Performance Analysis of Microstrip Antenna with Two Shape of Patch and Two Feeding Technique

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Abstract—This paper describes comparison of performance analysis of two shape of patches with two different feeding techniques for microstrip patch antenna. In this paper two types of feeding techniques(Microstrip line feed and coaxial probe feed) are used. Microstrip line feed and coaxial probe feeds are contacting scheme, in which RF power is fed directly to the radiating patch using connecting element such as microstrip line. Paper describing Rectangular and Square patch with this two feeding techniques and gives better understanding design parameters of antenna and their effect on return losses, bandwidth and VSWR. Simulation is done using design software HFSS.

Keywords: Microstrip patch antenna, Microstrip line(MSL) feed, Coaxial probe feed, Return loss, Bandwidth, VSWR , Resonant frequency, HFSS.

I. INTRODUCTION

With the advancement in wireless communication technology, the need for light weight and miniature size antennas has become a mandatory requirement in today's world. The most popular antenna in this category is micro-strip patch antenna. The micro-strip patch antenna is a type of radio antenna with a low profile that can be mounted on a flat surface. These antennas consist of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called as ground plane. The assembly is usually contained inside a plastic radome, which protects the antenna structure from damage. These antennas have several advantages over other antennas such as low profile, low weight, relatively low manufacturing cost, simple fabrication process, polarization diversity and can be easily modified and customize.

This paper considers two shapes of the patch used in micro-strip patch antenna that are as follows:

- Rectangular shaped patch micro-strip antenna.
- Square shaped patch micro-strip antenna.

A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The top and side view of a rectangular MSA (RMSA) is shown in Figure 1.

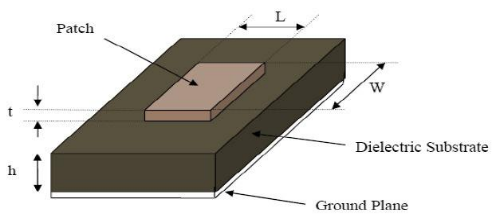

Fig. 1 : Basic Microstrip Patch

For the square patch antenna the length and width of the patch are same.

II. FEEDING TECHNIQUES

In this paper we are using two feeding techniques for the microstrip patch antenna they are as follows:

- Microstrip line feed.
- Coaxial prob feed.

This two techniques are called as contacting method.
In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line.

A. 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.

However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation. This method is advantageous due to its simple planar structure.

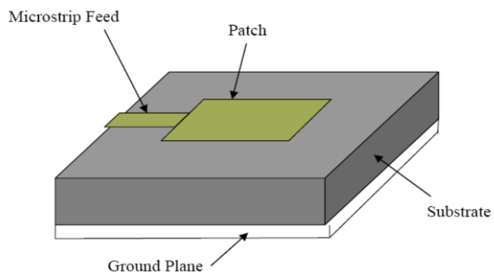

Fig. 2: Microstrip Line Feed

B. 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 not making it completely planar for thick substrates.

Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems.

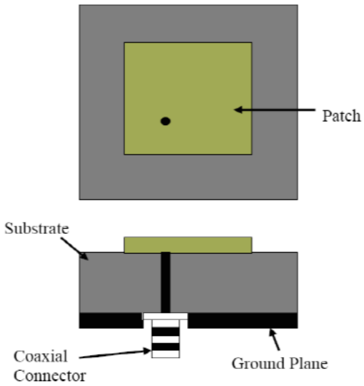

Fig. 3 : Coaxial Probe Feed.

III. DESIGN EQUATIONS

A. *For Rectangular patch antenna:*

- *Frequency of operation (fo):* The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for my design is 2.4 GHz for Bluetooth Application.
- *Dielectric constant of the substrate (er):* The dielectric constant of substrate material plays an important role in the patch antenna design. A substrate with a high dielectric constant reduces the dimensions of the antenna but it also affects the antenna performance. So, there is a trade-off between size and performance of patch antenna.
- *Height of dielectric substrate (h):* For the Microstrip patch antenna to be used in communication systems, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate should be less. After the proper selection of above three parameters, the next step is to calculate the radiating patch width and length.

