2005
5th INTERNATIONAL CONFERENCE ON ANTENNA THEORY AND TECHNIQUES

PROCEEDINGS

KYIV
UKRAINE
24-27 MAY

5th International Conference on

Antenna Theory and Techniques

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We wish to thank the following for their contribution to the success of this Conference

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Scientific-Production Company "ROMSAT" (Kyiv, Ukraine)
Joint Stock Company "INCOM" (Kyiv, Ukraine)

Technical Support

Publishing House "Izvestiya Vuzov" (Kyiv, Ukraine)

2005 5th International Conference on Antenna Theory and Techniques

IEEE Catalog Number: 05EX1108

ISBN: 0-7803-9261-2

The publication can be ordered at

IEEE Operations Center
445 House Lane
Piscataway, NJ 08854-4150
USA

+1 800 678 IEEE(+1 800 678 4333)
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MIMO-SYSTEM WITH PULSE SIGNALS

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Abstract

The new principle of pulse signals generating for MIMO-system transmit antenna is offered. It is based on inserting special relative time shift for signals in each channel. That results a superposition of pulses that are overlapped in time. After analog-digital transform of signal mixture on the receiving side the amplitude components of signals are evaluated by known signal arrival times, then the demodulation of transferred messages is executed.

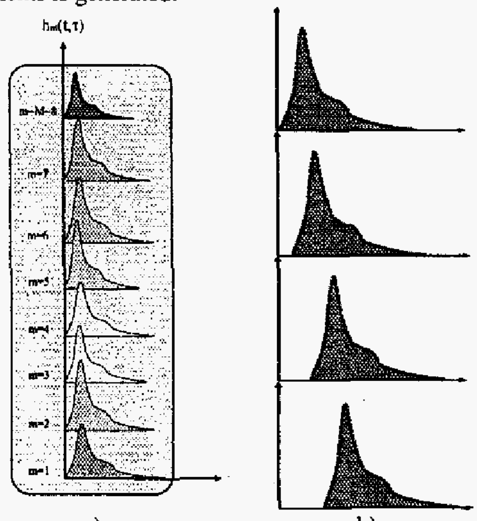
Keywords: MIMO, pulse signals, OFDM, SMART-antenna, digital bearforming, analog-to-digital converter, ADC

The wireless access to communication channels for MIMO-systems (Multiple Input - Multiple Output), based on digital antenna array (DAA), recently is spread abroad. These systems mainly use various OFDM signal modulation and consists of radio oscillation packets, which are long in time and orthogonal on frequency. Using of pulse signals in MIMO communication system results some difficulties.

This report considers the new approach for implementation of MIMO systems. In them the variants of OFDM-modulation of signals are mainly applied which represents packets concerning radio oscillations extended in time and orthogonal on frequency. At the same time, usage of pulse signals in communication systems by a principle "MIMO" before this time resulted the defined difficulties.

In the report the new approach of implementation of MIMO-systems is presented. Unlike known methods, it provides emission of single pulse signals by M separate elements of SMART-antenna. These signals have special interchannel time shift, which may be equidistant or irregular (see fig. 1). The pulses generated in different channels, may have different or similar rules of their bending variations, but these rules must be known. The amplitudes of partial pulses are modulated by multilevel amplitude or quadrature amplitude modulations (M-QAM). Unlike OFDM, orthogonality of carrying frequencies is not required, and their spectral region may be narrowed. In addition, the requirements to SMART-antenna transmitting channels instant dynamic range are reduced, because emitted pulses are time-overlapped in space (not in analog transmitting path).

By such operation scheme the receiving SMART-antenna obtains the mixture of M overlapped signals. For received messages demodulationthis mixture must be jointly processed on all antenna channels. By timestamps of signal mixture (that are obtained from synchronized array of antenna array in analog-to digital converter – ADC), the set of equations for unknown estimations of each partial pulse amplitude components is generated.



a) b)

Fig.1. a) Traditional emission of pulse signals by the antenna lattice (all signals in all channels are generated in the same time). b) Offered emission principle of pulse signals by the antenna array (the signals in all channels are generated in different times, but their mutual shift does not exceed duration of a single-pulse).

