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A Four-Element Cylindrical Dielectric Resonator Antenna with Improved Bandwidth for MIMO Systems

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***Abstract*--**A new four-element Cylindrical Dielectric Resonator Antenna with top loaded thin circular disc is designed to improve the bandwidth of MIMO systems. Unlike other antennas, the four-element Cylindrical Dielectric Resonator Antenna with top loading is easy to design and excite as it uses the dominant HEM (11δ) mode in each CDR. As much as 44.44% matching bandwidth with monopole like radiation pattern over entire band has been achieved.

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I.INTRODUCTION

Today there is a deep interest in antenna systems which operate frequencies in the millimeter-wave region 100-300 GHz. Conventional metallic antennas suffer problems with regard to power losses, radiated power capabilities and fabrication difficulties. These obstacles can be overcome if a simply shaped antenna with few conducting surfaces is designed. The dielectric resonator antenna meet this requirements and has been shown to be a good choice for use in this band.

Dielectric Resonator Antennas (DRAs) have been investigated during the last two decades and significant advances are being made in developing them for many applications. One major aspect of the state-of-the-art research with DRA is how to enhance the element bandwidth as evident from survey of open literature [1] – [3]. For DRAs with broadside radiation, different shapes [4]-[6] and composite structures [1], [7], [8] have been investigated. For monopole like type radiation pattern [9], only a few handful investigations with DRAs are available in open literature.

In this paper, we present a new approach with four element cylindrical dielectrics where the HEM 11(delta) mode is excited in each DRA element and the composite field patterns result in a uniform monopole like radiation over a wide bandwidth. Some previous studies also used four element probe-fed CDRA but elements were arranged in a conventional way and their aim was to study the broadside linearly polarized radiation with shaped directional pattern using HEM (11δ) mode.

II.THE ANTENNA CONFIGURATION

DRAs are nowadays popular due to their attractive features like high radiation efficiency, low dissipation loss, small size , light weight and low profile. Moreover, DRAs which posses a high degree of design flexibility, have emerged as an ideal candidate for wide band, high efficiency and cost effective applications.

A four-element CDRA is schematically shown in Fig.1.Each candidate of the composite structure is of height h and radius a and relative permittivity of 10.The entire antenna system is fed with a coaxial probe of outer radius 5 mm and inner radius 4.5 mm at the location of (7.5,0,0).The height of the probe is 2 mm. All the dielectric resonator antennas designed in this paper are simulated with Ansoft High Frequency Structure Simulator (HFSS) V13.0

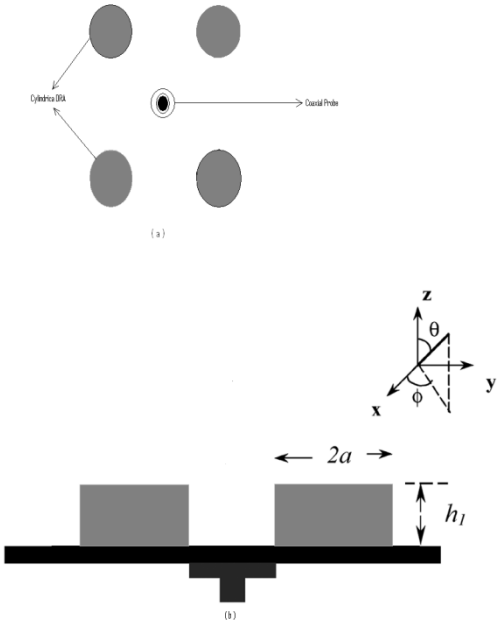

Fig.1 Four-element Cylindrical DRA fed by a coaxial probe. (a)Top view (b) Cross-sectional view

The antenna is simulated with a 50 ×50 mm^2 perfect electric conductor (PEC) ground plane radiating in a rectangular shaped cavity. The coaxial feed-port is modeled as a standard wave port.

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III.DESIGN & RESULTS

For studying the characteristics of the proposed antenna, our initial considerations for each CDRA for a=4.14mm and h=10mm and the HEM11(delta) mode resonant frequency in an individual element was obtained.

