93

Coaxial feed dual wideband dual polarized stacked microstrip patch antenna for S and C band communication

Cite as: AIP Conference Proceedings 2220, 130067 (2020); https://doi.org/10.1063/5.0001646
Published Online: 05 May 2020

Gunaram, Vijay Sharma, S. Shekhawat, Pawan Jain, and J. K. Deegwal

Principal
Kanoria PG Mahila Mahavidyalaya
JAIPUR

Coaxial Feed Dual Wideband Dual Polarized Stacked Microstrip Patch Antenna for S and C Band Communication

Gunaram[1,2], Vijay Sharma[2, a)], S. Shekhawat [3], Pawan Jain[3] and J K Deegwal[4]

[1]*Bhagwant University, Ajmer-305002, Rajasthan, India*
[2]*Department of Physics, Govt. Mahila Engineering College, Ajmer -305002, India*
[3]*Department of Physics, University of Rajasthan, Jaipur, India -302015, India*
[4]*Department of Electronics and Communication Engg., Govt. Mahila Engineering College, Ajmer -305002, India*

[a)] Corresponding author: phyvijay@gmail.com

Abstract. This article presents the stacked arrangement of a truncated ellipse act as driven patch loaded by a rectangular slot and a circular patch which is partially truncated and loaded by another rectangular slot. This structural arrangement gives rise a wide impedance bandwidth (-10dB) in two bands 3.14-4.13GHz (27.2%) with linear polarization in S band and 6.16-7.01GHz (12.8%) with circular polarization in C band. The peak gain value in both the bands are 7.72dBi and 6.64dBi respectively. This antenna is found useful for communication in S and C band respectively.

INTRODUCTION

Microstrip patch antenna (MPA) is considered as the heart of the modern communication devices due to its profound properties such as low profile, negligible weight and little size of antenna that is skillful of retaining great implementation over a substantial range of frequencies. The polarization reconfiguration, mulit-frequency or multiband behavior can be achieved with a little pain in comparison to other type of antenna. It isn't at all that MPA's have just favorable circumstances, there are some characteristic hindrances likewise exist with MPA's, the genuine basic being inborn low impedance bandwidth and low gain that restrict its application. A number of techniques can be found in literature to overcome these issues of low gain and impedance bandwidth [1-3]. Some of them includes Parasitically Coupled or Gap-Coupled Patches [4-5], Large Slot Aperture-Coupled Patches [6], Use of Thick Low Permittivity Dielectric Substrate [7-8], Stacked Microstrip Patches [9-10] etc. All these techniques have their own cons and pros. To access the continuity and approach of method of stacking some recent research is studied and it is as follows.

In [11], Mishra presented different multi-layered slot loaded patch antennas for wide band and dual band performance using HFSS EM tool for WLAN and WiMAX applications. The experimental results are also included to verify the simulate results. In [12], Hossain and Datto presented the performance of the probe feed technique and fed line technique on a stacked patch antenna of rectangular shape operating in the C-band using HFSS software. In [13], Asadpor presented a four layers stacked patch antenna for circularly polarization. The antenna comprises of double Y-shaped slot in circular patches fed by microstrip line. In [14], Ramos proposed a planar printed version of multilayer Yagi antenna for 5G communication using multilayer stacked arrangement of antenna. In [15], Katiyar et al offered a stacked arrangement of patch antenna in which lower patch is slotted by a U-shape slot whereas parasitic patch is loaded with a rectangular slot. In result the impedance bandwidth increases multi-fold in reference to conventional patch antenna. In [16] Yu et al offered an orthogonal polarized stacked dual band antenna includes a couple of 180◦ broadband microstrip baluns are engraved in the ground plane for energizing the antenna. In [17], Raheja et al proposed a stacked patch antenna consist of a square patch truncated at corners as driven patch whereas an elliptical patch works as parasitic patch. This antenna works in three bands with a single coaxial fed and generates

