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Hybrid Cylindrical Dielectric Resonator Antenna for Microwave Applications

Sneha Kanithi[1], Shweta Mahule[2], Anshul Gupta[3]
Department of Electronics and Telecommunication, NIT Raipur, India
[1]sneha.kanithi@gmail.com
[2]smahule666@gmail.com
[3]1321.anshul@gmail.com

ABSTRACT

In this article, simulation studies of hybrid cylindrical dielectric resonant antenna (CDRA) have been carried out for multi-band applications. Staircase-shaped microstrip feed is utilised to excite the cylindrical dielectric resonator. The proposed antenna shows quad-band characteristics i.e. 5.02-5.13 GHz, 5.48-5.75 GHz, 5.82-5.9 GHz, and 6.33-6.57 GHz with impedance bandwidth of 110 MHz, 270 MHz, 80 MHz and 240 MHz respectively. The impedance bandwidth and radiation characteristics of proposed antenna have been extracted with the help of Ansoft High Frequency Structure Simulator (HFSS) software. The proposed antenna affords compact size, appropriate gain and high radiation efficiency over the entire bands. The proposed antenna can be utilized for microwave applications between 5-6.5 GHz.

Key words: C-band, Cylindrical dielectric resonator antenna, partial ground plane, multiband

1. INTRODUCTION

Over the last few years, growth of wireless communications has increased across the world. Researchers in today's communication world mainly focuses to develop compact and multi band antennas so that it can be easily integrated on the communication device as well as same antenna can be worked for different applications. Microstrip antennas are primarily used to fulfill these requirements but they suffered from narrow bandwidth and low gain due to its high metallic losses. Significant developments have been done in the field of dielectric resonator antennas over the last three decades. The investigations performed by researchers on DRA have revealed the dielectric resonator antenna to be an adaptable and competent radiator. Flexibility in the design of DRAs makes it striking substitute to traditional low-gain antennas [1-4].

Several studies have been reported in open literature regarding multiband and compact dielectric resonator antenna. Some techniques to achieve multiband characteristic are: metal coated coaxial feed excited DRA [5], rectangular shape DRA excited by dual L-shape type microstrip line [6]. Similarly, different shapes of DRA have also been utilized to generate multiband characteristics [7-11].

This article shows the analysis of a cylindrical dielectric resonator antenna (CDRA), which is excited by staircase-shaped microstrip-feed structure. Section-II represents the antenna design. Section-III and Section-IV refer to simulation results and conclusion respectively.

2. ANTENNA GEOMETRY

The geometry of proposed CDRA excited with staircase-shaped microstrip feeding is shown in Figure 1. The permittivity of proposed cylindrical dielectric resonator is 17 (i.e. $\varepsilon_r = 17$, $\tan\delta = 0.002$). The cylindrical DR is placed over FR4 substrate ($\varepsilon_r=4.4$, $\tan\delta = 0.02$). The size of ground plane has been optimized through various simulations to obtain best impedance matching.

The dimensions of staircase-shaped feed structure are adjusted for the desired frequency band. The list of optimized parameters of proposed antenna is shown in Table 1.

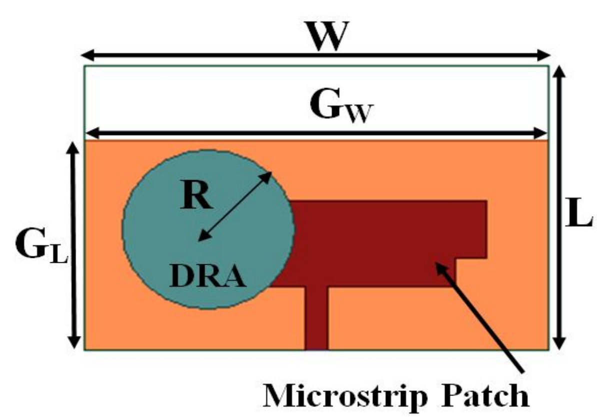


Figure 1: Schematic diagram of proposed antenna

Table 1: Optimized Parameters of Proposed Antenna

S. No.	Parameters	Dimensions	Materials
1.	Length of ground plane (G_L)	29.5	Copper
2.	Width of ground plane (G_W)	60	Copper
3.	Length of substrate (L)	40	FR4 (ε_r=4.4, tanδ = 0.02)
4.	Width of substrate (W)	60	
5.	Thickness of substrate (h_s)	1.57	
6.	Radius of DRA (R)	11.2	(ε_r = 17, tanδ = 0.002)
7.	Height of DRA (H_d)	10	

3. SIMULATED RESULTS

This section represents the simulation analysis of proposed antenna. The simulation studies of the proposed antenna have been carried out using ANSYS HFSS software. Figure 2 illustrates the simulated $|S_{11}|$ characteristic of the proposed antenna. Table 2 is engrossed on simulated resonant frequency, bandwidth and operating frequency range of all four bands.

