A design of lens antenna with high gain

Darong Gao[1,*]

[1]The Electrical Engineering College, Northwest Minzu University, Gansu 730030, China

Abstract. In this paper, A lens antenna with high gain is proposed. The antenna is composed of the microstrip antenna and the hemisphere dielectric lens, and the lens is loaded on the top. The polyethylene is used to fabricated the hemisphere dielectric lens. The antenna has dimensions of 47.58 mm $\times$ 47.58 mm $\times$ 24.79 mm, which is corresponding to the electrical size of $1.586\lambda0 \times 1.586\lambda0 \times 0.826\lambda0$, where $\lambda0$ is the free-space wavelength at 10GHz. The impedance bandwidth (return loss<-10dB) is 12.7%(9.24 GHz-10.51 GHz), and the peak gain is 9.06 dBi. The hemisphere dielectric lens can improve the gain of the microstrip antenna. The proposed lens antenna is suitable for wireless communications systems.

1 Introduction

In the recent years, with the development of technology and improvement of the antenna performance requirements, lens antenna becomes more and more attractive to the majority of researchers. In [1], The circular polarization plane luneberg lens antenna for wireless communication of millimeter wave was proposed, the lens antenna is fed by a microstrip antenna. A luneberg lens multiple-beam scanning antenna for millimeter-wave frequencies was introduced in [2], and the luneberg lens is filled by air, the antenna is fed by a planar antipodal linearly-tapered slot antenna. In [3], the beamspace large-scale multiple input multiple output lens antenna array for wireless power transfer was proposed. A two dimensional beam scanning K-band focal-shifted lens antenna was introduced in [4], the lens antenna is fabricated by three dimensional printing, the antenna features two-dimensional beamscanability, high gain, and good matching. In [5], a fresnel zone plate lens antenna was proposed, the antenna is fed by the high gain patch antenna, and the operating frequency of the lens antenna is 60 GHz. In [6], the high production tolerance and small antenna substrate antenna for 77 GHz long-range radar is proposed, the antenna composed of the dielectric lens and the pyramidal horn.

The lens antennas have been widely used in millimeter-wave frequencies, however, the low frequency lens antenna has rarely been reported.

In this paper, a high gain lens antenna is reported. The lens antenna is composed of the microstrip antenna and hemisphere dielectric lens, and the microstrip antenna is fit closely together. The impedance bandwidth (return loss<-10dB) is 12.7%(9.24GHz-10.51GHz), and the peak gain is 9.06 dBi.

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[*] Corresponding author: 568629455@qq.com

This paper is organized as follows. The Section 2 introduces the design method of antenna. The simulated results of the antenna are explained in section 3. The role of key parameters is discussed in section 4, and a brief conclusion is given in section 5.

2 Antenna design

(a)

(b)
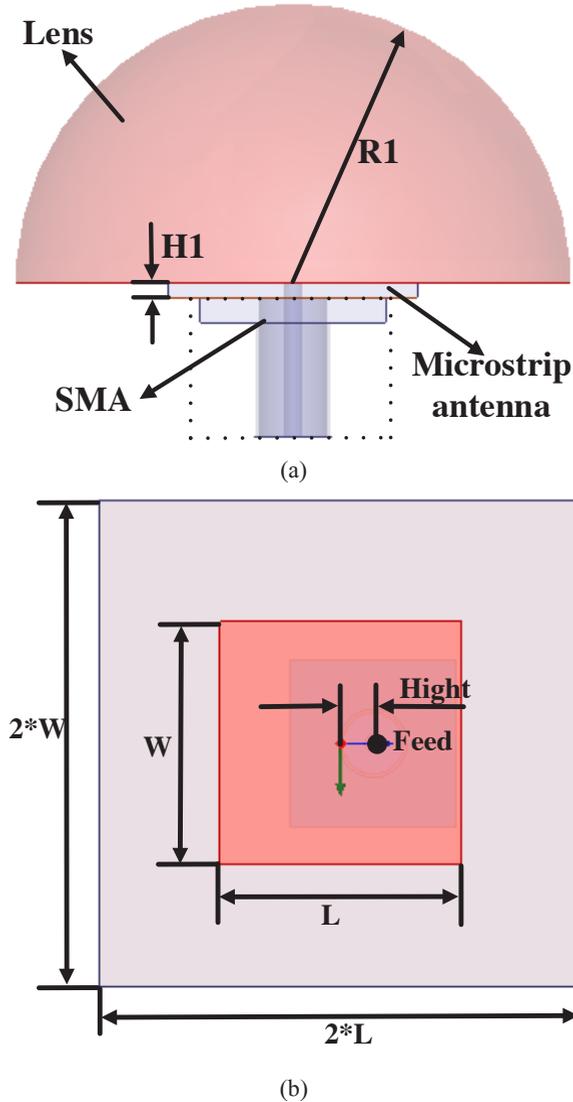
Fig. 1. Geometry of the proposed antenna. (a) side view. (b) geometry of the microstrip antenna.

