Comparative Study to Improve Antenna Parameters of Micro Strip Patch Antenna

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Abstract— Microstrip antennas due to their small profile design take less area. Further they can be modified by two techniques that are introducing different dielectric layer and designing different shape to the conducting surface in order to improve its Bandwidth, Gain, VSWR, Return Loss and Directivity. In this paper we have simulated the different Antenna shapes such as Rectangular, E-shape, Psi-shape Microstrip Antenna (MSA) by studying various Microstrip configuration & Mathematical design using High Frequency Structure Simulator (HFSS) software. The performance of single layer Rectangular MSA has been measured for different dielectric substrate materials. For FR-4 epoxy material cost is low where as improve in Bandwidth is achieved.

Key words: Bandwidth, VSWR, HFSS, Directivity, Techniques

I. Introduction

Different shape has brought out the new technique for improving the bandwidth of the rectangular microstrip patch antenna by means of modifying the structure instead of changing the dielectric material. Different shapes employ modification in the design structure which in general case found to be plane.

II. Designs Steps of microstrip antenna

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

The width of the Microstrip antenna is given as:

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

For c=3*10^8 m/s, f_0 =2.4GHz, ε_r =4.4 Then We get W=38 mm.

B. 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:

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

For ε_r =4.4 , h=1.6mm, W=38mm

Then We get ε_{reff} =4.085

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

The effective length due to fringing is given as:

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

For c=3*10^8 m/s, ε_{reff} =4.085, f_o=2.4GHz

Then we get L_{eff} =30.91 mm

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

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

For W=38mm, h=1.6mm, ε_{reff} =4.085

Then we get ΔL=0.7388mm

Hence the length the of the patch is:

$$L = L_{eff} - 2\Delta L = 29.44 \text{ mm} \quad (5)$$

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

$$Ls = L + 2*6h \quad Ls = 2*6h + L \quad (6)$$

Ls = 2*6(1.6) + 29.44 = 48.64mm

$$Ws = W + 2*6h \quad Ws = 2*6h + W \quad (7)$$

Ws = 2*6(1.6) + 38.76 = 57.23mm

E. Step 5: Calculation of feed Point(X^f, Y^f)

The position of the coaxial cable can be obtained by using

$$X_f = \frac{L}{2\sqrt{\varepsilon_{reff}}} = \frac{29.44}{2\sqrt{4}} = 7.36 \cong 7.5 \quad (8)$$

$$Y_f = \frac{W}{2} = \frac{38.76}{2} = 19.38 \quad (9)$$

III. SIMULATION TOOL

Now with having the dimensions it is required to model the design in the software based tool for example the software from Ansoft called HFSS. It is found to be precise antenna simulation software available in the market with ease of user friendly interface. Building of the 3-D drawing in HFSS is far easy because of its dynamic selection of geometrical shapes. The three different ground planes are designed by using Boolean and subtraction operation available in the HFSS.

IV. DESIGN SHAPES

A. To Design the Different Shape Model

To study the effect on Bandwidth, Return loss, VSWR and radiation pattern of rectangular MSA due to changing the shapes of Micro strip patch antenna, three different shapes has been considered i.e. Rectangular, E-shape and Psi-shape. Following models in Fig.1, Fig.2 and Fig.3 respectively shows the different shape.

