Design and Analysis of Dielectric Resonator Antennas for WLAN Applications

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Technology

In

Electronic systems and Communication Engineering

By

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CERTIFICATE

This is to certify that the thesis entitled**, "Design and Analysis of Dielectric Resonator Antennas for WLAN Applications"** submitted by Sri. **Chinmaya Sahoo** in partial fulfillment of the requirements for the award of Master of Technology Degree in electrical Engineering with specialization in **"Electronic systems and communication"** during session 2012-13 at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any degree or diploma.

Date:21st May 2013

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CHINMAYA SAHOO

TABLE OF CONTENTS

Chapter 6 Conclusion and Future scope

Abstract

The increasing use of wirless mobile communication systems demand the antennas for different systems and standards with properties like reduced size, broadband, multiband operation, moderate gain etc. The planar and dielectric resonator antennas are the present day antenna designer's choice. However, microstrip and Dielectric resonator antennas inherently have a narrow bandwidth. In this thesis, a low-cost compact microstrip line-fed antenna with dielectric patches resulting Wideband characteristics with a band dispensation is presented. The antenna was implemented on FR4 substrate with a thickness of 1.6 mm and relative permittivity (μ_r) of 4.4. It has a partial ground plane. This antenna is exited by a microstrip-line feed. The reflection coefficient (S_{11}) is less than -10 dB in 3.7 GHz−11.1 GHz frequency range with possible wideband (UWB) application. The proposed antenna is also simulated with band notch in 3.0 GHz-8.0 GHz frequency range by introducing an **T** shape DRA. The return loss results and radiation pattern plots of the antenna are included in this thesis. The performance characteristics of the proposed antenna are simulated using CST microwave studio 2011™ software and also designed antenna is fabricated and measured. And also, dielectric resonators in antenna applications are introduced and analyzed a rectangular stepped dielectric resonator antenna in this thesis. Here a low-cost compact microstrip line-fed equilateral triangular antenna is placed vertically with substrate for Wide-band characteristics is presented. The antenna was implemented on FR4 substrate with a thickness of 1.6 mm and relative permittivity (μ_r) of 4.4. It has a partial ground plane. The dielectric constant of the dielectric resonator is 10.2. This antenna is exited by a microstrip-line feed. The reflection coefficient (S_{11}) is less than -10 dB in 4.85 GHz−15 GHz frequency range with possible wideband (WB) application. The proposed antenna is simulated with and without dielectric resonator to demonstrate the effect of dielectric resonator. The return loss results and radiation pattern plots of the antenna are included in this thesis.

LIST OF TABLES

Table No. Page No.

ABBREVIATIONS USED

UWB	Ultra-wide band
WLAN	Wireless Local Area Network
VSWR	Voltage standing wave ratio
DRO	Dielectric resonator oscillator
DRA	Dielectric resonator antenna

CHAPTER: 1

INTRODUCTION

1.1 Introduction

Wireless communications have grown at a very rapid pace across the world over the last few years, which provide a great flexibility in the communication infrastructure of environments such as hospitals, factories, and large office buildings [1], [2]. WiMAX and WLAN are the standard-based technologies enabling the delivery of last mile wireless broadband access [3]. WiMAX refers to interoperable implementations of the IEEE 802.16 wireless-networks standard which can operate at higher bit rates 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 [4]. While WLAN standards in the 2.4-GHz range have recently emerged in the market, the data rates supported by such systems are limited to a few megabits per second. By contrast, a number of standards have been defined in the 5-6 GHz range that allow data rates greater than 20 Mb/s, offering attractive solutions for real-time imaging, multimedia, and high-speed video applications. To achieve the necessary applications a high performance wide band antenna with excellent radiation characteristics are required [1]. 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 [2], [5]-[7]. DRA can be in a few geometries including cylindrical, rectangular, spherical, half-split cylindrical, disk, hemispherical and triangular shaped [8].

In the last 2 decades, two classes of novel antennas have been investigated and extensively reported on. They are the microstrip patch antenna and the dielectric resonator antenna. Both are highly suitable for the development of modern wireless communications.

The main purpose of design any antenna is to obtain a wide range of bandwidth. Several bandwidth enhancement techniques have been reported on modified feed geometries and changing the shape of the DRA. By using different bandwidth enhancement techniques in this thesis different shape of dielectric resonator antennas are designed and simulated. There are few software available which allow the optimization of the antenna. Here, Simulation process was done by using Computer Simulation Technology (CST) 2011™. In this thesis, have been design different shapes of single and multiple dielectric resonator antennas for wireless applications. Bandwidth enhancement techniques are used to obtain a large bandwidth for particular resonant frequencies.

1.2 Thesis Motivation.

The main motivation of this thesis is now a days, mobile communication systems are becoming increasingly popular. Antennas for software-defined and / or reconfigurable radio systems need to have ultra-wide band or multi-band characteristics in order to be flexible enough to cover any possible future mobile communication frequency bands. One approach to provide such flexibility is to construct multi-band antenna that operates over specific narrowband frequencies. However, it would be extremely difficult to accurately achieve the frequency requirements of all future communication system. Alternatively, a small wideband antenna that covers a wide range of frequencies can be a good candidate not only for current multi-band applications but also for future communication systems operating on new frequency bands. Recently, it has been demonstrated that a wideband monopole antenna is promising to be used for mobile wireless devices such as notebook computers, mobile phones, and PDA (personal digital assistance) phones. With bandwidths as low as a few percent, wide band applications using conventional Microstrip patch designs and dielectric resonator antenna (DRA) designs are limited. Other drawbacks of patch antennas include low efficiency, limited power capacity, spurious feed radiation, poor polarization purity, narrow bandwidth, and manufacturing tolerance problems.

To overcome these problems for over two decades, research scientists have developed several methods to increase the bandwidth and low frequency ratio of a patch antenna and dielectric resonator antenna (DRA). The motivation to extend dielectric resonator antenna for wireless applications due to the dimension of a DRA is of the order of $\lambda 0/ \sqrt{\varepsilon r}$ where $\lambda 0$ is the free space wavelength and εr is the dielectric constant of the resonator material. Thus by choosing a high value of εr (10-100), the size of the DRA can be significantly reduced. There is no inherent conductor loss in dielectric resonators. This leads to high radiation efficiency of the antenna. This feature is especially attractive for millimeter (mm)-wave antennas, where the loss in metal fabricated antennas can be high. Many of these techniques involve adjusting the placement and/or type of element used to feed (or excite) the antenna. Wide band frequency operation of antennas has become a necessity for many applications. Microstrip antennas and DRAs are ultimately expected to replace conventional antennas for most applications.

In recent few decades, research scientists have developed several techniques to increase the bandwidth and obtain dual band response for an antenna. Many of these techniques involve adjusting the dimensions of ground or substrate material, using dielectric constant of material, more number of DRAs, or different type of feed (or excite) to the antenna. The recent boom in wireless communication industry, especially in the area of cellular telephony and wireless data communication, has lead to the increased demand for multi band antennas.

Requirements for the digital home include high-speed data transfer for multimedia

- content, short-range connectivity for transfer to other devices

- Satellite communication system
- Radar and Imaging
- Medical Applications
- Location and Tracking

1.3 Literature Review and Methodology

In 1939, richtinger theoretically demonstrated the microwave resonators in the form of un metalized dielectric spheres and triodes [1]. The more investigation done by okaya and barash who analyzed their modes in 1960s. Although open DRs were found to radiate many years ago, the idea of using the DR as an antenna had not been widely accepted until the original paper on the cylindrical dielectric resonator antenna (DRA) was published in 1983. After the cylindrical DRA had been studied , Long and his colleagues subsequently investigated the rectangular and hemispherical DRAs . In the mid-1990s more study concentrate on linear and planar DRA array from simple two-element arrays to complex phased arrays. The work created the foundation for future investigations of the DRA and its applications have received enormous attention in recent years . It was observed that the frequency range of interest for many systems had gradually progressed upward to the millimeter and near-millimeter range (100-300 GHz). At these frequencies, the conductor loss of metallic antennas becomes severe and the efficiency of the antennas is reduced significantly. Conversely, the only loss for a DRA is that due to the imperfect dielectric material, which can be very small in practice . Dielectric Resonator Antennas (DRA‘s) have become popular in recent years because of many advantages they offer like the small size, ease of fabrication; high radiation efficiency, increased bandwidth and low production cost, which manifests DRA in different types of Wireless applications. The main purpose of this thesis is to introduce the general techniques of bandwidth enhancement for designing different shapes of DRAs.

Second most important work in this thesis is design different shapes of DRAs for single and dual band frequency applications. All simulation results are obtained by using one simple method Computer Simulation Technology (CST). It is one of the most developed high performance software for the simulation of electromagnetic fields in all frequency bands. This technique is based on the implementation of unique, leading edge technology in a user friendly interface. It can be useful in industries as well as telecommunications, defense, automotive, electronics and medical equipment. CST microwave studio 2011 is a specialist tool for the 3D EM simulation of high frequency components. In technology leading R&D departments CST microwave studio2011 is the first choice due to its unparalleled performance. This technology enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and EMC effects. Especially user friendly, CST quickly gives an insight into the EM performance of high frequency designs. CST also provides great flexibility in tackling a wide application range through the variety of available solver technologies. CST MWS 2011 offers further solver modules for specific applications. In addition, CST MWS 2011 is embedded in several industry standard workflows through the CST design environment.

1.4 Thesis Outline:

The outline of this thesis is as follows.

In Chapter 1 the thesis overview is shown. The literature review for the project work is done in this chapter and the introduction to WLAN and WIMAX and its different standards are shown in this chapter.

Chapter 2: It presents the basic theory of DRAs, including the characteristics of the DRA and the advantages, Comparison to microstrip antennas, different feeding methods (coaxial feed, slot aperture, microstrip line feed, co-planar feed, dielectric image guide), the methods of analysis used for the DRA design such as Green‘s function, numerical methods as frequency domain and time domain analysis, finally The basic DRA shapes with different parameters as presented in this chapter.

Chapter 3: In this chapter the basics of antenna parameters such as gain, directivity, return loss, polarization, radiation intensity and antenna efficiency, input impedance, bandwidth, quality factor are presented.

Chapter 4: This chapter describes the different methods of Bandwidth enhancement of single and multiple DRAs, Methods are microstrip fed DRAs, dual-mode rectangular DRAs, air gaps, annular DRAs, stacked method, co-planar parasitic method, embedded method, by using impedance matching as flat matching strip, loaded notched, multi segment DRAs.

Chapter 5: This chapter describes the designs of DRA, Results & discussions.

1: Rectangular stepped Dielectric resonator antennas,

2: “**T**” shaped dielectric resonator antenna for dual band applications,

3:“**π**” shaped dielectric resonator antenna with

(a) Rogger Dielectric Material (b)Teflon Dielectric Material as DR element. & comparative studies.

4:-Simulation results obtained using the Computer simulation technology (CST), fabrication done by Agilent E5071C ENA series network analyzer, simulated and measured results compared, the simulation results (gain, directivity, etc.) has been obtained.

Chapter6: This chapter contains conclusion and suggestions for future work.

CHAPTER-2

DIELECTRIC RESONATOR ANTENNA.

2.1 Introduction

Wireless communications have grown at a very rapid pace across the world over the last few years, which provide a great flexibility in the communication infrastructure of environments [8]. Microstrip antennas and dielectric resonator antennas, both are the most popular and adaptable. As compared to microstrip antenna, the dielectric resonator antenna has much wider impedance bandwidth and higher efficiency. Dielectric Resonator Antennas (DRA) are used widely in today's electronic warfare, missile, radar and communication systems. They find use both in military and commercial applications. The Dielectric resonator antenna is constructed from dielectric resonator, subtract and ground with different excited feeding techniques [17].

Dielectric resonator (DR) first appeared in 1939, when Richtinger of Stanford University theoretically demonstrated that unmetallized dielectric objects in the form of triodes could function as microwave resonators [9]. However, his theoretical investigations failed to generate significant interest and practically nothing happened in this area for over 25 years. In the early 1960s, researchers from Columbia University, Okaya and Barash, reported the first ever DR in the form of a single crystal TiO2 [10]. Dielectric resonators were first popular as filter elements devices in microwave circuits with the first reported use as a radiating element not until the early 1980's when the smaller size potential and higher frequency applications boosted the research into the dielectric resonator antenna [1-2].

2.2 Basic Characteristics

Dielectric resonator antennas (DRA) possess some peculiar properties which render them very promising, especially for millimeter wave applications. Their high-radiation efficiency, bandwidth and polarization flexibility make them by far superior to conventional microstrip patch antennas (MPA). DRA are intrinsically immune to those surface wave power leakage and conductor loss problems, which plagues the MPA and reduces their efficiency.

DRA consists of high dielectric constant materials, high quality factors and mounted on a grounded dielectric substrate of lower permittivity. DRA is fabricated from low-loss and high relative dielectric constant material of various shapes whose resonant frequencies are functions of the size, shape and permittivity of the material. DRA can be in a few geometries including cylindrical, rectangular, spherical, half-split cylindrical, disk, and hemispherical shaped [1]. The DRAs have properties such as low phase noise, compact size, frequency stability with temperature, ease of integration with other hybrid MIC circuitries, simple construction and the ability to withstand harsh environments. The DRA has some interesting characteristics, like the small size, ease of fabrication; high radiation efficiency, increased bandwidth and low production cost. DRAs are very promising for applications in wireless communications [2], [7].

DRAs offer several attractive features including:-

- A wide range of dielectric constants can be used ($\varepsilon r = 10 - 100$), that allowing the designer to have control over the physical size of the DRA and its bandwidth.
- The Size of DRA is proportional to $\boldsymbol{\lambda_0/\sqrt{\varepsilon_r}}$, where $\boldsymbol{\lambda_0}$ is the free space wavelength at the resonant frequency, and ε_r is the dielectric constant of the material.
- The Size of DRA is proportional to $\lambda_0/\sqrt{\varepsilon_r}$, where λ_0 is the free space wavelength at the resonant frequency, and ε_r is the dielectric constant of the material.
- DRAs can be designed to operate over a wide range of frequencies from 1.3 GHz to 40 GHz [1].
- A high radiation efficiency (95%) due to the absence of conductor or surface wave losses.
- Several feeding mechanisms can be used (including slots, probes, microstrip lines, dielectric image guide, and coplanar waveguide lines) to efficiently excite DRAs.
- DRA can be excited by several modes, many of which radiate pattern similar to short electric or magnetic dipoles, producing either broadside or omni- directional radiation patterns for different coverage requirements [2].
- By selecting a dielectric material with low-loss characteristics, high-radiation efficiency can be maintained, even at millimeter-wave frequencies, due to an absence of surface waves and minimal conductor losses associated with the DRA [1], [2].

- ❖ A Wide control over size and bandwidth

- ❖ A tight tolerance: ± 1- 5%,

- ❖ A high quality factor Q: up to 10000 (f = 10GHz)

- ❖ A Wide range of temperature coefficient of resonance frequency: (-12…+30) ppm/ oC

- ❖ A Tolerance ± 0.5; ±1.0; ±2.0 ppm/ Oc

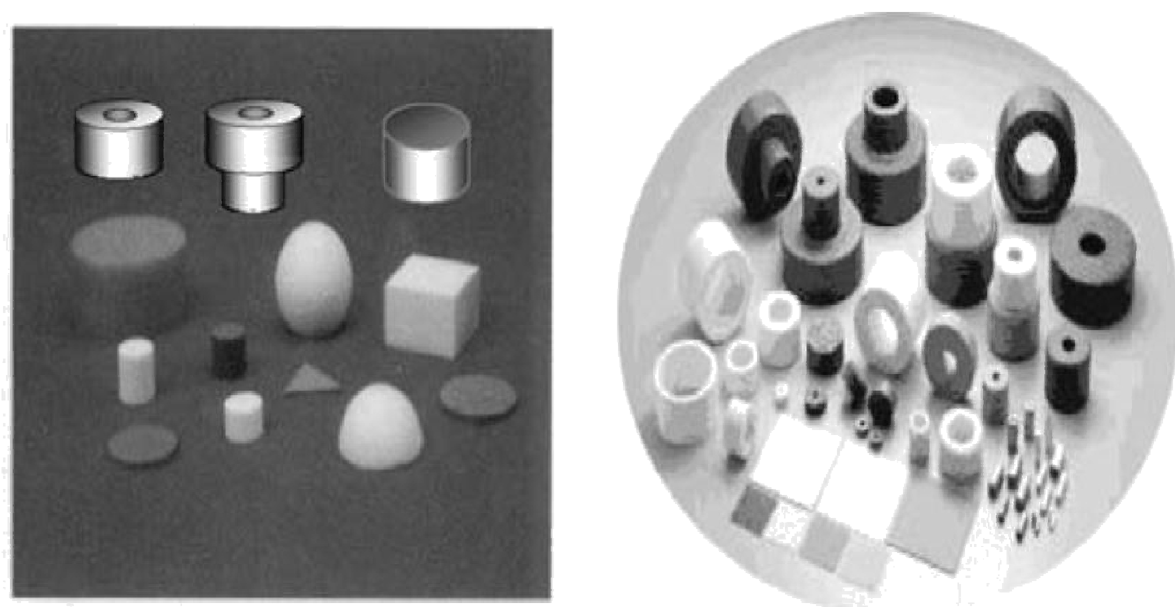


Figure 2.1 DRAs of various shapes (cylindrical, rectangular, hemispherical, low-profile circular-disk, low-profile triangular)

2.3 Advantages:

In the past few years, extensive studies on the DRA have been focused on resonators of various shapes, the feeding techniques, and bandwidth enhancement methods. Specific features of DRAs has made them suitable for a variety of applications specially millimetre wave (MMW) applications. DRAs can be easily coupled to almost all types of transmission lines. They can be integrated easily with MMIC circuits. In MMW applications conductor loss of metallic antennas become severe and the antenna efficiency decreases significantly, conversely the only loss for a DRA is that due to the imperfect material of the DRA which can be very small in practice. Therefore DRAs have high radiation efficiency. In comparison to microstrip antennas, DRAs have wider impedance bandwidths. For a typical DRA with dielectric constant of 10 the impedance bandwidth of 10% can be achieved. Avoidance of surface waves is another attractive advantage of DRAs over microstrip antennas. Single DRAs of different shapes has been possible, including rectangular, cylindrical, hemispherical, triangular, conical, etc. Among these different shapes cylindrical and rectangular are the most common and the rectangular has the advantage of having one more degree of freedom for design purposes. There are a variety of feed configurations, which electromagnetic fields can be coupled to DRAs [5]. Most common feed arrangements are microstrip aperture coupling, direct microstrip coupling, probe coupling and conformal strip coupling. Among these feed configurations, aperture coupling is more suitable for MMW applications. In aperture coupling configuration, since the DRA is placed on the ground plane of the microstrip feed, parasitic radiation from the microstrip line is avoided. Isolation of the feed network from the radiating element is another advantage of the aperture coupling method [1], [2], [7]. Dielectric resonator antennas (DRAs) have been extensively used for numerous applications since they have many attractive characteristics such as low profile, light weight, low cost, and inherently wide bandwidth. They could be used for numerous applications as both individual elements and in an array environment. In addition, wide bandwidth, low cost, low dissipation loss at high frequency, and high radiation efficiency are the inherent advantages of DRAs over conventional patch antennas. Compared with Microstrip antennas, which suffer from higher conduction loss and surface waves in antenna array applications, DRAs have high radiation efficiency and high power handling capability due to lack of metallic loss. Unlike the microstrip antenna, DRA does not support surface waves if placed on a ground plane directly [18]. [7]. In recent years, DRAs have been considered as potential antennas for mobile phone applications. A general problem in the miniaturization of RF resonators used in filters and small antennas is decrease of efficiency, due to conductor losses. In DRAs, lower conductor losses, compared to those in typical metal antennas such as microstrip patches can be expected because DRAs have fewer metal parts. Thus, DRAs are good potential alternatives, especially when very small antenna elements are needed. In addition, they can be easily incorporated into microwave integrated circuits because they can be fabricated directly on the printed circuit board (PCB) of the phone. Specific features of DRAs have made them suitable for a variety of applications specially MMW applications. DRAs have small size and low cost. They can be easily coupled to almost all types of transmission lines [19], [20]. Dielectric resonator antennas have several advantages compared to conventional microwave antennas, and therefore many applications cover the broad frequency range. Some of the principal advantages of dielectric resonator antennas compared to conventional microstrip antennas are [6]:

- ❖ DRA has a much wide impendence bandwidth than microstrip antenna because it radiates through the whole antenna surface except ground port while microstrip antenna radiate only through two narrow radiation slots.

