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Performance Analysis of Circular Microstrip Patch Antenna With Dielectric Superstrates

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***Abstract*: -** This paper demonstrates, the effect of dielectric superstrates on the performance of coaxial probe fed circular patch microstrip antenna with and without dielectric superstrates. The antenna can be designed at 2.4 GHz(ISM band) frequency and fabricated on Arlon diclad substrate, whose dielectric constant ($\in_r$) is 2.2. The theoretical formulation has been studied using cavity model analysis. In this paper experimentally studied the effect of dielectric superstrates on the parameters such as bandwidth, beam-width, gain and resonant frequency, input impedance, VSWR, return-loss etc. Measured results shows when placing the superstrate material above the substrate the antenna parameter will be changed and antenna resonant frequency will be shifted lower side, while other parameters have slight variation in their values. In particular, the resonant frequency increases with the dielectric constant of the superstrates. In addition, it has also been observed that return loss and VSWR increases, however bandwidth and gain decreases with the dielectric constant of the superstrates.

***Keywords:* -** *Circular Microstrip patch, Dielectric Superstrates, Resonant frequency, Bandwidth etc.*

I. INTRODUCTION

Circular patch microstrip antennas are becoming a popular for portable wireless system because they are light weight, low cost, low volume, easily manufacturable and also other characteristic such as low profile and conformable due this reason antenna can use airborne and spacecraft application. In several application circular patch microstrip antenna and arrays require a dielectric superstrate over radiating elements to provide protection from heat, rain, physically damaged and naturally formed(ice layers) during flight or severe condition[1], [2]. The antenna usually placed beneath plastic cover or protective dielectric superstrate. Such dielectric superstrate over microstrip antenna shift the resonant frequency and also slight changing the values of other parameters such as bandwidth, beam-width, gain etc. Several researchers have studied the effect of dielectric superstrate on the resonant frequency of circular microstrip patch antenna [1] - [24] with numerical method. All of this method is complex and time consuming. This paper experimentally investigated the effect of dielectric superstrates with and without on the performance characteristics of circular microstrip patch antenna such as bandwidth, beam-width, gain, resonant frequency etc. The obtained results shows that the resonant frequency will be shifted to lower side by placing superstrate above substrate, while other parameter have slight variation in their values. In particular, the resonant frequency increases with dielectric constant of the superstrates. In addition, it has also been observed that the return loss and VSWR increase, however bandwidth and gain decreases with the dielectric constant of the superstrates.

II. ANTENNA SPECIFICATION AND SELECTION OF SUBSTRATE MATERIALS

The geometry of a coaxial probe fed circular microstrip patch antenna is shown in Figure 1, Figure 2, and Figure 3. The antenna under investigation the diameter(D) of circular patch = 47.1mm, center frequency is 2.4GHz and feed point location is X=0 and Y=5.5mm is shown in Table 3, fabricated on Arlon diclad 880 dielectric substrate, whose dielectric constant($\in_{r1}$) is 2.2, loss tangent(tanδ) is 0.0009, thickness (h_1) is 1.6mm and substrate dimension is 100mm×100mm. The superstrate material can be used in the design of circular microstrip patch antenna such as (1) Arlon Diclad 880 whose dielectric constant ($\in_{r2}$) is 2.2, loss tangent (tanδ) is 0.0009 and thickness (h_2) is 1.6mm. (2) Arlon Ad 320 whose dielectric constant ($\in_{r2}$) is 3.2, loss tangent (tanδ) is 0.003 and thickness (h_2) is 3.2mm. (3) FR4 whose dielectric constant ($\in_{r2}$) is 4.8, loss tangent (tanδ) is 0.02 and thickness (h_2) is 1.6mm. (4) Arlon Ad 1000 whose dielectric constant ($\in_{r2}$) is 10.2, loss tangent (tanδ) is 0.0035 and thickness (h_2) is 0.8mm. The selection of substrate materials play important role for antenna design is shown in Table 1, Table 2. Dielectric substrate of appropriate thickness and loss tangent is chosen for designing the square patch microstrip patch antenna. A thicker substrate is mechanically strong with improved impedance bandwidth and gain [10]. However it also increases weight and surface wave losses. The dielectric constant ($\in_r$) is play an important role similar to that of the thickness of the substrate. A low value of

ϵ_r for the substrate will be increase the fringing field of the patch and thus the radiated power. A high loss tangent (tanδ) increases the dielectric loss and therefore reduce the antenna performance. The low dielectric constant materials increase efficiency, bandwidth and better for radiation.

