Cosine Alpha Tapered Beamforming Window for Uniform Concentric Circular Array using in High Altitude Platform System

Hamdy A. Sharshar
Department of Electronics and Electrical Communications Engineering
Faculty of Electronic Engineering, Menouf 32951, Menoufia University, Egypt

***Abstract*-Concentric circular antenna array (CCAA) has interesting features over other array configuration which can be used in High Altitude Platform communications system, that it can perform 360 degree scan around its center. The idea of cellular communication using HAPs is to produce equalize circular footprints on the ground with low interference and high capacity so Beamforming techniques are used which can increase the power of the pattern in the direction the signal is to be sent and modify the array elements to steer a set of beams to form cells on the ground but with reduce the size and weight of the antenna array. In this paper, we study the effect of tapered beamforming function on side lobe and beamwidth reduction in uniform concentric circular array (UCCA).We have used Cosine Alpha function as a tapered window which reduce SLL that can reach to (-39.77 dB).**

*Keywords— **Concentric circular antenna array, High Altitude platform, and Cosine alpha function.***

1-INTRODUCTION

The antenna system is one of the most important performance factors in a HAP configuration. The antenna system in HAP must be directional antenna with a high gain to cope with attenuation in high frequencies as the co-channel cells are interference limited by antenna beam overlap. Minimization of interference can be attained by side lobe minimization [1]. In the beamforming antenna, the beam formed by a combination of the array antenna and spatial digital signal processing "Smart antenna" or "Software Antenna". The beamforming technique doesn't actually modify the radiation pattern of the array but operates at software. The hardware complexity becomes lower after using the beamforming [2]. From the previous, the beamforming antenna array is more suitable for HAP communication systems [1].Uniform Concentric Circular Array are used in HAPs for multiple beam transmission on HAPs-Earth downlink .the tapered beamforming windows are used to minimize the side lobe level which improve the performance of the antenna system in HAPs by estimating the position of the wanted location, modify and steering the radiation pattern of the array antenna towered the wanted location. From the previous introduction, the main purpose of using tapered beamforming techniques is to increase the directivity of the beam, decrease the side lobe level and modify the beamwidth to intermediate value wanted in the design of the system [3]. There are many types of windows can use in tapered beamforming technique such as: Rectangular window, Bartelett window "Triangle window", Hann window, Hamming window, Blackman window, Kaiser window, Rieman window, Bohman window, passion window, Gaussian window, Dolph-chebyshev window and $\cos^{\alpha}(t)$ window[4]. In this paper, we will discuss the $\cos^{\alpha}(t)$ window and its effect in side lobe level of uniform concentric circular array.

2-STRUCTURE OF UNIFORM CONCENTRIC CIRCULAR ARRAY

Concentric circular array contain many concentric circles. The circular array consists of elements are placed in circular rings of different diameters, half wave separation space and different number of elements per ring. Figure (1) explains the configuration of Concentric Circular Array.

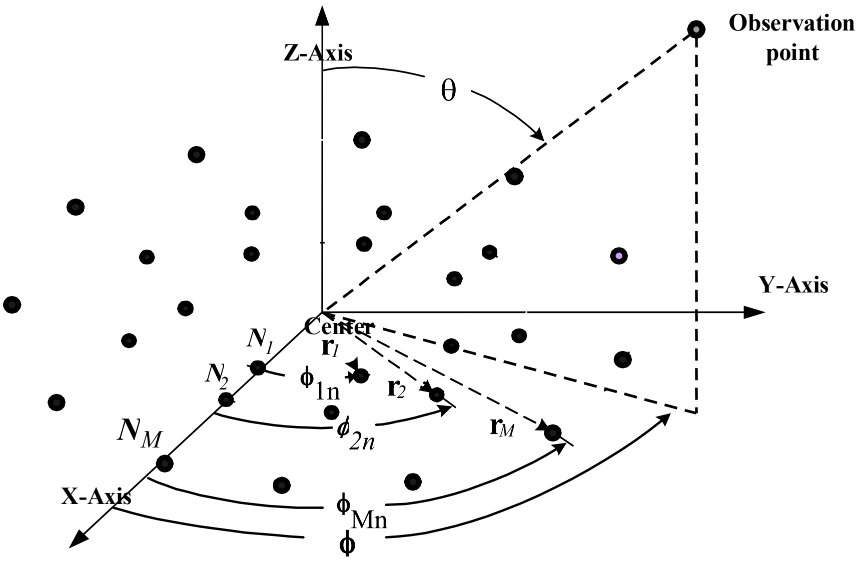


Figure 1: Concentric Circular Antenna Array.

ISSN: 2278 – 1323

"M" is the number of concentric rings. The (m^{th}) ring has a radius "r_m" and number of elements N_m where m= 1, 2, 3 …M.

