

Design And Development of A Dual-Band Circularly Polarized (Cp) Dielectric Resonator Antenna (Dra) Intended for Wlan and Wimax Applications

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Abstract—This paper presents the design and development of a dual-band circularly polarized (CP) dielectric resonator antenna (DRA) intended for WLAN and WiMAX applications. The proposed antenna employs an asymmetric Y-shaped dielectric resonator ($\epsilon_{dr} = 10$) mounted on a Taconic RF-35 substrate ($\epsilon_r = 3.5$, thickness = 1.52 mm) with a full ground plane. Circular polarization is achieved through the excitation of orthogonal modes by properly optimizing the geometrical dimensions and rotation angles of the Y-shaped arms. The antenna operates efficiently at two distinct frequency bands, covering the entire WLAN band (2.3–2.65 GHz) and WiMAX band (3.15–3.5 GHz). The fundamental and second-order modes are independently excited to generate right-hand circularly polarized radiation in both bands. The proposed design demonstrates good impedance matching, stable radiation patterns, and high polarization purity across the operating frequencies, making it suitable for compact and high-performance wireless communication systems.

Index Terms—Dielectric Resonator Antenna, Circular Polarization

I. INTRODUCTION

In recent years, the demand for high-speed wireless communication systems has increased dramatically due to the rapid growth of multimedia applications, mobile devices, and Internet-based technologies. Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) are two prominent standards that enable broadband connectivity across a wide range of devices

and services. WLAN typically operates in the 2.4–2.65 GHz frequency range, while WiMAX covers the 3.15–3.5 GHz band. To ensure reliable performance and efficient spectrum utilization, antennas designed for these systems must exhibit compact size, high gain, wide bandwidth, and stable radiation characteristics. Moreover, circular polarization (CP) has become a key requirement for modern antennas due to its superior ability to mitigate multipath fading, polarization mismatch losses, and orientation sensitivity between the transmitter and receiver.

Among various antenna structures, Dielectric Resonator Antennas (DRAs) have emerged as a promising alternative to conventional microstrip patch antennas for microwave and millimeter-wave applications. DRAs offer several advantages, including low conductor loss, high radiation efficiency, wide impedance bandwidth, and ease of excitation in different polarization modes. Their ability to be integrated with various feed mechanisms and substrate materials makes them highly versatile for compact and multi-band antenna designs. Additionally, DRAs can be tailored to generate circular polarization by exciting two orthogonal modes with equal amplitude and a 90° phase difference, thus fulfilling the requirements of modern wireless communication systems.

In order to achieve dual-band operation and circular polarization, various geometrical configurations and excitation techniques have been explored in recent literature. Common methods include the use of hybrid feeds, slot coupling, perturbation structures, and shape

modifications of the dielectric resonator. However, many of these designs suffer from limitations such as increased structural complexity, large size, or difficulty in achieving independent control of resonant frequencies and axial ratio bandwidths. Therefore, a simple yet efficient design that can simultaneously achieve dual-band circular polarization with compact size and high gain remains a research challenge.

In this work, a novel dual-band circularly polarized dielectric resonator antenna (CP-DRA) is proposed for WLAN and WiMAX applications. The proposed antenna employs an asymmetric Y-shaped dielectric resonator placed on a Taconic RF-35 substrate with a full ground plane. The Y-shaped configuration enables the independent excitation of fundamental and higher-order modes by optimizing the lengths and orientations of its arms. The antenna is excited through a single vertical-strip feed, which effectively couples energy into the resonator to generate circular polarization at both frequency bands. The resulting antenna achieves dual CP bands covering 2.3–2.65 GHz for WLAN and 3.15–3.5 GHz for WiMAX with good impedance matching and polarization purity.

Simulation results obtained using ANSYS HFSS demonstrate that the proposed design provides an impedance bandwidth of 2.6–3.6 GHz, encompassing both operating bands. The axial ratio remains below 3 dB across the desired frequency ranges, confirming the generation of circular polarization. Moreover, the antenna exhibits satisfactory gain values of 8.54 dB in the lower band and 6.92 dB in the upper band, making it highly suitable for wireless communication and networking applications requiring dual-band CP operation.

