National Conference on Innovative Research & Industrial Applications

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Investigations on Circular and Concentric Circular Antenna Array Using Circular Patch Antenna

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Abstract: The main objective of this project is to design an efficient circular and concentric circular array antenna for multipurpose applications. This paper shows a novel algorithm based on improved technique presented to enhance the performance analysis of beam-forming in smart antenna technology using N elements Concentric Circular Array (CCA) geometries. 3-ring CCAAs, one having the set of 4-, 6-, 8-, elements and the other having 8-, 10-, 12- elements, with and without centre element are considered. The proposed array shows a considerable improvement against the existing structures in terms of, size, directivity, HPBW and SLL reduction. To demonstrate the effectiveness and reliability of the proposed approach, simulation results are carried out in MATLAB.

Keywords: Circular Array, Concentric Circular Array, 3-Db Beam Width, Side Lobe Level(SLL,) Half Power Beam Width (HPBW).

I. INTRODUCTION

Adaptive beam-forming capabilities for smart antenna arrays are nowadays used to improve the performance of mobile and wireless communication systems. Due to the current interest of the known circular antenna arrays that have several advantages over other types of array antenna configurations, it is becoming increasingly important in the electromagnetic designs of future electronic applications such as: sonar, radar, mobile, commercial satellite communications systems, beam forming network, and a receiver or transmitter [2, 3]. Considering the diversity of aims searched by users, the increase in performance requirements for antenna arrays makes it necessary to extend current array synthesis methodologies to circular ring array, creating a new research problem (e.g., conformal phased array antenna). The latest circular geometry, also known as concentric circular array (CCA), is a planar array that contains many concentric circular rings of different radii and number of element. Its benefits including the flexibility in array pattern synthesis and design both in narrowband and broadband beam-forming applications especially at the base stations (in mobile radio communications system) [2]. However, uniformly excited and equally spaced circular ring array offers high directivity but suffers from high side lobe level (SLL) [1, 5]. Generally, antenna synthesis was started to require on intelligent systems such that genetic algorithms and neural network. Several articles shows that genetic algorithm (GA) is mainly used for side lobe reduction in the array pattern synthesis [6]. But, artificial neural network (ANN) have been studied in various application like pattern recognition systems, and have been exploited for inputoutput mapping, for system identification, for adaptive prediction, etc....

Therefore, we are interested to present in this paper the neural networks method that will be applied to the array pattern synthesis, highlighting their most important features and distinctive characters. In the interest of the best approximation property, this approach permits to model and optimize the antenna arrays system, by acting on many parameters of the array and taking into account predetermined general criteria. The goal is then to build a feedforward neural network with supervised learning that approximates the following array pattern’s function [1–8]. This study can show some fundamental details about the optimal size of a feedforward Neural Network to avoid over-fitting problems. After that sub-data sets will be created for training, test and validation, and then feed-forward neural network will be created and trained [8]. The output values will be generated and denormalized, and finally the performance of the neural network will be checked by comparing the output values with target values [12, 13]. This fact increases the complexity of the problem under consideration and fitting the neural network model, such as training function, architecture and parameter, that would improve and result more accuracy about input-output relations [10, 11]. Our main aim here is to consider the antenna array synthesis for regular uniform circular antenna Arrays geometries and especially in the extended concentric circular antenna Arrays [4, 5]. For the reason that the adoption of the neural network training algorithm as numerical optimization techniques, a few popular architectures are described to illustrate the need to develop an specific architecture to another problem.

II. PROBLEM FORMULATION: CONCENTRIC RINGS ARRAY MODEL

This paper addresses efficient beam forming techniques for concentric circular antenna arrays (CCAA)[10].The proposed geometry of a concentric circular antenna array is shown in

Figure 1. Where there are M concentric circular rings and the mth ring has a radius rm and the corresponding number of elements is Nm where m = 1; 2; ... ; M. Assuming that all elements are isotropic sources (in all the rings), then the array factor of the considered configuration on the x-y plane with central element feeding (Figure 1) may be written as the following relation

$$AF = 1 + \sum_{m=1}^{M}\sum_{i=1}^{N_m} W_m e^{j(Kr_m \sin(\theta)\cos(\phi-\phi_{mi})+\alpha_{mi})}$$

M = number of rings;
Nm = number of elements in ring m;
Wm = excitation current of elements on mth ring;
rm = radius of ring m = Nmdm 2π ;
dm = interelement spacing of mth ring;
k = wave number = 2π λ ; λ = signal wavelength; j = complex number;
θ = the zenith angle from the positive z axis;
φ = the azimuth angle from the positive x axis;
φmi = element angular separation measured from the positive x axis