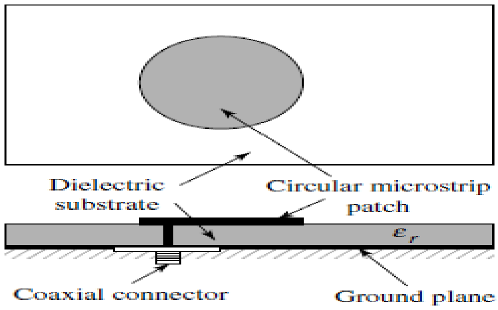

Figure 1: Circular microstrip antenna

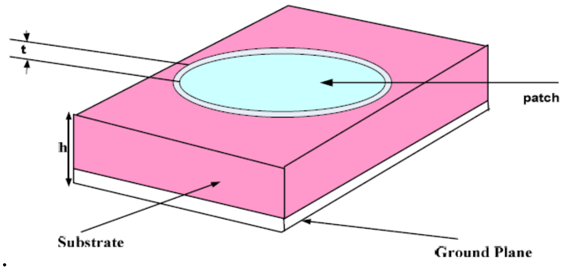

Figure 2: Structure of circular patch antenna

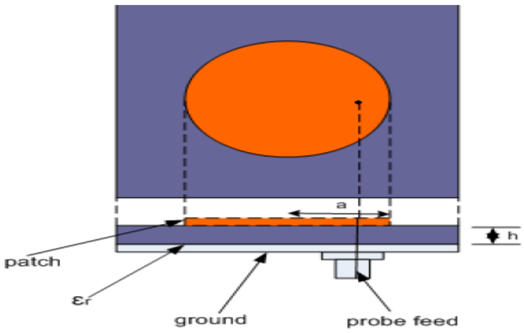

Figure 3: Circular microstrip antenna with probe feeding (8)

III. THEORITICAL FORMULATION

The circular microstrip antenna can be analyzed using cavity model in cylindrical coordinates [18]. The cavity is composed of two perfect electric conductors at top and bottom to represent the patch and the ground plane.

3.1. Electric and magnetic fields:

To find the fields with in the cavity, use the vector potential approach. For TM mode analysis need to calculate maganetic vector potential A_z . The cylindrical coordinates the homogeneous wave equation of

$$\nabla^2 A_z(\varphi, \emptyset, z) + K^2 A_z(\varphi, \emptyset, z) = 0 \qquad (1)$$

The electric and magnetic fields related to the vector potential A_z [18]

$$E_\rho = -j\frac{1}{\omega\mu\varepsilon}\frac{\partial^2 A_z}{\partial\rho\partial z},\ H_\rho = \frac{1}{\mu}\frac{1}{\rho}\frac{\partial A_z}{\partial\emptyset},\ E_\emptyset = -j\frac{1}{\omega\mu\varepsilon}\frac{1}{\rho}\frac{\partial^2 A_z}{\partial\emptyset\partial z}\quad H_\emptyset = -\frac{1}{\mu}\frac{\partial A_z}{\partial\rho}\quad E_z = -j\frac{1}{\omega\mu\varepsilon}\left(\frac{\partial^2}{\partial z^2} + K^2\right)A_z,\ H_z = 0$$

(2) Subject to the boundary conditions of

$$E_\rho(0 \le \rho^1 \le a, 0 \le \emptyset^1 \le 2\pi, z^1 = 0) = 0$$

$$E_\rho(0 \le \rho^1 \le a, 0 \le \emptyset^1 \le 2\pi, z^1 = h) = 0, H_\emptyset(0 \le \rho^1 \le a, 0 \le \emptyset^1 \le 2\pi, z^1 = h) = 0 \qquad (3)$$

The magnetic vector potential A_z reduces to [18]

$$A_z = B_{mnp} J_m(k_\rho \rho^1)[A_2 \cos(m\emptyset^1) + B_2 \sin(m\emptyset^1)]\cos(k_z z^1) \qquad (4)$$

With the constraint equation of

$$(k_\rho)^2 + (k_z)^2 = k_r^2 = \omega_r^2 \mu \epsilon \qquad (5)$$

The primed cylindrical coordinates $\rho^1, \emptyset^1, z^1$ are used to represent the fields with in the cavity while $J_m(x)$ the Bessel function of the first kind of order m, and

$$k_\rho = \chi_{mn}^1 / a \qquad (6)$$

$$k_z = \frac{p\pi}{h} \qquad (7)$$

m= 0, 1, 2… (8)

n= 1, 2, 3… (9)

p= 0, 1, 2… (10)

Inχ_{mn}^1 represents the zeros of the derivative of the Bessel function$J_m(x)$, and they determine the order of the resonant frequencies. The first four values ofχ_{mn}^1, in ascending order, are

$$\chi_{11}^1 = 1.8412$$
$$\chi_{21}^1 = 3.0542 \qquad (11)$$
$$\chi_{01}^1 = 3.8318$$
$$\chi_{31}^1 = 4.2012$$

3.2. Resonant Frequencies:

The resonant frequencies of the cavity, and thus of the microstrip antenna, are found [5] – [10]. Since for most typical microstrip antennas the substrate height is very small (typically h<0.05λ_o), the fields along z are essentially constant and are represented in (10) by p= 0 and in (7) by$k_z = 0$. Therefore the resonant freqencncies for the TM_{mn0}^z modes can be written using (5) as

$$(f_r)_{mn0} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\left(\frac{\chi_{mn}^1}{a}\right) \qquad (12)$$

Based on the values of (11), the first four modes, in ascending order, are TM_{110}^z whose resonant frequency is

$$(f_r)_{110} = \frac{1.8412}{2\pi a\sqrt{\mu\epsilon}} = \frac{1.8412}{2\pi a\sqrt{\epsilon_r}} \qquad (13)$$

Where $\vartheta_o$is the speed of light in free space.

