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# Design and Analysis of Microstrip Patch Antenna Using Different Feeding Techniques

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***Abstract-*** In this paper a microstrip patch antenna is designed using the different feeding techniques. Selection of feeding technique is very crucial point for an antenna design. If proper technique is not used for feeding the antenna, more power will be reflected back and reduce the power available for radiations and also affect the performance parameters like gain, return, loss and directivity of antenna. For the current paper the microstrip antenna is designed using the microstrip and coaxial feeding line. The results for both the designs are compared and analyzed. The return loss and bandwidth of probe feed antenna is -40.8 dB and 112 MHz which is higher than that transmission line feed antenna which is -27 dB and 88 MHz respectively. The gain is 7 dB and 5.74 dB for probe feed and transmission line feeding antenna respectively. The return loss, gain and bandwidth of antenna with probe feed are higher than that of transmission line feeding. But for a planar structure, probe feed is technique lose the planar characteristics of antenna.

***Keywords-*** Feeding techniques, Microstrip line patch antenna. Return loss, Gain of antenna.

## I. INTRODUCTION

An antenna is essential part of the wireless communication. But being a passive device antenna cannot radiate until it is fed by any active source like transmitter/oscillator. So for good performance an antenna should be fed properly. There are many techniques which can be used as a feeding method of antenna. Coaxial probe, microstrip line, proximity coupling and aperture coupling are mostly used feeding techniques [1]-[5]. Feeding may be classified as contacting and non-contacting. In contacting type of feeding, feed line is directly connected to the patch. Coaxial probe and microstrip line is directly connected to the patch, whereas aperture coupled and proximity coupled are not connected directly, but power is coupled to patch through a hole or slot on ground plane between the substrates. These four techniques are explained in brief as below.

**1.1** Microstrip Feeding Line

In microstrip feeding technique, a thin conductive strip, very less in width as compared to width of the patch is connected directly to the edge of the conducting patch as shown in fig (1). As this feed line can easily etched on the substrate and this kind of feeding is useful for planar structure without increasing the height of antenna. For proper impedance matching an inset feeding is also used without using any active component like diode etc. In inset feeding method a slot is made in the patch and feed line is inserted in slot till the good impedance matching is achieved. However this feeding technique is easy to design and analyze but when substrate height is increased, spurious feed radiations and surface waves are increased which decrease the bandwidth. Undesired cross polarized waves are also generated due to microstrip feeding technique [6].

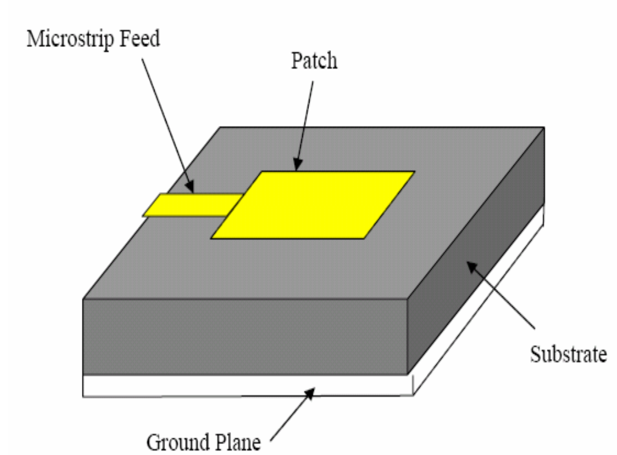


**Figure.1 Microstrip line feeding**

1.2 Coaxial Probe Feed

Another commonly used feeding line is coaxial probe feeding. In this technique the outer and inner conductor conductors are connected to the ground plane and radiating patch of antenna respectively. A Coaxial probe feed is shown in fig (2). This feeding technique is easy to fabricate and having low spurious radiations as compared to the microstrip feed line. However for the antenna having thick substrate, this technique not commonly used due to difficult to model and narrow bandwidth. As thickness of substrate is increased ($h > 0.02\lambda_0$), more length of probe is required which further increase the inductive impedance and create matching problem [6].

