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Bandwidth enhancement of Circular Microstrip patch antenna using different feeding techniques

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ABSTRACT— *This paper describes the performance analysis of coaxial feed and proximity coupled feeding techniques for X band microstrip patch antenna i.e for satellite communication, millitary applications etc. In this paper two types of feeding techniques (coaxial probe feed, proximity coupled feed) are used. From the two feeding techniques, coaxial probe feed is a contacting scheme, in which RF power is fed directly to the radiating patch using a connecting element whereas proximity coupled feed is a non-contacting schemes, in which electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. This paper describes the two feeding techniques and gives a better understanding of design parameters of an antenna (especially with respect to varying dielectric constant and height of the substrate) and their effect on return losses, bandwidth, VSWR and resonant frequency(9.86Ghz). Finally simulation is done using design software HFSS. Analysis of the results proved that proximity coupled feed gives a 16.39% increase in the bandwidth when compared to coaxial probe feed.*

KEYWORDS— *Microstrip patch antenna, coaxial probe feed, proximity coupled feed, return loss, bandwidth, VSWR, resonant frequency, HFSS*

I. INTRODUCTION

Modern wireless communication system requires low profile, light weight, high gain, and simple structure antennas to assure reliability, mobility, and high efficiency characteristics. Microstrip antenna satisfies such requirements. The key features of a microstrip antenna are relative ease of construction, light weight, low cost and either conformability to the mounting surface or, an extremely thin protrusion from the surface. This antenna provides all of the advantages of printed circuit technology. These advantages of microstrip antennas make them popular in many wireless communication applications such as satellite communication, radar, medical applications, etc. The limitations of microstrip antennas are narrow frequency band and disability to operate at high power levels of waveguide, coaxial line or even stripline. Therefore, the challenge in microstrip antenna design is to increase the bandwidth and gain.

The choosing of design parameters (dielectric material, height and frequency, etc) is important because antenna performance depends on these parameters. Radiation performance can be improved by using proper design structures. The use of high permittivity substrates can miniaturize microstrip antenna size. Thick substrates with lower range of dielectric offer better efficiency, and wide bandwidth but it requires larger element size. The distribution of voltages among the elements of an array depends on feeding network[1]. Suitable feeding network accumulates all of the induced voltages to feed into one point. The proper impedance matching provides high efficiency microstrip antenna[2]. Different radar systems such as synthetic aperture radar(SAR), shuttle imaging radar, remote sensing radars, and other wireless communication systems operate in L, C and X bands. Microstrip antenna is the first option for this high frequency band such as X-band due to its low cost, light weight, and robustness. These designed antennas are potential candidate for the X-band wireless applications due to the simplicity in structure, ease of fabrication and high gain and high efficiency[3,4]organization. This paper organized into four sections, Section I Antenna design, Section II Feeding techniques, Section III The design in HFSS and Section IV Conclusion.

II. ANTENNA DESIGN

Circular microstrip antennas basically consist of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side. The patch is generally made of conducting material such as copper and gold. The patch is very thin ($t \ll \lambda_o$ where λ_o is free space wavelength) and is placed a small fraction of a wavelength ($h \ll \lambda_o$ usually $0.003\ \lambda_o \leq h \leq 0.05\ \lambda_o$) above the ground plane.

The geometry of a circular microstrip patch antenna is shown in Figure 1. The antenna under investigation the diameter (D) of circular patch is 76mm for FR4_epoxy with center frequency as 9.86GHz , for a thickness of 1.6mm. Dielectric substrate of appropriate thickness and loss tangent is chosen for designing the circular patch microstrip patch antenna. A thicker substrate is mechanically strong with improved impedance bandwidth and gain. Besides these advantages it increases weight and introduces surface wave losses. The dielectric constant plays an important role similar to that of the thickness of the substrate[5].

FR-4 or (FR4) is a grade designation assigned to glass-reinforced epoxy laminate sheets, tubes, rods and printed circuit boards (PCB). FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant (*self-extinguishing*). FR-4 glass epoxy is a popular and versatile high-pressure thermo set plastic laminate grade with good strength to weight ratios. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength[6].

