Performance Analysis of Circular Patch Antenna for Various Heights at Ka Band

T.Akhila Sree, J.V.Likitha, B.Prabhakar, P.Rajesh, R.Satya Kalyan, P.Satish, P.Siddaiah

***Abstract*— This paper presents a detailed explanation on comparison of Microstrip circular patch antenna for different heights of patch. The antenna is operating in Ka band at frequency of 34.88GHz. The antenna has been designed and simulated on an FR4 substrate with dielectric constant of 4.4 and a thickness of 0.16cm.This paper also presents the detail steps of designing and simulating the circular patch antenna in Ka band. The design is analysed by Finite Element Method based HFSS Simulator Software (version 14.0) by which return loss, 3D polar plot and Gain of the antenna are computed. The simulated results show that the proposed antenna provides a good performance in terms of return loss and radiation pattern where different patch heights are needed.**

***Index Terms*— Circular patch, Ka band, Microstrip Antenna, HFSS, Return loss, Gain.**

I. INTRODUCTION

An Antenna is usually a metallic device for radiating or receiving radio waves.Microstrip antenna which consists of metallic patch on grounded substrate used for spectrum applications, government and commercial applications because of low profile in expensive to fabricate and simple. It is used to transport electromagnetic energy from transmitting source to antenna or from antenna to receiver. Circular patch antennas are most popular because of ease of analysis and fabrications, attractive radiation characteristics and low cross polarisation. The implementation of the Microstrip patch antenna is a milestone in wireless communication systems and is continuing to fulfil the changing demands of the new generation of antenna technology. The design of Microstrip patch antenna operating in Ka band is a difficult task.

The range of frequency of Ka band is 26.5 to 40GHz. Ka band is used in communication satellites, broadcast services and for specific applications for ISRO and NASA. Ka band is also used in close range targeting radars aboard military aircrafts and detection of vehicle speed.

II. DESIGN CONSIDERATIONS

Design considerations for Microstrip Circular patch antenna are as follows.

A. Frequency of Operation:

The Satellite Communication Systems uses the Ka-Band with frequency range from 26.5GHz - 40GHz. Hence the antenna designed must be able to operate in this frequency range. The operating frequency selected for the design is 34.0GHz.

B. Dielectric Constant of Substrate

The dielectric material selected is FR4 which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

C. Height of Dielectric Substrate

As the thickness of substrate increases, surface waves are induced within the substrate. Surface waves results in undesired radiation and decreases the efficiency of the antenna. Hence the height of the substrate is considered to be 0.16 cm.

D. Length and Width of the Dielectric Substrate

Both the length and width of the substrate are taken as 2λ.

$$C = \frac{\lambda}{f\sqrt{\varepsilon_r}}$$

E. Radius of the Patch

The radius of the patch is 1.0689mm, which is calculated using the formulae.

$$a = \frac{F}{\sqrt{\left(1+\frac{2h\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]}{\pi F \varepsilon_r}\right)}}$$

$$F=\frac{8.791*10^9}{f\sqrt{\varepsilon_r}}$$

$$a_e = a\sqrt{\left(1+\frac{2h\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]}{\pi F \varepsilon_r}\right)}$$

F. Height of the Patch

The antenna is designed for different patch heights (0.5cm, 1cm and 2cm).

III. DESIGN OF PROPOSED ANTENNA

In this paper the Microstrip circular patch antenna has been modelled and simulated at Ka-band. The patch is the dominant figure of a Microstrip antenna; the other

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components are the substrate and ground, which are below the patch. The analysis of patch antenna for 34 GHz of different heights of patch has been done using HFSS Software. The Proposed antenna design is as follows.

