International Journal of Electronics Signals and Systems

Volume 4 | Issue 3 Article 5

April 2022

A Low Profile Microstrip Patch Antenna using a Polygon-Shaped Patch for Wireless Applications.

Muthu Krishnan Ramar
B.S.Abdur Rahman Crescent Institute of Science and Technology, pearlkrish002@gmail.com

Kannan G
B.S.Abdur Rahman Crescent Institute of Science and Technology, kannan@crescent.education

A LOW PROFILE MICROSTRIP PATCH ANTENNA USING A POLYGON-SHAPED PATCH FOR WIRELESS APPLICATIONS

R. Muthu Krishnan[1], G.Kannan[2*]
[1]Research Scholar, [2]Associate Professor, Department of ECE,
B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai-48.
*- corresponding author, Email: pearlkrish002@gmail.com[1], kannan@crescent.education[2]

ABSTRACT

In this paper. a low profile microstrip patch antenna is presented. The FR4 substrate is chosen for the dielectric substrate with a height of 1.6 mm. The presented antenna employs a polygon-shaped patch as the radiator for operating at 2.4 GHz. Co-axial feed is selected to excite the resented antenna to retain the low profile property of the antenna. The simulated results of the proposed antenna were analyzed and the structure of the proposed antenna was validated through fabrication results. The vector network analyzer is used to measure the real-time return loss property of the presented antenna.

Keywords: Microstrip antenna, Polygon shape antenna, Antenna for WSN

I. INTRODUCTION

Drastic evolution in Wireless sensor networks demands good antenna design to cope with characteristics. Wireless sensor networks have a vast number of applications in different fields [1]. Wireless sensor networks consist of several single nodes which are connected to a network for sensor information transmission. Each node in the wireless sensor network is integrated with sensors, antenna, processor and power supply.

Antenna design plays a vital role in a Wireless sensor network in the aspects such as the size of the node, power consumption of the node and error rate of the data transmission [2]. In this proposed work, Polygon shaped antenna operating on a 2.4 GHz ISM Band was simulated and fabricated. The microstrip antenna made up of FR4 is a recent trend because of its affordable cost in the market compared to other available dielectric constant materials [3]. Design technique and proposed some layouts of polygonal patch antennas to be employed in UMTS and WLAN wireless communication systems have been presented in [4].The design of a wearable dual-band patch antenna for operating in the GSM-900 and 1800 bands were given in [5].A Dual-band textile antenna is fabricated with an annular circular slot and another couple of transverse slots in the corner of the patch in [6]. In [6], the antenna is proposed for mobile and global positioning system frequencies with good efficiency.

II. ANTENNA DESIGN

The proposed Antenna uses an FR4 dielectric substrate whose dielectric constant (ε_r) is 4.4 and the height of the FR4 are 1.6 mm. Initially, in the antenna design square patch is determined then it is transformed into a polygon shape by cutting out a patch in the corner of the square patch. The square patch length ($\lambda_g/2$) is determined using standard expression [7] of the desired frequency 2.4 GHz where λ_g is the guided wave length. For the proposed antenna, patch length is calculated by substituting dielectric constant (4.4) and desired frequency (2.4 GHz) parameters in the half-wavelength equation. The calculated patch size is 29.9 mm which is approximated to 29.75 for design. From the square patch, the equal amount of patch is meandered out from the corner of the square patch for optimum resonant operation Feed location is optimized to (14.875, 21) position to obtain good impedance matching.

The proposed polygon structure antenna was designed using HFSS software. The simulated results such as S_{11}response, VSWR, 2D and 3D radiation patterns have been simulated and analyzed. By analyzing antenna characteristics, the proposed can be studied completely. The proposed antenna design adds more flexibility which is one of the good characteristics of this antenna. The polygon structure proposed antenna suitability for wireless sensor networks is discussed in the following discussion.The clear structure of the proposed polygon structure is shown in Fig 1.1 in which the antenna design illustrated in x, y-axis coordinates with the top left corner of the patch is placed in origin (0, 0).Fabricated Antenna is measured using a vector network analyzer and their results are compared with simulated results for validation of the structure. The presented antenna radiates through four uneven cuts in the top layer patch. Circular polarization can be achieved by cutting two diagonal corners in the patch, but in the proposed system four cuts lead to miniaturization of the antenna. The four unequal cuts reduce the patch area and in turn bring resonance at the desired 2.4 GHz.