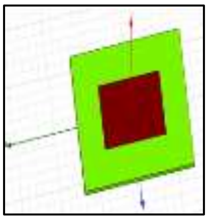


Fig. 1: Rectangular MSA

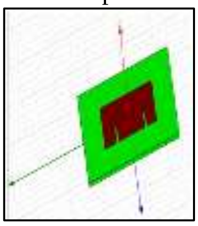


Fig. 2: E-shape MSA

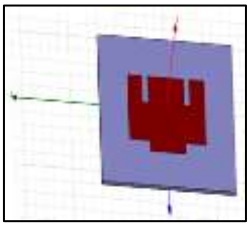


Fig. 3: Psi-shape MSA

V. RESULTS OF THE SIMULATION

A. Return Loss

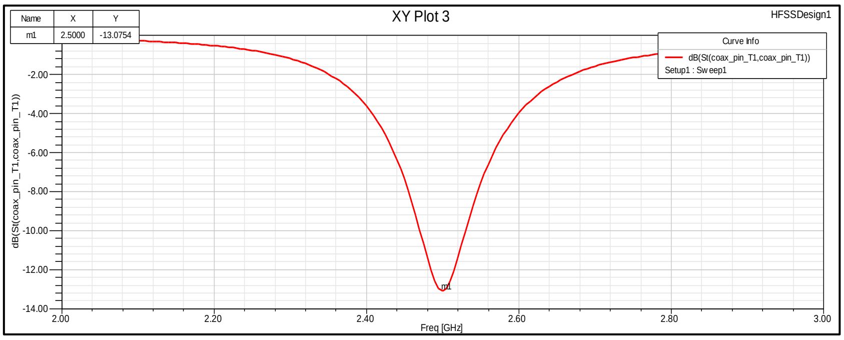


Fig. 4: Return Loss of RMSA

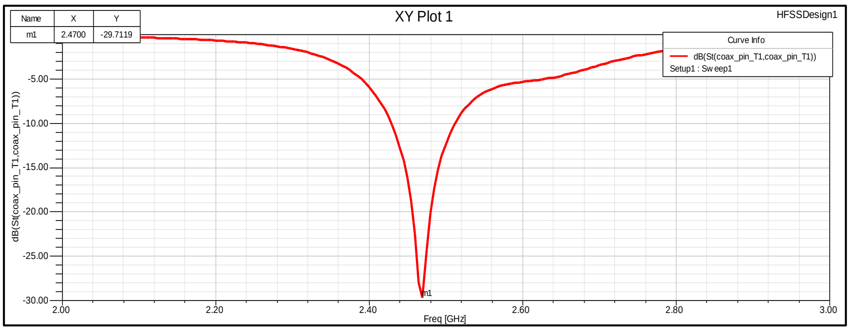


Fig. 5: Return Loss of E-shape

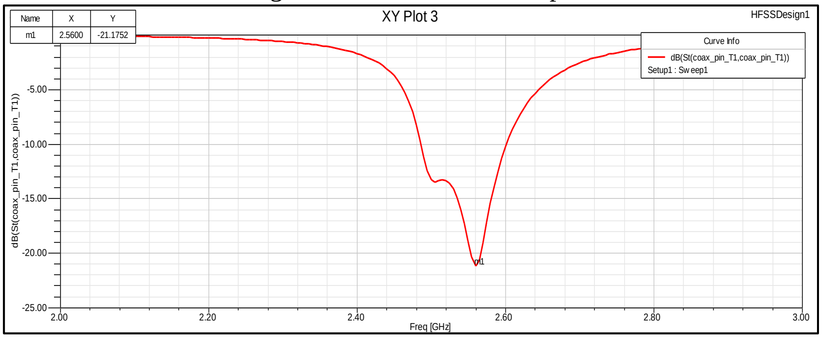


Fig. 6: Return Loss of Psi-shape

B. Bandwidth

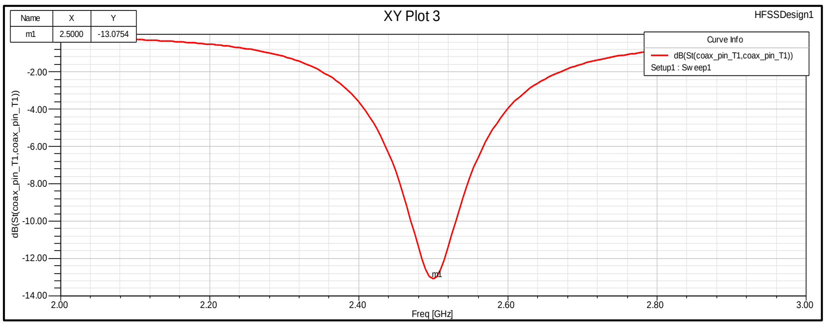


Fig. 7: Return Loss of RMSA

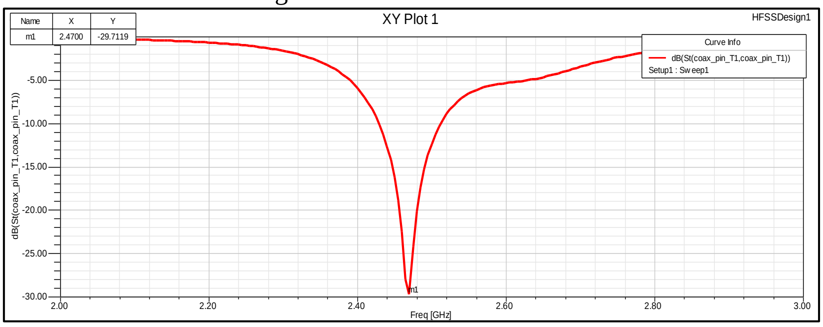


Fig. 8: Return Loss of E-shape

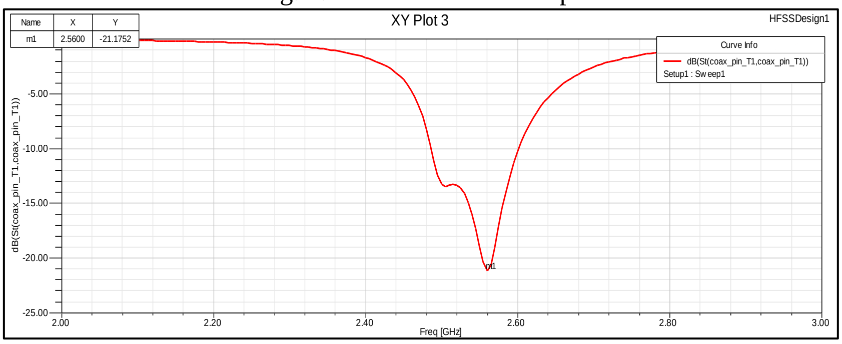


Fig. 9: Return Loss of Psi-shape

