

## DESIGN OF WAVEGUIDE ARRAYS TO PRODUCE LOW SIDE LOBES

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### ABSTRACT

Antenna is a radiating element which radiates in all directions into space. The antenna is used in wireless communication systems for the transmission and reception .single antenna element is not sufficient to produce required gain and bandwidth. That is the reason why arrays are designed by researchers.

Array is nothing but a group of elements arranged in rows (linear) or rows and columns (planar) which provides more gain and bandwidth. In an array system the main beam width is reduced by increasing number of elements, hence the gain and directivity is increased. The side lobe level of a linear array is -13.5 dB which is most advisable for point to point communication. In the present work by using standard amplitude distribution is used to reduce the side lobe level is reduced up to -22.0 dB and which is compared with the uniform linear array. Plots are drawn for small and large arrays from N=10, 20and 40.

In the present work the practical element arrays are designed for small and large arrays .the results are compared with the ideal arrays which came with good agreement. The practical element used in the present work is waveguide. The standard rectangular waveguide are used in this work to produce narrow beams and high gain, by neglecting inter element interference the designed wave guide arrays for N=10,20,40 by adopting standard amplitude distribution to these arrays side lobe level are also reduced and are compared with the isotropic arrays. The results come up with good agreement.

**KEYWORDS:** Antenna Array, Array Synthesis, Waveguide Array, Parabolic Amplitude Distribution, Pattern Multiplication

### INTRODUCTION

An antenna array is a group of antennas connected and arranged in a regular structure to form a single antenna that is able to produce radiation patterns which are not produced by individual antennas. In an array system the main beam width is reduced by increasing number of elements, hence the gain and directivity is increased.

Waveguide fed slot arrays have found applications in many radar and communication systems. Elliott presented a technique for designing linear and planar slot arrays [1], [2]. This design procedure includes external mutual coupling between horn elements in the array. Internal high order mode coupling between adjacent radiating slots through the TE<sub>20</sub> mode was also incorporated in the design procedure [3]. the internal higher order mode coupling between adjacent coupling slots in the feed waveguide and that between adjacent radiating slots have also been investigated by the method of moment solution of pertinent coupled integral equations[4],[5]. Waveguide resonant slot array antennas are used in many applications such as radar and wireless mobile communication system. In general, the longitudinal shunt slot which is

embodied in broad wall of rectangular waveguide is used to realize resonant array [6]. As another slot array antenna, the edge slot modified in side wall of waveguide is applied to the array antenna requiring a beam pattern of H-plane.

## WAVEGUIDE

Waveguide is a metal tube or other device, confining and conveying microwaves. Basically there are two different types of waveguides such as rectangular waveguide and circular waveguide which are propagate in three different modes.

In this paper open ended waveguide is considered and it is a type of rectangular waveguide, open at its end and terminated in a large ground plane.

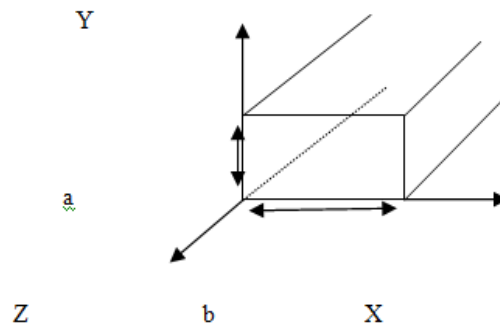


Figure 1: Open Ended Waveguide

## FORMULATION

The origin of coordinates taken at the middle of a transverse cross section rather than at a corner, the electric field of the incident TE<sub>10</sub> mode can be expressed in the form. [7]

$$E_y^i = C \cos \frac{\pi x}{a} e^{j(\omega t - \beta_{10} z)} \quad (1)$$

It will be assumed that these two fields comprise the bulk of ET in the aperture. Then

$$E_T = 1_y C^1 \cos \frac{\pi \xi}{a} \quad (2)$$

Equations (8) and (9) indicate that there is only an E<sub>0</sub> component, given in normalized form, given by

$$E_\varphi(\theta) = \pi^2 \cos \theta \frac{\cos \left( \frac{\pi a}{\lambda} \sin \theta \right)}{\pi^2 - 4 \left( \frac{\pi a}{\lambda} \sin \theta \right)^2} \quad (3)$$

In the YZ-plane ( $\varphi=90,270$ ), there is only an E<sub>0</sub> component, given by

$$E_\theta(\theta) = \frac{\sin \left( \frac{\pi a}{\lambda} \sin \theta \right)}{\left( \frac{\pi a}{\lambda} \sin \theta \right)} \quad (4)$$

Plots of the principal-plane field patterns, for the typical values  $(a/\lambda)=0.7$  and  $(b/\lambda)=0.35$ , are shown in below

figure.