The resonant frequency of (13) does not take into account fringing. As was shown for the rectangular patch. Fringing makes the patch look electrically larger. The circular patch a correction is introduced by using an effective radius a_e.

$$a_e = a\left\{1 + \frac{2h}{\pi a \epsilon_r}\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \qquad (14)$$

Therefore the resonant frequency of (13) for the dominant TM_{110}^zshould be modified by using (14) and expressed as

$$(f_r)_{110} = \frac{1.8412}{2\pi a\sqrt{\epsilon_r}} \qquad (15)$$

3.3. Resonant input impedance:

The input impedance of a circular patch antenna at resonance is real and the input power is independent of the feed point position along the circumference. Taking the feed as a reference point, the radial distance $\rho = \rho_o$ from the center of the patch for the dominant TM_{11} mode is [3]:

$$R_{in}(\rho^1 = \rho_o)\frac{1}{G_t}\frac{J_1^2(K\rho_O)}{J_1^2(Ka_e)} \qquad (16)$$

Since the resonant input impedance of a circular patch with coaxial probe fed is expressed as[18]:

$$R_{in}(\rho^1 = a_e) = \frac{1}{G_t} \qquad (17)$$

3.4.Fields radiated:

Applying the Equivalence principle to the circumferential wall of the cavity, the equivalent maganetic current density can be obtaind and assuming a TM_{11} mode the field distribution under the patch. Since the thickness of the substrate is very small, the filamentary maganetic current becomes[12]:

(18)

$$I_m = hM_a = \hat{a}_o 2hE_o J_1(Ka_e)\cos\emptyset$$

Using equation(5), the patch antenna can be treated as a circular loop and using the radiation equation the expression is given[3]

$$E_r = 0 \qquad (19)$$

$$E_\theta = -j\frac{K_o a_e V_o e^{-jk_o r}}{2r}\left[\cos\emptyset J_{02}^1\right] \qquad (20)$$

$E_{\emptyset} = j\frac{K_o a_e V_o e^{-jk_o r}}{2r}[cos\theta sin\emptyset J_{02}]$ (21)

IV. DESIGN OF CIRCULAR MICROSTRIP PATCH ANTENNA

Based on the cavity model formulation, a design procedure is outlined which leads to practical designs of circular microstrip antennas for the dominant TM^{z}_{110} mode. The procedure assumes that the specified information includes the dielectric constant of the substrate (ε_{r1}),the resonant frequency(f_r) and height of the substrate h.

4.1. Circular patch radius and effective radius:
Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by (Balanis, 1982)

$$a=\frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (22)$$

Where $F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}}$

Equation (1) does not take into considerations the fringing effect. Since fringing makes the patch electrically larger, the effective radius of patch is used and is given by (Balans, 1982)

$$a_e = a\left\{1+\frac{2h}{\pi\varepsilon_r}\left[ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{1/2} \quad (23)$$

Hence, the resonant frequency for the dominant TM^{z}_{110} is given by (Balanis,1982)

$$(f_r)_{110} = \frac{1.8412v_o}{2\pi a_e\sqrt{\varepsilon_r}} \quad (24)$$

Where vo is the velocity of light

V. MICROSTRIP ANTENNAS WITH DIELECTRIC SUPERSTRATE

5.1. Superstrate (radome) effects:

A circular microstrip patch may be subjected to icing or be coated with paint or other dielectric material for protection. These coatings affect performance of the microstrip antenna. In particular, the resonant frequency is lowered, causing tuning problems and severally degrading performance, which may serious, as the bandwidth of antenna is inherently low. When circular microstrip is covered with the dielectric superstrate or radome is shown in Figure 4, the characteristic impedance, phase velocity, losses, and Q factor of the line change as a function of the dielectric superstrate layer. The properties of a microstrip antenna with dielectric superstrate layer have been studied with the cavity model. The resonant frequency of a microstrip antenna covered with dielectric superstrate layer can be determined when the effective dielectric constant of the structure is known [8]. The change of the resonant frequency by placing the dielectric superstrate has been calculated using the following the expression [1].

$$\frac{\nabla f_r}{f_r} = \frac{\sqrt{\epsilon_e}-\sqrt{\epsilon_{eo}}}{\sqrt{\epsilon_e}} \quad (25)$$

