

# Dielectric Cover Layer Thickness Effect on Circular Microstrip Antenna Parameters

V. Saidulu



**Abstract**—This paper studies the effect of dielectric cover layer thickness on circular microstrip patch antenna parameters such as gain, bandwidth, beam-width, radiation patterns, return loss and VSWR. The proposed antenna is designed with 2.4GHz frequency in S-Band region. This operating frequency useful in ISM band applications. Circular patch antenna is designed with cavity model analysis and simulated using HFSS simulation software (Electromagnetic simulator). The coaxial probe fed is used for antenna design. In this paper the effect of dielectric cover layer on antenna parameters studied experimentally and comparing their performance characteristics. The simulation results shows that the antenna without dielectric cover layer obtained gain is 4.11dB and antenna with dielectric cover the gain is reduced to 2.87dB to 5.88dB based on thickness of the dielectric cover layer. The antenna bandwidth obtained without dielectric cover is 3% and with dielectric cover its bandwidth is reduced from 0.012GHz to 0.052GHz based on thickness of the cover layer effect. Similarly other parameters are investigated and compared. This proposed circular patch antenna is used in wireless and Wi-Fi applications.

**Keywords:** Dielectric Cover Layer, Bandwidth, Radiation Patterns, Vswr Etc.

## I. INTRODUCTION

The microstrip antenna is a microwave antenna used in microwave frequency applications [2]. The configuration and structure of microstrip patch antenna is simplest. The patch antenna geometry is consisting the radiating patch, dielectric substrate and ground plane is shown in Fig.1. The patch is fabricated with conductor materials. The patch conductor may be any shape but the conventional shapes are normally used for simplifying the analysis and performance predictions [2]. Microstrip antennas are having the several advantages over the conventional microwave antennas are low profile, planar configurations, no cavity backing is required, low fabrication cost, low scattering the cross section and patch antenna easily mounted on missiles, rockets and satellite without major alterations [1-5]. The microstrip patch antenna also having some of the limitations over the conventional microwave antennas are low gain because of loss, power handling capacity is low compare with conventional antenna and also antenna radiate into an half plane. The practical limitations of maximum gain which is around 20dB [2].

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Poor isolation between the patch and feed elements. These limitation may be overcome by using several methods and techniques. Some of the limitations may eliminate taking care during the antenna design and fabrication method. In this paper the effect of dielectric cover layer on circular microstrip patch antenna parameters studied experimentally and comparing their performance [2]. This proposed circular patch antenna is used in wireless and Wi-Fi applications at antenna designed frequency of 2.4GHz.

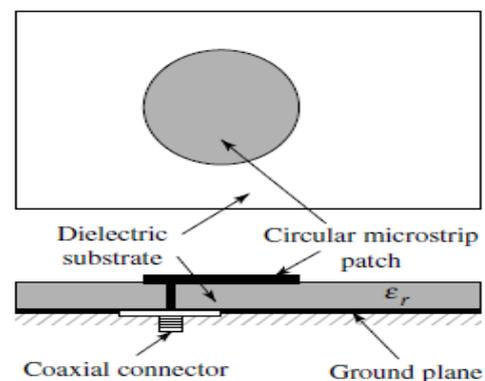


Fig1. Circular microstrip antenna

## II. SELECTION OF DIELECTRIC SUBSTRATE MATERIALS

The primary step is the selection of substrate materials for designing antenna. The low dielectric constant is better for enhance the fringing fields which account for better radiation [2-10]. The high dielectric constant is possibility of excitation of surface waves due to this effect antenna efficiency is reduced. Ideally the selection of dielectric constant materials should be low. If the substrate is more thick to improve antenna impedance bandwidth and also mechanically so strong, however it is also increase the weight and the surface wave loss. A high loss tangent materials are increases dielectric loss and antenna performance such as efficiency and gain is reduced [2-15].

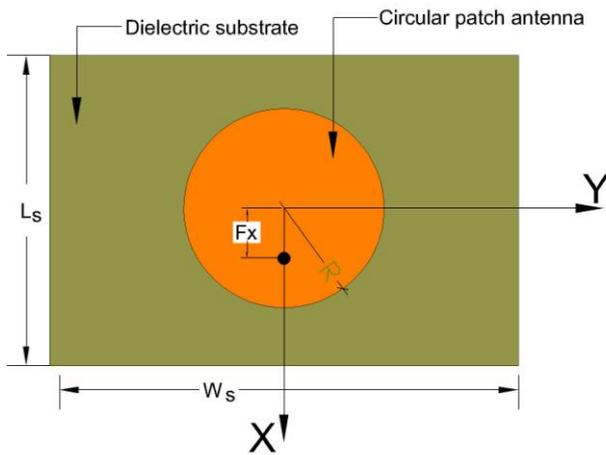
## III. CIRCULAR PATCH ANTENNA SPECIFICATIONS

The Arlon di clad 880 dielectric substrate, whose dielectric constant is 2.2, loss tangent is 0.0009 and the thickness (h) of the material is 1.6mm and the substrate dimensions are found 100mm×100mm. The antenna feed is coaxial probe and feed location is X=0mm, Y=5.5mm The substrate and dielectric cover layer (radome) materials are same specification for antenna design.



