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SLL Reduction of Spherical Array Using Thinning

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ABSTRACT: In this paper Side lobe level (SLL) ofspherical array is reduced using thinning. Spherical array is a volumetric array which has the advantages of both linear array and circular array. This is due to the fact that volumetric array behaves as circular array in azimuth plane and linear array in elevation plane. Thinning of antenna array is the process where some of the elements are switched off. Thinned arrays have the advantage of simplified feed networks and less cost.

KEYWORDS: Spherical antenna array, Thinned array, array factor, side lobe level.

I. INTRODUCTION

Antenna arrays are classified as linear arrays, planar arrays and volumetric arrays based on geometric alignment. Volumetric array follows some shape and consists of antenna elements conforming to the surface of the shape. Volumetric arrays are most preferred as they reduce the aerodynamic drag and so they can be used in avionics applications.

Linear array has excellent directivity and it could give the narrowest major-lobe in a given direction. But it does not work well in all azimuth directions. Circular array is suited to provide 360 of coverage in azimuth plane. Directional patterns obtained with a circular array can be electronically rotated within the plane of the array without a considerable change of the beam shape. This is because circular array does not have edge elements. Circular array has high side lobes. Moreover compared to linear and rectangular arrays circular arrays are less sensitive to mutual coupling between their elements.

Volumetric array behaves as circular array in azimuth plane and linear array in elevation plane. So these volumetric arrays combine advantages of both linear and circular arrays.

In this paper analysis of spherical array is done up to 21 rings. Optimization of Side lobe level (SLL) is done using thinning. Thinning is the process where some of the elements in the array are switched off. Thinned arrays yield better directive characteristics without degrading the performance. Thinned arrays have the advantage of simplified feed networks and less cost.

II. ARRAY DESCRIPTION

In spherical antenna array elements are symmetrically aligned. So the radiation pattern at any far field point over the space will view the analogous environment. Spherical antenna array can be viewed as arrangement of circular arrays one over the other. The radius of the circular arrays follows a definite set of rules and decreases as we progress away from the centre of sphere.

The arrangement of spherical array is as shown in fig.1. In this work a spherical array is designed by alignment of 2M + 1 circular arrays of different radius a_m and each circular array consists of N_m discrete and identical elements. As the radius varies, to have the equal inter element spacing of the circular array, the number of elements N_m varies for each circular array.

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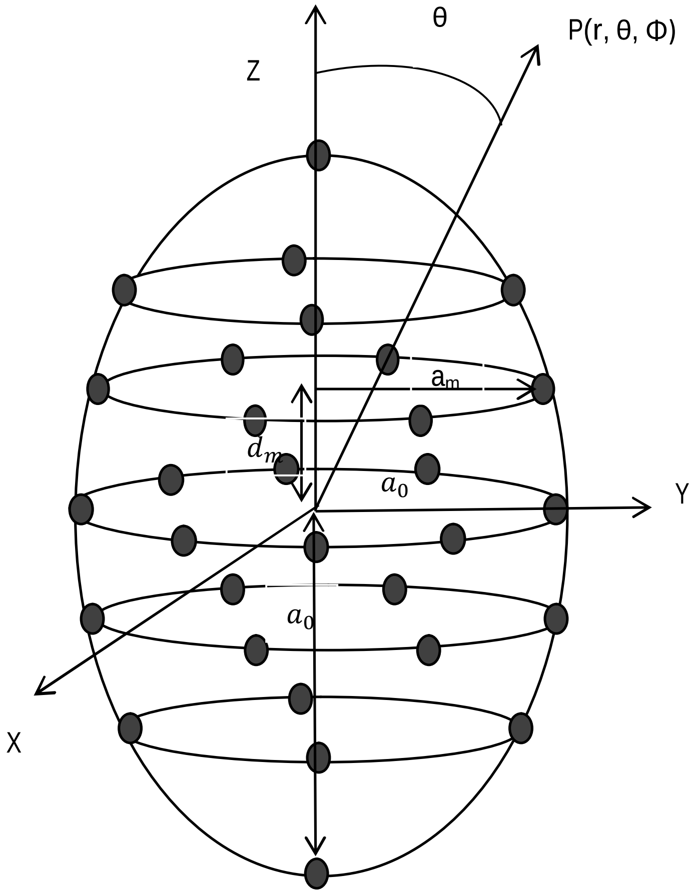

Figure 1.Spherical Antenna Array

The array factor for m^{th} circular array of spherical array can be rewritten from equation as:

$$AF(\theta,\phi) = \sum_{n=1}^{N} I_n * \exp^{(jka_m \sin(\theta)\cos(\phi-\phi_n)+j\Psi_n)}$$

Where, a_m is radius for m^{th} circular array can be calculated and given as in fig1.

