ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

Low Profile Omni directional Circularly Polarized Patch Antenna for WLAN Applications

G. Krishna Reddy, Dr. A. Jhansi Rani,

M. Tech, V. R. Siddhartha Engineering College, Andhra Pradesh, India

Professor, Dept. of ECE., V.R. Siddhartha Engineering College, Vijayawada, Andhra Pradesh, India

ABSTRACT- Circularly polarized (CP) antennas are widely used in modern wireless communication systems because of their immunity to multipath distortion and polarization mismatch losses. On the other hand, unidirectional radiation patterns are generally desirable since they can provide larger signal coverage and stabilize the signal transmission. As a result various Omni directional CP antennas have been proposed and investigated over the past few years. The design utilizes two monopole modes of a circular patch which connects to a modified ground plane by a set of conductive pins, to achieve wide-band impedance matching. The curved branches introduced at the edge of circular ground plane excite a degenerate mode and create CP fields. To verify the design, a prototype should be fabricated operating at 2.4GHz-WLAN band and measured reflection coefficient, radiation pattern, and antenna gain should agree well with simulation results. In this paper simulation carried out using arlonAD320A instead of RogersRT/duroid 5880 because cost of Rogers material is very expensive. But losses in arlon material are more. The losses are reduced by decreasing number of shorting pins and increase the radius of shorting pins. The prototype as a low profile $0.024\lambda_0$, a return loss value -30dB and a antenna gain of 4.68dB. To further characterize the design concept, a parametric study of the antenna is carried out using HFSS.

KEYWORDS: Circular polarization, low-profile antenna, Omni directional antenna, patch antenna, wideband antenna.

I. INTRODUCTION

In modern wireless communication circular polarized antennas are widely used because of their immunity to polarization mismatch losses and multipath distortion. For larger signal coverage and for stability of the signal transmission Omni directional radiation pattern is desirable. As a result various circularly polarized antennas with Omni directional radiation patterns have been proposed and investigated over the past few years. Due to a number of attractive features like light weight, small size, wide bandwidth, and low losses an Omni directional CP dielectric resonator antenna with inclined slots was presented in [1]. Two orthogonal components with different velocities produced by perturbation of the slot. Two orthogonal components made equal by changing slot size but different by 90^0 phase shift and it achieves 7.3% bandwidth.

By introducing parasitic strips into the slot the bandwidth enhanced almost twice compare with CP resonator antenna [2]. Four rectangular loop elements are printed on a flexible thin dielectric substrate and then rolled into a hallow cylinder [3]. This Omni directional CP antenna designed for 2G/3G mobile systems at a frequency band of 2GHz. For communication between a mobile station and stationary satellite a small circularly polarized conical beam antenna was designed. By changing the space between antenna elements and the inclination angle of the linear-antenna elements generates a CP conical beam in desired direction [4].

This antenna radiates in the desired direction by changing inclination angle. For communication between geostationary satellite and moving vehicles on the earth designed a new conical beam antenna called dielectric bird-nest antenna [5]. Low profile antenna radiation characteristics evaluated using method of moments (MoM). An electro magnetically coupled feed system was proposed to reduce the high input impedance of a loop antenna [6].