**Table 1: Circular patch antenna design specification**

Substrate material	Dielectric constant	Loss tangent	Substrate thickness (mm)
Arlon diclad 880	2.2	0.0009	1.6



**Fig.2. Circular patch antenna geometry**

**IV. CIRCULAR PATCH ANTENNA DESIGN**

Circular patch antenna designed using cavity model analysis. This model is improve the good physical insight of the patch antenna. The radius of the circular patch is calculated by using equation (1)

$$a = \frac{F}{\left\{ 1 + \frac{2h}{\pi \epsilon_r F} \left[ \ln\left(\frac{\pi F}{2h}\right) + 1.7726 \right] \right\}^{1/2}} \quad (1)$$

Where  $F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}}$

The effective radius of the circular patch is calculated by the equation (2)

$$a_e = a \left\{ 1 + \frac{2h}{\pi \epsilon_r} \left[ \ln\left(\frac{\pi a}{2h}\right) + 1.7726 \right] \right\}^{1/2} \quad (2)$$

Hence, the resonant frequency for the dominant mode is given by equation (3)

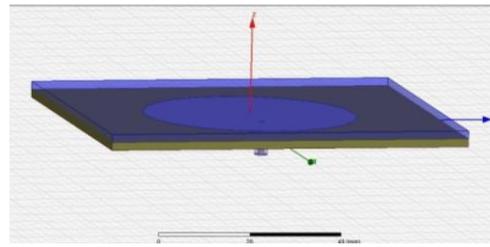
$$(f_r)_{110} = \frac{1.8412 v_o}{2\pi a_e \sqrt{\epsilon_r}} \quad (3)$$

Where \$v\_o\$ is the velocity of light in free space

The calculated theoretical dimensions are shown in Table 2. The designed circular patch (single antenna) with out cover is shown in Fig.2

**Table 2: Circular microstrip antenna design dimensions**

Type of Patch	Diameter(mm )	Feed Point(mm)
Circular patch antenna	47.1	5.5



**Fig.3. Circular microstrip Patch antenna with dielectric covers layer (radome)**

**V. CIRCULAR PATCH ANTENNA WITH DIELECTRIC COVER LAYER (RADOME)**

In this measurement, observed that the frequency will be shifted to lower side with the dielectric cover layer effect on patch antenna. Initially antenna designed frequency is 2.4 GHz (without cover layer) and with cover layer the frequency is shifted to 2.33GHz and other parameters are also affected and degrading the performance. The degrading the parameters such as VSWR, gain, BW and radiation pattern in VP and HP as shown In Table3.

**EXPERIMENTAL MEASUREMENTS**

The patch was fed through probe of 50Ω cable. The location of feed probe had been found theoretically and chosen as \$x=0, y= 5.5\text{mm}\$. Then the patch was covered with dielectric superstrate material such as Arlon Diclad 880 whose dielectric constant is 2.2, loss tangent is 0.0009 and thickness (\$h\$) is 1.6mm. The impedance characteristics were measured by means of HP 8510B network analyzer. The radiation pattern measurements were performed in the anechoic chamber by the use of automatic antenna analyzer. The setup for measurement of return loss is shown in Fig.4



**Fig.4. Setup for measurement of return loss of circular microstrip patch without dielectric cover**

**Table: 3 Measurement of antenna parameters without dielectric cover layer (radome)**

Dielectric constant	$f_0$ (GHZ)	BW (GHZ)	G (dB)	HPBW (VP) in degree	HPBW (HP) in degree
2.2	2.407	0.030	6.7	98.77	90.13

