LETTER *Special Section on Recent Technologies of Microwave and Millimeter-Wave Devices*

A NRD Guide Fed Dielectric Lens Antenna with High Gain and Low Sidelobe Characteristics

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SUMMARY A NRD guide fed dielectric lens antenna with high gain and low sidelobe characteristics is proposed for millimeter wave applications. The measured results showed very good performance at 60 GHz. It exhibited a gain of 24.9 dBi, 27 dB sidelobe level suppression.

key words: *NRD-guide, dielectric lens antenna, low sidelobe level, millimeter wave*

1. Introduction

Recently, millimeter wave applications are rapidly growing in modern high-speed and broadband wireless systems such as uncompressed HD-TV transmission, home link and radar for the collision prevention.

In this paper, a NRD guide [1] fed dielectric lens antenna with high gain and low sidelobe characteristics is proposed for millimeter wave applications. The proposed antenna is designed on the basis of the geometrical optics and Ansoft HFSS. Good radiation performances are confirmed with this antenna at 60 GHz.

2. Design of Dielectric Lens Antenna

The dielectric lens structure and coordinate systems are shown in Fig. 1. The dielectric lens is designed based on the geometrical optics [2]. The curvature of the lens is determined as a solution of the following two equations:

$$\sqrt{F^2+r_1^2}+n\sqrt{(z_2-F)^2+(r_2-r_1)^2}-z_2=(n-1)T \qquad (1)$$

$$\frac{r_1}{\sqrt{F^2+r_1^2}}=\frac{n(r_2-r_1)}{\sqrt{(z_2-F)^2+(r_2-r_1)^2}} \qquad (2)$$

where $n=\sqrt{\epsilon_r}$ is refractive index, F is focal length and T is height of lens. The equation (1) is a consequence of the equal optical length for all paths and the equation (2) expresses the Snell's law over S_1 base-plane.

Cross sectional views of the proposed antenna structure are shown in Fig. 2. The NRD guide consists of PTFE strips with height of 2.25 mm, width of 2.5 mm, relative permittivity ϵ_r=2.04±0.01 and loss tangent $\tan\delta$ =(2.1±0.1)×10^{-4}, inserted in a below cutoff parallel metal plate waveguide [1]. The dielectric lens is fixed on a foamed polystyrene ($\epsilon_r \approx 1$)

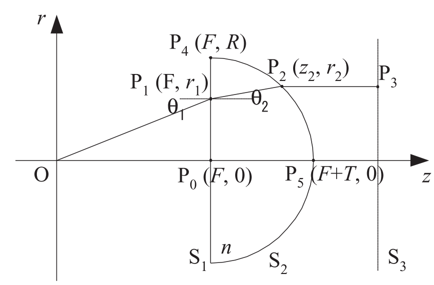

Fig. 1 Lens structure and coordinate systems.

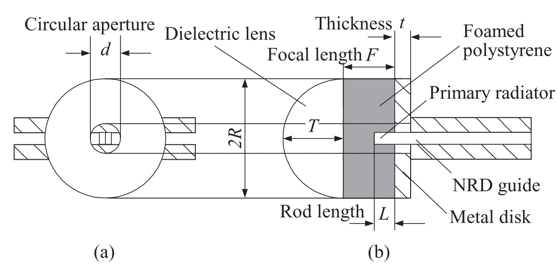

Fig. 2 Cross sectional views of the NRD guide fed dielectric lens antenna with the dielectric rod radiator (a) front view (b) side view.

cylindrical stand having height equal to focal length F. It is fixed on the metal disk of thickness t=3 mm. High-density polyethylene is adopted for dielectric lens material from viewpoints of easy fabrication and low $\tan\delta$. The ϵ_r and $\tan\delta$ of polyethylene are 2.29±0.02 and (2.6±0.3)×10^{-4}, respectively. These dielectric constants were measured at 48 GHz by the cutoff circular waveguide method [3]. The primary radiator is the tapered tip of NRD guide strip projected from the circular aperture at the center of the metal disk by length L=1 mm. The diameter of the circular aperture d is equal to 7 mm.

The dielectric lenses are designed by using Eqs. (1) and (2), and analyzed by HFSS. At first, the optimum focal length is determined for the maximum gain at 60 GHz assuming lens diameter $2R$ to be 32 mm. The simulated results are shown in Fig. 3. It is found that the maximum gain at 60 GHz can be obtained 26.5 dBi at F=12 mm. Then, the gain for F=12 mm is calculated as a function of the lens diameter. The calculated results are compared in Fig. 4 with the ideal curve estimated by Eq. (3) with efficiency η=100%.

$$G=\frac{(2\pi R)^2}{\lambda^2}\eta \qquad (3)$$

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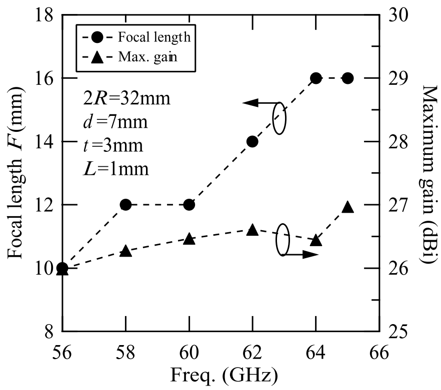

Fig. 3 The focal length that the maximum gain is obtained at each frequency.