- ❖ Higher efficiency.

- ❖ Avoidance of surface waves is another attractive advantage of DRAs over microstrip antennas

However, dielectric resonator antennas have some advantages:

- Light weight, low volume, and low profile configuration, which can be made conformal;

- DRA has high degree of flexibility and versatility, allowing for designs to suit a wide range of physical or electrical requirements of varied communication applications.

- Easy of fabrication

- High radiation efficiency

- High dielectric strength and higher power handling capacity

- In DRA, various shapes of resonators can be used (rectangular, cylindrical, hemispherical, etc.) that allow flexibility in design.

- Low production cost

- Several feeding mechanisms can be used (probes, slots, microstrip lines, dielectric image guides, and coplanar waveguide lines) to efficiently excite DRAs, making them amenable to integration with various existing technologies [1], [2], [5] - [7].

2.4 Feeding Method :

There are several techniques available to feed or transmit electromagnetic energy to a dielectric resonator antenna. The five most popular feeding methods are the coaxial probe, slot aperture, microstrip line, co-planar coupling and dielectric image guide [1], [21].

2.4.1 Coaxial Feed:

The Coaxial feed or probe feed is a very common technique used for feeding dielectric resonator antennas as shown in figure 2.2. In this method, the probe can either be placed adjacent to the DRA or can be embedded within it . The amount of coupling can be enhanced by adjusting the probe height and the DRA location. In DRA, various modes can be excited depending on the location of the probe. For the probe located adjacent to the DRA, the magnetic fields of the $TE_{11\delta}$ mode of the rectangular DRA are excited and radiate like a horizontal magnetic dipole. For a probe located in the center of a cylindrical DRA, the TE_{011} mode is excited and radiating like a vertical dipole. Another benefit of using probe coupling is that one can couple directly into a 50Ω system, without the requirement for a matching network. Probes are suitable at lower frequencies where aperture coupling may not be applied due to the large size of the slot required [2], [22].

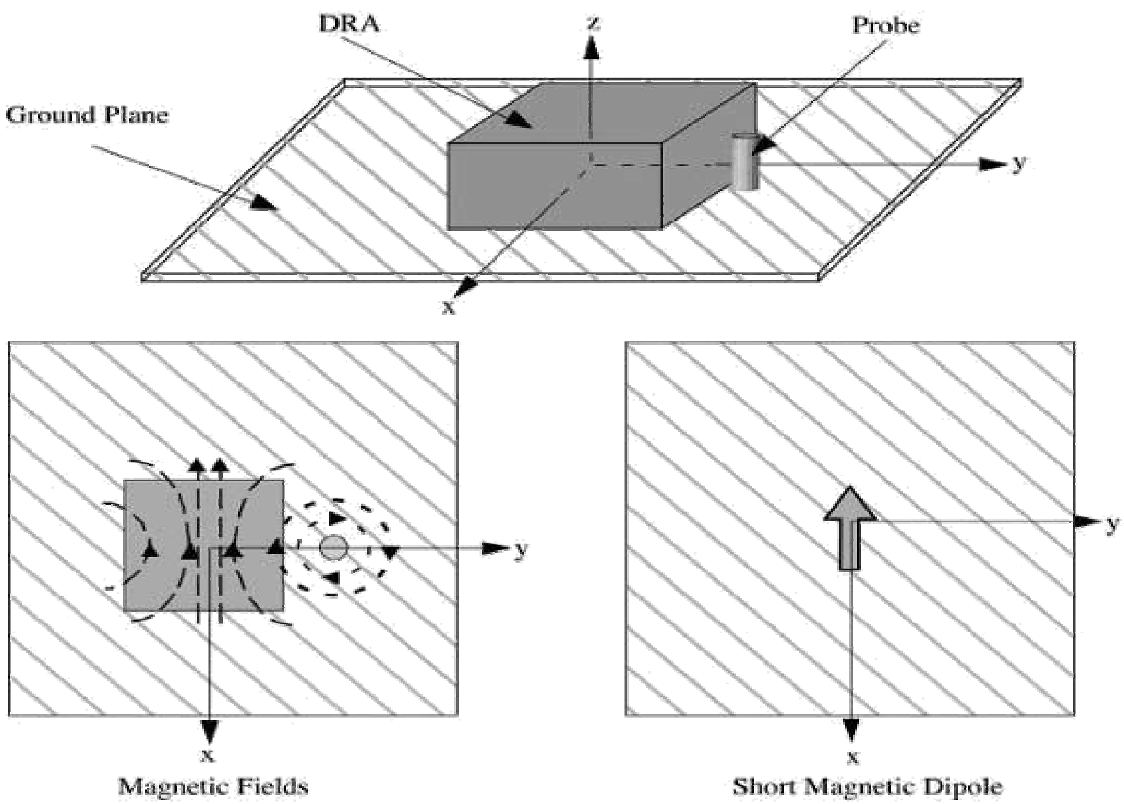


Figure 2.2 Probe-fed Dielectric resonator antenna

2.4.2 Slot Aperture:

In slot aperture method, a DRA is exciting through an aperture in the ground plane upon which it is placed. Aperture coupling is applicable to DRAs of any shapes such as rectangular, cylindrical or hemispherical. The aperture works like a magnetic current running parallel to the size of the slot, which excites the magnetic fields in the DRA. The aperture consists of a slot cut in a ground plane and fed by a microstrip line below the ground plane. For avoiding spurious radiation, feed network is located below the ground plane. Moreover, slot coupling is an attractive technique for integrating DRAs with printed feed structures. The coupling level can be changed by moving the DRA with respect to the slot. Generally, a high dielectric material is used for the substrate and a thick, low dielectric constant material is used for the top dielectric resonator patch to optimize radiation from the antenna [1]. The main drawback of this feed technique is that it is problematic to fabricate due to multiple layers, which also increases the antenna thickness. This feeding method also provides narrow bandwidth (up to 21%) [2].

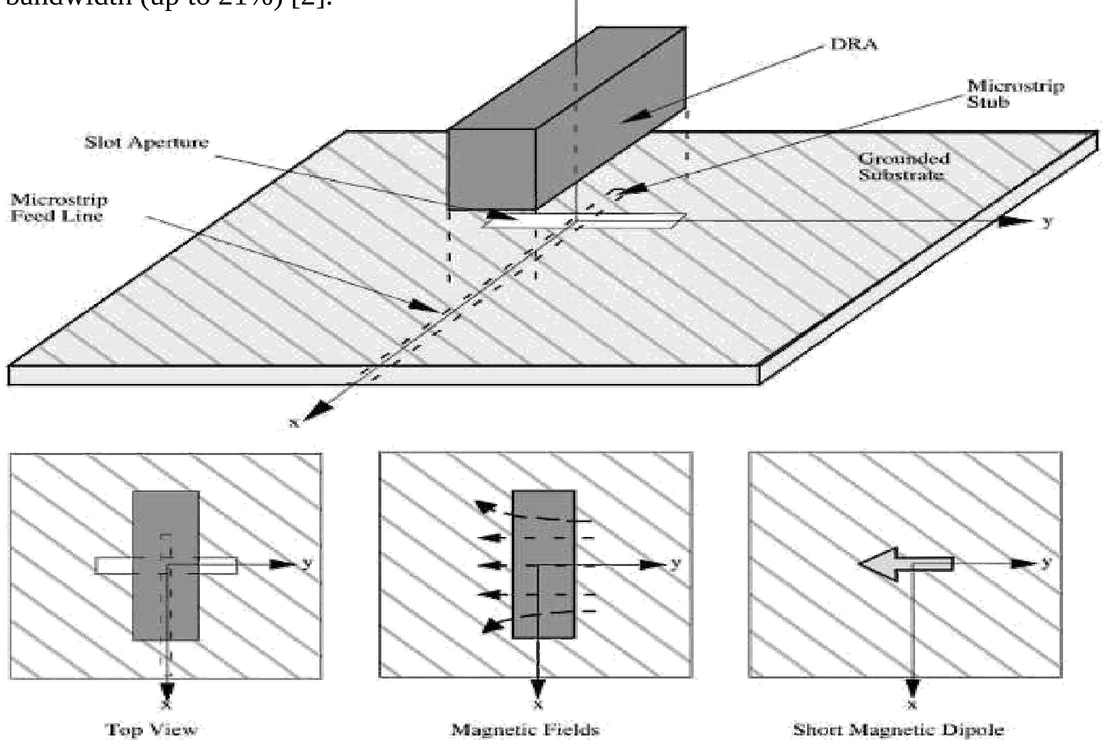


Figure 2.3 Aperture-fed Dielectric resonator antenna

2.4.3 Microstrip Line Feed:

In this type of feed technique, a conducting strip is connected directly to the edge of the patch as shown in figure 2.4. A common method for coupling to dielectric resonators in microwave circuits is by proximity coupling to microstrip lines. Microstrip coupling will excite the magnetic fields in the DRA to create the short horizontal magnetic dipole mode. The level of coupling can be changed by the lateral location of the DRA with respect to the microstrip line and on the relative permittivity of the DRA [2].

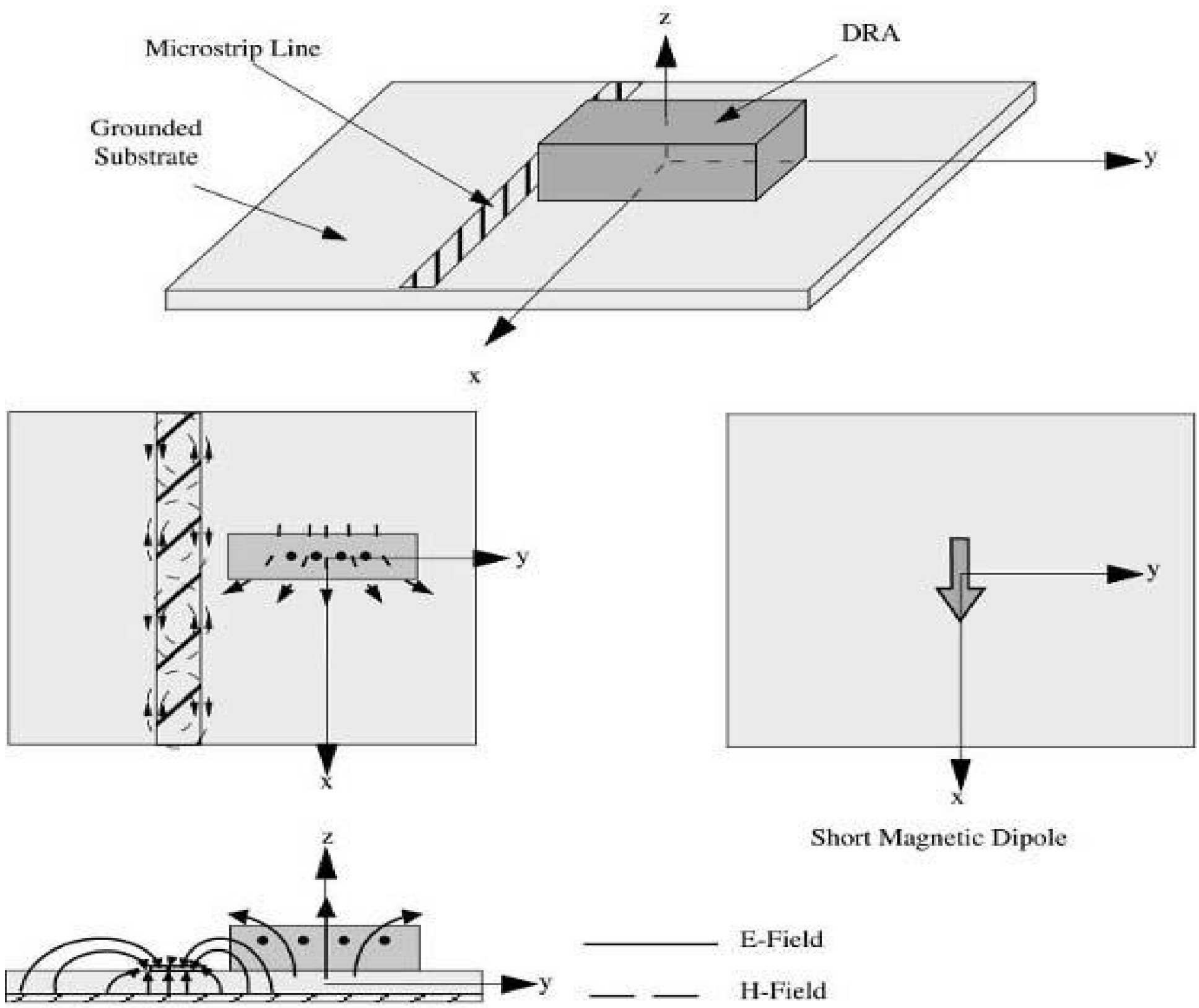


Figure 2.4 Microstrip-fed DRA

In DRAs, the amount of coupling is generally quite small for requiring wide bandwidth. Microstrip lines can be used as a series feed for a linear array of DRAs. This is an easy feeding technique, since it offers ease of fabrication and simplicity in modeling along with impedance matching. However as the thickness of the dielectric substrate being used, rises, surface waves and spurious feed radiation also rises, which hampers the bandwidth of the antenna [1]. One drawback of this method is that the polarization of the array is analysed by the orientation of the microstrip line such as the direction of the magnetic fields in the DRA will be parallel to the microstrip line [1], [2].

2.4.4 Co-Planar Feed:

The Co- planar feed is a very common technique used for coupling in dielectric resonator antennas. Here, figure 2.5 shows a cylindrical DRA coupled to a co-planar loop. The coupling level can be adjusted by locating the DRA over the loop [2].

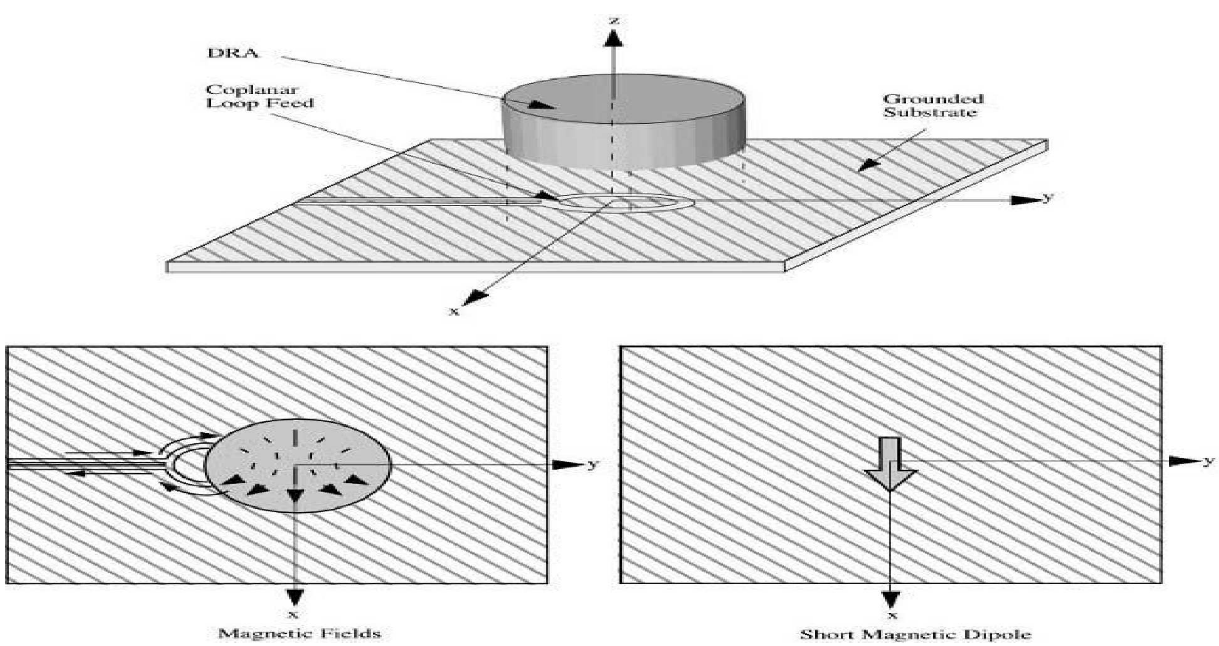


Figure 2.5 Co-planar loop-fed DRA

The coupling behavior of the co-planar loop is similar to coaxial probe, but the loop offers the advantage of being non-obtrusive. By moving the loop from the edge of the DRA to the center, one can couple into either the $HE_{11\delta}$ mode or the TE_{011} mode of the cylindrical DRA [1], [2].

