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Design, Simulation and Fabrication of Multilayer Structured Psi-Shape Microstrip Antenna for Wireless Applications

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ABSTRACT: In this paper efforts have been made to Design, Simulate and Fabrication of Multilayer Structured Psi-Shape Microstrip Antenna for Wireless Applications. Simulation is done for Multilayer Rectangular, E-shape and Psi-shape. Coaxial feed technique is used for its simplicity. FR – 4 epoxy substrate has been used. The performance of the designed antenna is analyzed in terms of Bandwidth, Return loss, Gain, VSWR and Directivity. It has been found that the Multilayer Psi-Shape has improved bandwidth and gain over Multilayer Rectangular and E-shaped MSA. In addition to this, we have fabricated the Psi-shape MSA and compared with simulated result.

Index Terms: Bandwidth, Gain, Return Loss, Multilayer, Psi-shape

I. INTRODUCTION

Antenna plays a very important role in the field of wireless application. There are different types of antennas used in various applications. Each type of antenna is good in their own properties and usage. Microstrip antennas play a very significant role in today's world of wireless communication systems as it is very simple in the construction using a conventional Microstrip fabrication technique.

The major disadvantages of Microstrip antennas are lower gain and very narrow bandwidth. The gain and directivity is the issue in fixed wireless local area network (WLAN) application where antenna of high gain and directivity is required [7]. The gain can be increased by using the Microstrip antenna array structure but this again increases the size [6,7]. Hence the gain of Microstrip antenna (MSA) is increased by slightly increasing the dimensions of patch antenna and multilayer structure with covered dielectric. For mobile devices, the antenna needs to be small and light weight for the user to carry it around and to enable compact design of the devices. For those purposes, the design of low profile Multilayer Microstrip Antenna is introduced.

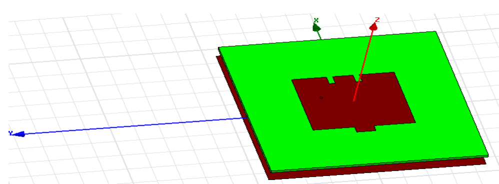


Fig. 1. The top view of a Multilayer Psi-shape MSA.

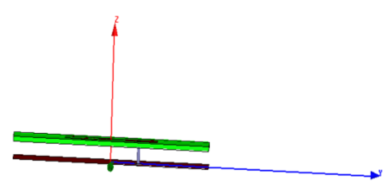


Fig. 2. Side view of Multilayer Psi-shape MSA showing probe feed.

Fig. 3. Photograph of top view of fabricated Multilayer Psi-shape MSA.

Fig. 4. Photograph of Side view of fabricated Multilayer Psi-shape MSA.

The top and side views of a simulated and fabricated antenna are shown in Figure1, Fig. 2, Fig. 3 and Fig. 4.

II. ANTENNA DESIGN CALCULATIONS

Essential parameters for the design of required antenna are as follows:

a] Frequency of operation (f_o): 2.4 GHz.

b] Height of dielectric substrate (h): For the Microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.6 mm.

c] Dielectric constant of the substrate (ε_r): The dielectric constant is the ratio between the stored amount of electrical energy in a material and to that stored by a vacuum. The lower the dielectric constant, the better the material works as an insulator and it resists electrons from being absorbed in the dielectric material, creating less loss. FR – 4 epoxy substrate has been used, which has dielectric constant of 4.4.

Design steps of Multilayer Structured Psi-shape Microstrip antenna [1]

Step 1: Calculation of the width of Patch (W):

The width of the Microstrip antenna is given as:

$$W=\frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad \text{.......(1)}$$

Step 2: Calculation of effective dielectric constant (ε_{reff}):

Fringing makes the Microstrip line look wider electrically compared to its physical dimensions. Since some of the waves travel in the substrate and some in air, an effective dielectric constant given as:

$$\varepsilon_{reff}=\frac{(\varepsilon_r+1)}{2}+\frac{(\varepsilon_r-1)}{2}(1+12\frac{h}{w})^{\frac{-1}{2}} \quad \text{...(2)}$$

Step 3: Calculation of Length of Patch (L):

The effective length due to fringing is given as:

$$L_{eff}=\frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad \text{.....(3)}$$

Due to fringing the dimension of the patch increased by ΔL on both the sides given as:

$$\Delta L=0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)} \quad \text{.....(4)}$$

