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SIMULATION OF MICROSTRIP ANTENNA PHASED ARRAY USING UNIFORM AND BINOMIAL DISTRIBUTIONS AND SCHELKUNOFF'S POLYNOMIAL BASED ARRAY BEAM SYNTHESIS METHOD USING MATLAB

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ABSTRACT
Antennas with given radiation pattern may be arranged in a pattern (line, circle, plane etc.) to yield a different radiation pattern. An antenna array is a configuration of multiple antennas (elements) arranged to achieve the given radiation pattern. These arrays are classified as linear array, circular array, planar array etc. based on placement or an arrangement of these multiple elements in a specific geometrical shape. There are multiple design issues of the antenna array are available in the form of different variables such as, shape of the array, element spacing between array elements, excitation amplitude of individual array element, excitation phase of the individual array element, patterns of array elements etc.

KEYWORDS: Microstrip Antenna, Uniform and Binomial Distribution.

INTRODUCTION
Multiplication Theorem:
Array Pattern = Element Pattern x Array Factor (AF)
where the element pattern is the radiation pattern of individual array element. It is always considered that an antenna array consist of identical types of elements (i.e. all elements are of same type). The array factor AF is the independent of antenna type assuming all elements are identical.
For N – element linear array 'AF' is given as

$$\mathbf{AF} = \sum_{n=1}^{N} e^{j(n-1)\phi}$$

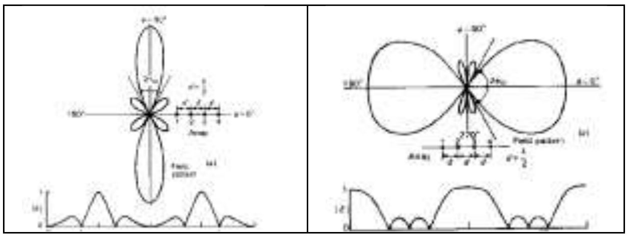
Also,

$$\mathbf{AF} = [\sin (N\varphi / 2)] / [N\varphi / 2]$$

Where
$\phi = kd\cos\theta + \beta$
K - wave number,
β - progressive phase shift,
φ = total phase shift

Broadside Array
Here maximum radiation is normal to axis of antenna array.
$\phi = kd\cos\theta + \beta$ as $\Theta = \Pi / 2$
$\phi=\beta=0$,for max. radiation

End fire Array
Thus, to have maximum array factor it is necessary all elements should have same excitation phase.
Here maximum radiation is along axis of antenna array.
$\phi = kd\cos\theta + \beta$ as $\Theta = \Pi$ or 0
$\beta = \pm kd$, for max. radiation



In the above figure broadside and end-fire array factor is shown for four linearly spaced antenna elements.

Procedure

1. Open a new M-script file in the Matlab
2. Write a Matlab code to implement equation of the array factor for given values of array element spacing, number of elements, initial phase, total phase shift etc.
3. Change the number of array elements and observe the pattern of array factor for broadside as well as end fire array types
4. Plot the array factor in dB (0 dB = 1 maximum value) with respect to angle for given values of elements of array N and their spacing d respectively
5. Change the spacing between array elements and observe the effect on array factor

Simulation of microstrip antenna phased array using uniform and binomial distributions:

The purpose of antenna array is detailed where important principle of pattern multiplication was studied. Arraying mechanism is performed to obtain more amount of gain in switched beam operations. In certain applications like military surveillance, radars are extensively utilized

The radars are usually incorporated with movable beam pattern generated by specific array configuration. The movable or switched beam is used to locate and track the target. The principle behind switching of the maxima beam of an antenna array is, controlled adjustment of phase shift of antenna array elements. These antenna elements are separated with fixed distance from each other and are excited with uniform equal amplitude, but the phase of this excitation could be different based on the position of maxima beam in the azimuth plane. Now a days electronic phase shifters making use of ferrite material are utilized for continuous and dynamic tuning of phase shit for multiple antenna elements in an array configuration. Normally the inter-element spacing between the array elements is chosen to be 0.5 . The greater spacing would result in more than one maxima lobe in the radiation pattern of entire array. When this arrangement is fed with equal amplitude to all the array elements, then this type is known as uniform array. On the other hand if amplitude distribution of array element follows binomial (Pascal triangle) distribution as shown below then it is known as binomial array. The antenna array could contain total odd or even number of antenna elements. In this experiment we are using three RMSA designed on the air dielectric with height around 2 mm, with 0.5 edge to edge spacing between them. This forms an odd array of three elements. One can go even for higher number of array elements either odd or even array. For quick simulation the finite ground for this three element array is not used.

For air dielectric

$\boldsymbol{\varepsilon_r = \varepsilon_{eff} = 1}$ and hence guide wavelength

$\lambda_g = \frac{\lambda}{\varepsilon eff} = 122.4$ mm at frequency f = 2.45 GHz.

Hence the approximate length of patch

$L = \frac{\lambda g}{2} = 61.2\ mm$

Height of the substrate =h< 0.02 λ_g =2.448 mm hence we take h=2 mm

The above substrate height is considered to be acceptable for excitation of surface waves which are undesired in nature for the operation of microstrip antenna.

