IFERP
ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Volume 11 Issue 3 March 2024

Hybrid Dielectric Resonator Antenna with Hexagonal Slotted Ground for C And X Band Application

[1] Chaitanya Bethala, [2] Manjunath Chari Kamsali
[1] Research Scholar, EECE Department, GITAM University, Hyderabad 502329, Telangana, India
[2] Professor, EECE Department, GITAM University, Hyderabad 502329, Telangana, India
Corresponding Author Email: [1] bchaitanya55@gmail.com, [2] mkamsali@gitam.edu

Abstract*— This article introduces a pioneering hybrid Dielectric Resonator Antenna (DRA) architecture, incorporating a Dielectric Resonator (DR) energized by a hexagonal ring patch through a microstrip feed. To enhance its performance, a ground structure modification is implemented by integrating a hexagonal slot. The combined hexagonal ring and DR configuration facilitate the realization of seven distinct operating bands, while the inserted slot in the ground structure significantly widens the antenna's impedance bandwidth. The proposed antenna demonstrates resonances at key frequencies of 5.1 GHz, 6.3 GHz, 7.1 GHz, 7.8 GHz, 8.3 GHz, 8.7 GHz, and 9.07 GHz. Moreover, the antenna exhibits a commendable gain exceeding 2 dBi and a directivity surpassing 4.5 across all resonating bands, highlighting its potential for a wide range of wireless communication applications.

Keywords*— Cylindrical dielectric resonator antenna, Dielectric resonator antenna, Rectangular Dielectric resonator antenna.

I. INTRODUCTION

In the contemporary realm of wireless communication, the demand for antennas exhibiting a combination of high radiation efficiency, low profile, cost-effectiveness, and high gain has surged. Among the available options, the dielectric resonator antenna stands out as the exemplar possessing all these desired attributes [1]. These antennas are commercially accessible in various shapes and sizes, with the cylindrical configuration being particularly favored for two compelling reasons. Firstly, it provides two degrees of freedom, enabling precise control over the quality factor. Secondly, it supports three distinct modes (TEmnp, TMmnp, HEMmnp) that facilitate the generation of diverse far-field patterns. This makes the cylindrical dielectric resonator antenna (CDRA) an ideal choice for modern wireless communication needs [2]. Notably, S. A. Long and his research team were pioneers in studying the fundamental radiating mode in CDRA, laying the groundwork for subsequent advancements in the field in 1982.

The contemporary landscape of antenna engineering is marked by a pervasive focus on endowing antennas with both multiband and dual-polarized capabilities. This shift is driven by three core motivations: Firstly, the integration of these features into a single antenna allows for its versatile application across a wide spectrum of wireless scenarios. Secondly, antennas equipped with such characteristics exhibit reduced sensitivity to orientation, enhancing their adaptability and ease of use. Finally, they contribute to the mitigation of multipath fading, a pressing concern in wireless communication environments [3]. To realize these objectives, the field of antenna engineering has witnessed a surge in diverse research endeavors. These include innovative techniques like the manipulation of rectangular-shaped dielectric resonator antennas through grooving and trimming, the development of hybrid cylindrical variants, and the exploration of probe-coupled half-elliptical ring-shaped configurations [4–8].

This article delves into the exploration of a dual-band dual-polarized hybrid cylindrical dielectric resonator antenna (CDRA). Employing defected ground strutter with stub to excite the DRA, this design serves a dual purpose: it excites two radiating hybrid modes within the RDRA and acts as a radiator itself. Within the 2.1 GHz frequency band, the proposed radiator exhibits linear polarized characteristics, while the 5.0 GHz frequency band showcases a combination of both circular and linear polarizations. This innovative radiating structure is well-suited for applications in 2G & 3G (2.1 GHz) and WLAN (5.0 GHz), attesting to its potential significance in the wireless communication landscape. The article is structured as follows: Section 2 provides an explanation of the proposed radiating structure and its analysis, is presented in Section 3. Final results and conclusions are presented in Sections 4 and 5, respectively.