The separation angle as the elements are uniformally spaced can be calculated:

$$\psi_m = \frac{2\pi}{N_m} \quad \text{……………………………………………. (1)}$$

The elements in the rings are located with an angle measured from the X-axis given by:

$\phi_{mn} = n\psi_m$ Where n= 1, 2…..N_m………………………. (2)

The field measured at the observation point is given by:

$$E_m(r,\theta,\phi) = \frac{e^{-jkr}}{r} \sum_{n=1}^{N_m} I_{mn} e^{jkr_m \sin\theta\cos(\phi-\phi_{mn})} \quad \text{………… (3)}$$

Where $k = \frac{2\pi}{\lambda}$ is the wave number, I_{mn} is the excitation coefficient (amplitude and phase) of the mn^{th} element and the array factor for one ring will be:

$$Af_m(\theta,\phi) = \sum_{n=1}^{N_m} I_{mn} e^{jkr_m \sin\theta\cos(\phi-\phi_{mn})} \quad \text{Where n=1, 2…..}N_m \quad \text{… (4)}$$

For all concentric circle array antennas, we assume that array factor above as the array factor of one element and to calculate the array factor of all concentric circle array antennas will be:

$$Af(\theta,\phi) = \sum_{m=1}^{M} Af_m(\theta,\phi) \times e^{jKr_m} \quad \text{……….. (5)}$$

$$Af(\theta,\phi) = \sum_{m=1}^{M} \sum_{n=1}^{N_m} I_{mn} e^{jKr_m (1+\sin\theta\cos(\phi-\phi_{mn}))} \quad \text{…… (6)}$$

The radiation pattern of the array antenna can be controlled by controlling the amplitude and phase of the excitation currents "I_{mn}" this is the first step to form the beam of the radiation antenna. [5, 6, 7].

3- THE TAPERED WINDOW (COSA(T))

The tapering window that we use in this paper is cosine alpha tapered window (W_T) that is shown in this section:

$$W_T = \cos^{\alpha}\left[\left(\frac{n}{N}\right)\pi\right] \quad \text{……………………………….. (7)}$$

Where n= -N/2…………., -1, 0, 1…………..N/2

Common values α: $1 \le \alpha \le 4$

The next figures shown the tapered window at different values of (α)

