Comparative Study of Microstrip Patch Antenna for Microstrip Feed Line and Different Substrate

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Abstract:

This paper describes different feeding technique and different substrate applicable to Microstrip patch antenna which is one of the important aspects. A good impedance matching condition between the line and patch without any additional matching elements depends on feeding techniques used and substrate used. After analysis micro strip feeding techniques for different substrate, this paper gives a better understanding of the design parameters of an antenna and their effect on Impedance, VSWR, bandwidth and gain. Finally, simulation is done using design software HFSS.

Index Terms – Microstrip Patch Antenna,Impedance Bandwidth, VSWR, HFSS, Gain.

I. INTRODUCTION

Microstrip patch antennas have number of advantages such as low profile, easy to fabricate and conformability to mounting hosts also size, return loss reduction and bandwidth enhancement and impedance matching are major design considerations for practical applications of microstrip antennas.The lightweight construction and the suitability for integration with microwave integrated circuits are of their advantages.

A comparison between microstrip feeding technique for different substrate has been done. Finally, a microstrip patch antenna at specific frequency i.e. 2.40 GHz has been designed and, simulated on the design software HFSS.

II. MICROSTRIP PATCH ANTENNA

Microstrip antenna consists of very small conducting patch which is built on a ground plane separated by dielectric substrate like RT Duroid etc. The patch is generally made of conducting material like copper or gold and that can be any possible shape [1]. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The conducting patch, theoretically, can be possible to design of any shape, In general rectangular and circular configurations are the most commonly used [1, 5]. Some of the other configurations used are complex to analyze and require large numerical computations.In its most fundamental form,a microstrip patch antenna consist of a radiating patch on one side of a dielectric substrate which has ground plane on the other side [1] is illustrated in fig 1.

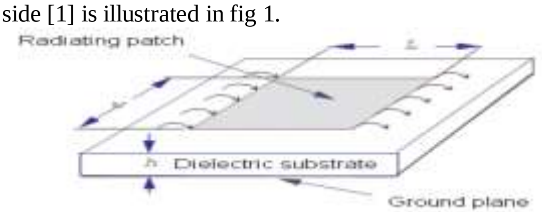

Figure 1: Structure of Microstrip Patch Antenna

III. Microstrip Line Feed

Microstrip feed technique; a conducting strip is made contact directly to the edge of the radiating patch or Microstrip patch. The conducting strip is having minimum in width as compared to the patch and Microstrip feed technique has the advantage that the feed can be etched on the same substrate to provide a planar structure [5, 6].It is an easy feeding Technique, since it provides ease of fabrication and simplicity in modelling as well as impedance matching. According to the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, that can affect the bandwidth of the antenna [6].

IV. DIFFERENT SUBSTRTE

For Microstrip patch antenna consists the patch which is mounted on the material that material is known as substrate which having the dielectric constant and loss tangent. The Four materials are used to design the Microstrip patch antenna for comparison of parameter.

a) FR4
b) Rogers RO33054
c) Taconic TLE
d) RT Duriod

V. DESIGN CONSIDERATIONS

Microstrip patch antenna consists of very thin metallic strip (patch) placed on ground plane where the thickness of the metallic strip is restricted by $t \ll \lambda 0$ and the height is restricted by $0.0003\lambda 0 \leq h \leq .05\lambda 0$. The Microstrip patch is designed so that its radiation pattern maximum is normal to the patch. For a rectangular patch, the length L of the element is usually $\lambda 0/3 < L < \lambda 0/2$ [1, 6].

V.I Procedure for Microstrip Patch Antenna

The Performance of the microstrip patch antenna depends on its resonant frequency, dimension. Depending on the dimension, the operating frequency, radiation efficiency, directivity, return loss are influenced. For an efficient radiation, Calculation of Geometrical Dimensions For the calculation of geometrical dimensions of the microstrip patch the fact that the electrical dimensions are larger than geometrical dimensions should be taken into consideration. This is caused by the existence of fringing field beyond the limit, given by the geometrical dimensions of the microstrip patch.

