Optimization of side lobes for wave guide arrays

A.GAYATHRI[1] M.SURENDRAKUMAR[2]

1. Research Scholar, JNTU Kakinada, Kakinada , Andhra Pradesh. INDIA
2. Principal,KLRCollegeofEngineering&Technology,Paloncha,Khammam,Telangana-State,India

ABSTRACT

Antenna is a radiating element which can be used in Wireless communication systems for the transmission and reception.singleantennaelementisnotsufficienttoproducerequiredgainandbandwidth. 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 providesmore gain and bandwidth. In an array system the main beam width is reduced by increasing number of elements, hence thegain and directivity is increased. The side lobe level of a linear array is -13.5 dB which is most advisable for point to pointcommunication.Inthepresentworkbyusingstandardamplitudedistributionisusedtoreducethesidelobelevelisreduced up to -22.0 dB and which is compared with the uniform linear array. Plots are drawn for small and large arraysfromN=10,20and40.

In the present work the practical element arrays are designed for small and large arrays .the results are comparedwith the ideal arrays which came with good agreement. The practical element used in the present work is waveguide. Thestandard rectangular waveguide are used in this work to produce narrow beams and high gain, by neglecting inter elementinterference the designedwave guide arrays for N=10,20,40 by adopting standardamplitude distribution tothesearrayssidelobelevelarealsoreducedandarecomparedwiththeisotropicarrays.Theresultscomeupwithgoodagreement.

KEYWORDS: AntennaArray,ArraySynthesis,WaveguideArray,ParabolicAmplitude Distribution,PatternMultiplication

INTRODUCTION

Anantennaarrayisagroupofantennasconnectedandarrangedinaregularstructuretoformasingleantennathat is able to produce radiation patterns which are not produced by individual antennas. In an array system the main beamwidthisreduced byincreasing number ofelements, hencethe gainand directivityisincreased.

Waveguide fed slot arrays have found applications in many radar and communication systems. Elliott presented atechnique for designing linear and planar slot arrays [1], [2]. This design procedure includes external mutual couplingbetween horn elements in the array. Internal high order mode coupling between adjacent radiating slots through the TE_{20}modewas alsoincorporated in thedesign procedure[3].theinternalhigherordermodecoupling between adjacentcoupling slots in the feed waveguide and that between adjacent radiating slots have also been investigated by the method ofmoment solution of pertinent coupled integral equations[4],[5]. Waveguide resonant slot array antennas are used in manyapplicationssuchasradarandwirelessmobilecommunicationsystem.Ingeneral,thelongitudinalshuntslotwhichis embodiedinbroadwallofrectangularwaveguideisusedtorealizeresonantarray[6].Asanotherslotarrayantenna,theedgeslotmodifiedinsidewallof waveguideisappliedto thearrayantennarequiringabeampatternofH-plane.

WAVEGUIDE

Waveguide is a metal tube or other device, confining and conveying microwaves. Basically there are two differenttypesofwaveguidessuchasrectangularwaveguideandcircular waveguidewhicharepropagateinthreedifferentmodes.

Inthispaperopenendedwaveguideisconsideredanditisatypeofrectangularwaveguide,openatitsendandterminated ina largegroundplane.

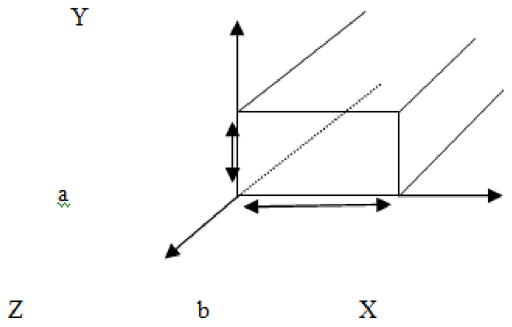

Figure1:OpenEndedWaveguide

FORMULATION

Theoriginof coordinatestakenatthemiddleof atransversecrosssectionrather thanatacorner, theelectricfieldofthe incident TE_{10}modecanbe expressedintheform.[7]

