International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Design of Dual Band Antenna with Defects on Patch and Ground for Wireless Applications

Ravi Kumar Palla, K. K. Naik

Abstract*: In this paper, a rectangular patch antenna with slits for dual band capabilities is presented. The suggested antenna works for two frequencies which are at 2.5 GHz and 5.1 GHz. The first operating frequency is in the band of 2.3 to 2.7GHz with -16.8dB reflection coefficient at 2.5GHz resonating frequency, whereas the second band is 4.6 to 5.5GHz with -29.2dB reflection coefficient at 5.1GHz resonating frequency. The simulation results exhibit that, the suggested antenna works for dual band frequency having impedance bandwidth of 482 and 844 MHz respectively. The gain is observed as 2.9 dBi and 4.2 dBi of respective bands. The first frequency band can be used for Industrial, Scientific and Medical(ISM) applications and second frequency band can be used for C-band applications.

***Index Terms*: defected ground structure, dual band, ISM, patch antenna**

I. INTRODUCTION

Recently, there has been much more demand of micorstrip patch antennas in all types of wireless communication applications. Many wireless communication systems need a single antenna for dual band applications. In the literature many antennas have been proposed to achieve dual bands. A small annular slotted antenna having symmetric slits for circular polarization is designed [1] for Compass Navigation Satellite System applications. Circular polarization is achieved by changing the radius of the annular slot and impedance matching is achieved by changing position of the tab. The reduction in antenna size is achieved by incorporating symmetric slits on the circular patch towards the radial direction. A Y-shaped monopole antenna with omni-directional radiation pattern and having broadband for various wireless applications is presented in [2]. A low profile octagon-star shaped microstrip patch antenna [3] having conical radiation pattern with circular polarization is proposed. By superimposing two square patches forming an octagon-star shape antenna used to generate omnidirectional circular polarization. A low profile and compact microstrip antenna array with dual-band capability having wide bandwidth was designed for multiple-input multiple-output applications and is presented in [4]. A low-profile horizontally polarized omnidirectional antenna [5] for 5G wireless local area network applications. Omni directional radiation pattern is achieved by theory of characteristic mode. A millimeter-wave antenna has a characteristics of compact, low cost and high gain with low side lobe level for 5G cellular applications is proposed in [6]. The antenna achieves a gain and impedance bandwidth of 21 dBi and 9.8% respectively.

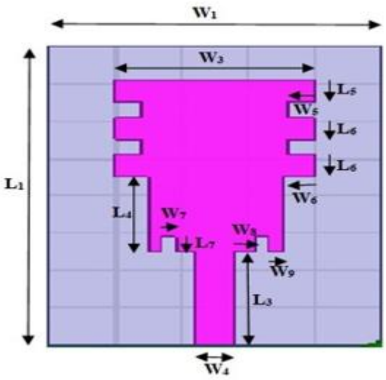
A circularly polarized microstrip antenna with characteristic of broad bandwidth is designed for an application of space communication. The radiation efficiency is improved by eliminating the conductor loss and is achieved by using high temperature superconductor. A microstrip antenna with low profile and differentially fed using shorting pins for broad impedance bandwidth is also presented. Impedance matching is obtained by circular disks placed below the radiating patch. In [7], a wearable antenna is proposed to resonate at 2.45 GHz in ISM band for on-body applications. A circularly polarized millimeter wave antenna array with L-shaped branches having wideband characteristics is discussed in [8]. P-i-n diodes based switchable between ON-body and OFF-body antenna resonating at 2.45 GHz for ISM band is presented in [9]. A low profile dual band antenna operating at ISM band for monitoring body signal continuously in-body communication and at ultra-wideband for off-body communications is presented. A miniaturized wearable antenna using fabric material operating at 2.4 GHz for ISM band applications is demonstrated. The antenna has sustainable performance even after the bending of the antenna which makes it suitable for wearable applications. A Y-shaped patch antenna [10] works at triple bands for various wireless applications is discussed. A miniaturized asymmetric coplanar waveguide fed antenna operating at worldwide interoperbility for microwave access and Wi-Fi applications is presented. In this, the miniaturization is achieved by effective utilization of ground plane. A compact monopole antenna having slits with L-shape on the corners of a rectangular patch for covering entire S-band is proposed in [11]. The antenna for biotelemetry applications including ISM band is miniaturized by introducing meander line on the patch, embedding a ground slot with an open end and with the introduction of shorting pin between ground and patch is presented in [12]. An inset feed rectangular patch antenna having small size with dual band capability for ISM band in vehicular applications is presented in [13]. It is noticed from the literature that some of the antennas are suggested for attaining circular polarization, some antennas are for attaining dual band operation, compactness and other parameters. Various techniques are suggested to get the dual bands. In this paper, a simple structured rectangular patch antenna with slits for dual band capabilities is presented in section II.

