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DESIGN OF CYLINDRICAL DIELECTRIC RESONATOR ANTENNA EXCITED USING L APERTURE FEED

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Abstract: This project proposes a design and development technique for bandwidth enhancement of cylindrical dielectric resonator (DRA) energized with an L Aperture feed is presented, which is suitable for wideband application. It is implemented by modifying the dimensions of Cylindrical Dielectric Resonator Antenna (CDRA). It reduces the effective permittivity because effective permittivity is inversely proportional to resonant frequency, so that it increases the resonant frequency of Dielectric Resonator Antenna (DRA). The substrate and Dielectric material used for investigation is Rogers RT 5880 and Alumina Ceramic of dielectric constant 9.9. Parametric analysis on the antenna is performed using Ansoft HFSS solver by varying different parameter and shape of Dielectric Resonator and length of feed line. The objective of this project is to optimize antenna parameters and thereby study the effects of antenna dimensions Length (L), Width (W) and substrate parameters, relative dielectric constant, substrate thickness on its performance. The novel exciting technique achieves a 2:1 VSWR bandwidth of 11.76% and peak and average gain of the proposed antenna is 8.92dBi. This project introduces to design antenna operating at 4.42GHz based on the Cylindrical Dielectric Resonator Antenna (CDRA) radius of 10 mm and height of 10mm. The variation of bandwidth for different feed parameters is also studied. High Frequency Structure Simulator (HFSS) software will be used to design a Cylindrical Dielectric Resonator Antenna.

Keywords: HFSS; Cylindrical dielectric resonator antenna; bandwidth enhancement; L- Aperture feed.

INTRODUCTION

Antennas are the main component in the Wireless Communication. Antennas can be regarded as the eyes and ears of wireless communication. Wireless communication is vast term that incorporates all kinds of procedures of connecting people and communicating between two or more devices using a wireless signal through wireless communication technologies. In the last decades antennas have become very famous in cellular communication. From Marconi, the concept of antenna was developed.

The crucial component of any device which is wireless is the antenna. In this view, two classes of antennas have been widely investigated and extensively reported in literature survey. The antennas are microstrip patch antenna and the dielectric resonator antenna (DRA). Both are highly suitable for the development of modem wireless communication systems. But, compared to microstrip patch antennas, dielectric resonator antennas are more suitable for mobile communications, because they offer the possibility to drastically decrease the antenna size.

Dielectric Resonators are made of low loss and low cost materials and it also has high dielectric constant which has been used efficiently as microwave components in the design of filters and oscillators because of their capability to store electromagnetic energy. Dielectric Resonator Antenna is available in different shapes and sizes. It comes in simple geometrics like circular, cylindrical, hemisphere, triangular, rectangular, spherical etc. In these shapes, cylindrical and rectangular shapes are the most popular ones. Dielectric Resonator Antenna has few characteristics. In our project, we have required an antenna with high gain and radiation efficiency. For this purpose, dielectric resonator antenna is the most suitable radiator.

I. PROBLEM STATEMENT

With the advancement and evolution in the current communication system, wired communication system has slowly been replaced due to the high demand in wireless and mobile technologies. Thus, antenna plays a vital role in this transition period. There are numerous wireless applications required by users worldwide. Besides that, devices nowadays are also more prefer to be mobile. Thus, the built in antenna must also be compact so as to be able to fit into the mobile device. Hence we are designing a Cylindrical Dielectric Resonator Antenna to obtain the good percentage bandwidth, reliability, low profile and low weight and excellent radiation characteristics and to obtain the increased bandwidth and to increase the gain of the Cylindrical dielectric resonator antenna with the relative position of the Dielectric resonator on L aperture feed is optimized.

II. OBJECTIVE

The objective of designing Cylindrical Dielectric Resonator Antenna using L Aperture feed is

(i) To design an antenna that has to accommodate all users' needs.

(ii) To design cylindrical Dielectric Resonator Antenna excited using L feed operating at 4GHz.