2.4.5 Dielectric Image Guide:

Dielectric image guide is another attractive coupling technique in DRAs, as shown in figure 2.6. Dielectric image guides offer advantages over microstrip at millimeter -wave frequencies since they do not suffer as severely from conductor losses. As with microstrip lines, the amount of coupling to the DRA is generally quite small, especially for DRAs with lower permittivity values, although it may be possible to increase the coupling by operating the guide closer to the cut-off frequency. The dielectric image guide is thus best utilised as a series feed to a linear array of DRAs [2].

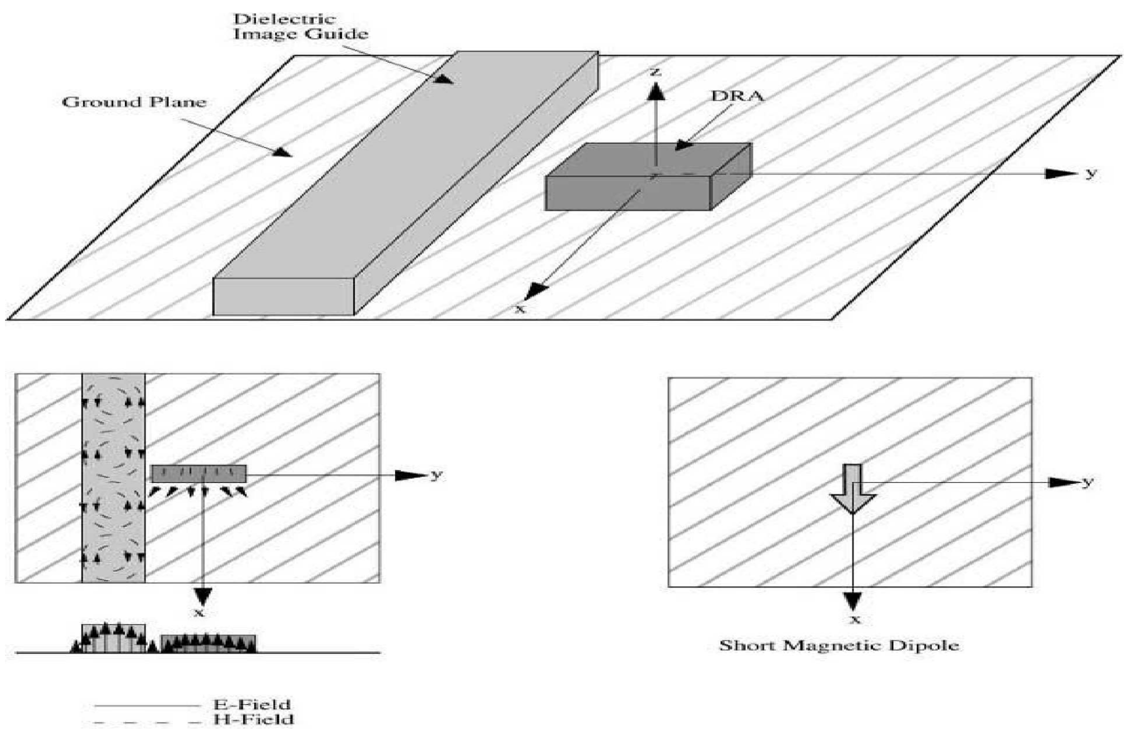


Figure 2.6 Dielectric image guide-fed DRA

2.5 Analytical Evaluation of Dielectric Resonator Antenna:

In designing, input impedance is the important parameter which is a feed to excite the DRA. Input impedance as a function of frequency is to determine the bandwidth of operation and for matching the antenna to the circuit. Unfortunately, there are no simple closed-form expressions for predicting the input impedance of the DRA when excited by a particular feed and rigorous analytical. Here, some of the techniques that have been used to predict the input impedance for DRAs excited by the various feed [1].

2.5.1 Green's function analysis:

For a probe-fed DRA, the input impedance (Z_{in}) can be determined using the following equation:

$$Z_{in} = \frac{-1}{I_0^2} \int (E.J_s)\ dS \tag{2.1}$$

E= Electric fields of the DRA

J_S = Applied source current density on the probe

I_O = Magnitude of the current on the probe

The electric fields of the DRA depend on the source excitation and determined by using:

$$E = \int (G.J_s) dS \tag{2.2}$$

Here, G represents Green's function for the DRA. By using some simple assumptions about a single-mode operation and the currents on the probe, the Green's function for a hemispherical DRA was first derived and was then used to predict the input impedance of the probe-fed DRA operating in the TE_{111} mode. This technique was also applied to a probe–fed hemispherical DRA operating in the TM101 mode. The input impedance of conformal strip feeds and aperture feeds can also be analyzed using Green's function. The advantage to this technique is the relatively fast computation time required to obtain the input impedance. It is useful method for analyzing the effects of altering probe dimensions and probe location and can be used for optimizing the input impedance. The main drawback is its limitation only to hemispherical DRA geometries. For other DRA shapes, different analytical techniques are required [1].

2.5.2 Numerical methods for analyzing DRAs:

Numerical methods for analyzing DRAs can be categorized into two groups, frequency domain technique and time domain technique. Each category offers advantages for particular antenna geometries [2].

2.5.2.1 Frequency domain analysis:

Two common frequency domain techniques that have been used to analyze DRAs are the method of moments (MOM) and the finite element method (FEM). The MOM was first developed for wire or metal antennas of arbitrary shape, but can be extended to include dielectric materials by introducing equivalent currents. The MOM involves discretizing the antenna into a number of small segments and solving for a set of unknown coefficient representing the current on one segment due to a known incident field. Analysis of DRAs is not limited to a hemispherical shape, and the technique can be used to also analyses simple cylindrical and rectangular DRA shapes. Determining the DRA input impedance using the MOM technique will require more computer memory and time than applying Green's function. Thus, MOM technique is not convenient tool for optimizing the DRA performance. MOM is used to investigate the effect of the air gaps and calculate internal field pattern of various modes of cylindrical DRAs [1], [2].

The FEM (Finite element method) can be used to analyses DRAs of arbitrary shape. Similar to the MOM, it involves a discretization of the geometry but whereas in the MOM only the DRA and the ground plane require segmentation , in the FEM the entire volume surrounding the DRA must also be discretized, thereby increasing the computational size of the problem. The advantage of the FEM is that it does not require the formulation of equivalent currents and can thus be readily applied to arbitrary shapes. Another advantage of the FEM is its availability as commercial software where graphical user interfaces are provided to simplify the geometrical definition of the problem. FEM is used to determine the effects of a finite ground plane on the radiation pattern of a DRA [1], [2], [7].

2.5.2.2 Time domain analysis:

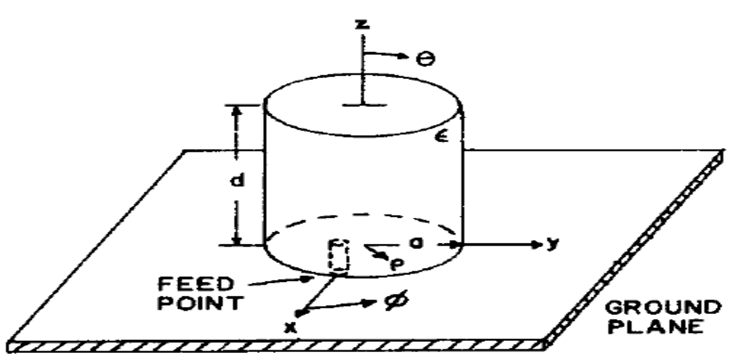
There are two time domain techniques that have been applied to analyzing DRAs are the finite difference time domain (FDTD) method and the transmission line method (TLM). These techniques require the entire volume around the DRA to be discretized and thus can be memory and time intensive. In it, wideband pulse used to excite the DRA, and by transforming the solution into the frequency domain, the input impedance can be determined over a wide frequency range. For frequency domain techniques, the problem would have to be re-simulated at every frequency of interest and obtaining the impedance response over a broad frequency range could be very time consuming. With the frequency domain methods, the time domain methods are good tools for analyzing the performance of a given DRA geometry, but are less useful for optimizing the performance of DRAs. FDTD is used to calculate circular polarization patterns of cross-shaped DRAs and input impedance of slot-fed rectangular DRA. Transmission line method used to calculate input impedance of microstrip-fed multi-segment DRAs [1], [2].

2.6 Basic-shaped Dielectric resonator antenna:

Three basic shapes of the DRA as Cylindrical, rectangular and hemispherical are the most commonly used. Here, we studied about different shapes of DRAs and their various field mode configurations. These analyses can be used to predict the resonant frequency, radiation Q-factor, and radiation pattern of DRA [1].

2.6.1 Cylindrical DRA:

Cylindrical DRA has advantages over hemispherical and rectangular shape DRA. It offers greater design flexibility, where the ration of radius/height controls the resonant frequency and the quality (Q) factor. By varying the DRA's dimensions different Q-factor can be obtained. In cylindrical DRA fabrication is much easier than hemispherical DRA and various modes can be easily excited which results in either broadside or omnidirectional radiation patters. It offers one degree of freedom more than the hemispherical shape, it has aspect ratio a/h which determines the Q factor for a given dielectric constant .



[1].

2.7 The geometry of cylindrical DRA

Different subclasses of DRAs can be derived from cylindrical shape such as split-cylindrical DRA, cylindrical-ring DRA, electric monopole DRA, disk-loaded cylindrical DRA, sectored cylindrical and ring DRAs, elliptical DRA, conical DRAs. Ring DRA which is a subclass of the cylindrical DRA that offers increased impedance bandwidth performance. Cylindrical dielectric resonators are used in circuit applications, filters, oscillators and especially in microstrip technology, where resonant waveguide cavities are not very practical. The geometry of the cylindrical DRA is shown in figure 2.7. It consists of a material with a height h, radius a, and dielectric constant (ε_r). This shape offers one degree of freedom more than hemispherical shape because it has aspect ratio a/h, which determines k_0a and the Q-factor for a given dielectric constant [1], [2].

2.6.1.1 Resonant frequencies:

In the analysis, the dielectric resonator antenna surfaces is perfect magnetic conductors, where wave functions which are transverse electric (TE) to z and transverse magnetic (TM) to z can be write as [2],

$$\psi_{TE_{npm}} = J_n\left(\frac{X_{np}}{a}\rho\right)\begin{pmatrix}\sin n\phi \\ \cos n\phi\end{pmatrix} sin\left[\frac{(2m+1)\pi z}{2d}\right] \tag{2.3}$$

$$\psi_{TM_{npm}} = J_n\left(\frac{X_{np}}{a}\rho\right)\begin{pmatrix}\sin n\phi \\ \cos n\phi\end{pmatrix} cos\left[\frac{(2m+1)\pi z}{2d}\right] \tag{2.4}$$

Where J_n = Bessel function of the first kind

Analysed resonant frequency of the npm mode is:

$$f_{npm} = \frac{1}{2\pi a\sqrt{\mu\varepsilon}}\sqrt{\begin{pmatrix}X_{np}^2 \\ X_{np}'^2\end{pmatrix} + \left[\frac{\pi a}{2d}(2m+1)\right]^2} \tag{2.5}$$

For TM mode, calculated resonant frequency is given by:

$$f_{TM_{110}} = \frac{1}{2\pi a\sqrt{\mu\varepsilon}}\sqrt{X_{11}'^2 + \left(\frac{\pi a}{2d}\right)^2} \tag{2.6}$$

where $X'_{11} = 1.841$

2.6.1.2 Equivalent magnetic surface currents:

In cylindrical DRA, the wave function of the fundamental TM_{110} mode is:

$$\psi_{TM_{110}} = \psi = J_1\left(\frac{X'_{11}\rho}{a}\right)\cos\phi\cos\frac{z\pi}{2d} \tag{2.7}$$

Cos ¢ is selected because feed position is at ¢ = 0 and Sin ¢ can be used if the probe is located at ¢ = π/2. By using wave function, various E-field can be anlaysed [2]:

$$E_\phi = \frac{1}{j\omega\varepsilon\rho}\frac{\partial^2\psi}{\partial\phi\partial z}, \quad E_z = \frac{1}{j\omega\varepsilon}\left(\frac{\partial^2}{\partial z^2} + k^2\right)\psi, \;\; E_\rho = \frac{1}{j\omega\varepsilon}\frac{\partial^2\psi}{\partial\rho\partial z} \tag{2.8}$$

Here primed and unprimed coordinates are used to indicate the source and field. From M = E × n, where n is a unit normal pointing out of the DRA surface.

The following equivalent currents are obtained [2]:

1) For the side wall

$$M_{z'} = \frac{\pi}{2j\omega a d}J_1(X'_{11})\sin\phi'\sin\frac{\pi z'}{2d} \tag{2.9}$$

$$M_{\phi'} = \frac{1}{j\omega\varepsilon}\left(\frac{X'_{11}}{a}\right)^2 J_1(X'_{11})\cos\phi'\cos\frac{\pi z'}{2d} \tag{2.10}$$

2) For the top and bottom

$$M_{\phi'} = \frac{\pi X'_{11}}{2j\omega\varepsilon a d}J'_1\left(\frac{X'_{11}\rho'}{a}\right)\cos\phi' \tag{2.11}$$

$$M_{\rho'} = \frac{\pi}{2j\omega\varepsilon d\rho'}J_1\left(\frac{X'_{11}\rho'}{a}\right)\sin\phi' \tag{2.12}$$

2.6.1.3 Q-factor of the lower-order modes:

$$k_0 a = \frac{\sqrt{3.83^2 + \left(\frac{\pi a}{2h}\right)^2}}{\sqrt{\varepsilon_r + 2}} \qquad (2.15)$$

For $TE_{01\delta}$ mode:

$$k_0 a = \frac{2.327}{\sqrt{\epsilon_r}} \left\{1 + .2123\frac{a}{h} - 0.00898\left(\frac{a}{h}\right)\right\} \qquad (2.13)$$

$k_0 a$

The value of can be calculated by using above equation.

For $TE_{01\delta}$ mode:

$$Q = 0.078192\ \epsilon^{1.27} \left\{1 + 17.31\left(\frac{h}{a}\right) - 21.57\left(\frac{h}{a}\right)^2 + 10.86\left(\frac{h}{a}\right)^3 - 1.98\left(\frac{h}{a}\right)^4\right\} \qquad (2.14)$$

Above equation shows the Q-factor for $TE_{01\delta}$ mode [1].

For $TM_{01\delta}$ mode:

For $TM_{01\delta}$ mode:

$$Q = 0.008721\ \varepsilon_r^{0.888413}\ e^{0.0397475\,\varepsilon_r} \left\{1 - \left(0.3 - 0.2\frac{a}{h}\right)\left(\frac{38 - \varepsilon_r}{28}\right)\right\} \times \left\{0.498186\ \frac{a}{h} + 2058.33\left(\frac{a}{h}\right)^{4.322261} e^{-3.50099\left(\frac{a}{h}\right)}\right\} \qquad (2.16)$$

Q-factor of the $TM_{01\delta}$ mode of the cylindrical DRA.

For $HE_{11\delta}$ mode:

$$k_0\, a = \frac{6.324}{\sqrt{\varepsilon_r + 2}} \left\{0.27 + 0.36\ \frac{a}{2h} + 0.02\left(\frac{a}{2h}\right)^2\right\} \qquad (2.17)$$

For $HE_{11\delta}$ mode:

$$Q = 0.01007\varepsilon_r^{1.3}\frac{a}{h}\left\{1 + 100e^{-2.05\left(\frac{a}{2h}-\frac{1}{80}\left(\frac{a}{h}\right)^2\right)}\right\} \tag{2.18}$$

Above equation shows the Q-factor of the $HE_{11\delta}$ mode of the cylindrical DRA [1].

2.6.2 Hemispherical DRA:

Hemispherical shape DRA offers an advantage over the rectangular and cylindrical shapes as the interface between the dielectric and air is simpler. By that, a closed form expression cab obtained for the Green‘s function.

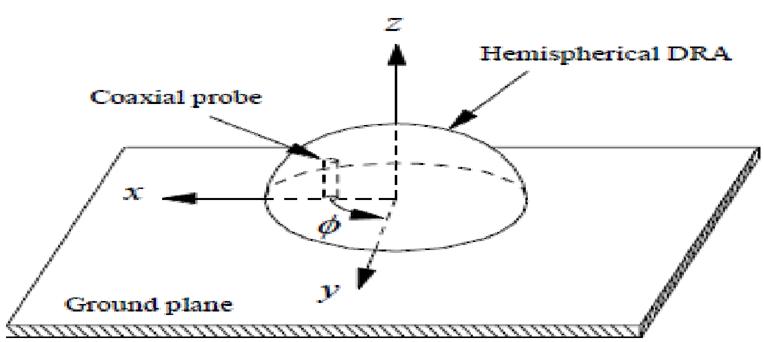


Figure 2.8 Configuration of a probe-fed hemispherical DRA

The hemispherical DRA is characterized by a radius a, a dielectric constant εr as shown in figure 2.8. Here, we assumed that the hemispherical DRA which is mounted on ground plane has infinite conductivity and infinite extent. Image theory is useful to equate the hemispherical DRA of radius ‗a‘ to an isolated dielectric sphere having the same radius. Transverse electric (TE) and transverse magnetic (TM) are different modes in dielectric sphere. Transverse electric(TE) modes having a zero value for the radial component of the electric field (E_r=0), while transverse magnetic(TM) modes have a zero radial component of the magnetic field (H_r=0). The two fundamental modes for hemispherical DRA are TE_{111}, whose radiation pattern is similar to a short horizontal magnetic dipole and TM_{101}, whose radiation pattern is similar to a short electric monopole .

2.6.2.1 TE_{111} mode approximation:

TE_{111} mode is the lowest order mode of the hemispherical DRA. This mode creates a far-field radiation pattern similar to a short horizontal magnetic dipole. It is having a wide beam with a broadside peak. The resonant frequency and radiation quality (Q) factor for the TE111 mode can be determined by solving the characteristic equation [1]:

$$\frac{J_{1/2(\sqrt{\varepsilon_r}\,k_0 a)}}{J_{3/2}(\sqrt{\varepsilon_r}k_0 a)} = \frac{H^{(2)}_{1/2}(k_0\,a)}{\sqrt{\varepsilon_r}\,H^{(2)}_{1/2}(k_0\,a)} \qquad (2.19)$$

Where J(x) = first order Bessel function

$H^{(2)}\,(x)$ = Second order Henkel function

k_0 = free space wave number

After obtaining k_0 value, the resonant frequency can be determined:

$$f_{GH_z} = \frac{4.7713\,Re\,(k_0 a)}{a_{cm}} \qquad (2.20)$$

The radiation Q-factor can be analysed is:

$$Q = \frac{Re(k_0 a)}{2Im(k_0 a)} \qquad (2.21)$$

By using above quality factor equation can estimate the fractional impedance bandwidth of an antenna.

$$BW = \frac{\Delta f}{f_0} = \frac{s-1}{\sqrt{s}Q} \qquad (2.22)$$

Here, Δf = absolute bandwidth

f_0 = resonant frequency

s = maximum acceptable voltage standing wave ratio (VSWR) [1].

