Lecture Notes in Electrical Engineering 702

G. T. Chandra Sekhar · H. S. Behera · Janmenjoy Nayak · Bighnaraj Naik · Danilo Pelusi *Editors*

Intelligent Computing in Control and Communication

Proceeding of the First International Conference on Intelligent Computing in Control and Communication (ICCC 2020)

Springer

Shaped Beams from Circular Aperture Antennas

J. Babu, B. Ramesh Reddy, J. Doondi Kumar, N. Siva Govind, and Baji Babu Mutte

Abstract The design of circular apertures for generating radiation pattern with controlled side lobe levels is attractive in communication and radar applications. The aperture distribution would cause the innermost side lobes to have individually specified heights. The research on circular aperture distribution to produce sum patterns with controlled side lobe levels is limited in the open literature. Hence, an attempt is made to obtain the shaped beams with controlled side lobe levels from circular aperture antennas. This is possible with a proper set of root positions. These root positions will yield the proper shaped beams from circular apertures. Different shaped beams are generated with new root positions. These shaped beams will have specified and controlled side lobe level.

J. Babu (✉)
Department of Electronics and Communication Engineering, Dadi Institute of Engineering and Technology, Anakapalle, Visakhapatnam, Andhra Pradesh 531002, India
e-mail: jettisanjay@gmail.com

B. R. Reddy
Department of Electronics and Communication Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, Krishna, Andhra Pradesh 521230, India
e-mail: brrece73@gmail.com

J. D. Kumar
Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu 641114, India
e-mail: jdoondikumarece@gmail.com

N. S. Govind
Department of Electronics and Communication Engineering, MVR College of Engineering and Technology, Paritala, Krishna 521180, Andhra Pradesh, India
e-mail: nandamuri429@gmail.com

B. B. Mutte
Department of Electronics and Communication Engineering, Godavari Institute of Engineering and Technology, Rajahmundry, Andhra Pradesh 533296, India
e-mail: bajibabumutte@gmail.com

G. T. C. Sekhar et al. (eds.), *Intelligent Computing in Control and Communication*, Lecture Notes in Electrical Engineering 702,
https://doi.org/10.1007/978-981-15-8439-8_15

Keywords Aperture distribution · Radiation pattern · Circular aperture antenna · Side lobes

1 Introduction

The most commonly used beam shapes in communication and radar applications are fan beam and pencil beam. The beam width of pencil beam will be narrow, whereas the beam width of fan beam is wide. The fan beams are used to simultaneously cover some degrees of azimuth and elevation.

Antenna aperture [1] is a measure of how effective an antenna is at receiving the power of radio waves. The antenna apertures which are mainly in use are circular aperture, rectangular aperture, and square aperture. The circular apertures are widely used when compared to other apertures, as they do not have any discontinuities while radiating. Usually the parabolic dish antenna and horn antenna will have circular apertures.

The circular aperture antennas [2] which produces the shaped beams are used in space communication. The shaped beams are produced by well-designed aperture distributions. The present work is centered on circular apertures. Taylor [3] has reported a method for design of circular apertures for generating radiation pattern with narrow beam width and low side lobe levels. The aperture distribution was further elaborated by Hansen [4].

Graham et al. [5] also presented a method for design of circular apertures for producing sum patterns with ring side lobes of arbitrary heights. A perturbation procedure has been devised that will determine the proper set of root positions once the height of each side lobe has been specified. The resultant patterns are called modified Taylor patterns.

Orchard et al. [6] presented a method aimed to produce a shaped pattern with controlled ripple and controlled side lobe levels from linear arrays with equal spacing. A pattern synthesis procedure was developed by Elliott and Stern [7, 8] using aperture antenna with a circular boundary.

The aperture distribution plays important role in producing shaped beams. It would cause the innermost side lobes (of a pattern) to have individually specified heights. This is possible with set of root positions. These root positions can also be modified with different methods, which will yield the proper shaped patterns from circular apertures. Hence, a method has been implemented that will determine the proper set of root positions with the specified side lobe level. In the present work, Elliott and Stern method has been extended to obtain the shaped patterns.

2 Shaped Patterns from Circular Aperture Antennas

The shaped beams can be generated from properly designed circular apertures [3]. The circular aperture with a radius R is shown in Fig. 1.

Here, θ is observation angle.

Φ is azimuthal angle measured from x-axis. It is assumed to be zero.

r is the distance from center of aperture to the point of observation.

The radiation pattern of circular aperture with radius R is given n Eq. 1

$$E(u) = \int_0^\pi p g(p) J_0(pu)\,\mathrm{d}p \tag{1}$$

where $g(p)$ is the aperture distribution function.

Here, $u = \frac{2R}{\lambda}\sin\theta$

The normalized radius is $p = \frac{\pi}{R}\rho$

Let $\overline{n}$ is a number controlling the degree of uniformity of the side lobes.

It assumes a finite positive integer more than 1.

If the circular aperture is uniformly excited, then $g(p) = 1$.

This will produce a sum pattern in the form as Eq. 2

$$E(u) = \frac{J_1(\pi u)}{\pi u} \tag{2}$$

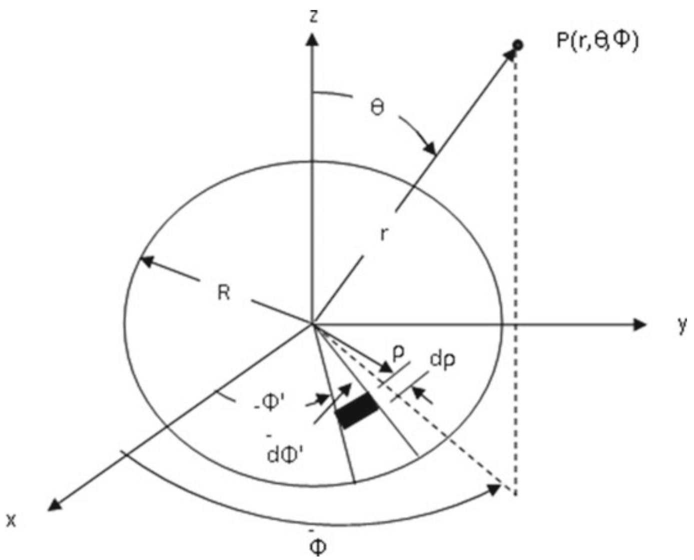


Fig. 1 Circular aperture

Here, $J_1(\pi u)$ is the Bessel function of first kind and first order.

The pattern shown in Fig. 2 has a main lobe and a family of side lobes that decay in height as the side lobe position becomes more remote from the main beam. Since this pattern is rotationally symmetric, the main lobe is observed to be pencil beam, surrounded by ring side lobes. How many of these side lobes are in visible space that depends on the aperture size. Since $u = 2a\sin\theta/\lambda$, the range of u corresponding to visible space is $0 < u < 2a/\lambda$.

The nulls of this pattern are given by Eq. 3

$$J_1(\pi \Upsilon_{1n}) = 0, \quad n = 0, 1, 2, 3, \ldots \tag{3}$$

The nth roots "Υ_{1n}" are called as Bessel function zeros.

In order to have the near-in side lobes at a quasi-constant controlled height, the aperture distribution function $g(p)$ should be expressed in a suitable form. Then, the pattern given by Eq. 2 is modified.

Taylor [3] has reported the solution to this problem. He has presented a method of circular aperture design to produce the radiation patterns with specific beam width and side lobe level. This analysis consists of moving the innermost $\overline{n} - 1$ nulls of Fig. 2 to achieve the desired level for the intervening side lobes. The pattern of circular aperture [3] is represented by Eq. 4

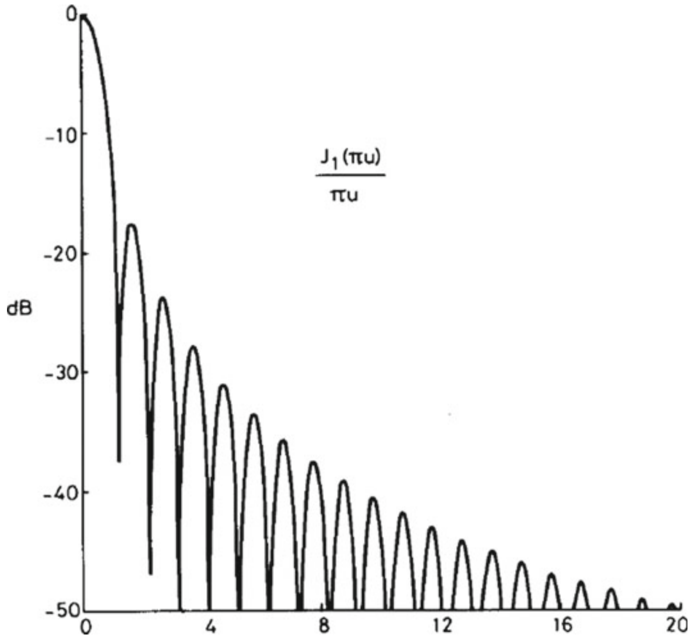


Fig. 2 Radiation pattern for circular aperture with uniform excitation.

$$E(u) = \frac{J_1(\pi u)}{\pi u} \prod_{n=1}^{\bar{n}-1} \left\{ \frac{1 - \frac{u^2}{\sigma^2[A^2+(n-0.5)^2]}}{1 - \frac{u^2}{\Upsilon_{1n}^2}} \right\} \tag{4}$$

Here, "A" is a parameter that describes the desired side lobe level. It is given by

$$A = \frac{1}{\pi}\cosh^{-1}(10^{\frac{-\mathrm{SLL}}{20}})$$

The beam broadening factor σ is given by $\sigma = \frac{\mathrm{u}_{\bar{n}}}{\sqrt{A^2+(\bar{n}-0.5)^2}}$

By letting $\mathrm{u}_{\bar{n}} = \sigma\left[A^2 + (\bar{n} - 0.5)^2\right]$, Eq. (4) can be expressed as

$$E(u) = \frac{J_1(\pi u)}{\pi u} \frac{\prod_{n=1}^{\bar{n}-1}\left[1 - \frac{u^2}{u_n^2}\right]}{\prod_{n=1}^{\bar{n}-1}\left[1 - \frac{u^2}{\Upsilon_{1n}^2}\right]} \tag{5}$$

The relation between desired side lobe level (SLL) and side lobe ratio η is given by SLL (in decibels) = $-20\log_{10}(\eta)$ dB.