(iii) To increase the bandwidth of the antenna by considering certain essential parameters such as resonant frequency, Gain, and Return loss.

III. ANTENNA DESIGN

The overall goal of a design is to achieve specific performance characteristics at a stimulated operating frequency. The first step in designing the Dielectric resonator antenna is to select the operating frequency and an appropriate substrate. A direct microstrip line excitation of Dielectric Resonator Antenna is anattractive configuration, because of its simplicity and it allows the making use of all advantages offered by printed technology for implementing feed distribution network in array fabrication. The problem with feeding Dielectric Resonator Antennas directly by a microstrip line is that, to achieve strong coupling, a Dielectric Resonator Antenna of high permittivity is required. A novel technique of modifying the geometry of the microstrip feed line into L shape to increase the bandwidth of single Dielectric Resonator Antenna is employed here.

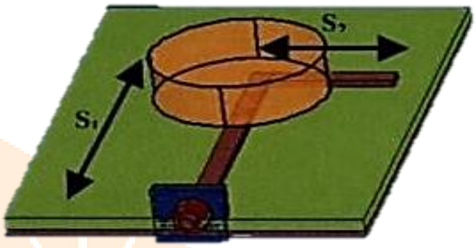

Figure 1 Cylindrical Dielectric Resonator Antenna using L Aperture Feed.

The antenna is comprised of low Alumina ceramic cylindrical dielectric resonator material of diameter D=20mm and height H = 10mm. The dielectric resonator material was prepared by conventional solid-state ceramic route. Microstrip line excited Dielectric Resonator Antenna is excited directly by a 50Ωmicrostrip line of width 4.65mm, and length S1= 40 mm, printed on a substrate (Rogers RT/duroid5880) of dielectric constant €r sub = 2.20, and thickness h =l.52 mm. The position of Dielectric Resonator on the etched feed line was optimized to get best resonance with excellent radiation performance, gain and bandwidth. All the antenna characteristics were studied after fixing the Dielectric Resonator in this position. Aperture feeding is placed in ZX direction where X=10mm, Y=2mm. To probe into the possibility of improving the impedance bandwidth, the conventional microstrip feedline for the excitation of Dielectric Resonators were modified in the form of L as depicted. In the case of L-aperture feed excitations, the arm length S1 is kept at 50 mm and branch length (S2) is varied from 0 to 40mm.

IV. ANTENNA ANALYSIS

Analysis of proposed radiator has been carried out on Ansoft HFSS simulation software. HFSS stands for high frequency structure simulator. HFSS is not freely available software. Because of ease of use. HFSS is mostly preferred while designing an antenna. Ansys HFSS is a commercial finite element method solver. There are some more software like CST,ADS, and FEKO, which can be used to design an antenna. It is a product of Ansys Company it isa FEM (finite element method) simulator. Ansys HFSS is 3D electromagnetic (EM) simulation software for designing and simulating high frequency electronics products such as antennas, antenna arrays, RF or microwave components, highspeed interconnects, filters, connectors, IC packages and printed circuit boards. Engineers worldwide use Ansys HFSS to design high- frequency, high-speed electronics found in communications systems, radar systems, advanced driver assistance systems (ADAS), satellites, internet-of-things (IoT) products and other high- speed RF and digital devices.