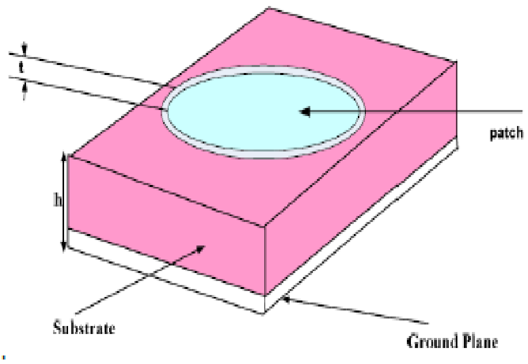

Figure 1 Structure of circular patch antenna

A. Circular Patch Radius and Effective Radius

Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by (Balanis, 1982)

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

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

The above equation for the radius of circular patch does not take into consideration the fringing effect. Since fringing makes the patch electrically larger, the effective radius of patch is used and is given by (Balanis, 1982)

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

Hence, the resonant frequency for the dominant TMz110 is given by (Balanis, 1982)

$$(f_r)_{110} = \frac{1.8412 v_0}{2\pi a_e \sqrt{\varepsilon_r}}$$

where v0 is the free space speed of light[7].

III. FEEDING TECHNIQUES

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The two popular feeding techniques used are the coaxial probe (contacting scheme) and proximity coupling (non-contacting scheme).

A. Coaxial Probe Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance.

However, its major drawback is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus making it completely planar only for thin substrates. Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. So to reduce these types of disadvantages, we will go for non-contacting schemes[8].

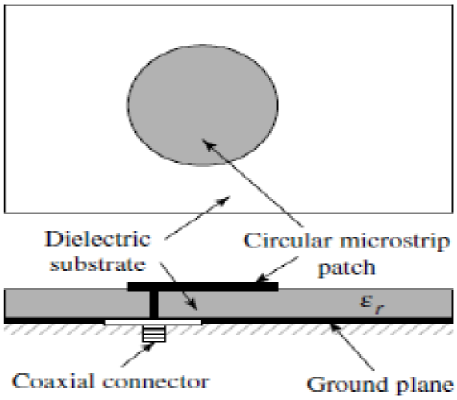

Figure 2 Coaxial probe Feed

B. Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%) due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances. This method is advantageous to reduce harmonic radiation of microstrip patch antenna implemented in a multilayer substrate[9].

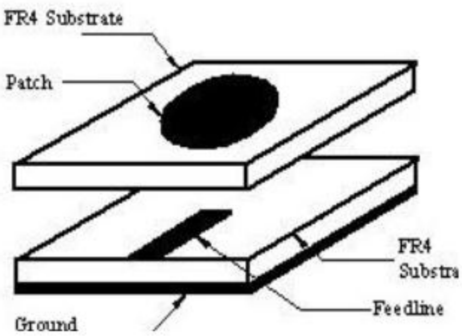

Figure 3 Proximity coupled Feed

IV. DESIGNING

A. Coaxial Probe Feed

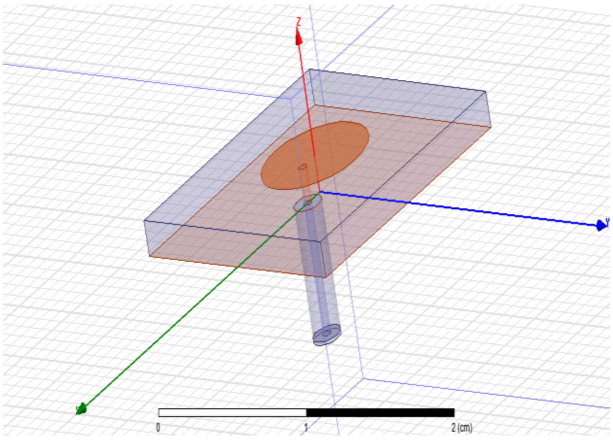

Figure 4 Design using Coaxial Feed

Observation from return loss at or below -10dB as shown in figure 5.
1. Resonant frequency=9.86GHz at -17.39dB
2. Bandwidth= f2 - f1= 10.17 - 9.57= 0.6GHz = 600MHz