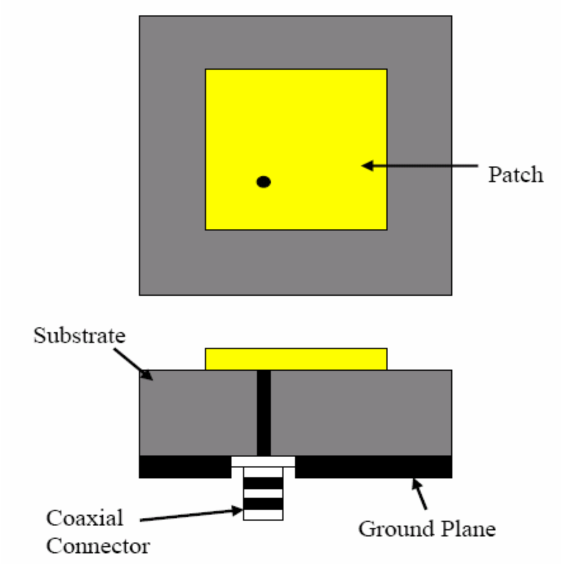


**Figure 2 Probe fed rectangular patch antenna**

1.3 Aperture Coupled

Both the techniques discussed above posses inherent asymmetries due to which undesired higher order modes are generated, which further causes cross polarized radiations. To avoid these problem non contacting feed techniques are used. An aperture coupled feeding technique is shown in fig. (3).

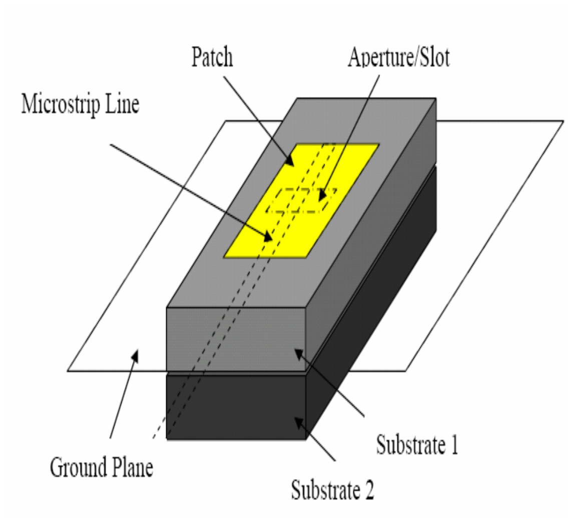


**Figure 3 Aperture Coupled Feed**

Aperture coupled is one of the non contacting feeding techniques. In this technique two substrates with different dielectric constant are separated by a conducting ground plane. A low dielectric constant substrate is placed above and a high dielectric substrate is placed below the conducting ground plane. A microstrip feed line is used below the lower substrate. The energy from microstrip line is transferred to radiating patch through a slot on the ground plane between substrates. The coupling between patch and transmission line is controlled by dimensions of feed line and slot on ground plane [7]. Due to multiple layers the antenna thickness is increased unnecessarily, and bandwidth is decreased [7]-[10].

1.4 Proximity Couple Feed

Another non-contacting feeding line is proximity-coupled feeding shown in fig (4). In this technique two dielectric substrates are separated by feed line and a radiating patch is placed on the top of the upper substrate. Proximity coupled feed provides higher bandwidth is. No cross polarizations are presented in this feeding technique. However fabrication of this feed line is difficult. To control the impedance matching, width-to-line ratio of the patch can be used [5].

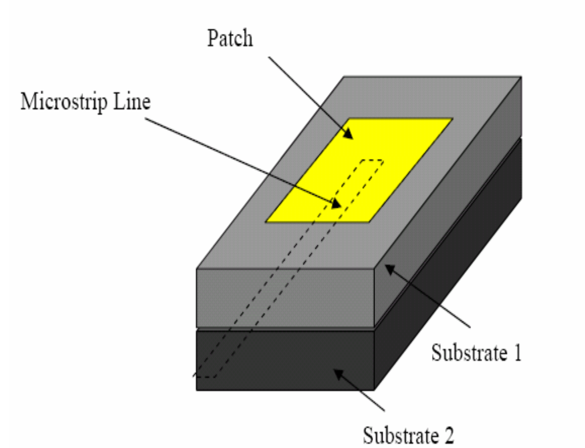


Figure 4 Proximity coupled feed

## II. DESIGN METHODOLOGY

In this paper a microstrip patch antenna is designed using transmission line feeding and then same antenna is simulated using the co-axial feeding. The results are observed and analyzed for both the design separately. For design of this antenna, combination of polyester and curtain cotton (polycot) in ratio of 65:35 is used as a substrate [11]. A thin conductive copper sheet is used as patch and ground plane of the designed antenna. The dimensions of antenna for 2.4 GHz are calculated using the following equations [6] [12].

