

Effect of Changing the Substrate in Multilayer Micro Strip Antenna

Nivedita S.Mahadik¹, Prof.Sheetal Bhujade²

P.G. Student, Department of ExTC, Saraswati College of Engineering, Kharghar, Maharashtra, India¹

Assistant Professor, Department of ExTC, Saraswati College of Engineering, Kharghar, Maharashtra, India²

ABSTRACT: This paper presents the effect of changing the substrate in Multi layer parasitic Micro strip Antenna at 5.8GHz . This antenna is designed by using different substrates for different layers. First layer element is made of FR4 substrate while other layers are of different substrates. Fractals are added on the top layer of antenna & it's effects are observed.

KEYWORDS: Micro strip Antenna, Rectangular Patch, Fractals, Co-axial feeding, Return Loss , Gain, Smith Chart, VSWR.

I. INTRODUCTION

Today's wireless systems requires the antennas of higher performance with small dimensions. To fulfil these requirements researchers are looking for more advanced antenna designs. Antennas which are used for these applications should be of low profile, light weight, low volume. All these requirements are overcome by using Micro strip antennas. Fractal is new class of geometry. The concept of fractal antenna came from fractals existing in nature. Antennas can be simulated by using different software's like IE3D, CST, HFSS. Antennas can be designed at different frequencies for different applications.

Generally, the structure of patch antenna consists of dielectric substrate which is on planar ground plane with radiating element on other side of substrate which is prepared with conducting materials [1]. Micro strip Antennas have several advantages & several disadvantages. These can be overcome by using different structures. Here, multilayer antenna is having three layers out of that first layer is of FR-4 substrate & top layer is of Rogers 5880. Second layer is change to examine the variations in results. For variations the materials which are used FR-4 of 1.6mm thickness & Rogers 5880 of 0.508mm thickness. These materials have been selected according to the availability in the market.

II. FRACTAL

The term Fractal means broken or irregular fragments. Each fractal is composed of multiple iterations of single geometry. It describes a complex set of geometries ranging from self similar to other irregular structure. The unique feature of fractals such as self- similarity and space filling. Here, the Sierpinski's carpet fractal geometry for rectangular shape is used. Here, the first iteration of fractal is used and its effects are studied.

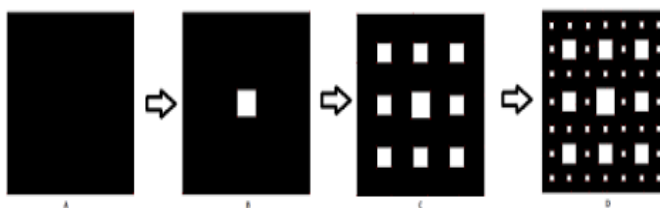


Fig 1. Geometry of Sierpinski's Carpet

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Fig 1 shows geometry Sierpinski's carpet and there is another type of geometry in fractal is Sierpinski's gasket. That is used for triangular shapes.

III. DESIGN OF RECTANGULAR PATCH ANTENNA

The Rectangular patch Micro strip antenna can be designed at frequency of 5.8 GHz. The materials which are used for this multi layer antenna are FR-4 & Rogers RT 5880.

A. Design steps at 5.8 GHz frequency:

1. Calculation of the Width (W)

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

2. Calculation of Effective Dielectric constant

(ϵ_{eff}):

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

3. Calculation of Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f \sqrt{\epsilon_{eff}}} \quad (3)$$

4. Calculation of Length Extension (ΔL):

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad (4)$$

5. Calculation of the resonant length of patch (L):

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

IV. FEEDING TECHNIQUE & SIMULATION SETUP

Feeding techniques are also important for designing the antenna. There are different types of feeding techniques for Micro strip antenna out of that co-axial feed method is adopted for this paper. The outer conductor of co-axial probe is connected to ground plane. The outer conductor is of copper while inner conductor is of Teflon. By the availability of latest simulation software, it has become very easy to implement our ideas. Here, the total size of antenna is 60mmx60mm. Total height of antenna is 8.225mm.