The simulated results of return loss for the four element cylindrical shaped dielectric resonator antenna are shown in Fig 2. The antenna resonates at a dual band of frequencies 1.54 GHZ, 13.3 GHZ with a return loss of -23.2 dB,-17.9 dB respectively, giving an impedance bandwidth of 27.22%.The radiation pattern at both resonating frequencies are shown in Fig 3.

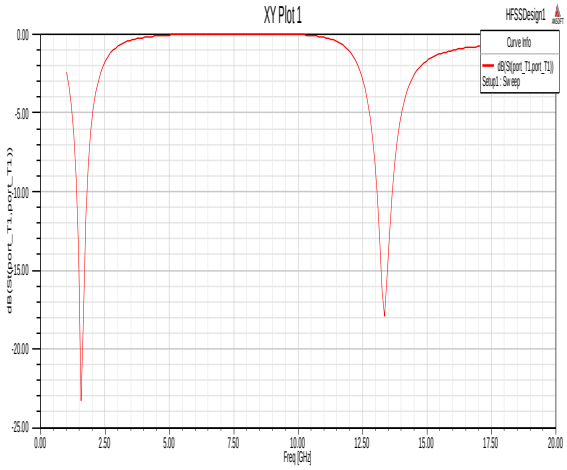

Fig.2 Return Loss for the four element cylindrical shaped dielectric resonator antenna

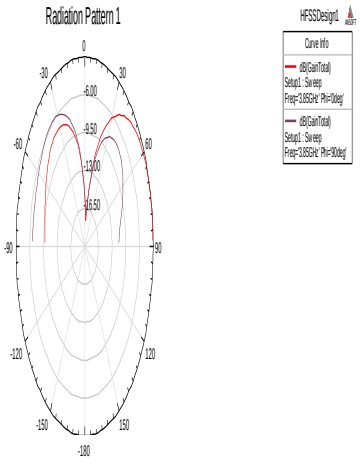

Fig.3 Radiation Pattern for the four element cylindrical shaped dielectric resonator antenna

A four element cylindrical dielectric resonator antenna by top loading with a thin circular disc is designed and is shown in Fig.4. The antenna resonates at a dual band of frequencies and giving an impedance bandwidth of 33.13% for circular disc of radius 7 mm and height 1.65 mm. The simulated results of return loss versus frequency and radiation pattern are shown in Fig.5 and Fig.6 respectively.

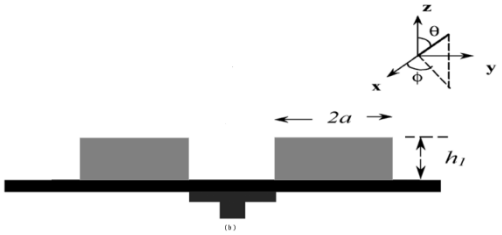

Fig.4 Cross-Sectional view of Four-element Cylindrical DRA by top loading a thin circular disc

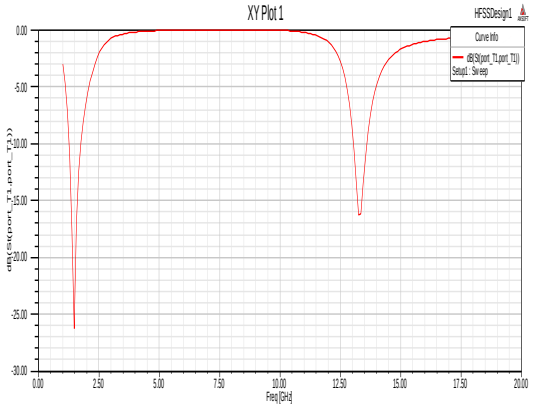

Fig.5 Return Loss for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.65 mm.

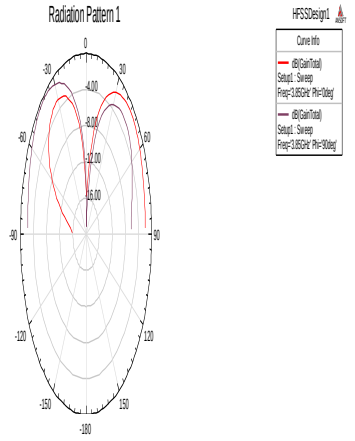

Fig.6 Radiation Pattern for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.65 mm.

