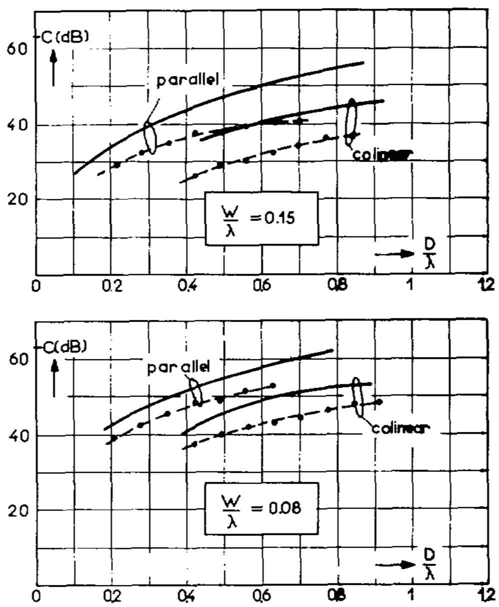

Fig. 4. Comparison between theoretical and experimental couplings between two short-circuited flat dipoles at resonance for different widths: $W/\lambda = 0.08, 0.15$. Case $h/\lambda = 0.17$, $H/\lambda = 0.08$. —— Theory. –• –• –• Experiments.

The coupling at resonance appears very weak when compared with that at nonresonance [3]. We note that the coupling becomes stronger as the width W/λ increases (for H/λ and D/λ given) while mutual impedance decreases. We can explain this fact by the relative decrease of the radiating resistance (10) which varies as $R_c^{\,2}$. Otherwise, when taking into account (7), we can say that for resonance s_{12} is approximately proportional to $R_c^{\,-4}$.

Fig. 4 compares experimental and theoretical coupling for $H/\lambda = 0.08$ ($h/\lambda = 0.17$) for two different widths: $W/\lambda = 0.15$ and 0.08. The correlation between theory and experiment is best when W/λ decreases, although experimental coupling values are always greater than the theoretical ones. The reason for this is the assumption of the theoretical model of a central current localized in the symmetrical plane.

For the case $W/\lambda = 0.15$ we have $R_c = 90\ \Omega$ and for $W/\lambda = 0.08$ we have $R_c = 125\ \Omega$. If we apply the above approximate variation law of $R_c^{\,-4}$ an approximate variation of 10 dB for mutual coupling can be explained.

CONCLUSION

We have found that coupling between two short-circuited flat dipoles at resonance is very weak especially in a parallel position (Figs. 3 and 4). When using such sources in an array, superdirectivity, that is to say, directivity greater than that given by a uniform illumination, can be achieved. The weakness of the coupling is probably due to a large reactive storage of energy in the immediate vicinity of the source. Thus for short arrays using only a few sources and especially at low frequency, superdirectivity can be used to reduce the antenna size.

REFERENCES

[1] G. Dubost, "Theory and experiments of a broadband short-circuited microstrip dipole at resonance," in *Proc. Workshop on Printed Circuit Antenna Technology*, Oct. 1979, pp. 32.1–32.13.

[2] G. Dubost and A. Rabbaa, "Couplage electromagnetique entre deux doublets plaques court-circuites," *C.R. Acad. des Sci.*, serie B 301, t. 288, May 1979.

[3] ——, "Couplage de sources petites par rapport a la longueur d'onde," *L'Onde Electrique*, vol. 60, pp. 54–58, June–July 1980.

[4] I. E. Rana and N. G. Alexopoulos, "Printed wave antennas," in *Proc. Workshop on Printed Circuit Antenna Technology*, Oct. 1979, pp. 30.1–30.38.

[5] H. C. Baker and A. H. Lagrone, "Digital computation of the mutual impedance between thin dipoles," *IRE Trans. Antennas Propagat.*, pp. 172–178, Mar. 1962.

Line-Source Excitation for Maximum Difference Slope with Given Sidelobe Level

ALFRED R. LOPEZ, SENIOR MEMBER, IEEE

Abstract—**A method is described for computing the difference excitation of a linear aperture that provides maximum slope ratio with a constraint on the sidelobe level. Elementary Bessel functions are used in the computations.**

I. INTRODUCTION

Difference patterns have been used for monopulse tracking radars [1], [4], and they are now beginning to find use in adaptive antenna communication systems. Optimum monopulse patterns and excitations have been described by Kinsey [1] where a computer program was developed to solve for the required excitation. Bayliss [2] described excitations which are essentially optimum when $\bar{n}$ is set at a particular value for the required sidelobe level. Both of these basic contributions to aperture theory fail to provide a direct simple description of the excitation function. This communication presents a method of computation which uses elementary Bessel functions.