Revised Manuscript Received on 30 July 2019.
* Correspondence Author
Ravikumar Palla*, Dept. of ECE, GMR Institute of Technology, Rajam, Srikakulam, AndhraPradesh, India.
K.K.Naik, Dept. of ECE, K L University, Guntur, India.

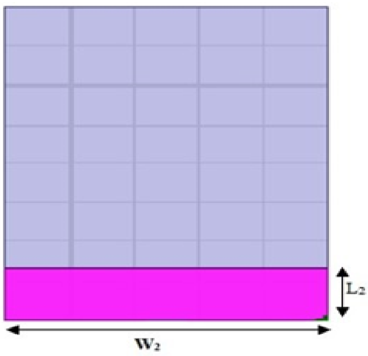
Dual band capability is achieved by using a defected ground structure. Results of the suggested antenna are discussed in section III. Finally, conclusions are given in section IV.

II. GEOMETRY OF SUGGESTED ANTENNA

Fig. 1 displays the geometry of rectangular patch antenna with slits. Initially the rectangular patch is considered as an antenna and it is fed with microstrip line. Later on slits are introduced at the appropriate places to resonate at the required frequencies. The antenna was fabricated on FR4 substrate having dielectric constant 4.4 with 1.59mm thickness. The substrate length is of 45 mm and width is of 25 mm. The optimised dimensions of the suggested antenna is shown in the below Table I. The suggested antenna is fabricated using FR-4 substrate plated with Copper on both sides and the design is etched using the solution SiO_2. The SMA Connector connects the ground plane and patch of the antenna. The fabricated antenna is displayed in the Fig. 2.

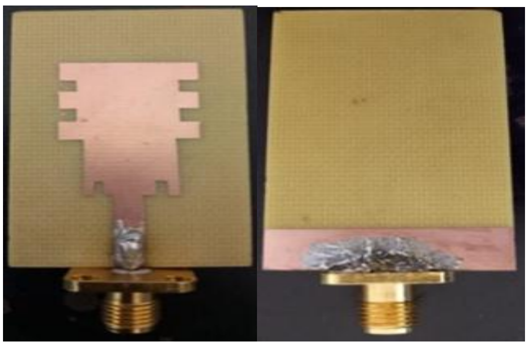


(a)



(b)

Fig. 1. Rectangular Patch Antenna a) Front view b) Rear view



(a) (b)

Fig 2. Prototype of Fabricated Antenna a) Top view b) Rear view

Table I: Dimensions of the suggested Antenna

Parameter	Value(mm)	Description
W_1	25	Width of Substrate
L_1	45	Length of Substrate
W_4	3	Microstrip line Width
W_3	15	Upper Rectangle Width
L_5,L_6	3	Upper Rectangle Slit Width
W_5	2	Upper Rectangle Slit Gap
W_6	2.5	Middle Rectangle Width
W_7	1	Slit Gap
W_9	1	Slit Width
L_4	10	Middle Rectangle Length
L_3	12.5	Lower Rectangle Length+ Microstrip line Length
L_7	2	Height of the slit
L_2	6.5	Ground Plane Length

III. RESULTS AND DISCUSSION

The reflection coefficient of the suggested antenna is shown in Fig. 3. From the result, it is noticed that the suggested antenna operates at dual frequencies 2.5 and 5.1GHz. At both the frequencies impedance bandwidths are 482 and 844 MHz respectively with the reflection coefficient of below -10dB. The suggested antenna is analyzed with help of electromagnetic solver HFSS which is on the basis of finite element method.