The designed aperture distribution function [3], which produces the radiation pattern of Eq. (5), is given by

$$g(p) = \frac{2}{\pi^2} \sum_{m=0}^{\bar{n}-1} \frac{E(\Upsilon_{1m})}{J_0^2(\Upsilon_{1m}\pi)} J_0(\Upsilon_{1m} p) \tag{6}$$

Here, $J_0(\pi u)$ is Bessel function of first kind and zero order.

It is observed that Eq. (5) removes the first $\overline{n} - 1$ root pairs of Eq. (2) and replaces them with $\overline{n} - 1$ root pairs at the new positions $\pm$ $\mathrm{u_n}$.

If there are $\overline{n} - 1$ side lobes, then the analysis is to move the innermost $\overline{n} - 1$ nulls of starting pattern to new positions.

The new positions of the selected inner most side lobes are given by Eq. (7)

$$u_n^2 = \Upsilon_{1n}^2 \frac{A^2 + \left(n - \frac{1}{2}\right)^2}{A^2 + \left(\bar{n} - \frac{1}{2}\right)^2} \tag{7}$$

These new root positions are substituted in Eq. (5) to obtain desired pattern.

3 Null Filling and Optimization of Desired Shaped Patterns from Circular Apertures

Graham et al. [5] presented a method for design of circular apertures for producing sum patterns with side lobes of different heights. The resultant patterns are called modified Taylor patterns. The aperture distributions for these modified Taylor patterns can be determined from Eq. (6). Orchard et al. [6] presented a pattern synthesis method to produce patterns from equi-spaced linear arrays. The array excitations are varied. Elliott et al. [7] presented a new method for shaped beam synthesis from equispaced arrays. Elliott et al. [8] reported a pattern synthesis procedure for circular apertures.

Usually, a sum pattern consists of a main lobe with adjacent side lobes. The height of each side lobe can be individually controlled. Such patterns find applications in radar and space communications.

Further flat-topped beams can also be obtained. In the present work, Elliott and Stern method has been extended to obtain the shaped patterns with controlled side lobes.

In order to obtain desired shaped patterns, the starting pattern will be taken as base to find out the starting root positions u and null locations γ. We can use Fig. 2 as the starting pattern. There is no null filling in this particular case. The root positions for this pattern is [1.21972.23313.23834.2411 5.2427]. For this, $u_n = \Upsilon_{1n}$ and $v_n = 0$.

If we anchor all the roots (of Taylor pattern) $u_n = \Upsilon_{1n}$ for $n > \bar{n}$, and move the inner roots for n= 1, 2, ..., $\overline{n} - 1$ to the new positions $u_n + jv_n \neq \Upsilon_{1n}$, the pattern takes the form of [8–10].

$$E(u) = f(u)\prod_{n=1}^{\bar{n}-1}\left[1 - \frac{u^2}{(u_n + jv_n)^2}\right] \tag{8}$$

where $f(u)$ is given as Eq. (9)

$$f(u) = 2\frac{J_1(\pi u)}{\pi u}\frac{1}{\prod_{n=1}^{\bar{n}-1}\left[1 - \frac{u^2}{\Upsilon_{1n}^2}\right]} \tag{9}$$

It is possible to find complex root positions $u_n + jv_n$ that will yield a pattern with properly filled nulls in the shaped region while maintaining controlled side lobe levels in the unshaped region [8]. A flat-topped beam with specified ripple level and specified side lobe level can also be obtained.

Usually, 2^M different continuous aperture distributions corresponding to the same shaped beams are obtained if there are M complex roots. These aperture distributions are all complex.

The u_n and v_n values can be placed in Eq. (8) to obtain the field pattern. This field pattern can be used in Eq. (6) to find the aperture distribution function.

4 Results

The Taylor radiation pattern of circular aperture with $\overline{n} = 4$, SLL = −30 dB is generated from Eq. (5). It is shown in Fig. 3. The respective aperture distribution is generated from Eq. (6). It is shown in Fig. 4.

For the case of inner most ring side lobe at −35 dB, and next adjacent four side lobes at −25 dB, the new root positions u_n are calculated with the help of Eq. (6). The u_n values are found to be [1.4839 1.8933 2.9268 3.9622 5.0416]. There is no null filling in this case. So, the v_n values are zeros.

By substituting these values in Eq. (8), the radiation pattern can be obtained. It is shown in Fig. 5. In this case, the five inner most side lobes are moved to [−35 −25 −25 −25 −25] (in dB).

For the case of side lobe levels at [00 −25 −25 −25] (in dB), the new root positions u_n are found to be at [0.6322 1.9308 3.7674 4.3929 5.2633]. The generated pattern is shown in Fig. 6.

For the above pattern, the first two nulls can be filled. So the values for v_1 and v_2 are taken as 0.1 instead of zero as was the value for earlier case. Using these values, the pattern is obtained and is shown in Fig. 7. For this case, the inner most side lobes are at [00 −25 −25 −25] and null filling $v_1 = v_2 = 0.1$.

The pattern of Fig. 7 can be converted to the flat-topped beam with a ripple of ±0.5 dB. For this case, the new root positions and the null-filling values are given

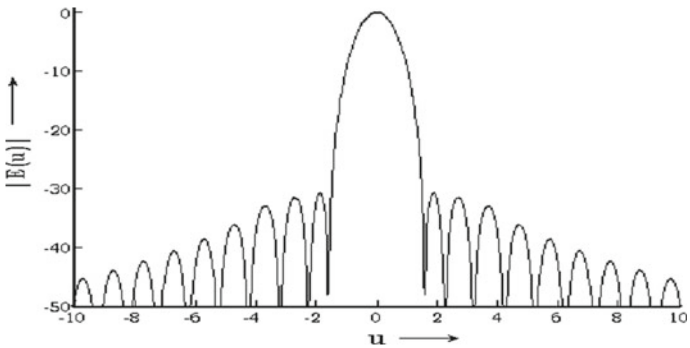
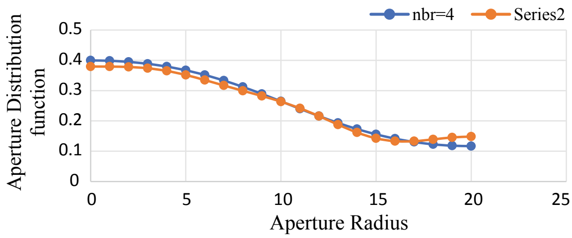


Fig. 3 Radiation pattern of circular aperture with $\overline{n}$= 4, SLL = −30 dB

Fig. 4 Taylor circular aperture distribution for SLL = −30 dB



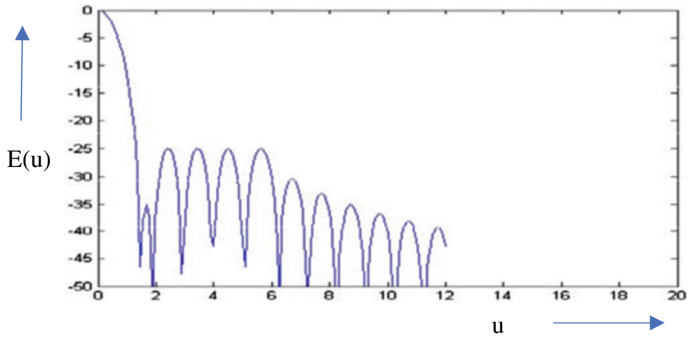


Fig. 5 Shaped pattern with inner side lobe at −35 dB, four side lobes at −25 dB

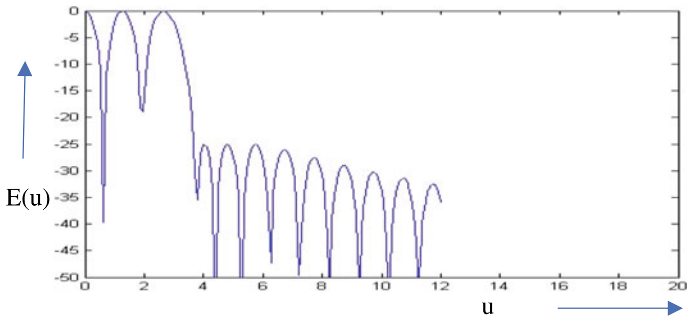


Fig. 6 Shaped pattern with two inner side lobes raised to zero dB

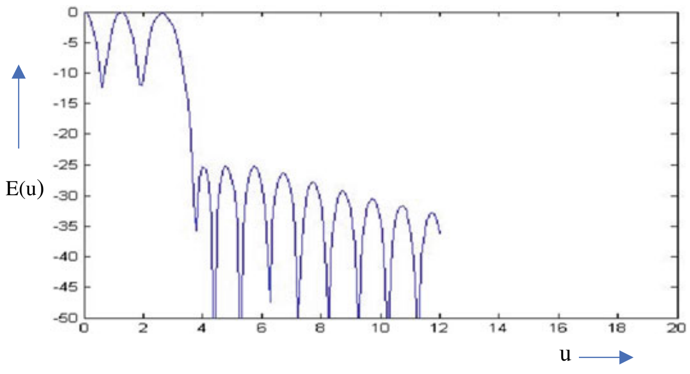


Fig. 7 Starting radiation pattern for a flat-topped beam with SLL = −25 dB

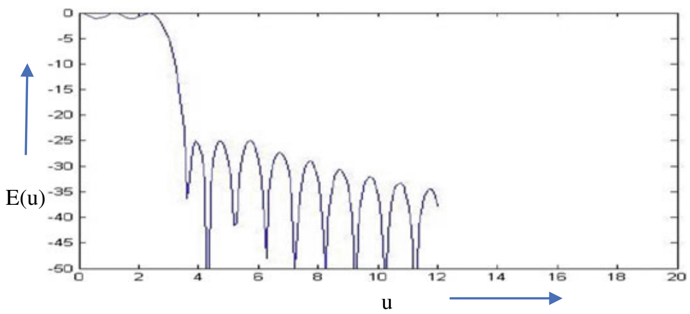


Fig. 8 Flat-topped radiation pattern with a ripple ±0.5 dB and SLL = −25 dB

as $u_n = [0.5967\ 1.7837\ 3.6420\ 4.3039\ 5.2119]$ and $v_n = [0.5225\ 0.5268\ 0\ 0\ 0]$.By substituting these values, the flat-topped radiation pattern can be obtained. It is shown in Fig. 8.