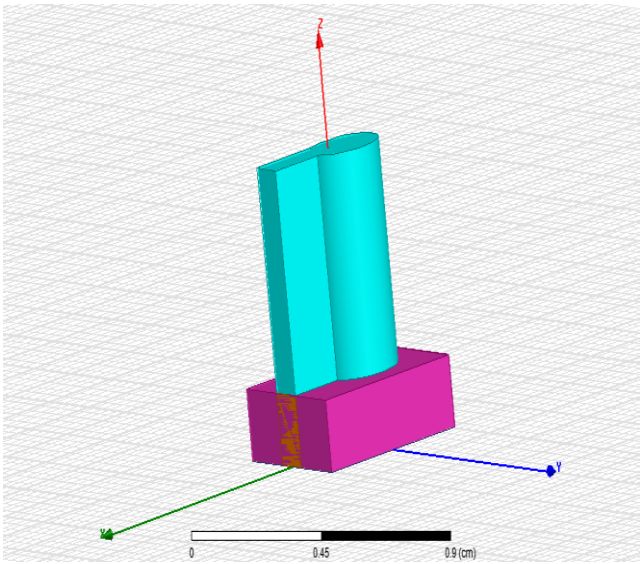

Fig. 1 Microstrip Circular Patch antenna

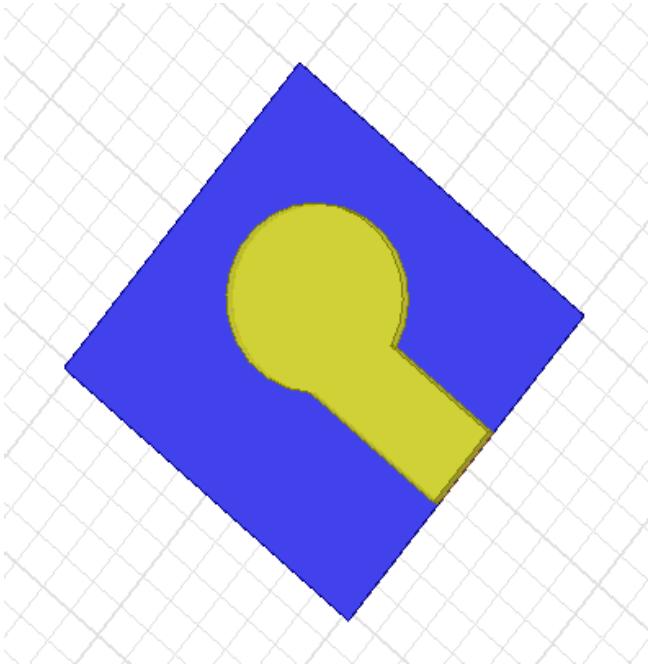

Fig. 2 Microstrip circular patch antenna top view

IV. RESULTS

Return loss, 3D polar plot and Peak gain are obtained using HFSS 14.0 software. The results are as follows.

1. Return loss:

The Return losses of different patch heights 0.5cm, 1cm and 2cm are 1.23db,-21.56db and -22.38db respectively. The antenna of patch height 2cm gives a better Return loss.

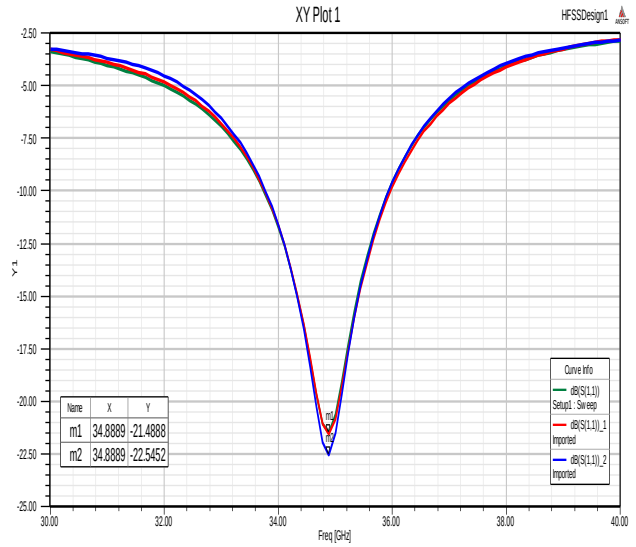

Fig. 3 Return loss

2. VSWR:

The VSWR for the different patch heights 0.5cm, 1cm and 2cm are 1.51, 1.45 and 1.32 respectively. All values are less than 2 which are desirable.