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

ItwillbeassumedthatthesetwofieldscomprisethebulkofETintheaperture.Then

$$E_T = 1_y C_1 \cos\frac{\pi\xi}{a} \quad (2)$$

Equations(8)and(9)indicatethatthereisonlyan$E_\varphi$component,giveninnormalizedform,givenby

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

In theYZ-plane(φ=90,270),thereis only an$E_\theta$component,givenby

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

Plotsoftheprincipal-planefieldpatterns,forthetypicalvalues(a/λ)=0.7and(b/λ)=0.35,areshowninbelow figure.

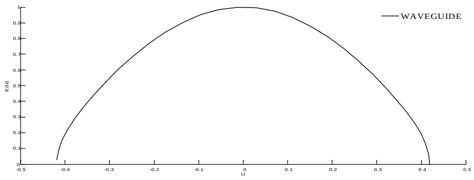

Figure2:NormalizedE-FieldPatternofanOpenEndedRectangularWaveguide

PARABOLICAMPLITUDEDISTRIBUTION

Thenormalizedparabolicamplitudedistribution[8]isgivenby

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

Theradiationpatternfor parabolicamplitude distribution usingthe equation(5) isrepresented inFigure.3.

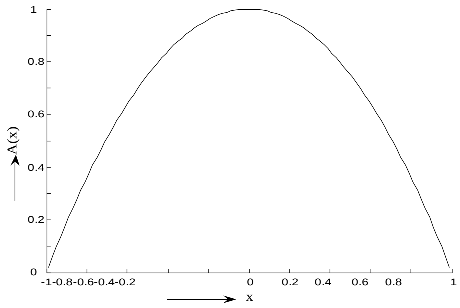

Figure3:ParabolicAmplitudeDistributionalongtheLineSource

PATTERNMULTIPLICATIONPRINCIPLE

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

factor.Totalradiation pattern=Element pattern XArrayFactor.

$$E_T(u) = E_\theta(\theta) \times \sum_{n=1}^{N} A(X).e^{\frac{j2\pi l}{\lambda} uX_n} \quad (6)$$

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

N=numberofelementsinarray

Where x_n is the location of the

n^{th}element,u=sin θ

$E_\theta(\theta)$=ElementPattern

$E_T(U)$=TotalradiationPatternoftheArray.

RESULTS

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

In the present work thewaveguide arrays are designed for small and large arrays .the results are compared withthe ideal arrays which came with good agreement. The amplitude distribution with element location is presented in thetabular forms from tables 1 to4. The discrete parabolic amplitude distribution for N=10, 20, 40 are presented from figures 4to 6 with specific locations by using formula (3). The standard rectangular waveguides are used in this work to producenarrow beams and high gain, by neglecting inter element interference and the designed wave guide arrays for N=10,20,40byadopting standard amplitude distribution to these arrays side lobe level are also reduced and are compared with the isotropic arrays and the plots are presented from10 to 12.The results are presented in the U-Domain.

Table1:ParabolicAmplitudeDistributionwithSpecificLocationofN=10Elements

S.No	Locationx_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

Table2:ParabolicAmplitudeDistributionwithSpecificLocationofN=20Elements

S.No	Locationx_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

Table3:ParabolicAmplitudeDistributionwithSpecificLocationofN=40Elements

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	0.2750	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

