ANALYSIS OF THE NORMALIZED CAPACITY OF TELECOMMUNICATION SYSTEMS

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Modern telecommunication systems widely use technology that uses multiple transmitting and multiple receiving antennas (MIMO, Multiple Input Multiple Output - many inputs, many outputs) in combination with coding and modulation algorithms [1, 6].

In a telecommunications system based on MIMO technology, it can significantly improve the efficiency of radio and communication systems compared to traditional systems with one transmitting and one receiving antenna.

However, in the presence of fading with significant spatial correlation in the radio channel, the efficiency of MIMO systems noticeably decreases [2].

When developing communication systems, it is necessary to take into account the spatial correlation of fading, which is usually described by a large number of parameters [1].

The studies have shown that one of the most important characteristics of the quality of functioning of telecommunication systems based on modern wireless cellular communication technologies is the normalized throughput of the systems.

To study the normalized throughput performance, consider a MIMO system with M transmit antennas and N receive antennas.

It is assumed that the investigated signal of MIMO systems at the receiver input has the following form [2]:

$$Y = H \cdot s + n\,, \tag{1}$$

where $Y-$ is the vector of received signals of dimension $N \times 1$; $H-$ complex channel matrix of dimension $N \times M$; $s-$is a vector of transmitted complex information symbols of dimension $M \times 1$; $n-$ complex Gaussian random vector of dimension $N \times 1$ with zero mean and correlation matrix:

$$E\{n \cdot n'\} = \sigma_n^2 \cdot I = (0.5\Delta F_k \cdot N_0) \cdot I\,, \tag{2}$$

where $I-$ is the identity matrix of dimension, $N \times N$; σ_n^2 is the noise dispersion in one receiving antenna.

Each element h_{ij} of the MIMO communication channel matrix H is a complex transmission coefficient from the $j-$th transmit antenna to the $i-$th receive antenna.

The total power radiated by all transmit antennas is:

$$P_m = E[s's] = M \cdot \sigma_S^2\,, \tag{3}$$

where σ_S^2 is the dispersion of the signal emitted by one antenna and is equal to: $\sigma_S^2 = N_0 \cdot \Delta F_S$.

Taking into account formulas (1), (2) and (3), it is necessary to emphasize that the elements of the vector s of complex information symbols are assumed to be independent discrete random variables with unit variances. The variances of the elements of the vector s and are equal to unity. In this case, it is assumed that Rayleigh fading occurs in the MIMO radio system. This means that each element of the MIMO radio channel matrix H is a complex Gaussian random variable with zero mean. In this case, the elements of matrix H can be uncorrelated or correlated with each other.

Based on formula (1), (2) and (3), we consider the normalized throughput $C_{\max.nor.}(M, V_b)$ of the system of radio engineering complexes using MIMO technology with a given complex matrix H is determined by the relation [1, 2]:

$$C_{\max.nor.}(M, V_b) = \log_2 \det\left(1 + \frac{\rho(P_m)}{M} H \cdot H'\right), \text{ bps/Hs.} \quad (4)$$

Relation (4) is a generalization of the known K. Shannon formula to the case of a MIMO communication channel for telecommunication systems, radio engineering complexes and mobile communication networks.

If the channel matrix **H** is a deterministic matrix, then the specific throughput $C_{\max.nor.}(M, V_b)$ will be a deterministic quantity. However, due to the presence of fading in real communication channels, the elements of the matrix **H** are random variables.

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