Step 1: Calculation of Width (W):

For an efficient radiator, practical width that leads to good radiation efficiencies is:

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

Where *c* is the free space velocity of light.

Step 2: Calculation of Effective Dielectric Coefficient (ereff) :

The effective dielectric constant is

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

Step-3:- Calculation of Effective Length (Leff) :

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

Step 4: Calculation of the Length extension (ΔL) :

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Step 5: Calculation of actual Length of Patch (L) :

The actual length of radiating patch is obtained by

$$L = L_{eff} - 2\Delta L$$

Step 6: Calculation of the Ground Plane Dimension (Lg and Wg) :

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$Lg = 6h + L.$$

$$Wg = 6h + W.$$

B. *For Square patch antenna:*

For an efficient radiator, practical length [4-6] that leads to good radiation efficiencies is calculated by transmission line model equation:

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

Where W is the width of the square shaped patch. fo is taken as 2.4 GHz resonant frequency and εr is the relative permittivity of the substrate.

For the square patch antenna the length of the patch is same as the width of the patch. So that, the length of patch is given by L=W.

The effective length of the patch which is used in this antenna is given by:

$$L_{eff} = L + \Delta L$$

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. Similar results for the finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L_g = W_g = 6h + L$$

Where Lg and Wg are the length, width of the ground and h is the height of the substrate. The dimensions for the substrate are similar to the ground except height.

IV. CALCULATED PARAMETER

Sr. No.	Parameter	Designed Value
1	Resonant frequency(fo)	2.4 GHz
2	Patch length(L)	37.37 mm
3	Patch width(W)	50.20 mm
4	Substrate height(h)	3.75 mm

5	Substrate length(Ls)	59.87 mm
6	Substrate width(Ws)	72.70 mm
7	Dielectric constant(εr)	2.1

Table. 1: Design Specifications for Rectangular patch

Sr. No.	Parameter	Designed Value
1	Resonant frequency(fo)	2.4 GHz
2	Patch length(L)	50.20 mm
3	Patch width(W)	50.20 mm
4	Substrate height(h)	3.75 mm
5	Substrate length(Ls)	59.87 mm
6	Substrate width(Ws)	72.70 mm
5	Dielectric constant(εr)	2.1