If $\epsilon_e=\epsilon_{eo}+\nabla\epsilon_e$ and $\nabla\epsilon_e\leq 0.1\ \epsilon_{eo}$, then

$$\frac{\Delta f_r}{f_r} = {}^{1}/_{2}\frac{{}^{\Delta\epsilon_e}/_{\epsilon e_o}}{1+{}^{1}/_{2}{}^{\Delta\epsilon_e}/_{\epsilon e_o}}$$

Where,

ϵ_e= Effective dielectric constant with dielectric superstrte

$\epsilon\ e_o$=Effective dielectric constant without dielectric superstrate

$\Delta\epsilon_e$= Change in dielectric constant due to dielectric superstrate

Δf_r =Fractional change in resonance frequency

f_r =Resonce frequency

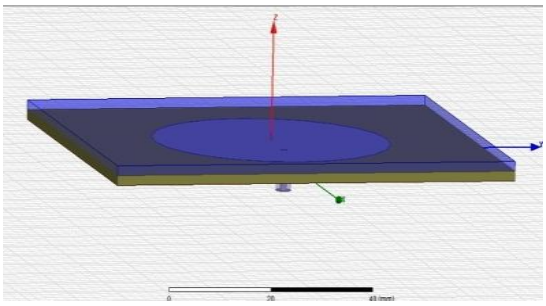

Figure 4: Circular microstrip antenna with superstrate

VI. RESULT AND ANALYSIS

6.1. Experimental measurement:

The geometrical structure under consideration of circular patch antenna prototype and superstrate material is shown in Figure 6, Figure 7, Figure 8, Figure 9. A circular patch of radius is 47.1mm on thick substrate with a dielectric constant 2.2 was fabricated. The patch was fed through probe of 50Ω cable. The location of feed probe had been found theoretically and chosen as X=0, Y= 5.5mm. Then the patch was covered with different thickness of the dielectric superstrate material such as (1) Arlon Diclad 880 whose dielectric constant (ϵ_r) is 2.2, loss tangent (tanδ) is 0.0009 and thickness (h_2) is 1.6mm. (2) Arlon Ad 320 whose dielectric constant (ϵ_r) is 3.2, loss tangent (tanδ) is 0.003 and thickness (h_2) is 3.2mm. (3) FR4 whose dielectric constant (ϵ_r) is 4.8, loss tangent (tanδ) is 0.02 and thickness (h_2) is 1.6mm. (4) Arlon Ad 1000 whose dielectric constant (ϵ_r) is 10.2, loss tangent (tanδ) is 0.0035 and thickness (h_2) is 0.8mm. The impedance characteristics were measured by means of HP 8510B network analyzer is shown in Figure 5. The radiation pattern measurements were performed in the anechoic chamber by the use of automatic antenna analyzer.

Figure 5: Fabricated microstrip antennameasurements

Figure 6: Fabricated Porto type rectangular patch with feed point location

Figure 7: Dielectric substrate (ϵ_{r1}) is 2.2 and superstrate materials(ϵ_{r2}) is 2.2

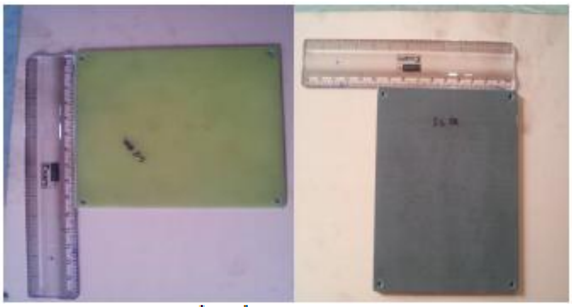

Figure 8: Dielectric superstrate(ϵ_{r2}) is 3.2 and superstrate materials(ϵ_{r2}) is 4.8

Figure 9: Dielectric superstrate(ϵ_{r2}) is 10.

VII. RESULT OF CIRCULAR PATCH ANTENNA

In order to present the design procedure of circular patch antenna achieving impedance matching for the case, the first prototype of the antenna was designed using Arlon diclad 880 substrate resonating at 2.4GHz and corresponding the results are shown in Fig. The obtained results show that the value of VSWR is 1.565 and Bandwidth is 3GHz, the Gain is 6.7dB and half power beam-width (HPBW) is 98.77^0.in HP and 90.1^0 in VP, input impedance is 60.696Ω and return loss is -15.558 is shown in Figure 10, Figure 15, however the corresponding data are tabulated is shown in Table 5, Table 7, Table 9, Table 10 and Table 12.

