International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1S, October 2019

A Slotted Single Feed Circularly Polarized Microstrip Patch Antenna with Suppressed Surface Wave Losses for WLAN Applications

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***Abstract*: The circularly polarized microstrip antenna has been of great importance in WLAN applications. A circularly polarized slotted circular patch antenna with co-axial feed geometry has been designed to meet the requirements. The antenna designed has been slotted at several locations to make it radiate circularly polarized radiation. Two metallic cylindrical vias have been inserted near the two diametric ends of the slot to improve the realized gain of the antenna. The antenna structure is resonating at 6.4 GHz with 3dB axial ratio bandwidth of 200MHz and gain of 9.8dB has been observed.**

***Index Terms*: circular polarization, circular patch, slots, axial ratio bandwidth, cylindrical metallic pins**

I. INTRODUCTION

The microstrip patch antennas are extensively being employed for wireless applications because of its planar geometry, ease of fabrication and installation, light weight and low cost[1-3]. Achieving polarization is one of the important features in the antennas as the wave behaviour changes with distance with Faraday's rotation and geometric differences at different locations. The circular polarization in microstrip patch antennas[1-2] is achieved by using dual feed antennas (with orthogonal feeds) and by perturbing the patch at specific locations. The perturbation of the patch is done at diagonal edges. In this paper equilateral triangles are being etched out at the diagonal locations.

There are several aspects that are being considered upon for elimination of some severe drawbacks in microstrip patch antenna like low gain. The gain is lowered due to several reasons but the most predominant one is propagation of surface wave modes. The dominant mode TM_0 mode mode propagates beneath the patch surface and gets radiated from the edges of the dielectric substrate. The parameters which get affected due to surface wave propagation are radiation efficiency and gain. The surface wave propagation can be suppressed by micromachining technology[4]. The cavity section of substrate beneath the metallic patch antenna is etched out in micromachining. The surface wave suppression can also be done using photonic bandgap structure.

Manuscript published on 30 October 2019.
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The artificially designed metasurface antennas [5] and holographic antennas are recently being used for this purpose. Metasurface antennas are also used for enhancing radiation efficiency and gain of the patch antennas. The patch antenna surface is not limited to a small portion of the dielectric substrate but it is extended to cover the complete surface of the dielectric substrate. The periodic arrangement of regular pattern is etched over the top metallic surface of the dielectric substrate. The propagation of surface wave mode is inhibited by designing artificial dielectric substrate. The artificial dielectric substrate is designed with periodic arrangement of metallic vias inserted in the dielectric medium. The metallic vias embedded in the dielectric substrate (Fakir's bed of nails) prove to act like Electromagnetic Band Gap (EBG) Structure. The EBG substrates are designed in such a way that they provide band gap characteristics to the propagation of surface wave modes. The periodic arrangement of cylindrical metallic pins proves to provide negative permittivity to the dielectric substrate. The pioneers in the field of artificial dielectrics are Winston Kock, Seymour Cohn, John Brown[6], and Walter Rotman[7]. The study of surface wave propagation and methods to eliminate it are being illustrated in research papers by R.J.King[8], Sievenpiper[9], Silverinha[10] et. al. The validation an proof of Reduced Surface Wave Theorem is postulated by Varada Rajan Komanduri[4].

The artificial dielectric designed is embedded grid of cylindrical metallic pins that has high impedance. The surface waves are attenuated due to this high impedance surface and this medium serves the function of directing the radiation in the desired direction of antenna's radiation.

II. ANTENNA DESIGN

The circular patch has been slotted with four rectangular slots and two circular slots. These slots have been cut in a way so that it provides a slight difference in longitudinal and latitudinal electric field vectors, due to which two near degenerate orthogonal modes are generated for achieving circular polarization.

The three metallic cylindrical pins have been embedded in the dielectric substrate for suppression of surface waves. The height of the pins has been kept same as that of substrate since the fringing fields entering into the substrate gets reflected towards the main radiation lobe at the very same transition point. The antenna is designed at 6.4 GHz as shown in Fig.1 for WLAN applications. Antenna design parameters are tabulated in Table. 1.

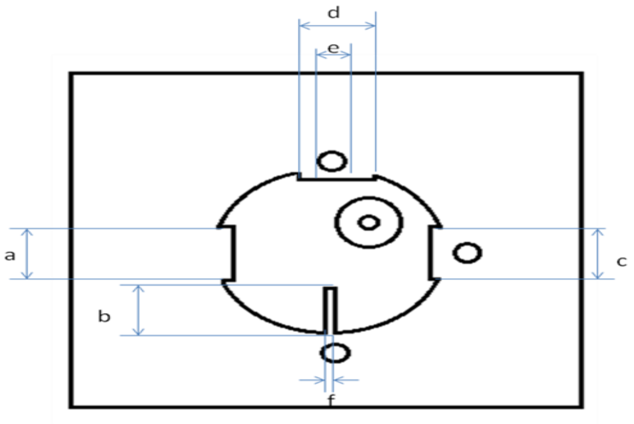

Fig.1 Top view of antenna designed

Table 1. Antenna Design parameters

Design Parameters	**a**	**b**	**c**	**d**	**e**	**f**
Dimension (mm)	**4.2**	**4**	**4.1**	**4.2**	**2**	**1**

I.THEORY OF SURFACE WAVES

The power losses in microstrip patch antenna occur due to transition of dominant quasi TEM mode into leaky mode. The leaky mode further splits into surface wave and space wave [1]. The dimensions (length, width) of the microstrip patch antenna plays a crucial role. At critical width propagation exists and the real propagation wave number is equal to the free space wave number with zero attenuation constant. At critical frequency the propagating mode divides into surface wave and leaky wave modes. While achieving the transition from critical to leaky wave undesirable effects are produced.