Table. 2: Design Specifications for Square patch

V. DESIGN IN HFSS

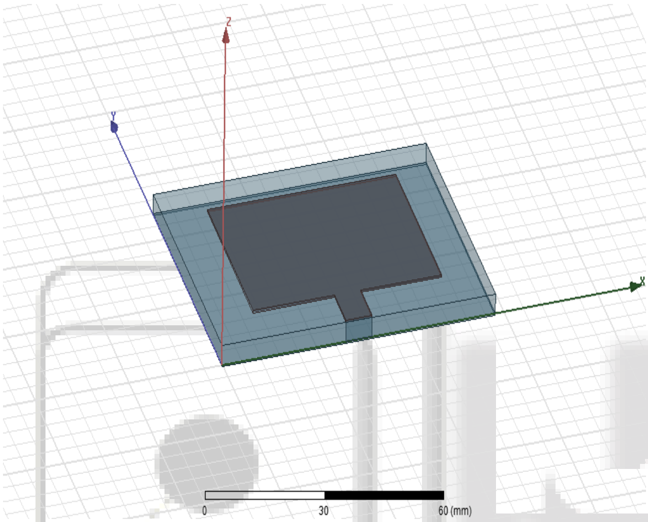

Fig. 4 : Rectangular patch using MSL technique

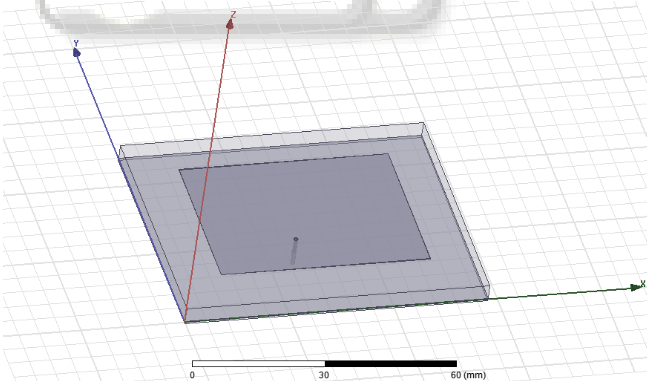

Fig. 5: Rectangular patch using Coaxial probe feed technique

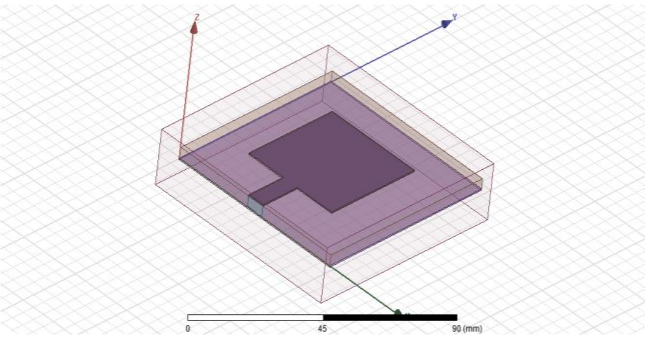

Fig. 6: Square patch using MSL technique

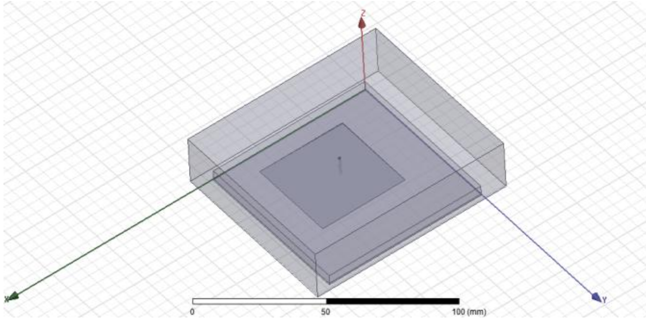

Fig. 7: Square patch using Coaxial probe feed technique

VI. SIMULATION RESULT AND ANALYSIS

A. *Rectangular patch antenna.*

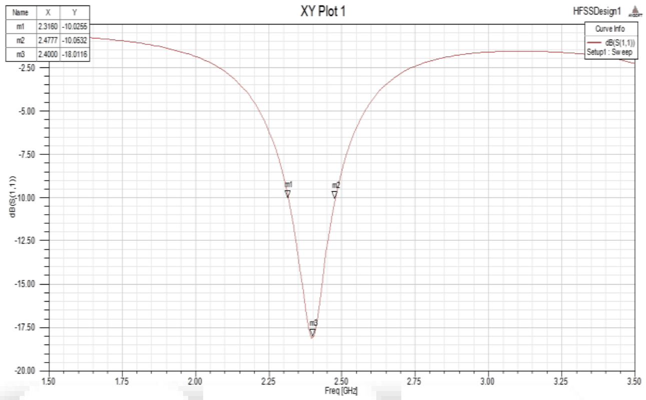

Fig. 8: Return loss V/S Frequency using MSL technique

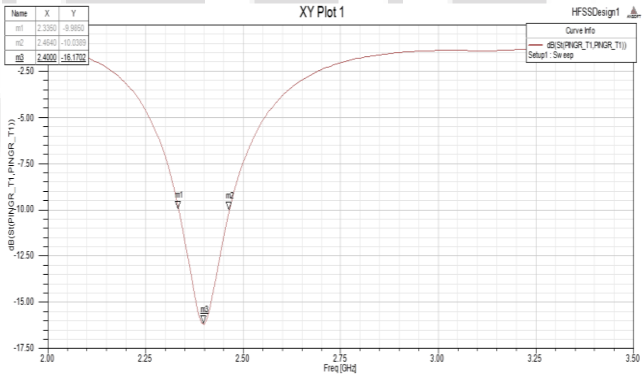

Fig. 9: Return loss V/S Frequency using Coaxial probe feed technique

The return loss curve v/s frequency for the Rectangular patch antenna by using microstrip line feed is presented in figure 8 and by using coaxial probe feed is presented in figure 9. The operating frequency of the proposed antenna is chosen at 2.4 GHz which is used for the Bluetooth appllication . From the figure 8 we got the return loss of -18.0116 dB at 2.4 GHz. From the figure 9 we got the return loss