

DESIGN A COMPACT H - SLOT MICROSTRIP PATCH ANTENNA FOR S-BAND APPLICATION

N.MohamedSabidha Banu¹, M.Shahul Hameed², Dr.M.Ramkumar Prabhu³

¹ P.G Student, Department of ECE, Dhaanish Ahmed College of Engineering, Padappai, Chennai, India.

²Assistant Professor, Department of ECE, Dhaanish Ahmed College of Engineering, Padappai, Chennai, India.

³Professor, Department of ECE, Dhaanish Ahmed College of Engineering, Padappai, Chennai, India.

¹sabithabanu.ece@gmail.com, ²shahmeap@gmail.com, ³mramkumarprabu@gmail.com

Abstract— In recent years there is a need for more compact antennas due to rapid decrease in size of personal communication devices. This paper deals with the problem of size and performance of antenna. This paper presents design and simulation of a square micro strip patch antenna with H - slot at 2.6 GHz for S- Band communications, which provides a radiation pattern along a wide angle of beam and achieves a good gain. The slot can improve good VSWR and reduce Return loss, the square microstrip patch antenna was analyzed using Ansoft/Ansys HFSS. The proposed inset feed square patch antenna provide good Resonant Frequency; Return Loss, VSWR, Radiation Pattern and the antenna Gain.

Keywords— Microstrip antenna, H- Slot, Inset feed, Return Loss.

I. INTRODUCTION

Microstrip patch antennas (also just called patch antennas) are among the most common antenna types in use today, particularly in the popular frequency range of 1 to 6 GHz. This type of antenna had its first intense development in the 1970s, as communication systems became common at frequencies where its size and performance were very useful. At the same time, its flat profile and reduced weight, compared to parabolic reflectors and other antenna options, made it attractive for airborne and spacecraft applications. More recently, those same properties, with additional size reduction using high dielectric constant materials, have made patch antennas common in handsets, GPS receivers and other mass-produced wireless products. This tutorial article is intended to provide basic information on patch antenna design and operation, directed to engineers who are mainly designers of RF microwave circuits. The paper hope that this information will assist them as they design circuitry connected to these antennas, or as they are called on to evaluate and specify a vendor's antenna product for their current project.

Antennas are indispensable elements of any wireless communication systems. There are several type of antenna are available they are wire antenna, log periodic antenna, travelling wave antenna, micro strip antenna, aperture antenna, reflector antenna. The wire antenna comprises of several antenna they are short dipole antenna, dipole antenna, half wave dipole, broadband dipole, monopole antenna and loop antenna. In spite of this antenna, in this project micro strip antenna is designed with frequency of 2.6GHZ. Micro strip antenna comprises of 2 antennas they are rectangular micro strip (patch) antenna and planar inverted-F antenna Micro strip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Micro strip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated. Microstrip antennas find many applications as they are low profile, light weight, conformable to surface and inexpensive to manufacture using printed-circuit technology. For a patch, the length L of the element is usually the $L < \lambda_g/2$ (where λ_g is the guide wavelength on the substrate). Thicker substrates with lower dielectric constant provide better efficiency and larger bandwidth but at the expense of larger element size. Thin substrates with higher dielectric constants lead to smaller element sizes, minimize coupling, but are less efficient and have relatively smaller bandwidth.

Microstrip patch antennas have enjoyed proliferated use in many circularly polarized applications due to their low-profile and useful radiation characteristics. In the last decade, the development of modern wireless systems has prompted increased investigation on microstrip radiators, with particular attention paid to improving performance and miniaturization. Compared to a circular patch for a given frequency the square geometry is smaller in size. In modern communication system requires low profile, light weight, high gain, and simple structure antennas to give surety reliability, mobility, and high efficiency characteristics. Due to the existence of growth in development of low cost, less weight, highly reliable, minimal profile antennas

for wireless devices, it poses a new challenge for the design of antenna in wireless communications. This paper presents design and simulation of a square microstrip patch antenna at 2.6 GHz for wireless communications that provides a radiation pattern along a wide angle of beam and achieves a good gain.