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

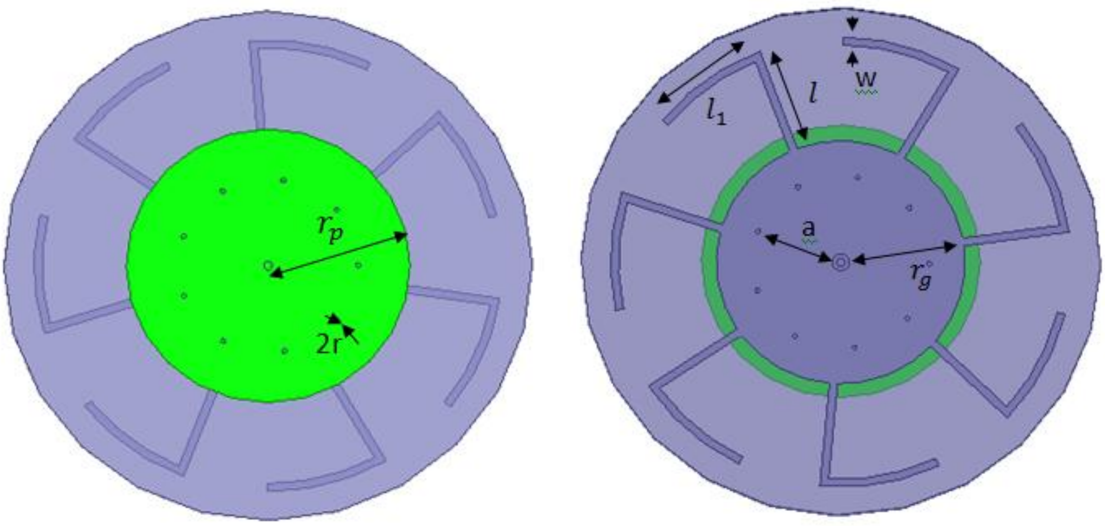
Vol. 3, Issue 8, August 2015

Circular mushroom structure with curved branches, it is based on the zeroth-order resonance mode to obtain an Omni directional radiation pattern and vertical polarization. In this paper low profile Omni directional CP patch antenna with a modified ground plane with extended curved branches [7]. A spiral antenna has small disk and is excited in phase radiates bidirectional beam. By using an extremely shallow cavity bidirectional beam from spiral disk is converted into unidirectional conical beam[8].

In this paper the simulation was carried out using arlonAD320A substrate instead of Roger RT/duroid 5880 and losses for arlon material are more. The losses can be reduced by decreasing number of shorting pins and increase the shorting pins radius. The main advantage of this antenna is circular polarization fields produce due to curved branches without effect on the input impedance, because curved branches not introduced on radiating element. In the fabrication process no additional element is required, so design of an antenna is as simple as that of linear polarized one. Patch of the antenna and ground plane are connected by number of shorting pins.

II. ANTENNA DESIGN

Fig.1 shows the design of an antenna. The top patch antenna has radius of r_p, ground plane has a radius of r_g, and each of extended branches has a width, radial length, arc length of w,l_0,l_1 respectively.



(a) **(b)**

Fig1. Design of CP antenna.(a)Top view (b)Bottom view

Because of the pins, a new fundamental TM_{01} mode is created in combination with the well-known classical mode of the patch antenna, a wideband electric dipole radiation is formed. On the other hand, the curved branches introduce a horizontal electric loop, which is equivalent to a horizontally polarized magnetic dipole. Omni directional CP fields will be obtained when the orthogonal electric fields of the electric and magnetic dipoles which have equal amplitude and quadrature phase. As shown in Fig. 1, these arc-shaped branches are oriented in a clockwise direction to generate right-hand circularly polarized (RHCP) fields. When the branches are oriented in a counterclockwise direction, Left-hand CP (LHCP) fields will be generated. It should be mentioned that there are other ways to introduce a magnetic dipole for developing a CP antenna. The curved branches are selected here because of their simple and symmetrical structure, which is important for providing Omni directional radiation. Table.1 provide specifications for CP patch antenna and simulate by using HFSS 14.0.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

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 vias	9
Shorting vias radius(r)	0.8mm

III. SIMULATED RESULTS

Fig. 2 shows a prototype of CP patch antenna design covering the 2.4 GHz WLAN band. The parameters are given by h = 1.6mm, r_p = 48.3mm, r_g = 43.1mm, l_1 = 39.6mm, l = 33.9mm, N = 9, a = 30.6mm, r = 0.8mm. The simulation for the antenna shown in Fig.1 was carried out using HFSS.13 software.