Step 1: Calculation of the Width of patch (W): The width of patch is given by (1)

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Where, c is free space velocity of light. $f_r$ is resonant frequency and is 2.4 GHz for the current design. A 3 mm thick polycot textile with relative permittivity of 1.48 is used as a substrate [11]. Due to presence of air between the patch and dielectric the permittivity is changed and known as effective permittivity ($\varepsilon_{reff}$) and given by

 

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

Where, h is height or thickness of the substrate.

Step 3: Calculation of the length extension ΔL, which is given by

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.2.58)\left(\frac{w}{h}+0.8\right)} \qquad (3)$$

Step 4: Now to calculate the length of patch

$$\mathrm{L} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta \mathrm{L} \qquad (4)$$

Where ΔL is the additional length on both side of the patch due to fringing fields

$$\mathrm{L}_{eff} = \mathrm{L} + 2\Delta\mathrm{L} \qquad (5)$$

$L_{eff}$ is the total length of the patch including the length due to of fringing effect.

The dimensions of patch calculated from above equations are given in table 1.

Table.1Dimensions of antenna

| | |
|---|---|
| Length | 48.60 mm |
| width | 56.50 |
| Substrate thickness | 3 mm |
| Dielectric constant of substrate | 1.48 |
| Loss tangent of substrate | 0.02 |
| inset feed depth | 17.13 mm |
| inset feed width | 11 mm |

Using these dimensions a microstrip patch antenna with inset feed is designed and shown in fig. (5). and same antenna using coaxial feeding is shown in fig. (6)

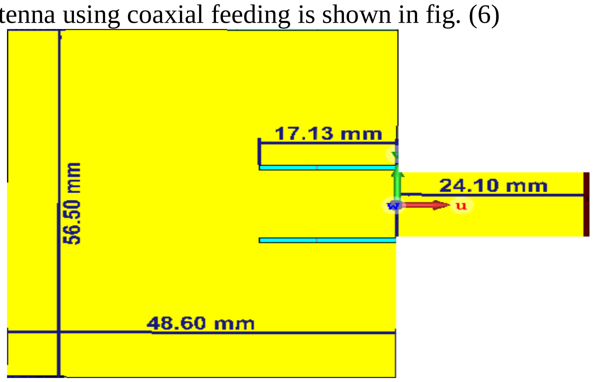


Fig.5 Antenna with inset feeding

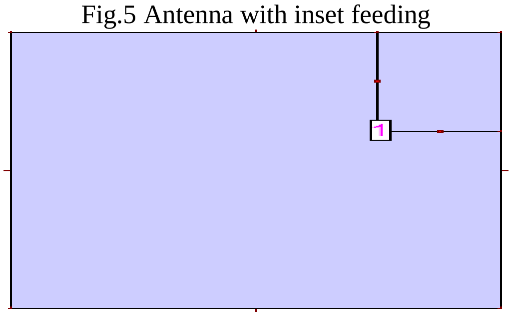

Fig.6 Antenna with probe feeding

## III. RESULT AND DISCUSSION

An inset Feeding technique is used for antenna shown in fig (5) and simulated using CST STUDIO SUITE 2018. The return with the S-parameter is shown in fig. (7).The antenna shown in fig (6) is simulated using HyperLynx 3D EM antenna design software and return loss is shown in fig 8.

