Design of Patch Antenna with Omni directional radiation pattern for wireless LAN applications

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Abstract— **Antennas with circularly polarization are largely used in present wireless communication systems because of their opposition to multipath distortion and polarization losses. On the other side, omnidirectional radiation patterns are mainly used since they can provide wide signal coverage and stabilize the signal transmission. As a result number of omnidirectional circularly polarized antennas have been designed and investigated over the past few years. The antenna design consist of modified ground plane connects to circular patch having two monopole modes by a set of conductive pins, to produce high impedance matching. The curved branches are designed at circumference of circular ground plane for producing a degenerate mode and producing circular polarization. The antenna prototype should be fabricated which is operating at 2.4GHz-WLAN band and measured radiation pattern, reflection coefficient, VSWR and antenna gain should well match with simulation results. In this paper simulation is done by using arlonAD320A in place of RogersRT/duroid 5880 because the cost of Rogers material is compare to arlon. But losses in arlon material are more, and these losses are reducing by decreasing number of shorting (or) conductive pins and increase the shorting pins radius. The prototype as a low profile 0.024 λ_n, a return loss value -30dB and gain of antenna is 4.68dB. To further characterize the design concept, and the antenna simulation is carried out using high frequency simulation software.**

Keywords— Circular polarization; low-profile antenna; Omni directional antenna; shorting pins; wideband antenna.

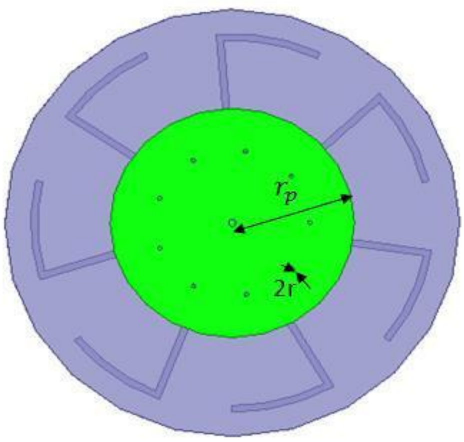
I. INTRODUCTION

In present wireless communication systems circularly polarized antennas are largely used because of their immunity to multipath distortion losses. For more signal coverage and to stabilize the signal transmission omnidirectional radiation pattern is desirable. As a result number of circularly polarized omnidirectional radiation pattern antennas have been developed over the past few years. Due to more advantages like small size, wide bandwidth light weight, and low losses an omnidirectional dielectric resonator antenna (DRA) circular polarization having inclined slots was presented in [1]. Orthogonal components with two different velocities of the slots with perturbation. These two orthogonal components made equal by changing size of the slot and they having 90^0 phase shift, so it achieves 7.3% bandwidth. By introducing parasitic strips into the slot the bandwidth increased almost twice compare with circularly polarized resonator antenna [2]. A printed antenna with four rectangular loop elements on a flexible thin dielectric substrate and insert into hallow cylinder [3]. This omnidirectional circular polarization antenna designed at a frequency band of 2GHz for 2G/3G mobile systems. For communication between a mobile station and stationary satellite a conical beam antenna with circularly polarization is desired. The antenna is designed by changing inclination angle of the linear-antenna elements and changing space between antenna elements it produce conical beam with CP in desired direction [4]. For communication between moving vehicles and geostationary satellite designed a new antenna called dielectric bird-nest antenna [5]. Evaluation of low profile antenna radiation is done by method of moments (MoM) [6]. Mushroom structure with circular curved branches, it depends on zeroth-order resonance mode to produce an Omni directional radiation pattern and vertical polarization [7].

In this paper the simulation was done using arlonAD320A substrate in place of RogerRT/duroid 5880 and losses for Arlon material are more. The losses can be reduced by reducing number of shorting pins and increase the shorting pins (or) conducting pins radius. The main advantage of this antenna is curved branches produce circular polarization fields without effect on the impedance of input, because curved branches not introducing on radiating element.

II. ANTENNA DESIGN

Fig. 1 shows the CP patch antenna design. Top patch of an antenna has radius of r_h, ground plane is design with radius of r_a, and each of extended curved branches has width, radial length, arc length of w, l_n, l_t respectively along circumference of a ground plane.



