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High Gain Elliptical Stacked Patch Antenna

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Abstract : In this paper wideband elliptical stacked patch antenna is proposed with two elliptical patchs stacked using coplanar waveguide feed. Two frequency bands are generated from the elliptical patches,First patch is activated for the frequency 2.4 GHz and the next patch is activated for the frequency 3.7GHz. Finally the two patches are stacked to create a fine tuning frequency band of 2 to 4GHz with high gain.The sharp beam antenna is desingned for WLAN applications. The air gap between the patches are designed by a polymer based sructure. LCP films are used as substrate of the radiating patches to improve the gain and efficiecy of the antenna.The aperture coupled devices give good impedance matching for wideband applications.Simulation result of the proposed antenna shows an average gain of 6dB for the specified frequency ranges and Maximum gain nearly 9dB was achieved between 2.4-3.2GHz frequency ranges.

***Keywords* :** Aperture, CPW, elliptical, Polymer, stacked patch, substrate.

1. INTRODUCTION

Rectangular or circular microstrip patch antennas are commonly used in microwave communication transmitter and receiver with narrow band frequency. A patch antenna is normally designed by a single substrate structure with coaxial feed, It makes the probe length high and which leads the input impedance more inductive. Aperture coupling described by Mestdagh *et al*.[2] operating at 30GHz. The efficiency is low for the above mentioned structure due to the dielectric and conductor losses with in the PCB substrate.

Another issue of semi elliptic monopole slot antenna for UWB system by M.Gobikrishna *et al*. [3] has low gain of 4dB. Multiband filters with elliptical and Gaussian dielectric resonators is presented by Samuel Angel Jaramilo *et al*.[5] an elliptical structure with diamentions 80 × 80mm for 1.6GHz and 4GHz. More Elliptical patch antennas are reported for narrow band applications.High temperature fabrication process have been used previously to fabricate suspended patch antenna , which leads the fabrication process very complex and expensive silicon substrate materials[6]. Recently B.Pan *et al*.[7] introduced a micromachined polymer piller between the substrate to create an air gap, but the bandwidth of the antenna is limited only 20%.In this paper we presented stacked patch antenna with two base substrate FR4 and Taconic PTFE with dielectric constant 4.4 and 2.2 respectively. Polyimide film used as the supporting substrate of the elliptical patches.

2. ANTENNA DESIGN

The proposed antenna design equation is given below :

$$A_e = a\{1 + 2h/\pi\varepsilon_1 a[\ln(\pi a/2h) + 1.7726]\}^{1/2}$$

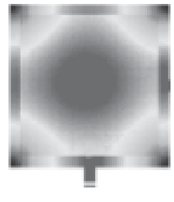

Fig. 1. Current distribution of elliptical patch

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Where *a*-actual radius, A_e – Effective radius, *h*-substrate height, ε_r – Permitivity of the substrate, The current distribution of the patch and effective area is shown in fig1.The elliptical patch1 antenna without stacking is demonstrated using microstrip feed on FR4 substrate shown in fig 2 and 3 for 2-3 GHz .The major and minor axis length of the ellipse are 19,13 mm.The total area of the patch antenna is 40 × 30 mm, the width of the strip feed *s* is 2.3mm and L1 is 15mm . Fig 4 shows the magnitude of the parameter S11 simulated by EM simualtor,It shows minimum return loss of -30dB achieved at 2.4 GHz .

