MODIFIED CONCENTRIC CIRCULAR MICROSTRIP ARRAY CONFIGURATIONS FOR WiMAX BASE STATIONS

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ABSTRACT

As the increasing demand for higher capacity, better coverage and higher transmission quality rises, array antennas are used in mobile communication systems. For WiMAX application different microstrip antenna array configurations such as uniform circular, uniform concentric and modified uniform concentric circular arrays are studied for 3.3 GHz frequency band. Based on the simulation results obtained it is shown that modified concentric circular array outperforms other array configurations in terms of half power beamwidth, number of side lobes and main lobe to side lobe ratio.

Keywords – *Half power beamwidth, Microstrip array, modified concentric circular array, WiMAX.*

1. INTRODUCTION

The demand for wireless mobile communication services are growing at an explosive rate, with the anticipation that communication to a mobile device anywhere on the globe at all times will be available in the near future. An array of antennas may be used in a variety of ways to improve the performance of communication systems. A very popular type of antenna arrays is the circular array which has several advantages over other schemes such as all-azimuth scan capability and the beam pattern can be kept invariant. Concentric circular array (CCA) that contains many concentric circular rings of different radii and number of elements have several advantages including the flexibility in array pattern synthesis and design both in narrowband and broadband beamforming applications [1–2]. WiMAX, Worldwide Interoperability for Microwave Access, is a telecommunication technology that provides wireless transmission of data using a variety of transmission modes from point to multi point links. The technology is based on IEEE 802.16 standard.

The WiMAX standard specifies 2 to 11 GHz as usable operating frequency range for modulation and channel access etc., WiMAX base station antenna requires a minimum gain of 18 dBi with a beamwidth of 10 degrees [3]. This paper focuses on the concentric and modified concentric microstrip patch array antennas for WiMAX applications. Microstrip patch antennas are popular, because they have a very low profile, mechanically rugged and can be conformable, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices. Microstrip Antennas are also relatively inexpensive to manufacture and design because of the simple 2D physical geometry [4-5]. In this work, the microstrip array is simulated at 3.3 GHz with substrate element as glass epoxy having dielectric constant ε_r = 4.4 for all discussed array configurations.

The paper is arranged as follows; in Section 2, the array geometry of uniform circular array (UCA) and its radiation characteristics are analyzed. Section 3 studies the uniform concentric circular array (UCCA) while Section 4 explains the proposed model, modified concentric circular array (MCCA) and the variations of half-power beamwidth (HPBW), number of side-lobes and main-lobe to side-lobe ratio. In Section 5, deals with the results and discussions of the existing and proposed circular array configurations and finally Section 6 concludes the paper with future work.

2. GEOMETRY OF THE UNIFORM CIRCULAR ARRAY

The circular array, in which the elements are placed in a circular ring, is an array configuration of very practical interest [6]. In uniform circular array, N elements are placed in a circular ring of radius ‘a’. The spacing between the elements is 0.5λ as shown in figure 1. Using circular array the beam scanning of 360^0 can be obtained without change in antenna design parameters [7].

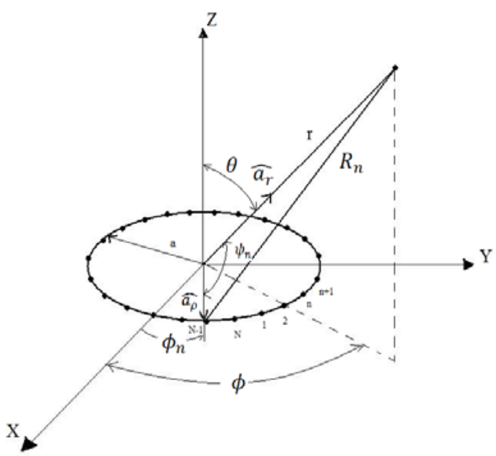

Figure 1. Uniform circular array

The array factor for the circular array is given by [6],

$$AF(\theta,\phi) = \sum_{n=1}^{N} I_n \, e^{j[ka\sin\theta\cos(\phi-\phi_n)+\alpha_n]} \quad (1)$$

where I_n = Amplitude excitation of nth element
α_n = Phase excitation of nth element.

The radiation pattern of 8 and 16 elements UCA is obtained by the array factor approach. From figure 2, it is evident that by increasing the number of elements, reduces the HPBW but with increase in side lobes.

