Comparison of Dual Frequency Rectangular Patch Antenna with and without Shorting Pin

J L N Swathi, Dr.P.Siddaiah

Abstract— **This paper presents comparison of a dual frequency rectangular patch antenna with shorting pin and without shorting pin technique to operate at Ku-band. The feeding technique used is microstrip feeding. Dual frequency is obtained at 12.33 GHz and 15.33 GHz. The antenna has been simulated on an FR4 substrate with dielectric constant of 4.4 and thickness of 0.157 cm. This paper also presents comparison of simulated results for the rectangular patch antenna in Ku-band without shorting pin and with shorting pin. The design is analysed by Finite Element Method based HFSS Simulator Software (version 14.0) by which return loss,3D polar plot, Gain of the antenna are computed and compared. The simulated results shows that the antenna with shorting pin technique provides good performance in terms of return loss and radiation pattern for dual frequency applications.**

Index Terms— **Rectangular patch, Ku-Band, shorting pin, Microstrip Antenna, HFSS, Return loss, Bandwidth, Gain.**

I. INTRODUCTION

Microstrip patch antennas are widely used in wireless communication systems because they are of low profile, light weight, low cost, conformal design, low power handling capacity and easy to fabricate and integrate. They can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth.

Dual-frequency operations are widely used in wireless systems and there are various ways to make a dual frequency antenna. Slit-loaded, slot-loaded, shorting pin loaded and circuitry-loaded patch antennas are some of the methods to form a dual frequency operation. Among these methods, inserting shorting pin is the most popular since it provides better upper to lower frequency ratios. It is also known that inserting shorting pin to an antenna significantly reduces the size of the antenna.

The design of microstrip patch antenna operating in Ku band is a difficult task. Ku band is primarily used in the satellite communication most notably for fixed and broadcast services. Ku-band is also used for satellite from remote location back to a television network studio for editing and broadcasting.

The proposed model is one such antenna which is a Microstrip fed rectangular patch antenna using shorting pin technique. It can be operated at Ku-band (12-18 GHz) [1]. In addition to its operation in Ku band the proposed antenna is also a dual band antenna. Dual frequency antenna is used in applications where transmission and reception should be done using same antenna. Many dual-band antennas have been improved to face the rising demands of a modern portable wireless communication device that is capable of integrating more than one communication standard into a single system. The proposed antenna is one such with improved return losses, gain and directivity. The comparison shows that patch antenna with shorting pin is best in terms of all antenna parameters.

Manuscript received August 06, 2014.

J L N Swathi, M.Tech student , Department of ECE, University College of Engineering and Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh.

Dr.P.Siddaiah, DEAN & Professor, Department of ECE, University College of Engineering and Technology, Acharya Nagarjuna University, Guntur, Andhra Pradesh

II. DESIGN CONSIDERATIONS

A. Frequency of Operation:

The operating frequency selected is 13.28 GHz in Ku-band. Ku-band is a portion of the EM spectrum in the microwave range of frequencies. Ku refers to “K-Under”, in other words the band directly below the K-band. IEEE standard frequency range is from 12-18 GHz.

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 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 0.157 cm.

D. Length and Width of substrate:

The length and width are chosen such that Length is 3 cm ($L > \lambda$) and width is 3 cm ($W > (\lambda/2)$).

E. Microstrip feed position:

The position of strip feed is adjusted so as to obtain dual frequency with good return loss.

F. Radius and position of Shorting pin:

The radius of shorting pin is 0.2 mm and position of shorting pin is adjusted to obtain dual frequency with good return losses. Shorting pin is placed from height of substrate to patch.

Other Antenna parameters like Width of patch (W), Length of patch (L) etc. are calculated from below equations.

$$W = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

$$L = \frac{v_o}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (2)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)(W/h + 0.8)} \quad (4)$$

III. DESIGN OF PROPOSED ANTENNA

In this paper the microstrip fed rectangular patch antenna with shorting pin and without shorting pin has been modelled and simulated at Ku-band. The patch(radiating part) is the dominant figure of a microstrip antenna; the other components are the substrate and ground, which are the two sides of the patch.

