Hybrid Z-Shaped Cylindrical Dielectric Resonator Antenna

B. Praveen Kumar¹, N.Rajasekhar², CH. Ramesh Kumar³, D.Baladiya⁴
Department of Electronics and Communication Engineering
LIET, Jonnada, India

Abstract:
The paper presents design and analysis of a multiband hybrid Z–shaped cylindrical dielectric resonator antenna (CDRA) with partial ground plane. The antenna design consists of Z-shaped CDRA along with dual circular shaped patch. Dual circular shaped patch is used to excite TE01δ mode, which also acts as a radiator. The proposed design operates in four frequency bands i.e. 2.3–3.1 GHz, 4–4.3 GHz, 6–6.6 GHz and 8.5–9 GHz. The proposed antenna may be suitable for different wireless applications like WiMAX (2.6/3.5 GHz) and satellite communication (7.9–8.39 GHz).

1. INTRODUCTION:
In the present years of cellular communication, multi-band, low profile antenna with dual polarisation is mostly required. Mobile communication plays a major role in the human life. The most common mobile application used in recent years is WiMAX. Similarly, satellite communications have wide range of applications in X-band (8–12.5 GHz) such as radar applications, air traffic control, weather monitoring. For this purpose, high gain circularly polarised antennas are well suited. To fulfil all these requirements, different types of antennas have been proposed. Hybrid dielectric resonator antenna (DRA) is one of the most suitable radiators due to its characteristics like, generation of higher order modes with a single dielectric resonator (DR) element and low dispersion loss on higher frequencies [1]. The radiation ability of DR was introduced by Richtmyer [2] and experimental work was started by Long et al. [3]. Antenna designs are linearly polarised in all working frequency bands. Such type of antennas cannot be used in satellite communication because the antenna must be less sensitive to the transmitter and receiver orientations in such applications. Circularly polarised antennas are used to overcome polarisation rotation effects due to the atmosphere in satellite communication and to achieve more information from targets in radar systems. Therefore, in modern days, researchers primarily focused on multi-band antennas along with dual polarisation. Recently, some of the researchers have been developed different novel shaped circular polarised DRA such as rectangular DRA along with four inclined slits on the sidewalls of rectangular dielectric resonator antenna (RDRA), coaxial probe fed semi eccentric annular shaped DRA, four staked rectangular DRA rotated by an angle of 30° with its adjacent layer. In this article, dual C-shaped patch loaded Z-shaped CDRA is presented. Z-shaped CDRA is a combination of two CDRA s having same dielectric constant. In order to reduce quality factor, offset is provided between upper and lower CDRA s. Dual C-shaped patch behaves like a radiator and also used to excite TE01δ mode. The proposed antenna can be used in different wireless applications such as WLAN, Wi-MAX and satellite communication. This article is organised in the following manner: Antenna design along with mathematical formulation is described in Section 2. Experimental results are discussed in Sections 3.

2. ANTENNA DESIGN AND MATHEMATICAL FORMULATION
The proposed antenna structure is shown in Fig. 1. Feeding structure and panoramic view of the proposed antenna are shown in Figs. 1, respectively. The proposed antenna structure is designed on FR4 substrate (εr = 4.4, tan δ = 0.02). The combination of two CDRA s with an offset between upper and lower CDRA s form Z-shaped CDRA Al2O3 (εAlumina = 9.8, tan δ = 0.002).

Table 1. Antenna parameters

<table>
<thead>
<tr>
<th>symbol</th>
<th>Value, mm</th>
<th>symbol</th>
<th>Value, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ls</td>
<td>50</td>
<td>D1</td>
<td>14.25</td>
</tr>
<tr>
<td>Ws</td>
<td>50</td>
<td>D2</td>
<td>8.375</td>
</tr>
<tr>
<td>Lg</td>
<td>25</td>
<td>T</td>
<td>1.25</td>
</tr>
<tr>
<td>Wf</td>
<td>2.7</td>
<td>H1</td>
<td>4.8</td>
</tr>
<tr>
<td>Hs</td>
<td>1.6</td>
<td>d1</td>
<td>15.2</td>
</tr>
<tr>
<td>d</td>
<td>6.8</td>
<td>d2</td>
<td>10</td>
</tr>
</tbody>
</table>
To calculate the resonant frequency for TE01δ mode in CDRA, it is compulsory to estimate the effective permittivity of the proposed CDRA.

For TE01δ mode

\[ f_r = \frac{2.337c}{2\pi a\sqrt{\epsilon_{\text{eff}}}} \left[ 1.0 + 0.2123 \left( \frac{a}{H_{\text{eff}}} \right) - 0.00898 \left( \frac{a}{H_{\text{eff}}} \right)^2 \right] \]

Where \( \epsilon_{\text{eff}} \) is the effective permittivity of the proposed Z-shaped CDRA, \( a \) is the radius of the complete radiating part of the Z-shaped CDRA, \( H_{\text{eff}} \) is the effective height of the proposed structure and \( c \) is the velocity of light. For calculating effective permittivity, Z-shaped CDRA can be viewed as a two-segment CDRA with an offset between lower and upper segments. Now, the proposed antenna design can be observed as three layers of stacked dielectric, i.e., FR4-alumina–alumina. Upper layer of stacked dielectric can be viewed as two permittivity in series, i.e., air–alumina. Middle layer can also be viewed in the same manner. By considering all above theory, effective permittivity is calculated as follows

\[ \epsilon_{\text{eff}} = \frac{H_{\text{eff}}}{(H_{\text{eff}}/\epsilon_{\text{upper}}) + (H_{\text{eff}}/\epsilon_{\text{lower}}) + (H_{\text{eff}}/\epsilon_{\text{sub}})} \]

\[ H_{\text{eff}} = H_U + H_L + H_S \]

**Figure 2.** Return loss variation with respect to the frequency of the proposed antenna design

![Return loss variation with respect to the frequency of the proposed antenna design](image)

**Figure 3.** Surface current distribution

![Surface current distribution](image)

### 3. Results

This section focuses on the approval of optimise simulated results of the proposed antenna. Fig. 4 shows far-field radiation pattern of the proposed antenna structure in both the principle planes (i.e., E and H plane) at 2.7GHz, 4.1GHz, 6.2GHz, and 8.1GHz.
4. CONCLUSION

In this paper, hybrid Z-shaped cylindrical dielectric resonator has been examined, which has the ability of generating multiple resonances. Dual Circular-shaped patch are used to excite TE01δ mode in Z-shaped CDRA and also used as a radiator. Fundamental modes along with some loaded modes are generated in dual Circular-shaped patch due to asymmetric feed position. The proposed antenna design has the capabilities to support different wireless applications like WiMAX (2.6/3.5/ GHz) and satellite communication (7.9–8.39 GHz).

5. REFERENCES