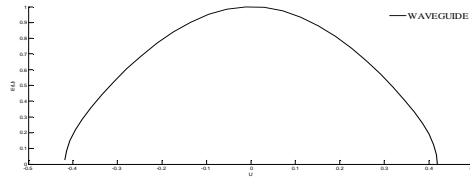


Figure 2: Normalized E-Field Pattern of an Open Ended Rectangular Waveguide

**PARABOLIC AMPLITUDE DISTRIBUTION**

The normalized parabolic amplitude distribution [8] is given by

$$A(x) = 1 - \left[ \frac{2x}{1} \right]^2 \tag{5}$$

The radiation pattern for parabolic amplitude distribution using the equation (5) is represented in Figure.3.

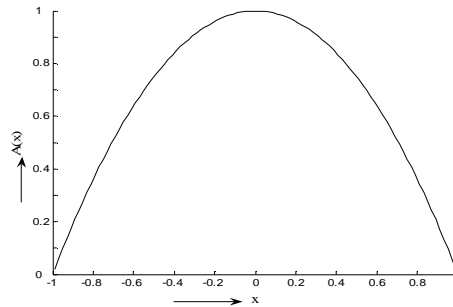


Figure 3: Parabolic Amplitude Distribution along the Line Source

**PATTERN MULTIPLICATION PRINCIPLE**

It is defined as the element pattern multiplied with the linear array factor.

Total radiation pattern = Element pattern X Array Factor.

$$E_T(u) = E_\theta(\theta) \times \sum_{n=1}^N A(X) \cdot e^{\frac{j2\pi}{\lambda} u X_n} \tag{6}$$

Where  $X_n = \frac{2n - N - 1}{N}$  spacing function (7)

N= number of elements in array

Where  $x_n$  is the location of the  $n^{th}$  element,

$u = \sin \theta$

$E_\theta(\theta)$  = Element Pattern

$E_T(U)$  = Total radiation Pattern of the Array.

## RESULTS

The parabolic amplitude is used to decaying the side lobe levels to the required level.. The side lobe level of a linear array is -13.5 dB which is not advisable for point to point communication. In the present work by using standard parabolic amplitude distribution to reduce the side lobe level up to -22.0 dB and which is compared with the uniform linear array.

In the present work the waveguide arrays are designed for small and large arrays .the results are compared with the ideal arrays which came with good agreement. The amplitude distribution with element location is presented in the tabular forms from tables 1 to4. The discrete parabolic amplitude distribution for N=10, 20, 40 are presented from figures 4 to 6 with specific locations by using formula (3). The standard rectangular waveguides are used in this work to produce narrow beams and high gain, by neglecting inter element interference and the designed wave guide arrays for N=10,20,40 by adopting standard amplitude distribution to these arrays side lobe level are also reduced and are compared with the isotropic arrays and the plots are presented from 10 to 12. The results are presented in the u- Domain.

**Table 1: Parabolic Amplitude Distribution with Specific Location of N=10 Elements**

S.No	Location $x_n$	Amplitude $A(x_n)$
1	-0.9	0.19
2	-0.7	0.51
3	-0.5	0.75
4	-0.3	0.91
5	-0.1	0.99
6	0.0	1.00
7	0.1	0.99
8	0.3	0.91
9	0.5	0.75
10	0.7	0.51
11	0.9	0.19

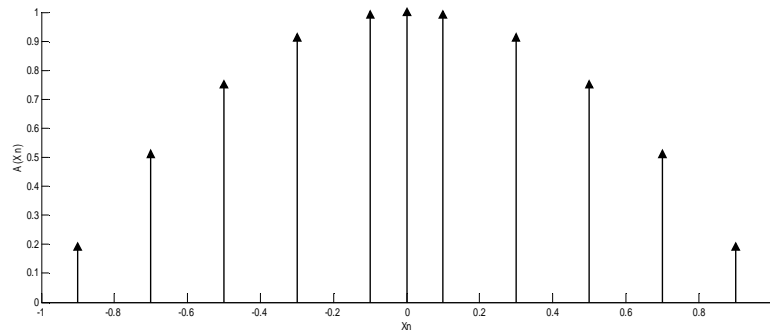
**Table 2: Parabolic Amplitude Distribution with Specific Location of N=20 Elements**

S.No	Location $x_n$	Amplitude $A(x_n)$
1	-0.95	0.0975
2	-0.85	0.2775
3	-0.75	0.4375
4	-0.65	0.5775
5	-0.55	0.6975
6	-0.45	0.7975
7	-0.35	0.8775
8	-0.25	0.9375
9	-0.15	0.9775
10	-0.05	0.9975
11	0.00	1.0000
12	0.05	0.9975
13	0.15	0.9775
14	0.25	0.9375