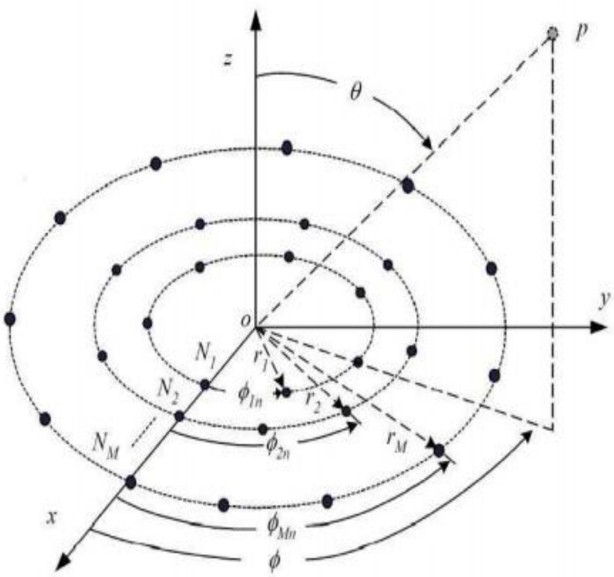

Fig1. Geometry of concentric circular antenna array

III. E-PLANE AND H-PLANE

The E-plane and H-plane are reference planes for linearly polarized waveguides, antennas and other microwave devices. In waveguide systems, as in the electric circuits, it is often desirable to be able to split the circuit power into two or more fractions. In a waveguide system, an element called a junction is used for power division. In a low frequency electrical network, it is possible to combine circuit elements in series or in parallel, thereby dividing the source power among several circuit components. In microwave circuits, a waveguide with three independent ports is called a TEE junction. The output of E-Plane Tee is 180° out of phase where the output of H-plane Tee is in phase. For a linearly-polarized antenna, this is the plane containing the electric field vector (sometimes called the E aperture) and the direction of maximum radiation. The electric field or "E" plane determines the polarization or orientation of the radio wave. For a vertically polarized antenna, the E-plane usually coincides with the vertical/elevation plane. For a horizontally polarized antenna, the E-Plane usually coincides with the horizontal/azimuth plane. E- plane and H-plane should be 90 degrees apart. In the case of the same linearly polarized antenna, this is the plane containing the magnetic field vector (sometimes called the H aperture) and the direction of maximum radiation. The magnetizing field or "H" plane lies at a right angle to the "E" plane. For a vertically polarized antenna, the H-plane usually coincides with the horizontal/ azimuth plane. For a horizontally polarized antenna, the H-plane usually coincides with the vertical/elevation plane.

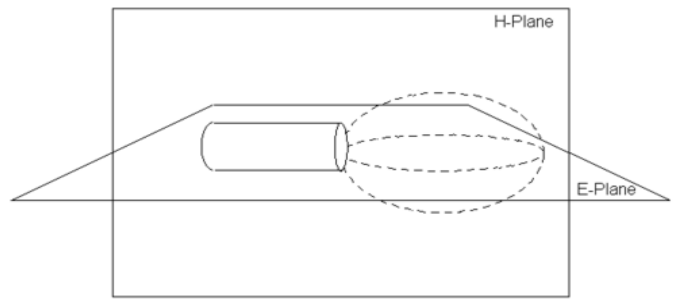

Fig2. Diagram showing the relationship between the E and H planes for a horizontally polarized directional yagi antenna.

IV. PARAMETERS MEASURED

A. Side Lobe Levels

In antenna engineering, side lobes or sidelobes are the lobes (local maxima) of the far field radiation pattern that are not the main lobe. The radiation pattern of most antennas shows a pattern of "lobes" at various angles, directions where the radiated signal strength reaches a maximum, separated by "nulls", angles at which the radiated signal strength falls to zero. In a directional antenna in which the objective is to emit the radio waves in one direction, the lobe in that direction has a larger field strength than the others; this is the "main lobe". The other lobes are called "side lobes", and usually represent unwanted radiation in undesired directions. The side lobe in the opposite direction (180°) from the main lobe is called the back lobe. In transmitting antennas, excessive side lobe radiation wastes energy and may cause interference to other equipment. Classified information may be picked up by unintended receivers. In receiving antennas, side lobes may pick up interfering signals, and increase the noise level in the receiver. The power density in the side lobes is generally much less than that in the main beam. It is generally desirable to minimize the sidelobe level (SLL), which is measured in decibels relative to the peak of the main beam. The main lobe and side lobes occur for both conditions of transmit, and for receive. The concepts of main and side lobes, radiation pattern, aperture shapes, and aperture weighting, apply to optics(another branch of electro-magnetics) and in acoustics fields such as loudspeaker and sonar design, as well as antenna design.

