IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Sp.Iss 6 , 2022

Split-Polarization WiFi Antenna with Defected Ground Structure (DGS) Capability for IoT and Medical Applications

D. Sreenivasa Rao

Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India.

DOI : 10.48047/IJFANS/11/S6/011

Abstract. The featured item showcases a square, reconfigurable antenna with dimensions of 20 x 35 x 0.8 mm^3, featuring four corner slots on the patch. These slots introduce additional modes that lend themselves to circular polarization. The transition between Linear Polarization (LP) and Circular Polarization (CP) is facilitated through a PIN diode situated within an L-shaped slot within the ground plane. The antenna design has undergone optimization and thorough analysis through simulations. The 3 dB axial ratio bandwidth and the -10 dB impedance bandwidth share a frequency range from 5.15 to 6.25 GHz, covering 19.3% of the spectrum. This prototype antenna has been subjected to testing in both forward and reverse polarization configurations. The operational frequency band encompasses the WLAN band, as defined by IEEE 802.11a (5150 - 5350 MHz, 5725 - 5825 MHz), and the HIPERLAN band (5450 - 5725 MHz). This frequency range aligns well with the balance observed between simulated and tested results. The antenna's omnidirectional radiation patterns make it particularly well-suited for use in portable wireless medical devices.

Keywords: patch antenna, reconfigurable, diode, multiband.

1. Introduction

Lately, there has been a significant focus on radio antennas featuring reconfigurable polarization due to their inherent advantages in mitigating signal degradation in complex propagation environments. This enhancement leads to a substantial improvement in transmission quality. The advantages of using reconfigurable antennas with varying polarizations have been particularly highlighted, both at the transmitting and receiving ends of indoor communication systems [1], [2]. While numerous frequency-reconfigurable antennas have been proposed in the literature, only a few polarization-reconfigurable antennas have been suggested. Achieving reconfigurability involves incorporating various types of switches, such as Varactor diodes, PIN diodes, MEMS switches, and so on [13]-[20].

One notable example is a single-feed square patch antenna featuring a rectangular slot with eight diodes placed within the slots to enable both frequency and polarization reconfigurability. This antenna offers a bandwidth of 12% at 5.2 GHz and 30% at 5.8 GHz [3].

Another innovation involves a microstrip patch antenna with a compact U-shaped slot. In the initial configuration, a PIN diode is inserted across the slot to switch between linear and circular polarization. In the second setup, a pair of PIN diodes is positioned across the arms of the U-shaped slot to transition between Right-hand Circular Polarization (RHCP) and Left-hand Circular Polarization (LHCP) within the 5.725 to 5.85 GHz range, catering to WLAN applications [4].

While some monopole and loop antennas have been designed to offer wideband performance, these designs tend to be intricate and complex. Notably, they require a substantial number of diodes, such as 64 diodes in [5] and 48 diodes in [6], as well as lumped components to achieve their intended functionality [5], [6].

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved**, **Volume 11, Sp.Iss 6 , 2022**

A notable design featuring a reconfigurable circularly polarized microstrip patch antenna with two symmetrical slots has been devised. These slots are integrated into the microstrip patch and equipped with a pair of PIN diodes to control their opening and closing. Depending on the state of the diodes (on or off), the proposed antenna emits either left-hand circular polarization (LHCP) or right-hand circular polarization (RHCP) [7].

In [8], an open patch antenna with a CPW-to-slot line transition feed was introduced to switch between vertical and horizontal polarization by manipulating a pair of PIN diodes. Polarization reconfigurability is achieved through this control mechanism.

[9] presents a dual-feed square patch antenna with openings at opposite corners. By placing a pair of PIN diodes in these openings and controlling them, the antenna can switch between horizontal and vertical linear polarization (LP) and right-hand and left-hand circular polarization (CP). The antenna's dimensions are 50 mm x 50 mm due to its dual feeds.

In [10], a single-feed monopole antenna with polarization reconfigurability is designed with dimensions of "20 × 35 mm^2." It features a slim L-shaped slot in the ground plane, and by manipulating the state of a pair of PIN diodes, it can achieve dual symmetrical polarizations, both vertical and horizontal. This antenna operates within the 5-6.4 GHz range.

[7]-[10] collectively demonstrate that by controlling the PIN diodes, it is possible to achieve either linear (vertical and horizontal) or circular polarization (LHCP and RHCP).

For WLAN applications, [11] introduces a shorted annular patch with a partially reflected surface fed by a Wilkinson power divider network. This network consists of four PIN diodes, which can be controlled to switch the antenna's polarization between linear and circular polarization (RHCP and LHCP). The antenna covers an impedance and axial ratio bandwidth of 4680 to 5330 MHz.