5 Conclusion

The Taylor patterns from circular aperture have been generated. These patterns are having narrow beam width and low side lobe levels. The aperture distribution reported by Taylor has been modified. The new aperture distribution which causes the inner-most side lobes to have individually specified heights is considered. This is possible with set of new root positions. The patterns are generated with the modified roots. These new root positions are useful in obtaining the patterns with a specified and controlled side lobe level. This method can also be applied to many modern antenna design applications which are aimed to produce the shaped beams with low and controlled side lobe level.

References

1. Raju GSN (2006) Antennas and wave propagation. Pearson Education India
2. Elliot RS (2006) Antenna theory and design. Wiley
3. Taylor TT (January, 1960) Design of circular apertures for narrow beam width and low sidelobes. IRE Trans Antennas Propagat AP-8:17–22
4. Hansen RC (1960) Tables of taylor distributions for circular aperture antennas. IRE Trans Antenna Propagat
5. Graham O, Johnson RM, Elliott RS (1978) Design of circular apertures for sum patterns with ring side lobes of individually arbitrary heights. Alta Frequenza J 47:21–25
6. Orchard HJ, Elliott RS, Stern GJ (February, 1985) Optimizing the synthesis of shaped beam antenna patterns. IEE Proc Microw Antennas Propagat Part H, 132(1):63–69
7. Elliott RS, Stern GJ (Octo) A new technique for shaped beam synthesis of equispaced arrays. IEEE Trans Antennas Propag 32(10):1129–1133

8. Elliott RS, Stern GJ (December, 1988) Shaped patterns from a continuous planar aperture distribution. IEE Proc Pt H. 135(6):366–370
9. Kim YU, Elliott RS (November, 1988) Shaped-pattern synthesis using pure real distributions. IEEE Trans Antennas Propagat 36(11):1645–1649
10. Elliott RS, Stern GJ (April, 1990) Footprint patterns obtained by planar arrays. IEE Proc Pt. H, 137(2)

INCEMIC 2010

11th International Conference on Electromagnetic Interference and Compatibility

Conference Proceedings

November 25-26, 2010

NIMHANS Convention Centre,

Bangalore, India

Organised by

Society of EMC Engineers (India)

ISBN: 81-963575-2-2 Softbound edition

Society of EMC Engineers (India) – SEMCE(I)

A4-312, Cauvery Block, National Games Complex

Kormangala, Bangalore – 560 047

Phone: 080 - 25714195 / 25244750

Fax: 080 - 25242873

Email: semcei.india@gmail.com

URL: www.semcei.org

Printed at : **Repromen Offset Printers Pvt. Ltd**
33 & 33/1, Krishna Reddy Colony,
Domlur Layout, Bangalore - 560 071
Phone : 2535 9973 / 2535 0759 / 2535 2999
Fax : 2535 2998
E-mail : info@repromenoffset.com / studiorop@gmail.com

www.repromenoffset.com

Ramp Patterns From Circular Apertures

J. Babu

Research Scholar, ECE Department,
AU College of Engineering (A),
Andhra University, Visakhapatnam
India -530003
E mail:jbabumtech@rediffmail.com

Dr.G.S.N. Raju

Professor of ECE Department,
Principal, AU College of Engineering(A),
Andhra University, Visakhapatnam
India -530003
E mail: drrajugsn@yahoo.co.in

Abstract : The work on the patterns of circular apertures reported in the open literature is minimum. Moreover the shaped patterns from such apertures is not available. In view of this an attempt is made to produce, ramp patterns from circular apertures using phase only control method. Both small and large apertures are considered and the patterns are realized by introducing a well designed phase functions.

I.INTRODUCTION

The design of circular apertures is reported by Taylor [1] to produce the directional characteristics having narrow main beam width with low side lobes. The set of continuous circular aperture distributions is developed by him. Similar work is also reported by several researchers [2-4] on the circular aperture distributions.

Ajoy Chakraborty et al [5] reported the method of design of circular aperture to produce the shaped beams. Pencil beams are widely used for point to point communications as well as high resolution radars. Ramp patterns have the applications similar to those of pencil beams.

In the present work, circular aperture is considered to generate shaped patterns such as Ramp patterns. The method consists of selection of suitable Amplitude distribution and the design of optimized phase function for a circular aperture. For a specified data on the beam width, the Ramp patterns are realized for different aperture sizes. It is found from the results that, the patterns are optimal for large apertures.

II. FORMULATIONS

Radiation Pattern of circular aperture:

A typical Circular aperture is shown in figure (1) along with the coordinate system. The radiation pattern produced by the circular aperture of the radius R appears in the form of [5]

$$E(\beta_x,\beta_y) = R^2\int_{x=-1}^{1}\int_{y=-\sqrt{1-x^2}}^{\sqrt{1-x^2}} A(x,y).e^{j\{\beta_x Rx+\beta_y Ry\}}dydx \quad (1)$$

where x and y are the normalised variables, $\beta_x = \beta\sin\theta\cos\phi, \beta_y = \beta\sin\theta\sin\phi$, $\beta = \frac{2\pi}{\lambda}$.

The complex aperture distribution can be represented by

$$A(x,y) = b(x,y).e^{j\alpha(x,y)} \quad (2)$$

where b(x,y) is the amplitude distribution function and α(x,y) is the phase distribution function.

After making few assumptions, the pattern can be expressed as

$$E(u) = \int_{x=-1}^{1} a(x).e^{j\left\{\frac{2\pi}{\lambda}Rx + \alpha(x)\right\}}dx \quad (3)$$

Where $u = \sin\theta$ and

$$a(x) = \int_{y=-\sqrt{1-x^2}}^{\sqrt{1-x^2}} b(x,y)\,dy \quad (4)$$

Equation (3) can be evaluated by the stationary phase method [6].

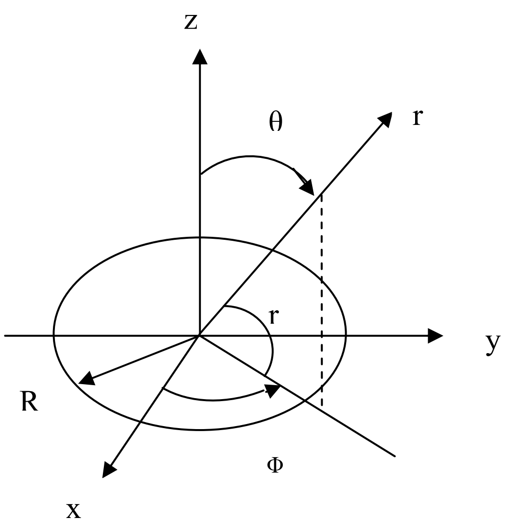


Fig 1 : Circular aperture

Determination of Phase function:

The desired radiation pattern is represented by

$E(u) = Ku$; for $u_1 \le u \le u_2$, (5)
where K is a constant, $(u_2 - u_1)$ is the desired beam width.

The energy relations can be expressed as

$$\frac{R}{\lambda}\int_{u_1}^{u_2}|E(u)|^2 du = \int_{x_1}^{x_2} a^2(x)dx \qquad (6)$$

$$\frac{R}{\lambda}\int_{u_1}^{u}|E(u)|^2 du = \int_{x_1}^{x} a^2(x)dx \qquad (7)$$

$$\frac{R}{\lambda}\int_{u}^{u_2}|E(u)|^2 du = \int_{x_1}^{x} a^2(x)dx \qquad (8)$$

From the equations (5) and (6) the constant K is obtained as

$$K^2 = \frac{1}{\frac{R}{3\lambda}.(u_2^3 - u_1^3)}\int_{-1}^{1} a^2(x)dx \qquad (9)$$

From the equations (5) and (7), the relationship between u and x is obtained as

$$u = \left[u_1^3 + (u_2^3 - u_1^3)\frac{\int_{-1}^{x} a^2(x)dx}{\int_{-1}^{1} a^2(x)dx}\right]^{\frac{1}{3}} \qquad (10)$$

The derivative of the phase function can be obtained as

$$\alpha'(x) = -2\pi\frac{R}{\lambda}\left[u_1^3 + (u_2^3 - u_1^3)\frac{\int_{-1}^{x} a^2(x)dx}{\int_{-1}^{1} a^2(x)dx}\right]^{\frac{1}{3}} \qquad (11)$$

For any aperture Amplitude distribution function b(x,y), the Phase distribution function α(x) can be determined by using equations (4) and (9) .

If for the Ramp pattern, $E(u) = Ku$; for $0 \le u \le 0.5$
$u_1 = 0$ and $u_2 = 0.5$; $u_1^3 = 0$ and $u_2^3 = 0.125$; $(u_2^3 - u_1^3) = 0.125$

The corresponding Phase distribution function can be obtained as

$$\alpha'(x) = -2\pi\frac{R}{\lambda}u$$

(5)

$$\alpha'(x) = -2\pi\frac{R}{\lambda}\left[0.125\frac{\int_{-1}^{x} a^2(x)dx}{\int_{-1}^{1} a^2(x)dx}\right]^{\frac{1}{3}} \qquad (12)$$

III.RESULTS

Using the expression (3), the radiation patterns are numerically evaluated by introducing the phase distribution. The above computations are made for the amplitude distribution b(x,y), which is given by

$$b(x, y) = 1 + \cos\pi\sqrt{x^2 + y^2} \qquad (13)$$

The numerically computed Phase distributions for R=25λ, 100 λ and for beam widths of 0.5 are presented in figures (3-4). The Corresponding, Radiation patterns are presented in figures (5-14).

