# Implementation of Windowing Technique for Minimizing the Side Lobes in Antenna Array Design

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## Article Info

## ABSTRACT

The objective of this project is to generate the radiation pattern of linear arrays like broad side array and end fire array by reducing the side lobes. This project is implemented by using MATLAB.

For some applications, single element antennas are unable to meet the gain or radiation pattern requirements so combining several single antenna elements in an array can be a possible solution. Array is a system of similar antennas oriented similarly to get greater directivity in a desire direction. Various techniques can be used to reduce the side lobes in the radiation pattern. Here, we employ windowing techniques for the reduction of side lobes. The 4-term Blackman-Harris window function is a good general purpose window, having side lobe rejection in the high 90s dB and having a moderately wide main lobe. The Kaiser-Bessel window function has a variable parameter, beta, which trades off side lobes for main lobe. It compares roughly to the Blackman-Harris window functions, but for the same main lobe width, the near side lobes tend to be higher, but the further-outside side lobes are low. Antennas exhibit a specific radiation pattern. Tapering of side lobes in the radiation pattern has several advantages and applications. These have wide importance in specific military applications. Military antennas are designed to have a narrow main beam as reasonable to give higher resolution and the lowest side lobes possible to reject echoes and jamming at other elevation angles. Radar was first developed for military purposes. The early surveillance radars often used a line feed and a cylindrical reflector. The radiation pattern from the line feed was shaped to provide lower side lobes and a slightly broader main beam with slightly less gain.

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## I. Introduction

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as "a means for radiating or receiving radio waves." In other

words the antenna is the transitional structure between free-space and a guiding device, as shown in the below figure. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna or from the antenna to the receiver. In the former case, we have a transmitting antenna and in the latter a receiving antenna.

## II. ANTENNA ARRAYS

An antenna array is a group of such that the currents running through them are of different amplitudes and phases. These are radiators of electromagnetic frequency and energy. Antenna arrays are the solution to the problem defined as the limitations of operating a single antenna. An example of the problem is that although a dipole antenna allows for better control of direction than an isotropic (Omni-directional) antenna as the length of the dipole increases, the control of direction decreases. Hence control by changing the length of a single antenna is very limited. Greater flexibility and control can be obtained for directing the beam with an arrangement of multiple radiators.

One of the main advantages of antenna arrays respect to other types of antennas is the ability to direct its beam electronically through the excitement phase between the elements. The design and development of radar systems with arrays is complex and costly. To reduce costs and risks, and to improve the performance of the arrays, we use simulations. These simulations must meet certain criteria: they have to be fast and determine the parameters of performance accurately. Because of the need to design antenna arrays and the current reliance on expensive programs, it was decided to create an own tool to obtain reliable results and access the program code to modify the design variables and made optimization.

### A. The Broadside Array

In many applications it is desirable to have the maximum radiation of an array directed normal to the axis of the array (broadside: $\theta = 90°$). To optimize the design, the maxima of the single element and of the array factor should both be directed toward $\theta = 90°$. Referring to (10c) o (10d), the maximum of the array factor occurs when

$$\Psi = kd\cos\theta + \beta = 0$$

Since it is desired to have the maximum directed toward $\theta = 90°$, such as shown in the Fig.

$$\Psi = kd\cos\theta + \beta = \beta = 0 \quad (\theta = 90)$$
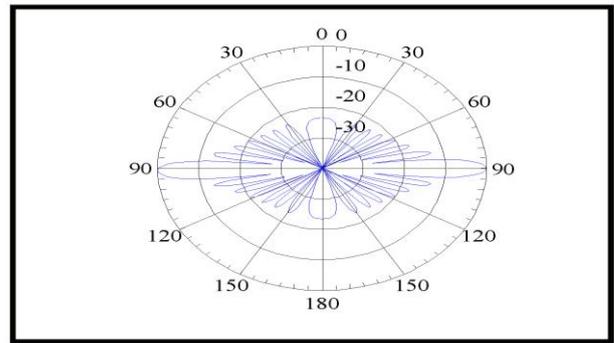