Without shorting pin technique:

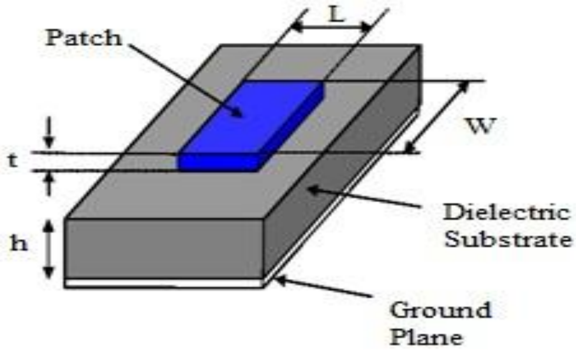

Fig. 1 Model of Microstrip antenna without shorting pin

With shorting pin:

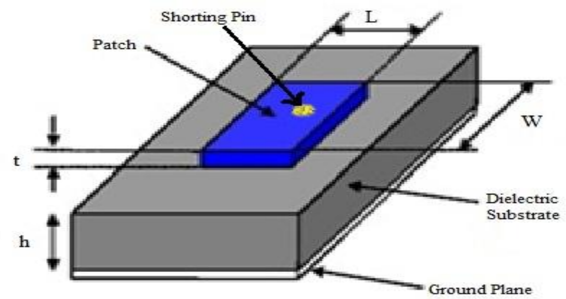

Fig.2 Model of Microstrip antenna with shorting pin (shown in yellow colour)

Shorting pin is a cylindrical metal structure made of PEC (Perfect Electric Conductor).

The analysis of dual band antenna for 12.33 GHz and 15.33 GHz frequency and the designing has been done using HFSS Software [2]. The Proposed antenna designed is as follows

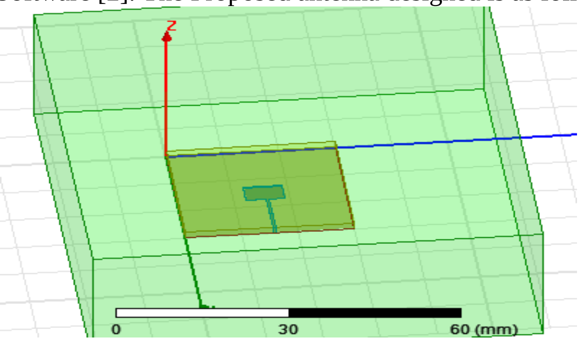

Fig.3 Designed Microstrip antenna without shorting pin

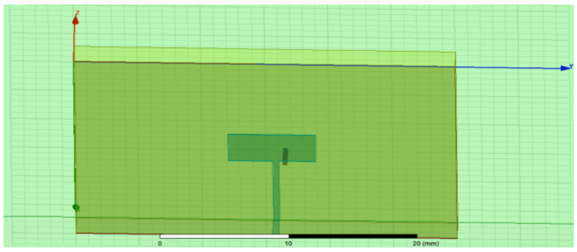

Fig.4 Designed Microstrip antenna with shorting pin

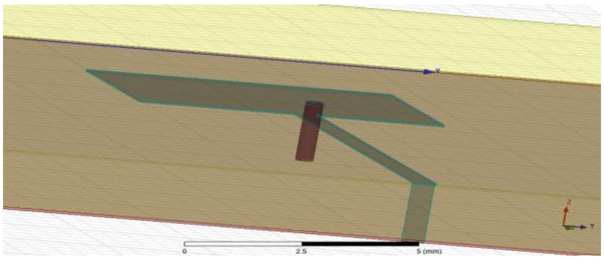

Fig.5 Designed Microstrip antenna with shorting pin(Zoomed View)

IV. RESULTS

The return loss, 3D polar plot, peak gain are obtained using HFSS 14.0. The comparison of results are shown in table 1.