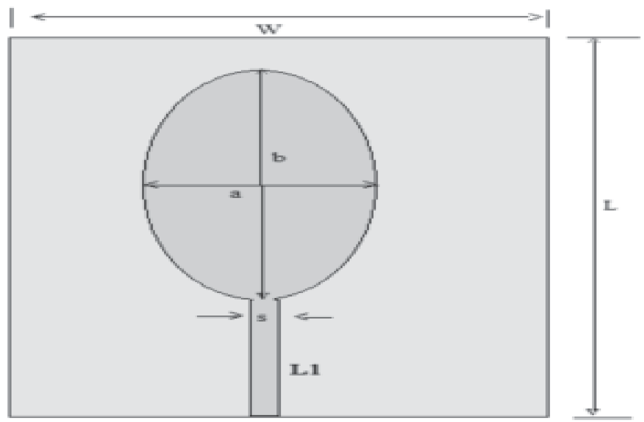

Fig. 2. Diamensions of Elliptical patch

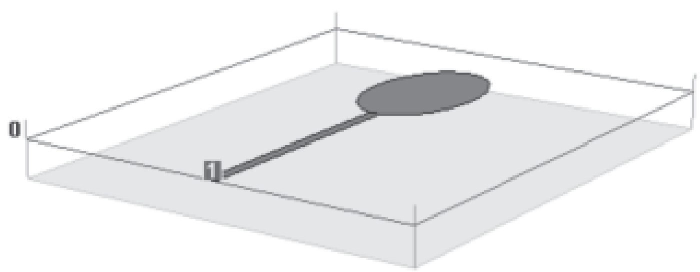

Fig. 3. Elliptical patch 1 on FR4 substrate

The next elliptical patch antenna design is proposed with major and minor axis of the ellipse are 14,10 mm for the band of frequency 3-4 GHz on FR4 substrate.

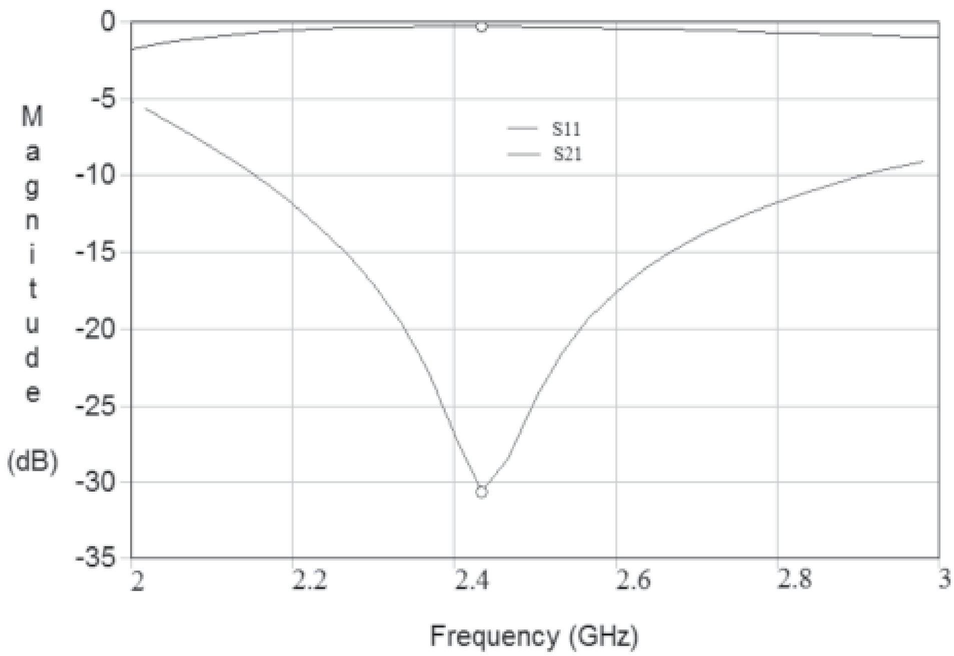

Fig. 4. S11, S21 for Elliptical patch 1

Table 1. Design Parameters of Strip Feed Elliptical Patch Antenna

Parameter	*Values*
Substrate thickness *h*	1.59mm
Loss tangent δ	0.025
Permitivityε_r	4.4
Area of the patch (LxW)	(40 × 30) mm
Major and minor axis of ellipse1(patch1)	19, 13mm
Major and minor axis of ellipse2(patch2)	14, 10mm

The width of the feeds are same in both antennas,Other common parameters are listed in the table1.The simulation result shown in Fig 5 which shows minimum return loss of -28 dB at 3.7 GHz .