By varying the height of circular disc to 1.05mm the CDRA gives an impedance bandwidth of 36.36%.The simulation results of return loss versus frequency and radiation pattern are shown in fig.7 and fig.8 respectively.

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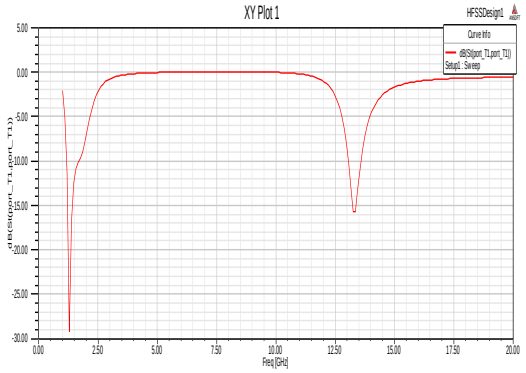

Fig.7 Return Loss for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.05 mm.

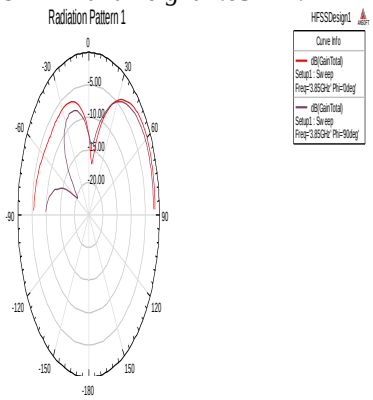

Fig.8 Radiation Pattern for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.05 mm

The four element CDRA by top loading a thin circular disc of height1.00mm resonates at a dual band of frequencies 1.5 4 GHZ, 13.2 GHZ with a return loss of -16.4 dB,-15.6 dB respectively, giving an impedance bandwidth of 44.44% . Fig.9 and Fig.10 shows the simulated return loss versus frequency and radiation pattern .

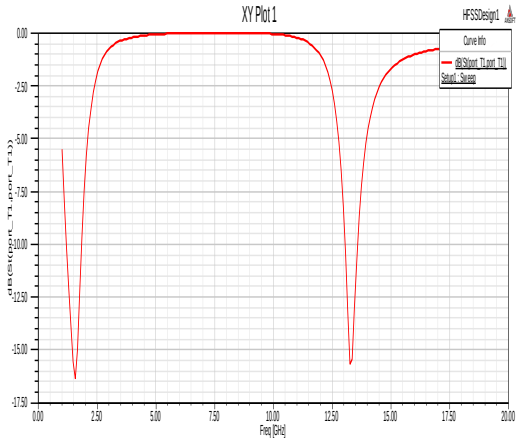

Fig.9 Return Loss for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.00 mm

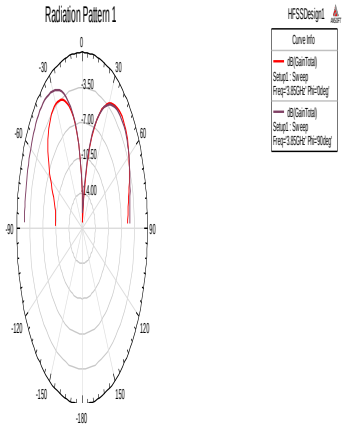

Fig.10 Radiation Pattern for a four element cylindrical dielectric resonator antenna by top loading with a thin circular disc of radius 7 mm and height 1.00 mm

A comprehensive view of some important design data obtained from simulation studies are provided in Table I.

TABLE I

ANTENNA PARAMETERS OPTIMIZED FROM SIMULATION STUDIES

a=4.14 mm, h=10 mm, relative permittivity =10

Design parameters			Bandwidth (%)
Circular disc	Radius (mm)	Height (mm)	
Without top loading	--	--	27.22
With top loading	7	1.65	33.13
	7	1.05	36.36
	7	1.00	44.44

IV.CONCLUSION

A new four element cylindrical dielectric resonator antenna fed by coaxial probe feed is designed. The proposed antenna resonates at a dual band of frequencies giving an impedance bandwidth of 44.44%. Hence the proposed system can be

used in many MIMO systems, where higher bandwidth and isolation is desired. Hence the proposed shape is much suitable for WIMAX applications.

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