International Journal on Future Revolution in Computer Science & Communication Engineering ISSN: 2454-4248
Volume: 4 Issue: 12 12 – 15

Perforated Dielectric Lens Antenna Design

M. Alcep
Department of ECC
Y.T.U.
Istanbul
mucahitalcep@gmail.com

F. Tokan
Assistant Professor
Y.T.U., Department of ECC
Istanbul
ftokan@yildiz.edu.tr

Abstract— In this paper, a dielectric lens in a three dimensional structure with a matching layer on a planar antenna platform was added to work on a high gain antenna. It has been shown that the antenna with the same parameters can be designed by reducing the cost of production by using the perforated dielectric lens method which can be used equivalent to the dielectric lens used. Due to the high production difficulties and high cost of lens antenna structures, alternative methods have been studied and successful results have been obtained by using a method with scientific innovation value.*This work was supported by Research Fund of the Yildiz Technical University. Project Number:FBA-2017-3070*

Keywords- *Perforated Antenna, Dielectric Lens, W-Band*

*****

I. INTRODUCTION

In recent years, wireless communication and electromagnetic signals have become indispensable in many systems we use in daily life with technological developments. These small dielectric lens antennas, which work at high frequencies, are widely used in millimeter wave and millimeter waveforms because these antennas have a high orientation, polarity purity and a simple structure for manufacturing.

Dielectric lens antennas fabricated with a dense dielectric material, allow good power transfer efficiency through the lens and enable fabrication of low-cost and compact-size lens antennas [1]. Dielectric lens antennas are inexpensive solutions for beam steering applications with their capability of being integrated to millimeter and sub-millimeter planar feeding structures [2-4].

Low-permittivity ϵ_r =3, low-loss materials are affordable solutions for dielectric lenses, which can be easily manufactured with standard tools. On the other hand, high-permittivity materials yield a more exact geometrical approximation to an elliptical lens and achieve a wider multiple-beam coverage range [5].

II. DIELECTRIC LENS ANTENNA DESIGN

More than one method was emphasized when starting the lens design. In this way, the results obtained were compared. The study was primarily started with a narrow-band aperture coupled antenna operating on a W-band, and then the proposed perforated dielectric structure for the W-Band system was tested. In this application, a single-layer matching layer method was first tried with λ / 4 and then the perforated dielectric lens structure method was used.

It is proposed that the dielectric constant value of the matching layer in the transition zone can be changed by opening holes on a homogeneous structure of the lens material due to the perforated structure proposed in this study, since it would be really laborious and costly to produce the adaptation layers on the lens antennas.

Instead of opening the holes on the adaptation circuit, the 3D printer is designed to make a design that is much cheaper and easier to manufacture.

W-band (74-80 GHz) in the work of the planar antenna, plain lens structure, the lens with a matching layer of lens and perforated matching layer of the radiation pattern of the structure, S-parameters and so on. The results of the study were obtained by comparison.

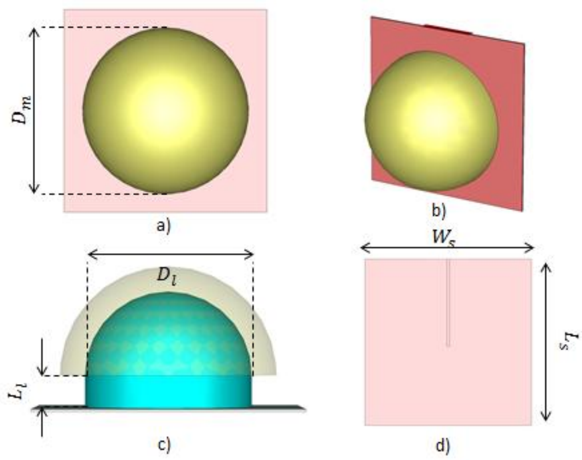


Fig. 1. Dielectric Lens Structure With Matching Layer

Table 1. Lens Parameters

D_m	16.24 mm
D_l	12 mm
L_l	2.3 mm
W_s	19.178 mm
L_s	19.178 mm

As an introduction to the narrow-band operation, the planar antenna platform was first started with a dielectric lens without a matching layer. The dielectric constant of the material used in the center is ϵ_r=9. L_l height of the cylinder in the structure of the parametrical parameters in the range of 2-3 mm in 0.1 mm intervals were performed and the best result was obtained for L_l =2.3 mm.

