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Half Cylindrical Dielectric Resonator Antenna for Dual Band Applications

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ABSTRACT
A dual-band half cylindrical dielectric resonator antenna is proposed in this paper for the 3.4/5.5 GHz. The proposed antenna consists of half circular cylindrical DR mounted on a finite ground plane. The designed DRA is excited by conformal patch connected to microstrip feed line which is an effective feed mechanism to obtain dual-band operation. The introduction of conformal patch with microstrip line can improve the impedance bandwidth of the antenna significantly. The Simulation process was done by using a CST microwave studio suite^{TM}2010. Parametric study is carried out by varying the height of the half circular dielectric resonator and height of the conformal patch. The simulated results show that it has a better resonant frequency for DR height, h_d =5 mm with patch height h_c=4.95 mm. The maximum peak gain achieved is 9.33 dBi and directivity varies from 3.71dBi to 5.61dBi at 3.43 GHz to 5.5 GHz respectively. The proposed design can use for WiMAX (worldwide interoperability for microwave access) applications which operate at 3.5 GHz and 5.5 GHz. With these features, this design of half circular DRA is suitable for dual-band wireless communication system.

Keywords
Half cylindrical Dielectric resonator antenna (DRA), Conformal patch feed, WiMAX.

1. INTRODUCTION
Wireless Communication has seen unprecedented growth over the last few decades. WiMAX is a standards-based technology enabling the delivery of last mile wireless broadband access [1]. WiMAX refers to interoperable implementations of the IEEE 802.16 wireless-networks standard which can operate at higher bitrates or over longer distances. It is capable of operating in 3.4-3.6 GHz frequency range as well as at 5.5 GHz band [2].

Over the past few years, the dielectric resonator antenna (DRA) has received extensive attention due to its several advantages such as light weight, low profile, low dissipation loss, high dielectric strength and higher power handling capacity. It can use different feed mechanisms such as probe, microstrip lines, slots, co-planar lines [3]. DRA can be in a few geometries including cylindrical, rectangular, spherical, half-split cylindrical, disk, hemispherical and triangular shaped [4]. It has some interesting characteristics, like the small size, ease of fabrication, high radiation efficiency, wide impedance width and low production cost. Among the different shapes of DRA, the cylindrical shape DRA offers greater design flexibility and easy fabrication [5-7].

A dual-band half cylindrical dielectric resonator antenna is presented in this paper. The proposed antenna can generate two resonant frequencies about 3.43 GHz and 5.5 GHz to cover 3.5/5.5 GHz WiMAX operating bands. Simulation process was done by using CST microwave studio suite^{TM} 2010 software and it is used to analyze the performance of the designed antenna such as return loss, gain and directivity, radiation patterns. The parametric study is carried out by varying the height of the conformal patch and DR. The obtained results show that the proposed antenna is suitable for WiMAX applications [8-11].

2. ANTENNA DESIGN
The geometry of the proposed half cylindrical DRA is shown in Fig. 1, where a half cylindrical DR is located at the upper side of the substrate with radius (r) = 19 mm and a relative permittivity constant ε_{r1} = 2.1.

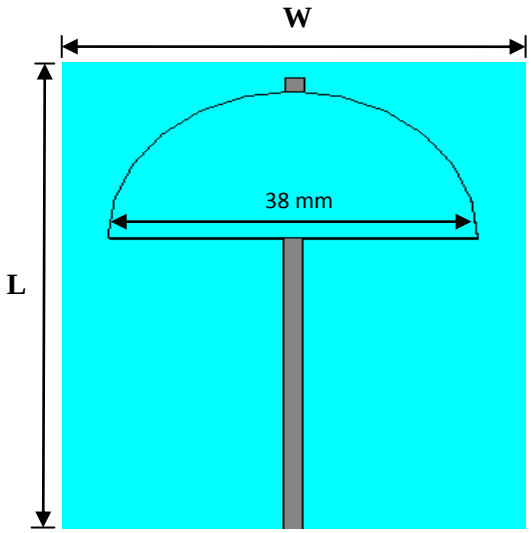


Fig 1: Geometry of the proposed half cylindrical DR antenna

The DRA is supported by Rogers RT 6002 substrate having dimension (L × W) 62 × 50 mm^2 with height (h_s) = 1.6 mm and dielectric constant (ε_{r2}) =4.4. The proposed DRA also consists of a rectangular DR piece of vacuum which has been removed from cylindrical DR. It is expected that by removing the half portion of the cylindrical DRA, its bandwidth can be increased [12], [13]. The dimension of the rectangular ground plane is ($L_g \times W_g$) 12.5 × 50 mm^2. The designed DRA is excited by a conformal patch located at the center of one side of half cylindrical DR and connected to the microstrip feed line. The conformal patch has dimension of length L_c= 0.05mm, width W_c= 3 mm and height h_c=4.95 mm . The microstrip feed line is printed on one side of substrate with dimensions of ($L_f \times W_f$) 59×2 mm^2. The proposed DRA is designed to provide WiMAX applications.