Return losses:

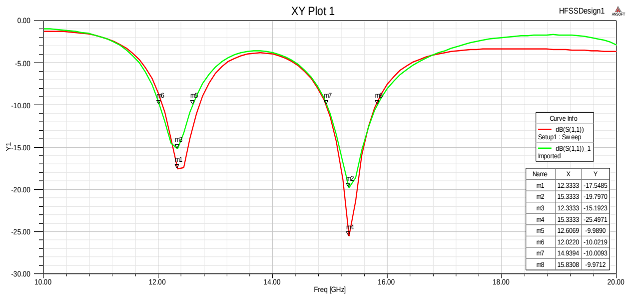

Fig.6 Compared Return Loss

(--- without shorting pin , --- with shorting pin)

Above are the results for return losses. Red colour line indicates return losses with shorting pin .Green colour line indicates return losses without shorting pin. Without shorting pin return losses are obtained at -15.19 and -19.79 dB. Whereas with shorting pin the return losses are obtained at -17.54 and -25.49 dB. By this it is clear that return losses are improved by using shorting pin.

Rectangular Stacked Plot:

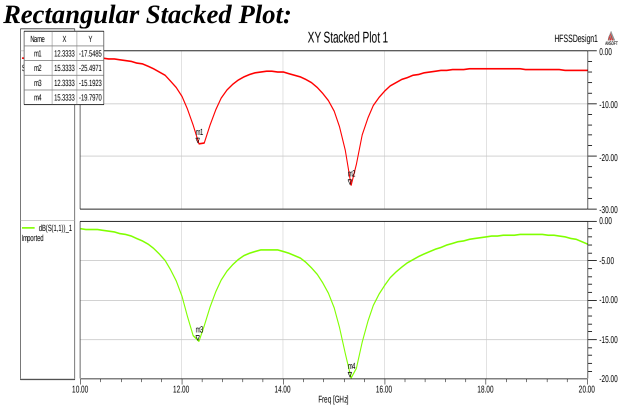

Fig.7 Compared Rectangular Stacked Plots

(--- without shorting pin , --- with shorting pin)

Smith Chart:

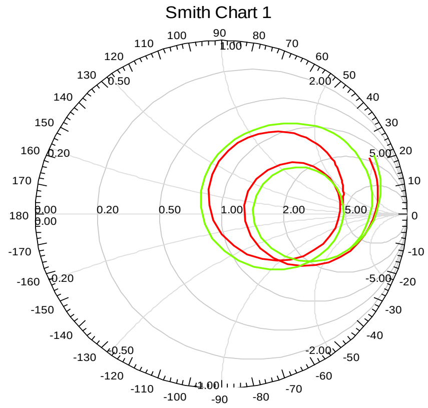

Fig.8 Compared Smith Charts(--- without shorting pin , --- with shorting pin)

3D Polar plot:

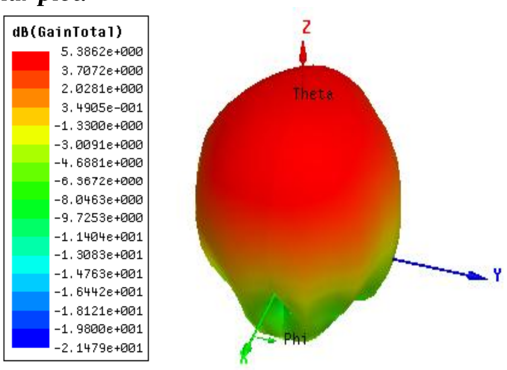

Fig.9 3D Polar Plot for Patch without shorting pin

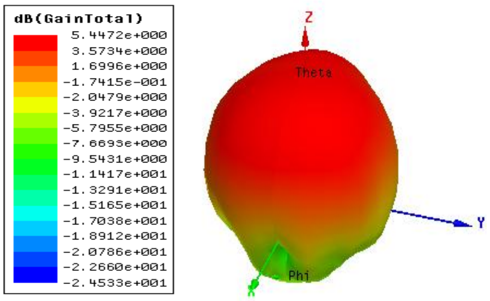

Fig.10 3D Polar Plot for Patch with shorting pin

From the above polar plots gain total without shorting pin is 5.386 dB and with shorting pin it is 5.44 dB. So, it is clear that gain total is improved with shorting pin.