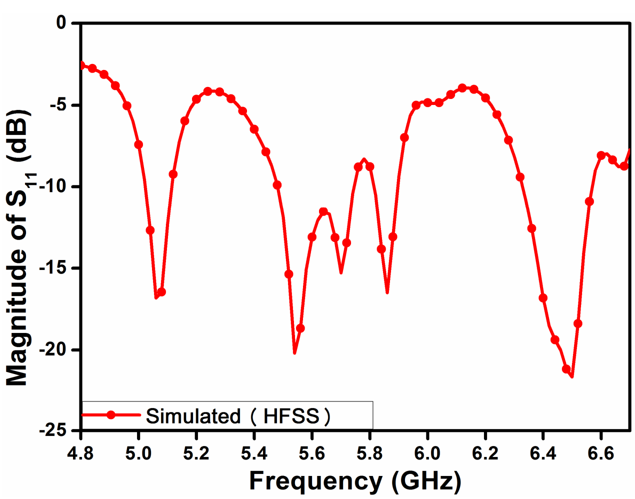


Figure 2: Simulated $|S_{11}|$ characteristic of proposed antenna

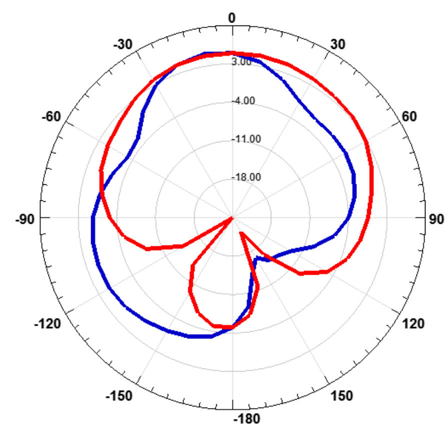
From Figure 2 and Table 2, it can be determined that the proposed structure covers the four frequency bands ranging from 5.02-5.13 GHz, 5.48-5.75 GHz, 5.82-5.9 GHz, and 6.33-6.57 GHz with impedance bandwidth of 110 MHz, 270 MHz, 80 MHz and 240 MHz respectively.

The simulated radiation patterns (co-polar and cross-polar) at four different resonant frequencies of 5.06 GHz, 5.7 GHz, 5.86 GHz and 6.5 GHz in the E- and H-plane are shown in Figures 3(a)-3(d) respectively. It's clear from Figure 3 that stable and good radiation patterns are obtained throughout the bandwidth.

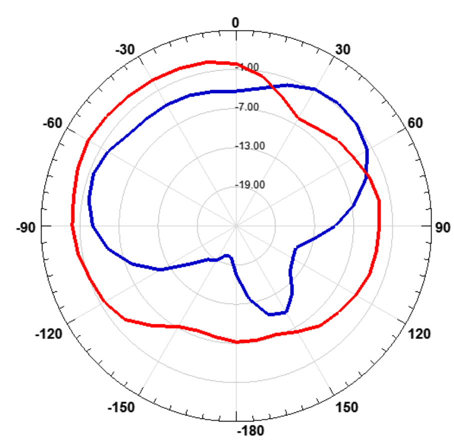
Simulated gains are found to be 5.27 dB, 3.82 dB, 5.15 dB and 5.57 dB at resonant frequencies of 5.06 GHz, 5.7 GHz, 5.86 GHz and 6.5 GHz respectively. The simulated radiation efficiencies are 79.41 %, 71.5 %, 72.96 % and 74.30 % at resonant frequencies of 5.06 GHz, 5.7 GHz, 5.86 GHz and 6.5 GHz respectively which evidences that the proposed antenna is an efficient radiator. It's clear from results that gain and radiation efficiency of proposed antenna is suitable for microwave applications in C-band.

Table 2: Simulated Parameters of Proposed Antenna

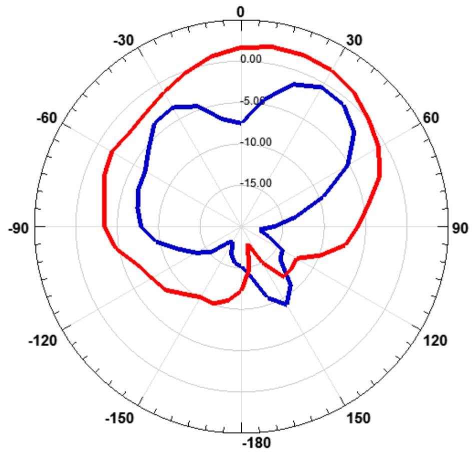
	Resonant Frequency (GHz)	Operating Frequency Range (GHz)	Bandwidth (MHz)
Band-I	5.06	5.02 – 5.13	110
Band-II	5.54 and 5.7	5.48 – 5.75	270
Band-III	5.86	5.82 – 5.9	80
Band-IV	6.5	6.33 – 6.57	240



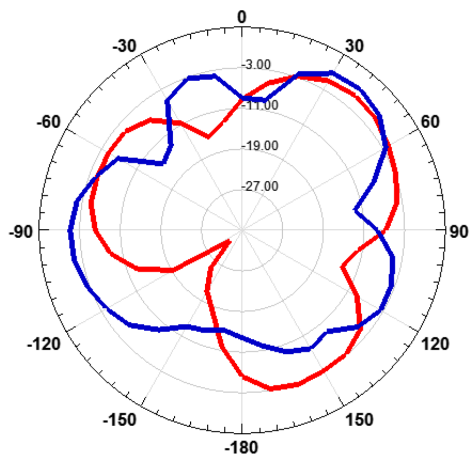
(a)



(b)



(c)



(d)

Figure 3: Simulated radiation patterns of proposed antenna in E- and H-planes (a) 5.06 GHz (b) 5.7 GHz (c) 5.86 GHz (d) 6.5 GHz

4. CONCLUSION

In this article, a cylindrical DRA excited with Staircase-shaped feed structures is presented. The proposed structure covers wide impedance bandwidth with high radiation efficiency, appreciable gain and radiation patterns. The developed antenna can be utilized for microwave applications between 5-6.5 GHz since it covers some portion of C-band.

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