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Different Type Feeding for Metamaterial Microstrip Patch Antenna Promising Future of Communication

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***Abstract*: A Microstrip Patch Antenna is a type of radio antenna with a low profile, which can be mounted on a flat surface. It is a narrowband, wide-beam fed antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate such as a printed circuit board with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. it is a antenna with the properties like high gain, planar & directivity & increased bandwidth when integrated with "so called metamaterials". This antenna provides conformable antenna structures which is suitable for integration with monolithic microwave integrated circuits (MMIC). In this paper, a comparative study between inset feed, microstrip feed and co-axial feed, on a rectangular microstrip patch antenna are done on the basis of S-parameter, Reflection gain, VSWR and Radiation Pattern using Hyperlynx 3D EM software.**

***Keywords*: EM: Electro Magnetic, MIC: Microwave Integrated Circuit, MMICs: Monolithic Microwave Integrated Circuits, MMs: Metamaterial, MTMs: Metamaterial, RF: Radio Frequency, RL: Return Loss, SWR: Standing Wave Ratio, VSWR: Voltage Standing Wave Ratio, WLAN: Wireless Local Area Network, ZIM: Zero Index Material, SRRs: Split Ring Resonators, S-parameter, Hyperlynx 3D.**

1. Introduction

Wireless communication and Satellite communication has been enhanced rapidly in the past decades and it has already a dramatic impact on human life. In the last few years, the development of wireless local area networks (WLAN) represented one of the principal interests in the information and communication field. This antenna has drawn the attention of researchers over the past work because of their many attractive features. The microstrip patch structures are relatively easy to manufacture and have turned microstrip analysis into an extensive research problem. Research on microstrip antenna in the 21st century aimed at size reduction, increasing gain, wide bandwidth, multiple functionality and system-level integration [3],[4]. Microstrip Patch Antenna consists of a conducting rectangular patch of width "W" and length "L" on one side of dielectric substrate of thickness "h" and dielectric constant "εr". Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible.

There are several techniques available to feed or transmit electromagnetic energy to a microstrip patch antenna. The role of feeding is very important in case of efficient operation of antenna to improve the antenna input impedance matching. The feeding techniques used in the microstrip antenna are divided into two important classes as given below:-

- *Contacting Feed:* In this method, the patch is directly fed with RF power using the contacting element such as microstrip line or coaxial line. The most commonly used contacting fed methods are Microstrip Feed and Co-Axial Feed.
- *Non-Contacting Feed:* In this method, the patch is not directly fed with the RF power but instead power is transferred to the path from the feed line through electromagnetic coupling. The most commonly used non contacting feed methods are Aperture Coupled feed and Proximity Coupled Feed.

2. Feeding techniques

The role of feeding is very important in case of efficient operation of antenna to improve the antenna input impedance matching [7]. The various types of feeding techniques are:

A. *Microstrip line Feed*

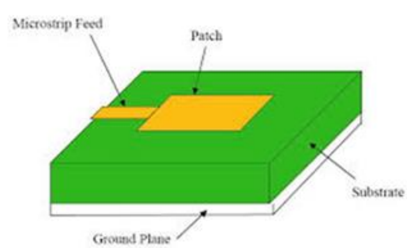

Fig. 1. Microstrip line feed

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure [8].

B. Inset Feed

In is a type of microstrip line feeding technique, in which the width of conducting strip is small as compared to the patch and has the advantage that the feed can provide a planar structure. [2] The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch input impedance without the need for any additional matching element. This can be achieved by properly adjusting the inset cut position and dimensions. [6]

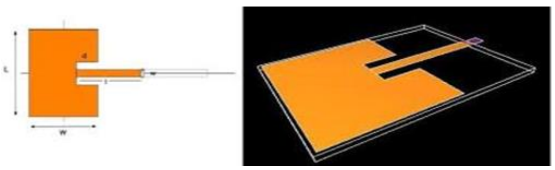

Fig. 2. Rectangular Microstrip patch antenna with an Inset feeding

C. Co-axial Feed

The Coaxial probe feeding is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial cable extends through the dielectric and is soldered to the radiating metal patch, while the outer conductor is connected to the ground plane. The advantage of this feeding scheme is that the feed can be placed at any desired location on the patch in order to match cable impedance with the antenna input impedance [5]. The main aim to use probe feeding is it enhances the gain, provides narrow bandwidth and impedance matching [6].

