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MIMO ANTENNAS IN THE 5TH GENERATION OF COMMUNICATION SYSTEMS AND AVIATION SYSTEMS

Abstract: *This article is devoted to the basic principles of MIMO. Examples of using this technology in aviation and 4G as well as 5G networks are analysed. The main disadvantages and advantages are explained in each of the particular applications.*

Keywords: *MIMO antenna, Two-Dimensional Circle Antenna Layout, Massive MIMO System, 4G, 5G, Aviation systems.*

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АНТЕННЫ MIMO В СИСТЕМАХ СВЯЗИ ПЯТОГО ПОКОЛЕНИЯ И В АВИАЦИИ

Аннотация: *В данной статье представлены основные принципы работы MIMO. Далее разобраны примеры использования этой технологии в авиации и в*

сетях 4G и 5G. Объяснены основные недостатки и преимущества в каждом из отдельных случаев применения.

Ключевые слова: *МИМО антенна, Двумерная круговая антенна, Массив МИМО система, 4G сети, 5G сети, Авиационные системы.*

Multiple-input-multiple-output (MIMO) is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the point of destination (receiver).

When broadcasting radio waves, the digital stream in the radio channel deteriorates. This is especially noticeable when you are surrounded by urban multi-story buildings, moving at high speed or moving away from an area that radio waves can cover. As a solution to this problem, a MIMO antenna was created, capable of transmitting information on several channels with a minimum signal delay. As a result, there is an increase in the speed of data distribution. Moreover, signal quality improves significantly. Simultaneous reception, as well as distribution of the digital stream by the antennas to the receiver, occurs through two independent cables. This allows to significantly increase the speed parameters. This article will show examples of the application of MIMO antennas in aviation and in the next-generation wireless technologies.

Interpolated airborne MIMO antenna array

For airborne communications, due to the resource-limited VHF / UHF / L-band spectrum, a MIMO antenna array is used, which improves throughput. Since the required optimum inter-element space depends on the relative distance between the aircraft and the ground station, azimuth and altitude and varies throughout the flight, the optimal power cannot be achieved. To solve this problem, a MIMO antenna array with interpolation from two orthogonal ULAs is proposed, which in its turn provides optimal MIMO transmission power during the entire flight.

The optimal inter-element space in this case can be represented as:

$$d_t d_r = \frac{0{,}385\lambda R}{\sqrt{(\cos\varphi)^2 + \frac{h^4}{R^4}(\sin\varphi)^2}}$$

h—flight height;

R—relative distance between the aircraft and GR;

φ— azimuth;

λ—walenght;

The proposed scheme can be compared with the traditional layout of a fixed antenna in the following cases:

1. A single antenna;
2. ULA with 4 antennas along the x axis only;
3. Two orthogonal ULA with 8 antennas (4 by x. 4 by y);
4. Virtual antennas;

With the same moderation parameters, this scheme has a larger capacity compared to the traditional ULA scheme.

Two-Dimensional Circle Antenna Layout for Aeronautical MIMO Communications

Multipath communication cannot be used in order to create Decorrelated channels due to the transmission of the line of sight (LOS). That is why a two-dimensional annular antenna array has been proposed and optimized in order to maintain the optimal throughput characteristics of the aircraft MIMO transmission.

In aviation communications, an important parameter is the propagation of electromagnetic waves, which affects the transmission of the line of sight (LOS).

Although LOS MIMO has been well studied in the ground mobile networks, the results of these studies cannot be applied in aviation communications.

For example, a rectangular planar antenna array is based on the optimization of fixed MOMO LOS, which requires of the receiving and transmitting antenna arrays to be parallel to each other. This condition does not allow the use of this technology in an airplane.

All these limitations led to the development of a two-dimensional circular antenna scheme for MIMO aviation communications.

Massive MIMO System

Use of the multiple antennas on the transmitter and receiver provides:

1. increase in the data transfer rate, because increased amount antennas allow to send more independent data streams;

2. improvement of a reliability, because the more antennas, the more paths along which the radio signal will propagate;

3. increased energy efficiency. The main station is able to focus the radiated energy towards the location of terminals.

An improved form of point-to-point MIMO technology is MIMO technology MU-MIMO. Differences of MU-MIMO from point-to-point MIMO are as follows: firstly, the terminals are separated by several wavelengths, and secondly, the terminals do not interact with each other in order to receive and transmit data.

The MU-MIMO systems currently are widely used in wireless technologies of the new generation. In this regard, there are several requirements for this technology:

1. ensuring high speed data transmission and communication reliability;
2. multi-user mode;
3. low power consumption.

In practice, beat interference has strong influence when many users are trying to get an access to the wireless connection. To solve this problem, MU-MIMO with very large antenna arrays (Massive MIMO) has been proposed. If the channel vectors are orthogonal, then the interference between consumers is significantly reduced. Therefore, users can be catered for with maximum data transfer speed at the same time.

Conclusion

In this article, 3 options for the application of MIMO antenna technologies in the modern world were analyzed. These are one of the many uses for this technology.

REFERENCES

1. Chao ZHANG, Keke PANG, Lu MA, «Interpolated airborne MIMO antenna array», IEEE Antennas and Wireless Propagation Letters, Vol. 14, Jan. 2015, pp. 72 – 75.

2. Chao ZHANG, Keke PANG, «Two-dimensional circle antenna layout for aeronautical MIMO communications», IEEE Antennas and Wireless Propagation Letters, Vol. 12, Dec. 2013, pp. 1566-1569.

3. Muaayed AL-Rawi, «Massive MIMO System: An Overview», International Journal of Open Information Technologies ISSN: 2307-8162 vol. 5, no. 2, 2017.