The rest of the paper has been divided into Five parts. Section 1 describes overview of antenna. Section 2 describes an overview of the Microstrip patch antenna. Section 3 describes design consideration of antenna. Section 4 describes simulation results. Section 5 describes the conclusion and future work respectively.

II. MICROSTRIP PATCH ANTENNA

As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shape. The square microstrip patch antenna is the widely used of all the types of microstrip antennas that are present. The substrate material, dimension of antenna, feeding technique will determine the performance of microstrip antenna. Hence among different feeding techniques, inset fed technique is used for the design of square microstrip patch antenna at 2.6GHz. The microstrip patch antenna is shown in fig 1. Microstrip patch antenna has a ground plane on the one side of a dielectric substrate which other side has a radiating patch as shown below in Fig 1.

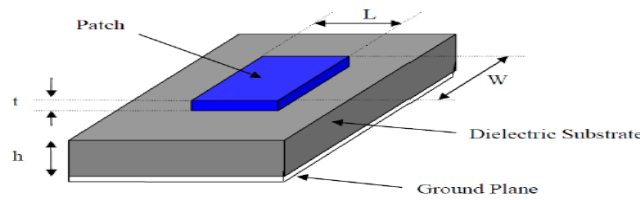


Figure 1. Microstrip antenna

A square patch is used as the main radiator. The patch is generally made of conducting material such as copper or gold and can take any possible shape. Dielectric constant of the substrate (ϵ_r) is typically in the range $2.2 < \epsilon_r < 12$. For good antenna performance, a low dielectric constant with thick dielectric substrate is desirable, as it provides better radiation, better efficiency and larger bandwidth.

A. Inset Feed Method

This typically yields high input impedance. Since the current is low at the ends of a half wave patch and increases in magnitude toward the center, the input impedance could be reduced if the patch was fed closer to the center. One method of doing this is by using an inset feed (a distance R from the end) as shown in the Fig 2. Since the current has a sinusoidal distribution, moving in a distance R from the end will increase the current by $\cos(\pi R/L)$ - this is just nothing that the wavelength is $2L$, and so the phase difference is $2\pi R / (2L) = \pi R/L$

Transmission line model depicts the microstrip antenna by two slots of width W and height h separated by transmission line of length L . The microstrip is a non-homogeneous of two dielectrics, typically, substrate and the air. Most of the electric field lines reside some part in the air and rest in the substrate. This results that transmission line does not support transverse electric magnetic (TEM) mode of transmission, as phase velocities would be different in substrate and in the air.

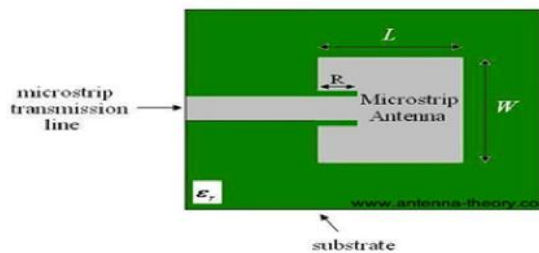


Figure 2. Patch antenna with inset feed

B. Microstrip Patch Antenna analysis Method

Assume a square microstrip antenna of width W , length L resting on the height of a substrate h . The coordinate axis was selected as the height along z direction, length along x direction and width along y direction. In order to operate in the fundamental mode, length of the patch should be slightly less than $\lambda/2$, where λ is the wavelength equal to λ_0 / \dots . The TM₁₀ implies that field varies a cycle of $\lambda/2$ along the length, and width of the patch has no variation. The microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends as shown in Fig 3.

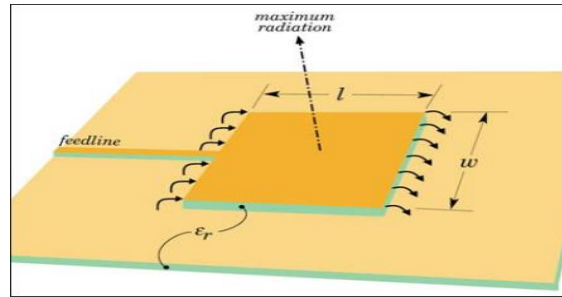


Figure 3 square patch antenna

The normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase as seen in Fig 4. Since the patch is $\lambda/2$ long and hence they cancel each other in the broadside direction. The tangential components which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure.



