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Design Analysis of Different Types of Feed to Microstrip Patch Antenna

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Abstract-* Antennas are one of the most significant component of RF microwave communication system. Microstrip patch antennas are widely used for this purpose. Having compact size with good characteristics are the prime advantage of microstrip patch antenna. Limitation with this patch antenna is also significant in terms of bandwidth. This paper presents different feeding analysis for patch antenna such as inset feed, transmission line feed, coaxial feed and aperture coupled feed.A microstrip patch antenna is designed and simulated at 2.4 GHz with the help of ANSYS HFSS simulation software. For the proposed antenna inset feed and coaxial feed are used .Return loss of -23.01 dB,-19.6 dB and antenna gain of 7.67dB, 7.69 dB are observed for inset feed and coaxial feed respectively.

***Index Terms-* aperture coupled, coaxial fed, inset fed, microstrip antenna.**

I. INTRODUCTION

With the growing technology, especially in communication system compactness of device with flexible integrated approach to other devices are in demand. A communication system can't be imagined without using antenna. Antenna is a device to transmit and receive the signal. Compactness with good characteristics are prime design issue for the researchers. The overall size of any RF device depends on the size of antenna. Striplines, Microstrip technology bring a significant change in communication system [1]. They are very compact with compared to their traditional microwave antennas such as horn antenna parabolic, reflector etc. In 1937 stripline concept was proposed by Robert M. Barett. After that in 1953 microstrip concept was initiated by Deschamps [2]. In stripline, a strip is inserted in a dielectric material. The dielectric material is coated both side.Microstrip structure is simpler than the strip line as a top layer is removed in strip line. The basic structure of microstrip patch antenna (MPA) is shown in fig. 1 which consists of a wider ground plane and other conducting sheet(patch) is placed on the top of dielectric (with permittivity ε_r & height h) [3]. This patch is excited by giving different feeding methods. When the excitation is given to the patch, radiation would occur and transmitted into the air [4]. Usually a simple patch antenna have half wavelength long patch size with a very large ground plane [5]. This type of patch antenna radiate a linearly polarize wave. The one of the main limitation with microstrip patch antenna is its bandwidth. A thick substrate to enhance the bandwidth but it provide more losses due to of surface waves. This is the art of antenna designing to get higher bandwidth good characteristics and maintaining its small size.

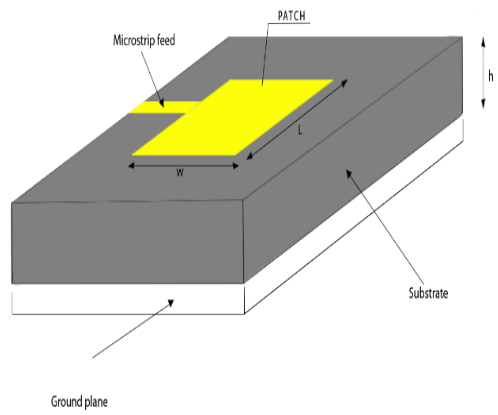


Figure 1. General structure of microstrip patch antenna (MPA)

Fringing field has a major role in the working of a microstrip antenna. The fringing field occurs between the periphery of the patch and the ground plane and is responsible for radiation. Fringing field is a function of the height of the substrate and the dimensions of the patch [6]. The fringing effect due to the edges of the patch of MPA is shown in the fig. 2.For MPA to give an effective radiation the structure should behave as a half wave resonator.

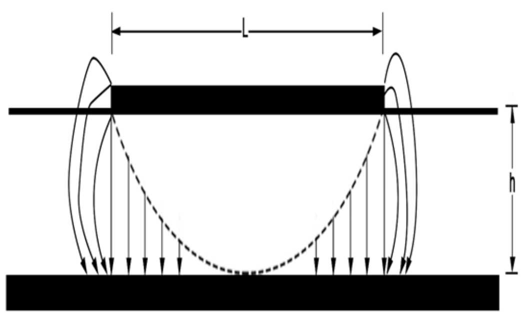


Figure 2. Fringing effect in MPA

II. FEEDING METHODS

To excite the antenna feeding is required. It can be done by direct contact or indirect contact. There are different methods to excite the MPA by using feeding lines [7]. In general four methods are extensively used for feeding purpose which are shown below in the figure.3 [8].