V. FABRICATION & TESTING

This antenna is fabricated and then tested by using VNA in laboratory. It consists of ground plane, first layer of FR-4 substrate, second and third layer are of RT- Duroid . Here, the middle layer substrate is changed & its results are observed during testing.



Fig 2. Top layer of proposed Multilayer Parasitic Antenna

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The antenna is proposed at 5.8 GHz frequency Fig.2 shows the top view of antenna after fabrication Tested and simulated results are discussed below. The size for first layer patch is 11.5mmx11.5mm.

VI. SIMULATION RESULTS

A. RETURN LOSS

Here, multilayer antenna is fabricated and simulated by using different materials. First and second layer both are of FR-4 material which is having thickness 1.6mm. While, upper layer is of RT 5880 of 0.508mm thickness. It is the parameter which indicates the amount of power that is "lost" to the load and doesn't return as a reflection. It is usually expressed as the ratio in dB relative to the transmitted signal power. Return loss is caused by impedance mismatch between two or more circuits.

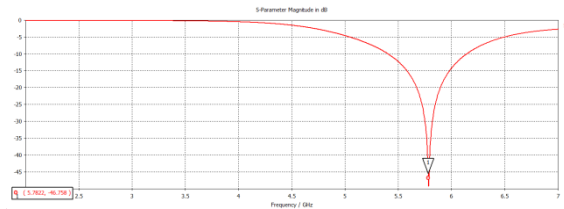


Fig.3 Return loss for Rogers 5880 in second layer

Plot of return loss is shown in Fig.3. Here, return loss is -46.75dB which is shown in Fig 3 & in FR-4 it is -36dB. The band for both is narrow band.

B. VSWR

It is the ratio between maximum voltage and minimum voltage along transmission line. Fig.4 shows VSWR value. 1.02:1 which denotes a maximum standing wave amplitude that is 1.02 times greater than the minimum standing wave value.

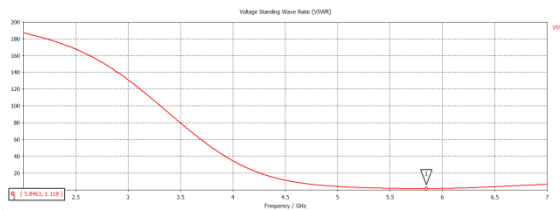


Fig 4. VSWR for Rogers 5880 substrate in second layer

By using FR-4 substrate in second layer of multilayer antenna it is 1.02 & for Rogers 5880 it is 1.11.

C. GAIN

Gain of antenna is actual realized quantity which is less than directivity due to Ohmic losses in antenna. It can also be defined as the ratio of maximum radiation intensity in given direction to the maximum radiation intensity from a reference antenna produced in the same direction with same power input.

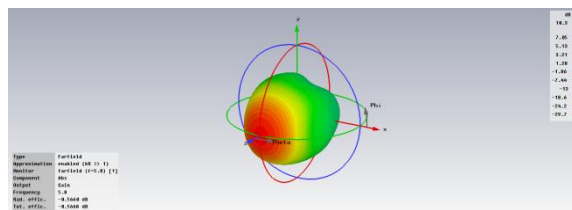


Fig 5. Gain for Rogers 5880 substrate in second layer

Here, Fig. 8 shows gain 10.26dB when second layer material is of Rogers 5880 while by using FR-4 it is 9.99dB.

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D. SMITH CHART

It is the tool of visualizing impedance of transmission line and antenna system as function of frequency. Smith chart is used to display an actual antennas impedance measured on Virtual network analyser (VNA).

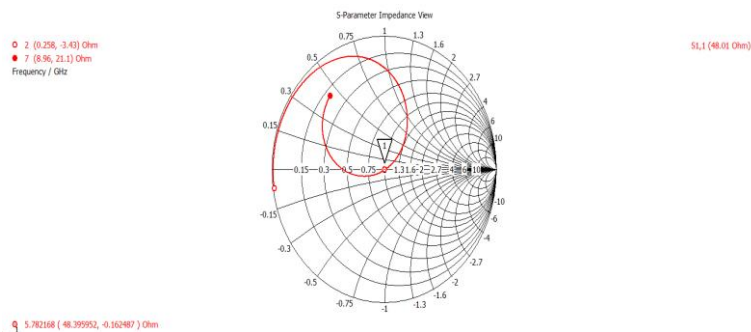


Fig 6. Smith Chart for Rogers 5880 substrate in second layer

Fig 6 shows the smith chart when Rogers 5880 substrate is used in middle layer. Fig shows 48Ω impedance during simulation which is close to 50Ω which is required.