II. DESIGN EVOLUTION

The proposed dual band DRA, designed for construction on an FR4 substrate with a dielectric constant of 4.4 and a loss tangent of 0.002, undergoes a two-stage design process. Initially, a basic seed antenna, engineered to operate at 5 GHz. To develop the proposed antenna, modifications involve in the feed structure with full ground. In terms of dimensions, the suggested antenna measures 50 mm x 50 mm x 1.6 mm. The DRA used has the dimension of 26 mm x 26

IFERP
ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Volume 11 Issue 3 March 2024

mm x 13 mm.

The proposed DRA has two stages of evolution, Ant 1 and Ant 2. The Ant 1 is a simple microstrip I shaped monopole with full ground. Ant 1 is not having impedance matching and therefore no resonance is achieved. Then the proposed antenna with modified ground and square shaped DRA is proposed as the final design. This antenna operates in seven bands, with resonance at 5.1GHz, 6.3 GHz, 7.1 GHz, 7.8 GHz, 8.3 GHz, 8.7 GHz and 9.07 GHz. These characteristics render it highly suitable for utilization in applications related to C band and X Band technologies. In Fig 1, the proposed antenna front view, back view and the perspective view are presented. In Fig 2, the antenna evolution stages are presented and in Fig 3 the parameters of the proposed Hybrid DRA are presented.

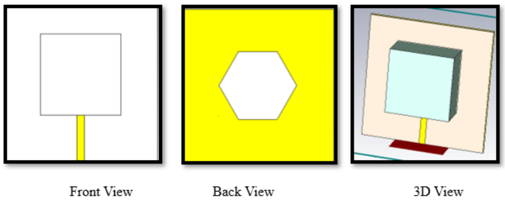

Fig. 1. Proposed Ground slotted Hybrid DRA.

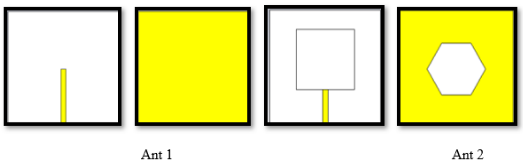

Fig. 2. Different stages of proposed Hybrid DRA with hexagonal slotted Ground.

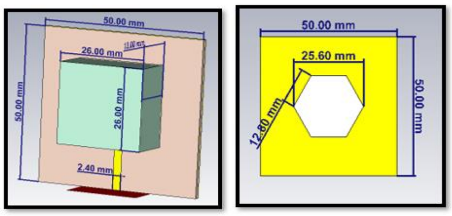

Fig. 3. Parameter Values of proposed Hybrid DRA with hexagonal slotted Ground.

III. RESULTS AND DISCUSSION

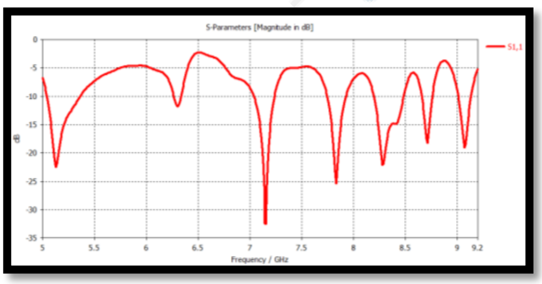

Fig. 4. Return loss plot of the proposed Hybrid DRA with hexagonal slotted Ground.

Return loss plot of the Ant 2 is presented in the Fig 4, which clearly depicts that the ant 2 operates in seven bands, with resonance at 5.1GHz, 6.3 GHz, 7.1 GHz, 7.8 GHz, 8.3 GHz, 8.7 GHz and 9.07 GHz. In Fig 5, the VSWR of the proposed antenna is presented, which shows that the VSWR value is less than 3 in the entire resonating band. The microstrip feed with hexagonal ring is rigors studied and the length of the feed is optimized with the help of the iterative design procedure. The feed is attached with the DRA is excited which couples the EM energy in to the DRA. Further the introduction the hexagonal slot increases the impedance bandwidth of the resonating band. the slot is optimized to have seven different operating bands. In Fig 6, the comparison plot between the Ant 1 and Ant 2 is presented. the figure clearly shows the effect of the DRA and the Hexagonal slot is responsible for the operating bands.

