Gain Improvement Techniques for Rectangular Microstrip Patch Antenna for Different Frequencies

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ABSTRACT

As we know, Microstrip antenna has limited gain, low efficiency and high return loss. All above parameters of antenna can be minimized by choosing proper substrate. While controlling of bandwidth, efficiency and radiation pattern of a rectangular patch antenna, permittivity of substrate is very crucial parameter.in this paper, comprehensive study of effects of various substrate having various thickness on performance parameters of rectangular patch antenna is studied at different frequencies using HFSS 13 tool.

Keyword – *Dielectric substrate FR4, Rectangular Patch Antenna, HFSS 13.*

1. INTRODUCTION

The expanding significance of wireless communication and multimedia services growing the efforts to the design and execution of microstrip patch structures. A patch antenna is expedient because of its low cost, small size, ease of fabrication, and can easily be integrated into many commercial transceiver systems. The microstrip patch antenna is an exceptional candidate for handy wireless devices. As Patch antenna has parameters like gain, efficiency, return loss, radiation pattern and VSWR. Gain of an antenna is vital parameter in wireless applications. Thick substrates are needed for superior antenna performance. But thick substrates have low dielectric constant. Patch size of antenna becomes less for materials having higher dielectric constant. However selection of substrate is an important part while designing an antenna [1].A microstrip patch antenna (MPA) involves of a conducting patch of any planar or non-planar geometry on one side of a substrate with plane on other side called as a ground. It is a widespread printed resonant antenna for narrow-band microwave wireless links that require semi-hemispherical exposure. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been profoundly studied and is often recycled as elements for an array [2]. These antennas are used in Mobile and satellite communication application, Global Positioning System applications, Radio Frequency Identification (RFID), Worldwide Interoperability for Microwave Access (WiMax) etc. [2].

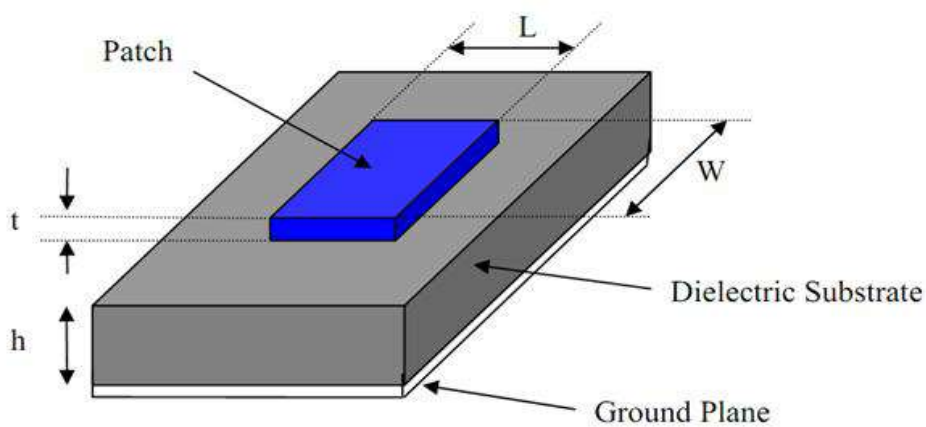

Fig1. Structure of Microstrip Antenna

2. LITERATURE REVIEW

Deschamps first projected the thought of the microstrip antenna in 1953. Nevertheless, practical antennas were industrialized by Munson and Howell in the 1970s [1,3,4]. The various advantages of MSA, such as its low weight, small volume and ease of fabrication using printed-circuit technology, led to the proposal of several conformations for innumerable applications. With growing requirements for singular and mobile communications, the mandate for smaller and low-profile antennas has conveyed the MSA to the forefront [1].

Rathi V *et al.* [5] has worked on effects of substrate thickness on antenna parameters. The designed frequency was 2.4 GHz. They have studied different properties by making changes in substrate parameters.

Chen,W *et al* [6]. has made an attempt to answer questions like i) how does the impedance of antenna changes with change in substrate thickness. ii) how does the impedance bandwidth of antenna changes with change in substrate thickness. iii) what is the effect of feed location on impedance bandwidth. Numerical results are presented to show the clear effects of each parameter.

3. ANTENNA DESIGN

In order to identify and verify the improvement for rectangular structure in microstrip antenna, the conventional Microstrip antenna design method is used [1].

