Side Lobe Level Reduction in Antenna Array Using Weighting Function

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Abstract— **Phased array antennas are generally used for the inherent flexibility to steer the beam electronically and also the need for specialized multi-function radar systems. In the antenna arrays the side lobe level is main problem which causes the wastage of energy. In this paper a different windowing techniques are used to suppress the side-lobes in linear, planar and circular array antennas, by varying the various parameters like number of antenna elements, scan angle, element spacing and window coefficients. The result of antenna gain pattern has been simulated by applying Kaiser, Hamming, Hann and Blackman window. It is revealed that the Blackman window is better for reduction of side lobe in analyzing linear, rectangular and circular array antennas.**

Keywords—Array antenna, Weighting Function, SNR, SLL and Gain pattern

I. INTRODUCTION

Array antenna which is comprised of a number of identical radiating elements in a regular arrangement and excited to obtained a prescribed radiation pattern, play significant role in detecting and processing signals arriving from different directions. The communication system depends on the antenna arrays for their performance. The synthesis of antenna array aims at obtaining a physical structure whose radiation pattern is close to the preferred radiation pattern whereas the use of a single element has numerous limitations in terms of directivity. The array also enabled the antenna system to be automatically steered – to receive or transmit information mostly from a particular direction without unconsciously moving the structure. Most of the applications recommend to attain high main lobe to side lobe ratio [1]. In this paper, a comparison of radiation pattern of linear, rectangular and circular antenna array for different window has been presented.

II. SYSTEM MODEL

A linear array is one consisting of a group of identical elements placed in one dimension along a given direction. Linear arrays may have equidistant or non equidistant element spacing. They are used in the analysis of the directional properties of arrays in antenna theory [2] and as building blocks for forming an array of arrays.

Figure 1 shows a linear array antenna consisting of N identical elements where the element spacing is d. Let element #1 serve as a phase reference for the array [3]. From the geometry, it is clear that an outgoing wave at the nth element leads the phase at the$(n+1)th$ element by $kdsin\beta$, where $k = \frac{2\pi}{\lambda}$

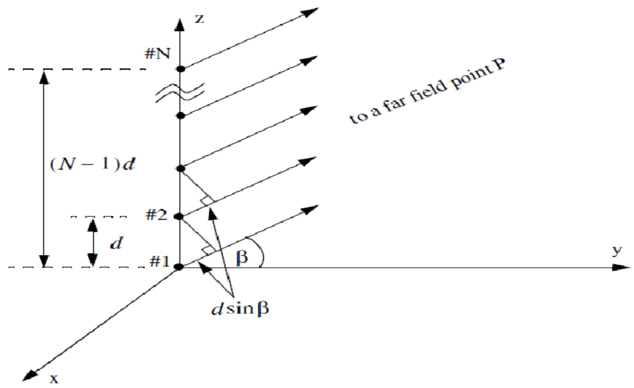


Fig. 1. Linear Antenna Array

The normalized intensity pattern is equal to

$$|E_n(sin\beta)| = \frac{1}{N}\left|\frac{\sin((Nkd\sin\beta)/2))}{\sin((kd\sin\beta)/2)}\right| \quad (1)$$

A planar array has all elements located in a single plane occupying a definite area [4]. Planar arrays have different configurations of elements.

Figure 2 shows a sketch of an $N \times N$ planar array formed from a rectangular grid. Other planar array configurations may be composed using a circular or hexagonal grid. Planar arrays can be steered electronically in both azimuth and elevation $(\beta, \emptyset)$.

$$|E(\beta,\emptyset)| = \left|\frac{\sin((Nkd_x\sin\beta cos\emptyset)/2))}{\sin((kd_x\sin\beta cos\emptyset)/2)}\right| \left|\frac{\sin\left((Nkd_y\sin\beta sin\emptyset)/2\right)}{\sin((kd_x\sin\beta sin\emptyset)/2)}\right| \quad (2)$$

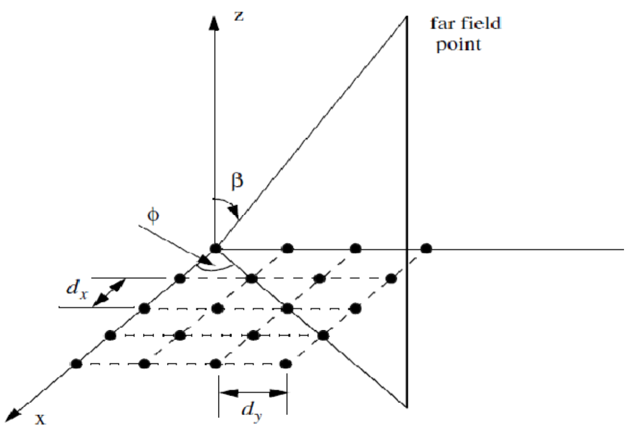


Fig. 2. Rectangular Antenna Array

Circular arrays can provide a 2D angular scan, both horizontal ∅ and vertical θ scans. Unlike 2D planar arrays, circular arrays are basically 1D linear arrays but in a circular form. It can scan horizontally for 360° with no distortions near the end-fire directions. Distortions in the array pattern due to mutual coupling effect are same for each element and this makes it easier to deal with the mutual coupling effect [5].