After this stage, by adding the matching layer to the lens structure, it was tried to bring the S-parameter below the level of -10 dB in the entire working frequency range (74-80 GHz) with the width of the matching layer λ / 4 and the dielectric constant ϵ_r = 3.55.

In this study, which we put forward as innovation, the perforated structure is introduced as follows. Instead of the material of the matching layer, it is provided to make the matching layer using material having the same dielectric constant as the basic structure. Since the dielectric constant of the basic structure is ϵ_r =9, the dielectric constant of the previous matching layer has been increased to ϵ_r =3.55 by opening holes on this structure. The following "Eq. (1)" is used for this:

Ei*1=Eh*Hy+Er*My (1)

Ei= Desired dielectric constant
Eh= Dielectric constant of air
Hy= Percentage of air
Er= Dielectric constant of material
My= Percentage value of material

Due to the geometrical structure of the sphere, the surface line of the sphere decreases logarithmically. Therefore, the radius in each layer to be drilled is reduced logarithmically. Calculations have been made to distribute the dielectric constant homogeneously in the matching layer.

According to the calculations made, the adaptation layer should be filled with homogenous air with 68% of the matching layer for the dielectric constant of ϵ_r=3.55 and the remaining 32% should be filled with ϵ_r=9 material which is the building material of the lens.

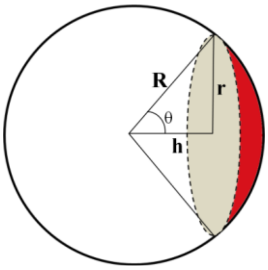
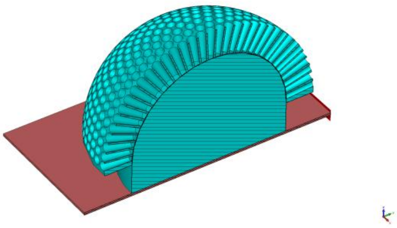


Fig. 2. Radius Change in Sphere Surface

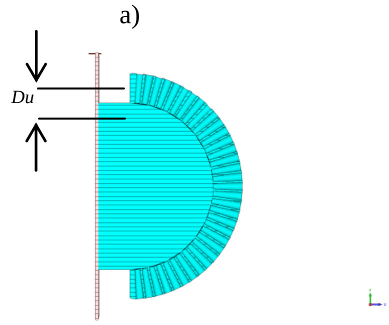
As a result of the calculations, the inner radius and the outer surface of the matching layer inside the carved half-square matching layer are different from each other. Basically in this study the default is provided by calculations on dielectric constant change surface areas with holes.

The diameter of the lean lens is D_l=12 mm. The width of the matching layer is D_u=2.12 mm. In this case, the radii of the holes to be formed in the adaptation layer must be increased from the inner radius to the outer radius so that the surface area formed by the inner radius and the surface areas formed by the outer radius are filled with air evenly. Figure 3 shows the pictures of the matching layer, which consists of 18 lines and has a total of 784 holes.

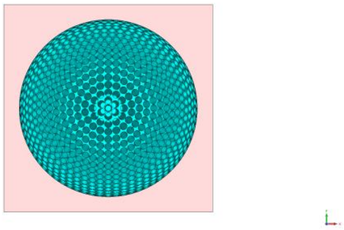
The radii of the holes formed on the matching layer were 0.25 mm on the inner surface of the matching layer, and the design was progressively increased to 0.33 mm when the outer surface of the matching layer gradually increased linearly towards the outer surface of the matching layer. In this way, the volume neglect is prevented during the increase of the radius. In this way, 784 holes were created in the matching layer and 68% air was provided, and simulations were started by assuming that the matching layer had a homogeneous dielectric constant of 3.55.



a)



b)



c)

Fig. 3. Perforated Dielectric Lens Structure (a) Perspective Section View (b) Side Section View (c) Top View

Figure 4 shows the results of the S-parameter simulation obtained for the perforated dielectric lens with a planar antenna platform, with and without a matching layer, and with a perforated fabric layer.

When the simulation results in Figure 4 are examined, it is seen that the dielectric lens antenna and the perforated dielectric lens antennas have similar S11 parameters.