The principles presented here are a further development of those described in [3] where the goal was to achieve maximum aperture efficiency of a sum pattern with a given sidelobe level. Here the objective is to achieve the maximum difference slope ratio [4], [5] of a difference pattern with a given sidelobe level.

II. DIFFERENCE SLOPE RATIO

The difference slope ratio (DSR) is defined as the ratio of the slope of the directivity pattern in the boresight direction for any excitation to that of the linear-odd excitation (highest possible slope-directivity product irrespective of sidelobe level) [5]. It can be expressed as

$$\mathrm{DSR} = \sqrt{\frac{3}{D^3}}\,\frac{2\int x f(x)\,dx}{\sqrt{\int f^2(x)\,dx}} \leqslant 1$$

$$(=1 \quad \text{when } f(x) = x).$$

Manuscript received July 11, 1980; revised October 14, 1980.

The author is with the Wheeler Laboratory, Hazeltine Corporation, Greenlawn, NY 11740.

$f(x)$ is line-source excitation (voltage or current) and D is length of line source. The objective is to maximize DSR with the sidelobe level constrained.

III. COMPUTATION OF EXCITATIONS

The emphasis in this communication is on directly describing the excitation function instead of concentrating on the pattern function. Fig. 1 shows the development of the difference excitation, starting with the Chebyshev excitation and pattern functions [3]. First the pattern is differentiated, and correspondingly the excitation is multiplied by "x." ($I_1(\cdot)$ is a modified Bessel function of the first kind and of order one.) Second the area of the impulse is increased by a factor A, so that the first and far sidelobes are at the same level. Third the impulse area is redistributed so that its "center of gravity" at the end of the curve is retained, and the deviation of the resulting excitation from the linear-odd excitation is minimized. This location and distribution of the impulse area results in a pattern whose main lobe and near sidelobes are approximately preserved, whose outer sidelobes taper down as required by realizable excitations, and for which the difference slope ratio is essentially a maximum.

Fig. 2 presents the characteristics of the difference excitations. For a specified difference pattern sidelobe level, the middle curve gives the sidelobe level for the Chebyshev pattern from which the difference excitation and pattern functions are derived. The top curve gives the factor for the required increase in the impulse area, and the bottom curve is the maximum difference slope ratio for a given sidelobe level.

Fig. 3 shows computed excitations for several sidelobe levels. The aperture variable is normalized so that the outer edge of the redistributed impulse area is at the edge of the aperture. For convenience the slope at the center of the aperture is set equal to unity for all of the excitations. These excitations have been evaluated numerically; the results show that the difference slope ratios differ insignificantly from the values given by Kinsey [1]. The difference is less than one half of one percent.

Fig. 4 shows a comparison of the excitation obtained by Kinsey [1] for his highest DSR with a 30 dB sidelobe level with that proposed in this communication. The similarity over most of the aperture is remarkable, considering the difference in the method of computation.

IV. CONCLUSION

The excitations described in this communication are simple and have the advantage that they can be obtained explicitly from well-known Chebyshev excitations by simply multiplying by the aperture variable and redistributing an impulse area in a prescribed manner. The author has found that such insight with respect to excitation components, which control main lobe or sidelobe envelope characteristics, is helpful in developing various desired pattern shapes.

ACKNOWLEDGMENT

The writer is grateful to his associates, Dr. Harold A. Wheeler and Mr. Peter W. Hannan for helpful discussions relating to this communication.