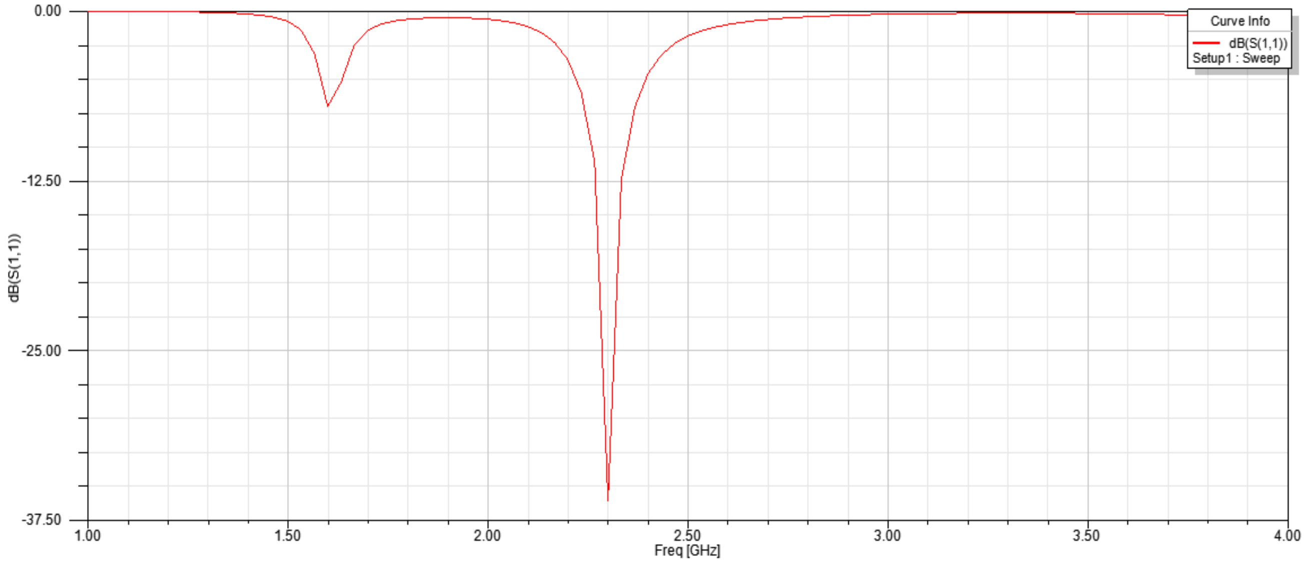


Fig.2: Variation of reflection coefficient of CP antenna with respect to frequency operating at 2.4GHz.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