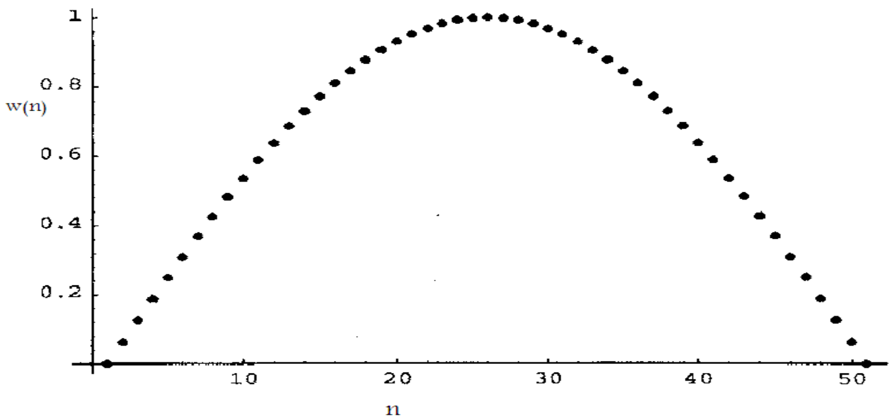


Figure (2) cosine widow with α=1

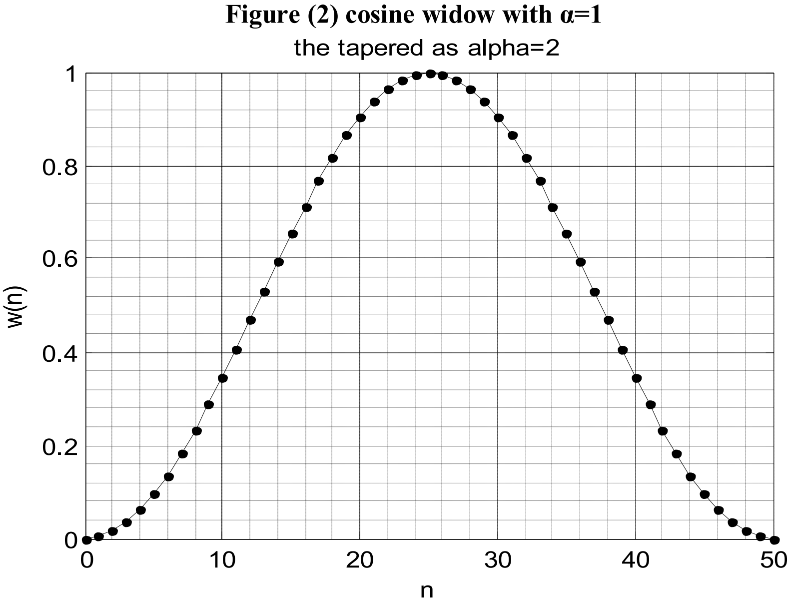


Figure (3) cosine widow with α=2

ISSN: 2278 – 1323

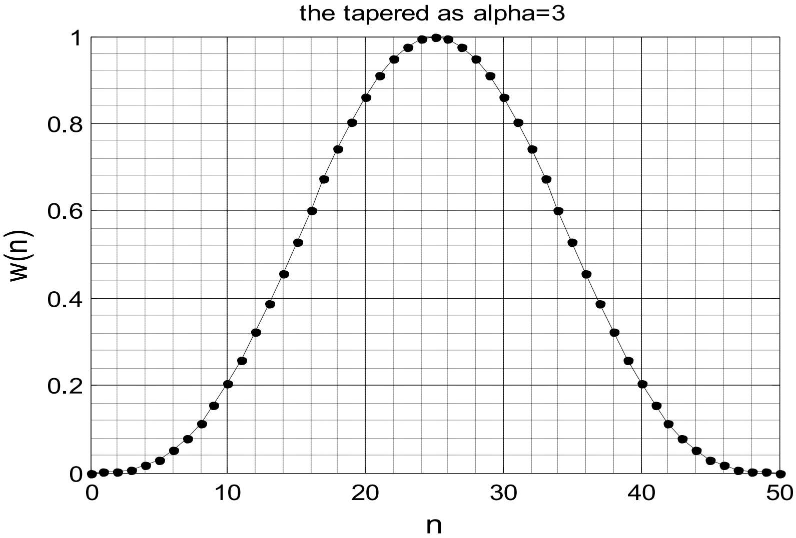


Figure (4) cosine widow with α=3

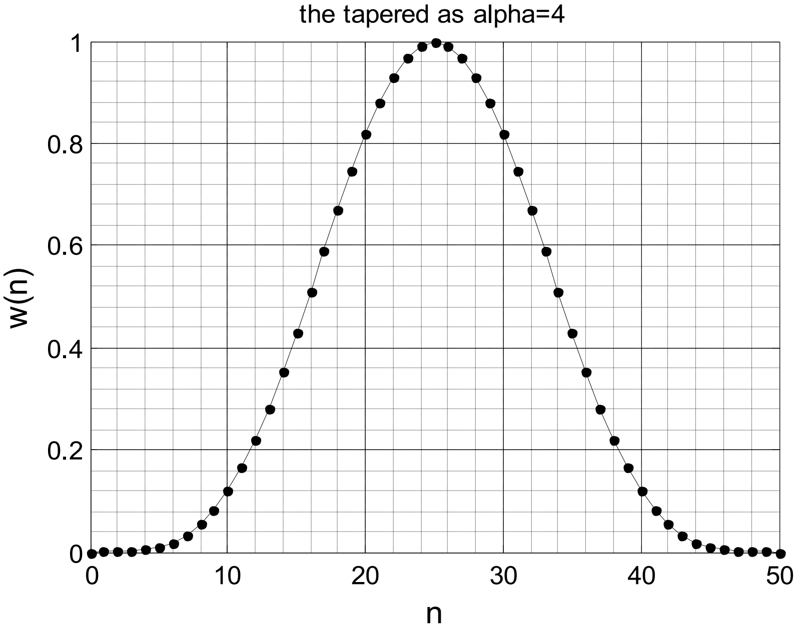


Figure (5) cosine widow with α=4

$$W_m = W_T Af_m(\theta_0, \phi_0) \quad (8)$$

Where (θ_0, ϕ0) is the direction of the main lobe and $Af_m(\theta_0,\phi_0)$ is the array factor at the desired direction.

$$G(\theta,\phi) = \sum_{m=1}^{M} W_m Af_m(\theta,\phi) \quad (9)$$

The power patterns for uniform and cosine alpha tapered will be shown in the next figures.

4- The effect of COSA window on the SLL of the radiation pattern of UCCA

To study the effect of cosine alpha on the radiation pattern of UCCA we change the value of alpha from 1 to 4 step 1 and change the number of rings on the array from 5 to 20 step 5 we find that the radiation pattern will be as shown in figures:

ISSN: 2278 – 1323

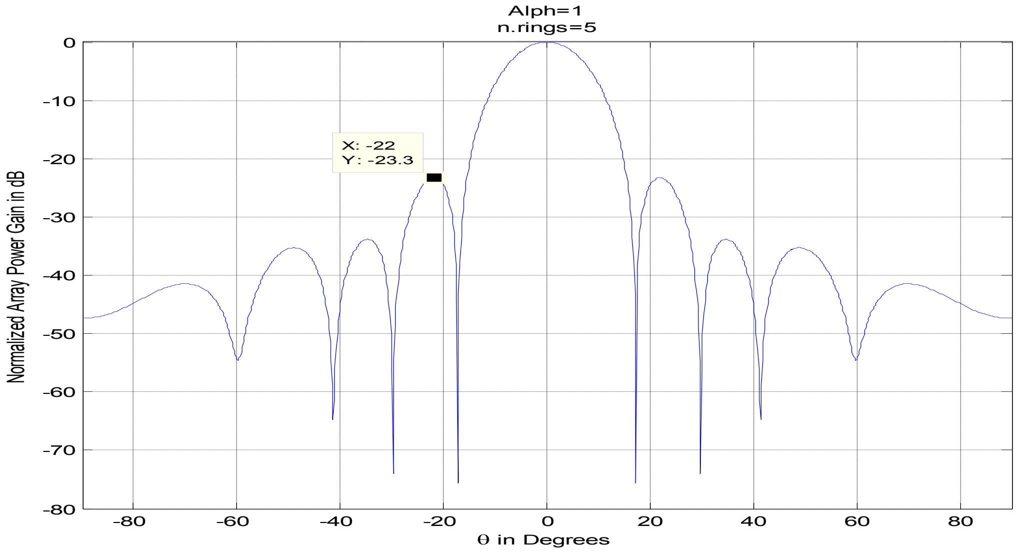


Figure (6) the radiation pattern of UCCAA with α=1 and n=5

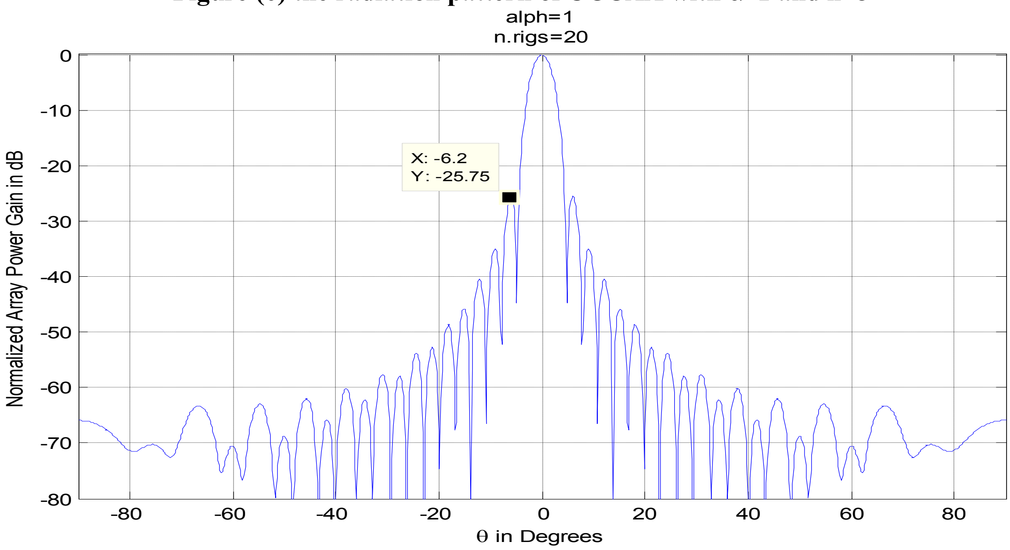


Figure (7) the radiation pattern of UCCAA with α=1 and n=20

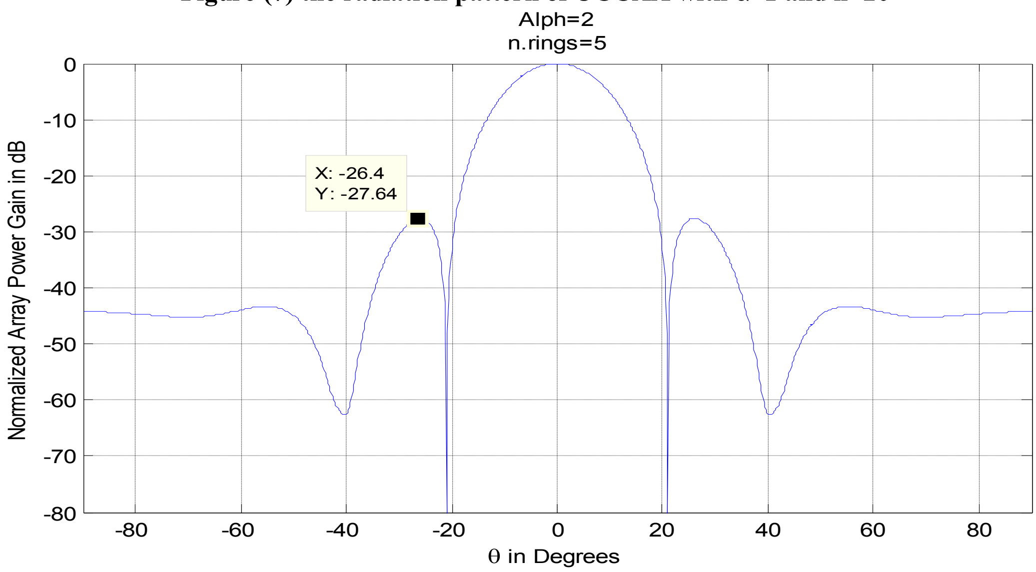


Figure (8) the radiation pattern of UCCAA with α=2 and n=5

ISSN: 2278 – 1323

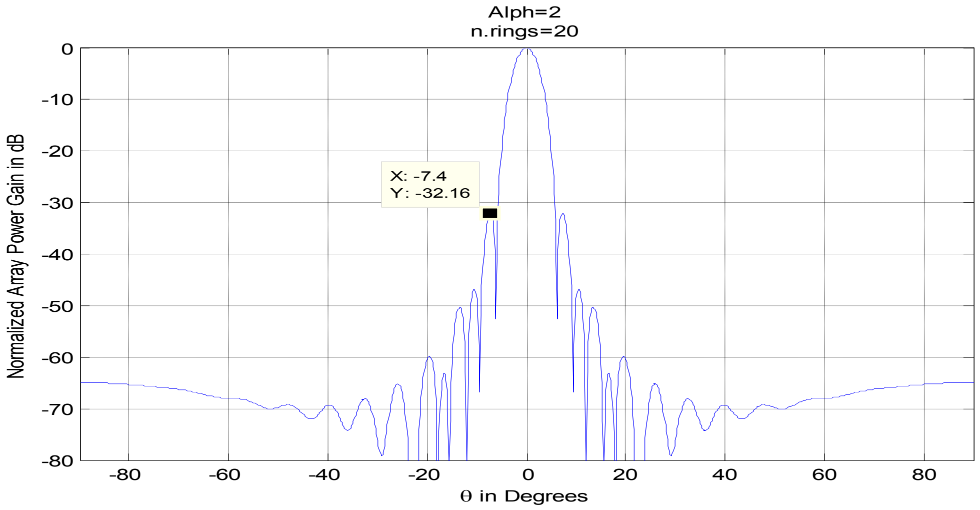