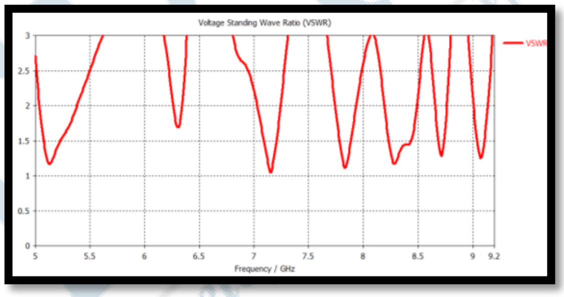

Fig. 5. VSWR plot of the proposed Hybrid DRA with hexagonal slotted Ground.

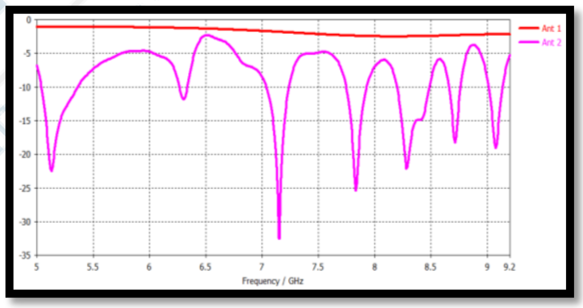

Fig. 6. S_{11} Comparison plot of the Ant 1 Vs Ant 2.

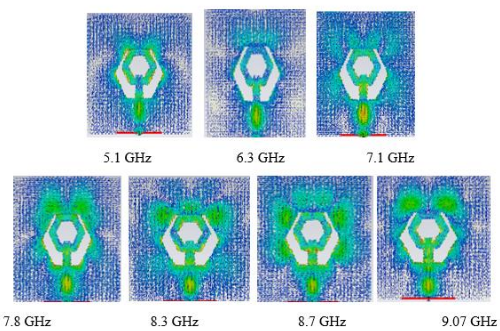

Fig. 7. Surface Current Distribution of the proposed Hybrid DRA with hexagonal slotted Ground.

In Fig 7, the surface current distribution at various resonating frequency is presented. The surface current is concentrated more on the hexagonal patch which couples the electromagnetic energy in to the DRA. The hexagonal slot and hexagonal ring at the bottom and top of the substrate, respectively create the inductance and capacitance which in turn create the new resonance.

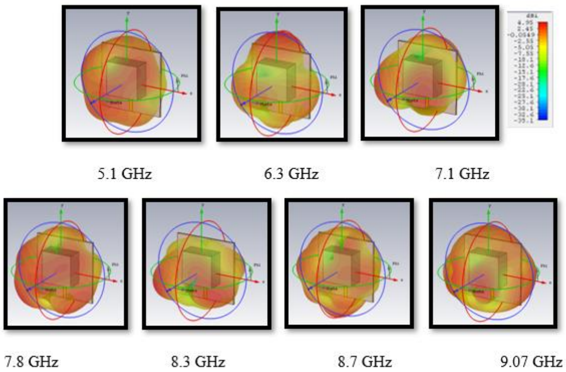

Fig. 8. Radiation Pattern of the proposed Hybrid DRA with hexagonal slotted Ground**.**

In Fig 8, the radiation pattern at various resonating frequency of the proposed DRA is presented. Which clearly resembles an omnidirectional pattern. Which is the major requirement for all the wireless communication topology. In Fig 9 the gain of the proposed DRA is presented; the gain is above 2 dBi in all the resonating bands. In Fig 10, the directivity is plotted against frequency of operation. It is noted form the figure, the directivity is above 4.5 in all the resonating bands.