$$E_n(r,\theta,\emptyset) = \sum_{n=1}^{N} a_n \frac{e^{-jkR_n}}{R_n} \tag{3}$$

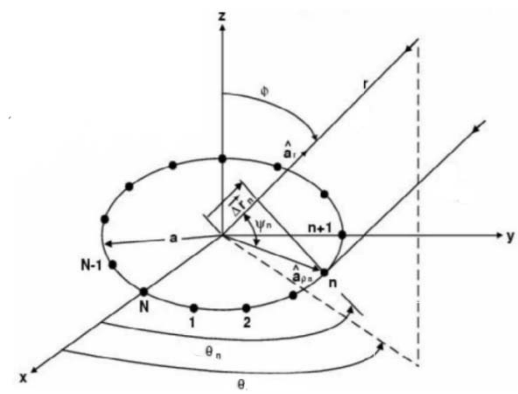


Fig. 3. Circular Antenna Array

III. SIMULATION

Simulation has been carried out for side lobe reduction in different antenna array using various windows. In the simulation we have used Kaiser, Hamming, Hann and Blackman window and observe the effect of window in Linear, Rectangular and Circular antenna array. MATLAB is used for linear antenna array whereas MATLAB based GUI interface is used for rectangular and circular antenna array.

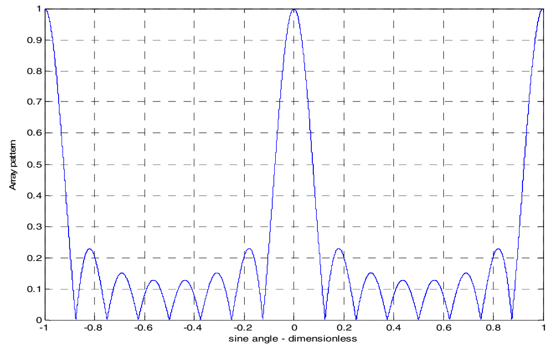


Fig. 4. Antenna Pattern of Linear Antenna Array

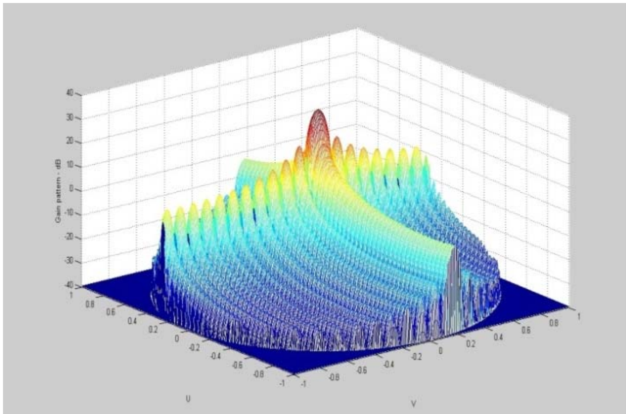


Fig. 5. Gain Pattern of Rectangular Antenna Array

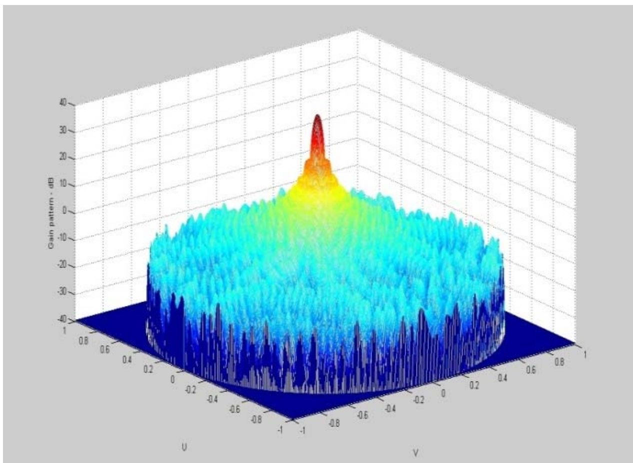
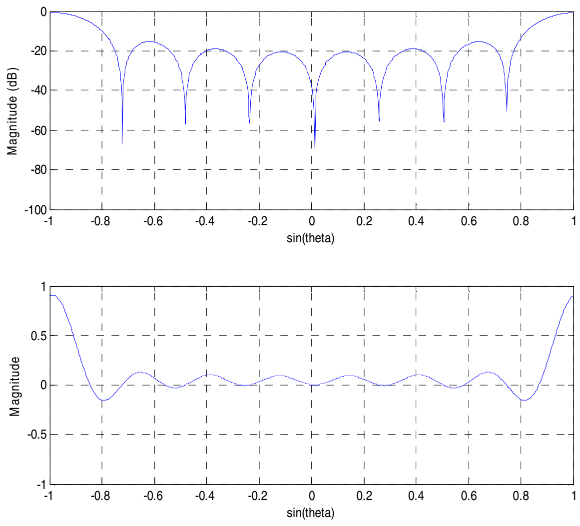


