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A Method of Modulating Signals with Space-Time Encoding Using Non-Linear Iteration Algorithm

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Abstract—In the conditions of limited frequency resource and along with increasing requirements towards transmission data rates in radio communications systems a demand for increasing their spectral characteristics arouses. One of technologies increasing the channel capacity by many times (compared to traditional radio communications systems with one transmitting antenna) is the space-time encoding technique. The absence of effective signal processing algorithms, having acceptable computational complexity, at the receiving side appears to be limiting factor for systems with space-time encoding. A new algorithm for demodulating signals with space-time encoding, which exceeds the known algorithm in interference immunity and possesses moderate computational complexity, is suggested.

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1. MODEL OF A SYSTEM WITH SPACE-TIME ENCODING

The space-time encoding is used in systems with several antennas at the transmitting side and several antennas at the receiving side, so-called MIMO (Multiple-Input-Multiple-Output) systems [1]. The basics of the MIMO system operation is explained in Fig. 1, where the simplest space-time encoding system V-BLAST (Vertical Bell Laboratories Layered Space-Time) [1] is shown.

In the V-BLAST diagram information symbols are demultiplexed into M substreams, which are modulated and radiated at the same frequency through M transmitting antennas. The transmitted signals, subject to the influence of Raleigh fading and additive white Gaussian noise (AWGN), arrive to N receiving circuits. A model of the signal received by N receiving circuits may be described by a system of linear equations

$$\begin{cases} y_1 = h_{11}\theta_1 + h_{12}\theta_2 + \ldots + h_{1N}\theta_M + \eta_1, \\ y_2 = h_{21}\theta_1 + h_{22}\theta_2 + \ldots + h_{2N}\theta_M + \eta_2, \\ \ldots \\ y_N = h_{N1}\theta_1 + h_{N2}\theta_2 + \ldots + h_{MN}\theta_M + \eta_N, \end{cases} \quad (1)$$

where $y_i, i = \overline{1, N}$ stands for the complex envelope sample at the ith demodulator's input corresponding to the ith receiving antenna; $\theta_j, j = \overline{1, M}$ denotes the transmitted complex information symbol, belonging to the set $\{\theta^{(1)}, \ldots, \theta^{(K)}\}$, where K represents the quadrature amplitude modulation (QAM) order; h_{ij} is the complex transfer coefficient of the propagation channel for the signal radiated by jth antennas and received by ith antenna; η_i stands for the complex Gaussian noise sample at the ith demodulator's input, possessing zero average and dispersion $2\sigma^2$.

The equations system (1) may be re-written in the vector-matrix form:

$$\mathbf{Y} = H\mathbf{u} + \mathbf{h}, \quad (2)$$

where $\mathbf{Y}$ denotes the complex samples vector of the received signal with dimension $N \times 1$; H represents the complex transfer coefficients matrix of the transmission channel with dimension $N \times M$; $\mathbf{u}$ stands for the