Metal Loaded Low Profile and Compact Dielectric Resonator Antenna for WiMAX/WLAN Applications

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ABSTRACT.

In this paper; a metal loaded coaxial fed low profile and Compact cylindrical dielectric resonator antenna (LPCDRA) is presented. Metal insertion is done for antenna miniaturization. This Low Profile Antenna is designed for WiMax/WLAN application and its input and radiation characteristics determined through the Ansoft High Frequency Structure Simulator (HFSS) Software and compared with CST Software. The proposed antenna provides wide Bandwidth (21%) and high average gain (4.83 dBi) with Monopole type Radiation Pattern. The antenna also provides a miniaturization of 20%.

Keywords— ***Cylindrical DRA, Low Profile DRA; WiMax/WLAN Band; Coaxial Probe fed; Monopole type Antenna***

I. INTRODUCTION

The Dielectric Resonator antenna (DRA) offers small size, mechanical simplicity, high radiation efficiency due to absence of inherent conductor loss, and no surface-wave losses [1]. DRAs enjoy more design flexibility in terms of shape such as cylindrical, hemispherical, rectangular etc. [2-4] and feeding mechanisms such as probe coupling [5], micro strip coupling [6], coplanar coupling [7] and aperture coupling [8]. However, one major limitation of the DRA is its limited bandwidth. To overcome this limitation, various bandwidth enhancement techniques have been developed such as optimizing the feeding mechanisms and DRA parameters, stacking multiple DRAs [9,10], inserting an air gap in the DR to lower the Q-factor [11,12], and changing the shape of DRA [13]. Miniaturization of Antenna can be achieved by introducing high dielectric material as the resonating part and insertion of metal plates onto the top and outer surfaces and centre as well as of the antenna [14, 15]. Multi-element DRAs can be used to achieve a much wider bandwidth compared to the single-element structure, or to realize operation at two bands for the same linear polarisation [16].

In this article, we have discussed the metal loaded cylindrical DRA for WiMax/WLAN applications. The metal is inserted inside the cylindrical DRA for miniaturization of antenna. By doing so the Radial Wave-number k_r contracted as compared to conventional CDRA and hence Resonate Frequency drooped.

II. ANTENNA STRUCTURE

Figure 1(a) demonstrates the Side View of the Metal Loaded LPDRA. It consists of ceramic material of dielectric constant $\varepsilon_r = 9.8 (Alumina)$ and loss tangent tanδ = 0.0021 acting as Cylindrical DRA. The Cylindrical DRA is placed on a Substrate made by FR4 ($\varepsilon_r = 4.4$) further over headed by copper metallic ground plane of size L_g x W_g mm^2. The inner and outer Diameters of the Loaded Metal Ring are taken as a=4mm and b=5mm respectively. In this antenna, coaxial probe fed excitation is used. The advantage of this type of excitation is that the antenna system can be directly connected to a 50 Ω circuit without the aid of any matching network. The probe height (H_p) above the surface of ground plane is found to be 4.8 mm through simulation using Ansoft's HFSS software to provide lowest return loss at resonant frequency. The optimized values of the parameters of the proposed antenna are given in Table 1.

Table 1- optimized parameter of the proposed Antenna

Parameter	Size(mm)	Parameter	Size(mm)
Diameter of the Cylindrical DRA (**D**)	24.0	Length of Ground Plane (**L**)	70.0
Height of the Cylindrical DRA (**H**)	6.5	Width of Ground Plane (**W**)	70.0
Length of the Probe ($\mathbf{H_p}$)	4.8	Height of Substrate	1.6
a	4.0	b	5.0

