Design of Dielectric Resonator Antenna for Wi-fi Applications

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Abstract : In this paper, a compact cylindrical dielectric resonator antenna fed by a microstrip line that is proposed for wireless local area network. In this structure, the dielectric resonator performs the functions of an effective radiator along with the feeding configuration. By modifying the structural parameters, the antenna is made to resonate at desired frequency. The proposed model involves a dielectric resonator with the resonant frequency of 2.4 GHz (Industrial, Scientific and Medical). The physical and geometrical parameters of these resonators are oscillating to achieve the required performance parameters. The designed antenna is small in size, less weight, reduced in cost and satisfactory confinement. The antenna analysis shows the desired return loss (<-10 dB), improved radiation pattern over working bands. The proposed antenna, functional parameters such as return loss, bandwidth, voltage standing wave ratio (VSWR), and radiation pattern are realized by the simulation of the structure with high frequency structure simulator (HFSS).

IndexTerms - Dielectric resonator antenna (DRA), ISM band operation, microstrip feedline.

I. INTRODUCTION

In the last two decades, the dielectric resonator antennas (DRA) [1] are in great demand due to their advantages such as absence of conducting loss, high permittivity, small in size, and ease of fabrication. In addition, ease of excitation, low dissipation loss at high frequency, large gain due to the absence of surface wave and conductor losses and ease of stacking to commonly used feeding techniques. In the recent years, much research has been done on the dielectric resonator. It's less volume and low profile, together with its lack of metallic surfaces makes it interesting for low conduction losses.

The dielectric resonator is commonly used in microwave systems for filters and oscillators but where its resonant modes are limited and narrowband. Presently the desire is to perceive what this gadget can accomplish as a antenna component. In recent years, theoretic and analysis examinations have been broadly considered by numerous researchers on DRAs of cylindrical, rectangular, and hemispherical shapes [2]-[12]. he utilization of dielectric resonators [3]-[15] in feeding components requires exact information to couple the resonators and circuits. So as to coordinate the DR to the feedline and to energize the desired mode in the resonator, the most widely recognized sustaining technique is the microstrip feedline [4]. Recently, hybrid dielectric resonator antennas have attracted extensive attention due to their wideband operation without increasing antenna volume. The proposed antenna resonate at desired frequencies. By arranging for the different radiating resonators' position, a compact [6] & [7], or frequency tunable [16]-[20] dielectric resonator antenna can be designed. However, the resonant feeding structure adopted in these reported designs, such as microstrip-fed aperture-coupled, co-axial probe coupling, co planar slot feed, CPW-fed slot arrangement offers more flexibility and is directly compatible with different mounting surfaces.

In this paper, in order to avoid via holes, the microstrip line feed to DRA is proposed [10]. It is the simplest method to energize DRAs. In this method, a microstrip line [11] printed on the same substrate excites a DR that could be placed directly over the microstrip line or nearby over the dielectric substrate. An advantage of microstrip feed is that it is easier to fabricate, match and model.

To exhibit the thought, the proposed DRA [12] is intended for ISM. The designed antenna has the maximum radiation directed toward and directed toward the outside in the industrial, scientific and medical (ISM) band [21]-[22] to transmit that information to a monitoring system. This design has the advantage of compact size, simple structure and can achieve desired radiating patterns. A parametric investigation of the receiving wire was completed, and the impact of the different parameters' execution is discussed.

II. ANTENNA CONFIGURATION

An investigated dielectric resonator antenna structure is as shown in Fig. 1. The dielectric resonator antenna [15], [16] is consist cylindrical dielectric resonator which is printed on the RT Duroid 6010 substrate and resonate at 2.4 GHz. The feed line is etched on the substrate at center position. The proposed antenna has the dimensions of 42 mm × 42 mm × 9.5 mm, and a RT duroid 6010 dielectric with a relative permittivity of $\varepsilon_r = 10.7$ and substrate thickness is 1.6 mm. The top resonator is used to transmit signals to external devices in the ISM band.

The RT duroid 6010 substrate with ground plane, it has dimension of 42x42(LxW) mm^2. The DRA with ceramic material has a radius of 10 mm, height of h_d=7.9 mm, and relative permittivity of $\varepsilon_d = 42$ as shown in Fig. 1. The centre point of DR is placed below the center line of the ground plane with an offset distance S_1 which is used to adjust the coupling energy between the microstrip-fed line and dielectric resonator. The 50-Ω feeding line has a length of L_f =18 mm and a width of W_f =3.0 mm.

