STUDY OF PHASED ARRAY ANTENNA AND RADAR TECHNOLOGY

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ABSTRACT

A phased array antenna is a set of 2 or more antennas or arrays in which the signals from each array are combined or processed to achieve maximum improved performance over that of a single antenna. The phased array antenna is used; to maximize the signal to interference ratio (SINR); to determine the direction of arrival of the received signals; to steer the angle of array to achieve maximum gain and directivity; interference cancellation from a particular direction; increase overall directivity and gain and to deliver multiplicity reception. In this paper, reduction of grating lobes and to achieve maximum beamforming and also the advantages and performance of phased array antenna has been discussed.

Keywords: *Phased Array Antenna & MATLAB*

INTRODUCTION

A phased array antenna is composed of two or more radiating elements and each element has its own phase shifter. Constructive interference amplified the beam in desired direction and sharpness of the beam is enhanced by destructive direction. The main beam of the phased array points in the direction of swelling the phased shift. For a phased array antenna is significant that the solitary radiating elements are steered for with a steady phase moving and the key direction of the beam therefore is transformed. Modern and urbane radar cliques use benefits of a Digital Beamforming style. By using phased array antenna in the radar technology, the cost of phased array radar is decreased and functionality is improved. There are following types of Phased array: antenna can change in direction swiftly and also have inertia scanning advantages (Marconi, 1906). The power of phased array antenna is typically better in the radiation area. Array antenna may be steered electronically or mechanically to achieve narrow directive beams in many directions. In general, each array has its own array factor to design a phased array antenna and knowing the array factor provides the designer with knowledge of the array's like;

- Grating lobes locations
- Rate of lessening of the side lobes
- Position of the nulls
- Altitude of the first side lobe as related to the main lobe
- Distance from the main peak to the first side lobe
- Null to null beam width.

There are three possible arrangements of arrays in phased array antenna as;

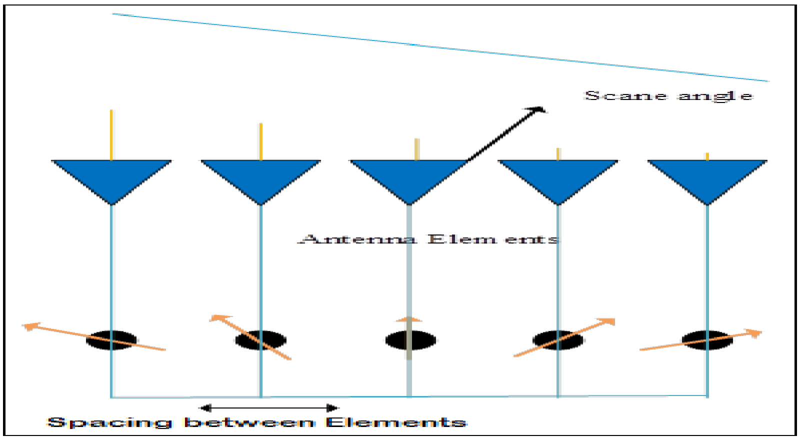
- Linear Arrays
- Planer Arrays
- Frequency scanning arrays but in radar technology linear arrays (Friis, Harald & Feldman).

LITERATURE REVIEW

Composition and Geometry of Phased Array Antenna

In this section, we will discuss the geometry of antenna arrays. Perceiving the array factor, we can see that arrays reception pattern depends on the positions of the antenna elements which make up the arrays. Beam width depends on the inter element spacing between element for an N element array, if N element array spacing is increased than beam width decrease. Increasing the size of the array, it would produce the grating lobes which are the undesirable direction pattern. To avoid the grating lobes, spacing between the elements should be half wavelength, sometimes it also called aliasing which produce same set of phases across the array when waves from two distinct directions is arrived. Antenna array deploy signals based on the phase difference, aliasing results unable to distinguish signals from dissimilar DOAs in the array (Robert, 2007). If spacing between adjacent arrays are non-uniform than aliasing exists, if spacing between arrays are uniform then maximum gain and directivity can be achieved.

Figure 1 Represent Phase Shifters and Scan Angle Pattern



For example, N=4 elements of linear array by locations will not display aliasing (Arnauld, 2006).

$$S = \begin{bmatrix} d1 \\ d2 \\ d3 \\ d4 \end{bmatrix} = \begin{bmatrix} 0 \\ C\lambda \\ C\sqrt{2\lambda} \\ C\sqrt{3}/2\lambda \end{bmatrix} \quad (1)$$

If the value of C is ≤10 in these 4 elements aliasing not exist.

Phased Array Principle

N-component staged display receiving wire vague clusters are correspondingly divided by a distance's" along a hub. Before joining every one of the signs together at the yield isolate variable time postponements are fused at every flag way to control the periods of the signs. A shaft should be episode upon the receiving wire cluster at a point of ϑ to the ordinary bearing. Because of the dividing between the receiving wires, the bar will encounter a period postpone indistinguishable to Eq. (2) in achieving back to back reception apparatuses.

$$\Delta\tau = \frac{2\pi S sin(\theta)}{\lambda} \tag{2}$$

Hence, the incident beam is a sinusoid with amplitude of E at the frequency w, the signals received by each of the antennas can be defined as (3)

$$X_i = Ee^{jn\Delta\tau} \tag{3}$$

To recompense for the delay of the signal arrived Output of variable block of each signal in separate channel can be represented by Eq. (4)

$$Xi = Ee^{-jn\Delta\tau}e^{-jn\alpha} \tag{4}$$

In above Equation, α represents the phase shift difference of two successive variable time delay blocks. The sum of all the signals normalized tot eh signal at one path is called array factor which is represented in Eq. (5).

$$Af = \sum_{n=1}^{N} e^{-jn(\Delta\tau-\alpha)} \tag{5}$$

According to Eq. (5), Array factor Af can be calculated by Eq (6) which is occurs at an incident angle.

