Comparison of Dual Frequency Antenna in Ka-Band with and without Shorting pin

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***Abstract*— This paper presents a detailed explanation on comparison of Microstrip circular patch antenna for dual frequency applications with and without shorting pin. At Ka-Band the antenna without shorting pin operates at 34.88GHz and 37.55GHz with an operational band width of 6.51GHz (32.79GHz to 39.30GHz) with a gain of 1.25 and return loss of -16.71db, with shorting pin the antenna operates at 32.22GHz and 36.22GHz with an operational band width of 9.92GHz (29.50GHz to 39.42GHz) with a gain of 1.93 and with a return loss of -30db. It is observed that the radius of the patch has reduced by half after inserting the shorting pin and also the height of the patch is reduced to 0.1cm from 0.5cm. The antenna has been designed and simulated on an FR4 substrate with dielectric constant of 4.4 and thickness of 0.21 mm. The design is analysed by Finite Element Method based HFSS Simulator Software (version 14.0),**

***Index Terms*— Microstrip antenna, Ka-Band, Dual Frequency, HFSS, Return Loss.**

I. INTRODUCTION

A common technique to reduce the overall size of a micro-strip patch antenna is to terminate one of the radiating edges with a short circuit. The short circuit can be in the form of a metal clamp or a series of shorting posts. Circular micro strip patch antenna with dual frequency operation is designed by shorting the patch and the results are compared with the conventional circular micro strip antenna (without a shorting post) which shows that the size of the circular micro strip antenna can be reduced for the same frequency application. It is also observed that the resonant frequency of the circular micro strip antenna with shorting post can be varied by varying its location. The technique of shorting post is used for dual frequency operation.

II. DESIGN CONSIDERATIONS

Design considerations for the 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 [1] 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 [1].

C. Height of Dielectric Substrate

As thickness of substrate increases, surface waves are induced within the substrate. Surface waves results in undesired radiation, decreases antenna efficiency and introduces spurious coupling between different circuits or Antenna elements, Hence the height of the substrate is considered to be 0.21 mm (h=0.05(λ)) [2].

D. Length and Width of the Dielectric Substrate

Both the length and width of the substrate are taken as 2λ [3].

E. Shorting pin

The radius of the shorting pin is 0.1cm and height is 0.21mm. The material used for the shorting pin is PEC and it is been placed in between the ground plane and the patch.

F. Radius of the Patch

The radius of the patch is 1.0689mm, which is calculated using the formulae [1].

$$a = F\{1 + \frac{2h}{\pi F \varepsilon_r}[ln(\frac{\pi F}{2h}) + 1.7726]\}^{-1/2} \quad (1)$$

where

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}} \quad (2)$$

$$a_e = a\{1 + \frac{2h}{\pi a \varepsilon_r}[ln(\frac{\pi a}{2h}) + 1.7726]\}^{1/2} \quad (3)$$

III. DESIGN OF PROPOSED ANTENNA

The above parameters are analysed and used in designing microstrip patch antenna in HFSS simulator, PEC is been used as material for the patch and coaxial feed is been used for feeding the antenna, the antenna without shorting pin operates at 34.88GHz and 37.55GHz with an operational band width of 6.51GHz (32.79GHz to 39.30GHz) with a gain of 1.25 and return loss of -16.71db, with shorting pin the antenna operates at 32.22GHz and 36.22GHz with an

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operational band width of 9.92GHz (29.50GHz to 39.42GHz) with a gain of 1.93 and with a return loss of -30db. It is observed that the radius of the patch has reduced by half and the height of the patch is reduced to 0.1cm from 0.5cm after inserting the shorting pin.