In order to reduce experimental cut-and-try design cycles, the simulation software HFSS is used to guide fabrication. By carefully adjusting antenna dimension, the proposed antenna can operate in ISM band, and a good impedance match for the operating frequencies can be easily attained.

III. PARAMETRIC STUDY

A compact cylindrical dielectric resonator antenna fed by a microstrip line is proposed for wireless local area network. In this structure, the dielectric resonator performs the functions of an effective radiator along with the feeding configuration. Figure1 exhibits the cylindrical dielectric resonator antenna, there are a number of parameters that influence the antenna characteristics. To achieve optimum antenna performance, a parametric study is carried out to analyse the characteristics of the DRA.

The cylindrical dielectric resonator is printed on the RT duroid 6010 (ε_r=10.7) on the height of substrate is 1.6 mm, initial parameters are chosen dielectric permittivity of the dielectric resonator is ε_d = 42, height of the DRA is h_d = 7.9 mm, offset distance S_1 =18 mm. The width and length of the microstrip feed line W_f and L_f are chosen to be 3 and 18 mm, consequently.

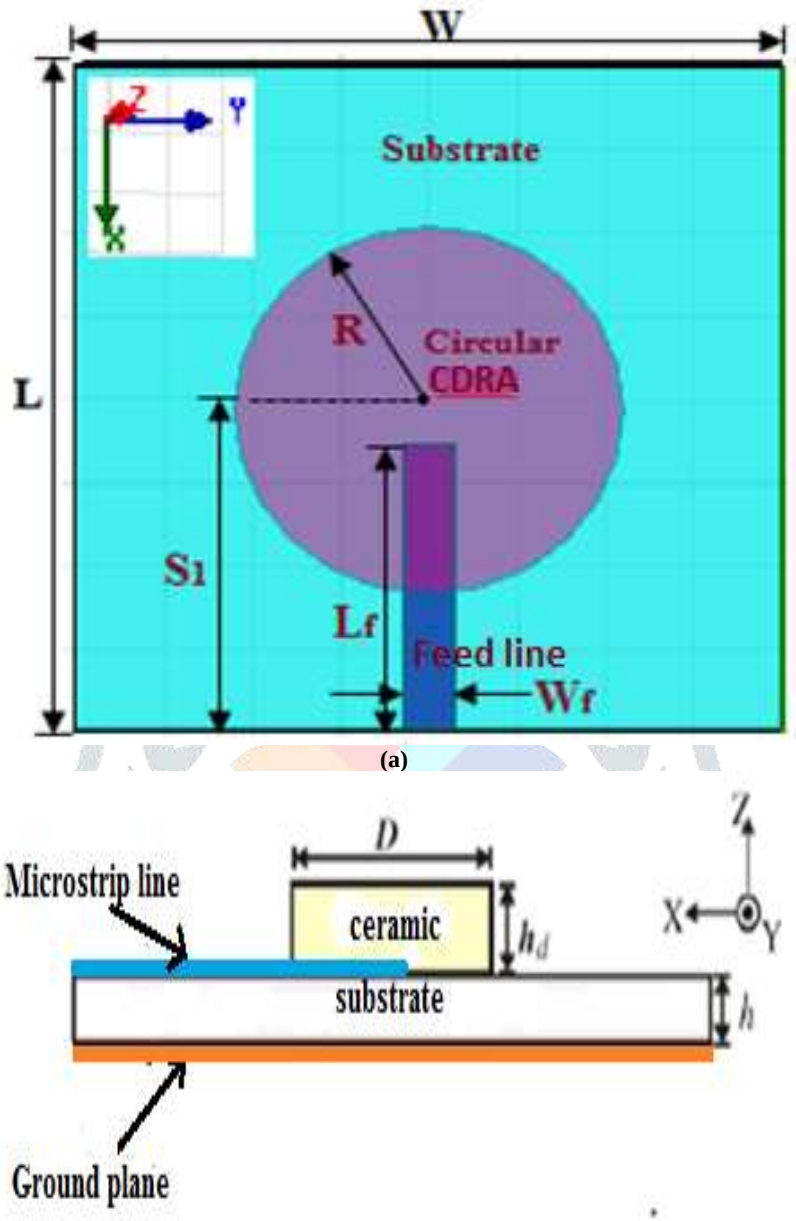

Fig. 1 Proposed dual band DRA (a) Top view; (b) Side view

The theoretical resonant frequency of the DRA is calculated by the following equation [5] and equal to 2.4 GHz which is well suited for industrial, scientific, medical (ISM).

$$f_r = \frac{c}{2\Pi R}\left(\frac{1.6 + 0.513x + 1.392x^2 - 0.575x^3 + 0.088x^4}{\varepsilon_d^{0.42}}\right)$$

Where, x = R/2h_d; c is the speed of light in free space; R, h_d and ε_d are the radius, height, and relative permittivity of the DRA, respectively.