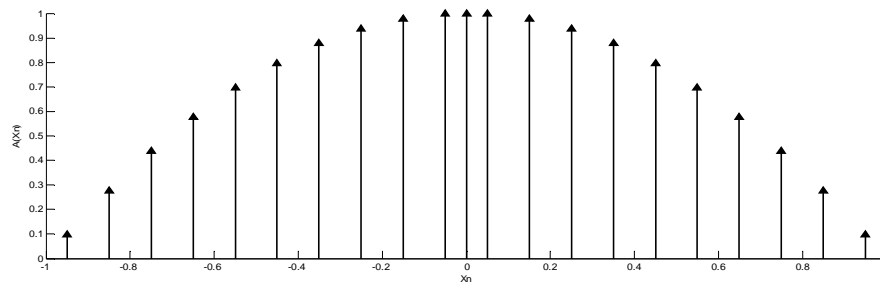
15	0.35	0.8775
16	0.45	0.7975
17	0.55	0.6965
18	0.65	0.5775
19	0.75	0.4375
20	0.85	0.2775
21	0.95	0.0975

**Table 3: Parabolic Amplitude Distribution with Specific Location of N=40 Elements**

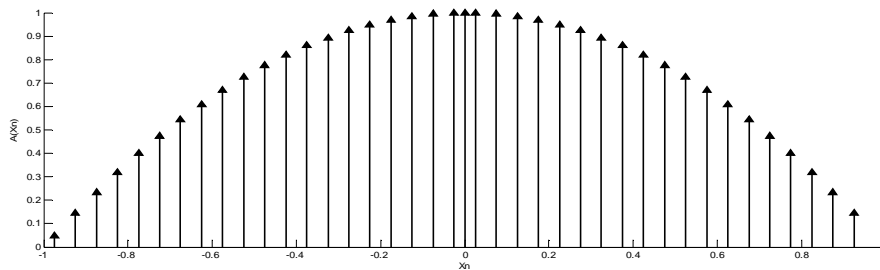
S.No.	Location $x_n$	Amplitude $A(x_n)$
1	-0.9750	0.0494
2	-0.9250	0.1444
3	-0.8750	0.2344
4	-0.8250	0.3194
5	-0.7750	0.3994
6	-0.7250	0.4744
7	-0.6750	0.5444
8	-0.6250	0.6094
9	-0.5750	0.6694
10	-0.5250	0.7244
11	-0.4750	0.7744
12	-0.4250	0.8194
13	-0.3750	0.8594
14	-0.3250	0.8944
15	-0.2750	0.9244
16	-0.2250	0.9494
17	-0.1750	0.9694
18	-0.1250	0.9844
19	-0.0750	0.9944
20	-0.0250	0.9994
21	-0.0000	1.0000
22	0.0250	0.9994
23	0.0750	0.9944
24	0.1250	0.9844
25	0.1750	0.9694
26	0.2250	0.9494
27	0.2750	0.9244
28	0.3250	0.8944
29	0.3750	0.8594
30	0.4250	0.8194
31	0.4750	0.7744
32	0.5250	0.7244
33	0.5750	0.6694
34	0.6250	0.6094
35	0.6750	0.5444
36	0.7250	0.4744
37	0.7750	0.3994
38	0.8250	0.3194
39	0.8750	0.2344
40	0.9250	0.1444
41	0.9750	0.0494



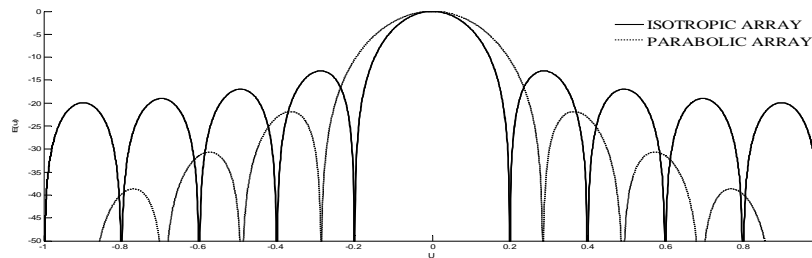
**Figure 4: Parabolic Amplitude Distribution with Discrete Locations of N=10 Elements**