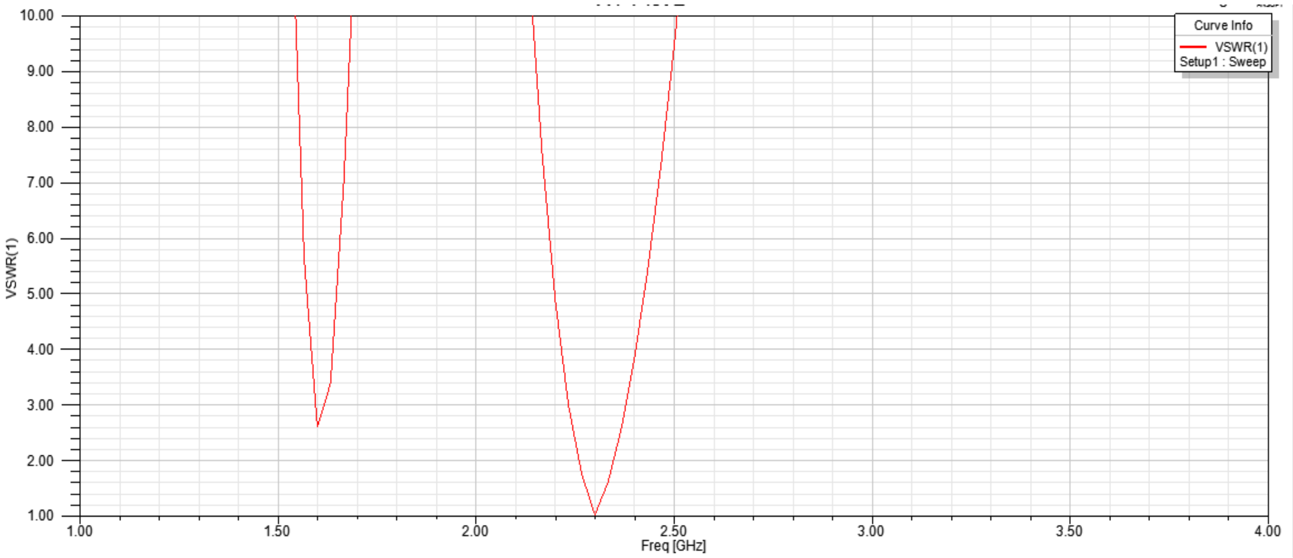
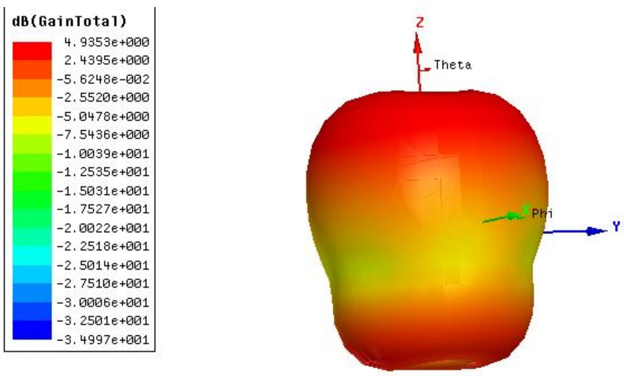


Fig.3: Variation of VSWR of CP antenna with respect to frequency operating at 2.4GHz.

Figs. 2 and 3 show the simulated reflection coefficient and VSWR of CP patch antenna. It is observed that Simulated 10-dB impedance bandwidth. ($|S_{11} < -10dB|$) is -35dB at a frequency 2.4GHz which is well accepted for WLAN applications.



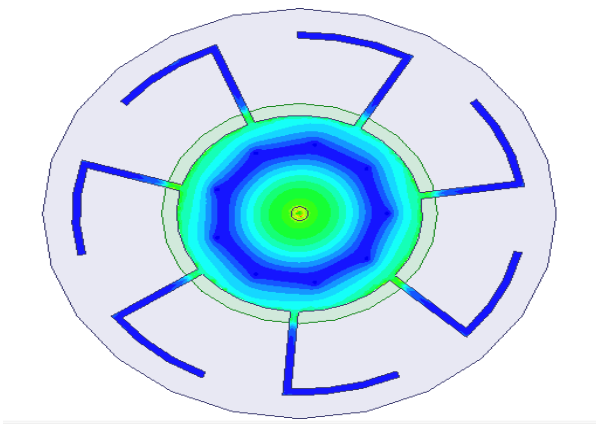


Fig4.Gain of an antenna simulated with HFSS in far field region. Fig5: Field distribution in CP antenna

Gain of an antenna measured at a frequency 2.4GHz using 3-D polar plot. Gain is a parameter which measures the degree of directivity of the antenna's radiation pattern. A high-gain antenna will radiate most of its power in a particular direction, while a low-gain antenna will radiate over a wider angle. The antenna gain (or) power gain of an antenna is defined as the ratio of the intensity (power per unit surface area) radiated by the antenna in the direction of its maximum output, at an arbitrary distance, divided by the intensity radiated at the same distance by a hypothetical isotropic antenna which radiates equal power in all directions. This dimensionless ratio is usually expressed logarithmically in decibels, these units are called "decibels-isotropic" (dB). 3-D polar plot for a Omni directional circularly polarized patch antenna shown in Fig.4.