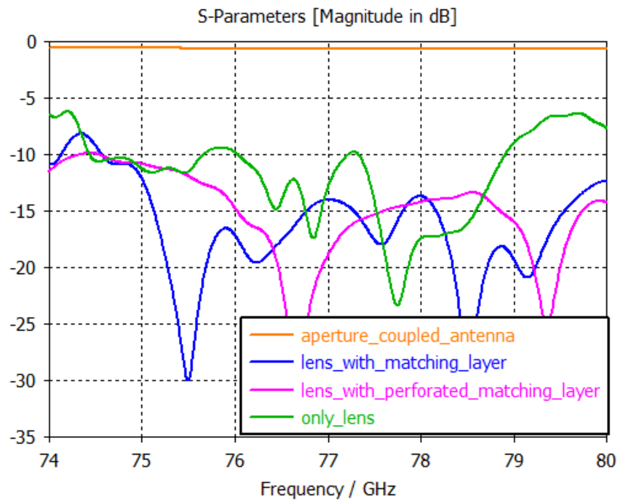


Fig. 4. S-parameter Simulation Result

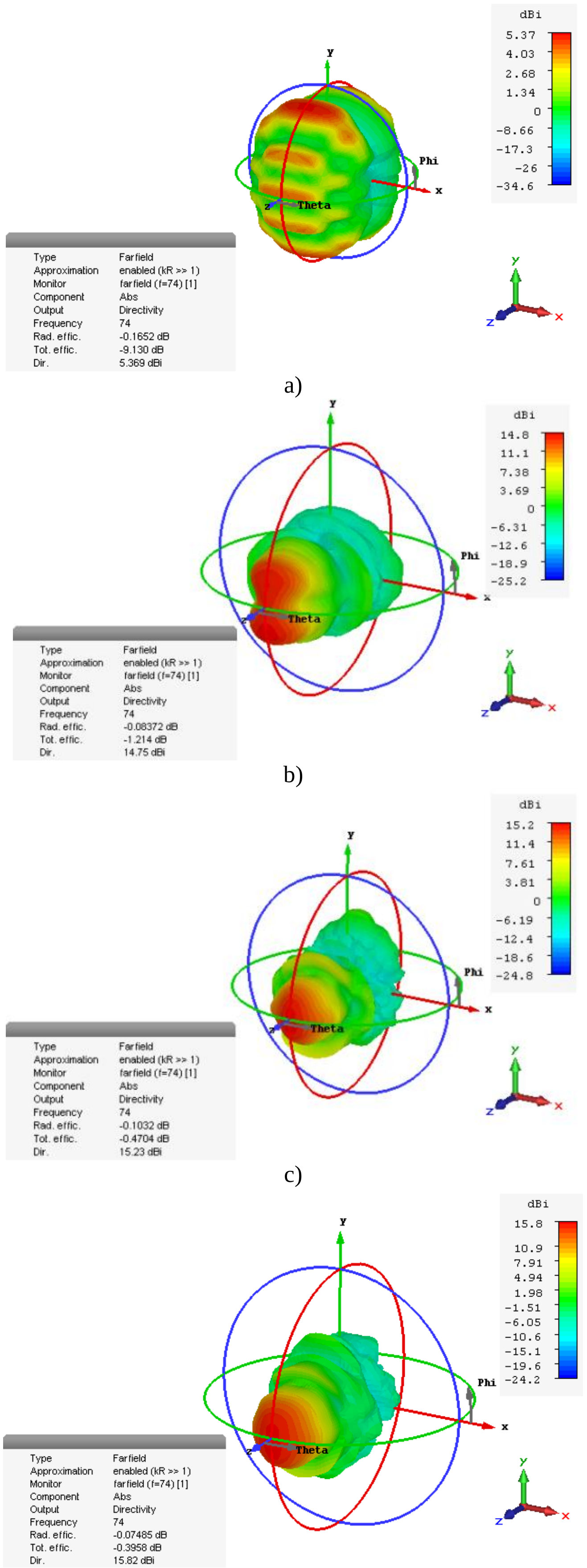


Fig. 5. 3D Simulation Results of Radiation Pattern (a) Planar Antenna (b) Lean Lens Structure (c) Matching Layer Lens Structure (d) Perforated Dielectric Lens Antenna