Figure (9) the radiation pattern of UCCAA with α=2 and n=20

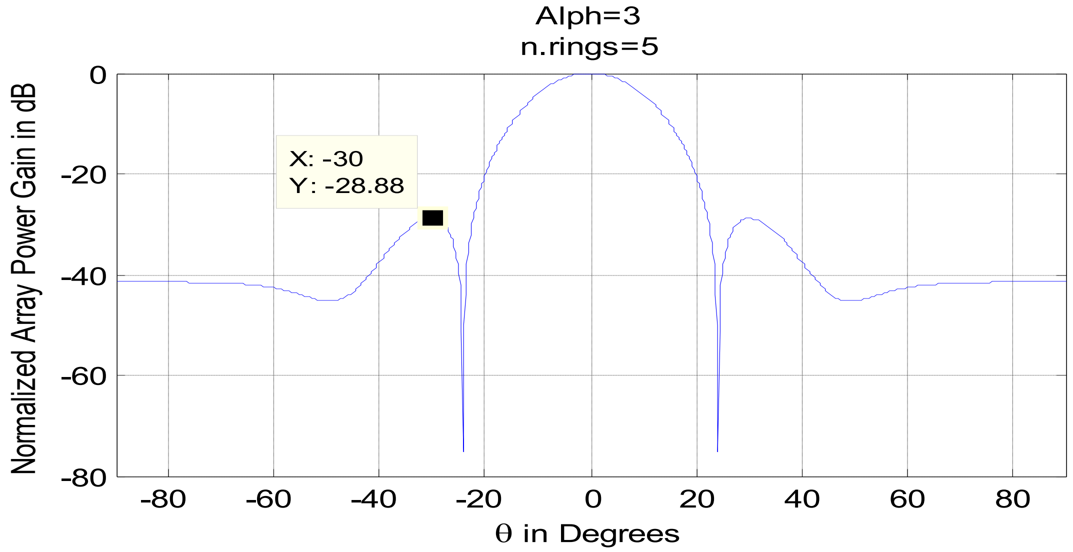


Figure (10) the radiation pattern of UCCAA with α=3 and n=5

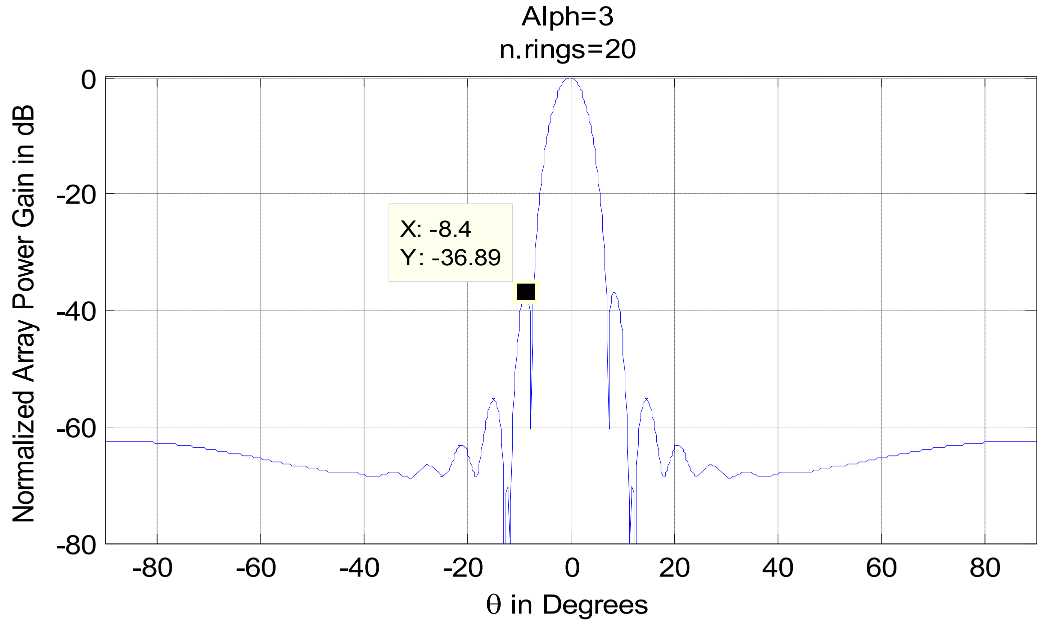


Figure (11) the radiation pattern of UCCAA with α=3 and n=20

ISSN: 2278 – 1323

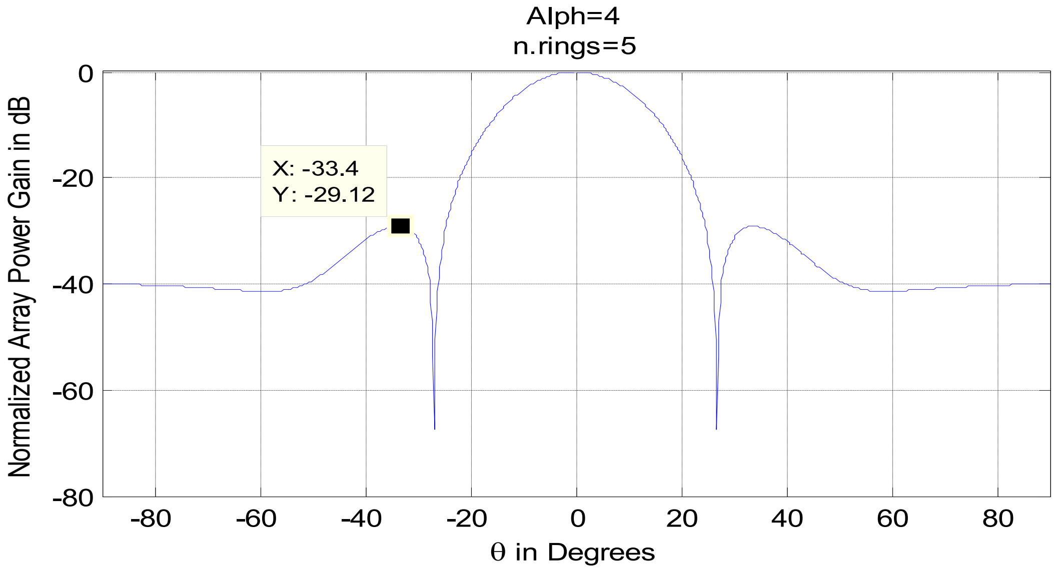


Figure (12) the radiation pattern of UCCAA with α=4 and n=5

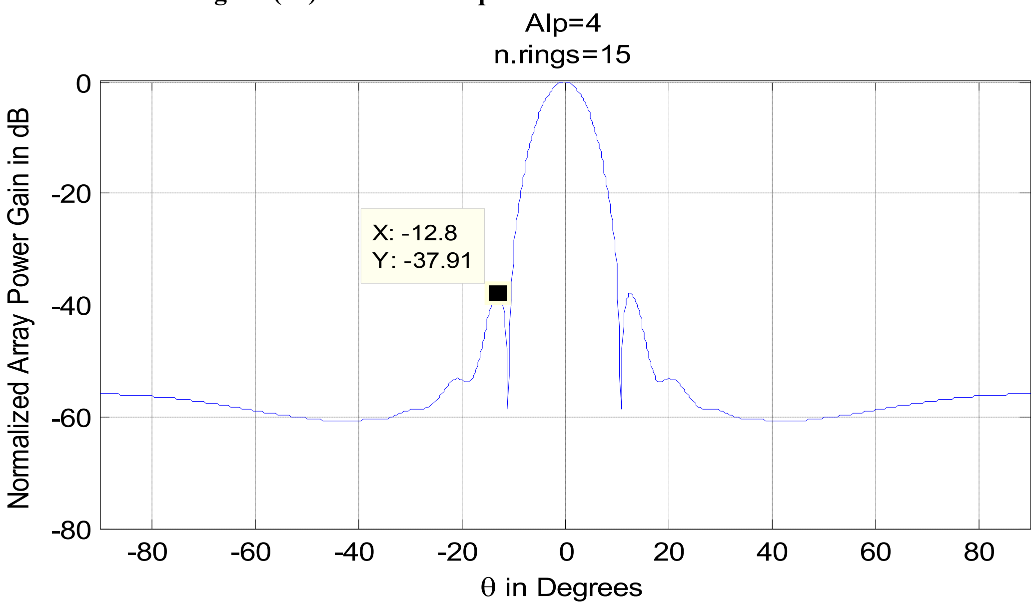