VIII. RESULT OF CIRCULAR PATCH ANTENNA WITH VARIOUS DIELECTRIC CONSTANTS

In order to observe the effect of dielectric supersrtrates on the antenna characteristics such as bandwidth, beam-width, gain and resonant frequency etc. The proposed antenna has been analyzed using various dielectric superstrates of dielectric constant (ϵ_{r2}) is 2.2, 3.2, 4.8, 10.2, corresponding frequency will be shifted 2.40GHz,2.32GHz,2.33GHz,2.33GHz. The obtained charactestics are shown in Fig. The Gain is varied from 1.5Db to 4.8dB,Bandwidth is varied from2.2 GHz to 3.0GHz, input impedance is varied from 35.756Ω to56.112Ω, HPBW is constant in HP i.e is $90.13^0$and in VP is varied from 70.39^0 to 79.39^0 is shown in Figure 10 to Figure 29 , however the corresponding data are tabulated in Table 6, Table 8, Table 11 and Table 12.

IX. MEASURENT ANALYSIS

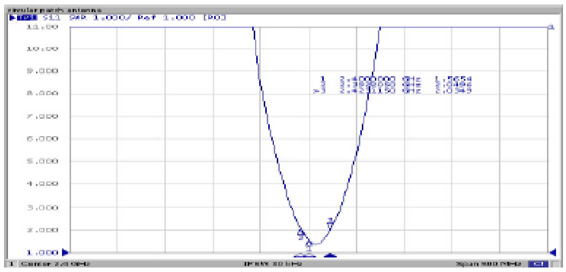

Figure 10: Experimental calculated VSWR plot without superstrate only at substrate(ϵ_{r1}) is 2.2

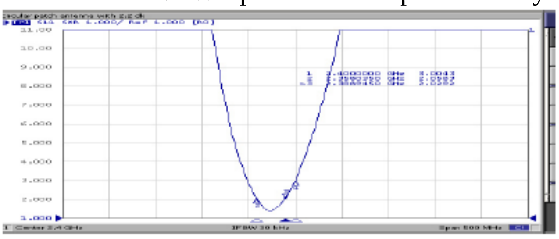

Figure 11: Experimental calculated VSWR plot with superstrate (ϵ_{r2}) is 2.2

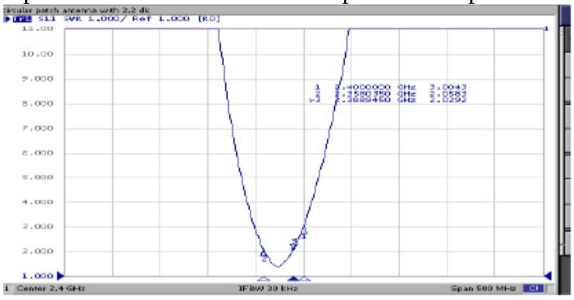

Figure 12: Experimental calculated VSWR plot with superstrate (ϵ_{r2}) is 3.2

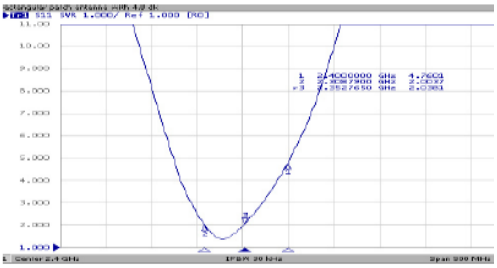

Figure 13: Experimental calculated VSWR plot with superstrate (ϵ_{r2}) is 4.8

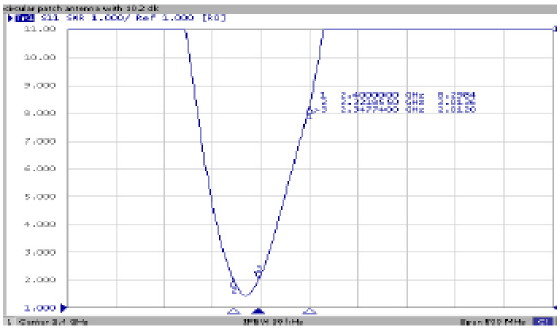

Figure 14: Experimental calculated VSWR plot with superstrate (ϵ_{r2}) is 10.2

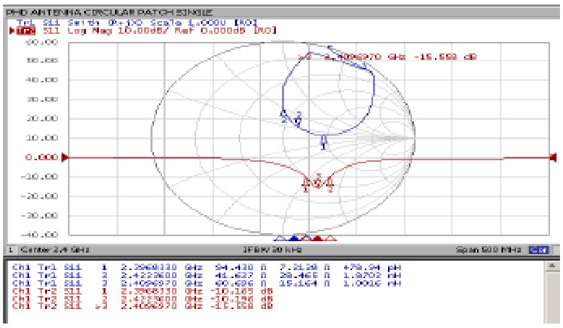

Figure 15: Experimental calculated return loss plot without superstrate only at substrate(ϵ_{r1}) is 2.2

Figure 16: Experimental calculated return loss plot with superstrate (ϵ_{r2}) is 2.2

