Effect of Ground Plane Length on Bandwidth of Circularly Polarized C-Slotted Microstrip Patch Antenna for Satellite Applications

Surendra Kumar Daiya[1] Tapan V. Nahar[2] Archana Mewara[3] Laxmi Narayan Balai[4]
[1]Student [2,3]Assistant Professor [4]Head of Department
[1,2,3,4]Department of Electronics and Communication Engineering
[1,3,4]Yagyavalkaya Institute of Technology, India [2] Global Institute of Technology, India

Abstract— This paper presents design of Circularly polarized C slotted microstrip antenna. Effect of ground plane length on antenna performance like bandwidth, resonant frequency and return loss is analyzed on HFSS Simulation tool. Proposed antenna found improvement in bandwidth by changing the ground plane length. Ground plane length is optimized at L=16 mm, 53.12% impedance bandwidth is obtained at 3.2 GHz frequency. Presented antenna can be used for Satellite communications.

Key words: Micro Strip Patch Antenna, Impedance Bandwidth, HFSS Meandered Slot, Circular Polarization

I. INTRODUCTION

Microstrip antenna is widely used for present wireless communication due to compact size, low profile, small weight, ease of fabrication and compatibility with printed circuits [1]. But its narrow bandwidth and low gain is the issue of research. A lot of efforts are done for bandwidth enhancement from 1953 by G.A. Deschamps [2] to till date. Bandwidth of Micro strip patch antenna can be improved by increasing the height, decreasing the dielectric constant and changing the shapes of patches [3]. By cutting different shapes of slot in the patch or ground plane, enhancement in bandwidth is observed [4]. Stacked arrangement of patches is also used for increasing the bandwidth [5]. Impedance matching networks like quarter wave transformer [6], corporate fed network [7] etc. are also used for increasing the bandwidth and minimizing the return loss. Defective ground structure [8] or partial ground plane is also the effective technique. Short circuit loading or capacitive loading techniques [9] are used to improve the return loss and control the resonant frequency in microstrip antennas [10-15]. By putting a single feed and truncating clover slots with extra perturbation, good performance of bandwidth can be achieved [10]. A pair of rectangular patch elements with staircase truncations at the patch-feed interconnection is designed in [11], results very good bandwidth performance. Another technique to enhance bandwidth is cutting slots of different shapes like H shape [6,7], U shape [3], Annular Ring shape [12] ,L shape [9] ,Inverted F Shape [10,11], Bowtie Shape [12] etc, in the patch which decreases the capacitance and Quality factor.

This paper consist approach for enhancing the bandwidth of Rectangular patch antenna by cutting the C shaped slot. Analysis of ground plane length on bandwidth, resonant frequency and return loss is also discussed. Proposed antenna is simulated using HFSS Simulation tool.

II. ANTENNA DESIGN & SIMULATED RESULTS

The conventional rectangular patch of 15.5*19 square mm is placed over dielectric substrate of 33*40*1.6 cube mm having dielectric constant of 4.4 and loss tangent of 0.002. Proposed geometry is shown in figure 1. The micro strip line of 15*4 square mm is used for feeding the patch. For increasing the bandwidth, C Shaped Slot is cut in the patch. Slot having 1mm gaps from all the edges of patch. Slot line width is 0.5mm. Partial ground plane of 33*16 square mm is used. Proposed antenna is simulated on HFSS Software.

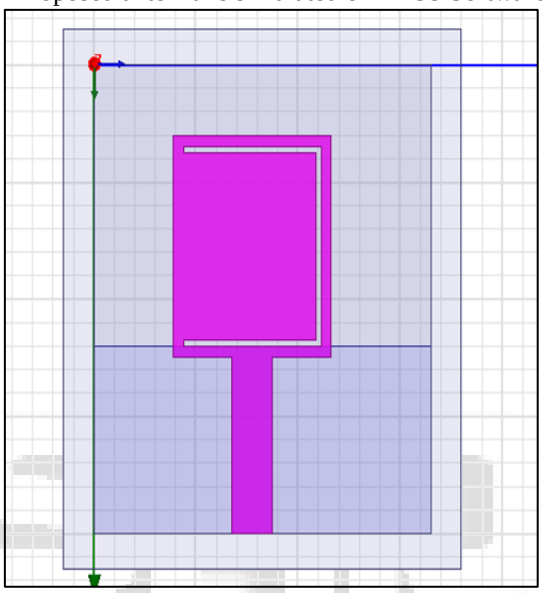


Fig. 1: Geometry of C- Slotted Patch Antenna

The simulated return loss versus frequency plot is shown in figure2. It is observed that antenna is tuned from 2.7 to 4.4 GHz having 53.12 % bandwidth at 3.2 GHz resonant frequency.