3. PARAMATERIC STUDY

Parametric study of the half cylindrical dielectric resonator antenna is carried out by using Computer Simulation Technology (CST) microwave studio suite™ 2010. From the simulated results, it was observed that the proposed antenna achieves an impedance bandwidth from 3.33 to 3.53 GHz and 5.30 to 5.87 GHz covering 3.4 GHz and 5.5 GHz WiMAX bands. Furthermore, to achieve dual band operation, the designed DRA is excited by using a conformal patch connected with microstrip feed line. Parametric study is carried out by varying the height of the conformal patch and DR of the half cylindrical DRA to achieve good antenna performance. Fig. 2 shows the simulated return loss for different heights of the conformal patch such as 3.95 mm, 4.95 mm, 5.95 mm, 6.95 mm, and 7.95 mm.

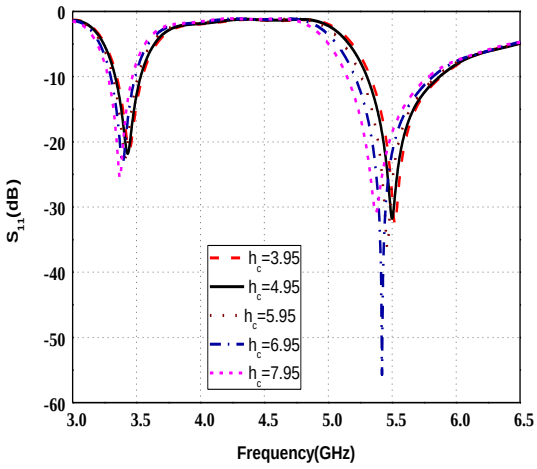


Fig 2: Comparison of return loss plots at various height of the conformal patch

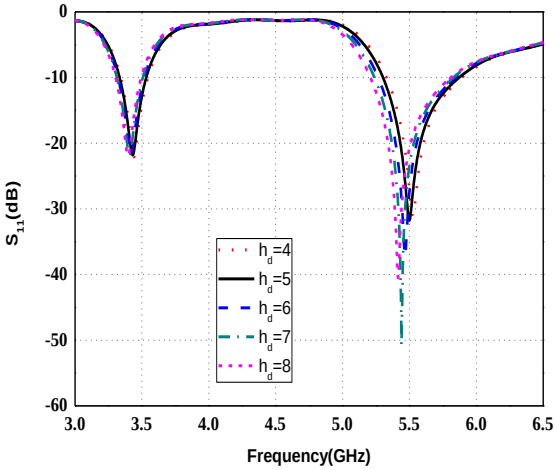


Fig 3: Comparison of return loss plots at various height of the half cylindrical DR

Fig. 3 shows the simulated return loss by varying the height of the DR from 4 mm to 8 mm. From fig. 4 we observe that the return loss of the proposed antenna at frequency 3.43 GHz is -27.38 dB and at 5.5 GHz is -31.75 dB. For the case, conformal height h_c= 4.95 mm and half cylindrical DR height h_d=5 mm, a dual bandwidth with good return loss is observed.

4. RESULTS AND DISCUSSIONS

4.1 Return loss charactertics

The design of the antenna was performed and optimized by using CST Microwave Studio Suit ™ 2010. Proposed antenna is resonating at 3.43 GHz and 5.5 GHz frequency covering 3.33 GHz to 3.53 GHz and 5.30 GHz to 5.87 GHz. The return loss obtained is about -21.79 dB and -31.75 dB. Fig. 4 shows the return loss characteristics of half cylindrical dielectric resonator antenna for WiMAX applications.

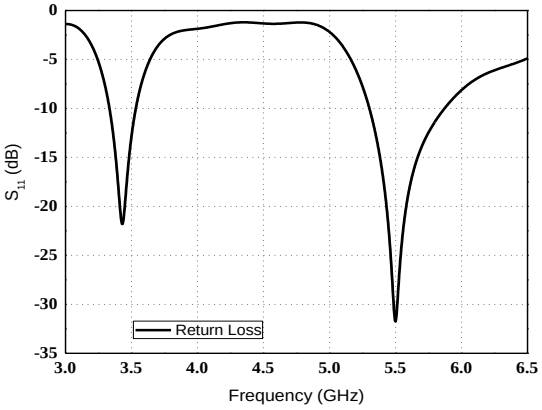


Fig 4: Simulated return loss plot of the proposed DRA

4.2 Gain and Directivity

The peak gain of antenna is 9.33 dBi in the overall frequency range. It is observed that the gain and directivity of the antenna are different in this paper. The maximum directivity achieved is 5.61 dB at 5.5 GHz. Fig. 5 shows the gain and directivity of the proposed antenna for WiMAX application. It is observed in the range of 3 GHz to 6 GHz.

