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Research Papers

RANDOM APPROACH THINNING ON SUM AND DIFFERENCE PATTERNS OF LINEAR ARRAYS

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Abstract

Several studies were made on linear arrays with equal and unequal spacing. But, unequal spaced arrays are found to exhibit some interesting characteristics which an equally spaced array cannot offer. However, with the use of unequal spacing, sidelobe level can be reduced to some extent provided that the total number of elements is greater than a certain number and the average spacing is approximately equal to or less than a half-wave length. In this paper, the radiation patterns of linear arrays are numerically simulated using random approach thinning. Thinning is a method by which the total number of active elements in a linear antenna array is reduced without causing major degradation in system performance. The present work is found to be useful in cost reduction while meeting some of the desired radiation characteristics.

KEYWORDS:
Linear arrays, thinning, radiation patterns, sidelobe level

INTRODUCTION

Thinning is a process to switch-off the power of active elements in linear array antenna without causing major degradation of the desired radiation characteristics. It is well known that the side lobe level of uniformly spaced linear arrays with uniform current excitation cannot be reduced from – 13.5 dB. However, the non-linear antenna arrays can be reduced the side lobe level some extent.

Andreasen [2] and Maffet [3] conducted some studies in which the aim was to develop broadband arrays and to reduce side lobes and suppress grating lobes. They assumed a minimum inter-element spacing of half-wave length. When there is no restriction on minimum spacing, there will be more freedom in the design of desired radiation patterns with unequally spaced arrays [4-5].

Haupt [6] considered the possibility of inter leaving thinned arrays to make use of given aperture size effectively. It contains contributions in terms of inter leaved arrays with non-uniform spacing, low side lobe level thinned difference arrays, inter leaved thinned sum and difference arrays and high aperture efficiency thinned arrays.

Ludwig [7] dealt with reflection coefficient and antenna gain both as a function of degree of thinning in a statistically highly thinned arrays. Some arrays are tested practically. Phased array systems using thinning concept are considered by. Lo [8] and Skolnik [9]. The number of radiating elements is statistically distributed on the array grid. As evident from the literature, no array thinning is optimized for the generation of desired radiation patterns. Some researchers are reported thinning on arrays using real-coded genetic algorithm [10], genetic algorithm [11], and binary PSO algorithm [12] to obtain desired radiation patterns.

In view of the above facts, some interesting studies are made on thinning linear arrays and the resultant radiation patterns are simulated. The present work involves random approach in thinning both large and small arrays. The radiation patterns are numerically computed and they are presented in sin-domain.

Analysis of Thinned Linear Arrays:

Linear array consists of 2N elements are considered. The spacing between two elements is d, which are fed with equal magnitude and phase. The geometry of uniform linear array is shown in figure 1. Assume that antenna elements are lies in the z-axis and considered distance between two elements is $\lambda/2$.

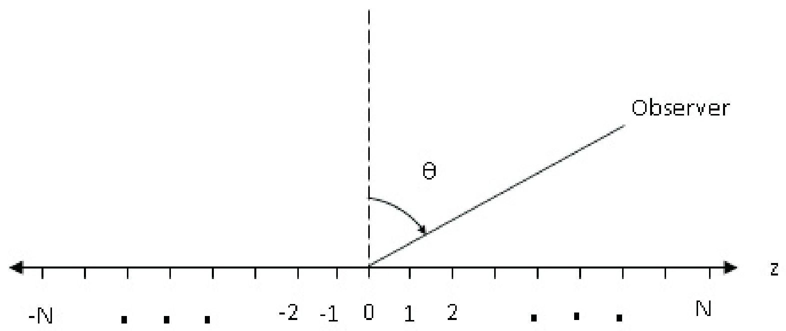

Fig. 1 Geometric of symmetric linear array along z-axis

The far-field radiation pattern of the linear array of isotropic radiator is given by [1]

$$E(u) = \sum_{n=1}^{N} A(x_n)\, e^{j\frac{2\pi L}{\lambda}[u x_n + \Phi(x_n)]} \quad (1)$$

Here,

E(u) : Electric Field Intensity with respect to u

u : Sinθ, θ is the angle of observer

$A(x_n)$: Amplitude Distribution

$2L/\lambda$: Array Length

N : Number of elements

X_n : Spacing function

$\Phi(x_n)$: Phase function

Proposed method:

Thinning is a method by which the total number of active elements in a linear array is reduced without causing major degradation in system performance. Here, considered the total number of elements on linear array are $N=N_T$, after thinning the total active elements are NA and in-active elements are N_{IA}.

By thinning, number of antenna elements to be turn-off and remaining antenna elements are turn-on in the formation of the far-field radiation pattern.