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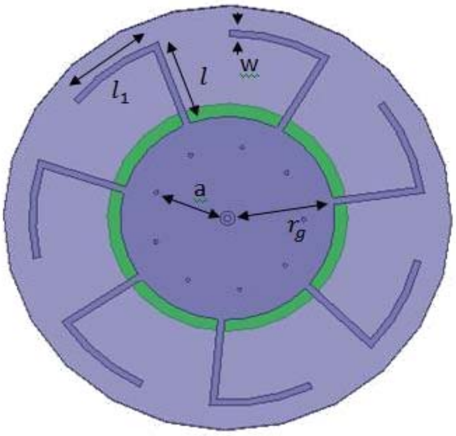


(b)

Fig. 1. Design of CP antenna. (a)Top view (b) Bottom view

A new fundamental TM_{0n} mode is created because of the shorting pins, in combination with the classical mode of the patch antenna, due to these a wideband electric dipole radiation is formed. Due to the curved branches a horizontal electric loop is formed, it is equivalent to a horizontally polarized magnetic dipole. The orthogonal electric fields of the electric and magnetic dipoles are having quadrature phase and equal amplitude then omnidirectional radiation pattern created. Arc-shaped branches are oriented in a clockwise direction it generates right-hand circularly polarized (RHCP) fields, and the branches are oriented in a anticlockwise direction, Left-hand circularly polarized (LHCP) fields are generated. It should be mentioned that there are many ways to introduce a magnetic dipole for developing a circularly polarized antenna. The curved branches are used here because of their symmetrical structure and simple design, symmetrical structure concept is important for providing omnidirectional radiation. Table.1 provide specifications for circularly polarized patch antenna and simulate by using HFSS 14.0.

Table 1: Specifications for CP patch antenna

Operating frequency	2.4GHZ
Feeding of the antenna	Coaxial
Substrate material	ArlonAD320A
Relative permittivity(ϵ_r)	3.2
Height of substrate(h)	1.6mm
Radius of substrate(R)	90mm
Radius of patch(r_p)	48.3mm
Radius of ground(r_g)	43.1mm
Branch width(w)	2.8mm
Branch length(l)	33.9mm
Arc length(l_1)	39.6mm
Number of shorting wires	9
Shorting wires radius(r)	0.8mm

III. SIMULATED RESULTS

The simulation for the antenna shown in Fig.1 was carried out using HFSS.13 software.

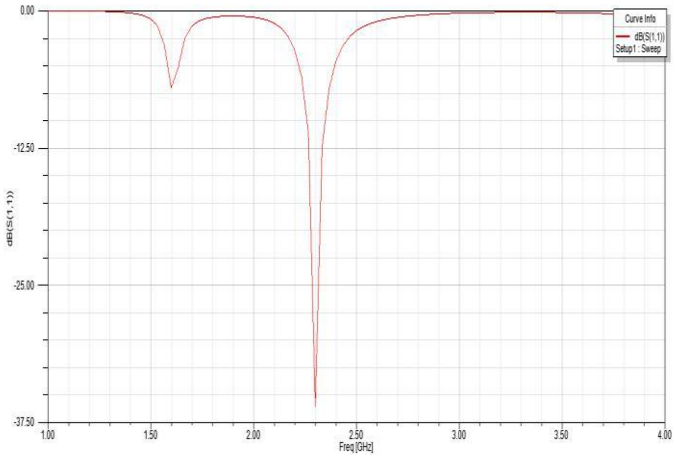


Fig. 2: Variation of reflection coefficient of CP antenna with respect to frequency operating at 2.4GHz.

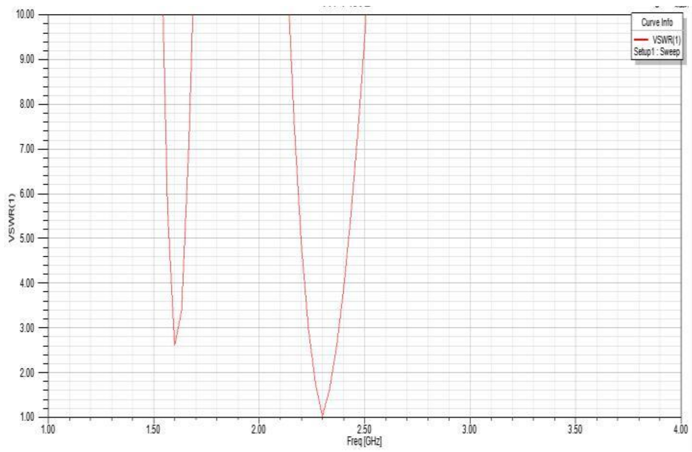


Fig. 3: Variation of VSWR of CP antenna with respect to frequency operating at 2.4GHz.