Hence the length the of the patch is:

L= Leff-2 ...(5)

Step 4: Calculation of Substrate dimensions (L_s and W_s):

Ls=L+6h Ls = 6h + L ……………………..(6)

Ws=W+6h Ws = 6h + W……………………(7)

Step 5: Calculation of feed point(X_f , Y_f):

The position of the coaxial cable can be obtained by using

$$X_f=\frac{L}{2\sqrt{\varepsilon_{reff}}} \quad \text{….(8)}$$

$$Y_f=\frac{W}{2} \quad \text{....(9)}$$

III. SIMULATED AND EXPERIMENTAL RESULTS

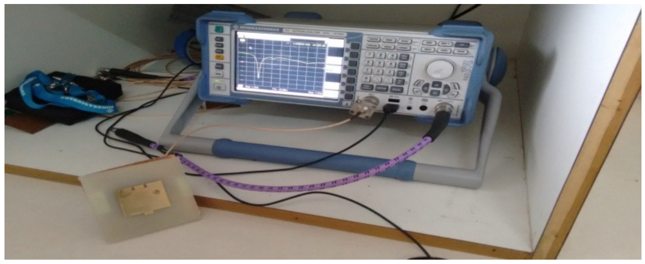


Fig. 5. Photograph of Experimental set up with Vector Network Analyzer (VAN).