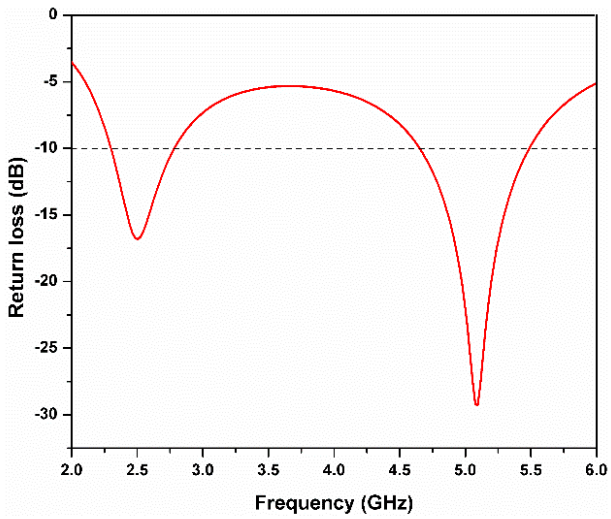
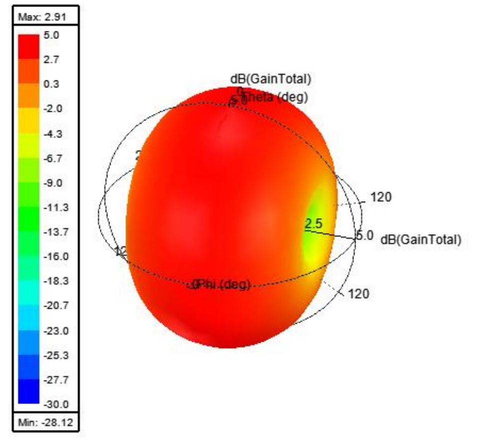
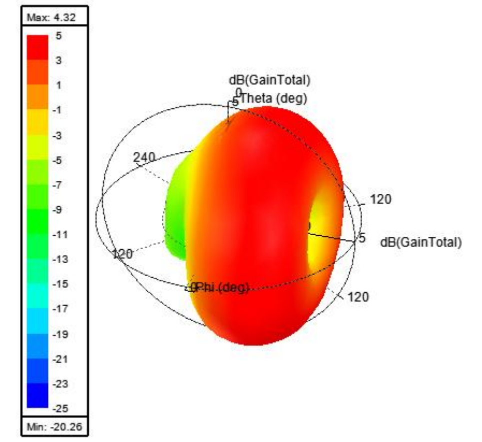


Fig 3. Simulated Return Loss of the suggested antenna

The observed antenna gain is 2.9 dBi and 4.2 dBi at 2.5 GHz and 5.1 GHz respectively and is shown in Fig. 4. The E-plane pattern and H-plane pattern of the suggested antenna at the resonating frequencies are shown in Figs. 5 & 6. It is noticed that omni-directional pattern is obtained in H-plane and figure of eight symbol is obtained in E-plane at both the frequencies.

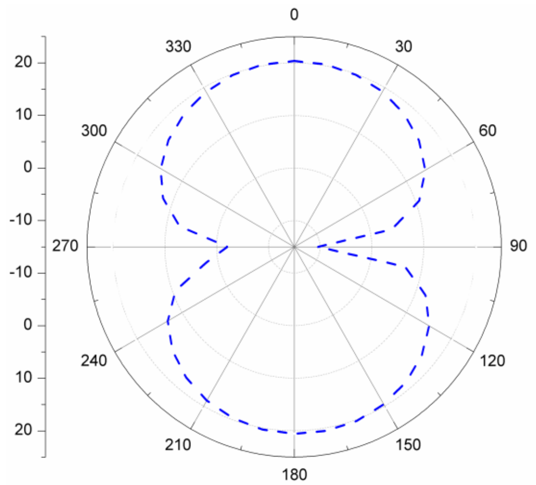


(a)

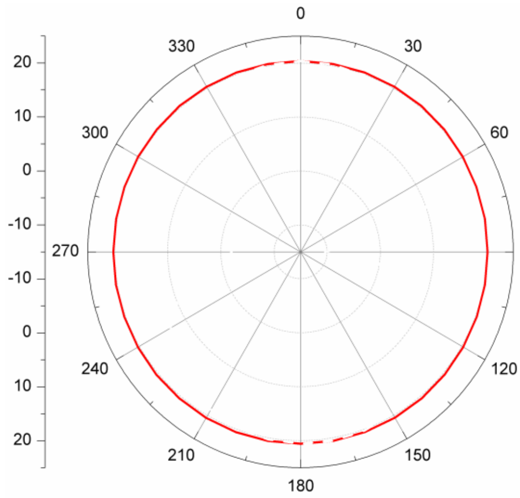


(b)