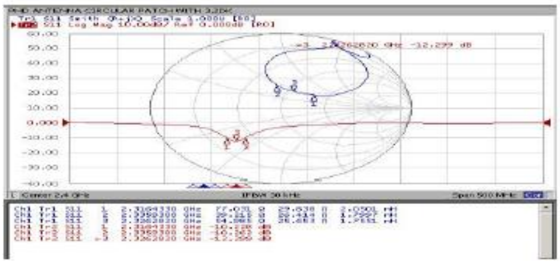

Figure 17: Experimental calculated return loss plot with superstrate (ϵ_{r2}) is 3.2

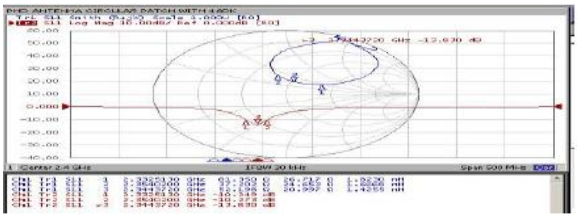

Figure 18: Experimental calculated return loss plot with superstrate (ϵ_{r2}) is 4.8

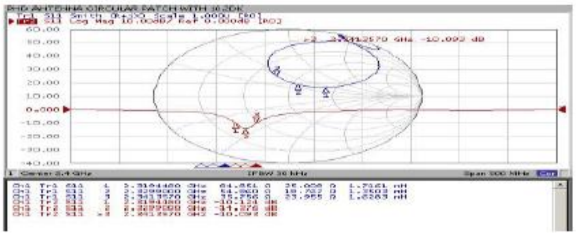

Figure 19: Experimental calculated return loss plot with superstrate (ϵ_{r2}) is 10.2

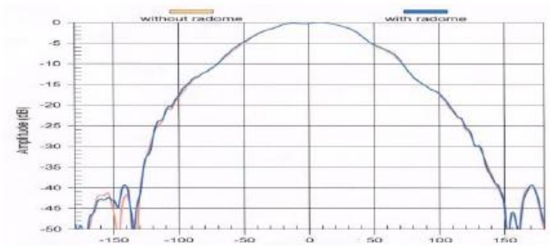

Figure 20: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot without superstrate (radome) at VP

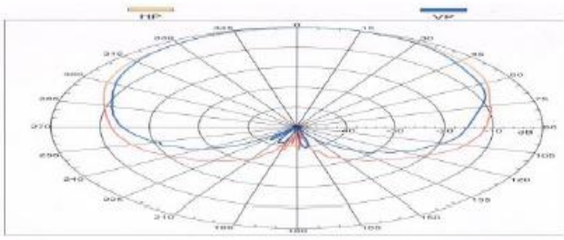

Figure 21: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot without superstrate (radome) at HP and VP

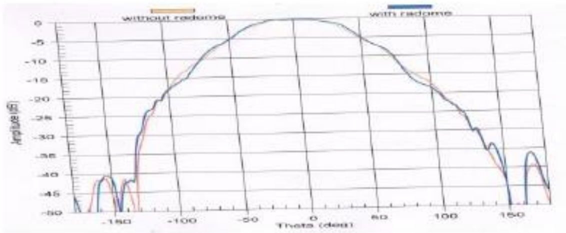

Figure 22: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at (ϵ_{r2}) is 2.2 at VP

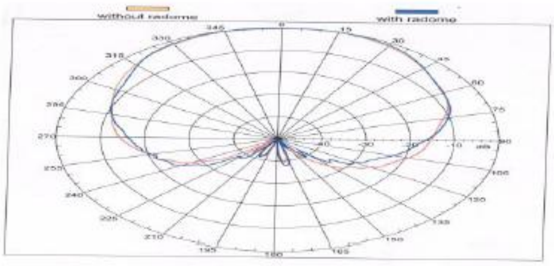

Figure 23: Exprimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at (ϵ_{r2}) is 3.2 at VP

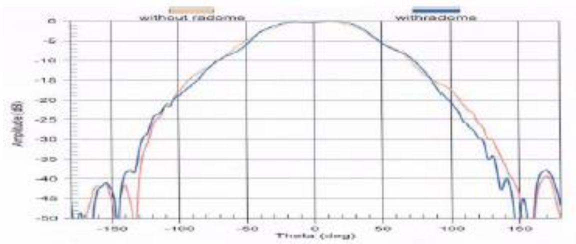

Figure 24: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at (ϵ_{r2}) is 3.2 at VP

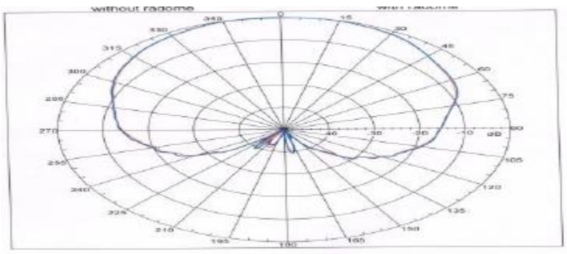

Figure 25: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at (ϵ_{r2}) is 4.8