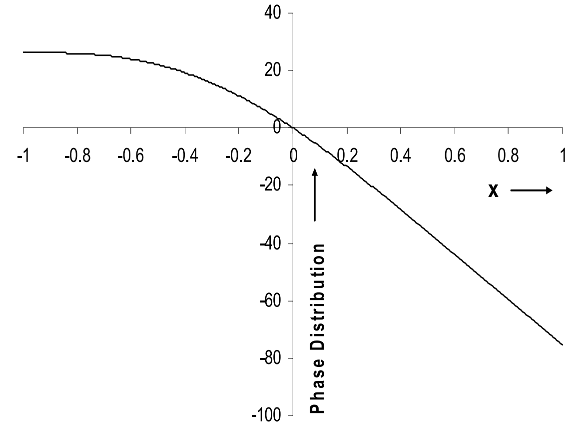


Figure 3: Phase distribution for R= 25λ, Beamwidth=0.5

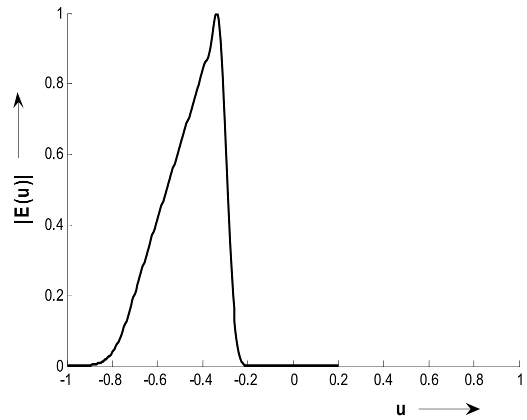


Figure 5: Radiation Pattern for R=25λ, Beamwidth=0.5

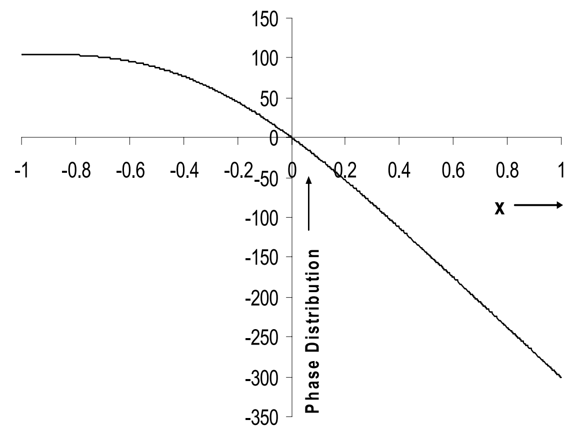


Figure 4: Phase distribution for R=100λ, Beamwidth=0.5

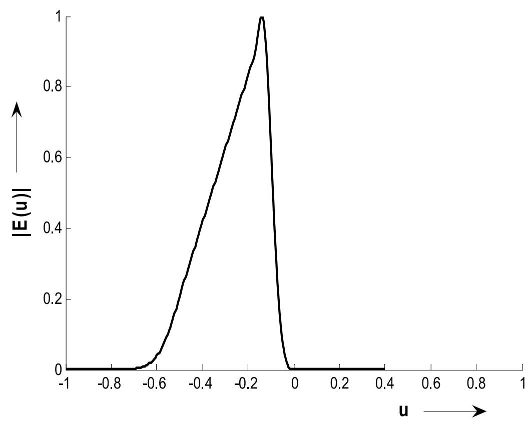


Figure 6: Radiation Pattern for R=25λ, Beamwidth=0.5

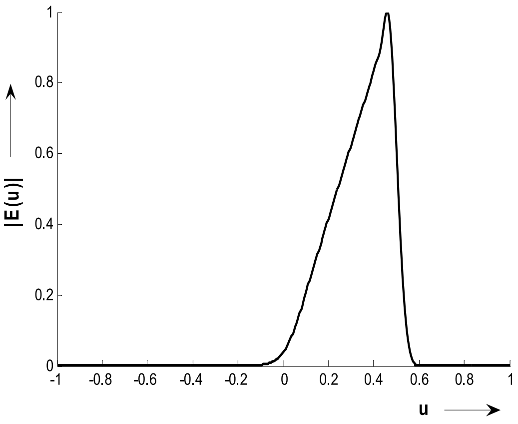


Figure 7: Radiation Pattern for R=25λ, Beamwidth=0.5

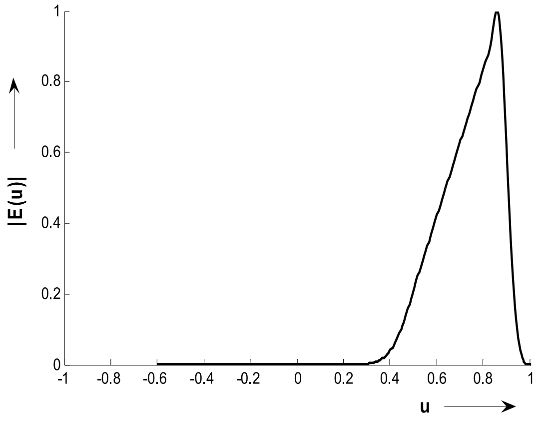


Figure 9: Radiation Pattern for R=25λ, Beamwidth=0.5

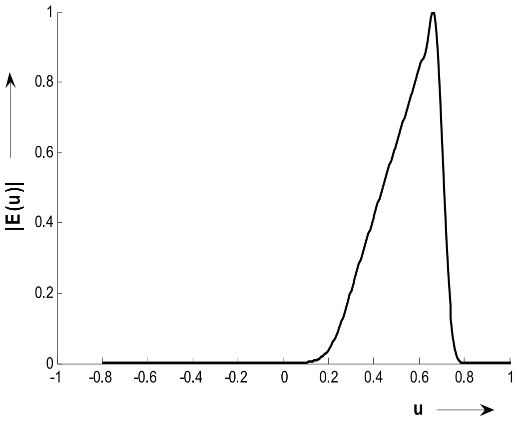


Figure 8: Radiation Pattern for R=25λ, Beamwidth=0.5

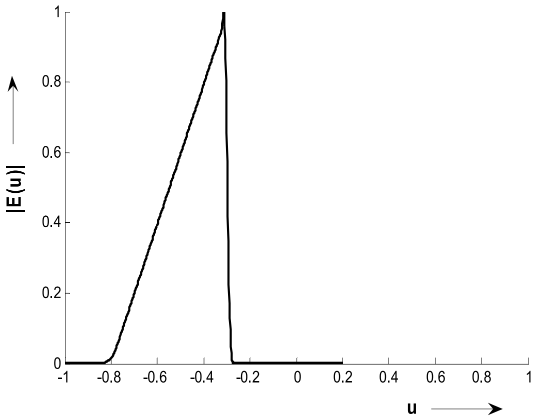


Figure 10: Radiation Pattern for R=100λ, Beamwidth=0.5

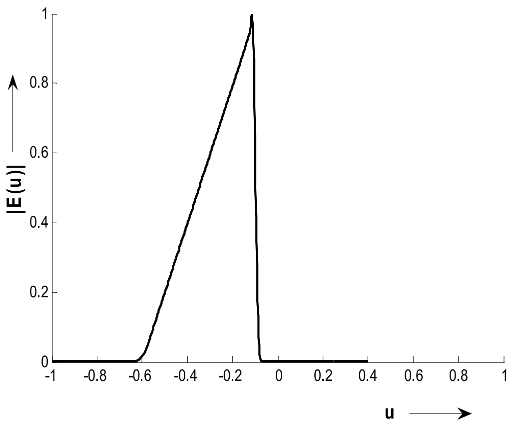


Figure 11: Radiation Pattern for R=100λ, Beamwidth=0.5

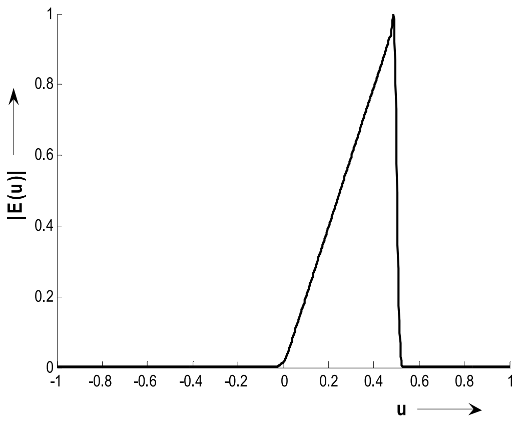


Figure 12: Radiation Pattern for R=100λ, Beamwidth=0.5

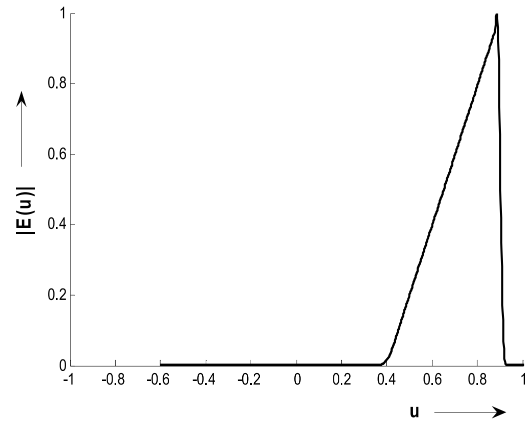


Figure 13: Radiation Pattern for R=100λ, Beamwidth=0.5

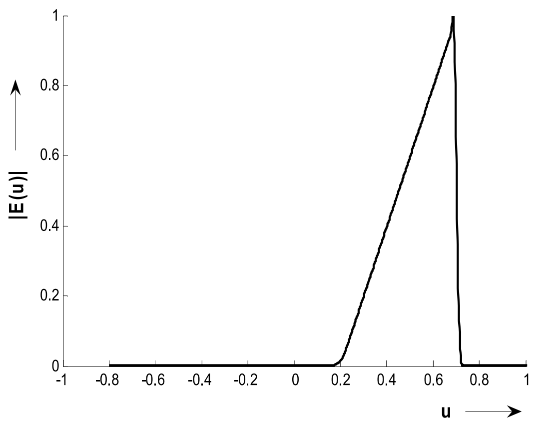


Fig 14: Radiation Pattern for R=100λ, Beamwidth=0.5

IV. CONCLUSIONS

It is evident from the results that ,the phase distribution obtained for the generation of ramp patterns is nonlinear and it varies in magnitude with size of the aperture and required beam width. The ramps generated in u-domain are very close to the desired ones, irrespective of the beam width. The method can be extended to any type of pattern.

REFERENCES

1.T.T.Taylor, "**Design of circular apertures for narrow beam width and low sidelobes",** IRE Transactions on Antennas and Propagation Vol AP-8, pp. 17-22; January, 1960.

2.GSN.Raju, "**Antennas and Wave Propagation",** Pearson Education Publishers, Chapters 4, 5.

3.R.C.Hansen "**Table of Taylor distributions for circular aperture antennas",** IRE Transactions on Antennas and Propagation, Vol. AP-8, PP. 23-26; January,1960.

4.J.Ruze, "**Circular aperture synthesis"**, IEEE Transactions on Antennas and Propagation**,** pp.691- 694; November 1964.

5.Ajoy Chakraborty, B.N.Das, and Gitindra S.Sanyal , **"Determination of Phase Functions for a Desired One-Dimensional Pattern**", IEEE Transactions On Antennas and Propagation, Vol. AP- 29, No.3, PP 502-506, May 1981.

