Method of "Neardistance" Researches of Environments

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Introduction:
Radio physical methods of remote research of natural environments are very perspective. In present time, in Vladimir region a regional program for the registration, investigation and subsequent monitoring of the status of natural environments is developed. Successful implementation of this program is only possible by using modern measuring technology. The author are encouraged to implement these measures on the basis of remote radio-physical methods and the use of unmanned aerial vehicles.

For solving many of ecologic problems important parameter is space resolution, in case of 3d task. Considering it, proposing to use antenna array focused in near field as an antenna for research. Flight altitude remote controlled aircraft is typically less than 50-100 meters, and the sizes of objects located on or under the surface of the earth, do not exceed several meters. To achieve this resolution array must have a considerable size (100-200 meters). The obvious way to implement an antenna with given dimensions is an approach equivalent to the synthesized aperture antennas. An original feature in this case is that these arrays should be focused in the near zone with respect to the radiating aperture.

In this case, the synthesized aperture is realized according to traditional concepts, i.e. relatively low-flying aircraft is periodically sent to an object includes low oriented emitter (moving along a rectilinear trajectory). Each time you turn changes the phase shift at the input emitter. The phase shift is calculated from the focusing condition of the field of individual emitters in a given area on the surface under study. If this is a synthesized aperture plane, the aircraft should be moved to a back-row winding path, carrying a two-dimensional phasing.

In order to simplify the research proposing to implement an antenna array with reduced number of emitters of synthesized aperture for which the trajectory of an aircraft may be limited by a contour or cross-flight within a given area.

In order to obtain characteristics realized focal area conducted computer modeling.

Results of computer modeling:
Computer modeling was conducted for plane array including 11×11 emitters. Investigated the influence of the array step and focal length on the position and size of the focal area. The geometrical parameters were set as a fraction of a wavelength λ. Were calculated and normalized

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relative to the maximum in the focal area field distribution in the focal plane passing through the axis orthogonal to it at the focal point.

The obtained result show that for array with a step $L < \lambda$ maximum of field in the focal region is shifted from the calculated point in the direction of the radiating aperture. For array with a step $L=0,5\lambda$ size of displacement $\Delta z=12\lambda$ - for a array with contour emitter placement (CnEP) $\Delta z=6\lambda$ - for a lattice with cross emitter placement (CrEP) $\Delta z=8\lambda$ - for a lattice with full filling (FF). The displacement decreases with increasing pitch and virtually non-existent for all types of arrays with a step. The length of the focal region in the plane of polarization for array with different step in the Table 1.

Table. 1. $\Delta z^{0,5}=f(L)\ f=15\,.\,\lambda$

L/λ	FF, λ	CnEP, λ	CrEP, λ
0,5	8,4	10	6,7
1,5	5,4	9,1	6,6
2,5	2,7	6,6	3,3

From the table 1 we can see, that in these conditions the length of focal area is minimal for full filling array, for which the rising of array step from $L = 0,5\lambda$ to $L = 2,5\lambda$ result to reduce length of focal area from $\Delta z^{0,5}|_{L=0,5\lambda}= 8,4\lambda$ to $\Delta z^{0,5}|_{L=0,5\lambda}= 2,7\lambda$. For array with cross type placement of emitters this value raised from $\Delta z^{0,5}|_{L=0,5\lambda}= 6,7\lambda$ to $\Delta z^{0,5}|_{L=0,5\lambda}= 3,3\lambda$ and much more increased for contour type placement of emitters: from $\Delta z^{0,5}|_{L=0,5\lambda}= 12\lambda$ to $\Delta z^{0,5}|_{L=0,5\lambda}= 6,6\lambda$.

To evaluate the effect of focal length to the length of the focal area were calculated with a similar function with $f = 30\,.\,\lambda$. They imply that the effect of a step in this case is shown with the same laws as in the previous case, but is characterized by large numerical values. The length of the focal area in the plane of polarization for array with different step with $f = 30\,.\,\lambda$ is shown in Table 2.

Table. 2. $\Delta z^{0,5}=f(L)\ f=30\,.\,\lambda$

L/λ	FF, λ	CnEP, λ	CrEP, λ
0,5	11,8	9,5	8,3
1,5	15,3	18,2	16,7
2,5	7,2	13,2	8,7

Comparison of the results given in Table 1 and Table 2 allows to conclude that increased the focal length resulted to increasing of focal area length.

Were calculated and normalized relative to the maximum field in the focal region of the dependence of the field distribution in the focal plane perpendicular to the axis.

These results suggest that the field distribution in the transverse plane is symmetric with respect to the polarization plane passing through the focal axis for different configurations of antenna arrays at any step and the focal length.

The relative level in the areas of incidental focus is minimal for array with full filling and increases for cross and contour type location of emitters.

The width of the focal area $\Delta x^{0,5}$ for array with different steps and the configuration of the location of emitters are shown in Table 3 with $f = 15.\lambda$ and in Table 4 with $f = 30.\lambda$.

Table. 3. $\Delta x^{0,5}=f(L)\ f=15.\lambda$

L/λ	FF, λ	CnEP, λ	CrEP, λ
0,5	2,5	2	3,66
1,5	0,88	0,7	1,24
2,5	0,64	0,52	0,86

Table. 4. $\Delta x^{0,5}=f(L)\ f=30.\lambda$

L/λ	FF, λ	CnEP, λ	CrEP, λ
0,5	4,9	3,7	7,5
1,5	1,7	1,3	2,4
2,5	1,1	0,84	1,5

From Table 3.4 it follows that the minimum width of the focal area of the array corresponds to the contour placement of emitters, and the maximum - a array with a cross type placement.

Thus, in this transition from the array plane with a complete filling of the radiating aperture of the array with the contour location of emitters is accompanied by increase in the focusing properties. As follows from Table 3.4, increasing the focal length in all cases accompanied by a broadening of the focal area, and an increase the step - its significant decrease.

Conclusion:

These results allow to conclude on the possible use of arrays with reduce filling to form a focused near-field zone without any significant loss of the focusing properties. In this case, to avoid displacement of the focal area should be used with a array with step $L \geq 2{,}5\lambda$.

The using of arrays with reduce filling results to increases the length of the focal area, with slightly in case of cross type filling: in 1.22 times (as in $L = 2{,}5\lambda; f = 15 . \lambda$, and when $f = 30 . \lambda$), a significant in case of contour type filling: in 2.44 times (for $L = 2{,}5\lambda; f = 15 . \lambda$) and in 1.63 times (for $L = 2{,}5\lambda; f = 30 . \lambda$).

The width of the focal area, with full filling of the radiating aperture $\Delta x^{0,5} = 64\lambda$ (for $L = 2{,}5\lambda; f = 15 . \lambda$), $\Delta x^{0,5} = 1{,}1\lambda$ (for $L = 2{,}5\lambda; f = 30 . \lambda$) - decreases in case the contour location of emitters: 1.23 times (for $L = 2{,}5\lambda; f = 15 . \lambda$) or 1.31 times (for $L = 2{,}5\lambda; f = 30 . \lambda$), and increases in case cross type location of emitters: 1.34 times (for $L = 2{,}5\lambda; f = 15 . \lambda$), or 1.36 times (for $L = 2{,}5\lambda; f = 30 . \lambda$).

For a plane array, focused in the near field, there is an optimum focal length corresponding to the minimum size of the focal area. For a square aperture is approximately equal to the optimal focus half the linear size of the aperture. Increasing the focal length on the optimal accompanied by a proportional increase in the size of the focal area.

Reference:

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