2.6.2.2 TM$_{101}$ mode approximation:

TM$_{101}$ modes have different characteristics than TE$_{111}$ modes. Here, TM$_{101}$ mode radiates like a short electric monopole antenna and excited by using a probe that is located at the center of the DRA. As same in TE$_{111}$ mode, here also by solving transcendental equation we can analyze resonant frequency and radiation Q-factor [1].

$$\frac{1}{\sqrt{\varepsilon_r k_0 a}} - \frac{J_{1/2}(\sqrt{\varepsilon_r}\, k_0 a)}{J_{3/2}(\sqrt{\varepsilon_r}\, k_0 a)} = \frac{\sqrt{\varepsilon_r}}{k_0 a} - \sqrt{\varepsilon_r}\,\frac{H^{(2)}_{1/2}(k_0 a)}{H^{(2)}_{3/2}(k_0 a)} \qquad (2.23)$$

Complex wave number k_0 can be used to determine the resonant frequency and Q-factor.

TM$_{101}$ modes have a lower Q-factor for $\varepsilon_r < 45$ and TE$_{111}$ modes have lower Q-factor for $\varepsilon_r > 45$. Here, Q-factor for the value of $\varepsilon_r \leq 20$ and $\varepsilon_r \geq 20$ [1]

$$Q = 0.723 + 0.9324\varepsilon_r - 0.0956\,\varepsilon_r^2 + 0.00403\varepsilon_r^3 + 5.10^{-5}\,\varepsilon_r^4 \qquad (2.24)$$

And,

$$Q = 2.621 - 0.574\varepsilon_r + 0.02812\varepsilon_r^2 + 2.59 \times 10^{-4}\varepsilon_r^3 \qquad (2.25)$$

2.6.3 Rectangular DRA:

The rectangular shape DRA has more advantages over cylindrical and hemispherical shape DRA. It offers a second degree of freedom which is one more than cylindrical shape and two more than hemispherical shape. It provides designer to have a greater design flexibility to achieve the desired profile and bandwidth characteristics for a given resonant frequency and dielectric constant. In an isolated rectangular dielectric guide, the various modes can be divided into TE and TM, but with the DRA mounted on the ground plane only TE mode can typically excited. The rectangular DRA can maintenance TE modes (TE^x, TE^y and TE^z) which would radiate like short magnetic dipole. The resonant frequency of each of these modes will be a function of the DRA dimensions. By properly choosing the DRA dimensions, the designer can avoid the unwanted modes to appear over the frequency band during operation. Resonant frequency of TE modes can be calculated by solving the transcendental equation [1]

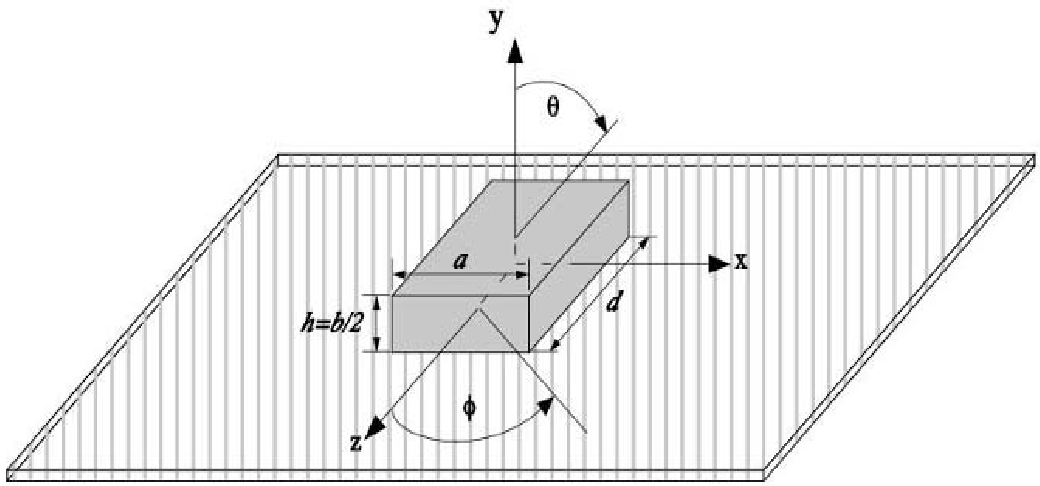
$$k_x \tan(k_x d/2) = \sqrt{(\varepsilon_r - 1)k_0^2 - k_x^2} \qquad (2.26)$$

Here, free space wave number $(k_0) = \frac{2\pi f_0}{c}$ $k_y = \frac{\pi}{w}$ $k_z = \frac{\pi}{b}$

$$k_x^2 + k_y^2 + k_z^2 = \varepsilon_r k_0^2 \qquad (2.27)$$

2.6.3.1 Dielectric waveguide model:

Dielectric waveguide model can be used for an isolated DRA in free space. Here we studied about field configuration, resonant frequency and Q-factor.



DRA on ground plane

Figure 2.9 Geometry of the dielectric resonator model

2.6.3.2 Field configuration:

$TE^{z}_{11\delta}$ Mode is using for a rectangular DRA with dimensions a, b>d. With dielectric

waveguide model, following fields can be calculated [2].

$$H_x = \frac{(k_x k_z)}{j\omega\mu_0} \sin(k_x x)\cos(k_y y)\sin(k_x z) \quad (2.28)$$

$$H_y = \frac{(k_y k_z)}{j\omega\mu_0} \cos(k_x x)\sin(k_y y)\sin(k_z z) \quad (2.29)$$

$$H_z = \frac{(k_x^2 + k_y^2)}{j\omega\mu_0} \cos(k_x x)\cos(k_y y)\cos(k_z z) \quad (2.30)$$

Electric field for x, y and z dimensions can be calculated by:

$$E_x = k_y \cos(k_x x)\sin(k_y y)\cos(k_z z) \quad (2.31)$$

$$E_y = -k_x \sin(k_x x)\cos(k_y y)\cos(k_z z) \quad (2.32)$$

$$E_z = 0 \quad (2.33)$$

$$k_x^2 + k_y^2 + k_z^2 = \varepsilon_r k_0^2 \quad (2.34)$$

2.6.3.3 Resonant frequency:

By using transcendental equation, the value of k_z is calculated. The normalised resonant frequency can be obtained by solving for k_0 in equation (2.34). The normalised frequency is:

$$F = \frac{2\pi a f_0 \sqrt{\varepsilon_r}}{c} \qquad (2.35)$$

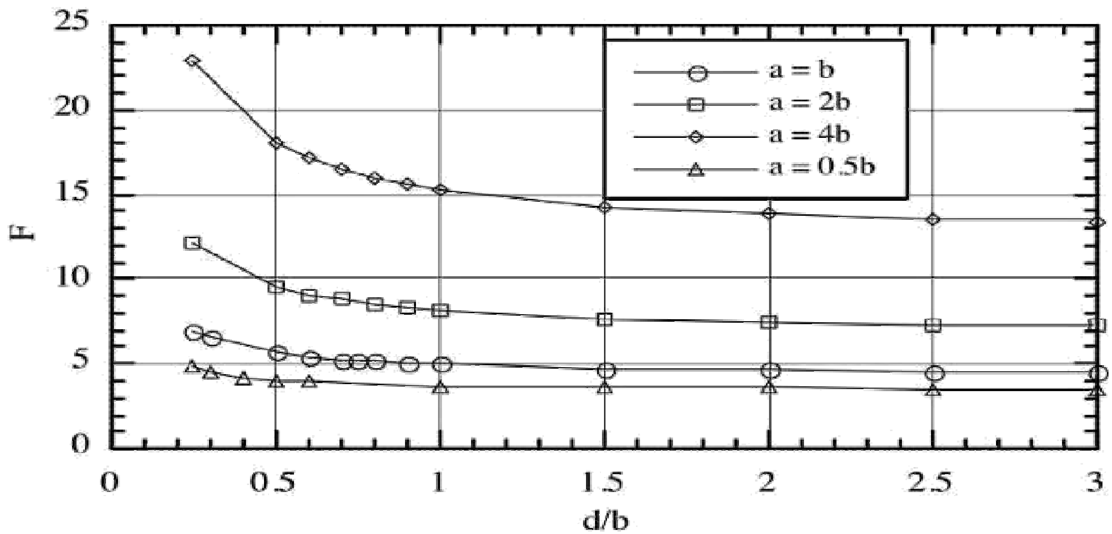


Figure 2.10 Normalised frequency of a rectangular DRA

In figure 2.10, the curves plot the normalised frequency (F) versus the ratio of DRA dimensions d/b for various ratio of a/b. Here, these curves are used to calculate resonant frequency of DRA without using transcendental equation. In example, the different dimensions have taken for calculating resonant frequency are ε_r=10, a= b= d= 10 mm, at d/b=1, the value of F=5 and f_0= 7.55 GHz [2].

$$W_e = \frac{\varepsilon_0 \varepsilon_r abd}{32}\left(1 + \frac{\sin(k_z d)}{k_z d}\right)\left(k_x^2 + k_y^2\right) \quad (2.37)$$

$$P_{rad} = 10k_0^4 |P_m|^2 \quad (2.38)$$

2.6.3.4 Q-factor:

Q-factor of the DRA can be determined by using:

$$Q = \frac{2\omega W_e}{P_{rad}} \quad (2.36)$$

Here, W_e = stored energy

P_{rad} = radiated power

W_e and P_{rad} can be calculated by,

Where P_m is the magnetic dipole moment of DRA:

$$P_m = \frac{-j\omega 8\varepsilon_0(\varepsilon_r - 1)}{k_x k_y k_z} \sin\left(\frac{k_z d}{2}\right)\hat{z} \quad (2.39)$$

By using Q-factor equation, we can calculate impedance bandwidth of the DRA:

$$BW = \frac{S - 1}{Q\sqrt{S}} \quad (2.40)$$

Where S is the maximum acceptable voltage standing wave ratio. Figure 2.11 shows the graphs plots of normalised Q-factor as a function of the DRA dimensions d/b for various values of dielectric constant and a/b. Normalised Q-factor is determined [2]

$$Q_e = \frac{Q}{\varepsilon_r^{3/2}} \quad (2.41)$$

CHAPTER-3

BASIC ANTENNA PARAMETERS

3.1 Gain:

The gain of an antenna is the ratio of the radiation intensity in a particular direction to the radiation intensity. Radiation intensity can be obtained if the power accepted by the antenna were radiate isotropically. If the reference antenna is an isotropic source then the ratio of the maximum radiation intensity of the antenna to the maximum radiation intensity of a reference antenna is the absolute gain of the antenna. The reference antenna is usually a loop, dipole, horn or any other antenna whose gain can be determined. The antenna gain is the product of the radiation efficiency and directivity. It is also a power ration and usually expressed in decibels (dB). The antenna gain is equal to the ration of radiation intensity to the total accepted power (input) divided by 4π.

G= 4π Radiate Intensity / Total Accepted Power……………….(3.1)

Here, we can show radiation intensity R(Θ,ϕ) by and total accepted power (input power) by Pin. If the reference antenna is a lossless isotropic antenna then

$G = 4\pi\ R(\Theta,\phi) / P_{in}$……………………………………………(3.2)

The gain of an antenna is usually expressed in decibels (dB). When the gain is referenced to the isotropic radiator, the units are expressed as dBi, but when referenced to the half-wave dipole, the units are expressed as dBd.

3.2 Directivity:

The directivity of the antenna is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. In any direction, directivity is equal to gain; if the antenna is without dissipation losses. The directivity of a non isotropic source is equal to the ratio of its radiation intensity in a given direction. Directivity can be expressed as (D) :

$D = 4\pi\ U/P_{rad}$……………………………………………………………….. (3.3)

If directivity implies the direction of maximum radiation intensity than:

$$D_{max} = D_0 = \frac{U_{max}}{U_0} = \frac{4\pi U_{max}}{P_{rad}} \qquad (3.4)$$

Here, D_0 = maximum directivity, U = radiation intensity, U_{max}= maximum radiation intensity, U_0 = radiation intensity of isotropic source, P_{rad} = total radiated power. If the values of U, U_{max} and U_0 are equal, than the directivity of an isotropic antenna is unity.

3.3 Return loss:

The return loss of an antenna is another way of expressing mismatch. It is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. The relationship between SWR and return loss can be obtained by

$$Return\,loss = -20\ \log|\Gamma|\ dB \qquad (3.5)$$

Where,

$$|\Gamma| = \frac{SWR - 1}{SWR + 1} \qquad (3.6)$$

3.4 Polarization:

The polarization of an antenna is the orientation of the electric field (E-plane) of the radio wave with respect to the earth's surface and is determined by the physical structure of the antenna and by its orientation. Polarization of an antenna does not depend with antenna directionality terms as horizontal, vertical or circular. Different polarization occurred for different directionality terms [5]. Thus, a simple antenna will have one polarization when mounted vertically, and a different polarization when mounted horizontally. There are few factors that affect polarization in antenna such as reflections. Most of the radio waves reflected from ionosphere, where reflected signals change their polarization randomly [1].

Polarization of the antenna can be predictable by antenna construction but in directional antennas, the polarization of side lobes and main propagation lobe can be different. Polarization can be classified as linear, circular or elliptical. If the electrical field at a point in space as a function of time always directed along a line, than the field is said to be linearly polarized. Linear and circular polarizations are special cases of elliptical and they can be achieved when ellipse becomes a straight line or a circle.

3.5 Radiation intensity and antenna efficiency:

Radiation intensity is defined as the power radiated from an antenna per unit solid angle. It is a far-field parameter and can be obtained by multiplying the radiation density by the square of the distance.

$$R = r^2 W_{rad} \qquad (3.7)$$

Where R is radiation intensity and

W_{rad} is radiation density (w/m^2) [5].

The total efficiency of an antenna depends on some parameters such as reflection efficiency, conduction efficiency, and dielectric efficiency. This reflection happened due to the mismatch between the transmission line and the antenna. Overall efficiency of an antenna can be written as:

$$e_0 = e_r e_c e_d \qquad (3.8)$$

Here, e_0 = total efficiency

e_c = conduction efficiency

e_r = reflection efficiency

e_d = dielectric efficiency.

3.6 Input impedance:

At a point where the transmission line is connected to the antenna, the antenna presents load impedance to the transmission line. This impedance is called the input impedance of an antenna. An impedance mismatch occurs, if the input impedance is equal to the characteristic impedance of the line Z_0. Input impedance of an antenna controls the standing wave ratio as it in relation with $Z_{0.}$ An antenna impedance is equal to the ratio of the input voltage E_i to the input current I_i. If it in general complex than it shows as

$$Z_i = \frac{E_i}{I_i} \qquad (3.9)$$

If the antenna input is at a current maximum and there is no reactive component to the input impedance than Z_i will be equal to the sum of the radiation resistance and the loss resistance.

$$R_r + R_0 \qquad (3.10)$$

Here, R_r = radiation resistance of the antenna

R_0 = loss resistance of the antenna

Input impedance of the antenna depends on many factors as antenna geometry, method of excitation, and its proximity to surrounding objects. For complex geometries, input impedance of an antenna can investigated only analytically while for simple shapes it determined experimentally [23].

3.7 Bandwidth:

The bandwidth of an antenna refers to the range of frequencies over which the antenna can operate correctly [5]. It can be calculated by

$$Z_i = R_i = BW = \left(\frac{F_H - F_L}{F_C}\right) \times 100 \qquad (3.11)$$

Where, F_H is the highest frequency in the band,

F_L is the lowest frequency in the band, and

F_C is the center frequency in the band.

3.8 Quality factor:

The quality factor and efficiency of an antenna are the antennas figures-of-merit. Both are interrelated and do not have complete freedom to individually optimum each other. The quality factor of an antenna represents the antenna losses. The total quality factor (Q_t) shows by the addition of all various losses in antenna [5].

$$\frac{1}{Q_t} = \frac{1}{Q_{rad}} + \frac{1}{Q_c} + \frac{1}{Q_d} + \frac{1}{Q_{sw}} \tag{3.12}$$

Where, Qt = total quality factor

Q_{rad} = quality factor due to radiation losses

Q_c = quality factor due to conduction losses

CHAPTER-4

BANDWIDTH ENHANCEMENT OF DRA's

4.1 Introduction:

Bandwidth enhancement is the main design concerns for most wireless applications of Dielectric resonator antennas. By choosing a low dielectric constant and the appropriate dimensions, a very low Q-factor can be obtained which implies that it is theoretically possible to design an isolated cylindrical or rectangular DRA with a very broad bandwidth. The impedance bandwidth of the DRA can be increased by changing the shape of the DRA (including conical, tetrahedron, ring, triangular etc). One simple method to enhance the impedance bandwidth is to use of modified feed geometries. An another approach is to enhancing the impedance bandwidth is by using multiple DRAs (array or stacked or embedded) instead of single DRA. An introduction of air gap between the dielectric resonator and the ground plane can also improve the impedance bandwidth of the DRA significantly. Also there can be used some other different methods to enhancing antenna bandwidth for different shapes of DRAs such as microstrip-fed DRAs, dual-mode rectangular DRAs, cavity-backed disk, air gaps method, notched rectangular DRA, inverted stepped pyramidal DRAs. In hybrid antennas, a simple method can be used that has a combination of a DRA with either microstrip patch or monopole antenna .

4.1.1 History of Microstrip Antenna:-

The concept of microstrip radiators was first proposed by Deschamps as early as 1953.The first practical antennas were developed in the early 1970's by Howell and Munson. Since then, extensive research and development of microstrip antennas and arrays, exploiting the new advantages such as light weight, low volume, low cost, low cost, compatible with integrated circuits, etc., have led to the diversified applications and to the establishment of the topic as a separate entity within the broad field of microwave antennas [2].

4.1.1 Microstrip-fed DRAs:

By addition of a simple microstrip matching stub, the bandwidth of microstrip-fed rectangular and cylindrical DRAs can be enhanced. High dielectric constant is used for efficient coupling between DRA and the microstrip feed line. The main drawback of this method is significant degradation in cross-polarization due to excitation in higher order modes.