C. VSWR

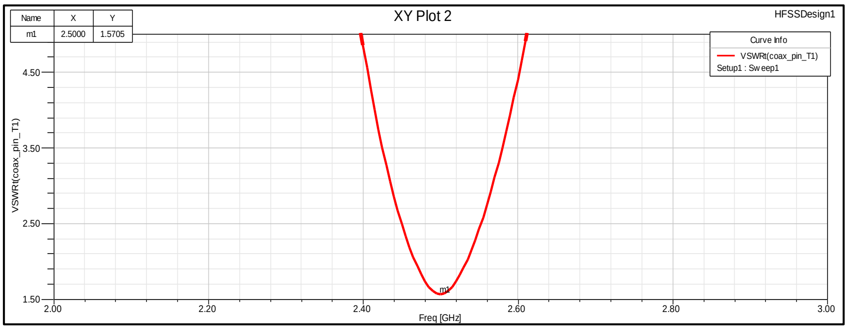


Fig. 10: VSWR of RMSA

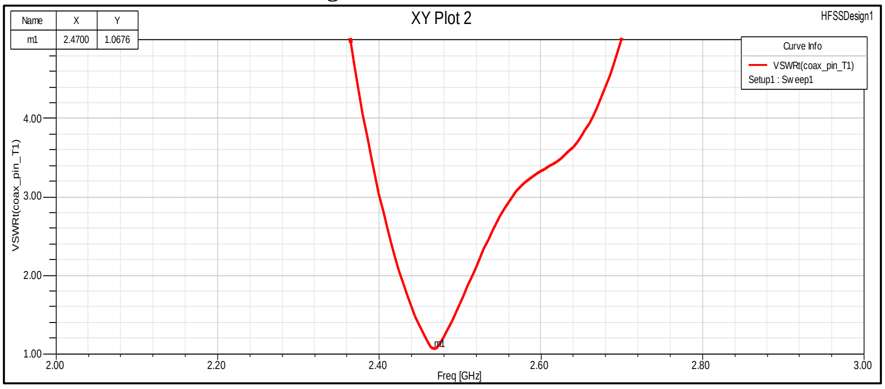


Fig. 11: VSWR of E-shape MSA

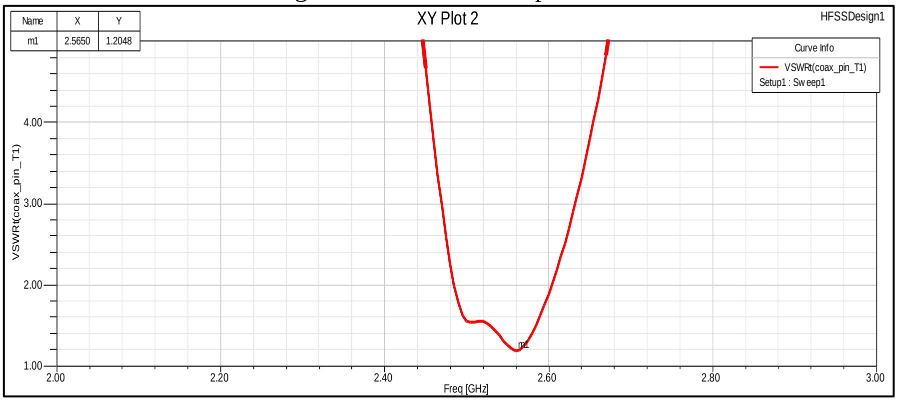


Fig. 12: VSWR of Psi-shape MSA

D. Directivity

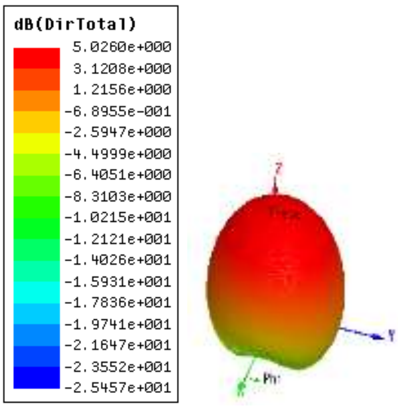


Fig. 16: Gain of RMSA

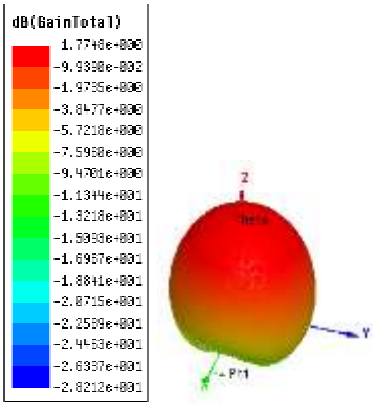


Fig. 17: Gain of E-shape MSA

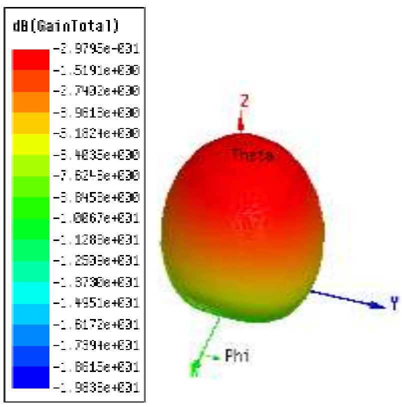


Fig. 18: Gain of Psi-shape MSA

E. Radiation Pattern

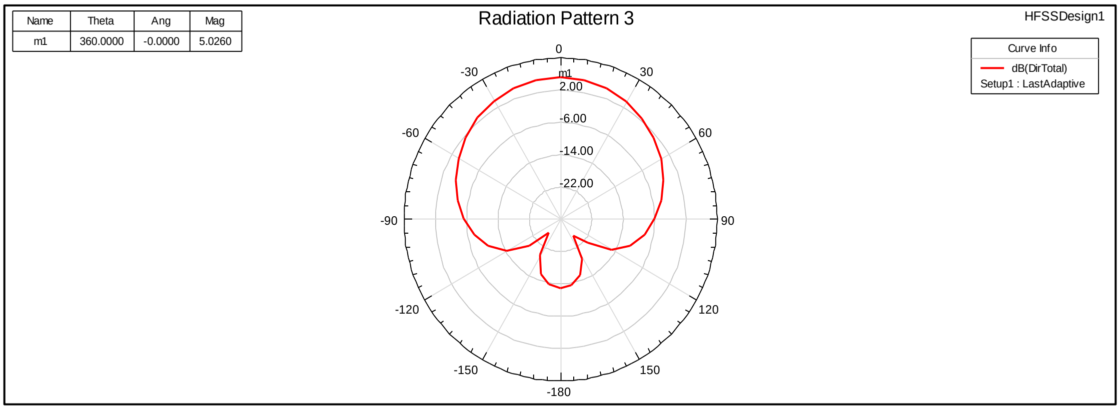


Fig. 19: Radiation Pattern of RMSA

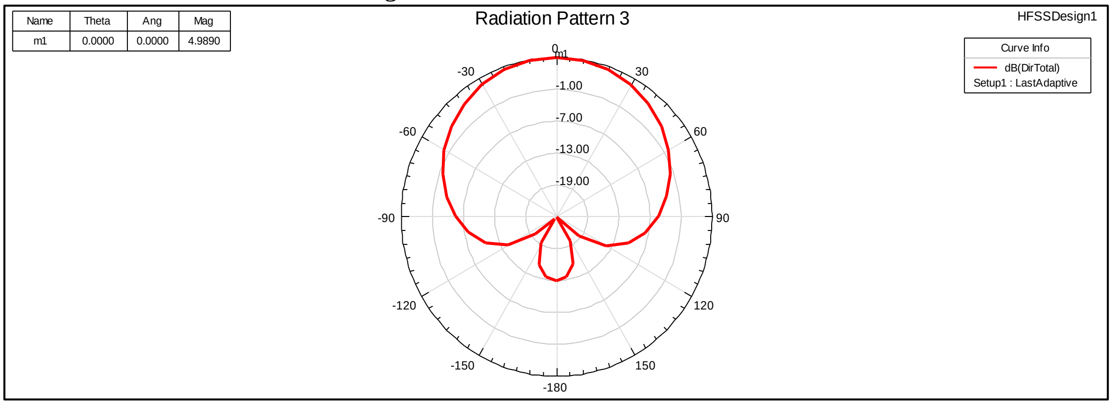


Fig. 20: Radiation Pattern of E-shape

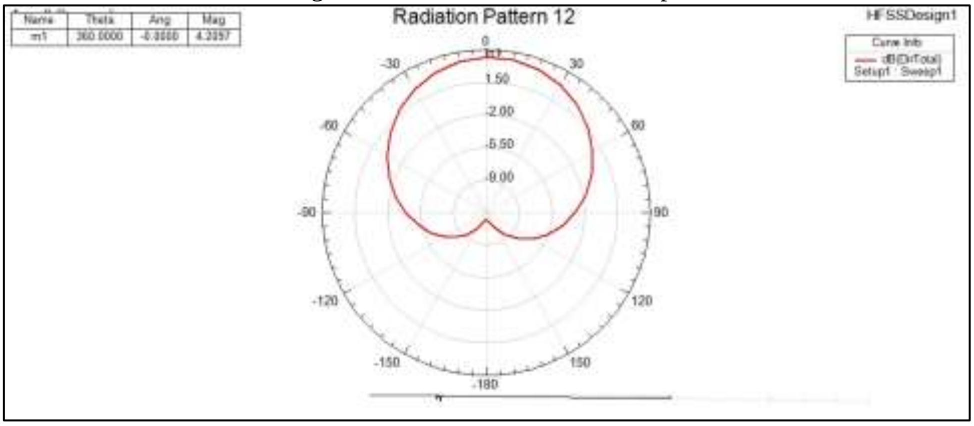


Fig. 21: Radiation Pattern of Psi-shape

