SHORT BACKFIRE ANTENNA WITH CONICAL BACK REFLECTOR AND DOUBLE SMALL FRONT REFLECTORS

Z. A. AHMED*

SUMMARY: A modified backfire antenna for x-band is tested and proposed. The antenna comprises a conical back reflector and double plane small front reflectors fed through an open-ended circular waveguides excited with the dominant TE_{11} mode. The antenna shows a relatively high gain (17.2 db), good suppression of sidelobes (18.2 db below the mainlobe) and symmetrical radiation pattern.

Key Words: Short backfire antenna.

INTRODUCTION

Short-backfire antennas are highly efficient radiators of simple and compact construction (1-3). The backfire principle provides a means for significantly increasing the directivity of an endfire antenna without effectively increasing its physical length (2-4). The backfire antenna is essentially a leaky cavity structure (1,5) which consists of a surface wave structure placed between two plane reflectors of different sizes. Chen *et al.* have developed an approximate calculation of the radiation field of a short backfire antenna based on measured aperture fields (1). Relatively few theoretical investigations have been made on the backfire antenna (1,5,6). One of these studies has been conducted by Zucker who has studied a long backfire antenna theoretical and provided some approximate data for design (5). These theoretical studies are not adequate for understanding the basic operational principles of this antenna.

Tomoyukizama shows an experimental study of a coupled resonant director antenna consisting of a dipole, a reflector, and disks. The measurement were carried out in 1.5 GHz and has obtained a relatively high gain per element and good suppression of sidelobes (7).

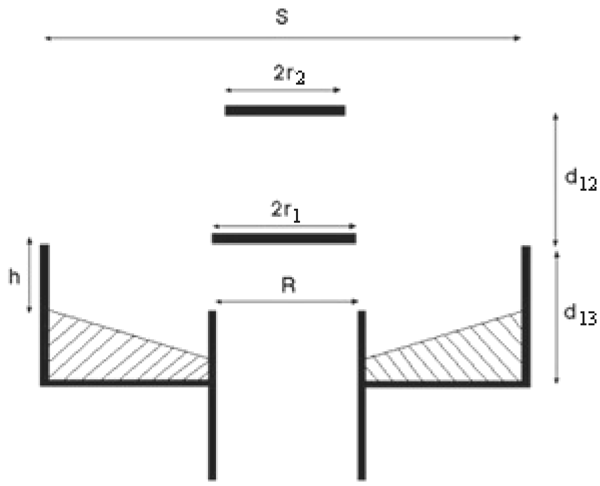
In puplished work by Al-Rashid (8), it was shown that when the plane pack reflector of a circular waveguide fed backfire antenna is replaced by conical reflector, the electrical characteristics can be significantly improved. The aim of this paper is to improve the electrical characteristics of this type of antenna by adding second small front reflector (disk). The measurement performed were carried out in the x-band (9 GHz) indicate a significant improvement in the antenna performance as compared to a similar backfire structure but with one small disk.

*From Department of Physics, College of Science, University of Basrah, Basrah, Iraq.

Table 1: Physical Dimensions of the two resonator Antenna.

Diameter of large reflector	:	s = 2.1 λ
Diameter of a small reflectors	:	$2r_1 = 0.6\ \lambda$
		$2r_2 = 0.4\ \lambda$
Distance between 1st small and 2nd small reflectors	:	$d_{12} = 0.5\ \lambda$
Distance between large and small reflectors	:	$d_{13} = 0.5\ \lambda$
Diameter of circular waveguide	:	R = 0.6 λ
Depth of the rim	:	h = 0.27 λ
Slant angle	:	$\varnothing = 12°$

Figure 1



ANTENNA STRUCTURE AND RESULTS

Figure 1 shows the structure of a two-resonator type antenna. The antenna consisting of a conical back reflector with rim depth (0.5 λ) and slant angle (12°) and two small front disks. The front reflectors are supported on a foamed plastic with relative permitivity very close to unity. The circular waveguide feed was excited by the dominant TE_{11} mode for which the radius of the waveguide can be obtained as:

$$r = \frac{\lambda c \rho}{2\pi}$$

where λ_c is the cut-off wavelength, and ρ is root of the Bessel function for the desired mode (9). The diameter of the waveguide feed was taken to be 0.6λ (λ being the free space wavelength), while the diameter of the back reflector was 2.1λ. The first front small disk was taken to be 0.6λ (8), while nine values have been tried which varied from 0.2λ up to 0.6λ for the second small reflector, and the optimum value of 0.4λ is displayed in measuring the radiation pattern of the antenna. The spacing between the back and first front reflector (d_{13}) and between first and second front disks were provided with flexibility for optimum adjustment.