$$a_m = sqrt({a_0}^2 - {d_m}^2)$$

To form a spherical geometry, such circular arrays are to be arranged in a linear fashion. The linear array factor for 2M+1 antenna elements can be rewritten from equation as:

$$AF_{lin}(\theta,\phi) = \sum_{m=-M}^{M} I_m * \exp^{j[kd_m \cos(\theta)+\beta]}$$

Hence, a spherical antenna array modelled with 2M + 1 circular array stacks can be represented by combining equations as:

$$AF_{sph}(\theta,\phi) = \sum_{n=1}^{N} I_n * \exp^{(jka_m \sin(\theta)\cos(\phi-\phi_n)+j\Psi_n)} * \sum_{m=-M}^{M} I_m * \exp^{j[kd_m \cos(\theta)+\beta]}$$

$$AF_{sph}(\theta,\phi) = \sum_{m=-M}^{M} \sum_{n=1}^{N} I_{nm} * \exp^{(jka_m \sin(\theta)\cos(\phi-\phi_n)+j\Psi_n)+(j[kd_m \cos(\theta)+\beta])}$$

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The above defined array factor expression gives a truncated spherical array with a slice at its top and bottom surface. Hence, to form a complete spherical array, an antenna element is added both at its top and bottom surface. The final expression for the spherical array factor with 2M + 1 circular array can be re-written as:

$$AF_{sph}(\theta,\phi) = \sum_{m=-M}^{M}\sum_{n=1}^{N} I_{nm} * \exp^{(jka_m \sin(\theta)\cos(\phi-\phi_n)+j\Psi_n)+(j[kd_m\cos(\theta)+\beta])} + exp^{(jka_0\cos(\theta))} + exp^{(-jka_0\cos(\theta))}$$

where, I_{nm} is the current excitation for n^{th} antenna element of m^{th} circular array, k is the propagation constant,θ is the elevation angle,φ is the azimuth angle, φ_{nm} is the azimuth position of n^{th} antenna element on m^{th} circular array, a_m is the radius for m^{th} circle of spherical array

$$a_m = sqrt(a_0{}^2 - d_m{}^2)$$

$a_0$is the radius of spherical array, ψ_n is the beam steering phase angle in azimuth direction, d_m is the distance of m^{th} circular array from reference circular array at the origin,β_m is the progressive phase shift between m^{th} and reference circular array

III. THINNING

In a fully populated array all the elements in an array are excited so that all are in 'ON' state. Thinning of an antenna array elements means to switch 'OFF' some of the antenna array elements, to produce narrowest beam width with lowest side lobe levels, without degrading the performance of an antenna array.
The degree of thinning is defined as the ratio of the number of elements removed from the filled array divided by the original number of elements. By using thinning, number of elements can be reduced which results in low cost and feeding to the elements is minimized.

Algorithm:

1. Generation of sets of amplitudes of array where some of elements are randomly switched off in each ring of array.
2. Evaluation of array factor, SLL and BWFN for each set of amplitudes.
3. Selecting best set of amplitudes giving the smallest SLL.
4. Plotting radiation patterns

IV. SIMULATION RESULTS

Side lobe level and FNBW of spherical array are observed up to 21 rings. Inter element spacing has been assumed 0.5λ and spacing between rings is considered as0.5λ. Numbers of elements of each ring are chosen to have equal inter element spacing of circular array.
Thinning is applied in order to get better SLL value. Table 1 shows SLLin dB and FNBW in degrees of spherical array with and without thinning.

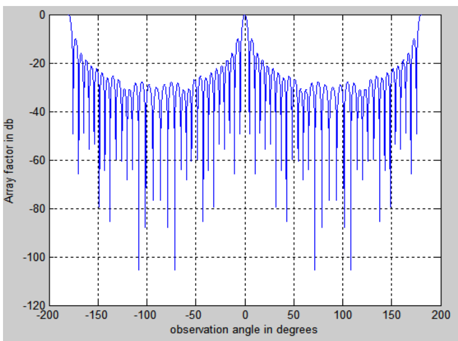

Fig.3 Array factor in dB for spherical array without thinning for 21 rings

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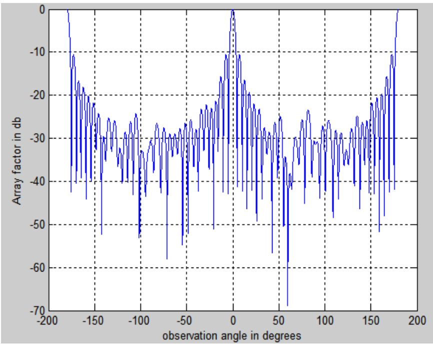

