International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA USING ALUMINA AND PAPER SUBSTRATE FOR WIFI APPLICATION

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Abstract - *The content of this paper is about the design of rectangular microstrip patch antenna with the help of alumina and paper substrate at a resonant frequency of 2.4 GHz which is used for wifi application. The designed antenna is simulated by using CST Studio Suite. The antenna is designed by using alumina having dielectric constant $\in_r$=9.8 with a thickness of h=1.5 mm and paper material having dielectric constant $\in_r$=1.75 with a thickness of h=0.27 mm. The performance of the antenna having different substrates is analyzed on the basis of comparison of gain, directivity, VSWR, BW and return loss.*

***Key Words**: Patch antenna, Gain, Return Loss, VSWR, Directivity, BW.*

1. INTRODUCTION

Because of many necessities in communication system, the requirement of antenna is more. Based on type and size of the antenna is classified into three types. They are simple antenna, complex antenna and identical antenna. When we are going for higher application the size of the antenna is also large. To reduce the size and cost of the antenna microstrip patch antenna is used. Microstrip patch antenna was first introduced in the year 1950s. Microstrip patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip patch antennas are becoming very widespread within the mobile phone market. It has an advantage of less weight, simple, low cost and easy to fabricate. It has a disadvantage of narrow band and low efficiency. Various techniques are employed to overcome this disadvantage. The general requirements for designing a patch antenna is ground plane, substrate, patch. The antenna can be designed in various shapes. In this paper the antenna is designed using rectangular slot on the patch. The designed antenna with substrate alumina having dielectric constant $\in_r$=9.8 with thickness 1.5 mm and paper having dielectric constant $\in_r$=1.75 with thickness 0.27 mm. Consider the microstrip patch antenna shown in Fig -1, the patch is of length L, width W and dielectric substrate of thickness h. The frequency of operation of the patch antenna is determined by length L. The width W of the microstrip patch antenna controls the input impedance. Larger widths also can increase the bandwidth.

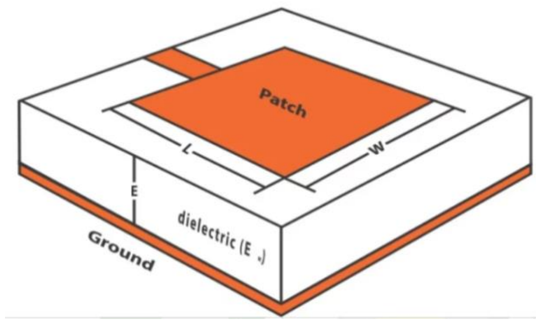

Fig -1: Microstrip patch antenna

2. DESIGN EQUATION

The designed antenna with alumina substrate having dielectric constant and thickness 9.8 and 1.5 mm. The width of the microstrip patch antenna is calculated by

$$W=\frac{c}{2fo\sqrt{\frac{\in_r+1}{2}}}$$

Where

$\in_r$= dielectric constant of the substrate,

c= velocity of light,

fo= resonant frequency,

W= width,

The width of the microstrip patch antenna is obtained as 26.89 mm after performing the calculation with an operating frequency of 2.4 GHz.

The length of the patch is given by,

$$\mathrm{L} = L_{eff} - 2\Delta L$$

L = length,

Where $L_{eff}=\frac{c}{2fo\sqrt{\in_{eff}}}$

The effective length is obtained as 21.06 mm from the above calculation.

The value of ΔL is calculated by,

$$\Delta L = 0.412h\frac{(\epsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{eff}-0.256)\left(\frac{W}{h}+0.8\right)}$$

h= height of substrate,

After performing above calculation the value of ΔL will be 0.6395 mm. The length of the patch is obtained as 19.781 mm after obtaining the values of L_{eff} and ΔL.

and $\epsilon_{eff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{w}\right)}}\right]$

The value of effective dielectric constant is obtained as 8.805 with the help of above equation.

The length and width of the ground plane is given by,

L_g=6h+L

W_g=6h+W

The above calculation is performed and the width of the ground plane is obtained as 35 mm.

