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Design of Lens Antenna for Enhanced Gain for WiMax Application

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Abstract: **This article presents the simulation based design of a Lens Antenna structure for WiMax application.This paper focus on the Gain enhancement by introducing the dielectric spherical lens structure for patch antenna. It is seen that the hemispherical lens with dielectric material Teflon with dielectric constant 2.1(Loss tangent 0.001) in proximity can be optimally placed along with patch antenna to increase the gain almost double (8.41 dB) as compared to the patch antenna without lens structure. The objective of the paper is to design and study the effect of gap between the patch and the lens structure on the bandwidth and gain of the antenna. By placing hemispherical lens structure on patch antenna bandwidth from 5.45 to 5.75 GHz with VSWR 2:1 is observed. The gain is found to be stable over the entire frequency band. The results are obtained through simulation by using Ansoft HFSSTM, a commercially available simulator based on finite element method. The size of a typical near optimum antenna is 66.66mm × 70.49mm × 1.57mm with the volume of 0.137X 10-3 m3 hemispherical lens antenna and can be considered suitable for WiMax application.**

1. INTRODUCTION

Microstrip patch antennas have been used widely in satellite communications, aerospace, radars, biomedical applications and reflector feeds, because of their advantages of a low profile, light weight and compatibility with integrated circuits. However, they suffer from disadvantages such as a narrow bandwidth (Less than 5%), low gain (Less than 6dBi) and excitation of surface waves, etc [1]. These disadvantages have limited their applications in many other fields. In order to overcome the bandwidth and less gain disadvantages of microstrip antennas, many techniques have been employed. One such case is use of Dielectric lens antenna.

Dielectric lenses are conventionally used as focusing devices to enhance the directivity gain of the primary source. They can also be used to generate multiple beams from a feed array. Lens antennas are widely used in millimeter wave applications such as automotive radar [2, 3], satellite transmissions [4], or indoor communications [5, 6]. Lens antennas typically consist of a dielectric lens (spherical or hemispherical) fed by a primary source (single feed or array). More recently, shaped beams have been obtained with spherical lens antennas [7] opening a new range of applications. In this article, a hemispherical lens antenna is designed for optimized gain and directive. This article is organized as follows. First, the rectangular patch antenna without lens structure is designed at operating frequency 5.55 GHz. In Section 2, hemispherical lens antenna is used along with basic patch antenna and gain of the entire system is optimized. Then simulation results are obtained and comparisons are made in Section 3. Conclusions are drawn in Section 4.

2. PRAPOSED ANTENNA DESIGN

I. Patch Antenna

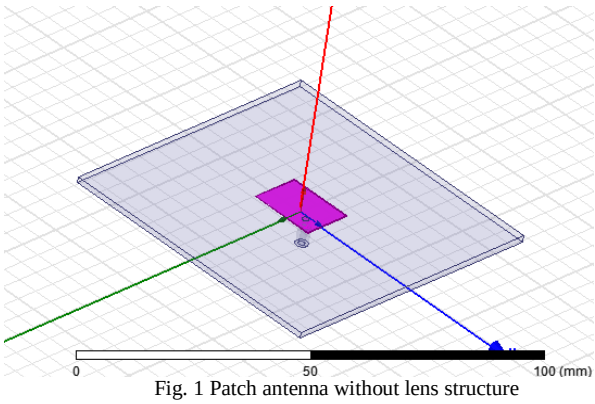

Fig. 1 Patch antenna without lens structure

First, a planar antenna operating in the frequency range 5.43 - 575 GHz is designed. The prototype is shown in Fig. 1. From the set of available materials FR4 with dielectric constant 4.4 and thickness (h) of 1.57 mm is chosen for use as substrate. The patch dimensions have direct influence on the operating frequency and gain. The patch length (L) and width (W) are found to be 11.6 mm and 16.44 mm respectively as shown in Table.1. The patch antenna is fed with a coaxial feeding connected to a point of the patch where the input impedance is 50 ohm.

Elements	L(mm)	W(mm)	h(mm)
Patch	11.6	16.44	0.1
Substrate	66.65	70.49	1.57

Table.1 Dimension of Patch Antenna

II. Lens Antenna

The HFSS simulator tool is used to build a model for the hemisphere lens antenna. The hemisphere lens is designed using Teflon dielectric with radius 29 mm and above the patch with some gap (g) as shown in Fig. 2.

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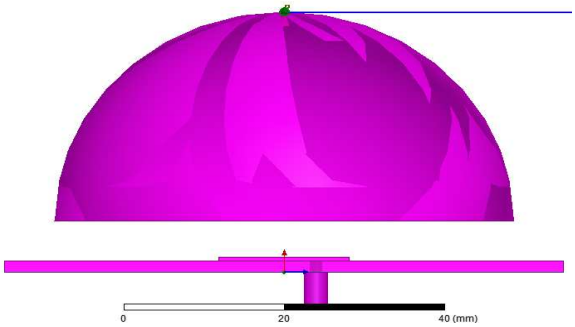


Gap between the patch and lens

Fig.2 Patch antenna with lens structure

3. SIMULATION RESULTS

1. Patch Antenna without Lens structure

The designed patch antenna without lens structure has central frequency of 5.59 GHz and a –10 dB return loss bandwidth of 285 MHz as shown in Fig.3. The other parameters like gain, VSWR, Bandwidth and Bandwidth percentage are obtained as shown in Table.2

BW(MHz)	%BW	VSWR	Gain(dB)
285	5.13	1.94 : 1.14	4.33

Table.2 Different parameters values of Patch antenna without lens.