Fig.5: Shows the variation of field distribution in CP antenna with coaxial feeding. The field is distributed in circularly and in all directions.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

IV. PARAMETRIC ANALASIS

To characterize the parametric study of circularly polarized Omni directional patch antenna using HFSS.

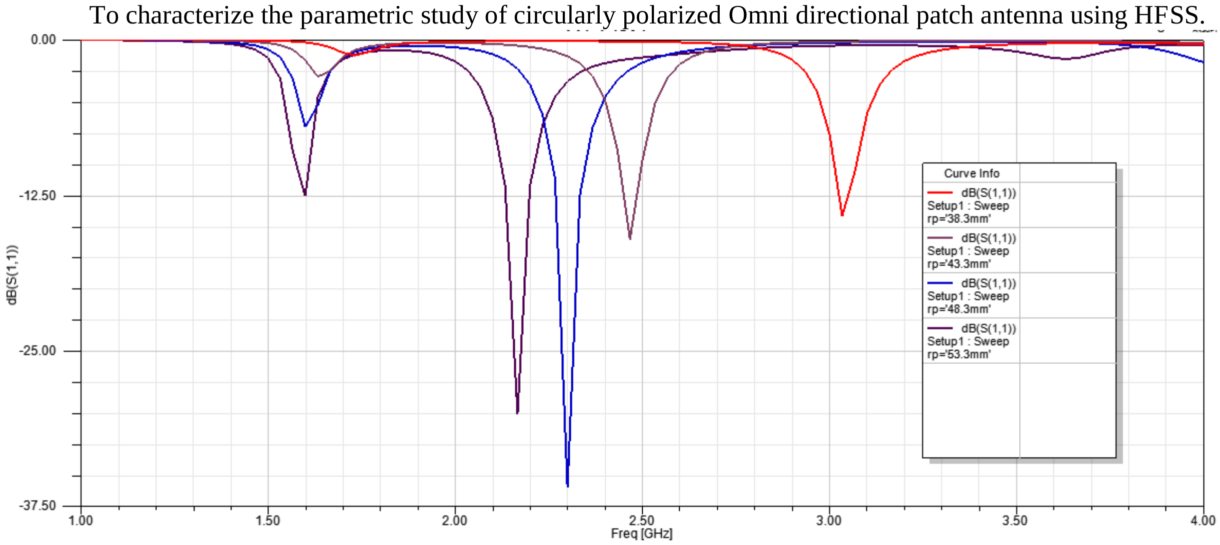


Fig.6: Return loss value for CP antenna for different patch radii r_p = 33.3mm, 38.3mm, 43.3mm, 48.3mm, and 53.3mm.

Fig.6 shows the simulated reflection coefficient and VSWR as a function of frequency for different patch radii of r_p = 38.3, 43.3, 48.3, 53.3mm. With reference to Fig. 6, the impedance pass band variation from 1.5GHz to 3GHz as r_p increases. This is expected since a larger resonant patch should have a lower resonance frequency. For Omni directional CP antenna the ground plane size also affects the antenna performance considerably.