3. DESIGN PARAMETER

Table -1: Dimensions of the designed rectangular microstrip patch antenna

Parameter	Types Of Substrate	
Values	Alumina	Paper
W(mm)	26.89	53.26
L(mm)	19.781	47.24
L_{eff}(mm)	21.06	47.394
ϵ_{eff}	8.805	1.739
ΔL(mm)	0.6395	0.152
L_g(mm)	28	48.86
W_g(mm)	35	54.92

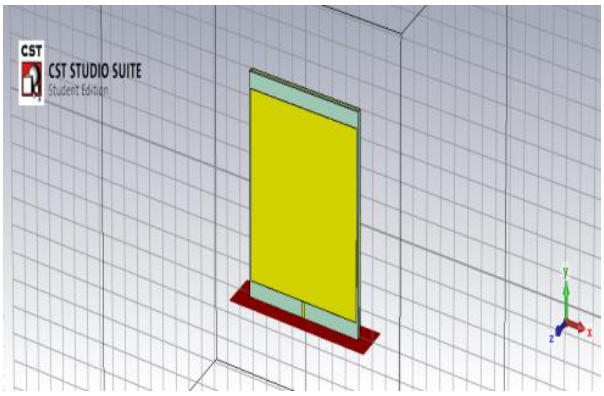

Fig -2: Geometry of rectangular microstrip patch antenna using alumina substrate.

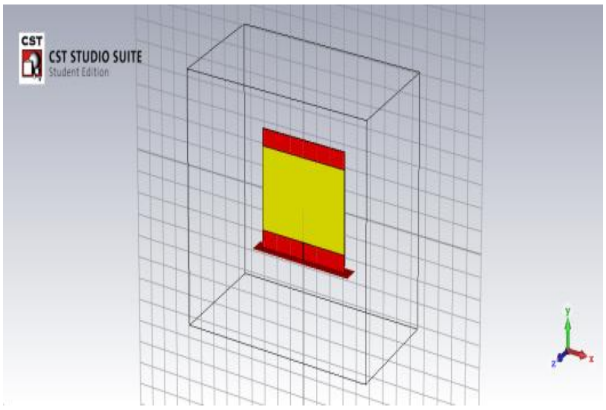

Fig -3:Geometry of rectangular microstrip patch antenna using paper substrate.

The rectangular microstrip patch antenna is simulated by using CST studio suite. The height of alumina and paper substrate is 1.5 mm and 0.27 mm and the dielectric constant of alumina and paper substrate is 9.8 and 1.75.

4. SIMULATED RESULTS

After simulation the return loss, gain, directivity and voltage standing ratios are calculated.

4.1 S Parameter

The electrical networks are characterized by S parameter or scattering parameter using matched impedances. In practice the most commonly quoted parameter in regards to antenna is S11. S11 represents how much power is reflected from the antenna hence S11 is known as reflection coefficient or return loss. If S11=0 dB then all the power is reflected from the antenna.

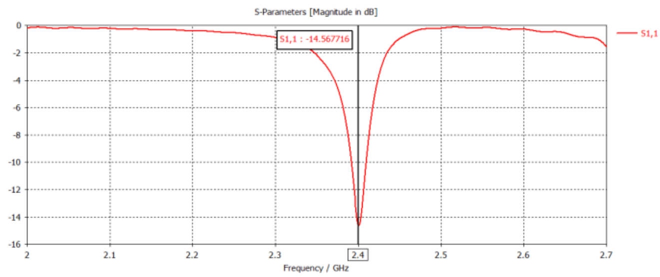

Fig -4: S11 Parameter of alumina substrate

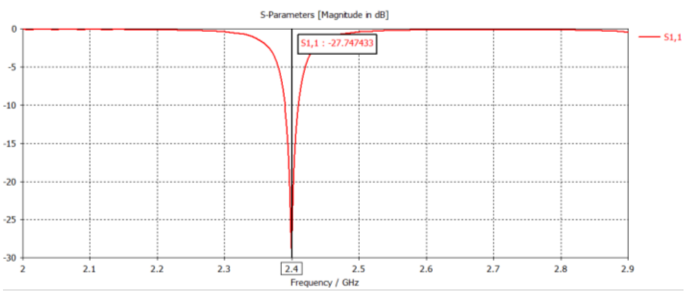

Fig -5: S11Parameter of paper substrate

The comparison of S-parameter of the antenna having two different substrate is shown in the above figure. The return loss of the antenna is minimum at 2.4 GHz. The return loss for microstrip patch antenna using alumina substrate is -14.567716 dB and paper substrate is -27.747433 dB.