Figure 4. Electric field lines

III. DESIGN CONSIDERATION OF ANTENNA

The paper has designed a Square patch antenna of the center frequency 2.6 GHz. Gain required as 11.5dBi. The antenna has employed a hybrid structure and using Rogers RT duroid 5880 as a substrate.

The three essential parameters for the design of microstrip patch antenna are:

- 1) Frequency of operation (f_0).
- 2) Dielectric constant of the substrate (ϵ_r).
- 3) Height of dielectric substrate (H).

For the microstrip patch antenna the height of the dielectric substrate is critical since the antenna should not be bulky. The resonant frequency of the antenna must be selected appropriately. The transmission line model will be used to design the antenna. The edge type feed is used in this design.

C. Antenna Design Calculations

- 1) Frings factor:

$$\Delta_L = 0.412 h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8\right)} \quad (1)$$

2) Calculation of length:

$$L = L_{eff} - 2\Delta_L \quad (2)$$

3) For a Micro strip patch antenna, the resonance Frequency is given as

$$f_{0} = C / (2\sqrt{\epsilon_{reff}}) \sqrt{((m/L)^2 + (n/W)^2)} \quad (3)$$

Where m and n are modes along L and W respectively.

4) Calculation of width:

For efficient radiation, the width W is given as

$$W = C / (2f_0 \sqrt{(\epsilon_r + 1)/2}) \quad (4)$$

5) Dielectric Substrate :

It was found suitable to select a thin dielectric substrate with low dielectric constant by considering the trade-off between the antenna dimensions and its performance. Thin substrate permits to reduce the size and also spurious radiation as surface wave, and low dielectric constant for higher bandwidth, better efficiency and low power loss. The simulated results were found satisfactory.

IV. SIMULATION RESULTS AND DISCUSSION

The three essential parameters for the design of a Square Microstrip Patch Antenna:

1. Frequency of operation (f_0): The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for the design is 2.6 GHz.
2. Dielectric constant of the substrate (ϵ_r): The dielectric material selected for our design is Rogers RT duroid 5880 which has a dielectric constant of 2.2. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.
3. Height of dielectric substrate (h):
For the microstrip patch antenna substrate is selected as 1.6 mm.

Table 1. Shows the parameter selected for design a square microstrip antenna. Inset feed value is noted and the different calculation noted for test purpose.

Table 1. Dimensions of patch antenna

Solution Frequency	2.6 GHz
Patch Dimension	53.9 mm
Substrate dimension along x	100 mm
Substrate dimension along y	90 mm
Inset feed width	1.5 mm
Inset feed length	20 mm
Slot dimension	45mm X 3mm

D. Structure of Patch Antenna Design

Fig 5. Shows the H-slot square patch antenna design in 3D model. It consists of patch elements on one side of a dielectric substrate and a planar ground on the other side. It was assigned with an air box boundary and virtual radiation to create far field radiation pattern and assigned with an excitation.

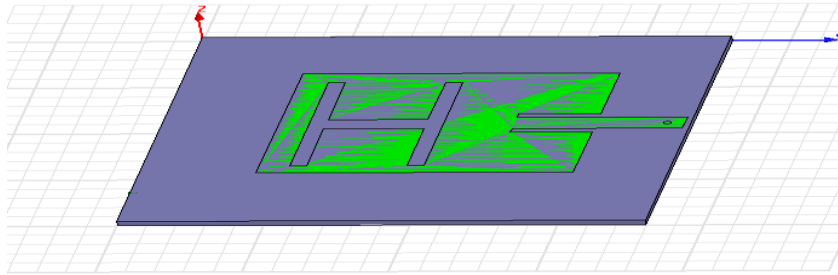


Figure 5. Feed microstrip antenna

Fig. 6, shows the full view of antenna, here the ground is taken as a rectangular and the medium for the ground is E-plan. A rectangular box is covers the antenna.