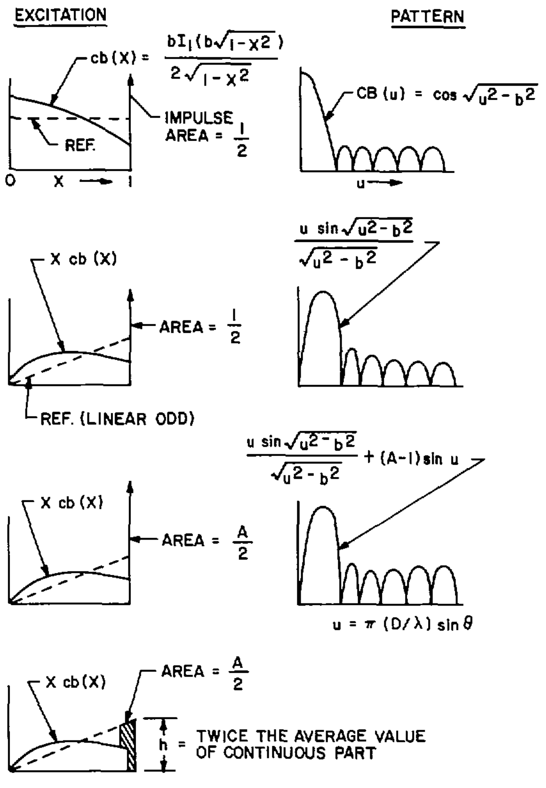

Fig. 1. Development of difference excitations.

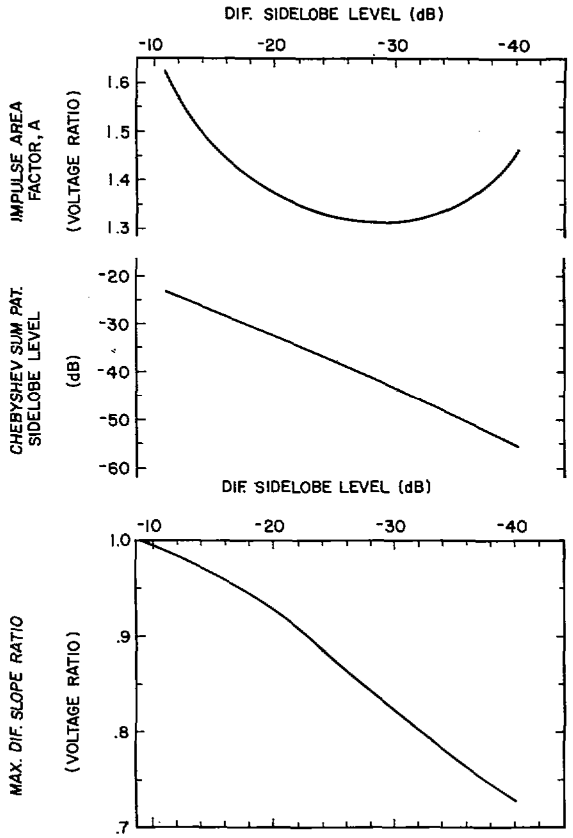

Fig. 2. Characteristics of optimum difference excitations.

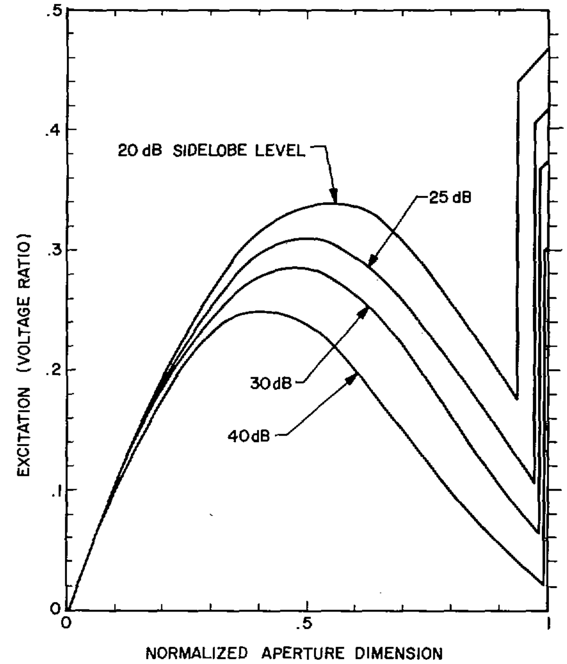

Fig. 3. Optimum difference excitations.