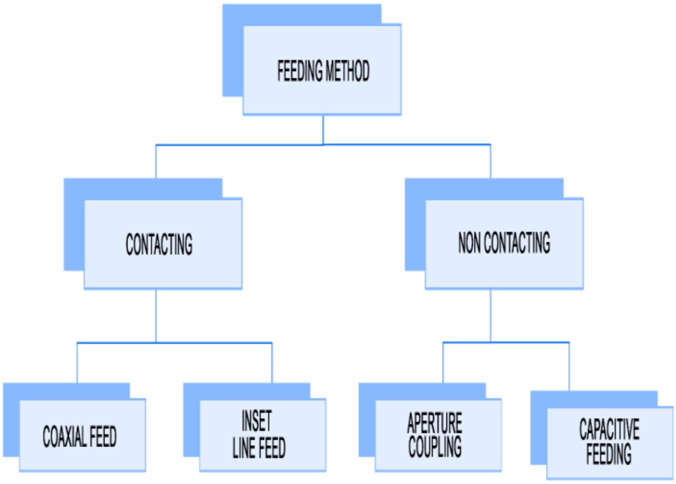


Figure. 3 Classification of feeding techniques

A. Aperture coupled feed

This is a non-contacting type of feeding method. The radiation of the patch is isolated from the feed line radiation. The basic design of microstrip patch antenna with this type of feed requires the two dielectric as shown in figure 4. The substrate whose thickness can be altered and optimized for different frequencies. The advantage of this antenna is that it has low spurious radiations, a better bandwidth and interference. Usually a lower dielectric constant material is used for upper substrate and a comparatively higher dielectric material for lower substrate to optimize radiations from the patch [9].

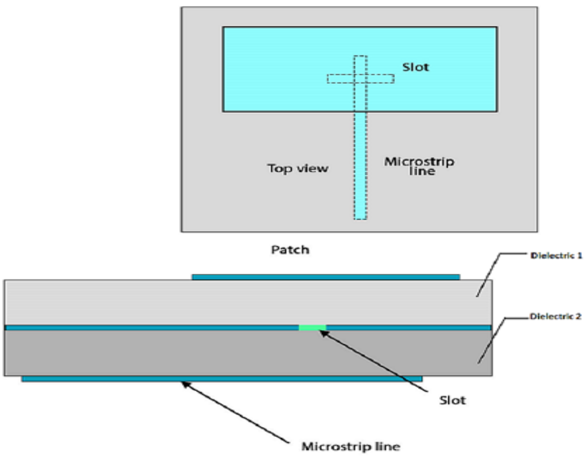


Figure.4 Aperture Coupled feed

B. Inset fed microstrip antenna

Figure 5 shows how inset feed is applied and Impedance of antenna must match with a 50 ohm source line. For this matching different types of matching techniques are available such as quarter wave transformer, triangular taper line etc. With the use of inset feed technique we can maintain the planarity the microstrip patch antenna. The variation in the input antenna impedance can be understood by the cosine square law [10].

$$\text{Zin} = \text{Zacos}^2 \frac{\pi y}{L}$$

Where Za is the input impedance of the antenna, y length of inset and L is length of the patch varying according to the position of the feed [8].

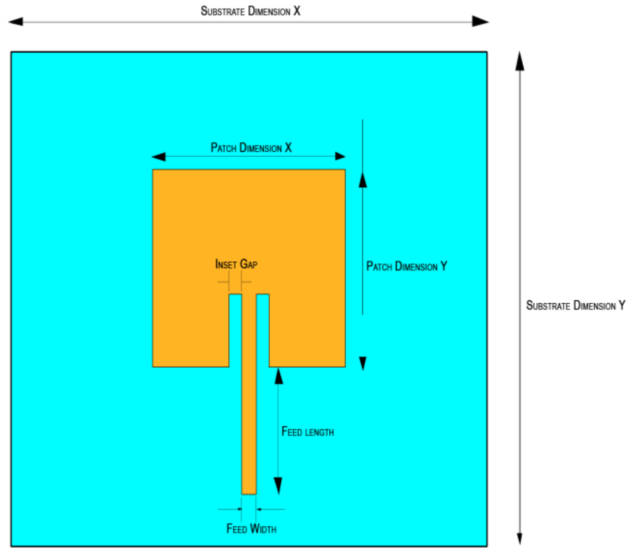


Figure 5 Inset fed Antenna

C. Coaxial fed microstrip antenna

This is one of the most popular and widely used feeding techniques in microstrip patch antenna [11]-[15] reported coaxial feed for MPA. The feed can be placed at any suitable position in the patch to match the input impedance. The inner conductor of the coaxial is connected to the patch passing through the substrate from the ground as shown in the fig.6. This type of feed technique has low spurious radiation. A disadvantage of coax feed is its fabrication process in which a hole has to be drilled into the substrate Likewise the radiation from the probe should also be taken into consideration as it may lead to unwanted results [16].