IV. SIMULATED RESULTS AND DISCUSSION

Figure 2 shows the simulated return loss of the proposed cylindrical DRA and ISM band is due to the DR. As observed in Fig. 2, the return loss of the proposed antenna ISM (2.4 GHz).

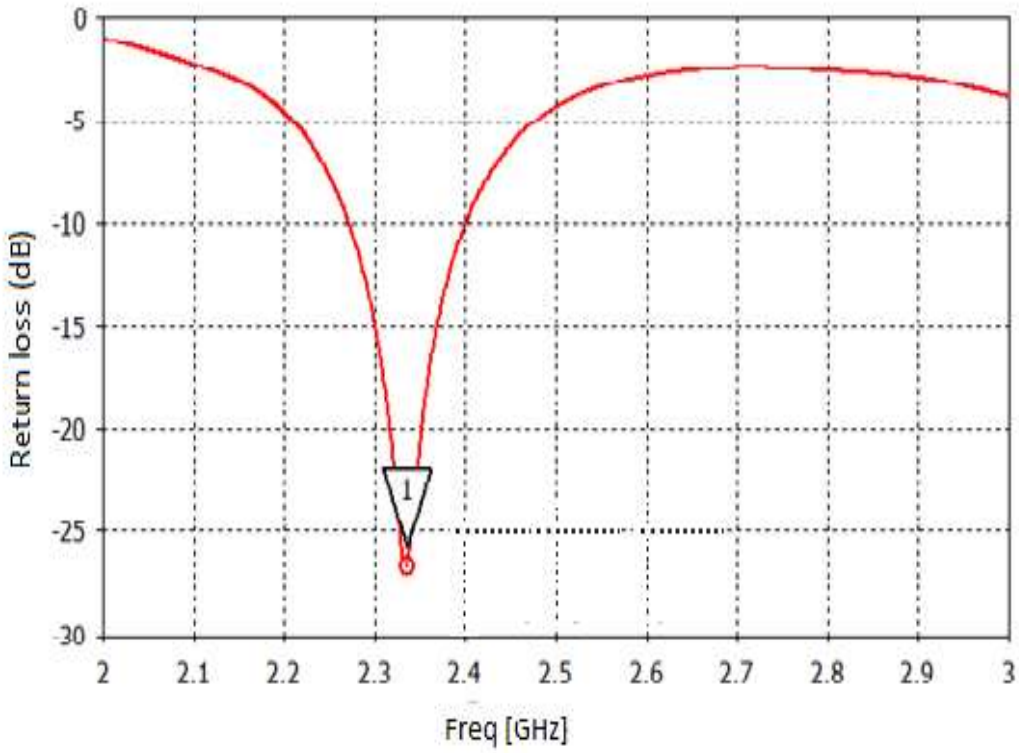

Fig. 2 Simulated return loss for the MICS and ISM band

It is observed -27 dB return loss at ISM band. As a result, a simulated lower band achieves an impedance bandwidth of 5.4 % (for S_{11} < -10 dB) corresponding to the centre frequency at 2.4 GHz. Note that there are no frequencies to be excited without the presence of dielectric resonator.