Fig. 6. Gain Pattern of Circular Antenna Array

Figure 4, Figure 5 and Figure 6 represent the gain pattern of Linear, Rectangular and Circular antenna array. In the figure there exists side lobe which reduces the signal strength.

IV. RESULT AND DISCUSSIONS

A performance comparison, in terms of side lobe reduction of different antenna array using Kaiser, Hamming, Hann and Blackman window has been carried out.



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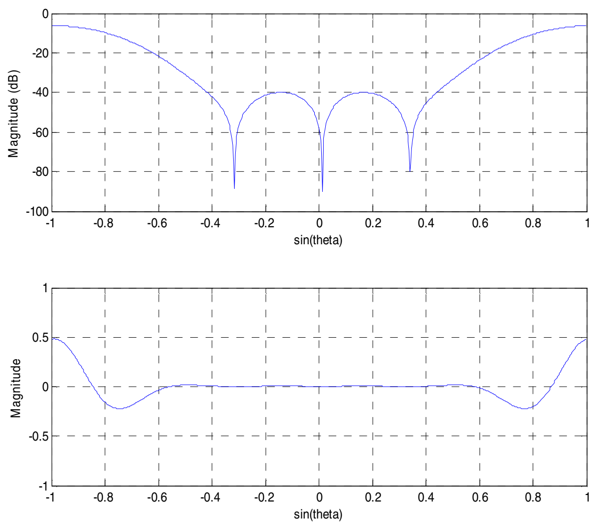

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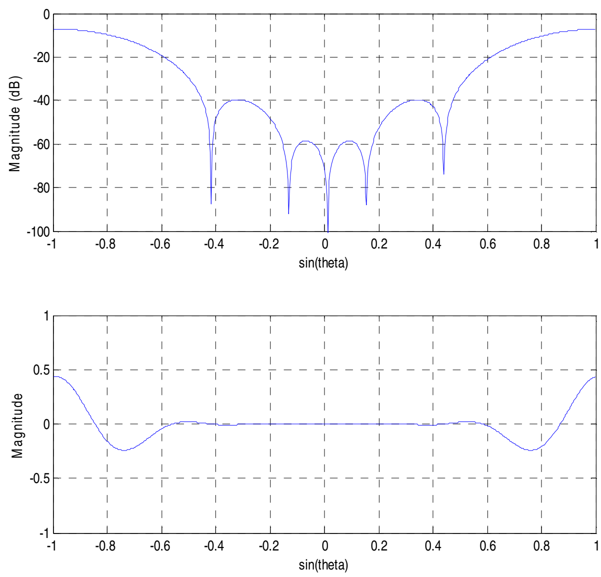

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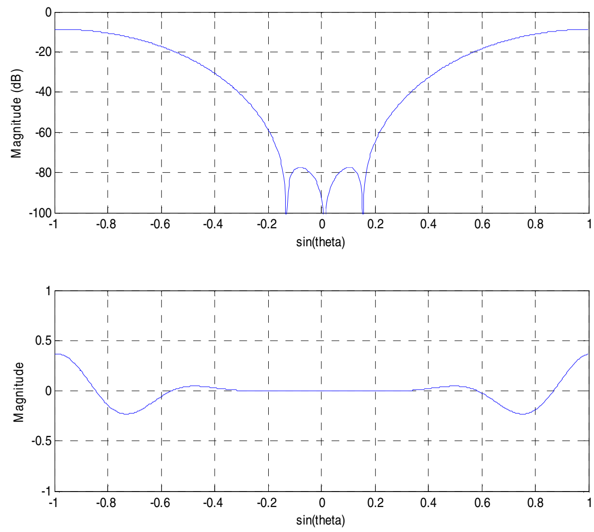
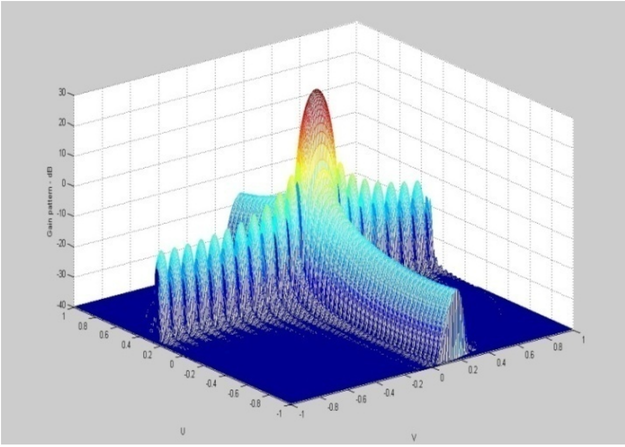


