PERFORMANCE COMPARISION OF DUAL CIRCULARLY POLARIZED MICROSTRIP PATCH ANTENNA - A REVIEW

[1]Amit Sharma, [2]Prof. S.K. Singh

ECE Department
Jabalpur Engineering Collage (J.E.C.)
Jabalpur, Madhya Pradesh, India

***ABSTRACT*: The need of designing a dual circularly polarized micro strip patch antenna is obvious, as in today's lifestyle and requirements, different applications like Mobile Communication, GPS, Satellite television broadcasting, remote sensing, wi-fi, Bluetooth, Infrared sensing, Wireless LAN etc, require an antenna which can mitigate the fading losses due to multi path effects, eliminates the problem of transmitter & receiver antenna orientation by providing polarization diversity. An approach to design easy to fabricate, efficient, multiband, broadband & high gain dual circularly polarized patch antenna is developed and proper result analysis with effects of specific techniques is studied.**

***Keywords*: Circularly polarized patch, PIN diode, RHCP, LHCP**

1. INTRODUCTION

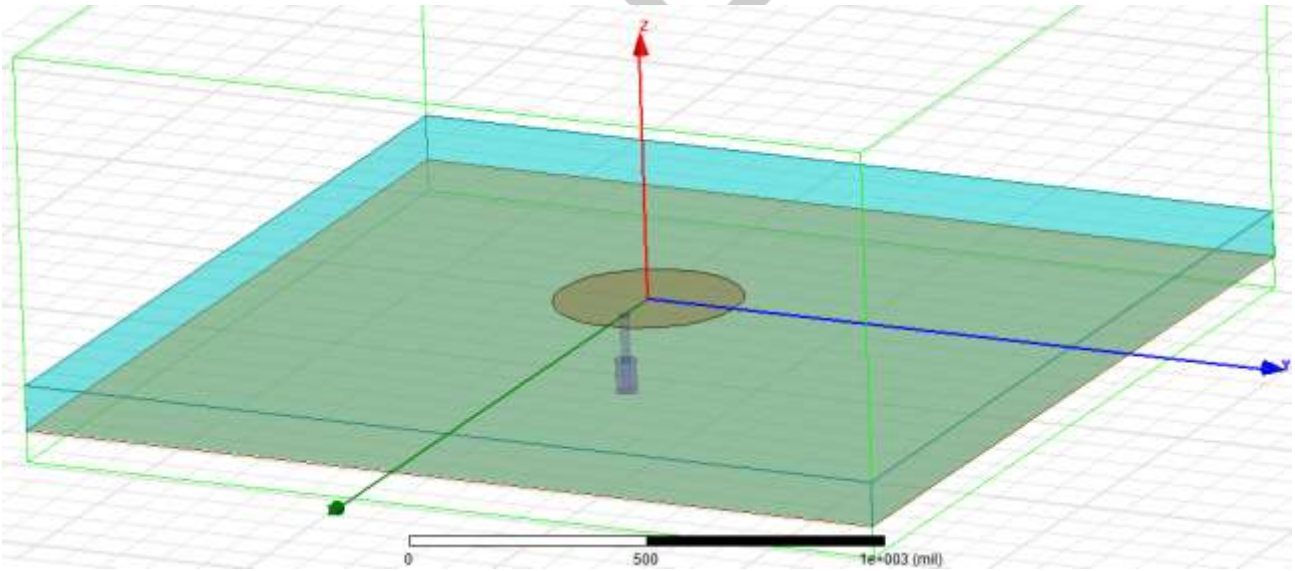
Circularly polarized (CP) antennas are very effective in combating multi-path interference, Faraday rotation effect, & orientation constraint between the transmitter & receiver antennas. Due to these advantages, CP antennas are particularly attractive for space based navigation systems, e.g. the global positioning system (GPS). [1, 2]

Circularly polarized microstrip patch antennas provide more advantages as compared to linearly polarized antennas in terms of polarization mismatch & multipath interference. [3]