**Table 4: Measurement of circular patch antenna parameters with dielectric covers layers (radome)**

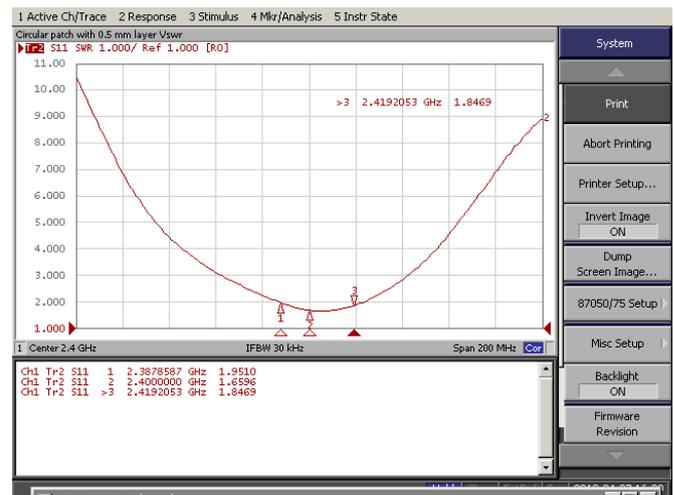
Cover layer Thickness in mm	Center frequency (GHz)	BW (GHz)	G (dB)	HPBW(HP) in degree	HPBW(VP) in degree
0.2mm	2.4096027	0.0521413	3.92	84.26	77.47
0.5mm	2.40353	0.0313	4.01	85.70	73.02
0.8mm	2.39392	0.0121	3.64	84.32	76.99
1.0mm	2.39392	0.0121	5.88	88.33	75.49
1.3mm	2.40353	0.0313	5.29	90.06	76.84
1.5mm	2.39392	0.0121	4.12	87.12	75.85
2.2mm	2.39244	0.2312	2.87	89.06	74.51
2.4mm	2.32324	0.0123	3.91	92.89	75.84
3.2mm	2.22345	0.0134	3.29	92.78	79.34

**Table 5: Measurement of circular patch antenna parameters with dielectric covers (radome)**

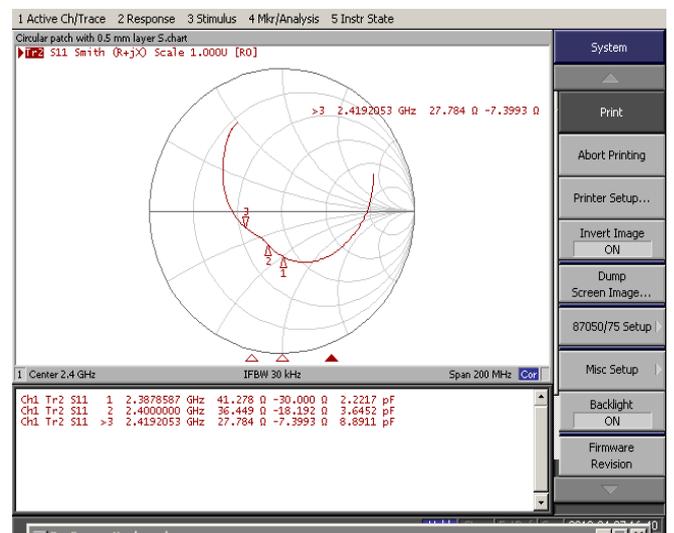
Thickness of dielectric cover	Frequency (GHz)	VSWR
0.5mm	2.387859	1.951
	1.6596	1.6596
	2.419205	1.8469
1.0mm	2.878587	1.8403
	2.4	1.6937
	2.419205	2.021
1.5mm	2.387859	1.7869
	2.4	1.8384
	2.419205	2.3557
1.3mm	2.387859	1.6824
	2.4	1.7765
	2.419205	2.4971
0.2mm	2.387859	2.3515
	2.4	1.8118
	2.419205	1.567
0.8	2.387859	3.0693
	2.4	3.8181
	2.419205	5.5812

**VI. RESULTS AND DISCUSSION**

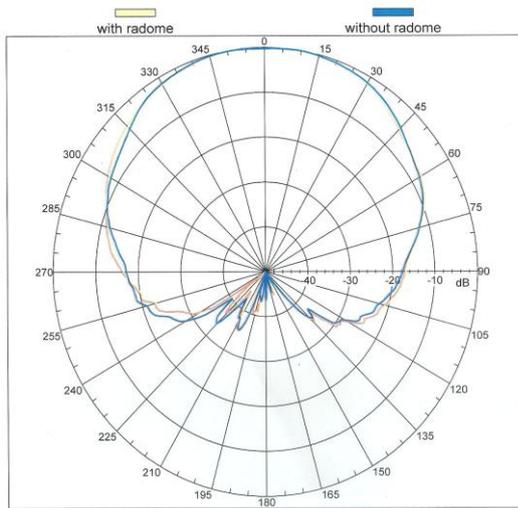
A dielectric cover layer on circular microstrip patch antenna has remarkable effects on its parameters such as gain, bandwidth, beam-width, radiation patterns, VSWR and return loss is shown in Table 3 and 4. and corresponding the measured plots which is shown Fig. 5 to 10. From the Fig. 5 to 10 and Table 3 to 4, observed the gain of the circular patch without cover layer is obtained 6.7dB and the circular patch with dielectric cover layer the gain is decreased to 2.87dB to 5.88dB based on thickness of dielectric cover. The measured bandwidth without cover is 0.30GHZ and BW is decreased to 0.012GHz to 0.0313GHz from 0.030GHz based on thickness of the cover layer when placing the above the circular patch antenna.