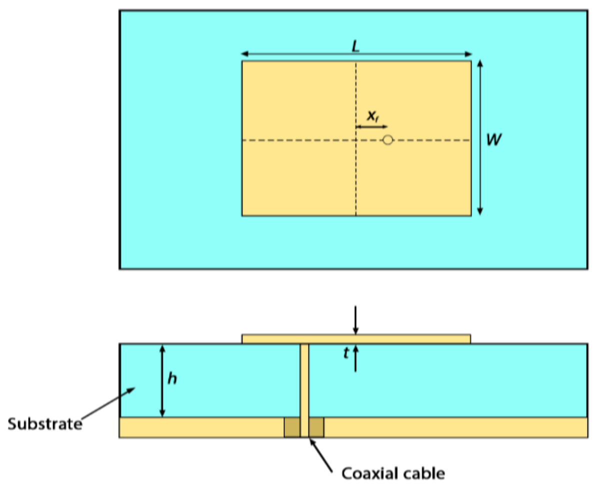


Figure. 6 Coaxial feeding technique

Table .I Comparison of feeding techniques.

	Microstrip Line Feed	Coaxial fed	Aperture Coupled feed	Proximity coupled Feed
Spurious Feed Radiation	More	More	Less	Minimum
Reliability	Better	Poor due to soldering	Good	Good
Fabrication	Easy	Requires soldering and drilling	Requires Alignment	Requires Alignment
Impedance Matching	Easy	Easy	Easy	Easy
Bandwidth(with impedance matching)	2-5%	2-5%	2-5%	13%

All the above discussed types of feeding techniques are summarized in the Table I [5].

III. DESIGN & SIMULATION

A microstrip patch antenna is design and simulated using ANSYS HFSS simulation software. Dimensions of patch are calculated using equations (1)-(4) [10].

Width of the patch

$$W = \frac{c}{2 f_r \sqrt{\varepsilon_0 \mu_0}} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \quad \ldots\ldots (1)$$

Effective dielectric constant

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{1}{2}} \quad \ldots\ldots (2)$$

Effective length of the patch

$$L_{eff} = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}\sqrt{\varepsilon_0 \mu_0}} - 2\Delta L \quad \ldots\ldots (3)$$

Due to fringing extra length of patch

$$\Delta L = .412h \frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad \ldots (4)$$

The MPA is designed with Rogers RT/duroid 5880™ as substrate having loss tangent of.0009, relative permittivity of 2.2 and relative permeability of 1 with a height of 1.575 mm. The dimensions of the patch are 49.41mm×41.36 mm (X×Y).Two types of feeding techniques, (i) inset feed (ii) coaxial feed are used for excitation. The dimensions of the ground are taken 83.6mm×123.39 mm(X×Y) .The dimension of the feed length and feed gap of the inset feed can be clearly seen from the figure 7.

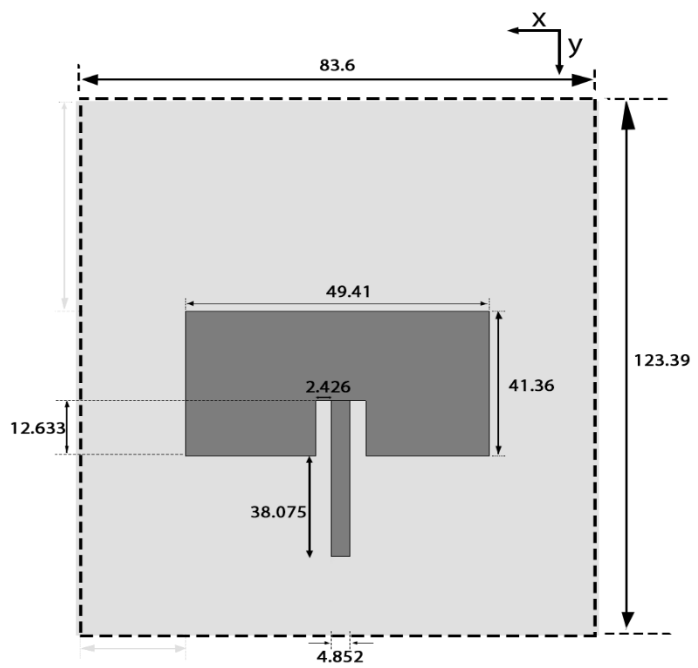


Figure.7 Inset Fed MPA with detailed dimension

IV. RESULT & CONCLUSION

The simulated return loss (RL) observations are reported in figure .8. RL of -23 dB and -19.56 dB are found for inset feed and coaxial feed respectively.