The two-resonator type antenna (test antenna) having the parameters shown in Table 1 was designed for x-band at 9.0 GHz, and all measurements were made at this frequency. Figure 2 shows the optimum radiation characteristic of the test antenna for E- and H-planes. Radiation pattern and gain were measured for circular two small reflectors plates of 0.6λ and 0.4λ diameter respectively. It was shown that the 3-db beam width and sidelobe level are reduced in both E- and H-

Table : 2

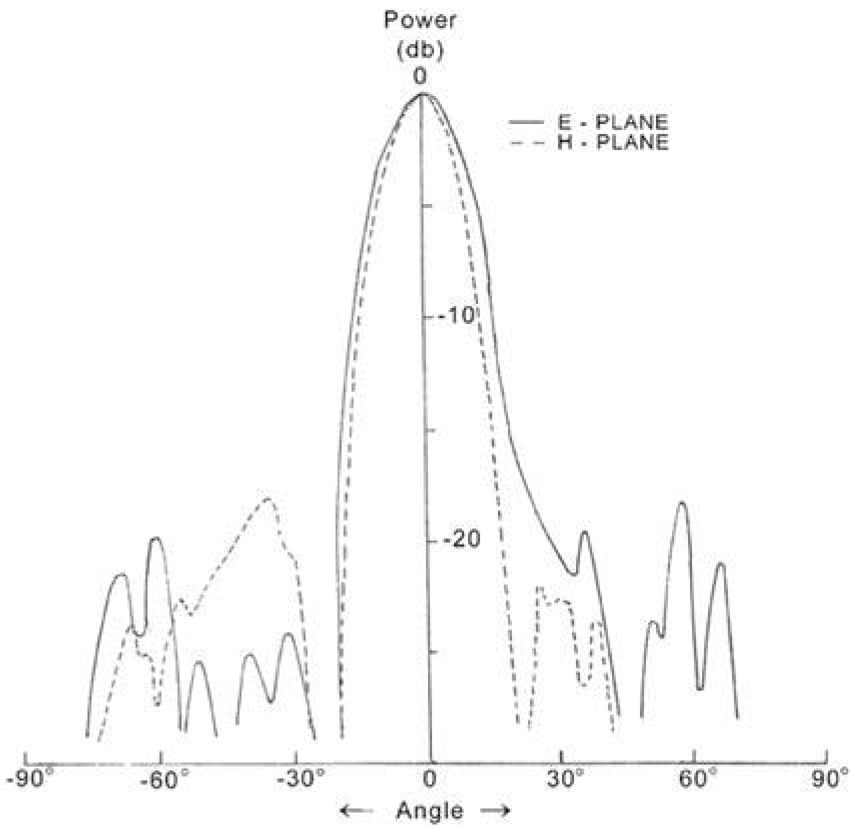
Type of antenna	B.W	S.L (db)			
		L	R	G (db)	S
A_1	36°	-16	-15	11.7	1.04
A_2	26°	-15.9	-16.2	16.2	1.04
A_3	18.5°	-19.6	-18.2	17.2	1.04

A_1 : Cup antenna

A_2 : B.f.a. with one small front reflector.

A_3 : B.f.a. with two small front reflectors (antenna under test).

Figure 2



planes and that the highest values of the antenna under test gain is 17.2 db which is generally higher by 1.0 db where compared with the antenna of one small front circular disk, and about 6 db over the cup antenna (10), where the other parameters were shown in Table 2.

Characteristics of three and four-resonator type antennas are also studied. Since the improvement of the gain obtained by the third and fourth disk is small, the two resonator type antenna seems to be a good practical compromise.

CONCLUSIONS

An improvement in radiation characteristics has been obtained when a slant angle of appropriate value is introduced into the back reflector (8). However, further improvement can be achieved when a second small front reflector is added to the antenna. It is uncovered that modified antenna has a symmetrical radiation pattern and sidelobe level of 18.2 db below the mainlobe level and directive gain of 17.2 db. This antenna may be useful in satellites, ships, aircraft and space vehicles because of its structural simplicity, light weight, small size and good radiation patterns.

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Correspondence:
Z.A. Ahmed
Department of Physics,
College of Science,
University of Basrah,
Basrah, IRAQ.