V. SIMULATION RESULTS AND COMPARISION

1. Microstrip Patch Antenna using Simple Feed

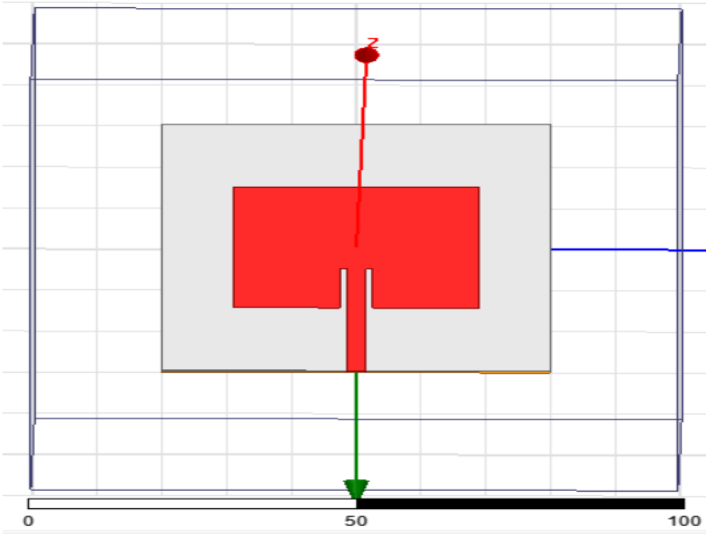

Figure 6.1 Top View of Simulated Microstrip patch antenna using simple feed

Table 6.1 shows different parameters Microstrip Patch Antenna

Parameters	Simple Feed
Resonating frequency	2.3 GHz
Return loss	-17.64 dB
VSWR	2.29
Percentage Bandwidth	6.32%
Gain	3.05 dBi

A microstrip patch antenna is designed to operate at 2.5GHz. Even though microstrip patch antenna offers excellent radiation characteristics their uses are limited due to narrow bandwidth. Various techniques to enhance bandwidth for microstrip patch antenna has been proposed. They are,

- Use of parasitic patches either stacked or coplanar geometry which can improve bandwidth
- Other bandwidth widening techniques was used which includes the use of thick substrate, multiple resonator and L probe.

However all these techniques increase the overall size and volume of the antenna which is the main disadvantage. L shaped microstrip feed has also been successfully applied too increase the bandwidth but it has not significantly altered the overall volume of radiating structure. Hence we moved on with designing a Dielectric Resonator Antenna.

2. Dielectric Resonator Antenna

Compared to microstrip patch antenna, Dielectric Resonator Antenna has much wider impedance. Moreover, the operating bandwidth of dielectric resonator antenna can be varied by suitably choosing dielectric constant of resonator materials and its dimensions. Dielectric Resonator Antenna is available in different shapes and sizes. It comes in simple geometrics like circular, cylindrical, hemisphere, triangular, rectangular, spherical etc. In these shapes, cylindrical and rectangular shapes are the most popular ones.

2.1 Rectangular Dielectric Resonator Antenna

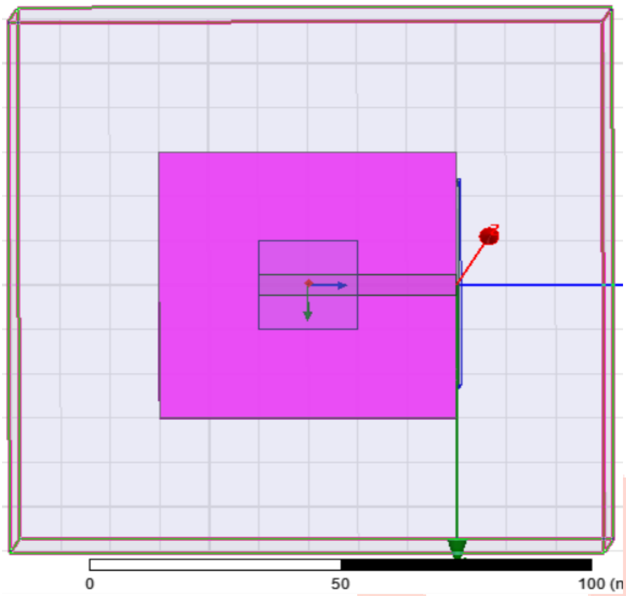

Figure 6.2 Top View of Simulated Rectangular Dielectric Resonator Antenna using Simple feed

Table 6.2 showing different parameters of Rectangular Dielectric Resonator using simple feed