Figure1: Broadside array factor with N = 15, d = λ/2.
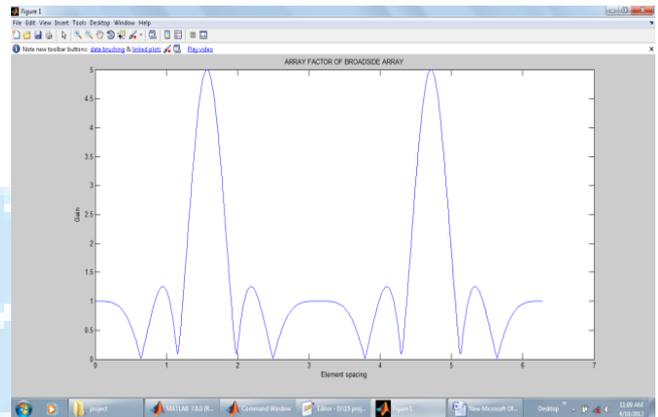


Figure2: output wave form of broad side array

### B. The End-Fire Array:

Instead of having the maximum radiation broadside to the axis, it may be desirable to direct it along the axis of the array (end-fire). As a matter of fact, it may be necessary that it radiates toward only one direction (either $\theta = 0°$, or $\theta = 180°$). To direct the maximum towards, $\theta = 0°$.

$$\psi = kd\cos\theta + \beta|_{\theta=0°} = kd + \beta = 0 \Rightarrow \beta = -kd$$

If the maximum is desired towards, $\theta = 180°$, then

$$\psi = kd\cos\theta + \beta|_{\theta=180°} = -kd + \beta = 0 \Rightarrow \beta = kd$$
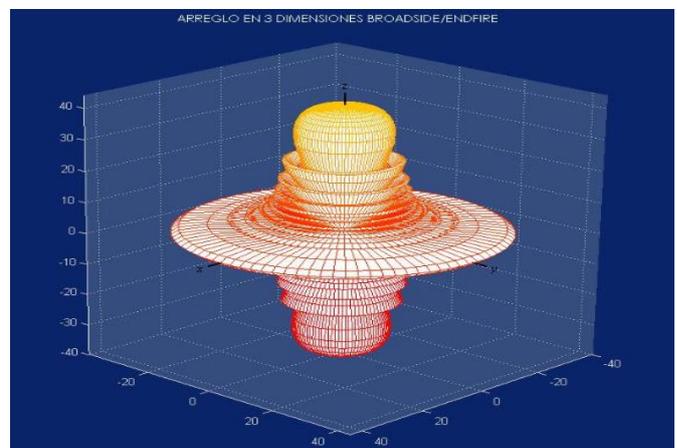


Figure 3 : Three-dimensional amplitude patterns for broadside/end-fire array of a 10- element with uniform amplitude: N = 10, β = 0, and d = λ
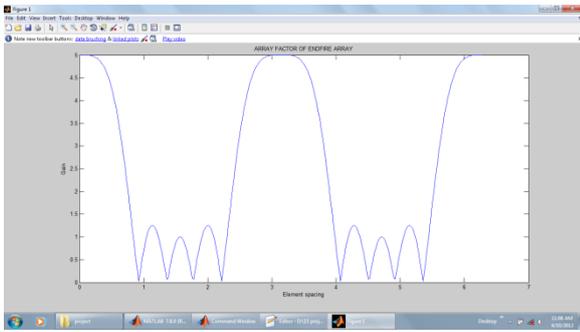
Figure 4: output wave form of end-fire array
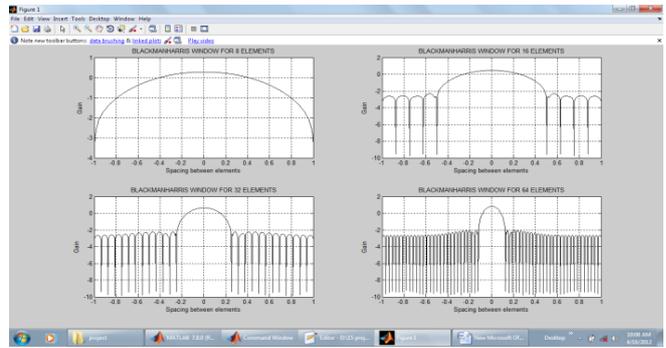


Fig 6: Radiation pattren of Blackman harries window

## III. WINDOWING FUNCTION

In signal processing, a window function (also known as an apodization function or tapering function) is a mathematical function that is zero-valued outside of some chosen interval. For instance, a function that is constant inside the interval and zero elsewhere is called a rectangular window, which describes the shape of its graphical representation. When another function or a signal (data) is multiplied by a window function, the product is also zero-valued outside the interval: all that is left is the part where they overlap; the "view through the window". Applications of window functions include spectral analysis, filterdesign, and beamforming.