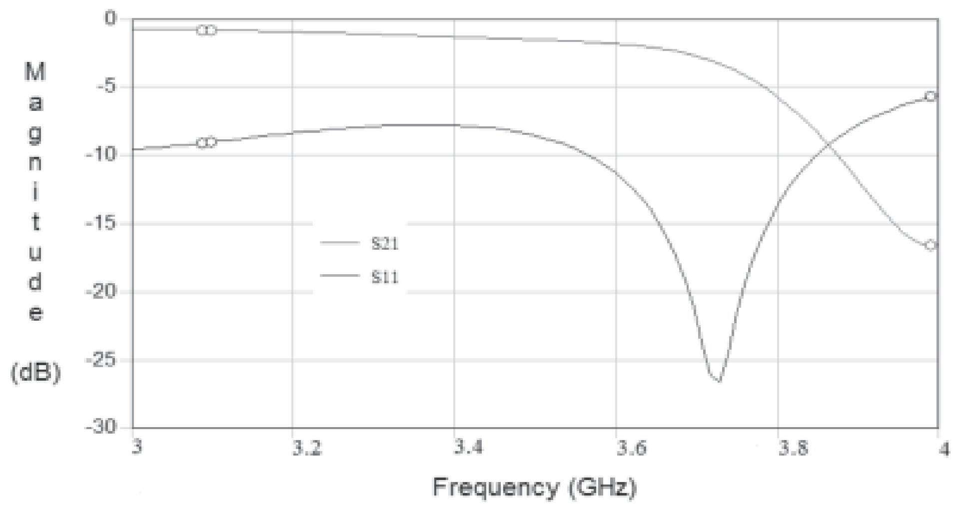

Fig. 5. S11,S21 for Elliptical patch 1

3. STACKED PATCH ANTENNA DESIGN

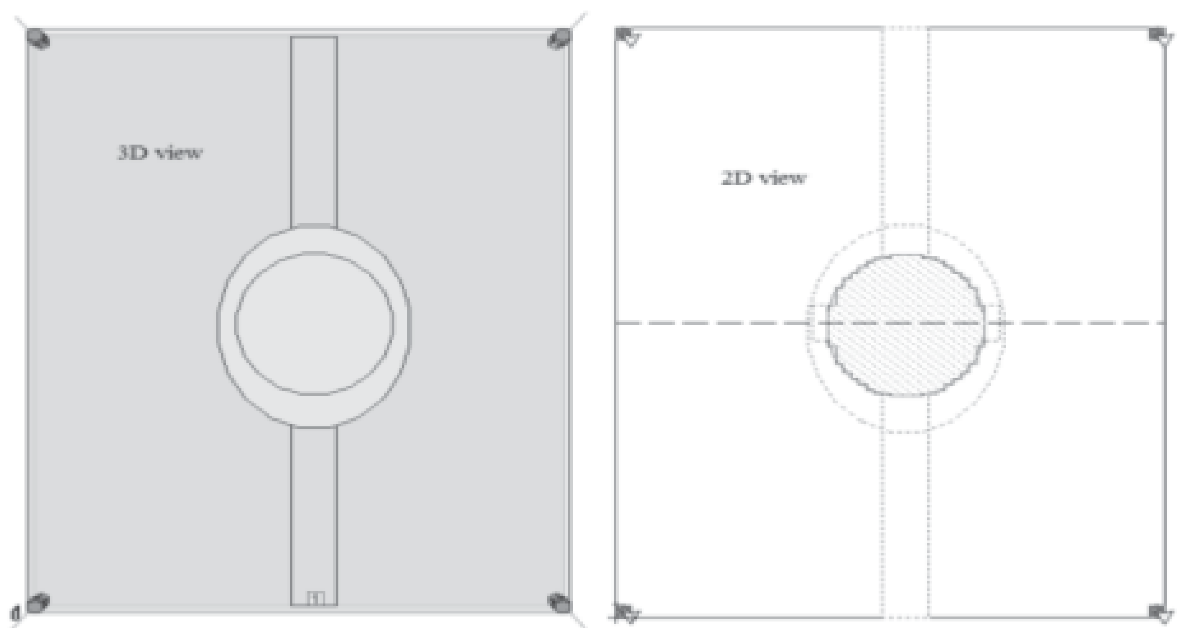

Fig. 6. Top view of CPW stacked patch

Fig 6,7,8 shows the top and overall view of elliptical stacked patch antenna [12] and bottom view of the coupling aperture substrate surface.The suspended patch is used to improve the bandwidth and efficiency of the antenna.In this paper two stacked patch antennas are simulated.First stacked antenna is desinged by FR4 base substrate and [9] LCP film coated arlon sustrate for suspended patches and second patch antenna is designed by Taconic base substrate and LCP film coated arlon substrate for suspended patches. The area of the aperture substrate is (40 × 30)mm and top suspended patch parameters are same as patch 2 shown in table 1 and bottom suspended patch parameters are same as patch 1 shown in table1 ,But this two patches are no feedlines on the sustrate because in stacked patch antenna aperture couped feed[8][11] is used. The substrate thickness and dielectric constant of different materials are listed in table II.