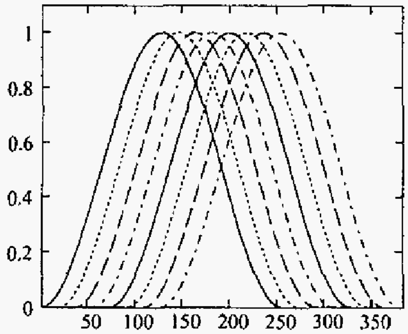


Fig.2. Schematic view of *M* pulse signal mixture on the input of receiver antenna lattice.

For decision of obtained equations set the least squares method is recommended. This method allows to evaluate optimal amplitude estimations under condition of Gaussian noises. Appropriate estimations are:

$$A^c = \mathrm{Re}\left(\left\{P^* P\right\}^{-1} \cdot P^* \cdot \dot{U}\right),$$

$$A^s = \mathrm{Im}\left(\left\{P^* P\right\}^{-1} \cdot P^* \cdot \dot{U}\right),$$

where, $A^s = \begin{bmatrix} a_1^s & \cdots & a_M^s \end{bmatrix}^T$, *Re* - real part of a complex vector, *Im* - imaginary part of a complex vector, P - signal matrix (which elements are discrete data of functions of bending pulse signals, according to their known time layout – with precision limited by discrete period duration only), U - vector of complex data for voltages of signal mixture on the output of the ADC.

By offered approach to construction of a MIMO-systems communication channels are provided for more resistance against unauthorized access, increasing transfer rate to large distances (compare with several hundreds meters in present MIMO-systems based on OFDM). It is essential, that the channel separation within system is reached by using dependence between interpulse time interval and a direction to subscriber. As the variant, each of *M* channels of active SMART-antenna may transmit packets that are overlapped in time and amplitude modulated. The main requirement is matching for interchannel packets shift and interpulse interval.

At exactly known arrival times for all signals (synchronized mode of the communication line) the possible evaluation precision for quadrature components of pulse amplitudes is determined by a low bound of the Cramer-Rao, for which the Fisher information matrix is: $I=\sigma^{-2}\cdot\left[P^T \cdot P\right]$, where σ^2 - noises dispersion of data in the analog-to-digital converter.

At asynchronous receiving (when the exact arrival times for signal packet is unknown, but interpulse shift is determined), for calculation of a possible precision of pulse amplitudes quadrature components estimation, the Fisher information matrix is used as follows:

$$I = \frac{1}{\sigma^2} \cdot \left[\begin{array}{c|c} P^T \cdot P & (A^* \otimes P^T) \cdot \dfrac{\partial P}{\partial Y} \\ \hline \left(\dfrac{\partial P}{\partial Y}\right)^T \cdot (A \otimes P) & \left(\dfrac{\partial P}{\partial Y}\right)^T \cdot (AA^* \otimes 1) \cdot \dfrac{\partial P}{\partial Y} \end{array} \right],$$

where $\partial P / \partial Y$ - Neudekker derivative for a signal matrix P by a vector Y (composed from unknown parameters of time shift of *M* signals); 1 - unit vector; A - vector of amplitudes of signals, $\otimes$ - symbol of multiplication by Kroneker, T - operation of transposition of matrixes, * - symbol of complex conjugate transposition.

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Підп. до друку 18.05.2005. Формат 60×84 1/16. Папір офс. Гарнітура – Times.
Спосіб друку – ризографія. Ум. друк. арк. 66,49. Обл.-вид. арк. 112,86. Зам. № 5-71. Наклад 150 пр.

Інформаційно-видавничий центр "Видавництво «Політехніка»" НТУУ «КПІ»
Свідоцтво про внесення суб'єкта видавничої справи до Державного реєстру видавців, виготівників і розповсюджувачів видавничої продукції ДК № 1665 від 28.01.2004
03056, Київ-56, вул. Політехнічна, 14, корп. 15
тел./факс (044) 241-68-78, 241-66-64, e-mail: izdatelstvo@ntu-kpi.kiev.ua

Computer Editor: Sergey Litvintsev
Publishing House "Izvestiya Vuzov" (Kyiv, Ukraine)
Printed: NTUU "KPI"