The thinning array factor (T_H) is defined as

$T_H = (N_T - N_A)$

$N_{IA} = N_T - N_A$

Here

N^T= total number of elements in the linear array

N_A= total number of active elements in the thinned linear array
N_{IA}=total number of inactive elements in the thinned linear array

Results and Discussions

Linear array is thinned by randomly removing approach and the sum and difference patterns are captured using the equation (1). The results are presented in figs. (2-15). Random thinning approach is considered three cases and observed the patterns are desired radiation characteristics. Here, total 30 elements are considered and evaluated sum and difference patterns are shown in figs. (2-3). Case I, 6 (30-6=24) elements are thinned (turn-off) from the linear array and presented the patterns in figs. (6-7). For the sake of comparison actual radiation pattern of 24 elements are presented in figs. (4-5). Thinned radiation patterns are having low sidelobe level and the beamwidth is less compare to figs. (6-7) patterns. Similarly, in case II 8 (30-8=22) elements and case III 12 (30-12=18) elements are thinned the patterns are presented respectively.

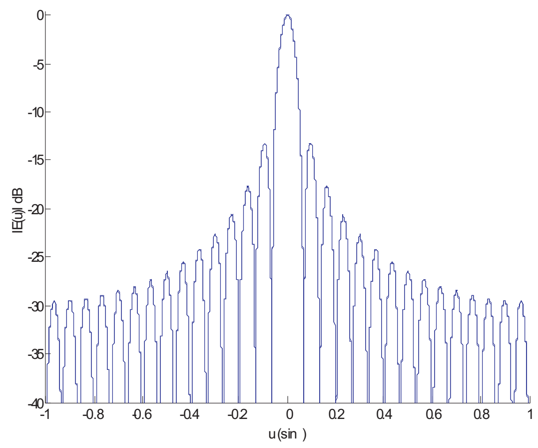

Fig. 2 Sum pattern of 30 elements

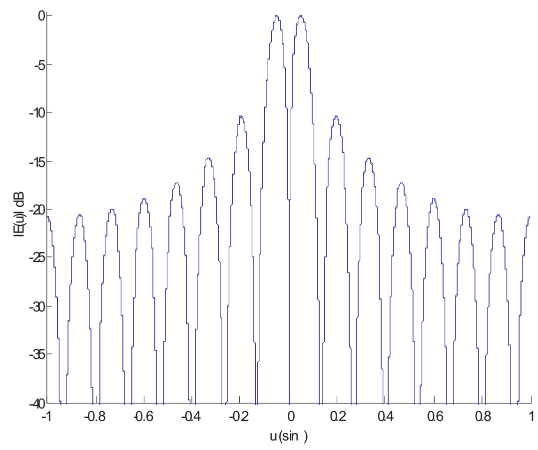

Fig.3 Difference pattern of 30 elements

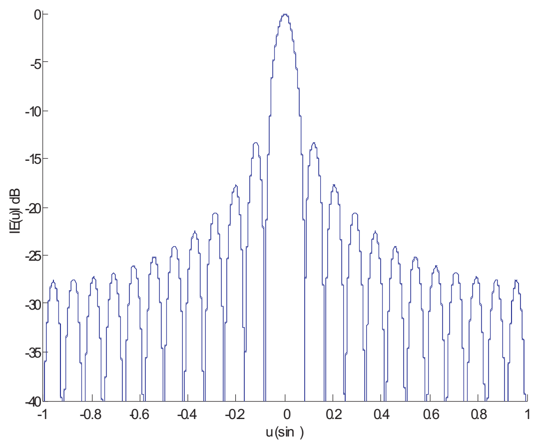

Fig. 4 Sum pattern of 24 elements

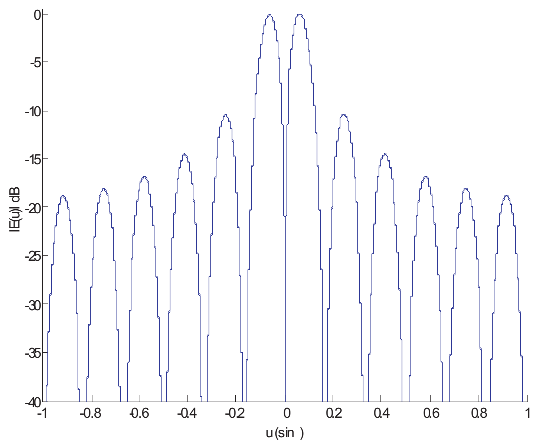

Fig. 5 Difference pattern of 24 elements

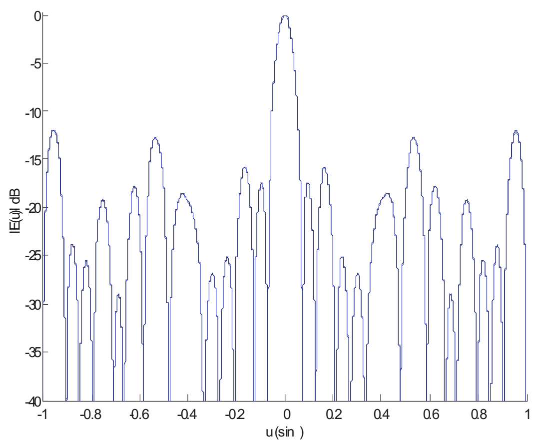

Fig. 6 Sum pattern of 30 elements with thinning 6 elements

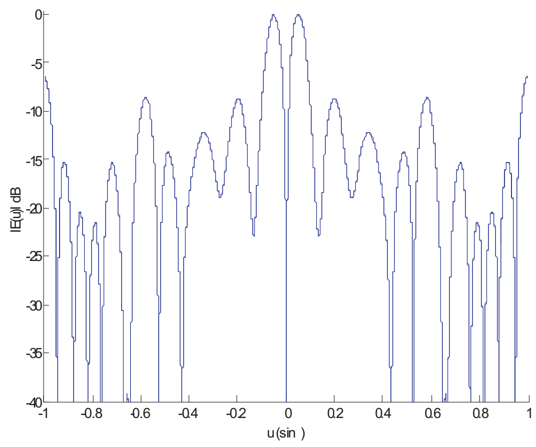

Fig. 7 Difference pattern of 30 elements with thinning 6 elements

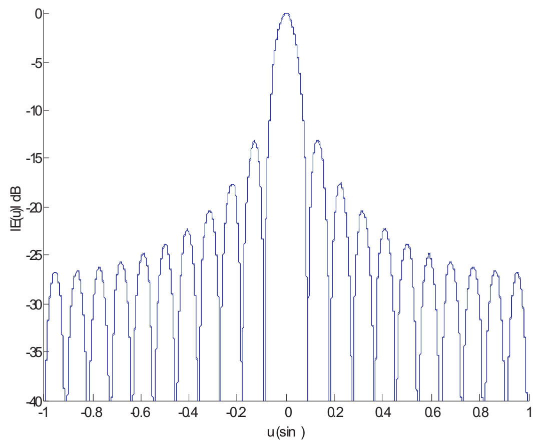

Fig. 8 Sum pattern of 22 elements

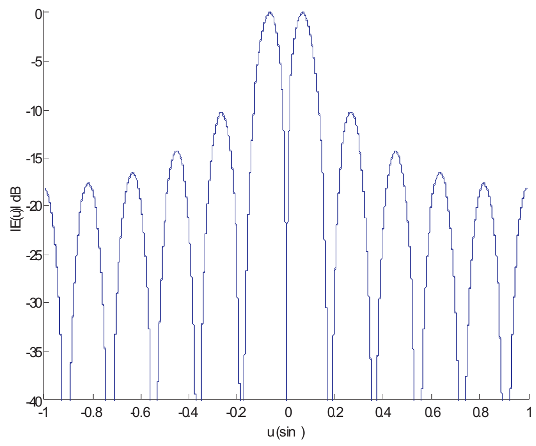

Fig. 9 Difference pattern of 22 elements

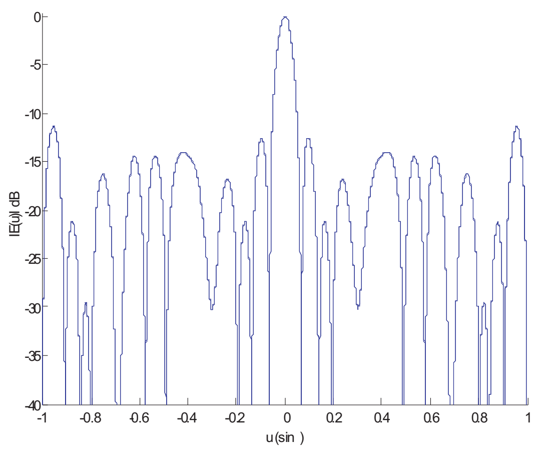