Figure (13) the radiation pattern of UCCAA with α=4 and n=15

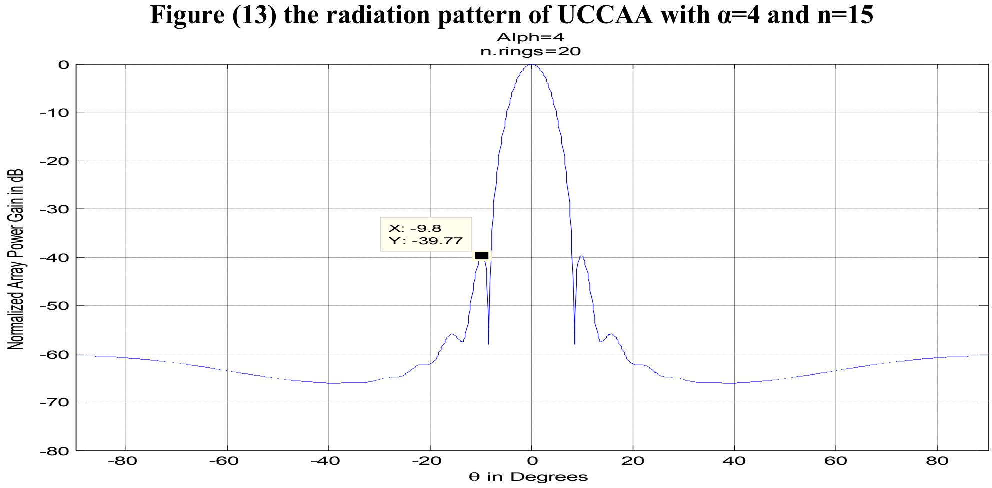


Figure (14) the radiation pattern of UCCAA with α=4 and n=20

We will put the maximum value of the Side Lobe Level in dB with various values of Alpha and changing the number of rings in the next table:

ISSN: 2278 – 1323

Alpha / n.rings	1	2	3	4
5	**-23.3**	**-27.64**	**-28.88**	**-29.12**
10	**-24.86**	**-30.42**	**-33.5**	**-34.92**
15	**-25.36**	**-31.51**	**-35.69**	**-37.91**
20	**-25.75**	**-32.16**	**--36.89**	**-39.77**

Table (1) Side Lobe Level in dB with various values of Alpha and changing the number of rings

From this table we can plot a figure explains the relation between the SLL and number of rings on the array with different value of alpha as shown in the next figure.

