International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-12, December 2014

Analysis of S-band Circular Patch Antenna with Different Feeding Techniques

Y. Laxmi Lavanya, K. Suresh, Prof. P. Siddaiah

Abstract— **The paper describes the performance of a circular patch antenna with various types of feeding techniques such as inset feed, probe feed, aperture coupled feed and proximity coupled feed. The antenna is designed for 2.4 GHz (ISM band). Various parameters like gain, percentage bandwidth and radiation efficiency are compared. The highest gain of 5.74 dB is observed for proximity coupled feed. The shape of radiation patterns also vary depending on the feed used.**

Index Terms— **aperture coupling, proximity coupling, radiation efficiency**

I. INTRODUCTION:

The study of microstrip patch antennas has gained attention over recent years due to their versatility. The microstrip patch antenna is basically a narrowband wide-beam antenna which consists of a radiating patch and a slightly larger ground, both separated by a dielectric material. They usually operate in the microwave frequency range, i.e. the size of antenna is small since it directly depends on wavelength corresponding to resonant frequency

The increasing demand for microstrip patch antennas in various commercial and military applications is due to their advantages like planar (2-dimensional) and low profile, ease of fabrication, compatibility with integrated circuit technology and conformability with a shaped surface. They are most suitable for aerospace and mobile applications.

There are also drawbacks such as very narrow bandwidth, low power handling capacity, high feed network losses and poor cross polarization [1]. Most of these can be overcome by developing innovative designs and configurations.

II. FEEDING TECHNIQUES:

Any conductor radiates at discontinuities when excitation is provided to it. The patch surface is a conductor and hence it radiates electromagnetic energy when excited from external source via a feed network.

There are many feeding methods in use. Most popular types of techniques through which the patch antenna can be fed are:

A. Inset feed
B. Coaxial feed
C. Aperture coupled feed
D. Proximity feed

A. *Inset feed:*

This is an extension of microstrip line feed in which the patch is excited through a microstrip transmission line attached to it. For better impedance matching, the feed line can be moved near to the patch center, where current is high (Z=V/I is low). The main advantage of this technique is that the feed line lies in the same plane as the patch.

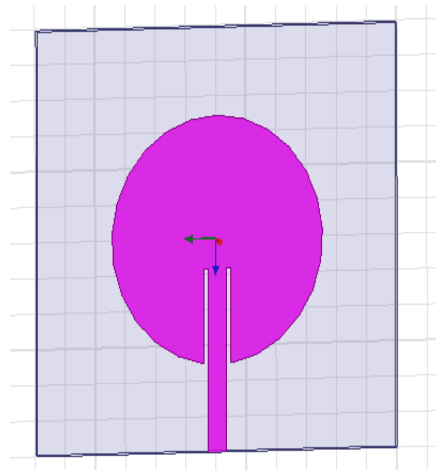

Fig. 1. Inset feed

B. *Coaxial feed:*

This type of feeding technique involves exciting the patch antenna using a coaxial probe. The outer conductor of the cable is connected to ground plane, while the center conductor (feed pin) extends up to the patch. In this technique, impedance matching can be achieved by varying the feed position.

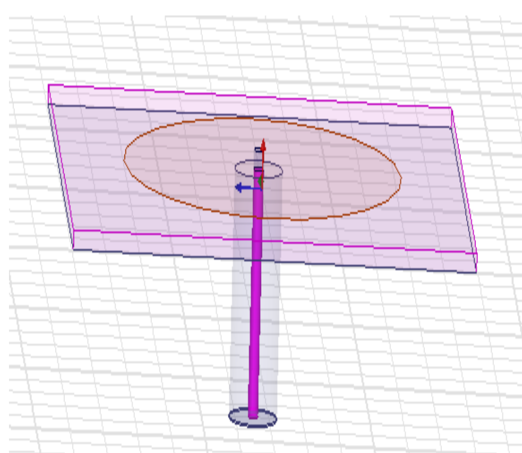

Fig. 2. Coaxial feed

C. Aperture Coupled/ Slot Coupled feed:

This novel feeding technique involves shielding of the feed network from the patch by a conducting plane. For coupling energy from the feed to the antenna, a slot or aperture is made on the conducting plane. Two types of substrates can be used: usually upper substrate with lower permittivity and lower substrate with higher permittivity. Thus both substrates can be chosen independently to optimize the radiation characteristics [2].

