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Analysis of An Elliptical Patch Antenna For C-band Satellite Communication Applications

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Research on radio frequency (RF) elliptical patch antennas is progressing in the realm of satellite communication applications due to the growing need for smart adaptive RF microstrip antennas. An elliptical patch antenna (EPA) with rhombus shaped monopole as partial ground plane intended for C-band satellite communication applications is presented in this paper. An EPA is designed and ana-lysed by using FEM analysis tool An-soft HFSSv13. An EPA occupies an area of 26 × 46 × 1.6 mm³. In the design of the EPA, the FR4 substrate is utilized, and its dielectric constant (εr) is 4.4. EPA consists of three layers: top layer is the resonating element, conducting material is copper and it consists of an elliptical patch attached to the monopole antenna. Middle layer is the material used, FR4 has been chosen as the dielectric material because of its robustness, low cost and light weight. Bottom layer is also the conducting layer made up of copper. Bottom layer consists of a rhombus structure attached to monopole as partial ground plane. EPA resonates at 4.6 GHz (3.9 GHz-6.3 GHz) and offers S_{11} of – 12.5 dB. At 4.6 GHz VSWR of 1.6 and 3 dBi gain of 4.8 dB have been obtained. Because of these results, the EPA is appropriate for both 5G wireless communication applications and C-band satellite communication applications.

Keywords: Next-generation applications, Patch antenna, Broadband antenna, HFSS, Satellite communication.

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1. INTRODUCTION

Multifunctional devices that can serve various applications while maintaining space and providing optimum performance are becoming more and more in demand in the quickly changing wireless communications sector [1]. A multi band RF slotted antenna has been designed and analyzed for RF biosensing applications [2]. The compactness and adaptability of contemporary wireless applications depend on the development and integration of small, effective, wideband antennas [3-4]. Because of their compact size, ease of manufacturing, and adaptability with integrated circuits, patch antennas are a popular option for a variety of wireless applications. Conventional MPAs have been widely used for many years in satellite communication, Wi-Fi, and other wireless systems [5-7]. However, research into ever-more complicated geometries and combinations has been prompted by the requirement of MPAs with a wider bandwidth, triple band capabilities, and distinct radiation properties [8-9]. Various antenna designs with slot arrangements that also allow for necessary bandwidth adjustments are analysed [10]. An UWB antenna with partial ground plane is proposed to operate in 5G band with an impedance bandwidth of 2.92 GHz [11]. Additionally proposed are L-shaped slots, T-shaped slots and elliptical/circular slots, in addition to a variety of additional slot types integrated into the multiband-operating antenna shape [12-15].

MPAs were tilizin in majority of the earliest patch antenna designs. These structures provided interoperability with integrated circuits, simplicity in design, and low efficiency. They needed a greater surface area, though, and were frequently narrow-banded. Researchers started looking into slot-based adjustments to overcome the intrinsic drawbacks of conventional patch designs. The original slot designs used circular or straight cuts, which somewhat increased bandwidth. The elliptical patch was a novel way to expand the bandwidth and multiband capabilities of the patch antenna. Better electric field distributions were made possible by the elliptical form's underlying geometric features, enabling the antenna to resonate at several frequencies. The potential for multi-resonant frequencies was the main benefit of employing a rhombus slot rather than a traditional patch. Therefore, applications requiring dual-band or multi-band operations found the concept especially intriguing. Additionally, by offering an improved impedance bandwidth, the elliptical patch expanded its suitability for a range of communication applications. At 4.6 GHz, the EPA architecture produces a total gain of 4.8 dBi. This would allow for the on-demand realization of the Wi-Fi 6E

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bands at sub-6 GHz, which include 5 GHz, and 6 GHz. The seamless connectedness of the world's expanding number of devices is its functional significance. The EPA design's potential high gain is expected to improve satellite communication applications and next generation wireless communication applications. The structure of this document is as follows. The EPA system design, together with its several configurations and system design parameters, is presented in Section II. The simulation results are displayed in Section III, along with a thorough explanation. Section IV concludes the paper.

2. DESIGN & ANALYSIS OF EPA

Fig. 1 depicts the model shape of the suggested innovative EPA design. Rhombus structure in the ground is intended to identify changes in the antenna's performance. SMA connector, is used to excite the EPA. As seen in Fig. 1, the EPA feed assembly is an edge feed that passes through the partial ground plane from below. EPA is designed by placing an ellipse oriented on left side, a rhombus attached to microstrip transmission line by subtracting a microstrip rectangle from the ground plane. Rhombus structure has been tilizin in the ground plane to attain high gain and wide bandwidth. Top surface and bottom surface of the EPA is shown in Fig. 1. Top surface is the ellipse attached to monopole antenna and bottom surface is the rhombus attached to monopole having a partial ground plane. Elliptical patch antenna is designed and analysed tilizing An-soft HFSSv13 tool. EPA occupies an area of $26 \times 46 \times 1.6$ mm^3. EPA is designed by tilizing FR4 substrate, having 4.4 ε_r, a *tan*δ of 0.02 and a thickness of 1.6 mm. EPA is designed by tilizing the following mathematical formulas.

