2-I B1

STATISTICALLY DESIGNED BLOCK EXCITATION IN PLANAR ARRAYS

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A method of reducing the number of elements in a large planar array is desired in order to simplify the feed system and to cut down the cost of the array. In this paper a statistical design method of a block excitation is discussed. The block excitation is one of the thinning methods retainning sources in their original positions and removing radiating elements. By this method the power sources of which the radiating elements have been removed will join with the neighbouring elements and radiate their powers to free space.

STATISTICAL FORMULATION OF BLOCK EXCITATION

A filled array is thinned in an aperture plane as shown in Fig. 1, while source distribution remains unchanged.

Let us consider N-element planar array. The source distribution is given as

$$\{A_n\} \quad (n=1,N).$$

Define the aperture distribution after removing some elements as

$$\{B_n\} \quad (n=1,N).$$

The aperture distribution at the point where the element is removed is zero (Refer to Fig. 1).

Whether or not the n'th element should be removed is determined by a random number R of the value is between zero and one.
Assuming probabilistic parameters p and q that satisfy

$$0 \le p,\ 0 \le q,\ \text{and}\ p+q < 1,$$

and
i) if the number R is in the region $0 \le R < q$, then n,n+1 and n+2'th elements are to be removed. The powers to these elements are then connected with the n+3'th element:that is

$$B_n = B_{n+1} = B_{n+2} = 0$$

$$B_{n+3} = \sqrt{\sum_{n=1}^{3} A_n^2} \simeq 2A_{n+3}$$

and call the next random number R' for the n+4'th element.
ii) if the number R is in the region $q \le R < p+q$, then the n'th element is to be removed and its power is connected with the n+1'th element:that is

$$B_n = 0$$

$$B_{n+1} = \sqrt{A_n^2 + A_{n+1}^2} \simeq \sqrt{2}A_{n+1}.$$

Then call the next random number R' for the n+2'th element.
iii) if the number R is in the region $p+q \le R < 1$, then the n'th element remains:that is

$$B_n = A_n$$

and call the next random number R' for the n+1'th element.

This procedure is to be repeated along the array elements from the fiest to the last. In this procedure all the elements have to be numbered in advance. If this method is repeated for the same array on different random number series probabilities of the states at the n'th element are represented as a stationally Markoff-chain for a large array.
These values are given as follows:

a) $(p+3q)/(1+p+3q)$ for $B_n = 0$

b) $(1-p-q)/(1+p+3q)$ for $B_n = A_n$

c) $p/(1+p+3q)$ for $B_n = \sqrt{2}A_n$

d) $q/(1+p+3q)$ for $B_n = 2A_n$.

The statistical mean values of B_n and B_n^2 are derived as

$$\overline{B_n}=\frac{1+(\sqrt{2}-1)p+q}{1+p+3q}A_n$$

$$\overline{B_n^2}=A_n^2 \quad .$$

DESIGN OF BLOCK EXCITATION AND PROPERTIES OF RADIATION PATTERN

As the block excitation can change the aperture distribution statistically, the prescribed aperture distribution that differs from the source distribution can be easily obtained.

Let the prescribed aperture distribution be

$$\{I_n\} \quad (n=1,N)$$

and let us assume certain numbers for p and q so that the following relation may be possible:

$$\overline{B_n}=kI_n.$$

where the subscript n of p and q means that the values of the parameters p and q may differ at points of each elements. Parameter k shows the extent of the thinning and its value usually lies between 0.5 and one if A_n and I_n are normalized to be one at a specified point.

The field intensity in the far field is expressed as

$$F(\theta,\phi)=\sum_{n=1}^{N}B_n\, e^{j\psi_n}$$

where θ,ϕ are the angular coordinates in the observation direction and ψ_n is the phase of the signal at the n'th element.

The mean values of the field intensity and the power pattern are given as

$$\overline{F(\theta,\phi)}= k\, F_0(\theta,\phi)$$

$$\overline{|F(\theta,\phi)|^2}=k^2|F_0(\theta,\phi)|^2+\sum_{n=1}^{N}(A_n^2-k^2I_n^2)$$

where F_0 denotes the field intensity of the prescribed aperture distribution :namely

$$F(\theta,\phi)=\sum_{n=1}^{N}I_n\, e^{j\psi_n} \quad .$$

The mean sidelobe level and the mean gain are shown as follows:

$$\overline{S}=\frac{1}{G_0}\left(\frac{1}{k^2\mu}-1\right)$$

$$\overline{G}=k^2\mu G_0+(1-\mu k^2)\simeq k^2\mu G_0$$

where

$$G_0=\left(\sum_{n=1}^{N}I_n\right)^2/\sum_{n=1}^{N}I_n^2$$

$$\mu=\sum_{n=1}^{N}I_n^2/\sum_{n=1}^{N}A_n^2 \quad .$$

The thinning ratio η in the blocke excitation is defined as the ratio of the number of the removed elements to the elements in the filled array. Its mean value is derived as

$$\overline{\eta}=\frac{1}{N}\sum_{n=1}^{N}\frac{p_n+3q_n}{1+p_n+q_n} \quad .$$

REFERENCES

Kahrilas,P.J.: HAPDAR - An operational phased array radar, Proc. IEEE vol. 56,no.11,pp.1967-1975,Nov.1968.

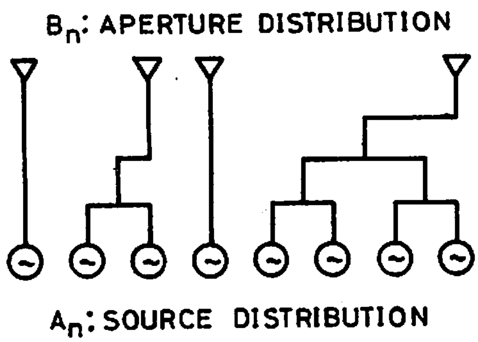

Fig. 1 Model of block excitation.