6.H.E.Shanks, **"A geometrical optics method of pattern synthesis for linear arrays"**, IRE Transactions on Antennas and Propagation., pp. 485-490,Sept. 1960.

AUTHOR'S BIO-DATA

J.Babu born in 1973 at Tade palli gudem, West Godavari Disrict (AP). He has completed B.Tech (ECE) from Jawaharlal Nehru Technological University, Anantapur (AP), India in 1996 and M.Tech (ECE) from Cochin University of Science& Technology, Cochin, Kerala state in 1998.

During 1998 to 2006, he worked as a faculty member of ECE Department in ASR College of Engineering, Tanuku. Sri Vasavi Engineering College, Tadepalli Gudem, Lakireddy Bali Reddy College of Engineering, Mylavaram, Krishna District (AP). Since 2006 he is working as Associate Professor of ECE Department, Maharajah Vijayaram Gajapathi Raj College of Engineering,Vizianagaram, Andhra Pradesh state, India.

He is doing research work, leading to Ph.D, on Antennas at ECE Department, AU College of Engineering, Andhra University, Vishakapatnam, under the guidance of Professor Dr GSN Raju.

His fields of interest are Electromagnetics, Antennas, Microwaves, Radar, EMI/ EMC.

Dr. G.S.N. Raju received his B.E., M.E. with distinction and first rank from Andhra University, Vishakapatnam and Ph.D. from IIT, Kharagpur. He is Professor of Electronics and Communication Engineering in Andhra University College of Engineering, Visakhapatnam, India.

He is in teaching and research for the last 30 years in Andhra University, Vishakapatnam. He guided 16 Ph.D.s in the fields of Antennas, Electromagnetics, EMI/EMC and Microwave, Radar Communications, Electronic circuits.

Prof. Raju has Published about 260 technical papers in National/ International Journals/Conference Journals and transactions.

He is the recipient of "The State Best Teacher Award" from the Government of Andhra Pradesh in 1999, "The Best Researcher Award" in 1994, Prof.Aiya Memorial "National IETE Award" for his best Research guidance in 2008 and "Dr. Sarvepalli Radha krishnan Award for the Best Academician of the year 2007".

He was a visiting Professor in the University of Paderborn and also in the University Karlsruhe, Germany in 1994.

At present he holds the positions of Principal, Andhra University College of Engineering (A), Visakhapatnam, Chief Editor of National Journal of Electromagnetic Compatibility, India.

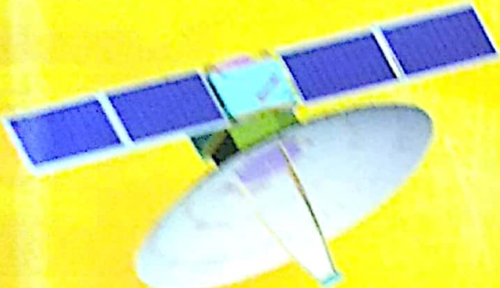
Prof. Raju has published five textbooks "Antennas and Wave Propagation", "Electromagnetic Field Theory and Transmission Lines", "Electronics Devices and Circuits", "Microwave Engineering", Radar Engineering and Navigational Aids".

Prof. Raju has been the best faculty performer in Andhra University with the performance index of 99.37%.

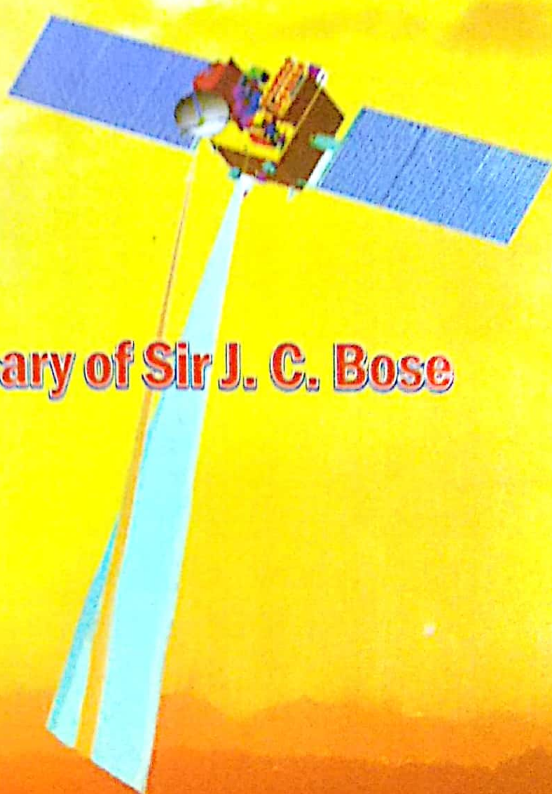
ICMARS-2009

19th-21st December 2009, Jodhpur

5th INTERNATIONAL CONFERENCE
ON
MICROWAVES, ANTENNA, PROPAGATION AND REMOTE SENSING



SOUVENIR



DEDICATED TO 150th Birth Anniversary of Sir J. C. Bose

INTERNATIONAL CENTRE FOR RADIO SCIENCE (ICRS)

An Institution of Laxmi Narayan Calla Education Foundation

"OM NIWAS", A-23, Shastri Nagar, Jodhpur-342003, (Rajasthan), India
Tel.: 91-291-2613123, 2640063 Fax : 91-291-2626166
Email : opncalla@yahoo.co.in Website : www.radioscience.org

SYNTHESIS OF CIRCULAR APERTURE RADIATOR FOR SHAPED BEAMS

J.BABU[1], G.S.N.RAJU

[1] *Electronics&Communications Engg Dept, MVGR College of Engineering, Vizianagaram(A.P),India,*
E mail:jbabumtech@rediffmail.com

[2]*Electronics&Communications Engg Dept, AU College of Engineering(A), Andhra University,Visakhapatnam,*
E mail: drrajugsn@yahoo.co.in

ABSTRACT

The design of circular apertures is reported by Taylor [1] to produce the directional characteristics having narrow main beam width with low side lobes. The set of continuous circular aperture distributions is developed by him. Similar work is also reported by several researchers [2-11] on the aperture distributions in tabular form.

Ajoy Chakraborty et al [12-16] reported the method of design of circular aperture to produce the shaped beams.

In the present work, the method reported by Ajoy Chakraborty is modified in order to produce the improved patterns. The method consists of selection of suitable Amplitude distribution and the design of optimized phase function for a circular aperture.

For a specified data on the beam width , the cosecant patterns are realized for different aperture sizes. It is found from the results that, the patterns are optimal for large apertures .The patterns for two typical aperture sizes are presented in figures[1-2]

It is possible to extend the work for discrete arrays[4] for any type of radiating element.

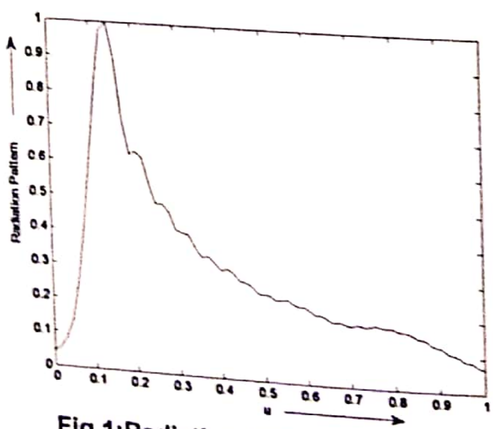


Fig 1:Radiation Pattern for R/λ=15

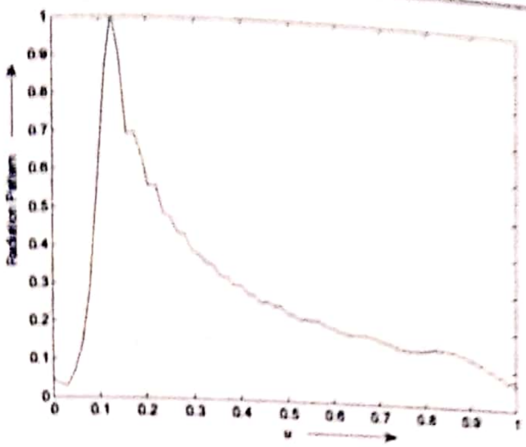


Fig 2:Radiation Pattern for R/λ=25

References:

[1]. T.T.Taylor,Design of circular apertures for narrow beam width and low sidelobes, IRE Transactions on Antennas and Propagation Vol . AP-8, pp. 17-22; January, 1960.

[2]. R. C. Hansen Table of Taylor distributions for circular aperture antennas, IRE Transactions on Antennas and Propagation,vol. AP-8, pp. 23-26; January,1960.

[3]. GSN.Raju,A Text Book on "Antennas and Wave Propagation",Pearson Education Pubishers, Singapore.

[4]. J.Ruze,Circular aperture synthesis ,IEEE Transactions on Antennas and Propagation, pp.691-694; November 1964

[5]. T.T.Taylor, A Synthesis method for circular and Cylindrical antennas composed of disctrete elements,IRE Transactions on Antennas and Propagation ,vol. AP-3, pp. 251-261; August 1952

[6]. D.K.cheng and F.I.Tseng,Maximisation of directive gain for circular and elliptical arrays, Proc.Inst. Elec. Eng., vol. 114,pp. 589-594, May 1967.

[7]. D. K.Cheng and F. I. Tseng, Pencil-beam synthesis for large circular arrays,Proc. Inst. Elec. Eng., Vol. 117, pp.1232- 1234, July 1970.

[8]. G.Borgiotti,Design of circular apertures for high beam efficiency and low side lobes, Alta Frequenza Journal, vol. 40, pp. 652- 657,Aug. 1971.

[9]. D.H.Sinnott,RF Harrington ,Analysis and Design of a circular antenna arrays by matrix methods, Vol AP-21,No.5,pp 610-614,September 1973.

[10].R.S.Elliott , Improved Pattern Synthesis for Equispaced Linear Arrays, Alta Frequenza., Vol. 51, pp.296-300, Nov./Dec., 1982.

[11]. R.S.Elliott , *A* New Technique for Shaped beam Synthesis of Equispaced Arrays, IEEE Trans. on Antennas & Propagation, Vol. AP-32,No.10, pp.1129-1133,October, 1984.

[12]. Ajoy Chakraborty,B.N.Das, and Gitindra S.Sanyal ,Determination of Phase Functions for a Desired One-Dimensional Pattern, IEEE Transactions On Antennas and Propagation, Vol. AP-29, No.3, PP 502-506,May 1981.

