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ADAPTIVE ANTENNA SYSTEMS OF TELECOMMUNICATION NETWORKS

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Abstract

In modern wireless telecommunication networks are widely used adaptation to change, for example, communication channel parametres. Adaptive modulation, the coding and so on is thus used, that considerably improves efficiency of systems. Recently adaptation also is used in antenna systems. Substantial increase of efficiency of wireless networks as a whole is thus reached. "Intellectual" antennas (Smart-antennas) which can change the form of the directional pattern depending on concrete circumstances in a communication channel, and ways of increase of their efficiency are investigated.

Keywords: Smart-antenna, MIMO, Matlab.

In modern wireless telecommunication networks are widely used adaptation to change, for example, communication channel parametres. Adaptive modulation, the coding and so on is thus used, that considerably improves efficiency of systems. Recently adaptation also is used in antenna systems. Substantial increase of efficiency of wireless networks as a whole is thus reached. "Intellectual" antennas (Smart-antennas) which can change the form of the directional pattern depending on concrete circumstances in a communication channel, and ways of increase of their efficiency are investigated.

1. APPOINTMENT OF INTELLECTUAL ANTENNAS

Often considerable part of energy which is radiated by base station, is used inefficiently. The matter is that antennas of base station provide circular or sector (in wide sector, 60 and more degrees) DN (directional pattern). If the signal appointed of concrete station, was sent in the form of a narrow beam only in its direction, and the direction of its moving was traced, it would allow to improve indicators of a network of a radio communication:

- to increase the relation a signal/noise and a radio covering zone;
- to reduce effect of multibeam distribution of waves as at use narrow-band antennas the longest ways of passage of a signal are excluded, reflection from the obstacles located on the big corners from the necessary direction.
- Use of intellectual antennas can be one of variants of the decision of the given problem. Hence appointment of intellectual antennas is elimination of signals of hindrances and allocation of a useful signal. If in an acceptance point the useful signal can guide in the antenna pressure Us, and i hindrance - pressure Ui on an exit of the intellectualantenna, generally, it should be provided pressure Usa.

$$Usa = k\ Us, \tag{1}$$

where to - efficiency of use of the intellectual antenna.

In an ideal case the intellectual antenna should suppress signals of hindrances completely. Concerning a useful signal one of possible variants of action of the intellectual antenna on a useful signal is transformation of initial signals of each of R elements AP in inphase and their addition. Application of the intellectual antenna can lead to considerable improvement of the relation a signal noise on a receiver input. Actually values of factor k (1) will be smaller because the intellectual antenna not only carries out function of strengthening of a useful signal, but also reduces influence of hindrances [1].

2. PROCESSING OF THE ACCEPTED SIGNAL IN INTELLECTUAL ANTENNAS

Possibility of maintenance of dependence (1) is based on use of differences between a useful signal and hindrances [2]. Such differences are different directions of receipt of a useful signal and hindrances. If it is necessary to define a direction of arrival of a useful signal and to trace movings of its source are used dynamically phased AP. In the most difficult case, adaptive AP, not only traces moving of a source of a useful signal, but also defines directions of receipt of signals of hindrances. In this case AP tries to provide dependence (1) directing main petals in a direction of a source of a useful signal and zero DN - in a direction of hindrances [3,5]. As a result on an exit of the intellectual antenna it is possible to receive, basically, the maximum value of a useful signal and completely suppressed signals of hindrances.

If the source of a useful signal is on distance considerably much more the geometrical sizes AP it is possible to consider directions of distribution of radio-waves which arrive on each element AP, - parallel. Then the distance of passage of a radio-wave from a source to each element AP will be a miscellaneous. If first element AP to consider basic and from it to carry out readout the difference of distances for i th and 1st element AP makes

$$\Delta d_i = d(i-1)\sin(v_s \bullet \frac{\pi}{180}), \qquad (2)$$

where d - distance between next radiators AP; v_s - A corner between a normal to axis AP and a direction of receipt of a useful signal, hailstones.

Presence of different distances leads to delay in time of receipt of a signal for each following element AP in comparison with the previous. Shift of phases makes

$$p_S = 2\pi dn \bullet \sin\left(\frac{v_s \pi}{180}\right), \quad dn = \frac{d}{\lambda}, \qquad (3)$$

where dn - normalised distance.

In turn it also leads to shift of phases between signals from one source, but accepted by separate elements.

