/s without loss of energy by polarization due to use polarization orthogonal antennae.

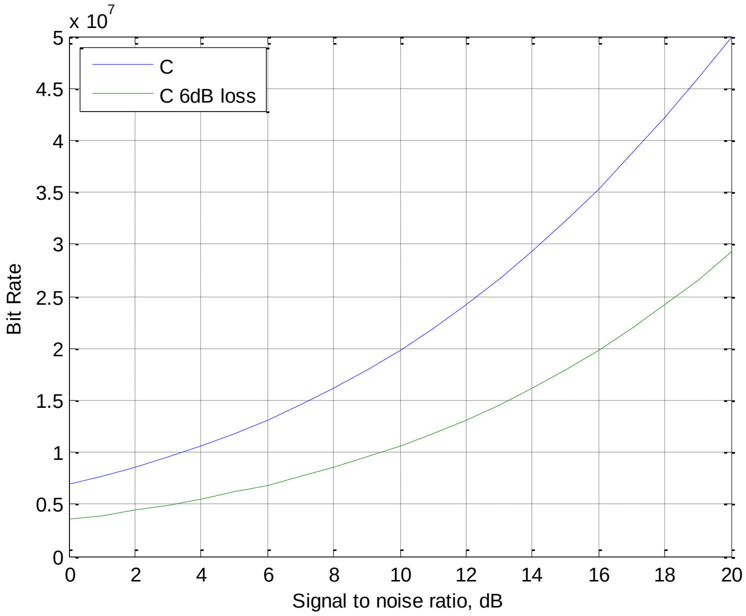

Fig. 6. Depends on BR to SNR

Conclusions

Result of experiment meaning that better BR without loss of energy at full polarization antennae. If BR is equal to 11Mb/s at SNR 10 dB at real and loss of energy at 6dB, then BR is equal to 20MB/s at SNR 10 dB and without loss of energy by polarization.

Basic suggestions on the use of polarization orthogonal aerials for increase Bit Rate in MIMO systems may be following:

need to use orthogonal polarization Antennae in conditions «without a line-of-sight»; in this case the total loss of energy may decrease;

need to knowing polarization parameters of signal in conditions «without a line-of-sight»;

the antennae construction needs to include double orthogonal polarization antennae;

the related algorithms are needed to use for channel additional antennae of orthogonal polarizations.

References: 1.*Бакулин, М.Г., Крейнделин, В. Б., Шлома, А. М.* Новые технологии в системах мобильной радиосвязи. − М. : Ин.связь. издат, 2005. 2. *W. Heath, Jr. and A. J. Paulraj*. Switching Between Diversity and Multiplexing in MIMO Systems // IEEE Trans. Commun., vol. 53, no. 6, pp. 962 – 968, June 2005. 3. *Вишневский, В.М.* Широкополосные беспроводные сети передачи информации / В.М. Вишневский, А.И. Ляхов, С.Л. Портной, И. В. Шахнович. – М. : Техносфера, 2005. – 592 с.

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