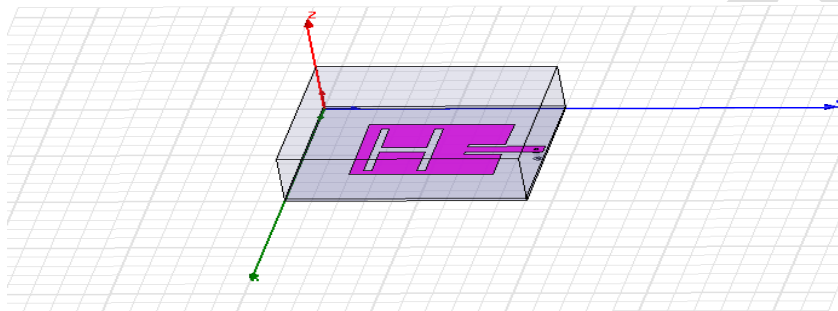


Figure 6. Full view of square patch microstrip antenna

The square patch microstrip antenna is simulated using Ansoft HFSS. The parameters evaluated were gain, beam width and return loss. Table 2 shows the comparison of proposed system with different frequency range. Here the Proposed system gave a good gain and result is satisfactory.

Table 2. Comparison of measured gain, return loss and bandwidth at two frequencies for single patch antenna.

Frequency in GHz	Substrate	Gain	Return Loss
2.25	Rogers RT RT duroid 5880	8 dB	-42dB
2.4	Rogers RT RT duroid 5880	9 dB	-14dB
2.6	Rogers RT RT duroid 5880	11.5 dB	-32.11dB

E. Radiation Pattern Plots

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for $\phi = 0$ and $\phi = 90$ degrees would be important.

Fig. 7.below shows the gain of the antenna at 2.6 GHz for $\phi = 0$ and $\phi = 90$ degrees and shows the radiation pattern of proposed system. The maximum gain is obtained in the broadside direction and this is measured to be 1.87 dBi for both, $\phi = 0$ and $\phi = 90$ degrees.

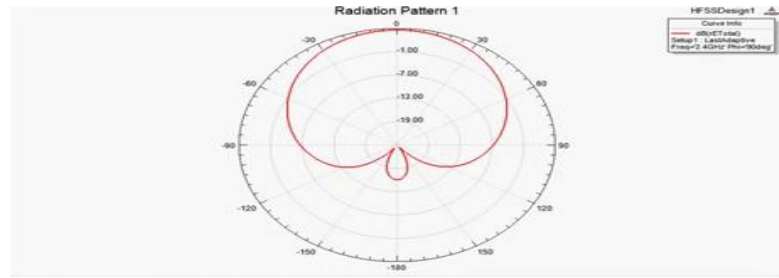


Figure 7. Radiation pattern of proposed system.

F. Return loss

The inset feed used is designed to have an inset depth of 20 mm, feed-line width of 1.8 mm and feed path length of 20 mm. A frequency range of 2.6 GHz is selected and 20 frequency points are selected over this range to obtain accurate results. The center frequency is selected as the one at which the return loss is minimum. The bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -9.5 dB (-9.5 dB corresponds to a VSWR of 2 which is an acceptable figure). Using PSO, the optimum feed depth is found to be at $Y_o = 13.2\text{mm}$ where a RL of -32 dB is obtained. The plot for frequency v/s return loss is shown in Figure 8.

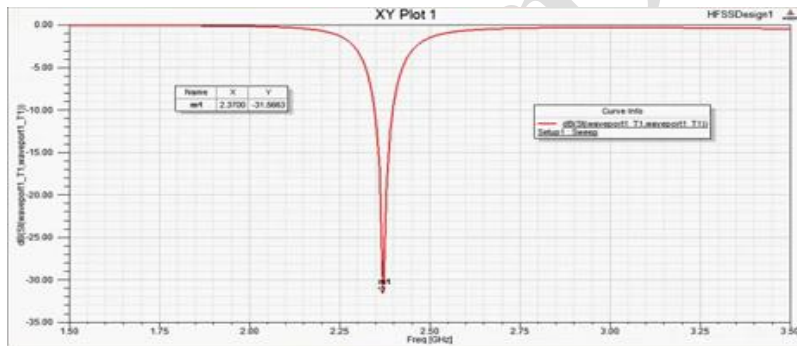


Figure 8. S-parameter plot for frequency v/s Return loss of proposed system

V. CONCLUSION

The design of H - slot square microstrip patch antenna with operating frequency 2.6 GHz suitable for s band application using inset feed feeding technique has been completed using HFSS software. The performance parameters were achieved with gain 11.5 dB and beam width 40 degrees in E-plane and 26 degrees in H-plane for patch antenna. The proposed antenna consists of a single patch for single operating frequency. In future two patches are going to be stacked and slots will be introduced to operate in two operating frequency to achieve high gain and good return loss.

