Comparison Between the Radiation pattern of Uniform Circular Array and Uniform Planar Array

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Abstract— **In the smart antenna system, the commonly used geometrical arrangements are uniform planar array, and uniform circular array, they adapt to radiate their own beam patterns. The antenna arrays with different geometrical arrangements may produce the diverse radiation properties. The overall radiation pattern of an array is determined by this array factor combined with the radiation pattern of the antenna element. The overall radiation pattern results in a certain directivity and thus gain linked through the efficiency with the directivity. A comparison of radiation patterns of these arrays is made in the present paper. And the comparative conclusions are drawn.**

Keywords- ***Smart antenna array; uniform planar array; uniform circular array; array factor; directivity.***

I. INRODUCTION

Over the last few years, there has been an increasing demand for better quality, increased capacity and new value added services on existing wireless mobile communications network. This demand has brought technological challenges to service providers. In the form of "smart antennas" or "adaptive array antennas", they meet the challenging demand and bring many benefits to the wireless communications services. These benefits include the enhancement of coverage and the channel capacity, lower transmitted power, better signal quality, higher data rate, and provided value-added services such as users' position location. For some applications single element antennas are unable to meet the gain or radiation pattern requirements. Combining several single antenna elements in an array can be a possible solution.

The use of multiple antennas element sources provides more degrees of freedom in antenna design, permitting more control over the radiation pattern of the antenna, than can be conveniently obtained with a continuous source. Further, the circuitry that interconnects the antennas may contain time-varying components, so that a time-varying antenna pattern may be generated. In particular, if the element excitation amplitudes are held fixed and the element phase is varied in a simple manner, the beam from the antenna can be moved rapidly without bulk physical motion of the antenna. The antenna elements can be arranged to form a 1 or 2 dimensional antenna array. Antennas exhibit a specific radiation pattern. The overall radiation pattern changes when several antenna elements are combined in an array. This is due to the so called array factor: this factor quantifies the effect of combining radiating elements in an array without the element specific radiation pattern taken into account. The overall radiation pattern of an array is determined by this array factor combined with the radiation pattern of the antenna element. The overall radiation pattern results in a certain directivity and thus gain linked through the efficiency with the directivity. Directivity and gain are equal if the efficiency is 100**%.**

In the smart antenna system, commonly used geometrical arrangements for array elements are uniform planar array (UPA) and uniform circular array (UCA). It is known that antenna arrays with different structures may radiate the different far-field characters, and generate the diversity of radiation patterns. Therefore, it is necessity to make a comparison of radiation patterns between these two forms of antenna arrays. This work is carried out in this paper and conclusions are drawn

II. UNIFORM ANTENNA ARRAY

In this paper comparison between UPA, UCA is done by using MATLAB software, under MATLAB signal processing toolbox is used. The antenna array design process is fundamentally similar to the filter synthesis problem. This enables the use of the signal processing functions in antenna array analysis and synthesis. Signal Processing Toolbox is a collection of tools based on the MATLAB numeric computing environment. The toolbox supports a wide range of signal processing operations, and radiation pattern can be obtained

Based on the narrow-band assumption [1], suppose the incident signal induced on the *kth* element of an antenna array, it is normally described in complex notation
As given in equation (1), Also ignoring the random noise

$$x_k = \rho_0 \exp(-j\omega\,\tau_k), \qquad k= (1, 2, 3, ..k) \tag{1}$$

also ignoring the random noise, here in equation (1) ρ_0 is the complex modulating function of incident wave. Supposing that signals from each element are multiplied by a complex weight w , the expression for the array output can be given by

$$Y_0 = \sum_{k=1}^{k} \omega_k\, x_k = \sum_{k=1}^{k} \omega_k\, \rho_0 \exp(-j\omega\,\tau_k) \tag{2}$$

and τ_k denotes the delay between the *kth* element and the reference element, where *k w* takes the form of

$\omega_k = \exp(j (k-1) \beta_\omega)$ and $\beta_\omega = 2\pi d \cos\theta_\omega / \lambda$

The normalized radiation pattern of an array can by easily obtained by

$$G(\theta) = |Y_0| / \max\{|Y_0|\} \quad (3)$$

$$\tau = (x\cos\theta\cos\phi + y\sin\theta\cos\phi + z\sin\phi) / c \quad (4)$$

For UPA, If *M* by *N* elements are arranged along the x axis and y axis to form a UPA, then (4) can be depicted by

$$\tau_k = (x_k \cos\theta\cos\phi + y_k \sin\theta\cos\phi) / c \quad (5)$$

Similarly, for a UCA placed elements in circular form, if the reference point is located at the center of the UCA, we may also rewrite (4) as

$$\tau_k = R\cos[2\pi(k-1) /k-\theta]\cos\phi /c \quad (6)$$

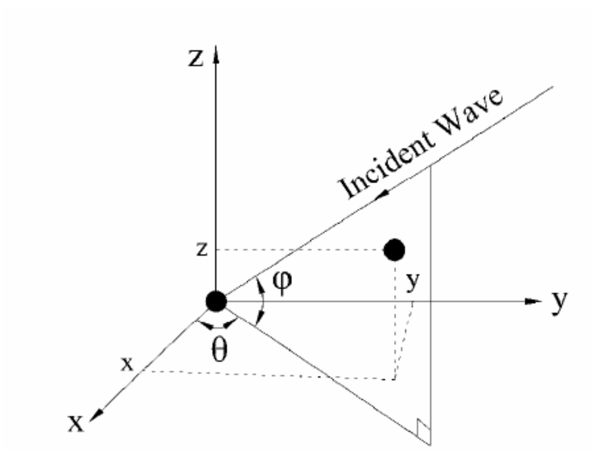


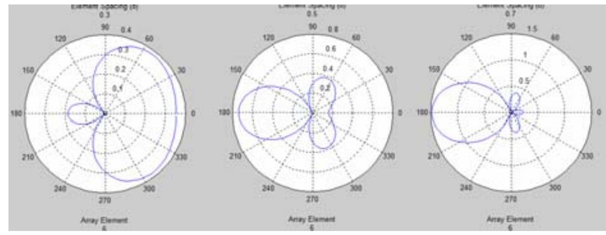
Fig.1. The coordinate system for two arbitrary elements in space