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

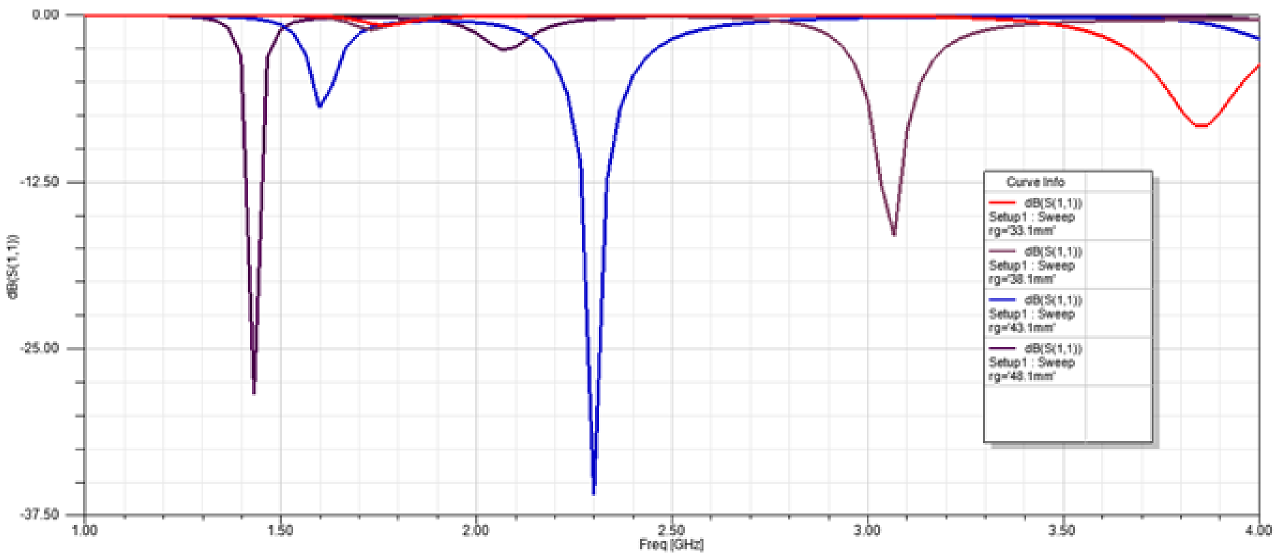


Fig.7: Return loss value for CP antenna for different ground plane radii r_g = 33.1mm, 38.1mm, 43.1mm, and 48.1mm.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

Shorting pins are cylinder like structure, which are connected to patch from ground plane. For shorting pins radius (r = 0.4mm, 0.8mm) return loss value will be maximum at a frequency 2.38GHZ, 2.4GHz respectively. Return loss minimum for (r = 0.2mm, 1.0mm) at a frequency 2.37GHz, 2.45GHz respectively as show in fig.8.