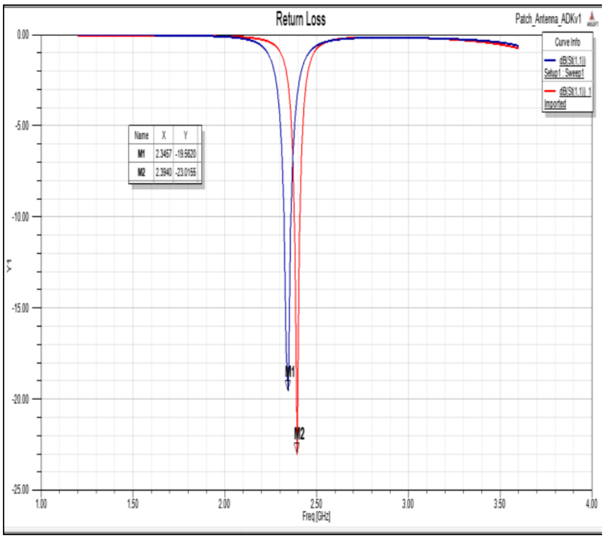


Figure. 8 Comparison of RL for Inset fed (red) and coax fed (blue)

A.VSWR (Voltage standing wave ratio)

The voltage standing wave ratio should lie within the range of 1 and 2. The figure .9 depicts the VSWR of the inset and the coax fed. From the graph the VSWR of inset fed is found to be 1.22 dB and 1.83 dB for coax feed.

B. Directivity

The directivity of the inset fed and coaxial fed are found to be 7.67 dB and 7.69 dB as shown in the figure 9.

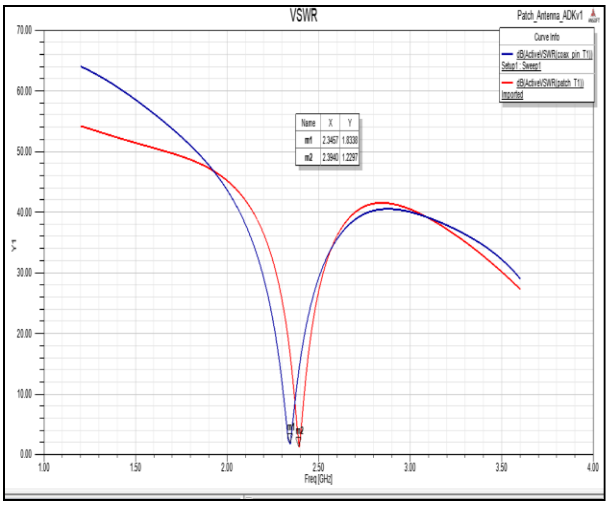
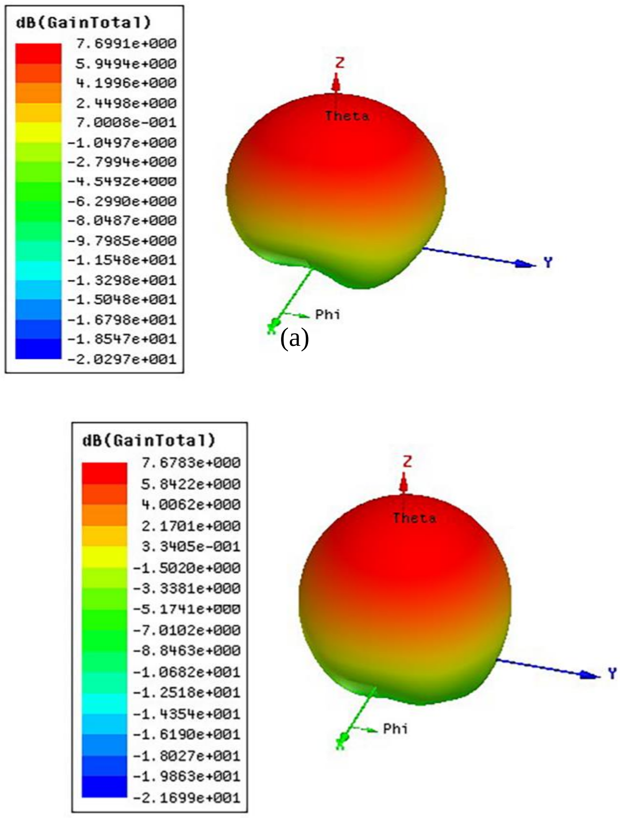


Figure 9.VSWR of Inset fed (red) and coax fed (blue)



(b)

Figure .10 Total 3D Gain (a) Inset fed (b) Coaxial fed MPA

The summary of the above shown results is tabulated in table II.

Table. II Results for Inset and Coax fed

	Inset Fed	Coaxial feeding
Return loss	-23	-19.56
Directive gain	7.67	7.69
VSWR	1.22	1.83

From the simulation result obtained for MPA; it can be concluded that for the same patch dimension and the substrate height the inset fed MPA gives us the more favorable return loss parameter.Though the values of the directive gain and the VSWR doesn't have any significant changes in both the feeds. Moreover when coaxial feed is used the resonance frequency shifted to 2.34GHz from 2.4GHz.The shifting in resonance frequency may be of the fringing fields so it is advisable to trim the length of the patch by 2-4% for the antenna to resonate at the desired frequency [5].

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