Parameters	Simple Feed
Resonating frequency	4.10
Return loss	-0.2043
VSWR	3.23
Percentage Bandwidth	4.01%
Gain	6.40

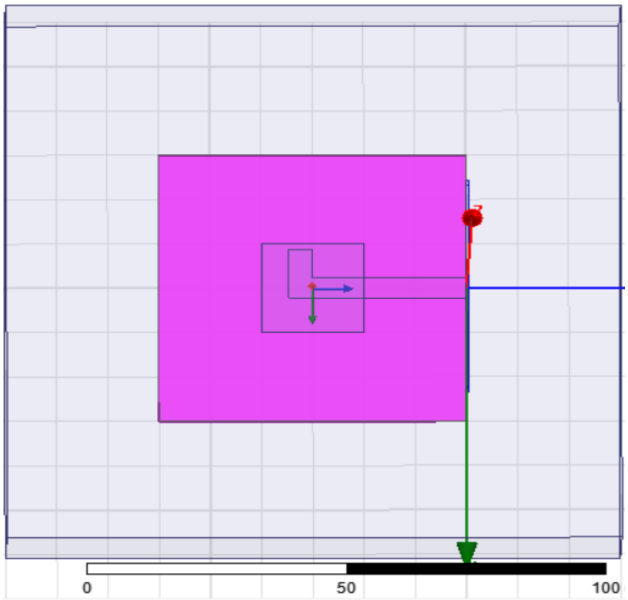

Figure 6.3 Top View of Simulated Rectangular Dielectric Resonator Antenna using L Aperture

Table 6.3 showing different parameters of Rectangular Dielectric Resonator Antenna using L Aperture Feed

Parameters	**L Aperture Feed**
Resonating frequency	4.08
Return loss	-4.7313
VSWR	3.76
Percentage Bandwidth	4.15%
Gain	8.65

Performance Analysis of Rectangular Dielectric Resonator Antenna

Table 6.4 Analogy of Rectangular Dielectric Resonator Antenna using different feedings

Typesof Feed	Freq (GHZ)	Return loss(dB)	Percentage Bandwidth (%)	Gain(dBi)	VSWR
Simple Feed	4.10	-0.2043	4.01%	6.40	3.23
L Aperture Feed	4.08	-4.7313	4.15%	8.65	3.76

2.2 Cylindrical Dielectric Resonator Antenna

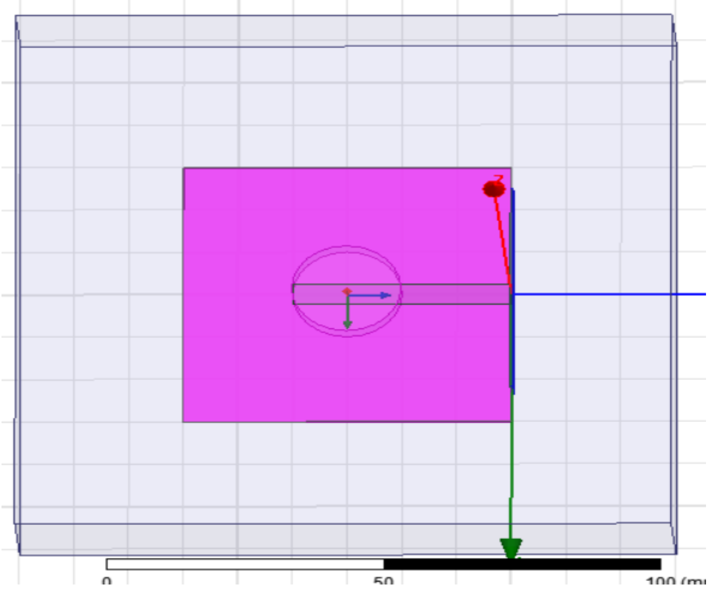

Figure 6.4 Top View of Simulated Cylindrical Dielectric Resonator Antenna using Simple Feed without aperture

Table 6.5 showing different parameters of Cylindrical Dielectric Resonator Antenna using Simple Feed