**Figure 5: Parabolic Amplitude Distribution with Discrete Locations of N=20 Elements**



**Figure 6: Parabolic Amplitude Distribution with Discrete Locations of N=40 Elements**



**Figure 7: Isotropic Array with Parabolic Function for N=10 Elements**

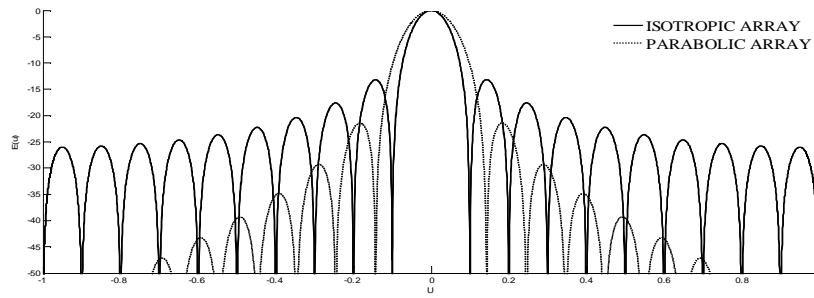


Figure 8: Isotropic Array with Parabolic Function for N=20 Elements

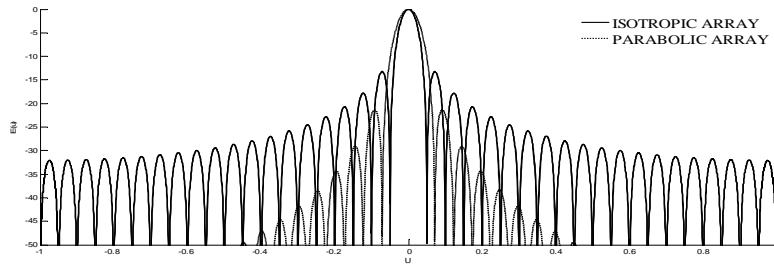


Figure 9: Isotropic Array with Parabolic Function for N=40 Elements

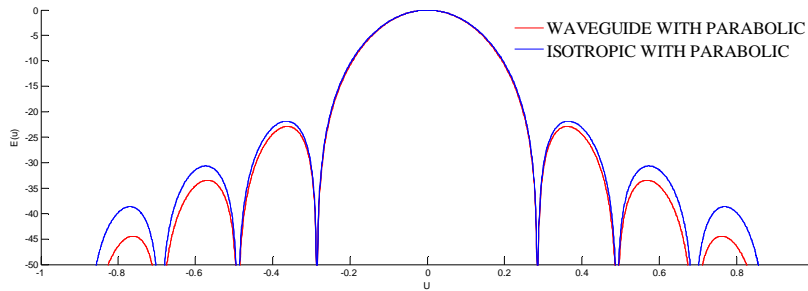


Figure 10: Synthesized Isotropic Arrays with and without Waveguide for N=10

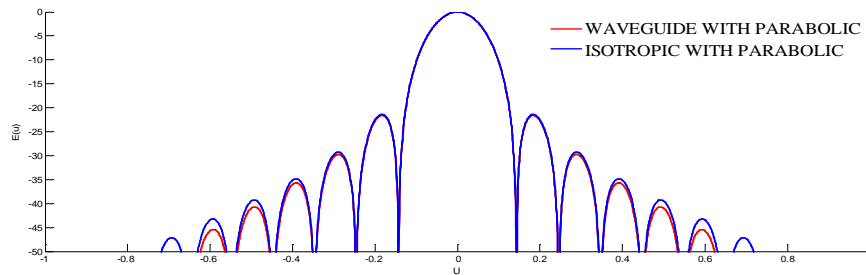
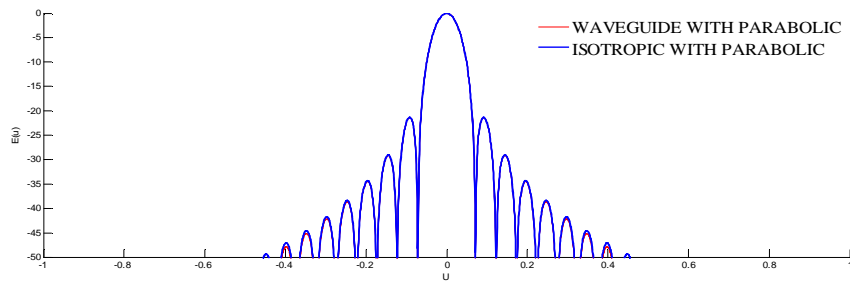


Figure 11: Synthesized Isotropic Arrays with and without Waveguide for N=20



**Figure 12: Synthesized Isotropic Arrays with and without Waveguide for N=40**

## CONCLUSIONS

In this work the waveguide arrays are designed to reduce side lobes by using parabolic amplitude distribution. The results are come up with good agreement. The amplitude distribution with element location is presented in the tabular forms from tables 1 to 4. The parabolic amplitude distribution for N=10, 20, 40 and 60 are presented from figures 8 to 11 with isotropic radiators and from 12 to 15 with waveguides. The results are useful for wireless communication and radar application. The side lobe level are reduced up to -22dB.

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