Using 3-D polar plot gain of an antenna measured at a frequency 2.4GHz plot. The degree of directivity of the antenna radiation pattern is measured by using gain . The antenna with high gain will radiate more power in a desired direction, while an antenna with low gain will radiate power over a wider angle. The antenna gain is defined as the ratio of power per unit surface area radiated by the antenna in the desired direction at an arbitrary distance, divided by the power per unit surface area radiated at the same distance by an isotropic antenna . 3-D polar plot for omnidirectional circularly polarized patch antenna shown in Fig.4.

Fig. 5 shows field distribution in circularly polarized antenna with coaxial feeding. The field is distributed all directions in circular direction.

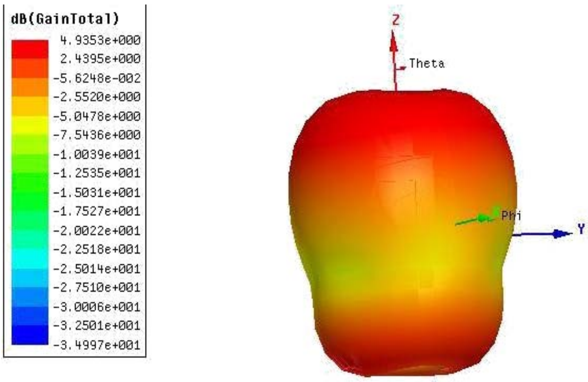


Fig. 4. Gain of an antenna simulated with HFSS in far field region

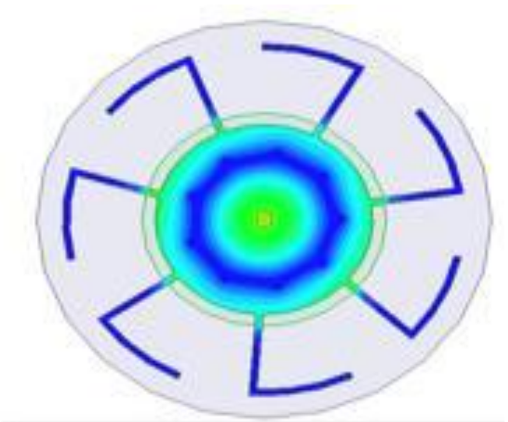
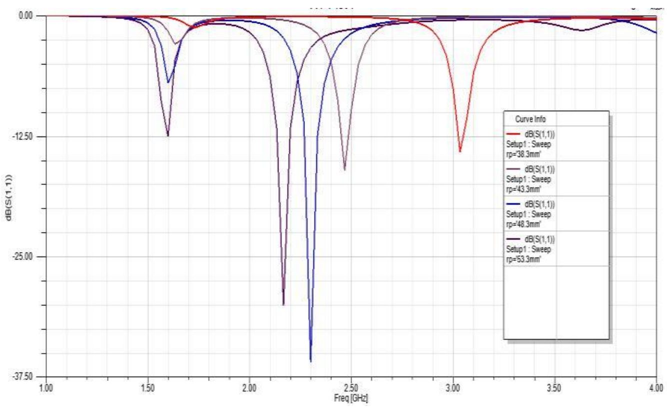


Fig. 5. Field distribution in CP antenna

IV. PARAMETRIC ANALASIS

Fig .6 shows the return loss and VSWR as a function of frequency for different patch radii of r_p = 38.3, 43.3, 48.3, 53.3mm. From Fig. 6, as r_p increases the impedance pass band varies from 1.5GHz to 3GHz. This is because of larger resonant patch should have a lower resonance frequency. For omnidirectional circularly polarized antenna the size of ground plane also affects the antenna performance considerably.