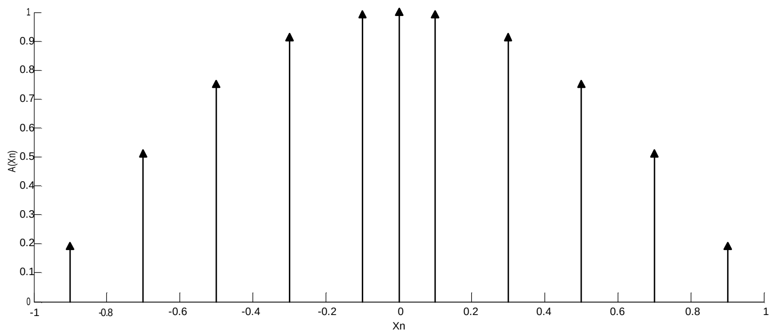

Figure4:ParabolicAmplitudeDistributionwithDiscreteLocationsofN=10Elements

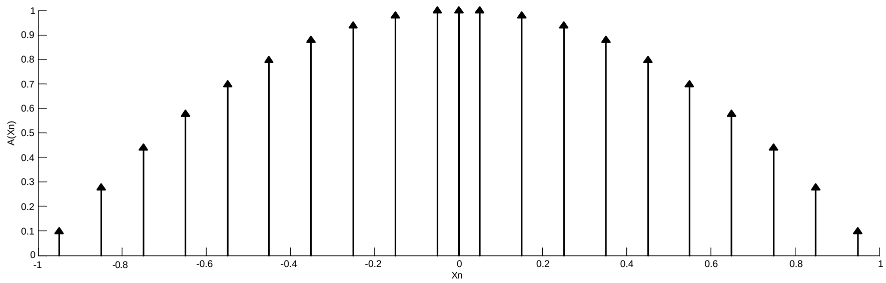

Figure5:ParabolicAmplitudeDistributionwithDiscreteLocationsofN=20Elements

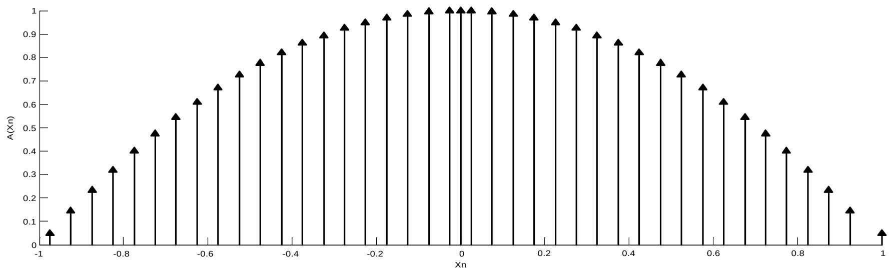

Figure6:ParabolicAmplitudeDistributionwithDiscreteLocationsofN=40Elements

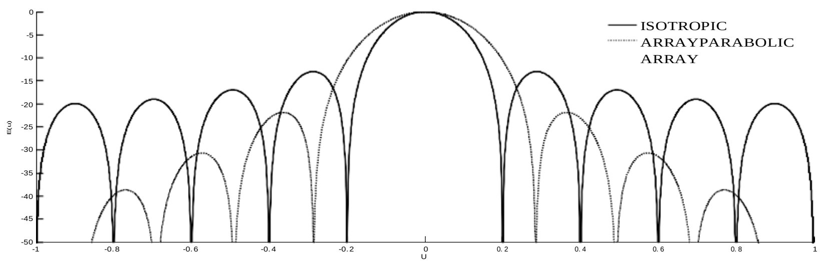

Figure7:IsotropicArraywithParabolicFunctionforN=10Elements

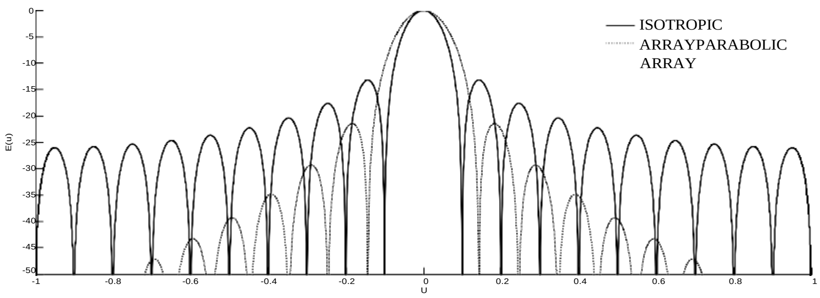

Figure8:IsotropicArraywithParabolicFunctionforN=20Elements

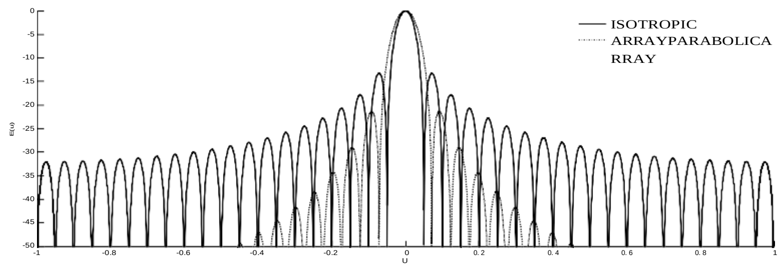

Figure9:IsotropicArraywithParabolicFunctionforN=40Elements

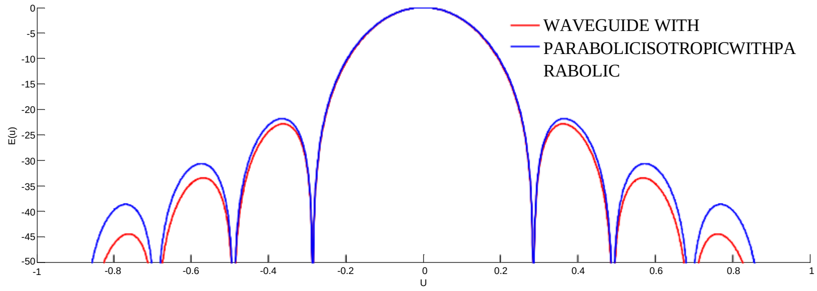

Figure10:SynthesizedIsotropicArrayswithandwithoutWaveguideforN=10