3rd International Conference on Condensed Matter and Applied Physics (ICC-2019)
AIP Conf. Proc. 2220, 130067-1–130067-6; https://doi.org/10.1063/5.0001646
Published by AIP Publishing. 978-0-7354-1976-6/$30.00

circular polarization at first two bands and linear polarization at third band. In [18], Gao et al to amplify the impedance bandwidth applied a configuration of stacked patch loaded with a set of conductive vias and a coupled annular ring and to support the computed outcome, the results were verified by measurements. In [19], Belen 3D printing technology for the realization of 3D stacked patch antenna array of 2×2 element. It is reported that technology used gives appropriate results and reduces the fabrication errors to a minimal. In [20], Malekpoor and Hamidkhani proposed a multiband compact patch antenna using technique of stacking. In their finding author used two circular patches of different dimensions and two shorting pins. By the insertion of a V-shaped slot in the upper circular patch fed by folded patch a large impedance bandwidth 28.4% (3.27–4.35 GHz) in first band and 21.7% (5.15–6.40 GHz) in second band is achieved. In [21], Sung offered a configuration of stack-ring antenna for dual circularly polarized (CP) performance . It is observed that each ring produces a resonance which is different from other and can be controlled by adjusting the gap among the rings. The dual band is having a frequency ratio of just 1.07.

This paper offers an arrangement of stacked configuration of modified elliptical and circular patches act as driven patch and parasitic patch respectively for dual polarization wideband antenna. This article is divided in following section. Section two includes antenna design and analysis which is followed by results and discussion in section three and conclusion in section four.

ANTENNA DESIGN AND ANALYSIS

In this part design of a stacked MPA is presented and analyzed. The design is start with a conventional structure of MPA consist of a double-copper layer on a FR-4 substrate in which on one layer there is a ground plane and on other side a truncated elliptical patch is printed and separated by a dielectric substrate having thickness h = 1.59 mm and the dielectric constant εr = 4.4. The dimension of semi major and semi minor axis is taken (a =14.5mm and b=13.0mm) nearly which nearly same as given in [22] and truncated symmetrically on both the sides. This antenna gives an impedance bandwidth (IBW) of 6.54% for measured frequency 2.75 GHz. Authors also achieved a 3 dB axial ratio bandwidth (ARBW) 2.71%. Later authors applied the stacking arrangement to same geometry to increase the performance of antenna as presented in [23] and achieved a 3 dB ARBW 3.33% along with 27.9% IBW and peak gain 6.78dBi. The improving result stimulates the authors of this article to work on this, for further improvement. The issue with the geometry presented in [22 & 23] is the size. Authors does not mention the size of ground plane which is a critical parameter in performance of antenna, perhaps it is designed on infinite ground plane and size is seems to be 100mm × 100 mm for fabrication purpose.

The outlined structure of the projected stacked antenna for dual wideband application is shown in Fig. 1. In this piece of work two different patches, one is driven patch which is directly connected to coaxial probe fed and other is parasitic patch which is excited by the driven patch (with the geometries given in Fig. 1(a, b, c)) on various layers of the dielectric substrates are stacked on one another. This strategy expands the overall height of the proposed antenna yet the size the planar way continues as before as that of a single-patch antenna. Both the patches are printed on FR4 epoxy substrate.

In this design the ground plane size is taken 100 mm × 100 mm. The dimension of driven patch such as semi major and semi minor axis is taken as (a =14.5mm and b=13.0mm). The truncation is adjusted to achieve best performance on both the sides. A circular patch is also printed on another double-copper layer of a FR-4 substrate acting as a parasitic patch with radius r=14.5mm which also truncated slightly in one side. Further to achieve the dual band performance with wide impedance bandwidth both driven patch and parasitic patch is further loaded by two rectangular slots of slightly different dimension. To energize the antenna, the coaxial probe fed arrangement is used. To accomplish this a SMA connector which matches to the characteristic impedance of 50 Ω is connected at a proper position on patch, to observed the desired result. All the simulation is carried out using CST EM tool [31]. The value of different design parameter (in mm) is given in Table -1. The parametric study of these effects is also studied and presented in further section.