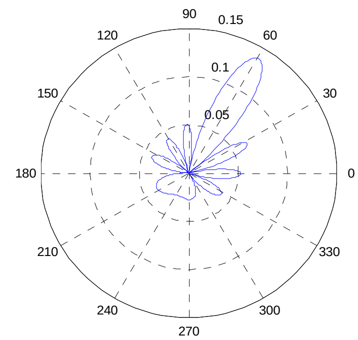

Figure 2.1 Radiation Pattern of UCA, N=8, DOA = 60^0

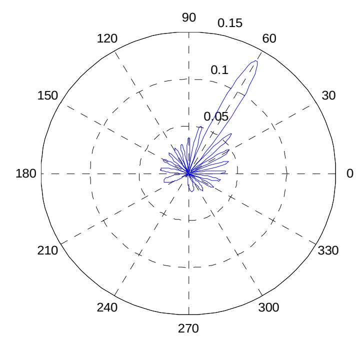

Figure 2.2 Radiation Pattern of UCA, N=16, DOA = 60^0

3. GEOMETRY OF THE UNIFORM CONCENTRIC CIRCULAR ARRAY

The concentric circular array, in which the elements are placed in a concentric circular fashion. Here the number of elements in each concentric circle decides the beam width and number of side lobes in the radiation pattern. Figure 3 shows the configuration of concentric circular arrays in which there are M concentric circular rings. The mth ring has a radius r_m and number of elements Nm where m = 1, 2, . . . , M. Assuming that the elements are uniformly spaced within the ring.

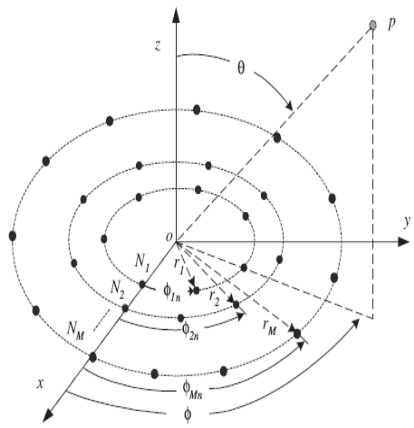

Figure. 3 Uniform concentric circular array

The array factor of concentric circle array is obtained by pattern multiplication concept. It is given by (2),

$$AF(\theta,\phi) = N I_o \sum_{n=1}^{N} J_{mN}(k\rho_o)\, e^{jmN(\pi/2-\xi)} \qquad (2).$$

In [8], it is found that the existence of the central element can control the side-lobe level with minimal beamwidth increase with the main lobe to side lobe ratio of 20 dB. This was achieved by increasing the number of rings in the array (M = 7, 8 and 15), which results in increased number of side lobes. For uniform concentric circular array (M=2), the half power beamwidth widens but the number of side lobes decrease as shown in figure 3.1.

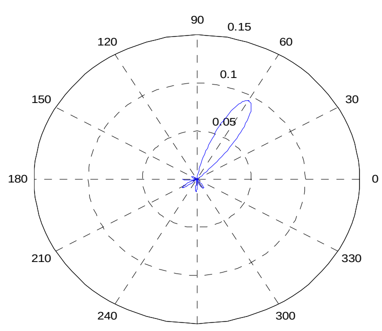

Figure 3.1 Radiation Pattern (Polar plot) of UCCA, M=2, DOA = 60^0, N_1 =4 and N_2 =8

4. PROPOSED METHOD

In proposed method the number of side lobes has been drastically reduced by using minimal number of rings (M = 4) in the array without affecting the main lobe to side lobe ratio. This is obtained by varying the number of elements in each ring rather than as a function of the number of element of the innermost circular array. The simulation is done for two cases, in case 1 by having N_1 through N_4 as 4, 8, 16, and 32 and in case 2 as 8, 16, 32, and 64 elements.