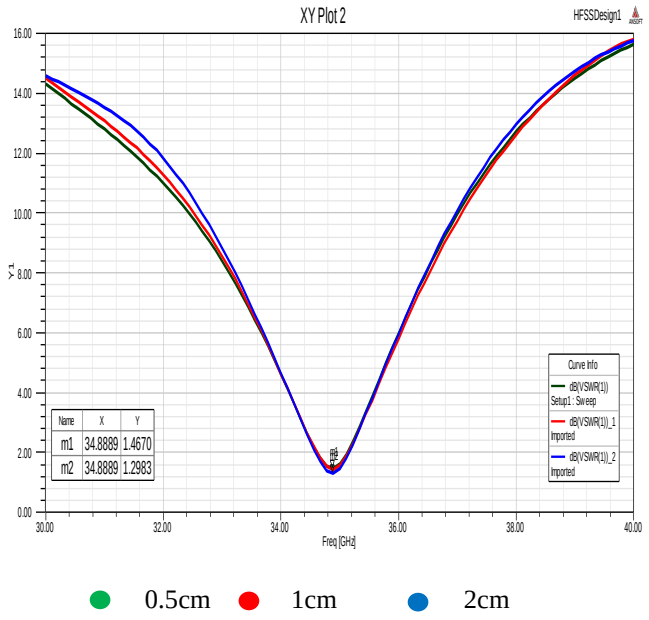

Fig. 4 VSWR

3. Peak gain:

The Peak gain for different patch heights 0.5cm, 1cm and 2cm are 3.155db, 3.429db and 3.951db respectively. The antenna with patch height of 2cm gives better peak gain. So whenever height of the patch is increased, then peak gain increases.

4. Peak directivity:

The peak directivity for different patch heights 0.5cm, 1cm and 2cm are 3.30, 3.8254 and 4.4162 respectively. The antenna with patch height of 2cm shows better directivity.

The comparison of various parameters is as follows:

Patch height 0.5cm

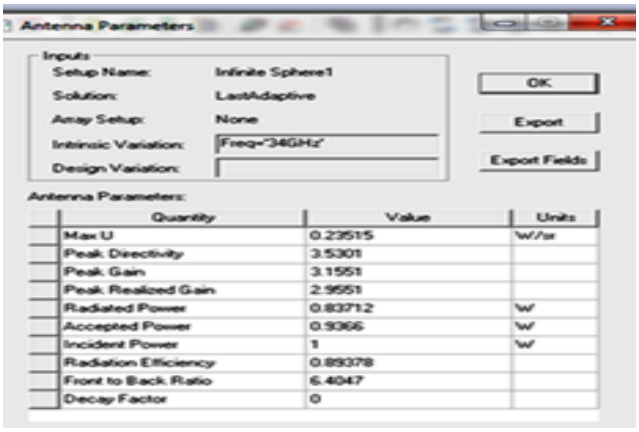

Fig. 5 Antenna parameters

Patch height 1cm

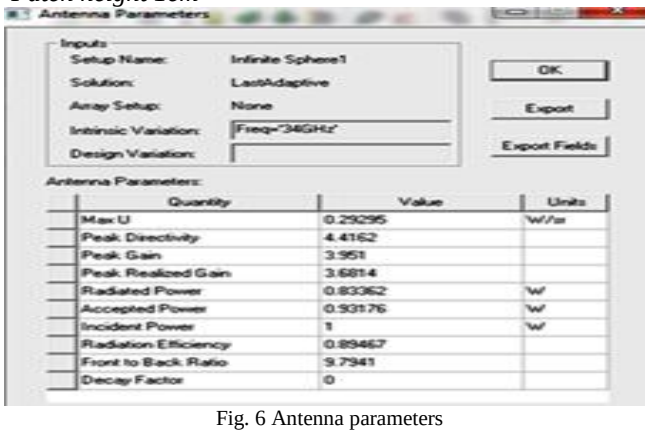

Fig. 6 Antenna parameters

Patch height 2cm

Fig.7Antenna parameters

Comparison table

A. Parameter	*B. Height of patch*		
	a) 0.5cm	*C. 1cm*	***D.*** *2cm*
Return loss	-21.23	-21.56	-22.38
Peak Gain	3.155	3.429	3.951
VSWR	1.51	1.45	1.32
Peak Directivity	3.5301	3.8254	4.4162

Table. 1 Designed Antenna parameters

5. 3-D Polar plots

The 3-D polar plots are obtained for designed antennas of different patch heights. Overall gains of designed antennas are 4.99, 5.35 and 5.96 for patch heights of 0.5cm, 1cm and 2cm respectively. So the antenna with patch height 2cm has more gain which is preferable in various applications.