(a) Calculated patch width

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

(b) Calculated effective dielectric constant

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

(c) Calculated the extended incremental length 'ΔL' of the patch due to fringing effect

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left[\frac{W}{h} + 0.264\right]}{(\varepsilon_{reff} + 0.258)\left[\frac{W}{h} + 0.8\right]} \qquad (3)$$

(d) Calculated the patch effective length Leff

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}} \qquad (4)$$

(e) Calculated the patch actual length

$$L = L_{eff} - 2\Delta L \qquad (5)$$

(f) Calculated Wavelength

$$\lambda_0 = \frac{c}{f_0} \qquad (6)$$

(g) Calculation of the ground plane dimensions for single patch (Lg and Wg):
Lg = 6h+L and Wg = 6h+W (7)

FR4 as the substrate with dielectric constant of 4.4. The rest of the basic parameters are: Resonant Frequency: fo = 2.4 GHz ,Substrate Permittivity: εr = 4.4 (FR4),Substrate Thickness: h = 1.6 mm ,Loss tangent: tan δ =0.002

ROGERS RO4350 as the substrate with dielectric constant of 3.66. The rest of the basic parameters are: Resonant Frequency: fo = 2.4 GHz,Substrate Permittivity: εr = 3.66 (ROGERS RO4350),Substrate Thickness: h = 1.6 mm,Loss tangent: tan δ =0.004

TACONIC TLE as the substrate with dielectric constant of 2.95. The rest of the basic parameters are:Resonant Frequency: fo = 2.4 GHz,Substrate Permittivity: εr = 2.95 (TACONIC TLE),Substrate Thickness: h = 1.6 mm,Loss tangent: tan δ =0.0028

RT Duroid as the substrate with dielectric constant of 2.2. The rest of the basic parameters are:Resonant Frequency: fo = 2.4 GHz ,Substrate Permittivity: εr = 2.2 (RT Duroid),Substrate Thickness: h = 1.6 mm,Loss tangent: tan δ =0.0009 from this calculation Microstrip patch antenna design in hfss software for two feed line and four substrate.

VI. DESIGNING

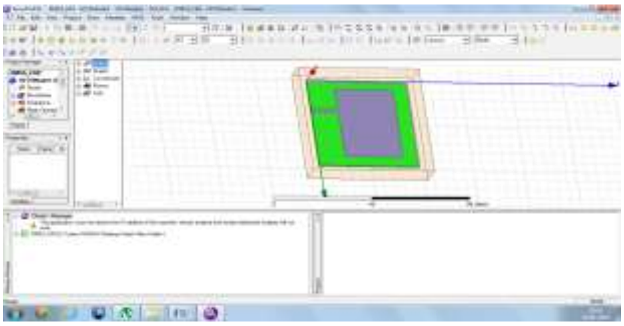

Figure 2 : RMSA Design of FR4 for microstrip feed

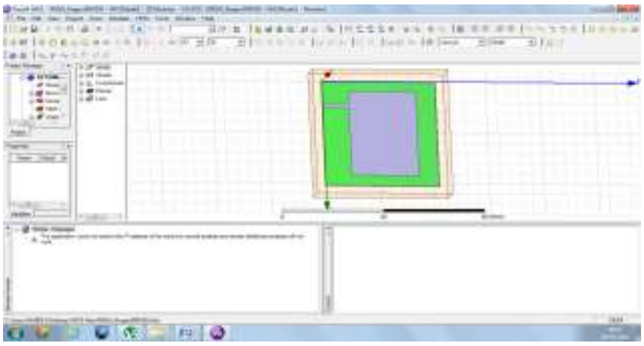

Figure 3 : RMSA Design of Rogers RO4350 for Microstrip feed.