Thus, the proposed dual-band CP-DRA offers an efficient, compact, and robust solution for next-generation WLAN and WiMAX communication systems, combining the benefits of dielectric resonator technology with advanced polarization and frequency agility.

Antenna Design

Figure 1 represents the geometry of the proposed dual-band CP DRA. An asymmetric Y- Shaped DR ($\epsilon_{dr} = 10$) is placed on top of a 1.52-mm thick Taconic RF-35 substrate ($\epsilon_r = 3.5$). The lower side of the substrate is fully covered with a ground plane of dimensions ($g_w \times g_l$). The Y-shaped DR is created by combining three rectangular arms long, medium, and short—with each of a height h . The long arm has a

length and width of $l_1 + l_4$ and w_1 , respectively. The medium and short arms are of lengths $l_2 + w_a$ and l_3 and widths w_2 and w_3 , respectively. Considering the origin at $-o_1$, the medium and long arms are rotated by α and β , respectively. The DR is placed at a distance of g_x and g_y from the lower right corner of the substrate. A single-point feeding mechanism that employs a vertical-strip is attached to the short arm of the DR for excitation. The vertical-strip has a length of $f_1 + f_2$ where the lower end is tapered by dimensions of $(w_3 - f_w) \times f_2$. The optimized geometric parameters are mentioned in Table 1.

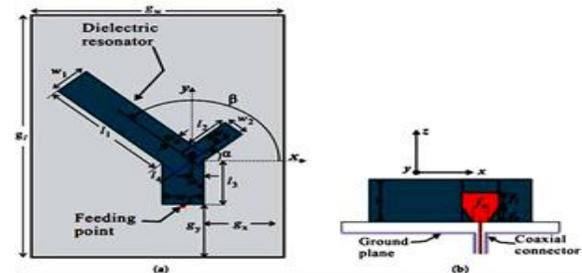


Fig 1.1 Geometry of the proposed antenna: (a) Top View; (b) Side view

| Parameters | Values | Parameters | Values |
|------------|----------|------------|----------|
| h | 20.5 mm | l_3 | 17.96 mm |
| f_w | 5 mm | l_4 | 5.27 mm |
| f_1 | 7 mm | w_a | 4.75 mm |
| f_2 | 7 mm | w_b | 4.5 mm |
| g_l | 120 mm | w_c | 3.5 mm |
| g_w | 70 mm | w_1 | 11.5 mm |
| g_x | 20.5 mm | w_2 | 7 mm |
| g_y | 32 mm | w_3 | 12 mm |
| l_1 | 40.13 mm | α | 45° |
| l_2 | 13.25 mm | β | 135° |

