"Design of Monopulse Radial Line Slot Antennas"

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Abstract: *The authors propose the design of one radial line slot antenna with two simultaneous beams, one broadside beam and one conical beam. The antenna is a radial line slot antenna, with the slots placed on the upper plate in concentric rings. The radiation element is a slot pair, designed for getting left hand circular polarization. The antenna has been designed for working between 13.4 and 14 GHz. Both beams are obtained independently through very simple excitation circuits. The conical beam is obtained by feeding directly with a coaxial probe, just in the center of the antenna, while the broadside beam is obtained by feeding through a microstrip circuit and four post excited with a difference o phase equal to 90°. Comparing both radiation patterns, amplitude and phase, theta and phi angles can be obtained.*

I. Introduction

A parallel plate slot antenna is an attractive candidate for high-efficiency and mass-produceable planar phased array antennas for microwave and millimeter-wave applications. Generally, the transmission loss in a waveguide is very small in comparison with other feedlines such as a microstrip line and a suspended line. A broadside radial line slot antenna working at 12 GHz was proposed in [1]. This design had higher efficiency than other designs [2], due to the higher uniformity of the electric field inside the waveguide because of the simmetry of the antenna. With this structure conical beam antennas had already been designed by exciting the antenna in the center through a simple coaxial probe [3]. In this paper we design an antenna that includes both patterns simultaneously. One simple application for this kind of antennas is the design of a monopulse antenna. Arrival theta and phi angles can be obtained comparing the amplitude and the phase of the signal received by both beams.

II. Antenna Structure

Fig. 1 shows the structure of the antenna. The slots are placed on the upper plate, designed to get uniform amplitude and phase. The slot element is a couple of slots separated one quarter of wavelength and tilted 90° one respect the other in order to get the left hand circular polarization. These elements are placed in concentric rings, on a glass teflon substrate. The angular distance is different for each ring, and depends of the number of pairs per ring, but it is adjusted to be around $0.8\lambda_o$. The radial distance between slots is one wavelength inside the waveguide, considering the effect of the length of the slots on it, in order to optimize the gain of the broadside beam. The length of each slot for every concentric ring is calculated to have uniform amplitude.

Fig. 2 shows the excitation circuit. It is fabricated on a separated box. For the conical beam one simple coaxial probe in the center of the antenna is used. The broadside beam is obtained with four coaxial probes, excited with the same amplitude and a phase shift of 90°. This is obtained by a microstrip circuit. The difference of phased for each post is obtained with the design of several planar branch line combiners.

The parameters of the designed antenna can be obtained in table I.

Central Frequency	*f (GHz)*	13.7
Polarization		LHC
Height of Parallel Plate Waveguide	*b (mm)*	3.05
Dielectric Constant	ε_r	2.17
Wall Thickness	*d (mm)*	0.10
Slot Width	*w (mm)*	0.3
Radial position of center of 1st slot	*r (mm)*	10.95
Antenna Radius	*R (mm)*	60
Number of Slot Pairs	*N*	72
Position of conical beam feeder	*cr (mm)*	0
Position of broadside beam feederes	*br (mm)*	4.2
Length of the pins	*l (mm)*	2.25

Table I: Antenna Parameters for the Analysis

III. Numerical Results.

The analysis of the antenna is realized with the method published in [4]. Fig. 3 and Fig 4 show the amplitude of the radiation pattern for both beams. Fig. 5 shows the phase of the radiation pattern for both beams. Theta angle can be obtained comparing the amplitude of both patterns in a margin of 10°, although the maximum theta angle can be changed modifying the position of the slot rings. The simmetry of antenna for the conical beam (in both upper plate and feeding system) place a very good null in theta = 0°. Also, the axial ratio, is very good for short values of theta angle.

Phi angle can be obtained comparing the phase of both patterns, constant phase for conical beam, and linear phase for broadside beam, for the whole range of phi. The simmetry of the antenna generates a very good uniformity of phase for the radiation pattern for the conical beam. The linearity of the phase for the broadside pattern depends on the separation of the four feeding posts. The designed distance of 4.2 mm is a compromise, to get a reflection coefficient better than −14 dB in the frequency band (Fig. 6). If that distance is increased the uniformity of the phase is a bit worst (also the gain of the antenna), but the reflection coefficient is improved.

IV. Conclussions and Next Research

We presented a simultaneous beam antenna that can be used for monopulse antenna. The structure is very simple, radial line slot antenna excited by several vertical posts. Both, theta and phi, arrival angles can be extracted, comparing the radiation pattern of the antenna, in amplitude and phase. In this moment we are manufacturing the antenna and the measurements will be showed at the conference.

The next step is the design of this kind of antenna for millimeter wave. In that case the feeding circuit is not convenient and we will study planar circuit for exciting the broadside beam and conical beam.

REFERENCES

[1] Manuel Sierra Pérez, J.M. Salamanca, María Vera Isasa, Manuel Sierra Castañer. "Synthesis of circularly polarised multiprobe feed radial line slot antenna". 1998 AP-S Digest Vol.2 Pag. 1184-1187.

[2] Vera M. "Diseño de Antenas de Ranuras sobre Guía Radial". Doctoral disertation. Universidad de Vigo (1996)

[3] M.P.Sierra, M.Vera, A.G.Pino, M.S.Castañer, "Analysis of slot antennas on a radial transmission line", International Journal of Microwave and Millimeter-Wave Computer-Aided Engineering. vol.6, n° 2, pp.115-127, Feb. 1996.

[4] A. Akiyama, T. Yamamoto, M.Ando, E. Takeda. "Conical Beam Radial Line Slot Antennas for 60 GHz Band Wireless LAN". 1998 AP-S Digest Vol.3 Pag. 1421-1424

[5] M. Skolnik. "Introduction to Radar Systems". 2nd Edition. McGraw Hill Int. 1980.

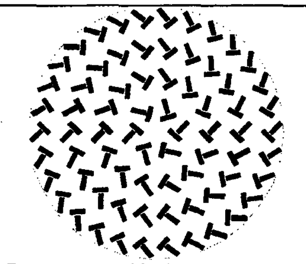

Fig.1: Geometry of the Antenna: Upper plate

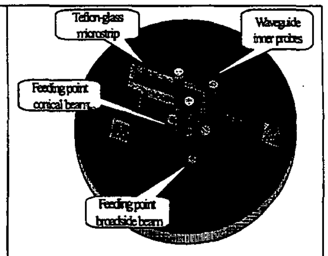

Fig.2: Geometry: Feeding circuit

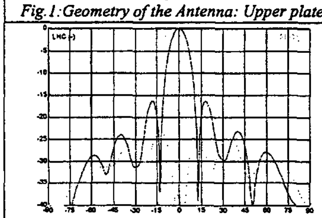

Fig. 3: Broadside beam. f = 13.7 GHz

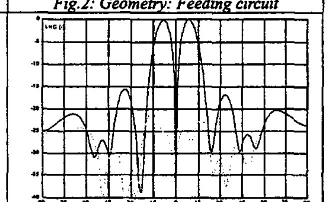

Fig. 4: Conical beam. f = 13.7 GHz

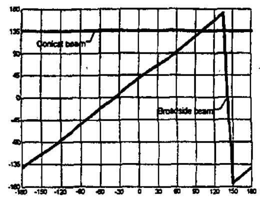

Fig. 5: Phase of Radiation Pattern. θ = 9°

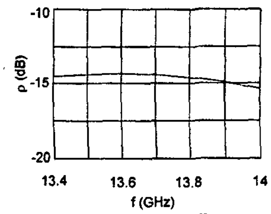

Fig. 6: Reflection Coefficient