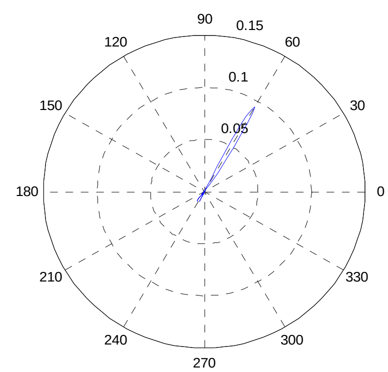

Figure 4.1 Radiation Pattern (Polar plot) of MCCA, M=4, DOA = 60^0
N_1 =4, N_2 =8, N_3 =16, and N_4 =32

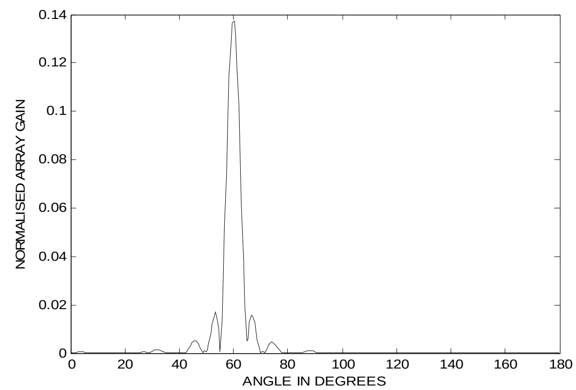

Figure 4.2 Radiation Pattern (Cartesian plot) of MCCA, M=4, DOA = 60^0 N_1 =4, N2 =8, N_3 =16, and N_4 =32

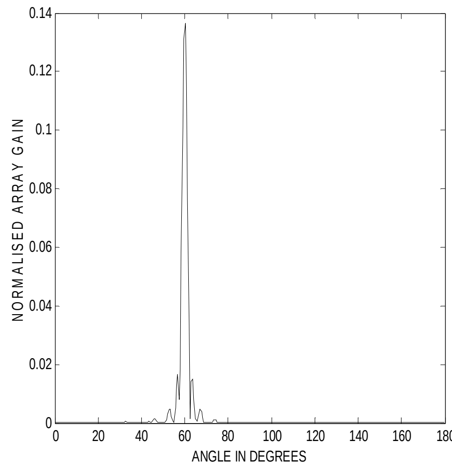

Figure 4.4 Radiation Pattern (Cartesian plot) of MCCA, M=4, DOA = 60^0 N_1 =8, N_2 =16, N_3 =32, and N_4 =64.

Table 1 Comparison of UCA and UCCA for DOA = 60^0

Array Configurations	HPBW (Degrees)	Number of Side Lobes
Circular (N=8)	20.6265	**7**
Circular (N=16)	10.3132	**16**
Concentric Circular	17.1887	**5**

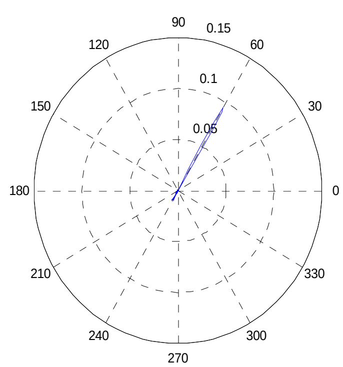

Figure 4.3 Radiation Pattern (Polar plot) of MCCA, M=4, DOA = 60^0 N_1 =8, N_2 =16, N_3 =32, and N_4 =64.

Table 2 Comparison of MCCA for DOA = 60^0

Modified Concentric Circular Array	HPBW (Degrees)	Number of Side Lobes	Main Lobe to Side Lobe Ratio (dB)
N1 =4, N2 =8, N3 =16, & N4 =32	4.5837	4	18.416
N_1 =8, N_2 =16, N_3 =32, & N_4 =64.	2.2918	3	18.272

5. RESULTS AND DISCUSSIONS

From table 1, the uniform circular array configurations are found to have high directivity and low beamwidth. When the number elements are increased the directivity and half power beamwidth can be improved but results in increased number of side lobes. When the elements are arranged in uniform concentric circular fashion (M=2), it is found that a single main lobe is formed with increased half power beamwidth but having less number of side lobes.

From table 2, the proposed modified concentric circular array (M=4), with case 1 and 2, it is evident that by varying the number of elements in each ring rather than increasing the number of rings have shown improved performance in terms of number of side lobes, reduced HPBW and desired main lobe to side lobe ratio. The MCCA which we have considered has outperformed other circular array configurations and found suitable for WiMAX base station antennas.

6. CONCLUSION

Concentric circular microstrip patch array configurations have been discussed and the array parameters such as the half power beamwidth, number of side lobes, and main lobe to side lobe ratio are analyzed. For WiMAX application requirements, the simulation results makes clear that modified concentric circular array without increasing the number of rings have improved performance. The extension of this work will be considering stacked circular and cylindrical array configurations by optimizing the mutual coupling effects due to surface waves.

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