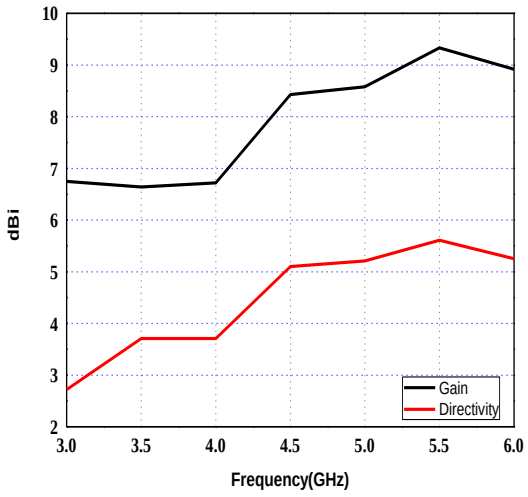
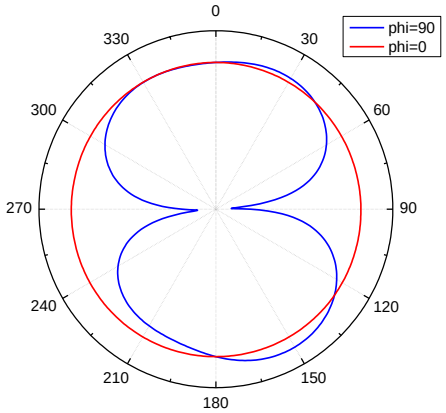


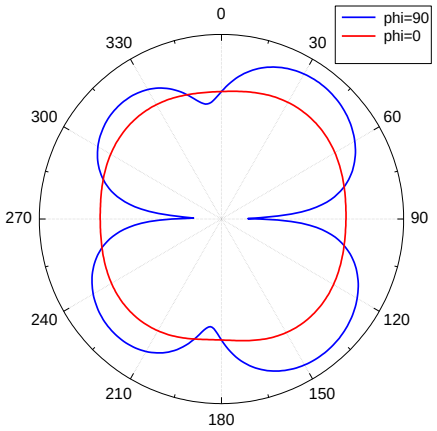
Fig 5: Simulated gain and directivity versus frequency

4.3 Radiation Pattern Charactertics

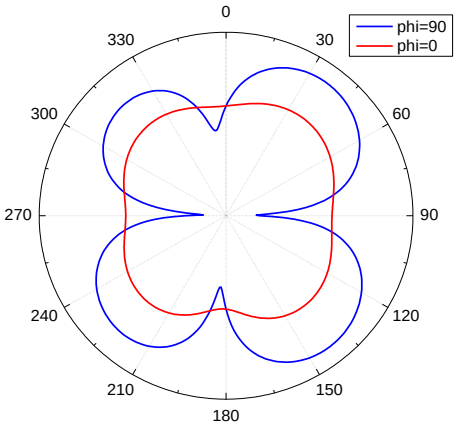
The simulated far filed radiation patterns of the proposed DRA are different for all frequencies. Fig. 6 shows the simulated radiation patterns at different frequencies (3 GHz, 3.4 GHz, 5 GHz, 5.2 GHz and 5.5 GHz). It shows that proposed antenna radiates in the broadside direction.



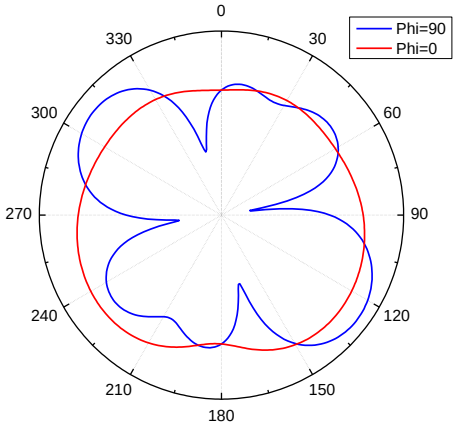
(a) At 3 GHz



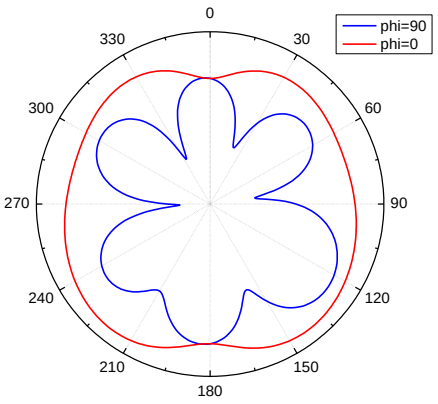
(b) At 3.4 GHz



(c) At 3.5 GHz



(d) At 5 GHz



(e) At 5.5 GHz

Fig 6: Simulated radiation patterns of proposed antenna at (a) 3 GHz, (b) 3.4 GHz, (c) 3.5 GHz, (d) 5 GHz and (e) 5.5 GHz

5. CONCLUSION

In this paper, a half cylindrical dielectric resonator antenna is presented for WiMAX applications. The proposed DRA consists of a half cylindrical DR and excited by conformal patch connected to microstrip line. The simulated results show that the designed antenna offered good impedance bandwidth from 3.33 GHz to 3.53 GHz and 5.30 GHz to 5.87 GHz, which covers WiMAX application band (3.5/5.5 GHz) in current wireless communication systems. It provides a maximum gain of 9.33 dBi and directivity of 5.61 dBi. The presented dual-band antenna is suitable for WiMAX applications.

6. ACKNOWLEDGEMENT

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