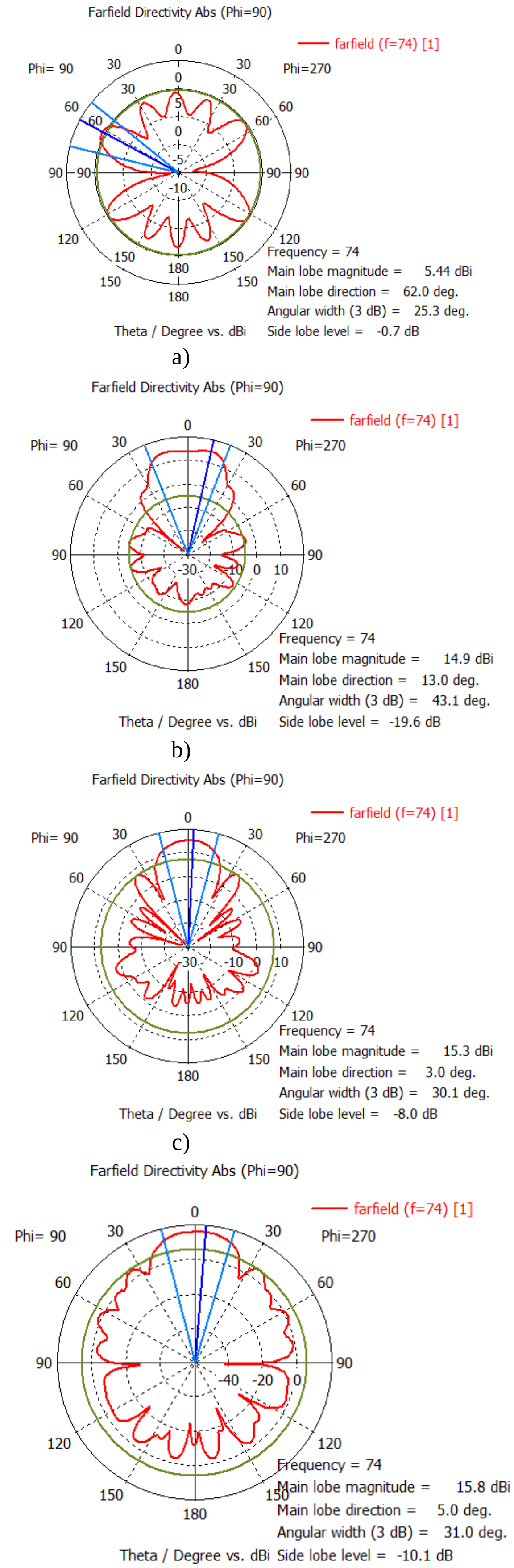


Fig. 6. Radiation Pattern Polar Coordinates simulation results (a) Planar Antenna (b) Lean Lens Structure (c) Matching Layer Lens Structure (d) Perforated Dielectric Lens Antenna

III. CONCLUSION

In this study, a design which is thought to have innovation value on dielectric lens antenna working in W-band (74-80 GHz) has been realized. In the design made, the dielectric constant of the dielectric lens antenna in the dielectric lens antenna is homogeneously distributed with the air instead of being a calculated solid transition material. According to the results of the study, according to the results obtained in the antenna operating frequency range of the antenna, the basic antenna parameters of the attenuation parameter, radiation pattern, radiation efficiency and impedance values are provided at the desired level. The results of the study show that the S11 attenuation parameter in the perforated dielectric lens antenna design is smoother, depending on the dielectric material density in relation to the dielectric lens structure with the transition pattern below the -10 dB level in the whole operating frequency range. In this way, the lens antenna design with the same characteristics was realized by decreasing the material diversity, reducing the production cost and reducing the design difficulty.

REFERENCES

[1]. F. Tokan, "Optimization-Based Matching Layer Design for Broadband Dielectric Lens Antennas" *Aces Journal, Vol. 29, No. 6, June 2014*

[2]. F. Sun and S. He, "Can maxwell's fish eye lens really give perfect imaging?" *Progress In Electromagnetics Research*, vol. 108, pp. 307-322, 2010.

[3]. B. Schoenlinner, X. Wu, J. P. Ebling, G. V. Eleftheriades, and G. M. Rebeiz, "Wide-scan spherical-lens antennas for automotive radars," *IEEE Trans. Microwave Theory Tech*., vol. 50, no. 9, pp. 2166-2175, September 2002.

[4]. M. Ettorre, R. Sauleau, L. Le Coq, and F. Bodereau, "Single-folded leaky-wave antennas for automotive radars at 77 GHz," *IEEE Antennas and Wireless Propagation Letters*, vol. 9, pp. 859-862, 2010.

[5]. L. Yang, C. W. Domier, and N. C. Luhmann, "Qband to v-band 1D and 2D elliptical lens antenna arrays," *Microwave and Optical Technology Letters*, vol. 49, no. 8, pp. 1798-1801, August 2007.