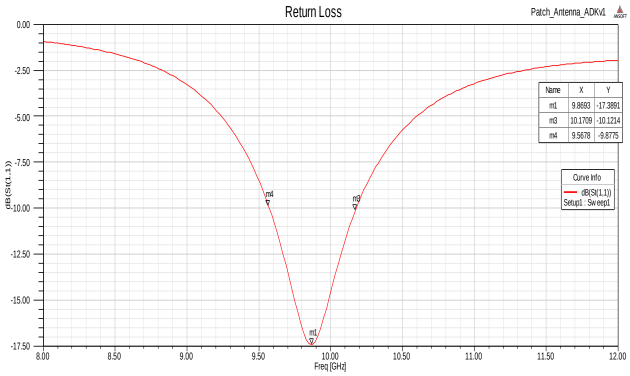

Figure5 Return loss plot using Coaxial Feed

Observation of VSWR (1.31) of Coaxial feed as shown in figure 6

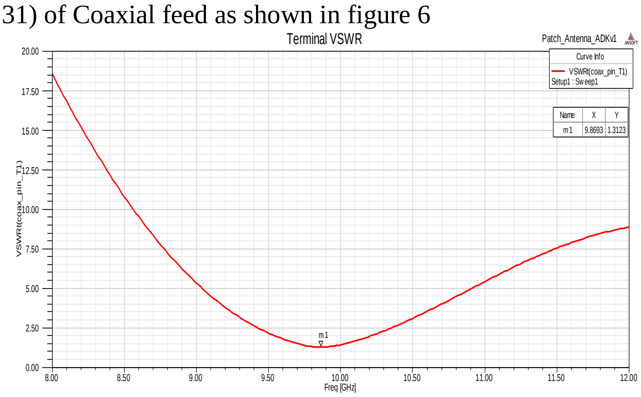

Figure6 VSWR plot using Coaxial Feed

B. Proximity Coupled Feed

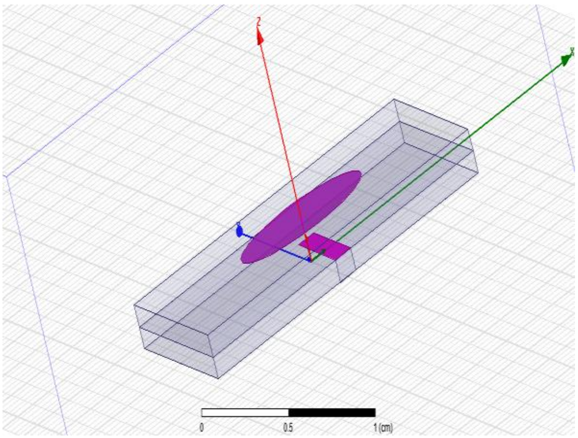

Figure 7 Design using Proximity Coupled Feed

Observation from return loss at or below -10dB as shown in figure 8 .
1.Resonant frequency=9.86 GHz at -38.49dB
2.Bandwidth= f2 - f1= 10.21 - 9.51=0.7GHz=700MHz