Fig 4. 3D Gain Patterns of the antenna (a) at 2.5 and (b) at 5.1GHz

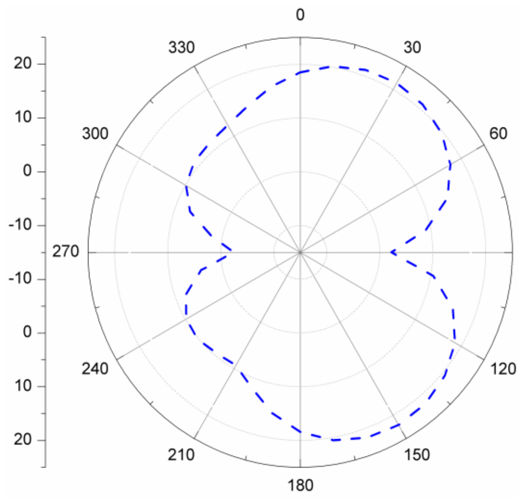


(a)

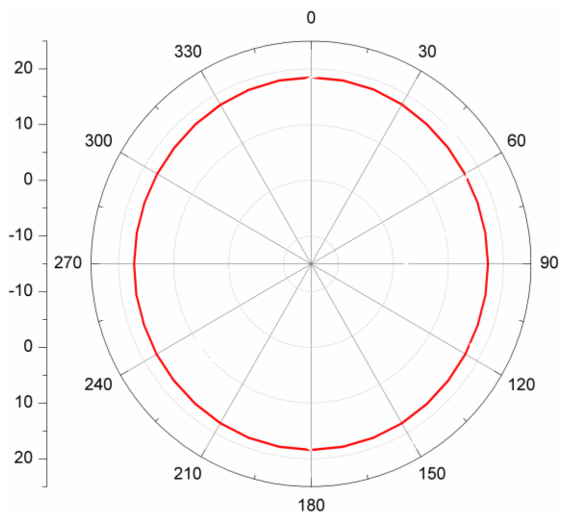


(b)

Fig 5. Patterns of the suggested antenna at 2.5 GHz (a) E-plane pattern (b) H-plane pattern



(a)



(b)

Fig 6. Paterns of the suggested antenna at 5.1 GHz (a) E-plane patern (b) H-plane patern

Retrieval Number: A3307058119/19©BEIESP
DOI: 10.35940/ijrte.A3307.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

IV. CONCLUSION

The suggested antenna has been operating at two frequencies with a reflection coefficient of below -10dB are from 2.3 to 2.7GHz with -16.8dB reflection coefficient at 2.5GHz resonant frequency, and 4.6 to 5.5GHz with -29.2dB reflection coefficient at 5.1GHz resonant frequency. The simulated results indicate that, the suggested antenna operating at frequencies 2.5 and 5.1 GHz with impedance bandwidths 482 and 844 MHz respectively and which can be used for Industrial, Scientific and Medical(ISM) applications and second frequency band can be used for C-band applications. The obtained antenna gains are 2.9 dBi and 4.2 dBi at the resonating frequencies.