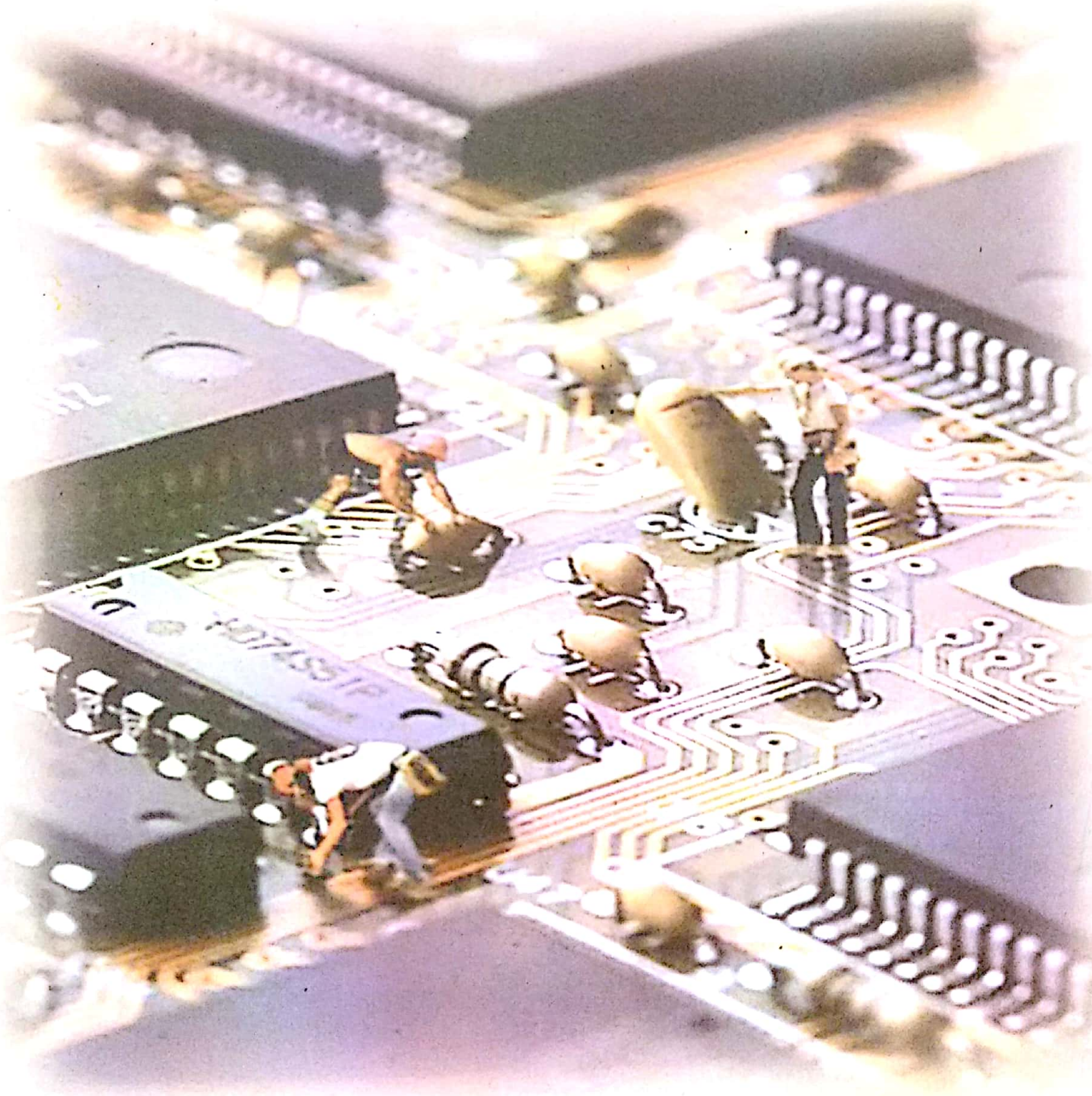
[13]. Ajoy Chakraborty,B.N.Das, and Gitindra S.Sanyal ,Beam shaping using Nonlinear phase distribution in a uniformly spaced Array, IEEE Transactions On Antennas and Propagation, Vol. AP-30, No.5, PP 1031-1034, September 1982.

[14]. Ajoy Chakraborty,B.N.Das,Phase scanning of one dimensional Problem,IEEE Transactions On Antennas And Propagation, Vol. AP-32,No. 2, PP 189-192,February 1984.

[15]. Ajoy Chakraborty, B.N.Das,Scanning of sector and Cosecant Beams generated by a circular aperture, IEEE Transactions On Antennas And Propagation, Vol. Ap-32, No.9, PP 1000-1003, September 1984.

[16]. Ajoy.Chakraborty, B.K.Sarap,B.N.Das, Synthesis of Phase function of an array of Rectangular wave guides for a desired beam shape,IEEE Transactions on Antennas& Propagation, pp.305-308,1983.

Proceedings of the
9th INTERNATIONAL CONFERENCE
ON ELECTROMAGNETIC
INTERFERENCE AND COMPATIBILITY
INCEMIC 2006



Organised by the
Society of EMC Engineers (India)
In Cooperative Sponsorship with the
IEEE EMC Society

Bangalore, India
23-24 February 2006

Comparative Studies on the Effect of Analog and Digital Phase Shifters on the Scanned Sum Patterns

J. Babu
Dept. of Electronics and Communication Engineering
LB Reddy College of Engineering
Mylavaram – 521 230.
Email : jbabumtech@rediffmail.com

Prof. G.S.N. Raju
Dept. of Electronics and Communication Engineering
AU College of Engineering
Visakhapatnam – 530 003.
Email : profrajugsn@yahoo.com

Abstract - Sum patterns [1-2] are very popular for point to point communications and higher angular resolution radars. The advanced communication and Radar systems require scanning at faster rate. This requires the implementation of scanning by Digital phase shifters.

In the present paper the effect of Digitization on this scanned sum patterns is consolidated.

I INTRODUCTION

Sum patterns are produced from the arrays of different Radiating elements. In most of the Radars and Communication applications, such patterns are scanned in different directions. Scanning is possible either by frequency or by phase control.

In the case of frequency scanning, the components in the system exhibit lot of limitations.

In view of this, phase control is frequently adopted. Depending on the application phase distribution is to be designed.

It is possible to introduce designed distribution either by Analog phase shifters or by Digital phase shifters.

In the present work a few distribution functions are designed for fixed amplitude distribution for different scan angles.

Using these functions the radiation patterns are numerically computed using both analog and digital phase shifters.

II EFFECT OF DIGITIZATION ON THE SCANNED SUM PATTERNS

For uniformly excited linear array, the radiation pattern is given by

$$E(\theta) = \frac{1}{N}\left[\frac{\operatorname{Sin}(\beta d N/2)(\operatorname{Sin}\theta - \operatorname{Sin}\theta_o)}{\operatorname{Sin}(\beta d/2)(\operatorname{Sin}\theta - \operatorname{Sin}\theta_o)}\right] \qquad (1)$$

where N is the Number of elements in the Array,
$\beta = 2\pi/\lambda$,

where λ is the operative wave length,
θ = angle from broad side,
d = spacing between the elements,
θ_o = scan angle.

When the required beam direction is along θ_o, the progressive phase shift required between successive elements is $\beta d \operatorname{Sin}\theta_o$.

When the 1st element is taken as the reference, the phase lead required to be given to the nth element is (n - 1)ϕ.

When Digital phase shifters [3] are used, it is not possible to provide exact phase required. The Phase shift is quantized to the nearest value of the exact phase.

As a result it introduces error in the beam direction. Taking the Center of the array as the reference, the required exact Phase shift is given by

$$\begin{aligned}\psi_n &= (n-0.5)\,\beta d \operatorname{Sin}\theta + (n-0.5)\phi \\ &= (n-0.5)\,[\beta d \operatorname{Sin}\theta + \phi]\end{aligned} \qquad (2)$$

The radiation pattern of array of N elements using analog-Phase shifters is given by

$$E(\theta) = \frac{2}{N}\sum_{n=1}^{N/2} \operatorname{Cos}[(n-0.5)(\beta d \operatorname{Sin}\theta + \phi)\,] \qquad (3)$$

The Radiation pattern with Digital-Phase shifters is given by

$$E(\theta)=\frac{2}{N}\sum_{n=1}^{N/2}\mathrm{Cos}[(n-0.5)(\beta d\mathrm{Sin}\theta+\phi_n)\,] \quad (4)$$

When N is odd, there exists center element and the exact Phase shift is given by

$$\psi_i = n[\beta d\ \mathrm{Sin}\theta+\phi] \quad (5)$$

The resultant Radiation pattern with Analog phase distribution is given by

$$E(\theta)=\frac{1}{N}\left[1+2\sum_{n=1}^{(N-1)/2}\mathrm{Cos}[n(\beta d\mathrm{Sin}\theta+\phi)\,]\right] \quad (6)$$

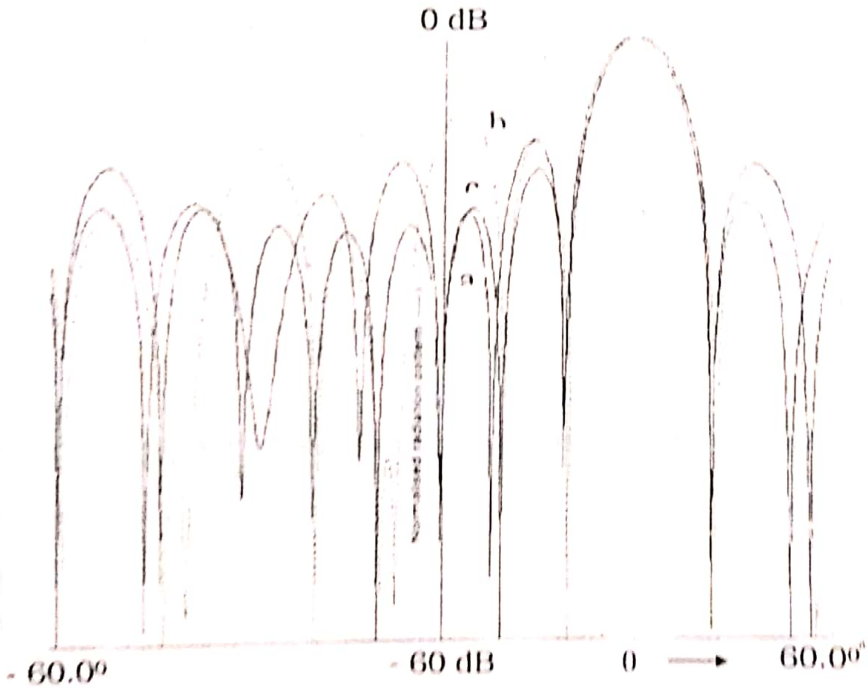


Fig 1- Sum pattern for scan of 30°, for (a) analog (b) 2 bit (c) 3 bit phase shifters

The Phase distribution is Digitized and

$$E(\theta)=\frac{1}{N}\left[1+2\sum_{n=1}^{(N-1)/2}\mathrm{Cos}[n(\beta d\mathrm{Sin}\theta+\phi_n)\,]\right] \quad (7)$$

III RESULTS

Using the expressions presented above, the Sum patterns are computed for scan angle of 30° for analog Phase distribution, 2 bit and 3 bit phase shifters. The variation of side lobe level for 2 bit, 3 bit, 4 bit, 5 bit and 6 bit phase shifters are presented in figs. 1 - 3.