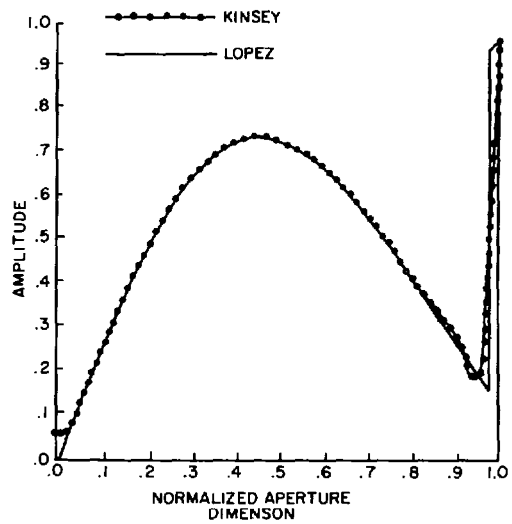

Fig. 4. Comparison of two forms of excitation intended for maximum difference slope ratio with 30 dB sidelobe level.

REFERENCES

[1] R. R. Kinsey, "Line Source Aperture Monopulse Excitations," G.E. Rep. AFCRL-68-0254, Contract AF19(628)-5905; Apr. 1968.

[2] E. T. Bayliss, "Design of monopulse antenna different patterns with low sidelobes," *Bell Syst. Tech. J.*, vol. 47, pp. 623–650, May-June 1968.

[3] A. R. Lopez, "Line source excitations for maximum aperture efficiency with given sidelobe level," *IEEE Trans. Antennas Propagat.*, vol. AP-19, pp. 530–532, July 1971.

[4] P. W. Hannan, "Optimum feeds for all three modes of a monopulse antenna I: Theory," *IEEE Trans. Antennas Propagat.*, vol. AP-9, p. 453, Sept. 1961.

[5] R. R. Kinsey, "Monopulse Difference Slope and Gain Standards," *IRE Trans. Antennas Propagat.*, vol. AP-10, pp. 343–344, May 1962.

[6] G. M. Kirkpatrick, "Aperture illuminations for radar angle-of-arrival measurements," *IRE Trans. Professional Group on Aeronautical and Navigational Electronics*, vol. PGAE-9, pp. 20–27, Sept. 1953.

[7] P. W. Hannan, "Maximum Gain in Monopulse Difference Mode," *IRE Trans. Antennas Propagat.*, vol. AP-9, pp. 314–315, May 1961.

[8] O. R. Price and R. F. Hyneman, "Distribution functions for monopulse antenna difference patterns," *IRE Trans. Antennas Propagat.*, vol. AP-8, pp. 567–576, Nov. 1960.

[9] E. J. Powers, "Utilization of the Lambda functions in the Analysis and Synthesis of Monopulse Antenna Difference Patterns," *IEEE Trans. Antennas Propagat.*, vol. AP-15, pp. 771–777, Nov. 1967.

Dual-Polarized Fan-Beam Feed Horn

RICHARD C. JOHNSON

Abstract—**A simple dual-polarized feed horn that radiates fan-shaped primary patterns is described. The radiated patterns for the two orthogonal polarizations are essentially identical and are suitable for illuminating cut paraboloidal reflectors with *f/D* ratios of about 0.3. The horn is similar to conventional flared waveguide feed horns except that the corners have been modified to yield an octagonally shaped aperture. The horn has the added advantage of suppressed *E*-plane sidelobes, thus reducing spillover radiation.**

I. INTRODUCTION

A simple paraboloidal reflector (dish) with a dual-mode square waveguide feed is a common dual-polarized antenna. Neglecting any flare that may exist in a square feed horn, the size of the square waveguide behind the feed can be selected so that only two modes propagate; they are the dominant transverse electric TE_{10} and TE_{01} modes. The two modes are orthogonal and identical in field configuration except that one is spacially rotated 90° in the waveguide with respect to the other. For purposes of discussion in this communication it always will be assumed that the TE_{10} mode is oriented with its *E*-field vertical, and the TE_{01} mode is oriented with its *E*-field horizontal. With a dual-mode coupler [1] the two orthogonal modes can be excited simultaneously and independently.

Antennas of the above type produce dual-polarized pencil beams, but for some applications a fan beam is required. For example one may desire to illuminate a cut paraboloid with a dual-polarized feed. In this case the feed should produce a fanned primary illumination pattern, and the shape of the primary pattern should be independent of the polarization.

Manuscript received June 16, 1980; revised August 4, 1980.

The author is with the Engineering Experiment Station, Georgia Institute of Technology, Atlanta, GA 30332.

0018-926X/81/0700-0673$00.75 © 1981 IEEE