B. Half-Power Beam Width

According to the standard definition, “The angular separation, in which the magnitude of the radiation pattern decreases by 50% (or -3dB) from the peak of the main beam, is the Half Power Beam Width." In other words, Beam width is the area where most of the power is radiated, which is the peak power. Half power beam width is the angle in which relative power is more than 50% of the peak power, in the effective radiated field of the antenna. When a line is drawn between radiation pattern's origin and the half power points on the major lobe, on both the sides, the angle between those two vectors is termed as **HPBW**, half power beam width. This can be well understood with the help of the following diagram.

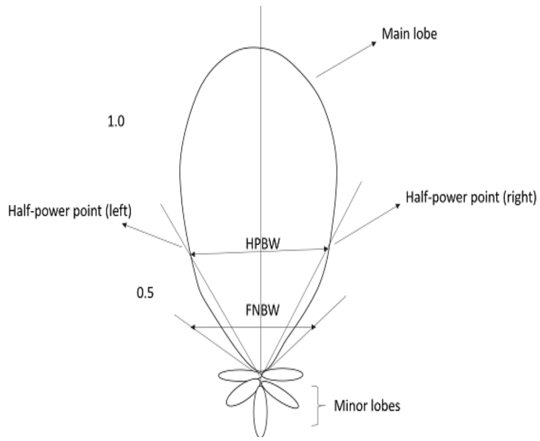

Fig3.

C. Directivity

Directivity is a fundamental antenna parameter. It is a measure of how 'directional' an antenna's radiation pattern is. An antenna that radiates equally in all directions would have effectively zero directionality, and the directivity of this type of antenna would be 1 (or 0 dB). RF antennas or aerials do not radiate equally in all directions. It is found that any realisable RF antenna design will radiate more in some directions than others. The actual pattern is dependent upon the type of antenna design, its size, the environment and a variety of other factors. This directional pattern can be used to ensure that the power radiated is focussed in the desired directions.

V. RESULT

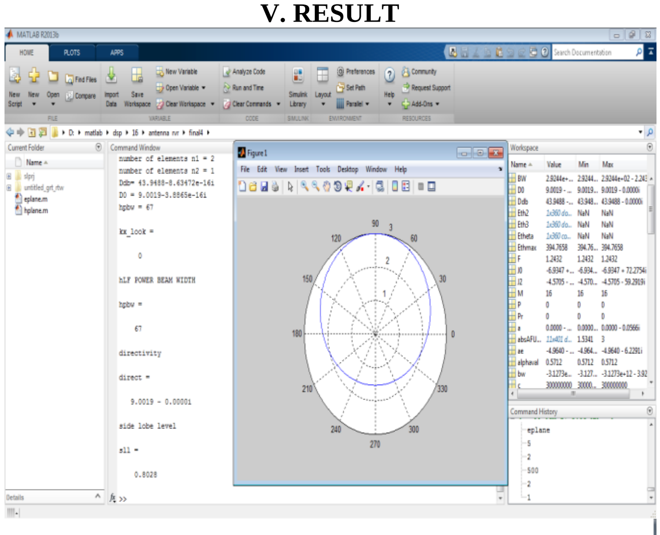

Fig4.

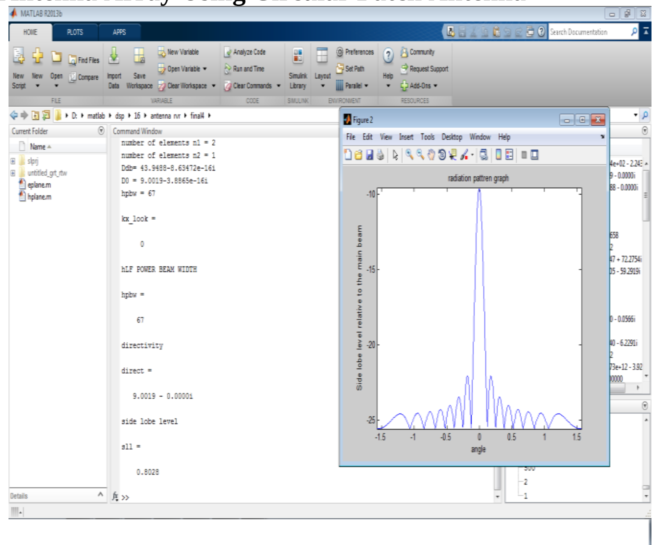

Fig5.

VI. CONCLUSION

Finally, it concludes the limitation of uniform circular antenna arrays to increase the gain and the directivity pattern. To enhance the radiation characteristics, it proposes to grow up the array elements numbers by introducing a concentric circular antenna configuration. Based on this simple geometry, it's possible to study other aperiodic (random cases) arrays of various geometries. It is also observed that the Directivity and more parameters are improved for low dielectric constant values.

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