A dual circularly polarized antenna can realize the right & left hand circular polarization (RHCP & LHCP); therefore, it is very significant for miniaturized systems with frequency reuse or polarization diversity. For dual-CP patch antennas, the isolation is another critical performance. Dual circularly polarized antennas with high isolation between the two polarizations can reduce the complexity of the systems that required CP diversity. Hence, it is desirable in most communication systems that one antenna not only has the dual circular polarization (CP), low cross-polarization, high gain & wide bandwidth (especially the fractional bandwidth higher than 30%), but also maintains its compact size & low profile. For this, a micro strip patch antenna is most suitable with its inherent capabilities such as low cost, less weight, low profile and multiband support.

Although they are less bulky and capable of resonating at different bands but they suffer from disadvantages like low bandwidth, low gain, poor polarization, high Q, and low efficiency. There are number of techniques for improving these drawbacks of patch antenna, which includes using fractal geometry, defective ground structure cutting slots etc.

Figure drawn below shows a basic circularly polarized microstrip patch antenna.



Following are the important formulas used to design a circular shaped micro strip patch antenna:-

Shape of the patch is circular; radius of the patch is given by (Balanis, 1982)

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

$$F = 8.791 * 10^9 / fr\sqrt{\varepsilon r}$$

Above equation of radius, does not take into consideration the fringing effect. Since fringing makes the patch electrically larger, the effective radius of patch is used & is given by (Balanis, 1982)

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

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

$$(fr)110 = 1.8412 v0 / 2\pi ae\sqrt{\varepsilon r}$$

Where, v0 is the free space speed of light.

DESIGNING SOFTWARE

We are designing this antenna using HFSS. HFSS is a commercial finite element method solver for electromagnetic structures from ANSYS. The acronym HFSS stands for High Frequency Structure Simulator. HFSS is one of several commercial tools used for antenna design and other complex circuit elements .There are six main steps to design and analyze an antenna in HFSS:-

a) Create geometry
b) Assign boundaries
c) Assign excitation
d) Set up the solution
e) Solve
f) Post-process the results

2. LITERATURE SURVEY

"A broadband dual circularly polarized patch antenna with wide beamwidth"- Changhong Zhang, Xianling Liang, Member, IEEE, Xudong bai, Junping Geng, Member, IEEE & Ronghong Jin, Senior Member, IEEE [4]:-

In this paper, the patch is excited by four cross slots via a microstrip line with multiple matching segments underneath the ground plane. For circular polarization, two orthogonal modes with 90 degree phase difference are generated by the seven coupling points with 22.5 degree difference in phase & space in a serial manner. In such a way, the higher modes can be suppressed in thick substrate to get better circular polarization. Wide axial ratio is achieved through multiple feed schemes. Here, the antenna contains two ports; port1 generates RHCP radiation, while port2 generates LHCP. [1536-1225; 2014 IEEE]

"A dual circularly polarized patch antenna for broadband millimeter wave (MMW) communication systems" Hussam al-saedi, jawad K. Ali, University of Tech. Baghdad, IRAQ, Wael M. Abdel-wahab, S. Gigoyan, University of waterloo, (UW), Canada [5]:-

In this paper a simple, three metallic layers broadband with beamwidth dual circularly polarized antenna is presented. It is an aperture coupled circular patch antenna used for dual circular polarization at Ka-band. Two microstrip lines are used to excite a circular patch through two slots to generate a broadband RHCP & LHCP radiation with high isolation between them. An aperture coupling is provided for wide beamwidth axial ratio. The proposed antenna is a good element candidate to be considered for compact polarization reconfigurable phased array antennas. Two different parts are used for two different polarizations, which are RHCP & LHCP at 30.5 GHz. [978-1-5090-2886-3/16/$31.00 © 2016 IEEE]

"Dual circularly polarized patch antenna using field transformation medium" Hongyu shi , Member, IEEE, Henry Giddens & Yang Hao, Fellow, IEEE [6]:-