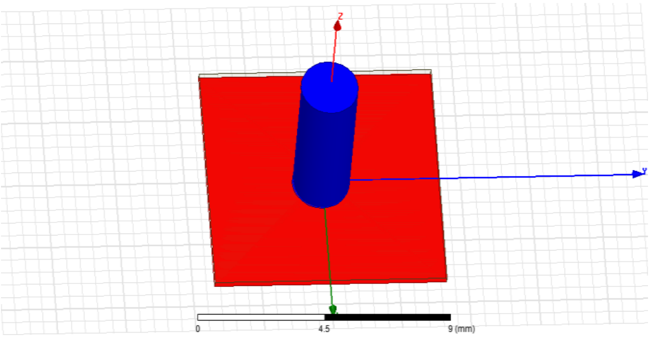

Fig. 1 Microstrip circular patch antenna without shorting pin

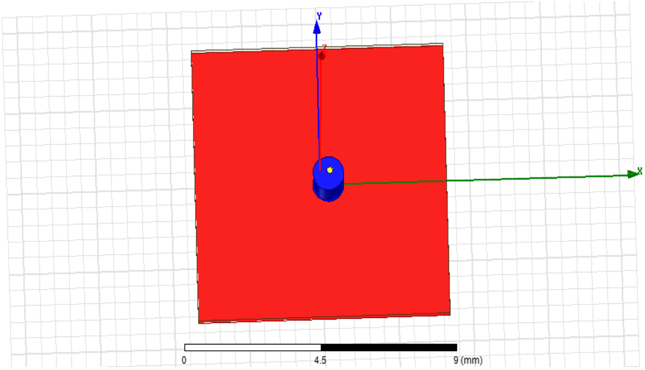

Fig. 2 Microstrip circular patch antenna with shorting pin

IV. RESULTS

Obtained results for the Microstrip circular patch antenna with and without shorting pin are as follows.

A. Return Losses

Antenna without shorting pin has a return loss of -16.71db at 37.55GHz and -15.14 db at 34.88 GHz while the antenna with shorting pin has a return loss of -30.01 db at 36.22 GHz and -14.24db at 32.22 GHz.

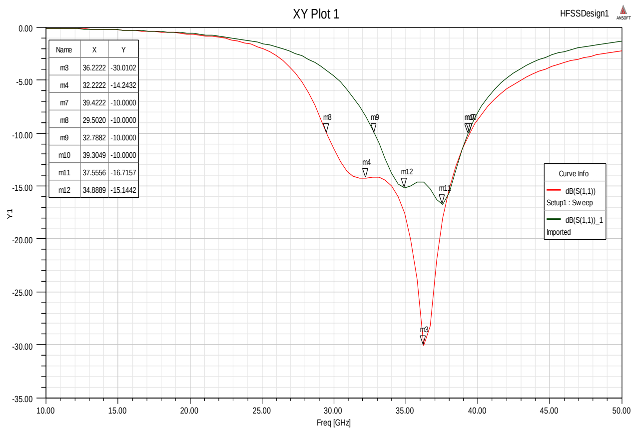

Fig. 3 Return loss (--- with shorting pin --- without shorting pin)

B. 3D Polar Plot

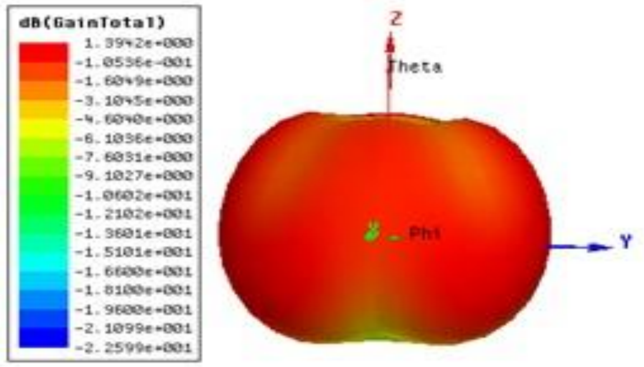

Fig. 4 3D Polar Plot (with shorting pin)

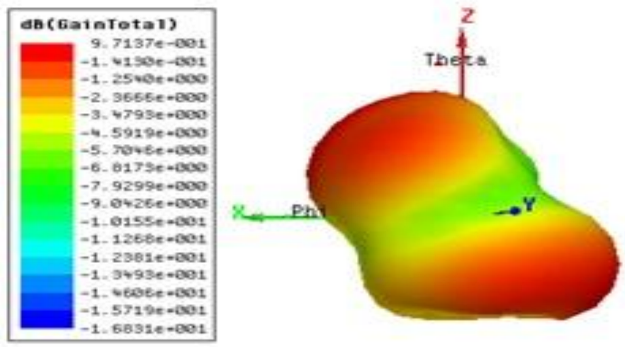

Fig. 5 3D Polar Plot (without shorting pin)

C. Comparison Table

The following table consists of various parameters of the antennas by which we can analyse the performance of the antenna.

Quantity	***Value without Shorting Pin***	***Value with shorting pin***
Peak Directivity	1.28	1.99
Peak Gain	1.25	1.97
Radiation Efficiency	0.9762	0.9944
Radiated Power	0.93	0.96
Accepted Power	0.95	0.97

Table.1 Antenna Parameters

V. CONCLUSION

From the above shown results it is clearly indicated that the antenna with shorting pin is showing better performance when compared to the antenna without shorting pin, and it is also observed that by placing a shorting pin the dimensions of the antenna has reduced to a considerable range. From the above results it can be clearly observed that this antenna is perfect for Ka-Band and Dual Band applications such as communication Satellites, Vehicle speed detection systems, High-resolution and close range targeting radars aboard military airplanes. The resonance frequency and impedance matching depend on the position of coaxial feed and shorting pin.

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