VII. EXPERIMENTAL RESULTS

Both multilayer antennas are tested by using Virtual network analyser for 5.8GHz frequency. Here, the measured results are discussed. The antenna parameters like return loss, VSWR and smith chart are measured under free space condition.

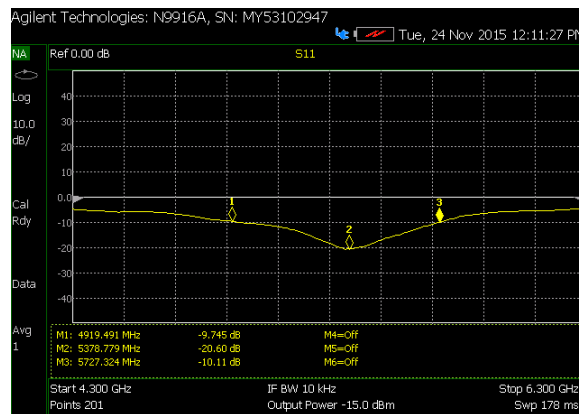


Fig 7. Return loss for multilayer antenna when second layer is of FR-4 substrate

Fig 7 shows the return loss for FR-4 substrate used for second layer. Graph shows that frequency resonates at 5.3GHz it is shifted as compared to the simulated results. Here, the return loss is -20.60dB.

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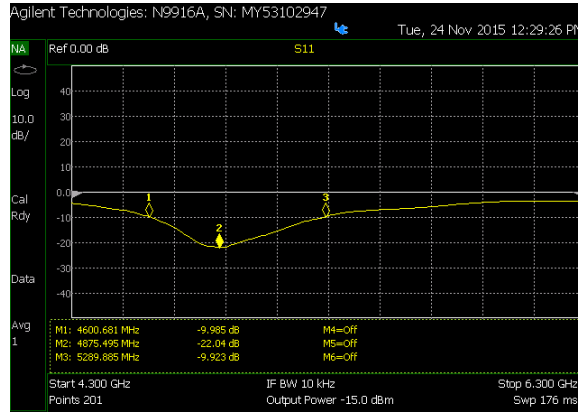


Fig 8. Return loss for multilayer antenna when second layer is of of Rogers RT5880 substrate

Fig 8 shows the return loss for Rogers 5880 substrate used for second layer here it is -22.04dB. Graph shows the centre frequency is shifted which is 4.8GHz.

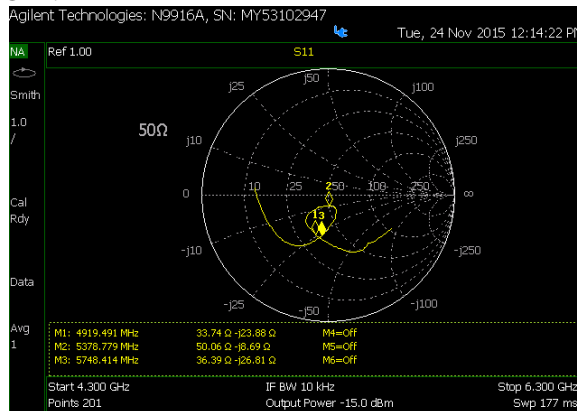


Fig 9. Smith Chart for multilayer antenna when second layer is FR-4 substrate.

Fig 9 shows the smith chart when for second layer FR-4 substrate is used. $50.06\Omega -j8.69\Omega$ shows that there is perfect impedance matching. From this it is conclude that antenna is capacitive.