Width of microstrip antenna

$w = \frac{C}{2f\sqrt{\frac{\varepsilon r + 1}{2}}}$=61.2mm

For uniform array, all the three RMSA's are excited with equal amplitude of voltage say 1V each. On the other hand in binomial array the three RMSA's are excited with amplitudes 1V, 2V, and 1V respectively. The central element has double amplitude compared to edge elements. This amplitude distribution in the binomial array follows Pascal triangle distribution for higher number of antenna elements. The amplitude distribution in the binomial array ensures minimum or no number of side lobes, but results in the increase of width of maxima beam. On the other hand the maxima lobe beam width in uniform array is quiet less in comparison with binomial array but there is presence of undesired side lobes.

The Pascal triangle for binomial tapering of amplitude is as shown below:

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1

1 1

1 2 1

1 3 3 1

1 4 6 4 1

1 5 10 10 5 1

and so on. The above number indicates the magnitudes of amplitude excitation of antenna array elements respectively.

The total phase of an antenna array containing 'n' elements is given as,

Φ = β d cos ϕ + α

Where **Φ** =total phase of antenna array

$\beta = \frac{2\pi}{\lambda}$ =phase shift constant

d=interelement spacing between array elements

=0.5λ

ϕ=azimuth angle for beam shifting in degrees

α=progressive phase shift between antenna array elements in degrees

Hence with the above equation we can find out the progressive phase shift required between the array elements for the specified valued of azimuth angle for beam shifting in phased array mechanism.

Procedure:

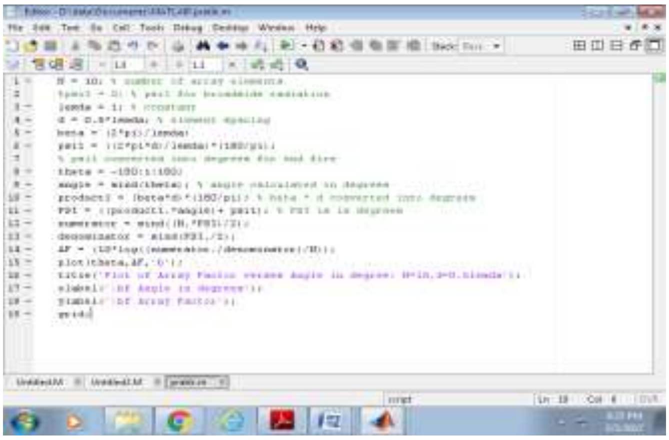
1. Start with new file in Genesys software, with the calculated dimensions of RMSA's form an odd array of three elements.
2. For quick simulation the finite ground plane is not used.
3. Perform radiation pattern calculations with two different momentum simulations. One for uniform array and second for binomial array.
4. Perform and observe beam shifting mechanism of phased array by specifying different progressive phase excitations of the array elements.
5. Plot the 2D and 3D radiation patterns for uniform as well as binomial array for different values of azimuth angles .

Observation Table

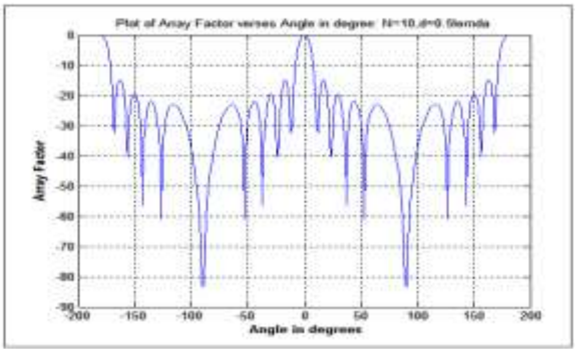
We note here that for uniform array we excite all elements with 1V each, and for binomial distribution we excite first element with 1V, second or middle element with 2V, and third element with 1V.

Azimuth angle for beam shift in degrees	**Individual phase shift in degrees for antenna elements**			**Progressive phase shift**
	Element-1	**Element-2**	**Element-3**	
30	0	-155.88	-317.76	-155.88
45	0	-127.27	-254.54	-127.27
60	0	-90	-180	-90
90	0	0	0	0
120	0	90	180	90

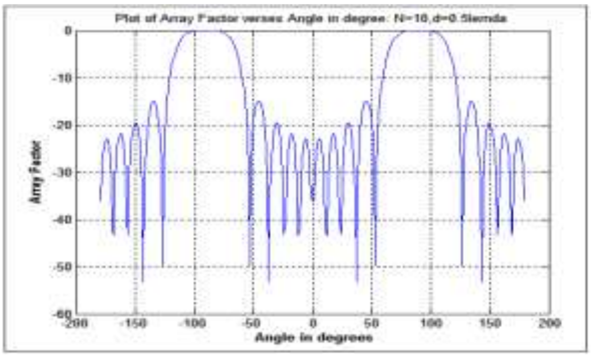
MATLAB Program / coding for Array factor calculation



Broadside radiation pattern when psi1 = 0

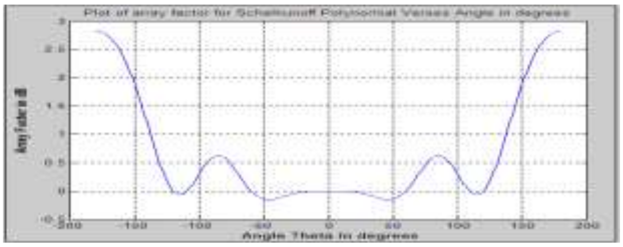


End Fire radiation pattern when psi1 = + / - (2*pi*d)/lemda



ANTENNA SYNTHESIS

Simulation of Schelkunoff's Polynomial based array beam synthesis method using MATLAB



CONCLUSION

Thus we have studied simulations using MATLAB

REFERENCES

[1] www.antenna-theory .com
[2] Lab manual Handbook on antenna.