Design Steps:

Designing the patch antenna is to employ the following formulas as an outline for the design procedures.

i. Width (W)

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \tag{1}$$

Where;
c - Free space velocity of light, 3 x 108 m/s
fr - frequency of operation
εr - dielectric constant

ii. Effective Dielectric constant (εreff)

$$\in \mathrm{eff} = \frac{\in r + 1}{2} + \frac{\in r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

Where;
εr - dielectric constant
h - Height of dielectric substrate
W - Width of the patch

iii. Effective Length (Leff)

$$L_{eff} = \frac{c}{2Lf_0\sqrt{\varepsilon_{reff}}} \tag{3}$$

Where;
c - Free space velocity of light, 3 x 108 m/s
fr - frequency of operation
εreff - effective dielectric constant

iv. Patch Length Extension (ΔL)

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

v. Actual Length of Patch (L)

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

4. ANTENNA MODELING

In this paper, rectangular patch antenna have been designed using HFSS13. The substrate material is FR4. Antennas are designed for different frequencies viz. 915MHz, 2.4GHz. To determine antenna measurements by conventional method we essential to offer some data like substrate thickness, its dielectric constant etc. Table No.1 Shows modeling of antenna for dissimilar frequencies using FR4 substrate having dielectric constant of 4.4.

Substrate Material	Frequency	Width (W)	Length (L)	Height(h)
FR4	915MHz	99.76mm	77.96mm	1.6mm
	2.4GHz	38.03mm	29.44mm	1.6mm

Table1. Dimensions of an Antenna with Different Substrates

5. RESULT COMPARISON

Thickness	Designed Frequency	Simulated Frequency	Antenna Gain	S11 Parameter	Thickness
FR4 (εr=4.4)	915MHz	915MHz	-2.5161dB	-20.56dB	1.6mm
	915MHz	915MHz	+01.39.dB	-20.91dB	9.0mm
	2.4GHz	2.36GHz	+0.5467dB	-17.17dB	1.6mm
	2.4GHz	2.30GHz	+01.16dB	-15.83dB	3.0mm

Table2. Result comparison of Designed Frequency and Simulated Frequency.

After modeling of antenna, the structure is simulated in HFSS 13 software and results are obtained for return loss (S11) and gain in dB.