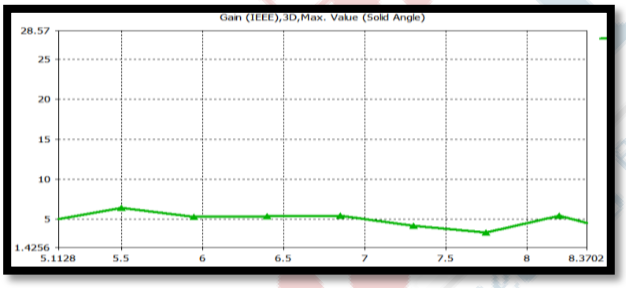

Fig. 9. Gain of the proposed Hybrid DRA with hexagonal slotted Ground**.**

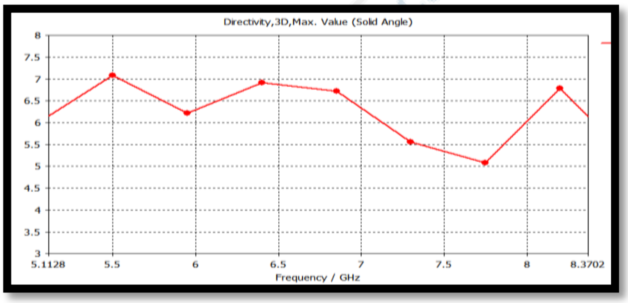

Fig. 10. Directivity of the proposed Hybrid DRA with hexagonal slotted Ground**.**

IV. CONCLUSION

In this article, a novel hybrid DRA structure is proposed, which employs the DR. The DR is feed with the hexagonal ring patch energized by the microstrip feed. The ground structure is modified by inserting a slot with hexagonal shape. The hexagonal ring with DR is responsible for the seven operating bands whereas the slot in the ground is responsible for the impedance bandwidth. The proposed antenna is having seven operating bands with resonance at 5.1GHz, 6.3 GHz, 7.1 GHz, 7.8 GHz, 8.3 GHz, 8.7 GHz and 9.07 GHz. The gain is above 2 dBi and the directivity is above 4.5 in all the resonating bands

REFERENCES

[1] A. Petosa,Dielectric Resonator Antenna Handbook (Artech House Antennas and Propagation Library. Norwood, MA, USA: Artech House, 2007.

[2] Long, S. A., M. W. McAllister, and L. C. Shen, “The resonant dielectric cavity an tenna,”IEEE Transaction on Antennas and Propagation, Vol. 31, No. 3, 406–412, 1983.

[3] Luk, K. M. and K. W. Leung, Dielectric Resonator Antenna, Research Studies Press L td.,Baldock, Hertfordshire, England, 2003.

[4] Khalily, M., M. R. Kamarudin, M. Mokayef, and M. H. Jamaluddin, “Omnidirectional circularly polarized dielectric resonator antenna for 5.2 GHz WLAN-applications,” IEEE Antennas and Wireless Propag. Lett., Vol. 13, 443–446, 2014.

[5] Sharma, A. and R. K. Gangwar, “Triple-band dual-polarized hybrid cylindrical dielectric resonator antenna with hybrid modes excitation,” Progress In Electromagnetics Research C, Vol. 67, 97–105, 2016.

[6] Lee, J. M., S. J. Kim, G. Kwon, C. M. Song, Y. Yang, K. Y. Lee, and K. C. Hwang, “Circularly polarized semi eccentric annular dielectric resonator antenna for X-band applications,” IEEE Antennas and Wireless Propag. Lett., Vol. 14, 1810–1813, 2015.

[7] Kajfez, D., A. W. Glisson, and J. James, “Computed modal field distributions for isolated dielectric resonators,” IEEE Trans on Microwave Theory and Tech., Vol. 32, 1609–1616, 1984.

[8] Balanis, C. A., Antenna Theory: Analysis and Design, John Wiley & Sons, Inc., Publication, 2005.