Some Design Considerations for Biconical Antennas

Derek A. McNamara, Dirk E. Baker and Louis Botha

ABSTRACT

This paper discusses the use of the body of revolution moment method formulation to predict the radiation patterns of biconical antennas, and describes a novel and practical feed point arrangement for fine-tuning the antenna reflection coefficient.

KEYWORDS

Biconical antenna, feeding mechanism, radiation pattern analysis.

INTRODUCTION

Biconical antennas [1] have been employed for many years in the microwave frequency range because of their broadband characteristics. When designing such antennas one is concerned with minimising the input reflection coefficient and obtaining suitable radiation pattern performance over the frequency band of interest. This paper discusses the use of the body of revolution (BOR) moment method techniques of Mautz and Harrington [2] to predict the radiation patterns of these antennas, and describes a practical feed point arrangement for fine-tuning the antenna reflection coefficient.

RADIATION PATTERNS

The biconical antenna is one of the canonical boundary value problems of electromagnetic theory. The vast amount of work published since Barrow et. al. [3] in 1939 has been summarised by Kraus [4] and Wait [5]. All these theoretical treatments involve simplifying assumptions and approximations in order to satisfy the required boundary conditions and to reduce the mathematical difficulties. Calculations based on these analyses are laborious, and the development of computer codes for one specific geometry is seldom warranted. On the other hand, the moment method techniques developed by Mautz and Harrington [2] for bodies of revolution (BOR's) are ideally suited to symmetrical shapes such as the biconical antenna. Because the method is general, the same computer code can be used to study the radiation properties of variants of this antenna (eg. biconical with end caps). The effect of the finite groundplane of a discone can also be ascertained via these BOR methods. We will confine our attention here to the traditional biconical geometry of Fig.1. Figs. 2(a) and 2(b) compare measured and computed BOR radiation patterns for the antenna in Fig.1 ($\Theta_o=60^\circ$, D=55mm). Fig.3 shows computed patterns of a similar biconical antenna ($\Theta_o=60^\circ$, D=147mm) for increasing frequency. It is possible through such an exercise to determine the pattern bandwidth, outside which unacceptable "pattern breakup" occurs.

FEEDPOINT TUNING MECHANISM

Impedance data for biconical antennas, derived mainly from experimental studies, is available in some detail in [6] and [1]. From these results it is known that the input impedance is reasonably constant over a wide frequency range for cone half angles $30^\circ \leq \Theta_o \leq 70^\circ$. In practice the input impedance is dependent on the cone spacing as well as the cone angle. At microwave frequencies it is common practice to support the cones using a spacer and it is not possible when producing biconicals in quantity to perform any fine-tuning by altering the cone spacing. Since a fine-tuning capability is desirable the feed-point geometry shown in Fig.1 was devised. In this way the antenna can be assembled with the foam spacer providing the best nominal spacing and the tuning slug (item 4 of Fig.1) adjusted to obtain the optimum reflection coefficient over the whole frequency band. By using the tuning mechanism a reflection coefficient of -20dB (VSWR of 1.2:1) on a 50Ω line was obtained in the 2 to 12 GHz

Submitted : November 1989
Accepted : August 1990

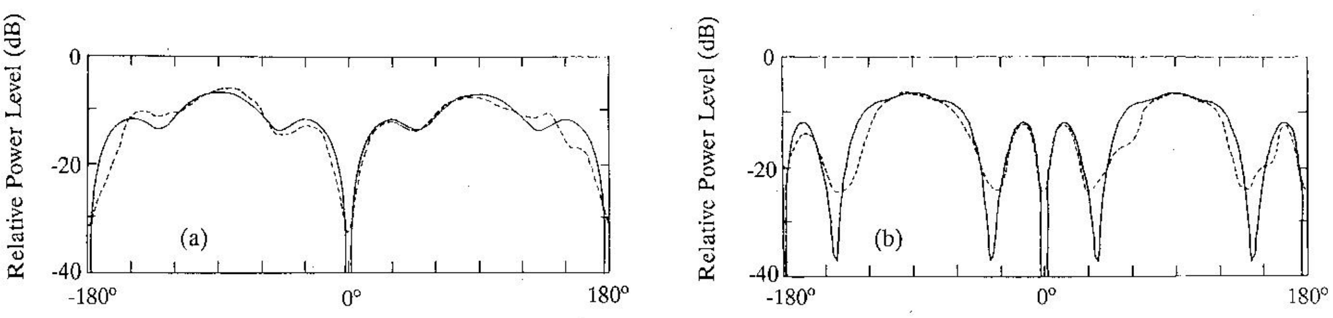

Fig.2 Computed (————) and measured (- - - -) E-plane patterns of a biconical ($\Theta_o=60^\circ$, D=55mm) at (a). 8GHz, and (b). 12GHz