If on AP which contains R elements, the useful signal which direction makes $v=v_s$ it is possible to present target pressure of elements AP in the form of a vector of pressure Su arrives. Alarm vector S which can be considered as a normalised vector of pressure Su often also is of interest. Often on AP except a useful signal signals of hindrances also arrive. If on AP which contains R elements, the hindrance signal which direction makes v=vz1 it will cause occurrence of corresponding pressure on an exit of each element AP in a kind, to a similar vector operates.

$$Su = u_s \bullet \begin{bmatrix} 1 \\ e^{ips} \\ \dots \\ e^{i(R-1)ps} \end{bmatrix}, \quad S = \frac{S_u}{u_s},$$

$$Zu_1 = uz_1 \bullet \begin{bmatrix} 1 \\ e^{ips} \\ \dots \\ e^{i(R-1)ps} \end{bmatrix}, \quad Z_1 = \frac{Zu_1}{uz_1}, \qquad (4)$$

where u_s - the amplitude of a useful signal accepted by each of elements AP

$pz_1 = 2\pi \bullet dn \bullet \sin(v_{z1}\frac{\pi}{180})$ phases displacement for a hindrance,

uz_1 - The amplitude of a hindrance induced on each of elements AP.

In a vector (4) first line displays a signal and a hindrance the accepted 1st element (a basic element from which shift of phases is deducted) AP, the second line - 2nd element AP and so on. Alarm vector S and a vector of hindrances Z_1 which can be considered as normalised vectors of pressure Su and Zu_1 often also is of interest [4].

On the basis of vectors of pressure (4) we will receive a vector of the target pressure caused both a useful signal and a hindrance, all elements AP

$$U_O = u_s \bullet \begin{bmatrix} u_s \bullet 1 & uz_1 \bullet 1 \\ u_s \bullet e^{ips} & uz_1 \bullet e^{ips} \\ \dots & \dots \\ u_s \bullet e^{i(R-1)ps} & uz_1 \bullet e^{i(R-1)ps} \end{bmatrix}, \qquad (5)$$

Let's consider an example of elimination of several hindrances and allocation of a useful signal

EXAMPLE 1.

The intellectual antenna containing AP with four elements, should provide elimination on an exit of signals of a hindrance and allocation of a useful signal:

Direction of receipt of a hindrance vz_2 =-75 degrees which directs in each radiator AP pressure amplitude 3.6 mV;

Direction of receipt of a signal vz_3 = 70 degrees which directs in each radiator AP pressure amplitude 1.2 mV;

On fig. 9 the result of processing of signals is resulted.

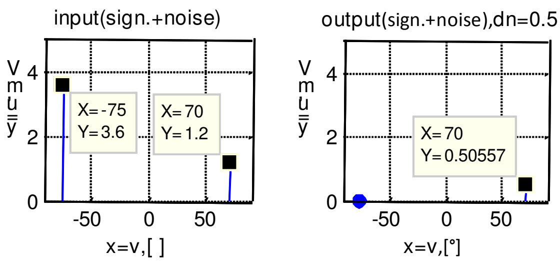

Fig. 1. Elimination of a hindrance and allocation of a useful signal.

In this case elimination of a hindrance and allocation of a useful signal, which, generally less than its maximum value resulted in dependence (4) is reached. Thus level of a useful signal, as a rule, the is less, than less difference (|vs-vz1 |) angular distances between a direction of a useful signal and a hindrance.

But, generally, a lack of elimination of a hindrance and allocation of a useful signal is what be received level of a useful signal can much less from its greatest possible value 1.2*4=4.8 mV. In this case the useful entrance signal made 1.2 mV, and after processing and hindrance elimination - makes only 0.5 mV.

3. Distance influence between elements AP on results of processing of signals in intellectual antennas

Intellectual antennas in which the normalised distance between elements AP made $dn = \frac{d}{\lambda} = 0.5$ were above considered, and such choice was not proved. Probably other value of the normalised distance between next elements AP in certain cases is more effective. We will consider influence of change of the normalised distance between elements AP on results of processing of signals in intellectual antennas.

EXAMPLE 2.

For data of the Example 1 we will define influence of the normalised distance dn on results of processing.

On fig. 2 the result of processing of signals is resulted

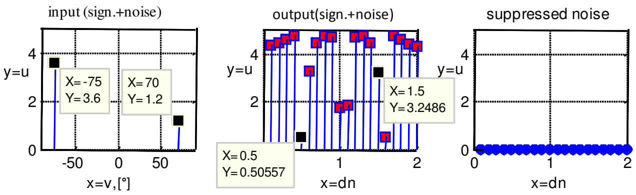

Fig. 2. Influence normalised distances between elements AP on elimination of a hindrance and allocation of a useful signal in smart-antenna

3. CONCLUSIONS

1. At influence on AP the intellectual antenna of a useful signal and signals of hindrances, using known algorithms it is possible to eliminate hindrances completely. However as a result of such processing the useful signal, which level much more low from the greatest possible level is often received.
2. It is shown that level of a useful signal can be increased considerably using changes normalised distances between elements AP. Practically to change normalised distance it is possible by use AP with superfluous number an element (thus, for example, it is used or the part of the next elements, or the same quantity of the elements chosen through one, through two etc. For example, in need of use in radio system AP with 4 elements is used AP with 10 elements, normalised distance between which dy. Thus using 1,2.3.4 elements one type AP with normalised in distance dn is received, using 1,3,5,7 elements new type AP with normalised in distance dn is received, using 1,4,7,10 elements following type AP with normalised in distance 3dn etc. is received.

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