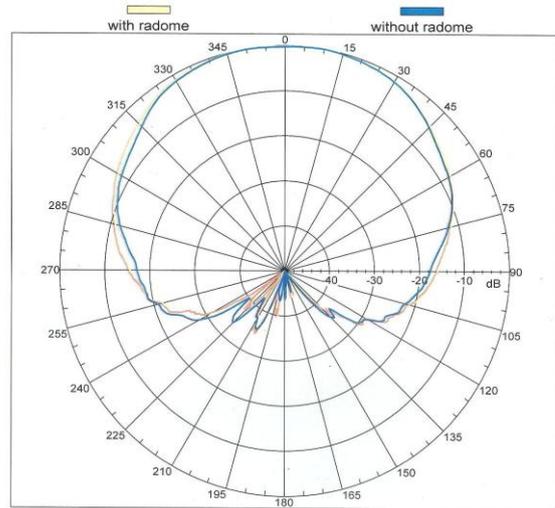
**Fig.5. Measured VSWR plot (0.5mm thickness)**



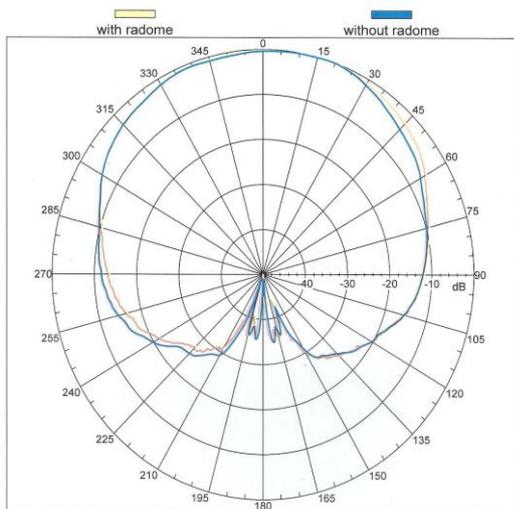
**Fig.6. Antenna impedance measurement (0.5mm thickness)**



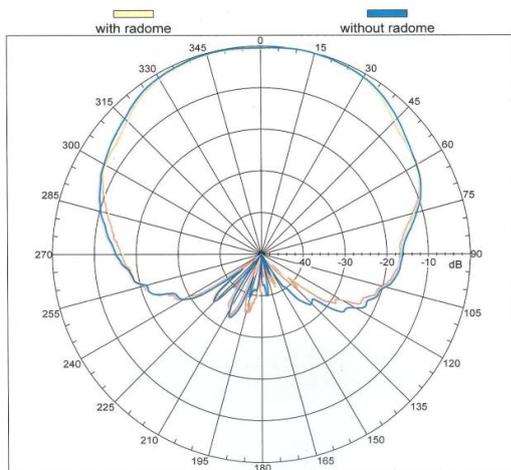
**Fig.7. Far field radiation pattern with and without cover layer (radome) at 1.0mm thickness in vertical polarization.**



**Fig. 10. Far field radiation pattern with and without radome (dielectric cover) at 3.2mm thickness in vertical polarization**



**Fig. 8. Far field radiation pattern with and without cover layer ( radome) at 1.0mm thickness in horizontal polarization**



**Fig 9. Far field radiation pattern with and without cover layer (radome) at 2.4mm thickness in vertical polarization**

## VII. CONCLUSION

The measured result observed from Table 3 to 5 and corresponding the VSWR, return loss and radiation pattern plots which is shown in Fig. 5 to 10, Which shows that the variation of VSWR with the thickness of the dielectric constant as thickness increases increase the VSWR, gain decreases as increasing the thickness of the dielectric cover (radome). Bandwidth of microstrip antenna increases as the increasing thickness of the dielectric constant. Initially the return loss increases with increasing thickness of dielectric dielectric cover and then decreases. The antenna beam-width in E-Plane increases from 84.26 degree to 92.78 degree and beam width in H-Plane increases from 77.47 degree to 79.34degree with variation of dielectric cover layer thickness on circular patch antenna. Increasing thickness of the dielectric cover layer for low dielectric constant materials, and decreases for high dielectric constant of the substrate materials.

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**Dr. V. Saidulu**, was in Hyderabad, T.S, INDIA, in 1974. He received his B.Tech in ECE, in the year 1998 and M.Tech. in ECE in the year 2001 from Institute of Technology Banaras Hindu University, U.P He received his Ph.D degree from JNTUH, Hyderabad. Currently he is working as Sr. Assistant Prof. in ECE Department, MGIT, Hyderabad. His research area is antennas and mobile communications. He has more

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