Surface waves travel in transverse direction and gets radiated from the edges of the patch antenna. The TM_0 surface wave mode propagates in conventional patch antennas.

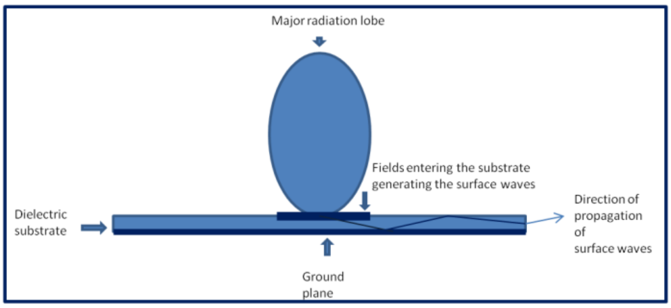

Fig.2 Propagation of Surface waves

Enhancing substrate thickness to improve the patch antenna bandwidth leads to increase in surface wave propagation. The surface waves can only be attenuated by providing discontinuity to the flow of surface wave power.

III. RESULTS AND CONCLUSION

The simulation is done by using EM simulation medium Ansoft HFSSv12.

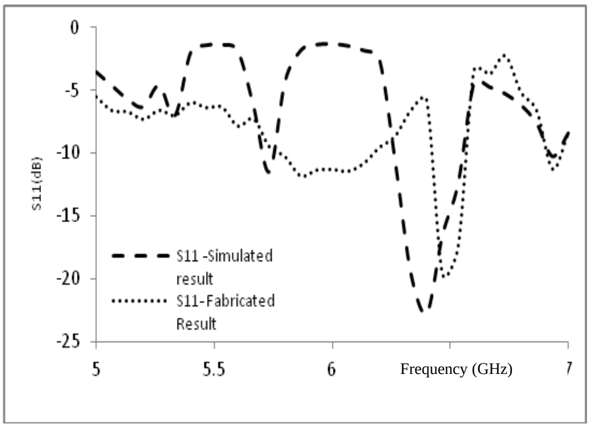

Fig.3. Simulation plot showing S11 characteristics

The antenna is designed for WLAN applications and is supposed to work in 5-6GHz frequency range. The S11 characteristics lies well in compliance with this.

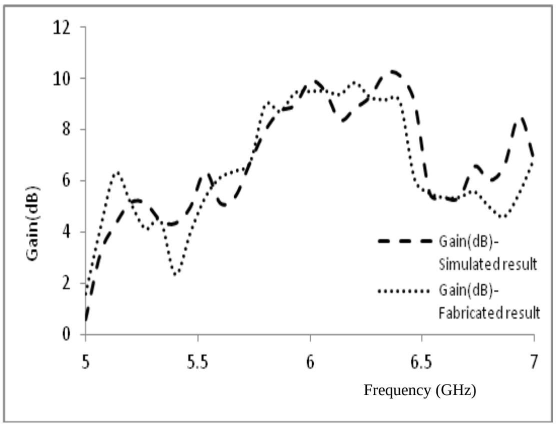

Fig 4. Simulation plot showing Gain characteristics

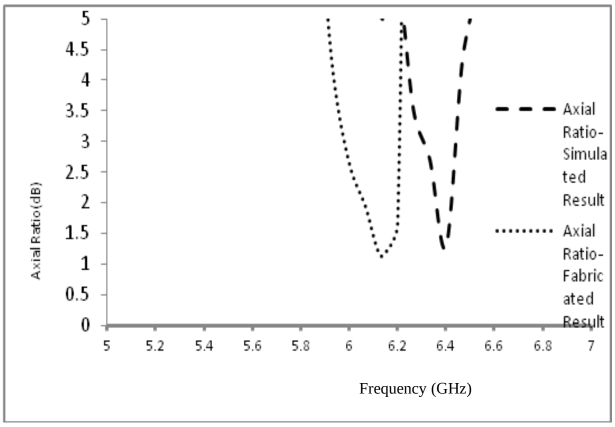

Fig.5. Simulation plot showing axial ratio characteristics

Retrieval Number: A10481091S19/2019©BEIESP
DOI:10.35940/ijeat.A1048.1091S19
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

The S11 characterisctics show that return loss of around -21dB at frequency 6.4 GHz. The maximum peak gain of around 9.8 dB is observed. The observations for axial ratio shows axial ratio bandwidth of around 200MHz.

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Manidipa Roy is M.Tech. in RF and Microwave Engineering. She had been associated with AIACT&R, Delhi. Currently she is working as Assistant Professor in ABES Engineering College, Ghaziabad, Uttar Pradesh. She has teaching and research experience of around seven years. She had been a Research fellow at Ambedkar Institute of Advanced Communication technologies and Research, Delhi. She had guided many under graduate and post graduate students in their projects. She has several publications in International and National Journals and Conferences. She is involved in several Sponsored projects and consultancy projects. She has been awarded Gold Medal in M.Tech. RF and Microwave from Guru Gobind Singh Inderprastha University, Delhi.

Dr. Ashok Mittal is M.Tech. in Microwave Electronics from University of Delhi, Ph.D. from Faculty of Technology, Delhi College of Engineering, University of Delhi. He has Teaching and industrial experience of around twenty six years. Before academics he had been associated with DRDO and BEL. In addition to hands on experience, he has several publications in Internal and National renowned journals and conferences. He has received NDRC Invention award, IETE IRS award, DSIR National R&D award at BEL, Best Counsellor award for IEEE-AIT student chapter. He is involved in providing research guidance to many M.Tech. and Ph.D. students and has successfully completed several corporate and industrial research projects.