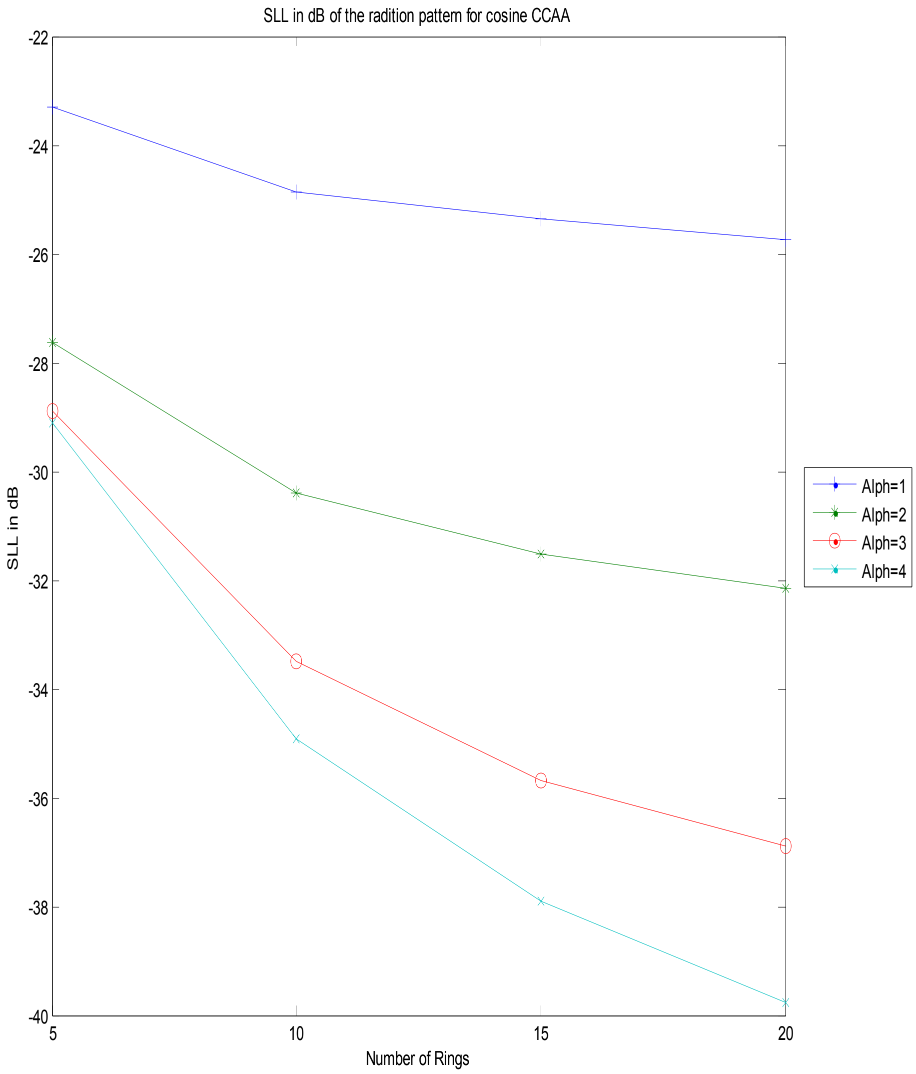


Figure (15) the side lobe level of UCCAA radiation pattern versus different number of rings with different values of α

ISSN: 2278 – 1323

5- Conclusion

In this paper we find that the "UCCAA" without using beamforming technique produce a radiation pattern with respectively SLL high (-18 dB) and wide beam width with low power these parameters increase the interference between the channels on the communications systems and reduce the CNR. The SLL in cellular communications needs to reduce especially in the center cell. The figures of the patterns that were displayed above explain the effect of cosine alpha window that reduce the SLL which can reach (-40dB) in figure (14). The number of rings in the antenna array also affects the SLL of the radiation pattern. It is found that for UCCAA the best SLL with value of (α=4) and number of rings equal (20 rings).

References

[1] S.Karapantazis and F.-N. Pavlidon, "Broadband communications VIA high altitude platforms: ASURVEY", IEEE communications surveys& Tutorials, first Quarter 2005, pp. 1-31, 2005.

[2] Leslie Balmer"signals and systems and introduction"2nd edition, Prentice Hall, 1991-1997.

[3] Alejandro Aragon-Zavala, Jose Luiscuevas-Ruiz and Jose Antonio Delagado-penin"High Altitude Platforms for wireless communications", Wiley&Sons, 2008.

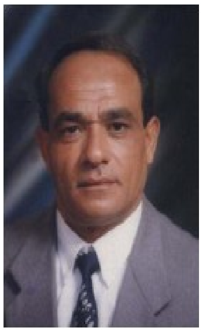
[4] Poularikas A.D."the handbook of Formulas and tables for signal processing"CRC press LLV, 1999.

[5] Moawad Dessouky, Hamdy Sharshar, Yasser Albagory, "Effeciecnt Sidelobe Reduction Technique for Small-Sized Concentric Circular Arrays," Progress In Electromagnetics Research, *PIER 65*, pp. 187-200, 2006.

[6] Moawad Dessouky, Hamdy Sharshar, Yasser Albagory, "A Novel Tapered Beamforming Window for Uniform Concentric Circular Arrays" Journal of Electromagnetic Waves and Applications, *JEMWA*, Vol. 20, No. 14, pp. 2077-2088, 2006.

[7] Moawad Dessouky, Hamdy Sharshar, Yasser Albagory, "Optimum Normalized-Gaussian Tapering Window for Side Lobe Reduction in Uniform Concentric Circular Arrays," Progress In Electromagnetics Research, *PIER 69*, pp. 35 –46, 2007.

[8] Balanis, C. A.,"Antenna Theory: Analysis and Design"Harper Row, New York, 1982.



Dr. Hamdy A. Sharshar was born in Menoufia State, Egypt country in 24 July, 1956. Received the B.Sc., M.Sc., and Ph.D. scientific degrees in the Electronics and Electrical Communications Engineering Department from Faculty of Electronic Engineering, Menoufia University in 1979, 1987, and 1993 respectively. Currently, his job carrier is Asscoc. Prof. Dr. in Electronics and Electrical Communications Engineering Department, Faculty of Electronic Engineering, Menoufia university, Menouf 32951, Egypt. His scientific master science thesis has focused on **Electromagnetic scattering by plane and curved surfaces**. As well as his scientific Ph. D. thesis has focused on **Helical Antennas**. His interesting research mainly focuses on wireless communication, radio over fiber communication systems, and optical network security and management. His areas of interest and experience in wireless optical access networks, analog communication systems, optical filters and Sensors, network management systems, multimedia data base, network security, encryption and optical access computing systems.

ISSN: 2278 – 1323