4.1.3 Dual-mode rectangular DRAs:

The impedance bandwidth of a DRA can be enhanced by exciting two or more modes. Both the modes should have similar radiation pattern. We can see enhancement by taking rectangular shape DRA which is fed by a flat probe and it excites in both modes. These modes can be spaced such that a broad impedance response achieved by choosing proper DRA dimensions.

4.1.4 Annular DRAs:

It is another method to enhance the bandwidth of single DRAs. In cylindrical DRA, we remove a section of the central portion to form a ring or annulus. In figure 4.2 shown a probe fed annular DRA. Due to removing the center portion, the low Q-factor is calculated, thus increment in the bandwidth. This type of annular DRAs offers a compact shape which is having advantage over parasitic elements. It shows that a probe is located at the center of the DRA which excite two different modes as $TM_{01\delta}$ and HE_{11}. Both modes indicate radiations like short vertical electric monopole and short horizontal magnetic dipole [2]. For $TM_{01\delta}$ mode the resonant frequency can be calculated by

$$f = \frac{c}{2\pi\sqrt{\varepsilon_r}}\sqrt{\left(\frac{\pi}{2H}\right)^2 + \left(\frac{x_0}{A}\right)^2} \quad (4.1)$$

Where, H = height of the cylindrical DRA, A= outer radius of the cylindrical DRA, B= inner radius of the cylindrical DRA [2]

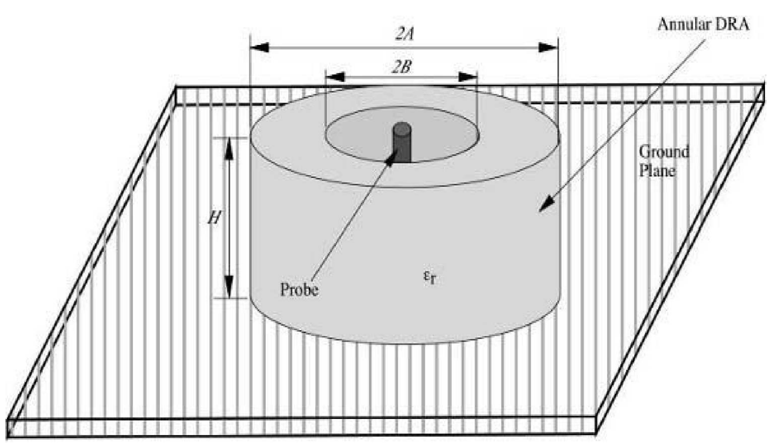


Figure 4.2 Probe fed annular DRA

4.2 Multiple DRAs:

One simple method to achieve wideband or dual-band operation and to enhance the impedance bandwidth can use two or more DRAs. In this method, each DRA resonate at same mode and slightly different frequency. Thus, the resulting output shows the increment in overall bandwidth. Figure 4.3 shows the two lumped-element RLC circuit model. Hence, each resonator has resonator frequency of f_1 and f_u and Q-factors Q1 and Q2. A wideband response is measured when the two resonators are cascaded together [2].

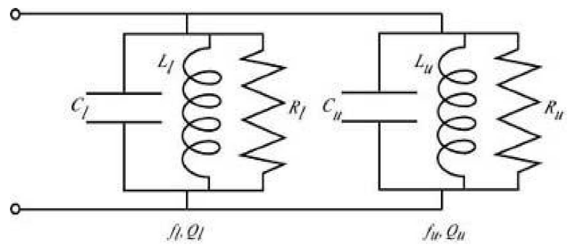


Figure 4.3 Lumped element model for a two DRA

these two frequencies are far away from each other than a dual-band operation is occur. Here, the difference between the dual band and wide band is arbitrary and depends on least return loss required by the application [2].

$$(\Delta f_u + \Delta f_l) = 2(f_u - f_l) \qquad (4.2)$$

(a) Two resonator response *$(\Delta f_u + \Delta f_l) = 2(f_u - f_l)$*

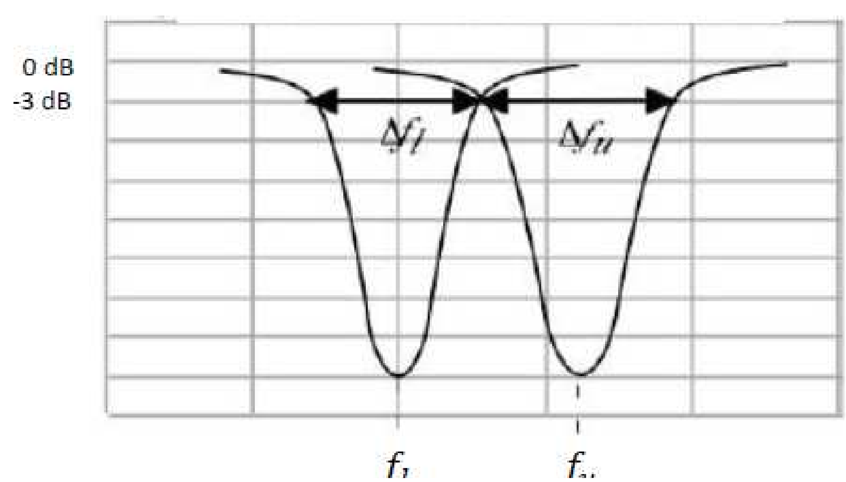
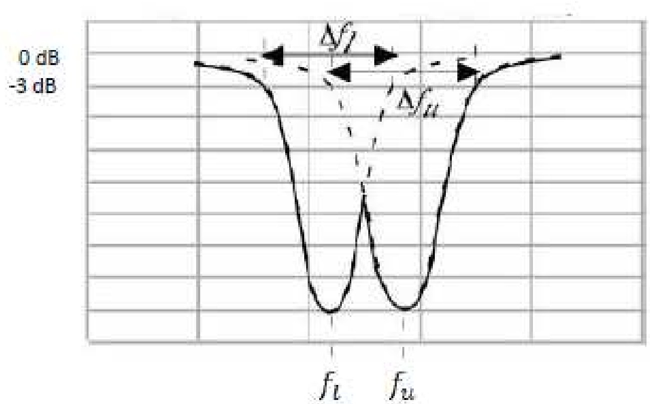


Figure 4.4 (a) Two resonator response

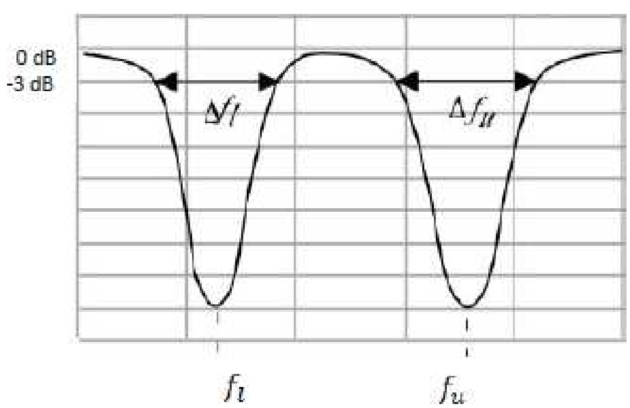
Here Δf is the bandwidth of the 3 dB response of each resonator. The above equation can be written in Q-factor terms as

$$\left(\frac{f_u}{Q_u}+\frac{f_l}{Q_1}\right)=2(f_u+f_l) \qquad (4.3)$$

Both resonant frequencies and Q-factor is used to guess whether a wideband or dual band performance achieved. If the right term is less than left term than dual band response obtained else wideband response [2].



(b) Dual-band response $(\Delta f_u+\Delta f_l) < 2(f_u-f_l)$



(c)Wideband response $(\Delta f_u+\Delta f_l) > 2(f_u-f_l)$

4.2.1 Stacked method :

A method for enhancing bandwidth in DRAs is stacking DRAs a top one another. In many cases with a single element DRA, desired specifications cannot be achieved. For example a high gain, directional pattern cannot be synthesized with a single DRA of any shape. In these applications, a DRA with appropriate element arrangement and feed configurations can be used to provide desired specifications. Dielectric Resonator Antennas (DRA's) have become popular in recent years because of many advantages they offer. The dominant mode radiation patterns in most of the probe-fed or slot fed structures are in the broadside direction of the elements. In DRAs stacked method is one of the highly efficient for bandwidth enhancement. Figure 4.5 shows a cylindrical stacked dielectric resonator antenna. The DRA stacked configuration contains two cylindrical discs of different materials vertically stacked, one atop the other, placed above a ground plane. Lower DRA is excited by a probe feed while the upper DRA is electromagnetically coupled, where the cylindrical DRA has radius (a), height (h) and relative dielectric permittivity (ε_r) [2].

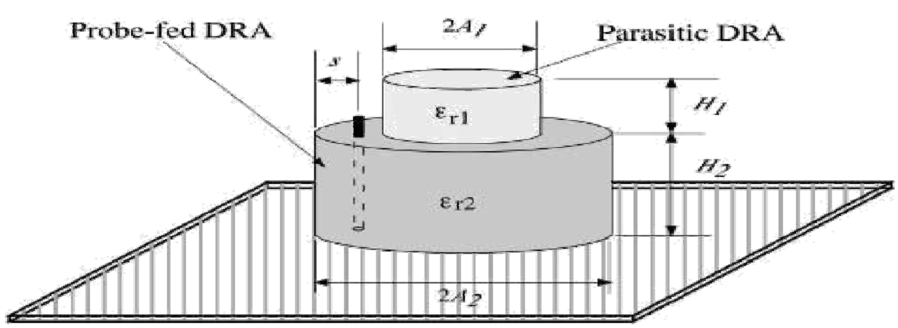


Figure 4.5 Geometry of Stacked cylindrical DRA

Air gaps can also be introduced in between DRAs to enhance the impedance bandwidth. The parameters corresponding to the cylinders can take as per requirement. The main disadvantage of this method is that the DRA geometry is not very low profile [2].

4.2.2 Co-planar parasitic method:

Regarding the mechanical structures and fabrications, Microstrip antennas have the advantage since etching can be used and the feeding mechanism and the antenna can be structured in one process with great accuracy in the alignment. The advantages become more appreciated in the structure of the arrays. DRA requires adhesive to mount the DR over the ground plane and more manual effort in the alignment of the DRA with the feeding structure. Another method to enhance the impedance bandwidth of DRA is by using array technique. In stack method, DRAs are stacking on top of each other that will add increment to the overall height of the antenna [1], [2]. For certain applications, there is height restriction in DRA design. An alternative method is used to enhance bandwidth of DRA called a co- planar parasitic method where DRAs can also be placed on the same plane. Here, the center element is excited by using any feeding method and adjacent elements are electromagnetically coupled. The main drawback is that here the problem becomes more pronounced in the structure of the array, where alignment of the individual elements and the array becomes more critical. The possible misalignment of the array elements could cause deterioration in the radiation characteristics of the antenna. To overcome this problem, it was suggested that the DRA array could be fabricated from a single sheet by perforating the area between the DRA elements with a lattice of holes [2].

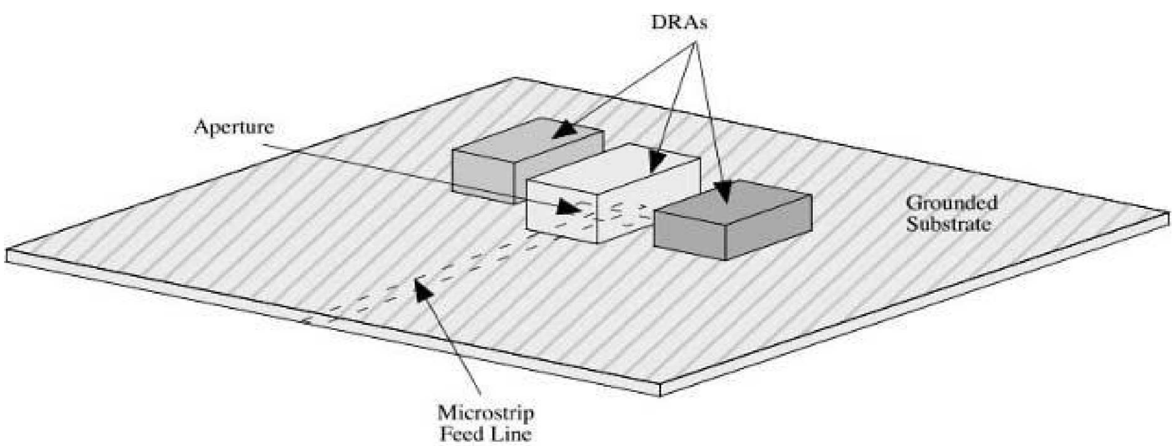


Figure 4.6 configuration of 3-DRAs using co-planar parasitic method

Figure 4.6 shows the wideband configuration of three DRAs. Here, center DR is connected with microstrip feed line. At the bottom there is ground and above it substrate placed. DRs placed above the substrate material [2].

4.2.3 Embedded method:

The bandwidth of DRA can be enhancing by using embedded technique where DRAs can also embedded within one another [1].

4.3 Bandwidth enhancements using impedance matching:

Impedance bandwidth of DRA can be enhanced by using matching networks. Here, some different methods for enhancing bandwidth are explained [2].

4.3.1 Flat matching strips:

In DRAs, at lower frequencies probe feeding is much better than aperture coupling because it is not feasible due to its large aperture size required. This feeding technique offers some advantages as it can be directly connected to a 50 ohm coaxial line and matching achieved by changing the height of the probe. This method also has some drawback as for normal shape probe feed is outside of the DRA material but to obtaining good results the probe must be placed within the DRA, which needs drilling a hole in the DRA material. While using a high permittivity DRA, we have to be very careful because the matching is very sensitive at the probe location as well as uncontrolled or small air gaps between the probe feed and DRA can change the results. In figure 4.7 Shown a probe fed DRA using flat metal strip that is printed onto the side of the DRA. By changing the dimension of height and width of the strip we can achieve good matching [2].

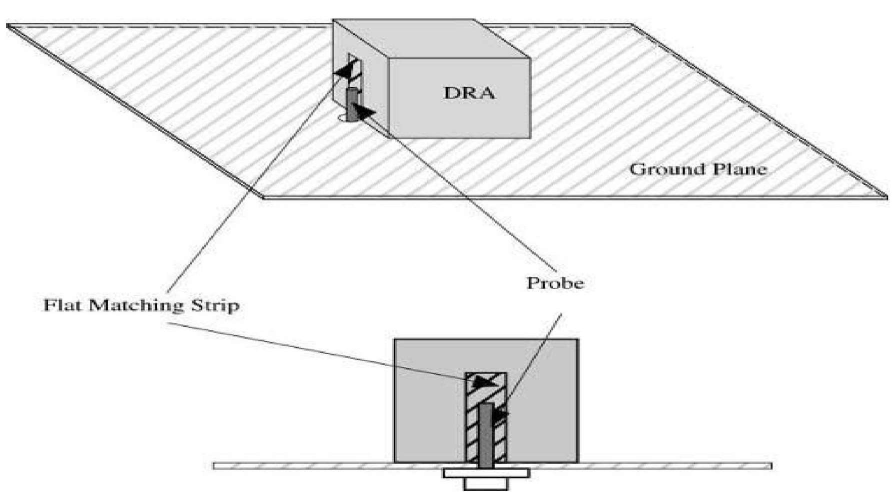


Figure 4.7 A probe fed DRA by using flat metal strip

4.3.2 Loaded notched DRAs:

In figure 4.8 shown an aperture fed notch DRA which offers a wideband or dual-band operation. The main difficulty with this method is due to air gaps by that we cannot achieve a good impedance match between the aperture and the DRA. Normally, a large aperture is required to obtain an adequate match which leads to high levels of back lobe radiation. We can reduce this problem by placing a high permittivity material over the aperture as shown in figure 4.8 [2].

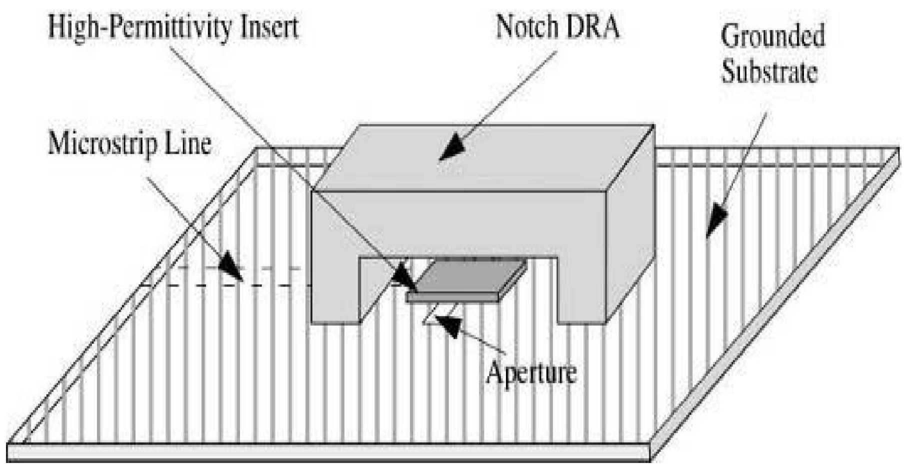


Figure 4.8 Aperture fed notched DRA

4.3.3 Multi segment DRAs

In previous methods, a high permittivity DRA is required to achieve a strong coupling when microstrip feeding is directly used. Due to that Q-factor is directly proportional to the permittivity and the achieved bandwidth is very narrow [2].