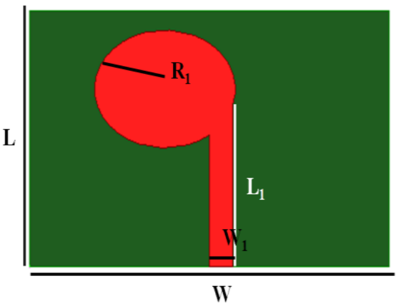
$$L = \frac{c}{2F_r\sqrt{\varepsilon_{reff}}} - 2\Delta l \qquad (1)$$

$$a = \frac{F}{\sqrt{1+\frac{2h}{\Pi\varepsilon_r}[\ln(\frac{\Pi f_r}{2h})+1.7726]}} \qquad (2)$$

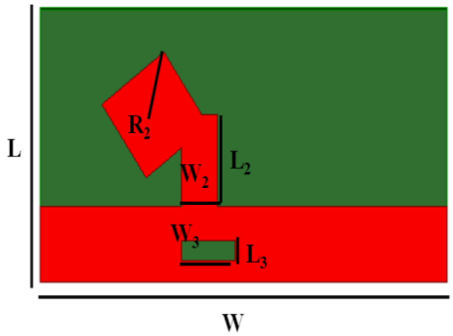
$$F = \frac{8.791*10^9}{f_r\sqrt{\varepsilon_r}} \qquad (3)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\left[\frac{12h}{w}\right]\right]^{-1/2} \qquad (4)$$

In the elliptical patch, '*a*' stands for the radius, which is found using Eq. (2), and '*L*' for the length, which is found using (1). In this case, the variable '*h*' stands for the material's thickness. Eq. (2) is used to generate *F*. The center frequency of the substrate is represented by f_r.



a



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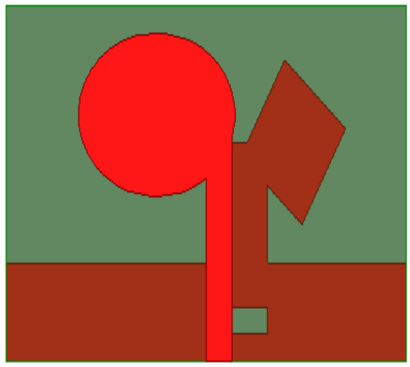


c

Fig. 1 – EPA (a) Top surface (b) Bottom surface (c) Isometric View

Table 1 – Measurements of EPA

Parameter	Values (mm)
L	26
W	46
L_1	18
W_1	3.05
L_2	16
W_2	4
L_3	6
W_3	2
R_1	6
R_2	6

3. RESULTS AND DISCUSSION

S_{11} and VSWR of EPA is shown in Fig. 2. EPA resonates at 4.6 GHz (3.9 GHz-6.3 GHz) and offers a S_{11} of -12.5 dB. The EPAs VSWR at the resonating frequency is in between 1 to 2 and is shown in Fig. 2. VSWR of 1.6 and 3 dBi gain of 4.8 dB has been observed at the resonating frequency. Because of its compact size, this antenna is a good option for C-band satellite communication applications as well as 5G wireless communication applications. This suggests that there aren't many reflected signals, guaranteeing effective signal transmission and reception. The overall gain for EPA is represented in three dimensions in Fig. 3. Different colours indicate different gain levels, while the color bar on the left shows the antenna's total gain in dB. The plot has an exceptional maximum overall gain of 4.8 dB.