Parameters	Simple Feed
Resonating frequency	4.18 GHz
Return loss	-3.61 dB
VSWR	1.08
Percentage Bandwidth	6.69%
Gain	7.02 dBi

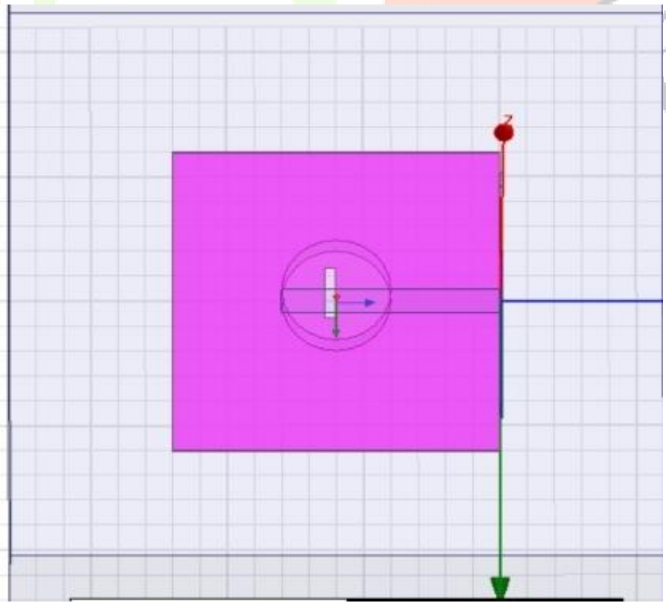

Figure 6.5 Top View of Simulated Cylindrical Dielectric Resonator antenna with Simple Aperture feed.

Table 6.6 showing different parameters of Cylindrical Dielectric Resonator Antenna with Simple Aperture feed

Parameters	**Simple Aperture Feed**
Resonating frequency	4.22 GHz
Return loss	-4.37dB
VSWR	1.7
Percentage Bandwidth	10.42%
Gain	7.16 dBi

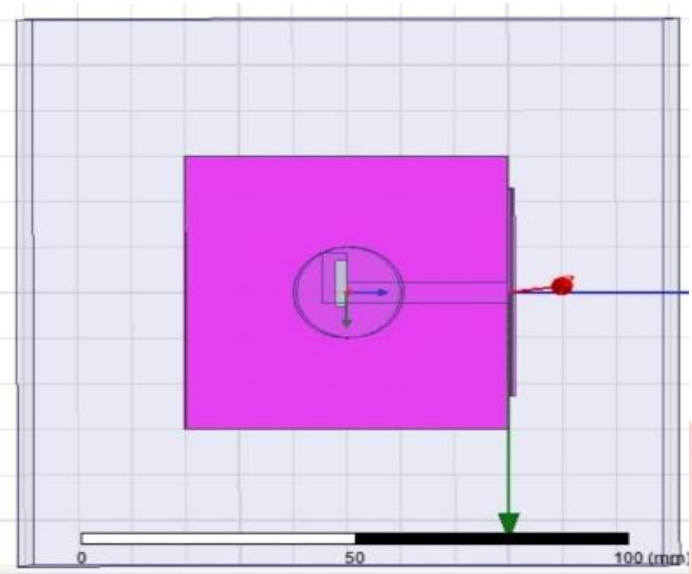

Figure 6.6 Top View of Simulated Proposed L Aperture Feed Cylindrical Dielectric Resonator Antenna

Table 6.7 showing different parameters of L Aperture feed Cylindrical Dielectric Resonator Antenna

Parameters	**L Aperture Feed**
Resonating frequency	4.42G Hz
Return loss	-4.6314 dB
VSWR	3.83
Percentage Bandwidth	11.76%
Gain	8.92 dBi

Table 6.8 Analogy of Cylindrical Dielectric Resonator Antenna using simple Aperture feed and L Aperture feed