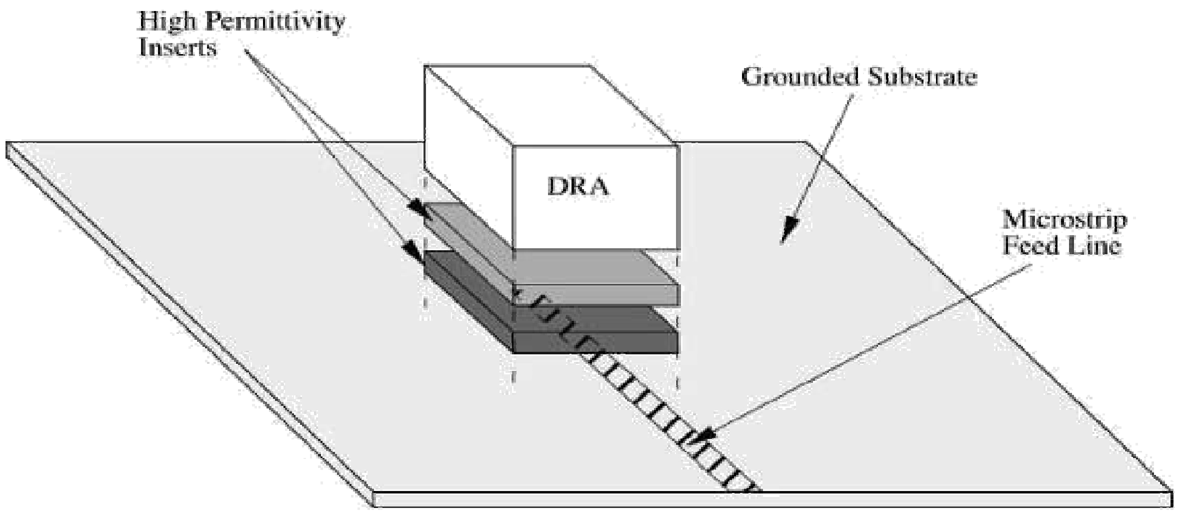


Figure 4.9 Multi segment DRA with more than one inserts

For wide band DRAs with lower permittivity, only small amount of coupling achieved between the DRA and the microstrip line. This problem can be solved by using microstrip line with an array technique where it radiates a small amount of power individually. This solution is not suitable for all applications as it requires a large number of DRAs. Here, multi segment DRA method is used for strong coupling between the microstrip line and the DRA. Figure 4.10 shows the MSDRA (multi segment DRA) configuration. It consists of a rectangular DRA of low permittivity below which one or more number of thin segments of different permittivity substrates are inserted [2], [21].

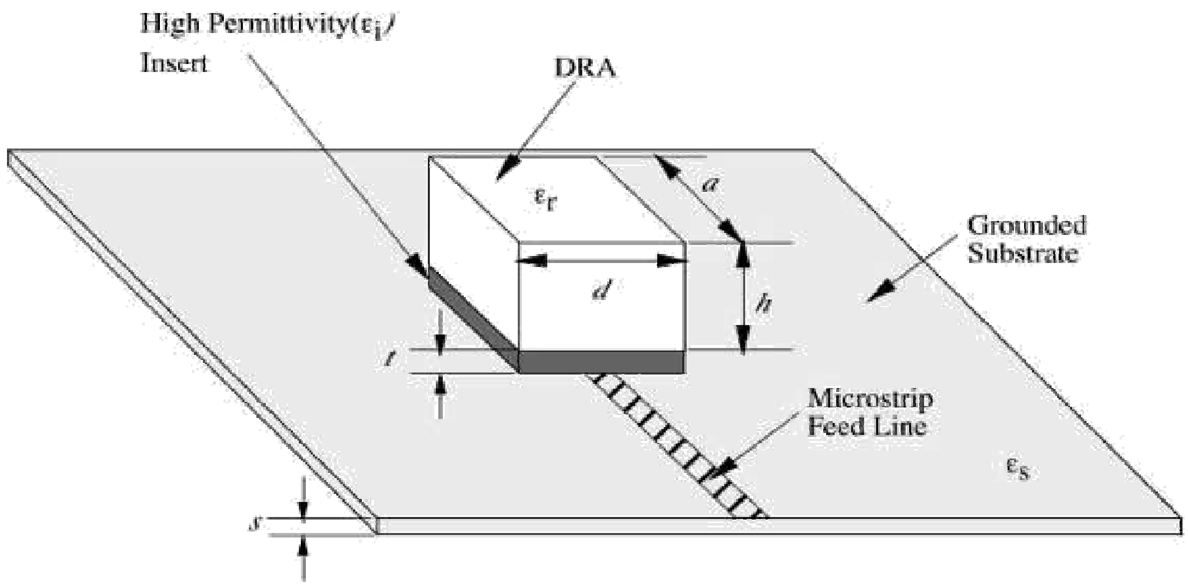


Figure 4.10 Multi segment DRA with single insert

As per the requirement of impedance match, we can add more number of inserts but it increases the complexity of the fabrication process and cost. So that, generally we prefer one inserts only. Above figure shows single inserted multi segment dielectric resonator antenna [2].

CHAPTER 5

DESIGN OF DRA FOR WLAN APPLICATIONS

5.1 Introduction:-

Bandwidth enhancement is the main design concerns for most wireless applications of Dielectric resonator antennas. By choosing a low dielectric constant and the appropriate dimensions, a very low Q-factor can be obtained which implies that it is theoretically possible to design an isolated cylindrical or rectangular DRA with a very broad bandwidth. The impedance bandwidth of the DRA can be increased by changing the shape of the DRA (including conical, tetrahedron, ring, triangular etc). One simple method to enhance the impedance bandwidth is to use of modified feed geometries. An another approach is to enhancing the impedance bandwidth is by using multiple DRAs (array or stacked or embedded) instead of single DRA. An introduction of air gap between the dielectric resonator and the ground plane can also improve the impedance bandwidth of the DRA significantly. Also there can be used some other different methods to enhancing antenna bandwidth for different shapes of DRAs such as microstrip-fed DRAs, dual-mode rectangular DRAs, cavity-backed disk, air gaps method, notched rectangular DRA, inverted stepped pyramidal DRAs. In hybrid antennas, a simple method can be used that has a combination of a DRA with either microstrip patch or monopole antenna.

5.2:DESIGN OF RECTANGULAR STEPPED DRA FOR WIRELESS LOCAL AREA NETWORK (WLAN) APPLICATIONS

5.2.1. Antenna Design:-

Here I proposed a Rectangular stepped dielectric resonator antenna fed by micro strip line for WLAN applications. The performance of the purposed designed antenna such as S parameter, input impedance, radiation patterns, gain and directivity are analyzed and discussed. The obtained results show significant performance improvement in terms of impedance bandwidth and radiation pattern. In this paper, the rectangular-shape stepped DRA of permittivity $\varepsilon r = 55$ is designed and simulated at 5.5GHz .The structure of the antenna is shown in Figure 1. The DRA is fed with direct 50 Ω micro strip line which has dimension 1.9 X 33mm^2. This microstrip line is photo-etched on substrate of permittivity $\varepsilon r = 3.38$. The height of the substrate was 0.813 mm while the width and length are 50 mm and 55 mm, respectively. The dimension of the 1st rectangular DR is 25mm (length) and 20mm (width) with height of 1mm. The dimension of the 2nd rectangular DR is 18.75mm (length) and 15mm (width) with height of 1mm. The dimension of the 3rd rectangular DR is 16.41mm (length) and 11.25mm (width) with height of 1mm In this design, the distance between rectangular DRA and open end of the microstrip line is 6mm .

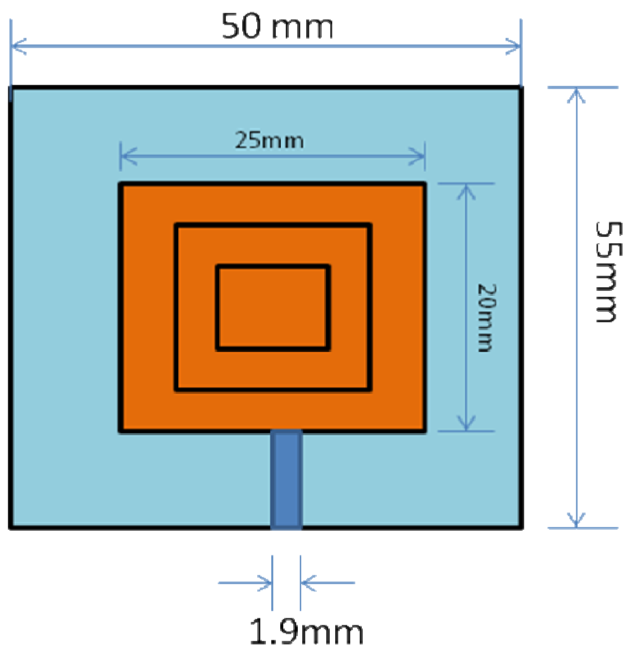


Figure:-a

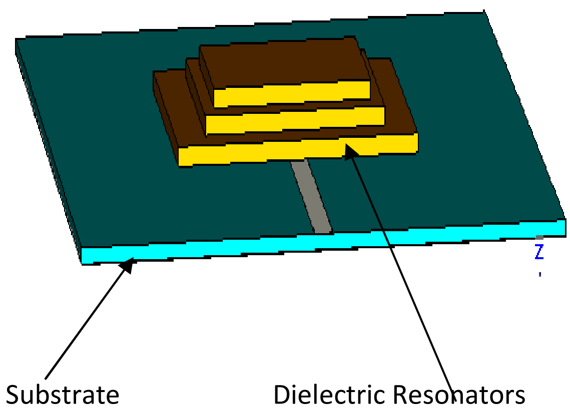
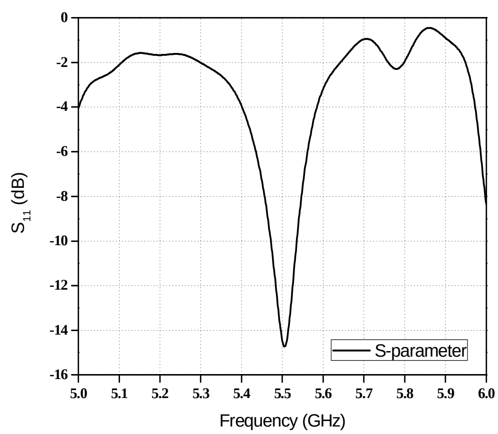


Figure:-b

Figure:5.1 Geometry of the purposed Stepped DRA. a) Top View. b) 3-D Front View.

5.2.3 Result and Discussions:-

The commercial 3D full wave electromagnetic (EM) simulation software CST Microwave studio, based on FIT method is used for simulation purposed stepped DRA whose return loss is -15.0 dB at frequency of 5.5 GHz shown in the Figure 5.2. . The lowest the return loss, the minimum is the loss and the DRA can accept maximum power from the source.



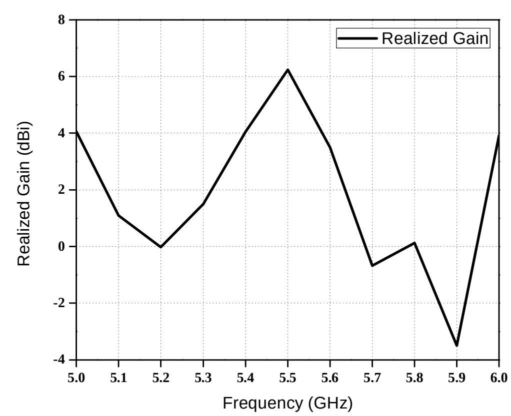
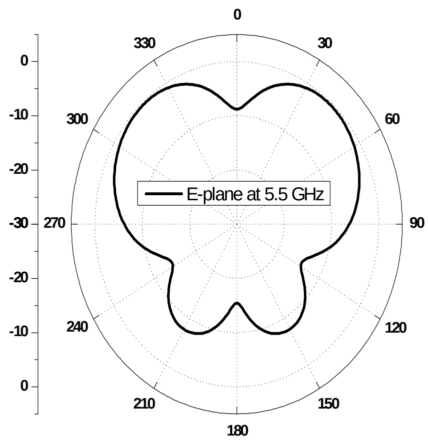


Figure:5.2

Simulated Return Loss in dB. Of DRA versus Frequency

Figure:5.3

Simulated Gain in dB. Of DRA versus Frequency



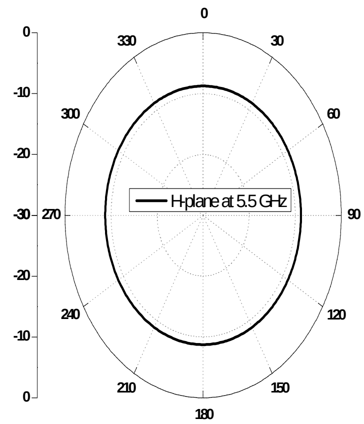


Figure:5.4 Radiation in E-Plane at 5.5GHz **Figure:5.5 Radiation in H-Plane at 5.5GHz**

Figure 5.4 and Figure 5.5 represent radiation patterns for both the E-plane and H-plane, respectively. Besides, it can be clearly observed that there is no radiation below the ground plane for the simulated pattern. E-plane radiation pattern shows a broad side plot where as H-plane radiation pattern shows Omni directional. The gain of antenna is well above 6dB in the frequency range. The figure 5 shows the relation between the gain and frequency range.It shows at 5.5GHz the gain is 6.48dB .

5.2.4. Conclusion:-

This paper presents rectangular DRA operating at 5.5 GHz. Hence, it provides high degree of freedom in controlling antenna performance. The simulated results show that the antenna is suitable for 5.5 GHz WLAN applications. Fabrication of proposed antenna will be carried out in future.

5.3:DESIGN OF RECTANGULAR DRA FOR WIRELESS ANTENNA APPLICATIONS: [Teflon (μ_r =2.1) as DR Element]

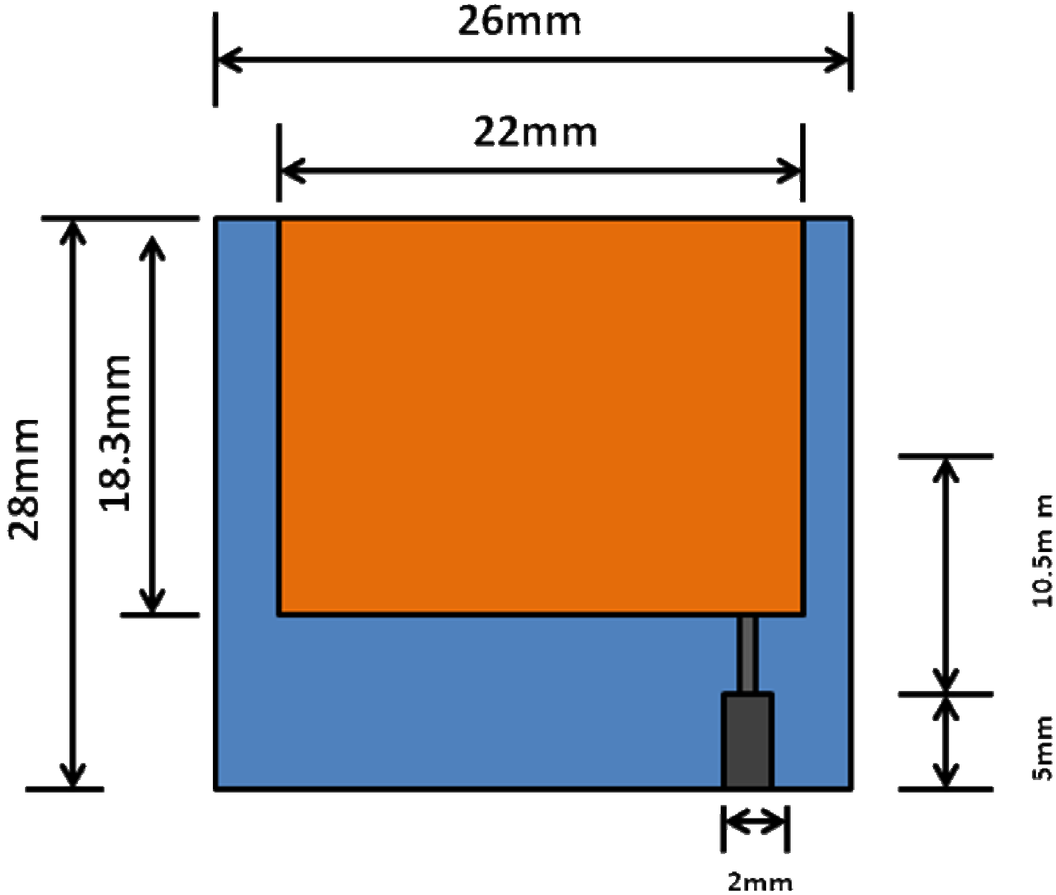


Figure 5.6

The geometry of the proposed Rectangular Shape DRA is shown in figure 5.6, where a Rectangular Shape DR is fabricated from the Rectangular patch having dimension ($L_d \times W_d$) 22 × 18.3 mm^2 with height H_d=3.0 mm at the upper side of the substrate and a relative permittivity constant ε_r= 2.1. The DRA is supported by FR-4 substrate having dimension (L × W) 28 × 26 mm^2 with height (h_s) = 1.6 mm and dielectric constant (ε_{r2}) =4.3. The proposed DRA also consists of a rectangular DR piece. The dimension of the rectangular ground plane is ($L_g \times W_g$) 26 × 11.7 mm^2 with 10x3.5 mm^2 cut away from the central plane area. The designed DRA is connected to the microstrip feed line. Two rectangular patch is used for microstrip feeding with one of the dimensions 1.90mm × 5.0mm × 0.07mm & other dimensions 1.0mm ×10.5mm × 0.07mm as a feeding mechanism,. The proposed DRA is designed to provide Dual Band wireless antenna applications.

5.3.1:Result & Discussions:

Return Loss & VSWR Versus Frequency Characteristics:

The return loss and input VSWR of Rectangular Shape DRA was simulated at different frequencies over 3.0 to 12 GHz using CST Microwave Studio suit 2011. From the simulated results, it was observed that the proposed antenna achieves an impedance bandwidth from 3.5 to 4.2 GHz and 7.8 to 9.0 GHz . Furthermore, to achieve dual band operation, the designed DRA is excited by using with microstrip feed line. The simulated variations of input VSWR as functions of frequency for the frequency range is shown the curve below and VSWR was 1.35 at 3.81 Ghz & 1.04 at 8.35 Ghz.