(d)

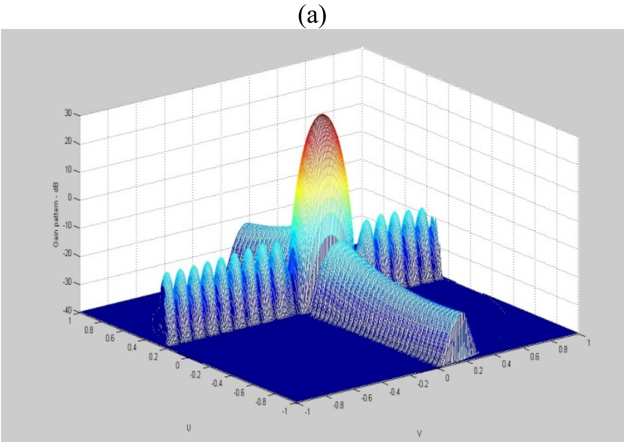
Fig. 7. Array Pattern of linear antenna array using (a) Kaiser Window (b) Hamming Window (c) Hann Window and (d) Blackman Window

Table 1. Peak Sidelobe level comparison for different type of window

Window	Peak Sidelobe Level (dB)
Kaiser	−20
Hamming	−40
Hann	−60
Blackman	−80



(a)



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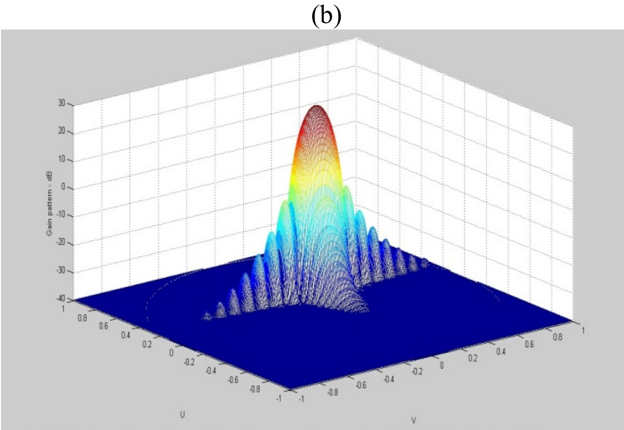

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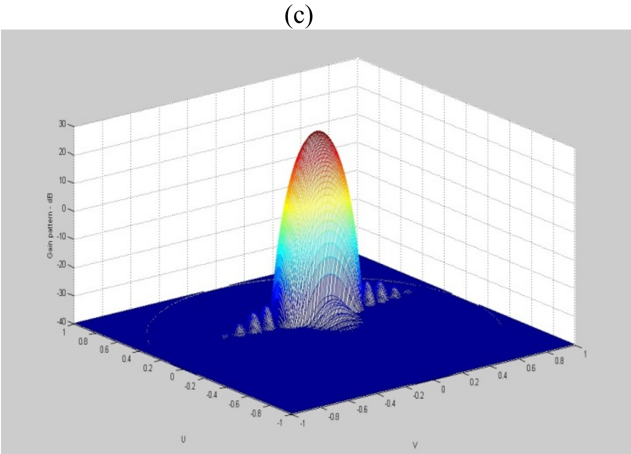
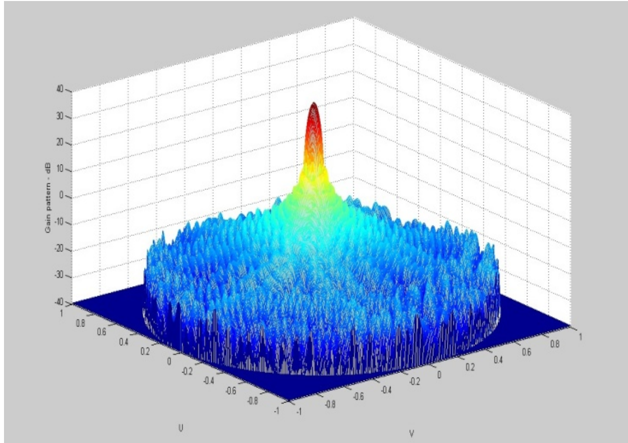
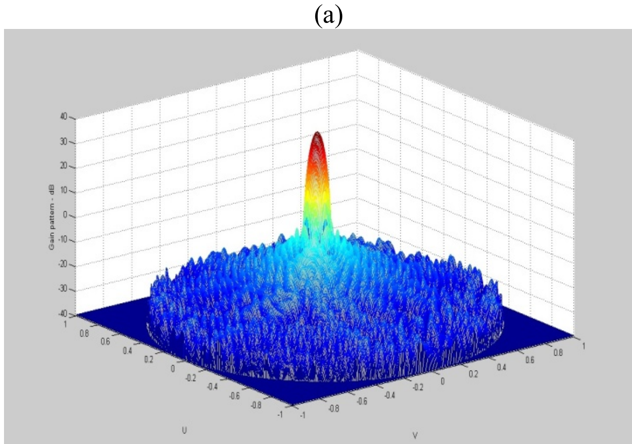