Fig. 10 Sum pattern of 30 elements with thinning 8 elements

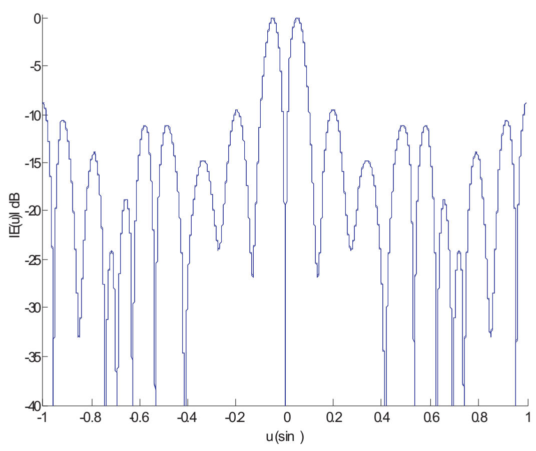

Fig. 11 Difference pattern of 30 elements with thinning 8 elements

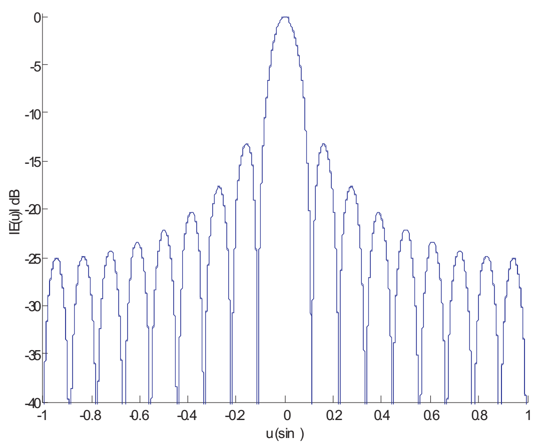

Fig. 12 Sum pattern of 18 elements

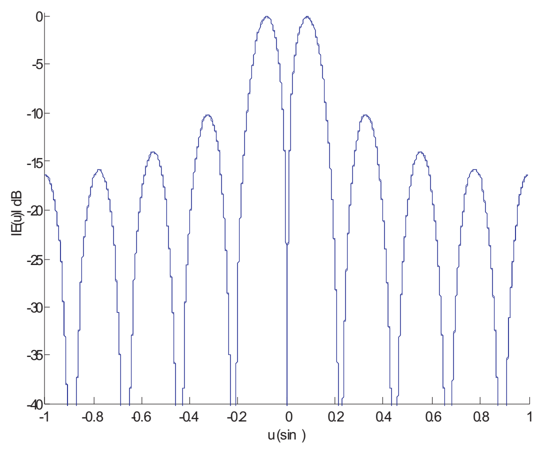

Fig. 13 Difference pattern of 18 elements

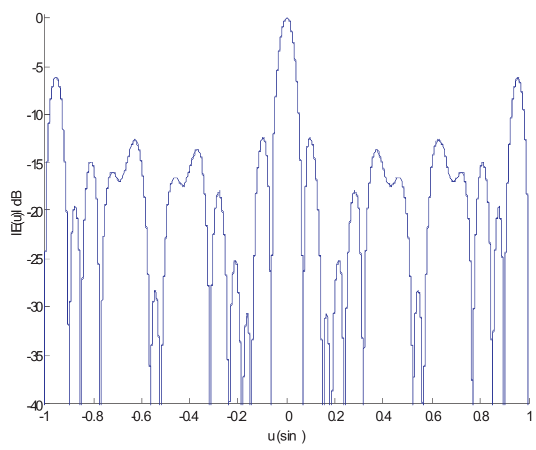

Fig. 14 Sum pattern of 30 elements with thinning 12 elements

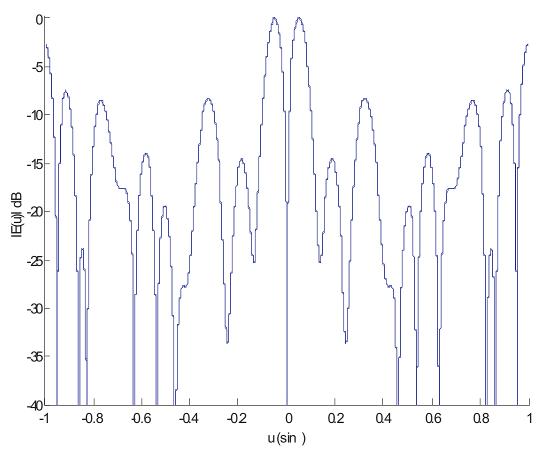

Fig. 15 Difference pattern of 30 elements with thinning 12 elements

CONCLUSIONS

By Thinning, we are able to obtain useful patterns with less number of elements. Both sum and difference pattern are presents. In case I 20% is thinned, case II 28% is thinned, and case III 40% is thinned form the linear array. Observed from the above results the desired radiation characteristics are found. These are useful in radar and communication applications.

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