Acknowledgment

We place on record and warmly acknowledge the continuous encouragement to Prof. C. Elayaraja, M.E., (Ph.D.), professor and head of the department PG, project co-coordinator, for providing us with all that is required to work on this project, last but not the least we express our sincere thanks to all our friends who have patiently extended all kind of help for accomplishing this undertaking. Finally we extend our gratitude to one and all who are directly or indirectly involved in the successful completion of this project work.

References

- [1] D. Pozar and S. M. Duffy, "A Dual-Band Circularly Polarized Aperture-Coupled Stacked Microstrip Antenna for Global Positioning Satellite," IEEE Trans. on Antennas and Propagation, Vol. 45, No. 11, pp. 1618-1625, Nov. 1997.
- [2] R. B. Waterhouse, "Broadband stacked shorted patch," Electronics Letters, Vol. 35, No. 2, pp. 98-100, Jan. 1999.
- [3] K. Yegin, D. G. Morris, N. F. Bally, R. J. Snoeyink, and W. R Livengood, "Integrated GPS and SDARS Antenna," US Patent Application 2006/0097924 A1, May 11, 2006.
- [4] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, 2000.
- [5] K. F. Lee, Ed., Advances in Microstrip and Printed Antennas, John Wiley, 1997.
- [6] D. M. Pozar and D. H. Schaubert, Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays, IEEE Press, 1995.
- [7] F. E. Gardiol, "Broadband Patch Antennas," Artech House.
- [8] S K Behera, "Novel Tuned Rectangular Patch Antenna As a Load for Phase Power Combining" Ph.D Thesis, Jadavpur University, Kolkata.
- [9] D. R. Jackson and J. T. Williams, "A comparison of CAD models for radiation from rectangular microstrip patches," Intl. Journal of Microwave and Millimeter-Wave Computer Aided Design, Vol.1, No. 2, pp. 236-248, April 1991.
- [10] D. R. Jackson, S. A. Long, J. T. Williams, and V. B. Davis, "Computer- aided design of rectangular microstrip antennas", ch. 5 of Advances in Microstrip and Printed Antennas, K. F. Lee, Editor, John Wiley, 1997.
- [11] D. M. Pozar, "A reciprocity method of analysis for printed slot and slot- coupled microstrip antennas," IEEE Trans. Antennas and Propagation, vol. AP-34, pp. 1439-1446, Dec. 1986.

Authors Short Profile:



N. Mohamed Sabidha Banu received the B.E Degree in Electronics and communication engineering from Mohamed Sathak Engineering College, Keelakkarai, Tamil nadu, india in 2012 and Pursuing M.E Degree in Applied Electronics in Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India.



Assistant Professor M. Shahul Hameed received His Diploma in Electronics and communication engineering from A.M.S Polytechnic College, Chennai, Tamil Nadu, India in 2004, the B.E Degree in Electronics and communication engineering from Rajalakshmi Engineering College, Chennai, Tamil Nadu, India in 2007 and M.E Degree in Applied Electronics in Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India. in 2013 respectively. He is with the department of ECE, Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India. His research interest is in the area of RF and Microwaves.



Professor M. Ramkumar Prabhu received the B.E Degree in Electrical and Electronics engineering from SACSMVMM Engineering College, Tamil Nadu, India in 2002 and M.E Degree in Applied Electronics in Jerusalem Engineering College, Chennai, Tamil Nadu, India in 2007, His PhD in Electronics and Communication Engineering from Bharath University, Chennai, Tamil Nadu, India in 2011 respectively. He has published more than 15 papers in various international journal and conferences; He is with the department of ECE, Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India. His major research interest is in the area of Microwave Engineering and VLSI.