4.2 Bandwidth

The Bandwidth (BW) of an antenna refers to the range of frequencies over which the antenna can operate correctly. The antenna's bandwidth is the number of Hz for which the antenna will exhibit an SWR less than 2:1. The bandwidth can also be described in terms of percentage of the center frequency of the band.

Bandwidth (BW) = Upper cut off frequency – Lower cut off frequency

The Upper and Lower cut off frequency for alumina substrate is 2.4102 GHz and 2.392 GHz. The bandwidth of the antenna using alumina substrate is calculated as 0.0182 GHz. Similarly the Upper and Lower cut off frequency for paper substrate is 2.4059 GHz and 2.3942 GHz. The bandwidth of the antenna using paper substrate is calculated as 0.0117 GHz.

4.3 Voltage Standing Wave Ratio

Voltage Standing Wave Ratio (VSWR) is a measurement that describes the impedance matching of the antenna to the radio or transmission line connected to it. Voltage standing wave ratio is also referred to as standing wave ratio.

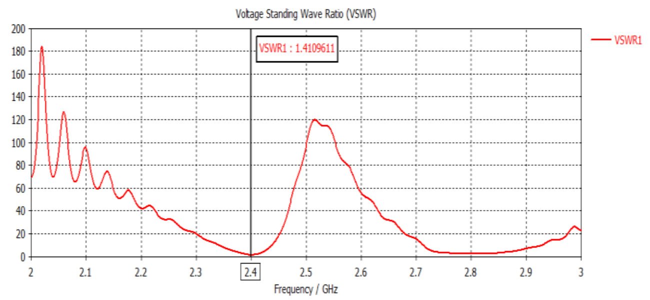

Fig -6: VSWR of alumina substrate

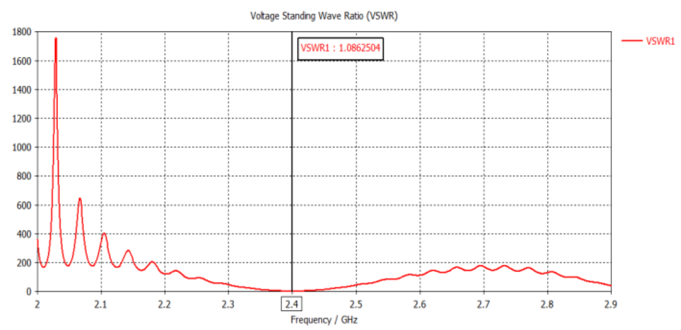

Fig -7: VSWR of paper substrate

The Voltage Standing Wave Ratio (VSWR) versus frequency graph of the designed antenna is shown in the above figure. It also shows the comparison of VSWR of antenna using alumina and paper substrate. The VSWR of antenna having alumina substrate is 1.41 and paper substrates 1.08 at 2.4 GHz.

4.4 Directivity

Directivity describes the direction of antenna's radiation pattern. If an antenna radiates equally in all direction then it has zero directionality and its directivity will be 1.