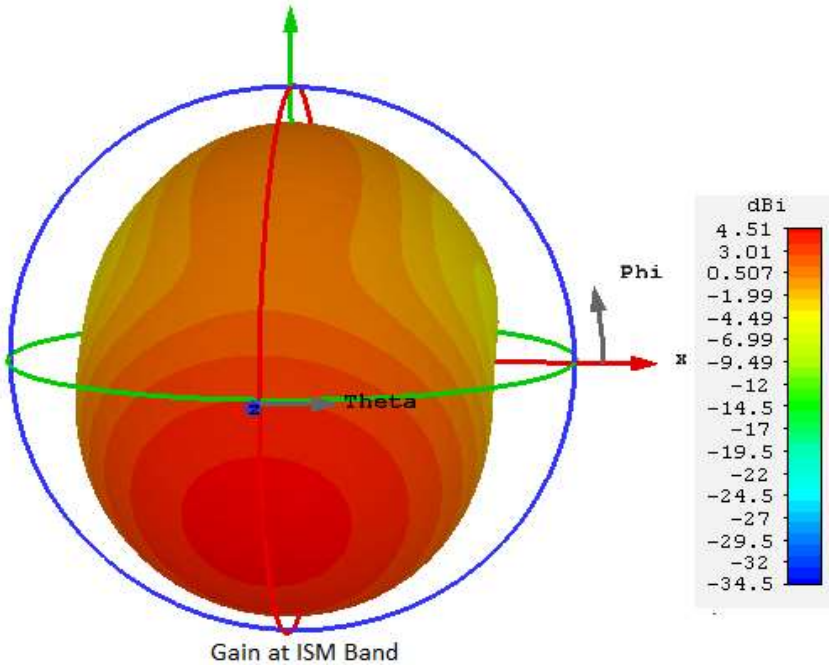

Fig. 3 Simulated Gain at ISM band

Fig 3 exhibits the radiation patterns of the simulated antenna structure for ISM (2.4 GHz) band. The proposed antenna has gain of 4.5 dBi at 2.4 GHz and the its radiates a maximum in the broadside direction at 2.4 GHz.

Fig 4 represents voltage standing wave ratio (VSWR) of the proposed structure, the VSWR of the proposed structure is around to 1.2 over the ISM band and it will be said that proposed lower band antenna offers good impedance matching characteristics.

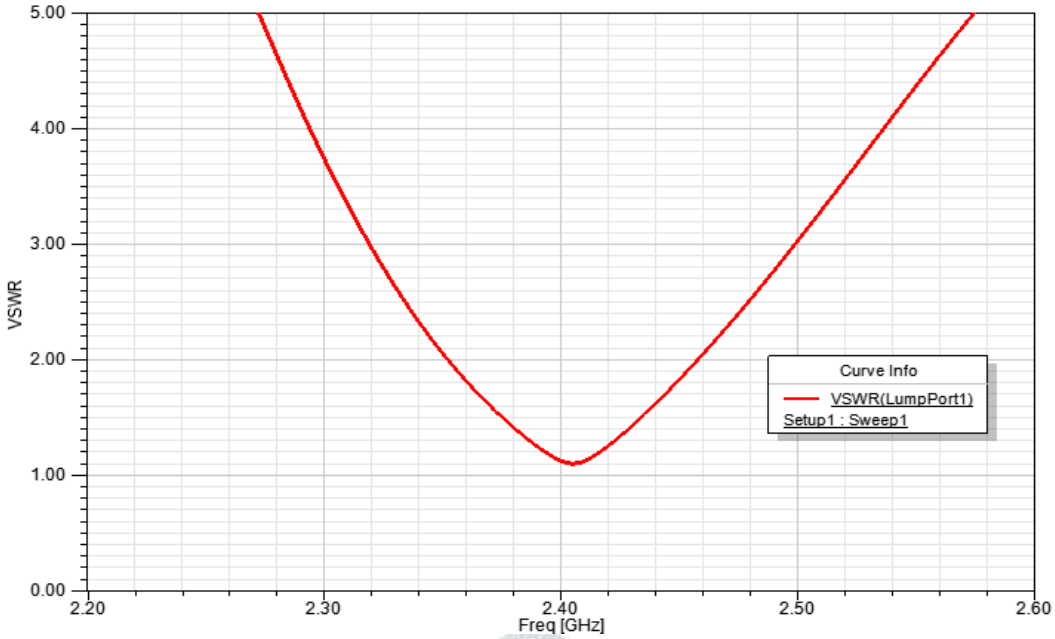

Fig. 4 Simulated VSWR at ISM band

IV. CONCLUSION

A compact dielectric resonator antenna fed by a microstrip line has been proposed. A parametric study is carried out to investigate the antenna functional and design parameters. The prototype has been simulated and it is observed that a bandwidth of 5.4% for ISM band, and a return loss of -27 dB. The bandwidths of the proposed antenna were wide enough to cover ISM bands (2380–2485 MHz). An investigated structure takes a small volume, and easy to model. The proposed model has adequate operational band width and gain and hence the proposed model is suitable for ISM applications.

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