Comparison Table:

Quantity	***Value without Shorting Pin***	***Value with shorting pin***
Peak Directivity	4.43096	4.49891
Peak Gain	3.4564	3.50529
Peak Realized Gain	2.11367	2.2802
Radiated Power	0.477024(W)	0.506835(W)
Accepted Power	0.611525(W)	0.650504(W)
Radiation Efficiency	0.780056	0.779142

Table.1 Antenna Parameters

V. CONCLUSION

After analysis, the characteristics of the proposed antenna with and without shorting pin are given as follows, Obtained dual band at 12.33 GHz and 15.33 GHz frequencies with an operational band widths of 0.7 GHz (12 to 12.7 GHz) and 0.97 GHz (14.83 to 15.8 GHz).So from table 1 it can be clearly say that characteristics of antenna with shorting pin enhanced at many parameters and this antenna is perfect for applications such as radar communication, military communication. Band width is also acceptable for both bands.

ACKNOWLEDGMENTS

Extending our grateful thanks to the authorities of Acharya Nagarjuna University for their support and encouragement to write this paper.

REFERENCES

[1]R. Azim, M. T. Islam, and N.Misran, “Dual polarized microstrip patch antenna for Ku-band application,” *Informacije MIDEM*,vol. 41, no. 2, pp. 114–117, 2011.

[2]M. Sanad, “Effect of the shorting posts on short circuit microstrip antennas,” Proceedings, IEEE Antennas and Propagation Society International Symposium, pp. 794-797, 1994.

[3]Pradeep Kumar, "Microstrip Antennas Loaded with Shorting Post", Scientific reasearch engineering,June 2009.

[4]N. Misran, M. T. Islam, N. M. Yusob, and A. T. Mobashsher,“Design of a compact dual band microstrip antenna for ku-band application,” in *Proceedings of the International Conference on Electrical Engineering and Informatics (ICEEI ’09)*, vol. 2, pp.699–702, Selangor, Malaysia, August 2009.

[5]M. T. Islam, N. Misran, and A. T. Mobashsher, “Compact dual band microstrip antenna for Ku-band application,” *Information Technology Journal*, vol. 9, no. 2, pp. 354–358, 2010.

[6]R. Porath, “Theory of miniaturized shorting-post micro-strip antennas,” IEEE Transactions, Antennas and Propagation, Vol. 48, No. 1, pp. 41-47, 2000.

[7]http://www.hindawi.com/journals/tswj/2013/378420/ *Dual-Band Operation of a Microstrip Patch Antenna on a Duroid 5870 Substrate for Ku- and K-Bands.*

[8]C.A. Balanis, Antenna Theory, 2nd Ed., John wily & sons, Inc., NewYork.1982.

[9]Girish Kumar and K.P.Ray, *“Broadband Microstrip Antennas,”* Artech House.

[10] Debatosh Guha and Yahia M.M.Antar, *“Microstrip and Printed Antennas,”* John wily & sons, Inc.

[11] Randy Bancroft, “*Microstrip and Printed Antenna Design*,” 2nd Edition, SciTech Publishing, Inc.

J L N Swathi obtained B.Tech degree in Electronics and Communication Engineering from DVR & HS MIC College of Technology in 2012. She is M.Tech (ECE) student at Acharya Nagarjuna University College of Engineering and technology, Guntur, India. Her areas of interest are Antenna & Wave Propagation, Antenna designing, Signal Processing.

Dr. P Siddaiah obtained B.Tech degree in Electronics and communication engineering from JNTUA College of engineering in 1988.He received his M.Tech degree from SV University Tirupathi. He did his Ph.D program in JNTU Hyderabad. He is the Chief Investigator for several outstanding Projects sponsored by Defence Organizations, AICTE, UGC & ISRO. He is currently working as Professor & DEAN, Department of ECE in University College of Engineering and Technology, Acharya Nagarjuna University, Guntur, India. He has taught a wide variety of courses for UG & PG students and guided several projects. Several members successfully completed their Ph.D under his guidance. Several members pursuing their Ph.D degree. He has published several papers in National & International Journals & Conferences. He is the life member of FIETE, IE & MISTE.