In [12], a 2x2 array antenna is presented with a dual-mode substrate integrated waveguide (SIW) cavity. Two sets of slots are incorporated into the SIW cavity plane, allowing for the achievement of linear polarization (LP), LHCP, and RHCP by adjusting the radiation phases with a suitable selection of the input port.

While the use of numerous switches in these designs may increase system complexity and limit practical implementation, the flexibility of frequency and polarization reconfiguration is essential not only for changing frequency bands but also for adapting polarization to various communication needs.

This paper introduces a simple rectangular open patch antenna with a Defected Ground Structure (DGS). Reconfigurable polarization is achieved by switching the PIN diode. The -10 dB bandwidth of the antenna covers the WLAN bands (IEEE 802.11a) in the frequency range of 5150 - 5350 MHz (indoor) and 5725-5825 MHz (outdoor), as well as HIPERLAN/2 (5470-5725 MHz). Circular polarization (CP) can be attained with four slots on the patch, providing two symmetrical modes with a quadrature phase. Section II presents the antenna design and parametric analysis for optimized design parameters. In Section III, experimental and simulated results are discussed in detail, followed by conclusions in Section IV.

2. STRUCTURE OF ANTENNA:

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved, Volume 11, Sp.Iss 6 , 2022**

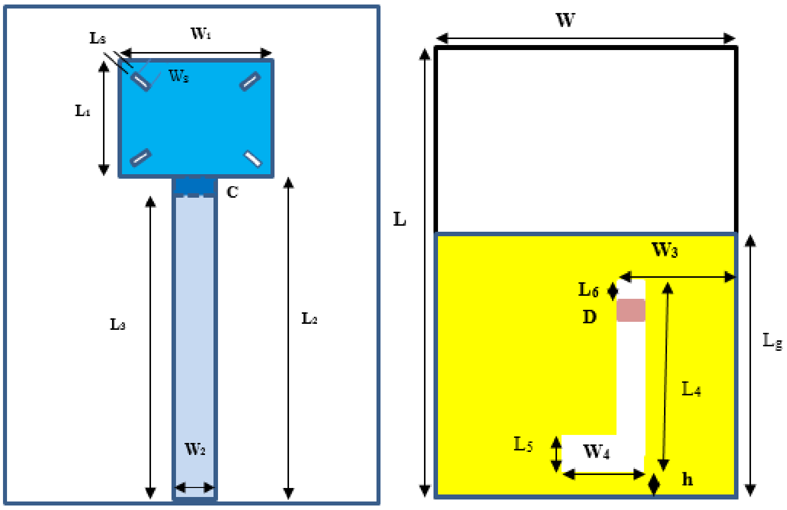

Fig. 1. Structure of the designed antenna (a) Front view (b) Rear view.

Figure 1 illustrates a wideband rectangular patch antenna with polarization reconfigurability. The rectangular patch antenna, measuring "20 × 35 mm^2," is positioned on a flat 0.8 mm-thick substrate made of Heatproof 4 material with a relative permittivity of 4.4 and a loss tangent of 0.02. The ground plane has dimensions of "20 × 20.5 mm^2." An L-shaped slot is incorporated into the ground plane. The antenna's structure and dimensions are depicted in Figure 1.

Following optimization, the depth of the L-shaped slot in the ground plane is chosen to be 2 mm. The "9 × 11.5 mm^2" rectangular patch is fed with a 50 Ω microstrip line, which is 2 mm wide and 20.5 mm long. Four rectangular slots, each measuring "3 × 1 mm^2," are introduced at the corners of the patch. To achieve the desired reconfigurability, a PIN diode is employed and is mounted across the L-shaped slot on the ground plane. The final configuration of the antenna is determined through parametric analysis to ensure a favorable Axial Ratio (AR) bandwidth. An Ansoft HFSS three-dimensional full-wave electromagnetic simulator is used for the simulation.