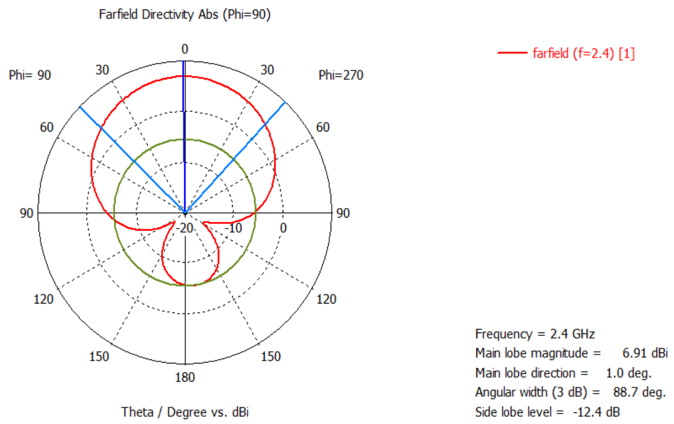

Fig -8: Directivity of alumina substrate

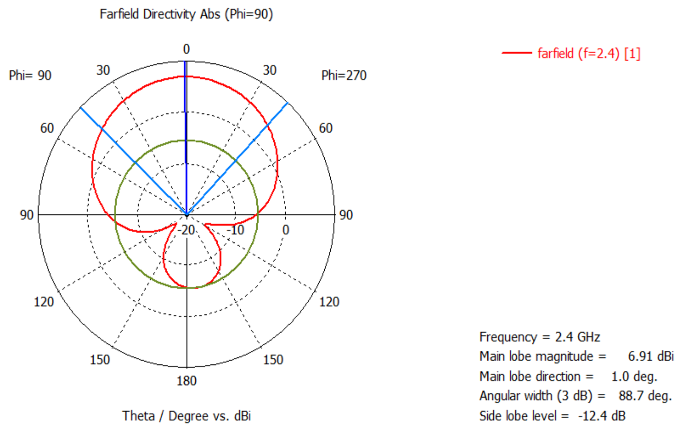

Fig -9: Directivity of paper substrate

The comparison of farfield directivity of the antenna having different substrates is shown in the above figure. The farfield directivity of antenna having alumina substrate is 4.42 dB and paper substrate is 6.91 dB at 2.4 GHz.

4.5 Gain

Gain is the conversion of input power into radio waves in a particular direction.

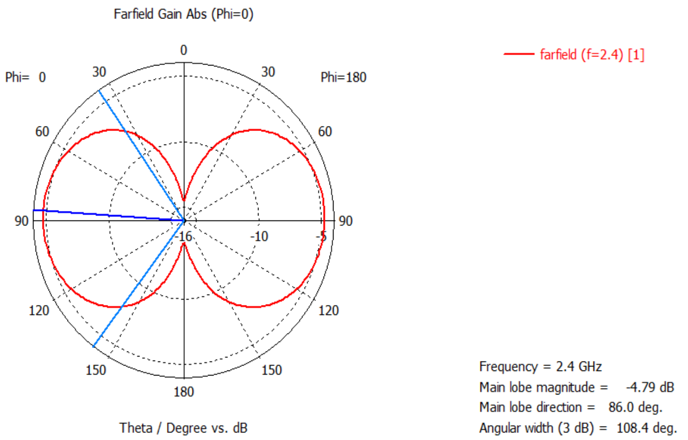

Fig -10: Gain of alumina substrate

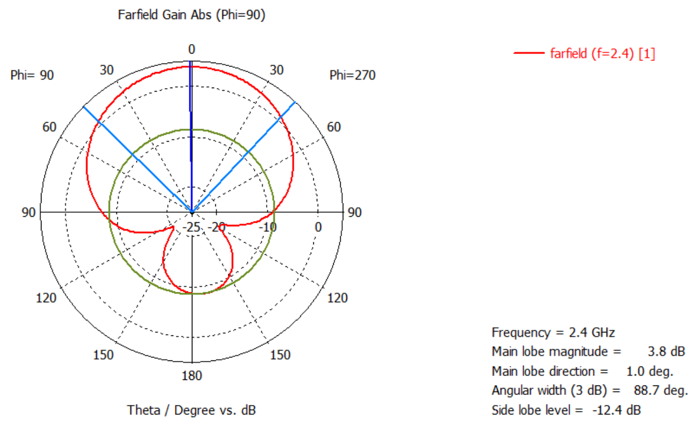

Fig -11: Gain of paper substrate

The gain of the antenna having two different substrates is shown in the above figure. The Gain of rectangular patch antenna with Alumina Substrate is observed to be 4.79dB and paper substrate is observed to be 3.8dB.

Parameter	Rectangular Patch	
Values	Alumina	Paper
Dielectric Constant(ϵ_r)	9.8	1.75
Return loss(dB)	-14.567716	-27.747433
VSWR	1.41	1.08
Gain(dB)	4.79	3.8
BW(GHz)	0.0182	0.0117
Directivity(dB)	4.42	6.91

5. Conclusion

This paper represents the design and analysis of rectangular microstrip patch antenna using two different substrates at a resonant frequency of 2.4 GHz. The simulation is done by using CST studio suite. The return loss is minimum for paper substrate compared to alumina substrate. Alumina substrate has a return loss of -14.567716 dB and paper substrate has a return loss of -27.747433 dB. The VSWR is less for paper substrate compared to alumina substrate. For higher efficiency both the gain and directivity is equal. To achieve a better result choose a substrate with minimum dielectric constant.

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