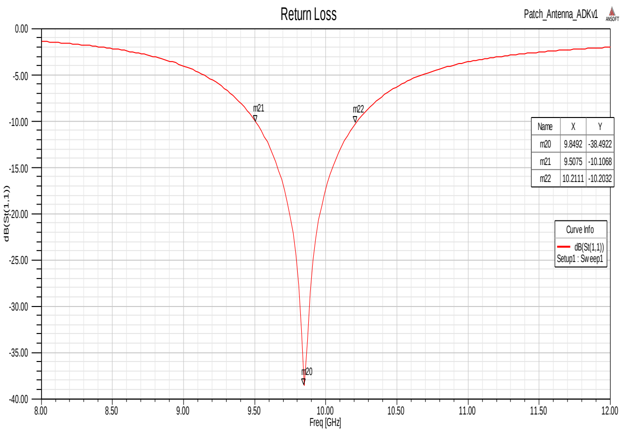

Figure 8 Return loss plot using Proximity Coupled Feed

Observation of VSWR (1.04) of Coaxial feed as shown in figure 9

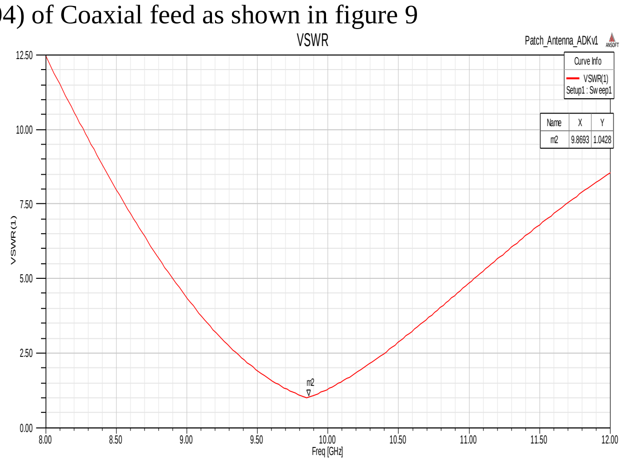

Figure 9 VSWR plot using Proximity Coupled Feed

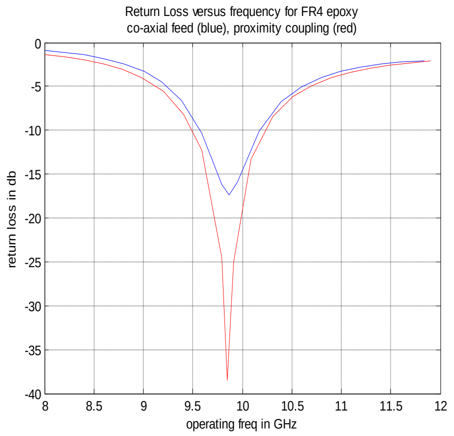

Figure10 Combined return loss differentiating two feeding techniques

To calculate the bandwidth increase

For coaxial probe:

$$\frac{10.17 - 9.57}{9.86} = 0.061 \Rightarrow 0.061 \times 100 = 6.1\%$$

For proximity coupled feed

$$\frac{10.21 - 9.51}{9.86} = 0.071 \Rightarrow 0.071 \times 100 = 7.1\%$$

$$\frac{(0.071 - 0.061) \times 100}{0.061} = 16.39\% \text{ increase in bandwidth.}$$

V. CONCLUSION

Finally, the optimum result of the two feeding techniques of circular patch antenna on FR4_epoxy substrate for X band applications has been investigated. A comparison is made between feeding techniques in terms of bandwidth, return loss and VSWR. So, we can see that selection of the feeding technique for a microstrip patch antenna is an important decision because it affects the bandwidth and other parameters also. A microstrip patch antenna excited by different excitation techniques gives different bandwidth, different efficiency etc.

Proximity coupling gives the best impedance matching and radiation efficiency. Coaxial feeding technique gives the least bandwidth. A 16.39% increase in bandwidth was obtained when proximity coupled feed was used in comparison with coaxial probe feed. We can also conclude that by changing the feed point where matching is perfect, the high return loss can be achieved at the resonant frequency. The various parameters like return loss, VSWR are plotted for each antenna. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required frequency band (X band).

REFERENCES

[1] Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters for X-band Applications in (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 2, o. 4, 2011

[2] BANDWIDTH IMPROVEMENT OF MICROSTRIP ANTENNA ARRAY USING DUMMY EBG PATTERN ON FEEDLINE in Progress In Electromagnetics Research, Vol. 127, 79–92, 2012.

[3] Active Microstrip Antennas Operating in X Band in PIERS ONLINE, VOL. 7, NO. 3, 2011

[4] M. F. Islam, et al., "Dual band microstrip patch antenna for SAR applications," Australian Journal of Basic and Applied Sciences, vol. 4, pp. 4585-4591, 2010.

[5] Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters for X-band Applications in (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 2, o. 4, 2011

[6] Analysis of Five Different Dielectric Substrates on Microstrip Patch Antenna in International Journal of Computer Applications (0975 – 8887) Volume 55– No.14, October 2012

[7] THE CIRCULAR MICROSTRIP PATCH ANTENNA – DESIGN AND IMPLEMENTATION in IJRRAS 8 (1) ● July 2011 www.arpapress.com/Volumes/Vol8Issue1/IJRRAS_8_1_11.pdf

[8] RECTANGULAR AND CIRCULAR ANTENNA DESIGN ON THICK SUBSTRATE in JOURNAL OF TELECOMMUNICATIONS, VOLUME 2, ISSUE 2, MAY 2010

[9] Design and Simulation of Nanotechnology based Proximity Coupled Patch Antenna at X-Band in International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 9, September 2013