

Comparative Study of Microstrip Patch Antenna For Probe Feed Line and Different Substrate

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Abstract— This paper describes probe 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 Probe feed technique 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.

Keywords— 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 various feeding techniques 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.

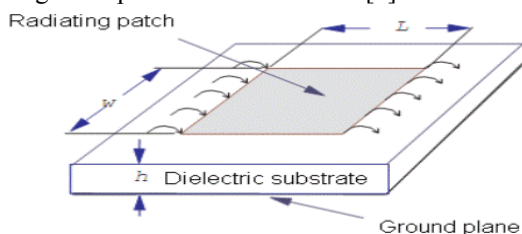


Figure 1: Structure of Microstrip Patch Antenna

III. PROBE/COAXIAL FEED

The Coaxial feed or probe feed is a very common or popular 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; the outer conductor is connected to the ground plane. The good advantage of this type of feeding technique is that the feed can be placed at any desired location inside the patch to perfect match with its input impedance. Also, the main disadvantage 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. It is seen above that for a thick dielectric substrate, which provides broad bandwidth.

IV. DIFFERENT SUBSTRATE

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.

- FR4
- Rogers RO33054
- Taconic TLE
- RT Duroid

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

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

(b) Calculated effective dielectric constant

$$\epsilon_{r_{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2} \quad (2)$$

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

$$\Delta L = 0.412h \frac{(\epsilon_{r_{eff}} + 0.3) \left[\frac{W}{h} + 0.264 \right]}{(\epsilon_{r_{eff}} + 0.258) \left[\frac{W}{h} + 0.8 \right]} \quad (3)$$

(d) Calculated the patch effective length L_{eff}

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{r_{eff}}}} \quad (4)$$

(e) Calculated the patch actual length

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

(f) Calculated Wavelength

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

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

FR4 as the substrate with dielectric constant of 4.4. The rest of the basic parameters are: Resonant Frequency: $f_0 = 2.4$ GHz, Substrate Permittivity: $\epsilon_r = 4.4$ (FR4), Substrate Thickness: $h = 1.6$ mm, Loss tangent: $\tan \delta = 0.002$

ROGERS RO4350 as the substrate with dielectric constant of 3.66. The rest of the basic parameters are: Resonant Frequency: $f_0 = 2.4$ GHz, Substrate Permittivity: $\epsilon_r = 3.66$ (ROGERS RO4350), Substrate Thickness: $h = 1.6$ mm, Loss tangent: $\tan \delta = 0.004$

TACONIC TLE as the substrate with dielectric constant of 2.95. The rest of the basic parameters are: Resonant Frequency: $f_0 = 2.4$ GHz, Substrate Permittivity: $\epsilon_r = 2.95$ (TACONIC TLE), Substrate Thickness: $h = 1.6$ mm, Loss tangent: $\tan \delta = 0.0028$

RT Duroid as the substrate with dielectric constant of 2.2. The rest of the basic parameters are: Resonant Frequency: $f_0 = 2.4$ GHz, Substrate Permittivity: $\epsilon_r = 2.2$ (RT Duroid), Substrate Thickness: $h = 1.6$ mm, Loss tangent: $\tan \delta = 0.0009$ from this calculation Microstrip patch antenna design in hfss software for probe feed line and four substrate.