The diagram above is showing the coordinate system for two arbitrary elements in space. Thus similarly as above the array output can be obtained using above equations and thus radiation pattern can be obtained using MATLAB software. Signal processing tool is used in obtaining the polar plots of radiation pattern.

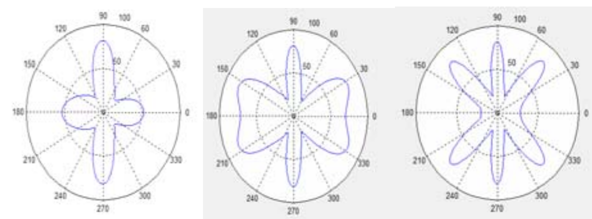
I. ANALYSIS AND COMPARISON

A. Influence of distance on radiation pattern

In this subsection, we analyze the influence of the inter-element distance *d* on radiation pattern, as illustrated in Fig. given below. It can be observed clearly that the beam widths of all major lobes became narrow and the number of minor lobes increases, when the inter-element distance increases. In addition, it can be found that for the UPA and UCA the directions of major lobes are not fixed, while the distance is varied. It is also observed that for UPA direction of major lobe is not fixed as the interelement spacing increase, while the numbers of element remain same. Furthermore it is also observed that UPA provide beam steering, whereas UCA does not have such capability.



(a) UPA for interelement spacing 0.3, 0.5,0.7, respectively

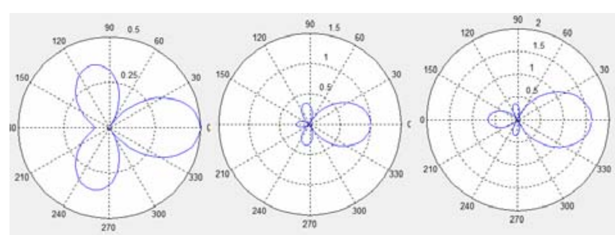


(b) UCA for interelement spacing 0.3, 0.5, 0.7, respectively

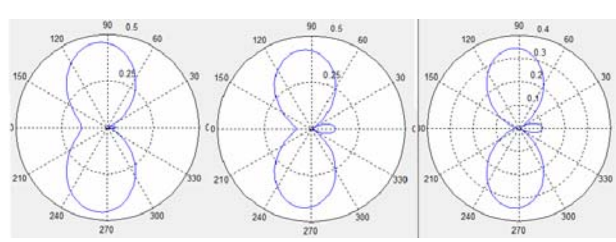
Fig. 2. The influence of a distance on radiation pattern for (a) UPA; (b) UCA

B. Influence of the number of elements on radiation pattern

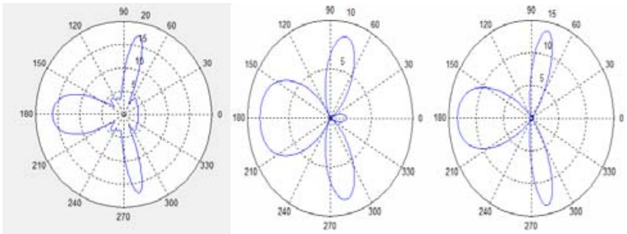
For UPA larger the number of elements, narrorower is the beam width of major lobes and greater is the number of minor lobes. For UCA directivity become increase. There is no significant change if we take even or odd number of elements. For UPA only if number of element is even, maxium radiation is along y-axis. If we take odd, radiation is along x-axis. UPA provide more symmetrical pattern than UCA. UPA provide directional beam wheras UCA is more suitable to construct omidirectional antennas.



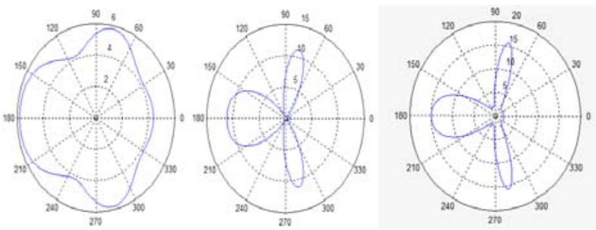
(a) UPA for even number of elements 4,6,8 respectively



(b) UPA for odd number of elements 3,5,7 respectively



(c) UCA for even number of element 4, 6, 8 respectively



(d) UCA for odd no. of elements 3, 5, 7 respectively

Fig. 3. The influence of the number of elements on radiation pattern for (a),(b)UPA; and (c),(d) UCA

IV. CONCLUSION

The radiation patterns of the UPA, UCA, are compared in the present paper. Directivity of UPA is more than UCA as it clearly visible in polar plots. However, the UCA is more suitable to construct an omnidirectional antenna. But for the UPA, it is more adaptable and can produce more symmetrical pattern when compared with the UCA, and the directivity of UPA is more than UCA. Future work can be to set the parameters on which maximum directivity can be obtained.

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