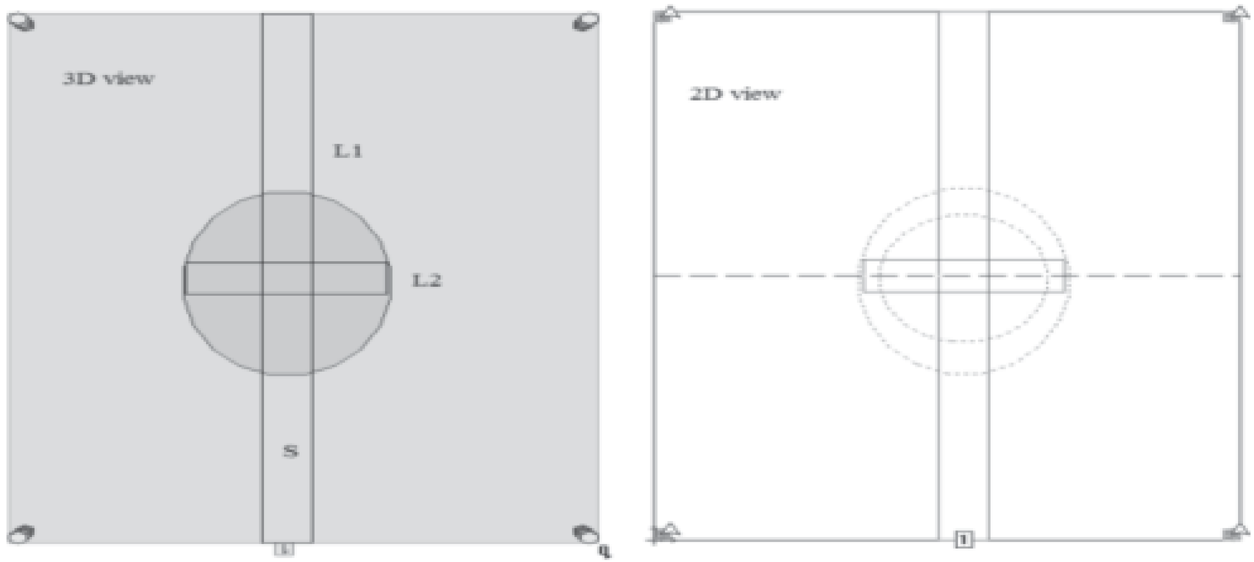

Fig. 7. Bottom view of aperture and feed substrate

(L1 = 50mm, L2 = 13mm, *s* = 2.3 fo CPW feed)

Both patches are seperated by a SU8 polymer with 1.4mm thickness shown in fig8. SU8 polymer rims are adjusted carefuly on the substrates to get good antenna performance.The stacked eliptical patches are designed to improve bandwidth. The top patch and the aperture are designed to be in close resonance for idle band operation[10]. The bottom stub and bottom patch are adjusted carefully for impedance matching.The height of the air gap between the pacthes and the length of the slot are chosen based on the gain bandwidth product .The overall design is simulated by IE3D EM simulator using the parameter values as mentioned in the tables.

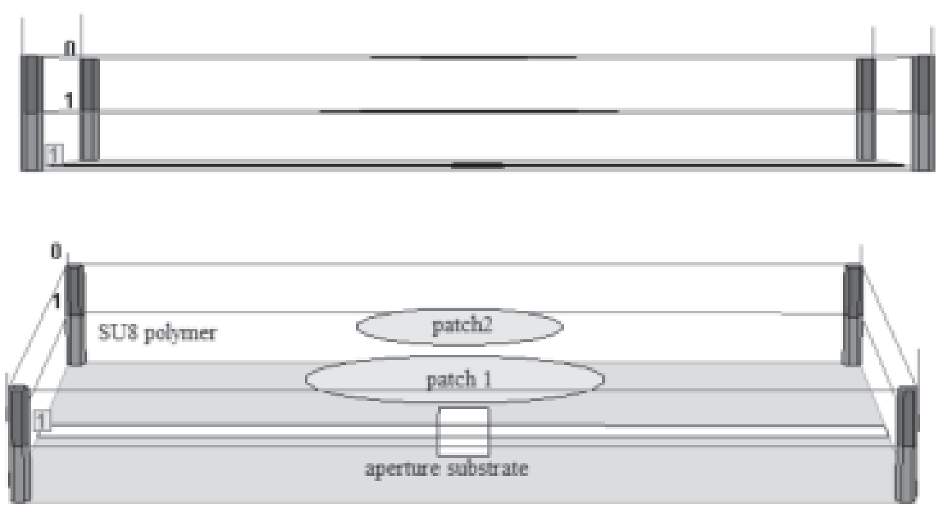

Fig. 8. Side and Over all view of elliptical stacked patch antenna (Layer1-Aperture, Layer 2-first patch, layer 3-second patch)