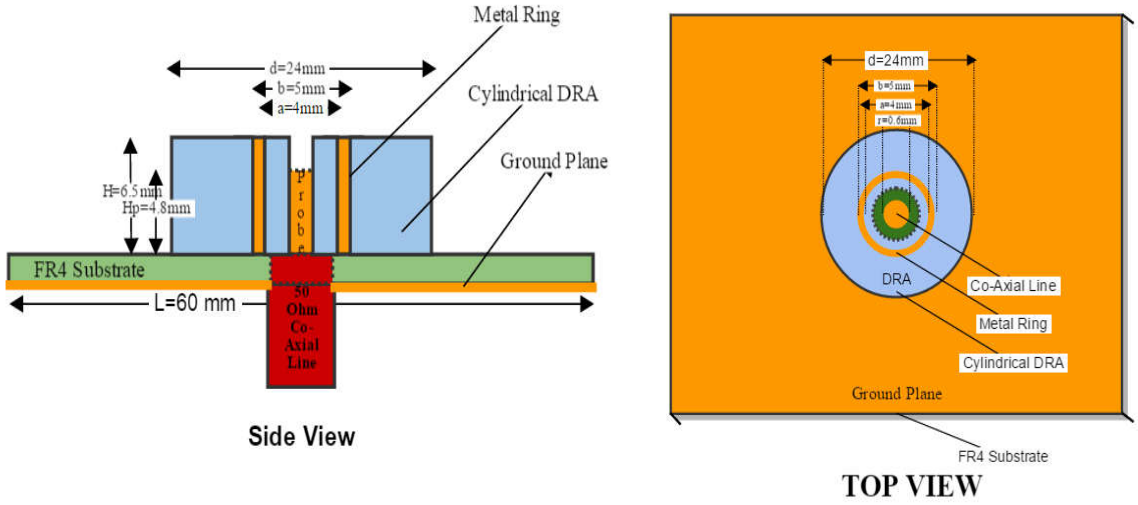

Fig.1 Geometry of the proposed structure of Metal Loaded Low Profile DRA above ground plane with probe fed excitation **(a)** Side View **(b)** Top View

III. RESULT AND DISCUSSION

In this section, the input characteristics are presented for the proposed Metal Loaded Cylindrical DRA. The results are offered for the return loss as a function of frequency. Wide input impedance bandwidth can be obtained in the case of Metal Loaded Cylindrical DRA using coaxial probe coupling by selecting the Diameter D=24mm and a height H=7mm of the Cylindrical DRA. The Inner and Outer Diameters of the Metal Ring is Optimized by a=4mm and b= 5mm respectively.

Figure 2 shows the simulated return loss versus frequency graph of the proposed Metal Loaded Cylindrical DRA after taking optimized parameters. The variation of return loss versus frequency was obtained using Ansoft's HFSS software and verified in CST. The simulated impedance bandwidth is 21% (from 5.05 GHz to 6.25 GHz with Resonate Frequency of 5.65 GHz) and 21% (from 5.1 GHz to 6.35 GHz with Resonate Frequency of 5.7 GHz) for return loss values below -10dB in HFSS and CST Software respectively.

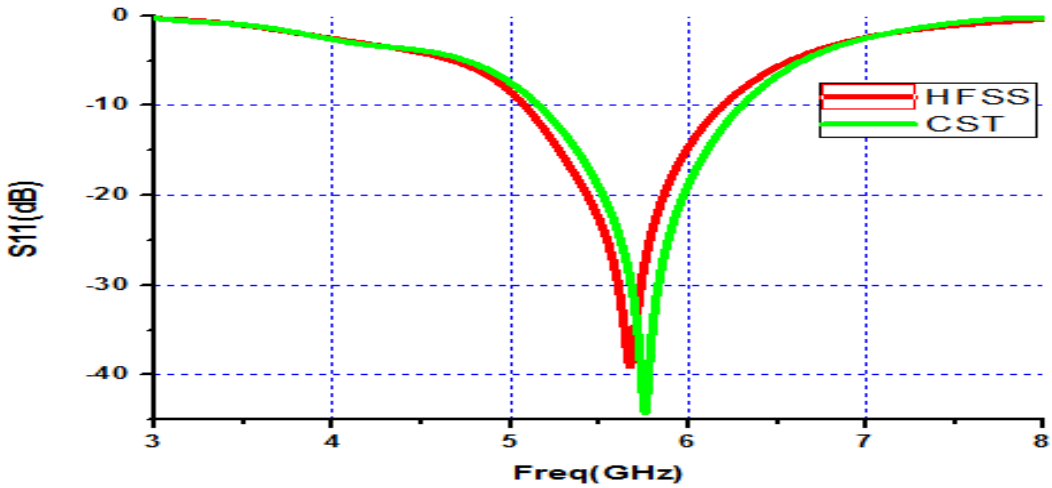

Fig.2 Simulated variation of return loss of the Proposed Four-element Conical DRA as a function of frequency.

The simulated far field patterns (both co-polar and cross-polar) of the proposed Four-element Conical DRA for *x-z* plane, y-*z* plane and x-y plane were obtained using Ansoft's HFSS software and then verified in CST Software at Resonate Frequency 5.65 GHz. The simulated radiation patterns of the proposed antenna for Resonate Frequency in three planes are shown in Figure 3. The figure shows Electric Monopole type radiation Pattern of the Antenna at resonant frequency of 5.65 GHz in both the Softwares.