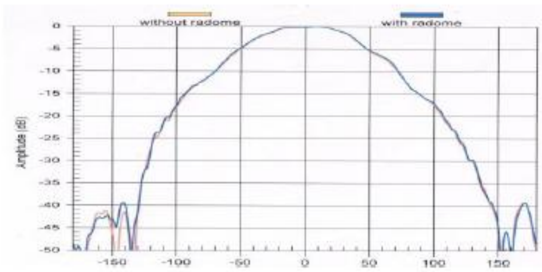

Figure 26: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at (ϵ_{r2}) is 4.8 at VP

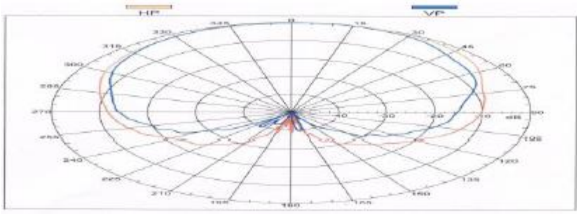

Figure 27: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate(radome) at(ϵ_{r2}) is 4.8 at VP and HP

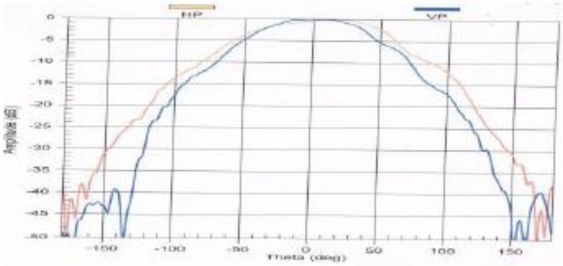

Figure 28: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at(ϵ_{r2}) is 4.8 at VP and HP

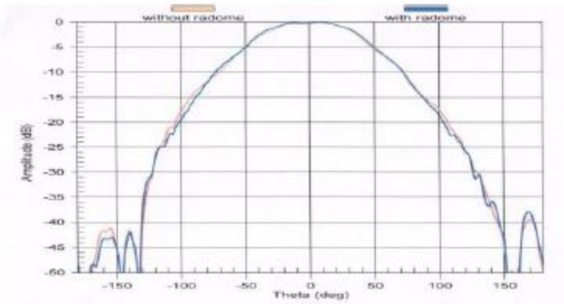

Figure 29: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at(ϵ_{r2}) is 10.2 at VP

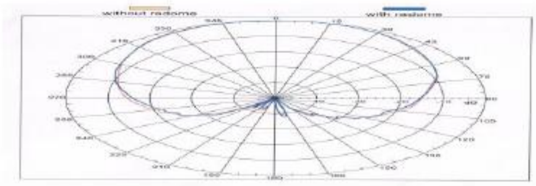

Figure 30: Experimental calculated far field amplitude of 2.4GHz radiation pattern plot with and without superstrate (radome) at(ϵ_{r2}) is 10.2 at VP

X. EXPERIMENTAL CALUCLATED DATA

TABLE 1: **Selection substrate material for designing of circular microstrip a patch antenna:**

Substrate material	Dielectric constant(ε_{r1})	Loss tangent(tanδ)	Substrate thicknes(h1), mm
Arlon diclad 880	2.2	0.0009	1.6

TABLE2: Selection superstrate material for designing of circular microstrip a patch antenna:

Superstrate Material	Dielectric Constant (ϵ_{r2})	Loss Tangent ($Tan\delta$)	Superstrate thickness (h_2),mm
Arlon diclad 880	2.2	0.0009	1.6
Arlon Ad 320	3.2	0.003	3.2
FR4	4.8	0.02	1.6
Arlo Ad 1000	10.2	0.0035	0.8

TABLE 3: Calculated Diameter and Feed point location of circular patch antenna:

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

TABLE 5: Experimental data, Bandwidth, Gain, Beam width of circular patch without superstrate:

ϵ_{r1}	(f_0),GHz	Band width,GHz	Gain (G), dB	HPBW (HP)	HPBW (VP)
2.2	**2.40766**	**0.03091**	**6.7/4.11**	**98.77**	**90.13**

TABLE6: Experimental data, Bandwidth, Gain, Beam width of circular patch with superstrate:

(ϵ_{r2})	(f_0),GHz	(BW),GHz	Gain (G), dB	HPBW (HP)	HPBW (VP
2.2	2.40766	0.03091	4.8	90.13	79.39
3.2	2.32525	0.02287	4.5	90.13	79.39
4.8	2.3398225	0.027895	1.4	90.13	70.39
10.2	2.3347975	0.025885	1.5	90.13	79.39

TABLE7: Experimental data, return-loss of circular patch without superstrate:

Substrate(ϵ_{r1})	Frequency(GHz)	Return loss(dB)
2.2	2.4096970	-15.558

TABLE8: **Experimental data, return-loss of circular patch with superstrate:**

Superstrate(ϵ_{r2})	Frequency(GHz)	Return loss(dB)
2.2	2.3775370	-16.291
3.2	2.326280	-12.299
4.8	2.344370	-13.830
10.2	2.3413570	-10.093