A. Simulated and Experimental Return loss and Bandwidth for proposed Multilayer Psi-shape Microstrip Antenna

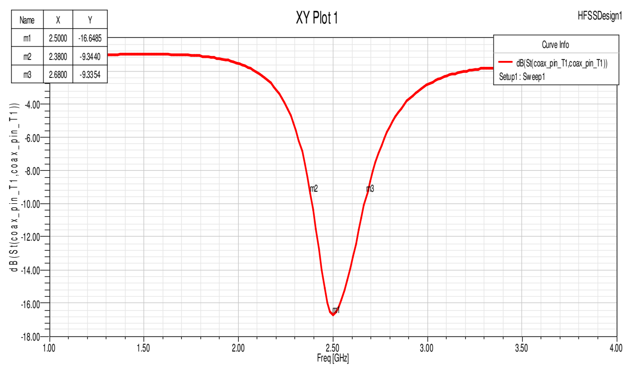


Fig. 6. Simulated Return Loss and Bandwidth of Multilayer Psi-shape MSA

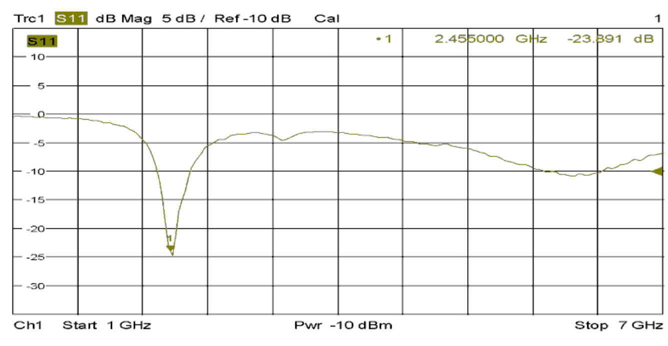


Fig. 7. Experimental Return Loss and Bandwidth of Multilayer Psi-shape MSA

B. Simulated and Experimental VSWR for proposed Multilayer Psi-shape Microstrip Antenna

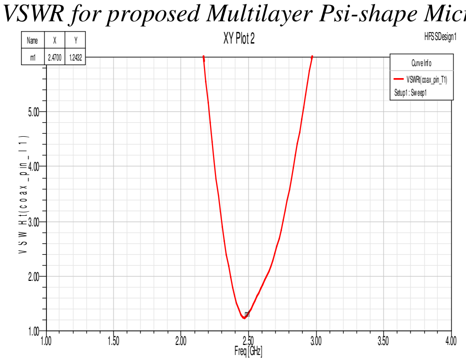


Fig. 8. Simulated VSWR of Multilayer Psi-shape MSA

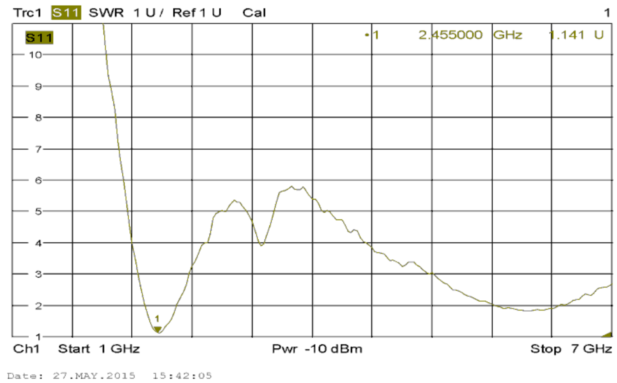


Fig. 9. Experimental VSWR of Multilayer Psi-shape MSA

C. Simulated Gain for proposed Multilayer Psi-shape Microstrip Antenna

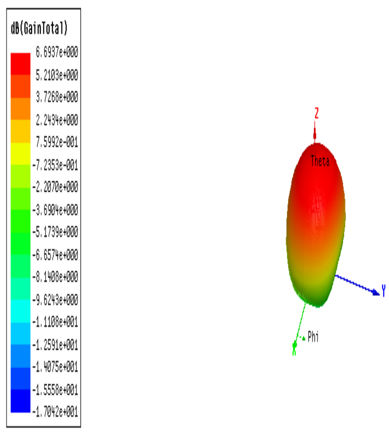


Fig. 10. Simulated Gain of Multilayer Psi-shape MSA

D. Simulated Directivity for proposed Multilayer Psi-shape Microstrip Antenna

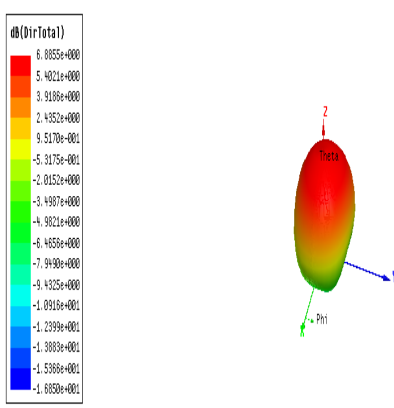


Fig. 11. Simulated Directivity of Multilayer Psi-shape MSA

IV. RESULT ANALYSIS

Table 1: Comparison of Simulated result for Different shape.

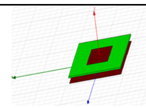
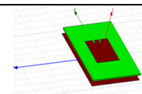
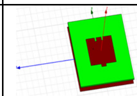
Parameters	**Different Structure**		
	Multilayer Structured Rectangular MSA	***Multilayer Structured E-shape MSA***	***Multilayer Structured Psi-shape MSA***
Design Model			
Operating Frequency (GHZ)	2.4250-2.6650	2.3650-2.6350	2.3800-2.6800
Return Loss(dB)	-14.8902	-19.2979	-16.6485
Bandwidth (MHz)	240	270	300
VSWR	1.4405	1.2432	1.3449
Gain (dB)	6.8154	6.6028	6.6937
Directivity (dB)	6.9778	6.8065	6.8855

Table 2: Comparisons of Simulated and Experimental results of Multilayer Psi-shape MSA.

Parameters	**Simulated**	**Experimental**
Frequency Range (GHz)	2.3800 -2.6800	2.3390-2.6310
Return loss(dB)	-16.6485	-23.891
Bandwidth(MHz)	300	292
VSWR	1.3449	1.1410

V. CONCLUSION

Design of Multilayer Structured Rectangular, E-shape and Psi-shape MSA has been simulated using An soft HFSS (High Frequency Structure Simulator) software. In this work, the performance of the antenna has been analyzed in terms of Return loss, Bandwidth, VSWR, Gain and Directivity. It has been observed that, the bandwidth of Multilayer Psi-shape MSA is improved over Multilayer Rectangular and E-shape MSA. It is found that operating frequency range for Simulated and Fabricated Multilayer MSA is 2.3800GHz -2.6800GHz and 2.3390GHz-2.6310GHz.The designed structure will provide the bandwidth which is required in various wireless applications like Bluetooth (2.4 GHz-2.484 GHz) and RFID (2.4 GHz - 2.5 GHz). In addition to this, we also have fabricated the Psi-shape MSA.

It has been observed that, the fabricated Psi-shape MSA shows nearly equal performance to that of simulated Psi-shape MSA. Multilayer Psi-shape MSA can be considered as better candidate for Wireless applications.

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