A more general definition of window functions does not require them to be identically zero outside an interval, as long as the product of the window multiplied by its argument is square integrable, that is, that the function goes sufficiently rapidly toward zero. In typical applications, the window functions used are non-negative smooth "bell-shaped" curves, though rectangle and triangle functions and other functions are sometimes used.

### A. Blackman Window:



Figure 5: Blackman window; α = 0.16; B=1.73

Blackman windows are defined as:

$$w(n) = a_0 - a_1 \cos\left(\frac{2\pi n}{N-1}\right) + a_2 \cos\left(\frac{4\pi n}{N-1}\right)$$

$$a_0 = \frac{1-\alpha}{2}; \quad a_1 = \frac{1}{2}; \quad a_2 = \frac{\alpha}{2}$$

By common convention, the unqualified term Blackman window refers to α=0.16.

### B. Kaiser Window:



Figure 7: Kaiser window, α =2; B=1.5
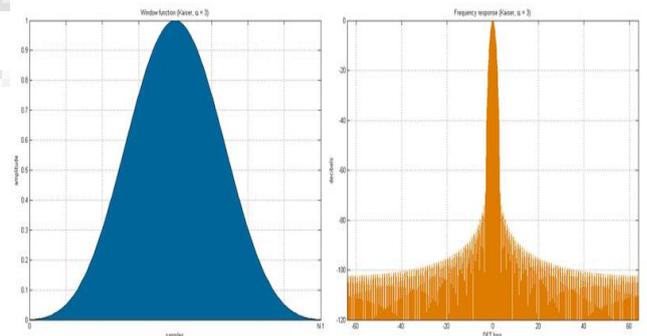


Figure 8: Kaiser window, α =3; B=1.8

A simple approximation of the DPSS window using Bessel functions, discovered by Jim Kaiser.

$$w(n) = \frac{I_0\left(\pi\alpha\sqrt{1-(\frac{2n}{N-1}-1)^2}\right)}{I_0(\pi\alpha)}$$

where $I_0$ is the zero-th order modified Bessel function of the first kind, and usually $\alpha = 3$.

- Note that:

$$w_0(n) = \frac{I_0\left(\pi\alpha\sqrt{1-(\frac{2n}{N-1})^2}\right)}{I_0(\pi\alpha)}$$
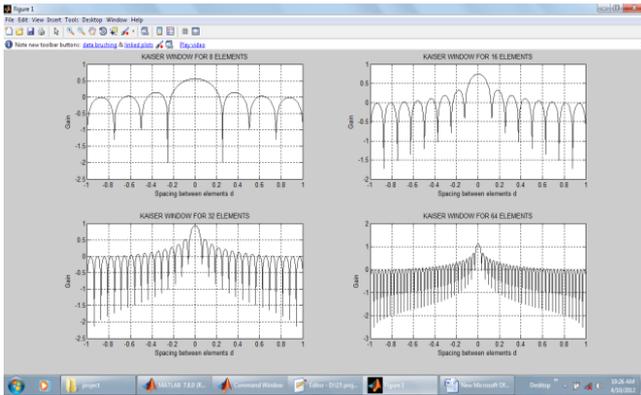


Figure 9 : Radiation pattern of Kaiser window

## IV. CONCLUSION

We have generated the radiation pattern of linear array which included end-fire and broad side array. We observed that the radiation pattern of these arrays contain side lobes. Side lobes should be reduced in order to avoid the interference and increase the gain of antenna. This could even make the antenna more effective. So there are a wide variety f techniques to reduce the side lobes. But here we concentrated on Windowing techniques. By using different windowing techniques the side lobe levels are reduced to the desired extent. This is the array tapering. We have employed various windows for array tapering. We have observed how the side lobes are reduced by changing the number of elements. We observed which window could best reduce the side lobes to the desired extent .Array tapering is useful in many applications but the most important is in military.

We employed window techniques to reduce the side lobe levels of linear array. The extension for this is to use these techniques for other kind of arrays by employing more windowing techniques.

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