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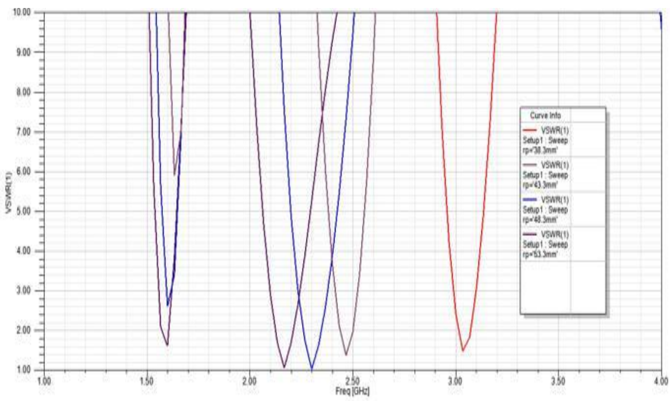

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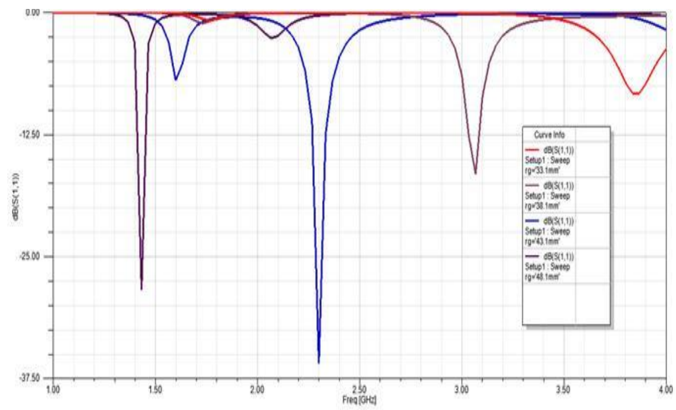
Fig. 6. Simulation results for CP antenna for different patch radii r_p = 33.3mm, 38.3mm, 43.3mm, 48.3mm, and 53.3mm. (a). return loss (b). VSWR

Return loss and VSWR for different ground plane radii of r_g = 33.1, 38.1, 43.1, 48.1, 53.3mm as a function of frequency shown in fig.7. From Fig. 7, the ground plane affects the pass band which various from 1.9GHz to 3.6GHz as r_g increases. The optimum radius of the ground plane at 2.4 GHz for the proposed design is given by r_g = 43.1mm.



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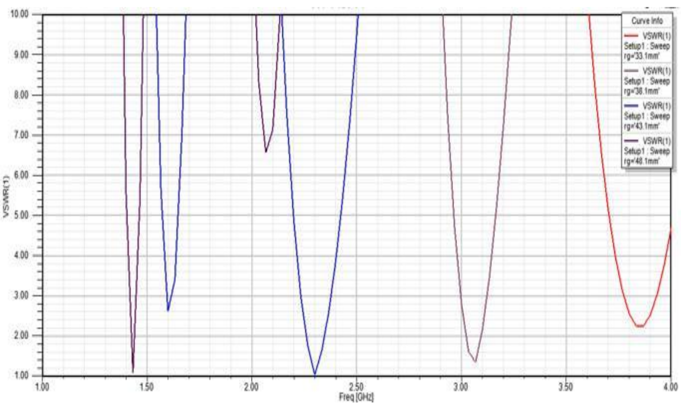


(b)

Fig.7. Simulation results for CP antenna for different ground plane radii r_g = 33.1mm, 38.1mm, 43.1mm, and 48.1mm. (a). Return loss. (b). VSWR

Shorting pins (or) conductive pins are cylindrical structure, which are connected to patch of an antenna from ground plane. For shorting pins radius (r = 0.4mm, 0.8mm) return loss maximum at a frequency 2.38GHZ, 2.4GHz respectively. Return loss value minimum for r = 0.2mm, 1.0mm at a frequency 2.37GHz, 2.45GHz respectively. Fig. 8 shows that radius of the shorting pins (or) conductive pins increases, the return loss value varies between -12.5dB to -28dB. For good matching number of shorting pins decreases and increases radius of shorting pins. To increases gain of antenna decreases the number of shorting pins.