Table 2. Design Parameters of Stacked Elliptical Patch Antena

Substrate	*Thickness*	*Dielectric Constant*
FR4	1.59 mm	4.4
Arlon	1.51mm	3
LCP film	0.1mm	3.2
Taconic	0.5mm	2.2

4. RESULT AND DISCUSSION

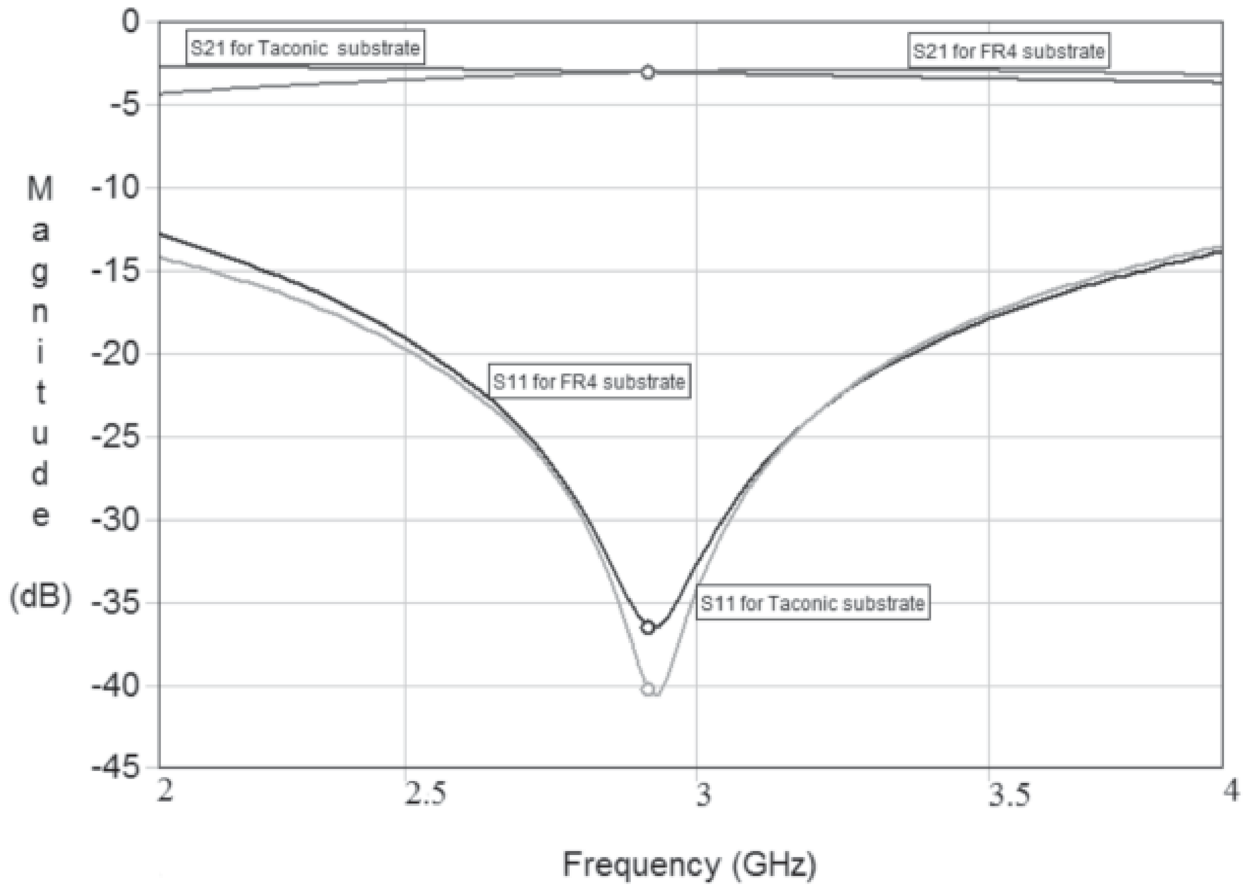

Fig. 9. S11, S21 for Elliptical patch1

Fig 9 shows the simulated results of suspended patch antenna on FR4 base substrate With LCP coated Arlon stacked patch and Taconic base substrate with LCP coated Arlon stacked patch .A15dBi standard gain horn antenna is used as transmitting antenna and 20dBi standerd gain horn antenna as the reference antenna.From the simulated results Taconic substrate patch antenna giving good performance than FR4 substrate. From fig 9, The return loss of FR4 substrate elliptical patch antenna is determined higher than other patch antenna nearly -37dB achieved at 2.7-2.9GHz frequencies.The return loss value is minimum achieved for Taconic substrate LCP film coated stacked patch antenna, -40dB at 2.7-2.9 GHz frequency ranges. The average return loss of -20dB