In this section, the lens antenna design process is devoted. The geometry and sizes of the lens antenna are shown in Fig. 1 and Table. 1, respectively.

The microstrip antenna is the feed source, and fed by 50 Ω SMA. The microstrip antenna was constructed on the substrate ROGERS 5880, the dielectric constant is 2.2, the thickness is 1 mm and the loss tangent is 0.0009.

Table 1. Units for magnetic properties.

Margin	mm
R1	23.79
H1	1.0
L	8.65
W	9.05
Hight	3.27

The radius of the hemisphere dielectric lens is 23.79 mm, and the polyethylene is used, the dielectric constant is 2.55, and the tangent is 0.0011.

The simulated results for the microstrip antenna and the lens antenna, The peak gain of the microstrip antenna is 7.8 dBi. After loading the hemisphere dielectric lens, the peak gain is 9.06 dBi, respectively. The impedance bandwidth and the radiation characteristic are improved by the hemisphere dielectric lens.

3 Antenna simulated results

The simulated results of the proposed antenna are shown in Fig. 2 and Fig. 3. It clear that the impedance bandwidth is 12.7%(9.24GHz - 10.51GHz), the peak gain is 9.06dBi.
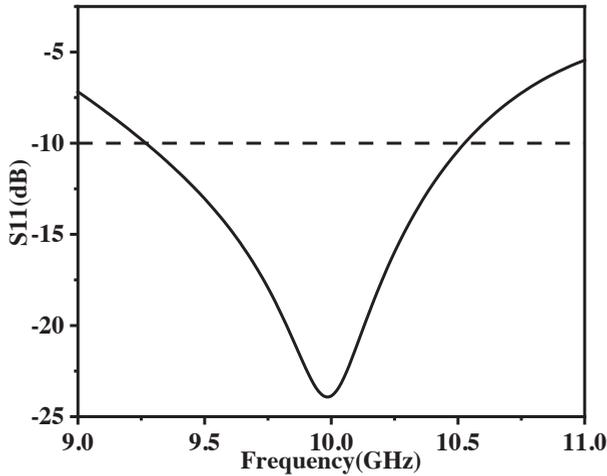
Fig. 2. Simulated reflection coefficient.

4 Parametric study

The parameters are studied and the key parameters are determined, i. e. the radius of the lens, the length and the width of the microstrip antenna.

Fig. 4 shows the effect of the microstrip antenna length L on the bandwidth of the proposed antenna. It is clear that the resonance point is increased with the length decreased. Other parameters have little influence on the antenna performance.

Fig. 3. Geometry of the proposed antenna. (a) side view. (b) geometry of the microstrip antenna.

Fig. 4. Photograph of reflection coefficient for different length of the microstrip antenna.

5 Conclusion

Feasibility of a lens is demonstrated for high gain. The antenna is composed of a microstrip antenna and a hemisphere dielectric lens. The antenna exhibits a bandwidth of 12.7% from 9.24 GHz to 10.51 GHz(return loss<-10dB), and the peak gain is 9.06 dBi. The antenna has dimensions of 47.58mm×47.58mm×24.79mm, the equivalent to $1.586\lambda 0\times 1.586\lambda 0\times 0.826\lambda 0$, where $\lambda 0$ is the free-space wavelength at the resonance frequency of 10 GHz. The hemisphere dielectric lens observably improved the gain of the microstrip antenna. The antenna has a wide range of wireless application foreground communication system.

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