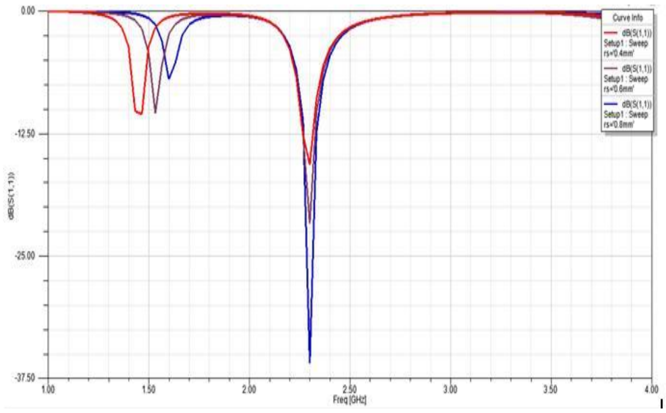
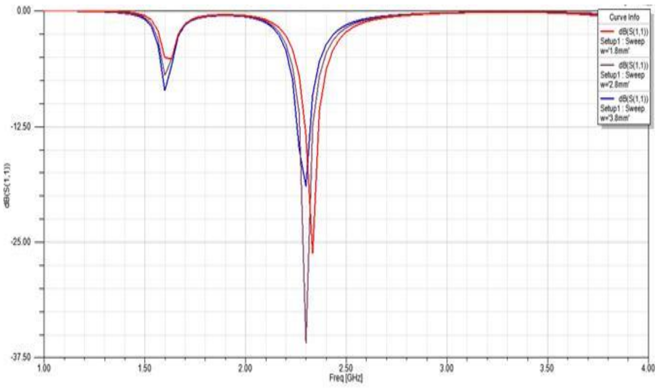


Fig. 8. Simulation result of return loss for CP antenna for differentshorting pins radii r = 0.4mm, 0.6mm and 0.8mm



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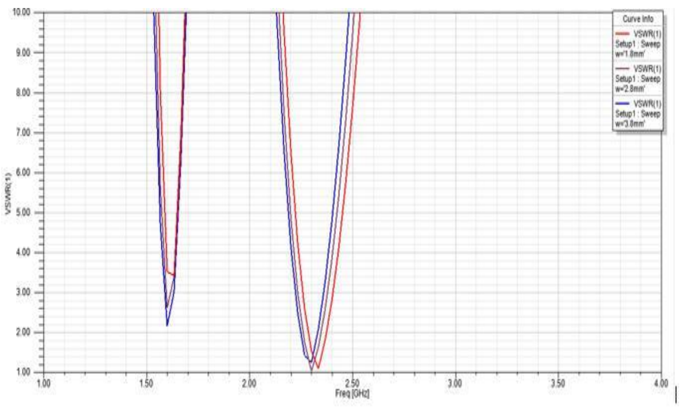

(b)

Fig 9: Simulation results for CP antenna for different branch width w = 1.8, 2.8, 3.8mm. (a). return loss. (b). VSWR

Fig. 9 shows return loss and VSWR values for different branch widths of w=1.8, 2.8 and 3.8 mm. The reflection coefficient not affected by change of w and good match is maintained across the impedance pass band regardless of w.

The losses due to shorting pins can be decreased by reduce the number of shorting pins to (N = 9) and increasing radius to r = 0.8mm. Table.2 shows results of simulation for various antenna parameters with respect to different substrate widths. For Rogers ($\varepsilon_r = 2.2$) return loss value is -25dB which is less than -10dB but operating at 2.9GHz it is not accepted for WLAN applications. Arlon ($\varepsilon_r = 3.2$) having substrate width 1.6mm operating at 2.4GHz and return loss value is less than -10dB which is well accepted for WLAN applications.

Table. 2 Comparisons of various antenna parameters for different substrate widths.

Antenna parameters	**Rogers**			**Arlon**		
	0.8 mm	1.6 mm	3.2 mm	0.8 mm	1.6 mm	3.2 mm
Return loss	-14.0	-25	-16	-20	-33	-13
VSWR	1.5	1.2	1.65	1.2	1.2	1.5
Bandwidth	2.85	2.75	2.4	2.4	2.4	2.2
Gain	4.69	4.45	4.64	4.9	4.60	4.56

V. CONCLUSION

In summary the patch of antenna and ground plane dimensions affect the return loss and VSWR values considerably. The basic structure of an antenna is a circular patch, which is shorted to an irregular ground plane by number of shorting pins (or) conductive pins. The losses can be reduced by increasing shorting pins radius and reduce number of shorting pins. Circular polarization fields are produced due to curved branches without affecting input impedance.

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