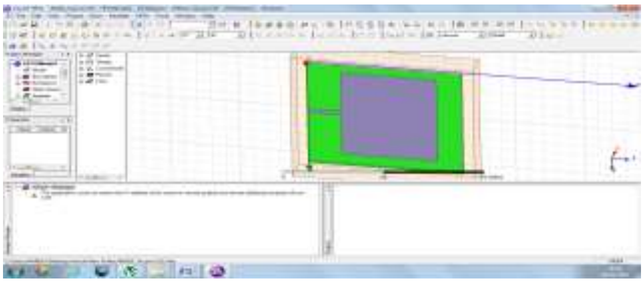

Figure 4 :RMSA Design of Taconic TLE for Microstrip feed

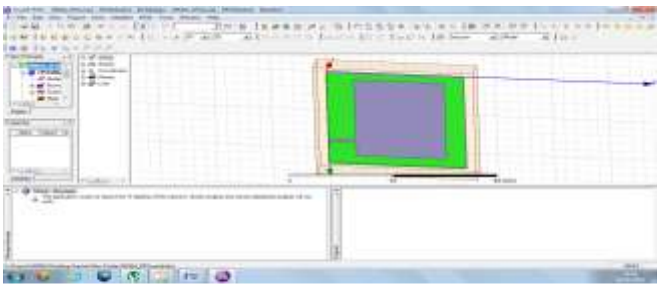

Figure 5 : RMSA Design of Rogers RT Duriod for Microstrip feed

VI. SIMULATION RESULT

VI.I For Microtrip Feed.