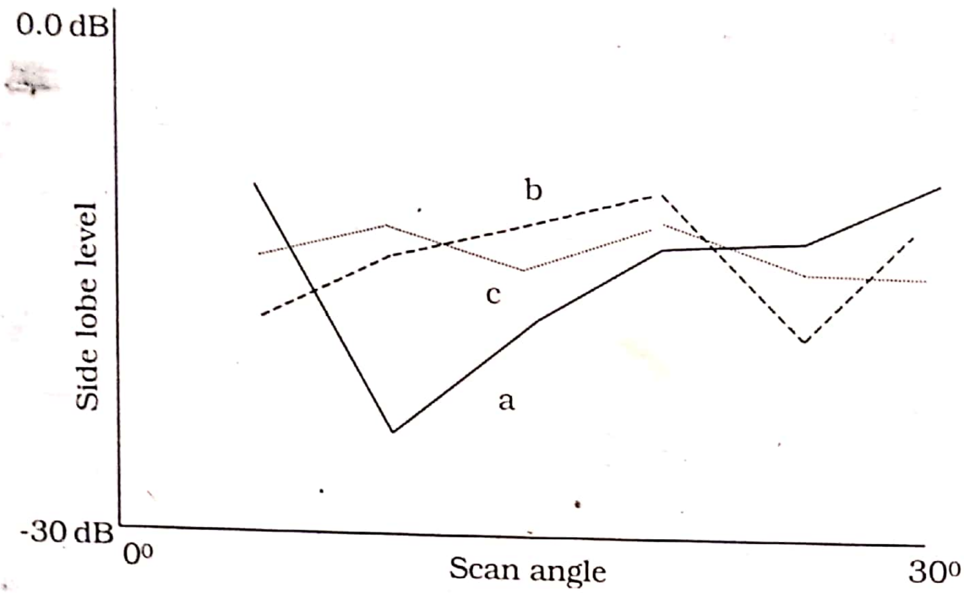


Fig 2- Variation of sidelobe level of radiation pattern with scan angle for (a) 2 bit (b) 3 bit (c) 4 bit phase shifters

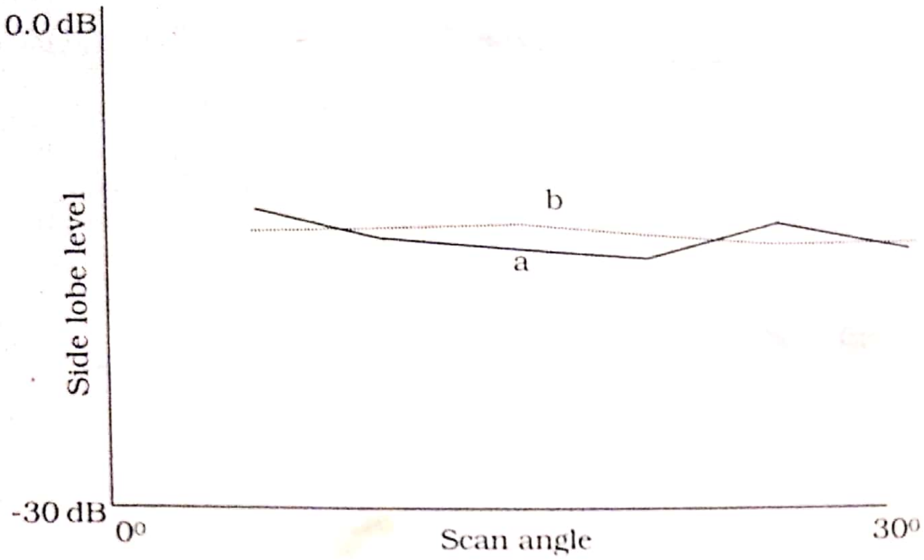


Fig 3- Variation of sidelobe level of radiation pattern with scan angle for (a) 5 bit (b) 6 bit phase shifters

IV. REFERENCES

[1] Antennas and Wave Propagation by G.S.N. Raju (Pearson Education).

[2] Antenna Theory and Design by R.S. Elliot.

[3] "A Method of generation of sum and SLS Difference Patterns" by P.V. Sridevi, G.S.N. Raju, A. Chakraborty & B.N. Das (Microwave and optical Technology letters, USA, Vol. 7, No12, pp 559-563, August 1994).

AUTHORS' BIO-DATA

GSN Raju received his BE, ME with distinction and first rank from Andhra University and PhD from IIT, Kharagpur. He is Professor of Electronics and Communication Engineering in Andhra University, College of Engineering, Visakhapatnam. He has guided 14 PhDs in the field of Antennas, Electromagnetics, EMI/EMC and Microwave and Radar Communications. He has published 150 technical papers in National/ International journals/ conference proceedings including IEEE (USA), IEE (UK), IETE (India), AMSE (France) Journals and transactions. He is the recipient of 'Best Teacher Award' from Hon'ble Chief Minister, Sri. N Chandra Babu Naidu and 'The Best Research Award' from Hon'ble Governor of Andhra Pradesh Shri K Krishnakanth in 1994. He was a visiting professor in the University of Paderborn and Karlsruhe, Germany in 1994. Dr Raju was Head of the Department of Electronics and Communication Engineering, AU during 1992-95. He holds the positions of Associate Editor of National Journal of EMC since 1995. Chairman, Board of Studies in ECE, EIE, Chairman IETE, Visakhapatnam Centre since 2002. Chairman, Society of Electromagnetic compatibility Engineers since 1993. Member, Board of Studies in Electronics and Communication Engineering in Sri Venkateswara, JNTU, and Kakatiya Universities. Convenor/Member of AICTE Expert Committee since 1994. Member, National Boardof Accreditation, AICTE since 1998. Coordinator, Centre for Bio-Medical Engineering, Andhra University since 2003. Convenor of several expert committees of Andhra University. His fields of interest are Antennas, Wave propagation, Radar and Microwave Communication, Electromagnetics, EMI/EMC, Electronic Device, Circuits and Bio-Medical Instrumentation.

J Babu, born in 1973, had completed his B Tech from JNTU, Hyderabad and M Tech from Cochin University. He is presently working as an Asso[illegible] Professor at LB Reddy College of Engg., Mylavaram, A.P.

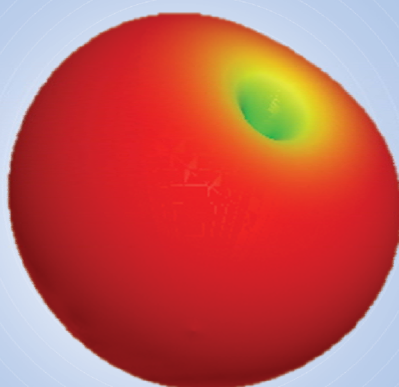
APSYM 2006

PROCEEDINGS OF APSYM 2006

National Symposium on

ANTENNAS & PROPAGATION

DECEMBER 14-16, 2006



DEPARTMENT OF ELECTRONICS
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI – 682 022

Co-sponsored by:
University Grants Commission
All India Council of Technical Education
Department of Science & Technology (Govt. of India)
Council of Scientific and Industrial Research (Govt. of India)
Kerala State Council for Science Technology and Environment (Govt. of Kerala)
IEEE Student Branch, Cochin

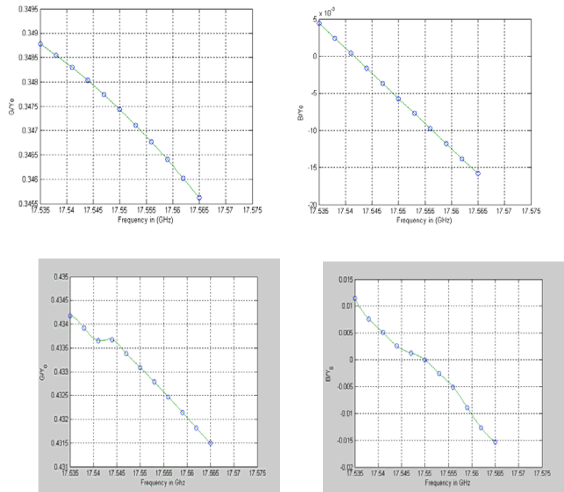


Fig.5. G and B graph for offset-2

IV.CONCLUSION

The method of moments using entire basis functions has been applied to the solution of the field in a longitudinal slot in rectangular wave guide. The measured susceptance-conductance curve is found to be excellent. The basis solution presented here can be used for computing the backward as well as the forward scattered wave amplitudes. The graphs are similar for moment method solution of the field and computed simulation technique.

REFERENCES

[1]. David M.Pozar, Microwave Engineering.
[2]. R.F. Harrington, Field Computation by Moments Methods.
[3]. R.J. Stegen."Longitudinal shunt slot characteristic", Hughes Tech Memo.261, Nov 1971

ANALYSIS OF SLOT EXCITED RECTANGULAR WAVEGUIDE

M. Surendra Kumar (1), B. Sada Siva Rao (2), J. Babu (3), G. Karunakar (4), G.S.N. Raju (5)

(1) Dept. of ECE, Raghu Engineering College, Visakhapatnam.
Email : s_kumarleo@yahoo.co.in
(2) Dept. of ECE, M.V.G.R. College of Engineering, Vizianagaram – 535005
Email : b_sadasivarao@yahoo.co.in
(3) Dept. of ECE, M.V.G.R. College of Engineering, Vizianagaram – 535005
Email : jbabumtech@rediffmail.com
(4) Dept. of ECE, GITAM Engineering College, Visakhapatnam – 530045
Email : karunakargodi@yahoo.co.in
(5) Professor, Dept. of ECE, AU College of Engineering, Visakhapatnam – 530003,
Email : drrajugsn@yahoo.com

ABSTRACT

Slot coupled waveguide junctions are commonly used in various applications. These junctions are used to generate desired polarized fields. The H and E plane T-junctions are analyzed by several Researchers. However, in the present work a slot excited rectangular waveguide is analyzed. The analysis consists of the estimation of self-reaction and discontinuity in modal current. The self-reaction is evaluated from the TE and TM modes.