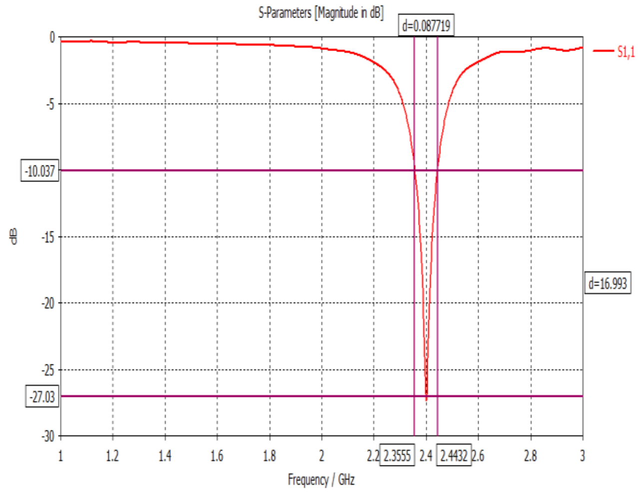


Fig.7 S-parameter

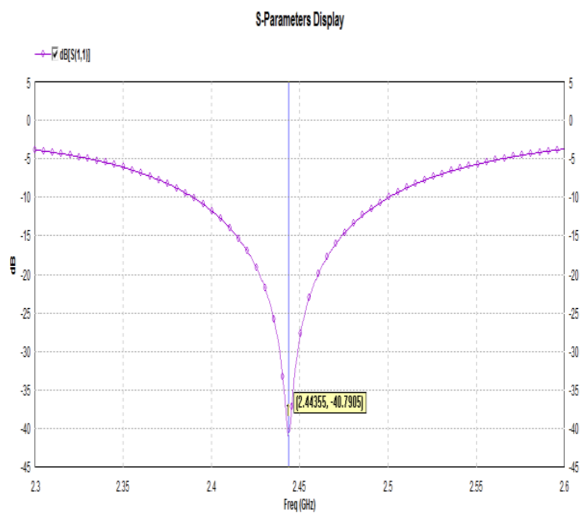


Fig.8 S-parameter

In fig 7 the s-parameter is shown for inset feed antenna. The return of antenna is -27.3 dB at 2.4 GHz. But in fig. 8 the return loss observed of antenna at 2.44 GHz is -40.8 dB. Bandwidth of inset feed antenna is 88 MHz whereas for the probe antenna it is 112 MHz.

**Radiation Pattern:** The radiation pattern represents the variation of field in different directions from the antenna. The radiation pattern of antenna with inset feed and probe feed is shown in fig 9 (a,b) and 10(a,b) respectively.

 

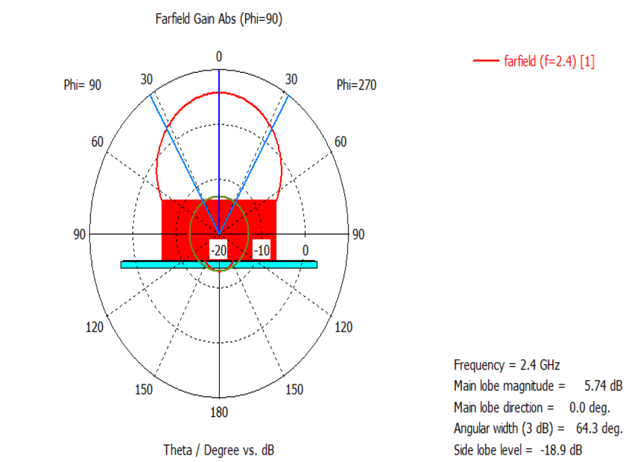

Fig 9 a. Elevation pattern gain

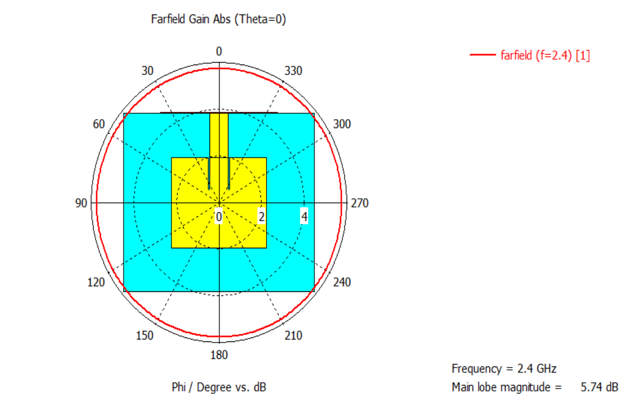

Fig. 9 b Azimuth pattern gain

In fig. (9.a) elevation gain pattern is given and maximum gain of antenna is 5.74 dB at 2.4 GHz frequency. In fig (9.b) azimuth pattern of gain is shown.