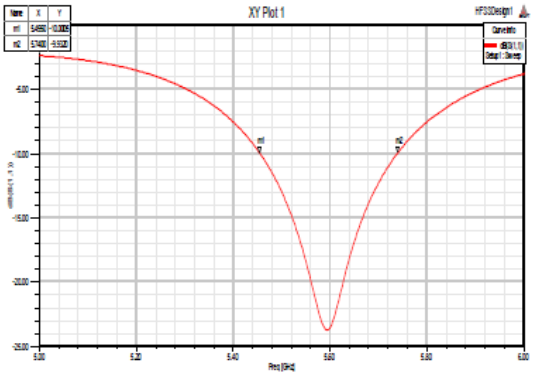


Fig.3 Return Loss of Patch antenna without lens

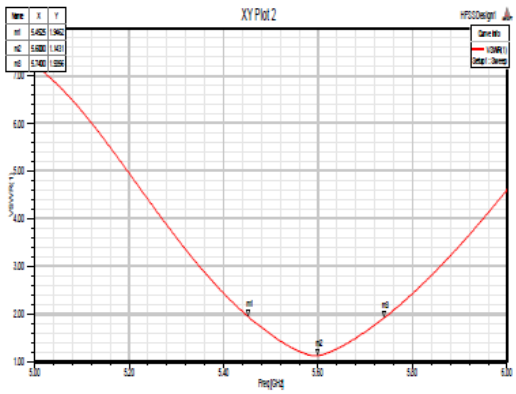
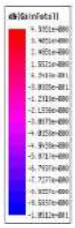


Fig.4 VSWR plot for Patch antenna without lens



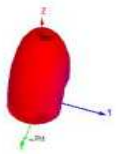


Fig.5 Polar plot of Patch antenna without lens

2. Patch Antenna with Lens structure

The designed patch antenna with lens structure has central frequency of 5.610 GHz and a –10 dB return loss bandwidth of 322.5 MHz as shown in Fig.3. The other parameters like gain, VSWR, Bandwidth and Bandwidth percentage are obtained as shown in Table.3

BW(MHz)	%BW	VSWR	Gain(dB)
322.5	5.25	1.02	8.7424

Table.3 Different parameters values of Patch antenna with lens.

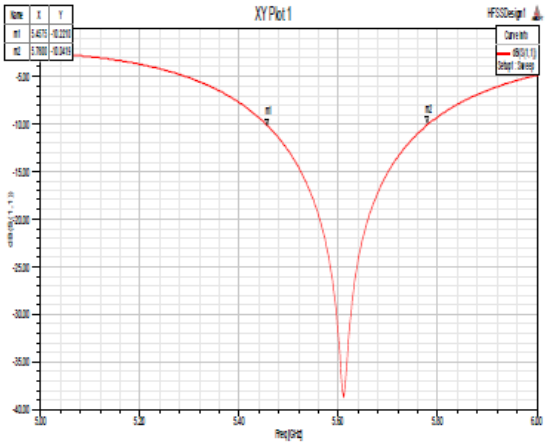


Fig.6 Return loss of Patch antenna with lens

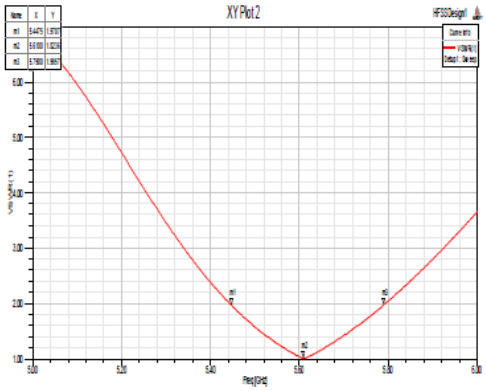


Fig.7 VSWR of Patch antenna with lens

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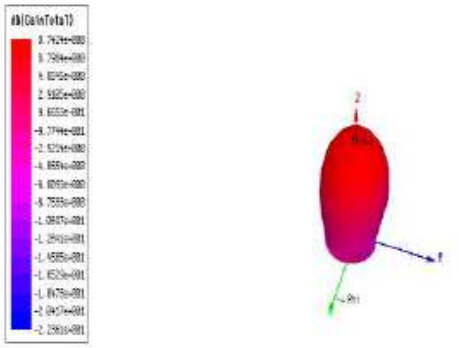

Fig.8 Polar plot of Patch antenna with lens

4. CONCLUSIONS

This work demonstrates that patch antenna with FR4 substrate and hemisphere Lens structure made up of Teflon with dielectric constant 2.1 on patch antenna with a distance of 5.63 mm operating at 5.45-5.75 GHz range applicable for WiMax application. The gain of patch antenna with lens is Around 8.7424 which is almost twice as compared to patch antenna without lens. Even the increase in bandwidth of around 37 MHz is also observed in case of patch antenna with lens structure.

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