Fig.4 to Fig.9 shows the bandwidth and return loss variations due to various structured antenna. The variation in return loss is observed in the range of -16.1236dB to -29.7119dB and variation in the bandwidth is in the range of 75 Mhz to 130Mhz. Similarly the variation in the VSWR is observed as shown in the fig.10 to fig.12

VI. CONCLUSION AND RESULT ANALYSIS

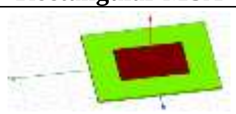
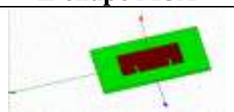
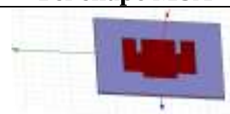
Parameters	**Rectangular MSA**	**E-shape MSA**	**Psi-shape MSA**
Design Shape			
Operating Frequency (GHZ)	2.4650-2.5400	2.4300-2.5250	2.4850-2.6150
Return Loss(dB)	-16.1236	-29.7119	-21.1752
Bandwidth (MHz)	75	95	130
VSWR	1.38	1.07	1.20
Directivity (dB)	5.0	4.9	4.12
Gain (dB)	1.9886	1.7748	-0.2979

Table 1: Comparison table for different shapes in MSA with Parameter

After simulating the three designed models, the results for the parameters such as Bandwidth, gain, VSWR and return loss are observed to be different for the same dimensioned patch antenna.

Design of different structured MSA has been simulated using Ansoft HFSS (High Frequency Structure Simulator) software. It has been observed that, the bandwidth of Psi-shape MSA is improved over RMSA and E-shape MSA. Psi-shape MSA can be considered as better candidate for wireless applications.

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