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Effect of Dielectric Cover Thickness Analysis on Rectangular Microstrip Patch Antenna in Wi-Fi Applications

Saidulu Vadtya

Abstract**:** ***This paper studies the effect of dielectric covers or superstrate with different thickness on rectangular microstrip patch antenna. The proposed antenna is designed at 2.4GHzfrequency using method of transmission line model. The dielectric covers or superstrates are providing protection to the antenna from different environmental hazards conditions. The HFSS electromagnetic simulation software is used for simulating the antenna using different dielectric superstrate covers. The different cover thickness affects is investigated on microstrip antenna and compared their performance with and without superstrates.***

Keywords**: Dielectric *Cover Thickness, Dielectric Substrates, Dielectric Superstrates, Microstrip Antenna, Resonant Frequency, Radiation Patterns, Etc.***

I. INTRODUCTION

Microstrip antenna is popularly called patch antenna which is used in high speed vehicles such as missiles and airplane, in aircraft and spacecraft, radar and military defense applications. This antenna is designed at 2.4GHz and working ISM band applications. The advantages microwave antenna over the low frequency is that increase the bandwidth and gain. These two parameters are essentials used in communications [1-4]. In this paper dielectric cover or superstrates effects are studied on rectangular patch antenna with different dielectric covers. The antenna is designed different dielectric covers and their performance is compared with and without dielectric covers or superstrates [5-14]. The designed geometry of single rectangular patch antenna without dielectric cover is shown in Fig.1. The coaxial probe fed method is used in this antenna design analysis. The characteristics and specifications of patch antenna is used in Wi-Fi applications.

II. ANTENNA DESIGN

The rectangular microstrip patch antenna is designed at the center frequency of 2.4GHz with arlon diclad 880 substrate. The dielectric constant of the substrate is 2.2, thickness of the dielectric substrate is 1.6mm and loss tangent is low which is 0.0009. The coaxial probe feed is used in this antenna design [6-9]. In the antenna design the dielectric cover material is also arlon diclad having with different thickness. The transmission line model is used for calculating all the dimensions of the patch antenna[10-14]. The equations of effective dielectric constant, the optimum patch width and length can be calculated using the equations (1-4).

$$W/H > 1 \quad (1)$$

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1 + 12\frac{H}{W}\right] - 1/2 \quad (2)$$

For width and length of antenna is calculated using the equation (2) and (4). For efficient antenna, the practical width is leads to radiation efficiency [2-8].

$$W = \frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}} = \frac{\vartheta_0}{2f_r}\sqrt{\frac{2}{\epsilon_{r+1}}} \quad (3)$$

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\mu_0\epsilon_0}} - 2\Delta \quad (4)$$

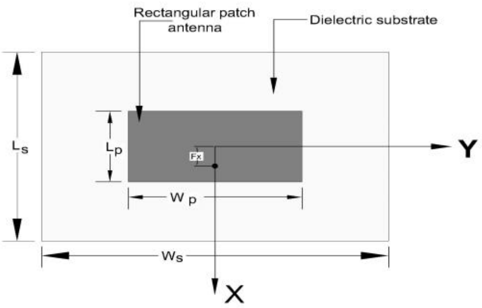

Fig 1. Microstrip Antenna

Using above the numerical equations antenna all the dimensions are calculated such as the width (Wp) =49.40 mm and length (Lp) =40.30 mm. The substrate width (Ws) =81.30mm and substrate length (Ls) =70.30mm. The antenna matched with free space impedance at the feed point (Fx=10mm and Fy =0.0mm**).**

III. MEASUREMENTS

The measurement of patch antenna without dielectric cover, the antenna resonant frequency (fr) =2.41 GHz, BW =0.203GHz and gain =7.3dB. Whereas HPBW in VP and HPBW in HP are 88.36^0 and 90.20^0. The measurement results of varying the different thickness of the dielectric cove above the patch which is shown in Table 2. The measurement results are good agreements with simulated. The antenna designed geometry is shown in Fig.1 and also measured VSWR, return loss, impedance and radiation patterns are in VP and HP shown in Figs. 2 to 7.

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The measurements of VSWR with different dielectric covers and other parameters such as gain, BW and gain other parameters are shown in Tables I and II. The antenna designed and center frequency is 2.4GHz.