Table 1: Optimized geometric parameters of the proposed antenna

II. SIMULATION USING HFSS

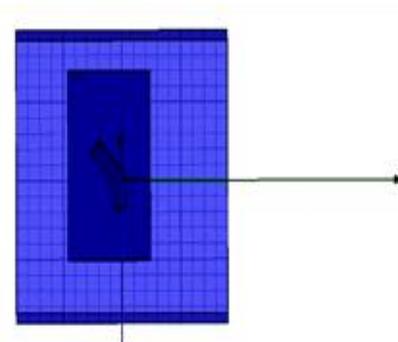


Fig 2.1 Structure of DR-1

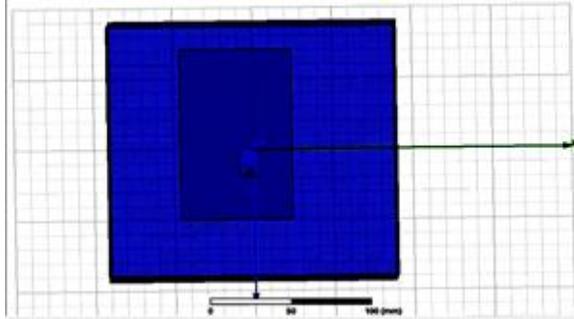


Fig 2.2 Structure of DR-2

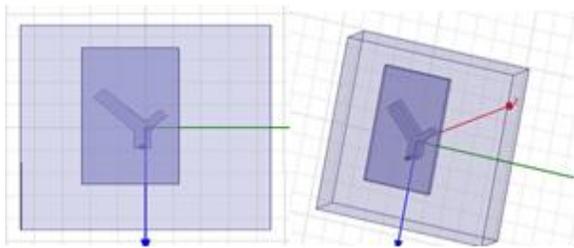


Fig 2.3 Structure of proposed DRA

III.SIMULATED & MEASURED RESULTS

Return loss

The return loss for circularly Polarized Dielectric Resonator -1 designed in HFSS is shown in figure 3.1. From this figure, it is observed that the return loss is -13.8 dB at 6.1GHz and it is less than -10dB from 5.9GHz to 7.2GHz.

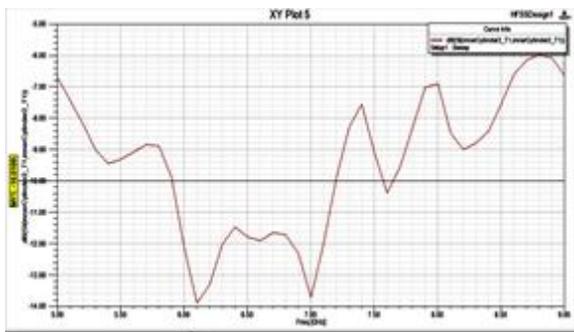


Fig 3.1 return loss of DR-1

Axial ratio

The Axial Ratio (AR) is defined as the ratio between the minor and major axis of the polarization ellipse. For a circularly polarized antenna, the closer the axial ratio is to 0dB. But, Practically the axial ratio can be considered below 3dB line in dB plot. The Axial Ratio of circularly polarized dielectric resonator-1 designed in HFSS is shown in the fig 2.8. From the

figure, it can be seen that axial ratio is less than 3dB from 2.45 GHz to 3 GHz.

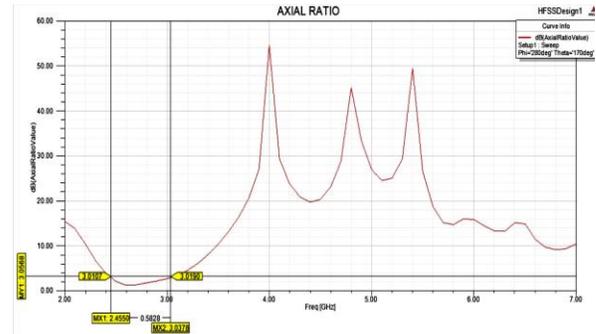


Fig 3.2: Axial Ratio

Gain:

Gain is nothing but the power transmitted per unit solid angle. The 3-D gain of circularly Polarized Dielectric Resonator-1 designed in HFSS is shown in figure 3.3. The gain of any antenna is more than 3dB for any applications. The gain observed for this antenna is 12.45 dB.

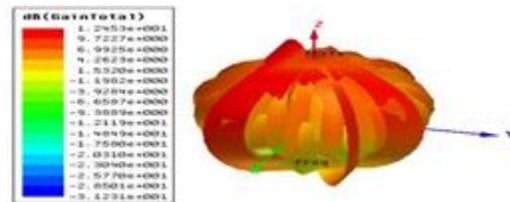


FIG 3.3 GAIN OF DR-1

3.1 SIMULATION RESULTS OF DR-2 USING HFSS

Return loss:

The return loss for circularly Polarized Dielectric Resonator -2 designed in HFSS is shown in figure 2.10. From this figure, it is observed that the return loss is -23 dB at 2.8GHz and it is less than -10dB from 2.5GHz to 3.3GHz.