TABLE 1. The values of different design parameter (in mm)

Parameter	Value	Parameter	Value
dimension of semi major axis 'a'(driven patch)	14.5	Radius of circular parasitic patch 'R'	14.5
dimension of semi minor axis 'b' (driven patch)	13.0	Length of ground plane Lg	60.0
Dimension of slot loaded in Parasitic patch l2×w2	7.40×9.00	Width of ground plane Wg	60.0
Dimension of slot loaded in Driven patch l1×w1	8.00×6.80	Substrate thickness 'h'	1.59
Value of left truncation in driven patch Y1	18.83	Height of air gap h4	5.0
Value of right truncation in driven patch Y2	16.28	Thickness of metallic patch 't'	0.035

Principal
Kanoria PG Mahila Mahavidyalaya
JAIPUR

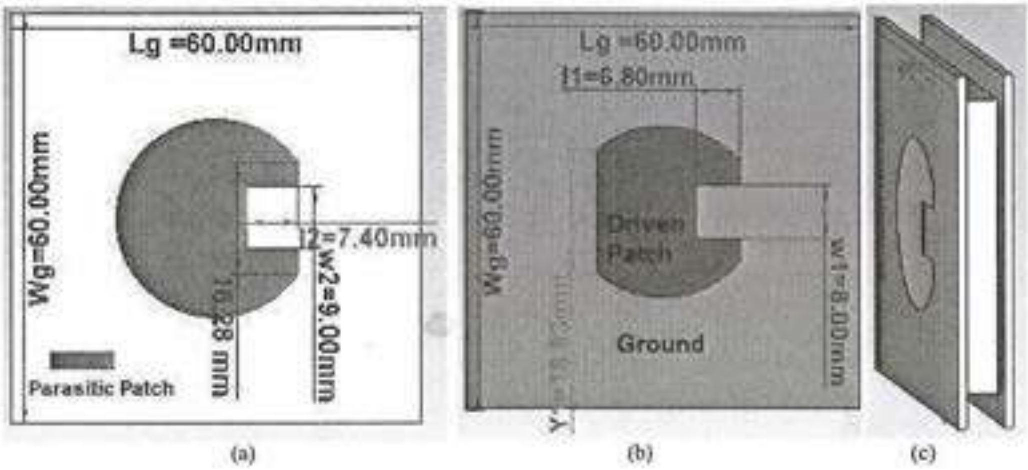

FIGURE 1. Configuration of the proposed antenna structure: (a) top layer shows the parasitic patch (b) middle layer shows the driven patch and (c) the orthographic side view

PARAMETER STUDY

To optimize the effect of various parameter on the performance of proposed antenna a parametric study of some of the parameter is given in the section.

The Effect of Air Gap 'h4'

Fig.2 shows the effect of air gap (height of air gap in between two layers of FR4 dielectric substrate), on reflection coefficient with varying frequency. It can be seen easily that as the height of air gap increases the IBW corresponds to -10dB increases because of the Q-factor of the proposed antenna decreases as the substrate permittivity of air is 1. For the value up to 4.0mm the IBW in higher band increase however not much improvement in lower band is achieve as the hump in lower band is above the -10dB. For value of air gap more than 5.0mm this bump in lower band is goes down to -10dB without affecting the higher band performance. The best optimized result for the band is achieved for an air gap value h4=6.0mm.

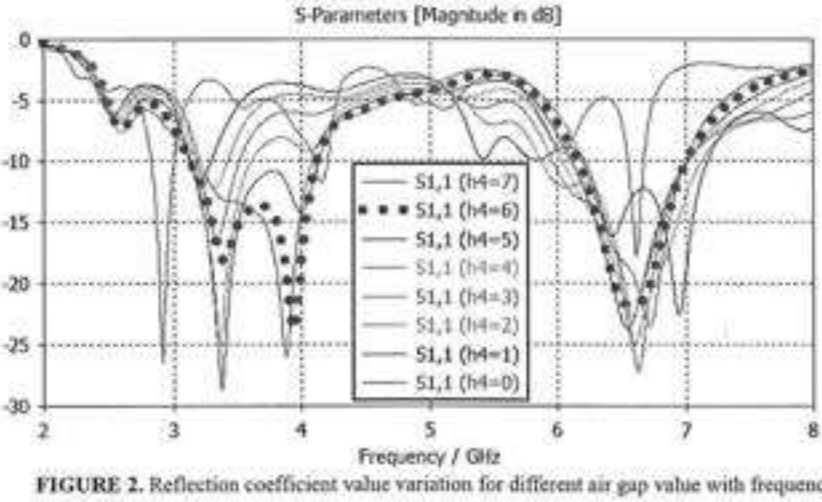

FIGURE 2. Reflection coefficient value variation for different air gap value with frequency

ACKNOWLEDGMENTS

Authors are thankful to RTU CRS Scheme (Under TEQIP III) and DST New Delhi for supporting this work.