Table 1: Measurement of VSWR with dielectric covers thickness

Dielectric Cover thickness in (mm)	Frequency (GHz)	VSWR
0.8	2.387417 2.4 2.403311	1.8655 1.6451 1.6367
1.3	2.387417 2.4 2.403311	1.7067 1.786 1.8429
1.5	2.37555 2.4 2.387417	1.9205 1.7332 1.6703
1	2.356071 2.4 2.369316	2.8184 1.6663 2.206
0.2	2.373289 2.4 2.387417	1.238 2.253 1.389
0.5	2.387417 2.4 2.403311	1.9083 1.6564 1.6457

Table II: Measurement of Antenna parameters with dielectric cover

Substrate Thickness	Resonant frequency (GHz)	Bandwidth (GHz)	Gain (dB)	HPBW (HP) in degree	HPBW (VP) in degree
0.2mm	2.38664	0.02671108	1.42	98.16	80.20
0.5mm	2.39536	0.0158941	0.93	99.15	74.86
0.8mm	2.39536	0.0158941	1.63	95.41	77.56
1.3mm	2.39536	0.0158941	1.83	105.33	79.72
1.5mm	2.38752	0.0249448	2.42	98.57	80.34
2.2mm	2.31243	0.021342	3.43	98.55	81.07
2.4mm	2.24321	0.014321	0.74	99.45	77.30
3.2mm	2.13434	0.023121	0.47	102.25	83.61

It is observed from the Table II, that the resonant frequency is shifted to lower side i. e to 2.38GHz for superstrate dielectric constant thickness is 0.2mm. Actually antenna designed at 2.4 GHz. Antenna with dielectric cover frequency is decreased to 2.13GHz from 2.4GHz and other parameters performance are affected with dielectric cover. The resonant frequency is decreased, gain is decreased, BW is decreased, and VSWR and return loss are increased as increasing thickness of the dielectric covers. The degrading the parameters such as VSWR, gain, BW and radiation pattern in VP and HP as shown in Table I and Table II .

IV. RESULTS AND DISCUSSION

Different thickness of dielectric covers which effects on patch antenna parameters. The resonant frequency is decreased to 2.134GHz from original designed frequency and other parameters such as BW and gain is also decreased as increasing thickness of the cover on the patch antenna. The measured BW, gain and value of VSWR is shown in Tables I and II. The gain is decreased to 0.47dB from 7.3dB. The bandwidth of microstrip patch without cover layer is 0.203GHz but with cover layer the bandwidth is obtained 0.0153 GHz to 0.0267GHz with varying different thickness. VSWR is increased as cover thickness is increased. The plot of return loss, VSWR, impedance and radiation patterns are shown in Figs 2 to 7 at different thickness of dielectric cover or superstrates.

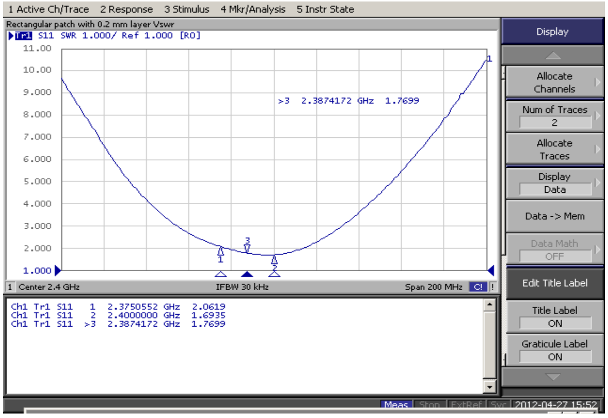

Fig.2. Measured VSWR at 0.2mm

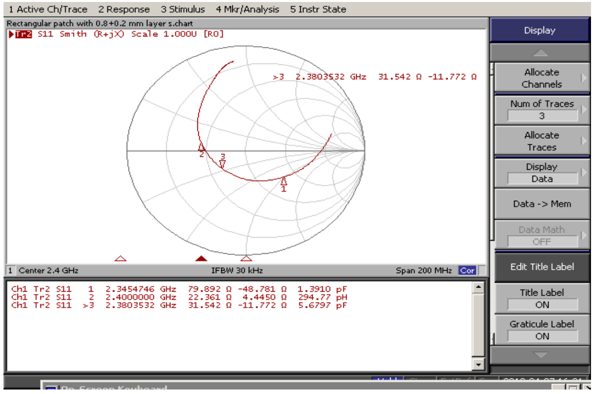

Fig 3. Antenna impedance at 1.0mm

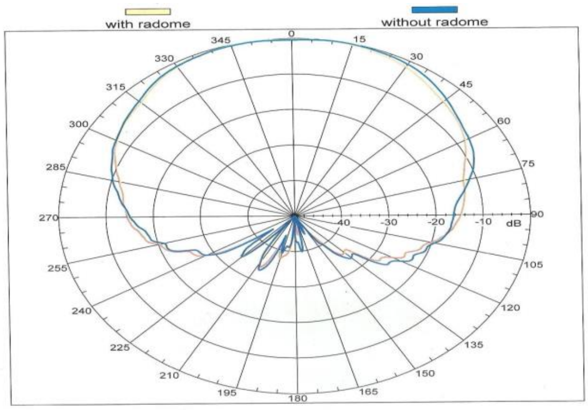

Fig 4. Dielectric cover at 1.0mm (Horizontal Polarization)