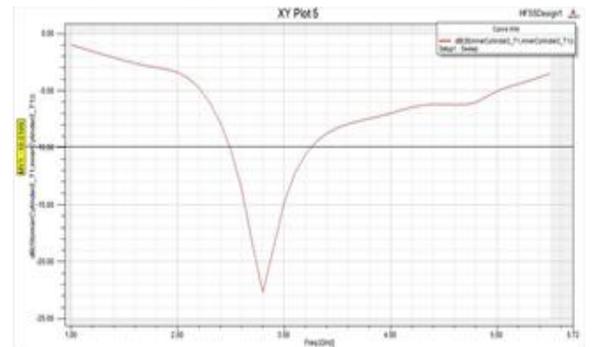


Fig 3.4 Return loss of DR-2

Axial ratio:

The Axial Ratio (AR) is defined as the ratio between the minor and major axis of the polarization ellipse. For a circularly polarized antenna, the closer the axial ratio is to 0dB. But, Practically the axial ratio can be considered below 3dB line in dB plot. The Axial Ratio of circularly polarized dielectric resonator-2 designed in HFSS is shown in the fig2.11. From the figure, it can be seen that axial ratio is less than 3dB from 4 GHz to 4.8 GHz.

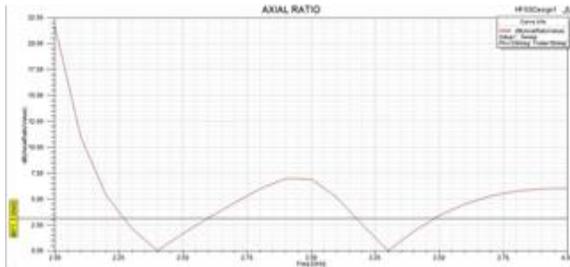


Fig 3.5 Axial ratio plot of DR-2

Gain:

Gain is nothing but the power transmitted per unit solid angle. The 3-D gain of circularly Polarized Dielectric Resonator-2 designed in HFSS is shown in figure 2.12. The gain of any antenna is more than 3dB for any applications. The gain observed for this antenna is 7.57 dB

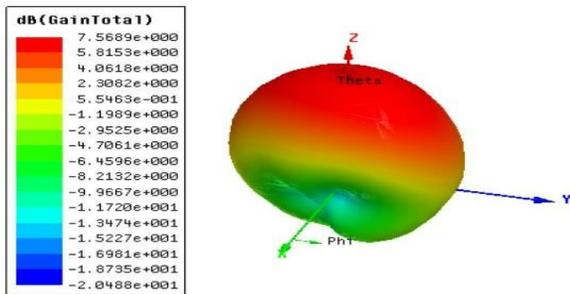


Fig 3.6 Gain of DR-2

IV. SIMULATION RESULTS OF PROPOSED DRA USING HFSS

Return loss:

The return loss for proposed circularly Polarized Dielectric Resonator designed in HFSS is shown in figure 2.13. From this figure, it is observed that the return loss is -23 dB at 3.2GHz and it is less than -10dB from 2.6GHz to 3.6GHz.

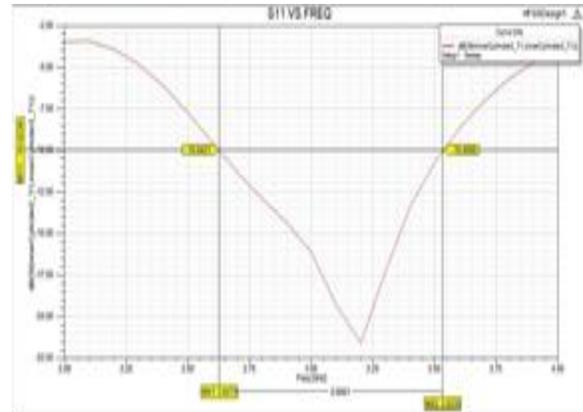


Fig 4.1: return loss of proposed DRA

Axial ratio:

The Axial Ratio (AR) is defined as the ratio between the minor and major axis of the polarization ellipse. For a circularly polarized antenna, the closer the axial ratio is to 0dB. But, Practically the axial ratio can be considered below 3dB line in dB plot. The Axial Ratio of proposed circularly polarized dielectric resonator designed in HFSS is shown in the fig 2.14. From the figure, it can be seen that axial ratio is less than 3dB from 2.3 GHz to 2.65 GHz in the lower band and from 3.15 to 3.5 in the upper band.

traffic management, air traffic control, and weather monitoring. Additionally, it was found that DRA has many advantages over other antenna in terms of radiation pattern, antenna gain, and high impedance matching capability.