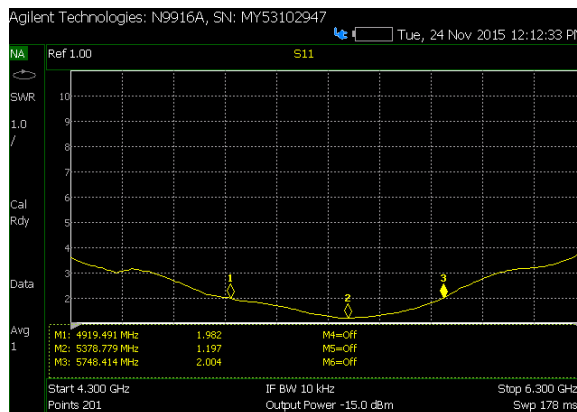


Fig 10. VSWR for multilayer antenna when second layer is of Rogers 5880 substrate

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Fig.10 shows VSWR which is 1.19 which is sufficient for any antenna. Practically, for any antenna it should be between 1-2.

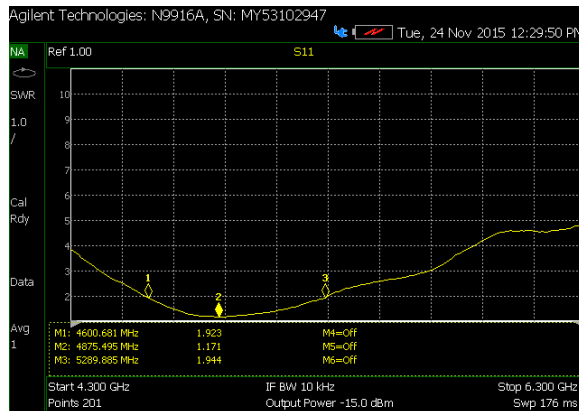


Fig 11. VSWR for multilayer antenna when second layer is of FR-4 substrate

Fig.11 shows VSWR which is 1.17 when FR-4 substrate is used in second layer of antenna at 4.8GHz frequency.

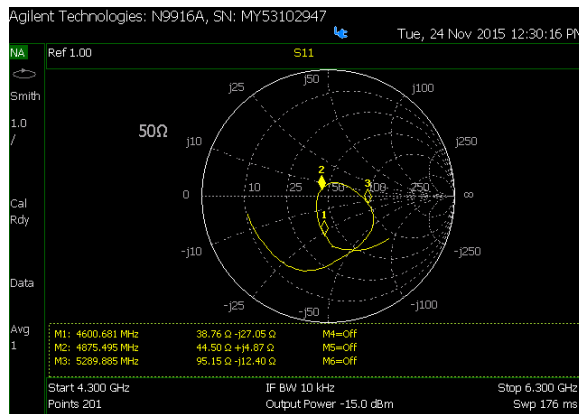


Fig 12. Smith Chart for multilayer antenna when second layer is of Rogers 5880 substrate

Fig 12 shows the smith chart from that one can conclude whether the antenna is capacitive or inductive. Equation $44.50\Omega + j 4.87\Omega$ shows the antenna is inductive.

VIII. CONCLUSION

Frequency shift is caused due to use of different substrates. Impedance of connector is kept as 50 Ohm while simulating, which benefited at the time of testing. As seen from smith chart impedance is nearly around 50 Ohm in operating band. There is change in band for simulation it is narrow while after testing it is broad band. So, bandwidth also changes. There is shift of band 5.8GHz frequency to 5.37GHz when there is use of FR-4 substrate. When Rogers 5880 is used for second layer of antenna the band is shifted from 5.8 GHz to 4.8 GHz. These small deviations from simulated results is evident due to difference in ideal simulation environment and practical lab environment. Also impurities in material, improper soldering because there was air gap while soldering etc. add up to shift in bands. These error can be minimised by using high quality tested materials, proper precautions while soldering and while testing of antenna. The antenna can be tested in standard environment like anechoic chamber testing set up. Change in substrate causes change in results due to its properties. The use of first iteration also causes the change in return loss and VSWR, but there is quite increase in gain after using fractal on the top layer of antenna.

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