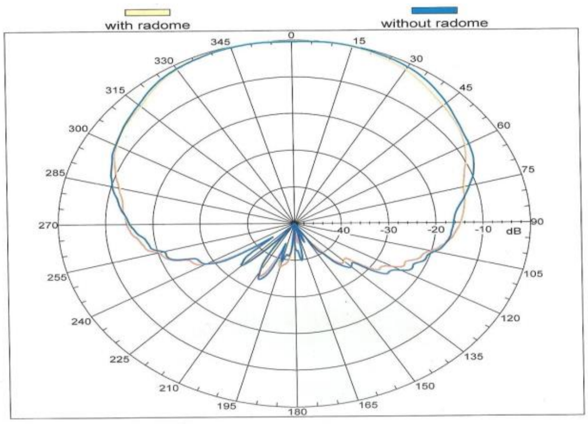

Fig 5. Dielectric cover at o.5mm (Vertical Polarization)

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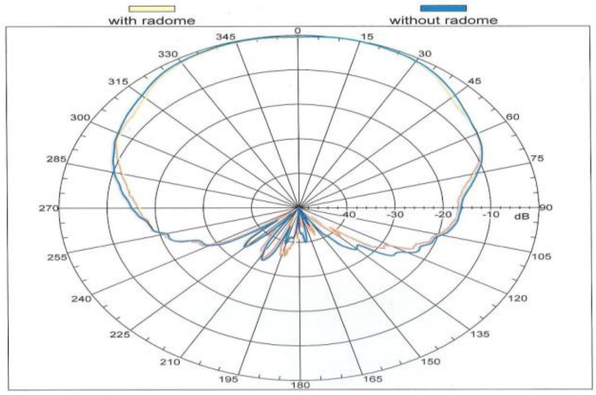

Fig 6. Dielectric cover at 2.4mm (Vertical Polarization)

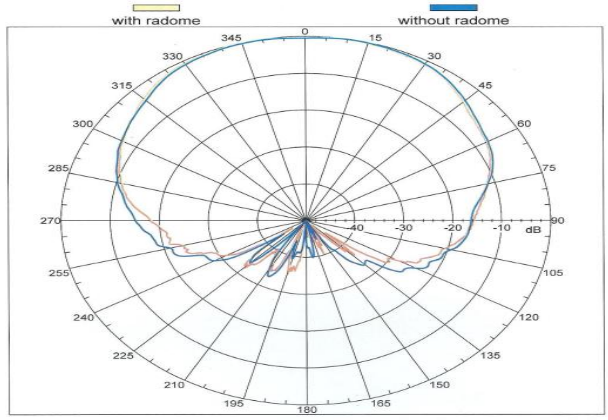

Fig 7. Dielectric cover at 3.2mm (Vertical Polarization)

V. CONCLUSION

The resonant frequency is decreased 2.13GHz from 2.4GHz, gain and BW is also decreased when increasing thickness of the dielectric cover. The rectangular patch antenna with dielectric cover layer thickness is shown in Tables 1 to 2. The antenna beam-width in E-Plane increases from 98^0 to 105^0 and beam width in H-Plane is also increased 80.20^0 to 83.61^0 as increasing thickness of the cover layer.

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Dr. V. Saidulu was born in T.S, INDIA, in 1974. He received his B.Tech in Electronics and Communication Engineering from Nagarjuna University in 1998 and M. Tech in Electronics Engineering (Microwave) from Banaras Hindu University (B.H.U), Varanasi, U.P in 2001 and Ph.D. in Electronics and Communication Engineering (Microstrip Antennas) from NTU Hyderabad in 2016. He worked as an Assistant Professor in the Department of ECE at CBIT from June 2002 to November 2004 and also worked as Assistant Professor in MGIT from November 2004 to June 2006. Currently he is working as an Associate Professor in the Dept. of ECE at MGIT since June 2006 to till date. He published 37 papers in international journals, national and international conferences. His research interests are in the area of Microstrip antennas, Wireless communications and mobile communications.

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