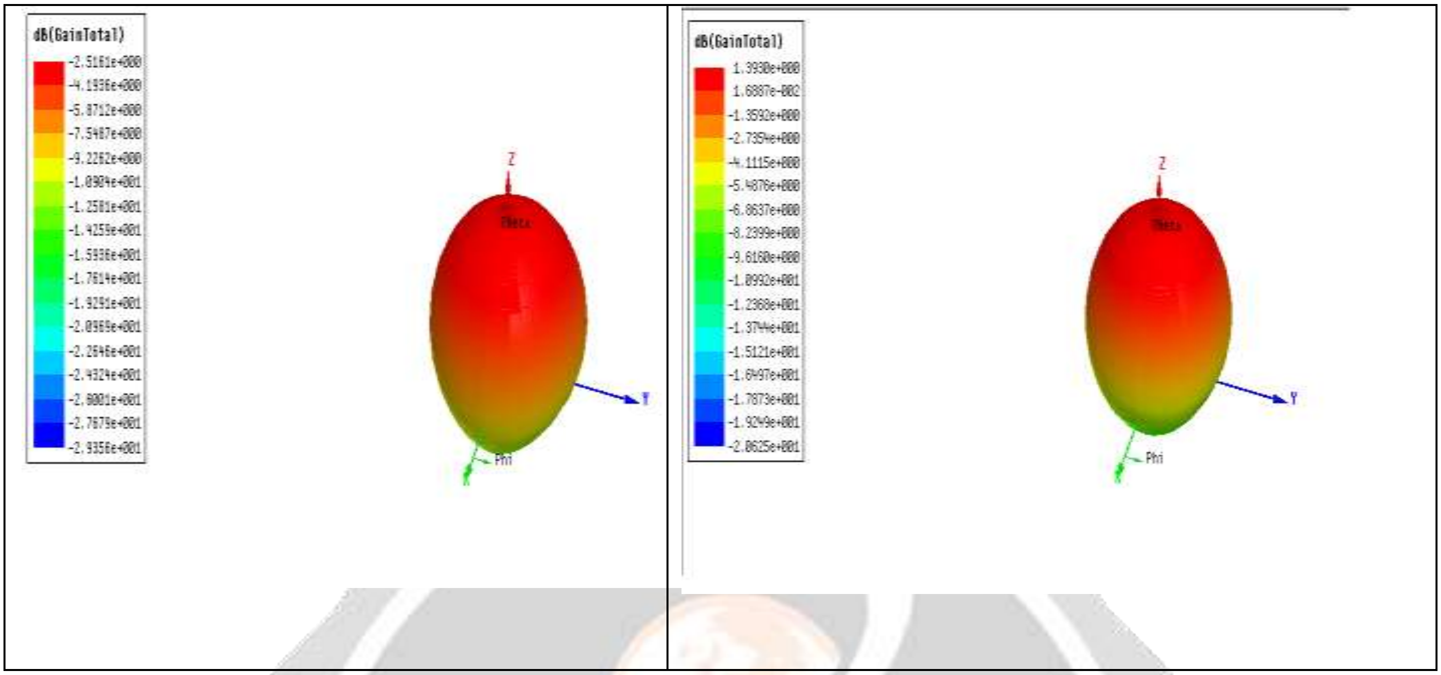

Fig2. Gain at 915MHz for 1.6mm and 9mm thickness

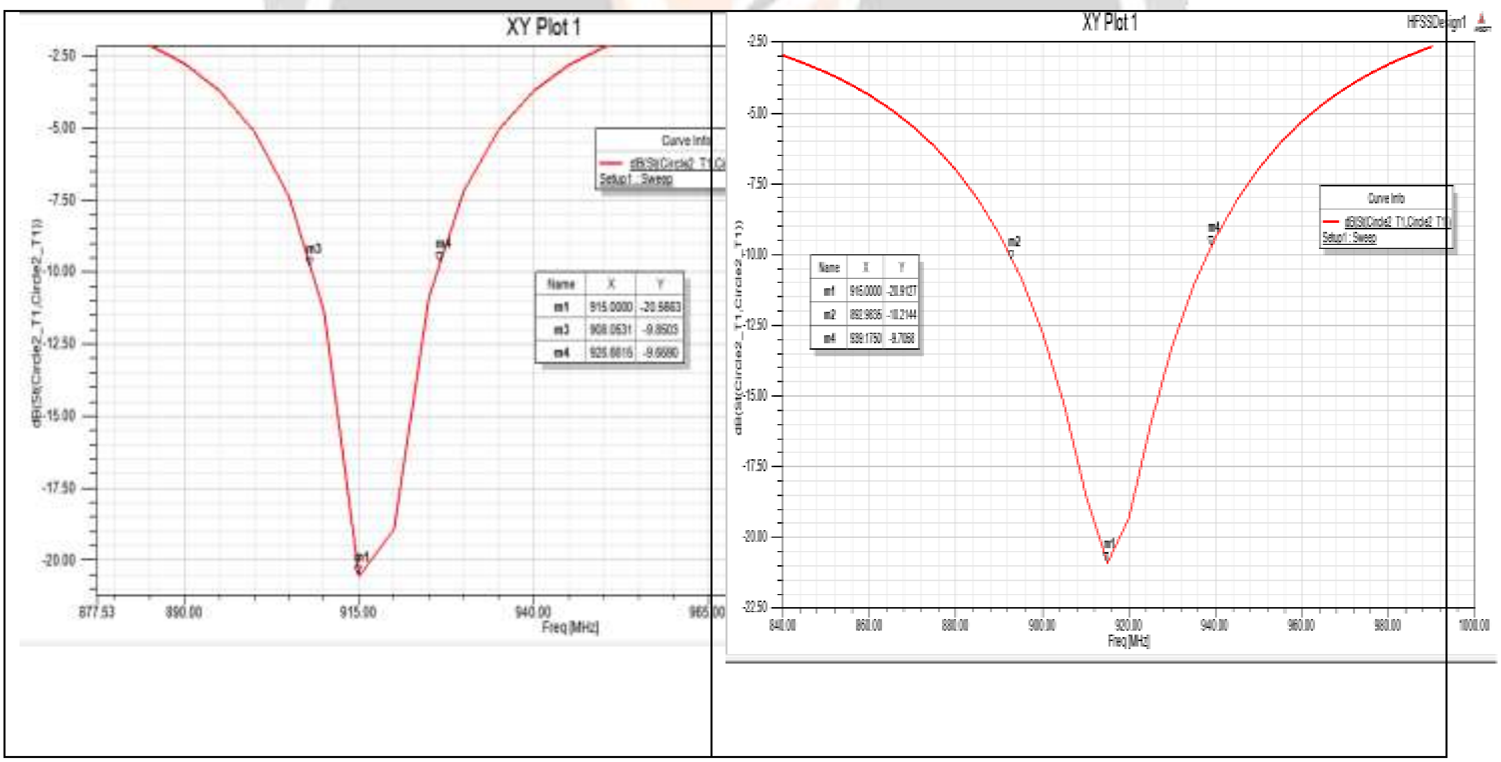

Fig3. Return Loss (S11) at 915MHz for 1.6mm and 9mm thickness

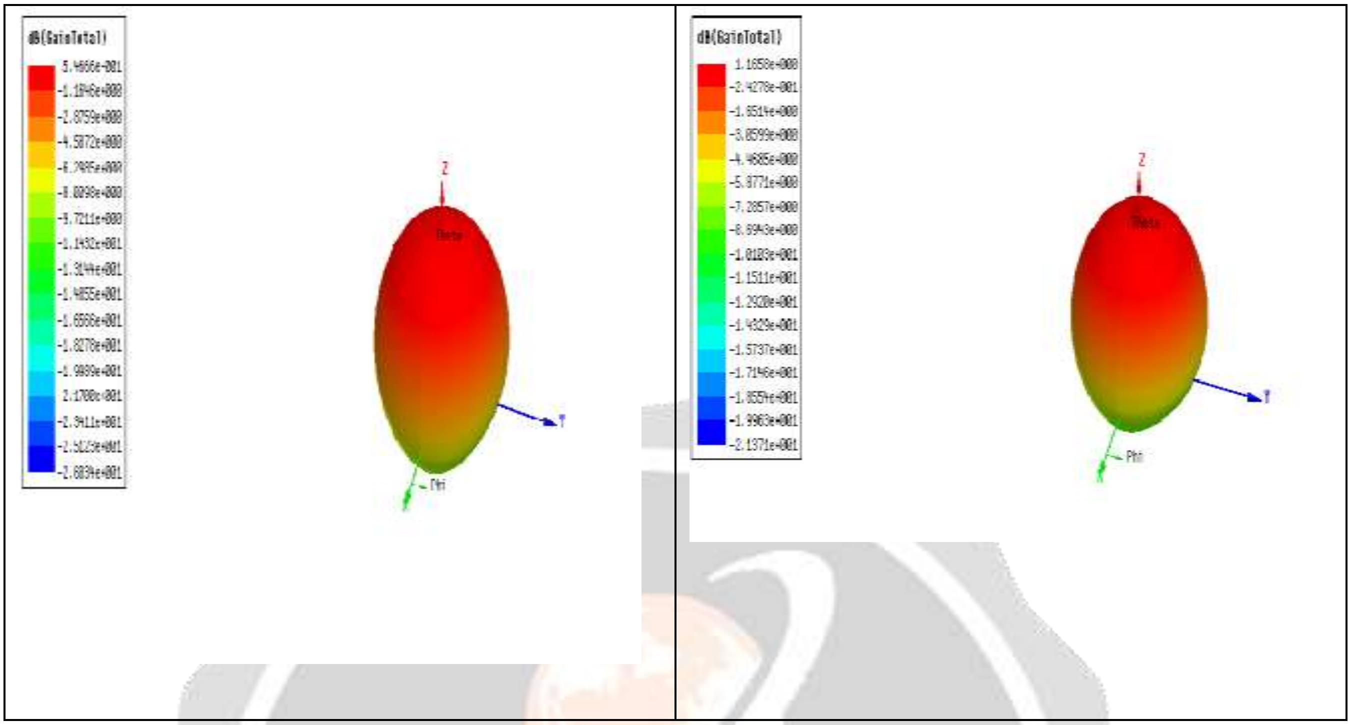

Fig4. Gain at 2.4GHz for 1.6mm and 3mm thickness

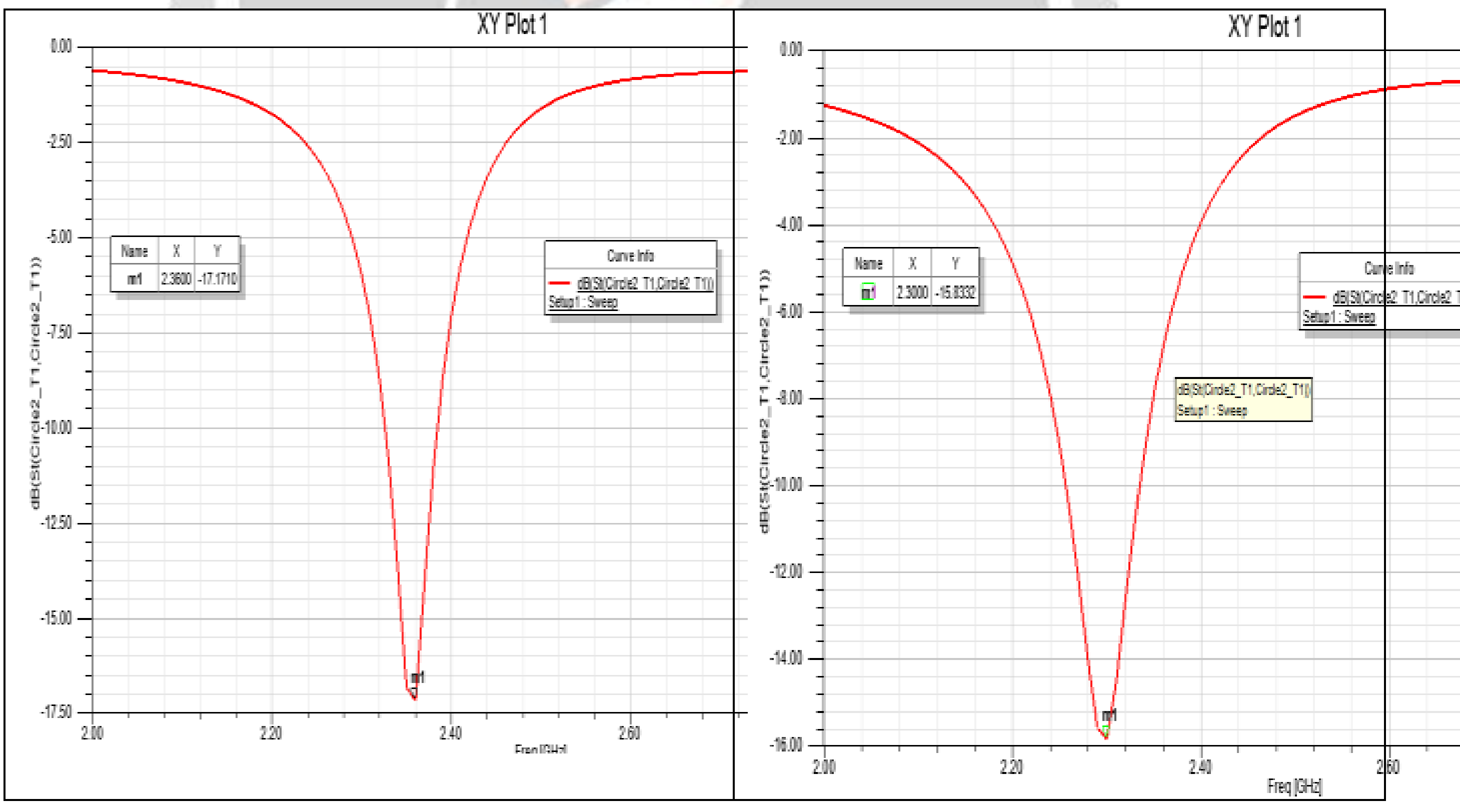

Fig5. Return Loss (S11) at 2.4GHz for 1.6mm and 3mm thickness

4. CONCLUSIONS

The enactment of microstrip antenna is predominantly depend on its construction and sizes but the substrate material shows substantial role in concert parameters such as Return Loss (S11). The rectangular patch antenna is designed for 2 different frequencies with FR4 for different thickness. The end result shows that FR4 material is somewhat appropriate for frequencies up to 4GHz. Above 4 antennas give result as gain mainly dependent upon thickness of substrate. Gain can be enhanced by increasing thickness of substrate up to considerable level.

5. REFERENCES

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