Fig.4 Array factor in dB for spherical array with thinning for 21 rings

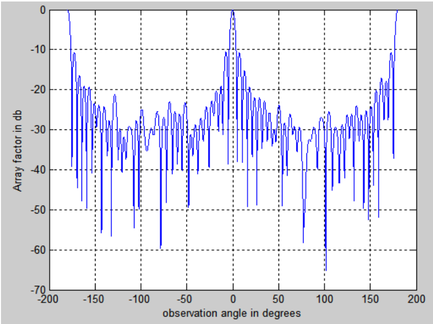

Fig.5 Array factor in dB for spherical array with thinning with random distribution for 21 rings

	Uniform distribution		**Thinning**		**Thinning with random distribution**	
NO OF RINGS	**SLL(dB)**	**FNBW (DEG)**	**SLL(dB)**	**FNBW (DEG)**	**SLL(dB)**	**FNBW (DEG)**
3	-9.4714	78.4	-11.821	78.3	-12.158	78.4
5	-11.494	48.2	-13.605	48.2	-14.040	48.6
7	-13.513	36.2	-15.896	36.4	-16.073	36.6
9	-14.611	29	-16.842	29.4	-16.888	29.5
11	-15.556	23.6	-17.932	23.5	-18.125	23.5
13	-15.842	20.4	-18.139	20.4	-18.549	20.6

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15	-16.177	17.8	-18.925	18.4	-18.982	18.1
17	-16.335	16	-18.942	16.3	-19.129	16.2
19	-16.560	14.2	-19.186	14.3	-19.617	14.2
21	-16.720	13	-19.217	13	-19.990	13.1

Ring no	**No of elements in corresponding ring**	**Element excitation for spherical array for 21 rings**
1	29	1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
2	40	0 1 1 1 0 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 0 1
3	47	1 0 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
4	53	1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 0 1 1 0 1 1 0 1 1 1 0 1 1 1 1
5	58	1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1
6	62	0 1 1 1 1 1 1 1 1 0 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
7	64	0 1 1 1 1 1 1 0 0 1 1 1 1 0 1 1 0 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 0 1 1 0 0
8	66	1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 0 1 1 0 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1
9	68	1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 0 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1 1 0
10	69	1 1 0 1 1 1 1 0 1 1 1 1 0 1 0 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1
11	70	0 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 1 0 1

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		1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 0 1 1 1 0 1
12	69	1 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 1 0 0 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 0
13	68	1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 0 0 1 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 0 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 0 1 0 1 1 1 1 0 1 1 1 1 1 1 0
14	66	1 1 1 0 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 0 1
15	64	1 1 1 1 0 0 1 1 1 1 0 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 0 1 1 1 1 1 1 0 0 1 1
16	62	0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 0 1
17	58	0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1
18	53	1 1 0 1 1 1 1 1 1 0 0 1 1 1 1 0 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 1 1 1 0 0
19	47	1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 0 1 0 1 1 1 1 1 1
20	40	0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1
21	29	0 1 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 0 1

V. CONCLUSIONSAND FUTURE SOPE

In this paper analysis of spherical antenna array with uniform amplitude distributionis done up to 21 rings. Optimization of SLL is done using thinning. It is observed thatFNBW is reduced from 51.6^{o} to 9.1^{o} in spherical array as the number of rings increased from 3 to 21.Thinning is applied in order to get better SLL value. By applying thinning SLL can be reduced.. For spherical array best SLL value is obtained is -19.217 dB for 21 rings.

SLL and BWFN can be optimized by varying distance between elements, phase shift between successive elements. Optimization techniques like genetic algorithm (GA), particle swarm optimization (PSO), differential evolution (DE), biogeography based optimization (BBO) and Ant colony optimization can also be used.

REFERENCES

[1]C.A.Balanis,AntennaTheory andDesign,3rdEdition,JohnWiley&Sons,2005.
[2]A.A.Lotfi,M. Ghiamy, M.N. Moghaddasi, and R. A.Sadeghzadeh,"An investigationof hybrid ellipticalantennaarrays,"IETMicrow.Antennas Prop., vol. 2, no. 1,pp.28-34,Jan.2008.
[3]A.A.Lotfi,M. Ghiamy, M.N. Moghaddasi, and R. A.Sadeghzadeh,"An investigationof hybrid ellipticalantennaarrays,"IETMicrow.Antennas Prop., vol. 2, no. 1,pp.28-34,Jan.2008.

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[4] P.Ioannides and C.A.Balanis,"Uniform Circular Arrays For Smart Antennas," IEEE Antennas and Propagation Magazine,vol.47, no.4, pp.192-206, Aug.2005.
[5] S.A.schelkunoff."A Mathematical theory of Linear Arrays," Bell system Technical Journal,vol.22, pp. 80-107, 1943.
[6] L.JosefssonandP.Persson,Conformalarrayantennatheoryanddesign.Johnwiley&sons,2006, vol.29.