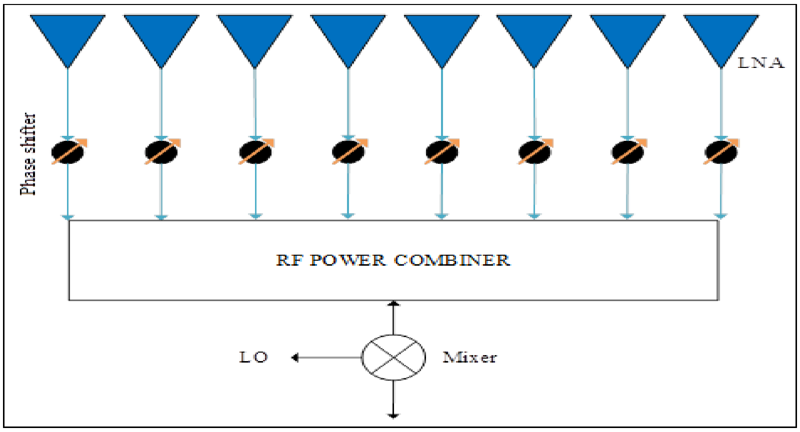
$$\frac{2\pi S}{\lambda}\sin(\theta) = \alpha \tag{6}$$

Incident angle also called scan angle, the wave arriving at the successive antennas in the linear delay progression is flawlessly (Danial, 2011). The array factor of all the combined output signals which are received at the receiver can be denoted as Eq. (7).

$$Af = \frac{sin^2\left[\frac{N}{2}\left(\frac{2\pi S}{\lambda}\sin(\theta_{in}) - \alpha\right)\right]}{sin^2\left[\frac{2\pi S}{2\lambda}\sin(\theta_{in}) - \alpha\right]} \tag{7}$$

So, array factor has maximum value at N^2. It also concluded that by increasing the number of arrays, beamforming, pattern and directivity also increased (Parker & David, 2002).

Figure 2 Block Diagram of N-elements of Phased Array



Target Modelling in Phased Array Radar

Phased array antenna is used in radar for multi-detection of multiple targets. Using phased array antenna, information of several targets with different speeds are collected due to phased array antenna it would be possible to obtain information of multi targets.

$$B_{p=B+1+\frac{2}{B}} \tag{8}$$

$$B = 10logL/\lambda\left\langle 1 + \left|\frac{sinL}{Pos}\right|.1\right\rangle - \ln(1-\beta) \tag{9}$$

$$T_{2.n} = B_{\frac{p}{N^2}}(2 - e^{-\sigma^2})\sum_{i=1}^{N}|R_n(P_i)| \tag{10}$$

B_p denotes the function of array parameters, N is the number of array elements and L is length of linear array and P_{os} is distance between array center and target center, β denotes the confidence level. σ^2 is the phase error variance from the scattering center (Wei, Zhang, Jun & Zhong, 2007).

Maximum Directivity in Phased Array Antenna

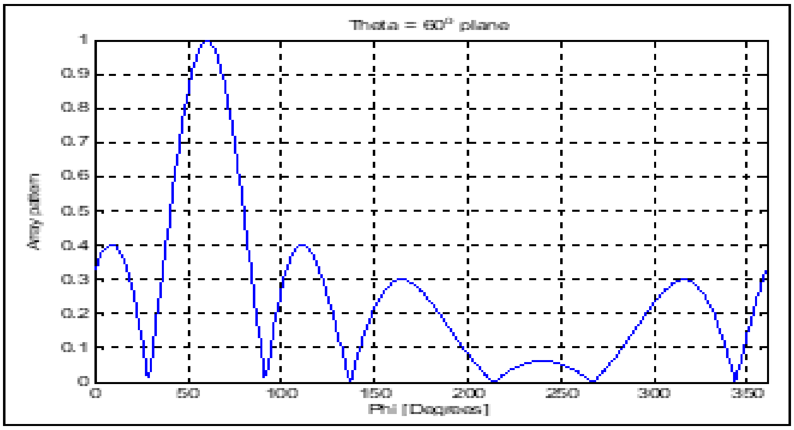
Directivity is defined the maximum directionality of the radiation pattern of a phased array element. Maximum directivity can be achieved by transmitting more radiation in a specific direction. So, directivity can be written in this form:

$$D = 4\pi\frac{U_{rad}(\theta,\vartheta)}{P_{total}} \tag{11}$$

$U_{rad}(\theta,\vartheta\ )$ represents the radiant concentration of transmitter in the direction $(\theta,\vartheta\ )$; P_{total} denote the total power of transmitter. Directivity measures the sensitivity toward radiation arriving from a specific direction in phased array. Directivity can be calculated by integration the far-field transmitted radiant intensity over all directions in space to compute total transmitted power (Jack, 1998).

SIMULATION RESULTS

Figure 3 Array Pattern at Theta 60 Plan



Grating lobes are created due to improper spacing between phased array elements but minimizing the grating lobes, maximum gain, directivity and beamforming achieved.

CONCLUSION

The direction of the peak sensitivity collective antenna can be altered with electronically phase shifters. Beam position can be switch fast as phase can be switch. The radar is to be designed for 2-D surveillance and fan type beam is proposed. Moreover, the fan beam is derived from the number of elements which would take part in the beam forming process. Total numbers of antenna elements are there for beam steering along the azimuth direction and few antenna elements are stacked together to provide fixed beam area along elevation.

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