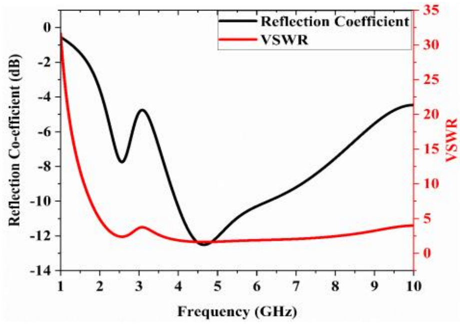


Fig. 2 – Obtained VSWR and Reflection Co-efficient of the EPA

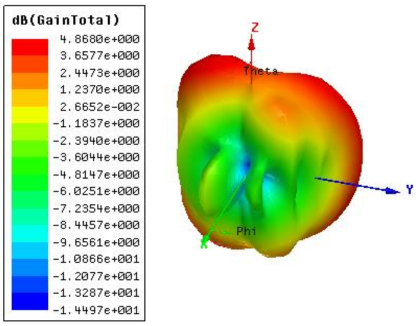
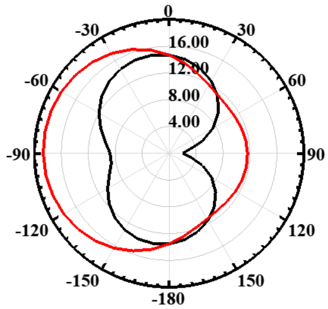
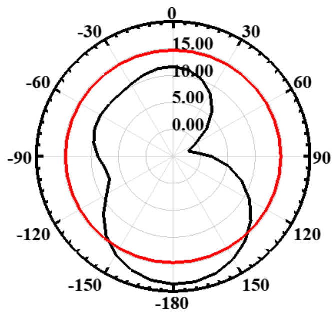


Fig. 3 – 3 dBi Gain of the EPA

The radiation pattern of the EPA at 4.60 GHz is shown in Fig. 4. Good co-poll and cross-poll differences in the broadside direction, i.e., more than 20 dB at all two frequency bands, are present in both major planes (E&H). Fig. 4 shows that at the resonant frequency, the radiation in the E- and H-planes is omnidirectional and bidirectional. EPA has good radiation properties. Fig. 5 displays the EPAs current distribution. The color red represents the largest field distribution.



a



b

Fig. 4 – Radiation Pattern for EPA at 4.6 GHz (a) *E*-plane (b) *H*-plane

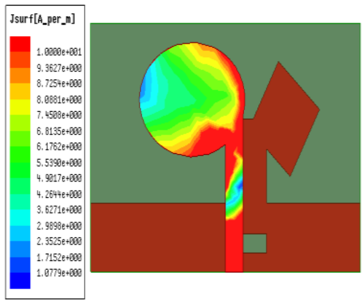


Fig. 5 – Proposed EPA's Surface Current distribution

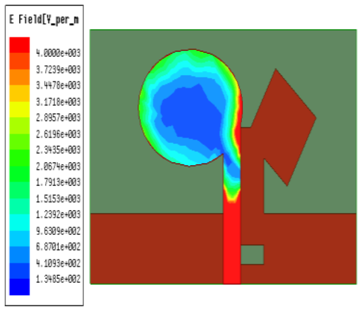


Fig. 6 – *E*-Field distribution of the EPA

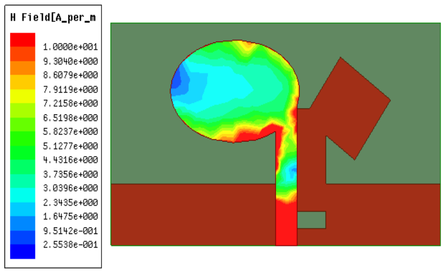


Fig. 7 – *H*-Field distribution of the EPA

It has been observed that the maximum value is 10 Am-1. The radiation zones are determined by the distribution of surface current in corners and center; the areas with the maximum radiation intensity are indicated in red. Figure 6 shows that the antenna's edges and center have the highest radiation intensity. The EPAs instantaneous electric and magnetic currents at 4.6 GHz are shown in Figs. 6 and 7. Maximum amount of distribution is represented by using red color and is observed across the corners and center of the patch. These results make the EPA suitable for C-band satellite communications utilised for uplink frequency and as well as 5G wireless communication applications.

4. CONCLUSION

An EPA is designed and analysed by using FEM analysis tool An-soft HFSSv13. An EPA occupies an area of $26 \times 46 \times 1.6$ mm^3. In the design of the EPA, the FR4 substrate is utilized, and its dielectric constant (ε_r) is 4.4. EPA resonates at 4.6 GHz (3.9 GHz-6.3 GHz) and offers a reflection coefficient of – 12.5 dB. VSWR of 1.6 and 3 dBi gain of 4.8 dB has been observed at the resonating frequency. These results make the EPA suitable for C-band satellite communication applications as well as 5G wireless communication applications.