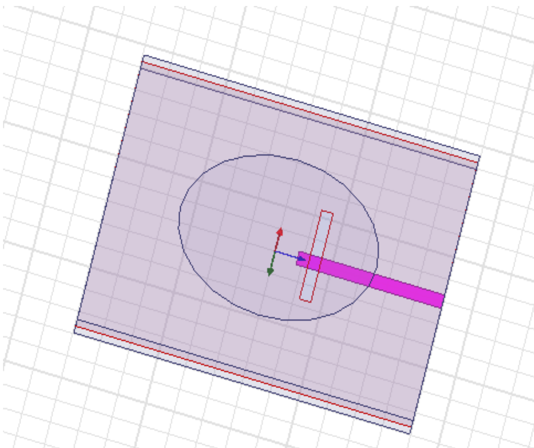

Fig. 3. Aperture coupled feed

D. Proximity Coupled feed:

This is an indirect feeding technique in which there is no direct contact between the feed network and the antenna. Two different substrates are used. The feed network lies between the two substrates, with the patch on top and ground at the bottom. Due to two substrates, the overall thickness of patch increases, thus increasing the bandwidth and also eliminates spurious feed radiation.

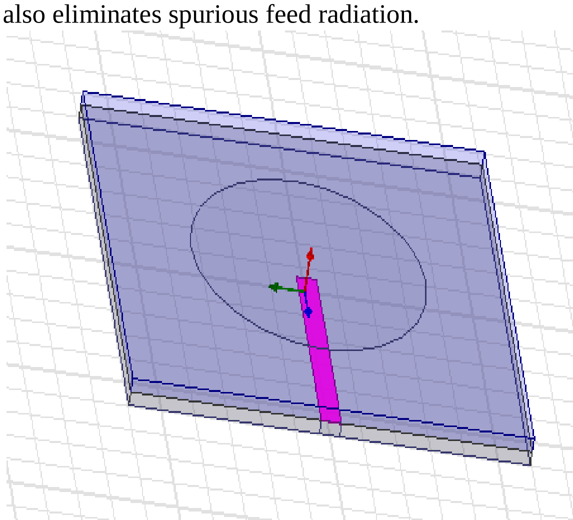

Fig. 4. Proximity coupled feed

III. ANTENNA DESIGN:

The most commonly used patch shapes are circular and rectangular. In addition, several shapes like triangle, hexagon, and ellipse are also used. The consideration of circular patch offers several advantages. Rectangular patch has two degrees of freedom, while circular has single degree of freedom [3]. Thus it is more convenient to control the radiation characteristics. Also the size reduces by 16% by using circular configuration, as compared to rectangular [4].

The radius of circular patch is given by

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

Where,

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}}$$

The above equation ignores the fringing effect, which makes the patch electrically larger. Thus the effective radius has to be considered which is given by [5]:

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

For the circular patch antenna with FR4 substrate (ε_r =4.4) and thickness h=1.6mm, to radiate at f_r = 2.4 GHz, the effective radius is calculated as a_e =17.47mm.

IV. SIMULATION:

The simulation of patch antenna is done using HFSS (High Frequency Structural Simulator) version 14.0. It uses finite element method (FEM) for solving electromagnetic structures and design of antennas, RF electronic circuit elements such as filters and transmission lines.

V. RESULTS AND ANALYSIS:

A. Inset fed patch:

The circular patch with 17.47mm radius is found to resonate at 2.43 GHz. An overall gain of 3dB is observed.