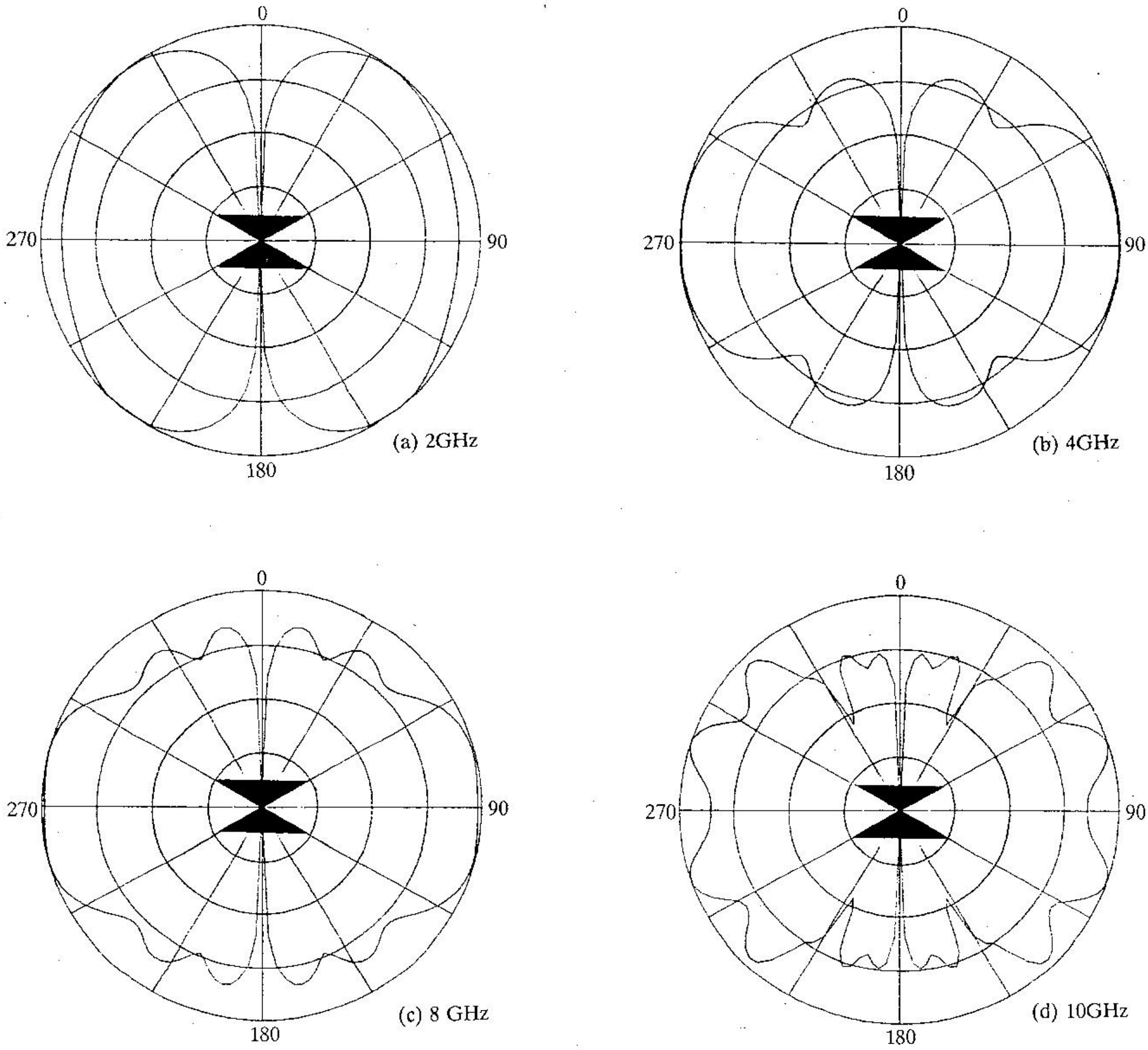

Fig.3 Computed E-plane patterns for a biconical antenna ($\Theta_o=60^\circ$, D=147mm) for increasing frequency. (Amplitude scale 10dB per division).

frequency range for an antenna with $\Theta_0 = 60^\circ$ and D = 147mm. This is particularly advantageous when using the biconical antenna with a polariser.

REFERENCES

[1] H.Jasik, **Antenna Engineering Handbook**, McGraw-Hill, New York, 1961.

[2] J.R.Mautz and R.F.Harrington, "Radiation and scattering from bodies of revolution", Appl.Sci.Res., Vol.20, pp.405-435,1969.