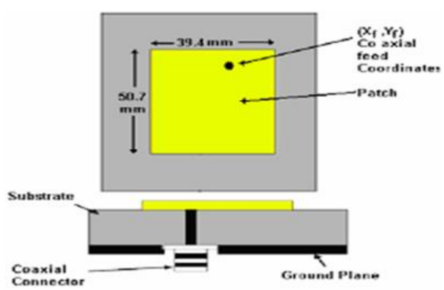

Fig. 3. Rectangular Microstrip patch antenna with a Coaxial feeding

D. Aperture coupled Feed

In aperture coupling the radiating microstrip patch element is etched on the top of the antenna substrate, and the microstrip feed line is etched on the bottom of the feed substrate in order to obtain aperture coupling. The thickness and dielectric constants of these two substrates may thus be chosen independently to optimize the distinct electrical functions of radiation and circuitry. The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized

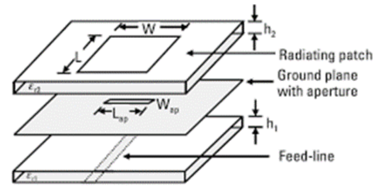

Fig. 4. Rectangular Microstrip patch antenna with an Aperture feeding

E. Proximity coupled feeding

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.

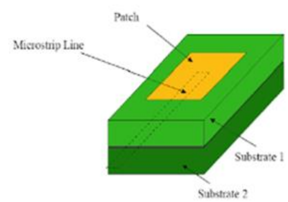

Fig. 5. Rectangular microstrip patch antenna with a Proximity Coupled feeding

3. Design equations

The equations involved in calculating the values of the above mentioned design parameters are:

- $\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[\frac{1}{\sqrt{[1+12\left(\frac{h}{W}\right)]}}\right]$
- $\Delta L = 0.412\text{h}\frac{(\varepsilon r+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+8\right)}$
- $\text{L} = \frac{1}{2f_r\sqrt{\varepsilon_{eff}}\ \sqrt{\mu o\ \varepsilon o}} - 2\Delta\text{L}$
- $\text{W} = \frac{\lambda o}{2}\left(\frac{\varepsilon_r+1}{2}\right)^{-\frac{1}{2}}$
- $L_{eff} = \text{L}+2\Delta\text{L}$

4. Design parameter

Table 1
Design parameters

S.No	Parameter Name	Designed Values
1.	Dielectric Constant, ε_r	4.4
2.	Resonant Frequency, f_r	1.9 GHz
3.	Loss Tangent	0.001
4.	Patch Length, L	37.20mm
5.	Patch Width, W	48.05mm
6.	Substrate Height, h	2.0mm
7.	Feed Width, w	4.178mm
8.	Feed line Length, FL	18.819mm
9.	Inset Depth, d	11.7284mm
10.	Inset feed Length, l	35.7534mm
11.	Co-axial X-coordinate,x	9.199
12.	Co-axial Y-coordinate,y	12.0125

These are the design parameters which we used in designing the microstrip patch antenna with the three different feed techniques.

5. Simulated result

A. S- Parameter

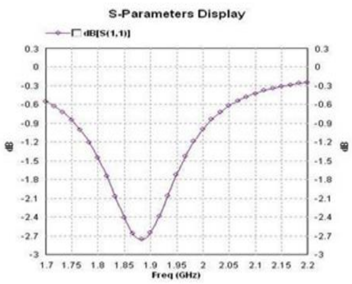

Fig. 6. S-parameter for Microstrip line Feed at S(1,1)

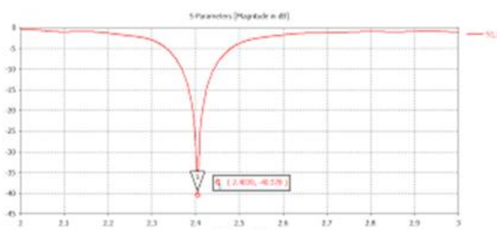

Fig. 7. S-parameter for Inset Feed at S(1,1)