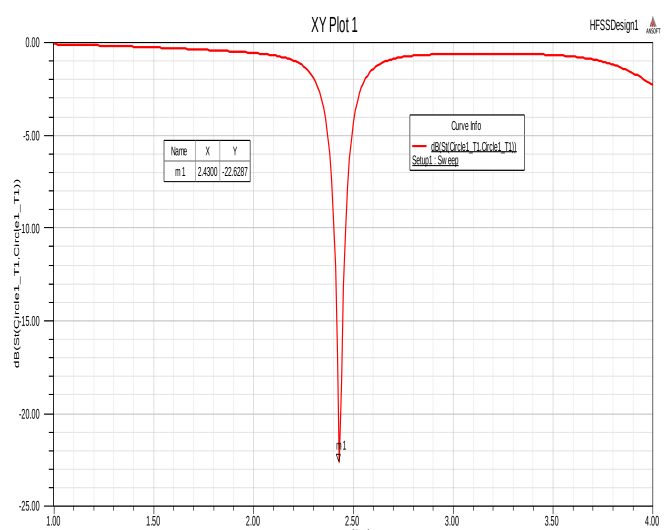

Fig. 5. Return loss

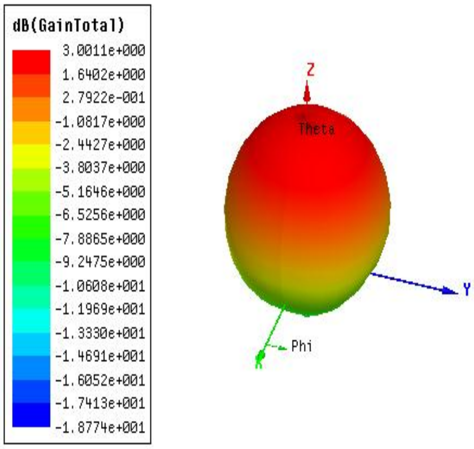

Fig. 6. Radiation pattern

B. Coaxial probe fed patch:

The patch radiates at 2.38 GHz with a total gain of 3.6 dB. The feed position is varied to achieve impedance matching.

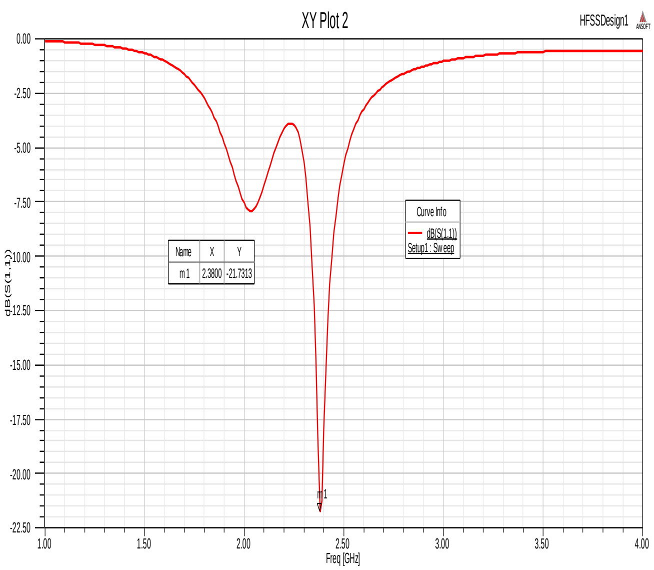

Fig. 7. Return loss

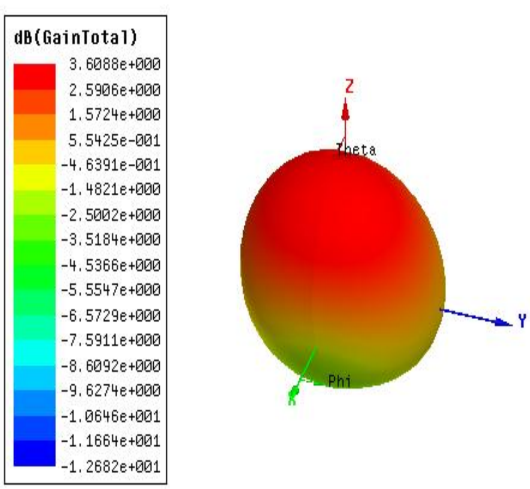

Fig. 8. Radiation pattern

C. Aperture coupled fed patch:

The upper substrate is polystyrene with a dielectric constant ε_r =2.6 and the lower substrate is FR-4 with ε_r =4.4. The slot in the ground plane has dimension 20x2. The patch radiates at 2.42 GHz with a gain of 4.95 dB.