INTRODUCTION : The basic theory on slot radiators is reported by Watson[1]. Several experiments are conducted by him and the data on coupling and impedance is reported. Several waveguides are coupled by rectangular slots and the theory of coupling was explained by him. A few types of coupling contain shut-series, series-series, series-shunt, shunt-shunt coupling of rectangular waveguides are analysed.

The theory of diffraction by holes is reported by Bethe [2] . However, the holes being small, and they are not used as radiators. Stevenson [3] has developed theory of slots in rectangular waveguides. The analogy with transmission line is developed and established by him. The detailed formulae for reflection and transmission coefficients are derived. Closed form expressions are presented with assumptions on the slots.

Marcuvtz et al. [4] reported a paper on the representation of electric and magnetic fields produced by currents and discontinuities in waveguides. It was shown that the discontinuity can be replaced by equivalent electric and magnetic currents.

Rumsay [5] has developed the concept of the self-reaction in electromagnetic waves. This theory is found to be extremely useful for the analysis of slot coupled waveguides and junctions. In the present work the concept of self-reaction and discontinuity in modal current are made use of for the analysis of slot excited waveguides.

FORMULATIONS

For the purpose of analysis in the guide, the electric field distribution in the aperture plane of the slot can be assumed to be of the form

$$\mathbf{E}_s = \mathbf{a}_x E_o \sin k(L-|z|)\delta(y-0) \qquad (1)$$

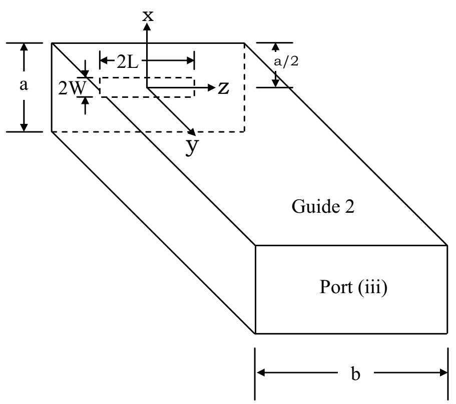


Fig. 1 Longitudinal slot exciting the coupled guide

where $K = 2\pi/\lambda$, λ being the wavelength and E_o is the maximum electric field in the slot, 2L is the slot length and 2W is slot width.

For the coordinate system shown in fig. 1, the variables are related as

$$\mathbf{e}^e = \mathbf{a}_y \times \nabla_t \psi^e \qquad (2)$$

$$\mathbf{e}^m = -\nabla_t \psi^m \qquad (3)$$

Here ψ^e and ψ^m are the normalized eigen functions for the electric and magnetic fields [6].

The relations between the modal vector functions for the electric and magnetic fields are of the form

$$\mathbf{h}^e_{mn} = \mathbf{a}_y \times \mathbf{e}^e_{mn} \qquad (4)$$

$$\mathbf{h}^m_{mn} = \mathbf{a}_y \times \mathbf{e}^m_{mn} \qquad (5)$$

The electric field in the aperture plane of the slot can be expressed in terms of modal voltages V^e_{mn} and V^m_{mn} and modal vector functions $\mathbf{e}^e_{mn}$, $\mathbf{e}^m_{mn}$ as

$$\mathbf{E}_s = \sum_m \sum_n \left[V^e_{mn}\,\mathbf{e}^e_{mn} + V^m_{mn}\,\mathbf{e}^m_{mn}\right] \qquad (6)$$

But $\mathbf{e}^e_{mn}$ and $\mathbf{e}^m_{mn}$ are orthogonal in nature. The expressions for the modal voltages are obtained from

$$V^e_{mn} = \int_{-W}^{W}\int_{-L}^{L} \mathbf{E}_s \cdot \mathbf{e}^e_{mn}\, dx\, dz \qquad (7)$$

$$V^m_{mn} = \int_{-W}^{W}\int_{-L}^{L} \mathbf{E}_s \cdot \mathbf{e}^m_{mn}\, dx\, dz \qquad (8)$$

The transverse component of the magnetic field in the guide is of the form

$$\mathbf{H}_t = \sum_m \sum_n \left[(Y_o)^e_{mn} V^e_{mn}\,\mathbf{h}^e_{mn} + (Y_o)^m_{mn} V^m_{mn}\,\mathbf{h}^m_{mn}\right] e^{-\gamma_{mn} Y} \qquad (9)$$

Where $(Y_o)^e_{mn}$ and $(Y_o)^m_{mn}$ are the characteristic admittances of TE and TM modes respectively, $\mathbf{h}^e_{mn}$ and $\mathbf{h}^m_{mn}$ are modal vector functions for transverse component of magnetic field.

From the above equations, the self-reaction is given by

$$\langle a,a\rangle = -\iint \left[\sum\sum (Y_o)^e_{mn} V^e_{mn}\,\mathbf{h}^e_{mn} + \sum\sum (Y_o)^m_{mn} V^m_{mn}\,\mathbf{h}^m_{mn}\right] . 2\,\mathbf{E}_s \times \mathbf{a}_y\, ds \qquad (10)$$

It can be reduced to the form

$$\langle a,a\rangle = 2\sum\sum (Y_o)^e_{mn}\left(V^e_{mn}\right)^2 + 2\sum\sum (Y_o)^m_{mn}\left(V^m_{mn}\right)^2 \qquad (11)$$

Here $(Y_o)^e_{mn} = \dfrac{\gamma_{mn}}{j\omega\mu}$, $(Y_o)^m_{mn} = \dfrac{j\omega\in}{\gamma_{mn}}$ and

$$\gamma_{mn} = \left[\left(\frac{m\pi}{b}\right)^2 + \left(\frac{n\pi}{a}\right)^2 - \left(\frac{2\pi}{\lambda}\right)^2\right]^{1/2}$$

The discontinuity in modal current, I is found out from the paper reported by Marcuvitz and Schwinger [7].

The admittance loading of the present configuration is given by

$$Y = -\frac{I.I}{\langle a,a\rangle}$$

The normalized admittance, $y_n = \dfrac{Y}{y_{o1}} = g_n + jb_n$

RESULTS

From the equations presented above, the normalized admittance is computed as a function of slot length for the centre frequency of X-band. The results are presented in a tabular form.

Length of the slot	Conductance	Susceptance
0.8	0.00034474541	0.012847405
1.0	0.0018193990	0.029449597
1.2	0.010792075	0.070986211
1.4	0.12158833	0.20779756
1.6	0.25400925	-0.23718566
1.8	0.068729490	-0.16688621
2.0	0.040116452	-0.13163435
2.2	0.031553663	-0.11757274

From the results it is found resonance takes place at a slot length of about 1.5 cm.

REFERENCES

1. W.H. Watson, "Resonant slots," JIEE (London), Vol. 93, Part 3A, pp. 747-777, 1946.

2. H.A. Bethe, "Theory of diffraction by small holes," Phys. Rev., Vol. 66, pp. 163-182, 1944.

3. A.F. Stevenson, "Theory of slots in rectangular waveguides," J. Appl. Phys., Vol. 19, pp. 24-38, January 1948.

4. N. Marcuvitz, "Waveguide Handbook," R.L. Series, Vol. 10, New York, McGraw Hill, 1951.

5. V.H. Rumsey, "The reaction concept in electromagnetic theory," Phys. Rev., Vol. 94. No. 6, pp. 1483, June 15, 1954.

6. R.F. Harrington, "Time-harmonic electromagnetic fields," New York, McGraw Hill, 1961.

7. N. Marcuvitz and J. Schwinger, "On the representation of electric and magnetic fields produced by the currents and discontinuities in waveguides," J. Appl. Phys. Vol. 22, No. 6, pp. 806-819, June 1951.

EFFECT OF BROAD DIMENSION OF RECTANGULAR WAVEGUIDE ON THE NORMALIZED CONDUCTANCE OF OPEN SLOT RADIATOR

R. Ramana Reddy (1), G.S.N. Raju (2)

(1) Research Scholar, Dept. of ECE, A.U. College of Engineering, Visakhapatnam – 530003,
Email : profrrreddy@yahoo.co.in
(2) Professor, Dept. of ECE, AU College of Engineering, Visakhapatnam – 530003,
Email : drrajugsn@yahoo.com

ABSTRACT

The rectangular waveguide narrow wall inclined slot radiators are used for the generation of horizontally polarized fields. The analysis of these radiators for their admittance characteristics is carried out by several researchers. However, the characteristics are controlled by basic slot parameters. In the present work, some studies are made to find the behaviour of admittance by waveguide dimension. The variation of normalized conductance and susceptance of a typical slot with the broad wall dimension is presented.

INTRODUCTION : The basic theory of slots in rectangular waveguides is reported by Stevenson [1]. The theory of slots is developed with the following assumptions.

1. The walls of the guide are perfectly conducting and have negligible thickness.
2. The slot is narrow, i.e. the ratio of length to width of the slot is much greater than unity.
3. The penetration of the field into the region behind the face containing the slot is negligible. In other words, problem is treated as if the guide face containing the slot has an infinite perfectly conducting plane on it.
4. The length of the slot is such that it is at resonance.

The well known results of Stevenson for the slot conductance are applicable only at resonance. Closed form expressions on the impedance characteristics of the centred slots are reported by Lewin [2]. The centred slots do radiate and the conductance changes marginally with slot shape.

The effect of slot inclination and its thickness on impedance characteristics are found to be significant and are reported by Oliner [3].

The Oliner work is centred around the slots in the broad wall of a rectangular waveguide. Oliner work assumes that the slot radiates into half space and it has rectangular ends. Slot conductance is determined using variational expressions and susceptance is estimated from the energy storage considerations.

Hsu and Chen [4] applied variational formulae developed by Oliner. The internal reactive energy is included and the admittance properties are studied.