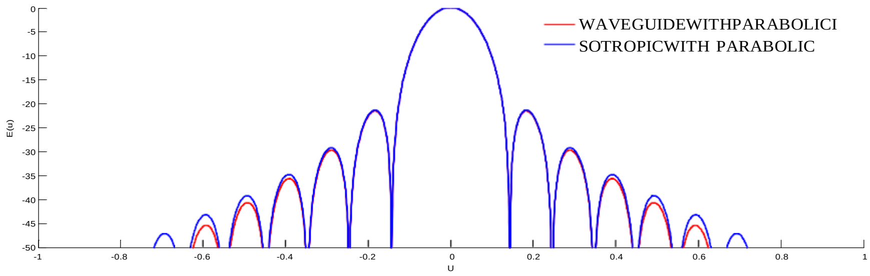

Figure11:SynthesizedIsotropicArrayswithandwithoutWaveguideforN=20

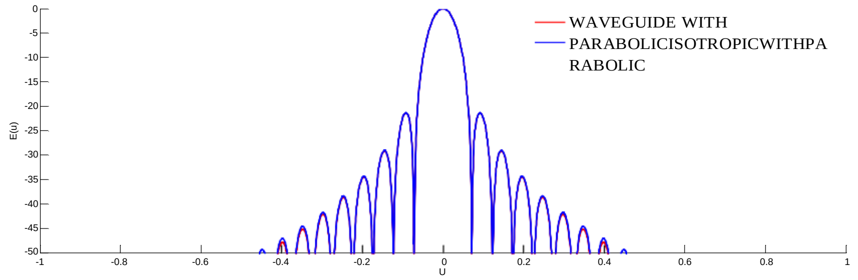

Figure12:SynthesizedIsotropicArrayswithandwithoutWaveguideforN=40

CONCLUSIONS

In this work the waveguide arrays are designed to reduce side lobes by using parabolic amplitude distribution. Theresults are comeupwithgoodagreement. The amplitude distributionwith element location is presentedin the tabularforms from tables 1 to 4. The parabolic amplitude distribution for N=10, 20, 40 and 60 are presented from figures 8 to 11with isotropic radiators and from 12 to15 with waveguides. The results are useful for wireless communication and radarapplication. The side lobe levelare reducedupto-22dB.

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