REFERENCES

1. M. Wen, Q. Li, K.J. Kim, D. L´opez-P´erez, O.A. Dobre, H.V. Poor, P. Popovski, *IEEE J. Sel. Top. Signal Process.* **16** No 1, 7 (2022) https://doi.org/10.1109/JSTSP.2021.3137669.
2. J. George, M.C. Uko, S.C. Ekpo, M. Ijaz, R. Kharel, Q. Wang, H. Ji, *12th International Symposium on Communication Systems, Networks and Digital Signal Processing* (CSNDSP) (IEEE: 2020)
3. R.N. Tiwari, P. Singh, B.K. Kanaujia, *Int. J. Microwave Wireless Technol.* **11** No 3 (2019).
4. R.N. Tiwari, R. Thirumalaiah, V.R. Naidu, G. Sreenivasulu, P. Singh, S. Rajasekaran, *AEU-Int. J. Electron. Commun.* **171**, 154919 (2023) https://doi.org/10.1016/j.aeue.2023.154919.
5. M. Uko, S. Ekpo, *Int. Rev. Aerospace Eng. J.* **14** No 5, 240 (2021) https://doi.org/10.15866/irease.v14i5.20361.
6. M. Uko, S. Ekpo, *Int. Rev. Aerospace Eng. (IREASE)* **13** No 3, 99 (2020) https://doi.org/10.15866/irease.v13i3.17998.
7. U. Tripathi, *J. Inst. Eng. India Ser. B* 104 No 3, 757 (2023) https://doi.org/10.1007/s40031-023-00879-y.
8. S.C. Ekpo, D. George, *IEEE Commun. Lett.* **15** No 9, 977 (2011) https://doi.org/10.1109/LCOMM.2011.072011.111073.
9. B.A. Esmail, S. Koziel, *AEU-Int. J. Electron. Comun.* **158**, 154470 (2023) https://doi.org/10.1016/j.aeue.2022.154470.
10. C.L. Bamy, F.M. Mbango, D.B.O. Konditi, P.M. Mpele, *Heliyon* **7** No 4, e06793 (2021) https://doi.org/10.1016/j.heliyon.2021.e06793.
11. X. Tang, Y. Jiao, H. Li, W. Zong, Z. Yao, F. Shan, Y. Li, W. Yue, S. Gao, *International Workshop on Electromagnetics: Applications and Student Innovation Competition* (iWEM) (IEEE: 2019).
12. D. Konhar, A.K. Behera, S.N. Mishra, D. Mishra, *J. King Saud Univ.-Eng. Sci.* **34** No 2, 108 (2022) https://doi.org/10.1016/j.jksues.2020.08.002.
13. Z. Ding, H. Wang, S. Tao, D. Zhang, C. Ma, Y. Zhong, *Sensors* **20** No 24, 7002 (2020) https://doi.org/10.3390/s20247002
14. Z.H. Ma, Y.F. Jiang, *Micromachines* **11** No 9, 828 (2020) https://doi.org/10.3390/mi11090828.
15. L.N. Rao, G. Immadi, M.V. Narayana, A. Navya, A.S. Madhuri, K. Rajkamal, *Progr. Electromagn. Res. Lett.* **117**, 89 (2024) http://dx.doi.org/10.2528/PIERL23111804.

Аналіз еліптичної патч-антени для супутникового зв’язку C-діапазону

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Дослідження еліптичних патч-антен радіочастотного (РЧ) типу прогресують у сфері застосування супутникового зв’язку через зростаючу потребу в інтелектуальних адаптивних РЧ мікросмужкових антенах. У цій статті представлено еліптичну патч-антену (EPA) з ромбоподібним монополем як частковою заземлювальною площиною, призначену для застосування супутникового зв’язку C-діапазону. EPA розроблена та проаналізована за допомогою інструменту аналізу скінченних елементів An-soft HFSSv13. EPA займає площу 26 × 46 × 1,6 мм³. У конструкції EPA використовується підкладка FR4, а її діелектрична проникність (ε_r) становить 4,4. EPA складається з трьох шарів: верхній шар – це резонансний елемент, провідний матеріал – мідь, і вона складається з еліптичної пластини, прикріпленої до монопольної антени. Середній шар – це використаний матеріал, FR4 був обраний як діелектричний матеріал через його міцність, низьку вартість та малу вагу. Нижній шар також є провідним шаром, виготовленим з міді. Нижній шар складається з ромбоподібної структури, прикріпленої до монополя як часткова площина заземлення. EPA резонує на частоті 4,6 ГГц (3,9 ГГц-6,3 ГГц) і пропонує S_{11} – 12,5 дБ. На частоті 4,6 ГГц було отримано КСХН 1,6 та коефіцієнт підсилення 3 дБі 4,8 дБ. Завдяки цим результатам, EPA підходить як для бездротового зв’язку 5G, так і для супутникового зв’язку C-діапазону.

Ключові слова: Патч-антена, Широкосмугова антена, Високочастотний набір антен з високою роздільною здатністю (HFSS), Супутниковий зв’язок.