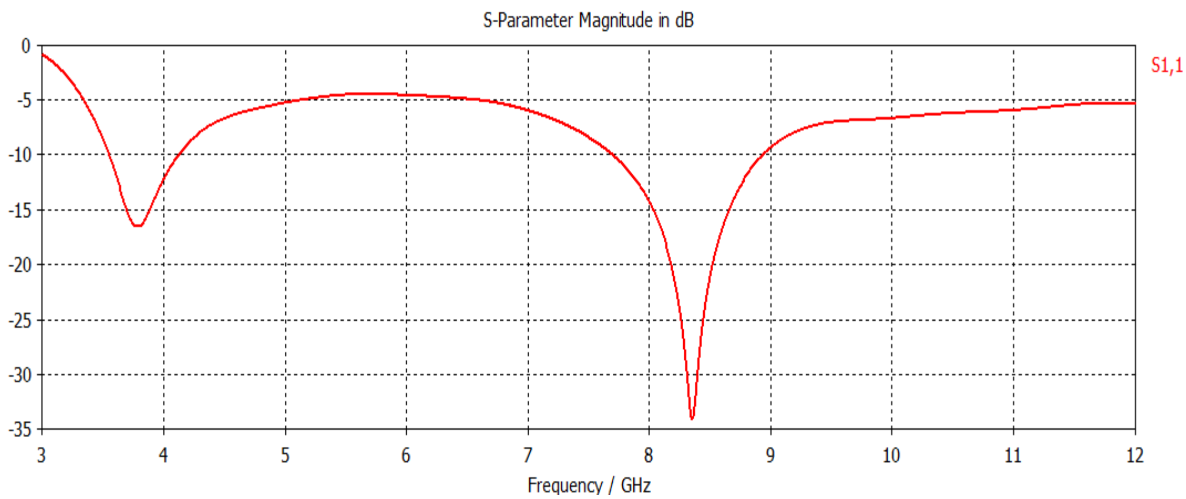


Figure 5.7

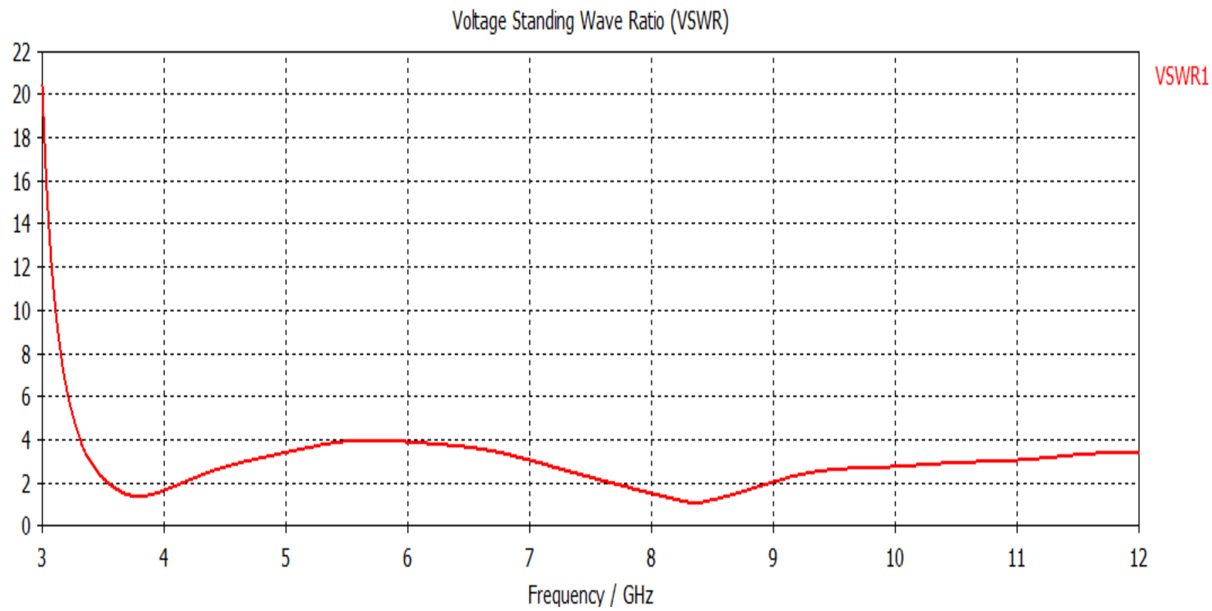


Figure 5.8

5.3.2. Gain and Directivity:-

The peak gain of antenna is 6.25dB at the frequency 3.81 Ghz & 5.75dB at the frequency 8.35 Ghz. The directivity of antenna is 7.85dB at the frequency 3.81 Ghz & 7.73dB at the frequency 8.35 Ghz. It is observed that the gain &directivity of antenna are different in this paper. The proposed antenna is to modify the shape to increase the return loss for wireless antenna application.

5.4:DESIGN OF "T" SHAPED DRA FOR WIRELESS ANTENNA APPLICATIONS : [Teflon (μ_r =2.1) as DR Element]

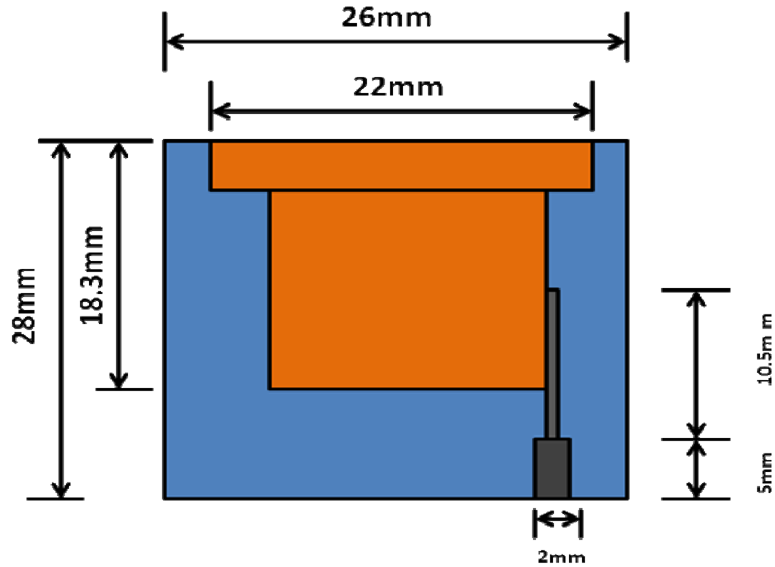


Figure 5.9

The geometry of the proposed T- Shape DRA is shown in figure 5.1, where a T- Shape DR is fabricated from the Rectangular patch having dimension ($L_d \times W_d$) 22 × 18.3 mm^2 with height H_d=3.0 mm at the upper side of the substrate with 2 mm from either side and a relative permittivity constant ε_r= 2.1. The DRA is supported by FR-4 substrate having dimension (L × W) 28 × 26 mm^2 with height (h_s) = 1.6 mm and dielectric constant (ε_{r2}) =4.3. The proposed DRA also consists of a rectangular DR piece. The dimension of the rectangular ground plane is ($L_g \times W_g$) 26 × 11.7 mm^2 with 10x3.5 mm^2 cut away from the central plane area. The designed DRA is connected to the microstrip feed line. Two rectangular patch is used for microstrip feeding with one of the dimensions 1.90mm × 5.0mm × 0.07mm & other dimensions 1.0mm ×10.5mm × 0.07mm as a feeding mechanism,. The proposed DRA is designed to provide Dual Band wireless antenna applications.

5.4.1:Result & Discussions:

Return Loss & VSWR Versus Frequency Characteristics:

The return loss and input VSWR of T shape DRA was simulated at different frequencies over 3.0 to 12 GHz using CST Microwave Studio suit 2011. From the simulated results, it was observed that the proposed antenna achieves an impedance bandwidth from 3.5 to 4.2 GHz and 8.0 to 9.4 GHz . Furthermore, to achieve dual band operation, the designed DRA is excited by using with microstrip feed line. The simulated variations of input VSWR as functions of frequency for the frequency range is shown the curve below and VSWR was with in 1-2.

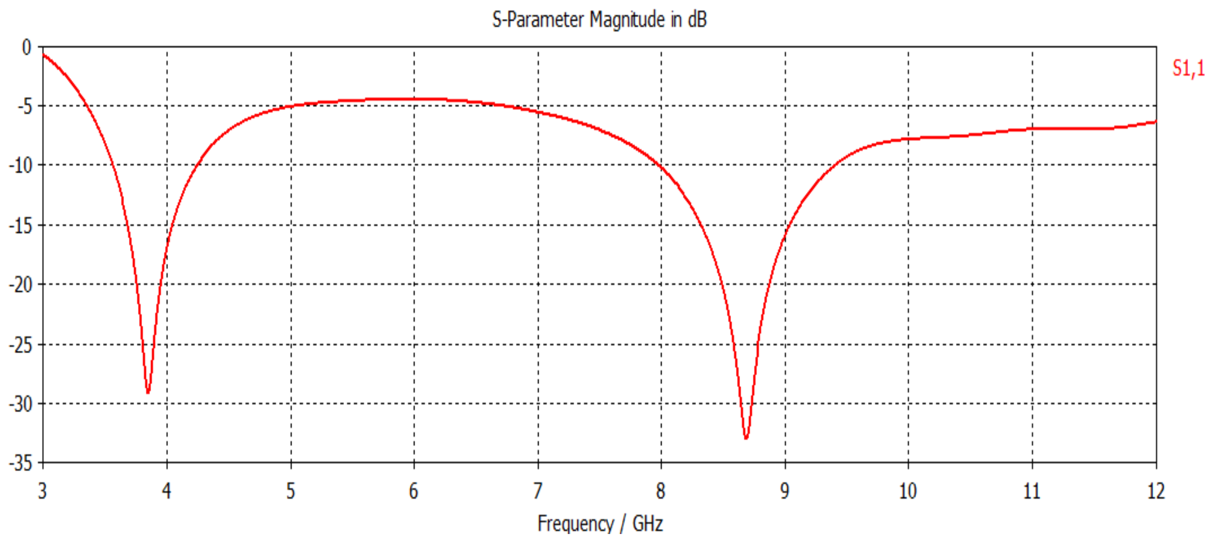
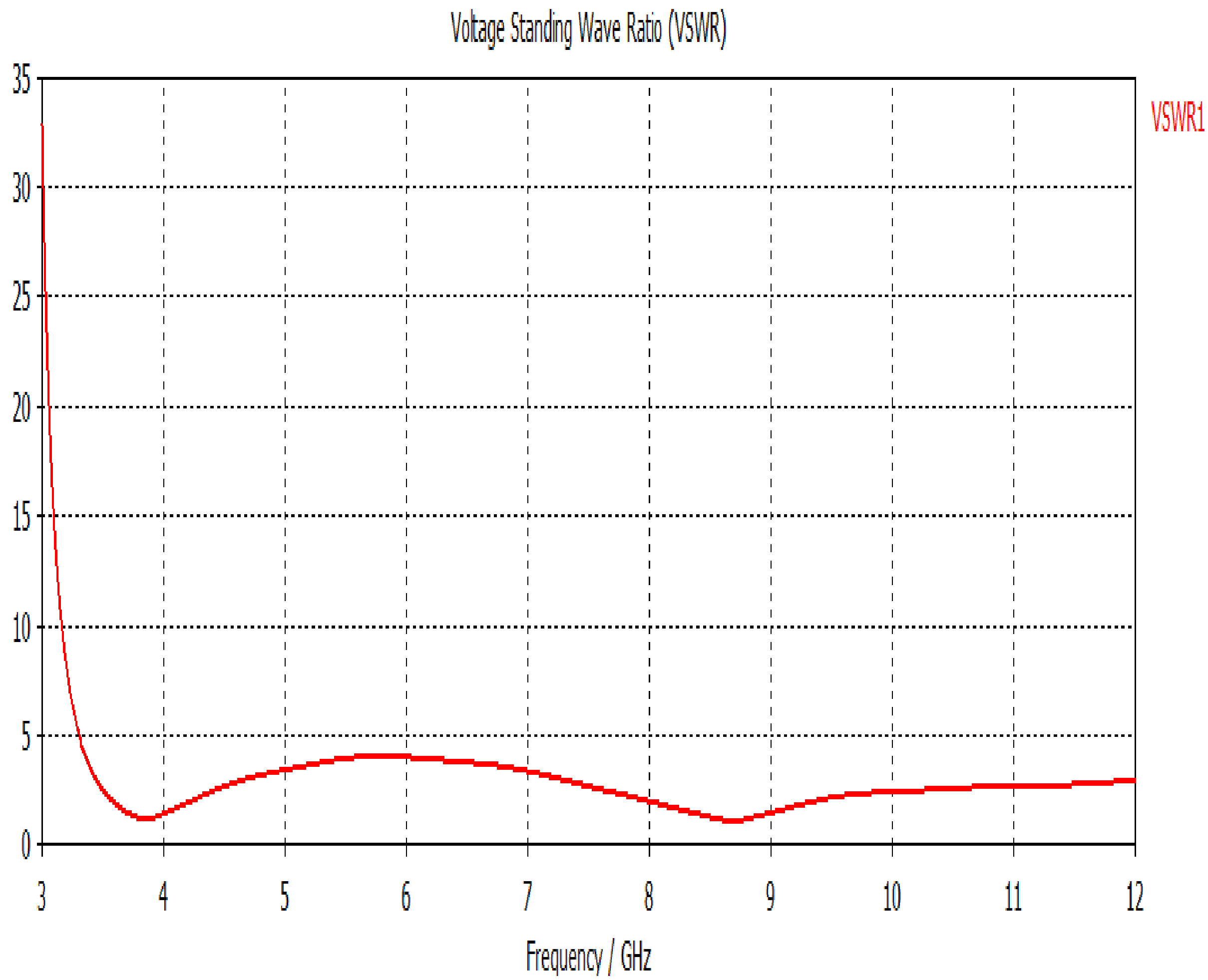


Figure 5.10



Voltage Standing Wave Ratio (VSWR)
VSWR1
35
30
25
20
15
10
5
0
3
4
5
6
7
8
9
10
11
12
Frequency / GHz

Figure 5.11

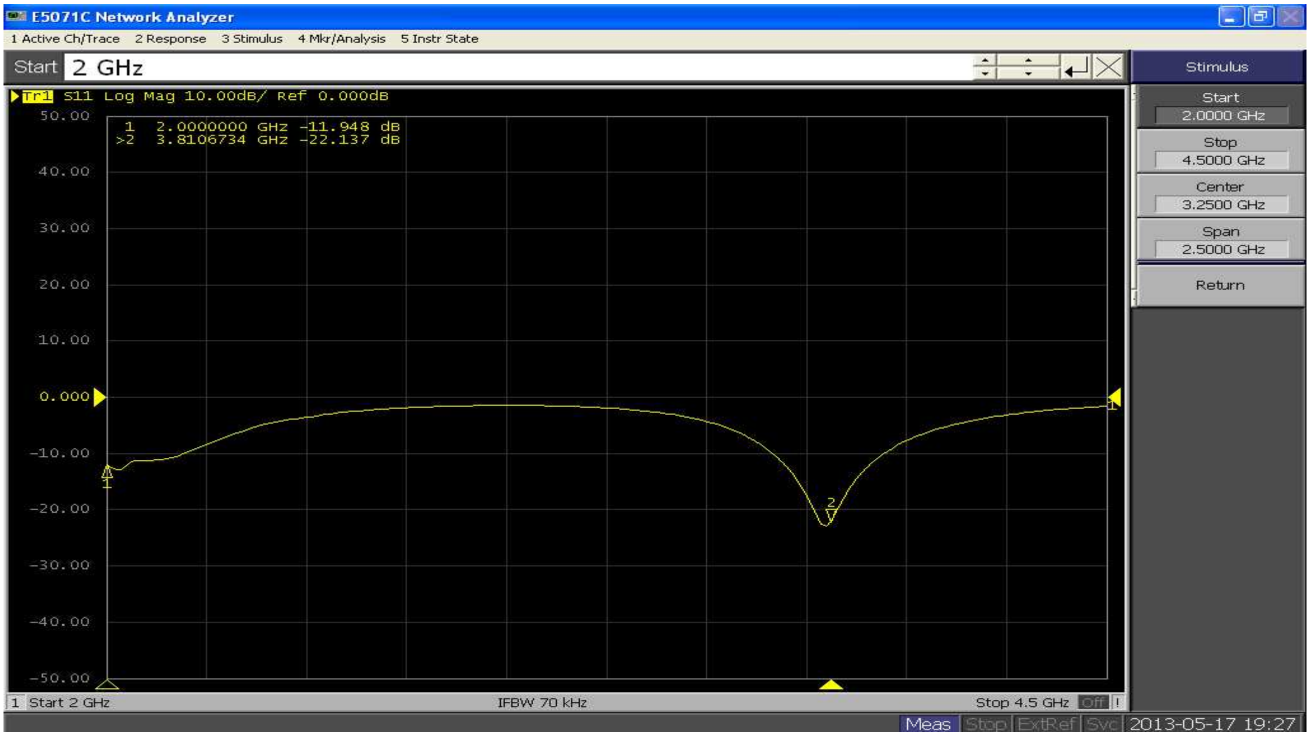


Figure 5.12

The measured value of return loss at one resonate frequency is at 3.81 GHz & -22.13 Db.

5.4.2.Gain and Directivity:-

The peak gain of antenna is 6.72dBi the overall frequency range. It is observed that the gain &directivity of antenna are different in this paper. The maximum directivity achieved is 7.69dB & gain is 5.63 dB at frequency 8.7 Ghz. The proposed antenna is for wireless antenna.

5.5: DESIGN OF π- SHAPED DRA FOR WIRELESS ANTENNA (WLAN) APPLICATIONS

CASE: 1(DR Element is <u>Teflon</u> having Permittivity μr=2.1for "π"shape antenna**)**

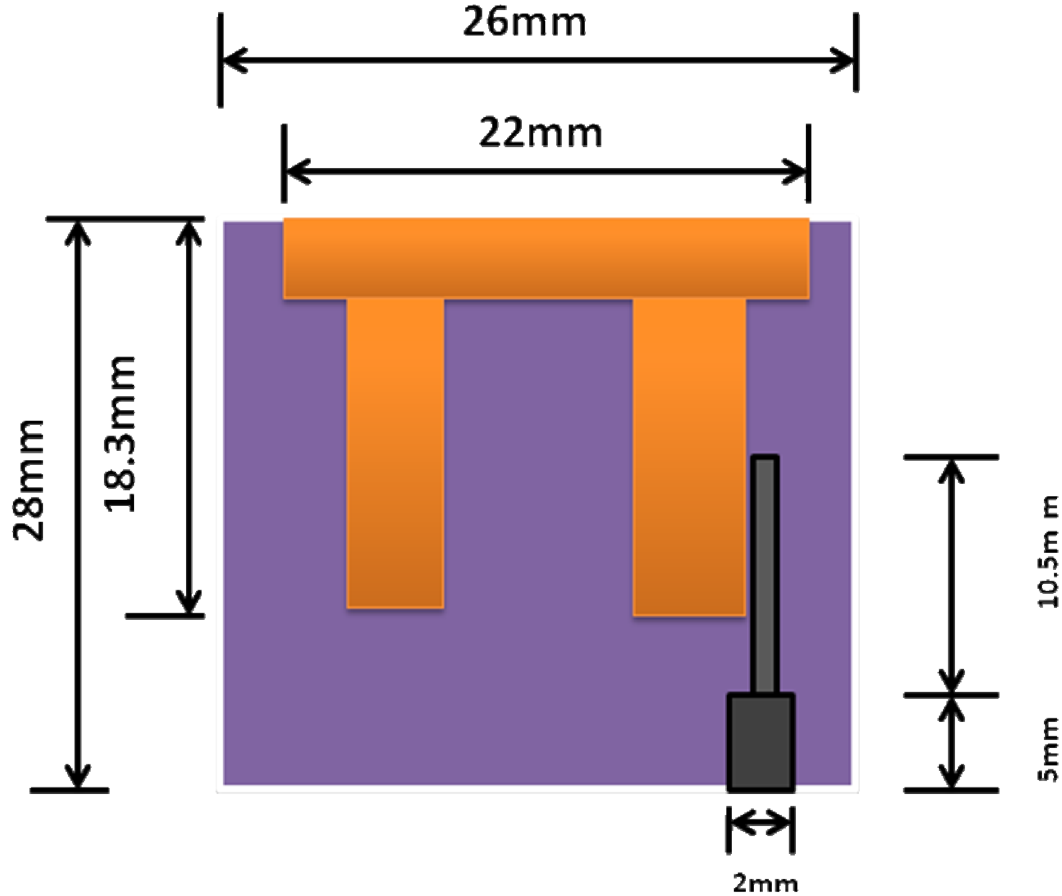


Figure 5.13

Fig1. shows the geometry of the proposed DRA, which consists of a dielectric resonator (DR) and a substrate with an area of 26 mm × 28 mm. The substrate used FR4 in the structure has a thickness of 1.6 mm and relative permittivity (εr) of 4.3. The dielectric resonator selected is Teflon having thickness 3.0 mm and a dielectric permittivity (εr) =2.1. The area rectangular of dielectric resonator is 22mm × 18.3mm is made into "π" shape by eliminating the 6x16.3 mm area from the central portion from dielectric resonator. Two rectangular patch is used for microstrip feeding with one of the dimensions 1.90mm × 5.0mm × 0.07mm & other dimensions 1.0mm ×10.5mm × 0.07mm as a feeding mechanism, which is connected with a 50 Ω Microstrip line. The square patch-feed mechanism gives good coupling between the patch and DR.