of -15.3580 dB at 2.4 GHz. By using microstrip line feeding technique, we are getting 161.7 MHz bandwidth where as by using coaxial prob feeding technique, we are getting 129 MHz bandwidth.

From the both the results of return loss for coaxial feeding and strip line feeding we observed that a considerable value obtained from both the cases which is showing return loss less than -10dB. For the coaxial feeding technique we go better result in compared with the strip line feeding as per the return loss is concerned. But we are getting more bandwidth with Microstrip line feeding technique as per the bandwidth is concerned.

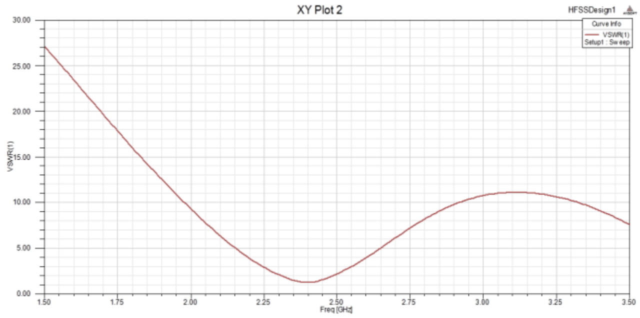

Fig. 10: VSWR Curve using MSL feed technique

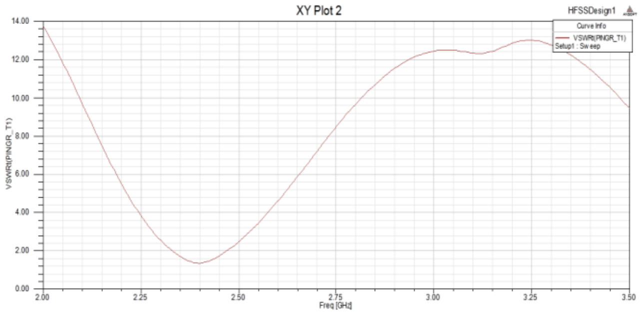

Fig. 11: VSWR Curve using Coaxial probe feed technique.

Figure 10 and figure 11 giving the VSWR curve Vs frequency for both the feeding techniques. The VSWR obtained from the coaxial feeded Rectangular patch antenna is about 1.40 and for the strip line feeded antenna the VSWR is 1.15 at 2.4 GHz. Both these values are maintaining the standardization with 2:1VSWR ratio.