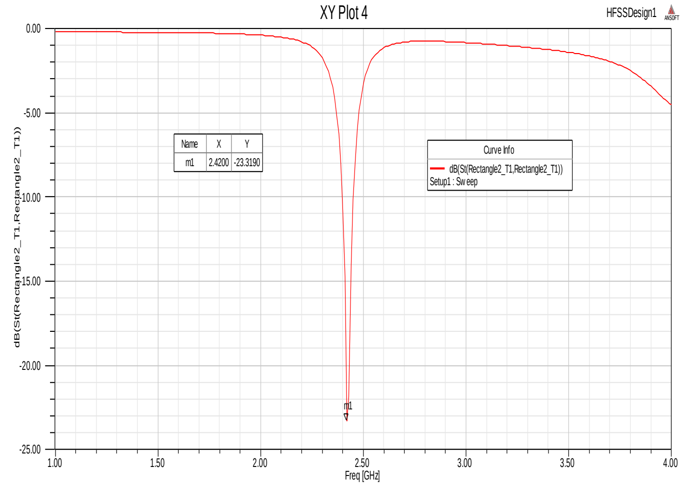

Fig. 9. Return loss

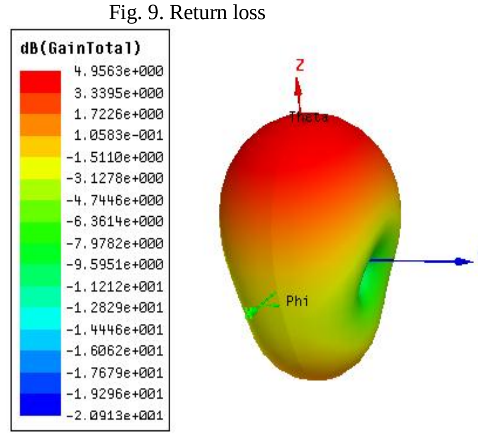

Fig. 10. Radiation pattern

D. Proximity coupled fed patch:

The upper substrate is Rogers RO4350 (ε_r =3.66) and lower substrate is FR-4 epoxy (ε_r =4.4). The antenna resonates at 2.4 GHz with a gain of 5.74dB.