Patch height 0.5cm

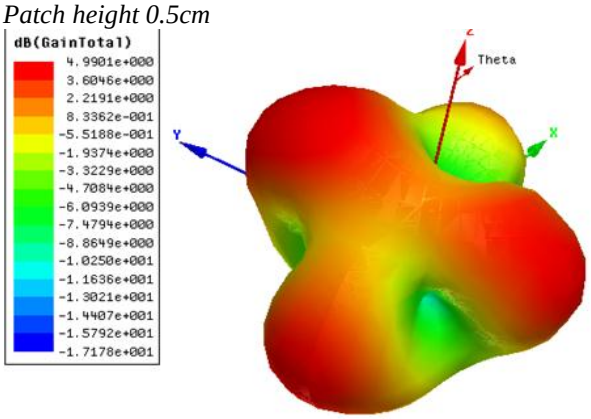

Fig. 8 3-D Polar plot

Patch height 1cm

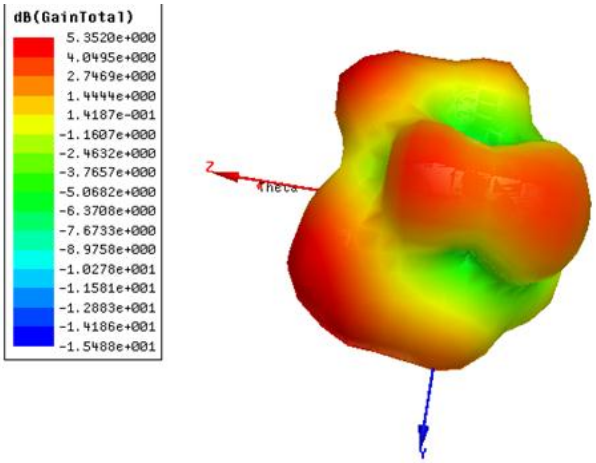

Fig. 9 3-D Polar plot

Patch height 2cm

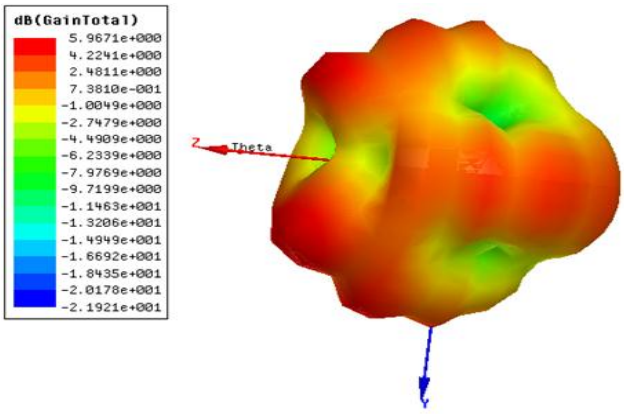

Fig. 10 3-D Polar plot

6. Radiation pattern

An antenna radiation pattern or antenna pattern is defined as a mathematical function or a graphical representation of the radiation properties of an antenna as a function of space coordinates. The radiation pattern obtained for designed antenna with different patch heights are shown in the figure.

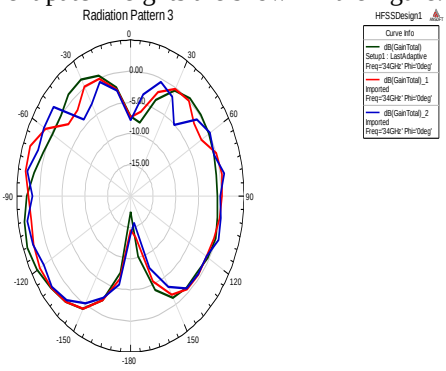

Fig. 11 Radiation pattern

The above figure shows that the antenna with patch height 2cm gives the better radiation pattern.

V. CONCLUSION

From the above shown results, it is clearly indicated that the antenna with patch height of 2cm is showing better performance when compared to the antennas with other patch heights of 0.5cm and 1cm.It can be clearly observed that this antenna is perfect for Ka Band among antennas with different heights of patch. The Return Loss and Peak Gain of the antenna at a patch height of 2cm are -22.38db and 3.951db respectively. So it is perfect for communication satellites and close range targeting radars aboard military aircrafts.

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