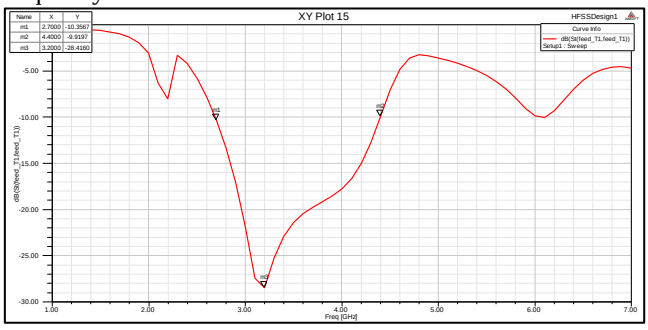


Fig. 2: Return Loss versus Frequency Plot

Voltage Standing Wave Ratio v/s frequency plot is represented in figure 3. It is obsereved that VSWR is 1.0789 at 3.2 GHz frequency. The VSWR is very close to 1 which shows perfect matching of impedences.

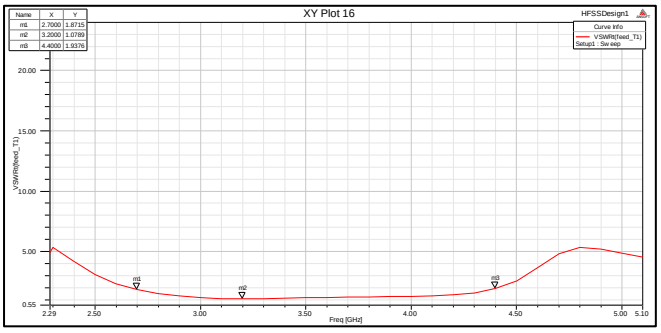


Fig. 3: VSWR versus Frequency Plot

Radiation pattern in 2D is shown in figure 4, it is observed that Gain of 1.3360 is achieved.

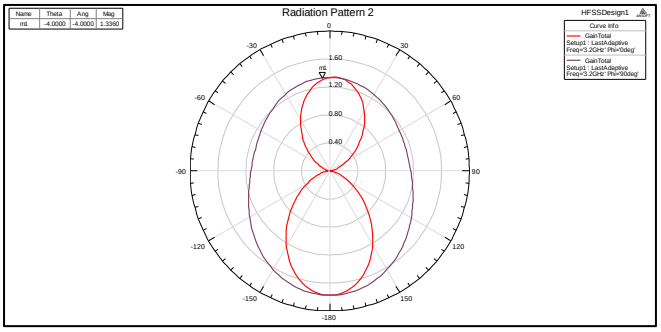
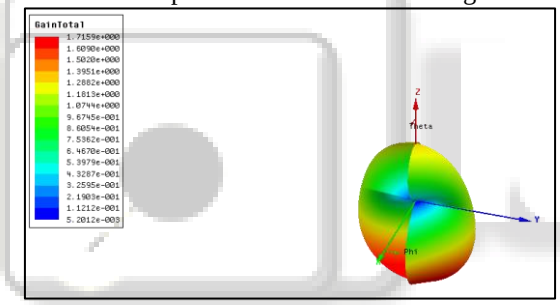


Fig. 4: Radiation Pattern in 2D

Radiation pattern in 3D is shown in figure 5.



Smith chart of proposed arrangement is shown in figure 6. Terminal Impedance at resonant frequency is 51.36 Ohm which suggests good matching.

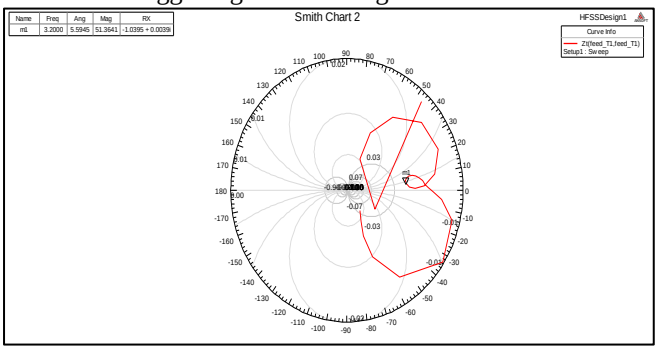


Fig. 6: Smith Chart

As shown in figure 7, axial ratio is less than 3 dB means proposed antenna provides circular polarization at those frequencies. Axial ratio is 0.9273 dB at 3.2 GHz frequency.