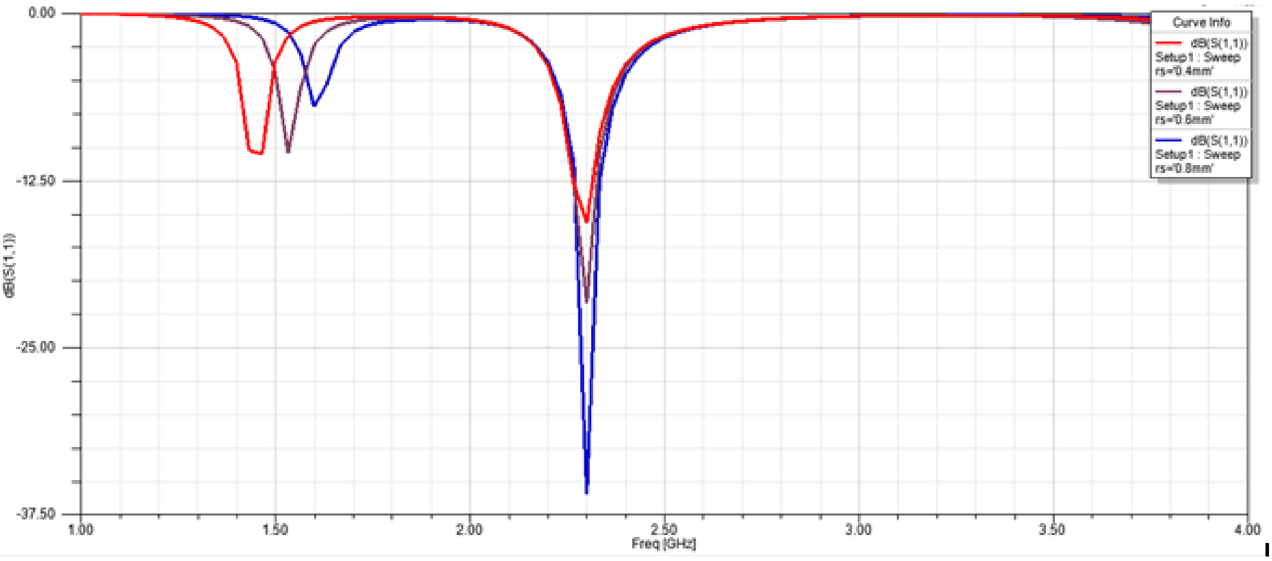


Fig 8: Simulation result of return loss for CP antenna for different shorting pins radii r = 0.4mm, 0.6mm and 0.8mm

Fig8 Shows that radius of the shorting pins increases the return loss plot varies between -12.5dB to -28dB. Number of shorting pins decreases then increases radius of shorting pins for good matching. To increases gain of antenna decreases the number of shorting pins.

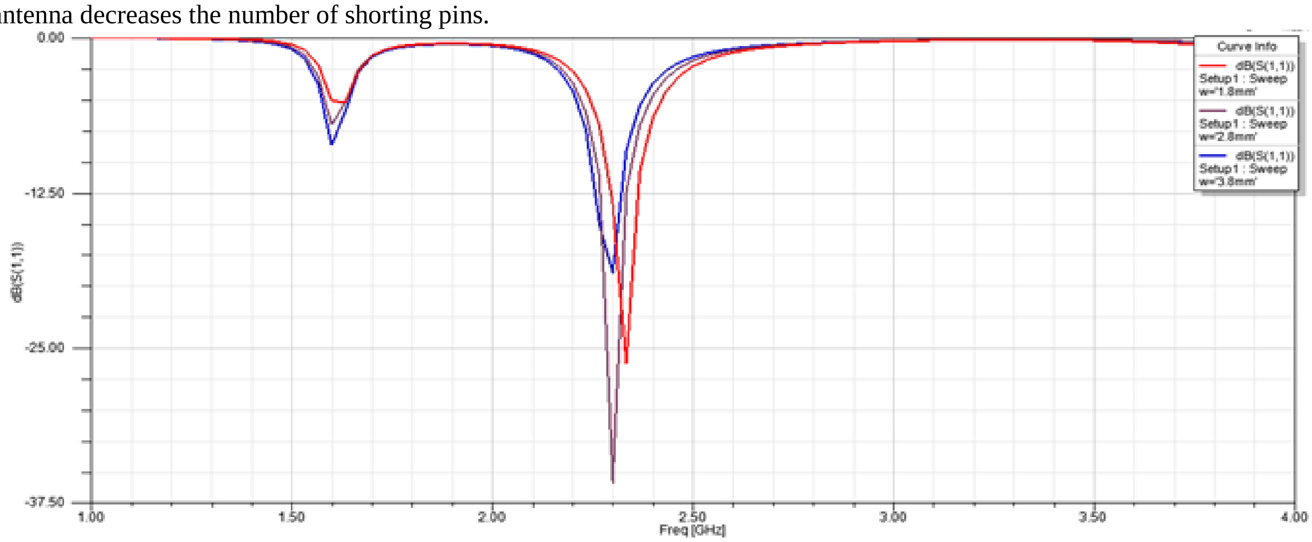


Fig 9: Simulation results for CP antenna for different branch width w = 1.8, 2.8, 3.8mm.

Fig. 9 shows the results using different branch widths of w=1.8, 2.8 and 3.8 mm. As can be seen from Fig. 9, the reflection coefficient is insensitive to the change of w and good match is maintained across the impedance pass band regardless of w.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2015

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

Antenna parameters	Rogers			Arlon			FR4		
	0.8mm	1.6mm	3.2mm	0.8mm	1.6mm	3.2mm	0.8mm	1.6mm	3.2mm
Return loss	-14.0	-25	-16	-20	-33	-13	-12	-35	-15
VSWR	1.5	1.2	1.65	1.2	1.2	1.5	1.7	1.0	1.4
Bandwidth	2.85	2.75	2.4	2.4	2.4	2.2	3.8	1.9	2.94
Gain	4.69	4.45	4.64	4.9	4.60	4.56	1.3	2.8	1.9