3. Results and Discussion

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Sp.Iss 6 , 2022

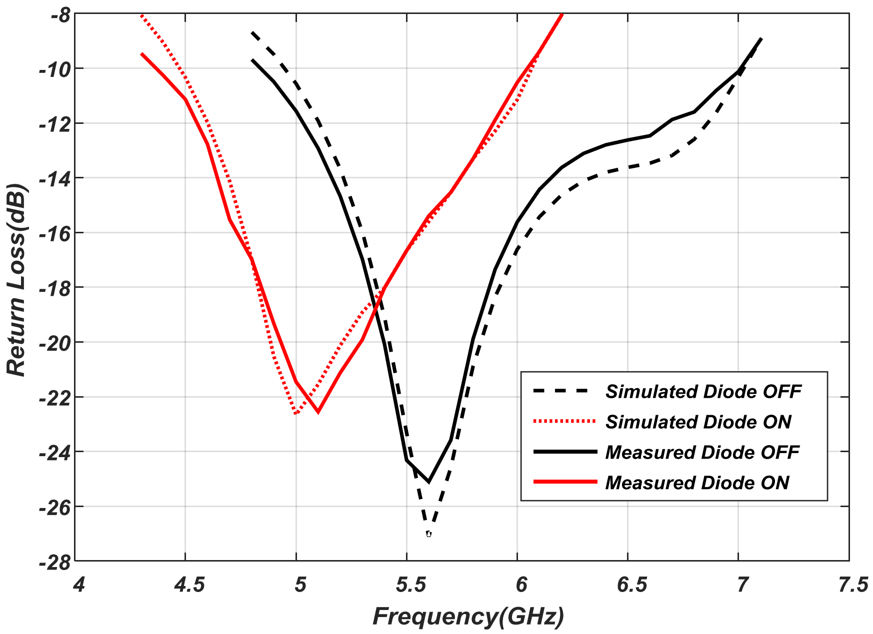

Fig. 2. Comparison between measured and simulated S11 for diode OFF and ON configurations.

The experimental results are compared with simulated results, as illustrated in Figure 2. The resonant frequency of the antenna is shifted from 5.1 GHz to 5.6 GHz, resonating at 5.1 GHz for the PIN diode in the ON state and at 5.6 GHz for the PIN diode in the OFF state, respectively. Figure 7 displays the measured and simulated -10 dB impedance bandwidth for the PIN Diode ON configuration, covering a range from 4.3 to 6.1 GHz (a bandwidth of 35%) and from 4.5 to 6.1 GHz (a bandwidth of 30%). Conversely, when the diode is in the OFF state, the measured and simulated return loss (S11) bandwidth spans from 4.8 to 7 GHz (37.3%) and from 5 to 7 GHz (33.3%). In both scenarios, the proposed antenna effectively covers the HIPERLAN bands (5450 - 5725 MHz) and the IEEE 802.11a WLAN bands (5150 - 5350 MHz and 5725 - 5825 MHz).

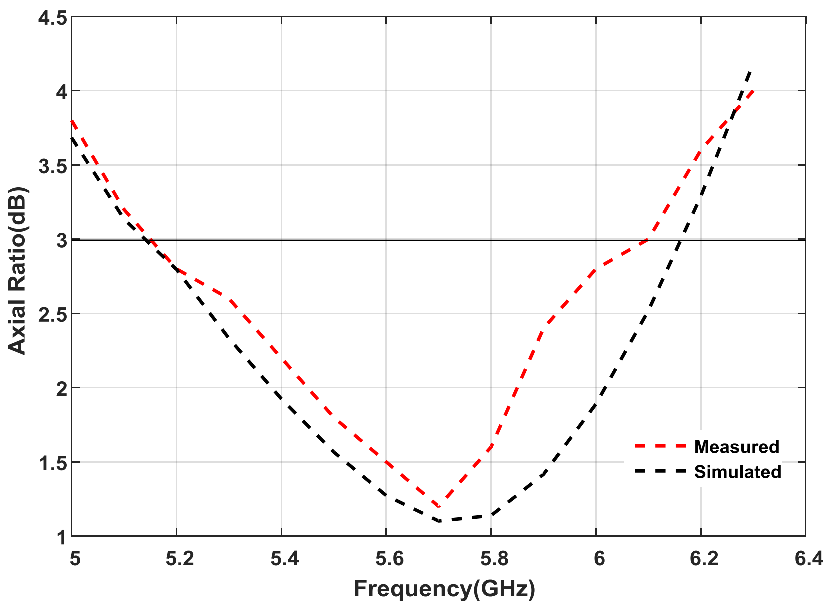

Fig. 3. Frequency vs axial ratios plot.

When the PIN diode is OFF, the antenna operates in a circular polarization state (RHCP). Figure 8 presents the measured and simulated Axial Ratio (AR) for the circularly

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved**, Volume 11, Sp.Iss 6 , 2022

polarized antenna. The 3-dB axial ratio bandwidth spans 1100 MHz, ranging from 5.15 to 6.25 GHz (19.3%), with the axial ratio remaining below 3dB throughout this bandwidth. Conversely, when the diode is ON, the antenna is linearly polarized (VP) with an axial ratio of 50dB. Figure 9 displays the antenna's surface currents for both the diode ON and OFF states.