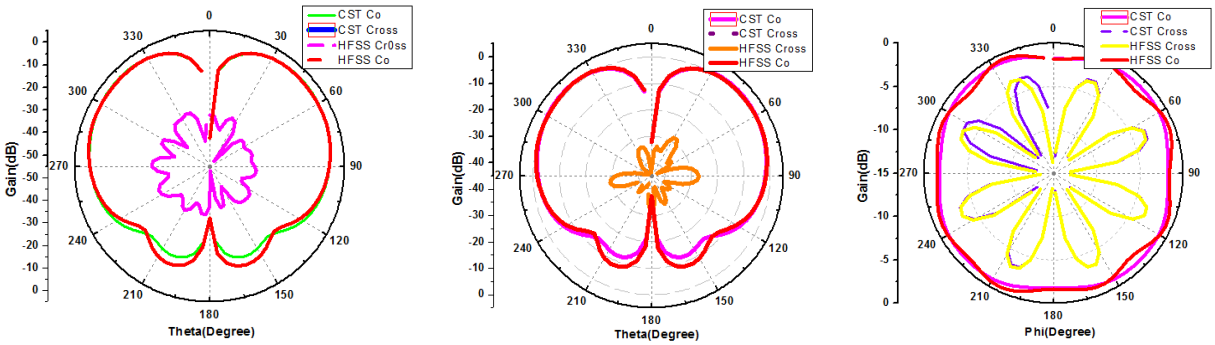

Figure 7-simulated radiation Patterns (Co and Cross Pol.) of proposed Four-Element Conical DRA antenna at Resonate frequency of 5.27 GHz in (a) X-Z Plane (b) Y-Z Plane (C) X-Y Plane

Figure 4 shows the simulated gains (in the boresight direction) over the frequency range from 5.0 to 6.25 GHz. Simulated gain was obtained using Ansoft's HFSS software and again verified in CST software. The proposed Metal Loaded Low Profile Cylindrical DRA offers simulated average gain of 4.83 dBi and 4.21 dBi in HFSS and CST Software respectively in the frequency range from 5.05 to 6.20 GHz.

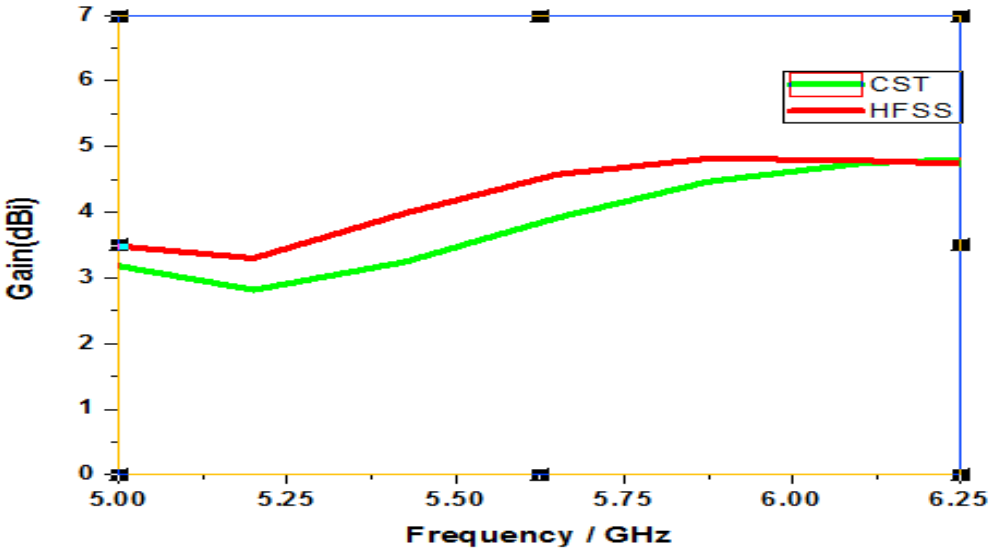

Fig. 8-simulated gain for proposed antenna over the frequency range 5.0 GHz to 6.25 GHz

IV. CONCLUSIONS

The purpose of this paper is to experimentally investigation of a Cylindrical DRA in which a metal plate is co-axially fitted and coupled by a Probe, and to illustrate its compactness and the usefulness of this structure for the realization of a wider band or dual-band operation. The proposed Antenna shows a wide bandwidth (21%) and high Average gain (4.83 dBi) with a monopole type radiation pattern. The miniaturization of antenna can be achieved by insertion of metal plate which contracted the Radial Wave-number k_r and hence Resonate Frequency drooped.

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