VI. DESIGNING

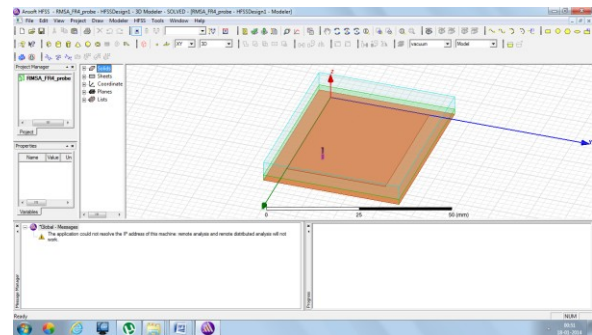


Figure 2: RMSA Design of Rogers FR4 Probe feed

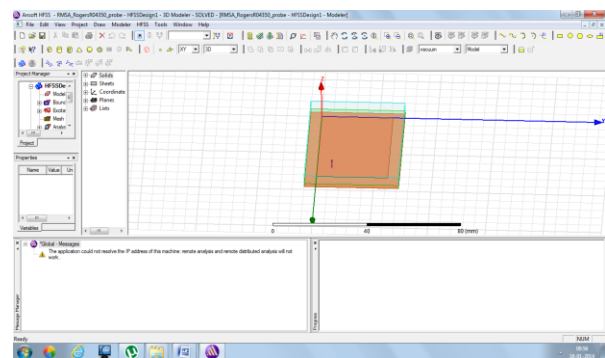


Figure 3: RMSA Design of Rogers RO4350 Probe feed

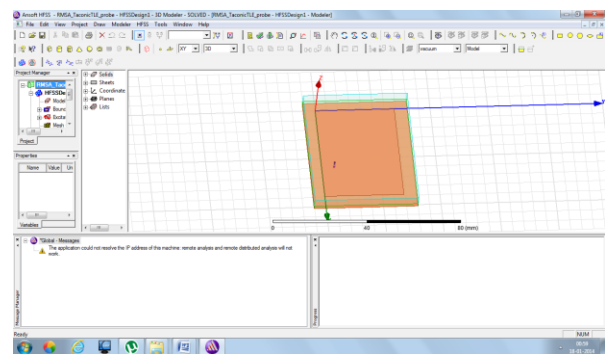


Figure 4: RMSA Design of Taconic TLE Probe feed

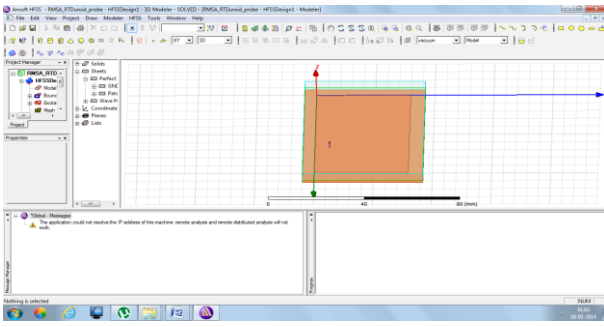


Figure 5: RMSA Design of RT Duroid Probe feed

VI. SIMULATION RESULT
 VI.1 Probe Feeding Result

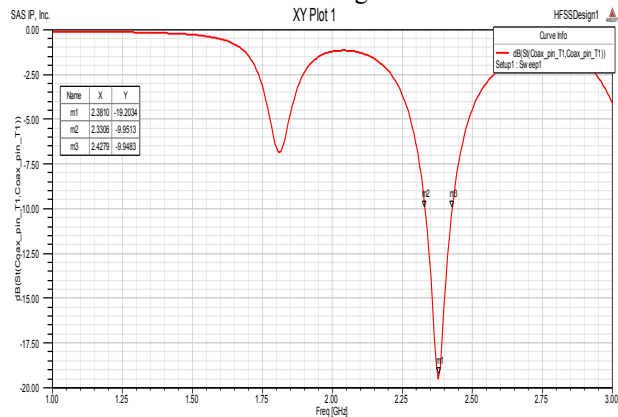


Figure 6: S11 graph of RMSA FR4

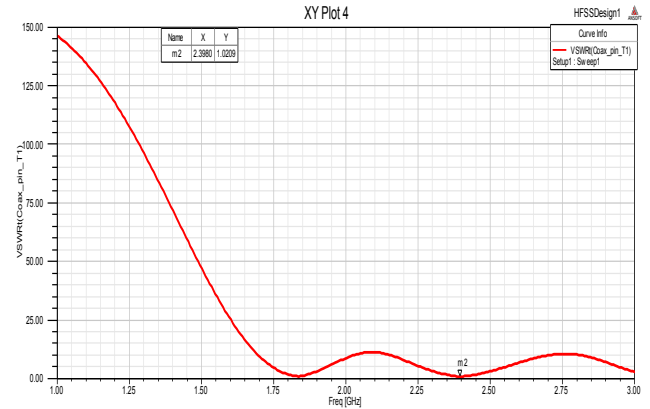


Figure 9: VSWR graph of RMSA Rogers RO435

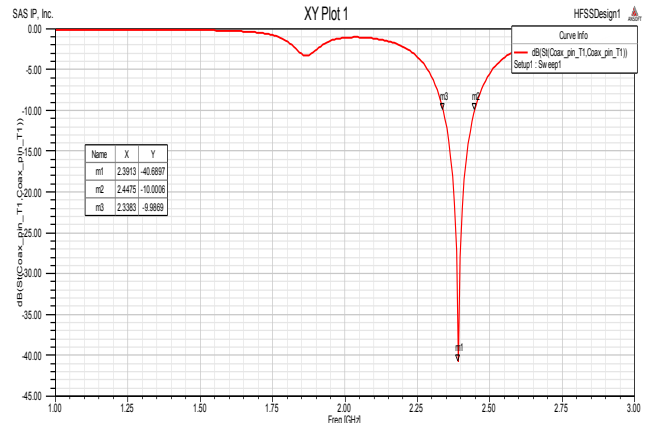


Figure 10: S11 graph of RMSA Taconic TLE

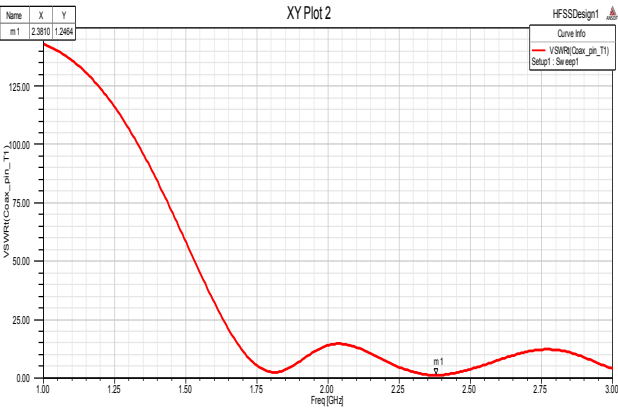


Figure 7: VSWR Graph of FR4

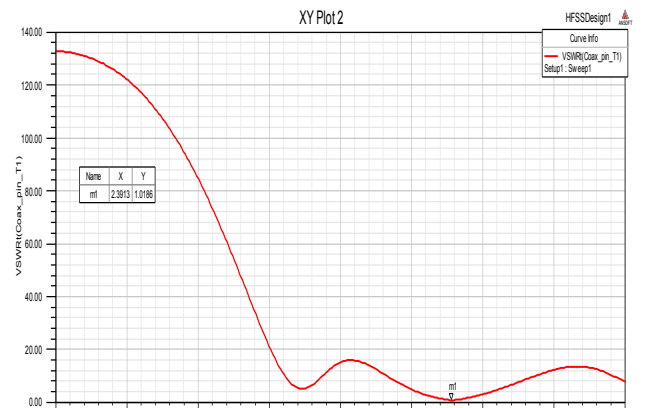


Figure 11: VSWR graph of RMSA Taconic TLE