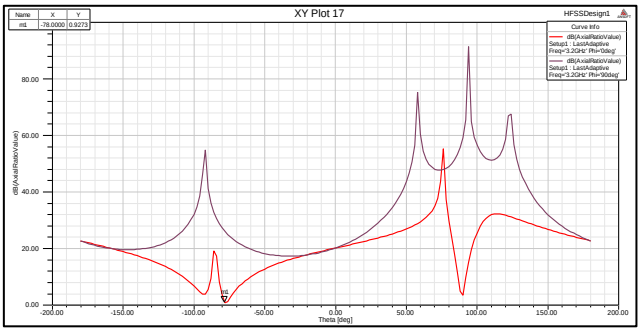


Fig. 7: Axial Ratio Plot

III. COMPARATIVE ANALYSIS OF LENGTH OF GROUND PLANE

Comparative analysis of resonant frequency, impedance bandwidth and return loss for different lengths of ground plane is shown in Table 1.1. It is observed that bandwidth is affected by ground plane length.

Ground Plane length	Fr	%BW	Return loss
L=5	2.07 2.37	7.24 9.70	-16.5 -37.56
L=10	2.10 2.5	6.19 14.4	-16.56 -38.16
L=12	2.6 4.9	19.23 15.10	-20.01 -17.20
L=13	2.6 5.2	21.92 19.23	-16.9 -16.06
L=14	2.8	25	-26.25
L=15	3 5.9	53.33 10.16	-18.3 -16.63
L=16	3.2	53.12	-28.41
L=17	4.3	40.46	-22.04
L=18	4.4	9.09	-18.25
L=20	4.5	13.33	-15.28
L=35	4.5	6.22	-19.39
L=40	4.5	6	-18.52

Table 1.1: Comparison Analysis of All Parameter

The Graph shown in figure 8 represents that resonant freq. is varied by changing the length of ground plane. For five length, there is dual band characterstics provided by the proposed antenna. Resonant frequency is between 4 to 6 GHz for ground plane length between 12 to 40 mm. and resonant frequency is between 2 to 3 GHz for ground plane length between L=5 to 16 mm.

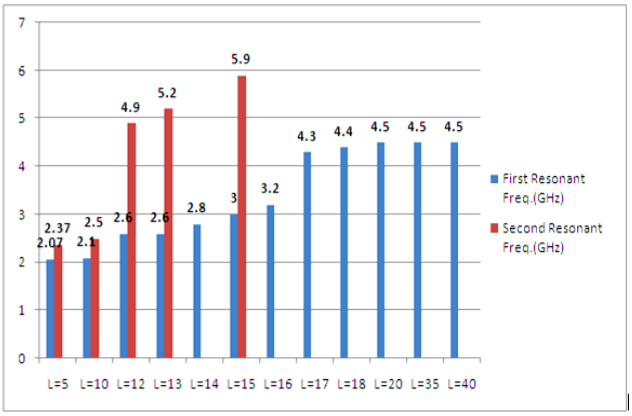


Fig. 8: Resonant Frequency Comparison Chart

Figure 9 represents the comparative analysis of Impedance Bandwidth. There is drastic improvement in bandwidth from 6% to 53.33 % by changing the ground plane length. It is analyzed that there is maximum bandwidth 53.33 % at ground plane length L=15mm. Dual band characteristics is provided by the antenna at ground plane length from 5mm to 15 mm. It is also observed that at 2 to 3 GHz resonant frequency, Impedance bandwidth 6.19% to 53.33% and at the 4 to 6 GHz frequency, resonant frequency is changed from 6 % to 40.46%.

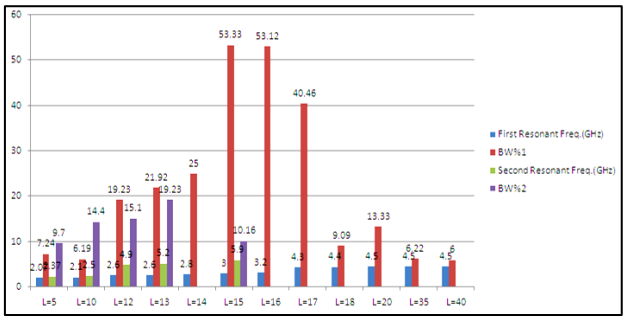


Fig. 9: Bandwidth Comparison Chart

Figure 10 represents the comparative analysis of Reflection Coefficient. As bandwidth is increased, return loss is comparatively decreased. For the resonant frequency 2 to 3 GHz, reflection coefficient(S11) is varied from -16.5 dB to -38.16 dB and minimum return loss (38.16 dB) is obtained at ground plane length L=10. For the resonant frequency from 4 to 6 GHz, reflection coefficient is varied from -15.28 dB to -22.04 dB and minimum return loss (22.04 dB) is obtained at ground plane length L=17.