REFERENCES

1. Ke-Ke Zheng and Qing-Xin Chu, "A Small Symmetric-Slit -Shaped and Annular Slotted BeiDou Antenna With Stable Phase Center.", *IEEE Antennas and Wireless Propagation Letters*., Vol. 17, no. 1, Jan. 2018, pp. 146-149.
2. Kalyan Monda and Partha Pratim Sarka, “Dual band compact monopole antenna for ISM 2.4/5.8 frequency bands with bluetooth, Wi-Fi, and mobile applications”, *Microwave and Optical Technology Letters*, Vol. 59, No. 5, May. 2017, pp. 1061-1065.
3. Xiaoxu Feng, Juhua Liu, “A Circularly Polarized Octagon-Star-Shaped Microstrip Patch Antenna with Conical Radiation Pattern” *IEEE Transactions on Antennas and Propagation*, Vol. 66, no. 4, Apr. 2018, pp. 2073-2078.
4. Lingyu Kong and Xiaojian Xu, “A Compact Dual-Band Dual-Polarized Microstrip Antenna Array for MIMO-SAR Applications” *IEEE Transactions on Antennas and Propagation*, Vol. 66, no. 5, May 2018, pp. 2374-2381.
5. Xu Yang, Ying Liu, and Shu-Xi Gong, “Design of a Wideband Omnidirectional Antenna with Characteristic Mode Analysis”, *IEEE Antennas and Wireless Propagation Letters*, Vol. 17, NO. 6, Jun. 2018, pp. 993-997.
6. Henry Abu Diawoo and Young-Bae Jung, “Broadband Proximity-Coupled Microstrip Planar Antenna Array for 5G Cellular Applications”, *IEEE Antennas and Wireless Propagation Letters*, Vol. 17, no. 7, Jul. 2018, pp. 1286-1290.
7. Carlos Mendes and Custódio Peixeiro, “On-Body Transmission Performance of a Novel Dual-Mode Wearable Microstrip Antenna”, *IEEE Transactions on Antennas and Propagation*, Vol. 66, no. 9, Sep. 2018, pp. 4872-4877.
8. Zheng Gan, Zhi-Hong Tu , Ze-Ming Xie, Qing-Xin Chu , andYue Yao, "Compact Wideband Circularly Polarized Microstrip Antenna Array for 45 GHz Application ", *IEEE Transactions on Antennas and Propagation*, Vol. 66, no. 11, Nov. 2018, pp 6388-6392.
9. Xunfeng Tong , Changrang Liu , XueguanLiu, Huping Guo, and Xinmi Yang, “Switchable ON-/OFF-Body Antenna for 2.45 GHz WBAN Applications”, *IEEE Transactions on Antennas and Propagation*, Vol. 66, No. 2, Feb. 2018, pp. 967-971.
10. K.K. Naik, Gopi Dattatreya, RPS Chaitanya, Ravikumar Palla and Sriram Sandhya Rani, “Enhancement of gain with corrugated Y-shaped patch antenna for triple-band applications”, *International journal of RF and microwave computer aided engineering*, Nov.2018, pp. 1-9.
11. Ketavath Kumar Naik, Ravi Kumar Palla, Sriram Sandhya Rani, Dattatreya Gopi, “Design of S-Band Antenna With L-Shaped Slits on Rectangular Patch With Defected Ground Structure”, *International Journal of Measurement Technologies and Instrumentation Engineering*, Vol. 7, Issue 2, Dec, 2018, pp. 50-58.
12. Muhammad Zada and Hyoungsuk Yoo, “A Miniaturised Triple-Band Implantable Antenna System for Bio-Telmetry Applications”, *IEEE Transactions on Antennas and Propagation*, Vol. 66, No. 12, Dec. 2018, pp. 7378-7382.
13. T. Sasikala, R. Arunchandar, M. A. Bhagyaveni and M. Shanmuga Priya, “Design of Dual-Band Antenna for 2.45 and 5.8 GHz ISM Band”, *National Academy Science Letters, Springer*, Oct. 2018, pp. 1-6.

AUTHORS PROFILE

Ravikumar Palla received the B.Tech degree in Electronics and Communication Engineering (ECE) from JNTU College of Engineering, Kukatpally, Hyderabad, India in 2005. M.Tech degree in RADAR and Microwave Engineering from Andhra University, Visakhapatnam, Andhra Pradesh, India in 2010. Currently he is working as Assistant Professor in the department of ECE, GMRIT, Rajam, Srikakulam, Andhra Pradesh, India and also pursuing the Ph.D. degree in K L University, Guntur, AndhraPradesh, India. His research interests include microstrip antennas, FSS, conformal antennas and Reconfigurable antennas.

K.K Naik received a B.Tech in Electronics and Communication Engineering (ECE) from Jawaharlal Nehru Technological University JNTU College of Engineering, Kukatpally, Hyderabad, India; M.Tech in Digital Electronics and Communication Systems from JNTU College of Engineering, Anantapur, India; and Ph.D. in ECE from the College of Engineering, Andhra University, Visakhapatnam, India. He is working as a Professor in the Department of ECE, Koneru Lakshamaiah Educational Foundation (deemed to be University), Guntur, India. He has two sponsored research projects from the Department of Science and Technology (DST) worth of Rs. 78,56,000. He also received the “DST Young Scientist Award” in 2014 from the Government of India, and the “Best Paper Award” at the International Conference InCMARS 2008. He is the referee for Sponsored Research Proposals of DST, SERB, Government of India. He is Associate Editor of International Journal of Electronics, Communications, and Measurement Engineering (IJECME), IGI Global, USA. He is a reviewer for various international and national journals and conferences like IEEE, Elsevier, and Springer etc. He has published over 54 research papers in reputed international and national journals and conferences. He is a Fellow IETE and a Senior Member IEEE, etc. His research interests include ring arrays, phased-array antennas, mic microstrip antennas, conformal antennas, SRR, EMI/EMC, and biomedical applications.