TABLE 9: Experimental data, VSWR of circular patch without superstrate:

Substrate(ϵ_{r1})	Frequency(GHz)	VSWR
2.2	2.4	1.5654

TABLE 10: Experimental data, VSWR of circular patch with superstrate:

Superstrate(ϵ_{r2})	Frequency(GHz)	VSWR
2.2	2.4 2.35850300 2.3889450	3.0043 2.0583 2.0292
3.2	2.4 2.3138180 2.3366850	9.7833 2.0724 1.9701
4.8	2.4 2.3258750 2.3537700	7.6515 2.0410 2.0542
10.2	2.4 2.3218550 2.347700	8.2984 2.0136 2.0120

TABLE 11: Experimental data, impedance, return-loss of circular patch with superstrate:

Substrate(ϵ_r)	Frequency(GHz)	Impedance(□)	Return loss(dB)
2.2(without)	2.40	60.696	-15.558
2.2	2.377	56.112	-16.291
3.2	2.326	54.985	-12.299
4.8	2.344	52.198	-13.830
10.2	2.341	35.756	-10.093

11. RESULTS AND DISCUSSION:

The measurement results carried out for the circular microstrip patch antenna can be designed at 2.4GHz and fabricated on Arlon ad 880 substrate, whose dielectric constant (ϵ_{r1}) is 2.2. In this paper experimentally carried out with and without dielectric superstrates on the parameter such as gain, bandwidth,beam-width, resonant frqency etc.The result obtained only microstrip patch without superstrate is gain(G) is 6.7dB, Bandwidth(BW) is 3 GHz ,half power beam-width(HPBW) is 98.77^0in horizontal polarization and 90.1^0 in vertical polarization, input impedance is60.696Ω, voltage standing wave ratio(VSWR) is 1.565 and return loss(RL) is -15.558dB.The microstrip patch with superstrates, the frequency will be shifted lower side from 2.4GHz to 2.32 GHz, Gain is varied from 1.4db to 4.8dB, the Bandwidth isvaried from 1GHz to 3GHz, VSWR is varied 2.583 to 2.013, return loss varied from -10.093 db to -16.291 dB and half power beam- width(HPBW) is constant in horizontal polarization i.e. is around $90.13^0$and beam width is increase in vertical polarization based on thickness of dielectrc superstrates i.e. from 70.39^0 to79.39^0. The highest gain is obtained at microstrip patch with dielectric superstrate, whose dielectric constant is ϵ_{r2} 2.2 at gain is 4.8dB and return loss is -16.291 dB is shown in Figure 10 to Figure 19 and corresponding data table can be tabulated is shown in Table 1 to Table 11.

XI. CONCLUSION

The design and development of circular microstrip patch antenna with and without dielectric superstrates presented. In this paper experimentally studied the effect dielectric superstrates with and without on the parameters such as bandwidth, beam-width, gain and resonant frequency etc. The result obtained only microstrip patch without superstrate is gain is 6.7dB, Bandwidth is 3 GHz,half power beam-width is 90.77^0 in horizontal polarization and 90.1^0 in vertical polarization,voltage standing wave ratio(VSWR) is 1.565, input impedance is 60.696Ω and return loss(RL) is-15.558. The microstrip patch with superstrates, the frequency will be shifted lower side from 2.4GHz to 2.32 GHz, Gain varying from 1.5dB to 4.8dB, Bandwidth varying from 2.2GHz to 3.0GHz, VSWR is varied from 2.013 to 2.583, return loss varying from -10.093db to -15.558 dB and half power beam- width is constant in horizontal polarization i.e around $90.13^0$and half power beam-width in vertical polarization is varied from 70.39^0 to 79.39^0based on the thickness of the dielectric superstraes, input impedance is varied from 35.756Ω to 56.112Ω. The highest gain is obtained at microstrip patch with dielectric superstrate , whose dielectric constant(ϵ_{r2}) is 2.2 at gain is 4.8dB and return loss is -13.635 dB is shown in Figure 10 to Figure 29 and corresponding data table can be tabulated is shown in Table 1 to Table 11. We observed experimentally results which are showing the variation of VSWR with different dielectric superstrate (radome) thickness, as dielectric superstrate thickness increases, VSWR increases. The variation of the antenna gain at different dielectric superstrate thickness as dielectric superstrate thickness increases, the gain decreases. The bandwidth of the microstrip antennas can also increases with increasing thickness of the dielectric superstrate for low dielectric constant materials, and decreases for high dielectric constant of the substrate materials. Initially the return loss increases with increasing thickness of dielectric superstrates and then decreases. The antenna beam width in vertical polarization increased from $70.39^0$to 79.39^0 and is constant at horizontal polarization is around90.13^0..

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