achieved at 2.5 to 3.5 GHz ranges. Fig 10 shows the gain variations as a function of frequency for the antenna device ,It shows maximum gain along 20o direction.The maximum gain 8-9dB of the simulated antenna determined at 2.7 to 2.9GHz frequency ranges and average of 6 dB gain achieved for other frequencies.

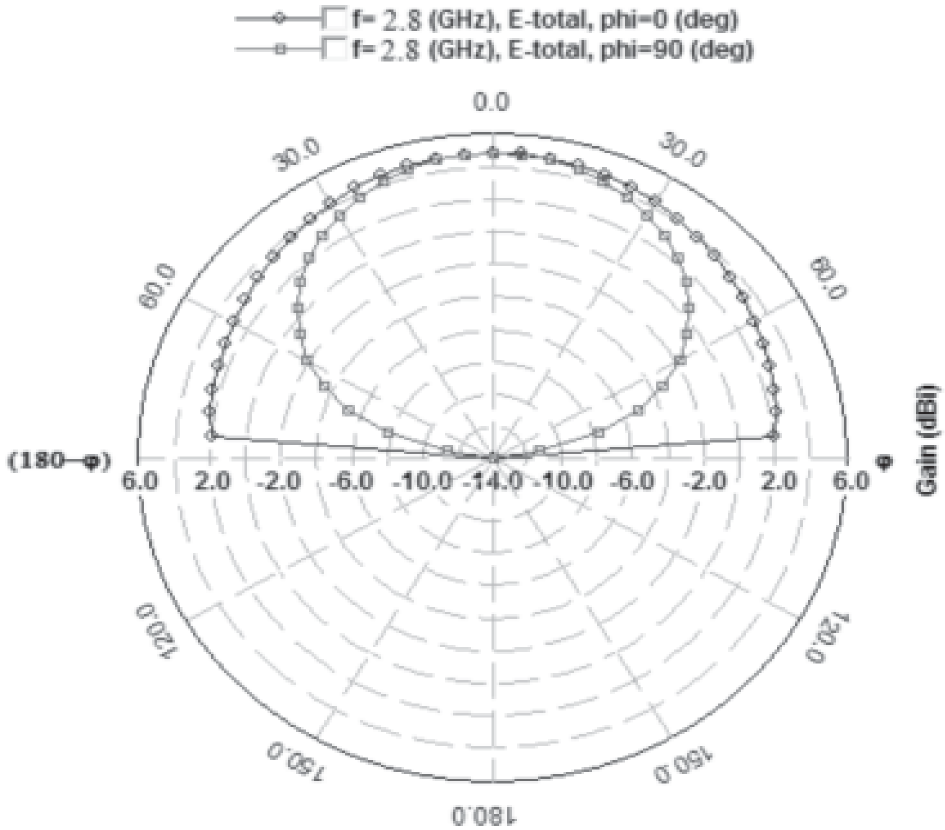

Fig. 10. Radiation pattern of elliptical stacked patch antenna(FR4, LCP film)

5. CONCLUSION

A wideband elliptical stacked patch antenna is designed and simulated for WLAN applications. The dimensions of the proposed antenna is very small (40 × 30)mm.The return loss measured at the desired antenna is minimum of -40dB for the specified bands.The idle band operation is achieved by optimally tuning resonances associated with the antenna device through the use of stacked patches.The bandwidth of the desired antenna is determined to be 40 percentage. The proposed antenna gives a sharp beem pattern at the specified frequencies .

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