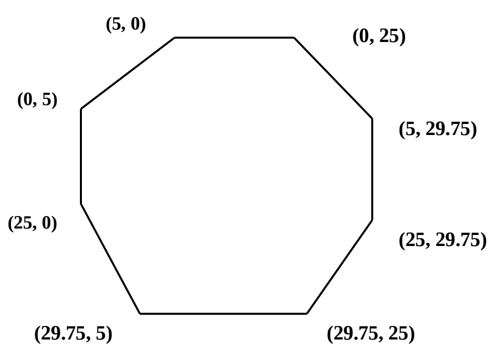

Fig.1.1 Topology of proposed Antenna

III. SIMULATED RESULTS

The proposed polygon structure antenna was designed using HFSS software. In Fig.1.2 simulated structure of the proposed antenna is given. The simulated results such as S_{11}response, VSWR, 2D and 3D radiation patterns have been simulated and analyzed.

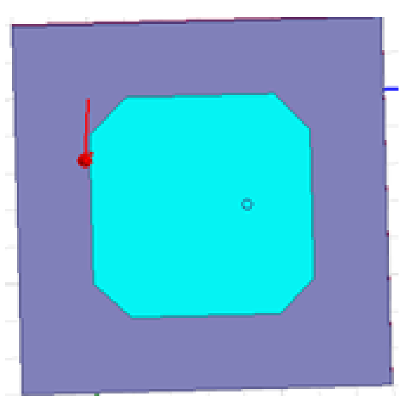

Fig.1.2 HFSS design of the proposed antenna

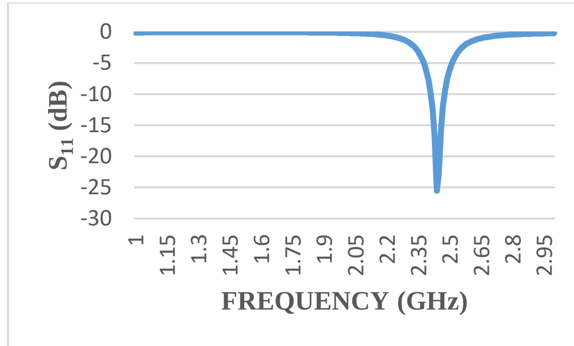

Fig.1.3 S_{11} Response of simulated proposed antenna

The S_{11} response of the simulated proposed antenna is shown in Fig.1.3.The S_{11} response of the simulated antenna has a resonant frequency at 2.44 GHz with the S_{11} response of -25 dB which is lower than -10 dB. The impedance bandwidth of the antenna ranges from 2.4 GHz to 2.6 GHz which is equal to 200 MHz and that covers the bandwidth of the Industrial, Scientific, and Medical band. The VSWR of the simulated proposed antenna is displayed in Fig.1.4. The VSWR of the simulated proposed antenna is 1.15 which is lower than 2. Through S_{11} and VSWR results it can be observed the reflection property of the antenna towards the 50-ohm feed. The 2D radiation pattern can be used to analyze the antenna coverage in the free space.