In this paper, a method is discussed that can adapt existing linear polarization diversity antenna in to circular ones with broad axial ratio angle. Hence, a dual circularly polarized antenna based on the field transformation (FT) method is presented. The antenna consists of a dual linearly polarized feeding patch & an FT wave plate as a reflector. The FT wave plate enables the realization of

a circularly polarized antenna that has a very wide-angle band & unidirectional radiation pattern, in both polarizations. Around 2.5 GHz, the reflective quarter wave plate has a dual circularly polarized property that makes it possible to realize a dual circularly polarized reflector antenna. The design contains two ports; port1 & port2 generate LHCP& RHCP radiation, respectively. [1536-1225© 2017 IEEE antennas & wireless prop. Letters vol. 16, 2017]

"Polarization reconfigurable circular patch antenna with a C- shaped slot"- Ka Ming Mak, Hau Wah Lai, Kwai Man Luk & Kin Lin Ho, July, 2016 [7]:-

In this paper, a simple & low profile C-slot circular patch antenna with reconfigurable ability is proposed for LP or CP. The antenna can be switched to allow orthogonal LP or LHCP & RHCP at a fixed frequency band. The property of polarization reconfiguration of the antenna is achieved by strategically switching the diodes ON & OFF. The two switching diodes are mounted over a concentric circular slot incorporated on the patch, so as to vary the orientation of the C- slot. [AP 1607-1055.Final, DOI 10.1109/TAP.2016.2640:41 IEEE Transactions on antennas & propagation]

"A wideband polarization reconfigurable antenna with partially reflective surface" Lu Yang Ji, Pei-Yuan Qin, Y. Jay Guo, Can Ding, Guang Fu, Shu-Xi Gong, Australian Research Council [8]:-

This paper presents a polarization reconfigurable partially reflective surface (PRS) antenna which employs a shorted annular patch (SAP) antenna as the source & a reconfigurable Wilkinson power divider network. Four pin diode are inserted into two branches of the power divider, enabling the antenna to switch its polarization among LP, left hand circular polarization (LHCP) & right hand circular polarization (RHCP) in an overlapped 10 dB impedance bandwidth & 3-dB axial ratio bandwidth of 4.7- 5.36 GHz. [0018-926X © 2016 IEEE, Transaction on Antennas & Propagation]

"Compact dual-band dual-mode circular patch antenna with broadband unidirectional linearly polarized & omni directional circularly polarized characteristics" Wen Quan Cao, PLA University of science & technology, Nanjing, Jiangsu, china [9]:-

It is meta-material based novel probe-feed single layer circular patch antenna with dual-band & dual-mode of polarization. The dual-band dual-mode characteristic is realized by using modified meta-material structure. Bandwidth enhancement is achieved by loading four curved patches around the circular radiating patch. By employing curved branches in the ground plane, CP property for n=0 mode with omni directional radiation patterns is obtained. [IET Microwave, Antennas & Propagation, pp. 1-7, © The institution of Engineering & Technology 2015]

"A circularly-polarized octagon-star-shaped microstrip patch antenna with Conical Radiation Pattern" Yuzhong Shi & Juhua Liu, Member, IEEE [10]:-

In this paper, the CP antenna has a single feed, a low profile & a very simple structure. The patch has an octagon-star shape, & can be considered as a superimposition of two square patches. By generating two orthogonal degenerated TM11 Modes from the two superimposed square patches.

"Low-profile circularly polarized patch antenna with high gain & conical beam" Hengfei Xu, Jianyi Zhou, Ke Zhou, Zhiquiang Yu, China [11]:-

In this paper, a conical beam CP antenna with a mono polar patch & an array is proposed. Vertically polarized electric field EΘ & horizontally polarized electric field Eϕ with 90degree phase difference, which are generated by the monopole & the array, respectively, are combined together to obtain conical-beam CP radiation.