Types of Feed	Freq Ghz	Return loss (dB)	Bandwidth (%)	Gain(dBi)	VSWR
Simple feed without aperture	4.18	-3.61	6.69	7.02	1.08
Simple Feed with aperture	4.22	-4.37	10.42	7.16	1.70
L Aperture Feed	4.42	-4.6314	11.76	8.92	3.83

RESULTS OF DIFFEREENT PARAMETERS

- Return Loss
- Voltage Wave Standing Ratio (VSWR)
- Gain in dBi
- Radiation Pattern

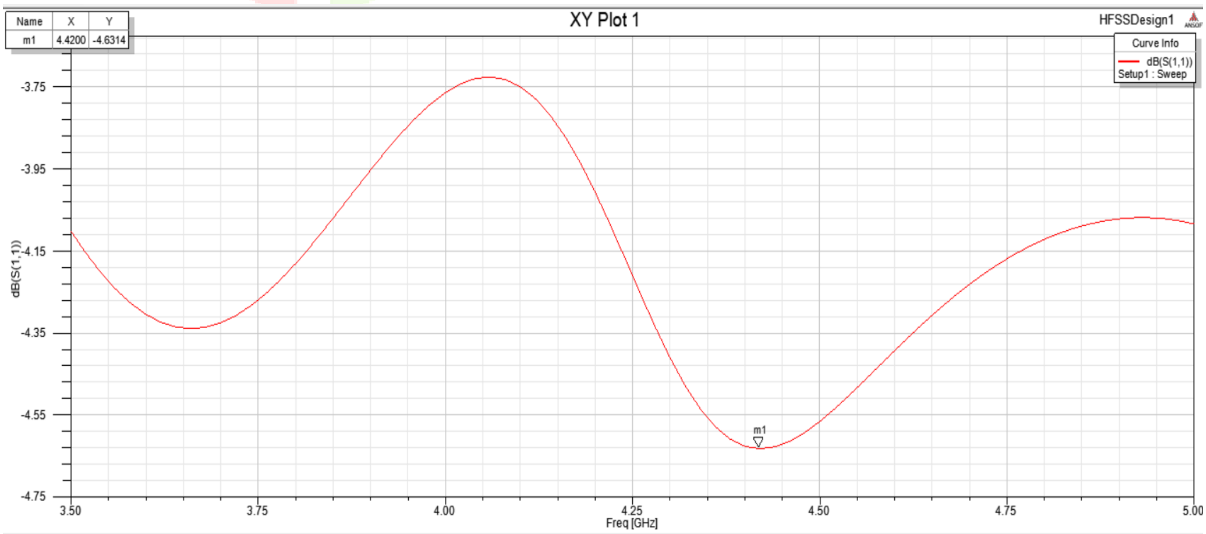

Figure 6.7 Return loss plot for Cylindrical Dielectric Resonator Antenna using L Aperture feed