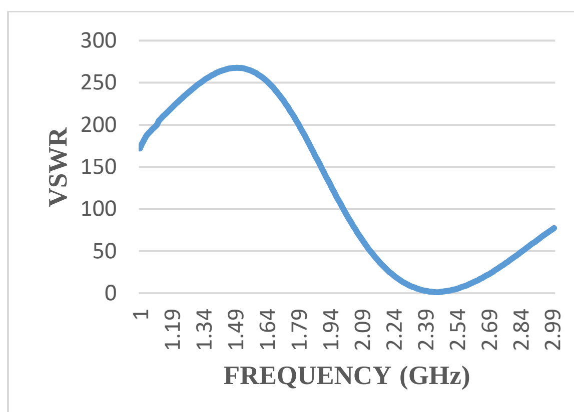

Fig.1.4 VSWR of the simulated proposed antenna

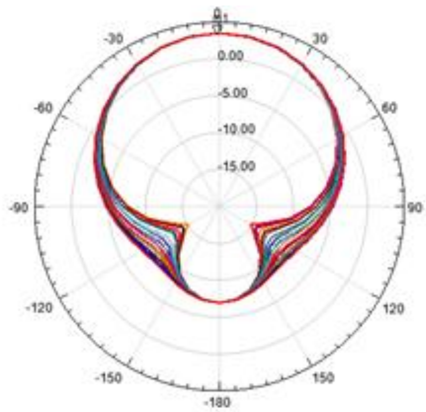

Fig.1.5 2D Radiation Pattern of Simulated Proposed antenna

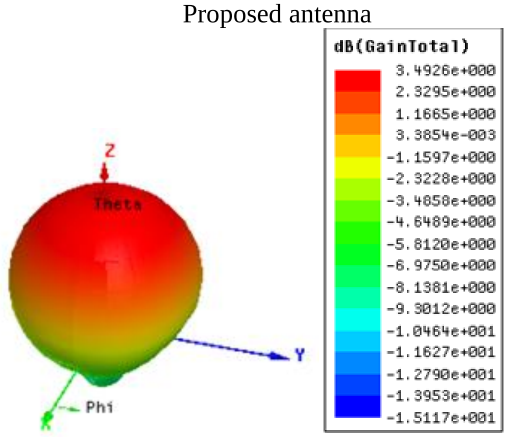

Fig.1.6 3D Radiation pattern of the simulated proposed antenna

The simulated 2D and 3D radiation patterns are shown in Fig.1.5 and Fig.1.6 respectively by analyzing the radiation pattern found that antenna gain is 3.5 dB. By observing the 3D radiation pattern, it is understood that the presented antenna has very low backward radiation and also the front-back ratio of the antenna is high for medium-range communication.

IV. EXPERIMENTAL RESULTS

The antenna is fabricated using a PCB milling machine at a cheap fabrication cost. By employing a good connector, its radiation properties are analyzed and discussed in this section. Fabricated Antenna is measured using a vector network analyzer and their results are compared with simulated results for validation of the structure. Fabrication of the antenna follows the standard process of etching out the four unequal cuts from the square patch and in turn producing the designed structure in the final antenna prototype.

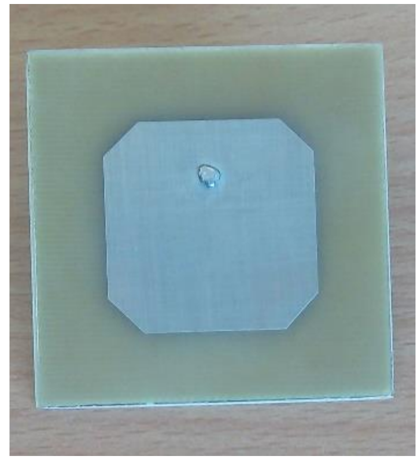

Fig.1.7 Fabricated Antenna

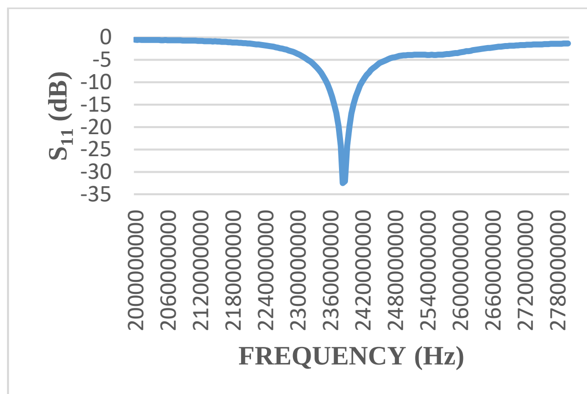

Fig.1.8 Measured S_{11} Response of the Proposed Antenna

As shown in Fig.1.3 Simulated Results of the proposed antenna have a centre frequency at 2.44 GHz with theS_{11} response of -25 dB. For minimum radiation efficiency from the antenna, it was defined as it must have an S_{11} response less than -10 dB. As proposed antenna simulated results show that it has -25 dB which shows it has good efficiency.