4. Conclusions

We present a Wideband Aperture Antenna designed for WLAN Applications with Switchable Polarization capabilities. This antenna is capable of providing both linear and right-hand circular polarization using a single PIN diode. The diode is strategically positioned across the aperture in the ground plane to minimize its impact on radiation characteristics. The antenna exhibits an Axial Ratio (AR) bandwidth of 19.3% for right-hand circular polarization (RHCP). At 5.5 GHz, the antenna achieves a peak gain of 2.5 dBic. The antenna model has been constructed and tested for both linear and circular polarization scenarios. The results of both simulations and experiments indicate that the proposed antenna is well-suited for portable medical devices.

References

1. Y. Lin and K. Hung, "Compact Ultrawideband Rectangular Aperture Antenna and Band-Notched Designs," in IEEE Transactions on Antennas and Propagation, vol. 54, no. 11, pp. 3075-3081, Nov. 2006, doi: 10.1109/TAP.2006.883982.
2. Young Jun Cho, Ki Hak Kim, Dong Hyuk Choi, Seung Sik Lee and Seong-Ook Park, "A miniature UWB planar monopole antenna with 5-GHz band-rejection filter and the time-domain characteristics," in IEEE Transactions on Antennas and Propagation, vol. 54, no. 5, pp. 1453-1460, May 2006, doi: 10.1109/TAP.2006.874354.
3. N. P. Agrawall, G. Kumar and K. P. Ray, "Wide-band planar monopole antennas," in IEEE Transactions on Antennas and Propagation, vol. 46, no. 2, pp. 294-295, Feb. 1998, doi: 10.1109/8.660976.
4. Subbareddy V., Madhav B.T.P., Prathyusha S., Gopi Janardhan G., Kalpanath N., Venkateswara Rao M. (2017),'A printed staircase serrated CPW antenna for UWB applications',ARPN Journal of Engineering and Applied Sciences,12(15),PP.4483-4488.
5. V. K. Allam, B. T. P. Madhav, T. Anilkumar, and S. Maloji, "A Novel Reconfigurable Bandpass Filtering Antenna for IoT Communication Applications," Progress In Electromagnetics Research C, Vol. 96, 13-26, 2019. doi:10.2528/PIERC19070805.
6. Subba Reddy V., Siva Ganga Prasad M., Madhav B.T.P. (2017),"Triple band notch tree structured fractal antenna for uwb applications",Journal of Advanced Research in Dynamical and Control Systems, 9 (Special Issue 14), PP.1755-1763.
7. Allam V., Madhav B.T.P. (2018) , 'Defected ground structure switchable notch band antenna for UWB applications',Smart Innovation, Systems and Technologies, 77 (),PP. 139- 145.
8. Anusha T., Ramakrishna T.V., Madhav B.T.P., Meena Kumari A.N. (2018) , 'Dual-Band-Notched CPW-Fed Antennas with WiMAX/WLAN Rejection for UWB Communication',Lecture Notes in Electrical Engineering, 471 ,PP. 559- 570.
9. Vamsee Krishna A., Madhav B.T.P. (2018) , 'Planar switchable notch band antenna with DGS for UWB applications',Lecture Notes in Electrical Engineering, 434 (),PP. 509- 518
10. Srinivas K.P., Khan H., Madhav B.T.P. (2018) , 'A CPW fed dual band notched UWB antenna for wireless medical applications',Indian Journal of Public Health Research and Development, 9 (6),PP. 306- 310.
11. Madhav B.T.P., Ram Kiran D.S., Alekhya V., Vani M., Avinash T., Sreekanth P., Anilkumar T. (2017),'An asymmetric liquid crystal polymer based fractal slotted UWB

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Sp.Iss 6 , 2022

monopole antenna with notch band characteristics',Rasayan Journal of Chemistry,10(3),PP.852-860.

12. Jetti C.R., Nandanavanam V.R. (2018) , 'Trident-shape strip loaded dual band-notched UWB MIMO antenna for portable device applications',AEU - International Journal of Electronics and Communications, Vol. 83, PP. 11- 21.
13. Pardhasaradhi P., Madhav B.T.P., Sai Tejini Varma S., Pavani V., Kumar G.M., Anilkumar T. (2019), 'Defected ground structure based reconfigurable UWB antenna for iot applications', International Journal of Recent Technology and Engineering, 8(1), PP.3030-3036.
14. Rama Krishna T.V., Madhav B.T.P., Geetanjali S., Parnika B., Bhargavi M.L., Tanmai A.S., Anilkumar T. (2019), 'Design and study of a CPW fed truncated circular patch switchable band-notched UWB antenna', International Journal of Recent Technology and Engineering, 8(1), PP.3037-3043.
15. Teja Babu K., Syam Sundar P., Madhav B.T.P., Prudhvi Nadh B., Kotamraju S.K. (2019), 'Dual notch UWB monopole antenna with u-shaped slots', ARPN Journal of Engineering and Applied Sciences, 14(11), PP.2125-2130.