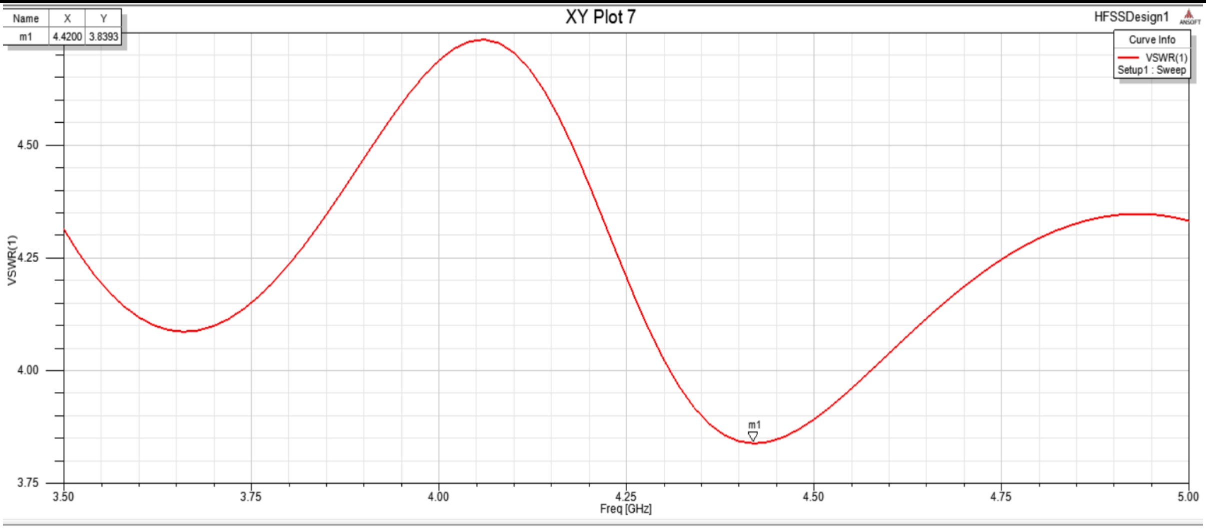

Figure 6.8 VSWR plot for Cylindrical Dielectric Resonator Antenna using L Aperture feed

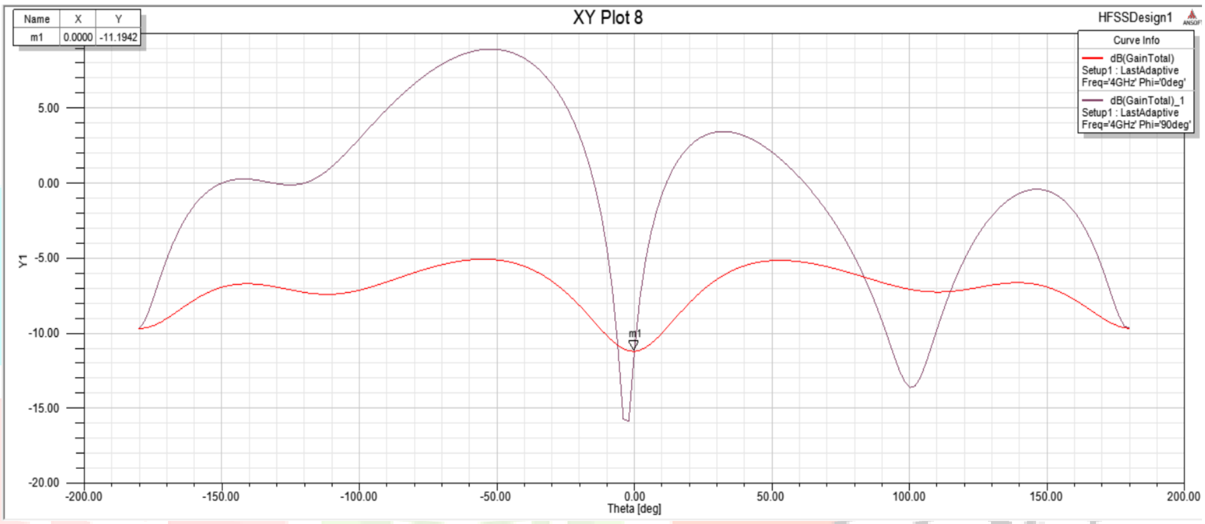

Figure 6.9 Gain plot for Cylindrical Dielectric Resonator Antenna using L Aperture feed