In Fig.1.8, the S_{11} response of the Fabricated Antenna is shown. Fabricated Antenna has acentre frequency at 2.38 GHz with theS_{11} response of -32 dB. Comparing simulated and measured results show that Fabricated Antenna has a frequency shift of 60 MHz.

As shown in Fig.1.4. Simulated results of theproposed antenna have a centre frequency at 2.44 GHz with a VSWR value of 1.15. For minimum radiation efficiency from the antenna, it was defined as it must have a VSWR value less than 2.

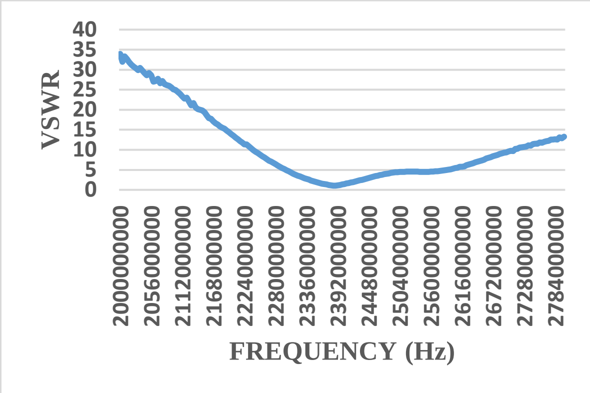

Fig.1.9 Measured VSWR Response of the proposed antenna

As proposed antenna simulated results show that it has a 1.15 VSWR value which shows it has good efficiency. In Fig.1.9. VSWR of Fabricated Antenna is shown. Fabricated Antenna has acentre frequency at 2.38 GHz with a VSWR value of 1.09.

V.CONCLUSION

The Proposed Polygon Shaped Patch Antenna simulated results show that it has a centre frequency at 2.44 GHz with theS_{11} response of -25 dB. For minimum radiation efficiency from the antenna, it was defined as it must have an S_{11} response less than -10 dB. As proposed antenna simulated results show that it has -25 dB which shows it has good efficiency. Measured Results shows that it resonates at 2.38 GHz with theS_{11} response of -32 dB. It shows that simulated and measured results have a variation which is frequency shift by 60 MHz. The Simulated VSWR and Measured VSWR is 1.15 and 1.09 respectively with some Frequency Shifts. The Proposed antenna have realized again of 3.65 dB. The performance of the proposed antenna is good at 2400 MHz and it is validated by analyzing measured Results.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Computer Networks, vol. 38, pp. 393- 422, 2002.

[2] K. Lorincz, D. J. Malan, T. R. F. Fulford-Jones, A. Nawoj, A. Clavel, V. Shnayder, G. Mainland, M. Welsh, and S. Moulton, "Sensor Networks for Emergency Response: Challenges and Opportunities," IEEE Pervasive Computing, vol. 3 (4), pp. 16-23, October-December 2004.

[3]Qiang Bai, Jonathan Rigelsford, and Richard Langley, ‘Crumpling of Microstrip Antenna Array’ IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 61, NO. 9, SEPTEMBER 2013.

[4] Mauro Manzini, Andrea Alù, Filiberto Bilotti, and Lucio Vegni, ‘Polygonal Patch Antennas for Wireless Communications’ IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 53, NO. 5, September 2004.

[5] Esther Florence Sundarsingh, Sangeetha Velan, Malathi Kanagasabai, Aswathy K. Sarma, Chinnambeti Raviteja, and M. Gulam Nabi Alsath,‘Polygon-Shaped Slotted Dual-Band Antenna for Wearable Applications’IEEEANTENNASANDWIRELESSPROPAGATIONLETTERS,VOL.13,2014.

[6] R. Muthu Krishnan, and Dr S. Tamil Selvi, ‘Dual Band Square Shaped Slotted Patch Antenna for Wearable Applications’ International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682 Vol.34, No.34, February 2015.

[7] Balanis. A.C, Antenna Theory: Analysis and Design, 3rd ed. Hoboken, NJ, USA: Wiley, 2012.

[8] D.M. Pozar, “Microwave Engineering”, Addison-Wesley Publishing Company, 1990, 726 pages.

[9] HFSS software version 18.0.