3. RESULTS ANALYSIS

Results analysis has been done using previous papers where dual circularly polarized antenna is achieved along with variations in return loss, axial ratio, gain, bandwidth etc. The performance comparison between some existing dual circularly polarized antennas is shown below:

REFERENCE	RETURN LOSS BANDWIDTH (S11)dB	AXIAL RATIO BANDWIDTH AR(dB)	PEAK GAIN (dBi)	Polarization diversity
[4]	37%	21%	9.8	LHCP-RHCP
[5]	15.1%	13.9%	5	LHCP-RHCP
[6]	Nominal	4% -5%	7.7	LHCP-RHCP
[7]	20%	4% (for CP), 20% (for HP & VP)	7	HP-VP, LHCP-RHCP
[8]	13%	13.1%	9	LP-RHCP-LHCP
[9]	14.9%	2%	7.1	LHCP-RHCP
[10]	2.4%	0.5%	3.9	CP
[11]	23.1%	9.6%	7.45	CP

4. PROPOSED ALGORITHM

STEPS:-

A) By using the values of center frequency and dielectric constant , calculate all the required design parameters.
B) Prepare the basic micro strip patch antenna design using HFSS.
C) After the simulation we check results (gain plot, return loss, axial ratio, VSWR, efficiency etc).
D) The axial ratio bandwidth should be greater than 3db. If the bandwidth is less then we try to improve the design.
E) The impedance bandwidth or s11 bandwidth should be high below -10db.if it is less we make changes to improve it.
F) By using FSS/Slotting/Fractal geometry/defective ground structure etc. we try to obtain better results.

5. CONCLUSION

In this paper, we can evidently conclude that by using design techniques discussed in this paper's literature, a dual circularly polarized patch antenna with high gain, high impedance bandwidth & high axial ratio bandwidth along with simple to fabricate & easy geometry can be designed.

REFERENCES

[1] Balanis CA, Antenna Theory ; Analysis and Design ; 3rd edition, New York (NY) ; Wiley-Interscience ; 2005.
[2] Kulkarni M. "Microwave and Radar Engineering", 4th edition , Umesh Publications ; 2010.
[3] Prasad K. D. "Antenna and Wave Propagation", 6th edition, Satya Prakashan ; 2012.
[4] "A broadband dual circularly polarized patch antenna with wide beamwidth"- Changhong Zhang, Xianling Liang, Member, IEEE, Xudong bai, Junping Geng, Member, IEEE & Ronghong Jin, Senior Member, IEEE
[5] "A dual circularly polarized patch antenna for broadband millimeter wave (MMW) communication systems" Hussam al-saedi, jawad K. Ali, University of Tech. Baghdad, IRAQ, Wael M. Abdel-wahab, S. Gigoyan, University of waterloo, (UW), Canada
[6] "Dual circularly polarized patch antenna using field transformation medium" Hongyu shi , Member, IEEE, Henry Giddens & Yang Hao, Fellow, IEEE
[7] "Polarization reconfigurable circular patch antenna with a C- shaped slot"- Ka Ming Mak, Hau Wah Lai, Kwai Man Luk & Kin Lin Ho, July, 2016

[8] “A wideband polarization reconfigurable antenna with partially reflective surface” Lu Yang Ji, Pei-Yuan Qin, Y. Jay Guo, Can Ding, Guang Fu, Shu-Xi Gong, Australian Research Council
[9] “Compact dual-band dual-mode circular patch antenna with broadband unidirectional linearly polarized & omni directional circularly polarized characteristics” Wen Quan Cao, PLA University of science & technology, Nanjing, Jiangsu, china
[10] “A circularly-polarized octagon-star-shaped microstrip patch antenna with Conical Radiation Pattern” Yuzhong Shi & Juhua Liu, Member, IEEE
[11] “Low-profile circularly polarized patch antenna with high gain & conical beam” Hengfei Xu, Jianyi Zhou, Ke Zhou, Zhiquiang Yu, China