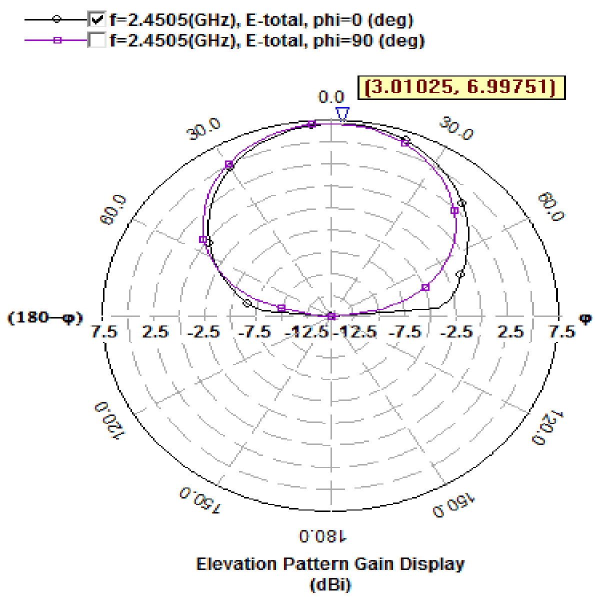

Fig. 10a Elevation pattern gain

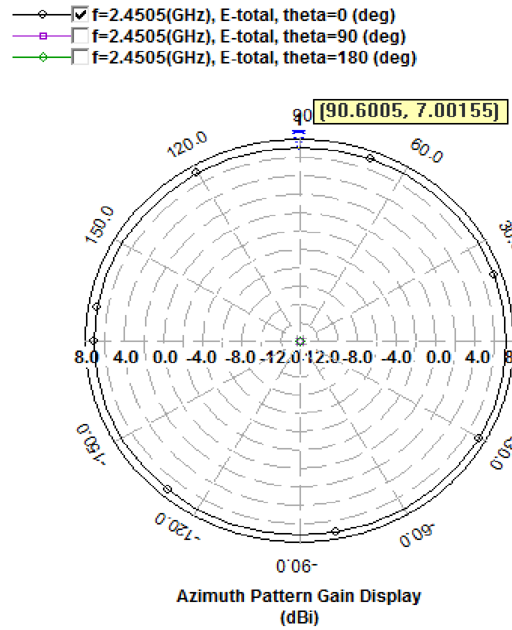

Fig.10b. Azimuth pattern gain

In fig. (10.a) elevation gain pattern with probe feed is given and maximum gain of antenna is 6.99 dB at 2.45 GHz frequency. In fig (10.b) azimuth pattern of gain is shown.

Conclusion: In this paper an antenna is designed with coaxial probe feeding and transmission line feeding. From the s-parameter of antennas, the return loss of antenna with probe feed is observed higher than antenna with transmission line feeding. Bandwidth of antenna with probe feed is 112 MHz where it is just 88 MHz for transmission line feeding. In context to gain of antenna, higher gain is observed for probe feed than the transmission line, which is 7 dB and 5.74 dB for probe feeding and transmission line feeding respectively. Although return loss bandwidth and gain for coaxial feed are higher but design and modeling of coaxial feed is complex as compared to transmission line. When height of antenna is required to increase a long coaxial feed is required which increase the conductive impedance and create the problem of impedance matching. Despite of these advantages of probe feeding, an antenna with transmission feeding line is preferred when planar structure is required.

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Prof. B.S. Sohi is currently holding the position of pro-vice chancellor in Chandigarh University. He has done incredible contribution to the field of research and served as the Director of the UIET, Panjab University Chandigarh. His research interests are electromagnetic, image processing, wireless communication and basic electronics.


 