5.5.1.Result & Discussions:

Parametric study of a "π" shape DRA (Teflon DR element) is performed by using Computer simulation Technology (CST) microwave studio suite 2010. Here, it is observed that by changing the DR element from Rogger having (permittivity εr=10.2) to DR element to Teflon having (permittivity εr=2.1), the resonant frequency is also varying. It gives the optimum result of resonating frequency 4.25 GHz. It shows that the resonant frequency of the proposed antenna varies with the DR element material changed from Roger to Teflon. From fig. 5 we observe that the return loss of the proposed antenna at frequency 4.25 GHz is -21 dB.

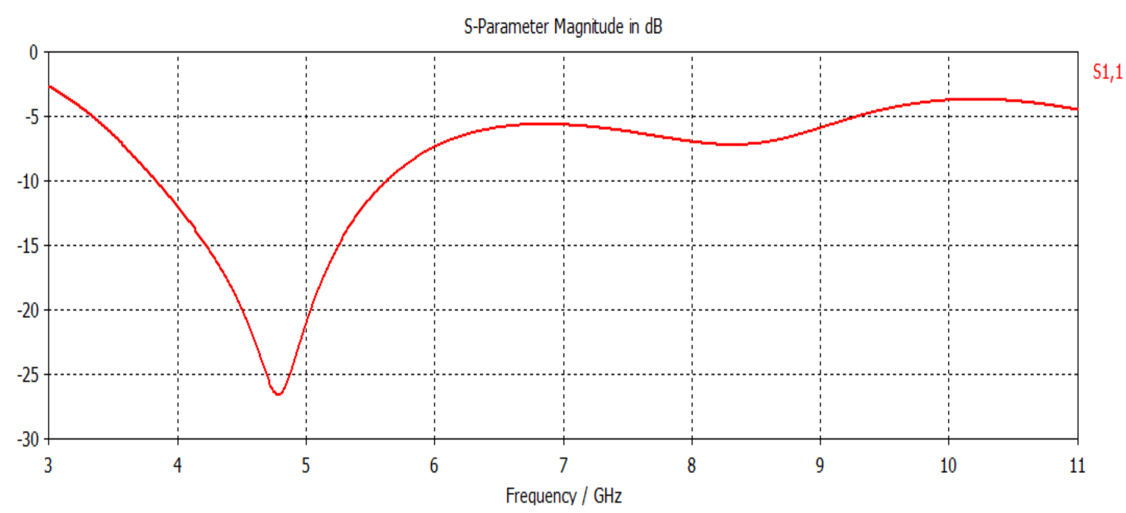


Figure:-5 Return Loss Vs Frequency

Figure 5.14

5.6:DESIGN OF π- SHAPED DRA FOR WIRELESS ANTENNA (WLAN) APPLICATIONS

CASE:-1(DR Element is <u>Roger</u> having Permittivity µr=10.2)

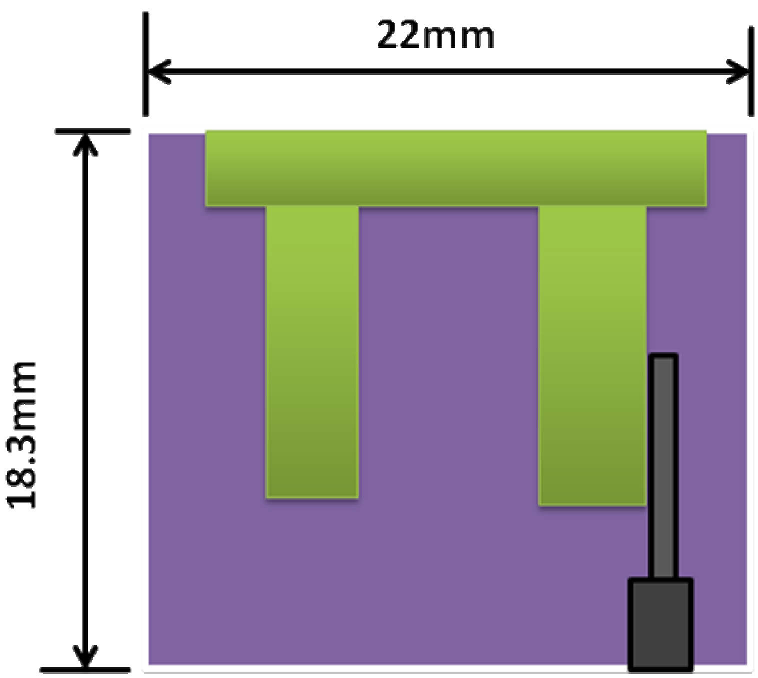


Figure 5.15 "π" shape DRA

5.6.1. Antenna Design:-

Fig1. shows the geometry of the proposed DRA, which consists of a dielectric resonator (DR) and a substrate with an area of 22 mm × 18.3 mm. The substrate FR4 used in the structure has a thickness of 1.6 mm and relative permittivity (εr) of 4.3. The dielectric resonator selected is Rogers TMM10 with a thickness 5.08 mm and a dielectric permittivity (εr) =10.2 The area rectangular of dielectric resonator is 22mm × 18.3mm is made into "π" shape by eliminating the 6x16.3 mm area from the central portion from dielectric resonator. Two rectangular patch is used for microstrip feeding with one of the dimensions 1.90mm × 5.0mm × 0.07mm & other dimensions 1.0mm ×10.5mm × 0.07mm as a feeding mechanism, which is connected with a 50 Ω Microstrip line. The square patch-feed mechanism gives good coupling between the patch and DR.

5.6.2. PARAMETRIC STUDY:

Parametric study of a "π" shape DRA is performed by using Computer simulation Technology (CST) microwave studio suite 2011. Here, it is observed that by varying the height of microstrip feed, the resonant frequency is also varying. It gives the optimum result of resonating frequency 5.5 GHz. It shows that the resonant frequency of the proposed antenna varies with the length of rectangular feed. From fig. 2 we observe that the return loss of the proposed antenna at frequency 5.5 GHz is -65 dB.

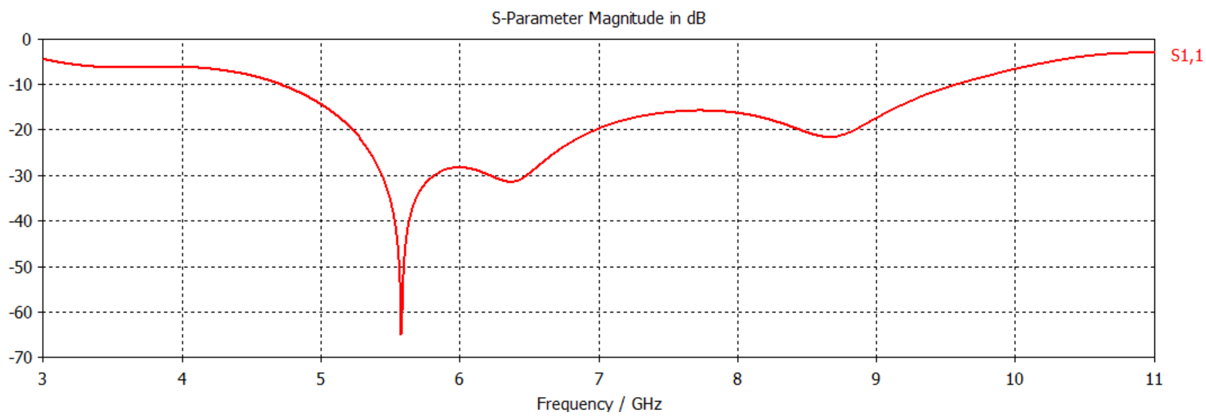


Figure 5.16

Fig:2 Return Loss Vs Frequency

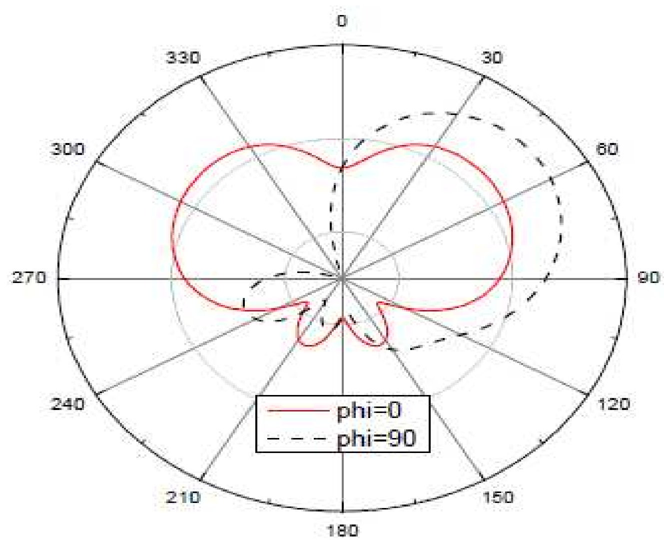


Figure:3 Simulated Radiation Patterns At 5.5 GHz.

5.6.3 CONCLUSION:-

In this paper, "π" shape DR radiator has been designed for WLAN applications. From the results obtained, it is observed that the shape of the DR radiator as well as the patch-feed mechanism is very important for improving the antenna bandwidth. The measured impedance bandwidth of the proposed antenna is spread over the entire frequency range from 4.7 GHz to 9.5 GHz and with stable broadside radiation patterns. The simulated results show that the antenna is suitable for 5.5 GHz WLAN applications.

Table:5.1

Comparative Analysis Of "π" shape DRA(DR Element Rogger & Teflon):-

Sl. No	DRA With **Rogger** DR Element	DRA With **Teflon** DR Element
1	Maximum Return Loss at 5.5Ghz	Maximum Return Loss at 4.8Ghz
2	Return Loss= -65dB	Return Loss= -26dB
3:-	Band width= High	Band width=Low
4:-	Directivity=2.49	Directivity=2.49
5:-	Gain=2.58	Gain=1.71
6:-	VSWR=1	VSWR=1.1

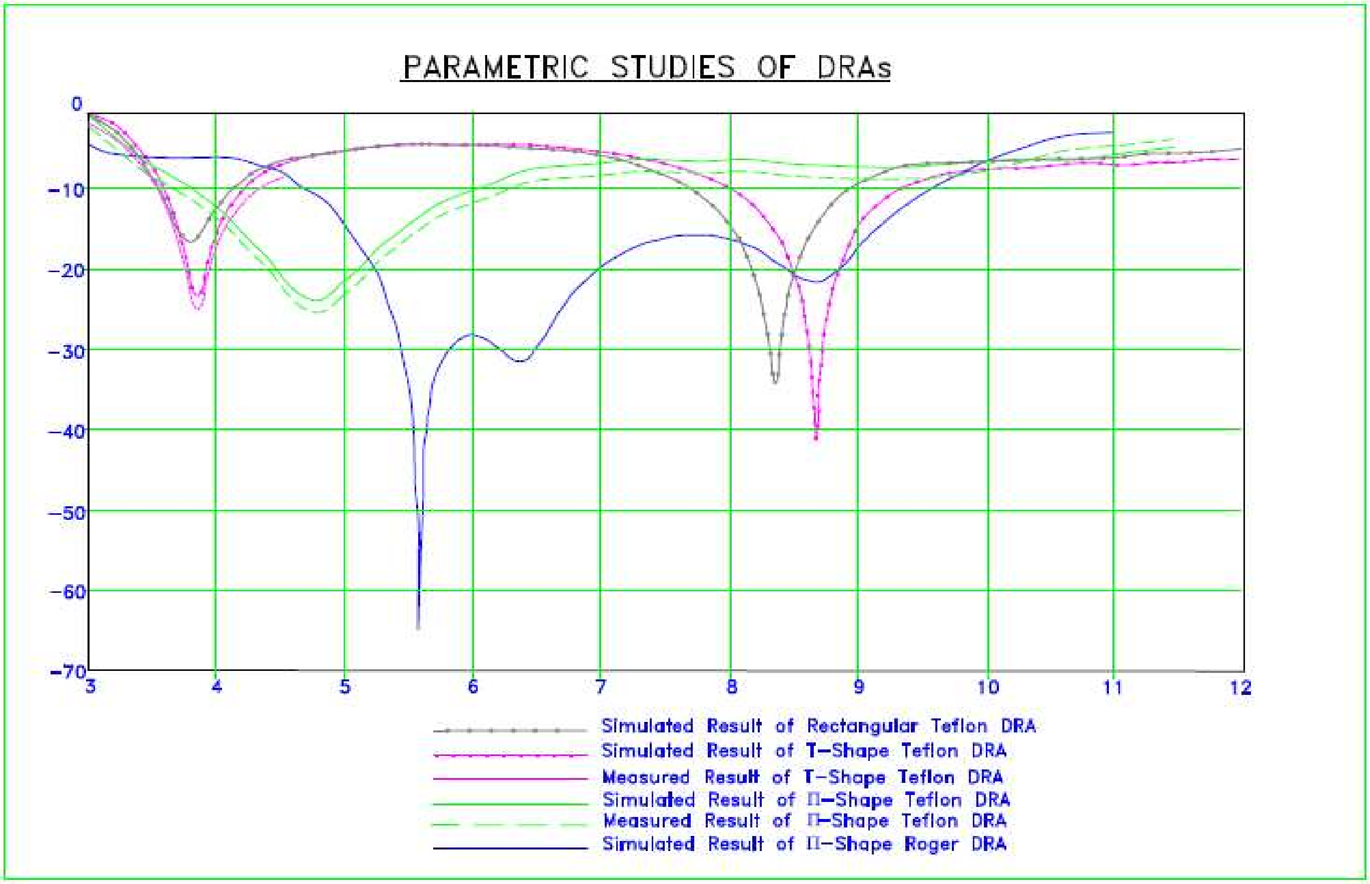
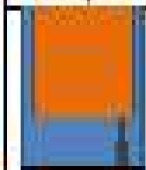
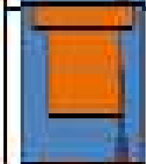
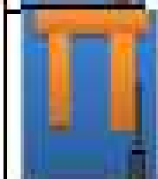


Figure:-5.17 Comparative Study of Retune Loss of Rogger DR & Teflon DR Element

Comparison Of Proposed Antenna's

DRA Shapes	Resonating Frequency	Return Loss	VSWR	BW	GAIN	Band
	3.8GHz 8.3GHz	-16 dB -32 dB	1.35 1.04	0.7GHz 1.0GHz	6.25 5.75	Dual
	3.8GHz 8.7GHz	-24 dB -41 dB	1.09 0.9	1.0 GHz 1.5 GHz	6.26 5.63	Dual
	4.8GHz	-26 dB	1.07	1.4 GHz	1.71	Single
	5.5 GHz	-65 dB	1.0	4.8 GHz	2.58	Single

5.7.CONCLUSION:

From the parametric studies we observe that Roger having dielectric permittivity (εr) =10.2 has better Band Width and return loss at 5.5 Ghz. From the results obtained, it is observed that the shape of the DR radiator micro strip feeding mechanism is very important for improving the Band Width.

CHAPTER:6

CONCLUSION AND FUTURE WORK

6.1Conclusion:

Different shapes of Dielectric resonator antennas have been studied in this thesis. In the first part of the thesis an introduction of DRA about its characteristics, advantages techniques have been studied applications and several bandwidth enhancement. Different shapes of DRAs like rectangular stepped DRA ”π” shaped DRA, “T” shaped DRA. designed for different wireless applications. Among all the design antenna the “T” shaped DRA provide Dual band wireless antenna application. And also the Rectangular stepped DRA is provide dual band application.

6.2Suggestions for Future Work:

Based on observations while completing this thesis, the following topics were identified which would helpful for further investigation

- Fabrication and measurements ”π” shaped Dielectric resonator antenna with Roger material and other designed DRAs will be carried out in future.

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- Since the impedance bandwidth of Dielectric resonator antenna can be enhanced by using multiple DRAs (stacked, embedded and DRA array), design of dielectric resonator antenna using embedded technique, will be carried out in future.

- Besides, the experience of designing DRAs with microstrip line feeding, Dielectric resonator array with dielectric image guide feeding can further be designed to minimize the metallic losses.

PUBLICATIONS:-

Publication:

[1] **Chinmaya Sahoo, Prof. P.K.Sahu and Prof. S K Behera —** “DESIGN OF RECTANGULAR STEPPED DRA FOR WIRELESS LOCAL AREA NETWORK (WLAN) APPLICATIONS” International Conference on Advance Computing and Communication, ICACC-2013 Capitol Hill, Ranchi, Jharkhand 16-March-2013 **,**

[2] **Chinmaya Sahoo, Prof. P.K.Sahu and Prof. S K Behera —** “DESIGN OF RECTANGULAR STEPPED DRA FOR WIRELESS LOCAL AREA NETWORK (WLAN) APPLICATIONS” ***International Journal of Advanced Computer Research (*IJACR)** ISBN 978-93-80747-80-2, March 2013.

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