B. Square patch antenna.

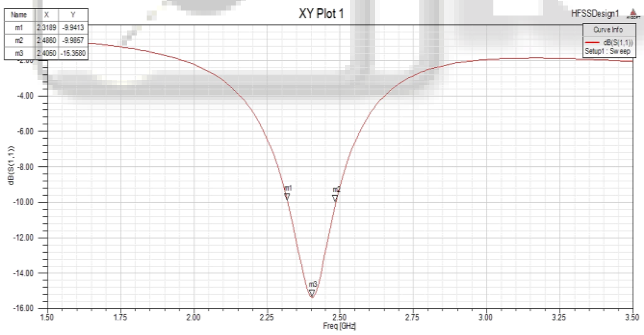

Fig. 12: Return loss V/S Frequency using MSL technique

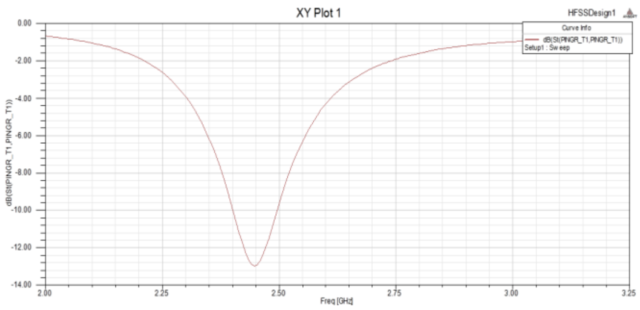

Fig. 13: Return loss V/S Frequency using Coaxial probe feed technique

The return loss curve v/s frequency for the Square patch antenna by using microstrip line feed is presented in figure 12 and by using coaxial probe feed is presented in figure 13.The operating frequency of the proposed antenna is chosen at 2.4 GHz which is used for the Bluetooth appllication . From the figure 12 we got the return loss of -15.3580 dB at 2.4 GHz. From the figure 9 we got the return loss of -15.00 dB at 2.4 GHz. By using microstrip line feeding technique, we are getting 167.1 MHz bandwidth where as by using coaxial prob feeding technique, we are getting 90 MHz bandwidth.

From the both the results of return loss for coaxial feeding and strip line feeding we observed that a considerable value obtained from both the cases which is showing return loss less than -10dB. For the coaxial feeding technique we go better result in compared with the strip line feeding as per the return loss is concerned. But we are getting more bandwidth with Microstrip line feeding technique as per the bandwidth is concerned.

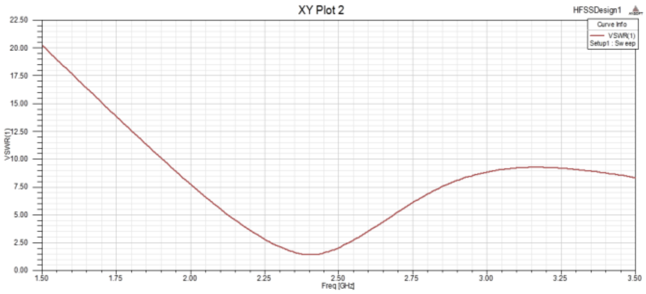

Fig. 14: VSWR Curve using MSL feed technique.

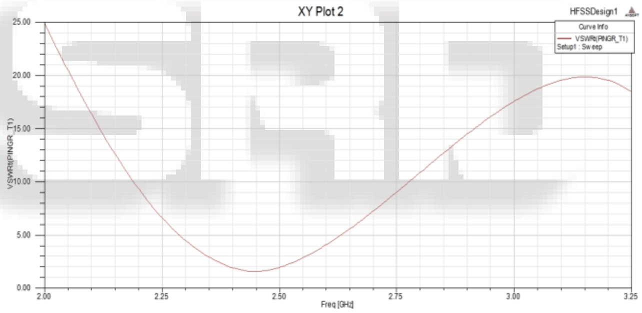

Fig. 15: VSWR Curve using coaxial probe feed technique.

Figure 14 and figure 15 giving the VSWR curve Vs frequency for both the feeding techniques. The VSWR obtained from the coaxial feeded Rectangular patch antenna is about 1.4 and for the microstrip line feeded antenna the VSWR is 1.5 at 2.4 GHz. Both these values are maintaining the standardization with 2:1VSWR ratio.

VII. CONCLUSION

A Comparative study of different shape of patch with feeding techniques has been simulated using HFSS simulation software. The comparison of two shape of patch with feeding techniques shows that Rectangular patch with Microstrip line feeding technique has the highest return loss of -18.0116 dB. The microstrip line feeding is preferable because of impedance mismatching with the case of coaxial feeding. Coaxial feeding requires number of trial and error methods for getting impedance bandwidth perfectly. Whereas for the strip line feeding impedance related problems can be almost avoided. we can get more bandwidth with rectangular patch with strip line feeding technique.

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