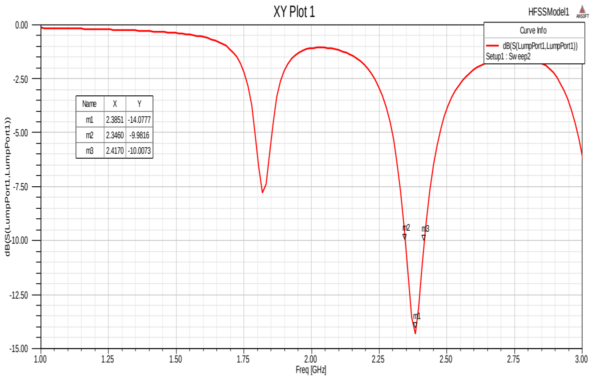

Figure 6: S11 graph of RMSA FR4

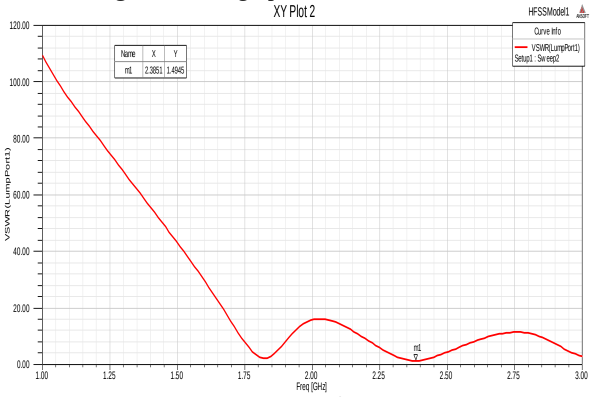

Figure 7: VSWR graph of RMSA FR4

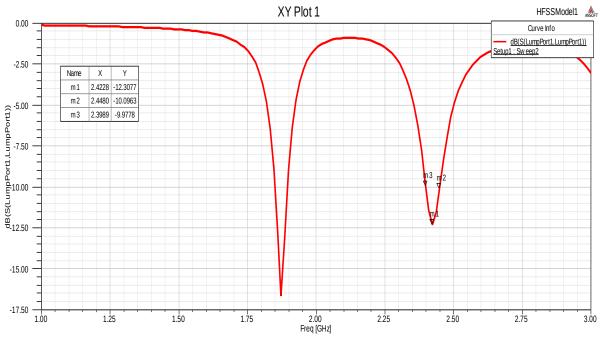

Figure 8: S11 graph of RMSA Rogers RO4350

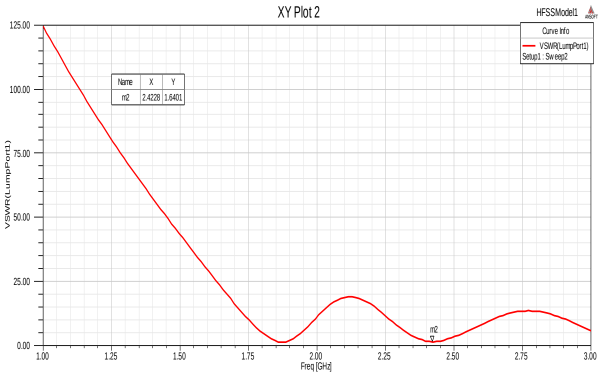

Figure 9: VSWR graph of RMSA Rogers RO4350

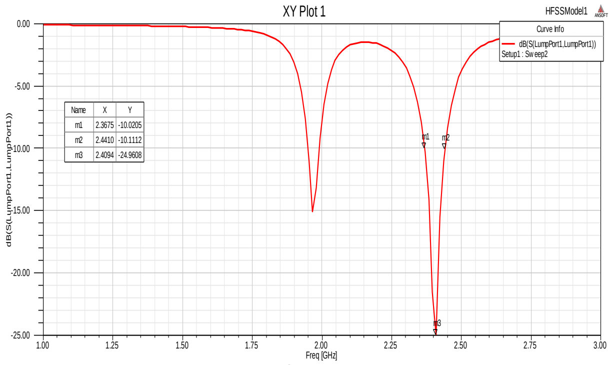

Figure 10: S11 graph of RMSA Teconic TLE

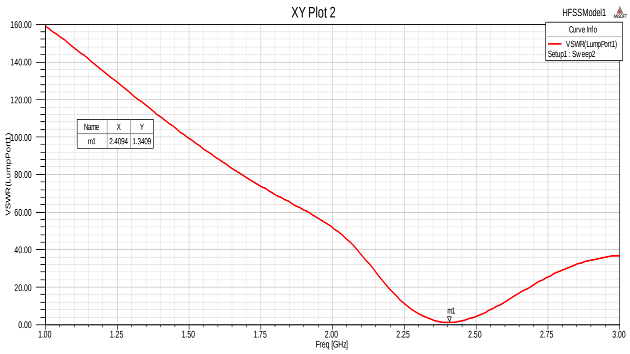

Figure 11: VSWR Graph of Taconic TLE

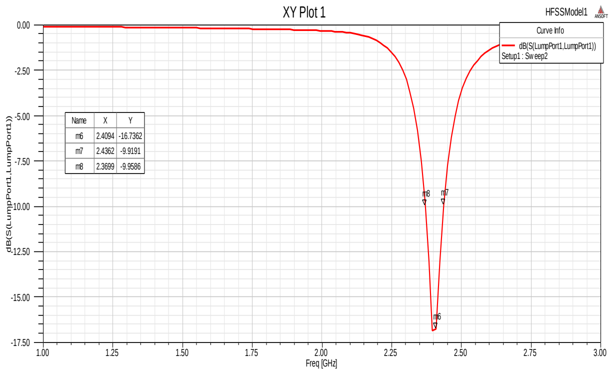

Figure 12: S11 graph of RMSA RT Duroid

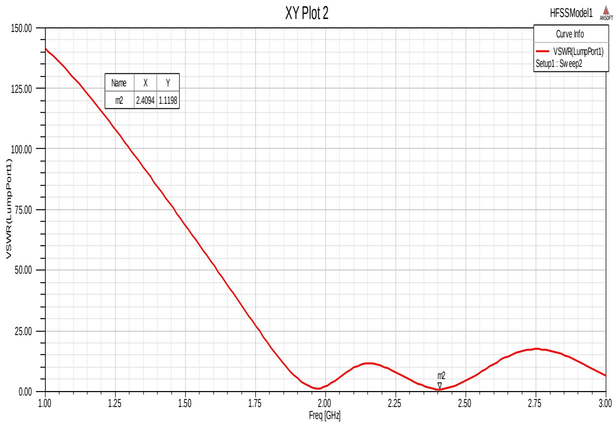

Figure 13: VSWR graph of RMSA RT Duroid

VI.II. Result of Microstrip Feed for Different Substrates at 2.4 GHz frequency

Substrate	Resonant Freq(s) [GHz]	VSWR	BW (MHz)	Gain (dB)	Impedance R+jX
FR4	2.40	1.631	71	0.330	32.75+j9.54
Rogers RO4350	2.40	1.916	49.1	1.732	34.96-j22.89
Taconic TLE	2.40	1.340	66.3	2.874	37.29-j0.124
RT Duroid 5880	2.40	1.198	73.5	3.323	44.79+j1.258

VII. Conclusion

Rogers RT Duroid 5880 is the best among the 4 substrates chosen as it has lowest loss tangent

Rogers RT Duroid 5880 gives best result in comparison to all the 4 substrates for microstrip feed.

microstrip feed as a better match is achieved resulting in better BW and gain.

References:

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