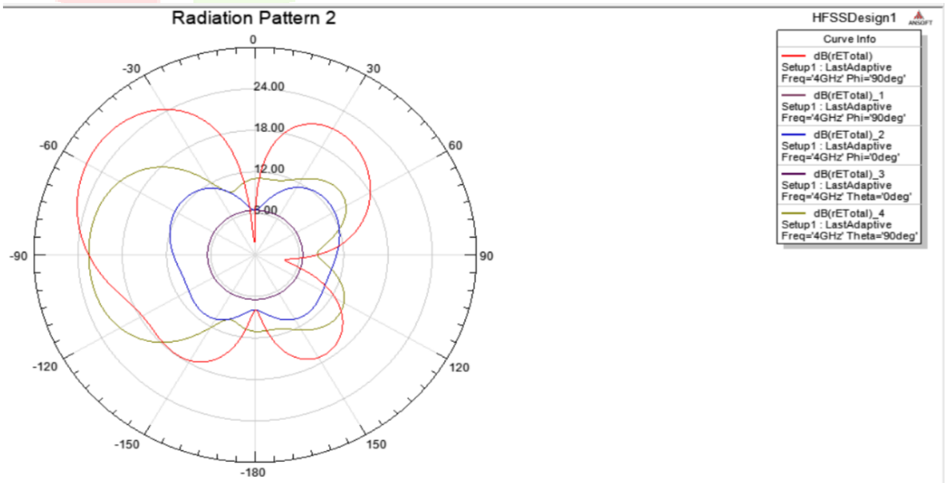

Figure 6.10 Radiation Pattern for Cylindrical Dielectric Resonator Antenna using L Aperture feed

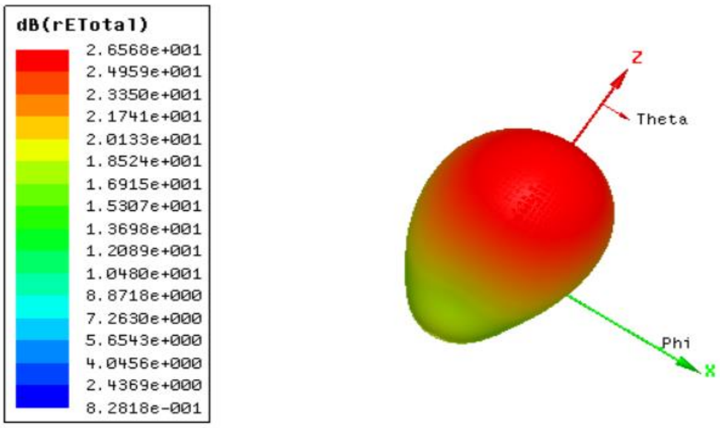

Figure 6.11 3D Radiation Pattern for Cylindrical Dielectric Resonator Antenna using L Aperture feed

VI. CONCLUSION

In this paper, we have demonstrated that the percentage bandwidth of different Feedingtechniques of two types of Antennas. They are Microstrip Patch Antenna and Cylindrical Dielectric Resonator Antenna and Rectangular Dielectric Resonator Antenna. The different Feeding techniques such as Simple Feed and L Feed are studied with respect to aperture. As shown in table 6.1, Microstrip patch antenna has not increased the expected parameters due to its narrow bandwidth. So antenna works was carried out using Rectangular Cylindrical Dielectric Resonator Antenna to increase bandwidth and gain. Table 6.4 shows the Analogy of Rectangular Dielectric Resonator Antenna using two types of feeding, simple feed and L feed. Compared to Microstrip Patch Antenna, Rectangular Dielectric Antenna increased few parameters according to the design but more works is carried out using Cylindrical Dielectric Resonator Antenna as it has low dielectric loss and wide bandwidth. The simple Aperture feed Cylindrical Dielectric Resonator Antenna operates at (4.22GHz) and obtained(10.42%) of bandwidth. The L Aperture Feed operates at (4.42GHz) and obtained (11.76%) bandwidth. On comparing with simple Aperture Feed and L Aperture Feed, the proposed L Aperture Feed Cylindrical Dielectric Resonator Antenna has achieved wide band operation with large useful bandwidth of 11.76% at 4.42GHz.

The proposed Antenna is made from two different materials to achieve the benefit of compact size and wider bandwidth operation. Due to the absence of conductor losses, the proposed antenna has high radiation efficiency. Considering these benefits, the antenna is proposed for WLAN applications, Mobile and Satellite communication, Wi-Fi, cellular phones and GPS system.

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