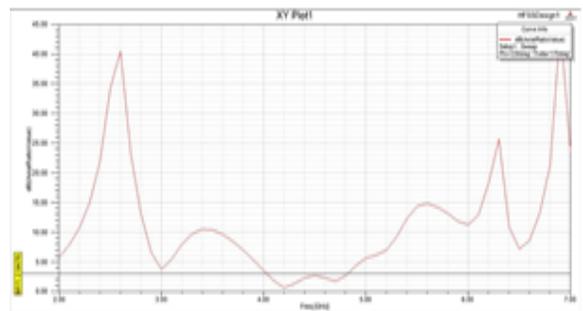


Fig 4.2: Axial ratio plot of proposed DRA

Lower band gain:

Gain is nothing but the power transmitted per unit solid angle. The 3-D lower band gain of proposed circularly Polarized Dielectric Resonator designed in HFSS is shown in figure2.15. The gain of any antenna is more than 3dB for any applications. The gain observed for this antenna is 8.54 dB.

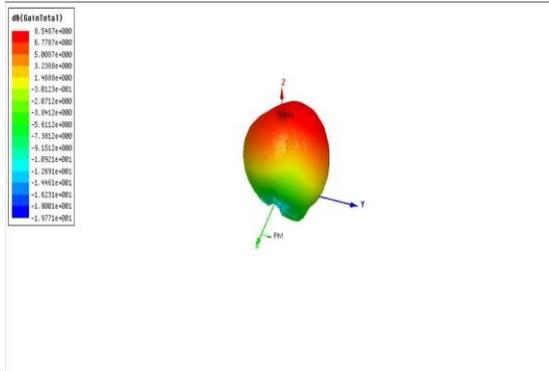


Fig 4.3: lower band gain of proposed DRA

Upper band gain

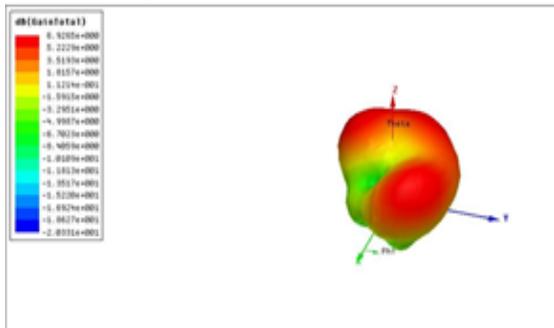


FIG 4.4: UPPER BAND GAIN OF PROPOSED ANTENNA

GAIN IS NOTHING BUT THE POWER TRANSMITTED PER UNIT SOLID ANGLE. THE 3-D UPPER BAND GAIN OF PROPOSED CIRCULARLY POLARIZED DIELECTRIC RESONATOR DESIGNED IN HFSS IS SHOWN IN FIGURE 2.16. THE GAIN OF ANY ANTENNA IS MORE THAN 3DB FOR ANY APPLICATIONS. THE GAIN OBSERVED FOR THIS ANTENNA IS 6.92 DB.

V. CONCLUSION

In this project, a novel dual-band CP DRA is proposed for WLAN and WiMAX applications. The circular polarization at the bands of interest is obtained due to the excitation of a fundamental and second order modes. The simulated data shows a wide - 10dB impedance bandwidth from 2.6GHz to 3.6GHz and the existence of two CP bands with 3dB Axial ratio bandwidths of (2.3 – 2.65) in the lower band and (3.15 – 3.5) in the upper band. The CP bands of the proposed antenna entirely cover WLAN and WiMAX frequency ranges and can be adopted in the transceiver design.

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