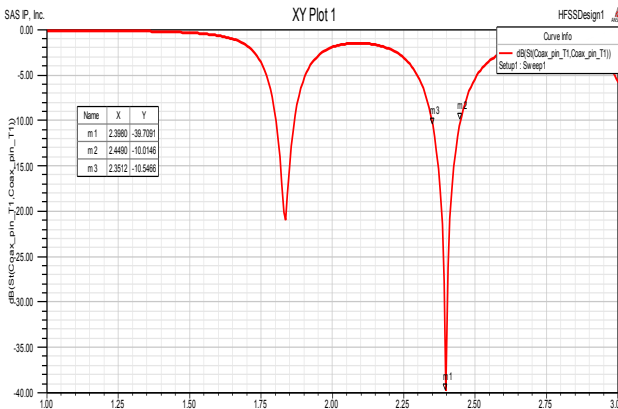


Figure 8: S11 graph of RMSA Rogers RO4350

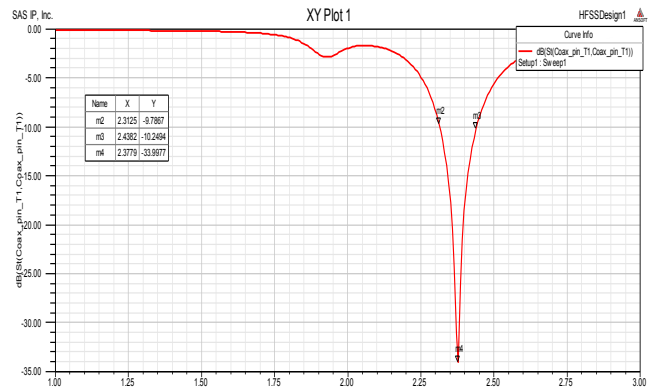


Figure 12: S11 graph of RMSA RT Duroid

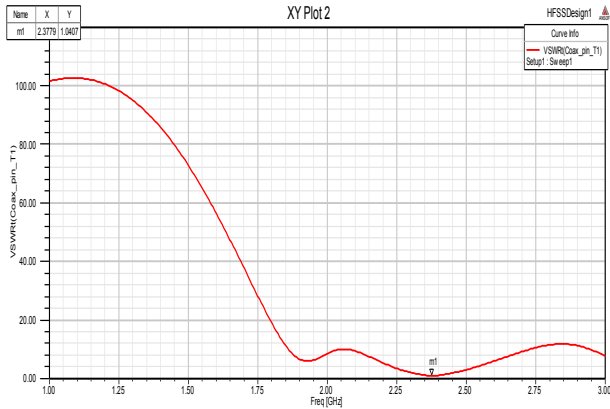


Figure 13: VSWR graph of RMSA RT Duroid

V.II Result of Probe Feed for Different Substrates at 2.4 GHz frequency.

Substrate	Resonant Freq(s) [GHz]	VS WR	BW (MHz)	Gain (dB)	Impedance R+jX
FR4_epoxy	2.40	1.426	97.3	1.32 1	35.12-j0.747
Rogers RO4350	2.40	1.045	97.8	1.58 0	49.61-j1.864
Taconic TLE	2.40	1.113	109.2	1.87 0	46.64-j3.725
RT Duroid 5880	2.40	1.294	125.7	2.03 5	39.56-j4.761

VI.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 with co-axial probe feed.

Probe/Co-axial feed is a better match is achieved resulting in better BW and gain

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