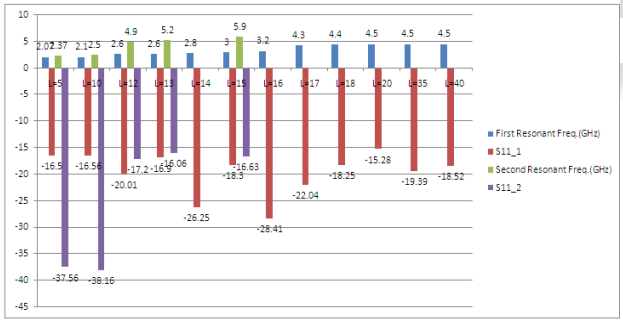


Fig. 10: Reflection Coefficient Comparison Chart

IV. CONCLUSION

In this paper, effect of ground plane length on antenna parameter is analyzed for circularly polarized C slotted microstrip patch antenna. Proposed antenna found improvement in bandwidth by changing the ground plane length. Ground plane length is optimized at L=16 mm. Other parameters are significant and 53.12% bandwidth is obtained at 3.2 GHz frequency and finds application in satellite communications.

REFERENCES

[1] John D Kraus, Ronald J Marhefka, Ahmad S Khan ,"Antenna & Wave Propagation", Fourth edition, TMH India
[2] G.A. Dechamps,"Micro strip Microwave Antennas", 3rd USAR Symposium on Antennas, 1953.
[3] Shikha Sukhija and Rakesh K. Sarin," A U-Shaped Meandered Slot Antenna for Biomedical Applications," Progress In Electromagnetics Research M, Vol. 62, 65–77, 2017
[4] Tapan Nahar and O.P.Sharma, "A Modified Approach for Bandwidth Enhancement of Microstrip Patch Antenna in L Band," National Seminar on Advancement in Wireless and Optical Applications (NSAWOA-2014) Proceedings, First Edition, Jan. 2014.
[5] Tapan Nahar and O.P. Sharma, "A Modified Approach for Bandwidth Enhancement of Microstrip Patch Antenna," Biyani International Conference (BICON-13), Vol. 8, Sept. 2013.
[6] Sudhir Bhaskar and Sachin Kumar Gupta,"Bandwidth Improvement of Microstrip Patch Antenna using H-Shaped Patch", IJERA,Vol.2,Issue 1, Jan-Feb.2012,pp. 334-338.
[7] Tapan Nahar and O.P.Sharma, "Bandwidth Enhancement of Corporate fed Bowtie Antenna Array operating in L band by changing the substrate material and ground plane length," International Journal of Computer Applications (0975 – 8887),Volume 107 – No 4, December 2014.
[8] Tapan Nahar and O.P.Sharma, "A Modified Multiband Bowtie Antenna Array used for L band Applications," International Journal of Engineering Research & Technology (IJERT), Vol.3, Issue 11, ISSN: 2278-0181, Nov. 2014.
[9] A. Kaya, "Meandered Slot And Slit Loaded Compact Microstrip Antenna With Integrated Impedance Tuning Network", Progress In Electromagnetics Research B, Vol. 1, 219–235, 2008.
[10] S. Ashok Kumar, T. Shanmuganantham, "Design of clover slot antenna for biomedical Applications", Alexandria Engineering Journal, 56, 313–317, 2017.
[11] B. L. Prakash, B. T. P. Madhav, B. Sai Parimala, T. Sravya and T. Anilkumar," Dual Band Notch Mimo Antenna with Meander Slot and Dgs for Ultra-Wideband Applications," ARPN Journal of Engineering and Applied Sciences, Vol. 12, No. 15, August 2017.
[12] S. Mirzaee and Y. Zehforoosh, "CPW-Fed Circularly Polarized Slot Antenna with Elliptical-Shaped Patch for UWB Applications", Journal of Communication Engineering, Vol. 6, No. 2, July-December 2017
[13] Tapan Nahar and O.P.Sharma, "Performance Comparison of Modified Structures of Corporate fed Microstrip Antenna Array for L band," International Journal of Electronics Circuits and Switching (IFRSAIIJECS), Vol.4, Issue 1, ISSN: 2277-5870, Jan. 2015
[14] Ravi Kant and D.C.Dhubkarya,"Design & Analysis of H-Shape Microstrip Patch Antenna, "Global Journal of Research in Engineering, Vol. 10, Issue 6 (Ver 1.0), pp. 26-29, Nov. 2010.
[15] M. Venkata Narayana, A.Vikranth, I. Govardhani, Sd. Khaja Nizamuddin, Ch. Venkatesh "A Novel Design of a Microstrip Patch Antenna with an End Fire Radiation for SAR Applications" International Journal of Science and Technology, Volume 2 No.1, January 2012.