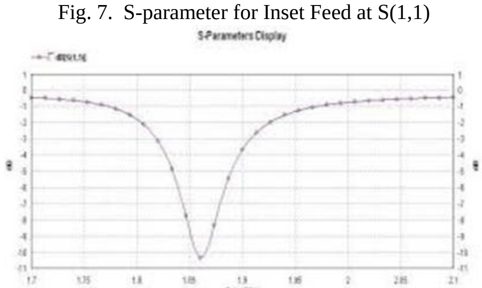

Fig. 8. S-parameter for Co-Axial Feed

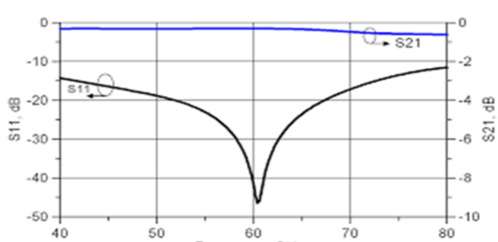

Fig. 9. S-parameter for Co-axial Feed

B. VSWR

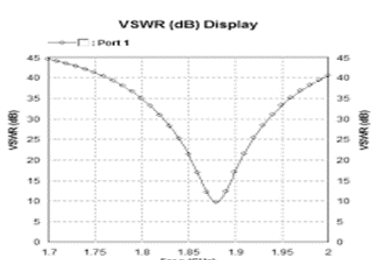

Fig. 10. VSWR for Microstrip line Feed

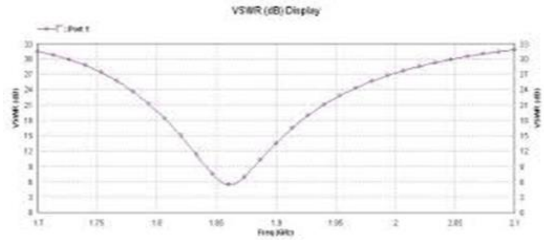

Fig. 11. VSWR for Inset Feed

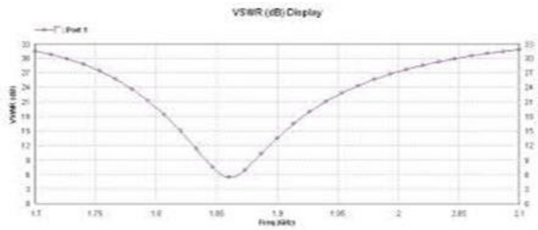

Fig. 12. VSWR for Co-axial Feed

C. Radiation pattern

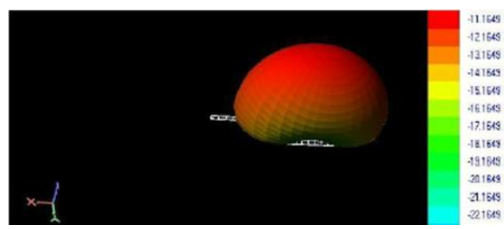

Fig. 13. Radiation pattern for Microstrip line Feed

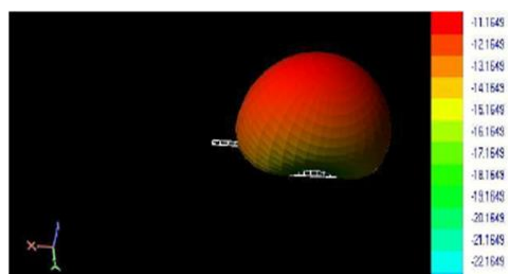

Fig. 14. Radiation pattern for Inset Feed

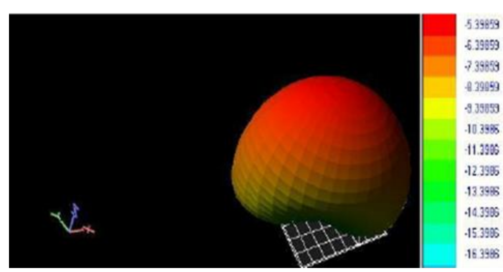

Fig. 15. Radiation pattern for Co-axial Feed

6. Conclusion

In this paper, a comparative study between different feeding techniques for a Rectangular Microstrip Patch Antenna is done. The microstrip line feeding, inset feeding and coaxial probe feeding are compared on the basis of the Radiation Pattern, VSWR, Reflection gain and S parameter. The simulation of the

Microstrip Patch Antenna for the three feeding techniques is performed on Hyperlynx 3D EM software. The comparison of feeding techniques shows that the Rectangular Microstrip Patch Antenna with the Inset Feed has the highest gain, lowest VSWR return loss for the dielectric material FR4 at a specific frequency of 1.9GHz. Thus it states that inset feed provides better impedance matching than the co-axial feed and microstrip line feed.

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