REFERENCES

1. I. J. Bahl and P. Bhartia, *Microstrip Antennas* (Artech House, Norwood, USA, 1980).
2. Ramesh Garg, Prakash Bhartia and Apisak Ittipiboon, *Microstrip Antenna Design Handbook* (Boston, Artech House, 2001).
3. Kin-Lu Wong, *Compact and Broadband Microstrip Antennas* (John Wiley & Sons, 2002).
4. Vijay Sharma and M.M. Sharma, FREQUENZ Journal of RF-Engineering and Telecommunications, **68**, 25-31 (2013).
5. Vijay Sharma, V.K. Saxena, K.B. Sharma and D. Bhatnagar, FREQUENZ Journal of RF-Engineering and Telecommunications, **66**, 69-74 (2012).
6. Soheyl Soodmand, International Journal of Electronics and Communications, **65**, 453-4575 (2011).
7. Teguh Firmansyah, Heradin, Suhendar, Romi Wiryadinata, M Iman Santoso, Yus Rama Denny, Toto Supriyanto, TELKOMNIKA, **15**, 1155-1163 (2017).
8. Vijay Sharma, V.K. Saxena, J.S. Saini, D. Bhatnagar, K.B. Sharma, D. Pal, L.M. Joshi, International Journal of Microwave and Optical Technology Letters, **52**, 1082-1087 (2010).
9. V. Sharma, B. Sharma, V. K. Saxena, K. B. Sharma, M. M. Sharma and D. Bhatnagar, Indian Antenna Week (IAW), Kolkata, India, (2011), pp. 1-4.
10. Vijay Sharma, B. R. Sharma, K.B. Sharma and D. Bhatnagar, Proceeding of SPIE (International Society for Optics and Photonics) Vol. 8760, (2013), pp. 87601 Q1 –Q8.
11. B. Mishra, V. Singh and R. Singh, Microsystem Technologies, **23**, 3467–3475 (2016).
12. M. B. Hossain and S. Datto, 2nd International Conference on Electrical, Computer & Telecommunication Engineering (ICECTE), Rajshahi, 2016, pp. 1-4.
13. L. Asadpor, T. Ghorbani and M. Rezvani, Journal of Instrumentation, **13**, (2018).
14. A. Ramos, T. Varum and J. N. Matos, Sensors (Basel, Switzerland), **18**, (2018).
15. Sanjay Kumar Katiyar, D.K. Srivastava and D.S. Chauhan, Journal of Engineering and Applied Sciences, **13**, 7414-7417 (2018).
16. Junnan Yu, Yufa Sun, Haoran Zhu, Fan Li, and Yade Fang, Progress in Electromagnetics Research M, **68**, 41–52 (2018).
17. D. K. Raheja, B. K. Kanaujia and S. Kumar, Wireless Personal Communications, **100**, 1585–1599 (2018).
18. S. Gao, L. Ge, D. Zhang and W. Qin, IEEE Access, **6**, 69575-69581 (2018).
19. MA Belen, Microwave and Optical Technology Letters, 1-4 (2018).
20. Hossein Malekpoor and Mehdi Hamidkhani, Electromagnetics, (2019), https://doi.org/10.1080/02726343.2019.1595379.
21. Youngje Sung, Journal of Electromagnetic Engineering and Science, **19**, 37-41 (2019).
22. P. Sekra, D. Bhatnagar, V. K. Saxena and J. S. Saini, International Conference on Emerging Trends in Electronic and Photonic Devices & Systems, Varanasi, India, (2009), pp. 353-356.
23. P. Sekra, S. Shekhawat, D. Bhatnagar, J. S. Saini and V. K. Saxena, Microwave and Optical Technology Letters, **53**, 947–952 (2011).
24. EM Simulation Software - CST Studio Suite, (2017).

Principal
Kanoria PG Mahila Mahavidyalaya
JAIPUR