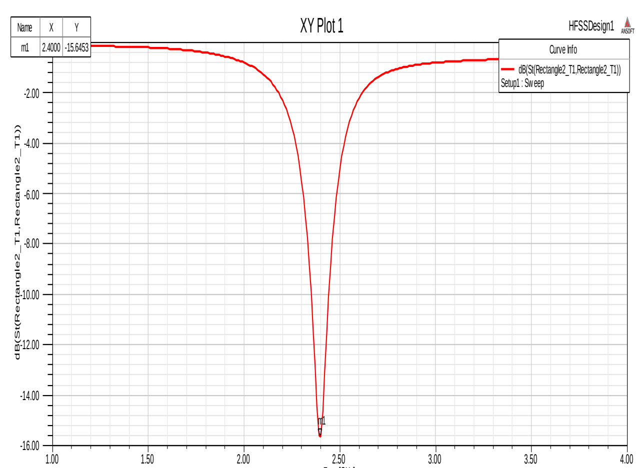

Fig. 11. Return loss

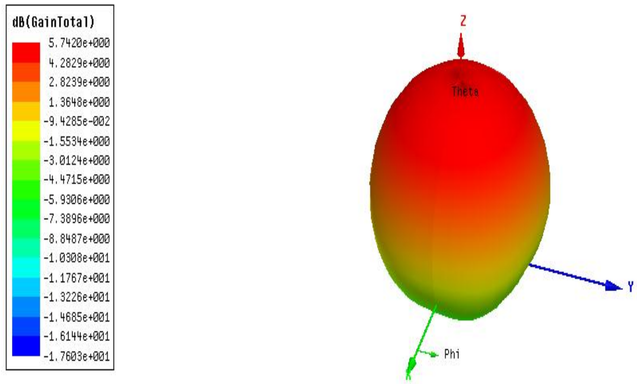

Fig. 12. Radiation pattern

Based on the above results, a comparison can be made on the performance of circular patch antennas with various types of feeds.

TABLE 1: COMPARISON OF FEEDING TECHNIQUES

Feed type	Gain (dB)	% BW	Radiation Efficiency
Inset	3	2.47	0.450
Coax Probe	3.6	4.20	0.792
Slot Coupled	4.95	2.19	0.864
Proximity	5.74	3.75	0.788

VI. CONCLUSIONS:

The above results indicate that the less commonly used feeding techniques such as aperture coupled feed and proximity coupled feeding are more efficient in terms of gain and radiation efficiency when compared to inset and coaxial probe feeds. The substrates in these feeding techniques can be chosen depending on the desired characteristics.

REFERENCES:

[1] "Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays" edited by David M. Pozar, Daniel H. Schaubert

[2] "Analysis of an aperture coupled microstrip antenna" IEEE Sullivan, P. ; Bell Labs., North Andover, MA; Schaubert, D.H.

[3] Md. Tanvir Ishtaique-ul Huque, Md. Al-Amin Chowdhury , Md. Kamal Hosain , Md. Shah Alam, "Performance Analysis of Corporate Feed Rectangular Patch Element and Circular Patch Element 4x2 Microstrip Array Antennas", International Journal of Advanced Computer Science and Applications, Vol. 2, No. 7, 2011.

[4] R. Garg, P. Bhartia, I. Bahl, A. Ittipiboon, Microstrip Antenna Design Handbook (Artech House inc., 2001

[5] Antenna theory: analysis and design, by Constantine A. Balanis

[6] David M. Pozar and Susanne M. Voda," A Rigorous Analysis of a Microstrip line Fed Patch Antenna", IEEE Transactions on Antennas and Propagation, vol. 35, no. 12, December 1987, pp. 1343-1350.

[7] Jing Liang and H.Y. David Yang," Analysis of a Proximity Coupled Patch Antenna on a Metalized Substrate" Antennas and Propagation Society International Symposium, IEEE, July 2006, pp. 2287-2290.

[8] P.J.Soh, M.K.A.Rahim, A.Asrokin, M.Z.A.Abdul Aziz, "Design, modeling and performance comparison of different feeding techniques for a microstrip patch antenna", Journal technology in university technology Malaysia, 47(D) Dis.2007 103-120.

[9] N. Herscovici. 1998. New considerations in the design of microstrip antennas. IEEE Transactions on Antennas and Propagation, AP-46, 6 (Jun. 1998), 807-812.

[10] Sekhar M, Siddaiah P "Performance of feed on dual frequency antenna in Ka band" IJIREEICE.

BIOGRAPHIES:

Y. Laxmi Lavanya obtained B.Tech degree in Electronics and Communication Engineering from MVGR College of Engineering, Vizianagaram in 2013. She is M.Tech (ECE) student at Acharya Nagarjuna University College of Engineering and technology, Guntur, India. Her areas of interest are Antenna and Wave Propagation, Antenna designing, Microwave and Radar.

K. Suresh obtained B.Tech degree in Electronics and Communication Engineering from Swarnanadhra College of Engineering & Technology in 2012. He is M.Tech (ECE) student at Acharya Nagarjuna University College of Engineering and Technology, Guntur, India. His areas of interest are Antenna designing, Image and Video 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.