(d)

Fig. 8. Gain pattern in rectangular array antenna using (a) Kaiser Window (b) Hamming Window (c) Hann Window (d) Blackman Window



(a)



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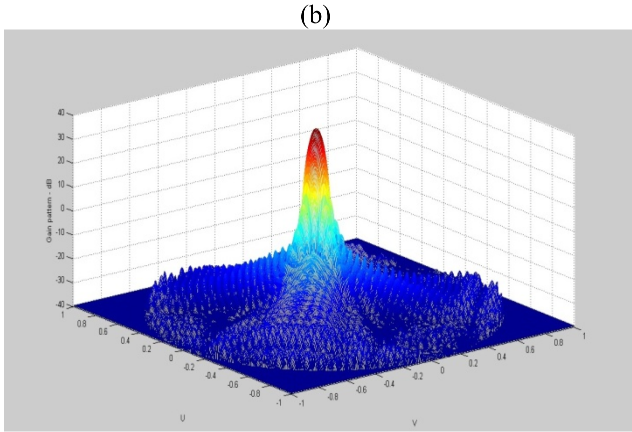

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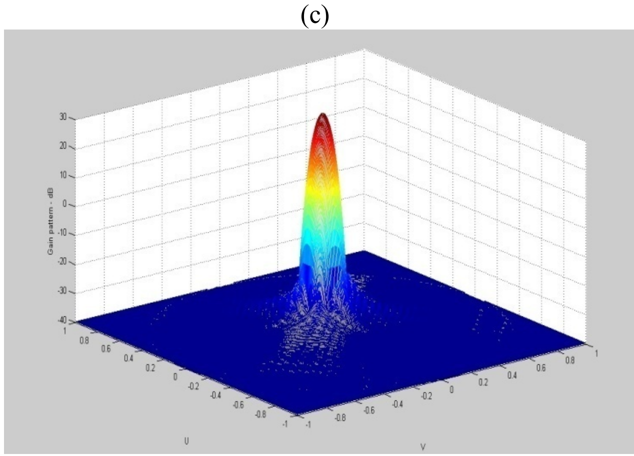

(d)

Fig. 9. Gain pattern in Circular array antenna using (a) Kaiser Window (b) Hamming Window (c) Hann Window (d) Blackman Window

From the above table and figures for the case of linear, rectangular and circular antenna array, it is clear that the reduction of side lobe can be possible by using any type of window. In the case of linear antenna array the peak side lobe level in Kaiser window is higher than Hamming, Hann and Blackman window. The peak side lobe level of Blackman window is -80 dB indicating maximum side lobe reduction. Again for circular and rectangular antenna array simulation has been carried out for Kaiser, Hamming, Hann and Blackman window separately and the simulated 3D results are depicted in figure 9 and reveals that the maximum side lobe reduction in the case of Blackman window.

V. CONCLUSIONS

In this paper, an investigation on side lobe reduction for different array antenna (linear, rectangular and circular) using different windowing technique has been presented. It is seen that the technique for the side lobe level reduction has led to very interesting and promising results that can be exploited to design reliable communication systems based on the detection capability proposed in the present work. The side lobes are different while using different window in different antenna array but Blackman window is better than others for maximum side lobe reduction and it shows better radiation pattern.

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