[3] W.L.Barrow, L.J.Chu and J.J.Jansen, "Biconical electromagnetic horns", Proc. IRE, Vol. 28, pp.769-779, Dec. 1939. (Correction in Vol.39, 1951)

[4] J.D.Kraus, **Antennas**, McGraw-Hill, New York, 1950

[5] J.R.Wait, "Electromagnetic radiation from conical structures", Chap.1 in : R.E.Collin and F.J.Zucker (Edits.), **Antenna Theory**, Part I, McGraw-Hill, New York, 1969.

[6] G.H.Brown and D.M.Woodward, "Experimentally determined radiation characteristics of conical and triangular antennas", RCA Review, Vol.13, No.4, pp.425-452, Dec. 1952

AUTHORS

Prof DA McNamara
B.Sc.(Eng.)(Cape Town), M.Sc.(Eng.)(Ohio State Univ.), Ph.D.(Cape Town), SMIEEE, MSAIEE, Department of Electronic and Computer Engineering, University of Pretoria, Pretoria, South Africa.

Dr DE Baker
B.Sc.(Hons)(Rhodes), M.Sc.(Rhodes), Ph.D.(Ohio State Univ.), Pr.Eng., SMIEEE, MSAIEE, EM-Lab (Pty) Ltd., Pretoria, South Africa.

Mr L Botha
B.Eng.(Pret.), MIEEE, MSAIEE
DAST, CSIR, Pretoria, South Africa

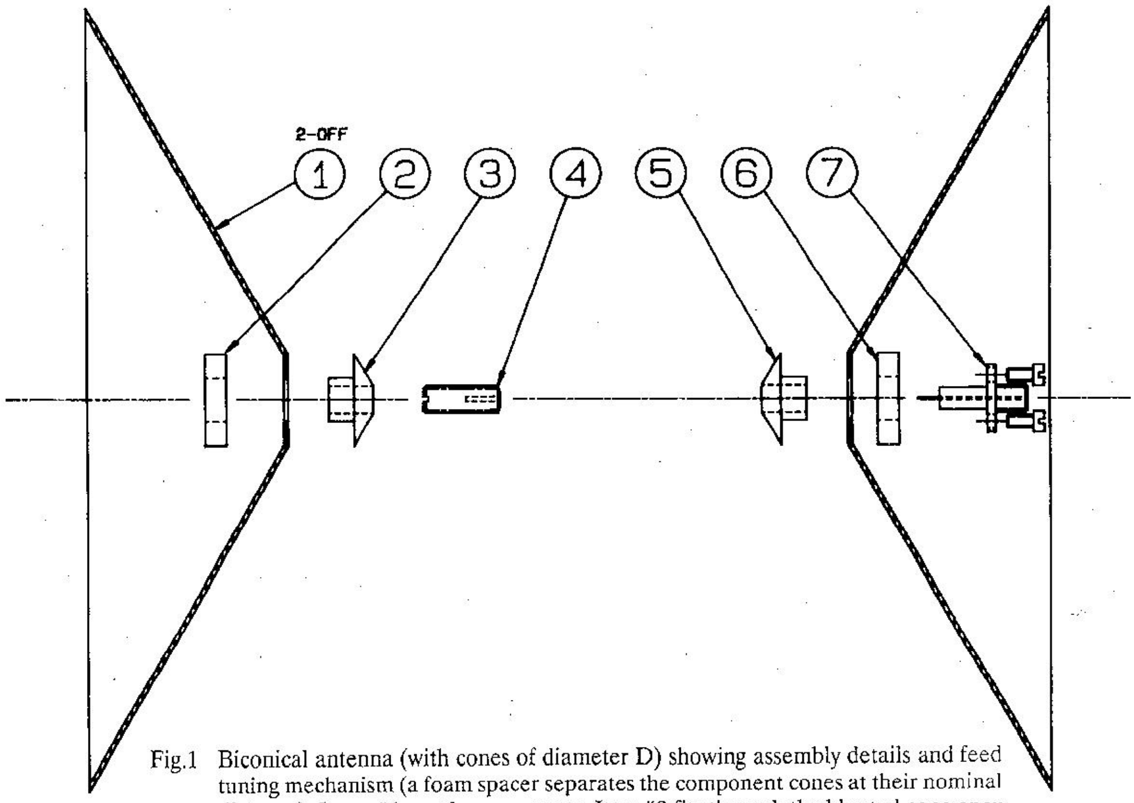

Fig.1 Biconical antenna (with cones of diameter D) showing assembly details and feed tuning mechanism (a foam spacer separates the component cones at their nominal distance): Items#1 are the spun cones. Item#3 fits through the blunted cone apex and screws into nut Item#2. Item#4 (a threaded insert) screws into Item#3, and screws down over the centre conductor of coaxial connector (Item#7). It provides the tuning capability. Item#5 fits through blunted cone apex and screws into nut Item#6. The central portion of Item#7 (connector) fits through Item#5 (unthreaded) and Item#6, and is then fixed to nut Item#6 which holds Item#5 in place.