The losses due to shorting pins can be reduced by decreasing the number of shorting pins to (N = 9) and increasing radius of shoring pins to (r = 0.8mm). Table.2 shows simulation results for various antenna parameters with respect to different substrate widths. For Rogers ($\varepsilon_0 = 2.2$) return loss value is -25dB which is less than -10dB but operating at 2.9GHz it is not accepted for WLAN applications. Arlon ($\varepsilon_0 = 3.2$) and substrate width 1.6mm having return loss value less than -10dB and operating at 2.4GHz which is well accepted for WLAN applications.

V. CONCLUSION

In summary the patch and ground plane dimensions affects the both return loss and VSWR values considerably. The basic structure is a circular patch, which is shorted to a irregular ground plane by number of shorting pins. The losses can be reduced by increases shorting pins radius and decrease number of shorting pins. Circular polarization fields produce due to curved branches without effecting input impedance.

REFERENCES

1. Y. M. Pan, K. W. Leung, and K. Lu, “Omni directional linearly and circularly polarized rectangular dielectric resonator antennas,” *IEEE Trans. Antennas Propag.*, Vol. 60, no. 2, pp. 751–759, Feb. 2012.
2. X. L. Quan, R. L. Li, and M. M. Tentzeris, “A broadband Omni directional circularly polarized antenna,” *IEEE Trans. Antennas Propag.*, Vol. 61, no. 5, pp. 2363–2370, 2013.
3. Y.M. Pan and K.W. Leung, “Wideband Omni directional circularly polarized dielectric resonator antenna with parasitic strips,” *IEEE Trans. Antennas Propag.*, Vol. 60, no. 6, pp. 2992–2997, 2012.
4. H. Kawakami, G. Sato, and R. Wakabayashi, “Research on circularly polarized conical-beam antennas,” *IEEE Antennas Mag.*, vol. 39, pp. 27–39, Jun. 1997.
5. Y. M. Pan and K. W. Leung, “Wideband circularly polarized dielectric bird-nest antenna with conical radiation pattern,” *IEEE Trans. Antennas Propag.*, Vol. 61, no. 2, pp. 563–570, 2013.
6. H. Nakano, K. Fujimori, and J. Yamauchi, “A low-profile conical beam loop antenna with an electromagnetically coupled feed system,” *IEEE Trans. Antennas Propag.*, Vol. AP-48, pp. 1864–1866, Dec. 2000.
7. B. C. Park and J. H. Lee, “Omnidirectional circularly polarized antenna utilizing zeroth-order resonance of epsilon negative transmission line,” *IEEE Trans. Antennas Propag.*, Vol. 59, no. 7, pp. 2717–2721, 2011
8. H. Nakano, H. Oyanagi, and J. Yamauchi, “A wideband circularly polarized conical beam from a two-arm spiral antenna excited in phase,” *IEEE Trans. Antennas Propag.*, vol. 59, no. 10, pp. 3518–3525, 2011.

BIOGRAPHY

G. Krishna Reddy obtained his B.Tech Degree in Electronics and Communications Engineering from SRK Engineering College, Vijayawada. Doing M-tech (communication and signal processing) in Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada.

Dr. A.Jhansi Rani obtained her B.Tech Degree in Electronics and Communications Engineering from Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada in 1991 and M.Tech Degree in Microwave Engineering from Institute of Technology, Banaras Hindu University, Varanasi in 1993. Later she joined as a Faculty in ECE Dept., of V.R.Siddhartha Engineering College, Vijayawada. She obtained Ph.D. Degree from JNTU, Hyderabad in August 2008. Presently, she is working as a Professor of ECE at V. R. Siddhartha Engineering College. Dr.Jhansi has more than 20 years of teaching experience.